SUPPLY-SIDE AND DEMAND-SIDE LEXICAL SEMANTICS

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Abstract.¹ Two methodological positions coexist in lexical semantics. The supply-side approach selects the topics of research from among the issues that are perceived as those that can be done. It relies on what is perceived as “possible” and “available” with respect to tools and resources. The demand-side places a premium on what must be done to put together a useful working application and, therefore, strives for the comprehensive coverage of a sublanguage/domain in descriptive semantic terms, licensing extensions to its methodology in the process. There are far-reaching consequences in the respective views of the two approaches on such essential issues as the relations between (computational) syntax and (computational) semantics, the feasibility and status of language-independent ontology as the basis of lexical semantics, and the amount of attention to comprehensive semantic description/representation of input text. The distinction between the two approaches is rooted both in the history of linguistics and in the philosophy of science. It is important to understand the two positions in order to match the expectations concerning practical results and declared goals of research in lexical semantics.

1. Two Schools in Lexical Semantics

Two distinct methodological positions can be detected in lexical semantics today. Though proclaiming the same overall goals, the researchers adhering to each of these schools differ in the means of attaining these goals. One

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school favors incremental selection of phenomena for research, building on existing methods which have been tested on some other, usually, syntactic phenomena. We will call this school "supply-side semantics" because it relies on what is perceived as "possible" and "available" with respect to tools and resources. The other school stresses the need of a comprehensive coverage of at least a sublanguage / domain of discourse in inherently semantic terms, which licenses extensions to methodology. We will call this school "demand-side semantics" because it proceeds from the perceived needs of computational applications that deal with meaning, irrespective of whether all the prerequisites for such descriptions are already in place or at least have been tried.

Let us try and define the commonalities as well as differences between the two approaches. The following are the major issues on which the schools are in broad agreement:

- the ultimate goal of lexical semantics is perceived as supporting contextual semantics, that is, the derivation of representations of text meaning in a formal language;
- in this light, the agenda of formal semantics as strictly compositional and acontextual is perceived as inadequate (see Kay, 1992: 309; Nirenburg and Raskin, 1996: 13-18);
- the quality criteria for semantic lexicons are broadly shared;
- the design preferences for the semantic lexicon include the idea of seeding the lexicon with basic senses and deriving the rest automatically;
- accordingly, lexical rules are perceived as a major theoretical and applicational device in lexical knowledge acquisition;
- the typology and inventory of the lexical rules are often non-controversial in themselves and can be often shared;
- there exists a shared commitment to a common theoretical paradigm, which is definitely post-Chomskian generative.

Some peculiarities of each of the approaches are discussed in what follows.

Methodologically, the supply-siders are pursuing the formulation of lexical meaning theories as algebraic entities in which the maximizing factor is formal elegance, descriptive power (attained, for instance, through generalization of rules), economy of descriptive means, and absence of exceptions. As a result of this, difficult issues and phenomena which cannot at present be subject to such discipline are not treated—they are either ignored or declared to be outside the purview of the theory. Thus, for instance, the issue of basic lexical meaning is rarely discussed in this tradition, while attention
centers on regularity of meaning shifts (and, most recently, differentiae—see, for instance, Hirst (1995) or Johnston et al. (1995) under the influence of paradigmatic morphosyntactic transformations and of unexpected syntagmatic cooccurrence of lexical forms in texts. The supply-siders are much more dependent than the demand-siders on the availability of off-the-shelf resources. This is why this approach can be (reasonably and inoffensively) referred to as supply-side: it is based only on what can be offered by the state of the art (or, we should perhaps say, science) in the formal description of linguistic theory divorced from world knowledge.

For supply-siders, the main issues include (among others):

- lexical semantics as an incremental extension of lexical grammar, or grammatical semantics, which, in turn, is an incremental extension of syntax;
- formalisms for representing lexical knowledge (e.g., the LRL of the ACQUILEX project): feature structures, typed feature structures and rules for their symbolic manipulation, default inheritance hierarchies, etc.;
- establishing lexical rules for relating word senses, wherever it can be achieved;
- constraining the power of lexical rules so that they do not overgenerate;
- capturing valuable generalizations about applicability of lexical rules.

