

Dealing with the dynamics of proof-standard in argumentation-based decision aiding

Ouerdane Wassila and Maudet Nicolas and Tsoukias Alexis¹

Abstract. Usually, in argumentation, the proof-standards that are used are fixed a priori by the procedure. However decision-aiding is a context where these may be modified dynamically during the process, depending on the responses of the client. The expert indeed needs to adapt and refine its choice of an appropriate method of aggregation, so that it fits the preference model inferred from the interaction. In this paper we examine how this aspect can be handled in an argumentation-based decision-aiding framework. The first contribution of the paper is conceptual: the notion of a concept lattice based on simple properties and allowing to navigate among the different proof-standards is put forward. We then show how this can be integrated within the Carneades model while still preserving its essential properties; and illustrates our proposal with a detailed example.

1 Introduction

From the seminal work of [7] to recent accounts (see e.g. [2]), argumentation has been advocated as a relevant approach to account for decision-aiding. Under such a perspective, an agent faced with several possible candidate actions (or alternatives) will seek a decision which is “sufficiently” justified in the light of the arguments which can be constructed for or against the considered alternative. One (important) aspect of argumentation is to define what valid justifications (sets of arguments) can be considered, for instance whether reinstatement should be used or not [12]. On top of that, though, a proper definition of what “sufficiently” means should be given, for in most situations conflicting justifications may typically be built for and against the considered decision. Doing that amounts to defining a *proof standard* [10]. In most applications (for example those dealing with legal issues), the proof standard to be used is fixed a priori, given exogenously by the procedure.

In this paper, the context we are interested in is that of a specific case of decision-aiding: an expert helps a decision maker in choosing a single decision to be undertaken, given that the different actions may be evaluated on several dimensions (criteria) which then need to be aggregated. By interpreting criteria as dimensions against which arguments can be constructed (we shall discuss this point later on) we see that the problem is very similar to the one discussed above. Except in trivial cases, these different criteria will indeed conflict and promote different decisions, and we should define what makes a decision sufficiently justified. What makes the problem challenging here is the following feature: part of the job of the expert is precisely to choose a given aggregation method and adapt it to the responses provided by the client during the course of interaction. It is indeed important to realize that not all the methods may be meaningfully used

for a given choice problem. The preference model of the decision maker inferred from the interaction with him discards or instead reinforce the reasons that the expert have to select a given method. For instance, the expert may realise during the process that a given criterion plays a prominent role. The purpose of this paper is precisely to provide a formal account of how this can be done conceptually and in practice in an argumentation-based setting.

The remainder of this paper is as follows. In the next section, we briefly overview the related works, either in the domain of argumentation-based decision-making, or in the field of multiple criteria decision-aiding. In Section 3 we present a motivating example which illustrates the need to cater for proof standards dynamic modification, in our context of decision-aiding dialogues. Our conceptual contribution is explicated in Section 4: we show how different properties can be used to indicate how proofs vary in the process. More specifically, we propose a concept lattice which will allow to navigate among the different aggregation techniques. In Section 5, we show more specifically how this proposal can be integrated in the recent Carneades model [9]. Section 6 concludes.

2 Related Work

In multicriteria decision-aiding, the question of how to chose or adapt the aggregation method is a central issue, which is typically left under the expert’s responsibility. Decision-aiding tools rarely address this aspect of the problem. Even in the case of *interactive methods* [16] which emphasize the need to take into account the client’s feedback, the objective is to explore the neighborhood of a given solution, not to modify the aggregation method itself. In fact, whether formal guidelines to help the expert in this process can be proposed is still a matter of intense discussions. The ambitious research program of *conjoint measurement* [4] is dedicated to the axiomatic study of aggregation methods: by providing characterization of the different aggregation methods under the form of sets of axioms, it provides a theoretically sound framework which may serve as a foundation for the interactive method selection procedures. Unfortunately, the different axioms used in such characterisations do not necessarily easily appeal to intuition. In particular, they do not give rise to “natural” ways to invalidate or reinforce them during the interaction. Although this approach inspires our work, we opted for a set of simple properties that do not necessarily match exactly such axioms. One approach which shares with us the objective to provide a simple and intuitive to discriminate can be found in [11]. However, such a work does not provide any operational way to guide the selection process.

