

## Behavior Analysis and the Growth of Behavioral Pharmacology

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Psychologists, particularly those influenced by the work of B. F. Skinner, played a major part in the development of behavioral pharmacology in the 1950s and 1960s. Revolutionary changes in pharmacology and psychiatry, including the discovery of powerful therapeutic agents such as chlorpromazine and reserpine, had produced a surge of interest in drug research. Pharmaceutical companies began hiring psychologists with operant conditioning backgrounds so as to compete successfully in the search for new drugs. Psychologists, most of whom were skilled in the behavior-analytic approach, started to assume prominent positions as authors and editors for the *Journal of Pharmacology and Experimental Therapeutics* as its emphasis on behavior increased. This also proved true with the other publications founded to deal with the popularity of behavioral pharmacology. Especially important were contributions by B. F. Skinner, Peter B. Dews, and Joseph V. Brady.

*Key words:* behavioral pharmacology, history, *Journal of Pharmacology and Experimental Therapeutics*, B. F. Skinner, Joseph V. Brady, Peter B. Dews

Beginning about 50 years ago, some psychologists with an interest in drug research left the departments in which they received their education and moved into the medical schools, usually into departments of pharmacology or psychiatry, or into a rapidly growing pharmaceutical industry. They were reacting to revolutionary changes in psychiatry, largely the result of the introduction of the first two important tranquilizers, chlorpromazine and reserpine, drugs that promised to control psychotic behavior. As the psychologists moved toward pharmacology, many of them started to submit their work to the pharmacology society's own publication, the *Journal of Pharmacology and Experimental Therapeutics (JPET)*. The coverage of behavior

in this journal will be described in detail. Many of these psychologists were strongly influenced by B. F. Skinner's approach to behavioral research, so it is appropriate to turn first to the efforts made by Skinner in the mid-1930s to study drugs.

### *Skinner's Early Drug Studies*

Scientists developing new tools for studying behavior frequently check to see how drugs affect their new method. Sigmund Exner (1873), for example, included data on how a subject performed more slowly in reaction-time experiments after drinking a bottle of Hochheimer wine. About 30 years later, Ivan Pavlov, soon after his initial work on conditioned reflexes, asked a member of his laboratory group, Igor Zavadski, to study the actions of alcohol, morphine, cocaine, and caffeine on delayed conditioned responses in some trained dogs (Zavadski, 1908; see Laties, 1979). Recall that Pavlov had been a professor of pharmacology before becoming a professor of physiology.

Skinner also followed this tradition. In his autobiography, he described the genesis of his early drug studies (Skin-

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Dedicated to the memory of Lou Lasagna (1923–2003).

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ner, 1938, pp. 409–416; Skinner & Heron, 1937) this way:

Sherrington, Magnus, and Pavlov, the physiologists I had chosen as models, had looked at the behavioral effects of a few well-known drugs, such as ether, caffeine, nicotine, strychnine, curare, and the bromides. At Minnesota, W. T. Heron and I, and a student of Heron's, Elaine Wentink, tried a few of the newer drugs, such as Bensedrine (which, like caffeine, greatly increased the rate of responding during periodic reconditioning and extinction) and phenobarbital (which, like bromides, greatly reduced it). (1983, p. 49)

His curiosity apparently satisfied with these findings, Skinner let 15 years pass before showing any further interest in drug research. However, he was immensely interested in applications of his research to societal problems, and had already written the utopian novel, *Walden Two* (Skinner, 1948). While still at Minnesota, he had also made significant progress in developing a technology of animal training that yielded techniques he felt certain would be applicable to humans (Skinner, 1958).

In 1952, back at Harvard and in the midst of a large study of reinforcement schedules, he again turned toward pharmacology, this time with profound effects on that field. But his influence was primarily exerted through the actions of two others, both important in the early development of behavioral pharmacology. One, Peter B. Dews, was also a major participant in the account of how psychologists came to an important role in the affairs of *JPET*, so I will describe that role as well as the story of his interaction with Skinner below under *Psychologists as JPET Editors*. The other man, Joseph V. Brady, was heavily involved in the movement of psychologists into the drug industry, so Skinner's relation to that event will be described under *Psychologists Invade the Pharmaceutical Industry*.

#### *Behavioral Studies in JPET*

The events of the mid-1950s are best understood when compared with the

earlier efforts of pharmacologists and psychologists to deal with the drug-behavior interaction. Because the pharmacology society's main journal dominated its field for the first half of the 20th century, one can follow the growth of American and British behavioral studies with relative ease. *JPET* was founded in 1909 by John J. Abel, the first professor of pharmacology at the Johns Hopkins School of Medicine (Chen, 1969; Parascandola, 1992). He actively solicited the collaboration of British pharmacologists, and they were included on the editorial board from the beginning. The first issue incorporated a friendly welcome to all scientists:

[This journal's] pages will be open not only to pharmacologists and workers in experimental therapeutics, but also to the representatives of any of the biological or medical sciences who may wish to offer papers that have a close relationship to pharmacological or therapeutical questions. (Editorial Announcement, Vol. 1, No. 1, June 1909)

*Pharmacologists as students of behavior.* No psychologists published in this journal for many years. However, a small number of pharmacologists and physiologists showed that it is quite possible to study some kinds of behavior without the benefit of formal training in psychology and, by the time psychologists discovered the receptivity of the journal to their work, many of the topics that dominated research for generations more had been treated to some extent within its pages.

