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Data Science Conversation

A Conversation with Dr. David S. Salsburg

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Abstract

Dr. David S. Salsburg's career has been an exceptional one. He was the first statistician to work in Pfizer, Inc., and later became the first statistician from the pharmaceutical industry to be elected as an ASA fellow. He played a vital role as a statistician in Pfizer, Inc. at a time when the drug approval process was developed. For his contributions, Dr. Salsburg was awarded the Career Achievement Award of the Biostatistics Section of the Pharmaceutical Research and Manufacturers of America in 1994, for "significant contributions to the advancement of biostatistics in the pharmaceutical industry". Dr. Salsburg also managed to achieve something rare among scientists, which is to popularize his field of research and make it accessible and enjoyable to laypeople. Dr. Salsburg is possibly best known for his book "*The Lady Tasting Tea – How Statistics Revolutionized the 20th Century Science*", in which he combines simple and engaging explanations of statistical methods, and why they are needed, along with personal stories told with a great deal of generosity, fondness, and humor about the people who developed them. Dr. Salsburg's admiration for the those statisticians shines through. In this interview, Dr. Salsburg shares his own stories and perspectives, from his childhood, through his service in the Navy and his long and productive career in Pfizer, Inc. to his equally productive retirement, in which he authored "The Lady Tasting Tea" and other books.

Keywords *data science; education; industrial statistics; statistical application*

1 Introduction

Dr. David S. Salsburg had a long and productive career as a statistician, working for Pfizer Inc. He was the first statistician hired by Pfizer, and later he became the first statistician from the pharmaceutical industry to be elected as an American Statistical Association (ASA) member. When he joined the company, many of the procedures which are used nowadays in order to get new drugs approved by the Food and Drug Administration were not yet in place. Dr. Salsburg's work paved the way to better and safer drugs, by establishing rigorous statistical methods, and through collaborative work with toxicologists and pharmacologists.

Dr. Salsburg was born in 1931, and grew up in Wilkes-Barre Pennsylvania and then in Hartford, Connecticut. He studied History at the University of Pennsylvania and earned his B.A. (honors) in 1952. After finishing his B.A., Dr. Salsburg served for three years in the U.S. Navy as an officer (1952–5). Between 1955 and 1960 he pursued a business career, and then worked as a high school teacher (1960–1). He completed his M.S. in Mathematics in 1963 (Trinity College, Hartford), and after one year as a graduate student in Mathematics at Brown University

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(1963–1964), he transferred to the University of Connecticut (UConn), where he got a Ph.D. in Statistics in 1966. He held academic positions at Trinity College, Hartford (1962–3) and the University of Pennsylvania (1966–1968), as well as part-time positions at UConn (1968–73), Connecticut College (1983), Harvard University, School of Public Health (1996–7), and Yale University (2004–2017). From 1968 and until his retirement in 1995, Dr. Salsburg worked at Pfizer Inc., in Groton, CT. He received several honors, including being elected Fellow of the American Statistical Association (1978), and receiving the PhRMA Distinguished Statistician Lifetime Achievement Award (1994). He was also the recipient of the Smolar Award for Excellence in North American Jewish Journalism (1975), and the University of Connecticut Distinguished Alumnus Award (2008).

Remark: Dr. Salsburg curriculum vitae is provided in the supplementary material, and it contains a complete list of his professional and academic positions, his published research, and his books.

Dr. Salsburg managed to do something rare among scientists, and statisticians in particular. He managed to popularize the field by conveying statistical ideas in a clear and entertaining way in his famous book, "The Lady Tasting Tea" (Salsburg, 2001). This book, which as told below, is a collection of dinner-time stories told at the Salsburgs' house, has been used by many teachers. The important ideas behind many statistical methods are conveyed in simple terms, and with many stories about the people behind these results. Dr. Salsburg's admiration for the protagonists of his stories shines through. With generosity, fondness and humor, Dr. Salsburg brings to life the people who shaped the field as we know it today. For example, in the chapter about Kolmogorov, the reader gets to know a unique genius, who excelled in many areas and was a dedicated teacher and a family man who lived life to its fullest, until the very end. Thus, after reading the chapter, Kolmogorov becomes much more than the axioms he is perhaps most known for.

Dr. Salsburg's appreciation for statistics, its history, and mostly the people who contributed to it has lead him, together with Professor Harry O. Posten (UConn) to establish The Pfizer Colloquium. The event today has two parts – a colloquium, and a conversation with the Distinguished Statistician. Today, the colloquium is being held in honor of Dr. Salsburg and the conversation is in memory of Professor Harry O. Posten. The prestigious event began in 1978, with C.R. Rao, from the Indian Statistical Institute, as the guest of honor, and has been going on to this day (in 2024, the honored statistician is Prof. Nancy Reid, University of Toronto, Canada). The event is currently supported by Pfizer Inc., the UConn Department of Statistics, and the American Statistical Association (ASA).

Remark: For video recordings of past Distinguished Statistician colloquium events, see the ASA YouTube channel, https://www.youtube.com/@AmstatVideos and the Pfizer Colloquium web page, https://statistics.uconn.edu/pfizer-colloquium/.

This interview was conducted in two parts – some questions were presented during a Zoom call, while others were done by email exchanges between the authors and Dr. David Salsburg. In this interview we use abbreviated names, so that **NT** stands for Naitee Ting, **HB** stands for Haim Bar, and **DS** stands for Dr. David Salsburg. At places in the conversation, we added brief annotations via Remark.

2 Chronography

Dr. Salsburg is known for his long and impactful career with Pfizer Inc., and as an author. We talked to him about his childhood, his college years, the time he served in the Navy, and other important landmarks in his life.

