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A Conversation with Dennis Cook

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Abstract. Dennis Cook is a Full Professor, School of Statistics, at the University of Minnesota. He received his BS degree in Mathematics from Northern Montana College, and MS and PhD degrees in Statistics from Kansas State University. He has served as Chair of the Department of Applied Statistics, Director of the Statistical Center and Director of the School of Statistics, all at the University of Minnesota.

His research areas include dimension reduction, linear and nonlinear regression, experimental design, statistical diagnostics, statistical graphics and population genetics. He has authored over 200 research articles and is author or co-author of two textbooks— An Introduction to Regression Graphics and Applied Regression Including Computing and Graphics—and three research monographs, Influence and Residuals in Regression, Regression Graphics: Ideas for Studying Regressions through Graphics and An Introduction to Envelopes: Dimension Reduction for Efficient Estimation in Multivariate Statistics.

He has served as Associate Editor of the *Journal of the American Statistical Association, The Journal of Quality Technology, Biometrika, Journal of the Royal Statistical Society* and *Statistica Sinica*. He is a four-time recipient of the Jack Youden Prize for Best Expository Paper in *Technometrics* as well as the Frank Wilcoxon Award for Best Technical Paper. He received the 2005 COPSS Fisher Lecture and Award, and he is a Fellow of the American Statistical Association and the Institute of Mathematical Statistics. The following conversation took place on March 22, 2019, following the banquet at the conference, "Cook's Distance and Beyond: A Conference Celebrating the Contributions of R. Dennis Cook." The interviewers were, Efstathia Bura (Effie), Bing Li, Lexin Li, Christopher Nachtsheim (Chris), Daniel Pena, Claude Messan Setodji and Robert Weiss (Rob).

Key words and phrases: Bayesian methods, central subspace, Cook's distance, envelope methods, influence, neural networks, optimal experimental design, regression diagnostics, sufficient dimension reduction.

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1. BACKGROUND

Chris: I seem to recall that you were the "Fonz" of Havre Montana, that you rode a motorcycle, you wore a leather jacket and you tore down car engines and rebuilt them.

Jami's parents were not crazy about the idea of their daughter going out with you. Care to comment?

Dennis: It's true. I did rebuild car engines, ride a motorcycle and have a leather jacket. I also built hydroplanes. I built three of them. The first one actually scared me so much that I couldn't ride in it. I sold that one, and built another one. The third one I built was after getting married. It had to be a two-seater so Jami could come along. I was predisposed to anything that would go fast. The second part of your question is, I think, an understatement.

Effie: If memory serves well, you got your start in statistics as a high school student, figuring out how to analyze experiments or exercises at an agricultural experimental station. Could you fill in the blanks? And did this impact your early interest in design? How did your life and upbringing in rural Montana influence your choice of study and career path.

Dennis: Between my sophomore and junior years in high school, I needed a summer job to pay for all the things that I wanted to do, like work on car engines and build hydroplanes. We lived out in the country and about two miles from our house was an agricultural experiment station where I obtained a job. I spent the first half of my first summer clearing rocks out of a field. About midway through the summer, the head of the agronomy department asked if I would rather work for them. My response was "Do I have to pick rocks?" He said no and I said yes. That started my involvement with experimental design and other experimental constructs.

Chris: Anything particular about your life in Montana beyond the agricultural experiment station that might have influenced where you went? I mean your choice of statistics.

Dennis: No. But I can fill in more about my choice of statistics later.

Rob: Tell us about your high school and undergraduate training in mathematics. Did you have mathematical leanings in high school, or mathematically related hobbies?

Dennis: In high school, I was interested in anything having to do with the physical sciences. I hated anything to do with the social sciences. I didn't have any particular fondness for mathematics, likely because my math teacher was very stern. For example, he would send students to the blackboard and give them a problem to work. If he didn't think you were doing adequately, he'd fling an eraser at you, hard. We always knew who was having trouble because they would leave class with chalk dust on them. At one point, he announced to the class that I was going to end up in reform school. Context here is important. My high school town had the highest per capita representation in the state reform school. So it was a fairly rough place.