The first behavioral study to appear, appropriately enough considering the contributions to behavior made at Harvard in later years, was by Martin, Grace, and McGuire (1914–1915) from the Harvard Medical School. They reported how an analgesic, acetphenacetin, increased an unambiguously psychological subject, the absolute threshold for "electrocuteaneous sensibility." Three years later David I. Macht, a member of Abel's department at Johns Hopkins, published two articles on the analgesia produced by opium alkaloids, with electrical stimula-

tion of various body areas producing the pain (Macht, Herman, & Levy, 1916; Macht, Johnson, & Bollinger, 1916). His next behavioral study was on the effects on antipyretics on hearing acuity, and in it he gave a name to his field (Macht, Greenberg, & Isaacs, 1920). It began:

The effects of drugs on psychological functions have been the subject of remarkably little investigation on the part of either psychologists or pharmacologists. While references have often been made in a vague way to the psychic effects of pharmacological events, only few of them have been subjected to experimental investigation. . . . [omitting 10 lines describing studies of alcohol, caffeine, bromides, strychnine, and opium alkaloids] . . . With such few exceptions, the domain of what we may be permitted to call "Psychopharmacology" is virgin soil, full of promise. (p. 149)

The following year he published his first study of the rat's performance in a circular maze (Macht & Mora, 1921), using a maze borrowed from John B. Watson, the founder of behaviorism, whose laboratories were then only a short walk from Macht's. (Their affiliation was given as "From the Pharmacological and Psychological Laboratories, Johns Hopkins University.") This maze study was followed by a half dozen more in *JPET* over the next two decades, with Macht using the technique to measure what would now be called side effects, behavior toxicity, or behavioral disruption. At some time before 1921, Macht became a member of the American Psychological Association (Cattell & Brimhall, 1921).

Bessie Davidson (1925) published seven articles on intoxication by inhalants plus one on orally administered caffeine (only the first, on nitrous oxide, is listed among the references). These included behavioral data on memory tests, simple and choice reaction time, tapping rate, steadiness of fine movement, writing, typing and several other measures, and all were on a single human subject. Incidentally, the work on inhalants may mean that Davidson was the first woman to publish in behavioral toxicology, and the

article on caffeine could extend the claim to behavior pharmacology (Latties & Lees, 2003).

In the late 1920s, addictive behavior and tolerance were investigated by men whose influence was to increase greatly during the following decades (e.g., Eddy & Downs, 1928; Tatum & Seevers, 1929).

During the 1930s, pharmacologists continued to publish steadily on behavior. Barlow and Gledhill (1933) measured the "tranquilizing effects" of morphine in combination with a series of sedatives, including several barbiturates, possibly the first use of a term that would achieve great popularity two decades later. Their method involved "recording graphically the spontaneous muscular as well as the respiratory movements of rats tied in a dorsal position on small animal boards" (p. 37). Later, Himmelsbach, Gerlach, and Stanton (1935) used this restraint technique in studying addiction and tolerance. Hanzlik (1931) investigated chronic alcohol consumption by pigeons given a choice between water and alcohol, which were presented in inverted glass cylinders—a technique much utilized from then on. They chose the alcohol, an early instance of drug self-administration. Continuing the work he had started with Tatum (Tatum & Seevers, 1929), Seevers (1936) published the first of a series on opiate addiction in the monkey. Thus, by the end of the 1930s, pharmacologists had initiated work within what eventually became major areas of behavioral interest: pain and analgesia, addiction and tolerance, and, to a lesser extent, learned behavior. The growth over time of these three areas is summarized in Table 1.

*Psychologists start publishing in JPET.* Although psychologists must have known of *JPET*'s existence—frequent reviews of the drug literature appeared in the *Psychological Bulletin* and included references to the relevant articles in *JPET* (Darrow, 1929; Meyer, 1922; Poffenberger, 1914, 1916, 1917, 1919)—I have been unable to find a

TABLE 1

**Behavioral articles by subject in the *Journal of Pharmacology and Experimental Therapeutics* 1909–1970**

Years	Pain and analgesia	Addiction and tolerance	Learned behavior	
			Scheduled	Other
1909–1915	0	0	0	0
1916–1920	2	0	0	0
1921–1925	0	0	0	14
1926–1930	0	4	0	3
1931–1935	5	2	0	4
1936–1940	7	9	0	3
1941–1945	11	6	0	2
1946–1950	23	5	0	0
1951–1955	27	7	2	6
1956–1960	23	5	10	27
1961–1965	22	10	13	18
1966–1970	18	5	32	16

*Note.* The categories are not mutually exclusive.

single instance of one who published in the pharmacology journal before 1931.

Curt Richter, who earned his PhD from Johns Hopkins in 1921 with John B. Watson as his mentor (Richter, 1985), was the first psychologist to publish in *JPET*. His article appeared in 1931 (Table 2; Culler and Jenkins, listed with him here, both published their work in 1934). He reported on electrical skin resistance in men sleeping under the influence of drugs such as amytal and chloral hydrate. Only 10 other psychologists contributed to *JPET* over the following 25 years. Their interests ranged from physiological variables such as the rage shown by decorticated monkeys (Mettler & Culler, 1934) to simple endpoints such as reaction time (Goodnow, Beecher, Brazier, Mosteller, & Tagiuri, 1951; Horst & Jenkins, 1934) and more complex skills like tracking behavior (Payne & Moore, 1955).

Table 2 also shows a sudden surge in behavioral research in the mid-1950s, prompted by the revolution in biological psychiatry. Chlorpromazine was introduced in 1954, after which the discovery of other behaviorally active agents became the focus of intense research in the pharmaceutical industry

(Cook, 2002; Healy, 2002; Swazey, 1974). Concurrently the National Institute of Mental Health (NIMH) initiated a broad program devoted to psychopharmacology. This provided grants that supported a rapid expansion of research within the universities (see Brady, 1997).