2.1 Childhood

HB: *Tell us about your childhood and your upbringing. Are there people making important impact on your life? Who and how?*

DS: My father was born in this country. My mother immigrated as a child of six. All four of my grandparents were born in eastern Europe, my father's family from Lithuania, my mother's family from White Russia. I had one brother two and a half years older than me, a sister two and a half years younger than me and another brother five years younger than me. Our home was one where education, books, and reading were prominent. My mother enjoyed murder mysteries and romance novels. She would take these books out of the library and devour them, often starting and finishing a book in one evening. My father was a veteran of World War I and an admirer of Teddy Roosevelt, whose biography he frequently quoted. He had a subscription to Time magazine and the local newspaper, and he knew a great deal about American history.

My father ran a kosher meat market, and he used the less desirable cuts to make luncheon meats (rolled beef, corn beef, hot dogs, salami, and baloney), which gave him an edge over other kosher meat markets, who often had to throw away the less desirable cuts. My father and mother were active in the Jewish War Veterans (JWV) and its Women's Auxiliary. My mother was on a national board and attended annual meetings of the JWV Auxiliary.

We moved from Wilkes-Barre Pennsylvania to Hartford, Connecticut, the summer before I entered the 3rd grade. I knew how to read and could handle complicated sums before that. There was a branch of the public library across the street from our elementary school, and my older brother, Zev, and I spent many an afternoon browsing among the books. We started in the children's section and read all the Poppy Ott mystery books. By the time I had reached 6th grade, we were reading books from the main part of the library. We both became fans of Harold Lamb and his popular history books. I went to junior high (in the same set of buildings as the elementary school, across the street from the library). This was at a time when the theories of education were that children in grades 7–9 would be too enmeshed in the emotional turmoil that resulted from puberty and could not be expected to learn much in those grades. Instead, we spent classroom time and homework reviewing math and grammar from the previous grades. Zev found a college astronomy textbook and proceeded to do all the quizzes at the end each chapter. I found the books by Hendrick van Loon and spent hours in the world of his vivid imagination.

All four children in my home had music lessons. I took flute lessons from Asher Zlotnick, who introduced me to more than the flute, as he taught me about the forms of symphonies, concertos, overtures, etc. He was replacing his collection of 78 rpm records with 33 1/3 rpm vinyl records, and he gave me some of the outdated 78's, which I took home and listened to over and over.

So what were the major influences on my intellectual development before high school? A home where learning and reading were paramount, Asher Zlotnick who introduced me to classical orchestral music, and the pages of Harold Lamb and Hendrick van Loon.

2.2 The Navy and College Years

NT: *Before embarking on a career in statistics, you served in the Navy. Can you share some stories from this period in your life?*

DS: The year before I went to college, the U.S. Navy had decided that it needed to recruit its officers from more than the capacity of the Naval Academy in Annapolis. This was to meet the expected need for more officers as the Navy began an enlargement. Admiral James Holloway devised a scheme where the Navy would pay the college tuitions for students who were about to finish high school and could pass a rather stiff exam covering a wide range of topics. The Holloway plan was also aimed at increasing the cultural diversity of the officer corps, which, until then, was drawn primarily from white well-to-do protestant families. I took the exam and was offered a position in the Naval Reserve Officers' Training Corps (NROTC) at whatever college I could get into. I was accepted by the University of Pennsylvania (liberal arts college), where I was mustered into the Naval Reserve Officers Training program.

By the time I finished my undergraduate studies (major history), the Korean War had started, so my tour of active duty was raised to 3 years, and I was assigned my first berth on the anti submarine destroyer, USS Saufley, stationed out of Key West, Florida. As the most junior officer on board, one of my jobs was to oversee the officers' mess. The head steward (who really ran the mess) told me that we needed more teaspoons. And so, using the funds the officers paid to maintain their mess, I ordered a dozen teaspoons. However, the social milieu of the US Navy officer corps was that of the well-to-do white protestant world of the Northeast, "teaspoons" were thin little sticks with tiny bowls (for serving tea). What I wanted were called "dessert spoons". Never having been invited to dinner at the Astors', I did not know that. Needless to say, the captain of the ship was not happy. But, Holloway's plan was working. By the time I had finished my tour of active duty, there were many more officers with Irish and Jewish names, and there were black officers, and even (horrors!!) female officers. I've often wondered how many ships' officers mess had unused stashes of teaspoons.

Upon graduation from college, I had about a week home and then reported for duty as an ensign on the USS Saufley, an anti-submarine destroyer stationed in Key West, Florida. The Korean War was in full battle, and I have a battle ribbon to attest to this, but I was always stationed on the other side of the world. I was named fire control officer on the Saufley and had to learn the details of weapons and fire control from the manuals, from firsthand experience as we ran through war games, and to learn what really happens from the senior petty officers in charge of the men I was to command. I was also named the ship's education officer. So, while I had very few men interested in getting more formal education, I had access to paperback versions of college texts that I could read on my own. So, I was able to read through courses on European and American history, on ethics, and theories of knowledge. Two of the books that fascinated me were a history of mathematics by Smith, and an anthology of articles from modern math journals called, "What is Mathematics" with Herbert Robbins as one of the compilers.

Remark: The book "What is Mathematics" was written in 1941 by Herbert Robbins and the famed mathematician Richard Courant (Courant and Robbins, 1996). It appeared in multiple languages and a second edition was printed in 1996 (with Ian Stewart). Robbins is most well known among statisticians for introducing the empirical Bayes approach (Robbins, 1951, 1992). He also made important contributions in Boolean algebra and graph theory. To read more about Robbins, see the Wikipedia page: https://en.wikipedia.org/wiki/Herbert_Robbins.

I was also now surrounded by men who did not come from homes where books and knowledge were important, and the "street knowledge" they possessed was often filled with errors and strange ideas. But, I also had some good friends among my fellow officers and retained those ties of friendship with two of them after we had all returned to civilian life.

When I graduated from college, my grandmother asked me what kind of graduation present I would like. I asked her to get me one or two volumes of the Soncino Books of the Bible, where the Hebrew and Aramaic of the books of the Old Testament were presented with modern commentary. She bought me the 14 volumes that had been published up to that date. By the time my three years of active duty were complete, I became the only person on the Saufley (and possibly in the entire Navy) who had read through all of the books of the Hebrew Bible with detailed commentary.

