Editor's Preface

Mathematical linguistics enjoys considerable popularity these days – even if there is a good deal of uncertainty about just what it is. Prospective linguists are anxious to find out how much mathematics will be required of them and some would no doubt like to know which areas within linguistics might safely be considered non-mathematical. The increasing use of the formalisms of mathematics and logic in describing the structure of human language has given rise to a large field of study called *formal linguistics* and, as expected in the age of the computer, there is now a very active field called *computational linguistics*. These developments were part of the 'revolution' in linguistics generally associated with the advent of transformational generative grammar. Of course, mathematics had been used before that revolution, but its role changed radically in the 1960's and 1970's. The emphasis on formal rules and derivations in syntax brought mathematics of a certain type into the foreground, and the attempt to formalize semantic representation in grammars of natural languages sent linguists scurrying to books on mathematical logic.

Now, one might take mathematical linguistics to include any mathematical study of human language or of formal languages that have some of the properties of human language: for example, statistical studies of texts (word frequency counts, etc.), studies of the algebraic properties of generative grammars and the languages they generate, use of computers in automatic translation, applications of probability theory in glottochronology and in the construction of probabilistic grammars, use of recursive function theory in the study of generative grammars, representation of linguistic structure by directed graphs, mathematical analysis of speech sounds in acoustic phonetics, etc. It is difficult to say where this list would end since mathematics can be applied in some way to nearly any topic in linguistics.

But the notion that mathematical linguistics is the collection of ALL mathematical studies of linguistic phenomena is rejected at the outset in this book. The authors take a point of view which may seem rather narrow to some readers: (1) that mathematical linguistics is a particular mathematical discipline, (2) that it is essentially non-quantitative, and (3) that it is situated within the theory of algorithms. Their starting point is the concept of language as an effective function which maps meanings onto texts, or vice versa. The study of this function constitutes the discipline of mathematical linguistics. It follows that this book is not simply a review of possible uses of mathematics in linguistics, but an account of how a particular branch of mathematics is involved in the meaning-text relation.

The question of just what constitutes mathematical linguistics is to some extent a terminological one. Bar-Hillel wrote (1964: 185): 'the adjective "mathematical" is quite all right if "mathematics" is understood in the sense of "theory of formal systems" ', and he suggested that this discipline might better be called 'algebraic linguistics'. It may be of interest to see how this topic is treated by other writers in the field, so let us compare just a few.

Solomon Marcus (1967) introduces the reader to the use of mathematical modeling for investigating language structure. In his book, which assumes a considerable degree of mathematical sophistication on the part of the reader, Marcus is concerned with analytic rather than generative grammar: analytic grammar takes a language as given in the form of a certain subset of strings over some vocabulary and provides a structural description of these strings (sentences). The description referred to is made from the point of view of classical structural linguistics, with the emphasis on distributional relations of words and substrings within sentences.

In Harris (1968) the author formulates an abstract system to characterize natural language, starting from the data of language and 'finding within the data such relations as can be organized into a suitable model'. That model is developed within the framework of Harris's theory of transformations, which is outlined in the same book. The abstract system he finds adequate to characterize the actual sentences of natural language is expressed in terms of a set of primitive arguments and five sets of operators whose operands are either primitive arguments or resultants of operations. Recursivity follows from the application of operators to resultants.

In contrast with the approach of Marcus or Harris, Baron Brainerd (1971) and Robert Wall (1972) introduce a variety of mathematical topics, as such, to the linguist. They include material from logic, sets, functions, relations, Boolean algebra and the mathematical theory of generative grammars. Brainerd relegates to an appendix a brief discussion of algorithms – a topic which is of central importance to Gladkij and Mel'čuk. Wall takes a definite stand on the use of the term 'mathematical linguistics': for him it means 'the study of formal models of generative grammars and closely allied devices called abstract automata' (p. xiii).

The relation between automata theory and mathematical linguistics had been pointed out by Bar-Hillel in a 1962 lecture *The Role of Grammatical*

Models in Machine Translation (included in Bar-Hillel 1964): 'just as mathematical logic had its special offspring to deal with digital computers, i.e., the *theory of automata*, so structural linguistics had its special offspring to deal with mechanical structure determination, i.e., *algebraic linguistics*, also called, when this application is particularly stressed, *computational linguistics* or *mechano-linguistics*. As a final surprise, it has recently turned out that these two disciplines, automata theory and algebraic linguistics, exhibit extremely close relationships which at times amount to practical identity' (pp. 186–7).

Automata theory has certainly played a key role in the study of formal grammars, as can be seen for example in the early work of Noam Chomsky. In particular, Chomsky established important results on the equivalence of classes of automata and generative grammars in 'Formal Properties of Grammars' (Chomsky 1963). The relation between formal grammars and automata has been examined in detail by various authors (e.g., Hopcroft and Ullman 1969, Gladkij 1973) and many investigations have been carried out on the generative power of grammars proposed for natural languages, culminating in the proof by Peters and Ritchie (1971, 1973) that transformational grammars of the kind proposed by Chomsky (1965) have the weak generative capacity of type-0 grammars, i.e. that they are equivalent to Turing machines and can generate all recursively enumerable sets. Gladkij and Mel'čuk examine the properties of different classes of grammars in some detail, but they do not discuss the work of Peters and Ritchie.

Gladkij and Mel'čuk open their book with an explanation of their view of mathematical linguistics in Chapter 1. After presenting the general concept of formal grammar in Chapter 2, they discuss the hierarchy of generative grammars (weak generative capacity) in Chapter 3 and examine the possibility of describing natural languages by means of generative grammars in Chapter 4. Chapter 5 deals with internal properties of generative grammars, including estimates of derivational complexity. Chapter 6 includes a discussion of categorial grammars and predictive analyzers, logical analysis of language, semantic languages, and the modeling of linguistic research. Reprints of three articles by the authors form a supplement at the end of the book. In one of these articles, 'Tree Grammars: A Formalism for Syntactic Transformations in Natural Languages,' they stress the importance of separating relationships of linear arrangement and relationships of 'syntactic contingency' (e.g., dependency): 'we consider it desirable to include two different mechanisms in the apparatus for describing the syntax of natural language: one should deal with syntactic structures which are devoid of linear order, and the other should map appropriately developed structures into word strings'. Syntactic structure, including 'surface structure', is represented by dependency trees and does not specify the order of the terminal elements. If in a given language a particular syntactic relation is manifested by a specific word order, the final mapping carries the corresponding surface structure into a string of words in the proper order.

The main body of this book does not require more than a rudimentary knowledge of mathematics on the part of the reader. There are a number of books available, in addition to those already referred to, whose purpose is to provide general mathematical background considered essential for the study of formal linguistics (e.g., Barbara Hall Partee, 1978), but the present book does not offer a background course in mathematics for linguists. The authors, a mathematician and a linguist, develop the theory of formal grammars at a leisurely pace, backing up the formal presentation with well motivated informal discussions. They have included numerous applications of the theory to various subsystems of Russian, with English glosses provided for the examples. Important theorems are listed in an appendix along with references to the pages on which they occur in the book and to proofs, which are found elsewhere.

This book provides a welcome addition to the literature on mathematical linguistics. Some familiar ground is covered in a refreshingly distinct manner and, as well, the authors present some ideas of their own which may not be so familiar to many generative grammarians. But whatever the reader's theoretical persuasion may be, he should find this a stimulating approach to the subject of mathematical linguistics based on the authors' view of language as an effective function relating meanings and texts.

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