自然言語処理 80－4
（1990．11．22）

文脈を用いた曖昧性解消の一アプローチ

佐野 洋　福本文代
(財) 新世代コンピュータ技術開発機構
長澤郁子†　末廣香緒里†
† (株) 富士通研究所
小野寺浩††
†† 富士通エフ・アイ・ビー株式会社

概要

本稿では、単一化に基礎を置く文脈処理の一アプローチについて報告する。まず、統語上の曖昧性の要因となる現象を制限するための枠組みについて説明する。この構造的曖昧性を含む構成素構造は言語現象と密接に関連している。本稿は、この構造を利用し、いわゆる意味表現や外界の知識を用いずに曖昧性の解消を行う手立てを提案する。この方法は言語心理学的なアプローチに基づくものでテキストの読みにおける処理モデルを応用した。本手法は、自然言語実験支援環境LINGUISTの上に構築され、現在、実システム上で評価中である。

Ambiguity Resolution: A Context-Based Approach

SANO, Hiroshi　FUKUMOTO, Fumiyo
INSTITUTE FOR NEW GENERATION COMPUTER TECHNOLOGY (ICOT)
4-28-1 MITA, MINATO-KU, TOKYO 108, JAPAN.

NAGASAWA, Ikuko†　SUEHIRO, Kaori†
† FUJITSU LABORATORIES LTD.
ONODERA, Hiroshi††
†† FUJITSU FACOM INFORMATION PROCESSING CORPORATION.

Abstract

The aim of this paper is to present a unification grammar formalism versatile enough to allow a constituent structure to contain facilities for expressing uncertain dependencies. We discuss the representation of functional dependencies to limit compositional linguistic structure. We also report on a mechanism for ambiguity resolution which operates over the constituent structures and which uses a context derived from a perceptual-syntactic knowledge base. The approach described here is based on psychological reality with respect to linguistic phenomena and its strategy is to process units during reading. This resolution mechanism is implemented in LINGUIST, which is an experimental natural language processing system being developed in the framework of logic programming.

1 Introduction

Ambiguity resolution is a longstanding problem in the area of natural language processing. As a sentence is often ambiguous out of context, combinatorial properties of words with lexical entries, of phrases with syntactical categories, and of potential scopes with quantifiers bring about combinatorial explosion in interpreting a sentence. Ambiguity resolution is difficult, but resolution strategy is different. There are several reports and proposals for describing the processing structure and for representation of meaning of a sentence in context. The processing sequence of lexical, syntactical, and semantic analysis is emphasized in some approaches. Others claim that an integrated framework that the semantic analysis performs early in the course of analysis of lexical and syntactic level of processing is required. A cost-based approach [12] and a multi-strategy approach [13] were also reported.

In recent years, the utility of unification as a general tool in computational linguistics has been given widespread recognition. In the unification-based approach, the structures that grammar operates have to be described more or less directly, so their explicit compositional nature seem unable to deal with semantic organization because the syntactic form of a sentence is not the only source of semantic construction of meaning [4]. Moens [3] argued for the notion of higher levels of organization in unification grammar and introduced a sort system for problems of ambiguity resolution. Pollack [4] demonstrated that the integrated framework relaxed the constraints of compositional semantics. The framework was able to allow pragmatic information to act in such a way as to support interpretation processing of meaning.

In this paper, we discuss the representation of constituent structures in a unification-based grammar approach. In particular, we discuss compositional natures which influence the structural ambiguity in a representation of sentences. The compositional approach of semantic interpretation of a sentence involves making a great effort to analyze it; the syntactic form of a sentence is not the only source of information about its meaning. Thus, the compositional natures must be attended to in order to devise a representation of sentences for ambiguity from a computational point of view. We describe a unification-based grammar formalism called Localized Unification Grammar (LUG). The formalism is under development in the sixth research laboratory at ICOT. In outline, LUG can be described as a combination of strictly compositional structure with functionally uncertain structure caused by context freeness.

In the remainder of this paper, we examine the effect of the formalism on the representation of structural ambiguity.