Clipping crew at Assiniboine Agricultural Experiment Station in 1961. *This is where Dennis, center seated row, was first exposed to Statistics.*

I liked the physical sciences and actually entered two science fair competitions. For the first, I built a repulsion coil because I enjoyed shooting aluminum rings across the room. My second project was a much more involved cloud chamber. From the 1930s to the 1950s, a cloud chamber was the main tool used in physics to characterize particles. I think the muon was first identified that way. I built my chamber for the first time at the regional competition and it worked like a dream. After winning the regional competition, my science teacher encouraged me to enter the state competition. Again, it worked like a dream until someone came by and took a flash picture. The flash from the bulb ruined the whole thing. Instantly, there were millions of particles passing through the chamber and the atmosphere collapsed.

Dennis' first winning science fair experiment, circa 1959.

Rob: How did you pick your undergraduate college?

Dennis: I went to Northern Montana College, which was the only local college and the only one I could afford. It offered four basic programs, liberal arts, teaching, nursing and modern farming methods. I graduated with a degree in math education.

Rob: How much math was there?

Dennis: My choice of mathematics as a major was really based on convenience. Between high school and college, I joined the military where I developed a dislike for queues. College registration took place in a large gymnasium. When I registered, there were long lines at the tables for all majors, except mathematics, where there was no line. Consequently, I became a math major.

Rob: So did they give you teaching skills that helped you when you got around to actually being a teacher?

Dennis: The education was okay until I did my student teaching at the local high school. I was really high on teaching mathematics and at one point I spoke to my class for perhaps 45 minutes trying to get them excited about a particular topic in junior algebra. After the lecture, my supervisor took me aside and read me the riot act because he said I shouldn't talk to the students for more than about 10 minutes. I decided he was right and I never ever did that again. And I never taught in high school again, either. That was when I made my decision to go to graduate school.

2. GRADUATE SCHOOL AND BEYOND

Chris: Your early work was in the area of population genetics. How did that happen, can you tell us what interested you in that area?

Dennis: I was always interested in biology. In my undergraduate work, I majored in math with a minor in biology, which I really enjoyed. During our botany class, Jami and I drove to Glacier Park and spent two or three days wandering around picking plants and classifying them for a class project.

I'm going to back up a minute here, and describe how I picked my graduate school. We didn't have any extra money at the time, which dictated my criteria for grad schools: they couldn't require the Graduate Record Exam and they couldn't require a fee to process your application because we couldn't afford it. I still didn't know if I wanted to go into statistics or mathematics, so I applied to two schools in math and two in statistics. My decision rule was to accept the first one that offered me a fellowship. I started at Kansas State University with an NIH fellowship and then received an NDEA fellowship. I never served as a TA. Those fellowships enabled me to complete my PhD in three years from my BS.

Now, in graduate school, you asked me how I got into population genetics. During my first semester in grad school, I purchased a book from Dick Beckman because he said I would need it if I were going into genetics. I hadn't decided to pursue genetics but I purchased the book from him, anyway. It was on stochastic differential equations and their use in solving genetics problems. I became fascinated with the topic and eventually wrote my dissertation in the area. Come to find out, Dick had an extra copy of the book that he was just trying to unload it on me.

Rob: So how did your work evolve into what we consider more mainstream statistics? Was it a sharp transition, gradual and why?

Dennis: It was a sharp transition. I worked in population genetics from the time I arrived in Minnesota until after I achieved tenure. I was on the graduate faculty of the genetics department and I worked closely with Ralph Comstock, who was friends with R. A. Fisher. They used to ride horses together, as I recall. We spent considerable time studying Fisher's work in population genetics. In fact, my first real exposure to Fisher was through population genetics. I worked also with Frank Enfield and Dan Hartl. By the time I got tenure, Ralph Comstock and Frank Enfield had retired, and Dan Hartl had moved on. No one in the statistics department was actively working in genetics and I felt a little isolated, so I decided to switch to statistics. I had done almost no statistics at that point, aside from one paper in aerial survey with Frank Martin.

Rob: I think of you as having a love of travel and is that true? And where did that come from?

Dennis: I enjoy being there, I hate getting there. I like to talk with people from different countries. Every group has a different take on statistics and a different philosophy about how things should be done. Then that information goes into the background and rolls around, and eventually you hope it's going to inform what you do subsequently.

Chris: Morocco?

