Natural Language and Everyday Reasoning

Fred Sommers

§.1 Until the advent of modern predicate logic as inaugurated by Gottlob Frege and codified in Whitehead's and Russell's Principia Mathematica, Aristotle's term logic of natural language, was 'primary logic' and the Stoic logic of propositions was secondary. After Frege and the Principia, the primacy was reversed. As the Kneales say of the Stoics:

> The logic of propositions which they studied is more fundamental than the logic of general terms which Aristotle studied in the sense that … it is presupposed by the second [which] is primary because it must come at the beginning of any systematic development. If we adopt this practice, we reserve the title, 'general logic' for the study in which we are concerned not only with the notions of negation, conjunction, disjunction and disjunction but also with the notions of generality expressed by 'every' and 'some.' General logic, so defined, includes primary logic… and cannot be developed without it… Within this scheme Aristotle's syllogistic takes its place as a fragment of general logic, in which theorems of primary logic are assumed.[1]

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[1] William and Martha Kneale, The Development of Logic, Oxford University Press, 1960, p. 511.

[1] Cf. Fred Sommers, *The Logic of Natural Language*, Chapter 9. Oxford, Clarendon Press.1982

General or modern logic, is what we today call 'predicate logic.' In Modern Predicate Logic (MPL), 'Every man is mortal' has the form 'For every x, if x is a man then x is mortal' and 'some man is wise' has the form 'There is an x, such that x is a man and x is wise,' respectively incorporating the conditional and conjunctive forms of primary logic in the categorical propositions of syllogistic logic. MPL regiments multiply general sentences with the conditional and conjunctive forms of primary logic in formally accounting for an inference like

(T) Some sea turtle is older than every human, hence every human is younger than some sea turtle. In proving the validity of (TM), MPL expresses its premise as the quantified conjunction

(P*) There is an x such x is a sea turtle and For every y, if y is a human being then x is older than y

$$\exists_x(\mathrm{Turtle}_x \;\&\; (\forall_y(\mathrm{Human}_y \supset \mathrm{Older}_{xy}))$$

and its conclusion as the quantified conditional

(C*) For every y, if y is a human, there is an x such that x is a sea turtle and x is older than y

$$\forall_y(\mathrm{Human}_y \supset \exists_x(\mathrm{Turtle}_x \;\&\; \mathrm{Older}_{xy}))$$

and showing that '(P*) ⊃(C∗)' is a logically true or '(P∗) & ~(C∗)' is logically false.

It is now generally assumed that traditional (Aristotelian) term logic of natural language is deductively weak, being incapable of accounting for the validity of arguments like (T) which involve relational sentences, that have predicates with more than one general subject. Michael Dummett's view of the revolution that Frege wrought and that Principia Mathematica codified, is fairly representative:

> **Modern logic stands in contrast to all the great logical systems of the past… in being able to give an account of sentences … that depends upon the mechanism of quantifiers and bound variables. For all the subtlety of the earlier systems, the analysis of the structure of the sentences of human language which is afforded by modern logic is, by its capacity to handle multiple generality, shown to be far deeper than they were able to attain. (1993: xxxii).**

A traditional logic confined to sentences of natural language seemed unable to account for inferences involving relations. and multiply general sentences. To deal with an inference like (T), Frege devised a symbolic language into which one recasts 'Some sea turtle is older than every human' in a notation of quantifiers and bound variables. Says Dummett: "Frege had [thereby] solved the problem which had baffled logicians for millennia by ignoring natural language." P20

That Predicate Logic, in contrast to traditional term logic, could account for arguments involving "multiply general" propositions exposes the double mistake of regarding syllogistic logic as primary logic and of regarding the variable-free sentences of natural language as adequate vehicles for facilitating logical inference.

According to Dummett Frege believed that "natural language is in principle incoherent." And he says: "Undoubtedly his predisposition to adopt such a belief was formed by the experience which the discovery of the quantifier-variable notation had given him." P21

It is certainly true that Aristotle's logic of natural language had provided no clear way to handle arguments with relational sentences. Augustus de Morgan had pointed this out, as had Leibniz before him. But preFregean logicians did not believe, nor is it in fact true, that a logic of natural language cannot formally validate an inference like (T) without regimenting its premise and conclusion as sentences that embody forms of 'primary' logic and some form of quantifier/variable analysis . One may rightly point out that pre-Fregean logicians *did not know how to validate* inferences involving multiple generality. But that does not mean that a traditional logic of natural language is in principle incapable of providing a formal, variable-free account of them, that does not presuppose the primacy of propositional logic.[2] And there is reason to believe that a variable-free account is an account is possible.

