# Wigmore, Toulmin and Walton: The Diagramming Trinity and their Application in Legal Practice

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**Abstract**

These notes summarise three distinct approaches to the diagramming of argument (and for two of the three, for legal argument in particular). The three approaches are all supported by a diagramming tool known as Araucaria that automatically translates between the different approaches. In the talk, I shall argue that such automatic translation is useful in allowing individual users to use and combine the analytical devices they find most useful in the each of the three approaches, and in supporting a community of users that employ different analytical techniques.

*Key words:*
*PACS:*

## 1 Diagramming

The technique of argument diagramming is widely used in informal logic [1], and in the teaching of philosophy and critical thinking [2]. It also has a long history going back at least as far as the start of the nineteenth century [3]. It has recently been attracting attention in both decision support and computational linguistics, and there are a wide range of software tools available targetted at different markets (see [4] for a good review). Perhaps surprisingly, most of these tools adopt a similar style of diagramming; Araucaria is amongst a small number that actively support and encourage the use of widely different styles of analysis. The next three sections briefly review three popular and influential styles (each of which reflect a theoretical architecture for argument understanding).

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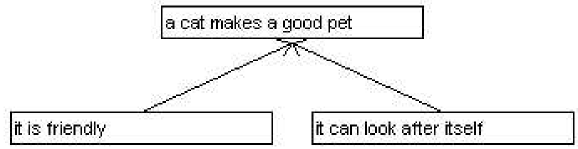


Fig. 1. A simple convergent argument in Araucaria

### *1.1 Diagramming the Standard Account*

The most common diagramming technique does not have an official name, so we will refer to it simply as a *standard* diagram. A standard diagram is a tree with the conclusion of the argument as the root node. Some authors draw the root node at the top of the tree, while others invert the tree so that the root node is at the bottom of the diagram. We will use the former convention, although Araucaria allows either type of diagram.

Each node in the diagram can be supported by one or more additional nodes, each of which represents a premise in the argument. Premises can be of two main types: *convergent* or *linked*. A convergent premise stands on its own as support for another node, while a linked premise must link with one or more other premises to form support. As an example, the argument "a cat makes a good pet because it is friendly and it can look after itself" consists of a conclusion ("a cat makes a good pet") supported by two convergent premises ("it is friendly" and "it can look after itself"). Either premise provides support for the conclusion without the other, although the two together form a stronger argument than either on its own. A convergent premise is drawn as a node with a single arrow leading to the conclusion it supports. See Fig 1.

An example of a linked argument would be the following. "Jon understands Newton's laws of motion because Jon got 90% in the first year physics course and the first year physics course covers Newton's laws of motion". Here the conclusion is that "Jon understands Newton's laws of motion" and this is supported by the premises "Jon got 90% in the first year physics course" and "the first year physics course covers Newton's laws of motion". These two premises are linked because neither on its own is sufficient evidence from which to draw the conclusion that Jon understands Newton's laws of motion. Linked premises are shown as connected by a horizontal line which in turn gives rise to a single arrow connecting all linked premises in that group to the conclusion they support. See Fig 2.

Standard diagrams support the notion of a *refutation*, which is an argument that refutes or argues against another node in the diagram. In propositional logic, the notion of refutation is that for a given statement P, there is a state-

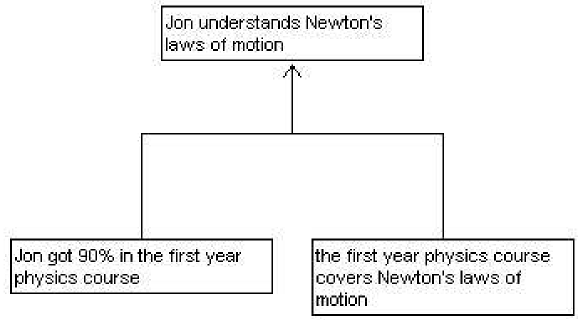


Fig. 2. A simple linked argument in Araucaria

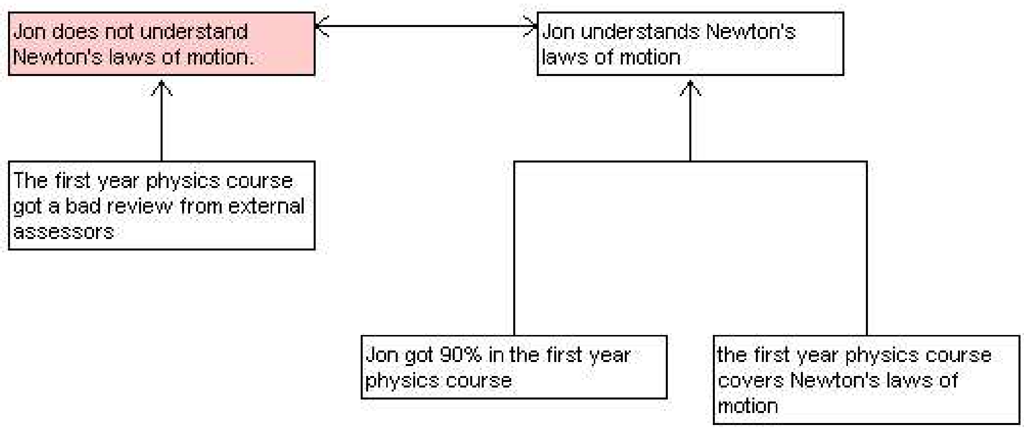


Fig. 3. An argument with a refutation.

ment not-P which is the logical opposite of P. Since each statement can have only one logical opposite, the standard diagram allows only a single refutation for any given node. Of course, in a 'real' argument, there could be a number of arguments against a given proposition. In the standard diagram, such a situation is represented by creating the single refutation node for the proposition which is to be refuted, and then to draw in the various arguments against the proposition as supports for the refutation. In the example above, the refutation to the conclusion "Jon understands Newton's laws of motion" is "Jon does not understand Newton's laws of motion". This refutation could be supported by the proposition "the first year physics course got a bad review from external assessors" as shown in Fig. 3.

In Araucaria, a refutation is drawn as a node to the left of the proposition it is refuting, and is connected to the proposition by line with arrows on both ends.

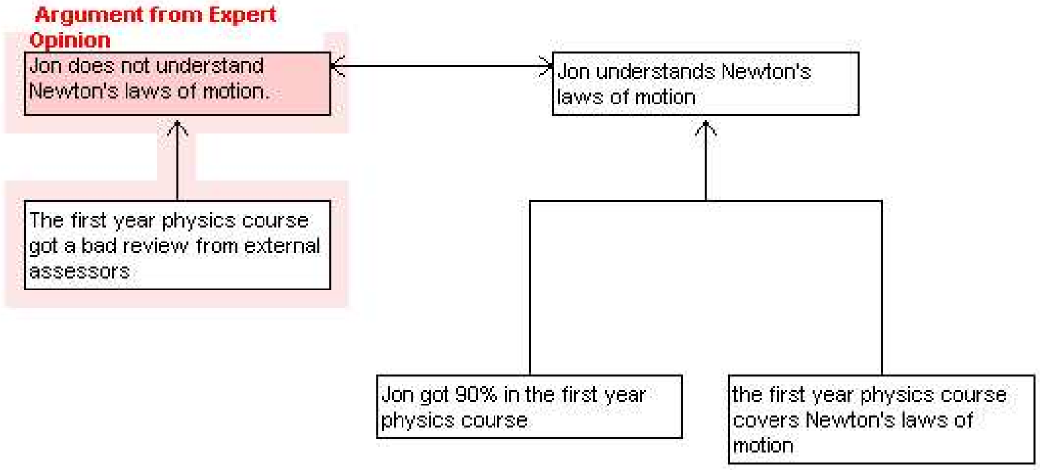


Fig. 4. The refutation and its support form an example of the scheme 'argument from expert opinion'.

