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JERZY NEYMAN (1894–1981)

The Russian period, 1894–1921

Jerzy Spława-Neyman was born on 16 April 1894, into a noble family, in the town of Bendery on the river Dniester. He disliked the prefix Spława, and except for some early works he published under the name Neyman. Out of respect for that decision, we use only the shortened form of his surname here. Klonecki (1995) reports that, according to his sources, the Neyman family came to Poland in the 17th century from German or Dutch lands.[1]

Neyman was the grandson of a participant in the uprising of 1863. For his part in the insurrection his grandfather had been burned alive in his own house, his property confiscated, and his ten (according to J. Neyman) sons sent to Siberia. Only his youngest son Czesław – who would be Jerzy's father – was allowed to settle in Bendery in the European part of Russia. Czesław Neyman graduated in law in Kiev. There he also married Kazimiera Lutosławska. Jerzy Neyman, whose father was a successful man, was initially educated at home. He had a governess, and also attended an unofficial Polish school which operated in private homes. When at the age of ten he went to the secondary school in Simferopol, he knew five languages (French, German, Polish, Russian and Ukrainian) and was ahead of his colleagues with his knowledge in many fields, with the exception of Russian history and geography.

In 1906 Neyman's father died, and his family moved to Kharkov, where they had relatives. After he completed secondary school in 1912 his mother sent Jerzy with a group of students on a rail journey around Europe. In autumn of 1912 Neyman began his studies at Kharkov University. At first he was interested in physics, which was a result of the publication at that time of the theory of relativity and the recent Nobel Prize awarded to Marie Curie. In 1914 he went on

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a students' academic expedition to Mongolia. However, because he had no talent for manual laboratory work, he dropped physics that same year and began to study Lebesgue's book *Leçons sur l'intégration et la recherche des fonctions primitives*. This resulted in a paper on the Lebesgue integral (530 pages of tiny dense manuscript in the Russian language), for which Neyman received a gold medal in 1916. During his studies Neyman attended S. Bernstein's lectures in probability and mathematical statistics. In his introduction to *Early Statistical Papers of J. Neyman* (University of California Press, 1967), their author began by giving thanks to Bernstein, from whom he had learnt to concentrate on genuinely difficult problems. In 1917 Neyman completed his studies and became a research assistant in the university's mathematics department, as well as a lecturer at Kharkov polytechnic and assistant to A. Przeborski.

The years 1917–1919 were extremely difficult. The First World War, the Bolshevik revolution and the civil war were not conducive to work and led to a marked deterioration in living conditions. In 1919 Neyman was diagnosed with tuberculosis and sent to the Caucasus. There he met the Russian painter Olga Solodovnikova, whom he married in 1920. Ten days after the wedding Neyman was arrested by the Russians and imprisoned for several weeks. In 1920 Neyman passed his master's degree exam and became a university lecturer. He also worked with Professor M. Yegorov in the field of agricultural experimentation.

The Polish-British period, 1921–1938

Following the Riga Treaty of 1921, under an exchange of families, Neyman went with his mother and grandmother to Poland. Thus he saw that country for the first time at the age of 27. They settled in Bydgoszcz, in the house of Neyman's brother Karol. His wife, who had typhus, remained for the time being in Russia. Neyman made contact with Professor W. Sierpiński, who studied the results from Neyman's aforementioned manuscript, and suggested sending one of them, which turned out to be a new result, to the journal *Fundamenta Mathematicae*. The paper was accepted and appeared in 1923 under the title *Sur un théorème métrique concernant les ensembles fermés*. Sierpiński hoped that, starting from the new academic year, it would be possible to obtain a post for Neyman at a Polish university. The most likely institution was the university in Lvov (Lwów). However Neyman wanted to begin working straight away, and became a senior statistical assistant at the National Scientific Agricultural Institute in Bydgoszcz, which was headed by Professor K. Bassalik. Initially he engaged in intense further studies of statistics and agricultural experimentation. Around the end of 1921 he obtained funds for a journey to Berlin and for the purchase of statistical journals and books there. Neyman spent more than a year in Bydgoszcz, and while there wrote several papers on applications of probability theory to agricultural experimentation.

