Argumentation Schemes. History, Classifications, and Computational Applications

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Abstract

Argumentation schemes can be described as abstract structures representing the most generic types of argument, constituting the building blocks of the ones used in everyday reasoning. This paper investigates the structure, classification, and uses of such schemes. Three goals are pursued: 1) to describe the schemes, showing how they evolved and how they have been classified in the traditional and the modern theories; 2) to propose a method for classifying them based on ancient and modern developments; and 3) to outline and show how schemes can be used to describe and analyze or produce real arguments. To this purpose, we will build on the traditional distinctions for building a dichotomic classification of schemes, and we will advance a modular approach to argument analysis, in which different argumentation schemes are combined together in order to represent each step of reasoning on which a complex argument relies. Finally, we will show how schemes are applied to formal systems, focusing on their applications to Artificial Intelligence, AI & Law, argument mining, and formal ontologies.

1 Introduction

The purpose of this paper is threefold: 1) to describe the schemes, showing how they evolved and how they have been classified in the traditional and the modern theories; 2) to propose a method for classifying them based on ancient and modern developments; and 3) to outline and show how schemes are interrelated and can be organized in a modular way to describe natural arguments or produce complex arguments. Historically, the schemes evolved from the Aristotelian topics, the so-called places to find arguments. But looking over the descriptions Aristotle presented of them in the *Topics*, for the most part they do not appear to very much resemble the argumentation schemes in the contemporary list of Walton, Reed and Macagno [Walton *et al.*, 2008]. Of course there are exceptions, such as the topic for argument from analogy described in Aristotle, which is recognizable as standing for the same kind of argument as the current scheme for argument from analogy, even though the detailed description of it is quite different.

Argumentation schemes are instruments for argumentation, involving the activity of critically evaluating a viewpoint and the reasons given in its support. For this reason, every scheme has a corresponding set of critical questions, representing its defeasibility conditions and the possible weak points that the interlocutor can use to question the argument and evaluate its strength. A critic who has no counter-arguments ready to hand can search through the list of critical questions matching the argument he is confronted with in order to look for clues on how the argument can be attacked that might suggest sources of evidence that could be used to build up a whole line of argumentation that furnishes a way of refuting the argument.

The fundamental challenge that a theory of argumentation schemes needs to face is the problem of finding a useful and sound classification system. The schemes need to be usable, easily identifiable, and at the same time they need to allow the user to detect the most specific pattern of argument that can fit the text or that can be employed for producing an argument suitable to the circumstances and the purpose. In any classification system, entities can be classified in many different ways, depending on the purpose of the classification. The purpose of the classification system will determine the criteria for classification that are adopted in that system. For example, a much more detailed classification of animals may be useful in biology than the kind of classification that might be useful for law, or for classifying animals as they are spoken and written about in everyday conversational English. We need to begin by specifying the purpose of the classification, so that some guidance can be given on how to identify the criteria used in the classification system. From this perspective it is useful to examine how the study of argumentation schemes evolved.

2 Introducing argumentation schemes

Argumentation schemes represent forms of argument that are widely used in everyday conversational argumentation, and in other contexts such as legal and scientific argumentation. But for the most part these arguments are not adequately modeled by deductive forms of reasoning of the kind familiar in classical logic or as statistical inferences based on the standard Bayesian account of probability. They represent the premise-conclusion structure of an argument, and they are defeasible. Their defeasibility conditions are shown as a set of critical questions, dialectical instruments to help begin the procedure of testing the strength and acceptability of an argument by weighing the pro and con arguments.

2.1 Nature of the schemes

Argumentation schemes are stereotypical patterns of inference, combining semantic-ontological relations with types of reasoning and logical axioms and representing the abstract structure of the most common types of natural arguments [Macagno and Walton, 2015]. The argumentation schemes provided in [Walton *et al.*, 2008] describe the patterns of the most typical arguments, without drawing distinctions between material relations (namely relations between concepts expressed by the warrant of an argument), types of reasoning (such as induction, deduction, abduction), and logical rules of inference characterizing the various types of reasoning (such as *modus ponens*, *modus tollens*, etc.). For this reason, argumentation schemes fall into distinct patterns of reasoning such as abductive, analogical, or inductive ones, and ones from classification or cause to effect.

In order to design a system for classifying the schemes, it is useful to understand their limits, and investigate how the dimensions of an argument (material relation and logical form) are merged. For example, consider argument from cause to effect [Walton *et al.*, 2008, p.328]:

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.

Table 1: Argument from cause to effect

This argumentation scheme is based on a defeasible *modus ponens* scheme [Verheij, 2003a] which is combined with a semantic causal relation between two events. The material (semantic) relation is merged with the logical one. However, this combination represents only one of the possible types of inferences that can be drawn from the same semantic-ontological connection. The actual relationship between the material and the logical relation is much more complex. For example, consider the classic Aristotelian causal link between "having fever" and "breathing fast," and see how this cause-effect relation can be used to draw a conclusion based on different logical rules [Macagno and Walton, 2015; Macagno, 2015])

1. He had fever. (Fever causes breathing fast). Therefore, he (must have) breathed fast.
2. He did not breathe fast. (Fever causes breathing fast). Therefore, he had no fever.
3. He is breathing fast. (Fever causes breathing fast). Therefore, he might have fever.
4. He has no fever. (Fever causes breathing fast). Therefore, he may be not breathing fast.
5. You may have fever. When I had fever, I was breathing fast, and you are breathing fast.

Cases (1) and (2) proceed logically from defeasible deductive axioms, i.e. the defeasible *modus ponens* (in 1), and the defeasible *modus tollens* (in 2). Cases 3 and 4 proceed from abductive reasoning. In (3) the conclusion is drawn by affirming the consequent, while in (4) the denial of the antecedent can be rephrased by contraposition as "not breathing fast is caused by having no fever," leading to a conclusion drawn abductively [Walton *et al.*, 2008, pp.169–173]. In (5) the conclusion is based on an inductive generalization from one single case.

Schemes represent only the prototypical matching between semantic relations and logical rules (types of reasoning and axioms). This matching is, however, only the most common one. The material and the logical relations can combine in several different ways. Hence this distinction needs to be taken into account order to classify the schemes.

2.2 Why schemes are important

Critics often ask how these schemes can be justified, given that they resisted analysis as deductive or inductive forms of argument of the kind recognized as valid in the dominant 20th-century logic tradition [Walton and Sartor, 2013].

Schemes are becoming extremely important for practical reasons. First, argumentation schemes are instruments for analyzing and recognizing natural arguments occurring in ordinary and specialized discourse. For example, arguments from political discourse have been analyzed using the schemes, and the argumentative profiles of the candidates have been brought to light considering their preferences of the types of arguments used [Hansen & Walton, 2013]. Thousands of real examples of these forms of argument have been analyzed in the argumentation literature, such as the considerable literature on fallacies, with the aid of tools like argument mapping [Reed *et al.*, 2007; Rowe *et al.*, 2006]. On this basis, the structure, use, and importance of schemes for argumentation studies have been justified inductively. This method consists in the following steps:

1. The structure of a scheme is outlined considering the literature on the topic.
2. A significant mass of examples of arguments is analyzed using the scheme, adapting and modifying the scheme so that it can best describe the specific natural arguments.
3. It is shown that the form of argument represented by the scheme under analysis is significantly important for the study of argumentation as it occurs in natural language discourse (and other specialized contexts such as legal discourse).
4. Empirical justification is given that this form of argument needs to be recognized as a basic scheme for argumentation.

Second, schemes are instruments that can be used for the purpose of teaching critical thinking. Informal logic is a field is known for having grown from its origins in textbooks that departed from formal logic and instead proceeded on the basis of analyzing numerous examples of arguments from ordinary discourse, such as those taken from magazines and newspapers. There is an abundance of such textbooks full of examples of everyday arguments related to topics such as the informal fallacy of appeal to authority, false cause, and so forth. During its growth stage and subsequent theoretical flowering, the field followed this trend by stressing the importance of analyzing real arguments “on the hoof”. For example, the handbook *Informal Logic* [Walton, 1989] was based on hundred 150 key examples, many of them illustrating forms of argument now identified with argumentation schemes, including personal attack, uses and abuses of expert opinion, arguments from analogy, arguments from correlation to cause, and so forth. These textbooks and continued academic writings on informal logic contained a very large number of such examples, often analyzed in minute detail. Argumentation schemes, such as argument from expert opinion, are tested against the real examples, to discuss the respects in which the abstract scheme fits or does not fit the vagaries of the real-life example. This body of data confirms that certain types of arguments, mainly the ones subsequently identified as argumentation schemes, are not only extremely common, but are also highly influential in daily practices of argumentation.

Third, schemes can be used in education both for teaching students how to argue and for learning through argumentation [Erduran and Jimenez-Aleixandre, 2007; Erduran and Jiménez Aleixandre, 2012; Rapanta and Walton, 2016]. The interest in argumentation and the patterns for representing natural arguments is growing [Rapanta *et al.*, 2013]. The argumentation schemes illustrated in [Walton, 1995; Walton *et al.*, 2008] have been applied to science education in order to represent students' arguments and improve the quality thereof [Rapanta and Macagno, 2016], retrieve the implicit premises, and assess and rebut their reasoning in a systematic fashion [Macagno and Konstantinidou, 2013], or to assess the quality of argumentation [Duschl *et al.*, 1999; Ozdem *et al.*, 2013]. However, a crucial problem arising out of the use of schemes in education is their differentiation [Kim *et al.*, 2010; Nussbaum and Edwards, 2011]. Students often fail to understand the differences between various types of arguments, and the recent developments in education tend to conflate the schemes instead of providing criteria for classifying or distinguishing between them.

Fourth, schemes have now been recognized as important for argument mining, and it has also been recognized that there are too many schemes for handy use [Mochales Palau and Moens, 2009; Mochales Palau and Moens, 2011]. Configuring the relationships between clusters of them, and the internal structure of each cluster, would help in the research efforts to apply the schemes as working tools to a broader range of problems as the field of computational linguistics has moved forward.

From a theoretical point of view, schemes fit into current formal argumentation models such as ASPIC+ [Prakken *et al.*, 2015], DefLog [Verheij, 2003a] and the Carneades Argumentation System [Walton and Gordon, 2012]. Among the basic schemes presented in the list of 60+ schemes in chapter 9 of [Walton *et al.*, 2008] are argument from expert opinion, argument from sign, argument from example, argument from commitment, argument from position to know, argument from lack of knowledge, practical reasoning (argument from goal to action), argument from cause to effect, the sunk costs argument, argument from analogy, *ad hominem* argument, and the slippery slope argument. These schemes are at this point well enough recognized in the argumentation literature that no detailed account of them needs to be given in this paper, except for the ones that we will focus on to illustrate general characteristics of schemes discussed in detail in the paper.

Moreover, Walton and Sartor [Walton and Sartor, 2013] have shown that the basic defeasible schemes can be justified by the teleological argument. According to this reasoning, the use of a specific scheme is warranted by the fact that it can serve an agent's goals better than using nothing, and better than other alternative schemata the agent has at its disposal. This kind of justification of basic schemes is essentially a practical one saying that these schemes, even at their current state of development, are proving to be useful in such areas as artificial intelligence and multiagent computing. Defeasible schemes allow agents to arrive at a presumptive conclusion on how to proceed in a situation where continuing to collect evidence may cause delay, taking time and costing money.

This form of justification of schemes applies both to goals of epistemic cognition (getting to the truth of a matter) and goals of practical cognition (making the best choice in given circumstances). The importance of the schemes has also been acknowledged in the history of dialectics. The forms of argument, their critical and defeasible dimension, and their structure was long ago acknowledged in the earlier concerns of the Sophists, who pointed out forms of argument useful for persuasion and deliberation [Schiappa, 1999; Tindale, 2010]. In the *Topics* [Aristotle, 1991b] and in the *Rhetoric* [Aristotle, 1991a], Aristotle set out a list of topics that, providing the abstract and general hypothetical premises of dialectical syllogisms, can be considered to be the predecessors of the argument patterns developed in modern times [Macagno *et al.*, 2014; Rubinelli, 2009; Macagno *et al.*, 2014].

The tradition of the topics was continued through the Middle Ages, with various theories aimed at providing a classification and an analysis of the nature of the schemes [Bird, 1962; Gabbay and Woods, 2008; Green-Pedersen, 1984; Green-Pedersen, 1987; Stump, 1982; Stump, 1989]. Study of the kinds of schemes that are the focus of this paper was eclipsed during the Enlightenment, as the dominant view became firmly entrenched that the only forms of reasoning that can be identified with rational thinking are those of deductive logic, and inductive reasoning of the kind used in games of chance. But the study of these schemes made a comeback in the 20th century at the beginning of, and after the rise of argumentation studies as a respectable discipline, once the basic schemes were identified by Hastings [1963], Perelman and Olbrechts-Tyteca [1969], Kienpointner [1992], Walton [1995], Grennan [1997], and Walton, Reed and Macagno [2008]. From that point onwards, the study of schemes has been recognized as important for building computational models of argumentation, and especially for applying these models to argumentation in natural language discourse.

2.3 Classification of the schemes: how to proceed

In this paper, it is shown how the complex project of classifying schemes needs to proceed by matching a top-down approach with a bottom-up approach, and in particular that this bottom-up approach needs to begin by studying relationships between clusters of nested schemes. From a top-down approach, dichotomic criteria of classification need to be found, allowing the user to decide the scheme needed, both by direct identification and by exclusion. For this purpose, an overview of the existing classification systems developed in the tradition and in the recent theories can provide useful criteria. From a bottom-up approach, relationships within groups of schemes need to be studied, and then how one group fits with another can be studied. Walton [2012] took a bottom-up approach that began with some examples at the ground level of cases where two schemes seem to apply to the same real example of an argument found in a text, leading to a difficulty of determining which scheme fits the argument. Working from there, we identify clusters of schemes that fit together, and then at the next step, we examine how these clusters can be fitted together. Once clusters of schemes are fitted together into larger groups, we can gradually learn how they fit into an overarching system.

3 The topics in the dialectical and rhetorical tradition

Argumentation schemes describe patterns from which specific arguments can be drawn. In this sense, they can be seen as the modern development of the traditional concept of *topos*, the conditional expressing a generic principle from which some of the specific premises warranting the conclusion in an argument can be drawn. The purpose of this section is to show how the ancient account of *topoi* and *loci* can be considered as the ground and the predecessor of the modern theory of schemes.

