Argumentation Schemes and Generalisations in Reasoning about Evidence

Henry Prakken
Institute of Information and Computing Sciences
Utrecht University
PO Box 80089
3508 TB Utrecht, The Netherlands
henry@cs.uu.nl

Chris Reed
Department of Applied Computing
University of Dundee
Dundee DD1 4HN
Scotland
chris@computing.dundee.ac.uk

Douglas Walton
Department of Philosophy
University of Winnipeg
Winnipeg, Manitoba
R3B 3E9 Canada
d.walton@uwinnipeg.ca

ABSTRACT

This paper studies the modelling of legal reasoning about evidence within general theories of defeasible reasoning and argumentation. In particular, it is studied how Wigmore's method for charting evidence and its use by modern legal evidence scholars can be exploited by modern visualisation software for argumentation, and how a formal account of the method can be given in terms of logics for defeasible argumentation. Two notions turn out to be crucial, viz. argumentation schemes and empirical generalisations.

1. INTRODUCTION

This paper addresses the modelling of legal reasoning about evidence within general theories of defeasible reasoning and argumentation. In AI & Law evidential reasoning is a little studied topic. Of the few studies that have been made, some zoom in on specific aspects, such as Lutomski (1989) on reasoning with statistical evidence, and Bromby & Hall (2002) on the credibility of eyewitness testimonies. Other research takes its starting point in mathematical or computational models, such as probability theory (e.g. Jøsang & Bondi, 2000) or model-based reasoning for automated diagnosis (e.g. Keppens & Zeleznikow, 2002). We instead follow a more cognitively inspired approach, aiming to stay close to the evidential reasoning forms used in practice. We think that such an approach is theoretically worthwhile in itself, but it may also be practically useful for certain types of applications. Imagine, for instance, 'knowledge management' software for criminal investigations, i.e., software that allows the investigator to store and organise its findings (cf. the MarshalPlan project of Schum & Tillers, 1991). Arguably such software will have better chances of success if it is based on the reasoning forms used in practice.

In particular, we take our starting point in legal theory, studying a method for structuring evidential reasoning that goes back to John Henry Wigmore (1931), and which was recently rediscovered by modern Anglo-American legal evidence theorists such as Anderson, Schum, Tillers and Twining; see e.g. Schum (1994) for an overview. (A similar approach was taken by Verheij (2000), discussing the "anchored narratives" theory of legal evidence proposed by forensic psychologists, e.g. Wagenaar et al, 1993).

Wigmore developed a graphical method for charting legal evidence, a tool for making sense of a large body of evidence. Stripped to the bones, his charts depict the arguments that can be constructed from a given body of evidence, as well as possible sources of doubt with respect to these arguments. At the time, Wigmore's charting method went largely unnoticed, but today his method looks surprisingly modern, anticipating recent AI models of defeasible reasoning as well as recent software for argument visualisation. Our aim is to explore both these directions. In Section 4 we will apply the argument visualisation system Araucaria (Reed & Rowe, 2001) to a Wigmore-style analysis of legal evidence, and in Section 5 we will capture some of the 'logic' underlying Wigmore's charts in an outline of a formal account of evidential reasoning in terms of John Pollock's work on defeasible argumentation.

The element that unites these sections is the notion of argumentation schemes. When looking at evidential reasoning (or indeed at reasoning in general), one sees that many arguments, as well as attacks on them, are instances of recurring patterns, such as inferences from witness or expert testimonies, causal arguments, or temporal projections. The idea of systematising reasoning in terms of such argumentation schemes rather than just in terms of abstract principles of inference is the subject of much current study in argumentation theory. In fact, much AI (& Law) work can also be regarded as studying argumentation schemes (although it is usually not presented as such). For instance, we think that John Pollock's work on prima facie reasons is of this kind, as is much AI & Law research on modelling legal argument. However, to our knowledge, the only AI & Law work that addresses argumentation schemes for evidential reasoning is Lutomski (1989), who studies ways of using and attacking statistical evidence.

In light of this, the aim of this paper is twofold:

Showing how recent developments in legal evidence theory can be analysed in formal models of defeasible reasoning and utilised in software for visualising legal arguments.

Arguing for the relevance of the idea of argumentation schemes to models of evidential reasoning, and indicating a possible formalisation of reasoning with such schemes.

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The rest of this paper is organised as follows. In Section 2 Wigmore's charting method is discussed by way of an example chart, and in Section 3 the notion of argumentation schemes is introduced. Then in Section 4 the Araucaria system is applied to the example chart of section 2. Section 5 then outlines a formal account of Wigmore-style evidential reasoning with argumentation schemes, within the formal framework of Pollock (1987,1995,1998), and applies it to the same example chart. We have chosen Pollock's approach since its emphasis on epistemology makes it suitable for modelling evidential reasoning. We conclude in Section 6 with a comparison with related work and some issues for future research.

2. WIGMORE'S CHARTING METHOD

A Wigmore chart looks very much (in broad outline) like the kind of argument diagram often used in logic textbooks to visualise the inferential structure of a given specimen of natural language argumentation. In an argument diagram the various premises and conclusions are represented as statements (propositions). The diagram is a set of points joined by lines (arcs). Each point (vertex) represents a statement. Each statement is only represented once on the diagram. Each line represents an inference from one or more statements to another statement. Because it represents an inference, each line is normally drawn as an arrow, indicating a direction of the inference from premises to conclusion. Such a diagram is fairly simple. It looks like a directed graph of the kind so familiar in AI. A Wigmore chart looks like this too, but has all kinds of special features and notation that make it highly distinctive. The purpose of the Wigmore chart is to represent the proof of facts in the evidence presented on either side in a trial. Thus there are all kinds of special notations for distinguishing features like circumstantial evidence as opposed to testimonial evidence. It is best to begin with an example, to explain how the Wigmore evidence chart works.