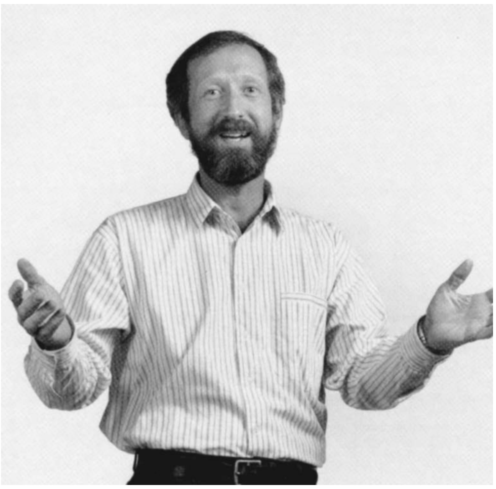
Dennis: Chris and I went to Morocco to attend the thesis defense of one of my PhD students, Abdel Ibrahimy. We were advised before leaving to drink only bottled water and to not eat anything raw, but otherwise we had a good time. USAID required that we use US carriers so we couldn't fly direct to Casablanca and instead we traveled via Paris. On the return trip, we visited the top of the Eiffel Tower. We didn't stay long because the movement of the tower really unnerved Chris. Chris, do you remember that?

Chris: I had been there 20 years earlier and I had no problem, but I got up there and I just freaked out and I had to get back down.

Dennis: After leaving the Eiffel Tower, we found a nice little restaurant and had dinner. Maybe 15–20 minutes after leaving the restaurant, I was really sick, as a local dumpster can verify. Chris started having similar symptoms after we returned to Minnesota the next day. Our symptoms followed the same progression until we were both okay. That was a bit of coordination that hadn't been planned.

Chris: I would add that Dennis' student took us from Rabat to Fez. We stayed in a hotel there and we were having dinner when the belly dancer came over and started dancing by our table. And then she invited us to dance with her. I think it was the three of us—three statisticians. Sure, we're going to get up and dance with this belly dancer, right? Just go away. Next thing I know, Dennis is up dancing with the belly dancer and doing a good job of it! (Of course, he does nauseatingly well at everything he tries, including art.) He was the only one who had the courage to get up and dance with the belly dancer.

Dennis: I was going to leave that bit off.



Classic teaching attitude, according to those who might know.

3. DESIGN OF EXPERIMENTS

Chris: (To audience). Now, you're all going to get a chance, but I have to ask a few questions about design. At this point, you may have the impression that Rob and I are asking all the questions. But when we get into diagnostics and dimension reduction, all these other panelists will take over. So let me ask a question or two about design. And my first question is as follows. Your first student, Larry Thibodeau, did a thesis on optimal design. At that point, you were focused on diagnostics and population genetics. How did that happen?

Dennis: That came about because David Harville, who at the time was at Iowa State, had written a paper on design construction where he claimed that something was not possible using optimal design. I looked at it and I thought, "That can't be right." So when Larry came to work with me, we started thinking about the problem and it wasn't very long before we had the solution and that led to a JASA paper on marginally restricted D-optimal designs.

Chris: A lot of your work has been motivated by real problems. That's particularly true in design. I recall that in about 1977, I was working on my thesis in St Paul, and you came in late one afternoon—it might have been the evening—which is very strange for you because you were always early—and you said you just returned from flying around in a small plane above Hudson's Bay, maybe above the arctic circle, counting geese. And you've also counted wild horses and designed surveys. I also recall your work with Monsanto, and you helped us when I was at General Mills. Could you talk about applications and some of your experiences? Particularly counting geese in Hudson's Bay.

Dennis: My work in aerial survey design started when Frank Martin connected me with wildlife biologists who were doing aerial surveys of moose in northern Minnesota. They were particularly concerned with undercounting because of a failure to observe all moose present during the survey. Survey areas were centered on frozen lakes where the pilot could land to drop off and pick up observers. During my time with the survey, the plane could accommodate only one observer. The others waited on the ice for their turn, huddled around a fire to keep warm. That experience led to a JASA paper in which I described a design that allows adjustment to account for visibility bias.

