Professor of ~~Magic~~ Mathematics

DON ALBERS
Mathematical Association of America

Persi Diaconis, professor of mathematics at Harvard, has just turned 50, but the energy and intensity of the 14-year old Persi who left high school to do magic full time for the next ten years of his life still burns brightly.

His work in mathematical statistics was so good that he was awarded a $200,000 MacArthur Foundation Fellowship, tax free and no strings attached. The purpose of the awards, for which applications are neither solicited nor accepted, is to free creative people from economic pressures so they can do work that interests them. In spite of his mathematical achievements, Diaconis insists that he is better at magic, his first career, than he is at statistics. After ten years of doing magic on the road, he decided to try college. At twenty-four, he enrolled as a freshman. Five years later he had earned his PhD from Harvard.

Diaconis applies mathematics to a wide range of real-world problems, claiming that "I can't relate to mathematics abstractly. I need to have a real problem in order to think about it."

Not long ago he established a major result about card shuffling that is of importance to anyone who plays cards and who would like assurance that the cards in a deck are in random order. Diaconis proved that a deck of cards needs to be shuffled seven times in order for the cards to be in random order. He says "You might think as you shuffle a deck more and more times it just gets more and more random. That is not the way it works at all. It is a theorem that this phenomenon of the order of cards being intact as you go from one, two, three shuffles... to being essentially random happens right at seven shuffles."

Diaconis is ranked among the top three "close up" magicians in the world. Close up magic is done tableside as opposed to on a stage. How much does Professor Diaconis love magic? His response is crystal clear: "If I could have had a professorship in magic, and if the world recognized magic the way it does mathematics, I probably would be doing magic full-time and never would have done mathematics or statistics."

His background in magic and statistics has also proved useful in exposing psychics, including Uri Geller. He is currently working on books about coincidences and mathematical magic.

A Magical Beginning

ALBERS: At the age of 14, you left your New York City home and spent the next ten years on the road practicing magic. What made you do that?

DIACONIS: That's simple. The greatest magician in the United States was a man named Dai Vernon. He called me up one day and said, "How would you like to go on the road with me?" I said, "Great," and he said, "Meet me at the West Side Highway two days from now at two o'clock." So with what money I could pick up and one suitcase, I went on the road. It was simply a question of a mag-

Photograph by Cathy Saloff-Coste

Strange looking dice! What is this, Persi, mathematics or magic?

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netic, brilliant expert in the field calling on me, just as a guru calls on a disciple. I was quite honored and excited to do it.

A: What did your parents say to your leaving home to practice magic?

DIACONIS: I didn't ask them. I just left home. My parents were upset at my leaving, but somehow they found out that I was okay. For a long time I was the black sheep of the family. Only when I started graduate school at Harvard did my family begin to think that I wasn't terrible.

A: So they felt very bad about your going off to practice magic.

DIACONIS: Sure they did, I was being groomed to be a virtuoso musician. I went to Julliard from the ages of 5 to 14. After school and on weekends I played the violin. All of my family members (mother, father, sister, and brother) are professional musicians. They thought I was going to become a violinist and having me desert music for magic was not very appealing to them. I think they have come to accept it all now. They never came to accept the magic, even though I was good at it. I was better at magic than I am at what I do now.

A: How did you get into magic?

DIACONIS: When I was five years old, I found the book *400 Tricks You Can Do* by Howard Thurston. I picked it up and figured out that I could do a few tricks. I soon did a little magic show at my mother's day camp. I clearly remember that show. I was the center of attention. I wasn't horrible apparently, and magic became a hobby. I sent in my dimes for mail-order catalogs on magic, and for my birthday I would ask for tricks as presents. When I got to public school I met other kids who were magicians and I joined the Magic Club. I threw myself into it with a real fury. All the energy that I didn't put into doing homework or anything else connected with school I put into magic. On many days I would cut school and hang out at the magic store until closing time.

A: Who would assemble at the magic store?

DIACONIS: Older magicians and other kids who were interested in magic. In New York City there was a big, lively magic community. When I was 12, I met Martin Gardner at the cafeteria where magicians used to hang out. He was the kindest, nicest man, and he took time out to show me some lovely, little tricks that I could do. (Gardner, in addition to being a great writer, also is an accomplished magician.) He saw that I was a troubled kid and took a liking to me. He told me to call him if I had any questions. So I used to call him and talk about magic, and he got me interested in working on mathematical tricks because he would warm to that.