In addition to the basic structure of the tree in a standard diagram, Araucaria supports several other features. An argumentation scheme [5] can be drawn by selecting several supports or nodes and then selecting the scheme to which they belong. This is shown in the diagram by a coloured outline of the selected supports and nodes. Full information on the particular scheme can be obtained by bringing up a dialog box which displays the role of each premise in the scheme and which critical questions have been answered. In addition, Araucaria allows the editing and creation of sets of schemes, so the user can customize existing schemesets or create new ones (the software currently supports approaches to schemes advocated by Walton [5], Grennan [6], Perelman and Olbrechts-Tyteca [7], Katzav and Reed [8] and Pollock [9]).

In the example above, the refutation and its support could be an example of the scheme “argument from expert opinion”, in which a conclusion is stated to be true because experts in the field say it is true. Fig. 4 shows the scheme added to the diagram shown in Fig. 3.

In a natural argument, some propositions will have greater validity or force than others. In a standard diagram, a force can be represented as an *evaluation* of the support line connecting a proposition with its conclusion. Typically an evaluation is just a number such as a percentage value which indicates how strong the inference is between the two nodes. Araucaria allows evaluations to be defined for any support arrow, and evaluations can be any text (not just numbers).

When analyzing text, different propositions can be derived from different sources. For example, in the “cats make good pets” argument above, the vari-

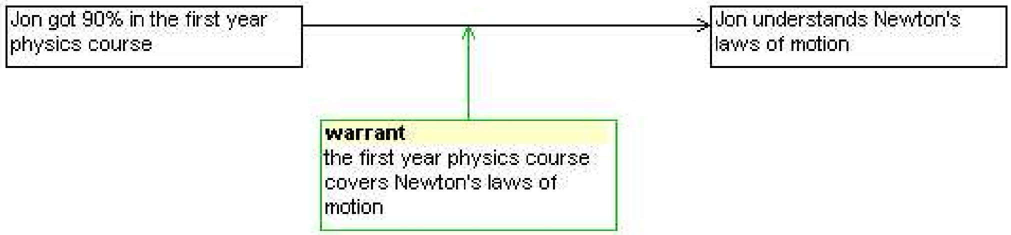


Fig. 5. A Toulmin diagram showing the basic datum-warrant-claim complex.

ous convergent arguments may have been obtained by a primary school teacher asking the class for reasons that cats make good pets, and each convergent argument may come from a different child. In such a case, a proposition can have an *owner*, which is someone who proposed that argument. Araucaria allows a given proposition to have one or more owners, which can be defined as text strings.

### *1.2 Diagramming the Toulmin Account*

The Toulmin diagram [10] in its original form is based on the datum-warrant-claim (DWC) complex. The claim is the conclusion of the argument, which is supported by the datum. The warrant provides justification for the statement that the datum supports the claim. Thus the DWC seems closest to the notion of a linked argument in a standard diagram. We might say that Jon understands Newton's laws of motion (the claim) because he got 90% in the first year physics course (the datum). On its own, however, this could leave the reader wondering if the physics course's coverage of Newton's laws was sufficient to provide even a very good student with an understanding of them. Thus we provide the warrant which states that the first year course does indeed provide a through grounding in Newton's laws. In Araucaria, a warrant is drawn as a green node with a link into the line connecting the datum and the claim.

A simple Toulmin diagram containing only a single DWC complex is drawn as in Fig. 5. The datum is on the left and connects to the claim on the right by a horizontal line. The warrant links into the line from below as shown. The diagram thus illustrates the idea that the warrant supports the inference from datum to claim, rather than the claim directly. This diagram is produced by Araucaria as a direct translation of the standard diagram shown in Fig. 2. See below for a discussion of the translation of diagrams.

A Toulmin diagram provides the *rebuttal* as the mechanism for rebutting an argument. A rebuttal appears as another node that links into the DWC by a vertical line from below. The fact that the rebuttal also impacts on the link

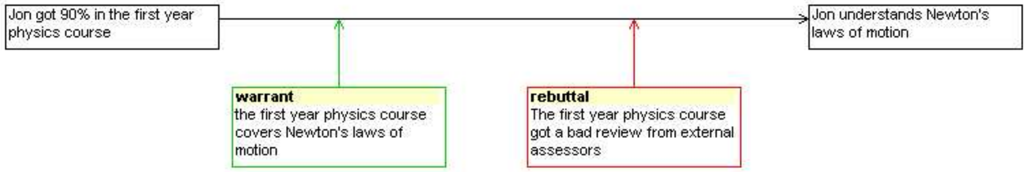


Fig. 6. A Toulmin diagram with a rebuttal.

between datum and claim shows that it attacks the inference from datum to claim, rather than being a strict negation of the claim as is the case with the refutation node in the standard model. In the example above, we might add a rebuttal to the argument by saying "the first year physics course got a bad review from external assessors" which casts doubt on the value of getting a high mark in the course, thus undermining the implication that getting 90% in it would imply a sound knowledge of the material covered by the course. The correspondence between the Toulmin rebuttal and the standard refutation is discussed in more detail below in the section on translating Toulmin diagrams. In Araucaria, the Toulmin rebuttal is drawn as a red node connecting to the datum-claim link, as shown in Fig. 6.

The final feature in a Toulmin diagram is the *qualifier*. A qualifier plays roughly the same role as an evaluation in standard: it provides a measure of the confidence in the DWC complex. Qualifiers are also attached to the link between datum and claim, and are indicated in Araucaria as yellow triangular nodes.

### *1.3 Diagramming the Wigmore Account*

A diagramming model was produced by Wigmore in the early 20th century to allow diagrams of legal arguments. The structure is superficially similar to the standard diagram in that the argument is drawn as a tree with the root node at the top, but there are some important differences. Usually, there are two main trees for a single court case: one for the argument from the prosecution and the other for the defense. Within each tree, the top level node is typically the central charge in the case which is either to be proved, in the case of the prosecution, or refuted, in the case of the defense. We will consider the prosecution's argument in what follows.

The root node can have three groups of nodes connected to it (see Fig. 7). The main evidence supporting the central charge is presented as a block of testimonial or circumstantial nodes. Testimonial evidence is evidence introduced as testimony by witnesses, so could consist of accounts of what the witnesses saw, or other evidence supposedly known as facts by the witnesses. Circumstantial evidence is evidence that is inferred from other facts, such as "the defendant

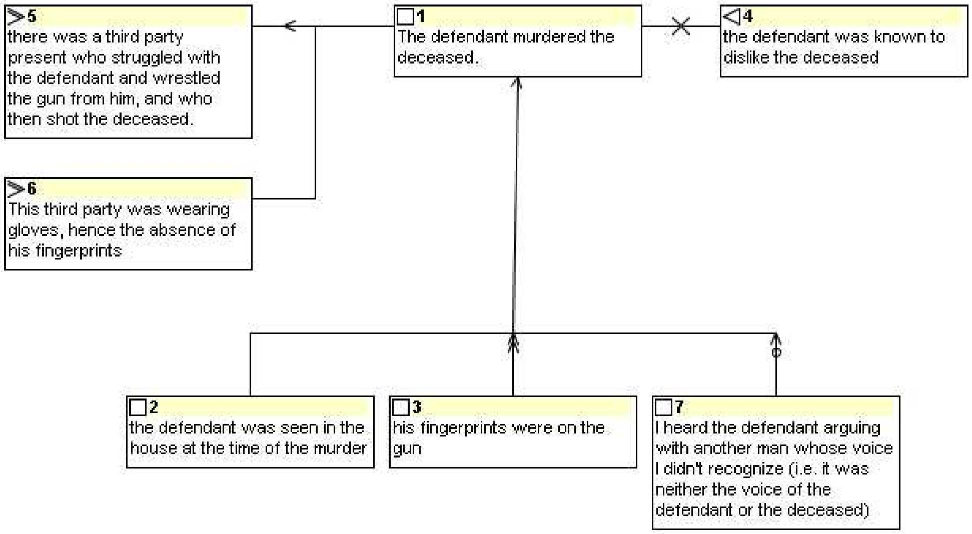


Fig. 7. A Wigmore diagram.

was seen in the house at the time of the murder and his fingerprints were on the gun, so it can be inferred that he shot the deceased". This group of nodes thus corresponds to the basic facts (or statements that can be presumed to be facts since they were given under oath) pertaining to the charge. Nodes 2 and 3 in Fig. 7 represent these arguments (we will consider node 7 below).

