Charles Spearman: Founder of the London School

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Charles Spearman - Courtesy of University College, London

Few would dispute the claim that Charles Edward Spearman (1863-1945) is Britain's premier psychologist and indeed one of the enduring figures in the history of behavioral science. Some twenty years ago, I asked a number of psychologists to list the names of whomever they considered to be the five or six most important persons in the history of psychological testing. Among all the nominations, only three names were common to everyone's list: Galton, Binet, and Spearman. If Galton was the father of psychometrics, Spearman was its chief developer, architect, and engineer. He is far more famous today and much more frequently cited in the literature than any of his contemporaries in academic psychology in the first half of the twentieth century. In fact, citations of Spearman's works in the technical journals have steadily increased since his death in 1945 and markedly so since about 1970. And the number of references to Spearman's major contributions continues to climb. This accelerated rate of citations is an exceptionally rare phenomenon, as the annual number of citations of most scientists' publications typically decline rapidly after they deaths. Their individual contributions are either forgotten or are amalgamated with the accumulated empirical background of their special field without any lasting personal identity.

At least four reasons account for Spearman's lasting and even growing renown:

(1) His theoretical and methodological contributions were notably creative and original and have been continually used and developed further over the last fifty years.

(2) They have engendered controversy, theoretical arguments, and an increasing rate of empirical research testing his theories.

(3) The chief topic of his research – the nature and causes of variation in human intelligence – has attracted enormous interest with the spread of universal public education, the visibly increased range of individual differences in educability and scholastic performance in the school-age population, and the increasing cognitive requirements for employability in the technological, information-intensive modern world.

(4) Finally, Spearman established a coherent scientific approach to the study of variation in human behavioral traits that came to be known as the London School, so named because his work and influence were associated with his position as professor (and head)) of the

Department of Psychology in University College, London. The London School's essential aim is the advancement of psychology as an empirical, quantitative, biological science. Specifically, it has focused on the measurement and taxonomy of individual differences in human mental abilities and personality traits and the investigation of their nature and nurture, that is to say, the genetic and environmental factors responsible for the wide range of differences between individuals in all psychological or behavioral characteristics. Researchers pursuing the aims of the London School are inescapably indebted to Spearman's pioneer efforts. Moreover, even today they continue to find in his works many key insights and hypotheses for empirical investigation.

The London School, though most directly formed by Spearman, actually had its roots in the works of Charles Darwin (1809-1882) and especially those of Darwin's half-cousin Sir Francis Galton (1822-1911). Spearman acknowledged Galton as having the greatest influence on his own activity in psychology. In recent years, the London School's centre of gravity has shifted from London to the University of Edinburgh, where its most industrious exponent today is Ian Deary, the Professor of Psychology there. Previous luminaries of the London School were Professors Sir Cyril Burt and Hans Eysenck, both of the University of London (and both Fellows of the Galton Institute).

Born into a well established family in London in 1863, Spearman attended private schools, where he showed strong interests in mathematics, science, and what he refers to in his brief autobiography as a "secret devotion to philosophy," saying that, as an adolescent, his "deepest urge was to probe further into the nature of existence, knowledge and goodness" (1930, p.299). In college, he majored in engineering, and because he had become interested in the philosophies of India, he secured a commission in the Royal Engineers of the British Army in hopes that he might be stationed in India. Instead, he was sent to Burma, where his distinguished service in civil engineering won him a medal and promotion to the rank of major. His continuing study of philosophy led him to believe that the debated issues in philosophy could be properly dealt with only through the development of psychology as an empirically testable science. Hence, at the age of 34, he resigned his commission and went to Leipzig, Germany, to study experimental psychology in the laboratory of Wilhelm Wundt (1832-1920). At that time, Wundt headed the only university department in the world that awarded a Ph.D. degree in psychology. He is now generally acknowledged as the founder of experimental psychology, as Galton is known as the founder of differential psychology (which includes psychometrics and behaviour genetics). Spearman wrote of his 14 years of army service as "¼ the greatest mistake of my life ¼ [based on] the youthful delusion that life is long. For these almost wasted years, I have since mourned as bitterly as ever Tiberius did for his lost legions." (1930, p. 300) Yet in the midst of his stay in Leipzig, his doctoral study was interrupted for nearly three years by his being recalled to military service during the Boer War. After returning to Leipzig to complete his last two years of study, he was awarded his Ph.D. degree. He was by then a married man, age 42, but with probably far more distinguished scientific accomplishments to his credit than probably any other new PhD in the history of psychology.

