

Visualization tools, argumentation schemes and expert opinion evidence in law

DOUGLAS WALTON †

*Department of Philosophy, University of Winnipeg, Winnipeg,
Manitoba R3B 2E9, Canada*

[Received on 27 January 2007; received on 13 July 2007; accepted on 14 July 2007]

Presented at the workshop on “Graphic and visual representations of evidence and inference in legal settings” at Cardozo School of Law, New York City, 28th – 29th January 2007.

New models of evidential reasoning have been closely tied in with the development of visualization tools in artificial intelligence, especially automated systems for argument diagramming. Surveying several models and visualization tools recently developed in artificial intelligence, this paper argues that any discussion of visualization methods or tools of this sort should focus on their suitability for visualizing argumentation schemes, including critical questions. The classic scheme, used in this paper to illustrate how schemes need to be a vital part of advancing argumentation technology in tools for evidence visualization in law, is that for argument from expert opinion. The visualization of argumentation schemes is illustrated using a new version of the scheme, which takes into consideration Supreme Court rulings on the admissibility of expert witness testimony.

Keywords: questioning expert testimony; evidential reasoning; argument diagrams; artificial intelligence in law; argumentation technology.

1. Introduction

As shown by several of the papers in this special issue, current technology being developed for argument visualization, much of it based on an argumentation model and using new tools from argumentation theory, shows much promise in solving problems of interest to the community of scholars studying evidence in law. The notion of an argumentation scheme is central to this technology. It will be the contention of this paper that any discussion of visualization methods or tools should focus on their suitability for visualizing argumentation schemes, including critical questions. Argumentation schemes are stereotypical patterns of reasoning used in everyday conversational argumentation and other contexts, notably legal and scientific argumentation (Walton and Reed, 2003). The leading systems for analysing, evaluating and visualizing arguments of the kind of central importance to evidence law, described by the other papers in this volume, use argumentation schemes as their central structure for representing different species of reasoning from premises to a conclusion. Argumentation schemes are especially important for representing the notion of evidence because each different kind of evidence has its own distinctive structure of reasoning or argumentation scheme (Prakken, 2003).

† Email: d.walton@uwinnipeg.ca

There is already a considerable literature in the field of argumentation studies on the argumentation scheme for argument from expert opinion, and in particular how this form of argument can be rebutted or undercut by the asking of critical questions (Walton, 1997; Reed and Walton, 2005; Gordon, 2005; Gordon and Walton, 2006). In the argumentation literature, the problem has been posed as one of how to evaluate an argument from expert opinion when one of the critical questions matching the argumentation scheme is asked (Walton and Reed, 2003). As it happens, this particular form of argument has also been of central and intense concern in Anglo-American evidence law in the past three decades, and the courts are in the process of developing and refining criteria used to determine the admissibility and judge the evidential value of expert opinion testimony. The strategy of this paper is to use this particular scheme to illustrate the lessons to be learned from all argumentation schemes of this general sort concerning the development of argumentation technology as it relates to the evaluation, analysis and evaluation of evidence in law. There is simply no space to deal with all the schemes in this paper, and it makes sense to use argument from expert opinion as the example of a scheme to be considered, given that this particular form of reasoning is of such central importance in law as it relates to evidence.

In the present paper, it is shown that the legal formulation of argument from expert opinion needs to take a different form from the one currently accepted in argumentation studies. The courts have developed specific criteria for the admissibility of expert opinion testimony, from Frye and Daubert onwards, that need to form the basis of the new version of the scheme. The new scheme specifically designed in this paper to deal with problems of both the admissibility and the evaluation of expert opinion testimony in law is more precisely formulated for use in a trial format as a form of evidence. A set of critical questions matching this new legal argumentation scheme is also presented. Both are based on the legal wisdom furnished by the cases tried by the courts in recent years, as well as on the existing structure of the scheme for argument from expert opinion.

2. Argumentation schemes introduced

Even those of us who are not specialists in logic, artificial intelligence or other technical disciplines that have to do with the modelling of reasoning know that, for a long time, the two models of rational argument that dominated logical reasoning were deductive logic and inductive reasoning of the kind used in statistics and the standard (Bayesian) probability calculus. The schemes that have proven to be of most interest, not only for modelling the kind of reasoning so commonly used in analysis and evaluation of evidence in law but also for studying ordinary conversational argumentation, do not fit either of these quantitative models. They are qualitative, as opposed to quantitative, in several senses. Arguments fitting the schemes can be evaluated on a priority basis as stronger or weaker, but it is not generally so useful to rate the strength or weakness in a quantitative or numerical way. They need to be evaluated in relation to what is called the context of dialogue, in which there is a standard of proof for the success of an argument set at the opening stage of the dialogue. Arguments fitting schemes of this sort are used to respond to doubts and questions expressed by a second party to whom the argument was addressed in a dialogue. Such arguments are defeasible in a way different from the deductive and inductive kinds of arguments that we are traditionally familiar with. They are defeasible (open to defeat) through the asking of critical questions that match the scheme. A burden of proof, so-called, shifts back and forth between the proponent and the respondent as critical questions are asked and answered. Thus, the worth of an argument depends on its procedural status as a dialogue proceeds from an opening stage through an argumentation stage to a closing stage.

This paper is on argumentation schemes of this sort, the critical questions that match these schemes and the role of such schemes and critical questions as tools for argument visualization, analysis and evaluation, especially as related to legal evidence. There are many argumentation schemes of this sort. The latest research recognizes some 65 of these schemes.¹ They are the historical descendants of the so-called topics of Aristotle, traditionally thought to be useful for inventing arguments as well as for analysing them. Quite a few schemes have been identified and studied in the recent literature—see [Hastings \(1963\)](#), [Perelman and Olbrechts-Tyteca \(1969\)](#), [Kienpointner \(1992\)](#), [Walton \(1996\)](#) and [Grennan \(1997\)](#). Independently, some schemes especially fundamental in scientific reasoning have been studied in artificial intelligence. Pollock's (1995) OSCAR identified a few of these schemes and [Josephson and Josephson \(1994\)](#) provided an analysis of abductive reasoning that can be easily seen as representing an argumentation scheme. Increasingly, schemes are being recognized in computational domains like multi-agent systems as holding potential for making significant improvements in the reasoning capabilities of artificial agents used as argument assistants for lawyers ([Verheij, 2005](#)). Most of the schemes that are of central interest in argumentation theory represent forms of plausible reasoning that do not seem to fit very well into the traditional deductive and inductive models. Such schemes are called 'presumptive' in [Walton \(1996\)](#). However, it is quite possible to treat familiar deductive and inductive forms of reasoning as schemes as well ([Grennan, 1997](#)).

Some of the most common presumptive or plausible reasoning schemes are the following: argument from witness testimony, argument from position to know, argument from expert opinion, argument from popular opinion, argument from example, argument from analogy, practical reasoning (from goal to action), argument from verbal classification, argument from vagueness of a verbal classification, argument from sign, argument from popular practice, argument from sunk costs, argument from appearance, argument from ignorance (lack of evidence), argument from cause to effect, argument from correlation to cause, abductive argumentation scheme, argument from consequences, argument from alternatives, argument from threat, argument from fear appeal, argument from pity, argument from commitment, *ad hominem* argument (various subtypes), argument from inconsistent commitment, argument from bias, argument from gradualism, slippery slope argument (various types), argument from an established rule, argument from an exceptional case and argument from precedent. Each scheme has a set of critical questions that represent standard ways of critically probing into an argument to find its potential weak spots. The original motivation of schemes was to help teach university students skills of critical thinking, e.g. of the kind needed to write an essay. Thus, they are typically expressed in a way that needs more cleaning up if they are to be formalized in a manner that would make them more useful for artificial intelligence ([Verheij, 2003](#)). Another problem with schemes concerns the distinction between merely questioning an argument and what could be called rebutting it, meaning to attack the argument by offering evidence against it. This distinction is fundamentally important for informal logic, where we have to counsel students that it is possible to merely question an argument critically without trying to refute it by posing a counter-argument.