A strong temptation for a supply-sider is provided by such easily obtainable artifact resources as machine-readable dictionaries, tagged corpora, frequency lists, etc.\(^2\) that seems to yield results that, when a real application is contemplated, may prove to be usable. How about, say, a procedure which runs over a very large corpus and furnishes a word list? Can one assume that this procedure should be immediately adopted as part of an NLP project of the future? It is fair to say that, for a supply-sider, the answer is yes. In fact, a supply-sider’s arsenal, consists of any such available or easily developable procedures.

The demand-siders tend to be much more cautious with respect to such procedures. Before incorporating one or committing to develop another such procedure, they want to make sure that there is a legitimate place for this procedure in the overall architecture of an NLP system they are developing. Thus, is it a given that one needs a word list at any stage of analysis or generation? Or, is it possible that the words will appear at the input and need to be analyzed morphologically and lexically as part of the system analyzer, which will never actually use the word list as a useful resource?

The theoretical work in demand-side lexical semantics is different in other ways as well. Wilks (1994: 586) illustrates this difference well: "There is a great difference between linguistic theory in Chomsky's sense, as motivated entirely by the need to explain, and theories, whether linguistic, AI or whatever, as the basis of procedural, application-orientated accounts of language. The latter stress testability, procedures, coverage, recovery from error, non-standard language, metaphor, textual content, and the interface to general knowledge structures." Accordingly, the demand-side approach pursues theories which are capable of supporting practical applications.

Note that the theories produced by the supply-side group can also strive to support practical applications, but they are typically a side effect of theoretical pursuits. In practice, a lot of additional work is always needed to implement a supply-side theory as a computer program, because such theories are usually not formulated with such processing in mind and often do not easily lend themselves to such applications. The problems with demand-side theories include difficulties in algebraic definition and testability and falsifiability exclusively through experimentation.

Burning issues in lexical semantics for the demand-siders include (among others):

- determining the number of lexemes in a lexicon (breadth);
- establishing criteria for sense specification and delimitation;
- granularity issue I: determining the threshold of synonymy (beyond which two word senses would share a meaning);
- granularity issue II: determining the threshold of ambiguity (that is, the appropriate number of senses for a lexeme, whether listed or derived with the help of lexical rules);
- tuning the depth and breadth of lexical description to the needs of a particular application;
- enhancing the levels of automaticity in lexical acquisition.
The rest of this chapter will focus on three important distinctions between the two schools of lexical semantics. They concern the treatment of the following issues:

- the relations between semantics and syntax;
- the role of a language-independent world model, or ontology, in lexical semantics; and
- the place of comprehensive descriptions.

2. Semantics and Syntax

The supply-siders take the task of describing lexical meaning to be almost seamlessly connected to lexicalized syntactic theory: "[T]he role of the lexicon in capturing linguistic generalizations[:] more and more of the rules of grammar are coming to be seen as formal devices which manipulate (aspects of) lexical entries, and in the sense that many of these rules are lexically governed and must, therefore, be restricted to more finely specified classes of lexical items than can be obtained from traditional part-of-speech classifications" (Briscoe, 1993: 2), whereas the demand-siders do not treat syntactic information as privileged but just as one of many clues helping to determine meaning.

The supply-siders look for ways to treat semantics as an extension of syntax. As much meaning information as possible is sought using the simpler syntactic tools in order to avoid difficult meaning analysis. The demand-siders question whether this is tenable or even at all possible; they feel that the time and talent spent on the ingenious ways of bypassing semantics on the way to meaning should have been spent on computational semantics proper; that meaning is unapproachable other than directly, though with any assistance that syntax (and pragmatics, and context and other knowledge sources) can provide, wherever and whenever necessary.

