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TAKING FACT ANALYSIS SERIOUSLY

*Bernard Robertson**

*G.A. Vignaux***

ANALYSIS OF EVIDENCE: HOW TO DO THINGS WITH FACTS BASED ON WIGMORE'S SCIENCE OF JUDICIAL PROOF. By *Terence Anderson* and *William Twining*. Boston, Mass.: Little, Brown and Co. 1991. Pp. xxx, 457. \$24.

INTRODUCTION

The "new evidence scholarship" has so far consisted mainly of articles and conference papers in which new evidence scholars argue in arcane disputes.¹ Some of the ideas have started to rub off in evidence textbooks,² but few scholars have attempted written proselytization.

One exception is William Twining,³ who in two previous books⁴ challenged conventional evidence teachers to reconsider their basic principles. With Terence Anderson,⁵ he has now published *Analysis of Evidence* with an accompanying Teacher's Manual (*Manual*). This was always intended to be the second limb of Twining's project,⁶ but it

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1. See, e.g., Symposium, *Decision and Inference in Litigation*, 13 CARDOZO L. REV. 253 (1991); Symposium, *Probability and Inference in the Law of Evidence*, 66 B.U. L. REV. 377 (1986).

2. See RICHARD D. FRIEDMAN, *THE ELEMENTS OF EVIDENCE* (1991); ANDREW LIGERTWOOD, *AUSTRALIAN EVIDENCE* (1988).

3. Quain Professor of Jurisprudence, University College, London.

4. WILLIAM TWINING, *RETHINKING EVIDENCE* (1990) [hereinafter TWINING, *RETHINKING EVIDENCE*]; WILLIAM TWINING, *THEORIES OF EVIDENCE: BENTHAM AND WIGMORE* (1985) [hereinafter TWINING, *THEORIES OF EVIDENCE*].

5. Professor of Law, University of Miami.

6. See WILLIAM TWINING, *Introduction: The Story of a Project*, in TWINING, *RETHINKING EVIDENCE*, *supra* note 4, at 5-7. Twining has explored the boundaries and content of Evidence in a number of essays now collected in TWINING, *RETHINKING EVIDENCE*, *supra* note 4, and attempted to uncover its conceptual and theoretical underpinnings in TWINING, *THEORIES OF EVIDENCE*, *supra* note 4. As a result, a subject previously regarded, in the U.K. and New Zealand at any rate, as a "professional" subject to be taught in a technical fashion has become a battleground on which no fundamental assumption is safe. Part of the motivation for the study was to consider the future of a subject normally conceived of as a body of rules, when the rules were being steadily eroded or abolished in most Commonwealth jurisdictions. Today Evidence courses in the U.K., New Zealand, and Australia are moving in one of two directions: either toward what in the U.S. would be termed "Constitutional Criminal Law," motivated by legislation such as the Police and Criminal Evidence Act, 1984, ch. 60 (Eng.), and the New Zealand Bill of Rights Act, No. 109 (1990), or toward exploring the process of "proof," motivated by writers such as Twining and Sir Richard Eggleston. See SIR RICHARD EGGLESTON, *EVIDENCE, PROOF AND PROBABILITY* (2d ed. 1983).

is also the first book from the new evidence movement designed to be picked up by noninitiates and used for teaching.

I. FACT ANALYSIS

Analysis of Evidence seeks to breathe new life into Wigmore's largely ignored *Science of Judicial Proof*,⁷ where Wigmore set out to develop a *novum organum*, a rigorous method of thinking about facts in legal cases. The structure of argument and proof, he pointed out, was ripe for systematic study, because it had been regarded as a skill to be picked up through working with more senior practitioners who had not themselves been trained in fact analysis.⁸

Although *Analysis of Evidence* addresses other evidence analysis techniques such as the narrative method⁹ and the trial book,¹⁰ the Wigmore Chart serves as the book's centerpiece. The Wigmore Chart aims "to determine rationally the net persuasive effect of a mixed mass of evidence."¹¹ It provides a formalized scheme, necessary because "the mind is unable to juxtapose consciously a larger number of ideas." Consequently, "each coherent group of detailed constituent ideas must be reduced in consciousness to a single idea; until the mind can consciously juxtapose them with due attention to each, so as to produce its single final idea."¹²

The formalized scheme is achieved by breaking down the case's evidence into propositions, each containing a single point (see Table 1). The propositions may be matters provided by depositions, inferences drawn from witness evidence, generalizations that contribute to the drawing of inferences, or even alternative explanations for events dreamed up by the chartist. The chartist draws a hierarchical chart showing the relationships between these propositions. Thus, in Figure

7. JOHN H. WIGMORE, *THE SCIENCE OF JUDICIAL PROOF AS GIVEN BY LOGIC, PSYCHOLOGY, AND GENERAL EXPERIENCE AND ILLUSTRATED IN JUDICIAL TRIALS* (3d ed. 1937) (previously published as *The Principles of Judicial Proof* in 1913 and 1931).

8. *Id.* at 4.

9. Wigmore scorned the narrative method, in which the evidence is simply recited and classified according to which matters it is relevant to, though even that requires the lawyer to think in more Wigmorean terms than does the mere telling of a story. Anderson and Twining see more merit in narrative as a method of conveying information to the factfinder (p. 158). They also explore the ideas of *theory*, a legally significant, logical statement of what a party has to prove; *story*, a narration of the relevant events; and *theme*, an idea around which the presentation of the case in court is built. Appreciation of the difference between these concepts is vital for both the practitioner and the scholar. For discussion of a failure to distinguish between *theory* and *story*, see Bernard Robertson & G.A. Vignaux, *Extending the Conversation about Bayes*, 13 *CARDOZO L. REV.* 629, 631-32 (1991).

10. The "trial book" is simply a lawyer's device for organizing what he or she needs to try a particular lawsuit. Typically, it will include pleadings, checklists, copies of documents to be introduced and statements or depositions to be used, outlines for opening and closing, outlines or anticipated "scripts" for direct and cross-examination of witnesses, jury instructions, and memoranda of law . . . P. 266.

11. John H. Wigmore, *The Problem of Proof*, 8 *ILL. L. REV.* 77, 79 (1913).

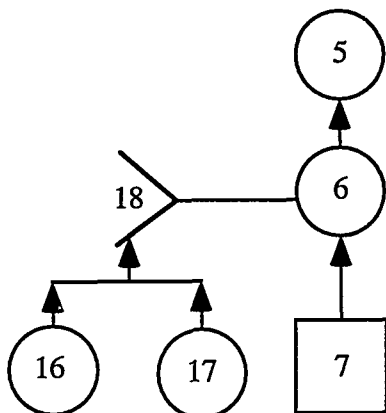
12. *Id.* at 80 (emphasis omitted).