From there, the CEO of a Canadian company called Interdisciplinary Systems read my JASA paper and contacted me for help with a snow goose survey they were conducting around Eskimo Point, which is along the west coast of Hudson's Bay close to the Arctic Circle. According to the CEO they were having trouble with erratic counts and couldn't get a handle on the problem. I agreed to join the survey to see if I could help, although I didn't really have a plan. I accompanied the survey team the day after I arrived in Eskimo Point. The plane was a four-seater. There was an observer on the pilot's right counting geese out the right side of the plane, an observer behind the pilot, looking out the left side of the plane, and then me in the back corner wondering what I was supposed to be doing. We flew for about an hour and I noticed that the head of the observer in front of me was bobbing. Worse, the observer beside me was napping with his head was against the window. After awhile they both woke up and starting counting again. So I figured that I knew what the problem was. After returning to base, I formulated two recommendations for the project manager: Set a firm time for lights-out in the evening, and land the plane after every hour of survey time so the observers could take a break. After that the counts stabilized, so my main job was done. I stayed there for another week or two, got to know the Eskimo people a bit and had a good time. What does this story have to do with design? R. A. Fisher told us that there are three important things in design: randomization, replication and local control. And this was clearly an instance of local control.

Preparing to conduct a mark-capture experiment to estimate wild horse abundance around Reno, NV. Horses were marked by Dennis with a paint-ball gun while he was tethered to and hanging outside the helicopter.

Chris: One last question in design. As you know there's been an ongoing argument in the design of experiments about the relative merits of optimal versus classical design. George Box denigrated optimal design by referring to it as "alphabetic optimality." What are your thoughts?

Dennis: I hate it when people try to elevate their point of view by promoting dismissive or disrespectful characterizations of other views. That simple feeling has occasionally guided my research. When George Box started promoting the pejorative phrase "alphabetic optimality," I thought, "That's what I want to work on."

4. DIAGNOSTICS

Daniel: One of the greatest successes of your career was the important idea of influential observations and Cook's Distance. We have seen that even your sons know about this topic! Now 40 years after the introduction of this concept, what was the motivation that led you to this idea? And what do you think has been its impact on the evolution of the statistics and the diagnostic field?

Dennis: I still think it was a successful solution to the problem. There have been improvements; you are responsible for one of them. But the whole idea I still think was a success. It came about inadvertently when I happened to be at the right place at the right time. And it really started the field of diagnostics, I think.

Claude: I can follow up on that. Every time I teach my students, every time I tell them about Cook's Distance, they all think "Oh! This is one of the greatest things!" Was there any reason in particular that you sent it to *Technometrics*?

Dennis: At that time, *Technometrics* was the place to publish regression papers because, more than any other journal, it reached people who use regression. It has since evolved to more of a specialized journal, which I think was the original intent.

Chris: Can you tell the rat story?

Dennis: This is the story of why I developed Cook's Distance. I was working with Paul Weibel, who was an animal scientist at the University of Minnesota. Paul had conducted an experiment to confirm a theory of his, but the subsequent regression analysis actually contradicted his theory. He contacted me to check his analysis, thinking he might have made a mistake somewhere. But my analysis agreed with his, which left him quite disappointed.

I was teaching a regression class at the time and decided to use Paul's regression as an example, but I didn't want to use the whole dataset. So I selected a subset that would fit on an overhead projector slide. I did a quick reanalysis of the selected data and—to my surprise—the answers came out to be pretty much as Paul expected. My immediate reaction was I had committed a computational mistake. I ran it again: no, it was the same. I then ran the other part of the data and got what I had before, essentially. Through a process of trial and error, I discovered that one key rat in the dataset controlled the results. If I took the rat out I got what Paul was expecting, and if I left the rat in I got the original results that contradicted Paul's theory. This really concerned me because at the time I was unaware that this kind of thing could happen. Regression was visualized largely as fitting a line through a point cloud and taking one point out of that cloud wouldn't change the results materially. But here I took one point out of the cloud and everything changed. I didn't know how to look for these points or what caused them and there was nothing useful in the literature. I remember worrying about whether this phenomenon had gone unnoticed in my past consulting, and deciding that I needed methodology for my future work. That's why I did Cook's Distance. I didn't really intend to publish it at the time but my colleagues in the applied department encouraged me to do so. It was a solution at the right point in time. And it just took off. A couple of years later, I was in the audience during a session on diagnostics at the annual meetings. One of the speakers started talking about Cook's Distance. I didn't associate it with my work until he showed the formula and I thought "Hey, that's me!" I also realized first hand that once you publish something it can take on a life of its own and you lose control. No one sought my acquiescence for the name.

