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THE LOGIC OF THE ARGUER. REPRESENTING NATURAL ARGUMENTATIVE DISCOURSE IN ADPOSITIONAL ARGUMENTATION

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Abstract

In this paper, we show how to represent natural argumentative discourse through Adpositional Argumentation, a uniform framework for expressing linguistic and pragmatic aspects of such discourse on various levels of abstraction. Starting from representing the utterer and the utterance, we expand to claims and minimal arguments, finally focusing on complex argumentation in three different structures: convergent (many premises), divergent (many conclusions), and serial (an argument whose premise is the conclusion of another argument). An innovative feature of the framework is that it enables the analyst to provide a granular description of natural argumentative discourse, thus letting the logic of the arguer dynamically unfold while the discourse is presented without enforcing any particular interpretation.

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1 Introduction

Natural argumentative discourse can be defined as a piece of natural language resulting from someone's effort to convince an interlocutor or audience of the acceptability of a particular point of view. As the the name indicates, the main feature of such discourse is the presence of argumentation as a means to establish or increase that acceptability within the context of a disagreement—for a short overview of definitions of argument(ation) see Wagemans (2019) [30].

Disagreements may arise within a great many different contexts, and the characteristics of a concrete piece of natural argumentative discourse usually vary with the specific settings or the sub-genre within which it is produced, e.g., a court case, a scientific paper, or a conversation in the pub. Since the 1950s, scholars in the field of Argumentation Theory (AT) have studied a great many such sub-genres of argumentative discourse, describing the rules and conventions that govern the exchange of arguments within each specific setting. Making use of concepts, theories, and models from the longstanding traditions of logic, dialectic, and rhetoric, they have developed a rich set of insights on the constituents of various types of arguments, the micro and macro structure of different sub-genres of argumentative discourse, as well as the stylistic features thereof. In combination with normative standards regarding the validity, reasonableness, and effectiveness of argumentation, these insights are used for providing theoretically informed analyses and evaluations of argumentative texts and discussions—for a comprehensive survey of historical backgrounds, approaches, and applications see van Eemeren et al. (2014) [27]; for a concise overview of the philosophy of argument see Wagemans (2021b) [31].

Approaching the subject from a different angle, Computational Argumentation (CA) developed since the 1990s from a branch of Artificial Intelligence into an independent field of research. So far, researchers in CA have developed various computational models of argument that are used, for example, in developing tools for argument mapping, argument mining, and computer-aided human decision-making—for an overview of the development of the discipline, see Bench-Capon and Dunne (2017) [3]; for a representative collection of recent work, see Modgil et al. (2019) [20] and Prakken et al. (2020) [23].

Until now, there is hardly any interaction between the fields of AT and CA. Their quiet coexistence is reflected in the fact that researchers in CA have only used a small part of the plethora of insights developed by researchers in AT, while the latter shy away from abstract models and formal tools as such. A possible reason for this lack of interaction is the methodological distance between the humanities and the sciences: since the insights developed within AT, although profound and detailed, are expressed in a rather informal way, they are not easily transferred in models

suitable for computation. And since these models are abstract and formal, they are difficult to apply by researchers in the humanities. As a result, many insights potentially useful for researching natural argumentative discourse are ignored or misunderstood.

A second observation we make is that the development of tools and models of natural argumentative discourse requires a formalization of linguistic material, which implies that *part of the information is lost*. While such a loss of information is not necessarily or always a problem, the requirement of formalization as such does create the challenge of finding the right balance between, on the one hand, the level of linguistic detail to be incorporated in the tool or model and, on the other hand, its robustness from a formal point of view.

While we acknowledge that it is not always possible for discourse expressed in natural language to be completely unambiguous, we firmly believe that increasing the level of detail in the formalization can drastically reduce the possible sources of disagreement about the interpretation. To identify the interpretative issues in the text as precisely as possible, it needs to be formalized as rigorously as possible without resulting in a loss of relevant details or a decrease in the richness of the information that can be represented. After all, in natural argumentative discourse, it is not uncommon to refer to arguments previously stated, or parts of them, to enhance the cohesion of the whole argumentation. It is, therefore, essential for the analyst at any stage to be able to represent detailed information in case it is ever needed in subsequent stages of the analysis.

Against this background, Adpositional Argumentation has been developed as a comprehensive framework for representing interpretations of natural argumentative discourse. Adpositional Argumentation is rigorous in its formalism and directly based on the linguistic material expressed in the discourse. Each level of abstraction is clearly stated, so that part of the information may be hidden without running the risk of being lost. Table 1 offers an overview of the levels of abstraction represented in Adpositional Argumentation, which will be illustrated in the following sections of this paper.

Current approaches in AT only seem suitable for formalization at the the surface level of the argumentation. Walton et al. (2008) [33], for instance, conceive an ‘argumentation scheme’ as consisting of a set of statements (a conclusion and one or more premises), occasionally formalizing elements within these statements (such as ‘A’ for authority or ‘C’ for consequence). The widely used model by Toulmin (1958) [25], to mention another example, contains a claim, datum, warrant, backing, rebuttal, and qualifier, which are connected in a specific way. However, both Walton’s and Toulmin’s conceptualizations of argumentation do not give any cue on how to analyze the internal structure of each element functioning in the argumentation. Except for

<i>symbol</i>	<i>level of abstraction</i>	<i>domain of reference</i>	<i>main references</i>
λ, Ω, ω	argumentation structure	pragmatics	this paper
$\alpha, \beta, \gamma, \delta$	argument form and type	pragmatics	Wagemans (2019) [30] Gobbo et al. (2019) [12]
σ, π	statements in arguments	pragmatics	Wagemans (2016) [28] Gobbo et al. (2019) [12]
ρ, ξ, φ	voice and utterance	pragmatics	Gobbo et al. (2022) [16]
ϵ	valency structure	syntax (& semantics)	Gobbo & Benini (2013,2011) [11, 10]
μ	word structure	morphology (& semantics)	Gobbo & Benini (2011) [10]

Table 1: Overview of the levels of abstraction in Adpositional Argumentation

Toulmin’s qualifier, there is no explicit representation of the linguistic constituents of an argumentation, neither on the morphosyntactic nor the semantic level. To represent the relevant information contained in natural argumentative discourse, we need a deeper level of formalization of the linguistic material and the argumentative fabric.

In CA, rigorous formalizations such as those based on Dung’s (2005) [6] notion of argumentation frameworks abstract away from the information contained inside an argument, such as the the distinction between conclusions and premises, as well as from the linguistic material used to express it—for the state-of-the-art on that field, see at least Baroni, Toni, and Verheij, 2020) [2]. In other formal approaches, minimal arguments are often treated as atoms, i.e., they cannot be broken down to analyze specific linguistic details or modes of expression. Inference Anchoring Theory (IAT), for instance, works on the level of illocutions and provides information on the speaker, speech act, and propositional content. However, it does not enable the analyst to label more fine-grained discourse elements, such as subjects and predicates of propositions or the voice entity and the voice predication—see, e.g., Budzynska et al. (2016) [4].

The above-mentioned problems of insufficient formalization of relevant insights, on the side of AT, and loss of information, on the side of CA, are especially salient because natural argumentative discourse, like any other communication expressed in natural language, may be interpreted in many ways. This does not only apply to the

interpretations provided by different audience or readers, but also for those provided by different analysts of the same piece of discourse. Now, sometimes, disagreements about the interpretation of the discourse are easily solved, for instance, because there happens to be a misunderstanding on the part of one of the interpreters that, once pointed out, is immediately labeled as such. There are, however, also disagreements that need to be solved by discussing specific aspects of the interpretation or even its methodology. In this case, it helps if the analysts can justify their reconstruction of the discourse in a detailed and unambiguous way.

The specific aim of this paper is to illustrate how Adpositional Argumentation can provide a representation of complex argumentation and to discuss how such a representation provides insights into the logic of the arguer, which dynamically unfolds while the discourse is presented. To this end, Section 2 is an introduction to the fundamental notion of ‘adpositional tree’ (‘adtree’). We outline its background in the Philosophy of Information and explain its general structure, before delving into the levels of abstraction introduced in Table 1. We start from morphology and syntax, used to represent linguistic information in natural language. Then, in Section 3, we turn to the pragmatic levels of abstraction, from the utterance to argumentation. We explain the basic notions of voice and utterance and differentiate between the representation of explanation and argumentation. In Section 4, we zoom in on the representation of individual arguments, using the argument categorization framework of the Periodic Table of Arguments (PTA) to represent their essential characteristics. We then move from the level of abstraction of individual arguments to the level of complex argumentation structures. Section 5 shows how to formalize the notions of convergent, divergent, and serial argumentation and represent them in adpositional trees. Finally, in Section 6, we reflect on how the analyst can provide an interpretation of the logic of the arguer based on the representation of the linguistic and pragmatic information contained in natural argumentative discourse.

2 Abstract and linguistic adpositional trees

2.1 Abstract adpositional trees

Within the Philosophy of Information, Floridi (2011) [7] defines *observables* as data with a structure imposed on them. In this way, data can be treated as variables, on different levels of abstraction. Data do not speak per se: a structure is needed to pass from the level of data to that of information. Once information is established, the analysts can give their respective interpretations. If these interpretations are directly accepted by the counterpart, we are in the realm of explanation; otherwise, if one part has to convince the counterpart of the acceptability and validity

of the interpretation, we are in the realm of argumentation. In the latter case, acceptance—if it happens—comes only after the counterpart has been convinced. Richer information, that is, a more granular and refined structure imposed on the data, minimizes the risk of misunderstanding between the parts involved, as their interpretations share the same foundations as explicitly as possible.

Within Adpositional Argumentation, the main tool to represent observable linguistic material—and the argumentative information they carry on—is the adpositional tree (adtree). In general, trees are the obvious way to represent hierarchical information about natural language, especially in the field of syntax: they are less liberal than graphs and more human-readable than linear formulas in capturing the deep structure underlying word order, called by Chomsky (1965) ‘surface structure’ [5]. However, there is no general agreement on the optimal form of trees to represent information that is grounded in natural language material, depending on the grammatical theory adopted—for a recent overview, see Müller (2020) [21].

Adtrees keep the general standpoint that recursion is possible; however, putting all information explicitly can be inconvenient for the analyst. For example, if the focus is on the pragmatic levels of abstraction, such as utterances and argumentation, as illustrated in Figure 1, triangles (\triangle) in leaves may hide morphological and syntactic information.

In its minimal form, the adtree represents two elements and their relationship, with one element ‘ruling’ the other. As pictured in Figure 1, conventionally, the ruler is called ‘governor’ (*gov*) and it is put on the leaf on the right side; conversely, the leaf on the left side hosts the ruled element, which is called ‘dependent’ (*dep*). Their connecting relation is represented as an adposition (*adp*), i.e., something that stays in-between: it can be a linguistic preposition, a conjunction, or an argument type, depending on the level of analysis.