Consider a child that knows that all horses are animals. An averagely bright 8 year old can intuitively reason 'So anyone that rides (owns, feeds, sees…) a horse rides (owns, feeds, sees…) an animal.' She must then have applied some *legitimate* method of reasoning that *instantly* gets her from 'every X is Y' to 'So every R to an X, is R to a Y.' *What method can that be?* Asking that question is a bit like a bewildered spectator asking how a conjurer could possibly have rapidly pulled several rabbits out of a small hat. How does he do *that*? Indeed, a child's ability to move "with the speed of thought" from 'all horses are animals' to 'every rider of a horse is a rider of an animal' not only raises the question of how she makes that inference so *quickly* but how she can make that inference at *any* speed. Since she reasons in the variable free

[2] Cf. Fred Sommers, *The Logic of Natural Language*, esp. Chapter 9. Oxford, Clarendon Press.1982

sentences of natural language, she ought not be able to make that inference *at all*, let alone make it in a split second. It takes a trained logician several *minutes* to derive 'every rider of a horse is a rider of an animal' 'from 'all horses are animals.' For he first translates the sentences into the notation of predicate logic and then, using laws of quantifier interchange and primary logic he shows in about 8 carefully justified steps, that '$\forall x[(Horse_x \supset Animal_x) \supset \{\forall y(Horse_y \& \exists x(Rider_{xy} \supset \exists z(Animal_z \& Rides_{yz})\}]$' is a logical truth.

No child can reason in the manner of modern predicate logic. But it is an undenialb efact It is a fact that even children reason intuitively, rapidly, and *correctly* with multiply general sentences. So, outside of the classroom, do trained logicians. In THE MENO, Plato asked how children and other logically untutored human beings are capable of intuitive reasoning. That raises a question that is neither asked nor answered by practitioners of modern predicate logic: how does a child intuitively and instantly infer 'every R to an A is R to a B' 'from 'every A is B' in a language that lacks the quantifier/bound variable mechanism of modern predicate logic? An adequate answer must present a legitimate logical method that can be applied in milliseconds to the variable-free sentences of natural language in which a child reasons.

§.2 If we go back to a prefregean time when logicians thought of logic as the science that describes how we actually reason in natural language, we find Thomas Hobbes in the 17th century confidently stating that we reason intuitively in an algebraic manner: "By the ratiocination of our mind, we add and subtract in our silent thoughts, without

the use of words."[3] The Kneales say that Hobbes thought of reasoning as "a species of computation" but they note that "his writing contain in fact no attempt to work out such a project." [4]

Later in the 17th century, Leibniz endorsed Hobbes view:

> **Thomas Hobbes, everywhere a profound examiner of principles, rightly stated that everything done by our mind is a computation by which is to be understood either the addition of a sum or the subtraction of a difference. So just as there are two primary signs of algebra and analytics, + and –, in the same way there are, as it were, two copulas. [5]**

Though Leibniz talks of the plus/minus character of the positive and negative copulas, neither he nor Hobbes say anything about the plus/minus character of the other common logical words that mentally drive our intuitive, everyday deductive judgments, words like 'some', 'all', 'if', and 'and', each of which actually turns out to have an oppositive, +/-, character that allows us, in our "silent thoughts" to ignore its literal meaning and to reckon with it as one simply reckons with a plus or a minus operator in elementary algebra or arithmetic. These 'logical constants' of natural language propel our reasoning. Because Hobbes and Leibniz did not focus attention on the +/- character of natural language's logical constants, they did not provide a guide for a research program that could develop a +/- logic that describes what goes on actual 'ratiocination.' I will argue that a developed +/- logic provides a way *back* from modern predicate logic --- the logic of quantifiers and bound variables, which

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[3] The English Works of Thomas Hobbes, vol. I, W. Molesworth (ed), London, Kessinger. 1839, p.3.

[4] William and Martha Kneale, T*he Development of Logic*, Oxford University Press, 1960, p. 511.