Though Wundt inspired Spearman's admiration and devotion, he was not the major influence on Spearman's thinking. That decisive influence came, while Spearman was still a doctoral student, from reading Galton's book *Inquiries into Human Faculty and Its Development* (1883), probably the first important work in differential psychology, the study of individual differences. This was followed up by reading Galton's *Hereditary Genius* (1869). Two aspects of Galton's works especially attracted Spearman: first, Galton's idea of measuring individual differences in sensory, motor, and cognitive abilities precisely in the laboratory by means of specially devised apparatuses and techniques; and second, Galton's notion of individual differences in a general mental ability that enters into every kind of sensory and mental activity that involves discrimination or choice. Galton theorised that individual differences in this mostly hereditary

general ability is the main cause of the wide range of variation in individuals' lifetime achievements, along with such supporting personality traits as zeal and persistence of effort. However, when experimental tests of Galton's theory that acuteness of sensory discrimination would reflect differences in the general ability association with intellectual achievement were performed in 1901 in America, in James McKeen Cattell's psychological laboratory in Columbia University, the results appeared to refute Galton's conjecture. In fact, Galton's own research, based on thousands of persons tested in his own laboratory in the South Kensington Science Museum (now the Victoria and Albert Museum), hardly appeared any more promising. These discouraging findings, which cast a pall over Galton's approach to the measurement of mental ability for many decades, produced an effect just the opposite of discouragement for Spearman. They aroused his strong investigative zeal. Still a student, with the most meager of resources at his disposal (and without the approval of his mentor Wundt, whose research interests were quite different from Galton's) Spearman performed a study with school children to test the Galtonian notion that individual differences in sensory discrimination were positively correlated across different sensory modalities and were also positively correlated with mental ability as reflected in school grades, test scores in various scholastic subjects, and teachers' subjective rankings of their pupils' levels of intelligence. The results of his study, when the data were subjected to innovative types of statistical analysis first invented by Spearman, supported Galton's position. Spearman noted that the earlier, discouraging investigations had not taken proper account of the effects of measurement error and restriction of the range of ability (in college students highly selected for intelligence). To overcome these effects, Spearman invented the now well-known "correction for attenuation" of the correlation coefficient, permitting a calculation of the correlation between two variables as if each had been measured perfectly, without any measurement error. While still a student, Spearman published this work in 1904 in an article titled "'General intelligence' objectively determined and measured" in the prestigious *American Journal of Psychology*. Although its findings supported Galton's theory of general ability, by far its most important contribution was its methodology. Spearman had invented a rigorous mathematical method, which later became known as factor analysis, for proving the existence of a general factor of mental ability (which he termed the *g* factor) that enters into all cognitive tasks, however diverse they may be. Spearman's 1904 article on this experiment is now regarded as one of the great classics in the history of psychology. It has even shown an increasing rate of citations over the past fifty years. This article and his later book *The Abilities of Man* (1927) are now generally regarded as Spearman's most important works. By comparison, his 1906 PhD thesis on a typically Wundtian subject, "Illusions in Spatial Perception," has remained in total obscurity.

Already with a brilliant reputation from his 1904 article, Spearman, in 1907 at age 43, was appointed to the considerable position of Reader in Psychology in University College, London. Four years later he was promoted to professor and head of the psychology department, a position he held until his retirement, in 1932, when he was succeeded by Cyril Burt (1883-1971). During his career, Spearman received many academic honors, including Fellow of the Royal Society and membership in the United States National Academy of Science. He became a Fellow of the Eugenics Society of London (later renamed The Galton Institute) early in his career, and expressed his eugenic opinions in a more hard boiled fashion than ever did Galton himself, writing in 1912, for example, "One can conceive the establishment of a minimum index [of general intelligence] to qualify for parliamentary vote, and above all, for the right to have offspring." In 1945, with failing health at age 82, he committed suicide by jumping from the top story of the London University Hospital, where he was a patient.

