FINDING THE LOGIC IN ARGUMENTATION

Abstract

It is a problem for argumentation studies as a field that although it has useful tools like argumentation schemes, it is not based on some underlying logic like classical deductive logic, or inductive rules of probability. In this paper it is shown, however, that there is a defeasible logic of a kind widely used in the field of artificial intelligence and law that can be brought in to fill this gap. It is shown how a computational system called Carneades can be used to model reasoning underlying typical defeasible argumentation schemes. By using the examples of the scheme for argument from expert opinion, it is shown how there is a general defeasible *modus ponens* form of reasoning that underlies argumentation schemes, and that fits with a defeasible logic of the kind most useful for argumentation studies.

Is there some way can take further steps forward in argumentation studies by finding the logic of defeasible argumentation schemes? In this paper it will be argued that there are resources from artificial intelligence that offer hope as useful ways of helping us to move forward. One of these is called defeasible logic. It is a species of logic that recognizes of defeasible inferences that are open to defeat by counter-arguments and exceptions to rules. The other resource is the Carneades system (Gordon, 2010). Although argumentation schemes and matching critical questions have been usefully incorporated into previous argument mapping technologies (Walton, Reed and Macagno, 2008), until Carneades there was no underlying model of reasoning that can weigh the critical questions matching a scheme into the balance of argument evaluation. Carneades models the critical questions as three kinds of premises of an argumentation scheme. In this paper, it is shown how these two resources can be combined to open the way to finding the logic of argumentation, even if we do not know all of its properties yet. As a bonus, this approach provides a method of argument construction, a capability especially useful for rhetoric.

The field of argumentation studies needs to be based on some model of logical reasoning. Although deductive and inductive models of reasoning are useful in some instances, there is a growing consensus that there also needs to be some third alternative standard of correct reasoning to evaluate the strength or weakness of an everyday conversational argument. Those working on defeasibility have focused more on reasoning/inference, while those in informal logic have strongly focused on argument (Bench-Capon and Prakken, 2010). Arguments are evaluated (in the dialectical tier) by examining counter-arguments that attack them. Once one has looked at all the arguments that support a given argument, and balanced them against all the arguments that attack it, one can judge which side has more probative weight on balance, the pro or the con. But each of these single pro or con arguments needs to be evaluated (at the illative core) in its own right, as well as with respect to how it balances against opposed arguments. How should this be done? The answer is that it is best done with argumentation schemes.

1. Argumentation Schemes

Many single arguments fit argumentation schemes. In many instances, the preferred method of argument identification, analysis and evaluation centers around the application of argumentation schemes to the given text. Once an argument is identified, how it is to be evaluated depends on how well it answers critical questions matching the scheme that fits the argument. To sum up this method, we can say that there are two aspects to it. One is the evaluation of each single argument. This is the illative or logical part. Here argumentation schemes play the key role. The dialectical part is seeing how the pro and con arguments are balanced when used in a wider perspective to resolve an unsettled issue.

The most widely useful argumentation schemes that fit arguments in everyday conversational argumentation are defeasible ones (Walton, Reed and Macagno, 2008). A good example is argument from expert opinion. This scheme is not well modeled by a deductive interpretation. Basing it on an absolutely universal generalization, to the effect that what an expert says is always true, does not yield a useful logical model. Indeed such a deductive model would make the scheme into a fallacious form of argument by making it unalterably rigid. In practice, evaluating an argument from expert opinion is best carried out by seeing how well it survives the testing procedure of critical questioning (Walton, 1997).

The simplest scheme representing argument from expert opinion, as formulated in (Walton, 1997, 210) with some minor notational changes[1], is shown below with two premises and a conclusion. *E* is an agent that can possess knowledge in some field of knowledge *F*.

Major Premise: Source *E* is an expert in field *F* containing proposition *A*.
Minor Premise: *E* asserts that proposition *A* (in field *F*) is true (false).

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

A given argument from expert opinion should be evaluated by the asking of critical questions and judging the replies to them in a dialogue. These are the six basic critical questions matching argument from expert opinion (Walton, 1997, 223).

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

According to (Walton, 1997), if a respondent asks any one of the six critical questions, it shifts a burden of proof to the proponent's side, and this shift defeats the argument temporarily until the critical question has been answered. The problem with using defeasible schemes with critical questions as a tool of argument evaluation useful for AI is that it is not easy to represent questions in a tree structure of the sort standardly used for argument visualization and evaluation. If the critical questions could be treated as additional premises that are implicit in the argument, it could help to solve this problem could be easily solved. But the additional problem is that the shifting of the burden when critical questions are asked does not take place in a uniform way. In some instances, merely the asking of the question is sufficient to defeat the argument, but in other instances the shift does not occur unless the critical question is backed up by at least some evidence.