We also focus on the ambiguity resolution strategy using LUG formalism. A substantial subset of grammar rules for modern Japanese written in LUG is operational and currently implemented in LINGUIST, an experimental natural language processing system.

In section two, we briefly discuss the linguistic evidence which affects the representation with respect to structural ambiguity. Section three of this paper outlines the LUG formalism. In section four, we show how our representation of LUG demolishes structural ambiguity better than compositional approaches. Finally in section five, we will explain how the resolution process works.

2 Syntactic-semantic interaction

2.1 Compositional restrictions

The constituent structure is proposed as an amalgamation of compositional units that are identified in a sentence. A compositional unit is generally identified with the segmentation of the syntactic base into psychologically "real" units, such as phrases. Thus, the constituent structure is viewed as an intermediate level of representation between phrases (being a facile unit of syntax and parsing) and an internal representation such as logical form. With further processing, constituent structure could be reconfigured later to construct an unambiguous structure for the sentence. Two restrictions are imposed on the use of compositional units because the constituent structure produced by grammar should represent ambiguity compactly.

- Constituent structure should represent neutral representation that can be reconfigured later.
- Neutral representation should be distinguished from the obligatory constituent that can be produced by the generally compositional nature.

One restriction is the ability to be able to reduce space to be analyzed. This helps keeping the constituent structure uniform because different functions of the phrases constitute the same words. In point two, this restriction assumes that semantic interpretation and pragmatic processing are made necessary. Without the context processing, the constituent structure produced by LUG may represent units incompletely with respect to syntactic level.

2.2 Linguistic phenomena

The usefulness of being able to express restricted constituent structure with compositional ambiguity can be illustrated by consideration of adjunct.

(1)	Hitogomi	de	Jon	to	Lucy	wo	mitsuketa.
	A crowded place	in	Jon	and/ with	Lucy		spotted.

There are at least two ways to read this sentence,

(1-1) Jon and (I) spotted Lucy in a crowded place.

(1-2) (I) spotted Jon and Lucy in a crowded place.

Structural ambiguity in propositional phrases may modify, at least, nouns (1-1) and verb phrase (1-2). In (1-1), subject-conjunction relation supports the event of spotting. As compared with this reading, (1-2) says that the collective reading of the object holds the event. This structural ambiguity is a cause of inefficiency in processing, an inefficiency known as context-freeness. In this example, given contextual information about discourse entities, the ambiguity is expected to be resolved. In Japanese, both complements of nominative and of objective can be omitted when the discourse entities corresponding to referents are introduced. This dose not rule out an object-conjunction reading for the propositional phrase ('Jon to') in (2).

(2)	Hitogomi	de	Jon	to	mitsuketa.
	A crowded place	in	Jon	and/ with	spotted.

The meaning of sentence (2) is as ambiguous as sentence (1) in (2-1) and (2-2). Typically, grammar rules for handling coordinate phrases require at least two coordinates by means of syntactical elements, such as 'Jon to Lucy' ('Jon and Lucy'). This example demonstrates that the representation corresponding to the meaning in (2-2) can not be constructed in terms of constituent structures in a compositional way.

(2-1) Jon and (I) spotted (ϕ) in a crowded place.

(2-2) (I) spotted Jon and (ϕ) in a crowded place.

Such ambiguity presents an indeterminacy for the knowledge base. Contextual information, like discourse entities and given information, limits the meanings that the sentences with attachment can have, but compositional structures. A postpositional phrase being marked with the Japanese postposition 'to' does the work in two ways, each of which depends on contextual information. A single representation for constituent structure is needed in order to treat the range of the phenomena.

In the next section, we develop a grammar formalism for handling compositional ambiguity including the above phenomena.

3 The LUG form

LUG being developed in the framework of logic grammar constitutes a unification-based grammar formalism. The LUG form shares unification-based phrase structure grammar with functional application associated with combinatorial properties of phrases. It differ from phrase structure grammar in restricting compositional natures to minimal structures.

