SENTENCE PROCESSING LIMITATIONS IN JAPANESE APHASICS

Tadao Miyamoto and Joseph F. Kess

Department of Linguistics
University of Victoria

1.0. INTRODUCTION

The recent history of aphasiology in Japan has produced an enormous range of both psychological and neurological literature on aphasia (Kawahata et al., 1987; Kawamura, 1990; Sakuma et al., 1989; Tanaka et al., 1987; see also Kess and Miyamoto, in press). Much of this research has focussed on the word as a basic unit, particularly the written word (Besner and Hildebrandt, 1987; Hatta, 1985; Tamaoka et al, 1992). This tendency can be partially attributed to the historical preoccupation of psychology with the word as an accessible unit of measurement in language structure. But in Japanese research it is largely due to the unique relationships between the several orthographical types that Japanese employs, namely, phonographic symbols called *kana* and ideographic symbols called *kanji*, and the generally accepted belief that they involve somewhat different processing mechanisms (Yokayama, 1991).

However, there has been some evidence of a new research trend in which the primary interest is in sentence processing and sentence comprehension (Hagiwara, 1986; 1989; 1990a,b,c; 1991; Hagiwara and Caplan, 1990; Otsu, 1989). This new focus is sufficiently innovative and potentially productive enough to have captured the interest of the discipline of Japanese aphasiology. A common assumption in this new research paradigm is that aphasic syntax differs from that of normal subjects in that aphasics have lost the notion of syntactic hierarchicality. The corollary of this loss of syntactic hierarchicality is that aphasics must depend on some kind of compensatory strategy, one based on linear cues.

This paper questions whether aphasic sentence processing can be characterized as simply having suffered a loss of syntactic hierarchicality. In reviewing previous work, we note that aphasics do seem to maintain certain aspects of syntactic hierarchy and that their limitations in sentence comprehension may just as easily be explained by a limited storage buffer in processing memory. Influenced by recent work on the directionality of syntactic branching (Hawkins, 1990; Dryer, 1992), we attempt to reinterpret recent claims in Japanese explorations in Linguistic Aphasiology, specifically, Hagiwara 1986 (see also Hagiwara, 1989, 1990a, b, c, 1991; Hagiwara and Caplan, 1990) and offer a different explanation for sentence processing limitations in Japanese aphasics.

2.0. APHASIC PROCESSING OF SIMPLE SENTENCES

Hagiwara (1986) focuses on word-order and structural Case asymmetry between nominative and accusative as well as the interplay between lexical vs. syntactic case. First, it is postulated that sentences in the canonical word order of a language are the easiest to process for all speakers of that language, including aphasics (Hagiwara, 1986:45). Thus, the **N-N-V** word order would be easier for Japanese aphasics than the **N-V-N** word order.

Secondly, it is also postulated that case-markers which have a case-assigning function will be utilized by aphasics in interpreting sentences [Hagiwara, 1986:52]. Given Saito's (1985) argument that unlike in English, in which nominative Case is assigned by INF, a functional category, in Japanese, the structural (abstract) nominative Case is assigned by morphological (non-abstract) nominative case itself, Hagiwara speculates that the Case-assigning property of nominative case is more salient than that of accusative case, whose structural abstract Case is assigned by a verb. Thus, for example, aphasics may be more sensitive to nominative Case than to accusative Case, so that, for example, they will dismiss sentences without the nominative Case as ungrammatical, while accepting those without accusative Case as grammatical.

A third assumption concerns the role of lexical vs. syntactic information in case-assignment. It is expected that the distinction between lexically determined case-markers and syntactically determined case-markers will be reflected in aphasics' performance on grammaticality judgments (Hagiwara, 1986:57). The expectation is that because aphasics tend to preserve lexical information over syntactic information, Japanese aphasics will process lexically-determined case better than syntactically-determined case.

Hagiwara (1986) reports a series of experiments with simple sentences designed to test these three assumptions. 30 Aphasics performed two tasks, a grammatical judgment task and an object manipulation task, using two toy animals which correspond to two nouns phrases of specific thematic roles.

The results from the Japanese aphasics showed no difference in ease of processing for canonical and non-canonical word orders. The Japanese aphasics processed both orders of **N-N-V** and **N-V-N** equally well, a finding also reported by Fujita (1977). The one exception to this finding was that the aphasics had difficulty processing a **N-V-N** which was produced when the object was right-dislocated to produce a word order of **N-V-N (Object)**.

