*Statistical Science*
2017, Vol. 32, No. 1, 138–164
DOI: 10.1214/16-STS595


# A Conversation with Lynne Billard

**Nitis Mukhopadhyay**

*Abstract.* Lynne Billard was born in Toowomba, Australia. She earned her B.Sc. (Honors I) in 1966, and a Ph.D. degree in 1969, both from the University of New South Wales, Australia. She is perhaps best known for her ground breaking research in the areas of HIV/AIDS and Symbolic Data Analysis. Broadly put, Professor Billard's research interests include epidemic theory, stochastic processes, sequential analysis, time series analysis and symbolic data. She has written extensively in all these areas and more through numerous fundamental contributions. She has published more than 200 research papers in some of the leading international journals including *Australian Journal of Statistics*, *Biometrika*, *Journal of American Statistical Association*, *Journal of Applied Probability*, *Journal of Royal Statistical Society*, *Journal of Time Series Analysis*, *Nature*, *Sequential Analysis*, *Statistical Science*, *Statistics in Medicine* and *Stochastic Processes and Their Applications*, plus book chapters in a number of acclaimed edited volumes.

Professor Billard has (co-)edited or (co-)authored eight prestigious books including her authoritative text (co-authored with E. Diday), *Symbolic Data Analysis: Conceptual Statistics and Data Mining* (2006) published by Wiley. During the period 1969 through 1980, the career path took her to travel to University of Birmingham (U.K., 1969–1970), State University of New York at Buffalo (1971, 1974–1975), University of Waterloo (Canada, 1971–1974), Stanford University (California, 1974), Florida State University at Tallahassee (1975–1980), Naval Postgraduate School (U.S.A., 1979), University of California (Berkeley, 1979), Imperial College (1986), Isaac Newton Institute, Cambridge (1993), and other prestigious places.

She had joined the Department of Statistics at Florida State University as an Associate Professor in 1975 and during 1976–1978 she served as the Associate Head there. She became a Professor at Florida State in 1980 but went on leave to visit the Department of Computer Science and Statistics at University of Georgia, Athens. She joined the same department in Georgia permanently as Professor of Statistics and Head in 1980. When the Department of Statistics was formed in Georgia under Professor Billard's leadership, she became its Professor and Head (1984–1989). Since 1992, she has held the most prestigious and coveted position, the University Professor, in the University of Georgia.

She served as an Associate Editor for numerous journals including the *Journal of American Statistical Association* and *Statistical Analysis and Data Mining*. All her life, she has served extensively by holding high-level offices as well as memberships of both national and international committees

*Nitis Mukhopadhyay is Professor, Department of Statistics, University of Connecticut, Austin Building U-4120, 215 Glenbrook Road, Storrs, Connecticut 06269-4120, USA (e-mail: nitis.mukhopadhyay@uconn.edu).*

at several scholarly international societies including the American Statistical Association (ASA), the Institute of Mathematical Statistics (IMS), International Biometrics Society (IBS) and Eastern North American Region (ENAR), Bernoulli Society and the International Statistical Institute (ISI). For example, Professor Billard was elected President of ENAR (1985), International Vice President (1993, 1996) and International President (1994, 1995) of IBS and President of ASA (1996).

She has earned many honors and awards, including Fellow of the IMS (1988), Fellow of the ASA (1980), Fellow of the American Association for the Advancement of Science (2001) and elected membership in the ISI (1980). Professor Billard received several prestigious awards including the S. S. Wilks Medal (1999) of the ASA. Its citation read, "For significant contributions to the theory and methodology of statistics and the advancement of scientific knowledge in a variety of fields, especially in the area of HIV/AIDS; for effective leadership on issues of public interest, particularly with respect to the decennial census; for energetic professional service nationally and internationally; and for influential dedication to the statistical education of both statisticians and the public at large."

She was honored by the Founders Award (2003) from the ASA. She received the Committee of Presidents of Statistical Societies (COPSS) Elizabeth Scott Award (2008) and FN David Award (2013), as well as the Janet L Norwood Award (2011). In 2015, she was installed as an Honorary Member of the Statistical Society of Slovenia.

Professor Billard travels extensively to scientific conferences as an invited participant, works harder than many half her age, and continues to inspire through her writings and uniquely affectionate presence.

The following conversation began August 1, 2011, at the Joint Statistical Meetings held in Miami, Florida.

## EARLY GROOMING

**Mukhopadhyay:** Lynne, please begin with your childhood? Where were you born? How about your parents?

**Billard:** I was born in Toowomba, an aboriginal word, meaning swamp, in the garden city of Australia. I inherited three things in particular from my mother. My blue eyes, mathematics and hand-eye coordination—I cannot take credit for them. My mother was absolutely brilliant. She was a genius in the real sense of the word. She skipped two grades in school and in her state-wide exam (held at the end of her schooling years) earned 3 first class honors in Math 1, Math 2 and Physics. No one else did so prior to her—nor since, at least at her school. She was just brilliant.

My mother wanted to be a school teacher like many of her predecessors in the family. She was very young, so much so that the Teachers' College would not take her because when she finished, she would still be younger than the students she would be teaching. Her older brothers said, well, she should go straight to the university. This was in the 1930s, the family had no money—her father had died when she was nine. Her two older brothers arranged and paid for her to go to the university. Because of that, she wanted her children to go to the university regardless of whether or not the family could afford it.

**Mukhopadhyay:** Which Australian university did your mother attend?

**Billard:** She attended the University of Sydney.

**Mukhopadhyay:** Is that where you went, too?

**Billard:** That is a good question. Actually, "No". I went to the University of New South Wales (UNSW) because I received a cadetship to go there. An Australian would ask why University of New South Wales. In those days, students normally attended one of the big universities in their home state. My cadetship was connected with the University of New South Wales, the "MIT of Australia". Early on, this cadetship and my mother were both crucial in steering my career. My

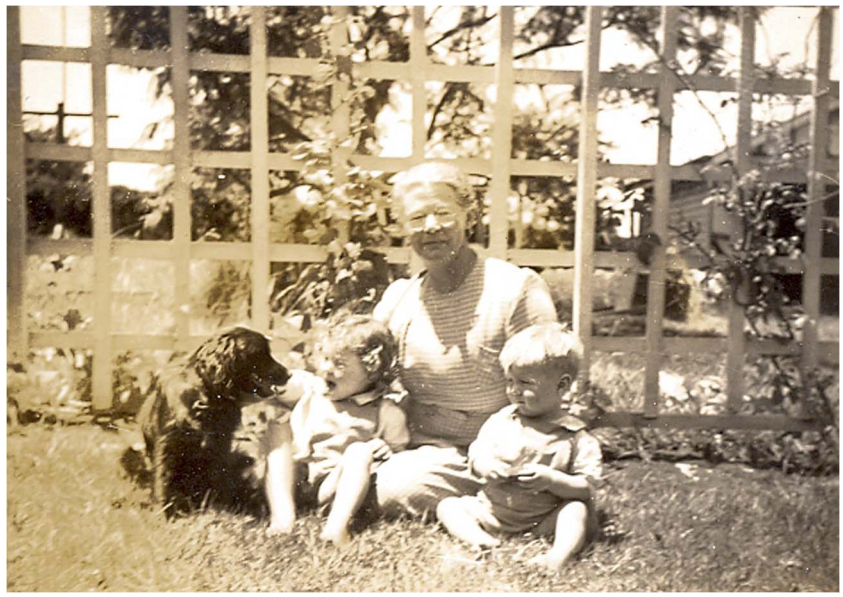

FIG. 1. *Lynne and brother, Geoff, with their paternal grandmother, Flo (Jacobsen) Billard.*

mother wanted me to go to the best possible university even if it was outside my home-state of Queensland.

FIG. 2. *Parents Col and Chris with children: Geoff, Ron, Brian, Irene and Lynne.*

**Mukhopadhyay:** What was your mother's specialty?

**Billard:** Mathematics. My father was a hard worker, a very good organizer, and he became an administrator. My mother said I inherited the best from both.

**Mukhopadhyay:** It indeed sounds great that you inherited good stuff from both parents.

**Billard:** Indeed so, but mathematics came from my mother.

## LOVE OF MATHEMATICS

**Mukhopadhyay:** While we may revisit this topic, let me ask a related question. Did you like mathematics from the beginning when growing up?

**Billard:** Oh I loved it, all of it.

**Mukhopadhyay:** At that time, I suppose lots of people did geometry. What did you like most—geometry or algebra?

**Billard:** I liked both. I learned solid geometry. Calculus was magical.

**Mukhopadhyay:** Do you recall some teachers other than your parents who were particularly influential?

**Billard:** Let me first say I always thought I would want to go into mathematics. I considered being either a science or math teacher. In the junior year of my schooling, we had guidance counselors come in who gave us all IQ tests and who then sat down with each of us asking what we wanted to do as a career. While I loved mathematics, I thought there were not many jobs

in it. The counselors assured me that I would get a job in mathematics.

**Mukhopadhyay:** That assurance must have made you feel more confident.

**Billard:** It was great to learn that I could pursue a career in mathematics. We had a mathematics teacher, John Phillips, who added new and extra material in the class for my benefit—only I did not know it at the time, after all, not everything could be on the exams. Anyhow, in hindsight this was appreciated. He then went on to become a university professor. I found out about 12–15 years ago, at a high school reunion, that he always said on the first day of a class: "Girls, do not think you cannot do mathematics," and "Boys, do not think girls cannot do mathematics". He went on adding "One of the best two mathematicians I have known was a woman". He was apparently referring to me. Talk about being a role model unknowingly! John Phillips passed away recently.

**Mukhopadhyay:** This is an example of a role model and mentor that you were not aware of for a very long time. Any others you may recall?

**Billard:** How true! There was Professor Blatt who was important, and Professor Douglas was in there in the mix, too, though I was unaware of their roles at the time.

**Mukhopadhyay:** I suppose your high school year was the calendar year. If I am not mistaken, school started last week in January and went until a week or two before Christmas. Did you finish high school in December of 1961?

**Billard:** That is correct.

## PRESTIGIOUS CADETSHIP LEADS TO UNIVERSITY OF NEW SOUTH WALES, AUSTRALIA

**Mukhopadhyay:** You had told that your cadetship was connected with UNSW. Since that was indeed a turning point in your early career, please explain the prestigious cadetship.

