ARISTOTLE'S LOGIC AT THE UNIVERSITY OF BUFFALO'S DEPARTMENT OF PHILOSOPHY

La lógica de Aristóteles en el Departamento de Filosofía de la Universidad de Búfalo

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ABSTRACT
We begin with an introductory overview of contributions made by more than twenty scholars associated with the Philosophy Department at the University of Buffalo during the last half-century to our understanding and evaluation of Aristotle's logic. More well-known developments are merely mentioned in order to make room to focus on issues at the center of attention from the beginning: existential import and, more generally, the analysis of categorical propositions. I include a list of the UB scholars, a list of collaborators and supporters from fellow institutions, a bibliography of relevant publications by UB scholars, and a bibliography of important related works.

Keywords: underlying logic, many-sorted logic, range indicator, sortal variable, quantifier-noun-variable, Buffalo-Cambridge interpretation.

RESUMEN
Este artículo inicia con una visión introductoria de las contribuciones realizadas durante la segunda mitad del siglo pasado a nuestra comprensión y evaluación de la lógica de Aristóteles por más de veinte académicos asociados al Departamento de Filosofía de la Universidad de Búfalo. Los desarrollos más conocidos se mencionan con el objetivo de abrir espacio a temas que desde el principio llamaron nuestra atención: el importe existencial y, de modo más general, el análisis de las proposiciones categóricas. Incluyo una lista de los profesores de la UB, una lista de colaboradores y apoyos de instituciones hermanas, una bibliografía de las publicaciones relevantes de los profesores de la UB, y una bibliografía de trabajos relacionados importantes.

Palabras clave: lógica subyacente, lógica de varios sortales, indicador de rango, variable *sortal*, cuantificador-nombre-variable, interpretación Búfalo-Cambridge.

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If you by your rules would measure what with your rules doth not agree, forgetting all your learning, seek ye first what its rules may be.
(Richard Wagner, *Die Meistersinger*)

1. Introductory Overview

Among the things that the University of Buffalo's Department of Philosophy will be remembered for, one of them might be the half-century-long tradition of contributing to the understanding of the most important logic book ever written: Aristotle's *Prior Analytics*. One of the first contributions is William Parry's "Quantification of the Predicate and Many-sorted Logic" in *Philosophy and Phenomenological Research* (1966). Parry's paper shows how Aristotle's categorical syllogistic can be faithfully represented *as logic* in modern symbolic logic. One of the last contributions to date is a May 2008 lecture that refers to and builds on Parry's paper. That lecture is my own "Aristotle's Many-sorted Logic", abstracted in the *Bulletin of Symbolic Logic* (2008).[1] It would require a book to do justice to the whole subject. In a few pages, I will try to give the flavor and scope of the tradition, which combined philosophy, classics, logic, mathematics, and history. I begin with a general overview and then deal in more detail with one issue that occupied several of us including Parry and me for several years.

The central figures were George Boger, James Gasser, John Kearns, John Mulhern, Mary Mulhern, William Parry, Lynn Rose, Michael Scanlan, and me. The group is collectively known as the Buffalo Syllogistic Group.[2] Many of their ideas were first presented in the Buffalo Logic Colloquium, the UB Philosophy Colloquium, or in UB seminars and classes. At least three of them originated in discussions during or following a colloquium presentation.

UB philosophy scholars have been involved in several dramatic changes that have taken place in the half-century beginning around 1960. Perhaps the most dramatic is that, as the result of efforts of several of us and some others, it is no longer generally believed that Aristotle's "syllogistic" was an axiomatic theory –like Euclid's geometry, Peano's arithmetic, a theory of linear order of points on

1 This lecture was part of a three-hour "tutorial course" of the Logic School at the Center for Logic, Epistemology, and History of Science at the State University of Campinas, Sao Paulo, Brazil (*cf.* Corcoran 2009).