1, which shows a portion of a Wigmore Chart from *Analysis of Evidence*, Witness 3's statement (7) is evidence for (6), which in turn supports proposition (5). But proposition (18), supported by propositions (16) and (17), leads us to downplay the probative value of (6) on (5).¹³

TABLE 1: A PARTIAL LIST OF PROPOSITIONS
FOR FIGURE 1 (P. 147)

5. *X* left *Y*'s house at 5:00 p.m. on January 1.
6. W[itness]3 saw *X* leave *Y*'s house at 5:00 p.m. on January 1.
7. W3: I saw *X* leave *Y*'s house at 5:00 p.m. on January 1.
16. The sun had set before 5:00 p.m. on January 1.
17. A claimed eyewitness identification made after the sun has set is doubtful.
18. It may have been someone other than *X* whom W3 saw leave *Y*'s house.

FIGURE 1: PART OF A BASIC WIGMORE CHART (P. 148)



In practice the chart and the list of propositions develop interactively. Early attempts to draw a chart usually reveal deficiencies in one's list of propositions, which accordingly starts to expand. This forces one to consider exactly how items of evidence prove different propositions.

This analytical process assists a number of stages of the legal process. For the investigator, it can help to identify possibilities and indicate which evidence should be sought to prove or disprove those possibilities; for the prosecutor, it serves as a checking device to ensure that the most appropriate provable charges have been laid and to identify any further investigation required; for the lawyer preparing for

13. The different shaped symbols hint at the type of proposition or evidence involved. For example, the circle depicts circumstantial evidence or inferred propositions; the open angle identifies arguments providing alternative explanations for an inference; and the square depicts testimonial assertions. P. 145.

trial, it serves the additional purpose of enabling an issue-by-issue construction of the case for presentation to the jury; and for the historian examining a cause célèbre, it offers a tool for rigorously examining the facts and arguments proffered and for considering the effects of new information. Indeed, *Analysis of Evidence* emphasizes that the first step in any successful analysis is to determine one's standpoint. This is achieved by asking the questions: *Who am I?; At what stage in what process am I?; and What am I trying to achieve?* The second question emphasizes that the lawyer and investigator are involved in dynamic processes, in which information and priorities may change during the period from an initial incident or consultation to trial.

The value of fact analysis has long been recognized in a number of fields.¹⁴ Two recent developments have caused the legal world to take renewed notice of fact analysis. First, large law firms increasingly use computer-based litigation support systems, and courts also use computers for managing the evidence in complex cases. At present these are only sophisticated storage and retrieval systems; a system that actually helps the litigator to structure the case is an obvious next step.¹⁵ Second, the move toward skills-based legal training in a number of jurisdictions has created demand for teachable systems for analyzing cases. Many lawyers, in the course of their practice, work out more or less formal systems for displaying the structure of a case. This demonstrates the value of such systems. If legal training included such an analytical framework, junior lawyers could avoid much unnecessary distress.

Neville Carter, working alone from a copy of Wigmore's *Science*, designed one system for analyzing cases for the New Zealand Law Professionals Course.¹⁶ This model starts at Level One, the appropriate sources of law, from which one identifies Level Two, the cause of action or charge. The elements of the cause of action are determined at Level Three. Level Four consists of those propositions that constitute the matters to be proved at Level Three. Level Five consists of the evidence from witnesses and documents. The process of inference, upon which *Analysis of Evidence* concentrates, takes place largely between Levels Four and Five. In a minority of instances, a Level Four proposition is inferred directly from an item of evidence, but in most cases a more complex process of inference is involved. Often this will require combining inferences from items of evidence. All this activity takes place "between" Level Four and the bottom level, and it seems

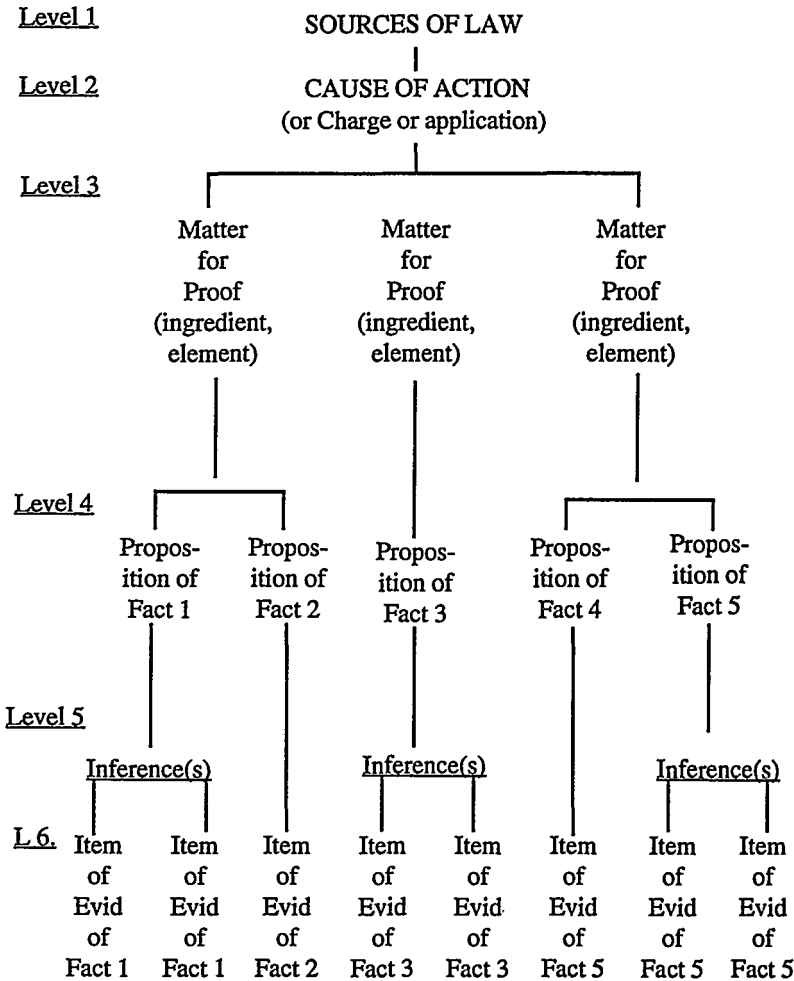
14. See, e.g., DAVID SCHUM, EVIDENCE AND INFERENCE FOR THE INTELLIGENCE ANALYST (1987).

15. Academics are attempting to develop such systems. See, e.g., David A. Schum & Peter Tillers, *Marshalling Evidence Throughout the Process of Fact-Investigation: A Simulation — Parts I to IV* (1989), Reports 89-01 to 89-04 (unpublished manuscript).

16. New Zealand Law Socy. Seminar, *Winning Your Case — Structuring Proof and Closing Evidentiary Loopholes* (New Zealand Law Society, Wellington, 1988) (Neville Carter, leader).

sensible to insert a new level into the scheme so that the charting of the inference process can be properly discussed. The current version of the model therefore has six levels (see Figure 2).¹⁷

FIGURE 2: THE 6-LEVEL MODEL FOR FACT ANALYSIS



The Carter model relates the various levels to statements of claim, particulars, and other procedural aspects of the New Zealand legal system. Thus, Carter takes Wigmore's basic idea and adapts it to one particular standpoint: that of the lawyer preparing for trial in a particular jurisdiction. Oddly enough, this is the standpoint from which

17. New Zealand Law Socy. Seminar, *Preparing to Win: Analyzing Facts in Legal Cases* (New Zealand Law Society, Wellington, 1991) (Bernard Robertson, leader).