**Billard**: First, let me say that in those days after graduation from a high school, we took state-wide exams at the end of schooling (covering material from the last two years—junior and senior years in US parlance). Also those in the state of New South Wales thought their system was the best. UNSW had access to those scores from state-wide exams. I guess I made some sort of "short-list" and was invited to the university for a week of IQ tests and the like, followed by interviews. The university wanted the very best students from across the country—and so customarily gave 3 cadetships to 3 men each year. However, I and two other women also received a cadetship our year.

**Mukhopadhyay:** How was the chain of 3 cadetships going to 3 men finally broken? That must be an interesting story.

**Billard:** In America, I once was speaking with a faculty person who told me that he had been one of

FIG. 3. *The three women mathematics cadets at UNSW. From left to right*: *Sue Ahrens*, *Lynne Billard*, *and Jane Reeves in Coventry*, *England*, 1993.

the people who was selecting candidates for a cadetship. He told me how one year Professor Blatt wanted to select a woman. Blatt, a very famous, internationally renowned, and highly regarded professor in applied mathematics was pushing this idea very hard. The faculty person telling me the story said he himself was opposed to the idea of including a woman. Eventually, although selection committee members did not want to change the policy of 3 cadetships going to 3 men, out of respect to Professor Blatt such was his enormous stature, they added 3 cadetships for 3 women for that year. But, they were not going to forgo the 3 to men!

This faculty person went on "And darn it if those women did not do better than the men"! He was flabbergasted when I said "I know, I was one of them". He said he knew I was the best from my state—he had taught me for a short time in a short course—but he did not know or remember I was a cadet. Years later, Professor Douglas told me that at the selection stage I had two strikes against me—being a woman and being a Queenslander! Anyhow, for that year, the university system added 3 new spots for women and I was one of those women selected for a cadetship.

**Mukhopadhyay:** I request you to clarify one point. You have mentioned that a professor in the US was in the selection committee to pick the cadets, but it was an Australian program. My question is, how so?

**Billard:** He was a professor in the US when he was telling me the story. He was originally an Australian and was a member of the selection committee to pick the cadets.

**Mukhopadhyay:** The cadetship was surely a turning point. What did this cadetship entail?

**Billard:** No doubt, it was a turning point. I was at the right place at the right time/year.

The cadetship program paid me a living wage beginning my college year in 1962. It was enough to live on. We were exempt from tuition fees. We were officially academic staff members. My parents did not have to pitch in financially to put me through college—in fact my first reaction upon receiving the news was that they could now afford to send (the third child) to university. I could not afford to buy many textbooks. So I borrowed them from the library. We had to do double math honors, and upon graduation teach for three years at an average of about eleven hours a week.

**Mukhopadhyay:** This created a great opportunity for you to teach at the same time! You must have loved it.

**Billard:** You are absolutely right about that. Of course it was. Teaching and learning went hand-in-hand. I learned quickly a number of ways to identify students who had difficulties in class and how to help them.

## GROUNDWORK AT UNSW

**Mukhopadhyay:** Looking back, what else went on at the time when you began attending UNSW?

**Billard:** Cadets had to do double mathematics honors. And so I did mathematics and statistics. The first year, physics and chemistry were also required courses. The physics program wanted me to switch to a physics cadetship after my first year's results were out. But I loved mathematics and stayed with that. I also did psychology, English and economics.

**Mukhopadhyay:** In your undergraduate, did some courses stand out perhaps more than others?

**Billard:** We did measure theory from P. R. Halmos's book (Halmos, 1950) which I thought was pretty interesting. The calculus text of G. B. Thomas (Thomas, 1966) was simple and painless.

**Mukhopadhyay:** Halmos's measure theory book is a classic. I learned my first course in measure theory from Halmos, too. Lynne, when did you learn hardcore real analysis?

**Billard:** That is a good question, I could go back and look at records to recall what we did and when. There was a Birkhoff and MacLane (1941) book on modern algebra. It was fascinating that he used operators and good complex analyses. You are asking good questions, and I am not prepared.

**Mukhopadhyay:** Lynne, you have a wonderful memory. Please do not worry.

**Billard:** A solid grounding in linear algebra and linear manifolds (Kuiper, 1962) put me to an advantage in dealing with essentials in statistics later. Willmore's (1959) book on differential geometry was fun. I remember Graybill's (1961) book in linear models and learning many theorems on quadratic forms and other statistical tricks. I thought they were pretty. When I graduated and started teaching, the first thing I did was go back and buy those books of Graybill (1961) and Cochran and Cox (1957), and others.

**Mukhopadhyay:** At some point, you started moving toward statistics. Will you please take me there?

**Billard:** As I said, I was a student at the "MIT of Australia". The first year was common for all, but in doing math honors I had to study extra material. If I remember correctly, the honors mathematics students had about ten hours of lectures weekly (instead of reduced hours for the nonhonors students). And, our lectures were at an accelerated pace, so that we had completed the nonhonors course material by the end of the second term, and went on to cover much more material.

I should add here that lectures went "all year" for three terms, with the exams all bunched at the end of the year, usually there were no tests, what we call midterms in the US, along the way. In the 2nd year, cadets had to take pure mathematics and at least one of applied mathematics and statistics (all at the honors level, again part of the cadetship rules).

For me, that meant I had to select between applied math, pure math and statistics. Of course, I did not have any idea about statistics. So, I asked around mathematics people and they said students always found statistics was the hardest. Therefore, I wanted to go into statistics. Throughout my schooling, I always went with the hardest choice. I just loved to be challenged. In North America, many mathematicians tend to look down upon statisticians nearly equating statisticians as failed mathematicians. I found this out much later. But, in Australia, statistics was considered the hardest field and hence some of the best mathematicians went into statistics. I may have entered the field of statistics for the wrong reason, but I am sure glad that I arrived there.

**Mukhopadhyay:** What about other subjects?

**Billard:** As my 3rd subject, I took physics—again because it was the toughest choice, but in a sort-of way to keep my options and interest in physics open. It was a crazy schedule and people said I was nuts. In the 3rd year, I did pure mathematics and statistics, and in the 4th year, did just statistics.

All those mathematics and statistics courses were taken at the honors levels (which entailed more materials and more lecture hours than for the nonhonors students). In the 4th year, there were few people who taught beyond Halmos (1950). We were left to study hard-core analysis from Rudin (1964) plus Pitt's (1963) measure theory book on our own, but there were compulsory exam questions asked from these materials! I found that quite interesting and demanding, and in the end I did very well.

**Mukhopadhyay:** So, that is how you learned hard-core real analysis. After completion, did you go for the Masters degree?

**Billard:** No, I had to complete 3 years of teaching first, a requirement of the cadetship contract. The faculty was trying to talk me into going to Stanford to do a Ph.D., but I said I cannot do that since I had signed on the dotted line for the cadetship. I did not want to dishonor my commitment (to teach), and so I stayed and fulfilled my teaching obligations and pursued my Ph.D. program simultaneously.

## PH.D. PROGRAM AT UNSW

**Mukhopadhyay:** Is it then correct that you jumped from undergraduate to a Ph.D. program?

**Billard:** That is correct. Some of the other cadets were also simultaneously teaching and going on to pursue Ph.D. programs.

**Mukhopadhyay:** What was the beginning of your Ph.D. program like? Did you decide to work with one particular faculty member right away?

**Billard:** It was the British system; you work—independently—for a while and see what happens. It is an interesting story. I do not know if you knew Manu Vagholkar. He was a very good teacher, one of the best instructors, and his area was sequential analysis.

**Mukhopadhyay:** Yes, I know Vagholkar's name. His Ph.D. thesis (1955) was devoted to statistical decision theory to sampling inspection schemes. Then his paper with G. B. Wetherill (Biometrika, 1960) on most economical binomial sequential probability ratio test was a "must read" when I was growing up.

**Billard:** Vagholkar taught a course in sequential analysis. Each chapter in Wald's (1947) book has the hypotheses test, the OC function and the ASN function. Chapter 9 had a two-sided test for a normal mean, but without the OC or ASN functions. He was the graduate coordinator but I think he probably had not had any students working with him. He wanted me to complete that chapter in some sense.

I did put in a lot of work on the test. It was a very difficult task. It went on, and a year and half later, David Cox came out to spend 6 weeks in the department prior to the ISI and IBC meetings held in Sydney in August/September, 1967.

**Mukhopadhyay:** David Cox was certainly the best person to talk with regarding the specific problem on hand. What an opportunity?

**Billard:** I know. I talked with Cox about this chapter in Wald's book on a two-sided test. I said this has got to be a very difficult problem for a graduate student to resolve because all sorts of people, including Barnard and Cox himself, would have tried this out earlier; Cox agreed.

Anyway, I showed Cox what I had done. The last week he was there, he drew me something on a sheet of paper, and at the bottom he wrote that I might want to try something like this instead. Before Cox left, I explained to him how I would go about it and he said that sounded good. He said, "If you need any help, just write to me".

I did not need additional help, and it became the basis for my Ph.D. thesis. Vagholkar signed off on my

FIG. 4. *From left to right*: *Mitch Gail*, *Juliet Shaffer*, *Nancy Geller*, *David Cox and Lynne Billard at the Joint Statistical Meetings*, 2011.

thesis. It was submitted in October 1968 and the Ph.D. degree was awarded in a commencement ceremony held in Australia in May 1969 (Billard, 1968).

**Mukhopadhyay:** Where did you submit your thesis work for publication?

**Billard:** This was submitted to the Royal Statistical Society (Billard and Vagholkar, 1969). I remain incredibly grateful to David Cox for encouraging me and guiding me to continue working on the topic that was originally suggested by Vagholkar. Cox always gives wonderful talks with very deep but very simple expositions. That is an extremely hard combination to accomplish.

**Mukhopadhyay:** I am aware of a number of your major contributions in sequential tests during your early career. Will you throw some light on that?

**Billard:**. I developed interesting properties of some two-sided sequential tests for a normal distribution (Billard, 1972). One problem with many sequential tests is that they are often open-ended, that is, the termination of sampling may occur in the distant future. In order to adjust for such practical inconvenience, I investigated a truncated partial sequential procedure (Billard, 1977).

**Mukhopadhyay:** On a different note, however, you began playing bridge during your graduate program at UNSW, did you not? What happened?

**Billard:**. Yes, indeed, we all started playing bridge in January or February of 1968. One of my friends was on the way to becoming a master bridge player and sometimes he would grab me to play but after 2–3 weeks I noticed it was taking too much time from my perspective. I loved it but did not want to play late at night. The next two days after a game were spent analyzing.