[5] *Leibniz: Logical Papers*, G.H.R. Parkinson (ed, transl), Oxford: Clarendon Press, 1966, p. 3.

became ‘standard logic’ in the last century – to Aristotle’s term logic of natural language that had been standard logic for millennia.

I do not believe that Aristotle has been legitimately supplanted. Using Aristotle’s common sense conception of the logical form of the categorical sentences of natural language, I will show how a child, using its native language moves “logibraically” with “the speed of thought” from ‘All horses are animals’ to ‘It can’t possibly be true that someone riding a horse isn’t riding an animal.’

§.2.1 Some years ago, preoccupied with the question of intuitive reasoning that Plato had raised in the Meno and without realizing that I was corroborating Hobbes's conjecture, I discovered that the 'LOGICAL CONSTANTS' of natural language that figure prominently in our intuitive everyday reasoning could be reckoned with as one reckons with the plus/minus operators in elementary algebra.[6] I found, for example, that 'is,' 'and', 'some,' and 'then,' are "PLUS-WORDS" but that 'isn't,' 'not,' 'all,' and 'if,' are "MINUS-WORDS."

Natural language is our language of thought. In reasoning intuitively we unconsciously exploit the +/- character of the familiar logical words that drive 'ratiocination;' we reckon with a positively or negatively charged logical constant of natural language as if it were a plus or minus operator in a simple expression of elementary algebra. As Plato noted, children have some innate algebraic know-how. For example, in some form a child knows that addition is commutative. Suppose too that it innately treats 'is' and 'some' as "plus-words." Reckoning with the plus/minus character of the natural constants enables a young child to instantly recognize that 'some$^{\{+\}}$ teachers are$^{\{+\}}$ men' "says the same thing" 'some$^{\{+\}}$ men are$^{\{+\}}$ teachers.' A nine year child can reckon that 'Some$^{\{+\}}$ dogs aren't$^{\{-\}}$ friendly,' is "logibraically" equivalent to Not$^{\{-\}}$: All$^{\{-\}}$ dogs are$^{\{+\}}$ friendly':

Discursively: Not$^{\{-\}}$: All$^{\{-\}}$ Dogs are$^{\{+\}}$Friendly ≡ Some$^{\{+\}}$Dogs aren't$^{\{-\}}$Friendly
⇓ ⇓ ⇓ ⇓ ⇓
Logibraically: - (- Dogs + Friendly) = + Dogs – Friendly

I eventually came to believe that we mentally reason by instinctively exploiting the algebraic, +/- character of the logical constants of natural language. 'And' is a plus-word. One way a teenager may quickly get from 'Every^{-} horse is^{+} an animal' to 'so

[6] Cf. *The Logic of Natural Language*, Oxford, Clarendon Press.1982

every^{-} owner of a^{+} horse is^{+} an owner of an^{+} animal' is to add a tautological premise and to infer a conclusion from the *two* premises:

Every$^{\{-\}}$Horse is$^{\{+\}}$ an Animal and$^{\{+\}}$ Every$^{\{-\}}$ Owner of a$^{\{+\}}$Horse is$^{\{+\}}$ an Owner a$^{\{+\}}$ Horse:

Conjoining them yields the conclusion, 'Every^{-} Owner of a^{+} Horse is^{+} an Owner of an^{+} Animal.' $[-H+A] + [-(O+H)+(O+H)] \Rightarrow [-(O+H)+(O+A)]$

Or the teenager may reason indirectly, showing it can't possibly be true that some owner of a horse *isn't* an owner of an animal. For if that were true, we should have:

(i) Every^{-} horse is^{+} an animal and^{+} (ii) Some^{+} owner of a^{+} horse doesn't^{-} own an^{+} animal. From these two premises it would absurdly follow that

(iii)Some^{+} owner of an^{+} animal doesn't^{-} own an^{+} animal:

$$\text{(i) } [-H+A] + \text{(ii) } [+(O+H) -(O+A)] \Rightarrow \text{(iii) } +(O+A) - (O+A)$$

$$\begin{array}{ll} \text{(i)} & -H+A \\ + \text{ (ii)} & +(O+H) -(O+A) \\ \therefore \text{ (iii)} & +(O+A) - (O+A) \end{array}$$

(iii) is unacceptable but (i) is true: To avoid the unacceptable *reductio* conclusion, we must reject and negate premise (ii). Since –[+(O+H) -(O+A)] = -(O+H)+(O+A), we indirectly arrive at '-(O+H)+(O+A)': Every owner of a horse is an owner of an animal.

