Effects of prosodic boundaries on ambiguous syntactic clause boundaries in Japanese

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Abstract

We report the results of experiments designed to investigate the effects of prosodic boundaries on resolving ambiguous syntactic clause boundaries in Japanese. The head-final, pro-drop nature of this language generates abundant syntactic attachment ambiguity for sentences that contain relative clauses. Two types of sentences with differing head nouns modified by relative clauses were examined. Syntactic attachment preferences for these two types of sentences in the absence of overt prosody were assessed in a written study. Results indicated that readers retrieved one clear meaning for one type whereas ambiguity was not clearly resolved for the other type. A sentence comprehension study was conducted using auditory versions of both sentence types, each produced with two prosodic structures. Results demonstrated the crucial use of prosodic boundary information in retrieving syntactic clause boundary information. Most importantly, prosodic boundaries affected the way listeners posited empty pronouns for the subject of main or subordinate predicates. These results demonstrated the fundamental importance of prosodic phrasal structure to the assignment of syntactic constituency during sentence comprehension, particularly in the case of a head-final, pro-drop language.

1. Introduction

Kang and Speer (2003) demonstrated that prosodic boundary information was crucially used by listeners in the resolution of syntactic clausal ambiguity in Korean. In contrast to English, Korean has neither lexical stress nor pitch accents (Jun, in press, among others). In addition, Korean syntax differs from English in that it includes pro-drop, verb-final structure and the presence of complementizers after an embedded clause, the combination of which contributes to abundant syntactic clausal ambiguity. Given this, Kang and Speer argued that prosodic boundaries could provide some of the most salient and reliable information about the structure of spoken sentences and potentially assume a fundamental role in spoken language processing in Korean.

Although it is well-known that Japanese shares many syntactic properties with Korean, its prosodic structure is distinctly different, including lexically assigned pitch accents (Venditti, in press, among others). Given syntactic similarity but intonational difference, we tested to see if Japanese sentence comprehension relies similarly on prosodic boundary information as listeners understand syntactic ambiguities. Japanese materials were temporarily and globally ambiguous sentences, with syntactic structures comparable to those used in Kang and Speer’s Korean study. For example, the two-word sentence-initial fragment in (1) is ambiguous such that the initial nominative-marked NP may be the subject of either the immediately following verb, or the sentence-final main verb.

(1) Takeshi-ga nyuuin-shiteiru ..... Takeshi-nom was hospitalized ..... Depending on the types of head nouns modified by relative clauses, this fragment can be continued as in (2), or as in (3).

(2) Takeshi-ga nyuuin-shiteiru oba-o nagusameta Takeshi-nom was hospitalized aunt-acc consoled

‘Takeshi comforted the aunt who was hospitalized.’

(3) Takeshi-ga nyuuin-shiteiru byooin-o sagashita Takeshi-nom was hospitalized hospital-acc looked for

a. ‘(Someone) looked for the hospital where Takeshi was hospitalized.’

b. ‘Takeshi looked for the hospital where (someone) was hospitalized.’

At the completion of the sentences, (2) is not ambiguous anymore (temporary ambiguity) while (3) still shows ambiguity (global ambiguity). The critical difference for these two examples is that for (2), the initial noun cannot be the subject of the following embedded verb whereas for (3) the initial noun may or may not be the subject of the embedded verb. In addition, for the type of sentence (3), pro needs to be posited for the subject of the main verb (3a) or of the embedded verb (3b), and the referents of this pro should be recovered from the context. For the purposes of this discussion, the type of sentence (2) will be called a gap type (since the embedded clause is analyzed as a kind of relative clause involving a gap in English) and (3), a pro type (since the ambiguity centers on the positing of an empty noun phrase).

