Autonomous Modular Grammar and Prosody in Japanese

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Abstract

One of the toughest problem in analyzing or generating Japanese prosody from a compositional point of view is to deal properly with two kinds of information from two inconsistent syntactic sources. Autonomous Modular Grammar proposed in this paper surmount this difficulty by setting up two independent modules in syntax and relating them by means of constraints called interface.

1. Introduction

Recently, much discussion has been raised on BRACKETING PARADOX, i.e. phenomena in which the constituent structure required by a component of grammar is inconsistent with the grouping manifested by another component [3, 10, 12, 13]. The paper addresses this issue by investigating how to construct from a compositional point of view Japanese prosody which is a result of interplay of information from two mutually mismatching syntactic sources. I propose a framework of grammar, called Autonomous Modular Grammar, equipped with two independent modules in syntax and constraints relating them. It is illustrated that this approach solves the dilemma more concisely and efficiently than the conventional ones.

2. Autonomous Modular Grammar

In Autonomous Modular Grammar, a grammar is made up of subgrammars called MODULES each of which can independently form feature structures. In order for a module to produce feature structures, it need not wait for the output of another module. In this respect it is different from the traditional theories such as Transformational Grammar in which reprepresentations are processed incrementally by being passed along the hierarchically ordered components.

Each module, if let alone, bring about a wide set of feature structures including non-well formed ones. To avoid these, INTERFACE is defined to specify relationships between modules and is used to constrain the output to be compatible with the specifications in other modules.

Typed Unification Grammar [1] and its application to formal syntax, Head-Driven Phrase Structure Grammar [11], are adopted as a framework

for embodying Autonomous Modular Grammar. In Typed Unification Grammar, all linguistic knowledge is represented in a hierarchy of types associated with feature structures. Types are used to infer in an object–oriented way linguistic information according to the type definition in grammar and lexicon. Typed Unification Grammar provides an ideal basis for giving a shape to the idea of Autonomous Modular Grammar, because module, Autonomous Modular Grammar's basic concept, can be represented as an independent object using type.

The proposed view of grammar is similar to Sadock's [12] Autolexical Syntax in assigning bimodular analysis to the cases in question. However, it is essentially different from his theory in its ability to specify modules whenever they are found to be appropriate, instead of recognizing as modules only those levels such as morphology, syntax, and semantics in the conventional hierarchical models of grammar. This allows to separate syntax into multiple independent modules, which are used to good advantage in the following part of this paper. Moreover, Sadock's conception about module is insufficient from a computer linguistic point of view, because his theory based on Generalized Phrase Structure Grammar [5] does not grant a module an independent productive status[1]. In contrary my theory enables production of representations by each module, because it is realized by a type having a property as object in computer science.

3. Prosody in Japanese

Japanese sentential prosody is a result of interplay between various factors such as phonology, morphology, lexicon, and different parts of syntax. Therefore, it serves as a test of how far the task of modularizing and integrating linguistic information has been overcome.

In Japanese, accent emerges as different pitch patterns in certain syntactic domains, called ACCENTUAL PHRASES (APs) in this paper. They have been traditionally classified into two patterns, ACCENTED and UNACCENTED [8]. The accented AP has a sharp fall from high pitch to low. The unaccented AP has no such fall, but has a relatively flat pitch pattern. Since each AP can have only one fall, if any, and the fall is carried by a mora[2], an AP with n morae has at most $n + 1$ (actually, much less) different pitch patterns.

An AP consists of a leftmost LEXICAL WORD, i.e. noun, verbal or adjectival stem, or adverb, plus any number of GRAMMATICAL WORDS, i.e. postpositions, clitic complementizers, or verbal or adjectival conjugational endings. It is known that the right–hand grammatical word plays the role of functor whose argument is the left–hand sequence made up of a lexical word plus any number of grammatical words, and the accentual information for the whole phrase can be obtained by recursive function application.