1. *kuma-ga zoo-o oshita.* 'The bear pushed the elephant.'

2. *Kuma-ga oshita zoo-o.* (Right-dislocation)

Secondly, the results for the Case-asymmetry between nominative vs. accusative demonstrated that the aphasics were sensitive to the absence of nominative Case, judging sentences without nominative Case as ungrammatical and those without accusative Case as grammatical.

1. Nominative **ga** is missing:
   **Kooen de wa kodomo-tachi-( ) gomihiroi-o shiteimasu.*
   'In the park children are picking up litter.'

2. Accusative **o** is missing:
   Ekiin-ga kippu-( ) kitte-imasu. 'A member of the station staff is punching a ticket.'

Thirdly, the experimental results indicated that aphasics retained the capability to correctly make lexical case-assignments. But their abilities in syntactic case-assignment were said to be severely damaged. For example, in causatives and in the usage of emphatic particles, they commonly made mistakes.

1. Causative:
*Watashi-wa haguruma-o/*ni kaiatensasemashita.* 'I made a gear turn.'

2. Emphatic Particle:
*Katosan-wa yasai-*o-dake tabemashita.* 'As for Mr. Kato, he ate only vegetables.'

These experimental findings are given the following interpretation (Hagiwara, 1986, 1990). Firstly, concerning word-order, aphasics are portrayed as losing their sense of syntactic hierarchicality, and in order to compensate, they rely on the linear strategy of thematic role assignment. Thus, Japanese aphasics should assign the thematic array of **[Agent-Theme]** whenever they encounter the word order of **N-N-V**. Whenever they encounter the word order of **N-V-N**, however, they mistakenly assign the word order of **[Theme-Agent]**. Because of this strategy in thematic role assignment, the aphasics make massive mistakes with sentences containing a **N-V-N(Object)** word order. Instead of the correct assignment of **[Agent-Theme]**, the aphasics wrongly assigned **[Theme-Agent]** to sentences containing a **N-V-N(Object)** sequence.[1]

Secondly, concerning the structural Case-asymmetry, the experimental results do demonstrate that a knowledge of Case-theory was maintained by the aphasics, in that they retained the asymmetry between nominative and accusative Case. Thirdly, concerning the lexical and syntactic case difference, Hagiwara reports that lexically-determined case was retained while syntactically-determined case was damaged.

3.0. APHASIC PROCESSING OF COMPLEX SENTENCES

Hagiwara (1986) reports on an aphasics' comprehension of complex sentences. Ten subjects (two mildly damaged and eight severely damaged patients) participated in an experiment which tested comprehension by object manipulation in response to sentences constructed by mixing clefting, passivization, and relativization. The following is a few of the examples, including the basic simple sentence.

1. Simple Active:
kuma-ga zoo-o oshita. 'The bear pushed the elephant.'

2. Pseudo-cleft Object Relative:
kuma-ga oshita zoo-ga tsukamaetano-wa usagi-da.
'The one that the elephant that the bear pushed caught was the rabbit.'

3. Pseudo-cleft Subject Relative:
Kuma-ga oshita zoo-o tsukamaetano-wa usagi-da.
'The one that caught the elephant that the bear pushed was the rabbit.'[2]

Each of the resulting complex sentences has four NP slots, as exemplified by the formulaic sequence below.

1. *Kuma ga kirin o oshita usagi o nadeta.*
'The bear patted the rabbit that pushed the giraffe.'
Agent Theme V1 Agent Theme V2[3]

Comprehension was measured by whether the aphasics assigned the proper thematic roles to these four NP slots. The results of this experiment may be summarized in a hierarchy of processing difficulty for these complex sentences, as shown in (I) below (Hagiwara, 1986:97).

