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NATURAL LANGUAGE SOURCEBOOK

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Center for Technology Assessment
Center for the Study of Evaluation

and

Computer Science Department

UCLA

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The Natural Language Sourcebook was a research component in the development of the Artificial Intelligence Measurement System (AIMS). The Sourcebook is a compilation of 197 processing problems addressed or "handled" by intelligent computer systems. The problems, culled from the literature in artificial intelligence, computational linguistics, and cognitive psychology, have been classified into a scheme with an artificial intelligence bent and cross-referenced to companion schemes one with a linguistic and one with a cognitive-psychological perspective on the types of issues reflected in the problems. Each entry in the Sourcebook, called an "exemplar," consists of (1) one or more sentences, a fragment of dialogue or a piece of text which illustrates a conceptual issue, (2) a reference, and (3) a discussion of the

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problem a system might have in understanding the example.

An electronic version of the Sourcebook database was developed in a Hypercard environment to facilitate use of the multiple classification schemes (Herl, September 1990). The Hypercard version of the Sourcebook is accompanied by a user's manual (Herl, August 1990).

References

Herl, H. August 1990. User's Manual, HyperCard Database for the Natural Language Sourcebook. Center for Technology Assessment, UCLA Center for the Study of Evaluation.

Herl, H. September 1990. Designing a HyperCard Database for the Natural Language Sourcebook. Center for Technology Assessment, UCLA Center for the Study of Evaluation.

Table of Contents

Sourcebook Introduction

This document, the *Natural Language Sourcebook*, represents an attempt to provide researchers and users of natural language systems with a classification scheme to describe problems addressed by such systems. It is part of a much larger research effort conducted at the UCLA Center for Technology Assessment to explore alternative methods for evaluating high technology systems. In this project, Artificial Intelligence Measurement System (AIMS), the strategy was to explore the extent to which multidisciplinary methods, from the fields of artificial intelligence, education, linguistics, psychology, anthropology, and psychometrics, could be combined to provide better characterizations of the scope, quality, and effectiveness of AI systems. The areas of focus across the entire project have included: expert system shells, expert systems, natural language interfaces, including front-ends to databases and expert systems,text understanding systems and vision systems. The overall strategy of the project was to determine first the scope of implementations in the field, either through a classification system or compendium describing the types of efforts in a field, then to determine strategies for assessing the effectiveness of particular implementations. The goal of the project was first to test the concept that such systems can be evaluated and second to determine alternative approaches for establishing benchmarks of performance. This approach is a rather radical departure from typical "evaluation" approaches in the AI field. These are more

focused on the assessment of a particular strategy in terms of its theory and are less focused on attempting to develop standard metrics against which systems can be measured.

Clearly, the matter of standardization was a critical issue in our studies, especially since most efforts emphasize fairly well specified domains. The Sourcebook compilation represents one strategy for attempting to "standardize" discussion of natural language systems, a strategy that attempts as well to represent the diversity of particular systems. The Sourcebook should help researchers and users sharpen their understanding of claims made on behalf of existing systems or to identify gaps for future research and development. The focus of the Sourcebook is the types of problems purportedly addressed, or more colloquially, "handled" by natural language systems. For example, the system may purport to "handle ellipsis" or "resolve anaphoric reference," but what does this claim actually mean? Does it mean the system can deal with all cases or just certain types? What classification of "types" of ellipsis or anaphora is the author of the system using? Without a common classification of the problems in natural language understanding, authors have no easy way to specify clearly what their systems do; potential users have trouble comparing different systems, and researchers struggle to judge the advantages or disadvantages of different approaches to developing systems. While these problems have been noted over the last ten years (Woods, 1977; Tennant, 1979), research developing specific criteria for evaluation of natural language systems has appeared only recently (Guida and Mauri, 1984, 1986). The

Sourcebook presents a classification and identification by example of problems in natural language understanding. Identification by example removes confusion over general claims, such as the claim that a system has the ability to "handle ellipsis." Although the Sourcebook in its present form does not exhaustively cover the range of problems in natural language understanding, it could be extended to do so.

Previous Work on Natural Language Evaluation

What the field of natural language calls evaluation largely focuses on descriptive characteristics of systems rather than on methods to determine the effectiveness of system performance. Such a perspective certainly conflicts with social science approaches to evaluation—approaches which call for relatively complex indicators of context, goals, processes, and outcomes in evaluating innovations of various types. The evaluation strategies described by writers working from within the AI perspective emphasize evaluating the quality of the research rather than the performance of particular implementations. Within that constraint, Woods (1977) discusses a number of dimensions along which the complexity and responsiveness of natural language systems can be measured. In particular, three approaches he considers are the following: (a) a "taxonomy of linguistic phenomena," (b) the convenience and perspicuity of the model used, and (c) processing time and size of code. He draws attention to the great effort involved in doing evaluation by any of these

methods and to the importance of a "detailed case-by-case analysis."

As Woods points out, the difficulty of a taxonomic approach is that the taxonomy will always be incomplete. Any particular phenomenon will have many subclasses, and it is often the case that the published examples cover only a small part of the problem. A system might claim to resolve pronoun reference in general; however, the examples might be limited to pronoun reference in parallel constructions. To make any taxonomy useful, as many clear subclasses as possible must be identified. The taxonomy should serve, not only as a description of what has been achieved, but as a guide to what still needs to be accomplished.

Tennant and others (Tennant, 1979; Finin, Goodman and Tennant, 1979) make a distinction between the conceptual coverage and the linguistic coverage of a natural language system and argue that systems have to be measured on each of these dimensions. Conceptual coverage refers to the range of concepts properly confronted by the system and linguistic coverage to the range of language used to discuss the concepts. Tennant (1979) suggests a possible experimental separation between conceptual and linguistic coverage.

The distinction these authors make is important and useful, in part for emphasizing the significance of the knowledge base for usability of a natural language system. But the examples that Tennant (1979) gives for conceptual completeness (presupposition, reference to discourse objects) seem to be part of a continuum with topics like ellipsis and anaphora, which are more clearly

linguistic. For this reason a sharp distinction between conceptual coverage and linguistic coverage is not drawn here.

Bara and Guida (1984) give a general overview of issues in evaluation of natural language systems. They emphasize the importance of measuring competence, what the system is capable of doing, over performance, what users actually do with the system. The question remains as to how one measures competence.

Guida and Mauri (1984, 1986) present the most formal and detailed approach to evaluation of natural language systems. They consider a natural language system as a function from sets of input to sets of output. Assuming a measure of error (closeness of the actual output to the intended output) and a measure of importance of each input, Guida and Mauri evaluate a system by the sum of the errors weighted by the importance of the input. (The more important inputs get higher weights.) It is assumed that the user can assign these measures in some reasonable way. They give some suggestions for this assignment and work out a small example in detail (1984, pp.28-30).

The advantage of a careful, formal analysis is that it focuses attention on the key role of the "importance" and "error" measures. In practice, the importance measure has to be defined on categories of input rather than individual items of input. The difficulty is determining what these categories are for a natural language. A system that handles five types of ellipsis but not the type the user most needs would be of little use. With a description of the varieties of issues involved, a user can define

specific needs and give idiosyncratic weights to the different categories of input.

One method often used in computer science to describe the coverage of a system is a test suite. A test suite is a set of inputs which is given to a program at each stage of its development to test the program's performance. One reason test suites have been used for natural language evaluation is that they are simple and precise.

Hewlett-Packard (HP) presented one such suite covering a variety of tests of English syntax at the 1987 Association for Computational Linguistics meeting. But the approach seems very limited. For example, although a parser might parse one example of a "Bach-Peters sentence (periphery)," it could fail on another syntactically similar sentence which is semantically different. The HP test suite does not measure how well the system understands what is going on. The categories are those derived from a particular syntactic theory, rather than categories that users work with. In addition, the test suite tests only a very limited range of linguistic phenomena, and the evaluation is simply pass/fail. When a sentence fails to pass, it is not always clear why without looking at the implementation. For these reasons, a more generally useful method than test suites of this type was sought.

The Sourcebook Project

The Sourcebook was designed to describe the coverage of conceptual and linguistic problems by natural language systems. The examples in the Sourcebook illlustrate problems that arise in the context of computational language processing. Building systems intended to read real text or interact with real users raises complex problems of interaction of linguistic phenomena. Looking at these phenomena computationally focuses attention on issues that are often neglected in more theoretical analyses.

The Sourcebook is a database of examples of representative types of problems in natural language understanding drawn from the artificial intelligence, computational linguistics, and cognitive science literature. The examples in the Sourcebook are taken primarily from the literature although some examples have been added to fill in gaps where the published examples seemed incomplete. Each entry in the Sourcebook, called an "exemplar," consists of (1) one or more sentences, a fragment of dialogue or a piece of text which illustrates a conceptual issue, (2) a reference, and (3) a discussion of the problem a system might have in understanding the example. An example is used to illustrate each problem, but it is the discussion that defines the type of problem by delineating the information-processing issues involved.

The natural language examples present many types of processing problems. While there are often strong similarities among the exemplars, each represents a slightly different approach to the processing problems at issue. The identification and discussion of these problems in each exemplar is influenced by the

analysis given in the original source (cited in the exemplar). Examples without a citation were generated by the authors. The Sourcebook presently contains 197 exemplars and provides a classification scheme reflecting an artificial intelligence perspective for the types of issues represented by the examples.

In addition, the Sourcebook includes two alternative classification schemes, one designed by a computational linguist and one by a cognitive psychologist. These two additional schemes provide a basis for cross-referencing the processing problems. Linguistic and cognitive-psychological cross-referencing of the exemplars allows the user to explore alternate relations among the examples in the Sourcebook. Each exemplar has at least one linguistic cross-reference and one cognitive-psychological cross-reference.[1] Because of the inherent overlap in some areas of the linguistic and cognitive-psychological classification schemes, only the exemplars which lend themselves to a pragmatic classification are finely cross-indexed according to the cognitive-psychological classification scheme. For further discussion of cross-indexing, see the cross-indexing section at the end of this document.

The exemplars are grouped into four categories of related problems: single-utterance, connected-utterance, true-dialogue, and ill-formed input. The classification was based directly on the exemplars. An a priori theory for this classification scheme was not assumed, but rather patterns in the exemplars were sought.

[1] To facilitate use of these multiple classification systems and to assist users who come from other disciplines, an electronic version of our database has been implemented in HyperCard. It is available with a users manual at nominal cost from the UCLA Center for Technology Assessment.

Group I includes input which the system can understand using only existing, stored knowledge. This knowledge might be knowledge about syntax, semantic constraints, or world knowledge, but it specifically excludes knowing the results of processing previous input. These examples are the ones most commonly discussed in linguistics and artificial intelligence texts.

In Group II problems, the system must be able to integrate information spread over a series of utterances and must be able to refer back to earlier utterances, but the system need not have any model of the user. The only interaction between the system and the user is that the user makes statements or requests, and the system processes them. Typical Group II problems are anaphor, ellipsis, and story understanding.

In Group III problems, the system must know not only about the sequence of utterances read but also something about the user's goals, intents, and expectations. Group III examples do not necessarily involve an actual two-way dialogue between the system and the user, but they at least involve building or accessing a model of the user. Group III problems involve an interchange between two knowledgeable entities. Group III capabilities are needed for intelligent interfaces to expert systems.

Groups I, II, and III form an important block because they cover examples of normal language use. The remaining group, Group IV, Ill-formed Input, covers examples which do not conform to normal use but which a program may nevertheless encounter.

A Note on the Terminology

The terms "single-utterance," "multiple-utterance," and "true-dialogue" are used to suggest the typical examples of the first three groups. The typical Group I problem is parsing an input in isolation from other inputs. The typical Group II problem is parsing an input where the parser requires information from earlier inputs. The Group III examples need not show an actual dialogue, but there is an assumption that the essence of dialogue is being able to make judgments about the goals, expectations, and beliefs of the other participant. The "true" part of the term, "true dialogue," is used to emphasize that the system does not simply give responses to the user's input, but brings to bear knowledge about users and their use of language in deciding on the response. Of course, many of the Group III examples will consist of a single sentence, and some of the Group I examples can be broken up into more than one sentence. The names are chosen for convenience to point to the most representative examples.

Summary

By drawing examples from a range of the artificial intelligence, computational linguistics, and cognitive science literature, and including not only examples that have been successfully addressed but variations that have not yet been solved by systems, the Sourcebook gives a broad view of linguistic phenomena. The "example-based" approach has enabled us to study

specific processing issues clearly and in some detail and has made it possible to discuss the issues across different disciplines. By emphasizing the general processing problems presented by the examples, rather than implementation issues, we have been able to make the problems accessible to the general reader and open to comment by specialists outside of computational linguistics. This conceptual classification has begun to map the terrain of problems in processing language.

At this point we estimate that we have covered ten percent of the relevant literature. The classification itself has gaps and the exemplars are not fully classified. But even in its present form, the Sourcebook promises to be a valuable tool for researchers in computational linguistics and related fields. We hope the community of interested users will join with us in continuing to extend the coverage of problems in the Sourcebook and in refining the classification scheme we have used.

Sourcebook Classification

I. Single-utterance issues
   A. Identification of syntactic units
   B.Ambiguity
      1. Lexical
      2. Attachment
   C. Modifier attachment
      1. Prepositional phrase
      2. Other
   D. Reference
      1. Anaphoric
      2. Non-anaphoric
      3. Distinguishing anaphoric from non-anaphoric reference
      4. Temporal
   E. Metaphor and novel language
   F. Other

II. Connected-utterance issues
   A. Anaphora
   B. Ellipsis
   C. Integrating complex information
   D. Reasoning, argumentation, story understanding
      1. Irony
      2. Plans and goals
      3. Belief modification
      4. Argumentation
      5. Summarizing
   E. Metaphor

III. True-dialogue issues
   A. User goals and plans
   B. Logical presuppositions
   C. Speech acts
   D. Meta-linguistic discourse

IV. Ill-formed input
   A. Mistakes
      1. Mistypings
      2. Syntactic constraint violations
      3. Semantic constraint violations
   B. Non-standard input
      1. Incomplete sentence
      2. Casual structure
      3. Idiolect

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Group I: Single-Utterance Issues

Group I includes input (utterances) which the system can understand using only existing, stored knowledge. This knowledge might be knowledge about syntax, semantic constraints, world knowledge, etc., but it specifically excludes knowing the results of processing previous input. The typical Group I problem involves parsing an input in isolation from other inputs. Most of the examples in this group are single sentences, but it should be noted that a "single-utterance" may consist of more than one sentence. The examples in Group I are the ones most commonly discussed in the linguistics and artificial intelligence literature.

SINGLE-UTTERANCE ISSUES

Identification of Syntactic Units

Exemplar I.A. (#1)

Problem

(1) The tough coach the young.
(2) The tough coach married a star.
(3) The tough coach married people.

(Huang & Guthrie, 1985, pp. 10, 3, 11, respectively)

Discussion

The sentences above illustrate the problem of recognizing noun groups: (a) "the tough" vs. "the tough coach" and (b) "people" vs. "married people." The problem could also be considered a problem of determining lexical categories of words: the segment "the tough coach" in isolation could be parsed as Det Noun Verb or as Det Adj Noun. When the segment is part of a complete sentence, the parser must be able to determine whether "tough" is functioning as an adjective or a noun and whether "coach" is functioning as a noun or a verb.

A strongly syntax-oriented parser could resolve the problems in the first two cases by requiring a unique verb such as "coach" in example (1) and "married" in example (2). Once the parser specifies a verb, the structure of the rest of the sentence is determined: specifying "coach" as a verb in example (1) implies that "tough" is a noun. The third example is ambiguous in isolation but would presumably be resolvable in context.

Linguistic: I.A.1. Noun/verb
I.A.2. Noun/adjective
I.A.4. Verb/participial adjective
I.B.1.a. Noun
I.B.1.b. Verb
I.C.1. Noun phrase structure
I.C.10. Syntactic ambiguity
I.C.11. "Garden path" sentences

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Identification of Syntactic Units

Exemplar I.A. (#2)

Problem

(1)...mental building block
(2)...large Chinese restaurant
(3)...meat shop owner
(4)...fearless Chinese soldier
(5)...heavy cigar smoker
(6)...Indian Ocean cruise line
(7)...giant shrimp cocktails

(Gershman, 1982, pp. 182-185)

Discussion

In the noun groups above, there are some complications in attaching noun-modifiers to nouns. In "heavy cigar smoker," "heavy" modifies "cigar smoker" not "cigar." In "Indian Ocean cruise line," however, "Indian" modifies "Ocean" and not "Ocean cruise line."

The following principles help the parser determine the attachment of modifiers to nouns:

1) Only concepts built by adjacent words can modify each other: "mental block" is not the same as "mental building block."

2) Semantic information about words is stored as the words are read. The parser should be able to test both forward and backward associations of words: "heavy" can modify "cigar," but "smoker" can be modified by "cigar" also. However, "heavy cigar" as a modifier of "smoker" gives an incorrect meaning, while "heavy" as a modifier of "cigar smoker" gives a reasonable phrasal meaning.

In ambiguous segments such as "giant shrimp cocktails," parsing according to the above two principles gives only one parse tree. The parser uses the first acceptable modification grouping consistent with left-to-right processing. Therefore, with ambiguous phrases it never considers a second interpretation. People, however, give one of two equally likely interpretations: 1) a shrimp cocktail which is giant or 2) a cocktail made of giant shrimp.

Linguistic: I.A.1. Noun/verb
I.A.2. Noun/adjective
I.A.3. Noun/participial adjective
I.C.1. Noun phrase structure

SINGLE-UTTERANCE ISSUES

Identification of Syntactic Units

Exemplar I.A. (#3)

Problem

The U.S. fight in Vietnam is hopeless.

(adapted from Gershman, 1982, p. 185)

Discussion

This example shows the importance of collecting potential parse trees and disambiguating words based on the overall syntax of the sentence. "Fight" can, in general, function as either a noun or a verb. In the above example, until the word "is" is read, we do not know whether to take "fight" as a verb or a noun.

The noun/verb ambiguity of "fight" means that the syntax of "The U.S. fight in Vietnam" is ambiguous. One syntactic problem posed by the noun/verb ambiguity of "fight" is difficulty in determining what the head noun of the subject noun group is. The head noun of a noun group usually indicates the base concept of the group. Thus, recognizing the head noun is a key task for a parser. Head nouns are generally followed by non-nouns because the head noun is usually the last word of a noun group and most noun groups are followed by non-nouns: verbs, prepositions, articles, etc. Therefore, in a left to right parse of the above example, if "fight" is taken to be a verb, then the head noun is "U.S."; if "fight" is taken to be a noun, then "fight" is the head noun (followed by the preposition "in").

Linguistic: I.A.1. Noun/verb
I.C.1. Noun phrase structure
I.C.11. "Garden path" sentences

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Identification of Syntactic Units

Exemplar I.A. (#4)

Problem

U.S. Assistant Secretary of State Marshall Green...

(Gershman, 1982, p. 186)

Discussion

In many strings such as "Angry doctors in Boston...," prepositions mark the end of a noun group. In some cases, however, the prepositions cannot be interpreted as signaling the end of a noun group. In the example above, "Secretary of State" should be parsed as a constituent of the noun group, rather than having the noun group stop after "Secretary."

There are two ways in which this problem might be handled. One way is to have the lexical entry for "Secretary" store information about possible phrases that it could be part of. The other is to have the parser look first for special phrases like "Secretary of State." The first approach assumes that we have a list of all likely phrases. The second leads to a combinatorially explosive parsing problem.

Linguistic: I.C.1. Noun phrase structure

Cognitive-psychological: I.A. Processing syntax

Identification of Syntactic Units

Exemplar I.A. (#5)

Problem

Doctor Dana Blauchard, the medical examiner...
Amherst, a small town in Massachusetts...

(Gershman, 1982, p. 188)

Discussion

In order for the parser to process the appositives in the examples above, it must be able to (1) determine if the appositive relation is in fact the correct one and (2) if it is, merge the properties indicated by the two noun groups into one representation.

Identification of an appositive structure is not straightforward. There is no uniquely identifying syntactic structure characteristic of appositives. The only indications of apposition are adjacency of noun groups and separation by commas. But as the segment "Doctor Dana Blauchard, the dentist, and the insurance salesman" shows, adjacency and commas are not sufficient to specify an appositive.

To understand an appositive, a parser must merge properties indicated by the two noun groups into one consistent concept or representation. Because this representation must be internally consistent, parsing difficulties may arise if specific characteristics of the two noun groups are contradictory (e.g., the first noun group is animate and the second inanimate).

Linguistic: I.C.7. Appositive

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Identification of Syntactic Units

Exemplar I.A. (#6)

Problem

John Smith, 33, was elected.

(Gershman, 1982, p. 187)

Discussion

Modifiers of proper names (ages, addresses, occupations) often have special structure and special conventions for their use. For example, the "33" in most American newsprint refers to age, but in Uruguay it would refer to the number of a political party. Because these modifiers are idiosyncratic and specific to particular uses, they require very specific processing routines.

Linguistic: III.C. Ellipsis

Cognitive-psychological: I.C.6.b.5.a. List attributes
I.C.6.b.4. Identification

SINGLE-UTTERANCE ISSUES

Identification of Syntactic Units

Exemplar I.A. (#7)

Problem

Water pump pulley adjustment screw threads damage report summary

(Waltz, 1982b, p. 24)

Discussion

Even though a system may understand a large number of words, the words may be combined into syntactic units in a way that reflects not just grammatical correctness, but also real-world structure specific to a particular concept. The example above is a large noun group where the meaning of each of the individual words is fairly concise, but the internal syntactic structure and the meaning of the phrase cannot be found by strict grammatical combination. This example points out that in order to understand a phrase, a parser has to consider not only the order of the words, but the parts of machinery and their relationships.

Linguistic: I.C.1. Noun phrase structure

Cognitive-psychological: I.C.2.b. World knowledge: MOPs

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#1)

Lexical

Problem

(1) While I was driving home, I ran into a parked car.

(2) While I was driving home, I remembered I needed some milk. I ran into a Seven-Eleven and picked up a half-gallon.

(3) John was racing down the street trying to catch a bus. All of a sudden, his neighbor Fred stepped out of a doorway into his path. John ran into Fred and knocked him down. Fortunately, he wasn't hurt.

(4) After not seeing Fred for years, John ran into him at the Seven-Eleven.

(Birnbaum, 1985, pp. 815-820)

Discussion

The phrase "ran into" has different meanings in different situations:

In (1) it means a vehicle accident took place.
In (2) it means that someone changed location quickly.
In (3) it means a collision between two people.
In (4) it means a coincidental encounter.

An understander must have knowledge of the possible meanings and the ability to use context information to choose the right interpretation.

Linguistic: I.B.1.b. Verb

Cognitive-psychological: I.C.2.c. World knowledge: Experiential

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#2)

Lexical

Problem

(1) I have a new car.
(2) I have a friend.
(3) I have good news.
(4) I have a cold.
(5) I had breakfast.
(6) This shirt has a nice color.

(Steinecker & Trost, 1983, p. 628)

Discussion

Words like "have" are highly ambiguous. In addition to the meaning of "possessing an object," "have" also indicates much more abstract relationships between the other constituents of the phrase. In the example above, one sense of "have" is that the person is sick; another is that he ate a meal; and still another is that one of the properties of an object has a certain value. It is difficult to define all possible meanings of highly polysemous words like "have."

Linguistic: I.B.1.b. Verb

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#3)

Lexical

Problem

(1) The game was so lopsided that Fred got bored and walked home after the seventh inning.

(2) The pen was in the box along with assembly instructions.

(Birnbaum, 1985, p.817)

Discussion

Many AI systems use some sort of frame-based approach to disambiguate words. The basic idea is that certain words have different meanings within a particular frame. For example, "home" within the baseball frame means "home plate," even though in general "home" is the place where one resides. In (1), however, even though the baseball frame is active, "home" has the latter meaning. Similarly, while "pen" within the "box" frame means a writing implement, in (2) it is likely to be a playpen, since pens are not usually assembled.

Note: See Exemplar I.B.1. (#4) for another example of this processing problem.

Linguistic: I.B.1.a. Noun

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#4)

Lexical

Problem

(1) Nadia's new car is a lemon.
(2) Nadia's new car is the color of a lemon.

(Hirst & Charniak, 1982, p. 95)

Discussion

Lemon has two meanings. In (1) it means a poorly made car. In (2) it means a small, sour, yellow fruit. Usually a frame or script is used to disambiguate such words. If the word appears in the eating context, the "small yellow fruit" meaning is selected. If the word appears in the automobile context, the "poorly made car" meaning is selected. However, in (2), the disambiguation technique fails.

Note: See Exemplar I.B.1. (#3) for another example of this processing problem.

Linguistic: I.B.1.a. Noun

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#5)

Lexical

Problem

(1) A man threw up a ball.
(2) A man threw up dinner.

(Small, Cottrell, and Shastri, 1982, p. 248)

Discussion

The meaning of "threw up" differs in the two examples above. In (1) it means "to propel into the air." In (2) it means "to vomit." The object following "threw up" disambiguates it. That is, the meaning cannot be determined until the object following "threw up" is identified. A parser would retain both meanings of "threw up" until the object is known.

The problem with the two possible meanings of "throw up" is complicated by the fact that one meaning of the adjacent words "throw up" is more common than the other. After reading "throw up," the reader interprets it to mean "vomit" and expects either a null object or a food object to follow. A reader does not expect an object like "ball" because, when talking about objects that are hurled through the air, it is more common to place them before the particle "up," as in "throw a ball up," than it is to put them after the particle as in "throw up a ball." This first usage is unmarked, the second marked.

Linguistic: I.B.1.b. Verb

Cognitive-psychological: I.C.2.c. World knowledge: Experiential

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#6)

Lexical

Problem

(1) I live out of town.
(2) I hit her out of anger.
(3) I threw the ball out of the window.
(4) The statue is made out of marble.

