ABSTRACT
        The goal of this study is to understand the ways in
which humans apply relevant modules of knowledge of language to an
input sentence in a parsing process. To this end, quantifier float
constructions in Japanese are analyzed, as a case study, on the basis
of the view that the output in parsing comprises discrete and
multiple categories. Then, a framework for analysis is provided with
two relevant modules of knowledge of language in which the output or
judgements of a given sentence by native speakers could be classified
into categories. Finally, on the basis of an analysis of the main
features of the output, the problem of ways that the process of
applying the relevant modules of knowledge of language is organized.
Although the paper discusses a constraint on the phenomenon of
quantifier float constructions in Japanese in relation to problems of
parsing, this does not mean that a performance-based explanation
replaces traditional, grammar-based notions. The problems of parsing
that are addressed are only concerned with the process in which
knowledge represented by the grammar-based notions is applied and
with outputs from the process. (VWL)

Parsing as a Process of Applying I- Language Modules: A case of Study Based in the Processing of Quantifier Float Constructions in Japanese.

Yasuo Kaneko
Kushiro Public University of Economics

Parsing as a process of applying I-language modules: A case study
based on the processing of quantifier float constructions in
Japanese*

Yasuo Kaneko
Kushiro Public University of Economics

1. Introduction.

     The goal of this study is to understand the ways in which
humans apply relevant modules of knowledge of language to an
input sentence in a parsing process. To this end, we will
analyze quantifier float constructions in Japanese, as a case
study, on the basis of the view that the output in parsing
comprises discrete and multiple categories. Then we will provide
a framework for analysis with two relevant modules of knowledge
of language in which the output or judgements of a given sentence
by native speakers could be classified into the categories.
Finally, on the basis of an analysis of the main features of the
output, we will consider the problem of the ways in which the
process of applying the relevant modules of knowledge of language
is organized.
     Although the present paper will discuss a constraint on the
phenomenon of quantifier float constructions in Japanese in
relation to problems of parsing, this does not mean that a
performance-based explanation replaces traditional, grammar-based
explanations of the constraint. What substitutes for the
notions which play an important role in the traditional
explanations of the constraint are also grammar-based notions.
The problems of parsing which we will address are only concerned
both with the process in which knowledge represented by the
grammar-based notions is applied and with outputs from the
process.

1.1. Problems
     Generally speaking, parsing can be defined as a process
which receives a PF as an input and creates a corresponding LF
(or more) as an output. We could def'ne parsing in this way very
easily (Figure 1).
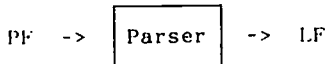
             PF -> | Parser | -> LF

          Figure 1. A definition of parsing

The ease of defining it, however, does not warrant any easy
solution of problems which we face when we try to understand the
detailed processes of parsing in humans. There seems to be no

agreement even as to the overall structure of a human parser. It
seems to me that this situation requires us to go back to and to
reconsider original issues of the so-called parsing problem.
 I think that the parsing problem is both

(I) an analogous problem to Plato's problem in language
acquisition, and at the same time,
(II) an inverse problem of Descartes' problem in language
production.

 By "an analogous problem to Plato's problem" I mean that a
sentence does not contain enough information in itself to allow
us to interpret it fully. Thus the poverty of stimulus in
sentence interpretation, which is due to partial realization of
information conveyed by an expression, parallels the poverty of
stimulus in language acquisition. To put it another way, a parser
cannot create an LF solely on the basis of a PF; (s)he must
contain a rich set of knowledge of language to apply to an input
sentence.
 By "an inverse problem of Descartes' problem" I mean that
the human sentence parsing process faces a problem of
unpredictability of any aspects of an input sentence, which is
caused by the creativity in language production.
 Therefore, in order to understand the human sentence parsing
process, we need to answer the following two questions.

(I') How do humans apply a rich set of knowledge of language to
an input sentence and recover the information which is omitted at
the time of encoding of an expression or lost during the
transmission ?
(II') How do humans cope with the unpredictability of any aspects
of an input sentence, which is caused by the creativity in
language production ?

Correspondingly, a theory of the human sentence parsing process
must consist of two aspects:

(I'') an aspect which concerns itself with the process of
applying a rich set of knowledge of language to an input
sentence, and
(II'') another aspect which concerns itself with those mechanisms
and procedures which make it possible for humans to cope with the
unpredictability of any aspects of an input sentence.

 I think that we can realize the first aspect of the
theory of the human sentence parsing process as an idea that
parsing is a process of applying the knowledge contained in the
modules of the I-language (Chomsky 1986) to an input sentence.
The principle-based parsing (e.g., Berwick, 1991; Johnson, 1989;
Wehrl, 1988) is an attempt to realize this idea. Although, in
fact, this paradigm contains a variety of approaches (cf.
Berwick, et al., 1991), straightforward and comprehensive
attempts to realize the idea are made in Fong (1991), where, for
now, they explore computational possibilities of control
structures which apply relevant modules of knowledge of language

to an input sentence on the basis of logical dependencies among
the modules. However, what matters in psycholinguistic studies is
not just the computational possibilities but empirical facts
about the process of applying the modules to an input sentence.
We do not know anything about the latter.

On the other hand, the second aspect of the theory, that
is, the aspect concerning the r :ser's flexibility when (s)he
must cope with the unpredictability of an input sentence,
clearly has to do with the following various kinds of mechanisms
and procedures which give the parser the flexibility. These
include a look-ahead buffer which holds unstructured items to
delay syntactic decisions (Marcus, 1980), a method of
underspecification which is intended to avoid unnecessary
commitment to positing nodes which lack evidence for the
existence at the time of expanding X bar rules (Marcus. Hindle, &
Fleck, 1983; Barton & Berwick, 1985), a race model which
computes possible structures in parallel and discards
unnecessary structures immediately (Frazier & Fodor, 1978; McRoy
& Hirst, 1990), error recovery procedures such as backtracking
and more intelligent ones, to mention just a few. However, it is
safe to say that the way in which this second aspect of the
theory can be realized seems to be still globally unclear,
witness the controversies such as delayed use (e.g., Frazier,
1990) vs. immediate use (e.g., Tanenhaus & Carlson, 1989) of
argument structure information.