Since sapient animals have evolved to natively possess some rudimentary algebraic know-how, both the direct and indirect ways of reasoning are available even to a child.

§3. Aristotle's logic of terms preceded the Stoic logic of psitions by some two hundred years. In Aristotle's day and for more than two thousand years thereafter, term

logic was 'primary logic.' Indeed Leibniz, who regarded term logic as primary logic, looked for a way to incorporate propositional logic as a special branch of term logic:

> **If as I hope, I can conceive all propositions as terms, and hypotheticals as categoricals, and if I can treat all propositions universally, this promises a wonderful ease in my symbolism and . . . will be a discovery of the greatest importance.**[73]

In my view, neither logic is "primary." However, Leibniz's hope of a unified logibraic syntax becomes a reality the moment we extend the +/– calculus to propositional connectives like 'if'…then' and 'both …and' as in 'If p then q' and 'not(both p and not q)'.

Just as we logibraically represent the logical equivalence $^{\{-\}}$ $^{\{+\}}$

$$\textbf{All}^{\{-\}}\textbf{ X is}^{\{+\}}\textbf{ Y} \equiv \textbf{Not}^{\{-\}}\textbf{: Some}^{\{+\}}\textbf{ X is not}^{\{-\}}\textbf{Y}$$

as $$-X+Y = \quad -(+X + (-Y)),$$

so we logibraically represent the logical equivalence

$$\textbf{if}^{\{-\}}\textbf{ p then}^{\{+\}}\textbf{ q} \equiv \textbf{not}^{\{-\}}\textbf{: both}^{\{+\}}\textbf{ p and not}^{\{-\}}\textbf{-q}$$

as $$-p+q \;=\; -(+p +(-q)$$

WHY 'IF' IS A MINUS WORD AND 'THEN' IS A PLUS-WORD.

Consider the propositional conjunction 'both p and q'. Intuitively, the words 'and' and 'both' behave as plus-operators. Their plus-like character is evident in the commutative character of the conjunction 'Both p and q', where 'and' and 'both' behave like the addition operators in the algebraic expression '+x+y'.

$$\begin{array}{cccccccccc} \textbf{Both}^{\{+\}} & \textbf{p} & \textbf{And}^{\{+\}} & \textbf{q} & \equiv & \textbf{Both} & \textbf{q} & \textbf{And} & \textbf{p} \\ \Downarrow & & \Downarrow & & & \Downarrow & & \Downarrow & \\ + & p & + & q & \equiv & + & q & + & p \end{array}$$

The equivalence shows that 'both' and 'and' are "plus-words."

We can therefore transcribe 'Not: both p and not-q' as '–(+p+(–q))'.

Not: both p and not-q
⇓ ⇓ ⇓ ⇓
– (+ p + (– q))

But what is the +/– transcription of 'if...then'? Neither 'if' nor 'then' has an obviously plus-like or minus-like character. However, we know that 'Not: both p and not-q)' transcribes as '–(+p+(–q)) and also know that 'If p then q' is logically equivalent to 'Not: both p and not-q'. We may therefore determine the plus/minus character of 'If p then q' by equating 'If{?} then{?} q' to 'Not{-} (both{+} p and not{-}q)':

If{?} pthen{?} q =def Not: both p and not-q
⇓ ⇓ ⇓ ⇓ ⇓ ⇓
– p + q =def – (+ p + (– q))

The definitional equivalence of ''if p then q' to 'not: both p and not-q' uncovers the logibraic character of 'if' and 'then': 'If' is a minus word and 'then' is a plus word.

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Note the difference between expressing the equivalence of 'If p then q' to 'Not: both p and not-q' in the conventional symbolism as

$$p\supset q \equiv \sim(p\&\sim q)$$

and expressing it "logibraically" as

$$-p+q = -(+p+(-q))$$

In the conventional notation, one proves the equivalence by truth tables. In logibraic notation, the does not need tol be explained or proven; it is perspicuous as an algebraic truism.

