

JOHAN VAN BENTHEM

*Mathematics Institute, University of Amsterdam*

# ESSAYS IN LOGICAL SEMANTICS

D. REIDEL PUBLISHING COMPANY

A MEMBER OF THE KLUWER



ACADEMIC PUBLISHERS GROUP

DORDRECHT / BOSTON / LANCASTER / TOKYO

**Library of Congress Cataloging-in-Publication Data**

**CIP**

Benthem, J. F. A. K. van, 1949–  
Essays in logical semantics.

(Studies in linguistics and philosophy ;  
v. 29)

Bibliography: p.

Includes indexes.

1. Semantics. 2. Semantics (Philosophy) I. Title. II. Series.  
P325.B426 1986 412 86-417

---

Published by D. Reidel Publishing Company,  
P.O. Box 17, 3300 AA Dordrecht, Holland.

Sold and distributed in the U.S.A. and Canada  
by Kluwer Academic Publishers,  
190 Old Derby Street, Hingham, MA 02043, U.S.A.

In all other countries, sold and distributed  
by Kluwer Academic Publishers Group,  
P.O. Box 322, 3300 AH Dordrecht, Holland.

All Rights Reserved

© 1986 by D. Reidel Publishing Company, Dordrecht, Holland

Reprint of the original edition 1986

No part of the material protected by this copyright notice may be reproduced or utilized in any form or by any means, electronic or mechanical including photocopying, recording or by any information storage and retrieval system, without written permission from the copyright owner

ESSAYS IN LOGICAL SEMANTICS

STUDIES IN LINGUISTICS AND PHILOSOPHY

formerly *Synthese Language Library*

*Managing Editors:*

ROBIN COOPER, *University of Wisconsin*

ELISABET ENGDAHL, *University of Wisconsin*

RICHARD GRANDY, *Rice University*

*Editorial Board:*

EMMON BACH, *University of Massachusetts at Amherst*

JON BARWISE, *CSLI, Stanford*

JOHAN VAN BENTHEM, *Mathematics Institute, University of Amsterdam*

DAVID DOWTY, *Ohio State University, Columbus*

GERALD GAZDAR, *University of Sussex, Brighton*

EWAN KLEIN, *University of Edinburgh*

BILL LADUSAW, *University of California at Santa Cruz*

SCOTT SOAMES, *Princeton University*

HENRY THOMPSON, *University of Edinburgh*

VOLUME 29

## TABLE OF CONTENTS

INTRODUCTION	vii
PART I / CONSTRAINTS ON DENOTATIONS	
Chapter 1 / Determiners	3
Chapter 2 / Quantifiers	25
Chapter 3 / All Categories	55
Chapter 4 / Conditionals	72
Chapter 5 / Tense and Modality	101
Chapter 6 / Natural Logic	109
PART II / DYNAMICS OF INTERPRETATION	
Chapter 7 / Categorical Grammar	123
Chapter 8 / Semantic Automata	151
PART III / METHODOLOGY OF SEMANTICS	
Chapter 9 / Logical Semantics as an Empirical Science	179
Chapter 10 / The Logic of Semantics	198
REFERENCES	215
INDEX OF NAMES	221
INDEX OF SUBJECTS	223

## INTRODUCTION

Recent developments in the semantics of natural language seem to lead to a genuine synthesis of ideas from linguistics and logic, producing novel concepts and questions of interest to both parent disciplines. This book is a collection of essays on such new topics, which have arisen over the past few years.

Taking a broad view, developments in formal semantics over the past decade can be seen as follows. At the beginning stands Montague's pioneering work, showing how a rigorous semantics can be given for complete fragments of natural language by creating a suitable fit between syntactic categories and semantic types. This very enterprise already dispelled entrenched prejudices concerning the separation of linguistics and logic. Having seen the light, however, there is no reason at all to stick to the letter of Montague's proposals, which are often debatable. Subsequently, then, many improvements have been made upon virtually every aspect of the enterprise. More sophisticated grammars have been inserted (lately, lexical-functional grammar and generalized phrase structure grammar), more sensitive model structures have been developed (lately, 'partial' rather than 'total' in their composition), and even the mechanism of interpretation itself may be fine-tuned more delicately, using various forms of 'representations' mediating between linguistic items and semantic reality. In addition to all these refinements of the semantic format, descriptive coverage has extended considerably. Nowadays, we possess valuable (though by no means conclusive) formal semantic accounts of a wide variety of linguistic phenomena beyond Montague's original samples — in particular, many of them independent from the intensional preoccupations which are the philosopher's burden.

