Strategies for Parsing Syntactically Ambiguous Sentences by Japanese Learners of English

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In this paper the question of how advanced learners of English process syntactically ambiguous sentences is investigated. First, some recent L1 studies investigating human sentence processing were reviewed. Then, the results of two experiments which explored how Japanese learners of English process sentences were reported. The subjects were presented with syntactically ambiguous English sentences segmented into some parts on the computer screen. For Experiment I, sentences containing transitive verbs and intransitive verbs were presented. For Experiment II, sentences containing verbs which were predominantly used in direct-object versus clausal complement constructions were presented. The reading time for each segmentation was measured. The predictions made were (1) subjects process the sentences in a structure-based way (e.g. Minimal Attachment, Frazier & Rayner, 1982) or (2) they alternatively process the sentences based on lexical information. The results showed that the subjects' syntactic process was influenced by lexical information gained from the verb presented in the sentences (e.g. transitivity and post verbal structures), and that this information was utilized in on-line processing.

1. Introduction

How do foreign language learners of English process sentences? In the classroom it is often observed that Japanese learners of English cannot comprehend sentences because they cannot syntactically process, or parse, them. Instead, they simply put (or interpret) the meaning of words regardless of the syntactic structures of the sentences. One of the reasons they cannot process the sentences is that they have not succeeded in acquiring the lexical information which is retrieved from verbs. Lexical information, here, means information about which particular syntactic construction a verb can take. Thus, it is possible to postulate that L2 learners who have stored the information and can apply it to the on-line processing of sentences may have good levels of proficiency.
If this turns out to be correct, therefore, good evidence for the validity of grammar teaching and learning will be obtained. So, the primary aim of this study is to investigate empirically the mechanism of the on-line sentence processing by Japanese learners of English. However, since there are very few studies which have explored the on-line process by L2 learners, I will, first, review previous studies conducted in an L1 context. Then, two experiments which were conducted will be reported. In these experiments the subjects' reading time will be examined by means of the "reader-paced reading" task.

2. Experimental Evidence

In the L1 context there has been much discussion about how and when lexical information is utilized in processing sentences. The study of this issue falls into two camps: one is "structure-based" processing and the other is "lexically generated" processing. In the former, lexical information is utilized as a "filter" or checking mechanism for initial syntactic analysis. In the latter, on the other hand, lexical information "guides" the processor.

(1) Structure-based processing

Those who advocate "structure-based" processing (Rayner & Frazier, 1982; Rayner, Carlson, & Frazier, 1983) claim that an initial syntactic analysis is assigned on the basis of purely syntactic information, regardless of what lexical item (i.e., verb) the sentence contains. According to Rayner & Frazier (1982), the human syntactic processor, or the parser, assigns a single structural analysis to incoming input, based on two general strategies; these are Minimal Attachment and Late Closure.

1. Minimal attachment: Attach incoming material into the phrase-marker being constructed using the fewest nodes consistent with the well-formedness rules of the language.

2. Late closure: When possible, attach incoming lexical items into the clause of phrase currently being processed (i.e., the lowest possible nonterminal node dominating the last item analyzed). (Frazier & Rayner, 1982)

They claim that these strategies are confirmed by "garden-path" phenomena. According to this view, since the parser, following the strategies above, initially pursues just a single analysis of a sentence, minor disruption and reanalysis often take place during reading (this phenomenon of disruption and reanalysis is called a "garden-path" phenomenon). I will give some examples which account for this claim. The strategy of minimal attachment will be applied to the processing of a sentence fragment, such as that shown in [1]. In [1] the noun phrase 'the answer' is syntactically ambiguous, because it can be identified either with a direct object of the verb 'know' (such as in 1a) or with a subject of the following subordinate clause (such as in 1b). The principle of
Minimal Attachment predicts 1a is easy to process, since 1a follows the principle (see Figure 1a and 1b). According to the principle of Minimal Attachment, the noun phrase, 'the answer', is attached to the VP node because it postulates fewest nodes possible. However, the perceiver has to reconstruct the analysis when he or she encounters the verb phrase, such as "was correct" in 1b, and the sentential clause, "the answer was correct" is analyzed as S (sentence) node.