For these two types of sentences, written and auditory sentence comprehension experiments were conducted. The written study assessed readers’ preferred syntactic representation for these sentences in the absence of overt prosody, while the auditory study examined the effects of prosodic phrasing on the comprehension of these two types of sentences.
2. Syntactic attachment preferences for two sentence types

A written comprehension study assessed the preferred interpretation of the two types of ambiguous sentences. For this test, two lists were created. Each list contained 18 gap type and 18 pro type sentences along with 36 filler items with different syntactic structures. Gap, pro, and filler sentences were mixed and pseudo-randomized so that no three sentences of the same type occurred consecutively. 16 native speakers of Japanese participated for the payment of 7 dollars each. On each trial, participants read a sentence and answered a comprehension question. Since the critical information involved the subject of embedded predicates in both (2) and (3), the question took the form of “Who was hospitalized?” Along with the questions, three counterbalanced response choices were provided. For the gap type, these included NP1 (e.g., definitely Takeshi), NP2 (e.g., definitely aunt) and either NP1 or NP2 (e.g., either Takeshi or aunt). For the pro type, the response choices included NP1 (e.g., definitely Takeshi), NP2 (e.g., definitely someone other than Takeshi) and either NP1 or someone else (e.g., either Takeshi or someone other than Takeshi). Figure 1 shows the results from this written test.

![Figure 1](image_url)

Figure 1: Mean proportion of three response types for visually presented gap and pro type sentences.

Arcsine transformed proportions of responses in the three categories were analyzed in a 2 (sentence type) x 3 (response type) repeated measures analysis of variance (henceforth, ANOVA). The results for the temporarily ambiguous gap type sentences indicated that readers retrieved one clear meaning by sentence end. The NP2 response was chosen as the answer to the comprehension question for these sentences on the vast majority of trials, significantly more often than both other response types (F1 (1,2) = 34.35, p < .001; F2 (1,2) = 9.46, p < .001). On the other hand, the response distribution for pro type sentences indicated a slight preference for the interpretation where the initial NP was the subject of the immediately following predicate, but a clear awareness of the presence of an ambiguous interpretation. The difference in the proportion of listener choices of NP1 vs. ‘either NP1 or someone else’ was significant only by items (F1 (1,15) = 1.55; F2 (1,17) = 5.58 p < .05), while both of these responses were chosen more often than ‘definitely someone else’ (F1 (1,15) = 27.64, p < .001; F2 (1,17) = 67, p < .001).

3. Prosodic boundaries influence syntactic attachment preferences

For the same two sentence types given in (2) and (3), two prosodic versions of each syntactic type were produced by a female, native Japanese phonetician; one with an Intonation Phrase boundary (IP, henceforth, see Venditti, in press) immediately following the initial NP and the other without an IP boundary at the same location. Prosodic structures beyond this IP were held constant for each item.

Four lists were created with a 2 x 2 factorial design (two syntactic types and two prosodic types). The same 36 test items used in the written experiment were pseudo-randomized with 36 filler items. 40 native speakers of Japanese from Daito Bunka University in Tokyo, Japan participated for the payment of 1000 Japanese Yen. Each participant heard one prosodic version of each test item and completed two tasks. First, they indicated as quickly as possible whether they understood each sentence or not. Second, they answered the same comprehension questions asked of readers in the written experiment, with one of the same three responses.

For all sentence types, listeners indicated they understood the sentences more than 90% of the time (96% for the gap sentences with an IP, 94% for the gap sentences with no IP, 93% for the pro sentences with an IP and 96% for the pro sentences with no IP).

Figure 2 shows the mean end-of-sentence comprehension times for the four spoken sentence types.

![Figure 2](image_url)

Figure 2: Mean end-of-sentence comprehension times for gap and pro type sentences in two prosodic conditions.

Comprehension times were submitted to a 2 (syntactic forms) x 2 (prosodic structures) repeated measures ANOVA. Results indicated that listeners were slower to process gap type sentences without an IP boundary than they were to process those same sentences with an IP boundary after the first NP. Response times were shorter for gap sentences with IP boundaries (mean RT = 1402 ms) than for those without IP boundaries (mean RT = 1402 ms) (F1 (1,39) = 6.34, p < .05; F2 (1,35) = 5.84, p < .05.) For these sentences, results were consistent with models that predict easier processing when prosodic and syntactic boundaries coincide than when they do not (Kjelgaard & Speer, 1999).