Photograph courtesy of Harvard University

Professor Diaconis posed in front of one of his favorite paintings in his Harvard office.

A: Did you know that Martin Gardner was a big name?

DIACONIS: Sure. I knew who the other magicians respected, who was famous and who was not so famous. He was obviously a very special guy, the kind of guy who could go on and on about things and remain interesting and never be pompous, just kind and instructive. He also was genuinely delighted if I showed him a new twist on a trick that he might know. He didn't try to put someone down because it was a trivial twist on something. When I showed him a new little idea, he would make a note of it. Every once in awhile he would put something of mine into his "Mathematical Games" column in *Scientific American* magazine and that was a great thing for me.

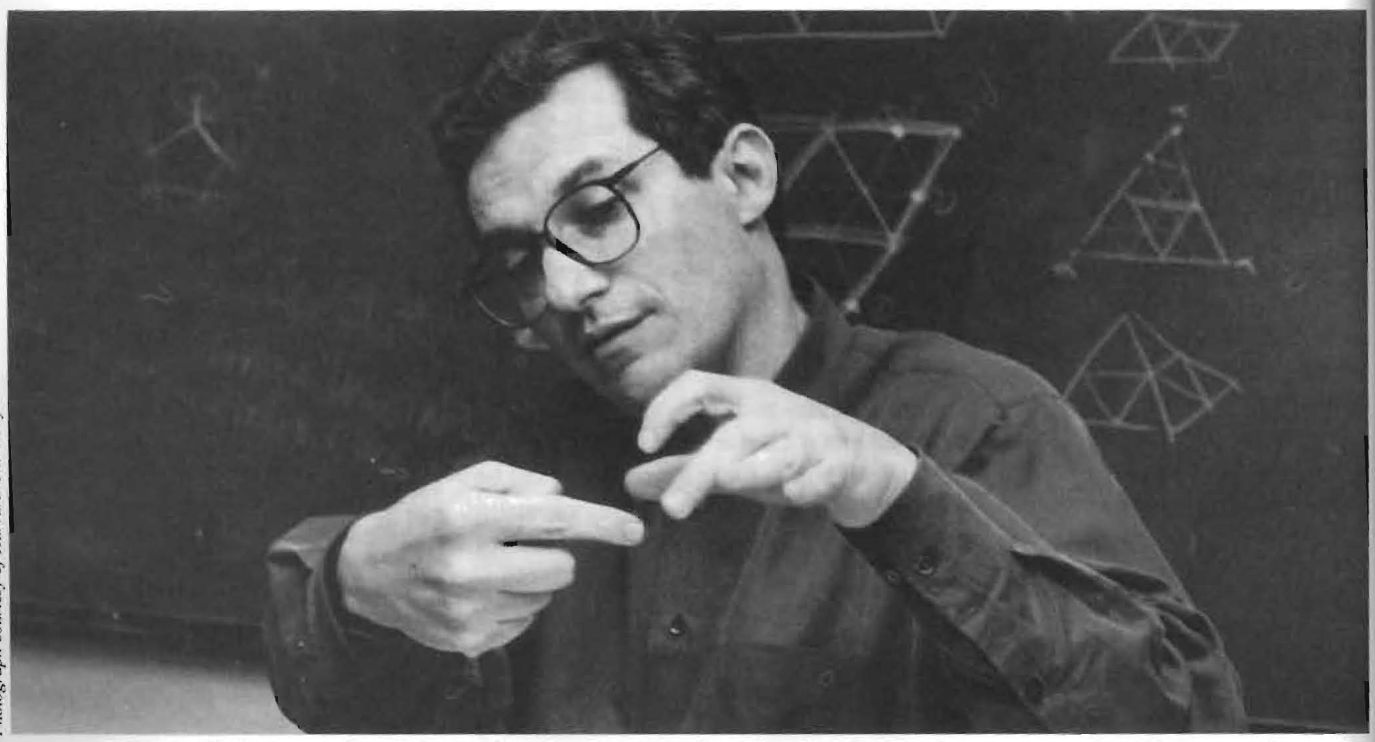
On the Road

A: You went on the road at age 14. What were those years like?