Wigmore thought he was writing.¹⁸ Carter's work and *Analysis of Evidence*, however, show that Wigmore provided only the logical core, to be adapted and extended to fit the requirements of various standpoints.

Analysis of Evidence provides basic instruction in drawing a chart together with real and fictional cases suitable for the beginner. The book provides extensive quotations from Wigmore's original work and authorial commentary, some of which are expanded in the *Manual*. Because an evidence teacher cannot easily find cases that neatly test the various aspects of fact analysis, the uninitiated teacher will find this compendium most helpful.

This is a process that can only be learned by doing, thus students and teachers face a lot of hard work. The authors are sanguine about the task of teaching such a system; they state that giving feedback is easier than performing the analysis in the first place (*Manual*, pp. x-xi). Our own experience suggests that the best way for teachers to learn to teach fact analysis is for them to think their way through a major exercise themselves.¹⁹ Their task may be mainly to "incite, excite, and advise," but they can only be credible by providing the clear sense of direction that comes from having traveled the road first.

This is particularly true in view of the standard criticisms made upon first introduction to such systems. Busy practitioners often state that they do not have the time and energy to chart every, or even any, case in this way. Other lawyers maintain that this system only puts on paper what they already do in their heads. This reflects the more academic debate about whether Wigmorean analysis is a descriptive or prescriptive system and, if it is prescriptive, whether the patient needs a cure. The answer, sufficient for practical purposes, is twofold: first, Wigmorean analysis is an attempt to capture the way we think when we think at our best; second, the experience of formally conducting a major analysis causes the process to be internalized. This exercise will actually improve one's analytical skills without always having to use pencil and paper. This has certainly been our own experience, but to convince a class one needs to have had this experience oneself.

Once one has tried out the basic techniques, one can proceed to the more sophisticated problems provided and issues raised in *Analysis of Evidence*. Twining devotes considerable attention to the Edith Thompson case,²⁰ but one will soon find other cases, perhaps more local or topical, to use as centerpieces. Antipodean examples are pro-

18. Wigmore, *supra* note 11, at 77-79.

19. This view is supported by comments to us by instructors in the early days of the new style Professional Course in New Zealand, who were pitched into teaching fact analysis with little preparation.

20. For earlier evidence of Twining's fascination with this case, see WILLIAM TWINING, *Anatomy of a Cause Célèbre: The Case of Edith Thompson*, in TWINING, *RETHINKING EVIDENCE*, *supra* note 4, at 262.

vided by the *Thomas*²¹ and *Chamberlain*²² cases.

Analysis of Evidence was, the authors tell us, ten years in the making (p. xxix). During that time the authors taught fact analysis to classes at undergraduate and postgraduate levels, and in the *Manual* they give us the benefit of their experience. They and others writing on fact analysis also have improved on Wigmore's work. These improvements can take two forms: they can extend the analysis to solve problems impossible under traditional Wigmoreian analysis or they can improve the internal detail of chart construction.

The greatest shortcoming of Wigmore's system is that the choice of ultimate *probandum* has to be made before the analysis can begin. Thus, the standpoint is that of a lawyer at a fairly late stage of a case preparing for trial, or of an investigator who has formulated a fairly clear hypothesis as to what happened. Even then the ultimate *probandum* is regarded as a purely factual matter. Although *Analysis of Evidence* indicates that the choice of the ultimate *probandum* depends upon the procedural and substantive law, the method does not rigorously consider these factors.

Scholars have addressed the problem of how to get to the ultimate *probandum* from the mess of facts brought to an attorney by a client or complainant. Schum and Tillers suggest devices such as chronologies, analysis by issue, analysis by factual hypothesis, and the method of multiple working hypotheses.²³ The least useful solution has been in longest practical use — the organization of evidence witness by witness.

Herein potentially lies the most useful development of fact analysis in professional legal training. Because problems are raised in particular classes, the law student knows that a problem involves, for example, contracts, criminal law, or property. Clients do not bring lawyers their problems categorized in this way. Thus, the lawyer's first question has to be "what area(s) of law are we concerned with?" Often this may be obvious, but experience shows that the obvious can be misleading. The trap to avoid is singlemindedly following the obvious while ignoring possible alternative courses of action. Applications for leave to file late amendments to complaints often bear witness that a practitioner has fallen into this trap. An exercise at a New Zealand Law Society Continuing Legal Education seminar was designed to sensitize students to this problem.²⁴ Students received a disorganized letter from an aggrieved businessman about the collapse of an important

21. *Thomas v. Regina*, 1972 N.Z.L.R. 34 (1971).

22. *Chamberlain v. Regina*, 51 A.L.R. 225 (1984) (Austl.). This is the case dramatized in the film *A CRY IN THE DARK* (Warner Bros. 1988).

23. David A. Schum & Peter Tillers, *Marshalling Evidence for Adversary Litigation*, 13 CARDOZO L. REV. 657 (1991).

24. New Zealand Law Society Seminar, *Preparing to Win*, *supra* note 17.

deal. Whether or not a contract exists is deliberately doubtful, but many seminar participants devoted great energy to the contract questions and failed to consider estoppel and other areas of law. Systems are needed to help lawyers identify the most appropriate ultimate *probandum*. Schum and Tillers and, dare we say, the present reviewers have provided a start in this direction.²⁵

As regards the second form of improvement — the internal reform of the chart — Anderson and Twining recommend a radical simplification of Wigmore's notation. Wigmore proposed numerous symbols and variations that differentiate between defense and prosecution evidence and kinds of evidence. Few of these distinctions serve any particularly useful purpose, and the modern tendency is to use as few different symbols as possible. The important question is whether a useful distinction can be made. Anderson and Twining offer two suggestions: a symbol to indicate hearsay evidence and a symbol to indicate generalizations for which no evidence is offered. The second suggestion is particularly useful. As the authors point out, Wigmore himself failed to realize the great virtue of his system: that it makes explicit the generalizations and assumptions upon which the reasoning crucially depends (pp. 66-69). The extent to which a case's reasoning process depends upon such assumptions is graphically shown by the use of symbols to identify them. These generalizations (as opposed to the facts asserted) may turn out to be the vulnerable points in an opponent's argument. One of the most valuable uses of the Wigmore Chart is in exposing these weaknesses.

In the course of teaching fact analysis, we have found that the distinction between two different structures of argument suggests a change in notation. In one case (Figure 3(a)) a particular *probandum* is supported by a series of *probans*,²⁶ each increasing the probability of the *probandum*. If any *probans* are removed, the *probandum* would still be supported; conversely, all the *probans* could be true and yet the *probandum* could be uncertain. In other cases (Figure 3(b)), every proposition supporting an argument must be true to give rise to the *probandum*. In such cases the *probandum* is often a logical combination of the *probans*; if they are true, the *probandum* follows. The link between *probans* and *probandum* is one of deduction.²⁷ To distinguish the two situations in one's diagrams seems useful but is difficult to do with the form used by Wigmore, and copied by many students, in which lines lie only vertically or horizontally. This form does not

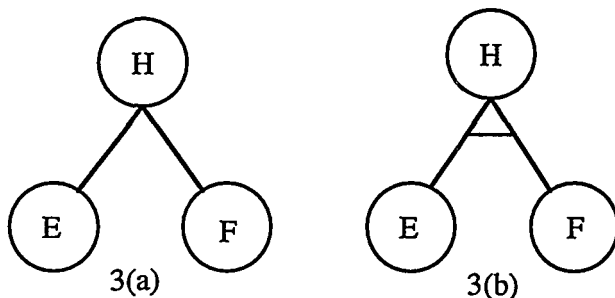
25. See *supra* note 17, *supra* note 23 and accompanying text.

