LOUIS LEON THURSTONE
1887—1955

A Biographical Memoir by
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Biographical Memoir

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On September 19, 1955, one of the world’s greatest psychologists passed from the scene. It is quite appropriate to say that Louis Leon Thurstone was to psychology of the first half of the twentieth century what Gustav Theodore Fechner was to the last half of the nineteenth. Fechner was the father of quantitative psychology; Thurstone was its chief torchbearer in recent years. In addition to his many novel contributions during the past thirty years, we have as memorials to him the Psychometric Society and the journal Psychometrika, both of which were founded through his initiative. Their motto was essentially his own motto: The development of psychology as a quantitative, rational science.

Thurstone was born in Chicago, May 19, 1887, to parents of native Swedish stock. The family name was Thunström but was later changed to a form that would better suit the American scene. His father had been an instructor in mathematics in the Swedish Army, and later became, in turn, a Lutheran minister, a newspaper editor, and a publisher. His mother was interested in music and musically talented. Leon and his sister, Adele, two years younger, started piano lessons when quite young. Leon showed a transitory interest in composing, whereas Adele later completed a college degree in music.

Thurstone’s elementary education was obtained at several places—Berwyn, Illinois; Centerville, Mississippi; Stockholm, Sweden (both public and private schools); and Jamestown, New York. High
school was completed in Jamestown. In high school he won a competition in geometry. With some of the prize money he purchased a Kodak, which marked the beginning of a lifelong hobby of photography, in which he later demonstrated considerable artistic skill. As a sophomore, his first notable literary effort was in the form of a letter on "How to Save Niagara," which appeared in the *Scientific American*. This was an attempt to solve the problem of utilizing large portions of Niagara's waters for power purposes while preserving the beauty of the falls, a lively issue at the time.

His second publication, also in the *Scientific American*, demonstrated his potentialities for creative thinking. As a high school sophomore he developed a geometric method for trisecting an angle, a solution that went beyond Euclidian geometry. Later, in college, he developed an equation for his solution.

Enrolled in electrical engineering at Cornell, Thurstone took a special interest in experiments in physics of the singing arc. The experiments took the direction of a method by which sounds could be recorded on film. He also worked on the designing of a new type of motion-picture camera and projector that eliminated flicker completely by means of a continuously running film.

His first notable interests in psychology arose during his studies of engineering at Cornell. A course on machine design particularly appealed to him. In this connection he was struck by the fact that among the problems of machine design are some concerned with the properties of the men who are to operate the machines. Today, of course, there is a growing effort and body of information along these lines, sometimes included under the heading of "human engineering." He also became interested in human learning as a scientific problem and attended a few lectures in psychology.

Having constructed a working model of his motion-picture projector, on which he secured a patent, he succeeded in having it demonstrated at the Thomas A. Edison laboratory. Although Edison was reported as being impressed, he did not decide to change over to the production of Thurstone's model. He did, however, offer
Thurstone a position in his laboratory, which Thurstone accepted effective upon his graduation from Cornell. Thurstone's observations of the way in which Edison went about his work undoubtedly had much to do with his interest in the psychology of creative thinking, later in life.

His stay in the Edison laboratory was brief, owing to his desire to return to an academic setting. In the fall of 1912, Thurstone became instructor in engineering at the University of Minnesota, where he taught descriptive geometry and drafting. There he took his first course in experimental psychology and started his study of the learning function (performance as a function of practice time). In the summer of 1914 he started graduate work in psychology at the University of Chicago. A fellow student, now rather noted in other fields, was Beardsley Ruml.

In the fall of 1915, Thurstone accepted an assistantship in the new and active Department of Psychology at the Carnegie Institute of Technology, where the emphasis was on research in applied psychology. Earning his doctorate from Chicago in 1917, he was rapidly promoted at Carnegie, until he was Professor and head of the department in 1920, a position that he held until 1923. His wartime service included work in the trade-test division of the Army, where his methods of testing and of test appraising were put to use. In 1923 and 1924 he devoted a time to research in the Institute of Government, research aimed at the improvement of civil service practices. His efforts in this connection, and his later counsel, have had lasting effects upon the civil service.

In the summer of 1924 he was married to Thelma Gwinn whom he had known as a graduate student in psychology. That fall he became Associate Professor of Psychology at the University of Chicago. Subsequent academic assignments, briefly listed, include appointment to full professorship in 1928 and to Charles F. Gray Distinguished Service Professor in 1938. In the meantime, he established and directed the Psychometric Laboratory in the Social Sciences Division, in which capacity he continued until his retirement from Chicago in 1952. He had much to do with the institution
of the unique examining system at Chicago and with its policies and practices in the Board of Examinations. During the year 1948-1949 he was visiting professor at the University of Frankfort. In the spring semester of 1954 he was visiting professor at the University of Stockholm and lectured at other Swedish universities as well as at the universities of Helsinki and Oslo. Upon his retirement from Chicago he became Research Professor and Director of the Psychometric Laboratory at the University of North Carolina, which was his affiliation at the time of his death.