[1] The girl knew the answer......
[a] The girl knew the answer by heart.
[b] The girl knew the answer was correct. (cf. Frazier, 1987)

![Fig. 1a](image)

The reanalysis observed in 1b manifests itself as longer reading time and regression of eye movement. Frazier & Rayner and their colleagues observed the perceivers' eye movements and confirmed their theory. They attribute the garden-path phenomena to the problem of efficiency; that is, there is a limitation on human immediate memory capacity (Rayner, Carlson, & Frazier, 1983). Thus, information on all levels of linguistic structure, such as phonological, lexical, syntactic, and semantic structure must be integrated as quickly as possible. They claim that the integration "might eliminate or drastically reduce the need for multiple representations." (Rayner et al., 1983: 359). In their theory, therefore, lexical information comes into play when the initial syntactic analysis is evaluated. For example, Mitchell (1987) postulates a two-stage syntactic processor. In his model, lexical information "filters" or "checks" the structures hypothesized in the initial syntactic parsing.

(2) Lexically generated processing

Ford et al. (1982) propose the principle of Lexical Preference. In this they hypothesize that a lexical item has the strongest form and that it influences the course of parsing "by suggesting which to choose among a set of alternatives in a phrase structure rule". (p. 747) For example, in 2a and 2b each different verb appears to have the identical structure: a subject, an object, and a prepositional phrase. However, it is supposed that there are different strengths of lexical forms in each verb; the strongest form for "want" is a subject and an object and for "position" a subject, an object and a prepositional complement. Thus, the sentence is analyzed in different ways when one lexical item (i.e. verb) is replaced by another.
2a. The woman \([v_p \text{wanted} [n_p \text{the dress} [p_p \text{on that rack}]]]\).
2b. The woman \([v_p \text{positioned} [n_p \text{the dress} [p_p \text{on that rack}]]]\).

\(\text{cf. Mitchell & Zagar, 1986}\)

Mitchell & Holmes (1985), Holmes (1987), and Holmes et al. (1987) investigated whether lexical information guides the perceiver's initial syntactic analysis. Holmes (1987), for example, discovered that initial syntactic processing is influenced by the preference of lexical items. She presented the sentences containing the verbs classified according to the bias either toward a noun phrase complement or toward a sentential complement. The basic finding was that more garden-path phenomena occurred in sentential-complement sentences like 1b containing verbs biased towards a noun phrase object than a sentential complement.

Since the purpose of this paper is not to evaluate or assess the models of syntactic processing in the L1 context, I will not make any further attempts to determine which model is more theoretically confirmed and has more validity. Rather, I have reviewed these above so that they can be models for the syntactic analysis of L2 learners. In the following section two experiments will be reported to explore how lexical information functions in sentence processing by L2 learners.

3. Experiments

The following two experiments show how lexical information is utilized in L2 learner's on-line sentence processing. The methods used in both experiments basically follow Mitchell (1987) and Holmes (1987). In Experiment I, the question of whether the transitivity of verbs influences the processing was explored. In this experiment sentences containing obligatory intransitive verbs or optionally transitive verbs were presented. In Experiment II the influence of lexical information on the types of post-verbal structure was examined. Sentences containing verbs which are biased either towards a noun phrase object or towards a sentential clause were presented. Both tasks were done through a reader-paced reading task and reading time was measured. In this task subjects could see experimental material on the screen until they scroll it at their own rate.