26. We are aware that the plural of *probans* is *probantia* but it seems ostentatious and obfuscatory to use it.

27. See *infra* note 29 and accompanying text. This matter is more fully discussed by Justice Roden in *Regina v. Shepherd* (No. 3), 39 A. Crim. R. 266 (1988) (Austl.). See the commentary in Bernard Robertson & G.A. Vignaux, *Inferring Beyond Reasonable Doubt*, 11 OXFORD J. LEGAL STUD. 431 (1991).

guide the eye intuitively along the structure of the argument. Alternatively one can use lines that proceed directly, at an oblique angle, from *probans* to *probandum*. One can then distinguish the two structures of argument on the chart by borrowing a convention from the artificial intelligence disciplines such as shown on diagram 3(b).

FIGURE 3: TWO FORMS OF SUPPORT FOR PROBANDUM H



As evidence teachers, we have also encountered difficulties when a number of versions of some event have to be considered. An example is provided by the various ways in which the hapless Moses Young might have died.²⁸ The *probandum* in the case is that he died as a result of drinking poisoned whisky knowingly given him by the Accused. An intermediate proposition such as *Young died of poisoning* is required. But the facts suggest that Young may have died of old age, of the colic, or from an injury sustained in a recent accident. In analyzing the facts, the usual first approach is to draw a chart in the manner of Figure 4.

This structure presents a conundrum. Every proposition assumes the negative of its converse, yet in the chart the converse proposition has to be made explicit. The analyst also faces a difficulty in framing the alternative proposition *X*. On one hand, it could be identical to the *probandum*, but this would be an otiose result. Conversely, if no proposition *X* appears, the chart becomes rather disorganized. To deal with this problem one could adopt a divided "sausage" with each of the various possibilities having a compartment. *Probans* can then be connected with the appropriate compartments. The chartist then must allocate some sort of plausibility to the various alternatives and proceed with the process of inference.

28. See *Hatchett v. Commonwealth*, 76 Va. 1026 (1882). The case appears in JOHN H. WIGMORE, *THE PRINCIPLES OF JUDICIAL PROOF* 66-71 (1931).

FIGURE 4: A WIGMORE CHART FOR THE ALTERNATIVE EXPLANATIONS OF MOSES YOUNG'S DEATH

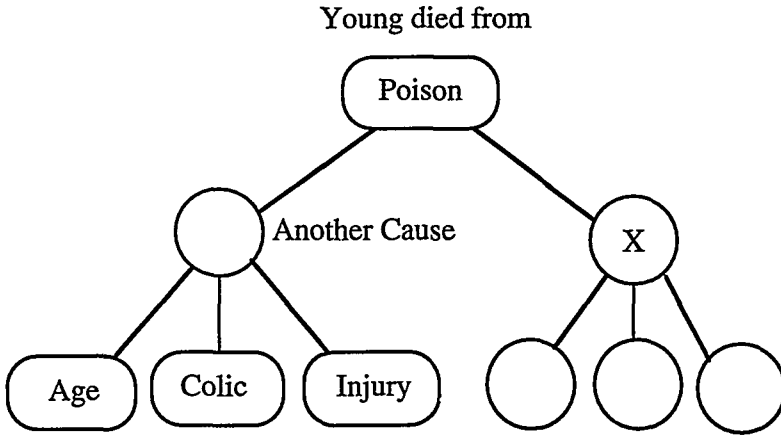
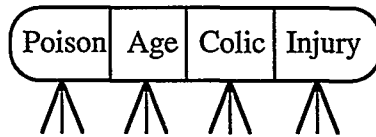


FIGURE 5: THE "SAUSAGE" NODE



Likewise it might be worth developing set diagrams for some common inference structures.²⁹ Thus the logical structure of an argument about identification can be exposed. This structure would apply to any identification proposition, such as *the accused was the culprit*. Such a statement may well be the ultimate *probandum* or the penultimate *probandum* and may depend upon other evidence, but if it depends upon identification it may be charted as in Figure 6:

29. While making students think things out for themselves is valuable, if we can save them time and effort by showing them what we have thought out in previous years, then perhaps they can develop further insights that have not occurred to us.

FIGURE 6: A WIGMORE CHART FOR IDENTIFICATION

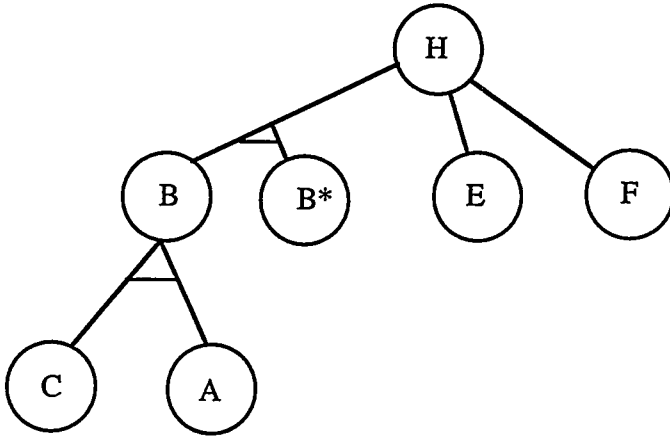


Figure 6 represents a simple case of identity of the Culprit (*probandum*, *H*). Three pieces of evidence are available: blood typing from a bloodstain at the scene (*B*), an eyewitness identification (*E*), and a matching footprint (*F*). A more precise definition of the propositions is listed in Table 2:

TABLE 2: PROPOSITIONS FOR IDENTITY

- H = "The Accused and the Culprit are the same person"
 E = "An eyewitness identifies the Accused as being at the scene"
 F = "A footprint matching the Accused's shoe was found at the scene"
 B = "The blood types of both the Accused and the Culprit are X"
 B* = "Only 1 in 50 of the population share blood group X"
 C = "The Culprit's blood type was X"
 A = "The Accused's blood-type is X"

In this example, only the blood-typing evidence, *B*, is taken to any detail. We know the blood type is X and that it is shared by only one in fifty of the population. This is important inferential information. A more common blood type would provide less probative weight for identity. Proposition *B** is a generalization indicating the value of evidence *B* rather than its truth.³⁰ Thus in more abstract terms the identification structure has propositions as shown in Table 3:

30. The structure found in the area of *B* and *B** would be repeated in the "F" sector of the chart.

TABLE 3: PROPOSITIONS FOR IDENTITY IN ABSTRACT FORM

- B = "The Accused and the Culprit share certain characteristics"
 B* = "Those characteristics are so unusual that the similarity has probative value"
 C = "The Culprit's characteristics were X, Y, Z"
 A = "The Accused's characteristics are X, Y, Z"

This provides an abstract framework for considering any identification problem. Doubtless analogous structures could be developed for other common inferential problems.