In the domain of argumentation, the notion of proof standard has recently received much attention (see [10] for a recent survey). The notion of *accrual of arguments* [15] essentially tackles the same is-

¹ University of Paris-Dauphine, France, email: {wassila.ouerdane, maudet, tsoukias}@lamsade.dauphine.fr

sue: how to aggregate different arguments together. Usually in argumentation, as mentioned above, the notion of proof standard that should be used is determined by a given context. This is especially true in the legal domain, where the proof standards that should be used are well identified. For instance, under the “*scintilla of evidence*” proof standard, a small piece of evidence is enough to make the claim justifiable. Under the “*preponderance of the evidence*”, the available evidence should make the claim more probable than not. The strongest requirement is attached to the “*beyond reasonable doubt*”, whose definition is clear from the name. Depending on the nature of the case, the proof standard required may be different. In a criminal case for instance, this latter definition is appropriate.

The use of proof standard is not restricted to legal field and can be used in a context of decision-making. For instance, *Hermes*, a groupe decision support system where argumentation is used to enhance group decision making, used proof standards to calculate an *activation label* associated to the component of the system [13]. Indeed, the *Hermes* system organized the knowledge under the form of a discussion graph, which consists of: *issues* (decision to be made, or goal to be achieved), *alternatives* (different choices attached to an issue), *position* (proposition or claims that defend the selection of an alternative) and *constraints* (a qualitative way to weight reasons for and against the selection of an alternative). Thus, the activation label associated to each alternative, position and constraint is used to indicate their *status* (*active* or *not active*). This status allows to accept (or reject) a position and to distinguish the recommended alternatives from the rejected one.

A more recent account, in the same vein, is proposed in the Carneades framework [9]. A distinctive and very appealing feature of this approach is that the acceptability of claims is computed on the way an argument is attacked or defended in a given argument graph, but also on the *dialectical status* of the different moves that brought the arguments, as well as on the proof standards attached to them. The approach will be detailed further in Section 5, when we give the detail of how our notions can be integrated in this framework.

Finally, we note that the notion is seldom discussed in the context of Dung’s abstract framework [6]. This is certainly due to the fact that this framework does not model explicitly arguments in favour of a given claim. However, there may some way to provide an interpretation of this notion, based for instance on the type of extensions arguments belong to [3].

A final word is useful on the exact relation between these two notions. It is certainly possible to “retrieve” many multicriteria aggregation procedures by means of argumentation. This is done for example in [1]. However, as noted by these authors, only the most simple aggregation procedures can be captured this way. This is essentially due to the (mostly) qualitative nature of the argumentation process. On the other hand, multicriteria aggregation makes (typically) assumption that argumentation would *not* do when defining proof-standards. In particular, argumentative approaches emphasize that the reasons in favour and the reasons against some conclusion should be treated separately. Proof standards as usually proposed in argumentation are intrinsically *bipolar*, in other words they constitute techniques to aggregate *pros* and *cons* (see [5]).

3 A Motivating Example

We assume that a decision maker specifies his evaluation model, comprising of four actions $A = \{a_0, a_1, a_2, a_3\}$, five criteria $H = \{h_0, h_1, h_2, h_3, h_4\}$, and the following performance table:

	h_0	h_1	h_2	h_3	h_4
a_0	7	6	2	3	5
a_1	6	4	8	4	7
a_2	3	2	5	5	3
a_3	7	7	2	0	2

- (1) S: I recommend a_1 as being the best choice
- (2) U: Why is that the case?
- (3) S: because a_1 is globally better than all other alternatives
- (4) U: Why?
- (5) S: Because a_1 is preferred to each other alternatives by a majority of criteria: it is ranked first on h_2 and h_4 , and is only beaten by a_2 on h_3 . But a_1 beats a_2 on h_0 .
- (6) U: I see, but I would prefer a_0 to a_1
- (7) S: Why?
- (8) U: Because a_0 is better on $\{h_0, h_1\}$
- (9) S: Fine. But then why is not a_3 preferred?
- (10) U: No. a_3 is too bad on h_3 . This would not be justifiable.