2 For the record, the whole group includes J. Anton, G. Boger, J. Corcoran, N. Garver, J. Gasser, J. Glanville, C. S. Gould, E. Hacker, S. Iverson, J. Kearns, D. Levin, L. Mohler, J. Mulhern, M. Mulhern, S. Nambiar, W. Parry, J. Richards, L. Rose, M. V. Rorty, J. M. Sagüillo, M. Scanlan, J. Swiniarski, D. M. Tress, and R. Zirin.

a line, or a theory of class inclusion–.[3] As incredible as this may seem today, before the 1970s, the dominant view was that Aristotle's system was not really an underlying logic: it was thought to be an axiomatic theory that presupposed an underlying logic never articulated by Aristotle. This would call into question the view that Aristotle was the founder of logic (*cf.* Smith 1989; Corcoran 1994). How could Aristotle be the founder of logic if he never presented a system of logic? There were axiomatic theories studied in Plato's Academy.

Instead, today the dominant view has two main theses. The first is that Aristotle's *Prior Analytics* articulated a rigorous formal logic for deducing conclusions from arbitrarily large premise sets –as are encountered in axiomatic mathematics and science–.[4] The second is that Aristotle had proposed a rule-based natural deduction logic as opposed to an axiom-based logic. Both of these points were pioneered by UB scholars. George Boger[5] titled his chapter in the 2004 *Handbook of the History of Logic,* "Aristotle's Underlying Logic," to proclaim allegiance to this distinctively modern revolutionary interpretation.

The new interpretation of Aristotle's logic emerged independently and simultaneously[6] in the spring of 1971 in two places in different continents: the University of Buffalo and the University

3 As far as I know the earliest rigorous presentation of the viewpoint was made in 1929 by Jan Łukasiewicz. A remarkably similar theory was advanced independently in 1938 by James Wilkinson Miller. For further discussion, see my 1994 paper. Paul Rosenbloom mentions the general idea in 1950 without referencing Łukasiewicz or Miller (*cf.* 196).

4 This first thesis, which was not endorsed or even discussed by Lukasiewicz, has been accepted by many scholars who do not accept the second thesis. Barnes is a notable example. He describes the syllogistic as an underlying logic (2007, 360) that is used to deduce conclusions from arbitrarily many premises, not just the traditional two (2007, 364).

5 Boger worked with UB professor John Anton as an undergraduate, and his 1982 PhD was supervised by William Parry. The second reader was UB professor John Glanville.

6 At least two of the systems discussed in my 1974a article were presented at the 1971 Linguistics Institute: to my summer graduate course "Logic and Linguistics" and to the research seminar led by Edward Keenan of UCLA and me. In fact, Peter Malcolmson, then a student in the course, discovered the key lemma in the completeness proof now published in my 1972 *JSL* paper. Using his research notebooks, Timothy Smiley (per. comm.) confirmed the approximate date of his discovery of materially the same system in *Prior Analytics*. For the record, in 1971, when he spent the summer at UB, Peter Malcolmson was a graduate student in Mathematics at UC Berkeley. He went on to earn a PhD and he is now Professor of Mathematics at Wayne State University in Detroit.

of Cambridge. The question of priority is immaterial.[7] The story is recounted in my 1994 paper "Founding of Logic". One of the firmest signs that the new Buffalo-Cambridge interpretation was taking hold among Aristotle scholars was the publication of a new translation[8] of Aristotle's *Prior Analytics* based on it. The translator was the accomplished classicist-philosopher Robin Smith, and one of the publisher's readers was Michael Frede, one of the acknowledged leaders in the field of Greek logic.

