From Eugenics to Scientometrics:
Galton, Cattell and Men of Science

Benoît Godin

3465 Durocher Street
Montreal, Quebec
Canada H2X 2C6
benoit.godin@ucs.inrs.ca

Project on the History and Sociology of S&T Statistics
Working Paper No. 32

2006

Previous Papers in the Series:

1 B. Godin, Outlines for a History of Science Measurement.
2 B. Godin, The Measure of Science and the Construction of a Statistical Territory: The Case of the National Capital Region (NCR).
3 B. Godin, Measuring Science: Is There Basic Research Without Statistics?
4 B. Godin, Neglected Scientific Activities: The (Non) Measurement of Related Scientific Activities.
5 H. Stead, The Development of S&T Statistics in Canada: An Informal Account.
6 B. Godin, The Disappearance of Statistics on Basic Research in Canada: A Note.
7 B. Godin, Defining R&D: Is Research Always Systematic?
8 B. Godin, The Emergence of Science and Technology Indicators: Why Did Governments Supplement Statistics With Indicators?
9 B. Godin, The Number Makers: A Short History of Official Science and Technology Statistics.
10 B. Godin, Metadata: How Footnotes Make for Doubtful Numbers.
11 B. Godin, Innovation and Tradition: The Historical Contingency of R&D Statistical Classifications.
12 B. Godin, Taking Demand Seriously: OECD and the Role of Users in Science and Technology Statistics.
13 B. Godin, What's So Difficult About International Statistics? UNESCO and the Measurement of Scientific and Technological Activities.
14 B. Godin, Measuring Output: When Economics Drives Science and Technology Measurements.
15 B. Godin, Highly Qualified Personnel: Should We Really Believe in Shortages?
16 B. Godin, The Rise of Innovation Surveys: Measuring a Fuzzy Concept.
17 K. Smith, Measurement of Innovation in Europe: Concepts, Experience and Results.
18 B. Godin, A Note on the Survey as Instrument for Measuring S&T.
19 B. Godin, Rhetorical Numbers: How the OECD Constructs Discourses on Science and Technology.
20 B. Godin, Are Statistics Really Useful? Myths and Politics of Science and Technology Indicators.
21 B. Godin, The New Economy: What the Concept Owes to the OECD.
22 B. Godin, The Most Cherished Indicator: Gross Domestic Expenditures on R&D (GERD).
23 B. Godin, Technological Gaps: Quantitative Evidence and Qualitative Arguments.
24 B. Godin, The Knowledge-Based Economy: Conceptual Framework or Buzzword?
25 B. Godin, The Obsession for Competitiveness and its Impact on Statistics: The Construction of High Technology Indicators.
26 B. Godin, Globalizing Indicators: How Statisticians Responded to the Political Agenda on Globalization.
27 B. Godin, The Who, What, Why and How of S&T Measurement.
28 B. Godin, Research and Development: How the "D" got into R&D.
29 B. Godin, Technological Progressiveness as a Precursor to the Concept of High-Technology.
30 B. Godin, The Linear Model of Innovation: the Historical Construction of an Analytical Framework.
31 B. Godin, Science, Accounting and Statistics: the Input-Output Framework.

Canadian Science and Innovation Indicators Consortium (CSIIC)
3465 Durocher Street, Montreal, Quebec H2X 2C6
Telephone: (514) 499-4074 Facsimile: (514) 499-4065
www.csiic.ca

Abstract

In 1906, James McKeen Cattell, editor of *Science*, published a directory on men of science. *American Men of Science* was a collection of biographical sketches of thousands of men of science in the United States and was published periodically. It launched and was used in the very first systematic quantitative studies on science. Cattell used two concepts for his statistics: productivity, defined as the number of men of science a nation produces, and performance or merit, defined as scientific contributions to research as judged by peers. These are the two dimensions that still define the measurement of science today: quantity and quality.

This paper analyzes the emergence of statistics on science and the very first uses to which they were put. It argues that the measurement of science emerged out of interest in great men, heredity and eugenics, and the contribution of eminent men to civilization. Among these eminent men were men of science, the population of whom was thought to be in decline and insufficiently appreciated and supported. Statistics on men of science thus came to be collected to document the case, and to contribute to the advancement of science and of the scientific profession.

From Eugenics to Scientometrics: Galton, Cattell and Men of Science

Introduction

Measuring science has become an "industry". Governments and their statistical offices have conducted regular surveys of resources devoted to research and development (R&D) since the 1950s. The methodology used is that suggested and conventionalized by the OECD Frascati manual, adopted by member countries in 1962, and now in its sixth edition. [1] Since the 1990s, national governments have also conducted regular surveys on innovation, again based on an OECD methodology known as the Oslo manual. [2] More recently, scoreboards of indicators have appeared that collect multiple indicators on science, technology and innovation. [3]

Academics are regular users of the statistics collected by official organizations, among them economists who, over the last five decades, have produced a voluminous literature on measuring the contribution of science to economic growth and productivity. [4] Academics are also producers of their own statistics. Using scientific paper counts as a tool, sociologists and others have studied the "productivity" of scientists since the early 1900s. [5] Today, a whole community of researchers concerned with counting papers and citations called themselves bibliometricians.

When, how and why did science come to be measured in the first place? This paper documents the emergence of statistics on science and the very first uses to which they

---

[1] OECD (1962), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development*, Paris.

[2] OECD/Eurostat (1997), *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data* (Oslo Manual), Paris.

[3] The OECD has published a biennial publication entitled *Science, Technology and Industry Scoreboard* since 1995 and the European Commission has published an *Innovation Scoreboard* since 2001.

[4] Z. Griliches (1998), *R&D and Productivity: The Econometric Evidence*, Chicago: University of Chicago Press.

were put. We owe the first systematic efforts to James McKeen Cattell (1860-1944), owner and editor of *Science* for fifty years, and his directory *American Men of Science*. [6] The directory, published periodically beginning in 1906, collected biographical sketches of thousands of men (and women) [7] of science in the United States. It launched, and was used in, the very first systematic series of quantitative studies on science. We must go further back in history, however, to properly document the emergence of statistics on science. Cattell's efforts were preceded by sporadic but influential measurement exercises conducted in the nineteenth century, among others by the British scientist Francis Galton (1822-1911). In the literature, Galton is discussed mainly for two outputs. [8] The first was his studies on heredity and eugenics. The second was his statistical innovations like correlation and regression. This paper adds a neglected but influential contribution by Galton: the measurement of science. Galton took men of science as the object of study in at least three of his publications, the most important one being *English Men of Science* published in 1874. This book has rarely been studied [9] – as rarely, in fact, as statistics on science has been in the literature on the history and sociology of statistics. [10] In the book, Galton conducted a sociological study of British science based on a survey

---

[5] B. Godin (2006), On the Origins of Bibliometrics, *Scientometrics*, forthcoming.

[6] By systematic I mean the regular use, for analytical purposes and over a continuous period of time, of statistics on science.

[7] In this paper, I use the expression "men of science" for both men and women, as it was used to describe all scientists in the 19th Century.

[8] K. Pearson (1914-1930), *The Life, Letters, and Labours of Francis Galton*, Cambridge: Cambridge University Press, 4 volumes; R. Schwartz Cowan (1972), Francis Galton's Statistical Ideas: The Influence of Eugenics, *ISIS*, 63, pp. 509-528; R. Schwartz Cowan (1977), Nature and Nurture: The Interplay of Biology and Politics in the Work of Francis Galton, in W. Coleman and C. Limoges (eds.), *Studies in the History of Biology*, Baltimore: Johns Hopkins University Press, pp. 133-207; V. L. Hilts (1973), Statistics and Social Science, in R. N. Giere and R. S. Westfall (eds.), *Foundations of Scientific Method: the 19th Century*, Bloomington: Indiana University Press, pp. 206-233; D. A. Mackenzie (1981), *Statistics in Britain, 1865-1930*, Edinburgh: Edinburgh University Press, chapter 3; D. J. Kevles (1985), *In the Name of Eugenics*, Cambridge: Harvard University Press, chapter 1; T. M. Porter (1986), *The Rise of Statistical Thinking, 1820-1900*, Princeton: Princeton University Press, pp. 128-146; M. Bulmer (2003), *Francis Galton: Pioneer of Heredity and Biometrics*, Baltimore: Johns Hopkins University Press.

[9] One exception is: V. L. Hilts (1975), A Guide to Francis Galton's English Men of Science, *Transactions of the American Philosophical Society*, 65 (5), pp. 3-85.

[10] Cattell's contributions to statistics on science, as with Galton's, have rarely been documented. Certainly, *American Men of Science* is generally mentioned in biographies on Cattell, but the directory and the statistical studies that came out of it are poorly studied. For exceptions, see: D. S. Webster (1985), James McKeen Cattell and the Invention of Academic Quality Rankings, 1903-1910, *Review of Higher Education*, 8, pp. 107-121; M. M. Sokal (1995), Stargazing: James McKeen Cattell, American Men of Science, and the Reward Structure of the American Scientific Community, 1906-1944, in F. Kessel (ed.), *Psychology, Science, and Human Affairs: Essays in Honor of William Bevan*, Boulder: Westview Press, pp. 64-86.

of 180 eminent men of science. It was after studying Galton's works that Cattell launched his directory.

The thesis of this paper is that the measurement of science emerged out of interest in great men, heredity and eugenics, and the contribution of eminent men to civilization. Among these eminent men were men of science, the population of whom was thought to be in decline and insufficiently appreciated and supported. Statistics thus came to be collected to document the case, and to contribute to the advancement of science – and of the scientific profession. The statistics conceived were concerned with measuring the size of the scientific community, or men of science, and its conditions.

Several authors have documented the efforts of scientists toward the institutionalization of science in the nineteenth and early twentieth centuries. In looking at organizations specifically dedicated to the advancement of science, for example, they have analyzed the different strategies and resources used by scientists and the forms that institutionalization took. [11] This paper is devoted to analyzing a poorly-studied resource, namely the collection of statistics. The period covered is from 1865, the year Galton published his first statistics on men of science, to *circa* 1944, the year of Cattell's death. The first part of the paper discusses where Cattell's idea of measuring men of science comes from. It looks at Galton's studies on eminent men, particularly Galton's writing on men of science, from the point of view of statistics on science. It documents the main elements of this work, which would later influence Cattell's studies and statistics. The second part turns to Cattell as an advocate for science with statistics as his tool, and how he adapted Galton's ideas on great men, heredity and eugenics to support the cause of the advancement of science. It focuses on Cattell's use of two concepts, one that measured quantity (productivity), and the other quality (performance). The third part analyzes how the intellectual and socioeconomic context, as well as Cattell's personal background,

[11] S. G. Kohlstedt (1976), *The Formation of the American Scientific Community: The American Association for the Advancement of Science, 1848-1860*, Urbana: University of Illinois Press; S. G. Kohlstedt, M. M. Sokal and B. V. Lewenstein (1999), *The Establishment of Science in America: 150 Years of the American Association for the Advancement of Science*, London: Rutgers University Press; R. MacLeod and P. Collins (1981), *The Parliament of Science: The British Association for the Advancement of Science, 1831-1981*,

contributed to the emergence of statistics on science, and the impact of these two factors on the specifics of the statistics produced.

English Men of Science

Galton's measurements of science were based on his belief that the progress of civilization rests on great men, whose numbers were in decline. This idea was much in vogue in nineteenth-century England, when Francis Galton got interested in heredity. [12] Echoing these views, Galton suggested in 1869: "the qualities needed in civilized society are, speaking generally, such as will enable a race to supply a large contingent to the various groups of eminent men". [13] To Galton, however, there were only 233 eminent British men for every one million population, while "if we could raise the average standard of our race one grade" there would be 2,423 of them. [14] Similarly, for higher degrees of "intelligence": "All England contains only six men between the age of thirty and eighty, whose natural gifts exceed class G; but in a country of the same population as ours, whose average was one grade higher, there would be eighty-two of such men; and in another whose average was two grades higher no less than 1,355 of them would be found". [15] Briefly stated, fertility, or what Galton called the productiveness of eminent families, was, in his opinion, too low.

When Galton started working on differences in intellectual ability and the role of heredity in the 1860s, he needed, first and foremost, a precise definition and a measure of "intelligence". This was a task every statistician before him had declined, including

---

Northwood: Science Reviews Ltd; H. Gispert (2002), *Par la science, pour la patrie: l'Association française pour l'avancement des sciences, 1972-1914*, Rennes: Presses universitaires de Rennes.

[12] On demography and degeneration, see: J. C. Waller (2001), Ideas of Heredity, Reproduction and Eugenics in Britain, 1800-1875, *Studies in the History of Biological and Biomedical Sciences*, 32 (3), pp. 457-489; R. A. Soloway (1990), *Demography and Degeneration: Eugenics and the Declining Birthrate in Twentieth-Century Britain*, Chapel-Hill: University of North Carolina Press; D. Pick (1989), *Faces of Degeneration: A European Disorder, c.1848-c.1918*, Cambridge: Cambridge University Press.

[13] F. Galton (1869), *Hereditary Genius: an Inquiry into Its Laws and Consequences*, Honolulu, University Press of the Pacific, 2001, p. 393.