(Wilks, 1975, p. 264)

Discussion

The phrase "out of" is highly ambiguous. In (1) it refers to an object's location relative to another object. In (2) it refers to the relationship between an emotion and an action. In (3) it refers to a location an object passed through. Finally, in (4) it refers to the material an object is made of. Translating these sentences into another language could potentially result in "out of" being translated into words or phrases with four different meanings.

Linguistic: I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.C.2.c. World knowledge: Experiential

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#7)

Lexical

Problem

(1) Mary is going to John.
(2) Mary is going to the john.
(3) A hooker is going to a john.

Discussion

There are three senses of the word "john" used in the examples above: (1) a proper name, (2) the euphemism for toilet, and (3) the slang term for the customer of a prostitute. To select the proper sense a parser has to consider both local information and context provided by the sentence. The local information in the sentence is the capitalization and determiner: capitalization indicates a proper name, the definite article indicates a commode, and the indefinite article indicates the customer of a prostitute. The third example shows how the contextual information provided by "hooker" can also be used to select the word sense.

Linguistic: I.B.1.a. Noun
I.B.2. Idiomatic phrases

Cognitive-psychological: I.C.2.a.2. Scripts: Multiple

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#8)

Lexical

Problem

She walked towards the bank.

(Winograd, 1983, p. 92)

Discussion

In the example, the word "bank" has at least two possible meanings. "She" could be walking toward a financial institution or the side of a river. Note that the syntactic parse doesn't change with the sense. For both senses, "the bank" is the object of the prepositional phrase following the verb. The sentence doesn't provide enough context to disambiguate the meaning, so parsers that assign a semantic value to "bank" have to be able to delay or undo an assignment when the context becomes available.

Linguistic: I.B.1.a. Noun

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#9)

Lexical

Problem

(1) He called up his poor old lonely mother.
(2) He called up the stairs to his mother.
(3) He called her up long distance twice a week.

(1 and 3 from Winograd, 1983, p. 136)

Discussion

Examples like this show that the lexicon has to contain more than just single-word entries. A single-word entry for "call" is sufficient to process example (2), but if the parser does not have a separate lexical entry for "called up," it will run into problems with examples (1) and (3). In the first sentence "up his ...mother" might be treated as the direction that he is calling, as in "called up the stairs" in (2). Recognizing that this interpretation doesn't make sense is one clue for a phrasal interpretation.

The parser could list idioms as static phrases (lists of words). But as these examples illustrate, an idiom can be separated ("called her up") and retain its meaning.

Another option is to have lexical entries contain variables. Thus the entry for "called up" would be "called ?x up," where "?x" resolves to a human ("called John up"), a pronoun ("called her up"), or null ("called up"). In this case, the parser has to find the missing object of the call. This general approach is characteristic of phrasal parsers.

Linguistic: I.A.7. Preposition/particle
I.C.4. Phrasal verb structure

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#10)

Lexical

Problem

A tiger ran quickly through the jungle.

(Waltz, 1982b, p. 24)

Discussion

The word "quickly" has no specific meaning beyond the sense that the tiger ran faster than usual. What is "quickly" for a cow might not be "quickly" for a tiger. What is "quickly" for a tiger in the jungle might not be "quickly" for a tiger in an open area. Understanding "quickly" depends on using the full context given.

Linguistic: III.L. Adjective/adverb range

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#11)

Lexical

Problem

(1) Did any plane crash more than five times last month?
(2) Did any plane have more than 10 hours of maintenance last month?

(Waltz, 1982b, pp. 25-26)

Discussion

These examples show that even in a limited context (military planes and their maintenance records), there can be difficult problems of ambiguity. Here, "plane" can mean either an individual plane or a class of planes (F-14, A-7, etc.). Choosing the correct meaning of an ambiguous word often requires access to considerable and detailed world knowledge. In (1), we assume that it means the class of planes because it is unlikely that an individual plane would be allowed to continue flying after five crashes in a month. But in (2), 10 hours of maintenance is too small a number for an entire class, so "plane" probably means individual plane.

Linguistic: III.E. Generic noun phrase

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#12)

Lexical

Problem

(1) John gave Mary a book
(2) John gave Mary a kiss.
(3) John gave Mary a chance.
(4) John gave Mary a cold.
(5) John gave in.
(6) John gave a laugh.
(7) John gave notice.

(2-7 from Riesbeck, 1982, pp. 39-40)

Discussion

The usual meaning of the verb "to give" involves a transfer of possession as in (1). For use in a natural language understanding system, this definition must be augmented with the role of the actors in the giving (the subject and object of the verb), and how potential prepositional phrases fit into the giving. This type of definition will provide a useful parse for "John gave Mary a book," but none of the other examples above use "gave" in the transfer of possession sense. Systems that have "transfer of possession" for the lexical entry "gave" will come up with an incorrect representation for giving a kiss, a chance, or a cold.

The various meanings for "gave" can come about from different ways of generalizing or extending the basic notion. In (4) the understander can imagine John literally transferring the cold viruses. In (2) and (3) the understander can reify "kiss" and even "chance" and imagine them being given to someone. In (6) and (7) the use of "gave" indicates that John is transferring something away from himself without specifying a recipient.

Although these semantic extensions can sometimes be explained, in general it is difficult to guess what extension is being made. For example, in (5) the expression "gave in" indicates that John has surrendered possession rather than someone else necessarily taking possession. Generally these uses have become idiomatic, and a parser simply has to know the particular meanings.

Linguistic: I.B.1.b. Verb
I.B.2. Idiomatic phrases

Cognitive-psychological: I.B. Processing semantics
SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#13)

Lexical

Problem

(1) John asked Mary to marry him. He gave her a ring.
(2) John wanted to talk to Mary. He gave her a ring.

(Riesbeck, 1982, p. 41)

Discussion

These are examples of sentences that give lexically expectation-based systems a hard time, and show that expectations based on context are necessary for disambiguation as well. In the sentence "He gave her a ring," "ring" could be a phone call or a finger ring. Having expectations associated with "gave" does not help to resolve this ambiguity because each reading corresponds to a sense of "gave." In order to interpret the sentence "He gave her a ring," the context provided by the previous sentence needs to be invoked.

The problem with applying context, however, is recognizing when and how such information should be applied. In a novel there may be hundreds of previous sentences, each evoking its own context that could be applied to a case of lexical ambiguity. In the examples above, it should be noted that the second sentence is an enablement of the first sentence.

Linguistic: I.B.2. Idiomatic phrases

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#14)

Lexical

Problem

(1) There was renewed fighting today between Israeli and Syrian forces. Syrian soldiers fired mortars at Israeli positions in the Golan Heights.

(2) Bill fired clay pots at 300 degrees.
(3) The boss fired John at 3 this afternoon.
(4) The boss fired John at the company headquarters.

(1-3 from DeJong, 1982, pp. 163-164)

Discussion

These examples show ambiguity not just in the verb "fired" but in the preposition "at." As suggested by (1), a simple rule would be that "fired at" means "shot." But as (2) and (3) show, "at" can have other meanings than the target or direction of "fired"; the presence of an "at" phrase cannot be taken as evidence that in this case "fired" means "shot." As (4) shows, even restricting the object of "at" to a location does not allow us to distinguish between the possible meanings of "fired" as "shot" and as "terminated employment."

Linguistic: I.B.1.b. Verb
I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#15)

Lexical

Problem

The astronomer married a star.

(Waltz & Pollack, 1984, p. 338)

Discussion

When people read this utterance, they sometimes initially take "star" to mean a celestial body, giving the sentence a possibly humorous meaning. This is because the word "astronomer" activates an astronomy frame. The correct meaning of "star" as an actor or actress is reached only after the initial meaning is realized to be nonsensical.

In this exemplar we see that although a word may have specific associations within a particular frame, it is not always the case that these associations are realized when the frame is active. The parser must be able to alter a usual meaning to fit the situation of a particular sentence.

Linguistic: I.B.1.a. Noun

Cognitive-psychological: I.A.4.b.2. Frame or script-based: Indefinite reference
I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#16)

Lexical

Problem

Returned bombs to enemy ship.

(Granger, 1983, p. 194)

Discussion

In this sentence "returned" can mean "fired back at" or "gave back" (peaceably). This sentence can be disambiguated by considering the normal goals of actors. Military personnel do not normally turn over control of weapons to enemies. This assumption could be overridden by further context.

Linguistic: I.B.1.b. Verb

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#17)

Lexical

Problem

(1) The pen is in the box.
(2) The box is in the pen.

(Bar-Hillel, 1964, p. 175)

Discussion

The problem is how the word "pen" can be recognized as a writing implement in the first sentence, and a playpen or stockpen in the second. To do the disambiguation, the system has to realize the relation between the size and location of typical examples of the objects. If the system knows that typical examples of writing pens are small compared to typical boxes which in turn are small compared to typical playpens, it can make an informed guess about the meanings in each case.

Linguistic: I.B.1.a. Noun

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#18)

Lexical

Problem

(1) Have the students who were tardy take the exam.
(2) Have the students who were tardy taken the exam?

(Winograd, 1983, p. 369)

Discussion

The problem here is deciding whether "Have" is the main verb as in (1) or an auxiliary verb as in (2). The decision cannot be made until most of the sentence has been read and other components recognized. The noun phrase "the students who were tardy" can be the object as in (1) or the subject as in (2). Only when "take" or "taken" has been identified as the infinitive or past participle will "Have" be understood. The parser must be able to suspend the decision about "Have" and continue to parse other terms. In general, there is no a priori upper bound to how long the decision will have to be suspended.

Linguistic: I.A.5. Verb/Auxiliary
I.C.11. "Garden path" sentences

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#19)

Lexical

Problem

(1) He cut the roll.
(2) Look at this cut.

(1 from Cottrell, 1985, p. 209)

Discussion

The word "cut" can be either a verb, as in (1) above, or a noun, as in (2). The word "cut" also has several different meanings as a verb. It can mean dividing an object into more than one piece; it can mean failing to attend, as in "He cut class this morning." The word "roll" is ambiguous as well. It can be a verb, as in "roll the ball" or a noun, as in the sentence here.

Linguistic: I.A.1. Noun/verb
I.B.1.b. Verb

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#20)

Lexical

Problem

(1) The table rocks during the earthquake.
(2) The granite rocks during the earthquake.

(Lesmo & Torasso, 1985, p. 776)

Discussion

In both (1) and (2), "rocks" means that something is shaking back and forth. When people process (2), however, "rocks" is often first attached to "granite" as a noun and then changed to its verb meaning either when "during" is heard or when the end of the sentence is reached. The parser must be able to handle the ambiguity between the noun and verb meanings.

Linguistic: I.A.1. Noun/verb
I.C.1. Noun phrase structure
I.C.11. "Garden path" sentences

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#21)

Lexical

Problem

(1) What does it taste like?
(2) What taste does it like?

(Winograd, 1983, p.4)

Discussion

In (1) the speaker is requesting a comparison of flavors. In (2) the speaker is requesting information regarding some unknown taster's preference. The ambiguity in these examples comes from part-of-speech ambiguity. "Taste" can be a noun or a verb and "like" can be a verb or a preposition. Here the sentences are disambiguated by word order and syntactic structure since the two sentences have exactly the same words.

Linguistic: I.A.1. Noun/verb
I.A.6. Verb/preposition

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.1. (#22)

Lexical

Problem

I saw that gasoline can explode.

(Winograd, 1983, p. 93)

Discussion

This example is ambiguous due to the multiple parts of speech of "can." In one reading "can" is a noun, and the noun phrase "gasoline can" is the thing that is exploding. In the second reading, "can" (with the meaning "be able") is the modal auxiliary of the intransitive verb, so the meaning of the sentence is that gasoline is able to explode. There is no way without more context to determine which reading is correct, so a parser has to be able to produce both.

Linguistic: I.A.9. Demonstrative/complementizer
I.C.10. Syntactic ambiguity

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.2. (#1)

Attachment

Problem

John made his password secret.

(Gershman, 1982, p. 186)

Discussion

This sentence illustrates a problem in identifying noun groups. The word "secret" can be a noun or an adjective. The general rule for noun groups says that the adjectives come before the nouns. A simple interpretation would then be that the sentence refers to a "password secret" as a single item, as in "screwdriver handle." But the system very likely does not have knowledge of such a thing as a "password secret."

The correct interpretation can be derived from expectations based on "made." "Made" is polysemous and appears often in idioms and fixed phrases, but one sense is seen in the form "X made Y Z," meaning that "X changed the state of Y to Z" or "X gave Y the property Z." This sense matches the adjective use of "secret" and gives the correct sense of the sentence. If there is no such thing as a "password secret," this seems to be the only acceptable interpretation.

Linguistic: I.A.2. Noun/adjective
I.B.1.b. Verb
I.C.10. Syntactic ambiguity

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.2. (#2)

Attachment

Problem

(1) I heard an earthquake singing in the shower.
(2) I heard an earthquake sing in the shower.

(Wilks, 1975, p. 270)

Discussion

Even though (1) is ill-formed and should contain "while," semantic constraints which indicate that earthquakes do not sing nor do they take showers allows for the determination that the speaker is the one singing in the shower. If the string were "I heard an earthquake while singing in the shower," the proper vehicle for attachment would be in place and there would be no ambiguity.

In (2), it is not possible that "sing" is functioning as an adverb as "singing" is in (1). The only interpretation of "sing" is that the earthquake is singing. In this case, the semantic constraints on "earthquake" lead to the determination that the string is unacceptable because it makes no sense.

Linguistic: I.C.3. Participial modifier attachment
I.C.10. Syntactic ambiguity

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.2. (#3)

Attachment

Problem

(1) ...the old men and women...
(2) ...the old men and woman...
(3) ...the old men and their dogs...

(Winograd, 1983, p. 92)

Discussion

The problem in the first phrase is determining whether just the men are old, or both the men and women are old. In other words, does the adjective modify the whole conjunct (the old men and women) or just the noun immediately following (the old men and women).

Examples (2) and (3) show noun phrase conjunctions where the adjective attachment is not a problem. In "the old men and woman," the men are old and the woman is not. This is determined by the plural vs. singular in the conjunct. In parsing noun phrases, this type of distinction can be used to make the correct attachment. In "the old men and their dogs," the possessive pronoun is used to mark the dogs as belonging to the men. In this case there is no ambiguity.

Linguistic: I.C.1. Noun phrase structure
I.C.10. Syntactic ambiguity
III.F. Scope of modifier

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Ambiguity

Exemplar I.B.2. (#4)

Attachment

Problem

Blanche: Gracie! Where did you get all these lovely flowers?

Gracie: Well, George told me Betty was in the hospital and that I should go visit her and take her flowers. So, when she wasn't looking, I did!

(Riesbeck, 1982, p. 41)

Discussion

This exchange, taken from the George Burns and Gracie Allen television show, plays off the dual meaning of "take" and the dual interpretation of "her" in the phrase "take her flowers." The understanding of "take" that is expected is that Gracie should take flowers to Betty. This is what people usually do when they visit someone in the hospital. The reading that Gracie uses is to take the flowers from Betty. The ambiguity in the phrase is also a function of the attachment of "her." If "her" is the indirect object of the verb and "flowers" is the direct object, then we have the first reading. The second reading has "her" as a possessive on flowers, so "her flowers" is the direct object of the verb. Due to the context, this ambiguity is not noticed until Gracie makes it explicit.

There are two issues that this example raises: (a) not getting bogged down in resolving ambiguity when it first arises and (b) recognizing that the second reading is humorous. With the pervasiveness of ambiguity in natural language, selecting a reading and committing to it, while keeping other meanings available, should be done as the text is being read. The problem of recognizing humor in language is an open research area.

Linguistic: I.A.8. Pronoun/possessive pronoun
I.C.10. Syntactic ambiguity

Cognitive-psychological: I.C.7.a. Expectation: Of the speaker

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#1)

Prepositional phrase

Problem

(1) Joe bought the book that I had been trying to obtain for Susan.

(2) Joe bought the book that I had been trying to finish for Susan.

(3) The woman wanted the dress on that rack.
(4) The woman positioned the dress on that rack.
(5) The window dresser wanted the dress on that rack.

(1, 3, and 4 from Shieber, 1983, p. 700)

Discussion

In (1) the preferred attachment of "for Susan" is to "obtain" rather than to "bought," but in (2) it is to "bought." Because these sentences are identical except for the use of "bought" or "finish," the different attachments reflect differences in the subcategorization properties of these two words.

In (3) the preferred attachment of "on that rack" is to "dress," referring to the current location of the dress, but in (4) the preferred attachment is to "positioned" referring to where the woman put the dress. This difference may be a result of lexical differences between the verbs. However, as (5) shows, a change of role for the subject will change the preferred attachment even with the same verb and sentence structure (preferred attachment of "on that rack" to "wanted"). In speech, the attachment in (5) might be shown by stressing "that."

Linguistic: I.C.2. Prepositional phrase attachment
I.C.10. Syntactic ambiguity

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#2)

Prepositional phrase

Problem

(1) John bought the book which I had selected for Mary.
(2) John bought the book which I had selected at a lower price.

(Lesmo & Torasso, 1985, p. 775)

Discussion

In (1) the preferred attachment of the prepositional phrase "for Mary" is to "selected." Example (1) is taken to mean that the book that John bought was the same one that I had selected for Mary.

In (2) the preferred attachment of the prepositional phrase "at a lower price" is to "bought." Example (2) is taken to mean that John bought the same book I did, but he paid a lower price. In this case, the semantics of the expressions involved is more important than adjacency in determining the preferred attachment.

Linguistic: I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#3)

Prepositional phrase

Problem

John saw the child on a hill with a telescope.

Discussion

There are several possible interpretations of this sentence which correspond to several possible attachments of "with a telescope." Was the telescope the instrument of seeing? Was it with the child? Or does "with a telescope" modify hill, thereby distinguishing this hill from another? Normally these multiple possibilities are resolved by context. In order to do this, a parser must be able to apply existing context, or it must be able to retain the multiple possibilities until enough context appears. Tomita (1985) discusses a parser that deals with this kind of ambiguity.

Linguistic: I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.C.1.b. Context: Non-military
I.C.9. Point of view of the speaker

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#4)

Prepositional phrase

Problem

(1) Ross drove to town with reckless abandon.
(2) Ross drove to town with Nadia.

(Hirst & Charniak, 1982, p. 95)

Discussion

In (1) "reckless abandon" is an instance of the manner case of "drove." It further specifies the type of driving done. In (2) "Nadia" is an instance of the accompanier case of "drove." It further specifies who was riding in the car. Both are introduced with the preposition "with." An understander must be able to use semantic knowledge to resolve the ambiguity.

Linguistic: III.A. Semantic case role

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#5)

Prepositional phrase

Problem

(1) I hit John in the park.
(2) I hit John on the nose.
(3) I hit John in the stomach.
(4) I hit John on the beach.

(1 and 2 from Schank, 1980, p. 245)

Discussion

To understand these sentences, it is necessary to have semantic information about the object of the preposition.

In (1) the prepositional phrase provides the location where the hitting action took place.

In (2) the prepositional phrase describes the location that was hit. But the preposition used is not sufficient to determine this. Consider (3) and (4).

Example 3 describes the object that was hit, using the same preposition "in" that was used in (1) to describe the action's location.

Example 4 describes the location, using the same preposition "on" that was used in (2) to describe the object that was hit.

Syntactic information is not sufficient to understand the action's object and location. To understand the simple sentences above, the parser must be able to discriminate between locations on the body and spatial locations where a fight can take place. This can be done by accessing semantic information through the lexicon.

Linguistic: I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#6)

Prepositional phrase

Problem

(1) I read a story about evolution in ten minutes.
(2) I read a story about evolution in the last million years.

(Allen, 1987, p. 315)

Discussion

These sentences illustrate the problem of identifying the attachment of a prepositional phrase. In (1) the phrase "in ten minutes" refers to the time spent reading, and in (2), the phrase "in the last million years" refers to the time over which the evolution took place. This is a form of disambiguation and, in this case, it cannot be done on syntactic grounds. The system needs information about the typical time scales for events like reading and evolution to choose the correct attachment.

Linguistic: I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#7)

Prepositional phrase

Problem

(1) John went to Boston.
(2) John Doe of General Motors...
(3) John broke the window with a hammer.
(4) John dined to the sound of his favorite record.

(Gershman, 1982, p. 189)

Discussion

These examples illustrate four ways that prepositional phrases can relate to the rest of the sentence.

In (1) the phrase is predicted by the expectations associated with the verb.

In (2) the phrase appears as a modifier of the noun phrase.

In (3) the phrase provides an optional instrumentality for the action.

In (4) the phrase describes the environment in which the event described by the rest of the sentence is embedded.

The problem is in deciding which of these usages is appropriate for each sentence.

Linguistic: I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#8)

Prepositional phrase

Problem

The execution of convicted murderers...

(Gershman, 1982, p. 189)

Discussion

Prepositional phrases are not restricted to modifying full clauses. In this example, the prepositional phrase "of convicted murderers" is attached to "execution." In this case, "execution" includes an expectation that the victim will be referred to by an "of" prepositional phrase.

Linguistic: I.C.1. Noun phrase structure
I.C.2. Prepositional phrase attachment

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.1. (#9)

Prepositional phrase

Problem

(1) John was at the top of the mountain.
(2) The President of Uruguay...
(3) John Doe of General Motors...

(Gershman, 1982, p. 190)

Discussion

The problem in these examples is to determine the relationship between the "of" phrases and the noun being modified. Words like "top" or "president" normally expect an "of" phrase to follow. Top of what? President of what? The expected phrase has an expected relation to the noun. "President of X" refers to a top executive of X.

In other cases the "of" phrase is unexpected. When reading "X of Y" where X is a person and Y is an organization, the parser must use more general heuristics to guess the relationship between them, e.g., "John Doe" and "General Motors."

Linguistic: III.H. Genitive phrase

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.2. (#1)

Other

Problem

(1) John saw the Grand Canyon flying to New York.
(2) The boy who hit Mary ran away.
(3) John gave Mary a book describing Persian rugs.

(Gershman, 1982, pp. 192-193)

Discussion

Gershman identifies three problems in handling participial phrases and relative clauses as postnominal modifiers: (a) finding the concept that the phrase is modifying, for example, in (1), finding that "flying to New York" modifies "John" (or more accurately the verb "saw") rather than "the Grand Canyon," (b) organizing the processing of the modifier, for example the sentence "The boy hit Mary" and the relative clause of (2) should be handled in the same way, and (c) determining where the modifying construction ends and the higher level construction continues. The third problem is illustrated by contrasting the second and third sentences. In (2), "ran away" is a continuation of the higher level construction, whereas, in (3), "describing Persian rugs" is a modifier of "a book."

Linguistic: I.C.3. Participial modifier attachment

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Modifier Attachment

Exemplar I.C.2. (#2)

Other

Problem

(1) The statement that the election which he lost ended his career dismays him.

(2) The only one who the fact that George resigned pleased was Tom.

(Blank, 1985, p. 752)

Discussion

The problem with these sentences is in recognizing that the ending verb phrase attaches to the beginning noun phrase, not to the embedded noun phrase. In (1) what "dismays him" is "the statement," not the "election which he lost." Other incorrect candidates for attachment include "the election" and "his career." In (2) the phrase "was Tom" connects to the phrase "The only one"; "the fact" and "George" should not have the phrase attached to them.

Linguistic: I.C.9. Complex sentence structure

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#1)

Anaphoric

Problem

(1) Arthur wants to see him.
(2) Arthur wants to see himself.
(3) Arthur wants somebody to see him.

(Winograd, 1973, p. 153)

Discussion

In (1) "him" refers to somebody other than Arthur. We can resolve this referent from syntactic information. Most verbs are preceded by the actor of the action and followed by the object, which is usually assumed to be someone else unless the object is reflexive. If a reflexive pronoun is used, such as "himself" in (2), we know the action's actor and the object are the same. Syntactic information is not always sufficient to resolve pronouns, however. In (3), from a syntactic perspective, the pronoun "him," because it occurs in an embedded clause, might or might not refer to Arthur. In this case, semantic information outside the sentence is needed to resolve the reference.

Linguistic: III.B.1.a. Reference within the clause

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#2)

Anaphoric

Problem

We were afraid the milk might make the baby sick, so we boiled it.

(Waltz, 1982b, p. 26)

Discussion

In this example, "it," from a syntactic perspective, can refer to either the baby or the milk. Resolving the reference requires making a plausibility judgment based on common sense knowledge. If the system simply chose the most recent possible reference it would give the wrong answer.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#3)

Anaphoric

Problem

(1) More students flunked than thought they would.
(2) More students flunked than they thought would.

(Winograd, 1983, p. 185)

Discussion

In the examples above, the problem is to resolve the reference of "they." In (1) "they" refers to a subset of the students who took the test. In (2) "they" refers to people other than the students, perhaps the teachers. Explaining this resolution depends on understanding the use of ellipsis and a complex set of references to groups of the students. The comparison in (1) is between the subset of the students who flunked and the subset of students who expected to flunk. In (2) it is between the subset who flunked and the subset who someone else expected would flunk. These subsets have to be created and the references resolved.

Note: For further discussion of the problems of ellipsis in the examples above see Exemplar I.F. (#4).

Linguistic: III.B.1.b. Quantified noun phrase referent
III.C. Ellipsis

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#4)

Anaphoric

Problem

(1) As I swung the hammer at the nail, the head flew off.
(2) As I hit the nail with the hammer, the head came off.

(1 from Allen, 1987, p. 315)

Discussion

In these sentences, "the head" could refer to the head of either the hammer or the nail. But the head of the nail is unlikely to fly off while the hammer is being swung. Therefore, in (1), "head" probably refers to the hammer. Example (2) is less clear. The impact of the hammer on the nail could cause either part to break. However, since(2) says "came off," "the head" here probably refers to the head of the nail since the head of the hammer coming off would be more aptly described using a dynamic verb such as "flew off." The system needs to have knowledge about typical structure and behavior of the tools and perhaps some naive physics to make this resolution.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: I.C.6.b.7.a. Cause and effect

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#5)

Anaphoric

Problem

When we entered the kitchen, we noticed that the stove had been left on.

