Argument Visualization Tools for Corroborative Evidence

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Artificial intelligence and argumentation studies have recently developed new tools for argument visualization that are useful for analyzing the structure of different kinds reasoning about evidence in law. This paper studies how three such systems, Araucaria[1], Carneades[2] and Deflog[3] visually represent corroborative evidence. In corroborative evidence, one piece of evidence supports another, as in a case where a witness saw the defendant leaving a crime scene, and DNA evidence taken from a bloodstain also placed him at the crime scene, corroborating the witness testimony evidence. This paper extends the previous research of (Walton and Reed, 2008) on corroborative evidence. The goals are to understand different kinds of corroborative evidence better, and to help avoid errors (logical fallacies) in managing, analyzing and evaluating it. Corroborative evidence is defeasible, and can be erroneous. Double counting is a fallacy that occurs where evidence supporting a conclusion is counted twice, resulting in an over-evaluation of what the true result should be (Redmayne, 2000).

The focus of this paper is on the use of argumentation schemes in tools for argument visualization representing legal evidence. The latest research recognizes some sixty-five of these schemes (Walton, Reed and Macagno, 2008). In the literature on schemes, one is typically used as the classical example, namely argument from expert opinion, a form of argument has also been of central and intense concern in Anglo-American evidence law in the past three decades. In this paper we will concentrate on corroborative expert opinion testimony. If an expert witness testifies to a conclusion C, and a second expert also testifies to C, this second testimony, as well as boosting up the evidential value of C, may also boost up the evidential value of the testimony of the first expert. This type of corroborative testimony, as common as it is in legal evidence, is an instance of double counting. It is shown in the paper how these problematic evidential reasoning structures can be expressed more clearly by representing corroborative evidence with argument visualization tools. A fundamental distinction is drawn between two basic types of corroborative evidence, and it is shown how drawing this distinction is useful for coping with logical problems of evidence like the fallacy of double counting.

1. What is Corroborative Evidence?

Corroborative evidence can be broadly defined as any evidence that further supports some evidence that already exists in a case. The evidence that is already there can be called the primary evidence, and the evidence that supports it can be called the secondary evidence. What is meant when it is said that the secondary evidence supports the primary evidence is that the secondary evidence increases the probative weight of the primary evidence. Let's take an example where a witness testified that she saw the defendant drive his car into a red car. Subsequent to that a second witness testified that he saw red paint on the fender of the defendant's car on the day after the accident. In this case both kinds of evidence are based on testimony. The primary evidence is the testimony of the first witness that she saw the defendant drive his car into the red car. The secondary, or corroborating evidence, is the testimony of the second witness that he saw red paint on the fender of the defendant's car. In other cases, corroborating evidence can combine different types of evidence. For example, a witness might testify that she saw the defendant at the

[1] http://araucaria.computing.dundee.ac.uk/
[2] http://carneades.berlios.de/downloads/
[3] http://www.ai.rug.nl/~verheij/aaa/

crime scene on the day the crime was committed. This would be the primary evidence. The secondary evidence might be DNA evidence taken from blood samples found at the crime scene matching the defendant's DNA. In this case, the secondary evidence is not testimonial evidence, but it might appear in a trial in that form, as expert scientific testimony would be required to prove that the DNA found at the crime scene matched that of the defendant. Corroborative evidence is historically associated with the method of agreement, the method of difference and the method of concomitant variation codified by Francis Bacon and developed by John Stuart Mill. Corroboration may also be taken to refer to the requirement in countries like Scotland where the testimony of a single witness is required to be supported by some additional evidence before it is admissible. In Scots law, what is called corroboration requires that two or more sources are required in order for witness testimony to count as evidence. There are two versions of this requirement, an older and a newer one (Wilson, 1960, 101). According to the older version, every crucial fact in a criminal case must be approved by the evidence of two witnesses. According to the newer version, the facts proving a criminal charge emanate from two separate and independent sources of evidence. The older version is the more demanding requirement.

In general, where you already have some primary evidence, the relationship of the secondary evidence to it can be pro or contra. Pro secondary evidence supports the primary evidence, whereas contrast secondary evidence undermines, or is opposed to the original primary evidence. Pro and contra arguments are well known in argumentation studies. In some cases one argument supports another, by other making it stronger, while in other cases one argument attacks another, opening it to criticisms or counter-arguments that make it weaker. Corroborative evidence is classified as pro secondary evidence. Schum (1994, 124) draws a comparable distinction between two kinds of legal evidence he calls evidential harmony and evidential dissidence. Evidential dissidence is characterized by contradiction and conflict. It refers to the kind of case in which one source reports that a particular event occurred, while another source report reports that it did not occur. The one item of evidence is evidentially opposed to the other, meaning that it leads to an opposite conclusion. In contrast to evidential dissidence, evidential harmony refers to the kind of case in which the two items of evidence both point in the same direction, leading by inference to the same conclusion.

A problem is with corroborative evidence is that the same evidence may be counted twice. Corroboration can tricky, however. It can be susceptible to the fallacy of double counting (Walton and Reed, 2008, 531). Suppose for example when throwing a pair of dice we want to calculate the probability of coming up with a 5. We might try to calculate the probability as 1/6 + 1/6 = 1/3. But this answer would be wrong, because the event of both dice showing a 5 has been counted twice. The real probability is 11/36.

To raise questions about double counting of corroborative evidence, Redmayne (2000, pp. 150) studied this sort of case. A complainant C testifies that she has a recovered memory of being abused by D at age twelve, but then later, D confesses that he did abuse C when she was that age. The confession is corroborative evidence of the memory report. However, Redmayne (p. 151) noted that while the confession increases the probative value of the memory, it also has considerable probative value which, when added to the slight probative value of the memory, convinces us that the abuse occurred (p. 151). Here the fallacy of double counting is committed because the recovered memory evidence is counted twice.