2.1 An Example: the Umilian Case

The best source on charting is the second edition of Wigmore's Principles (1931). In this book, Wigmore (1931, pp. 62-66) used the case of Commonwealth v. Umilian (1901, Supreme Judicial Court of Massachusetts, 177 Mass. 582) to illustrate how method of evidence charts in an actual case. A combination of two small charts for one aspect of the case that Wigmore himself used (1931, pp. 56,59) is displayed below.

Each arrow represents an inference. Wigmore describes it as "provisional force given to an inference by affirmatory evidence, testimonial or circumstantial". What the arrows join together (the circles, squares, and so forth) are "kinds of evidence" representing "human assertions" offered as "testimonial facts" or "circumstantial facts" (p. 52). These could be called "facts" for short. Circumstantial evidence is represented by a square, while testimonial evidence is represented by a circle. A triangle represents corroborative evidence that strengthens or supports an inference. For example (p. 53), "No third person was near the parties when the knife was found" or "Witness stood close by, was not excited, (and) was (a) disinterested spectator". An angle represents "explanatory evidence" that explains away the effect of some other evidence (p. 53). A double bar at the top line of the angle tells us that this explanatory evidence was offered by the defendant. A dot within any of these symbols means "we now believe it to be a fact". The infinity symbol below a fact means that the fact was "observed by a tribunal, or judicially admitted or noticed" (p. 53). For example, a witness's assertion made in court on the witness stand would fit this category, or a coat shown in court (p. 52).

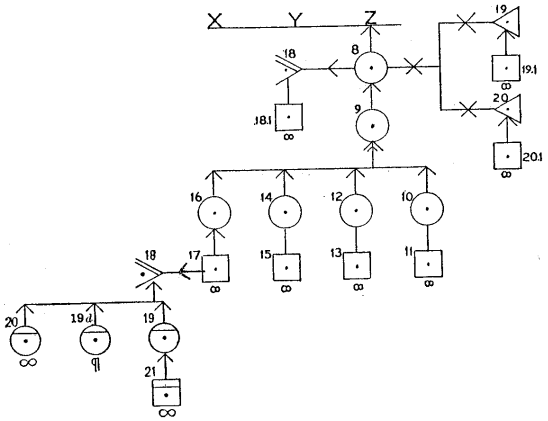

Figure 1: A Wigmore chart for the Umilian case

There are some bits of Wigmore's notation that are less clearly explained. Notice that some lines have arrows while other do not, and some lines have an X on them. The X on the line signifies that the inference represented by the line is "a strong one" (Wigmore, 1931, p. 55). Also, the positioning of the facts, that is whether the lines are vertical or horizontal, seems to be significant. Wigmore tells us "A supposed fact tending to prove or disprove the existence of another fact is placed below it", whereas an explanatory fact "tending to lessen or strengthen the force" of a fact, is place to the right or left of it.

The case of Commonwealth v. Umilian was a murder trial in which Umilian was accused of murdering Jedrusik. Wigmore presented many details of the evidence in the case. It would take too long to try to present all of this evidence. Instead we present a summary, consisting mainly of those facts of the case that are represented on the small chart in Figure 1.

2.2 Some Facts of the Case

U (Umilian) and J (Jedrusik) worked together as farm labourers until one day in December 1899 when J disappeared. In April, his headless body was found in the well 500 feet from the barn. In November, U had gone to a priest to have the marriage ceremony performed between him and a woman who had been working as a maid at the farm. He found that the priest had received a letter charging him with having a wife and children in the old country. The priest to refuse to marry him, and sent someone to investigate the letter. It turned out that J had written the letter and that its contents were not true. U was then married by the priest, but showed that he was very angry with J, and made threats of vengeance against him. There was much other circumstantial and testimonial evidence listed by Wigmore, but the gist of it, in

relation to the small chart, is that U and J were isolated in the area of the barn for the period around the murder, so if anyone other than U had committed the murder, it is highly likely that he or she would have been detected.

With every chart Wigmore presented a "key list" numbering all the facts. Below are set out the various facts from Wigmore's key list (pp. 64-66) that appear on the small chart. Z, he tells us (p. 56) is "one of the ultimate probanda under the pleadings, viz. that the accused killed the deceased". (A probandum is something that has to be proven.) Note that, since we combine two separate charts, the numbers 18, 19 and 20 are each used for two different nodes. The nodes referred to in the key list as 18(2), 19(2) and 20(2) can be found in the chart's bottom left corner.

KEY LIST

Z: The charge that U killed J.
8: Revengeful murderous emotion toward J.
9: J's falsely charging U with bigamy, trying to prevent the marriage.
10: Letter received by priest stating that U already had a family in the old country.
11: Anonymous witnesses to 10.
12: J was author of letter (although it was in a fictitious name).
13: Anonymous witnesses to 12.
14: Letter communicated by priest to U.
15: Anonymous witnesses to 14.
16: Letter's statements were untrue.
17: Anonymous witnesses to 16.
18: U's marriage being finally performed, U would not have had a strong feeling of revenge.
18.1: Wigmore does not tell us what this represents. Maybe it is witness testimony.
18(2): The witness is biased.
19: U and J remaining in daily contact, wound must have rankled.
19.1: Witness to daily contact.
19(2): The witness is a discharged employee of U.
21: Anonymous witness to 19(2).
19d: Discharged employees are apt to have an emotion of hostility.
20: Wife remaining there, jealousy between U and J probably continued.
20.1: Witness to wife remaining.
20(2): The witnesses's strong demeanor of bias while on the stand.

