Women in Statistical Science: An Historical Perspective

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1. Introduction

Just four women's names fall among well over 100 names (Johnson & Kotz, 1997) that will always be connected with the early history of statistical science: Florence Nightingale (1820–1910); Gertrude Cox (1900–1978); F.N. (Florence Nightingale) David (1909–1993) and Elizabeth (Betty) Scott (1917–1988). Career paths and opportunities were very different for these women compared with the men of the same generation. To qualitatively illustrate these differences, first we have matched the single woman covering the period up until the start of this century with her contemporary, Francis Galton (1822–1911), and this is the subject of Section 2. The other three women can be grouped, and 'matched' with their contemporaries and/or collaborators, and we have selected William (Bill) Gemmell Cochran (1909–1980), Jerzy Neyman (1894–1981) and Samuel (Sam) Stanley Wilks (1906–1964), as covering the next period including the post World War II expansion of universities along with the introduction of the discipline of Statistics, in its own right, into academic curricula. Evaluation of their opportunities and career paths is the subject of the third Section. Historical numbers of recognised women are too small for satisfactory comparisons to be made. So the final section summarises some relevant, related, research.

2. Nightingale - Galton

Florence Nightingale was educated at home, coming from a well-connected family whose expectations were that she would find a suitable husband and continue the same lifestyle as her parents. She had a calling. Increasingly today the image of the "Lady of the Lamp" is being replaced by the "Passionate" Statistician, and it is this latter contribution to humanity on which we concentrate here. Her vision was her recognition that collection of reliable data is essential to any worthwhile determination of policy. Nightingale was aware that mortality statistics should be age-specific as crude death rates could be misleading, and was aware of the need to allow for confounding effects in observational studies. She developed graphical methods to convey complex statistical information dramatically to a broad audience. However, her reports were often criticised as not being "dry" enough, as 'Statistics should be the driest of all reading'. Prejudice against women in Victorian England meant that others (men) always presented for her, or she submitted in writing. At age 38 Nightingale was elected to (what became) the Royal Statistical Society, becoming the first woman member. In 1874 her contributions to statistical science were recognised by her election as an Honorary Member of the American Statistical Association.

Francis Galton came from an intellectual family and after eschewing a career in medicine, his parents wishes, started a life of exploration. At the age of 38 he was elected a Fellow of the Royal Society for his geographical studies. From the age of 43 he became obsessed with genetics and the use of statistical methods for the study of all kinds of questions, from the relationship between heights of parents and their children, to constructing a "Beauty-Map" of the British Isles. Galton coined the statistical terms 'median', 'quartile' and 'correlation', as well as 'eugenics' for the

improvement of the human species by selected parenthood. He is the father of "statistical scales" which are widely used today despite the weak analogy that underlies their use. Galton founded the journal *Biometrika* and by his will founded the Galton Chair of National Eugenics, having, however, earlier thwarted Nightingale's plan to endow a Chair in Applied Statistics at Oxford University.

3. Cox, David, Scott - Neyman, Wilks, Cochran

Gertrude **Cox** grew up on a farm, and spent several years preparing to become a deaconess in the Methodist Episcopal Church, before at age 25 enrolling at Iowa State College. Graduation was followed by two years as a graduate assistant at Berkeley, returning to Iowa State to assist George Snedecor by heading the new statistical laboratory there. Her appointment to organise and head a Department of Experimental Statistics at North Carolina State College, is attributed to Snedecor's recommendation, after listing several men's names, including 'Of course if you would consider a woman for this position I would recommend Gertrude Cox of my staff.' So, in 1941, Cox became the first female full professor and first female department head at North Carolina State College.

F.N. **David** graduated from Bedford College for women and was offered a job as an actuary, but the offer was withdrawn when it was discovered that the "F.N. David" who had applied was a woman. So she became Karl Pearson's research assistant, later attending lectures by Fisher, but 'was not allowed to ask questions because she was a woman.' During WWII, David worked for the British Government, returning to University College London (UCL) where eventually she was named Professor in 1962, only the second at UCL. In 1967 she moved to the University of California (UC) at Riverside to establish a department of statistics, eventually retiring to UC Berkeley. She claimed 'two lessons [haunted her] all her life. First that women tend to be unfairly treated and second that if you persevere difficulties can be overcome.'

