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## Aristotle, science and the dialectician's activity

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**UNIVERSITÉ DE LILLE**  
&  
**UNIVERSITÉ DU QUÉBEC À MONTRÉAL**

**Aperçu de la thèse  
Dissertation overview**

PHD THESIS DEFENDED BY  
**ZOE McCONAUGHEY**

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ACADEMIC FIELD **PHILOSOPHY**

SPECIALITY **HISTORY AND PHILOSOPHY OF LOGIC**

**ARISTOTLE, SCIENCE AND THE  
DIALECTICIAN'S ACTIVITY**  
**A DIALOGICAL APPROACH TO ARISTOTLE'S LOGIC**

UNDER THE JOINT SUPERVISION OF

**SHAHID RAHMAN** UNIVERSITÉ DE LILLE  
**MATHIEU MARION** UQAM

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Two independent events converged in Lille while I was just a third year student at the philosophy department. First, there was the *Prior Analytics* seminar in Fall 2011, co-organized by Michel Crubellier and Shahid Rahman, who was also teaching a course on dialogical logic. Then Göran Sundholm was invited to Lille in Spring 2012 to give a series of lectures on Per Martin-Löf's Constructive Type Theory, which led me to take an Erasmus semester in Leiden the following year to study under his supervision. Ten years later, this dissertation reflects the crosspollination of these research programs and the influence of these three professors: the dialogical framework developed by Shahid Rahman, whose door is always open to students; the notation of Constructive Type Theory that Göran Sundholm brought to Lille together with his passion for the history of logical notions; and the study of Aristotle's logical works, a subject I came to cherish by attending Michel Crubellier's seminars and discussing the texts with him. I would like to express my most profound and heartfelt gratitude to all three professors, who have each in their own way shaped my way of thinking.

Since 2014, I have had the good fortune of participating in the STL reading seminars on the *De Anima* and the *Theaetetus*; these gave me a glimpse of the right way to study ancient texts while showing how fruitful and inspiring collaborative work can be. I would like to thank all the participants and organizers.

In 2012–2015, during my years as Master student, Shahid Rahman circulated a draft of Mathieu Marion and Helge Rückert's paper "Aristotle on Universal Quantification: A Study from the Point of View of Game Semantics," published in 2016. This paper proved pivotal for my future research since it paved the way to using dialogical logic to approach Aristotle's syllogistic. As my dissertation project was progressively emerging in 2015, it thus stood to reason that Mathieu Marion should become the joint supervisor. I am very grateful for this unique opportunity, which has opened new domains and methods for me to assimilate. What is more, studying at the Université du Québec à Montréal (UQAM) has shown me a different academic system, and enabled me to follow seminars and to meet brilliant new people among the professors and the students. This

exchange program was more fruitful and inspiring than can be briefly mentioned here.

I received several grants during the first three years of my dissertation. Chief among them was a grant from the *Conseil Régional Nord-Pas de Calais* (now *Hauts-de-France*) accounting for half of the total, which complemented a generous funding from the UQAM (*bourse de troisième cycle*, *bourse de recrutement FSH du programme de bourses d'excellence*, and *Bourse d'études de l'UQAM avec appariement CIRST*), and from the Université de Lille. I wish to thank these institutions for their support. My gratitude also goes to the philosophy department of the Université de Lille for giving me the opportunity to teach a number of courses during five years. My thanks also go to the *École Doctorale des Sciences de l'Homme et de la Société* and the STL laboratory, which have helped cover my travel expenses, provided training, and funded research projects I co-organized throughout my Ph.D. years.

Particularly notable is the SYZETEIN project, initiated in 2016 in Lille with Giulia Scalas and Sequoya Yiaueki, and which has progressively grown beyond our expectations, and is now in the hands of a new generation of Ph.D. students. There was also the workshop “Understanding Logical Concepts Through their History” organized in Lille with Florent Sinniger in 2019, which included lectures by Göran Sundholm on all three days and lectures from Barbara Bartocci on Medieval logic and from Michel Crubellier on Ancient logic. I would also like to mention my participation in two collaborative publications: *Immanent Reasoning or Equality in Action* with Shahid Rahman and Nicolas Clerbout, published by Springer in 2018, and the editorial project *Women's Perspectives on Ancient and Medieval Philosophy* with Isabelle Chouinard, Aline Medeiros Ramos, and Roxane Noël, which has just been published by Springer (2021).

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I am very grateful to all those who have gone through the grueling task of reading and correcting my prose – the quirkiness and remaining errors are my own.

I would like to thank all these people. This dissertation is dedicated to their generosity.

**Note.** Being a woman, I have adopted in this dissertation the convention of using the masculine as default grammatical gender. Certain examples use the expression "white human," meaning a person who is "pale," in the sense of not tanned; this is a common example in Aristotle for referring to simple predication or to an accident of human beings (something that can be so or not so); it never had, neither today nor in Antiquity, any implied meaning. Finally, it is worth pointing out that any modification I make on a translation is explicated in a footnote, except for standardization of spelling and punctuation, such as the choice of "premise" implemented throughout the dissertation.

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# GENERAL INTRODUCTION

## Outline of the current chapter

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## Overview of the dissertation

The aim of this dissertation is to produce a formal analysis of Aristotle's assertoric syllogistic that is historically and hermeneutically sensitive. The point is not to simply develop a logic that has the same *results* as Aristotle (mere formalization); it is also to develop these results in a way akin to Aristotle's own way of doing (historical sensitivity). Having the same results developed in a fashion similar to Aristotle's requires first understanding what Aristotle did. The main claim of the dissertation is that Aristotle's logic is best understood from a dialogical approach. However, as stressed in chapter 1, the chosen approach to logic has an impact on how logical texts are interpreted. Thus, it needs to be justified in relation to Aristotle's texts: when adopting a dialogical approach, it must be shown that such an approach is appropriate for understanding Aristotle's logic. This is the central task of this dissertation, carried

out in chapters 2 to 3, which argues for a dialogical approach to syllogistic but also to Aristotle's scientific inquiry, identifying a pre-causal, inherently dialectical stage in scientific inquiry. The relevance of this approach cannot be justified through modern considerations, which would risk misunderstanding Aristotle's point; it must be justified through the texts and their context alone, without imports from modern logic. Thus, no prior knowledge of modern logic is required in order to follow and assess the relevance of the dialogical interpretation of Aristotle's logic carried out in these two chapters. Once the dialogical interpretation has been unraveled and justified, it makes sense to formalize the assertoric syllogistic in a modern dialogical framework, which is done in chapter 4. This final chapter provides a unified framework based on pragmatist principles enabling a modern, formal rendering of Aristotle's syllogistic figures, their reduction to the first figure, *reductio ad absurdum*, and ecthesis, thus proving that everything Aristotle does can be done in the modern framework. In addition, in appendix A, all the cases in Aristotle's syllogistic that are not valid are shown to be invalid in the modern framework as well. In this fashion, a complete formalization of Aristotle's assertoric syllogistic is provided in a modern dialogical framework.

The idea defended in this dissertation, that Aristotle's logic is best approached from a dialogical perspective, is grounded in an interpretation of Aristotle's texts, in particular the *Analytics* in which his logic and conception of science are developed, and is supported by a modern formalization of assertoric syllogistic in a dialogical framework. As an overall consequence, the merits of the dialogical approach to logic in general will be highlighted.

## **Principles of the dialogical approach to logic**

The conception of logic defended here is based on dialogues: reasoning is done through interaction, either outwardly when someone else is present with whom to interact through questions and answers (or challenges and defences) in order to produce an argument against or in favor of a certain idea, or inwardly when a person is not actually there to play the antagonist role, but that role is nonetheless played in one's own mind.<sup>1</sup> The two parties may have a common goal, for instance finding truth; nonetheless, their roles remain antagonistic during the exchange, just like using a two-man saw requires

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<sup>1</sup>This distinction between two interaction forms, outward or external dialogues and inward or internal dialogical interaction, has been discussed by Catarina Dutilh Novaes, most recently and at length in 2021.



antagonistic roles in order to cut a piece of wood. The idea is that reasoning always takes place as a form of interaction between antagonistic parties, even in one's own mind. There is empirical evidence for this, such as when trying to figure something out, one proceeds through questions and answers, or when trying to examine something, one proceeds by raising objections and trying to answer them. However, this approach is not first and foremost a description of empirical dialogues or arguments; rather, it relies mainly on considerations regarding the *foundations* of logic: logic is considered as something *built out of* interaction and not just that happens to be produced through it.<sup>2</sup> Under the dialogical conception of logic, interaction constitutes meaning and is governed by rules; these rules are norms made explicit, norms that are themselves produced through interaction – produced in a conceptual rather than an empirically generative sense. It is interaction regulated by common norms that produces meaning in language, and it is from the set of interaction rules explicating the meaning of what is said that logic emerges.