Another sea change is the increasingly successful defense of Aristotle against the once widely held view that Aristotle arbitrarily limited logic to the four categorical propositional forms. It had been completely obvious, at least as far back as Boole and Peirce, that no finite number of propositional forms is sufficient to account for the logic in scientific thought. UB logicians, starting with Lynn Rose (1968), took Aristotle's general definition of syllogism literally. Smith's translation reads as follows:

> A deduction [*syllogismos*] is a discourse [*logos*] in which certain things having been supposed, and something different from the things supposed results of necessity because these things are so. By 'because these things are so', I mean resulting through them, and by 'resulting through them' I mean 'needing no further term from outside in order for the necessity to come about'. (*APr.* A1 24b10-15)

Anchoring their thinking in the bedrock of Aristotle's definition, the scholars worked toward establishing the fact that Aristotle's basic viewpoint was not artificially restrictive; rather, it was intentionally broad enough to encompass almost all of the logic that has been developed in the two millennia since Aristotle opened logical investigations.[9] The conclusion explicitly drawn was that Aristotle founded logic *per se*, not just categorical syllogistic.

Once the above framework was in place, UB scholars applied it to clarify other issues in the Aristotelian corpus. George Boger used it to treat reduction, paradoxes, and invalidity methodology. Michael Scanlan[10] worked on compactness and, more generally, on Aristotle's discussion of infinite arguments and infinite deductions.

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7 Timothy Smiley's paper (1973) was completed around the same time as my 1972 paper.

8 No translation was ever based on an interpretation taking syllogisms to be sentences –whether universalized conditionals as in Łukasiewicz or of some other form. All interpretations took a syllogism to be determined by its premises and its conclusion, thereby making it impossible to understand how there could be a direct and an indirect syllogism having the same premises and the same conclusion.

9 This viewpoint is articulated prominently in my latest paper "Aristotle's Demonstrative Logic" (2009).

10 Scanlan completed a 1982 PhD supervised by me with UB professor John Kearns as second reader. Scanlan had previously completed an MA with John Anton before coming to UB.

Today I want to limit myself to a single one of the areas in which UB scholars have contributed: Aristotle's views on the nature of categorical propositions and, in particular, his view of the existential import of universal propositions. For reasons of space, the rest of my paper will deal mostly with one part of that issue, namely, the existential import of universal categorical propositions and the nature of categorical propositions.

2. Universal Categorical Propositions

Aristotle made it perfectly clear that the universal categorical propositions such as "Every rectangle is a rhombus" and "No rectangle is a rhombus" were about their respective subjects and predicates, rectangles and rhombuses, not about other things such as people, clouds, peas, flowers, promises, regrets, pains, loyalties, etc. There is no textual justification to equate a two-term Aristotelian universal affirmative such as "Every rectangle is a rhombus" with a three-term restrictive-clause universal such as "Every figure which is a rectangle is a rhombus" or with a proposition about absolutely everything such as "Everything which is a rectangle is a rhombus".[11]

The issue of whether the English sentence

Every rectangle is a rhombus

expresses the same proposition as

Everything which is a rectangle is a rhombus

or as

Everything is a rectangle if it's a rhombus

Is hardly relevant to the issue of how Aristotle is to be interpreted. It would be interesting to know the history of both issues. Who was the first to take a universal affirmative such as "Every rectangle is a rhombus" to be about everything? Who was the first to say that Aristotle took a universal affirmative such as "Every rectangle is a rhombus" to be about everything? There seems to be no reason to think that a certain one of these events predated the other.

The fact that a given interpreter of Aristotle thinks that two sentences express the same or logically equivalent propositions is

11 Robin Smith (*cf.* 1989 XXV) was not the first person to deserve criticism for the misstep of taking "Everything which is A is B" as schematic of an Aristotelian universal affirmative. It should be "Every A is a B". There are two mistakes: (1) the Aristotelian universal proposition is not about everything and (2) the terms are substantives not attributives. Thankfully, he did not make the third error of taking the terms and the copula as plurals as "All things which are A are B" or "All A's are B's", a mistake repeatedly made by Łukasiewicz (1957 1 2, passim).

no justification for thinking that Aristotle so treats them or for so treating them in an interpretation of Aristotle. A similar rule should guide translators dealing with number in the grammatical sense: a translator who regards plural and singular grammatical number as logically indistinguishable is not thereby justified in translating Aristotle's plural Greek words into singular English words. By the way, I know of no disagreement about the fact that "some prime number is even" is true, while "some prime numbers are even" is false. Likewise, the singular particular affirmative "some prime is an even" needs to be distinguished from the corresponding plural "some primes are evens".