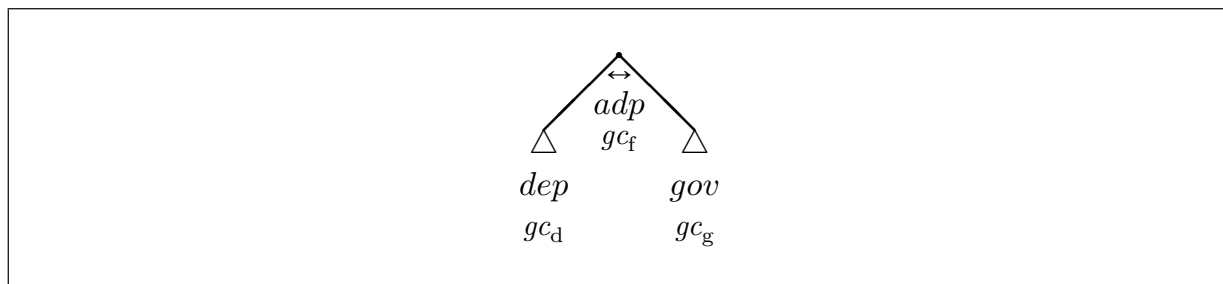


Figure 1: The standard abstract adtree

It is important to distinguish the observable linguistic material elements by their function, as natural language is ambiguous and the the same element may have different functions depending on the context. For this reason, adpositions, governors, and

dependents are equally labeled by ‘grammar characters’ (*gc*). The word ‘grammar’ here goes well beyond the linguistic denotation as it means a set of rules for transforming the functions respectively of the tree or sub-tree indicated by the character. The grammar character of the adposition is the final result (*f*) of the interaction between the grammar characters of the governor (*g*) and the dependent (*d*). Finally, the small arrow of the adposition indicates information prominence, i.e., whether the governor is more prominent than the dependent, or vice versa. Prominence is a level of abstraction which is different from the asymmetrical relation between the governor and the dependent. In an adtree, information prominence goes from the most prominent to the least prominent, regardless of the relation between governor and dependent—for a comprehensive explanation, see Gobbo and Benini (2011) [10]. As will become apparent in the following sections, the actual values of characters and prominence depend on the concrete type of observables represented in the adtree.

Adtrees were introduced initially to give an account of linguistic information of written natural language material, mainly morphological and syntactic. However, they were also used to express information on different levels of abstraction in pragmatics, such as Searle’s speech act taxonomy—see Gobbo and Benini (2011) [10] for details. The latter includes argumentation, which is the focus of the representation framework of Adpositional Argumentation and this paper in particular.

2.2 From abstract to linguistic information

In the present context, the data are the linguistic material contained in the piece of natural argumentative discourse to analyze, while their information is represented in the form of adpositional trees. For instance, a grammar character in a linguistic adtree may indicate the part-of-speech, such as a verb (I) or a noun (O), while one in an argumentative adtree may indicate the type of statement expressed in a conclusion or a premise of an argument, for example, a statement of fact (F) or a statement of value (V).

Adtrees distinguish between the governor-dependent relation and the direction of information prominence. Figure 2 shows a linguistic example by contrast: a hypothetical person A. is evaluated in her or his possibility to pay the bill; if people consider A. rich, the fact that A. rich is more prominent (left); vice versa, it will be A.’s possibility to pay to be more prominent (right). This distinction is evident from the choice of the linguistic adpositions ‘and’ and ‘but’ respectively.

On the linguistic level, the distinction between the governor-dependent relation and information prominence may be under-specified, such as in the genitive case in Latin and Greek. In particular, genitives may sometimes be interpreted both subjectively and objectively. A standard example is the Latin nominal syntagm

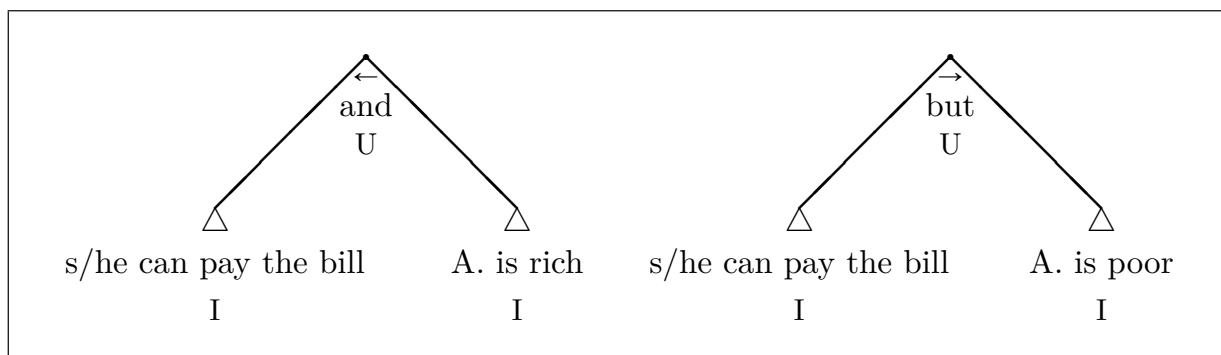


Figure 2: Example of information prominence in contrast

amor matris (mother’s love), in Figure 3.

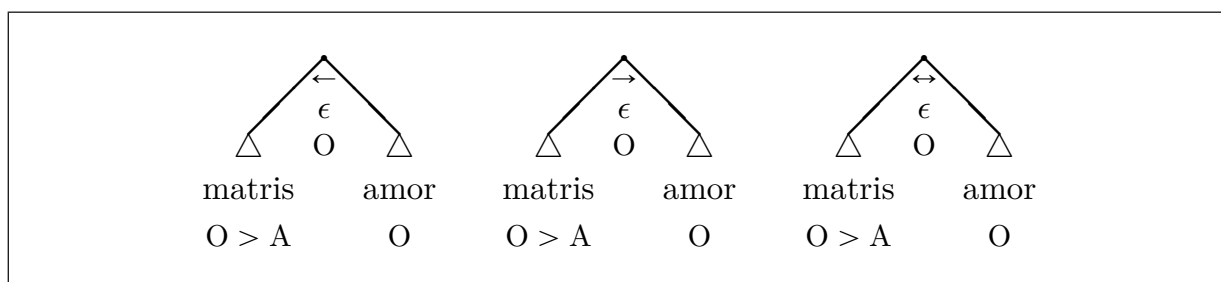


Figure 3: Example of information prominence in contrast

If the genitive is subjective, the meaning is *mater amat*, i.e. ‘the mother loves (her children)’ (adtree on left); by contrast, if the genitive is objective, the meaning *filiī matrem amant*, i.e. ‘children love their mother’ (adtree in the center). Disambiguation is possible only if the context is known: if the context is not at disposal, information prominence will be represented by a left-right arrow (\leftrightarrow), to indicate under-specification (adtree on the right).

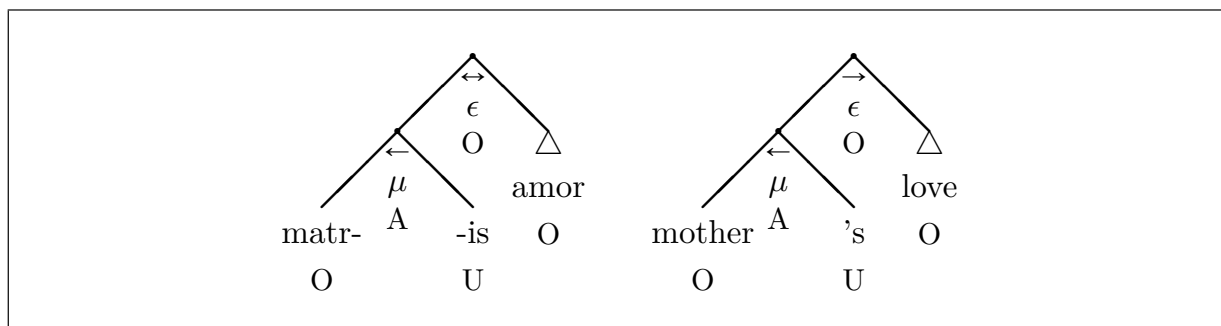


Figure 4: Example of linguistic morphosyntactic adtree

Figure 4 unhides the morphological information (μ) of the word *matris* (mother’s) expressed in Figure 3 in the compact form: O>A. The morphosyntactic adtree of the English correspondent is provided on the right, for the reader’s sake. However, please note that while the information prominence in Latin is underspecified (\leftarrow) as explained before, by default in the English syntagm ‘mother’s love’ the genitive is subjective, henceforth prominence is on the mother, which stays as the nominal (O) part of the dependent. For more details on linguistic adtrees and their transformations, see Gobbo and Benini [10].

3 Pragmatic adpositional trees

3.1 The concept of voice: Who is saying what?

The pragmatic level of analysis focuses on how language is *used* for various purposes, such as explaining what someone does not yet know or convincing them of something they do not yet accept. This level presupposes not only the presence of linguistic material—the observable data, ‘something’ that is uttered—but also the presence of an utterer, i.e., ‘someone’ performing the act of uttering the linguistic material, such as ‘says’ or ‘writes’. It is important to underline the fact that utterers are observables too, i.e., they are not only imagined in the mind of the analyst but they are a real part of the information, and therefore they need to be represented explicitly. In other words, the utterance in its most general form (‘something that someone says’) includes the indication of who is saying what, and this can completely change the interpretation; in fact, the utterer rules the actual content of what is said: therefore, in the adpositional tree, the actual content depends on the utterer and the way he or she expresses the content itself. In fact, in analyzing natural language examples in real or fictional worlds, we cannot dismiss the role of the utterer; otherwise, we lose information, with the risk of inserting unnecessary biases in the analysis. For instance, the common offering ‘have some wine’ would intend something completely different if it is said by a friend during dinner or by the March Hare to Alice during the Mad Tea Party in Wonderland, as, in the latter case, on the table “there was nothing but tea” (Chapter VII).

In Adpositional Argumentation, the layer of the act of uttering is an adtree indicated with the adposition φ_x . The act of uttering is conventionally called ‘voice’, following a convention in narrative studies [16]. As illustrated in Table 1, the adposition φ_x is more abstract than ϵ and μ , respectively representing syntax and morphology—and encapsulate, in their leaves, most of the semantics. For this reason, φ_x , indicating the uttering, shall appear as a governor of the uttered content, representing the fact that the uttered content depends on the existence of the ut-

terance. The act of uttering is constituted by two elements: an utterer and a sign of predication—Figure 5.

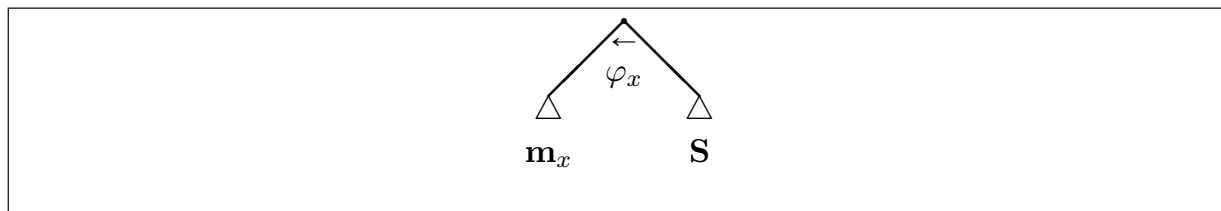


Figure 5: Abstract adtree for voice

The sign of predication is generically indicated as a verb of saying (S) while the utterer is indicated with a lower-case letter of the Latin alphabet showing the order of appearance in the discourse or text (generically: m), and marked with an index x , a natural number indicating the distance from the author, whose voice is indicated as a_0 . Conventionally, the leaves of levels of abstraction above morphosyntax, i.e., pragmatic and argumentative, are represented in bold. Finally, if needed, its information prominence can be inverted, for instance, when the focus is on the utterer instead of the predication. The concept of voice has been introduced and widely discussed in Gobbo, Benini, and Wagemans (2022) [16].

