

Louis Leon Thurstone

*Creative Thinker*  
*Dedicated Teacher*  
*Eminent Psychologist*

by  
Dorothy Adkins Wood  
The University of North Carolina

## Acknowledgments

My principal acknowledgment should be made to the subject of this biographical sketch, Louis Leon Thurstone. This is true not only because his many scientific accomplishments have provided a rich subject matter for a would-be historian but also because he himself wrote an autobiography, a condensed form of which was published (173).\*

I am indebted to his wife and active collaborator, Dr. Thelma Gwinn Thurstone, for placing the original version of the autobiography at my disposal. I am also grateful to her for many other kinds of assistance in the preparation of this account—for providing access to a complete file of Thurstone's publications, for the initial assembling of the bibliography, for providing the photographs that have been used, and finally for reviewing the manuscript in its entirety.

This manuscript has been read critically, also, by Dr. Lyle V. Jones, who was formerly Thurstone's active collaborator at The University of Chicago and later followed Dr. Thelma Gwinn Thurstone as his successor in the role of Director of the Psychometric Laboratory at The University of North Carolina. I express to him, too, my appreciation of numerous suggestions for clarification and other types of improvements.

The first photographic portrait, upon the occasion of Leon's graduation from high school, was made by Nelson Brothers, Jamestown, New York, in 1907. The second, attributable to Harris and Ewing, Washington, D. C., was taken in 1924, when Professor Thurstone was appointed to the faculty of The University of Chicago. The third was taken in 1938 by Kenneth Heilbron of *Time*. A personal friend and Chicago neighbor of the Thurstones, Carl Davis, made the fourth in 1951. Thurstone himself took the pictures of the buildings in which his Psychometric Laboratory was housed, first at The University of Chicago and later at The University of North Carolina.

D.A.W.

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\*The numbers in parentheses refer to the corresponding titles of books, monographs, and articles listed on pages 38-68, with numbers in parentheses. These numbers should not be confused with the numbers of the Psychometric Laboratory Reports, which are listed separately.

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*Louis Leon Thurstone*

On May 29, 1887, was born in Chicago, Illinois, one who was to be widely acclaimed as the most eminent psychometrician of his time and whose name will survive as that of one of the world's most creative psychologists. Louis Leon Thurstone was the son of Conrad and Sophie Stroth Thurstone, both of whom were born in Sweden. The family name, originally Thünström, was changed because it was so frequently mispronounced and misspelled. His father joined the Swedish army and acquired the educational background to enable him to teach mathematics and fortifications. Later he became a Lutheran minister, a newspaper editor, and a publisher. The family lived in Chicago, then in Stockholm, Sweden, and later in several other towns in the United States.

*Early Education*

Thus it was that the schools attended by Leon included ones in Chicago; Berwyn, Illinois; Centerville, Mississippi; both a public school and a boys' school in Stockholm; and finally an elementary and a high school in Jamestown, New York, where his family moved from Stockholm in 1901.

His mother, being possessed of an excellent voice and a strong interest in music, saw that both the boy and his younger sister, Adele, were exposed to the piano at early ages. Adele persisted and earned a Bachelor of Music degree. Leon in his high-school years was fascinated by a course in harmony and occasionally experimented with musical composition. Although he discontinued formal study, his interest in and fine appreciation for classical music were retained.

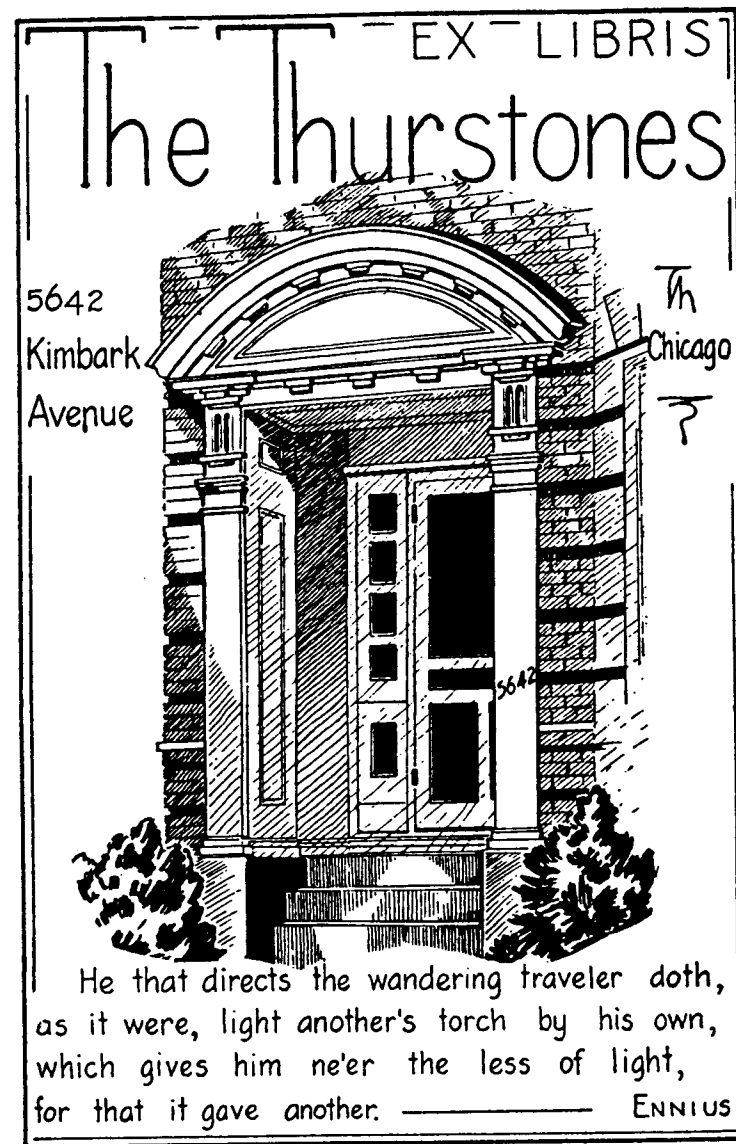
Louis Leon Thurstone  
May 29, 1887 — September 29, 1955

When he was eight years old, the youth Thurstone was transplanted to Stockholm, where he was a foreigner among his classmates. Upon his return to the United States at the age of 14, he was again cast in this role. He later remarked that, disturbing as this sequence of experiences was to him, it nonetheless probably contributed to an attitude of objectivity. In Sweden, he had observed that all of the heroes of episodes narrated in history textbooks were Swedes, whereas upon his return to the United States he similarly noted that all of the historians' plaudits were showered upon Americans. This seeming lack of objectivity in the recital of history doubtless fostered his interest in certain areas of social psychology in which he believed a subjective approach was a deterrent to scientific progress.