After 2–3 weeks of not being available to play bridge—usually because I had become a squash player—the others stopped asking me. In the end, I submitted my dissertation in October that year, finished my 3-year term of teaching in November, and went on my way to England, but the bridge players were still there another two years later!

**Mukhopadhyay:** Many excellent statisticians were also master bridge players. For example, I recall Deb Basu and Somesh DasGupta. You knew Milton Sobel for sure. Milton was a devout chess maestro.

**Billard:** In a way, I experimented with the right thing then (laughs). When I was at Florida State University at Tallahassee, during lunch time, Ralph Bradley and other faculty members would play bridge and others would watch. I enjoyed those days but we only played over the lunch hour, never beyond. I remember Deb Basu was a very good bridge player. But, I have not played in a very long time, although I may go back to bridge upon my retirement.

FIG. 5. *Lynne Billard* (5*th from right*) *played Varsity Hockey for UNSW.*

## THE BIG WORLD: BIRMINGHAM-BUFFALO-WATERLOO-STANFORD

**Mukhopadhyay:** What happened immediately after you completed your Ph.D. degree from UNSW?

**Billard:** After finishing the Ph.D. degree, I went to England for 1 year to see the world. That was December of 1968. I went to the University of Birmingham. Henry Daniels was Chair and one of the professors. That was a faculty position, I was called a lecturer. I realized that I could not see the world in 1 year, and so stayed a 2nd year.

**Mukhopadhyay:** But, what made you visit the University of Birmingham in the first place?

**Billard:** Well, David Cox asked me to go to Imperial College. I had an offer from him and an offer from Joe Gani at Sheffield. I do not exactly remember why I picked University of Birmingham. I know that they had some famous people. It was probably because theirs was the first offer. In hindsight, maybe I should have gone to Imperial.

**Mukhopadhyay:** What brought you to the United States?

**Billard:** In the middle of winter (January, 1971), I came to Buffalo, New York, for six months on my way back to Australia from England and I am still here.

**Mukhopadhyay:** Lucky for the US, but what had transpired?

**Billard:** Well, that is an interesting story. You recall that the International Statistical Institute (ISI) meeting was held in Sydney in August/September of 1967. The International Biometric Conference (IBC) was a week or two earlier. Even though I was incredibly shy, the 2nd shyest person in the world, I went to the banquet to see some of the famous people.

I sat at a round table with ten people. Joe Gastwirth sat on one side of me and Norman Severo on the other. Norman Severo from Buffalo, New York, started telling me about what he was doing in epidemic theory. I found it pretty interesting. Three years later, 1970, I received a letter from Buffalo explaining that Seymour Geisser was going on sabbatical leave, they needed someone for 6 months and was I interested.

I thought, why not? This gave me a chance to see North America. On January 1st, 1971, I came to SUNY at Buffalo as a visiting assistant professor. Talk about benefits of going to a banquet (laughs). I visited Buffalo until the end of August 1971 (though I did detour to east Africa for six weeks mid-summer).

**Mukhopadhyay:** The weather was probably brutal. How did you manage?

**Billard:** Having grown up in sub-tropical Queensland, the snow was a novelty for me.

**Mukhopadhyay:** Same year, in September, you moved to University of Waterloo. How did that come about?

**Billard:** At the time, Buffalo and Waterloo shared a lot of people and activities; so, I moved to Waterloo, Canada, as an assistant professor. I was there from September 1971 through December 1973.

**Mukhopadhyay:** Who did you meet in Waterloo then?

**Billard:** In Waterloo, I saw Jim Kalbfleisch, not Jack. I believe Jack returned later sometime in my last year there. I also met Jerry Lawless, Mary Thompson, and V. P. Godambe. Then, part of the year 1974, I was on leave from Waterloo to visit Stanford as an assistant professor.

**Mukhopadhyay:** What happened next?

**Billard:** Then they talked me into going back to Buffalo (9/74–6/75). By this time, at both Buffalo and Stanford (in the Summer 1975), I was a visiting associate professor. Any time an opportunity came to me to go to a top-rated department, I took it thinking that it would give me some good experience to count on when I returned to Australia. If you looked at my resume in the 70s, you would think that I could not hold a job (Laughs), though I did get promoted and tenured along the way.

**Mukhopadhyay:** (Laughs) But, how did you continue your research? Did you have good mentors who kept you focused?

**Billard:** Basically, in all those places, I worked on my own to move ahead my research agenda. Nobody was telling me I should be doing my research—it was simply something I enjoyed doing. At Birmingham, I respected Henry Daniels a lot. At Buffalo, Norman Severo inspired me. At Stanford, the osmosis of its environment stimulated me very much. I respected what they had to say and I always listened.

FIG. 6. *Lynne Billard and Nancy Reid. Lynne taught Nancy at Waterloo. Photo from JSM* 2016.

**Mukhopadhyay:** Please tell me more about your feelings when you were at Stanford.

**Billard:** I went to Stanford from Waterloo. For some reason, they liked my teaching. They were looking for good teachers. I was working on my research/publishing. Some of my best ideas for research came out of my time at Stanford in 1974. I would go to lunch with faculty and I would attend the seminars. All my work was still singly authored. I think it is a good example of osmosis taking place when you are in a nurturing and stimulating environment; it generated ideas. I found that valuable. Anderson, Stein, Morris, Solomon, Stone, Efron, Olkin and others were there. I think it was a critical move for me, even though I thought initially that I was on my way back to Australia.

## MOVE TO TALLAHASSEE, FLORIDA AND THEN TO ATHENS, GEORGIA

**Mukhopadhyay:** From Stanford, you were back to Buffalo (1974–1975). In the meantime, you went back to Stanford in the summer months of 1975. In July 1975, you moved to the Department of Statistics at Florida State University as an associate professor. Please share that part of your story.

**Billard:** Florida State offered me an associate professor's position in 1975 and I moved there. Ralph Bradley was the Head. I was an Associate Head for 2 years from 7/1976–6/1978. When Ralph stepped down from the Headship, I stepped down from being Associate Headship (so the new head could make his own appointment). Myles Hollander became Head after Ralph.

**Mukhopadhyay:** Who else were there at Florida State then?

**Billard:** Deb Basu was there when I arrived. Also, J. Sethuraman and Frank Proschan were there at the time. There were lots of very good people there. The environment was highly stimulating. I was still working on a number of papers of my own and I had started having some very good graduate students there. I enjoyed my time in Tallahassee.

**Mukhopadhyay:** What made you move to the University of Georgia, Athens?

FIG. 7. *Front left to right*: *Dawn Tolbert*, *Lynne Billard*, *Marion and Ralph Bradley. Back left to right*: *Unknown*, *unknown*, *John Tolbert at Georgia*. *Photo*: *Courtesy of Melissa Pettigrew.*

**Billard:** I visited the University of California-Berkeley during the fall semester 9–12/1979 upon Jerzy Neyman's invitation to work with him for a semester. While there, I had a call from Georgia. I had never heard of the department but somehow they persuaded me at least to come to take a look. They lured me and I visited Georgia twice. What had happened was that the department at Georgia had been reviewed badly with many recommendations, one of which was to bring someone from the outside for the Headship. During the year 1980–1981, I was on leave from Florida State and came to the University of Georgia, Athens, as the Professor and Head of the Department of Computer Science and Statistics (9/1980–8/1984). I came in with mixed emotions. After considerable discussions with the Dean, I started rebuilding the program from the ground up.

**Mukhopadhyay:** So, what did you do?

**Billard:** I began talking with Ralph Bradley about it. One thing I learned at Stanford was that sometimes universities do not follow through with their promises. So, I planned to ask that promises not only be in writing but more importantly be written into the budget. Georgia was trying to bring the department up to a national level. I thought about the offer for nearly a month, prepared a five-year plan, and asked for "the moon".

**Mukhopadhyay:** What did you aim for?

**Billard:** Many things, including being able to bring in a senior distinguished professor who was highly regarded by our profession and who would be expensive. By now, this was about March–April 1980. The Georgia Dean, Jack Payne, phoned to tell me he would give me what I had requested. Before I could even ask, he immediately said he would transfer me to the Associate Dean, Charlie James, to write them into the budgets.

**Mukhopadhyay:** This was clearly a Dean with whom you could work.

**Billard:** Indeed, yes, how could I turn him down? Soon after, Ralph Bradley came to tell me he was interested in joining me there (at Georgia). And, he did indeed come, after his ASA Presidential year.

**Mukhopadhyay:** What did you change at Georgia?

**Billard:** We had to change everything. For example, in the first four years, we radically changed all degree requirements for all 6 degrees, course content of existing courses, and added 36 new courses in the curricula. The best way to symbolize the level of changes made was in the statistics Ph.D. program. When I arrived the most advanced course was based on Hogg and Craig's (1965) text. For our revamped Ph.D. program, now the first course was based on Bickel and Doksum's (1976) text. That is, we began with a starting point more advanced than what was in the end of the program prior to my arrival. We literally made tons of changes with the establishment of a more rigorous and advanced curricula in statistics, and also in computer science. In fact, we probably did more for computer science than for statistics that first year.

**Mukhopadhyay:** Put simply, you had to enact an enormous culture change.

**Billard:** Yes! There were now expectations of publications from dissertations, research from faculty, computer capabilities established, re-organization of teaching expectations, the addition of teaching assistantships

and their use in attracting top students, the list goes on. Also, after four years, we split into two departments creating a separate Department of Statistics, and also a Department of Computer Science. The University reckoned I was doing essentially four jobs—heading two separate departments and orchestrating radical changes in both. I should stress though that the upper administration was enormously supportive of what we were doing.

## BOOKS AND PAPERS INFLUENCING EARLY CAREER

**Mukhopadhyay:** Which books or papers from your predecessors did you find indispensable or very helpful in your early career?

**Billard:** David Cox had just put out a book with David Miller on stochastic processes and I actually used some parts from that book (Cox and Miller, 1965) in my doctoral research. Also, I relied upon Ted Anderson's (1960) paper and a paper of Gordie Simons from Chapel Hill (Simons, 1967). The work of Norman Johnson, one of my Ph.D. thesis examiners, influenced me. I met him once at Chapel Hill. He remembered me, knew that David Cox gave me the idea, but I did not know him well.