3.2 From explanatory to argumentative information

As we remarked above, there are various discourse genres, such as *explanation* and *argumentation*. Within pragmatics, as the study of the use of language for various purposes, the attribution of these genre labels is based on the utterer’s anticipation of the epistemic and doxastic status of the addressee. In short, when the utterer anticipates a lack of knowledge on the part of the addressee, the discourse produced is explanatory, and when the utterer anticipates a lack of acceptance, it is argumentative. Since the linguistic marker ‘because’ functions in both genres, it may only become clear from the context which of the two is instantiated. The utterance ‘The cake tastes like carton because it does not contain sugar’, for instance, counts as an explanation if it is clear from the the context that the addressee agrees that the cake tastes like carton but does not yet know why this is the case.

Within Adpositional Argumentation, these two main types of information are represented on the left branches of an adtree with the voice as a right branch, as the content—be it explanatory or argumentative—depends on the voice. When the utterer is explaining something, the relation between the act of uttering and the actual content is indicated by the Greek letter ρ_x . When the utterer is directly conveying argumentation, the relation between the act of uttering and the actual

content is indicated by the Greek letter ξ_x ; conventionally, we name it as an act of expressing a viewpoint. Figure 6 illustrates the respective abstract pragmatic adtrees, where the content is signaled by the dots (...).

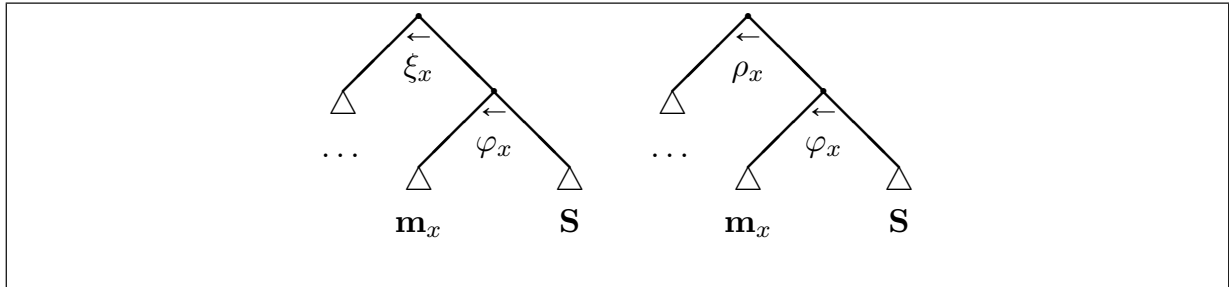


Figure 6: Abstract pragmatic adtrees for viewpoint (left), and reported speech (right)

In natural argumentative discourse, it may also occur that someone reports (ρ_x) the viewpoint of someone else (ξ_y), as in Figure 7. The reported content may be an explanation or an argumentation.

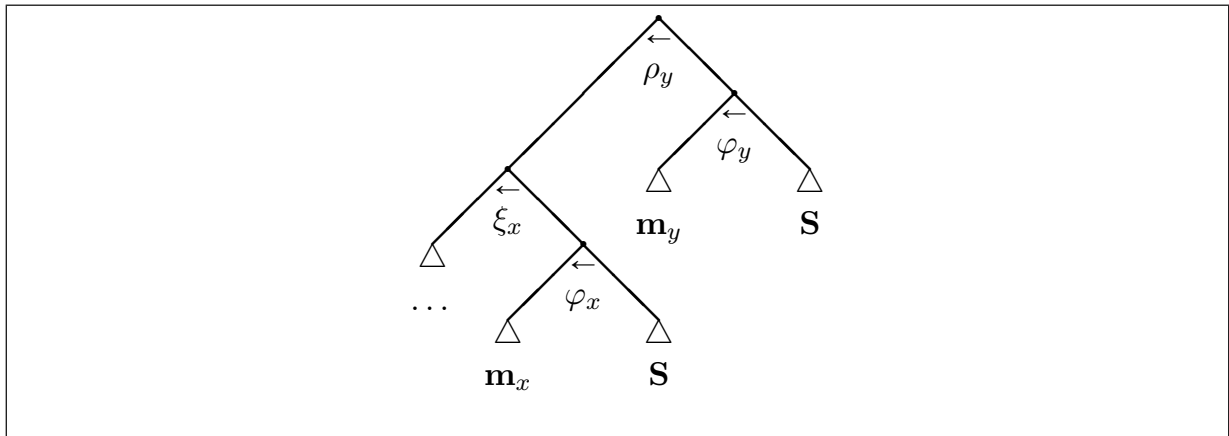


Figure 7: Abstract adtrees for reporting someone else's viewpoint

Figure 8 offers an example of a reported explanation. The sentence ‘George said the cake tastes like carton because it does not contain sugar’ is an example of a reported explanation. When annotating natural argumentative discourse, it is important to acknowledge the parts that are not argumentative but merely explanatory. Those parts may be annotated by linguistic adtrees, without referring to any argumentation framework such as the PTA, whose representation in the form of adtrees is illustrated in the next sections. In particular, the ‘because’ in the sentence should not be treated as argumentative, but just as a linguistic indicator, in this case, a unifier (U) of the two phrases ‘the cake tastes like carton’ and ‘It does not

contain sugar’. For an extensive explanation of valency in linguistic adtrees, represented by superscripts and subscripts, such as in the grammar characters I_2^2 , E_2 , O_1 in Figure 8, please see Gobbo and Benini (2013,2011) [11, 10].

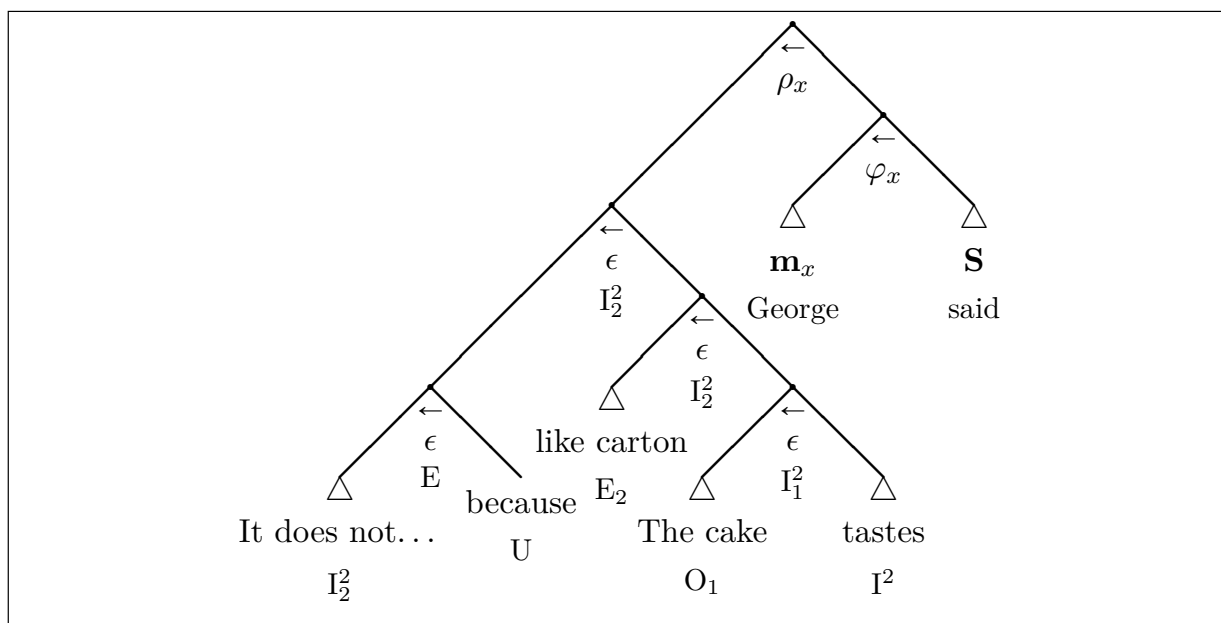


Figure 8: Exemplar adtree of reported speech of an explanation

It may also occur that someone reports (ρ_x) the viewpoint of someone else (ξ_y), including one or more arguments. A concrete example of such reported argumentation may be found in the opening lines of an exercise from a textbook on argumentation, already analyzed in Gobbo, Benini, and Wagemans (2022) [16]:

In his article “Plagiarism: A rich tradition in science”, editor John Lowell argues, referring to an article by dr. P. Smith, that Copernicus was also guilty of plagiarism:

In this case, the corresponding adtree has a sub-tree with the reported argumentation, as pictured in Figure 9.

Figure 9 shows the structure of reported speech without delving into the analysis of the subsequent argumentation: the utterer (a_0), being the author’s voice (φ_0) reports (ρ_0) that the voice entity ‘editor John Lowell’ (b_1) argues about the accusation of Copernicus being guilty of plagiarism. While linguistic details of the voice entity b_1 are left hidden (Δ), the adtree also shows part of the linguistic structure of the voice entity’s predication, distinguishing the the verb ‘argues’, which governs the circumstantial ‘In his article “Plagiarism: A rich tradition in science”,’.

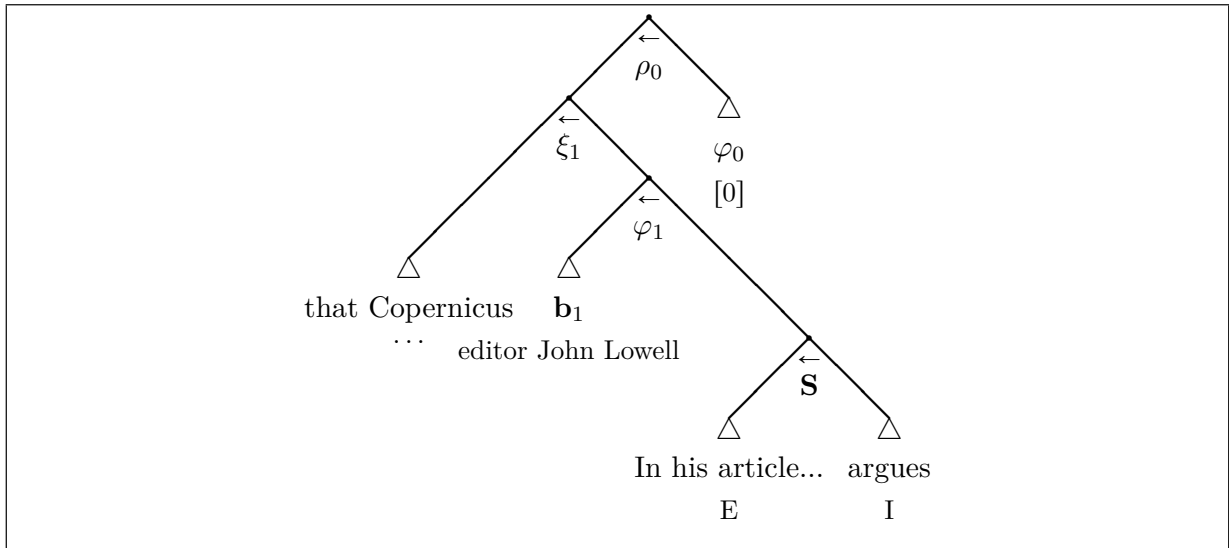


Figure 9: Reported speech of a voice

It is worth remarking that viewpoints and reported speech are represented as adtrees when the information of who is saying what is explicitly stated in the text; otherwise, it is always possible to represent the viewpoint ξ_0 of the author a_0 as the governor of the linguistic material included in the argumentative adtree in the dependent ‘as it is’. Finally, adtrees can represent the extreme case of the author referring to themselves in the third person, as Caesar did in *De bello Gallico*, with a ρ_0 for the reporting and an m_0 for the voice subject, whose distance from the author is, in this case, zero.

