

CASE, A DEEPER MATTER

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ABSTRACT

The case markers wa and ga in Japanese are analyzed in a framework similar to Fillmore's case grammar. I argue on both semantic and syntactic grounds that wa- and ga-noun phrases are transformationally derived from conjoined sentences, the markers wa and ga being morpho-phonemic variants of the conjunctions ba 'if' and wa 'but'. It is shown that the relationships expressed by wa and ga cannot be determined by the underlying semantic relationships alone.

1. Fillmore's case theory (1968a, 1968b) was a serious discussion on the much neglected aspects of grammatical case. Chomsky (1969:8-9) rejected Fillmore's arguments on the ground that they are incorporable in the standard theory of generative grammar and that they depend upon the principles of semantic interpretation. Yet there are instances of case relations which are indefinable in terms of the deep structure case categories or the syntactic relations among sentence constituents alone. The present paper is mainly concerned with two case markers in Japanese, wa and ga, and proposes an alternative for conservative descriptions of them. This analysis is based on the assumption that case relations derive from underlying sentential relations and that case forms, if overtly realized as in Japanese, are transformationally created from the conjunctions which primarily define underlying sentential relations.

2. Fillmore's categorical description of cases was based on the various syntactic relations which hold between the predicate verb and the co-occurring noun phrases in the deep structure of a sentence. Categories being fundamentally a positional notion, the semantic contents of the case relations had to be supplied by lexical features of the verbs and nouns. There was no obvious reason why his categories could not be collapsible into lexical features as well, other than the fact that his categories were somehow considered to represent closer relation to the speaker's underlying conceptual framework. Moreover his grammar contains a given case relation to a single occurrence with respect to one verb, and to one or more noun phrases, by virtue of their selectional restrictions in the same sentence.

Take "John weighs 200 pounds," for example. Its semantic meaning is not that he weighs 200 pounds in a literal sense, but that it is "John's

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body which weighs 200 pounds." Yet "John" and "John's body" are not synonymous in the given context, since "John's body" implies his dead body. Even if such semantic details are set aside, and "John's body weighs 200 pounds" is assumed to be the relevant underlying sentence, the two separate case relations between "the body" and "weighs 200 pounds," have to be specified; namely, the possessor-possessed between "John" and "body" and the dative-action, or whatever it may be called, between "the body" and "weighs 200 pounds." A further deep structure analysis may take some sentence such as "body belongs to John" as a base form for "John's body;" then a series of transformations would apply to it prior to the constituent structure assignment to "John weighs 200 pounds" which is relevant to the case relation between "John" and "weighs..." in the Fillmore-type grammar. Then his deep structure cases no longer determine their semantic interpretations.

Subject noun phrases in different cases were also observed by Fillmore as not conjoinable, yet given two different case nouns in appropriate context that restriction seems to diminish, such as

- (1) John and his suitcase weigh 200 pounds

or

- (2) John and the weather are unpredictable

They are semantically and syntactically correct. Any superficial combination of noun phrases, as long as it does not conflict with the speaker's judgment, seems to be permissible. Needless to say, case relations are basically semantic and cannot be defined in terms of essentially IC relations combined with co-occurrence and selectional restrictions alone.

3. The following sentences in Japanese,

- (3) tonari wa onna da "(if it is) the neighbour, it is a woman"

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(4) tonari ga onna da "the neighbour (no one else) is a woman"

are superficially alike in that both assert "is a woman" with respect to the topic matter "neighbour." But there is a subtle difference in the way that "neighbour" figures in each sentence. In (3) the topic "neighbour" is mentioned and identified as an individual of mutual acquaintance among the speakers. In (4) "neighbour" is also identified as a topic matter, but there it implies exclusion of anyone and anything else as a competing topic. In closer analogy, suppose the "neighbour" in front of us is to be differentiated from the "neighbour" living behind us; then the "neighbour" in front is mentioned with case ga to eliminate all others from the scope of reference. For example,

(5) usiro de naku, mae ga onna da

"not the neighbour living behind us, but the one living in front of us,
is a woman"

Should wa-case subject occur in the same context,

*(5.1) usiro denaku mae wa onna da

the sentence will result in anomaly or mere nonsense.