Let us briefly analyze this dialogue. We follow [14] and assume that different types of arguments can be constructed to capture different aspects of these dialogues. In turn (1), the system suggests that the action a_1 is the best one, without giving further information. In turn (2), the user challenges this proposition and asks for a justification, which is given by the system in the turn (3). The justification given explains that a_1 is better than any other action (technically, this is a Condorcet winner). Not satisfied with this explanation, the user asks for more explanations. The system offers the detailed explanation on turn (5). Now on turn (6) the decision maker puts forward the alternative that he feels intuitively as being the best here. The system challenges this claim and at turn (8) the decision maker gives an explanation based on the fact that a_0 is better on two criteria: h_0 and h_1 . The system again challenges the claim by emphasizing that on this basis a_3 should then be preferred. Finally the decision maker gives a reason for *not* accepting a_3 : a very low score on criteria h_3 .

From (1) to (5) the dialogue amounts to revealing an increasingly detailed evidence for a specific recommendation. The dialogue moves that are of interest for us come right after. In both turn (8) and (10) the responses of the decision maker would trigger a difficult task for the system, since the assumptions made at the beginning of the dialogue turn out to be inadequate, and then invalidate the method initially chosen to compute the recommendation. More precisely, in turn (5), the system used the majority principle to justify the recommendation a_1 . However, in turn (8) the user does not seem to follow the same reasoning, since he proposed a coalition of two criteria to support his best choice.

4 Navigating Through Proof Standards

Dealing with such dynamics of the proofs poses a number of challenges. The first one is to define a principled way to identify an adequate proof standard, given the current state of the interaction. The second one is to design a mechanism that will allow to automatically update the proof as a result of the client’s responses. We now discuss these two issues in turn.

How to identify a proof? The key idea here is to identify a set of properties that will help us to discriminate each procedure. Such properties will correspond to some characteristics of the decision maker’s preferences, corresponding to a set of conditions supporting the use of a given proof.

First of all, we assume that each proof obeys the following principle: *sufficiently supporting reasons must be provided, and no strong opposing reasons should be provided*. This principle is sometimes called concordance/discordance in the multicriteria decision aiding literature [4]. A proof standard instantiates this principle by applying different (separate) proofs on each side (leaving maybe the discordance side void in case this principle does not apply). Note that this dichotomy does not necessarily correspond to bipolarity, as each side may involve arguments *pro* and *con*. Instead, the concordance side provides necessary conditions for reasons to support a given claim, whereas the discordance side provides sufficient reasons to discard a given claim.

We now propose and briefly discuss three simple properties. These properties are by no means exhaustive, and there are clearly many other which could be proposed (for instance to cater more specifically for bipolar aggregation methods or proof standards used in argumentation, see e.g. [5]). These properties permit nevertheless to illustrate our purpose as they allow to distinguish a large variety of methods practically used in multicriteria decision aiding.

- **Ordinality (ORD.)**. Only the ordering of actions is relevant for comparison, in particular the specific difference of performance values is not.
- **Anonymity (ANO.)**. It suggests that all criteria are exchangeable;
- **Independence (INDEP.)**. Preferences expressed on a criterion do not depend on preferences expressed on another criterion.

Take the *weighted sum*. Each criteria separately has a different weight assigned, so anonymity is not satisfied. The preferential information is also not only ordinal, since the numerical values of the performance are used to compute the overall score. Finally, preferential independence is satisfied since it is possible for the decision maker to express his preferences on a given criterion regardless of other criteria.

As a second example consider now *simple majority*. Here we just count the number of criteria in favour a given claim, so the proof is anonymous. It is also purely ordinal, and satisfies preferential independence.

Table 1 provides more examples of classical aggregation methods which can be taken as proof standards in our context. Again, they should just be taken for illustrative purpose. In particular, they are not necessarily independent, which means that not all combinations is necessarily meaningful. We shall come back on that point later.

