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Analogical Reasoning and Semantic Rules of Inference

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The nature of Aristotle's topics has been a crucial issue in the Middle Ages (Abaelardi *Dialectica*, 254) and in the modern and contemporary studies on natural inferences (De Pater 1965; Stump 1982; 1988; Kienpointnter 1986). One of the crucial debates concerned their function, i.e. whether they were instruments for finding arguments or rules on which dialectical and rhetorical inferences were based (Bird 1962). The interpretation of the Aristotelian topics as rules of inference, defended by Abelard and Ockham (Bird 1962; Stump 1989), is of fundamental importance for the analysis of natural inferences and argumentation studies in general, as it would lead to a more complex formalization based on the semantic relations between the terms of a consequence (Bird 1960).

Inferences such as "This pen is red; therefore it is colored" cannot be considered as purely logical, in the sense of purely formalized according to the semantic system used in modern formal logic. Inferences of this kind hold in virtue of semantic relations between the terms in the antecedent and the consequent, called *habitudo* in the ancient dialectical theory (Abaelardi *Dialectica*, 263-264). The *habitudo* is the semantic-ontological respect under which the terms are connected to each other, and on which the force of the inference depends[1] (Abaelardi *Dialectica* 254; Rigotti & Greco Morasso 2010: 494). In the example above, the passage from the quality "to be red" attributed to the subject to the different quality "to be colored" is grounded on a relation of semantic inclusion between these two predicates, i.e. a genus-species relation (Bird 1962: 309). 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 (*Topics* 102a 31-32). For this reason, it is predicated of what the species is predicated of. This rule

1 Locum ergo generaliter definientes uim inferentiae dicimus (Abaelardi *Dialectica*, 254).

follows directly from the type of semantic-ontological relation between the terms. (Abaelardi *Dialectica*, 315; see also Stump 1989: 36):

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", witch 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.

Interpreted as rules of inference, the topics connect the semantic-ontological relations with common knowledge, or rather the shared semantic system. The necessity of dialectical inferences hinges crucially on the shared nature of the terms (Abaelardi *Dialectica*, 257)[2]. This approach can lead to a deeper reconstruction of natural arguments combining semantics with logical rules. In order to show how these two interconnected dimensions can be used to analyze and (quasi-)formalize the structure of everyday reasoning, we will investigate the semantic-ontological structure of one of the more complex types of inference in Aristotle's dialectical and rhetorical works, analogy.

2 Quae quidem inferentiae, quamuis imperfectae sint quantum ad antecedentis constructionem, tamen necessitatem ex rerum natura saepissime tenent ueluti ista quam prius posuimus de 'animali' ad 'animatum', cum uidelicet natura animalis, cui animatum ut substantialis forma inest, ipsum animal praeter animationem existere nusquam patiatur. Perfectio itaque necessitatis etiam in his est inferentiis, non constructionis. Cum enim dicimus: *si est animal, est animatum* quantum quidem ad rerum naturam quam nouimus, de veritate consequentiae certi sumus, quia scilicet animal sine animato non posse subsistere scimus, non quidem quantum ad complexionem inferentis. Quamuis enim animal in se animatum contineat, nulla tamen apponitur propositio quae animal in animato contineri demonstret. (Abaelardi *Dialectica* 257).

1. Similarity as abstraction

The logical structure of ἀναλογία, or rational correspondence, was developed by Aristotle in the *Topics* in close connection with the notion of similarity (*homoiotês*) and the maxims related thereto (Bartha 2010: 36). Similarity consists in identifying a characteristic common to distinct entities or states of affairs, which can be essential, i.e. semantic (Rigotti & Greco-Morasso 2006; Rigotti 2008; Walton & Macagno 2009), or accidental, i.e. corresponding to predicates that can be attributed to the head of the syntactic construction but not necessarily. From a logical-semantic point of view, this process of discovering a common semantic or accidental feature can be conceived as a kind of abstraction, resulting in the identification of a genus, a predicate that can be attributed to different entities different in kind.