[14] *Ibid*, p. 398.

[15] *Ibid*, p. 399.

Quetelet. [16] To this end, Galton elected to pursue the notion of genius. *Hereditary Genius*, published in 1869, had in fact two purposes, measuring intellectual ability in a population, and documenting the role of heredity in the transmission of intellectual ability, most of the existing literature having looked mainly at the second goal. For this paper, the first purpose is as important as the second.

Words Used for Men of Intelligence and Reputation in Nineteenth and early Twentieth Century Literature

Genius	Great
Eminent	Successful
Famous	Noteworthy
Illustrious	Superior
Noted	Distinguished
Celebrated	Prominent
Gifted	Notable

Hereditary Genius first developed a measurement of the distribution of intellectual ability within the British population as a whole. Galton began by estimating, based on evidence he did not provide, that there had been no more than about 400 geniuses in world history. But how many eminent men are living now? To answer the question, Galton constructed a scale of ability based on the assumption that intellectual ability is distributed according to the law of error (or normal distribution). The top of the scale had three grades: extraordinary genius (world history), highly eminent (living), and illustrious (living). To estimate the number in each of the classes, Galton looked at the 2,500 names mentioned in the British biographical handbook *Men of the Time*, published in 1865. He confined his analysis to those men who were over 50 years of age (850) because a "man must outlive

[16] V. L. Hilts (1973), Statistics and Social Science, *op. cit*.

the age of fifty to be sure of being widely appreciated". [17] This definition allowed him to exclude notoriety for a single act, and to focus on men who maintain their position over time. He estimated that 500 of them were decidedly well-known to persons familiar with literary and scientific society, saying of his typical study subject "he has distinguished himself pretty frequently either by purely original work, or as a leader of opinion". [18] Galton then divided his estimates by the British population over 50 years old (2 million), and arrived at the following distribution of ability, which followed Quetelet's law of error: "the deviations from the average – upward towards genius, and downward towards stupidity – (…) follow the law that governs deviations from all true averages": [19]

Genius	400
Illustrious	1 in one million population
Eminent	250 in one million population

It is clear from the above method that Galton's definition and measure of genius was based on reputation, rather than ability *per se*. To Galton, genius expressed "an ability that was exceptionally high and, at the same time, inborn", [20] a natural ability "as a modern European possesses in a much greater average share than men of the lower races", [21] like men of the pen and artists. [22] To Galton "high reputation [was] a pretty accurate test of high ability". [23] "By reputation, I mean the opinion of contemporaries, revised by posterity – the favorable result of a critical analysis of each man's character, by many biographers". And "by natural ability, I mean those qualities of intellect and

[17] F. Galton (1869), Hereditary Genius, *op. cit*., p. 51.
[18] *Ibidem*.
[19] *Ibid*, p. 72.
[20] F. Galton (1869), Hereditary Genius, *op. cit*., p. 26.
[21] *Ibid*, p. 27.
[22] *Ibid*, p. 78. Galton's definitions of genius were many in his works: "What is usually meant by genius, when the word is used in a special sense, is the automatic activity of the mind, as distinguished from the effort of the will" (F. Galton (1874), *English Men of Science: Their Nature and Nurture*, London: Macmillan, p. 23). "Genius has lost its old and usual meaning, which is preserved in the term of an ingenious artisan, and has come to be applied to something akin to inspiration" (F. Galton and E. Schuster (1906), *Noteworthy Families (Modern Science): An Index to Kinships in Near Degrees between Persons Whose Achievements Are Honourable, and Have Been Publicly Recorded*, London: John Murray, p. xvii).
[23] F. Galton (1869), Hereditary Genius, *op. cit*., p. 46.

disposition, which urge and qualify a man to perform acts that lead to reputation". [24] Ability and reputation were to Galton the same thing; the latter was an indicator of the former: "Few have won high reputations without possessing these peculiar gifts. It follows that men who achieve eminence, and those who are naturally capable, are, to a large extent, identical". [25]

Having defined genius, Galton turned to the transmission of heredity, his second and main task. To this end, he looked at family histories of judges, statesmen, commanders, literary men, men of science, poets, musicians, painters, and divines. He chose 300 families containing nearly 1,000 eminent men (977), of whom 415 were illustrious. The source of his data was biographical dictionaries: "the lists were drawn without any bias of my own, for I always relied mainly upon the judgments of others, exercised without any knowledge of the object of the present inquiry, such as the selections made by historians or critics". [26]

From the analysis of the data, Galton derived his law of heredity or distribution of ability among kinsmen, according to which "the nephew of an eminent man has far less chance of becoming eminent than a son, and that a more remote kinsman has far less chance than a nephew". [27] Galton calculated that the chances of kinsmen of illustrious men rising or having risen to eminence is, on average, 1 out of 6. Regarding men of science specifically, he found that one-half have one or more eminent relations: "to every 10 illustrious men, who have any eminent relations at all, we find 3 or 4 eminent fathers, 4 or 5 eminent brothers, and 5 or 6 eminent sons". [28] Men of science were thus exceptionally productive of eminent sons, and this Galton attributed to family environment (as opposed to heredity for other professional groups).

---

[24] *Ibid*, p. 77.
[25] *Ibid*, p. 78.
[26] *Ibid*, p. 30. One gets little information on the sources in *Hereditary Genius*. The paper Galton published four years earlier should be consulted to this end: F. Galton (1865), Hereditary Character and Talent, *Macmillan's Magazine*, 12.
[27] F. Galton (1869), Hereditary Genius, *op. cit.*, p. 81. See also, pp. 274 and 381. The law was first expressed in 1865 as follows: "The father transmits, on an average, one half of his nature, the grandfather, one fourth, the great-grandfather, one eight, the share decreasing step by step in a geometrical ratio, with great rapidity".
[28] F. Galton (1869), Hereditary Genius, *op. cit*., p. 378.

Five years after *Hereditary Genius*, Galton turned entirely to this specific group of illustrious men – men of science – and claimed that "the evidence here collected (…) strengthens the utmost claims I ever made for the recognition of the importance of hereditary influence". [29] In *English Men of Science*, Galton defined men of science as being fellows of the Royal Society or having qualifications, such as having earned a medal, having presided over a learned Society or a section of the British Association, having been elected to the council of the Royal Society, or being a professor at some important college or university. Based on these criteria, Galton drew up a list of 180 men – out of 300 existing British men of science, as he estimated, or 1 in 10,000 of the population – a list "nearly exhaustive in respect to those men of mature age who live in or near London".

Whereas *Hereditary Genius* was based on a statistical study of biographical dictionaries, in *English Men of Science* Galton chose as his source of information the survey, that is, "autobiographical replies to a very long series of printed questions addressed severally to the 180 men". One hundred were selected for statistical treatment. Galton gathered information on four aspects of the group: antecedents, qualities, motives and education. Two results deserve mention here. First, the answers of respondents on the origins of their taste for science (motives) served as an indicator of heredity. The analysis showed that 59 of the men of science said that their taste for science was innate (Table 1): "6 out of every 10 men of science were gifted by nature with a strong taste for it", observed Galton; "certainly not 1 person in 10, taken at haphazard, possesses such an instinct; therefore I contend that its presence adds five-fold at least, to the chance of scientific success". [30] "A strong and innate taste for science is a prevailing characteristic among scientific men", [31] concluded Galton, based on faith in (and the memories of) his

[29] F. Galton (1874), English Men of Science, *op. cit*., p. vii.
[30] *Ibid*, p. 195.
[31] *Ibid*, p. 192.

respondents, and ignoring the fact that one-third cited having been encouraged at home (environment), mainly by their fathers. [32]

Table 1.

Origin of the Taste for Science

(Number of respondents)

Innate taste	59
Fortunate accident	11
Indirect opportunities and indirect motives	19
Professional influences to exertion	24
Encouragement at home of scientific inclinations	34
Influence and encouragement of private friends and acquaintances	20
Influence and encouragement of teachers	13
Travel in distant regions	8
Residual influences, unclassified	3

Source: F. Galton, *English Men of Science*, p. 149.

Second, the analysis of antecedents revealed that men of science had less children than their parents: their living children between ages 5 and 50 was on average 4.7, as opposed to 6.3 for the families these men of science came from. To Galton, the numbers revealed a clear "tendency to an extinction of the families of men who work hard with the brain", [33] "a danger to the continuance of the race". [34]

[32] The analysis Galton made of educational profiles also contradicted his thesis on heredity: "My returns show me that men of science are not made by much teaching, but rather by awakening their interests, encouraging their pursuits when at home, and leaving them to teach themselves continuously throughout life" (p. 257). Briefly stated, science was not wholly hereditary, contrary to Galton's claims.
[33] F. Galton (1874), English Men of Science, *op. cit*., p. 37.
[34] *Ibid*, p. 38.

Galton concentrated on men of science again in 1906 for the third and the last time in his life. *Noteworthy Families* was "to serve as an index to the achievements of those families which [have] been exceptionally productive of noteworthy persons". [35] Since "the fellowship of the Royal Society is a distinction highly appreciated by all members of the scientific world", Galton sent a questionnaire to all living fellows of the Royal Society in the spring of 1904. He also drew names from biographical dictionaries (among them *Who's Who*, *British Dictionary of National Biography*, *Encyclopedia Britannica*). In total, he sent 467 questionnaires and received 207 replies. He retained 100 completed returns for statistical purposes, corresponding to 66 families. Galton found, again, that "a considerable proportion of the noteworthy members in a population spring from comparatively few families". [36] He estimated this proportion of noteworthy persons to the whole population as 1 to 100. The main result of his study, however, was a lessening of the population of noteworthy men. Galton observed 207 noteworthy members in the families, as opposed to a statistical expectation of 337.

Galton's works on men of science have been very influential. *English Men of Science* was the first quantitative "natural history" or "sociology" of science, as he himself called it – published at the same time as one by Alphonse de Candolle, discussed below. *English Men of Science* relied on a dedicated survey among a specific group of men, while most studies of eminent men were based on biographical dictionaries, as *Hereditary Genius* had been, or on institutional data, like membership in scientific societies. [37] Certainly, in the mid-1850s, censuses began collecting information on professions, among them teachers and professors, and could have been used for measuring science. But the category "men of science" (or scientists) did not exist in the classifications used. Galton

---

[35] F. Galton and E. Schuster (1906), Noteworthy Families, *op. cit*., p. ix.
[36] *Ibidem*.
[37] L. Levi (1869), On the Progress of Learned Societies, Illustrative of the Advancement of Science in the United Kingdom during the Last Thirty Years, in *Report of the 38th Meeting of the British Association for the Advancement of Science* (1868), London: John Murray, pp. 169-173; L. Levi (1869), A Scientific Census, *Nature*, November 25, pp. 99-100; L. Levi (1879), The Scientific Societies in Relation to the Advancement of Science in the United Kingdom, in British Association for the Advancement of Science, *Report of the 49th Meeting*, London: J. Murray, pp. 458-468; A. de Candolle (1873), *Histoire des sciences et des savants depuis deux siècles, d'après l'opinion des principales académies ou sociétés scientifiques*, Paris: Fayard, 1987; E. C. Pickering (1908), Foreign Associates of National Societies, *Popular Science*

must be credited with having offered the first quantitative estimates regarding the number of men of science in a population.

Galton's work on heredity was driven by his social rank (an intellectual conservative Victorian), a fact well documented today, [38] and a political program, the improvement of the race by selection of men, spurred by what he measured as the decline in the number of eminent men, and he suggested that there were consequently policy lessons to be learned from his data. "Much more care is taken to select appropriate varieties of plants and animals for plantation in foreign settlements, than to select appropriate types of men", claimed Galton in *Hereditary Genius*. [39] "A man's natural abilities are derived by inheritance, under exactly the same limitations as are the form and physical features of the whole organic world (…). It would be quite practicable to produce a highly-gifted race of men by judicious marriages during several consecutive generations (…). [But] social agencies of an ordinary character, whose influences are little suspected, are at this moment working towards the degeneration of human nature". [40] "If we could raise the average standard of our race only one grade", suggested Galton, "what vast changes would be produced! The number of men of natural gifts equal to those of eminent men of the present day, would be necessarily increased more than tenfold". [41]

Applied to men of science, Galton's utopia took the following form. "Science has hitherto been at a disadvantage, compared with other competing pursuits, in enlisting the attention of the best intellects of the nation, for reasons that are partly inherent and partly artificial", he wrote in *English Men of Science*. [42] There is a "tendency to abandon the colder attractions of science for those of political and social life (…). Those who select some branch of science as a profession, must do so in spite of the fact that it is less

Monthly, October, pp. 372-379; E. C. Pickering (1909), Foreign Associates of National Societies II, *Popular Science Monthly*, January, pp. 80-83.

[38] R. Schwartz Cowan (1977), Nature and Nurture: The Interplay of Biology and Politics in the Work of Francis Galton, *op. cit*.; D. A. Mackenzie (1981), Statistics in Britain, 1865-1930, *op. cit*.; J. C. Waller (2001), Gentlemanly Men of Science: Sir Francis Galton and the Professionalization of the British Life-Sciences, *Journal of the History of Biology*, 34, pp. 83-114.