By reason of his having lived in Stockholm and having attended schools where he was only occasionally exposed to spoken English—and that with a British accent—he acquired facility in the Swedish language which he retained to a remarkable degree in his later life. When he returned to this country, his first ambition was to regain mastery of English. He has told how he sometimes spent an entire hour with a tutor practicing a single sentence or even a particular word. Anyone who heard him speak or who was exposed to his lucid prose could only marvel at the efficacy of his diligence in this direction.

While in high school, Leon elected a course in sketching and charcoal. He received a cash award in the Prendergast competition in geometry, using the money to purchase a bicycle and a box camera. These events were forerunners of his strong interest in photography, which was always his principal hobby and in which he displayed noteworthy skill, especially in composition. This high-school boy also had mastered three typewriter keyboards—one on an old Caligraph typewriter, one the standard keyboard on his father's Williams typewriter, and one on a Simplex typesetting machine. This feat seems quite remarkable in a day when command of a single keyboard seems to be a signal accomplishment.

At the age of 14, an impasse occurred when Leon declined to learn the catechism in the face of expectations of his father that he would be confirmed in the Lutheran church. The final compromise solution was that he would be permitted to choose three



*The Thurstones' bookplate, shown here, was made from an etching based upon a photograph that he had taken of the doorway of what was for many years their home in Chicago.*

questions to which he was willing to learn the answers. Of course he had to read the entire catechism in order to be able to make his selection, so he has told us somewhat ruefully that his seniors really won the case.

As the time for graduation from Jamestown High School approached, Leon requested private audience with the principal. Concerned with the requirement that each senior present a five-minute talk to the school assembly—a group of several hundred students—he announced that he would never attempt such an ordeal and that the principal could prevent his graduation if this was the only possible solution. Faced with such a decision, the principal allowed an exception, one which was to prove influential in the development of twentieth-century psychology.

Not until five years later, when he approached his first teaching assignment, did Leon ever address an audience. In citing this incident, Thurstone commented, surely with tongue in cheek: "I admire especially the abilities of men who can address an audience graciously even when they have nothing definite to say, because that has always been beyond me."

Thurstone's first publication was a letter to the *Scientific American*, written when he was a high-school sophomore (24). The hydroelectric power companies at Niagara Falls had been accused of diverting so much water to their power plants that the beauty of the falls was impaired. He proposed a simple solution to the conflict that he argued would provide for ample power and at the same time preserve the tourist attraction. Thurstone the engineer was beginning to emerge.

Another high-school experience may have influenced his later interests. The New York State Regents system provided uniform high-school achievement examinations throughout the entire state, and this applied to his own high school in Jamestown. Thurstone attributed his later concern with problems of large-scale educational and psychological measurement, as for example those dealt with by the Educational Testing Service, to his early exposure to that testing program.

As a high-school sophomore, Leon developed a French curve that could be used with a straightedge for trisecting any angle. Later, when a college freshman, he wrote the equation for the solution (which of course was not within the restrictions of Euclid-

ian geometry). It constituted his second publication, again in the *Scientific American* (25).

### *His Engineering Education*

At Cornell University, which Thurstone entered in 1908, he began training in civil engineering but changed to electrical engineering. That he did not choose physics is probably fortunate for the psychological world, for it is possible that he might have persisted in it. He did do some experimental work with one of the physics instructors and also began to work on a design for a motion-picture camera and projector. Every point on the screen was continually lighted so that there was no dark interval or flicker. The machine was built and demonstrated several years later.

Through a course on machine design, Thurstone became fascinated with the psychological aspects, especially those concerning visual-motor coordination. As an outgrowth of this interest, he suggested a number of improvements in early models of desk calculating machines that were adopted. He always regarded the application of psychological considerations to machine design as an important field.

As a college student, Thurstone was sensitive to the general ineptness of many teachers. In his senior year we find him producing a sophisticated editorial for the *Sibley Engineering Journal*, of which he was editor-in-chief, concerned with the efficiency of teaching in the College of Engineering (26). Undoubtedly this interest was primarily responsible for his movement into psychology, for his early concentration in this field was related to the learning process. Even while he was still studying engineering, he was curious as to the amenability of the learning function to scientific study and found himself visiting lectures by such psychologists as Bentley and Titchener.

Shortly before his college graduation, Thurstone was able to arrange to demonstrate his model motion-picture projector, which in the meantime had been patented, in the laboratory of Thomas A. Edison in East Orange, New Jersey. Edison and his staff regarded the model with considerable favor but decided against producing it because of the necessary retooling that such a change

would have required. Edison did, however, offer the young inventor an assistantship in his laboratory, an activity that Thurstone pursued after having received his degree in mechanical engineering. In daily encounters with Edison, Thurstone was impressed by his tremendous fluency of ideas, reporting that for every failure he immediately had several new ideas to be explored. This unusual opportunity for close association with genius at work probably played some part in Thurstone's later interest in the general question of creativity and, more directly, in his development of tests of ideational fluency.

### *His First Academic Post*

Seeking a return to an academic setting, the young graduate engineer in the fall of 1912 began teaching descriptive geometry and drafting in the College of Engineering at The University of Minnesota. He was at once impressed by the great individual differences in the ability to visualize evidenced among his students in descriptive geometry. This observation was a precursor to his development of tests to measure differences in spatial abilities.

In the course of his teaching, Thurstone constructed some wire models to illustrate the principles of projection and rotation. He also observed wide differences in students' abilities to learn free-hand lettering and developed a formal procedure for teaching it by applying the principles of the Pahlman system of teaching handwriting, to which he had been exposed in Sweden. A lettering book that he prepared was printed by a Chicago publisher (2), but he characteristically notes that he never had any reports as to whether or not any of the books were sold!

### *The Shift to Psychology*

Becoming more and more interested in the experimental study of learning, while at Minnesota he obtained some instruction in psychology from Herbert Woodrow and J. B. Miner. After two years there, in the summer of 1914 he enrolled for graduate

study in psychology at The University of Chicago. Reporting on his formal induction to this field, Thurstone has written as follows (173, p. 300):

I recall one of my first impressions of graduate students of psychology. When they were asked a question, they would start to talk fluently, even when they obviously knew nothing about the subject. [Thus, just as Edison may have suggested the factor of ideational fluency to him, perhaps it was the psychology student who stimulated the idea of verbal fluency.] . . . One of my first courses was called advanced educational psychology . . . I used to wonder what the elementary course could be like if the course that I was taking was called 'advanced.' I soon became accustomed to the fact that prerequisites did not mean anything and that there was no real sequence of courses in psychology, even though they were listed by number and title to give the appearance of a sequence . . . I never had an elementary course in psychology or in statistics.

Thurstone's early work in psychology was concentrated on problems for which some kind of continuous function might be discovered to describe psychological effects. He turned to the learning function as a thesis topic and fitted a hyperbola with two parameters to the typewriter learning record of each subject (3). One parameter, the asymptote, was interpreted as the physiological limit. The other represented the rate at which the limit was approached. Thurstone has commented that the hyperbola was nothing but a simple empirical equation and that an engineering sophomore could have done as well. He had minored in education because of his strong interest in teaching and learning, but he has remarked upon the exceedingly trivial and dull nature of courses in education.