[Pollock \(1995\)](#) drew an important distinction between two kinds of arguments that can attack and defeat another argument, calling them rebutting defeaters and undercutting defeaters. A rebutting defeater (rebutter) gives a reason for denying a claim ([Pollock, 1995](#), p. 40), and therefore, it can be said that a rebutter attacks the claim or conclusion of the argument it is aimed at. An undercutting

¹ As noted above, in the literature on schemes, one is typically used as the classical example, namely argument from expert opinion.

defeater (undercutter) has a different aim. It attacks the inferential link between the claim and the reason rather than attacking the claim (p. 41). This distinction seems clear enough in principle, but it is very easy to get in trouble with. It is best to cite Pollock's (1995, p. 41) leading example.

For instance, suppose x looks red to me, but I know that x is illuminated by red lights and red lights can make objects look red when they are not. Knowing this defeats the prima facie reason, but it is not a reason for thinking that x is *not* red. After all, red objects look red in red light too. This is an *undercutting defeater* (Pollock's italics).

The object may still be red, for all we know, despite the undercutter stated above. The new data undercut the original argument by removing the support of the inferential link between the premises and the conclusion. But it does not rebut the original argument by showing that the conclusion is false.

Schemes for defeasible argumentation are being widely applied to examples of everyday conversational argumentation in studies on informal logic. But can they be applied to law, where the management of expert opinion evidence is not only fundamentally important but also highly controversial and subject to considerable ongoing controversy? Verheij (2003) showed that schemes are potentially useful in law and artificial intelligence, but they have many rough edges that need to be smoothed out before they can be formalized in a manner that would make them useful for computing. He chose *argumentum ad hominem* as his example scheme for analysis, but many of the same basic points can be made about any scheme, as will be shown by considering argument from expert opinion.

3. Argument from expert opinion

Expert opinion evidence has itself been very controversial within law as a form of argument to be judged as admissible and to be evaluated in trials (Kaye *et al.*, 2004). Standards are still in a process of evolution, and some fundamental issues appear to still not be resolved. An open question is the extent to which argumentation schemes need to be tailored to specific domains, and in particular whether argument from expert opinion might be much more manageable in evidential reasoning in law if the scheme was to be expressed in a format compatible with the framework of a legal system like that of American law and the standards and methods currently being developed in that framework for managing this kind of evidence in trials (Godden and Walton, 2006). Some moves in this direction would be extremely useful to explore, and would greatly enrich the value of argument visualization tools as applied to evidential reasoning in law. The scheme representing argument from expert opinion as a form of argument was formulated in Walton (1997, p. 210) as follows:

Scheme for Argument from Expert Opinion

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

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

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

The six basic critical questions matching the appeal to expert opinion, as indicated in Walton (1997, p. 223), are listed below.

Critical Questions for Argument from Expert Opinion

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 E's assertion based on evidence?

The expertise question is based on the assumption that the expert has knowledge in a field or practical mastery of a skill. In the conventional formulation of the argumentation scheme for argument from expert opinion used in argumentation studies, one of the critical questions is the trustworthiness question. The trustworthiness question concerns the general ethical trustworthiness of the expert as a source that can be relied upon to tell the truth.² Asking it casts doubt on the assumed honesty and objectivity of the expert as a source. Each critical question can have critical subquestions under it.

Schum (1994, p. 107) treats factors like previous convictions related to dishonesty, other misconduct related to dishonesty, character evidence regarding honesty and testimonial bias, under the heading of veracity. He treats objectivity as a separate factor in assessing witness credibility. Schum and Morris (2007) distinguish between two primary categories of assessing witness testimony that they call competence and credibility. Under the general category of competence, they cite four factors: 'appropriate sources', 'in a position to observe', 'understanding of what was observed' and 'ability to communicate'. Under the general category of credibility, they cite three factors: 'veracity', 'objectivity' and 'observational sensitivity'. In their analysis, they emphasize that these two major categories are frequently confused, leading to serious inferential errors. This method of classification is highly significant, not only because it is the basis of the structure of inference used in the Mace system developed by Schum and Morris for assessing witness testimony but also because it is consistent with the experience regarding witness testimony accumulated in our legal system since the year 1352 (Schum, 1994, p. 106). Thus in Section 9 below, when we turn to the task of revising the argumentation scheme for argument from expert opinion to reconfigure it in a form suitable for legal use, we will adapt the structure to Schum's format. One of the subquestions of the trustworthiness question is the bias question. This question asks whether the expert is biased to one side or the other in the dispute at issue. For example, it might be questioned whether an expert is biased based on the claim that the expert has something to gain, e.g. financially, by supporting one side or the other of the issue being disputed. According to Kaye *et al.* (2004, p. 335), one of the most frequent criticisms of experts in trials is that they exhibit undue partisanship. They are even said to become 'the hired mouthpieces for the parties' points of view instead of objective spokesmen for scientific truth'. Since experts are generally paid to testify by a side, they are often criticized as hired guns, sometimes with very good justification. It was pointed out by Kaye *et al.* (2004, p. 341) that even though the 'true' expert for hire may not be all that common in the courts, there are still a number of more subtle problems that stem from partisan expert opinion evidence, including selective presentation of evidence and testimony shaded to support the party paying the expert.

It should be noted as well that argument from expert opinion can be seen as resting on a defeasible generalization DGE: whenever source E is an expert in subject domain D containing proposition A who asserts that proposition A (in domain D) is true (false); generally (but subject to exceptions), A may plausibly be taken to be true (false). Such a generalization can be seen as an implicit premise

² See Walton (1997, p. 215) for a fuller account of the trustworthiness question.

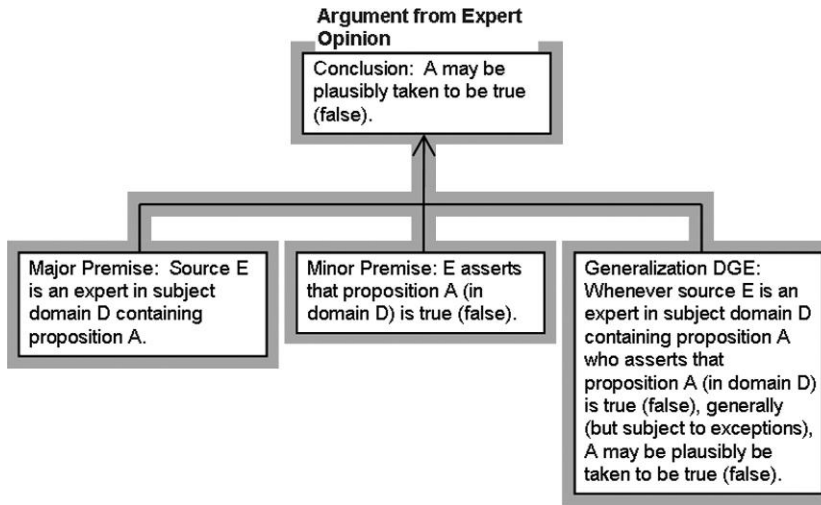


FIG. 1. Argument from expert opinion with scheme and generalization.

of the scheme for argument from expert opinion.³ Corresponding to every defeasible argumentation scheme is a generalization of this sort that links the premises to the conclusion. This generalization rests on the presumption in favour of expert opinion. In Toulmin terminology, the generalization is the warrant of the inference (Reed and Rowe, 2006).

How a generalization provides support for warranting an argument from expert opinion can be illustrated in the Araucaria diagram in Fig. 1.