In a unification-based grammar, different kinds of information are represented using the same representation as feature-value pairs. These feature-value pairs are commonly specified using sets of equations. In LUG form, each equation is of the form **feature(value)** and bundles of equations use the form of list structure. Grammar rules in LUG are written in DCGs[2] and implemented in Prolog to take advantage of the efficiency of Prolog unification. The LUG form has a uniform structure called basic triple as follows.

$$\left(\begin{array}{c} CAT \\ \left[\begin{array}{l} SYN : list\ of\ attribute-value\ pairs \\ REL : list\ of\ attribute-value\ pairs \\ F : subcategorization\ list \end{array} \right] \end{array} \right)$$

Figure 1: LUG form

CAT is the rule identifier that is treated as a non-terminal symbol in grammar rules, and the structure as a whole is declared to be of CAT. CAT is specified for SYN, REL and F features. Each SYN and REL is a list of attribute-value pairs. REL contains a quasi-variable that can be referred through sharing, but SYN dose not. A characteristic of LUG formalism is the use of a quasi-variable. By letting the REL part contain a quasi-variable that stands for a category expression, the LUG form takes advantage of having a neutral representation that can be reconfigured or re-unified later. Thus, the form used in LUG contains facilities for expressing uncertain functional applications that lead to compositional ambiguity. As a familiar example of this, an uncertain functional application corresponding to a relative phrase has several alternatives for the dependence of a head noun on some verb complement to its right. The quasi-variable standing for the verb can depend on the head noun in terms of a neutral expression.

F is a list of complements that are directly subcategorized by the category CAT and can be a help in

dealing with free word order and omission of complements. F consists of two lists, each containing elements corresponding to syntactic restriction posed on complements that the verb dominates. The explicit representation for the complements marked 'unfilled' forces the grammar rules to handle the linguistic phenomena from the observation that a noun phrase ellipsis in the subject position is normally used to make direct predication as to the generic person in Japanese. Another observation, that neither subjective and objective are syntactically required to form a sentence, must be also considered.

As an example, the rule for the complement-predicate form is written in LUG as follows:

$$\begin{array}{c} yougen\_2 \\ \left[\begin{array}{l} VSYN \\ [\{[\text{grl(comp,CASE)}|\text{AdvSYN}],\text{AdvREL},\text{AdvF}\}|\text{VREL}] \\ ([(\text{CASE,comp,AdvX})|\text{VAL}],[\text{VRL-(CASE,comp,AdvX)}]) \end{array}\right] \end{array}$$

$$\Rightarrow$$

$$\begin{array}{c} renyoushi\_2 \\ \left[\begin{array}{l} [\text{grl(comp,CASE)}|\text{AdvSYN}] \\ AdvREL \\ AdvF \end{array}\right], \end{array} \quad \begin{array}{c} yougen\_2 \\ \left[\begin{array}{l} VSYN \\ VREL \\ (VAL, VRL) \end{array}\right] \end{array}$$

Figure 2: Example 1

This rule says that 'yougen_2' (a verb-phrase) can consist of 'renyoushi_2' (a noun-phrase with case marker) and 'yougen_2' (a verb-phrase) with the features shared properly. Namely, 'renyoushi_2' and 'yougen_2' must agree in subcategorization.

3.1 Implementation

LUG is currently implemented in LINGUIST, an experimental natural language processing system being developed in the framework of logic programming. The constituent structure expression corresponding to uncertain functional application can be described in terms of a tagged form which consists of a tag-feature basic triple pair. The tag-feature, being equivalent to other features, is as follows:

tag-attribute(X,Y)

Figure 3: Tag-feature

Where, each X and Y is a quasi-variable, the former stands for a head phrase, a phrase whose dependency to be resolved is supported by the latter. Syntactic-semantic interactions generalize tag-features relating a basic triple leads to being of compositional ambiguity. Thus, the tag form can describe a constituent structure to which a reduction process must be applied.

3.2 Tag-features

In this section, we will describe how these properties influence constituent structure ambiguities and discuss the positioning of tag-features over linguistic phenomena.