2. Argumentation Schemes

The two models of rational argument that dominated logical reasoning in the west since the Enlightenment period were deductive logic and inductive reasoning of the kind used in statistics and the standard (Bayesian) probability calculus. However, forms of argument that have proven to be of most interest for modeling the kind of reasoning so commonly used in analysis and evaluation of evidence in law do not fit either of these quantitative models. However, they can now be represented by the device of defeasible argumentation schemes (Walton, Reed and Macagno, 2008). Such schemes have been put forward as a helpful way of characterizing structures of human reasoning, like argument from expert opinion, that have proved troublesome to view deductively. Attempting to deductivize the reasonable examples, by viewing the major premise as a conditional not subject to exceptions (e.g. if *X* says *Y* then *Y* is true) does not tend to work out well in many instances, as these arguments are typically defeasible. Some of the most common defeasible schemes are the following: argument from witness testimony, argument from expert opinion, argument from analogy, practical reasoning (from goal to action), the abductive argumentation scheme, and argument from precedent.

The etymology of the term 'defeasible' comes from medieval English contract law, referring to a contract that has a clause in it that could defeat the contract. However, the origin of the term in recent analytical studies in philosophy and law is the paper 'The Ascription of Responsibility and Rights' of H. L. A. Hart (1949; 1951). Hart's notion was that a claim could be tentatively acceptable because it is supported by evidence, but later found unacceptable because circumstances show that the case is an exception to the general rule supporting the claim. This is the concept of a defeasible argument, of the kind so common in legal argumentation and evidence. Such defeasible arguments need to be evaluated in relation to a case in which there is a standard of proof for the success of an argument set at the opening stage of the procedure. Arguments fitting defeasible schemes of this sort are used to respond to doubts and questions expressed by a second party to whom the argument was put forward to support a claim at issue. Such arguments are open to defeat through the asking of critical questions that match the scheme. Each scheme has a set of critical questions that represent standard ways of critically probing into an argument to find its potential weak spots. A burden of proof shifts back and forth as critical questions are asked and answered. 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).

The original motivation of schemes was to help teach university students skills of critical thinking, of the kind needed to write an essay, for example. Thus schemes 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.

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 as well, 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 AI, 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.

The scheme that we will mainly focus on in this paper as fundamental to the modeling of corroborative evidence is called argument from expert opinion, with its set of matching critical questions (Walton, Reed and Macagno, 2008, 310).

Scheme for Argument from Expert Opinion

Major Premise: Source *E* is an expert in subject domain *S* containing proposition *A*.
Minor Premise: *E* asserts that proposition *A* is true (false).
Conclusion: *A* is true (false).

Critical Questions for Argument from Expert Opinion

CQ_1: *Expertise Question*. How credible is *E* as an expert source?
CQ_2: *Field Question*. Is *E* an expert in the field that *A* is in?
CQ_3: *Opinion Question*. What did *E* assert that implies *A*?
CQ_4: *Trustworthiness Question.* Is *E* personally reliable as a source?
CQ_5: *Consistency Question.* Is *A* consistent with what other experts assert?
CQ_6: *Backup Evidence Question.* Is *E*'s assertion based on evidence?

Another scheme that is vitally important to consider in relation of corroboration of evidence in law is the one for argument from testimony (Walton, Reed and Macagno, 310).

Scheme for Argument from Witness Testimony

Position to Know Premise: Witness *W* is in 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 be plausibly taken to be true (false).

Critical Questions for Argument from Witness Testimony

CQ_1: Is what the witness said internally consistent?
CQ_2: Is what the witness said consistent with the known facts of the case (based on evidence apart from what the witness testified to)?
CQ_3: Is what the witness said consistent with what other witnesses have (independently) testified to?
CQ_4: Is there some kind of bias that can be attributed to the account given by the witness?
CQ_5: How plausible is the statement *A* asserted by the witness?

The critical questions obviously represent attacks or rebuttals that can be directed against a defeasible argument, and hence they are very important for analyzing in evaluating defesaible argumentation generally. A limitation of most argument visualization tools of the kind that have been developed so far is that they basically represent statements and inferences as boxes and arrows on a diagram, and therefore they do not represent critical questions, or how such critical questions might attack or rebut a given argument. Our interest in this paper is limited to positive argument support, and especially corroboration, and there is no space to study problems of argument rebuttal and refutation. But it will turn out that studying how such critical questions match argumentation schemes plays an important role in understanding corroborative evidence.

3. Three Argument Visualization Tools: Araucaria, Carneades and ArguMed

The technique of argument diagramming is now widely taught using introductory logic textbooks. Its origin in such courses has been ascribed to the introductory logic textbook of Monroe Beardsley (1950). However, it was highly developed and applied to legal evidence well before that time by John H. Wigmore (1913), and has also been used for teaching legal reasoning about evidence (Anderson, Schum and Twining, 2005). New software for argument mapping (Reed and Rowe, 2004; Kirschner *et al.*, 2003) is now moving these methods forward. Here we will apply three such systems to the problem of representing the structure of corroborative evidence.

The first of these three systems, called Araucaria, based on an Argumentation Markup Language (Reed and Rowe, 2003), is available as freeware on the internet. Araucaria is a software tool for analyzing arguments that helps a user to reconstruct and diagram a given argument using a point-and-click interface. The user moves the text of discourse containing an argument as a text file into a box on a left window of the Araucaria interface, and then highlights each statement (premise or conclusion). Each highlighted statement appears as a text box in the right window and the user can then draw an arrow representing each inference from a set of premises to a conclusion. The outcome is a chain of argumentation that appears on the right as an argument diagram. Once the argument has been fully diagrammed it can be saved for further use in a format called AML (Argument Markup Language).

