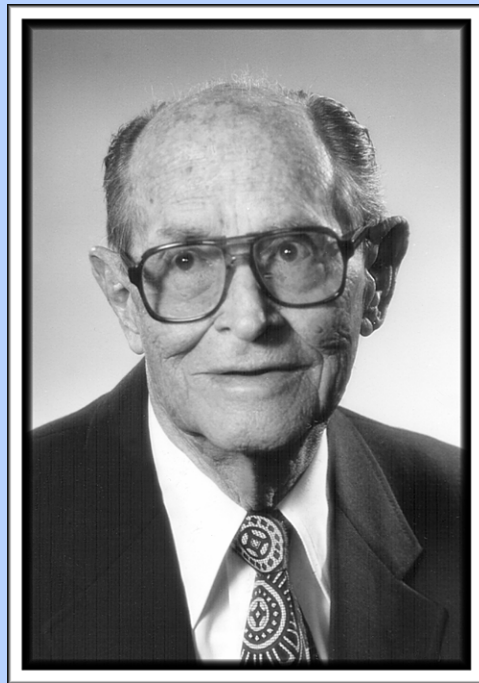




A Conversation With Ledyard R Tucker



*Listening.
Learning.
Leading.*

A Conversation With Ledyard R Tucker

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ETS, Princeton, N.J.

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¹ Neil J. Dorans is Ledyard R Tucker's last doctoral student in the Department of Psychology at the University of Illinois. This interview completed a quarter century after Tucker had chaired his last dissertation committee, about six decades after he started working with L.L. Thurstone.

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Ledyard R Tucker (1910 – 2004)

Bio Information

Ledyard R Tucker, or “Tuck” as he became known to his colleagues, was born on September 19, 1910, to Sarah and Reese Tucker in Glenwood Springs, Colorado. He attended the Glenwood Springs Elementary School and the Garfield County High School, graduating in 1928. He attended the University of Colorado from 1928 to 1933, including two six-month stints with a construction company in San Antonio, Texas. After graduating with a degree in electrical engineering in the midst of the Depression, Tucker drifted from Colorado to Texas to Chicago looking for work. He was fortunate to obtain a Works Progress Administration-like² position as a research assistant to Professor L. L. Thurstone³ at the University of Chicago, where he started working in January 1934. Thurstone immediately recognized Tucker’s analytical and spatial talents and encouraged him to pursue further education, which Tucker did, first in economics and then in psychology. He continued to work as Thurstone’s research associate and as an instructor at the University of Chicago, completing his Ph.D. in 1946. He was widely regarded as Thurstone’s most prominent protégé.

In 1944, Tucker took a position in statistics with the College Entrance Examination Board. In 1947, when the Educational Testing Service was founded, Tucker became the first director of statistical analysis. In 1952, he switched to the Research Department, where he stayed until 1960. He was a lecturer in psychology at Princeton University from 1948 until 1960. Tucker moved to academia full-time in 1960 when he joined the University of Illinois, where he held appointments as professor of psychology and professor of educational psychology.

In 1962, he was appointed professor in the University of Illinois Center for Advanced Studies, a prestigious appointment. Included among the many awards and

² The Works Progress Administration (WPA) was a federal relief measure established in 1935 to offer work during the Depression years to the vast number of unemployed U.S. citizens through a wide variety of public-works programs, including highway and building construction, reforestation, and rural rehabilitation. The WPA also funded cultural and research programs, such as the Federal Arts Project, Federal Music Project, Federal Theater Project, and Federal Writers' Project. The WPA was terminated in 1943 when employment increased during World War II.

³ L.L. (Louis Leon) Thurstone was central figure in the development of psychometrics, the science that measures mental functions. Thurstone developed statistical techniques for multiple-factor analysis of performance on psychological tests.

honors he received were the ETS Distinguished Service to Measurement Award (1981), the American Psychological Association's (APA) Distinguished Scientific Contribution Award (1987), the highest honor awarded by APA, and the Lifetime Achievement Award from Division 5 of APA (1997). Tucker also served as president of the Psychometric Society and of Division 5 of APA.

When Tucker retired in 1979, he was viewed as a pioneer and an intellectual giant in the field of psychometrics from the 1940s to the 1980s. He made major foundational contributions to the development of statistical methods in the areas of test theory, factor analysis, and scaling, which are still clear and relevant today. Tucker, who continued to consult well into his 70s, died on August 16, 2004, at the age of 93 in his home in Savoy, Illinois.