4. These characteristics of wa and ga may be more clearly exhibited in certain discourse situations, like story-telling. For example, in the passage "Once upon a time there was a horse. The horse...", the first instance of "horse" is always designated by ga. In conjunction with what we have observed as a peculiarly distinguishing function of ga, we may explain that the topic matter of a story must initially be identified from any other thing which the audience may have in mind. Therefore, once "the horse" is distinguished and introduced as a specified topic of discussion, it is thereafter predictably referred to by anaphoric wa, beginning with the second occurrence. In real life, however,

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logic often yields to an unpredictable motivation of a speaker, and a non-initial occurrence of "horse" may be ga-distinguished if the speaker chooses to re-specify it as "horse" to the exclusion of anything else in the story in order to stimulate renewed interest among the audience ~~or~~ for some other reason.

5. Distributionally, ga- and wa-specified subjects are restricted to certain sentence types. Wh-subjects in interrogative sentences are always identified by ga.

(6) dare ga kuru ka "who is coming"

Recall that the semantic sense of ga points out some presupposed topic matter to uninitiated conversationalists. Ga in the question sentence is interpretable as "a unique individual who is coming--not anyone else who may come;" indeed, something which is expected to be revealed by a reply cannot possibly be assumed in advance. Therefore the case must be marked by ga.

Likewise, in subordinate sentences the embedded subjects of relative and nominalized sentences, for example, are always associated with ga,

(7) tori ga tobu sora "the sky where the bird flies"

(8) tori ga tobu koto "that the bird flies"

The same explanation applies here. Consider that these embedded subjects must be uniquely distinguished with respect to their antecedent or their nominalizer in a manner as,

(7.1) "the sky where the bird, not anything else, flies"

(8.1) "the fact that the bird, not anything else, flies"

The case wa, therefore, which has no such distinguishing function, cannot occur in these sentence types.

Wa, on the other hand, occurs exclusively in sentences asserting a universal truth,

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(9) hi wa asa noboru

"the sun rises in the morning"

or announcing the occurrence of a not-unexpected event,

(10) x team wa maketa

"x team has lost"

where a sufficient acquaintance with "x team" is presumably shared by the audience and where a subtle knowledge of x team's weaknesses exist, so that "x team" is identified by wa and its failure to win is no surprise.

Suppose we replace these wa with ga, then their interpretations will be quite different.

(9.1) hi ga asa noboru

"the sun (which we know, not any other) rises in the morning"

(10.1) x team ga maketa

"x team (not to be confused with any other) has lost"

In (1.1) it is sensed that the speaker is singling out "the sun" from other things which can rise, such as "the moon," "the stars," "rockets," etc.; thus the "rising of the sun and not the rising of any other thing" is established beyond question.

(10.1), in comparison with (10) can cause general emotion (surprise, shock, disbelief, etc.), as experienced upon learning of a totally unexpected event. The speaker may have in mind some other team which could have lost, but not "x team." Therefore ga-subject in this context may be interpretable as identifying one thing removed from all other things.

6. To sum up our observation of wa- and ga-occurrences so far, wa seems to distinguish a topic matter with reference to awareness of it upon the part of the speakers, while ga seems to distinguish a topic matter from, among, or in contrast with, other competing topics. As difficult as their formalization may appear to be, these semantic characteristics are definable in grammatical terms.

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Compare these sentences.

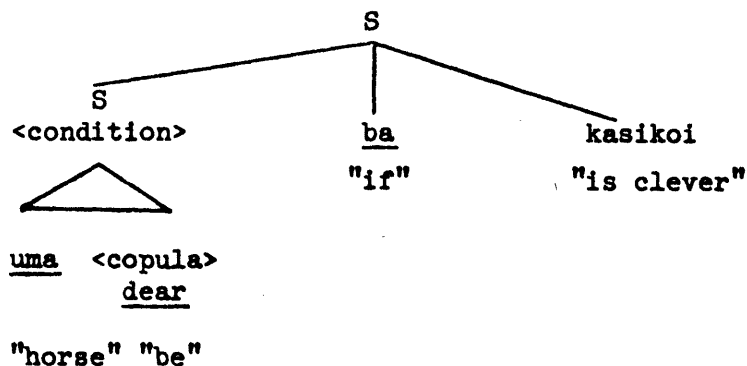
(11) uma nara ba, kasikoi

"if it is a horse it is clever"

(12) uma wa kasikoi

"(if it is) a horse (it) is clever"

The meaning of ba-connected sentence is strikingly similar to the sentence with single occurrence of wa-subject. Moreover the segments ba and wa resemble each other in phonetic shape. Suppose ba and wa share a common syntactic source, then a compound sentence with approximately the following description may be considered to underlie (11) and (12).