A proper exposition of Spearman's scientific legacy is beyond the scope of this brief sketch, but they have has been summarised elsewhere (see References). Here, in capsule form, are his best recognised contributions:

Spearman is known as the father of classical test theory, which treats a measurement (e.g. a numerical score on a test item or on a whole test composed of various items) as consisting of a "true score" (t) plus an "error" component (e). That is, an observed score X = t + e. From this simple formulation many features of psychometric tests can be derived and quantified, such as the test's reliability. The Spearman-Brown prophecy formula, for example, predicts the length of test (i.e. number of test items) needed to achieve a specified level of reliability (i.e., the proportion of true-score variance).

Spearman's best know and most widely used contribution to statistical methods is the rank-order coefficient of correlation, a nonparametric and scale-free index of association between two variables generally used when the correlated variables are only an ordinal scale or when the parametric statistical assumptions required of Pearson's interclass correlation coefficient or of Fisher's intraclass correlation are not met.

The invention of a mathematical technique known as *factor analysis* is generally attributed to Spearman, but the form of factor analysis he invented and was the first to apply in psychology has long since been replaced by more complex methods essentially derived from Karl Pearson's invention of principal components analysis in 1901. Spearman, however, was the first to conceive of a number of different observed variables (e.g. scores on various mental tests) as reflections of some smaller number of hypothetical, or *latent*, variables which could be more or less precisely determined by a factor analysis of the matrix of correlations among all of the observed variables. Thus Spearman was really the founder of an important aspect of psychometrics known today as *latent trait theory*. In 1904, this was a profound and highly innovative insight, and Spearman's mathematical implementation of it was a major achievement.

The identification of a *general factor* of individual differences in all mental abilities, which Spearman called simply *g* (strictly eschewing the term 'intelligence'), is undoubtedly his most important empirical discovery. Just as physicists can describe precisely the conditions under which the effects of gravitation can be observed and measured, Spearman showed how the effects of his *g* factor can be observed and measured. It is not itself an ability, but some property of the brain that causes all forms of mental abilities (at least all those that psychometricians have been able to measure) to be positively correlated. The great variety of mental tests, however diverse in information content, skills, and task demands, all measure something in common, but to varying degrees. The common factor is *g*. Spearman at first argued that the true scores on each mental test reflected only two factors – the *g* factor common to all tests and also a factor that is *specific* to each particular test. It was known as the 'two-factor theory' of mental abilities. Further studies based on larger numbers of diverse tests made it apparent that although all mental tests reflect *g* in common, there are groups of rather similar tests (e.g., verbal, numerical, spatial, mechanical, etc.) that also have other factors in common besides just *g*. Spearman noted that the kinds of tests that are most highly "loaded" with the *g* factor are those that call for "the eduction of relations and correlates" and evince "abstractness." Although he could measure quite precisely by means of factor analysis the degree to which a given test is *g*-loaded (ranging on a scale from 0 to 1), he never discovered the neurophysiological cause(s) of *g*. He could only refer to *g* metaphorically as some form of "mental energy" in which people differ and which various mental tests elicit to different degrees. The underlying physiological causes of individual differences in *g* are still largely a mystery, but we now know that *g* is more genetically heritable than are any other ability factors measurable by mental tests and that *g* has more anatomical and physiological brain correlates than any other psychometric factors. Variables such as brain size, nerve conduction velocity, the amplitude of evoked brain waves, and the brain's glucose metabolic rate while performing mental tasks are all correlated with *g*. One of the liveliest fields of research in the cognitive neurosciences today is the search for the physical basis of *g*. Spearman himself foresaw this development, but he knew it could be realised only with a technology far in

advance of his time. That technology is now available for present-day brain research. It provides the means whereby, in Spearman's words, "physiology will achieve the greatest of all its triumphs" (1927, p. 408).

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