For the sake of simplicity, in the following, we will consider viewpoint as the default indication of the utterance, that is, all the adtrees presented in the next sections will be ruled by the utterer putting forward an argumentation, unless indicated otherwise. For more details on how to represent more complex structures of reported speech, see Gobbo, Benini, and Wagemans (2022) [16].

4 Representing claims and minimal arguments

In this paper, with the term ‘argumentation’ we indicate the fabric of arguments put forward in a discourse or text expressed in natural language, while ‘argument’ is reserved for a single element of that fabric. An argumentation generally consists of a collection of premises, a collection of conclusions, and a way to relate them: all these pieces are observables, as they can be recognized in the piece of natural argumentative discourse at hand. As described and discussed in Section 3, it is also

essential to analyze the the context in which the argumentation is uttered.

Before analyzing how complex argumentation could be represented and interpreted, it is worth considering the simple case where the collections of premises and conclusions are minimal. Indeed, a collection is a structure that groups together and coordinates the involved elements. Hence, leaving out the grouping structure for the moment allows us to simplify the study of argumentation greatly. Also, elements may be either atomic assertions (called *statements* in the following) or arguments themselves: again, it is far simpler to assume that the elements of a collection are atomic. These two hypotheses provide a fair point to start describing how argumentative adtrees are constructed. So, in this section, we assume the above collections to contain at most one statement, addressing the general case in Section 5.

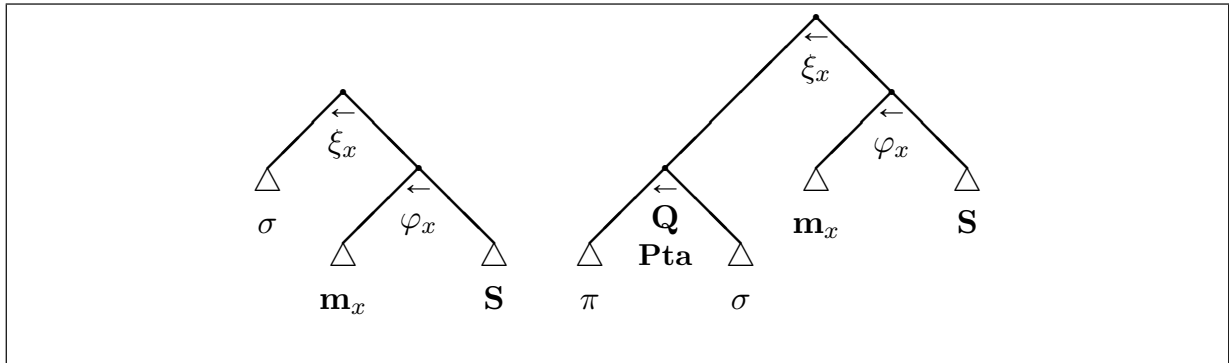


Figure 10: Abstract adtrees of a claim (left) and a minimal argument (right)

In the first place, we observe that there is no object whose acceptability the arguer aims to establish or increase when the conclusion is absent. Thus, by the very meaning of the notion, without a conclusion there is no argument. Therefore, there are only two cases for a simple argument: first, one conclusion with no premise; second, one conclusion and one premise. The former case is called a *claim*, i.e., an unsupported statement, while the latter is a *minimal argument*. Figure 10 illustrates the respective abstract adtrees in which the Q indicates a generic quadrant $(\alpha, \beta, \gamma, \delta)$.

A claim is then a statement that is atomic with respect to the argumentative level of abstraction. It is represented as a leaf in the argumentative part of the adtree, and functionally it may act as a premise or conclusion for another argument. As a side note, observe how a claim may be the root of an adtree which further analyses its internal structure with respect to another level of abstraction, for example, its linguistic representation. Hence, the natural interpretation of a claim A in isolation is the sequent $\vdash A$ in the logic of the arguer, while it becomes an assumption when used as a premise, so an element in the left-hand side of a sequent. These two uses

are special cases of convergent and divergent arguments, as explained in the next section.

Within Adpositional Argumentation, the premise is indicated by the Greek letter π and the conclusion by σ . The prominence is identified by the shape of the argument: retrogressive (\leftarrow) when it is ‘ σ because π ’; progressive (\rightarrow) when its shape is ‘ π then σ ’. Since a minimal argument contains a conclusion σ and a premise π , but the conclusion is necessary while the premise is optional, it is natural to think that σ rules over π . This fact is reflected in the adtree representation where the governor, the right leaf, is σ , and the dependent, the left leaf, is π . Thus, the representation privileges the retrogressive normal form of an argument: σ because π . Consequently, its intended interpretation in the logic of the arguer is the sequent $\pi \vdash \sigma$.

An apparent problem with the intended interpretation $\pi \vdash \sigma$ is that the arguer states this sequent because it holds by some inference rule r : this rule r is **not** an observable, and in most cases in the real world, it is unknown not only by the analyst or the counterpart in the discourse, but even by the arguer. Therefore, according to the principle that an adtree must represent the argument ‘as it is’, as close as possible to what can be observed, the adposition in the root of the adtree for a minimal argument has to identify the ‘inference rule’ as objectively as possible, according to what is observable.

4.1 Representing minimal arguments

Because the inference rule cannot always be precisely identified from the observables, we need a more fine-grained analysis of the content of the statements functioning as the conclusion and the premise of the argument. For this reason, we represent minimal arguments in terms of the argument categorization framework of the Periodic Table of Arguments (PTA)—see Wagemans (2016,2019,2020,2023) [28, 30, 29, 32]). This framework conceptualizes an ‘argument type’ as a collection of instantiated values of three different parameters (form, substance, and lever). The determination of the first parameter, the argument form, requires breaking down the statements functioning as the conclusion and the premise of the argument into a subject, indicated with small roman letters (a, b, ...), and a predicate, indicated with capital roman letters (X, Y, ...). The determination of the third parameter, the argument lever, provides the inference rule and thus indicates an aspect of the logic of the arguer. For the present purposes, we refer to Table 2 for an overview of the configurations of the subjects and predicates in the four basic argument forms (named α , β , γ , δ) distinguished within the theoretical framework of the PTA and their corresponding levers.

From a structural point of view, the abstract argumentative adtrees correspond-

<i>name</i>	<i>conclusion</i> σ	<i>premise</i> π	<i>retrogressive normal form</i> <i>of minimal arguments</i>	<i>lever</i>
α	a is X	a is Y	a is X, because a is Y	X R Y
β	a is X	b is X	a is X, because b is X	a R b
γ	q(a is X)	r(b is Y)	q(a is X), because r(b is Y)	q R r
δ	q(a is X) [is T]	q(a is X) is Z	q [is T], because q is Z	[T] R Z

Table 2: Overview of abstract minimal argument retrogressive forms

ing to the three forms α , β , and γ are very similar, as Figure 11 illustrates.

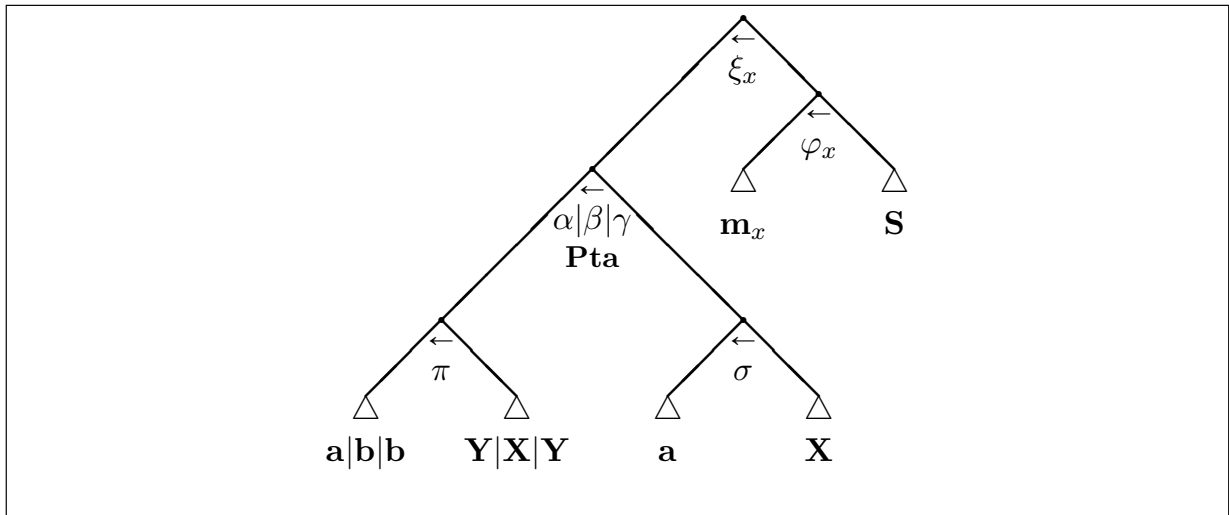


Figure 11: Abstract argumentative adtrees: α , β , and γ quadrants

The symmetry of α , β , and γ arguments is not found in δ arguments. This is because, in the latter, the arguer supports the acceptability of the conclusion by attributing an external property to it: the conclusion is deemed acceptable, for instance, because some authority endorses it or because not accepting it leads to bad things. If we indicate the acceptability of the conclusion as ‘T’ and the external property attributed to it as ‘Z’, we can represent the form of δ arguments as ‘q [is T], because q is Z’. It is important to note that the predicate T correlated to the statement q which represents the subject and the predicate as a whole, under the form: [is T] has **no** relation to the operator of truth in logic \top , but should be read as ‘is trustworthy’.

The above difference between, on the one hand, α , β , and γ arguments and, on the other hand, δ arguments is reflected in the lever, which represents an aspect of the logic of the arguer, namely the inference rule. In the first three forms, the lever

is found in the components of the premise and the conclusion, namely a, X and b, Y. The relation between these pieces of the statements is what allows to relate the premise with the conclusion, and the relation is generally found in the semantics.

On the contrary, the lever of a δ argument does not depend on the components of the conclusion. The arguer aims to establish or increase the acceptability of the conclusion by predicating something of it as a whole. The lever is thus a relationship between the external property (Z) and the trustworthiness (T) of the conclusion as such, which is usually not expressed in the linguistic material—see also Table 1. As mnemotechnics, we say that α , β , and γ arguments provide a first-order relation, while δ envisages a second- or higher-order relation. The reader is adverted that such terminology has **no** logical value.