**Example** For instance, as will be argued in this dissertation, the meaning of universal quantification – “all of the *subject* are *predicate*,” e.g. “all of the cetacea are viviparous” – can be made explicit through the following rule: if I make a universally quantified claim in a discussion, then, for any instance of the subject that someone else may choose, I have the duty to state that this instance is also an instance of the predicate, *i.e.*, that the predicate applies to this instance. In other words, if I say in a discussion that “all cetacea are viviparous,” another participant may test this claim by bringing forth an instance of cetacean, e.g. dolphins, and I will be committed to saying that dolphins are viviparous. The meaning of universal quantification (“all of the *subject* are *predicate*”) thus resides in interaction, and is based on norms of conduct embodied in duties and rights: the others have the right to choose an instance of the subject, and I have the duty to commit to the claim that the predicate applies to the chosen instance. In this regard, logic, which emerges from the use of these meaning-defining interaction rules, rests on norms, in particular on deontic norms resulting in duties and rights. Under this dialogical approach, logic rests on ethics. What is more, meaning is constituted through interaction and the norms embedded in it which is a pragmatist “meaning as

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<sup>2</sup>There are studies that focus more on the empirical side than on the foundational aspects. See for instance, in the dialogical tradition, the work of Dutilh Novaes (2013), or the pragma-dialectic project of Frans H. van Eemeren and Rob Grootendorst (1992). The dialogues in the Paul Lorenzen and Kuno Lorenz tradition are not taken straight out of the empirical world, but are a rational reconstruction of argumentation grounded in a dialogical approach to meaning and reasoning, and aim at better understanding these grounds (rather than empirical discourses).

use” conception of meaning.<sup>3</sup>

The universal quantification example is “formal” in the sense that it does not depend on the particular meaning of the subject and predicate involved: the same interaction rule holds for any subject and any predicate at all. Rules could be stipulated for the meaning of the terms themselves, such as what would count as cetacean, viviparous, uneven, or any other term.<sup>4</sup> Such rules would however be specific for each term, bringing us to a material (or substantive) level of consideration which is a lower limit of logic regarding propositions<sup>5</sup> – an upper limit being questions of validity, discussed below.

This dissertation adopts a dialogical approach to logic regarding two objects: ancient logic on the one hand, through a dialogical interpretation of Aristotle’s logic, and modern logic on the other, through a modern formalization of the proposed interpretation of Aristotle’s logic in a dialogical framework. Each of these two objects require specific methodological considerations. But first, a distinction between a particular logic and a logical framework must be made in order to understand the problems of method regarding the modern formalization of an ancient logic that intends to be historically sensitive: Aristotle’s assertoric syllogistic is a particular logic whose results can be equally expressed in different logical frameworks, based on different conceptions of logic; but all of the conceptions of logic are not equally close to Aristotle’s own conception of logic, so if the *results* can be equally expressed in various frameworks, the *way these results are produced* varies from one framework to another and can be closer or farther from the way Aristotle produced his own results. Since the way logical results are produced is also something that should be reproduced as best as possible in a formalization, the choice of the logical framework must be justified. What is more, since a framework imports with it a certain conception of logic, which orients the logician’s interpretation of Aristotle’s texts, it should be shown that the conception of logic imported with a framework can be grounded by an interpretation of the texts that does not make any

<sup>3</sup>Robert Brandom (1994, 2001) studies the meaning of terms in an inferentialist way, expounding on the principle of *meaning as use*; he develops the conception of meaning as “games of giving and asking for reasons,” which is close to the present dialogical approach – see Mathieu Marion (2010) for details on the link between Brandom’s inferentialism and Lorenzen and Lorenz’s dialogical framework.

<sup>4</sup>For rules at the material level, see for instance Shahid Rahman, Zoe McConaughy, et al. (2018, chapter 10).

<sup>5</sup>The passage from meaning in situations of utterance (singulars identified with the use of deictics) to meaning independent of the particular situation of utterance (individual schemas constructed out of particular tokens or actualizations) is examined by Lorenz (2010, pp. 71–79). In this paper, he argues that the other approaches to logic must take for granted two presuppositions when they deal with propositions, namely the *independence-presupposition* and the *individuation-presupposition* (Lorenz, 2010, p. 74); these two presuppositions are accounted for in the dialogical approach, providing a good reason for adopting such an approach to logic.

reference to modern logic. A unified conception of Aristotle's logic should thus emerge from the interpretation of the texts and correspond to the conception that underpins the chosen modern framework.

Chapter 1 examines the methodological difficulties of studying an ancient logic from a modern perspective and stresses the interpretation biases that a logical framework can introduce and which may go unnoticed if the choice of framework is not justified. A brief presentation of the dialogical framework will here be provided, stressing a few major differences with other frameworks.

## The dialogical framework vs. other frameworks

The dialogical approach presented above stems from the work of Paul Lorenzen and Kuno Lorenz, originating in the Erlangen school whose program was developed by Wilhelm Kamlah and Lorenzen (1967).<sup>6</sup> While the initial project has been pursued in various directions, Shahid Rahman and the Lille school furthered dialogical logic in the Lorenzen and Lorenz tradition, developing for instance the Immanent Reasoning framework used in this dissertation, which combines the dialogical framework with the technical notation of Per Martin-Löf's Constructive Type Theory.

Various studies have shown that the initial dialogical logic was not so much a particular logic than a logical *framework* in which a variety of logics could be developed, such as the original intuitionistic logic, classical logic, modal logic, to name but a few. Chapter 4 will develop assertoric syllogistic in this dialogical framework, thus adding one more logic that can be rendered in this framework. Among other logical frameworks are the model-theoretical and the proof-theoretical frameworks. We usually speak of proof-theoretical and model-theoretical *semantics* rather than frameworks. I will use the broader term "framework" to refer to a general way for propositions to be constituted, to have meaning, and for validity to arise. In this regard, speaking of semantics is reductive, as it does not account for the constitution of propositions, and can be misleading if it gives the idea that there is an accompanying syntax: in model-theory, the semantics presupposes a syntax that determines well-formed formulas (the semantics does not deal with the constitution of propositions); in proof-theory, the semantics is

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<sup>6</sup>The main original texts of dialogical logic have been collected in Lorenzen and Lorenz (1978). Lorenz (2001) and Peter Schröder-Heister (2008) provide historical overviews of the beginning of dialogical logic, while Rahman and Laurent Keiff (2005) cover later developments.

also the syntax, since meaning is determined in terms of proof, which are constituted from rules that provide meaning as well as their use (speaking of a “semantics” should thus not give the impression that there is an underlying syntax).

Proof-theory has the same *meaning as use* principle as the dialogical approach, but, as we will see below, the dialogical framework separates the level of meaning from the level of proofs: meaning is determined by the rules (as in proof-theory), which determine how a game can be played; if a game about a given thesis can be played, that is, if after a finite number of moves a player has no rule-abiding option left, then the thesis is a proposition<sup>7</sup>; proofs, on the other hand, come from winning strategies, that is, from a birds-eye perspective on all the possible games (see below). Meaning and the constitution of propositions is fully determined at the level of individual games (*i.e.* the application of the rules), while proof is built out of all the possible applications of the rules at the level of strategies. The dialogical framework thus has affinities with proof-theory, but cannot be reduced to it.

The dialogical framework implements in a technical way the philosophical and foundational considerations presented as the “dialogical approach”. The technicalities allow logics to be fully developed in the framework, producing the same results as in other frameworks (such as the proof-theoretical or the model-theoretical frameworks) but on a different foundational basis, namely, on a dialogical and pragmatist basis. In particular, the technicalities account for the fact that the dialogical framework does not deal with empirical dialogues, though they take the form of dialogues between two players, the Proponent, referred to as *he* by convention, and the Opponent, referred to as *she*.<sup>8</sup> A logical dialogue game is governed by explicit rules, such as the rules mentioned above defining the meaning of logical constants (such as universal quantification) through interaction, and rules regulating the course of the game, stipulating for instance that

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<sup>7</sup>The finite character of dialogues is constitutive of the notion of proposition. The rules are made in such a way that their application progressively reduces the possibilities of the players until one has no possibility left (that player loses). Other traditions of dialogical logic, such as that of Walter Felscher (1985), admit infinite dialogues. This misses the fact that propositions are defined through dialogue-definiteness, to the effect that infinite dialogues would not be able to ground the notion of proposition in a dialogical setting. As stressed below, the Lorenzen and Lorenz tradition’s task is more foundational than empirical.

<sup>8</sup>A certain number of criticisms raised against dialogical logic in the Lorenzen and Lorenz tradition have overlooked the fact that the dialogical framework is more concerned with the foundation of logic than with a description of empirical discussions. As suggested by Rahman (n.d.), this confusion may stem from an apparent continuity between Lorenzen’s (1955) Operationist logic and his later dialogical logic, while the dialogical logic is more of a rupture with the previous work (which was indeed anchored in everyday life and actions). See for instance Wilfrid Hodges (2001) who often takes empirical implausibility as an objection against Lorenzen-style dialogues. The response of Erik C. W. Krabbe (2001, p. 37) is clear on the point that Lorenzen-style dialogues are not empirical dialogues.

the Proponent is the player who makes the first statement, that each player makes a move in turn (either challenging a previous move made by the other, or answering a challenge), and that after a finite number of moves the player who had the last word wins while the other loses. The relevant rules for syllogistic are provided in chapter 4; I will here simply outline how the dialogical framework recovers the key notion of validity through dialogical games.