[39] F. Galton (1869), Hereditary Genius, *op. cit*., pp. 40-41.

[40] *Ibid*, p. 45.

[41] *Ibid*, p. 398.

[42] F. Galton (1874), English Men of Science, *op. cit*., p. 258.

remunerative than any other pursuit". [43] To Galton, "the possession of a strong special taste [for science] is a precious capital, and that it is a wicked waste of national power to thwart it ruthlessly by a false system of education". [44] Such tastes "are as much articles of national wealth as coal and iron". [45]

To sum up, Galton's work on men of science was characterized by four elements. First was his choice of this group of men because they were part of a larger group of eminent men. Second was his interest in the perpetuation of the stock of men of science, or productivity. Third was the measurement of these men's abilities, a measurement soon to be called performance. The final element was a thesis on heredity, as opposed to environment, that he had difficulty proving beyond doubt. As a psychologist and man of science himself, James McKeen Cattell would continue and improve on Galton's program of measuring eminent men. He would initiate the first systematic collection of data on men of science. He would conduct regular analyses of the data, with special emphasis on the socioeconomic conditions of men of science. And he would draw policy lessons from his statistics, as Galton did.

American Men of Science

James McKeen Cattell was born on May 25, 1860. [46] After his graduation from Lafayette College in 1880, he went to Europe to study philosophy. He remained there for seven years, a large part of the time in the laboratory of Wilhelm Wundt in Leipzig, where he

---

[43] *Ibid*, pp. 258-259.
[44] *Ibid*, p. 196.
[45] *Ibid*, p. 223.
[46] For biographical information on Cattell, see: R. S. Woodworth (1914), The Psychological Researches of James McKeen Cattell: A Review by Some of His Pupils, *Archives of Psychology*, 30, April; *Science* (1944), James McKeen Cattell: In Memoriam, 99 (2565), February 25, pp. 151-165; A. T. Poffenberger (ed.) (1947), *James McKeen Cattell, 1860-1944: Man of Science*, 2 volumes, Lancaster: Science Press; M. M. Sokal (1971), The Unpublished Autobiography of James McKeen Cattell, *American Psychologist*, 26, pp. 626-635; M. M. Sokal (1980), Science and James McKeen Cattell, *Science*, 20 (4452), July 4, pp. 43-52; M. M. Sokal (1981), *An Education in Psychology: James McKeen Cattell's Journal and Letters from Germany and England, 1880-1888*, Cambridge (Mass.): MIT Press; M. M. Sokal (1982), James McKeen Cattell and the Failure of Anthropometric Mental Testing, 1890-1901, in W. R. Woodward and M. G. Ash (eds.), *The Problematic Science: Psychology in Nineteenth-Century Thought*, New York: Praeger; M. M. Sokal (1987), James McKeen Cattell and the Mental Anthropometry: Nineteenth-Century Science

became the first American to earn a PhD in experimental psychology in 1886. He then moved to Cambridge, England, lectured at St. Johns College and established the first English laboratory in experimental psychology. It was there that he met with F. Galton and began studying individual differences and mental testing, two terms he coined. [47] In 1889 he became professor at the University of Pennsylvania, and in 1891 he moved to Columbia University, where he organized a department of psychology, one of the best in the country, where he worked until 1917. He was dismissed because of his regular quarrels with the president of the university on the participation of faculty members in university affairs, a decision catalyzed by a public letter against the war he sent to members of Congress.

In 1895, Cattell acquired the weekly journal *Science*, established in 1883 by Alexander Graham Bell and Gardiner G. Hubbard (and made the official journal of the American Association for the Advancement of Science, or AAAS, in 1900), which rapidly ran into financial difficulties. As Cattell himself recalled: "*Science* when liberally subsidized by Mr. Bell and Mr. Hubbard was conducted at an annual loss of $20,000". [48] It is still not totally clear today why Cattell wanted to own the journal, but one thing is sure: Cattell re-established *Science* as a viable journal within a few years, with an editorial committee, and edited the journal from 1895 to 1944.

A few years after having acquired the journal, Cattell's research on mental testing became fruitless. Cattell had initiated a large-scale program testing Columbia students every year, similar to Galton's experiment in museums and public expositions. In the end, however, it appeared that he was measuring psychological behaviour (like alertness)

---

and Reform and the Origins of Psychological Testing, in M. M. Sokal (ed.), *Psychological Testing and American Society, 1890-1930*, Rutgers University Press.

[47] J. M. Cattell (1890), Mental Tests and Measurements, *Mind*, 15 (59), pp. 373-381; J. M. Cattell and L. Farrand (1896), Physical and Mental Measurements of the Students of Columbia University, *Psychological Review*, 3, pp. 618-648.

[48] J. McKeen Cattell (1902), The Carnegie Institution, *Science*, 16 (403), p. 467. See also: J. M. Cattell (1926), The Journal "Science" and the American Association for the Advancement of Science, *Science*, 64 (1658), October 8, pp. 342-347.

rather than mental abilities, and he was criticized for this. [49] Cattell partly redirected his efforts away from experimental psychology. Besides editing *Science* and the *Popular Scientific Monthly* (the latter until 1915, when he founded the *Scientific Monthly*), [50] Cattell turned to another kind of statistical analysis than experimental psychology: the "scientific" study of science. To Cattell, applying statistics to study men of intelligence, above all men of science, was highly desirable: "the accounts of great men in biographies and histories belong to literature rather than to science (…). It is now time that great men should be studied (…) by the methods of exact and statistical science". [51] There was a specific motive behind such studies, a motive learned from Galton. In an early study on eminent men, Cattell explained: "Are great men, as Carlyle maintains, divinely inspired leaders, or are they, as Spencer tells us, necessary products of given physical and social conditions? (…). We can only answer such questions by an actual study of facts". [52] And he continued as follows: "We have many books and articles on great men, their genius, their heredity, their insanity, their precocity, their versatility and the like, but, whether these are collections of anecdotes such as Professor Lombroso's or scientific investigations such as Dr. Galton's, they are lacking in exact and quantitative deductions (…). Science asks how much? We can only answer when we have an objective series of observations, sufficient to eliminate chance errors (…)". [53] Cattell's concrete proposal was to observe, classify, measure and compare.

As a first step in this program, Cattell selected 1,000 men from six biographical dictionaries or encyclopedias (two English, two French, one German and one American) to study the racial distribution of eminence among nations. [54] The sample population was

[49] In retrospect, Cattell was still justifying such an orientation. See: J. McKeen Cattell (1924), The Interpretation of Intelligence Tests, *The Scientific Monthly*, 18 (5), May, pp. 508-516. On Cattell's failure, see: M. M. Sokal (1982), James McKeen Cattell and the Failure of Anthropometric Mental Testing, *op. cit.*

[50] Cattell also founded and edited several journals in psychology (*Psychological Review, Archives of Psychology, Psychology and Scientific Method*) and education (*School and Society*), and set up, in 1921, the Psychological Corporation for the promotion of applied psychology. All these activities were conducted without subsidies, as he was proud of saying. He also launched the Science Press in 1923.

[51] J. M. Cattell (1903), A Statistical Study of Eminent Men, *Popular Science Monthly*, February, pp. 359-377, p. 359.

[52] *Ibid*, p. 361.

[53] *Ibid*, p. 376.

[54] Cattell's study on eminent men, published in 1903, extended over many years. See: J. M. Cattell (1895), On the Distribution of Exceptional Ability, *Psychological Review*, 2 (2), pp. 155-156.

composed of those names that appeared in the lists of at least three of the dictionaries, and that were allotted the greatest space on average, a method soon to be called historiometry.[55] The statistics showed that only a few nations produce eminence: “France leads, followed pretty closely by Great Britain. Then there is a considerable fall to Germany and Italy”. [56] To Cattell, the moral was clear: “The progress to our present civilization may have depended largely on the comparatively few men who have guided it, and the civilization we hope to have may depend on a few men (…). If we can improve the stock by eliminating the unfit or by favoring the endowed – if we give to those who have and take away from those who have not even that which they have – we can greatly accelerate and direct the course of evolution. If the total population, especially of the well endowed, is larger, we increase the number of great men”. [57]

As a continuation of this study, Cattell devoted his efforts to men of science. His first statistical study looked at a select group of 200 psychologists, and analyzed their academic origin (institutions), course and destination. [58] This study included most of what would define Cattell’s work in the following years: identifying the best men of science, explaining their performance, comparing with other nations, and suggesting courses of action.

Cattell classified psychologists into four equal groups of what he called scientific merit, as ranked by peers. As Galton had, he measured reputation, not ability or performance: “there is, however, no other criterion of a man’s work than the estimation in which it is held by those most competent to judge”. [59] The results showed that “the differences are not continuous, but there is a tendency towards the formation of groups or species”. [60] Two main groups or types were identified: “there are leaders, and the men of moderate

[55] “Historiometry is to history what biometry is to biology”: the statistical study of men through dictionaries and biographies. F. A. Woods (1909), A New Name for a New Science, *Science*, 30 (777), November 19, pp. 703-704; F. A. Woods (1911), Historiometry as an Exact Science, *Science*, 33 (850), April 14, pp. 568-574.
[56] J. M. Cattell (1903), A Statistical Study of Eminent Men, *op. cit.*, p. 371.
[57] *Ibid*, p. 377.
[58] J. M. Cattell (1903), Statistics of American Psychologists, *American Journal of Psychology*, 14, pp. 310-328.
[59] *Ibid*, p. 314.
[60] *Ibid*, p. 315.

attainments, the leaders being about one-tenth of the whole number. The leaders are again broken into four groups – say, of great genius, of moderate genius, of considerable talent, and of talent". [61]

Having identified a select group of psychologists, Cattell compared their scientific contributions to those of other nations: "In order to compare our productivity with that of other nations, I have counted up the first thousand references [papers] in the index to the twenty-five volumes of the *Zeitschrift fur Psychologie*". [62] "In a general way, it appears that each of our psychologists has on the average made a contribution of some importance only once in two or three years". [63] Overall, Germany led in scientific contributions. "America leads decidedly in experimental contributions to psychology, we are about equal to Great Britain in theoretical contributions, [but] almost doubled by France and Germany, and decidedly inferior to Germany, France, Great Britain, and Italy in contributions of a physiological and pathological character". [64]

How did Cattell explain such a "poor" record? He observed that the 200 psychologists came from 76 institutions (colleges), but studied at a small number of universities. This sufficed for him to draw the following conclusion: "psychologists are born, not made. After the men have graduated from college, and when their work has been chosen, they are gathered for their special studies into a few universities. It does not seem, however, that they are turned into psychologists at these universities. They simply select for study the universities that have reputation and facilities, being often attracted by fellowships or the hope that the university will assist them in securing positions". [65] To Cattell, the moral was again clear: "The conditions present certain serious drawbacks. The time of the men is occupied in teaching, and in administrative, clerical, or missionary work, which, together with their great dispersal, is not favorable to the cultivation of a spirit of scholarship and research (…). Psychology in America has received fewer contributions from those not professionally engaged in teaching it than is the case in other countries. In

[61] *Ibid*, p. 316.
[62] *Ibid*, p. 327.
[63] *Ibid*, p. 328.
[64] *Ibid*, pp. 327-328.

Great Britain there has always been a group of men, largely selected from the wealthy classes, who have not earned their livings by teaching, but have devoted themselves to research and authorship". [66]

The data used in Cattell's study of psychologists came from his directory in progress, *American Men of Science*. The origins of the directory can be traced to a contract granted to Cattell by the newly-created Carnegie Institution of Washington (1902). The Institution was the second most important philanthropic foundation in the United States (the other being the Rockefeller Foundation created in 1901) entirely devoted to funding men of exceptional quality and their research. [67] As Cattell recalled, "Mr. Carnegie has specified as one of the main objects of his foundation, to discover the exceptional man in every department of study whenever and wherever found, inside or outside of schools, and enable him to make the work for which he seems specially designed his life work". [68] But how to find exceptional men? How to distribute money among fields? As N. Reingold documented, "tension spread widely within the communities of American scientists and scholars who might potentially benefit" from the Carnegie Institution. [69] "At present we are conducting a species of Havana Lottery, with monthly drawings, in which the inexperienced and the inexpert man is almost as likely to receive a prize as the expert and the experienced man", commented president R. S. Woodward at a Carnegie Institution trustees' meeting in December 1906. [70] The solutions imagined were many: [71] sending circular letters to scientists in order to get information on their work, setting up advisory committees, constructing a checklist of current research endowments, and…compiling a biographical directory. The latter solution was Cattell's suggestion.

[65] *Ibid*, p. 325.
[66] *Ibid*, p. 327.
[67] R. E. Kohler (1991), *Partners in Science: Foundations and Natural Scientists, 1900-1945*, Chicago: University of Chicago Press, chapter 2.
[68] J. McKeen Cattell (1902), The Carnegie Institution, *op. cit*., p. 467.
[69] N. Reingold (1979), National Science Policy in a Private Foundation: the Carnegie Institution of Washington, in A. Oleson and J. Voss (eds.), *The Organization of Knowledge in Modern America, 1860-1920*, Baltimore: John Hopkins University Press, p. 313.
[70] Cited in N. Reingold (1979), National Science Policy in a Private Foundation, *op. cit*., pp. 322-323.
[71] H. S. Miller (1970), *Dollars for Research: Science and its Patrons in 19th Century America*, Seattle: University of Washington Press, pp. 174-175.

