Abstract
The present study deals with conflict resolution process in metaphorical interpretation for the noun phrase. In order to make the problem more explicit, we have reviewed the knowledge representation with conflict both from cognitive psychology and artificial intelligence. Then, we propose a semantic model which is obtained from the notion of Linguistics as Chemistry. That is, the model called "Semistry" is introduced so as to interpret a metaphor semantic bonds between nouns. By using production system coupled with context free parser (ELINGOL), the working system called META-SIM is constructed to analyze the noun phrase metaphor. Finally, there are discussions on a role of metaphor in human cognitive processing.

1. Introduction
A conflict resolution in semantic analysis is regarded as an important problem in natural language processing. In case of a human cognitive system, this kind of problem was discussed in the realm of behavioral decision making theories, such as Festinger's (1957) theory of cognitive dissonance and Abelson's (1968) Psychological implication. And also, it was discussed in the field of cognitive psychology which dealt with the human information processing mechanism, especially long-term memory (LTM) representation.

The work of Kintsch (1969) in his structure of semantic memory was useful for insight into the conflict resolution in lexical item stored in LTM. He particularly made his attention on the problems on how one semantically unacceptable a sentence.

If one selects the problem from artificial intelligence field, McDermott's (1974) TOPLP in "Ring formalism" was suggestive to a design of inference mechanism which could interpret unacceptable knowledge in a simple world model.

This formalism also guided us about a construction of lexical data in natural language processing.

By following these current issues on knowledge representation, the present study focuses the problem of conflict resolution in semantic analysis of Metaphor both from viewpoints of cognitive psychology and artificial intelligence. For this purposes, we propose a new semantic model which can deal with the metaphorical interpretation together with the inference mechanism. And then, we will demonstrate examples of metaphorical analysis which is based on the proposed semantic model.

2. Semantic representation with conflict knowledge
Metaphor plays an important role in our understanding of language and of the world we describe through language. Thus, there have been a number of researches on the nature of metaphor since the time of Aristotle.

Recently, historical survey on metaphor was made by Ortony, Reynolds & Alter (1978) on their paper titled "Metaphor: Theoretical and Empirical Research". Their main concerns on metaphor are to develop a model of metaphoric comprehension both from Psychological reaction time study and "Schema" based theoretical framework. To quote their paper:

"The structure of a shema is of a series of variables together with relationships among them. There are constraints on the values that the variables may take, but these constraints are rarely absolute, although some values are typical than others. This kind of representation system appears to offer greater flexibility for matching incoming information to previously stored knowledge, and with this flexibility comes a better prospect for dealing with nonliteral use of language. The metaphorical interpretation would be achieved by finding that schema or those schemata that matched the input in such a way as to minimize the required changes in variable range."

Certainly, the idea of schema described above is one of convergences on the knowledge representations proposed by Rumelhart & Ortony (1977) and Bobrow & Norman (1975). Here, the procedure for the metaphorical interpretation is a kind of pattern-matching process which is based on a semantically acceptable interpretation. In order to make a discussion more explicit, let us consider the same type of problem which deals with knowledge acquisition through the conflict or contradict resolution.

For this purpose, we focus our attention to the semantic structure which is stored in an understanding system.

In case of Kintsch model, this problem is to define a lexical entry used in the semantic memory. And further, the notion of acceptability of sentence is defined by the use of production rules which are applied to the set of propositions stored in memory system. If there exists a production rule for a set of
proposition, the sentence is semantically acceptable. And if not, the sentence is semantically unacceptable. Therefore, if two sentences are unacceptable, the memory system must decide which one to keep and which one to disregard by choosing the one with acceptability. In case of McDermot's TOPLE, this kind of contradiction is resolve through the notion of "ring" which can absorb the confliction. This process is accomplished through a procedure called DOUBT. By this procedure, the system can find the allowable course of action to take to patch up a ring. In this connection, Tanaka (1980) in his SRL, this procedure is carried out through the use of production rule called "without description". In SRL representation which is an extension of Bobrow & Winograd's KRL, knowledge is organized around conceptual entities with associated descriptions and procedures. Therefore, by embedding various procedures to knowledge, lexical item is represented by knowledge unit with associated descriptions and procedures. One type of conceptual entities is the use of hierarchical relation which was actively utilized by the work of Carbonell's SCHOLAR (1970). In SRL, hierarchical concept is accomplished through part-whole and class-inclusion relations. And further, the conflict resolution was made by the use of the without description. In contrast to TOPLE, a bird like Pengin is represented by the following way.