4.2 Two examples of minimal arguments

The first example illustrates first-order relations, while the second one will clarify how δ arguments work. The statement ‘I think *Interstellar* is great’, which contains the claim ‘*Interstellar* is great’, referring to the feature film directed by Christopher Nolan in 2014—see Figure 12.

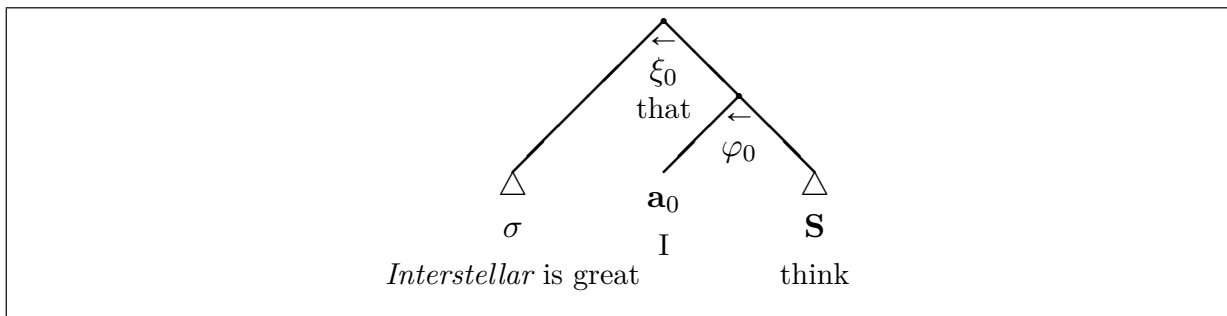


Figure 12: ‘I think that *Interstellar* is great’

Admittedly, it is generally more effective to argue through something more substantial than a simple claim. In general, the arguer, who is also the utterer, in this case, supports the previous statement with a subsequent one, adding a statement such as ‘It is directed by Nolan’. What we obtain is a minimal argument: ‘*Interstellar* is great because it is directed by Nolan’, which is represented in Figure 13.

In the example, when observing the two statements *prima facie*, we note that the argument form is α , with the following distribution of subjects and predicates: ‘*Interstellar* (b) is great (X), because it (b) is directed by Nolan (Y)’. The lever is thus a relationship between the predicates X and Y. What concrete relationship that is, is something for the analyst to decide, as this aspect of the logic of the arguer is not included in the linguistic material. The values of the parameters form (α) and

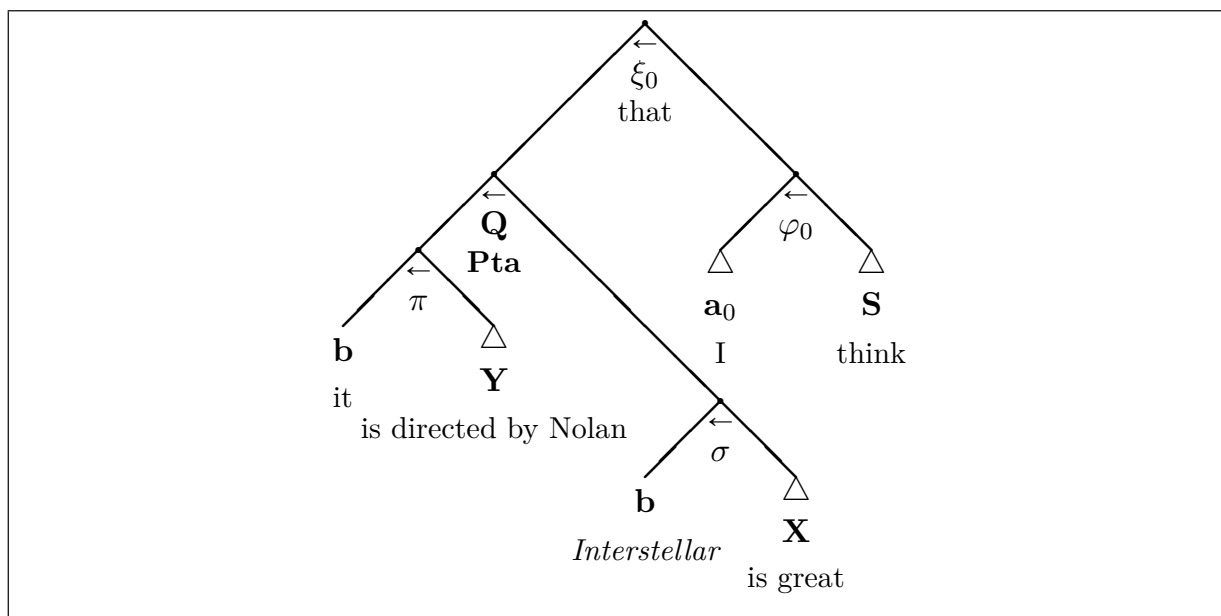


Figure 13: ‘I think that *Interstellar* is great because it is directed by Nolan’

substance VF, expressed via the pair of argumentative characters of value (V) of the conclusion σ and fact (F) of the premise π reduce the number of possibilities here, as the framework of the PTA suggests it to be an ‘argument from criterion’ (Cr). This means that the relationship between the predicates is such that the predicate of the premise functions as a criterion for the predicate of the conclusion: ‘being directed by Nolan is a criterion for being great’.

The second example illustrates how the δ arguments may imply the introduction of a new voice. Consider the minimal argument ‘Infinity is not unique because Cantor said so’: it is clear that the ‘so’ particle is an anaphora, in other words, it is a way to avoid to repeat linguistic material already expressed previously, in this case ‘Infinity is not unique’. In adtrees, anaphoras are indicated by the arrow that turns back to the right \curvearrowright , immediately followed by the target addressed by the place marker—analogously, cataphoras, i.e. anticipations of linguistic material explained later in the text, shall be indicated in adtrees as \curvearrowleft . The δ authority (Au) argument represented in Figure 14 has the conclusion ‘Infinity is not unique’ in the governor and the premise ‘Cantor said so’ in the dependent. The premise contains as a subject the conclusion by means of the anaphoric (\curvearrowright) ‘so’ and as a predicate the voice ‘Cantor said’.

Observe that the statement ‘infinity is not unique’ is established as a whole and not in force of its components: in this very aspect lies the unique feature of the δ arguments—Figure 14.

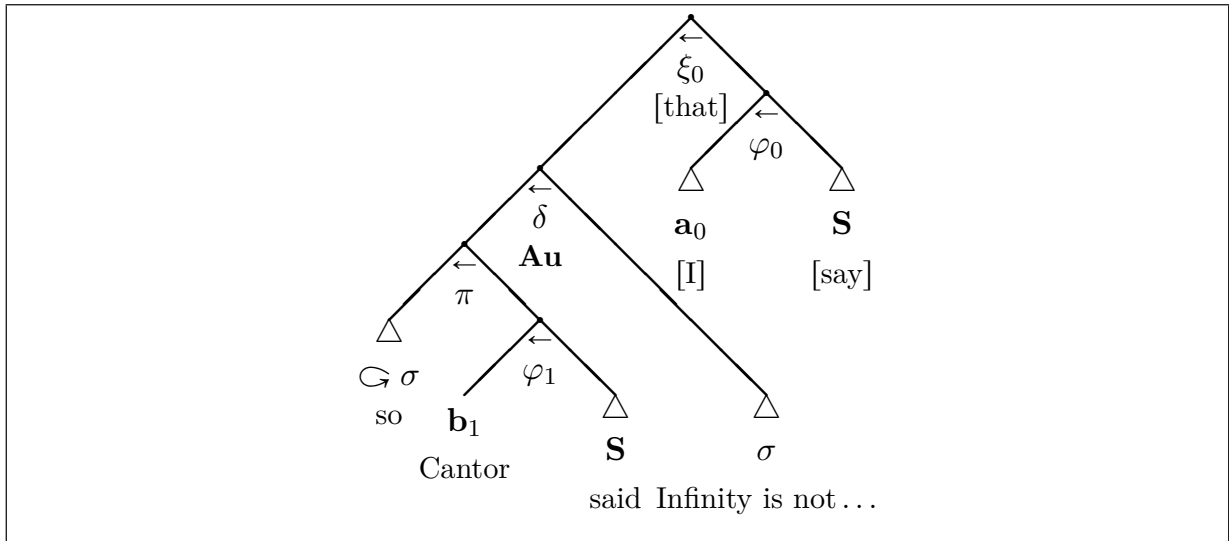


Figure 14: The adtree of ‘Infinity is not unique because Cantor said so’

Figure 15 shows the argumentative levels of abstraction of the two examples, in contrast, hiding all linguistic details.

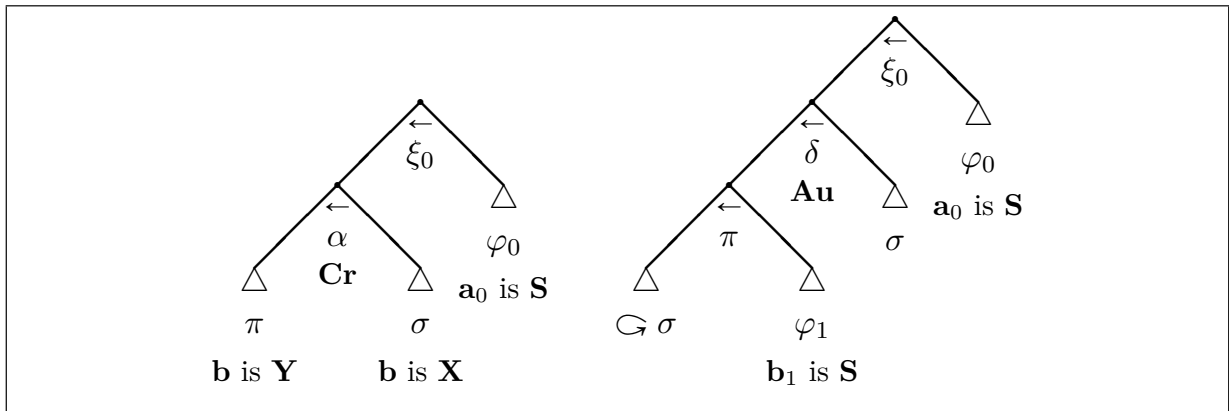


Figure 15: Argumentative adtrees of the two examples in contrast

Argument types of all four forms α , β , γ , and δ , are based on a lever of some sort—see Table 2. However, while form and substance are pieces of information based on observables, the lever is not always—or rather: usually not—explicitly present in the linguistic material. In this case, the PTA is used as a heuristic for formulating the lever, which is made possible by its conventional validity as a classification framework based on taxonomies of argument types (argument schemes, fallacies, and other means of persuasion) from the informal traditions of dialectic and rhetoric. This information is enough to identify the potential attacks by the the

counterpart in the argumentative discourse on the solidity of the argument lever—see Hinton and Wagemans, (2021) [17]. In other words, while the representation of minimal arguments in Adpositional Argumentation is not enough to identify the logic of the arguer in use, it allows attacking the argument since it makes explicit the observable nature of the inference. We can therefore conclude that the representation injects the tradition of AT in a solid formalism through the PTA, mitigating the gap between AT and formal approaches such as CA exposed in the Introduction.

