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WORKS BY VON MISES

SUPPLEMENTARY BIBLIOGRAPHY

Richard von Mises (1883-1953), who contributed notably to the field of applied mathematics, was born in Lemberg, in the Austro-Hungarian Empire. His father, Arthur von Mises, held a doctoral degree from the Institute of Technology in Zurich and was a prominent railroad engineer in the civil service. On his travels all over the empire he was often accompanied by his family, and von Mises was born on one of these journeys. The family home was in Vienna. Von Mises was the second of three brothers; the eldest, Ludwig, is an economist of international reputation; the youngest died while still a boy. His father's family included engineers, physicians, bankers, and civil servants. Among the members of his mother's family were philologists and bibliophiles.

Von Mises attended the Akademische Gymnasium in Vienna and graduated in 1901 with high distinction in Latin and mathematics. He then studied mechanical engineering at the Vienna Technical University. In 1906, immediately after finishing these studies, he became an assistant to Georg Hamel, who had just accepted a professorship of mechanics at the Technical University in Brunn (now Brno). In 1908 von Mises was awarded a doctorate by the Technical University in Vienna and in the same year obtained the *venia legendi (Privatdozentur)* at Brunn, with an inaugural dissertation entitled *Theorie der Wasserrader* (1908). But after only one year (at the age of 26), he was called to Strasbourg as associate professor of applied mathematics, the field he made famous.

After five happy and fruitful years in Strasbourg, von Mises joined the newly formed Flying Corps of the Austro-Hungarian Army at the outbreak of World War I (he already had a pilot's license). He was soon recalled from service in the field to act as technical adviser, organizer, and instructor. In the *Fliegerarsenal* in Aspern, he taught the theory of flight to German and Austrian officers; these lectures constituted the first version of his *Fluglehre* (1918), which went through many editions. He was commissioned to design the first large airplane of the empire, the "Grossflugzeug." At the same time he was working on two basic papers on probability (discussed below).

When the war was over, von Mises could not return to Strasbourg, which had become French. After a brief interlude as lecturer in Frankfurt, he was called in 1919 to the Technical University in Dresden as professor, and in 1920 to the University of Berlin as professor of applied mathematics and director of the Institute of Applied Mathematics. This institute was actually founded by him and was a precursor of several similar institutes in Europe and America. In 1921 he founded the *Zeitschrift filr angewandte Mathematik und Me-chanik,* the first journal of its kind. As its editor until 1933, he exerted a profound influence on applied mathematics all over the world. For von Mises, applied mathematics included mechanics, practical analysis, probability and statistics, and some aspects of geometry and philosophy of science. He educated a generation of young applied mathematicians. His first assistant was Hilda Geiringer, who held a PH.D. in "pure" mathematics but turned, under his influence, to applied mathematics. She became his collaborator and later his wife.

When, in 1933, von Mises recognized that it would be both unwise and undignified to remain in Berlin, he accepted the position of professor of mathematics and director of the mathematical institute in Istanbul, Turkey, at the university that had been revitalized by Kemal Atatiirk. He reorgan-ized the institute, lectured in French and in Turkish, maintained close relations with Turkish professors and dignitaries, and became a leading figure at the university. But in 1939, with the approach of World War n, he felt he had to leave Istanbul; and he accepted a position as lecturer in the School of Engineering at Harvard University. There, he was appointed, in rapid succession, associate professor and Gordon McKay professor of aerodynamics and applied mathematics. He continued his own scientific work as well as the education of undergraduates, postgraduates, and research workers.

The fields to which von Mises made distinctive contributions are (1) mechanics and geometry, (2) probability and statistics, (3) philosophy of science, and (4) analysis. Of these, the first two categories occupied him the most. Geometry captivated him all his life, and most of his geometric contributions are closely connected with mechanics.

The outstanding feature of his work is a striving for clarity and complete understanding. In his contributions to mechanics no vague statements, no *ad hoc* engineering theories are tolerated; explanations of observations follow strictly from the principles of mechanics. Particularly important achievements are his *Theorie der Wasserrader* (1908); his wing theory (1917-1920), which is based on con-formal mapping; and his celebrated work on plasticity (1913; 1925; 1928a; 1949).

The main directions of von Mises' thought on the theory of probability appeared in his first major papers on the subject, the "Fundamentalsatze der Wahrscheinlichkeitsrechnung" and the "Grundlagen der Wahrscheinlichkeitsrechnung," both of 1919. Von Mises considered probability as a science of the same epistemological type as, say, mechanics. Its mathematical construction is distilled from experience. The main concept, introduced in the "Grundlagen," is the *Kollektiv* (also denoted as "irregular collective"), which, in the simplest case, idealizes the sequence of results of the repeated tossings of a coin under unaltered circumstances. The collective as a mathematical notion is thus an infinite sequence of zeros and ones (heads and tails). If among the first *N* terms of the sequence there are *N0* zeros and N1 ones, *N0* + Nt = *N,* the *frequencies N0/N, N,/N* are given. For reasons of mathematical expediency it is then assumed that, in the abstract sequence, the *limits of these frequencies* exist as *N* tends toward infinity. In addition, the infinite sequence is to have the property of *randomness;* vaguely explained, this means the following: if we consider not all *N* trials (not all *N* terms of the sequence) but only the second, fourth, sixth, … or only those whose number is a prime number or only those which follow a run of three "ones," we obtain by such a *selection* a frequency *N[/N'* (and *N'0/N'),* and it is postulated that for any such selection

This p_1 is the *probability* of the result one, and $p_0 = 1 — P_1$ is that of the result zero. Randomness is the mathematical equivalent of the "impossibility of a gambling system" and thus characterizes the sequences which form the subject of probability calculus.