Putting all these components together, it is possible to get an overview of the evidence represented on the small chart, and see how all the various items of evidence fit together in an inferential structure leading to the ultimate probandum Z.

We now proceed to summarizing Wigmore's explanation of argumentation represented in the small chart (pp. 56-57,9). Circle 8 is the revengeful murderous emotion. The arrow from 8 to Z "signifies provisional force" that 8 gives to Z. 9 is J's attempt to prevent U from marrying. It gives provisional force to 8. The dot in 8 indicates that it is believed by the drawer of the chart that the revengeful emotion was excited. Angle 18, just to the left of 8, is the fact that U actually married the woman, which tends to explain away the revengeful emotion. Square 18.1 is the testimony to the fact of marriage. The infinity symbol beneath it means that the evidence was heard in court. Triangle 19 means that U and J remained in daily contact after the marriage, thus keeping the emotion alive. Triangle 20 means that the wife remained there, and thus the emotion was intensified. That covers the top half of the chart. Looking now at the bottom half, 9 represents J's attempts to prevent the marriage. Each of 10, 12, 14 and 16 are bits of circumstantial evidence that go towards supporting 9. The line across these four arrows meeting the arrow that goes to 9 represents a "composite fact" joining all four elements 10, 12, 16 and 14. Each of these is individually backed by a bit of testimonial evidence – 11, 13, 15 and 17 respectively. The composite fact line is reminiscent of what is called a linked argument in modern argument diagramming. Finally, the bottom left part of the chart (which Wigmore actually depicted as a separate chat on p. 59) represents an attack on the truthfulness of one of the witnesses. Angle 18(2), placed just left of square 17, stands for the attack that one of the witness testifying to 16 was biased, while the structure below angle 18(2) represents support for the claim of bias.

Historically, the charts were not a success. Still, there are reasons to study the Wigmore chart. The diagram, when it is stripped to its essentials, and when some newly discovered features of argument structure have been incorporated, can reveal the logical structure of evidential reasoning in a powerful way, and this structure can be extremely useful for automating legal argumentation of the kind especially prominent in evidence law. Thus the theoretical implications for logic, law and AI are quite deep.

One very important aspect of Wigmore's method, as emphasized by recent evidence scholars (e.g. Schum, 1994) is that he sees charting not primarily as an attempt to express reasons for belief but to express reasons for doubt. Wigmore's basic purpose is more critical than constructive. It is to lay bare the possibilities of doubt by making the weak points in a chain of argumentation explicit. It shares this purpose with recent developments in argumentation theory. Argumentation schemes represent typical presumptive forms of reasoning that need to be analysed and evaluated in specific cases by using matching sets of critical questions. The critical questions function as a device to help make doubts explicit.

3. ARGUMENTATION SCHEMES

Argumentation schemes are forms of argument that represent stereotypical patterns of human reasoning. They have been proposed to model structures of human reasoning that are troublesome to view deductively, and that have even been classified as fallacious in the past. Although such arguments can sometimes be fallacious, in other instances they can be reasonable. For example, appealing to expert opinion could be reasonable if the field of the expert is appropriate, and other conditions are met. But, of course, as the logic texts have so often pointed out, such arguments can sometimes be fallacious appeal to authority. One might try to "deductivize" the reasonable instances, by viewing the major premise as a conditional that is true if the authority is knowledgeable. For example, a deductivist might view the major premise as the material implication: if *X* says *A* then *A* is true. But this deductivist strategy fails, unless the authority is omniscient, meaning that epistemic closure of the knowledge base can be assumed. But it is rare, if it ever occurs, that an expert knows everything, and thus that her knowledge in a domain is beyond challenge. Thus for many, or perhaps even all cases of appeal to expert opinion, the deductivist approach does

not work. Thus the motivation for recent research into argumentation schemes has been this tension between forms of argument that are clearly reasonable in some instances, but that cannot be analysed as deductively valid (Kienpointner, 1992; Walton, 1996; Reed & Walton, 2001).

Perelman and Olbrechts-Tyteca (1969) cited numerous distinctive kinds of arguments that shift a weight of evidence on a balance of considerations. Hastings (1963) worked out the first modern taxonomy of argumentation schemes. A comprehensive list of argumentation schemes has been offered by Kienpointner (1992). Some schemes classified as presumptive in (Walton, 1996) are: argument from sign, argument from example, argument from commitment, argument from position to know, argument from expert opinion, argument from analogy, argument from precedent, argument from gradualism, and the slippery slope argument.

3.1 Argument from Expert Opinion

Argument from expert opinion is not only a very common form of argumentation, it is also highly controversial. It is represented by the following argumentation scheme in the analysis given in (Walton, 1997, p. 210).

Major Premise: Source *E* is an expert in subject domain *S* containing proposition *A*.

Minor Premise: *E* asserts that proposition *A* (in domain *S*) is true (false).

Conclusion: *A* may plausibly be taken to be true (false).

As shown by experiments in social psychology, there is a tendency to defer to experts, sometimes without questioning, resulting in fallacious appeals to authority. When confronted with such an appeal, the best reaction is to have some critical questions ready. The following six basic critical questions matching the appeal to expert opinion have been recommended in (Walton, 1997, p. 223).

1. *Expertise Question*: How credible is *E* as an expert source?
2. *Field Question*: Is *E* an expert in the field that *A* is in?
3. *Opinion Question*: What did *E* assert that implies *A*?
4. *Trustworthiness Question*: Is *E* personally reliable as a source?
5. *Consistency Question*: Is *A* consistent with what other experts assert?
6. *Backup Evidence Question*: Is *A*'s assertion based on evidence?