DIACONIS: During the first few years I was in very good company. I was being shepherded around by Dai Vernon, a brilliant man, the magician's magician and the best inventor of subtle sleight-of-hand magic of the century. He taught me magic: we talked magic morning, noon, and night. Since he was sort of old, and since I could do the sleight-of-hand very well, when he would give magic lessons, he would have me demonstrate tricks, and then he would explain them. So my experience was vaguely structured and very colorful—a lot more colorful than I choose to put into any interview. I met all kinds of interesting street people, was often broke, hitchhiked, and so forth. I left Vernon when I was about 16 and was on my own. He went on to Hollywood to found what is now known as the Magic Castle, which is a fabulous magic club, a private, wonderful magic place where movie stars hang out. I decided I didn't want to do that and would stay on my own. So I stayed in Chicago, lived in a theatrical hotel, and played club dates, usually for $50 a night. I did pretty well that way. I eventually drifted back to New York, doing magic and pursuing it as an academic discipline, inventing tricks, giving lessons, and collecting old books on magic, which I still do. It was just my life. I did it with all my energy.

A: Magic very often has card tricks associated with it and perhaps card playing. Were you playing cards at the same time?

DIACONIS: No, not at the beginning. Much later somehow I got a copy of Feller's famous book on probability, and I got interested in probability that way.



Photograph courtesy of Harvard University

Diaconis illustrates a point. He claims that "inventing a magic trick and inventing a theorem are very similar activities."

A: How did that happen?

DIACONIS: It was due to another friend of mine, Charles Radin, who is a mathematical physicist at the University of Texas. He was in college on the straight and narrow while I was still doing magic. We had been kids together in school. One day he went to Barnes and Noble Bookstore to buy a book and I went along for the ride. He said Feller was the best, most interesting book on probability, and I started to look at it. It looked as if it was filled with real-world problems and interesting insights, and so I said, "I'm going to buy it." He said, "You won't be able to read it," I said, "Oh, I can do anything like that." Well, in fact, I couldn't; I tried pretty hard to read Volume 1 of Feller, and it's one of the big reasons I went to college, for I realized that I needed some tools in order to read it.

A: What college?

DIACONIS: I started at City College at night. They wouldn't take me during the day because I was something of a strange person, so I went for a couple of years at night taking one or two courses. I discovered that I liked college, and I decided to try for a degree. I finished up in two and a half years. It was a short time after I started college that I dropped magic as a vocation.

Martin Gardner and Graduate School

A: How did you end up at Harvard?

DIACONIS: I graduated from City College in January, and decided to start graduate school in mid-year. It turned out that some places, including Harvard, did accept mid-year applications. Harvard's mathematics department hadn't taken anyone from City College in 20 years. All of my teachers said Harvard didn't accept any students from City College, even the really good ones. So, I decided not to apply in mathematics. Instead I applied in statistics; it was the only statistics department I applied to. At the time, I didn't very much care about statistics, but I thought it would be fun to go to Harvard. I thought I would try it for six months and see if I liked it. I did like it, they liked me, and I stayed on to finish a PhD. Because of my strange background I probably wouldn't have gotten into Harvard had it not been for the intervention of Martin Gardner. I was talking to Martin a lot during that time, asking his advice as to where to go, and he was, of course, professing to know nothing about mathematics. I said I was thinking of applying to the Harvard statistics department, and he said that he had a friend there named Fred Mosteller. Now Fred Mosteller is a great statistician, who in his youth had invented some very good magic tricks. There is, for example, a trick called the Mosteller Spelling Trick, which is still being used today. Martin wrote a letter in which he said something like, "Dear Fred. I am not a mathematician, but of the ten best card tricks that have been invented in the last five years, this guy Diaconis invented two of them, and he is interested in doing statistics. He really could change the world. Why don't you give him a try?" Fred later told me that I would not have been admitted if it had not been for that letter.

Statistics is the Physics of Numbers

A: You have spent most of your professional life working in statistics. What is statistics to you?

DIACONIS: Statistics, somehow, is the physics of numbers. Numbers seem to arise in the world in an orderly fashion. When we examine the world, the same regularities seem to appear again and again. In more formal terms, statistics is making inferences from data. It is the mathematics associated with the application of probability theory to real-world problems, and deciding which probability measure is actually governing.

Photograph by Cathy Saloff-Coste

Professor Laurent Saloff-Coste, right, of the University of Toulouse has been Diaconis's main collaborator for the past several years. Here we see them discussing a problem of finite Markov chains, and perhaps where to have dinner.

A: Do you think of statistics as part of mathematics?

DIACONIS: Yes. It is part of applied mathematics. There is something about making inferences that goes beyond mathematics. In mathematics you must have something that is correct and beautiful, and that is enough to qualify as mathematics. In statistics, however, there is the question of trying to decide what is true in the world, and that is somehow going beyond any formal system.