In contrast, listeners were faster to process pro type sentences without an IP boundary than they were to process those same sentences with an IP boundary after the first NP.
Response times were shorter for pro sentences without an IP after the initial noun (mean RT = 1234 ms) than for those with an IP in that location (mean RT = 1408 ms). This effect approached but did not reach statistical significance (F1 (1,39) = 3.14, p = .08; F2 (1,35) = 2.81, p = .10). The relative difficulty of processing pro type sentences that contained a prosodic boundary after the initial noun can be attributed to the effect of prosodic boundary information. Because the initial noun is an available and accessible candidate to be the subject of the embedded verb, this would seem the most obvious interpretation for listeners. However, the observed difficulty suggests the situation was otherwise; a prosodic boundary after the initial noun led them to build a structure where the initial NP was not the subject of the embedded verb. In such a case, listeners must also posit an empty pronoun (so-called a small pro), which is possible in a pro-drop language like Japanese. Since it is pragmatically awkward to posit an empty pronoun for the subject of an embedded predicate in the absence of any preceding context, sentences in the pro IP condition would be more difficult to understand.

For ease of exposition, responses to the comprehension questions will be discussed separately for gap and pro type sentences.

Figure 3: Mean proportion of each response choice for gap type sentences in two prosodic conditions.

Comprehension question results for the temporarily ambiguous gap type sentences are shown in Figure 3. There were significantly more correct NP2 choices (the head noun in example (2)) for the gap IP condition, where syntactic and prosodic boundaries coincided (90.8%), than for the gap noIP condition, where no IP boundary followed the initial NP (82.4%) [F1(1, 39) = 15.96, p < .001; F2(1, 35) = 8.872, p < 0.005]. Therefore, when no Intonation Phrase boundary intervened between the initial NP and the following verb, prosodic grouping influenced syntactic grouping, inducing more erroneous responses even for these unambiguous sentences.

For pro type sentences, the presence or lack of an Intonation Phrase boundary was used to resolve standing syntactic ambiguity. The results are shown in Figure 4.

There were significantly more choices of the initial NP (Takeshi in example (3)) when there was no Intonation Phrase boundary (60.2%), as compared to when there was an Intonation Phrase boundary at the same location (33.7%) [F1 (1, 39) = 49.37, p < 0.001; F2 (1, 35) = 30.068, p < 0.001]. Hence, the absence of an Intonation Phrase boundary following the initial NP biased listeners toward the interpretation where the initial NP was the subject of the following embedded verb. The reverse pattern was found for NP 2 choices (someone other than the initial NP). There were significantly more NP2 choices (40.4%) when there was an Intonation Phrase boundary after the initial NP than when there was no such boundary (15.4%) [F1 (1, 39) = 35.67, p < 0.001; F2(1, 35) = 20.578, p<0.001]. Thus, listeners posited a pro subject for the embedded verb, which is remarkable especially in the absence of any preceding context that could have identified its referent.

4. Discussion and conclusion

As in Korean, the results demonstrated the fundamental importance of prosodic phrasal structure to the assignment of syntactic constituency during sentence comprehension, particularly in the case of a head-final, pro-drop language. Although experiment 1 demonstrated with a reading task that our gap type sentences were only temporarily ambiguous, evidence was found that the absence of prosodic boundary between the initial NP and the following verb induced more erroneous answers to questions in the sentence comprehension task as well as longer reaction times. This suggests that the misalignment of prosodic and syntactic boundaries caused processing difficulty in this temporarily ambiguous structure. The pro type sentences, which were globally ambiguous, demonstrated a clear effect of prosodic boundary information on resolving the location of syntactic clausal boundaries. Depending on the presence or absence of a prosodic boundary, listeners assigned a different syntactic clause boundary to the same sentence even if this required them to posit an empty pronoun for the embedded predicate, which is very rare in the absence of any preceding context.

5. References

