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ABSTRACT

Advanced learners of second languages and natural language processing systems both demand much more detailed lexical information than conventional dictionaries provide. Text composition, whether by humans or machines, requires a thorough understanding of relationships between words, such as selectional restrictions, case patterns, factives, and other kinds of verb implicature. For verbs, we need to know whether they are action or stative, performative or not, and what kinds of complements they take. It is important to know whether an adjective is non-predicating, non-attributive, action, or stative. For nouns, we need relations like taxonomy, part-whole, membership, and modification, and also attributes like count, mass, human, and animate. This paper discusses these and other kinds of lexical information found only implicitly, if at all, in most commercial dictionaries. (MSE)

DIGGING IN THE DICTIONARY: BUILDING A RELATIONAL LEXICON TO SUPPORT NATURAL LANGUAGE PROCESSING APPLICATIONS*

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Advanced learners of second languages and natural language processing systems both demand much more detailed lexical information than conventional dictionaries can provide. Text composition, whether by humans or machines, requires a thorough understanding of relationships between words, such as selectional restrictions, case patterns, factives and other kinds of verb implicature. For verbs we need to know whether they are action or stative, performative or not, and what kinds of complements they take. It is important to know whether an adjective is non-predicating, non-attributive, action, or stative. For nouns we need relations like taxonomy, part-whole, membership, and modification, and also attributes like count, mass, human, and animate. This paper discusses these and other kinds of lexical information found only implicitly, if at all, in most commercial dictionaries.

INTRODUCTION

Advanced learners of second languages and natural language processing systems both need much more detailed lexical information than conventional dictionaries can provide. Native speakers say 'doctor of medicine' but 'specialist in orthopedics,' even if they have to look up orthopedics to discover the spelling or meaning. Complementizers are especially confusing: wish and want are much alike, but we say 'I wish (that) he would go,' but 'I want him to go,' not 'I want that he would go.' Most conventional dictionaries, even those that explain subtle distinctions of meanings in a sophisticated vocabulary, assume that their users know how to combine the simple words. Natural language understanding and generation programs require even more detailed lexical information and are less well-equipped to learn from examples. It is the designers of dictionaries for advanced learners that have led the way in categorizing the kind of information that is needed and in trying to obtain and organize this information.

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DICTIONARIES FOR ADVANCED LEARNERS

The first to propose a design for a radically new type of dictionary were the Soviet linguists Apresyan, Mel'cuk, and Zholkovsky (1970). They proposed an Explanatory-Combinatory Dictionary that would explain the morphology of the word and its government patterns, describe the lexical universe of the entry word, and the way it combines with other words into phrases. The description of the lexical universe places a term in its semantic field and discriminates between synonyms and near synonyms. The most distinctive and original feature of their proposal was the the list of 'lexical functions.' These functions include the classical relations of synonymy and taxonomy as well as about fifty others, such as:

Son - typical sound	Son(<u>cat</u>) = <u>meow</u>
Liqu - destroying verb	Liqu(<u>mistake</u>) = <u>to correct</u>
Prepar - ready for use	Prepar(<u>table</u>) = <u>to lay</u>
Inc - increase verb	Inc(<u>tension</u>) = <u>to mount</u>
Dec - decrease verb	Dec(<u>cloth</u>) = <u>to shrink</u>

Mel'cuk has published fifty sample entries for French (1984) and a much more complete dictionary of Russian.

Three very interesting dictionaries have been published for advanced learners of English: the Oxford Advanced Learners Dictionary, edited by Hornby (1974), the Collins English Learner's Dictionary (Carver, 1974), and the Longman Dictionary of Contemporary English (Procter, 1978). All three contain detailed information about selectional restrictions, sentential complements, and semantic fields. The Longman Dictionary has a controlled vocabulary of 2,000 words and comes in an American version.

Although none of these dictionaries contains all the features described by Mel'cuk, they provide advanced learners with information not available in other English dictionaries. With great vision the publishers of these dictionaries have made them available in machine readable form for research in lexicography and natural language processing. The Longman tape contains further information too bulky to put in the printed book.

It is clear that lexical knowledge involves not only words but phrases. Becker (1975) argues that people generate text by sticking together large swatches of preformed phrases, some only two or three words in length ('by no means'), some a whole sentence ('I am so glad to see you again'). Table I summarizes Becker's classification of phrasal information needed in the lexicon. If natural language processing systems are to create text that sounds natural, they have to have phrasal lexicons.