I began teaching time series analyses and modeling when I was at Waterloo in the 70's. Since I knew nothing about it, later I asked why they gave me time series to teach. They said "Well you worked in sequential analysis. Is it not the same thing?" Anyhow, I sat down and learned it in order to teach it and subsequently I was doing a lot of research in time series. The Box and Jenkins book came out in 1972 or around that time and it was a very important book for my growth.

**Mukhopadhyay:** Would you please name a few classic books from your time that shaped your creative thinking?

**Billard:** Bailey's (1964) book on stochastic models was the only place, that I can recall, with material on nonlinear birth- or death-rates. Feller's books (1966, 1957) were seminal. Graybill's (1961) book had many fundamental ideas. David Cox's (1965) stochastic processes book with Miller was fantastic. The Samuel Wilks book (1962) and the M. G. Kendall book (1946) were certainly influential in my career path. The Kendall and Stuart book (1958) was like an encyclopedia.

**Mukhopadhyay:** Is there a classic text that you continue to go back to for teaching?

**Billard:** I teach design of experiments to students from agriculture. Cochran and Cox (1957) has been a great resource. It is very easy to read. I do use some of it when I am getting into statistical principles. It is a classic. A lot of students buy the book after the course. Plus, Cox (1958) is one of the most elegantly written books around.

**Mukhopadhyay:** Another book that comes to my mind is that of Snedecor (later, Snedecor and Cochran, 1967).

**Billard:** Yes, that is right, but it is more like a recipe kind of book. I still use it occasionally in my design class. There is a book edited by Owen Davies from 1960 which I came to know about when I was in England. It does not cover that many topics in design but what it does cover, it covers well—it gives you the essence and examples and the Appendix gives you theory. I normally have that on my list for students to buy if they can find it.

There is a story on that. The previous Department Head in Georgia was very supportive of me when I came on board. He retired after a year or two and eventually he would come in less frequently. When he did come to the university, he would come into my office, want coffee, and chat for a couple of hours. Later he moved to Florida to live with his son. He left all his books for me. The Davies book (1960) was one of them. That was the only thing he had that I kept, the rest were sent to the library. Not many people know of that book since it has been out of print. I never lend it out (Laughs).

## CO-EXISTENCE OF ADMINISTRATIVE COMMITMENT AND RESEARCH PRODUCTIVITY

**Mukhopadhyay:** When you moved from Florida to Georgia, you knowingly accepted a load of administrative commitment. What was happening to your research?

**Billard:** First and last, I was determined to keep a thread of research going. I was still doing a lot of population modeling (e.g., Billard, 1981) and some sequential stuff. I had an idea of a sequential $t$-test with a student working on it (e.g., Arghami and Billard, 1982, 1991). I did some empirical Bayes modeling and estimation with another student (e.g., Meshkani and Billard, 1992, Billard and Meshkani, 1995). Fortunately, it was still easy to generate research ideas, but I would hand many over to other people especially students; I might give the basic outline and structure and let them fill in the flesh, do the actual integration so-to-speak.

**Mukhopadhyay:** You made a number of crucial contributions in epidemic theory. Please throw some light on that aspect of your research.

**Billard:** The mathematics used in epidemic theory is extremely difficult. To contrast with classical statistical models, in epidemic theory they turn out to be nonlinear processes. It primarily involves nonlinear transition probabilities and related matters. Working with partial differential equations is reasonably difficult mathematics—at least when the equations do not fit into the long-established and widely known classes.

**Mukhopadhyay:** On top of those difficulties, there may be censoring at play, too!

**Billard:** Oh, sure. A simple general epidemic model had been developed by Ross (1910) on malaria. Ross's model was deterministic as were all the ensuing models for a slew of population modeling situations, not just those in epidemic theory. Feller (1939) wrote a paper essentially saying "hey listen up guys, life is stochastic, not deterministic".

It was Bartlett (1949) who first set up a stochastic version of the general epidemic which described transitions from the susceptible to the infected, and then infected to recovered individuals (and those who were never infected again). It was a simple model with nonlinear birth rates. Gani (1965) solved that problem for a population of size 2 or 3. Norman Severo at Buffalo came up with a recursive idea (Severo, 1967, 1969).

**Mukhopadhyay:** Did you not solve the problem for a population of any size?

**Billard:** I thought I did. Severo was actually using a lot of combinatorial theory. I took his idea and was sticking things into blocks and looked into combinatorial patterns in the blocks. Out of that I came up with a solution for a general epidemic of any size (Billard, 1973). Later, I discovered what I had developed was a solution to a class of partial differential equations which had not yet been solved.

**Mukhopadhyay:** Where were you at the time?

**Billard:** I was at Buffalo when I began research on the basic paper. Then, I was in Waterloo by the time I obtained a solution to a class of partial differential equations. Severo was working on it, too. We made it a joint paper even though the work was done separately and submitted it to a journal. It was accepted immediately (Billard and Severo, 1974). They asked us to add one sentence saying where it had been used (Billard, 1973). That was the time when I really became a mathematician.

## MAJOR AREAS OF HIGH-IMPACT RESEARCH IN GEORGIA

**Mukhopadhyay:** Are you in a position to summarize some of your high-impact research that you have carried out while you have lived in Georgia?

**Billard:** I think that there are two important areas, the most important would be AIDS related research. I worked on the HIV-AIDS incubation period. There were 4 or 5 papers written in the 1980s (e.g., Medley et al., 1987, 1988) or maybe in the early 90s.

Years earlier, David Cox wanted me to take a job at Imperial, but I never did, because I thought I would end up there forever. So, I eventually went there to spend a sabbatical.

**Mukhopadhyay:** Did you and David have a plan to work together on something concrete?

**Billard:** We were going to work on a problem in design of experiments and did a lot of preparatory work beforehand. This was August 1986. A week before I arrived at Imperial, Roy Anderson from biology had come to David with the US HIV-AIDS data from the Centers of Disease Control (CDC). At the time, Anderson had done a lot of mathematical modeling in biology but not epidemics that I can recall.

David knew I had done a lot of work in epidemics during the 70s. He asked me if I would like to do this. I did the mathematics and finished by October. We did not want to wait until I returned to Georgia in January to run the data through our computer. So, Anderson's student, Graham Medley, worked with me and carried out the computations on the Imperial College computer. I still remember sitting in David's office in November discussing the final results which were really very different from what was known at the time (Lui et al., 1986).

**Mukhopadhyay:** What did you discover that was so interesting and unexpected?

**Billard:** We were confident in our mathematics. But we did not know if we needed more observations for greater robustness. It was largely believed at the time that the incubation period from infection until diagnosis was 2–3 years. But, dividing up the data into groups of small children, adults and elderly, we found that the incubation time for small children was about 3 years, while for adults it was more like 8+ years. The standard deviation was quite large too so it became what was called the *ten year* figure.

And so if you think of the age cohort 17–27, college students, they would not see their own friends dying with AIDS within that window. That is, they were less likely to change their behavior or life style. It was going to change health education radically as to how the administration went about educating people. I still remember the first time I heard a commercial on radio, driving to work. I just sat in my parked car listening

to it and thought "that is our work". That ad made me shudder. It had a huge impact on our society.

**Mukhopadhyay:** What did you do then?

**Billard:** I remember talking with David and he said "Let us get it out". I came back to Georgia and wrote it all up and sent it back to him. By now, it was February 1987. By March or April, David had contacted me saying someone (I am not sure who, but I think it was the Editor of *Nature*) wanted a 1000-word summary of our work to put it out there immediately. That came out in August of 1987 (Medley et al., 1987).

The rest came out in a Royal Society journal the next year along with all the mathematical details (Medley et al., 1988). That work was extremely important and received numerous citations. It won the ASA Application Paper award. I felt incredibly privileged again. I was just in the right place at the right time. Somehow, Everett Koop, the US Surgeon General, entered into this. It is my impression that he had met with David Cox and Roy Anderson in England probably in May 1987.

**Mukhopadhyay:** The necessary mathematics was largely new, was it not?

**Billard:** It was new mathematics in the following sense. We had censored observations. What was known at the time, going back to work done in the 1950s I believe, was that there were (say) $n$ observations, for which the beginning and end points (times) were known for $k$ of them, and only the beginning points were known for the other $n - k$ observations, the censored ones. All we had were the $k$ observations with their beginning and end points. The data were blood transfusion diagnosed cases of AIDS, and so it was possible retrospectively to determine the month and year of the transfusion and hence of infection with HIV. We had the month and year of diagnosis with AIDS.

But, we did not know $n$, the total number of cases, or, more accurately we did not know the $(n - k)$ nor obviously did we know what the censored times were since diagnosis with AIDS had not yet occurred. What was happening when they thought the incubation period was just two years was to base the average on the people they knew about. We had to build a new model by incorporating into it the missing $n - k$ observations as well as a particular distribution for the incubation period. In the first version, we did not have enough information at the time to know if the incubation period had a Gamma or Weibull distribution.

**Mukhopadhyay:** Did you expect a big difference when you used a Gamma or Weibull distribution for the incubation period?

**Billard:** Under a Weibull distribution, we obtained that "10 years" figure. We were also able to estimate the number $n - k$ that was missing. The Gamma gave us twice as many missing. Three or four years later I drove down to the CDC office to get the next updated data set. Well, we had to convince them, easy enough, to assemble those data—they were very overworked. They quickly realized the importance and so within a short span, it—the data set—was mailed off to us. We analyzed that and we were obtaining the same results which corroborated the original results.

And someone else independently had estimated that there were 400 missing, which was exactly our finding using a Weibull distribution. It was new in the theory of truncated data for estimating the number of missing observations and building that into the model. The analysis was also new in our proposal as we considered different age-groups. Often we do not see the benefits in our work right away, but here we did. I felt privileged as a statistician.

**Mukhopadhyay:** How about your recent significant area of research involving symbolic data?

**Billard:** Yes, the other thing I think is potentially important is the work that I am doing now on what is called symbolic data. Maybe "symbolic" is a wrong word. Edwin Diday in France invented the idea back in 1987. Classical data are where you have a single point in a $p$-dimensional space. For symbolic data, if you are in one dimension, it may be that you have an interval, not a point. If it is in two dimensions, your observation maybe a rectangle.

That is your starting point, but in general observations need not be convex bodies. How do you analyze such data? I actually think that this is going to be very important in the future especially because we will face massive datasets such as these. Edwin Diday and I have a textbook (2006) that has been quite successful. Arnie Goodman (2011) opines this field as one of the two most important emerging new ideas over the horizon.

