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A Conversation with Arthur Cohen

Joseph Naus

Abstract. Arthur Cohen was born in 1933. He received his B.A. in mathematics from Brooklyn College in 1955, and then went to graduate studies in statistics at Columbia University. In 1957, he took leave from Columbia to serve for two years at the Communicable Disease Center, Public Health Services. He returned to Columbia, completed his studies and received his Ph.D. in mathematical statistics in 1963. Art joined the statistics department at Rutgers as an Assistant Professor, and two years later became Associate Professor. From 1968 through 1977, he served as chairman of the department during a critical period in its development. For 52 years, his wisdom has helped guide the department in its rise to excellence.

Art served as Editor of the *Annals of Statistics* for three years, Co-editor of the *Journal of Multivariate Analysis* for eleven years, as Associate Editor of the *Journal of the American Statistical Association* and the *Journal of Statistical Planning and Inference*, each for five years. Art has over 140 publications. In an influential series of fifty-two *Annals of Statistics* and *JASA* papers, Art and co-authors developed wide ranging and fundamental results in decision theory, admissibility, Bayes' procedures, sequential tests, complete class theorems, directional tests, order restricted inference and multiple testing. Art is a Fellow of the Institute of Mathematical Statistics, the American Statistical Association and the International Statistical Institute.

Key words and phrases: Admissibility, *Annals of Statistics* Editor, change points, Columbia Statistics, Communicable Disease Center, Epidemic Intelligence Service, ordered restricted inference, Public Health Service, Rutgers Statistics, step-up and down procedures, testimators, variable selection.

This conversation between Art Cohen, Joe Naus and Harold Sackrowitz took place over several days in December 2015.

1. EARLY DAYS AND COLUMBIA STATISTICS

Harold: How did you end up in the statistics department at Columbia?

Art: I was a math major in college, took education courses and was preparing to be a high school teacher. In my senior year at Brooklyn College, I took a statistics course in the math department with Professor Smith who was also exposed to mathematical statistics for the first time. I did really well in the course. Many of my friends were math majors. The high achieving ones were going to graduate school, but not in statistics. Since most of the bright people I knew were going to graduate school that influenced me to try it as well. As captain of the basketball team at Brooklyn College, I knew all the phys-ed professors. One told me that Columbia had just started a statistics program. Columbia appealed to me because I could commute from home. None of my six older siblings or parents made any input. It was serendipitous and put me on a path that I was happy to stay on for the past 60 years.

Joe: Who were the faculty at Columbia?

Art: When I entered the program at Columbia in 1955, there was an all star cast of professors including Herb Robbins, Ted Anderson, Howard Levine, Howard Raiffa, Herman Chernoff, Herb Solomon and Manny Parzen. The air was full of hard core mathematical statistics and decision theory á la Abraham Wald who was there as the father of the department.

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FIG. 1. *Art upon graduation from college in* 1955.

Harold: That was pretty good for a start-up program. Who did you have for courses?

Art: Professor Robbins was a magnificent lecturer and he was a joy to have in my first probability course. He was also a source of memorable incidents. At the weekly seminars, when it was called for, he would interrupt the speaker by declaring out loud, "I don't know what the hell you are talking about." Howard Levene taught inference. Linear models were with Manny Parzen, Herb Solomon for quality control. Howard Raiffa taught a course in advanced inference. He taught some decision theory in this class, and was a dynamic exciting teacher.

Harold: Did you apply for the Master's or Ph.D.?

Art: I applied to the mathematical statistics graduate program at Columbia, and was accepted. I took the Ph.D. qualifying exam toward the end of my second year. Four students took the exam and all of us got zero. All the questions could be traced to the faculty's most recent publications. They decided to give another test that was more reasonable, and then two of us passed; fortunately, I was one of them. I then went to the Public Health Service in Atlanta for two years, and then returned to Columbia.

FIG. 2. *Brooklyn College Basketball Team. Art* (*number* 6) *is first row on right.*

2. PUBLIC HEALTH SERVICE

Joe: How did you come to join the Public Health Service?