In the *Posterior Analytics*, Aristotle pointed out that analogy could be used for identifying a characteristic common to various entities different in a genus (see also Hesse 1966, Ch. 4), and for which no name exists (*Posterior Analytics*, 98a20-23):

> Again, another way is excerpting in virtue of analogy; for you cannot get one identical thing which pounce and spine and bone should be called; but there will be things that follow them too, as though there were some single nature of this sort.

The pounce (of a cuttlefish), the spine (of a fish), and the bone (of an animal) do not belong to the same genus, but they can be conceived as the same because they share the same semantic-ontological trait, "osseous nature." As Aristotle points out in the *Metaphysics*, analogy presupposes a difference in genus of the concepts that can be considered as the same from a relational point of view (*Metaphysics* 1016b31-1017a2). The spine, the bone, and the pounce do not belong to a known common semantic genus, as in Greek there was no word referring to a more generic predicate that indicated the characteristic of being osseous and being a structure. However, these concepts can be thought of as having the same function considering their relation with the body of the various types of beings. They can fall under the nameless category (Hesse 1965: 329; Hesse 1966; Glucksberg & Keysar 1990) of "osseous nature" (*Posterior Analytics* 74a8), which is functionally essential even though it has no name and is not part of the definition of the concepts (Macagno &Walton 2009). This abstract and unnamed predicate can be also different, depending on the respect under which the terms of the analogy are taken into consideration. If the final cause instead of the material one is considered, the aforementioned concepts can be

considered to be "structures sustaining the body." Analogy, in this sense, can be considered as an instrument for defining (or redefining) concepts by bringing to light some features that can be considered as essential. Clearly, the selection of what should count as essential and common to the terms of the comparison depends on how the analogy is framed, i.e. how the terms are selected and for what purpose.

This treatment of similarity applies also to accidental similarities. For instance, if we consider the famous analogy "a sailor is to his ship, as a teacher is to his classes" (Petri Hispani *Summulae Logicales*, V, 34), we notice that a sailor and a teacher are essentially different, as their definitions are different. However, for the purpose of the analogy they are regarded as the same, as the analogical relation provides a specific criterion under which the terms fall (*De nominum analogia*, c. IV, 36[3]; Indurkhya 1992: Ch. 2). This generic "concept" is abstracted based on their specific relationship, the viewpoint that constitutes the purpose of the comparison, and not on their absolute meaning (definition) (c. V, 49-50[4]). In this respect, essential and accidental similarities can be thought of as characterized by the same process of abstraction. However, while in the first case the analogy selects some traits that are already part of the semantic structure of the terms (they are in this sense essential), in case of accidental comparisons the compared concepts are contextually redefined, and a characteristic that is not a component of their meaning becomes the unnamed genus. This process of abstraction is crucial for understanding the logic of analogical reasoning.

2. Reasoning from a common semantic genus

As mentioned in the above, the relations of likeness (semantic similarity) constitute a genus that can be already known or unnamed. The discovery or the abstraction of a common named or unnamed genus is at the basis of the same type of reasoning, based on the topics that Aristotle provided in the most generic form as follows (*Topics* 114b 29-32):

> Again, look at things which are like the subject in question, and see if they are in like case; e.g. if one branch of knowledge has more than one object, so also will one opinion; and if to possess sight is to see, then

3 In analogis vero, quoniam fundamenta analogae similitudinis diversarum rationum sunt simpliciter, et eiusdem secundum quid, idest secundum proportionem.

4 Unde sicut non est alia ratio quare unum proportionaliter non est unum absolute, nisi quia ista est eius ratio formalis; ita non est quaerenda alia ratio, cur a similibus proportionaliter non potest abstrahi res una; hoc enim ideo est, quia similitudo proportionalis talem in sua ratione diversitatem includit.

