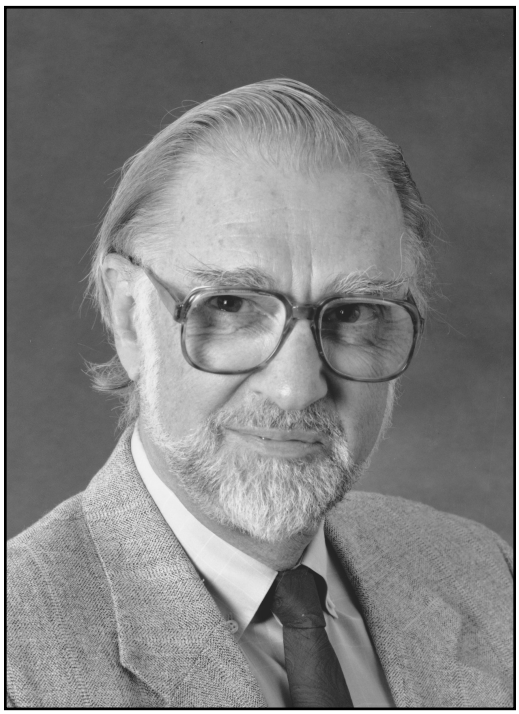
R. DUNCAN LUCE



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ROBERT DUNCAN LUCE died on 11 August 2012. He was one of the most prominent mathematical psychologists of the 20th century and was very good at experiments as well.

Birth and Family Background

Robert Duncan Luce was born in Scranton, Pennsylvania, on 16 May 1925; he was the only child of Robert Renssalear Luce and Ruth Lillian Downer Luce. Duncan's father was born in Scranton in 1882 and died in Watertown, Massachusetts, in 1978. He graduated from the University of Pennsylvania with a dental degree and served in World War I with the U.S. Army Medical Corps. Following the war, he worked in Boston for the U.S. Public Health Service. He met Ruth, a Wellesley student, and married her following her graduation in 1921. Ruth was born in Orange, New Jersey, in 1898 and died in Scranton in 1971. The newlyweds lived in Boston for a couple of years after their marriage but returned to Scranton before Duncan was born (probably around 1923).

The Luce family came to the United States in the 1640s, and Robert was descended from Henry Luce of Martha's Vineyard. The Downer family was also one of the founding families, coming to America in the 1640s, originally to Newbury, Massachusetts. Ruth's father was Ira Relyea Downer. Her mother, Lillian Stalker Downer, was also a Wellesley graduate.

Education

Duncan attended Scranton public schools and matriculated at MIT in 1942. As a boy, his two interests were drawing and airplanes. At MIT, he majored in aeronautical engineering. He joined the U.S. Navy V12 program as a freshman, graduating in 1945. He trained as a catapult and arresting gear officer and was commissioned in the U.S. Navy as an ensign in the summer of 1945. He was assigned to the USS Kearsarge, an Essex-class aircraft carrier under construction in the Brooklyn Naval Shipyard. He participated in the Kearsarge's shakedown cruise but was, like many other veterans, released from active duty in the spring of 1946. He was admitted to the mathematics Ph.D. program at MIT for the fall 1946 term and received his Ph.D. in 1950. His interest in aviation led him to obtain his private pilot's license in the mid-1950s, and he owned a Beechcraft Musketeer until the late 1960s, when he stopped flying because he felt that the mix of general and commercial aviation at most U.S. airports had become too dangerous for private aircraft.

Academic Positions

Duncan held a large number of academic positions during his lifetime. From 1950–53 he continued at MIT as Co-director, Group Networks Laboratory, Research Laboratory of Electronics. Then he went to Columbia University, where he was Managing Director, Behavioral Models Project (1953–57) and Assistant Professor of Mathematical Statistics and Sociology (1954–57). From 1957–59 he was Lecturer on Social Relations at Harvard University. He then served at the University of Pennsylvania as Professor of Psychology (1959–68) and Benjamin Franklin Professor of Psychology (1968–69). He next went to the Institute for Advanced Study, in Princeton, New Jersey, from 1969–72. He moved to the University of California, Irvine, where he was Professor of Social Science from 1972–75. He then returned to Harvard for 12 years, serving as Alfred North Whitehead Professor of Psychology (1976–81); Professor and Chairman, Department of Psychology and Social Relations (1981–84); and Victor S. Thomas Professor of Psychology (1983–88). In 1988, he became Victor S. Thomas Professor of Psychology, Emeritus. As his last move, he went back to the University of California, Irvine, where he was Distinguished Professor of Cognitive Sciences (1988–94); Director, Irvine Research Unit in Mathematical Behavioral Science (1988–92); and Director, Institute for Mathematical Behavioral Science (1992–98). He also served as Professor of Economics from 1993–94. Finally, from 1994 until his death in 2012, he was Professor Emeritus and Distinguished Research Professor of Cognitive Sciences, and Research Professor of Economics.