Art: I was finishing up my second year at Columbia and completing the Master's degree. Someone from the Public Health Service came to visit the department. They asked Professors Robbins and Anderson if there were statisticians who would care to enter the Public Health Service for two years to fulfill their military service. The Korean War which had started in 1950 was still going on and eligible young men were being drafted for two years. The CDC and the National Institute of Health were two government supported health agencies who had connections with the US Public Health Services. The latter was given partial status as a military branch of service during the draft. It was 1957, I was draft eligible, getting married and thought it would be a good time to satisfy my military obligation and also practice statistics. The CDC was more than convinced about the value of statistics. They had a statistics group headed by Robert E. Serfling, and staffed by several Ph.D.s in statistics. Data collections on health issues, drug evaluations, surveys and epidemiological investigations were everyday activities involving statistics. I met with Dr. Serfling, and decided to join his group.

Joe: Were you married when you moved to Atlanta?

Art: We got married a month after I was down there, and lived in Atlanta for two years. It was extremely rewarding. Everyone was dedicated to the *n*th degree; the atmosphere was all gung-ho, Dr. Alexander Langmuir, a famous epidemiologist, was in charge of our group, the epidemic intelligence service (EIS). The EIS was staffed with about twenty physicians, two or three statisticians, and maybe two veterinarians. All were serving their military obligation for a two-year period. About a month after, we were all there, we would occasionally have meetings. At one meeting, Dr. Langmuir announced that there was an epidemic of cholera in India. He asked, "Who of you would volunteer to go to India to study the epidemic?" As soon as he finished his sentence, all twenty doctors in the group jumped up and said "choose me!" That atmosphere prevailed for all two years that I was there. Another epidemiologic study concerning the Asian flu was headed by Dr. Fred Dunn. At a discussion of the results of the study, one of the participants said at 6 p.m. that he had to leave. At this point, Dr. Dunn emphatically reminded him that, as part of the US armed services, we were on duty 24 hours a day and he should not leave. Everyone was extremely conscientious and dedicated. It rubbed off. It was inspiring.

Joe: The EIS was a rapid response team of the CDC set up and funded in 1951. The Korean War had been going on for a year and many US soldiers got sick and thousands died from an infection called Korean hemorrhagic fever. There was fear of biological warfare. You were working with giants in epidemiology. Alexander Langmuir, was a dynamic and dedicated leader who inspired many pioneers in the field. His work and influence at the EIS is described in the compelling book Inside the Outbreaks [12]. One of the many people he influenced was Fred Dunn who is famous for developing an anthropological-behavioral-epidemiological approach to world health problems involving infectious diseases [11]. One case was the flu epidemic in Louisiana. That 1957 flu epidemic led to over 100,000 cases spread throughout the US and spread worldwide [12]. Can you tell us your experiences on this?

Art: The CDC was asked to evaluate the efficacy of a new vaccine for Asian influenza, which was arriving in the US in the late 1950's. A team was formed consisting of a few M.D.s, a nurse and a statistician. We decided to conduct a clinical trial at the Atlanta Federal Penitentiary, a good place to conduct such a study. There were 4 treatment groups encompassing 3 dosage levels and a control. We asked for prisoners to volunteer and when we were at the prison we asked if there were any volunteers who were also willing to offer blood specimens in addition to being vaccinated. We wanted to measure antibody counts before and after vaccination. At the prison, we were in a large room with some 200 prisoners. The M.D. leading the study called out "Are there any volunteers willing to offer blood specimens?" One man, 6 feet 5 inches tall and weighing 275 pounds—he resembled a football lineman—shouted "I'll volunteer!" He charged up to the nurse's station and the nurse pulled out a syringe. Upon seeing the needle, the volunteer fainted. Since he immediately recovered, most of his fellow prisoners had a hearty laugh. The study worked out well and the vaccine proved to be effective. The study results were summarized in a paper in the *Journal of the American Medical Association*.

Harold: In your group, did you actually go out to work in the field or were you mainly working with data and statistics?

