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Felix Bernstein

b. 24 February 1878, in Halle/Saale, Germany
d. 3 December 1956, Zürich, Switzerland

Summary

Felix Bernstein was a mathematician and statistician who is remembered for the "Schröder–Bernstein Theorem" of set theory. He was appointed director in 1907 of what he was to develop into the Göttingen Institute for Mathematical Statistics, and in 1911 was involved in the formulation and proof of what became known as the Borel–Cantelli lemmas. Bernstein worked out in 1924 the correct hypothesis for the genetic transmission of human bloodgroups, on the basis of the available statistical material.

Felix Bernstein was born into a Jewish family with a considerable intellectual as well as political tradition. His father, Julius Bernstein, was a professor of physiology at Halle University. His mother was born Sophie Levy. His grandfather Aron Bernstein (1812–1884) had been a journalist and honorary doctor of Tübingen University. The intellectually precocious Felix attended university seminars of Georg Cantor's (the founder of set theory) even before graduating from Gymnasium in 1896, and proved in that same year what is still known today as the Schröder–Bernstein-Theorem, to the effect that two sets which can be injected into one another have the same cardinality. He did not, however, become a student of mathematics right away. Instead, he spent one year studying philosophy, archaeology, and art history in Italy (at Pisa and Rome). And only the year after did he enrol in mathematics; he was a student at Munich, Halle, Berlin, and Göttingen, and obtained his doctorate in 1901 with a thesis on set theory. His thesis advisor was David Hilbert. Still entirely in the domain of pure mathematics, Bernstein's second Göttingen thesis (Habilitationsschrift) on the class field of an algebraic number field followed in rapid succession in 1903. This Habilitation gave Bernstein the right to teach at university level; he settled as Privatdozent in his hometown. The breadth of his scientific interests already at that time can be seen from the subject that Bernstein chose for his inaugural lecture there: the Kant–Laplace (q.v.) theory of the planetary system. During his time as Privatdozent in Halle, Bernstein worked and lectured primarily on pure mathematics.

But this period also marked the beginning of his contact with statistics and insurance mathematics in both teaching and research. In 1906, Bernstein declined a job offer from the insurance industry, thus documenting his intention to embark on an academic career, which at that time he still wished to be in pure mathematics. But in 1907 he accepted the appointment as director of the mathematical division of the Göttingen Seminar für Versicherungswissenschaft, an institution that had been founded in 1895. At first he held this responsibility as a simple Privatdozent. But in 1911 Felix Bernstein obtained his first academic position, that of a planmäßiger a.o. Professor für mathematische Statistik und Versicherungsmathematik in Göttingen, thus becoming a civil servant before WW I. In 1913, he married Edith Magnus. Two children, Marianne and Ulrich, stem from this marriage.

For reasons of his frail health, Bernstein was not to serve in military action during WW I, but he was eventually used for the war effort, teaching statistics to invalid soldiers and working for the office of leather rationing in Berlin. During his time in the capital, he made contact with a number of well-known public figures of the day, among them the banker and politician Hjalmar Schacht. In 1918, after the end of the war, Felix Bernstein was among the founders of the left-liberal Deutsche Demokratische Partei (DDP), along with Hjalmar Schacht, Walter Rathenau, Theodor Heuss, and others. He also was the vice chairman of the Göttingen branch of this party in the first years after the war. When Felix Bernstein was commissioned in the fall of 1919 by the Ministry of Finance to devise the first state loan of the Weimar Republic (Deutsche Sparprämienanleihe), this was naturally seen by many onlookers as a corollary of his political involvement. Indeed, being active for the DDP, Bernstein joined the small minority of German university professors which were loyal to the new democratic state, instead of longing for a renewal of the wilhelmian Kaiserreich. And by accepting to work for the Minister of Finance Matthias Erzberger (who, to recall but this, had dared to propose as early as 1916 that Germany seek an immediate peace agreement without annexing new territory), Bernstein allied himself with the politician who was perhaps the most hated by right wing nationalists. Erzberger was in fact murdered by right wing extremists in the Summer of 1921.

