Encompassing uncertainty in argumentation schemes

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Abstract

In existing literature, little attention has been paid to the problems of how the uncertainty reflected by natural language text (e.g. verbal and linguistic uncertainty) can be explicitly formulated in argumentation schemes, and how argumentation schemes enriched with various types of uncertainty can be exploited to support argumentation mining and evaluation. In this paper, we focus on the first problem, and introduce some preliminary ideas about how to classify and encompass uncertainty in argumentation schemes.

1 Introduction

Mining and evaluating arguments from natural language text (Green et al., 2014) is a relatively new research direction with applications in several areas ranging from legal reasoning (Palau and Moens, 2011) to product evaluation (Wyner et al., 2012). Argumentation schemes (Walton et al., 2008) are commonly adopted in this context as a first modeling tool: it is assumed that natural arguments adhere to a set of paradigmatic schemes, so that these schemes can be used both to drive the identification of the arguments present in the text and, after that, to support their formal representation. As a further step, the assessment of argument justification status requires to identify the relations among them and to apply a formal method, called *argumentation semantics* to derive the status from these relations. For instance, the well known[1] Dung's theory of abstract argumentation (Dung, 1995) focuses on the relation of attack between arguments and provides a rich variety of alternative semantics (Baroni et al., 2011) for argument evaluation on this basis.

When dealing with natural language sources, one of the challenging problems is to handle the uncertainty of arguments. In fact, natural language statements typically include several kinds of uncertainty. This calls for the need to encompass uncertainty in the formalisms which are meant to provide a representation of natural arguments, first of all in argumentation schemes, in order to avoid that some useful information carried by the text source is lost in the first modelling step.

To illustrate this problem, let us consider a simple example concerning two conflicting natural language excerpts E_1 and E_2, possibly taken from some medical publications:

E_1: According to [Smith 98], drug X often causes the side effect Y.

E_2: According to recent experimental trials, it is highly likely that drug X does not increase the probability of the side effect Y.

In order to identify argument structures in these texts, one may resort to specific argumentation schemes. Referring to the classification proposed in (Walton et al., 2008), E_1 can be represented by an argument A_1 which is an instance of the scheme *Argument from Expert Opinion*, while E_2 by an argument A_2 which is an instance of the scheme *Argument From Falsification*.

After A_1 and A_2 are identified, it may be noted that (though expressed with different linguistic nuances) their conclusions are in conflict: briefly, A_1 leads to the claim that X causes Y, while A_2 to the claim that X does not cause Y. As a consequence, a mutual attack relation between A_1 and A_2 can be identified. Then, the arguments and their attacks can be formalized as an abstract argumentation framework $AF = (\{A_1, A_2\}, \{(A_1, A_2), (A_2, A_1)\})$ and the status of arguments in AF can be evaluated according to a given argumentation semantics. For instance, under grounded semantics, both A_1 and A_2 are not accepted. It must be noted however that such a modelling approach

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[1] Due to space limitations, we assume knowledge of Dung's theory in the following.

(and the relevant outcome in terms of argument evaluation) overlooks some information which is (implicitly or explicitly) carried by the text and that may lead, in particular, to have one of the arguments prevailing over the other. For instance, as considered in (Bex et al., 2013), one may have a preference relation over argument schemes so that, for instance, the scheme *Argument From Falsification* is preferred to the scheme *Argument from Expert Opinion*. Accordingly, A_2 would be preferred to A_1, and the attack relation would not be mutual, due to the inability of A_1 to attack A_2 (see the notion of *preference-dependent* attack in (Bex et al., 2013)). In this case, we would get a different argumentation framework $AF' = (\{A_1, A_2\}, \{(A_2, A_1)\})$. Then, under grounded semantics, A_1 is rejected, while A_2 is accepted.

However, a static preference relation on the adopted scheme appears too rigid: in most cases the preference for an argument over another one is not simply based on their structure but, rather, on their content. To exemplify, in this case, one may have different opinions on the reliability of the source [Smith 98], mentioned in E_1, and of the experimental trials mentioned in E_2. Moreover, the two excerpts include several terms expressing vagueness and/or uncertainty, like *often*, *highly likely*, *the probability of*, that may be taken into account in the preference ranking of arguments. However, this is not possible in the approach sketched above, since the argument schemes adopted in the formalization do not encompass these forms of uncertainty and the relevant information carried by the text is lost in the first modelling step.