Art: I did both. I went to New York to study what was going on regarding Asian influenza, spoke to someone in the New York Health Department and got

FIG. 3. *Epidemic Intelligence Service* 1957. *Art first row on left*; *Ida Sherman* 2*nd row fourth from left*; *Richard Cornell between* 3*rd and* 4*th rows* (2 *people behind the person next to Art*).

some information. Typically, I would not go to epidemic sites, but was involved heavily with statistical chores. Dr. Serfling asked me to study epidemics of Asian influenza—which was just arriving in the US at that time—to help identify which locations in the US were experiencing an epidemic. Luckily, I had just come out of Columbia, and had taken a course in regression and linear models. It was a very nice project to use trigonometric regression to fit flu and pneumonia deaths which would follow some type of sine cosine curves or combination of them, with a trend term thrown in. I developed a linear model with confidence bands that described flu and pneumonia deaths for the past few years which we would extrapolate to the following year. With these bands, we would be able to identify by sight when a location was exceeding the threshold to indicate an epidemic in flu and pneumonia. It is interesting that the CDC is still applying similar bands to locate epidemics.

Joe: You also published a survey manual with Robert E. Serfling, Ida Sherman and Richard Cornell [13]. It is a quite important manual. Can you tell us more about it?

Art: The Salk polio vaccine had just come out in the fifties. Our team at the Public Health Service wanted to estimate for various cities throughout the country, how many individuals were vaccinated. Dr. Serfling, the leader of our statistics group, Ida Sherman, Richard Cornell and I developed a household survey that was inexpensive and very easy to carry out. We visited various cities throughout the country. I got to visit Salt Lake City, Denver, St. Louis and Wichita, Kansas to conduct surveys, and other people in the group went to other cities. The surveys were a big hit. The cities were very happy to have this public health activity.

Joe: Figure 3 shows you, Richard Cornell and Ida Sherman. I know Langmuir, Robert E. Serfling, and Jack Karush were your colleagues. Were any of them in the picture?

Art: No. Richard Cornell is a biostatistician at the University of Michigan School of Public Health. Robert E. Serfling was the father of Robert J. Serfling, a noted probabilist at the University of Texas, Dallas. Jack Karush was working at the CDC. He was an excellent mathematician and he taught me measure theory while we were there. This proved very helpful when I returned to Columbia. Jack Hall was also affiliated

with the CDC, was a speaker at the orientation when I came, and taught a class at the CDC.

Joe: I see you had a report on an Atlanta Rabies Survey [10] with co-authors Robert E. Serfling and Ernest Tierkel. Tierkel worked at the CDC. He dedicated his life to developing programs and the use of vaccines to reduce the public health threat of rabies in the US and these became a model for the world. He became Assistant Surgeon General [15]. How did you get involved in the rabies survey?

Art: I participated in a CDC survey to estimate the number of dogs in Atlanta. We selected households to inquire how many dogs were in homes. The homes were selected in a random way by using street maps. One home of many that I was assigned to, oddly had five dogs playing in its front garden. When I inquired about the number of dogs owned by that particular household they told me "one." "But look there are five dogs in your garden." The person in the home responded by saying "Oh. They just took up." The survey was well received and welcomed by the city.

3. RETURN TO COLUMBIA STATISTICS

Art: I returned to Columbia from the Public Health Service in 1959 to continue in the program, prepared well and passed the Ph.D. oral exam in 1961. When I came back to Columbia, the Department of Mathematical Statistics was willing to give me a teaching assistantship for a stipend of about $2000 per year plus free tuition. Because I had worked in the Public Health Service, the School of Public Health offered me a fellowship of $4500 per year with free tuition for the next four years plus funds to go to meetings. John Fertig was in charge at that point. So I gladly took the fellowship. I took some courses at the School of Public Health, but had no obligations, whereas previously as a teaching assistant in Statistics, I had to grade and assist a Professor.

Joe: What courses did you take at the School of Public Health?

Art: Some basic courses in public health. Professors Ruth Gold and Agnes Berger taught courses with applications in the field of Biostatistics.