For example, the noun *mikan* 'mandarin orange' has an accent fall on the first mora when pronounced alone. Throughout this paper, the mora on which the fall is located in an accented AP is indicated in bold face,

like ***mikan***. In contrast, an AP without such a marking is unaccented (e.g. *sakura* 'cherry blossom'). Now, the postposition *nado* 'and so on' is an accent functor which, when combined to an unaccented sequence, forms a phrase with a fall on the postposition's initial mora (e.g. *sakura* ***nado***), while when following an accented string the whole phrase preserves the fall location of the left-hand sequence (e.g. from ***mikan*** and *nado*, ***mikan*** *nado*). On the other hand, there is a group of postpositions, such as the nominative case marker *ga*, that do not alter the accentual property of the left-hand sequence. Thus, if *sakura* ***na****do* 'cherry blossoms, etc.' is followed by *ga*, it results in *sakura* ***na****do ga* 'cherry blossoms, etc. -NOM.' Figure 1 illustrates how the accentual information of a phrase can be obtained by that of its rightmost functor (Fs on the tree nodes in the fifure) and that of the sequence standing on the left of the functor (As in the figure). The accent of an AP with any number of postpositions, auxiliary verbs, and conjugational endings, can be calculated likewise by means of recursive function application.

The lower inverted tree in Figure 2 diagrams how the phrase *aoi ookina meron wa* 'green, big melon-TOPIC' is segmented into accentual phrases. Note that this way of composition, called A-STRUCTURE hereafter, mismatch with the usual one obtained on the basis of meaning, indicated by the upper tree in the figure and called C-STRUCTURE.

A-Structure has been traditionally regarded as the only source of prosodic information. However, as Kubozono [9] has made clear, C-Structure plays an important role in Japanese prosody, too. When two adnominal adjuncts modify a noun, a second adjunct directly modifying the head noun has a higher pitch peak than a second adjunct modified by the first adjunct. Therefore, in the pair of examples (1a-b), *ookina* in sentence (a) has a higher pitch peak than *remon* in (b).

(1) a. [aoi [**ookina** meron]]
green big melon
'a green, big melon'

b. [[aoi **remon**] no nioi]
green lemon GEN smell
'the smell of a green lemon'

The motivation for this difference is clearly to make the semantic unity of the second chunk *ookina meron* in (a) more prominent.

4. Solution

In this way, in order to specify prosodic information in Japanese sentence, information from both A-Structure and C-Structure must be dealt with. Central to this task is the problem of how to integrate concisely and effectively information from these two different syntactic sources. Using the