Table 1. Some proof standards and their properties

Methods	ORD.	ANO.	INDEP.	NO VETO
Simple majority	×	×	×	×
Weighted Majority	×		×	×
Outranking method	×		×	
Mean		×	×	×
weighted sum			×	×
Non linear value model				×
Oligarchies	×			×

An interesting but difficult question is whether different proofs can conceivably instantiate the concordance and discordance side. For instance, if the decision maker exhibit an ordinal method to establish supporting reasons, can he use a completely different way to decide when a reason is sufficient to discard a claim? The practice suggests that this may indeed be the case, the typical case being the use of a

veto specifying a threshold (on a criteria) above/below which a claim is judged unacceptable. For simplicity reasons, we shall assume in what follows that the proof for the discordance can be a veto, if any. To sum up, in the Table 1 the three first properties will help to identify proofs for the concordance side (such as simple majority) and the last one to specify the existence of a veto.

How to choose a proof? The difficulty of choosing a procedure is mainly due to the fact that at the beginning of the process, it is virtually impossible to have all the preferential information of the decision maker. Moreover, such preferences may change and evolve during the interaction, leading to corrections or new information being provided. Despite such difficulties, the system should be able to decide on the fly whether a procedure is appropriate or not.

We assume a set $R = \{r_0, r_1, \dots, r_n\}$ of potential proofs to be used by the system, and a set $P = \{p_0, \dots, p_k\}$ of properties as identified previously. At each time step of the dialogue t we denote by $\mathcal{I}_t$ the available preferential information and by R_t the methods that are compatible with $\mathcal{I}_t$, that is, methods that are still eligible to be used by the system.

However, defining the set of compatible methods is not good enough, as the system should select *one* method as being its favoured method, the one it will base its current reasoning on. The idea here is just to opt for methods that are *simple* for the user to understand. In theory this is a tricky problem to rank the proof standard according to a simplicity criteria which is certainly difficult to grasp. The solution proposed here allows in a sense to circumvent the problem: the system requires to start with a favorite proof to be used: this can be provided by the expert, or sometimes the decision maker himself (who may be familiar with a specific proof). This would typically be, for instance, a *weighted sum* or *simple majority*. Technically, when the system makes this first choice among the set R , the properties corresponding to this procedure are assumed to be true *by default*. Now as the user provides more preferential information (during the interaction), the system should be able to adapt and jump to the new favoured method. To do that, the system will be based on the one hand on the *set of properties* identified previously and on the other hand on the *decision maker's responses*.

The mechanism is almost in place. We just need to specify how to guide the navigation among the different candidate proof standards, depending on the properties that are currently satisfied or contradicted. To account for that, we propose to formalise the relationship between the set of properties and the set of proofs by a *Concept Lattice* as proposed in *Formal Concept Analysis* (FCA) [8]. In our context, a *formal concept* corresponds to a pair (R_i, P_i) , such that $R_i \subseteq R$ the set of proofs and $P_i \subseteq P$ the set of properties. Let $prop(p_k, r)$ a boolean function returning true when the property p_k indeed belong to the set of properties attached to r . The navigation works as follows: position yourself in the lattice at the initially chosen proof (attached to this proof the property vector with values assumed to be as required by the corresponding proof). Then, depending on the response of the decision maker, the system will “slide” to the next reachable proof. This gives a natural interpretation of how simple is a proof standard, namely how close (in terms of the number of properties that differ) it stands from the initially chosen proof standard. For instance, the Fig. 1 gives an example of such a lattice by considering that the first chosen procedure is the Simple Majority with the vector (1111).

Usually, the *concept lattice* is a complete lattice such that the concepts are partially ordered by inclusion: the lattice is composed of nodes that are formal concepts and edges that represent the links of

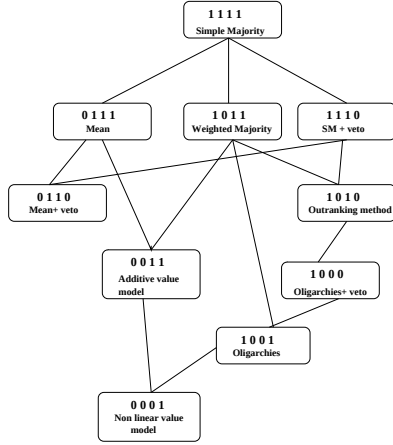


Figure 1. An example lattice for navigating among proofs

specialization/generalization. However, in our context this is not necessarily the case as some combination of properties do not necessarily specify any procedure, see *e.g.* Fig. 1). A further difficulty which may occur is that it may also be the case that a given response is ambiguous as to what property is concerned, as it is illustrated in the following example, in which case a heuristics should be used.