We have no doubt of the chart method's efficacy as a teaching and explanatory aid. Whenever an argument has to be picked apart, it is useful to state one's propositions in a formal style and use a diagram to show how they link up. Before formally introducing fact analysis, Robertson acclimatizes students to Wigmorean analysis by using it as a teaching aid while discussing subjects such as relevance and similar facts.³¹ Likewise, articles and judgments, which discuss whether one proposition can properly be inferred from another, could often be clarified by the use of such a method. The argument by Peter Mirfield in *An Alternative Future for Corroboration Warnings* provides an example where the method could be useful.³² While the passage is written with admirable lucidity, perhaps the writer and certainly the reader would have benefited from a chart of the argument. The use of charts by Their Lordships in the course of their disagreements in *Regina v. Kearley*³³ about exactly what can be inferred might have been novel but would have been of considerable assistance in clarifying both the authors' and readers' understanding.

II. FACT ANALYSIS AND PROBABILITY

Anderson and Twining treat fact analysis and probability as separate issues. The book contains an appendix on "Probability and Proof" written by Philip Dawid (pp. 385-441). The *Manual* contains further material, including a reprint of Twining's article.³⁴ The authors, however, leave the reader unclear as to whether or how the two subjects are connected.

Both Twining and Dawid treat probability as essentially a part of statistics. This results in a presentation that leads to arguments about the applicability of probability to legal cases and dismays many stu-

31. As an example of the value of graphical techniques in explaining legal concepts, see Richard D. Friedman, *Route Analysis of Credibility and Hearsay*, 96 YALE L.J. 667 (1987).

32. Peter Mirfield, *An Alternative Future for Corroboration Warnings*, 107 LAW Q. REV. 450, 457-58 (1991).

33. [1992] 2 App. Cas. 345.

34. *Manual*, pp. 167-76 (reprinting William Twining, *Debating Probabilities*, 2 LIVERPOOL L. REV. 51 (1980)).

dents who pursued law hoping to escape from mathematics.³⁵ Our own experience indicates that many students put the probability material into a separate conceptual box, which remains locked once the material is covered.³⁶

In the *Manual* the authors describe the development of their approach to probability and their own discussions about whether it is a separate matter or a central issue (pp. 68-70). We have been through a similar process which has recently culminated in the realization³⁷ that probability must be approached as an extension of logic, and that statistics is a special case, or worse, a series of special cases, of the use of probability. As Twining perceptively stated in *Debating Probabilities*, "[t]he life of the lawyer of the future will need to include logic as well as statistics."³⁸

If probability is a matter of logic, then clearly Wigmore analysis and Bayesian analysis of a case are closely connected, if not the same operation. To assess the probabilities, the case must be divided into simple, verifiable propositions with their logical relationships represented in some way. This may implicitly occur in the act of creating a Wigmore Chart. The decision to draw a line connecting one symbol to another suggests that the one symbol is relevant to the other, which can only mean that the chartist has decided that the symbols' degree of association (measured by the likelihood ratio) is high enough to compensate for the additional complication in the chart.

Consideration of more detailed matters also reveals a close connection between a Wigmore Chart and Bayesian analysis. The Rule of Total Probability, also known as "The Extension of the Conversation," states that, in considering the probability that *H* is true, we must consider that *H* might be true when *A* is true and also when *A* is false. We must combine these with the probabilities that *A* is true or false. In formal notation:

$$P(H) = P(H|A) P(A) + P(H|\text{not}A) P(\text{not}A).$$

If there are two items of evidence (*A* and *B*) to be considered in assess-

35. For various reasons probabilistic analysis is usually referred to in the legal literature as *Bayesian analysis*, and we use this phrase hereafter. For discussion, see Robertson & Vignaux, *supra* note 9, at 629.

36. In our teaching, Professor Vignaux contributed to every seminar in the LL.M. Evidence course. It was thus much harder for the students to duck probabilistic argument than in a course where a statistician gives a discrete set of lectures and then leaves.

37. We were enormously assisted by reading the published and unpublished work of E.T. Jaynes, Wayman Crow Professor of Physics at Washington University, St. Louis, Mo. *E.g.*, E.T. Jaynes, *Clearing up Mysteries — The Original Goal*, in MAXIMUM ENTROPY AND BAYSEAN METHODS 1 (J. Skilling ed., 1989); E.T. Jaynes, *Probability Theory as Logic*, in MAXIMUM ENTROPY AND BAYSEAN METHODS 1 (Paul F. Fougère ed., 1990).

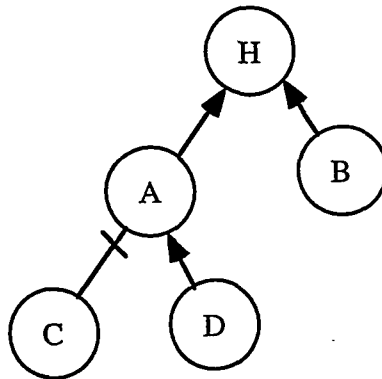
38. Twining, *supra* note 34, at 64. This argument is developed in full in Bernard Robertson & G. A. Vignaux, *Probability — The Logic of the Law*, 13 OXFORD J. LEGAL STUD. (forthcoming 1993). This contrast, between probability as logic and statistics as usually taught, means that students with backgrounds in conventional statistics, far from being able to tackle extra work, as asserted in the *Manual* (p. 71 n.8), may have more to unlearn.

ing the probability of *A* then we must consider all four combinations where *A* and *B* are both true, either one is true, or both are false. Thus we have, in formal notation:

$$\begin{aligned}
 P(H) = & P(H|A, B) P(A, B) \\
 & + P(H|notA, B) P(notA, B) \\
 & + P(H|A, notB) P(A, notB) \\
 & + P(H|notA, notB) P(notA, notB).
 \end{aligned}$$

A or *B* may themselves depend on evidence (*C* and *D*), in which case the conversation is extended to include them. This can easily be visualized in a Wigmore Chart by a descending tree structure expanding at each level as shown in Figure 7. Here *C* and *D* both affect the plausibility of *A*. Propositions *A* and *B* tend to support *H*. The bar across the *C-A* link indicates that *C* tends to reduce the plausibility of *A*. The arrows indicate support.

FIGURE 7: CASCADING INFERENCE AND “EXTENDING THE CONVERSATION”



As we have argued elsewhere, this may resolve the long-running debate between “holists” and “particularists.”³⁹ Bayesian analysis is usually assumed to be a particularist rather than a holist device. But we see from Figure 7 that Bayesian analysis does indeed offer a tool for considering a case from the top down as well as from the bottom up, and for assessing the probability of the prosecution’s case given all the evidence.⁴⁰

39. Robertson & Vignaux, *supra* note 9, at 634-36.

40. Conditional probability also offers a solution to the semantic difficulty of indicating exactly which point a proposition is about. Ordinary use of language imprecisely discerns which precise point a proposition is making. The sentence *Hatchett gave Young a poisoned bottle*, for example, could be intended to focus on whether a bottle Hatchett admittedly gave Young was poisoned, Hatchett gave Young a bottle (that happened to be poisoned), or it was Young to whom Hatchett gave the poisoned bottle. The clearest way of resolving this difficulty seems to be to frame the propositions conditionally: *given that Hatchett gave a bottle to Young, it was poisoned*.