Omitting all nonessential details, (11) and (12) are derived through the optional deletions of this structure such as

- i. uma dear ba kasikoi
- ii. uma nara ba kasikoi (11)
- iii. uma \emptyset ba kasikoi
- iv. uma wa kasikoi (12)

Sentence (11) emerges as a consequence of stylistic change in base copula form. When the copula is further deleted at stage iii, by virtue of the conjunction ba "if" being brought next to the segment uma "horse," it is

altered to wa morphophonemically, thereby giving rise to sentence (10).

7. The present postulation of a conditional sentence as the deep structure of wa-subject is not based on a frequently unreliable phenomenon of synonymy alone. The underlying conditional sentence contains as its main verb a copula "be." Not only does this copula's function represent the most neutral of all verbal relations, but the Japanese copula is unique in its co-occurrence with caseless nouns. Observe,

i. uma nara ba 'if it is a horse'

*ii. uma ga nara ba

*iii. uma wa nara ba

It has been said that underlying information as to how something is pinpointed and established as a topic, is essential in order to determine the cases of such topic when it emerges as a grammatical form. A topic is assigned ga if the speaker wishes to single it out, whereas it is assigned wa if he assumes presupposed knowledge of it on the part of other participants in the discourse. Only if something is first pinpointed individually and named can any comprehensible assertion be made about it; otherwise no speaker-topic relation exists, and therefore no case is assignable to anything. The copula-caseless-noun relation postulated in the deep structure of wa-subject seems to recall a primitive stage when some particular thing arose as a sentence subject in a general way.

8. There is also a syntactic basis for postulating copula-ba-conditional sentences as underlying wa-subject formation. Despite the fact that wa-subject is originated from ba-conditional sentences, there are curious non-occurrences of wa-subject from any ba-conditional sentences, such as

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(13) kimi ga ike ba, boku wa ikanai 'if you go, I will not go'

*(13.1) kimi wa ike ba, boku wa ikanai

(14) uma ga tuyokere ba, usi mo tuyoi 'if a horse is strong, so is a cow'

*(14.1) uma wa tuyokere ba, usi mo tuyoi

Ga-case subjects occur consistently in these sentences and, furthermore, their predicate verbs are not copulas. Remember, the copula verb in Japanese is under co-occurrence restriction with a caseless noun. Therefore a given ba-conditional sentence, if it contains a copula, must also contain a caseless noun. According to our analysis, the copula verb in this particular context of ba-conditional sentence is deletable and, as a result, a conjunction ba "if" is structurally brought next to the caseless noun, thereby assigning to the noun what is interpretable as the case wa. Mutual exclusion between wa-case subject and non-copula ba-conditional sentence may be explained as due to the unique association of copula-ba-conditional sentence with wa-subject formation. Interestingly enough, not only can the copula-caseless noun recur in ga-subject formation, but when it does it explains the absence of ga-subject in ga-compound sentences.

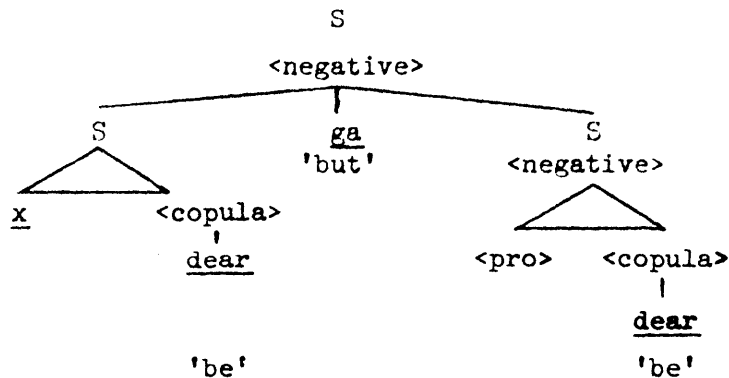
9. A quite similar analysis is applicable to ga-subject formation, since there happens to be the homophonous sentence conjunction ga 'but'. Its meaning, when it occurs as a sentence conjunction such as

(15) are wa ii ga, kore wa warui 'that is good but this is bad'

(16) kare wa konai ga boku wa konai 'he does not come but I will not come'

Based on such meaning relation between a ga-connected compound sentence and a ga-specified subject, we may conjecture that a ga-subject may be derivable from a very specific instance of the former having roughly the following description.