(1) Experiment I
(a) Method

\textbf{Materials.} The basic experimental material consisted of 12 sentences between 10 and 15 words long (See Appendix A). Each sentence consisted of a preposed subordinate clause followed by a main clause starting with a noun phrase. This noun phrase could be interpreted as the object of the subordinate verb or the subject of the main clause. However, in every case the noun phrase following the subordinate verb was the subject of the main clause. Further, the sentences were constructed in such a way that two
alternative verbs could be used in the subordinate clause; in one set of conditions the verbs were obligatory intransitive verbs and in the other set the verbs were optionally transitive verbs. These verbs were originally used in Mitchell (1987). The materials were segmented into two parts (see Table 1). On half of the trials the segmentation was made at a clause boundary (marked by single oblique line in Table 1). On the rest of the trials the sentences were segmented after the noun phrase (marked by double oblique line). Thus, the noun phrase could be interpreted as either the direct object or the main clause subject.

Table 1. A Sample of the Experimental Materials

<table>
<thead>
<tr>
<th>Optionally Transitive Verb</th>
<th>Intransitive Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>As soon as he had phoned/ his wife/ started to prepare for the journey.</td>
<td>As soon as he had arrived/ his wife/ started to prepare for the journey.</td>
</tr>
</tbody>
</table>

In addition to the experimental materials, 25 filler sentences were also presented. These sentences were composed of various syntactic structures. A simple Yes/No question was followed by the display of each sentence to encourage the subjects to understand the meaning and to prevent them from proceeding to the next display without having understood the sentences.

Procedure. The material was presented by means of a subject-paced reading task on a CRT display unit controlled by an NEC-9801 micro computer. After the first display was presented, the subjects read it and pressed the Space Bar, and the first part was immediately replaced by the second part. The materials were displayed half-way down the screen with the left side of each display adjusted. After the subjects pressed the Space Bar for the last display, the question was immediately shown on the screen. The reading time for each section was recorded by the computer. The subjects answer the question by pressing one of the keys for 'Yes', 'No', or 'I don't know'. About 5 seconds after they responded to the question, the next trial was displayed.

Each subject read 12 experimental sentences in all. In half of the trial they saw the sentences which contained an optionally transitive verb. In the rest of the trials intransitive verbs were used. Furthermore, in half of each of the two types the segmentation was made at the clause boundary, and in the other half the main clause subject noun phrase was included in the first display. These sets were counterbalanced so that each set of the sentences was presented to five different subjects. The main experimental session was preceded by a practice session.

Subjects. The subjects were 20 students (14 undergraduate and 6 graduate students) at Hiroshima University. They were majoring in English language education and
training to be non-native English teachers. The homogeneity of the subjects was not controlled, but their overall proficiency was approximately at advanced level.

(b) Predictions.

1) If subjects processed the sentences in a structure-based way, there would be garden-path effects both in the sentence where the first display contained an intransitive verb followed by a noun phrase and in the sentence in which the first display contained a transitive verb plus a noun phrase. 2) If subjects processed the sentences based on lexical information, on the other hand, garden-path phenomena would be found only in the sentence in which the first display contained a transitive verb followed by a noun phrase.

(c) Results and Discussion.

The results are shown in Table 2. The figures shown in the table are the mean reading time per character for each display. These results were submitted to a three-factor repeated measures ANOVA with subjects as a random effect, and verb type, segmentation position, and display (first or second) as fixed factors. The significant effects were as follows: (1) Main effects: display (F(1,20)=4.90, p<.05); segmentation position: (F(1,20)=16.19, p<.01); (2) Two-Way interaction: display×segmentation position: (F(1,20)=16.00, p<.01); display×verb type: (F(1,20)=7.51, p<.05).

