

## Polysemy: Theoretical and Computational Approaches

Yael Ravin and Claudia Leacock (editors)

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As the editors of this volume remind us, polysemy has been a vexing issue for the understanding of language since antiquity.<sup>1</sup> For half a century, it has been a major bottleneck for natural language processing. It contributed to the failure of early machine translation research (remember Bar-Hillel's famous *pen* and *box* example) and is still plaguing most natural language processing and information retrieval applications. A recent issue of this journal described the state of the art in automatic sense disambiguation (Ide and Véronis 1998), and Senseval system competitions have revealed the immense difficulty of the task (<http://www.sle.sharp.co.uk/senseval2>). However, no significant progress can be made on the computational aspects of polysemy without serious advances in theoretical issues. At the same time, theoretical work can be fostered by computational results and problems, and language-processing applications can provide a unique test bed for theories. It was therefore an excellent idea to gather both theoretical and applied contributions in the same book.

Yael Ravin and Claudia Leacock are well-known names to those who work on the theoretical and computational aspects of word meaning. In this volume, they bring together a collection of essays from leading researchers in the field. As far as I can tell, these essays are not reprints or expanded versions of conference papers, as is often the case for edited works; instead, they seem to have been specially commissioned for the purposes of this book, which makes it even more exciting to examine.

The book is composed of 11 chapters. It is not formally divided into parts, but chapters dealing more specifically with the computational aspects of polysemy are grouped together at the end (and constitute about one-third of the volume).

Chapter 1 is an overview written by the volume editors. Yael Ravin and Claudia Leacock survey the main theories of meaning and their treatment of polysemy. These include the classical Aristotelian approach revived by Katz and Fodor (1963); Rosch's (1977) prototypical approach, which has its roots in Wittgenstein's *Philosophical Investigations* (1953); and the relational approach recently exemplified by WordNet (Fellbaum 1998), which (although the authors do not mention it) can be traced back to Peirce's (1931–1958) and Selz's (1913, 1922) graphs and which gained popularity with Quillian's (1968) semantic networks. In the course of this overview, Ravin and Leacock put the individual chapters into perspective by relating them to the various theories.

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<sup>1</sup> The editors, citing Robins (1967), attribute the first observations of the "complex relations between meanings and words" to the Stoics, but reflection on polysemy can be traced back at least to Aristotle.

In Chapter 2, "Aspects of the Micro-Structure of Word Meanings," D. Alan Cruse addresses the issue of the extreme context-sensitivity of word meaning, which can result in an almost infinite subdivision of senses. However, Cruse believes that there are "regions of higher semantic density" within this extreme variability, which he calls sense-nodes, "lumps of meaning with greater or lesser stability under contextual change." As Cruse admits, this is only a metaphor, and as such, may not be highly useful to the researcher. In the rest of the chapter, Cruse attempts to build a typology of these nodes, listing their properties and providing tests to detect them. The tests (e.g., the zeugma effect in sentences such as *John and his driving license expired yesterday*) are not entirely new (e.g., Quine 1960; Cruse 1986; Geeraerts 1993), but are integrated here into a coherent framework that places context-dependency at the very heart of the theory.

Chapter 3 by Christiane Fellbaum is devoted to "autotroponymy." This term requires a two-step explanation. *Troponyms* are verb hyponyms, referring to specific manners of performing actions denoted by other verbs. For example, in English, *stammer*, *babble*, *whisper*, and *shout* are troponyms of *talking*. *Autotroponymy* is a special case that occurs when the verbs linked by this relation share the same form, as in *The children behaved / The children behaved well*. The author explains autotroponymy in terms of conflation of a meaning component not expressed on the surface. For example, in *The children behaved*, the verb includes a hidden adverbial (*well / satisfactorily / appropriately*). Fellbaum gives a typology of autotroponyms that is based on the nature of the conflated element (noun, adjective, adverbial), and she discusses their syntactic and semantic properties in detail.

In Chapter 4, "Lexical Shadowing and Argument Closure," James Pustejovsky explores verbs such as *butter*, which block the expression of a generic argument, as in \**Mary buttered her bread with butter*, while allowing for a specific one, as in *Mary buttered her bread with expensive butter from Wisconsin* (see Levin 1993), and verbs such as *risk*, which can occur in contradictory contexts with roughly the same meaning, as in *Mary risked death to save her son / Mary risked her life to save her son* (see Fillmore and Atkins 1995). Pustejovsky introduces the concept of "lexical shadowing," which he defines as "the relation between an argument and the underlying semantic expression, which blocks its syntactic projection in the syntax." For example, the underlying semantics of the verb *butter* "shadows" the expression of the substance that is spread and allows only for specialization of the shadowed argument. For verbs such as *risk*, the shadowing is of a different type: it is the expression of one argument that shadows the expression of another, in a strictly complementary fashion. Pustejovsky explains these cases of argument optionality or complementarity in the framework of the Generative Lexicon (Pustejovsky 1995) and its various devices, among which "coercion" plays a central role.