Three additional ways of reconstructing the logical form of argument from expert opinion were set out in (Reed and Walton, 2003, 201-203), where they were called Version *II*, Version *III* and Version *IV*, Version *I* being the original one stated above. Version *I* is a very simple form of argument from opinion. Version *II* adds a conditional premise that reveals a Toulmin-style warrant on which this form of argument is based.

[1] The earlier version (Walton, 1996, 65) used the variable *D* to represent the domain of knowledge, while the version here uses the field *F* of knowledge.

Argument from Expert Opinion (Version *II*)

Major Premise: Source *E* is an expert in subject domain *S* containing proposition *A*.
Minor Premise: *E* asserts that proposition *A* (in domain *S*) is true (false).
Conditional Premise: If source *E* is an expert in a subject domain *S* containing proposition *A*, and E asserts that proposition *A* is true (false), then *A* may plausibly be taken to be true (false).
Conclusion: *A* may plausibly be taken to be true (false).

If you look at version II you can see that the argument has a *modus ponens* structure as an inference. It has the form called defeasible *modus ponens.* Verheij (2001, p. 232) proposed that defeasible argumentation schemes fit a form of argument he called *modus non excipiens*: as a rule, if *P* then *Q*; *P*; it is not the case that there is an exception to the rule that if *P* then *Q*; therefore *Q*. This form of argument can be used for evaluating defeasible inferences like the Tweety argument: If Tweety is a bird, Tweety flies; Tweety is a bird; therefore Tweety flies. This form of argument was called defeasible *modus ponens* (DMP) by Walton (2002). An example (Copi and Cohen, 1998, p. 363) also illustrates DMP: if he has a good lawyer then he will be acquitted; he has a good lawyer; therefore he will be acquitted. This argument is defeasible. Even though he has a good lawyer, he may not be acquitted, because even a good lawyer can lose a case. Nevertheless his having a good lawyer is a reason for defeasibly accepting the conclusion that he will be acquitted, on a balance of considerations.

Using a concept from defeasible logic called defeasible implication, or the defeasible conditional as it might be called, we can represent DMP is having the following form.

Major Premise: *A* => *B*
Minor Premise: *A*
Conclusion: *B*

The first premise states the defeasible conditional, 'If *A* is true then generally, but subject to exceptions, *B* is true'. The scheme for argument from expert opinion can now be cast into something close to the DMP form as follows.

Major Premise: (*E* is an expert & *E* says that *A*) => A
Minor premise: *E* is an expert & *E* says that *A*
Conclusion: *A*

This form of argument is not exactly the same as DMP because the conditional in the major premise has a conjunctive antecedent. The scheme has this form: (*A* & *B*) => *C*, *A* & *B*, therefore *C*. Nevertheless, it is a substitution instance of the DMP form. We could say that in its general outline it has the structure of the DMP form of inference.

The analysis so far, however, does not take into account the critical questions for the argument from expert opinion. The suggestion made by Reed and Walton is that the conditional premise could be expanded to take the critical questions into account in a still more fully expanded version of the scheme. Note however that the scheme called version III below is not the same in all respects as the one called version III in (Reed and Walton, 2003, 202).

Argument from Expert Opinion (Version III)

Major Premise: Source *E* is an expert in subject domain *S* containing proposition A and *E* asserts that proposition *A* is true (false), and *E* is credible as an expert source, and *E* is an expert in the field *A* is in, and *E* asserted *A*, or a statement that implies *A*, and *E* is personally reliable as a source, and *A* is consistent with what other experts assert, and *E*'s assertion is based on evidence.
Conditional Premise: If source *E* is an expert in a subject domain *S* containing proposition *A*, and *E* asserts that proposition *A* is true (false), and *E* is credible as an expert source, and *E* is an expert in the field *A* is in, and *E* asserted *A*, or a statement that implies *A*, and *E* is personally reliable as a source, and *A* is consistent with what other experts assert, and *E*'s assertion is based on evidence, then *A* may plausibly be taken to be true (false).
Conclusion: *A* may plausibly be taken to be true (false).

Version III makes both the major premise and the conditional premise seem highly complex. But a theoretical advantage of it is that, once analyzed after the fashion of the analysis of version 2 above, it can be shown to fit the DMP format.

We might not like such complex premises, and think that the logical form of argument from expert opinion is a defeasible argumentation scheme could be expressed in a more perspicuous fashion by treating each of the critical questions as a separate premise. The outcome of this style of reformulation was called version IV by Reed and Walton (2003, 202).