3.1 Aristotle

The idea of providing general principles of inference from which various arguments can be drawn was the ground of Aristotle's *Topics* and *Rhetoric*. The Aristotelian *topoi* can be conceived as principles [De Pater, 1965, pp.150–159] having often the form of "P, then Q". The various semantic (material) relations between P and Q, or the "nature of the things which the terms of the argument represent or stand for" [Green-Pedersen, 1987, p.413], constitute the differences between the various *topoi*. For example, P and Q can be related by a relation of genus-species, *definiens-definiendum*, contraries, similarity, etc. The function of the *topoi* in the mechanism of argument production can be explained as follows [Slomkowski, 1997, p.45]:

> The enthymemes seem to be instances of *topoi*; or, expressed differently, enthymemes are arguments which are warranted by the principle expressed in the *topos*. Thus hypothetical syllogism would fall under a *topos* insofar as it falls under its major premiss in which the essence of the hypothetical syllogism is expressed.

Topoi can be considered as the external general rules of reasoning of an enthymeme, or the genera of the major premises of dialectical and rhetorical syllogisms. *Topoi* can work as rules, namely as the principle of inference guaranteeing the passage from an enthymematic premise to the conclusion. For example, we consider the following enthymeme [Slomkowski, 1997, p.51]: âĂć

âĂć Doing greater injustice is a greater evil.

âĂć From "what is more A is more B", you may infer: "A is B".

âĂć Doing injustice is an evil.

The *topos* can be also used as a general principle from which it is possible to draw the specific premises of a hypothetical syllogism [Bird, 1960; Bird, 1962; Macagno *et al.*, 2014]. For example, the same argument mentioned above can be completed by adding the major premise that is an instantiation (an axiom-instance) of the *topos* from the more [Slomkowski, 1997, p.53] (Table 2):

General principle	If being more A is more B, then A is B.
Specific instantiation of the *topos* as a premise	If doing greater injustice (A) is a greater evil (B), then doing injustice (A) is an evil (B).
Minor premise	Doing greater injustice (A) is a greater evil (B).
Conclusion	Doing injustice (A) is an evil (B)

Table 2: *Topoi* as general principles of inference

The aforementioned mechanism of specification (or instantiation) of the *topoi* brings to light a fundamental distinction that Aristotle draws between generic *topoi* and the *idia* (the specific topics) [Rubinelli, 2009, pp.59–70]. While generic *topoi* are abstract and commonly shared conditionals under which specific premises can be found, the specific *topoi* represent premises warranting the conclusion ([De Pater, 1965, p.134]; [Stump, 1989, p.29]) that are accepted within specific disciplines, such as ethics, law, or medicine. For example, consider the following specific topic [Lawson, 1885, p.262]:

> Where a person does an act, he is presumed in so doing to have intended that the natural and legal consequences of his act shall result.

In specific domains of knowledge, specific *topoi* can be listed as instruments of invention, premises that can be used to construct arguments in support of typical conclusions.

Generic topics can be considered as abstractions from the specific ones, or more correctly, an abstraction from a large number of specific topics. They provide classes of both necessary and defeasible inferences [Bird, 1960; Bird, 1962; Christensen, 1988; Drehe, 2011; Stump, 2004]. In the first class fall some maxims setting out definitional properties of meta-semantic concepts, i.e. concepts representing semantic relations between concepts, such as definition, genus, and property. For example the *locus* from definition, which establishes the convertibility between definition and *definiendum*, represents also the essential logical characteristic that a predicate needs to have in order be considered as a "discourse signifying what a thing is." Other *loci*, such as the ones based on analogy or the more and the less, are only defeasible, as they represent only commonly accepted relationships. In the *Topics* [Aristotle, 1991b], Aristotle focuses most of his analysis on the topics governing the meta-semantic relations between concepts, i.e. genus, property, definition, and accident. The Aristotelian account was developed in the Latin and medieval dialectical tradition, which developed classifications of the topics (called *loci*) based on the type of material relation they represent.

3.2 Cicero

Cicero [Cicero, 2003] reduced the Aristotelian list of *topoi* to 20 *loci* or maxims, grouping them in generic categories (differences) and dividing them in two broad classes, the intrinsic and the extrinsic topics [Stump, 1989]. While the first ones proceed directly from the subject matter at issue (for instance, its semantic properties), the external topics (the Aristotelian arguments from authority) support the conclusion through contextual elements (for instance, the source of the speech act expressing the claim) (Cicero, *Topica*, 8, 3–4). In between there are the topics that concern the relationship between a predicate and the other predicates of a linguistic system (for instance, its relations with its contraries or alternatives). We represent the topics of Cicero in Table 3 below.

Cicero pointed out some *loci* that, on his view, are principally used by dialecticians. Such topics, named *loci* from antecedents, consequents, and incompatibles (no. 8, 9, and 10 in Table 1), represent patterns of reasoning based only on the meaning of the connector of the hypothetical premise (if...then). For instance, if such a premise holds, and the antecedent is affirmed, the consequent follows necessarily (topic from antecedents) (Cicero, *Topica*, 53, 1–25). These *loci* seem to be aimed at establishing commitments based on previous commitments. In other words, instead of increasing the acceptability of a viewpoint based on the acceptability of the content of the premises on which it is grounded, such topics lead the interlocutor to the acceptance of a conclusion because of his previous acceptance of

Intrinsic		Extrinsic
Directly from the subject matter	***From things somehow related to the subject matter***	
1. *definitio* • By material parts (whole-part definition) • By essential parts (genus-species definition) 2. *notatio* (etymological relation)	1. *Coniugata* (inflectional relations) 2. *Genus* (genus-species relation) 3. *Forma* (species-genus relation) 4. *Similitudo* (similarity relation) 5. *Differentia* (difference relation) 6. *Contraria* (4 types of opposite relation) 7. *Adiuncta* (relation of concomitance) 8. *Antecedentia* 9. *Consequentia* 10. *Repugnantia* (incompatibles) 11. *Efficentia* (cause-effect relation) 12. *Effecta* (effect-cause relation) 13. *Ex comparatione maiorum, minorum, parium* (comparison)	Authority

Table 3: Cicero - Classification of generic topics

other propositions [Green-Pedersen, 1984, p.256].

Cicero connected the theory of topics to the division of discourse according to the Hermagoras stasis, the issue of the discussion, formulating the proposition to be proved or disputed [Kennedy, 1963, p.303]. He provided a classification of the topics according to their function for addressing a specific type of issue, namely conjecture, definition, and qualification (Cicero, *Topica*, 87) (Table 4).

Conjecture	**Definition**	**Qualification**
Cause, effect, circumstances	Definition, description, notation, division, partition, consequent, antecedent, inconsistencies, cause and effect, *adiuncta*.	Comparison

Table 4: Cicero - Division of topics by issue

Cicero's classification of topics became the ground for Boethius' works, which are the basis of the medieval dialectical tradition ([Stump, 1982]; [Stump, 1989]; [Stump, 2004]).

3.3 Boethius

Boethius commented on and organized Cicero's *loci* in his *In Ciceronis Topica* and *De Topicis Differentiis*, distinguishing between necessary and plausible connections and between dialectical and rhetorical *loci*. The treatise on *De Topicis Differentiis* includes *loci* that in Cicero and previously in Aristotle were distinguished as dialectical and rhetorical topics.

Boethius underscored how while dialectical *loci* stem from the rules of prediction and the logic-semantic properties of the predicates, rhetorical *topoi* represent the possible connections between things having different qualities (*De Topicis Differentiis*,1215C).[1] Some dialectical topics, such as topics from definition or genus and species, are necessary [Macagno and Walton, 2014, Ch.3], while others (for instance, from *adiuncta*) represent only frequent connections. This relation between probable and necessary consequence was studied in the Middle Ages. Garlandus Compotista classified topics according to their logical (demonstrative) role. Topics from whole (which includes definition and genus), along with part and equal became the foundations of categorical syllogism [Stump, 1982, p.277].

In Boethius the Aristotelian *topoi* are interpreted as *maximae propositiones* falling under *differentiae*, genera of these maxims. *Maximae propositiones* are general principles, also called axioms. They are general (indefinite in respect to particulars) and generic propositions that several arguments can instantiate, and they have warranting the conclusion in an argument as a primary role. The relationship between the terms of the premises and the conclusion, namely the respect under which they are regarded, is called *differentia*, representing the criterion of appropriateness or the genus of maxims. The maxim is found from the genus of the *maximae propositiones* and the relationship between the terms of the first premise [Stump, 1989, p.6]. The structure of a topic are illustrated in Table 5.

First term:	Every virtue is advantageous.
Middle term:	Justice is a virtue.
Second term:	Therefore justice is advantageous.
Maxim:	What belongs to the genus, belongs to the species.
Differentia:	From the whole, i.e. the genus

Table 5: Argument and maxim in Boethius

[1] Rhetorical *loci* are similar in form to the dialectical ones, but they proceed from frequent connections between things, from stereotypes and not from semantic properties of concepts (for instance, usually people addicted to alcohol are dissolute, this person is alcoholic, therefore he is dissolute. See Boethius *De Topicis Differentiis*1215b).

Topoi are divided into three main categories: intrinsic, extrinsic and intermediate. While the first two categories are similar to Cicero's organization, the third is based on different principles. *Loci medii* represent semantic connections of grammatical relations, such as from words stemming from the same root, or semantic relations of division underlying the definition of the word (Table 6).

Intrinsic Loci		
From substance	From things accompanying the substance	
•From the definition •From the description •From the explanation of the name	•From the whole (genus) •From the integral whole •From a part (species) •From the parts of an integral whole •From efficient cause •From the matter	•From the end •From the form •From the generation (effects) •From the corruption •From uses •From associated accidents
Intermediate Loci	**Extrinsic Loci**	
•From inflections •From coordinates •From division	•From estimation about a thing •From similar •From what is more •From things that are less •From proportion	•From contraries •From opposites with reference to privation and possession •From relative opposites •From opposites with reference to affirmation and negation •From transumption

Table 6: Boethius - Division of the dialectical *loci*

Boethius distinguishes the dialectical *loci* from the rhetorical ones. Rhetorical topics are drawn from not from the concepts (representing the abstract relations between concepts), but from the things and how things usually are. For example, while the dialectical topic from genus proceeds from the definition of a concept (if a person is drunk, he is also intoxicated), the rhetorical one concerns how a more generic concept is usually related to a more specific one (usually if someone is not dissipated, he does not get drunk). Boethius takes from Cicero the rhetorical topics, not dealing with the abstract principles of inference concerning concepts, but with the circumstances concerning the specific cases[2]. For instance, reasoning from place,

[2]They are different from the preceding topics, because the preceding topics either contained deeds or adhered to deeds in such a way that they could not be separated, as place, time, and the rest, which do not desert the action performed. But those things that are associated with the

name, time depends on the fact, stem from the factors of the event and not from the logic-semantic relations between concepts. The rhetorical topics are organized into the four classes pointed out by Cicero (*De Topicis Differentiis*,1212A-1214A) (Table 7).

Intrinsic Loci			
Person		Action	
• Name (Verres) • Natura (Barbar) • Mode of life (Friend of nobles) • Fortune (Rich) • Studies (Architect)	• Luck (Exiled) • Feelings (Lover) • Disposition (Wise) • Purpose • Deeds • Words	• Gist of the deed (Murder of a relative) • Before the deed (He stole a sword) • While the deed occurs (He struck violently) • After the deed (He hid him in a secret place)	• When: Time (night) and opportunity (people were sleeping) • Where: Place (bedroom) • How: Method (secretly) • With the aid: Means (with many men)
Comparing circumstances	**Extrinsic Loci**		
• Species • Genus • Contrary • Result • Greater • Lesser • Equal	• By what name to call what has been done • Who are the doers of the deed • Who approve of its having been thought up • What is the law, custom, agreement, judgment, opinion, and theory for the thing. • Whether the thing is contrary to custom • Whether men generally agree to these things.		

Table 7: Boethius - Division of the rhetorical *loci*

3.4 Abaelardus

During the Middle Ages, the focal point of the study of argument was the connection between dialectics and demonstration. Beginning with the XI century, Garlandus Compotista analysed the categorical syllogisms as proceeding from topics from whole, part, and equal. On the other hand, he conceived all the topics under the logical forms of topics from antecedent and consequent, whose *differentiae* (the *genera* of *maximae propositiones*) are the syllogistic rules [Stump, 1982, p.277]. In the XII

action do not adhere to the action itself but are accidents of the circumstances, and they provide an argument only when they enter into comparison. The arguments, however, are taken not from contrariety but from a contrary, and not from similarity but from a similar, so that the argument seems to be taken not from a relationship [such as contrariety] but from things associated with the action [such as contraries]. Those things are associated with the action which are related to the very action at issue (*De Topicis Differentiis*,1214B 6-1214C 19).

century, Abelard in his *Dialectica* examined the structure of dialectical consequence in its components for the first time [Kienpointner, 1987, p.283]).

Abelard described topics as imperfect inferences, different from valid categorical syllogisms. In this work, the *maxima propositio*, expressing a principle of inference, is related to the function of invention. The *maxima* is the general principle that is useful for finding the propositions accepted by everybody or the by the wise (the *endoxa*) relative to the subject dealt with in the argument. From this perspective, the structure of an argument is similar to a syllogism. The main difference lies in the nature of the assumptions, the propositions connecting the general principles to the subject of the reasoning. While dialectical inferences depend on the content of the propositions (or, rather, on the terms and their connections), syllogisms depend only on the form. The difference between form and content can be explained with the following cases. A syllogism such as:

> Every man is an animal
> But every animal is animate
> Therefore, every man is animate

depends on a rule of inference, that is [Abaelardus, 1970, p.262]:

> *posito antecedenti ponitur consequens* (if the antecedent is affirmed, the consequent is affirmed as well))

The connection between the terms of the inference depends only on their position in the propositions. On the other hand, dialectical inferences cannot be resolved only by considering the positions of the terms. These inferences are imperfect, since assumptions are needed for the conclusion to follow from the premises. For instance, the consequence

> If he is a man, he is an animate being

is necessarily valid since it is known that "animate being" is the genus of man and "whatever is predicated of the species is predicated of the genus as well." The inference depends on the local connection between the terms, on the *habitudo*. The *habitudo* is the topical relation, the semantic-ontological respect under which the terms are connected to each other in a (dialectical) syllogism ([Green-Pedersen, 1984, p.185]; [Green-Pedersen, 1987, p.415]), and on which the strength of the inference depends [Abaelardus, 1970, pp.254-257]. The mechanism of an argument scheme can be shown by the ancient model of Abelard [Abaelardus, 1970, p.315], in which the assumptions were connected to the axioms, to the maxims the *locus* proceeded from [Stump, 1989, p.36] (Table 8).

