

# **The inferential arrow: A comment on interdisciplinary conversation**

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The papers by Tim van Gelder<sup>1</sup> and by and Chris Reed and Glenn Rowe<sup>2</sup> reflect well both the complexity of the issues involved in trying to create a generic and flexible mapping tool useful for the study of various kinds of inference and the ingenuity that is being devoted to addressing these issues. I am particularly intrigued by the efforts described by Reed and Rowe to use a software tool, Araucaria, to translate among different diagrammatic tools developed by various theorists. As an evidence scholar, I come at this primarily with an interest in understanding the tool's use in analyzing evidence and inference in tried cases. In other words, I come at it largely as Wigmore would. So I am particularly interested in how Wigmore's famous chart method translates into other diagrammatic templates.

Like many evidence teachers, I have drawn pictures with my students to reflect the inferential relationships between evidence and disputed facts. Central to courses on admissibility of evidence is the classic and simple diagram – an item of evidence with an arrow pointing to the disputed fact:

E —————> F

In these diagrams, usually suppressed but sometimes explicit, is the generalization about the way the world is or the way it works that supports the inference in question. For example, a jury presented with Willard's testimony that Delbert was seen running from the scene of a murder must assess the strength of the inference from that evidence to the prosecution's claim that Delbert committed the crime by appealing to various generalizations about the motives of someone who flees a crime scene, such as 'people who run from a crime scene are more likely to be acting out of consciousness of guilt and a resulting fear of apprehension than out of other motives.' This kind of generalization is closely related to a Toulmin "warrant." Thus, I am especially interested in translation between Wigmore diagrams and

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<sup>1</sup> Tim van Gelder, *Rationale: Making People Smarter Through Argument Mapping*, \_\_ Law, Probability & Risk \_\_ (2007).

<sup>2</sup> Chris Reed & Glenn Rowe, *A Pluralist Approach to Argument Diagramming*, \_\_ Law, Probability & Risk \_\_ (2007).

Toulmin diagrams.

The inferences involved in tried cases are not deductive. This fact affects the problem of translating the kind of map of evidence produced by Wigmore into the diagrams more familiar to logicians. Of course, some logicians do concern themselves with inductive and abductive inferences, but many of these—those who do not use the probability calculus—often do so in ways that try to preserve the binary “yes/no” quality of deductive logic. For example, defeasible reasoning, in which the truth of premise E is taken to warrant conclusion F unless one of several defeasing conditions is present (as opposed to not present), tries to preserve what I call the “toggle-switch” mental framework, studiously avoiding the problems of quantifying gradations of belief.<sup>3</sup> I understand this tendency: it seems necessary to match the way that ordinary people talk about their inductive inferences much of the time. But it does lead to problems. Not necessarily insurmountable problems, but problems nonetheless.

I am a probabilist in these matters. I do appreciate the possibility that toggle-switch thinking may be important for developing and clarifying our intuitions about the strength of evidence. And I am fully supportive of the efforts to develop structures of thought, such as defeasible reasoning, into computer-assisted reasoning tools. As this effort proceeds, however, I think it is important to watch for confusions that can arise because of an analytical framework that privileges ‘yes/no’ thinking.

I will try to illustrate this point in one particular drawn from the papers on which I am commenting. That particular is the meaning of “the arrow.” I’m referring to the arrow that connects premises with a claim in the standard format, or datum with a claim in a Toulmin diagram, or evidence with a factum probandum in a Wigmore diagram. My question is this: *What exactly is signified by drawing such an arrow?* When such an arrow is present, what are we supposed to understand that to mean? This would seem to be such a basic question that one would expect a clear and unequivocal answer. But that is not what I find.

To set aside some tangential issues, let me say at once that I am not concerned with whether drawing the arrow entails the truth of an inferential claim as opposed to a proposal or hypothesis of the truth of such a claim, or even as opposed to the belief by the analyst that such a claim is true. An analyst might well draw such an arrow before he or she is confident about the truth of the inferential connection. Rather, I am concerned with the nature of the inferential connection that is asserted or denied, believed or disbelieved, true or false.

