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SOMETHING TO RECKON WITH

THE LOGIC OF TERMS

GEORGE ENGLEBRETSEN

With a foreword by
FRED SOMMERS

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For **Morgan**,

definitely someone to reckon with

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FOREWORD
by Fred Sommers

I teach logic, but unless I want to be left strictly alone I've learned long ago not to tell that to anyone I've just met. Quite a few people are put off by logic (and logicians). Yet people reason all the time, and mostly they reason correctly. Why then is logic so alien a subject to so many?

George Englebretsen's book tells why and introduces the reader to logic in a way that is altogether "friendly" and natural. Though it is not a formal text, it does what current logic texts do not do: it makes you recognize the processes of your own thinking; it shows them to you in ways that make them familiar again. It gives you one "aha" experience after another. To appreciate Englebretsen's novel approach to logic, it is necessary to have some idea of how the subject is currently taught and why it is so alienating.

You hear someone say "I've petted a crocodile but I never petted an amphibian." You think to yourself: "That can't be right! Crocodiles are amphibians." Using your native logical abilities you intuitively saw that the following two sentences cannot *both* be true together:

(P1)

(1*) every X is a Y; (2*) someone R'd an X but did not R a Y.

The crocodile contradiction fits the pattern P1, and so does this one:

(1') every Norwegian is a Scandinavian.
(2') someone who cheated a Norwegian never cheated a Scandinavian.

As our examples illustrate, we often *recognize* inconsistency when we come across it. Related to this is our ability to infer conclusions from premises. For example, given our feeling that sentences of pattern P1 are inconsistent, we are confident that inferences of form L1 are 'valid'.

(L1)

(1i) every X is a Y

(2i) /everyone who R's an X R's a Y

(The little stroke sign that precedes the sentence in (2i) should be read as 'therefore', 'hence', or 'so'.) An example of an inference that fits the pattern (L1) is

(A1) every horse is a mammal
/Everyone who rides a horse rides a mammal

Similarly, we easily recognize the validity of the inferences

Every crocodile is an amphibian. So anyone who pets a crocodile pets an amphibian.

Every Norwegian is a Scandinavian. So anyone who cheats a Norwegian cheats a Scandinavian.

Here is a different pattern of inference that we all instinctively recognize as valid.

(L2) every X is a Y
some X is a Z
/some Y is a Z

An inference that fits this pattern is

(A2) every horse is a mammal
some horses are white
/some mammals are white

We intuitively see the conclusion of A2 really does follow from the premises.

Our logical instincts are healthy, but when it comes to *explaining* why a given pattern of reasoning is valid or invalid, we must call on the professional logician. Just here, the modern teachers of logic have failed the public. For in most contemporary institutions of higher learning we practice and teach a style of logic that keeps the average intelligent layperson at arm's length. If you ask a well-trained logician to explain why a statement of the form 'every X is Y' is incompatible with a statement of the form 'someone R'd an X but didn't R a Y', he will rightly tell you that taking them both to be true and applying rules of logic will lead you to an overt contradiction of the form 'some X is not an X'. But he will point out that before you can show this yourself, you will have to learn how to translate a sentence like 'some who petted a crocodile didn't pet an

amphibian' into the language of symbolic logic and learn the rules for manipulating its formulas. Now, learning the symbolic language and the rules usually takes a good half of a semester's college logic course. The translations use letters and symbols like the following:

C for 'is a crocodile'
A for 'is an amphibian'
P for 'petted'
(x) for 'for every x'
(Ey) for 'there is an x'
Pyx for 'y petted x'
⊃ for 'if . . . then'
& for 'and'
~ for 'not'

Using these symbolic abbreviations, the student learns to "translate" 'every crocodile is an amphibian' and 'someone who petted a crocodile did not pet an amphibian' as

(1t) (x)(Cx ⊃ Ax)
(2t) (Ex)(Cx & (Ey)(Pyx & (z)(Az ⊃ ~Pyz)))

Reading (1t) as 'For every x, if x is a crocodile, then x is an amphibian' and (2t) as 'There is an x such that x is a crocodile and there is a y such that y petted x and for every z, if z is an amphibian, then y did not pet z'.

