Statistical Inference to Legal Argumentation

an address at the **Beyond the Formula II** statistics conference
Rochester, New York
June 18, 1998
by

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This text has been edited and expanded from the original presentation

Good afternoon. I would like to begin by thanking Bob Johnson, Gary Egan and the other members of the Conference Committee of "Beyond the Formula II" (Sonya Armstrong, Mark Harris, Pat Kuby, and David McNitt) for inviting me here to discuss the role that science in general and statistics in particular play in our modern justice system.

What I would like to do this afternoon is provide you with a little background on how expert witnesses are used in court cases to introduce statistical testimony. Then I'll cite some examples of where courtroom statistics have gone awry and discuss how this has given rise to several proposals to improve the way science is used in legal disputes. Finally, I'll talk about how mathematics educators might be able to use their classrooms to both directly and indirectly shape the outcome of future cases.

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At the outset I want to establish that there is a fundamental difference in how a scientist pursues questions of fact and how the courts use scientific facts. Modern science deals in statistical probabilities and never gets past *theories* of how the universe is structured. Even when science calls something a law, it really means a well-established theory. That's because science achieves enlightenment by trying to disprove the theories it posits. To draw a final conclusion would be to shut the door on the persuit of knowledge. Moreover, science tries to say things that apply universally. Science tries to find general rules, and views individual variance from the norm as exceptions which, because of the strength of competing factors, actually increase the certainty of the general conclusions (that is, they prove the rule).

The law is not like that. Our justice system is aimed at weighing whether some individual acted rightly or wrongly in a single instance: a sample of one. Indeed, a person's previous behavior, offered as evidence that the defendant has a character which is typical of someone who commits the offenses layed out in the allegations, is largely inadmissable.

The courts charge juries with drawing final conclusions beyond any reasonable doubt. (In contrast, a scientist who fails to express doubt over his most well-established theories is considered a dogmatist.)

Courts try to establish causality, where statistics posits only strong correlations. Trials end while questions raised by science go on forever. Good science draws inferences from all the

evidence. In the adversarial atmosphere of the court room, good lawyering draws inferences from selected points of evidence which advance the client's interests.

Given these fundamental differences, it might be thought that the courts are no place for statistical inference. I believe that would be wrong. When we examine case after case, we find that experts are regularly involved in the trial of facts in every phase.

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A case can be generally divided into these phases: investigation, discovery, trial, and penalty. There are specific differences between civil and criminal cases, and real cases can go through many different phases depending on the court of jurisdiction and the motions placed before that court. For my purpose here, however, these four phases cover most of the business that occurs in any case.

Investigation involves independent collection of information about suspicious acts. Thought typically the work of law enforcement, corporations go through periodic investigations also--in the form of audits--to assure that its funds are being properly handled. One of the responsibilities of the Attorney General in our state is to register charities, real estate ventures, and securities dealers. Registration involves the submission of financial reports against which we run statistical models to try to identify patterns which might point to fraudulent activity. Such analysis has allowed our units to discover what one bureau chief has called the boutique scam of the season.

In consumer frauds investigations of on-line services, we have set up computers which can automatically dial a service like Prodigy or Compuserve to randomly sample how frequently a consumer might get a busy signal. These efforts are used to determine whether, for example, there is a problem which was raised in a complaint to the state attorney general by citizens. Indeed, complaints themselves are the subject of analysis as we examine our own phone logs to determine whether there are rising trends in one criminal area or another.

The point of all this, of course, is to determine whether to file charges in a court of law and thus open a formal case.

Discovery is the next phase in a case. It is where parties in a dispute lay out the evidence for each other. In a case where expert witnesses will be brought in to talk about scientific facts, an experienced lawyer will ask his opponents to produce all statistical evidence the expert witness has used to draw preliminary conclusions, an explanation of the methods used to arrive at inferences, and references to academic literature supporting all underlying postulates.

Consider the following excerpt from a discovery motion (in which a defendant asks the court to order the prosecution to provide information relevant to the case involving DNA testing):

"[Discovery]...should include , upon request: (1) Copies of autorads, with the opportunity to examine the originals. (2) Copies of laboratory books. (3) Copies of quality control tests run on material utilized. (4) Copies of reports by the testing laboratory ... [and it goes on to list publications supporting the theories involved in the assessment, names of other experts in the field, explanations of the methodologies used, and so forth]

It's during discovery that many cases are settled. Well, actually, it's just after jury selection. The attorney will look at the evidence, then look at the jury; look at the evidence, then look at the

jury. Then he decides.

Trial phase. Where pre-trial hearings fail to produce a settlement (or an admission of guilt), juries are summoned to make a common man's assessment of the facts. It is critically important to our justice system that ordinary men, selected from among the citizenry without prejudice, evaluate the claims of competing parties. Yet in cases with complex scientific arguments, the jury's ability to correctly decide has been called into question.

