

CAN COMPUTERS HANDLE ADVERBS?*

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ABSTRACT

The adverb is the most complicated, and perhaps also the most interesting part of speech. Past research in natural language processing, however, has not dealt seriously with adverbs, though linguists have done significant work on this word class. The current paper draws on this linguistic research to organize an adverbial lexicon which will be useful for information retrieval and natural language processing systems.

1. INTRODUCTION

There have been many studies on nouns, verbs, and adjectives in NLP systems. Adverbs have received far less attention.

It is very difficult for natural language processing (NLP) systems to handle adverbs because of the large number of syntactic roles that adverbs can assume in sentences. Adverbs can modify verbs, adjectives, adverbs, clauses, or the whole sentences. Adverbs obey complicated positional and selectional restrictions. Many adverbs change meanings when they change their positions in sentences. Despite this complexity, linguists have made significant progress developing a comprehensive set of adverbs classifications, and elucidating

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the semantic and syntactic properties of these different classes of adverbs.

In this study, we give some indication of how a sophisticated and well structured adverbial lexicon can help NLP systems to handle adverbs. Our lexicon builds on the work of several linguists. Their work has helped us to organize information about adverbs from the Collins English Dictionary (CED) and other sources. The adverbial lexicon is organized using the Oracle Relational Database Management System.

Semantic classes of adverbs and selectional restrictions are discussed in Section 2. Section 3 treats functional classes and describes some of the properties of certain functional classes of adverbs. Section 4 presents some possible applications. Finally, Section 5 concludes.

2. SEMANTIC CLASSIFICATION OF ADVERBS AND SELECTIONAL RESTRICTIONS.

With minor variations, Jacobson [1964] and Quirk et al. [1985, p438-74] classify adverbs semantically as: adverbs of time, manner, degree, location, direction, transition and hedges. Adverbs of time, for example, answer questions such as "When?," "How often?," "How long?." Some examples of adverbs in this class are "before," "during," "now," "forever," "seldom," etc. Adverbs of manner answer questions like "How?" and "In what manner (way)?" Examples are "quickly,"

"like," "together," and "without." Hedges indicate fuzzy restrictions such as "essentially," "sort of," and "virtually" [Lakoff, 1972].

We have classified adverbs by systematically analyzing CED definitions. More details on this process can be found in Conlon et al., [1990] and Pin-Ngern [1990]. These semantic classes are stored in our adverbial lexicon as in Table 1.

**ADV_CED(WORD,H/G#,SENSE#,
SUBSENSE#,SEMANTIC_CLASS)**

<i>about</i>	1 2 1	DEGREE, TIME
<i>actually</i>	1 1 1	MOOD
<i>between</i>	1 2 2	PLACE, DIRECTION
<i>down</i>	1 2 7	POSITION
<i>evidently</i>	1 1 1	MOOD

Table 1. Adverb classification from CED

The first line indicates that in CED, the adverb "about" with homograph number 1, sense number 2, and subsense number 1 belongs to the degree and time class. (To facilitate exposition, the tables here and below are not normalized.)

Huang [1975] provides a similar classification of adverbs based on semantic usage with verbs. These classes of adverbs include:

State of Mind Adverbs. Adverbs in this group indicate a participant's state of mind. Examples are carefully and willingly in the following sentences:

He carefully stepped into the room.
Mary was willingly taken advantage of ...

Evaluative Adverbs. These adverbs express an evaluation of the actor's

participation in the event such as "clumsily" in "*He clumsily stepped on the snail.*"

Adverbs of Result. These describe aspects of the result of an event such as the adverb "correctly" in the sentence "*He spelled the words correctly.*"

Huang's classifications can also be incorporated into Table 1.

These adverb classifications can be extremely useful to NLP systems, in particular, in the statement of selectional restrictions (or preferences). Huang describes a number of selectional restrictions between adverbs and other parts of speech. Some examples are:

Adverbs of manner or direction can modify verbs of motion.

Adverbs of result are proper to accomplishment and achievement verbs.

Time and locative adverbs usually occur in action sentences and specify the temporal and spatial circumstances of the events.

Degree adverbs express the degree or extent of a certain quality or state and presuppose an analysis of grading properties in the semantics of adjectives in particular.

Conjunctive adverbs are used in almost the same way as conjunctions.

This type of information should help text generation systems to select appropriate types of adverb to suit nouns, verbs, adjective, and adverbs which have already been chosen. It may also be useful for resolution of ambiguity in natural language understanding applications (see Radford [1988, p372] for an example of a sentence in which selectional restrictions resolve ambiguity). Information about selectional restriction are stored as in Table 2.

**ADV MANNER(WORD,H/G#,SENSE#,
SUBSENSE#,VERB,SENTENCE)**

clumsily 1 1 1 dynamic action
slowly 1 2 1 dynamic action

Table 2. Selectional Restrictions for Adverb of Manner

From the above examples, "clumsily" and "slowly" can modify dynamic verbs and action sentences.

3. FUNCTIONAL CLASSIFICATION AND THE SYNTACTIC BEHAVIOR OF ADVERBS

Jacobson [1964] groups adverbs into four major functional classes: modifying adverbs ("*Luckily he is very careful*"), complementary adverbs ("*Please come in*"), referential adverbs ("*This section, in particular, is important*"), and conjunctive adverbs ("*He will not leave unless she asks him to*").

Adverbs that function as modifiers, in turn, can modify verbs ("*He spelled correctly*"), adjectives ("*They are very tall*"), other adverbs ("*He works extremely well*"), or even clauses and the whole sentences ("*Fortunately he was not drunk*").