### *Applied Psychology at the Carnegie Institute of Technology*

Having been rejected for the draft for World War I as underweight, while still a graduate student he accepted an assistantship in Walter V. Bingham's newly established Division of Applied Psychology at the Carnegie Institute of Technology. This work,

although oriented primarily toward applications of psychology, also seemed to provide opportunity for theoretical interests. Thurstone continued on at Carnegie after having received his doctorate from Chicago, until he became a full professor and chairman of the Department of Psychology.

The work at Carnegie clearly was at the forefront of applied psychology, and especially of the intensive development of psychological tests. One important problem was to overcome irrational arguments against objective testing, such as that it was absurd for a clerk to score an examination in a subject he knew nothing about. The many varieties of tests developed at Carnegie in attempts to predict scholarship and vocational success almost certainly must have influenced Thurstone's later impatience with a single over-all index of general intelligence, which he has referred to as "a hodge-podge of unknown abilities combined at unknown weights." In the early days at Carnegie, tests for various cognitive functions, including visualization and word fluency, were being developed. Even then the seeds were being sown for the later development of the fruitful concept of primary mental abilities, together with the insightful approach to the study of test performance known as multiple-factor analysis.

With the onset of World War I, the Carnegie objective tests were made available for use by the Army. Thurstone was assigned to work on oral trade tests in Newark, and initiated the "keyword" principle, whereby a response that includes any of a number of specified key words is counted as correct. This device permitted the administration and scoring of tests in various trades by persons themselves unfamiliar with the work in question. Later, during mobilization for World War II, we again find Thurstone generously making available to military establishments countless tests produced in his laboratory. Throughout this period, he served as a member of the Committee on Classification of Military Personnel in the Office of the Adjutant General.

While at Carnegie, Thurstone wrote *The Fundamentals of Statistics* (7), for use in self-defense, as he says, when offering a course for women in the Research Bureau for Retail Training. He purposely limited his treatment to the simple rudiments. Later he often disparaged it, because of its omissions of qualifications and reservations that had become commonplace. Nonetheless, many

students for whom this little book constituted their introduction to statistics have had reason to be grateful that it made the subject seem quite easy and thus did not intimidate them. Perhaps all statistics texts should be written for women bent upon a career in retailing.

At Carnegie also was written a monograph on *The Nature of Intelligence* (5), which reportedly grew out of ideas initiated by Professor Mead's lectures at Chicago in what was then known as social psychology. Thurstone himself has said that he never read a textbook summary of the ideas in this monograph that he could understand. Perhaps a fresh look may be illuminating. The author was trying to reconcile the disparities between the point of view implied in abnormal psychology and psychiatry that action begins in the person himself and the stress upon various features of the stimulus-response sequence to the neglect of the person. In a previous paper on "The Stimulus-Response Fallacy in Psychology" (54), he had argued for replacement of the sequence "stimulus—person—behavior" by the sequence "person—stimulus—behavior." In a still earlier article, "The Anticipatory Aspect of Consciousness" (39), he had developed the theme that a concept is an unfinished act which points toward a type of adjustment.

In this monograph, he advanced these ideas, his main thesis being that mental life is action in the process of being formulated and that the several cognitive categories should be interpreted as differing mainly in the degree of completion of the act. Upon pursuing to its limits the assumption that conduct originates in the person, he concluded that intelligence is the "capacity to live a trial-and-error existence with alternatives that are as yet only incomplete conduct" (5, p. xv). In reaching this point of view, Thurstone observed the overt trial and error, randomly determined, of lower forms of animals. He then analyzed, in turn, perceptual trial and error, ideational trial and error, and conceptual trial and error. "Intelligent conduct implies the inhibition of a motive at an undefined stage in order to make it focal in its incomplete form" (5, p. 122).

This analysis still seems instructive and is appropriately regarded as a forerunner of much later discussions of implicit trial-and-error behavior. In fact, in many ways it is a more complete treatment than those that have followed.

### *A Brief Period of Applied Psychological Work in Washington*

Early in 1923, Thurstone had left Carnegie for Washington to help a foundation-supported Institute for Government Research in some inquiries into methods of selecting civil service personnel. His task was to prepare instructional manuals and specimen materials that would assist civil service agencies in learning to use the new objective examining devices. Here again we find this scholarly man quite willing to work upon the application of his knowledge, skill, and ideas to very practical problems.

During his period in Washington, he discussed with friends in the Department of the Navy the possibility of investigating the problem of learning during sleep. This may well have been a novel idea as applied to adult subjects for the purpose of developing mastery of definite skills or subject matter. In any case, Thurstone was encouraged to conduct some experimentation on the learning of the Morse code. An instructor presented code associations at night while the subjects were asleep, alternating practice with no-practice periods every half-hour. The class in Washington completed the course in record time and a more controlled experiment was begun at Hampton Roads. Unfortunately for science, however, the instructors of the control group feared that their teaching efficiency was under surveillance. Hence they apparently provided several hours of additional practice per day to the control group.

The experiment failed. The experimenter, nevertheless, learned an important lesson about the conduct of psychological experiments in government or industrial settings. This was that the planner of an investigation must be assured that the persons who actually carry out the work and collect the raw data themselves understand explicitly the procedures to be followed and are able and willing to participate objectively.

Shortly after this attempted study had foundered, Thurstone was to leave Washington. He never returned to any further controlled experimentation in the field of sleep learning, although he continued to believe that it might be a profitable and interesting field for study.

In Washington, he became acquainted with Dr. C. R. Mann, the

Director of the American Council on Education, who proposed that he prepare a psychological test to be used in selecting or classifying college students. This assignment he undertook, with the assistance of Thelma Gwinn, who also had joined the staff of the Institute for Government Research. Together they were responsible for the editing of successive annual editions of the *American Council on Education Psychological Examination* for 24 years, an achievement that occasionally led Mr. Thurstone to deplore his lack of business acumen.

### *Contributions to Test Theory*

In the summer of 1924, Leon and his co-worker, Thelma, were married. They returned to Chicago, where he had been appointed Associate Professor of Psychology at The University of Chicago. Here he taught a course in descriptive statistics; but the principal challenge was a course in mental test theory, an area greatly in need of some organization at that time. Because teaching in this field was based mainly upon test manuals and devoted principally to details of the Stanford-Binet test and because mental test work enjoyed very low prestige, Thurstone had strong motivation to get to the heart of basic problems in psychological measurement.