To *prove* the inconsistency of (1t) and (2t), the student proceeds to apply rules to them to get new propositions that follow from these two, moving along until she or he deduces a formula that is of the form (Ex)(Px & ~Px), which may be read as 'something is such that it is both a P-thing and a not-P-thing'. Now this is an overt contradiction and it shows that the original two propositions cannot both be true. I won't show you how the contradiction is actually derived. Even if you know how to translate the sentences of your arguments into the symbolic language, and know the rules for manipulating the formulas, the proofs take time and considerable ingenuity. Many students enjoy the challenge. Unfortunately, far more are put off by the whole process, feeling perhaps that something as obvious as good reasoning need not be approached in so complicated a fashion.

That feeling happens to be right. We can say in one sentence why modern logic is so forbidding and arcane: Modern logic is unfriendly because, as it is currently presented, you cannot do logic unless you have learned an artificial symbolic language to be used in "translating" ordinary sentences into logical formulas. The symbolic translations that today's students of logic must master are alien to the average person because they contain phrases and constructions not found in the original sentences.

Consider the sentence 'every crocodile is an amphibian' and its translation as (x)(Cx ⊃ Ax), which we may read as 'anything is such that if it is a crocodile then it is an amphibian'. That rendering is perhaps a bit closer to the English sentence than 'for every x, if x is a crocodile, then x is an amphibian'. Even so, both renderings are a far cry from 'every crocodile is an amphibian'. Both contain the construction 'if . . . then' and a pronoun 'it' (in the form of the variable 'x'). The original English sentence has no pronouns and no connective phrase of the form 'if . . . then'. So the student might well ask, Is this way of construing the sentence really necessary?

Or take 'some horses are white', the second premise of A2. That is translated as a formula that uses (Ex) and &:

(3t) (Ex)(Hx & Wx)

and is read as 'there is an x, such that x is a horse and x is white', or, more freely, as 'something is such that it is a horse and it is white'. But again, 'some horses are white' has no pronouns, nor does it contain the word 'and'. The translation of (3t) thus complicates the original sentence. And many a layperson gets the unhappy feeling that professional logicians may be making things unnecessarily complicated. The complexity shows up more dramatically in dealing with a sentence like 'someone who petted a crocodile never petted an amphibian'. The translation, (2t), introduces three pronouns and constructions using 'and' and 'if . . . then', none of which are found in the original sentence.

We are all logical. We all enjoy using our minds to make inferences, to detect false reasoning, to check on the reasoning of others. So it's really a pity that modern logic is so unfriendly. We should expect logic to be easy! It should be natural! It should be fun! And it can be. There is a way of doing logic that is natural and enjoyable. *Something to Reckon With* introduces you to it while giving the history of how logic took its unfriendly turn in the last century. Englebretsen begins where one must begin: with the analysis of the logical form of the simplest sentences we use in our everyday reasoning. That takes him immediately to the distinction between logical words such as 'some', 'and', 'if', and 'not', which determine the form of the sentence, as opposed to words such as 'farmer', 'book', or 'runs', which contribute the content or matter of the sentence.

The vehicle for rational thought is the sentence. For example, we may infer 'not every farmer is a non-citizen' from 'some farmers are citizens'. In 'some farmers are citizens', 'citizens' and 'farmers' are the material elements. The words 'some' and 'are' determine the form of the sentence; they are called "formative" elements. Aristotle, who liked to place the formative elements between the two material elements, preferred to write 'some farmers are citizens' as 'citizen belongs to some farmer'.