Chapter 5, by Charles Fillmore and Sue Atkins, is a case study in lexicography. They analyze the sense divisions and definitions of the verb *crawl* in various dictionaries and compare them with corpus evidence from the British National Corpus. It is well known that dictionaries exhibit large discrepancies, and although they claim to be based on the analysis of corpus data, many sense distinctions that show up in a corpus are not reflected in dictionary entries. This is not entirely unexpected, since after all, no dictionary claims exhaustive coverage of a language, and some selection must be made by the lexicographer. This is even an explicit goal in four of the six dictionaries examined here, which are learners' dictionaries that attempt to illustrate the "core" uses of words for learners of English. It is striking, however, to see the extent to which lexicographers differ regarding their choices and assessment of what constitutes an important meaning a learner should acquire. Fillmore and Atkins are

perfectly right in noting that lexicographers lack objective criteria for sense division and information extraction from corpora. The FrameNet project they describe in an appendix (see <http://www.icsi.berkeley.edu/~framenet/>) is an attempt to achieve a systematic understanding and description of the meanings of lexical items and grammatical constructions by looking at a large number of attested examples, sorting them according to the conceptual structures (semantic “frames”) that underlie their meanings, and describing the associated information in terms of semantic roles, phrase types, and grammatical functions. The numerous observations regarding sense connections in the corpus examples result in a network-like organization of meanings, which can be used in both monolingual and bilingual lexicography. The last section of the chapter illustrates this possibility using the verb *ramper*, the French equivalent of *to crawl*.

Chapter 6, “‘The Garden Swarms with Bees’ and the Fallacy of ‘Argument Alternation’” by David Dowty, comes back to the argument problem already tackled by Fellbaum and Pustejovsky in their respective chapters and proposes syntactic structures as an explanatory principle for alternations in meaning. The author is concerned with agent / location alternations such as *Bees swarm in the garden* / *The garden swarms with bees*. He departs from the usual point of view that such pairs express the same meaning and differ only in syntactic form. Using the large set of examples in Salkoff (1983), Dowty groups verbs that participate in such alternations into five semantic classes and then shows that the two forms exhibit many semantic differences related to the informational structure of the sentence. The locative-subject form makes the location the topic of discourse, with the predicate ascribing an abstract property to the location. Some tests show the difference in meaning. For example, the *with*-phrase object must be semantically “unquantified” in the locative-subject form (compare *A roach crawled on the wall* / *\*The wall crawled with a roach*), the locative-subject form is more suited to metaphor than the agent-subject form, and so forth.

Chapter 7 by Cliff Goddard outlines Wierzbicka’s “natural semantic metalanguage” (NSM) approach to semantic analysis (Wierzbicka 1996, etc.), which is based on the idea that every language possesses a core of undefinable words (“semantic primes”). Complex expressions (words or grammatical constructions) can be described by means of explanatory reductive paraphrases composed of combinations of semantic primes. This “definitional” framework provides a diagnosis technique for detecting polysemy. For any given word, one can first assume that it has a single meaning and try to state it in a reductive paraphrase. If this turns out to be impossible and several paraphrases are needed to describe the word’s range of uses, then the word has distinct meanings. For example, there is no single paraphrase in terms of primes that could predict the range of uses of the French word *fille*, meaning both *daughter* and *girl*, and therefore the word must be split into two distinct meanings. Using this test, Goddard shows that dictionaries very often posit false and unnecessary polysemy, and occasionally false monosemy. He also shows how the technique can be used on grammatical constructions, and he applies it in detail to *have a VP* expressions (*have a stroll*, *have a chat*, etc.). The chapter ends with a discussion of how aspects of figurative language can be handled within this framework.

In Chapter 8, “Lexical Representations for Sentence Processing,” George Miller and Claudia Leacock raise the following question: “Why isn’t a dictionary a good theory of the lexical component of language?” They share Fillmore and Atkins’s dissatisfaction about dictionary making. For them, the main shortcoming of dictionaries is their lack of contextual information that would enable a user to make the correct association between senses and actual contexts. In their introduction, they give a convincing example from previous experiments. Schoolchildren given dictionary definitions of English

words produced sentences such as *Our family erodes a lot*, which sounds bizarre until you read the definition of *erode*: ‘eat out, eat away’. According to Miller and Leacock, what is missing from dictionaries is a satisfactory treatment of the lexical aspects of sentence processing. The rest of the chapter is devoted to a discussion of the two types of context that can be used to associate a given context with a particular word sense: local context (the immediate neighbors of the word under focus) and topical context (the general topic or domain of the text or conversation). The authors show that local context cues are very precise when they occur, but often simply do not occur. On the other hand, topical context is very efficient in helping discriminate between homographs, but not very helpful for identifying the different senses of a polysemous word. Miller and Leacock consider the combination of the two sources to be a major avenue of research.