The structure in Fig. 1 shows how the generalization provides an additional premise for the argumentation scheme for argument from expert opinion. The defeasible generalization holds as a premise in a normal kind of case, but it can default in an exceptional case, and the argument from expert opinion will fail, once the case is shown to be exceptional by a critic.

There has been a problem with how the set of critical questions matching a scheme should be handled as a device that can be used in an automated system of argument analysis and evaluation. In 2001, Chris Reed posed the question of whether the critical questions can be represented on an argument diagram as implicit premises of the argument. The other critical questions can be seen as implicit premises because the argument does not hold up without these assumptions being part of it. Questions 4 and 5 are different. If there is evidence that the cited expert is biased or dishonest, that attacks the argument, but to advance such an attack, the questioner surely has to produce some evidence of bias or dishonesty. And if the expert's assertion can be shown to be inconsistent with what other experts in the same field say, that allegation is only an effective criticism if it is backed with some evidence concerning what these other experts have said. The difference between the other critical questions and questions 4 and 5 could be described as one of the burden of proof. You could say that critical questions 4 and 5 have a positive burden of proof attached, whereas the other critical questions demand a response once asked, even if no evidence is given to back them up. Thus, the problem of how to manage critical questions relates to the more general problem of burden of proof in argumentation.

³ See Anderson *et al.* (2005, Chapter 10) on generalizations in legal reasoning about evidence.

4. The problem of making schemes more precise

Verheij (2003) has investigated how argumentation schemes could be formalized in such a way that they could be used in computing systems for argumentation. He suggested that it may be useful to treat some of the questions in a different way from others. Critical questions that point to exceptions to a general rule only undercut an argument, while others could be seen as refuting the argument by denying implicit assumptions on which it rests or by pointing to counter-arguments. He began by showing that critical questions can have four different kinds of roles:

1. They can be used to question whether a premise of a scheme holds.
2. They can point to exceptional situations in which a scheme should not be used.
3. They can set conditions for the proper use of a scheme.
4. They can point to other arguments that might be used to attack the scheme.

Verheij's formalization of the roles of critical questions depends on the well-known distinction in the literature due to Pollock (1995, pp. 40–41), cited above, between undercutters and rebutters. A rebutter only has to be any argument with a conclusion that is opposed to that of the original argument. The rebutter would defeat the opposed argument if it is the stronger argument of the two. The undercutter is the weaker form of attack since it only undermines the inferential link, whereby the original argument supported its conclusion.

Verheij pointed out that the critical questions that criticize the premises of a scheme can be seen as redundant, from a computational point of view, because they merely ask whether the premise is true. It is a condition of the use of any argument that the premises are true or at least acceptable. Thus, he argued that critical questions that merely restate a premise of an argumentation scheme are redundant and can be ignored. For example, the field question, in the list of critical questions matching argument from expert opinion above, could be said to be redundant because the major premise already says that E is an expert in domain D containing proposition A.

In Verheij's method of argument diagramming, called ArguMed, undercutters are drawn by a device called entanglement. An undercutter is represented diagrammatically as a line that points from a text box to another line, indicating that an undercutter attacks the inferential link between the premises and conclusion of the original argument depicted. A key difference between *Araucaria* and ArguMed is that entanglement is not possible in *Araucaria*. Lines can only go from nodes to a node, but never from a node to a line connecting nodes.

5. The problem of diagramming schemes with critical questions

Araucaria represents arguments from expert opinion using a different kind of diagram that models arguments based on an important distinction. A linked argument is one where both (or all) premises are needed to support the conclusion, whereas a convergent argument is one where each premise supports the conclusion independently of the other(s). *Araucaria* also has a tool for displaying selected argumentation schemes on the diagram. For example, the *Araucaria* diagram shown in Fig. 2.

What is displayed in Fig. 2 is a linked argument with its two explicit premises in the two bottom boxes at the left linked together with a third premise. The third premise, shown in the darkened box with the dashed lines around it, is an implicit premise that has been added in. The conclusion of the argument is shown in the top box. The inference from all three premises to the conclusion is

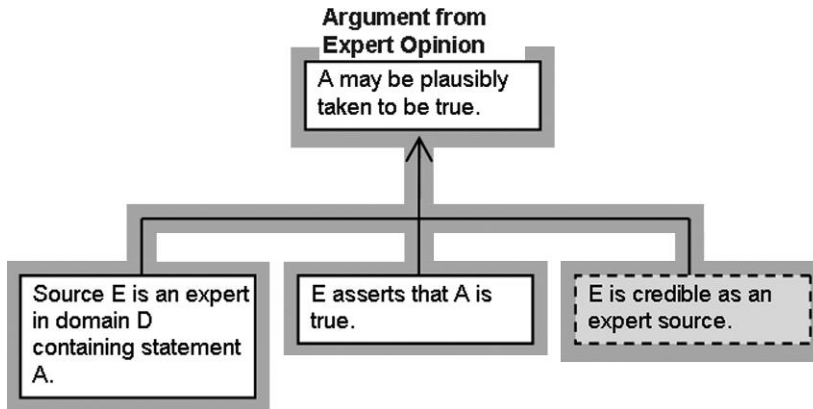


FIG. 2. Araucaria diagram with implicit credibility premise as rebutter.

warranted by the argumentation scheme for argument from expert opinion. The scheme is displayed by its name above the conclusion at the top and its scope by the coloured outline around the argument.

As shown in Fig. 2, the implicit premise ‘E is credible as an expert source’ functions as a kind of critical question. This premise is part of a linked argument. If any premise in a linked argument is questionable or fails to hold, the support of the argument as a whole for its conclusion falls down. Thus, the implicit premise as shown in Fig. 2 functions like a rebutter. Once made explicit, it shifts a burden of proof onto the proponent of the argument from expert opinion to support it or the argument falls down. Thus, this diagram can be seen as a way of representing the credibility critical question as a rebutter. If the implicit assumption that E is credible as an expert source fails, the whole argument from expert opinion is defeated.

Another way of representing a critical question as an additional implicit premise of an argumentation scheme is shown in Fig. 3. In Fig. 3, the trustworthiness critical question is represented as an implicit premise. Recall that the bias question is regarded a subquestion of the trustworthiness question. Hence in Fig. 3, the implicit premise that E is trustworthy is shown as backed up by another implicit premise stating that there is no evidence of bias on the part of the proponent of the argument. If evidence of a bias were to be shown, that would undercut the trustworthiness premise.

Here, there is a contrast with Fig. 2 where the critical question functioned as a rebutter. The claim that E is not trustworthy needs to be backed up by evidence of some sort of bias before the original argument from expert opinion is defeated. As long as there is absence of any bias shown, the expert remains trustworthy and the argument holds up. Only if specific evidence of bias is given, does the argument fail. Merely asking the critical question is not enough to defeat the argument. Hence, the trustworthiness question acts as an undercutter, as opposed to a rebutter.

Note that there is at least one other option for representing the kind of argument shown in Fig. 3. An implicit premise stating that there is evidence that E is biased could be drawn as a refutation of the premise that E is trustworthy. The trustworthiness premise would seem to function as undercutter because evidence of bias needs to be given to defeat the argument.

