

# Selected Bibliography on Aristotle's Theory of Categorical Syllogism

## BIBLIOGRAPHY

1. Barker Evelyn M., "Unneeded surgery on Aristotle's "Prior Analytics", " *Notre Dame Journal of Formal Logic* 25: 323-331 (1984).  
"The article takes issue with Ross's bracketing of lines 45a9-16 of Aristotle's "Prior Analytics" I 28 because they involve Aristotle in an "elementary logical error." Describing Aristotle's "method of identities" for finding syllogistic premises, I point out the lines contain an essential leg of Aristotle's argument that this method handles all cases in which the incompatibility between the attributes of a subject e and a predicate a generates a syllogistic conclusion that A does not belong to some E. Also, Aristotle's claim that incompatibility of attributes in such cases always resolves into identity of attributes is valid."
2. Barnes Jonathan. Grammar on Aristotle's terms. In *Rationality in Greek thought*. Edited by Frede Michael and Striker Gisela. Oxford: Clarendon Press 199. pp. 175-202  
"However that may be, Aristotelian syllogistic concerned itself exclusively with monadic predicates. Hence it could not begin to investigate multiple quantification. And that is why it never got very far. None the less, the underlying grammar of Aristotle's logic did not in itself block the path to polyadicity. The later Peripatetics were conservative creatures and they lacked logical imagination. Moreover, Aristotle himself had assured them that his syllogistic was adequate for all serious scientific needs. As for Aristotle, his service to logic is nonpareil, and it would be grotesque to hide him for lack of inventiveness. It is true that, in logical grammar, he did not climb above the level which he attained in the *de Interpretatione*. But the *Analytics* does not represent a fatal, or even a new, grammatical excursion. And the story of Aristotle's fall, like the story of the fall of Adam, is a myth."
3. Barnes Jonathan. Proof and the Syllogism. In *Aristotle on science. The "Posterior Analytics"*. *Proceedings of the eighth Symposium Aristotelicum held in Padua from September 7 to 15, 1978*. Edited by Berti Enrico. Padova: Antenore 1981. pp. 17-59
4. Berka Karel. La syllogistique aristotélicienne, reconstruction historico-logique. In *Penser avec Aristote*. Edited by Sinaceur Mohammed Allal. Paris: Éditions érès 1991. pp. 429-432
5. Bird Otto. *Syllogistic and its extensions*. Englewood Cliffs: Prentice-Hall 1964.
6. Boger George. The modernity of Aristotle's logic. In *Aristotle and contemporary science - Vol. II*. Edited by Sfondoni-Mentzou Demetra, Hattiangadi Jagdish, and Johnson David M. Bern: Peter Lang 2001. pp. 97-112

"Summary.

We have identified five aspects of Aristotle's syllogistic to highlight the remarkable modernity of his logical investigations: (1) Aristotle took logic to be a formal part of epistemology. A logic is an instrument for establishing knowledge of logical consequence; this is a principal concern of the science of logic. (2) *Prior Analytics* is a metalogical treatise on the syllogistic deduction system. Aristotle exhaustively treated all possible combinations of elemental "syllogistic" argument patterns to determine which have only valid argument instances. (3) Aristotle recognised the epistemic efficacy of certain elemental argument patterns having only valid instances, and he explicitly formulated them as rules of natural deduction in corresponding sentences. (4) *Prior Analytics* is a proof-theoretic treatise in which Aristotle described a natural deduction system and demonstrated certain of the logical relationships among syllogistic rules. In fact, Aristotle modelled his syllogistic in a rudimentary way for this purpose. One important metasystematic result is to have established the independence of a set of deduction rules. Finally, (5) Aristotle worked with a notion of substitution sufficient for distinguishing logical syntax and semantics. In this connection he also distinguished validity from deducibility sufficiently well to note the completeness of his logic. Our reading of *Prior Analytics* takes Aristotle to have treated the process of deduction much as

modern mathematical logicians do and not to have been confused about some fundamental matters of logic. Least of all was he confused, as some commentators believe, about a distinction between "following necessarily" and "being necessary," both in respect of the distinction between a *syllogismos* or a deduction and a demonstration and of the distinction between assertoric logic and modal logic. Aristotle clearly distinguished between (1) a given sentence's following necessarily from other given sentences and (2) a given sentence denoting a state of affairs to be necessary (or possible). Seeing that he was concerned with the deduction process helps us to avoid such an error. In any case, Aristotle recognised that, while the conclusion of a given argument follows necessarily from its premises, this necessity might not be evident to a participant. He knew that the epistemic process of deduction produces knowledge, or makes evident, that a given sentence follows necessarily from other given sentences. He considered the product of this epistemic process to be an argumentation that includes a deductive chain of reasoning in addition to the premises and conclusion. He recognised using deduction rules in the epistemic process for establishing validity, and that this process can be applied in a purely mechanical and computational way. Furthermore, Aristotle distinguished (1) the subject matter of a given argument from (2) the use to which a given argument might be put from (3) the varying expertise of a participant. All these matters are distinct from (4) the formal matters underlying any of them. And precisely to examine these formal matters was his project in *Prior Analytics*. In this connection, then, we understand Aristotle to have distinguished two kinds of knowledge that cannot be otherwise: (1) knowledge of what is true or false, which pertains to sentences, and (2) knowledge of what valid or invalid, which pertains to arguments." pp. 110-111

7. Clark Michael. *The place of syllogistic in logical theory*. Nottingham: University of Nottingham Press 1980.
8. Corcoran John, "Completeness of an ancient logic," *Journal of Symbolic Logic* 37: 696-702 (1972).
9. Corcoran John, "A mathematical model of Aristotle's syllogistic," *Archiv für Geschichte der Philosophie* 55: 191-219 (1973).