Argument from Expert Opinion (Version IV)

Major Premise: Source *E* is an expert in subject domain *S* containing proposition *A*.
Minor Premise: *E* asserts that proposition *A* (in domain *S*) is true (false).
Conclusion: *A* may plausibly be taken to be true (false).
Conditional Premise: If source *E* is an expert in a subject domain *S* containing proposition *A*, and *E* asserts that proposition *A* is true (false), then *A* may plausibly be taken to be true (false).
Expertise Premise: *E* is credible as an expert source.
Field Premise: *E* is an expert in the field that *A* is in.
Opinion Premise: *E* did assert *A*, or made a statement that implies *A*.
Trustworthiness Premise: *E* is personally reliable as a source.
Consistency Premise: *A* is consistent with what other experts assert.
Backup Evidence Premise: *E*'s assertion is based on evidence.

In version IV, all the critical questions are built in as premises. Here we have a form of the argumentation scheme that we can work with, even though the issue of burden of proof for these premises needs to be discussed. This form the argument no longer fits the DMP form, but it could be seen as having something like that form in defeasible logic. These considerations take us to the point where we need to think more generally about the properties of defeasible logic.

2. Outline of Defeasible Logic

Defeasible logic is a logical system, originally attributed to (Nute, 1994), meant to model reasoning used to derive plausible conclusions from partial and sometimes conflicting information. A conclusion derived in defeasible logic is tentatively accepted, subject to new information that is continually incoming. At any point this new information may require the retraction of a proposition that was previously accepted. However, it is possible to see defeasible argumentation in a dialectical framework, where new information can come in during the argumentation stage, but then cannot come in after the closing stage is reached.

The basic units of defeasible logic are called facts and rules. Facts are statements that are accepted as true within the confines of a discussion. Here we use the terms proposition and statement interchangeably. Statement are denoted by letters, *A*, *B*, *C*, …., and so forth, using subscripts if we run out of letters. There are two kinds of rules, called strict and defeasible rules. Strict rules are universal in that they are meant to admit of no exceptions e.g. 'All penguins are birds'. A strict rule has the form of a material conditional with a conjunctive antecedent of the following form: $A_1, A_2, A_n\ldots, \rightarrow B$. With this kind of rule, it is not possible for all the A_i to be true and the *B* false. Defeasible rules are rules are subject to exceptions, e.g. 'Birds fly'. A defeasible rule has the form $A_1, A_2, A_n\ldots, \Rightarrow B$, where each of the A_i is called a prerequisite, all the A_i together are called the antecedent, and *B* is called the consequent. With this kind of rule, it is possible for all the A_i to be true and the *B* false. For example, if the particular bird Tweety being discussed is a penguin, the conclusion that Tweety flies cannot be inferred. In a system of defeasible logic, one rule can conflict with another. However, such a conflict can sometimes be resolved by using a priority relation defined over the set of rules that determines the relative strength of any two conflicting rules. In addition, defeasible logic is able to tell whether a conclusion is or is not provable.

There are two types of conclusions in a defeasible logic. A definite conclusion cannot be retracted, even if new information comes in that goes counter to it. A defeasible conclusion can be retracted if new information comes in that goes counter to it. It is possible to have four types of conclusions (Governatori et al., 2004):

- Positive definite conclusions: meaning that the conclusion is provable using only facts and strict rules;
- Negative definite conclusions: meaning that it is not possible to prove the conclusion using only facts and strict rules;
- Positive defeasible conclusions: meaning that the conclusions can be defeasibly proved;
- Negative defeasible conclusions: meaning that one can show that the conclusion is not even defeasibly provable.

A defeasible conclusion *A* can be accepted if there is a rule whose conclusion is *A*, whose prerequisites are facts, and any stronger rule whose conclusion is ~*A* has prerequisites that fail to be derived.

How the reasoning process is carried out in a defeasible logic can be explained as an argumentation method. To prove a conclusion you have to look at the argument both for against the conclusion by carrying out three steps (Governatori, 2008).

1. Give an argument for the conclusion to be proved
2. Consider the possible counter-arguments for the conclusion that can be given.
3. Defeat each counter-argument by showing that some premise does not hold or by producing a stronger counter-argument for the original argument.

A conclusion is proved as the outcome if there is at least one argument supporting it and all the arguments against it are defeated.

An important component of defeasible logic is the notion of a defeater of an argument. A defeater is a counter-argument that shows that one of the prerequisites (premises) of the original argument does not hold, or a stronger argument that proves the opposite conclusion of the original argument, or an argument that challenges the applicability of the inference from the premises to the conclusion.

Now we have reached the point where we need to consider whether version IV of the scheme for argument from expert opinion, as well as other schemes, can be represented in a defeasible logic form. In this form, the premises A_1, A_2, A_n are prerequisites that go along with a defeasible rule of the form A_1, A_2, A_n…, => B to derive the conclusion C. But before pursuing this suggestion, we need to examine the issue of burden of proof for these premises.