Daniel: Well, you have done a lot of work on graphical methods. Now, in the big data environment, with so many variables, which kind of plots do you think are going to be more useful to understand the relationship between the response and the predictors?

Dennis: I think there are lots of fundamental issues in big data that need to be resolved before we ever get to the point of asking what we should plot. There are so many aspects to big data that it's hard to talk about it, in general. So let's think about a version of big data that involves inference. One of the reasons we exist as a discipline is because we insist on giving reliable measures of uncertainty to the statements that we make. Here's a simple thought experiment. There are about 120 million registered voters in the United States. Let's suppose you wanted to infer about the population of registered voters. Let's also suppose that you can purchase one of two datasets, one resulting from a true simple random sample of, say, 2000 registered voters or the other resulting from a convenience sample of 30 million registered voters. You have no information on how the convenience sample was collected, but you do know that it gives accurate information on each registered voter in the sample. Which one are you going to pick? Just now, I don't think we have the necessary tools to give a crisp answer to that question.

Effie: Maybe it relates to, and maybe you will give the same answer. Are case diagnostics relevant in the age of big data?

Dennis: They are more relevant than they ever were. For instance, I would like a diagnostic that could estimate the effective size of a big dataset. By effective sample size I mean the size of a simple random sample that would produce estimators with the same properties. Intrinsic biases in big datasets can swap anything that we think we know by classical statistical methods. Why did almost everybody mispredict the outcome of the 2016 election?

5. DIMENSION REDUCTION AND ENVELOPES

Lexin: Dennis, what do you think of as mainstream, among the families of sufficient dimension reduction and envelope methods? And also, what are the limitations, in your opinion, that the researchers in this area should pay more attention to?

Dennis: Well, this morning I would have said that the main limitation is our inability to properly deal with inference following reduction, which is a concern that I have had for a long time. But today we heard Bing Li's talk in which he provided a road map for mitigating that concern. So thank you, Bing!

Sufficient dimension reduction methods were designed for the model development phase of an analysis and as such have little to offer in model-based analyses. That's where envelopes come in. Envelopes are descendants of sufficient dimension reduction that are designed to reduce estimative and predictive variation in model-based analyses. They are part of a natural evolution of dimension reduction ideas and methods.

Daniel: Which is, in your opinion, the most important result you have obtained in dimension reduction in regression?

Dennis: That's easy: The central subspace. In the early 1990's, I was interested in graphics and trying to understand how you could construct a low-dimensional projection of a high-dimensional plot without losing regression information. Adequate foundations were not yet developed and sufficient dimension reduction was still embryonic. I recall being frustrated because I couldn't make any progress on answering the question. I finally saw what was needed while teaching an advanced topics class. I explained the idea to the class and said we needed name for the construction. Dave Nelson, a student in the class, said "Let's call it the central subspace."

Daniel: A technique that is used a lot in machine learning is neural networks, and they are based on linear combinations of variables. Do you think that your results on dimension reduction, that look also at linear combinations of variables could be useful to understand the effect of variables in neural networks?

Dennis: I think they could be. What's happening inside of neural networks is kind of a mystery and I do think that dimension reduction can help us understand that. I don't know how to do it, but if you get all the ducks lined up, things will likely be clarified.

Left: Awarded Alumni Fellow by Kansas State University, his alma mater. Right: Dean's metal, 2005.

6. RESEARCH APPROACH AND PHILOSOPHY

Chris: We're going to switch gears and talk a little bit about your research approach and your philosophy.

Claude: I think the question I want to ask is about frequentist and Bayesian paradigms. Knowing you for so many years, I've always thought you were frequentist, until somebody said today that you actually started as a Bayesian. I can be wrong, but also, I feel like a lot of the things you've done—I haven't seen a lot of papers that you've actually published using a Bayesian paradigm. And also, I know that, in the 1970s and 1980s, at the University of Minnesota it was very big into Bayesian statistics. I know Ian Pardoe, for example, worked with you in a Bayesian paradigm, correct? So, could you give your thoughts about the Bayesian and frequentist paradigms?

Dennis: One of the things I've always liked about statistics is that almost always we have different ways of looking at a problem. Statistics would be intellectually much poorer if we didn't have both Bayesian and frequentist paradigms. The first paper I ever wrote was a Bayesian paper and I've advised three Bayesian dissertations.