He first scrutinized various educational scales and found them resting upon the assumption that the distributions of scores for various age groups differed only with respect to the mean. In order to improve the quantitative description of general intelligence, Thurstone decided to permit two parameters to vary for different age groups, the mean and the dispersion. Thence appeared in 1925 his first paper on measurement theory, presenting a scaling method for psychological tests (66). This he regarded as one of his best articles.

A year later, he blasted the foundation from under the mental-age concept (69), a feat that has yet to come to the attention of many of our friends who worship at the altar of the I.Q. In the same year, he proposed that an appropriate test score would be the value exceeded by as many successes as there are failures below it, thus allowing for some errors due to distractibility rather than lack of ability (70).

Somewhat later, noting that the relation between mean scaled score and standard deviation for each age group for some particular test data was linear, he extrapolated the line until it reached zero dispersion. (This may be regarded as an example of serendipity, because he had not requested his research assistant to make the plot in question.) The ingenious reasoning was that the point on a scale at which variability of test performance becomes zero can be regarded as a rational origin. For several scaled tests, this line of attack yielded an origin at a few months before birth (83). Having a method for scaling test data with a check on internal consistency and for locating a rational origin, he turned to the construction of a mental growth curve (90). His conclusion was that the growth curve is S-shaped. He entertained some doubts, however, as to the location of the inflection point, believing that it might vary with different levels of intelligence.

Through a part-time affiliation with the Institute for Juvenile Research in Chicago, Thurstone was able to place Dr. Richard Jenkins, later Director of the Institute, on a research assistantship. They collaborated on a monograph on the problem of intelligence in relation to age of parents and birth order, published in 1931 (10).

The lack of a textbook on mental test theory was finally met by a lithoprinted book entitled *The Reliability and Validity of Tests*, published in the same year (9). This book clearly was much more needed elsewhere than its author had anticipated, for a demand persisted long after it had been out of print. In later years, Thurstone had planned its revision into an elementary textbook, but this project was not completed.

In 1937 appeared a paper with a fresh slant on the problem of speed versus power in the appraisal of intelligence (125). The central idea of his 1919 work on the anticipatory aspect of consciousness (39) recurs in a paper on creative talent, which he wanted to distinguish from lesson-learning ability and scholarship. This paper, delivered at the 1950 Invitational Conference on Testing Problems, also contained some leads on experimental investigations of the problem of creative talent (175).

### *Development of Psychophysical Methods*

Thurstone himself regarded as his best contribution to psychological theory his initial paper in the field of subjective measurement, entitled "Psychophysical Analysis," which appeared in 1927 (73). Here he first tackled the problem of how to deal with a subjective unit of measurement and with stimuli unrelated to any ordinary physical dimensions. In presenting the older psychophysical methods to students, he found it dull to deal with comparisons of pairs of weights. Instead, he asked which of two nationalities is preferred or which of two offenses is the more serious, for example. The proportion of subjects who preferred stimulus  $j$  to stimulus  $k$  was tabulated for all stimuli. The problem then was to explore whether a rational theory could be developed to fit the observed proportions. Introducing the concept of the discriminial dispersion, Thurstone inventively formulated the equation of comparative judgment.

A penetrating series of additional articles dealing with subjective measurement were forthcoming in this highly productive period, six more being published in 1927 (71, 72, 74, 75, 76, 77). These developed the new approach to psychological measurement further, related the law of comparative judgment to previous concepts such as Weber's law and Fechner's law, and illustrated the application of the new law to the measurement of social values. In later papers, he examined the inconsistency of the phi-gamma hypothesis with Weber's law (85), some of the limitations of the method of equal-appearing intervals (89), the use of the method of rank order as a substitute for the more laborious method of paired comparisons in the collection of data (103), and the problem of the numerical evaluation of the dispersions of stimuli presented by the constant method (109).

These early papers assumed a unidimensional subjective continuum but contained tests for the adequacy of this assumption. Thurstone soon recognized that some psychological problems are concerned with a multidimensional domain. Later extensions of the experimental methodology and analytical procedures to cover this case have proved feasible, as is of course well known.

As an outgrowth of conversations with a mathematical economist, Henry Schultz, Thurstone developed an interest in the applicability

of psychological measurement concepts to problems in economics. In a 1931 article on "The Indifference Function" (102), the satisfaction that the owner of a specified quantity of a commodity derives was treated as measurable in terms of the subjective unit of measurement, the discriminial error. The equation for the indifference curve was based upon the psychological postulate that motivation toward accretion of a commodity is inversely proportional to the amount already possessed. Several of his later formulations of measurement theory and methods seem to have sprung from this early venture into economics. In Chapel Hill, for example, where he went in 1952, he continued to work with his former collaborator, Lyle V. Jones, on the experimental determination of the zero point in a scale of utility and was able to demonstrate that subjective values are additive. This was accomplished by locating an origin in such a way that the sum of the scale values for two stimuli is equal to the scale value of the combination of the two stimuli (188).

In the meantime, the obverse psychophysical problem of the prediction of choice had engaged Thurstone's attention. Previously, the chief concern had been with allocating each psychological object to a point in a subjective space. The obverse problem, given the scale parameters for a set of objects, is to predict the relative popularity of these objects when subjects are presented with a choice of one among the set. The general notion was to examine the effects of the discriminial dispersion upon prediction of choice. In a 1945 paper (143), Thurstone demonstrated that the dispersion of affective values, as well as the average affective value of a proposal, is significant in the measurement of social attitudes of a group. Still later, the techniques for the prediction of choice, using the method of successive intervals, were applied to the prediction of menu selections (165, 170, 176).

Constantly seeking improved methods, in the 1950's Thurstone was still investigating several new approaches to the subjective metric. A new scaling method was derived to escape the assumption of normality of the subjective distribution for each stimulus. The less restrictive assumption that repeated judgments by the same individual will be normally distributed on the subjective continuum also was explored (182, 183).

A 1954 paper on "The Measurement of Values" provides an

edifying review of fundamental concepts of subjective measurement, presented with the enlightened perspective that only a lifetime of thinking and working could have developed (179).

### *The Measurement of Attitudes*

The most widely popularized application of Thurstonian methods for the study of subjective values has been to the measurement of social attitudes, where physical stimulus measurement is irrelevant. Hence this development will be traced briefly, apart from the main stream of psychophysical research that flowed from the Psychometric Laboratory. An article appearing in 1928 with the challenging title, "Attitudes Can Be Measured" (80), gives the assumptions and an outline of the method of equal-appearing intervals for the construction of an attitude scale. In the same year was offered another method for the derivation of a rational base line for describing the distribution of opinion, such that equal intervals on the scale represent equal-appearing opinion differences (82). The unit of the scale was the discriminial dispersion of the statements. Still a third paper applied the method of paired comparisons and the law of comparative judgment to a study of nationality preferences (84). In 1929 came the monograph on *The Measurement of Attitude*, co-authored with E. J. Chave and describing in detail the application of measurement techniques to attitudes toward the church (8). Thurstone regarded the method of paired comparisons as a far more sensitive method for appraising attitudes than the statement scales, but noted that the former is not so generally applicable to social issues.