There is also another type of development. Exhaustive description of fragments is useful, all the more so because of increasing contacts with computer science, trying to implement the above theories computationally. But, there remains the more global aim of understanding broad patterns in natural language, both within specific languages and across different ones. At this level too, logic and linguistics can meet and

interact. Notably, in between general concerns of category/type fit and detailed semantic description of single lexical items, one can study the behaviour of various specific categories of expression in their entirety. For instance, the theory of ‘generalized quantifiers’ has inspired a logico-linguistic investigation of the category of determiner expressions in natural language, attempting to find out precisely the range of admissible semantic denotations for these expressions. Montague Grammar would allow, in principle, just any denotation of the appropriate type; but the above research has produced powerful and natural constraints. Although this goes beyond mere fit of syntactic category and semantic type, such an investigation does not go into complete lexical detail about any specific determiner expression. It is just this middle road which gives one a handle on important questions about natural language which have seemed hitherto rather metaphysical than scientific. For instance, given certain independently motivated constraints, which of the semantic possibilities left are actually realized by natural language expressions? If all of them are, this may be interpreted as the statement that natural language attains some optimum of expressibility — and we have realized part of the philosopher’s dream, to explain *why* there are the things there are.

By itself, the generalized quantifier framework is just a convenient semantic format for determiner and quantifier expressions. But, it has proven very fruitful both as a medium of semantic description and a vehicle for semantic theorizing. The latter will be demonstrated in the first six chapters of this book.

Both general and special model-theoretic constraints are studied for *determiners* in Chapter 1, leading to several definability theorems. The notions and proof techniques obtained in this way are then used to evaluate recently proposed ‘semantic universals’, i.e., general regularities, of determiner meanings across all human languages. For instance, natural language contains ‘systematic gaps’: determiners with certain combinations of features are missing — and we want to understand why. (Thus, with one bold leap of the imagination, we double traditional areas of research, studying both what does and what does not occur in natural language.) Among the determiners, there is a distinguished class of ‘logical’ items, and such *quantifiers* are the topic of Chapter 2. Here, new themes arise for logical research. For instance, various intuitions of ‘logicality’ are developed, leading to more sophisticated hierarchies of logical constants than the usual set. Moreover, earlier conditions on

determiner denotations can now be re-interpreted as possible patterns of inference — and we arrive at a study of ‘inverse logic’, classifying possible quantifiers validating given clusters of inferences. This, of course, is the mirror image of the usual Aristotelean mode of logical research, which describes inferential behaviour of already given quantifiers. The notions and results of the first two chapters can be generalized to arbitrary types of expression, in line with current tendencies to take a broader *cross-categorical* view of linguistic denotations. This is the theme of Chapter 3, which investigates the various manifestations of similar or related constraints across such categories as determiners, noun phrases, adjectives and connectives.

Up till this point, only extensional denotations have been considered. But, our type of investigation can also be transferred to an intensional setting. Chapter 4 demonstrates this for the case of *conditionals*, viewed as generalized quantifiers involving sets of possible worlds for their antecedents and consequents. One conspicuous topic here is to develop general intuitions of ‘conditionality’ in a more systematic fashion than is usually done in philosophical logic. Moreover, some unity of perspective results for the multitude of existing ‘conditional logics’ infesting the latter discipline. Afterwards, a similar road takes us into the traditional heartland of intensionality: the area of *tense and modality*. Thus, in Chapter 5, a reasonable hierarchy of denotational constraints provides a new classification of linguistic tenses.

Finally, in Chapter 6, another aspect of this enterprise is highlighted. These latter-day semantic trends are actually reminiscent of traditional logic, in particular the Syllogistic. Some connections between the two are explored, and especially, an outline is given of a *natural logic*, being a system of logical inference based directly on grammatical form, without any artificially created ‘logical form’ level.

It should be stressed again that these are theoretical questions, be it often with a direct descriptive motivation. Given the results obtained in these chapters, it seems that the present simple generalized quantifier perspective represents some optimum on the curve of compromises between faithful description and elegant general theory of natural language.

Next, the book turns to questions concerning the mechanics of interpretation. An interest in an account of semantic interpretability independent from syntactic grammaticality leads us to consider a more flexible *categorical grammar* allowing various rules of type change for

expressions, as required by the varying needs of interpretation. Such a system of rules is gaining attention from a growing community of linguists these days, reviving the old Ajdukiewicz/Bar-Hillel framework. In particular, in Chapter 7, we shall provide a semantics for a system of type change rules essentially due to Lambek in the fifties, which has had to wait for recognition until the transformational juggernaut had passed.