The words 'citizen' and 'farmers', which now appear at each end of the sentence, are *terms* (as in 'terminals') and the expression 'belongs to some' then acts as the "term connective" that joins the terms to form the sentence. Another way of forming a sentence with these terms is 'citizen belongs to every farmer' (Aristotelian for 'every farmer is a citizen'). Since 'belongs to' is common to both connectives, we may dispense with it and write the two sentences as 'citizen some farmer' and 'citizen every farmer'. Englebretsen soon introduces the reader to an algebraic way of representing the two term connectives 'some' and 'every'. Using '+' for 'some' we write 'citizen some farmer' as 'C+F'. This allows us to represent the equivalence of 'some farmer is a citizen' to 'some citizen is a farmer' as an equation:

C+F = F+C
citizen some farmer = farmer some citizen

The equivalence shows that 'some' behaves like the addition sign.

What about 'every'? To see how 'citizen every farmer' can be transcribed as an algebraic formula, we note that 'every farmer is a citizen' is equivalent to the denial of 'some farmer is a non-citizen' The Aristotelian form for the denial that some farmer is a non-citizen is 'it is not the case that non-citizen some farmer'. Using '−' for negative words like 'not' and for negative particles like 'un' or 'non-', 'not: non-citizen some farmer' transcribes as

−((−C)+F)

which is algebraically equivalent to 'C−F'. This suggests that in logic the word 'every' behaves like the subtraction in algebra. And indeed it does so behave. Note that 'not: non-citizen some farmer' (Aristotelian for 'it is not the case that some farmer is a non-citizen) is logically equivalent to 'citizen every farmer'. The equivalence is algebraic:

C−F = −((−C)+F)
citizen every farmer = not (non-citizen some farmer)

Englebretsen's aim is to show the reader how we "reckon with sentences" in much the way we reckon with numbers or simple algebraic expressions. Using the plus/minus way of representing formatives, he soon introduces the reader to more natural ways of transcribing sentences into algebraic formulas. The following words or expressions are '+': 'some', 'and', 'is', 'it is the case that'. The following words or expressions are '−': 'not', 'non', 'every', 'if', 'it is not the case that'. Here are some examples of algebraic transcriptions.

every farmer is a citizen	$-F+C$
some farmer is a non-citizen	$+F+(-C)$
some farmer is a gentleman and a scholar	$+F+\langle G+S \rangle$
some boy envies every astronaut	$+B_1+(E_{12}-A_2)$
no senator is a non-citizen	$-(+S+(-C))$
everyone who cheats a Norwegian cheats a Scandinavian	$-(C_{12}+N_2)+(C_{12}+S_2)$

Note that a contradictory sentence such as 'some man is not a man' transcribes as a sentence of the form '$+X+(-X)$', which literally "says nothing." Note also that when we add sentences like 'someone who cheated a Norwegian didn't cheat a Scandinavian' to 'every Norwegian is a Scandinavian' we get a contradictory form:

1. $+(C_{12}+N_2)-(C_{12}+S_2)$
2. $-N+S$

$/ +(C_{12}+S_2)-(C_{12}+S_2)$

In contrast, anyone who uses the symbolic translations will find that it takes many steps and considerable ingenuity to show that the two sentences lead to a contradiction. It would, however, be a mistake to think that we can move easily from the vernacular sentence to the algebraic transcription. Some "regimentation" is required.

An English sentence like 'every whale is a mammal' transcribes directly into algebraic notation as '$-W+M$'. Similarly, its equivalent, 'no non-mammals are whales', transcribes directly as '$-(+(-M)+W)$'. Sentences that come ready made for direct transcription are called "canonical." In real-life reasoning, however, canonical English sentences, all ready to be transcribed into algebraic formulas, are the exception rather than the rule. We are at least as likely to come across 'the whale is a mammal' and 'only mammals are whales' as 'every whale is a mammal' or 'no non-mammals are whales'.

Regimenting sentences to make them suitable for reckoning is an important tool in practical reasoning. It is essential to expose the structure of argument by giving each sentence its proper form. The methods presented by Englebretsen may then be used to reckon with in order to arrive at a conclusion. Consider, for example, the following simple argument that is clearly valid.

Some sport cars that have no automatic transmissions are convertibles.
/ Some convertibles that lack automatic transmissions are sports cars.