In the present paper I will focus on the first aspect of the
parser. How can we provide a more constrained picture of parsing
as a process of applying the l-language modules ? I will address
this problem in the next section.

1.2. The nature of output in the human sentence parsing process:
A possible source of constraint

A possible constraint on the structure of the process of
applying the l-language modules might come from the
following observations:

"So-called "ungrammatical" or "deviant" sentences are often quite
readily parsable and even perfectly intelligible." (Chomsky 1991,
p.19)
"Sentences like what do you wonder who likes or John is proud
Bill, ⁺hough hard to understand, don't cause people to collapse
like a rule-based system would." (Berwick, 1991, p.117)

In other words, any sentence can receive some interpretation.
Therefore, the dichotomy between grammatical sentences and
ungrammatical ones no longer holds. This simple statement implies
a very profound change of view of the nature of parsing in
general and of the nature of output in particular, because this
negation of the dichotomy discards altogether both the
traditional view of language as a set of sentences which are
well-formed linear strings of words and the traditional view of
a parser basically as an automaton which accepts the string as
well-formed or rejects it as ill-formed (Chomsky 1990).

The goal of this study is to understand what kind of
organization of the process of applying the l-language modules

could produce the output with the observed nature in parsing.
To this end, my point here is to take up as serious subjects both
the view of parsing as a process of applying the I-language
modules and the view of the nature of the output in parsing and
to examine what this change of view of the nature of the output
implies on the basis of a concrete phenomenon of the so-called
quantifier float constructions in Japanese. First, let me remind
you here of the phenomenon.

2. Quantifier float constructions in Japanese.

In the following pairs of sentences, which roughly mean the
same thing, the (b) forms of them are called quantifier float
constructions.

(1)a. San-nin-no   gakusei-ga ik-i-mas-i-ta,
      3 people GEN student NOM go POLITE PAST
      ("Three students went.")
   b. Gakusei-ga san-nin ik-i-mas-i-ta.
(2)a. San-nin-no gakusei-o   ik-ase-mas-i-ta.
                    ACC   CAUSATIVE
      ("(Someone) made three students go.")
   b. Gakusei-o san-nin ik-ase-mas-i-ta.
(3)a. San-nin-no gakusei-ni   shukudai-o das-i-mas-i-ta.
                    DAT homework give
      ("(Someone) gave homework to three students.")
   b.?Gakusei-ni san-nin shukudai-o das-i-mas-i-ta.
      ("(Someone) gave homework to three students." or
       "Three people gave homework to students.")

Phrases like "san-nin" in the (b) forms are called floating
numeral quantifiers (henceforth abbreviated as FNQ).
     Some linguists describe the correspondence between these
pairs of sentences in terms of movement. However, in this study,
we shall limit our attention to an aspect of this phenomenon that
there is a correspondence between the (a) forms and (b) forms in
some cases but not in others. Then we shall consider what kind
of constraints must be there in order for the (b) forms to make
sense (cf. Miyagawa 1989).
     As these examples show, there seems to be some constraints
on this correspondence. Incidentally, in terms of movement, we
can say that some constraints exist on the possibility of
"launching" or "floating" a numeral quantifier from a noun
phrase (henceforth, NP) which the quantifier originally modifies.
Then what are the constraints like ? The studies which have been
done so far have tried to characterize or define the constraints
in terms of some linguistic concepts such as the following. Let
me give you a very brief review of the studies. First, a
constraint was characterized or defined in terms of grammatical
relations such as subject and object; that is, quantifiers can
be floated from subject NPs and direct object NPs but not from
other oblique NPs (Okutsu 1969; Kamio 1977).
     After that, the constraint was redefined in terms of
surface cases such as nominative and accusative, because some
other examples show that NPs which are subject and at the same

time dative cannot launch quantifiers;

(4)a. San-nin-no gakusei-ni shukudai-ga konas-e-mas-i-ta.
      SUBJECT NP DAT   do   POSSIBLE
    ("Three students managed to finish homework.")
   b.?Gakusei-ni san-nin shukudai-ga konas-e-mas-i-ta.

That is, quantifiers can be floated from nominative NPs and accusative NPs but not from other oblique NPs (Shibatani 1977).

Recently, definitions of the constraint became more complicated, accomodating concepts such as the obligatory nature of a modified NP as an argument with respect to a predicate, the distance between an FNQ and a modified NP, the kind of an intervening element between an FNQ and a modified NP, and word order (Haig 1980; Shimozaki 1989), although it is also pointed out in Miyagawa (1988; 1989) that the constituent which the FNQ can modify is basically an NP which receives " a thematic role from an external source such as the verb" (1989, p.27).

3. An alternative analysis.

3.1. Two kinds of top-level computations and multiple categories of output

However this line of studies might proceed, it seems to me that they have all overlooked the following point. That is, there is a serious problem in their way of looking at the data on which their arguments are based.

Above all, these studies are, even quite recently (for example, Miyagawa, 1988; 1989), based on data which presuppose a rather rigid dichotomy between grammatical sentences and ungrammatical ones. However, as has been well-known since the early days of generative grammar, there is much heterogeneity among the judgements made by native speakers on a given sentence (cf. for example, Shibatani 1982).

Moreover, there are some attempts to introduce such concepts as a degree of acceptability into the data (for an explicit introduction of the concept of degree, see Shimozaki, 1989). However, the mere introduction of the degree concept will not suffice. In this kind of study, it is implicitly assumed both that the number of categories of the output in parsing is only one and that the degree of acceptability is the difference within that one and the same category. However, this assumption would not hold a priori.

As a solution to these problems, there is an alternative way of looking at the data. As we will see later in more detail, we can make certain discrete distinctions in the data. The distinctions are different from both the dichotomy and the degree of acceptability. They are presumed to correspond to the output of parsing in humans. I would like to propose that we should base studies of quantifier float constructions on the data which reflect these distinctions.

