History of Logic from Aristotle to Gödel (www.historyoflogic.com)

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Aristotle's Logic: General Survey and Introductory Readings

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A summary of Aristotle's syllogistic

"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 *συλλογισμός* 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: knowledge of what L is true or false, which pertains to sentences, and (2) knowledge of what is valid or invalid, which pertains to arguments." (pp. 110-111)

Gorge Boger, "The Modernity of Aristotle's Logic" in: Demetra Sfendoni-Mentzou et al. (eds.), *Aristotle and Contemporary Science. Vol. II*, Bern: Peter Lang 2001, pp. 97-112.

The modernity of Aristotle's logic

"Only recently have we been able to recover something of Aristotle's promethean accomplishments relating to logic. Indeed, we are recognising more and more that part of the history of modern mathematical logic is to have re-invented the wheel that Aristotle turned many years ago. It is astonishing that for .hundreds of years, perhaps dating to before the Port Royal Logic, Aristotelian logic, or traditional logic, has been taught without a single reference to the process of deduction. This was the practice of R. Whately, W. S. Jevons, H. W. B. Joseph, J. N. Keynes, R. M. Eaton, and many others. It is still the practice in untold numbers of introductory textbooks on categorical logic to test a syllogism according to rules of quality, quantity, and distribution, and entirely to overlook the deduction process of chaining syllogisms, not to mention the glaring traditionalist error of taking a syllogism to be either a valid or invalid argument. Jan Łukasiewicz can be credited with being the first to shed light on the syllogistic by examining it with the theoretical apparatus of mathematical logic. But Łukasiewicz and his followers really only "improved" the traditionalist interpretation with a sophistication afforded by mathematical logic. Both lines of interpretation took Aristotle's presentation in *Prior Analytics* to be his own axiomatization of the syllogistic. While traditionalists awkwardly drew lines between sentences (or sentence patterns) in different syllogisms to indicate their logical relationships (their so-called reductions or analyses), axiomaticists such as Łukasiewicz cleverly turned a *συλλογισμός* into a logically true conditional proposition that could be processed by a propositional logic. In this way the axiomaticists aimed to elucidate the logical relationships among the syllogisms. Again, the epistemic process of deduction explicitly treated in *Prior Analytics* was overlooked. It was not until the early 1970s with the independent works of John Corcoran and Timothy Smiley that the case for Aristotle's reputation as a logician of consummate intelligence and originality was well argued. They established Aristotle to have been concerned with the deduction process just as many modern logicians are. Corcoran and Smiley also used mathematical logic to model Aristotle's syllogistic. However, instead of finding an axiomatization of a logic, they discovered a natural deduction system. But they remained puzzled by reduction, in part, we believe, because they did not think that Aristotle modelled his own system of deduction rules nor that he could envisage distinguishing syntax and semantics. Our interpretation builds on the work of Corcoran and Smiley, and now on that of Robin Smith whose 1989 translation of *Prior Analytics* has incorporated their findings. We believe, however, that Aristotle did model his own system. In particular, we see him as treating a *συλλογισμός* as a rule of deduction in *Prior Analytics* A.4-7, and that he himself was able proof-theoretically to determine certain mathematical properties of his deduction system. He was able to refine the system by eliminating redundant rules, and he affirmed his system's completeness. These are Aristotle's own accomplishments, not merely those of modem logicians who, using mathematical logic, believe themselves to have discovered features of the syllogistic unknown to Aristotle. Indeed, modern logicians might wonder at their "having spoken" Aristotelian logic their whole lives, without any idea of it." (pp. 111-112)

Gorge Boger, "The Modernity of Aristotle's Logic" in: Demetra Sfendoni-Mentzou et al. (eds.), *Aristotle and Contemporary Science. Vol. II*, Bern: Peter Lang 2001, pp. 97-112.

Logic as Formal ontology

"There are several different conceptions of the nature of logic. Here I want to contrast an ontic conception with an epistemic conception. On one ontic conception logic investigates certain general

aspects of 'reality', of 'being as such', in itself and without regard to how (or even whether) it may be known by thinking agents: in this connection logic has been called formal ontology. On one epistemic conception, logic amounts to an investigation of deductive reasoning per se without regard to what it is reasoning about; it investigates what has been called formal reasoning. On this view, logic is part of epistemology, viz. the part that studies the operational knowledge known as deduction. It has been said that one of the main goals of epistemically-oriented logic is to explicate the expression 'by logical reasoning' as it occurs in sentences such as: a deduction shows how its conclusion can be obtained by logical reasoning from its premise-set.