2.3 Graduate School – University of Connecticut

HB: *Please share with us about your UConn days – any special memories? Interesting stories about the department, professors or graduate students? What prompted you to make the transition from mathematics to statistics?*

DS: In 1964, I was in my first year as a Ph.D. candidate in the department of mathematics at Brown University. I had already received a master's degree in mathematics at Trinity College in Hartford. When I applied for the Ph.D. program at Brown I did not realize that Brown had two mathematics departments – the Math Department (where I was accepted) and an applied math department (which was the type of math I really enjoyed). My year of study at Brown filled in some holes in my knowledge of abstract mathematics, but it soon became clear to me that the only faculty members looking for graduate students to advise were involved in algebraic topology – a subject that used "diagram chasing" for proofs and that was not very exciting to me. One of my fellow students at Trinity had been Jimmy Woods, who had graduated from the Coast Guard Academy and came back to head its math department when he received his MS degree. Jimmy wrote to me about the new department of Mathematical Statistics that was opening up at the University of Connecticut in Storrs and suggested I look into it. Bob Riffenburgh had been named the chairman of the new department and he had promised to have his first Ph.D. candidates within three years. He knew he could fulfill this promise by recruiting students like me who had completed most or all of their course work elsewhere and who were ripe for beginning work on their Ph.D. theses.

Remark: To read more about Bob Riffenburgh's life and career, see Bar and Yan (2023).

In addition to the courses I'd taken, Fran and I also had a growing family. Our first two children Pam and Dena, had been born before I started at Brown, and Fran gave birth to our third, Elizabeth, the tenth day I was at UConn.

I switched to the Statistics Department at UConn and found myself in an interesting collection of older students. Within a year, four of us had passed the preliminary exams and were ready to start our own research. Sam Zahl, who had, himself only recently received a Ph.D. in math at Harvard, became my advisor. Harry Posten, the faculty member with the longest tenure in the department, took on two of the students. I am not sure who was the advisor of the remaining member of the four. The four students, all of whom were successful in their research, were Vidya Taneja (who took his first Ph.D. position at University of Illinois), Larry Hatch (who went to work at the CIA), Mohammed Aziz (who returned to his native Morocco), and myself.

Although we often shared insights as students and graduated together, I fear I have lost track with all of them and with my other fellow students at UConn.

HB: *What was your dissertation about?*

DS: Oh, my, it was something from operations research. There's an inventory theory in operations research about how you maintain an inventory, so that you balance the cost of maintaining the inventory and having it there when it's needed. And the one unanswered question I looked at was, what happens if there is a substitute for the thing you have in the inventory for some of the people? How does that change the pattern? And so I just worked up the mathematics of the cost of requirement cost of replacement and put it all into a big mess, stirred it up a bit, and came out with a formula. I thought I made a contribution, a small one, but I guess enough to get a Ph.D. I was asked at one of the sessions I went to, if I thought that anybody was ever going to use my results. And I said, no, that the 'big S, the little S' procedure that everybody uses seems to be satisfying.

2.4 A Career with Pfizer Inc.

NT: *A major part of your career was your time with Pfizer Inc. Please tell us your experiences at Pfizer. Any interesting people, events, or stories?*

DS: I joined Pfizer Central Research in 1968 and stayed there for 27 years. In 1962, Congress had passed an amendment to the food and drug law, giving the FDA authority to require that any new drug has to be shown to be effective. Until then, they could only pass on whether the new drug was "safe." During the years after World War II, the medical community had begun to use randomized clinical trials to examine the efficacy of a given treatment. Prior to that, medical journals published case studies that showed both safety and efficacy, and the medical schools introduced courses in statistics that established double blind randomized trials as the "gold standard." Drug companies that wanted to market a new medicine were now being held to that standard.

Pfizer was one of the first companies to succeed in getting the FDA to approve a new drug (an anti-depressant Navane). Dr. Sheldon Gilgore was the newly named head of the clinical research department, and he was as unfamiliar with this new type of clinical investigation as most of the medical community. He "solved" the problem by having the clinics he used for the studies to design and analyze their own data. But, Gilgore did not like leaving the design and interpretation in the hands of many different independent clinicians.

[After completing the Ph.D.] I had taken a tenured position on the faculty of the University of Pennsylvania. I had the summer free and was allowed to earn money on my own during that time. Fran's father was quite ill at that time, and we did not know how long he would last. We rented a house in New London, CT, near her parents' home, so he could see the grandchildren, and I went looking for summer work to pay for our extra expenses. My resumé arrived at Dr. Gilgore's desk just as he was wondering where he could find a "statistician" to help design studies for three new drugs.

He got his "statistician" and I got paying work for the summer.

Oh, what a great place to be working! I saw large amounts of data derived from structured randomized studies. There was a late model IBM computer for me to use. There were studies to be designed, and people with expertise in areas I knew nothing about. They'd hand me a bunch of numbers, and I'd say, "Gee Whiz. How did you get these numbers, and what do they mean?"

As a simple example, I found that there was a "standard" method for measuring some event in the pharmacology labs. It was standard practice in the pharmacology labs for the technician to take two readings of the assay and use the average–unless, of course, one of them was "wrong". In which case, the technician would take a third measurement and average the two "good" ones.

I pointed out to one of the pharmacologists the problems with this "standard" procedure, that it made more sense to always take three measurements and use the median of the three – which has a smaller variance than the average of two. That memo was copied and sent around to more than just the one lab where I had seen the problem. Some years later, I was visiting the research labs of another company in New Jersey. There on the lab wall was a Xeroxed copy of my old memo.

It was a great place for a statistician. I learned about pharmacology, chemistry (and structure activity relationships), pharmacy (the formulation of drug delivery systems), toxicology, and animal husbandry.

