

## History of Logic from Aristotle to Gödel

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### Aristotle's *Prior Analytics*: the Theory of Categorical Syllogism

#### INTRODUCTION: MODERN INTERPRETATIONS OF ARISTOTLE'S SYLLOGISTIC

N.B.: For the references, please see [Selected Bibliography on Aristotle's Theory of Categorical Syllogism](#)

"When modern logicians in the 1920s and 1930s first turned their attention to the problem of understanding Aristotle's contribution to logic in modern terms, they were guided both by the Frege-Russell conception of logic as formal ontology and at the same time by a desire to protect Aristotle from possible charges of psychologism. They thought they saw Aristotle applying the informal axiomatic method to formal ontology, not as making the first steps into formal epistemology. They did not notice Aristotle's description of deductive reasoning. Ironically, the formal axiomatic method (in which one explicitly presents not merely the substantive axioms but also the deductive processes used to derive theorems from the axioms) is incipient in Aristotle's presentation. Partly in opposition to the axiomatic, ontically-oriented approach to Aristotle's logic and partly as a result of attempting to increase the degree of fit between interpretation and text, logicians in the 1970s working independently came to remarkably similar conclusions to the effect that Aristotle indeed had produced the first system of formal deductions. They concluded that Aristotle had analyzed the process of deduction and that his achievement included a system of natural deductions including both direct and indirect deductions which, though simple and rudimentary, was semantically complete. 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. Aristotle's Logic: New Goals, New Results Our understanding of Aristotle's logic has increased enormously in the last sixty years. It is gratifying to review the cascade of progress beginning with the independently achieved but remarkably similar advances reported in 1929 by Jan Lukasiewicz and in 1938 by James Wilkinson Miller. Penetrating examination and critical evaluation of the Lukasiewicz-Miller viewpoint in the 1950s and 1960s set the stage for work in the early 1970s by Timothy Smiley and myself. Subsequent work in the late 1970s and early 1980s by various people including Timothy Smiley, Robin Smith, Michael Scanlan and myself can be seen as culminating, at least for the moment, in the 1989 translation and commentary on *Prior Analytics* by Robin Smith." (pp. 9-10)

From: John Corcoran, *The Founding of Logic. Modern Interpretations of Aristotle's Logic*, *Ancient Philosophy*, 14, 1994, pp. 9-24.

"Jan Lukasiewicz, by his own account, entered the lists in 1923 as an interpreter of ancient logic from the standpoint of modern formal logic. In that year he began defending his view of the contrast of Stoic logic with Aristotelian logic; this view appeared in print for the first time in 1930.(1) This was followed by the Polish version in 1934, and the German in 1935, of his landmark paper, 'On the History of the Logic of

Propositions' [1967]. During the same period Lukasiewicz was lecturing on Aristotle's syllogistic. An authorized version of his lectures on this and other logical topics was published by students at the University of Warsaw in 1929, republished in Warsaw in 1958, and finally translated into English in 1963 under the title *Elements of Mathematical Logic* [1963]. Lukasiewicz elaborated his researches until he issued in 1951 his now famous monograph *Aristotle's Syllogistic from the Standpoint of Modern Formal Logic* [1951]. A second edition, enlarged but not revised, appeared in 1957, its author's death having occurred in the previous year.

Lukasiewicz thus has held the field for nearly half a century. Questions have been raised about some details of his interpretation, and corrections have been made of some of his mistakes in matters of fact, but, so far as I know, no one had brought a direct challenge against the main lines of Lukasiewicz's interpretation of Aristotle's syllogistic and its place in ancient logic until John Corcoran did so in 'A Mathematical Model of Aristotle's Syllogistic' [1973]. Indeed, so spectacular a tour de force was Lukasiewicz's book that, despite his own protestations that he was setting out the system merely "in close connexion with the ideas set forth by Aristotle himself" ([1951], p. 77) and "on the lines laid down by Aristotle himself" ([1951], p. VIII), his account has gained wide acceptance as the definitive presentation of Aristotle's syllogistic, and some writers lead one to believe that Aristotle's system is no more and no less than what Lukasiewicz proposes.

Lukasiewicz's view, very briefly put, is this: The logic of Aristotle is a theory of the relations A, E, I, and O (in their mediaeval senses) in the field of universal terms ([1951], p. 14). It is a theory of special relations, like a mathematical theory ([1951], p. 15). As a logic of terms, it presupposes a more fundamental logic of propositions, which, however, was unknown to Aristotle and was discovered by the Stoics in the century after him ([1951], p. 49). Aristotle's theory is an axiomatized deductive system, in which the reduction of the other syllogistic moods to those of the first figure is to be understood as the proof of these moods as theorems by means of the axioms of the system ([1951], p. 44).

Corcoran has proposed, on the other hand, that Aristotle's syllogistic is not an axiomatic science but rather a natural deduction system, and that the theory is itself fundamental, presupposing neither the logic of propositions nor any other underlying logic.