"Our purpose in the present article is to present a mathematical model designed to reflect certain structural aspects of Aristotle's logic. Accompanying the presentation of the model is an interpretation of certain scattered parts of the *Prior* and *Posterior Analytics*. Although our interpretation does not agree in all respects with those previously put forth, the present work would have been impossible without the enormous ground work of previous scholars - especially Jenkinson, Lukasiewicz and W. D. Ross - to whom we are deeply grateful.

Our interpretation restores Aristotle's reputation as a logician of consummate imagination and skill. Several attributions of shortcomings and logical errors to Aristotle are seen to be without merit. Aristotle's logic is found to be self-sufficient in several senses. In the first place, his theory of deduction is logically sound in every detail. (His indirect deductions' have been criticized, but incorrectly on our account.) In the second place, Aristotle's logic presupposes no other logical concepts, not even those of propositional logic. In the third place, the Aristotelian system is seen to be complete in the sense that every valid argument storable in his system admits of a deduction within his deductive system, I. e. every semantically valid argument is deducible.

In the present paper we consider only Aristotle's theory of non-modal logic which has been called "the theory of the assertoric syllogism" and "Aristotle's syllogistic." Aristotle presents the theory almost completely in Chapters 1, 2, 4, 5 and 6 of the first book of *Prior Analytics*, although it presupposes certain developments in previous works - especially the following two : first, a theory of form and meaning of propositions having an essential component in *Categories* (Ch. 5, esp. 2a 34- 2b 7) ; second, a doctrine of opposition (contradiction) more fully explained in *De Interpretatione* (Ch. 7, and cf. Ross, p. 3)." p. 191

10. Corcoran John, "Aristotelian syllogisms: valid arguments or true universalized conditionals?," *Mind* 83: 278-281 (1974).
11. Corcoran John. Aristotle's natural deduction system. In *Ancient logic and its modern interpretations. Proceedings of the Buffalo Symposium on Modernist Interpretations of Ancient Logic, 21 and 22 April, 1972*. Edited by Corcoran John. Dordrecht: Reidel 1974. pp. 85-131  
"In the present article we attempt to show that Aristotle's syllogistic is an underlying logic which includes a natural deductive system and that it is not an axiomatic theory as had previously been

thought. We construct a mathematical model which reflects certain structural aspects of Aristotle's logic and we examine both the mathematical properties of the model and the relation of the model to the system of logic envisaged in certain scattered parts of *Prior* and *Posterior Analytics*. Our interpretation restores Aristotle's reputation as a logician of consummate imagination and skill. Several attributions of shortcomings and logical errors to Aristotle are shown to be without merit. Aristotle's logic is found to be self-sufficient in several senses. In the first place, his theory of deduction is logically sound in every detail. (His indirect deductions have been criticized, but incorrectly on our account.) In the second place, Aristotle's logic presupposes no other logical concepts, not even those of propositional logic. In the third place, the Aristotelian system is seen to be complete in the sense that every valid argument expressible in his system admits of a deduction within his deductive system; i.e., every semantically valid argument is deducible.

There are six sections in this article. The first section includes methodological remarks, a preliminary survey of the present interpretation and a discussion of the differences between our interpretation and that of Lukasiewicz. The next three sections develop the three parts of the mathematical model. The fifth section deals with general properties of the model and its relation to the Aristotelian system. The final section contains conclusions." p. 85

12. Corcoran John, "Argumentations and logic," *Argumentation* 3: 17-43 (1989).

13. Corcoran John, "The founding of logic. Modern interpretations of Aristotle's logic," *Ancient Philosophy* 14: 9-24 (1994).

"Where the interpretations of the 1920s and 1930s attribute to Aristotle a system of propositions organized deductively, the interpretations of the 1970s attribute to Aristotle a system of deductions, extended deductive discourses, concatenations of propositions, organized epistemically. The logicians of the 1920s and 1930s take Aristotle to be deducing laws of logic from axiomatic origins; the logicians of the 1970s take Aristotle to be describing the process of deduction and in particular to be describing deductions themselves, both those deductions that are proofs based on axiomatic premises and those deductions that, though deductively cogent, do not establish the truth of the conclusion but only that the conclusion is implied by the premise-set.

Thus, two very different and opposed interpretations had emerged, interestingly both products of modern logicians equipped with the theoretical apparatus of mathematical logic. The issue at stake between these two interpretations is the historical question of Aristotle's place in the history of logic and of his orientation in philosophy of logic. This paper affirms Aristotle's place as the founder of logic taken as formal epistemology, including the study of deductive reasoning. A by-product of this study of Aristotle's accomplishments in logic is a clarification of a distinction implicit in discourses among logicians -- that between logic as formal ontology and logic as formal epistemology." p. 10

14. Corcoran John, "Aristotle's *Prior Analytics* and Boole's *Laws of Thought*," *History and Philosophy of Logic* 24: 261-288 (2003).

"*Prior Analytics* by the Greek philosopher Aristotle (384 - 322 BCE) and *Laws of Thought* by the English mathematician George Boole (1815 - 1864) are the two most important surviving original logical works from before the advent of modern logic. This article has a single goal: to compare Aristotle's system with the system that Boole constructed over twenty-two centuries later intending to extend and perfect what Aristotle had started. This comparison merits an article itself.

