

## REVIEWS

domain-specificity in language ability. To his credit, Everett himself (in Chapters 4–7 and 10, in particular with references to the idea of modularity) points this out.

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**Yoad Winter**, *Elements of formal semantics: An introduction to the mathematical theory of meaning in natural language* (Edinburgh Advanced Textbooks in Linguistics). Edinburgh: Edinburgh University Press, 2016. Pp. vi + 272.

Reviewed by DANIEL LASSITER, Stanford University

Scholars get interested in semantics for all kinds of reasons. Some of us are primarily interested in connections with formal pragmatics, lexical semantics, logic, philosophy of language, epistemology, or one or another branch of metaphysics. Some are mainly interested in syntactic connections – often, in devising a theory of meaning that complements a preferred model of syntax. Others are concerned about the relationship between meaning and language processing, or reasoning and concepts, or connections with culture. And then there are those who are not primarily interested in one of these interfaces, but instead in the internal structure of meaning in natural languages – in what kinds of formal systems could capture the various kinds of inferential connections between words, phrases, and sentences. As we might expect, then, there are numerous introductory textbooks available that cater to many different perspectives.

To this mix, Yoad Winter has added an introductory semantics textbook that focuses squarely on the formal systems perspective – specifically, on model-theoretic semantics in the tradition of Montague 1973, and related work in formal

grammar. While there are several existing texts with a similar focus, Winter's is distinguished in three main ways: it is fairly brief, it succeeds in being clear and precise without being overly technical, and it presents – for the first time – an easy introduction to De Groote's (2001) Abstract Categorical Grammar with applications to scope ambiguity and long-distance dependencies. In this short review I will summarize briefly how the book is structured, commenting along the way, and then proceed to discuss its relationship to some of the other textbooks on the market and some suggestions for how to use it with different groups of students.

After an introduction explaining basic motivations for semantic theorizing and a quick review of set theory, Winter sets out in Chapter 2 to explain key analytic concepts of formal semantics: entailment, contradiction, and the distinction between grammaticality and sensicality (semantic well-formedness). He then introduces the concept of a model, and of denotation as a relation between expressions and aspects of a model. Focusing on the truth and falsity of sentences in models, the analytic concepts introduced earlier in the chapter are given precise formal interpretations. Here, Winter introduces the 'truth-conditionality criterion' as the key empirical constraint on formal models of meanings: if a sentence  $S_1$  'intuitively entails' sentence  $S_2$ , then, for all models  $M$ ,  $S_1$  truth in  $M$  implies  $S_2$ 's truth in  $M$ . The chapter goes on to discuss some simple examples of sentence meanings being composed from the meanings of lexical items, explains the distinction between lexical and compositional semantics, and introduces the concept of compositionality. Direct compositionality is briefly mentioned as an especially restrictive version of the compositionality requirement, where surface structures must be directly interpreted. Finally, a detailed example of structural ambiguity is given and analyzed in terms of a simple context-free grammar coupled with rules of interpretation.

Chapter 2, the first contentful chapter of Winter's book, already covers a great deal of material, in relatively high-level terms, in just 24 pages. Most of the book is written in a similar style: fairly difficult concepts are introduced in a precise, yet largely non-technical, way and illustrated with one or two examples. As a rule, the examples are well-chosen and clear, but the presentation is often quite abstract, presupposing a good deal of intuitive facility with set-theoretic concepts, and the exposition moves quickly. I suspect that students without significant prior exposure to formal semantics and logic will have a difficult time keeping up with the pace of it. On the other hand, students who are comfortable with dealing with mathematical concepts at a fairly high level of abstraction will find this chapter to be an ideal introduction to the main concerns and assumptions of formal semantics. I also appreciate Winter's choice to begin with a discussion of models and their fundamental importance in formal semantics. While some introductory textbooks present models as an advanced topic or omit them altogether (e.g. Heim & Kratzer 1998), I think that this way of presenting things does students a disservice since it can be taken to imply that mathematical rigor is a mere afterthought in formal semantics, rather than a fundamental concern.