Expert testimony has become an increasingly important type of evidence, and is the subject of much recent investigation (e.g. Morsek, 2001; Malsch & Nijboer, 1999). For this reason the exact formulation of critical questions is worth further study. Suffice it to say that, in many cases, asking one of the basic critical questions above will lead to critical subquestions at a deeper level of examination.

3.2 Appeal to Witness Testimony

The following argumentation scheme represents the form of appeal to witness opinion as an argument. The variable *W* stands for a witness. A witness is an agent that has incoming information about things it can perceive as facts or data, and that can relay that information to another agent. The variable *A* stands for a statement (or proposition, taken to be an equivalent term).

Position to Know Premise: Witness *W* is in a position to know whether *A* is true or not.

Truth Telling Premise: Witness *W* is telling the truth (as *W* knows it).

Statement Premise: Witness *W* states that *A* is true (false).

Conclusion: *A* may plausibly be taken to be true (false).

What kinds of critical questions should be appropriate for evaluating the form of argument called appeal to witness testimony? Of course, one of the premises of the appeal to witness testimony is the assumption that the witness is telling the truth. In court, a witness takes an oath to tell the truth. As indicated by the truth telling premise, there is a general presumption that the witness is telling the truth. This premise can be a source of default if critical questions are asked that raise relevant doubts.

When evaluating an appeal to witness testimony, because it is a position to know argument, the evaluator has no direct access to the evidence that the witness presumably possesses. This form of direct verification, by observation of the facts, is not possible. Hence the best the evaluator can do is to test the consistency of the account given by the witness, to see if the account hangs together, and is consistent with other evidence that is known about the case independently of the testimony. Probing into the consistency of the witness's account is achieved by asking critical questions. Critical questions relating to consistency concern the internally consistency of what the witness said, consistency with known external facts, and consistency with what other witnesses said. Wagenaar et al. (1993, p. 38) have studied such questions in evaluating the plausibility of witness testimony in accounts offered by witnesses in trials. Other critical questions important to cite in this connection concern the bias of the witness and the plausibility of the account offered. There are many indicators of bias. One of the most important ones is the finding that witness has something to gain by testifying in a certain way. Another is the language used by the witness. For example, the language may have strong emotive connotations that are accusatory. Another indicator is the selectivity of the witness's account. The account may stress details on one side, but overlook details that should be on the other side. If a witness is biased, it doesn't necessarily follow that the witness is lying. The bias could be unintentional. This plausibility factor can react on the evaluation of the appeal to witness testimony in various ways. If the statement made by the witness is highly implausible, it can backfire on the credibility of the witness. However, in some cases, the implausibility of the statement made can actually be a basis for conjecturing that what the witness claimed is really true. For example, if two independent witnesses have made the same implausible claim, it could suggest that their observations are careful and accurate.

The role of such critical questions has been discussed extensively in legal literature on witness testimony and examination. Schum (1994, p. 325) has identified three requirements of the credibility of the testimony of a witness that can be questioned: (1) veracity, or whether the witness believes what she said, (2) objectivity, or whether what was reported corresponds to the event believed, and (3) observational sensitivity, or observations of linkages between events. Bromby and Hall (2002) devised a system to advise on the credibility of witness testimony by citing factors of (1) competency, (2) compellability, including the connection between the witness and the accused and any immunity the witness may have, and (3) reliability, which includes position to know factors. There remain many fine points to be clarified. What is most important here, however, is to see how sequences of dialogue in legal cases can involve complex argumentation in which asking critical questions can increase or decrease the probative weight of an appeal to witness argument as evidence.