Accordingly, this article does not discuss many other historically and philosophically important aspects of Boole's book, e.g. his confused attempt to apply differential calculus to logic, his misguided effort to make his system of 'class logic' serve as a kind of 'truth-functional logic', his now almost forgotten foray into probability theory, or his blindness to the fact that a truth-functional combination of equations that follows from a given truth-functional combination of equations need not follow truth-functionally. One of the main conclusions is that Boole's contribution widened logic and changed its nature to such an extent that he fully deserves to share with Aristotle the status of being a founding figure in logic. By setting forth in clear and systematic fashion the basic methods for establishing validity and for establishing invalidity, Aristotle became the founder of logic as formal epistemology. By making the first unmistakable steps toward opening logic to the study of 'laws of thought' -- tautologies and laws such as excluded middle and non-contradiction -- Boole became the founder of logic as formal ontology."

15. Corcoran John, "Aristotle's demonstrative logic," *History and Philosophy of Logic* 30: 1-20 (2009).

"Demonstrative logic, the study of *demonstration* as opposed to persuasion, is the subject of Aristotle's two volume *Analytics*. Many examples are geometrical. Demonstration produces *knowledge* (of the truth of propositions). Persuasion merely produces *opinion*. Aristotle presented a general *truth-and-consequence conception of demonstration* meant to apply to all demonstrations. According to him, a demonstration, which normally proves a conclusion not previously known to be true, is an extended argumentation beginning with premises known to be *truths* and containing a chain of reasoning *showing* by deductively evident steps that its conclusion is a *consequence* of its premises. In particular, a demonstration is a *deduction* whose premises are known to be true. Aristotle's *general* theory of demonstration required a prior *general* theory of deduction presented in the *Prior Analytics*. His general *immediate-deduction chaining conception* of deduction was meant to apply to all deductions. According to him, any deduction that is not immediately evident is an extended argumentation that involves a chaining of intermediate immediately evident steps that *shows* its final conclusion to follow logically from its premises. To illustrate his general theory of deduction, he presented an ingeniously simple and mathematically precise *special* case traditionally known as the *categorical syllogistic*."

16. Crivelli Paolo, "Empty terms in Aristotle's logic," *Boston Area Colloquium in Ancient Philosophy* 17: 237-269 (2001).

"Aristotle's logic can accommodate non-referring terms. Genuine affirmations must contain both a referring subject and a referring predicate; sentences that contain non-referring subjects or non-referring predicates are not genuine assertions. In appendix : The translation of *De interpretatione* 8. 18A23."

17. Cutler Darcy Allen. Aristotle and Modern Logic. In *Mistakes of reason. Essays in honour of John Woods*. Edited by Peacock Kent A. and Irvine Andrew D. Toronto: University of Toronto Press 2005. pp. 207-223
18. Ebbinghaus Kurt. *Ein formales Modell der Syllogistik des Aristoteles*. Göttingen : Vandenhoeck & Ruprecht 1964.
19. Frede Michael, "Stoic vs. Aristotelian syllogistic," *Archiv für Geschichte der Philosophie* 56: 1-32 (1974).

Reprinted in: M. Frede - *Essays in Ancient Philosophy* - Minneapolis, University of Minnesota Press, 1987 pp. 99-124.

20. Galvan Sergio, "A formalization of elenctic argumentation," *Erkenntnis* 43: 111-126 (1995).

"In the Aristotelean philosophical tradition, elenctic argumentation (*Elenchos*) is conceived as a form of dialectical foundation of a thesis.

It takes place in the context of discussion for and against a given thesis and consists in showing that, as the denier of this thesis argues against the opponent, he is unable to maintain his position unless he presupposes the thesis itself, which thus prevails and is consequently proven. As is well known, Aristotle used this form of argumentation in many areas of his inquiry, since he regarded it as an extremely effective technique not only in the speculative sciences but in the physical and practical sciences as well. Particularly fortunate - because of its subsequent widespread use and because of the broad reflection that it stimulated - was Aristotle's application of this form of dialectical argumentation in Book Four of the *Metaphysics* in order to justify the principle of non-contradiction. Apart from its historical influence, this application is of especial importance because it evidences Aristotle's intention to prove, not any thesis whatsoever, but a logical principle, and this expresses his claim for an epistemically absolute proof - in the form of self-proof - of the principle itself.

It does not appear, however, that elenctic proof of the non-contradiction principle can be accomplished successfully. In fact, demonstration that this proof is impossible is the purpose of the present essay, in which I propose a formalization of the argument - i.e. a formal reconstruction of the argument intended to give it a sufficiently precise specification - which highlights the conceptual difficulties that lie at its root." p. 111

21. Glashoff Klaus, "Aristotelian syntax from a computational-combinatorial point of view," *Journal of Logic and Computation* 15: 949-973 (2005).
22. Goddard Len, "The inconsistency of Aristotelian logic?," *Australasian Journal of Philosophy* 78: 434-437 (2000).

