Mathematical Methods in Linguistics

Barbara H. Partee, Alice ter Meulen, and Robert E. Wall
(University of Massachusetts, Amherst; University of Washington;
and University of Texas, Austin)

Dordrecht: Kluwer Academic
Publishers (Studies in Linguistics and
Philosophy 30), 1990, xx + 663 pp.
Hardbound, ISBN 90-277-2244-7, $99.00,
Dfl 225.00, £79.00; paperbound, ISBN
90-277-2245-5, $25.00, Dfl 80.00, £19.75

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1. All other texts on the mathematics of language are now obsolete. Therefore, instead of going on about what a wonderful job Partee, ter Meulen, and Wall (henceforth, PMW) have done in some ways (breadth of coverage, much better presentation of formal semantics than is usual in books on mathematics of language, etc.), I will leave the lily ungilded, and focus on some points where the book under review could be made far better than it actually is.

2. Perhaps my main complaint concerns the treatment of the connections between the mathematical methods and the linguistics. This whole question is dealt with rather unevenly, and this is reflected in the very structure of the book. The major topics covered, corresponding to the book's division into parts (which are then subdivided into chapters) are set theory, logic and formal systems, algebra, "English as a formal language" (this is the heading under which compositionality, lambda-abstraction, generalized quantifiers, and intensionality are discussed), and finally formal language and automata theory. Now, the "English as a formal language" part deals with a Montague-style treatment of this language, but it does not go into contemporary syntactic analyses of English, not even ones that are mathematically precise and firmly grounded in formal language theory. Having praised the book for its detailed discussion of the uses of formal semantics in linguistics, I must damn its cavalier treatment of the uses of formal syntax. Thus, there is no mention anywhere in it of generalized phrase structure grammar or X-bar syntax or almost anything else of relevance to modern syntactic theory.

Likewise, although the section on set theory deals at some length with nondenumerable sets, there is no mention of the argument of Langendoen and Postal (1984) that NLs are not denumerable. Since this is perhaps the one place in the literature where set theory and linguistics meet, one does not have to be a fan of Langendoen and Postal to see that this topic should be broached.

3. Certain important theoretical topics, usually ones at the interface of mathematics and linguistics, are presented sketchily and even misleadingly; for example, the compositionality of formal semantics, the generative power of transformational grammar, the nonregularity and noncontext freeness of NLs, and (more generally) the question of what kinds of objects one can prove things about.

Let us begin with the principle of compositionality (i.e., that "the meaning of a complex expression is a function of the meanings of its parts and of the syntactic rules by which they are combined"). PMW claim that "construed broadly and vaguely

enough, the principle is nearly uncontroversial, but Montague's precise version of it places rather severe constraints on admissable [sic] systems of syntax and semantics" (p. 318). But I can find no reference to any constraints beyond the requirement that both the syntax and the semantics are to be given by a recursive specification (*ibid*). And it is not even clear what this means: for example, can a syntactically basic expression correspond semantically to a nonrecursive function?

While PMW mention later that the principle as stated forces us to assume that any expression that is semantically ambiguous must be syntactically ambiguous as well (p. 338), they do not point out that this is the *only* consequence that might be construed as being subject to factual testing. Given the mythic status of compositionality in much of the literature on formal semantics, PMW could have done the field a big favor by explicitly noting that essentially *any* conceivable system of syntax and semantics can be described compositionally.

This point about the toothlessness of the compositionality constraint comes up in a second connection as well. In their discussion of the generative power of transformational grammars (pp. 557–558), PMW criticize (the relevant version of) TG for being "capable of generating sets of strings that are not possible natural languages" (since they generate all r.e. sets). This kind of criticism would be at least as appropriate in connection with the principle of compositionality, as noted. Indeed, more so, since as Chomsky has often pointed out, there are important respects in which the formalization of TG on which all the generative capacity results were based departed from his theoretical intent, whereas there has never been a similar defense of compositionality. That is, neither Frege, Montague, nor anybody else has ever come out and said, to paraphrase Chomsky: "Look, formally it may be that any conceivable syntax-semantics system is compositional, but actually I have a much more restricted idea of compositionality in mind, one that you have not captured in your formalization—and never will."