Given the pervasiveness of vagueness and uncertainty in natural language this appears to be a severe limitation for the use of argumentation schemes in argument mining from texts. To overcome this problem we envisage the study of argumentation schemes extended with uncertainty in the context of the process sketched in Figure 1. Here argumentation schemes with uncertainty are used to extract arguments from texts, keeping explicit the relevant uncertainties that can then be used in the step of argument evaluation using suitable abstract formalisms and semantics with uncertainty. As to the latter step, the study of extensions of Dung's framework with explicit uncertainty representation is receiving increasing attention in recent years (Li et al., 2011a; Thimm, 2012; Hunter, 2013a; Hunter, 2014) while, to the best of our knowledge, lesser work has been devoted to encompassing uncertainty in argumentation schemes.

This long-term research goal involves several basic questions including:

1) How the uncertainty reflected by natural language text can be explicitly formulated in argumentation schemes?

2) How argumentation schemes enriched with various types of uncertainty can be exploited to support argument mining and evaluation?

3) Which is (are) the most appropriate abstract formalism(s) for the evaluation of arguments with uncertainty?

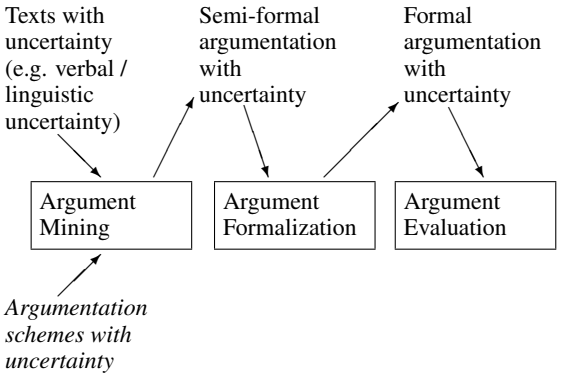

Figure 1: From natural language to argument evaluation: a schematic process

By focusing on the first question, this paper presents some preliminary ideas for encompassing uncertainty in argumentation schemes.

The paper is organised as follows. We review some examples of uncertainty classifications in natural language texts in Section 2 and analyze the non-uniformity of uncertainty representation in existing argumentation schemes in Section 3. Then, in Section 4 we exemplify and discuss a preliminary approach for encompassing uncertainty in argumentation schemes. Finally, Section 5 concludes the paper.

2 Classifying uncertainty types in natural language texts

In natural language texts different types of uncertainty can be identified. To give a brief account of the richness and complexity of this topic and of the research activities that are being carried out in this area, we quickly recall some examples of uncertainty classifications considered in the literature.

In the context of scientific discourse, de Waard and Maat (2012) distinguish knowledge evaluation (also called epistemic modality) from knowledge attribution (also called evidentiality). The former basically concerns the degree of commitment with respect to a given statement, while the latter concerns the attribution of a piece of knowledge to a source. Accordingly, different kinds of uncertainty can be identified.

For instance, according to de Waard and Maat (2012), sources of knowledge may be distinguished into the following categories:

1) Explicit source of knowledge: the knowledge evaluation can be explicitly owned by the author ('*We therefore conclude that* ...') or by a named referent ('*Vijh et al. [28] demonstrated that* ...').

2) Implicit source of knowledge: if there is no explicit source named, knowledge can implicitly still be attributed to the author (' *these results suggest* ...') or an external source ('*It is generally believed that* ...').

3) No source of knowledge: the source of knowledge can be absent entirely, e.g. in factual statements, such as '*transcription factors are the final common pathway driving differentiation*'.

Since different sources may have different degrees of credibility, this leads to identify a first type of uncertainty, namely the (possibly implicit) *source uncertainty*.

As to knowledge evaluation, de Waard and Maat (2012), following Wilbur et al. (2006), distinguish four *levels of certainty* in the degree of commitment of a subject to a statement: 1) Doxastic (firm belief in truth), 2) Dubitative (some doubt about the truth exists), 3) Hypothetical (the truth value is only proposed), and 4) Lack of knowledge.

This kind of evaluation, called *uncertainty about statements* in the following, is typically expressed through suitable linguistic modifiers.