Among the basic inference patterns in standard propositional logic are the principles knows as *Modus Ponens, Modus Tollens* and *Hypothetical Syllogism. All* are perspicuous in the +/– notation:

Modus Ponens	Modus Tollens	Hypothetical Syllogism
–p+q	–p+q	–p+q
<u>p</u>	<u>–q</u>	<u>–q+r</u>
∴ q	∴ –p	∴ –p+r

§4 Here is a very partial but representative list of natural language constants that figure in everyday intuitive reasoning:

'SOME'('A'..), 'IS' ('WAS,' 'WILL BE,' ETC.), 'BOTH,' 'AND', and 'THEN' are "PLUS- WORDS;" 'EVERY,'('ALL,''ANY'..),'NOT,' ('NO,' 'AIN'T,' 'UN-,' ETC.), and 'IF' are "MINUS- WORDS."[7]

Evolved sapient animals have some rudiments of innate mathematical know-how that enables them to reason well with the sentences of our native language—including relational sentences. Originally an inspired conjecture of Thomas Hobbes, plus/minus discursive reasoning will, I expect, be found to be a cognitively veridical psychological reality.

I believe we *unconsciously* reckon 'logibraically' with the natural logical constants and I expect that cognitive science will subject it to empirical tests. Of course cognitive scientists will not enter the picture and arrive at an empirical judgment on the plus/minus hypothesis before they become aware that the logical constants natural language *have* a +/- character. That will take some time since ("full disclosure"), despite repeated efforts to attract the attention of analytic philosophers to

[7] Readers will find accounts of the +/- logic in the author's The Logic of Natural Language (Oxford, Clarendon Press, 1982), chapter 9; in "Predication in the Logic of Terms," Notre Dame Journal of Formal Logic 31 (1990): 106–26 ; "The World, the Facts, and Primary Logic," Notre Dame Journal of Formal Logic, 34 (1993): 169–82; and in An Invitation to Formal Reasoning (Aldershot, Ashgate, 2000), with G. Englebretsen.

the Plus/Minus character of the natural language constants, I must report that I have failed to interest even academic logicians in the minus-like behavior of natural logical constants such as 'if,' 'every,' and 'not,' or the plus-like behavior of 'then,' 'some,' 'and,' and 'is.' Modern logical thinking, perhaps overly impressed by Frege's concept-script and his very strong opposition to "psychologism," is unaccustomed to regarding reasoning in a way that calls for actually describing what we mentally do when we reason with the variable free sentences of natural language to arrive at correct deductive judgments. I am hopeful however that logical theory will increasingly be influenced by cognitive scientists who approach reasoning empirically, by studying what is actually taking place in everyday "ratiocination." It is plainly true that reason in sentences of our natural language, not in formulas of a constructionist notation devised by a brilliant 19th century mathematical logician.

I firmly believe that we reason by reckoning with the oppositively charged logical constants of natural language. If that is mistaken, logicians ought at least be interested in showing that it *is* mistaken but so far they have shown little interest in my formal thesis that the natural constants are oppositively charged and no interest at all in the empirical, psychological, hypothesis that we reason intuitively by exploiting the oppositively charged characters of the natural logical constants in actual reasoning. I first published the formal +/- thesis in 1970[8] and have elaborated on it in print many times since . Some philosopher of langauge, notably Peter Strawson, have commended the plus-minus hypothesis. Others, notably Peter Geach, have angrily rejected it. [9] But in the main, both the formal and the empirical theses have been met with a snubbing

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9 Most notably Peter Strawson in his review of my book …. And in his preface to

silence; in any case there is not a single article in the literature that examines them critically. I shall say no more about this curiously dismissive reaction to a serious challenge to the reign of predicate logic.

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§.5.1 Being aware that distributing the external minus sign of '-(-a+h+t)' inward changes the internal signs, a teenager will immediately recognize that it is equal to '+a+(-h)-t'. The same teenager is just as quick to see that 'Not: every archer had hit some target' is logically equivalent to 'Some Archer had missed every target'; here we find that he reckons "logibraically," distributing the external "minus-word" 'not' to all the words in its scope and changing 'every$^{\{-\}}$' to 'some$^{\{+\}}$,' 'hit$^{\{+\}}$ to 'hit$^{\{-\}}$' (treating the contrary words 'hit' and 'missed' as being positively and negatively 'charged') and changing 'some$^{\{+\}}$' to 'every$^{\{-\}}$:'

Not^{-}: Every^{-} archer will^{+} hit^{+} some^{+} target ≡ Some^{+} archer will $^{+}$ miss^{+}every^{-} target
- (- archer + (+hit) + target) = + archer + (-hit) - target)

In transforming 'not every archer will hit a target' into 'some archer will miss every target' we reason in just the way we reason in elementary algebra when transforming '-(-a+h+t)' to '+a+(-h)-t'. The difference between the two moves is that when people reason with meaningful logical words like 'not', 'every', 'some' and 'is' or with logical contraries like 'hit' and 'miss', they are unaware that they are reasoning with the the negative charge of meaningful words like 'not,' 'every,' and 'missed or the positive charge of meaningful words like 'will,' 'some,' and 'hit'.