In December 1922 Neyman began working for the National Meteorological Institute in Warsaw, where he looked after equipment and collected data. Also, in

1923, probably thanks to A. Przeborski, who had also come to Poland from Kharkov, Neyman became his assistant at Warsaw University. At the same time he began giving classes as a lecturer in mathematics and statistics at the Central Agricultural College (SGGW). He then had a total of 25 teaching hours a week at those two institutions. From 1924 he gave additional classes at the Jagiellonian University in Cracow, and from 1927 he also worked for the beet producers K. Buszczyński and Sons. In 1928 he organized a Biometrical Laboratory at the M. Nencki Institute. In order to enable his pupils and colleagues to publish their work, and to popularize his own ideas, he founded the journal Statistica and published it from 1929 to 1938. He also worked with the Institute of Social Affairs, the Central Statistical Office and other institutions.

Based on his papers on agricultural experimentation written in Bydgoszcz, in 1924 Neyman received the title of doctor of mathematics from Warsaw University. His examiners were the professors T. Kotarbiński, S. Mazurkiewicz, A. Przeborski and W. Sierpiński. It should be noted that a part of his doctoral thesis, which was published in Roczniki Nauk Rolniczych (Annals of Agricultural Sciences) in 1923, was translated into English and published in 1990 with extensive commentary in the journal Statistical Science. In 1928 Neyman gained his post-doctoral habilitation degree at Warsaw University.

In 1924, thanks to K. Bassalik and W. Sierpiński, Neyman received a one-year Polish government scholarship for a stay at University College London, with Karl Pearson. Among the results was the publication of versions of three earlier works of Neyman in the journal Biometrika. Next, with the support of Pearson and Sierpiński, Neyman received a scholarship from the Rockefeller Foundation, which he used for a year's stay in Paris, with Borel at the Sorbonne and with Lebesgue at the Collège de France. In 1926 he began working with Egon Pearson, the son of Karl. Their contacts were intensive, and in 1934 Neyman gained the post of lecturer at University College London, which solved his problem of having no permanent employment and no real prospects of obtaining a professorship in Poland, which had made his material situation very difficult. In spite of living and working in London, Neyman maintained contact and cooperation with his Polish team. He worked at University College until 1938. It should be pointed out that Neyman wanted to work in Poland. Reid (1982, p. 127) cites dramatic fragments of Neyman's correspondence in the matter of finding a suitable post for him at any institution in Poland.

In the course of those 18 very difficult years, Neyman managed to achieve an unimaginably great amount. A list of his works, included in the above-mentioned volume of early works of J. Neyman, includes 65 papers from 1923–1938, one textbook giving an introduction to probability theory, and two monographs written in Polish in 1933 and 1934. And these are not all of his publications, as can be seen from the bibliography drawn up by B. Łazowska (1995). Many of the works are extremely substantial, which sometimes even led to problems publishing them.

The list of his works naturally includes publications motivated by current application problems arising in connection with Neyman's work at the institutions mentioned earlier. They included in particular agricultural experimentation, biometrics, sampling methods and problems related to insurance.

As a result of questions asked by E. Pearson, Neyman became interested in the issue of hypothesis testing. In 1928 his first joint work with Pearson appeared, titled On the use and interpretation of certain test criteria for purposes of statistical inference, published in the journal Biometrika in two parts (pages 175–240 and 263–294). The work concerns mainly the likelihood ratio test, and introduces the concept of a set of alternatives, errors of the first and second type, the power function, and a definition of the likelihood ratio statistic. It is then shown that different known tests can be obtained by this general method, and an investigation is made of the asymptotic equivalence of the likelihood ratio test and the chi-squared test. As a result of further discussions with Pearson, Neyman formulated a problem of testing in the language of problem of optimization, and in 1930 proved the basic Neyman–Pearson lemma. This was included in 1932 in a paper of Neyman and Pearson concerning uniformly most powerful and uniformly best tests in a class of similar tests. That work, titled On the problem of the most efficient tests of statistical hypotheses, was accepted by the Royal Society, presented by Karl Pearson at the Society's meeting in November 1932, and published in 1933 in Philosophical Transactions of the Royal Society (pp. 289–337). The paper is of fundamental importance in the theory of the testing of hypotheses given a fixed sample size. As is noted by Le Cam and Lehmann (1974), by introducing tests as solutions to clearly defined optimization problems, Neyman and Pearson provided a model for general decision theory, later developed by A. Wald, and for mathematical statistics in general. In 1992 that work was selected for inclusion in a volume of the most important achievements in fundamentals of statistics in the 20th century (Breakthroughs in Statistics, Vol. I, Springer). A similar distinction went to Neyman's work On the two different aspects of the representative method: the method of stratified sampling and the method of purposive selection, presented in 1934 at a meeting of the Royal Statistical Society and published in the Journal of the Royal Statistical Society (1934, pp. 558–625), which was included among the greatest 20th-century achievements in statistical methodology (Breakthroughs in Statistics, Vol. II, 1992, Springer). This work was based on a monograph of 1933, written in Polish and resulting from Neyman's work for the Institute of Social Affairs. In 1935, in Annals of Mathematical Statistics (pp. 111–116), Neyman published the paper On the problem of confidence intervals. In the summer of 1936 he continued to work intensely on confidence intervals, and presented his result on the duality of interval estimation and testing. E. Pearson rejected it for Biometrika as being too long and mathematical, but the work appeared under the title Outline of a theory of statistical estimation based on the classical theory of probability in 1937 in Philosophical Transactions of the Royal Society (pp. 333–380). It was presented at a meeting of the Royal Society by Jeffreys. In 1935, at a meeting of the