> also to possess hearing will be to hear. Likewise also in the case of other things, both those which are and those which are held to be like. The rule in question is useful for both purposes; for if it is as stated in the case of some one like thing, it is so with the other like things as well, whereas if it is not so in the case of some one of them, neither is it so in the case of the others. Look and see also whether the cases are alike as regards a single thing and a number of things; for sometimes there is a discrepancy. Thus, if to know a thing is to think of it, then also to know many things is to be thinking of many things; whereas this is not true; for it is possible to know many things but not to be thinking of them. If, then, the latter is not true, neither was the former that dealt with a single thing, viz. that to know a thing is to think of it.

These principles of inference were developed in the medieval tradition, and led to the generic *locus*[5] from likeness characterized by the principle "like is judged by like," specified by the following maxims (Petri Hispani *Summulae Logicales,* V, 33):

> if one of [the] likes is present , the other is present as well.
>
> if one of [the] likes is absent, the other is absent as well.

The generic maxims, provided by Aristotle in the second book of the *Topics*, were then made more specific in the following books of the same work, adapting them to two types of logic-semantic connections, the predicables genus and property (*Topics* 124a15).

The most basic type of reasoning from likeness is based on the type of essential and known similarity. The two likes are known to belong to the same genus, and inasmuch as a predicate is attributed to the analogue, it is also attributed to the primary subject. For instance, a man and a dog are animals, and since dogs breathe (or have instincts), men will breathe (or have instincts) as well. However, this type of reasoning holds only for specific predicates: it is reasonable to conclude that men breathe because so do dogs, but it would be incorrect to draw the conclusion that men have wings or four legs because birds are winged or dogs are four-legged. In order to understand the nature of admissible predicates, it is necessary to investigate the logic of analogical reasoning starting from its basic component, i.e. the logic of the notion of genus and the topics related thereto. Aristotle defines a genus as "what is predicated in what a thing

5 This is the term used to depict the Greek *topos*.

is of a number of things exhibiting differences in kind" (*Topics* 102a31-32), and is characterized in particular by the following topic (*Topics* 121a 10-14):

> Clearly, therefore, the species partake of the genera, but not the genera of the species; for the species admits the account of the genus, whereas the genus does not admit that of the species.

The species (dog) can admit the definition of the genus (animate being), but the genus cannot be defined through its species. This principle was analyzed by Boethius and explained through the following locus: "Whatever is present to the genus is present to the species" (*De Topicis Differentiis* 1188B, 21-22)[6], in the sense that "the essence of the genus and the accidents adhering to that essence are also part of the species" (*De Topicis Differentiis*, note 67). In this sense, Boethius took into account the essential predications, i.e. the predicates that either express a semantic feature of the genus or are related to its semantic characteristics. For instance, since animals breathe and have instincts inasmuch as they are animate beings, dogs and men breathe and have instincts. Clearly these topics concern the characteristics that the generic concept has or may have intensionally, and not extensionally. Aristotle developed the logic of genus-species relation concerning non-essential predications by setting out the following topics (*Topics* 111a17-32):

> In the present instance the demonstration proceeds from the genus and relates to the species; for judging is the genus of perceiving; for the man who perceives judges in a certain way.
>
> Again, it may proceed from the species to the genus; for all the attributes that belong to the species belong to the genus as well; e.g. if there is a bad and a good knowledge there is also a bad and a good disposition; for disposition is the genus of knowledge. Now the former commonplace argument is false for purposes of establishing a view, while the second is true. For there is no necessity that all the attributes that belong to the genus should belong also to the species; for animal is winged and quadruped, but not so man. All the attributes, on the other hand, that belong to the species must of necessity belong also to the genus; for if man is good, then animal also is good. On the other hand, for purposes of overthrowing a view, the former argument is true while the latter is false; for all the attributes which do not belong to the genus do not

6 In Latin: "quae generi adsunt speciei adsunt."

> belong to the species either; whereas all those that are wanting to the species are not of necessity wanting to the genus.