I suggest that there is a conflict in the literature between an assumption that the arrow indicates relevance and an assumption that the arrow indicates evidential persuasiveness, what lawyers would call sufficiency or (decisive) weight of the evidence. I will further suggest that those who come at diagramming from the legal perspective will tend to think of the arrow in terms of relevance, while those who come at the process from an informal logic perspective will tend to think of the arrow in terms of evidential

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<sup>3</sup> This is common in the field of “informal logic,” which forms one of the great traditions in argument mapping, of which Toulmin is a part. See Reed & Rowe, *supra* note 2, at [4].

persuasiveness. Making these assumptions explicit will assist the process of creating accurate translation.

In the paper by Reed and Rowe, the meaning of the arrow is only explained in the context of articulating the difference between a “convergent premise” and a “linked premise.” The need to distinguish these necessitates greater precision about the meaning of the arrow in any such diagram, even one that involves only a single premise.<sup>4</sup> Convergent premises are premises that converge on a conclusion (their Fig. 2), while linked premises are premises that must be joined in some way to function in the inference (their Fig. 3). Here is how they explain the difference:

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.<sup>5</sup>

From this, one takes an arrow to indicate “support” for an inference. But what does “support” mean? This is clarified in their explanation of linked premises, where they state:

[T]wo premises are linked because neither on its own is sufficient evidence from which to draw the conclusion. . . .<sup>6</sup>

In other words, “support” entails sufficiency of the evidence to draw the conclusion that the claim is true. That is, inserting an arrow between a convergent premise and a claim means that, if the premise is true, then one is entitled, or perhaps required, to infer that the claim is true, unless perhaps certain defeasing conditions (or rebuttals) are also true, and this is so, or at least can be so, even if one or more of the other convergent premises is false. Correspondingly, inserting an arrow between a set of linked premises and a claim means that, if all the linked premises are true, then one is entitled (or required) to infer that the claim is true, again absent defeasing conditions; whereas no such inference is warranted (though the claim might still be true) if any one of the linked premises is false.

This makes perfect sense if one thinks of the arrow as indicating evidential persuasiveness. This seems to have been Toulmin’s assumption, when he presented his diagrams. Although he recognized degrees of persuasiveness, he did not draw the arrow unless the inference reached, albeit defeasibly, a minimal degree of persuasiveness, a degree indicated by his qualifiers “probably” and “presumably.”<sup>7</sup> These qualifiers suggest an inference to a claim that is at least more probable than not (again, defeasibly). Similarly, and more explicitly, one philosopher of science, Peter Achinstein, has recently argued at length that the claim “E is evidence of H” entails, under the linguistic conventions of scientists, that

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<sup>4</sup> Van Gelder notes that the distinction between linked premises and convergent premises has been “a difficult one for logicians to pin down.” Van Gelder, *supra* note 1, at [6].

<sup>5</sup> Reed & Rowe, *supra* note 2, at [7].

<sup>6</sup> *Id.*

<sup>7</sup> See Stephen E. Toulmin, *The Uses of Argument* 100 *passim* (1964).

the truth of E makes H more probable than not.<sup>8</sup>

As already suggested, students of the law of evidence will recognize this kind of analysis as pertaining to the question of sufficiency of evidence to support a verdict or to satisfy the burden of persuasion on the merits. And therein lies the rub. Wigmore was precise in defining what he meant by drawing an arrow between evidence and a factum probandum, and it was not sufficiency in either of these senses. It was relevance. As Wigmore put it: “The sign  $\curvearrowright$  signifies ‘tends to prove’.”<sup>9</sup> He was quite clear that no single premise need rise to the level of proof adequate to satisfy the burden of persuasion in the case in order to be connected by an arrow to a fact that is to be proved.<sup>10</sup> This difference is probably attributable to the fact that a lawyer, like Wigmore, is very often concerned with questions of admissibility, as to which relevance is a critical starting point, whereas non-lawyers rarely concern themselves explicitly with that issue.