(PENGIN
  unit
  (self (a TORI without
        (hasp = TOSU )))
  (part-of nil)
  ...
  other descriptions )

Fig. 1 SRL's description for pengin

Although we made a quick overview of the related topic on the knowledge with conflict resolution, it is necessary to consider a semantic model which can accept semantically conflict knowledge. That is, any lexical item stored in the understanding system should process a change of meaning through the metaphorical use.

In this section, we will propose a new semantic model in which semantic elements are compared to chemical elements. Here, chemical elements are referred to the dynamic aspect of meaning. In a sense, the theory can be considered as an extension of Arnold Zwicky's 1973 paper, "Linguistics as Chemistry", in Anderson & Kiparsky (Eds.), A Festschrift for Morris Halle. In this connection, some preliminary work on 'Linguistic Chemistry' was carried out by Harada & Mizoguchi (1977) in which semantics and lexical elements were also compared to chemical elements (such as molecules, atoms, protons, neutrons and electrons). A large part of syntax is now compared to a theory of semantic 'bondage'. The semantic equivalent of 'chemical reaction' is a theory of semantic amalgamation. The analogy with chemistry may not be completely felicitous, but at the present moment it is at least useful in shaping a new theory of semantics.

The first step for constructing a chemically interpreted model of semantics, or "Semistry", so to speak, is to study bondage among atoms and molecules. For this, it is necessary to develop a theory of valence. Valence is defined as the capacity of an atom to enter into chemical (or semantic) combination with other atoms. It is possible to assign a value to the valence displayed by an atom in particular compound. This notion must be the reader who is well-informed of the European tradition of "Valenzgrammatik".

Here, however, we will develop a theory of valence totally independently of European tradition.

Before going into a detail of Semistry, let us show you a concrete example which is selected from Schank (1973) of his Conceptual Dependency theory (CDT for short). Here, "Semantic primitives of CDT" are compared to chemical elements. In the chemical elements, there are three types of chemical bondages: 1. Single bond 2. Double bond 3. Triple bond.

If we look at CDT representation of a sentence through the viewpoint of Semistry, we will recognize a similarity between chemical molecules and CDT structure. From this insight, we can make a analogy of semantic 'isomer', depending on a mode of bondage between the semantic primitives. For example, CD structure of PP(picture producer) and ACT (action) is represented in the Fig. 2 in which two way dependency is interpreted as a double bond in case of Semistry. If one of the valence shifts to another pair of primitive as shown in Fig. 2, then the structure is called semantic resonance.

In case of PP with the extra valence, some modifiers will be possible to link the activated part of PP. If the activation will occur at the ACT, the extra valence part will be embedded with the related case in CDT. Since it is not the purpose of the present paper to develop an impeccable account of Semistry, let us take another example from a lexical item which is related to the present study.

In the analysis of lexical structure, words are not really defined in the standard dictionaries in any precise way in case of the human cognitive system. There are various means to be employed to indicate their meaning more or less precisely, but these means are usually sufficient for the cognitive processing. They may be extralinguistic means (such as diagram) or linguistic definition, both explicit and implicit. Neither of these
The format of lexical item is adapted by the use of distributed semantic links (or single bonds) between words. That is, a word or lexical item is surrounded with semantic features $S_1, S_2, ..., S_n$.

