Introduction: Visualizing Evidence and Inference in Legal Settings

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By now it is an old story: legal scholarship in the English-speaking world about the law of evidence began to change in the late 1960s and early 1970s. This shift in the direction of Evidence scholarship came to be known as the "New Evidence Scholarship" – "NES," for short. A characteristic (but not universal) feature of much of NES – particularly in the early days – was a preference for formal mathematical argument about evidence and inference and about decisions based on uncertain evidence and inference.

NES aroused controversy from the moment of its birth (or rebirth). Laurence Tribe almost succeeded in turning NES into an example of sudden infant death syndrome; his powerful 1971 attack on "trial by mathematics" almost succeeded in killing off the baby.[1] Other observers, while not necessarily rejecting the need for a shift in the direction of Evidence scholarship, followed the anti-mathematicist trail that Tribe had blazed. (But scholars such as Richard Lempert, David Kaye, and David Schum saved the mathematicist branch of the new scholarship from premature oblivion.[2])

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I owe many debts to many people for their help in organizing that conference. My creditors include Henry Prakken (program chair), Tom Cobb (deputy program chair), Jonathan Gottfried (coordinator of local arrangements), and Alisa Norr.

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[1] Laurence Tribe, *Trial by Mathematics: Precision and Ritual in the Legal Process*, 84 Harvard Law Review 1329 (1971).

[2] See, e.g., Richard O. Lempert, *Modeling Relevance*, 75 Michigan Law Review 1021 (1977); David H. Kaye, *The Laws of Probability and the Law of the Land*, 47 University of Chicago Law Review 34 (1979); David A. Schum & Anne W. Martin, *Formal and Empirical Research on Cascaded Inference in Jurisprudence*, 17 Law & Society Review 105 (1982); Richard Lempert, *The New Evidence Scholarship: Analyzing the Process of Proof*, 66 Boston University Law Review (1986).

Many of the attacks on mathematical analysis of evidential inference were misdirected; many of them – probably the vast majority of them – rested on basic misunderstandings about the nature and possible uses of mathematics. (Some critics seemed to assume that numbers are only good for counting. Other observers seemed to assume that all mathematical expressions amount to recipes for solving problems.) But some of the attacks on mathematical argument about evidence and inference harbored, even if not always distinctly, intuitions that seem to have considerable substance.

One such intuition is that it makes little sense to ask people such as jurors to use a method of analysis or argument – such as Bayesianism – that is beyond their "common," or "ordinary," understanding.[3]

Another important intuition is that the nuances and complexities of real-world evidence and inference are too great to be captured by any type of formal analysis.

Both of these intuitions involve assumptions about the cognitive capacities of human beings and the human brain. One reason I am interested in visualization of evidence and inference is that I suspect and hope that visualization of evidence and inference can make the logic of formal analytical methods such as Bayesianism more readily intelligible to so-called ordinary people – to people such as judges, jurors, law teachers, and law students, to people such as me.

I am interested in visualization for another reason: I also suspect that visualization may help to remedy or ameliorate certain cognitive limitations that afflict even very extraordinary people, even people with extensive training in logic and mathematics, for example.

[3] Intuitions such as these, however, almost certainly have to be qualified and hedged. For example, in some situations ordinary people perform better if they are allowed to use tools – such as thermometers, lasers, and computers – whose workings they may not understand.

These two conjectures of mine can be stated in the following deliberately-suggestive way: I suspect that visualization can make it possible for the extraordinary computational capacity of the ordinary brain to do a better job of taking advantage of whatever assistance explicit formal argument about evidence is capable of providing.

Whether some complexities and nuances of real-world evidence and inference in legal proceedings are beyond the limits of formal analysis is still an open question. But I have a theoretical prejudice that bears on the question of how complex inference should be managed and addressed: I suspect that the people who tend to believe that the solution to the problem of complexity is generally to wash out some details – I suspect that the people who think we need simple and simplifying heuristics[4] are on the wrong track. I suspect that the devil is generally in the details and I suspect that washing out detail generally degrades rather than enhances inferential performance. If I am right about this, every effort should be made to develop tools that makes it possible for human decision makers to increase (rather than decrease) the number of evidential premises and evidential inferences that decision makers should try to consider when they address uncertain factual hypotheses.

Having said that attention to detail is important, I hasten to say that large amounts of detail do present a serious problem, particularly for the enterprise of developing and deploying formal argument about evidence and inference. I take it as gospel that assessment of the sort of evidence ordinarily found in real-world litigation (and in many other decision making situations) usually involves numerous evidential premises and numerous evidential inferences. An abundance of evidentiary and inferential detail presents a serious difficulty for the dream of explicit and comprehensive formal analysis of evidence in legal proceedings. As the number of items of evidence increases and as the number of pertinent possible inferences increases, the resources required to consider the inferences suggested or supported by a body of evidence increases exponentially. If a human actor who uses a formal method of analysis (such as

[4] See, e.g., Gerd Gigerenzer, Peter M. Todd & ABC Research Group, SIMPLE HEURISTICS THAT MAKE US SMART (1999).