The second group of nodes contains corroborative evidence. This is evidence introduced to support the central charge or testimonial/circumstantial evidence. Thus corroborative evidence is introduced on the side of the party attempting to establish the claim in the root node and would be seen as supportive evidence in the context of the argument. In the argument above, the claim that "the defendant was known to dislike the deceased" could be introduced as corroborative evidence since it establishes motive. The distinction between corroborative and testimonial evidence is not precise and is in many cases subjective. Node 4 in Fig. 7 shows the corroborative argument.

The third group of nodes contains explanatory evidence. This is evidence introduced by the opposite side in the case, and it attempts to lessen the credibility or deny outright the claim being made. In the above example, the defense may introduce the explanatory evidence that "there was a third party present who struggled with the defendant and wrestled the gun from him, and who then shot the deceased. This third party was wearing gloves, hence the absence of his fingerprints." Nodes 5 and 6 in Fig. 7 show the above evidence as two explanatory arguments.

In a Wigmore diagram, these three sets of nodes are placed in specific locations relative to the node they support (or deny, in the case of explanatory evidence). The testimonial/circumstantial nodes are placed below the central node, the explanatory nodes are on the left and the corroborative nodes are on the right. All nodes within each group are drawn as linked into a single support arrow, which in turn impinges on the central node.

The nodes and edges in a Wigmore diagram have a variety of symbols that are used to adorn them. We will not give a complete catalogue here, but an outline of the main categories of these symbols will be useful.

Each node itself can be evidence introduced either by the prosecution or defense, thus the symbols for the various nodes occur in pairs. The main symbol for each type of node is defined for the prosecution, and the corresponding symbol for the defense adds an extra horizontal bar within the symbol. Thus the symbol for testimonial evidence introduced by the prosecution is a square, and for similar evidence introduced by the defense, it is a square with a horizontal line drawn inside it. In Fig. 7, the symbols are shown to the left of the identifying number in the top line of each text box. The original Wigmore diagram showed only the symbol and associated number, and the analyst had to make reference to a separate text to provide the link between the diagram and the case notes. Araucaria allows both the full-text version of the Wigmore diagram (shown in Fig 7) and the traditional version to be drawn.

The connections between nodes can have a variety of symbols added to them. An unadorned line indicates some 'average' degree of support. Extra force in the support is indicated by adding various arrowhead or cross symbols (depending on the particular link), while a lessening of support, as might occur in with an explanatory node which argues against the claim, is indicated by a backwards pointing arrowhead. In Fig. 7, for example, the double arrowhead leading from node 3 indicates strong support for the conclusion. The backwards arrow on the link from node 5 indicates that node 5 detracts from the conclusion. The X on the line from node 4 indicates that corroborative node 4 reinforces the conclusion. There are a number of other symbols that can be used to indicate varying degrees of support between nodes.

Wigmore distinguishes between the support provided by individual nodes and the aggregate support provided by all the nodes in a particular group. For example, in the set of testimonial nodes, each node in the set can have its own influence on the claim by being assigned its own degree of force. Some nodes may have average force, some strong and others very strong force. Taken together, the net effect of all the nodes in the group may be judged by the analyst to have 'strong' (as opposed to 'average' or 'very strong') force, so the single link leading from the line that groups all the nodes together can be assigned a symbol indicating what Wigmore calls the "net probative force" of all the testimonial nodes taken together. The line joining the set of nodes 2, 3 and 7 to the main conclusion is shown with a single arrow on it, which indicates that the net probative force of these three nodes is 'provisional'.

We have seen that the explanatory nodes provide a type of refutation or rebuttal mechanism in that they represent evidence provided by the opponent of the main claim. However, individual or aggregate links in a Wigmore diagram can be labelled as *negatory* nodes by placing a small circle on the line in the diagram. Wigmore is not entirely clear what this negatory symbol means, but it seems from the few examples he provides that it is intended to indicate that the evidence does not support the claim. Thus a testimonial node in the example given above might state "I heard the defendant arguing with another man whose voice I didn't recognize (i.e. it was neither the voice of the defendant or the deceased)". If this evidence was given by a prosecution witness, it would be included in the diagram as a testimonial node but given negatory force since it doesn't support the prosecution's claim that the defendant and deceased were alone in the room at the time of the shooting. This node is shown as node 7 in Fig. 7.

A hallmark of Wigmore diagrams is that many of the assignments of force or even the group into which a given bit of evidence is inserted can be quite subjective. The degree of force assigned to a particular node, or whether a node is testimonial or corroborative could vary from one analyst to another. The Araucaria representation of Wigmore diagrams is flexible enough to allow editing of the diagram to suit any taste.

## 2 Translation

### *2.1 Motivation & Desiderata*

Argumentation theory enjoys a rich scholarly debate about how best to conceive of, and then, analyse real argumentation. There is no general consensus because different authors tend to focus on different aspects. The approach taken by the Araucaria project has been to try to support this diversity whilst maintaining a core coherence, and to do so by engineering pragmatic solutions for translating between the different styles of theoretical and practical analysis.

Our experience working with these multiple theoretical approaches to argument analysis has yielded desiderata for the process:

(i) Translation should be deterministic, always providing the same output for any given input

(ii) Translation should be symmetrical, i.e. translation from A to B should be 1:1 and onto, as should backtranslation from B to A, so that backtranslation from translation is always equivalent to identity
(iii) Translation should make maximal use of a common interlingua where possible
(iv) Where (iii) cannot be met, theory specific analysands should be included by extending the interlingua

The role of the interlingua here is taken on by the formal framework for analysis, presented in section **??**. In implementation for Araucaria this is rendered as the Argument Markup Language, AML, a standard XML-based language which may be used to represent arguments, though in principle a more flexible system such as the AIF [11] could be used. Here we explore the translation of Toulmin and Wigmore diagram types into standard notation, and back again.

### *2.2 Translating Toulmin Analyses*

In translating from a Toulmin diagram to a standard diagram, we need to consider the various components of a Toulmin diagram and how they correspond to features in a standard diagram. The elements of a Toulmin diagram we will consider are atoms, warrants, backings, qualifiers and rebuttals.

#### *2.2.1 Atoms*

Although the notion of what constitutes an argument or an atomic component of an argument [8] [12][13] is highly contentious, we will adopt the view that there is little difference between atomic statements in any of the models of argument. A standard premise can serve as a Toulmin datum or warrant, for example.

#### *2.2.2 Warrants*

The simplest construct in a Toulmin diagram is the datum-warrant-claim (DWC) complex. The warrant can be interpreted [14] as a reason for the datum being relevant to the claim. As such, it is reasonable to interpret the datum and warrant in a DWC as a pair of linked premises in the standard model. Figure 8 [1] shows a typical translation.