In a paper, "Theory of Attitude Measurement" (88), Thurstone in 1929 also described the method of similar reactions. The degree of similarity of attributes, or the extent to which they co-exist in the same individual, is measured in terms of the  $\Phi$ -coefficient, which permits the allocation of the attributes along a continuum. Thurstone's 1931 presidential address to the Mid-western Psychological Association soon thereafter covered developments to that date in the field of attitude measurement (107). Much of this work, which was financed by the Payne Fund, was

treated in a lithoprinted monograph and later comprised a portion of a book (112).

Although it seems to have had no formal inauguration, perhaps for historical purposes Thurstone's Psychometric Laboratory at The University of Chicago may be considered to have been launched at the time he moved his office and staff to the Social Science Research Building at 1126 East 59th Street. This was in the spring of 1930, at a time when Thurstone was encountering great interest in the application of attitude scales to many issues and to all sorts of groups. He soon became disenchanted, however, with the relative lack of concern for the methodological problems which to him constituted the significant issues. With a growing realization that his laboratory might be swamped by the relatively trivial applications of attitude measurement techniques, he abandoned this field to clear the path for the development of multiple-factor analysis.

Thurstone sporadically reverted to problems that could be regarded as falling within the general area of social psychology, such as the use of obverse factor analysis to describe voting records of Supreme Court judges (171) and the application of psychophysical concepts to the study of the growth of a social group (The University of Chicago Psychometric Laboratory Report No. 74). But social-psychological content did not return to dominate the Psychometric Laboratory as it had been threatening to do in the heyday of attitude scale construction.

### *Multiple-Factor Analysis*

Although Thurstone was most pleased with his success in breathing life into psychophysics—an evaluation in which later historians may concur—probably his productive work in multiple-factor analysis was accorded more attention in his lifetime. As long ago as 1922 he had made a note on the original observation equation, but he did not return to it until seven years later. Even then, other commitments prevented full attention to the problem for another year or so. Early efforts were supported by annual grants from the Social Science Research Committee at The University



*Thurstone's first Psychometric Laboratory was housed in this Social Science Research Building at The University of Chicago.*

of Chicago and by the Carnegie Corporation. When he saw that further special grants would be needed, he approached the Carnegie Corporation with a request for funds to develop what he called multiple-factor analysis, making clear that he could provide no assurance that the big gamble he proposed would be successful. That initial award of \$5,000 was followed by several others, to be sure. Its size, however, might indeed give pause to the untried research worker of today who glibly and confidently requests a grant of \$200,000 or more for a couple of years of inquiry into some limited area.

At many points the career of Thurstone reveals the value of cross-fertilization of ideas between different disciplines. At lunch one day with two University of Chicago colleagues, a mathematician and an astronomer, he asked a question about some arithmetical operations that he was performing with rectangular arrays of numbers. They told him that he was extracting the root of a matrix and referred his curiosity about matrices to another mathematician. He then put himself in the hands of a tutor in order to learn the elements of matrix algebra. Anyone who has looked at the mathematical introduction to *The Vectors of Mind* (15) or *Multiple-Factor Analysis* (21) will attest to the success of this digression. Later, one of these same colleagues helped him to state the question he was trying to solve in developing the principal-axes solution, which turned out to be an old problem in celestial mechanics and one that Thurstone himself had previously encountered in theoretical mechanics.

Impatient with the long-standing debate on Spearman's single-factor method, the universality of a general factor, and the role of group factors, Thurstone hit upon the expedient of posing the basic question in a new form. Instead of asking whether a table of correlation coefficients supported a general factor, he wondered how many factors must be postulated in order to account for the observed correlations. The power of this approach was that whether or not one factor should be regarded as general could be answered factually for each study.

In view of the still widespread preoccupation with the problem of a general factor in the early thirties, Thurstone at one time set out to investigate the relation of his multiple-factor approach to Spearman's method. Having jotted down the tetrad difference

equation on a piece of paper, he at once saw that it represented the expansion of a second-order minor. (If all of these vanish, the rank of the matrix is unity. If not all second-order minors vanish but all third-order minors do so, the rank is two; and so on). Thus a new way of asking a question led to insight. Once again it is evident that a part of Thurstone's genius resided in his ability to recast problems into a form that pointed to their solution.

Thurstone's excursions into multiple-factor analysis led to several additional extensions of the earlier approach. These include the concept of communalities, the notion of rotation of the reference frame, the use of oblique reference axes, the principle of factorial invariance, and the highly significant idea of simple structure. This insightful solution to the problem presented by the infinite number of possible positions of the reference axes may indeed be Thurstone's most noteworthy single contribution to factor analysis. Other methodological ideas were concerned with second-order factors and studies on the effects of selection upon factorial structure.

Among criticisms to which the new approaches to factor analysis were subjected has been their lack of concern with such statistical niceties as the standard error of a factor loading. In his early publication on elementary statistics, Thurstone had written (7, p. 165):

Throughout the study of the probable error, and the other statistical constants that measure the reliability or unreliability of statistical measures, one should bear in mind that they give us some indication of the expected degree of fluctuation in successive samples selected in the same way, and that this indication refers to the *least important\** of the various causes that disturb the validity of statistical findings, namely, the factor of chance fluctuation.

Consistently enough, Thurstone's interests and energies were focused upon important scientific discoveries, not upon chance fluctuations. He has noted that his emphasis had been on factor analysis as a scientific method as distinguished from the statistical condensation of data, although he regarded the latter as a legitimate problem for study.