Thurstone's contributions to psychological measurement grew out of his dissatisfaction with psychology as he found it. For example, little or no attention had been given to the description of learning curves in terms of mathematical equations. In connection with his doctoral dissertation Thurstone found that a large number of different empirical equations might be applied. In 1930 he published the derivation of the first general, rational equation for a learning curve. He demonstrated that under certain, somewhat standard conditions the learning function is S-shaped. From his general function he deduced other relationships, which have been supported by learning data. For example, he deduced that learning varies as the 3/2 power of the number of items (beyond the memory span) in a memorized list.

He very early observed that practices of psychological testing were developing apparently without adequate foundations of theory to support them. He proceeded to do something about this from two directions, psychological and statistical. A major contribution to psychological theory was in his monograph on intelligence, which appeared in 1924. He developed and supported the thesis that the degree of intelligence is related to the degree of incompleteness of an act at which it becomes focal in consciousness. Becoming highly aware of an act during its early stages offers much opportunity to bring to bear upon it a wider range of choice or determination. This conception was poorly understood and Thurstone himself did
little more to investigate intelligence from this particular point of view, at least explicitly.

From the standpoint of statistically oriented theory, Thurstone's new conceptions of testing were decidedly more notable. One of his chief, early concerns had to do with the development of a rational metric for mental ability. He rejected raw-score scales and mental-age scales because of uncertainty concerning equality of units and location of a meaningful zero point. He developed a method called "absolute scaling," based upon the concept of item difficulty, on which he published a report in 1925. Using measurements based upon the absolute-scaling method, he was able to estimate that the zero point of mental ability, as represented in test performance, should be placed at an age several months before birth. Using the same type of measurements, he concluded that the mental-growth function is typically S-shaped, with the inflection point at about the ten-year level.

Of all the statistical bases for tests that Thurstone developed, that of factor theory and factor analysis is the one for which he will be longest remembered. It is true that factor analysis was not new with Thurstone; Charles Spearman had initiated factor analysis in psychology as much as a quarter century earlier. Even before Spearman, Karl Pearson had proposed the idea of factor analysis as a statistical procedure. Thurstone came to the problem with a fresh approach, derived a more generalized theory, and developed procedures that prevail, in this country at least, today.

Whether it was Thurstone's engineering background or his natural habits of thinking, or both, in being faced with a new problem he usually went to the heart of it, reducing it to its simplest terms. He would, in effect, ask, "What are the variables involved? How are they interrelated?" He also recognized that all too frequently in psychology the readily available variables are not the fundamental ones. Thus, latent in any test-score scale, for example, there are probably one or more significant underlying variables or dimensions.
Spearman and his followers had focused most of their attention upon what they believed to be the single intellective factor $g$, which was believed to be common to all tests involving cognition. While recognizing the existence of group factors (factors of limited generality among tests), they played down the importance of such components. Where only $g$ exists in a group of tests, it alone determines their intercorrelations, and the latter exhibit a pattern of simple proportionality, except for sampling errors. The group factors were regarded by Spearman as primarily disturbers of the picture of simple proportionality and as having little psychological significance.

In approaching the factor problem, Thurstone simply asked the question, "How many factors are needed to account for the intercorrelations and how general is each factor?" He regarded a table of intercorrelations among tests as a matrix and applied to it the mathematics of matrix algebra. This called for a number of new conceptions and led to a more general theory in which the Spearman $g$-factor model is a special case. The number of common factors is represented by the rank of the matrix. The concept of communality was introduced by Thurstone to stand for the sum of the proportions of common-factor variance of a test. This concept aroused considerable criticism, but it is now generally recognized that communality cannot be ignored.

In the practice of factor analysis, Thurstone developed his centroid method of extracting factors. A similar summational method has been developed by Cyril Burt in England. But Thurstone differs most from Burt and his followers in insisting that the centroid method gives an arbitrary reference frame that usually makes no psychological sense. The reference frame must be rotated in order to arrive at positions for the axes that are psychologically meaningful. His chief criterion as to where to rotate lies in his concept of simple structure. Roughly, simple structure means that with tests represented by vectors extending from the origin of the $n$-dimensional reference frame, there are definite regions of higher and lower
density of test vectors. The meaningful axes are located at regions of high density. This procedure results in a factor pattern for a group of tests, with each test exhibiting relations to a minimal number of factors and each factor tending to have relations to a minimal number of tests. The principle of simple structure thus provides criteria for a unique solution to the rotation problem.