The genus-species inferences can be summarized in the following table:

Principle of inference	Example
Whatever is present to the genus is present to the species.	Animals breathe. Therefore, dogs breath.
All the attributes that belong to the species belong to the genus as well.	A dog is four-legged. Therefore, an animate being is four-legged.
All the attributes that do not belong to the genus do not belong to the species either.	An animate being is not bi-dimensional. Therefore a dog is not bi-dimensional.

Table 1: Principles of inference in analogical reasoning

This logic of the genus and species can explain the nature of the first kind of reasoning from likeness, indicating the type of predicates that can be transferred in the inference. In particular, in order for a predicate to be transferred from the species to the genus, and the genus to a different species thereof, it needs to be attributable to the concept itself, i.e. the intension of the predicate.

3. Reasoning from an unnamed genus

The second type of similarity is the ground of the type of reasoning that Aristotle refers to as "analogical." Aristotle applied this type of argument to the attribution of two kinds of predicables, genus and property.

Analogical reasoning can be used to support the attribution of a predicate as a genus, based on an identical genus-species relation as follows (*Topics* 124a16-18)

> Thus (e.g.) the relation of the pleasant to pleasure is like that of the useful to the good; for in each case the one produces the other. If therefore pleasure is essentially good, then also the pleasant will be essentially useful; for clearly it will be productive of good, seeing that pleasure is good.

The reasoning is based on a proportion, semantically conceived as a relation of "production": the pleasant is related to pleasure as the useful to the good. This proportion, however, leads to an inference based on the logical-semantic topics (Macagno & Walton 2009) related to the genus-species relation. In this case, "to be productive of good" is regarded as the unnamed genus of "to be productive of pleasure"; therefore, the pleasant is a species of "to be produc-

tive of good", namely the useful. The reasoning is grounded on the attribution of the generic logic-semantic property of being "the genus of" to the unnamed analogical genus "to be productive of." The proportion represents an essential semantic feature of the two antecedents, as in both cases the first predicate is (essentially) productive of the second one. Since the relationship is essential in nature, the topic of genus-species applies, and can be represented as follows:

Principle of inference	Example
All the attributes that belong to the species belong to the genus as well.	What produces the good is the genus of what produces pleasure. Therefore, what produces a generic concept is the genus of what produces a specific concept.
Whatever is present to the genus is present to the species.	What produces a generic concept is the genus of what produces a specific concept. Therefore, the useful is the genus of the pleasant.

Table 2: Structure of the reasoning from unnamed genus – genus

This type of analogical reasoning is grounded on an abstraction, resulting in the creation of the abstract category "to be productive of." We can consider this passage as an asymmetric or vertical relation (see Hesse 1966: 59; Bartha 2010: 43-44). This abstract concept is then used to trigger an inference aimed at attributing a predicate as a genus, and it is grounded on a horizontal relation between the analogical, unnamed genus and the generic predicate. In this specific case, the relation is essentially connected with the concept, as it establishes that what produces a generic concept is the genus of what produces a specific concept.

The other type of analogical reasoning that Aristotle describes in the *Topics* concerns the attribution of a predicate as a *property*, which is defined as "something which does not indicate the essence of a thing, but yet belongs to that thing alone, and is predicated convertibly of it" (*Topics* 102a18-19). Reasoning from analogy can proceed from this type of predication as follows (*Topics* 136b33-137a8):

> […] inasmuch as the relation of the builder towards the production of a house is like that of the doctor towards the production of health, and it

> is not a property of a doctor to produce health, it will not be a property of a builder to produce a house.
>
> […] inasmuch as the relation of a doctor towards the possession of ability to produce health is like that of a trainer towards the possession of ability to produce vigour, and it is a property of a trainer to possess the ability to produce vigour, it will be a property of a doctor to possess the ability to produce health.