Araucaria was the first argument visualization tool to incorporate the use of argumentation schemes. User-customizable sets of schemes are provided that can be helpful to the user when analyzing arguments. The user can search through a menu of argumentation schemes, and apply a selected scheme to an argument, displaying how the premises are connected to the conclusion by an inference fitting the scheme Once the argumentation scheme has been identified, the basic weak points that a critic could use to attack a given argument are identified by a set of critical questions matching each argumentation scheme that appears on the menu (as shown in figure 3).

Araucaria supports a distinction drawn from informal logic that distinguished between two basic types of arguments. In a linked argument, each premise goes together with another, or with others, to support a conclusion. Typical syllogisms, for example, are linked, because the two premises work together to support the conclusion. In a convergent argument, each argument independently supports the conclusion. A convergent argument can be seen as two separate arguments supporting the same conclusion. To put this distinction another way, the two sources of evidence in a convergent argument are taken to be independent of each other.

To show how to represent corroborative evidence using Araucaria, let's take a typical corroborative case of argument from expert opinion in which we have two experts called Source 1 and Source 2, testifying that statement P is true. This evidential situation is visualized in figure 1 as a convergent argument in which there are two arguments from expert opinion. The presumption of drawing the arguments this way is that each argument from expert opinion is taken to be independent of the other.

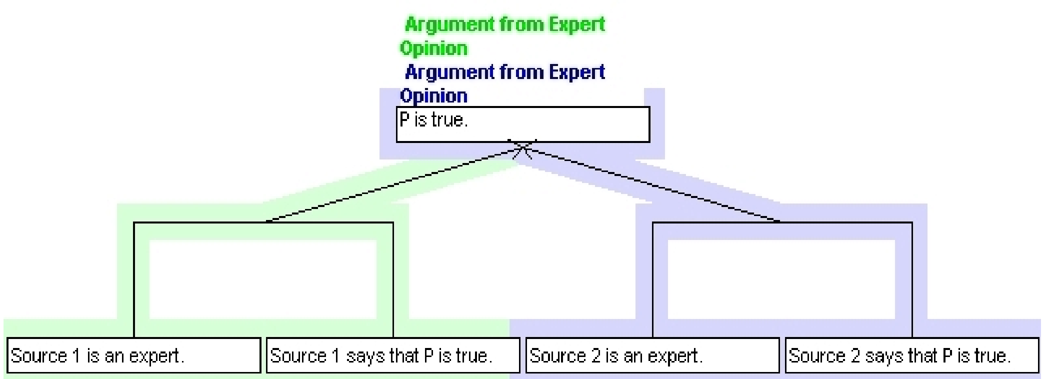

Figure 1: Corroborative Expert Opinion Evidence

In the example shown in figure 1, there are two linked arguments, each of which is an argument from expert opinion. Each is shown by the colored shading around each argument and the matching colored label. Yet if we look at the two arguments together, each of them is a convergent argument supporting the ultimate conclusion at the top.

The Carneades system is a computational model that builds on ontologies from the semantic web to provide a platform for employing argumentation schemes in legal reasoning (Gordon, 2005). The model is an abstract functional specification of a computer program that can be implemented in any programming language. It defines structures for representing various elements of argumentation, and shows how they function together in arguments (Gordon, Prakken and Walton, 2007). These elements include atomic propositions, arguments, cases, issues, argumentation schemes and proof standards. Arguments in the Carneades system are visualized using a directed labeled graph. Nodes represent arguments and arrows represent binary relations. The argument from expert opinion that was shown in Araucaria in figure 1 is shown in Carneades in figure 2. The premises and the conclusion are shown at the top right as a set of statements (propositions). Each of them appears again as a statement in a text box as shown in the argument diagram displayed on the left. The conclusion statement ‘P is true’ appears at the top. The two nodes (circles) represent the two arguments. The argumentation scheme for argument from expert opinion appears in each node, although the schemes are not visible as the diagram is displayed in figure 2. Note that there were only text boxes in an Araucaria diagram, other than the arrows (lines) representing the inferences from premise to conclusions. In a Carneades diagram, there are nodes, lines and text boxes.