This political background is essential for understanding why Felix Bernstein found himself, between 1920 and 1922 (with various repercussions even much later), at the center of a political/moral crucible staged by his colleagues from the Göttingen Philosophische Fakultät (which at that time still grouped together humanities and sciences—this same conservative Fakultät also refused for a long time to grant a Habilitation to Emmy Noether, the mother of Modern Algebra). Only Richard Courant, David Hilbert, and Carl Runge spoke up in favor of Bernstein, underlining his scientific excellence against charges questioning his integrity on the grounds of the unwritten code of honor of German civil servants.

Bernstein did not play his cards very well in dealing with his colleagues. Right after the end of the war in 1918, the Institut für mathematische Statistik had been founded at Göttingen, with Bernstein as director (recall by way of comparison the founding of von Mises' (q.v.) institute for applied mathematics in Berlin around the same time). In fact, Bernstein's promotion to a position of ordinary professor seemed imminent at that time. But instead of waiting for this to happen, he had the unusual idea of requesting his promotion himself in a letter to the ministry dated 7 June 1919. With the affair about the state loan aggravating his position, the promotion was put off until 13 October 1921, when the ministry appointed him personal ordinary professor against the will of the majority of the Göttingen faculty.

Bernstein's mathematical works cover a wide range of subjects. In pure mathematics, aside from the contributions to Set Theory and Number Theory already alluded to, he also dealt with isoperimetric problems, with the Laplace Transform and with convex functions.

His more theoretical contributions to statistics and actuarial studies appear to have had only limited impact on the development of the subjects. But let us mention Bernstein's variant and further development (in publications between 1929 and 1932) of K. Pearson's (q.v.) method of estimating the parameters of a known distribution from their power moments. Other papers are noteworthy for the original use of pure mathematical inspiration in statistical contexts—for instance, in 1906 and 1907 Bernstein deduced Gauss's (q.v.) error function under weak hypotheses using the theory of convex functions.

Suppose $\{A_n\}$ is a sequence of events in some probability space. Borel's (q.v.) zero-one law, stemming from a paper on continued fractions of 1909, states that if the events $\{A_n\}$ are independent, then if the sum of the $P(A_n)$ converges, the probability that an infinite number of the events occurs is zero. But if the sum diverges to infinity, the probability that infinitely many occur is 1. In 1911 Felix Bernstein actually gave a completely correct proof of this; and also showed that the conclusion in the *divergent* case held under a condition weaker than independence (see Barone & Novikoff, 1978). A few years later, F. Cantelli showed that the hypothesis of independence could be dropped entirely from the *convergence* part by using Boole's (q.v.) Inequality. This result is now sometimes known as *the* Borel–Cantelli Lemma.

Bernstein's reflections on the least-square-method (in lecture courses and papers 1913–1915) characteristically culminated in an axiomatic approach; and in 1928 he would propose to interpret bloodgroup data as projective coordinates of points on Steiner's surface, ostensibly hoping for "new algebraic problems" to arise from the probabilistic interpretation of this algebraic surface.

The last example falls under the predominant focus of Bernstein's production in the 1920s, the various applications of statistics to genetics. The main novelty in these papers clearly lies in Bernstein's insightful arguments about the intended applications, rather than on statistical theory or technique. In order to appreciate this work, recall that, in the 1920s, there was no way to read the human genetic code; rather, the coding of genetic information had to be deduced from the way in which it was passed on to future generations. In the case of plants, such deductions were rendered comparatively easy by the possibility of evaluating several consecutive generations produced in controlled experiments. But in "Mendelian Anthropology", as it was called at the time, the available data usually concerned only the brothers, sisters, and parents of individuals showing a certain phenomenon. Information about families without this phenomenon, as well as the precise genetic coding of the phenomenon in terms of chromosomes and alleles, had to be guessed. Bernstein's work of the 1920s (and also later) addressed this problem. He entered into long lasting polemics against W. Weinberg on different methods of extrapolating missing information about unaffected families (R. von Mises also contributed to this debate, proposing a criterion to decide between Weinberg's and Bernstein's hypotheses). And in 1924–25, Felix Bernstein brilliantly managed to correctly guess the genetic transmission of the blood groups A - B - AB - 0, using population genetics and a triple allele hypothesis: Each human being carries one of three possible genetic markings which Bernstein labels A, B, R, the combination of which in parents gives the following observable blood groups of the child: AA and AR lead to A; BB and BR to B; AB to AB, and RR to O. The frequencies p, q, r of these markings A, B, resp. R $(p+q+r = 1)$ thus lead to observable frequencies of blood groups in the same population according to $\mathrm{O} = r^2$, $\mathrm{A} = p^2 + 2pr$, $\mathrm{B} = q^2 + 2qr$, $\mathrm{AB} = pq$. Consequences of these relations turned out to be in much better agreement with observed frequencies than the previously used Hardy–Weinberg model which was based on the assumption of a binary genetic information. See Lancaster (1994) for further discussion.