And, Pfizer was also a great place for this statistician's family. Eastern Connecticut had several amateur theater groups, and one of them was sponsored by Pfizer. The Pfizer Players put on a musical every spring. The director and the pit orchestra were hired with money put out by the personnel department of the company. Income from tickets to the performances was used to reimburse the company, and the rest of the profits went to charitable organizations. When our oldest child, Pam, was 12, she tried out for the role of one of the two young girls in "Fiddler on the Roof", and was accepted into the company. After a couple of rehearsals, the head of the group asked me to join the men's chorus, pointing out that I was coming to rehearsals to bring our daughter, anyway. Thus, I found myself in the first act, advancing to the footlights with three other members of the chorus and singing about being a "son" in the little town.

We stayed with the Pfizer Players for seven years, and each of our children was in at least one of the plays during that time. It enriched our children's lives as we met new people and the experience gave us all an education about the workings of a modern musical.

Remark: Figures 1 and 2 show David in Pfizer Players productions with family members.

NT: *You were the first statistician at Pfizer, Inc. Can you tell us about your first project at the company, and how as the only statistician you are able to contribute?*

DS: Well, the first thing I was given to look at, we were planning the clinical trials for an antidepressant, and they were looking at other uses of the same antidepressant. And so I got involved in the design of the study. Nothing much came of that. The first really successful thing was, we had an Alpha blocker, a nerve blocker. and they had been sort of poisoned. The drug companies had gotten into trouble before, but our campus came up with one that was purely alpha blocking, and we tried it, first for depression, and then for different digestion problems, and it seemed to work quite well. So that was the first successful one I worked on. The chemical name was Prazosin, and the brand name was Minipress.

NT: *And that was for lowering blood pressure, right? And what were the statistical input or impact on that drug?*

DS: Yeah, the first studies were for blood pressure. They then began trying it in other situations, but the marketing people took over the development of it, so I wasn't involved in them. Attempts have been made to look at Alpha blockers before this, and they had a bad reputation of causing side effects. This one seems to be purely effective in what it was doing.

NT: *What were the statistical inputs in the development process of that drug?*

Figure 1: Left: David and daughter Pam in *Fiddler on the Roof*, Pfizer players. Right: David with daughter Dena and son Dan in *The Most Happy Fellow*, Pfizer players.

DS: The marketing people prepared some of the scripts to be sent around, and one said something about it being highly significant. I pointed out that the word significance is reserved for whether the p-value was less than 0.05, and that sort of set them back. They didn't know there was mathematics behind it all.

Anyway, I was not the first statistician in the drug industry. Mike Free, I think, at Smith-Klein was the first one, but I was the first one to get involved in the actual design and analysis of the studies from the very beginning to the end.

NT: *Other statisticians in the drug industry in those years included Charlie Sampson, Larry Gould, and Charlie Redman.*

DS: Yeah, and Mavis B. Caroll. There were a number of statisticians working in the industry. People like Mavis Carroll and Redman had come over from being part of the marketing divisions. The most outspoken one was Mike Free who had very strong opinions, and thought very little of some of the marketing people he had to work with. They had just set up the Biopharmaceutical subsection of the ASA when I joined Pfizer, and so I was involved in the early meetings of that particular section.

HB: *And that brings up the next question: you also have the distinction of being the first fellow of the American Statistical Association from the Pharma industry. Can you elaborate on your feeling when you were selected, and about your contributions that played a role in the committee's decision to select you?*

DS: I saw some interesting things that might be worth looking, and my first published investiga-

Figure 2: Left: David and daughter Pam in *Annie Get Your Gun*, Pfizer players. Right: David and daughters Dena and Liz in *Showboat*, Pfizer players.

tion dealt with what happens when not just the mean change, but changes in other parameters of the distribution, and I had written for the pharmacologists I was working with, whose knowledge of mathematics pretty well stopped at algebra, and maybe a little calculus. I think I was named an ASA fellow on the basis of that and similar publications.

HB: *How did it make you feel? Did you feel like a trailblazer?*

DS: Actually, I felt a little concerned that I got it when all these people like Mike Free who had been working in the field before I was, and doing good work. My wife told me 'It's not for me to judge. They gave it to you. Take it and run'.

NT: *Over the years, many other statisticians joined Pfizer. Can you tell us the impact it had on you, and can you assess the impact you have had on your colleagues? When I joined Pfizer in 1987 you've been Pfizer for almost 20 years, and I know I've been hugely impacted by you as a role model, and as an early mentor.*

DS: Well, you were there when there were few enough statisticians that I got to know everybody, and I think I gave you some advice that you should try and get some publications out, because that's what impresses people and moves you up in the profession.

Well, it's an interesting field, the division of labor is easy for management to manage. You got the chemists who dream up something new, and then the pharmacologists who try it out in animal models, and then the pharmacists who figure out what's going to get absorbed in human being, and the clinicians, and they all sort of work on a common pattern, and anybody who does something slightly different in the pattern is looked upon with a little bit of suspicion.

So it gave me an interesting view of multiple cooperations from a number of different fields, and I learned an awful lot because I'd go into a meeting, and I'd be the only one there with a statistical background, and they'd be talking about something, and I couldn't understand it, so I stopped them and say, gee whiz! Can you really measure this? How do you measure this thing? And that got them thinking about aspects of the study they never thought about.

HB: *Which professional accomplishments of yours are you most proud of?*

DS: Well, the thing I hoped I would be most proud of was my involvement in the Jackknife, which was an idea of Tukey's that essentially created a randomized subset of the data, and began looking at it in terms of these fake things that were generated by the same process. I thought that would go quite far. I got a couple of papers published, but somehow it didn't take with the people who were using statistics. They didn't recognize what I thought was the great value of the jackknife.

I met a lot of very interesting and thoughtful people through the American Statistical Association Meetings. I was just thinking about Chester Bliss the other day, and thinking of him as a person and as a contributor to some basic ideas. It was a lot of fun and a lot of questions that we were eager to get answered. Once I was on the board of the company I began getting queries from pharmacologists and from pharmacists, the ones who made up the formulations from chemists, and even a few marketing people sometimes checked me out.