Consequence	If Socrates is a man, he is an animate being.
Maxim	What the species is said of, the genus is said of as well.
Assumption	But "man," which is the species of "animate being" is said of Socrates; also therefore "animate being," which is clearly its genus.
Assumption 1	"Man" is a species of "animate being."
Syllogism 1	• What the species is said of, the genus is said of as well. • Man is species of "animate being". • Therefore, if man is said of anything, "animate being" is said of it as well.
Syllogism 2	• If "man" is said of anything, "animate being" is said of it as well. • Socrates is a man. • Therefore Socrates is an animate being.

Table 8: Rules of inference and the material structure of arguments in Abelard

In the example above, the passage from the predicate "to be a man" attributed to the subject to the different predicate "to be an animate being" is grounded on a relation of semantic inclusion between these two predicates, i.e. a genus-species relation [Bird, 1962]. This relationship guarantees the inference based on a rule (the maxim) that expresses a necessary consequence of the concept of genus itself. The genus expresses the generic fundamental features of a concept, answering to the question "what is it?" and is attributed to all the concepts different in kind (Aristotle, *Topics* 102a 31-32). For this reason, it is predicated of what the species is predicated of.

After Abelard, in the 12th century, the notion of form of inference was developed into a reduction of all topical inferences to syllogisms. Later on, in the 13th century analytical consequences were analysed as following from topics "*dici de omni*" and "*dici de nullo*" (Every A is B, Every B is C, therefore every A is C). Demonstration is for this reason based on a topical relation (from the whole)[Green-Pedersen, 1984, p.256].

4 Modern Theories of Schemes

In the modern and contemporary theories on argumentation (or argument) schemes, several types of classification have been advanced [Walton *et al.*, 2008]. In this section, the most relevant theories on schemes and the classification thereof will be summarized.

4.1 Perelman and the New Rhetoric

Perelman and Olbrechts-Tyteca divided their system of *topoi* into two broad categories, defined based on the two purposes that they considered to be the basic ones, finding associations and dissociations between concepts [Perelman and Olbrechts-Tyteca, 1969, p.190]. According to the *New Rhetoric*, arguments from association are divided in three main classes: Quasi-logical Arguments, Relations Establishing the Structure of Reality, and Arguments based on the Structure of Reality, while dissociation constitutes a distinct class. This classification can be represented in Table 9.

<table>
<tr><th colspan="2" rowspan="2">Quasi-Logical Arguments</th><th colspan="2">The Relations Establishing the Structure of Reality</th></tr>
<tr><th>Establishment through Particular Case</th><th>Reasoning by Analogy</th></tr>
<tr><td colspan="2">▪ Contradiction and Incompatibility
▪ Identity and Definition
▪ Analyticity, Analysis and Tautology
▪ The Rule of Justice
▪ Arguments of Reciprocity
▪ Arguments of Transitivity
▪ Inclusion of the Part in the Whole
▪ Division of the Whole into its Parts
▪ Arguments by Comparison
▪ Argumentation by Sacrifice</td><td>▪ Example
▪ Illustration
▪ Model and Anti-model</td><td>▪ Analogy
▪ Metaphor</td></tr>
<tr><th colspan="4">Arguments based on the Structure of Reality</th></tr>
<tr><th>Sequential Relations</th><th>The Relations of Coexistence</th><th>Double Hierarchy Argument</th><th>Differences of Degree and Order</th></tr>
<tr><td>▪ Causal Link
▪ Pragmatic Argument
▪ Ends and Means
▪ Argument of Waste
▪ Argument of Direction
▪ Unlimited Development</td><td>▪ Analogy
▪ The person and His Acts
▪ Argument from Authority
▪ The Speech as an Act of the Speaker
▪ The Group and its Members
▪ Act and Essence
▪ Symbolic Relation</td><td></td><td></td></tr>
</table>

Table 9: Classification of the arguments in the New Rhetoric

This classification is based several criteria, namely on the conceptual/ontological structure (association-dissociation; the reference to the structure of reality), the logical structure (quasi-logical vs. non-logical arguments), and the type of relations between concepts (sequential vs. coexistence). However, the interrelation between all these criteria is not specified, and there is not a unique rationale linking all such different arguments.

4.2 Toulmin

A different approach is provided by Toulmin, Rieke and Janik (1984), in which they classified arguments based on the basic functions of the warrants on which the arguments are grounded. Nine general classes of arguments were distinguished, subdivided into subclasses [Toulmin *et al.*, 1984], shown in Figure 1.

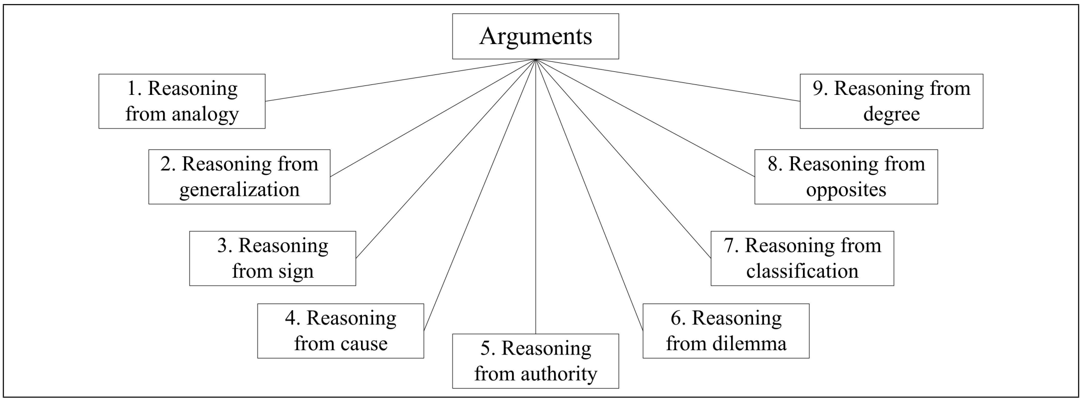

Figure 1: Classification of the arguments in Toulmin

Also in this case, different criteria are used in the classification. Some schemes represent types of reasoning (such as generalization, sign, or analogy); others are characterized by logical rules of inference (dilemma, opposites); others refer to the content of the argument (authority, classification, cause, degree). The relationship between the various criteria is not given.

4.3 Kienpointner

Kienpointner in *Alltagslogik* provides a complex and fine-grained classification, based on four criteria: 1) the type of inference; 2) the epistemic nature of the premises; 3) the dialectical function of the conclusion; and 4) the pragmatic function of the conclusion. On his view, every scheme 1) can proceed from different logical rules; 2) must be real (namely based upon the truth or likeliness of the premises), or fictive (grounded upon the mere possibility) (epistemic nature of the premises); 3) it must be pro or contra a certain thesis (dialectical function); and 4) it must have either a descriptive or a normative conclusion (pragmatic function) [Kienpointner, 1992, p.241]. In this sense, all the schemes can have descriptive or normative, pro or contra, real or fictive variants. The classification provided in *Alltagslogik* groups 21 schemes in three abstract classes characterized by the typology of the inferential rule: argument schemes using a rule; argument schemes establishing a rule by means of induction; argument schemes both using and establishing a rule (Figure 2).

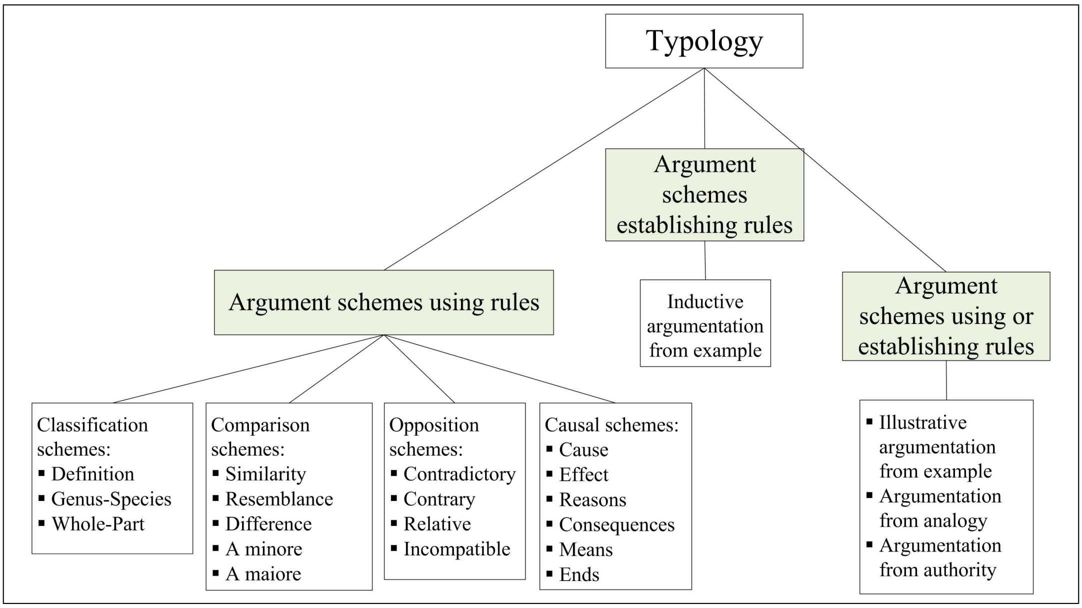

Figure 2: Classification of the arguments in Kienpointner

The first class, as shown in Figure 2, is subdivided in its turn in four content-based categories: classification, comparison, opposition, and causal schemes [Kienpointner, 1992, p.246]. Based on the aforementioned criteria, all the argument schemes may in turn have descriptive or normative variants, different logical forms (*Modus Ponens*, *Modus Tollens*, Disjunctive Syllogism, etc.), different dialectical purposes (establishing or countering a viewpoint), and different word-world relation (fictive – real).

This system of classification is aimed at distinguishing first the type of reasoning (induction, deduction), and then differentiating between the various material relations. The possible limitation of this system is that while the material relation of many deductive schemes is specified and distinguished, the content dimension of the inductive schemes is not pointed out.

4.4 Pragma-Dialectics

The pragma-dialectical system of classification of schemes consists of three basic schemes [Van Eemeren and Grootendorst, 1992]: 1) symptomatic argumentation; 2) argumentation based on similarities; and 3) the instrumental argumentation. The first scheme represents type of argumentation in which the speaker tries to convince his interlocutor "by pointing out that something is symptomatic of something else." In this type of pattern, what is stated in the argument premise is a sign or symptom of what is stated in the conclusion. The second scheme is grounded on a relation of analogy between what is stated in the argument premise and what is stated in the conclusion. In the third type of scheme the argument and the conclusion are linked by a very broad relation of causality. Other arguments are classified under these categories [Van Eemeren and Grootendorst, 1992]. For instance, arguments based on inherent qualities or a characteristic part of an entity or from authority are regarded as belonging to the symptomatic argumentation; arguments pointing out the consequences of an action or based on the means-end relationship are considered as subclasses of causal arguments [Garssen, 2001].

This system of classification is grounded on a twofold criterion. While causal argumentation is characterized by a material relation, analogical argumentation represents a type of reasoning independent from the specific content of the premises and conclusion. Symptomatic argumentation is a combination of these two criteria, as a sign or a symptom presupposes an abductive pattern and a material causal relation.

4.5 Grennan

In Grennan's [Grennan, 1997, pp.163-165] typology, the structurally valid inductive[3] inference patterns are classified according to 9 warrant types, derived from Ehninger and Brockreide's typology [Brockriede and Ehninger, 1963]. The warrant types include possible reasons for inferring conclusions from premises, all belonging to the "logical mode" (and not to other types of motivations, such as emotions). The argument patterns can be summarized as follows:

1. **Cause to Effect**: The phenomenon mentioned in P produces the one in C.
2. **Effect to Cause**: The phenomenon mentioned in P is best explained by C.
3. **Sign**: The phenomenon mentioned in P is symptomatic (naturally or conventionally) of one reported in C.
4. **Sample to Population**: What is true of sample of X is also true of other Xs.
5. **Parallel Case**: What is true of the referent of P is also true of other Xs.
6. **Analogy**: *B1* is to *B2* in C as *A1* is to *A2* in P.
7. **Population to Sample**: What is true of Known Xs is also true of this X.

[3] Inferences, in an informal logic perspective, are considered inductive, since argumentation does not deal with deductive validity. The criterion for discriminating between acceptable and unacceptable patterns is provided by a logical intuition.

8. **Authority**: S (the assertor of C) is a reliable source.

9. **Ends-Means**: The action mentioned in C generally achieves the end mentioned in P.

The patterns mentioned above are individuated on the basis of the warrant type. Together with this criterion of argument classification, Grennan presents a typology of claims. Each argument can be analysed relative to the type of warrant and to the kind of conclusion to be supported. The types of claim identified by Grennan [Grennan, 1997, p.162] can be represented in Table 10.

Type of Claim	Example
1. *Obligation Claims:* X must do A.	"Sam must apologize."
2. Supererogatory Actuative Claims: X ought to do A (they express a judgment that is in the interests of someone other than X for X to do A)	"I ought to help the needy in this area."
3. Prudential Actuative Claims: X ought to do A.	"Canadians ought to avoid heart diseases."
4. *Evaluative Claims,* of which there are three kinds: grading, rating, and comparison.	"This is a good cantaloupe." "Steffi Graf is the best female tennis player at this time." "Gretzky is a better hockey player than Howe was."
5. *Physical-World Claims,* which include both physical brute facts and institutional facts.	"The sun is setting." "The Dodgers beat the Giants three to two in eleven innings."
6. *Mental-World Claims,* which ascribe mental phenomena.	"He is upset."
7. *Constitutive-Rule Claims,* which are based on definitions and other necessary truths and falsehoods.	"In this election, majority should be defined as a majority of members present and voting." "Solid iron does not float in water."
8. *Regulative-Rule Claims,* which express obligations and prohibitions.	"Driving on the right is obligatory."

Table 10: Grennan: Classification of schemes

The types of warrant and the types of claim are the two criteria underlying Grennan's typology of argument patterns, each characterized by a premise, a warrant, and a conclusion. In the diagram below are represented the valid and useful patterns of arguments for obligation claims resulting from this classification [Grennan, 1997, p.162] (Figure 3).