It is important not to read too much in to Figure 8. We are not claiming that the diagram captures the full meaning of the particular argument struc-

[1] The example is from Hansard, and is taken from the AraucariaDB online corpus.

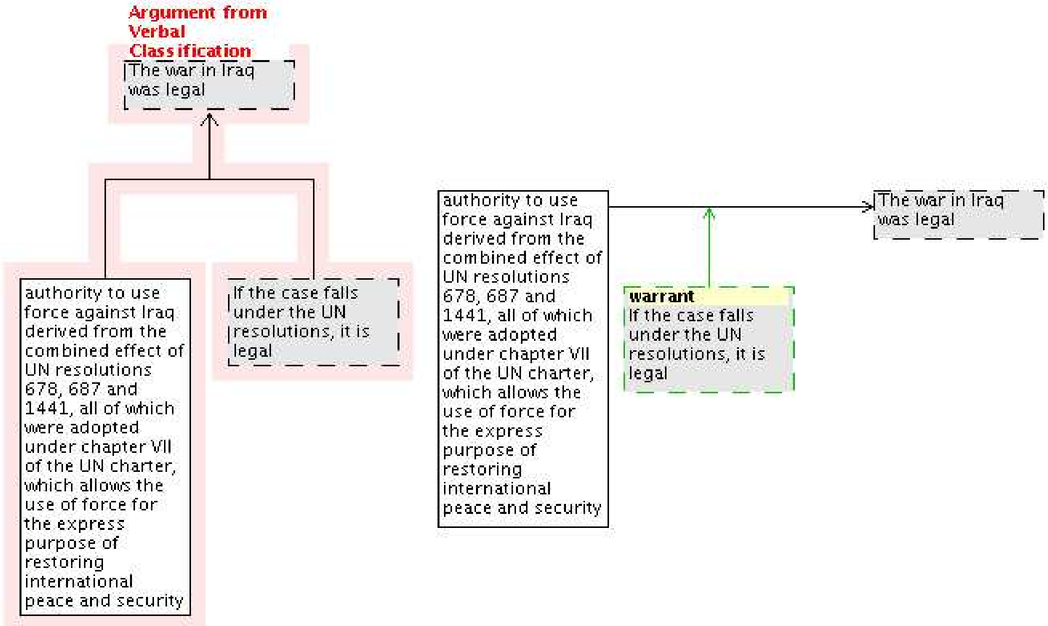


Fig. 8. A linked argument as a single DWC complex

ture; rather we are proposing a reasonable interpretation of one diagramming system in terms of the other, using those features of each system that are available. Some authors certainly do not regard a warrant as equivalent to a standard premise [15] but since the standard system has no exact equivalent to the Toulmin warrant, the premise seems the best we can do. Figure 8 merely attempts to depict the argument so that it would make sense to workers using either system.

Figure 8 also highlights a closely related point of correspondence in the translation. In the standard analysis, the example has been marked as an instance of a particular argumentation scheme. Toulmin analyses do not usually employ such devices. However, as both [5] and [8] have pointed out, argumentation schemes can be seen as analytic devices for handling warrants. So perhaps Toulmin warrants are best translated as instances of particular schemes. There is unfortunately a practical problem with this solution. Where Toulmin analyses identify a warrant explicitly, and can therefore mark any number of different warrants as such, models of argumentation schemes are in their infancy and are consequently limited. Though efforts at taxonomic work have begun (vide Walton, and Katzav and Reed, ibid), coherent and wide-ranging systems of argumentation schemes are simply not available. There is, however, a way forward. With recent proposals for seeing argumentation schemes as (at least in part) shorthand for a number of characteristic implicit premises or sets of implicit premises ([16]), the explicit warrant of a Toulmin analysis might be seen as one of the linked premises associated with a scheme in a standard analysis. This leaves scope for the analyst to identify a scheme from those that are available, but does not necessitate such identification in the automated translation process. We return to the issue again in the context of rebutting, below.

One challenge remains. In the standard treatment, a linked argument can have any number of premises, while a Toulmin DWC complex typically contains only one datum and one warrant. Assuming we wish to preserve all the premises in the standard diagram when translating to Toulmin, we need to broaden the Toulmin diagram to allow either several data or several warrants, or both.

Allowing several data in a single DWC complex is not necessary and seems to violate the spirit of the Toulmin model. The datum provides the basis from which to build an argument to support a claim. (It is possible that several different data can give rise to separate arguments, each of which supports the same claim. We consider this below.)

We are left with allowing a single datum with several warrants supporting a single claim. Though taking liberties with the Toulmin picture, this meets objectives (iii) and (iv) from the introduction, and most importantly, means that as described in objective (v), analysts working in either tradition needn't worry about the foibles of the other (just because Toulmin diagrams can be constructed in which more than one warrant supports the move from datum to claim does not mean that such analyses will be at all common for those working in the Toulmin framework).

### *2.2.3 Complex Arguments*

A similar approach is required with another general problem. The standard treatment allows the construction of analyses of arbitrary complexity and depth. Toulmin was unconcerned with such larger scale structures, and focused therefore upon the simple, individual argument with its six components. The simplest solution is to allow each component in a basic Toulmin diagram to act as a claim and thus acquire its own support. This mirrors the structure of a standard diagram where each premise can in turn serve as a conclusion for other premises in layers below it in the tree.

In the Araucaria implementation of Toulmin diagrams, all elements in a Toulmin diagram except the qualifier are therefore allowed to act as claims and have support attached to them. In addition, we also allow more than one such construct to support a single claim.

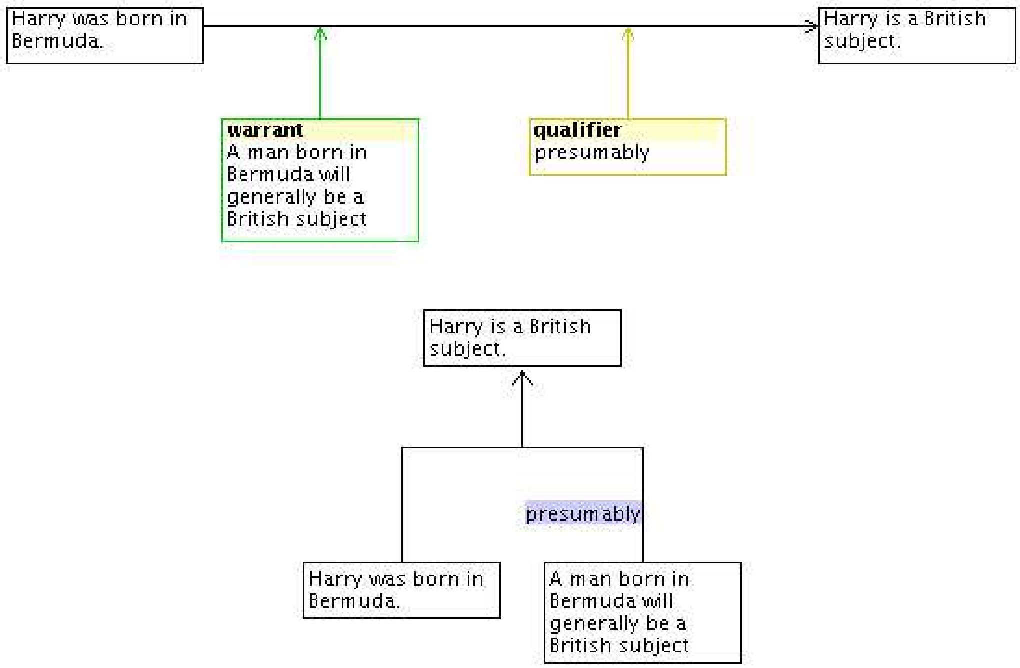


Fig. 9. Mapping evaluations and qualifiers between Toulmin (upper) and Standard Treatment (lower)

### *2.2.4 Qualifiers*

In the standard treatment, qualifiers (called “evaluations” in the standard treatment tools in Araucaria) are rarely included in analyses and diagrams: when they are, they are identified with support relations. Thus, qualifiers work as a modality or modifier, expressing the degree of support captured by an arrow between two argument components. This role is very similar to that carried out by the qualifiers in the Toulmin approach, so we translate one in terms of the other, as in Figure 9. Here, we use Toulmin’s introductory example.