Any minimum-threshold-of-persuasion concept of what it means to be “evidence” or a “permissible inference,” whatever its resonance with ordinary or scientific discourse, certainly will not work well for lawyers as a limitation on graphical displays. It renders the lawyer’s concept of “relevant evidence” useless in a great many of the contexts where lawyers use it. To speak of E as being relevant to H makes sense (on Achinstein’s account, for example) only if the probability of H on E is greater than 0.5. This means that information that increases the probability of H from 0.1 to 0.4 cannot be called “relevant evidence”; it can be called relevant information, perhaps, but not relevant evidence, because it is not evidence at all. This, however, is simply not the way lawyers think about the matter. I take it this is clear to the readership of this journal, but just in case, consider the following standard definition of “evidence”:

Any facts considered by the tribunal as data to persuade them to reach a reasoned belief on a probandum. The term is sometimes used to refer to evidential data or autoptic preferences and sometimes to refer other facts taken as established for purposes of argument.<sup>11</sup>

There is no requirement in this that the probandum (the thing to be proved) must be more probable than not given the evidence. Combine this generous conception of evidence with the following canonical definition of relevance:

“Relevant evidence” means evidence having any tendency to make the existence of any fact that is of consequence to the termination of the action more probable or less probable than it would be without the evidence.<sup>12</sup>

With these conceptions, information considered at trial that increases the probability of a

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<sup>8</sup> See Peter Achinstein, *The Book of Evidence* (2001).

<sup>9</sup> John Henry Wigmore, *The Science of Judicial Proof* §16 at 31 (3d ed. 1937).

<sup>10</sup> *Id.*, § 4.

<sup>11</sup> Terrence Anderson & William Twining, *Analysis of Evidence* 445 (1991).

<sup>12</sup> Fed. R. Evid. 401.

“fact of consequence” from, for example, 0.1 to 0.4 is clearly relevant evidence.

A focus on relevance would seem to explain why Wigmore did not differentiate between convergent evidence and linked evidence. He would surely have endorsed such a distinction if his arrows indicated sufficiency, for certain items of evidence (like direct evidence of the crime) may well be sufficient without more to support a verdict, while other evidence (especially circumstantial evidence) will usually have to be taken together with other evidence before the appropriate level of persuasiveness will be reached. However, Wigmore’s arrows meant only that a premise is relevant to its claim, that it tends to prove (or disprove) the claim. That tendency can be large or small, but it need not reach the “toggle” of sufficiency. Of course, relevance is binary, too; evidence tends to prove or it doesn’t. But once one focuses on that particular binary judgment, it alerts one to the gradational notion of probative value and its implications. Wigmore’s arrows indicated merely the existence (or hypothesized, or believed) non-trivial probative value. In that context, what use would Wigmore have for the concept of linked premises?

Reed and Rowe point out that one of the curiosities of translating Wigmore diagrams into standard diagrams is that in the former the distinction between linked and convergent premises is missing. In translation, therefore, the distinction must be suppressed in the sense that all premises must be translated as either linked or convergent. Because linkage suggests something that is not clearly recognized in Wigmore’s diagrams, the only option is to represent all premises as convergent when translating into standard form.<sup>13</sup>

It is worth noting that the meaning of “the arrow” is explained rather differently in a supporting paper distributed for the conference, the one coauthored by Chris Reed, Douglas Walton, and Fabrizio Macagno. In that paper, once again, the meaning of the arrow is specified only in connection with an explanation of the difference between convergent and linked premises, an explanation attributed to James Freeman. Quoting Freeman, Reed and his coauthors write:

“If a premise is not relevant to the conclusion, then its being true does not increase the likelihood of the conclusion” (Freeman, 1991, p. 105). In the case of a linked argument, the irrelevance of one or more premises is avoided only if they are connected with the others.<sup>14</sup>

This clearly endorses the notion that the support that is entailed by connecting a premise with a claim by an arrow is just the notion of relevance, not sufficiency. And it raises the following question: Is this notion, attributed to Freeman and entirely consistent with Wigmore, the meaning of the arrow that Reed et al. really intend to employ in their Araucaria diagrams?

Returning to Reed and Rowe’s present paper, their example of convergent premises

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<sup>13</sup> Reed & Rowe, *supra* note 2, at [23-24]. As they note, there is an inherent confusion in the fact that Wigmore did not use converging arrows; all his arrows graphically have a similar form as linked premises in the standard diagrams. *Id.*

<sup>14</sup> Chris Reed, Douglas Walton, & Fabrizio Macagno, *Argument Diagramming in Logic, Law, and Artificial Intelligence*, 22(1) *Knowledge Engineering Review* 87, 99 (2007).

leaves the answer unclear.<sup>15</sup> They posit the claim, taken from the famous case of Sacco and Vanzetti:

C: Peiser was under a bench when the shooting started.