The primacy of syntax is not always proclaimed by the supply-siders up front. Thus, Pustejovsky (1995: 5-6) first states only that "there is no way in which meaning can be completely divorced from the structure that carries it. This is an important methodological point, since grammatical distinctions are a useful metric in evaluating competing semantic theories," and then proceeds to discuss the semantic import of the study of categorial alternation, as made popular in recent years by B. Levin (e.g., 1993) in the following terms: "...the diversity of complement types that a verb or other category may take is in large part also determined by the semantics of the complements themselves... I will argue... that alternation classifications do not constitute [semantic?—SN&VR] theory."
It is more typical, though, for the supply-siders to assume that every syntactic distinction determines a significant semantic distinction and that every semantic distinction has a syntactic basis or at least a syntactic clue or diagnostic. This more radical stance is, for instance, expressed repeatedly in Pustejovsky (1995) as the dependence of semantics on “basic lexical categories” (*op.cit.*: 1), on “syntactic patterns” and “grammatical alternations” (*op.cit.*: 8), as the search for “semantic discriminants leading to the distinct behavior of the transitive verbs” in the examples (*op.cit.*: 10), or as an “approach [that] would allow variation in complement selection to be represented as distinct senses” (*op.cit.*: 35). It is indeed in the analyses of examples (as well as examples used by other lexical semanticists subscribing to the idea of generative lexicon—see, for instance, Lascarides, 1995: 75) that the apparently complete and unquestioned dependency on syntax comes through most clearly.

In reality, syntax and semantics are much less congruent. Thus, in Chomsky (1957), the differences between the famous ostensibly parallel constructions *John is eager to please* and *John is easy to please* are explained in terms of tough-Movement and the availability or non-availability of alternating constructions. It would be a mistake, however, to conclude, with the supply-siders, that these different syntactic behaviors constitute the semantic difference between *eager* and *easy*. We have demonstrated elsewhere (Raskin and Nirenburg, 1995) that these differences are not at all syntax-dependent. Semantically, *easy* is a typical event-modifying scalar whose value is a range on the *EASE/DIFFICULTY* scale; *eager* is an event-derived adjective modifying the *AGENT* of the event. This semantics difference does, incidentally, explain the different syntactic behaviors of these adjectives but not the other way around.

Recently there has been some interest in “grammatical semantics,” the subset of the semantics of natural languages which is overtly grammaticalized in that it concentrates on the contributions of the meaning of closed-class lexical items and morphemes to the overall meaning (see, for instance, (Frawley, 1992)—cf. (Raskin, 1994); in computational-semantic literature, (Levin, 1993) and (Nirenburg and L. Levin, 1992)—who call this field “syntax-driven lexical semantics”—are noteworthy). This is a perfectly legitimate enterprise and a valid proposal about the boundaries between syntactic and semantic descriptions, as long as one keeps in mind that open-class items should also be taken into account.

It is also very important to understand that grammatical semantics does not assume that each syntactic distinction is reflected in a semantic distinction—instead, it looks at those semantic distinctions which do have some morphological and syntactical phenomena associated with it. Consequently, grammatical semantics does not have to engage in recurring
frustrating searches for a semantic distinction for various subclasses of lexical items conforming or not conforming to a certain rule (see, for instance, Briscoe et al., 1995; Copestake, 1995; or Briscoe and Copestake, 1996).

Wilks (1996) presents another example of a division of labor between syntax and semantics. He shows that up to 92% of homography recorded in LDOCE can be disambiguated based exclusively on the knowledge of the part of speech of a homograph. Homography is, of course, a form of polysemy (broadly understood in NLP as associating one form with several senses) and it is useful to know that the labor-intensive semantic methods are not necessary to process all of it. Thus, semantics can focus on the residual polysemy where syntax does not help. In a system not relying on LDOCE, a comparable result may be achieved if word senses are arranged in a hierarchy, with homography at top levels, and if disambiguation is required only down to some nonterminal node in it. Needless to say, the work of semantics is made easier by this to a very small extent, but every little bit counts!

The dependence on syntax in semantic analysis may lead to artificially constrained and misleading analyses. Thus, analyzing the sense of fast in fast motorway (see, for instance, Lascarides, 1995: 75) as a new and creative sense of the adjective as opposed, say, to its sense in fast runner, ignores the important difference between syntactic and semantic modification precisely because of the implicit conviction that the use of the adjective with a different noun subcategory, which constitutes, since Chomsky (1965), a different syntactic environment for the adjective, automatically creates a different sense for fast. As established in Raskin and Nirenburg (1995), however, many adjectives do not modify semantically the nouns they modify syntactically, and this phenomenon covers many more examples than the well-known occasional pizza or relentless miles. Separating syntactic and semantic modification in the case of fast shows that it is, in fact, a modifier for an event, whose surface realization can be, at least in English, syntactically attached to the realizations of several semantic roles of, for instance, run or drive, namely, AGENT in fast runner, INSTRUMENT in fast car, and LOCATION (or PATH) in fast motorway. Throughout these examples, fast is used in exactly the same sense, and letting syntax drive semantics distorts the latter seriously.