**Based on a conversation Neil J. Dorans had with
Ledyard R Tucker on October 30, 2003⁴**

Tuck, you were known for your superb spatial reasoning skills and your strong analytic skills. Where did they come from?

Tucker: Let me start with my experiences before I attended the University of Chicago because they set the stage for those later experiences. I was always a poor student in the linguistic areas. I was told I had a bad memory for words. I did poorly in school until we began to do mathematics. Up to that point, most class work involved reading and spelling, which was hard for me. When we started doing mathematics and science in high school, I began to do very well.

In high school, I was allowed to go into the chemistry lab after school, where I simulated production of compounds that were produced in chemical factories. For example, I made sulfuric acid. It is a complicated process. I was able to do that in high school, create chemical compounds made by chemical companies using knowledge about chemistry and experimental techniques that I learned in school and from outside reading.

⁴ This document is based on an article that first appeared in the *Journal of Educational and Behavioral Statistics*, American Educational Research Association and American Statistical Association, Summer 2004.

I entered the Western Slope Science competition and took first prize in chemistry as a junior and second prize in physics as a senior. I also received a National Honor Society award for my work in science as a high school student.

I became interested in lots of science and engineering while I was in high school. When I enrolled in the University of Colorado, I planned to become an electrical engineer. Even in college I had trouble with the linguistic classes.

I completed all my course work at Colorado, but didn't attend the graduation ceremony because I had not paid my tuition. A few years later I paid the money and received my degree. It was 1933. We were in the midst of the Depression. So I was a trained electrical engineer looking for a job in the worst of economic times.

What was it like to leave college in 1933? Few people reading this article were living at that time, let alone graduating from college. Not having enough money to pay for tuition is such a distant thought to many living today. Try to give us a sense of what it was like.

Tucker: It was hard. My family was poor. While in college, I was a boarder. I washed dishes, stoked the fire in the morning, shoveled snow, and did other jobs for my room and board. I worked for a construction company near San Antonio for two six-month periods while I was an undergraduate. After school I went back to San Antonio looking for work, but there were no jobs with that company.

I hitchhiked back north towards Dubuque, Iowa, looking for work. I drifted through the Midwest, hitchhiking, and took a coal car on a train. I bused dishes at a cafeteria in Chicago. I was a forlorn man. I couldn't find a job. There were no jobs to be found.

Fortunately the federal government had a program, an academic version of the Works Progress Administration program. As part of my application to this program, I took a test. Because I scored high, L. L. Thurstone said he wanted me on his staff. I had come to Chicago very poor and desperate for work. I felt very lucky to be working for Thurstone. The job with Thurstone turned out to be the last job I ever needed to apply for.

So you arrived in Chicago from Colorado in the midst of the Depression. What was it like in Chicago?

Tucker: Electrical engineers were trained in matrix algebra. As a result, I was ahead of most of my colleagues in Thurstone's lab because of my undergraduate training and my capacities for spatial reasoning.

One thing that struck me immediately was the wisdom of Thurstone's multifactor perspective on human abilities. As I said earlier, I am poor at linguistics, which made it hard for me to get my point across. On the other hand, I am strong with respect to quantitative and spatial abilities. My own pattern of abilities supported Thurstone's perspective about the multifaceted nature of human abilities. So I studied the mathematics of this approach and found the foundation to be very interesting to me.

The University of Chicago was a wonderful place to be at that time. Many folks who were associated with Thurstone's lab founded the Psychometric Society. People like Dorothy Adkins, Harold Gulliksen, Paul Horst, Marion Richardson, John Stalnaker, and Dael Wolfle were around at various times. It was quite a group at that time. The profession was small and I knew most everyone in it.

Today, computation is done in a flash. Computers enable us to take for granted what was once mind-boggling. They also allow us to be careless in our computations. Former students and colleagues have always marveled at your capacity to get things right the first time you program something. While you made heavy use of technology throughout your career, you started in the field when there were no computers. What was it like?

Tucker: People were the computers back then. In Thurstone's lab, there were about five of us sitting at desks with mechanical desk calculators. Everything was done by hand. We used graph paper to plot points. We would sit down and look at the points and rotate the axis on the graphs.

Our first factor analysis involved 57 variables and about 200 people. The Bursar's Office had IBM equipment that took binary scores and produced proportions correct for each item and proportions correct for pairs of items. We

took these proportions and used a table lookup process in a book to convert them to tetrachoric correlations.