23. Granger Gilles Gaston, "Le syllogisme catégorique d'Aristote," *L'Age de la Science* 3: 281-310 (1970).
24. Hintikka Jaakko. Le logicien incontinent d'Aristote. In *Aristote aujourd'hui*. Edited by Sinaceur Mohammed Allal. Paris: Éditions érès 1988. pp. 94-112
25. Ierodiakonou Katerina, "Aristotle's use of examples in the *Prior Analytics*," *Phronesis* 47: 127-152 (2002).
26. Jacobs William, "Aristotle and nonreferring subjects," *Phronesis* 24: 282-300 (1979).  
"It is a widely accepted view amongst scholars that Aristotle believed that the subject of an assertion might fail to refer. Two texts, *De Interpretatione* XI 21 a 25-28 and *Categories* X 13 b 12-35, are generally cited as evidence for this belief. In this paper I will argue that both passages have previously been misunderstood and that Aristotle did not accept the possible referential failure of the subject of an assertion. In Section I, after first discussing the standard interpretations of both texts, I note the difficulties which result from these accounts. In Section II I offer a brief general argument showing that Aristotle's own account of what an assertion is implies that it is impossible for the subject of an assertion to fail to refer. In Section III I present my own analysis of each passage and show that when properly understood neither is in any way concerned with the problem of referential failure."
27. Jacobs William, "The existential presuppositions of Aristotle's logic," *Philosophical Studies* 37: 419-428 (1979).
28. Johnson Fred, "Three-membered domains for Aristotle's syllogistic," *Studia Logica* 50: 181-187 (1991).  
"The paper shows that for any invalid polysyllogism there is a procedure for constructing a model with a domain with exactly three members and an interpretation that assigns non-empty, non-universal subsets of the domain to terms such that the model invalidates the polysyllogism."
29. Johnson Fred, "Syllogisms with fractional quantifiers," *Journal of Philosophical Logic* 23: 401-422 (1994).  
"Aristotle's syllogistic is extended to include denumerably many quantifiers such as more than  $2/3$ ' and exactly  $2/3$ .' Syntactic and semantic decision procedures determine the validity, or invalidity, of syllogisms with any finite number of premises. One of the syntactic procedures uses a natural deduction account of deducibility, which is sound and complete. The semantics for the system is non-classical since sentences may be assigned a value other than true or false. Results about symmetric systems are given. And reasons are given for claiming that syllogistic validity is relevant validity."
30. Johnson Fred, "Apodictic syllogisms: deductions and decision procedures," *History and Philosophy of Logic* 16: 1-18 (1994).
31. Kapp Ernest. Syllogistic. In *Articles on Aristotle. Vol. 1 Science*. Edited by Barnes Jonathan, Schofield Malcolm, and Sorabji Richard. London: Duckworth 1975. pp. 35-49  
Originally published as 'Syllogistik' in: Pauly-Wissowa's *Real-Encyclopädie der classischen Altertumwissenschaft*, IV A, 1931 cols. 1046-1067. Reprinted in E. Kapp - *Ausgewählte Schriften* - Hrsg. von Hans und Inez Diller, Berlin, de Gruyter, 1968, pp. 254-277.
32. Kelly Charles J., "The logic of the Liar from the standpoint of the Aristotelian syllogistic," *Notre Dame Journal of Formal Logic* 32: 129-146 (1991).
33. Keyt David. Deductive logic. In *A Companion to Aristotle*. Edited by Anagnostopoulos Georgios. Malden: Wiley-Blackwell 2009. pp. 31-50
34. Lukasiewicz Jan. *Aristotle's syllogistic from the standpoint of modern formal logic*. Oxford: Oxford University Press 1951.  
Second edition 1957 with a new chapter on Aristotle's modal logic.
35. Lukasiewicz Jan. *Elements of mathematical logic*. Oxford: Pergamon Press 1963.  
Translated from Polish by Olgierd Wojtasiewicz.  
Original edition: *Elementy logiki matematycznej* - Warszawa, 1929.
36. Lukasiewicz Jan. On the history of the logic of propositions. In *Polish logic 1920-1939*. Edited by McCall Storrs. Oxford: Oxford University press 1967. pp. 66-87  
Originally published in Polish as *Z historii logiki zdan*, *Przegląd Filozoficzny*, 37, 1934; translated by the author in German as: *Zur Geschichte der Aussagenlogik*, *Erkenntnis*, 5, 1935, pp. 111-131.

Translated in English in: Storrs McCall (ed.) - *Polish logic 1920-1939* - Oxford, Clarendon Press, 1967 pp.66-87 and also in: J. Lukasiewicz - *Selected works* - Ludwik Borowski (ed.) - Amsterdam, North-Holland, 1970 pp. 197-217.