Of-type feature

The of-type feature is organized around relative phrases. Since Japanese has no relatives, the dependence of a head noun on some verb complements to its right is ambiguous. It depends on the nature of the head noun, so constituent structure is so constructed that it has nothing to do with syntactic structure base as shown in (3). The word 'taberu' means 'eat' in English.

(3) (3-1) taberu hito ('a man/men')
'a man who eats (something)'
(3-2) taberu mono ('something')
'something to eat'
(3-3) taberu toki ('time')
'when (I/you) eat (something)
(3-4) taberu oto ('noise/sound')
'(I hear someone eat)'

Of the four examples in (3), where the verb form is adnominal, there is no difference in compositional form with respect to a turn of phrase. It seems that the dependence between a head noun and its relative clause is a matter of degree of relation of an event to the head noun. Thus, the of-type feature would point out that a head noun is in a position that gives it the potential that the relative clause describes.

Inmanner feature

Because Japanese has particles which denote syntactical case role, the grammatical role is often uniquely determined by its article form. It can be understood without making their its position. On the other hand, the fact that the particles take many kinds of case role in their form as regards efficiency causes structural ambiguity in the attachment of postpositional phrases. A complement marked with the particle 'ni' is actually the dative complement and is on an equal footing with postpositional phrases standing for time relation, locational relation and so on. In this feature described here, the independence of the particles is emphasized so that the inmanner feature can be seen as a connector that may hold between the complement

and the event described by the verb in a head phrase. Although in some cases this kind of ambiguity may be reduced by restriction associated with particular propositional phrases, the knowledge base approach based on event calculus is required. The Inmanner feature calls attention to a requirement of a reduction process concentrated on event processing.

Attach(ment) feature

The Attach(ment) feature is generalization from the observation of the fact that causal relation, time sequence relation, implicature relation and so on seem to be evidence for a structure that involves ambiguity. The linguistic variation of the attach(ment) feature can be described as subordinate phrases. In general, ambiguity resolution is achieved to provide ammunition for semantic reduction processes dealing with relations between events.

Distinction between inmanner feature and attach(ment) feature is sensitive to the structure of the main phrase. If the verb is tenseless, the adverbial phrase contains compositional ambiguity and is attached to the phrase as the complement specified in 'inmanner'. In addition the presence or absence of its tenselessness characteristics, its feature is also affected by its factuality/factitiousness, aspectuality and politeness.

Co-refer feature

The Japanese system of expression in which the subject is absorbed into the predicate primary divides sentences into a topic and a descriptive phrase. Most linguists agree there is such a division in Japanese sentence structure. To make a topic phrase, the particle 'wa' is used. From the syntactic point of view, not only the subjective and objective complement but also other complements such as those that stand for time relation are equally eligible to serve as topic phrases. A standard example of an ambiguity is as follows:

(4) (4-1) sakana wa tabeta
'The fish was taken in feeds.'
(4-2) sakana wa tabeta
'(I) ate the fish dinner'/'The fish was eaten (by a cat or etc.)'

For lack of salient features, we claim that the canonical form, like the propositional form, of a sentence should not be syntactically derived from a sentence with a topic marker. The Co-refer feature served for this assumes a context processing where information used eliminate ambiguity is not limited to syntactic sources.

As we have mentioned, the LUG form separates the context-dependent aspect from the context-dependent aspect by using a tag-feature in a uniform expression. Finding the appropriate relation, in other words ambiguity resolution, is a longstanding and difficult problem. Resolution technique and processing strategy requiring a lot of semantic and pragmatic knowledge are an integral part of artificial intelligence. In the next section, we describe a strategy to remove ambiguity from the LUG form.

4 Clarification strategy

In our approach to ambiguity resolution strategy, an approach based on psychological reality is addressed and its strategy characterizes processing unit in reading with respect to linguistic phenonema that are perceived as continuous within the limitations of the human information processing. Kozminsky[1] described the function of the processing unit in reading, a unit which is characterized as a segment that includes the information necessary for it to interpret an utterance. Kozminsky points out that relationships between semantic units are defined that rely on syntactical organization. Syntactic relationships between their corresponding phrases also depend on semantic organization. ARIEL[6] demonstrated the function of givenness as the discourse functions of given information. It serves as both a condition of use imposed on linguistic forms and as a cognitive principle correlated with specific discourse function. In [6], givenness strengths were introduced and the strengths' instructions to the addressee about where to search for that information were also discussed.