Example 1 We have only a performance table, we can admit that the most simple procedure is the simple majority without any veto (1111). Now, the update of the procedure will depend on the user's responses during the dialogue. For instance, if the answers refer to a difference in performance between two actions we can have two ways to interpret that. The first one is that such difference represents a penalty that can not be compensated. In other terms, it represents a strong negative reason against a given conclusion. Thus, in this case we are in presence of a kind of a veto in the discordance and the corresponding combination is (1110). In the second case, such difference is interpreted as the existence of a compensation, and therefore the ordinality of the supporting side is challenged. In this case, we move towards the combination (0111), corresponding to the mean.

This, finally, gives us a procedure *update_proof(.)* which takes as parameters the responses and the current information state. To be able to specify more precisely how this will proceed, we need a more detailed representation of the current state of the interaction, more explicit on how the properties can be modified. The Carneades model provides a framework upon which this can be built.

5 Integration in the Carneades Model

We now show how this mechanism can be integrated in the state-of-the-art Carneades model for [9].

Acceptability in the Carneades model. The acceptability of a statement in the Carneades model is determined in an arguments graph. Two kinds of nodes are used: *statement* nodes and *argument* nodes. Statements are declarative sentences (in a given language) and argument nodes are (instantiated) argument schemes. Furthermore, arguments graph have different kinds of edges that link the premises and conclusions of the arguments. The acceptability of the statement depends essentially on three elements: its dialectical status during the dialogue (*stated*, *questioned*, *accepted* and *rejected*), its proof

standard and its *premises types*. Indeed, depending on their type, different requirement are attached to the premises considered. *Ordinary premises* must be supported with further ground, *assumptions* can be assumed to hold until they are questioned, and finally *exceptions* don't hold in the absence of evidence to the contrary. Determining the acceptability of a statement is eventually the result of a procedure which recursively determine the acceptability of its premises on the basis of the elements mentioned above (for more details see [9]).

An extended acceptability function. In our case, an argument graph is constructed with the arguments exchanged during the decision aiding process. We consider the same types of nodes, such that the statements are constructed on the basis of preferential information provided by the user and the argument nodes are instantiation of different types of argument schemes for the decision aiding context (see [14] for more details). Now what is missing is a way to represent explicitly the proof standard, so that it can be (indirectly) discussed and challenged as any other statement in the graph. Specifically, it should have its own dialectical status during the dialogue and thus its own acceptability. We draw the attention of the reader that the dialectical status of a proof can be either “*stated*” or “*rejected*”. The practice of decision-aiding indeed tells us that the decision-maker is not able to explicitly accept a proof-standard.

Technically, a new link is added to represent the fact that a given proof is assigned to a statement. The proof standard itself is a statement of a special type, to which are attached the different properties discussed in the previous section (graphically, such a link is represented by a double line edge with no arrowhead, see Fig. 2).

The acceptability function of [9] is extended in an obvious way: now the system requires that the statement satisfies the proof standard attached to it, and also that the proof standard is itself acceptable:

$$acceptable(s, G) = satisfies(s, ps(s), G) \wedge acceptable(ps(s), G)$$

There is theoretically a risk of infinite recursion here, as the acceptability of a proof may itself obey to a different proof, etc. However, this case does not occur: for the statement nodes of type “proof standard”, a unique way to assess the acceptability is imposed, as a single argument will be considered to support the use of this proof (This assumes of course that no other argument are advanced pro or against the use of a specific proof standard—we leave this issue open for future works). Hence this argument must be defensible. Indeed if the properties discussed in Section 4 are conceived as a set of premises of an argument supporting “theoretically” the use of a specific proof standard, then contradicting one of this property will invalidate the acceptability of the proof standard. More precisely, Table 1 specifies the content of the premises that the argument supporting the use of the proof standard uses as assumption premises. Take for instance the *weighted majority*: the content of the property premises will be “ordinality”, “not anonymous” and “independence of criteria”.