Traditionally in a Wigmore Chart, evidence is regarded as supporting or undermining a particular hypothesis. But no piece of evidence can in itself support or undermine a hypothesis. Evidence can only help us to choose between hypotheses. Often the alternative hypothesis is left unstated, but this is not conducive to clarity and seems partly responsible for the belief that some evidence can have an "intrinsic value," whereas the value of any evidence depends upon the hypotheses being compared. In the problem of how to represent alternative explanations for a particular event,⁴¹ we adopt an expanded "sausage" node that contains all the alternative hypotheses rather than having a separate node for each. Relevant evidence is then connected in the chart to this expanded node rather than to any particular hypothesis. Once this is done, one's view of the evidence is changed. Rather than seeing particular pieces of evidence as supporting particular hypotheses, one sees more clearly that the role of each item of evidence is to discriminate among the alternatives. One considers the probability of the evidence given each hypothesis, which means that one is starting with arrows *downward* from the hypothesis to the evidence rather than *upward* as the arrows in a Wigmore Chart normally flow. This leads to calculating likelihood ratios to assess how well the evidence succeeds in discriminating between pairs of hypotheses. Bayesian analysis and Wigmore analysis have then been combined.

III. WIGMORE AND DECISION ANALYSIS

Wigmore viewed his system as "only an attempt at a working method, which may suffice for lack of any other yet accessible."⁴² Those writing about Wigmore analysis eighty years later must therefore consider whether subsequent developments might have overtaken Wigmore.

Wigmore developed his system years ahead of any similar methods published in the scientific literature.⁴³ In recent years other disciplines, such as Operations Research, have developed graphical methods that deal with formal analysis of decisionmaking. These include decision trees, influence diagrams, and Bayes networks. These quantitative techniques assist the analyst not only in describing the problem and communicating information about structure, but also in calculating the effect of the truth of one proposition or piece of evidence on the plausibility of others.

In this section we propose to examine decision trees, influence diagrams, and Bayes networks in turn and compare each with Wigmore diagrams. This will be done with the aid of examples, including an

41. See *supra* note 29 and accompanying text.

42. Wigmore, *supra* note 11, at 79.

43. See, e.g., Sewell Wright, *Correlation and Causation*, 20 J. AGRIC. RES. 557 (1921).

identification problem. In this way we hope to examine whether these modern methods have advantages over the "attempt at a working method" and to see what light they cast on Wigmore diagrams and vice versa.

Decision trees bear a superficial resemblance to Wigmore Charts. As well as Wigmore's proposition nodes, they have nodes representing decisions and values of outcomes, but these do not have to be used and we subsequently ignore them in this presentation. Different values for propositions (such as true and false) have their own nodes that are linked by arcs giving conditional probability values. The trees conventionally work horizontally rather than vertically like Wigmore Charts. For example, in Figure 8(a), nodes *C* and *NC* represent cloudy and noncloudy weather.⁴⁴ *R* and *NR* represent rain and nonrain in the afternoon. Conditional probabilities are associated with the links between them. For example, link *C-R* is associated with conditional probability $P(R|C)$ — that is, the probability that it will rain in the afternoon, (*R*), given that it is cloudy in the morning, (*C*). The tree can also be used for inference, to calculate the probability that it was cloudy in the morning given the evidence that it rained in the afternoon, $P(C|R)$. The decision tree is beneficial because many of the calculations can be carried out directly on the diagram.

Professor Richard Friedman, in his modification of decision trees, combines nodes that lead to the same final state (see Figure 8(b)).⁴⁵ Thus the node *R* via *C* (the event that it rains in the afternoon and was cloudy, *C*, in the morning) and the node *R* via *NC* (the event that it rains in the afternoon and was not cloudy, *NC*, in the morning) would be combined into a single *R* node. This more closely resembles the corresponding Wigmore Chart and has some distinct advantages when summing the effects of the various paths to each of the end nodes. At an intermediate stage, though, it may be more useful to keep (*R C*) and (*R NC*) separate, because they may give rise to different consequences as we go farther into the tree. The same problem arises in drawing a Wigmore Chart when a proposition (piece of evidence) plays more than one role. The proposition can be represented either by a single symbol with multiple radiating arcs or by a separate symbol at each point in the chart at which the proposition is relevant.

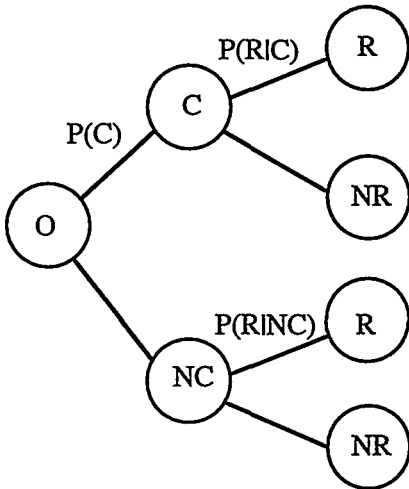
Influence diagrams generalize and simplify decision trees (see Figure 8(c)). They also have nodes for decisions and values of outcomes. They can handle problems that decision trees cannot, but they are not so transparent to use; much of the information is buried in associated tables. Bayes networks are influence diagrams without nodes for decisions and values of outcomes.

44. The example is borrowed from Professor Richard Friedman's *Omphalos*. See Richard D. Friedman, *A Diagrammatic Approach to Evidence*, 66 B.U. L. REV. 571, 572 (1986).

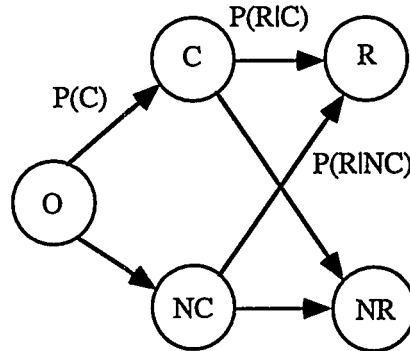
45. *Id.* at 580-81.