More specifically, this alternative framework for analysis claims the following points. First of all, (i) the number of categories of output in parsing is ·lural. Second, (ii) each category of the output corresponds to a combination in which some

principles or factors involved in the processing of quantifier
float constructions are violated and others are not.
A maximally well-formed sentence is represented as a combination
in which none of the principles involved are violated. Thus, this
alternative analysis claims that there are as many cases in
which quantifier floating is impossible as combinations in which
the principles involved are violated. Finally, (iii) a difference
in the degree of grammaticality or acceptability, if any, is
within each of the categories of the output.

Then how can we realize this alternative framework for
analysis ? First of all, we can say that primacy of such
factors as grammatical relations and surface cases in the process
of interpreting the quantifier float constructions seems
doubtful. Rather, I would like to propose that two factors,
the possibility of theta-role assignment and the possibility of
establishing modification relation from an FNQ to a modified NP,
play primary roles in the process involved. Now let me explain
involvement of these two factors in the process briefly.

3.1.1. Theta-role assignment
One of these factors is the possibility of assigning a
theta-role to an FNQ in a sentence. For example, in sentence (1-
b), the verb can assign the same agent-role to the FNQ and the
nominative NP. In the more interesting case of sentence (3-b),
the verb can assign, on the one hand, an agent-role to the FNQ;
however, it assigns, on the other hand, a goal-role to the
dative NP. Thus, in this case, the FNQ and the dative NP which
the FNQ is originally intended to modify receive different theta-
roles.

(5)a. 200 kg.-no rikishi-ga   dohyo-ni aga-t-ta.
              Sumo wrestler Sumo ring mount. PAST
   ("A Sumo wrestler who weighs 200 kg. mounted the Sumo ring.")
   b.*Rikishi-ga 200 kg. dohyo-ni aga-t-ta. (Otsu 1988)

In sentence (5-b), the FNQ, "200 kg.", cannot receive any theta-
role from the verb, in marked contrast to examples (1-b) and (3-
b). This situation, which makes sentence (5-b) "ungrammatical",
constitutes another category of output from the processing of
quantifier float constructions.

A note on the relation of this analysis to the theta-theory
would be in order here. This analysis apparently seems to violate
the theta-theory because the FNQ that is not an argument receives
a theta-role. Even if the FNQ could have an argument status, the
analysis violates the theta-criterion anyway because one and the
same theta-role is then assigned to the two arguments.

However, we could avoid this violation by positing something
like the theta-role transmission principle proposed by Jaeggli
(1981) (the following explanation is cited from Dorr, 1991). The
theta-role transmission principle is represented as follows;

(6)   [Cl. + Case i + Theta j]...[NP + Case i] =>
        [Cl. + Case i + Theta j]...[NP + Case i + Theta j].

where "Cl." stands for a pronominal clitic.

(7)   Le regalé un libro a Juan.
        CL gave a   book to John
        (" I gave a book to John.")

In sentence (7), "Le" is ["le" + accusative + patient] and "a Juan" is ["a Juan" + dative]. So, "a Juan" does not yet have a theta-role. Moreover, it cannot receive a theta-role directly from the verb without violating the theta-criterion, because the theta-role which it can receive is the same as the theta-role already assigned to the pronominal clitic, "Le". However, through this principle it can receive a theta-role without the theta-criterion violation.

By analogy, we could propose something like;

(8)   [NP + Case i + Theta j + feature k]...[FNQ + feature k] =>
        [NP + Case i + Theta j + feature k]...[FNQ + Theta j +
        feature k].

where "FNQ" stands for the floating numeral quantifier and "feature" stands for some semantic features discussed below.

3.1.2. Modification

Another factor is the possibility of establishing modification relation from an FNQ to a modified NP. Here the term "modification" is used "as a general term for relations such as qualification of and quantification over", following Sportiche (1988, p.429) and Ueda (1990, pp.86-87). For example, in sentence (1-b), the FNQ, "san-nin", can be easily interpreted or judged to be able to modify the preceding NP. In sentence (3-b), the FNQ, "san-nin", is not easily interpreted to be able to modify the preceding NP. This situation contributes to the "unacceptability" of this sentence. Note that it does not always follow that this combination of a dative NP and a FNQ contributes to "unacceptability";

(9)a. San-nin-no   gakusei-ni it-te-mora-t-ta.
      3 people GEN   student DAT go   want   PAST
      ("(Someone) wanted three students to go."
   b. Gakusei-ni san-nin it-te-mora-t-ta.

When we interpret the FNQ in the context of this sentence, the same combination does not necessarily lead to "unacceptability" but to a partitive interpretation.

3.1.3. Output

Taking into account these two factors, we can propose the following structure of "what is being computed", in Marr's (1982) sense, and of what is output in the process of interpreting the quantifier float constructions. First, there are two kinds of computations on the top-level (Figure 2).

NP   FNQ   .   FNQ   Predicate
^   ^
|_____| |_____|
Modification   Theta-Role Assignment

62
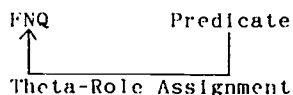
Figure 2. Two kinds of computations on the top-level:
modification and theta-role assignment. These schemata
represent only two constituents involved and order them
according to the word order of the Japanese language.

These two kinds of computations on the top-level determine the
overall pattern and major features of the output in parsing.

Second, modification and theta-role assignment have the same
structure of alternatives (Figure 3); first, both divide into
"possible" and "impossible", and in the case of "possible", both
divide into "equal" and "not equal to". Incidentally, "not equal
to" in the "possible" case of modification means a so-called
partitive interpretation.

```
        modification                    theta-role assignment
  impossible    possible          impossible    possible
          equal    not-equal-to            equal    not-equal-to
```
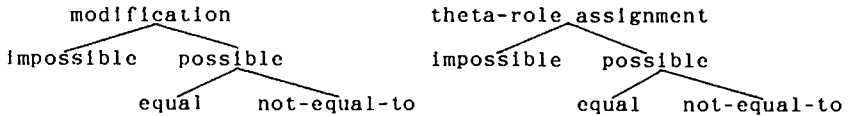
Figure 3. The structure of alternatives in modification
and theta-role assignment.