*The increasing role of behavior analysts.* From 1956 through 1960, a total of 75 articles in *JPET* contained at least some behavioral data (Table 2). Psychologists were authors or coauthors of 24 (32%) of these. In an effort to assess the influence of behavior analysis on this field, I determined whether or not each of these authors had ever published in the *Journal of the Experimental Analysis of Behavior (JEAB)* by searching the abstracts database at the *JEAB* Web site. This measure of whether an author should be considered to be a "behavior analyst" is crude but defensible in this context; it misses some who should be counted, but does not produce many false positives. As can be seen from the many names that appear in boldface in Table 2, operant conditioners had discovered *JPET*. About one third of the psychologist-authors who published in *JPET* between 1956 and 1960 had also published in *JEAB*. Throughout the next

TABLE 2

**Psychologist-authors in the *Journal of Pharmacology and Experimental Therapeutics* 1909–1970**

Years	Total behavioral articles	Total by one or more psychologists	Psychologist-authors <sup>a</sup>
1909–1915	1	0	
1916–1920	3	0	
1921–1925	17	0	
1926–1930	8	0	
1931–1935	15	4	E. A. Culler, W. L. Jenkins, C. P. Richter
1936–1940	22	1	J. D. Elder
1941–1945	23	2	R. R. Brown, H. C. Hamilton
1946–1950	25	1	J. E. Birren, H. B. Schapiro
1951–1955	43	3	R. E. Goodnow, R. B. Payne, J. M. von Felsinger
1956–1960	75	24	<b>R. Ader</b> , R. E. Belleville, J. E. Dorff, G. T. Hauty, <b>E. Hearst</b> , <b>G. A. Heise</b> , H. E. Hill, E. R. John, C. Kornetsky, R. E. Miller, A. F. Mirsky, <b>W. H. Morse</b> , J. V. Murphy, J. Olds, R. B. Payne, R. G. Pearson, A. J. Riopelle, G. M. Smith, R. P. Travis, <b>T. Verhave</b> , A. I. Wagman, <b>W. Wagman</b> , <b>B. M. Wenzel</b>
1961–1965	76	16	<b>J. B. Appel</b> , <b>P. L. Carlton</b> , <b>C. B. Ferster</b> , <b>I. Geller</b> , J. A. Harvey, H. F. Hunt, <b>E. Hearst</b> , <b>M. E. Jarvik</b> , A. J. Karoly, <b>R. T. Kelleher</b> , C. Kornetsky, <b>V. G. Laties</b> , S. K. Sharpless, G. M. Smith, E. L. Walker, <b>B. Weiss</b>
1966–1970	89	37	<b>H. Barry III</b> , D. A. Booth, <b>F. C. Clark</b> , F. Grabarits, <b>H. M. Hanson</b> , J. A. Harvey, <b>M. E. Jarvik</b> , <b>R. T. Kelleher</b> , C. Kornetsky, <b>V. G. Laties</b> , <b>J. W. McKearney</b> , D. E. McMillian, <b>N. K. Mello</b> , <b>W. H. Morse</b> , A. Oliverio, J. M. Ordy, <b>R. Pickens</b> , R. W. Russell, <b>R. I. Schoenfeld</b> , D. S. Segal, <b>L. S. Seiden</b> , G. M. Smith, <b>M. Stitzer</b> , S. S. Tenen, <b>J. R. Thomas</b> , <b>T. Thompson</b> , E. T. Uyeno, <b>B. Weiss</b> , <b>A. Weissman</b>

<sup>a</sup> Names in boldface are those of *JEAB* authors.

decade, this proportion increased to about two thirds. Table 1 also reflects this influx, with schedule-controlled operant behavior becoming the dominant learned behavior type. The dip in the number of psychologists publishing in *JPET* during the first half of the 1960s probably occurred because of the appearance of two new outlets for drug-behavior papers, *JEAB* in 1958 and *Psychopharmacologia* in 1959 (in 1974, it was renamed *Psychopharmacology*).

#### *Psychologists as JPET Editors*

*Peter B. Dews.* The story of how psychologists came to become so heavily involved with a pharmacology

journal must begin with Skinner's return to Harvard in 1948 and his subsequent intensive study of reinforcement schedules in a close collaboration with Charles B. Ferster (Ferster, 1970; Ferster & Skinner, 1957). In 1952 Skinner was introduced to Otto Kraye, chairman of the Department of Pharmacology at Harvard Medical School. Skinner told Kraye that he had developed some techniques that might be useful to pharmacologists (Skinner, 1983, p. 50). The timing was right because Kraye had just hired Peter B. Dews, a young British pharmacologist with a medical degree from the University of Leeds and a PhD in physiology from the University of Minne-

sota. This is how Dews (1987) recounted his January, 1953, introduction to operant behavior:

Within a short time of arriving in Boston I made a visit to Skinner in his laboratories in the basement of Memorial Hall with Peter Witt. . . . We chatted with Fred for a few minutes and then he said Charlie Ferster would show us around the laboratory. . . .

In order to understand why what I saw that morning was immediately fascinating, a little personal history is necessary. The first project I was involved in when I started pharmacology was on the behavioral effects of tetrahydrocannabinols (Yes, there was interest in THC's in 1945, and had been for years before that.) Studying their behavioral effects in either humans or laboratory animals was frustrating in the extreme. There seemed to be no methods available to study behavioral effects of drugs continuously in real time in the manner we were accustomed to studying the physiological effects. The paper of Skinner and Heron of 1938 was published in a psychological journal and had no effect on pharmacology that I have been able to detect.