**Mukhopadhyay:** Would you please elaborate for a layman with an illustration?

**Billard:** One may want to look at my nontechnical introduction (Billard, 2011). Basically, in classical statistics, the kind we have done for ever, observation values are points in space, for example, $x = 17$, or $x = 23.1$, etc. Symbolic data can be interval-valued, for example, the interval $[15, 20]$ in 1-dimensional space. In 2-dimensional space, the classical values could be $x = (17, 39)$, while for intervals it could be $x = ([2, 5], [36, 41])$, that is, a rectangle instead of a point in 2-dimensional space.

FIG. 8. *Symbolic data colleagues. Front left to right*: *Lynne Billard*, *Edwin Diday*, *Myriam Goossens*, *Yves Lechevallier*, *Paula Brito*, *Francisco de Carvalho*.

More accurately, rather than a rectangle, it could be a hypercube in 2-dimensional space. The question then is "How do you analyze this set of intervals"? What you cannot do is to take the interval midpoints and analyze those. You only have to think through the following situation: Suppose you have two data sets each of size one, one consists of the interval [8, 12] and the second contains the interval [5, 15]. Both have the same midpoint (10); so analyses based on the midpoints will give the same answers for these two data sets. Yet, clearly, the two intervals are differently valued, so clearly the answers should be different in general.

That is, any analysis has to take into account the internal variations within each observation. That is where the trickiness usually enters into the analyses. Instead of interval data, it could be histogram data, or lists, or distributions, or. . . ; there are many types of symbolic-valued observations.

**Mukhopadhyay:** How do these kinds of data arise in practice?

**Billard**: The most frequent use will be when aggregating observations from a larger data set. Think if you like of a medical database with its millions and millions of entries. The insurer or researcher is probably not interested in your visit to a health provider on some given occasion. They might not even be interested in the collection of your visits. They are more likely to be interested in the set of 46 year old men, or 53 year old women with a certain condition, lung cancer, say.

So, all the observations relating to 46 year old men with lung cancer are aggregated. It is improbable that the medical diagnostics for all those aggregated observations are precisely the same. Rather, the pulse rates, for example, could take values in the range 54 to 78 say, that is, an interval [54, 78] or better still a histogram of values. There are gzillions of ways to aggregate data depending on the scientific questions at hand. Whichever way the aggregation proceeds, the resulting data will perforce be symbolic valued. With the large data sets being generated today, these ideas will become more and more critical.

**Mukhopadhyay:** But, aggregations may occur on "smaller" data sets, too.

**Billard**: Yes, of course. A few years back, as part of my collaborations with the Medical School at the University of Dijon, France, we were looking at some heart attack data. Doctors felt "in their bones" that where you were first admitted after a heart attack, such as a cardiac unit, or a noncardiac unit (of which there are many types), and so forth, had an impact on survival rate. But, classical analyses did not reveal this.

However, when patients were aggregated into "pathways", the corresponding symbolic CART analysis did indeed show that the first admission unit was not just important but *the* most important indicator of survival.

By "pathway" here, we mean the unit track followed by a patient, for example, a patient could be first admitted to a cardiac unit and then later sent home (a one-stop pathway), or s/he could be first admitted to an ICU, then a cardiac unit, then back to ICU and then home (a three-stop pathway), and the like. This was published in Quantin et al. (2011).

And, of course, some data regardless of the size of the data set are naturally symbolic. For example, species data are symbolic valued.

**Mukhopadhyay:** What kind of mathematics and/or data analysis does one encounter here? Do you borrow strength, for example, from the work of Geoff Watson, Ulf Grenander, Kanti Mardia or perhaps another colleague such as David Brillinger, on geometric and spatial models or shape analysis?

**Billard:** There are essentially two broad directions. One is to develop symbolic methodological analogs of all the statistical methods we have for classical data from over a century of work. At one level, this uses the same mathematics as before. So, yes, the ideas of these folks apply. For example, a principal component analysis (PCA) asks us to find the eigenvalues, etc., of a covariance matrix. The same applies here, except that the entries in that covariance matrix require covariance structures of symbolic data such as interval data.

At another level, this involves developing computational algorithms to implement the symbolic methodology. This is where it is the most difficult, as it usually involves tricky complicated but very logical thinking. So, it certainly draws upon mathematical skills to wind your way through it. One of my Georgia colleagues once wrote of "...bend(ing) your brain (around) building a histogram of histogram-valued data" (Lazar, 2013).

**Mukhopadhyay:** What may be other directions?

**Billard:** Another broad direction is to develop mathematical underpinning to these methods. An analogy here is with the bootstrap. The bootstrap methodology was "ad hoc" albeit intuitively satisfactory. Then, after Bickel and Freedman (1981) and Singh (1981) validated it mathematically, the idea really took off. For symbolic data, with one of my students (Le-Rademacher and Billard, 2011), we were able to validate the earlier results for the mean and variance of interval data, originally developed by Bertrand and Goupil (2000). This involved conditional moments, and lots of concentration! There are clearly lots of opportunities for new works in these directions.

**Mukhopadhyay:** We discussed at length your major areas of research including Sequential Analysis, HIV/AIDS and Symbolic Data Analysis. In your view, as a summary, which publications will you cite as your top five contributions?

**Billard:** Probably the most important has to be the two-paper set: *Nature* 1988, *Proceedings Royal Society B London*, 1987 on HIV/AIDS that we talked about earlier, even if only because of the importance of their results to society.

The *JAP* 1973 paper on factorial moments of epidemics would perhaps be next, since although I did not realize it at the time, this involved finding a solution to a class of partial differential equations previously unsolved. It was fun working on the blocking determinations and the underlying combinatorics.

The *Symbolic Data Analysis* book (2006) with Edwin Diday I suppose is important because it is the first pedagogical book on the subject; but perhaps more importantly, in writing that book, all sorts of unsolved problems reared up their heads, giving me lots of dissertation ideas. In fact, we need to do a second edition since there are now many new results—but, I have to finish a (different) book on clustering of symbolic data first.

Another might be a time series paper with Yuqing Dai (2003) not because of its content—it is "just a paper"—but because of what it did for me, in the late 90s I think it was. A referee had asked for a second example, fair enough. For complicated reasons unrelated to anything, my former student-coauthor was no longer in a position to take care of this. There were "samples" so-to-speak of his algorithms in his dissertation's Appendix. However, it was replete with macros and proc IML's about which I knew very little, and so was unreadable to me.

**Mukhopadhyay:** How did you approach this?

**Billard:** I had to sit down and learn how to do the not-easy-by-any-means computer programming, from scratch. That put me into a different path. Soon after, our faculty person who had taught computational statistics retired. It was a hoot really, as I was actually the person who knew more about this than anyone else in the department even though I was academically the oldest. So, I taught the class, and of course learnt even more programming. Needless to say, this has been a real asset today.

**Mukhopadhyay:** Any other papers?

**Billard:** The papers with another student Jennifer Le-Rademacher (2011, 2012) are also important because they are expected to change foundational directions in symbolic data. And, of course, the political science census paper (Billard, 2000) because of its impor-

tance to the Census 2000 and its use in political science classrooms.

## MENTEE-MENTOR: RELATED MATTERS

**Mukhopadhyay:** When you were moving up, who stood out as your role models? Who were watching your back?

**Billard:** In my career, I was happy being myself. I admired Jerzy Neyman, Betty Scott, David Cox, Jim Douglas, Niels Kielding, Steffan Lauritzen, Ingram Olkin, David Kendall, Henry Daniels and others. I came to know many of them, but I was always content within myself and tried to improve myself in steps.

I never tried to emulate. I enjoyed reading books of people who achieved and admired them. I love to see people succeed. It never occurred to me to do as well as another person. At heart, I am not a competitor—much to my mother's chagrin.

What was, still is, important to me was to do ***my*** best, to do as well as ***I*** could myself. We cannot all be good at everything. But there is a something that each of us can do—another lesson from my mother! I cannot sing, so I do not try. I do enjoy listening to those who can. I watch and wonder how it is that they can produce this beautiful sound, it is way beyond my comprehension.

**Mukhopadhyay:** Any special acquaintances you remain particularly grateful to?

**Billard:** My mathematics teacher John Phillips at school of course. I fondly remember Jim Douglas from the UNSW who as Head of the Department of Statistics led me to embark upon a statistics career with the prestigious cadetship awarded to me in the 1960s. It gave me the biggest break in my professional life. Everything else moved on from there, obviously with much help from other mentors many of whom I have mentioned earlier: David Cox, Norman Severo and Ralph Bradley were especially helpful.

**Mukhopadhyay:** You have previously talked at length about Ralph Bradley. Would you mention some of your other colleagues from the University of Georgia, Athens, especially those who arrived during your Headship there?

**Billard:** Bill McCormick was there when I came. T. N. Sriram is still there. Both are going strong. There are others who are still doing well, but are now at different institutions. Others, for example, Basawa, retired from Georgia. Some of the Computer Science faculty members that I hired are still there, including its current Head.

**Mukhopadhyay:** What is your advice to younger colleagues? How do you mentor them?

**Billard:** The advice I give young people, perhaps beyond the level of an assistant professor, is very basic: Go to business meetings (e.g., at JSM or ENAR) even though very few people attend these. Be willing to help out if someone is looking for people to help. It will be important to do a good job and then one will be asked to do something else.

It is often rewarding and personally I have done these both professionally and non-professionally. My father did a lot of that. He served on the Australian version of the American school boards and PTA, and helped in building sporting facilities and so on. So, "service" has been in my blood. Usually, I myself did not seek out any particular position, but once appointed, I wanted to do the best I could. One opportunity would lead to another.

**Mukhopadhyay:** Your point is that one cannot just sit in a quiet corner and hope that someone else will come to recruit.

**Billard:** You are right. You may volunteer at an opportune time when an established colleague is looking to fill some positions in a committee. You may begin locally by serving in a local chapter of a national or international scholarly organization. You may become the eyes and ears of local statistical activities and evolving initiatives for the *IMS Bulletin* or the *Amstat News* or the *Biometric Bulletin*.

**Mukhopadhyay:** How can we hope to make newcomers more interested to stay within a profession involving statistical science?