And they identify two convergent premises for this claim:

P<sub>1</sub>: Canstantino testified that Peiser was under a bench when the shooting started.

P<sub>2</sub>: Peiser admitted under cross-examination that he was under a bench when the shooting started.

What is interesting about this example is that it is (plausibly) consistent with either a relevance-based inferential arrow or a sufficiency-based inferential arrow. Either premise by itself is relevant to the claim; and either premise (ordinarily) would be legally sufficient to establish the claim and either premise by itself (depending on information about the credibility of Canstantino and of Peiser) would be persuasive, in the absence of rebutting information, that the claim is true.

In a draft of the present paper (distributed for the conference), Reed uses a different example of convergent premises, one that implicitly (perhaps unintentionally) resolves this ambiguity.<sup>16</sup> He posits the claim:

C: A cat makes a good pet.

And he specifies the following two premises for this claim:

P<sub>1</sub>: It (presumably, the cat) is friendly.

P<sub>2</sub>: It (the cat) can look after itself.

The premise, “The cat can look after itself,” is certainly insufficient evidence to draw the conclusion that the cat makes a good pet, for the obvious reason that one needs some additional evidence that the cat is friendly, in good health, and so forth. If this is right, then, according to the sufficiency criterion of the arrow that Reed gives (in both papers), these are linked premises, rather than convergent ones. If, however, one takes the arrow as indicating relevance, as Freeman and Wigmore would, then it is certainly true that each of the indicated premises is relevant: the truth of either one of these raises the probability that the cat makes a good pet even if one doesn’t know anything about its other characteristics. And this is the result–convergent premises–that Reed endorsed in that paper.

If, then, we take the inferential arrow as signifying relevance, what are we to do with the idea of linked premises? Should we, like Wigmore, abandon the construct entirely? Once the arrow is identified as entailing relevance, linked premises would seem to involve conditional relevance, the idea that one item of evidence is irrelevant in the absence of some

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<sup>15</sup> See Reed & Rowe, *supra* note 2, at [7].

<sup>16</sup> Chris Reed, Wigmore, Toulmin and Walton: The Diagramming Trinity and their Application in Legal Practice, at 2 (unpublished ms., dated 22 Dec. 2006).

other. This idea has been called a “myth” in the law review literature,<sup>17</sup> and this claim, if true, would seem to explain the absence of linked premises in Wigmore diagrams. Conversely, the persistence of this myth may be associated with toggle-switch thinking applied (or misapplied) to the concept of relevance.

The slippery, if not mythical quality of conditional relevance is illustrated by Reed and Rowe’s example of linked premises.<sup>18</sup> They posit the claim:

C: Sacco was not one of the men leaning on the pipe-rail fence when, before the crime, Frantello passed the two men on his way to Hampton House.

The premises considered in this example are these:

P<sub>1</sub>: Sacco speaks broken English.

P<sub>2</sub>: The man on the fence was speaking “American.”

This example, again, seems to fit both assumptions about the inferential arrow. The two premises together would likely be sufficient, absent rebuttal evidence, to establish the claim, but either without the other does not do so. Indeed, either premise without the other seems to be irrelevant, so that the example could support a relevance-based understanding of the inferential arrow that allows for linkage.

But perhaps not. The second premise, and the testimony that asserted it, is relevant without knowing the first premise (or rather, without perceiving the testimony that asserted the first premise) because the background information for the case put Sacco as an Italian immigrant, less likely to be speaking “American” than someone randomly selected from among the general population of the area of the crime. Similarly, if the first premise is considered without the second, it is (arguably) relevant and exculpatory: Sacco’s speaking broken English makes it less likely that he would not be incriminated by other testimony if he were present; without such testimony, it is less likely that Sacco was present. So the linkage idea begins to evaporate.<sup>19</sup>

My purpose, however, is not to rehash the debates over conditional relevance. Rather my purpose is to raise an important qualification to the conclusion that conditional relevance is a rare phenomenon and thereby suggest that there might be practical value in the concept of linkage even under a relevance-based understanding of the inferential arrow. Reflection on these Araucaria translation exercises in relation to Toulmin diagrams reveals at least one way in which conditional relevance is quite intelligible. As already noted,

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<sup>17</sup> See, e.g., Vaughan Ball, *The Myth of Conditional Relevancy*, 14 Ga. L. Rev. 435 (1980).