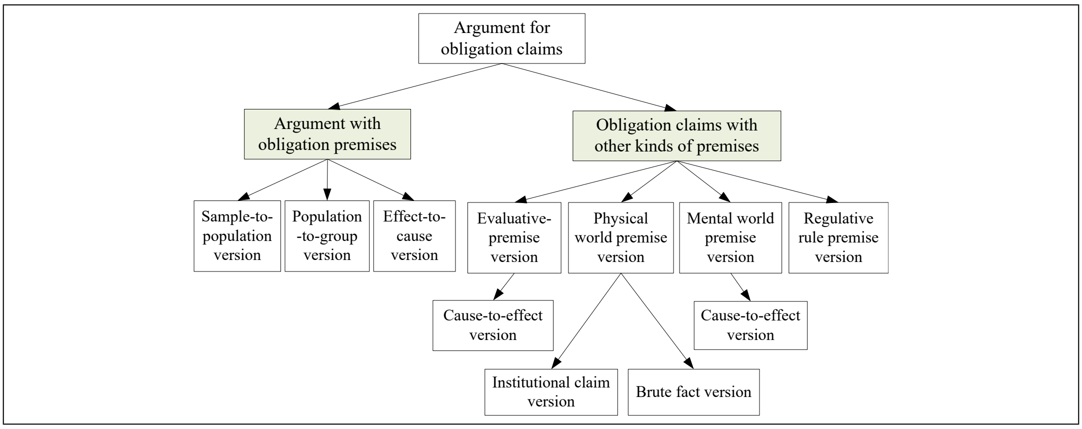

Figure 3: Classification of the arguments for obligation claims in Grennan

Grennan's typology develops the distinction between the warrant type and the kind of conclusion. The typology is extremely deep as regards the relation between speech acts and argument, but is limited to 8 warrant types.

4.6 Katzav and Reed

Rooted in the schemes presented by Walton [Walton, 1995], the classification system of Katzav and Reed [Katzav and Reed, 2004b] aims to classify an argument by virtue of the "relation of conveyance" that the complex proposition constituting the argument represents. These relations of conveyance describe how it is that one fact necessitates another, such as in the following example [Katzav and Reed, 2004a, p.2]:

> Consider, by way of illustration, a case in which the causal relation is operative: in the circumstances, the fact that the US military attacked Iraq caused the fall of Saddam′s regime. Thus, in the circumstances, and via or in virtue of the obtaining of a causal relation, the fact that the US military attacked Iraq necessitated, or made it liable that, Saddam′s regime fell.
>
> Using the causal relation and the above statements about Saddam′s regime, we can construct the following simple argument:
>
> (1) Saddam′s regime fell, because the US military attacked Iraq and if the US military were to attack Iraq, Saddam′s regime would fall.
>
> In (1), the fact that the US military attacked Iraq is represented as conveying, via the causal relation, the fact that Saddam′s regime fell. That the relation of conveyance represented is the causal relation is implicit in the subjunctive conditional "if the US military were to attack Iraq, Saddam′s regime would fall."

In [Katzav and Reed, 2004b] the nature of such relations of conveyance is unpacked and connected to the concepts of warrant and scheme and to the work of Kienpointner [Kienpointner, 1992] and Walton [Walton, 1995]in particular. In [Katzav and Reed, 2004a], they sketch a high-level classification of relations of conveyance. At the topmost level, they distinguish between "internal" and "external" relations, whereby the former depend solely upon intrinsic features (and therefore encompass definitional, cladistic, mereological and normative relations, amongst others), whilst external relations depend upon extrinsic features (thereby covering such as spatiotemporal and casual relations, amongst others). Beneath this, the classification is further broken down into groups of schemes: those of specification, constitution, analyticity and identity under intrinsic relations and causal and non-causal under extrinsic (due largely to the fact that so many schemes rely upon causal relations). The full top-level classification tree (which identifies the main branches but does not give an exhaustive specification) is given in the scheme below:

Internal relation of conveyance
Relation of specification

- Relation of species to genus
- Relation of species to genus
- Relation of genus to species
- Determinable-determinate
- Etc.

Relation of constitution

- Abstract fact constitution
- Constitution of normative facts
- Constitution of positive normative facts
- Constitution of negative normative facts
- Constitution of non-normative abstract facts
- Constitution of necessary conditions
- Constitution of causal law
- Constitution of singular causal conditionals
- Constitution of constitution facts
- Constitution of Possibility
- Constitution of Impossibility
- Etc.

Concrete fact constitution

- Species/kind instance constitution
- Property instance constitution
- Property constitution by properties
- Property constitution by particulars
- Etc.
- Constitution of singular causal facts
- Relation of a part to a whole
- Relation of whole to one of its parts
- Etc.

Relation of analyticity

- Relation of sameness of meaning
- Relation of stipulative definition
- Relation of implication

Relation of identity

- Relation of qualitative identity
- Relation of numerical identity
- Etc.

External relation of conveyance
Non-causal dependence

- Non-causal law
- Conservation
- Conserved quantity
- Conserved quality
- Etc.
- Symmetry
- Spatial symmetry
- Etc.
- Nomological incompatibility
- Thing location incompatibility
- Thing type incompatibility
- Etc.
- Topological structure conveyance

Causal dependence

- Efficient cause conveyance
- Causal law
- Singular cause to effect
- Singular effect to cause
- Common cause
- Final cause conveyance

Though the mapping from individual relations of conveyance in this classification to the argumentation schemes in [Walton, 1995] and particularly [Walton *et al.*, 2008]is not a trivial 1-to-1 correspondence, those schemes have been slotted in successfully in later work with a computational focus such as [Bex and Reed, 2011].

4.7 Lumer and Dove

The last system of classification that we consider was provided by Lumer and Dove (Lumer & Dove, 2011), using three general classes, each including subclasses:

1. Deductive argument schemes
    - Elementary deductive argument schemes;
    - Analytical arguments:
    - Definitoric arguments
    - Subsuming legal arguments:
2. Probabilistic argument schemes
    - Pure probabilistic argument schemes (statistics, signs);
    - Impure probabilistic argument schemes (best explanation);
3. Practical argument schemes
    - Pure practical argument for pure evaluations;
    - Impure practical argument schemes (for justification of actions; justification of instruments);
    - Arguments for evaluations based on adequacy conditions;
    - Arguments for welfare-ethical value judgements;
    - Practical arguments for theoretical theses.

This system consists of a mix of two distinct criteria, logical and pragmatic. While the first two classes are characterized by the type of reasoning, the last one is a type of argument with a specific pragmatic purpose, recommending a course of action. Moreover, the subclasses are defined based on both logic-based and content-based criteria, where together with distinctions based on the logical form (analytic schemes; probabilistic schemes) there are subclasses based on the nature of the premises (definitoric; subsuming).

All these types of classification show how a sole criterion is not sufficient for providing a clear and comprehensive classification of schemes. In order to understand what criteria can be used and in what abstract categories can be considered as the most basic ones, it is necessary to analyze the structure of the schemes. Once the common components of these heterogeneous combinations of premises and conclusions are brought to light, it is possible to find criteria for organizing them for specific purposes.

5 Using the schemes: A classification system

Argumentation schemes can be conceived as the prototypical combination of semantic (or topical) relations with logical rules of inference [Macagno and Walton, 2015; Macagno *et al.*, 2016; Walton and Macagno, 2015]. A classification based on the semantic link can provide an instrument for bringing to light the material relation between premises and conclusion, but the same semantic relation can be combined with types and rules of reasoning, and lead to various types of conclusion. For instance, causal relations are the ground of the argument from cause to effect, but also of arguments from sign and practical reasoning. Argumentation schemes merge the most common combinations between types of reasoning and material relations. For this reason, we need first to distinguish between these two levels, distinguishing between the various types of reasoning in Table 11.

Type of reasoning	Deductive axioms	Induction	Abduction
Type of argument	Argument from definition, genus...	Argument from example	Argument from (improper) signs
	Argument from cause to effect	...	Practical reasoning
	Argument from consequences	...	Argument from best explanation
	Argument from commitment	...	...

Table 11: Types of argument and types of reasoning

A multi-logical perspective needs to be taken into account as a classification criterion, in which the logical form can be described using distinct types of reasoning, which in turn can include various logical rules of inference (MP, MT). However, in the Latin and Medieval tradition, the formal rules of inference are treated as maxims and not as distinct levels of abstraction. For this reason, the two levels of the general, semantic topics and of the logical rules are not distinguished, and the possible interconnections between them are not taken into account. The modern theories of argumentation schemes propose classifications essentially mirroring the ancient approach. The logical rules are treated at the same level as the semantic-ontological topics, and not as distinct levels of abstraction. A possible solution is to acknowledge the discrepancy between logical form and semantic content as a divergence in kind, and try to show how these two levels can be interconnected.

A possible overarching principle can be found in the pragmatic function of the schemes, namely what they have been intended for. Argumentation schemes can be thought of as instruments for reconstructing and building arguments (intended as discourse moves), i.e. analytical or invention tools. For this reason, in order to provide a classificatory system to retrieve and detect the needed scheme it can be useful to start from the intended purpose of an argumentation scheme. From an analytical point of view, the analysis of an argument in a discourse, a text, or dialogue presupposes a previous understanding of the communicative goal (and, therefore, the "pragmatic" meaning) of the argument and the components thereof. For example, an argument can be aimed at classifying a state of affairs, supporting the existence of a state of affairs, or influencing a decision-making process.

This teleological classification needs to be combined with a practical one. The generic purposes of a move need to be achieved by means of an inferential passage. In this sense, the classificatory system needs to account for the possible (argumentative) means to achieve the pragmatic purpose of an argument. Not all the semantic relations underlying the schemes can support all the possible conclusions or purposes of an argument. Definitional schemes are aimed at supporting the classification of a state of affairs; they cannot lead to the prediction or retrodiction of an event. Similarly, a pattern of reasoning based on the evaluation of the consequences of an action or an event can be used to establish the desirability of a course of action brining it about. However, it cannot be reasonably used to establish the truth or falsity (or acceptability) of a proposition. For this reason, the analysis of the pragmatic meaning (i.e. the purpose) of an argument provides a criterion for restricting the paradigm of the possible means to achieve it. The crucial problem is to find categories of argument purposes that can establish criteria for distinguishing among classes of semantic relations, which in turn can be specified further according to the means to achieve such goals.

The first distinction to be made is based on the nature of the subject matter, which can be 1) a course of action or 2) a state of affairs. In the first case, the goal is to support the desirability or non-desirability of an action; in the second case, the schemes are aimed at providing grounds for the acceptability of a judgment on a state of affairs. The ancient dialectical accounts (Cicero, *Topica*; Boethius, *De Topicis Differentiis*) distinguished between two types of argumentative "means" to support a conclusion, namely the "internal" and the "external" arguments. The first ones are based on the characteristics of the subject matter (such as arguments from definition or cause). The latter derive their force from the source of the statement, namely from the authority of who advances the judgment or the proposal (arguments from authority). This first distinction can be represented as shown in Figure 4.

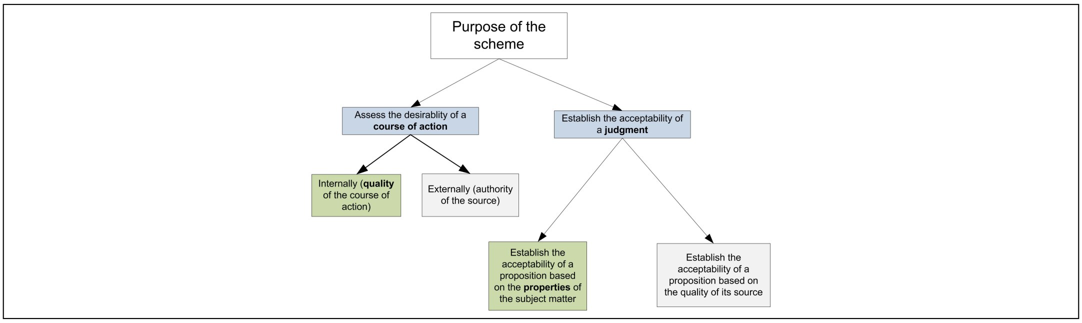

Figure 4: Purposes of an argument

The acceptability of a conclusion can be supported externally in two ways. If the argument is aimed at establishing the desirability of a course of action, the authority can correspond to the role of the source ("You should do it because he told you that!"). Otherwise, the popular practice can be a reason for pursuing a course of action ("We should buy a bigger car. Everyone drives big cars here!"). External arguments can be represented in Figure 5.

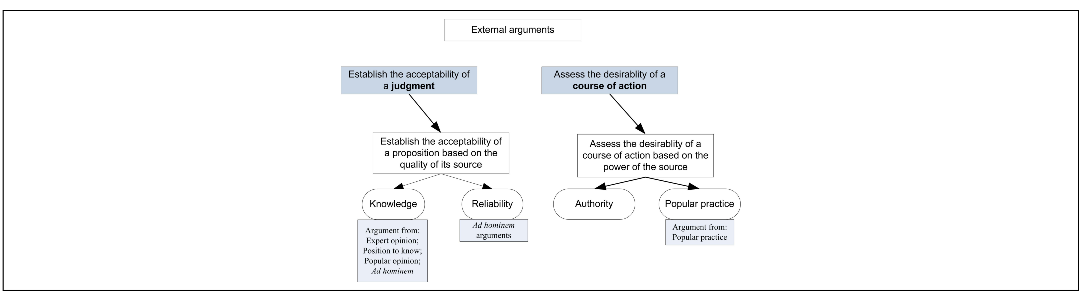

Figure 5: External arguments

When external arguments are used to support also a judgment on a state of affairs, the relevant quality of the source is not the speaker's authority (connected with the consequences of not complying with the orders/conforming to common behavior) but rather with the source's superior knowledge. The quality of the source can be also used negatively to show that a source is not reliable (it is not a good source), and that consequently the conclusion itself should be considered as doubtful (*ad hominem* arguments).

Internal arguments can be divided into the two categories of arguments aimed at assessing the desirability of a course of action, and the ones supporting the acceptability of a judgment. Courses of action can be classified as desirable or not depending on the quality of their consequences (the course of action is a condition of a resulting positive or negative state of affairs) or their function in bringing about a desired goal (an action is productive of a pursued state of affairs) (Figure 6).

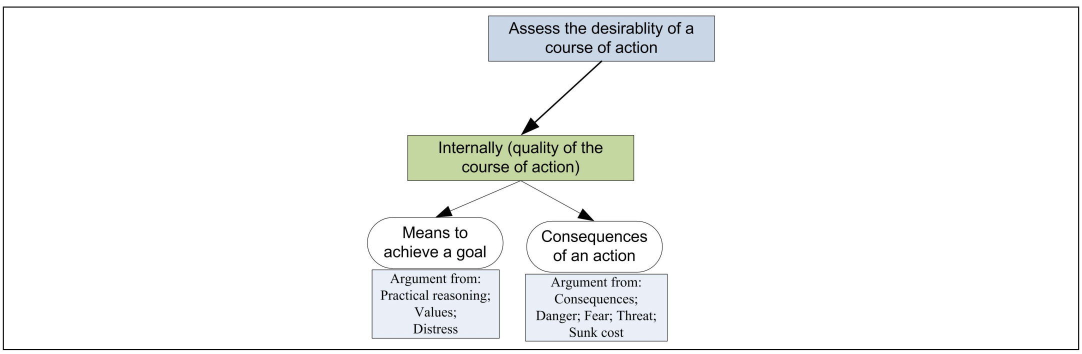

Figure 6: Internal practical arguments

The arguments used to provide grounds for a judgment on a state of affairs can be divided according to the nature of the predicate that is to be attributed. The most basic differentiation can be traced between the predicates that attribute the existence of a state of affairs (the occurrence of an event or the existence of an entity in the present, the past, or the future), and the ones representing factual or evaluative properties.