Industrial and Agricultural Section of the Royal Statistical Society, Neyman presented a joint paper written with K. Iwaszkiewicz and S. Kołodziejczyk on orthogonal designs and randomized blocks. This was printed in 1935 in a supplement to the Journal of the Royal Statistical Society (pp. 107–180). The paper, along with the work of R.A. Fisher, had great importance in the development of experimental planning. In 1937 Neyman published a paper in Skandinavisk Aktuarietidskrift (pp. 149–199) titled 'Smooth' test for goodness of fit, which proved another milestone in the development of statistics. In it he gave an asymptotically optimal solution to the problem of testing the fit of a set of observations to a fully known continuous distribution. In this work Neyman introduced sequences of local alternatives (contiguous distributions), which in the 1960s became a standard tool of asymptotic statistics. The test introduced in that paper remained almost completely forgotten for years, although that has changed radically in recent decades.

In 1935 Neyman and E. Pearson founded a new journal called Statistical Research Memoirs. In 1936 Neyman's son Michael was born. In 1937 Neyman was invited to an international probability congress in Geneva. In addition S. Wilks invited him to give a series of lectures in the United States. On his travels in the States his work aroused much enthusiasm, and the visit itself was a huge success. In November 1937 G. Evans sent Neyman an invitation to set up a statistical centre in Berkeley, California. He was also offered a professorship at Ann Arbor, Michigan. In 1938, a few days after his 44th birthday, Neyman accepted the Berkeley offer. Among other things, this decision meant that he would escape the consequences of the Second World War in Europe. It should be remembered that many of Neyman's Polish colleagues and students died during the war. E. Scott (2006) writes that in 1952 Neyman dedicated to them an extended edition of a volume of his thoughts on statistics, titled Lectures and Conferences on Mathematical Statistics and Probability, listing their names and how each of them died. The first edition of the volume (edited with the assistance of W. Deming) had appeared in 1938 under the title Lectures and Conferences on Mathematical Statistics. The book gained great renown in the United States, and helped to popularize Neyman's ideas and results.

The American period, 1938–1981

On 12 August 1938 Neyman arrived in Berkeley and set to work with great vigour. He worked on setting up the Statistical Laboratory and giving numerous lectures (for example, in 1939–1940 he lectured for 25 hours a week). He began gradually to assemble a team. Elizabeth Scott, an astronomy graduate, became his assistant. He also employed E. Fix, but unfortunately was not able to obtain a post for A. Wald, who had escaped from Nazi persecution in Europe. Neyman gained his first distinctions from the American statistics community: he was invited to give a lecture at a joint conference of the American Statistical Association and the International Statistical Institute, and became a member of the organizing

committee of the 10th Mathematical Congress and an editor of the journal *Annals of Mathematical Statistics*. The outbreak of war and aggression towards Poland distressed him deeply. He made efforts to help his fellow Poles. Among other things, through the Kosciuszko Foundation, he arranged a scholarship for A. Zygmund, which enabled the latter to emigrate with his family to the United States and probably saved his life. In 1942 E. Lehmann became Neyman's assistant. However racial problems meant that he was not able to employ D. Blackwell. Neyman not only set up the Laboratory, but also began to work closely with many university faculties at Berkeley (Genetics, Geology, Hygiene, Agriculture), and this activity was valued very highly.

