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IN MEMORIAM

Bernard Weiss 1925–2018

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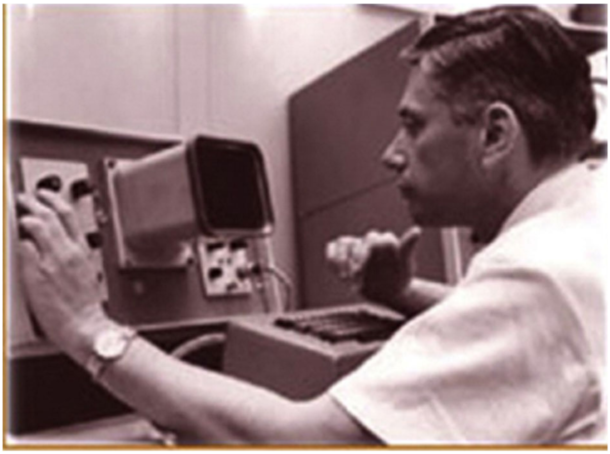

Bernie Weiss pioneered the application of the experimental analysis of behavior to detect subtle effects of exposure to environmental contaminants that act on the nervous system. In doing so he developed an entirely new discipline in the environmental health sciences and paved the way for such notable achievements as the removal of lead from gasoline, which the CDC has recognized as among the top public health accomplishments in the U.S. His work elevated the status of behavioral science in neurotoxicology as well as the neurosciences. Bernie frequented behavior analytically oriented meetings early in his career but even after neurotoxicology consumed most of his attention he followed and drew from the behavioral literature throughout a career that spanned sixty years. His creativity in applying behavior principles to address important social questions warrants an obituary in this journal.

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Bernard Weiss was born in Brooklyn, NY, in 1925. Fascinated with flying but suffering "from a deficit of imagination of the more serious consequences accompanying flying in combat," (Weiss, 2009, p 833) he enlisted as a sixteen-year-old in the Air Force and flew on a bomber crew in the Pacific Theater. After the war, he completed an undergraduate degree in Psychology under the G.I. Bill, but only after completing two years as an English Major. Bernie was forced to acquire a middle name by the Brooklyn College Registrar's Office so, displaying his sharp sense of humor, he briefly assumed the name Bernard Ulysses Weiss because of his fascination with James Joyce's novel. Bernard Weiss enrolled in a doctoral program in Experimental Psychology at the University of Rochester, without a middle name but with a roommate, Victor Laties, who would become a life-long colleague and collaborator. It was joked that one was more senior than the other (I think it was Vic) because he arrived on campus a day sooner than the other and secured their apartment. Bernie completed his doctorate in Experimental Psychology in 1954 with a dissertation on the psychophysics of movement (Weiss, 1954).

This former president of his high school radio club wanted to use computers to investigate behavior, an interest that an IBM engineer apparently termed "delusional" in 1962 (Weiss, 2009). Clear-thinking as always, though, he came across an announcement of a NIH-Sponsored Summer workshop in 1963 to work with eleven other scientists to identify laboratory applications of a new technology called the minicomputer, which could be housed in a laboratory instead of a centralized computer facility. He harnessed the classic LINC (Laboratory Industrial Computer, named after Lincoln Labs), to perform microanalyses of behavior under different schedules of reinforcement, a technique that offered marvelous detail about the structure and function of voluntary behavior at a molecular level (Weiss, 1970). Using a visual technique they called "outlier plots," Weiss and his student, Tom Gott, showed that selected drugs disrupted the cohesiveness of the fixed-ratio response pattern in subtle ways, even when overall rates were unaffected (Weiss & Gott, 1972). Throughout his career, Bernie Weiss insisted on the power of microanalyses to reveal important details about the disruption of behavior by drugs and environmental contaminants.

His involvement in the environmental health sciences dates to 1961 when Harold Hodge, the chair of Pharmacology at the University of Rochester and president of the Society of Toxicology, sent a technician to Peter Dews' behavioral pharmacology laboratory at Harvard. Hodge, having seen the devastating effects of mercury vapor on behavior, wanted a behavioral component to Rochester's toxicology program, an inspiration that made it one of the world's leaders in research and education of R's toxicology program one of the world's top research and training programs. On Dews' recommendation, Hodge invited Bernie and Victor Laties to set up a behavior lab to study toxicology and pharmacology.

After completing his Summer Workshop with the LINC, Bernie returned to his alma mater in 1965 with his former roommate and immediately set up an extraordinary, highly advanced computerized laboratory that was unmatched anywhere in the world. The laboratory minicomputer, first the LINC and then its descendants manufactured by the Digital Equipment Corporation, were harnessed to study behavior and its disruption by environmental contaminants at lower and lower exposure levels. With his students and post-docs, he was among the first, if not the first, to report chemical effects on vision, somatosensory function, motor function, self-administration, voluntary running, stimulus control, thermoregulation, and "schedule-controlled operant behavior (SCOB)." Among the chemicals that they examined were drugs (especially neuroleptics and psychomotor stimulants,), atmospheric pollutants, solvents, and heavy metals. He repeatedly demonstrated the power embedded in incredible flexibility afforded by our understanding of how to shape operant behavior to particular uses as well as the detail and control afforded by the appropriate application of computer technology.