If you take a strong lexicalist position, that is, if you believe that much of our linguistic knowledge is stored in the lexicon, then the range of what is considered to be lexical information expands to include case arguments for verbs, generic fillers of functional relation slots like subject and object, and triggers for syntactic rules like dative shift (as in 'Mary gave the ball to me' vs. 'Mary gave me the ball'). Also included are selectional restrictions, collocations, and lexical-semantic relations such as taxonomy and part-whole. Many of these new types of information are as important to computers as to second language learners--along with traditional lexical information like etymology, morphology, and phonology (all being used by programs that read text aloud [Church, 1986]). Furthermore, human lexical knowledge involves not only isolated words and phrases but whole networks of related words. The easiest and most natural way to express this kind of semantic information about the words and phrases in the lexicon is to make extensive use of the lexical functions proposed by Apresyan, Zholkovsky, and Mel'cuk (1970) and of other lexical semantic relations (Evens, Litowitz, Markowitz, Smith, and Werner, 1980; Evens and Smith, 1978).

1. Polywords	to blow up
2. Phrasal Constraints	by pure (sheer) coincidence
3. Deictic Locutions	for that matter
4. Sentence Builders	X gave Y a song and dance about Z
5. Situational Utterances	You are very welcome! How can I ever repay you?
6. Verbatim Texts	When I consider how my life is spent

Table 1. Categories from Becker's phrasal lexicon.

To build a large lexical database by hand would require the resources available to the publisher of a commercial dictionary. The only possible strategy is to extract as much information as possible from a machine readable dictionary. While several British dictionary publishers have made dictionary tapes available for research and other tape sources are available from the Oxford Archive, there is only one American dictionary available to researchers in machine readable form: <u>Webster's Seventh Collegiate Dictionary</u> (W7). John Olney, who produced the original W7 tapes, described his reasons for choosing to transcribe W7 instead of another American dictionary (1968). He was very favorably impressed by the large quantity of citations collected by the staff at the G&C Merriam Company and their systematic analyses of these citations.

W7 is an excellent source for lexical information. Some of that information, such as part of speech, is stated explicitly in each lexical entry, but even more information, particularly information about lexical-semantic relationships, such as taxonomic relationships and typical object of verbs is expressed implicitly and, therefore, must be extracted from definitions. Given the quantity of data available to us in W7 and our goal of building a large lexical database, we decided to try to extract as much as possible automatically. This decision implied that we had to parse the definitions.

After much discussion of possible parsers we chose to use Sager's (1981) Linguistic String Parser (LSP) from the Courant Institute at New York University. Although the theoretical framework on which this parser is based is somewhat out of fashion, the parser is an elegant, modern piece of software, which has been used to parse a large number of scientific papers. Sager and Grishman encourage others to use the LSP and make available a set of well-written manuals. The LSP has a large and sophisticated grammar, a ten thousand word lexicon, and excellent facilities for adding rules to the grammar and for expanding the lexicon. We have used the LSP to parse thousands of W7 definition texts and have found the LSP to be a valuable tool for dictionary research as well as for other natural language processing projects. We would be glad to give copies of our grammar for W7 definitions (and the LSP Mandarin grammar, which we have created for experiments in parsing and text generation) to anyone interested.

In the remaining sections of this paper we will discuss our concept of a lexical database and describe our attempts to extract some of this important lexical information from W7 using Sager's LSP.

LEXICONS FOR NATURAL LANGUAGE PROCESSING

Most existing natural language processing systems attack very specialized problems using handmade lexicons containing only a few hundred words. Before natural language processing systems can expand to understand input from wider domains, they need much larger lexicons containing precise and detailed syntactic and semantic information. Text generation systems require even more knowledge than natural language understanding systems.

We have set out to build a large relational lexicon for natural language processing applications containing as much detailed syntactic and semantic information as possible (Ahlswede, Evens, Markowitz, and Rossi, 1986). Whenever it is feasible, we have extracted information automatically from W7. We began by constructing an interactive lexicon builder (Ahlswede, 1985b) for use when we could not find the information we needed in machine readable form, or when further human input was required to classify entries properly. The interactive lexicon builder includes routines that add an entry, edit existing entries, give a list of all the relations being used in the lexicon with examples, keep track of words that have been used in other entries, but are not yet defined themselves, etc.