Joe: Who were the faculty at Columbia when you came back?

Art: When I came back from the Public Health Service, Anderson, Robbins and Levene were still there. Chernoff and Parzen had gone to Stanford. There were many new professors including Jerry Sacks, Don Ylvisaker, Ron Pyke, Lajos Takacs. Colin Mallows was at Bell Labs but he came to teach for a year and we interacted.

Harold: Who were some of the other students in Statistics when you were there?

Art: Ester Samuel-Cahn, Lakshmi Venkatraman, Ted Matthes—he wrote a paper I frequently quote by Matthes and Truax.

Joe: How did you choose an advisor?

Art: Getting an advisor at Columbia was not so easy. They had a reputation for not giving anything away, and your thesis has to be done to a large extent independently. I spoke to some professors including Professor Anderson about problems to work on. Professor Anderson asked me one question and that was all that was necessary. He asked, "Is a testimator admissible?" Ted Anderson was a superlative advisor, and I'm very grateful. He really showed me how to pursue and generalize problems, what questions to ask.

Joe: What is a testimator?

Art: If X is a normal random variable with mean μ and variance 1, and you want to estimate μ with respect to squared error loss, a testimator would be an estimator that if you observe $X = x$ in an interval containing zero, but not too much different from zero, say $(-1, 1)$, then you would estimate μ to be zero. But if the observation x fell outside the interval $(-1, 1)$, then you would estimate μ by x. Such testimators were popularly used to test whether a regression coefficient is zero, and if it wasn't zero, you would include the regression coefficient in the linear model. I not only answered the question of whether a testimator was admissible, but produced a whole battery of results about linear estimators in multivariate models and linear estimators of linear combinations of multivariate mean vectors. This resulted in two papers [1, 2] in 1965. Paper [1] proved that not only is the testimator inadmissible for squared error loss, but showed how you could pick a different loss function, squared error with a penalty factor, for which the testimator is admissible. This is interesting as testimators and squared error losses with a variety of penalty factors are still very much in vogue. In paper [2], the answers for the vectors that are coefficients of the variables that give you an admissible estimator is visually beautiful. All vectors that lie in and on a specific ellipsoid are admissible, and all other coefficients are inadmissible. It is rare that you can get such an elegant solution to a broad problem like this. These papers really hooked me into research. Paper [3] grew out of the 1965 papers.

Joe: Paper [3] is widely cited with 133 citations, 27 in the past four years, with several recent applications

to image processing, and smoothing filters. I remember the excitement when Charles Stein came out with his startling inadmissibility result, and there was great pioneering work in admissibility.

Harold: There was a lot of research in the 1960's. Baranchik was my advisor, and Stein was his advisor.

Art: I spoke to Charles Stein about my research, after it was well known about his famous inadmissibility result. He said be wary that you only want two of the variables to be multiplied by one, and that comment helped me in developing my solution. My 1966 paper [3] looks at linear estimators of the observed vector that are admissible for the mean vector with respect to squared error loss. One of the properties is that the matrix multiplying the observed vector has characteristic roots all between zero and one, but not more than two that are exactly one. This was one connection with Stein's work. Another connection is with my student Bill Strawderman's thesis and joint paper [14].

4. RUTGERS

Joe: You came to Rutgers in 1963. How did you choose Rutgers?

Art: The CDC asked me to come back. Yeshiva University School of Medicine and Vermont Medical School offered me a job. They heard about me through Professor Fertig who was head of the Columbia School of Public Health. Then someone at Columbia was told that Rutgers was looking for applicants because a number of their professors, Martin Wilk and Roger Pinkham were leaving. I was living in Sheepshead Bay in Brooklyn, and could commute for a year to see if I liked it before making a permanent move. That's why I interviewed at Rutgers.

Harold: Did they have the Verrazano Bridge at that time?

Art: No, I had to take the Holland Tunnel.

Joe: You commuted every day?