Bayesianism) must allocate even a very small increment of time – one or two or three seconds, let us say – to each premise and to each step in a complex evidential argument, it becomes hard to imagine how a comprehensive explicit formal analysis of even a relatively small amount of evidence presented in a legal proceeding can ever be done by any real human being.[5] Furthermore, the difficulty of just keeping in mind all of the necessary or important parts of an inferential argument (including its evidential premises) seems to increase enormously as the number of evidential premises and inferential links increases; the task is akin to trying to play *n*-dimensional chess blindfolded.[6]

That's the way I see things, and that's why I hoped that a conference on "graphic and visual representations of evidence in legal settings" (http://tillers.net/conference.html) would shed light on how or whether visualization can contribute to the solution of two possible problems: (i) the possible problem of the unintelligibility of complex formal argument about evidence and inference; and (ii) the possible problem of the impracticability[7] of explicit formal analysis of evidence and inference in legal proceedings.[8]

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[5] Indeed, the increase in the amount of time that seems to be required to assess evidence is so great that one is led to wonder how evidence can be consciously assessed in any meaningful way under any circumstances.

[6] For example, some of us may think, at least sometimes, that we have a pretty good understanding of the logic of Bayesianism. But few of us seem to have a good handle on the workings of likelihood ratios and all the rest of that Bayesian stuff when the transition from evidence to ultimate hypothesis involves a chain or a web of inferences; in that situation it becomes very difficult for even an astute student of Bayesian logic to picture how Bayesian logic works. See Schum's work on cascaded inference in, e.g., David A. Schum, THE EVIDENTIAL FOUNDATIONS OF PROBABILISTIC REASONING (Wylie & Sons. 1994). See also, e.g., David A. Schum & Anne W. Martin, n. 2, *supra*.

[7] I am far from convinced that the advent of the computer solves the "impracticability problem." Even the most fervent advocates of computational approaches to inference have not yet explained how the assessment of the sort of evidence presented in legal proceedings can be completely automated. Compare the Solomon Project hoax. *Jury Tampering*, in Talk of the Town, New Yorker (Feb. 5, 1996); Mark Landler, *Joey Skaggs, who delights in practical jokes on the press, has got a million of them,* New York Times Section D p. 5 (Jan. 29, 1996); Steve Rhodes, *Skaggs Solomon Project Prank on the O.J. Simpson Trial*,

Let me wind up these introductory comments by making an observation about the relationship between "visualization" and graphs. The title of this conference and of this special issue of *Law, Probability and Risk* conjoins visual images and graphs. But some of the conference participants and contributors to this special issue – perhaps even a majority of them – do not think that methods of visualizing inference are their primary interest but think instead that the logic of inference is their main interest. If asked to explain why they sometimes use graphs that take the form of visual images, some of the contributors to this special issue might reply that a visual image of a graph is accidental from the standpoint of graph theory and that everything that a visual representation of a graph – a representation with symbols that look like arcs and nodes – might have to say about evidential inference can be equally well expressed or better expressed with

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http://tigerbeat.vox.com/library/post/skaggs-solomon-project-prank-on-the-oj-simpson-trial.html (Jan. 15, 2007). For example, I am confident that any approach to evidential inference in litigation currently under consideration implicitly supposes that human beings would have to observe testifying witnesses and enter the evidence presented by and generated by such witnesses into some sort of database. This process of observation and data entry might appear to be a simple task. But if this task is properly done, it is anything but simple; it requires, for example, a considerable amount of interpretation – and, yes, drawing of inferences. Moreover, the process of evaluating and then recording pertinent testimonial data is extraordinarily time-consuming. For example, a witness makes a facial expression during her testimony. The following sorts of questions might arise: What kind of smile was it? Was it a smile or was it a jeer? How long did it last? Etc. Similar sorts of questions would arise about every other part of a witness's testimony and behavior. In addition, if it turns out that a human actor must participate in the development of arguments based on such evidence, the extent to which computers can be expected to increase the efficiency of inferential activity diminishes still more.

[8] Some observers might prefer to characterize this second problem as the problem of the computational intractability of problems of evidence and inference in legal proceedings. But I prefer my formulation (a formulation couched in terms of "practicality" or "impracticality") because, at least at this stage in human history, we cannot hope to make it possible for human decision makers to consciously assess – explicitly consider – all of the enormous number of inferences and calculations that the brain must make to generate even the simplest of conclusions about the world. Some subterranean evidential premises and evidential inferences we just have to trust; we human beings – given the limits of our knowledge and the limits on our time and resources – are just not up to the task of making all information processing explicit.

mathematical expressions and equations. The use of a graph, they might assert, is a mere "convenience."

I can't argue and I don't want to argue with students of graph theory who take this view: my sense is that they have a lot of eminent company and powerful arguments on their side. But I wonder if serious students of graph theory would agree that the following hypothesis does no violence to graph theory: although a visual image of a graph is matter of mere convenience from the standpoint of graph theory and is in no way essential from that point of view, graphs that "look like" graphs – i.e., visual images that have elements that "look like" nodes and arcs – sometimes synchronize better with natural human cognitive processes, with the workings of the human brain.

I am trying to lead graph theorists down a particular garden path. I have noticed (and I suspect that many other people have noticed) that when graph theorists try to explain themselves, they often use visual images as well as mathematical expressions and equations to describe their reasoning. I imagine (but I don't really know) that some graph theorists would explain their use of visual images as an unfortunate but necessary concession to the intellectual limitations and weaknesses of dunces such as P. Tillers, who often have trouble following lengthy arguments made only with mathematical expressions. But I wonder if this sort of condescending (though entirely accurate) response offers backhanded support for the conjecture that visual images are sometimes excellent vehicles for getting ordinary human brains to work the way we want them to work – and the way we think that our brains, if properly assisted, can work.