Table 2. Mean Reading Time (msec) per; Character in Experiment I

<table>
<thead>
<tr>
<th>Display</th>
<th>Segmentation Position</th>
<th>At Clause Boundary</th>
<th>After Clause Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intransitive</td>
<td>Transitive</td>
<td>Intransitive</td>
</tr>
<tr>
<td>Display 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100.64</td>
<td>94.03</td>
<td>111.46</td>
<td>83.55</td>
</tr>
<tr>
<td>Display 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>81.52</td>
<td>97.42</td>
<td>137.18</td>
<td>155.41</td>
</tr>
<tr>
<td>Total</td>
<td>182.16</td>
<td>191.45</td>
<td>248.64</td>
</tr>
</tbody>
</table>

There were major two findings:

1. In the sentences in which the first display contained an optionally transitive verb and the following ambiguous noun phrase, subjects were garden-pathed. The evidence for this is that the difference of mean reading time between the two displays was larger for transitive verbs (71.86 msec) than for intransitive verbs (25.72 msec). The difference in the former was significant (F(1,10)=10.96, p<.01). However, this phenomenon was not observed in the sentences in which segmentation was made at a clause boundary.

2. It seems that there is a large difference in the first display which contains a verb plus a noun phrase. This is indicated by the mean reading time for the first display.
containing a transitive verb plus a noun phrase (83.55 msec) and for an intransitive verb plus a noun phrase (111.46 msec). However, this difference was not significant. Therefore, no garden-path effect was observed for the sentence containing an intransitive verb.

(2) Experiment II
(a) Method

Materials. The basic experimental materials consisted of 12 sentences of 7 to 12 words long. In these sentences, based on the results from Holmes (1987), verbs were classified into 1) those which prefer to take a noun phrase as a direct object (NP-bias verbs), 2) those which prefer to take a sentential complement clause ("That"-bias verbs) (See Appendix B). The sentences were further presented either with the verbs followed by a "that" complementizer or not. These sentences were segmented into three parts and displayed (See Table 3). In every trial, sentences were constructed so that each contained a sentential clause following the main verb. The first part contained the subject and the verb, and when the "that" complementiser was presented, it was added to this display. The second display contains a subject noun phrase of the subordinate clause. The noun phrase in this display could be interpreted either as a direct object of the preceding verb or a subject of the following clause. The third display contained a verb phrase of the subordinate clause and, therefore, became a disambiguating region. The four types of sentences were counterbalanced so that a subject would not see the same sentences in the task. As was done in Experiment I, a simple question was presented after the subject pressed the key for the third display. Further 25 filler sentences were presented.

Table 3. A Sample of Experimental Materials in Experiment II

<table>
<thead>
<tr>
<th>NP-bias Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>My neighbor found (that)/ his small son and the dog/ had gone.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>That-bias Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>The students knew (that)/ several solutions to the problem/ would be possible.</td>
</tr>
</tbody>
</table>

Procedure and Subjects. The procedure of the presentation was the same as in Experiment I, and a reader-paced reading task was used. Twenty subjects were the same subjects who participated in Experiment I. The reading time for each display was measured by the computer.

(c) Predictions
1) If subjects processed the sentences in the structure-based way, the garden-path phenomena would be observed both in the sentences containing NP-bias verbs and in those containing "that"-bias verbs, when the complementizer 'that' is reduced. 2) If they
analyzed the incoming data based on lexical information, instead, the garden-path effect would be observed only in the sentences containing NP-bias verbs.

Table 4. Mean Reading Time (msec) per Character in Experiment II

<table>
<thead>
<tr>
<th></th>
<th>NP-bias Verbs</th>
<th>&quot;That&quot;-bias Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>That</td>
<td>Reduced</td>
</tr>
<tr>
<td>Display 1</td>
<td>86.95</td>
<td>86.90</td>
</tr>
<tr>
<td>Display 2</td>
<td>95.76</td>
<td>93.18</td>
</tr>
<tr>
<td>Display 3</td>
<td>99.22</td>
<td>124.61</td>
</tr>
<tr>
<td>Total</td>
<td>281.93</td>
<td>304.69</td>
</tr>
</tbody>
</table>

(d) Results

The results were shown in Table 4. The mean reading time per character for each display was submitted to a three-factor ANOVA with repeated measures. The significant results were: 1)Main effect: Display (F(2,15)=4.22, p<.05), 2)Two-Way Interaction: Display X With/out "that"-complementizer (F(2,15)=2.19, .10<p<.25).