Postulating a new sense for fast in fast motorway begs the notorious issue of the "plasticity" of the adjectival meaning (see Raskin and Nirenburg, 1995: 21; specifically, on the plasticity of adjectival meaning, see also Marx, 1977, 1983; Szalay and Deese, 1978; and Lahav, 1989), i.e., the tendency of many, if not all, adjectives to modify their meanings depending on that of the nouns they modify syntactically. The meaning of the adjective good is perhaps the most explored example of this phenomenon (see,
for instance, Ziff, 1960; Vendler, 1963; Katz, 1972; Pustejovsky, 1995: 32; Fodor and Lepore, 1998: 11). Our own argument against the proliferation of different senses for good is two-fold: first, the adjective practically never modifies semantically the noun it modifies syntactically, expressing instead a general positive attitude to the concept evoked by the noun on the part of the speaker; secondly, we argue against the further detailing of the meaning on the grounds of granularity and practical effability, i.e., basically, that, in MT, for instance, an equally generalized notion of goodness will be expressed in another natural language by a similar adjective, which does appear to be a universal or near-universal—the fact that, by and of itself, would indicate the integrity of the vague concept of goodness in the human mind (Raskin and Nirenburg, 1995: 28-29, 43-47, and 49-50). The upshot of this discussion is that no purported syntactic distinctions should lead automatically into the fracturing of one meaning into several.

Distinguishing word senses on the basis of differences in syntactic behavior does not seem to be a very promising practice (cf. the Dorr et al., 1995 attempt to develop B. Levin's approach into doing precisely this) as well, because such an endeavor can only be based on the implicit assumption of isomorphism between the set of syntactic constructions and the set of lexical meanings. But it seems obvious that there are more lexical meanings than syntactic distinctions in any language, orders of magnitude more. That means that syntactic distinctions can at best define classes of lexical meanings, and indeed that is precisely what the earlier incursions from syntax into semantics achieved: just very crude, coarse-grained taxonomies of meanings in terms of preciously few features. On top of that, the case of good above further weakens the isomorphism assumption by demonstrating that it does not hold also because there are cases when several purported syntactic distinctions still correspond to the same meaning.

3. The Role of Ontology

Computational ontologies are not yet a ubiquitous resource similar to MRDs or even WordNet. This is why, it seems, the supply-siders do not include them in their arsenal. This means that they must find other means of explaining word meanings in ways understandable by computers or skirt the issue of meaning representation. This also means that they have to find an alternative way of justifying the provenance and status of atomic categories of meaning description or, again, to try and disregard this concern altogether. A very typical and unexceptional example of such an attitude is the unexplained use of the semantic categories information(y), physobj(x), 2-dimen(x), contain(S,x,y) and write(T,x,y) in the lexical definition of tape in Pustejovsky et al. (1993):
Leaving aside the question of the composition and cardinality of the set of the Aristotelian qualia structures (CONST, FORMAL, TELIC, AGENTIVE), the status of the *values* for these properties remains unclear. These cannot be words of English (at least, because two of them in the example are clearly not!). Therefore, one must conclude that they must be a part of some other symbol system which is not explicitly introduced (see Nirenburg et al., 1995 for a discussion).

The nature and purpose of ontology in computational linguistics is understood differently by different authors, see Nirenburg et al. (1995) for a discussion. One recurring trend in the writings of scholars from the AI tradition is toward erasing the boundaries between ontologies and taxonomies of natural language concepts. This can be found in Hirst (1995), who acknowledges the insights of Kay (1971). Both papers treat ontology as the lexicon of a natural (though invented) language, and Hirst's objections are, basically, along the lines of the redundancy and awkwardness of treating one natural language in terms of another. Similarly, Wilks et al. (1996: 59) see ontological efforts as adding another natural language (see also Johnston et al., 1995: 72), albeit artificially concocted, to the existing ones, while somehow claiming its priority.