The model-theoretical framework is based on the notions of model and truth, the meaning of a proposition being determined by its truth-values, with different possibilities constituting different models; in such a framework, the validity concerns propositions and is defined as truth of a proposition in all models. The proof-theoretical framework is based on the notion of proof, the meaning of a proposition being determined by what counts as a proof for it; in such a framework, validity refers to closed proofs, *i.e.*, proofs in which all the assumptions are called for by the application of the rules that allow building the proposition being proved.

As mentioned above, the dialogical framework is based on the notion of rights and duties, the meaning of a proposition being determined by what each participant in a discussion has the right or the duty to do – one party's right being also the other party's duty. In the dialogical framework, the notion of validity of a proposition is secured through the notion of winning strategy for the Proponent: the Proponent is capable of winning for any choice the Opponent may make. Being capable of winning requires a certain perspective on all the possible interaction that can take place during a game; this perspective is the strategic perspective, and it is based on individual games, in which actual choices are made, which is the perspective of games. Games are played according to the game rules, which define the interaction during the game as well as the meaning of what is being said. These games are finite, which ensures that the thesis is a proposition. Thus, after a finite number of moves following the rules of a game, it can be determined which player has won and which has lost (ensuring that the thesis is a proposition); if, for any choice the Opponent may make, the Proponent always has a way of winning a game about a given thesis, then he has a winning strategy, which is the dialogical equivalent for saying that the proposition is valid. The dialogical framework can thus produce the notion of validity out of meaning, which is determined by the rules of interaction, and dialogue-definiteness, which defines the notion of proposition. A *valid proposition*, in the dialogical framework, is a thesis that generates a game won by the Proponent (the thesis generates a dialogue and thus a *proposition*) and that can be won by the Proponent for any choice the Opponent may have (the Proponent has a

winning strategy, the proposition is thus *valid*).

Various logics can be developed in the same framework and they will share the same foundational principles (such as what meaning or validity are). The same logic (*e.g.*, intuitionistic logic) can be developed in different frameworks (*e.g.*, in a model-theoretical and a dialogical framework); in each framework, the same *results* will be obtained (the same propositions will be valid, the same invalid), but the logic will have different foundational principles: meaning will come from a truth-function in the model-theoretical framework, and from the rules of interaction in the dialogical framework; validity in the model-theoretical framework will come from truth in all models, while in the dialogical framework it will come from a winning strategy, which comes from a perspective taken on individual, meaning-providing interactive games.

As mentioned above, distinguishing a particular logic from the logical framework in which it is developed is an important preliminary for the whole project of this dissertation: since one of the key points is to provide a modern formalization of Aristotle's assertoric syllogistic that is historically sensitive, and since a particular logic like syllogistic can be developed in various logical frameworks with the same results but not the same principles, the choice of the logical framework will produce a formalization of syllogistic that has principles more or less close to the principles Aristotle himself used when developing his syllogistic. For instance, choosing a model-theoretical framework will import a distinction between syntax and semantics, a distinction which, as discussed in chapter 1, may be foreign to Aristotle's conception of language. On the other hand, as will be argued in this dissertation, choosing a dialogical framework allows staying close to the historical context of the practice of dialectical debates, a context very present in Aristotle's texts. What is more, certain features of the dialogical framework, such as the distinction between meaning and proof, can help the interpretation of Aristotle's texts, like determining what a *sullogismos* is, though this interpretation then has to be justified by resorting only to Aristotle's texts. The main claim of this dissertation is that the dialogical approach makes Aristotle's logic more understandable; as a consequence, the dialogical framework, whose foundations rest in the dialogical approach, can provide a formalization of Aristotle's assertoric syllogistic that yields the desired results, as in other frameworks, but also yields them in a way close to Aristotle's own. We will now turn to the dialogical approach in Aristotle's logic.

## The dialogical approach to Aristotle's logic

Chapters 2 to 3 present and defend the idea that Aristotle's logic is best approached from a dialogical perspective. These chapters develop a dialogical interpretation of Aristotle's logic – encompassing syllogistic, dialectic, and scientific inquiry – without any reference to modern logic in order to justify this interpretation only through the texts and their contexts. Once the dialogical approach has been shown to be appropriate when dealing with Aristotle's logic, it is legitimate to choose the dialogical framework in order to formalize Aristotle's assertoric syllogistic, which is done in chapter 4.

In one sense, it is natural to adopt a dialogical approach to Aristotle's logic, since dialectical debates were common practice at the time and one of Aristotle's logical treatises, the *Topics*, explicitly deals with dialectic and constitutes a kind of handbook for the dialectician. But in another sense, this approach raises difficulties, since the syllogistic of the *Prior Analytics*, considered the most logical of his treatises, does not have a dialogical form; what is more, Aristotle himself clearly distinguishes dialectical and scientific arguments, and says that the *Prior Analytics* and the *Posterior Analytics* aim toward scientific knowledge. The traditional interpretation of Aristotle's logic thus tends to separate the context of dialectical debates from the context of syllogistic and of scientific research, adopting what can be called by contrast a monological approach in these last two domains.<sup>9</sup>

A dialogical approach to Aristotle's logic as a whole therefore needs to explain what is dialogical in syllogistic and in what sense scientific research can be dialogical when Aristotle distinguishes dialectical and scientific arguments. A dialogical approach to syllogistic is presented in chapter 2, while chapter 3 focuses on the relation between science and dialectic.

The monological approach to syllogistic focuses only on one aspect of syllogisms (and of the *sullogismos*), namely the premise-to-conclusion direction, and on a small portion of the *Prior Analytics* (the first twenty chapters of the first book); it is also primarily a syntactic conception of syllogistic. As shown in chapter 2, this is a restrictive interpretation of syllogistic. On the contrary, by showing how the meaning of quantified propositions, which constitute syllogisms, is determined in the *Prior Analytics* by the same rule found in dialectic and repeated several times in the *Topics*, a broader

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<sup>9</sup>See the introduction to chapter 2 for the traditional interpretation and a distinction between monological and dialogical approaches.

conception of syllogistic is produced, including an analytic conclusion-to-premises interpretation used in particular in the *pons asinorum* (*Prior Analytics* I 26–31), in addition to the more syntactic premises-to-conclusion interpretation. The role objections have in the *Topics* and the *Prior Analytics* reveals a common basis for these two treatises, which, I argue, is what the dialogical approach is about: it puts the focus on objections and the switch of the burden of proof it produces, and stresses the recurring presence of these considerations throughout the *Prior Analytics*. Under the dialogical reading, syllogistic is intimately coupled with the rest of the *Prior Analytics*, which provides the means for actually using syllogistic, for instance in dialectical debates, but also in scientific contexts.

Chapter 3 starts by defusing a possible misunderstanding: the dialogical approach to Aristotle's logic does not mean that his logic is reduced to applications in dialectical debates. In particular, the context of dialectical debates is not suitable for scientific research. So, in what sense is Aristotle's conception of scientific research dialogical? In this chapter, I argue in favor of a scientific use of dialectic that does not take the form of debates but that mobilizes tools and capacities developed through dialectical training. Dialectic in scientific inquiry is however not limited to tools and capacities: there is a stage in scientific inquiry that is of a dialectical nature in the sense that it requires what is done in dialectic, and that doing it is doing what is done in dialectic. This supposes defining the function of dialectic independently from its application in the context of debates. A certain definition of dialectic is proposed to this end: a content-determining inquiry circumscribing the adequate extensions of the subjects under investigation and proceeding through the identification of coextensive and incompatible terms. I will argue that this is the fundamental function of dialectic, and that dialectical debates make a certain use of this function (towards victory over the opponent), while the context of scientific inquiry makes another use of it (towards an adequate description of the subject at hand), a use that involves divisions, the *pons asinorum*, syllogistic, as well as other dialectical tools. Under this reading, dialectic in science takes the form of pre-causal investigations, which aim at producing an adequate description of the subject matter at hand. The adequate description is a difficult task, as can be seen in the *History of Animals*; a comparison with Plato's *Laches* will stress the dialectical nature of the description task. This task is dialogical in the sense established in chapter 2, which is characterized by the task of raising objections and trying to reject them: finding an appropriate description requires looking for counterexamples that will progressively allow a proper definition of the subject at hand. Adequate descriptions enable causal



problems to emerge and find solutions, as in the *Parts of Animals* or *Generation of Animals*, to name but the two major biological treatises that provide causal explanations to facts identified in the *History of Animals*. The passage from description (primary and true predication) to causal explanation is a theme of *Posterior Analytics* II, as well as the *pons asinorum* of the *Prior Analytics*.