FIGURE 8: A DECISION TREE (A), A CORRESPONDING FRIEDMAN ROUTE DIAGRAM (B), AND AN INFLUENCE DIAGRAM OR BAYES NETWORK (C), FOR THE OMPHALOS WEATHER PROBLEM

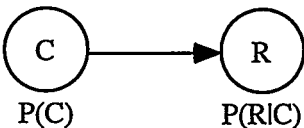
(a) Decision Tree



(b) Route Diagram



(c) Influence Diagram or Bayes Network



Bayes networks set out, in an acyclic network⁴⁶ of nodes connected by directed arcs,⁴⁷ the propositions to be proved, and the data (in the form of propositions) on which we expect to base proof. These form the nodes of the network. The nodes represent all the alternative values of a hypothesis. They correspond to the “sausage” node we suggested above.⁴⁸ Thus, node *C* in Figure 8(c) corresponds to both the *C* and *NC* nodes in the decision tree and route diagram. Directed arcs (arrows) between the nodes indicate influences, that is, conditional dependence (more precisely, the absence of an arc joining two nodes asserts conditional independence between them). Conditional probabilities are not associated with the arcs but with each node, the

46. A network where no loops or connections are allowed — in fact, where circular reasoning is forbidden.

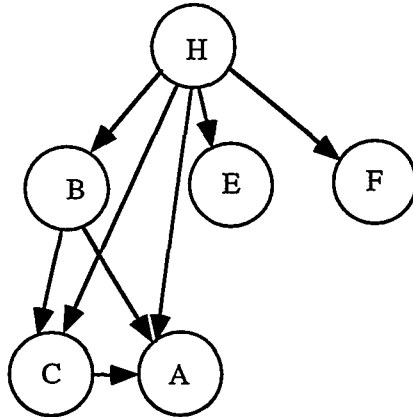
47. These are lines with a direction, or arrows.

48. See *supra* note 41 and accompanying text.

conditioning propositions being those nodes linked to it by incoming arcs. Thus the node for rain in the afternoon, R (corresponding to the nodes R and NR), has an associated conditional probability table $P(R|C)$ and the arc CR tells us that C is a conditioning proposition (i.e., it influences R). Conditional probability tables must be established for each proposition (node). At this stage the diagram represents the problem prior to the receipt of evidence. It represents all the possible values that one assumes the evidence could take.

Figure 9 represents in Bayes network form the same problem of identification shown in Figure 6. Nodes $A, B, C, E, F,$ and H represent propositions (see Table 2). H is the hypothesis we seek to establish (the ultimate *probandum*), A and C are items of evidence to be testified to by witnesses, and E and F are intermediate propositions inferred from other witness evidence.

FIGURE 9: A BAYES NETWORK FOR IDENTIFICATION



Node B can take on not only the value X but any other blood type. Assume node B can have one of the values $B1, B2, B3, B4,$ or “No Match” where $B1-B4$ would each correspond to both the Accused and the Culprit having the same blood type such as A, B, AB, or O, and “No Match” would mean that the blood types of Culprit and Accused do not match. We also have information about the frequencies of the blood types in the general population. C can take on one of the values $C1, C2, C3,$ or $C4,$ where, for example, $C3 =$ “The blood type of the Culprit is AB,” and A can similarly take on one of the values $A1, A2, A3,$ or $A4,$ where each corresponds to a particular blood type of the Accused. Immediately we have a much richer class of problem. At this stage, before the blood is typed, we have set up the system to handle any result possible.

Examining node E more simply demonstrates the conditional probabilities associated with each of the nodes. Assume $E =$ “An

eyewitness identifies the Accused as being at the scene" or, we assume, not E = "An eyewitness fails to identify the Accused as being at the scene." Before an identification lineup is held, one of the factors (and the only one charted in the figure) that affects the probability that the eyewitness will identify the Accused as having been present at the scene (E) is whether or not the Accused was present (H). Thus, E is conditionally dependent upon H , and the precise effect of H is described by a conditional table (see Table 4) associated with node E .

TABLE 4: CONDITIONAL PROBABILITIES FOR E GIVEN H

		P(E H)	
		E	not E
H	0.8	0.2	
not H	0.1	0.9	

These probability estimates (made *before* the identification lineup and based on background information) will be arrived at by considering the evidence in the individual case, such as the lighting, distance, time, and so forth relating to the circumstances in which the perpetrator was seen.⁴⁹ These probabilities are coherent for each condition (the probabilities sum to one horizontally),⁵⁰ but each condition has different probabilities for E and *not E*. The asymmetry of this example doubtless reflects reality; the probability of an error depends upon precisely which error we are discussing. The probability that the witness would make a wrong identification of an innocent Accused, $P(E|\text{not } H) = 0.1$, is not the same as the probability that the witness would fail to identify a guilty Accused, $P(\text{not } E|H) = 0.2$.⁵¹

The *bandum* H has no entering arcs and is called a source node. The chartist must provide H with a prior probability based upon information other than that being charted. Since the diagram shows the effect of evidence on probability assessments, there must be an initial assessment to be affected by the whole body of evidence. For example, prior information⁵² may lead us to the probabilities that $P(H) = 0.001$

49. These factors are known in England and New Zealand as the *Turnbull* factors. See *Regina v. Turnbull*, [1977] 1 Q.B. 224 (1976).

50. Clearly this must be the case because, if the accused was present, for example, either E or *not E* must occur.

51. Lawyers have a naive concept of the "reliability of a witness," which implies that a witness will have a consistent error rate determined by some internal factor such as honesty or competence. Obviously people tend to lie or make mistakes under pressure of circumstances. A self-serving lie is intuitively more likely than a self-disserving lie and becomes more likely as the cost of revealing the truth rises. See A.P. Dawid, *The Difficulty About Conjunction*, 36 THE STATISTICIAN 91 (1987).

52. The expression "prior information" or "prior probability" simply means any information other than that being considered at present — or an assessment of probability based upon such information. It does not necessarily mean prior in time or order of consideration, but a convenient example is a case where there is a fixed pool of 1,000 suspects and before considering any other evidence we might consider the probability of guilt for each of them to be 0.001.

and $P(\text{not } H) = 0.999$; odds of 1 to 999 that the Accused is the Culprit or odds of 999 to 1 against the conclusion.

Because the network conveys more information more precisely, it appears much more complicated than the corresponding Wigmore Chart. The complexity of the links between nodes B , C , and A reflect that they all depend on H and that B contains much, but not all, of the information available in the combined nodes A and C . B is redundant but is included here for comparison with the Wigmore Chart in Figure 6. The generalization B^* in Figure 6 is not charted in Figure 9 because it is embedded in the conditional probability table for B . Nodes A and C are connected in Figure 9 because, once one knows B and C , the value of A is determined. Because the network represents the complete probability structure of the model before the truth of any proposition has been asserted, it can process all possible combinations of evidence. It could determine, for example, the effect on H of the information that the blood type of the Culprit is A ($C1$) while that of the Accused is AB ($A3$); a combination that goes beyond merely informing the chartist of the proposition "not B ." It can also flag impossible combinations of evidence, for example, $B1$ combined with $C1$ and $A3$. But once we have established one piece of evidence — for example, that the Culprit's blood type is X — the network simplifies considerably and comes to resemble the Wigmore Chart in structure, though the arrows still point towards the evidence rather than towards the *probandum*.