(I) **Simple Sentences > Cleft > Passives > Conjoined > Relatives**

The sentence types and Mean are listed in the following table. (Hagiwara, 1986: Table 5.7: 97)

1. Simple Active (9.7)
2. Pseudo-cleft Subject (8.5)
3. Psuedo-cleft Object (7.8)
4. Psuedo-cleft Agent Passive (7.3)
5. Simple Passive (7.3)
6. Active Non-canonical (7.2)
7. Psuedo-cleft Subject Passive (7.2)
8. Passive Non-canonical (7.1)
9. Conjoined (6.5)
10. Subject-Object Relative (6.3)
11. Psuedo-cleft Object Relative (5.2)
12. Subject-Subject Relative (4.9)
13. Pseudo-cleft Subject Relative (4.3)
14. Object-Object Relative (2.8)
15. Object-Subject Relative (2.5)

As Hagiwara points out, a significant fact concerning the above result is that embedding per se does not cause difficulty. This fact can, for example, be demonstrated by comparing a (non-embedded) conjoined sentence with an (embedded) subject-object relative clause sentence.

1. Conjoined Sentence:
   Kuma ga zoo o oshite usagi o tsukamaeta.
   'The bear pushed the elephant and caught the rabbit.'

2. Subject-Object Relative Clause-Embedded Sentence:
   Kuma ga oshita zoo ga usagi o tsukameta.
   'The elephant that the bear pushed caught the rabbit.'

As seen in the Table 5.7, between these two types of sentences, there is no significant difference in processing difficulty. Another significant fact, which is related to embedding, is that the sentences which were most poorly-performed by the aphasics were those of Object-Object (OO) and Object-Subject (OS) relative clause sentences; especially, the latter was the most difficult sentence type for them:

1. **(OO)**: *Kuma ga zoo ga oshita usagi o tsukamaeta.*
   'The bear caught the rabbit that the elephant pushed.'

2. **(OS)**: *Kuma ga zoo o oshita usagi o tsukameta.*
   'The bear caught the rabbit that pushed the elephant.'

An interesting fact we should make a note of is that these OO and OS sentences are center-embedded, a branching type which is most difficult to process for any subjects in any type of language, let alone for Hagiwara's subjects.

The same explanation that was given for aphasics' comprehension of simple sentences is given for these results, namely, that thematic role is assigned in a linear fashion. Such **OO** and **OS** relative clause sentences are difficult because the aphasics assigned thematic roles "locally". This local assignment was, however, not compatible with the intended parsing of these sentences, because the sentence-initial NP belongs to a matrix clause, and the two following NP's belong to the embedded clause. This incompatibility between actual sentence structure and the strategy of local thematic role assignment is held out as the reason why there was such a high error rate. Hagiwara explains that "in interpreting OO and OS relatives, patients tend to base their interpretation on the linear sequence of lexical categories, not taking the hierarchical organization of syntactic structure into consideration (1986:101)," and further, that this is because "the use of linear interpretive strategies for sentence comprehension is a language-universal characteristic of aphasics (1986:101)."

There is, however, one inconsistency found in Hagiwara's interpretation of her findings. That is, Hagiwara claims that in comprehending complex sentences, the aphasics abandoned their compensatory strategy based on Case-theory, which was an important heuristic in their processing of simple sentences (Hagiwara, 1986: 103-104). This claim was made to account mostly for the aphasics' processing of the OO and OS relative clause sentences, both of which has the *ga*-marked NP at the sentence onset:

OO relative: [NP-ga ...

OS relative: [NP-ga ...[4]

According to Hagiwara, in both types of sentences, the nominative case-marker **ga** should have been used by the aphasics to correctly assign 'agent' to the sentence initial NP. However, there was a mixed result; the aphasics chose either 'agent' or 'theme'. To account for this mixed result, Hagiwara simply explains that aphasics discard the Case-based strategy when they process complex sentences.

4.0. A PROCESSING EXPLANATION BASED ON LIMITATIONS OF MEMORY BUFFER

We prefer to offer a processing explanation which is based on the limitations of the storage buffer in aphasics' working memory. This explanation resolves the discrepancy between the results for simple and complex sentences, AND allows us to reconcile the fact that Hagiwara's (1986) subjects manifested the same kinds of processing difficulty in dealing with different sentence types as normal subjects do. That is, simple sentences were easiest, while relative clause sentences, especially those involving center-embedding, were the most difficult to process.