The dialogical approach to Aristotle's logic in general, that is, to syllogistic, dialectic, and scientific inquiry, provides a reading of the logical treatises unified by the dialectical context, which can take the form of debates or of (pre-causal) scientific inquiry. It puts the focus on objections and their rejection, understanding a *sullogismos* as the moment in an argument where one knows no objection against the conclusion will hold, provided was has already been posited.

## The dissertation in context

Defending a dialogical approach of Aristotle's logic by putting an accent on dialectic is not new. Christian August Brandis (1835, *e.g.* p. 258) argues in favor of a priority of the *Topics* over the *Analytics* (the latter presupposing the presentation of arguments in the former); Ernst Kapp (1942, pp. 83–86) recapitulates his idea that syllogisms and induction in the *Organon* are considered as ways of teaching and learning, which introduces a conversational context between two persons (questioner and respondent, or teacher and disciple) and gives the *Topics* an important role; Eric Weil (1951) considers syllogistic to be but a pre-requisite for dialectic. The role of the *Topics* in Aristotle's scientific work has been re-evaluated since the "biological turn" of the 1970s (see *e.g.* Robert Bolton, 1990, p. 186); and works such as those of G. E. L. Owen (collected in 1986) or Terence Irwin (1988) have insisted on the dialectical character of Aristotle's philosophy as a whole. More recently, Michel Crubellier (2011, 2014b) has insisted on the dialectical context of the *Organon*. These are but a few landmarks in the modern defenses of Aristotle's dialectic, which include other, no less important contributions such as Jean Marie Le Blond ([1939] 1973), J. D. G. Evans (1977), Suzanne Mansion (1961a), among others. A dialogical approach to Aristotle's logic, scientific work, and philosophy has thus been proposed on many occasions, and many more than the few mentioned here.

However, these studies have not been coupled with a modern formalization endeavor. This means that the formalizations of syllogistic currently available do not stem from

a dialogical interpretation of Aristotle's logic. Though a modern formalization is not an argument in favor of this or that interpretation, it acts as an external warrant for the interpretation formalized. Thus, when facing competing interpretations, the fact that one of them can be formalized while the other cannot plays in favor of the formalizable interpretation and against the other. In providing a dialogical interpretation of Aristotle's logic and a formalization of it in a modern dialogical framework, the dialogical approach to Aristotle gains weight and can concurrence the currently accepted formalization of John Corcoran (1972) and Timothy Smiley (1973), which are not dialogical.

An overview of the history of modern formalizations of assertoric syllogistic is provided in chapter 1, together with considerations regarding the method of formalizing an ancient logic. The dialogical interpretation of Aristotle's logic is developed in chapters 2 to 3, and the formalization of assertoric syllogistic under this interpretation is provided in chapter 4 with *ecthesis*, indirect deduction, and reductions to the first figure, and is extended in appendix A by showing that the invalid moods in Aristotle's syllogistic are also invalid in the dialogical framework.

The result is a comprehensive dialogical approach to Aristotle's logic – understood as encompassing syllogistic, dialectic, and scientific inquiry – whose assertoric syllogistic can be formalized in a dialogical framework. The overall aim of this dissertation is thus to better understand Aristotle's logic and promote a dialogical approach to logic in general, including modern logic.

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# CHAPTER 1

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## INTERPRETATION BIASES OF MODERN STANDPOINTS ON ARISTOTLE'S LOGIC

### Outline of the current chapter

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## Introduction

This dissertation develops a dialogical interpretation of Aristotle’s logic from a historical point of view (chapters 2 to 3) and from a modern logical point of view (chapter 4). The work as a whole intends to show how modern formalizations can help understand an ancient logic. However, in logic as in any other field, there is a danger of circularity when approaching ancient texts: a modern scholar may argue that Aristotle’s texts should be interpreted in a certain fashion, without noticing that this interpretation stems from the scholar’s own modern standpoint on the subject at hand. In other words, the danger consists in seeing in Aristotle what one has oneself put, and by arguing that Aristotle’s conception on the subject was so and so, give historical justification for one’s modern standpoint. This is a classical problem of hermeneutics.

I will not tackle the hermeneutic problem in general, but I will insist on the fact that, contrary to what has long been believed, this problem does apply in the realm of logic and should be acknowledged when studying ancient logics, and all the more when trying to formalize such a logic in a modern logical framework. Thus, modern logicians who try to formalize Aristotle’s logic in a modern logical framework should proceed with caution in their endeavor, lest their modern conception of logic unconsciously influences their interpretation of Aristotle’s texts. If we take the dilemma proposed by Alasdair MacIntyre (1984, p. 31), quoted on footnote 8 on page 24, according to which philosophies of the past are either transmuted “so as to make them relevant to our contemporary problems and enterprises,” or are read so much in their own terms that they are like “museum pieces,” then it is clear that logicians who try to provide a modern

formalization of Aristotle's logic risk falling in the first horn of the dilemma: in wanting to produce a modern rendering of syllogistic, they risk inadvertently transmuting Aristotle's logic in a way that fits their needs. As we will see in section 1.2, this dilemma was already set out by Vittorio Sainati (1968) with respect to Aristotle's logic. He argued, like MacIntyre, that one *could* read ancient philosophies without necessarily falling prey to one of the two horns, and he developed an interpretation of Aristotle's logic using the genetic reconstruction methods of Jaeger, an interpretation that also used modern logical formalizations. Similarly, Kurt Ebbinghaus (1964) was aware of the problem and he developed, in line with the program of the school of Erlangen, a reconstruction of Aristotle's assertoric syllogistic in Lorenzen's (1955) operationist framework that was also historically sensitive, insisting on the heuristic aspect of such an endeavor.

Though I agree with the common idea that it is probably impossible to develop a completely faithful interpretation of an ancient text, in the sense of an interpretation absolutely free from any modern bias or preconception, this dissertation makes the wager, with Sainati, Ebbinghaus, but also Jan Łukasiewicz and Corcoran, that, if it cannot be entirely deleted, the circularity problem can at least be substantially reduced. I will follow the method that Mathieu Marion (2013, 2020) adapts from MacIntyre's (1984) work for the purpose of modern approaches to ancient logics, and which insists on the fact that one needs to be aware of the circularity problem, make one's preconceptions as explicit as possible, and justify the proposed interpretation of Aristotle's logic *in his own context*.<sup>1</sup> This chapter will deal with the need to acknowledge the circularity problem when formalizing ancient logics and in this regard will mostly be cautionary, pointing out various biases in the history of modern formalizations of Aristotle's assertoric syllogistic; it will also highlight important steps in this history and how logicians have struggled with this problem when propounding their own formalization. In order to make the preconceptions regarding logic as explicit as possible and justify the proposed dialogical interpretation of Aristotle's logic through his own context (and not through modern logical considerations), the exposition of the interpretation will be separated from that of the modern formalization. The dialogical interpretation of Aristotle's logic will thus first be presented in chapters 2 to 3 and defended without any recourse to modern logic in order to avoid justifying it through modern arguments and conceptions. On the contrary, special care will be taken in order to ground the interpretation in

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<sup>1</sup>See also the criticisms Ernst Kapp raises against commentators of ancient logical texts: "There is only one indispensable requirement: we must have learned to explain a given classic passage from a given classic context, instead of trying to explain it by simply substituting traditional modern notions for original old ones" (Kapp, 1942, p. 21; see also p. 74). This chapter stresses the fact that this criticism is as topical as ever.

the context of Aristotle's work and the broader intellectual context of the time. This interpretation will then be formalized in chapter 4. Separating the exposition of the interpretation from the formalization is a tool for reducing the circularity problem pointed out.

In this chapter, a brief history of the modern formalizations of Aristotle's assertoric syllogistic will first be sketched in section 1.1. Next, in section 1.2, the problem of interpreting an ancient logic from a modern logical perspective will be approached by presenting Łukasiewicz's pioneering work and the objections Sainati raised against it. Then, the problem will be taken anew in section 1.3, focusing on methodological comments made by Ebbinghaus, Corcoran and Claude Imbert. Finally, a few bias cases will be considered in section 1.4, in particular regarding the syntax-semantics distinction common in many modern frameworks.

## 1.1 A short history of modern formalizations of Aristotle's assertoric syllogistic

Logic has long enjoyed a privileged status in the history of philosophy: while it is common practice in other fields to be wary of one's modern preconceptions on the subject, to the effect that one should try to understand ancient authors only from their texts and their own historical context, there has been an understanding that logic was different, that there was only one universal and invariant logic, so that if Aristotle was a "good logician," his logic would have to reflect it. However, this very conception of logic as invariant rules out the possibility of various logics, be they coexisting or succeeding one another in time, so that the "correct" conception of logic (still under the hypothesis it is invariant) necessarily is the current one at the time of speech: Aristotle is then considered a "good" logician only if his logic meets the current standards of logic, whatever these may be.<sup>2</sup> Thus, with this conception of logic as invariant, modern logicians could approach Aristotle's logic with a certain preconception of what Aristotle's logic was supposed to be, since there was but one logic, namely the modern logician's own. For instance, as discussed below, Bertrand Russell considered Aristotle not to be a good logician, while Łukasiewicz considered Aristotle's logic to be

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<sup>2</sup>It is the rise of a pluralist conception of logic, in which many logics coexist and can be formulated in various logical frameworks, that allows looking at Aristotle's logic as a logic among many, a logic that can thus be studied in its idiosyncrasies, rather than a logic that is to be judged according to current, supposedly universal, standards.