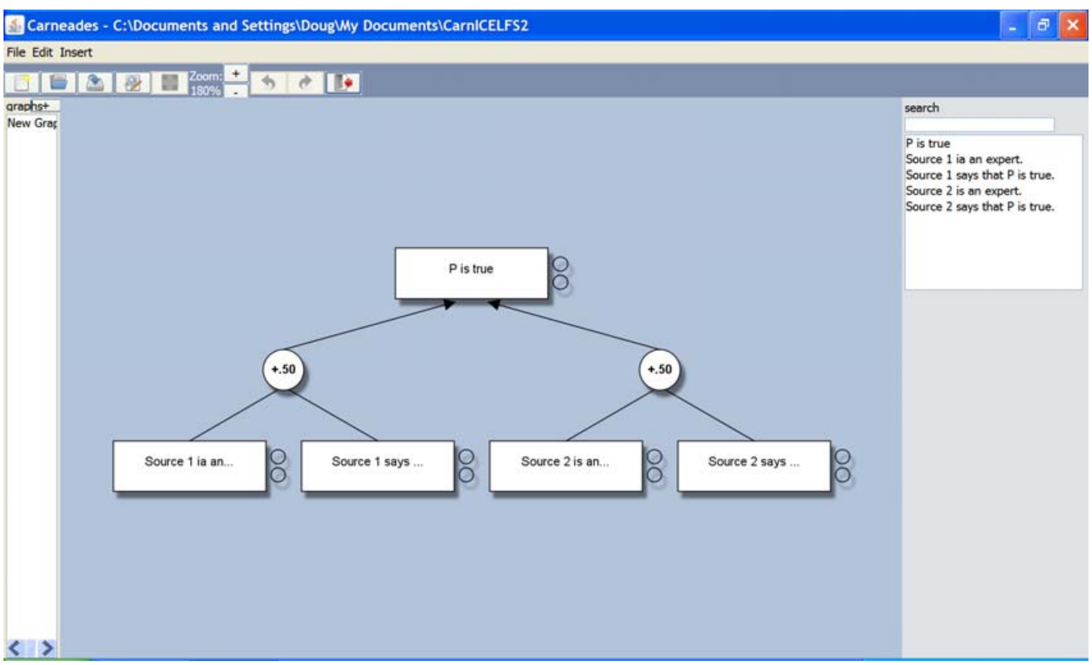

Figure 2: Screen Shot Showing Argument in Carneades

The distinction between linked and convergent arguments is represented in a different way in Carneades than it was in Araucaria. In a linked argument as shown in Carneades, like each of the two arguments from expert opinion in figure 2, the argument, shown as a node, has all the premises underneath it leading into that node. Convergent arguments are shown as separate arguments, like the two arguments from expert opinion shown in figure 2.

A key difference between Araucaria and Carneades is how the critical questions are modeled. In Araucaria the critical questions are represented on the menu when any argumentation scheme is applied to an argument, as shown in figure 3.

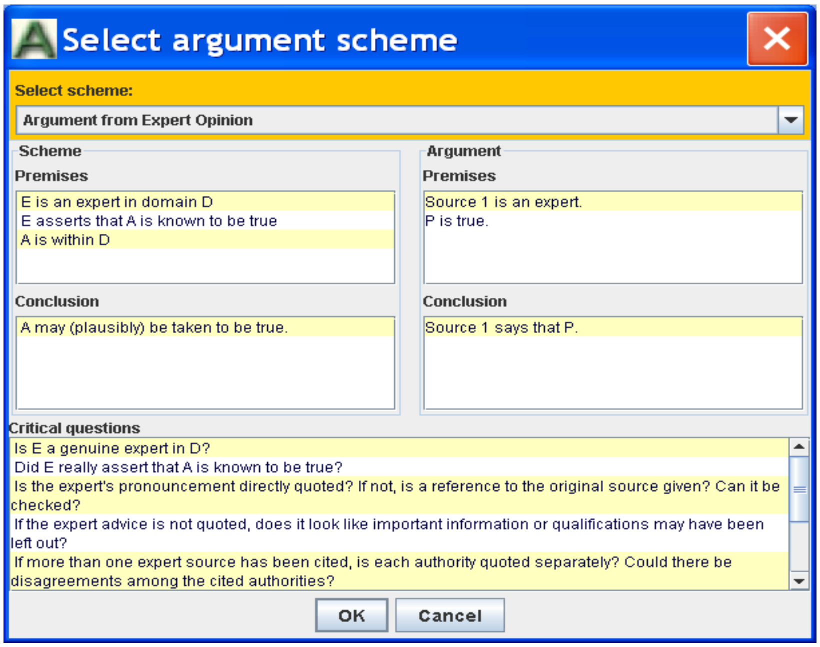

Figure 3: Screen Shot of Araucaria Menu with Critical Questions

But Araucaria does not represent the critical questions on the argument diagram itself, for example as shown in figure 1. The problem is that the critical questions cannot easily be modeled as statements, or even as rebuttal arguments attacking the original argument. The reason is that there are two different theories about what should happen to the original argument when a critical question is asked. For example consider CQ2, the field question: Is E an expert in the field that A is in? If the proponent who put forward the original argument from expert opinion fails to give any answer to this question, it seems like the original argument should default. But then consider CQ4, the trustworthiness question: Is E personally reliable as a source? In response to this question, the proponent could say, “Of course she is personally reliable. How can you impugn her integrity? Can you prove she is not personally reliable?” This situation amounts what is often described as a shifting back and forth of the burden of proof or disproof.

On the one theory, when a critical question is asked, the burden of proof shifts to the proponent’s side to answer it. On the other theory, merely asking the question does not defeat proponent’s argument until the respondent offers some evidence to back it up. Carneades approaches this problem by distinguishing three types of premises of an argument, called ordinary premises, assumptions and exceptions (Gordon and Walton, 2006). The ordinary premises are the ones stated as premises in the scheme. They are assumed to hold, but can be questioned. The assumptions are additional premises that are, like ordinary premises, assumed to hold. The exceptions are premises that are assumed not to hold, and that only come to be accepted if evidence can be given to show they do hold. The trustworthiness question is classified as an exception. It is assumed to hold unless evidence is offered to show that it does not hold. The consistency question is also classified as an exception. Merely asking this question does not make the argument default. The critical questioner must back up the question with some evidence of a second expert who disagrees with the opinion of the first one before the argument will default. The field question is classified as an assumption. It is assumed that the expert is an expert in the right field, and if this is questioned the argument defaults, even without any evidence being given that she is not an expert in the right field. The premises that the expert is credible as an expert, and the premise that what she says is based on evidence, are also classified as assumptions. We will see below that this way of representing critical questions has implications for the modeling of corroborative evidence.

Verheij (2003) has developed a formal system called DefLog for modeling legal argumentation. In DefLog arguments are taken to be made up of premises and a conclusion so that any argumentation scheme has the following form (176).

Premise 1. *Premise 2*. . . . *Premise n*. Therefore *Conclusion*.

Verheij (p. 177) uses an argument diagramming method called ArguMed to represent argumentation schemes and show how they apply to legal argumentation. The structure of any scheme as represented in ArguMed is shown by the argument diagram in figure 4, redrawn from the diagram in (Verheij, 2003, p.177).