In 1902, at the request of the executive committee of the Carnegie Institution, Cattell started compiling a biographical index of men of science of the United States. [72] He collected a preliminary list of 8,000 names from scientific societies, universities, biographical dictionaries, journal authorships and requests to the readers of journals like *Science*. During the summer, he sent to these names a form to be returned, asking for the following information:

- name with title and mailing address,
- department of investigation,
- place and date of birth,
- education and degrees,
- positions,
- honourary degrees and other scientific honours,
- membership in scientific and learned societies,
- subjects of research.

After four years of work, instead of four months as originally planned, the directory was published. [73] It was more exclusive than the initial collection of data. This first edition contained about 4,000 biographical sketches of men of science, restricted to those men "who have carried on research work" and "contributed to the advancement of pure science" (natural science). "There is here given for the first time a fairly complete survey of the scientific activity of a country at a given period", stated Cattell. [74] By 1944, the last year Cattell edited the directory before he died, the document contained biographical information on over 34,000 men of science (Table 2).

[72] J. M. Cattell (1902), A Bibliographical Index of the Men of Science of the United States, *Science*, 16 (410), November 7, pp. 746-747.
[73] J. M. Cattell (1906), *American Men of Science: A Biographical Directory*, New York: The Science Press.
[74] *Ibid*, p. v.

Table 2.

Number of Entries in *American Men of Science*

(1906-1944)

1906	4,000
1910	5,500
1921	9,600
1927	13,500
1933	22,000
1938	28,000
1944	34,000

American Men of Science was the tool Cattell used to conduct all of his statistical studies on science. In retrospect, the whole program of Cattell's statistical studies for future years was sketched out in an address before the American Society of Naturalists in January 1903, and published in *Science* under the title *Homo Scientificus Americanus*. [75] Here, Cattell briefly summarized his motivations, described the collection of data, showed a preliminary statistical distribution of 4,000 men of science among 12 disciplines, [76] presented the method for classifying a thousand of them as the most valuable, and announced statistical studies to come: distribution in different parts of the country (states, cities, universities), place of birth, education, age, mobility between institutions, rate of promotion, and character and quantity of research. [77] These studies were published in *Science* at the same time as the publication of a new edition of the directory *American Men of Science*, and were subsequently reprinted in the latter.

[75] J. M. Cattell (1903), Homo Scientificus Americanus, *Science*, 17 (432), April 10, pp. 561-570.
[76] Mathematics, physics, chemistry, astronomy, geology, botany, zoology, physiology, anatomy, pathology, anthropology, and psychology.

Cattell envisaged two uses for the directory. The first was to study the number, or productivity as he called it, of men of science in the country and their performance. From the more eminent men of science, “we can tell whether the average scientific standard in one part of the country, at a given university, etc., is higher or lower than elsewhere; we can give quantitatively, the men being weighted, the scientific strength of a university or department. It would be possible to determine more exactly than by existing methods who should be a fellow of the American Association or a member of the National Academy. It is possible to correlate age, education and other factors with scientific eminence”. [78] This was precisely the message included in the memorandum sent to men of science for inclusion in the directory: “the first problem to be considered is the distribution of scientific men among the sciences and in different regions, etc., including the relative rank of this country as compared with other countries in the different sciences, the relative strength of different universities, etc.”.

Cattell’s second motive with regard to his directory examines “the old question of the relative contribution of heredity and environment”. “We have to determine what conditions of both nature and nurture are favorable for the production of usefulness and greatness in scientific work. We should like to know at what age the future of a man can be foretold with a given degree of probability, at what age he has his most original ideas, at what age he does his most efficient work, at what age he is likely to become a public nuisance. We want to know what conditions of health, habits, family, employment, rewards and the like are favorable for scientific performance”. [79]

Productivity

Using the directory, Cattell would, in the decades to come, invest the energy he previously devoted to experimental psychology toward measuring the number of scientific men in the country and their conditions. Two concepts were fundamental to his works. The first was “productivity”, defined as the number of men of science a nation

---

[77] The last three items were never studied.
[78] J. M. Cattell (1903), Homo Scientificus Americanus, *op. cit*., p. 567.

produces. [80] The idea goes back to Galton. On several occasions, Galton used the terms productiveness and productivity to discuss the number of children arising out of marriages (fertility), [81] the families exceptionally productive of noteworthy persons, [82] the number of eminent men coming out of different schools, [83] the number of great men in different periods, [84] and the number of men of science a nation produces: "the different nations vary at the different epochs in their scientific productiveness". [85]

The idea was also present in the work of Alphonse de Candolle (1806-1893). While Galton was working on *Hereditary Genius*, de Candolle, a Swiss botanist, published, partly as a critique of Galton's thesis on heredity, a book on the social factors affecting the development of science. [86] This book considerably influenced Galton, because de Candolle argued for nurture, not nature. [87] De Candolle concentrated on foreign members of three Academies (Paris, London and Berlin) over the period 1666-1869, that is, "men from whom publications have influenced scientific progress most" (my translation). De Candolle justified his choice of such a select group of men as follows: "le nombre de titulaires [foreign members] est ordinairement limité, d'où il résulte une succession de comparaisons d'autant plus sérieuses qu'il y a moins de places à pourvoir". [88] De Candolle was mainly interested in the causes of scientific "productivity". Most of his analysis of these causes was qualitative (socio-historical). He discussed eighteen causes, among them heredity, education, religion, family, values, government and

[79] *Ibidem*.
[80] Productivity as output (scientific papers) was also present in some of Cattell's analyses, as in his study of psychologists in 1903, but the general meaning of the term was that of productivity as reproduction, or perpetuation of the stock of men of science.
[81] F. Galton (1869), Hereditary Genius, *op. cit*. p. 36.
[82] F. Galton and E. Schuster (1906), Noteworthy Families, p. ix.
[83] F. Galton (1874), English Men of Science, *op. cit*. p. 67.
[84] *Ibid.* p. 227.
[85] F. Galton (1873), On the Causes Which Operate to Create Scientific Men, *Fortnightly Review*, March, 19, p. 347.
[86] A. de Candolle (1873), Histoire des sciences et des savants depuis deux siècles, d'après l'opinion des principales académies ou sociétés scientifiques, *op. cit*.
[87] "I undertook the inquiry of which this volume [*English Men of Science*] is the result, after reading the recent work of de Candolle (…). It so happened that I myself had been leisurely engaged on a parallel but more extended investigation – namely, as regards men of ability of all descriptions". F. Galton (1874), English Men of Science, *op. cit*., p. v.
[88] A. de Candolle (1873), Histoire des sciences et des savants depuis deux siècles, d'après l'opinion des principales académies ou sociétés scientifiques, *op. cit*., p. 12.

institutions, culture, and language. But he also produced several descriptive statistics on foreign members by discipline (including social sciences) and epoch, and statistics on the national and social origins of men of science. Above all, de Candolle calculated ratios of men of science to total population in order to compare nations in terms of "productivity". De Candolle used terms like "répartition" and "proportion" (share) rather than productivity or productiveness, [89] and called his numbers "importance" [90] and "valeur", [91] but the idea of a stock/population ratio and quantitative comparisons between countries was fundamental to his results. He found that small countries, above all Switzerland, were first in terms of foreign members in scientific societies over the entire period he studied.

Cattell studied productivity with two kinds of statistics. He compared American states and institutions in terms of both absolute and relative (per million population) numbers of men of science. The first statistical study of *American Men of Science* appeared in 1906 and was concerned with the geographical distribution of American men of science. [92] Cattell looked at the origins of scientific men (birthplace) and their present position (residence). He found concentrations of origin in a few regions: Massachusetts and Boston were identified as the intellectual center of the country. To Cattell, this fact contradicted Galton's thesis: "the inequality in the production of scientific men in different parts of the country seems to be a forcible argument against the view of Dr. Galton and Professor Pearson that scientific performance is almost exclusively due to heredity. It is unlikely that there are such differences in family stocks as would lead one part of the country to produce a hundred times as many scientific men as other parts (…). The main factors in producing scientific and other forms of intellectual performance seem to be density of population, wealth, opportunity, institutions and social traditions and

[89] He used the term "production" once (p. 163).
[90] Number of men of science a country has divided by the total number of men of science.
[91] Number of men of science divided by million population.
[92] J. M. Cattell (1906), A Statistical Study of American Men of Science III: The Distribution of American Men of Science, *Science*, 24 (623), December 7, pp. 732-742.

ideals". [93] According to Cattell, "the scientific productivity of the nation can be increased in quantity, though not in quality, almost to the extent that we wish to increase it". [94]

The distribution of men of science by residence revealed the same concentration. Here, Cattell developed a method for evaluating gains and losses of regions based on comparing numbers for births and numbers for residence: if a state produced 1,000 men of science (birth) but retained only 800 of them (residence), then it had lost 200 to other states (mobility). Cattell's estimates showed that large centers like Massachusetts and New York maintain their position and that Washington and California gain, but that the South "remains in its lamentable condition of scientific stagnation". [95] The position of Washington was used here as an example for "those of us who believe that the future of scientific research depends largely on its support by the nation, the states and the municipalities". [96] Cattell also found concentrations in a few cities: three-fourths of scientific men lived in 39 places. To Cattell, "the lack of men of distinction in whole regions and large cities is a serious indictment of our civilization. The existence of cities such as Brooklyn and Buffalo is an intellectual scandal". [97]

The second edition of the directory (1910) allowed Cattell to develop statistical comparisons over time. Cattell reiterated the fact that: [98]

> we are at present almost wantonly ignorant and careless in regard to the conditions which favor or hinder scientific work. We do not know whether progress is in the main due to a large number of faithful workers or to the genius of a few. We do not know to what extent it may be possible to advance science by increasing the number of scientific positions or how far such an increase might be expected to add to the number of men of genius. We do not know to what extent increased salaries, better facilities and greater leisure would favor the quantity and quality of our work. We do not know to what extent non-rational sanctions, such as reputation, offices, titles, degrees, prizes, membership in exclusive societies and the like are effective. We do not know whether it is wise to combine teaching with research or applied

[93] *Ibid*, pp. 734-735.
[94] *Ibid*, p. 735.
[95] *Ibid*, p. 736.
[96] *Ibid*, pp. 736-737.
[97] *Ibid*, p. 738.
[98] J. M. Cattell (1910), A Further Statistical Study of American Men of Science, *Science*, 32 (827), November 4, pp. 633-648, p. 634.

> with pure science (…). It is surely time for scientific men to apply scientific method [statistics] to determine the circumstances that promote or hinder the advancement of science.

The statistical analysis was entirely expressed in an evaluative or moral tone, using terms like gain or loss, success or failure, leadership, deficiency in productivity, progressive centers, and sinister and discreditable records. Cattell measured that the states of Massachusetts and Connecticut showed the greatest gains – nearly one-fourth of new men of science resided in these two states, which have just 5% of the US population – that the western states have about maintained their positions, while the southern states fell still further behind, and big cities were losing to an extent that is "ominous". [99] In general, "the increase in the number of scientific men of standing is only about one-half so large as the increase in the population of the country (...). In no country does there seem to be a group of younger men of genius, ready to fill the places of the great men of the last generation". [100] To Cattell, "eminent men are lacking and this we must attribute to changes in the social environment": [101] the growing complexity of science, educational methods, lack of fellowships and assistantships as well as prizes, teaching load, and low salary. "The salaries and rewards are not adjusted to performance", unlike Germany, Great Britain and France, where the "exceptional men have received exceptional honors (…). Methods should be devised by which scientific work will be rewarded in some direct proportion to its value to society - and this not in the interest of the investigator, but in the interest of society". [102]

Cattell's analysis of scientific productivity was solely based on men of science living in the United States. This was a huge limitation, as Cattell always wanted to compare the situation in this country to that in other countries. In fact, he ended his first statistical study on men of science in 1906 as follows: "It would be desirable to compare the scientific men and the scientific work of the United States with those of other nations, and I hope to collect data on this subject. It is my impression from such information as is

[99] *Ibid*, p. 640
[100] *Ibid*, p. 645.
[101] *Ibid*, p. 646.
[102] *Ibid*, p. 648.

on hand that we produce from one seventh to one tenth of the world's scientific research, but that we have not produced one tenth of its recent great discoveries or its contemporary great men (…). It is obvious that we should collect without delay the information that would tell us where we stand among the nations". [103] Cattell waited until 1914 to collect such data, and published the results quite late because of the war (1926). [104] Using the British *Who's Who in Science*, he calculated that the United States was now in advance of other nations in the number of scientific men. [105]