The following are the major findings:

1. For sentences containing NP-bias verbs, a significantly greater difference was observed from display 2 to 3 when the complementizer “that” was reduced (31.43 msec) than when it was presented (3.46 msec) (F(1,15)=4.79, .05<p<.10). In other words, the garden-path effect was observed in the sentences containing NP-bias verbs. However, this difference was not observed for sentences containing “That”-bias verbs.

2. When “that” was presented, it seemed to function as a “cue” for the structural type following the verb. Thus, no garden-path effect was observed either in NP-bias or “that” bias verb sentences.

4. General Discussion

In these two experiments the question of how advanced Japanese learners of English process syntactically ambiguous sentences was investigated. The results produced the evidence that they analyzed the sentence on the basis of lexical information retrieved from the verbs presented. Although the result obtained from Experiment I was a little weak, it can be concluded that lexical information is utilized and guides sentence processing by advanced learners. If these learners read very efficiently, it will be an essential factor for second language learners to have acquired lexical information. This assumption is partly confirmed by the study conducted by Ard & Gass (1987). They showed the evidence that, as learners become more advanced, they acquire syntactic
patterns *lexically*, a phenomenon which was traditionally considered to be knowledge *syntactically* acquired. Thus, it will be interesting to investigate whether there is a difference between strategies used by advanced learners and those used by beginners.

**REFERENCES**


**Acknowledgements.** I wish to thank Yuya Koga, Hiroshima University, Graduate Study for his efforts to design the computer program which was used in the experiments. I am very grateful to Naoki Sugino, Shogo Miura, and Helen Wright, Hiroshima University, for their helpful comments on an earlier draft of this paper.

**Notes**

1) The term “proficiency” is primarily identified with the degree of the learner’s speed and comprehension in reading.
2) For lack of space only the Minimal Attachment strategy was described. For details about the Late closure strategy, see Frazier & Rayner (1982).

Appendix A. Experimental Materials for Experiment I

1. Though George really wanted to (read/ sleep) the story bothered him.
2. As soon as he had (phoned/ arrived) his wife started to prepare for the journey.
3. After the dinner guests had (eaten/ talked) the desserts were taken away by the waiters.
4. After the child had (visited/ cried) his uncle gave him candies.
5. Just before the girl (knocked/ smiled) the door opened by itself.
6. Before he (interrupted/ appeared) the conversation had been carried out smoothly.
7. When the customer had (visited/ complained) the manager changed what he said.
8. While the young boys were (playing/ swimming) football was on television at home.
9. After my aunt (typed/ died) the story about her life was published.
10. When the old man sat (smoking/ yawning) the pipe was discovered on the floor.
11. As the woman (traveled/ woke) the world was found to be totally changed.
12. As my brother (cooked/ came) the chicken was burned black in the oven.

Appendix B. Experimental Materials for Experiment II

<NP-Bias Verbs>
1. The child expected (that) her christmas card would please her friend.
2. The boy accepted (that) the answer was correct.
3. My neighbor found (that) his small son and the dog had gone.
4. The students heard (that) the lecture by Professor Green was cancelled.
5. The teacher understood (that) the student’s problem was serious.
6. The students observed (that) the behavior of the animal was very strange.

<“That“-bias Verbs>
1. The students knew (that) several solutions to the problem would be possible.
2. The scientist discovered (that) the effect of the earthquake was very small.
3. The girl learned (that) the beautiful poem was quite famous.
4. The scientist tried to prove (that) the theory was quite correct.
5. Our boss decided (that) the plans would be changed.
6. One of the students explained (that) the cause was brought by them.