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## CHAPTER 2

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# SYLLOGISTIC AND DIALECTIC

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## Introduction

The core of Aristotle's logic lies in the theory of the various figures of the *sullogismos* developed in *Prior Analytics* I 1–26, called syllogistic; it is often understood together with its application in the axiomatic method of demonstration (scientific *sullogismos*) of *Posterior Analytics* I. The question however remains open as to how this syllogistic relates to the rest of the *Organon*: is the syllogistic of *Prior Analytics* I 1–26 a self-standing logic, an extension of it being the theory of the scientific *sullogismos* (demonstration) of *Posterior Analytics* I? Or is syllogistic just an important step in a larger conception of logic?

The first approach, which considers syllogistic as the high point of Aristotle's *Organon* – either in its purely logical aspect in the *Prior Analytics* or in the role it plays in constituting the scientific method of demonstration in the *Posterior Analytics* – has generally been the dominant interpretation of the *Organon*.<sup>1</sup> Reducing logic to syllogistic is indeed common in modern approaches, which focus on the part of the *Organon* that can most easily be formalized, while reading the *Organon* as oriented towards the theory of demonstration has been institutionalized by the Neoplatonic curriculum (see below), and can be traced back at least to the edition of the Aristotelian corpus by Andronicus of Rhodes who more or less gave the *Organon* the form we now know.

The second approach, which will be defended in this dissertation, has been adopted for just as long as the first, yet without becoming predominant: it insists on the context of dialectical debates, which is the focus of the *Topics*, and understands syllogistic in this context rather than on its own, or as solely being oriented towards (a certain conception of) scientific demonstration. More recently, the work of Kapp (1942) has promoted this more dialogical approach to Aristotle's logic, influencing Ebbinghaus' approach discussed in chapter 1 and Marion and Helge Rückert's approach discussed in section 2.3.1. Even with the steady rise of interest for the *Topics* and dialectic in Aristotle's scientific work since the 1970s, Aristotle's logic is still predominated by the first approach, which can be called monological in contrast to the dialogical approach.

Reviewing the Neoplatonic curriculum, as well as the way this curriculum is based on

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<sup>1</sup>See for instance Wolfgang Detel's opening lines: "Aristotle's logic and theory of science have been handed down to us in two texts that are nowadays called *Prior Analytics* and *Posterior Analytics*, respectively" (Detel, 2006, p. 245).

Andronicus' editorial work (first century BCE<sup>2</sup>), and then comparing them both with an alternative interpretation that gives more place to the *Topics*, will provide an example of the two diverging approaches to Aristotle's *Organon* as well as an illustration of the issues at stake when adopting one approach over the other. This chapter will argue in favor of the second (dialogical) approach by insisting that it does not exclude the first (monological) approach but rather fully integrates it.

## The monological and the dialogical approaches to Aristotle's logic

### The Neoplatonist curriculum

The Neoplatonist school was founded by Plotinus (third century CE), in which the practice of exegesis of Aristotle's and Plato's texts took a central place (Philippe Hoffmann, 2006, p. 597). The philosophical curriculum culminated in the study of Plato (the "great mysteries"), prepared by a prior study of Aristotle (the "small mysteries") which started with the logical writings of the *Organon* in a didactic and systematic order that followed Andronicus of Rhodes' editorial work: first the *Categories*, then the *De Interpretatione*, then the *Prior Analytics* and the *Posterior Analytics* (Hoffmann, 2006, pp. 597 & 601 & 605–606 & 612). The study of logic thus culminates in the *Posterior Analytics*, the treatise dealing specifically with scientific knowledge (*episteme*), which is secured through demonstration (*apodeixis*), i.e., a scientific deduction (*sullogismos epistemonikos*). When studying philosophy, Aristotle's logic came first, and it was conceived as the studying of an instrument of thought oriented towards scientific knowledge. Since scientific knowledge requires mastering a special kind of deduction (*sullogismos*), the study of demonstrations should be preceded by the study of deduction (*sullogismos*) in general, the object of the *Prior Analytics*. Thus, the study of the *Posterior Analytics* requires the previous study of the *Prior Analytics*. In turn, the *Prior Analytics* require some previous study: deduction in general (*sullogismos*) being a combination of propositions, the study of deductions should be preceded by the study of propositions, which is the object of the *De Interpretatione*. And propositions being a combination of terms, these should be studied only after having studied terms without composition, the object of the *Categories*. The analysis of scientific deduction, the main object of the *Posterior Analytics*, thus produces a curriculum for approaching Aristotle's logic provided in table 2.1 on the following page.

<sup>2</sup>See Andrea Falcon (2017) for difficulties in giving precise dates.

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## CHAPTER 3

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# SCIENCE AND THE DIALECTICIAN'S ACTIVITY

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## Introduction

A case was made in chapter 2 for reading Aristotle's logic with the context of dialectical debates in mind. A major problem regarding this dialogical approach is however left standing: since Aristotle explicitly distinguishes dialectical and scientific arguments, how can an interpretation that insists on the dialectical roots of his logic account for science and demonstrations (scientific arguments)? Chapter 3 aims at solving this problem. First, in section 3.1, the problem itself, which is traditional (see for instance Weil, 1951), will be presented. It will be argued in particular that "one-on-one dialectical debates," *i.e.*, actual debates between two parties (the questioner and the answerer) directly discussing a thesis and ending in the victory of one over the other, are not suited for scientific inquiries. However, as developed in sections 3.2 to 3.4, dialectic should not be reduced, as it often is, to the context of one-on-one dialectical debates between a questioner and an answerer, even though that context most explicitly showcases dialectic. Another dimension of dialectic should also be considered: while one-on-one dialectical debates focus on winning against a particular adversary defending a thesis in a certain way, a broader use of dialectic considers *any possible* way an adversary can defend the thesis and tries to win against all of these possible variations. Such a broader use of dialectic is present, for instance, in Plato's dialogues when the characters start the inquiry anew, since another argumentative path is then followed, giving a richer idea of the whole problem. It is also present in Aristotle's scientific works when he strengthens some of his predecessors' arguments in order to be able to refute them even if they had argued differently: Aristotle's refutation

is not against this or that predecessor (*ad hominem* argument), but against the theses themselves, whoever the theses' champions may be (*ad argumentum* argument).

There are not two dialectics, but two different perspectives on the use of dialectic: it can be used in debates against one particular interlocutor, or it can be used in a more general context of inquiry, which focuses on the thesis and the argument rather than on how one person may happen to defend the thesis and build the argument, and thus tries to develop arguments that cannot be destroyed *at all*, regardless of the possible interlocutor. I argue in this chapter that this more general context of inquiry is scientific in the sense of searching for truth. In this regard, scientific inquiry uses dialectic in this broader perspective that does not focus on one particular opponent. The broader use of dialectic is not as explicitly dialogical as the paradigmatic context of one-on-one dialectical debates; it is however dialogical in the sense that it requires the same tools and capacities used in one-on-one debates, which are therefore called dialectical tools and capacities and are acquired through dialectical training in one-on-one debates; and it stems from the practice of individual debates in the sense that it takes into account *any possible* variation on a thesis.

Understanding the scientific use of dialectic requires focusing on the training: how dialectical training transforms the person who undergoes it; how it builds a certain disposition (*hexis*) towards opinions, a disposition necessary for scientific inquiry; how various capacities are developed, such as being able to foresee consequences of propositions; how the mind needs to be prepared for seeing the truth, and how this preparation in part requires appropriate dispositions of the mind, and in part requires tools developed in dialectical training such as collections of opinions, *aporiai*, *topoi*, predicables, categories, and divisions. Dialectical training also prepares the mind for the broader (scientific) use of dialectic, just like training with individual chess games prepares the mind for playing simultaneous games (see section 3.3.1 for this analogy). Under this reading, dialectical training is required for scientific inquiries by providing appropriate thinking habits that do not stop at a first result or difficulty, as well as tools and practices that will allow one to examine properly the subject at hand and determine *what it is*; this is a necessary albeit insufficient pre-demonstrative stage of the scientific inquiry, which ends when the causal relations are exposed in a demonstrative stage.