Betty **Scott** attended her local university, UC Berkeley, which then had no women professors except in physical education. Her interests lay initially in astronomy, but women were explicitly forbidden from using the telescopes at Mount Wilson; the sole role was that of assistant. She was urged not to get a Ph.D. for she would then be over-qualified in astronomy. So she became increasingly involved in work that resulted at age 32 in her Ph.D. and an assistant professor post in mathematics. Scott became a professor of statistics in 1962, and chair of the Statistics Department, UC Berkeley, 1968–73.

Jerzy **Neyman** was born into difficult times for his family, yet he was able to attend the University of Kharkov and study mathematics at undergraduate and graduate levels. At age 27, political circumstances brought him to the land of his forbears, Poland, and in 1923 he completed his doctoral thesis from the University of Warsaw on probabilistic problems in agricultural experimentation. In 1924 he obtained a postdoctoral position to study under Karl Pearson at UCL, where he met Egan Pearson, Gosset and Fisher. Back in Poland Neyman's statistical activities continued to be very broad, but more political crises were impinging. So in 1934 he accepted a position as Reader at UCL, resigning when war seemed imminent, and accepting an offer from UC Berkeley. He is well known for his many collaborations, including those with David and Scott.

Sam **Wilks'** family farmed a small Texan ranch, and he first attended North Texas Teachers' College, obtaining a B.A. in architecture in 1926. From there he was associated with the Mathematics department at the University of Texas (M.A., 1928), studying statistics 1929–1931 at the University of Iowa under Ritz. After obtaining his PhD, Wilks was at Columbia (with Hotelling) and then at UCL (with E. Pearson) and later Cambridge University (with Wishart). In 1933 he assumed a post at Princeton University, and then, after time devoted to the war effort, was promoted to professor of mathematics at Princeton in 1944.

Bill **Cochran** was placed first in the University of Glasgow Bursary Competition, and after completing his first degree won a scholarship to study mathematics at Cambridge (with Wishart). In 1934, Yates succeeded Fisher as Head at Rothamsted. Cochran was offered a vacant post there but had not finished his doctoral course. Yates later wrote '… it was a measure of good sense that he accepted my argument that a Ph.D., even from Cambridge, was little evidence of research ability,

and that Cambridge had at that time little to teach him in statistics that could not be much better learnt from practical work in a research institute.' Following five years there, Cochran accepted a post at Iowa Statistical Laboratory where he collaborated with Cox. Then in 1946 he was encouraged by Cox to join her newly-created Institute in North Carolina to develop the graduate program there, but this left him little time for research, so he moved first to Johns Hopkins University, then to Harvard University.

All six achieved notoriety and success through their achievements, not only in their chosen research areas (details of which will be presented) but also as founders of Societies and major academic journals. All six received many honours, but the men received both more (on average) and generally at a relatively younger age than the women. For example, all were elected Members of the ISI; in fact Cox was the first female elected, in 1949. Cochran was ISI Vice President from 1963–67, then ISI President from 1967–71, and Neyman was elected an Honorary Member in 1966, and Honorary President in 1972. In contrast, Cox was ISI Treasurer from 1955–61 and Scott was Vice President from 1981–83.

4. Relevant Related Research

Were we to repeat the above exercise by producing a second (or a third, or …) set of four men and women from our history, we very quickly run out of women to match the comparatively endless list of men. There have been women who graced the pages of our journals a century ago, (e.g., Mary Roberts Smith, Lucy Salmon, and Amy Hewes), but they are not household names. The obvious question is Why? Certainly, women are essentially the equal of men in terms of their mathematical abilities, as contemporary research has shown (with apparent differences accounted for by differential course-taking and related opportunities). Also, at least in the U.S., women have earned a substantial share of the bachelor's degrees with a major in the mathematical sciences; from available data, one-third of such degrees in 1966 went to women, rising to 46% by 1985 where it has hovered to the present. It is in the transition to graduate degree education, and from graduate degrees to the workplace and thence advancement up that ladder where women have not made the progress expected. To illustrate, we focus briefly on some U.S. data. For some countries, this lack of progress starts at earlier levels of education. Where overlapping data exist across countries, comparable conclusions prevail.

The percentage of doctorates to women has steadily climbed from 5% and 5.7% in the 1950s and 1960s, passing the pre-World War II levels of 14.8% in the late 1970s, and continuing to 16% in the 1980s and 21% during 1990-97. In 1990 and 1997, 17.7% and 23.4%, respectively went to women; for the statistical sciences these figures are 24.5% for 1990-97, and 19.7% and 25.3% for 1990 and 1997. Except for the 1990s, these increases in percentages of women are primarily due to decreases in the numbers of men. The 1990s have witnessed real increases in numbers of both men and women, though the number of men in 1997 is still only 82% of the number in 1975.