Looking closely at the sentence structures involved, it is clear that when the word span required to recognize any local syntactic tree exceeds two words, the results reported for aphasics' sentence-processing deteriorates in direct proportion to the span. This fact squares nicely with observations by Hawkins (1990) that suggests human parsers construct a mother node as soon as possible, and that they begin attaching immediate constituents to that mother node as soon as possible. This principle of **Early Immediate Constituents** postulates that human parsers prefer to maximize the left-to-right Immediate Constituent-to-Word ratios of the phrasal nodes. Very simply, parsing is easier if a parser can see all the sister nodes of a mother in the smallest number of words. Such a principle would predict the difficulty which parsers have with constructions which are center-embedded, as well as our inability to deal with syntactic relationships laid out in a mirror-image branching direction. For example, the processing ramifications of this notion of Early Immediate Constituents (EIC) can be seen in (1) through (4) below (see Hawkins, 1990; Dryer, 1992).

1. A[B C[D E[ ]]]

2. A [C[E[ ] D] B]

3. A [B C[E[] D]

4. A [C[D E[]] B]

In (1) and (2), the recognition of the IC's of A is equally prompt. In both cases, the parser requires only two words to recognize A. That is, in (1), the parser has recognized all the IC's of A by the time that D is encountered; In (2), because a parser does not recognize the first IC of A (which is C) until D is encountered, the number of words it took to recognize all the IC's of A is still just two words. In contrast, in (3) and (4), more than two words are required for the recognition of all the IC's of A. That is, in (3), the second IC of A (which is again C) cannot be recognized until the parser encounters D. The situation is similar in (4), in that a parser cannot recognize the IC's of A until B is encountered. As a result, the processing of the mixed-branching structures in (3) and (4) is harder than the uni-directional structures in (1) and (2).

If we now apply this notion of Early Immediate Constituents to Hagiwara's (1986) experimental results on complex sentences, the results become transparent. The sentences were divided into three groups according to level of difficulty experienced by the aphasic subjects.

1. Easy sentence to process: Simple Active

2. Relatively difficult sentences to process: Pseudo-cleft Subject, Pseudo-cleft Object, Pseudo-cleft Agent Passive Simple Passive, Active Non-canonical, Pseudo-cleft Subject Passive, Passive Non-canonical, Conjoined, Subject-Object Relative, Pseudo-cleft Object, Subject-Subject Relative, and Pseudo-cleft Subject Relative

3. Very difficult sentences to process: Object-Object Relative, Object-Subject Relative

These sentence types can also be divided, however, according to the word span required to recognize and construct their mother nodes. Interestingly, the groupings which emerge are exactly the same as the groupings listed above. Thus, the sentence in category (1) requires no more than two words to recognize its mother nodes. For sentences in category (2), the parser requires at least three words to recognize their mother nodes. And in the case of category (3), the most difficult sentence types, more than four words are required to recognize a mother node.

The clearest case is the simple sentence in category (1).

1. *Kuma ga zoo o oshita*, 'The bear pushed the elephant.'

In this sentence, the parser has an optimum IC-to-mother node ratio (see Hawkins, 1990:236); only two words are necessary in order to recognize its mother nodes. Once the sentence initial NP, [*kuma-ga* 'bear-NOM'] is given, the parser requires only the object NP, [*zoo-o* 'elephant-ACC'] to construct the VP node. Since this is the other IC of the mother node S, this allows the parser to immediately construct the mother node S. Very simply, the sequence of the two words [*kuma-ga zoo-o*] allows the parser to construct the matrix S. Thus, for the recognition of either of the mother nodes, the parser's buffer need not contain more than two words, causing little difficulty in processing. And indeed, this parsing task caused little difficulty for the aphasics.

Next, if we consider the sentences in category (2), there is at least one mother node which requires a three-word span for its recognition. An example of this three-word span is seen in the Subject-Object Relative Clause sentence below.

1. *Kuma ga osita zoo ga usagi o tukamaeta.*
'The elephant that the bear pushed caught the rabbit.'

As we process this sentence from left to right, the two sentence-initial words, [*kuma-ga osita* 'bear-NOM pushed'], does not allow the parser to construct the first mother node of lower S. This is because the object NP, [*zoo-ga* 'elephant-NOM'], which is required to construct the other IC of the lower S (namely, the lower VP) is not available yet. It is only after we encounter [*zoo-ga* 'elephant-NOM'], the raised NP, that the parser can construct the object NP node of the relative clause. And it establishes this object NP node in the relative clause by postulating an Empty Category (EC), as in [*kuma-ga EC-o osita zoo-ga*]. This then allows the parser to construct the lower VP, which in turn allows the parser to construct the lower S. This lower S can only be constructed by the parser after reviewing three words [*kuma-ga osita zoo-ga*].