**Billard:** The profession of statistics opens up a great career for someone who loves mathematics. But, one of the problems is that people are not doing enough thorough mathematics in high school. The basic "thinking" has to come back into classrooms and students and teachers alike should cultivate a culture of serious "thinking" first. How one solves a problem has to be valued significantly more than a bottom-line solution. I believe that the present trend has to change through teaching differently.

Once students learn how to really appreciate mathematics in high schools, many will move into the field of statistics. A statistician may work in collaboration with colleagues from agriculture, actuarial science, astronomy, biology, bio-surveillance, communication science, engineering, environmental science, financial markets, genetics, health, insurance, medicine, neural network, pharmaceuticals, psychology—you name it. I challenge everyone out there to name a single profession other than statistics that prepares one to do all these things as needed.

**Mukhopadhyay:** How do you "sell" statistical ideas to your students or clients?

**Billard:** In the end of the last lecture of a service methods course, I tell my students how much I have enjoyed teaching the class and that one day they are going to go out there to fulfill their roles as social scientists, geneticists, food scientists, or whatever. All I could do was to explain a few of the sound principles, but they must keep up to date with their own discipline.

A client may not be able to keep up with everything that has been going on in statistics, but at least now they have learned that there are available statistical methods that can help. They should remember to consult with qualified statisticians in the course of their own substantive area research. That was all that I could accomplish. Quite often, past students from service courses will return for some help in their own research. I have found that statistical research in another field is never routine.

**Mukhopadhyay:** How can we bring more women, more minorities, into our departments? Surely, you have tackled that issue.

**Billard:** Yes, I have tried, and it is still a problem. One of the things I was involved in, and it was not my idea, came about when I was approached in 1987 about submitting a proposal to NSF. The NSF had noticed that women were not getting grants, not applying for grants, and there were not many women in our field. It was even suggested what a proposal should address and propose. Nancy Flournoy and Mary Ellen Bock, and Judy Sunley, all program officers at NSF at the time, were important to the enterprise.

I changed two things in particular: The proposed workshop title was changed to "Pathways to the Future" which turned out to be a fortuitous title. But the major thing suggested was that I deliver an opening presentation on what should, should not, be done to achieve academic success. Instead of doing it myself, I asked Betty Scott to deliver the opening address. Furthermore, she had data! This turned out to be the key. That was her last professional address as unfortunately she died a few months later.

The first Pathways was held in conjunction with the IMS meeting in Colorado held in 1988. In subsequent years, I did give that opening talk; but over the course of the Pathways weekend, we covered a lot of issues and basically put out the data. Most people (including women) did not think that there was a problem, but once they saw real data, true realization started to set in. The last one of these was held at the JSM in Toronto, 2004. At some point, the ONR co-supported this "Pathways" project.

FIG. 9. *Lynne Billard presenting Kathryn Chaloner with* 2014 *Elizabeth Scott Award. Kathryn Chaloner attended the first Pathways workshop held in* 1988, *the year Elizabeth Scott gave the Opening Address. Photo*: *Courtesy of ASA.*

**Mukhopadhyay:** Would you say that the "Pathways" project had some measure of success?

**Billard:** It turned out to be a great success. We had each young woman participant talk a little about themselves and had sessions on how to apply for grants and types of grants, how to write papers, how to read reviews, not to get too involved in service (while still an assistant professor, but insist on being included after that), and never forget research.

The last thing I said was "You are going to go out there and there may be 3000+ attendees, very few females, but when you see a woman, go up and talk to her". In the first two or three years, nearly all the women who would show up at the JSM had been to a "Pathways" workshop, which was exciting to see. The NSF was correct. This push was clearly needed. Later, other agencies funded similar workshops in other areas of sciences including mathematical sciences. Things have changed for the good.

**Mukhopadhyay:** In a classroom filled largely with men, a handful of female students may actually feel intimidated at times whether the teacher is a man or a woman.

**Billard:** Yes, women feel intimidated by the presence of a large number of men in a class, and often women drop out. Women are promoted at a slower rate than are their men counterparts. By and large, women

are getting hired as assistant professors at pretty much the rate they are earning Ph.D. degrees, but they are not being promoted and tenured at the same rate as men. Also, the salary gap is getting larger. This is what the data are saying despite our (mis)perceptions that there are no longer any problems overall.

**Mukhopadhyay:** Why do you think that this continues to happen?

**Billard:** I have looked at a number of studies. When a woman, or a man is hired for a beginning level position, s/he is hired off potential. Also, to a large extent, universities have to hire some women even though they will never admit it. So, a woman is still hired off potential depending upon who her major professor was or which university she had attended. But, as time passes, salary raises, promotion and tenure decisions, acceptance/rejection of applications for grants tend to be decided subjectively. There are studies showing that if a paper is perceived to be written by a male, it has a higher acceptance rate than if it was perceived to be written by a female. Some women in power perpetuate some biases. We want to believe that there is no bias, but it is there in different shapes, forms and colors.

**Mukhopadhyay:** In the short term, what can colleges or universities do to attract and keep more women in our student body as well as faculty?

**Billard:** Well, the most important thing is for women to be evaluated as fairly as for men. But that is a long-term project.

In the short term, most universities and colleges do not provide daycare. They should. It is a factor. If you look at data, among those women who do succeed in the sciences, 80% are married to other scientists. What this means is that those women scientists are included into networking through their husbands, and that is critical. Also, the few women who reach the top have largely sacrificed marriage and/or children. The higher administration in a college or university should genuinely take into account and address important family issues that may directly or indirectly discourage women to enter and stay on.

**Mukhopadhyay:** When I take a look at the list of colleagues delivering prestigious and named lectures, the keynote or plenary lectures, I rarely see a woman's name. In our profession, there are many distinguished colleagues who happen to be women. Why are they not given the same fair exposure as a man frequently does? Some reasons may be obvious: Women may not be nominated at all. Most conferences are run by men. Most international program committees are dominated by men. When I have pushed very hard, sometimes I have been successful to include a woman's name as a major speaker. But, often a woman's name may be added as a token in the end of a long list that is already full of men. Changes come very slowly in favor of women, if there is any change at all. This goes back to the same issue, but the same old ongoing trend pains me. What is your take on this?

**Billard:** You are observing something that is clearly real. In our profession, looking the other way where women are concerned has unfortunately become a big part of our culture. Many people behaving in a certain way unfortunately make such behavior justifiable or more acceptable in our society. We have a very long way to go to see the equality of men and women colleagues at all levels. Thanks for all the push in the right direction.

**Mukhopadhyay:** On a different matter, what do you think about the issue of certification of statisticians? Must a statistician go through the ASA's certification process?

**Billard:** Professional engineers, accountants and so on, need certification as a license to work. Our license, I believe, is our training. We do not need certification generally across the board though some sectors might.

**Mukhopadhyay:** You groomed many Ph.D. advisees under your wings. Please feel free to mention some of them and their theses work in broad terms?

**Billard:** Let me mention a few names here such as Roger Longbotham, Fouad Mohamed, Raja Srinivasan, Won Kyung Kim, Sung Duck Lee, Jiin-Huarng Guo, Yuqing Dai, Ye Wang and Yaser Samadi. All worked on different aspects of time series models.

Many have worked in types of epidemic modeling, for example, Susan Conlon, Pepi Lacayo, Zhen Zhao, Gigi Williams, Anjali Srivastava, Li Jen Lee and Hejiao Hu.

More recently, Jennifer Le-Rademacher, Jaejik Kim, Wei Xu, Charlie Chen and Fei Liu, have worked on a variety of problems in symbolic data analyses.

Earlier, there was important work done by Nasser Arghami in sequential analysis as were the empirical Bayes results of Reza Meshkani. Vani Sundaraiyer and Joni Ancona focused on estimation issues.

I am proud of all of them. Some became Deans, one even became the equivalent of our Vice-President of Research. Some have retired, some died. Some were chronologically older than I was at the time, though they did not know it!

## SERVICE TO PROFESSION

**Mukhopadhyay:** Your record of service to the profession is both outstanding and long. Let me begin with

FIG. 10. *Lynne Billard's family gathered during her ASA Presidential Address at the JSM* 1996. *From left to right*: *Ron*, *Sally*, *Linda*, *Lynne*, *LoisAnn and parents Chris and Col*.

your election to the President of the American Statistical Association (1996). How did it come about?

**Billard:** Well, it was a wonderful opportunity. It was very interesting because when I was asked to run in November 1993—it was Thanksgiving break—I had been out of town and came back to find a phone message regarding a "nomination". The last thing on my mind was to become the president of the American Statistical Association (ASA). What had been happening up to then, I wore a number of different hats and knew a lot of people, and would often receive calls to recommend some names for one position or another.

So, I initially assumed it was another inquiry like that. My first reaction was to wait till the following week—after Thanksgiving—to return the call, but I had a five hour drive and decided to call to see what type of nominations they wanted so I could be thinking of possible people to suggest en route. I kept thinking of potential names for a future president. I clearly did not understand but eventually I realized that they wanted me to be on the ballot, and it became so different than what I was thinking.

FIG. 11. *Lynne Billard and her parents*, *Chris and Col*, *at Lynne's ASA Presidential Address at the JSM* 1996.

**Mukhopadhyay:** What came next when you realized what was happening?

**Billard:** I had already been elected to serve as the President of the International Biometric Society (IBS) in 1994 and 1995, so I said that I would have to think about running for the president's office of the ASA. After Thanksgiving, I called back and told them I did not think I could do this since, if I were elected, I did not want to compromise one position because of another.

They said the nomination committee had already discussed that matter and did not think it would be a problem. I said if you do not think it is a problem, then sure, you may put me on the ballot. Consequently, I was elected President, ASA, to serve in the year 1996. I had a very busy four consecutive years.

**Mukhopadhyay:** What was in store for you as the IBS President?

**Billard:** I am the sort of person who does not accept a position and say I am going to do $x$, $y$ and $z$. I would never campaign. Instead, I like to talk with people and find out what has been done and what other organizations have been doing, and then find out what we needed to do to move forward.


FIG. 12. *Lynne Billard and Niels Keiding, two tireless contributors to both IBS and ISI.*

As an example, the IBS office had one part-time secretary, but I was aware that something more was needed including a reorganization of its administrative structure. I set up a committee to look into the possibilities for a professional business office management. Their recommendations then went through the Executive Committee and then the Council. The decision was made to take this route.