If there are multiple evaluations in a standard analysis, it is the one attached to the warrant (i.e. the premise that stands in the Toulmin “warrant” role) that is identified as the qualifier. Most of Toulmin’s examples suggest that the qualifier modifies the scope of the warrant, or is picking out the defeasibility, plausibility or presumptive nature of the warrant (so, in the example above, it is the “generally” of the warrant that seems to require qualification of the claim with “presumably”). Toulmin points this out explicitly in introducing qualifiers: “Warrants are of different kinds, and may confer different degrees of force on the conclusions they justify” [10, p. 100].

### 2.2.5 Backings

A backing is a node that provides support for a warrant. In Toulmin's original diagram structure, in which only a single DWC complex is considered, this is the only way in which a warrant could be supported. In Araucaria, as mentioned above, we allow any component of a Toulmin diagram, except for the qualifier, to serve as a claim in its own DWC construct. Thus a warrant can be supported both by data and by backings.

The distinction between the two is subtle and is discussed more fully in [17]. Suffice it to say here that Araucaria allows a warrant to be supported by any number of data, in the same way as a normal claim, and also by any number of backings. A backing can, in turn, serve as a claim in its own DWC structure. In a standard diagram, a Toulmin backing is translated into a normal premise supporting the statement corresponding to the warrant.

### 2.2.6 Rebuttals

The final component of the Toulmin picture is perhaps the single most troublesomeand most interesting from a theoretical point of view: rebuttals. Most standard treatment systems involve some mechanisms for identifying conflicts: propositional negations, counter-positions, incompatibilities, etc. For some reason, there does not seem to have emerged a consensus on how best to deal with the issue diagrammatically. This has transferred directly into software implementations of diagramming methods: Reason!Able, for example uses coloured arrows [18], Argue! has lines terminated in diamonds [19] and so on. Araucaria's solution is to use double-headed horizontal lines, and to restrict any given proposition to a single conflicting proposition (though that proposition in turn may have an additional conflicting proposition that is not the first, and so on). Whatever the exact mechanism for handling and representing these conflicts, the challenge is the same: is it possible to construe Toulmin rebuttals in terms of standard treatment refutations?

There seem to be (at least) four possible standard treatment interpretations of the Toulminian notion of rebuttal, summarised in Figure 10.

The first candidate is that a rebuttal refutes its claim (we use rebuttal to refer specifically to that Toulmin role, and refutes to refer specifically to the countering relationship expressed by a horizontal line in Araucaria's implementation of the standard treatment). The single largest problem with this approach is that it seems to fail to capture accurately the function of the Toulmin rebuttal. Not only the examples in [10], but even the very diagrams that label rebuttals with unless, suggest that rebuttals function not to refute the claim, but to capture exceptions, objections or ways in which the argument may not apply (and may perhaps not apply in the case at hand). In this way,

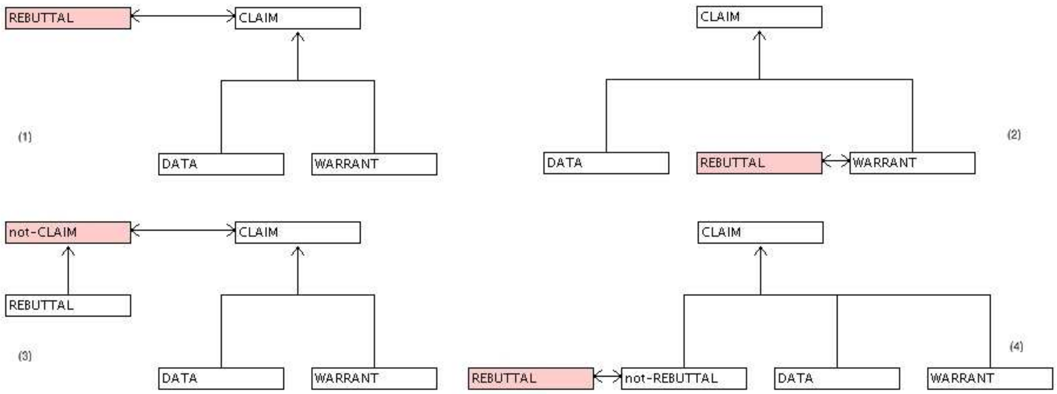


Fig. 10. Four candidate standard treatment interpretations of Toulmin rebuttals

rebuttals are functioning in a manner akin to undercutters in Pollock's [9] terminology. Undercutters take on the role of defeating an argument by attacking the inference, the way by which a conclusion was derived. Of course, in the Toulmin framework, the way by which a conclusion was derived is captured specifically by the warrant. Perhaps then, a second possible interpretation is more favourable: the rebuttal refutes the warrant. Again, though, this perverts the explication laid out by Toulmin. In the initial example, used in Figure 4, above, the warrant is A man born in Bermuda will generally be a British subject. It is surely not the case that the rebuttal, Both his [Harry's] parents were aliens refutes this general statement. Even if the rebuttal is true in a specific circumstance, the general presumptive rule might nevertheless hold true. It might be argued that what the rebuttal does serve to do in this case is to lend implicit support to the conclusion that (in this case) Harry is not a British subject. This, then, offers a third possibility: that a rebuttal supports a refutation of the claim. The claim, C, has some counterposition which might be expressed loosely with the gloss, it is not the case that C. This component itself is then supported directly by the rebuttal. Though this seems to work in the Harry case, it captures our intuitions poorly since the rebuttal is now interpreted as being entirely distinct from the data and warrantunder this interpretation a rebuttal is interacting only with the claim, and not with the way in which the claim is being derived. Furthermore, if the relationship between rebuttal and Pollock-style undercutter is close, then Pollock's analysis is in direct conflict with this third option, for, crucially, undercutters do not offer support for any counter to the conclusion. Pollock offers the example shown in Figure 11.

Here, the fact that an object is illuminated by red light offers no support whatsoever for concluding that the object is not red. But it certainly casts doubt on the inference from its looking red to its actually being red.

Is there, therefore, a way of capturing this undercutting style of attack that seems so close to the Toulminian notion that a rebuttal serves to identify ob-

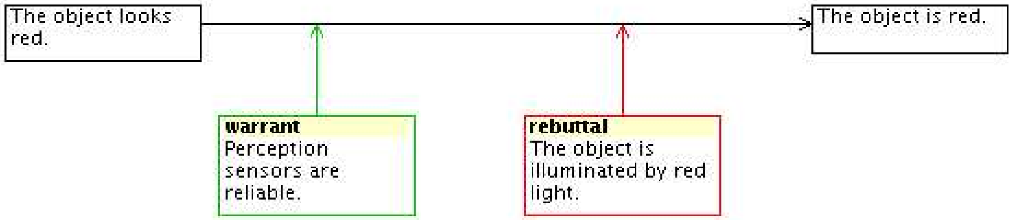


Fig. 11. Pollock-style undercutters as Toulmin rebutters

jections or exceptions to the way in which the conclusion has been reached using the warrant? There are two ways of achieving such a representation that are structurally identical, but semantically quite different. The first is to reify the inference. In this way, the DWC complex implicitly includes another componentrepresented, perhaps, by the horizontal line. The inference then runs, roughly, given the datum and the warrant, it is reasonable to conclude the claim. It is this implicit premise, that the rebuttal refutes. The approach has a direct counterpart in more traditional models of inference. A conventional approach to first order logic uses the principle of modus ponens to get from premises $A$ and $(A \rightarrow B)$ to conclusion $B$. But it is just as reasonable to extract the leap of faith or inference rule and identify it explicitly, as a premise: $A, (A \rightarrow B), (A \wedge (A \rightarrow B)) \rightarrow B$. The Carrollian regress looms instantly, and threatens the Toulmin model in an identical way if we go down this path. In addition to being a sly way of deductivising any non-deductive theoretical framework, a further problem is that it is far from clear that having the rebuttal refute this implicit premise is any better than having it refute the warrant. It may well be that the datum and warrant do still plausibly support the claim, even if the rebuttal holds.