Mark Stevenson and Yorick Wilks tackle this issue in Chapter 9, “Large Vocabulary Word Sense Disambiguation,” in which they propose a methodology for combining several knowledge sources into a word sense disambiguation system. Their first source of information is syntactic in nature and is provided by the Brill part-of-speech tagger. The semantic information present in the local context is then used in two ways. The overlap between *Longman Dictionary of Contemporary English* definitions and the local context is computed by means of an improved version of Cowie, Guthrie, and Guthrie’s (1992) simulated-annealing technique, and selectional restrictions are resolved by means of *LDOCE* semantic classes. The larger context is handled with techniques that map it to the subject categories provided by *LDOCE* for each sense (“pragmatic codes”). The efficiency of each of these modules taken separately ranges from 44 to 79 percent, but Stevenson and Wilks show that using machine learning techniques, the modules can be combined in an efficient way to produce 90 percent correct disambiguation, which is quite high for an unrestricted vocabulary system.

In Chapter 10, “Polysemy in a Broad-Coverage Natural Language Processing System,” William Dolan, Lucy Vanderwende, and Steven Richardson describe the approach to polysemy processing taken in the MS-NLP broad-coverage natural language understanding system. The core of their system is MindNet, a network-structured computational lexicon extracted from machine-readable dictionaries (MRD) augmented with corpus information. MindNet uses the same general approach as the MRD-based spreading activation networks proposed by Véronis and Ide (1990), although in a much more sophisticated version including labeled connections, backward links, weighted paths, and so on. The authors depart from most computational approaches to polysemy in that they believe that word meaning is “inherently flexible,” that making predefined inventories of discrete senses is unsuitable for broad-coverage applications, and that no sharp boundaries should be drawn between senses. Their approach is reminiscent of Cruse’s, presented earlier in this book. For these authors, “understanding” is no more than identifying an activation pattern in the network.

In previous publications, Hinrich Schütze held a position similar to Dolan, Vanderwende, and Richardson’s with respect to predefined sense inventories. For Schütze, many problems require *discrimination* among senses but do not require explicit sense *labeling*, and the techniques he has proposed extract the sense divisions from the corpus itself (see Schütze 1998): a sense is a group of contextually similar occurrences of a word. This approach is almost the opposite of Goddard’s. In Chapter 11, Schütze looks at word sense disambiguation from the perspective of connectionism. After surveying some of the literature on disambiguation, he presents an algorithm that has grown out of two major concerns in connectionist research: psychological plausibility and large-scale applicability. He describes an application to information retrieval

that demonstrates that his algorithm can be applied to very large text collections (500 megabytes of text from the *Wall Street Journal*).

The most noticeable feature of this book is probably its wide range of contributors and the broad scope of the topics it encompasses. As the title implies, it addresses both theoretical and computational aspects of polysemy, and within these two areas, very different research trends are pursued. The book gives a very good overall picture of current issues in polysemy and of the diverse ways of approaching the topic. It should therefore hold an important place on the shelves of any researcher in the fields of lexical semantics and word sense disambiguation, and will certainly be valued by many of our graduate students.

The wide-angle snapshot offered by this book also reveals a very striking fact about current lexical semantics. Apart from one chapter, all theoretical discussions are supported solely by invented examples. Lexical semantics, and probably semantics in general, has not yet made the paradigm shift that has occurred or is occurring in other branches of linguistics, such as syntax, where empirical evidence now replaces intuition as the normal body of data to be studied. Another recent book (Sampson 2001) quite brilliantly shows how the lack of objective evidence has been misleading linguistic research for decades and has placed the discipline on the fringe of modern science. The lack of objective evidence is probably even more dangerous in semantics than in other areas of linguistics. The extreme flimsiness of introspection-based tests is acknowledged by lexical semanticists themselves—for instance, how much agreement would there be on whether or not a given coordination is a zeugma?—and such tests make it almost impossible for semantics to satisfy the minimal requirement that science has demanded since Karl Popper, that of refutability.

Interestingly enough, the one chapter that does use corpus examples (Chapter 5 by Fillmore and Atkins) pertains to lexicography. Lexicographers indeed have a long tradition of examining objective evidence, which computer tools and electronic corpora have made it possible to systematize. However, several chapters (Chapter 5 by Fillmore and Atkins, Chapter 7 by Goddard, Chapter 8 by Miller and Leacock) express their dissatisfaction with current dictionaries, on the grounds that they lack theoretical criteria to back their organization. It is also worth noting that the only computational approaches to word sense disambiguation able to claim some minimal degree of efficiency are linguistically blind ones (like those reported in this book), as if an insurmountable gap existed between theories and applications. A paradigm shift in lexical semantics is therefore not just a scientific necessity; it is also a practical one. I am convinced that no major breakthrough in language-processing applications and lexicography can be made until theories of meaning are based on the observation of real data.

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