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It consists of two sentences, one of which contains the aforementioned copula-caseless noun relation. The sense of distinguishing the ga-specified topic matter from all else is symbolized by a pro-form¹ dominated by S with the contextual feature <negative>. The latter will give rise to a conjunction ga 'but' through the feature transfer in appropriate position of diagram above. After the pro-form and copula deletions,

i. x dear ga 'is x'

develops. This can be a stylistic variant of ga-subject in Japanese, but by further deleting the copula we obtain a more colloquial form of ga-subject,

ii. uma ga 'horse'

As has been briefly mentioned in section 8, ga-subject never occurs in ga-compound sentences from which the copula verb is absent, such as

(17) kare wa iku ga, boku wa ikanai 'he will go but I will not go'

*(17.1) kare ga iku ga, boku wa ikanai

Now, recall the parallel non-occurrences of wa-subject in ba-conditional sentences. I have explained that this is because of the unique relation of wa-subject and the copula-ba-conditional sentence. We have just seen how ga-case subject develops from a particular ga-compound sentence, i.e. only if it contains a copula as its main verb. Ga-case subject and wa-case subject are thus similar in their derivation and appear to be similarly

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constrained in their distributions with respect to ba- and ga-compound sentences. The copula-caseless noun relation is not only generalized as underlying both wa- and ga-case subjects, but is considered to explain their peculiar distributions² as well.

10. We have explored how the two kinds of subjects arise from underlying sentences. It was assumed that some correspondence must exist between the semantic content of ba- and ga-compound sentences and wa- and ga-subjects, because the conjunctions of ba 'if' and of ga 'but' seem to preserve their meaning when they are realized as case markers. Their syntactic relatedness is subsequently accounted for at no added cost to the grammar, which already has to account for ba-conditional and ga-compound sentences. Furthermore, the purely synchronic analysis of ba and wa, as a basically single form, coincides with the historical hypothesis that they separated during the period of Proto-Japanese.

11. Among various explanations of wa and ga, traditional Japanese grammarians have described them as two types of nominative particles, with added information as to how they might be semantically interpreted. But little attention has been given to their varied surface distributions, such as their occurrences in isolation or in combination, in many varieties of semantic and syntactic contexts. Observe

- (18) uma wa tikara ga tuyoi
'(if it is) a horse, its strength (not anything else) is great'
- (19) uma ga tikara wa tuyoi
'a horse (not anything else), (if it is) its strength is great'
- (20) uma wa tikara ga tuyoku wa aru
'(if it is) a horse, its strength (not anything else)
is in the state of being great'

*(20.1) uma wa tikara ga tuyku ga aru

(21) otooto ga uma ga kowai

'my younger brother (no one else) is afraid of horses
(not anything else)'

(22) otooto ga uma wa kowai

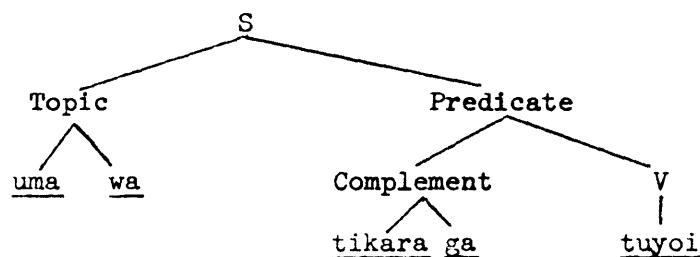
'my younger brother (no one else) is afraid of (if it is) horses'

(23) otooto wa uma wa kowa-garu

'(if it is) my younger brother is afraid of (if it is) horses'

*(23.1) otooto wa uma ga kowa-garu

For even a few examples like these, we may have to explain that (a) wa- and ga-cases occur freely in the subject positions, e.g. (18), (19); (b) wa- and ga-cases occur in the object position, e.g. (21), (22); (c) ga-case cannot occur between the verb stem and the auxiliary verb, e.g. (20); (d) ga-case is under co-occurrence restriction with certain verbs, e.g. (23). More structure-minded grammarians³ such as Mikami (1959, 1963) have tried to go beyond the traditional analysis of cases by postulating a sentence analysis which will accommodate wa- and ga-subjects in a single sentence. According to their scheme, at least a sentence like (18) can be described as