Nothing pleases me more than being able to take some mathematical idea and apply it to solve a problem. But the bottom line for me has to be that I actually get an answer to the problem. In the case of the card shuffling, how many times do I have to shuffle a deck of cards? The answer is seven for real shuffles of a deck with fifty-two cards. Without the number seven at the end, all of the underlying mathematical ideas wouldn't mean as much to me.

A: The group theory is more beautiful for you as a result.

DIACONIS: Absolutely! I can't relate to mathematics abstractly. I need a real problem in order to think about it, but given a real problem I'll learn anything it takes to get a solution. I have taken at least thirty formal courses in very fancy theoretical math, and I got A's and wrote good final papers, and it just never meant anything. It didn't stick at all; that's something about me.

My PhD thesis involved a very concrete problem, namely the crazy first digit phenomenon. If you look on the front page of *The New York Times,* and observe all of the numbers which appear there, how many of them do you think will begin with one? Some people think about a ninth. It turns out empirically that more numbers begin with one, and in fact it is a very exact proportion of numbers that seem to begin with one; it is .301. Now that's an empirical fact, and it's sort of surprising. It comes up in all kinds of real data. If you open a book of tables, and look at all of the numbers on the page, about 30% of them begin with one. Why should that be? It's always been that way for me. There is some question and some set of mathematical tools, and often the question has been asked several times, and eventually the question drives you on to understand the set of tools, and then for me the game isn't finished until the set of tools yields the answer. This can take years. There are questions I have worked on for 30 years. Until I get the right answer, I don't stop.

The Art of Finding Real Problems

A: How do you find real problems?

DIACONIS: That's probably what I'm best at. What makes somebody a good applied mathematician is a balance between finding an interesting real-world problem and finding an interesting real-world problem which relates to beautiful mathematics. In my case, I browse an awful lot, sit in on courses, and read a lot of mathematics. As a result, I have a rather superficial knowledge of very wide areas of mathematics. Also, I am reasonably good at talking to people and finding out what ails them problemwise.

Psychics and ESP

A: How did you become involved with psychics and ESP research?

DIACONIS: ESP is a nice example of an area where my background in magic and my interest in statistics come together. It's a marvelous, clear example of a nice applied math problem. Any respectable proof of parapsychology by the standards of today is statistical in nature, and therefore in order to be a good investigator you have to know about statistics. One of the big problems for parapsychology investigators is that sometimes they work with people who cheat, deliberately or subconsciously, or both.

My involvement began when *Scientific American* reviewed a book that contained a report of a psychic in Denver who purported to make psychic photographs with his mind. Investigators would bring their Polaroid cameras and snap a picture of this guy's head, and usually they would get a picture of his head; but once in a while the photographs would look something like a fork, or a biplane, or Cro-Magnon Man or

something like that. Martin Gardner arranged for me to go to Denver to investigate him; and while I was there I caught him cheating unquestionably. Over the years I have investigated several so-called psychics, as a kind of hobby and also as a source of interesting problems. I guess it's also a service to the scientific community. It's hard for ordinary scientists to do a good job at debunking psychics. We may all feel that it is baloney, but it's very hard to determine why.

Debunking

A: Why is it hard for scientists to debunk psychics?

DIACONIS: It's because most people (a) don't know the tricks, and (b) don't have the statistical background. It is very easy for the tricks to be concealed in poor statistics. A combination of (a) and (b) can be devastating. You can be a terrific physicist or mathematician, but if you don't have experience in running experiments with human subjects and with cueing, etc., you may have a very tough time. Having the experience often makes it very obvious what's wrong, and when you point out the trick or statistical fallacy to somebody else, they say "aha." It's hard for people to spot it on their own.

A: The public's interest, in ESP, astrology, and numerology is very high. How do you explain their fondness for it?

DIACONIS: It is a basic human reaction to wonder at something surprising such as an unusual coincidence. That seems to be a hard-wired reaction in people. Perhaps it is wired in there for protection. I think it is unquestionable that we have a pattern-detecting mechanism that works and is alerted and delighted by surprising coincidences.

When I was a performer, I learned that it is much easier to entertain people by pretending that your tricks are real magic, than to do wonderful tricks and just present them as tricks. People, if you let them, are quite willing to believe the most outlandish things, and the fact that you can do a little sleight-of-hand and actually make something happen in addition to creating a spell of wonder makes it all the more believable. Large proportions of our undergraduates believe that parapsychology is a demonstrated fact.