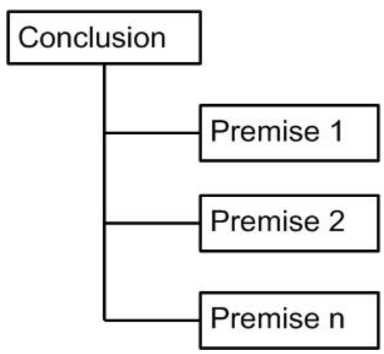

Figure 4: Structure of an Argument in *ArguMed*

The structure in figure 4 can represent any argumentation scheme, including argument from witness testimony, and argument from expert opinion.

The interesting thing about ArguMed here is that it can be used to represent two different kinds of corroborative evidence. Let's use argument from expert opinion as a case in point. In figure 5, we simplify matters by not showing each of the premises in this scheme individually. We use the short cut (heuristic) version of the scheme, which has the simple form, 'Expert E says that P, therefore P'. We use the case in which two experts are involved, and each claims that P. The first way of representing corroborative is shown in figure 5. Expert 1 says that P, and this is evidence that P is true. However, expert 2 also says that P, and this new evidence corroborates the earlier evidence.

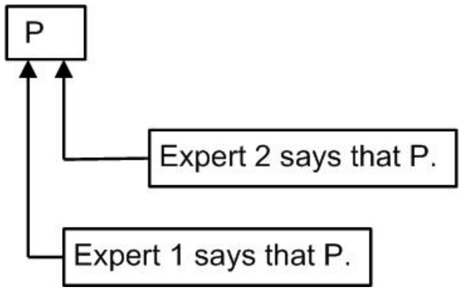

Figure 5: One Type of Corroboration in *ArguMed*

Figure 5 represents the more obvious way of viewing corroborative evidence in which each expert opinion is supposedly independent of the other, and each supports P. However, in *ArguMed*, a statement can support a conclusion in different ways, because an inference line can drawn from a statement to another inference line in a different manner from that shown in figure 5. Positive argument support can also be represented, in cases of “supporting that a statement is a reason for another” (Verheij, 2003a, 305), using the kind of evidence structure presented in figure 6.

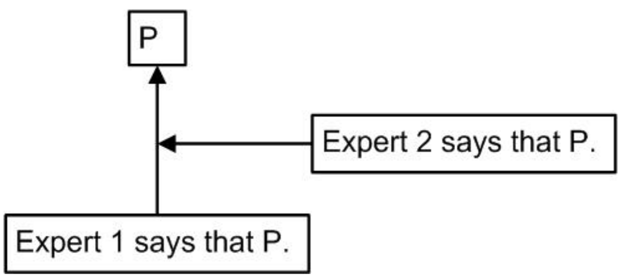

Figure 6: Positive Argument Support in *ArguMed*

In the example shown in figure 5 we have a different kind of corroborative evidence. First there is an argument from the premise ‘Expert 1 says that P’ to the conclusion P. But the other statement shown above it, ‘Expert 2 says that P’ supports (corroborates) the original argument by giving a reason to support it. This support is shown graphically in figure 6 by the arrow going from the statement ‘Expert 2 says that P’ to the argument ‘Expert 1 says that P; therefore P’. A legal example will be given in section 4 to illustrate the difference between these two kinds of corroborative evidence.

Each of these three systems for visually representing the argumentation has special features that represent corroborative evidence in different ways. Araucaria represents statements as text boxes that appear as nodes in a directed graph in which the root node is an ultimate conclusion to be proved. Araucaria has capabilities for representing argumentation schemes and some capability for representing critical questions matching a scheme. Carneades goes a step further by recognizing different kinds of premises of a scheme called ordinary premises, assumptions and exceptions. Hence Carneades can (so to speak) represent the critical questions on the graph itself. Carneades represents arguments as nodes of a graph where lines are drawn from the premises to a node and from that node to a statement representing the conclusion of the argument. In both systems however, the boxes representing statements and lines on the diagram representing inferences show as making up a graph. The structure of argumentation in both systems is that of a conventional directed graph. ArguMed is an entirely different approach to modeling argumentation in which the lines can be drawn to other lines. If one argument supports another, a line can be drawn from a second argument to that of a first one. If one argument supports the other, the line drawn from it to the other has a normal arrowhead, whereas if one argument attacks (refutes) the other, the line drawn from it to the other has an X as an arrowhead. Thus ArguMed has interesting capabilities for representing corroborative evidence in a different way from the other two systems.

4. Two Types of Corroborative Evidence

Schum (1994, 124) posits two forms of corroborative evidence represented as case 1 and case 2, shown in figure 7.