These functional classes help to organize knowledge representation schemes involving adverbs, and are also essential for understanding the syntactic properties of adverbs. Jackendoff, for example, classifies adverbs as subject-oriented, speaker-oriented (sentence), and manner adverbs, and represents the meaning structures of these adverbs in essentially prolog form as follows:

Adverb class: Sentence
Prolog-like formula: $ADJ(f(NP^1, \dots, NP^n))$
Example: EVIDENT(WALKED(JOHN,IN))
It is evident that John walked in.
Evidently, John walked in.

Adverb class: Subject-oriented
Prolog-like formula: $ADJ(NP^1, f(NP^1, \dots, NP^n))$
Example: CLUMSY(FRED, DROPPED(FRED, THE BOOK))
It was clumsy of Fred to drop the book.
Clumsily, Fred dropped the book.

Adverb class: Manner
Prolog-like formula: $[f/ADV](NP^1, \dots, NP^n)$
Example: [RAN/QUICKLY](SUE,HOME)
Sue quickly ran home.

Figure 1.

Huang uses similar prolog-like formulas to represent the semantic structure of adverbs.

This same functional classification also allows Jackendoff to derive positions of adverbs by using parse trees. According to Jackendoff, sentence adverbs must be attached to an S-node, while manner adverbs are attached to VP nodes. Thus the sentence adverb "evidently" can appear in positions such as the following:

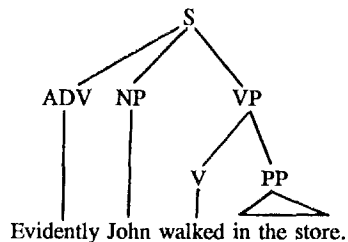


Figure 2.

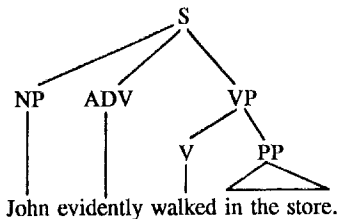


Figure 3.

A similar parse tree could be constructed for "John walked in the store, evidently." On the other hand, the sentence ***John walked evidently in the store,*" is impossible because the parse tree does not allow "evidently" to be attached to the S node (see figure 4.)

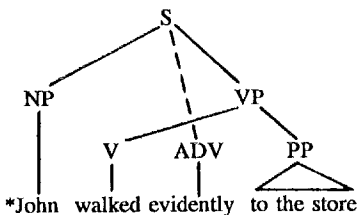


Figure 4.

For a similar discussion, see McCawley [1988, p631-40] and Radford [1988, p73, 93].

Classification of adverbs by functional class is given in tables such as Table 3.

**ADV_MOD(WORD,H/G#,SENSE#,
SUBSENSE#,MODIFYING_CLASS)**

<i>evidently</i>	1	1	1	<i>sentence</i>
<i>happily</i>	1	1	1	<i>sentence, speaker, manner</i>
<i>clumsily</i>	1	1	1	<i>subject, manner</i>

Table 3. Classifications of Modifying Adverb Based on Modification Class

Additional information about adverbial positions in sentences has been collected by Jacobson [1964]. This information should supplement the information in Table 3, and should also be helpful for information retrieval and NLP applications. This information is organized as in Table 4.

**ADV-JACOBSON(WORD,H/G#,SENSE#,
SUBSENSE#,POSITION)**

<i>after</i>	1	2	1	<i>E4</i>
<i>constantly</i>	1	1	1	<i>M1, M3, M4, E1, E5</i>
<i>exactly</i>	1	1	2	<i>M3, M4</i>
<i>otherwise</i>	1	2	1	<i>M3, E1, E4, E5</i>

Table 4. Adverb Positions in Sentences Collected by Jacobson

Thus, "constantly" is found in "middle" and "end" positions. More details about each position can be found in Jacobson [1964].

4. APPLICATIONS

A sophisticated adverbial lexicon should help NLP systems to handle adverbs appropriately. NLP systems will be able to use information in the adverbial lexicon in parsing, language understanding, and text generation systems.

Suppose, for example, that a parser has to parse a sentence of the form: "John [Adv] walked to the store." The parser can determine how to treat the adverb by looking in the lexicon to see whether the adverb is a sentence or a verb phrase adverb. For example, if "quickly" is the adverb in the sentence, it is a manner adverb, so it should be attached to the verb or verb phrase node. On the other hand, if the adverb is "evidently" then it is a mood adverb (speaker oriented sentence modifier), and so, should be attached to the S node.

Once the sentence has been successfully parsed, the language understanding system can then create prolog-like formulas of the form indicated in Figure 1. Similarly, the text generation system should be designed to take prolog-like formulas such as those in Figure 1 and successfully translate them into natural language. The functional class then places restrictions on the position of the adverbs, as in Figures 2, 3, and 4.

Finally, selectional restrictions can be used to reduce lexical ambiguity in language understanding systems, and assist in word choice in text generation (see Section 2).

5. CONCLUSION

NLP systems can handle adverbs, if the adverbial lexicon provides enough relevant information with appropriate knowledge representation techniques. The tables in our lexicon include, among others,

Table 1: Semantic classifications of each adverb.

Table 2: Selectional restrictions.

Table 3: Modifying class (sentence, speaker, manner, etc.).

Table 4. Jacobson's dictionary of adverb placement.

This adverbial lexicon can be used in combination with Tables for other parts of speech to implement NLP systems.

These tables, with others, should allow NLP systems to break down the intimidating complexity of the adverb class, and so, handle parsing of sentences with adverbs, adverb placement, knowledge representation related to adverbs, and selectional restrictions between adverbs and other parts of speech.

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