3. Introduction to Carneades

Carneades is a mathematical and computational model consisting of mathematical structures and functions on these structures (Gordon, Prakken and Walton, 2007). Carneades models the structure and applicability of arguments, the acceptability of statements, burdens of proof, and proof standards, for example preponderance of the evidence (Gordon and Walton, 2009). Carneades has been implemented using a functional programming language (Gordon and Walton, 2006). It has a graphical user interface that anyone can download at no cost to make argument maps to analyze and evaluate arguments (https://github.com/carneades/carneades). Statements can be questioned, stated, accepted or rejected. A statement that appears in a white box with no checkmark is only stated, not accepted or rejected. A statement that appears in a darkened (green) box with a checkmark ✓ is accepted. A statement that appears in a darkened (red) box with a checkmark × is rejected.

Consider the Tweety example of defeasible reasoning shown in figure 1. The conclusion of the argument, the proposition that Tweety can fly, is shown at the left. The two ordinary premises, the rule that birds normally fly, and the factual statement that Tweety is a bird, are shown at the top on the right. Both of these premises are indicated as accepted, as shown by the checkmarks that appear in front of them. The argument is a pro argument for the conclusion as shown by the + in the node representing the argument. However, the bottom box at the right containing the statement that Tweety is a penguin, is also accepted. This premise is an exception (indicated by the broken line), meaning that if accepted it defeats the argument. Hence the conclusion that Tweety can fly is shown is rejected, as indicated by the × in front of it.

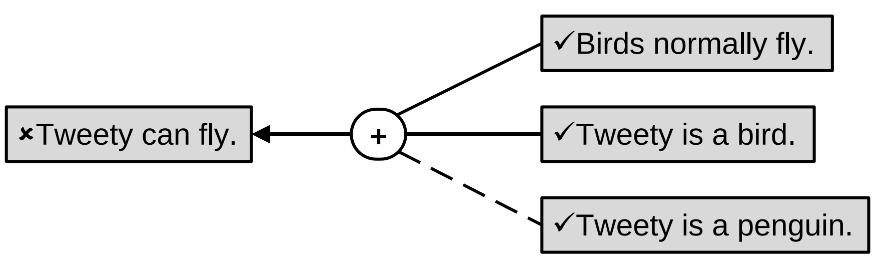

Figure 1: How Carneades Represents Defeasible Reasoning

If the statement that Tweety is a penguin was not accepted, then the remaining two premises would be sufficient to prove the conclusion, and the conclusion would automatically be accepted.

To give another example of how the mapping tool displays an argument diagram we can look at figure 2. Carneades can represent both pro and contra arguments. Both of the arguments shown in figure 1 are pro-arguments, as indicated by the + in the argument node. The conclusion of the argument is shown in the text box at the far left. It is shown in a darkened box and has an

X in front of the statement to be proved, that academic qualification ensures success in life. The argument presented at the second depth has four premises. The first three premises are joined to the argument node with the solid line indicating that they are ordinary premises. The fourth premise, the statement that Bill Gates is an exception, is in a darkened box with a checkmark in front of the statement, indicating that this statement has been accepted. At the third level, on right of the diagram, there is an additional pro argument with two premises supporting the argument that Bill Gates is an exception. The remaining three premises are shown in boxes with a white background, indicating that they have been stated but not accepted.