From a semantic-organizational view, the process of computing complete interpretations of sentences often requires unlimited intra- and extra-linguistic knowledge and inference. The processor demands complex knowledge representations to remove ambiguity in a sentence. While the notion of limited-domain is adopted depending on the task of the application domain, knowledge-based approaches are on a footing with semantic-organization and cost a lot of complexities.

The proposal described here thus utilizes perceptual-syntactic sights for dealing with disambiguation of sentences. As we mentioned in section three, the complex syntactical-semantical structure notion that the LUG form has is designed to enable efficient utilization of this kind of information. The emphasis is on the advantages: it is possible to reduce the cost in processing and develop grammar rules and natural language processing systems independently of the application domain.

4.1 The context-based approach

In this section we propose a general framework for ambiguity resolution based on the perceptual-syntactical knowledge sources. The knowledge sources, given information, phrasal saliency, and dependence of linear word stream are mutually dependent. None of them alone is sufficient so the integration of these knowledge sources guides inference for processing ambiguity.

Givenness preference

As ARIEL[6] mentioned, givenness functions in linguistic analysis on two levels: the strictly linguistic notion level and the crucial discourse notion level. The former serves as a condition of use imposed on many linguistic forms. The latter, as ARIEL demonstrated, is correlated with specific discourse functions with respect to general cognitive principles. According to [6], givenness has a scale in terms of accessibility to discourse entities, those in short-term memory and so on, and are characterized by the various forms with respect to the linguistic categories.

Because givenness marks that there is some connection between the objects talked about and some context, a phrase marked given impose constraints on what can be referred to as discourse entities.

Phrasal saliency preference

Apart from being a very useful feature(Of-type, Inmanner and Co-refer) for standing for compositional ambiguity, they reflect phrase state being determined under the control of sentence level such as S-Structure, introduced to explain how syntactic dependencies contribute to semantic interpretaions.

Table 1 below presents a few examples:

Table 1: Phrasal saliency

Inmanner	postpositional phrase	(located in X)
Attach(ment)	spacio-temporal adverb	(located in X/)
Co-refer	topicalized phrase	(located in X//)
	conditional phrase	

For example, topicalized phrases are searched first for possible discourse entities. The phrase marked with 'Co-refer' should be preferred over the phrase marked with 'Inmanner'. The phrase marked with 'Attach(ment)' takes the middle position.

Linear word stream and structural complexity preference

Sentences with a subordinate/main clause order are better recalled than sentences with a main/subordinate clause order [1]. The explanation is that the subordinate clause interpretation is postponed to the time of listening to the main clause on which it is dependent. In Japanese, words which express the fundamental nature (corresponding to main phrase) of a sentence come at the very end of sentence as a rule [11]. Although a long sentence is effective in creating tension in the reader, the main phrase comes far behind the subject. Thus a lot of small clauses and phrases in between give the reader a difficult time understanding the central meaning of the sentence. This leads limitations of the memory to allow a definition of a concept of a processing unit.

The order of linear word stream and the depth of the nest by means of structural complexity are parameterized to specify over syntactic structure.

In the following section we will explain how the resolution process works using a perceptual-syntactical knowledge base.

5 Dealing with the LUG form of ambiguity

The constituent structure represented with LUG as a parse tree includes the ambiguous phrases to be resolved. The process of resolution works by applying the applicability rules first to find the ambiguous phrases using tag-attributes as a lever which releases the combinatorial properties of a phrase. Then the preference rules are applied to tag-feature a triple pair. If the pair passes the constraints test imposed on preference rules, a functional relation of the sense of a structure representing semantic organization is put instead of the tag-feature. When application of the reference rules to a phrase ends in fail, the phrase has uniform structure in LUG and is left ambiguous. If possible, another pragmatic process associated with the extra-linguistic knowledge base can resolve the ambiguity in the same framework of unification. After the dependencies on context have been resolved, the constituent structure has no tag-features, indicating a complete interpretation of a sentence.