These things are summarized in Table 1.

Table 1. Contents of computation and output.

modification		theta-role assignment		output
possibility	identity	possibility	identity	
possible	equal	possible	equal	(1)well-formed
possible	equal	possible	not-equal-to	(2)different theta-roles
possible	equal	impossible	irrelevant	(3)nonexistent
possible	not-equal-to	possible	equal	(4)partitive interpretation
possible	not-equal-to	possible	not-equal-to	(5)different theta-roles
possible	not-equal-to	impossible	irrelevant	(6)nonexistent
impossible	irrelevant	possible	equal	(7)nonmodifiable
impossible	irrelevant	possible	not-equal-to	(8)different theta-roles
impossible	irrelevant	impossible	irrelevant	(9)impossibility of theta-role assignment

Needless to say, more subtle distinctions in the output can be made, for example, on the basis of the fact that there is a case in which we find it impossible to assign any theta-role to an FNQ in the context of a sentence at a first-pass analysis, but we find it possible, in turn, at a second-pass analysis. However, possibilities like this are not pursued here, and thus distinctions based on the possibilities are not incorporated into the analysis proposed here.

An example of the output (9) in Table 1 is the sentence (5-b). The main feature of this sentence consists of the fact that it is impossible to assign any theta-role to the FNQ and that the FNQ remains without a theta-role.

(10) Gyuuniku-ga 200 kg. ur-e-mas-i-ta. (Otsu 1988)
      beef   sell passive
      ("A 200 kg. of beef was sold.")

In contrast to this, sentence (10), which contains the same FNQ as the sentence (5-b), is maximally well-formed and therefore falls under the type of output (1) in Table 1. In this case, first, the FNQ can modify the preceding NP because "gyuuniku" is a mass noun and "kg" is a suitable unit for a mass noun. Second, the predicate "sell" can assign a theme-role to the FNQ. We can explain a similar sentence (11) (Kamio, 1977) in the same way.

(11) *Kuruma-o 2000 cc kau.
       car   buy
       ("(Someone) buys a 2000 cc of car.")

In this case, the FNQ cannot modify the preceding NP because a suitable unit for counting cars is "dai", not "cc". However, the predicate "buy" can assign a theme-role to the FNQ under the interpretation that the theme has the function of a mass noun. This theme-role is the same as the theta-role which is assigned to the accusative NP "kuruma". Thus the sentence (11) falls under the type of output (7) in Table 1.

The sentence (3-b) is an example of output (8) in Table 1 if the modification is judged to be impossible as is usually the case, where "Gakusei-ni" has a goal-role and "san-nin" has an agent-role. If the modification is judged to be possible in this sentence, then the output of the same (3-b) falls into output (2) or (5) in Table 1, depending on the judgement of equality.

3.2. Subfactors affecting the top-level computations

It seems possible that these two factors of theta-role assignment and modification are also affected by some other minor factors, apart from structural positions, although it might become clear that these subfactors must be recast in structural terms (cf. references in (iv), for example). First, the factors which might affect judgement of the possibility of modification from an FNQ to a modified NP are as follows:

(i) whether or not an auxiliary number or a numeral classifier

(for details, see e.g., Denny, 1979), which constitues a quantifier with a numeral, is a suitable unit for counting objects which a set denoted by a modified NP includes or for measuring a property which a modified NP has. For examle, "kg" in sentence (5-b) is not a suitable unit for humans.
(ii) whether or not [NP + postpositional particle + FNQ] is read as a single intonational constituent.
(iii) what kind of predicate constitutes a context for interpretation. For example, although the FNQ in sentence (4-b) is not usually judged to be able to modify the preceding NP, the one in sentence (9-b) can be judged to be able to modify the preceding NP. This might mean that the possibility of modification from an FNQ to a preceding NP depends on the context for interpretation, which is provided by the predicate.
(iv) kind of intervening constituents (Sportiche, 1988; Ueda, 1990).
(v) distance (Shimozaki, 1989).
(vi) whether or not the FNQ is a focus of new information (Katagiri, 1991; 1992).
(vii) whether or not a modified NP agrees in number with the FNQ (Okutsu, 1986).

Second, one of the factors which might affect judgement of the possibility and identity of theta-role assignment is:

(i) whether or not the semantic features which a theta-role requires are consistent with the semantic features of FNQ.

(12)a. San-nin das-u.
              give PRESENT
       ("Three people give (something).")
    b. San-dai das-u.
          problem PRESENT
       ("(Someone) gives three problems (to someone).")

In sentence fragment (12-a), the FNQ, "San-nin", has a semantic feature, [+animate], which is consistent with one of the semantic features that an agent-role has. Thus this feature makes it possible to interpret the FNQ as playing an agent-role in this fragment. In contrast to this, the FNQ, "San-dai", in sentence fragment (12-b) has a semantic featutre, [-animate], which makes it impossible to interpret the FNQ like th one in (12-a).
    It might also be possible that these factors are in turn affected by certain subfactors. For example, the factor of whether or not the FNQ is a focus of new information, which affects the possibility of modification, is affected by the following subfactors (Katagiri 1991; 1992).

(i) whether or not there is a contrasting form,
(13) Hanako-wa bounenkai-ni hutatsu shinnenkai ni m ttsu i-t-ta.
              year-end party   2   New Year's party 3
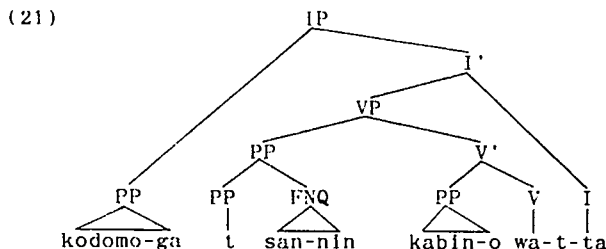   ("Hanako went to two year-end parties and three New Year's parties.")
(ii) whether or not there ia an emphatic particle "mo",
(14) Hanako wa kotoshi party-ni mittsu-mo i-t-ta.

