ROBERT ARTHUR RESCORLA

Robert Arthur Rescorla, emeritus Professor of Psychology at the University of Pennsylvania, the world's most distinguished scholar in the area of the psychology of animal learning, and a great teacher, died in Austin, Texas on March 24, 2020. He was 79, and his death followed complications resulting from a fall in his home.

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

Dr.Rescorla received his Ph.D. 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 at Penn, as the James M. Skinner Professor of Science (1986-2000) and later Christopher H. Browne Distinguished Professor of Psychology (2000-2009) until his retirement 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, President of the Eastern Psychological Association (1986), and received the Distinguished Scientific Contribution Award from the American Psychological Association (1986). He became

William James Fellow of the American Psychological Society (1989), was awarded the Howard Crosby Warren Medal of the Society of Experimental Psychologists (1991), and Doctoris Honoris Causa, University of Ghent (2006) and was elected as a member of the American Academy of Arts and Sciences (2008).

As a graduate student in Richard L. Solomon's laboratory, Rescorla wrote two very important theoretical papers for the Psychological Review, and from that time on his ideas, more than those of any other scholar, drove theorizing in the field of associative learning. In a 1965 empirical paper with fellow graduate student Vincent LoLordo, Rescorla found that although a stimulus that repeatedly precedes footshock comes to evoke Pavlovian conditioned fear, a stimulus that tells the organism that an otherwise expected footshock 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. But in his first Psychological Review paper –Pavlovian conditioning and its proper control procedures-Rescorla went beyond Pavlov by suggesting a theoretical framework for these results-the idea that the contingency between CS and US determines the nature and extent of conditioning. Rescorla suggested, and soon afterwards showed, that to the extent that the probability of the US is greater in the presence of the CS than in its absence, the CS will evoke an excitatory CR-say fear if the US is footshock. If the shock is more likely in the absence of the CS than in its presence, the CR will be inhibitory. If the US is equally likely in the presence and absence of the CS-the so-called zero-contingency case, no conditioning will occur. This reformulation of Pavlovian conditioning, and association, in terms of contingency (information value) as opposed to simple occasional contiguity, opened the exploration of Pavlovian conditioning as a model for how an animal (including a human) makes sense of the world, in terms of causal relations. 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 if we think of the background stimuli in the conditioning chamber- call them context- as being present throughout the conditioning session, then the zero-contingency case, in which the CS does not become conditioned, boils down to a mixture of context alone trials and trials on which context is accompanied by the discrete CS, and the US is equally likely in both kinds of trials. He further saw that this case was formally similar to the case in which a CS is repeatedly followed by the US, and then a second CS is added to the first as conditioning continues with the same US. Kamin showed that the second stimulus does not become conditioned, and called this the blocking effect. These findings drove Rescorla, along with his Yale colleague Allan Wagner, to develop a mathematical model, published in two elegant chapters in the early seventies, that computed the change in associative strength accruing to each CS present on a Pavlovian conditioning trial. The key was the idea that the amount of conditioning that would accrue to a CS on a trial depended on the discrepancy between the combined associative strength of all the CSs present on that trial and the maximum associative strength that the US would support. Of course the model predicted blocking, Wagner's relative validity effect, the effects of manipulating the contingency between CS and US, and many other standard outcomes. Moreover, the model suggested several new experiments, and predicted their results, too. Results that were discrepant with the model led others to propose modifications and alternatives, and they are still being developed,

but the Rescorla-Wagner model left its lasting mark on the form that theorizing in associative learning would take. It is unquestionably the most influential, widely cited and widely built upon theory of associative learning.

The second Psychological Review paper, written with Rescorla's mentor, Richard L. Solomon, was titled "Two-process learning theory: Relationships between Pavlovian conditioning and instrumental learning". The authors considered ways in which Pavlovian conditioned emotional/motivational processes could play a role in the control of instrumental responding, and then proposed that the interaction of the Pavlovian and instrumental processes could best be understood by superimposing Pavlovian CSs upon instrumental responding, e.g., by presenting a CS that had been paired with food to a rat that was engaging in food-reinforced instrumental behaviour, and observing how the rate of instrumental responding changed during the CS. Since 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 paper, a Citation Classic, was very positive; experiments on PIT abounded. At first these experiments were purely behavioural, but in recent years behaviourally 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.

Although his theorizing became the primary focus of activity in the field of associative learning, 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 two hundred incisive empirical papers included multiple experiments with

replications, so the findings were ironclad. And so Rescorla made a disproportionate contribution to the list of findings that other investigators would have to take into account when designing experiments to answer their own questions. Among Rescorla's most beautiful experiments were the studies of extinction performed in the last decade of his career.

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 is, to the best of our knowledge, the only psychologist who 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 usually 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 of situations. He was an unusual combination of openness coupled with very high research standards.

Along with his monumental research achievement, 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, School of Arts and Sciences, in 1999. In contrast to the almost exclusive focus on research potential and accomplishments in faculty hiring and promotion, he advocated for an explicit role for dedication to students and teaching quality. As the undergraduate Dean in the school of arts and sciences at Penn, he continued his devotion to undergraduate education, focusing on including active

research experience in the undergraduate experience. He was the compleat academic.

Robert A. Rescorla is survived by his spouse of 28 years, Shirley Steele of Austin, Texas, by his former wife Leslie Rescorla, their sons Eric and Michael Rescorla, by Eric's spouse Lisa Dusseault and their sons Darwin and Lincoln, by Michael's spouse Melanie Schoenberg Rescorla and their sons Alexander and Nicholas, by his first wife Marged Lindner, and by his sister Barbara Rescorla Brandt of Gallup, NM.

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Obituary written by Vincent LoLordo, Paul Rozin, Randy Gallistell, and Martin Seligman.