Art: I commuted to Columbia every day, and for the first year at Rutgers I only had to be there three days a week, and one day I slept over. The salaries were low, and it was a heavy teaching load, three courses a semester—but I thought all schools would be that way. You pretty much had your choice of courses, and they were nice courses. It sounded like an opportunity because the big shots left. After the first year, I decided I would stay and we bought a house and moved.

Joe: When you came in 1963, Statistics had been organized as a Statistics Center reporting directly to the Dean of the Graduate School. Martin Wilk had been Graduate Director, and headed the recently developed Ph.D. program, and together with Roger Pinkham helped run the program and advise students. As research faculty, they helped maintain the quality of the program, and turned out some excellent students, such as Sam Shapiro who developed the Shapiro–Wilk test. Wilk's and Pinkham's leaving left a void of senior research faculty. Were Wilk and Pinkham still at Rutgers when you arrived?

Art: No, they left in June 1963. I came in September.

Harold: You weren't here that long when you suddenly became in charge of the department. What was it like? Did they tell you to try to build it or that you could hire a certain number of people?

Art: I was here for four years and you could recognize there were some issues. There were not widely accepted quality standards for graduate students and faculty. I was thinking about leaving after four years, and I guess you (Joe) took a leave of absence.

Joe: In order to get promoted at that time, we were told that we would have to be able to get an offer as an Associate Professor from another university. Saul Blumenthal went to NYU and stayed there. I got offers from Northwestern and City College, went to City College for a year, and returned to Rutgers as an Associate Professor with tenure.

Art: I was not subject to that; I came a year earlier. I was promoted to Associate Professor after I was here two years, and after my third year I was given tenure. This was remarkably fast. I also learned at the end of my fourth year that the Dean of the Graduate Studies was discussing matters with the Chair who gave a very positive review of me. So much so, that before my fifth year started, the Dean asked me to consider serving as acting Chair. The previous Graduate School Dean had recently retired and the new graduate school dean placed great emphasis on quality of research. We had an outside visiting committee that included William Cochran and other prominent statisticians that evaluated the program and faculty, and made recommendations to the Dean. The Dean also consulted with Ken Wolfson, the head of the mathematics department. I became Chair, and Henry Teicher came as a senior faculty. Together with Dick Gundy, Henry and I were heavily involved in the transformation to build up the research quality of the program. I was told I could hire two new faculty. I hired you (Harold) and Dick Gundy recommended hiring Burgess Davis.

Harold: Did they promise you additional hires?

Art: There were no promises. Two years later (1970), we hired Bob Berk and Bill Strawderman.

FIG. 4. *Groundbreaking for Mathematics, Statistics, Computer Science Building* (*left to right*) *Rutgers President Mason Gross, Doug Eastwood* (*Director of the Computer Center*), *Art* (*Chair of Statistics*), *Ken Wolfson* (*Chair of Mathematics*), *Provost Richard Schlatter, Saul Amarel* (*Chair of Computer Science*). *From Special Collections and University Archives, Rutgers University Libraries.*

Shortly afterward, we contacted Larry Brown, who was interested and we hired him in 1972. An outside visiting review team that included Jack Hall reported to the Dean that they were tremendously impressed by our department. Shortly after the Dean heard the review of the committee, we were ranked (by the National Research Council) as third in the country in terms of impact of research of faculty. Wow, this was within four years of my becoming acting chair. The Dean was dazzled by that, gave me the credit for hiring great people, and wanted me as Chairperson.

Harold: How long were you Chairman?

Art: I was Chairman for about nine years (1968-1977) though I had a year leave. The Dean was happy, had confidence in the department and supported it. We did stress quality in terms of research and we also wanted good teaching. Our emphasis on research was borne out over the years in terms of the department's reputation.

Joe: Tell us about your experience with the department's graduate students.

Art: We turned out very good graduates. One of the things that handicapped our department and still handicaps it today is the lack of teaching assistantships and fellowships. The university does not give as many relative to other schools, so that the number of good students we can get is limited.

Joe: When you came to Rutgers do you remember the situation with computers?