Penalty phase. Finally there is a penalty phase. In civil cases, statistics often plays a preeminent and more powerful role than in other phases. In class action suits, for example, the actual harm of each and every victim might not be known. America OnLine's was challenged in several states with having sold unlimited access to the Internet, but then failing to provide sufficient means for customers to make local phone calls to America OnLine facilities through which the Internet could be reached. To determine the amount of time all customers were deprived of access requires inferences drawn from fewer sample points which are representative of the whole population. Here is where samples collected during investigation can be brought back for use in assessing a penalty. Say that 50% of the time random calls to America OnLine phones across the state returned busy signals. An attorney might argue in court that America OnLine should return to consumers half of what they paid during the period under dispute.

One of the most interesting statistical cases used in recent memory is that in the Minnesota tobacco settlement. Recall that Minnesota was successful in having Phillip Morris turn over a raft of internal documents during discovery in which the company repeatedly makes the connection between nicotine and addiction. After that, the state had no obligation to show any correlation (in the hopes of proving causality) between smoking and cancer or smoking and addiction. Phillip Morris admitted guilt and the trial then turned to assessing how much damage the tobacco company had caused, and how much it would have to pay in damages. At one point in the proceedings the tobacco company expert examines graphs which the plaintiffs have introduced. The graphs show the confidence interval in a sample purporting to show the number of nursing home related deaths from tobacco related illnesses. (Blue Cross of Minnesota was one of the plaintiffs, so there was a keen interest in assessing damages which could compensate nursing homes.) The tobacco company argued that a prudent approach to assessing damages would be to select a figure at the low end of the confidence interval, a savings of several millions of dollars for the company.

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Perhaps no other cases in recent memory have made the public more aware of the use of statistical evidence than (1) the O.J. Simpson murder trial (in which he was acquitted of criminal charges) and (2) the civil trial which followed (in which he was found responsible for the wrongful death of the murder victims). Expert witnesses played such a prominent and public role in these actions that it might have seemed that there was a new dawning of science on the legal scene. In fact, expert witnesses have played a major part in litigation for most of this century, and have been a major jurisprudential issue for longer.

There is a very important point of law associated with expert testimony. You see, most testimony given in depositions and trial examination is about a witness's direct experience with the case. The neighbor saw the defendant carrying a rifle similar to that used in the hold up. The sporting goods clerk recalls the defendant purchasing a ski mask in the middle of July. The co-worker observed the defendant making reservations on a flight to South America. But such

witnesses may not offer up their opinions or hearsay. An ordinary witness may not say, for example, that the defendant's actions are similar to other crooks he has met in his lifetime. And testimony to the effect that the defendant fits a profile of criminal manic depressive disease would be thrown out if uttered by a casual witness. Yet this is exactly the kind of testimony which is admissible when presented by an expert.

Experts have special standing in a court of law. Scientists and mathematicians are well-regarded in the legal system. In a 1974 sample of 1,400 judges and lawyers, 75% of the respondents felt that scientific evidence was more credible than other types of evidence. As Cameron and Edge wrote in 1979, "scientists are seen as disinterested, open-minded, impartial, emotionally detached, supremely rational and possessed of scrupulous mental hygiene which transcends ideology, politics and self-interest."

But all this begs a number of questions. How does the court know when an expert is an expert? By what standard is the testimony of an expert judged? When experts disagree, how can a jury sort out fact from fantasy?

Let me set the stage for some of these issues by referring to a capital case in Alcorn County, Mississippi. An expert witness was asked to test two pieces of rope. Each rope was stained with an unknown material. The expert was asked to determine whether the material was the same on each rope. The expert testified that the first rope was stained with a substance that was a "complex hydrocarbon." On the second rope, the expert reported that it too was stained with a "complex hydrocarbon." Now on this testimony, each of us here today, being complex hydrocarbons, are perhaps also implicated in the capital crime. Of course, the testimony was rubbish and provided no hint of whether the substance on each rope was the same in a common sense meaning of the term. But the charlatan scientist's ruse was only exposed on appeal. Neither the trial judge, nor the parties in the dispute, nor--most importantly--the jury saw through the hoax.

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Now consider Sevill v. State tried in 1981. This was a rape and murder trial in which human hairs found on the victim were compared with those of the defendant. Joe Andrews of the Mississippi crime lab--incidentally, all of my example where the state loses are in other states--told the jury that the odds of finding two people with matching pubic hairs would be 1-in-800, and scalp hairs would be 1-in-3500. Andrews predicated his statistics on a study which was allegedly conducted in Canada among subjects, all of whom were Caucasian. (No argument was made for why this study was applicable to the local population, though other studies looking at, for example, blood types have shown substantial disparities between different areas of the United States.) In the trial, Andrews stated that while one hair matching the known sample had moderate odds, the number would go up if more hairs from the victim could be matched. Listen to the courtroom dialogue; the prosecutor is examining the expert witness:

> **Prosecutor:** [As you just answered]...about one out of every eight [hundred] people might have one similar pubic hair? Is that correct?
>
> **Expert Witness:** ...yes, sir.

Prosecutor: And you said if you had eight thousand [people], it might be ten people [who match]; but, consider this. If you had two pubic hairs that matched, would that make the odds one-in- eight hundred times eight hundred?