The arguments supporting a prediction or a retrodiction are aimed at establishing whether or not an event has occurred or will occur, or whether an entity was or will be present (existent). The arguments proceeding from casual relations (in particular from material and efficient causes) bear out this type of conclusion. The other type of predicates can be divided in two categories: factual judgments and value judgments. The first type of predicates can be attributed by means of reasoning from classification, grounded on descriptive (definitional) features and supporting the attribution of a categorization to an entity or an event (Bob is a man; Tom is a cat). Value judgments are classifications that are not based on definitions of categorical concepts (to be a cat) but rather on values, or rather hierarchies of values. Such judgments proceed from criteria (or more specifically, criteria of importance to the audience to whom the argument is presented) for classifying what is commonly considered to be "good" or "bad." Also the reasoning underlying the attribution of evaluative predicates, such as "to be a criminal," can be considered as belonging to this group of arguments. These latter patterns are grounded on signs of an internal disposition of character, which in its turn is evaluated. The distinctions discussed above are summarized in Figure 7 below.

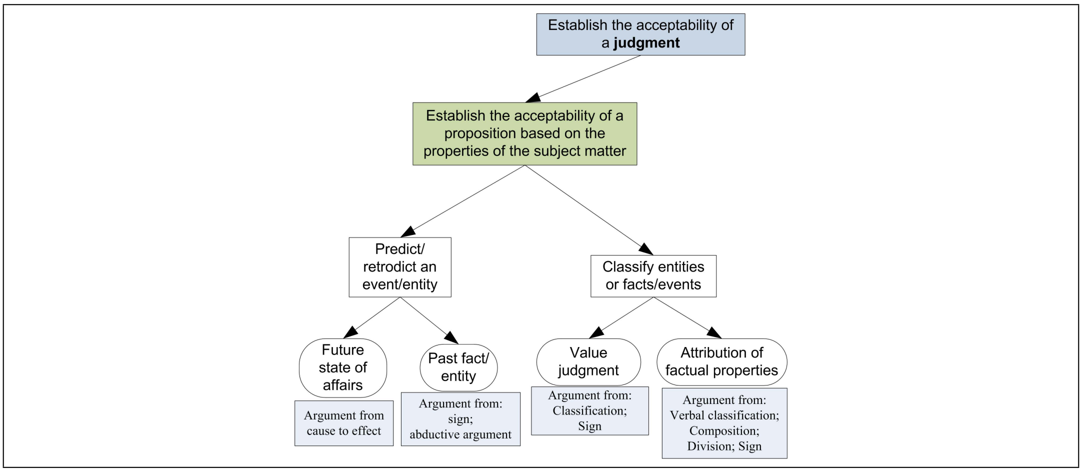

Figure 7: Establishing the acceptability of a judgment (SoA)

This system of classification of argumentation schemes is based on the interaction between two criteria, the (pragmatic) purpose of an argument and the means to achieve it. This tree model can be used both for analytical and production purposes. In the first case, the speaker's intention is reconstructed by examining the generic purpose of his move, and then the possible choices that he made to support it, based on the linguistic elements of the text. Depending on the desired level of preciseness, the analysis can be narrowed down until detecting the specific scheme, namely the precise combination of the semantic principle and the logical rule supporting the conclusion. In this fashion, the analyst can decide where to stop his reconstruction. This analytical model can be of help also for educational purposes, as it can be adapted to various teaching needs and levels. For production purposes, the nature of the viewpoint to be supported can be analyzed using the most generic criteria set out above (What is under discussion, a decision or a fact? The occurrence of an event or its classification? The naming of a state of affairs or its qualification?). Such questions closely resemble the ones that were at the basis of the rhetorical theory of stasis, namely the issues that can be discussed [Heath, 1994]. These distinctions are then combined with the specific alternative strategies to support the defended viewpoint.

The aforementioned system of classification can also account for the interrelation between the semantic relation and the different types of reasoning, namely logical forms. For example, the desirability of a course of action can be assessed internally by taking into consideration the means to achieve a goal. This pattern of reasoning can be stronger or weaker depending on whether there is only one or several alternatives. The paradigm of the possible means will determine whether the reasoning is abductive or deductive, resulting in a more or less defeasible conclusion. The same principle applies to the other semantic relations, such as the ones proceeding from cause or classification, which can be shaped logically according to inductive, analogical, deductive, or abductive types of reasoning.

6 A bottom-up approach to classification: Clusters of decision-making schemes

Argumentation schemes are characterized by both "family" resemblances and actual interconnections [Walton and Macagno, 2015]. Practical reasoning, value-based reasoning, value-based practical reasoning, argument from positive consequences, argument from negative consequences, and the slippery slope argument are related by the same similar structure based on value judgments and practical outcome. Such schemes are often also interconnected when we analyze the structure of actual arguments. However, in order to understand and choose between similar and interrelated schemes, it is necessary to examine their relations and their differences. The simplest and most intuitive version of the scheme for practical reasoning (Table 13) uses the first-person pronoun "I" to represents a rational agent, an entity that has goals, some knowledge of its circumstances, and the capability of taking action to change those circumstances. It also has sensors to perceive its circumstances, and to perceive at least some of the consequences of its actions when it acts to change its circumstances. Such a rational agent also therefore has the capability for feedback. When it perceives changes in its circumstances due to its own actions, it can modify its actions or goals accordingly, depending on whether the consequences of its actions are deemed to contribute to its goals or not. This simplest form of practical reasoning [Walton *et al.*, 2008, p.95] can be described as a fast and frugal heuristic for jumping to a quick conclusion that may later need to be retracted in the light of further considerations (Table 12).

Major Premise:	I have a goal G.
Minor Premise:	Carrying out this action A is a means to realize G.
Conclusion:	Therefore, I ought (practically speaking) to carry out this action A.

Table 12: Argument from Practical reasoning

The defeasible nature of this simple form of practical reasoning is brought out by the observation that it typically provides a starting point for action that needs to be challenged by the asking of critical questions as the agent moves ahead. Below is the standard set of critical questions matching this scheme.

CQ1 What other goals do I have that should be considered that might conflict with G?

CQ2 What alternative actions to my bringing about A that would also bring about G should be considered?

CQ3 Among bringing about A and these alternative actions, which is arguably the most efficient?

CQ4 What grounds are there for arguing that it is practically possible for me to bring about A?

CQ5 What consequences of my bringing about A should also be taken into account?

The last critical question, CQ5, often called the side effects question, concerns assessment of the potential negative consequences of carrying out the action described in the conclusion of the scheme. If negative consequences of this course of action are identified, that is a reason for withdrawing the conclusion and considering an alternative course of action that might avoid the negative consequences. Use of the term "negative" implies that values are involved, and that a rational agent is assumed to have values as well as goals that it bases its practical reasoning on.

A complication is that there is another closely related argumentation scheme associated with this critical question, Argument from negative consequences. This scheme, widely recognized in the literature, cites known or estimated consequences of a proposed course of action as presenting a reason, or set of reasons, against taking the course of action initially indicated by the practical reasoning scheme. Argument from negative consequences also has a positive form. According to the scheme for argument from positive consequences, known or estimated consequences that have a positive value for the agent are cited as a reason, or set of reasons, supporting the carrying out of the action initially considered. Below the versions of the two basic argumentation schemes for arguments from consequences are formulated as they were in [Walton *et al.*, 2008, p.101]. The first one is called argument from positive consequences (Table 13).

Premise:	If A is brought about, good consequences will plausibly occur.
Conclusion:	Therefore A should be brought about.

Table 13: Argument from positive consequences

Premise:	If A is brought about, bad consequences will plausibly occur.
Conclusion:	Therefore A should not be brought about.

Table 14: Argument from negative consequences

The second one is called argument from negative consequences (Table 14).

In both instances, an implicit premise could be made explicit in the scheme stating that if good (bad) consequences will plausibly occur, A should (not) be brought about. As with the basic form of practical reasoning, arguments from positive or negative consequences are defeasible. The premise offers a reason to accept a proposal for action tentatively, subject to exceptions as new circumstances come to be known by the agent. In these formulations, the expression "good consequences" refers to consequences taken by the agent to have positive value, and the expression "bad consequences" refers to actions taken to have negative value. These observations bring us to another pair of schemes closely related to the ones for argument from positive consequences and argument from negative consequences.

The relationship between a state of affairs, its classification according to a value, and the commitment to an action is represented in terms of value. Values (differently from [Atkinson *et al.*, 2005];[Bench-Capon, 2003]) are regarded as grounds for a type of reasoning independent from and related to (or rather, presupposed by) practical reasoning. This reasoning guarantees the so-called "practical classification" [Westberg, 2002, p.163] of a state of affairs and the commitment thereto. The scheme for argument from positive value is formulated in Table 15 as in [Walton *et al.*, 2008, p.321]:

Premise 1:	Value V is positive as judged by agent A.
Premise 2:	If V is positive, it is a reason for A to commit to goal G.
Conclusion:	V is a reason for A to commit to goal G.

Table 15: Argument from positive value

The corresponding scheme representing argument for argument from negative value is formulated in Table 16.

Premise 1:	Value V is negative as judged by agent A.
Premise 2:	If V is negative, it is a reason for retracting commitment to goal G.
Conclusion:	V is a reason for retracting commitment to goal G.

Table 16: Argument from negative value

Argument from positive consequences typically supports an argument taking the form of basic practical reasoning by giving justification for going ahead with the contemplated action. Argument from negative consequences presents a reason against taking the action being considered by citing consequences of it that would contravene the values of the agent.

Another more complex argumentation scheme has also been recognized in the literature [Bench-Capon, 2003] that combines all the schemes mentioned above. This scheme describes a form of argument called goal-based practical reasoning that combines basic practical reasoning with value-based reasoning. The version of this scheme (Table 17) is from [Walton *et al.*, 2008, p.324].

The scheme for value-based practical reasoning can also be formulated in a more explicit way that brings out an important aspect of practical reasoning, namely the circumstances of the case that can be observed by the agent and used by as a basis for reaching a decision on what to do. According to the version of the scheme formulated in [Atkinson *et al.*, 2005], any action the agent takes can be seen as a transition from the current set of circumstances to a new set of circumstances, as the agent moves forward to attempt to realize its goal.

Premise 1:	I have a goal G.
Premise 2:	G is supported by my set of values, V.
Premise 3:	Bringing about A is necessary (or sufficient) for me to bring about G.
Conclusion:	Therefore, I should (practically ought to) bring about A.

Table 17: Argument from goal-based practical reasoning

The last decision-making argument is the slippery slope argument, sometimes also called the wedge argument. Different varieties of slippery slope argument have been recognized, such as the causal slippery slope argument, the precedent slippery slope argument, the linguistic slippery slope argument, which depends on the vagueness of terms or concepts, and a more complex (all-in) form of slippery slope argument that combines the simpler variants. A good place to start is a simple version of the slippery slope type of argument formulated as the basic scheme in [Walton *et al.*, 2008, p.340] (Table 18).

First Step Premise:	A_0 is up for consideration as a proposal that seems initially like something that should be brought about.
Recursive Premise:	Bringing up A_0 would plausibly lead (in the given circumstances) to A_1, which would in turn plausibly lead to A_2, and so forth, through the sequence $A_2, \ldots A_n$.
Bad Outcome Premise:	A_n is a horrible (disastrous, bad) outcome.
Conclusion:	A_0 should not be brought about.

Table 18: Argument from goal-based practical reasoning

According to [Walton *et al.*, 2008, p.340], the following three critical questions match this basic scheme.

CQ1 What intervening propositions in the sequence linking up A_0 with $_n$ are actually given?

CQ2 What other steps are required to fill in the sequence of events, to make it plausible?

CQ3 What are the weakest links in the sequence, where specific critical questions should be asked on whether one event will really lead to another?

So here we have a cluster of schemes all closely related to each other. The argument from negative consequences is one of the critical questions matching the basic scheme, but the scheme for argument from negative consequences is itself based on the closely related scheme for argument from negative values.

Clarifying the relationships among this cluster of schemes enables us to draw an important distinction widely discussed in the philosophical literature on practical reasoning between two distinct types of practical reasoning: instrumental practical reasoning and value-based practical reasoning. When it comes to classifying the arguments within this cluster of schemes, it would seem reasonable to venture as a hypothesis that the basic scheme for practical reasoning is the simplest form of it, while the scheme for value-based practical reasoning is a more complex variant of the scheme. It combines the basic scheme with the schemes for argument from values. On this approach to drawing distinctions within the cluster, arguments from positive consequences can be taken as species of arguments from positive value, and arguments from negative consequences can be taken as species of arguments from negative value. Practical experience in using assistants to use argumentation schemes to identify types of arguments in natural language text suggests that the assistants sometimes find it difficult to classify a particular argument identified in a text as fitting one or more of these schemes. It can be helpful for this purpose is to give the assistants identification conditions that attempt to formulate key essential requirements of the type of argument represented by a particular scheme.

The following is a set of three identification conditions for the type of argument matching the scheme for instrumental practical reasoning: (1) An agent (or group of agents in the case of multiagent reasoning) is attempting to arrive at a reasoned decision on what course of action to take in a given set of circumstances requiring some action, (2) the circumstances provide evidence on which to build pro and con arguments, arguments for and against the course of action being considered, (3) the agent is basing its decision on its goals, as well as its perception of the circumstances of the case, (4) arguments need to be weighed against each other as stronger or weaker reasons for taking this action or not, and (5) the agent purports to be using this evaluation of the stronger or weaker reasons as its basis for taking the action or not. Here the four conditions describe an agent deciding whether to take a particular course of action or not. But it needs to be recognized that in some situations there may be several alternative courses of action to be considered, and the agent is trying to decide which of them would be the best course of action, based on the reasons provided by its goals and the circumstances of the case.