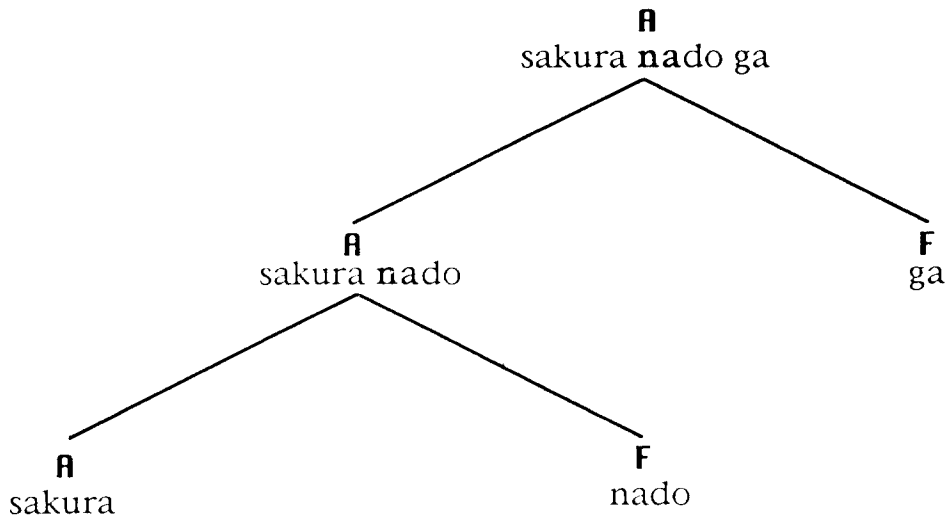

Figure 1: Recursive Accent Formation

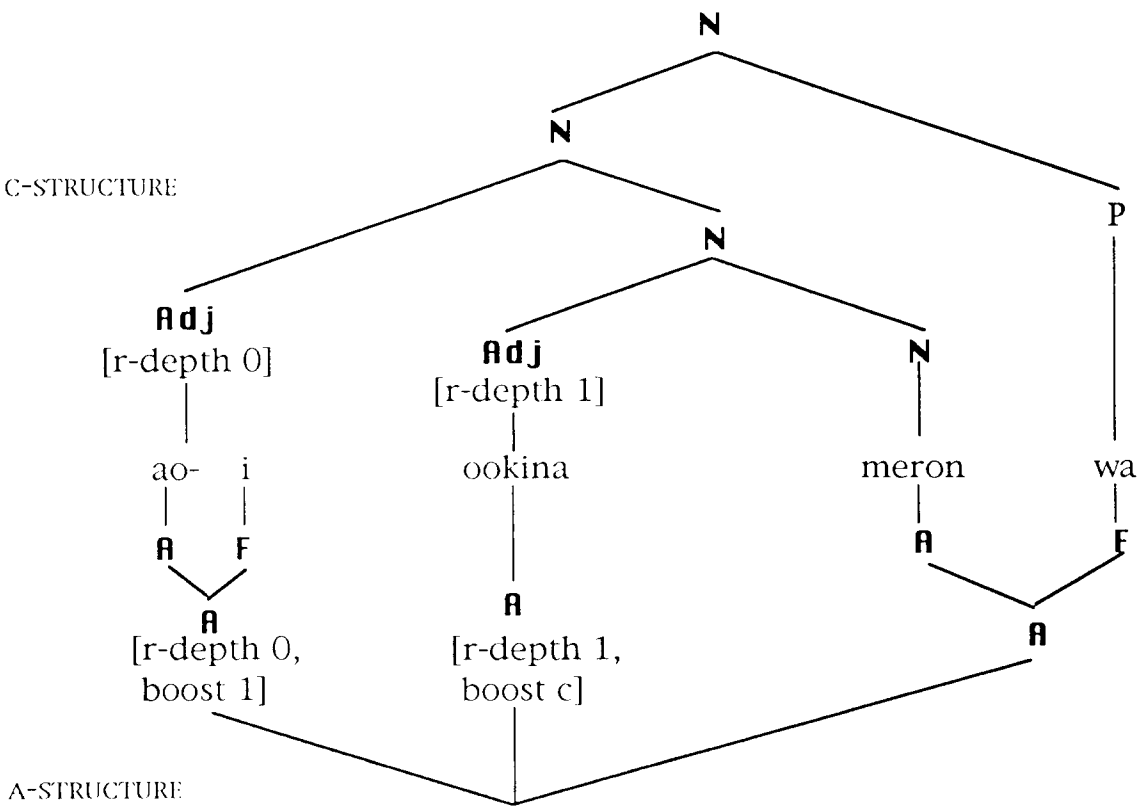

Figure 2: A-Structure and C-Structure for *aoi ookina meron wa*

framework of Autonomous Modular Grammar, A–Structure and C–Structure are defined as independent modules of syntax, whose task is to produce feature structures representing the two syntactic structures. The module (i.e. type specification) for A–Structure builds up a sequence of feature structures representing accentual phrases, equipped with accentual information. The one for C–Structure, besides being used for constructing semantic structure, calculates the location of adjunct words, i.e. adjectives, genitive NPs, etc., in the modification nesting. The RELATIVE-DEPTH value in Figure 2 is computed each time Adjunct Principle concatenates the adjunct to the modified phrase. The RELATIVE-DEPTH value for the first word is 0, as it is always set to be. After the information on RELATIVE-DEPTH value is transmitted to each AP in the A–Structure, it is used to compute fundamental frequency for the AP. Since the second word *ookina* is a daughter of its predecessor *aoi*'s sister, its RELATIVE-DEPTH value is 1. This indicates that the second adjunct *ookina* is by one step DEEPER than the first adjunct. On the basis of the RELATIVE-DEPTH value 0 of the first AP, its BOOST value 1 is obtained by means of the function *get-boost*(x) in type specification (2) below. For the second AP, since its RELATIVE-DEPTH value is 1, its BOOST value is set to c, a constant greater than 1, and as its result the second nominal adjunct *ookina* is boosted.

(2) $$\textit{acc-phrase}\left[\ \right] \Longrightarrow \left[\ \text{PHON}\ \left[\begin{array}{ll}\text{RELATIVE-DEPTH} & \boxed{1}\\ \text{BOOST} & \textit{get-boost}(\boxed{1})\end{array}\right]\right]$$

The question now arises: how is this transmission of the information on RELATIVE-DEPTH from A–Structure to C–Structure possible?

This transmission is carried out by defining INTERFACES, i.e. constraints relating the two modules of syntax.

