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Science **337**, 1619 (2012);
DOI: 10.1126/science.1229851

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published weekly, except the last week in December, by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005.

RETROSPECTIVE

R. Duncan Luce (1925–2012)

A pioneer in the social sciences combined mathematics and psychology to understand human behavior.

James L. McClelland

Robert Duncan Luce, a mathematician who sought to provide axiomatic formulations for the social sciences, died on 11 August 2012 in Irvine, California, at the age of 87. His passing was marked by an outpouring of sadness at the loss of a revered colleague and expressions of veneration for his many substantive, institutional, and personal contributions to the mathematical social sciences.

Luce was a mathematician before he was a social scientist. His achievements cut across the political, social, economic, and social sciences for over 60 years. These contributions were recognized early in his career, with election to the U.S. National Academy of Sciences in 1972, and later at the highest level, with the U.S. National Medal of Science in 2003.

Luce received his Ph.D. in mathematics from the Massachusetts Institute of Technology (MIT) in 1950, with a thesis that addressed a topic in abstract algebra. His first publication applied ideas from this field to provide a mathematical definition of a "clique" within a social network, and explored using a matrix to capture the connections among individuals that might also be represented in a graph. This method has become standard in computer science, with applications across the social sciences and many other branches of science.

In the 1950s, Luce tackled the problem of choice. His seminal treatment of this issue in his 1959 book, *Individual Choice Behavior: A Theoretical Analysis*, provided the foundation for a vast range of investigations in psychology and economics. In essence, he proposed an abstract and general axiom that gives rise to the following principle of choice: The relative probability (p) of choosing item a or item b is independent of other available choices. Suppose in a choice between an apple and a banana, you choose the apple two-thirds of the time, and the banana one-third of the time, for a probability ratio of 2:1. If I add a third choice (a pear), then you might sometimes choose the pear, but the ratio of apple to banana choices should still be 2:1. Luce showed that if his general axiom is true, we can define for each item a positive strength S, such that whatever the set of alternatives, $p(a)/p(b) = S(a)/S(b)$. Luce's theory was important, not because it was true—although there are circumstances in which it is approximately true—but because its success or failure can lead to insight into the processes underlying choices and decisions. A great deal of work since Luce's theoretical analysis explores the situations in which his theory may be right or wrong.

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In the 1960s, and for the rest of his career, Luce's focus shifted to fundamental questions of measurement, with a particular emphasis on measuring psychological quantities such as value or loudness. Social scientists distinguish between physical quantities such as units of sound intensity or ounces of gold, on the one hand, and psychological variables such as perceived loudness and value or utility on the other; the behavioral and economic actions of individuals, groups, and organizations depend on the psychological quantities involved. From the 1960s onward, Luce sought to establish fundamental principles relevant to the measurement of these psychological quantities. In joint work with the statistician John Tukey in 1964, Luce showed that experiments simultaneously varying the effects of two factors on a simple response measure can allow the establishment of unique functions characterizing the effect of each factor—provided, as in the choice work, some simple and intuitively plausible axioms apply. For example, suppose we create batches of cookies, varying the size of each cookie in the batch and the number of cookies in the batch; we present people with choices between two batches, each with a different combination of cookie size and cookie number; and we simply ask each participant to say which batch they would prefer. Then, if the axioms hold for their responses (and if we collect sufficient judgments), we can reconstruct unique functions indicating how size and number affect perceived desirability of a batch of cookies. In this way, psychological forms (and other forms) of measurement can proceed with nothing more than comparative judgments of desirability. This is useful because explicit estimates of perceived value are easily influenced and may not measure the factors that determine preference when faced with a real choice between alternatives. The approach is widely used in perceptual psychology, behavioral economics, and throughout the social and decision sciences. Luce continued to reflect on the fundamental measurement issues until the end of his career, collaborating with other mathematically inclined social scientists, including Louis Narens and Patrick Suppes.

Luce's career took him to many institutions, including Harvard University, Columbia University, the Institute for Advanced Study at Princeton, the University of Pennsylvania, and the University of California, Irvine. In 1988, he began a second stint at Irvine as a Distinguished Professor of Cognitive Sciences and Economics to found the Institute for Mathematical Behavioral Sciences, where he explored the foundations of measurement.

A generous supporter of colleagues and a careful mentor, Luce contributed in many quiet ways to advance the goals of the social and behavioral sciences. He was instrumental in creating the *Journal of Mathematical Psychology*, and played a lead role in several multivolume works, including the *Handbook of Mathematical Psychology* and the *Foundations of Measurement*.

Luce saw the marriage of mathematics and behavioral science as a gamble. After receiving the National Medal of Science from President George W. Bush, he said, "I guess that 1950 gamble back at MIT paid off." It certainly paid off for our understanding of human behavior.

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10.1126/science.1229851

Published by AAAS