No acceptable account of everyday actual reasoning can afford to make light of the fact that we think and reason in meaningful sentences of natural language. A cognitively veridical logic takes the characterization of logic as 'Laws of Thought' literally. We normally reason by exploiting the +/- character of the logical constants of ourf language of thought. The advantage of reasoning that way is altogether lost when one abandons natural language to reason in the canonical formulas of modern predicate logic. The main task of a course in formal logic is to clarify for the students what is already intuitively obvious to them. us. A teenager of average intelligence will take no more than a few seconds to move from (1) 'Not every team won some a game' to (2)'Some team team failed to win a single game.' He learns how he got (1) from (1) to (2) when his teacher tells his that he reasoned the +/- way by reckoning that '-(-T + W +G)' is entails '+ T + (-W) – G' . No one who is given an standard MPL account of this inference is ever likely to say: Aha, so that how I intuitively" so quickly and confidently arrived at that conclusion!" When I got round to teaching logic the +/- way, I got many an 'Aha!' reaction to my logibraic account of an inference.

An Aristotelian Logic of Natural Language

§6. The +/- logic is 'a logic of natural language' because the logical constants of natural language can be reckoned with as one reckons with the plus/minus operators of elementary algebra. It is also an Aristotelian logic because, the Dictum de Omni --- the governing principle of inference in Aristotelian Logic--- sanctions the logibraic way of inference. According to the D.O.:

WHAT'S TRUE OF EVERY$^{\{-\}}$ M IS TRUE OF WHATEVER IS$^{\{+\}}$ AN M.

By the D.O., when Ψ is said to be true every$^{\{-\}}$ M in one premise and 'is$^{\{+\}}$ an M' is said to be true of something in a second premise, the 'middle term,' M, occurring negatively in the first premise, is said to 'distributed;' occurring positively in the second premise, it is said to be 'undistributed.' When we add the first premise to the second, the negative middle term logibraically cancels the positive middle term of the second premise, replacing it by Ψ in a conclusion in which no middle terms appears. When the middle term is undistributed in both premises, there can be no coancelation and no conclusion can be drawn (the "fallacy of undistributed middle"). Valid arguments have the form

{Ψ}(-M)
…+M
∴ …Ψ

E.g.,

i. **ii.**

All^{-} Mammals are^{+} warm-blooded All^{-} Mammals are+ warm-blooded -M + P All^{-} Dolphins are+ Mammals Some+ Sea Creatures are+ Mammals ±S + M
∴All- Dolphins are+ warm-blooded Some+ Sea Creatures are+ warm-blooded ±S + P

The D.O. also applies to relational arguments. Take de Morgan's 'Tail of a Horse' inference:

(Δ) Every horse is an animal, so every tail of a horse is a tail of an animal.

Applying the D.O., we may prove (Δ) valid by an indirect argument showing that affirming its premise but denying its conclusion entails a self-contradiction. For suppose it's true of every horse that it is an animal but also true of some horse that its tail isn't a tail of an animal. Since by the first premise, 'is an animal' is true of every

horse, it must, by the D.O., also be true of whatever is a horse. So, given the second premise, it would be true of a horse whose tail is not a tail of any animal that it is an animal whose tail is not a tail of an animal. That self-contradictory consequence comes out clearly if we logibraically add the premise of (∆) to the denial of its conclusion. When we do that, we cancel the middle term, 'horse' and arrive at a blatant absurdity of form 'some X is not an X', viz., that some tail of an animal is not a tail of an animal.

(1) –H+A: Every horse is an animal; 'Is an animal' is true of every horse.
+(2) +(t+H) – (t+A); Some tail of a horse isn't a tail of an animal; It's true of somethng that is a horse that its tail is not a tail of an animal.
∴(3) +(t+A) - (t+ A); So, it's true of some animal that its tail is not a tail of an animal.