These bonds between word and semantic features are usually single bonds with homogeneous tension. In that case, the resonance is observed among the semantic features of word. In case of metaphorical semantic analysis, especially, noun-noun phase, the first noun modifies the second. So, the resonance is broken and the first noun in metaphorical relationship must include the meaning that is interpreted by the second.

Therefore, in order to determine the meaning of a noun phase, there must be an intersection of meaning between $M^*$ and $M$. If such intersection exists between the first and the second, the double bond is constructed in the Fig. 3. In this way, word definition can be turned by adding procedure for unacceptable semantic link. The process is regarded as semantic change of meaning from Semistry's viewpoint. The change of meaning in metaphor is classified by the following categorical transformation as is shown in Table 1.

Thus, the idea of Semistry is proposed so as to meet the present purpose of metaphor semantic analysis. The experimental system
1. From Object to Human
   Contextual transformation
   \[ M^* = \text{Object} \quad M = \text{Human} \]

2. Bond between Object and Human
   Link transformation
   \[ M^* = \text{Object} \quad M = \text{Human} \]

3. Transformation from Human body to Object, Location
   \[ M^* = \text{Human body} \quad M = \text{Object & Location} \]

4. Animal & Location's Personification
   \[ M^* = \text{Animal & Location} \quad M = \text{Human} \]

5. Pseudo-personification
   \[ M^* = \text{Object & Animal & Location & Abstract} \quad M = \text{personification's Object} \]

6. From Abstract to Concrete Object
   \[ M^* = \text{Abstract Object} \quad M = \text{Concrete Object} \]

Table I. Metaphorical Transformation
called META-SIM is designed and tried out through the use of ELINGOL developed by Tanaka et al (1978).

3. Metaphor analysis of noun phrase

In this section, we show the case study based on the idea shown before. At the first stage, we analyzed a noun-noun metaphor using ELINGOL coupled with production system designed with a viewpoint of standard control structure.

The present studies focus on a noun-phrase in metaphorical use in Japanese, such as

I. Metaphor
   "noun + noun"

II. Simile
   1. M^* no m^* SIM M no m, (m^* of M^* SIM m of M)
   2. M^* no m^* SIM M or m, (m^* of M^* SIM M or m)
   3. M^*(or m^*) SIM M no m, (M^*(or m^*) SIM m of M)
   4. M^*(or m^*) SIM M or m

In the above notation, SIM represents a similarity between two nouns in Simile, and a noun denoted a small letter is a part of noun denoted a capital letter.

In this case study, we use a ELINGOL (Extended Linguistic Oriented Language) for the parser (syntactic analyzer). The ELINGOL is a context free parser extended at ETL, and it has a semantic processing parts that the user can write any semantic processing program in terms of LISP.

Dictionary

The description in dictionary used in this case study is as in Fig. 4

Each dictionary item consists of four parts, the first is item of the word, the second is the syntactic category of the word, the third is the part used in case of some ambiguities,
the noun phrase. So, at first, two nouns to
be interfered must be chosen, the choice is
desired in terms of a syntactic structure and
semantic part-whole relation network, because,
in Japanese, there are many paraphrase only one
noun phrase that has same meaning.

Then, new semantic interpretation is
obtained from an intersection which is
accomplished through the search of the two noun
definitions. When an intersection occurs, the
system focuses the matched semantic features
extracted in the search to construct an
interpretation. Thus, the search process
corresponds to the conflict resolution process
to produce the "inferred meaning". In this
way, interpretation of metaphorical use is
accomplished.

Here, we show the detailed semantic
procedure for each cases shown before.

(I) noun-1 + noun-2, Metaphor
Top level function : NPSEM
Procedure:
By metaphorical interference between noun-1
and noun-2, metaphoric semantics is obtained
from an intersection of semantic features between
two nouns.

(II - 1) M* no m* SIM M no m, Simile
Top level function : MTSEM1
Procedure:
First, by comparing noun semantic between M*
and m*, to that of M and m, the system can
decide the semantic of "M* no m*" and "M no m".
Then metaphorical semantics is obtained by
contrasting noun phrase semantic between
semantic of "M* no m*" and that of "M no m".

