

## *Book review*

*Unification Grammars* by Nissim Francez and Shuly Wintner, xii + 312 pages, Cambridge University Press, 2012. Hardcover, ISBN-13 978-1-107-01417-6.

This book is an introduction to unification grammars, as used for modelling the syntax of natural languages, with a strong emphasis on mathematical properties. Much of the book is filled with formal definitions of concepts, and theorems and their proofs, complemented by copious examples.

The book is aimed at undergraduates and graduates with some basic knowledge of both computer science and linguistics. More precisely, the authors assume a background roughly equivalent to at least one year of undergraduate studies in mathematics plus an introductory course in syntax, which to me seems a plausible minimum background required to understand the content of this book.

Chapter 1 provides motivations for the chapters that follow. After a brief discussion of syntax, the authors make their case that in order to pose and verify precise claims about the structure of languages, one first requires formal means of describing these languages, with unification-based formalisms singled out as the main focus of the current book. The following six pages give a succinct account of a selected number of phenomena in the syntax of English that will be modelled in later chapters. This discussion is mostly clear, although use of jargon such as ‘saturation’ (p. 8) might not be understood by part of the target audience. Moreover, it is not motivated why a fragment of English called  $E_{subcat}$  would disallow the sentence *Rachel feeds Jacob the sheep* (p. 8).

The remainder of the first chapter discusses formal languages, context-free grammars and mildly context-sensitive grammars, and their strengths and weaknesses for describing natural languages. It seems unfortunate to me that the term ‘head’ was used to refer to the left-hand side of a context-free rule, considering that the term usually has a different meaning in recent models of syntax, in particular where it concerns lexicalized grammars. That ‘some refer to [tree-adjoining languages] as the class of mildly context-sensitive languages’ (p. 29) may, in a literal sense, be true, but in my experience the former class has recently been more often identified with the languages generated by linear context-free rewriting systems. Less than elegant is that the notion ‘phrase of category’ is covered by two different definitions (Definitions 1.3 and 1.8).

Chapter 2 introduces four different views of feature structures, viz. as feature graphs, as equivalence classes of isomorphic feature graphs, as abstract feature structures (expressed in terms of sets of paths), and as attribute-value matrices. It is proven that these four views become equivalent if one restricts attention to their most relevant properties. One minor point of criticism is that after the terms

‘tag’ and ‘variable’ are introduced, both terms are used interchangeably (cf. Definitions 2.47 and 2.49); the discussion might have been easier to follow had only one term been used consistently.

Unification is discussed in Chapter 3. It is shown that it can be formulated in different but equivalent ways, for each of the four views of feature structures mentioned above. In addition, an algorithmic formulation of unification is presented. The chapter ends with a discussion of generalization, as the dual to unification.

Chapter 4 defines unification grammars, in terms of multirooted feature structures. Once more, different but equivalent ways are presented to formalize such structures. It is then shown how unification grammars generate languages, with derivation trees as an auxiliary concept.

Chapter 5 resumes discussion of the fragments of English informally introduced in Chapter 1, but now they are formalized in terms of unification grammars. Some of these grammars are worked out in detail, which is quite valuable from a didactic perspective. In other cases, gaps are left in the discussion. E.g. Example 5.17 (p. 184) deals with the ditransitive verb ‘give’, which is given a subcat list containing two NPs. It is not explained however why the first NP (for the indirect object) is constrained by ‘CASE : *acc*’, while no such constraint is placed on the second NP (for the direct object). Rule (4) on p. 186, introducing a slash feature, is formulated in a confusing manner: because there is no constraint on any slash feature in the right-hand side, the rule could be used several times, to discharge arguments in the subcat list one by one, while only the last argument would have to be accounted for by rules higher up in the derivation. The same holds for rule (8) on p. 190. The presented solution to describing relative clauses via empty categories, in Example 5.27 (p. 195), ignores the fact that an epsilon rule as shown entails a rather blunt form of overgeneration.

Chapter 6 addresses computational properties of unification grammars, as well as their expressiveness. The universal recognition problem for unification grammars is related to termination of Turing machines. In this part of the text, there is the misleading phrase ‘nonaccepting state at the end of the computation’ (p. 229); since the transition function is defined to be total for all configurations that are not in the final state, a configuration without accepting state can never be at the end of a computation.

Then, a restriction on unification grammars (off-line parsability) is presented that makes the recognition problems decidable. It is further shown that unification grammars without reentrancy generate exactly the context-free languages and it is stated without proof that one-reentrant grammars generate exactly the tree adjoining languages. The chapter ends with a discussion of parsing for unification grammars, on the basis of a parsing strategy that is sometimes referred to as ‘bottom-up Earley’.

Chapter 7 summarizes the previous chapters and reiterates the authors’ emphasis on rigorous formalization of linguistic concepts, as the basis for proving claims about languages. It also contains a brief outlook on other grammatical formalisms.

Every chapter except the last ends on a ‘further reading’ section containing bibliographical notes. Throughout the text, there are also many exercises, intended

to deepen the understanding of the reader by letting them investigate examples or complete mathematical proofs of stated theorems.

The many figures generally provide good intuitions and are pleasing to the eye, with a few exceptions, such as the overlapping arrows on p. 95, and numbers not quite fitting within their boxes as on p. 73, Example 2.24. The disproportionately small vertical space following exercises frequently confused me. For example, the word ‘Thus’ on p. 51 immediately following Exercise 2.18 could easily be misunderstood as a continuation of the exercise, while it in fact refers to what precedes the exercise. Lack of explicit references between running text and ‘floating’ text elements were another frequent cause of confusion for me. For example, Example 2.10 on p. 47 mentions variable  $n$  and function  $d$ , which only make sense after reading the proof of Theorem 2.11 on pp. 47-48, and conversely, the proof is easier to understand with the help of Example 2.10, but no cues are provided to link the two and they are moreover separated by Definition 2.10.

Appendix A provides a list of used symbols, with page numbers where they are first used, Appendix B briefly discusses standard mathematical notions, such as sets, relations and functions, and Appendix C offers solutions to selected exercises.

The book contains typos, some with the potential to cause confusion, but this is mitigated by a list of errata maintained by the authors, to be found at: [http://cl.haifa.ac.il/ug/Unification\\_Grammars.html](http://cl.haifa.ac.il/ug/Unification_Grammars.html) .

All in all, the book offers a good introduction to unification grammars, which is exceptional in its rigorous mathematical treatment. It may be particularly well suited for use in university courses that not only seek to convey to students some basic knowledge and understanding of unification grammars, but moreover attempt to familiarize them with formal descriptions and mathematical proofs. Those who expect a broad treatment of unification grammars and their applications however will find that the authors have limited their attention to the most important mathematical foundations, at the expense of many other topics. For example, handling of semantics and of *typed* unification grammars does not receive more than a cursory remark.

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