12

this year   EMPHATIC
        ("Hanako went to three parties this year.")
(iii)whether a clause represent a result (15-a) or a state (15-b).
(15)a.Kodomo-ga geragerato hutari wara-t-ta.
        children   loudly   laugh
        ("Two children laughed loudly.")
    b.Kodomo-ga geragerato hutari wara-t-te-i-ta.
    ("Two children were laughing loudly.")

        Another factor, whether or not the FNQ agrees in number with
the   modified   NP,   which affects   the   possibility   of   the
modification, is further affected by the following subfactors.

(i)   whether   or   not there is a   discrepancy   between   implicit
singularity   of   a common noun in Japanese and the   plurality   of
FNQ (Okutsu, 1986).
(16)   Gakusei-ga tegami-o suu-nin ka-i-ta.
                   letter   several write
       ("Several students wrote a letter.")
(17)   Gakusei-ga koogi-o suu-nin sabo-t-ta.
                   class   cut
       ("Several students cut the class.")
The relative awkwardness of sentence (16),   compared with that of
sentence (17), may be attributed to subfactor (i).
(ii)   Whether   or   not   there is a   discrepancy   between   the
singularity of a proper noun and the plurality of FNQ.
(18)   Taro-ga tegami-o suu-nin kaita.
(19)   "Sato"-ga 8-nin "Suzuki"-ga 5-nin kono   gakko-ni-wa
                                         this school LOC TOPIC

       i-mas-u.
       there are
       ("There   are   eight   "Sato"   and   five   "Suzuki"   in   this
       school.")
The awkwardness of sentence (18),   compared with the   naturalness
of sentence (19), may be attributed to subfactor (ii).

        Returning to the structure of what is computed in processing
quantifier   float   constructions,   how   can   we   give   concrete
computational   substance   to the proposed structure   of   the   two
computations   on   the top-level? In the next   section,   we   will
address this problem.

3.3.   Subcomputations of modification and theta-role assignment.
        In   this section,   we will first consider the computation of
modification   relation from an FNQ to a modified NP and then   the
computation   of theta-role assignment from the predicate   to   the
FNQ.

3.3.1. Modification
        Here,   we   will define the computation of the possibility of
modification relation from the FNQ to the modified NP in terms of
the notion of c-command:

(i)   to   judge whether the FNQ can modify the PP if the   FNQ   c-
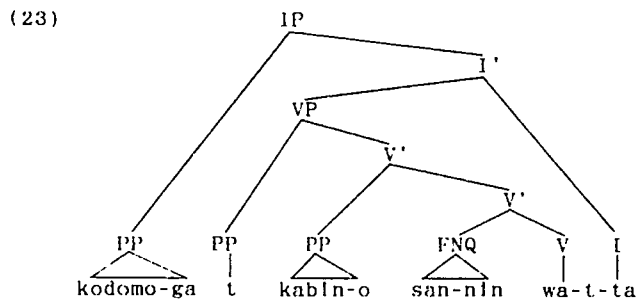commands a PP or the trace of a PP.

13

Here, let me demonstrate this by considering very simple sentences. In computing the c-command relation, we will assume the Japanese phrase structure according to Ueda (1990) with some minor modifications. For example, in sentence (20), we assume a structure like (21), where the FNQ c-commands the trace of PP; therefore, we are led to judge that the FNQ can modify the NP.

(20) Kodomo-ga san-nin   kabin-o wa-t-ta.
     children NOM 3 people vase ACC break PAST
     ("Three children broke a vase.")

(21)

```
                    IP
                 ／    ＼
                       I'
                    ／   ＼
                  VP
               ／    ＼
             PP        V'
          ／  |  ＼   ／  ＼
        PP   PP  FNQ  PP   V   I
        △    |   △   △   |   |
    kodomo-ga  t  san-nin  kabin-o wa-t-ta
```

On the other hand, in sentence (22), we assume a structure like (23), where the FNQ does not c-command the trace of PP "kodomo-ga", therefore, we are led to judge that the FNQ cannot modify the NP.

(22)*Kodomo-ga kabin-o san-nin watta.

(23)

```
                    IP
                 ／    ＼
                        I'
                     ／   ＼
                  VP
               ／    ＼
             PP        V'
          ／  |  ＼    ／  ＼
        PP   PP       V'
        △    |      ／   ＼
    kodomo-ga  t   PP   FNQ   V   I
                   △    △    |   |
                 kabin-o  san-nin  wa-t-ta
```

Ueda(1990) explains the ungrammaticality of sentence (22) in the following way. First, "kodomo-ga" and "san-nin" form a single constituent and have the structure (24) at the D-structure.

(24) [np [np kodomo-ga] san-nin]

Second, "kodomo-ga" moves obligatorily from the VP-internal subject position to the specifier position of IP. Third, although "kabin-o" must move by scrambling, "adjunction to VP by scrambling is prohibited" (p.97). Therefore, sentence (22) is
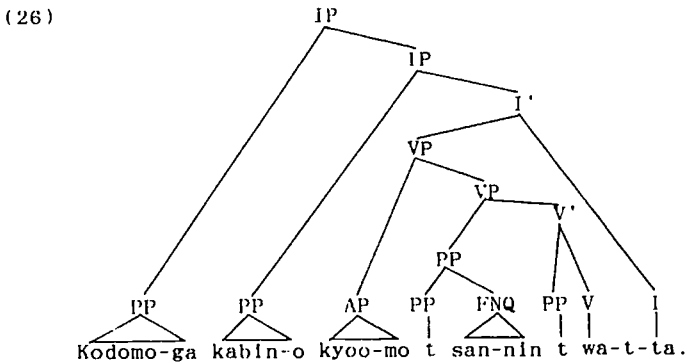
ungrammatical.

Although the analysis of Ueda (1990) can explain the ungrammaticality of (22), the impossibility of the modification from the FNQ to the NP in the sentence (22) remains to be explained. Because the structure (24) always exists at the D-structure, the modification relation should also hold in spite of the ungrammaticality. However, the modification relation does not hold. Therefore, there must be something which makes the modification impossible other than the violation due to the prohibited adjunction to VP.