Actually linguistic modifiers have a quite generic nature and have been the subject of specific studies by themselves: Clark (1990) provides an extensive review of experimental studies concerning the use of *linguistic uncertainty* expressions, such as *possible*, *probable*, *likely*, *very likely*, *highly likely*, etc., and their numerical representation. Linguistic uncertainty is pervasive in natural language communication. On the one hand, it can be regarded as a form of *uncertainty expression* (alternative to, e.g., numerical or implicit uncertainty expressions) rather than as a distinct uncertainty type. On the other hand, linguistic uncertainty may be regarded as a generic type of uncertainty, of which other more specific forms of uncertainty are subtypes. This generic type can be associated to those natural language statements to which a more specific uncertainty type can not be applied. For the sake of the preliminary analysis carried out in this paper, we will adopt the latter view.

Regan et al. (2002) distinguish between epistemic uncertainty (uncertainty in determinate facts) and linguistic uncertainty (uncertainty in language) and claims that the latter has received by far less attention in uncertainty classifications in the fields of ecology and biology. Linguistic uncertainty is in turn classified into five distinct types: vagueness, context dependence, ambiguity, indeterminacy of theoretical terms, and underspecificity, with vagueness being claimed to be the most important for practical purposes. In fact, all of them refer in some way to the problem that some natural language expressions admit alternative interpretations. Hence this classification is focused on a specific form of uncertainty and the use of the term linguistic uncertainty here is rather restricted with respect to other works.

Taking into account the discussion above, in this paper we consider, as a starting point, three uncertainty types:

1) *Source uncertainty*, denoted in the following as U_1, concerning the fact that to evaluate the credibility of different statements one may take into account the credibility of their sources;

2) *Uncertainty about a statement*, denoted as U_2, arising in situations where a subject making a statement expresses a partial degree of commitment to the statement itself;

3)*Linguistic uncertainty or uncertainty inside a statement*, denoted as U_3, namely uncertainty generically present in natural language statements, with no further more precise meaning specified.

For instance in the sentences "*According to [Smith 98]*, Drug X causes headache" and "*According to recent experimental trials*, Drug X causes headache", one may identify U_1 since they refer the statement "Drug X causes headache" to a source (a paper and clinical trials, respectively).

On the other hand, the sentence "It is *likely* that Drug X causes headache" provides an example of U_2 since the statement "Drug X causes headache" is not regarded as certain.

Finally, a sentence like "Drug X *sometimes* causes *severe* headache" provides an example of U_3.

For a more articulated example including several uncertainty types, let us consider the following text, taken from (Swenson, 2014): "*..., the Mg inhibition of the actin-activated ATPase activity observed in class II myosins is likely the result of Mg-dependent alterations in actin binding. Overall, our results suggest that Mg reduces the ADP release rate constant and rate of attachment to actin in both high and low duty ratio myosins.* "

Here, some expressions (*likely* and *suggest that*) indicate a partial commitment of authors to the corresponding statements (U_2), and the knowledge source is made explicit by the citation of (Swenson, 2014) (U_1). Further, the vague terms (*high* and *low*) correspond to a form of generic linguistic uncertainty inside the relevant statement (U_3).

3 Non-uniformity of uncertainty representation in existing schemes

Given that uncertainty pervades natural language texts and argumentation schemes appear as suitable formal tool for argumentation mining from texts, the question of how to capture uncertainty in argumentation schemes naturally arises. This appears to be an open research question, as the state-of-the-art formulation of argumentation schemes (Walton et al., 2008) does not consider uncertainty explicitly, and, more critically, does not seem to deal with uncertainty in a systematic way, though somehow recognizing its presence. To exemplify this problem let us compare two argumentation schemes[2] from (Walton et al., 2008).

The first scheme we consider, called *Argument from Position to Know* (APK), is defined as follows:

Major Premise: Source a is in a position to know about things in a certain subject domain S containing proposition A.
Minor Premise: a asserts that A (in domain S) is true (false).
Conclusion: A is true (false).
CQ1: Is a in a position to know whether A is true (false)?
CQ2: Is a an honest (trustworthy, reliable) source?
CQ3: Did a assert that A is true?

In this scheme, no explicit uncertainty is included, but the critical questions correspond to several forms of uncertainty that may affect it.

The second scheme, called *Argument from Cause to Effect* (ACE), is defined as follows:

Major Premise: Generally, if A occurs, then B will (might) occur.
Minor Premise: In this case, A occurs (might occur).
Conclusion: Therefore, in this case, B will (might) occur.
CQ1: How strong is the causal generalization?
CQ2: Is the evidence cited (if there is any) strong enough to warrant the casual generalization?
CQ3: Are there other causal factors that could interfere with the production of the effect in the given case?