Performance

Productivity was the first concept Cattell introduced in his statistical analyses. The second was that of "performance". Whereas productivity measured quantity, performance measured quality or merit, defined as "contributions to the advancement of science, primarily by research". Cattell's method relied on evaluation by peers. He occasionally measured these contributions by counting papers, [106] but his main method rested on the evaluation of men of science by judges or peers. As Galton had chosen dictionaries as his source of data because of their objectivity (the "judgments of others"), Cattell believed that "expert judgment is the best, and in the last resort the only, criterion of performance". [107] He asked ten leading representatives of each of the twelve sciences he selected to arrange the men of science in order of merit (rank) (see Appendix). [108] The "positions assigned to each man were averaged, and the average deviations [probable error] of the judgments were calculated [and individuals arranged in order]. This gave the

[103] J. M. Cattell (1906), A Statistical Study of American Men of Science III, *op. cit*., p. 742.
[104] J. M. Cattell (1926), The Scientific Men of the World, *The Scientific Monthly*, 23 (5), November, pp. 468-471.
[105] Systematic international comparisons did not really begin before the late 1950s. Before Cattell's estimates, only Alphonse de Candolle had offered some data. Galton's numbers on the worth of races in *Hereditary Genius* was mostly anecdotal. For a critique of Galton's numbers, see C. H. Cooley (1897), Genius, Fame and the Comparisons of Races, *Annals of the American Academy of Political and Social Science*, IX (3), Mat, pp. 1-42.
[106] J. M. Cattell (1903), Statistics of American Psychologists, *op. cit*; J. M. Cattell (1917), Our Psychological Association and Research, *Science*, 45 (1160), March 23, pp. 275-284; J. M. Cattell (1929), Psychology in America, *Science*, 70 (1815), October 11, pp. 335-347.
[107] J. M. Cattell (1906), A Statistical Study of American Men of Science II: The Measurement of Scientific Merit, *op. cit*., p. 702.
[108] In subsequent editions, Cattell did not choose the judges himself but consulted the top ten men in each science.

most probable order of merit". [109] To Cattell, "the probable errors not only tell the accuracy with which the [scientific men] can be arranged in the order of merit, but they also measure the differences between them [degrees of merit]. [110] This, indeed, I regard as the most important result of this paper". [111]

This result was, in fact, only a relative breakthrough. Galton had already used rankings in *Hereditary Genius* – his scale of ability. [112] What was new in Cattell's work was twofold. First, Cattell applied the method to men of science. Indeed, Galton did not use any scale of ability in *English Men of Science*, to his own dissatisfaction. [113] Such a scale appeared only thirty years later, in *Noteworthy Families*. [114] Secondly, Cattell used peers to rank individuals, whereas Galton's scale of ability was entirely based on statistical laws.

Evaluation of performance by peers, or reputation, was the method Galton relied upon for selecting his population (dictionaries), and Cattell was conscious of the limitations: "it should be distinctly noted that the figures give only what they profess to give, namely, the resultant opinion of ten competent judges. They show the reputation of the men among experts, but not necessarily their ability or performance (...). There is, however, no other criterion of a man's work than the estimation in which it is held by those most competent to judge." [115] To justify the method further, Cattell compared his procedure of votes to that used in elections to a scientific society, or in filling chairs at a university.

[109] J. M. Cattell (1906), A Statistical Study of American Men of Science: The Selection of a Group of One Thousand Scientific Men, *Science*, 24 (621), November 23, pp. 658-665, p. 661.
[110] "Converting relative positions into degrees of quantitative differences" was first used by Cattell to measure perceptions in the intensity of light (J. M. Cattell (1902), The Time of Perception as a Measure of Differences in Intensity, *Philosophical Studien*, 19, pp. 63-68) and in his study of Columbia students (J. M. Cattell and L. Farrand (1896), Physical and Mental Measurements of the Students of Columbia University, *op. cit*).
[111] J. M. Cattell (1906), A Statistical Study of American Men of Science II, *op. cit.*, p. 702.
[112] See also: F. Galton (1875), Statistics by Intercomparison, with Remarks on the Law of Frequency of Error, *Philosophical Magazine*, 4 (49), pp. 33-46.
[113] See the footnote on p. 261 of *English Men of Science*: "I also omit the description of a notation I proposed to replace indefinite words such as "large", "considerable", because I have made no use of it in the volume. It is a modification of the class notation used by me in my "Hereditary Genius", and was alluded to and illustrated in my lecture before the Royal Institution, in 1874. I have by no means abandoned its advocacy, but have learnt the necessity of explaining and exemplifying it in considerable detail before its merits and convenience are likely to become as generally recognized as I believe they deserve to be".
[114] F. Galton and E. Schuster (1906), Noteworthy Families, *op. cit.*, p. xxii.
[115] J. M. Cattell (1906), A Statistical Study of American Men of Science: The Selection of a Group of One Thousand Scientific Men, *op. cit.*, p. 661.

His method was said to be superior: “the academy has no method of comparing performance in different sciences”. [116] To Cattell, “the methods of selection used in this research are more accurate than those of any academy of sciences, and it might seem that the publication of the list would be as legitimate as that of a list of our most eminent men selected by less adequate methods. But perhaps its very accuracy would give it a certain brutality”. [117] In other words, “it would require courage to do this, and perhaps it would not be possible to obtain the arrangement if it were to be made known”. [118] With hesitation, Cattell then added a star (with no ranking) to the names of the top thousand men of science in the directory.

In all his statistical analyses, including his numbers on productivity, Cattell retained the top thousand men of science: “These are the thousand students of the natural and exact sciences in the United States whose work is supposed to be the most important”, claimed Cattell. [119] All through his life, Cattell had to explain at length and justify the procedure, because his statistics relied wholly on this selected group of men of science, not on the population at large as indexed in the directory. [120] A few months before Cattell’s death (January 1944), a debate emerged in *Science* on the stars denoting the top thousand men of science. Jaques Cattell, son of James and co-editor of the directory since the fourth edition (1927), reminded the readers that a majority of men of science had already voted for the continuation of the system. [121] S. S. Visher, a US geographer who published several statistical analyses of Cattell’s directory over twenty five years, also confirmed this result with his survey of starred scientists in 1946. [122] One year later, the star system was nonetheless abandoned.

[116] *Ibid*, p. 665.
[117] *Ibid*, p. 664.
[118] *Ibid*, p. 636.
[119] J. M. Cattell (1906*)*, American Men of Science: A Biographical Directory, *op. cit.*, p. vi.
[120] See: J. M. Cattell (1906), A Statistical Study of American Men of Science: The Selection of a Group of One Thousand Scientific Men, *op. cit*; J. M. Cattell (1906), A Statistical Study of American Men of Science II: The Measurement of Scientific Merit, *op. cit.*; J. M. Cattell (1922), The Order of Scientific Merit, *Science*, 56 (1454), November 10, pp. 541-547.
[121] J. Cattell (1943), Stars in American Men of Science, *Science*, 97 (2526), May 28, p. 487.
[122] S. S. Visher (1947), *Scientists Starred 1903-1943 in American Men of Science*, Baltimore: Johns Hopkins University Press, p. 546.

Cattell classified the starred men of science into groups of hundreds, often analyzed in terms of two classes: figures were given for the five hundred who are more distinguished and for the five hundred whose reputations are less, followed by the totals and the number per million of population. Cattell never compared the performance of the first thousand of his men of science to the rest of the population. Only once did he compare the first thousand to the second thousand. What Cattell observed from the distribution would become a fact much studied later in the literature – that the distribution of merit follows an "exponential law" rather than the normal distribution of ability shown in Galton's work: "the first hundred men of science cover a range of merit about equal to that of the second and third hundreds together, and this again is very nearly equal to the range covered by the remaining seven hundred. The average differences between the men in the first hundred are about twice as great as between the men in the second and third hundreds, and about seven times as great as between the men in the remaining groups". [123]

Measuring performance allowed Cattell to estimate gains and losses in ranks or places: those men of science who have attained a place in the thousand and those who have lost their place over time. To Cattell, such a statistic "is a truly dramatic figure expressing with almost brutal conciseness the efforts, the successes and the failures of seven years of a man's life". [124] The method worked as follows: "If a gain of one place in the last five hundred is taken as the unit, a gain of one place in the upper hundreds would be approximately as follows: V. = 1.5; IV. = 2; III. = 3; II. = 6; I. = 10. Dividing the first hundred further, a gain in the lower fifty equals 8, and gains in the two upper twenty-fives, respectively, equal 10 and 14". [125] Cattell's estimates showed that "men were more likely to lose in position than to gain (...). Even men of established reputation do not maintain their positions". [126] Cattell then ranked institutions by the order of merit of their scientific men, and offered his readers the first league table of universities in the history of statistics on science (Table 3). "I give this table with some hesitation, but it appears in

[123] J. M. Cattell (1906), A Statistical Study of American Men of Science II: The Measurement of Scientific Merit, *op. cit*., p. 707.
[124] J. M. Cattell (1910), A Further Statistical Study of American Men of Science II, *op. cit*., p. 672.
[125] *Ibidem*.
[126] *Ibid*, p. 673.

the end it will be for the advantage of scientific research if it is known which institutions obtain and retain the best men (...). A table such as this might have some practical influence if the data were made public at intervals of ten years". [127] The table showed Harvard, Columbia and Chicago as leaders in terms of their share of the top thousand scientific men. All in all, Cattell calculated that about half of the thousand scientific men were connected with 18 institutions.

Table 3.

Distribution According to Present Position of the Thousand Men of Science

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	**Total**
Harvard	19	8.5	3	6.5	3.5	6	4.5	5.5	3.5	6.5	**66.5**
Columbia	7	6	6.5	4.5	5	4.5	5.5	6	4	11	**60**
Chicago	7	10	3	6	2	2.5	3	2	1.5	2	**39**
Cornell	3	6	3	2	3	1.5	3	3.5	4	4.5	**33.5**
U.S. Geological Survey	6	3	4	4	4	1	3	3	2	2	**32**
U.S. Department of Agriculture	3	4	2	4	3	2	3	3	3	5	**32**
Johns Hopkins	9	2	5.5	0	1.5	2	4.5	0.5	1	4.5	**30.5**
California	1	2	2	4	3	4	1	5	1	4	**27**
Yale	2	5.5	3	3.5	5.5	2	1	0	2	2	**26.5**
Smithsonian Institution	3	2	4	5	2	0	1	3	1	2	**22**
Michigan	1	3	6	3	3	0	0	1	1	2	**20**
Mass. Inst. Tech.	1	2	2.5	4	2	3	2	0	0	3	**19.5**
Wisconsin	1	3	1	2	0	3	2	4	2	0	**18**
Pennsylvania	2	1	1	3.5	2.5	1.5	1	2	0.5	2	**17**
Leland Stanford, Jr.	3	1	1	1	3	2	2	1	1	1	**16**
Total											**459.5**
Princeton											**14.5**
Minnesota, Ohio State											**10**
New York University											**9.5**
Missouri, Nebraska, Northwestern											**9**
National Bureau of Standards, U.S. Navy, Am. Mus. Nat. History											**8**
Carnegie Institution, Clark, Iowa, Syracuse, Virginia, Wesleyan											**7**
Bryn Mawr, Cincinnati, Dartmouth, Illinois, Indiana, N.Y. Botanical Garden, Smith											**6**
Brown, Kansas, North Carolina, Texas, Washington (St. Louis)											**5**
Field Columbian Museum,. General Electric Co., St. Louis, Western Reserve, Pennsylvania State, Rutgers											**4**
Lehigh											**3.5**
Philadelphia, Acad. Nat. Sciences Amherst, Case, College of City of New York, Colorado College, Colorado University, Havenford, Purdue, Rockefeller Institute, Simmons, Tufus, Vassar, Worcester											**3**
Grand Total											**730**

Source: J. M. Cattell (1906), *A Statistical Study of American Men of Science III*, p. 739.

[127] J. M. Cattell (1906), A Statistical Study of American Men of Science III: The Distribution of American Men of Science, *op. cit*., p. 739.

The table was only the first ranking Cattell produced. [128] He also constructed a combined index of strength of institutions as follows. He attributed weighted (but arbitrary) values to each group of one hundred men of science and calculated totals for each university. The method was as follows: "A man in the lower four hundred being the unit, those in the other hundreds were assigned ratings as follows: VII. and VI. = 1.2; V. = 1.4; IV. = 1.6; III. = 1.9; II. = 2.2; I. = 3. The first hundred were subdivided, the lower fifty being assigned 2.5, and the upper twenty-fives, respectively, 3 and 4". [129] The statistics showed that Harvard, Chicago and Columbia led, but Wisconsin, Illinois and Carnegie had the greatest gain as compared to 1906. Cattell then presented a detailed ranking on strength of departments by university (Table 4).

Table 4.