The revision which is proposed here assumes (I) that a structure like (24) does not always exist at the D-structure and (II) that a structure like (24) is posited only if there is evidence for movement by scrambling. For example, consider the sentence (25).

(25) Kodomo-ga kabin-o kyoo-mo san-nin wa-t-ta.
                        today also
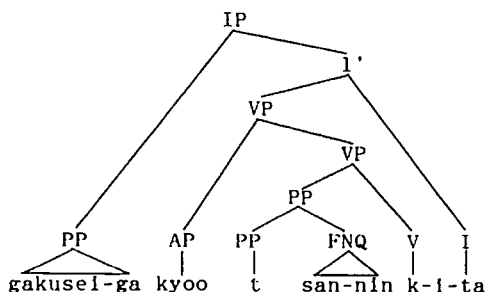   ("Three children broke the vase also today.")

In this case, "san-nin" is more often judged to modify "kodomo-ga" in contrast to (22). The revised analysis assumes that there is evidence for the movement by scrambling in this sentence because "kodomo-ga" and "kabin-o" appears in higher positions than "kyoo-mo" which is originally in a higher position than the other constituents at the D-structure.

(26)


```
                        IP
                       /  \
                      /    IP
                     /    /  \
                    /    /    I'
                   /    /    / \
                  /    VP   /   \
                 /    / \  /     \
                /    /   VP       \
               /    /   /  \       \
              /    /   /    V'      \
             /    /  PP    / \       \
            /    /  / \   /   \       \
          PP   PP  AP PP FNQ  PP V     I
          |    |   |  |   |    |  |     |
   Kodomo-ga kabin-o kyoo-mo t san-nin t wa-t-ta.
```

The same kind of analysis holds for sentence (27), the structure of which is shown in (28).

(27) Gakusei-ga kyoo san-nin k-i-ta.
   student NOM today 3 people come PAST
   ("Today three students came.")

(28)

```
                        IP
                       /  \
                      /    1'
                     /    / \
                    /   VP   \
                   /   / \    \
                  /   /   VP   \
                 /   /   / \    \
                /   /  PP   \    \
               /   /  / \    \    \
             PP   AP PP  FNQ  V    I
             /\   |  |   |    |    |
        gakusei-ga kyoo t  san-nin k-i-ta
```

This definition of the computation of the possibility of modification relation in terms of c-command relation is not entirely new. Miyagawa (1988; 1989) introduced the mutual c-command requirement for establishing the modification relation, which Miyagawa (1988; 1989) regarded as "predication", between an FNQ and a modified NP. Miyagawa's (1988; 1989) argument is as follows. First, the necessity for introducing the c-command condition is shown in the following pairs of sentences and structures (Miyagawa, 1989, pp.28-29).

(29)a. Tomodati ga 2-ri Tanaka-sensei ni atta.
        friends NOM 2-CL Prof. Tanaka DAT met
        ("Two friends met Prof. Tanaka.")
     b.*Tomodati ga Tanaka-sensei ni 2-ri atta.

(30)a.

```
                    S
                   /|\
                  / | \
                NP  NQ  VP
                |   |   /\
                |   |  /  \
           tomodati ga 2-ri Tanaka-sensei ni atta
```

     b.

```
                   *S
                   / \
                  /   \
                NP     VP
                |      / \
                |     /   \
           tomodati ga  Tanaka-sensei ni 2-ri atta
```
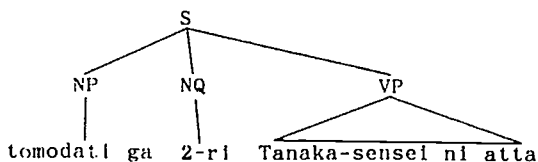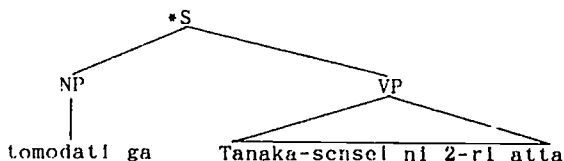
In (29a), the modification is possible and this fact is captured in (30a) by the structural condition that the FNQ c-commands the modified NP because the first branching node, S, dominating the FNQ also dominates the modified NP. On the other hand, the modification is impossible in (29b) and this fact is captured in (30b) by the structural condition that the FNQ does not c-command the modified NP because the first branching node, VP, dominating the FNQ does not dominate the modified NP.
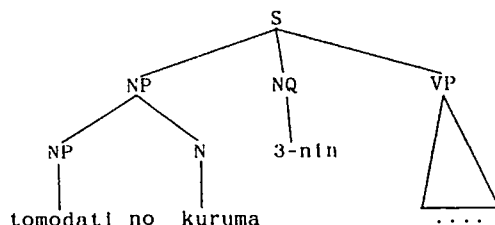
However, Miyagawa (1988; 1989) argues that this c-command condition is not a sufficient condition and introduces the mutual

c-command requirement. According to Miyagawa (1989, pp.29-39), the necessity for introducing the mutual c-command requirement is shown in the following example.

(31) *[NP Tomodati no kuruma] ga   3-nin kosyoosita.
          friends GEN car NOM   3-CL broke down

(32)

In sentence (31), the modification is impossible even if the FNQ c-commands the modified NP Thus only the condition that the FNQ c-commands the modified NP is not a sufficient condition to exclude constructions like sentence (31). In constructions like sentence (29a) where the modification is possible, the FNQ c-commands the modified NP as was seen above, and at the same time the modified NP c-commands the FNQ because the first branching node, S, dominating the NP also dominates the FNQ. On the other hand, in constructions like sentences (29b) and (31) where the modification is impossible, the FNQ does not c-command the NP as in sentence (29b), or the FNQ c-commands the NP but the NP does not c-command the FNQ as in sentence (31).