**Mukhopadhyay:** What did it mean in reality?

**Billard:** This meant we needed another committee to select a management company to do this for us. The most difficult aspect, in an emotional sense, was telling the part-time secretary of the pending changes. Therefore, just prior to the selection process work, the IBS Treasurer Steve George and I flew to Washington to tell her personally about the pending plans. Even though the then-current labor laws did not require any notice at all, nevertheless giving her our best estimate that the new management arrangements would be in place in 3–4 months after which her services would no longer be required, was never going to be easy. In the end she had 13 months' notice.

Potential management firms were identified, interviewed, selections made and contracts signed. With the new management in place a year or so later, the administration of the IBS was totally reorganized. Within the first year, the changes were substantial—and although this set-up costs more than the part-time secretary, we got our money back within six months, primarily through better arrangements for the journal.

**Mukhopadhyay:** Such a huge change must have had other positive impacts on the IBS.

**Billard:** Yes, of course. This outside professional management set-up helped us to become more professional, to establish legally acceptable frames for much of what we do/did. We had to establish succession procedures (e.g., if someone could not continue for the duration of their term of office), develop a logo, plus lots of other crucial matters. Also, I visited many of the regions and participated in their regional conferences. The members seemed to like that connection with the IBS through the presence of its sitting President. This made them feel more a part of the larger society.

**Mukhopadhyay:** In contrast, what did you face as the President-Elect for the ASA?

**Billard:** For ASA, it was a time of turmoil. During my time, there were 3 different executive directors. One just finished (Barbara Bailar, January 1995), one was interim (Dan Horvitz, March–November 1995), and a new permanent one (Ray Waller, November 1995) to be brought in. There was a period of six weeks or so in January–February 1995 when ASA had nobody in the executive director's position. Mitch Gail was the President and I was the President-Elect. I flew in once a week—Mitch drove! We visited the ASA office to deal with numerous administrative issues. We were simply trying to hold everything together. Times were not easy, but the ASA staff members were terrific at keeping the association running.

**Mukhopadhyay:** What were some of the issues then in the ASA that needed your immediate attention?

**Billard:** A long-range planning committee was set up, and one of the big things we did was to look at issues surrounding the ASA journal publications. Most of ASA's income came from its journals and in particular from library subscriptions. I knew that the economy was not great and realized that the very initial stages of electronic journals were looming on the horizon. The academics were suggesting the journals be put up there for free, but it would still incur some cost. Through the Internet, we may share knowledge quickly, but at the time the cost for putting together print and electronic journals was about the same. I knew that doing away with print was coming. It was my sense. I was glad, however, that I did not have to deal with it directly, just prepare the ASA for the inevitable!

**Mukhopadhyay:** What were some of the priorities set for the ASA then to generate revenues?

**Billard:** I seriously started looking to find alternative ways to generate new income. The ASA had conferences and short courses on its plate, but it used to run only a small number of them. Through the recommendations made by the long-term planning committee, we began looking at conferences and short courses and their frequencies as well as duration, charges, registration fees and other alternative sources to generate income. Everything was on the table. This process

took a year or two, but this set in motion the seed for having short courses run all week long and charging participants market prices, among other things, for the ASA to generate income. The ASA's tax-exempt status played a key role.

**Mukhopadhyay:** I recall that many issues came to the forefront in Washington regarding how both the census and Census Bureau were run. Surely, as ASA's president, you were pulled in that direction. Am I right?

**Billard:** Indeed, yes! I set up a blue-ribbon panel to deal with the census matters, with Janet Norwood as panel Chair. Both the Republicans and Democrats were concerned about different aspects of the operation. By mid-1990s, the Republicans were basically worried that if we did sampling, they would lose seats when redistricting was done, and so they did not want sampling in the census. They were carrying on about how many statisticians do not believe in sampling because one may come up with biased estimates. The blue-ribbon panel put out a report that endorsed sampling. The Research Council of the National Academy of Sciences had a couple of panels that also endorsed sampling. President Bill Clinton and the Congress were sent an official letter from some of the past ASA presidents regarding this matter. I do not remember all the exact details now.

**Mukhopadhyay:** I recall that this letter had to be drafted in a rush. Do you remember?

**Billard:** Yes, it was Friday afternoon in early June 1997, I believe. Idaho had suffered from huge flooding, earlier in March I think it was. Congress was about to pass a flood relief bill, but in a rider they said that there would be no sampling or statistical procedure of any description in the census. I received a phone call, drafted a letter quickly, and picked up the phone to talk with Jon Kettenring, then-President of ASA. I told Jon that we have to send a letter. The Hill would not care whether the letter came from Billard or Kettenring, but they would care—or, should care—if the letter came from the President of the ASA. Before he had a chance to say anything, I said I would co-sign it and contact the other past presidents and perhaps they would like to cosign as well.

**Mukhopadhyay:** That was a huge undertaking on your part.

**Billard:** I faxed a copy of the letter to all past presidents of the ASA and every single one of them wanted to sign. Well, all the nongovernment ones signed, the past presidents still working for the government were barred from such actions. However, they were all included in the FAX so as to keep everyone in the loop. Monday afternoon I am up in the ASA office in Virginia, when at 4:30 pm, I received a phone call from Janet Norwood asking how we were planning to proceed with this letter. When I told her we were "stuffing letters" so to speak to mail out the next day, she replied "That'll be too late". Fortunately, an ASA staffer had come out of journalism and knew of some wire service. Subsequently, that same night by 8 pm, we wired the letter to President Bill Clinton, Vice-President Al Gore, the Congress, the House and Senate, so that everyone had a copy on his/her desk before their meetings next morning. The final Bill was passed the next day and signed into law **without the rider**. Janet Norwood thought that it was a very cleverly prepared letter. A copy appeared in *Amstat News* (July, 1997).

**Mukhopadhyay:** That was indeed a great political victory for statistical science. By the way, you have testified in the Congress a number of times. Would you like to share one such experience?

**Billard:** The Horn bill actually came up when I was the ASA President and I testified in the Congress. That was an interesting new experience for me.

Later, in July 1998, I plus a demographer and a geographer were asked to address the National Press Club in Washington on the census. At the time, the political controversies still revolved around the sampling issue. Congress heard about this, did not want to come to the Press Club, and asked us to meet with them on the Hill in the afternoon.

The plan was for each of us to speak for about ten minutes and then open it up for Q&A. In the end, the whole experience became quite comical but very exhilarating and interesting, especially on the Hill. Up there usually staffers come and go, but this afternoon, they kept coming but never leaving! We constantly ran out of handouts, someone running outside to make yet another set of 30+ copies. Both in the morning and in the

FIG. 13. *Lynne Billard testifying on the Horn Bill in the Congress, March* 1996. *Seated on her right was John Knapp representing the Council of Professional Associations for Federal Statistics.*

afternoon, the sessions had to be stopped (after 3+/− hours) because we had to go ourselves.

The questions were almost exclusively on sampling issues. My handout became the *STATS* article (Billard, 1999). We must have been successful as after that the Congress, the House and Senate, were no longer going around saying that sampling was no good. They shifted their arguments to constitutional issues.

A year or two earlier, the Secretary of Commerce (William M. Daley) had set up an Advisory Board to the Census, and in 1998 I was appointed a member of that committee. It turned out to be one of the most interesting things that I ever did. A paper (Billard, 2000) in a political science journal tries to look at the issues in a fairly balanced manner. The Editor of the journal said this paper would be used in political science 101 classes. Many universities actually did so and it was more widely read than any of my other statistical papers (Laughs).

## BOOK WRITING

**Mukhopadhyay:** You have (co-)edited and (co-)authored eight books. Do you want to mention some of them?

**Billard:** Probably, my most important book (2006) is on symbolic data analysis co-authored with Edwin Diday. It began as a research monograph, but we finally finished it as a pedagogical textbook.

**Mukhopadhyay:** Was it hard for you to write this book?

**Billard:** Symbolic data analysis was new. I have taught out of it to my graduate students. It was an interesting exercise. It took me longer than usual to finish the book because I had to get on top of the subject. Also, the material is very computational and highly algorithmic. For every single example in the book, I had to write a computer program to tackle it. I learned a lot by doing this.

**Mukhopadhyay:** When writing a book, in general, do you write papers on the topic first, then combine them and transform it into a book or is it the other way?

**Billard:** A bit of both. That also depends on the book's topic as well as its level.

## MEMORABLE CONFERENCES, TRIPS AND LECTURES

**Mukhopadhyay:** Lynne, you have been a world traveler. Please share with me some of your memorable experiences.

**Billard:** Let me see. The 1967 IBC and ISI in Sydney, when I was still a student, are memorable for what they did, through David Cox and Norman Severo, in launching my career. Never dreaming that one day I would be traveling the world, I went to all the talks so as to see and hear all those famous names I had only read about. It was absorbing and fascinating. Someone even sought me out to introduce me to Gertrude Cox, saying as the only women there we had to meet each other. Needless to say, Gertrude was Gertrude and so chatted with me some; what a thrill!

It is true that from then onwards I attended almost all the ISI sessions over the years, because they were in interesting locales. Remember I was an Australian living in a remote part of the world and travel in those days was expensive and difficult—nothing like today. A lovely side-benefit is that I met lots of very interesting people from so many nations.

**Mukhopadhyay:** Do you recall what was so special about the IBS Austrian Regional meeting?

**Billard:** Another meeting was the IBS Austrian Regional meeting (in 1994)—important because it led to the world of symbolic data. Actually, I remember this for two reasons. One is that the day before, I went to the Vienna Opera to hear a performance of Beethoven's Fidelio, a performance I would not have heard except that it was Beethoven and I really like Beethoven in all his manifestations. That particular performance was out-of-this-world, even the local audience would not let up. I spent years trying to buy a copy of that particular performance but the opera shop had long sold out.

Anyhow, I eventually arrived at the Regional meeting, a bit late because of Beethoven. There seemed to be only two other women present, Rutgers' Regina Liu talking about data density and Anuska Ferligoj from the University of Ljubljana. It so happens that Anuska had been organizing international conferences in Slovenia for many years, and she wanted me to accept an invitation to speak. Meantime, having learned how difficult it was for women to be recognized fully, I finally accepted her invitation during my ASA Presidency year. This conference was held over a week in a remote forest. Anuska insisted on her (three) international invited speakers sitting together over meals. One of those speakers was Edwin Diday, from France; Edwin talked about symbolic data all week. Two years later, Edwin invited me to France to work on a problem he had in time series and symbolic data. Although I had gone to Slovenia thinking I was helping out Anuska, in the end, it was I who benefitted enormously!