In February 1942 Neyman was engaged to solve optimization problems for the military. The project was carried out at the Berkeley Statistical Laboratory, with varying intensity, until the end of the war. In October 1944, together with a group of American mathematicians, he was sent to England for the purpose of researching the effectiveness of certain bombs. Also in 1944 he gained American citizenship. He was also able to bring P. Hsu to work for a time at Berkeley.

In 1945 Neyman organized a symposium in statistics and probability, at which he presented a paper titled *Contribution to the theory of the chi-square test*, which among other things introduced the class of best asymptotically normal (BAN) estimators, which are much more convenient to use than the classical estimators obtained by the method of maximum likelihood, and are useful in many complex problems. The symposium was a great success. The holding of the symposium was motivated by a desire to celebrate the end of the war and to facilitate a return to theoretical research following several years of work on applications for the American military. In 1946 Neyman was invited by President Truman to join a team of international observers for the Greek elections. That summer he was invited to spend a semester at Columbia University, where A. Wald worked, and where Neyman was offered a professorship and numerous privileges. These offers proved effective as a means of applying pressure to gain significant advantages for his Laboratory at Berkeley. In particular, posts were found there for M. Loève and C. Stein. In 1947 Neyman was elected vice-president of the American Statistical Association, and in 1948 he became president of the International Statistical Institute. Recognition for his achievements can also be seen in the fact that most of the papers appearing in *Annals of Mathematical Statistics* at that time related to problems which had been set and considered in earlier works by Neyman. In 1948 Neyman and Pearson renewed publication of *Statistical Research Memoirs*; the series continues to be published today under the new title *University of California Publications in Statistics*. After ten years of Neyman's activities Berkeley had become one of the two strongest centres for statistics in the United States, the other being Columbia University.

In 1949 Neyman took his first sabbatical to Europe. First he visited London, where he gave lectures and had discussions with Pearson. Next he lectured in Paris. While there he met L. Le Cam, and recruited him to the Laboratory. He also received a great distinction while in Paris: he became the first non-French author

to be asked to work on a volume in the Borel Series. After Paris he visited Warsaw and many other Polish cities. He also met with his brother Karol.

In 1950, after Neyman's return from Europe, a second Berkeley Symposium took place. Neyman was constantly fighting for the Laboratory's funding and position. The situation was so difficult that Neyman gave up his work on his contribution to the Borel Series. Problems were multiplied by the death of A. Wald in an air crash, and the consequent attempts by Columbia University and other institutions to take over part of Neyman's group. In 1951, in response to questions put by the astronomer C. Shane, Neyman and Elizabeth Scott began a long period of intense collaboration on the dynamics of galaxies. This led to a series of around twenty papers, which are regarded as being among Neyman's most important works on applications. For several months in the academic year 1952/1953 Neyman worked in Bangkok, helping P. Sukhatme to organize a centre for training in sampling methods. In 1953 Neyman employed D. Blackwell and H. Scheffé. Also in 1953 he separated from his wife Olga.

In 1954 a decision was taken to set up a Department of Statistics at Berkeley. Neyman prepared the third Berkeley Symposium, where alongside work on probability and statistics there were papers presented in the fields of astronomy, physics, biology and health issues, econometrics, industrial mathematics and psychometrics. This trend was continued at subsequent Symposia. In the same year Neyman, A. Tarski and three other American mathematicians were invited to the Mathematical Congress in Amsterdam to give lectures on the future of mathematics. In 1955 the Department of Statistics began its work, under Neyman's direction. A year later Neyman resigned from that position, while retaining the lifetime post of head of the Statistical Laboratory.

In 1958 he took another sabbatical. He travelled widely, including to Poland. He also wrote his fundamental work on C(α) tests, which appeared in a volume dedicated to H. Cramér. Until the end of his life Neyman remained bitter that this work had not gained due recognition. Reid (1986, pp. 251–252) quotes a diplomatic statement of Neyman on that subject. The construction of C(α) tests, initiated by a modest publication by Neyman in 1954 in *Trabajos de Estadistica* (pp. 161–168), was key to the development of adaptive methods and asymptotically efficient semiparametric statistics. Unfortunately most works on these subjects make no mention of the originator of the significant idea behind them. E. Scott (2006) notes that during Neyman's lifetime his fundamental results quickly came into practice and found a place in basic textbooks, becoming "classical knowledge" in a sense, and for many it was no longer clear who their originator was. Neyman reconciled himself to the situation.