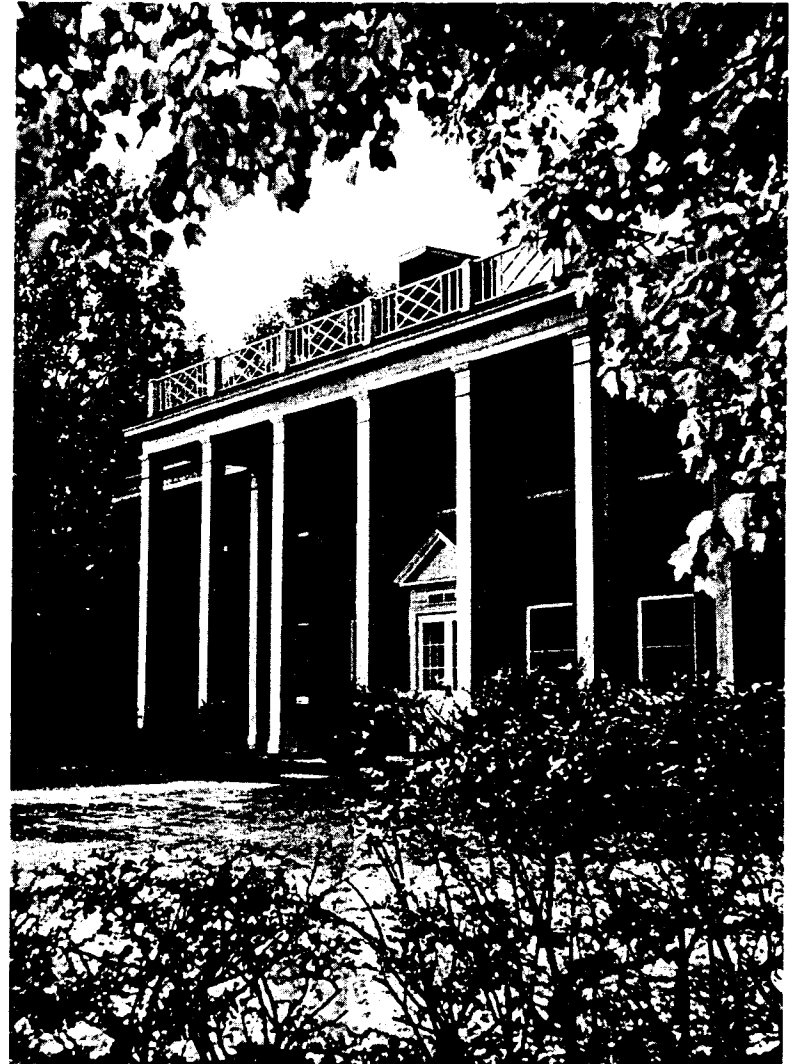
\* The italics are mine.

Thurstone's first paper on multiple-factor analysis was published in 1931 (105), and a factorial analysis of vocational interests appeared in the same year (106). A booklet on *The Theory of Multiple Factors* (11) and his presidential address to the American Psychological Association, "The Vectors of Mind" (113), were published in short order. A major book bearing the latter title came out in 1935 (15). The more extensive revision, *Multiple-Factor Analysis*, was produced in 1947 (21). Several other articles listed in the bibliography also deal with methods of multiple-factor analysis.

Thurstone's developments in this area have not been without controversy, especially those concepts and methods that were intended to resolve some of the problems of factorial indeterminacy. These include the communality idea, the principle of simple structure, and the use of an oblique reference frame when it is helpful. In the main, it seems fair to say that students and others who have seen these concepts given extensive trial in Thurstone's laboratory or elsewhere and who have observed the facilitation of interpretations of factorial results that ensues have been favorably disposed toward their use. Perhaps, however, I should not be offering a judgment of this sort, which will be open to the charge of bias by those who do not share it.

In 1952, Thurstone retired from The University of Chicago and established his Psychometric Laboratory at The University of North Carolina, where he went as its Director and as Research Professor of Psychology. Still at the advancing frontiers of factor analysis, he developed an analytical method of rotating the reference axes (181), at about the same time that several other persons began to work on this problem from different angles.

I chanced to be seated next to Leon in a plane en route to Helsinki from Stockholm at about seven o'clock on a gray morning in 1954. He did not enjoy air travel and upon such occasions typically withdrew to the privacy of his own thoughts. I was suddenly aroused from my lethargy by his startling statement, "I have just thought of a new method of factor analysis." He went on to describe the technique that involves solely the off-diagonal entries in the correlation matrix, thus avoiding the communality problem (184). Although this approach appeared promising, it seems not yet to have been followed up to any extent.



*When Thurstone went to The University of North Carolina, he established his Psychometric Laboratory in Nash Hall.*

### *Applications of Multiple-Factor Analysis*

Once the basic techniques of multiple-factor analysis were available, major applications of this powerful approach proceeded concurrently with further refinements of methodology. The first large study entailed the development of a battery of 57 tests of various cognitive functions, administered to 240 subjects. A brief report of this work appeared in *Psychometrika* in 1936 (120), and a more complete treatment as *Psychometric Monograph No. 1*, in 1938 (17). This experiment was followed by a number of others, often with the active assistance of Thelma Gwinn Thurstone; and several sizeable studies were completed in his laboratory as student dissertations.

As results began to accrue and several factors had been identified in more than one study, an experimental battery of tests of primary mental abilities for use in schools was made available in 1938. The early forms were distributed by the American Council on Education; later, simplified and shortened forms became available from Science Research Associates. In these and many other efforts, Leon was fortunate in having the able collaboration of his wife, who was largely responsible for the development of appropriate tests for a factorial study of the abilities of five-year-old children. A new set of tests was based upon this study. It was followed by a series of booklets designed expressly to offer young children training in different primary mental abilities.

The Thurstones came to the opinion that the rejection of the early doctrine of formal discipline had been a mistake. They believed that extensive practice in a certain type of thinking will actually augment the overt performance to the definite advantage of the individual. This effect could well be so important as to overshadow the appraisal of the native endowment of the individual by stable tests. That problem can be solved by the selection of suitably novel material for test purposes.

### *The Founding of Psychometrika*

Although Thurstone always insisted upon giving credit to others

for the founding of the Psychometric Society and of its journal, *Psychometrika*, he was clearly close to the nucleus of the 10 or 12 persons who brought these into being in 1936. This group contained several of his former students, but others as well. The psychological journals were wont to reject manuscripts that contained mathematical notation or to insist that the mathematics be relegated to an appendix or be eliminated. Started with a few small loans, the journal has been a financial success almost from its inception. Its purpose was to foster the development of psychology as a quantitative rational science, a goal to which Thurstone truly devoted his professional life. The venture always enjoyed his active support. He was the first president of the society and served for many years as Chairman of the Editorial Council. In the early days, the journal was shipped in bulk by the printer to his office. Its remailing to subscribers constituted an irksome and often a harrowing experience.

### *Examining Achievement at The University of Chicago*

In 1931, Thurstone was appointed the first chief of the Board of Examinations of the College at The University of Chicago, a post that he held for some seven years. He initiated several important ideas in the examining procedures. He insisted that the examinations become public property once they had been given, in order to evade the problem of fraternity files. This of course meant that new questions had to be constructed repeatedly, a requirement that doubtless had desirable effects on the curriculum. The identity of the student was not known to the person who assigned the marks, which were determined by inspection of score distributions. Whenever possible, the examinations were objective. The faculty itself was responsible for developing them in collaboration with an examiner on the central examining staff. Many of the teachers became quite skillful in adapting their course content to various types of objective test items (14).

Thurstone soon came to feel that the practice of determining a mark for a whole year's study in a field on a single comprehensive examination is a mistake. He expressed the opinion that

freshmen and sophomores need the assurance and guidance of frequent appraisal of their work, and that instruction is not complete unless the student has considerable contact with an experienced teacher. Even so, he felt that lectures can be very effective when they are well done.