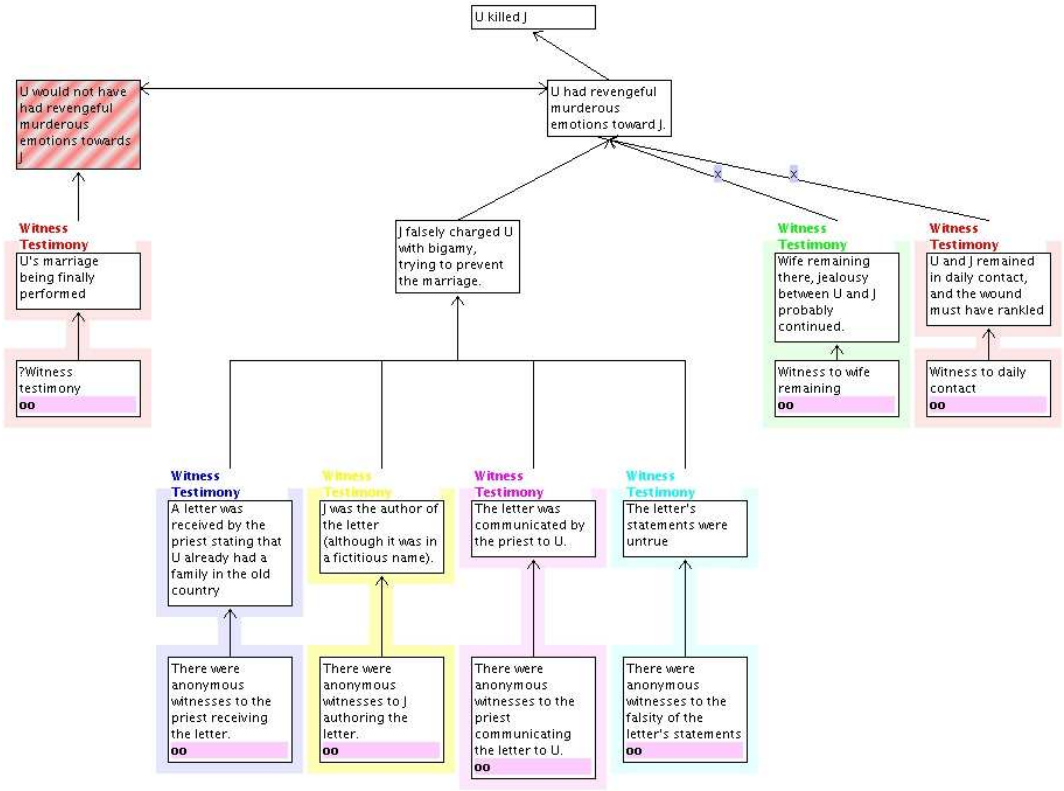

Figure 2: The Umilian case in Araucaria

4. THE CASE IN ARAUCARIA

In this section we look at Wigmore's charts as a forerunner for modern software for visualising argumentation. In recent AI & Law research several such systems have been proposed, notably Loui et al.'s (1997) Room 5 system and Verheij's (1999) ArguMed system. Moreover, Carr (2003) has investigated the use of Questmap (Conklin & Begeman, 1988) to the teaching of legal argumentation. We instead use the Araucaria system, since a main feature of that system is its support for reasoning with argumentation schemes. After a brief outline of the system, we apply it to the Umilian case as charted by Wigmore.

4.1 The Araucaria System

The aim of Araucaria is to provide a means for both students and scholars of argumentation to analyse the structure of natural argument and be able to exchange and discuss analyses using a common format, the Argumentation Markup Language (Reed & Rowe, 2001). In addition to being used for teaching in universities and schools, it is also being used in the construction of an online research corpus of natural argumentation (Katzav *et al.*, 2003).

One of the unique features of Araucaria is its handling of argumentation schemes. It supports user definition of custom sets of schemes, and currently includes two sets, one corresponding to Walton's taxonomy (Walton, 1996), and the other to a classification developed during the course of corpus construction. For the definition of any given argumentation scheme, Araucaria supports the characterisation of conclusion, premises and critical questions for the general scheme, and then allows instances of that scheme to be associated with particular parts of a given argument. The system then displays a list of critical questions for that scheme, thus suggesting possible counteraguments to the user.

In diagramming, premises are placed below conclusions, and both propositions and the connections between them can be labelled (according to their provenance or evaluation). In cases where a complex of propositions is joined through an argumentation scheme, the entire complex is highlighted and labelled with the scheme. A counter-argument is shown in a shaded box linked by a horizontal arrow to the proposition to which it is a counter.

Araucaria performs no natural language understanding; it functions simply as a tool for the analyst, allowing the identification of propositional components, their interrelations, and their evaluations and dialectical role (each node can be marked to indicate who it is to be attributed to, and to indicate evaluative strength probabilistically or qualitatively).

4.2 Visualisation of the Umilian Case

Araucaria's can be used to diagram the Umilian case, easily handling the various classes of information in Wigmore's original, with only one or two deviations. Thus, the relationships between premises and conclusions is in the same arrangement, with Wigmore's 'composite fact' concerning J's letter rendered as a linked argument (in which the premises exhibit a mutual inter-dependence in order to demonstrate the conclusion), and the murderous emotions conclusion acting as a premise for the conclusion that U killed J. One apparent difference in the structure concerns the refutation: where Wigmore conflates the implicit counter-argument with the support for that counter-argument, Araucaria provides both explicitly, showing the counter-argument in the shaded box, and then the support for it beneath. Araucaria also distinguishes between explicit and enthymematic (implicit) components of an argument, to make it useful for researchers in argumentation who argue that reconstruction is an important stage in argument analysis. Araucaria's handling of enthymematic components thus means that the fact that the counter-argument is implicit is thus also represented (in the diagram, by hatching).

The instances of witness testimony are captured in the seven uses of the Witness Testimony scheme, and in each case, the premise is marked 'oo', to indicate its explicit presentation to the court (matching Wigmore's 'infinity' symbol). Notice that in this analysis, we are therefore providing a type to the argument (*viz.* Witness Testimony) rather than to the premise (the witness's actual testimony), since it is conceivable that the same evidence might be used in some other argument (say in establishing the reliability of a particular witness).

Finally, Wigmore offers a range of labels for links between claims; an example of his marker for a strong argument, 'x', is shown in this Araucaria analysis in the two left-hand supports for the claim about murderous emotions.

5. OUTLINE OF A FORMAL ACCOUNT

In this section we outline a formal account of the reasoning underlying Wigmore's charts. In doing so we will ignore the 'syntactic sugar' used by Wigmore and concentrate on the following elements: the nodes (with possibly a ∞ label), the vertical links and the horizontal links.

Which formal account is plausible? Schum (1994) seems to interpret them as a predecessor of Bayesian probabilistic networks. A strong point of such networks is their theoretical foundation in probability theory. However, they require a large amount of probabilistic input information that is often not available. We propose instead to regard Wigmore's charts as a forerunner of theories of defeasible argumentation. In particular, we interpret the nodes as standing for propositions, the vertical links as expressing defeasible inferences, and the horizontal links as being relations of attack or defeat between arguments.

To capture the defeasible reasoning underlying the charts, we choose to use Pollock's argument-based framework for defeasible reasoning (see e.g. Pollock 1987,1995,1998), since Pollock's emphasis on epistemological reasoning is very relevant for evidential reasoning, and his notion of prima facie reasons is very similar to the notion of argumentation schemes. In applying the framework, we will for simplicity restrict ourselves in the following ways: we do not discuss suppositional arguments, and we ignore issues of strength of arguments; instead, we focus only on the representation of evidential knowledge and on the construction of evidential arguments and counterarguments with such information. Moreover, since we aim to give a general picture of how evidential reasoning fits into the formal framework, we will suppress many technical details.