<sup>18</sup> Reed & Rowe, *supra* note 2, at [7-8].

<sup>19</sup> To be sure, though relevant, either premise would be of little probative value without the other, perhaps so little that the testimony asserting it would properly be excluded as a waste of time were it not for evidence supporting the other premise. See, e.g., Dale A. Nance, *Conditional Relevance Reinterpreted*, 70 B.U. L. Rev. 447, 474-75 (1990). But that is not the same thing as conditional relevance. Intuitions of this sort may account for the tenacity of the conditional relevance idea. In any event, linkage could be built into Wigmore diagrams, if not the other types, by interpreting the inferential arrow as denoting not only logical relevance but practical relevance or even admissibility.

relevance depends on generalizations about the way the world works that form Toulmin-style warrants for an inference. (To make warrants work in the relevance context, Toulmin diagrams must be generalized to allow warrants that are weaker than “usually” (as in “F is usually true when E is true.”); one needs warrants like “more often” (as in “F is more often true when E is.”) In this spirit, I refer to “Toulmin-style” warrants in “Toulmin-style” diagrams.) Such generalizations, in combination with the datum, E, often do not render the inferred fact, F, more probable than not, but only more probable than it would be without the evidence in question. But that is still a linkage that we might appropriately call conditional relevance and use in a Wigmore diagram (as well as its translates).<sup>20</sup>

From one point of view, it doesn’t matter whether a premise comes from explicitly evidenced information or from background knowledge. Premises are premises. But in the evidence law world, this makes a huge difference. It is not only that, as Toulmin put it, “data are appealed to explicitly, warrants implicitly.”<sup>21</sup> Background information that functions as a Toulmin-style warrant is not formally admitted as evidence, at least not in the usual case.<sup>22</sup> That is why Wigmore’s diagrams generally lack the linked premises structure. To put it otherwise, *Wigmore diagrams are, essentially, Toulmin-style diagrams without the warrants, or rather, with the warrants suppressed.*<sup>23</sup> That is done, I presume, in order to keep the diagram focused on formally admitted evidence, testimony and tangible things that are presented to the trier of fact.<sup>24</sup> Suitably modified, Wigmore diagrams could include warrants as linked premises.<sup>25</sup>

But even if we remain true to Wigmore’s original limitation, that does not mean that

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<sup>20</sup> To be clear, this kind of linkage is not what legal theorists have traditionally meant by the notion of conditional relevance. They have argued about cases in which two pieces of case-specific evidence have such interdependence. In relevance-modified Toulmin terms, they have argued about cases in which two pieces of “data” (each triggering its own DWC complex) are linked, not about the linkage of datum to warrant.

<sup>21</sup> Toulmin, *supra* note 7, at 100.

<sup>22</sup> Toulmin commented similarly: “[W]arrants are general, certifying the soundness of all arguments of the appropriate type, and have accordingly to be established in quite a different way from the facts we produce as data.” *Id.*

<sup>23</sup> Wigmore diagrams also differ from the traditional Toulmin diagrams in allowing for multiple premises and, once again, using clearly relevance-based inferential arrows. Traditional Toulmin diagrams, because they presume an arrow of sufficiency, can only incorporate multiple premises by collecting them all together in one complex premise, as illustrated in Reed and Rowe’s Figure 9. Reed & Rowe, *supra* note 2, at [17].

<sup>24</sup> Wigmore did, however, incorporate into his charts propositions of which the judge takes formal judicial notice, which is a substitute for testimonial and real evidence allowed only when the proposition is beyond reasonable dispute. See, e.g., Fed. R. Evid. 201. Such propositions Wigmore marked with a “¶”. See Wigmore, *supra* note 9, at 863. These propositions might, of course, be generalizations that would constitute warrants.

<sup>25</sup> In their version of Wigmore charting, Terry Anderson and Bill Twining have included premises marked “G” for “a generalization that is likely to play a significant role in an argument in a case, but that is not a proposition that will be supported by evidence or that the tribunal will be formally asked to notice judicially.” Anderson & Twining, *supra* note 11, at 146.