(Allen, 1987, p. 346)

Discussion

In this case, the system needs to know about things found in, or associated with, possible referents. This requires that a reference to "kitchen" make available rather extensive knowledge about kitchens, either by including the knowledge in some form of working memory or by including a pointer to a larger knowledge base. The system must be prepared to search this knowledge when locating "the stove."

Note: See Exemplar I.D.1. (#6) for discussion of a similar problem.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#6)

Anaphoric

Problem

When we entered the kitchen, we saw that the gas had been left on.

(Allen, 1987, p. 347)

Discussion

This example shows the difficulty of any simple approach to reference resolution. The "gas" does not refer to kitchen as a whole, but only to the stove. To handle this example, the system needs to have extensive knowledge of kitchens and of the components and functions of all of the objects associated with kitchens. This raises the possibility of combinatorial explosion. If some other element of a kitchen could be powered by gas, the system might have to consider all the possibilities and choose the most likely reference.

Note: See Exemplar I.D.1. (#5) for discussion of a similar problem.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#7)

Anaphoric

Problem

Sam and Bill wanted to take the girls to the movies, but they didn't have any money.

(Winograd, 1973, p.153)

Discussion

In the sentence above, "they" refers to Sam and Bill. Why doesn't it refer to the girls? Understanding this referent requires cultural knowledge. A person who takes another person to the movies is usually expected to pay. One enablement of the goal of taking someone to the movies is having enough money to pay for the tickets and perhaps for a snack and transportation as well. Other enablements might be that the other person wants to go, that it is possible to get to the movies from wherever the people are, that there is a movie being shown, and so on. From this knowledge, "they" is understood to refer to the ones needing money to pay for the movies, in this case, Sam and Bill.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: I.C.2.e. World knowledge: Cultural

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#8)

Anaphoric

Problem

The city councilmen refused the women a permit because
(1) they feared violence.
(2) they advocated revolution.
(3) they were Communist.

(1 and 2 are discussed in Winograd, 1972, p. 33 and Waltz, 1982b, p. 14; (3) was discussed by Pylyshyn in a talk to the Cognitive Science Society, August 1986.)

Discussion

These examples illustrate the problem of resolving pronoun references using world knowledge. In (1) "they" refers to the city council, and in (2) "they" refers to the women. The sentences are structurally identical, so the disambiguation depends on applying common sense knowledge about who "feared violence" and who "advocated revolution." The disambiguation cannot be done until the complete clause is parsed; what "they" are doing is a necessary component of finding the referent. This world knowledge must be shared by the speaker and the listener. According to Pylyshyn, (3) was used in a talk in Italy where the City Council was predominantly Communist. The example was puzzling to most of the listeners.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.1. (#9)

Anaphoric

Problem

The soldiers fired at the women and several of them fell.

(Wilks, 1975, p. 265)

Discussion

To whom does "them" refer, the soldiers or the women? Most readers take "them" to refer to the women. Why? Because they infer that when someone is shot, he falls, and the soldiers did the shooting, so it must be the women that fell. Knowledge of the effects of shooting is needed to resolve this pronoun reference. Notice that this is not knowledge associated with the individual words but instead general world knowledge associated with the action being described.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

Reference

Exemplar I.D.2. (#1)

Non-anaphoric

Problem

(1) ...the long-haired Swede who does not shave during the course of the Wimbledon.

(2) ...the world's best tennis player.

(Nadathur & Joshi, 1983, p. 603)

Discussion

Both of the phrases above are used to refer to Bjorn Borg. To recognize the referent, it is necessary to apply considerable real-world knowledge (in this case, knowledge about Bjorn Borg's personal habits and his proficiency at his job).

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: I.C.2.b. World knowledge: MOPs

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.2. (#2)

Non-anaphoric

Problem

...the woman with the martini...

(Waltz, 1982b, p. 23; Perrault and Cohen, 1981, p. 222)

Discussion

Using this definite description poses problems depending on the knowledge state of the speaker and hearer. If the woman has traded her martini for water, or, worse yet, has her martini glass filled with water, and only one of the speaker and hearer knows this, then how can the correct reference be made? This example points out problems with reference between speaker and hearer, where each has different beliefs about (a) the context and (b) what their conversational participant knows. An approach to this problem is for the system to keep a model of the person (or user) it is conversing with separate from the model of the world. In this way differences between the participant's beliefs and the system's beliefs can be distinguished.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: I.C.5. Model used by the speaker

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.2. (#3)

Non-anaphoric

Problem

(1) I want to meet the chairman of Chrysler.
(2) I want to be the chairman of Chrysler.
(3) I want to be the Newton of AI.

(adapted from Allen, 1987 p. 355)

Discussion

Resolving definite references requires that the system distinguish between referential and attributive uses. In (1) "the chairman of Chrysler" refers to the current holder of that position, presently Lee Iacocca. But in (2), the speaker does not want to be Iacocca but rather to hold the job Iacocca holds.

In (1) "the chairman of Chrysler" is said to be referential because it refers to a specific object. In (2) it is said to be attributive because it describes a characteristic or set of characteristics. In (3) the use is metaphorical, referring to the historical role that Newton played in physics rather than any particular job Newton held. For example, it does not mean that the speaker wants to be the AI equivalent of the director of the mint in England.

Recognizing the reference in the above cases requires that the system be able to process several levels of abstraction, and especially for (3), to access world knowledge.

Linguistic: III.B.2.d. Definite noun phrase reference: Other
III.N.1. Metaphor

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.2. (#4)

Non-anaphoric

Problem

(1) I own a dog. It has brown fur.
(2) I don't own a dog. It has brown fur.
(3) I didn't see a man leave a bag.
(4) I don't own a dog. It was stolen.

(2-4 from Allen, 1987, pp. 355-356)

Discussion

Normally, a reference to an object, like "dog" in (1), would cause the system to create a corresponding object in working memory. The attempted reference of "it" in (2) should fail because there is no such dog. But it is very difficult to make a general rule for these cases.

Sentence (3) could reasonably be followed by "but I heard it," "It was a woman who left it," "He left a box," "but Jill saw him," "But I saw a man take one," or even, "But I see him doing it now." The only thing being denied is the conjunction of all the components. And as (4) shows, sometimes the denied object can be referred to later under some circumstances.

Linguistic: III.B.1.b. Quantified noun phrase referent

Cognitive-psychological: I.B. Processing semantics

Reference

Exemplar I.D.2. (#5)

Non-anaphoric

Problem

(1) Lions are dangerous.

(2) Ants are one of our most durable life forms. They can live in highly radioactive areas without problem.

(3) The ant is one of our most durable life forms. It can live in highly radioactive areas without problem.

(4) Each boy received a model airplane. They are always good presents for 10-year-olds.

(Allen, 1987, p. 356)

Discussion

In (1) the reference is not to the set of all lions. Many lions might be tame. Rather, (1) creates a reference to a generic or prototype lion and describes a stereotypical feature for the generic lion. As (2) and (3) show, the generic type can be created by singular definite or plural indefinite reference and can be referred to by the appropriate singular or plural pronoun.

As (4) shows, the generic class can be created by a specific reference. The model airplanes mentioned in the first sentence are the specific set given to the boys. The generic class can then be referred to later. The difficulty is in recognizing that either "it" or "they" is referring to the prototype and not to any specific object or objects. In (4) "they" refers to the generic model airplanes, not just the ones given to the boys.

Linguistic: III.B.1.c. Generic noun phrase referent

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.2. (#6)

Non-anaphoric

Problem

(1) At the party, after each boy receives a present, he has to go to the owner and thank him before he can open it.

(2) Each boy received a model airplane. They then took the planes out to the field to try them out.

(3) Each boy received a model airplane. They are always good presents for 10-year-olds.

(Allen, 1987, p. 356)

Discussion

In (1) the phrase "after each boy receives a present" introduces a set of boy-present pairs, with the phrase "each boy" representing a variable ranging over the set of boys. The system has to create these sets and then has to recognize not only that both uses of "he" refer to that variable, but that "it" refers to the present corresponding to the "boy" variable.

In (2) "they" refers directly to the set of boys created by the first sentence. In (3) "they" refers not to the set of airplanes created in the first sentence but to a generic instance of these airplanes.

The parser must be prepared to deal with references of the types discussed above.

Linguistic: III.B.1.b. Quantified noun phrase referent
III.B.1.c. Generic noun phrase referent

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.3. (#1)

Distinguishing anaphoric from non-anaphoric reference

Problem

(1) Fred was discussing an interesting book in his class. He is friendly with the author.

(2) Fred was discussing an interesting book in his class. He is friendly with an author.

(Bien, 1983, p. 677)

Discussion

In (1), "the author" refers to the author of the "interesting book" mentioned in the first sentence. But in (2), "an author" refers to the author of some other book. The first use of "author" is anaphoric as indicated by the use of the definite article and should be resolved by looking for possible authors already referred to. In this case, the reference is indirect through the mention of book. The second use is non-anaphoric as indicated by the use of the indefinite article. In this case, the understander, person or parser, should create a new instance of an author. The word "author" is used differently, depending on the article preceding it, and the understander has to be sensitive to these differences.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: I.C.2.b. World knowledge: MOPs

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.3. (#2)

Distinguishing anaphoric from non-anaphoric reference

Problem

(1) We are leaving for the city.
(2) We are leaving for a city.

(Winograd, 1983, p. 4)

Discussion

Use of a definite or indefinite article can indicate whether or not the speaker believes the listener knows the object being referred to. In the first example, by referring to the place that they are leaving for as "the city," the speaker implies that the specific city is supposed to be known to the listener of the sentence, and that the speaker wants the listener to keep the city in mind. In contrast, saying "a city" implies that the speaker thinks that there is no reason to specify the city for the listener.

When a parser encounters a definite reference, it has to try and find what is being referenced. A definite reference can be resolved as a conventional usage, such as "the City" for San Francisco or New York, or as something available from context. The indefinite article might imply a generalized version of the object being referenced. The parser needs to know whether to search among its known objects or to create a new object.

Linguistic: III.B.2.b. Discourse context relevant for interpretation

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.3. (#3)

Distinguishing anaphoric from non-anaphoric reference

Problem

(1) Rocky was shot to death by the policeman.
(2) Rocky was shot to death by a policeman.

Discussion

One use of definite and indefinite articles is to distinguish between a general and specific class member. Consider the set of sentences as the first sentences of a story. When Rocky is shot by "a policeman," it is a general policeman who will not be a character in the story. The indefinite article identifies the policeman as nothing more than an instance of the role, rather than an actual reference to a person. On the other hand, the use of the definite reference identifies "the policeman" as the person who shot Rocky. There is a particular policeman in the story who can be referred to later.

Linguistic: III.B.2.b. Discourse context relevant for interpretation

Cognitive-psychological: I.B. Processing semantics

Reference

Exemplar I.D.3. (#4)

Distinguishing anaphoric from non-anaphoric reference

Problem

(1) Fred was discussing an interesting book in his class. I went to discuss a book with him afterwards.

(2) Fred was discussing an interesting book in his class. I went to discuss a book with him afterwards. It appeared later to be the same book.

(Bien, 1983, p. 677)

Discussion

The customary use of the indefinite article is to introduce a new topic. Thus, the reference to "a book" in (1) would normally be taken to refer to a different book than the "interesting book" already referred to, and the system would likely create a new object in its database. But as (2) shows, subsequent information might indicate that what was thought to be two books might be one book after all. What appeared to be non-anaphoric reference might actually be anaphoric. The system must be prepared to reconcile multiple, apparently distinct, references to an object.

Linguistic: III.B.2.b. Discourse context relevant for interpretation

Cognitive-psychological: II.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Reference

Exemplar I.D.4. (#1)

Temporal

Problem

John was leaving on Thursday yesterday.

(Grover, 1982, p. 91)

Discussion

"Thursday" refers to when John was planning to leave. "Yesterday" refers to the time when the knowledge about John's departure date was acquired. To arrive at this meaning, it is necessary to understand the referents of temporal relationships. The parser must be able to manipulate multiple time intervals, vague event durations, and the pragmatic significance of the past progressive.

Linguistic: I.C.2. Prepositional phrase attachment
III.I. Temporal relations, causation

Cognitive-psychological: I.C.6.b.2.d. Denotation: Time

Reference

Exemplar I.D.4. (#2)

Temporal

Problem

(1) John said a week ago that Mary will leave in 3 days.
(2) John said a week ago that Mary would leave in 3 days.

(Yip, 1985, p. 809)

Discussion

Each of these utterances is understood only when Mary's supposed departure date has been computed. In (1), Mary will leave three days from now. In (2), Mary was expected to have left four days ago (three days after the time at which John was speaking). An understander must know enough about the use of tenses to make the correct inferences.

Linguistic: III.I. Temporal relation, causation

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#1)

Problem

Can you connect a video disk drive to the two megabytes?

(Carbonell & Hayes, 1983, p. 129)

Discussion

In this case the user intends "the two megabytes" to mean "the computer with two megabytes of memory." This sort of substitution is very common and is often not even seen by the speaker as an error. In time these uses often lose their "metaphorical" quality and become standard. There are systematic principles for metonymic reference and a knowledgeable understander should be able to make a connection between "two megabytes" and the corresponding computer. The difficulty arises in knowing just how far back to follow the association links. Should "two megabytes" stand for the memory, the computer with the memory, or the system of which the computer is a part? Often, these distinctions will be unimportant but the system might still require extensive domain knowledge to make that decision. In more complicated cases, the system might have to query the user to resolve ambiguities.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.3.a. Domain specific knowledge: Technical

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#2)

Problem

(1) The car drank gasoline and purred to itself.
(2) The car drank gasoline and the taxi diesel.

(Fass & Wilks, 1983, pp. 184-185)

Discussion

In processing the first clause of (1), "car" does not satisfy the selectional restrictions on the usual meaning of "drink." Extending "car" metaphorically will allow the parser to handle both clauses in (1). However, it leaves a problem with (2) where a separate extension has to be done for "taxi." Processing (2) can be better handled by relaxing the selectional restriction on "drink." This approach is less satisfactory for (1). These examples show the importance of a good knowledge base, conceptually organized, for understanding semantic extensions.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#3)

Problem

A stack is an ordered list in which all insertions and deletions occur at one end called the top.

(Weischedel, 1983, p. 424)

Discussion

The sentence above is adding information by defining a new meaning for the word "stack" as a special kind of list. Presumably, the system already understands the notions "list," insertion," and "deletion." Understanding the reference to "at one end" requires that the system not only has the literal description of the list (as some kind of data structure), but also somehow understands the "list as a linear structure" metaphor. Understanding the metaphorical use means the understander must be able to recognize the use of this metaphor and understand how it applies to the rest of the objects in the sentence.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#4)

Problem

(1) You can kill a process by typing control C.
(2) You can get into lisp by typing "lisp" to the shell.
(3) To leave the mail program, type "exit."
(4) Run a file through the spell program to check for spelling mistakes.

(Martin, 1986, pp. 728-729)

Discussion

All four of these examples contain metaphorical uses of familiar words. For example, a process cannot be literally "killed." In (1), "kill" means to stop a process from running. This kind of metaphor is used very often in evolving domains and an understander cannot always be expected to possess all metaphors it will encounter. Instead the understander must be able to recognize the novel use of a metaphor from its knowledge of the literal meaning of the word and the context in which the word is being used.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#5)

Problem

(1) John ate up all the food.
(2) John ate up the compliments.
(3) Robbie's legs ate up the space between him and Susie.

(2 and 3 from Waltz, 1982a, p. 86)

Discussion

The word "ate" means to consume food; "ate up" implies avidity and thoroughness as in (1). However, in both (2) and (3) "ate up" is extended to objects other than food by extending aspects of its use in (1). In (2), the implication is still one of eager taking in, but in this case it is of compliments, rather than food. In (3), "ate up" implies a thorough consumption not of food but of space. For a system to understand these metaphorical uses, it must have access to knowledge about these related aspects of the phrase and be able to generalize meanings in one or more of these dimensions.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#6)

Problem

(1) Bow Valley jumped 2 1/2 to 25.
(2) Rio Algom eased 1/2 to close at 39 1/2.
(3) Abitibi was up sharply, gaining 5 to 49 1/4.

(Kittredge & Mel'cuk, 1983, p. 658)

Discussion

All of the sentences above describe the change in the value of an object, in this case, a share of stock in a company. All involve using verb forms ("jumped," "eased," "gaining") in a metaphorical sense to describe changes in the values of stock prices. Further, the metaphor of price must be understood to follow a vertical scale, with energy being needed to move upwards, which explains why "jumped" means increased and "eased" means decreased. Finally, these sentences are only understood when a representation of the stock's new value and its change from the old value has been computed.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#7)

Problem

(1) Big as a barn.
(2) Sly as a fox.
(3) Dry as a bone.

(Waltz, 1982b, p. 16)

Discussion

Understanding metaphor in natural language is often a problem of finding an analogy between the two items being compared. In these examples, a degree of an attribute (big, sly, and dry) is being described by reference to another object.

One approach to understanding these similes is to try to make the analogy, as a system would have to do for novel metaphoric usage. In the first case, we might reason that barns are large compared to other buildings, so anything that is "Big as a barn" would have to be large relative to other members of the class being compared.

A second approach is to list these similes as multi-word entries or phrases in the lexicon with the metaphoric meaning explicitly given. This approach is especially useful when metaphoric meanings are not readily apparent, such as "Sly as a fox."

Linguistic: III.N.2. Simile

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#8)

Problem

The thought escaped me like a squirrel darting behind a tree.

(Waltz, 1982b, p. 24; from Ortony, 1975, p.49)

Discussion

In the sentence above, the disappearance of thought is being described in relation to the actions of a squirrel. This metaphor is quite specific: it focuses on one possible action of the squirrel (darting behind a tree) and not many possible others (cracking a nut, chasing another squirrel, etc.). Because the relation between thought and squirrel is not extended to multiple characteristics of thoughts and squirrels but instead focuses on a single characteristic of each--the disappearance of thought and the darting of squirrel behind a tree--Waltz refers to this example as a "small metaphor" (contrast with "large metaphor" in exemplar I.E.9). Note that there is no way to talk about thought other than metaphorically. Even to say that a thought "escapes" is a metaphor since we have no literal language to describe what thoughts actually do other than perhaps the language of brain neurology.

Small metaphors are pervasive in language use, but they are very difficult to make sense of using only the linguistic data in the sentence. The understanding of an analogy involving even a specific event, like a squirrel darting behind a tree, is difficult even though substantial world knowledge may be available. In this example, we are supposed to think that the thought was present and then went away quickly, not that the thought had a long furry tail still visible or that the thought was terrified or hiding from a pursuer.

Linguistic: III.N.2. Simile

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#9)

Problem

Nationwide inflationary pressure coupled with a draining of resources from the southeastern states by private enterprise has frustrated efforts of the local governments to fight poverty in these states.

Discussion

In Waltz' terms, a "large metaphor" is an encompassing structural mapping between two domains (Waltz, 1982b, p. 24). In the hydraulic metaphor for economics, money is analogous to water: it flows from place to place, is stored in reservoirs, builds up pressure, etc. Economic processes are difficult to conceptualize since there are no concrete objects to attach to the processes being described. Many of the ways of talking about these concepts are borrowed from liquid processes. The analogy can be used instructively by applying words from the liquid domain. These words give the reader a way of understanding the abstract concepts. Understanding words like "flow" and "pressure" in an economic discussion requires making the structural mapping and applying the mapping to economic objects and relations.

Linguistic: III.N.1. Metaphor

Cognitive-psychological: I.C.3.b. Domain specific knowledge: Everyday

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#10)

Problem

Enemy scudded bombs at us.

(Granger, 1983, p. 193)

Discussion

Often in casual usage, people use unusual or idiosyncratic words. In many cases the system will be able to guess from context a likely meaning for the word. In this case, the combination of "enemy," "bombs" (weapons), and "at" suggests that "scudded" means that bombs were fired or otherwise thrown.

Linguistic: IV.H. Novel usage

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#11)

Problem

(1) John picked up the foobaz.
(2) John wrote with a foobaz.
(3) John used an ink foobaz.

(Keirsey, 1982, p.99)

Discussion

After reading the three sentences above, it should be clear that "foobaz" is a synonym for pen. However, none of the individual sentences alone provides enough information for us to draw this conclusion. Sentence (1) suggests a "foobaz" could be any object. In both (1) and (2), John could have picked up and written with any writing implement, e.g., a pencil. In sentence (3), a "foobaz" could be a blotter. As an understander reads these sentences, the meaning of "foobaz" must gradually be refined from some object, to some writing implement, to a pen.

Linguistic: IV.H. Novel usage/inventions

Cognitive-psychological: I.C.6.b.5.b. Combine attributes

SINGLE-UTTERANCE ISSUES

Metaphor and Novel Language

Exemplar I.E. (#12)

Problem

Native: Remember the story of David and Goliath? David took on Goliath.

(Zernik, 1985, p. 171)

Discussion

Suppose that a listener is familiar with "take" and "on" but has never heard the phrase "take on." In this case, the reference is clearly to some event in the David and Goliath story. Suppose the following dialogue takes place.

Learner: David took Goliath somewhere?
Native: No. David took on Goliath.
Learner: He took on him. He won the fight?
Native: No. He took him on. David attacked him.
Learner: He took him on. He accepted the challenge?
Native: Right.

The Learner begins by assuming that "took" is the most important word and ignores "on." But when this strategy fails (as indicated by the Native's "no"), the Learner begins to look for aspects of the story to suggest possible new meanings. For example, David's defeat of Goliath is an important aspect of the story, so the Learner might guess that "take on" might mean defeat. By the end of the exchange, the Learner has acquired the meaning of this phrase and used it to understand the original sentence.

Another approach to the problem would be to add the phrasal verb "take on" to the lexicon.

Linguistic: I.C.4. Phrasal verb structure

Cognitive-psychological: I.C.6.b.8.b. Explanation

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#1)

Problem

(1) Load, read, and rewind the tape in that order.
(2) Metaphorically speaking, John's ideas are out of this world.

(Hayes & Carbonell, 1983, p.668)

Discussion

The prepositional phrase "in that order" is meant to suggest a correspondence between the order of the lexical items preceding it in the sentence and the order in which they are to be executed. The phrase "metaphorically speaking" is meant to suggest that "out of this world" is not to be taken literally. Both of these phrases are metalinguistic utterances; they refer to how the sentence should be interpreted by the reader.

Linguistic: III.Q. Metalanguage

Cognitive-psychological: I.C.6.b.6. Instruction

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#2)

Problem

(1) George kicked the ball.
(2) The ball was kicked by George.

Discussion

The noun phrases "George" and "the ball" in the sentences above have the semantic roles of actor and object experiencing the action (hereafter referred to as object) respectively. Generally in English, the noun phrase that functions as actor is the grammatical subject of a sentence and occurs first in the sentence; the usual word order is actor before object. But systematic exceptions to this word order occur in passive sentences.

A parser must be able to identify the semantic roles of the noun phrases in a sentence as either actor or object. Identification of roles based on the sequential order of actor before object works well in most cases but will fail for passive sentences. In the active sentence (1) above, the actor "George" precedes the object "ball," but in the passive sentence (2) the order of actor and object is reversed.

One way the parser can handle passives is to recognize them by the syntactic pattern they present. When a sentence is identified as passive, the parser will know (1) that the usual semantic role order is reversed: the object noun phrase precedes the actor noun phrase, if the actor noun phrase occurs at all, and (2) that the object rather than the actor is the grammatical subject of the sentence.

Linguistic: I.C.5. Passive
III.A. Semantic case role

Cognitive-psychological: I.A. Processing syntax

Other

Exemplar I.F. (#3)

Problem

Bill, I've been asked to clarify the enclosed letter.

(Jensen, Heidorn, Miller, and Ravin, 1983, p. 151)

Discussion

The word "Bill" could be inserted in many places in the sentence above. It would be unreasonable to write grammar rules that match each possible insertion point. The parser needs to understand the rest of the sentence and then see "Bill" as a possible addressee. This requires a relaxed parsing where constituents, whose roles are not at first apparent, can be saved and analyzed as the parse proceeds.

Linguistic: I.C.8. Vocative

Cognitive-psychological: I.B. Processing semantics

Other

Exemplar I.F. (#4)

Problem

(1) More students flunked than thought they would.
(2) More students flunked than they thought would.
*(3) More students flunked than the instructor thought they would.

(Winograd, 1983, p. 185)

Discussion

In the sentences above, various elements are omitted from the subordinate clauses introduced by "than." The clauses in which the ellipsis is grammatical follow a regular pattern of composition: either the subject of "thought" is omitted or the subject of "would [flunk]" is omitted. When neither is omitted, as in (3), the sentence is ungrammatical.

Although the sentences above show a regular pattern of ellipsis, there is no general theory of ellipsis that explains both these particular patterns and patterns in other elliptical sentences. Without such a general theory of ellipsis, the parser must use specific regularities, such as those noted above, to analyze each type of ellipsis independently.

Note: Examples (1) and (2) also present problems of anaphoric reference. For a discussion see Exemplar I.D.1. (#3).

Linguistic: III.B.1.b. Quantified noun phrase referent
III.C. Ellipsis
III.G. Comparative constructions

Cognitive-psychological: I.B. Processing semantics

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#5)

Problem

The impact of transformational grammar on modern linguistics cannot be underestimated.

(Riesbeck, 1982, p. 50)

Discussion

The interesting thing about this example is the contrast between the way it is usually read and what it actually says. The intent of the sentence, as uttered by a careless speaker, is to say that transformational grammar has had a great impact on linguistics. However, if the impact cannot be underestimated, it means that there was no impact on modern linguistics. This sentence seems to be a blend of "cannot be overestimated" and "should not be underestimated."

Should a system that reads text like this read it as a human does, getting the intended meaning, or read more mechanically, and get the literal reading? Should the system be puzzled by this usage, figure out what the author meant to say, and continue? These types of questions are outside the scope of traditional linguistics, but can be expected to arise when natural language systems meet the real world.