3 Lady Tasting Tea and other Books

In the book "The Lady Tasting Tea", Dr. Salsburg educates the reader about statistical methods, why they are important, and when they should be used, while also providing the historical context for these methods – how they filled scientific gaps, how difficult some of them have been, and for some, how their timing was so crucial. Statisticians often find that their field is intimidating to others, but "The Lady Tasting Tea's" greatest achievement is that it succeeds in educating people about statistical ideas and a certain kind of thinking about science, without scary formulas or complicated logic.

HB: *You are most known with the book "Lady Tasting Tea – How Statistics Revolutionized the 20th Century Science" (Salsburg, 2001). Please let us know about the background of this book, and the challenges you may have faced in order to have the book published.*

DS: In 1968, I joined Pfizer Central Research, where I was given one day a week off to affiliate with an academic institution. I took a position at UConn in Storrs, CT, and spent that entire day on the campus. I taught one course in data analysis, visited with faculty members, and spent most of the day in the library, where they had an entire set of issues of Biometrika, into which I could immerse myself. In 1986, the first issue of the journal Statistical Science appeared, and included interviews with prominent statisticians at that time. All of this gave me a wealth of historical details, which I often talked about at dinner table at home.

Remark: In the first issue of Statistical Science the section devoted to conversations with prominent statisticians featured an interview with Charles Stein (DeGroot, 1986).

When I retired from Pfizer, my wife Fran suggested that I write up some of the stories I'd been telling our children. This soon became a book describing how different statistical methods were developed and something about the initial problem(s) that were being solved and the men and women who developed them. H. Fairfield Smith was on the UConn faculty then, and we had

many conversations about the usefulness and development of many models. Smith had been a student of R. A. Fisher and was present at many gatherings during the 1940's.

That book, "The Lady Tasting Tea", is often used as supplemental material for courses in elementary statistics. There are two English editions (one hard cover one soft cover), and it has been published in 7 foreign language editions: Arabic, Portuguese, Thai, Chinese (2 editions), and Japanese (2 editions).

Remark: The book's title refers to the famous spontaneous experiment ran by R.A. Fisher during a social gathering on a sunny summer afternoon in Cambridge, to test the claim of one of the attendees that tea tasted different depending on whether the milk or the water is poured first. Hugh Smith, who published his papers under the name H. Fairfield Smith and later became a professor at UConn, was one of Fisher's students, and was present during that event. In the late 1960's, a couple of years after finishing his Ph.D. at UConn, Dr. Salsburg had many visits to the UConn campus in Storrs, and during one of his visits he heard this story from H. Fairfield Smith. (Salsburg, 2001, Chapter 1).

NT: *Talking about books, we are interested in learning your other book "The Use of Restricted Significance Tests in Clinical Trials". Please share your thoughts on restricted significance tests.*

DS: "The Lady Tasting Tea" was a popular science book about statistics, and I was not expecting it to have any effect on the practice of statistics or science. In addition to "The Lady Tasting Tea" I wrote four academic books, which I hoped would make useful reference books.

The publishing of academic books used to be a profitable venture for publishers. There might be 10 or fewer scientists working that field who would be interested in the material. However, the academic books were an important means of providing a large extended view of some subject, and university and other academic libraries would be expected to hold a copy in their stacks. The development of e-books like Amazon's Kindle has essentially destroyed that source of income for the publishers. As the world of academic books was closing, I wrote my four academic books and got three of them published the old-fashioned way.

As I read through back issues of Biometrika, I looked forward to the personal opinion editorials Pearson had in each issue. In these articles, which provided insight into Pearson's wide ranging intellectual activities, I'd often find short descriptions of some investigation he had made. In one of them, for instance, he described how he had counted the number of nesting storks he had seen in walks about London. He then showed the correlation coefficient between the number of storks seen and the number of babies born in that district of London. By calculating statistical measures of unrelated events, he got a feel for the random noise associated with the events he was measuring.

I thought that this was a good way to show the budding statistician what spurious relationships look like. I generated collections of "random" numbers on the computer that had something more than random noise, that made it look like an event of interest. My book, "Understanding Randomness" (Salsburg, 1983) displayed these spurious "relationships" and described how they were generated. I got some nice comments, one book review, and a couple of letters inquiring about some aspect of the tables. The book, a small paperback, wormed its way into the inner stacks of academic libraries and was never seen or heard from again. A few years later, John Tukey and a group of his students published "The Princeton Robustness Study" (Andrews et al., 1972; Salsburg, 2016, Chapter 8), which did something similar but backed up the tables with a theoretical structure of contaminated data.

My second attempt at an academic book resulted from my work at Pfizer with the toxicologists. It was clear to me that the FDA was far ahead of industry toxicologists on the use

of statistical models. A company with a new drug had to have completed a sequence of animal studies and results had to be analyzed statistically with rigid requirements to declare something "significant." I looked through the requirements and put together a book, "Statistics for Toxicologists" (Salsburg, 1986). It had a modest run of sales, then toxicology textbooks began introducing sections on the statistical analysis of standard studies, and my book retreated to the inner shelves of the libraries.

My last academic book resulted from my admiration of Jerzy Neyman. His clear restatement of hypothesis testing in the 1940's with Egon Pearson (Neyman et al., 1933) had remade the world of statistical analysis, but he kept diddling with the formulation and produced a geometric approach that sharpened the procedure and made it a tool that had many more applications, something he called restricted hypothesis testing. I read his paper and saw immediately that it could vastly improve the ability to show efficacy in a clinical study. When I proposed using restricted testing, the reviewers at the FDA were negative. Somehow it looked like mathematical sleight of hand to show some result "significant" when it really was not. They needed to see a paper published in a refereed journal showing its application in clinical studies. I gave them more than that. I wrote a book describing its use in specific clinical studies (Salsburg, 1992). It was published by a reputable publisher, Springer-Verlag. I retired from Pfizer soon after. I am not privy to discussions with FDA anymore, so I do not know the fate of my endeavor.