For Aristotle, the terms –"rectangle" and "rhombus" in the examples– were substantives; they were not attributives such as "rectangular" and "rhombic", nor were they complexes such as "every rectangle", "a rhombus", and "no rectangle". For Aristotle, the subjects and predicates were syntactically interchangeable in the sense that everything serving as a subject also serves as a predicate and conversely: if "Every X is a Y" is a categorical proposition so is "Every Y is an X". Each categorical proposition contained two substantive terms –"Every quadrangle that is a square is a rectangle", which has three substantives, is not categorical– and no categorical proposition contained any attributive terms –"Every quadrangle that is square is rectangular" is not categorical. Each categorical proposition was about the individuals falling under its terms and not about anything else, certainly not everything.[12]

Yet many modern writers not only took categorical propositions to be about absolutely everything; they also took them to have only one substantive instead of Aristotle's two and they took them to have two attributives instead of Aristotle's none: "Every thing that is square is rectangular" is not categorical. Moreover, if this was not bad enough, the same modern writers took the two universals to be propositions that did not carry the information Aristotle took them to have. These modern writers not only falsified Aristotle's view; they had the gall to go further and denigrate Aristotle for views he never held. The familiar three-step libeling process involves: (1) attributing to the victim theses the victim did not hold; (2) exhibiting real or imagined flaws in the theses; and (3) blaming the victim for such mistakes. UB logicians were not the first to defend Aristotle against such deceptive and unfair attacks.[13]

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12 This misinterpretation of Aristotle's *Prior Analytics* was made by Boole and by Frege (*cf.* Corcoran 2004; 2005b).

13 There are many prominent logicians who defended Aristotle against unjust criticism. One I happen to remember at the moment is the Alonzo Church PhD Paul Rosenbloom: "A great deal of nonsense has been written even by otherwise competent authors on the relation between Boolean algebra and the Aristotelian logic of classes.

3. Rebutting the Accusations

Among the spurious theses falsely attributed to Aristotle is the false proposition, call it S for 'spurious', that all arguments in the same form as the following two are valid.

> <u>Everything is such that if it is rectangular, then it is rhombic.</u>
> Something is such that it is rectangular and it is rhombic.
>
> <u>Everything is such that if it is rectangular, then it is not rhombic.</u>
> Something is such that it is rectangular and it is not rhombic.

Notice that in each case the premise is a universalized *conditional* and the conclusion is the corresponding existentialized *conjunction*. The premise is not transformed into the conclusion merely by replacing 'every' with 'some'; it is also necessary to change 'if…, then' into 'and', so to speak.

To see that these are invalid, consider the following two arguments with the universe of discourse limited to figures of plane geometry in which nothing is spherical.

> <u>Everything is such that if it is spherical, then it is rhombic.</u>
> Something is such that it is spherical and it is rhombic.
>
> <u>Everything is such that if it is spherical, then it is not rhombic.</u>
> Something is such that it is spherical and it is not rhombic.

In both cases the premises are universal propositions having no counterexamples and thus are true. The conclusions are existential propositions having no proexamples and thus are false (Cohen-Nagel 1993 xxv; Corcoran 2005a 205). These two arguments are thus invalid, contrary to what was attributed to Aristotle.

The spurious thesis was substituted for the genuinely Aristotelian view, called G for 'genuine', that the following are valid.

> <u>Every rectangle is a rhombus.</u>
> Some rectangle is a rhombus.