All entries contain relational information, regardless of the part of speech of the headword. The other information included depends heavily on the part of speech. Verb entries are the most extensive; they contain case information combined with selectional restrictions, tell whether the verb is active or stative, whether it can be put in the passive voice or not. If the verb is a performative, then the performative class is given. If it can take sentential complements, then the complementizers are listed, along with information about implicature, and whether the verb supports not-transportation. Noun entries list plural forms, factivity, and attributes such as animate, human, concrete, count vs. mass. For adjectives we include selectional information, action vs. stative status. If the adjective cannot appear in predicate position or attributive position that fact is noted. Special classes of adjectives are marked as being ordinal or cardinal, as well as for color, size, time, etc. We are still trying to figure out adverb categories, aside from the obvious time, duration, position, manner, cause, etc.

RELATIONS IN THE LEXICON

Lexical-semantic relations express relationships between words and concepts in the dictionary. They include Mel'cuk's lexical functions as well as case relations like agent, patient, instrument; collocational relations, which identify words that go together like bread and butter, concrete relations such as part-whole, and made-out-of, and various types of grading relations, (as expressed in Monday-Tuesday-Wednesday and hot-warm-cool-cold). Synonymy and antonymy are the only relations expressed overtly in W7, therefore we have had to search for hidden expressions of other relations.

Our greatest success has come from recurring word patterns that signal specific relationships. These patterns are often called 'defining formulae.' Defining formulae consist of one or more specific words in a rigid pattern; sometimes they also involve special punctuation like parentheses (Smith, 1985). Table 2 shows a few of the defining formulae that appear in W7 along with the relations that they identify. The formula "Any" + NP consistently signals a taxonomic relationship between the noun being defined and the head noun of the NP. The similar pattern "Any of a" + NP usually marks a biological taxonomy with the scientific name of the taxonomic superordinate given in parentheses. The formula "to make" + Adj clearly expresses a causative. The formula "To" + VP + ("as" NP) names the typical object of the verb being defined inside the parentheses. More details about defining formulae for nouns in W7 can be found in Markowitz, Ahlswede, and Evens (1986) and Amsler (1980).

Defining formulae often tell us about attributes too. Noun attributes include count vs. mass, concrete vs.

abstract, human vs. animate vs. inanimate, and gender. The formula "A member of" + NP tells us about the element-set relation and also signals that the noun being defined is human. The formula "One who" + VP also signals a human noun, while, at the same time, giving us the generic agent for the verb. We hoped that the formula "One that" + VP would signal a non-human noun, but that turned out not to be true. Most, but not all, of the nouns defined in this way are human.

Formula	Relation	Examples
"any" + NP	taxonomy	nectar: any delicious drink
"any of a"		capuchin: any of a genus (cebus) of South American monkeys
"young"	child	puppy: a young dog
		lamb: a young sheep
"to make" + Adj	cause	heat: to make warm or hot
		redden: to make red or reddish
"to" + V + ("as" N)	generic object	mount: to put or have (as artillery) in position
		lay: to bring forth and deposit (an egg)
"one who"	generic	ghost: one who ghost-writes
"one that"	agent	instructor: one that instructs

Table 2. Defining formulae from W7.

VERB CLASSES

The stative/action distinction is important in the generation of dialog. Stative verbs characterize states of being like owning, being, and resembling, while action verbs name acts like moving, thinking, and doing. Not surprisingly, most verbs fall into the action class and are characterized by their ability:

1. to appear in imperative form (e.g., 'Move! Bite that dog!' but not 'Resemble your mother!' and 'Own the house!')
2. to take the progressive aspect (e.g., 'He is moving, he is biting the dog,' but not 'She is resembling her mother.')
3. to serve in sentential complements of verbs of ordering (e.g., 'I told her to bite the dog,' but not 'I told her to resemble her mother.')

The best clue we have found for identifying action verbs in W7 is to look at the definitions of nouns derived from verbs. Those that are defined as "the act of <x>ing," where x is a verb, are typically action verbs. We have taken this route because we have been unable to extract consistent formulae directly from the verb definitions and the verb entries in W7 do not tell us which verbs normally are used in imperative or in progressive forms. Unfortunately, the formula, "the quality or state of <x>ing," is not a reliable signal for stative verbs (e.g., "condensation: the quality or state of

"to make" + Adj	cause	heat: to make warm or hot redden: to make red or reddish
"to" + V + ("as" N)	generic object	mount: to put or have (as artillery) in position lay: to bring forth and deposit (an egg)
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Some verbs that take sentential complements display rather complex implication patterns between the main verb and the complement. Verbs like realize, for example, indicate that the speaker presumes the complement to be true, e.g., 'Mary realized that she was wearing magic shoes.' Verbs like pretend, on the other hand, imply that their complements are false, as in, 'Mary pretended that she was wearing magic shoes.' The Kiparskys (1970) gave the name factive to the class of verbs that behave like realize and pointed out that the presumption holds even if the main verb is negated, as in, 'Mary did not realize that she was wearing magic shoes.' Joshi and Weischedel (1973) did a much more complete analysis of implicature relations between verbs and their complements; their results are summarized in Table 5. (Here R stands for the main verb, S for the sentential complement.)