This mechanism can be compared to the aforementioned analogical reasoning concerning the attribution of a genus. In this excerpt, Aristotle sets out two proportions. The first proportion can be expressed as "*x* produces *y*", where *y* represents what characterizes the profession of *x*. The second proportion can be stated as "*x* has the ability to produce *y*", where *y* represents what characterizes the profession of *x*. In both cases there is a twofold abstraction from specific cases to a generic concept and its univocally identifying feature. In this case, the horizontal relation between the abstract genus (profession) and the abstract and generic predicate (to possess the ability to produce/to produce what characterizes a profession) is convertible and concerns the concepts abstracted. For this reason, the topic governing the passage of a predication from the genus to species applies (given the identity of the genus with the definite description). The reasoning that characterizes the second proportion can be represented as follows:

Principle of inference	Example
All the attributes that belong to the species belong to the genus as well.	A trainer has the ability to produce vigor. Therefore, to have the ability to produce what characterizes a profession is the property of the profession.
Whatever is present to the genus is present to the species.	To have the ability to produce what characterizes a profession is the property of the profession. Therefore, a doctor has the ability to produce health.

Table 3: Structure of the reasoning from unnamed genus – property

The rules characterizing genus and species and governing analogy are different in the case of negative analogy. In the first proportion, an analogical genus and a generic property (to produce what characterize the profession) are abstracted, but this predication is denied based on the fact that a specific predication is not the case. The logic underlying this inference is different and proceeds from a different topic. Its structure and rules can be represented as follows:

Principle of inference	Example
Wathever is present to the genus is present to the species.	To produce health is not a property of a doctor. Therefore, to produce what characterizes a profession is not a property of the profession.
All the attributes that do not belong to the genus do not belong to the species either.	To produce what characterizes a profession is not a property of the profession. Therefore, to build a house is not a property of a builder.

Table 4: Structure of the reasoning from unnamed genus – negative reasoning

The dialectical treatment of analogy shows how this type of reasoning is grounded on a process of abstraction, consisting in finding a generic property common to the terms of the comparison (the two couples, in case of the Aristotelian analogy). This abstraction of a predicate attributable as a genus to the specific terms triggers the inferences constituting the genus-species relation. In particular, analogy can be thought of as a mechanism consisting in the generalization of a predication based on a specific case, the analogue (species-genus inference), followed by a predication in which the generic predication is attributed to the other specific instance, the primary subject (genus-species inference). Only some types of predication can be governed by the topics of genus and species. In particular, such rules can govern the predicates representing a characteristic of the abstract concept (such as in the case of the attribution of a genus), or the ones that are related to (motivating) its semantic features, such as in the case of the attribution of a property.

Conclusion

Analogical reasoning is a complex pattern that has been investigated in the dialectical medieval tradition under distinct labels (see Brown 1989). Analogy is based on a comparison and a transfer of a predication from the analogous to the primary subject. These two distinct passages can be accounted for and related to each other from the same logic-semantic perspective that can be drawn from the interpretation of Aristotle's topics as semantic-ontological rules of inference. The first step consists in distinguishing the distinct reasoning processes underlying analogical reasoning, i.e. what properties or features make two concepts or states of affairs similar, and what rules warrant the transfer of the predicate from an individual concept to the other. The first passage can be accounted for from a logical-semantic point of view as a process of abstraction of a common genus, which can correspond to the selection of an unnamed semantic feature common to the terms of the comparison, or the treatment of an accidental (non-semantic) characteristic as a pragmatically essential one. In both cases the process of choosing the predicate making the terms to be the same is guided by the analogical predicate. The process of abstracting is the basis for the application of the topics, or rules of inference, governing the attribution of the analogical predicate to the genus and to the primary subject. In this fashion, the transfer of the predication can be formalized and assessed according to specific semantic-ontological rules. In this sense, analogy can be thought of as a process of contextual definition or redefinition, yielding a conclusion drawn from the common analogical genus according to the topical rules of inference.

This analysis of analogy as a twofold process of abstraction and species-genus inference can account for essential (i.e. intensional) and accidental similarities. In dialectical analogies, the ones analyzed in the *Topics*, the abstraction singles out a feature that is part of or related to the meaning of the terms and that is relevant under the respect imposed by the analogical predicate. This process can shed light on the mechanisms underlying reasoning from accidental similarity analyzed in the *Rhetoric*.

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