Expert Witness: That is normally the way that you multiply statistical values. If you have a certain set of events and each one of those has a statistical probability that it will occur, then if you want to consider both of those probabilities together, then you multiply your two probabilities by each other to achieve your final probability.

Prosecutor: So if my arithmetic is correct, instead of being one out of eight hundred, that makes it one out of sixty-four thousand --

[At this point the defense counsel rises to raise an objection. Clearly he sees something wrong here and wants to put a ready end to it. Unfortunately, all he sees is that the prosecutor is doing calculations which the witness is supposed to do. He isn't even aware that the prosecutor's arithmetic is wrong.]

Defense Counsel: Your Honor, I want to object to leading [the witness. Counsel is reporting statistics which the witness has not raised.]

Prosecutor: [to the witness] Do you have something to write on? Can you do eight hundred times eight hundred in your head?

Witness: I believe it would be six hundred and forty thousand.

Prosecutor: So that would be the odds: one-in- six hundred and forty thousand?

Witness: Yes, sir, that's correct.

Prosecutor: With just two pubic hairs?

Witness: Yes, sir..

Prosecutor: And in addition, [there] were chest hairs?

Witness: Yes sir. There were other hairs. There were chest hairs recovered from the shirt. There was a chest hair recovered from the sample of the victim at autopsy, and there were two pubic hairs, yes, sir.

Prosecutor: And does each one of these additional findings increase the odds?

Witness: If you go by the multiplication of probability, yes sir.

Of course, using this expert's misunderstood product rule, with twelve matching hairs, the chance that Belvill was not guilty becomes about one-in- ten to the 34. Since there are only about five billion people on the planet, the chance that someone else committed the murder was virtually zero, and Belvill faced the electric chair.

Of course you could use the product rule if the events were random. The odds of heads in a coin flip is 1/2. The probability of heads twice in a row is 1/2 times 1/2 or 1/4. But you can rarely say the same thing of a crime scene. Criminal investigations are not stochastic processes. All of the evidence collected at a crime scene are one event. There is no randomness. In fact, police do not act randomly in finding a potential perpetrator. The victim says, "He was a tall, greying man with a beard," and the police go out looking for tall greying men with beards. And when they find one, they try to obtain whatever evidence they can which will link that one sample point to the crime scene.

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So then, what does one do about the misuse of statistics in a court room where none of the participants have adequate understanding of how to weigh such evidence?

In 1927, in the case Frye v. the United States, the principle was established that there would have to be some measure by which a presiding judge would determine whether expert testimony is admissible. The standard included that an expert must be properly educated in the field about which he is to testify, and he must use principles which are generally upheld in the scientific community. But there's always an exception that wrecks the rule, isn't there? The classic cases cited to discredit this approach involve a community of three experts in voice print detection. Three consultants published a number of articles in which they claimed that the positive identity of a person could be established by statistical comparison of sound frequencies from a unknown recorded voice with those of a defendant. In court, each of these three experts would cite each other.

In 1983 the rules of admissibility in federal cases was changed. Instead of relying on the phantom community of scholars and the mere fact of publication as evidence that an expert was in the court, judges are now required to directly evaluate the science underlying the presented facts. So in federal cases, justices are now expected to understand with the precision of the expert OR they may throw out testimony because it is too confusing.

Some say that the problem is with expert witnesses, and that we need to have better experts come forward. On the face of it, with some experts receiving $200 - $300 an hour plus expenses, it seems that there is incentive to come forward. But it's not quite as pretty a picture. An expert witness is at the disposal of the court calendar and there is not a trial to attend on every work day. So it is important to stress at meetings like this the importance of scientists and statisticians to express their civic duty. (Incidentally, you express that duty typically by putting an add in the American Bar Journal or on the Internet offering your services for hire.)

Others say that the fault lies with judges. Jurists need to be better educated.

And of course, most would point to the juries themselves. Following the Simpson trials, many observers suggested that the court system resort to professional jurors. Citizens who would be trained in evaluation of scientific evidence, or at least the arguments made in support of the factual nature of such evidence. For my part, I do think that jurors should at least be asked to read Larry Gonick's *Cartoon Guide to Statistics* and Huff's *How to Lie with Statistics*. But we stretch it when we suggest that we need professional jurors. We would be establishing panels of wise magistrates rather than common men, and hearkening back to Plato's pie-in-the-sky vision of philosopher kings. And at any rate, the approach is impractical. What kind of training would be sufficient for a juror who might have to evaluate DNA samples, glove manufacturing methods, knife classifications, airline scheduling operations, and psycological profiles all in one case?

Still another approach is to have the courts hire expert interpreters of facts: educators who can objectively explain complex statistics and scientific theories to judge and jury.

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At this point in my talk I was planning to draw conclusions about the importance of training in statistics for all those who might be involved in the justice system. Clearly, a jury of common men today need some of the basics.

It occurs to me that there is a manner in which educators, teaching courses in statistics, can provide direct involvement. The notion arises from the experiment in California Superior Court where all unsealed papers in cases must be made available on the Internet.