5.1 Outline of Pollock's Framework

Essentially, Pollock augments the inference rules of classical logic (which he calls "strict reasons") with a set of defeasible inference rules (which he calls "prima facie reasons"), and he defines how defeasible inferences can be attacked. Prima facie reasons are not meant to express domain-specific generalisations (as in e.g. default logic); Pollock intends them to be general epistemic principles for obtaining beliefs from other beliefs and perceptual inputs, such as memory, statistical reasoning and induction. Arguments can be constructed by chaining reasons, starting from given input information (INPUT). As usual in logic, arguments can be represented in two alternative ways. To express the order in which the inferences are made, they can be displayed as deductions, i.e., as sequences of formulas that are either in INPUT or are derived by applying a reason to one or more earlier members in the sequence. To represent instead the inferential dependencies between the propositions in an argument, arguments can be depicted as AND trees, where the links represent applications of reasons. Finally, Pollock combines sets of such trees into an AND/OR graph and adds defeat links between nodes, resulting in an "inference graph". Clearly, such a graph is very similar to a Wigmore chart.

Pollock defines two ways in which a (defeasible) argument can be defeated. Such an argument can be *rebut* with an argument for the opposite conclusion, and it can be *undercut* with an argument why a prima facie reason does not apply in the given circumstances. Consider, for instance, an argument "The suspect was at the murder scene at the time of the murder since witness John says so" (applying a prima facie reason "if a witness says φ, one may infer φ"). This argument is rebut by another application of the same reason: "The suspect was not at the murder scene since witness Bob says he was with him in the pub at the time of the murder, and one cannot be in two places at the same time". And the argument is undercut by "It was too dark, so John could not

have made a reliable identification" (applying another reason "if a witness says φ but the circumstances make reliable observation of φ impossible, one may not infer φ"). Intuitively, undercutting attacks do not argue that the attacked conclusion is false, but only that the conclusion is not sufficiently supported by its premises.

Finally, given a collection of arguments and their defeat relations, the dialectical status of an argument must be defined, to identify the defeasibly valid inferences. Pollock's definition is equivalent to preferred semantics, but nothing prevents the use of another appropriate semantics, such as grounded semantics (used by e.g. Prakken & Sartor, 1996).

What makes Pollock's approach especially interesting for us is his work on the various kinds of prima facie reasons, resulting in a general theory of epistemic defeasible reasoning. For present purposes, five reasons are especially relevant. We now paraphrase them and some of their undercutters as defined by Pollock (1987,1995,1998). Mostly, Pollock states them with numerical probabilities, but since, as noted above, in legal contexts reliable numbers are often not available, we give qualitative versions. We also leave Pollock's so-called "projectibility" conditions and some technical detail implicit. As for notation, if principle R says that P is a prima facie reason for Q, then "S is an undercutting defeater of R" is shorthand for "S is a prima facie reason for "P is not a prima facie reason for Q"" (this presupposes that reasons can somehow be expressed in the object language).

The full picture can be summarised as follows. First *perception* is applied to sense data, yielding specific beliefs, and *memory* is used to record and retrieve these data. Then *induction* infers general rules from them, after which the *statistical syllogism* derives new specific beliefs from these rules. Finally, beliefs thus derived *persist* over time.

R1: Perception: *Having a percept with content φ is a prima facie reason to believe φ*

In legal contexts perception applies to witness testimonies, but also to tangible evidence as presented at trial. Pollock (1987) formulates a general undercutter for perception, which we paraphrase as follows:

"The present circumstances are such that having a percept with content φ is not a reliable indicator of φ" undercuts R1.

Clearly, this undercutter is just the tip of the iceberg of theories on the reliability of perception.

R2: Memory: *Recalling φ is a prima facie reason to believe φ.*

One undercutter (Pollock, 1987) is: *"φ was originally based on beliefs of which one is false" undercuts R2.*

R3: Statistical syllogism: *'c is an F' and 'F's are usually G's' is a prima facie reason for 'c is a G'*

This principle drives default reasoning with empirical generalisations. The main undercutter is subproperty defeat (which we give in a weak and a strong qualitative form):

'c is an F&H' and 'it is not the case that F&H's are usually G's' is an undercutter of R3.

'c is an F&H' and 'F&H's are usually not G's' is an undercutter of R3.

R4: Induction: *'most observed F's were G's' is a prima facie reason for 'F's are usually G's'*

Pollock formulates various undercutters to induction based on *bias of samples*.

R5: Temporal persistence: *Believing that φ is true at T_1 is a prima facie reason for believing φ at a later time T_2.*

Temporal persistence is an important aspect of evidential reasoning. For instance, in civil cases the usual way to prove that one has a legal right (e.g. ownership) is to prove that the right was created (e.g. by sale plus delivery). The other party must then usually prove later events that terminated the right. The Umilian case illustrates that temporal-persistence arguments are also common in criminal cases (see Section 5.5 below).

The (implicit) condition of projectibility is very important for this principle: clearly, many propositions, such as a position of a moving object, do not typically persist in time, so they are not "temporally projectible".

The general scheme for undercutters of temporal persistence arguments is *"Having reason to believe ¬φ at T_2 between T_1 and T_3 is an undercutter of R5".* (Actually, Pollock restricts this to percepts of ¬φ).