5.1 Implementation

We have developed a processor of ambiguity resolution using a perceptual-syntactic knowledge base. The processor is currently implemented in LINGUIST.

The resolution process works sentence by sentence in a roughly top down left-right path across the sentence structure. Thus, when faced with a candidate for the cause of an ambiguity, the process goes to the

second stage, where preference rules determine certain functional relations to apply a semantic structure to the phrase. After evaluating the preference rules, a desirable functional application has to be introduced to make a semantic interpretation. At the same time, discourse entities in context are derived by imposing applicability rules on phrases. Abstract syntactic features relating to discourse function (givenness, saliency and so on) are attached to the number of phrases checked. They will be used in the second stage of resolution.

The resolution process calls itself recursively for each phrase. This resolution cycle mainly limits its process to the boundary specified by structural complexity preference and a completely resolved structure is constructed on return from the recursion.

5.2 An Example

The following, a simple example, shows the process of explaining of ambiguity resolution. The treatment of context is also illustrated.

(5) (5-1) ke-ki ga amatta
(cake NOM be-left)
'The cakes were left.'
(5-2) gakusei ga kita/ / kuru/ /
(student(s) NOM came/ / come/ /)
'The students came/come.'
(5-3) minna tabeta
(all/everything ate)
'All the students ate them/(I/We) ate them all.'

In the contexts (5-1) and (5-2)/, 'gakusei' ('student(s)') and 'kita' ('came') are marked given information, but in the sentnece sequence (5-1) and (5-2)//, they are not regarded as given, unless the formal level is considered. The above distinction relies only on the syntactic form of the main phrase.

The last sentence in (5) has at least two readings with respect to quantifier scope: one might be that a scope operates on the subjective *all the students ate them*; the other might be that a scope operates on the objective *(I/We) ate them all.* Figure 4 shows the concise structure representing the last sentence.

$$\left[\begin{array}{c} attach(E,M), \\ \left(\begin{array}{c} ind(M) \\ sort(M, \text{“minna”}) \end{array} \right) \end{array} , ind(E), sort(E, \text{“tabeta”}), arg(E,[A,O]) \right]$$

Figure 4: Constituent structure

Interpreting (5-3) requires context information. The structure allows a structural ambiguity of the form attach(E,M) to be resolved, permitting access to information that keeps track of context. There is information given in context: the phrase marked with syntactical givenness. In the example above, when 'gakusei' ('student(s)') introduced into the context before sentence (5-3) is uttered, it is not necessary to introduce a new parameter or semantic object corresponding to 'gakusei' ('student(s)') as subject. Due to the information given by the context, only the scope operating over the subjective can hold the event of 'tabeta' ('ate') as follows:

$$\left[\begin{array}{c} quantify(\text{“minna”}, S, E), \\ \left(\begin{array}{c} ind(S), \\ sort(S, \text{“gakusei”}) \end{array} \right) \end{array} , ind(E), sort(E, \text{“tabeta”}), arg(E,[S,O]) \right]$$

Figure 5: Resolved structure

This information can be derived from the constituent structure that LUG produces and the resolution process in processing the constituent structure by using perceptual-syntactical knowledge base. Context is itself like a list of constituent structures which correspond to sentences, and which contain information about perceptual-syntactical saliency. Linear word stream and givenness preference affect the resolution process in a processing context. This information is sufficient to resolve the ambiguity in the sentence (5-3).

This example shows how the tag-feature being left unresolved uses contextual information derived from perceptual-syntactical knowledge base to clarify its interpretations.

6 Conclusion

We have described how a unification based grammar formalism, LUG, can provide the facilities for expressing the compositional ambiguity associated with syntactic-semantic interaction. Thus we have one way of expressing phrases including structual ambiguity as a tag-feature. We have developed a processor of ambiguity resolution that operates in a LUG framework using a perceptual-syntactic knowledge base. Context evaluation for reduction passes through (1) givenness preference, (2) phrasal saliency preference and (3) linear word stream and structural complexity preference before terminating.