5 Representing complex argumentation

Real-world argumentation is often complex: it may contain multiple premises, sometimes multiple conclusions, and one argument may use a conclusion of another argument as a premise, yielding a chain of arguments—see, e.g. Freeman (2011) [8]. A proper representation of natural argumentative discourse has to cope with all these cases. We call *convergent* complex argumentation with one conclusion and many premises, while conversely more conclusions driven by one premise will be called *divergent*. Finally, complex argumentation using as a premise the conclusion of another argument is called *serial*. The representation suggests a way to interpret the argumentation, providing clues on the logic of the arguer, which could and should be identified to see how an argumentation conveys acceptance or refusal.

A concrete argumentation, i.e., one that is expressed in natural language, may contain conclusions and premises that can be convergent, divergent, and serial at the same time. The guiding principle ruling composition is that the premises are in the dependent part of an adtree, while the conclusions are in the governor part; finally, the adposition specifies how the complex argumentation is constructed, and thus how it should be represented. In the following, the three cases of complex argumentation are discussed in detail and separately. However, the formalism allows for smoothly composing the representations of the three cases, if needed.

5.1 Convergent argumentation

Convergent argumentation is characterized by having more than one premise. The key idea to represent them is to combine all the premises into a single one.

To obtain a sound representation of all the premises without introducing new information beyond the observables, one has to remark that the premises are ordered in the textual exposition of the argument, thus there is an observable list of premises π_1, \dots, π_n with $n > 1$. The representation, depicted in Figure 16, divides the list into two parts π_x and π_y , in a process detailed below, and assigns the prominence accordingly. The adposition is completed by a λ symbol to indicate the combination

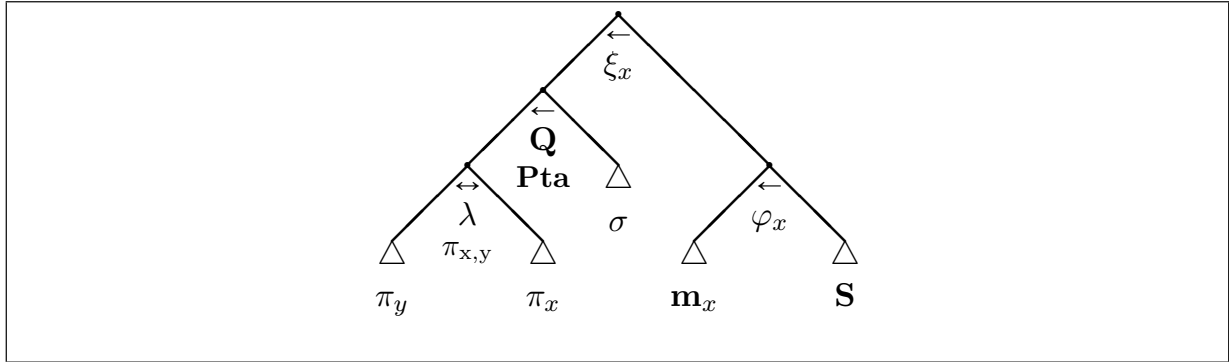


Figure 16: The abstract adtree of convergent argumentation

operation, and the label $\pi_{x,y}$ to remind both the elements and the order in which they have been combined (as usual, these pieces of information are omitted when they can be reconstructed from the context).

The interpretation of the λ operation within an argument as in Figure 16 is a sequent $\pi_{x_1}, \dots, \pi_{x_n} \vdash \sigma$ in the logic of the arguer, where π_{x_1, \dots, x_n} is (the label of) the adtree grouping all the premises. The order of the premises is a consequence of the dependencies among them. Indeed, the logic of the arguer is generally unknown and not observable, thus the analyst has to determine whether two premises π_x and π_y are independent, so $\pi_x \leftrightarrow \pi_y$, or if π_x depends on π_y , thus $\pi_x \leftarrow \pi_y$, or vice versa. This piece of information is sometimes present in the text, so it may be observable, but it could also be added by the analysts, based on their experience and understanding, in which case the adtree is not objective, but represents the point of view of the analyst. In the following, we assume fair representations, which incorporate observable dependencies among premises only.

To better understand what dependency is in this context, consider the argument “the number n is odd (σ) because $n - 1$ is even (π_1), n is a natural number (π_2), and n is strictly positive (π_3)”. It is clear that $\pi_1 \leftarrow \pi_3$ and $\pi_3 \leftarrow \pi_2$ since the subtraction on naturals would be undefined unless $n > 0$, and in turn $n > 0$ makes no sense in a number system without an order and 0. Hence, the right way to order the premises by their dependency would be $\pi_{2,3,1}$ which is the right order a mathematical analyst should impose on the combination. Observe how putting π_1 in evidence as the first uttered premise emphasizes its importance in conveying the validity of the conclusion, which is not a proper argumentative aspect but rather pertains to the pragmatic level of abstraction.

Moreover, dependencies among the premises provide insight into the the logic of the arguer. In fact, the structure of the left-hand side of a sequent distinguishes logics in which assumptions are collected in sets, e.g., classical logic with the LK

presentation, see Schwichtenberg et al. (1996) [24], from those in which assumptions are represented as a partial order, e.g., dependent types, see Martin-Löf [19] and Homotopy Type Theory [26]. Of course, other structures (multisets, linear orders, etc.) are possible, and they hint at specific families of logics.

Independence of premises provides a hint on how attacking the combination may elicit information about the arguer’s logic. If the counterpart attacks a variant adtree, in which the independent premises are permuted, and the arguer defends its original argument refuting the permuted representation, the variant is observably not admissible in the logic of the arguer, thus revealing a hidden dependency. This fact suggests that studying the transformations of argumentative adtrees, like the permutation of independent premises or conclusions, is a powerful instrument to better understand them, and to provide formal clues to orient the dialogue and clarify the arguments. But this lies beyond the scope of the present work. The specifications of the argument types in the PTA in a convergent argument, see Figure 16, are obtained following the analogy with Chemistry: a minimal argument is analogous to an atom of matter, while a complex argumentation structure is analogous to a molecule. Hence, the quadrant is usually γ since the lever is rarely found. However, there are exceptions: for example ‘The Blues Brothers is a cult movie (σ) because it has superb music on the score (π_1) and it stars John Belushi at his best (π_2)’ can be identified as an α argument, and the ‘molecule’ is composed of two atoms which are both St (Standard), so the adposition becomes (α, St^2) —see Figure 17. The St^2 part denotes the ‘raw formula’ for the argument type, analogously to H_2O which denotes water in Chemistry: it describes the general form of the argument, while its inner structure is represented in the relationship between the dependent and the governor.

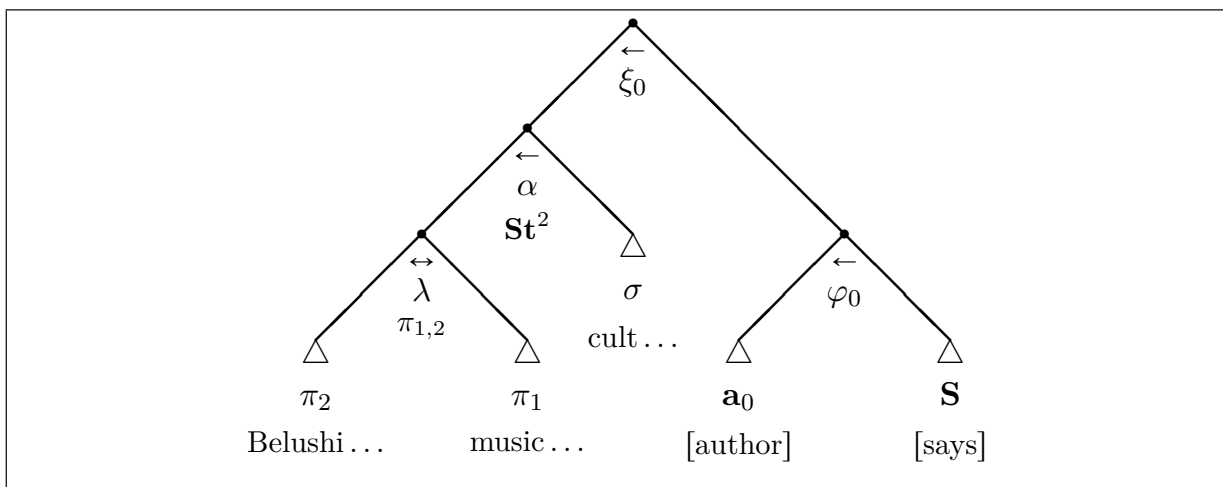


Figure 17: The adtree of ‘The Blues Brothers is a cult movie because... and...’

In the general case, because a complex argumentation may mix statements of value, policy, and fact, and furthermore can combine them into involved structures, the raw formula for precisely identifying the ‘molecule’ is still an open problem to be addressed in the future: a brief discussion can be found in the Conclusion.

In the end, it is worth observing that a combined element may be an argument itself rather than a statement. For example ‘Lily wears a raincoat (σ) because it’s very cloudy so it may rain (π_1) and, if it rains and she is not well covered then Lily could get a cold (π_2)’. Both premises π_1 and π_2 are arguments: π_1 is ‘it may rain (σ_{1a}) because it’s very cloudy (π_{1a})’, and π_2 is ‘Lily could get a cold (σ_{2a}) because it rains (π_{2a}) and (λ) Lily is not well covered (π_{2b})’.

In general, using arguments in place of statements models *hypothetical reasoning*: the premise which is an argument $\pi_a \vdash \sigma_a$ tells that $\pi_a \vdash \sigma_a$ is assumed to be valid in order to deduce the conclusion, even if the arguer does not establish the premise π_a . In the example, π_2 has been asserted, and its premises may be attacked: for example, the counterpart may reply ‘Since Lily already has six layers of clothes on, she is well covered’.

5.2 Divergent argumentation

Divergent argumentation is characterized by having multiple conclusions grouped together so that the premise aims at establishing all of them. Analogously to premises in convergent argumentation, see Section 5.1, the conclusions are ordered as a list $\sigma_1, \dots, \sigma_n$ by the text material. Thus, the way to represent them is the same as for the combination of premises in convergent argumentation, as shown in Figure 18, including the analysis of dependencies among conclusions.