37. Lukasiewicz Jan. Philosophical Remarks on Many-Valued Systems of Propositional Logic. In *Polish logic 1920-1939*. Edited by McCall Storrs. Oxford: Oxford University Press 1967. pp. Originally published in German as: *Philosophische Bemerkungen zu mehrwertigen Systemen des Aussagenkalküls*, Comptes rendus des séances de la Société des Sciences et des Lettres de Varsovie 23, 1930.  
Translated in English in: Storrs McCall (ed.) - *Polish logic 1920-1939* - Oxford, Clarendon Press, 1967 pp. 40-65 and also in: J. Lukasiewicz - *Selected works* - Ludwik Borowski (ed.) - Amsterdam, North-Holland, 1970 pp. 153-178.
38. Marshall Jr.David, "Lukasiewicz, Leibniz and the arithmetization of the syllogism," *Notre Dame Journal of Formal Logic* 18: 235-242 (1977).  
"Lukasiewicz' second axiomatization of the assertoric syllogism ("Aristotle's syllogistic", 1957) consists of four axioms of assertion and one of rejection. n arithmetic interpretation is presented proving the independence of the latter. Lukasiewicz himself demonstrated all five consistent by means of an arithmetization due to Leibniz. This arithmetization, we are told by Louis Couturat ("La logique de Leibniz", 1901) was thought by Leibniz himself to have been invalid. Whether and why Leibniz in fact took this (mistaken) view, is discussed briefly."
39. Martin John N., "Aristotle's natural deduction reconsidered," *History and Philosophy of Logic* 18: 1-15 (1997).  
"John Corcoran's natural deduction system for Aristotle's syllogistic is reconsidered. Though Corcoran is no doubt right in interpreting Aristotle as viewing syllogisms as arguments and in rejecting Lukasicwicz's treatment in terms of conditional sentences, it is argued that Corcoran is wrong in thinking that the only alternative is to construe Barbara and Celarent as deduction rules in a natural deduction system. An alternative is presented that is technically more elegant and equally compatible with the texts. The abstract role assigned by tradition and Lukasiewicz to Barbara and Celarent is retained. The two 'perfect syllogisms' serve as ' basic elements' in the construction of an inductively defined set of valid syllogisms. The proposal departs from Lukasiewicz, and follows Corcoran, however, in construing the construction as one in natural deduction. The result is a sequent system with fewer rules and in which Barbara and Celarent serve as basic deductions. To compare the theory to Corcoran's, his original is reformulated in current terms and generalized. It is shown to be equivalent to the proposed sequent system, and several variations are discussed. For all systems mentioned, a method of Henkin-style completeness proofs is given that is more direct and intuitive than Corcoran's original."
40. Mignucci Mario. Expository proof in Aristotle syllogistic. In *Aristotle and the later tradition*. Edited by Blumenthal Henry and Robinson Howard. Oxford: Clarendon Press 1991. pp. 9-28  
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41. Mignucci Mario. Aristotle's theory of predication. In *Studies on the history of logic. Proceedings of the Third Symposium on the history of logic*. Edited by Angelelli Ignacio and Cerezo Maria. Berlin: Walter de Gruyter 1996. pp. 1-20
42. Mignucci Mario. Che cos'è un sillogismo aristotelico? In *Momenti di storia della logica e di storia della filosofia*. Edited by Guetti Carla and Pujia Roberto. Roma: Aracne Editrice 1996. pp. 39-58  
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43. Morgenstern Amy S., "Commentary to Paolo Crivelli: *Empty terms in Aristotle's logic*," *Boston Area Colloquium in Ancient Philosophy* 17: 270-281 (2001).
44. Morrison John J., "The existential import of a proposition in Aristotelian logic," *Philosophy and Phenomenological Research* 15: 386-393 (1955).
45. Mulhern Mary. Corcoran on Aristotle's logical theory. In *Ancient logic and its modern interpretations. Proceedings of the Buffalo Symposium on Modernist Interpretations of Ancient Logic, 21 and 22 April, 1972*. Edited by Corcoran John. Dordrecht: Reidel 1974. pp. 133-148  
"Corcoran, it seems to me, has made a very important contribution to our understanding of Aristotle's logic, and the suggestions offered in what follows should not be construed as impugning

in any substantive way the value of that contribution.

Of the many points Corcoran raises, I intend to take up four: (1) whether syllogistic is a science; (2) whether the theory of propositional forms presupposed by syllogistic is adequate; (3) whether Aristotle had a doctrine of logical truth; and (4) whether Aristotle considered reasoning natural or conventional." p. 136

46. Negro Camillo. *La sillogistica di Aristotele come metodo della conoscenza scientifica*. Bologna: Patron 1967. pp.
47. Novak Joseph A., "Some recent work on the assertoric syllogistic," *Notre Dame Journal of Formal Logic* 21: 229-242 (1980).

"Over the last few decades there have been many attempts to approach the Aristotelian syllogistic by utilizing the techniques of contemporary formal logic. The aim of this paper is to examine the most significant of these attempts and evaluate their fidelity to and consistency with Aristotle's own basic exposition of the syllogistic as expressed in the *Prior Analytics* (Book I, 1-2; 4-6).

Two major approaches to the formalization of the assertoric syllogistic can be distinguished in the literature. The first and older approach construes the syllogistic as an axiomatic system, while the second and more recent approach considers the syllogistic as a natural deduction system. Since many of the attempts of the first sort fail to be mentioned in current discussion, this paper will try to summarize them and only make a concluding reference to the second approach which is readily accessible in the more recent publications.

There are two main issues which must be confronted in the case of each attempt to present Aristotle's assertoric syllogistic as an axiomatic system: first, whether the method of representation, i.e., the logical alphabet and the well-formed formulas of the system, conforms to Aristotle's own approach; second, whether the specific formulas chosen as axioms and definitions, the rules of inference, and the manner of proof, etc., are faithful to or at least consistent with Aristotle's writings. Although it might appear that the first issue, a discussion of the logical symbols employed, is

not of any real value, one must remember that Aristotle's logic seems tied to some basic philosophical or, better, metaphysical presuppositions. That there can be a close link between certain symbolical representations and some ontological positions is clear in the case of some other philosophers.

One instance in the twentieth century is Gustav Bergmann whose espousal of a bare particularist theory of individuation is linked to his employment of a type of Russellian formal language (Bergmann, G., *Meaning and Existence*, University of Wisconsin Press, Madison, 1960).