Linguistic: IV.G. Unclear goal

Cognitive-psychological: I.C.6.b.8.d. Implication

Exemplar I.F. (#6)

Problem

(1) John Doe was arrested last Sunday morning after holding up the New Haven Savings Bank.

(2) A man entered the New Haven Savings Bank about 10:00 a.m. Saturday morning and demanded that a teller fill a shopping bag with money. According to witnesses, the suspect took the money to a parked car and drove off. He was caught only minutes later, however. John Doe is being held at the police station in lieu of $50,000.

(3) Police apprehended John Doe, a suspected bank robber, in a drugstore in downtown New Haven. Doe was taken to the New Haven police station where he is being held in lieu of $50,000 bond.

(DeJong, 1982, p. 159)

Discussion

The examples above illustrate different ways that a crime and arrest scenario may be described. In (1) the arrest is specifically mentioned. The arrest context then allows the reader to disambiguate "holding up" as describing a robbery. In (2) there is no specific word that indicates either a crime or an arrest. The reader must infer the crime from the actions described so that "caught" is understood to mean "arrested." In (3) the arrest is mentioned specifically, but the crime is only indirectly referred to with no details given.

Context is often important for disambiguating semantic and syntactic ambiguity. To use context, the parser has to be able to recognize contexts and to tell when a context is being activated and deactivated.

Linguistic: I.B.1.b. Verb

Cognitive-psychological: I.C.2.a.1. Scripts: Single

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#7)

Problem

Good luck to you and yours and I wish you the VERY best in your future efforts.

(Jensen, Heidorn, Miller, and Ravin, 1983, p. 150)

Discussion

The first conjunct (Good luck... yours) is a complete, understandable utterance, though not a complete sentence. A person has no trouble understanding its pairing with the second conjunct, but a parser might. If the first conjunct is parsed as a noun phrase, the parser will be unable to find a phrase to pair it with in the second conjunct. This is because coordinating conjunctions like "and" join only constituents of the same type. The parser can handle the example sentence if it understands that the colloquialism "Good luck to you and yours" functions as a sentence in this context. The second conjunct will then match the first.

Linguistic: IV.A. Fixed phrases/colloquialisms

Cognitive-psychological: I.C.6.b.3. Connotation

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#8)

Problem

(1) John and Mary went to the pictures.
(2) Bill designs cars and Jack aeroplanes.
(3) Bill designs commercial and military aeroplanes.

(1 and 2 from Fong & Berwick, 1985, p. 870)

Discussion

One use of "and" is to conjoin subject noun phrases to indicate that a group of objects performs a particular action. For example, in (1) the "and" is used to indicate that both actors in the sentence went to the movies. However, in (2) "and" does not group the two items surrounding it, "cars" and "Jack," as it does in (1). In (2), "and" conjoins the two sentences "Bill designs cars" and "Jack [designs] aeroplanes." In general, the conjunction "and" joins only constituents of the same type, noun phrases in (1) and sentences in (2). Sentence (3), although superficially similar to (2), is not a conjunction of two sentences. In (3) "and" conjoins two adjective modifiers of "aeroplanes."

Linguistic: I.C.6. Coordination
III.C. Ellipsis

Cognitive-psychological: I.A. Processing syntax

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#9)

Problem

(1) He gave the house plants to charity.
(2) He gave the boy plants to water.
(3) He gave the boy plants to charity.

(1 and 2 from Winograd, 1973, p. 153)

Discussion

There are two related problems in these sentences: recognizing noun groups correctly and identifying the recipient of the verb "gave." In (1) the word preceding "plants" is "house," which is taken as an adjective modifying plants. But in (2), a structurally similar sentence, the word preceding "plants" is "boy," which does not modify plants but is taken as the recipient of the plants. This difference might be understood because our knowledge of the world leads us to expect to hear about "house plants" but not about "boy plants." But as (3) shows, that expectation can be overridden if there is another recipient mentioned in the sentence. Since "charity" is specified as the recipient in (3), this sentence strongly suggests that there are also "girl plants" somewhere.

Linguistic: I.C.1. Noun phrase structure
I.C.9. Complex sentence structure

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual

SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#10)

Problem

(1) John believes that Bill won the race and Mary the pole vault.
(2) ...and that Mary almost did.
*(3) ...and that Mary the pole vault.

(Winograd, 1983, p. 185)

Discussion

The examples above show two ways in which coordinated action can be expressed. In (1), the parallel between Bill winning the race and Mary winning the pole vault is shown through ellipsis. The listener fills in the missing word "won." In (2), Bill's winning and Mary's almost winning is shown through the anaphoric use of "did." "Did" here stands for "won the race."

The two structures of sentence coordination in (1) and (2) above differ in two respects: a) whether or not the complementizer "that" introduces the clause, and b) whether or not a verb appears in the clause. When the complementizer "that" introduces the clause, the verb "did" appears in it and when the complementizer "that" is absent, the verb is absent as well. Sentence (3) shows that when "that" is present and there is no verb, the sentence is confusing. Sentence (3) feels ill-formed without a verb to show just what Mary did with regard to the pole vault.

Linguistic: III.C. Ellipsis

Cognitive-psychological: I.A. Processing syntax

Other

Exemplar I.F. (#11)

Problem

(1) I have never seen a man taller than Mary.
(2) John is taller than Bill is fat.
(3) They have many more enemies than we have friends.
(4) They have many more enemies than we have.
(5) They have many more enemies than we.

(1-3 from Winograd, 1983, p. 185)

Discussion

Selecting the items to be compared and the scales on which to compare them are the problems illustrated by this set of examples. There is no syntactic theory that adequately accounts for the construction of comparative sentences. Although the word "than" is usually used to indicate a contrast, finding the correct contrast is often problematic.

Sentence (1) is the simplest case. In (1) the scale is Mary's height with possible alternatives being compared on the same scale. But when the comparison is not so direct, the parser might have to pay attention not only to the different items being compared, but possibly to the scales that the items are being measured on.

In (2) we have a contrast between John's height and Bill's weight, so the parser has to make an abstraction (i.e., normal weight to normal height) in order to understand the comparison. For example, if Bill is very fat, then the parser can infer that John is extremely tall.

In (3) the parser has to understand that the comparison is between two different sets that can be compared on the same scale (cardinality). In (4) and (5) the comparison is between number of enemies in both cases.

Linguistic: III.G. Comparative constructions

Cognitive-psychological: I.C.6.b.7.e. Association

Other

Exemplar I.F. (#12)

Problem

(1) Several dozen injuries were reported in the clashes in Teheran today between supporters and opponents of the Shah Mohammed Riza Pahlevi.

(2) A small earthquake shook several Southern Illinois counties Monday night, the National Earthquake Information Service in Golden, Colo., reported.

(3) A gunman who diverted a Vermont bound bus with more than 25 passengers from the Bronx to Kennedy International Airport and killed two hostages surrendered on a runway late last night ending a daylong siege of terror and gunfire.

(Riesbeck, 1982, p. 38)

Discussion

The three sentences above are examples of the kinds of sentences that appear in newspaper articles. Such sentences are designed to convey a maximal amount of information in a minimal amount of space. Because space is at a premium, many sentences in newspaper articles contain idioms and cliches, run-on constructions, and many prepositional and adverbial phrases which may be ambiguous due to multiple attachment possibilities. All the sentences above contain multiple prepositional and/or adverbial phrases whose attachments could potentially pose problems for a parser. The attachment of one prepositional phrase in sentence (3) will be discussed in detail. This attachment problem is characteristic of the others.

In sentence (3), a classic run-on sentence, the prepositional phrase "from the Bronx to Kennedy International Airport" could logically modify "diverted," "a Vermont bound bus," or "25 passengers." Determining the attachment of this prepositional phrase requires complex semantic reasoning: because the bus was Vermont bound, "from the Bronx to Kennedy International Airport" probably modifies something else but it could possibly modify "a Vermont bound bus" if it is describing one leg of the bus's journey that ultimately ends in Vermont. It would be a little unusual to specify where

the passengers were bound separately from where the bus was bound unless this information was relevant to the particular event being described. Since this is not the case here, "from the Bronx to Kennedy International Airport" probably doesn't modify "25 passengers." It seems likely that "from the Bronx to Kennedy International Airport" modifies "diverted," especially since the gunman surrenders on a runway. There is nothing, however, in the syntactic structure of this sentence which would lead the understander to prefer this attachment over the others.

Sentences typical of newspaper writing violate many of the rules and structures that apply to "normal" sentences. To process language of all types, parsers must be able to handle the problems that journalistic writing presents.

Linguistic: I.C.9. Complex sentence structures

Cognitive-psychological: I.C.6.b.5.c. Summarize
SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#13)

Problem

Did the red lorry move from the drive-way to the parking lot?

(Neumann & Novak, 1983, p. 725)

Discussion

This question addresses whether or not a specific event as described with certain constraints recently took place. Being able to answer it requires a mental model of the scene to which the question is referring. In this case, the understander needs a model of various objects, their current locations and their recent past locations, and the ability to reason about time.

Linguistic: III.J. Location and movement

Cognitive-psychological: I.C.1.b. Context: Non-military
SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#14)

Problem

(1) The businessman flew the plane to Cairo.
(2) The pilot flew the plane to Cairo.
(3) The mummy flew to Cairo.
(4) The plane flew to Cairo.
(5) The pigeon flew to Cairo.

(Bayer, Joseph, and Kalish, 1985, p. 790)

Discussion

All of the sentences above refer to an actor moving an object to a location, using an instrument. However, in each case the actor, object, location, or instrument varies. In (1) the object being flown is the businessman, and the actor doing the flying is unknown. In (2) the object being flown is the pilot, who is also the actor doing the flying. In these two sentences, role information about businessmen and pilots is necessary to identify the actor and object. In (3) the object is the mummy (as with the businessman), except in this case, the object is cargo rather than a passenger. In (4) the location is Cairo but there is no information about actors or objects. In (5) the pigeon is the instrument, actor, and object. The structure of these three sentences is the same; role information about their subjects is needed to understand them correctly.

Linguistic: III.A. Semantic case role

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual
SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#15)

Problem

(1) Flying planes can be dangerous.
(2) Falling planes can be dangerous.
(3) Buying planes can be dangerous.

(Winograd, 1983, p. 138)

Discussion

The sentences above appear to have similar syntactic structures since they differ only in the root of the present participle. But similar surface patterns do not always indicate similar syntactic relations and meanings. The different syntactic relations of (2) and (3) are both possible for the ambiguous sentence (1). The two potential meanings of (1) are: a) it is dangerous to pilot a plane, b) planes that are flying pose a danger (they may crash into other planes or the ground).

Substitution of either "buying" or "falling" for "flying" renders the sentence unambiguous. (1) is ambiguous because "plane" can be understood as the thing that's flying (subject) or the thing that's being flown (object). But selectional and subcatagorization restrictions on "buy" and "fall" prevent double interpretations of "plane" as subject and object when "plane" occurs with these verbs. The selectional and subcategorization restrictions limit the types of subjects and objects that can occur with each verb. "Buy" must have an animate subject but can have an inanimate object. "Fall" is intransitive so it can't have an object, only a subject. In the former case, "plane" can be the object of "buy" but not the subject; in the latter case, "plane" must be the subject of "fall."

To understand the sentences above, the parser needs to do more than identify "flying," "falling," and "buying" as modifiers of "planes." It should be able to apply either linguistic knowledge of syntactic relations and selectional and subcategorization restrictions or conceptual knowledge of what planes can do and what can be done to them.

Linguistic: I.C.1. Noun phrase structure

Cognitive-psychological: I.C.2.d. World knowledge: Conceptual
SINGLE-UTTERANCE ISSUES

Other

Exemplar I.F. (#16)

Problem

(1) Warren is eager to please.
(2) Warren is easy to please.

(Winograd, 1983, p. 138)

Discussion

These sentences show that a change of adverb can change the object of the verb "to please." In (1) the act of pleasing is directed outward from Warren to someone else. In (2) the act of pleasing is directed back toward Warren by some other person. In (1) the object of "to please" is someone other than Warren. In (2) the object of the verb is Warren.

Linguistic: I.C.9. Complex sentence structure

Group II: Connected Utterance Issues

In Group II problems, the system must be able to integrate information spread over a series of utterances and must be able to refer back to earlier utterances, but it need not have any model of the user. The only interaction between the system and the user is that the user makes statements or requests and the system processes them. Typical Group II problems are anaphora, ellipsis, and story understanding.

CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#1)

Problem

Richard hadn't heard from his...roommate Paul for years...When a letter finally arrived...Richard was anxious to find out how Paul was.

Unfortunately, the news was not good. Paul's wife Sarah wanted a divorce. She also wanted the car, the house, the children, and alimony. Paul...didn't want to see Sarah walk off with everything...he was hoping for a favor from the only lawyer he knew. Paul gave his home number in case Richard...could help.

Richard eagerly picked up the phone...After a brief conversation, Paul agreed to have lunch with him...He sounded extremely relieved and grateful.

(Dyer, 1982, p. 265)

Discussion

The reference of the pronoun "he" in the final sentence of the text above cannot be resolved using grammatical information alone. There are two possible referents for this pronoun, Paul and Richard, and choosing the correct referent requires knowledge of the affective state of the characters.

Using the context provided, the parser should be able to infer that Paul is in need of help and that Richard is in a position to give it. The parser should also know what "relieved" and grateful" mean in relation to the goal of finding help. It should recognize that it is the person seeking help who is "relieved" and "grateful" when this goal is realized.

Using knowledge of the goals and affective states of characters in the text, the parser can determine that "he" in the final sentence of the example refers to Paul.

Linguistic: III.B.1.g. Pronoun reference: Other
III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.8.b. Contextual
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#2)

Problem

(1) The next day after we sold our car, the buyer returned and wanted his money back.

(2) The day after we sold our house, the escrow company went bankrupt.

(3) The day after we sold our house, they put in a traffic light at the corner.

(1 from Allen, 1987, p. 346)

Discussion

In (1) "buyer" refers back to a participant in one of the roles in the "selling a car" event. The system must search not only the direct possible antecedents (the "selling") but must also consider aspects of the selling to resolve the reference. In (1), there is nothing specific to "car" about resolving the reference. But in (2), finding the reference of "the escrow company" involves looking past the general "buying" script and searching through aspects of selling specific to selling houses. There is a general problem here with controlling the amount of search while still looking deep enough. In (3), the system has to go from the house to the location to the street to the corner to understand the reference.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: II.C.2.a.2. Scripts: Multiple
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#3)

Problem

Take the long blue tube that has two outlets on the side--that's the main tube. Place the small blue cap over the hole on the side of that tube. Take the nozzle-looking piece, the clear plastic one, and place it on the other hole that's left, so that the nozzle points away.

(Goodman, 1983, p. 134)

Discussion

The paragraph above was excerpted from a dialogue in which one participant was telling the other participant how to put a water pump together. Many of the phrases in this description are vague. What is "the nozzle-looking piece" or "the other hole that's left"? What does "points away" mean? The listener must be able to understand colloquial descriptions using context, i.e., perceptual information, relative orientations, physical principles, and goals.

Linguistic: III.J. Location and movement

Cognitive-psychological: II.C.6.b.5.b. Description: Combine attributes
II.C.6.b.6. Instruction

II.C.6.b.7.g. Relation: Among parts
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#4)

Problem

(1) U: How do I print the file fetch.l?
(2) S: To print the file fetch.l type "lpr fetch.l."

...(intervening commands and questions)...

(3) U: Has the file fetch.l been printed yet?
(4) S: The file fetch.l is in the line printer queue.
(5) U: How can I cancel it?
(6) S: To remove file fetch.l from the line printer queue type "lprm arens."

(Arens, 1986, p. 599)

Discussion

The "it" in utterance (5) could refer to the printer queue, the file "fetch.l," the "lpr" command, or the effects of executing "lpr fetch.l." In this case "it" actually refers to the effects of executing "lpr fetch.l," i.e., the print job itself. This entity is never actually mentioned anywhere in the dialogue but it can be inferred from the use of the lpr command several lines earlier. It is therefore necessary to retain a complete model of the context and to have a method of selecting which active entry in the context is the desired referent.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#5)

Problem

U: List gauss.for in the diablo printer
S: GAUSS.FOR queued for printing
U: Is GAUSS.FOR being printed?
S: GAUSS.FOR is 25th on the queue.
U: Forget it then!

(Hayes & Carbonell, 1983, p. 670)

Discussion

Understanding that "it" in the last utterance refers to the action of printing the file (and not, e.g., the request for information, the file, or the queue) requires a logic of actions. In this case, the request for information is completed but the printing is still pending. Thus, the printing can be forgotten.

Linguistic: III.B.1.d. Propositional referent

Anaphora

Exemplar II.A. (#6)

Problem

(1) They think that feeding each other would be dangerous.
(2) His mother likes John.

(Berwick, 1983, p. 710)

Discussion

These are both cases of forward reference. Information following the pronoun is needed to resolve its referent. In (1), "each other" and "they" refer to the same set of people. Similarly, in (2), "his" can refer to John. Normally, the system will try to resolve an anaphoric reference by looking for a referent among things it already knows about. In these cases, the system must be able to hold such a reference open and continue to look for referents as it continues to process the sentence.

Note: For further discussion of forward reference, see Exemplar II.A. (#14).

Linguistic: III.B.1.e. Forward reference

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#7)

Problem

The waiter came over to John's table. He ordered a hamburger.

(Riesbeck, 1982, P.41)

Discussion

The target problem in this example is establishing who ordered the hamburger. There are two candidates: John and the waiter. To select John as the referent of the pronoun, the context established by the first sentence has to be used, and the roles of John and the waiter in this context must be instantiated.

There are two problems with using a knowledge structure like a restaurant script (Schank and Abelson, 1977) for resolving pronoun reference. The first problem is activation. In this example, the restaurant context is activated by two parts of the text. The first part is the word "waiter," and the second part is what he is doing. Note that both of these sections are necessary to understand that "restaurant" is applicable. (Compare the example text to "The waiter got off work and went to a bar; he ordered a hamburger.") The activation problem shows that lexical entries not only need definitions associated with them, they also need the potential contexts, roles, and themes that could be brought in by the usage of the word.

The second problem is using the knowledge structure to resolve the pronoun reference. Assuming that the restaurant script is known to be the currently active script, that John is the customer, and that he has been seated, the next thing that the script predicts is that he order. When the sentence says that someone did indeed order, the system can make the inference that it was the expected party, i.e., John.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: II.C.2.a.1. Scripts: Single
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#8)

Problem

An Exxon oil refinery was nationalized by Uganda. It was paid $1.2 million in compensation.

(DeJong, 1982, p. 165)

Discussion

In the Predictor/Substantiator model used by FRUMP (DeJong, 1979), pronoun reference is done by assigning the pronoun to its predicted conceptual item. In the above example, "it" in the second sentence is assigned based on the nationalization script. The nationalization script predicts that the owner of the target of the takeover will be given compensation. When the second sentence mentions paid compensation, the recipient of the payment is assigned from the owner role in the script.

This method of pronoun reference contrasts with systems that construct a list of possible referents for a pronoun, and make the selection based on linguistic clues, like number and gender. This process can be cumbersome. The FRUMP method, on the other hand, starts with the scriptal prediction and then uses linguistic data to confirm it. By using high-level knowledge sources to make predictions, this method of pronoun resolution makes text interpretation more efficient.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: II.C.2.A.1. Scripts: Single
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#9)

Problem

(1) John murdered Bill. His funeral was held on Monday.
(2) John murdered Bill. His trial was held on Monday.

(Maida, 1984, p. 235)

Discussion

In (1) the funeral refers to Bill's funeral. In (2) the trial refers to John's trial. The first reference can be determined by recognizing that "murdered" implies dead and that funerals are held for dead people. The second reference requires knowledge of social judgments: murder is considered a crime, and therefore, John must go on trial.

Linguistic: III.B.1.f. World knowledge required to determine referent

Cognitive-psychological: II.C.2.b. World knowledge: MOPs
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#10)

Problem

We bought two guitars at the store. The new one was cheap but the used one was expensive.

(Allen, 1987, p. 335)

Discussion

"The new one" and "the used one" clearly refer to each of the "two guitars" mentioned in the first sentence. Resolving the reference requires the system to be able to treat the guitars as individuals as well as a set. The reference resolution cannot simply check for number agreement. In addition, the system has to recognize that new information is being given about the guitars and to modify its knowledge accordingly.

Linguistic: III.B.2.a. Reference to member of previous set

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#11)

Problem

We bought a new desk. When it was delivered, we found out that the drawer was broken.

(Allen, 1987, p. 335)

Discussion

In this example, the system must recognize "the drawer" is the drawer of the "new desk." This means that the system must have knowledge about the components of desks and must be prepared to search through components of possible referents when trying to resolve the reference. It is not enough to simply compare possible matches on a list of previously encountered lexical items.

Linguistic: III.B.2.c. World knowledge relevant for interpretation

Cognitive-psychological: II.C.6.b.5.a. List attributes

CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#12)

Problem

(1) Jack lost the race. It surprised Sam.
(2) Jack's losing the race surprised Sam.
(3) Jack surprised Sam by losing the race.
(4) The race surprised Sam by its outcome.

(1 from Allen, 1987, p. 336)

Discussion

The difficulty for the system is recognizing the referent of "It" in (1). A simple algorithm would look through a history list for the most recent possible referent. This would be anything single and plausibly neutral. But what might be on this list? As Allen (1987, p.354) notes, the subject of "surprised" in (1) must be a fact or an event. Semantically, the subject of "surprised" is always an event although the grammatical subject may be a concrete object as in (3) and (4) above. The grammatical subject "Jack" in (3) above refers to what Jack is doing and so conceptually "Jack" denotes an event in which Jack is a participant. To resolve the reference of "It" in (1), the system must be able to consider recent facts, events, actions, etc. This means that when the system reads "Jack lost the race," it must add not only "Jack" and "race" to working memory, but also the event of Jack's losing the race.

Linguistic: III.B.1.d. Propositional referent

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#13)

Problem

Jack congratulated the winner. After some hesitation, Sam did it too.

(Allen, 1987, pp. 336 and 354)

Discussion

Resolving the reference of "it" requires the system to keep track of recently mentioned things of all kinds, not just noun phrases. The phrase "did it" suggests that "it" refers to an action and in fact "did it" refers to the verb phrase "congratulated the winner."

In general, the referent of "it" might be a fact, an event, an object, etc. The usual way to handle this problem is to keep a list of things that have been introduced and work backwards looking for a possible match.

Linguistic: III.B.1.g. Pronoun reference: Other

Cognitive-psychological: II.A. Processing Syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#14)

Problem

When he returned home, John found his front door open.

(Allen, 1987, p.357)

Discussion

Sometimes a pronoun or other anaphor is found for which the referent has not appeared. Normally, the system searches through some list of known things. In a case like this, it needs to add the unresolved reference to its list rather than trying to force the best match with an object already known. The system should also expect to find the forward reference quickly. Just how quickly and just how hard the system should work at trying to force a match with an existing object before assuming a forward reference is difficult to describe in general. In this case, a syntactic feature, a pronoun in a subordinate clause, makes the forward reference more likely although backward reference is still the best guess. The possibility of forward reference means that even when a definite reference is found, as with "John," the system must check for any existing unresolved references.

Note: For further discussion of forward reference, see Exemplar II.A. (#6).

Linguistic: III.B.1.e. Forward reference

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#15)

Problem

While diving near the old wreck, we found an old coin and a rusty knife. We took these objects to the harbor police when we returned.

(Allen, 1987, p. 348)

Discussion

The problem here is identifying the referent of "these objects." A simple algorithm is to look through a list of recently mentioned things for a possible match. In this case, however, nothing plural has been mentioned. In resolving the referent, the system must be able to recognize that the coin and the knife can be combined into a set and referred to in the plural. The system need not have the set explicitly in working memory, but if it doesn't, it must be able to infer its existence.

Linguistic: III.B.2.d. Definite noun phrase reference: Other

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#16)

Problem

We found seven coins on the next dive. The oldest was dated 1823.

(Allen, 1987, p. 348)

Discussion

The problem here is identifying the referent of "the oldest." The system must have recorded the seven coins in some form of working memory and must be able to recognize that individuals from the set can be referred to later.

Linguistic: III.B.2.a. Reference to member of previous set

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#17)

Problem

I used two scuba tanks for those dives. The 1600 psi tank was my favorite because it is very compact.

(Allen, 1987, p. 348)

Discussion

There are two issues here. The first issue is identifying the referent of "the 1600 psi tank" as one of the two tanks mentioned previously. The second issue is recognizing that two new pieces of information (it is the speaker's favorite, it is compact) are being given about the selected item and that information should be added to working memory or to the database.

Linguistic: III.B.2.a. Reference to member of previous set

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Anaphora

Exemplar II.A. (#18)

Problem

On our trip to the store we saw one dog on our street, another in the park, and yet another outside the store door. The largest was a German shepherd.

(Allen, 1987, p. 350)

Discussion

In this example, to find the referent of "the largest" the system must be able to recognize that the three dogs mentioned can be considered as a group and that comparisons can then be made within the group and an individual selected. Examples like these show the complexity of a history list approach. Either many implicit elements have to be generated and added to the list (e.g., the set of three dogs, the set of dogs not near our house, etc.), or the mechanism for searching for possible referents must have extensive reasoning abilities.

Linguistic: III.B.2.a. Reference to member of previous set
III.C. Ellipsis

Cognitive-psychological: II.A. Processing syntax
CONNECTED-UTTERANCE ISSUES

Ellipsis

Exemplar II.B. (#1)

Problem

(1) Is Prof. Smith teaching Expert Systems next semester?
Natural Language?

(2) Is Prof. Smith teaching Expert Systems next semester?
Prof. Jones?

(3) I want to cash this check. Small bills only, please.