Wigmore could never have made use of the linked premise idea, if a graphical technique (analogous to that used in standard diagrams) were employed that would distinguish linked from convergent premises. Several important classes of examples come to mind. First, sometimes warrants are not within the common knowledge of the ordinary people selected to be triers of fact. (I have elsewhere called this the “relevance unknown” problem.<sup>26</sup>) In that case, expert witnesses are commonly used to supply such warrants. A forensic scientist might testify that only one in 1,000,000 persons randomly drawn from the general population will share the DNA profile found on the victim and in the cells of the defendant. Such testimony can constitute or inform the warrants that are used to assess other formally introduced evidence, and they could properly be shown as linked in a Wigmore diagram with a relevance-based inferential arrow.

Further, under modern rules of admissibility, sometimes warrants are supplied by testimony, usually expert testimony, even if the topic is not one beyond the range of common experience, that is, even if common experience can provide a generalization that establishes relevance.<sup>27</sup> In such contexts, it would still make sense to link such testimony with the case specific testimony (the Toulmin datum) to which the warrant-providing testimony applies, assuming again that a graphical format were available for this purpose in Wigmore diagrams. However, in this context the concept of linkage would be slightly different. The linked warrant would not, at least in many cases, be strictly *necessary* for the relevance of the other premise; other, common sense warrants available to the trier of fact might suffice to make the datum relevant. When we go down this road, therefore, we are reaching for a different concept of premise linkage, one that is itself “unlinked” from the criterion of the inferential arrow; that is, an arrow might be appropriate from the case-specific evidence (the Toulmin datum) to some fact of consequence in the case – because the datum is relevant to that fact – even if the warrant-providing testimony were not present. Thus, premise linkage would not depend on the idea that one premise is *necessary* to support the inference from another.

Down this road more generally is the idea that linkage means, not necessity, but interdependence. That is, premises would be linked when the probative value of one is affected by the truth of the other, even when neither premise is strictly necessary for the relevance or sufficiency of the other. Many items of evidence are related in this way, and this could be the basis for a distinction between linked and convergent premises. The latter would not involve any such interdependence: two premises would be convergent if the probative value of one is independent of the other. Implementing such an idea requires, however, a reasonably clear convention on how to conceive of the probative value of evidence. Arguably, Wigmore did allow for this kind of linkage: not all of his items of evidence relevant to the same fact at issue are portrayed as simply convergent on that fact; instead, there are *groups* of evidence. Within the group, the items of evidence are convergent, and the groups then converge on the fact at issue. These groupings presumably indicate Wigmore’s judgment that the various items of evidence that appear in only one

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<sup>26</sup> See Nance, *supra* note 19, at 456 n.30.

<sup>27</sup> See Fed. R. Evid. 701, 702.

group do not affect the probative value of the evidence to be found in other groups. That is, they are not “linked” to such other groups.

So where does that leave us? First, if the enterprise of mapping is to be useful to lawyers, it is important to be able to mark the difference between case specific premises and supporting generalizations, as well as the difference between explicitly evidenced premises (including generalizations that are evidenced) and implicit generalizations lying in background beliefs. These markings, of course, need to be recoverable in the sense that translation from one type of diagram to another and back again should return all the features originally present in the diagram.<sup>28</sup> It is very encouraging to see the efforts that are being made to accomplish this kind of translatability.

But these efforts are, I think, likely to fail unless one keeps clear the distinction between relevance, on the one hand, and sufficiency or persuasiveness on the other. Translation algorithms will not work faithfully if the inferential arrow means something completely different in one diagram type than it does in the other, unless special account is somehow taken of the difference. As I have suggested, there is a clash of analytical cultures going on here. Perhaps it reflects my bias in favor of legal analysis, but it seems to me that a relevance-based inferential structure is more fundamental than a sufficiency one. As noted by Reed and Rowe, all three formats they discuss have additional devices (such as multiple arrowheads in a Wigmore diagram) that can accommodate an interest in sufficiency and persuasiveness.<sup>29</sup> Conversely, if the inferential arrow is taken to entail some threshold degree of persuasiveness (as might be assumed in standard or Toulmin diagrams), then how is one to mark inferences structures that do not rise to such a level? Yet is important to be able to do so.

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<sup>28</sup> Reed and Rowe recognize the importance of this principle. See Reed & Rowe, *supra* note 2, at [15] (desiderata (ii)).

<sup>29</sup> *Id.* at [18, 26].