Art: The biggest difference in statistics from my time is the advances in the use of computers for statistics. When I was in the Public Health Services, I took a course in computers at Georgia Tech; but computers were just starting. Certainly today, in the training in statistics, computers have to be an integral part. It is now rare that you will see research in statistics that will not involve computations, even if just used to evaluate procedures. In theoretical statistics, it is an indispensable tool, and in practical statistics you can't do without it. Computers have revolutionized statistics.

5. RESEARCH

Joe: When you came to Rutgers what research areas were of particular interest to you?

Art: We got into order restricted inference very soon. Harold had an interest in it because his thesis was concerned with estimating the largest mean of a collection of normals. I got interested just before Harold came to

FIG. 5. *Art and Anita*, 2005.

Rutgers, because Saul Blumenthal was also here and was interested in ordered parameters. For many years, we were interested in ordered restricted inference, not just for exponential family models; we also got into categorical models.

Harold: We have been doing multiple testing for ten years. The way we got started is someone called you as an expert in multiple testing. Tell us more.

Art: Professor Tamhane of Northwestern invited me to present a paper at a conference on multiple testing. I knew nothing about multiple testing at the time. He must have been aware of our papers on testing on ordered restricted parameters and he extrapolated to our being an expert on multiple testing. We had tested more than one parameter, but treated them separately. Harold eventually represented us at the meetings, and we wrote the joint paper [9].

Joe: From 1974 through 1981, you wrote seven papers with Larry Brown. Can you tell us more about it?

Art: Larry joined Rutgers in the 1970's. He is a phenomenal mathematician, absolutely brilliant and it was delightful to work with him. We wrote a whole series of papers together. Some were on common means; most were decision theory related: complete class theorems, admissibility, Bayes procedures; some dealt with sequential analysis. Some papers I wrote with Larry had multiple authors, some with Harold, some with Bill, some of sequential papers with Bob Berk. Larry was one of the world leaders in decision theory. It was a wonderful period for me and others in the Department to have Larry here.

Joe: You also had papers with Ester Samuel-Cahn from Hebrew University in Jerusalem.

Art: Ester and I were students together at Columbia. She was a student of Herb Robbins. She is a very talented researcher, became President of the Israel Statistical Society, and won the Israel Medal (the highest State honor for Researchers, equivalent to the US National Medal). We were fortunate that Ester visited here a number of times on sabbaticals and summers. Harold and I, separately and together, did joint research with her. We enjoyed her friendship and working with her for many years. We were very saddened at her recent passing.

Harold: Did you spend time at Stanford?

Art: Yes, for several summers in the early eighties. My son was a graduate student at Berkeley and I visited Stanford a few weeks at a time. I met Akaike and Takeuchi from Japan. One year Chuck Stone was visiting from Berkeley, and we had a lot of discussions and he made suggestions for problems.

6. CURRENT RESEARCH

Joe: What are your current and recent research interests?

Art: My research currently and over the past ten years is very exciting and is on multiple testing. All this has been done with Harold, and sometimes with students. We developed a multiple testing method that has statistical optimality properties. In addition, when applied to specific cases, like variable selection, the statistics in our method coincide with those used in forward regression, a very popular variable selection method. When involved with the problem of detecting change points, the statistics match up with those used in what is called binary segmentation, a popular method to detect change points. We even have multiple testing procedures in ordinal testing models. So here is a method that matches current popular methods, but that is universal in that it applies in any multiple testing situation, and has optimality properties, like admissibility and oftentimes consistency. We also demonstrated for the most popular testing methods implemented in software packages, one is step-up, and another is step-down, that

under a wide variety of situations, those procedures are inadmissible. This is a theoretical result; we don't get procedures that are uniformly better in terms of a risk function. Yet the results are of great practical interest, as these procedures have other traits that indicate shortcomings. For example, for the step-up procedure you can make a modest change in just one statistic and it can make the procedure go from "accept 1000 procedures" to "reject 1000 procedures." I would not use the results of these procedures in these software packages. Currently, we are very interested in a problem that has been getting a lot of attention, namely statistical inference after testing or multiple testing. We were into this problem in our 1987 paper [6]. Recently, it has caught fire, with several papers on this topic. We want to apply multiple testing followed by estimates of changes in change points. That is, we want to estimate the difference in values when a change point occurs. What is the increase or decrease? We did work with a student on nonparametric multiple testing procedures [4]. We also have some papers on confidence estimation following multiple testing [5]. In a different research direction, another area that Harold and I worked on dealt with stochastic ordering of odds ratios used to analyze contingency tables. It was ordered restricted inference and led to some probability notions on positive dependence, association and unbiased tests. An early paper on this topic is [7].