Attempts at presenting the syllogistic in a formal way have proceeded along four lines: first, the attempt to present the syllogistic by means of the first-order predicate calculus; second, the classic attempt of Lukasiewicz to develop the syllogistic; third, the attempt to present the syllogistic as a theory of classes; fourth, Lejewski's attempt to relate the syllogistic to Lesniewski's ontology. Each of these attempts will be treated below in light of the two issues raised above."

48. Parry William T. and Hacker Edward A. *Aristotelian logic*. Albany: State University of New York Press 1991.
49. Patterson Richard, "The case of the two Barbaras: basic approaches to Aristotle's modal logic," *Oxford Studies in Ancient Philosophy* 7: 1-40 (1989).
- " Aristotle's modal propositions use modal copulae rather than modal predicates or modally qualified *dicta*; the familiar contrast between predication of *dicta* and of things is inappropriate to the Aristotelian modalities. Despite what may appear to be vacillation on Aristotle's part between *de re* and *de dicto* modality, the copulae interpretation can serve to unify the two types."
50. Patterson Richard, "Conversion principles and the basis of Aristotle's modal logic," *History and Philosophy of Logic* 11: 151-172 (1990).

"Aristotle founds his modal syllogistic, like his plain syllogistic, on a small set of 'perfect' or obviously valid syllogisms. The rest he reduces to those, usually by means of modal conversion principles. These principles are open to more than one reading, however, and they are in fact invalid on one traditional reading (*de re*), valid on the other (*de dicto*). It is argued here that this way of framing the contrast is not Aristotelian, and that an interpretation involving modal copulae allows us to see how these principles, and the modal system as a whole, are to be understood in light of close

and precise connections to Aristotle's essentialist metaphysics."

51. Patterson Richard, "Aristotle's perfect syllogisms, predication, and the *dictum de omni*," *Synthese* 96: 359-378 (1993).
52. Patzig Günther. Aristotle's theory of syllogism. A logico-philological study of Book *A* of the *Prior Analytics*. Dordrecht: Reidel 1968. pp.  
English translation by Jonathan Barnes of G. Patzig - *Die aristotelische Syllogistik. Logisch-philologische Untersuchungen über das Buch A der Ersten Analytiken* - Göttingen. Vandenhoeck & Ruprecht, 1959.
53. Patzig Günther, "Aristotle and syllogisms from false premisses," *Mind* 68: 186-192 (1959).
54. Patzig Günther. Problèmes actuels de l'interprétation de la syllogistique d'Aristote. In *Aristote aujourd'hui*. Edited by Sinaceur Mohammed Allal. Paris: Éditions érès 1988. pp. 270-275
55. Rose Lynn, "Premise order in Aristotle's syllogistic," *Phronesis* 11: 154-158 (1956).  
"Upon examination of all of the syllogisms in the "Prior Analytics," it is found that Aristotle has relatively strong tendencies to write the major premise before the minor premise in the first figure and in the second figure and a considerably weaker tendency to write the major premise first in the third figure. These tendencies are explained in terms of 'left-right' and 'adjacency' factors that are connected with Aristotle's treatment of the syllogism as a rectilinear array of the three terms."
56. Rose Lynn, "Aristotle's syllogistic and the Fourth Figure," *Mind* 74: 382-389 (1965).
57. Rose Lynn. *Aristotle's syllogistic*. Springfield: Charles C. Thomas 1968.  
Contents: I. Plato's dialectic and Aristotle's syllogistic 3; II. The varieties of predication 13; III. The three figures 16; IV. The non-use of rules 27; V. Validation by reduction 34; VI. Invalidation by counterexample 37; VII. The syllogistic system 53; VIII. The Fourth Figure and the indirect proof 57; IX. Subalternation 80; X. Premise order 81; Appendix. I. The square of opposition 99; II. The mnemonic lines 102; III. The perfection of Aristotle's First Figure 104; IV. Theophrastus and the indirect moods 109; V. The diagrams of the three figures 133; VI. John Locke's criticisms of Aristotle and the syllogism 137; Bibliography 144; Index 147-149.

"Aristotle's work in formal logic has received a great deal of scholarly attention; nevertheless, it remains largely misunderstood. Aristotle's logic has often been equated with traditional "Aristotelian" logic (a usage as unhistorical as "Platonic" love or "Epicurean" tastes), or, which is even worse, judged and evaluated in accordance with how closely it follows or "fails" to follow that traditional logic. Even when efforts have been made to understand Aristotle's logic in its own right, Aristotle has usually been very shabbily treated. He has commonly been accused of errors that he never made at all, such as neglecting or overlooking the fourth figure. Even his way of conceiving the syllogism as a linear array of three terms has been lost on minds handicapped by later, but not thereby better, ways of thinking.

Although I hope that this book will contribute towards a better understanding of what Aristotle did and did not accomplish in his syllogistic, I have by no means attempted to treat Aristotle's syllogistic in its entirety. (For one thing, I have confined myself to the assertoric syllogistic and not gone into the modal logic at all.) The principal task of this book has been to explore the consequences of accepting the Aristotelian syllogism as a linear array of three terms. This approach to Aristotle sheds light on many hitherto mysterious aspects of Aristotle's logic; it provides new insights into what Aristotle was doing in the *Prior Analytics* and enables us to correct numerous misconceptions about his logic.