By contrast, in the Mikrokosmos approach, an ontology for NLP purposes is seen not at all as relying on natural language but rather as a language-neutral "body of knowledge about the world (or a domain) that a) is a repository of primitive symbols used in meaning representation; b) organizes these symbols in a tangled subsumption hierarchy; and c) further interconnects these symbols using a rich system of semantic and discourse-pragmatic relations defined among the concepts" (Mahesh and Nirenburg, 1995: 1). The names of concepts in the ontology may look like English words or phrases but their semantics is quite different and is defined in terms of explicitly stated interrelationships among these concepts. The function of the ontology is to supply "world knowledge to lexical, syntactic, and semantic processes" (*ibid*), and, in fact, we use exactly the same ontology for supporting multilingual machine translation.

An ontology like that comes at a considerable cost—it requires a deep commitment in time, effort, and intellectual engagement. It requires a well-developed methodology based on a clear theoretical foundation (see Mahesh, 1996). The rewards, however, are also huge: a powerful base of prim-
itives, with a rich content and rich inheritance, that is made available for
the lexical entries, assuring their consistency and non-arbitrariness. We
address and reject as inapplicable (Nirenburg et al., 1995) the standard charge
of irreproducibility for ontologies: on the one hand, we accept as expected
that different groups and individuals will come up with different ontolo-
gies, even for a limited domain; on the other hand, our experience shows
that groups and individuals with similar training and facing an identical
task would, indeed, come up with similar ontologies. Note, for comparison,
that no two grammars or lexicons of particular languages, even in a given
theoretical paradigm, are expected to be identical!

To enhance the uniformity of ontology acquisition (for instance, by dif-
ferent acquirers), we have developed weak semi-automatic methods of ac-
quision, supported by semi-automatic acquisition tools. We have also dis-
covered heuristic techniques and recurring patterns of acquisition. Again,
this adds to the cost of lexical semantic work. This cost, however, buys a
very desirable (at least, to us) result—the much enhanced depth and com-
plexity of lexical entries not resulting from lexical acquisition but rather
contributed “free of charge” by the inheritance, properties, and constraints
on pre-acquired ontological concepts on which the lexical entries are based.

4. Comprehensiveness of Descriptions

The demand-side computational linguistics has blanket coverage of texts
in a domain as a major goal. Correspondingly, all phenomena that are
attested in certain texts must be accounted for, whether one can find an
elegant solution to the problem or not or whether any solution at all can
be found at a certain grain size of description. Thus, in Mikrokosmos, for
every sentence of every input text the system must be able to produce,
at no or minimum information loss, a text meaning representation, TMR,
at a reasonable grain size. Such blanket coverage of inputs is not taken
for granted in many quarters: note how it is quite acceptable in the area
of corpus-based word sense disambiguation to run experiments on half a

3The Mikrokosmos lexicons fit Fillmore and Atkins’ (1992: 75) vision of an ideal dic-
tionary of the future: “...we imagine, for some distant future, an online lexical resource,
which we can refer to as a “frame-based” dictionary, which will be adequate to our
aims. In such a dictionary (housed on a workstation with multiple windowing capabil-
ities), individual word senses, relationships among the senses of the polysemous words,
and relationships between (senses of) semantically related words will be linked with the
cognitive structures (or ‘frames’), knowledge of which is presupposed by the concepts
encoded by the words.”

4It is notable, again, that Fodor and Lepore (1998: 1) attack Pustejovsky (1995) for
too much complexity in his lexical entries while we advocate here much more complex
entries.
dozen carefully selected ambiguous items (see, for instance, Yarowsky, 1992; Resnik, 1995).

The supply-side approach shares this practice of high selectivity with regard to its material with the rest of theoretical linguistics. In a typical paper, interesting, usually fine grain-size phenomena are selected; borderline cases carefully examined; elegant solutions often found. The unexciting mass of run-of-the-mill language phenomena is typically not tackled beyond some suggestions for general rules. Thus, in the generative lexicon approach, new and relatively specialized lexical rules have been focused upon, at the expense of large-scope rules that may be more obvious (see Nirenburg and Raskin, 1996). In theoretical linguistics, borderline cases are dwelt upon as testing grounds for applicability of certain rules that may expose vulnerability in a paradigm. In both cases, an assumption is tacitly made that the ordinary cases are easy to account for, and so they are not worth processing. As we mentioned elsewhere (Raskin and Nirenburg, 1995), in the whole of transformational and post-transformational semantic theory, only a handful of examples has ever been actually described, with no emphasis on coverage.