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## CHAPTER 4

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# SYLLOGISTIC IN THE IMMANENT REASONING FRAMEWORK

### Outline of the current chapter

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## Introduction

The modern formalizations of Aristotle's syllogistic discussed in chapter 1 take an interpretation of syllogistic in the lines of the premise-to-conclusion interpretation presented in section 2.2.1. Sections 2.3.1 to 2.3.3 argued in favor of an alternative interpretation, which understands syllogisms as the point in a discussion where a conclusion can be advanced knowing that, given what has been previously said, no objection raised against it will hold – in other words, given what has been said, the conclusion necessarily follows. This alternative interpretation reads the syllogisms of the *Prior Analytics* in the context of dialectical debates prevalent in the *Topics*. Chapter 3 argued that there is a dialectical context of inquiry in which pre-demonstrative scientific inquiries can, and must, take place; since this dialectical context was shown not to be one-on-one dialectical debates, all dialectical contexts are not reducible to opinion (as in one-on-one debates), they can also establish truth. Thus, reading syllogisms in a dialectical context is not reductive, in the sense that it would reduce syllogisms to matters of opinion; rather, it ties syllogisms to the roots of inquiries for truth, where the process of inquiry can hardly be dissociated from its content, from its substantive aspect. The no-counterexample interpretation of the *dictum de omni* – providing the explanation of the meaning of quantified statements – on the one hand and the procedure of *ecthesis*



implementing the *dictum*, *i.e.*, the rules determining this meaning, on the other allow to bridge the gap between formal syllogisms using schematic place-holders and the substantive aspect of inquiry. Indeed, through the recapitulation interpretation, the *dictum de omni*, and *ecthesis*, syllogisms are tied to objections: *the conclusion of a syllogism necessarily holds given the premises* means that no objection against the conclusion can hold provided these premises, which is ensured through the fact that the meaning of the premises is explained through objections, which are checked through the ecthetic procedure of setting out an instance and thus reasoning on an instance – *i.e.*, on a substantive case.

The interpretation of syllogisms based on the no-counterexample interpretation of the *dictum de omni* and its implementation through *ecthesis* (section 2.3.1) is thus complementary with the interpretation of syllogisms as recapitulations of a discussion (section 2.3.3) – *i.e.*, the point where one can state a conclusion knowing that from what has been said, no objection will hold. The traditional premise-to-conclusion interpretation of syllogisms (which focuses on *Prior Analytics* I 4–26, see section 2.2.1) is not incompatible with what can be called the no-counterexample dialogical interpretation of syllogisms developed in sections 2.3.1 to 2.3.3, on the condition that the premise-to-conclusion interpretation is understood as one perspective on syllogisms among other, more fundamental, perspectives, so that the premise-to-conclusion perspective has but a little scope – a preparatory scope as suggested by Crubellier (2017) quoted on page 144.

The dialogical no-counterexample interpretation of syllogistic will here be formalized using the modern dialogical framework called Immanent Reasoning; this will give weight to the claim that such an interpretation is logically sound. The Immanent Reasoning framework is a dialogical framework in the Lorenzen and Lorenz tradition that integrates the notation of Martin-Löf's Constructive Type Theory (CTT). The framework has been developed in Rahman, Zoe McConaughey, et al. (2018). Since it is a logical *framework*, various different logics can be produced in it, such as assertoric syllogistic, which will be this chapter's task. The advantages of this framework for formalizing the interpretation of syllogistic defended in chapters 2 to 3 is that it has 1) a dialogical structure, 2) a rule-based approach to meaning, 3) the means to explicit the instances implicit in subject-predicate statements, 4) an exhaustive method, and 5) a seamless structure going from validity (strategy level) to propositions (play level) and content (material level).

- 1) **The dialogical structure** The logic is carried out in plays, *i.e.*, debates between two parties who endorse the role of proponent – defending a statement called the thesis – or of opponent. This structure is parallel to the dialogical context of one-on-one dialectical debates with the answerer who must defend a thesis and the questioner who challenges it. However, the recapitulation interpretation of syllogisms entails that it is the proponent whose role is parallel to that of the questioner and the opponent whose role is parallel to that of the answerer: the dialogical plays for syllogisms start when in the dialectical debate the questioner has arrived at the point of *sullogismos* – he can bring the conclusion forward knowing that, from what has been said, no objection will hold; the answerer can then raise objections but in the end, if it was a genuine *sullogismos* (as syllogisms are), he will have to concede defeat, just like in the dialogical play the opponent can carry out all the moves she wishes (following the game rules) she will end up losing when the thesis is a syllogism. The dialogical structure of the Immanent Reasoning framework thus reflects the recapitulation interpretation of the *sullogismos* and the rooting of syllogistic in a dialectical context. It should be noted that this recapitulation interpretation separates the interaction embedded in the recapitulation of the argument from the interaction constituting the debate: during the recapitulation, the players are focusing on the argument, making sure no objection against it may hold. It is thus not the normal question and answer debate or everyday discussion, which focuses on the subject matter at hand, not on a particular argument.
- 2) **A rule-based approach** The dialogical plays are defined through game rules, specifying the interaction that can take place between the players and how the play starts, ends, and so on. The meaning of the quantified statements is defined through interaction rules (the particle rules, see section 4.2); this reflects the interpretation of the *dictum de omni* as explaining the meaning of the universal statements through a rule – namely, that for the universals no counterexample can be found.
- 3) **Expliciting instances** The Immanent Reasoning framework uses CTT which can explicit the instances hidden in the subject-predicate structure of propositions; this reflects the interpretation of the *dictum de omni* as a rule based on instances (counterexamples) and on *ecthesis* as a procedure carrying out these rules.
- 4) **An exhaustive method** The dialogical counterpart to validity in other logical frameworks is the existence of a winning strategy for the proponent (see in particular Nicolas Clerbout, 2014), which is produced through exhausting all the relevant

plays on a thesis, *i.e.*, taking into account all the plays in which the opponent can choose to play a different move and showing that in each case, the proponent has the means to win. Thus, from the level of plays (isolated debates between an opponent and a proponent ending after a finite number of moves with one player winning, the other losing) the level of strategies emerges when adopting a perspective encompassing all the possible plays on a given thesis, determining what is relevant and what is not, and making sure that the proponent is capable of winning for *every* relevant play. A play in which only the instance has changed (*e.g.* *f* instead of *d*) is not relevant, but a play in which the opponent can make a different choice is relevant. This exhaustive approach at the core of the strategy level reflects the importance of exhaustive approaches of a scientific problem in the dialectical pre-demonstrative stage of inquiry examined in section 3.3.

- 5) **A seamless structure** There is no separation between considerations on validity and considerations on meaning: validity in the Immanent Reasoning framework is provided through the existence of a winning strategy for the proponent by taking all the relevant plays into account, while it is at the level of plays that the meaning of statements is defined and that a proposition is determined. This seamless structure reflects the interpretation of syllogistic based on the no-counterexample interpretation of the *dictum de omni* and on a dialectical context dealing with content; it also reflects the continuity between the search of meaning (*ei esti* and *ti esti* questions, see section 3.3) when establishing relevant databases for a scientific inquiry and the discovery of a middle term allowing to build a demonstration (scientific *sullogismos*) – see section 3.4. The present formalization will not develop the material play level but stay at a formal play level.

What is more, section 3.2 insisted on interpreting dialectic as tools that prepare and transform the mind, endowing one with those very tools. The means for this teaching and acquisition are the one-on-one dialectical debates, which are good situations for noticing and using those tools, but which do not exhaust all the possible situations for using them, as argued in sections 3.3 to 3.4. The learning situation is important to stress as it allows to look at dialectic neither as a procedure that can be followed and that would lead one to some truths (as argued was the case in Bolton, 1990) nor as a mere psychological help (as are the interpretations of dialectic that do not make it attain truth, such as in Irwin, 1988 who needs a second type of dialectic). Two things should be noted on this “fine line” interpretation between procedure and psychology. First, the fact that it grounds dialectic in a learning situation allowing one to master

the dialectician's tools and thereby transforms that person into a dialectician makes this interpretation very compatible with the rational reconstruction of what meaning and propositions are proposed by Lorenz, one of the founders of dialogical logic in the Lorenzen tradition (Lorenzen and Lorenz, 1978), which involves interaction and teaching-learning situations (*e.g.* in the papers collected in Lorenz, 2010). Second, it preserves a tension between what can be called a subjective and an objective side of statements – which was examined in the case of *episteme* in section 3.2.2 – that is present in Frege's work, who preserved judgments while rejecting psychologism. It is Martin-Löf's (1984) work that allowed to have a formal notation marking the difference between a proposition and a judgment. This tension is also at the heart of the dialogical framework, since it keeps the two sides of statements – subjective judgment and objective proposition – while resolving the tension through interaction: the subjective component (present in judgments or in understanding) has meaning because it can be the object of some interaction – the fact that someone else reacts appropriately sanctions its common meaning or objectivity. It is thus interaction that constitutes meaning, interaction that fashions the minds of people and the concepts they use – not the other way around (Lorenz, 2010; Marion, 2010).

The formalization of this interpretation of syllogistic is not an *argument* in favor of the interpretation of Aristotle in the sense that a formalization does not help establish the interpretation was *Aristotle's* conception of syllogistic – historical arguments are required for that. Nonetheless, building a formalization can provide good incentive to the reader for adopting the proposed interpretation by furnishing an external (*i.e.*, non-historical) warrant that the interpretation is sound (without saying it was Aristotle's). Arguments defending that this interpretation was Aristotle's conception of syllogistic is the purpose of chapters 2 to 3, which invoke historical evidence and arguments without resorting to modern logical reconstructions.