(3) $$\textit{acc-phrase}\left[\begin{array}{ll}\text{PHON} & \textit{get-acc-phrase}(_{\textit{base}}\left[\ \text{R-DEPTH}\ \boxed{1}\ \right], \textit{g-word}\left[\ \right])\\ \text{R-DEPTH} & \boxed{1}\end{array}\right]$$

Type specification (3) is used to form an AP from the left–hand sequence and the right–most grammatical word. The function

$$\textit{get-acc-phrase}(_{\textit{base}}\left[\ \text{R-DEPTH}\ \boxed{1}\ \right], \textit{g-word}\left[\ \right])$$

performs the task of obtaining the correct phonological structure for the whole AP. Accentual information is computed by this function, too. In type specification (3), it is specified that the RELATIVE–DEPTH value of the whole phrase is the same as that of the BASE, i.e. the left–hand sequence. Since a lexical sign in C–Structure coincides with a base in A–Structure,

their RELATIVE-DEPTH features share the same value. As a result, the RELATIVE-DEPTH values of the lexical sign in C-Structure and the AP in A-Structure are constrained to be the same.

Interface in Autonomous Modular Grammar is in this way a feature constraint that specifies an output of a module by relating it to another module. In general, the task of interface is to make explicit how two modules are mutually related when these modules are not homomorphic to each other.

5. Limits in TG Model

The problem discussed has been known as BRACKETING PARADOX. Its standard solution has been 'head movement' in the GB framework [2, 4] which, for example, moves the genitive particle *no* from the rightmost leaf in the structure for *aoi remon no* 'of a green lemon' in Figure 3 into a place adjacent to the nominal head *remon*, leaving a trace t_i behind.

However, this way of solution is confronted by some serious difficulties. Here I will limit myself to the most crucial one. Japanese has a special compound noun, named S-STRUCTURE COMPOUND by Kageyama [7], which has status as a single lexical item but nevertheless must be regarded as compounded in S-Structure, i.e. at the last stage of syntax because of case selection, honorification, anaphoric reference of its constituent, etc., which are typical of sentence. One of its most remarkable feature is that its constituents preserve the original accents. For example, from *shin**ku**ukoo* 'new airport' and *kensetsu* 'construction,' an S-Structure compound *shin**ku**ukoo-kensetsu* 'new airport construction' is formed. Notice that the latter part of the compound *kensetsu* preserves its own accent pattern, 'unaccented.' This fact raises a dilemma when it is suffixed by a postposition, for example:

(4) shin**kuu**koo- kensetsu **na**do
new airport construction EXEMPLIFICATIVE
'new airport construction, etc.'

In example (4), the accentual unity of *kensetsu **na**do* can be seen in the placement of accentual fall on the fifth mora ***na***, which results from the accentual properties of both the constituents. From a point of view of conventional syntax, *shin**ku**ukoo-kensetsu* and ***nado*** must be treated as two distinct words. From a standpoint of phonology, on the other hand, (4) should be segmented into *shin**ku**ukoo* and *kensetsu **na**do* .

Autonomous Modular Grammar can easily deal with such cases. It assigns to phrase (4) both C-Structure (the upper tree in Figure 4) and A-Structure (the lower tree in the figure). The essence of the solution lies in splitting in A-Structure the compound into two separate APs the latter of which is still followed by the postposition with phonologically clitic status, while in C-Structure the whole compound constitutes one word.