The final alternative then, is to introduce an implicit premise, but have that premise represent nothing more than the counter of the rebuttal. This implicit premise might be seen (by the analyst) as an additional warrant. It could be that it is an attack on the entire inference scheme. It could be a specialisation of the warrant that is expressed. But perhaps the most common and accessible interpretation will be that this missing premise is some kind of implicit assumption. In this way, it is very similar to the implicit components expressed in argumentation schemes ([5], [8]). The approach taken in Araucaria (partly because it is designed also to handle such theoretical structures) is to use this scheme-like approach in implementation (cf. [16]. This approach naturally handles conditions of exception or rebuttal [10, p. 101] and circumstances in which the general authority of the warrant [should] be put aside (ibid.) as well as the full range of interpretations of rebutting used by analysts based on Toulmin's brief and ambiguous presentation. It also means that there is a clear relationship between components of argumentation schemes in the standard treatment and their (automatic) characterisation in Toulmin diagrams.

There remains a problem. The function of a rebuttal in a Toulmin diagram is, on our understanding of it, one of challenging an inference. The function of standard treatment refutation, at least as implemented in Araucaria, is one of representing some sort of dissonance between statements. These two theoretical frameworks thus manifest a fundamental difference in the way they handle inference: essentially, the former has a metaphysical basis that identifies multiple forms of inference, whilst the latter is cast in the deductivist mould. The only straightforward way in which translation between them might be accomplished is to reify the inference types of the former, so that they can be represented explicitly as statements in the latter. The problem then, is that it might be argued that the richer model is weakened by its translation to the more formal model. The first observation to make in response to such a challenge is that it is interesting and perhaps surprising that an apparently simple diagramming translation problem is intimately tied to the great deductivist debate that is still going strong (witness, e.g. [20] and its responses). We do not here seek any kind of resolution of that debate, but rather seek to build a pluralistic approach that allows analysts and researchers to work within their many theoretical frameworks, allows work conducted in one to be re-used in another, and, perhaps, allows research exploring the differences between frameworks to have practical support.

### *2.3 Translating Wigmore Analyses*

#### *2.3.1 Introduction*

The diagram structure introduced by Wigmore [21] is used primarily for the analysis of legal arguments. Wigmore defines three broad categories of premises: testimonial or circumstantial evidence such as would be presented by witnesses or introduced by the judge as factual evidence, explanatory evidence, which is designed to argue against testimonial or circumstantial evidence, and corroborative evidence, which supports previously introduced testimonial or circumstantial evidence.

#### *2.3.2 Evidential Relations*

A testimonial or circumstantial evidence node may have up to three supporting groups of nodes: other testimonial or circumstantial evidence, explanatory evidence and corroborative evidence. Each of these three groups of nodes are represented in the diagram by a set of nodes that have support edges converging on a single edge which then supports the parent node.

There is a superficial diagrammatic resemblance between the Wigmore notation for a group of supporting nodes and the linked argument structure in the

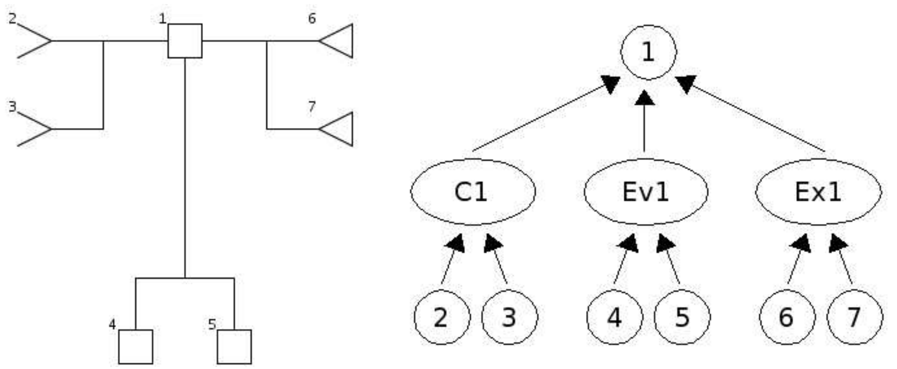


Fig. 12. A sample Wigmore diagram (a) and possible deep structure representation (b)

standard diagram. It is tempting, therefore, to infer an equivalence between these two structures. However, we believe this correspondence is illusory. The linked argument in a standard diagram implies that all the premises making up the linked group of nodes are required for the connection between these nodes and the node they support. Common examples of linked arguments are found in argumentation schemes: the argument from expert opinion, for example, requires both that the expert have appropriate domain knowledge, and that the proposition they are advocating lies within that domain. In a Wigmore diagram, however, all nodes of a given type that support another node are grouped together, regardless of whether some of these nodes form linked arguments and others stand alone as support for the parent node.

A Wigmore diagram also strongly reinforces pictographically the tripartite grouping of all evidence. One possible way of representing a Wigmore analysis is therefore to introduce virtual "aggregation" nodes in the argument that aggregate all the corroborative evidence supporting a node, all the explanatory evidence supporting a node, and all the other (i.e. testimonial or circumstantial) evidence supporting a node. These intermediate nodes might then be further supported in their turn by convergent arguments from the various premises. An analysis such as Figure 2a, for example, might be rendered at a deep level by the representation in Figure 2b, with C1, Ev1 and Ex1 aggregating the corroborative, testimonial and explanatory evidence for claim 1, respectively.

In this way, the ontological status of nodes in the Wigmore analysis (i.e. whether they are corroborative, explanatory or testimonial/circumstantial) is captured by structural features in the AML deep representation. Unfortunately, this misrepresents the arguments in an important way. The role of "corroborating" evidence is, as the terminology suggests, one of working with elements of testimonial and circumstantial evidence to support a claim. In this respect, it is most similar to traditional linked argumentation  but the linkage crosses the groupings in 12b  so, for example, it might be that 2 and

4 form a linked argument, and 3 and 5 form a linked argument. The analysis in 12b not only makes such relationships opaque, it absolutely proscribes the representation of such relationships.

The problem is compounded in that an analysis performed in the Wigmore style provides no mechanism for determining which premises of a claim are linked and which are not. Thus we have no choice but to represent all the nodes supporting another node in a Wigmore diagram as single, unlinked nodes in a standard diagram. Similarly, there is no distinction in a standard diagram between the concepts of explanatory, corroborative, testimonial or circumstantial evidence, so all nodes from all these groups must be treated equally when drawn in a standard diagram.

We can use similar considerations to translate in the reverse direction: from standard to Wigmore. A standard diagram does not contain any information on the type of evidence represented by a node, so we really have no choice but to represent all standard nodes, linked or convergent, as one node type in Wigmore. For convenience, Araucaria interprets all standard nodes as testimonial affirmatory nodes (represented by a plain square) in Wigmore.