When Charlie showed me the pigeon laboratory in 1953, it was immediately apparent from the counters and cumulative recorders that behavioral phenomena were being studied in a way that was well suited for application to pharmacology. In spite of my reservations about pigeons as subjects for drugs, in a short time we had planned a joint project, on effects of pentobarbital on fixed-interval responding, and immediately started experiments. (p. 460)

The initial series of five studies that Dews completed did much toward introducing operant behavior to pharmacologists because they appeared in the pharmacology society journal, *JPET*. The first and fourth to appear were especially influential. In the first, Dews (1955) showed how different patterns of schedule-controlled behavior were differentially sensitive to a drug: Fixed-interval performance was much more sensitive to disruption than was fixed-ratio performance. In his fourth article, he investigated just which aspects of the behavioral performance were most important in producing a drug's effects and tentatively concluded that the response rate itself seemed to be an important determinant, no matter how the rate was originally produced (Dews, 1958b). What motivated the behavior also seemed to be of secondary importance, a conclu-

sion that went against the prevailing wisdom about the importance of motivation.

This is an oversimplification; some limitations were discovered by Dews and others over the decades that followed (cf. Branch, 1984, 1986). But his work led to much fruitful research and helped point up the importance of behavioral mechanisms of action in this area. According to the Institute for Scientific Information's *Science Citation Index*, Dews' 1955 article was cited about 30 times by 1965 and 110 times by 1980. The 1958 article was also cited about 30 times by 1965 but reached 160 citations by 1980.

Although Dews had no formal training in psychology, he almost immediately started to spend some of his time on questions concerning schedule control, publishing in *JEAB* when that journal started in 1958. In fact, he was one of the group that founded *JEAB* and served as its initial editorial board (Dews, 1987; Kelleher & Morse, 1987; Laties, 1987).

Over the next several decades Dews, William H. Morse, and, after 1961, Roger T. Kelleher attracted a steady stream of postdoctoral students to Harvard Medical School, many of whom went on to distinguished careers in behavioral pharmacology. Morse, Skinner's student, joined Dews at the medical school in 1955. Kelleher, who moved to Harvard from Smith, Kline & French, had previously spent 2 years at the Yerkes Laboratories of Primate Biology, an experience described by Dewsbury (2003). Detailed appreciations of this remarkable trio's contributions have recently been published (Barrett, 2002; Miczek, Katz, & Bergman, 2002).

In mid-1957, Dews was appointed to *JPET*'s editorial board. It was a time when pharmacology as a science was entering a highly productive phase. One measure of this was the character of the editorial board. Of its 21 members, three were later awarded Nobel prizes: Julius Axelrod in 1970, Earl W.

Sutherland, Jr., in 1971, and Robert F. Furchgott in 1998.

When *JPET* appointed its first "specific field editors" in 1959, Dews was named the editor for behavioral pharmacology, a position he held for 6 years (Figure 1). His research reputation was steadily growing and, in 1962, Harvard named him the Stanley Cobb Professor of Psychiatry and Psychobiology.

I must insert a personal note here. My first job, after my doctorate from the University of Rochester and a post-doctoral year at Brown University, was in the Department of Medicine at Johns Hopkins. I was hired in 1955 by Louis Lasagna, the head of a new Division of Clinical Pharmacology. After a year, we were joined by Bernard Weiss, another Rochester graduate. Lasagna joined the *JPET* editorial board in 1957, along with Dews. When Dews was selected as specific field editor 2 years later, Lasagna was given the matching position for clinical pharmacology. Weiss and I served as occasional guest reviewers for both men. A new chief editor was selected in 1965, and he named a new set of field editors. This time Weiss, who had just moved from Hopkins to the University of Rochester Medical School (as had I), was named to succeed Dews, becoming the first psychologist to serve in this capacity. Kelleher was put on the editorial advisory board, as was I. At that time, the pharmacology society itself had only 14 psychologists as members, out of a total membership of about 1,200 (Chen, 1969, pp. 5–119).

Weiss was succeeded as field editor by Kelleher in 1971. Kelleher served for a decade and was succeeded in 1981 by John A. Harvey of the University of Iowa. In 1992, Harvey was followed by Lewis S. Seiden of the University of Chicago and Linda A. Dykstra of the University of North Carolina, both University of Chicago PhDs. They served as co-field-editors until 1997. (Seiden, whose degree was in physiological psychology, had already served as the field editor for both

neuroendocrinology and neuropharmacology!) All these psychologists had backgrounds in operant behavior. Most of them had published in *JEAB*, as shown in the far right column of Figure 1. However, Harvey has spent his research career in physiological psychology and neuroscience, concentrating on brain function and such problems as classical conditioning of the rabbit's nictitating membrane (Harvey, 1987). But, the thesis adviser for his 1959 doctorate from the University of Chicago was Howard F. Hunt, who had been influenced by Skinner while earning his own doctorate at Minnesota (Skinner, 1979, p. 266).

Harvey had sufficient breadth to be named the editor in chief of *JPET* in 1992, serving until 1999. His successor, S. J. Enna, reorganized the editorial process, replacing the field editors with a board of associate editors who received manuscripts appropriate to their competencies and then sent them to editorial advisory board members for review. In 1999, one of the associate editors was James E. Smith, a 1973 University of Minnesota PhD in psychopharmacology. In 2002, Alice M. Young, another Minnesota graduate, joined him as an associate editor. Their training and publication records testify to their credentials as behavior analysts, despite an absence of papers in *JEAB* (e.g., Hemby, Dworkin, & Smith, 1999; Young, McMullen, Makhay, & Goushaw, 2002).