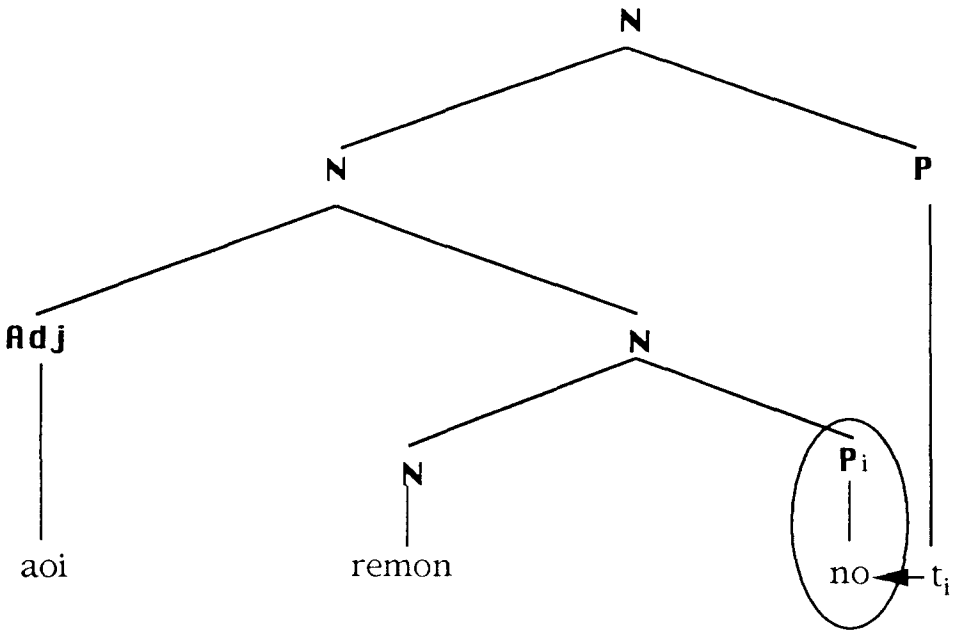

Figure 3: Head Movement of Genitive Particle *no*

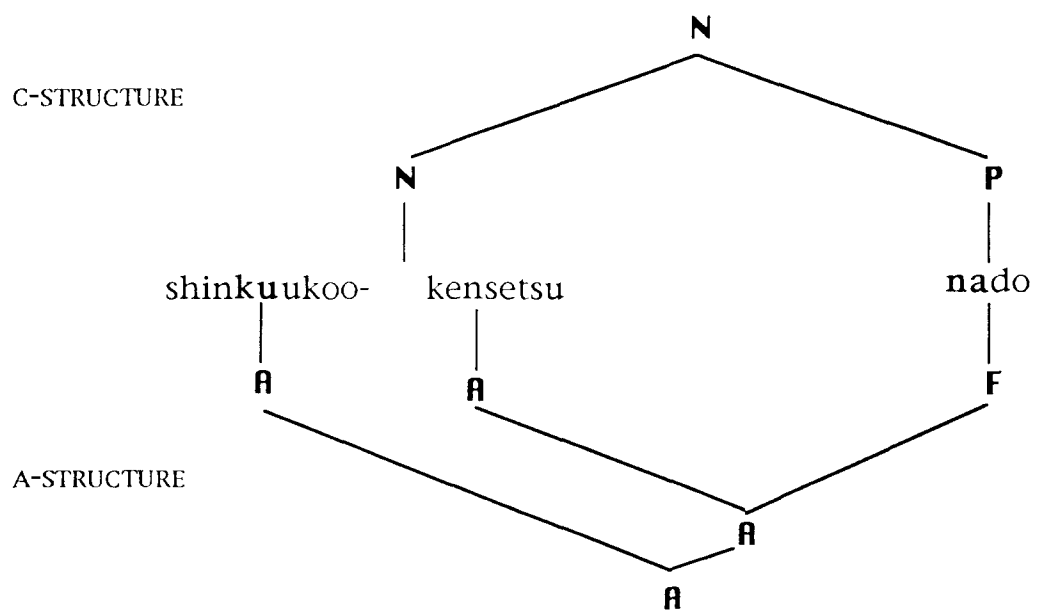

Figure 4: A-Structure and A-Structure for *shinkuukoo-kensetsu nado*

On the other hand, it is impossible for the head movement approach as it is to produce a structure corresponding to the A–Structure above, because *shinkuukoo-kensetsu* 'new airport construction' is a single lexical item, and therefore there is no way just to pick up the latter part of compound and concatenate it with the postposition *nado* to constitute a single AP. It might seem that assigning distinct syntactic positions to the two elements would solve the problem. However, this creates another problem by blurring the boundary between syntax and morphology. As Kageyama [7] has proved, in Japanese a clear-cut distinction must be drawn between these components of grammar, because morphological units can only under very restricted conditions behave like syntactic units in terms of dislocation of inner element, embedding of a verb phrase, and anaphoric reference of its constituent.

The method proposed here is similar to Kageyama's [7] Module Morphology in which he applies Compound Accent Formation Rule both to lexicon and to syntax. However, it is not clear in his theory how he can avoid redundant information in the accent rule application without splitting the rule into two separate parts with similar specifications. Within our framework no redundancy is left, because A–Structure, which constructs accentual information, is modular in the true meaning of the word and it interacts with C–Structure only when necessary through interfaces.