Joe: Do you have favorite research papers?

Art: One of my favorite papers is my thesis paper [2] because of the elegance for the reasons explained, and it hooked me into research. The problem is to estimate a linear combination of the parameters of a mean vector. You want to estimate by a linear combination of the variables. The estimate would be $\beta^T X$ where β is a vector of constants. Those vectors β that lie in or on an ellipsoid comprise the admissible estimators. The ellipsoid had a center that was related to the coefficient vector of the parameters which was related to the variance covariance matrix of the random vector. Everything got tied in together in an exquisite way.

Joe: Could you mention a few of your many outstanding graduate students and tell us where they are now?

Art: All did excellent theses, and most are in teaching and research groups. Bill Strawderman is a Professor at Rutgers, Linda Davis a Professor at George Mason University, Minya Xu is at Peking University, Chaunwan Chen works for Google. Richard Laue and James Maher are both retired from Bell Labs, Wen Chiou is a statistician at the National Institutes of Health. Glenn Shorrock, Dubashis Kushary, Zhi Zhang, and Greg Manco are all at universities.

FIG. 6. *Art in his office*, *February* 2016.

Joe: Have you had any interesting experiences in your consulting activities?

Art: Yes. Auditing insurance claims is a popular practice and I consulted with a number of law firms that represented companies that wanted to sue the insurance company. The goal was to find a good lower confidence bound of the amount overpaid to present to the Court. In one such case, an audit revealed that a major insurance company was paying billions of dollars over what the auditor found should have been paid. It occurred to me that a smart way to audit would be to do it in two stages. The first stage would be to audit statements to see if, based on amount of claim, it would be worthwhile to sample. This led to an idea for a research paper [8] with Harold, on auditing claims in two stages.

7. EDITORSHIP

Harold: You were Editor of the *Annals of Statistics*, Co-Editor of the *Journal of Multivariate Analysis*, and Associate Editor of *JASA*. How did you do all that? You were getting four papers a day.

Art: The *Journal of Multivariate Analysis (JMA)* was tricky. There were five of us who were co-editors, then there was one editor, and then it went back to five co-editors. I was asked to be the sole editor of *JMA* right after I was Editor of the *Annals of Statistics*, but I turned it down. The *Annals of Mathematical Statistics* became the *Annals of Statistics*, and Ingram Olkin was the editor. After Ingram, I became editor for a three-year term. My Associate Editors were a cast of statistics stars whose collective knowledge was all encompassing. All bases were covered by true experts.