The fact is that the latter is consistent and can be formulated as a perfectly good deductive science. Many writers interpret Aristotle's "All As are Bs" by "A is a subset of B" and his "Some As are Bs" by "the intersection of A with B is non-empty" for arbitrary elements in a Boolean algebra and then find that some of Aristotle's valid moods do not hold. This, they say, shows that his logic is fallacious. There is, however, no reason why this particular interpretation must be accepted as the only one; rather, the consistency of Aristotle's system and the failure of this interpretation show that this one cannot be accepted" (196). With all due respect, Rosenbloom erred in trusting his source to have schematized Aristotle correctly: "All As are Bs" should have been "Every A is a B". Moreover, if the letters stand for substantives, then they cannot also stand for proper names of sets as is required by "A is a subset of B".

No rectangle is a rhombus.
Some rectangle is not a rhombus.

The premise of the first is obtained from the conclusion by replacing 'some' with 'every'; in the second it is more complicated; 'some' is replaced with 'no' and the 'not' is deleted. Notice that we are dealing with the left and right sides of squares[14] of opposition; these sides are sometimes referred to using the expression 'subalternate' or 'subalternation'. By the way, Frege (1879), at the end of § 12, implicitly made the substitution of S for G. But, since he was quite used to think of *subalternation* –the deduction of the existential from the corresponding universal– as cogent, he did not criticize the substituted thesis S, even though S was in conflict with his own logic.[15]

These issues will below be dealt with in a broader context. Before continuing, it is important to note that UB scholars were also instrumental in crediting Aristotle with the *method of counterarguments* just used to establish invalidity. Moreover, they were also involved in clarifying that this method is a variant of the *method of countermodels* used in modern mathematical logic. Previously, some scholars did not know it was there in *Prior Analytics*;[16] others, who were perceptive enough to notice its presence, thought that it was erroneous and could not be used to establish invalidity.[17] Others, who were perceptive enough to notice its presence and to see that it could indeed be used to establish invalidity, either did not appreciate its importance or did not see its connection to the method of countermodels.

Aristotle's method was to show a given argument invalid by producing a counterargument, an argument in the same logical form, having true premises and a false conclusion. This is the only method recognized in *Prior Analytics,* even though other methods must have been in use in Plato's Academy. In the first place, there are arguments whose invalidity is *transparent*: it is obvious that "Something rectangular is rhombic" does not follow from "Nothing is rectangular". In the second place, every argument known to be invalid can be used as

14 *The* original formal "square of opposition" that appears in Apuleius admits of indefinitely many concrete instantiations each of which is naturally called *a* square of opposition. Moreover, schemes analogous to the original square have also been called squares of opposition. In particular, every new interpretation of what Aristotle's categorical propositions were gives rise to a "new" square of opposition.

15 To the best of my knowledge, Frege never criticized Aristotle, as least not on this issue, which is to Frege's credit. But he never admitted his mistaken acceptance of the two invalid arguments. Could his inattention have been a Kuhnian paradigm-induced blindness?

16 W. D. Ross and G. Patzig are examples that come to mind (*cf.* Boger 2004).

17 The view of Łukasiewicz is discussed in footnote 16 of Corcoran (1974a).

a kind of lever or catalyst to recognize other invalidities: in any valid one-premise argument, every proposition that implies the premise implies the conclusion. But "Nothing is rectangular" implies the premise of the first of the two arguments in question without implying the conclusion. Therefore, the first argument is invalid.

Similarly in the case of the second argument, we observe the following: it is obvious that the conclusion "Something rectangular is not rhombic" does not follow from "Nothing is rectangular", which obviously implies the premise. Thus, the second is invalid. The principle underlying this application of the *method of weakened premises* is this: nothing that follows from the premises of an invalid argument implies the conclusion. In order for a given argument whose conclusion is the conclusion of an invalid argument to be invalid, it is sufficient for the premises of the invalid argument to imply those of the given argument.