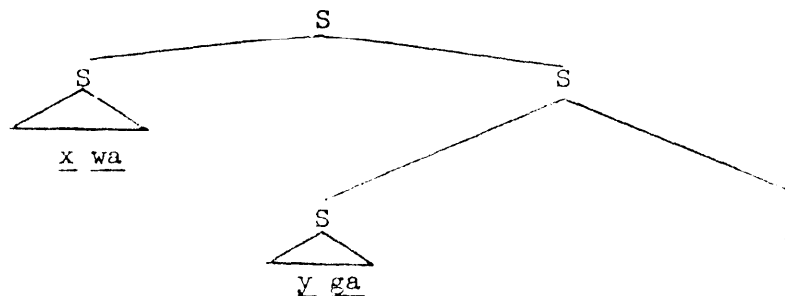
Yet they make no provision for wa- and ga-subject occurrences in other combinations. Since their grammar has no power of permuting any sentence segments, I do not see how sentences like (19) - (23) can be accounted for.

On the other hand, distributionists,³ among them Bloch (Miller 1970) have categorized the different occurrences of wa- and ga-subjects by

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separate labels, making elaborate IA accounts of their surface distributions. In earlier generative grammars⁴ wa- and ga-subjects were either introduced as deep structure constituents or inserted in appropriate positions in surface structure. Undoubtedly these grammarians are able to account for complex occurrences of wa- and ga-subjects, but they do so at what in my opinion is an excessive cost to grammar. Accordingly we must deduce that the semantic interpretation of wa- and ga-subjects is determined by the lexical features attributable to case segments wa and ga. In consideration of the complex nature of wa- and ga-subjects which we have previously discussed, however, it is suspected that their interpretations are due to their inherent lexical contents. Moreover there is no basis for believing that such relational terms as case markers should have independent lexical status, since the meaning of relation is determined by interpretation of its context alone. What seems to be common among these explanations is a preoccupation with the categorical and constituent analysis of cases, while little consideration is given to semantics.

In the present analysis of cases, constituent or categorical consideration is irrelevant, since the positions of wa- or ga-case occurrences are determined by the conjoining and embedding relations among the underlying sentences from which they develop. For example, if the highest structure in a sentence gives rise to wa-case segment it is automatically interpreted as the main subject of a sentence. If ga-segment arises from the sentence structure, embedded one degree deeper, it may also be interpreted as some kind of subject.



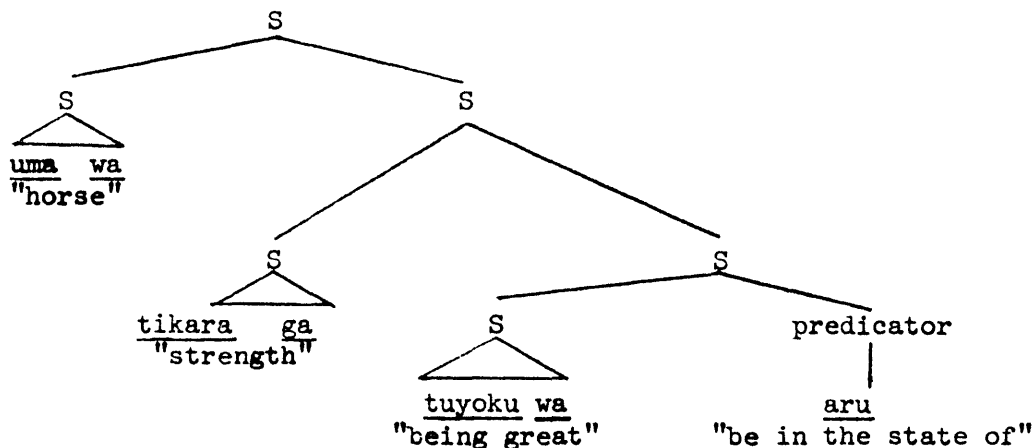
Or if a given predicator happens to be a transitive type verb, its subject, whether wa- or ga-specified, can be superficially called the object.

Wa-occurrence between a verb stem and an auxiliary verb, as in (20), may be analyzed in essentially the same manner.