We took these tetrachorics and used the mechanical calculators to extract centroid factors. And then factored the residual correlations until we ended up with 13 factors. Rotation of axes was performed from inspection of graphs of pairs of factors. Computations were made from rotations indicated on the graphs. A year elapsed from the time we received the tetrachorics until the factor analysis was complete. Quite different from today.

There are many apocryphal stories about the R “without the period” that serves as your middle name. For example, one story that I heard and passed on maintains that in order to graduate from the University of Chicago, you had to have a middle name. So you adopted R because you had factored so many correlation matrices by hand and R seemed like an appropriate middle name. Recently you told me that this story was false. What is the real story about the R “without the period” that is your middle name?

Tucker: The R came from my parents. While I haven't checked my birth certificate recently, I'm sure I have had it all my life, so I attribute it to them. But the people who can answer that question are long gone. My best hypothesis, and it is only a hypothesis, is that I was named after an Uncle Ledyard Romulus and that my parents didn't like the Romulus so that just used the R. But this is only a guess.

Eventually you left Chicago. But you needed to complete your dissertation and other requirements. Is there a special story behind your dissertation?

Tucker: The story behind my dissertation is a little unusual. I hadn't selected a dissertation topic in 1943. I had already published several papers in journals such as *Psychometrika*. So Thurstone picked out one of the publications and said something like, “This is your dissertation, you pass, and you don't have to get it published because it is already published.” At my defense, I recall that I knew more about canonical correlation than my committee did, so I taught them about it. I was offered a job with the College Board. I had been offered

jobs before that, but Thurstone didn't think they were the right for me.

Thurstone believed that this job with the College Board was the correct job for me in 1944. John Stalnaker was interested in bringing me to the College Board.

What major contributions did you make while at the College Board?

Tucker: The College Board offices were at 2 ½ Chambers Street in downtown Princeton in a converted garage. The College Board was in Princeton at that time. World War II was going on while I was at Chicago, and I received a deferment because I was doing research work. When I went to the College Board, my deferment continued because I was brought in to write research reports on projects for the Navy. I didn't do a good job. Linguistic work was not my strength.

In time, I took over direction of scoring, computing, and tabulating. One of the problems I faced immediately was the scaling of raw scores onto the SAT scale. Admissions people were noticing that scores were not as expected. I discovered several reasons for these problems. A major reason was that the College Board scaling procedures did not take in to account the fact that World War II had changed the composition of the test-taking population. As the War went on, the test-taking group became more and more composed of women. The procedures used by the College Board didn't take this shift in population into account. In addition to the population shift, there were errors in computation that had been made in 1943 and 1944 that contributed to the score problems.

To address the population shift problem, I applied the theory of selective sampling to the score equating process. I recommended the use of an anchor test to adjust for the effects of selective sampling. This procedure became known as "Tucker equating" because Bill Angoff called it that. I was never comfortable with my name being attached to the method because the procedures for taking into account selective sampling had been established long before I applied them to the equating process.

You were an original employee of the Educational Testing Service (ETS) and headed up the statistical analysis portion of the company.

Tucker: ETS started in 1947 with offices on Nassau Street and 2 ½ Chambers Street that were connected to each other. So I changed companies but not buildings. I was the first director of statistical analysis at ETS. The group was about 10 people or so. I used my experience from College Board to set up this group. I established four areas. Bill Angoff was placed in charge of validity analysis. Frances Swineford was put in charge of item and test analysis, Henrietta Gallagher took charge of computing and tabulation. I always liked the equating work, so I had responsibility for that.

In 1952, you switched to the Research Department at ETS to pursue some of the work in individual differences that distinguishes your career. Please tell us how you became interested in some of these topics.

Tucker: Back in the 1950s, researchers interested in how people learned over time averaged information across people. They tended to ignore the variety of people. I viewed the data as a table containing the performance of people at different occasions of time. I did components analysis in an effort to identify the variety of individuals in learning.

At the time I was doing my work on learning curves, I was aware of work being done by C. R. Rao. An Indian statistician with a considerable reputation, Rao had published several articles on psychometric issues. He published these articles as a very accomplished statistician, but he was not addressing psychological questions about learning curves. In general, not enough attention was being paid to the variety of people.

Around that time, Sam Messick was interested in individual differences in the context of multidimensional scaling. I was asked by Harold Gulliksen and Sam to look into this problem. Back in those days and throughout my career, people would come to me as a methodologist and ask me to engineer a solution to their problem. I had the idea that there might be different types of people that perceive things in different ways. This led to my publication with Sam of what was the first multidimensional scaling model that allowed for the variety of individuals.