The identification conditions for the value-based species of practical reasoning are the same as the five identification conditions for instrumental practical reasoning, except that another condition needs to be added: (6) the agent is justifying its decision based on its values, as well as on its goals and its perception of the circumstances of the case. The aforementioned cluster of arguments is characterized by several types of relations, which can be of help in distinguishing them and detecting their possible nets. For example, argument from negative consequences is one of the questions matching the scheme for argument from practical reasoning. So this relationship could be described by saying that argument from negative consequences is a counterargument, a rebuttal or undercutter that can defeat an argument from practical reasoning in a given case, provided that the negative consequences can be specified, and provided that it can be shown that these consequences are indeed negative.

Already from these remarks one relationship emerges. Argument from negative consequences is based on argument from values, and is a species of argument from values. Another relationship already shown above, is that value-based practical reasoning is a more complex form of argument than instrumental practical reasoning. Value-based practical reasoning is a species of instrumental practical reasoning with argument from values added on to it.

Another relationship that emerges is that the slippery slope type of argument is clearly a subtype and special instance of argument from negative consequences. It is less evident that the slippery slope argument is also a species of value-based practical reasoning. However, it can be seen that it is. In the case of the slippery slope argument, the agent doing the decision-making must be assumed to have some goals and values in mind that the other party, the agent attacking its argument, can appeal to when mounting a slippery slope argument. Let's call the two parties the agent and critic. The slippery slope type of argument is inherently negative. The critic is using the argument to warn the agent that if he takes a first step, or continues a series of steps that he has already started, these steps will lead to a loss of control that cannot be anticipated in advance so that the sequence of actions will ultimately result in a catastrophic outcome. The critic has to assume that the agent has some values that both of them share, so that they can both agree that the outcome warned of by the critic is catastrophic, that is highly negative and worth avoiding. The critic has to assume that the agent has some goals and is acting in a rational manner so that it is trying to either achieve or at least be consistent with these goals as it carries out an action supposedly designed to fulfill them. Otherwise the critic's argument is not going to have much force and will be unlikely to deter the agent from moving ahead.

What especially distinguishes the slippery slope as a distinctive type of argument are three premises, the recursive premise, the grey zone premise and the loss of control premise. Given these observations, we can see how the value-based practical reasoning argument is embedded into the basic slippery slope argument and is a part of it. As shown in Figure 8, the basic slippery slope type of argument, represented by the scheme formulated above, is at the center of a cluster of other related schemes.

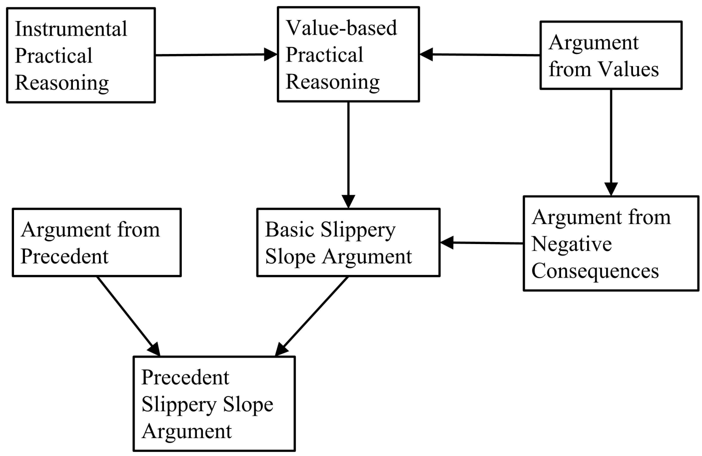

Figure 8: Cluster of Schemes

The basic slippery slope argument is derived from value-based practical reasoning as its core argument structure, where value-based practical reasoning is a combination of instrumental practical reasoning and argument from values. So here it is shown how these schemes are structured together into a cluster. It is also shown that the basic slippery slope argument is a species of argument from negative consequences, as scheme that is in turn built partly from the scheme for argument from values. So these five schemes form a cluster. But the basic slippery slope argument also has several subtypes, including the precedent slippery slope argument, the causal slippery slope argument, and the variety of slippery slope argument deriving from vagueness of a verbal criterion. According to the analysis of the slippery slope argument given in [Walton, 1992] these four species of the slippery slope argument are subtypes of a more general form of argument called the all-in slippery slope argument.

Here we put forward the hypothesis that there is a basic, minimal type of slippery slope argument from which these other more specialized variants are derived. To indicate the existence of such connections in Figure 8, we have inserted the name of the scheme for the precedent slippery slope argument underneath the schemes for argument from precedent and the basic slippery slope argument. This classification indicates another aspect of the cluster of schemes surrounding the category of slippery slope arguments.

7 Using argumentation schemes: Nets of Argumentation Schemes

Argumentation schemes are imperfect bridges between the logical (or quasi-logical) level and the conceptual one [Macagno and Walton, 2015; Macagno, 2015]. From a conceptual (material) point of view, schemes usually represent an inferential step from a specific type of premise to a specific type of conclusion. However, there is a crucial gap between the complexity of natural argumentation, characterized by several conceptual passages leading to a conclusion, and the schemes. In order to reason from consequences, we need to classify a state of affairs, evaluate it positively or negatively, and then suggest a suitable course of action, which can lead to further reasoning steps, for example from commitment. A single argumentation scheme cannot capture the complexity of such real argumentation. For this reason, we need to conceive the relationship between arguments and schemes in a modular way, in terms of nets of schemes.

A real argument can be described through interconnected and interdependent argumentation schemes, each of them bringing to light a single argumentative step that can be explicit, presupposed, or simply implied. In order to explain the idea of nets of schemes, we consider the following example taken from the debates during the conflict between Russia and Ukraine in 2014. In this case, the British Foreign secretary William Hague commented on Russia's intervention in Crimea and Ukraine as follows[4]:

Example 7.1 (The Hague Speech)**.** *Be in no doubt, there will be consequences. The world cannot say it is OK to violate the sovereignty of other nations. This clearly is a violation of the sovereignty independence and territorial integrity of Ukraine. If Russia continues on this course we have to be clear this is not an acceptable way to conduct international relations.*

This example is apparently an easy case of argument from consequences, in which Russia's continuation of its military operations is depicted by the British Foreign Secretary as leading to undesirable consequences. However, this reasoning involves also a classification of Russia's behavior as a"violation of the sovereignty independence and territorial integrity of Ukraine," and a qualification of this behavior as unacceptable by the UK and the "world." By pointing out the shared values to which the world countries are committed (the sovereignty of other nations cannot be violated), the speaker makes explicit the commitment against Russia's behav-

[4]Ukraine crisis: William Hague warns Russia of economic fallout. *The Guardian*, 3 March 2014. Retrieved from: https://is.gd/Kw8Vax. (Accessed on 15 May 2017)

ior, which is represented by the vague notion of "consequences." We represent this structure in Figure 9.

Figure 9: Net of arguments in the Hague Example

In Figure 9 the dotted boxes represent the tacit premises and the tacit ultimate conclusion, which are taken for granted by the speaker but are needed for reconstructing his reasoning. The classification, the reasoning from commitment, and the argument from consequences are deeply interconnected. The alleged world's commitment to consequences against Russia depends on the classification of the state of affairs [Macagno and Walton, 2014; Walton and Macagno, 2009], which fits into the value of "protecting nations' sovereignty." This commitment leads to an implicit threat, namely a consequence that is presupposed to be negatively evaluated by Russia.

This analysis can be applied to the structure of a slippery slope argument, such as the one advanced by the Russian defense analysts in reply to the help provided by the United States to Ukraine (which includes weapons and hardware)[5]:

Example 7.2 (The Global Escalation)**.** *U.S. provision of military aid to Ukraine would be seen by Moscow as a declaration of war and spark a global escalation of Ukraine's separatist conflict, Russian defense analysts said.*

This argument stems from a classification (US provision of military help is a declaration of war), and leads to a chain of negative consequences (global escalation)

[5]Russia Would See U.S. Moves to Arm Ukraine as Declaration of War. *The Moscow Times*, 9 February 2015. Retrieved from: https://is.gd/hxO6MW (Accessed on 15 May 2017)

that ultimately are going to affect the Western countries. Also in this case, the central argument (the slippery slope) is associated with other arguments (argument from classification and from values), resulting in the net shown in the graph in Figure 10.

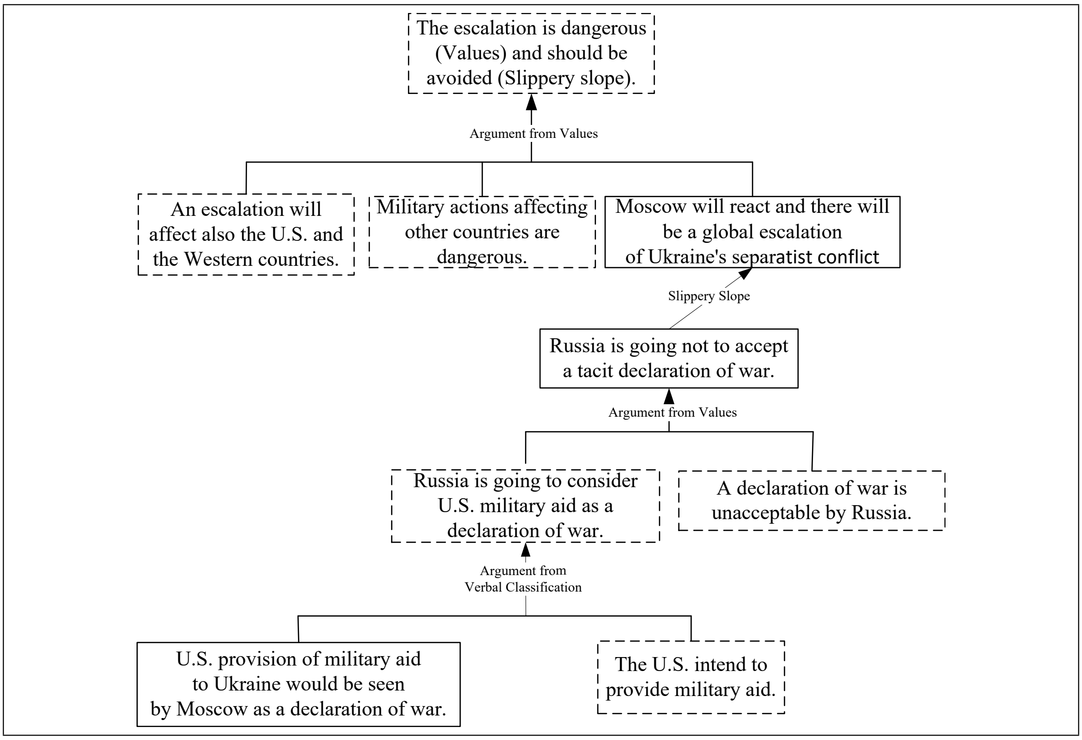

Figure 10: Net of arguments in the global escalation example

In this case, the classification justifies the slippery slope, whose force partially depends on the fact that the escalation is claimed to be global, affecting also other countries. The evaluation of this consequence therefore combines with the chain of events claimed by the analysts, and leads to the practical conclusion of avoiding the provision of military aid.

A special feature of this example is its compressed style of presentation. Slippery slope is a complex form of argument built around a connected sequence of actions and consequences starting from an initial action or policy and then proceeding through a sequence to an eventual outcome. However in many examples, the intervening sequence is left implicit, concealing a chain of intervening propositions that have to be filled in as implicit assumptions of the argument. These implicit assumptions are needed to make it fit the scheme for the slippery slope type of argument. The example really is a slippery slope argument, but in order to prove that it is, several implicit premises or conclusions have to be filled in that are essential. These intervening links are basically filled in by common knowledge concerning the normal way we expect military inventions to take place and to have consequences. By using an argument map that reveals the network of argumentation into which the given slippery slope argument fits, the puzzle of unraveling the network of argumentation using a cluster can be solved in any given case of argument interpretation.

On the perspective presented in this section, we notice that argumentation schemes appear in nets instead of in clear and independent occurrences. A scheme can capture only one passage of reasoning, while the nets can map a more complex argumentative strategy, involving distinct and interdependent steps.

8 Using Argumentation Schemes in AI and law

In the sections above we have shown how argumentation schemes have been developed theoretically, providing a system of classification and representation thereof. One of the most important areas of application of the schemes is computing, and in particular artificial intelligence. In this section, we will show very briefly how argumentation schemes have been used in AI and AI and Law, and in particular the principles guiding the formalization thereof. It is far from a complete survey, but merely attempts to show how schemes are currently being applied and modeled. It also tries to convey very briefly how schemes have evolved as they have been used for different purposes in different AI systems and areas. The discussion includes the problem of how to model critical questions matching each scheme, and how schemes are being used in AI and Law in argument mining, case-based reasoning and statutory interpretation.

The paper that introduced argumentation schemes to the AI and law community was [Verheij, 2003b]. This paper proposed the use of argumentation schemes, as a main tool for analysis in AI and law, stating [Verheij, 2003b, p.168] that the argumentation scheme is "a concept borrowed from the field of argumentation theory." Verheij investigated how argumentation schemes could be formalized for use in computational settings. He proposed [Verheij, 2003b, p.176] that any argumentation scheme can be expressed in the following format: Premise 1, Premise 2,..., Premise n, therefore Conclusion. Verheij visually represented the graph structure of an argumentation scheme by building an argument mapping software tool called ArguMed.

A formal analysis of argumentation schemes of Reed and Walton [Reed and Walton, 2005] defined a set of attributes, T, associated with propositions by a typing relation that associates every proposition to a set of attributes called a type. On this analysis a scheme is comprised of a set of tuples <SName, SConclusion, SPremises> where SName is some arbitrary token [Reed and Walton, 2005, p.179]. The gist of the analysis is that a particular scheme is given a unique name which is associated with a conclusion type and a set of premise types. An instantiation of a scheme of a type represented by a unique name must have a conclusion of the right type, and each premise must also be of the right type.

Prakken [Prakken, 2005, p.34] remarked that schemes act very much like the rules used in rule-based computer systems. The problem was that AI systems, as well as argument mapping tools of the kind used in argumentation theory, including the software systems developed in AI to assist with the building of argument diagrams, use a model of argument where the premises and conclusions are propositions. Along these lines, the structure is basically a graph with arcs joining the various points representing the propositions that can be identified as premises or conclusions. So far then it seemed that schemes were amenable to being fitted into AI systems without undue difficulty, but the central problem posed at that point was how to model the distinctive set of critical questions matching each scheme. One proposal, commented on below, is to model the critical questions as additional premises of an argument fitting a scheme.

But there was a big problem with this way of proceeding because different critical questions act in different ways in this regard. Sometimes merely asking a critical question is enough to defeat the target argument, whereas in other instances the asking of the question does not defeat the target argument unless some evidence is offered. The issue turned out to be one of burden of proof [Gordon *et al.*, 2007]. In some instances, merely asking a critical question is enough to shift the burden of proof onto the proponent who put forward the argument. In other instances, the burden of proof does not shift unless the questioner can provide some backup evidence to support the question.