The Ten Strongest Departments in Each Service Together With Their Gain or Loss in a Period of About Four Years

Mathematics			Physics			Chemistry			Astronomy		
Chicago	16.8	+2.8	Harvard	19.6	+6.1	Mass. Tech.	19	+5.9	Chicago	8.9	+1.9
Harvard	14.2	1	Bur. Stand.	15.9	+3.4	Yale	13.6	+4.4	California	8.7	-1.2
Columbia	8.4	-1.3	Princeton	9.8	+3.9	Dept. Agr.	12.8	+6.5	Harvard	7.9	+1.4
Yale	8.1	+1.2	Hopkins	9.4	+3.2	Harvard	11.3	-2.5	Carnegie	6.8	+3.6
Illinois	8	8	Chicago	9.3	+4.1	Hopkins	11	+3.6	Yale		
Princeton	6.9	+2.7	Columbia	9.1	-8.9	Cornell	8.9	-9.7	Columbia		
Cornell	6.9	+0.1	Mass. Tech.	9	+2.8	Columbia	8.5	+1.4	U.S. Navy		
Wisconsin	6.7	+6.7	Cornell	8.3	-1.6	Illinois	8.3	+7.3	Wisconsin		
Mass. Tech.	4.1	+1.9	Carnegie	8.1	+4.9	Wisconsin	8.2	+1.8	Pennsylvania		
Stanford			Dept. Agr.	6.1	-0.9	Chicago	8.1	+2.4	Michigan		
Geology			**Botany**			**Zoology**			**Physiology**		
Geol. Surv.	40.3	-5.3	Harvard	18.3	+3.2	Harvard	22	+8.8	Harvard	9.9	+0.1
Yale	9.5	+0.4	N.Y. Bot.	13.5	0	Columbia	18.1	+1.4	Yale	7.1	+2.2
Harvard	7.9	-1.2	Dept. Agr.	13	-11.6	Chicago	13.8	+1.6	Hopkins	6.1	-1.1
Chicago	7.4	-1.3	Chicago	12.9	+2.3	Am. Museum	10.9	-2.6	Rockefeller	4.9	+2.7
Wisconsin	6.4	+2.2	Cornell	10	+2.8	Cornell	8.8	+2.3	Chicago	4.6	+1.4
Smithsonian	5.1	+1.3	Stanford	5.9	+2.2	Yale	8.8	+2.3	W. Reserve	4.2	+4.2
Cornell	4.9	-0.3	Wisconsin	5.2	+1.1	Stanford	7.6	+0.9	California	4	+1.8
Hopkins	4.6	+1.5	Mo. Bot.	5.2	+1.4	Dept. Agr.	7.6	+0.7	Wisconsin		
Stanford			Carnegie	5.1	+5.1	Smithsonian	6.5	-2.4	Cornell		
Columbia			Hopkins			Princeton	5.6	2	New York		
Anatomy			**Pathology**			**Anthropology**			**Psychology**		
Hopkins	6.8	-1.0	Harvard	16.5	+4.1	Smithsonian	10.1	-3.3	Columbia	11	+1.4
Harvard	4.9	-0.3	Hopkins	11.5	1	Columbia			Harvard	10.2	0
Michigan			Chicago	7	2	Harvard			Clark	5.2	+0.5
Wistar			Columbia	6.2	+0.2	Field Museum			Cornell	5	+0.5
Wisconsin			Rockefeller	6.1	+1.5	California			Chicago	4.4	+2.8
Minnesota			Michigan	6	-1.3	Am. Museum			Iowa		
Columbia			Penns.	4.8	-0.3	Brooklyn			Wellesley		
Missouri			New York			Clark			Wisconsin		
Pennsylvania			P.I. Bur. Sol.						Stanford		
Chicago			Wisconsin						Indiana		

Source: J. M. Cattell (1910), *A Further Statistical Study of American Men of Science II,* p. 685

[128] Cattell offered a second ranking table (p. 741) on institutions having produced (educated) more men of science.
[129] J. M. Cattell (1910), A Further Statistical Study of American Men of Science II, *op. cit*., p. 683.

Having computed all these figures, a question immediately occurred to Cattell. Considering that performance can be measured, is it possible to calculate a man's economic value? Cattell thought it was. He started by comparing the distribution of men of science with several variables and showed that performance was correlated with an institution's size in terms of number of instructors, number of students and extent of facilities. In general, he found "one scientific man of standing for each fifty-three thousand dollars invested in buildings and grounds". Cattell then continued and suggested that "those in the lead are not incomparable with the others", if one takes salary as a proxy: "if a university pays its more distinguished professors three times as much as its younger assistant professors, it estimates the one to be worth three times as much as the other". [130] Cattell indeed found that salaries increase with distinction: they were three times as high in the upper hundred as in the lower third.

Heredity

Cattell would continue analyzing statistics on men of science on this same line up until the 1930s, looking at changes that took place in the distribution of sciences, and in the origins and position of scientific men since the last series of data. [131] Measuring productivity and performance, however, was only the first objective of Cattell's program of research. The other was the old question of heredity and environment, as he called it. In fact, as Galton's student and as a psychologist, one of Cattell's areas of "interest was

[130] *Ibid*, p. 682.

[131] J. M. Cattell (1906), A Statistical Study of American Men of Science: The Selection of a Group of One Thousand Scientific Men, *Science*, 24 (621), November 23, pp. 658-665; J. M. Cattell (1906), A Statistical Study of American Men of Science II: The Measurement of Scientific Merit, *Science*, 24 (622), November 30, pp. 699-707; J. M. Cattell (1906), A Statistical Study of American Men of Science III: The Distribution of American Men of Science, *Science*, 24 (623), December 7, pp. 732-742; J. M. Cattell (1910), A Further Statistical Study of American Men of Science, *Science*, 32 (827), November 4, pp. 633-648; J. M. Cattell (1910), A Further Statistical Study of American Men of Science II, *Science*, 32 (828), November 11, pp. 672-688; J. M. Cattell (1915), Families of American Men of Science: Origin, Heredity and Performance, *Popular Science Monthly*, May; J. M. Cattell (1917), Families of American Men of Science II: Marriages and Number of Children, *Scientific Monthly*, 4 (3), March, pp. 248-262; J. M. Cattell (1917), Families of American Men of Science III: Vital Statistics and the Composition of Families, *Scientific Monthly*, 5 (4), October, pp. 368-377; J. M. Cattell (1922), The Order of Scientific Merit, *Science*, 56 (1454), November 10, pp. 541-547; J. M. Cattell (1927), The Origin and Distribution of Scientific Men, *Science*, 66 (1717), November 25, pp. 513-516; J. M. Cattell (1928), The Scientific Men of Harvard and Columbia, *Science*, 67 (1727), February 3, pp. 136-138; J. M. Cattell (1933), The Distribution of American Men of Science in 1932, *Science*, 77 (1993), March 10, pp. 264-270.

in human heredity and eugenics". [132] In 1915-17, he then looked at the families of American men of science. [133] He conducted a survey among the top thousand men of science and analyzed the nationality and race of their parents, their occupation, age of marriage and size of family. He arrived at two results. First, on the social origins of men of science, he reported: "It is here shown that 43% of our leading scientific men have come from the professional classes. We may conclude that more than one half per cent of our men of science come from the one percent of the population most favorably situated to produce them". [134] Was it a matter of natural capacity (heredity), as Galton thought, or opportunity (environment)? Both: "The specific character of performance and degree of success are determined by family position and privilege as well as by physical heredity". [135] Cattell drew the following conclusions: [136]

> The children of scientific men should be numerous and well cared for. But we can do even more to increase the number of productive scientific men by proper selection from the whole community and by giving opportunity to those who are fit (…). While we should welcome and support a eugenic movement tending to limit the birth of feeble-minded and defective children and encouraging the birth of those that are well endowed, it appears that under existing conditions of knowledge, law and sentiment, we can probably accomplish more for science, civilization and racial advance by selecting from the thirty million children of the country those having superior natural ability and character, by training them and giving them opportunity to do the work for which they are fit. We waste the mineral resources of the country and the fertility of the soil, but our most scandalous waste is of our children, most of all of those who might become men and women of performance and of genius (…). We can attribute the inferiority of scientific performance in America as compared with Germany, France and Great Britain to lack of opportunity rather than to lesser racial ability (…). When the conditions become as favorable for other sciences as they have been for astronomy, the United States will assume leadership in scientific productivity.

The second result of the studies on families carried the same political message: "The families from which our scientific men come had on average 4.7 children, and those

---

[132] J. McKeen Cattell (1924), The Interpretation of Intelligence Tests, *op. cit*., p. 508.
[133] J. M. Cattell (1915), Families of American Men of Science: Origin, Heredity and Performance, *op. cit.*; J. M. Cattell (1917), Families of American Men of Science II, *op. cit*.; J. M. Cattell (1917), Families of American Men of Science III, *op. cit*. A few years later, D. R. Brimhall, co-author of the third edition of the directory, analyzed the data further. See: D. R. Brimhall (1922), Family Resemblances Among American Men of Science, a series of four papers published in *The American Naturalist* in 1922-23.
[134] J. M. Cattell (1915), Families of American Men of Science: Origin, Heredity and Performance, *op. cit.*, p. 786.
[135] *Ibid*, p. 788.

scientific men who are married and whose families are complete have on average 2.3 children". [137] Echoing Galton, Cattell concluded: "It is obvious that the families are not self-perpetuating (…). If the families of the scientific men should increase at the rate of the general population [which they don't], the thousand leading scientific men would have some 6,000 grandchildren instead of fewer than 2,000. These well-endowed and well-placed people would probably have an average economic worth through their performance of not less than $100,000, and the money loss due to their non-existence is thus $400,000,000". [138] To Cattell, society has obligations with regard to children of professors. He suggested that universities give scholarships to the sons of men of science, and pay a higher salary for the married professor. These were his suggestions for the reproduction of the "species".

Discussion

Two factors explain Cattell's involvement in measuring men of science and the specific kind of statistics he developed. First was the intellectual and socioeconomic context of the time, characterized by the valorization of great men, among them men of science, of whom Cattell was a member, their decline in numbers, and the "poor" economic conditions of these men. This set the stage for his interest in men of science as a statistical group or category, and how he conceptualized and shaped his statistics and used them for the cause of the advancement of science. The second factor was Cattell's own life: his personal background in experimental psychology, and two professional setbacks – the failure of his program of research on mental testing, and his dismissal as professor from Columbia University. The latter event is intimately linked to Cattell's ideas about the "control" of universities.

[136] *Ibid*, p. 788-790.
[137] J. M. Cattell (1917), Families of American Men of Science II: Marriages and Number of Children, *op. cit*., p. 793.
[138] *Ibid*, p. 797.

At the beginning of the twentieth century, American men of science believed that science in the United States was lagging Europe in terms of basic research and opportunities. To generations of American men of science, from the astronomer S. Newcomb to the physicist R. A. Millikan, the problem of American science was not lack of scientists nor their quality, but what they called a lack of incentives: too few scientific journals of American origin, no publicly-funded academy nor prizes, no job opportunity for the scientific investigator, no public appreciation of science. [139] "How short-sighted a thing it is", argued Millikan, "for any country to fail to find in some way the funds necessary for carrying on research and development work". In fact, the early 1900s was a time when direct funding of men of science, by way of privately-funded philanthropy, was just beginning; [140] industrial laboratories that could hire or consult men of science were few; [141] government support for university research was limited. [142] This was the context out of which efforts for the advancement of science developed. Scientists became activists, organizing themselves (AAAS, Committee for One Hundred, National Research Council), developing a public rhetoric stressing the role of science in social progress, and lobbying for substantial increases in financial support for science. [143]

---

[139] S. Newcomb (1874), Exact Science in America, *North American Review*, 119, pp. 286-308. See also: S. Newcomb (1902), Conditions Which Discourage Scientific Work in America, *North American Review*, 543, pp. 145-158; R. A. Millikan (1919), The New Opportunity in Science, *Science*, 50, 1291, September 26, pp. 285-297.

[140] R. E. Kohler (1991), Partners in Science: Foundations and Natural Scientists, *op. cit.*

[141] K. Birr (1979), Industrial Research Laboratories, in N. Reingold (ed.), *The Sciences in the American Context: New Perspectives*, Washington: Smithsonian Institution Press, pp. 193-207; D. C. Mowery and N. Rosenberg (1989), The US Research System Before 1945, in D. C. Mowery and N. Rosenberg, *Technology and the Pursuit of Economic Growth*, New York: Cambridge University Press.

[142] A. H. Dupree (1957), *Science in the Federal Government: A History of Policies and Activities to 1940*, New York: Harper and Row; D. S. Greenberg (1967), *The Politics of Pure Science: An Inquiry into the Relationship Between Science and Government*, New York: New American Library; H. S. Miller (1970), Dollars for Research: Science and its Patrons in 19th Century America, *op. cit.*

[143] R. H. Kargon (1974), *The Maturing of American Science*, Washington: AAAS; S. G. Kohlstedt, M. M. Sokal and B. V. Lewenstein (1999), The Establishment of Science in America, *op. cit.*

To Cattell, as scientist, editor of *Science* and the most active member and significant figure of the AAAS, the advancement of science … and of the scientific profession became his leitmotif. At several times, he explicitly expressed this objective: [144]

> The writer has on various occasions called attention to the economic conditions which limit scientific research. One of the objects of the present work is to improve these conditions (...). The two most important services for society - the bearing and rearing of children and creation in science and art - are exactly those for which society gives no economic returns, leaving them dependent on instincts which are in danger of atrophy (...). The scientific investigator is usually an amateur. He has wealth or earns his living by some profession, and incidentally does what he can to advance science for love of the work. This has its good side in producing a small group of men who are not subject to purely commercial standards. But (...) the most adequate expression of appreciation is direct payment for the service rendered.