### *Approaches to Personality Measurement*

A recurrent interest of Thurstone was in the elusive realm of personality. We see evidence of his early attention to the writings of Freud and other psychoanalytic literature in his early book on *The Nature of Intelligence* (5). He has confessed that, although he had felt that the center of psychology lay in this general field, he was unable to invent any experimental leverage for dealing with it. He therefore turned to other problems more amenable to rigorous analysis.

He and Thelma at one time developed a personality schedule patterned after the Woodworth questionnaire (98). In response to demand for it, he arranged for its publication by the University of Chicago Press. He has wryly commented that he found that he was still owing the Press money after it had printed some 75,000 copies!

At the request of Beardsley Ruml, Thurstone spent a quarter working with Elton Mayo in Philadelphia. He found the experience highly profitable but reported that he was unable to produce a written exposition of Mayo's psychological system.

When Dr. David Lenz was introducing the Rorschach test in this country, he and Thurstone discussed the possibility of objectifying the scoring and interpretation. The speculation intrigued Thurstone, but his attention was already committed to scaling methods and other problems of test theory.

He returned to this early interest shortly after World War II. His approach was to attempt to tease out the psychological hypotheses implicit in such tests as the Rorschach and to supplement the list with others related to the diagnostic value of various objective measures. He assembled a set of over 60 tests representing various more or less plausible hypotheses concerning the

outcropping of personality traits in objective test performance. In general, the subjects would be unaware of the examiner's purpose. Many of the tests were projective for the subject but fairly well structured for the examiner. Thurstone felt that projective devices left open at both ends were hopeless for scientific study.

After Thurstone moved to Chapel Hill, he was still very actively intrigued by this area. Perhaps the most interesting objective test of personality that he had devised was that for color-form preference.

A fairly short temperament schedule was the product of factorial studies of personality questionnaires with many hundreds of items (166, 169). It contained 20 questions for each of seven scores. The schedule was planned for the appraisal of temperamental traits of normal persons who differ widely. A studied attempt was made to avoid terms appropriate only to the psychiatric clinic, not only in the questions asked but also in the terminology used to describe the traits.

The promising work in this field was by no means pursued to its limits and remains an area in which some major contributions to psychological theory and techniques should be forthcoming. Thurstone himself regarded the study of objective individual laboratory tests of temperament as one of the most challenging areas for psychological research in this generation.

### *Thurstone as a Teacher*

Students were the lifeblood of Professor Thurstone. In a real sense, he needed to teach. He depended upon students sometimes as a sounding board for new ideas and again as a source of inspiration. But beyond that, he felt an obligation to stimulate and develop new talent. I recall once having been asked how one could account for the marked productivity of Thurstone's students. I am still not completely sure. One factor, clearly, was a kind of mutual selectivity. Promising students flocked to him, and he in turn sought them out. The quality of the raw material alone is an insufficient answer, however. Thurstone devoted much time to individual consultation with students, listening to and evaluating

their ideas, offering modifications or substitutions as they occurred to him, and in various other ways inciting them in the direction of further creativity. The emphasis in Thurstone's laboratory was never upon recapitulating results of earlier work but rather upon developing techniques or applying old ones in new contexts. Perhaps the opportunity for close collaboration with Professor Thurstone at the frontiers of research is the most prominent environmental influence in accounting for the eminence of many of his former students.

In his classes and seminars, Thurstone applied two quite different teaching techniques. His regular classroom periods were likely to be devoted to rather highly formalized lectures, exhibiting a masterful organization of subject matter presented with a simplicity bordering on the elegant. Teaching a class was never a haphazard chore to Thurstone. No matter how many times he had taught a subject, he clearly demonstrated fresh preparation for each class meeting. He did not want his classes to meet at a very early hour in the morning, but neither did he prefer them in the afternoon. The reason for this, he confided, was that on a day his class was to meet he never felt quite comfortable about devoting himself to any other work until after he had discharged his responsibility to the class.

When Professor Thurstone in 1938 was awarded an appointment as Charles F. Grey Distinguished Service Professor at The University of Chicago, where he had already been made a full professor three years after his original appointment in 1924, he could have been free to relinquish all teaching in order to devote full time to research. The same opportunity was available when he went to The University of North Carolina. With considerable self-insight, however, he elected in both cases to continue to expend a portion of his energies upon teaching. He profited from students perhaps as much as they gained from him. We thus can understand his attitude that a long commitment to a university appointment allowing full time for research is likely to be sterile for most individuals.

The other type of teaching at which Thurstone excelled was through the weekly seminars at his home. These were not informal bull sessions. Anyone with an idea was encouraged to present it to the seminar, which typically included several graduate students

in psychology, mathematical biophysics, or some other field related to mathematics or statistics; a number of faculty members from these same areas; and often special visitors. The presentation itself was likely to be quite formal, but it did not have to deal with a completed theory or research project. Any new idea was welcome. Then, over coffee and Swedish rolls, came a more informal period of questions, criticisms, and often fruitful suggestions. Those who had been encouraged to participate in these seminars rarely permitted anything to interfere with their attendance. Some of them may even have designed their own homes to provide a permanent installation of a blackboard, which has been a prominent characteristic of Thurstone living. In the Chapel Hill house is a retractable blackboard that can be available either to the study or to the spacious living room.

Just as Thurstone worked on his lectures to students, so did he meticulously write complete manuscripts for public speeches. He would have felt that an informal, off-the-cuff talk was an imposition on his audience. If he accepted an invitation to speak—and he did so frequently—his listeners could be assured that he would come prepared. He was generous with his time and displayed a not inconsiderable talent for interpreting psychological concepts to lay groups. For them, too, he was a superb teacher.

As we have seen, the original interest in experimental approaches to learning and teaching was responsible for Thurstone's shift to psychology from engineering. He did not devote a great amount of time to learning research beyond his dissertation study (3), although two significant articles appeared in 1930: "The Learning Function" (93) and "The Relation Between Learning Time and Length of Task" (94). Some of his former students and co-workers have continued to explore the application of quantitative approaches to learning data. Again, while he did not actively conduct experimental investigations of teaching, he had definite convictions on methodology. He felt, for example, that most teaching was wasteful of time because of an erroneous assumption that a lot of class discussion is educative. Thurstone held the belief, rather, that it was the instructor's responsibility to plan lectures and even illustrative examples with scrupulous care. He once said that he had never walked in to a class without feeling a certain responsibility for as many man-hours as there were students, and

never walked out without wondering whether he had succeeded in making it worth while for them to have come.

This pre-eminent teacher also had some revolutionary ideas about curriculum development, especially in relation to psychology. He suggested that a department should itemize all of the ideas, principles, and facts that should be included in the total departmental offerings and that these should then be assembled in appropriate sequences and groupings to constitute courses. Thus tiresome duplication could be avoided and prerequisites would have meaning. Changes in a course or new offerings would not be introduced without detailed discussion within a department, and new teaching material would be carefully prepared. Thurstone also thought that for graduate courses an effort should be made to reduce to an absolute minimum the amount of reading to be required of students. This strikes one as a refreshing point of view in the face of the preponderant opinion that advanced students should read everything ever written in their field. Thurstone pointed his finger especially at psychology, a field in which he found much of the writing to be expansive and verbose. He argued that the teacher might best summarize such writing in order to conserve student time.