In this case, in addition to the implicit uncertainty corresponding to critical questions, explicit expressions of uncertainty are included, namely the modifier *Generally* and the *might* specifications in the parentheses.

Clearly the representation of uncertainty in the two schemes is not uniform (since the second scheme encompasses explicit uncertainty in the premises and the conclusion, while the first does not) but it is not clear whether this non-uniformity is based on some underlying difference between the schemes or is just accidental in the natural language formulation of the schemes. Indeed, it seems possible to reformulate these schemes in a dual manner (adding explicit uncertainty mentions to the first one, removing them from the second one) while not affecting their meaning, as follows:

APK with explicit uncertainty:
Major Premise: Source a is (possibly) in a position to know about things in a certain subject domain S containing proposition A.
Minor Premise: a asserts that A (in domain S) is (might be) true (false).
Conclusion: A is (might be) true (false).

ACE without explicit uncertainty:
Major Premise: If A occurs, then B will occur.
Minor Premise: In this case, A occurs.
Conclusion: Therefore, in this case, B will

[2]Recall that an argument scheme basically consists of a set of premises, a conclusion defeasibly derivable from the premises according to the scheme, and a set of critical questions (CQs) that can be used to challenge arguments built on the basis of the scheme.

occur.

The above-mentioned non-uniformity suggests that a more systematic treatment of uncertainty in argument schemes is needed in order to face the challenges posed by the representation of natural language arguments.

Indeed, a recent work (Tang et al., 2013) addresses the relationships between uncertainty and argument schemes in a related but complementary research direction. While the work described in the present paper aims at enriching argumentation schemes proposed in the literature with explicit uncertainty representation in a systematic way, Tang et al. (2013) introduce several novel argument schemes concerning reasoning *about* uncertainty. This is done using Dempster-Shafer theory of evidence in the context of a formalism for the representation of *evidence arguments*. Different schemes basically differ in the choice of the rule for (numerical) evidence combination among the many alternative combination rules available in the literature, and the critical questions in each scheme refer to the applicability conditions of the relevant rule (e.g. Is each piece of evidence independent?). Investigating the possible reuse of some of the specific ideas presented by Tang et al. (2013) in the context of our broader modelling approach is an interesting direction of future work.

4 Encompassing uncertainty in argumentation schemes

Devising a systematic approach to encompass natural language uncertainty in argumentation schemes is a long term research goal, posing many conceptual and technical questions and challenges, partly evidenced in the previous sections. We suggest that such an approach should include the following "ingredients":

1) a classification of uncertainty types;

2) a characterization of the uncertainty types relevant to each argumentation scheme;

3) a formalism for the representation of uncertainty evaluations (of various types) in actual arguments, i.e. in instances of argument schemes;

4) a mechanism to derive an uncertainty evaluation for the conclusion of an argument from the evaluations concerning the premises and the applied scheme.

While each of the items listed above is, by itself, a large and open research question, we provide here some preliminary examples of point 2, using for point 1 the simple classification introduced in Section 2. In particular we suggest that the scheme specification should be accompanied by an explicit account of the types of uncertainty it may involve, while the use of linguistic uncertainty expressions in the scheme (like in ACE above) should be avoided within the natural language description of the scheme itself. This approach prevents the non-uniformities pointed out in Section 3 and enforces the adoption of clear modelling choices about uncertainty at the moment of definition of the scheme. In particular, as evidenced below, it may point out some ambiguities in the definition of the scheme itself.

In the following examples, we explicitly associate uncertainty types with the premises of the considered schemes (that may affected by them) and with the critical questions (that point out the potential uncertainty affecting the premises). Analysing the uncertainty possibly affecting the scheme itself or its applicability (that may also be expressed by some critical questions) is left to future work (and requires a richer classification of uncertainty types), while, according to point 4 above, the uncertainty about the conclusion is regarded as a derived notion and, for the sake of the present analysis, is considered as derived uncertainty, denoted as DU. The syntax we use to associate uncertainty types with parts of argument schemes is as follows: $\{\ldots\}[\mathrm{U_x}, \ldots]$, where the part of the scheme (possibly) affected by uncertainty is enclosed in braces and is followed by the relevant uncertainty type(s) enclosed in brackets.