My treatment of the *Prior Analytics* has been quite sympathetic, and my conclusions are generally favorable; indeed, one of the aims of this book is to exonerate Aristotle's work in formal deductive logic." p. V

58. Ross William D., "The discovery of syllogism," *Philosophical Review* 48: 251-271 (1939).
59. Shepherdson John C., "On the interpretation of Aristotelian syllogistic," *Journal of Symbolic Logic* 21: 137-147 (1956).
60. Simons Peter, "Tree proofs for syllogistic," *Studia Logica* 48: 540-554 (1989).  
"This paper presents a tree method for testing the validity of inferences, including syllogisms, in a simple term logic. The method is given in the form of an algorithm and is shown to be sound and complete with respect to the obvious denotational semantics. The primitive logical constants of the

system, which is indebted to the logical works of Jevons, Brentano and Lewis Carroll, are term negation, polyadic term conjunction, and functors affirming and denying existence, and use is also made of a metalinguistic concept of formal synonymy. It is indicated briefly how the method may be extended to other systems."

61. Smiley Timothy, "Syllogism and quantification," *Journal of Symbolic Logic* 27: 58-72 (1962).
62. Smiley Timothy, "What is a syllogism?," *Journal of Philosophical Logic* 2: 136-154 (1973).
63. Smiley Timothy, "Aristotle's completeness proof," *Ancient Philosophy* 14: 25-38 (1994).  
"In *Prior Analytics* I 23 Aristotle presents a completeness proof for syllogistic logic, or so I maintain. I reconstruct the crucial step, which I take to be his highly condensed argument that every syllogistic-style deduction with more than two premises can be reduced to a series of syllogisms proper. I detect two big holes in the argument, but show that they can be filled without recourse to anachronistically modern methods. I end with a principle about the ordering of terms, and discuss the connections between it, Platonic division and Aristotle's exclusion of the fourth figure."
64. Smith Robin, "The mathematical origins of Aristotle's syllogistic," *Archive for History of Exact Sciences* 19: 201-210 (1978).  
"Interpretation of the syllogistic theory presented in *Prior Analytics* I.4-7. This syllogistic theory is more properly regarded as mathematics than as logic as understood by most contemporary logicians."
65. Smith Robin, "What is Aristotelian ecthesis?," *History and Philosophy of Logic* 3: 113-127 (1982).  
"I consider the proper interpretation of the process of ecthesis which Aristotle uses several times in the "Prior analytics" for completing a syllogistic mood, i.e., showing how to produce a deduction of a conclusion of a certain form from premisses of certain forms. I consider two interpretations of the process which have been advocated by recent scholars and show that one seems better suited to most passages while the other best fits a single remaining passage. I also argue that "ecthesis" for Aristotle means 'setting out' the case to be proved using letters. Aristotle's remarks about the use of letters in mathematical proofs suggest that he had some understanding of rules equivalent to universal generalization and existential instantiation; the 'proofs through ecthesis' are so-called because they rest on the latter rule, with which use of letters is involved in a special way."
66. Smith Robin, "The axiomatic method and Aristotle's logical methodology," *Southwest Philosophical Studies* 8: 49-59 (1982).  
"I argue that Aristotle developed the syllogistic in the "Prior Analytics" in order to use it in resolving the question, presented in "Posterior Analytics" A 3, whether proof of every proposition is either necessary or possible. His method, which rests on an analysis of the possible structure of proofs derived from the study of syllogisms in the "Prior Analytics", resemble modern proof theory in both style and purpose."
67. Smith Robin, "Completeness of an ecthetic syllogistic," *Notre Dame Journal of Formal Logic* 24: 224-232 (1983).  
"In this paper I study a formal model for Aristotelian syllogistic which includes deductive procedures designed to model the "proof by ecthesis" that Aristotle sometimes uses and in which all deductions are direct. The resulting system is shown to be contained within another formal model for the syllogistic known to be both sound and complete, and in addition the system is proved to have a certain limited form of completeness."
68. Smith Robin, "Immediate propositions and Aristotle's proof theory," *Ancient Philosophy* 6: 47-68 (1986).  
"I argue that Aristotle's main reason for developing the theory of deductions (syllogisms) in the "Prior Analytics" was its use as a proof-theoretic instrument to solve problems about demonstrative sciences. thus, concerning the old problem of the relation of the two "Prior" and "Posterior Analytics", I hold that the "Prior" is "propter", and therefore "post", the "Posterior". This is shown in greater detail through an analysis of the role of 'immediate' propositions in his theory."
69. Smith Robin, "Dialectic and the syllogism," *Ancient Philosophy* 14: 133-151 (1994).
70. Striker Gisela, "Notwendigkeit mit Lücken," *Neue Hefter für Philosophie* 24/25: 146-164 (1985).
71. Thom Paul, "Ecthesis," *Logique et Analyse* 74-76: 299-310 (1976).
72. Thom Paul, "Aristotle's syllogistic," *Notre Dame Journal of Formal Logic* 20: 751-759 (1979).
73. Thom Paul. *The syllogism*. München: Philosophia Verlag 1981.

Contents: Preface 11; Part One. Aristotle's syllogistic. I. Elementary syntax 19; II. Basis of the system 32; III. Theses 45; IV. Non-theses 56; V. Interpretation and application 69; Part Two. Syllogistic and its extensions. Introduction 89; VI. System *A* 91; VII. Subsystems 109; VIII. Extensions 119; IX. Rejection 147; X. Ecthesis 164; Part Three. The theory of the syllogism. Introduction 179; XI. Syntactic theory 181; XII. Aristotle's syntactic theory 193; XIII. Semantic theory 216; XIV. Epistemological theory 227; Appendix 1. The Gergonne relations 253; Appendix 2. *Termini obliqui* and the logic of relations 255; Appendix 3. Medieval ecthetic systems 257; Notes 261; Bibliography 289; Indices. Index 1. Aristotelian passages 299; Index 2. Definitions 306; Index 3. Names 409-312.