Von Mises then built up probability theory, by means of collectives, in one or more dimensions. In 1938 Abraham Wald proved the "consistency"— i.e., existence in the mathematical sense—of the collective, indicating precise conditions. Von Mises accepted Wald's results as a necessary and valuable complement. He felt that in mathematics, as well as in any other science, the unceasing improvement and refinement of existing concepts must parallel the creation and extension of new concepts.

Von Mises' theory is in contrast with the a prior-istic theory of Laplace, whose definition of probability is both logically unsatisfactory and too narrow. Laplace and his followers therefore had to distinguish between a "theoretical" and an "empirical" probability; the mathematical theorems proved with the theoretical definitions were then unhesitatingly applied to problems where Laplace's "equally likely" and "favorable" events often failed to exist. Von Mises showed in a penetrating analysis that for modern probability, as used in physics, biology, and some of the social sciences, Laplace's definition is quite insufficient.

Von Mises' frequency theory also differs from today's abstract measure-theoretical approach, most closely associated with Kolmogorov. The contrast is not between "frequency" and "measure": in von Mises' developments, as well as in Kolmogorov's, both frequencies and measures are essential. Von Mises wanted to lay the conceptual foundations of the science of probability; Kolmogorov, the axiomatic foundations of the calculus of probability. [See Probability.]

The "Fundamentälsatze" deals with two basic general problems. (1) Given *n* distributions (for example, η dice with given probabilities $p_i^{(v)}$ $i= 1,2, …, 6$; $v = 1,2,…, n$ for the six faces of the dice), with results X_v in the *vth* trial, what is the distribution, as $n \to \infty$, of the sum $X_1,…,X_n$ (equivalently, of the average) of these results? Regarding this group of problems, indicated here by a very special case, von Mises proved in 1919 two basic "local" theorems and studied the most general problem. (2) Perhaps an even more important contribution is his formulation and study of the second fundamental problem. Consider again a very special case. A coin with *unknown* heads-probability is thrown η times, and "heads" turn up Hi times. What inference can we make from this observed result about the unknown heads-probability of the coin? Obviously, this is the typical problem of inference from an observed *sample* to an unknown "theoretical" value. This problem was considered by von Mises as the crucial problem of theoretical statistics. This "Bayesian" point of view has been widely attacked by R. A. Fisher and his students but seems to be more and more accepted today. For von Mises, statistics was just one (very important and general) application of probability theory.

In the last years of his life von Mises introduced the fundamental concept of a *statistical function* (as important as the concepts earlier introduced by him of *distribution* and of *sample space),* which led to vast generalizations of the two problems of the "Fundamentalsatze." Von Mises' work in probability and statistics is incorporated in many papers and in three books: his *Wahrscheinlichkeitsrech-nung* of 1931 (Volume 1 of *Vorlesungen aus dem Gebiete der angewandten Mathematik),* a comprehensive textbook of his theory; his *Probability, Statistics and Truth* (1928b), a lucid presentation in nontechnical language of his foundations of probability and their applications in statistics, biology, and physics; and his lecture notes, *Mathematical Theory of Probability and Statistics* (1964), which restates and extends the foundations of the theory and builds on them a unified theory of probability and statistics, with particularly original contributions to statistics.

Von Mises did not believe that statistical explanations in physics—and other domains of knowledge—are of transient utility while deterministic theories are the definite goal. He thought that a judgment of what constitutes an "explanation" is, like anything else, subject to change and development. The "Laplacean daimon" of complete deter-minacy is no longer accepted, nor is an immutable law of causality. Philosophers, von Mises thought, are apt to try to "eternalize" the current state of scientific affairs, just as Kant held Euclidean space as an absolute category. In contrast with these "school philosophers," he called himself a "posi-tivist." In an address given shortly before his death he said, "He is a positivist who, when confronted by any problem reacts in the manner in which a typical contemporary scientist deals with his problems of research." Von Mises thought of science in the general sense of the German *Wissenschaft.* In his book *Positivism* (1939) he followed up this conception through the various domains of thought and of life.

Von Mises loved poetry: He could recite long passages from Goethe, as well as from such modern poets as Hofmannsthal, Verlaine, Altenberg, and, in particular, Rilke. In Rilke's esoteric poetry he found a confirmation of his belief that in areas of life not yet explored by science, poetry expresses the experiences of the mind:

Nicht sind die Leiden erkannt, nicht ist die Liebe gelernt, und was im Tod uns entfernt,

ist nicht entschleiert. Einzig das Lied iiberm Land heiligt und feiert.

Pain we misunderstand,

love we have yet to learn,

and death, from which we turn,

awaits unveiling.

Song alone circles the land

hallowing and hailing.

Sonnets to Orpheus, First Part, xix.

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Von Mises was a recognized authority on the life and work of Rilke. Over a lifetime, he compiled the largest privately owned Rilke collection (now at Harvard's Hough ton Library), for which a 400-page catalogue was published in 1966 by the Insel Verlag, Leipzig.

Hilda geiringer

*[For the historical context of von Mises' work, see the biography of*laplace; *for discussion of the subsequent development of von Mises' ideas, see the biographies of*fisher, R. A.; Wald.]

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