A related question governs entry into doctoral programs. In the 1970s, the number of men earning doctoral degrees in the mathematical sciences was roughly 6% of the number earning bachelor's degrees five years earlier; for women, this was 1.1%. By the 1990s, the corresponding figures were roughly 11.5% for men and 3.8% for women, i.e., the proportion of men going on to the doctorate had doubled and for women, there was a 3.5-fold increase. Put another way, the proportion of men proceeding to the Ph.D. degree was almost six times that of women in the 1970s, and three times in the 1990s. Therefore, while the data still show there is a considerable dropoff of interest among women mathematics majors in continuing, these data do suggest that marginally fewer women are deterred, with more, both proportionally and in absolute numbers, successfully completing their doctorates.

Discouraging as these graduate statistics might be, the more difficult hurdles lay in the workplace itself. The most substantial study is the Ahern and Scott (1981) matched triad study covering employment and promotion in the 1930s - 1970s; other data covering earlier decades and the 1980s support their conclusions. Specifically, compared to men, women were employed at

much lower rates and failed to move up the promotion and tenure ladder. Further, the women's positions were primarily at the lower rated institutions. The few women who "survived" in some manner were exceptionally outstanding. Indeed, research has verified that as quality and productivity level increase, the gap between that quality and reputation for women widens. Men in general experience no such gap; see, e.g., Persell, 1983.

There has been a shift in the past ten years however. In 1987, for mathematical and computer sciences combined, 40.2% of faculty were male Full Professors, 23.4% were male Associate Professors, 16.8% were male Assistant Professors which along with "other faculty" gave 90.7% of the faculty being men; the corresponding figures for females were 2.2%, 2.7% and 3.3%, respectively, giving 9.8% of the faculty being women. By 1997, the figures were for men 37.4%, 25.0% and 16.7% for each rank, and for women 2.7%, 4.2%, 5.3% for each rank, with 85.8% and 14.2%, respectively, of the total faculty being men and women. The increase in the total number of women hired over this ten year span is largely accounted for by the overall increase in numbers and the decrease in male Full Professors (due presumably to retirements). However, men are still being hired, as is evident by their increase in numbers at all other ranks. Furthermore, of the Assistant Professors, in 1987, 84% were men and 16% were women, while in 1997, 76% were men and 24% were women. Note that these proportions approximately match the relative proportions of doctoral awards for this period. However, these figures do not take into account years spent in a given rank; and there still remains evidence that women spend a longer time in each rank before promotion. Thus, in contrast, 5.2% of the Full Professors in 1987 were women, and only 6.7% in 1997. While these data might bring some comfort, it is important to realize that although they reflect the trends observed over all disciplines and over all types of institutions, the percentage of women is 2-3 times higher outside of mathematics than within mathematics. Data also show that women fare better in lower-ranked disciplines with increasing representation as the status of the institution falls (e.g., in 1998, in U.S. mathematics departments categories I, IIA, IIB, III, and IV, women constituted 28.3%, 36.4%, 38.1%, 46.7% and 47.2%, respectively, of the faculty; this was 33.8% overall, surpassing the pre-World War II figure of 29%).

Therefore, more progress is needed but the trends do seem to be headed in the right direction, at least as far as initial hiring is concerned and to a lesser extent as far as promotion and tenure are concerned. Unfortunately, the gap in salaries has remained essentially unchanged with if anything slightly larger discrepancies than in the past. Billard (1994) gives more more historical data, including reviews of studies attempting to explain the reasons behind the lack of progress for women this century.

REFERENCES

Ahern, N. F. and Scott, E. L. (1981). Career Outcomes in a Matched Sample of Men and Women Ph.D.s: An Analytical Report. National Academy Press, Washington.

Billard, L. (1994). Twenty years later: Is There Parity for Academic Women? NEA Higher Education Journal 10, 115-144.

Johnson, N. L. and Kotz, S. (eds) (1997). Leading Personalities in Statistical Sciences. Wiley, NY.

Persell, C. H. (1983). Gender, Rewards and Research in Education. Psychology of Women Quarterly 8, 33-46.

FRENCH RÉSUMÉ

Seules quatre femmes apparaissent parmi les 100 noms qui ont marqué l'histoire de la statistique. Dans cette présentation, nous comparons les carrières et les opportunités de ces femmes avec celles de leurs contemporains masculins, et nous résumons d'autres recherches sur ce sujet.