The directly compositional approach that Winter discusses briefly in Chapter 2 is in fact the one used in the book, though this point is not much emphasized here or elsewhere. Indeed, drawing the distinction between ‘compositional’ and ‘directly compositional’ theories in the introductory chapter is one of Winter’s few, oblique acknowledgments that there are ways that one could set up the syntax/semantics interface other than the one being pursued. I return to this point briefly below.

Chapter 3 introduces types and semantic domains, functional application and  $\lambda$ -calculus, and gives linguistic examples including the analysis of transitive verbs and reflexive pronouns. It also discusses coordination, negation, and some issues in the lexical semantics of adjectives. The material in this chapter is fairly standard, though again the exposition moves quickly. There are also some choices that are non-standard for an introductory text, such as the purely semantic treatment of reflexive pronouns as higher-order functions on verb meanings. This is a helpful move, since it gives a simple illustration of the power of the  $\lambda$ -calculus. Another helpful move in this chapter are the examples and exercises around solving type equations, emphasizing that when  $A$  has a functional type and combines with  $B$ , there are always two possible types for  $B$ . This should be useful practice in thinking about discovery procedures for semantic analyses, and also in setting up the discussion of generalized quantifiers and type-lifting in the next chapter. Chapter 4 follows up with standard material on generalized quantifiers and their formal properties, monotonicity properties of determiners, and coordination and type-lifting. The presentation is brisk but clear, with well-chosen examples.

Chapter 5 begins with a puzzle: Why do *Some child that saw Mary* and *Some child that Mary saw* mean different things? In the type-driven approach to composition pursued so far, [*saw Mary*] and [*Mary saw*] should pick out the same thing, since linear order is not considered. Winter uses this point to motivate why some attention to syntax is crucially needed, even if we are mainly interested in the semantic composition. Long-distance dependencies are also explained briefly and used to motivate the need for a formal treatment of mismatches between word order and semantic composition. Winter introduces Abstract Categorical Grammar (ACG: De Groot 2001, with a close relative in Muskens’s (2003) Lambda Grammars) as a modular approach to the syntax/semantics interface that makes it possible to manipulate word order without modifying the assumptions made so far about how composition works. He starts by explaining hypothetical reasoning in natural deduction proofs, and goes on to show how this idea can be generalized to model function composition/ $\lambda$ -abstraction (for use in treating relative clauses, for example). Winter then explains how this approach fits into a modular, sign-based conception of composition, and implements a simple system for computing semantic and phonetic representations in parallel, both using  $\lambda$ -calculus. He then shows how these tools can be used to give formal derivations of quantifier scope alternations and long-distance dependencies, using relativization as the key example.

Chapter 6 follows this presentation with motivations for adopting an intensional (possible-worlds) semantics, focusing on cases of unknown identity between the bearers of names (*Lewis Carroll wrote Alice vs. Charles Dodgson wrote Alice*). Possible worlds are introduced and motivated as a solution. (Winter does not mention that it is quite controversial whether names can be treated as picking out their referents contingently, which would be required for there to be possible worlds differing in whether *Carroll* and *Dodgson* pick out the same person: see Kripke 1980 and much following literature.) He then gives a general recipe for converting a purely truth-conditional semantics in the style presented in earlier chapters into an intensional semantics. The final sections discuss how *de re/de dicto* ambiguities (e.g. in *Bill wants to meet a surfer*) could be treated using the ACG machinery introduced earlier to account for quantifier scope ambiguities. A brief concluding chapter gives many suggestions for further reading on topics in semantics, pragmatics, and beyond.