Corcoran's proposals have a good deal to recommend them. First, Corcoran provides a faithful reconstruction of Aristotle's method. Although Lukasiewicz gives a system that does arrive at Aristotle's results, obtaining and rejecting laws corresponding to the moods which Aristotle obtains and rejects, his derivations, by substitution and detachment from axioms, have nothing in common with Aristotle's own method. Indeed, Lukasiewicz must say that Aristotle's proposals about method are wrong, and that Aristotle did not and could not use the technique of perfecting syllogisms, which Aristotle claims over and over again that he is using.<sup>(2)</sup> Corcoran, on the other hand, not only makes perfect sense of the doctrine of perfecting syllogisms, but he is willing to take Aristotle at his word instead of being content to elaborate a system allegedly in close connexion with Aristotle's ideas. The upshot is that Corcoran succeeds, as Lukasiewicz did, in reproducing Aristotle's results, and he succeeds, as Lukasiewicz did not, in reproducing Aristotle's method step by step, so that the annotated deductions of his system D are faithful translations of Aristotle's exposition. Corcoran's concern for method is prompted by his belief that Aristotle shared this concern. I think there can be no doubt that he is correct. Aristotle sets out his method in detail which if concise is yet minute, and when, at the beginning of Chapter XXX of the first book of the *Priora* (46a4), he summarizes his work so far, he speaks not of the same results in philosophy and every kind of art and study whatsoever, but of the same method (686g) in all these branches of inquiry.

Corcoran's interpretation also has the virtue of making sense of Aristotle's views concerning the place of syllogistic in his doctrine as a whole. While Lukasiewicz apparently held that syllogistic was a science which must take its place beside the other sciences in the Aristotelian scheme, Corcoran proposes to take syllogistic as the underlying logic of the demonstrative sciences. Lukasiewicz held further that syllogistic itself presupposes propositional logic as an underlying logic -- of which Aristotle, however, was ignorant. Corcoran, by contrast, suggests that syllogistic is a fundamental logical system, presupposing no other." pp. 133-135

(1) Lukasiewicz [8]. See Storrs McCall *Polish Logic 1920-1939*, Oxford University Press, Oxford, 1967, p. 69, n. 1, for Lukasiewicz's remark concerning the date of his first proposals.

(2) Lukasiewicz [1951], p. 44. For texts in *An. Pr.* and *An. Post.* see Corcoran [3].

From: Mary Mulhern, 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 John Corcoran, Dordrecht: Reidel 1974, pp. 133-148

## CONTEMPORARY EVALUTATIONS OF ARISTOTLE'S LOGIC

"As a kind of summary of our research we present a review of what we take to be the fundamental achievements of Aristotle's logical theory. In the first place, he clearly distinguished the role of deduction from the role of experience (or intuition) in the development of scientific theories. This is revealed by his distinction between the axioms of a science and the logical apparatus used in deducing the theorems. Today this would imply a distinction between logical and nonlogical axioms; but Aristotle had no idea of logical axioms (but cf. 77a22-25). Indeed, he gave no systematic discussion of logical truth ( $Axx$  is not even mentioned once). In the second place, Aristotle developed a natural deduction system which he exemplified and discussed at great length. Moreover, he formulated fairly intricate metamathematical results relating his central system to a simpler one. It is also important to notice that Aristotle's system is sound and strongly complete. In the third place, Aristotle was clear enough about logical consequence so that he was able to discover the method of counter instances for establishing invalidity. This method is the cornerstone of all independence (or invalidity) results, though it probably had to be rediscovered in modern times (cf. Cohen and Hersh). In the fourth place, his distinction between perfect and imperfect syllogisms suggests a clear understanding of the difference between deducibility and implication -- a distinction which modern logicians believe to be their own (cf. Church, p. 323, fn. 529). In the fifth place, Aristotle used principles concerning form repeatedly and accurately, although it is not possible to establish that he was able to state them nor is even clear that he was consciously aware of them as logical principles. The above are all highly theoretical points -- but Aristotle did not merely theorize; he carried out his ideas and programs in amazing detail despite the handicap of inadequate notation. In the course of pursuing details Aristotle originated many important discoveries and devices. He described indirect proof. He used syntactical variables ( $\alpha$ ,  $\beta$ , etc.) to stand for content words -- a device whose importance in modern logic has not been underestimated. He formulated several rules of inference and discussed their interrelations. Philosophers sometimes say that Aristotle is the best introduction to philosophy. This is perhaps an exaggeration. One of the Polish logicians once said that the *Analytics* is the best introduction to logic. My own reaction to this remark was unambiguously negative -- the severe difficulties in reading the *Analytics* form one obstacle and I felt then that the meager results did not warrant so much study. After carrying out the above research I can compromise to the following extent. I now believe that Aristotle's logic is rich enough, detailed enough, and sufficiently representative of modern logics that a useful set of introductory lectures on mathematical logic could be organized around what I have called the main Aristotelian system. From a modern point of view, there is only one mistake which can sensibly be charged to Aristotle: his theory of propositional forms is very seriously inadequate. It is remarkable that he did not come to discover this for himself, especially since he mentions specific proofs from arithmetic and geometry. If he had tried to reduce these to his system he may have seen the problem (cf. Mueller, pp. 174-177). But, once the theory of propositional forms is taken for granted, there are no important inadequacies attributable to Aristotle, given the historical context. Indeed, his work is comparable in completeness and accuracy to that of Boole and seems incomparably more comprehensive than the Stoic or medieval efforts. It is tempting to speculate that it was the oversimplified theory of propositional forms that made possible the otherwise comprehensive system. A more adequate theory of propositional forms would have required a much more complicated theory of deduction -- indeed, one which was not developed until the present era." p. 130-131

Cohen, P. J. and Hersh, R. "Non-Cantorian Set Theory", *Scientific American*, December 1967, pp. 104-116.

Church A., *Introduction to Mathematical Logic*, Princeton 1956.

Mueller, Ian, 'Stoic and Peripatetic Logic' *Archiv für Geschichte der Philosophie* 51 (1969), 173-187.

From: John Corcoran, Aristotle's Natural Deduction System. In *Ancient Logic and Its Modern Interpretations*. Edited by Corcoran John, Dordrecht: Reidel 1974, pp. 85-131

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