The reader may be wondering how these rules conform to our desire to use the AML structure to represent all arguments as standard and then translate to other diagram types. If Wigmore diagrams contain properties not representable in standard, how do we store these properties in AML, thereby ensuring that our second desideratum is met? The answer is that no interchange format will be able, a priori, to cater for all possible representational and operational schemes that involve argument [11]. Instead, AML is designed to support extensibility through a simple "role" mechanism that allows new ontological categories to be catered for in the representation, without the representation having to revise existing analyses. Specifically, individual propositions within an analysis can be marked as taking on a particular role in a particular class. So, for example, in the Toulmin class, a proposition might be marked as a "warrant" - a concept that only makes sense in the context of Toulmin analyses. Of course, if these extensions are not only numerous but also individually significant, then the benefits of an interchange language such as AML are eroded. The exponentially expensive problem of translation between the different classes returns. AML takes a pragmatic solution, providing as much generic capability as possible, and supporting extensions that are intended to be small scale. If particular software systems aim to make use of these extensions in translation then they are not prohibited from doing so.

In the Wigmore case, the four basic types each represent different roles: corroborative, explanatory, testimonial and circumstantial.

### *2.3.3 Evidential Ownership*

A further complication arises in that Wigmore diagrams distinguish explicitly between evidence offered by prosecution and that offered by defence (the extra top-most bar indicates diagrammatically the latter). Though neither Araucaria nor AML pretend to be able to handle either dialogue or a record of dialogue, they nevertheless both support identification of “owners” in standard analyses i.e. the identity of the individual, group of viewpoint of which a given proposition is claimed. This is useful for analysing arguments in which, for example, a counter-argument to the author’s position is presented and countered. The same machinery can be put to use for distinguishing between prosecution and defence arguments, inasmuch as Wigmore analyses allow the specification of just exactly those two owners and no others. This is an example of desideratum (iii) driving representational re-use.

### *2.3.4 Evidential Sense*

Wigmore explicitly distinguishes between evidence that is affirmatory and evidence that is negatory. Unfortunately, Wigmore’s presentation leaves it unclear as to exactly what is meant by negatory evidence (and there are few examples of it in his writings). There are three possible interpretations:

(1) Evidence can only be defined as negatory with respect to other evidence (implicit or explicit) that is affirmatory. So for example, the claim that “the murderer was in the garden” might be classified as negatory with respect to another claim that “the murderer was in the house”.
(2) There is something intrinsic to negatory evidence which means that a human can inspect a claim and determine whether or not it is negatory. Such a determination could conceivably be related to burden of proof (so, e.g., a claim such as “there is no evidence that the murderer was in the house” as affirmatory).
(3) Negatory means virtually nothing at all, making only a rhetorical distinction rather than a truth functional one (so that, e.g., “the murderer was not in the house” is negatory whilst “the murderer was in the garden” is not).

Option 1 is at the heart of most concepts of negation and contrariness: in propositional accounts, $p$ derives its interpretation from the meaning of $p$; in Araucaria-style analyses, a refutation links a claim and counterclaim; in the Toulmin diagram, a rebuttal works to cancel the data-claim connection. Yet there is no indication that this was what Wigmore intended, and the few examples suggest that evidence can be negatory quite independently of other claims that are available. Option 2 would require highly contentious linguistic and philosophical assumptions, but in any case, is computationally intractable and therefore of limited interest here. Option 3 though perhaps one of the most disappointing from a formal point of view seems to resonate most closely with Wigmore's account. There is social psychological evidence that positively presented evidence may be looked upon more favourably than negatively presented evidence [22]. Perhaps therefore, it is this linguistic or rhetorical effect that Wigmore is tackling with his "negatory" class (given that juratorial presentation is a constant motivation for Wigmore). For a representation scheme, this requires nothing more than a single additional role tag for the evidence "sense" indicating whether a piece of evidence is affirmatory or negatory. We return to the problem of "negatoriness" in the context of the relations between propositions, below.

#### *2.3.5 Force of Premise Support*

The categories of support forces in a Wigmore diagram offer interesting scope for finding corresponding structures in a standard diagram. Looking back at Figure 1, we see that there are various symbols such as arrowheads, double arrowheads, Xs, double Xs, little circles and so on that are drawn on the support edges. These symbols all indicate either the degree or force with which that edge implies support for the node to which it leads, or whether the force is affirmatory (supports the conclusion) or negatory (detracts from the conclusion).

The degree of support has a natural correspondence in the evaluation feature of a standard diagram (which has been equated with the qualifier in a Toulmin diagram). We can therefore use the Wigmore description of the force as an evaluation label in a standard diagram. For example, the single arrowhead on the support edge from node 4 to node 3 in Figure 1 indicates provisional support, while the double arrowhead on the edge leading out of node 7 indicates strong support. Other symbols have similar meanings: a complete list can be found in [21]. One oddity is the "detracts" force, which could be equated with negatory support. Wigmore, however, does not do so, and therefore neither does Araucaria's interpretation of Wigmore analysis  even though that leaves diagrams in which "support" arrows are, somewhat counterintuitively, labelled with "detracts".

#### *2.3.6 Force of Evidential Group Support*

An important complication is that Wigmore analyses permit a very slightly finer-grained analysis of these evaluative components. For each premise, an evaluation is possible  in Figure 1, for example, premises 5, 6, 7 and 8 can each have independent evaluations. In addition, however, the set of testimonial evidence (composed of premises 5, 6, 7 and 8) can also itself have an evaluation

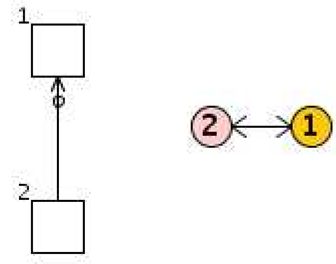


Fig. 13. Simplistic negatory/refutational translation from Wigmore (a) to Standard (b)

that is separate again. Recall from the previous section that the ontological categories into which evidence is divided are simply being marked as "role" tags on the evidence nodes themselves in AML, with the result that there are no nodes in the deep representation corresponding to the set of testimonial evidence. There is, therefore, no edge in that deep representation to which an evaluation can be attached. Where then does such evaluation belong? The solution is to recognise that these evaluations are intimately tied to the claim to which they lead  i.e. the evaluation on a set of testimonial evidence is not attached to any particular member of the set, but rather to the claim that the set putatively supports. For each of the three sets that a given claim can have (corroborative, explanatory, testimonial/circumstantial), a new role tag is provided that takes the evaluative force marked for that edge. This role tag is attached to the claim.

### *2.3.7 Negatory Force*

The presence of a small circle on an edge in a Wigmore diagram (such as that on the edge leading from node 8) indicates negatory force, which means that the node argues against its parent. This clearly suggests some relation to the refutation in the standard model (or the rebuttal in Toulmin). When translating the Toulmin rebuttal into a standard analysis, the closest match is to introduce an "added negation", so that in essence a rebuttal is the contrary of an implicit warrant. In the Wigmore case, it may seem that we have a more straightforward situation, since Wigmore does not consider the subtle nuances of the Toulmin datum-warrant-rebuttal model. If a node supports another node with negatory force, then in Wigmore, the implication is that the first node counters or refutes the statement being made in the second node. Thus it may seem that we could simply map any node with negatory force on another into a refutation in the standard model, as suggested in Figure 13.