In both Figs 2 and 3, the scheme for argument from expert opinion has been represented in a guise where each critical question is represented as an additional implicit premise, supplementing

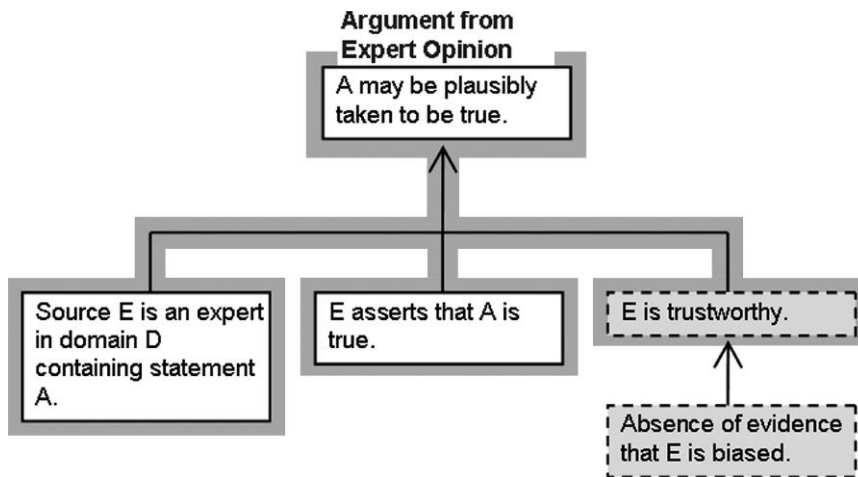


FIG. 3. Araucaria diagram with implicit trustworthiness as undercutter.

the original premises of the scheme. But still, even though we can represent critical questions as additional implicit premises, on either system of argument diagramming, this method still fails to distinguish very well between those critical questions that function as undercutters and those that function as rebutters. For the argument in Fig. 3 is still defeated if the premise that the expert is trustworthy fails to hold. The contrast between the argument structures shown in Figs 2 and 3 still does not seem to be enough to model the distinction between types of critical questions that are undercutters and types that are rebutters.

Looking at these examples has shown us that Araucaria can represent arguments attacking a previous argument from expert opinion by claiming that the expert is biased. However, what Araucaria does not appear to do very well is to model such a bias attack, when it takes the form of a critical question that is a subquestion of the trustworthiness question, in a single way that can be automated by representing the critical question on the argument diagram.

Araucaria's argument diagramming method is an excellent way of representing arguments made up of premises and conclusions (propositions), but it seems to reach its limits when it comes to representing critical questions. Araucaria does represent refutation as a special type of argument on a diagram, and it does represent owners of arguments, but that is about as far as it goes in representing dialogue notions. Modelling questions in argumentation, as opposed to propositions and inferences on sets of propositions, is something this kind of diagramming technology is not meant to do, lest it become too complex and thereby less useful.

There is a system of computer-supported collaborative argumentation called Compendium that does utilize questioning as part of the method for evaluating an argument. Compendium is widely used to help with tasks in which people work together using computer infrastructure. The papers in Kirschner *et al.* (2003) show how Compendium has been used to model argumentation in academic domains and commercial decision making. Compendium integrates materials like articles, spreadsheets and pictures that have not been utilized by simpler diagramming techniques like Araucaria. It is based on the issue-based information system (IBIS) model of argument. An interesting recent development is that Compendium has been modified to use argumentation schemes. This

development is of interest because now that it has such capabilities, the question arises whether it could be used to analyse and evaluate arguments from expert opinion of the kind so commonly used in law.

If we take a look at the argument from expert opinion as shown in Fig. 4, we can get an idea of how this scheme is managed by Compendium.⁴

Three sets of schemes can be applied to arguments in Compendium, including a Pollock set and a Walton set. Figure 4 shows how the critical questions match the scheme work, following the formulation of them in the Walton scheme set. The critical questions are represented as issues. Issues are displayed as nodes with question marks in the IBIS system. To answer these questions, one has to add position nodes for each of the possible answers (e.g. for the issue ‘Is E a genuine expert in D?’, one would add a position ‘Yes, E is a genuine expert in D.’ and a position ‘No, E is not a genuine expert in D.’). One can then add arguments pro and con for each of these answers.

There is one striking way in which Compendium models argument differently from Araucaria. As shown above, Araucaria draws a key distinction between linked and convergent arguments. Compendium does not apply this distinction to premises of arguments. To see this, we should note in Fig. 4 how each premise of the argument from expert opinion is represented as a separate argument, rather than as a premise of a single argument. Araucaria modelled the premises in an argument from expert opinion as linked, whereas Compendium models them as premises in a convergent argument. This way of diagramming arguments stems from the IBIS system. Since arguments are atomic in IBIS, it is not possible to visualize the premises of an argument. That is, there is not a separate node for each premise, but only a single node for the whole argument. This feature explains why each of the premises of the scheme for argument from expert opinion shown in the Compendium example in Fig. 4 was shown as a separate argument.

Because of this feature, it is hard to see how one can visualize argumentation schemes like that for argument from expert opinion in Compendium. An argumentation scheme of this sort is a pattern for a single argument, showing how several premises work together to support or rebut some conclusion. Since IBIS does not provide a way to visualize the premises of arguments, it is hard to see how it can visualize some way in which arguments like that for expert opinion can instantiate argumentation schemes.

We seem to have reached some limits at this point, and what is needed is some better way of visualizing argument with argumentation schemes and their matching sets of critical questions. Compendium does not model premises working together in a scheme, even though Araucaria does that very well. But Araucaria is limited in displaying the subtler nuances of shifts in the burden of proof from one side to the other in argumentation. We now move to a system that can do both these things, Carneades (Gordon *et al.*, 2007). It takes the next step forward by representing the critical questions on the argument diagram and distinguishing between different kinds of effects on defeating the original argument that different kinds of critical questions have. The original motivation of the Carneades system was to accommodate two different variations on what happens when a respondent asks a critical question (Walton and Gordon, 2005). On one theory, as indicated above, when a critical question is asked, the burden of proof shifts to the proponent’s side to answer it. On another theory, merely asking the question does not defeat proponent’s argument until the respondent offers some evidence to back it up. Carneades approaches this distinction by distinguishing three types

⁴ This screen shot was taken from Compendium courtesy of Simon Buckingham Shum, who has given me his permission to use it: <http://compendium.open.ac.uk/openlearn/compendium-arg-schemes.html>.