In the 1950s and 1960s, those involved with drug studies were frequently strong in their knowledge of behavior but weak in their command of pharmacology. A significant number retrained themselves so well that they went on to successful careers in departments of pharmacology in medical schools; indeed, several either serve or have served as chairs of their departments. They are now being succeeded by men and women who either supplemented their behavioral graduate programs with postdoctoral training in pharmacology or hold degrees from interdisciplinary training grants from the





National Institutes of Health aimed at turning out competent behavioral pharmacologists. Young and Smith represent this new wave.

Figure 1 also shows a gradual increase in those with significant psychological training who also have helped edit *JPET*, with a total of 14 on the board as of June, 2003. Almost all of these have published research on operant behavior, half in *JEAB* and most of the rest in the other journals mentioned above. About half the current board members share a history of post-doctoral work at Harvard Medical School.

### *Psychologists Invade the Pharmaceutical Industry*

*Joseph V. Brady.* In the mid-1950s, psychologists specializing in animal behavior suddenly enjoyed a new and promising opportunity for employment. Pharmaceutical companies raced to set up behavioral laboratories to help them develop new therapeutic drugs. The person most responsible for guiding operant conditioners toward those jobs was Joseph Brady, who finished his PhD in 1951 at the University of Chicago, with Howard Hunt as his adviser. Using the conditioned emotional response preparation (Estes & Skinner, 1941), Hunt and Brady published on the effects of electroconvulsive shock, representing an early application of operant techniques to a physiological question (Brady & Hunt, 1951; Hunt & Brady, 1951).

Brady was in the regular Army and was assigned to the Walter Reed Army Institute of Research after graduation, where he became head of a division of experimental psychology. He hired a star-studded group that included Murray Sidman, who had just finished his degree at Columbia University. The Korean War was in progress, and that

gave Brady the opportunity to collect a strong research team of draftees, some of whom already had impressive training in operant conditioning.

In 1956, Brady published a *Science* article that was influential in demonstrating how operant behavior techniques could be useful in describing the actions of behaviorally active drugs. He showed that reserpine and amphetamine affected suppressed behavior differentially, the former abolishing the suppression, the latter accentuating it. He ended his paper with the statement that the method offered "an approach to the selective assessment of specific drug-behavior relationships in the affective sphere while providing a control for the general behavioral and motor disturbances that frequently develop as nonspecific side effects of such drug administration" (1956, p. 1034; cf. Brady, 1991). This kind of selectivity was just what was needed to support intelligent guesses as to which chemicals would have important clinical effects. Other articles in *Science* from the Walter Reed laboratories had described the use of scheduled behavior maintained by intracranial stimulation (Sidman, Brady, Boren, Conrad, & Shulman, 1955) and the usefulness of a timing behavior schedule in characterizing drugs (Sidman, 1955). (In an earlier *Science* paper, Sidman, 1953, had described the novel avoidance schedule that involved no discriminative stimulus indicating when a shock was imminent, a procedure that was destined to become eponymous as "Sidman avoidance.")

Other operant conditioners had also published their work in *Science*, then a friendlier outlet for such papers than the American Psychological Association journals. For example, Hill, Belleville, and Wikler (1954) described using a conditioned suppression schedule

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Figure 1. Psychologists who served in editorial positions with the *Journal of Pharmacology and Experimental Therapeutics*, 1957–2003. The far right column shows how many articles each editor has published in the *Journal of the Experimental Analysis of Behavior*.

to study analgesic drugs, reporting that morphine would reduce the amount of suppression. Ferster (1954) used a multiple schedule comprised of a fixed-interval alternating with a nondiscriminated avoidance schedule, and concluded that "More complicated behavioral processes, such as discrimination procedures or other schedules of food reinforcement, could also be used alternately with the avoidance procedure to serve as base lines for the emotional by-products of the avoidance behavior or side effects of analgesic drugs" (p. 270).

*The selling of behavior analysis—and behavior analysts.* Brady took the lead in selling the operant approach and in suggesting likely job candidates to drug companies. A visit to the Walter Reed laboratories, strategically located in Washington, DC, was impressive enough to convince many drug house research directors that they should seriously consider this approach to behavior. Here is how Brady (1997) described what happened:

It took a visit from a neuropharmacologist—Irwin Slater, an associate of K. K. Chen at the Eli Lilly Laboratories in Indianapolis—to kick off what proved to be a boon for the behavioral pharmacology business and a goodly number of its early adherents. The invitation extended by K. K. Chen to make a presentation on the topic of drugs and behavior at a Lilly pharmacology seminar was followed in quick succession by 1) establishment of what was probably one of the first behavioral pharmacology initiatives in an industrial setting at the Lilly Laboratories and 2) a dizzying round of behavioral research presentations at virtually every large pharmaceutical company in the country. By the late 1950's/early 1960's, more than a dozen professionally staffed behavioral pharmacology laboratories were conducting studies in the most visible of the drug company facilities including . . . [there follows a list of companies and of some of the psychologists shown in Table 3]. . . . These behavioral folks had cast their lot with the pharmaceutical industry and a "golden age" of behavioral pharmacology was launched! (pp. 174–175)

Table 3 shows how rapidly psychologists established themselves in the drug industry. Only six were employed at the end of 1955, but this number grew to 13 by the end of the following year, to 17 in 1957, and stabilized be-

tween 15 and 18 through 1963. Note where they came from: seven from Columbia, with Keller and Schoenfeld, and three from Harvard, with Skinner. Another five came from Walter Reed, where they had been with Brady and Sidman.