Three-mode factor analysis grew out of this multidimensional scaling work. While I was at ETS, I had observed that Charles Osgood of the University of Illinois had collected data from three modes—concepts, scales, and subjects—in his semantic differential research. I thought that the data should be analyzed differently than it was. He collapsed over people and threw away individual differences data. So I developed the 3-mode factor analysis approach, a very general model for evaluating individual differences data. It was able to deal with the variety of people.

My interest in modeling the variety of individuals had commercial implications. One year, Chrysler had designed a new car and had used market research to guide its development. They averaged across people and came up with the wrong answer. They built a car that was designed to appeal to the average consumer. But there was no average consumer. The average consumer didn't buy cars. Instead there were types of people who were attracted to different types of cars. Chrysler almost went out of business.

The approach to modeling that I employed for learning curves, scaling of stimuli, and semantic differential analysis was also applicable to marketing data. I may have been one of the early advocates of niche marketing, which recognizes that there are types among people that need to be modeled. Proctor and Gamble successfully followed my recommendations.

Why did you leave ETS for the University of Illinois around 1960?

Tucker: I had a long association with Lloyd Humphreys since the days when I was at Chicago and he was at Northwestern. I kept in touch with Lloyd through the years when he worked for the Air Force during the War. Lloyd was the head of the Psychology Department at the University of Illinois. One day he came to town and offered me a full professorship. It was an offer that I couldn't turn down. Lloyd and Lyle Lanier were committed to expanding the Quantitative Psychology Program at the University of Illinois. Hiring me as a major focus of their effort.

I had worked with Harold Gulliksen on the ETS Psychometric Fellows Program for graduate students that was a part of Princeton University at the time. I had

taught graduate courses at Princeton. So I had developed an appetite for academia. I wanted more interaction with graduate students. Besides, I was getting bored with my work in the Research Division at ETS and looked forward to solving problems from other domains.

Several of your graduate students became adept at simulating data using your library of FORTRAN functions and the Tucker-Koopman-Linn simulation model. Why did you develop the Tucker-Koopman-Linn model?

Tucker: I was unhappy with people working in methodology who manufactured artificial data that perfectly agreed with their models. Most simulations were merely demonstrations that the program was written correctly. These demonstrations did not evaluate the usefulness of the methodology because the simulated data was not real. The Tucker-Koopman-Linn approach provided a mechanism for introducing noise into made-up data so as to make it more realistic. Then this more realistic data could be used to evaluate different models. That was the idea. The problem of inferring substantive conclusions from simulated data still exists. We just have to keep advocating the generation of more realistic data. The Tucker-Koopman-Linn model is one way to do that.

Are there any ways in which you think our field (meaning psychometric methods and statistics as applied to psychological research) may have gone astray over the last 50 years or so?

Tucker: Hypothesis testing has been overused. There was this young fellow who operated under the misconception that the only data worth collecting is that which can be used to test a statistical hypothesis. He never looked at the data to see what was going on in the data. He did his hypothesis tests and went on to dream up elaborate explanations for his significant effect. I argued with him, but he insisted that you should not look at the data, just the significance test. This made me unhappy.

I don't trust people's imagination when it comes to interpreting significance tests. Just like I don't trust verbal arguments. It is so easy to speak falsehoods even when you don't intend to. You can make so many verbal inferences and

statements that look all right but are incorrect. There are no checks on it. I don't trust doing research entirely by your imagination. You need to look carefully at the data and try to understand it.

Significance testing leads to an overdependence on automated rules that don't always tell the story right. Henry Kaiser attempted to do the computing without looking at the data with his little jiffy. This is dangerous. I think you have to stop and take a look and see what the data is telling you. Don't use some automatic rule as a substitute for data analysis.

Measures of goodness of fit can be helpful but they can also be misleading—especially the global ones. These measures should not be a substitute for careful evaluation of residuals. They depend on things that are unrelated to fit. In small samples, global measures are rarely significant. In large samples, statistical significance can be associated with trivial effects.

I worry that we were led astray by relying too much on automatic rules.

At ETS, there is a monthly seminar called TuckerWorks, which is set up to encourage staff to share works in progress. You always shared your works in progress with your many students and colleagues. This unselfish sharing of your work is cited as an exemplar for this series. In addition, you as a person are cited as a role model for the profession. You have earned a reputation not only as a scholar, but also as a true gentleman who epitomized civility.

Tucker: Thank you. I am pleased that there is an interest in what I did so many years ago.