This completes our very brief overview of Pollock's theory of eistemic defeasible reasoning. We will now discuss how evidential reasoning as captured in Wigmore's charts can be reconstructed within this theory. Two notions are especially important: generalisations and argumentation schemes.

5.2 Generalisations

One point stressed by current evidence theorists (e.g. Twining 1999) is the key role of empirical generalisations in evidential arguments. According to Schum (1994), such generalisations, which lawyers usually leave implicit, are the "glue" which holds evidential arguments together. For example, in Wigmore's chart of the Umilian case, the inference of node 8 from node 9 is arguably based on "If x tries to prevent y's marriage with false claims, a revengeful murderous emotion from y towards x tends to be created". Clearly, the probative force of the inference depends to a large extent on the strength of this generalisation. (Interestingly, Wigmore's chart also contains an explicit generalisation, viz. 19d).

5.2.1 Obtaining and Applying Generalisations

In Pollock's framework, generalisations are applied with the statistical syllogism, and part of their critical testing can be modelled as the search for counterarguments. One subtlety not captured by our current qualitative version of the syllogism is that generalisations often come with different modalities, such as "almost always, probably, usually, sometimes". This is an issue that we leave for future research.

Something also seems to be missing from Pollock's original account. Pollock simply assumes that all generalisations are based on the reason from *induction*, and that attacks on generalisations can be expressed as undercutters of this reason. However, the generalisations used in evidential reasoning are often not based on careful empirical testing. In fact, according to Twining (1999) they are often based on folk beliefs, infected with value judgements, prejudice or ideology, and so on. Therefore, the induction scheme must be supplemented with other sources of

generalisations, and suitable undercutters for these sources must be formulated. We now briefly sketch how this could be done.

Anderson (1999) distinguishes five kinds of generalisations according to their sources: scientific, expert-based, general knowledge, experience-based and belief-based generalisations. The first source is captured by the induction scheme and the second source will be captured by the expert testimony scheme (see below). Experience-based and perhaps also belief-based generalizations seem to be based on a commonsense counterpart of scientific induction (briefly discussed by Pollock 1995, pp. 82-3). Furthermore, the general-knowledge source could be formulated as a new prima facie reason:

R6: general knowledge: *'It is general knowledge that φ' is a prima facie reason for φ*

Possible undercutters are that a piece of general knowledge is infected by prejudice or value judgements, etcetera.

A typical argument then looks as follows (ending each line with the reason with and the preceding lines from which the line is inferred, and suppressing classical reasoning steps):

1 It is general knowledge that "If x tries to prevent y's marriage with false claims, then usually a revengeful murderous emotion from y towards x is created". (INPUT)

2 So (presumably) If x tries to prevent y's marriage with false claims, then usually a revengeful murderous emotion from y towards x is created (1, R6)

3 J tried to prevent U's marriage with false claims (INPUT)

4 So (presumably) a revengeful murderous emotion from U towards J was created" (2,3,R3)

If R6 is not regarded as an argumentation scheme but as a generalization, an extra line 1' between 1 and 2 must be added containing that generalization, and 2 is then derived by from 1 and 1' by the statistical syllogism.

5.2.2 Attacking Generalisations

As said above, critically testing generalisations is just as important as obtaining and applying them. In our account, four ways to attack a generalisation can be modelled.

1 *Attacking that they are from a valid source of generalizations*, e.g. "it is not general knowledge that If x tries to prevent y's marriage with false claims, then usually a revengeful murderous emotion from y towards x is created".

This attack can be modelled as a rebutting attack on a subargument for the intermediate conclusion that something is general knowledge.

2 *Attacking the defeasible derivation from the source*, for instance: "it is indeed general knowledge that if x tries to prevent y's marriage with false claims, then usually a revengeful murderous emotion from y towards x is created, but this particular piece of general knowledge is infected by folk belief".

This attack can be modelled as an undercutter of R6.

3 *Attacking application of the generalisation in the given circumstances.* This can be modelled as the application of applying more specific generalisations (e.g. "If x tries to prevent y's marriage with false claims but y is known to be not violent and aggressive, then usually not a revengeful murderous emotion from y towards x is created", or the weak form with "not usually") Then the subproperty defeater of the statistical syllogism undercuts the use of the general default.

4 *Attacking the generalisation itself.* Such an attack takes the form of an argument for the negation of the attacked generalisation (provided that this can be expressed in the object language). An example of such an attack is the combination of the above more specific generalisation with the claim that the additional condition is not unusual, or perhaps even that it is usual, as in "People are usually not aggressive and violent".

The main difference between attacks of the third and the fourth kind is that the third kind of attack accepts the generalisation as a general rule, but denies its application in the case at hand, while the fourth kind of attack denies the generalisation as a general rule ("it is not the case that usually ..."). A detailed discussion of this difference would involve much logical detail, which is outside the scope of the present paper.

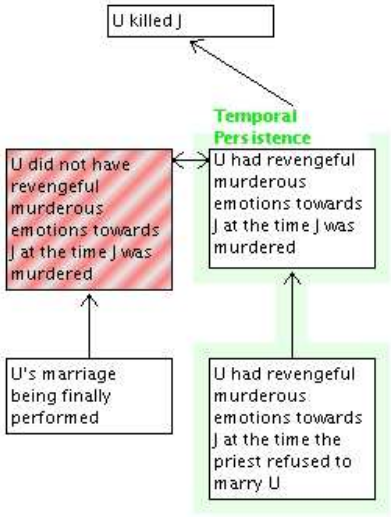

Figure 3: temporal persistence in the Umilian case

5.3 Argumentation schemes

We now turn to the formulation of argumentation schemes in Pollock's framework, focusing on the schemes from expert and witness testimony. The main question is whether these schemes must be regarded as additional prima facie reasons or as empirical generalisations: in the latter case applying the schemes boils down to applying the (qualitative) statistical syllogism. Technically, the main difference is that the body of reasons is fixed while generalisations can be inferred from, and attacked on the basis of, other knowledge. Now, is it conceivable that someone wants to argue against the expert and witness testimony schemes in general? Or will all attacks take the form of rebutters or undercutters of applications of these schemes? We tentatively believe the latter. Therefore, we will formulate the two testimony schemes as additional prima facie reasons. However, formulating them instead as generalisations is straightforward: what below are undercutters must then be formulated as the second premise of the subproperty defeaters of the statistical syllogism.