"The three Parts of this book deal respectively with the formal analysis of Aristotle's non-modal syllogistic; with the inter-relations between various syllogistic systems, their subsystems and extensions; and with the most fundamental question about the syllogism, *viz.* What is it? Part One aims to effect a synthesis of recent work (both logical and philological) on the non-modal sections of the *Prior Analytics*, within the framework of a new formal system which combines features of Lukasiewicz's 'axiomatic' approach with features of the 'natural deduction' approach of Corcoran and Smiley.

This system is identified, in Part Two, as one of a family which also includes the semantically complete systems of Lukasiewicz and Corcoran. Extended systems are also considered, in which rejected formulae are axiomatised, and negative or singular terms added. In particular, formal analyses are given of Aristotle's own logics of negative and singular terms, and it is shown that the whole system of categorical syllogisms can be based on a system of singular syllogisms with the Aristotelian rules of *ecthesis*.

The multiplicity of syllogistic systems discussed in Part Two gives rise to the search (carried out in the third Part) for properties *essential* to the syllogism, which would recur in any genuinely syllogistic system. A complex syntactic property of the categorical syllogism is first described, then a semantic one, and finally one which I will term epistemological (without wanting to sink into psychologism). The principal standpoint in this Part is a purely theoretical one - the semantic discussion being within the context of the contemporary debate on entailment, and the epistemological one belonging to the theory of fallacies. But the historical approach of the first two Parts is not wholly abandoned, and a detailed account is given of those parts of the *Prior Analytics* (not often read) which include Aristotle's own attempts at metatheory.

With some reluctance, and in the interests of brevity, I have adopted a style of exposition which is generally dogmatic rather than dialectical, in that it seeks merely to state the truth rather than to allow the true view to emerge in stages from partial truths or mistaken opinions. Also, interpretations or theories which seemed to me *wholly* wrong have in general not been mentioned: there are just too many of them. On the other hand, I have tried to include reference to what seemed to me the most important contributions of the ancient and medieval commentators. I have proceeded (as Aristotle would have said) from what is best known in itself, to what is best known for us, beginning with the basis of an uninterpreted formal system, and ending with a statement of the function of the syllogism and the use of the system. So, in a sense, the reader will not know why the beginning is as it is, until he has come to the end. For the benefit of readers who can't stand the suspense, I have tried to make the end independently intelligible, so that they can begin there, and then go to the beginning, ending in the middle with a kind of *syllogismus interruptus*." pp. 11-12

74. Thom Paul, "The two Barbaras," *History and Philosophy of Logic* 12: 135-149 (1991).  
 "This paper examines three recent discussions of Aristotle's system of syllogisms with apodeictic and assertoric premisses. Though they contain no cross-references, and though they arrive at disparate interpretations, all three pieces share a common aim. That aim is to construct an intuitively graspable interpretation of Aristotle's modal syllogistic which is based on metaphysical considerations. I argue that none of these authors has succeeded in this; nevertheless, I share their broad aim, and attempt to show that a more satisfactory interpretation can be formulated by combining and developing elements drawn from all three."
75. Thom Paul, "Apodeictic ecthesis," *Notre Dame Journal of Formal Logic* 34: 193-208 (1993).

76. Thompson Marley, "On the elimination of singular terms," *Mind* 68: 361-376 (1959).
77. Weimann Hermann, "Aristotle on the reducibility of all valid syllogistic moods to the two Universal moods of the First Figure (*Apr* A7, 29b1-25)," *History and Philosophy of Logic* 25: 73-78 (2004).
78. Westerståhl Dag, "Aristotelian syllogisms and generalized quantifiers," *Studia Logica* 48: 577-585 (1989).
79. Williams Mark F. *Studies in the manuscript tradition of Aristotle's Analytica*. Königstein: A. Hain 1984.
80. Williamson Colwyn, "Squares of opposition: comparisons between syllogistic and propositional logic," *Notre Dame Journal of Formal Logic* 13: 497-500 (1972).  
 "It has been pointed out, for example by Bochenski, (1) that the principles of propositional logic now known as DeMorgan's Laws bear a certain resemblance to the laws depicted in the traditional Square of Opposition.  
 The analogy, however, is not as perfect as it could be. The aim of this paper is to explore some of the consequences of seeking a more exact comparison between syllogistic and propositional logic."  
 (1) J. M. Bochenski, *A Précis of Mathematical Logic*, Holland (1959), p. 14
81. Williamson Colwyn, "How many syllogisms are there?," *History and Philosophy of Logic* 9: 77-85 (1988).  
 "The incompleteness and artificiality of the 'Traditional logic' of the textbooks is reflected in the way that syllogisms are commonly enumerated. The number said to be valid varies, but all the numbers given are of a kind that logicians should find irritating. Even the apparent harmony of what is almost invariably said to be the total number of syllogisms, 256, turns out to be illusory. In the following, it is shown that the concept of a "distribution-value", which is related to the traditional theory of distribution, and the familiar concept of "quantity" together suffice to produce a far better way of enumerating syllogisms and a more complete understanding of the systematic features of syllogistic logic."

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