This reductio reasoning, which validates all arguments of form 'Every X is Y, so every R to an X is R to a Y, is an example of how traditional term logic accounts for arguments involving multiply general propositions.

Aristotelian term logic is a logic of natural language --- the variable-free 'language of thought' we use in actual everyday reasoning. By contrast modern predicate logic (MPL) is a rational reconstruction of actual reasoning whose symbolic language with its grammar of quantifiers and bound variables is not the language of actual ratiocination.

The grammar of MPL is, in Quine's words, "an artificial grammar designed bylogicians …that we tendentiously call standard," a "made for logic," grammar[10] that "facilitates logical inferences" which, presumably, cannot be facilitated in natural language whose logical grammar lacks the quantifier/bound-variable mechanism of MPL . Quine

[10] Cf. W.V. Quine, *Philosophy of Logic* , Prentice Hall (1970), p35-36.

candidly acknowledges that many find the use of an artificial grammar disconcertingly irksome and cumbersome. But he firmly maintained that its adoption for standard logic is scientifically necessary: .

"All of austere science submits pliantly to the Procrustean bed of predicate logic. Regimentation to fit it . . . serves not only to facilitate logical inference, but to conceptual clarity." [11]

In fact there are no valid logical inferences that a predicate logic can facilitate, that cannot also be facilitated by a simple, non-Procrustean, Aristotelian term logic that exploits the +/- character of the logical constants that drive our everyday reasoning with the sentences of natural language. There may be some other reasons to employ a Fregean rational reconstruction of deductive reasoning but there are none that could support the claim that Frege's constructionist logic is more 'scientific' than Aristotle's logic of natural language.

Frege had an ingenious idea of how we *might* be reasoning. Though he believed that we could and should be reasoning the quantifier- bound-variable way, he probably knew better than to claim outright that people actually were reasoning that way. There is no reason to think they are. Natural language, the language of actual ratiocination, is variable free. It is true that it lacks the quantifier-binding mechanisms of modern predicate logic; it is *not* true that this renders MPL deductively more powerful than the +/- logic of natural language.

Frege's rational reconstruction of reasoning has been "Standard Logic" for a whole century. As the Kneales say about Frege's contribution to logic: "The use of

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[11] W.V. Quine, *Quiddities*, Cambridge: Harvard University Press, (1987), p. 158.

quantifiers to bind variables is the main distinguishing feature of modern logical symbolism and the device which gives it superiority… over ordinary language. 1879 is the most important date in the history of the subject."[12]

That generally accepted historical verdict badly misprizes Aristotle's logical legacy and grossly overestimates Frege's. Newton's scientific physics did properly supplant Aristotle's physics, but, unlike his Physics, Aristotle's logic of natural language is not unscientific and Frege is no Newton.

Pace Frege, Dummett, Quine, et al, reasoning in natural language is no less 'scientific' than reasoning in the quantifier-variable manner of modern predicate logic, it is only much simpler, more natural, and more efficient, enabling even children, who natively possess some algebraic know-how, to reason intuitively, rapidly, but safely and correctly. As Hobbes correctly averred, natural reasoning is "logibraic." Hobbes's is a psychological theory. Frege, who believed that natural language was deductively inferior, opposed "psychologism" which regarded logic as "the laws of thought in the sense of an empirical psychological account of Frege could not be expected to be sympathetic to the Hobbesian thesis that we "silently" reason the +/- way. Nevertheless, that way turns out to be strikingly more efficient than any rational reconstruction of inference by the methods of modern predicate logic.

Logical theory now faces a future that will increasingly be shaped by empirical findings of cognitive science of how we actually reason and by evolutionary theories of the origins of rationality in our primate ancestors. Once biologists and cognitive

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[12] ***The Development of Logic*, Oxford: Oxford University Press, 1960, p. 511. 1879 is the year Frege's *Concept-Script* appeared.**

psychologists become aware of the hypothesis that we may be reasoning by unconsciously exploiting the algebraic powers of the logical words of our language of thought, they will find ways to empirically test it. Our sapient species uses natural language descriptively. It also uses natural language in reasoning. . When I think of a 'best explanation' of why our sapient species is as fluent in reasoning as it is in describing the world, I cannot help but believe that cognitive science will find that Hobbes had divined the correct answer about five hundred years ago.