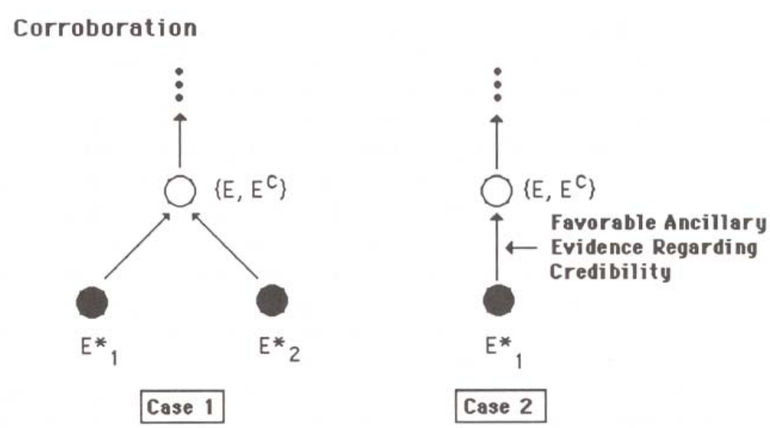

Figure 7: Schum’s Two Types of Corroborative Evidence

Case 1 represents a form of corroborative evidence in which two or more sources report E*, the statement that event E occurred. In case 2, one source reports E* and a second source provides ancillary evidence favorable to the credibility of the first source. Case 1 looks similar to the kind of corroborative evidence modeled in ArguMed in figure 5, while case 2 looks similar to the kind of corroborative evidence modeled in ArguMed in figure 6. However, it is important to note that nodes in Schum’s diagrams can represent sources or they can represent statements made by sources. Hence his diagrams of evidence are in many respects different from those of Araucaria, Carneades or ArguMed, in which nodes represent statements (and arguments in the case of Carneades). However, in some respects they are comparable. The arrows joining the nodes represent inferential steps (18). Also, it can be seen in his diagram of testimonial evidence (103) that factors drawn on the arrows, like veracity, observational sensitivity and objectivity, are reminiscent of the critical questions matching the scheme from witness testimony.

What Schum brings to the forefront is the idea that some kinds of corroborative evidence work by enhancing the credibility of a source. In argumentation terms, this is like evidence that supplies a favorable answer to a critical question, for example the question ‘Is the expert trustworthy?’. To follow up this line of inquiry, it is useful to consider a legal case using expert opinion testimony that appears to involve two distinctively different kinds of corroborative evidence.

The question raised in this case was whether a toxicology report indicating a blood alcohol reading of .13 is admissible in the civil trial without independent corroborative evidence beyond expert opinion (Stetler v. CDL Medical Technologies, Inc., 63 Pa. D. & C. 4th at 277, Affirmed by 852 A.2d 1264 (Pa. Super. 2004); Appeal Denied by 860 A.2d 124 (Pa. 2004)). In this case there was a test of blood-alcohol content (BAC) showing that the decedent in a motorcycle accident had a blood-alcohol reading of .13. However, there was no other evidence of his being intoxicated. There were no eyewitnesses, there were no skid marks left by the motorcycle, there was no evidence that he was drinking prior to the accident, and there was no evidence of erratic driving or any physical characteristics of the decedent suggesting he was under the influence of alcohol. The Court had to meet a test with two requirements. The first is a finding that the blood alcohol content had to be over .1, and the second is that there has to be corroborative expert testimony sufficient to establish that the person's blood alcohol content rendered him incapable of safe driving. Both experts agreed that if the BAC of .13 was accurate, the decedent was so intoxicated that he was unfit to drive. In order to satisfy the second requirement, the court held an evidentiary hearing where the defendants were required to produce evidence through expert testimony to establish the accuracy of the BAC. A second expert was called to testify about the accuracy of the BAC test made by the first. The second expert testified that the BAC test was reliable and scientifically accurate as an indicator of the decedent's true blood-alcohol count.

In general, we could say that there might be two ways in which the evidence provided by the second expert could corroborate the evidence provided by the first. The first, as above, is a case where the second expert is testifying at the test made by the first expert is accurate and reliable. The other would be a case in which the second expert has access to the blood sample and tests it directly himself to see whether the BAC came out to be at the same level as the finding reported by the first expert. These are two separate cases of corroborative evidence. Let's call the first type supportive corroborative evidence.

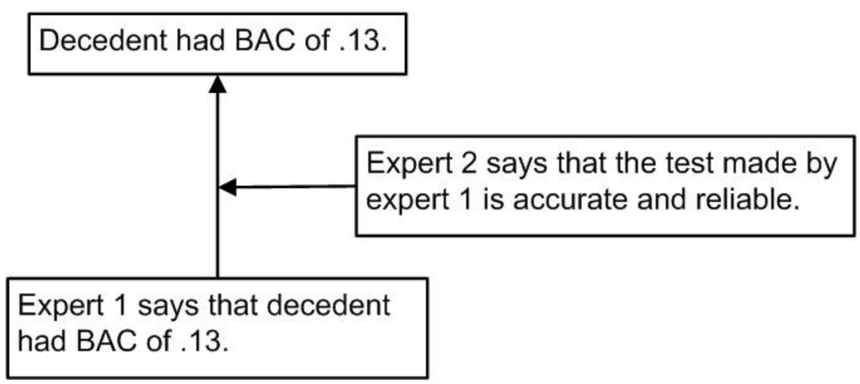

Figure 8: Supportive Corroborative Evidence

In the case of supportive corroborative evidence, the second argument is supporting the inferential link between the premises and conclusion of the first expert's argument. Using the ArguMed convention, the supportive corroborative evidence is shown in figure 8. In the second case, the second expert's testimony is directly supporting the conclusion that the decedent had the BAC stated by the first expert, as shown in figure 9. In figure 9, each of the two expert opinions (presumably) independently support conclusion P as arguments, so the second corroborates the other by providing additional support for the same conclusion. Let's call this type of evidence convergent corroborative evidence.

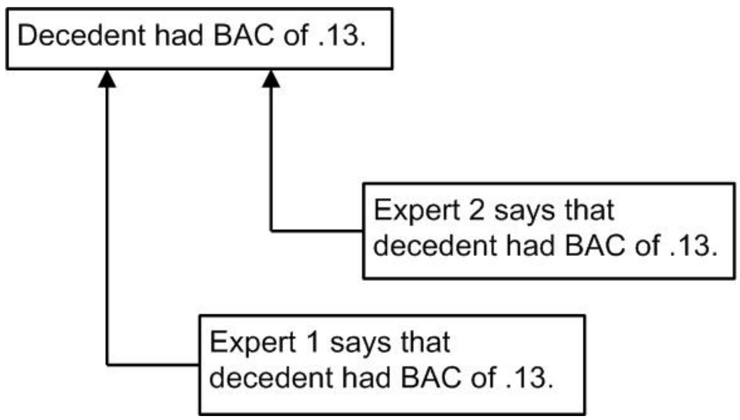

Figure 9: Convergent Corroborative Evidence

The example shown in figure 9 is an instance of the first type of corroborative evidence shown in ArguMed in figure 5, and it also looks similar to the structure shown in case 1 of Schum's figure 7. In contrast, the example in figure 8 fits the other kind of corroborative evidence shown in ArguMed in figure 6. It also looks to fit the kind of corroborative evidence shown in Schum's figure 7 as case 2.

