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PETER WHITTLE

1927–2021

Elected in 2016

"For contributions to the mathematics of operations research and statistics."

BY FRANK P. KELLY

PETER WHITTLE, who died August 10, 2021, at 94 years of age, will be remembered as an outstanding pioneer across the fields of probability, statistics, and optimization. He wrote a number of important papers, but it is in his books that one can best appreciate the broad sweep of his achievements and the simplicity, unity, and generality of his approach. His 12 major volumes covered times series, prediction, constrained optimization, dynamic programming, optimal control, stochastic systems, the foundations of probability theory, and neural nets. Several of these works were ahead of their time: indeed some of his early works appear to have been written for the audience of today, such is the extent to which they anticipated developments.

Peter was born in Wellington, New Zealand, on February 27, 1927. His parents, Percy Whittle and Elsie Tregurtha, were New Zealanders of 19th century British and Irish extraction. His father, an orphan, began working at the post office in 1914 and rose to become assistant postmaster for Wellington; his mother was a schoolteacher. Peter spent his first 22 years in the spectacularly beautiful Island Bay, a suburb south of Wellington, facing onto Cook Strait.

He graduated from the University of New Zealand with a BSc in mathematics and physics in 1947, ranked first in the

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country in the exams for these subjects, and an MSc in mathematics in 1948. He intended a career in mathematical physics, but vacation work in the NZ Department of Scientific and Industrial Research (DSIR) offered statistical problems from agriculture and biometrics that attracted his scientific interest. His first paper was on the design of experiments.

A traveling scholarship in 1949 took him to Uppsala, Sweden, for his doctoral work under Hermann Wold. Profoundly influenced by Maurice Bartlett (NAS 1993), then working in Manchester, Peter began his work on time series analysis. In his doctoral thesis and four papers following from it he essentially solved the large-sample inference problem for a stationary time series generated by a linear Gaussian model. The terms "multivariate Whittle likelihood" and "Whittle estimation" are now common, but at the time this early groundbreaking work was not widely appreciated. Whittle remarked that, perhaps in unconscious emulation of the admired Bartlett, he wrote too gnomically.

In marked contrast, his corresponding analysis for spatial processes, published in 1954, had an immediate and sustained impact.[1] His asymptotic inference theory for Gaussian processes and related spatial processes was ahead of its time in considering power law covariance functions, now central in image analysis.

Peter returned in 1953 to his home country and the DSIR. Work on New Zealand rabbits (imported pests of the first order) produced the Whittle threshold theorem for stochastic process models of an epidemic. Oscillations in oceanographic data (from the Island Bay rock channels) uncovered nonlinear effects. During this period he also became interested in polymerization and in reversibility, both topics he would later return to.

Peter believed that his subsequent interests and career were largely shaped by his time in the NZ DSIR, working on problems from geophysics, agriculture, and industry. His superior

[1] Whittle P. 1954. On stationary processes in the plane. *Biometrika* 41(3/4):434–49.

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there wrote "His genuine interest in people and their work, his boyish sense of humour and lack of pretension, made it possible for him to carry his own intellectual preeminence without exciting jealousy or antagonism."

Peter came back to Britain in 1959 as a lecturer in the Statistical Laboratory, Cambridge. In 1961 he succeeded Bartlett as chair of mathematical statistics at Manchester, where his interest in optimization developed; he kept his interest in spatial processes, with his student David Brook producing an early result on Markov random fields; and he obtained his first results on networks of queues and partial balance.

In 1967 Peter returned to Cambridge as the first Churchill Professor of Mathematics for Operational Research, a newly established chair endowed by Esso. The position gave him the perfect platform for his vision that what needed developing was not just narrow-sense operational research but the whole area of what in Cambridge is now termed "applicable mathematics." This includes, for example, probability, statistics, optimization, game theory, and aspects of disciplines such as control theory, communications theory, and mathematical economics that might be pursued by someone technically based in probability and optimization. Developments in the United States had convinced Peter of not only the practical importance of these topics but also the depth and coherence of the theory they generate.

He felt that the subject of statistics itself is thoroughly penetrated by optimization concepts and is viewed aright only when embedded in this larger context (a view now taken for granted in statistics generally and in areas such as machine learning). He set about creating the new courses to deliver this vision, and this began an evolution of the Mathematical Tripos at Cambridge that has continued to this day. He served as director of the Cambridge Statistical Laboratory from 1973 to 1986.