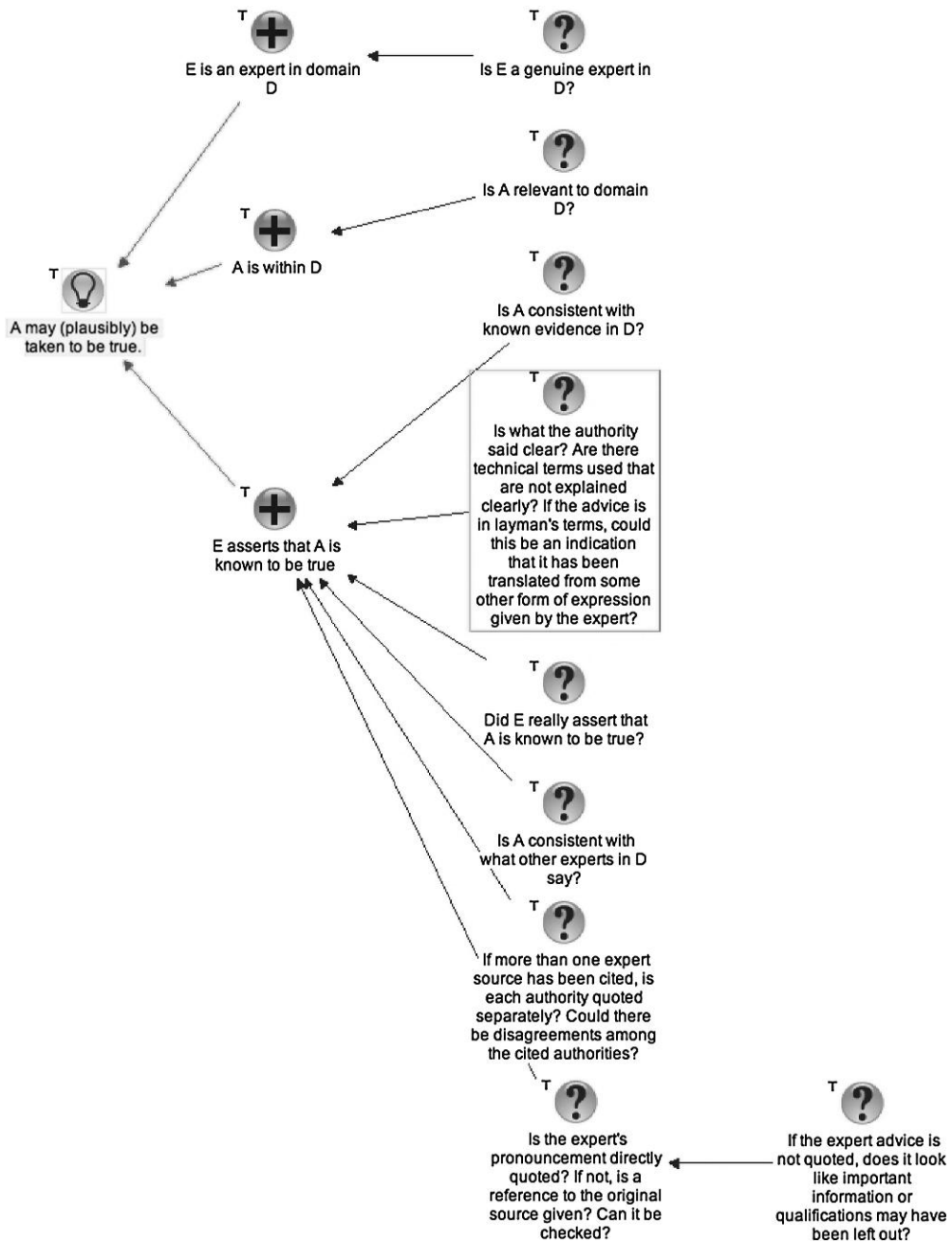


FIG. 4. Compendium screen shot showing argument from expert opinion.

of premises, called ordinary premises, assumptions and exceptions. Ordinary premises behave like assumptions at issue. An assumption holds if it is undisputed or accepted, but not if it is rejected. An undisputed ordinary premise holds if its statement is acceptable, given its proof standard, or if it has been accepted, but not if it has been rejected. Exceptions hold unless the statement of the exception has been proven acceptable. When we turn to revising the scheme for expert opinion for use in law, the new version will be based on this approach.

6. More specific critical questions for argument from expert opinion

The Supreme Court provided guidelines for assisting in decisions about the admissibility of expert knowledge, now generally known as the Daubert factors (Godden and Walton, 2006, p. 270):

Testability: whether it [the evidence, theory or technique] can be (and has been) tested.

Error Rate: the known or potential rate of error.

Peer Review: whether the theory or technique has been subjected to peer review and publication.

General Acceptance: the ‘explicit identification of a relevant scientific community and an express determination of a particular degree of acceptance within that community’ (Daubert at 594).

As noted in Godden and Walton (2006, p. 271), Owen (2002, p. 358; following the notes to the amendment of the Federal Rules of Evidence (FRE) 702) cited a fifth criterion.

‘Control Standards: whether its operation has been subjected to appropriate standards of control’.

These criteria are applied in pretrial Daubert hearings held to determine the admissibility of expert testimony as evidence in a given case.

In 2000, the courts made several amendments to the FRE. Rule 702 was amended to include three rules for the admissibility of expert testimony (Godden and Walton, 2006, p. 273).

[A qualified expert may testify] if (1) the testimony is based upon sufficient facts or data, (2) the testimony is a product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

The question of how the standard of reliability is to be met in a given case is left to the discretion of a trial judge. In addition to the Daubert factors, notes to the FRE 702 amendment also propose the following additional criteria (Godden and Walton, 2006, p. 274).

Whether experts are ‘proposing to testify about matters growing naturally and directly out of research they have conducted independent to the litigation, or whether they have developed their opinions expressly for the purposes of testifying’ [Daubert at 1317].

Whether the expert has unjustifiably extrapolated from an accepted premise to an unfounded conclusion [with reference to Joiner at 146].

Whether the expert has adequately accounted for obvious alternative explanations [with reference to *Claar v. Burlington*].

Whether the expert ‘is being as careful as he would be in his regular professional work outside his paid litigation consulting’ [*Sheehan v. Daily Racing Form Inc.*, at 942].

Whether the field of expertise claimed by the expert is known to reach reliable results for the type of opinion the expert would give [with reference to *Kumho* at 1175].

(FRE 702, notes; see also Owen, 2002, pp. 361–362).

The question now to be posed is whether these more specific criteria for admissibility currently being developed in the courts can be accommodated to a version of the scheme for argument from expert opinion that might be suitable for a more fine-grained set of critical questions. The place to begin is the set of more fine-grained critical questions that have already been developed in argumentation.

The six main critical questions for argument from expert opinion were presented in Section 3. However, under each of these main critical questions, a set of subquestions has been recognized through studies of many examples of argument from expert opinion in conversational argumentation. The list below is taken from the summary in Godden and Walton (2006, pp. 278–279).

1. *Expertise Question*: How credible is E as an expert source?
 - 1.1 What is E’s name, job or official capacity, location, and employer?
 - 1.2 What degrees, professional qualifications or certification by licensing agencies does E hold?
 - 1.3 Can testimony of peer experts in the same field be given to support E’s competence?
 - 1.4 What is E’s record of experience, or other indications of practiced skill in D?
 - 1.5 What is E’s record of peer-reviewed publications or contributions to knowledge in D?
2. *Field Question*: Is E an expert in the field (domain) that A is in?
 - 2.1 Is the field of expertise cited in the appeal a genuine area of knowledge, or area of technical skill that supports a claim to knowledge?
 - 2.2 If E is an expert in a field closely related to the field cited in the appeal, how close is the relationship between the expertise in the two fields?
 - 2.3 Is the issue one where expert knowledge in *any* field is directly relevant to deciding the issue?
 - 2.4 Is the field of expertise cited an area where there are changes in techniques or rapid developments in new knowledge, and if so, is the expert up-to-date in these developments?
3. *Opinion Question*: What did E assert that implies A?
 - 3.1 Was E quoted in asserting A? Was a reference to the source of the quote given, and can it be verified that E actually said A?
 - 3.2 If E did not say A exactly, then what did E assert, and how was A inferred?
 - 3.3 If the inference to A was based on more than one premise, could one premise have come from E and the other from a different expert? If so, is there evidence of disagreement between what the two experts (separately) asserted?

- 3.4 Is what E asserted clear? If not, was the process of interpretation of what E said by the respondent who used E's opinion justified? Are other interpretations plausible? Could important qualifications be left out?
4. *Trustworthiness Question*: Is E personally reliable as a source?
- 4.1 Is E biased?
- 4.2 Is E honest?
- 4.3 Is E conscientious?
5. *Consistency Question*: Is A consistent with what other experts assert?
- 5.1 Does A have general acceptance in D?
- 5.2 If not, can E explain why not, and give reasons why there is good evidence for A?
6. *Backup Evidence Question*: Is E's assertion based on evidence?
- 6.1 What is the internal evidence the expert used herself to arrive at this opinion as her conclusion?
- 6.2 If there is external evidence, e.g. physical evidence reported independently of the expert, can the expert deal with this adequately?
- 6.3 Can it be shown that the opinion given is not one that is scientifically unverifiable?

It is clear that there is quite a lot of work to be done in integrating these critical questions with the kinds of critical questions and other criteria for admissibility in law that the courts are already in the process of formulating.

7. Refining the expert opinion scheme for use in law

The original schemes and their critical questions were devised to help students in critical thinking courses identify, analyse and evaluate arguments in everyday conversational argumentation. Not only they can be reconfigured for use in AI but also they may require special refinements for use in law. Below is a new version of the scheme for argument from expert opinion put forward for use in Carneades.