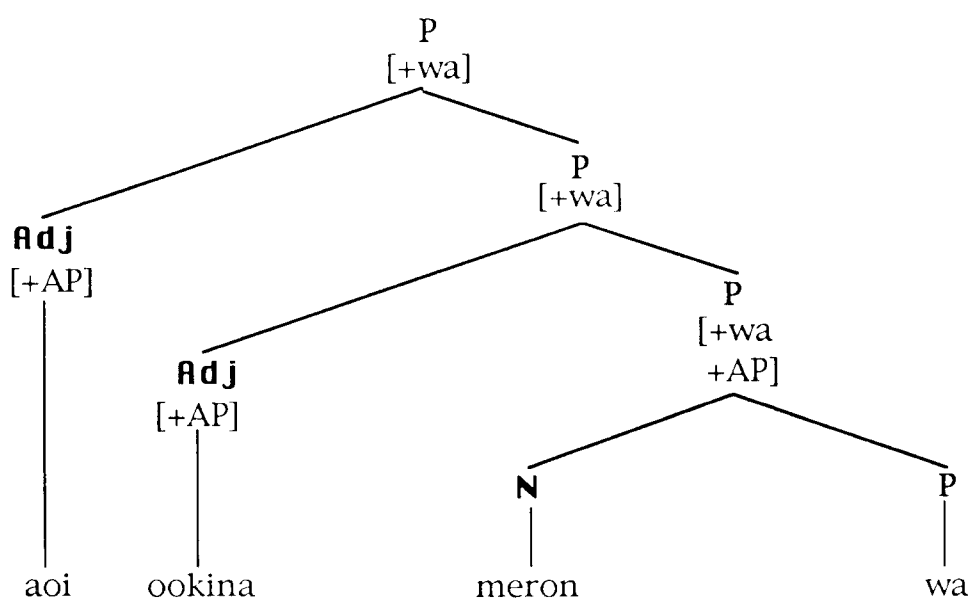

Figure 5: Alternative Structure by Means of HPSG

A word is perhaps due here on another possibility that fits the HPSG machinery. This was in fact proposed to me by Byung-Soo Park at the conference of ACLIC and PACFOCL. It is to concatenate first *meron* and *wa* in *aoi ookina meron wa* 'green, big lemon-TOPIC,' and then succesively combine the adjectives with the postpositional head[3] (see Figure 5). The fact that *wa* topicalizes the whole phrase is indicated by a feature, represented as [+wa] in the figure, which is passed as a Head Feature from the postposition to the whole phrase. The segmentation into APs can be made easier if we in this way keep attention not to concatenate two constituents that do not make the same AP while there existing another constituent that does compose an AP with one of them. Then the whole phrase can be analyzed into APs on the basis of simple lexical and syntactic knowledge, as indicated by feature [+AP] in Figure 5.

However, Japanese sentence structure is too complicated to allow such an analysis. In the following example,

(5) Hilary ga aruku **no** wa
Hilary SUBJ walk COMP TOPIC
that Hilary walks-TOPIC

the complementizer *no* makes from the sentence a nominal phrase, which is in turn suffixed by the topic marker *wa*. If we follow the above analysis, *aruku no wa* must first constitute a PP, because these are pronounced as a single AP, and then be concatenated with the subject NP *Hilary ga*. The information that the verb *aruku* 'walk' subcategorizes for an animate subject but not for an inanimate subject must be somehow passed up to the postpositional phrase *aruku no wa*, since this information helps to screen out anomalous constructions such as

(6) ***Ishi ga** aruku no wa
stone SUBJ walk COMP TOPIC
'that the stone walks-TOPIC'

Of course, it is unusual for a PP to subcategorize for a subject, and never sanctioned by other facts in Japanese syntax.

6. Conclusion

It has been explained that Autonomous Modular Grammar enables to specify independent modules in syntax and composes Japanese prosodic information by the interaction between them. The method covers cases extending beyond the morphology/syntax border for which a truly modular approach is indispensable.

Notes

1 Chomsky's idea about module is in this respect not sufficient, either.

2 Mora is an abstract temporal unit that does not necessarily coincide with the syllable. A long vowel consists of two morae. Geminative consonants, whose first part is called 'sokuon' in traditional grammar, are two independent morae.

3 Here I follow the JPSG framework [6] which regards the postposition as head.

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