Large-scale applications require a finer-grained description of every lexical-semantic phenomenon present in a subsurface delineated by a corpus than whatever can be attained in approaches which use just a handful of features, often conveniently borrowed from syntax. What these applications need is a theory determining a methodology for complete descriptive coverage of the material. The implementation of any such project clearly demonstrates that the proverbial ordinary case is not so common after all: nontrivial decisions and choices must be made in ordinary cases, many of them widely applicable and extrapolable to large classes of data. Such decisions may introduce categories which end up as part of linguistic theory. In other words, the descriptive tasks are closely linked to pure theory. This was well understood by the American descriptivists of the first half of the century, but it has not been part of the linguistic experience—or education—for several decades now.

Proper theorists carry out descriptive work in full expectation that a close scrutiny of data will lead to, often significant, modifications of their a priori notions. Thus, the sizable theoretical-linguistic scholarship on the lexical category of adjective barely touches on the concept of scale (see Raskin and Nirenburg, 1995: 4-21), while even a cursory look at the data shows that it is very natural to represent the meaning a prevalent semantic subclass of adjectives using scales: e.g., big (scale: SIZE), good (scale: QUALITY), or beautiful (scale: APPEARANCE). Consequently, the discovery of a

5It is especially true of English, where the grammatical realization of non-scalar, denominal modifiers is usually nominal.
few dozen scale properties underlying and determining the meaning of the statistically dominant subclass of English adjectives becomes an important descriptive subtask, basically completely unanticipated by the preceding theory.

Conversely, the borderline case of the relational/qualitative adjective, such as old used as a relational in old boyfriend, in the sense of 'former,' on the one hand, and qualitatively in old man, on the other, the case which has been presumed to be central to the study of the adjective (Raskin and Nirenburg, 1995: 16-17), in reality is easily merged with other numerous cases of multiple senses of the same word within the adjective superentry, receiving the same, standard treatment.

5. Conclusion

At first glance, the difference between the demand- and supply-side approaches may be reduced to the time factor: if the demand-siders are successful in developing a useful tool and putting it on the shelf of computational linguistics the supply-siders will embrace it at the next opportune moment. For example, once the time and effort on building an ontology is expended, the resulting artifact assumes a new status. Now, instead of arguing about the plausibility of such a resource, the supply-siders may coopt it as a part of their toolkit and use it as the basis of their investigations. Indeed, the "use it because it is there" attitude is prevalent among the corpus-oriented computational linguistics in general. True to the definition of supply-side research, even the direction and goals of research often become motivated simply by the availability of a resource. The difference between the two approaches is rather deep. One can trace its roots back to the atomistic vs. structural distinction in the early 20th century linguistics as well as to some general issues in the philosophy of science. Thus, early linguistic semantics focused entirely on meaning change of individual words\(^6\) (see, for instance, Bréal, 1897; Darmesteter, 1887; Paul, 1886). Later semantics has been interested in meaning representation of larger language units. Obviously, the early authors could not account for the meaning of, say, a sentence on the basis of their diachronic analysis, no matter how deep, of a handful of words in any sentence. On the other hand, later semanticists definitely needed to know word meanings, among other things in order to represent sentence meaning. So, deep knowledge of separate phenomena is not necessarily of great help in trying to account for the meanings in running text.

\(^6\)It is, of course, incorrect to say that present-day atomists work with individual words. Instead, they operate with individual and separate rules applicable to groups of words.
We can attempt to solve this common methodological contradiction of depth and breadth through an approach which presupposes description of meaning through the operation of a family of plug-in "microtheories," each responsible for a small set of phenomena and capable of being advanced largely independently of the rest of the microtheories, quite in the spirit of the supply-side approach (see Raskin and Nirenburg, 1995:2-3). It is only through uniting such microtheories into a coherent family jointly providing sufficient coverage that the individual supply-side contributions may be put together to satisfy the demands of a real application.

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