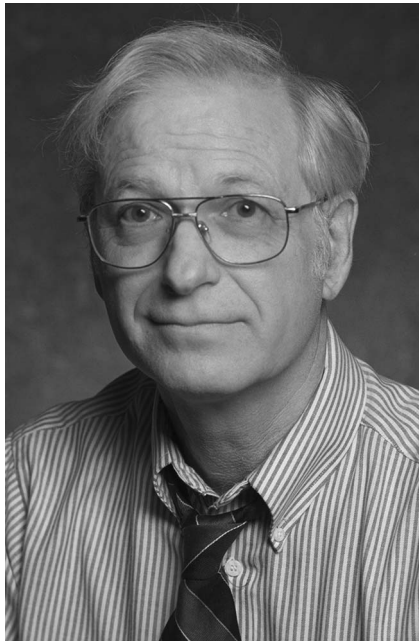# IN MEMORIAM

Robert A. Rescorla (1940–2020)

Robert Arthur Rescorla, emeritus professor of psychology at the University of Pennsylvania, died in Austin, Texas, on March 24, 2020, following a fall in his home. He was 79. Rescorla was the world's most distinguished scholar in animal learning and a great teacher.

Rescorla was born May 9, 1940, in Pittsburgh, Pennsylvania, to Mildred Jenkins Rescorla and Arthur R. Rescorla and was raised in Westfield, New Jersey. He was an undergraduate at Swarthmore College, where he received highest honors. During that period, he studied with Henry Gleitman, Solomon Asch, and Hans Wallach. He began graduate work at the University of Pennsylvania (Penn) in 1962 and started his research on Pavlovian conditioning under the mentorship of psychologist Richard Solomon, who was studying the interaction of Pavlovian conditioning and instrumental learning processes in avoidance learning.

Rescorla received his PhD from Penn in 1966 and took a position as assistant professor of psychology at Yale University, where he rose to the rank of full professor. He returned to Penn as professor of psychology in 1981 and remained there, as the James M. Skinner Professor of Science (1986–2000)

and later Christopher H. Browne Distinguished Professor of Psychology (2000–2009), until he retired in 2009.

At Penn, Rescorla served with distinction as chair of psychology (1985–1988) and dean of the College of Arts and Sciences (1994-1997). He was elected to the National Academy of Sciences in 1985, received the Distinguished Scientific Contribution Award from the American Psychological Association (1986), became William James Fellow of the American Psychological Society (1989), and was awarded the Howard Crosby Warren Medal of the Society of Experimental Psychologists (1991).

As a graduate student in Richard L. Solomon's laboratory, Rescorla published a 1965 empirical article with fellow graduate student Vincent LoLordo in which they demonstrated that although a stimulus that repeatedly precedes foot shock comes to evoke Pavlovian conditioned fear, a stimulus that tells the organism that an otherwise expected foot shock will not occur becomes a Pavlovian conditioned inhibitor of fear. These findings can be construed as an extension of Pavlov's findings from the domain of salivary reflexes to the much more interesting domain of emotional responses. Rescorla then wrote two theoretical articles for the *Psychological Review*. From that time on, his ideas, more than those of any other scholar, drove theorizing in the field of associative learning.

In his first *Psychological Review* article—"Pavlovian Conditioning and Its Proper Control Procedures"—Rescorla went beyond Pavlov by suggesting a theoretical framework for these empirical results—the idea that the contingency between conditional stimulus (CS) and unconditional stimulus (US) determines the nature and extent of conditioning, not their temporal pairing. Soon afterward he showed that, in the so-called zero-contingency case, no conditioning occurs, no matter how frequently the US is paired with the CS. This result opened the exploration of Pavlovian conditioning as a model for how an animal (including a human) makes sense of the causal relations in the world, sorting out which events predict which other events. Like all great experimental discoveries, this raised profound and heretofore unasked theoretical questions, one of which was how to define contingency. That question is still being adjudicated.

Later analytic and empirical work by Rescorla, along with important experiments by Leon Kamin and Allan Wagner, further extended the domain of Pavlovian conditioning to the case where several stimuli are present on a trial. Rescorla pointed out that all of these results were instances of the

operation of the same underlying contingency principle: If the context or other stimulus in which a CS occurred already predicted the frequency with which the US occurred, then the "redundant" CS, the CS that did not convey any additional information, did not become conditioned. These findings led Rescorla and his Yale colleague Allan Wagner to develop a mathematical model, published in two elegant chapters in the early 1970s, that computed the change in associative strength accruing to each CS present on a Pavlovian conditioning trial as a fraction of the difference between the maximum associative strength that the US would support and the combined associative strengths of all the CSs present on the trial. The model accounted for the results of the experiments by Rescorla, Kamin, and Wagner. Moreover, it suggested several new experiments and successfully predicted their results. The Rescorla–Wagner model of associative learning has been the most influential, widely cited, and widely built-upon theory of associative learning for the last 50 years.