Implicature classes are very important for discourse understanding and generation because they link the discourse to the speaker's view of the world. To date we have not been able to find a satisfactory way of identifying the implicature class of a verb by simply using W7. We are trying to see if we can extract more clues from Householder's verb categories.

Class	Implicational Structure	Examples
Factive	R(S) --> S	Jerry realized that
	~ R(S) --> S	Meg baked the cake.
Implicative	R(S) --> S	We managed to
	~ R(S) --> ~S	finish the job.
Only-if	~ R(S) --> ~S	They allowed Jim to to visit China.
If	R(S) --> S	Larry persuaded Bill to accept the job.
Negative-If	R(S) --> ~S	Larry prevented Bill from winning.
Negative Implicative	R(S) --> ~S	John failed to go.
	~ R(S) --> S	
Counter-Factive	R(S) --> ~S	Mary pretended that
	~ R(S) --> ~S	Ben went home.

Table 5. Classification of main verbs in predicate complement constructions (adapted from Joshi and Weischedel, 1973).

An interesting class of verbs called 'performatives' was first described by Austin (1962) as part of his theory of speech acts. Performatives are action verbs which, when spoken, actually perform an act. When, for example, people say, 'I warn you,' they are simultaneously uttering some words and performing an act of warning. Performative verbs were also studied by Vendler (1972) and then Vendler's classification was reviewed and reorganized by McCawley (1979). We have actually been using McCawley's categories in our lexicon and, therefore, Table 6 represents McCawley's point of view. To date, we have been unable to identify defining formulae for performatives, but we have achieved some success in classifying additional verbs by checking to see if the sense-level synonyms for definitions of a verb appear in our lists of performative verbs.

<u>Class</u>	<u>Description</u>	<u>Examples</u>
Verdictives	"essentially giving a finding as to something." (Austin, 1962, p. 150)	acquit diagnose estimate
Commissives	"promising or otherwise undertaking"	promise espouse agree
Behabitives	"have to do with attitudes and social behavior" (p. 151)	curse thank apologize
Expositives	"make plain how our utterances fit into the course of an argument or conversation"	concede illustrate assume
Operatives	"acts by which the speaker makes something the case" (McCawley, 1979, p. 153)	abdicate appoint levy
Exercitives	McCawley divides in two:	
Imperative	"an imperative act gets the addressee to do the thing in question because it is the speaker's desire"	admonish forbid beg
Advisories	"an advisory act gets him to do it because it is good"	advise exhort

Table 6. Performative verbs.

ADJECTIVE CATEGORIES

We have developed a large list of useful adjective relations (Ahlswede, 1985a), but we are still searching for more information about adjective classes and relevant attributes. The action/stative distinction seems to be as important for adjectives as it is for verbs. There is one important difference, however; adjectives seem to be stative more often than not, while more verbs seem to belong to the action category. Action adjectives behave much like action verbs. They occur after imperative and progressive forms of the verb <u>to be</u>. <u>Kind</u> is an action adjective while <u>tall</u> is stative, as the examples in (1) make clear:

(1) Be kind!
* Be tall!
Sally is only being kind.
* Sally is only being tall.

The stative-action parameter seems to be easier to identify in W7 definitions for adjectives than it is for verbs. The many adjectives defined by the formula "Of or relating to" seem to be stative, e.g., "literary: of or relating to books." Adjectives defined as "Being ..." seem to belong consistently to the action class, e.g., "cursed: being under or deserving a curse."

While most adjectives can appear in both attributive and predicate positions, some are not non-predicating and others are non-attributive. It is perfectly appropriate to refer to our neighbor as 'an electrical engineer,' but we do not say 'this engineer is electrical.' The phrase 'a civil engineer' is ambiguous, because it may refer to a person who designs bridges or to a polite engineer. If we say, 'The engineer is civil,' the ambiguity disappears; only the polite sense is possible. Two very common non-attributive adjectives are awake and asleep. I can say 'My class is awake' or 'My class is asleep,' but I cannot refer to 'my awake class' and 'my asleep class.'