By the time my restricted tests book was published, the world of academic books was dead – killed by the e-book. I tried a couple of e-books on Kindle, and once in a while one of them sells. One described an analysis I had run on the Hebrew of the books of the Old Testament to determine which books or passages had been written by the same authors (Salsburg, 2013a). The other consisted of short chapters, each describing life after leaving office for the past presidents of the United States (Salsburg, 2013b). After leaving Pfizer, I wrote a book on common problems in the design and analysis of animal and human studies. It has been published by SAS (Salsburg and Chiappa, 2020).

4 Encounters with Prominent Statisticians

HB: *Can you tell us about your encounters with prominent statisticians? Can you please share some stories about John Tukey, whom you've met early in your career?*

DS: Since I entered the world of statistics in 1962, I've had the pleasure of meeting and even working with many prominent statisticians. In many cases, I made contact during the annual summer meetings of the ASA. During one of those early meetings, I was looking for a place to put my luncheon tray, saw a white haired man sitting alone, and asked if I could join him. I, thus, met Chester Bliss (inventor of probit analysis in toxicology). We had an interesting conversation about toxicology and his early experiences in agricultural studies. Thereafter, we would arrange to have lunch together at least once at subsequent meetings. His insights into the ways randomness plays a role in field studies added greatly to my own understanding of the interplay between science and statistics. I've gotten to know many other prominent statisticians through serving on ASA committees, taking part in joint government, academic, and industry/government projects. I've had the pleasure of being involved with H. Fairfield Smith, Gottfried Noether, Ed Deming, and many others, often with a single interaction, other times serving on joint ASA committees, or industry-government panels.

My career overlapped with John Tukey's in time, but I had little contact with him outside of meetings. My major contact occurred as I was finishing my Ph.D. studies and went on a tour

of colleges, presenting my thesis and looking for a position in academia.

One of my first visits was to Princeton, where Tukey, himself, met me at the train. He drove me around, showing me where I and my family could live and where the synagogue was, and we ended up in a large seminar room where I was to present my results. People had begun to gather there. Tukey presented me to the faculty member who was in charge of the session and then retreated to one of the back rows to await my presentation.

My thesis dealt with a problem from operations research. It found an optimum restocking algorithm when the item in question could be replaced by a similar item that was almost adequate to the needs of the person seeking the original item. I gave my talk. Several members of the audience asked questions or suggested further uses for my main theorem.

Then, Tukey put down the papers he had been correcting during my talk. He walked down the aisle to the front of the room, picked up some chalk, and proceeded to show me how my derivation belonged to a class of proofs and how, with a few modifications, my result could be expanded to many similar situations.

"Wow", I said to myself, "I'm playing in the big leagues now."

Tukey offered me a position. It would not be a tenured faculty position, but I would be in charge of a consulting arm, and the work would put me in contact with many opportunities to more permanent positions. He gave me a week to consider the offer. As I left on the train, I was dancing on air. John Tukey had taken notice of me and made an offer.

Later that week, I gave my talk at Yale and got no immediate offer. Then I went to the University of Pennsylvania, from where I had graduated 9 years before. The statistics department was in the Wharton School of Business. I got a delightful reception and engaged in an intellectually exciting discussion about this entire class of operations research questions. Dick Clelland, the department head, offered me a tenured position for much more than Tukey had offered and many opportunities to be a consultant for industry in the operations research unit.

I was away from home when Tukey called to see if I would accept the position he offered. Fran was home. She told him about the offer from Penn. He asked me to hold off a decision for a week, while he looked for more funding. A few days later, he called back with an increased salary, but still less than Penn's. We were deeply in debt with three children and one on the way at that time, so I took the offer from Penn.

As a statistician Tukey was redoing the entire science. I read his papers and attended his talks at meetings. His prodigious output of ideas influenced my own work, in particular the results of the Princeton Robustness Study.

NT: *What other individuals had the most influence on you, and why?*

DS: That's a tough question. Well, I never met him personally, but R.A. Fisher had a great influence on me. When I read Statistical Methods for Research Workers (Fisher, 1925), I began to look at it from the standpoint of not 'were the mathematics pretty?' but was the result something that was consistent and made sense? In terms of personality, well, Tukey, of course, had an effect on me, because his papers were all very well thought out. I think the main things I learned past my schooling, was how to interact with people from other fields, and keep in mind that they're just as proud of their accomplishments as you are of yours.

My first boss with Sheldon Gilgore who was in charge of the clinical research, and before I came on board he had been told about this new thing that FDA was requiring, which was statistical analyses of the results, so he looked around the company and found that there was a woman who was a statistician who was in charge of quality control and he invited her up to come and help out. She came up, and all she did was criticize him, and the designs of studies,

he thought were very fine, until he got rid of her in a hurry, and he figured 'so that's what statisticians are? Just a bunch of harping critics'.

NT: *Yes, as teachers we have to prepare our students how to interact with people of different profession. Do you have any practical advice for us and for the readers how to communicate better and more effectively with people from other fields?*

DS: I had one question that always floored them and got me on their side, and that was, gee whiz! How do you measure this thing, anyway? The advice for anybody who's in the sciences is to respect the person you're dealing with. That person most likely has a Ph.D., also, and knows a lot more than you do about the subjects he or she is working on. Anyway, it's nice being among people who are engaging in research, and who are verifying what they thought they knew, and finding out things they didn't know, and to be involved with them you have to go in and ask things like, Gee whiz! How do you measure this thing?

5 Perspectives

NT: *Having witnessed the development of many theories and methods during your time as a statistician, can you think of any that excited you most, and why?*

DS: Well, the most exciting thing was to see a new drug get accepted and get into use and proved to be an important part of the medical armamentarium, but mathematically, what excited me the most was to see how real data actually felt and met certain requirements that you had in the courses. I think that the problem that statistics was meant to solve was the fact that when you get real data for real experiments you get different numbers of what should have been the same thing, and you don't have to know what to do about it. Stephen Stigler, at University of Chicago went back to the original notebooks of some of the great scientists of the 19th century, like Michelson on the speed of light, and looked at what they actually did do, and it turned out that they would run a number of experiments, but they'd report only the results of the ones that were right (Stigler, 1986). And he said, how do we know which one's right? The thing that excited me the most was the fact that, as Stigler pointed out, observations vary and in different ways, that means that you can't just simply take an average and hope that you're doing the best.