Version 1 of Legal Argument from Expert Opinion

Ordinary premise 1: E is an expert in knowledge domain D.

Ordinary premise 2: E said that statement S is true.

Assumption 1: S is in D.

Assumption 2: E has depth of knowledge in D.

Conclusion: S may plausibly be taken to be true.

Version 1 is similar to the original scheme, except that the statement that S is in D, which was in the major premise of the original version, now becomes an assumption. Another difference is that the domain is now called a knowledge domain instead of subject domain. What the new version makes clear is that the expert E is an expert because E is assumed to possess knowledge. This new version

fits with the notion of an expert as a source or database containing knowledge. The final difference is Assumption 2, which speaks of the depth of knowledge in the knowledge domain. This premise is built on the notion that some experts can have more knowledge than others. Thus, we can consider an alternative to Assumption 2 premise:

Assumption 2*: The knowledge of E about D is deep enough to know about S.

This version makes depth a matter of degree. To the extent that E's depth of knowledge is judged deep enough to know whether or not S is true, the argument is made stronger.

Next, let us consider two other assumptions attached to the scheme:

Assumption 3: What E asserts is based on evidence.

Assumption 4: What E said asserts or implies S.

There are some questions about the formulation of these two assumptions. What is meant by the expression 'what E asserts'? Does it refer to the precise text of his testimony, quoted or some interpretation (the statement meant) by this testimony? We take it to refer mean the text of his testimony. But this leads to the next question. What is meant by 'implies' in the premise 'What E said asserts or implies S'? If logical implication is meant, the 'what E said' would have to be some other statement, i.e. a proposition, not the raw quoted text of this testimony. The issue of logical implication can only be addressed after we have interpreted the testimony, moving from the sentences of the raw text to some proposition. For these reasons, it could be suggested that we change this assumption to address the issue of whether S is a reasonable interpretation of his testimony, rather than whether it is implied by his testimony.

Next, there is some uncertainty about the meaning of the expression 'what E asserts' as being 'based on evidence'. This expression seems ambiguous because it is not clear whether 'what E asserts' refers to his actual testimony or some interpretation of this testimony. Is it meant that there is evidence that E actually said (the quoted text, not some interpretation) what he is claimed to have said? Perhaps, he has been misquoted.⁵ Or is the question meant to ask whether there is evidence that E based his testimony on further evidence. This could be called second-degree evidence. The question is whether E had based his testimony on a careful consideration of evidence? In a legal context, it can be assumed that the latter is meant since in courts of law, at least, there usually will be no issue about the content of his testimony. The procedures of the court, with their court reporters, are fairly reliable.

Putting all these considerations together, the following alternative scheme is herewith proposed.

Version 2 of Legal Argument from Expert Opinion

Ordinary premise 1: E is an expert in knowledge domain D.

Ordinary premise 2: E said the sentence S*.

Ordinary premise: S is a reasonable interpretation of S*.

Assumption 1: S is in D.

Assumption 2: The knowledge of E about D is deep enough to know about S.

Assumption 3: E's testimony S* is based on his own careful analysis of evidence in this case.

Exception 1: S is inconsistent with what other experts in D say.

⁵ Quotation as providing a kind of evidence that can sometimes be subject to abuse through misquotation and manipulation is a subject of current research by Douglas Walton and Fabrizio Macagno.

Exception 2: E is not trustworthy.

Conclusion: S may plausibly be taken to be true.

The old version of the expertise question asked how credible E is as an expert source. The term ‘credibility’ was misleading because it seemed to suggest something more like the trustworthiness question. Now, this potential misunderstanding can be removed. The depth of knowledge presumption refers to mastery of the domain of expertise. The trustworthiness exception refers to things like bias or dishonesty. If the expert has a financial gain at stake or has been known to lie in the past, these are the sorts of questions that come under the general heading of trustworthiness. Thus, ethical or personal trustworthiness is contrasted with the depth of knowledge in a field of expertise.

In view of the analysis of witness testimony of [Schum and Morris \(2007\)](#), cited in Section 3 above, we have reconfigured the labelling of the premises in version 2 of the scheme as follows: Ordinary premise 1 is now labelled as the competence premise. It assumes that the source cited is a genuine expert, meaning that his opinion will be based on appropriate sources of knowledge, and that he not only is in a position to be aware of these sources and to understand them at an appropriate level of technical competence but also has the ability to communicate them so that they can be understood by laypersons. Exception premise 2, formerly called the trustworthiness critical question, is now relabelled as the credibility question. We now take the term ‘credibility’ to refer not to the mastery of the domain of knowledge of the expert but to matters of the expert’s reliability as a source that is not only presumed to have some access to the truth of the matter being discussed but who can be relied upon to convey it to others in a balanced way. These reformulations lead us to version 3.

Version 3 of Legal Argument from Expert Opinion

Competence premise (Ordinary premise): E is an expert in knowledge domain D.

Statement premise (Ordinary premise): E said the sentence S*.

Interpretation premise (Ordinary premise): S is a reasonable interpretation of S*.

Domain premise (Assumption): S is in D.

Depth of knowledge premise (Assumption): The knowledge of E about D is deep enough to know about S.

Careful analysis premise (Assumption 3): E’s testimony S* is based on his own careful analysis of evidence in this case.

Other experts premise (Exception): S is inconsistent with what other experts in D say.

Credibility premise (Exception): E is not credible.

Conclusion: S may plausibly be taken to be true.

Under credibility are included matters of veracity, i.e. matters of whether the witness is telling the truth or at least attempting to do so within the confines of what he or she knows or does not know. Also included is the assumption of the objectivity of the expert. Thus, the notion of bias comes under this heading. Instead of observational sensitivity, the third factor included under credibility in the analysis of Schum and Morris, we include the factor of the expert’s openness to the contrary evidence and his judicious management of possible errors or inaccuracies in what he previously said. This includes matters of how he reacts to criticisms, apart from his own careful analysis of evidence in the case as required by Assumption 3. Schum and Morris include observational sensitivity as an important factor under the heading of credibility in judging witness testimony generally. However, in the special case of expert witness testimony, although observational sensitivity is important, it is less in the forefront than in the case of eyewitness testimony. With respect

to arguments based on expert opinion, the five factors of a credible arguer cited in Walton (1999, pp. 267–268) move to the forefront. In the case of expert testimony, what is most important is how the expert reacts to and is sensitive to relevant evidence that appears to be opposed to his own conclusion.

Generally speaking, the original scheme, with its ordinary premises, needs to be simple to have explanatory power. It is useful to keep the basic scheme simple, but at the same time to make it take complications into account so that the premises do defeasibly imply the conclusion. The assumptions and exceptions are then taken as additional factors that need to be taken into account, or may need to be questioned, to be sure that no gaps exist of a kind that would make the basic argument unreliable. This is the reason why, in this paper, we have moved forward in several stages. First, we presented the basic scheme for argument from expert opinion. It is meant to be simple, and it can be easily recognized by anyone how it represents a common kind of argumentation often used in conversational discourse as well as in special contexts like law. Then, we refined this scheme, making it somewhat more complex by reformulating the basic critical questions as ordinary premises, assumptions or exceptions. Then, we started to examine more specific critical questions, many of them compatible with, or even closely corresponding to, criteria for admissibility of expert testimony in law based on recent court rulings. Clearly, in the scope of this paper, we cannot deal with the specifics of how to try to fully integrate the legal criteria with the list of specific critical subquestions developed in argumentation theory. The best we can do is to comment on some factors and open the issue to further discussion.