I read very thoroughly for ten years all of the refereed, serious parapsychology literature. There is not a single, repeatable experiment in that literature. Most people don't seem to know that.

The business card of the professional magician, Persi Warren (Diaconis), who left home at age fourteen and performed professionally for the next ten years.

A: Do you still do music?

DIACONIS: I don't do music anymore, but I still do magic. The way I do magic is very similar to mathematics. I do it seriously as an academic discipline. I study its history. I invent tricks, and I write material for other magicians. I meet with them, do tricks occasionally and practice. That's an activity that is not very different from mathematics for me. I subscribe to 20 magic journals. You might say I do magic as a hobby, but for me it's quite close to math.

Inventing a magic trick and inventing a theorem are very similar activities in the following sense. In both subjects you have a problem that you're trying to solve with constraints. In mathematics, it's the limitations of a reasoned argument with the tools you have available, and with magic it's to use your tools and sleight-of-hand to bring about a certain effect without the audience knowing what you're doing. The intellectual process of solving problems in the two areas is almost the same. When you're inventing a trick, it's always possible to have an elephant walk on stage, and while the elephant is in front of you, sneak something under your coat, but that's not a good trick. Similarly with mathematical proof, it is always possible to bring out the big guns, but then you lose elegance, or your conclusions aren't very different from your hypotheses, and it's not a very interesting theorem. One difference between magic and mathematics is the competition. The competition in mathematics is a lot stiffer than in magic.

A Professorship in Magic

A: Why did you leave magic as an occupation?

DIACONIS: I left the performing part of it. Show business is very different from being a creative magician. In fact, the reason I left it is because you can't be too creative. There is tremendous pressure to do the same 17-minute act: it works and it gets laughs. I can remember very clearly changing the closing trick of my act, a trick with butterflies. I took the butterfly trick out to do something else. After my performance, my agent rushed up to me backstage, and said I couldn't take the butterfly trick out of my act. He said, "That's what I book you on." At that point, I wondered if I was going to end up doing the same seventeen minutes for the next twenty years.

Magic can be done as a very academic and creative discipline; it's very similar to doing mathematics, except for the fact that the world treats you more seriously

if you're a mathematician. If you say that you're a professor at Harvard, people treat you respectfully. If you say that you invent magic tricks, they don't want to introduce you to their dog.

A: When you were doing magic, you said that you were following the wind. Are you still following the wind?

DIACONIS: When I was young and doing magic, if I heard that an Eskimo had a new way of dealing a second card using snowshoes, I'd be off to Alaska. I spent ten years doing that, traveling around the world, chasing down the exclusive, interesting secrets of magic. Since then I've worked in number theory, classical mathematical statistics, philosophy of statistics, psychology of vision and pure group theory. What happens now is that if I hear about a beautiful problem, and if that means learning some beautiful math machine, then, boy, I'm off in a second to learn the secrets of the new machine. I'm just following the mathematical wind. ■

Don Knuth's Solutions to the Word Ladder Problem

(See p. 23 for Gardner's article on Word Ladders)

ROGUE	SHOES	SHOES	BLACK	BLACK	BLACK
vogue	shots	shops	slack	slack	brack
vague	slots	chops	slick	shack	brace
value	sloth	crops	slice	shark	trace
valve	slosh	cross	spice	share	trice
calve	slush	cress	spine	shale	trite
carve	blush	crest	shine	whale	write
carte	brush	CRUST	whine	while	WHITE
carts	crush		WHITE	WHITE	
parts	CRUST				
parks					
perks	BEANS	BEANS	COSTS	COSTS	COSTS
peaks	beats	beams	coots	coats	coats
leaks	seats	seams	clots	chats	boats
leaps	spats	shams	plots	chaps	blats
leapt	spars	shame	plats	claps	plats
least	spare	shale	plate	clans	plate
BEAST	share	shall	place	plans	place
	shale	shell	peace	plane	peace
ROGUE	shall	SHELF	PENCE	place	PENCE
vogue	shell			peace	
vague	SHELF			PENCE	
value					
valve	GRASS	GRASS	GRASS		
calve	grabs	gross	crass		
carve	crabs	grows	cress		
carte	cribs	grown	tress		
carts	cries	groan	trees		
cants	cried	groat	treed		
cents	creed	great	greed		
bents	greed	greet	GREEN		
beats	GREEN	GREEN			
beaus					
beaut					
BEAST					