Very frequently the optimal achievement of simple-structure solutions calls for oblique rotations of factor axes. Oblique rotations have become the rule in the Thurstone procedures of analysis. In terms of theory, this meant to Thurstone that the psychological factors are correlated; they are not statistically independent. The correlation between a pair of factors is estimated from the cosine of the angle of separation between them. The matrix of intercorrelations of the first-order factors can be factor analyzed, giving rise to second-order factors. These are factors among factors, and Thurstone regarded them as having genuine psychological meaning. On this point there is not general agreement among investigators. Noting that Spearman's g factor is not found among the first-order factors, Thurstone suggested that it could probably be found among the second-order factors. Thurstone's major publications on factor theory and method were The Vectors of Mind (1935) and Multiple Factor Analysis (1947).

Having developed procedures for factor analysis, Thurstone carried out a number of factor-analytic studies, often in collaboration with his wife Thelma. In 1938 he reported his first findings on aptitude factors, which he called "primary mental abilities." This study involved a battery of 57 tests administered to 240 superior university students. Similar studies were made with children in different age groups, even at the kindergarten level, showing essentially the same primary mental abilities at all levels. He subsequently developed and published for general use two different test batteries (for two age groups) for measuring five of the primary mental abilities. These are commonly known as the Thurstone PMA batteries. The obvious implication is that a profile of factor scores
should replace the commonly used single IQ score in describing a child. Such a change in assessing the intelligence of individuals has taken place very slowly.

Thurstone also carried out factor analyses in the areas of temperament and interest traits, followed by publication of instruments to assess individuals in the factors indicated. With Mrs. Thurstone he produced for a number of years successive forms of the American Council on Education Examination, a very widely used college-aptitude test. In his latest years he was very occupied with research on performance tests of non-aptitude traits of personality.

Among Thurstone's most significant contributions were those on psychophysics and psychological-scaling methods. He was very dissatisfied with the classical psychophysics of Fechner, Wundt, and G. E. Müller because of its restriction to the measurement of limens or thresholds and of points or intervals of subjective equality. He saw in the traditional psychophysical methods the possibility for a much broadened use in psychological measurement, including the assessment of social, economic, aesthetic, and moral values, as appreciated by human individuals.

Classical psychophysics, being interested ultimately in the functional relationships between quantified psychological events and quantified physical events, was confined to those areas of experience in which measurable physical variables are obvious. Measurements on psychological scales were actually very infrequently made, for limens and the like were referred back to physical scales. Thurstone put the emphasis upon psychological scaling. Indeed, where corresponding physical variables are not readily available this is a natural step.

Starting with human judgments that have the crudest quantitative properties, the problem, as Thurstone saw it, was to derive scale values of a relatively high order of measurement by combining such information. As an important step in achieving this objective, he developed his well-known law of comparative judgment. The rationale for this law involved the introduction of new
concepts, such as the *discriminal process* and the *discriminal dispersion*. A specified stimulus or object at any moment arouses a certain discriminal process in a certain individual. Over a population of occasions, or over a population of individuals, there is a variability in quantity of process along some specified psychological continuum. The frequency distribution of those quantities has a mean and a standard deviation, two well-known statistical values. Assuming a normal distribution of the discriminal processes, certain deductions follow concerning the relation between the proportion of the time that one stimulus is judged greater than another and their linear separation on a psychological continuum. It is not necessary to assume independence between discriminal processes from pairs of stimuli, over occasions or over individuals. The possible correlation between processes is taken into account in the law of comparative judgment.

The law of comparative judgment makes possible a wide range of scaling operations, whether the data come from the method of pair comparisons or from other methods from which comparative judgments may be inferred such as the method of rank order. The stimuli being compared may be of almost any kind, such as crimes to be judged for seriousness, nationalities to be judged for desirability or handwriting samples to be judged for excellence. From the standpoint of theory, the law of comparative judgment provided a basis of explanation of why it is that Weber's and Fechner's laws are sometimes not both experimentally verified in the same situation.

In another area of measurement Thurstone adapted the psychophysical method of equal-appearing intervals to the calibration of opinions concerning specified issues, institutions, or other social stimuli. The aim was to arrive at some 20 to 25 statements of opinion, regarding prohibition, for example, that belong at psychologically equal steps along a continuum of attitude, from the most extremely favorable attitude to the most extremely unfavorable attitude. An "attitude scale" was thus developed. The instrument could then be
used to evaluate the characteristic position of a person on this con-
tinuum or the average position of a specified population. This
involves the step of asking each person to say which of the opin-
ions he endorses and noting their scale values. With his students
Thurstone developed attitude scales for such matters as treatment
of criminals, patriotism, war, the Negro, labor unions, communism,
birth control, and censorship.