(adapted from Carberry, 1983, p.59)

Discussion

The elliptical phrase in the first example can be understood by matching on types. If "Expert Systems" and "Natural Language" are both recognized as the names of classes, then the phrase is elliptical for: "Is Prof. Smith teaching Natural Language next semester?" Similarly, in the second example, "Prof. Jones" matches "Prof. Smith." But the third example is more difficult. Here the listener needs to understand just what "cashing a check" entails. The elliptical phrase here matches to a part of the check-cashing schema.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.C.2.b. World knowledge: MOPs

II.C.6.a.4. Identification
CONNECTED-UTTERANCE ISSUES

Ellipsis

Exemplar II.B. (#2)

Problem

- What is the size of the 3 largest single port fixed media disks?
- And the price and speed?

(Carbonell, Boggs, Mauldlin, and Anick, 1983, p. 655)

Discussion

The second sentence above must be understood by the system as requesting the price and speed of the fixed media disks discussed in the previous sentence. To do this requires knowledge that "price" and "speed" are possible attributes of fixed media disks.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.C.6.a.4. Identification
CONNECTED-UTTERANCE ISSUES

Ellipsis

Exemplar II.B. (#3)

Problem

User: How might a file be created in UNIX?
UC: ...
User: A directory?

(Wilensky, 1982, p. 103)

Discussion

The User's second sentence, "A directory?" is incomplete and makes little sense by itself. However, in this example, the user's second utterance is understood as "How might a directory be created in UNIX?" Understanding this utterance requires that the system recognize that it is a variation on a previous utterance. The system must choose the right previous utterance and interpret the new utterance in the context of the old. For example, it does not mean "How might a file be created in a directory?" although that sentence makes sense by itself.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.B. Processing semantics
CONNECTED-UTTERANCE ISSUES

Ellipsis

Exemplar II.B. (#4)

Problem

(1) Max gave Sally a nickel, and Harvey a dime.

(2) John kissed Mary, and I think that Frank said that Mary thought that Harry would have too.

(Berwick, 1983, p. 710)

Discussion

These sentences contain elliptical references to verb phrases. Sentence (1) represents the following sentence with the bracketed words deleted: Max gave Sally a nickel, and Harvey [gave Sally] a dime. Sentence (2) represents the sentence: John kissed Mary, and I think that Frank said that Mary thought that Harvey would have [kissed Mary] too. These sentences cannot be understood until these deleted verb phrases have been filled in.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.B. Processing semantics
CONNECTED-UTTERANCE ISSUES

Ellipsis

Exemplar II.B. (#5)

Problem

Which aircraft required more than 10 hours maintenance in June, 1979?

...(answer)

July?

(Waltz, 1982b, p. 17)

Discussion

This question sequence is from a dialogue with the PLANES natural language front end to a database of aircraft flight and maintenance data. The example shows how a questioner can take advantage of the sequential environment provided by a previous question in formulating a next question. In this case, the second question can be heard as a repeat of the first question with July substituted for June.

To answer this kind of question, a system has to save questions in case the user performs this kind of ellipsis. In attempting to answer the incomplete query "July?" the system has to search back and substitute the new information into the old question. Note that the second question could contain other sections or multiple sections of the previous question: "20 hours?" "April and May of 1977?" etc.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.B. Processing semantics
CONNECTED-UTTERANCE ISSUES

Ellipsis

Exemplar II.B. (#6)

Problem

Midway sighted enemy. Fired.

(Granger, 1983, p. 193)

Discussion

The second sentence is elliptical for "Midway fired." This might be recognized by matching the verbs between the two sentences ("sighted" and "fired") and inferring a parallel subject and object. If the message is recognized as a description of an attack, an "attack-schema" can be used to fill in the roles. In the attack, the normal sequence "move," "see," "fire" suggests the Midway as the one who fired and some unspecified enemy as the target.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.C.2.b. World knowledge: MOPs
CONNECTED-UTTERANCE ISSUES

Integrating Complex Information

Exemplar II.C. (#1)

Problem

A combination filter system for an enclosed disc drive in which a breather filter is provided in a central position in the disc drive cover and a recirculating air filter is concentrically positioned about the breather filter...

(Lebowitz, 1983, pp. 232-235)

Discussion

This text is taken from a patent abstract about a computer disk drive. It describes physical relationships such as "containment" and "on top of" among several different objects such as a disk drive cover and an air filter. To understand this text requires recognizing and understanding descriptions of physical objects and the relationships between them.

Linguistic: I.C.1. Noun phrase structure
I.C.9. Complex sentence structure
III.J. Location and movement

Cognitive-psychological: II.C.6.b.7.g. Relation: Among parts
CONNECTED-UTTERANCE ISSUES

Integrating Complex Information

Exemplar II.C. (#2)

Problem

(1) A magnetic head supporting mechanism equipped with a magnetic head positioning carriage of a interchangeable double side type flexible disc drive apparatus comprising a carriage having a pair of arms which is rotated in detachable to a double side type flexible disc and arms ...

(The first phrase is taken from a patent abstract.)

(2) A disc head supporting a spindle made of magnetic material

(Lebowitz, 1985, pp. 858-859)

Discussion

The two phrases above describe an object by providing the relationships between its parts. To understand even the shorter phrase above, it is necessary to recognize that "disc head" is a single thing and that "made of magnetic material" refers to the spindle rather than the disc head. Considerable real-world knowledge about objects must be applied to understand these descriptions.

Linguistic: I.C.1. Noun phrase structure
I.C.3. Participial modifier attachment
I.C.9. Complex sentence structure

Cognitive-psychological: II.C.6.b.7.g. Relation: Among parts
CONNECTED-UTTERANCE ISSUES

Integrating Complex Information

Exemplar II.C. (#3)

Problem

A modulator comprising two transistors each having collector, emitter and base electrodes, means for applying a direct voltage across said emitter electrodes...

(Phillips, 1983, p. 690)

Discussion

In the above sentence, which is taken from a patent description, the phrase "means for applying" can be attached structurally to either "a modulator comprising" or "two transistors." Domain-specific knowledge about voltage and electrodes is necessary to understand that "means for applying" attaches to "a modulator comprising." The parser must be able to access this information and make these decisions as the parse is running, to avoid mismatching phrases. Practically, it is important to integrate syntax and pragmatics in the parse.

Linguistic: I.C.1. Noun phrase structure
I.C.9. Complex sentence structure

Cognitive-psychological: II.C.3.a. Domain specific knowledge:

Technical

CONNECTED-UTTERANCE ISSUES

Integrating Complex Information

Exemplar II.C. (#4)

Problem

I-5 south

Rosecrans exit--get over to the far left--and it will be about the third stoplight that's the Midway drive intersection.

To the left a steakhouse or wooden looking building that's some kind of restaurant. Catty-corner is an automobile dealership. On the western corner is another restaurant. I can't remember what's on the direct right.

Be in the left-hand only lane. And turn left on Midway Drive.

About two to three long blocks down on the right is the main post office. You can't miss it. It looks rather like San Quentin.

(Riesbeck, 1982, p. 46)

Discussion

This text is a set of instructions on how to get to a post office in San Diego. As is often the case with informal speech, it is full of incomplete or run-on sentences, fragments, and irrelevant information. For example, the phrase "I-5 south" must be interpreted as "Go south on I-5." And in "Rosecrans exit--get over to the far left," the getting over is supposed to happen before the exiting. By parsing the text in the context of "instructions," specifically road directions, many of these problems can be solved. Understanding the objects, clauses, and sentences in terms of a directed map that is being constructed gives the program a means for disambiguation and a measure of how much understanding has been accomplished.

Linguistic: III.J. Location and movement
IV.G. Unclear goal

Cognitive-psychological: II.C.6.b.6. Instruction
CONNECTED-UTTERANCE ISSUES

Integrating Complex Information

Exemplar II.C. (#5)

Problem

The pineapple is to the left of the banana.
The pear is behind the banana.
The lemon is to the right of the pear.
The apple is to the right of the lemon.

(Wender, Wagener, and Wittman, 1986, p. 853)

Discussion

These four sentences are understood only if the reader can describe the relative positions of the objects. The reader should know, for example, that the pear is also behind the pineapple, and that the apple is to the right of the pear, even though these things were not explicitly stated. An understander must be able to build appropriate spatial representations of the relative positions of objects.

Linguistic: III.J. Location and movement

Cognitive-psychological: II.C.6.b.7.f. Relation: Logical

CONNECTED-UTTERANCE ISSUES

Integrating Complex Information

Exemplar II.C. (#6)

Problem

The goldfish is in a goldfish bowl.
The goldfish bowl is on a shelf.
The shelf is on the desk.
The desk is in a room.
Is the goldfish in the room?

(Waltz, 1982b, p. 26)

Discussion

The problem in these sentences is to understand the various relations among the objects. Prepositions like "in" and "on" are extremely ambiguous, even when restricted to spatial domains. Compare, for example, the phrases "the crack in the wall," "the desk in the room," and "the face in the mirror." The parser must be able to build a representation for "in" and "on" relations that will allow it to make the necessary spatial reasoning.

Linguistic: III.J. Location and movement

Cognitive-psychological: II.C.6.a.6.f. Relation: Logical
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.1. (#1)

Irony

Problem

Jim Fixx had a heart attack while jogging.

(Dyer, Flowers, and Reeves, in press)

Discussion

Syntactically and semantically this sentence is straightforward. However, to a reader who knows Jim Fixx as an author who promoted jogging as a means to good health, this sentence is very interesting. The interest springs from the irony of the situation. How is the irony, the point of the sentence, recognized? Extracting the irony requires accessing the relevant beliefs of the characters and recognizing violations of those beliefs.

Linguistic: III.O. Irony

Cognitive-psychological: II.C.7.b. Expectation: Of the listener
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.1. (#2)

Irony

Problem

Frank hated his job at the factory. He wanted a job where he wouldn't have to work so hard. He envied his friends who went to college, and didn't have to work. So Frank quit building cars and enrolled at the local University. However, as a student, he was soon working harder than he ever had in his life.

(Norvig, 1983, p. 284)

Discussion

This story is interesting, at least partially, because it is ironic: the character Frank attempts to work less and ends up working more. Understanding the point of the story requires recognizing the ironic outcome.

Linguistic: III.O. Irony

Cognitive-psychological: II.C.7.b. Expectation: Of the listener

CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#1)

Plans and goals

Problem

John wanted to commit suicide. He got a rope.

(Hendler, 1985, p. 131)

Discussion

After reading these two sentences, most people infer that John will attempt to hang himself. One way they can make this inference is by realizing that one plan for committing suicide is to hang oneself, and an enablement of that plan is possessing a rope.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.b. Instrumental and

CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#2)

Plans and goals

Problem

Susan saved her money from her allowance. One day she rode her bike to the bookstore and bought the book that her teacher had recommended. Susan did very well on her math test the following week.

(Q) Why did Susan buy the book?
(A) So that she could study from it and do well on her exam.

(Luria, 1982, p. 72)

Discussion

Answering the question requires understanding and inferring Susan's goals. A simple answer would be that Susan bought the book to achieve the low-level goal of possessing that book. But to really understand this story, her buying the book has to somehow be connected to her doing well on the exam. Making this connection allows us to give the correct answer: she bought the book to achieve her high-level goal of doing well on the exam. Doing well on the exam is never stated as a goal, however, and must therefore be inferred.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.a.7.c. Prediction
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#3)

Plans and goals

Problem

(1) My windshield is broken, help.

(Gershman, 1981, p. 423)

(2) Q: The 3:15 train to Windsor?
A: Gate 10

(Allen & Perrault, 1980, p. 145)

Discussion

The first example is one given to an Automatic Yellow Page Advisor. The user's goal of replacing the windshield must be inferred, as must the related user goals of finding out the telephone numbers or locations of repair shops that replace windows.

The second example is an interaction between an unknown person and an information attendant in a train station. Here the asker's goals include finding out from which gate the train leaves, and also any other useful information such as whether the train is late, full, cancelled, etc. These goals must be inferred.

Linguistic: II.B. Discourse relation of clause
III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.6.c.1. Relations among goals
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#4)

Plans and goals

Problem

John wanted to impress Mary. He asked Fred if he could borrow his Mercedes for the evening.

(Wilensky, 1983, p. 42)

Discussion

Unless we assume a schema that says that one borrows a fancy car whenever one has a date, John's asking Fred if he can borrow the car must be understood as a plan for impressing his date. Doing so involves inferring a causal explanation for John's request: fancy cars impress women; therefore, John needs a fancy car. One way to get a car is to borrow it. Therefore, John must ask Fred if he can borrow his car.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.1. Relations among goals

CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#5)

Plans and goals

Problem

(1) A bum on the street came over to John. He told John he wanted some money.

(2) A man came over to John and pulled out a gun. He told John he wanted some money.

(3) John's son came over to John. He told John he wanted some money.

(Wilensky, 1983, p. 44)

Discussion

The last sentence of (1), (2), and (3) is the same, but in each case it gets a different interpretation, depending on the action that precedes it. In (1) the last sentence is viewed as panhandling, in (2) it is viewed as a robbery, and in (3) it is viewed as a simple request. The meaning of an action is dependent on the actions that precede it. Understanding the sentence goes beyond the literal understanding of someone communicating a desire for money.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.8.b. Presuppositions of the

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#6)

Plans and goals

Problem

(1) John wanted to watch the Monday night football game. He also had a paper due the next day. That night, John watched the football game. John failed Civics.

(2) John wanted to marry Mary. He also wanted to marry Sue. John took Mary out and proposed to her. She agreed. Later, John called Sue and told her he wouldn't be seeing her anymore.

(Wilensky, 1983, p. 57)

Discussion

Understanding (1) involves inferring that the reason John failed Civics is that John spent the time he should have spent working on his Civics paper watching Monday night football. In other words, in this case John's passing Civics and watching the football game are conflicting goals.

Similarly, understanding (2) requires inferring that the reason that John dumped Sue is because John is marrying Mary. That is, John cannot keep seeing other women once he is married. These examples point out that an understander must keep track of multiple goals and interactions between them.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.1. Relation among goals
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#7)

Plans and goals

Problem

(1) John told Mary he wanted to watch the football game. Mary said that she wanted to watch the Bolshoi Ballet. Mary put on Channel 3. John got out the lawnmower.

(2) John wanted to win the high hurdles. Bill also wanted to win the high hurdles. John won the race. Bill was very upset.

(Wilensky, 1983, p. 57)

Discussion

Understanding these examples involves recognizing that one character's achievement of a goal prevents another character's achievement of his goal. In (1) John got out the lawnmower because Mary's decision to watch the ballet prevented him from achieving his goal of watching the football game. In (2) Bill did not win the race because John won it. His goal was usurped by John.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.1. Relations among goals
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#8)

Plans and goals

Problem

John was in a hurry to make an important business meeting. On the way over, he ran into an old girlfriend who invited John up to her apartment. John called up his boss and asked if the meeting could be postponed.

(Wilensky, 1983, p. 72)

Discussion

Understanding this example requires understanding that John has abandoned one goal to pursue another. Here he has given up his goal of attending the business meeting in order to spend time with his ex-girlfriend. To understand why he has abandoned his goal, an understander must recognize that he had two conflicting goals and opted for one over the other. This means an understander has to be able to infer the relative importance of various goals to the character.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.1. Relations among goals

CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#9)

Plans and goals

Problem

John wanted to simmer two dishes on his camp stove, but the stove only had one burner.

(Wilensky, 1983, p. 65)

Discussion

In the sentence above, John may have to perform some action in order to achieve his goal. For example, he may have to find another burner. To make this inference, the understander must know that a stove having only one burner prevents John from simmering two dishes on it. This involves recognizing that one enablement of the plan of simmering a dish is having a burner, and that a burner cannot be used for more than one dish at a time. The understander must recognize the conflict in a plan that requires the same resource at the same time.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.b. Instrumental and

CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#10)

Plans and goals

Problem

(1) Ann got into her car. She went for a drive. She arrived at the movie theater. She got a ticket.

(2) John wanted money. He got a gun and walked into a liquor store. He told the owner he wanted some money. The owner gave John the money and John left.

(Wilensky, 1983, pp. 146-147)

Discussion

In (1) Ann bought a ticket because she wanted to see the movie. In (2) John got a gun because he wanted to rob the liquor store, and he left because he didn't want to get caught. The characters' actions fulfilled enablements of plans they wanted to execute. In (1), by buying the ticket Ann is able to enter the theater and see a movie. In (2), by getting a gun John is able to rob the liquor store, and by leaving he avoids getting caught.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.b. Instrumental and

CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#11)

Plans and goals

Problem

(1) John had to blow up two bridges, but he only had one explosive charge.

(2) John wanted to put up two posters, but he only had one thumbtack.

(Wilensky, 1983, p. 66)

Discussion

In both (1) and (2) John has a goal conflict that results from limited resources. In (1) the conflict between blowing up one bridge or blowing up the other derives from the fact that an explosive charge can only be used once and is then destroyed. In (2) the conflict between putting up one poster or putting up another arises because a thumbtack can only be used in one location at a time. Understanding consumptive properties of objects and plans is necessary to recognize goal conflicts.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.1. Relations among goals
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#12)

Plans and goals

Problem

(1) John and Bill were stranded in the desert with only enough water for one of them to make it to the nearest town. Then they stumbled upon an oasis.

(2) John wanted to watch the football game, but Mary wanted to watch the ballet. Mary put on Channel 3. She found out that the ballet was postponed until later that day.

(Wilensky, 1983, p. 112)

Discussion

The last sentences in both (1) and (2) describe the resolution of the characters' goals. In (1), finding the oasis solves John and Bill's goals of having enough water, resolving a potential competition between them. In (2), finding that the ballet was postponed allows John to achieve his goal of watching the football game and thwarts Mary's goal of watching the ballet. An understander must relate the effects of each described action to the goals of the characters.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.1. Relations among goals
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#13)

Plans and goals

Problem

(1) John thought killing animals was morally wrong. He also thought that eating vegetables made one healthy.

(2) John had to stay home because he expected a visitor. He also had to stay in his study because he was trying to write a paper.

(3) John thought he needed some exercise. He also felt like he needed some fresh air, so he decided to go jogging in the park.

(Wilensky, 1983, pp. 113-114)

Discussion

In all three examples, the understander must track multiple goals of a character and recognize when one plan achieves all of these goals. To understand (1), it is necessary to realize that John has two goals--to avoid killing animals and to be healthy--and that these goals are related because as a vegetarian he can achieve both. Similarly, in (2), John's goals are to meet his visitor at home and to study. Both can be achieved if he stays home and studies. Finally, in (3), John's goals are to exercise and to get fresh air, both which can be achieved by jogging outdoors.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.2. Goal: Subsumption
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#14)

Plans and goals

Problem

(1) John got a job 50 miles from where he lived. He decided to buy a car.

(2) John got tired of going to a singles' bar every night. He decided to get married.

(3) John thought that commuting to work was a waste of energy. He decided to move into the city.

(Wilensky, 1983, pp. 115-116)

Discussion

To understand the connection between the first and second sentences in (1), (2), and (3), it is necessary to realize that the second sentence in each describes a plan for resolving a repeatedly occurring goal. In (1) buying a car achieves the daily goal of getting to work quickly and easily. In (2) getting married achieves the goal of having constant companionship. In (3) moving to the city achieves the goal of having a short commute.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.a. Cause and effect
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#15)

Plans and goals

Problem

(1) John and Bill were partners playing golf. Bill hit a shot into the rough. John sneakily moved the ball into a better position.

(2) The United States and China were afraid of the Soviet Union, so they signed a mutual defense pact.

(Wilensky, 1983, pp. 122-123)

Discussion

To understand certain actions of characters, it is necessary to understand that they share a goal. In (1), to understand why John moved the golf ball and helped Bill, it is necessary to recognize that since they are golf partners, they share the goal of winning. In (2), to understand why the U.S. and China signed a mutual defense pact, one has to realize that they share a goal of avoiding a Russian attack. Defending each other helps achieve this goal.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.c.3. Goal: Concordance
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#16)

Plans and goals

Problem

Paul's wife Sarah wanted a divorce. She also wanted the car, the house, the children, and alimony. Paul...didn't want to see Sarah walk off with everything...he was hoping for a favor from the only lawyer he knew. Paul gave his home phone number in case Richard...could help.

(1) Richard eagerly picked up the phone and dialed.
(2) Richard morosely picked up the phone and dialed.

(Dyer, 1982, pp. 265-266)

Discussion

Suppose these two sentences were followed by the question "Did Richard agree to take Paul on as a client?" After reading (1), the likely answer is "yes." After reading (2), however, the likely answer is "no." Understanding these examples should allow the reader to make an inference about the likelihood of the lawyer taking Paul as a client. To make this inference, Richard's effective state must be taken into account.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.b.8.c. Prediction
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.2. (#17)

Plans and goals

Problem

The Crow was sitting in the tree with a piece of cheese in her mouth. The Fox walked up to the bottom of the tree and said to the Crow, "Crow, what a beautiful voice you have; please sing for me." The Crow was very flattered and began to sing. When she did, the cheese dropped out of her mouth. The Fox grabbed the cheese and ran away laughing.

(Dolan & Dyer, 1986, p. 489)

Discussion

Readers have not understood this story unless they get the point of the story: there can be an ulterior motive behind flattery. Recognizing that this is the point of the story requires understanding that the fox flattered the crow in order to make her sing, in order to get her to release the cheese, so the fox could eat it. In essence, to understand this story involves understanding that the crow failed to anticipate outcomes.

Linguistic: II.B. Discourse relation of clause
II.C. Discourse segment function
III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.b.7.c.1. Relation among goals
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.3. (#1)

Belief modification

Problem

He plunked down $5 at the window. She tried to give him $2.50 but he refused to take it. So when they got inside, she bought him a large bag of popcorn.

(O'Rorke, 1983, p. 306)

Discussion

A reader might well conclude that the first sentence is about making a bet. Given this interpretation, the second sentence seems to describe someone else trying to get a piece of the bet. When the third sentence is read, these previous assumptions are usually invalidated and reinterpreted as actions related to buying a ticket to the movies. A story understander must be able to make reasonable assumptions based on what it has read so far, but it must also have a way to revise those assumptions based on subsequent information.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.8.d. Implication
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.3. (#2)

Belief modification

Problem

The Reagan Administration argues that America does not need an industrial policy since all government has to do to guarantee economic success under capitalism is keep out of the way. Yet the Reagan administration has just...increase[d] tariffs on large motorcycles from 4.4 percent to 49.4 percent.

(Alvarado, Dyer, and Flowers, 1985, p.228)

Discussion

This paragraph is taken from an editorial about trade policy. The author argues against a specific action of the Reagan administration, the increase of tariffs on Harley-Davidson competitors, by asserting that the increase contradicts stated administration economic beliefs. To understand the argument, it is necessary to recognize the basic belief from the first sentence and to be able to predict appropriate actions, given that belief. The actual action then contradicts the expected action which leads the reader to question either the logic of the administration's actions or the sincerity of its stated beliefs.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.b.7.f. Relation: Logical
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.3. (#3)

Belief modification

Problem

(1) Milton Friedman: Interest rates will rise as an inevitable consequence of the monetary explosion we've experienced over the past year.

(2) Lester Thurow: With high growth choked off by high interest rates, the deficit will be bigger, not smaller.

(Riesbeck & Martin, 1986, pp. 383, 386)

Discussion

These sentences are descriptions of beliefs that one action results from another. An understander should be able to recognize or to build these causal connections as part of the process of understanding the input.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.6.b.7.a. Cause and effect
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.3. (#4)

Belief modification

Problem

The CIA called in an inspector to check for bugs. The secretaries had reported seeing roaches.

(Eiselt, 1985, p. 863)

Discussion

After reading the first sentence, a reader might assume that an "inspector" is a CIA agent and that "bugs" refer to hidden microphones. But after reading the second sentence, "bugs" is more likely to be taken to refer to insects and "inspector" to refer to an insect-killer. Even though an understander decides that it has enough information to identify references(for "inspector" and "bugs" in this example), it must be prepared to modify these assumptions based on information in subsequent sentences.

Linguistic: I.B.1.a. Noun

Cognitive-psychological: II.C.2.e. World knowledge: Cultural

Reasoning, Argumentation, Story Understanding

Exemplar II.D.4. (#1)

Argumentation

Problem

Some people are against computers because computers eliminate people's jobs. However, the automobile industry did the same thing to people in the horse carriage industry. Yet consumer demand for autos was strong enough that eventually more jobs were created in the auto industry than were lost in the horse carriage industry. In the end, the economy benefitted by the introduction of the new technology.

(August & Dyer, 1985, p.845)

Discussion

In this paragraph the author argues by analogy that the computer industry will provide more jobs than it eliminates. To understand this point, it is necessary to recognize that the computer industry is being compared to the automobile industry, and that they share certain features. Because of these shared features, one can conclude that, like the auto industry, the computer industry will lead to a net increase in jobs.

Linguistic: II.C. Discourse segment function

Cognitive-psychological: II.C.6.b.8.d. Implication
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.4. (#2)

Argumentation

Problem

Recent protectionist measures by the Reagan Administration have disappointed us...[voluntary] limits on Japanese exports of automobiles...are...bad for the nation...Far from saving jobs, the limitations on exports will cost jobs. If we import less, foreign countries will earn fewer dollars. They will have less to expend on US exports. The result will be fewer jobs in export industries.

(Alvarado, Dyer, and Flowers, 1985, p. 229)

Discussion

Much of this paragraph is a description of a chain of reasoning. The chain goes something like this: limitations on exports cause foreign countries to earn fewer dollars, so the countries have less money to spend on U.S. exports, so that there will be fewer jobs in export industries. This argument is then used as an attack on certain measures of the Reagan administration. The presumptive justification for the measures is that they will save jobs. But this argument claims that the measures will, in fact, lead to a loss of jobs. This pattern of argument is very common but the argument chain itself and the argumentation pattern must be inferred by the reader. They are never explicitly stated.

Linguistic: II.B. Discourse relation of clause
II.C. Discourse segment function

Cognitive-psychological: II.C.6.b.7.f. Relation: Logical
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.4. (#3)

Argumentation

Problem

(1) A strike cripples Pan Am.