We can calculate the effect of asserting the truth of a piece of evidence (such as the eyewitness evidence, E) by carrying out standard probability calculations. This is usually done by computer, but we can look at some simple examples. Asserting E to be true, we can calculate the probability $P(H|E)$. In our example, from the prior probability $P(H)$ and the conditional probability table ($P(E|H)$, Table 4), we can calculate that the probability of H given E is now 0.0079 (odds of about 125 to 1 against).⁵³ Thus, the eyewitness evidence is not particularly strong but does cut down the odds against the *probandum*.⁵⁴

In most cases the calculation can also be made using the likelihood ratios of the evidence, by comparing the ratio of the probability of getting the evidence if H is true to the probability of getting the evidence if H is not true.⁵⁵ In our case the likelihood ratio of the eyewitness evidence is $0.8/0.1 = 8$ (see Table 4). This is quite low. Some

53. The calculation uses Bayes' Rule, combining $P(H)$ and $P(E|H)$. $P(H|E) = P(H) \cdot P(E|H) / P(E) = 0.001 \times 0.8 / 0.1007 = 0.007944$. $P(E)$ is calculated by extension of the conversion as $0.8 (0.001) + 0.1 (0.999) = 0.1007$.

54. Much evidence will be assigned some probability rather than being regarded as certainly true. This complicates the calculations but poses no problem for a computer.

55. The likelihood ratio is equal to $P(E|H) / P(E|\text{not } H)$. Where H can take on more than two alternative values, the hypotheses can be compared two at a time.

scientific evidence can have ratios in the thousands or millions. Once we introduce the likelihood ratio of uncertain evidence, we can adjust the odds of the *probandum H*, which we previously determined to be 1 to 999 that the Accused is the Culprit. The odds of *probandum H*, given the evidence *E*, are the odds before the evidence (1 to 999) multiplied by the likelihood ratio (8). This gives odds of 8 to 999 or 1 to 125, for the *probandum H*, that the Accused is the Culprit.

The evidential weight of asserting a second piece of evidence combines with the weight of the previous evidence. If, for example, we assert *B3* (both Culprit and Accused have blood type AB), this is equivalent to asserting both *C3* and *A3*, each one by itself having no evidential weight on the probability of identity. If blood type AB has a frequency in the population of 1 in 50, this evidence has a likelihood ratio of 50. Thus, by itself, it would change the odds of *H* from 1 to 999 to 50 to 999 or 1 to 19.9.

The effect of combining the evidence, eyewitness (*E*) and blood type (*B*), is established by multiplying the two likelihood ratios together.⁵⁶ The combined weight of the evidence is $(8)(50) = 400$. This changes the odds in favor of *H* from 1 to 999 to 400 to 999 or about 1 to 2.5. The posterior probability of *H* given *E* and *B1*, $p(H|E, B1)$, is about 0.29.

These calculations are all done by computer. Behind the scenes the calculations are represented on the network by changing the directions of the arcs (corresponding to calculating $P(H|E)$ from $P(E|H)$) and updating the conditional probability tables. If the directions are changed so that the arcs point upward toward the *probandum*, additional links appear between the different pieces of evidence. These links correspond to the predictability of unknown evidence (say *F*) from known evidence (say *B1*). Knowing *B1* gives information about *H*, which, in turn, changes our probabilities for *F* before we learn about it in court. This sophisticated logic is much more difficult to recognize in an equivalent Wigmore Chart or decision tree.

A Wigmore Chart in its classical form assumes a predetermined hypothesis and a body of evidence from a completed investigation. It is a snapshot of a problem at a particular instant in time and thus, as has been pointed out by many researchers, it fails to capture the dynamic, even messy, nature of real-life problems.⁵⁷ Bayes networks enable one to process information and to move from a description of the problem predata to a description of the problem postdata. One can even add evidence one piece at a time and examine the result at each step. Bayes networks are therefore more dynamic than Wigmore Charts.

56. Because *E* and *B1* are independent of each other.

57. Peter A. Tillers & David Schum, *Charting New Territory in Judicial Proof: Beyond Wigmore*, 9 CARDOZO L. REV. 907, 941-51 (1988).

Despite this, the standard exposition of both Bayes networks and decision trees assumes a defined problem and a predetermined set of influences. It also implies a process neatly and clearly divisible into problem definition and data gathering. But knowledge of the problem is required in order to identify relevant influences. Moreover, as one acquires more knowledge, one may discover new effects which have to be investigated. The stages of the process are more interactive and dynamic than the model can describe. Research effort is now being devoted to determine how one formulates hypotheses and moves from one position capable of being represented by a Wigmore Chart to another.⁵⁸

The most obvious difference between Wigmore Charts and Bayes networks is that no mechanism for assessing probabilities exists in Wigmore Charts. Wigmore did provide a symbolic vocabulary to indicate belief and disbelief in a proposition and to indicate whether a proposition supported or undermined the next higher proposition in the chain of inference. These symbols could show strength of belief in a crude way — one dot meant a proposition was believed, two dots meant it was strongly believed. Sensibly, he gave no instructions as to how to formulate these strengths of belief or how to combine them. Likewise, propositions affecting each other's value as evidence could be linked by horizontal lines (as in the link between propositions 18 and 6 in Figure 1), but Wigmore did not explain how these influences were to be incorporated. Such interactions are handled routinely using conditional probability matrices in Bayes networks.

A Wigmore Chart tends to expand as more and more steps in the reasoning are teased out. This often involves making explicit the generalizations on which steps in reasoning are based. In drawing a Bayes network, in contrast, these generalizations tend to disappear into the conditional probability tables for the nodes.

The suggested modifications to the Wigmore structure make a Wigmore Chart more closely resemble a Bayes network. This need not cause alarm, because computer software is available to handle any of the calculations. The lawyer needs to perform three tasks: to establish the evidential structure of the case, to incorporate data from witnesses, and, where no expert assessment is available, to make judgments about the value of that evidence. As with the Wigmore Chart, lucidity is required, not computational skill. We are confident that versions of Bayes network software specially designed for legal cases will soon be available.

Wigmore's system is therefore quite consistent with modern methods of decision analysis but incomplete, as he himself recognized. In fact, the similarities in concept between Bayes networks and Wig-

58. Schum & Tillers, *supra* note 23.

more's "attempt at a working method" identify Wigmore as one of the unrecognized forefathers of modern decision analysis methods. Lawyers, however, need to be aware that other methods are now accessible.

CONCLUSION

Our conclusion, therefore, is that probability as logic points the way to the integration of the disparate strands in the new evidence scholarship by uniting Wigmorean and Bayesian analysis. Elsewhere we argue that probability as logic also solves the problems identified by Twining and other doubters about probabilistic analysis of legal cases.⁵⁹

Analysis of Evidence is one part, and a valuable part, of a project in which Twining has helped to revitalize the study of evidence and proof. As the authors frequently remind us, the book has been some ten years in gestation. In the meantime others, some stimulated by Twining and Anderson, have advanced understanding of fact analysis in a number of ways. The climb that brought us to our present views began with our standing on the shoulders of Twining and Anderson, but it has also been helped by the recent writing of Ronald Allen, Richard Friedman, David Schum, Peter Tillers, and others. Some of this writing is referred to in the *Manual*, but the themes pursued are not integrated into the text of *Analysis of Evidence*. This means that the book will not give a comprehensive "feel" for what has recently been going on in the field unless it is read in conjunction with the *Manual* and the references therein. Nonetheless, *Analysis of Evidence* is a welcome new venture in the proselytization of fact analysis and an excellent starting point for law teachers new to the area.

59. Robertson & Vignaux, *supra* note 38.