The problem here is that the standard model (with its heritage in a propositional account) only allows a maximum of one refutation for any given node (i.e. refutation is a relationship between a proposition and its contrary, between p and not-p). In Wigmore, however, any number of nodes may support

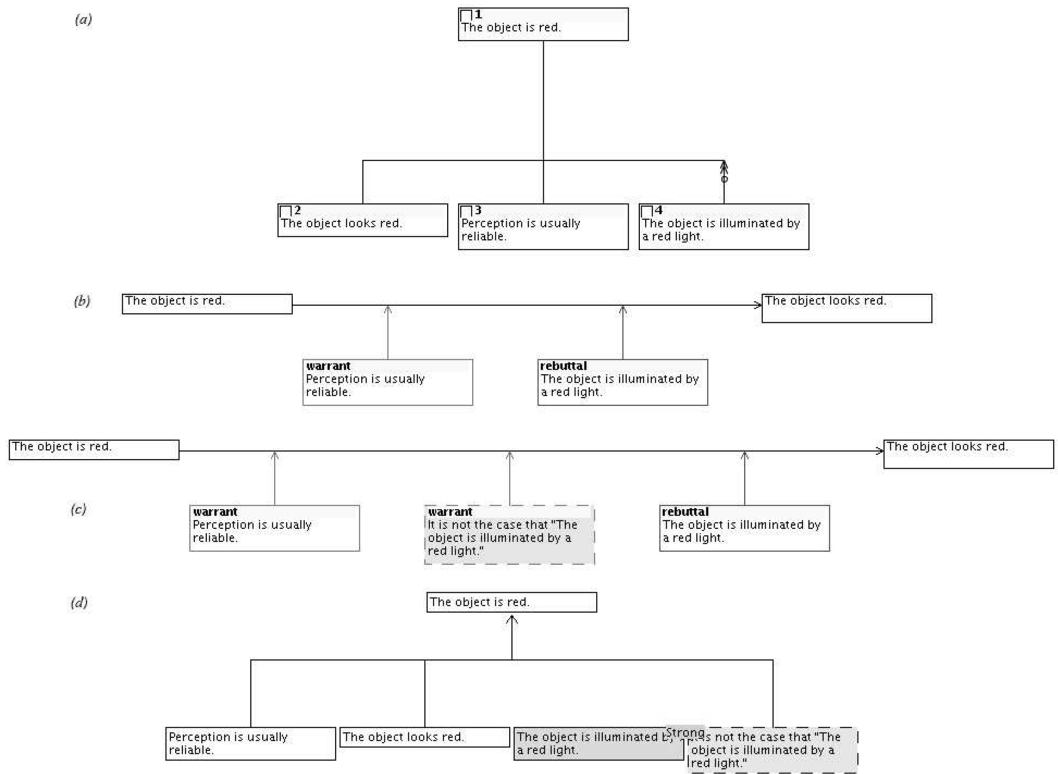


Fig. 14. Pollock's example (a) analysed as a Wigmore diagram; (b) its translation into a Toulmin diagram; (c) the Toulmin diagram showing its implicit "added negation"; and (d) the translation to a standard analysis (NB. Qualifiers have been omitted to improve clarity)

another node with negatory force. More importantly, Wigmore's use of negatory force seems to be functioning in a different way, typically functioning not as straightforward refutation, but rather much more like the rebuttal in a Toulmin diagram. The challenge can be addressed by exploiting this similarity with the Toulmin case: by introducing an added negation which is refuted directly by the node with negatory force. This added negation node in turn supports (positively) the node supported directly in the Wigmore diagram. In fact, the simplest way of understanding the translation is not by comparing it with the standard treatment at all, but rather, by considering its translation to a Toulmin diagram (which then, of course, yields a standard analysis by existing translation mechanisms). Figure 14 demonstrates the idea using an example from [9]:

## 3 Applications

To underscore the importance of tying formal models of argumentation theory to applications with end users, we briefly review some ofthe application domains in which Araucaria has been deployed. As freely downloadable software, it is difficult to estimate the size of the current user group accurately; web server logs indicate between 1,000 and 2,000 downloads to unique IP addresses each year since 2001, and a further 1,000 or so package CDs have been distributed. The software has wide geographical appeal (with Chinese and Hebrew versions in development) with known users in over 40 countries, but more surprising is the range of domains, including not just the academic and pedagogic domains that might be expected but requests have also been received demonstrating use of the software by engineers building safety cases, barristers preparing cases, doctors conducting complex diagnoses, statisticians representing test designs and more. Here we focus on a couple of the more significant user groups.

### *3.1 Applications in Education*

The majority of Araucaria's users are probably instructors and their students. The development team has had close contact with three undergraduate courses, one in philosophy at Winnipeg, one in legal theory at Groningen, and one in argument and computation at Dundee. Student users – particularly those outside the computational sciences – make for demanding requirements on software, and it is through many hundreds of students' feedback that the software has been updated on a rolling basis. The ability to do simple graph matching automatically has been a great boon for instructors with large class sizes (which are characteristic of North American critical thinking courses in particular). For although complex arguments have too many potentially "right" analyses for completely automated marking to be feasible, smaller exercises with less variability and interpretability are well within the scope of Araucaria's automatic marking, and provide instructors with much more flexibility than is afforded by traditional multiple choice alternatives. Full classroom evaluations of critical thinking software is fraught with difficulties, but following the trailblazing of Reason!Able's assessments [23], and the requirements for the process laid out in [24], Araucaria will be undergoing controlled assessment as part of its longer term development.

### *3.2 Applications in Legal Practice*

In 2004, Araucaria was trialled by a number of magistrates in the Ontario Court of Justice. The remit of magistrates in Ontario is interesting because it covers a wide range of cases from the mundane to the headline-hitting. Specifically, at one end of the scale, magistrates are faced with processing traffic violations, and this represents and hugh majority of the caseload, with 60-70 cases requiring attention per day. Each case is small and follows a stereotypical pattern in which the number of alternative arguments and decisions is relatively small. On the other hand, there are much rarer, but much larger environmental law cases involving, from time to time, large, multi-national corporations. These cases can be protracted, lasting weeks or months, and can involve huge amounts of testimony and argument. Informal trials were set up by the magistrates themselves to explore the potential role of software in the process of preparing summing up arguments. The trials demonstrated that software tools, and Araucaria in particular, was found to be useful in the large complex cases – and that is exactly where a computer scientist's intuition would expect a tool to play a significant role. Much more interesting therefore, was the feedback that Araucaria was also being used extensively in processing the smaller cases, and specifically, that by setting up a small number of argumentation schemes, magistrates were able to very rapidly go through the associated critical questions as a kind of check list (and a number of minor modifications of the Araucaria interface were tailored to this process to streamline interaction). As a result, a programme of roll-out has been initiated for all new appointments, which will eventually cover the entire magistracy in the province - over 400 individuals. Larger scale trials and feedback mechanisms are planned.

### *3.3 Applications in Autonomous Communications*

There is a rich area of research in multi-agent systems exploring the uses to which argumentation can be put in structuring communication between agents [25]. Sophisticated models of such interchange are starting to be developed, taking into account a wide range of argumentation-theoretic concepts [26]. These models have, to date, been rarely implemented (though there are exceptions [27], [28], for example). One of the reasons for this relative scarcity is not only that it is time consuming to implement the protocols (which is the point made in [27]) but also that it is difficult to construct the knowledge that agents will use as the basis for their inter-agent arguments. For this, Araucaria and tools like it can be a great practical help (given that their output can be converted down into an appropriate framework style). Early evidence for this utility comes from initial assessments of argumentation scheme usage in agent communications in which patterns of data were constructed manually in Araucaria and then transformed automatically to produce many thousands of variants, with which to populate agent knowledge bases and thereby frame evaluation tests [29]. With an increase in the number and flexibility of tools for argument creation, and the ability for those tools to produce framework-style output, this trend is set to continue.

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