Verheij [Verheij, 2003b] noted that there were variations on how the critical questions work in this regard. He noted that critical questions that point to exceptions to a general rule only undercut an argument while others could be seen refuting the argument in one of two different ways. One way is to deny an implicit assumption on which the argument depends. Another is to point to counter-arguments that can be used to attack the given argument. Verheij [Verheij, 2003b, p.180] showed that critical questions can perform four distinctively different kinds of roles:

1. They can be used to question whether a premise of a scheme holds.

2. They can point to exceptional situations in which a scheme defaults.

3. They can frame conditions for the proper use of a scheme.

4. They can indicate other arguments that might be used to attack the scheme.

It is currently widely assumed in AI that there are three ways you can attack an argument. You can attack one or more of the premises (premise attack), you can attack the conclusion (conclusion attack), or you can attack the inferential link joining the premises to the conclusion (for example by arguing that an exception applies). The last mode of attack is called undercutting [Pollock, 1995]. The first role would be that of a premise attack. The second and third roles would be undercutting attacks. The fourth role might refer to an undercutter but could also perhaps be taken to refer to a conclusion attack. So here the problem is posed of how to model critical questions given that critical questions can perform more than one function.

ASPIC+ [Prakken, 2010] is a formal argumentation system that consists of a logical language L with a binary contrariness relation that operates like negation along with two kinds of inference rules, strict and defeasible, defined over L. ASPIC+ is based on the abstract argumentation framework (Dung, 1995) which can be defined as a pair (Args, R), where Args is a set of arguments and a binary relation R on Args is called the attack relation. The underlying idea of the formalism is that each argument in a sequence of argumentation forming a directed graph structure can be defeated by other arguments so that a_2 defeats a_1, a_3 defeats $a_2, \ldots,$ and defeats a_{n-1}. Arguments in the graph can be labeled as "in" or "out". An argument is rejected (out) if it is attacked by any other argument that is in. An argument is accepted if it is not attacked by any other argument that is "in". Note that the notions of argument and argument attack are taken as primitive in an abstract argumentation system, so that such a system by itself provides no way of modeling the premises and the conclusion.

In the system developed in [Prakken *et al.*, 2015] for case-based reasoning, preferences among factors are established in the present case, and then these preferences can be applied to the current case. One of the argumentation schemes (CS1) of can be used to briefly explain how such schemes are meant to be used in legal arguments from precedent. In all these schemes, for purposes of presentation, it is assumed that the arguer is putting forward the current argument (curr) to support the side of the plaintiff.

$$\frac{\text{commonPfactors(curr; prec)} = p,\quad \text{commonDfactors(curr; prec)} = d,\quad \text{preferred}(p; d)}{\text{outcome(curr)} = \text{Plaintiff}}$$

According to this scheme, the current argument should be decided for the plaintiff because the common p factors were preferred to the common d factors in the precedent argument. [Prakken *et al.*, 2015] uses a running example to illustrate how an argument fitting a scheme can be attacked by other arguments in the formal system representing the argumentation in a legal case.

Argument schemes are being used in AI and Law for argument mining. Moens, Mochales Palau, Boiy and Reed devised techniques for automatically classifying arguments in legal texts by using indicators of rhetorical structure expressed by conjunctions and adverbial groupings [Moens *et al.*, 2007, p.226]. They identify words, pairs of successive words, sequences of three successive words, adverbs, verbs and modal auxiliary verbs. This work has been applied to legal argumentative texts [Mochales Palau and Moens, 2009; Mochales Palau and Moens, 2011]. By classifying types of arguments using argumentation schemes they built a system for searching for arguments in legal cases [Mochales Palau and Moens, 2008]. The project used human annotators supervised by legally trained personnel to identify arguments in texts of the European Court of Human Rights [Mochales Palau and Ieven, 2009]. Their results suggested that it would help to have additional criteria that can be applied to judge whether a given argument fits a particular scheme.

Rahwan et al. [Rahwan *et al.*, 2011] carried forward research on the automated identification of particular schemes by developing an OWL-based ontology of argumentation schemes in description logic that showed how description logic inference techniques can be used to reason about automatic argument classification. Their method of identifying schemes has been implemented in a web-based system called Avicenna [Rahwan *et al.*, 2011, pp. 11–13]. A user can search arguments by using schemes along with other tools.

Gordon and Walton [Gordon and Walton, 2006] proposed a solution to the problem of how to model critical questions by using three kinds of premises (ordinary premises, assumptions and exceptions) in the Carneades Argumentation System (CAS). This solution used information about the dialectical status of statements (undisputed, at issue, accepted or rejected) to model critical questions in such a way as to allow the burden of proof to be allocated to the proponent of the argument or the critical questioner as appropriate for the case in point. On this way of proceeding, ordinary premises need to be supported by further arguments even if they have not been questioned. In the case of exceptions, however, the critical questioner is the one who has to offer evidential support to make his criticism defeat the argument.

Version 4 is the current implemented formal and computational system of CAS, based on the formal model of argument [Gordon and Walton, 2016] called CAS2. CAS2 provides support for cumulative arguments, cyclic argument graphs, practical reasoning, and multi-criteria decision analysis. The source code of all four versions can be accessed on the Internet[6]. Carneades 4 is now online [7]. CAS2, as implemented in version 4 of Carneades, provides a formal model that uses argumentation schemes.

In the CAS2 model [Gordon and Walton, 2016] an argumentation scheme is defined as a tuple (e, v, g), where e is a function for weighing arguments which instantiate a scheme, v is a function for validating arguments, to test whether they properly instantiate an argumentation scheme, and g is a function for generating arguments by instantiating the scheme. The validation function tells us whether the argument instantiates a particular scheme, but then, once a set of schemes has been specified, the system can apply their validation functions to given argument to whether that scheme is instantiated, or not, by the given argument.

An argument is defined as a tuple (S, P, C, U), where S is the scheme instantiated by the argument; P, a finite subset of L, is the set of premises of the argument; c, a member of L, is the conclusion of the argument. U is an undercutter of the argument [Pollock, 1995]. In version 4 of CAS an issue is defined as a tuple (O, F), where O represents the options (called the alternative positions) of the issue, and F is the proof standard of the issue. Argument graphs in CAS version 4 are tripartite, rather than bipartite, as in the previous versions, with separate nodes for statements, arguments and issues. Argument diagrams in version 4 are extended with a new node type, diamonds, for representing issues. There can be any number of issues you like in a single diagram. Argument evaluation is carried out by labeling statements *in, out* or *undecided*. A statement is *in* if and only if it has been assumed to be acceptable to a rational audience, or has been derived from such assumptions via the application of the arguments, argument weighing functions and proof standards used in CAS. A statement is *out* if and only if it is neither assumed nor supported by arguments and would therefore be rejected by a rational audience. A statement is *undecided* if it is neither *in* nor *out*.

Carneades 3 uses backwards-chaining, in a goal-directed way, whereas Carneades 4 uses forwards-reasoning to derive arguments from argumentation schemes and assumptions. Both strategies, forwards and backwards reasoning, have their advantages. Forwards reasoning allows CAS to invent arguments using argumentation schemes, such as the scheme for argument from expert opinion, where the conclusion is a second-order variable ranging over propositions. Only Carneades 4 can construct arguments using formalizations of all of the twenty or so schemes currently built into the system.

Case-based reasoning (CBR) is vitally important for AI and Law and for understanding legal reasoning generally. CBR evaluates an argument in a given case

[6]Retrieved from: https://github.com/carneades

[7]Retrieved from: http://carneades.fokus.fraunhofer.de/carneades

by comparing and contrasting its features to those of prior cases that have already been evaluated [Aleven, 1997]. These prior cases are stored in a knowledge base which supplies similar precedent cases that can be pro or con the evaluation being considered in the given case. In some systems widely known in AI and law [Ashley, 1990], judgments of similarity between a pair of cases are decided by the factors that they share. Special argumentation schemes have been built to model arguments from precedent using factors in case-based reasoning [Gordon and Walton, 2009; Wyner and Bench-Capon, 2007; Wyner *et al.*, 2011]. Prakken et al. [Prakken *et al.*, 2015] offered a formal version of these legal case-based argumentation schemes using ASPIC+.

Walton, Sartor and Macagno [Walton *et al.*, 2016] showed how canons of interpretation can be translated into argumentation schemes. This project was carried out by by analyzing the most common types of statutory arguments found in legal examples and certain key forms of interpretive legal argumentation found in the work of Tarello [Tarello, 1980] and McCormick and Summers [MacCormick and Summers, 1991]. Steps were carries out to show how these legally recognizable forms of argument can be formulated as argumentation schemes. Among the schemes modeled are argument from ordinary meaning, argument from technical meaning, argument from precedent, argument from purpose, *a contrario* argument, historical argument and the non-redundancy argument. It was shown using classical examples of statutory interpretation in law how these schemes (and others) can be incorporated into computational argumentation systems such as CAS and APSIC+ and applied to displaying the pro-contra structure argumentation in legal cases using argument mapping tools.

In the following sections we will illustrate shortly two other computational applications of argumentation schemes, namely their role in argument mining and formal ontologies.

9 Using Schemes for Argument Mining

Argumentation schemes also have an important role to play in a major new area of computational research into argumentation: argument mining. Argument mining focuses on the development of algorithms and techniques for the automatic extraction of argument structure from natural language text. Though it has connections to areas such as sentiment analysis and opinion mining, it represents a substantially more demanding task. There are two features that make argument mining so difficult. The first concerns the availability of data and the second, the limits of statistical approaches to language understanding.

Many approaches to mining syntactic and semantic structure from unrestricted natural language have, since the late 1990s, been based heavily in statistical analysis: essentially, modelling the regularities in language by examining and comparing many, many different examples. The most robust syntactic parsers, for example, are based not on theoretical linguistic analysis — which proved on the whole to be too limited and too brittle — but on statistical models based on corpora typically comprising millions of examples [Koehn *et al.*, 2003]. Though the machine learning mechanisms upon which such techniques depend vary, one feature that they share is the need for such large datasets from which to draw regularities. If, therefore, argument mining is to be able to deploy the same techniques, it requires large datasets, and datasets not just of argumentation *per se*, by argumentation that has been analysed for its structure. As anyone involved in the teaching of critical thinking skills will attest, such analysis of argument structure is both demanding and extremely time consuming. Until very recently there were few datasets, and those that did exist were available in idiosyncratic representation languages, with little re-use between research teams and projects — so what effort was invested in data collection and analysis was regularly lost. Two approaches have started to change this.

First, there have been attempts to collect datasets specifically for community use. The first example is the Internet Argument Corpus, IAC [Walker *et al.*, 2012], which collects 390,000 examples. The problem facing the IAC is that it is designed primarily from a text-processing viewpoint, with little argumentation theory sitting behind it. As a result, the conception of argument that it embodies is very thin and more or less unrecognisable to researchers from argumentation theory and computational models of argument, viz., quote-response pairs with associated polarity (additional features including sarcasm and nastiness are marked for subsets). A second example is more directly rooted in informed models of argumentation. The Potsdam Microtext Corpus [Peldszus and Stede, 2016] provides artificially constrained — but completely human-generated, natural language — arguments that are structured according to the work of Freeman [Freeman, 1991] with explicit distinction between, for example, linked and convergent arguments, undercutting and rebutting attacks and so on. Another unique advantage of the Microtext Corpus is that it has been professionally translated so that both English and German versions exist: to our knowledge this is the first parallel corpus of argumentation. On the other hand, the fact that every argument is required to contain a total of five components (premises and conclusions), whilst providing a vitally useful "laboratory" for testing techniques, risks placing a severe limitation on the subsequent generalizability of those techniques to unrestricted arguments in the wild. The limited size of the corpus — just 130 examples — also places limitations on what can be accomplished using traditional statistical machine learning techniques.

The second approach has been to provide infrastructure specifically for collecting, publishing, sharing and re-using corpora. Whilst there are now several platforms for online analysis of argument (argunet[8], debategraph[9], AGORA-net[10], Rationale-Online[11], etc.) none provide open access to the data in machine processable ways, except, as far as we are aware, for the infrastructure offered by the Argument Web [Rahwan *et al.*, 2011; Bex *et al.*, 2013]. The Argument Web is a vision for an interconnected web of arguments and debates, regardless of the software used to create them, analyse them or extract them, and regardless, too, of the uses — academic, social or commercial — to which they might be put. The vision supports, for example, the academic analysis of an argument presented in a political broadcast; the automated analysis of responses to it on social media; the deployment of automated dialogue games for online users to interact with both original and responses; the automated summary of the status of the debate to a government policy department; and the delivery of a corpus comprising the debate to researchers in argument mining. Argumentation schemes in the style of [Walton *et al.*, 2008] form a cornerstone of the Argument Web, as a way of providing a rich ontology of reasoning forms. Further details of this ontology occur in the next section; here we focus on the tools and the ways in which they can be used to develop corpora.

Though the first publicly available corpus of argumentation was developed using Araucaria (viz. AraucariaDB, see [Reed and Walton, 2005]), the software itself is now very old and virtually obsolete. Though it remains the only software to handle large analyses, such as the ones developed by Wigmore for mapping cases, and the only to interchange between Wigmore, Toulmin and Freeman styles of analysis, it has been superseded in its core functionality by the Online Visualisation of Argument tool, OVA [Janier *et al.*, 2014]. OVA provides a simple-to-use interface for analysing existing argumentation in both monologue and, in the extended OVA+, also dialogue. It supports enthymeme reconstruction; argumentation scheme analysis; critical question processing; serial, linked, convergent and divergent structures; undercutting, rebutting and undermining attacks; and in OVA+, locution analysis; dialogue game rule analysis; illocutionary force identification; the role of *ethos* [Duthie *et al.*, 2016] and personal attacks; and ultimately, full Inference Anchoring Theory analysis [Budzysnka and Reed, 2011]. Analyses from OVA can be stored in AIFdb, a database infrastructure fabric for storing and accessing argument data [Lawrence *et al.*, 2012].