This was undoubtedly Bernstein's most original and lasting scientific result. His 1929 book *Variations- und Erblichkeitsstatistik*, even though rather tersely written, contains a fairly complete survey of his work in the field up to that year. Numerous passages in this book also show, as does a series of articles of about the same time, Bernstein's preoccupation with the search for genetic markers of different races, the goal being to detect the (racial) mixing of population groups. Bernstein tried (in vain) to get funding for a very large scale investigation of the blood group distribution throughout Germany.

In the summer semesters of 1928 and 1929 Bernstein worked in the U.S. at the Cold Spring Harbor Laboratory of the Long Island Biological Association. On December 1st 1932, he left Göttingen for his third trip to the U.S. He would not return to Europe for 15 years. The Nazis formally dismissed him on 24 November 1933 according to the catch-all clause §6 of the civil service law of 7 April 1933 (this was, so to say, the "routine" treatment of "non-aryan" scholars who had already been civil servants before 1914).

In the United States, Bernstein survived on college teaching jobs. There is an interview with a colleague of Bernstein's at the State University of New York (SUNY) at Binghampton (http://www.math.binghampton.edu/dept/kentinterview.html) who says: "... I was really quite honored to be head of his department, and he seemed to appreciate my cooperation with his troubles and the fact that he had to teach only undergraduate low level mathematics courses. There was no graduate program in those days at all ..." R. Siegmund-Schultze (2001) quotes from the Rockefeller papers (21 May 1934): "B. was the one definite misfit among the displaced scholars." He also quotes a letter of Bernstein's to Albert Einstein from March 1949, where Bernstein bitterly bemoans not having been treated according to his scientific excellence.

In 1948, Göttingen University granted Bernstein a pension, and the year 1949 he spent in Rome as a Fulbright professor, at Corrado Gini's (q.v.) institute.

Felix Bernstein was elected Member from the USA of the International Statistical Institute, primarily through the agency of Gini, in 1951. There is a letter dated 24 June 1954 from R.A. Fisher (q.v.) advising that Bernstein's name is at the head of the list of the Council of the Royal Statistical Society of distinguished persons proposed as Honorary Fellows. On 5 July 1954 Bernstein responded: "... after so many hard years this is a wonderful confirmation ... that my efforts have not been in vain ... every normal human being is in need of such testimony of one's usefulness."

In 1999 SUNY (Binghampton) announced the Felix Bernstein and Craig Squier Teaching Assistantships for graduate study towards the MA or PhD degree. These carried a stipend of $ 14,000 and a full tuition scholarship. The university cited Bernstein as co-developer of the Cantor–Bernstein theorem (at the age of 19), full-time lecturer in mathematics at Triple Cities College, and world renowned statistician and pioneer in the field of population genetics.

Siegfried Koller had been Bernstein's thesis student in 1931; his thesis dealt with damage to the child that may result from parents having different blood groups. This subject was well embedded into the research on the mixing of genetic phenomena with respect to race which was clearly top level research in the 1920s and 1930s. In concordance with a large international debate about eugenics, there was even a project for a law on eugenics during the last years of the Weimar Republic. It was only the Nazis, however, who passed such a law, as early as July 1933 (Gesetz zur Verhütung erbkranken Nachwuchses—Law for the prevention of hereditarily sick offspring), which fixed a list of eight "hereditary diseases" that were to be counteracted by forced sterilization. By far the most important among these indications in the actual application of the law (see the Göttingen case study by Benshausen, Dahms *et al.* in Becker *et al.*, 1998) was "congenital feeble-mindedness" (angeborener Schwachsinn) the diagnosis of which was based on a simple kind of intelligence test. Activities of scientists such as Koller in support of compulsory sterilization allows one to appreciate what it meant for Germany to force politically lucid senior people like Felix Bernstein into emigration.

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— Norbert Schappacher

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