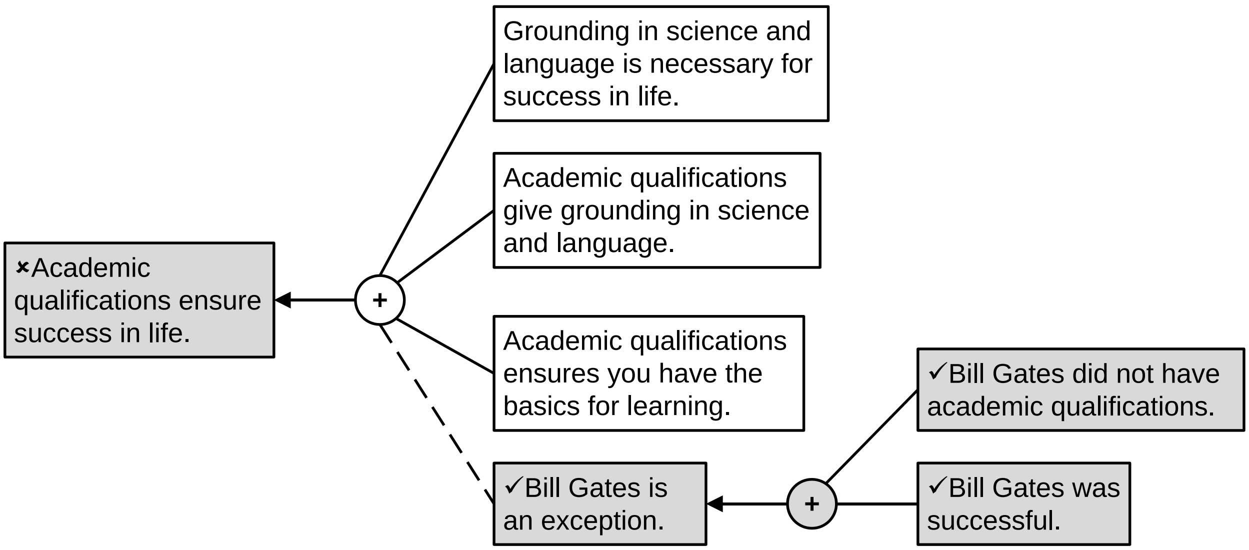

Figure 2: The Bill Gates Example

This example illustrates the distinction between ordinary premises that are assumed to hold but are not acceptable if they are questioned, and premises that represent exceptions. The three statements in the white boxes are ordinary premises, while the premise at the bottom at the second depth is put forward as an exception. This means that it does not defeat the argument for the ultimate conclusion merely by being stated. In order to defeat the argument, evidence to back it up has to be given.

In the example, as shown in figure 2, the exception is backed up by an argument containing two premises both of which have been accepted. Originally these two statements were only stated, not accepted, and so each of them was contained in a white box. However, once these premises were evaluated as accepted, they each appear in a darkened box with a checkmark ✓ in front. Then the conclusion drawn from them, the statement that Bill Gates is an exception, is automatically inserted as accepted by Carneades. Once this happens, the status of the conclusion of the argument, the statement that academic qualification ensures success in life, is changed from stated to rejected. Carneades will then change the sign in the text box to a checkmark ×. On the screen the conclusion, which was formerly in the box with a white background, will now appear in a box with a red background. Rejection is redundantly indicated by both the color of the box and a checkmark in front of the statement.

How counter-arguments are represented by Carneades can be shown using another example shown in figure 3. At the top there is an argument with two premises. The statement that

Encyclopedia Britannica is reliable is accepted, as shown by the checkmark in front of it. But the other premise, stating that Wikipedia is as reliable as Encyclopedia Britannica, shown in the white box below it, is stated but not accepted. However, backing it up is another argument with a premise claiming that a study in the journal *Nature* found Wikipedia as reliable as Encyclopedia Britannica. But this premise is only stated, not accepted. Below this pro argument there is also a con argument. The premise of this con argument has another single-premised argument supporting it. But this premise, the statement that Wiki articles can be written by non-experts, is accepted.

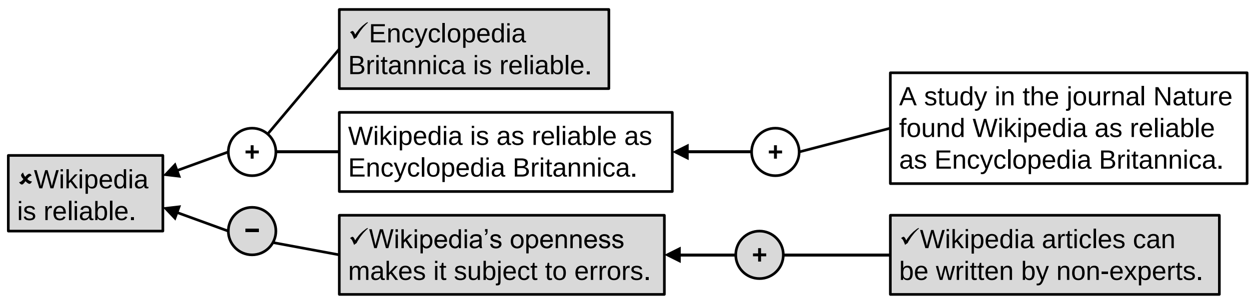

Figure 3: The Wikipedia Example

How is the argumentation in this case evaluated by Carneades? The conclusion was initially rejected, but is the pro argument strong enough to overcome that rejection? No, it is not. The con argument is applicable. Its single premise is accepted because it is supported by an argument in which the only premise is accepted. But the pro argument is not applicable, because one of its premises, the statement that Wikipedia is as reliable as Encyclopedia Britannica, is only stated, not accepted. Morevover, the further argument that supports it has a premise that is not accepted.

Next we can ask, looking at figure 4, what would happen if the premise 'A study in the journal *Nature* found Wikipedia as reliable as Encyclopedia Britannica' were accepted? What happens is that Carneades puts a checkmark in front of that statement, showing it to be accepted, and when that happens, it also makes the statement 'Wikipedia is as reliable as Encyclopedia Britannica' accepted. Carneades automatically puts a checkmark in front of that statement once the premise in the argument supporting it has been accepted. The outcome is shown in figure 4.