Winter's book has useful references to further readings in each chapter, both within formal semantics and drawing connections to computational, philosophical, and psychological issues. The exercises are well-designed and integrated into the text, in that most sections contain advice about when to stop and pursue them. Given the rapid pace of the presentation, doing the exercises carefully will be vital for most students to fully comprehend the material. The prose flows well and the book has clearly been carefully edited, with only a handful of errors that I detected and none that would lead to serious confusion.

Overall, *Elements of Formal Semantics* is precise, clear, and admirably brief. While not too technical, it employs a fairly high level of mathematical abstraction, and will probably be tough going for students who are not accustomed to this. However, it will be very informative and useful for those who are. It could also be used as a second text for students who need to pursue a more leisurely introduction first, or for self-study by philosophers, computer scientists, etc. looking for a quick introduction to the key problems of formal semantics. Among textbooks that focus on directly compositional approaches, Winter's book is most comparable to Jacobson 2014, which is built around Combinatory Categorical Grammar (CCG). Jacobson's textbook assumes a similar level of mathematical sophistication, but moves more slowly, covers more topics, and contains a good deal of explicit theory comparison with more standard, non-directly-compositional approaches. Carpenter 1997 is excellent, but far longer and more technical, and would make a good second text for students who have mastered the material in Winter's book. Among textbooks that take a non-directly-compositional approach, Winter's book is (for example) more rigorous than Heim & Kratzer 1998, but less theoretically engaged with other areas of linguistics. Chierchia & McConnell-Ginet 1990 is explicitly model-based like *Elements of Formal Semantics*, but more engaged with pragmatics and mainstream syntax, and also much longer.

Chapters 5 and 6 of Winter's book, which integrate the standard material of earlier chapters with ACG, are the book's most original contribution. I found them to be extremely clear and helpful – indeed, reading them clarified much of ACG's

motivation for me, and I have incorporated them into my introductory semantics classes. Even more impressively, this is to my knowledge the first presentation of ACG at an introductory level, most previous work in this framework being quite technical. This is all very much to the credit of *Elements of Formal Semantics*. At the same time, I am not convinced that these chapters would, on their own, constitute a sufficient introduction to the syntax/semantics interface for students with no prior background. In addition to being the most conceptually difficult part of the book, these chapters do not discuss alternative approaches or explain how the solution being offered differs from them. Students with no previous syntax or semantics who study them carefully will still find themselves unable to read work written in the Heim & Kratzer 1998 style that has become a kind of *lingua franca* in formal semantics. Students with some background in mainstream syntax will likely come away with many unanswered questions about how ACG relates to the kind of syntax that they have been taught elsewhere, or how the approach could be adapted to a different model of syntax.

Thus, while I agree fully that ACG is well-motivated conceptually and formally, I have reluctantly concluded that Winter's book cannot yet provide a standalone introduction to the syntax/semantics interface for most students. To further contextualize the otherwise excellent discussion in Winter's Chapters 5 and 6, I have supplemented these chapters with materials from three sources: Heim & Kratzer 1998 (a standard syntax-first source on scope and long-distance dependencies, starting from basically government-and-binding assumptions); von Stechow & Heim 2011 (for a presentation of intensionality starting with assumptions similar to Heim & Kratzer); and Jacobson 2014 (for a CCG-based directly compositional account of scope, long-distance dependencies, and binding, with explicit theory comparison to Heim & Kratzer 1998).

In recent years, we have seen some hints of renewed engagement between theoretical syntax/semantics and formal grammar, and an increasing recognition of the importance of Marr's (1982) levels of analysis in understanding how formal theories relate to language processing and language use. These developments have started to lead to methodological and, perhaps, sociological changes in how we theorize about language. If they continue, we will spend less time arguing about representational details – leaving such questions to explicitly processing-oriented work – and put this effort into being empirically careful and formally rigorous. *Elements of Formal Semantics* fits well into this optimistic vision of the future: students will have to do some work to figure out how to relate it to other, more familiar formalisms, but they will be better linguists for having done so, and will come away with a deeper understanding of the mathematical structure of theories of meaning and grammar.

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