However, if we could assume that "3-nin" appears under the VP in the structure (32), the mutual c-command requirement is not necessary, because "3-nin" does not then c-command "tomodati" anyway. Moreover, although "3-nin" and "kuruma" c-command mutually under the structure (32), "3-nin" cannot modify "kuruma". Therefore, even the structural requirement alone is not sufficient. Like our framework for analysis, we need to take into account such a factor as whether or not a numeral classifier which constitutes an FNQ with a numeral is a suitable unit for counting or measuring objects denoted by a modified NP.

According to our proposed framework for analysis, there is another factor which we need to take into account. What makes sentence (31) anomalous lies in the fact that it is difficult to have "kosyoosita" assign a theme-role to "3-nin" and "3-nin" remains without a theta-role, at least at a first-pass analysis, because "kosyoo" is usually associated with [- animate] thing.

3.3.2. Theta-role assignment

Next, we will pro. se a hypothesis of computation of theta-role assignment from the predicate to an FNQ, which consists of the following four steps:

(I) to retrieve the argument structure of the predicate.
(II) to check whether or not the semantic features of FNQ can satisfy a theta-role provided by the argument structure. If

possible,
(iii)to check whether or not postposition or case markers do not
govern the FNQ and whether or not the predicate governs the FNQ.
(iv) to judge whether the predicate can assign a theta-role to
the FNQ if postposition or case markers do not govern the FNQ and
the predicate governs the FNQ.

It is assumed here that this procedure functions as a
default mechanism in the case where there is no argument to which
a theta-role of the argument structure of the predicate can be
assigned. When there is an argument to which a theta-role can be
assigned, something like the theta-role transmission principle
replaces the procedure.

3.3.3. Quantifier shift constructions: Evidence

A partial support of the computational processes of the
modification and the theta-role assignment comes from a fact that
there is no problem for the modification and the theta-role
assignment in the output from an interpretation process of the
so-called "quantifier shift constructions" (Shibatani 1977), in
which FNQ appears in between a modified NP and postposition.
Compare the quantifier float constructions ((b) sentences) and
the "quantifier shift constructions" ((c) sentences) in the
following set of sentences (Otsu 1988).

(33)a. San-nin-no   kasyu-ni   puropoozu s-i-mas-i-ta.
       3 people GEN singer DAT propose   do   PAST
       ("(Someone) proposed to three singers.")
    b.*Kasyu-ni san-nin puropoozu s-i-mas-i-ta.
    c. Kasyu-san-nin-ni puropoozu s-i-mas-i-ta.
(34)a. San-nin-no kasyu-kara sain-wo   mora-i-mas-i-ta.
                  ABLATIVE autograph get
       ("(Someone) got autograph from three singers.")
    b.*Kasyu-kara san-nin sain-wo mora-i-mas-i-ta.
    c. Kasyu-san-nin-kara sain-wo mora-i-mas-i-ta.
(35)a. San-nin-no kasyu-no-mae-ni   tat-i-mas-i-ta.
                          in front of stand
       ("(Someone) stood in front of three singers.")
    b.*Kasyu-no-mae-ni san-nin tat-i-mas-i-ta.
    c. Kasyu-san-nin-no-mae-ni tat-i-mas-i-ta.

In the quantifier shift constructions, it is always possible to
establish the modification relation from the FNQ to the NP
because the structure is like the following:

(36)   PP
               NP
           NP   FNQ   P
           | | |
        kasyu san-nin ni
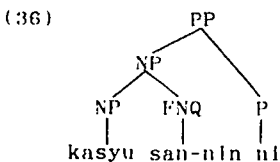
Moreover, it is also always possible to assign the same theta-
role both to the FNQ and to the modified NP because the theta-

role which is assigned to the NP is transferred to the FNQ by something like the theta-role transmission principle in structures like (36).

4. Conclusion.

To summarize, the structure of what is computed in processing quantifier float constructions is rather straightforward. Two factors of possibilities of theta-role assignment to FNQ and of establishing modification relation from FNQ and modified NP play primary roles in the processing. Interaction of these two factors determines nine, not two, categories in output which are shown in Table 1.

Now, by way of conclusion, we would like to discuss some of implications which the analysis proposed here might have for one of the original issues, that is, the question of how the process of applying I-language modules to an input sentence is organized. First, the analysis makes use of natural notions of operations such as modification and theta-role assignment, which are involved anyway in the ordinary processes of sentence comprehension. Moreover, these two operations are generators, as contrasted with filters like Case Filter, Empty Category Principle, and so on, if we could divide the principles into these two categories as Fong (1991) does. Therefore, if our analysis which attempts to characterize or define the constraint on quantifier float constructions in terms of these notions is correct, the analysis might show that what determines major features of output in parsing are generators, not filters.

Second, intuitive contents of major features of output in parsing, which are shown in Table 1, show that the factor of theta-role assignment contributes more to the major features of the output than another factor of modification. Therefore, if this is correct, this difference in the contribution to the major features of the output might also mean something about the organization with respect to these two modules.

As a related question, we would like to consider the nature of the human parser. The task of parsing has been traditionally conceived to be restricted to phrase structure parsing or X bar parsing. However, a reconsideration of one of the original issues might show that the task of parsing is not necessarily restricted to X bar parsing. It includes all the processes which apply other I-language modules of syntactic component of grammar as well as X bar rules. In this conception of parsing, such modules as theta-role assignment play primary roles as seen above. However, this might not necessarily mean that the parser is communication-oriented because what is involved in syntax (e.g., Grimshaw, 1990) and in parsing (Pritchett, 1992) may not be the contents of theta-roles. The exact nature of parsing must be determined in relation to other modules of sentence comprehension and to the nature of the interface between the parser and these other modules.