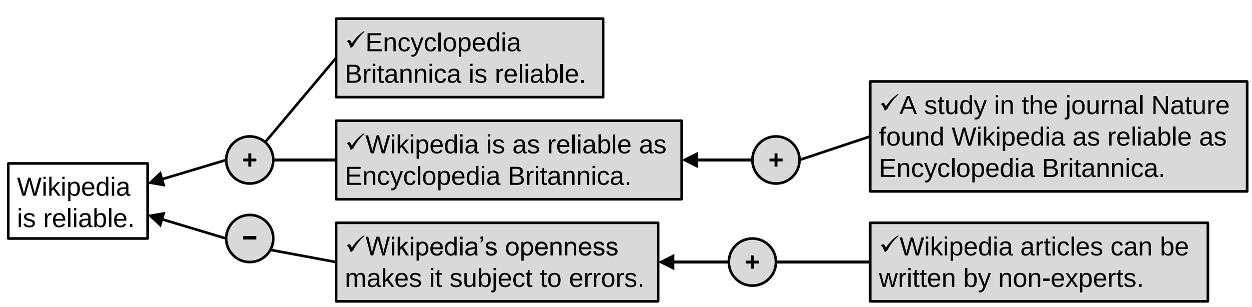

Figure 4: Wikipedia Example with All Premises Accepted

Carneades has recognized in the cases shown in figure 4 that both arguments are applicable. Now we have a deadlock. We have one applicable pro argument and one applicable con argument. Even though there is an applicable argument supporting the ultimate conclusion, still that conclusion is shown as merely stated, and not as accepted. Now we have an idea of how Carneades works, we can go on to explain how Carneades' way of managing argumentation schemes and critical questions makes it compatible with defeasible logic.

4. How Carneades Models Critical Questions

Version IV of the defeasible argumentation scheme for argument from expert opinion treated each critical question as a separate premise of the argument. But is it justified to see all these premises as being on an equal footing? Some of them seem to be more easily acceptable and others. For example, the premise that *E* is an expert is not explicitly stated premise in the original scheme, and this premise needs to hold for the argument to stand up. But what about the premise that what *E* says is consistent with what other experts assert? This does not seem to need to hold in order for the argument to stand up. Indeed, if a critic were to ask this question, in order for the mere asking of the question to defeat the argument, he would presumably have to give some evidence that what he says is not consistent with what other experts assert. The advantage of the way Carneades uses defeasible logic is that it takes these differences between the critical questions into account.

Carneades distinguishes different ways the critical questions matching an argument from expert opinion are represented on an argument diagram. These different ways have led to two theories about requirements for initiative shifting when critical questions matching the argument from expert opinion are asked (Walton and Godden, 2005). According to one theory, in a case where the respondent asks any one of these critical questions, the initiative automatically shifts back to the proponent's side to provide an answer, and if she fails to do so, the argument defaults (is defeated). On this theory, only if the proponent does provide an appropriate answer is the plausibility of the original argument from expert opinion restored. According to the other theory, asking a critical question should not be enough by itself to make the original argument default. On this theory, the question, if questioned, needs to be backed up with some evidence before it can shift any burden that would defeat the argument.

The premises that the expert is credible as an expert and that what she says is based on evidence are assumed to hold, but if they are questioned, there is a burden on the advocate of the argument from expert opinion to offer support for them. Credibility means that the expert is assumed to have knowledge of the field in which she is an expert. Merely asking either of these two questions makes the argument default. The premises that the expert is trustworthy and that what she says is consistent with what other experts say, in contrast, only need to be given up if some evidence can be given to show they are true. For example, if the expert was shown to be biased or a liar, that would presumably be a defeater because it would call trustworthiness into doubt. But unless some evidence is given to back up such a strong allegation, it incurs a burden of proof and is not to be accepted. So merely asking either of these two kinds of critical questions is not enough by itself to make the argument default. The burden of proof to provide backup evidence is on the critical question asker, in order to make the argument default. The ordinary premises that the expert really is an expert and that she is an expert in the subject domain of the claim are also assumed to be acceptable. These premises are initially assumed to hold, but merely asking one of these critical questions should be enough to make the argument default until the arguer responds appropriately.

This way of classifying the critical questions of the argument from expert opinion scheme was first advocated by Walton and Gordon (2005). It can be summarized as follows.

Ordinary Premise: *E* is an expert.
Ordinary Premise: *E* asserts that *A*.
Ordinary Premise: *A* is within *F*.
Assumption: It is assumed to be true that *E* is a knowledgeable expert.
Assumption: It is assumed to be true that what *E* says is based on evidence in field *F*.
Exception: *E* is not trustworthy.
Exception: What *E* asserts is not consistent with what other experts in field *F* say.
Conclusion: *A* is true.

This way of configuring the logic of an argument from expert opinion is represented in figure 5. Each ordinary premise is represented by a solid line joining that premise to the argument node. On the computer screen, such a line is shown in green. Each assumption is represented by a dotted line joining that premise to the argument node. On the screen, this type of line is also shown in green. Each exception is shown as a premise joined by a dashed line that goes from it to the argument node. On the screen such a line is shown in red.