Convergent corroborative evidence recalls the notion of the convergent type of argument that, as we showed above, is modeled by Araucaria. In a convergent argument, each premise independently of the other gives a reason to support the conclusion. Supportive corroborative evidence is reminiscent in argumentation theory of the idea of responding to a critical question. We need to recall that the fifth critical question matching the scheme for argument from expert opinion asks whether what is asserted by the expert is consistent with what other experts assert. Instead of having two independent arguments we have one supporting the other by rebutting a potential weakness in the first argument. If one expert has agreed with what another has said, that new argument will boost up the evidential value of the argument based on what the first expert said.

Both supportive and convergent evidence fit the original definition of corroborative evidence we started out with. The secondary argument supports the primary argument by presenting additional evidence to the evidence that already exists in a case. But the two types of corroboration provide evidential support in different ways. One gives additional evidence independent of the original argument while the other strengthens the original argument by patching up a potential weakness in it.

5. The Fallacy of Double Counting

We now return to the danger of committing the fallacy of double counting by counting evidence twice. Consider again the kind of case in which witness testimony by the victim pointed to the defendant, but then later, the defendant confessed to having committed the crime. Each item of evidence separately leads to the conclusion that the defendant committed the crime. But the confession may be very convincing as evidence, so much so that it has a spill-over effect of corroborating the witness testimony, which by itself might be weak. The corroboration effect could make the witness testimony seem more credible to a jury as an account that now appears to describe something that really happened. This could be a fallacy, as we noted in section 1, because the confession is counted twice, first as evidence for the conclusion that the defendant committed the crime, and second as evidence that the witness was telling the truth.

The logical solution to the problem preventing ourselves from committing the fallacy is simple. To prevent ourselves from committing this fallacy, we must subtract the amount of the value of evidence taken earlier from the confession when we come to consider the value of the witness testimony as supporting the conclusion that the defendant committed the crime (Redmayne, 2000, p. 151). However, although this solution is simple enough in theory, in practice might be hard to stick to it when summing up the evidence for and against a claim at issue in the holistic way we usually do this. It might be hard for a judge to explain the fallacy to a jury with enough clarity and force to get them to stick to the logical way of adding in corroborative evidence and not giving in to the natural inclination to commit the fallacy.

One help could be to visualize the evidence. For example, consider a case of corroborative evidence testimony as shown in figure 10.

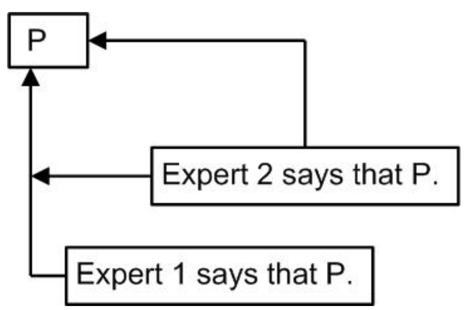

Figure 10: Corroborative Expert Testimony with Double Counting

The problem displayed is that the evidence in the middle text box is counted twice. If you remove the top arrow, the case is an ordinary one of supportive corroborative evidence. If you remove middle arrow, the case is an ordinary one of convergent corroborative evidence, with both items of testimony independently supporting P.

To explain to someone how to prevent the fallacy of double counting from occurring, we have to be aware that there can be two different kinds of corroboration, supportive and convergent. These evidential relationships can become even more confusing when dealing with typical cases of expert testimony where the testimony of one expert witness corroborates that of another. Consider the kind of evidence shown in figure 11.

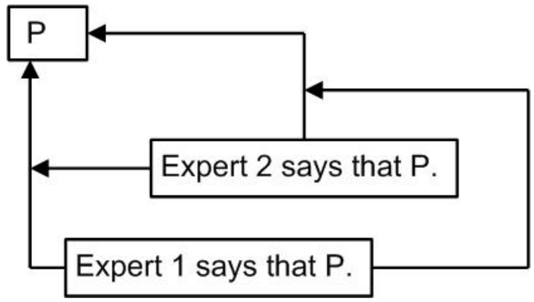

Figure 11: Double-Double Counting in Corroborative Expert Testimony

In this kind of case, what each expert says supports the conclusion P, but at the same time, each expert supportively corroborates what the other says. It might be hard to resist this kind of double-double counting even in routine cases of the use of expert testimony evidence. For naturally, when two experts agree, their agreement not only boosts up each of them as credible experts, but what each says provides independent evidence that supports the statement they agree on.

Carneades also has a way of throwing light on the problem, by distinguishing the different kinds of premises in an argument like argument from expert opinion that represent critical questions matching a known argumentation scheme. Carneades models convergent corroborative evidence in the manner shown in figure 12, where there are two independent arguments from expert opinion supporting the conclusion that statement P is true. Carneades models supportive corroborative evidence by displaying additional premises that correspond to critical questions, as shown in figure 12.