This example has been limited to the case of quantifier scope reduction. However, it should be clear that the mechanism based on context may be used to resovle the vagueness.

The complete version of grammar written in LUG for modern Japanese is still under development. How-

ever, a substantial subset of Japanese grammar in the domain of editorial text is operational.

The syntactic structure stays in close relation to the context in which the information is transmitted. We expect further formulation of the degree of relationships between perceptual syntactic construction and organizational semantic interpretation. This interdependence explains how certain dependence and uncertain dependence influence ambiguity. It seems to allow also for an economical account of the topic-predicative structure of the sentence.

Acknowledgements
The authors would like to thank Hideki Yasukawa for his advice in discussion and the members of the NLU group at ICOT for giving impetus to this study.

References

[1] Ely Kozminsky. (1985), *The Processing Unit in Reading*, THEORETICAL LINGUISTICS, Vol.12, 1985

[2] Fernando C.N. Pereira, David H.D. Warren. (1980), *Definite Clause Grammars for Language Analysis - A Survey of Formalism and a Comparison with Augmented Transition Networks*, Artificial Intelligence, 13, 231-278, 1980. 1985

[3] Marc Moens, Jo Calder, Ewan Klein, Mike Reape, Henk Zeevat. (1989), *Expressing Generalizations in Unification-based Grammar Formalisms*, Proc. of the Fourth Conference of the European Chapter of the ACL, 1989.

[4] Martha E. Pollack, Fernando C.N. Pereira. (1988), *An Integrated Framework for Semantic and Pragmatic*, Proc. of 26th Annual Meeting of the ACL, 1988.

[5] Michael Barlow. (1988), *Unification and Agreement*, Proc. of Fourth Conference of the European Chapter of the ACL, 1988.

[6] Mira Ariel. (1985), *The Discourse Functions of Given Information*, THEORETICAL LINGUISTICS, Vol.12, 1985.

[7] Hiroaki Kitano, Hideto Tomabechi, Lori Levin. (1989), *Ambiguity Resolution in the* DMTRANS PLUS, Proc. of Fourth European Conference of the ACL, 1989.

[8] Jaime G. Carbonell, Ralf D. Brown. (1988), *Anaphora Resolution: A Multi-Strategy Approach*, Proc. of AAAI-88, 1988.

[9] Jerry R. Hobbs, Mark Stickel, Paul Martin, Douglas Edwards. (1988), *Interpretation as Abduction* Proc. of 26th Annual Meeting of the ACL, 1988.

[10] Douglas B. Moran. (1988), *Quantifier Scoping in the SRI Core Language Engine*, Proc. of 26th Annual Meeting of the ACL, 1988.

[11] Haruhiko Kindaichi. (1978), *THE JAPANESE LANGUAGE*, CHARLES E. TUTTLE COMPANY, Rutland·Vermont : Tokyo·Japan, 1978.

[12] Hiroaki Kitano, Hideto Tomabechi, Lori Levin. (1989), *Ambiguity Resolution in the* DMTRANS PLUS, Proc. of Fourth Conference of the European Chapter of the ACL, 1989.

[13] Jaime G. Carbonell. (1988) *Anaphora Resolution: A Multi-Strategy Approach*, Proc. of the 12th International Conference on Computational Linguistics, VOL.1, 1988.

[14] Jos de Bruin, Remko Scha. (1989), *THE INTERPRETATION OF RELATIONAL NOUNS*, Proc. of Fourth Conference of the European Chapter of the ACL, 1989.

[15] Remko Scha, David Stallard. (1989), *Multi-level Plurals and Distributivity*, Proc. of Fourth Conference of the European Chapter of the ACL, 1989.

[16] Robert C. Moore. (1989), *Unification-Based Semantic Interpretation*, Proc. of 27th Annual Meeting of the ACL, 1989.

[17] Suart M. Shieber. (1985), *Evidence against the Context-freeness of Natural Language*, LINGUISTICS AND PHILOSOPHY, Volume 8, No.3, 1985.