In graduate school, I was quite warm toward the Bayesian paradigm. When I got to Minnesota, Seymour Geisser built a really strong Bayesian group, but they were overbearing in the promotion of their philosophy. For instance, Bayesian seminar speakers in the early years would often start by describing how stupid frequentists were. The speakers might give some clever problem and then ask the frequentists in the audience how they would proceed. After coaxing a little discussion, the speaker would then explain how the frequentists were wrong because of a twist in the story that was revealed only after the discussion. I found these sorts of presentations to be disingenuous.

I think I said before that I don't like philosophies that try to build themselves up by gratuitously demeaning others. If you can't do things fairly on an equal footing, you ought not to be saying anything at all. I think that sort of attitude turned me off. But I wasn't turned off to Bayesian statistics per se, I just didn't want to be associated with the overbearing Bayesian community.

Claude: It's good to know. I'm going to switch gears. The question I'm going to ask, I think Jami already answered my question, but I feel like every ten years you change directions and find something new. I think Jami already said you're a sponge, that you absorb everything. And I think that's the answer to my question. Why do you do that? When you actually find something new, I've always wondered if you just get bored with your current work, and say, "Nah, I gotta find something else to do." Why? How?

Dennis: I think boredom may be part of it, but I don't think it's the main thing. In research, it can actually be a hindrance to know too much about the literature, because knowing too much can put blinders on you. People tend to make the biggest impact in a field when they first enter it because then they are not hamstrung by the inertia of the past. Of course, you want to be faithful to the past and give appropriate credit, but I tend to address the literature after I've demonstrated proof of concept for my ideas. It's a technique that can waste a lot of time and you could end up reinventing the wheel, but I've not found that to be a problem. Also, switching research areas helped me avoid competition with former PhD students who turned out to be active researchers, as most of mine have become.

Lexin: Which topic or direction do you choose to move to next? As you know, it's quite an investment of time and energy to move into a new research area. How do you make this choice? What advice do you have for junior faculty?

Dennis: The genesis of every one of my research areas was always a specific applied problem. The solution to a specific problem can often be adapted to address related problems; then other people get involved and the methodology starts to grow. Eventually, a new research area emerges and the problem that started it all gets lost in the past. That's natural evolution in methodology.

Lexin: Okay. You actually already answered my next question. What do you think is the role of real scientific applications in your research?

Dennis: It's crucial. For example, your work in tensors was motivated by problems in brain imaging. I'm sure you can imagine extending that work to other more abstract problems, if you haven't already done so. Two or three papers down the road, brain imaging might be lost and now you're doing math problems. But the genesis was brain imagining.

Lexin: So, also, among all your publications, I'm just curious, which one do you like most?

Dennis: I'm going to give an easy answer to that. The publication I like most is always the one I'm working on now. If you continue to grow as a scientist and you continue to think about what you've done in the past, there's a sense in which everything you've done is somehow flawed. Not mathematically flawed in the sense of an error, but perhaps you didn't extend it in the right way or you didn't present in the right way or you wished you'd done something differently. The only exception to that is the one you're doing right now, which isn't flawed. It never is.

Daniel: You have traveled a lot and I would like to know which of the trips that you have done have had an important influence on your ideas, your career, or your personal life.

Dennis: I can't remember going on a trip and having an epiphany about anything, but the attitudes and the ways people think guides your work as you integrate with everything else. Having an exposure to different ideas is important for informing your own future. For example, I received a lot of good feedback during my short course in Madrid. I took that home and it actually changed the way I did some things. Intellectual diversity is important for any statistician.

7. FUTURE

Chris: Last area now, relating to the future. We have a couple of questions in that regard and I'm going to start with what I think is the most important question: Which is more important, water skiing or statistics?

Dennis: Depends on the time of the year. In the winter it's statistics, in the summer not so much.

Effie: So the question is about people, I mean, data science today and people who call themselves data scientists without necessarily having formal statistical training. So the question is, also jointly with Claude, how do you feel about these new denominations: data science, artificial intelligence, maybe with respect to statistics?

Dennis: Well, data science isn't a term that I associate with a crisp definition. We have an understanding about it in Minnesota. But to someone in industry it might be something else; for instance, it might mean little more than database management.