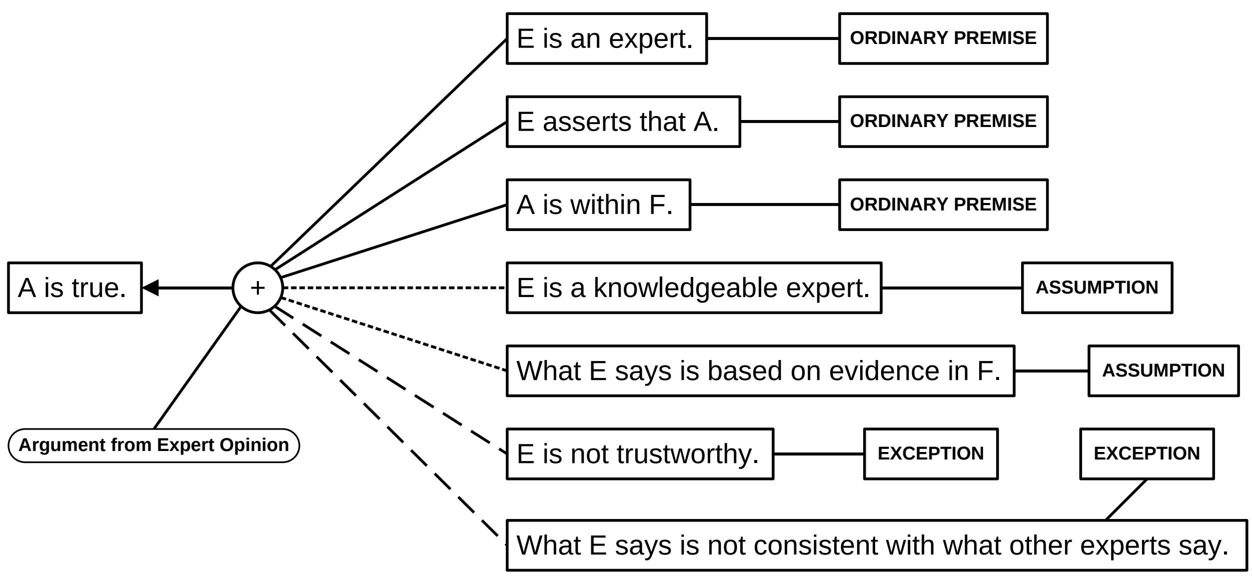

Figure 5: Carneades Visualization of Argument from Expert Opinion

It is now easily seen how the way arguments from expert opinion are represented on the Carneades model fits the format of version IV of the four versions of the argumentation scheme for expert opinion presented above. As we will now show, this way of managing argumentation schemes and critical questions makes Carneades compatible with defeasible logic.

5. Logical Structure of Schemes in Defeasible Logic

Verheij (2008, 24) commented on several of the defeasible argumentation schemes and remarked that if you look at them with eyes slightly narrowed, they share the same form. In his way of structuring this form, the defeasible rule *A*, *B*, *C*, … => *Z* uses the connective of the same kind used in defeasible logic. *A*, *B*, *C*, … *Z* is a set of propositions (statements).

A, *B*, *C*, … => *Z*
A, *B*, *C*, …

Z

According to Verheij (2008, 24), when you look at the schemes in this way, they have the general form of the DMP inference rule.

Bench-Capon and Prakken (2010) outline a semi-formal logical structure in which reasoning takes the form of applying and combining argumentation schemes. Their account draws on existing work on logics for defeasible argumentation developed in AI and law. This work defines arguments as inference trees formed by applying strict and defeasible inference rules. Like Verheij, they assume that the logical language contains a connective => for defeasible rules. Bench-Capon and Prakken (2010, 159) put this inference structure forward as the basic argumentation scheme for applying defeasible rules. On their view, the first premise is the name of the rule in the inference. $P_1, \ldots, P_n$ is a set of facts and *Q* is a fact.

$P_1, \ldots, P_n \Rightarrow Q$
$P_1, \ldots, P_n$

Q

Bench-Capon and Prakken (2010, 159) see this structure as an argumentation scheme that has a set of critical questions matching it. On their account, negative answers to the critical questions give rise to counterarguments, and conflicts between arguments for and against a proposition at issue are resolved using rule priorities.

In section 4 it was shown how Carneades model critical questions matching this scheme by dividing the premises into three types, ordinary premises, assumptions and exceptions. The assumptions behave like the ordinary premises in that they are assumed to hold and have a burden of proof, meaning that if they are questioned that is enough to defeat the argument. If the opponent questions a premise that is an exception, that is not enough in itself to defeat the argument however. The argument is only defeated if evidence is given to show that the exception applies in the case. This distinction between the two kinds of premises means that argumentation schemes have to be configured in a special way.