Table 3 includes information on whether they could be considered to be knowledgeable about operant conditioning. The numbers after each name show that an impressive proportion of them—19 of 26—published at least once in *JEAB*, which only started publication in 1958. However, once again our crude measure does not pick up many who are known to have managed operant laboratories (e.g., Finocchio ran a laboratory devoted to drug discovery at CIBA for a dozen years but had little opportunity to publish, a frequent problem for those working in industry).

Several of those who took jobs in industry at this time were also involved in other ways with *JEAB*, then or later in their careers (Hineline & Laties, 1987; Laties, 1987). Boren, Verhave, and Anger were on the initial editorial board. Boren and Catania served as the second (1961–1963) and fourth (1967–1969) editors, respectively. Kelleher later served as an associate editor (1963–1967).

*Was this "invasion" an instance of technology transfer?* When psychologists took positions in the drug industry, they brought with them techniques that were swiftly adapted to the needs of their new employers, presumably enabling the companies to compete more successfully in developing new drugs. The rather informal transfer process bears scant resemblance to models such as the one described by Penny-packer and Hench (1997), with distinct preliminary stages of quantification, repetition, and verification before an actual transfer takes place. But hasn't the operant conditioning technology developed within academia been applied within industry to an important societal problem, the need for new medicines?

TABLE 3

## Psychologists hired by pharmaceutical companies 1955–1963

Hired in 1955 or before		
John J. Boren (17) <sup>a</sup>	Columbia (1954) <sup>b</sup>	Merck (1955–1961)
Donald H. Bullock (7)	Columbia (1950)	Smith Kline & French (1955–1956)
Arnold B. Davidson (2)	Temple (1964)	Wyeth (1956–1958)
		Smith Kline & French (1955–1973)
		Hoffmann-LaRoche (1973–retirement)
Ronald T. Hill (1)	Columbia (1967)	Lederle Labs (1949–1959)
		Geigy (1960–1975)
George C. Stone (1)	University of California–Berkeley (1954)	G. D. Searle (1955–1958)
Thom Verhave (23)	Columbia (1956)	Lilly (1955–1961)
1956		
Douglas G. Anger (7)	Harvard (1955)	Upjohn (1956–1966)
Jacques A. Chevalier (0)	University of California–Berkeley (1954)	Abbott (1956–1964)
Robert E. Edwards (0)	University of Washington (1952)	Sterling-Winthrop (1956–1962)
Dom V. Finocchio (0)	Pittsburgh (1954) (Walter Reed, 1956)	CIBA (1956–1967)
George A. Heise (2)	Harvard (1952)	Hoffmann-La Roche (1956–1962)
Francis Mechner (8)	Columbia (1957)	Schering (1956–1961)
C. Robert Schuster (8)	University of Maryland (1962)	Smith Kline & French (1956–1957)
1957		
Bernard M. Bernstein (0)	Northwestern (1959)	G. D. Searle (1957–1960)
		Lederle (1960–1970)
Peter L. Carlton (3)	University of Iowa (1955) (Walter Reed, 1955–1957)	Squibb (1957–1963)
Irving Geller (2)	American (1957) (Walter Reed, 1952–1957)	Wyeth (1957–1964)
Harley M. Hanson (10)	Duke (1956)	Merck (1957–retirement)
Roger T. Kelleher (1925)	NYU (1955) (Yerkes, 1955–1957)	Smith Kline & French (1957–1961)
1958		
Albert Weissman (8)	Columbia (1958)	Pfizer (1958-retirement)
1959		
B. P. H. Poschel (0)	University of Illinois (1956)	Parke, Davis (1959–retirement)
Larry Stein (5)	University of Iowa (1955) (Walter Reed, 1955–1957)	Wyeth (1959–1979)
1960, 1961		
No new hires		
1962		
A. Charles Catania (1950)	Harvard (1961)	Smith Kline & French (1962–1964)
David L. Margules (0)	University of Michigan (1962)	McNeil (1962–1964)
		Wyeth (1964–1970?)
Carl L. Scheckel (0)	Fordham (1963)	Hoffmann-La Roche (1962–1971)
1963		
Robert Clark (3)	Columbia (1958) (Walter Reed, 1958–1962)	DuPont (1963–retirement)

<sup>a</sup> Total number of *JEAB* publications.<sup>b</sup> Year in which doctorate was awarded.

*Skinner's role.* Skinner catalyzed the development of behavioral pharmacology, prodding others to action on applied extensions of his laboratory findings. He eagerly took advantage of any opportunities that arose to proselytize for what he firmly believed was the correct approach to drug research. He also played a relatively small but important part by serving as a consultant for several companies, only stopping in 1963 when he had to comply with the conditions of a Research Career Award from NIMH (Skinner, 1983, p. 247). In his autobiography he writes of a 1955 interaction with industry, which conveys the flavor of those heady times:

At lunch in the Oak Room at the Plaza he [Karl Beyer of the Research Laboratories of Sharp and Dohme] told me that the company was setting up a program to study drugs bearing on mental illness. He had visited half a dozen laboratories, including Cliff Morgan's at Johns Hopkins, Richard Solomon's in the Harvard Department of Social Relations, Neal Miller's at Yale, and Harry Harlow's at Wisconsin. He had also talked with Peter Dews at the Harvard Medical School and with Charlie [Ferster] and me, and he saw certain advantages in operant methods: standard equipment was available, the experiments required little attention, and some research on drugs had been done, with more underway. He had also talked to Joe Brady at the Walter Reed Army Medical Center in Washington. Brady and a colleague, Howard Hunt, had worked with the conditioned suppression that Bill Estes and I had called "anxiety," in which a stable rate of responding on an interval schedule was suppressed by an otherwise innocuous stimulus which on a number of occasions had been followed by a shock. Electroconvulsive shock, then widely used in the treatment of depression, eliminated the suppression, and Brady had found that reserpine, an antidepressant, had the same effect. . . . Beyer told me that Sharp and Dohme would be installing operant equipment in their laboratories . . . and that John Boren, a student of Fred Keller's . . . would take charge. Could I visit the project four times a year as a consultant? [Skinner returned to West Point a few months later in 1955 for his first visit as a consultant.] Joe Brady and I met at a rather posh hotel where rooms had been reserved for us, and as we drove out together, again in a limousine, we were not unaware that an operant analysis had rather conspicuously arrived. (pp. 99–101)