[8]Retrieved from: http://www.argunet.org/ (Accessed on 10 May 2016)

[9]Retrieved from: http://debategraph.org/Stream.aspx?nid=61932&vt=ngraph& dc=focus (Accessed on 10 May 2016)

[10]http://agora.gatech.edu/ (Accessed on 10 May 2016)

[11]https://www.rationaleonline.com/ (Accessed on 10 May 2016)

One side effect of using AIFdb is that the data is easily transportable to other forms, both representational (in being able to convert to formats required for Carneades [Walton and Gordon, 2012] and Rationale [van Gelder, 2007], for example), and processable — in being able to convert via ASPIC+ [Modgil and Prakken, 2013] to abstract frameworks [Dung, 1995] via formal equivalences established in [Bex *et al.*, 2013]. More importantly for our current purposes, sets of analyses in AIFdb can be configured to constitute a corpus using the AIFdb corpus management tools [Lawrence and Reed, 2015] available online at corpora.aifdb.org, and AIFdb current constitutes the largest publicly available dataset of analysed argumentation. These tools enable research teams to define corpora comprising both analysed argumentation and raw text; both argumentative and non-argumentative source material; both raw data and metadata. Corpora themselves are aggregable providing flexible structuring options to manage dependencies between teams, projects, and objectives. The original AraucariaDB corpus is available on this infrastructure, but so too are smaller datasets focusing specifically on argumentation schemes, such as the Argument Schemes in the Moral Maze, comprising excerpts from the BBC Moral Maze radio programme that involve 35 instances of argumentation schemes and the ExpertOpinion-PositiveConsequences corpus comprising 71 examples of just these two schemes.

With the availability of appropriate datasets becoming less of an impediment, various approaches to automatically recognising argument structure have been developed. The majority have been focused specifically on statistical models, which brings us to the second major challenge facing argument mining: the limits of such models. Whilst it is certainly the case that statistical approaches are starting to deliver results for argument mining, and will undoubtedly continue to do so, it is also the case that the more sophisticated conceptions of argument developed in argumentation theory remain extraordinarily demanding. The reason for this lies precisely in their sophistication. With so many patterns of argumentation, so many structures, so many ways in which components can be left implicit, so many types of reasoning, the amount of data required to train statistical models becomes not just unwieldy but unreasonable and, quite probably, unattainable.

Consider a comparison with syntactic analysis, where statistical models have been so successful. The number of rules governing how different parts of speech can be legally combined run in theoretical linguistics to tens of examples. In statistical models, it is hundreds (which is why they are so successful). The number of rules governing how argument components can be assembled (and left implicit) runs, by combination across argumentation schemes, to thousands or more. So whilst we might expect statistically oriented techniques to deliver us good results on simple and strongly generalizable aspects of argument recognition, for the type of analysis that is typically taught to students of critical thinking classes, more is required. It is looking increasingly likely that having strong, well defined conceptions of argument, dialogue and argument schemes provide exactly the sort of additional information required to guide machine learning processes by acting, in essence, as priors to that process: defining expectations about what is likely to be seen. This combination of statistical and structural approaches is looking very promising. In particular, we provide examples here that tap in specifically to structure provided by argument schemes.

Feng and Hirst [Wei Feng and Hirst, 2011] aimed to classify arguments into the type of scheme employed. Like some of the earliest work in argument mining, such as [Moens and Mochales Palau, 2007], they also used the AraucariaDB corpus as a starting point, because it was the only dataset at that time with annotated examples of argumentation schemes. They used the 65 argumentation schemes from [Walton *et al.*, 2008], but emphasized the importance of the five schemes they found to be the most commonly used ones in their corpus: argument from example, argument from cause to effect, practical reasoning, argument from consequences and argument from verbal classification [Wei Feng and Hirst, 2011]. The number of occurrences of these most common five schemes constituted 61% of the kinds of arguments identified in their database [Wei Feng and Hirst, 2011, p.998]. They used a variety of features with which to train the machine learning classifiers including key words and phrases as textual indicators of argumentation schemes. They identified, for example, twenty-eight keywords and phrases associated with the scheme for practical reasoning, including "want", "aim", "objective", and modal verbs like "should", "must" and "need" [Wei Feng and Hirst, 2011, p.991]. Their results were extremely promising, providing classification accuracies ranging from 0.64 to 0.98.

Building on this approach, Lawrence and Reed ([Lawrence and Reed, 2015] extended the model to use argumentation schemes not just as a target for machine learning but to aid the very process of identifying argumentative structure (rather than presupposing it as input, as in Feng and Hirst). The intuition is that argumentation schemes do not connect propositions that are all alike, but rather are associated with particular types of propositions. In this way, arguments from positive consequence will typically conclude with a normative statement in the subjunctive mood; arguments from expert opinion will typically have a premise which reports, either directly or indirectly, the speech of another; arguments from analogy will include a premise which attributes some property to some individual; and so on. If it is possible to identify instances of some of these types, it will constrain the potential argument structures that can be reassembled. If, for example, an automatic algorithm can spot the lexeme said, there is a reasonable chance that we have reported speech, which in turn increases the chance that it is part of an expert opinion argument. If we can find the lexeme expert in a sentence close by, we can be even more sure we have argument from expert opinion and can start looking nearby for a conclusion — and that conclusion is likely to be a sentence which has strong semantic similarity with the clause that follows “said”. In this way, knowing *a priori* about argumentation scheme structure helps to constrain the problem of automatically recognising the argument structure. It turns out that this hypothesis is borne out by results.

Lawrence and Reed report (ibid.) results ranging from an F1 performance of 0.59 to 0.91 for detecting scheme components and of 0.62 to 0.88 for identifying scheme instances. Operationalising argumentation scheme structure in this way depends, however, upon “knowledge engineering”, or, more specifically, “ontology engineering” — the construction of explicit computational models that capture scheme structure and the commonalities, similarities and classificatory relationships between schemes. It is to this question that we turn next.

10 Schemes in Formal Ontologies

The Argument Interchange Format, AIF, is not just a representation language for argument structure; it also has a formal definition rooted in description logic; that is to say, it provides a core ontology for describing argument (though that core is rather compact, it admits of extension using “adjunct ontologies” that extend it to handle features such as dialogical interaction, user- and social-oriented features, and so on). The AIF was laid out initially in [Chesñevar *et al.*, 2006] and extended in its description logic specification in [Rahwan *et al.*, 2007]. Given this basis, it is then rather straightforward to extend it to further specify not just that two propositions might be linked by an application of a rule of inference (or “RA”), but to also specify the different types of such rules of inference, that is to define an ontology of argumentation schemes. This ontology not only describes the structure of argumentation schemes in machine-processable form, but also defines relationships between schemes (such as generalisation-specification relationships) and relationships between scheme components (such as that knowledge assertions occur as premises in several different schemes). By way of example, snippets of the ontology concerned with the argumentation scheme from expert opinion are shown in Figure 11 below.

```
<Class IRI="#ExpertOpinion_Inference"/>
    <ObjectIntersectionOf>
      <Class IRI="#Presumptive_Inference"/>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasConclusion"/>
        <Class IRI="#KnowledgePosition_Statement"/>
      </ObjectSomeValuesFrom>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasFieldExpertise_Premise"/>
        <Class IRI="#FieldExpertise_Statement"/>
      </ObjectSomeValuesFrom>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasKnowledgeAssertion_Premise"/>
        <Class IRI="#KnowledgeAssertion_Statement"/>
      </ObjectSomeValuesFrom>
    </ObjectIntersectionOf>

<Class IRI="#ExpertOpinion_Inference"/>
    <ObjectIntersectionOf>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasCredibilityOfSource_Presumption"/>
        <Class IRI="#CredibilityOfSource_Statement"/>
      </ObjectSomeValuesFrom>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasExpertiseBackUpEvidence_Presumption"/>
        <Class IRI="#ExpertiseBackUpEvidence_Statement"/>
      </ObjectSomeValuesFrom>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasExpertiseInconsistency_Exception"/>
        <Class IRI="#ExpertiseInconsistency_Statement"/>
      </ObjectSomeValuesFrom>
      <ObjectSomeValuesFrom>
        <ObjectProperty IRI="#hasLackOfReliability_Exception"/>
        <Class IRI="#LackOfReliability_Statement"/>
      </ObjectSomeValuesFrom>
    </ObjectIntersectionOf>

<Class IRI="#ExpertiseInconsistency_Conflict"/>
    <ObjectIntersectionOf>
      <Class IRI="#Exception_Conflict"/>
      <ObjectExactCardinality cardinality="1">
        <ObjectProperty IRI="#hasConflictedElement"/>
        <Class IRI="#ExpertOpinion_Inference"/>
      </ObjectExactCardinality>
      <ObjectExactCardinality cardinality="1">
        <ObjectProperty IRI="#hasExpertiseInconsistency_Exception"/>
        <Class IRI="#ExpertiseInconsistency_Statement"/>
      </ObjectExactCardinality>
                              </ObjectIntersectionOf>
```

Figure 11: Snippet of Argumentation Scheme Ontology

In the first stanza, the conclusion and premises concerning the knowledge assertion (that the expert said something) and the field expertise (that the speaker is indeed an expert) are set up. In the second stanza, the remaining premises (those captured as presumptions and exceptions) are added in, covering credibility, backup evidence, consistency between experts and expert reliability. The third stanza shows how one of these, consistency between experts, can be used to drive a stereotypical way of attacking this inference — i.e. the posing of a critical question (see [Reed and Walton, 2005] for the mechanics of operationalizing critical questions in this way). The aim here is just to give a flavour of how all the important components of argumentation schemes — structure, description and critical questions — can be captured in a formal ontology. The full ontology is available online at http://arg.tech/aif.owl, and is used by many of the Argument Web online services.

Two benefits of this approach are demonstrated in [Rahwan *et al.*, 2011]. The first is an economy in specification, that allows more specific schemes to be defined in terms of minor additions to more general ones. The second, much more importantly, is that these structures support automated reasoning, in three distinct ways. First, it becomes possible to reason across argument structures, identifying, for example, transitivity of inferences, so that if X is used to infer Y, and Y to infer Z, the dependence of X on Z can be inferred automatically. Of course such reasoning is not at all unique to ontologically based systems, but is a convenient side benefit. An ontologically more interesting way of performing automated reasoning is to perform automatic classification. This is where formal ontologies, and the reasoning systems constructed on top of them, excel. Rahwan et al., exemplify this technique by showing how fear appeal arguments are naturally classifiable as a subset of negative consequence arguments. The third and final way of performing automated reasoning is also of use in designing and implementing dialogue systems. By virtue of hierarchical relationships between schemes that are represented in, or inferable from, the ontology, it also becomes possible to infer appropriate critical questions that might be asked of a given argument. Thus, for example, all of the critical questions of a superclass can be asked of an instance of a sub-class of argumentation schemes. In these ways, formal representation of argumentation schemes in an explicit ontology can contribute to the computational techniques for analysing, processing and interacting with arguments.

11 Conclusions

Argumentation schemes represent the abstract structures of the most common and stereotypical arguments used in everyday conversation and specific fields, such as law, science and politics. They appear as a set of premises having an abstract form with variables and constants, leading to an abstract conclusion. They are abstract in the sense that they provide a form for structuring inferential relation between the premises and the conclusion. Some schemes are based on the most abstract relations (classification, cause, authority), while others specify the most abstract premises including some further detail (negative consequences; expert opinion *ad populum* argument) [Walton *et al.*, 2008].

The abstract nature of the schemes allows the analyst to detect the structure of natural arguments, and recognize patterns occurring in everyday reasoning. This paper has shown how they can be applied to real arguments in natural language discourse, and in technical discourse as well, for that matter. In this paper, it has been shown how these schemes, at their current state of development can be used as tools to identify kinds of arguments in a text, and beyond that how they can be an important part of argument evaluation. Throughout the history of logic and rhetoric there has always been some uncertainty about the role of the topics [Bird, 1962]. Some have seen them as forms of logical inference that can be used to show that arguments are valid, where the term "valid" is used in a wider sense that can include not only deductively valid arguments but also defeasible arguments that have an identifiable structure as fitting a particular topic. Others have seen the topics of as having a search function that can be used to find arguments to prove a designated conclusion. The search function is supposed to help an arguer select arguments that have premises accepted by the audience to whom the argument is directed [Kienpointner and Kindt, 1997].

Schemes can also be used for argument construction. As we saw in this paper, an argumentation scheme is taken to have a warranting function that enables an inference to be drawn from a set of premises to a conclusion. This practical way of justifying schemes indicates their usefulness not only for argument evaluation, but also for argument construction, also called argument invention in the long history of the subject tracing back to the Sophists and Aristotle. An argument invention device would enable an arguer to search for an argument that could be used to support a claim s/he wants to prove [Kienpointner, 1987]. When viewed in this way, topics can be seen to have a use as components of an argument construction function, for use in a system for finding arguments. The schemes can be used as instruments for producing arguments, allowing the user to decide the type of argument he considers the most applicable to his purpose, and then develop a specific line of reasoning from the premises or evidential facts he has to the conclusion he needs to prove. In this guise, the schemes are dialectical instruments for use in the task of argument construction.

The advent of IBM's new Watson Debater tool [Aharoni *et al.*, 2014] is a leap forward for argument invention because it enables a user to quickly search through a database such as Wikpedia and find useful pro and con arguments supporting or attacking a designated claim. Once this tool comes onto the market, it will greatly stimulate research on argument invention in argumentation studies. The Debater tool does not (so far) use argumentation schemes, but there is a formal and computational argumentation system, the Carneades Argumentation System (CAS)[12]. By inputting information into the CAS find arguments assistant, a user who has a

[12] https://carneades.github.io/ (Accessed on 10 May 2016)

database containing propositions recording the commitments of the audience, the automated assistant constructs a chain of argumentation where the conclusion of the chain is the proposition is the goal proposition that the speaker wants to persuade the audience to accept, called the arguer's ultimate claim, or ultimate *probandum*, the proposition to be proved, in the language of the ancient *stasis* theory [Walton and Gordon, 2012]. The argument assistant searches through the commitments of the audience and uses a repository of argumentation schemes in its knowledge base to collect a set of arguments moving from these premises to the ultimate claim. If there are such arguments available the assistant gives that information, but may suggest a partial way forward.

Argumentation schemes are instruments that can be used in different ways to many disciplines addressing the analysis of discourse in general, and reasoned discourse in particular. The current research on schemes can improve noticeably the field of application and make this tool crucial for a deeper analysis of argumentative exchanges. To this purpose, argumentation schemes need first to be integrated within a theory of discourse interpretation. Schemes can be powerful instruments for representing arguments and relations between sentences. However, at present they presuppose an interpretation of discourse. This line of research could show how schemes can represent interpretation, and how they can be used to assess what interpretation is the best one [Macagno, 2012]. A second challenge in this area is to link the theory of dialogue types and discourse moves (utterances) to argumentation schemes [Macagno and Bigi, 2017]. By showing how certain schemes are the most adequate to pursue specific dialogical ends, it is possible to map not only a set of useful tools for argument production, but also a set of presumptions for interpreting and classifying arguments based on the type of dialogue.

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