(20) um wa tikara ga tuyoku wa aru

"(if it is) a horse, its strength (not anything else) is in the state of being great"

The relation between what appears to be the nominalized form of a verb stem tuyoku "being great," and its auxiliary verb aru "to be in the state of," is abstractable as the same relation which holds between wa- or ga-subjects and their predicators. There is no reason why we cannot consider the verb stem tuyoku as a special instance of the subject of an auxiliary verb predicator aru. Then the syntactic relations among the three surface subjects in (20) are



and their relative occurrences seem to depend upon the degree of closeness in their relation to the predicator. In meaning, tikara "strength" is directly related to the verb stem tuyoku "being great," but is indirectly related to the predicator aru "to be in the state of." Therefore it is taken out of the structure which consists of the immediately related terms tuyoku "being great" and aru "to be in the state of," and is assigned the next higher

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position. Uma "horse" is even farther removed in semantic relation from the predicator aru "being in the state of;" therefore it is moved to the highest position in the sentence. According to the newly reassigned syntactic positions in this sentence the three terms may be simply considered as three different instances of subject.

12. The distribution of wa and ga cases seems to be a matter of selectional restrictions between the relevant semantic terms. We have observed that ga-case is restricted in its occurrences with certain verbs, while wa-case seems to appear freely elsewhere. The case ga occurs with either so-called intransitive verbs, such as

(24) hito ga kuru "someone is coming"

or pseudo-verbs,

(25) kare wa uma ga kowai "he is afraid of horses"

(26) kare wa uma ga kirai "he has dislike for horses"

These pseudo-verbs, which have traditionally been classified as adjectives and nominal verbs, can be verbalized through formal changes.

(25.1) kare wa uma wa kowa-garu "he fears horses"

(26.1) kare wa uma wa kirau "he dislikes horses"

In (25.1) the adjective has formed a compound with an auxiliary garu, which may inherently select the wa-case segment. The verb in (26.1), on the other hand, has developed through reclassification of itself as a true verb with the loss of its requirement for ga-case segment. Thus, when these pseudo verbs emerge as true verbs of one kind or another, they become similar to transitive verbs in their common selection of the wa-case segment in the object position.

Any term which will eventually be realized as a surface verb must be

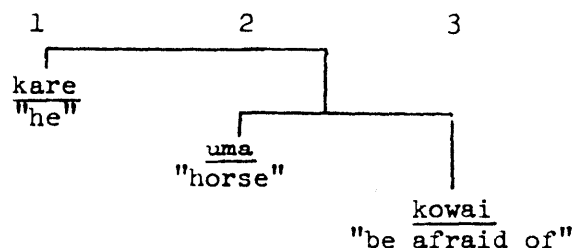
specified by such features as <verb>, <transitive>, <intransitive>, <adjective> and so on. If a given verbal has the feature <transitive>, the term which is semantically its object will develop into a ba-conditional sentence first, from which a wa-case object will arise. If it has the feature <intransitive> or <adjective>, then either a wa- or ga-case subject or object will develop from the ba- or ga-compound sentences through the same processes.

13. Let us take (25) as an illustration for retrieving the case formation processes, step by step.

(25) kare wa uma ga kowai

"(if it is) he is afraid of horses (not anything else)"

I assume that (25) contains two sets of terms: (kare, uma) "he, horse" and (uma, kowai) "horse, be afraid of" which share the term uma "horse." On account of this, these pairs may form a three-term set (kare, uma, kowai) and a new semantic relation may emerge out of their combination. Supposedly these terms at this stage have already been specified for their semantic properties as well as selectional restrictions. Kare or its underlying term may consist of such features as <agentive>, <animate>, <human>; uma as <agentive>, <animate>, <non-human>, <fearless>; kowai as <verb>, <adjective>, <with animate agent> and so on. Based on these features, at least one semantic relation among these terms is interpretable as,