Section 4.1 will develop the CTT notation for quantified statements that allows to explicit the instances underlying subject-predicate notations. Section 4.2 will then develop the basic game rules for the no-counterexample dialogical interpretation of syllogistic, rules that reflect the rules of the *dictum de omni et de nullo* and that implement *ecthesis*. Section 4.3 proves that the plays for the conversions and the three figures of the syllogism can be won by the proponent using the basic game rules for *ecthesis* presented in section 4.2. Table 4.1 on page 310 provides an overview of the types of proofs explicitly used (marked with their reference) or mentioned (marked with  $\diamond$ ) in *Prior Analytics* I 2–6, the chapters in which Aristotle goes through all the

possible combinations for conversions and syllogisms in order to prove the valid ones and reject those that are not. Only the categorical syllogisms are dealt with here, the modal ones are not. From this table, it is clear that Aristotle especially uses *ecthesis* in the case of the first figure (and in *e-conversion*), where reduction to the first figure is not possible, though he also uses or mentions it in a few other cases. The core idea of the dialogical no-counterexample interpretation of syllogistic is that this *ecthesis* procedure can always be used, it is the default mode of proof.

Section 4.4 introduces rules augmenting the basic rules for *ecthesis* in order to have plays with indirect deductions, which Aristotle occasionally resorts to or mentions (see the column “indirect” in table 4.1 on the next page). The indirect plays for the conversions and three figures are then carried out, with the proponent winning.

Section 4.5 introduces another set of rules augmenting the basic *ecthesis* rules: first conversion rules allowing to convert statements during a play (and not just use conversions as the starting thesis, as what is talked about), then reduction rules for reducing second and third figure moods to first figure moods. The plays for the second and third figure moods are then reduced to first figure moods, with the proponent winning – to the exception of *Baroco* (second figure) and *Bocardo* (third figure) which cannot be reduced, a feature recognized by Aristotle as he provided indirect proofs for them (see table 4.1 on the following page).

Finally, in the appendix A, the plays for the *invalid* moods are carried out, with opponent capable of winning each time.

In this regard, the Immanent Reasoning framework is capable of formalizing the no-counterexample dialogical interpretation of syllogistic defended here by showing that all the valid moods of the syllogism are won by the proponent with the *ecthesis* rules, with the indirect rules and with the conversion and reduction rules, and that all the invalid moods are lost by the proponent with the *ecthesis* rules. What is more, when Aristotle carries out a justification of a mood (cases referenced in table 4.1 on the next page, to the exception of the *ecthesis* ones), the play and the text of the justification are put in parallel in order to see that the dialogical formalization is an explicitation of Aristotle’s way of proceeding.

Before providing the formalization of the dialogical no-counterexample interpretation of syllogistic in the Immanent Reasoning framework, the choice of this framework rather than another dialogical framework needs to be further discussed.

Table 4.1: Synoptic view of the types of proof in Aristotle's syllogistic (first line) and in the Immanent Reasoning formalization (second line, with table reference)

Type	Name	Form	Ecthesis	Indirect	Reduction
Conversion <i>APr. I 2</i>	e-conv	$AeB : BeA$	25a14–17 <i>T. 4.14 p. 357</i>	25a14–17 <i>T. 4.31 p. 377</i>	
	a-conv	$AaB : BiA$	<i>T. 4.15 p. 358</i>	25a17–19 <i>T. 4.33 p. 381</i>	
	i-conv	$AiB : BiA$	<i>T. 4.16 p. 359</i>	25a20–22 <i>T. 4.35 p. 383</i>	
First Fig. <i>APr. I 4</i>	<i>Barbara</i>	$AaB, BaC : AaC$	25b37–40 <i>T. 4.10 p. 346</i>	<i>T. 4.37 p. 385</i>	
	<i>Celarent</i>	$AeB, BaC : AeC$	25b40–26a1 <i>T. 4.12 p. 353</i>	<i>T. 4.38 p. 386</i>	
	<i>Darii</i>	$AaB, BiC : AiC$	26a23–25 <i>T. 4.13 p. 355</i>	<i>T. 4.39 p. 387</i>	
	<i>Ferio</i>	$AeB, BiC : AoC$	26a25–28 <i>T. 4.11 p. 352</i>	<i>T. 4.40 p. 389</i>	
Second Fig. <i>APr. I 5</i>	<i>Cesare</i>	$MeN, MaX : NeX$	<i>T. 4.22 p. 366</i>	<i>T. 4.41 p. 390</i>	27a5–9 <i>T. 4.58 p. 414</i>
	<i>Camestres</i>	$MaN, MeX : NeX$	<i>T. 4.21 p. 365</i>	$\diamond$ <i>T. 4.42 p. 391</i>	27a9–14 <i>T. 4.60 p. 416</i>
	<i>Festino</i>	$MeN, MiX : NoX$	<i>T. 4.23 p. 367</i>	<i>T. 4.43 p. 392</i>	27a32–36 <i>T. 4.62 p. 419</i>
	<i>Baroco</i>	$MaN, MoX : NoX$	<i>T. 4.20 p. 364</i>	<i>T. 4.44 p. 393</i>	27a36–b1
Third Fig. <i>APr. I 6</i>	<i>Darapti</i>	$PaS, RaS : PiR$	28a22–26 <i>T. 4.24 p. 368</i>	$\diamond$ <i>T. 4.46 p. 396</i>	28a17–22 <i>T. 4.64 p. 421</i>
	<i>Felapton</i>	$PeS, RaS : PoR$	<i>T. 4.25 p. 370</i>	$\diamond$ <i>T. 4.47 p. 397</i>	28a26–30 <i>T. 4.66 p. 423</i>
	<i>Disamis</i>	$PiS, RaS : PiR$	<i>T. 4.27 p. 372</i>	<i>T. 4.48 p. 399</i>	28b7–11 <i>T. 4.68 p. 424</i>
	<i>Datisi</i>	$PaS, RiS : PiR$	<i>T. 4.26 p. 371</i>	$\diamond$ <i>T. 4.49 p. 400</i>	$\diamond$ <i>T. 4.70 p. 426</i>
	<i>Bocardo</i>	$PoS, RaS : PoR$	28b20–21 <i>T. 4.28 p. 373</i>	28b17–20 <i>T. 4.50 p. 401</i>	
	<i>Ferison</i>	$PeS, RiS : PoR$	<i>T. 4.29 p. 374</i>	<i>T. 4.52 p. 404</i>	28b33–35 <i>T. 4.72 p. 428</i>

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## GENERAL CONCLUSION

The dialogical approach to Aristotle's logic developed in this dissertation allows for a comprehensive and unified interpretation of syllogistic, dialectic, and scientific inquiry (chapters 2 to 3). A formal analysis of the dialogical interpretation of assertoric syllogistic is provided in chapter 4 and produces, in the dialogical framework, a modern formalization that is historically grounded. As argued for in chapter 1, this dissertation progresses using two successive methodological standards: first, it presents and justifies the proposed dialogical interpretation of Aristotle's syllogistic, dialectic, and method of scientific inquiry by focusing on Aristotle's texts, without importing modern logical considerations (chapters 2 to 3); second, it provides a full formal analysis of the dialogical interpretation using the modern dialogical framework (chapter 4 and appendix A). In this fashion, the justification of the dialogical interpretation of the *Organon* is based on historical grounds, with as little biases introduced from modern logic as possible.

While the presentation and justification of the historical interpretation is kept separate from its formal analysis in the modern dialogical framework, the upshot is a complex argument in favor of the dialogical foundation of logic in general – both in its Aristotelian roots and in its modern ramifications. Under this reading, reasoning in general – be it for everyday reasoning, for the study of arguments themselves, or for pursuing an inquiry, *e.g.* a scientific inquiry – is fundamentally dialogical in the sense that it is based on a dynamic and interactive process that constitutes the meaning of what is at stake by means of commitments and entitlements embodied principally in possible objections and their rejection. In short, what counts as an objection constitutes meaning and inserts what is said in a dynamic process of meaningful argumentation. This argumentation is called dialogical because of the interaction embedded in the

possibility of objections, which supposes a commitment to successfully defend the claim against objections or abandon the claim itself. This interactive, “dialogical” foundation of argumentation can take the form of external dialogues between parties assuming antagonist roles, but it is not limited to it since meaning itself is constituted on this interactive basis: any piece of meaningful argumentation is dialogical in this sense.