Awards

During his lifetime, Duncan received many awards and prizes for his distinguished work in psychology. The list given here is by no means complete. In 1954 he was appointed a Fellow at the new Center for Advanced Study in the Behavioral Sciences, located at Stanford but not part of the university. The center became very prominent in the behavioral and social sciences after that time. In 1963, he was elected to the Society of Experimental Psychologists, and in 1966 to the American Academy of Arts and Sciences. From 1966–67, he again was appointed Fellow, Center for Advanced Study in the Behavioral Sciences, and that academic year, he also held a Senior Post-doctoral Fellowship, National Science Foundation. From 1968–69 he was Visiting Professor, Organization of American States, Rio de Janeiro, Brazil. In 1970, he was given a Distinguished Scientific Contribution Award by the American

Psychological Association. Then in 1972, he was elected to the National Academy of Sciences and, from 1980–81, held a Guggenheim Fellowship. From 1984–85, he was Visitor, AT&T Bell Laboratories, Murray Hill, New Jersey. In 1986 he was awarded the American Association for the Advancement of Science Prize for Behavioral Science Research. From 1987–88 he was again a Fellow at the Center for Advanced Study in the Behavioral Sciences. In 1994 he was elected to the American Philosophical Society, and in 2001 he received the Gold Medal Award for Life Achievement in the Science of Psychology from the American Psychological Foundation. Then, in 2003, he received the Daniel G. Aldrich, Jr. Distinguished University Service Award, University of California, Irvine. Other awards earned in 2003 were the National Medal of Science and the Frank P. Ramsey Medal of the Decision Analysis Society. The next year (2004), he received the Norman Anderson Lifetime Achievement for Contributions to Psychology, Society of Experimental Psychologists. Finally, in 2007, he was awarded an Honorary Doctorate of Mathematics at the University of Waterloo.

Books

Duncan published a number of important books. His first was *Games and Decisions*, written jointly with Howard Raiffa, published in 1957 and reprinted in 1989 by Dover Publications. This work is one of the early books on game theory, and it received a lot of attention. In 1959 he published *Individual Choice Behavior: A Theoretical Analysis*, which I consider in many ways his most original work. I comment on it in more detail later. In 1971 he published (with David Krantz, Amos Tversky, and myself) Volume I of a three-volume treatise, *Foundations of Measurement*. Volume II appeared in 1989 and Volume III in 1990. This brief listing of the three volumes on measurement does not do justice to Duncan's many scientific contributions to measurement theory, many of which are expounded in detail particularly in Volume III, of which he was the first author. I mention here the topics of nonadditive representations, scale types, and dimensional invariance, to each of which a chapter was devoted.

In 1986 he published his longest and most substantial single book, *Response Times: Their Role in Inferring Elementary Mental Organization*. I believe that no work in the literature exists that is comparable to this one in its combination of detailed attention to results of many experiments and the development of mathematical models to fit the data. In more ways than one, it is a remarkable book, so dense and full of facts about little noticed findings that it is seldom read from cover to

cover by anyone; rather, it is much used as an important reference about many kinds of experiments involving response times.

Sound & Hearing (1993) is Duncan's most important textbook, which evolved from courses he repeatedly gave on the subject matter named in the title at several universities over a decade or more of opportunities to develop, revise, and extend the content. It remains, after some time, one of the most satisfactory introductions to sound and hearing for psychologists. As with his other works, it is noteworthy for its remarkable intertwining of detailed experimental results and the development of elementary mathematical models to describe and explain the experimental findings. The subject matter is genuinely complicated and subtle, but Duncan does an excellent job of giving students a serious introduction to what remains today a more important topic of scientific study than when the book was first published.

Duncan's book *Utility of Gains and Losses: Measurement-Theoretical and Experimental Approaches* (2000) is, above all, a tribute to his persistence in continuing to think about fundamental problems that interested him. Its focus goes back to research in the 1950s, almost 50 years before this book was published. However, fundamental problems about choice and utility were still unsolved. His kind of concentration was able to bring new insights to a set of concepts concerned with utility theory that he had already examined with some care in Chapter 3 of *Individual Choice Behavior* (1959), but now with new thinking about the concepts and new experiments to test them.

As can easily be seen from looking at the long and complicated bibliography of Duncan's scientific work over many decades, it is not feasible to discuss very much of it in any sort of detail because it is so extensive, running from his first publication in 1949 ("A Method of Matrix Analysis of Group Structure," written with A. D. Perry) to several articles still in press more than six decades later at the time of his death.