(2) Tough laws will not stop the use of dangerous drugs but will instead lead to obscene profits.

(3) ...a pesticide that silenced birds, threatened West Coast peregrine falcons and bald eagles, and possibly caused cancer in humans.

(Shoham & Dean, 1985, p. 90)

Discussion

Each of these examples above expresses a causal connection (or lack of such a connection) between events. Understanding these connections requires understanding temporal sequences. In (1) the strike preceded Pan Am's (metaphoric) ill health. In (2) after tough laws are passed there will be no cessation of the use of illegal drugs. In (3) the danger to people and animals came later than the appearance of the pesticide. An understander must be able to recognize that each example refers to an implicit temporal chain of events connecting one event to another event or state.

Linguistic: III.I. Temporal relation, causation

Cognitive-psychological: II.C.6.b.7.a. Cause and effect
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.4. (#4)

Argumentation

Problem

(1) The Iraquis caused the Persian Gulf War.
(2) The Iranians caused the Persian Gulf War.
(3) The Iranians fought in the Persian Gulf War.
(4) The Iraquis fought in the Persian Gulf War.

(Flowers, 1982, p. 270)

Discussion

In an argument, (2) might be said in order to contradict (1). To see the contradiction, it is necessary to know that, normally only one person or group is blamed for having "caused" a war.

Examples (3) and (4) are structurally very similar to (1) and (2), but they cannot be taken as contradictory. To understand that they are not contradictory requires the knowledge that wars typically have many participants. Thus, the understander must have enough knowledge about wars to interpret (1) and (2) as argumentative and (3) and (4) as not argumentative.

Linguistic: II.C. Discourse relation of clause

Cognitive-psychological: II.C.2.e. World knowledge: Cultural

Reasoning, Argumentation, Story Understanding

Exemplar II.D.5. (#1)

Summarizing

Problem

(1) John graduated college. John looked for a job. The Xenon Corporation gave John a job. John was well liked by the Xenon Corporation. John was promoted to an important position. John got into an argument with John's boss. John's boss gave John's job to John's assistant. John couldn't find a job. John couldn't make a payment on his car and had to give up his car. John also couldn't make a payment on his house and had to sell his house and move to a small apartment. John saw a hit and run accident. A man was hurt. John dialed 911. The man's life was saved. The man was extremely wealthy and rewarded John with a million dollars. John was overjoyed. John bought a huge mansion and an expensive car and lived happily ever after.

(2) John worked for the Xenon Corporation. The Xenon Corporation fired John. John could not pay for his house and his car. John was broke. John saved a man's life. The man gave John some money. John was rich. John got a new car and a new house.

(Wilensky, 1983, pp. 150-151)

Discussion

Example (2) is a summary of (1). It captures the point of the story, namely, that John was broke, John saved a man's life, and the man gave John lots of money. A reader has understood (1) only if he can provide a summary like (2). Notice that the summary leaves out many events, such as dialing 911. The summary also takes numerous instances, such as John selling his car and house, and turns them into a single description: John was broke.

Linguistic: II.C. Discourse segment function

Cognitive-psychological: II.C.6.b.5.c. Summarize
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.5. (#2)

Summarizing

Problem

(1) An Arabic speaking gunman shot his way into the Iraqi Embassy here (Paris) yesterday morning, held hostages throughout most of the day before surrendering to French policemen, and then was shot by Iraqi security officials as he was led away.

(2) One unconfirmed report said that up to 100 armed men, believed to be members of the Shiite Moslem sect, took a number of persons hostage and occupied Mecca's Great Mosque, killing a Saudi clergyman in the process.

(Riesbeck, 1982, p. 45)

Discussion

Riesbeck notes that "Newspaper stories commonly have very long sentences that string together several events and descriptions" (p.45). Sentences like these are often hard to handle if the parser tries to build a complete syntactic parse first, or if it tries to look up every word as it goes along before building a meaning representation. One way of dealing with the linguistic problems that sentences like these pose is to ignore the details altogether. People reading stories seem to focus on the interesting words and only later, if at all, do they analyze the details. The interesting words ("gunman," "embassy," "hostages," etc.) lead to high-level knowledge structures which lead to expectations about words and events in the sentence. These expectations help to disambiguate words and syntactic structures.

Linguistic: I.C.9. Complex sentence structures

Cognitive-psychological: II.C.6.b.5.c. Summarize
CONNECTED-UTTERANCE ISSUES

Reasoning, Argumentation, Story Understanding

Exemplar II.D.5. (#3)

Summarizing

Problem

An operating system is constituted by a set of programs which are used to monitor the execution of the user programs and the use of resources. One of the main reasons for utilizing operating systems is that they allow several processes to run at the same time.

(Fum, Guida, and Tasso, 1985, p. 843)

Discussion

One way to show how well a piece of text has been understood is to present a brief summary of it. To produce this summary, it is necessary to understand which parts of the text are the most important. In the example above, the concept being defined (operating system) and its major purpose (allowing different programs to run at the same time) should be included in a summary.

Linguistic: II.C. Discourse segment function

Cognitive-psychological: II.C.6.b.5.c. Summarize
CONNECTED-UTTERANCE ISSUES

Metaphor

Exemplar II.E. (#1)

Problem

My wife is the sparkle on summer dew. She brightens the dawn of the lovliest morning. To my dismay, the sparkle on summer dew has just run off with the milkman.

(adapted from Cohen, 1979)

Discussion

In the example above, the metaphor in the first sentence comments on the nature of the wife, and the metaphor in the third sentence identifies the reference of the grammatical subject of the sentence. If the third sentence were to appear out of context, its meaning would be unclear. This metaphor of the wife as the sparkle on summer dew must be active throughout an extended passage of text in order for the text to be intelligible.

Linguistic: III.B.2.b. Discourse context relevant for interpretation
III.N.1. Metaphor

Cognitive-psychological: II.C.2.d. World knowledge: Conceptual
CONNECTED-UTTERANCE ISSUES

Metaphor

Exemplar II.E. (#2)

Problem

(1) Professor Emeritus Robert Williams, for many years the foundation of the history department, is no longer as mentally adept and innovative as he once was. The rock is becoming brittle with age.

(2) The large outcrop of granite on your left has numerous small fractures in it. The rock is becoming brittle with age.

(3) Professor Emeritus Robert Williams, for many years the foundation of the geology department, is no longer as mentally adept and innovative as he once was. Yesterday, when examining a specimen of weathered granite, he incorrectly identified it as sandstone. The rock is becoming brittle with age.

["The rock is becoming brittle with age" is cited in Morgan (1979) from its original source in Reddy (1969) as an example of a sentence that can function either literally or metaphorically. The rest of the above examples were generated by the authors.]

Discussion

The sentence "The rock is becoming brittle with age" can be interpreted either literally or metaphorically. The meaning of this sentence can be determined only in context. In example (1) above, the parser must understand that the reference of "the rock" is Professor Emeritus Robert Williams. This reference of "the rock" necessitates a semantic extension of the usual meaning of the noun "rock." In the example (2), the reference of "the rock" is literal.

The problem the parser faces is knowing when it should search for a literal referent and when it should search for a metaphoric one. Example (3) is especially confusing. Although the metaphoric reference of "the rock" is correct, it is very difficult to see how a parser could understand this, given that a literal reference is available as well.

Linguistic: III.B.2.b. Discourse context relevant for interpretation
III.N.1. Metaphor

Cognitive-psychological: II.C.2.d. World knowledge: Conceptual

Group III: True-dialogue Issues

In Group III problems the system must know not only about the sequence of utterances read but also something about the user's goals, intents, and expectations. Group III examples do not necessarily involve an actual two-way dialogue between the system and the user but they at least involve building or accessing a model of the user. We assume that the essence of dialogue is being able to make judgments about the goals, expectations and beliefs of the other participant. With true-dialogue issues, the system does not simply give responses to the user's input but brings to bear knowledge about users and their use of language in deciding on the response. Group III problems involve an interchange between two knowledgeable entities.

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#1)

Problem

(1) Q: Has a yellow car gone by?
A: Yes, one yellow one on Hartungstreet.

(2) Q: Have several vehicles stopped on Biberstreet?
A: Yes, two.

(Wahlster, Marburger, Jameson, and Busemann, 1983, p. 644)

Discussion

Simply responding with "yes" to either of the above questions, without any further response, would literally answer the question but result in a frustrated questioner. A helpful answer requires further information. For example, one must infer in (1) that the first questioner's goal might be to find out where a yellow car was observed. In (2), the second questioner's goal might be to know how many vehicles have stopped. Inferring these user goals is a task that requires reasoning about the user's goals.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.1. Verification

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#2)

Problem

Could you mount a magtape for me? It's T376. No ring please. Can you do it in five minutes?

(Allen, Frisch, and Litman, 1982, p. 66)

Discussion

The user's utterances specify a goal and then further refine it. The first utterance suggests that the user wants a tape mounted. The latter utterances specify this goal further, letting the system know that the user wants a particular tape mounted within the next five minutes and without a ring. That is, the second and third utterances specify further information about the object upon which the system should act, and the fourth specifies the time when the system should act.

Note: For a discussion of the above example as an indirect speech act see Exemplar III.C. (#2)

Linguistic: III.K. Coherent/related content
IV.F. Sentence fragment

Cognitive-psychological: II.C.6.b.2.a.1. Quantification: Exact

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#3)

Problem

U: Could you mount a magtape for me? It's T376. No ring please. Can you do it in five minutes?

S: We are not allowed to mount that magtape. You will have to talk to the head operator about it.

U: How about tape T241?

(Allen, Frisch, and Litman, 1982, p. 66)

Discussion

Standing by itself, outside of this dialogue, the last utterance makes little sense. But in the example above its meaning is that the user's goal of mounting tape T376, expressed as an indirect speech act [see Exemplar III.C. (#2)], should be replaced with a goal of mounting tape T241. Understanding the ellipsis (T241 for T376) is only part of the problem. The system must recognize that the user has activated a new goal with the elliptical substitution.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.B. Processing semantics

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#4)

Problem

U: I need some more disk space.
S: Type "rm *."

(Wilensky, 1982, p. 105)

Discussion

In this example, the system has given the user some bad advice: "rm *" is the UNIX command that removes all of the user's files. The reason for this mistake is that the system did not infer that the user's goal is not simply to have more disk space. The user also wants to preserve his existing files. This means that the user's goal is really to get an increase in the total space available to him. The system has to interpret the user's utterance in terms of this higher level goal which it first has to recognize. The problem is that the user has many goals and somehow only the relevant goal should be addressed.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.b.7.c.3. Goal: Concordance

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#5)

Problem

U: Has John checked in yet?
S: No--shall I let you know when he has?

U: Has John checked in yet?
S: Yes--shall I let you know when the rest of the committee members do?

(Webber & Mays, 1983, p. 651)

Discussion

In each of these examples, the system offers to take further action that it believes fits the user's goals. The user might want some information that is not currently available, and the question (or a related question) should be renewed at a later time. In the first situation, the user's goal is inferred to be finding out when John arrives. In the second, it is inferred that the user wants to know when people associated with John will arrive. Inferring these goals requires the system to reason about possible future states of the world.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.1. Verification

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#6)

Problem

(1) Last time we met we had an excellent dinner together.
(2) This product is going to be a big seller.

(Wahlster & Kobsa, 1986, p. 957)

Discussion

Suppose the two sentences above are uttered by the same speaker during the course of a business conversation. In (1) the speaker assumes the role of a friend. In (2) the speaker assumes the role of a salesman. Different expectations are associated with each role, so the hearer must be able to infer the role of the speaker.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.g. Intention: To play a role

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#7)

Problem

Is Professor Smith teaching Expert Systems next semester?

(adapted from Carberry, 1988, pp. 26-27)

Discussion

To respond helpfully to this utterance, the hearer must understand the user's plans. This user could want to take Expert Systems only if it is taught by Professor Smith. Or the user could want to take Expert Systems only if Professor Smith is not teaching it. Or the user may want to take some course taught by Professor Smith. The response will vary depending on which of these plans the user is assumed to have.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.1. Verification

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#8)

Problem

U: Is there a lamp near to every bed?
S: Yes, next to almost every one.

(Hoeppner, Christaller, Marburger, Morik, Nebel, O'Leary, and Wahlster, 1983, p. 592)

Discussion

Taken literally, the question can only be answered "yes" if there is, in fact, one lamp next to every bed. One bed without a lamp and the question would require a "no." Yet, if the questioner's goal can be inferred to be "Is it likely that there will be a lamp next to my bed?" the answer above is reasonable. Recognizing when an approximate answer is satisfactory requires that the answerer have a model of the questioner's goals.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.1. Verification

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#9)

Problem

U: Should I take discrete math and data structures this semester?

R1: Yes, data structures is a requirement for all later Computer Science courses and discrete math is corequisite for Data Structures.

R2: Yes, you usually take them both first semester, sophomore year.

R3: Yes, they are both offered next semester, but not in the spring, and you need to get them out of the way as soon as possible.

R4: Yes, if you take data structures this semester, you can take intro to AI next semester.

(McKeown, Wish, and Matthews, 1985, p. 794).

Discussion

Depending on the user's goals, the question above is understood differently. If the user's goal is known to be completing requirements quickly, (U) is understood to be asking whether these courses are requirements for later courses, leading to response (R1). If the user's goal is known to be taking AI as soon as possible, (U) is understood to be asking whether these courses are necessary to take AI, leading to response (R4). Similar inferred user goals lead to responses (R2) and (R3).

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.5.a. Description: List attributes

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#10)

Problem

User: Add a dual disk to the order.
System: A dual ported disk. What storage capacity?

(Carbonell & Hayes, 1983, p. 133)

Discussion

The response by the system is a form of elaboration ellipsis. The system intends to confirm the missing information and gather more needed information without interrupting the conversational flow. In each case, the utterance must be recognized as referring to the topic introduced by the user. This kind of cooperative dialogue is very common when the user believes that he is dealing with someone who understands natural language. It is often assumed that "understanding language" means understanding the user's goals and sharing common assumptions.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.8.b. Presuppositions of speaker: Contextual

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#11)

Problem

User: Give me a dual port tape drive.
System: A dual port tape drive?
User: Sorry, a dual port disk drive.

(Carbonell & Hayes, 1983, p. 133)

Discussion

The system simply echoes the semantically incomprehensible part of the input. The user should recognize the question marking as indicating that the system found this phrase problematic. Then the user's response must be seen as offering a substitute phrase. "Sorry, ..." is a stock corrective phrase and clues the system that the user recognizes the mistake and will offer a substitute.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.4. Identification
II.C.6.c. To command

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#12)

Problem

I'm only interested in A-7's.

(Waltz, 1982b, p. 19)

Discussion

This example is excerpted from user input to a database front-end. The purpose is to tell the system that "restricted to A-7's" is implicit in the questions. This might be a correction to an earlier question, or a preparation for a series of subsequent questions. In the latter case, the restriction is in effect until the user indicates that it is no longer in effect. Such declarative information cannot be parsed directly into a query, but must be added to the system's expectations about the user's needs.

Linguistic: III.K. Coherent/related content

Cognitive-psychological: II.C.6.b.6. Instruction

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#13)

Problem

(1) Give me a month by month status report for F-4's.
(2) Which plane had the worst maintenance record?

(Waltz, 1982b, p. 18)

Discussion

The examples above are taken from user input to the PLANES natural language front-end to a database of aircraft flight and maintenance data. These inputs are problematic for a database front-end. The system does not in general know what kind of information a user might want in a "status report." Creating a status report requires the ability to reason about the data that is contained in the database, as well as about the relations between them. Similarly, the plane with the "worst maintenance record" cannot be determined without knowing what defines worst. Each of these queries requires that the system be able to reason about the user's needs.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.5.c. Summarize

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#14)

Problem

U: Give me a large capacity disk.
S: With dual ports?
U: Yes, and a universal frequency adapter.

(Carbonell & Hayes, 1983, p. 133)

Discussion

Each of the two sentence fragments have to be recognized as elaborations of the previous utterance. This sort of ellipsis is common in ongoing dialogues in which speakers assume a goal known to both of them. In this case the user is engaged in defining, in several steps, his needs for a disk. Both participants are building a model of what the user wants by establishing a basic topic and adding to or modifying the default features for that topic. Closure of this model building might be marked by a sentence beginning with a phrase like "also give me" to introduce a new topic.

Linguistic: III.C. Ellipsis
III.K. Coherent/related content
IV.F. Sentence fragments

Cognitive-psychological: II.C.6.c. To command

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#15)

Problem

U: What is the price of the three largest single port fixed media disks?
U: Speed?
U: Two smallest?

(Carbonell & Hayes, 1983, p. 134)

Discussion

In the example above, the third query is ambiguous. The fragmentary sentences are reformulations of the earlier queries. Certainly, the second question refers to the speed of the "three largest...disks." In the third question, "Two smallest?" can be seen to replace "three largest" on semantic grounds (the only possible such match in either earlier query). The system may have difficulty deciding whether to make the replacement in the second (speed) or the original (price) question. This ambiguity cannot be resolved from the surface input. The system needs to have a model of the user's goals.

Linguistic: III.C. Ellipsis

Cognitive-psychological: II.C.6.a.2.a.1. Quantification: Exact

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#16)

Problem

(Q) Do you want a piece of chocolate?
(A) I just had an ice cream cone.

(Schank, 1980, p. 249)

Discussion

In this dialogue fragment, we understand the second sentence to mean "No." To do so, it is necessary to infer that having eaten terminates any hunger goal, which eliminates the goal of having more food, which means that the respondent does not want a piece of chocolate. These inferences involve causal and enablement relations. For example, having food enables eating it, and eating food causes one to no longer be hungry.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.1. Verification
II.C.6.b.8.d. Implication

TRUE-DIALOGUE ISSUES

User Goals and Plans

Exemplar III.A. (#17)

Problem

What courses deal with computers?

(adapted from Tennant, 1979, p. 876)

Discussion

If the knowledge base only has information about the specified topics of courses, it will return only those courses that explicitly mention computers and not ones that mention specific hardware or software topics. To give a useful answer, the system must have knowledge of the relationships among the objects that the user might ask about and that the system knows about.

Linguistic: III.K. Coherent/related content

Cognitive-psychological: II.C.6.a.2.b. Denotation: Composition

TRUE-DIALOGUE ISSUES

Logical Presuppositions

Exemplar III.B. (#1)

Problem

Who is teaching C.S. 239 this quarter?

(adapted from Kaplan, 1982)

Discussion

This utterance presupposes that there is a course "C.S. 239" and that it is being offered this quarter. If either of the presuppositions are incorrect, the correct answer is unclear. If the question is part of a larger query to generate a list of all courses, it might be reasonable to answer "no one" or nil. But more commonly, the user would like to know if, in fact, the course isn't being offered rather than that it does not have an instructor assigned. To give the helpful response, the system must have access to enough domain knowledge to understand and test the presuppositions.

Linguistic: III.D. Presupposition

Cognitive-psychological: II.C.6.a.2.b. Denotation: Composition

TRUE-DIALOGUE ISSUES

Logical Presuppositions

Exemplar III.B. (#2)

Problem

(1) Israel can't negotiate with the PLO because they don't even recognize Israel's right to exist.

(2) Israel doesn't recognize the PLO either.

(3) But the PLO is just a bunch of terrorists.

(Birnbaum, 1982, pp. 63-65)

Discussion

To understand this argument, utterance (2) must be seen as an attack on utterance (1). Somehow Israel's not recognizing the PLO is an attack upon the PLO's not recognizing Israel. And (3) must be understood as an attack on (2). The implicit meaning of (3) is something like: "Since the PLO is a terrorist organization, Israel does not have to recognize them." Following this argument requires that the understander have access not only to the surface meanings of the sentences, but also to the underlying world knowledge about political relations and to the implicit structure of the argument that connects the utterances.

Linguistic: II.B. Discourse relation of clause

Cognitive-psychological: II.C.2.e. World knowledge: Cultural
II.C.6.b.8.d. Implication

TRUE-DIALOGUE ISSUES

Logical Presupposition

Exemplar III.B. (#3)

Problem

How many propeller replacements were made for A-4's?

(Waltz, 1982b, p. 26)

Discussion

Before an understander attempts to answer a concrete question, it should determine whether the situation presented in the question corresponds correctly to a real-world situation. Understanding a sentence is more than just forming a database query or a logical form. The A-4 is a jet aircraft, and thus does not have a propeller that can be replaced. Questions that make a plausibility error should be targeted for correction by the system. It is more efficient to check for propellers on A-4's before constructing the query, than to ask and get a zero answer. In the case of the A-4's, a helpful system would answer "The A-4 does not have a propeller."

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.2.a.1. Quantification: Exact
II.C.8.b. Presuppositions: Contextual

TRUE-DIALOGUE ISSUES

Speech Acts

Exemplar III.C. (#1)

Problem

(1) It's cold in here.
(2) Turn on the heater.
(3) Shut the window.

(Ellman, 1983, pp. 600-601)

Discussion

Example (1) is an indirect request for the listener to perform an action. Utterance (1) is intended to motivate the listener to perform some action necessary to achieve the speaker's goal of staying warm. To understand the utterance, this goal of the speaker must be inferred or already known, and the meaning of the utterance must be interpreted as a request for an action. Examples (2) and (3), on the other hand, are direct requests; the speaker's request for action is explicit and does not need to be inferred.

Linguistic: III.P. Indirect speech acts

Cognitive-psychological: II.C.6.c. To command

TRUE-DIALOGUE ISSUES

Speech Acts

Exemplar III.C. (#2)

Problem

(U) Could you mount a magtape for me? It's T376. No ring please. Can you do it in five minutes?

(S) We are not allowed to mount that magtape. You will have to talk to the head operator about it.

(Allen, Frisch, and Litman, 1982, p. 66)

Discussion

Utterance (U) is a query about the system's abilities. It could be taken narrowly as a question about the system's physical capabilities. But it is actually intended as a request for the system to perform an action, which makes it an indirect speech act. If the system cannot recognize the indirect speech act, it might only answer "yes" to (U) and then refuse to mount the tape when the user specifically requests it. Even if the system interprets "could" to cover permission as well as capacity, it might still only say "no." But if the system recognizes the indirect speech act, it can give the helpful suggestion about the head operator. Recognizing the query as an indirect speech act requires knowledge of the user's goals.

Linguistic: III.P. Indirect speech acts

Cognitive-psychological: II.C.6.c. To command

TRUE-DIALOGUE ISSUES

Speech Acts

Exemplar III.C. (#3)

Problem

(1) That cake that you made looks delicious.
(2) No planes crashed in January, right?

(Waltz, 1982b, p. 23)

Discussion

A single sentence can have many purposes and interpretations. The first example, for instance, can be understood as giving the speaker's opinion about the cake, praising the cook, or requesting some of the cake. The second sentence both states a belief and requests a confirmation of that belief.

Examples like this pose problems for systems that come up with only one meaning for a sentence. Because a system may be expected to use any one of multiple speech acts for a given sentence, it must be able to recognize all of the possible speech acts associated with the sentence.

Linguistic: III.M. Inferring goal from context and world knowledge

Cognitive-psychological: II.C.6.a.1. Verification
II.C.9. Point of view of the speaker

TRUE-DIALOGUE ISSUES

Meta-Linguistic Discourse

Exemplar III.D. (#1)

Problem

U: Print gauss.rel on the diablo printer.
S: GAUSS.REL is not a printable file.
U: Oops, I meant gauss.for.

(Hayes & Carbonell, 1983, p. 668)

Discussion

Here, the user's second utterance tells its listener to substitute gauss.for for gauss.rel in the user's first utterance. This is a metalinguistic reference across utterances in the dialogue. To understand its meaning, the hearer must be able (a) to infer an object for which gauss.for can be substituted and (b) to understand that this utterance is intended to cancel the effect of the first utterance. In this way, it is different from ellipsis. There are two important issues here. First, how is the meaning of such corrective metalinguistic utterances derived? And second, how does the understanding of previous utterances in the dialogue change based on these corrective utterances?

Linguistic: III.Q. Metalanguage

Cognitive-psychological: II.C.6.c. To command

TRUE-DIALOGUE ISSUES

Meta-Linguistic Discourse

Exemplar III.D. (#2)

Problem

X: I heard Sally got tenure. [Sally approaches.]
Y: Well, speak of the devil.

(Gasser & Dyer, 1986, p. 388)

Discussion

The expression "speak of the devil" cannot be understood by understanding the individual words. Neither is it like a conventional fixed phrase or idiom. Understanding the expression means knowing that a new person has just arrived on the scene, and that this person is the current focus of the dialogue.

Linguistic: I.B.2. Idiomatic phrases
III.Q. Metalanguage

Cognitive-psychological: II.C.1.b. Context: Non-military

Group IV: Ill-formed Input

Ill-formed input is often difficult to classify because the input may miss being well-formed for one of a number of different reasons. For example, lack of number agreement between subject and verb as in "he do it" might be due to wrong number for the subject (they do it), wrong number for the verb (he does it), wrong tense in the verb (he did it) or a missing word (he can do it). For this reason, it is difficult to classify ill-formed input based on the form of the input.

Our interest here is in analyzing NLP issues according to the user's expectations and the information processing problems involved. From this viewpoint, it is useful to divide ill-formed input into two broad categories: input which the user will see as ill-formed(e.g., typing mistakes) and input which the user expects the system to handle but which is non-standard in some way. These two categories require different processing strategies.

Simple mistakes like misspellings or words left out can be corrected by spelling checkers or semantic information or simply by pointing out the error to the user and asking for a correction. But non-standard usage--incomplete sentences or non-standard sentence structure--needs a more sophisticated interaction between the user and the system. If the input sounds reasonable to the user, it might be difficult to explain why the system cannot accept it. It is often hard for the user to anticipate exactly what degree of incompleteness of a sentence the system will be able to handle.

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.1. (#1)

Mistypings: Spelling

Problem

Add two fixed haed dual prot disks to the order.