Regimented and transcribed, the argument looks like this:

$$+\langle +S+(-A)\rangle +C$$
$$/ +\langle +C+(-A)\rangle +S$$

Consider next a slightly complicated piece of reckoning that involves a relation with several subjects.

1. some sailor gave every child a lollipop
2. Some children were orphans
3. All lollipops are delicious
4. Every sailor was an American

To see what conclusion we may draw, we transcribe the sentences algebraically:

1. $+S_1+G_{123}-C_2+L_3$
2. $+C+O$
3. $-L+D$
4. $-S+A$

Adding these premises we get the conclusion:

$$+A_1+G_{123}+O_2+D_3$$

which is the transcription of 'some American gave some orphan something delicious'.

As a final example of how logic is approached in this book, we look at a problem in a book on logic written by the author of *Alice in Wonderland*. Lewis Carroll presents three premises and asks the reader to supply a fourth statement as a conclusion.

(1) No terriers wander among the signs of the Zodiac.
(2) Nothing that does not wander among the signs of the Zodiac is a comet.
(3) Nothing but a terrier has a curly tail.
(4) / ???

In solving problems of this kind we are better off relying not on our wits but on a mechanical procedure for drawing conclusions from premises. The tricky part is to regiment the sentences by paraphrasing each one in a way that permits us to transcribe it algebraically. The following transcriptions introduce letters that stand for the terms of the argument (viz., T = terrier, W = wanderer among the signs of the Zodiac, C = comet, S = curly-tailed).

Using these term letters, we may represent the argument thus:

(1) no T is a W	-(+T+W)
(2) no non-W is a C	-(+(-W)+C)
(3) no non-T is an S	-(+(-T)+S)

Having represented the premises in algebraic transcription, we can add them up to derive the conclusion in a mechanical way. Driving minus signs inward gives us '-T-W-(-W)-C-(-T)-S' which equals '-C-S'. The conclusion '-C-S' or '-(+C+S)' stands for 'every comet isn't curly tailed' or, equivalently, 'no comet is curly tailed'.

Well, a foreword should just briefly introduce; it may do no more than whet the reader's interest. Aristotle defined us as rational animals. To be rational is to think. Englebretsen's novel book brings you to a delightful landscape laid out with the pathways of good thinking. Along the way, he takes you quickly through the history of the subject, including our own times, when professional logicians succumbed to the temptation to use an unnecessarily complex technical symbolism. It is a symbolism that works well enough but alienates the lay public by straying too far from the language it actually uses in its everyday reasoning. Englebretsen tells how and why that happened and engagingly shows how we can put matters right again.

PREFACE

Philosophy teaches us to talk with an appearance of truth about all things, and to make ourselves admired by the less learned.

Descartes

Through careful study of official answers to questions asked in Parliament one learns that the length and number of words used may effect a considerable economy in the quantity of information conveyed.

J.A. Chadwick

Classical Greek rhetoric, in contrast to logic, allowed an argument to rest on examples and analogies, commonplaces and truisms. In inventing logic Aristotle recognized that, even as a tool for rhetorical science, something far more objective and rigorous is required of argumentation. Aristotle's formal logic was, in Leibniz's judgment, one of the most beautiful inventions of the human mind. Beautiful or not, the fact is that for most of the past twenty-four centuries a relatively small number of people have taken a special interest in the discipline of logic. This is so partly because logic, like its close partners of old, grammar and rhetoric, has been considered trivial, not just in the literal sense of belonging to a trio, but in the sense of being unproductive. Yet, as Peter Geach has observed, "Logic is unproductive like book-keeping, but without sound accountancy a productive business may smash." Logic keeps the accounts of rational thought and discourse. And a good job that is. Formal logic may also have been considered trivial because it seems to care so much more for the little words than the big ones. Formal logicians care not a fig for words such as 'consideration', 'craftiness', or 'catalogue'. But they will go mad for words like 'if' and 'and' and 'all', not to mention 'or' and 'no'. Still, if we are to have sound business practice as well as rational thought and discourse, it is well that we have accountants and logicians.