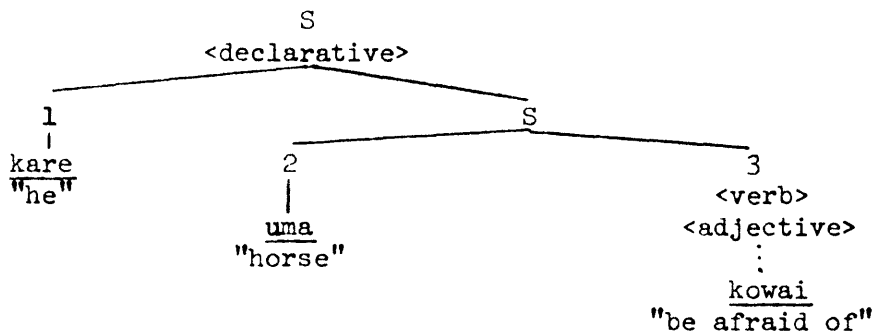


Term 2, 3 are compatible in meaning, but term 1 is related to 3 by virtue

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of the underlying co-occurrence of term 1 with term 2. In some intuitive sense, kare "he," in comparison with uma "horse," is hierarchically pre-dominant over the latter with respect to kowai "be afraid of." The relations among these terms may alternatively be defined by the statements that "he" is an agent of "be afraid of horse" and that "horse" is the patient of "be afraid of." This kind of semantic role assignment has been much discussed recently in terms of deep structure categories (Fillmore 1968a, Landendoen 1970:59-84). Since each term in question is presumed to consist of semantic features, I should consider that a relation between particular terms can be defined with reference to their semantic features alone. In fact, case assignment occurs at this stage as a matter of selectional restrictions. The term uma "horse" is not only assigned a patient role but its surface case realization with ga is determined by the features such as <verb, adjective> inherent to the co-occurring term kowai "be afraid of."

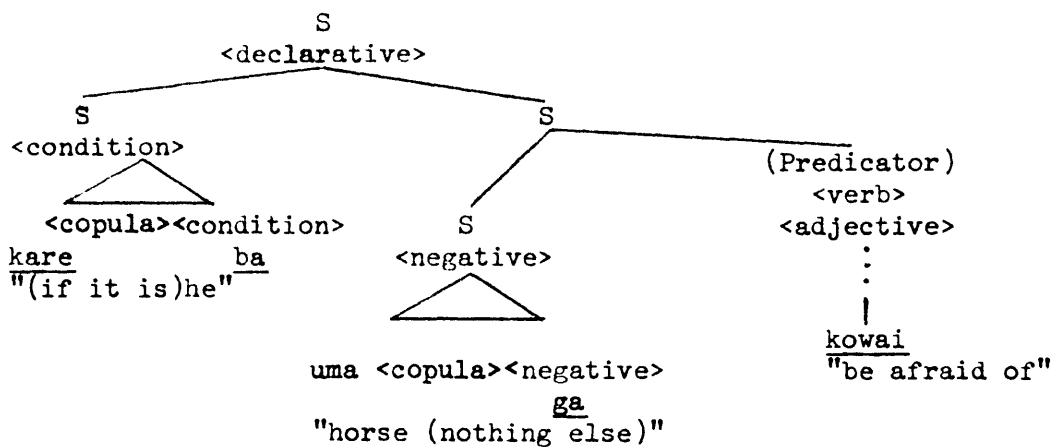
The semantic relation which underlies (25) is subsequently reanalyzed into constituent relations and the terms are assigned to their respective positions in a particular sentence frame.



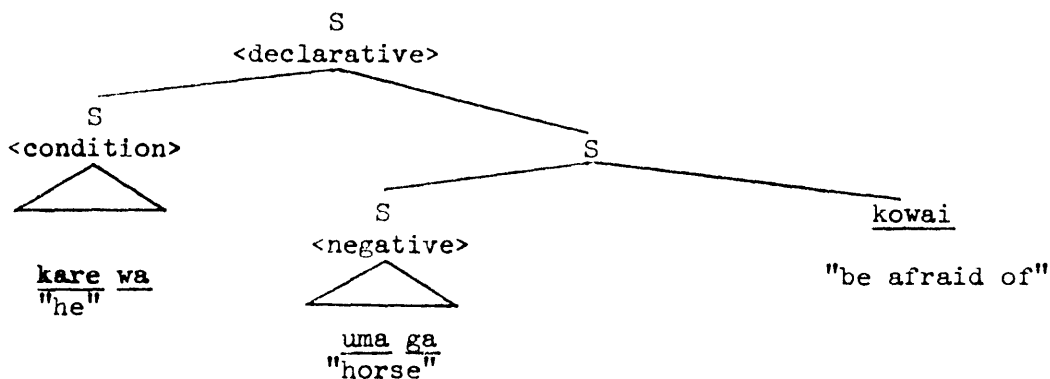
Term 1, due to its remote relation to the term 3, is assigned to the highest position in the sentence; and term 2 is placed in a position lower than term 1 and inside the structure shared with term 3, probably due to the

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because of its co-occurrence with the inherently <adjective> verb kowai "be afraid of" may be subjected to ga-compound sentence expansion, and it will subsequently arise as ga-case object. Term 1 in what may be called the subject position is under no selectional restriction with the verbal term 3, therefore it may be derived from ba-compound sentence. Syntactic development of the sentence (25) from this point onward is roughly as in the following diagram.