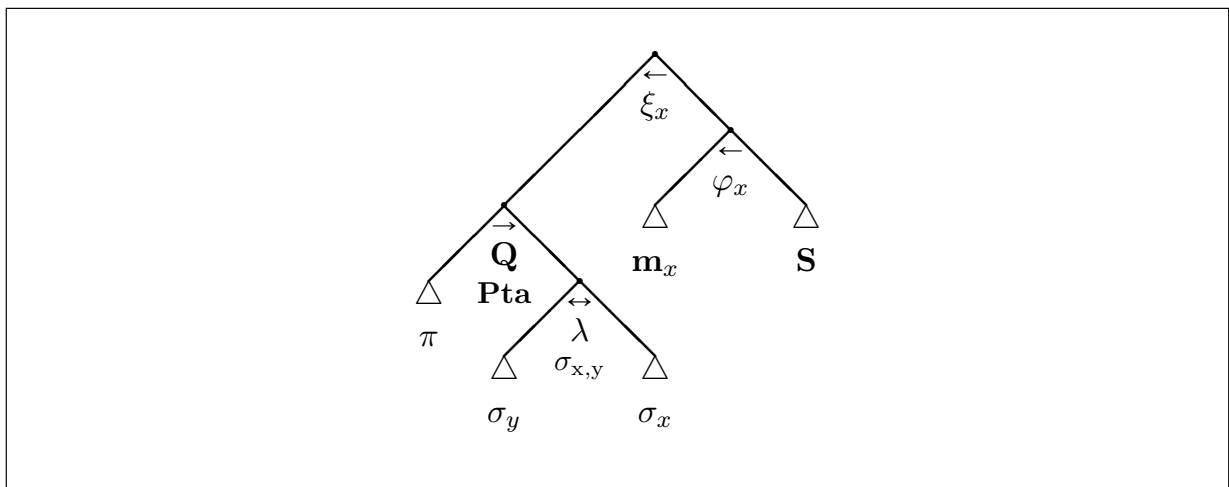


Figure 18: The abstract adtree of divergent argumentation

Reminding that an argument is interpreted as a sequent $\pi \vdash \sigma$ from the interpretation of the premise to the interpretation of the conclusion in the logic of the arguer, when the conclusion is $\sigma_1, \dots, \sigma_n$, it should be interpreted in the product of σ_x and σ_y , according to the notation in Figure 18. When σ_x and σ_y are independent, we could reasonably expect that the product is Cartesian, that is, conjunction; when σ_y depends on σ_x , we should expect the product to be an amalgamation, like the Σ operator in Martin-Löf's *An Intuitionistic Theory of Types* [19].

In general, the optimal guess for the product is the categorical product of σ_x and σ_y in the category of statements whose arrows are sequents. However, this is an educated guess at best, since the underlying category may not have all the finite limits. Hence, divergent arguments provide deeper but uncertain clues on the logic of the arguer. How to devise an attack strategy to elicit stronger information about the nature of the product in the logic of the arguer is still a work in progress.

Consider the argument ‘The house is cold and we cannot cook hot food because the gas supply is broken’. Clearly, it is a divergent argument from the premise ‘the gas supply is broken’ (π) to the conclusions ‘The house is cold’ (σ_1) and ‘we cannot cook hot food’ (σ_2). Also, the conclusions are factually independent. Hence, the argument is represented as in Figure 19.

Observe how prominence between the conclusions σ_1 and σ_2 has been left unspecified, since they are independent. However, if this text is a fragment of a phone conversation of a house owner complaining to a gas company, we could suppose that the heating problem would be more relevant in the rest of the call.

A critical feature one needs in order to interpret arguments as sequents, and, at the same time, to have a notion of product, is that the apparently trivial δ argument “ S because S ” must hold, which tells, when S is a collection of premises/conclusions, that the product is the reification of structure on the collection of the premises. This link between premises and conclusions is required in Adpositional Argumentation: the requirement is imposed by using the same constructor λ both in convergent and divergent arguments.

An important observation is about incoherent collections of premises/conclusions *in the logic of the arguer*: they will never be formed by the arguer; however, the counterpart may form a counter-argument having arbitrary premises/conclusions to attack the arguer’s argument, even when these are incoherent for the arguer. This kind of attack is effective to understand what the arguer considers non-admissible, creating observables, in the form of replies from the arguer, about inner aspects of the logic of the arguer.

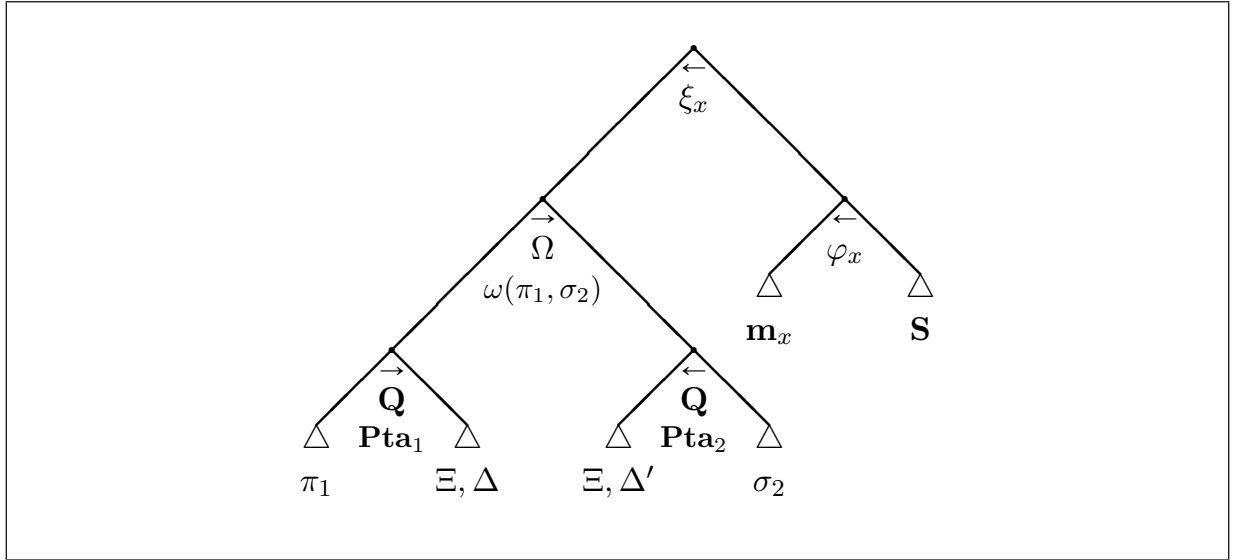


Figure 20: The abstract adtree of serial argumentation

or $\Xi, \Delta' \vdash \sigma_2$ and reordering the combined elements under the λ 's. In this respect, the adopted representation has the purpose to strictly follow the linguistic material: indeed, a serial argument with convergent/divergent components usually emphasizes the connecting component Ξ , and hides the Δ and Δ' premises and conclusions in the composed argument. For example, consider the argument a driver made to the insurance company: ‘The car crashed into the tree because the car was skidding, and it was skidding because the road was wet; then, the car crashed into the tree because the road was wet’. There are two arguments, ‘the car was skidding because the road was wet’ (A_1) and ‘the car crashed into the tree because the car was skidding’ (A_2); they are serially composed to obtain ‘the car crashed into the tree because the the road was wet’ using the pivot ‘the car was skidding’, conventionally marked by Ξ . The corresponding representation is shown in Figure 21.

A more complex example is ‘The car crashed into the tree because I touched the brakes and the car was skidding, and it was skidding because the road was wet and I lost control, then the car crashed into the tree because the road was wet’. Here, differently from the previous example, there is a convergent and a divergent argument involved in the pivot Ξ . The corresponding adtree is shown in Figure 22.

Interpreting the serial composition of arguments as a cut is natural, but it does not tell that in the logic of the arguer the cut rule is admissible, but rather that the specific instance represented in the the serial argument can be observed and thus it can be carried on in the logic of the arguer.

Moreover, the sequent $\pi_1 \vdash \sigma_2$ is not necessarily the exact result of the serial

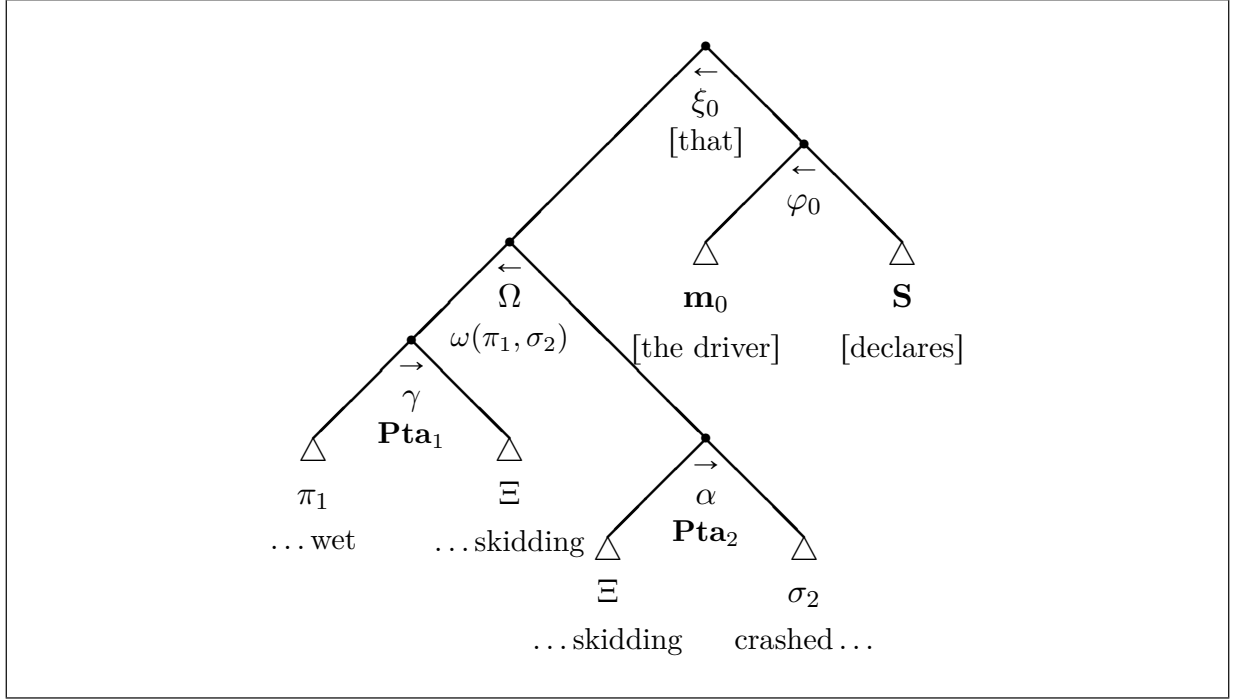


Figure 21: Adtree for ‘the car crashed...’, simple version

composition: depending on the logic of the arguer, the sequent could be different, eventually involving (parts of) the Δ 's. Therefore, it has been indicated by $\omega(\pi_1, \sigma_2)$ in the representing adtree, where the ω operation yields the resulting sequent from the ‘cut’ of the two represented arguments, which are really the left and right subtrees. For example, if the arguer reasons using linear logic (see Girard (1987) [9]), or dependent type theory (see Martin-Löf (1975) [19, 26]) or a paraconsistent logic (see Avron et al. (2018) [1]) the resulting sequence may differ from $\pi_1 \vdash \sigma_2$, involving, e.g, further premises on which π_1 depends on.

To further clarify, when the second argument is $\Xi \vdash \sigma_2$, which is the usual way in which serial composition is written down, Ξ appears to be an independent premise. Nevertheless, this is not always the case: for example, in homotopy type theory [26], Ξ may depend on (a part of) π_1 , thus the second argument should be really understood as $\pi_1, \Xi \vdash \sigma_2$. However, hiding this fact is an essential ingredient to make neat, compact, and vividly understandable proofs in that theory: the ‘logic’ of that theory requires hiding dependencies to support intuition and clarify reasoning.