The question of the dialectical status of these premises is now raised. In practice, most of the aspect of this proof standard is transparent to the decision-maker, as he is not supposed to discuss these concepts. To account for this, we suppose that the dialectical status of these premises is “assumed true”, to differentiate with *stated* which is supposed to be made explicit in the dialogue.

Critical responses, positive and negative evidence. To each of these premises is now attached a list of possible *critical responses*,

Table 2. Examples of Critical responses.

Property	Positive and Negative Evidences
Ordinality	PE: the difference between x and y is not significant for me. NE: the difference between x and y on the criterion h_i is too small, large, ...
Anonymity	PE: replacing the criterion h_i by h_j is the same result; all the criteria play the same role NE: the criterion h_i is more important than the criterion h_j x is better than y on the coalition of criteria $\{h_i, h_j\}$
Independence	PE: Every thing being equal on the rest of criteria, I prefer x to y on the criterion h_i because $h_i(x) > h_i(y)$ (Ceteris Paribus sentence) NE: if x is preferred to y on the criterion h_i it should be the same on the criterion h_j if x is preferred to y on h_i then w should be preferred to z on h_j
No Veto	PE: any difference of performances is meaningful of preferences NE: comparing x to y on the criterion h_i , x is not acceptable, x is too bad, x is not satisfactory

which play the same role as critical questions (a set of questions that represent attacks, challenges or criticisms to a given argument scheme). Critical responses play the same role, except that the decision maker is typically not aware that it constitutes a counter-argument to some claim. These responses correspond to typical manners that the decision maker may contradict a given property. There is an important difference to make between two types of responses:

- *Positive Evidence (PE)*—these responses provide supporting evidence to the fact that the property is satisfied. This would typically consist of general statements that the decision maker may make, e.g. “the difference between x and y is not significant for me” would be positive evidence for ordinality.
- *Negative Evidence (NE)*—these responses provide an explicit counter-example to a specific property, e.g. “frankly the score of this alternative x is so much better than the one of y that I can’t take y ” would be negative evidence for ordinality.

The reader must bear in mind here that the decision maker is *not* supposed to be competent to state general features of his preference. The only thing that the decision-maker is expected to do is to express some preference by comparing alternatives. This means that the two types of evidence have very different consequences, and this will be made explicit in what follows.

Following [9], the critical responses will be modeled as premises (Table 2 provides an example of some possible critical responses). The type of premises used here depends on the kind of evidence required. As explained earlier, negative evidence is sufficiently convincing since it provides an explicit counter-example. They will be modeled as *assumptions*. On the other hand, positive evidence may require further ground to be acceptable. They will be modeled as *ordinary premises*. The system may subsequently test the decision-maker with a series of question to establish some grounds upon which the validity of the claim may be granted via a *property testing subdialogue*.

Property testing subdialogues. The idea of a property testing (PT) subdialogue is that the system enters into an embedded dialogue with the objective to back a positive evidence claim. Again, as the decision maker himself is not in a position to provide some reasons to back this claim, the process will be guided by the system. Typically, the system will generate some test questions specifically designed to perform some sort of verification. Let us take a very simple example. Suppose that the decision maker claimed that “all criteria play exactly the same role”, a positive evidence for the *anonymity* property. Now the system performs some permutations

on the names of the criteria (leaving the the values of actions unchanged) and checks:

(S): Would you still prefer alternative x now?

This can be repeated a number of times. In the end the system has gained sufficient knowledge to decide whether this property can indeed continue to be considered true in the rest of the interaction (although there is no way to formally establish this of course). Typically, a PT subdialogue then terminates with either the system having established sufficient evidence for the claim (in which case the status of the property will move to *stated*), or the decision maker having provided an answer explicitly contradicting the disputed property (in which case the status of the complement of the property will move to *accepted*.) We can come up with similar types of dialogues for other properties, possibly involving fictive alternative.²