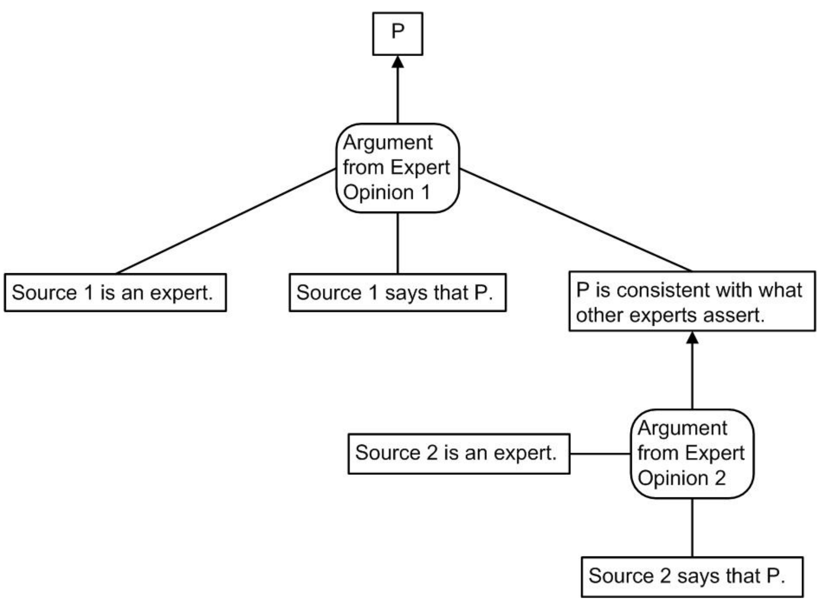

Figure 12: Supportive Corroborative Evidence Displayed in Carneades

We should recall that the consistency critical question asks whether the statement P (the conclusion) is consistent with what other experts assert. We should recall from the discussion of critical questions as assumptions and exceptions that this critical question is classified as an exception, meaning that is assumed not to hold unless new evidence comes in showing that it does hold, and that only if such new evidence comes to light does the argument from expert opinion default. Looking at figure 12, we can see that the second argument from expert opinion supports the statement that P is consistent with what other experts assert on the ground that source 2, another expert, has also said that P is true. In other words, the second argument from expert opinion supports a premise of the first one by arguing that a potential exception to the defeasible argumentation scheme for the first one does not hold.

This method of modeling convergent corroborate of evidence and supportive corroborative evidence is a good way to clearly instruct a user how to distinguish between the two types of evidence, and thereby how to avoid, or at least be aware of the fallacy of double counting. It is different from the methods used by Araucaria or ArguMed. Using the Carneades system we can take the approach of viewing supportive corroborative evidence as an argument structure that essentially represents how the argument that fits a particular scheme responds to a critical question right on the diagram itself. As we saw, Araucaria does represent critical questions matching a scheme on one of its menus, and does have the device of refutation to display on the diagram how one statement or argument can refute another. However, neither of these systems (so far) has the capability to represent how one argument responds to critical questions (right on the diagram) itself by displaying ordinary premises, assumptions and exceptions as different kinds of premises. Carneades shows convergent corroborative evidence as an instance of two arguments supporting the same conclusion and shows supportive corroborative evidence as an instance of one argument supporting a premise of another.

6. Conclusions

This work is a refinement and extension of certain aspects of the analysis of corroborative evidence first put forward in (Walton and Reed, 2008). The earlier work was more concerned with the evaluation of corroborative testimonial evidence, and it used only the Araucaria system to study how the plausibility of one argument is used as corroborative evidence to boost up the probative weight of another argument. The earlier work included positive boosting and negative argument rebuttal. This later work has excluded cases of rebuttal, and has also not addressed the evaluation problem of how one argument supports another by increasing its plausibility value. In this paper we did not put plausibility values on the nodes or arrows. Instead, the present paper has concentrated on how corroborative evidence is visualized in three different software systems for argument mapping, and has been (almost) exclusively concerned with the case of argument from expert opinion.

The earlier paper proposed two hypotheses as possible explanations of how such increases of probative weight should be modeled in corroborative argumentation. The first hypothesis (Walton and Reed, 2008, 541) was that the boost effect of plausibility value in cases of corroborative evidence can be explained by the way the corroborating argument responds to a critical question. To explain the boost effect when the opinion of a second expert corroborates one previously put forward by a first expert, Walton and Reed (2008, 541) proposed the hypothesis that the second argument rebuts the objection that other experts might disagree. In other words, it answers the critical question about consistency with other experts. The second hypothesis proposed by Walton and Reed (2008, 542) was to put forward a special argumentation scheme for corroborative evidence. In the present paper, only the first hypothesis was explored, and some evidence moving it forward and helping us to understand it better was found by studying the capabilities of the three selected argument visualization tools for displaying aspects of the structure of reasoning in corroborative evidence.

The investigations in this paper have brought out the importance of the distinction between the two fundamental kinds of corroborative evidence, supportive corroborative evidence and convergent corroborative evidence. On the basis of what was found, it can be conjectured that it is the potential for confusion between these two kinds of corroborative evidence that is at the root of the fallacy of double counting. Schum (1994, 124) modeled the structure of these two basic types of evidence using an evidence visualization system, an important step in the study of the logical structure of corroborative evidence. Another step was the study of the structure of corroborative evidence using Araucaria (Walton and Reed, 2008). One of the next steps along the way was the finding of a legal case in which the notion of supportive corroborative evidence is clearly represented, and clearly contrasted with convergent corroborative evidence. This case (Stetler v. CDL Medical Technologies) concerned corroborative evidence supporting expert testimony evidence. The next step in the investigation was the discovery of the different and interesting ways the distinction between these two kinds of corroborative evidence can be visualized in Carneades and ArguMed. Further research needs to extend and examine both approaches to see how each can be applied to other legal evidence cases, and to study what the comparative powers of each model are.

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