The availability of scaling methods and of attitude scales made
possible some excursions by Thurstone and his students into the
study of social-psychological problems. For example, there were
studies of the effects of certain motion pictures upon the attitudes
of children toward the seriousness of certain crimes, toward the
Chinese, and toward the Negro. The summational effect of viewing
two or more films was also detected. Thurstone regarded the field
of social psychology as being amenable to the isolation of variables
and the study of their quantitative interrelationships, an obvious
scientific approach that seemed foreign to too many who had se-
lected that field of investigation.

Among Thurstone’s last contributions to psychological-measure-
ment theory was an exploration into the logical problems of pre-
dicting first choices from knowledge of mean scale positions and
dispersions of objects. Some deductions were made that should
be of interest in politics and merchandising. He had also developed
scaling procedures for judgments that place objects in successive
categories. This method, and others, were used in studies of food
preferences for the armed services.

Thurstone’s breadth of professional interests was shown not only
by the variety of fields he chose for investigation but also by the
variety of organizations with which he was affiliated and in which
he showed leadership. He was a Fellow in the American Psychologi-
cal Association (President 1932-1933), the American Association
for the Advancement of Science, the American Statistical Associa-
tion (Board of Directors), and the American Academy of Arts and
Sciences. He was Honorary Fellow in the British, Spanish, and
Swedish Psychological Associations. He was a member of the Midwestern Psychological Association (President 1930-1931), the Society for the Promotion of Engineering Education (Council member), the American Society for Human Genetics (Advisory Editorial Committee), the American Philosophical Society, the Chicago Psychology Club (President 1928-1929), and the Chaos Club, Chicago. He was elected to the National Academy of Sciences in 1938. He rendered editorial service to several psychological journals. His honorary societies included Phi Delta Kappa, Sigma Xi, and Eta Kappa Nu.

His social affiliations included the Acacia fraternity, the Quadrangle Club (Chicago), and the Chicago Literary Club. With his family he frequently spent summers at the family residence at Wabigama Club, Elk Lake, Rapid City, Michigan. Special honors included the Award of the American Psychological Association for the best published paper of 1949 and the Centennial Award, Northwestern University, 1951.

A very important component of the heritage left by Thurstone is represented by his former students. He was a stimulating lecturer, always clear and logical. His seminars were regarded as a treat and were attended repeatedly. A number of post-Ph.D. individuals were commonly present. His students generally caught the spirit of the challenge that had dominated Thurstone's career—to make psychology a quantitative, rational science—and many of them have carried on in that same spirit.

The Thurstones had three sons, Robert Leon (born in 1927), Conrad Gwinn (born in 1930), and Frederick Louis (born in 1932). It may be expected that they, too, having chosen the fields of physics, medicine, and engineering, will carry on in the scientific tradition set for them by their illustrious father.
KEY TO ABBREVIATIONS

Am. J. Human Gen. = American Journal of Human Genetics
Am. J. Psychol. = American Journal of Psychology
Am. J. Soc. = American Journal of Sociology
Am. Psychol. = American Psychologist
Educ. Rec. = Educational Record
Educ. Rev. = The Educational Review
Eng. Educ. = Engineering Education
J. Appl. Psychol. = Journal of Applied Psychology
J. Cons. Psychol. = Journal of Consulting Psychology
J. Educ. Psychol. = Journal of Educational Psychology
J. Exper. Psychol. = Journal of Experimental Psychology
J. Gen. Psychol. = Journal of Genetic Psychology
J. Higher Educ. = Journal of Higher Education
Mus. Quart. = The Musical Quarterly
Person. J. = Personnel Journal
Psychol. Bull. = Psychological Bulletin
Psychol. Rev. = Psychological Review


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LOUIS LEON THURSTONE

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MICROFILMS

The following microfilms may be obtained from The University of Chicago Library, Department of Photographic Reproduction.


No. 1771  Measurement of Social Attitudes (Collection of attitude scales), edited by L. L. Thurstone. Positive copy, $1.80, includes postage.

No. 1772  Psychometric Laboratory Reports (inc. 3, 15, 16, 17, 18, 22, 23, 24, 25, 29, 30, 32, 34, 39, 40, 41, 42, 43, 44, 45, 46, 47), by L. L. Thurstone. Positive copy, $2.55.


No. T 1136  Word Reactions and Temperament, by Mrs. Frances Smith. 1951. $1.50.


The following microfilms and photocopies may be obtained from the American Documentation Institute, 1719 N Street, N. W., Washington 6, D. C.