PMW's discussion of the claim that English is not regular (pp. 480–482) or context-free (pp. 503–505) evokes a series of somewhat similar comments.

First of all, the nonregularity "proof" is based on sentences such as *The cat the dog the rat the elephant admired bit chased died*. Specifically, PMW construct a regular set $A * B * died$, where A is "some finite set... of common noun phrases" such as {*the cat, the dog, the rat, the elephant, the kangaroo*} and B is "a finite set... of transitive verbs" such as {*chased, bit, admired, ate, befriended*}, and then claim that its intersection with English is precisely the set $\{x^n y^{n-1} died\}$, where $x \in A$, $y \in B$.

Here, PMW might have mentioned that there are objections to this kind of claim about the string sets of natural languages (such as Manaster Ramer 1983, 1987), the point being that (at least some of) the supposedly ungrammatical sentences actually are grammatical. Thus, PMW's argument crucially demands that sentences with more transitive verbs than NPs be ungrammatical. Yet, if we accept the possibility of *the elephant admired* as an NP meaning 'the elephant that is admired' (e.g., in a context where it is contrasted with *the elephant despised*), then *The cat the dog the rat the elephant admired bit chased bit died* would have to be grammatical as well. Even worse, PMW cite approvingly Chomsky's early arguments about the nonregularity of English without mentioning the extensive literature that has shown the lack of mathematical rigor in these arguments (Levelt 1974; Daly 1974; Manaster Ramer 1983).

PMW's discussion of non–context-freeness is much better in that it does refer to Pullum and Gazdar's (1982) rebuttal of the early arguments of Chomsky and others. Yet they then cite the Swiss German argument of Shieber (1985) as "unassailable on either formal or empirical grounds," when in fact it has been shown to contain a serious (if perhaps nonfatal) flaw in the mathematical reasoning (Manaster Ramer

1988; Ojeda 1988). PMW might have been better off referring to Culy (1985) or any of a number of other arguments against context-freeness (see Gazdar and Pullum 1985 and Manaster Ramer 1986 for the literature up to that time).

Finally, PMW again missed a chance to do the whole field a major service by teaching the student not to think that one can prove anything about a nonmathematical object such as English. On the contrary, they themselves repeatedly employ this abusive turn of phrase. The point here is simply that theorems can only be proved about mathematical objects, such as a formalization of somebody's idea of English, but whether this formalization fits the facts of the real world is something that is *forever* open to question. Hence, no theorem is about *English*.

4. The book shows signs of being put together out of prefabricated pieces without sufficient thought being devoted to the coherence or esthetics of the final product. Thus, the brilliant work of van Benthem on using automata to model certain areas of formal semantics is discussed in an appendix tacked on to the very end of the book. More generally, it is a pity that despite their unique qualifications for the job, PMW did not attempt in any way to integrate or even relate the different areas of mathematics of language. For example, I would have welcomed some clarification of the relation between the Montagovian ideas of syntax in the "English as a formal language" part of the book to the formal language-theoretic framework in the contexts of which other syntactic theories are discussed.

5. The usefulness of PMW's book as an introduction to a well-established field of inquiry is somewhat limited by the repeated use of nonstandard terminology, such as "finite automaton language" or, to choose an especially bad example, "algorithm" in the sense of a deterministic algorithm (p. 517). Finally, the book is marred by editing, spelling, and other errors too numerous to list. All this can easily be corrected and should not be a serious problem to a knowledgeable instructor. But it can be annoying.

Having said all this, I might add that this hefty book can be used as a basis for a whole series of courses, at various levels. There are lots of exercises, with selected solutions. It will also be a handy basic reference tool, with much more information per topic than required by many students, and brief but useful topical bibliographies. But precisely because this book is likely to be used in so many different ways by so many different people, I would urge the authors and the publisher to put out a second revised edition quickly.[1] And I would advise those readers who can to wait for the same before spending their money. Still, those who are about to teach a course, or need a general reference tool, in the area of mathematics of languages, would be well advised to grit their teeth and get a copy of the present edition.

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1 *Editor's note:* After this review was written, a second printing of the book, with corrections, was announced for May 1992.

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