In 1960, although he had reached retirement age, Neyman continued to work intensively and obtained significant funds for further projects. He was awarded an honorary doctorate by the University of Chicago, became an honorary member of the Royal Statistical Society, and together with Elizabeth Scott received a prize from the American Association for the Advancement of Science. In 1960 the fourth Berkeley Symposium took place. In the following year Neyman spent

much time travelling; he visited Leningrad, went to Moscow for a meeting with Bernstein, and also reached Kiev and Kharkov. A direct result of that visit was the arrangement of the translation into English of E. Dynkin's book on Markov processes.

In 1963 Neyman travelled in the southern states of the USA. Moved by the problems of race, he organized a collection of funds for scholarships, and wrote a letter to H. Cramér in the matter of a Nobel Peace Prize for Martin Luther King.

In 1964 Neyman celebrated his 70th birthday. In recognition of that occasion he was given an entry in the Great Book of the National Academy of Sciences, and received an honorary doctorate from Stockholm University. In 1965 a volume of papers dedicated to Neyman was published, edited by F. David. In 1966 he became the first non-Briton to be awarded the gold medal of the Royal Statistical Society, and the University of Berkeley published three volumes of work by Neyman and Pearson. Also in 1966 he became an overseas member of the Polish Academy of Sciences. We should also note that the fifth Berkeley Symposium took place in 1965.

In 1968 Neyman and Le Cam organized protests against the war in Vietnam. In spite of this, in 1969 Neyman became one of twelve Americans to receive the country's highest scientific award, the Medal of Science, "for laying the foundations of modern statistics and devising tests and procedures that have become essential parts of the knowledge of every statistician."

The year 1970 saw the holding of the sixth Berkeley Symposium, with an extensive programme related to biology and environmental pollution. The symposium was supplemented by three conferences held in spring 1971. It should be remembered that proceedings were printed for each of the six symposia, and Neyman was the editor or co-editor of each one of these ever more voluminous works. Also in 1971 Neyman and A. Zygmund began work on a collection of essays on various revolutionary changes in science, which they referred to as "Copernican". The volume, prepared for the 500th anniversary of the birth of Copernicus, and titled *The Heritage of Copernicus: Theories "More Pleasing to the Mind"*, was published in 1974 on the occasion of Neyman's 80th birthday.

In 1974 a meeting *To Honour Jerzy Neyman* took place in Warsaw, and a collection of the papers presented there was published in 1977. Neyman received honorary doctorates from Warsaw University and the Indian Statistical Institute. Volumes of *Annals of Statistics* and *International Statistical Review* were dedicated to him. There was also founded a "Jerzy Neyman Lectureship in Mathematical Statistics". In 1979 Neyman became an overseas member of the Royal Statistical Society.

Neyman's American period produced several works of great importance for the development of asymptotic statistical methods, such as BAN estimators and $C(\alpha)$ tests. However the main topic of interest for Neyman in that period was the building and verification of probabilistic models for a number of natural phenomena. The first paper in that series was published in *Annals of Mathematical Statistics* in 1939 (pp. 35–57) with the title *On a new class of*

`contagious' distributions, applicable in entomology and bacteriology, and concerned the modelling and analysis of clusters. Subsequent work concerned matters of the formation of clusters with regard to modelling of the spread of epidemics and modelling of the distribution of galaxies in the universe. For more than twenty years Neyman worked on problems of weather modification. He was also interested, among other things, in carcinogenesis, the dynamics of population growth, and analysis of competing risks. Analysing his papers written in Poland and during the American period, we find that more than a half of Neyman's approximately 200 publications relate to matters of applications. More details concerning the entirety of Neyman's work can be found in reports by Klonecki and Zonn (1973), Le Cam and Lehmann (1974), Le Cam (1995) and Scott (2006).

J. Neyman died at Berkeley on 5 August 1981. He had remained active until the very end of his life. In June 1981 he had attended a conference on cancer, organized jointly with Le Cam. Even the day before his death he was working in hospital on a book on the subject of weather modification.

Finally we recall the view expressed by Elizbeth Scott (2006), who knew Neyman well – she wrote that Neyman always spoke of Poland with tenderness, and that he was proud of its heritage, although sometimes he could be critical of the actions of the Polish authorities.

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