To be logical is to think, speak, or write in a certain way. To reckon is (1) to consider, to heed, to include, to regard, (2) to count, to compute, to calculate, to sum. I use the word in both senses in this essay. Logic is something to be considered when engaged in any kind of rational endeavour, and it is, in itself, something worthy of special regard. Any attempt at an understanding of ourselves as rational beings must include an assay of our logical abilities. And in all of our *rational* discourse we must always heed the dictates of logic. This first sense of 'reckon' is used implicitly throughout this essay. What I do explicitly here is focus on logic as reckoning in the second sense. Thus to be logical, to reason properly and correctly (and consciously), is to count, compute, calculate, sum.

Of course, logicians have always treated logic this way. In this respect, the logic that dominates today is no different from that of earlier times. But today's logic offers a quite different notion of what it means to compute logically. Today's logic is "mathematical logic," the standard version being the first-order predicate calculus with identity. It was developed just over a century ago, its authorship eventually, and rightly, credited to Gottlob Frege. In the 1880s, Frege outlined a system of logic very different from the traditional one (syllogistic), which had dominated the field since Aristotle. What made Frege's logic so different, so revolutionary, was that it was grounded on a completely new theory of logical syntax (the study of those little words). A theory of logical syntax is a systematic account of the logical forms of all sentences that enter into deductive inferences. Based on its theory of logical syntax, Frege's logic proved to be very effective. It allowed modern mathematical logicians to build a logical calculus adequate to the demand to account for logical reckoning involving all sorts of sentences: categoricals, compounds, singulars, and relationals. It is now used to do a very wide variety of logical and mathematical tasks and serves as a basis for much research in linguistics, psychology, and computer programming. It is definitely something to reckon with.

The great power and beauty of the standard, Fregean system, not to mention its hegemony in the schools, notwithstanding, it is not a perfect tool for logical reckoning. Its rapid and complete ascendancy has been due to the weakness of its rival—the old syllogistic. That system was based on a theory of logical syntax very different from the one familiar to Fregeans today. The old theory construed all sentences as categorical. As such it had to make some unnatural concessions in order to accommodate singular sentences, and compound and relational expressions were virtually unaccounted for. This system, based on such a theory of logical syntax, was easily supplanted by its new, more powerful Fregean rival. Still, there are some things to be said in favour of the old theory. For one thing, its account of the logical form of categorical sentences at least (and these are, arguably, the most common of natural-discourse sentences) was far more natural than the one offered by Fregean syntax. Many linguists today continue to parse sentences of natural language in a way similar to the old theory rather than the new.

Oversimplifying, we may say that modern mathematical logic is powerful but often complex and unnatural; old syllogistic is natural and relatively simple but weak. Mathematical logicians tend to dismiss the charge that their calculus is complex and unnatural by denigrating natural language as inherently illogical anyway. Mathematical logic, after all, was

developed by mathematicians and philosophers interested primarily in establishing the foundations of mathematics (thus accounting for mathematical reckoning). Their search for a theory of logical syntax, therefore, was guided by the model of mathematical expression rather than by natural language. As could be expected, once the system was built it fit poorly with inference made in the medium of natural language. Yet natural language, not mathematics, is the primary medium for thinking, speaking, and writing in the vast majority of contexts. Mathematics does indeed need a logic, as Frege saw. But whatever the logical needs of mathematics are, they are not necessarily the logical needs of those who seek to understand natural language. What is required is a logic of natural language that rests on a theory of logical syntax general enough to account for the logical forms of all kinds of sentences entering into deductive inferences, powerful enough to account for the validity or invalidity of all such inferences, applicable to sentences expressed in the medium of natural language, and simple enough to be used as a tool of reckoning by all who must or care to do so.