4. Aristotelian, Boolean, and Modern Logics

Aristotle's doctrine of existential import includes the thesis that every universal proposition implies the corresponding existential: the A implies the I, and the E implies the O (*cf.* Smiley 1962; Mignucci 2007). One common view is that Aristotle's doctrine of existential import conflicts with modern logic whereas Boole's doctrine is in agreement with it. This view could not be further from truth. First, Boole accepted as valid absolutely every argument accepted as valid in Aristotle's system.[18] Thus any conflict with modern logic found in Aristotle's logic would be found in Boole's to the extent that Boole's logic is faithful to his own philosophy. Second, as noted first by Smiley and then by Parry, Aristotle's logic can be translated into modern logic so that the fit is exact. If categorical sentences are translated into many-sorted symbolic logic, according to Parry's method or the other method given below, or any of several other methods,[19] an argument with arbitrarily many premises is valid according to Aristotle's system if and only if its translation is valid according to modern standard many-sorted logic. To use mathematical jargon, Aristotle's system can be embedded in modern many-sorted logic. As Parry showed in a discussion after a 1973 meeting of the Buffalo Logic Colloquium,[20] this result can be proved from the combination of Parry's insights (*cf.* 1966 343) with my proof of the completeness of Aristotle's categorical logic (Corcoran 1972 696-700).

One of the key ideas in many-sorted logic is that it is possible (perhaps necessary) to treat substantives and attributives differently:

18 This has been established in several studies, including my paper "Aristotle's Prior Analytics and Boole's Laws of Thought" (2003).

19 Other methods of translation can be found in Smiley (1962) and Gupta (1980).

20 Personal communication.

the logical forms of "Ann is a woman" and "Ben is a man", which are expressed using the common nouns 'woman' and 'man', are to be distinguished from the logical forms of "Ann is female" and "Ben is male", which are expressed using the adjectives 'female' and 'male'. The first two use the 'is' of identity; the second two use the 'is' of predication.[21] In the early 1970s, a day or two after discussing with Parry the evolution of his own thinking on theses matters, following a meeting of the Buffalo Logic Colloquium, I found a note from him in my department mail box that read: "At the time I did not realize that the 'is' in 'Jones is a wise man' is the 'is' of identity and not the 'is' of predication" (Boger *et al.* 1988). Parry took the sentence 'Jones is a wise man' to express the proposition "Jones is a man who is wise", with the first 'is' for identity and the second for predication.

Parry pioneered taking Aristotelian logic as many-sorted symbolic logic using sortal variables. The ranges of the sortal variables are all non-empty as with ordinary one-sorted logic. Each range is assigned independently of all others (Church 1956 340; Parry 1966 342). For example if the sortal variable *m* ranges over men, "Jones is a man"[22] could be expressed 'Jones is some man', 'Some man is Jones', 'There is a man that is identical to Jones', 'There is a man that Jones is identical to' or

$$\exists m\ (\mathrm{j} = m).$$

Here the sense of 'man' is carried by the variable *m*. The forced non-English reading of $\exists m$ as 'There exists *m*' gives way to the more expressive 'There exists a man *m*'. In contrast, "Jones is a man", which involves the substantive "man", and "Jones is wise", which involves the attributive "wise", would be expressed as follows:

$$\mathrm{Wj}$$

This takes the letter W for the predicate 'is wise' and thus carries the sense of the 'is' of predication. Wj would mean "is wise + Jones" with the standard phonetic pronunciation: *dubya jay*. It would probably be pedagogically, linguistically, and heuristically more effective to reverse the order from Wj to jW. Then 'jW' would mean "Jones + is wise" and could be read: *jay dubya* or *jay is dubya*.[23]

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21 There is a discussion of the identity/predication distinction and its relevance to interpretations of universal sentences in my Introduction to Boole (2003) and in my paper comparing Aristotle and Boole (*cf.* Corcoran 2003 271ff).

22 This hardly resembles the view in Peano (1889) that takes 'Jones is a man' to be a sentence with three constituents: 'Jones', 'is a' and 'man', with the first naming Jones j, the second expressing the membership relation ε, and the third naming the class of humans, say *M*. Thus, 'Jones is a man' translates as 'j ε *M*'.