Cattell believed in the benefits of (applied) science to society, although he could not measure them properly: [145] "Those listed in the directory have probably done more for the welfare of the American people than all the business men of New York and all the political leaders in Washington". [146] However, according to him, the conditions under which science was actually conducted were detrimental to socioeconomic progress. This he criticized all through his life, and he explained at length in a paper published in 1922 entitled *The Organization of Scientific Men*, in which he called on men of science to organize themselves to improve their conditions, as "men who labor with their hands have learned to unite in trade unions". [147] To Cattell, "the entire development of our

[144] J. M. Cattell (1906), A Statistical Study of American Men of Science III, *op. cit*., p. 737. Following are three other citations in the same vein: "It would be well if [these figures] were widely known, as they would tend to awaken civic pride and improve the conditions of intellectual activity" (J. M. Cattell (1906), A Statistical Study of American Men of Science III, *op. cit*., p. 736). "The advancement of science and the improvement of the conditions under which scientific work is done are of such vast importance for society than even the most modest attempt to introduce scientific method into the study of these conditions has some value" (J. M. Cattell (1910), A Further Statistical Study of American Men of Science I, *op. cit*., p. 633). "The ultimate object of the work is the study of behavior with a view to advancing scientific research" (J. M. Cattell (1922), The Order of Scientific Merit, *op. cit*., p. 541).

[145] He suggested some anecdotal numbers in J. M. Cattell (1906), A Statistical Study of American Men of Science III, *op. cit*., p. 633.

[146] J. M. Cattell (1937), The Sixth Edition of the Biographical Directory of American Men of Science, *op. cit*., p. 265.

[147] J. M. Cattell (1922), The Organization of Scientific Men, *The Scientific Monthly*, June, pp. 568-578, p. 571.

civilization is due to the applications of science", [148] and "the rewards of science are queerly out of proportion to what science has accomplished for human welfare". [149] But although joy in work "may be the greatest in the creative work of art and science (…), it does not give exemption from the ordinary needs of life; it can scarcely exist if the worker has not the means and the time to do his work in the best way (...). The people and the state must learn to pay for the products of scientific research". [150] To Cattell, "each nation should contribute in proportion to its consumption". [151] He thus joined his voice to the call for 1% of national resources to be devoted to research: "Science would be indefinitely richer if a cent were paid to it each time a match was struck or a pin used. Full payment would be three fourths of the wealth produced annually by the industrial nations". [152] "Why can not scientific men learn how to retain even one per cent of such [economic wealth resulting from the application of science], which when reinvested in research would again yield high usury to science and to society". [153]

Statistics on science was an integral part of Cattell's arsenal of resources for improving the conditions of men of science and promoting the advancement of science. He took advantage of a work conducted at the instigation of the Carnegie Institution – a pioneering and influential directory of men of science – published regular statistical analyses of the biographical information it contained, and used the numbers to suggest ways in which the nation could produce more men of science, and universities could devote more time to research, increase salaries and award prizes. Cattell was admittedly aware of the limitations of his statistics, [154] but to him statistics were a "valid objective

---

[148] *Ibid*, p. 568.
[149] *Ibid*, p. 569.
[150] *Ibidem*.
[151] *Ibid*, p. 570.
[152] *Ibid*, p. 569.
[153] *Ibid*, p. 578. The 1% figure was probably taken from E. B. Rosa, chief physicist at the Bureau of Standards, who compiled, for the first time in American history, a government budget for "research-education-development" in 1920. Rosa estimated that government's expenditures on research amount to 1% of the federal budget. See: E. B. Rosa (1921), Expenditures and Revenues of the Federal Government, *Annals of the American Academy of Political and Social Sciences*, 95, May, pp. 26-33. See also: E. B. Rosa (1920), Scientific Research: The Economic Importance of the Scientific Work of the Government, *Journal of the Washington Academy of Science*, 10 (12), pp. 341-382.
[154] In his very first statistical paper on men of science in 1906, Cattell identified the following limitations to his directory as a source of data: duplication of names because of disciplinary boundaries, whereas science is really interdisciplinary; liberal admission of men to be included in the directory, including teachers (not

method": [155] "The figures here given", he claimed, "show the advantage of statistics over general impressions (…). It may be hoped that an exposition of the true conditions will be of service to science". [156]

That Cattell concentrated on demography (counting men of science), rather than other dimensions of science like output (counting scientific papers), has to do with the intellectual context of the time. The end of the nineteenth century and the early twentieth century were epochs that valorized great men, as the case of Galton illustrates. But Galton was not the only individual to hold such a view. Many authors devoted themselves to the study of genius and its sources (heredity or environment), because of the contribution of genius to "civilization". [157] Also, many believed that the stock and, above all, the quality of populations was declining because the "unfit" were reproducing at a greater rate than the professional classes, from which most eminent men came. [158] Together with Galton, the British statistician K. Pearson was a good representative of this eugenics rhetoric: we cannot recruit the nation from its inferior stocks without deteriorating our national character". [159] To Pearson, the "terrible fall in our birth-rate since 1877 has been a differential fall. It is a fall which concerns chiefly the fitter

involved in research); reputation as a measure of performance rather than ability; subjective estimates of judges.

[155] J. M. Cattell (1922), The Order of Scientific Merit, *op. cit*., p. 547.

[156] J. M. Cattell (1910), A Further Statistical Study of American Men of Science II, *op. cit*., p. 688.

[157] For statistical studies of the time on eminent men, see: C. Lombroso (1891), *The Man of Genius*, London: Walter Scott; A. Odin (1895), *Genèse des grands hommes: gens de lettres français modernes*, Paris: Welter; H. Ellis (1904), *A Study of British Genius*, London: Hurst and Blackett; P. Jacoby (1904), *La sélection chez l'homme*, Paris: Félix Alcan; F. Adams Woods (1906), *Mental and Moral Heredity in Royalty: A Statistical Study in History and Psychology*, New York: Holt; S. Nearing (1914), The Geographical Distribution of American Genius, *Popular Science Monthly*, 85, pp. 189-199; S. Nearing (1916), The Younger Generation of American Genius, *Scientific Monthly*, 2 (1), pp. 48-61; E. L. Clarke (1916), *American Men of Letters: Their Nature and Nurture*, New York: Columbia University; E. Huntington and L. F. Whitney (1927), *The Builders of America*, New York: William Morrow.

[158] D. Pick (1989), Faces of Degeneration: A European Disorder, c.1848-c.1918, *op. cit*.; R. A. Soloway (1990), Demography and Degeneration: Eugenics and the Declining Birthrate in Twentieth-Century Britain, *op. cit*.

[159] K. Pearson (1901), *National Life from the Standpoint of Science*, London: Adam and Charles Black, p. 28.

members of all classes. The fitter of all classes, from the artisan to the executive, have fewer and fewer children, but the unfit maintain their old numbers”. [160]

For a while, Cattell was a eugenics sympathizer and, as discussed above, one of his first statistical studies was on eminent men. When he turned to science specifically, men were therefore the immediate unit he imagined for statistics. And he chose to measure the cream of the crop, or men of the highest ability, those he identified with a star. However, with time, a very short time indeed (1903-1906), Cattell seems to have changed his mind and departed from ideas on the hereditary basis for scientific excellence. [161] His thoughts became more nuanced, as he explained in 1914: “We do not know whether the progress of civilization has in the main been due to great men who have directed it, or whether these are essentially by-products and epiphenomena of social and economic forces”. [162] Cattell’s own conviction was: “What a man can do is prescribed at birth; what he does depends on opportunity”. [163] To Cattell, social and economic opportunities were as important as heredity, and this explains why he put stress on the socioeconomic conditions of men of science in his country. Cattell’s personal background and experience, as a man of science, is partly responsible for this change of mind.

Cattell’s Biography

Cattell owed his interest in statistics partly to his training. As an experimental psychologist, Cattell was well acquainted with measurement, and very early in his career he had occasion to meet and work with Galton in London. Cattell’s program on mental testing, however, came to a halt in the early 1900s: he began being criticized for the narrowness of his approach. The tests developed by the French psychologist Alfred Binet

---

[160] K. Pearson (1913), *Nature and Nurture: the Problem of the Future*, Cambridge: Cambridge University Press, p. 28. See also: K. Pearson (1909), *The Scope and Importance to the State of the Science of National Eugenics*, London: Dulau and Co.

[161] The heredity/environment issue led to a debate between Cattell and F. A. Woods, author of *Mental and Moral Heredity in Royalty*, *op. cit*. See: *Science* (1909), American Men of Science and the Question of Heredity, 30 (763), August 13, pp. 205-210.

[162] J. M. Cattell (1914), Democracy in University Administration, *Science*, 39 (1005), April 3, pp. 491-496, p. 494.

[163] J. M. Cattell (1914), Science, Education and Democracy, *Science*, 39 (996), January 30, pp. 158.

came to be preferred to his own. This was his first professional setback.[164] Cattell turned to the cause of the advancement of science by way of editing *Science*, among others journals, and by collecting statistics.

A second professional setback occurred in 1917: Cattell was dismissed as a professor from Columbia University. [165] This decision was the outcome of years of his criticizing university administrators. To Cattell, the growth of universities had transformed the institutions into bureaucratic machines. “We appear at present to be between the Scylla of presidential autocracy and the Charybdis of faculty and trustees incompetence”. [166] To Cattell, universities had lost their spontaneity and creativity. Dogmatism, formalism, discipline, routine, control, machinery and efficiency were the terms he used to characterize the modern American university. [167] Briefly stated, “the methods of business corporation and the political machine have been somewhat wantonly applied to educational administration”. [168]

Cattell’s public criticisms appeared in a series of three papers published in *Science* and entitled *University Control,* among others. [169] His main target was university presidents: “In the academic jungle the president is my black beast (…). The time of the president is largely occupied with trying to correct or to explain the mistakes he has made”. [170] To Cattell, “that the president should decide which professor shall de discharged and which have his salary advanced, which department or line of work shall be favored or crippled, is the most sinister side of our present system of university administration”. [171] To support his views, Cattell enrolled the opinions of his colleagues. In 1911, he used the list

---

[164] Cattell’s method of order-of-merit (ranking) remained quite influential, however.

[165] For Cattell’s point of view on the dismissal, see: J. M. Cattell (1917), Columbia University and Professor Cattell, *Science*, 46 (1189), October 12, pp. 363-364. For an analysis of the dismissal, see: C. S. Gruber (1975), *Mars and Minerva: World War I and the Uses of Higher Learning in America*, Baton Rouge: Louisiana State University Press, pp. 187s.

[166] J. M. Cattell (1906), University Control, *Science*, 23 (586), March 23, pp. 475-477, p. 476.

[167] J. M. Cattell (1912), University Control, *Science*, 35 (908), May 24, pp. 797-808.

[168] *Ibid*, p. 803.

[169] J. M. Cattell (1906), University Control, *op. cit.*; J. M. Cattell (1912), University Control, *op. cit.*; J. M. Cattell (1912), University Control II, *Science*, 35 (909), May 31, pp. 842-860. See also: J. M. Cattell (1914), Democracy in University Administration, *op. cit*.

[170] J. M. Cattell (1912), University Control II, *op. cit.*, p. 845.

[171] *Ibid*, p. 848.

of *American Men of Science* and asked starred men of science for their opinions on a proposal for reforming universities. 299 replies were received. 85% favoured a plan of representative democracy and limits to the powers of the president. These public positions were detrimental to Cattell's career as a professor. What he deplored, namely that "a university which dismisses professors when the president thinks that they are inefficient or lacking in loyalty to him is parasitic on the great academic traditions of the past and of other nations", [172] was in fact done to him in 1917.

It is no surprise then that, to Cattell, statistics were seen as part of the solution to administrative abuses because of their objectivity. At several points, Cattell indicated how his numbers could help enlighten decisions. In 1910, he suggested that the rankings could inform a student's choice of university: "Students should certainly use every effort to attend institutions having large proportions of men of distinction among their instructors". [173] After 1917, it was the method of votes he used to rank men of science by order of merit that was presented as having useful applications: in industry, for selecting those most deserving promotion (a selection free from favouritism), even for selecting a boss; in university, for the payment of salaries that would no longer depend on the choice of the president, but on a procedure that would be "more conductive to cooperation and goodwill". [174]

And there were further uses of statistics. Universities were only one of the two types of institutions Cattell criticized. The other was Academies. As early as 1902, Cattell qualified the national and regional American academies of science as stationary and atrophied in condition: [175] "Membership in an academy as an honor, the presidency as a distinction, foreign members, medals, prizes and the like, seem to me to belong to the childhood of science (…). We need a center in each community for organization and social intercourse. As capitalists unite in corporations and laborers in trade unions, so

[172] J. M. Cattell (1912), University Control II, *op. cit.*, p. 849.
[173] J. M. Cattell (1910), A Further Statistical Study of American Men of Science II, *op. cit*., p. 681.
[174] J. M. Cattell (1922), The Order of Scientific Merit, *op. cit*., p. 542.
[175] J. M. Cattell (1902), The Academy of Sciences, *Science*, 16 (416), December 19, pp. 965-974.

men of science should unite in their academies”. [176] To Cattell, this “center” was the AAAS, the organization to which he contributed over all his life. [177] His statistical work reflected these ideas. He preferred consulting peers and drawing statistics from their rankings in order to assess contributions to science or performance: measuring merit was more objective than elections to an honourary institution with “modest functions”. And he suggested that statistical rankings should be used as a substitute for votes in scientific societies, as the directory already was, according to him, in official bodies “in connection with appointments, awards, the acceptance for publication of manuscripts and the like”. [178]

Conclusion

Cattell launched a whole field of study, scientometrics, a specialty concerned with measuring science in a systematic way. He did so with a unique tool that occupied him (and his son Jaques). As editor of the journal *Science*, but also as a member of committees and boards of several scientific organizations, among them the executive committee of the AAAS, Cattell had been a valuable advocate for the scientific community for almost fifty years. But it was statistics, he hoped, that would contribute to the enlightenment of the public. He devoted enormous energies to counting men of science and drawing comparisons in order to measure scientific “productivity”: nations, states, cities and universities that produced more men of science were encouraged to continue to do so; those that produced less were invited to increase their productivity.