In the new version of the scheme above, the term ‘said’ is meant to be ambiguous. It can refer to two types of cases. One is where the expert actually asserted statement *S*. The other is the kind of case where the expert did not state *S* explicitly, but nevertheless, based on the text of discourse recording what the expert actually said, it can be reasonably inferred that the expert is committed to statement *S*. This kind of distinction is very important because experts often speak in technical terms and may express qualifications so that it is very hard for the layperson user to interpret what the experts said correctly and draw the right conclusion from it on what the expert is advising. If the expert actually asserted *S* explicitly, there is not such a big problem. But if the expert said something that logically implies this is true, given other non-explicit premises, e.g. based on common knowledge, the critical questioning has to bring out doubts that can be raised about how to interpret the text of discourse of what the expert said. This aspect of the scheme clearly relates to critical subquestions listed under the opinion question in the list of specific critical questions presented above. Was the expert directly quoted when his opinion *S* was rendered? Can it be verified that the expert actually made the statement *S* in question in the exact same words it was brought forward? If the expert did not say *S* exactly, what did he assert? Could the conclusion drawn by inference be based partly on some other source? Is what the expert said clear? If not, was the process of interpretation a reasonable one? These are the critical subquestions under critical question 3, the opinion question.

The distinction to be made clear here is that in some cases, what the expert said is quoted, while in other cases it is paraphrased. Even if what the expert said was quoted word for word, the quotation can be used out of context and the fallacy of wrenching from context committed. In still other cases, whether the expert’s statement *S** was quoted or not, there remains the question of whether *S** can properly be taken to mean *S*, the statement to be proved. One problem posed is what standard of inference is being used to infer *S* from *S**. This is the question of argumentation schemes.

The reformulation above proposes handling this ambiguity differently, by explicitly distinguishing the expert’s actual testimony, i.e. the sentence of his testimony *S**, from the statement *S*, which is

some interpretation of the meaning of this testimony. Of course, this meaning will also be expressed as a sentence in natural language. And the sentence we choose to 'name' the statement may be equal to the text of the expert's testimony.

8. The critical questions

One important difference between the way expert testimony is handled as evidence in law and the way arguments from expert opinion are treated in everyday conversational argumentation is that the law treats questions of admissibility different from questions of evaluation. Much of the current literature regarding issues of expert testimony concerns questions of admissibility of such evidence in a trial. The four Daubert factors (Godden and Walton, 2006, p. 270), stated above in Section 6, were the following: (1) testability, (2) error rate, (3) peer review and (4) general acceptance. The FRE, as shown above in the same section, included three additional factors: (1) whether the testimony is based on sufficient facts, (2) whether it is a product of reliable methods and (3) whether the methods have been applied reliably to the facts of the case. The five additional questions stated in notes to the FRE and noted by Godden and Walton (2006, p. 274) were the following: (1) whether the opinion of the expert was expressly developed for the purposes of testifying, as opposed to growing naturally a lot of the research, (2) whether the expert might have on justifiably extrapolated from an accepted premise to unfounded conclusion, (3) whether the expert has considered alternative explanations, (4) whether the expert is being as careful as he would in his regular professional work and (5) whether the field of expertise claimed by the expert is known to reach reliable results.

A list of appropriate critical questions based on these concerns can be drawn up as follows. Generally, it is assumed that genuine expert testimony is based on facts or data, as well as being based on a theory or technique that is reliable. It is assumed that the expert has applied this theory or technique in a reliable way to the facts of the case.

CQ1: Is the opinion put forward by the expert based on some theory or technique?

CQ2: Can the theory or technique put forward by the expert be tested?

CQ3: Has the theory or technique put forward by the expert been tested?

CQ4: What is the known or potential rate of error of the theory or technique?

CQ5: Has the theory or technique been subject to peer review and publication?

CQ6: What is the degree of acceptance within the scientific community fitting the field of expertise?

CQ7: Does the expert's opinion grow out of the research conducted independently of the litigation or has it been developed expressly for the purpose of testifying?

CQ8: Has the expert unjustifiably extrapolated from an accepted premise to an unfounded conclusion?

CQ9: Has the expert adequately accounted for alternative explanations?

CQ10: Is the expert being as careful as he would in his regular professional work?

CQ11: Is the field of expertise claim by the expert known to reach reliable results for the type of opinion given?

Some of these critical questions appear to overlap somewhat with the six critical questions already considered for the basic argument scheme for argument from expert opinion described above. But for the most part, they represent new critical questions that are especially important when considering scientific evidence of the kind so commonly used as expert testimony in courts. Therefore,

the question is raised whether a special scheme for argument based on expert testimony is needed for legal uses. Such a specialized legal scheme would be based on the original argument scheme used in argumentation theory, but it would be a more detailed scheme specially designed for legal purposes.

Additional critical questions are suggested from the work of Schum (1994), who has studied factors like convictions related to dishonesty and testimonial bias under the heading of veracity. He treats objectivity as a separate factor from veracity in assessing credibility of witness testimony. Schum generally distinguishes between two primary categories for assessing witness testimony that he calls competence and credibility. It would seem that the majority of the critical questions considered above would fall under the heading of competence rather than credibility. Perhaps, CQ7 and CQ10, however, would fall under the heading of credibility. The big problem confronting the application of any formal dialogue system to the management of expert testimony as a form of admissible evidence in law is the relationship between the scheme and the critical questions representing this form of argument. We have already seen above that there are problems even in fitting the relatively simple argument scheme for argument from expert opinion into a dialogue system that can deal with the problem of the balance of power between proponent who puts forward an argument fitting the scheme and the respondent who raises critical questions appropriate for that scheme. The problem is made considerably more complex and formidable once the scheme is revised for legal use, and additional critical questions of the kind considered above are included.

9. State of the art

This paper has surveyed several different argument visualization tools that show promise for analysing evidence in law in a way that should be useful for many purposes, including summarization of evidence in cases, assisting lawyers to more systematically present arguments based on evidence in a case and assisting judges to evaluate evidence. Although these tools share some common features, it has been shown how they also model different aspects of evidence in differing ways. Such differences may not turn out to be a bad thing, as the ways these tools are to be precisely applied are still under development, and they may be put to a wide range of differing uses. Indeed, it should be stated here that Carneades is not yet supported by software tools, at least not tools comparable to interactive editors like Compendium or Araucaria. At this stage of its development, it is first and foremost a mathematical model. However, in the paper by Tom Gordon in this volume, it is shown how the diagramming method for Carneades can be compared with the diagramming methods of Compendium and Araucaria.

It has been argued here that a common characteristic to many of these visualization systems is they need to be based on argumentation schemes, including not only the traditional forms of argument recognized in deductive and inductive logic but also defeasible forms of argument that are a central focus of research now in artificial intelligence. The problem studied in this paper was how to represent the critical questions attached to the scheme for the argument from expert opinion. One of the main conclusions was the proposal to revise this scheme for special use in a legal context. As we did this, many issues about how to represent schemes and critical questions in the evolving systems for argument diagramming came up for discussion. We looked at the Araucaria system and the Carneades system, examining in each system how the critical questions can be accommodated to argument visualization technology, and represented somehow in the visually presented analysis of a given argument. Some of the inherent difficulties of this task have been shown in this paper, but some of the progress that has been made is clearly evident as well. It has been shown that the project

is not an easy one because it closely relates to other concepts that are vitally important to the new models of evidential reasoning. These concepts include the notions of argument defeat, rebuttal, and undercutting. Although these concepts are fundamental to argumentation theory itself, some grounds have been presented to think they are not altogether clear or uncontroversial. As well, the notions of generalization, burden of persuasion and presumption are closely tied in to the attempts to deal adequately with the operation of critical questions in argumentation schemes.