HB: *Can you tell us about some experiences and challenges you recall from your clinical and non-clinical projects?*

DS: Once in a while I got called in on problems from the marketing division, and I guess the more interesting problems are the ones that chemists and pharmacologists brought to me. One of the problems they had was an article would be published showing some remarkable results to some particular biochemical change, and they could not replicate that article in their own labs. And this problem of non-replicable results seems to still be with us. I don't know whether the people doing it recognize they're being dishonest, or whether they're just taking out the good stuff.

NT: *Some of the drugs you worked on have been successful, while others not. Can you share your thoughts about why some drugs may fail?*

DS: That's hard. The failed drugs failed for many reasons. Sometimes they had trouble getting a formulation that actually got absorbed and did its work in the human body. I found at the very

beginning that the pharmacologists are frequently reporting the good results and stuff that had too much variability they were throwing out, and that leads to results that cannot necessarily be replicated. I gained a great deal of respect for the people working in the other fields because they understood what they were doing, and they understood enough physiology and enough chemistry to know when the thing was happening, that they thought would happen.

Tenidap is an example a drug that failed. One of the problems is that it showed up when there were a lot of other drugs treating the same thing. And I think, you know, there's a lot of human personality involved in whether a drug goes forward and somebody who may be in charge of this, and a number of drugs getting through the pharmacology may have taken a dislike to a particular compound, believing that it would not work, and that compound gets a little more scrutiny than others do. I can think of a couple of drugs that were killed because marketing felt that there they couldn't really market it in the face of the competition, and I remember a couple that were killed because the effects they got in the animals occurred in humans, but only at doses that were dangerously high. It's interesting. Once you get out of the animals who sit there quietly and let you turn hotspots on their tails and do things like that and get into humans do things like walking across cold kitchen floors and doing other things that rats don't do, you get into some interesting complications. You know, 'Man is not a big rat'... (Habert et al., 2014).

NT: *It is widely known that you have a very successful family life – in most public occasions, we see Fran with you. You have four well-educated children and many grandchildren. How can you live such a successful family life, in addition to a successful career?*

Remark: Figures 3 shows David in the Pfizer office with two of his grandchildren, Ben and Matt.

DS: The Almighty (or was it the mysterious workings of evolution?) has implanted in all of us a desire to love and be loved. With love as the grease and a willingness to bend your ways, I think everyone can find a way to combine family and career.

Before we were married, Fran asked what kind of a father would I be. She had good memories of her own father, home every evening to have dinner with the family and then available to help the children with their homework and to read to them. He was deeply involved in their family life, and she had good memories of her Dad. I agreed with her and agreed that this was the kind of father I wanted to be. I was able to have an interesting career in statistics and also enjoy the pleasures of family life. For most of us there is work and there is home. They are not refuges, one for the other. They are part of having a full life.

Figure 3: David in his Pfizer office with grandsons Ben (left) and Matt (right).

Remark: Dr. Salsburg published a book of over 1,000 love poems he has written over the years to his wife, Fran (Salsburg, 2006). The book's cover contains the following description: "*David and Fran Salsburg were married on Feb. 22, 1959. Through their courtship and for 47 years of marriage, David has written her love poems, many of them sonnets. This is the poetic record of their love.*"

HB: *Any advice to young statisticians? Or young people, in general?*

DS: The statistical models you learned about in your studies will soon be replaced by more sophisticated ones, and the basic methods of calculation, like least squares, will soon be inadequate to meet the needs of data analysis. Keep up with the new discoveries of statistics by following at least four general theory journals, and one specific to your current field of research of activity. (I would suggest, JRSS, Biometrika, JASA, and the Annals of Statistics to start with.) Wherever you are, academia or industry, set aside at least one day a week to read the journals. In academia, reading journals is considered an important part our career. In industry, you can charge the time spent on journals to one of your tasks, if the company practices careful time accounting.

Get and maintain contact with other statisticians at annual meetings. Don't be afraid to approach some well-known person. I've found that even the most prominent academicians are delighted to hear about new problems.

If you are teaching an elementary course, try to give the students a sense of the joy that comes when you can design and/or analyze a study that provides new knowledge.

NT: *What is your opinion about the future of statistics in the pharmaceutical industry. You mentioned an early interest in ethics. Are there any concerns, going forward, related to new technologies?*

DS: Since I retired from Pfizer in 1995, I've had little or no contact with the developers of new drugs, so I have no insights about current developments. I do know that, when I was at Pfizer, the pharmacologists frequently had difficulty reproducing studies that appeared in journals. When I looked at the studies they showed me, I often found "results" that were too structured to be the sort of data I had seen from pharmacological studies run at Pfizer. I don't know if this problem still exists. But, if it does, this may still play a role in the development of new drugs. I keep up with the field by reading the AAAS journal, Science, but I seldom see these problems in the studies described therein.

HB: *Thank you David! It has been a pleasure hearing your stories and insights.*

DS: Well, I don't know if I gave you any insights, but I've had fun. Thank you.

6 Commentary by Joseph C. Cappelleri

Joseph C. Cappelleri joined Pfizer Inc. in 1996 after being a faculty member at Tufts University School of Medicine and, before then, earning his MPH in Epidemiology from Harvard University, Ph.D. in Psychometrics from Cornell University, and MS (statistics) from the City University of New York. Among the most published authors and prolific medical researchers in the history of Pfizer and the pharmaceutical industry, he has co-authored hundreds of publications and external presentations on clinical and methodological topics, including regression-discontinuity designs, meta-analysis, and health measurement scales. As an adjunct professor, he has served on the faculties of Brown University (Biostatistics), Tufts Medical Center (Medicine), and the University of Connecticut in Statistics. He is an elected Fellow of the American Statistical Association (ASA), an elected recipient of the Long-Term Excellence Award from the Health

Policy Statistics Section of the ASA, and an elected recipient of the ISPOR Avedis Donabedian Outcomes Research Lifetime Achievement Award.