Statistics on science emerged in an intellectual context characterized by interest in great men as builders of civilization. Accordingly, every measurement was concerned with measuring men. This was Galton’s and Cattell’s orientation, but also that of other, more sporadic, measurements on science based on biographical dictionaries like *Who’s Who*,

[176] *Ibid*, p. 974.
[177] In *The Organization of Scientific Men* (1922), Cattell contrasted the commitment to democracy of the AAAS to the aristocratic character of the National Academy of Sciences: a “social club”, “wrapped in the inertia of its great traditions and bearing the Atlantean load of a crystallized earth”, and “where members write obituaries of each other when they die”.
[178] J. M. Cattell (1937), The Sixth Edition of the Biographical Directory of American Men of Science, *op. cit*., p. 265.

[179] or membership lists of institutions like Academies. [180] Related to this question of great men was that of heredity/environment. While Galton opted for heredity, with much difficulty in proving his case, even contradicting himself in *English Men of Science*, Cattell believed in environment, or opportunities. His interest in the advancement of science arose from his recognition that opportunities, or the then-current economic conditions of men of science, were detrimental to research. Statistics were developed to document the case.

Galton and Cattell Statistical Analyses

	Galton	**Cattell**
Objective	Improvement of the race	Advancement of science
Unit	Eminent men [(1)]	Men of science (research)
Problem	Decline in number of kinships	Lack of opportunities for research
Cause	Heredity	Environment
Solution	Selection	Conditions of work
Statistics		
Sources	Dictionaries	Directory
	Survey	Survey
Concepts	Productivity	Productivity
	Scale of ability	Order of merit

[(1)] Men of science were looked at only as part of eminent men or geniuses.

Cattell's personal background is as important as the intellectual and socioeconomic context in explaining his interest in statistics and the use he made of them. As an

[179] The first editions appeared in 1899.
[180] L. Levi (1869), On the Progress of Learned Societies, *op. cit*.; L. Levi (1869), A Scientific Census, *op. cit*; L. Levi (1879), The Scientific Societies in Relation to the Advancement of Science in the United Kingdom, *op. cit*.; A. de Candolle (1873), Histoire des sciences et des savants depuis deux siècles, d'après l'opinion des principales académies ou sociétés scientifiques, *op. cit*.; E. C. Pickering (1908), Foreign Associates of National Societies, *op. cit*; E. C. Pickering (1909), Foreign Associates of National Societies II, *op. cit*.; R. Pearl (1925), Vital Statistics of the National Academy of Sciences, *Proceedings of the National Academy of Sciences*, 11, pp. 752-768; R. Pearl (1926), Vital Statistics of the National Academy

experimental psychologist, Cattell had already mastered measurement techniques. He learned how to apply them to men of science when he studied Galton's work. After his program on mental testing failed, because of alternative and more focused tests from France, he turned to this kind of statistics. The orientation he gave to his statistics was influenced by his ideas about universities. Cattell believed in freedom, democracy and the scientific community (peers). To Cattell, the ideal model of a university was the medieval university and the nineteenth century German university, a time when the university was its men. [181] He thought statistics, because they are objective, could and should be used for decisions in university affairs as a substitute for administrators' *manoeuvres* of control, for academies' elections of eminent members, and for evaluation of performance.

Cattell's directory and statistical analyses have had a notable impact on both academic and official measurements of science. For twenty-five years (1922-1947), S. S. Visher from Indiana University (geography) published regular statistical analyses of the directory in many journals, looking at geographical distribution, training, age, birthplace, race, family background and influences on the decision to become scientist. [182] Equally, historians and sociologists started measuring science the way Cattell had done, that is, by counting the number of men of science across nations. [183] Derek Price, an advocate of bibliometrics (counting papers and citations), used Cattell's directory to document his laws of scientific progress, namely the prediction of leveling off in the number of men of science. [184] At about the same time, psychologists also started looking at men of science from a quantitative point of view in order to study scientific creativity. [185] With regard to

of Sciences, *Proceedings of the National Academy of Sciences*, 12, pp. 258-261; A. Schuster (1925), On the Life Statistics of Fellows of the Royal Society, *Proceedings of the Royal Society*, A107, pp. 368-376.

[181] "The medieval university (…) was extraordinarily un-hierarchical, democratic, anarchic, in its organization. The university was then, as it now should be, the professors and the students. The professors (…) had complete control of the conditions under which degrees were given and in the selection of their colleagues and successors (…). Its great performance was in large measure due to this freedom" (p. 798). J. M. Cattell (1912), University Control, *op. cit*.

[182] The studies are collected in S. S. Visher (1947), Scientists Starred 1903-1943 in American Men of Science, *op. cit*.

[183] G. Sarton (1923), History of Science, *Carnegie Institution of Washington Yearbook*, 22, pp. 335-337; P. A. Sorokin and R. K. Merton (1935), The Course of Arabian Intellectual Development, 700-1300 A.D.: A Study in Method, *ISIS*, 22, pp. 516-524.

[184] D. S. Price (1963), *Little Science, Big Science*, New York: Columbia University Press.

[185] See, for example, the collection of papers from the 1930s and later by H. C. Lehman, reprinted in *Age and Achievement* (1953), Princeton: Princeton University Press.

official measurements, the US National Resources Committee used *American Men of Science* for statistics in the first report on government research in the United States (1938). [186] The US Bureau of Labor Statistics and the Department of Defense also used the directory for measuring qualified personnel in the country. [187] In 1949, the Office of Naval Research joined the National Research Council as co-editor of the eighth edition of the directory. Of equal influence, *American Men of Science* served as model for similar directories in government. [188]

After World War II, counting men of science systematically got into the official measurement of science, and came to be standardized by way of what is known as the OECD Frascati manual. [189] It also offered scientists a powerful tool to lobby for funds. Shortly, the scientific community and its organizations would develop a discourse on shortages of scientists, and government organizations on gaps with the USSR in scientific manpower. The rhetoric was used, with success, to persuade the public and the President to devote increasing sums of money to scientific research, above all basic research. [190]

Cattell used two concepts for measuring science. These have remained with us since, and define the current efforts at measuring science: productivity and performance. The concepts measured quantity and quality. Today, counting scientific papers and citations are representatives of the respective concepts. What has changed since Cattell is that

---

[186] National Resources Committee (1938), *Research: A National Resource (I): Relation of the Federal Government to Research,* Washington: USGPO.

[187] US Department of Labor (1951), *Employment, Education, and Earnings of American Men of Science*, Bureau of Labor Statistics, in cooperation with the Department of Defense, Bulletin no. 1027, Washington. At the same time, the American Society for Engineering Education also used the directory: Engineering College Research Council (1951*), University Research Potential: A Survey of the Resources for Scientific and Engineering Research in American Colleges and Universities*, Committee on Relations with Military Research Agencies, in collaboration with the Research and Development Board of the Office of the Secretary of Defense, Washington.

[188] National Resources Planning Board (1942), *National Roster of Scientific and Specialized Personnel*, Washington. In 1952, the roster was transferred to the National Science Foundation, charged with developing the instrument further. National Science Foundation (1961), *The National Register of Scientific and Technical Personnel,* NSF 61-46, Washington. Other rosters were also established in the Office of Naval Research: one on top scientific personnel (1948) and another on engineering personnel (1949).

[189] OECD (1962), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development*, DAS/PD/62.47, Paris.

[190] B. Godin (2005), *Measurement and Statistics on Science and Technology: 1920 to the Present*, London: Routledge, chapter 13.

counting men of science is no longer the statistics *par excellence*. Money devoted to R&D is now the preferred statistics. Admittedly, Cattell did produce some financial data. Using *Science* as a vehicle, he published several lists of institutional funds (grants) for research starting in 1903, [191] and organized the AAAS Committee of One Hundred concerned with the collection of information on grants for scientific research, whose (quite imperfect and incomplete) lists were published between 1916 and 1918. [192] But this kind of data was sporadic. From the 1920s on, however, interest in organizations, accounting and efficiency replaced interest in great men, and statistics on science started to become institutionalized. [193] After World War II, money devoted to R&D became the most cherished indicator although, according to several experts, statistics on men of science remained the more robust and the most reliable. [194]

[191] Like the Carnegie Institution. See: *Science* (1903), Grants Made by the Carnegie Institution, 18 (469), December 25, pp. 801-822. The British journal *Nature* published such lists as early as 1872. See *Nature* (1872), The British Association, 6, August 29, p. 357.
[192] C. R. Cross (1916), Grants for Scientific Research, *Science*, 43 (1115), May 12, pp. 680-681; C. R. Cross (1916), Grants for Scientific Research, *Science*, 44 (1124), July 14, pp. 50-51; C. R. Cross (1916), Grants for Scientific Research, *Science*, 44 (1129), August 18, pp. 229-232.
[193] B. Godin (2005), Measurement and Statistics on Science and Technology, *op. cit.*
[194] R. N. Anthony (1951), *Selected Operating Data for Industrial Research Laboratories*, Harvard Business School, Boston (Mass.), pp. 3-4: "In view of these difficulties [accounting methods and definitions], we decided to collect only a few dollar figures (…) and to place most of our emphasis on the number of persons"; W. H. Shapley (1959), in National Science Foundation, *Methodological Aspects of Statistics on R&D: Costs and Manpower*, NSF 59-36, Washington, p. 13: "Manpower rather than dollars may be a preferable and more meaningful unit of measurement"; C. Freeman (1962), Research and Development: A Comparison Between British and American Industry, *National Institute Economic Review*, 20, May, p. 24: "The figures of scientific manpower are probably more reliable than those of expenditures"; C. Falk, and A. Fechter (1981), *The Importance of Scientific and Technical Personnel Data and Data Collection Methods Used in the United States*, Paper presented for the OECD Workshop on the Measurement of Stocks of Scientific and Technical Personnel, October 12-13, 1981, p. 2: "At the current time scientific and technical personnel data seem to be the only feasible indicator of overall scientific and technical potential and capability and as such represent a most valuable, if not essential, tool for S&T policy formulation and planning".

Appendix.

Cattell's Memorandum to Peer Judges of Scientific Merit

The undersigned is making a study of American men of science. The first problem to be considered is the distribution of scientific men among the sciences and in different regions, institutions, etc. including the relative rank of this country as compared with other countries in the different sciences, the relative strength of different universities, etc. It is intended that the study shall be continued beyond the facts of distribution to what may be called the natural history of scientific men.

For these purposes a list of scientific men in each science, arranged approximately in the order of merit, is needed. This can best be secured if those who are most competent to form an opinion will independently make the arrangement. The average of such arrangements will give the most valid order, and the degree of validity will be indicated by the variation or probable error of position for each individual.

It is obvious that such an order can be only approximate, and for the objects in view an approximation is all that is needed. The judgments are possible, because they are as a matter of fact made in elections to a society of limited membership, in filling chairs at a university, etc. By merit is understood contributions to the advancement of science, primarily by research, but teaching, administration, editing, the compilation of text-books, etc., should be considered. The different factors that make a man efficient in advancing science must be roughly balanced. An effort may be made later to disentangle these factors.

In ranking a man in a given science his contributions to that science only should be considered. Thus, an eminent astronomer may also be a mathematician, but in ranking him as a mathematician only his contributions to mathematics should be regarded. In such a case, however, mathematics should be given its widest interpretation. It is more difficult to arrange the order when the work cannot readily be compared, as, for example, systematic zoology and morphology, but, as already stated, it is only expected that the arrangement shall be approximate. The men should be ranked for work actually accomplished, – that is, a man of sixty and a man of forty, having done about the same amount of work, should come near together, though the man of forty has more promise. It may be possible later to calculate a man's value with allowance for age.

In case there is noted the omission of any scientific man from the list who should probably have a place in the first three quarters, a slip may be added in the proper place with his name and address. In case there are names on the list regarding which nothing is known, the slips should be placed together at the end. The slips, as arranged in order, should be tied together and returned to the undersigned.

It is not intended that the lists shall be published, at all events not within ten years. No individual list will be published. They will be destroyed when the averages have been calculated, and the arrangements will be regarded as strictly confidential.