A useful approach might be to apply Thurstone's ideas for curriculum overhaul and teacher preparation to much of the formal graduate teaching that is needed, and then combine it with the more informal seminars and on-the-job research training at which he also excelled. Were we to do this, the time necessary for the ordinary student to complete Ph.D. training could be reduced substantially or at least expended more profitably.

### *Contacts with Foreign Psychologists*

Inevitably, a psychologist of Thurstone's achievements attracted the favorable attention of psychologists abroad, and he was justifiably proud of the accomplishments of foreign students who came to this country to participate in the activities of his laboratory. Among these were Charles Wang and E. H. Hsü from China; Mariano Yela from Spain; John Karlin, Mrs. Melany E. Baehr,

and Mrs. Carol Pemberton, all of whom come from South Africa and later settled here; Nicholas Margineanu, who may still be a political prisoner in Rumania; Jean Cardinet from France; Sten Henrysson from Sweden; Per Saugstad from Norway; and Horace Rimoldi from Argentina. In addition, a number of post-Ph.D. fellows from this country chose the Psychometric Laboratory for a year of study, among these having been Allen L. Edwards, Lyle V. Jones, and J. E. Birren.

Inevitably, too, Thurstone was accorded opportunity to teach and lecture in foreign countries. In 1948, both he and Thelma held appointments as Visiting Professors at The University of Frankfurt. The scheduling of lectures and seminars was such as to provide opportunities for visiting lectures at Marburg, Heidelberg, Münster, and elsewhere. There were also lectures in Paris and at the International Congress of Psychology in Edinburgh and a full month of lectures and consultation in Sweden.

Again in the spring of 1954, he was appointed Visiting Professor at The University of Stockholm. This trip, during part of which Thelma (and I, too, most fortunately) joined him, included a period of several weeks at the Institute for International Research in Education at Frankfurt am Main, Germany, as well as lectures at The University of London, Uppsala, Lund, Göteborg, Oslo, and Helsinki, as well as a memorable two days with Sir Godfrey and Lady Jennie Thomson in Edinburgh.

After the 1948 visit, Thurstone remarked upon the lack of psychological measurement in Europe, except in the case of the British Isles and Sweden. He was puzzled by the well-nigh universal European psychologists' confidence in graphology. But he commented, again perhaps with tongue in cheek, that this might be a better bet than the American preoccupation with the Rorschach test. Both, he felt, should be regarded as experimental procedures rather than as established techniques to be relied upon in clinics.

One previous return to Europe is worthy of mention—his 1923 attendance of the International Congress of Psychology at Oxford. There he had met many of the European psychologists with whom he maintained contact in later years. He had also been able to spend a week in Sweden, where he found after two or three days that he could speak Swedish with ease, even after an absence of some 22 years. This same experience was of course repeated on his later visits.

### *Professional Affiliations and Recognition*

To Professor Thurstone came almost every honor that a psychologist could hope to achieve. His professional affiliations include the following: the American Psychological Association, of which he was president in 1932; the Division on Evaluation and Measurement of this Association, of which he was president in 1947; the Psychometric Society, which was founded largely at his impetus and of which he was the first president in 1936; the Midwestern Psychological Association, of which he was president in 1930; the Chicago Psychological Club, which elected him president in 1928; the Society for Promotion of Engineering Education, in which he was a Council member; the American Society of Human Genetics, which appointed him to its Advisory Editorial Committee; the American Statistical Association, in which he was on the Board of Directors; the Chaos Club, composed of representatives of several scientific fields in certain midwestern universities; the American Association for the Advancement of Science; the National Academy of Sciences; the American Academy of Arts and Sciences; and the American Philosophical Society. He was also elected Honorary Fellow of the British Psychological Society, of the Spanish Psychological Society, and of the Swedish Psychological Society. He has been on the Editorial Board of the *Journal of Experimental Psychology* and on the Editorial Council and Board of Editors of *Psychometrika*. He was the recipient of a 1949 award from the American Psychological Association for the best article published in any of the Association's journals (157), while in 1951 he received the Centennial Award from Northwestern University. The University of Göteborg conferred upon him an honorary doctorate in 1954.

Other clubs and fraternities of which Professor Thurstone was a member are the Quadrangle Club in Chicago, the Chicago Literary Club, the Cosmos Club in Washington, Eta Kappa Nu, the Society of the Sigma Xi, and Phi Delta Kappa.

Occupied as he was with a full professional life, Leon nonetheless had time for many friends and for his family. The eldest of his three sons, Robert, aged 34, has been teaching in the School of Engineering at North Carolina State College and expects to complete his Ph.D. degree in electrical engineering this year. The second, Conrad, aged 31, received his M.D. degree from The

University of Chicago and is currently Instructor in Surgery at the School of Medicine of Stanford University. The youngest, Fritz, aged 30, has obtained his Ph.D. from North Carolina State College, also in electrical engineering. After teaching there for a number of years, he now has accepted a position in the Department of Bio-Medical Engineering, Bowman Gray School of Medicine, Wake Forest College, Winston-Salem, North Carolina. Leon would have been proud of these more recent achievements of his boys, as he was of their earlier accomplishments.

In Chapel Hill, as in Chicago, the Thurstones constituted a center of gracious entertaining, despite the fact that Thelma has continued to remain active in professional work. Visiting psychologists from all over the world have flocked to the Thurstone home, where they always have received a cordial welcome. Colleagues in other university departments also developed great admiration and warmth of feeling for the Thurstones. A number of their Chicago friends established summer homes at Wabigama, a colony on Elk Lake near Rapid City, Michigan. There the Thurstone family spent many happy weeks during summer months, made all the more pleasant by their congenial associates in this venture in living.

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From this survey of Thurstone's life and scientific activities, we have seen that the literature of psychology is so replete with his contributions that it seems he must never have seriously considered a psychological problem without having contributed notably to its solution. He exhibited throughout his productive life a rare ability to capture the imagination of university colleagues and administrators, students, military leaders, industrialists, and representatives of foundations. He was distinguished by his insightful grasp of new problems, inventiveness in solving them, painstaking application in working out their solutions, and an infinite degree of skill in imparting ideas to others and in inspiring them, too, toward creative accomplishment.

To Louis Leon Thurstone—Mr. T., as he was affectionately known by students and co-workers in his laboratories—penetrating analyst, thrilling teacher, superb lecturer, exacting supervisor, inspired investigator, meticulous workman, talented photographer, genial host, distinguished guest, dependable friend—to him we of this gathering and the scientific world at large will forever be in debt.