A crucial point in understanding serial composition is that using a serial argument as the premise or conclusion of another argument one has to *extract* the composed arguments. The representation constructs an argument S which contains the arguments A_1 and A_2 to compose using the pivot Ξ . The result of the Ω op-

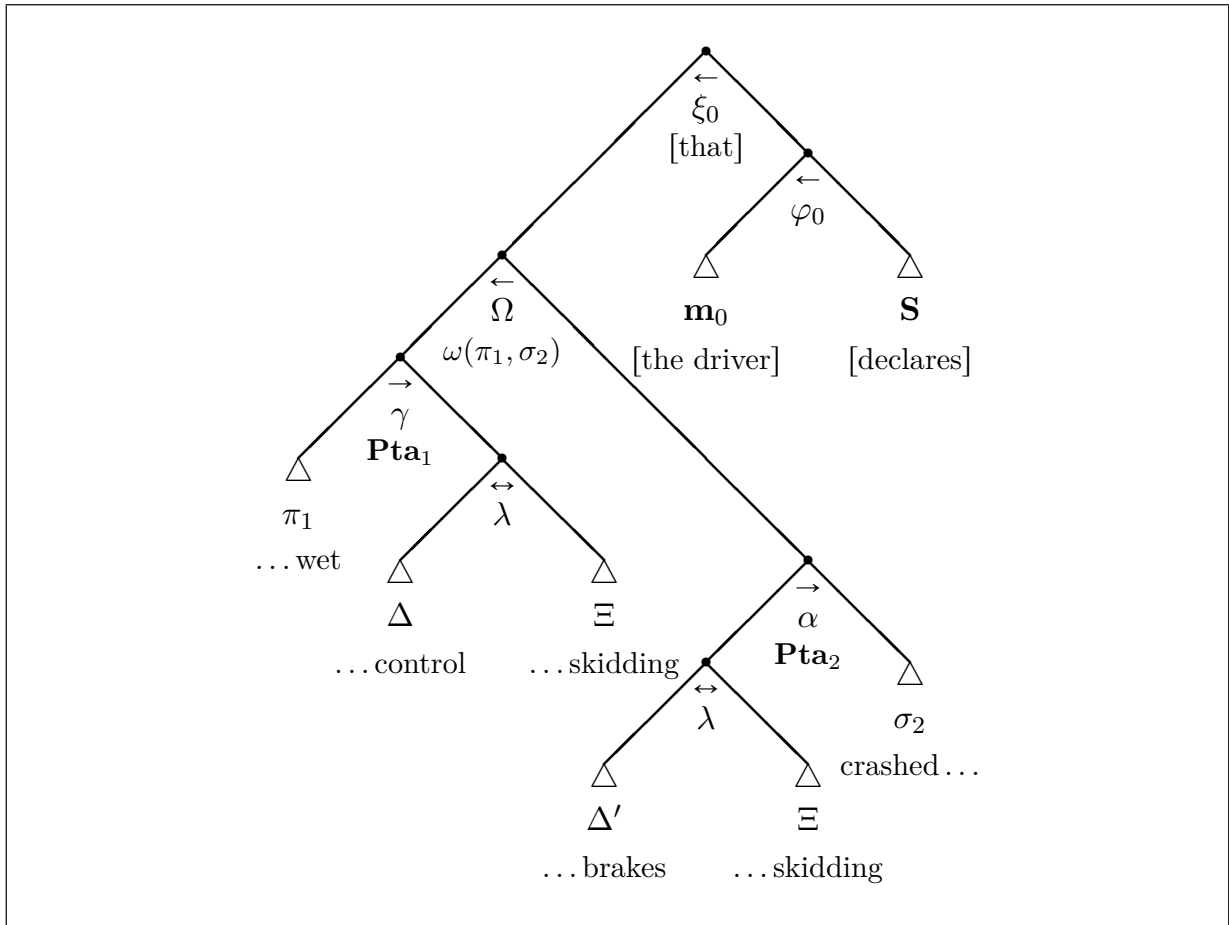


Figure 22: Adtree for ‘the car crashed...’, complex version

erator is a complex adtree containing all the pieces of information to reconstruct the composition, but the result, which, as discussed above is really $\omega(\pi_1, \sigma_2)$. To make this argument explicit in the representation, one needs a further inference that takes a Ω adtree as a premise and concludes with an adtree representing the result. Reprising the previous example in Figure 21, the complete representation of the serial argument is shown in Figure 23, where the δ inference is responsible for providing the conclusion that ‘the car crashed into the tree because the road was wet’. In summary, the whole argument reads ‘[the driver] [declares] [that] the car crashed into the tree (σ) because the road was wet (π), since (δ) the car was skidding (Ξ) because the road was wet (π_1), and the car crashed into the tree (σ_2) because the car was skidding (Ξ)’.

Therefore, the chosen representation closely adheres to the observable textual material, although its interpretation may significantly deviate because of the logic of the arguer: the Ξ may not be independent, the dependency being hidden from

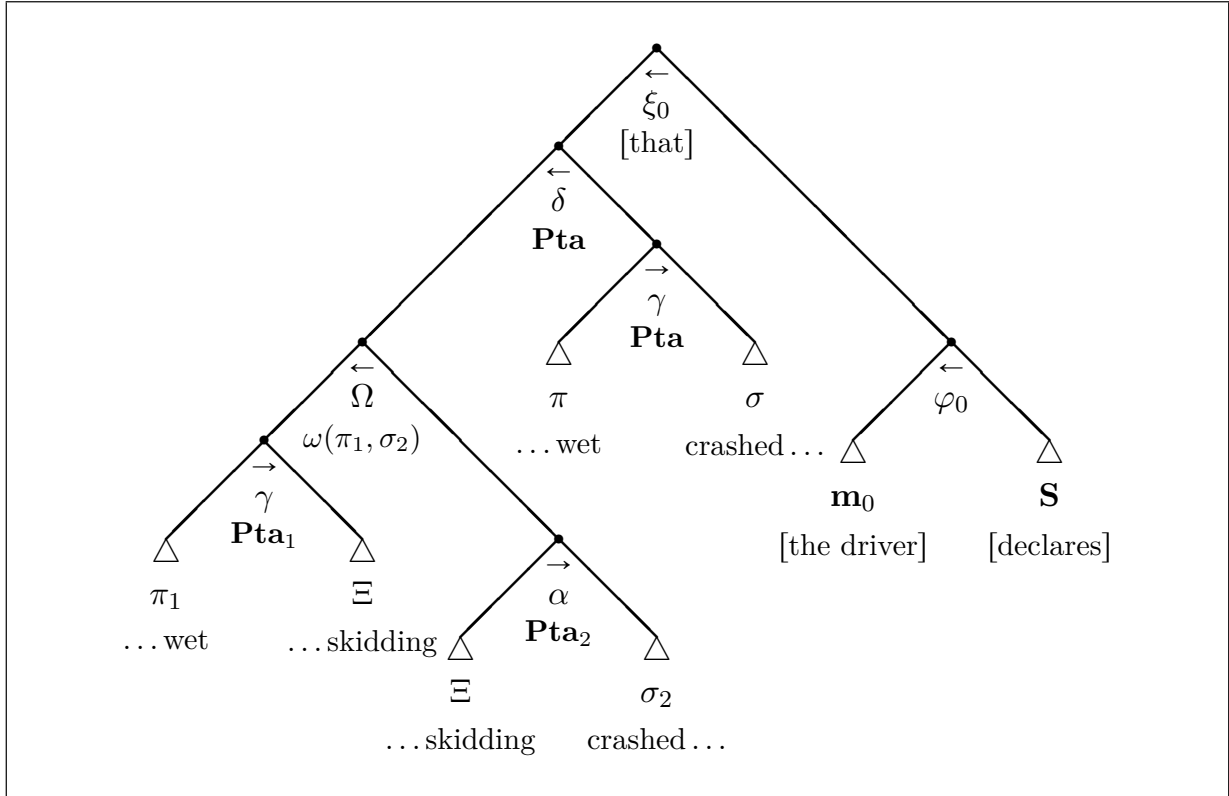


Figure 23: Adtree for ‘the car crashed...’, final

the observer, which resolves into having hidden premises in the sequent resulting from the serial composition; also, the cut applied to obtain the serial composition is not necessarily the classical one. In these cases, the ω operation, which is marked but unspecified in the representation, has to be filled in to understand the arguer’s argument. Of course, this is an evident point of attack, which may lead to clarify or to make evident a fallacy in the logic of the arguer. It is worth remarking that the δ extracting the final argument of a serial composition is responsible for making explicit the $\omega(\pi_1, \sigma_2)$ in the representation, i.e., for providing the result of the cut as it appears in the textual representation.

6 Conclusion

In this paper, we have illustrated a way to represent natural argumentative discourse in a formalism, the one of adpositional trees (see Section 2), which is uniform among many levels of abstraction, from the morphosyntactic (linguistic) to the argumentative (pragmatic) one. After showing, in Section 3, how the textual exposition of

argumentation, possibly complemented by explanations and voices, can be included as part of its representation, we moved to considering claims and minimal arguments in Section 4. While these subjects have also been treated in previous works by the authors, the intended interpretation of minimal arguments as sequents is made explicit here for the first time. Another novelty is that, building upon this intended interpretation, the notions of convergent, divergent, and serial argumentation have been introduced, represented, and interpreted. Their representation in adpositional trees has been modeled after that of the minimal argument to allow for arbitrary compositions of these argumentative structures, which are the fundamental ones.

Natural argumentative discourse is expressed in linguistic material, which eventually is the place where argumentation can be observed in real-world use. The logic of the arguer is used to convince the addressee of the validity and acceptability of the argumentation. This is a dynamic process: the logic of the arguer does not only show in the observables but mainly in what is inferred from them.

In the first place, forming an attack on a given argument has a double purpose: contesting its validity (direct attack), but also a better understanding of how its logic works (indirect attack). A systematic way to improve understanding is to consider variant arguments, i.e., natural language rewording of the argument in order to clarify them, and to propose them to the arguer: their acceptability provides clues on the logic of the arguer, specifically about which structural properties of the logic could be observed, which ultimately leads to an identification of the logic itself. Devising such inquiring strategies has been hinted at in the present article, but not developed.

Systematically deriving these strategies requires to identify linguistic variants of the same argument that may validate or confute hypotheses about the structural properties of logic: variants are obtained by transforming the original argument to test whether it is equivalent or acceptable for the arguer. What the reasonable transformations are, and how to orient them towards testing specific properties is still an open problem, and the subject of further research.

In a similar vein, there is no one-to-one mapping from the levers of the minimal arguments listed in the argument categorization framework of the Periodic Table of Arguments (PTA) to the levers in complex argumentation. As in Chemistry, in which a molecule is composed of many different atoms, complex argumentation derives its convincing force from many different minimal arguments, i.e., ways to transport the acceptability from the premises to the conclusions. In this respect, the adpositional representation shows the fine structure by which this transport of validity is performed, but a synthetic way to denote it, as the raw formula for a molecule in Chemistry, is still under development.

On a similar note, so far, Adpositional Argumentation has focused on repre-

senting monological discourse. Some aspects of the representation of complex argumentation are therefore still open. In particular, the dynamics of attacking and defending an argument in a dialogue (or a polylogue, in the sense of Lewiński and Aakhus (2014) [18]), require more investigation. Also, the relationship between the *representation* of natural argumentative discourse and its *evaluation* is only touched upon briefly in this paper, namely in identifying the points of attack, and is left for future work.

Acknowledgements

This article builds on previous works of the authors, in particular [12, 13, 14, 15, 16] whose outcomes are summarised in Sections 2,3 and 4, while the content of Section 5 is new or significantly extends previous achievements.

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