First, let us consider the APK scheme. Here, the major premise explicitly refers to a source a, so it can be associated with U_1 (as evidenced by the critical questions CQ1 and CQ2). Further one may consider that the inclusion of proposition A in domain S and the proposition A itself can be specified with some linguistic uncertainty (U_3). As to the minor premise, since it refers explicitly to a given assertion, it can be associated with uncertainty about assertions (U_2). Actually, the critical question CQ3 refers to the minor premise and its statement "Did a assert that A is true?" is, in fact, ambiguous as far as the type of uncertainty is concerned. On the one hand it might raise a doubt about the fact that a did actually make any assertion about A, on the other hand it might raise a doubt about the contents of the assertion made by

a. For instance, a might have made a weaker assertion, like "A is probably true", or a completely different assertion like "A is false". The three alternatives mentioned above are rather different and involve different uncertainty types. The possibility that a made a weaker assertion is a case of U_2, while if a made a completely different assertion (or no assertion at all) about A, the entire minor premise is challenged, and this amounts to be uncertain about the credibility of the (implicit) source from which we learned that "a asserted that A is true", hence a case of U_1. As this ambiguity is present in the current formulation of the scheme, we leave it unresolved and indicate both types of uncertainty for the minor premise and CQ3.

This leads to reformulate APK as follows:

Major Premise: {Source a is in a position to know about things in a certain subject domain S}[U_1] {containing proposition A}[U_3].
Minor Premise: {a asserts that A (in domain S) is true (false)}[$\mathrm{U}_1, \mathrm{U}_2$].
Conclusion: {A is true (false)}[DU].
CQ1: {Is a in a position to know whether A is true (false)?}[U_1]
CQ2: {Is a an honest (trustworthy, reliable) source?}[U_1]
CQ3: {Did a assert that A is true?}[$\mathrm{U}_2, \mathrm{U}_1$].

Let us now consider the ACE scheme. Its first premise is a causal generalization, which, as suggested by the use of *(might)* in its original formulation, is not always valid. In our simple classification this can be regarded as a form of linguistic uncertainty inside the statement (U_3). This kind of uncertainty may also affect the actual formulation of the statements A and B in the instantiations of the scheme. The major premise is challenged by CQ1 and CQ2. While their interpretation allows some overlap, CQ1 seems to concerns the "strength" of the causal generalization as it is formulated, while CQ2 refers to the implicit evidential source of knowledge supporting the causal generalization. Accordingly, CQ1 may be referred to U_3, while CQ2 to U_1.

The minor premise concerns the observation of a fact (the occurrence of A), that might involve linguistic uncertainty U_3. Indeed, also the observation of the occurrence of A might have a source, so that, in principle, the second premise might be affected by U_1, and one might have an additional critical question CQ+ like "Does A actually occur?", which would turn out very similar in nature to CQ3 in the APK scheme. The fact that a question like CQ+ is not considered in this scheme, points out a further non-uniformity in the formulation of argument schemes: one may wonder why a sort of explicit confirmation of the minor premise is required by a critical question in the APK scheme, while the same kind of confirmation is not required in the ACE scheme. While one might answer that similar questions may have a different importance in different schemes, we suggest that a further analysis is needed to address these issues in a systematic way and that a classification of uncertainty types can be very useful in this respect. To point out this, we add CQ+ in the revised version of the ACE scheme, with the relevant uncertainty type U_1 associated with the minor premise. Finally, CQ3 raises the question about possible other factors interfering with the causal relation between A and B, i.e. suggests the presence of possible exceptions in the application of the scheme. This kind of uncertainty is not encompassed in our simplistic preliminary classification, hence we let it unspecified (denoted as [??]), as a pointer to future developments. This leads to reformulate ACE as follows:

Major Premise:{If A occurs, then B will occur}[$\mathrm{U}_1, \mathrm{U}_3$].
Minor Premise: {In this case, A occurs}[$\mathrm{U}_1, \mathrm{U}_3$].
Conclusion:{Therefore, in this case, B will occur} [DU].
CQ1: {How strong is the causal generalization?}[U_3]
CQ2: {Is the evidence cited (if there is any) strong enough to warrant the casual generalization?}[U_1]
CQ+: {Does A actually occur?}[U_1]
CQ3: {Are there other causal factors that could interfere with the production of the effect in the given case?}[??]