**Mukhopadhyay:** Any highly visible Keynote or Plenary lecture?

**Billard:** You ask about Keynote/Plenary lectures. Well first, the data show women are rarely selected for these: Well let me be more precise—It is the named distinguished lectures that tend not to go to women. However, I have certainly given a lot of invited, some Keynote, presentations on symbolic data in the last ten years or so around the world. Perhaps, one of the first was at the 2004 International Federation of Classification Societies (IFCS) conference in Chicago. David Banks was Program Chair and thought symbolic data was an important new area. Since I have always strongly felt Program Committee members should not themselves be on the invited program, I was very much averse to giving a Plenary lecture myself. Besides I was scheduled to be at the IBC meeting in Cairns that same week. Anyhow, not to be deterred, David kept twisting my arm, and twisting it some more, until I eventually acceded.

This meant I attended the first part of IBC (Sunday–Wednesday), hopped on a plane Thursday (luckily I had two Thursdays), and delivered my talk during the second half of the IFCS conference (Thursday–Saturday). I think it was worth the effort!

**Mukhopadhyay:** Your ASA Presidential Address in Chicago was certainly inspiring (1996).

**Billard:** I suppose I cannot overlook that; memorable to me because my parents came from Australia, and some of my Australian and American family were there to share the occasion. This was also, I believe the first time power-point was used at an ASA talk; hard to believe today but it took 3+ months to prepare. How times have changed!

**Mukhopadhyay:** Do you want to share anything else on this topic?

**Billard:** I should mention "Girls Do the Maths" workshop held in May 2016 at UNSW. This has to be one of the most interesting and enjoyable days I have had. This was an all-day workshop for high school female mathematics students and their mathematics teachers (some of whom were men). I was asked to talk about a career in mathematics with details of my own. During long tea and lunch breaks, the participants would swamp me asking all sorts of questions. It was just incredibly uplifting to see all those girls so keenly interested in mathematics. The place throbbed! The initial expectation was to attract under 40 registrants; the room was twice changed to accommodate over 200. Following them uphill to the third location was quite amazing and exciting.

## HONORS, AWARDS, FAMILY AND BEYOND

**Mukhopadhyay:** You have received many prestigious awards and honors in your career. Do you wish to talk about one or two that you feel most proud of?

**Billard:** I was surprised by all of them. Probably the one to be most valued because to me it is the most prestigious is the S. S. Wilks award (1999) because that is

FIG. 14. *The Joint Statistical Meetings* 1999. *From left to right*: *Jonas Ellenberg* (*ASA President*), *Lynne Billard* (*Wilks Awardee*), *and Sally Morton* (*Wilks Selection Committee Chair*).

an award for a research career. Many do not know that I received that award. Talk about invisible women! I was very pleased and thrilled by it.

Also, I think the University Professorship from my university (1992) as its top recognition would rank high on the list. This is the most prestigious professorship awarded for services beyond research, for one's impact beyond normal scholarship, on the University of Georgia, Athens. Those are probably the two most important ones.

**Mukhopadhyay:** Would you like to share anything about your family? Where are they? What are they doing?

**Billard:** Well, I was the eldest of six children. You know a bit about me. The next child, Geoff, now long retired, was an accountant for mining companies. The third child, Brian, also now retired, started out as a mathematical biologist but soon moved into computer science for an Australian defense agency. The third brother, Ron, became a very prominent architect in Melbourne. And, my youngest sister, Sandra, teaches business psychology in a small school in Ballarat, Victoria.

There was another sister, Irene, the architect's twin, who died when she was ten after a 6 and 1/2 year illness. My mother kept her at home whenever she could—she required constant attention, and I of course helped. In a very real way, helping in her care (I was 10 when she became ill, and 17 when she died) defines a lot of who and what I am. However, it was my mother who was brilliant!

**Mukhopadhyay:** Anything beyond statistics?

**Billard:** My faith is very important to me. One aspect that defines me is that I am a mission-oriented person. I have taken many mission-teams to Haiti and Brazil to build schools. Actually, right now (2011) I am

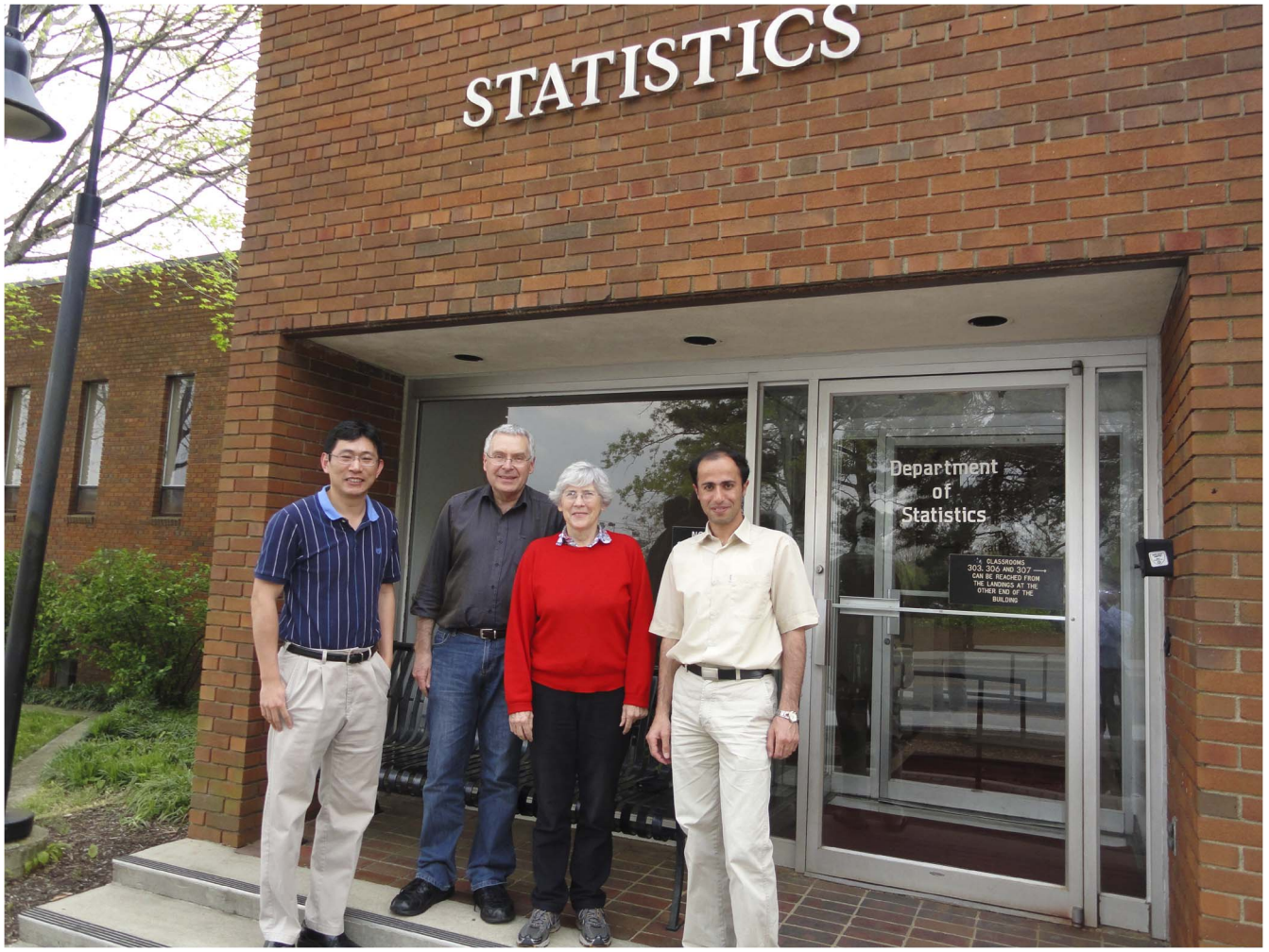


FIG. 15. *Yehua Li, Peter Hall, Lynne Billard, and Yaser Samadi at Georgia*, 2011.

in the middle of organizing a group of Americans as a medical team to go on a medical boat on the Amazon River in Brazil. We will keep going up the Amazon, stopping at villages to help. I've also been on medical teams to Guatemala. Mostly though, it is mainly building, and working with local people. In a way, you are absorbing something that improves your own life.

**Mukhopadhyay:** Would you want to go back to playing some high-level squash games on a regular basis? You do have that in your blood.

**Billard:** Oh, yes. There are a couple of guys with whom I played every week. I had to stop when I became busy with the care of my mother. However, she has now died. So, I am running to try to get back into shape to start playing again. Running, for me, is as boring-as-all-get-out. But I am highly motivated, as squash is such a great game. Well, the running only helps the endurance part, the quickness part is only recovered from playing.

**Mukhopadhyay:** Is the rumor that you were national champion true?

**Billard:** No, I was never the US champion, though I was player-coach for the 1977 US team that toured England and Wales. And, I was twice the finalist for the North American Open championships (losing to someone on the Australian team both years). However, nice as those "trophies" might be, for me the most rewarding aspect was being able to open up the game to women more than it was; there are many interesting stories there—for another time and place.

**Mukhopadhyay:** You have accomplished so much already. You are a role model for many of us. What does the future hold for Lynne Billard?

**Billard:** I do not want to retire and I am glad that I do not have to. I still have tons of ideas to develop and work with students. My biggest dilemma is whether to stay in the US or go back to Australia someday. Through the '90s, Peter Hall invited me to spend about six weeks each year at the Australian National University (and later in Melbourne) to help me unravel that dilemma. For now, I am settled here and I think the opportunities here are much better. There is a lot of research that I want to complete.

**Mukhopadhyay:** Anything else that we may have missed to touch upon in this conversation?

**Billard:** You are certainly thorough and probing with your comprehensive range of subjects and questions.

**Mukhopadhyay:** I have learned a lot from your life's work and life in general. You have been most kind to open your heart and soul, and I remain grateful to you for the same. I wish you a great continued journey. Lynne, thank you so much for having this conversation with me.

FIG. 16. *A* 2015 *portrait of Lynne Billard.*

## ACKNOWLEDGEMENTS

All photos accompanying this conversation piece came from Professor Lynne Billard's personal collection. We thank Professor Peter Green, the Editor, and other readers for sharing their enthusiasm with us.

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