By the time of Peter's second major work on time series (*Prediction and Regulation: Linear Least-Square Methods*, English Universities Press, 1963, rev. 2nd ed., 1983) his interest had moved from inference to prediction and control. His four

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volumes on optimization marked his continuing interest in stochastic control, and in temporal optimization generally, using dynamic programming ideas. *Optimization under Constraints: Theory and Applications of Nonlinear Programming* (John Wiley & Sons, 1971) is shot through with insight in a prose style combining power and economy.

Notable in *Optimization over Time, Dynamic Programming and Stochastic Control, Volume 2* (Wiley, 1983; volume 1 was published in 1982) is Peter's treatment of the multiarmed bandit problem. Despite its whimsical name this problem—the sequential allocation of effort in the presence of uncertainty—arises in areas as varied as the design of clinical trials or the choice of exploration avenues in artificial intelligence. The problem was first formulated during World War II and, as Peter famously remarked, efforts to solve it so sapped the energies of Allied analysts that someone suggested the problem be dropped over Germany as the ultimate instrument of intellectual sabotage.

Later, in *Risk-Sensitive Optimal Control* (Wiley, 1990) the complete theory for the linear/quadratic/Gaussian case is transferred to a significantly more general case.

His vision for the whole area of applicable mathematics was by now well established, providing the mathematical foundations for central areas of engineering and economics. Mathematicians often do not see the impact of their work on other fields. It is noteworthy that in the foreword to the second edition of *Prediction and Regulation* (University of Minnesota Press, 1983), Thomas Sargent (NAS 1983), later awarded the Nobel Prize in Economics for empirical research on cause and effect in the macroeconomy, wrote about the importance of Peter's work for understanding dynamic economic phenomena.

Peter's book *Probability via Expectation* (1970, expanded in 2000, 4th ed., Springer) is an exposition of probability theory that formulates its axioms in terms of expectation rather than measure, developing Peter's view that this approach has advantages at many levels. One advantage is that probability theory and probability of quantum theory are seen to differ

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in only a modification of the axioms—a modification rich in consequences, but (as in so much of Peter's work) succinctly expressible.

Peter had a lifelong interest in statistical/physical models, and his book *Systems in Stochastic Equilibrium* (John Wiley & Sons, 1986) collects his work on polymerization and random graphs and on partial balance in networks. His work on networks continued with *Neural Nets and Chaotic Carriers* (John Wiley & Sons, 1998) and *Networks: Optimization and Evolution* (Cambridge University Press, 2007).

In his final years he maintained his interest in neural nets, finding the notions of self-optimizing and self-organizing systems both fascinating and of enormous potential. But even he might have been surprised to see the pace of the ongoing realignment of mathematics, with statistics, optimization, and machine learning permeating applied mathematics and leading to remarkable advances across swaths of physical, biological, and social science.

His distinctions are too numerous to list, but it would be remiss not to note the Sylvester Medal of the Royal Society, the Guy Medal in Silver (1966) and Gold (1996) of the Royal Statistical Society, and the Lanchester Prize (1986) and John von Neumann Theory Prize (1997) of the US Institute for Operations Research and Management Science. He was a fellow of the Royal Society and in 2016 was elected a foreign member of the US National Academy of Engineering.

Peter married Käthe Blomquist in 1951 and they had six children. Käthe was Finnish and they had met in Uppsala; they did their courting in Swedish, a second language to each and their only common language.

He sometimes described himself as a "loner" and as far as his academic work was concerned he was certainly refreshingly away from the crowd. But it is hard to think of anyone who took such pleasure from his large family as really alone. The keenness of Peter's observation of personalities was another factor—to be read so clearly can be disconcerting.

As a schoolboy in New Zealand Peter played the flute in the school orchestra, and throughout his life he got pleasure

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from making and playing instruments. He was particularly attracted to woodwind instruments, especially the oboe. In his middle years he learned the flamenco guitar, mastering the *rasgueado*—the continuous drum-roll achieved with the backs of the fingernails. He also played the chanter—the part of the bagpipes that creates the melody without the bag and drones. Languages were another interest: French, Swedish, and Russian early in his life, and after retirement Scottish Gaelic, whose evocative charms fascinated him. He was a talented runner and kept up distance running into his later years. He also enjoyed carpentry, general DIY, and toymaking, finding them a useful counterweight to his academic work. Throughout his life he greatly missed New Zealand, and asked that his ashes be cast into the waters of Island Bay, which he had grown up overlooking.

Käthe died in 2020. She and Peter are survived by their children Martin (Christine), Lorna, Gregory (partner Lynda Jenkins), Jennifer Southam (Jeremy), and Elsie (partner Paul Tansley); seven grandchildren; and one great-granddaughter. Son Miles died in October 2021.

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