Relevant to the axiomatic method there would be two branches of epistemology: one to account for knowledge of the axioms and one to account for how knowledge of the theorems is obtained from knowledge of the axioms, in other words, one investigating induction and one investigating deduction. The latter is logic according to the epistemic conception.

On the ontic view of logic, on the other hand, logic is an attempt to gain knowledge of the truth of propositions expressible using only generic nouns (individual, property, relation, etc.) and other 'logical' expressions. In the framework of *Principia Mathematica* those are propositions expressible using only variables and logical constants. *Principia Mathematica* is an excellent example of an axiomatic presentation of logic as formal ontology. Below are some typical laws of formal ontology.

Excluded middle: Given any individual and any property either the property belongs to the individual or the property does not belong tothe individual.

Noncontradiction: Given any individual and any property it is not the case that the property both belongs to the individual and does not belong to the individual.

Identity: Given any individual and any property, if the property belongs to the individual then the individual has the property.

Dictum de omni: Every property A belonging to everything having a given property B which in turn belongs to everything having another property C likewise belongs to everything having that other property C.

Dictum de nullo: Every property A belonging to nothing having a given property B which in turn belongs to everything having another property C likewise belongs to nothing having that other property C.

Commutation of Complementation with Conversion: Given any relation R the complement of the converse of R is the converse of the complement of R.

From this sample of logic as ontic science we can see how the focus is on ontology, or, as has been said by others, on the most general features of reality itself and not on methods of gaining knowledge. According to Russell *Introduction to mathematical philosophy,* 1919, 169, 'logic is concerned with the real world just as truly as zoology, though with its more abstract and general features.' These six laws are purely ontic in that they involve no concepts concerning a knowing agent or concerning an epistemic faculty such as perception, judgement, or deduction. This is not to deny that there is an epistemic dimension to logic as ontic science but only to affirm that the focus if ontic. Every science in so far as it is science has an epistemic dimension. The epistemic differs from the ontic more as size differs from shape than as, say, animal differs from plant.

Logic as ontic science was referred to above as formal ontology. Logic as epistemic metascience may in like manner be called formal epistemology. It is important and interesting to note that both are called formal logic but for very different reasons. Some formal onticists justify the adjective formal by reference to the fact that its propositions are expressed exclusively in general logical terms without the use of names denoting particular objects, particular properties, etc. cf. Russell 1919, 197. Some formal epistemicists justify the adjective formal by reference to the fact that the cogency of an argumentation is subject to a principle of form and in particular to the following principles: (l) every two argumentations in the same form are either both cogent or both non-cogent, (2) every argumentation in the same form as a deduction is itself a deduction. In fact, some formal epistemicists such as Boole claimed, with some justification, that they were dealing with the forms of thought, i.e. with the forms of cogent argumentations. For more on cogency of argumentations and the principles of form see Corcoran 1989.

Formal onticists are often easy to recognize because of their tendency to emphasize the fact that formal ontology does not study reasoning per se. In fact, the formal onticists often think that the study of reasoning belongs to psychology and not to logic. For example, Łukasiewicz in his famous book on Aristotle's syllogistic makes the following two revealing remarks. Łukasiewicz 1957 pages 12 and 73, respectively. 'Logic has no more to do with thinking than mathematics. "[Aristotle's]

system is not a theory of the forms of thought nor is it dependent on psychology; it is similar to a mathematical theory...'
There are significant differences among formal onticists. For example, even among those that emphasize the truth-preserving character of deduction some accept the view that it is consequences-conservative as well and some reject this view. For example, Łukasiewicz 1929, 16 explicitly rejects the view that deduction is a process of information extraction. He says that in deductive inference '...we may obtain quite new results, not contained in the premises'." (pp. 17-19)

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

(to be continued...)

External links

A Bibliography: John Corcoran's Publications on Aristotle 1972-2015 (Preprint) An annotated bibliography of a leading interpreter of Aristotle' syllogistic

John Corcoran Publications available on line