Skinner continued his active interest in behavioral pharmacology during this time, despite his heavy publishing

schedule—both *Verbal Behavior* and *Schedules of Reinforcement* appeared in 1957. He also had growing programs in programmed instruction and teaching machines, primarily with James G. Holland (Holland & Skinner, 1961), and in the operant conditioning of psychotic patients with Ogden R. Lindsley (Lindsley, 1956; Rutherford, 2003). Three examples of his concurrent involvement with pharmacology, over a 7-month period, will make the point.

In early May of 1956, Skinner co-chaired (with Dews) a conference at the New York Academy of Sciences on "Techniques for the Study of Behavioral Effects of Drugs" (Dews & Skinner, 1956). Four of the eight papers were on operant conditioning, presented by Dews, Sidman, William Morse and Richard J. Herrnstein, and Donald S. Blough; the last three had been Harvard students. Hunt presented a paper on classical conditioning.

In September, Skinner presented a spirited defense of animal research in drug-behavior studies at a National Academy of Sciences conference on "Psychopharmacology: Problems in Evaluation" (Cole & Gerard, 1959). The subgroup for which his paper was written, the Committee on the Preliminary Screening of Drugs, included Hunt, Brady, and Dews, as well as Miller. He enunciated the need for research that focused on behavioral mechanisms of action rather than vaguely defined models: "One moves from the experimental analysis at the lower level to the human level, not by pointing out plausible analogies, but by constructing an experimental situation in which the same kinds of variables are manipulated" (Skinner, 1959, p. 228). This conference led to rapid action by NIMH, which produced a \$2,000,000 Congressional appropriation for research in this area. These funds were used to begin an active grants program.

Finally, as the capstone to his busy year, Skinner lectured on "the experimental analysis of behavior" to 31 (!)

chapters of the Society of Sigma Xi or the Research Engineers Society of America during November and December of 1956 (Skinner, 1999, p. 132). He included descriptions of three behavioral pharmacology experiments and showed figures from reports by Brady (1956), Dews (1956), and Ferster and Skinner (1957). The article appeared in the *American Scientist*, a magazine with a broad and influential readership (Skinner, 1957).

By the end of the 1950s, behavior analysts were clearly important players in the creation of behavioral pharmacology. What further can we conclude about Skinner's own contribution? Little of it was direct: the single published drug study in the mid-1930s, plus a small amount of similar experimental work with Ferster and Dews. Much more important was the fact that when pharmacology required reliable behavioral methods, his behavioral approach suited this need. His persistent attempts to attract others also paid off handsomely when Dews, Brady, and many others stepped forward and soon showed that operant conditioning techniques could serve as a strong handmaiden to drug discovery and development, as well as an essential aid to our understanding of human drug abuse.

### *Behavioral Pharmacology Today*

The current health of behavioral pharmacology is apparent from a brief examination of four aspects of its current status: (a) its place in three major organizations, the American Psychological Association (APA), the Association for Behavior Analysis (ABA), and the American Society for Pharmacology and Experimental Therapeutics (ASPET); (b) its performance within *JPET*, the pharmacology society's journal; (c) the increasing number of other journals available to authors; and (d) specialty organizations that now serve the field.

### *Behavioral Pharmacology in APA, ABA, and ASPET*

*American Psychological Association.* Since 1966, APA has had Division 28, the Division of Psychopharmacology, recently renamed "Psychopharmacology and Substance Abuse" to reflect a broadening mission (cf. Barry, 1997). It currently has about 800 members. This division has had 31 presidents, and all but six have published in *JEAB* (median = 6.5 papers; range, 1 to 22).

*Association for Behavior Analysis.* Although ABA does not have an organized behavioral pharmacology interest group, its annual convention includes "Behavioral Pharmacology and Toxicology" as a specialty area, with support for invited addresses and guaranteed noncompeting programming. A significant number of interested members attend; the May, 2003, convention devoted about 10 hr to platform presentations and several more hours to about 40 posters.

*American Society for Pharmacology and Experimental Therapeutics.* A Division of Behavioral Pharmacology was recently formed within ASPET. One of the 10 divisions active in developing the program for the annual meetings (see also below), it has about 160 members, which is about 5% of the society's active membership of 3,190 (*FASEB Directory*, 2003). This development confirms what has become obvious from this field's strong presence within *JPET* and at the annual convention. One of its first actions was to initiate the Peter B. Dews Award for Research in Behavioral Pharmacology Lecture. The person chosen for the 2002 award was William H. Morse.

Recent issues of *JPET* contain more behavioral pharmacology than was the case when psychologists first became involved in the editorial process. From 1966 to 1970, *JPET* published 1,360 articles, 89 (6.5%) of which contained at least some behavioral research—including measures of analgesia, and so

forth. In the single year, 2002, the journal published 578 articles. Of these, 48 (8.3%) were behavioral to some extent. The subgroup of schedule-controlled operant papers also increased as a proportion of all behavioral papers. Between 1966 and 1970, they comprised 2.4% (32 of 1,360) of the total; in 2002, this rose to 3.8% (22 of 578).