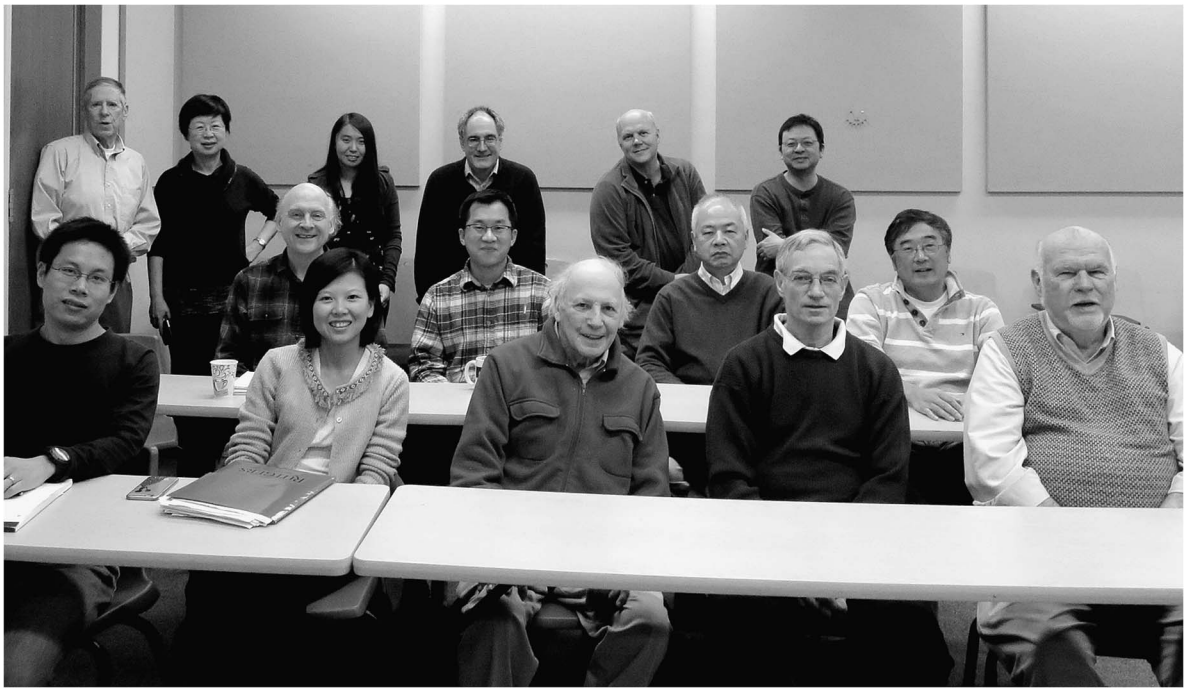

FIG. 7. *Art (front center) and his colleagues at Rutgers Statistics Department, February* 2016.

I relied heavily on the AE's and rarely if ever deviated from their recommendations. Their response time and the wonderful secretarial assistance I had led to much prompter action on submissions. The Associate Editors had very high standards and this resulted in very high quality papers. Even with the high quality, the numbers did not reduce and the journal was quite thick. In those days and ever since its inception, the *Annals of Statistics* and its predecessor the *Annals of Mathematical Statistics* were the elite and most prestigious among statistics journals. It was not only the honor of being editor of the *Annals*, but also what I learned from the papers and the Associate Editors. The entire process was most rewarding.

8. FUTURE DIRECTIONS IN TRAINING STATISTICS GRADUATE STUDENTS

Joe: What are your thoughts on training future Ph.D.s in statistics.

Art: Statistics is currently basking in big data, machine learning and computer interaction. The computer has to play a larger part in the curriculum. Nevertheless, there will always be a need to evaluate the merits of statistical procedures and compare their operating characteristics. This leaves openings for some of the traditional researchers to use risk functions and decision theory notions for such evaluations. I still think that theory of inference, and probability and stochastic processes, linear models are very valuable and should be kept as part of the curriculum. There may be a change in the composition of these courses. There should be heavy emphasis on computational methods. There may be greater emphasis on Bayesian inference and inference for big data, and less on Lehman inference, less on admissibility.

Harold: I think someday it will come back. If you are interested in optimal properties you will need to know classical decision theory.

Art: True, some of the areas we worked on have simmered down somewhat, but a few are still on the burner: Ordered restricted inference, categorical data analysis and decision theory notions including admissibility properties and complete class results. But should it get the emphasis it did, and still get the emphasis it does in our courses? On the other hand, two of my favorite areas, multiple testing and inference following model selection are still active topics needing additional research.

Joe: Are you retiring?

Art: Yes. I have a retirement date of January 1, 2017.

Joe: Any plans when you retire?

Art: My daughter and grandchildren live near us and they and my son are very close to me and my wife. My granddaughter is going to Rutgers and is a honcho at

the school radio. I will be Emeritus and of course will come back to the office.

Joe: Thanks you for sharing your life and its continuing story with us.

Harold: Happy retirement.

Art: Thank you.

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