(II - 2) M* no m* SIM M(or m), Simile
Top level function : MTSEM23
Procedure:
First, by comparing two noun semantics between
M* and m*, the system can decide the semantic
of "M* no m*", then metaphorical semantic is
obtained by contrasting noun phrase semantic
between "M* no m*" and that of "M no m".

(II - 3) M* no m* SIM M no m, Simile
Top level function : MTSEM3
Procedure:
First, by comparing noun semantic between M
and m, the system can decide the semantic of "M no m".
In this type, noun phrase contrasting has
three types. The first type is in case that
m* of M* is omitted because of m*=m. In this
case, by comparing noun semantic between M* and
m* (= m), the system can decide the semantic of
"M* no m*", and then, metaphorical semantics is
obtained by contrasting noun phrase semantic between
"M* no m*" and "M no m". The second type is in case that m* of M* is omitted but m* is
restricted by META-NOUN description m* of
m. In this case, by comparing noun semantic between M* and m*, the system can decide the
semantic of "M* no m*", and then, metaphorical semantics is obtained by contrasting noun phrase semantic between "M* no m*" and "M no m". The third type is other cases. In this
case, by comparing semantic between M*(or m*)
and that of "M no m".

Fig.6 Metaphor processing for "MOCHIHADA"

Result shown in Fig.6 is to deal with noun-noun
metaphor "MOCHIHADA (a soft white skin)"
The intersection occurs at the semantic feature's
description, then the slot of "P-PROPERTY" is
filled in the semantic feature of "MOCHI (rice cake)"

Next case study shown in Fig.7 is to deal
with "MOMIJI NO YOUNA TE (hand like as maple)"
known as "Simile"

Tree structure represents a result of parsing,
and it is one of the control structure of
semantic processes. In this semantic process,
first, noun "NOMIJI (maple)" and "HA (leaf)"
are interfered for noun phrase and produce a
new unit which means "MOMIJI NO HA (leaf of
maple)". Then, new unit "HA (leaf)" and noun
"TE (hand)" of someone are interfered for
metaphorical use, and produce a final result.

And, other case study "DAIKON NO YOUNA
HANAKO NO ASHI (leg of HANAKO like as DAIRON)"
and its paraphrase "HANAKO NO DAikon NO YOUNA
ASHI" are metaphorically analyzed into the same
semantic structures shown in Fig.8 and Fig.9.

In this case, the syntactic analysis is much
complex as is compared to the noun-noun phrase,
and semantic process is as like as before.
Fig.7 Metaphor processing for "MOMIJI NO YOUNA TE"

Fig.8 Metaphor processing for "DAIKON NO YOUNA HANAKO NO ASHI"
We have dealt with conflict resolution process in metaphorical interpretation for noun phrases. In order to make the discussion more explicit, we have reviewed the problem on conflict resolution both from cognitive psychology and artificial intelligence. Especially, we have made our attention to the problem of knowledge representation in human long-term memory and AI system. In this connection, the procedure for dealing with semantically unacceptable knowledge is stressed for the understanding of metaphor. That is, we have considered the dynamic aspect of meaning for word or lexical item in metaphor.

In order to penetrate the problem on representation of meaning in metaphor, the idea of "Semistry" is introduced so as to analyse the conflict resolution in semantic interpretation. The idea of Semistry has been derived from the notion of Zwicky's paper on "Linguistics as Chemistry" which is metaphorical interpretation on Chemistry. By applying the notion into semantic structure of lexical item, the dynamic aspect of meaning is explained by introducing the idea of "semantic bonds" which have further constructed semantic resonance among semantic features. A usual meaning is determined from the single bonds between word and semantic features. In order to determine the meaning of noun-noun phrase metaphor, there must be an intersection of meaning between the first and the second nouns. This kind of intersection is accomplished through the procedure for finding the matched semantic properties of the first and the second nouns.