(Carbonell & Hayes, 1983, p. 125)

Discussion

The parser should recognize "haed" and "prot" as unknown words. There are standard techniques for matching a misspelled word to a set of possible corrections. Syntactic considerations rule out "had" and "heed" and semantics rule out "hand" and "hated" for "haed." In this case, only "head" (and "port" for "prot") satisfy the semantic expectations generated by the context and the other words in the order.

Linguistic: IV.D.1. Spelling

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.1. (#2)

Mistypings: Segmentation

Problem

(1) Add two dual portdisks to the order.
(2) Add two dual port disks to the ord er
(3) Add two du alport disks to the order.

(Carbonell & Hayes, 1983, p. 126)

Discussion

These errors will probably initially appear as misspellings. Therefore, spelling correction will be tried. When traditional spelling correction methods fail, the system should try inserting, deleting and/or moving spaces with the goal of creating free-standing words that make sense in the context of the sentence. If there are compound errors, the problem compounds exponentially.

Linguistic: IV.D.3. Mechanical

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.2. (#1)

Syntactic constraint violations: Agreement failure

Problem

(1) Does the order include a disk drives?

(2) Show me the companies with an order that has a power adapter.

(3) Show me the companies with an order that have a power adapter.

(1 adapted from Carbonell & Hayes, 1983, p. 129.)

Discussion

Agreement failure is a common form of syntactic constraint violation. Most of the time, these failures are not serious problems. For example, in (1), it does not matter if the last phrase was supposed to be "a disk drive" or "any disk drives." But there are cases where the singular or plural reading would make an important distinction. In (2), the request covers those companies whose orders include a power adapter. In (3), the request includes any companies that already have an adapter (perhaps from an earlier order) as well.

Linguistic: IV.C. Ungrammatical

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.2. (#2)

Syntactic constraint violations: Tense assignment

Problem

Open fired.

(Granger, 1983, p. 194)

Discussion

This kind of error is more common in spoken input but is seen even in written input. (Users often write what they hear.) The system must be able to recognize the past tense and parse the underlying "open fire." Then the tense can be assigned back into the phrase to result in the correction: Opened fire.

Linguistic: IV.C. Ungrammatical

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.2. (#3)

Syntactic constraint violations: Missing preposition
Misplaced noun phrase

Problem

Move the accounts directory the file Data3.

(Fain, Carbonell, Hayes, and Minton, 1985, p. 114)

Discussion

Although this sentence has several grammatical errors, including a missing preposition, ("to"), and a misplaced noun phrase, ("the file Data3"), it is still understood as a command to move the file Data3 into the accounts directory. To handle this kind of input robustly, the parser should have access to information about likely objects in order to fill the slots of the basic verb. The missing word "to" must be inferred, and it must be realized that "the file Data3" is the object to be moved and "the accounts directory" is the destination to which it is moved.

Linguistic: IV.C. Ungrammatical

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.2. (#4)

Syntactic constraint violations: Missing article
Missing preposition

Problem

Copy new files my directory.

(Carbonell & Hayes, 1983, p. 127)

Discussion

Users often leave out function words where they think that the words are unnecessary. This may be because the users wish to be more efficient or to emulate a computer. Often, the missing constituents can be recovered by examining the semantics of the utterance.

Linguistic: IV.C. Ungrammatical

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.3. (#1)

Semantic constraint violations: Missing adjective

Problem

(1) Add two fixed head dual ported disks to my order.
(2) Add two fixed head ported disks to my order.
(3) Add two fixed head dual disks to my order.

(Carbonell & Hayes, 1983, p. 127)

Discussion

Compared to (1), examples (2) and (3) have a missing word whose absence is noted on semantic grounds. Recovery from missing constituents depends on exactly which words were left out. In (3), the "ported" can be inferred semantically because the only thing "dual" about disks is the number of ports. But in (2), "dual" cannot be recovered because all disks are ported.

Linguistic: IV.D.3. Mechanical

Cognitive-psychological: I.B. Processing semantics

ILL-FORMED INPUT

Mistakes

Exemplar IV.A.3. (#2)

Semantic constraint violations: Misunderstanding of the knowledge base

Problem

Add a floating head tape drive to the order.

(Carbonell & Hayes, 1983, p. 129)

Discussion

Semantic constraint violations are often due to the user's conceptual misunderstandings. These are difficult to detect if the parser is also considering the possibility of other types of errors. In addition these violations are often very difficult to resolve without interaction with the user. A parser relying heavily on semantic constraint satisfaction might confuse this kind of error with some other kind of error and find an unintended interpretation.

Linguistic: IV.D.4. Semantic

Cognitive-psychological: I.B. Processing semantics

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.1. (#1)

Incomplete sentence: Label with colon as sentence component

Problem

Example: Your percentage of $250.00 is $187.50.

(Jensen, Heidorn, Miller, and Ravin, 1983, p. 149)

Discussion

The string "Example: plus statement" is not a syntactically well-formed utterance because a single word rather than a complete sentence precedes the colon. However, the string does contain a complete sentence after the colon. A parser working strictly left-to-right will have trouble continuing past the colon. But a parser looking for maximal complete structures will find the longest phrase that makes a sentence and can recognize the first word as a label. Alternatively, a parser with good domain knowledge might recognize the "Example:..." as a common form in this domain.

Linguistic: IV.D.2. Punctuation

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.1. (#2)

Incomplete sentence: Sentence fragment

Problem

Good luck and good selling.

(Jensen, Heidorn, Miller, and Ravin, 1983, p. 149)

Discussion

This statement contains a complete thought to the writer, but to a syntactic parser, it fails to constitute a sentence. Statements like this cause problems for a parser that looks for well-formed sentences as input. An understander, whether a person or a machine, can recognize the implied "I wish you..." based on a model of the writer's goals and discourse knowledge about wishes.

Linguistic: IV.A. Fixed phrases/colloquialisms
IV.F. Sentence fragments

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.2. (#1)

Casual structure: Unnecessary constituents

Problem

(1) Add if you would be so kind two fixed head and if possible dual ported disks to my order.

(2) I think I need more storage capacity, so add two fixed head dual ported disks to my order.

(Carbonell & Hayes, 1983, p. 127)

Discussion

In addition to a basic request, the user might offer explanations or rationalizations, as in (2), or might add conventional stock phrases, as in (1), to the input. Some stock phrases might be known to the parser but generally these phrases will go beyond the parser's limited knowledge. One possible strategy is to try to find a well-formed structure in the recognizable part of the input and consider anything not recognizable as meaningless. However, if the parser had a good model of the user, it could be prepared for examples like (2) and include the user goal as part of its input. This would allow the system to interact reasonably with the user about his storage needs.

Linguistic: IV.A. Fixed phrases/colloquialisms

Cognitive-psychological: I.C.6.c. To command

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.2. (#2)

Casual structure: Out of order constituents

Problem

Two fixed head dual ported disk drives add to the order.

(Carbonell & Hayes, 1983, p. 129)

Discussion

This kind of ill-formed input can occur because the user does not want to retype a long description or because the user has a model of the system's expectations that calls for the object to be given before the action. This is primarily a problem for parsers that depend on getting information in a strict order or in a fixed form. If the phrases can be identified, then the utterance allows only one semantically well-formed interpretation.

Linguistic: IV.C. Ungrammatical

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.2. (#3)

Casual structure: Sentence boundaries

Problem

Locked on opened fire.

(Granger, 1983, p. 194)

Discussion

Casual or hasty input often runs on between sentences or leaves out crucial punctuation. If the system is prepared for this, the (partial) sentences "locked on" and "opened fire" can be parsed when no overall sentence can be seen.

Linguistic: IV.D.2. Punctuation
IV.F. Sentence fragments

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.3. (#1)

Idiolect: The fuzziness of grammaticality

Problem

(1) When you put former cheerleaders in a room, they discuss their numerousness.

(2) When you put former cheerleaders in a room, they discuss their own numerousness.

(Winograd, 1983, p. 186)

Discussion

The assignment of grammaticality is, in the end, the choice of an adult native speaker of the language, and not of a formalism that would accept or reject one of the above examples. If the adjective "own" makes the sentence admissible or inadmissible to a parser, the grammatical formalism is enforcing too strict a requirement. The assignment of acceptability should not be based solely on acceptance by grammar, but on the sense that can be made of the sentence using grammatical rules.

Linguistic: III.B.1.g. Pronoun reference: Other
IV.B. Semi-grammatical structures

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.3. (#2)

Idiolect: Syntax error--agreement

Problem

(1) A carbon copy of the Workman's Compensation forms are enclosed for your information.

(Jensen, Heidorn, Miller, and Ravin, 1983, p. 153)

Discussion

Often a usage which is judged grammatically incorrect by prescriptive standards is acceptable to some native speakers. In the example above the verb should be "is" in order to agree correctly with the singular subject "a carbon copy." Possible reasons for the use of the plural form of the verb here are (1) association of the verb with the most recent noun phrase, "Workman's compensation forms," and (2) the semantic interpretation of "copy" as plural because multiple items are being copied.

Agreement errors in general are common and errors involving complex noun phrases, such as the one above, are even more common. A user for whom the above sentence is acceptable may not understand why a parser would have difficulty understanding it, even if the parser tries to query the writer interactively. For these reasons, the parser should be able to understand and accept utterances with simple agreement errors and recognize that such errors have no significant impact on the meaning of an utterance. The parser can then routinely process text which includes simple agreement errors.

Linguistic: IV.B. Semi-grammatical structures

Cognitive-psychological: I.A. Processing syntax

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.3. (#3)

Idiolect: Incorrect and corrected constituents

Problem

(1) Add I mean remove a disk from my order.

(2) Add a single ported dual ported disk to my order.

(3) Add a high speed tape drive, that's disk drive, to the order.

(4) Add a dual ported disk drive, I mean tape drive, to the order.

(1-3 from Carbonell & Hayes, 1983, p. 128)

Discussion

If the user is convinced that the system understands English, he is more likely to let these kinds of errors stand, rather than erasing and rephrasing. These examples illustrate a primarily syntactic problem. The input does not have the expected form. Semantically based parsers can recognize that there are two components for the same slot and can apply strategies for choosing one constituent over the other (i.e., choosing the more recent constituent). Often pragmatic considerations are important in this process. In (3), the parser needs to recognize that "disk drive" should be substituted for "tape drive," not "high speed tape drive." But in (4), "tape drive" substitutes for "dual ported disk drive."

Linguistic: IV.E. Repairs, corrections

Cognitive-psychological: I.C.6.c. To command

ILL-FORMED INPUT

Non-standard Input

Exemplar IV.B.3. (#4)

Idiolect: Agreement and missing punctuation

Problem

What exactly does that 15 months do.

(Jensen, Heidorn, Miller, and Ravin, 1983, pp. 157-159)

Discussion

The intended reading of this sentence is: "What exactly does that fifteen-month period do?" To infer this reading, the parser must recognize that a question mark is missing and must know that a number used with a plural noun of time, such as days, months, years, etc., following a singular adjective such as "that," should be interpreted as a period of time. However, if the parser recognizes the agreement error between "that" and "months", it could attempt to correct the problem by changing "does that" to "do those." This change would produce a sentence which reflects the meaning intended by the user.

Linguistic: III.C. Ellipsis
IV.D.2. Punctuation

Cognitive-psychological: I.A. Processing syntax

Cross-indexing of Sourcebook Exemplars with Linguistic and Cognitive-psychological Classification Schemes

When the development of the Natural Language Sourcebook was undertaken, the artificial intelligence (AI) , computational linguistics, and cognitive science literatures were identified as the richest sources of processing problems. From those three bodies of literature the 197 example problems in the Sourcebook were culled and then classified from an AI perspective on the basis of the natural language processing problems they presented.

The authors recognized, however, that linguistic and cognitive taxonomies might provide different organizational approaches to the processing problems. For this reason, a linguist and an educational psychologist were asked to provide a perspective from each of their disciplines on how the processing problems might be classified. Two additional classification schemes emerged, one from linguistics and one from cognitive psychology. The linguistic classification scheme grew out of the Sourcebook exemplars. The cognitive-psychological classification scheme, on the other hand, was developed independently of the Sourcebook exemplars.

The cross-indexing information appears at the end of each exemplar. In addition, a discussion of the linguistic and cognitive-psychological classification schemes and the schemes themselves follow this introductory explanation. It will be clear from a comparison of these two schemes and the Sourcebook classification scheme that there is considerable

overlap across schemes. The processing problems represented in the Sourcebook classification and exemplars are often due to linguistic complexities or pragmatic issues, and certainly a cognitive-psychological approach relies heavily on the linguistic import of a given situation.

Author's Note

We gratefully acknowledge the assistance of Dr. Carol Lord, Intelligent Text Processing, Inc., Santa Monica, CA, who developed the Linguistic Classification Scheme and Dr. Merlin C. Wittrock, Graduate School of Education, UCLA, who developed the Cognitive-psychological Classification Scheme.

A Linguistic Classification of Exemplars from the Natural Language Sourcebook

There are a variety of approaches to the task of natural language understanding. Differences of approach can reflect different goals and different assumptions about the nature of language. As a result, comparing the claims of natural language processing systems can be difficult. The Natural Language Sourcebook has contributed to the establishment of common ground by providing examples (exemplars) of natural language processing problems collected from a survey of the artificial intelligence and related literature. The examples have been described and grouped in terms of the knowledge needed and the task being addressed.

Another potentially useful taxonomic approach is based on an analysis of a text into linguistic units. The set of exemplars in the Sourcebook present three major areas of analysis: (1) syntactic units, (2) discourse structures, and (3) semantic interpretation. These groupings have fuzzy boundaries because the task of analyzing human language is not easily compartmentalized into separate, distinct levels. Problems of semantic interpretation, for example determining anaphoric reference, can depend on syntactic structures (Group 1) as well as discourse context (Group 2) and world knowledge or commonsense knowledge. A fourth area has been included, ill-formed structures; the approach a particular system takes in dealing with a particular example of ill-formed input may vary widely depending on whether its authors

view the problem as one of determining syntactic structure (Group 1) or discourse relation (Group 2) or inferring missing semantic content (Group 3). It is hoped that an outline using this approach will be useful to investigators with linguistic perspective.

Notes on the Linguistic Classification

The first group, syntactic units, has been divided into three subgroups: grammatical category, wordsense, and constituent structure. Many of the exemplars are instances of ambiguity between two grammatical categories, so the grammatical category subgroup is further divided according to the categories between which a lexical item is ambiguous. These are: (1) noun/verb, (2) noun/adjective, (3) noun/participial adjective, (4) verb/participial adjective, (5) verb/auxiliary, (6) verb/preposition, (7) preposition/particle, (8) pronoun/possessive pronoun, (9) demonstrative/complementizer.

The second subgroup, wordsense, is divided into (1) instances in which a lexical item has more than one sense within a single grammatical category and (2) idiomatic phrases with meaning different from the literal combination of lexical items. The lexical items in (1) are further sub-grouped according to grammatical category: (a) noun and (b) verb.

Exemplars in the third subgroup, constituent structure, have been grouped for convenience, somewhat arbitrarily, into issues of (1) noun phrase constituent structure, (2) prepositional phrase attachment, (3) participial modifier attachment, (4) phrasal verb structure, (5) passive, (6) coordination, (7) appositive, (8) vocative, (9) complex sentence structures, (10) syntactic ambiguity, and (11) "garden path" sentences which typically require a syntactic re-structuring of the initial parse. Because these groupings are not mutually exclusive, an exemplar can occur in more than one subgroup and in more than one grouping within a subgroup.

The second major grouping, discourse structures, has three subgroups. The first subgroup, functional sentence perspective, includes exemplars for which the issues of discourse topic and focus of new information are relevant. The second subgroup contains exemplars for which the relations between clauses in discourse are important in order to make correct inferences about goals, plans, and events not explicitly stated in the text. For the third subgroup, the relevant discourse functions are those of segments of the discourse larger than the single clause.

The third major heading, semantic interpretation, contains exemplars grouped into 18 subgroups reflecting a range of problems of meaning. The largest subgroup, anaphora, includes problems of reference of pronouns and definite noun phrases. The exemplars are grouped roughly

according to the type of referent and the nature of the knowledge needed for interpretation.

The fourth grouping contains a variety of ill-formed structures, from colloquialisms to typographical errors, which a natural language system will need to handle.

Linguistic Classification

I. Syntactic units
   A. Grammatical category
      1. Noun/verb
      2. Noun/adjective
      3. Noun/participial adjective
      4. Verb/participial adjective
      5. Verb/auxiliary
      6. Verb/preposition
      7. Preposition/particle
      8. Pronoun/possessive pronoun
      9. Demonstrative/complementizer
   B. Wordsense
      1. Lexical items
         a. Noun
         b. Verb
      2. Idiomatic phrases
   C. Constituent structure
      1. Noun phrase structure
      2. Prepositional phrase attachment
      3. Participial modifier attachment
      4. Phrasal verb structure (verb-preposition, verb-particle)
      5. Passive
      6. Coordination
      7. Appositive
      8. Vocative
      9. Complex sentence structure
      10. Syntactic ambiguity
      11. "Garden path" sentences

II. Discourse structures
   A. Functional sentence perspective
   B. Discourse relation of clause
   C. Discourse segment function

III. Semantic interpretation
   A. Semantic case role
   B. Anaphora
      1. Pronoun reference
         a. Reference within the clause
         b. Quantified noun phrase referent
         c. Generic noun phrase referent
         d. Propositional referent
         e. Forward reference
         f. World knowledge required to determine referent
         g. Other
      2. Definite noun phrase reference
         a. Reference to member of previous set
         b. Discourse context relevant for interpretation
         c. World knowledge relevant for interpretation
         d. Other

C. Ellipsis
D. Presupposition
E. Generic noun phrase
F. Scope of modifier
G. Comparative constructions
H. Genitive phrase
I. Temporal relations, causation
J. Location and movement
K. Coherent/related content
L. Adjective/adverb range
M. Inferring goal from context and world knowledge
N. Metaphorical extensions
   1. Metaphor
   2. Simile
O. Irony
P. Indirect speech acts
Q. Metalanguage

IV. Ill-formed structures
A. Fixed phrases/colloquialisms
B. Semi-grammatical structures
C. Ungrammatical
D. Typographical errors
   1. Spelling
   2. Punctuation
   3. Mechanical
   4. Semantic
E. Repairs, corrections
F. Sentence fragments
G. Unclear goal
H. Novel usage/inventions

A Cognitive-psychological Classification Scheme for Natural Language Processing

From cognitive-psychological perspectives, the central purpose of natural language processing is to communicate meaning in everyday contexts. Everyday contexts are often complex and sometimes stressful as, for example, in the military services during warfare. When the conditions for communication are complex, natural language processors must be sophisticated enough to construct informed, useful answers to imperfectly coherent, sometimes ungrammatical questions. These processors must incorporate appropriate grammars, knowledge representation systems, language analyzers, conceptual dependencies, semantic networks, and representations of realistic contextual and pragmatic information, including the intention of the questioners, their background knowledge, and their restricted use of language under stress and fatigue.

The Natural Language Sourcebook provides examples (exemplars) of processing problems documented in the artificial intelligence and related literature. The classification scheme around which the Sourcebook is organized evolved from these exemplars. As an alternative classification approach, the following cognitive-psychological scheme was developed independently of the Sourcebook exemplars with a focus on the natural language processing (NLP) conditions which often arise under stressful military conditions (See Wittrock, 1989, for a discussion of

the cognitive-psychological principles involved in the following classification scheme).

The cognitive-psychological taxonomy can be applied to single utterances and connected discourse. Thus, the two major headings in the classification scheme are (I) Processing single utterances and (II) Processing connected discourse. Because both single utterances and connected discourse require syntactic, semantic, and pragmatic information to give them meaning, the next level of categories in the taxonomy includes (A) Processing syntax, (B) Processing semantics, and (C) Processing pragmatics. For the Sourcebook cross-indexing, the major emphasis is on exemplars which are pragmatic in orientation. Only the exemplars which lend themselves to a pragmatic classification are finely cross-indexed according to the cognitive-psychological classification scheme. However, the other exemplars each have a notation which indicates whether they would come under the broad heading of processing syntax or processing semantics according to the cognitive-psychological classification scheme. The focus on pragmatics for the cognitive-psychological cross-indexing provides a complementary perspective to the linguistic cross-indexing.

Cognitive-psychological Classification

I. Processing single utterances

A. Processing syntax
1. Type of sentences
a. Declarative
1.) Active
2.) Passive
b. Interrogative
c. Imperative

2. Types of phrases and clauses
a. Nouns vs. modifiers
b. Noun groups
c. Prepositions in noun groups
d. Appositives
e. Other modifiers

3. Word order
a. Standard
b. Inverted

4. Referents
a. Structure-based
1.) Of adjectives
a.) Post nominal
(1.) Participal phrases
(2.) Relative clauses
b.) Standard
2.) Of pronouns
a.) Direct
b.) Indirect
3.) Of objects
4.) Of phrases
b. Frame or script-based
1.) Definite references
a.) Referential
b.) Attributive
c.) Set
(1.) Generic
(2.) Individual
(3.) Attribute
d.) Number
(1.) Singular
(2.) Plural
e.) Articles
(1.) Definite
(2.) Indefinite
f.) Time
(1.) Past
(2.) Present
(3.) Future

g.) Interjection
h.) Previous utterances
(1.) Sentence
(2.) Text
2.) Indefinite reference
3.) Pronouns
4.) Other

5. Non-grammatical sentences
a. Spelling
b. Punctuation
c Missing words
d. Missing constituents
e. Wrong order
f. Semantic constraint violations
g. Sentence fragments

B. Processing semantics
1. Lexicon
a. Single word
b. Phrase

2. Literal meaning
a. Dictionary meaning
1.) Single meaning
2.) Multiple meaning
b. Technical term or phrase
1.) Single meaning
2.) Multiple meaning

3. Frame driven meaning
a. Frame relevant to disambiguating meaning
b. Frame irrelevant to disambiguating meaning

4. Inferential meaning
a. Idiom
b. Metaphor
c. Simile
d. Analogy
e. Colloquial phrase
f. Domain specific
1.) Indirect speech
2.) Focus or theme of text
g. Ellipses
1.) Sentence based
2.) Discourse based
h. Conjunctions
1.) Context based
2.) Context irrelevant
i. Comparatives
j. Anaphora
1.) Forward reference
2.) Standard reference

5. Modality
   a. Tense
      1.) Present
      2.) Past
      3.) Future
   b. Aspect
      1.) Perfect
      2.) Imperfect
   c. Form
      1.) Simple
      2.) Emphatic
      3.) Progressive
   d. Mood
      1.) Declarative
      2.) Interrogative
      3.) Imperative
   e. Essence
      1.) Positive
      2.) Negative
      3.) Indeterminate
   f. Modal
      1.) May
      2.) Can
      3.) Must
   g. Manner
   h. Time

6. Case
   a. Causal actant
   b. Theme
   c. Locus
   d. Source
   e. Goal

7. Metacognition
   a. Direction about inference building
   b. Direction about intention

C. Processing pragmatics
   1. Context
      a. Military
      b. Non-military

   2. World knowledge
      a. Scripts
         1.) Single
         2.) Multiple
      b. MOPs
      c. Experiential
      d. Conceptual
      e. Cultural

3. Domain specific knowledge
   a. Technical
   b. Everyday

4. Mode of knowledge
   a. Spatial
   b. Verbal

5. Model used by the speaker

6. Intention (goal, purpose) of the speaker
   a. To obtain or to infer information
      1.) Verification
      2.) Denotation
          a.) Quantification
              (1.) Exact
              (2.) Estimate
          b.) Composition (who, which, what)
          c.) Location
          d.) Time
      3.) Connotation (affect)
      4.) Identification
      5.) Description
          a.) List attributes
          b.) Combine attributes
          c.) Summarize
      6.) Relation
          a.) Cause and effect
          b.) Instrumental and enablement
          c.) Goal
              (1.) Relations among goals
              (2.) Subsumption
              (3.) Concordance
          d.) Correlation
          e.) Association
          f.) Logical
          g.) Among parts
          h.) Contradiction
      7.) Interpretation
          a.) Organization
          b.) Explanation
          c.) Prediction
          d.) Implication
          e.) Decision
          f.) Conclusion
          g.) Action
          h.) Planning
      8.) Evaluation
      9.) Persuasion
          a.) Action
          b.) Belief
     10.) Multiple functions
   b. To give or to help someone infer information
      1.) Verification

2.) Denotation
a.) Quantification
(1.) Exact
(2.) Estimation
b.) Composition (who, which, what)
c.) Location
d.) Time
3.) Connotation (affect)
4.) Identification
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e.) Decision
f.) Conclusion
g.) Action
h.) Planning
9.) Evaluation
10.) Persuasion
11.) Multiple functions
c. To command
d. To make a decision
e. To take action
f. To attain a goal
g. To play a role

7. Expectation
a. Of the speaker
b. Of the listener

8. Presuppositions of the speaker
a. Logical
b. Contextual
c. Psychological

9. Point of view of the speaker

10. Language of the speaker
    a. Standard-English
    b. Non-standard English
        1.) Black
        2.) Hispanic
        3.) ESL
        4.) Other

11. Emotion of the speaker
    a. Stress
        1.) Stressed
        2.) Not stressed
    b. Fatigue
        1.) Fatigued
        2.) Not fatigued

II. Processing connected discourse

A. Processing syntax
    1. Type of sentences
        a. Declarative
            1.) Active
            2.) Passive
        b. Interrogative
        c. Imperative

    2. Types of phrases and clauses
        a. Nouns vs. modifiers
        b. Noun groups
        c. Prepositions in noun groups
        d. Appositives
        e. Other modifiers