The latest version of a revitalized, revised, strengthened syllogistic logic, by Fred Sommers, is based on an exceedingly simple theory of logical syntax. Elements of such a theory can be traced back to the beginnings of logic itself—to Aristotle. Elements abound in the work of old syllogists from then on, but they are especially abundant in the logical remarks of Hobbes, the extensive writings of Leibniz, and the work of nineteenth-century algebraists such as De Morgan. The algorithm for this new syllogistic logic reflects the simplicity of theory of simple logical syntax in that it borrows directly from simple algebra or arithmetic. Moreover, this single algorithm is adequate to the demands of analysing deductive inferences involving categoricals, singulars, compounds, and relationals. When contrasted with the first-order predicate calculus with identity, the differences are striking. It not only matches but surpasses the standard calculus by analysing with ease a variety of inferences beyond the scope of the entrenched system.

What makes the system more natural than the standard system is that it formulates natural-language sentences with a symbolism whose own syntax closely matches that of natural language. (Few logicians today would dare to claim a high degree of naturalness, in this sense, for the standard logic.) The fact of its naturalness makes it easy to learn and teach (a second, foreign, "logical" grammar is not needed). It is also easy to learn and teach because no new symbolism is required. We are already familiar with the symbolism of simple algebra or arithmetic, with its unary/binary ambiguity for plus and minus signs. And this is how it should be. For centuries, logic was in the hands of a small group of priests and philosophers, useful but unused. For the past century, logic has been in the hands of a different small group of mathematicians and philosophers, useful but too complex to be used by others. The theory of logic presented here offers the hope of a system easily learned and easily used by anyone. And ease is important, for there is no gainsaying the fact that in an ever more complex (not to mention dangerous) age we can no longer afford the luxury of rearing generation after generation of citizens ill-equipped for the rigorous demands of clear, critical, logical thought and expression. A simple, natural, but powerful, system of logic, accessible to and usable by a majority, would be an important propaedeutic. It would, indeed, be something to reckon with.

Since I refuse to take all the blame for this essay I must take this opportunity to thank several people. Those few readers who may be familiar with my work already know the tremendous debt I owe to Fred Sommers. I first read Sommers while a graduate student in the mid-1960s. At the time, I had fallen under the influence of O.K. Bouwsma and the latter Wittgenstinians. I was enrolled in a seminar on category mistakes led by the logician Charles Sayward. We began with Sommers's 1959 *Mind* paper, "The Ordinary Language Tree." But I was not fooled. In spite of the title, which should bring a glow of warm anticipation to any good Wittgenstinian ready to examine it, the piece was filled with symbols, diagrams, and neologisms. His next paper, "Types and Ontology," was even worse—more symbols and diagrams. Despite my background in mathematics, I had become wise to the false charms of formal methods, and had developed a keen sense of the absurdity of philosophy. So I gave Sommers my first reading in a skeptical, even hostile, frame of mind. Still, I kept reading. I began corresponding with him and eventually had a first meeting in 1967. By then, I had come around. He had won me over—not by his personality (charming as it is), not by easy words or facile arguments—but by the sheer power of his ideas. His early work on category theory is not always easy reading, but the effort required to come to a full understanding of it is paid off many times over by the acquisition of a theory about the nature of language as a whole, and ontology as a whole, and their connection, which is a potentially powerful tool for the analysis of a very wide range of philosophical problems and concepts. This theory, the "tree theory," became the subject of my doctoral thesis and much of my subsequent work over the next several years.

Sommers's work on the tree theory eventually led him (with me, as usual, following more slowly) to the considerations of logic that resulted in his building of a new syllogistic, as found in his many papers after 1970 and his 1982 book, *The Logic of Natural Language*. The present essay is the latest of a large number of papers, books, and anthologies that I have produced exploring and exploiting his logical theories. I have been inspired by his thought, probed by his questions, humbled by his criticisms, provoked by his suggestions, warmed by his humour. Often I have done his ideas less than adequate justice and have even plagiarized him with hardly an effort to conceal, and, in spite of all this, he has yet to have me called to court. For all this (and so much more), I thank him.

Others, logicians and nonlogicians alike, who must be tarred with my brush of thanks are Bill Shearson, Harvey White, Jamie Crooks, Dale

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I have thanked Morgan by dedicating this essay to him (for he was with me for every page). But that dedication could be extended to the others whom I never fail to reckon with: Russell, Suzanne, Gaël, and Geneviève.

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