5 Conclusions

In recent years, the issue of combining explicit uncertainty representation and argumentation has received increasing attention, with several works dealing in particular with probabilistic argumentation (Dung and Thang, 2010; Hunter, 2012; Hunter, 2013b; Li et al., 2011b). These works are based on formal argumentation theories like Dung's abstract argumentation frame-

works (Dung, 1995) or logic-based argumentation (Hunter, 2013b). This paper suggests that these investigations on the formal side should be complemented by efforts on the conceptual and semi-formal side, with particular reference to the argumentation schemes model. Argumentation schemes provide a very intuitive semi-formal representation approach for natural arguments and are indeed adopted in several works as a first level modelling tool to identify and extract arguments from natural language texts. However, as evidenced in this paper, argumentation schemes need to be enriched and extended in order to capture the various kinds of uncertainty typically present in natural language arguments. The present work provides a preliminary contribution to this research line, by pointing out some problems and providing some simple examples of how they might be tackled. Future work directions are huge and include an extensive review of the uncertainty types considered in the literature, with special attention to works in the area of argumentation mining, and a systematic analysis of the various ways argument schemes may be affected by different uncertainty types.

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References

P. Baroni, M. Caminada, and M. Giacomin. 2011. An introduction to argumentation semantics. *Knowledge Eng. Review*, 26(4):365–410.

F. Bex, S. Modgil, H. Prakken, and C. Reed. 2013. On logical specifications of the argument interchange format. *J. Log. Comput.*, 23(5):951–989.

D. A. Clark. 1990. Verbal uncertainty expressions: A critical review of two decades of research. *Current Psychology: Research & Reviews*, 9(3):203–235.

A. de Waard and H. P. Maat. 2012. Epistemic modality and knowledge attribution in scientific discourse: A taxonomy of types and overview of features. In *Proc. of ACL 2012*, pages 47–55.

P. M. Dung and P. M. Thang. 2010. Towards (probabilistic) argumentation for jury-based dispute resolution. In *Proc. of COMMA 2010*, pages 171–182.

P. M. Dung. 1995. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming, and n-person games. *Artificial Intelligence*, 77(2):321–357.

N. Green, K. Ashley, D. Litman, C. Reed, and V. Walker, editors. 2014. *ACL 2014 Proceedings of the First Workshop on Argumentation Mining, Baltimore, Maryland, USA*.

A. Hunter. 2012. Some foundations for probabilistic abstract argumentation. In *Proc. of COMMA 2012*, pages 117–128.

A. Hunter. 2013a. A probabilistic approach to modelling uncertain logical arguments. *International Journal of Approximate Reasoning*, 54(1):47–81.

A. Hunter. 2013b. A probabilistic approach to modelling uncertain logical arguments. *International Journal of Approximate Reasoning*, 54(1):47–81.

A. Hunter. 2014. Probabilistic qualification of attack in abstract argumentation. *International Journal of Approximate Reasoning*, 55(2):607 – 638.

H. Li, N. Oren, and T. J. Norman. 2011a. Probabilistic argumentation frameworks. In *Proc. of TAFA 2011*, pages 1–16.

H. Li, N. Oren, and T. J. Norman. 2011b. Probabilistic argumentation frameworks. In *Proc. of TAFA 2011*, pages 1–16.

R. Mochales Palau and M.-F. Moens. 2011. Argumentation mining. *Artif. Intell. Law*, 19(1):1–22.

H. M. Regan, M. Colyvan, and M. A. Burgman. 2002. A taxonomy and treatment of uncertainty for ecology and conservation biology. *Ecological Applications*, 12(2):618–628.

A. M. Swenson. 2014. Magnesium modulates actin binding and adp release in myosin motors. *J. Biol. Chem*.

Y. Tang, N. Oren, S. Parsons, and K. Sycara. 2013. Dempster-shafer argument schemes. In *Proc. of ArgMAS 2013*.

M. Thimm. 2012. A probabilistic semantics for abstract argumentation. In *Proc. of ECAI 2012*, pages 750–755.

D. Walton, C. Reed, and F. Macagno. 2008. *Argumentation Schemes*. Cambridge University Press.

W. J. Wilbur, A. Rzhetsky, and H. Shatkay. 2006. New directions in biomedical text annotation: definitions, guidelines and corpus construction. *BMC Bioinformatics*, 7:356.

A. Wyner, J. Schneider, K. Atkinson, and T. J. M. Bench-Capon. 2012. Semi-automated argumentative analysis of online product reviews. In *Proc. of COMMA 2012*, pages 43–50.