    3. Word order
        a. Standard
        b. Inverted

    4. Referents
        a. Structure-based
            1.) Of adjectives
                a.) Post nominal
                    (1.) Participal phrases
                    (2.) Relative clauses
                b.) Standard
            2.) Of pronouns
                a.) Direct
                b.) Indirect
            3.) Of objects
            4.) Of phrases
        b. Frame or script-based
            1.) Definite references
                a.) Referential
                b.) Attributive

c.) Set
(1.) Generic
(2.) Individual
(3.) Attribute
d.) Number
(1.) Singular
(2.) Plural
e.) Articles
(1.) Definite
(2.) Indefinite
f.) Time
(1.) Past
(2.) Present
(3.) Future
g.) Interjection
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(1.) Sentence
(2.) Text
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b. Frame irrelevant to disambiguating meaning

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a. Idiom
b. Metaphor
c. Simile
d. Analogy
e. Colloquial phrase

f. Domain specific
    1.) Indirect speech
    2.) Focus or theme of text
g. Ellipses
    1.) Sentence based
    2.) Discourse based
h. Conjunctions
    1.) Context based
    2.) Context irrelevant
i. Comparatives
j. Anaphora
    1.) Forward reference
    2.) Standard reference

5. Modality
    a. Tense
        1.) Present
        2.) Past
        3.) Future
    b. Aspect
        1.) Perfect
        2.) Imperfect
    c. Form
        1.) Simple
        2.) Emphatic
        3.) Progressive
    d. Mood
        1.) Declarative
        2.) Interrogative
        3.) Imperative
    e. Essence
        1.) Positive
        2.) Negative
        3.) Indeterminate
    f. Modal
        1.) May
        2.) Can
        3.) Must
    g. Manner
    h. Time

6. Case
    a. Causal actant
    b. Theme
    c. Locus
    d. Source
    e. Goal

7. Metacognition
    a. Direction about inference building
    b. Direction about intention

C. Processing pragmatics
   1. Context
      a. Military
      b. Non-military

   2. World knowledge
      a. Scripts
         1.) Single
         2.) Multiple
      b. MOPs
      c. Experiential
      d. Conceptual
      e. Cultural

   3. Domain specific knowledge
      a. Technical
      b. Everyday

   4. Mode of knowledge
      a. Spatial
      b. Verbal

   5. Model used by the speaker

   6. Intention (goal, purpose) of the speaker
      a. To obtain or to infer information
         1.) Verification
         2.) Denotation
             a.) Quantification
                 (1.) Exact
                 (2.) Estimate
             b.) Composition
             c.) Location
             d.) Time
         3.) Connotation (affect)
         4.) Identification
         5.) Description
             a.) List attributes
             b.) Combine attributes
             c.) Summarize
         6.) Relation
             a.) Cause and effect
             b.) Instrumental and enablement
             c.) Goal
                 (1.) Relations among goals
                 (2.) Subsumption
                 (3.) Concordance
             d.) Correlation
             e.) Association
             f.) Logical
             g.) Among parts
             h.) Contradiction
         7.) Interpretation
             a.) Organization

b.) Explanation
c.) Prediction
d.) Implication
e.) Decision
f.) Conclusion
g.) Action
h.) Planning
8.) Evaluation
9.) Persuasion
a.) Action
b.) Belief
10.) Multiple functions

b. To give or to help someone infer information
1.) Verification
2.) Denotation
a.) Quantification
(1.) Exact
(2.) Estimation
b.) Composition (who, which, what)
c.) Location
d.) Time
3.) Connotation (affect)
4.) Identification
5.) Description
a.) List attributes
b.) Combine attributes
c.) Summarize
6.) Instruction
7.) Relation
a.) Cause and effect
b.) Instrumental and enablement
c.) Goal
(1.) Relations among goals
(2.) Subsumption
(3.) Concordance
d.) Correlation
e.) Association
f.) Logical
g.) Among parts
h.) Contradiction
8.) Interpretation
a.) Organization
b.) Explanation
c.) Prediction
d.) Implication
e.) Decision
f.) Conclusion
g.) Action
h.) Planning
9.) Evaluation
10.) Persuasion
11.) Multiple functions

c. To command

d. To make a decision

e. To take action
f. To attain a goal
g. To play a role

7. Expectation
   a. Of the speaker
   b. Of the listener

8. Presuppositions of the speaker
   a. Logical
   b. Contextual
   c. Psychological

9. Point of view of the speaker

10. Language of the speaker
    a. Standard-English
    b. Non-standard English
       1.) Black
       2.) Hispanic
       3.) ESL
       4.) Other

11. Emotion of the speaker
    a. Stress
       1.) Stressed
       2.) Not stressed
    b. Fatigue
       1.) Fatigued
       2.) Not fatigued

active:
describing a sentence (or clause) in which the grammatical subject denotes the agent of the action described by the verb (compare passive). "The man brushed the horse" is in the active voice.

actor:
see agent.

ad hoc:
addressing a particular, usually immediate problem without consideration for wider issues.

adjacent:
occurring directly next to one another. Two words or phrases are adjacent if one directly precedes or follows the other.

adverbial clause:
a clause that functions as an adverb. An adverbial clause modifies a verb and answers questions such as why? (e.g., "in order to get to the store"), when? (e.g., "as soon as we hear from you"), and where? (e.g., "wherever they looked").

adverbial phrase:
a phrase that functions as an adverb. An adverbial phrase modifies a verb and answers questions such as how? (e.g., "very quickly"), when? (e.g., "last week"), and where? (e.g., "in the forest").

affective:
referring to the emotional state of a person.

agent:
a semantic role assumed by a noun phrase. The agent in a sentence is the noun phrase that specifies who or what performs the action of a verb. The agent is typically animate.

agreement:
two grammatical elements are said to agree if they are both marked for the same value of a feature. Features that affect agreement in English are number and person, e.g., "he runs" (third person singular noun and verb) vs. "they run" (third person plural noun and verb). In other languages, case and gender features may also affect agreement.

ambiguous:
can be understood in more than one way. Sentences can be ambiguous because individual words have multiple meanings (lexical ambiguity) or because more than one syntactic structure fits the sentence (structural or attachment ambiguity). The sentence "She cannot bear children" is lexically ambiguous: the verb "bear" has three possible meanings here. The noun phrase "the old men and women" is structurally ambiguous: "old" can modify just "men" or "men and women."

anaphor *pl.* anaphora:
any word or phrase that gets its meaning by reference to something already mentioned: a pronoun is an example of an anaphor.

appositive:
a word, phrase, or clause, enclosed in commas, that specifies the meaning and is identical in reference to the word, phrase, or clause it follows. In the following sentence the noun phrase "my father's physician" is an appositive: "John Blake, my father's physician, will be joining us for dinner."

artificial intelligence (AI):
the field concerned with the design and construction of intelligent machines and with the operation of human intelligence.

attachment:
the association of one word or phrase with another word or phrase to form a syntactic structure.

attributive:
referring to the characteristic properties (attributes) of an object.

auxiliary verb:
a verb used with another verb to form tense, mood, or voice. In the sentence "We have eaten," "have" is an auxiliary verb.

cardinality (scale):
simple counting to indicate the number of elements in a group.

case:
an inflectional category that indicates the grammatical function of a noun phrase. For example, the functions of subject, direct object, and possessor are marked by nominative, accusative, and genitive (possessive) cases respectively. In English, case markings are evident in the different forms of pronouns: "he" (nominative),

"him" (accusative), and "his" (genitive).

clause:
    a syntactic constituent containing a single finite verb and a subject. An independent clause may stand alone as a sentence; a subordinate clause may not.

cognition:
    the process of human knowing, awareness, and judgement. cognitive *adj.*

cognitive science:
    the study of cognition.

combinatorial explosion:
    with respect to parsing: a situation in which the number of possible structural analyses increases dramatically with respect to the number of elements.

comparative:
    a grammatical construction that expresses a relation of comparison. In English the comparative is formed by adding "-er" to an adjective or by inserting "more" before it: "He is nicer than you"; "She is more argumentative than you," etc.

complementizer:
    a word such as "that" which introduces a subordinate clause as in "He heard that it will rain."

computational linguistics:
    an approach to linguistics that uses mathematical techniques, computer theory, and computer systems for understanding, generating, and translating natural human language.

conceptual parser:
    a parser whose operation is based on conceptual information (as opposed to structural information).

conjunct:
    a constituent composed of two words, phrases, or clauses and the conjunction linking them.

conjunction:
    any word linking one word, phrase, or clause to another. Typical conjunctions are "and," "or," and "but."

connected discourse:
    a text consisting of multiple utterances.

connotation:
the sense of a word; the part of its meaning that is relevant to the truth-value of the sentence it occurs in. Connotations specify qualities, actions, and functions associated with a word. The connotations of "boy" and "dancer" are different yet it is possible for them to denote the same object. In Exemplar I. D. 2. #1. phrases (1) and (2) have different connotations but they denote the same object. Compare denotation.

constituent:
any word or group of words that behaves syntactically as a unit. In the sentence "I found some red roses," "roses," "red," "red roses," and "some red roses" are all constituents, but "some red" is not.

constituent structure:
the sequential and hierarchical arrangement of constituents to form larger units. The constituent structure of the following sentence is given by brackets: [[[The] [egg]] [[fell] [[on] [[the] [[kitchen] [floor]]]]]].

context:
any text outside of the text (sentence, word, phrase, etc.) directly under consideration. Context can also refer to aspects of a non-linguistic situation in which the text under consideration is used. For example, "This is my mother" derives sense from a physical situation.

coordination:
the linking of two constituents of equal status by a conjunction, e.g., "[the necklace] and [the ring]."

correction:
a modified repetition for the purpose of verification.

database:
record of information in computer memory; typically assertions about particular instances rather than general rules.

database query:
a question about recorded information, presumably answerable by consulting information in a database.

declarative:
one of the four basic sentential functions (others are interrogative, imperative, and exclamation). A declarative sentence performs the function of stating. "She is nice" is a declarative sentence.

deep structure:
    within the framework of generative grammar, the structure of a sentence from which the surface or spoken/written structure is derived.

default *noun* :
    the option that is assumed in the case that no other is specified. default *adj.*

definite:
    designating an identifiable or known person or thing.

definite article:
    a noun specifier (determiner) that designates a definite reference. In English, the definite article is "the."

demonstrative:
    a word which refers to something by means of its physical relation to the speaker. The demonstratives in English are "this," "that," "these," and "those."

denotation:
    that object or concept in the experiential world which a word refers to: the denotation of "the boy" is the flesh and blood entity. Compare connotation.

determiner:
    a word which specifies a noun and immediately precedes either the noun it specifies or a modifier of that noun. "The," "some," "my," "two," "that," and "those" are examples of determiners in English.

dialogue:
    a series of interacting utterances by two or more people.

direct object:
    the noun phrase that a transitive verb acts on. In the sentence "John gave the book to Mary," "the book" is the direct object.

disambiguate:
    to determine the appropriate meaning of a word or phrase from among two or more possible meanings.

discourse:
    connected speech or writing consisting of more than one utterance.

domain knowledge:
    knowledge about a specific area of information such as computer programming, cooking, woodworking, etc.

echo:
the repetition of an utterance for various purposes such as clarification, verification, etc.

ellipsis:
omission of a word or words that are essential to the complete grammatical structure of a phrase or sentence but the meaning of which can be supplied by information in the surrounding context. In the following sentence, "bought" has been deleted from the clause "Mary bought one": "Roger bought two and Mary one." The omission of "bought" from the preceding sentence is an example of ellipsis.

embedded:
describing a sentence that is included within another sentence or describing any constituent of an embedded sentence. "I like John" is embedded in the sentence "Jane thinks I like John"; the noun phrase "her sisters" is embedded in the sentence "Jane was surprised to hear that her sisters are unemployed."

enablement:
a condition or situation which makes possible the occurrence of a particular event or action. In the sentence "John got into his car to go to the store," getting into the car is the enablement for going to the store.

exclamation:
one of the four basic sentential functions (others are declarative, interrogative, and imperative). An exclamation (or exclamatory sentence) shows the speaker's or writers's feelings. "What a lovely day!" is an exclamation.

exemplar:
in the Sourcebook: an example, a reference, and a discussion of a natural language processing problem.

finite verb:
a form of a verb which agrees with a subject, e.g., "runs" in "He runs." A non-finite verb does not agree. In English, the infinitive and participles are non-finite verb forms.

fixed phrase:
a group of words that are usually used together: "make" is the verb commonly used with "amends" in the phrase "to make amends."

frame:
a conceptual structure that encompasses a certain event. Specification of a frame includes the usual actors in an event, order of action, props, etc. For example, the classroom frame would include a teacher, students, books, desks, a pattern of instruction, etc. Often a frame which is active in a particular dialogue or text can help disambiguate meaning: "split the dough" has different meanings in the cooking and bank robbery frames.

front end:
a natural language system that accepts natural language input and/or responds with natural language output. Front ends serve as interfaces between databases and users. Front ends allow users with no knowledge of computer languages to access databases.

function word:
a small word that has grammatical meaning only and does not carry the content of an utterance: "to," "the," "can" (sense of "to be able"), and "is" are examples of function words, e.g., "John <u>can</u> swim."

garden path sentence:
a sentence which contains local syntactic ambiguities such that at some point or points in the processing of the sentence two or more rules of the grammar may be applied each of which leads to a different interpretation of the sentence. In complex sentences, the point at which the ambiguity can finally be resolved may be delayed by intervening material such as relative clauses [see, for example, Exemplar I.B.1. (#18)]. Sometimes a misinterpretation is made and a particular structure has to be reinterpreted when new grammatical information is encountered. An example of this is the following: "The horse raced past the barn fell." (Crain and Steedman, 1985, from Bever, 1970)

genitive:
inflected for the possessive case. In the phrase "John's ball" the noun "John" appears in the genitive. See case.

grammatical category:
a category of words that have a particular syntactic function and typically occur in the same structural positions: "noun," "verb," and "adjective" are examples of grammatical categories. For example, the category "adjective" designates words that usually function as modifiers of nouns and usually occur immediately prior to the noun they modify or prior to another adjective modifying that noun.

head noun:
the noun in a noun phrase that is modified by other words in the phrase and thus functions grammatically as the central word in the phrase. For example, "blocks" is the head noun in the noun phrase "many building blocks."

heuristic:
a procedure that aids in learning, discovery, or problem solving.

history list:
a record that consists of the syntactic analysis of the immediately preceding sentence plus an ordered list of all referents (objects, facts, events, etc.) mentioned in the last several sentences (Allen, 1987).

idiolect:
the particular language or dialect of an individual speaker. Each person speaks his or her own idiolect.

idiom:
a phrase whose meaning cannot be derived from the meanings of the individual words that constitute it. For example, "kick the bucket" means "die" and has nothing to do with buckets. An idiom is a phrase that has meaning only as a unit.

imperative:
one of the four basic sentential functions (others are declarative, interrogative, and exclamation). An imperative sentence performs the function of ordering. "Show me the photo" is an imperative sentence.

indefinite article:
a noun specifier (determiner) that designates a reference that is not known or established. In English, "a" and "an" are indefinite articles.

indirect object:
a noun phrase following certain transitive verbs that take two objects (direct and indirect). "Mary" in "I gave Mary a book" is the indirect object of "gave."

indirect speech act:
a speech act which is not explicit. For example, the utterance "It's cold in here" can function as an indirect request for someone to close a window.

infer:
to arrive at an idea not explicitly stated by reasoning from given information. inference *noun.*

infinitive:
a fixed verb form that can function as a verb, a noun phrase, or a complement of a verb. The infinitive is usually preceded by "to" as in "He wants to leave."

interjection:
an exclamation which is not usually connected grammatically to the rest of the text. "Oh" in "Oh, I forgot" is an interjection.

interrogative:
one of the four basic sentential functions (others are declarative, imperative, and exclamation). An interrogative sentence performs the function of asking. "Are you coming?" is an interrogative sentence.

intersentential:
between or among sentences.

intransitive verb:
a verb that does not occur with a direct object.

lexical:
refering to words as single units.

lexicon:
a list of words which includes information about the pragmatic and grammatical meanings and functions of each word.

local information:
grammatical information contained in the word or phrase under consideration.

logical form:
a level of linguistic representation which contains all the grammatically determined information that is relevant to the semantic interpretation of the sentence.

M.O.P. (memory organization packet):
a kind of memory structure in which information is stored in the form of packets. The content and organization of these packets reflects previously encountered events and experiences. The purpose of an M.O.P. is to provide expectations that enable the prediction of future events on the basis of previously encountered structurally similar events.

marked:
defined relative to unmarked. A marked term or construction is more restricted in use, has more specific connotations, or is less widely distributed than its unmarked counterpart. For example, "These books I like" has a marked word order and emphasizes the object of "like" i.e., "these books." The unmarked equivalent is "I like these books."

metacognition:
a person's understanding of his or her own cognitive system, e.g., a personal awareness of problem solving skills, the reading process, etc.

metalanguage:
any language used to talk either about itself or any other language.

metalinguistic:
refering to language as a phenomenon; using language to talk about language; functioning as comment on the discourse it appears in.

metaphor:
a relation in language between two objects or concepts one of which is used to help the reader or listener understand the other. In metaphor, one concept or object is used in place of another to express similarity or analogy. In the sentence "John flew to answer the phone" John did not actually fly, but the speed of his movement is compared to the speed of a flying bird and it is understood that John moved quickly. Compare simile. metaphoric(al) *adj.*

metonomy:
the use of a part or aspect of a whole to stand for the whole. metonymic(al) *adj.*

metonym:
a word used in metonomy.

modal:
an auxiliary verb that expresses notions like permission, possibility, obligation, and futurity. "May" and "will" are examples of modals.

modifier:
a word that modifies another.

modify:
to qualify or limit meaning. Adjectives are said to modify nouns because they qualify the noun they occur with: "red" in the noun phrase "a red house" qualifies the kind of house by specifying its color. Nouns can also be modified by prepositional phrases and other nouns.

natural language:
any language (system of arbitrary sounds) that has developed in the course of human history and is (or was) used by some group of people as the primary means of verbal communication.

natural language processing (NLP):
the computational analysis and interpretation of natural language.

nominative:
a) referring to nouns. b) inflected for the subject case. See case.

noun group:
see noun phrase.

noun phrase:
a constituent composed of a single noun or a noun and any associated modifiers (adjectives, prepositional phrases, etc.) and/or determiners ("a," "some," "the," "two," etc.).

number agreement:
a constraint on the grammatical forms of a noun and a verb which requires that both be marked for either the singular or plural (in English). See agreement.

parse:
to analyze, by means of heuristics or algorithms, a phrase or sentence of natural language. A syntactic parsing is presented as a formal representation of syntactic structure, usually associations of words into hierarchical groupings of constituents.

parser:
a program that takes natural language input and produces a structured internal representation (a parse).

parse tree:
a representation that makes explicit the syntactic structure determined by the parsing process. Often a parse tree is represented graphically, using branching nodes. Hence the name *tree*.

part of speech:
see grammatical category.

participial adjective:
a participle that functions as an adjective. See participle.

participial phrase:
a modifying phrase built on a past or present participle of a verb: the underlined portions of "the book described in the review" and "the plane flying to N.Y." are participial phrases in which "described" is the past participle of "to describe" and "flying" is the present participle of "to fly."

participle:
a word derived from a verb by the addition of either "-ing" or "-ed." There are two participles in English; the "-ing" form is the present participle and the "-ed" form is the past participle. Participles can function as parts of verb phrases such as "running" in the sentence "He is running", or as adjectives such as "running" in the noun phrase "the running dog."
participial *adj.*

particle:
A word such as "out," "up," or "back" when it is used in combination with a verb so that the two function as a single lexical item. The word "out" in "He threw out the trash" is a particle. Particles can occur adjacent to their associated verb (as above) or separated from it: "He threw the trash out." Particles differ from prepositions in that prepositions do not exhibit such alternate distribution patterns.

passive:
describing a sentence (or clause) in which the grammatical subject does not denote the agent of the action described by the verb (compare active). "The horse was brushed by the man" is in the passive voice. Passive sentences can be recognized by the use of the past participle form of the verb preceded by some form of the verb "to be": present (e.g., "is"), present progressive (e.g., "is being"), past (e.g., "was"), etc. A passive sentence need not always contain an explicit agent noun phrase (e.g., "The dog was fed"), but when it does, the appearance of "by" before the agent noun phrase also indicates that the sentence is passive.

past participle:
a participle that is in a past tense. See participle.

phrasal parser:
a parser which identifies phrase boundaries (sometimes refers to a parser in which working memory is restricted to the phrase currently being analyzed).

phrasal verb:
a verbal structure consisting of a verb plus a particle (see particle). For example, "gave back" in "She gave back the book" is a phrasal verb.

phrase:
a constituent which does not contain both a subject and a finite verb (compare clause). "The black cat" is a noun phrase; "playing in the yard" is a participial phrase; "likes the boat" is a verb phrase.

phrase attachment:
the association of a phrase with the word it modifies.

polysemous:
having multiple meanings within one syntactic class. Polysemous words are single words with more than one meaning, e.g., "lift" (to raise or to steal), and are distinguished from homonymic words which are distinct words that share the same form, e.g., "lie" (to assume a horizontal position) and "lie" (to intentionally make an untrue statement).

possessive:
see genitive.

possessive pronoun:
a pronoun occurring in the possessive (genitive) case. Examples of possessive pronouns in English are "his," "her," and "their."

postnominal:
occurring after a noun.

pragmatics:
the area of language study concerned with contextual factors, such as expectations and beliefs of speakers and listeners, that are relevant to the interpretation of sentences.

prepositional phrase:
a constituent composed of a preposition and any associated objects. "In the house" is a prepositional phrase where "the house" is the object of "in."

presupposition:
information about a word which is not part of the specific meaning of the word. What a speaker assumes rather than what he or she asserts. For example, use of the word "bachelor" conveys the information "unmarried" and presupposes "adult," "male," and "human."

pronoun:
A word that functions as a substitute for a noun phrase and is meaningful by identification with that noun phrase. A pronoun agrees in person, number, and gender with its noun phrase antecedent. Examples of pronouns in English are "he," "she," and "they."

proper name:
a noun that designates a particular person or thing rather than a class. Because their reference is unique, proper names do not take limiting modifiers. For example, "George" is a proper name. Also called *proper noun*.

proposition:
a statement or a proposal for action. propositional *adj.*

reading:
the interpretation that a person gives a text when he or she reads it. A particular text can have different readings depending on who reads it, in what textual context it appears, and when and where it is read (experiential context).

reference:
the association of a word and its referent. See referent.

referent:
that experiential object, event, or idea that a word indicates.

referential:
having the quality of indicating an object or idea in the experiential world.

reflexive pronoun:
a pronoun which refers to the same individual as (is coreferential with) some other noun phrase in the sentence. The reflexive pronouns in English end in "self" or "selves": "myself," "themselves," etc. Refexive pronouns have restricted distribution patterns: they cannot, for example, function as the subject of a sentence. "Himself saw John" is ungrammatical.

relative clause:
an embedded clause that is introduced by a relative pronoun (e.g., "who," "which," "what," or "that"). In the noun phrase "the man that I saw," "that I saw" is a relative clause.

scope:
the range of text that a quantifier modifies. The scope of the quantifier "some" in the noun phrase "some men and women" can be either "men" or "men and women."

script:
nearly synonomous with frame (see frame) with perhaps more emphasis on the actions of actors in the frame and the order of these actions.

selectional restriction:
a restriction on a verb specifying, in terms of features, the classes of words that may appear with it as subject or object. The features that specify these classes include things like + animate, + human, + edible. The selectional restrictions on the word "cough," for example, state that it needs a + human subject.

semantics:
the study of meaning. More specifically, the area of language study concerned with the senses of words (lexical meaning), phrases, and sentences. semantic *adj.*

sentence fragment:
a piece of text that is grammatical but not able to stand alone as a sentence; it lacks one or more of the necessary constituents of a sentence.

simile:
a relation in language between two objects or concepts one of which is used to help the reader or listener understand the other. The two objects or concepts are compared through the use of "like" or "as," e.g., "Her cheeks were like roses." Compare metaphor.

single utterance:
an utterance composed of one sentence or idea.

speech act:
an utterance characterized by the function it serves or the act it accomplishes. The many types of speech acts include requests, declarations, orders, and promises.

subcategorization:
shorthand for subcategorization constraints.

subcategorization constraint:
a restrictive constraint on a lexical item that specifies how it is to be used syntactically. The subcategorization constraints on "find" state that it must be followed by a noun phrase so that "Mitch found" is ungrammatical, but "Mitch found a ball" is grammatical.

subordinate clause:
a clause that cannot stand alone and must be joined in some way to an independent clause.

surface input:
the input (command or communication) which a computational system receives directly from the user. Does not include any background information.

surface structure:
within the framework of generative grammar, the structure of a sentence which is the output of operations on the deep structure. The surface structure corresponds to the spoken or written form of a sentence.

synonym:
one of two or more words or expressions in one language that have the same or nearly the same meaning, e.g., "couch" and "sofa."

syntactic structure:
the organization of a phrase or sentence into hierarchical constituents according to the principles of syntax.

syntactic unit:
see constituent.

syntax:
the area of language study which is concerned with how words combine with one another to form grammatical constructions. syntactic *adj.*

system (S):
a computer program with the ability to process natural languge.

transitive verb:
a verb that requires a direct object.

understander:
the person or other intelligent system that is processing the text in question.

unmarked:
defined relative to marked. An unmarked term or construction has a more general sense, is more neutral, or more widely distributed than its marked counterpart. For example, "I like these books" has an unmarked word order relative to the marked "These books I like." See marked.

user (U):
the person interacting with the system.

user knowledge:
the organization and content of the knowledge and goals internal to a user. This knowledge is implicitly involved in the user's interaction with a system.

utterance:
any language used in dialogue, e.g., phrase, word, sentence, etc.

verb phrase:
a constituent composed of a verb and any associated modifiers or object noun phrases. "Ate the cake" is a verb phrase where "the cake" is the object of "ate"; "ran quickly" is a verb phrase where "quickly" modifies "ran."

vocative:
the grammatical case used for the thing or person addressed. In the utterance "Doggie, come here," the noun "doggie" is in the vocative case. See case.

word class:
see grammatical category.

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Author Index