There are many advantages to the Araucaria system. It is fairly easy to use with little or no training, and has many nice features useful for representing reasoning about evidence in law and many kinds of legal argumentation. For example, it can represent schemes and implicit premises, do Wigmore diagrams, is free and is ready to use. There are also many advantages to the Compendium system. It can help users to manage large amounts of information and can be used to create argument maps that can clarify issues by helping to formulate arguments pro and con. It is also free and ready to use. The Carneades system is still under development, but has some special features shown in the treatment of argument diagrams for argument from expert opinion above:

- The role of each premise can be shown: major, minor, etc.
- The name of each critical question can be shown: trustworthiness, etc.
- The type of each premise is shown: ordinary, assumption, exception and negative.
- Other information can be derived and visualized: holding of premises, defensibility of arguments and acceptability of statements.
- The different kinds of critical questions can be shown as different kinds of premises on a diagram in a way that models key differences in burden of proof.
- An argument can be re-evaluated as holding or not as further moves are made in a sequence of argumentation that started with a designated issue.

Thus, there are also many advantages to the Carneades system that show its promise, not only as a formal model of argument for plausible reasoning generally and legal applications but also as a method of argument visualization. Not the least of these advantages is its unique capability to use argumentation schemes with their matching sets of critical questions to analyse and evaluate arguments, like argument for expert opinion, that are fundamentally important in legal reasoning about evidence.

Whatever system is used, we have argued that the scheme for argument from expert opinion needs to be reconfigured to be consistent with the general format for assessing the confidence and credibility of human sources in law, currently under development by Schum and Morris. Version 3 of the scheme proposed above, with its attached set of critical questions, are the tools needed, we argue, for working towards building a best automated argumentation system based on artificial intelligence that can be used to assist judging admissibility and assessment of expert opinion evidence in law. The bias question, on this analysis, comes under the credibility question, and is treated as an exception rather than an assumption or ordinary premise in version 3 of the scheme. Still, in Carneades, there remain many ways an argument can be attacked on grounds of bias other than by asking the credibility question or one of its subquestions, like the bias question. An argument can be straightforwardly attacked as biased, based on evidence that the expert has something to gain, and evidence to support this claim can be marshaled in the usual way with supporting arguments. There

is no fundamental problem about diagramming such arguments using either system. Argument from bias is another scheme representing a distinctive form of argumentation that can be used to attack a prior argument based on expert opinion. Still, we have argued that the scheme for expert opinion needs to have a set of critical questions attached to represent the standard ways of raising doubts about the acceptability of witness testimony evidence in a given case. And we have argued that the capability for representing such critical questions within the diagram itself is a useful advance.

Acknowledgements

I would like to thank the Social Sciences and Humanities Research Council of Canada for a research grant that supported the work in this paper.

REFERENCES

- TERENCE ANDERSON, DAVID SCHUM & WILLIAM TWINING, *Analysis of Evidence*, 2nd ed., Cambridge, Cambridge University Press, 2005.
- FEDERAL RULES OF EVIDENCE, December 1, 2005. Available at (February 9, 2007) <http://judiciary.house.gov/media/pdfs/printers/109th/evid2005.pdf>.
- DAVID M. GODDEN & DOUGLAS WALTON, Argument from Expert Opinion as Legal Evidence: Critical Questions and Admissibility Criteria of Expert Testimony in the American Legal System, *Ratio Juris*, **19**, 2006, 261–286.
- THOMAS F. GORDON, A Computational Model of Argument for Legal Reasoning Support Systems, *Argumentation in Artificial Intelligence and Law*, IAAIL Workshop Series, eds Paul E. Dunne and Trevor Bench-Capon, Nijmegen, Wolf Legal Publishers, 2005, 53–64.
- THOMAS F. GORDON, HENRY PRAKKE & DOUGLAS WALTON, The Carneades Model of Argument and Burden of Proof, *Artificial Intelligence*, **171**, 2007, 875–896.
- THOMAS F. GORDON & DOUGLAS WALTON, The Carneades Argumentation Framework: Using Presumptions and Exceptions to Model Critical Questions, *Computational Models of Argument: Proceedings of COMMA 2006*, eds P. E. Dunne and T. J. M. Bench-Capon, Amsterdam, IOS Press, 2006, 195–207.
- WAYNE GRENNAN, *Informal Logic*, Kingston, McGill-Queen's University Press, 1997.
- ARTHUR C. HASTINGS, A Reformulation of the Modes of Reasoning in Argumentation, *Ph.D. Dissertation*, Evanston, IL, 1963.
- JOHN R. JOSEPHSON & SUSAN G. JOSEPHSON, *Abductive Inference: Computation, Philosophy, Technology*, New York, Cambridge University Press, 1994.
- DAVID H. KAYE, DAVID E. BERNSTEIN & JENNIFER MNOOKIN, *The New Wigmore: A Treatise on Evidence: Expert Evidence*, New York, Aspen Publishers, 2004.
- MANFRED KIENPOINTNER, *Alltagslogik: Struktur und Funktion von Argumentationsmustern*, Stuttgart, Fromman-Holzboog, 1992.
- PAUL A. KIRSCHNER, SIMON J. BUCKINGHAM SHUM & CHAD S. CARR (eds), *Visualizing Argumentation*, Berlin, Springer, 2003.
- CHAIM PERELMAN & LUCIE OLBRECHTS-TYTECA, *The New Rhetoric*, Notre Dame, University of Notre Dame Press, 1969.
- JOHN POLLOCK, *Cognitive Carpentry*, Cambridge, MA, MIT Press, 1995.
- HENRY PRAKKE, Logical Dialectics: The Missing Link Between Deductivism and Pragma-Dialectics, *Proceedings of the Fifth Conference of the International Society for the Study of Argumentation*, eds Frans H. van Eemeren, J. Anthony Blair, Charles A. Willard and Francisca Snoek Henkemans, Amsterdam, SicSat, 2003, 857–860.

- CHRIS REED & GLENN ROWE, *Araucaria, Version 3.1*, 2006. Available free at <http://araucaria.computing.dundee.ac.uk/>.
- CHRIS REED & DOUGLAS WALTON, Towards a Formal and Implemented Model of Argumentation Schemes in Agent Communication, *Autonomous Agents and Multi-Agent Systems*, **11**, 2005, 173–188.
- DAVID A. SCHUM, *The Evidential Foundations of Probabilistic Reasoning*, Evanston, IL, Northwestern University Press, 1994.
- DAVID A. SCHUM & JON R. MORRIS, Assessing the Competence and Credibility of Human Sources of Intelligence Information: Contributions from Law, *Slide Presentation at Cardozo School of Law, January 20, 2007*.
- BART VERHEIJ, Dialectical Argumentation with Argumentation Schemes: An Approach to Legal Logic, *Artificial Intelligence and Law*, **11**, 2003, 167–195.
- BART VERHEIJ, *Virtual Arguments: On the Design of Argument Assistants for Lawyers and Other Arguers*, The Hague, Asser Press, 2005.
- DOUGLAS WALTON, *Argumentation Schemes for Presumptive Reasoning*, Mahwah, NJ, Erlbaum, 1996.
- DOUGLAS WALTON, *Appeal to Expert Opinion*, University Park, PA, Penn State Press, 1997.
- DOUGLAS WALTON, *One-Sided Arguments: A Dialectical Analysis of Bias*, Albany, State University of New York Press, 1999.
- DOUGLAS WALTON & THOMAS F. GORDON, Critical Questions in Computational Models of Legal Argument, *Argumentation in Artificial Intelligence and Law*, IAAIL Workshop Series, eds Paul E. Dunne and Trevor Bench-Capon, Nijmegen, Wolf Legal Publishers, 2005, 103–111.
- DOUGLAS WALTON & CHRIS REED, Diagramming, Argumentation Schemes and Critical Questions, *Anyone Who Has a View: Theoretical Contributions to the Study of Argumentation*, eds Frans H. van Eemeren, J. Anthony Blair, Charles A. Willard and A. Francisca Snoeck Henkemans, Dordrecht, Kluwer, 2003, 195–211.