Finally, we would like to discuss some implications of the analysis for psycholinguistic studies in general. First, this analysis might give a more natural explanation for the problem of acquisition of the constraint on quantifier floating. If we

characterized the constraint in terms of grammatical relations
or surface cases and we stated that "subject NPs and direct
object NPs can launch quantifiers but other oblique NPs cannot"
or "nominative NPs and accusative NPs can launch quantifiers but
other oblique NPs cannot". then it seems rather ad hoc to think
that the constraint stated in these terms is acquired,
represented, and used directly. In contrast to this, the problem
of acquisition might disappear if we could adopt the kind of
explanation of the constraint which is proposed here, because we
then do not use the constraint at all when we process
quantifier float constructions. Rather, there might exist only a
general process of applying I-language modules, and judgements
about quantifier float constructions which reflect the constraint
might follow derivatively or "deductively" from the process.
        Second, whatever individual differences might appear in
interpretation of quantifier float constructions could each be
attributed to one category of the output or another on the basis
of the structure of what is computed shown in Table 1.
        Of course, many problems remain to be solved. First of all,
the existence of pattern or of types of output in parsing must be
verified. Moreover, the psychological reality of judgements of
possibilities of modification and of theta-role assignment must
also be verified. However, it seems safe to say at least that
this line of studies which has been shown in this paper might
also shed some light on the nature of the human sentence parsing
process.

References

Barton E., and R. Berwick. 1985. Parsing with assertion sets
        and information monotonicity. Proceedings of the Ninth
        International Joint Conference on Artificial Intelligence,
        769-771.
Berwick, R.C. 1991. Principle-based parsing. In P. Sells, S.M.
        Shieber, and T. Wasow (eds.) Foundational issues in natural
        language processing. Cambridge, MA: The MIT Press.
Berwick, R.C., S.P. Abney, and C. Tenny (eds.) 1991. Principle-
        based parsing: Computation and psycholinguistics. Dordrecht:
        Kluwer Academic Publishers.
Chomsky, N 1986. Knowledge of language: Its nature, origin, and
        use. New York: Praeger.
Chomsky, N. 1990. On formalization and formal linguistics.
        Natural Language and Linguistic Theory, 8, 143-147.
Chomsky, N. 1991. Linguistics and adjacent fields: A personal
        view. In A. Kasher (ed.) The Chomskyan turn. Cambridge, MA:
        Basil Blackwell.
Denny. J.P. 1979. Semantic analysis of selected Japanese numeral
        classifiers for units. Linguistics, 17, 317-335.
Dorr, B.J. 1991. Principle-based parsing for machine translation.
        In R.C. Berwick, S.P. Abney, and C. Tenny (eds.). Principle-

based parsing: Computation and psycholinguistics. Dordrecht: Kluwer Academic Publishers.

Fong, S. 1991. Computational properties of principle-based grammatical theories. Ph.D. Thesis. MIT Artificial Intelligence Laboratory.

Frazier, L. 1990. Parsing modifiers: Special purpose routines in HSPM ? In D.A. Balota, G.B. Flores d'Arcais, and K. Rayner (eds.), Comprehension processes in reading. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Frazier, L. and J.D. Fodor. 1978. The sausage machine: A new two-stage parsing model. Cognition, 6, 291-325.

Grimshaw, J. 1990. Argument structure. Cambridge, Massachusetts: The MIT Press.

Haig, J.H. 1980. Some observations on quantifier floating in Japanese. Linguistics, 18, 1065-1083.

Johnson, M. 1989. Parsing as deduction: The use of knowledge of language. Journal of Psycholinguistic Research, 18, 105-128.

Kamio, A. 1977. Suuryooshi no shintakkusu: Nihongo no henkei o meguru rongi e no ichishiryoo. Gengo, 6, 83-91.

Katagiri, M. 1991. Review article: Shigeru Miyagawa Structure and case marking in Japanese: Syntax and semantics 22. 1989. San Diego: Academic Press. Studies in Language, 15, 399-414.

Katagiri, M. 1992. Review of Structure and Case Marking in Japanese: Syntax and Semantics 22 (Shigeru MIYAGAWA). Gengo Kenkyu, 101, 146-158.

Marcus, M.P. 1980. A theory of syntactic recognition for natural language. Cambridge, Massachusetts: The MIT Press.

Marcus, M., D. Hindle, and M. Fleck. 1983. D-theory: Talking about talking about trees. Proceedings of the 21st Annual Meeting of the Association for Computational Linguistics, 129-136.

Marr, D. 1982. Vision: A computational investigation into the human representation and processing of visual information. San Francisco: W.H.Freeman and Company.

McRoy, S.W. and G. Hirst. 1990. Race-based parsing and syntactic disambiguation. Cognitive Science, 14, 313-353.

Miyagawa, S. 1988. Predication and numeral quantifier. In W.J. Poser(ed), Papers from the second international workshop on Japanese syntax. Center for the Stduy of Language and Information.

Miyagawa, S. 1989. Structure and case marking in Japanese. Syntax and semantics, Vol.22. San Diego: Academic Press.

Okutsu, K. 1969. Suuryooteki hyoogen no bunpoo. Nihongo Kyooiku, 14, 42-60.

Okutsu, K. 1986. Nitchuu taishou suuryou hyougen. Nihongogaku, 5(8), 70-78.

Otsu, Y. 1988. A lecture on psycholinguistics for a TV program entitled "Exploring the intelligence: An approach from cognitive science" directed by Prof. G. Hatano.

Pritchett, B.L. 1992. Grammatical competence and parsing performance. Chicago: The University of Chicago Press.

Shibatani, M. 1977. Grammatical relations and surface cases. Language, 53, 789-809.

Shibatani, M. 1982. Shakaigengogaku to henkeibunpou. Gengo,

11(10), 24-31.

Shimozaki, M.   1989.   The quantifier float construction in Japanese. <u>Gengo Kenkyu</u>, 95, 176-205.

Sportiche, D.   1988.   A theory of floating quantifiers and its corollaries for constituent structure.   <u>Linguistic Inquiry</u>, 19, 425-449.

Tanenhaus, M.K.   and G.N.   Carlson 1989.   Lexical structure and language comprehension.   In W. Marslen-Wilson (ed.), <u>Lexical representation and process</u>.   Cambridge, Massachusetts: The MIT Press.

Ueda, M.   1990. <u>Japanese phrase structure and parameter setting</u>. University of Massachusetts Ph.D. dissrtation.

Wehri, E.   1988.   Parsing with a GB-grammar.   In U. Reyle and C. Rohrer (eds.), <u>Natural language parsing and linguistic theories</u>. Dordrecht: D.Reidel Publishing Company.