The scheme for argument from expert opinion can be shown to have a form that has a logical structure in defeasible logic, where one premise is a set of prerequisites that compose the antecedent of a defeasible conditional. The other premise states that this set of prerequisites holds. This form of argument has the following structure, where $A_1, A_2, \ldots, A_n$ is a set of assumptions, $E_1, E_2, \ldots, E_n$ is set of exceptions and *B* is a proposition. Let's call the structure of the general logical form for defeasible argumentation schemes the binary DMP form.

$[(A_1, A_2, \ldots, A_n) \& (E_1, E_2, \ldots, E_n)] \Rightarrow B$
$A_1, A_2, \ldots, A_n$
$E_1, E_2, \ldots, E_n$

B

This binary form has the DMP structure provided that the second and third premises can be conjoined so that they fit the antecedent of the first premise. In this way of modeling the argumentation scheme for argument from expert opinion, there are two different kinds of prerequisites, the assumptions, including the ordinary premises, and the exceptions, that have to be met or excluded for the conclusion to be defeasibly inferred.

Many of the other defeasible argumentation schemes that have been recognized, like argument from position to know, argument from commitment, argument from cause to effect, and so forth, have this general binary form in outline. They are all special instances of defeasible reasoning of this form, because they have a set of premises that can be regarded as a conjunction of prerequisites of two different kinds. If all the propositions in the conjunctions in the second and third premises are accepted, and the conditional premise also holds, then on the basis of defeasible reasoning the conclusion is also accepted as true. So it can be said that all of the defeasible argumentation schemes in this class share the general structure of binary DMP as their underlying form of reasoning.

This view of the matter agrees with Verheij’s (2003) view that if you look at schemes with eyes slightly narrowed they can be seen to share the same form. Hence this view is not in agreement with Bench-Capon and Prakken’s view that this structure is a particular argumentation scheme that has a special set of critical questions matching it. Even though in this paper evidence has been presented to show that the scheme for argument from expert opinion has this binary DMP form, it remains to be seen how many of the other schemes share it. Some of them, for example the scheme for argument from lack of evidence, also called the argument from ignorance, has a *modus tollens* (MT) form, and it is dubious whether MT holds in defeasible logic (Caminada, 2008). Also, some of the other schemes are more complex, and apparently need a separate study. For example, even though the slippery slope argument, in all four of its variants, does have a DMP format in general outline, it has other special premises, like the recursive premise, that need to be recognized as essential parts of the structure (Walton, Reed and Macagno, 2008).

6. Conclusions

It has been shown that there is a way we can take further steps forward in argumentation studies by finding a logic of defeasible argumentation schemes by using defeasible logic as part of Carneades. We have shown how Carneades incorporates defeasible logic and builds on it to provide a computational tool that not only enables us to do argument mapping, but to represent the critical questions matching defeasible argumentation scheme on an argument map. Carneades can use defeasible argumentation schemes not only to evaluate arguments but to construct them. It also has the capability for finding arguments needed to prove a claim in a given case. It has been shown how the Carneades argumentation system has a way of modeling argumentation schemes so that they can be evaluated as strong or weak. If the premises are accepted, and the argument fits a scheme, the argument is applicable. If an argument is applicable, the conclusion is automatically accepted by Carneades (Gordon, 2010). However, the argument may be applicable, but can still be defeated by an exception that is backed by evidence. It can also be defeated by a counter-argument. The Carneades argumentation system is dialectical, meaning that new information is always coming into the system until the dialogue is closed. In the Carneades system, argumentation in a dialogue always has three stages, an opening stage, an argumentation stage and a closing stage (Gordon and Walton, 2009).

We have shown how the Carneades model applies to a typical defeasible argumentation scheme, namely the one for argument from expert opinion. It has been also shown the argumentation scheme for argument from expert opinion has the general logical DMP form, and it has been suggested as a basis for further research that many of the other most common of the defeasible argumentation schemes share this form.

It has also been argued that the general logical binary DMP form is not itself an argumentation scheme, but is better seen as a general logical category of reasoning into which the schemes fit. Prakken (2010) also noted that some of the arguments categorized as argumentation schemes in the argumentation literature do not really seem to be schemes in a narrower sense applicable to many of the other schemes. Instead, they appear to be more general categories of reasoning. For example Prakken (2010) pointed out that the argument from negative evidence is very similar, if not identical to, the closed world assumption widely known in artificial intelligence (Clark, 1978; Reiter, 1980). Prakken thinks, therefore, that it is not itself an argumentation scheme, but a general logical principle underlying the use of schemes. This remark, we are suggesting, is also applicable to the general logical binary DMP form of reasoning, which, because of its generality, is better seen not as a specific argumentation scheme, but as a general form into which many of the commonly known defeasible schemes fit.

Further research is needed to examine the logical structure of other argumentation schemes to see how well they fit this model of the logical form of argumentation.

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