Effie: What does it mean in Minnesota?

Dennis: Well, in Minnesota I think it's seen as an academic discipline that balances statistics and computer science. The distinction I'm trying to make is that data sci-

Upper Left: Water skiing in 2019 *at age* 75. *His passion for more than* 60 *years. Upper Right: White-water rafting in New Zealand. Dennis and Jason were assigned to the bow because of their canoeing experience. Lower: Dennis' greatest source of pride, sons Jason and Christopher, and wife Jami of* 55 *years.*

ence in the large doesn't have a well-defined meaning. In business it is called Data Analytics.

Chris: Business Analytics.

Dennis: Business Analytics! So, we are evolving rapidly right now and how we're going to break out in 20 years is anyone's guess.

Effie: 20 years or sooner?

Dennis: It could be sooner. How long did Data Mining, a precursor to the data science, last? I suppose that lasted about a decade. All these problems are in a sense old; it's just that now we're all focused on the same problems. I recall that when Data Mining was a big issue, Steve Feinberg, who was then Chair of the Applied Department, stopped by my office and asked "Dennis, in Data Mining the datasets are huge and the standard errors are so small we effectively know the answers. What's the role for statistics?" I don't think we have answered that question yet.

Daniel: What are your plans for the future, both on a personal level and on the professional side? And which new area you would like to explore? Which countries or places would you like to visit in the future?

Dennis: I don't have any plans for the future. My future is going to be like my past. I'm going to go where the spirit moves me at the time.

Effie: Okay, this is totally about the future. So the first one relates to statistics, about what you think the field is evolving to? What is the next stage for statistics? And especially... because I think that your career has more or less overlapped with the development and the establishment of statistics as a formal field of study.

Dennis: That's a really hard question, because the answer requires a prediction and statisticians are terrible at prediction, particularly when we don't have a good model. There's a sense in which I don't think statistics should change, there's a sense in which I think it has changed too much already. In our excitement to respond to every trend that comes along, I think we may have lost sight of what makes statistics Statistics. I'm not talking about Minnesota; I'm talking about statistics in the large.

We tend to respond too fast to new trends and we tend to forget what identifies us as a discipline. If we forget what makes us a discipline, then there is an existential threat to our field. But if we don't forget, if we remember our foundations, then everything's going to be fine going forward.

Effie: A follow up to what you just said. What do you think makes statisticians being so willing to try to accommodate new trends?

Dennis: Statistics is largely a service discipline. We look to others to furnish us with new data types and experimental constructs. Einstein gave Physics the General Theory of Relativity which spawned the Big Bang and is essential to GPS applications. Big data didn't originate within statistics. So we follow new trends because that's in part what we do. There's nothing wrong with that. You get into problems when the new trend becomes a preoccupation, when you want to change the whole department or change its name or change its philosophy, when the goal becomes something you never were in the beginning. I think that's the existential threat.

Upper: Gathering of co-authors and former students to mark the start of the conference "Cook's Distance and Beyond." Middle: Daniel Peña and Chris Nachtsheim grilling Dennis during conference banquet. Lower: Dennis' reaction to Jami's toast at the conference banquet.

Effie: That is, from a psychological point of view, a sign of insecurity.

Dennis: Many people worry that computer science or data science or something else will absorb statistics, and we're just going to be washed away. And we will be if we forget what makes statistics Statistics. Why do we exist as a discipline?

Bing: What do you think of the roles that have been played and will be played by dimension reduction and variable selection?

Dennis: I'm convinced that dimension reduction, along the lines that we have developed and that you are developing, has a much bigger role to play than in the past. For example, I've never been comfortable with the way in which our discipline has embraced sparsity to the exclusion of everything else. I mentioned before that I like the availability of options in statistics, but for a long time now the prevailing attitude toward high-dimensional problems has been that its natural to assume sparsity. I find no sense in which it's natural. That overwhelming emphasis on sparsity has, I think, kept us from seeing other solutions and options. To be clear, I have nothing against sparsity per se, and I think it's a reasonable modeling construct. But it's not reasonable just because you have high-dimensional data.

Rob: Do you have any general advice for students just now starting graduate school in statistics?

Dennis: The most important thing is to pick problems that you enjoy working on and to work on them for the enjoyment that you get from them. If you can do that everything else should fall into place.

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