The proposed semantic model is designed and tried out for dealing with the noun phrase metaphor through the use of ELINGOL. Here, by parsing tree and LISP function in grammar, the inference system to resolve the conflict of semantic interpretation of metaphor was constructed. That is, the metaphor processing system would comprise a lexical item or word and associated inference mechanism to extract the meaning of metaphor. In order to proof the idea, the working system for the noun phrase is implemented by means of UCI-LISP (DEC-20) or HLISP (HITAC 8800-8700) and tried out with case studies.

As the conclusions, we have shown a possibility for approaching a semantic analysis of metaphor from an actual working system.

First, a new semantic model is proposed for dealing with metaphor. The idea of semantic resonance is introduced to explain "semantic bonds" which is derived from the comparison with Linguistic as Chemistry. Therefore, a role of metaphor is demonstrated in the present semantic model.

Second, the ELINGOL is utilized to unify the syntactic processing with the associated inference mechanism to extract metaphorical interpretation.

These cases are selected from the book called "A Stylistic Study of the Figuratives" (Nakamura, 1977). At the present state, number of items in dictionary is about 150.
Third, metaphor processing system called META-SIM is designed and tried out through case studies. We have discussed our experiences which was based upon the results of working system for metaphor processing system.

Although the present system and case studies are restricted to the noun-noun phrase, the meaning of smaller phrase can be useful to build up semantic analysis of larger phrase of metaphor. In this sense, the present study is the first step toward the semantic analysis of metaphor which has not been explored in the natural understanding system. And further, the study of metaphor will give us about much more fruitful inference mechanism for interpreting semantically unacceptable sentence. In the future, the role of metaphor must investigate for both educational purpose and design philosophy of any understanding system.

5. Acknowledgements

We indebted to many persons for suggestions and encouragement, especially to Dr. K. Fuchi and H. Tanaka of ETL Japan, T. Ishiwata of Ibaragi University, N. Terazu of Toyama University. We would like to special thanks to late Prof. S. I. Harada of Tokyo Metropolitan University for encouragement and effects for organizing research on discourse analysis for grant in aid for scientific research (Project number 211417, Agency number 310702). The special care was offered to the authors from Fujimic Computer Center Corporation (DEC-20).

6. Reference

1. Abelson, R. P., 1969, Psychological implication. In Abelson et al. (Eds.) Theories of cognitive consistency, Rand-McNally, New York.
2. Bobrow, D. G. & Norman, D. A., 1975, Some principles of memory schemata, In Bobrow & Collins (Eds.), Representation and understanding, New York: Academic Press.
3. Carbonell, J. R., Mixed-initiative Man-computer Dialogues, BBN Rep. No 1970, Cambr. Mass., 1970.
4. Festinger, L., 1957, A theory of cognitive dissonance, Stanford, Ca.: Stanford Univ. Press.
5. Kintsch, W., 1972, Note on the structure of semantic memory, In Tulving & Donaldson (Eds.), Organization of Memory, New York: Academic Press.
6. McDermott, D., Assimilation of new information by natural language understanding system, Cambr. Mass., MIT AI Laboratory Tech. Rep. 291, 1974.
7. Harada, S. I. & Mizoguchi, F., An introduction to linguistic chemistry, Unpublished manuscript 1977.
8. Ortony, A., Reynolds, R. E. & Arter, J. A., Metaphor: Theoretical and Empirical research, Psychological Bulletin, 1978, Vol. 85, pp. 919-943.
9. Rumelhart, D. E. & Ortony, A., The representation of knowledge in memory., In Anderson, Spiro & Montague (Eds.) Schooling and the acquisition of knowledge, Hillsdale, N. J., Lawrence Erlbaum Associates, 1977.
10. Schank, R. C., Identification of conceptualization underlying natural language, In Schank & Colby (Eds.), Computer models of thought and language. Freeman, 1973.
11. Tanaka, H. A Semantic Processing System for Natural Language Understanding, Research of the Electrotechnical Laboratory, No. 797, July 1979.