After optional deletions and appropriate morphophonemic interpretations, (25) will have approximately the following surfact structure.



Kare wa "he" and uma ga "horse" have been specified in their meanings through various states of their evolution, and are thereby interpretable in every context with which they have been associated with; hence by the time they arise in the surface structure of (25), their semantic meanings and their

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respective relations to a predicator term kowai "be afraid of" are fully specified. In the integrated description of cases with consideration of their semantic and syntactic aspects, the interpretation of any case occurrence should be determined by its derivation alone.

14. Fillmore's contention was that the deep structure is stated in terms of semantic role relationships and the given nominative expressions are transformationally brought into the surface case relations (1968a, 1968b). Although being in general agreement with Fillmore, I have shown that the case relations expressed by wa and ga cannot be determined by the underlying semantic relationships alone. The meaning of the case relations as specified by wa and ga appear to be much richer than what can be interpreted by the lexical features and selectional restrictions inherent to the relevant terms, and furthermore, the occurrences of wa and ga do not seem to be positionally constrained in accordance with the constituent relationships in a given sentence. Therefore, I suspect that wa and ga may not arise entirely from the deep semantic structure.

On the basis of some similarity between the inter-constituent and inter-sentence relations which are respectively defined by various cases and conjunctions, I have considered that the cases wa and ga are created transformationally from their cognate conjunctions. I have illustrated a simple mechanism by which the given nominal terms are first assigned to their sentence positions and, depending on their selectional restrictions with respect to their predicator terms, they are subsequently developed as either ba- or ga-compound sentences. As a result of deletions, the compound sentences are eventually reduced to the appropriate forms in which the conjunctions ba "if" and ga "but" are reinterpreted as the case markers wa and ga.

N O T E S

1. The range of topics which ga-subject may exclude is not necessarily restricted to what may be represented by pro-form,

(i) uma de naku, usi ga sinda 'not a horse but a cow died'

(ii) kare denaku, boku ga kita 'not he but I came'

where the thing in contrast with ga-subject is explicitly referred to. By simply substituting a full lexical item for the pro-form, any variety of ga-subject sentences can be developed, using basically the same set of grammar rules. For example, i, below, is formed through the following states,

(i.1) uma dear ga usi denaku sinda '(if it is) the horse, not the cow, which died'

(i.2) uma \emptyset ga usi denaku sinda By optional copula deletion

(i.3) usi denaku uma ga sinda By stylistic permutation

2. Kuno (1970, 1971) has observed that wa-subjects have both "thematic" and "contrastive" interpretations. It seems to me that the latter interpretation is due to the underlying wa-subject occurrence in ga-compound sentence which excludes ga-subject for the reason explained here. "Contrastive" interpretation of wa-subject should rather be attributed to the contextual meaning of ga-compound sentence in which wa-subject occurs.

3. I have classified "certain grammarians," generally, according to what seems to me to be characteristic of their descriptions. Individual grammarians have in varying degrees considered structural, distributional, and semantic aspects of wa and ga, but it is precisely this difference in degree which is the basis for my own classification. By "distributionists," I have grouped together so-called "Kokugogaku"-school grammarians and "Neo-Bloomfieldian" descriptivists (among them Bloch and his students) in the widest sense of that term. "Structuralists" include non-"Kokugogaku"-school linguists such

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as Mikami, and those who seem to share similar views with him on wa and ga.

4. Japanese grammars in TG framework have mainly consisted of unpublished doctoral dissertations, none of which, to my knowledge, have studied wa and ga in any substantial scope. However, Kuroda's (1969) recent article, "Remarks on the Notion of Subject with Reference to Words like Also, Even, or Only," can by no means be grouped together with the "earlier generative grammars." A discussion based on his analysis of wa and ga may develop into an independent work, therefore, it is not referred to specifically in this paper.

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