23 We can thank Frege for reversing the order. He thought that a predicate such as 'is wise' represents a function such as √: just as '√4' denotes 2, 'Wj' denotes the truth-value

Then, the proposition expressed by 'Jones is a wise man', paraphrased 'Jones is such that there exists a wise man *m* that Jones is identical to' or 'There exists a man *m* such that *m* is wise and Jones is *m*', could be expressed as follows:

$\exists m\ (\mathrm{W}m\ \&\ \mathrm{j} = m)$

My next example uses the sortal variables *s* and *p*, where *s* ranges over the spheres and *p* ranges over the polygons. Hilbert uses three classes of sortal variables: one for points, one for lines, and one for planes.

Every sphere is a polygon.	$\forall s \exists p\ s = p$
Some sphere is a polygon.	$\exists s \exists p\ s = p$
No sphere is a polygon.	$\forall s \forall p\ s \neq p$
Some sphere isn't a polygon.	$\exists s \forall p\ s \neq p$

Another approach interprets the quantifier phrases 'for every sphere *x*' and 'for some sphere *x*' fairly literally as being in the *quantifier-noun-variable* form taking 'for every' and 'for some' to indicate universal and existential quantifiers. Then 'sphere' indicates the domain of quantification, and '*x*' as the variable ranging over the domain. This approach uses range-indicators (corresponding to common nouns) with general (non-sortal) variables: Each initial occurrence of a variable follows an occurrence of a *range indicator* or "common-noun symbol" that determines the range of the variable in each of its subsequent occurrences. Of course, the subsequent occurrences of the general variable are bound by the quantifier preceding the range indicator. This is reflected in the practice of Tarski and others of using variables as pronouns having common nouns as antecedents as in "For every number *x*, *x* precedes x+1" where the first *x* refers back to number as antecedent. The word 'number' in 'For every number *x*' indicates the range of *x* in all three occurrences. To each range indicator a non-empty set is assigned as its "extension".

For example, if M is a range-indicator for "man" and *x* is a general variable, "Jones is a man" could be expressed 'some man *x* is such that Jones is identical to *x*' or

$\exists \mathrm{M}x\ (\ \mathrm{j} = x)$

of the proposition it expresses. This viewpoint is rare today even though the notation it gave rise to persists. It is similar to other vestiges of long-forgotten errors. We still use the word "Indian" for "Native Americans" even though we no longer regard them as natives of India. It is remarkable that some people who find "Indian" inappropriate are satisfied with the equally idiomatic "Native American".

In contrast, as above "Jones is wise" would be expressed:

Wj

Then, the proposition expressed by 'Jones is a wise man', paraphrased 'Jones is such that there exists a wise man x that Jones is identical to' or 'Some man x is such that x is wise and Jones is x', could be expressed as follows.

$\exists \mathrm{M}x\ (\mathrm{W}x\ \&\ \mathrm{j} = x)$

In my next example, the range indicators are S and P, where S indicates "sphere" and P "polygon".

Every sphere is a polygon.
Every sphere x is a polygon y.
For every sphere x there exists a polygon y such that $x = y$.
$\forall \mathrm{S}x \exists \mathrm{P}y\ x = y$

Some sphere is a polygon.
Some sphere x is a polygon y.
For some sphere x there exists a polygon y such that $x = y$.
$\exists \mathrm{S}x \exists \mathrm{P}y\ x = y$

No sphere is a polygon.
No sphere x is a polygon y.
For no sphere x is there a polygon y such that x is y.
For every sphere x, for every polygon y, x isn't y.
$\forall \mathrm{S}x \forall \mathrm{P}y\ x \neq y$

Some sphere is not a polygon.
Some sphere x is not any polygon y.
For some sphere x, every polygon y is such that x isn't y.
There exists a sphere x such that, for every polygon y, x isn't y.
$\exists \mathrm{S}x \forall \mathrm{P}y\ x \neq y$

Many-sorted logic with sortal variables is prominent in Hilbert (1899/1971) and merely described in Hilbert and Ackermann (1938/1950 102, Church 339). Many-sorted logic with range-indicators and non-sortal variables was pioneered by Anil Gupta in his book (1980) (*cf.* Corcoran 1999).