Another problem for text generation programs and advanced learners who are trying to write down complex ideas in English is the rule for combining a number of adjectives in attributive position. This rule seems to depend very markedly on the semantic categories of the adjectives in question. One version of this rule (Winograd, 1971) can be phrased:

demonstrative > ordinal >
cardinal > general > size > color

as in 'these first six handsome large red trucks.' In our lexical database we mark adjectives according to the categories, ordinal, cardinal, size, and color, along with time and measure, but we are sure that we are missing many other categories and much important selectional information for adjectives.

CONCLUSION

If we are we are going to do a better job of natural language processing, then we need to make explicit things which are implicit or missing in current commercial dictionaries. In this paper we have only touched on a few types of lexical information that we expect will be available in the dictionaries of the future. We hope that these dictionaries will also serve advanced learners of second languages.

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REFERENCES

Ahlswede, T. 1985a. "A linguistic string grammar for adjective definitions." In S. Williams, Ed. Humans and Machines: the Interface through Language, 101-127. Norwood, NJ: Ablex.

Ahlswede, T. 1985b. "A Tool Kit for Lexicon Building. Proc. 23rd Annual Meeting of the ACL, 268-276."

Ahlswede, T., Evens, M., Rossi, K., & Markowitz, J. 1986. "Building a lexical database by parsing Webster's Seventh Collegiate Dictionary." Advances in Lexicology. Centre for the New OED, University of Waterloo, 65-78.

Amsler, R. 1980. The structure of the Merriam-Webster Pocket Dictionary. Unpublished doctoral thesis, University of Texas.

Apresyan, Y., Mel'cuk, I., & Zolkovsky, A.1970. "Semantics and lexicography: towards a new type of unilingual dictionary." In F. Kiefer Ed., Studies in Syntax, 1-33, Dordrecht: Reidel.

Austin, J. 1962. How to Do Things with Words. London: Oxford University Press.

Becker, J. D. 1975. "The phrasal lexicon." In R. Schank & B. Nash-Webber, Eds., Theoretical Issues in Natural Language Processing, pp. 38-41, ACL.

Carver, D.J., Ed.. 1974. Collins English Learner's Dictionary. Birmingham: Collins Publishers.

Church, K. 1986. "Morphological decomposition and stress assignment for speech synthesis." Proc. 24th Annual Meeting of the ACL, 156-164.

Evens, M., Litowitz, B. Markowitz, J., Smith, R., & Werner, O. 1980. Lexical-Semantic Relations: A Comparative Survey. Edmonton: Linguistic Research, Inc.

Evens, M., and Smith, R. 1978. "A lexicon for a computer question-answering system." AJCL, 4, 1-96.
Hornby, A.S, Ed.. 1974. Oxford Advanced Dictionary of Current English. Oxford: Oxford University Press.
Householder, F. 1965. English Verb Classes. Bloomington: Indiana University Linguistics Club.
Joshi, A., & Weischedel, R. 1973. "Semantics of predicate complement constructions." Third IJCAI, Los Altos: William Kaufmann.
Kiparsky, P., & Kiparsky, C. 1970. "Fact." In Progress in Linguistics, Manfred Bierwisch and K.E. Heidolph, eds., 141-173. The Hague: Mouton.
Markowitz, J., Ahlswede, T. & Evens, M. 1986. "Semantically significant patterns in dictionary definitions." Proc. 24th Annual Meeting of the ACL, June 10-13, 112-119.
McCawley, J. 1979. "Remarks on the lexicography of performative verbs." In J. McCawley, Adverbs, Vowels, and Other Objects of Wonder, J. McCawley, 151-164. Chicago: University of Chicago Press.
Mel'cuk, I. 1984. Dictionnaire Explicatif et Combinatoire du Francais Contemporain. Montreal: University of Montreal Press.
Olney, J. 1968. To All Interested in the Merriam-Webster Transcripts and Data Derived from Them. Santa Monica: Systems Development Corporation L-13579.
Procter, P., Ed. 1978. Longman Dictionary of Contemporary English. Harlow and London: Longman.
Sager, N. 1981. Natural Language Information Processing. Reading, MA: Addison-Wesley.
Smith, R. 1985. "Conceptual primitives in the English lexicon." Papers in Linguistics, 18, 99-137.
Vendler, Z. 1972. Res Cogitans. Ithaca: Cornell University Press.
Winograd, T. 1971. Procedures as a Representation of Data in a Computer Program for Understanding Natural Language. MAC TR-84. Cambridge, Massachusetts: MIT Artificial Intelligence Laboratory.