Style Of Research

In Duncan's case particularly, there is a style and approach to intertwining experimental data and theory that is unique to him. I will try to give a sense of this by analyzing one of the important passages from his first book, *Individual Choice Behavior* (1959). He gets off to a quick start by stating on page 6 a single axiom that he uses as a basis for many pages of discussing concepts both experimentally and theoretically. What is surprising is the simple form of axiom 1. I quote it here, but begin with some of the preliminary analysis given on page 5;

in particular, the notation "$P_T(R)$" refers to the conditional probability measure P_T of the set R with T the domain of the conditional measure:

> Axiom 1. *Let T be a finite subset of U such that, for every $S \subset T$, P_s is defined.*
> (i) *If $P(x, y) \neq 0, 1$ for all $x, y \in T$, then for $R \subset S \subset T$ $P_T(R) = P_S(R)P_T(S)$;*
> (ii) *If $P(x, y) = 0$, for some $x, y \in T$, then for every $S \subset T$ $P_T(S) = P_{T-\{x\}}(S - \{x\})$.*

Throughout the book the expression "axiom 1 holds for the set T" is used to mean not only that it holds for T itself, but also that it holds for every subset of T (Luce, p. 6).

I believe axiom 1 is self-explanatory if one accepts the most elementary notions of set theory and probability, so I will not comment more. But I do want to quote Duncan's clear and simple interpretation of the axiom:

> Interpretation. Part ii of the axiom simply states that if y is invariably chosen over x then x may be deleted from T when considering choices from T. This seems reasonable. If one never selects liver in preference to roast beef, then in choosing among liver, roast beef, and chicken one can immediately reduce the problem to consideration of roast beef and chicken. (Luce, p. 6)

What is quite surprising is the sudden change of style and focus that occurs in this interpretation. He goes rapidly, and without comment, from an austere mathematical style to a discussion of roast beef and chicken. The contrast here is stronger than usual, but it is still a mark of Duncan's style, of how easily he can move, without apology or notice but with clarity, from a purely theoretical statement to a down-to-earth concrete example.

In contrast to the brevity of axiom 1 and its interpretation, the remainder of the chapter covers a surprisingly wide range of psychological concepts, particularly some analysis of Clyde Coombs' data from an earlier experiment; the concept of a ratio scale as a separate topic; the independence of the scale to be used; and the topic of algebraic approximations. Moreover, without the introduction of any further axioms, Chapter 2 is a rather detailed series of psychophysics applications of the basic theory centered around axiom 1. In that same spirit, without any further fundamental axioms, Chapter 3 is devoted to applications to utility theory and Chapter 4 to applications to learning theory. Duncan's patient explanation of cases in clear elementary mathematical language is particularly well illustrated in his meticulous but easy-to-follow discussion of the alpha, beta, and gamma learning models.

As already mentioned, Duncan published his first article in 1949. He was just 24 at the time. In the years that followed, he was too prolific for me to try to describe his many scientific papers in detail.

An important feature of Duncan's work is the large number of areas of psychology, about which he wrote, often with co-authors, in a serious collection of papers. In my experience, it is hard to think of anyone who had a wider scope and collection of co-authors than Duncan. For example, in the earlier years, he wrote many papers with David Green and A. A. J. Marley. The many papers with Green had an impact that almost amounted to a change in research on the nature of sound from a psychological standpoint.

I was fortunate to collaborate with Duncan over many years of work on the theory of measurement. In some ways, this collaboration had a rocky beginning. The original version of Duncan's 1959 book, *Individual Choice Behavior,* was widely circulated several years earlier with a red cover and was referred to as the "Redbook." He has, in this book, what seemed to be unusually simple axioms about behavior. Initially, I thought the axioms were too simple and clearly must be wrong. Duncan and I had vigorous arguments about this over an extended period of time. However, he finally convinced me that he was right and I was wrong. I am glad he persuaded me because I would feel pretty silly to have had such an opinion of such an important work. His interaction with me on this matter was typical: he gave a patient and careful explanation of what he believed about some area of psychology, as well as corresponding sharp, critical remarks on the work of others that he felt contained either errors or misjudgments.

Duncan also had perhaps the most efficient working habits of anyone I have ever known in the academic world. Given a deadline, he was always well on time and usually early. I can remember well when we were writing the multivolume work *Foundations of Measurement*. He and I had agreed to finish one of the chapters by a certain date. He was quite dissatisfied by my slowness in completing my part. He came from Irvine to Stanford and moved into my house with the assertion that he was not leaving until I had finished. Of course, he did not mean this literally, but we were the kind of friends that could talk this way to each other.

In his later years, Duncan was especially good at generating from the theory of measurement clever new axioms for unusual behavior by, for example, gamblers or other compulsive types in making choices. And he was very clever at testing new axioms by designing experiments put together to focus tests on just the right things.

He will be missed by many, but his work will remain as one of the great bodies of research in mathematical and experimental psychology, taken together, in all of 20th- and early 21st-century psychology.[1]

Elected 1994

PATRICK SUPPES[2]
Lucie Stern Professor of Philosophy, Emeritus
Stanford University

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2 Patrick Suppes died on 17 November 2014.