If we now look at the sentences in category (3), we note that they are either center-embedded sentences or sentences whose initial NP belongs to a matrix clause while following NP's are arguments of an embedded clause. Consider, for example, the Object-Subject Relative Clause Sentence below.

1. *Kuma-ga zoo-o osita usagi-o tukamaeta.*
'The bear caught the rabbit that pushed the elephant.'

In order to construct the mother node of the sentence-initial NP which belongs to the matrix S, the parser must encounter the second IC, that is, the VP which belongs to the matrix S. However, this VP cannot be established until the parser finds [*usagi-o* 'rabbit-ACC']. It is only after encountering this NP which, as the head of the object relative clause, allows the parser to construct the matrix object NP; and this in turn allows the parser to construct the upper VP. Consequently, in order to construct the matrix S node, the parser's buffer must retain four lexical words, namely, [*kuma-ga zoo-o osita usagi-o* 'bear-NOM elephant-ACC push rabbit-ACC']. It was this sentence that was so difficult for aphasics to process; their comprehension of the sentence was no better than chance.

5.0. CONCLUSION

In sum, it might not be a lacking sense of syntactic hierarchicality which is the sole cause of processing failure in aphasics. The source of processing difficulty might lie in the limited span of the buffer they bring to processing memory.

Such an explanation is also compatible with the nominative/accusative asymmetry. Non-canonical case-marking was apparently retained by the aphasics, and this retention of case asymmetry further implies that they are sensitive to the notion of external and internal argument, as well as to the mapping of these arguments into appropriate syntactic configurations. Because the nominative/accusative asymmetry requires an configurational asymmetry, we need not assume that the aphasics have lost a sense of syntactic hierarchicality. We might as easily say that the aphasics' grammar has been impaired in the the limited buffer that is brought to bear in processing memory.

NOTES

1 These findings also seem to establish the VP-constituent as the important processing unit for the Japanese aphasics (and probably for normal subjects as well).

2 Hagiwara does not provide the aphasic types of these patients.

3 These slots are filled in sequence by 'rabbit', 'giraffe', 'bear', and 'rabbit'.

4 The full sentences are listed in the Appendix.

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APPENDIX

1. Simple Sentence:
   Kuma-ga zoo-o oshita, 'The bear pushed the elephant.'

2. Pseudo-cleft Subject:
   Kuma-o osita-no-wa zoo-da, 'What pushed the bear was the elephant.'

3. Psuedo-cleft Object:
   Kuma-ga osita-no-wa zoo-da, 'What the bear pushed was the elephant.'

4. Psuedo-cleft Agent Passive:
   Kuma-ga osareta-no-wa zoo-ni-da,
   'What the bear was pushed by was the elephant.'

5. Simple Passive:
   Kuma-ga zoo-ni osareta, 'The bear was pushed by the elephant.'

6. Active Non-canonical:
   Kuma-o zoo-ga osita, 'The elephant pushed the bear.'

7. Psuedo-cleft Subject Passive:
   Kuma-ni osareta-no-wa zoo-da, 'What was pushed by the bear was the elephant.'

8. Passive Non-canonical:
   Kuma-ni zoo-ga osareta, 'The elephant was pushed by the bear.'

9. Conjoined:
   Kuma-ga zoo-o osite, usagi-o tukamaeta,
   'The bear pushed the elephant and caught the rabbit.'

10. Subject-Object Relative:
    Kuma-ga osita zoo-ga usagi-o tukamaeta,

'The elephant that the bear pushed caught the rabbit.'

11. Psuedo-cleft Object Relative:
Kuma-ga osita zoo-ga tukamaeta-no-wa usagi-da,
'The one that the elephant that the bear pushed caught was the rabbit.'

12. Subject-Subject Relative:
Kuma-o osita zoo-ga usagi-o tukameta,
'The elephant that pushed the bear caught the rabbit.'

13. Pseudo-cleft Subject Relative:
Kuma-ga osita zoo-o tukamaeta-no-wa usagi-da,
'The one that caught the elephant that the bear pushed was the rabbit.'

14. Object-Object Relative:
Kuma-ga zoo-ga osita usagi-o tukamaeta,
'The bear caught the rabbit that the elephant pushed.'

15. Object-Subject Relative:
Kuma-ga zoo-o osita usagi-o tukamaeta,
'The bear caught the rabbit that pushed the elephant.'