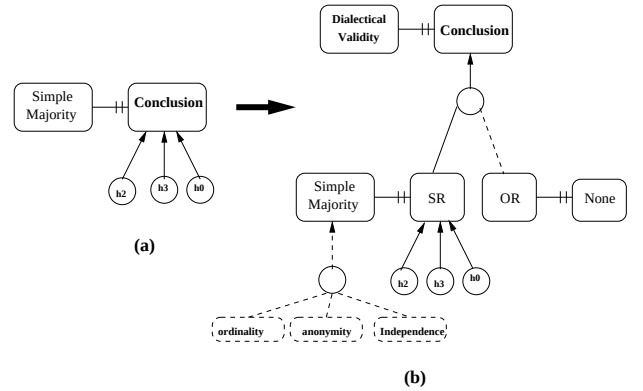


Figure 2. Example of explicit proof in an argument graph

Integrating the procedure. It is now time to gather the different pieces mentioned so far into a general procedure which makes explicit how our proposal can be integrated into a Carneades-based dialogue game. The general algorithm is as follows and supposes that the *update_proof(.)* procedure given in Section 4 takes as input the current state of the argument graph (G) and a given critical response

² Although there is debate in decision-aiding on the fact that a counter-example on a fictive example really constitutes an evidence that some property is violated.

(CR) and $\overline{p_i}$ stands for the complement of p_i . Moreover, termination (as long as the dialogue game it is inserted in also terminates) is guaranteed. It relies in particular on the fact that we do not allow contradictory positive evidence to be put forward, otherwise we will have an *inconsistency*. Thus, navigation in the lattice allows only a finite number of moves.

```

1 chose  $c_r \in R$ ;
2 forall  $prop(p_i, r) = \text{true}$  do
3   |  $status(p_i) \leftarrow \text{assumed\_true}$ 
4 end
5 while dialogue game not terminated do
6   play dialogue move;
7   if  $CR$  identified then
8     if  $CR = \langle NE, p_i \rangle$  then
9       if  $status(p_i) = \text{accepted}$  then
10        | return inconsistency;
11      else
12        |  $status(\overline{p_i}) \leftarrow \text{accepted}$ ;
13      end
14    else
15      if  $status(p_i) = \text{accepted or stated}$  then
16        | return inconsistency;
17      else
18        |  $status(\overline{p_i}) \leftarrow \text{questioned}$ ;
19        | property testing subdialogue();
20      end
21    end
22  end
23   $c_r \leftarrow \text{update\_proof}(CR, G)$ 
24 end

```

Let us give an example of how such a procedure can be used. Consider again the example of Section 3. In this example, on the basis of the performance table, the system has selected a first proof in order to construct a recommendation, which is the *Simple Majority* (it is explicitly given on turn (5) of the dialogue). This can be illustrated by the arguments graph³ of the Fig. 2 (a), where we can observe that an explicit proof is attached to the claim. Such a link allows to conclude that we have effectively enough supporting reasons for the claim according to some aggregation procedure $r_i \in R$. However, as it was mentioned before in this paper, the proof standard is a combination of two distinct proofs (concordance vs. discordance), therefore, we can distinguish two sides in the graph, as it is indicated in the Fig. 2 (b), where the Simple Majority is the proof for the supporting reasons. At this point, the acceptability of such a proof is true. Indeed, it is supported by a defensible Pro argument, because the status of all the premises (corresponding to the properties describing the proof) is assumed true. However, on turn (6) the user keeps refusing the recommendation, and argues that a_0 should be preferred. The system challenges this choice, and the user says that a_0 is better on h_1 and h_2 (on turn (8)). *This not only attacks the previous recommendation of the system, but also attacks the proof-standard currently used.* In fact, such a claim is interpreted as a NE against the property *anonymity* (see Table 2). Thus, according to our previous procedure, we have status (non anonymous) = accepted, and therefore the current proof is no longer warranted (because the argument is not defensible). Given this new information (see Fig. 1), the current proof-standard becomes a Weighted majority consisting of $\{h_1, h_2\}$, enforcing the system to use this proof-standard. Hence, although a_1 continues to satisfy the

³ For the sake of simplicity, we depicted only the elements of the graph that are relevant for the discussion.

majority, the proof-standard itself is invalidated. However, on turn (9), the system informs the user that a_3 should be the best according to this new proof. The user rejects the proposal by putting forward a negative reason against it (10). More precisely, the user gives a NE for the absence of a veto. Therefore, the new proof corresponds to the *weighted majority* for the supporting reasons and a veto for the opposing reasons (i.e. (1010)). Finally, the consequence on the graph is that to the statement “OR” we link the proof “veto”.