Remark: ISPOR is The Professional Society for Health Economics and Outcomes Research, formerly names the 'International Society for Pharmacoeconomics and Outcomes Research', hence the ISPOR acronym. To see the award background and past recipients, see the website, https://www.ispor.org/about/awards-grants/scientific-achievement-and-leadership-awards/avedis-donabedian-outcomes-research-lifetime-achievement-award.

I met David Salsburg in mid-1996 when he interviewed me for a position as a statistical scientist to support Health Economics and Outcomes Research groups in Groton, CT, and elsewhere at Pfizer. As a senior research fellow and then private consultant for Pfizer, he was working part-time on HEOR projects. I said, "Those are big shoes to fill!" I was immediately impressed and even inspired with David's keen and penetrating insights on methodological matters of both an applied and a theoretical nature. I said to myself, "Self, this is the right place for you to work!" I learned that David was the first statistician at Pfizer who become a Fellow of the American Statistical Association. Several years after that, I became enthralled with David's classic book "The Lady Testing Tea" and enthusiastically and personally handed my copious written comments to him about the book.

Over the years, my wife Rita and I have had dinner with David and his wonderful wife, Fran, who brings out the best in David (and, in turn, he brings out the best in her) and makes the room sparkle with her warmth, humanity, and intellect. Their love of their family (four children and even more grandchildren) is admirable and palpable. At the end of a year, Fran and David Salsburg shared their yearly news about themselves, their family, and current circumstances through letters worthy of saving and commemorating, written with grace and precision and blessed with holiday greetings and new year cheer. For example, in their letter "2020 with the Salsburgs," in the throes of the COVID-19 pandemic, they write: "In addition to reading books in our library that we always wanted to read and new ones, we have been kept busy. Fran continues to take piano lessons, meeting her teacher once a week via FaceTime. David is on data safety monitoring committees for ongoing clinical trials for proposed treatment of COVID-19, and he is completing his memoirs. We have been taking virtual balance/exercise classes given over Zoom by a physical therapist, a friend of daughter Liz."

On August 22, 2017, I was proud to host the return of the Salsburgs to their Pfizer home in Groton with a luncheon in honor of David that was formalized with his seminar presentation, "The Statistician and his or her Data: A romp through the perils of analyzing real data." This gathering was well attended by Pfizer colleagues who listened eagerly and carefully to a presentation that was summarized as follows: "As an experienced statistician who has burnt his fingers on problems that are not taught in graduate school, I have four admonitions:

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BEFORE RUNNING A FORMAL ANALYSIS --
  PLOT YOUR DATA
  LOOK AT YOUR DATA
  LOOK AT YOUR ESTIMATED VARIANCES
  USE AN ESTABLISHED METHOD TO ESTIMATE MISSING DATA.''
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Figure 4: August 22, 2017. Pfizer Inc., Research and Development, Groton, CT.

Figure 5: Pfizer statisticians with Fran and David Salsburg (seated). Pfizer Inc., Research and Development, Groton, Connecticut. August 22, 2017.

Figures 4 and 5 show Dr. Cappelleri and other statisticians from Pfizer Inc. with Fran and David Salsburg (2017).

7 Conclusion

It has been a great honor to communicate with David Salsburg, and hear his wonderful stories and insights. Dr. Salsburg had a big impact on statisticians in general, and on the authors in particular. His book "The Lady Tasting Tea" has inspired many educators, and helped make statistics popular and accessible, well beyond the Ivory Tower of academia. His substantial professional contributions to the field, and in particular to the way statistics plays such a central role in the critical process of drug approval, couldn't have come at a better time. It is now amazing to think that not that long ago, there was no formal process at all! The treatment for tuberculosis, for example, took decades to develop and bring to market (Murray et al., 2015). In 1882, Robert Koch made a breakthrough discovery of the cause of tuberculosis. Only in 1945 an anti-tuberculosis (streptomycin) was found, but it took years to find a viable alternative, since patients developed resistance to streptomycin rapidly. In 1952, a well-tolerated, affordable drug was finally found (isoniazid). Nowadays, the drug development and approval processes are much faster, safer, and methodical. We owe Dr. Salsburg (and his colleagues) a great deal of gratitude for his contributions.

Personally, Dr. Salsburg has been an inspiration to both authors. Naitee joined Pfizer in 1987 and met Dr. Salsburg. Throughout the past few decades, Naitee viewd Dr. Salsburg as a mentor and a role model. Dr. Salsburg showed Naitee that being a statistician in the pharmaceutical industry, we can still pursue a scientific career. Dr. Salsburg's passion of statistical science guided Naitee to enjoy a fulfilling scientific career. Haim has benefited greatly from Dr. Salsburg's writing, which he often uses when teaching classes in statistics. Haim shares with Dr. Salsburg a deep admiration for the great statisticians who revolutionized science in the twentieth century. The way that important statistical ideas are conveyed in a simple and engaging way in "The Lady Tasting Tea" serves as a guide for Haim, and educators all over the world.

To quote (a quote) from "The Lady Tasting Tea", "*[T]he gist of human genius is the longevity of one's youth. Youth has several traits, one of which is excitement*" (Salsburg, 2001, Chapter 14). Through his wonderful stories, Dr. Salsburg's excitement and love for the field is obvious and contagious. But his longevity of youth is also apparent in his anecdotes told in this interview. From taking part in plays and musicals, to delightful family dinner conversations, Dr. Salsburg exemplifies youthfulness and optimism.

We are truly grateful for the opportunity to communicate with Dr. Salsburg, and for his legacy.

Supplementary Material

Curriculum Vitae of Dr. David S. Salsburg.

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