Most of the 22 articles involving schedule-controlled operant behavior were concerned with drugs of abuse; appropriately, 17 were supported by the National Institute on Drug Abuse. The most popular technical procedures used during this year were drug self-administration (13 articles) and drug discrimination (seven articles), both now mature procedures with long histories and important enough to warrant the formation of separate specialty organizations (see below). There was a single study of analgesia that used a shock titration schedule, and one that examined a multiple-schedule baseline.

A larger sample of articles and a more sophisticated content analysis than I have provided here will be needed for any firm conclusions, but the overwhelming preponderance of drug-discrimination and drug self-administration articles confirms—for *JPET*—Branch's prediction of 20 years ago:

Pharmacologically oriented research using drug-discrimination paradigms will continue because the preparation has become a standard part of the pharmacologist's arsenal. Research on drug self-administration also will advance because of the obvious social relevance of such work. The picture for the rest of behavioral pharmacology is less clear. We know that environmental variables can modify a drug's behavioral effects. My suggestion is that we focus more closely upon behavioral mechanisms of action. (1984, p. 520)

*Other behavioral pharmacology journals.* Apart from *JPET*, at least five journals now compete for manuscripts by behavioral pharmacologists. Examinations of two of these, *Behavioural Pharmacology* (*BP*; founded in 1990) and *Experimental & Clinical Psychopharmacology* (*ECP*; 1993, published by APA), show that approximately the same relation holds for them as for *JPET* with regard to the psychologists

on their editorial boards who also publish in *JEAB*. For *BP*, 10 of the 24 or so psychologists in editorial positions in 1992, and 10 of the 20 on the 2002 board, have published in *JEAB*. For *ECP*, 11 of about 20 psychologists on the initial board in 1993, and 18 of 27 in 2003, have published in *JEAB*, as have its first two editors: C. R. Schuster and Warren K. Bickel.

The journal *Psychopharmacology* (1959) has broad interests: "from clinical psychopharmacology (including trials), to experimental studies on the effects of drugs on cognition and behavior in humans and laboratory studies in experimental animals." In 1959, Brady, Dews, and Hunt were among the seven psychologists on the advisory board. The journal had two sets of field editors in 2002, one "for North and South America," the other "for the rest of the world." The field editors for the subject areas of human cognitive psychopharmacology, alcohol and substance abuse in humans, and behavioral pharmacology in laboratory animals have published in *JEAB*, as have 4 of the 11 advisory editors listed under each of the three headings. Again, several of those who have not published in *JEAB* are nevertheless recognized as highly competent behavior analysts.

In its first year (1973), *Pharmacology Biochemistry and Behavior* (*PBB*) had six psychologists who published at least one paper in *JEAB* on its editorial board. Another three were active behavior analysts, but several others were not. In early 2003, *PBB* had five psychologists on its 46-person editorial advisory board who had published in *JEAB*, plus at least four more who are skilled in behavior analysis. The journal has a wide mission, publishing "original reports in the areas of pharmacology, biochemistry, and toxicology in which the primary emphasis and theoretical context are behavioral."

*JEAB*, which has published drug articles since its founding in 1958, has had an editor for behavioral pharmacology only since 1982. It provides an outlet for drug-related articles empha-

sizing behavioral mechanisms of action (Branch, 1984). For example, from 1991 to 2002, it published 80 drug-related papers, 11.2% of the total 712 articles (cf. Saville, Epting, & Buskist, 2002). My examination of 24 such articles appearing during the 5 years from 1998 to 2002 found that about half concerned either drug discrimination (seven) or drug self-administration (six), whereas the rest covered a wide variety of other aspects of behavior.

From this short summary, the conclusion follows that behavior analysis is well represented in the editorial affairs of all these journals. Behavioral pharmacologists are now afforded a broad choice of outlets for their research and should expect competent peer reviews everywhere. The journals certainly differ in their emphasis along a behavioral versus pharmacological gradient, with *JPET* at the pharmacological end of the scale, *JEAB* at the behavioral end, and the rest spread out between them. If the repeated calls for a greater research emphasis on behavioral mechanisms of drug action (e. g., Branch, 1984; Dews, 1958a; Laties & Weiss, 1969) are heeded, any newly developed procedures could first be described in the more behavioral journals, only later to mature into standard techniques appropriate to the pages of the more pharmacologically oriented journals.

*Behavioral pharmacology specialty organizations.* The number of specialty organizations devoted to behavioral pharmacology continues to grow. The major one for this hemisphere is the Behavioral Pharmacology Society (BPS; founded in 1955). Its annual meetings attract approximately 100 members. BPS has lately been meeting immediately before the annual convention of ASPET, thereby strengthening the latter's new behavioral pharmacology division. There are also the European Behavioural Pharmacology Society (est. 1984; about 320 members) and the Behavioral Toxicology Society (est. 1982; about 50 members). More specialized societies include the Soci-

ety for Stimulus Properties of Drugs (est. 1978) and the International Study Group Investigating Drugs as Reinforcers (est. 1974), each with about 80 members, as well as the Contingency Management Working Group (est. 1994), whose 40 members study drug abusers.

Now half a century old, behavioral pharmacology has become a target for study in its own right, a development that probably reflects the aging of its earliest members as much as anything else. The reader of this account, which emphasized changes that occurred at midcentury, should read what others have said about that and other periods in this field's history. Here are a dozen entry points for starters: Barrett (2002), Barrett and Sanger (1991), Barry (1997), Blackman (1991), Brady (1991, 1993), Branch (1986), Dews (1978), Jarvik (2001), Laties (1986), Pickens (1977), and Richelle (1991).

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