6 Conclusion

We proposed in this this work a mechanism to deal with the problem of choosing a proof standard within a decision aiding process, and showed how such a mechanism can be integrated into the Carneades model. It is clear that the identification of set of properties is a difficult task, one that goes much beyond our ambition in this paper. We plan to focus more specifically on bipolar methods in forthcoming works. We believe that an experimental study aiming at analyzing the behavior of the decision maker in a situation of decision support should allow to refine the types of reactions that the system should be prepared to deal with.

REFERENCES

- [1] L. Amgoud, J.-F. Bonnefon, and H. Prade, ‘An argumentation-based approach to multiple criteria decision’, in *Proc. of the 8th European Conf. on Symbolic and Quantitative Approaches to Reasoning and Uncertainty*, pp. 269–280, (2005).
- [2] L. Amgoud and H. Prade, ‘Using arguments for making and explaining decisions’, *Journal of Artificial Intelligence*, **173**, 413–436, (2009).
- [3] K. Atkinson and T. Bench-Capon, ‘Argumentation and standards of proof’, in *Proc. of the 11th Inter. Conf. on Artificial Intelligence and law*, pp. 107–116, (2007).
- [4] D. Bouyssou, Th. Marchant, M. Pirlot, A. Tsoukiàs, and Ph. Vincke, *Evaluation and decision models with multiple criteria: Stepping stones for the analyst*, 2006.
- [5] D. Dubois, H. Fargier, and J.-F. Bonnefon, ‘On the qualitative comparison of decisions having positive and negative features’, *Journal of Artificial Intelligence Research*, **32**, 385–417, (2008).
- [6] P. M. Dung, ‘On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and n-person games’, *Artificial Intelligence*, **77**(2), 321–358, (1995).
- [7] J. Fox and S. Parsons, ‘On Using Arguments for Reasoning about Actions and Values’, in *Proc. of the AAAI Spring Symposium on Qualitative Preferences in Deliberation and Practical Reasoning*, pp. 55–63, (1997).
- [8] B. Ganter and R. Willer, *Formal concept Analysis*, Springer, 1999.
- [9] T. Gordon, H. Prakken, and D. Walton, ‘The Carneades model of argument and burden of proof’, *Artificial Intelligence*, **171**(4), 875–896, (2007).
- [10] T.F. Gordon and D. Walton, ‘Proof burdens and standards’, in *Argumentation in Artificial Intelligence*, eds., I. Rahwan and G. Simari, (2009).
- [11] A. Guitouni and J.M. Martel, ‘Tentative guidelines to help choosing an appropriate MCDA method’, *European Journal of Operational Research*, **109**(2), 501–521, (1998).
- [12] J. F. Horty, ‘Argument construction and reinstatement in logics for defeasible reasoning’, *Artificial Intelligence and Law*, **9**(1), 1–28, (2001).
- [13] N. I. Karacapilidis and D. Papadias, ‘Hermes: Supporting argumentative discourse in multi-agent decision making’, in *Proc. of the 15th National Conf. on AI and 10th Innovative Applications of Artificial Intelligence Conference*, pp. 827–832, (1998).
- [14] W. Ouerdane, N. Maudet, and A. Tsoukiàs, ‘Argument schemes and critical questions for decision aiding process’, in *Proc. of the 2nd Inter. Conf. on Computational Models of Argument*, pp. 285–296, (2008).
- [15] H. Prakken, ‘A study of accrual of arguments, with applications to evidential reasoning’, in *Proc. of the 10th Inter. Conf. on Artificial intelligence and law*, pp. 85–94, (2005).
- [16] D. Vanderpooten, ‘The interactive approach in mcda: a technical framework and some basic conceptions’, *Mathematical and Computer Modelling*, **12**, 1213–1220, (1989).