In showing that, according to Aristotle’s logical texts, both dialectical debates and contentful meaning are based on the notion of objection, their dialogical foundations are established, opening the way for a dialogical understanding 1) of syllogistic, inserting it in the broader context of dialectic, and 2) of dialectic, defining this practice in such a way that it is not limited to debates, though of course, debates are also covered by the definition. While the usual, monological approach to syllogistic focuses almost exclusively on *Prior Analytics* I 1–26, chapter 2 shows how adopting such a dialogical perspective better integrates Aristotle’s assertoric syllogistic in the context of the *Prior Analytics* as well as that of the *Organon* as a whole. Chapter 3 focuses on the use of dialectic for scientific inquiry and shows how training in dialectical debates prepares the mind of the inquirer and provides important mental tools and abilities to can help any inquiry. Dialectic in this sense cannot be reduced to the practice of dialectical debates. At this point, the study could stop, resulting in a conception of dialectic that is a useful auxiliary for scientific inquiry. A tentative definition of dialectic is however provided that makes it more than a mere auxiliary: dialectic is defined as the the process of progressively determining the extension of terms through objections and their resolution. The presence of objections captures the dialogical foundations argued for before, while the focus on extensions makes this argumentative practice intimately linked to the meaning or content of the subject at hand. Under this reading, the pre-causal stage of scientific inquiry would be dialectic, so that dialectic would be a necessary, though not sufficient, part of scientific inquiry. As mentioned below, this definition calls for further research.

In developing a dialogical interpretation of Aristotle’s logic – understood broadly as encompassing syllogistic, dialectic, and scientific inquiry – together with a modern formalization of assertoric syllogistic in a dialogical framework, this dissertation provides a comprehensive dialogical alternative to current approaches to Aristotle’s *Organon*, including Corcoran’s and Smiley’s natural deduction or Łukasiewicz’s axiomatic interpretations and formalizations of assertoric syllogistic.

The dialogical formalization provided in chapter 4 and extended in appendix A gives



a central role to Aristotle's ecthesis, which is understood as implementing the *dictum de omni* rule that determines the meaning of quantification, as defended in chapter 2. Ecthesis grounds the figures of the syllogism in a pragmatist setting capable of proving the validity of all the valid moods. Appendix A proceeds in a similar fashion regarding the invalid moods, proving them to be invalid in the dialogical framework also. Additional rules are provided for reducing second and third figure moods to first figure moods, and for proceeding to *reductio ad absurdum*. Thus, most features of Aristotle's syllogistic are integrated in a unified framework. However, Aristotle's modal syllogistic falls outside of this dissertation's scope, as it would require a full study of its own. Since modal syllogistic is a continuation of assertoric syllogistic in the sense that it adds to the four quantified propositions (universal affirmative and negative, particular affirmative and negative) two modal qualifiers, namely being necessary and being possible, yielding a total of twelve types of predication instead of four: the four quantified propositions without modal qualifiers, with the necessity qualifier, and with the possibility qualifier. The syllogistic needs to be supplemented with the syllogisms that involve modally qualified propositions. The present dissertation provides a formalization of assertoric syllogistic in the dialogical framework based on a dialogical interpretation of the *Prior Analytics* in particular, and the *Organon* in general. This approach can now be further tested by a dialogical investigation of *Prior Analytics* I 8–22 accompanied by a formal analysis of the resulting interpretation using the dialogical framework.

Various studies have examined the mathematical origins of Aristotle's syllogistic. However, the dialogical approach suggests a complementary investigation of these origins found in public debates and polemics, which include rhetoric, but also the defense of the art of medicine. For instance, a possible source of inspiration for Aristotle's notion of necessity inherent to the *sullogismos* could be found in the comparison between the force of persuasion that comes from Gorgias' exhaustive account of the possibilities in the *Encomium of Helen* or the *Defense of Palamedes* and the one produced by other pieces of rhetorical discourse. What is more, the two Hippocratical treatises *Ancient Medicine* and *Art* show that polemics were ongoing in the medical domain, in particular regarding the existence of the art of medicine and what the principles of the discipline are. We have access to these polemics through texts that argue against absent parties, in the sense that we do not have a live dialogue between the contestants, to the effect that an argued discourse held by one person and taking into consideration opposing views provides a clear example of the process of internalizing an opponent in one's own way of thinking. In such a case, the general context is dialogical by being a polemic,

but the piece of argumentation in itself is also dialogical in its way of taking real or possible objections into account in shaping both the argument and the subject matter (something all the clearer when defining the art of medicine). While this dissertation focused on the dialogical *foundations* of Aristotle's logic, further studies in the direction of its origins could reveal a dialogical *genesis* of these foundations.

Finally, as testified by the international symposium "Aristotle's Dialectic and the Sciences" organized by Luca Gili and held on August 26–27, 2021, there is currently an increased interest in determining the exact nature of the relation between Aristotle's dialectic and science. In particular, as was suggested by James Allen and Colin G. King during the symposium, the work of Paolo Fait, "*Endoxa e consenso: per la distinzione dei due concetti in Aristotele*," 1998, and its more recent ramification in the work of Tobias Reinhardt, "On 'Endoxa' in Aristotle's 'Topics'," 2015, can provide new insights on Aristotle's notion of *endoxon* and on the work of the *Topics* as providing norms of premise acceptance, an interpretative path tread by King's forthcoming book *Aristotle's Theory of Dialectical Argumentation*. The proposition of defining dialectic as a process of progressively determining the extension of terms through objections and their resolution (section 3.4), which is the most tentative part of this dissertation, will benefit from this impetus in the studies of Aristotle and opens further investigations, among others on its relation to the *topoi* of the *Topics* and to its application in various scientific treatises.

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# APPENDIX A

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## APPENDIX – THE INVALID MOODS OF THE THREE FIGURES

### Outline of the current chapter

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<b>A.1 Synoptic view of the invalid moods of the three figures</b>	<b>435</b>
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### A.1 Synoptic view of the invalid moods of the three figures

Aristotle proves the completeness of syllogistics by proving that the valid moods are valid, and that the invalid moods are not valid (section 2.2.1). This exhaustive approach is possible because his system is finite: premises and conclusions are composed of one subject  $S$  and one predicated  $P$  and are either universal affirmative ( $PaS$ ), universal negative ( $PeS$ ), particular affirmative ( $PiS$ ), or particular negative ( $PoS$ ); and since a syllogism is composed of two premises and one conclusion, the combination of premises can only be one of those in table A.1 on the following page, each combination having one of the four possible conclusions (**a-e-i-o**-conclusion). What is more, since the

Table A.1: All the possible premise combinations

	A	E	I	O
A	aa	ae	ai	ao
E	ea	ee	ei	eo
I	ia	ie	ii	io
O	oa	oe	oi	oo

Table A.2: Color code

text	Valid mood
text	Invalid: Opponent has at least two choices

two premises need to be combined through a middle term, the major term being the predicate of the conclusion and the minor term the subject, Aristotle defines three figures for syllogisms, encompassing what he took to be all the possibilities: the first figure in which the middle term is subject of the first premise and predicate of the second (see table A.3a on page 438), the second figure in which the middle term is predicate of both premises (see table A.4a on page 439), and the third figure in which the middle term is subject of both premises (see table A.5a on page 440). A fourth figure was later added by Theophrastus, followed by the scholastics, in which the middle term was predicate of the first and subject of the second, but we will not develop this figure. There is thus a denumerable amount of possible combinations in syllogistics, organized by Aristotle in three figures.

In the *Prior Analytics* I 4–6, Aristotle examines each case one after the other, showing the validity of the valid moods by *ecthesis*, reduction to the first figure, or by indirect deductions, and showing the invalidity of the invalid moods through the method of triplets – see section 2.3.1. This triplet method consists in providing two sets of three terms, where one set shows that the premises and a-conclusion is true and the other that the premises and e-conclusion is true (he sometimes uses particulars and indeterminates) – in the two cases, the premises and conclusion are true, so that from the two premises, one cannot say that necessarily an affirmative or a negative conclusion follows, thus showing there is no necessity and consequently no *sullogismos*.<sup>1</sup>

A systematic approach will be taken here in order to show that the dialogical reconstruction of Aristotle's syllogistic through the Immanent Reasoning framework of chapter 4 based on the interpretation of Aristotle developed in chapters 2 to 3 also rejects the combinations Aristotle rejects; however, this will not be done through Aristotle's own method of triplets, which would require a material level – which may be produced but exceeds the scope of the present dissertation.<sup>2</sup>

<sup>1</sup>See tables 2.6 to 2.8 on pages 120–122 for an example in each figures of the triplet method.

<sup>2</sup>In the rules for material dialogues, the particular affirmative and negative rules would need to be so formulated that they are shown to be true even when one takes, for the affirmative, an instance that does not fall under the instance, and that does for the negative. This is not possible in the rules for the formal

Tables A.3 to A.5 on pages 438–440 provide an exhaustive view of the possibilities. When a mood is valid, the other possible conclusions are not dealt with. A short comment is provided describing why Proponent cannot win the play for the corresponding thesis, which is consequently shown to be an invalid mood. The plays are provided in appendix A.2; the first figure is completely developed, the second and third do not develop plays in which Opponent has at least two choices, and the plays in the first figure amply illustrate why this condition is sufficient for determining that Opponent will win the play. Four sets of premises (all particulars), already pointed out in table A.1 on the facing page, are not carried out, since whatever be the conclusion, Opponent has at least two choices and can thus prevent Proponent's victory.

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