It is not just mathematically oriented symbolic logicians such as Parry and Smiley who see the wisdom and justification of using many-sorted logic to represent or model Aristotle's four kinds of categorical propositions.[24] Recently, in his important article "Aristotle

24 For the record, I do not say that Aristotle's categorical propositions are expressible using many-sorted sentences but only that they are logically equivalent to propositions so expressible. I agree with Barnes (2007 264f) and many others that each categorical

on the Existential Import of Propositions" (2007), the late classicist Mario Mignucci said the following:

> If somebody is interested in a formal modern counterpart of Aristotle's theory, the best one was offered by Timothy Smiley some time ago, and it is based on the idea of adopting a many-sorted logic to interpret Aristotelian propositions (2007 134).

5. Interpreting and Evaluating Historical Logicians

There are evidently many pairs of propositions expressible with any pair of sentences. Consider the following pair:

Every rectangle is a rhombus.
Some rectangle is a rhombus.

Over the years, sentences similar to these have been taken to express propositions in many different forms: Aristotle's categoricals, Ockham's categoricals, Boole's equations, class inclusions, two-sorted prenexes, one-sorted quantifications, among others.[25] The fact that the proposition a given person expresses with the first does not imply the proposition which that person expresses with the second is no evidence about the relation of the propositions someone else expresses with them.

By the way, understanding a statement does not require knowing which proposition was stated and it especially does not require being able to categorize the proposition's logical form. When the parent tells the child "Alligators bite", in order for the child to understand the parent, it is not necessary for the child to know that the proposition is an indefinite and not a universal or existential. In fact, a listener can understand a speaker and yet be mistaken about the logical form of the proposition stated.

Even if we were somehow logically omniscient and could determine of any pair of propositions whether the first implies the second, what would we have to do to determine which propositions a given person was expressing? How do we justify a statement to the effect that a given person was incorrect about an implication? Aristotle's critics seem not to have asked themselves these questions. There are hermeneutic and epistemic issues that have been glossed over.[26]

Aristotle might have written the first word on logic. He told us: "[…] regarding deduction we had absolutely no earlier work

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proposition is a three-part entity composed of a "term", a "predication", and a "term": *pCs*, where *p* and *s* are distinct non-logical "terms" and *C* is one of the four Aristotelian copulas.

25 For Aristotle's categoricals and Boole's equations, see Corcoran (2003). For Ockham's categoricals see Corcoran (1981). For class inclusions, see Rosenbloom (1950). For others, see Łukasiewicz (1951).

26 These passages have benefited from discussions with Kevin Tracy.

to quote but were for a long time laboring at tentative researches" (*Sophistical Refutations* 184b).[27] But, as Aristotle also said himself, he did not write the last word on logic and the words he wrote were not all flawless.[28] Nevertheless, many people who thought they were advancing on the subject were actually making it worse. And many people who thought they were correcting Aristotle's errors were disagreeing with things Aristotle got right. In case after case, "criticisms" of Aristotle supposedly grounded in modern logic were authored by people who do not know what Aristotle did nor what modern logic is.

The Buffalo Syllogistic Group helped to keep these and other issues alive and helped to keep the intellectual world aware of the fascinating and momentous issues concerning the nature and origin of logic, one of the central fields that might shed light on the nature of rationality.

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27 This passage from *Sophistical Refutations* has been taken to be about Aristotle's work in that book and not about his work on logic in general including *Prior Analytics*. The dispute is somewhat mooted by the fact that either way he would have been equally justified.

28 See the last sentence in *Sophistical Refutations*.

detractors could be added, some from UB; several of our papers have been rejected by journals whose referees disapproved the Buffalo-Cambridge interpretation.)

This paper is dedicated to the memory of our late colleagues Professors Kenneth Barber and Peter Hare; both were enthusiastic supporters who would have enjoyed the paper and the reunion. The paper would have benefited from their suggestions and criticisms.

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