Then, in Chapter 8, another more dynamic aspect of interpretation is considered. There is an attractive, though slightly marginal folklore idea that certain types of expression should be given 'procedural' denotations, i.e., procedures for computing suitable values. For the special case of quantifiers, and later on for other categories too, we find *semantic automata* doing just this. Surprising analogies then come to light with the Chomsky Hierarchy of grammars and automata, both in its coarse and its fine-structure. Thus, what used to be viewed as a stronghold of pure syntax, now becomes an asset of semantics too. By this road, the usual concerns of learnability and computability then also enter the semantic realm.

Finally, we ascend to our highest level of abstraction, asking various methodological questions about the semantic enterprise — using some of the apparatus of contemporary philosophy of science. As it turns out, semantic theories may be viewed as *empirical theories* in a standard sense, and Chapter 9 shows how central questions in the philosophy of science correspond to standard logical concerns. Notably, the usual industry of proving completeness theorems can now be motivated as a search for 'eliminability' of theoretical terms, such as accessibility or similarity relations in possible worlds semantics. Still, there arises a Popperian worry, viz. that the latter research program might be 'irrefutable', in the sense of being able to semanticize any kind of data. Fortunately, an example can be presented which is provably beyond the resources of the possible worlds machinery. This result has a wider significance: similar suspicions of 'infallible success', and hence lack of real explanatory achievement, surround the Montagovian paradigm.

More systematically, Chapter 10 is devoted to an ascending ladder of goals for a semantic theory, viz. providing a faithful (compositional) account of denotations, accounting for given (non-)inferences, suggesting global regularities in languages and even semantic universals. A *logic of semantics* will then consist of a multitude of questions concerning the prospects at each level; several examples of which are given.

Notably, there remains a need for a better understanding of linguistic ‘information processing’, enabling us to make more concrete logical sense of various intuitions of ‘stability’, ‘minimal complexity’ and ‘efficiency’. And so, we have arrived at the Last Questions concerning natural language, which all discerning semanticists share and treasure.

The various chapters in this book are revised and expanded versions of a sequence of papers, many of which changed beyond recognition. I would like to thank the following institutions for their permission to use this material. D. Reidel Publishing Co. for ‘Determiners and Logic’ (*Linguistics and Philosophy* **6**, 1983, 447–478) [Chapter 1], as well as ‘Foundations of Conditional Logic’ (*Journal of Philosophical Logic* **13**, 1984, 303–349) [Chapter 4] — The Association of Symbolic Logic for ‘Questions about Quantifiers’ (*Journal of Symbolic Logic* **49**, 1984, 443–466) [Chapter 2] — North-Holland Publishing Co. for ‘A Linguistic Turn: New Directions in Logic’ (in P. Weingartner, ed., *Proceedings of the 7th International Congress in Logic, Methodology and Philosophy of Science, Salzburg 1983*, Amsterdam, 1986) [Chapters 3, 6] — The Center for the Study of Language and Information for ‘A Manual of Intensional Logic’ (CSLI Lecture Notes 1, Stanford, 1985) [Chapter 5] — Foris Publishing Co. for ‘Themes from a Workshop’ (in J. van Benthem and A. ter Meulen, eds., *Generalized Quantifiers in Natural Language*, GRASS series 4, Dordrecht, 1985, 161–169) [Chapters 3, 6], ‘Semantic Automata’ (in J. Groenendijk, D. de Jongh and M. Stokhof, eds., *Information, Interpretation and Inference*, GRASS series 5, Dordrecht, 1986) [Chapter 8] as well as ‘The Logic of Semantics’ (in F. Landman and F. Veltman, eds., *Varieties of Formal Semantics*, GRASS series 3, Dordrecht, 1984, 55–80) [Chapter 10] — John Benjamin Co. for ‘The Semantics of Variety in Categorical Grammar’ (in J. van Benthem, W. Buszkowski and W. Marciszewski, eds., *Categorical Grammar*, Amsterdam, 1986) [Chapter 7] — and the Polish Academy of Sciences for ‘Logical Semantics as an Empirical Science’ (*Studia Logica* **42**, 1983, 299–313) [Chapter 9] as well as ‘Possible Worlds Semantics: A Research Program that Cannot Fail?’ (*Studia Logica* **43**, 1984, 379–393) [Chapter 9].

And finally, I would like to thank all my colleagues in the Groningen circle of logic and linguistics — in our venerable free city at the cross-roads of semantic traffic from Poland, Scandinavia, America and Holland.