The second *Psychological Review* article, written with Solomon, was titled "Two-Process Learning Theory: Relationships Between Pavlovian Conditioning and Instrumental Learning." The authors considered ways in which Pavlovian conditioned emotional and motivational processes could play a role in the control of instrumental responding. They proposed that the interaction of the Pavlovian and instrumental processes could best be understood by superimposing Pavlovian CSs upon instrumental responding; for example, by presenting a CS that had been paired with food to a rat that was engaging in food-reinforced instrumental behavior and observing how the rate of instrumental responding changed during the CS. Because a Pavlovian CS can be either excitatory or inhibitory, a US can be appetitive or aversive, and an instrumental response can be either positively or negatively reinforced, these Pavlovian-to-instrumental transfer (now called PIT) experiments comprise an eightfold table. The response to this article, a Citation Classic, was very positive, and experiments on PIT abounded. At first these experiments were purely behavioral, but in recent years behaviorally sophisticated neuroscientists have added PIT to their methodology, and the number of studies using the technique to identify essential neural circuits in striatum, amygdala, and habenula has increased dramatically.

Rescorla and others liberated Pavlovian conditioning from its decades-long behavioristic frame. The response was primarily an indicator of the association of stimulus representations, that is, mental events. In over 25 studies, using second-order and robust simultaneous conditioning, he provided an associative basis for how simultaneously presented multiple attributes may become a new, compound mental entity. This was a major goal of the British associationists and is a major goal of modern cognitive science, essential to learning about objects in the world.

Bob Rescorla thought of himself as primarily an experimentalist, and his experiments on Pavlovian conditioning and instrumental learning would win any prize for the aesthetics of experimental design. Most of his nearly 200 empirical articles included multiple experiments with replications. Among Rescorla's most beautiful experiments were the studies of extinction performed in the last decade of his career. Several of these later studies concerned the clinically important phenomenon of spontaneous recovery from extinction. An early experiment in his studies of extinction established the phenomenon of reinstatement.

No portrait of Bob Rescorla would be honest or complete without a few words about his character. He was the very model of an empirical scientist, and behind that was a strong, perhaps inflexible, personality. His scientific standards were asymptotically high, and he did not tolerate any kind of looseness. He never had an article rejected and never had a grant rejected. He did not want to be wrong, and his signal to noise ratio was legendary: He rarely spoke at faculty meetings, but when he did, what he said was invariably true and often decisive. He intentionally, perhaps fervently, refused to let his reach exceed his grasp. Unlike many psychology professors, he did not aggressively promote hiring in his own area and, given his very high empirical standards, was amazingly tolerant of the work of scholars in areas of psychology with less experimental control. He was an unusual combination of openness toward other developments in psychology coupled with very high research standards in his own field.

Along with his monumental research achievements, Rescorla was also a passionate advocate for undergraduates and a great teacher. His lucid lectures in his animal learning course, offered for decades at Penn, were a model of clarity and intellectual engagement and earned him the Ira Abrams Teaching Award in 1999. He advocated for an explicit role for teaching in faculty hiring. As undergraduate dean in the School of Arts and Sciences at Penn, he focused on including active research experience in the undergraduate experience. From his early days at Yale he was also actively engaged in training graduate students and postdocs, many of whom have made major contributions to the field. He was the "compleat academic."

Robert A. Rescorla is survived by his spouse of 28 years, Shirley Steele, of Austin, Texas, and by his sister Barbara Rescorla Brandt, of Gallup, New Mexico. He is also survived by his first wife, Marged Lindner, and his second wife, Leslie Rescorla, along with their sons, Eric and Michael Rescorla; Eric's spouse, Lisa Dusseault, and grandsons Darwin and Lincoln; and Michael's spouse, Melanie Schoenberg Rescorla, and grandsons Alexander and Nicholas.

C. R. Gallistel[1], Vincent M. LoLordo[2], Paul Rozin[3],
and Martin E. P. Seligman[3]
[1]*Rutgers University*
[2]*Dalhousie University*
[3]*University of Pennsylvania*