Bernie railed against the common practice of applying quick and shallow behavioral techniques. Not only was it marginally informative–it was not fun! The joy in science came from linking the most advanced understanding of behavior, clinical signs and symptoms of contaminant exposures, and, if known, the neurobiological mechanisms to produce an advanced experimental model. The devices that became commonplace to people in his laboratory would amaze visitors ("I had no idea that could be done with behavior!"). Monkeys felt small needles glued to phonograph speakers to detect vibration sensitivity, observed screens of alternating dark and white stripes to test contrast sensitivity contours, held rods attached to analog devices to detect subtle changes in tremor, and self-administered organic solvents. Rats pressed levers to warm themselves in a cold room and lever-pressed so that interresponse time distributions could reveal subtle chemical effects on response integrity.

Bernie Weiss not only harnessed the science of behavior analysis in detecting adverse effects of drugs and contaminants, but he also exploited the methodological power of small-N experimental designs. For example, in a study of food colors he found reproducible effects in two children after repeated exposure. The paper was an outlier in literature on diet and ADHD, a literature that rigidly applied Psychology's obsession with group means and analyses of variance but that missed susceptible individuals (Weiss, 1981; Weiss et al., 1980). He was an early proponent of the importance of individual susceptibility, another theme that ran through his career.

His passion for behavior analysis was there at the beginning and infected those he came into contact with. In a retrospective he wrote:

> "Operant behavior requires three kinds of commitment on the part of the experimenter. First, a commitment to control and analyze behavior at what I call the molecular level . . .. Second, a willingness to study the principles of behavior and to frame experimental questions in those terms. And third, a willingness to grapple with the computer technology and associated instrumentation required to conduct contemporary behavioral research. Many researchers, unfortunately, in my view, have adopted procedures that seem superficially simpler, easier and cheaper but at the cost of depth of understanding. (Weiss, 2009, p. 839)

Influenced by the behavior analytic emphasis on individual behavior and the importance of the outlier, Bernie Weiss was at the forefront of raising concerns about the impact of lead on the most vulnerable populations. A key measure of lead's impact was, and is, score on an IQ test. He was among the earliest to note that the 3–5 point shift in IQ caused by lead may be difficult to detect in the middle of the range, but it was devastating at the extremes. Such a shift doubled the number of children who would be diagnosed as intellectually disabled and eligible for expensive educational services. This, he would note, was just one of the many challenges that plague the disadvantaged communities that so often bear the brunt of contamination. This not to say that he viewed the IQ test uncritically. At a meeting in which a young investigator was lamenting that a procedure called "repeated acquisition of behavior chains" was not more correlated with IQ tests Bernie noted that the problem lies with the inadequacies of the IQ test, not the procedure (later, in follow-up studies the correlations proved to be quite respectable).

Drawing from his deep understanding of individual behavior, he was among the first to raise concerns about how special populations such as the developing (Weiss & Spyker, 1974) or aging (Weiss & Simon, 1975) organism might be especially sensitive to contaminant exposure. For example, while scientists were just beginning to assess the behavioral impact of contaminant exposure, he and William Simon developed a mathematical model, coupled with data from the Parkinson's Disease literature, showing that if a neurotoxicant accelerated cell death by 0.1% the result would be the appearance of severe neurological deficits a decade sooner than they would otherwise appear.

Tracing back perhaps to what led him to begin college studying English literature, Bernie was an extraordinary writer. His grant applications read like a well-told story and were a joy to read. He wrote poems to the Adirondacks in Spring or a performance of a play by Bertolt Brecht. During the mid 80's he wrote a speculative novel about what might happen if a U. S. President became cognitively impaired while in office, perhaps developing Alzheimer's Disease. How could it be detected with the certainty that we would like and what would be the implications for our government?

Bernie Weiss exemplifies the observation, so often made and so easy to overlook, that good science has implications that are difficult to foretell. In his hands, the regular patterns revealed by *Schedules of Reinforcement* or the methodological strengths of small-N experimental design contributed to the removal of lead from gasoline, a redefinition of risk assessment to include behavior (Weiss, 1988; Weiss et al., 2008), the development of an ethical way to study pain that gives control over "painful" stimuli to the experimental subjects (Weiss, 1990, 2000; Weiss & Laties, 1970, the use of behavior to regulate toxic substances, and an appreciation of the sensitivity of the developing fetus or the aging organism to environmental challenges (Weiss, 1984). A visionary who took behavior analysis into surprising areas, his passing is a loss to us all just as his life was an inspiration.

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