We first discuss the scheme from witness testimony. In fact, several treatments are possible. Because of space limitations, we can discuss only one of them, following the terminology of Schum (1994). Let us first (rather arbitrarily) assume that the veracity of witnesses may be presumed (alternatively, it can be regarded as an additional premise of R7 below). Then the scheme can be formulated as the following reason:

R7: Witness testimonies: *'Witness W says φ' is a prima facie reason for believing φ.*
We define the following undercutter for this scheme: *"Witness W is not truthful" is an undercutter of R7.*

There is no need to formulate lack of a witnesses's objectivity and observational sensitivity as additional undercutters of this scheme. This is since a witness will always tell about his or her past observations, so φ will in practice always be of the form "I recall that I observed ψ". So reasoning with witness testimonies is in fact a chain of three prima facie reasons: the witness testimony reason, the memory reason, and the perception reason: first the witness scheme is used to infer "I recall I observed ψ", then the memory scheme provides "I observed ψ" and finally the perception scheme yields ψ. Thus lack of objectivity is handled by undercutters of both memory and perception, and defects in observational sensitivity by undercutters of perception.

Our treatment of the scheme from expert testimony is simpler:

R8: Expert testimonies*: 'E says φ' and 'E is expert about φ' is a prima facie reason for believing φ.*

Of the critical questions listed above in Section 3.1, we believe that the first is a matter of adding strength of reasons to our account, the fifth searches for rebutting applications of the same scheme, while the second and third question seem to be challenges of the premises of R8. This leaves the trustworthiness and backup evidence question as possible pointers to undercutters. But other interpretations may be possible.

5.4 A Formal Account of the Umilian Case

Obviously, the Umilian case contains several uses of the witness testimony scheme. Wigmore discusses one attack on such a use, viz. an attack on the inference of 16 from 17 on the ground that the witness was a discharged employee of the suspect (angle 18(2) and its supporting child nodes). This is an undercutter, concluding to "the witness is not truthful". The case also seems to contain two applications of the temporal persistence scheme (although Wigmore's chart leaves them implicit. Firstly, the revengeful emotion created when the priest refuses to marry U is assumed to persist till the time of the murder (shown in Figure 3 as a possible extension of Figure 2). This persistence argument is undercut by the argument that the emotion disappeared when the priest still agreed to marry U. This conclusion in turn persists till the time of the murder. Arguably, this application of temporal persistence is undercut by the argument that the emotion was recreated since U and J remained in daily contact and U's wife also remained there. The other inferences in the chart all seem to be based on implicit generalisations, which all seem to be of the general-knowledge, experience-based or belief-based type.

Computing the dialectical status of node 8 in our Pollock-style reconstruction, two sources of doubt prevent it from being a defeasible consequence of the theory. The first is the rebutting argument for node 18. This attack should be neutralised either by looking at the relative strength of the conflicting arguments, or by somehow undercutting the appeals to witness testimony on which node 18 is based. The second source of doubt is that one of the supporting child nodes, node 16, is undercut. This attack can be neutralised by providing alternative evidence of 16, or by attacking the argument that witness 17 is biased. An obvious target for such an attack seems the generalisation 19d.

6. CONCLUSION

In this paper we have studied how some common reasoning forms used in evidential legal reasoning can be analysed within general theories of defeasible reasoning and argumentation. We have seen that within Pollock's logic for defeasible argumentation a natural account can be given of two key concepts of evidential reasoning, viz. argumentation schemes and generalisations, in a way that captures the spirit of both Wigmore's charts and recent research of evidence theory scholars. We have also shown how the visual aspects of Wigmore charts can be captured in the Araucaria software and enhanced with support for visualising reasoning with argumentation schemes.

Verheij (2000) has earlier proposed that legal reasoning about evidence can be modelled as defeasible reasoning. In particular, he argues like us that the empirical generalisations used in evidential arguments can be modelled as default rules. He also applies his argument visualisation software ArguMed to an example. The main difference with Araucaria is the lacking in Argumed of the notion of argumentation schemes. Furthermore, Verheij (2002) suggests like us that argumentation schemes can be regarded as defeasible inference rules and negative answers to some critical questions as undercutters.

As for future research, our formal account should be further developed by adding qualitative means to express strength of evidential arguments. Also, more evidential argumentation schemes must be investigated, such as schemes for causal reasoning. Another important research topic is how allocations of the burden of proof can be made context-dependent rather than hardwired in the knowledge representation (cf. Prakken, 2001). Finally, as for visualising argumentation, a full formal underpinning of Araucaria in terms of our formal account should be investigated.

As a final remark, it should be noted that we have employed a high level of abstraction, focussing on the place of evidential reasoning forms in a general theory of reasoning. When applying our account to real cases, it must be supplemented with detailed knowledge-engineering research on sources of doubt of evidential arguments. Nevertheless, we think that our account has provided a framework in which such detailed research can be put to use.

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