Asymmetry between Encoding and Decoding of Wh-scope in Japanese[1]

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1 Introduction

It has been discussed in the recent literature that every Wh-question in Japanese must be accompanied by an appropriate prosodic (pitch) contour. Deguchi and Kitagawa (2002) and Ishihara (2003) point out that, for the speakers of Tokyo Japanese, the Wh-scope domain of a sentence correlates with the domain of focus prosody (henceforth FPD). The two alternative Wh-scope readings in (1) below contrast in the end position of FPD wherein the Wh-focus receives pitch prominence (indicated by bold-face capitals), followed by post-focal pitch-range reduction (henceforth PFR; indicated by a shade). The end of FPD is marked by post-COMP F0 rise (whose high tones indicated by capitals). This rise occurs at the matrix verb (e.g., *tasikameta* "confirmed") in (1a) for subordinate Wh-scope, while no such rise takes place for matrix Wh-scope, and hence PFR continues through the sentence-final matrix Q-COMP in (1b). We will refer to the former prosodic pattern as "Local" FPD and the latter pattern as "Global" FPD.

(1) a. Subordinate Wh-scope (Local FPD):
hokenzyo-wa [kanzyatati-ga **NA**ni-o tabeta-**ka**] taSIKAmetandesu ka?
health.dept.$_{TOP}$ patients-$_{NOM}$ what-$_{ACC}$ ate-$_{COMP\text{-}Q}$ confirmed -$_{COMP\text{-}Q}$

Wh-prominence PFR Post-COMP Rise

"Did the health department confirm [what$_1$ the patients had eaten t$_1$]?"

b. Matrix Wh-scope (Global FPD):
hokenzyo-wa [kanzyatati-ga **NA**ni-o tabeta-ka] tasikametandesu **ka**?
health.dept.$_{TOP}$ patients-$_{NOM}$ what-$_{ACC}$ ate-$_{COMP\text{-}Q}$ confirmed -$_{COMP\text{-}Q}$

Wh-prominence PFR

"What$_1$ is such that the health department confirmed [whether the patients ate it$_1$]?"

For those speakers who can detect such a prosody-scope correlation, the matrix Wh-reading accompanied by Global FPD as in (1b) is a legitimate interpretation.

Kitagawa and Fodor (2003, 2006) further argued that general preference for the subordinate Wh-scope reading as in (1a) is induced by extra-syntactic factors including general principles in sentence processing. [2] The preference in sentence comprehension for the subordinate Wh-scope reading can in fact be naturally predicted by a generalized version of a processing principle such as the Minimal Chain Principle (De Vinicenzi, 1989) or the Active Filler Strategy (Frazier, 1987). In Wh-questions in English with more than one possible gap position (for Wh-traces), the parser always prefers to associate the fronted Wh-phrase to the first encountered gap. Based upon their experimental results, Miyamoto

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[2] Also pointed out was that such a bias toward the preferred subordinate Wh-scope interpretation has often been taken as an instance of Subjacency effects in the syntax literature since Nishgauchi (1990) and Watanabe (1992). Kitagawa and Fodor (2003, 2006) also argue that pragmatics and prosody are other strong biasing factors.

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and Takahashi (2002) argued that a similar locality effect is observed also in Japanese between the Wh-in-situ and its associated Q-marker while Wh-interrogative constructions in this language do not involve overt Wh-movement. In both (2a) and (2b), the entire subordinate clause containing a Wh-phrase is scrambled to the sentence-initial position. The trace of the fronted clause is in the object position of the matrix clause. Their results showed that it took longer for people to read the subordinate verb plus the COMP when the COMP is not Q-marked (as in (2b)) than when it is Q-marked (as in (2a)). This result was interpreted as indicating that parsers generally attempt to establish the association between the Wh-phrase and the first-encountered COMP.

(2) a. [senmu-ga dono-pasokon-o tukatteiru-ka]$_1$ [kakarityoo-ga t_1 itta-no]?
director-$_{NOM}$ wh-computer-$_{ACC}$ is using-$_{COMP\text{-}Q}$ supervisor-$_{NOM}$ said-$_{COMP\text{-}Q}$
"Did the supervisor say what type of computer the director is using?"
b. [senmu-ga dono-pasokon-o tukatteiru-to]$_1$ [kakarityoo-ga t_1 itta-no]?
director-$_{NOM}$whch-computer-$_{ACC}$ is using-$_{COMP}$ supervisor-$_{NOM}$ said-$_{COMP\text{-}Q}$
"What type of computer did the supervisor say whether the director is using?"

In the case of the processing of the example in (1) above, when the Wh-phrase *nani-o* ("what-$_{ACC}$") in the subordinate clause is encountered, the parser attempts to find the Q(wh)-marked item that can license the Wh-phrase as early in the input as possible. The Q(wh)-marker at the end of the subordinate clause is the first one encountered, and therefore the parser attempts to establish dependency between this COMP and the subordinate Wh-in-situ. This presumably induces the preference for the subordinate Wh-scope reading. We assume that such a processing principle for locality in Wh-COMP dependency operates in the on-line processing of Japanese sentences, and will further investigate how this can also relate to the puzzling mismatch between the production and comprehension data we will encounter and discuss below.

2 Production Study

The purpose of this experiment is to examine if the speakers can indeed establish two distinct types of prosody-scope correlations when they utter scopally ambiguous Wh-questions, and if they do, in what respect and at which point in on-line sentence production and comprehension the two prosodic patterns are distinguished from each other. The previous studies predict that the crucial difference is to be found in the post-COMP F0 rise (Deguchi and Kitagawa, 2002; Ishihara, 2002; 2003), or the presence or absence of the Major phrase boundary preceding the matrix item (Hirotani, 2004). In this study, we measure the F0 peak values of post-COMP items — those of the matrix verbs in our examples, as well as several other items. The analysis of durational cues (silence interval and segment length) that are relevant to marking the beginning of FPD in a pre-Wh position, and the end of the subordinate Wh-scope domain (= Local FPD) in a post-COMP position are discussed in Hirose and Kitagawa (Submitted). In this paper, we will only discuss the F0 data.

2.1 Method

Materials Thirteen scopally-ambiguous Wh-interrogative sentences including and similar to (1), repeated below, were created as target sentences. The target sentences were embedded in a dialogue-like context including an answer to the target question, so that the subject can assign the intended scope correctly to each target sentence. The example of the dialogue for the subordinate Wh-scope reading is shown in (3), and the matrix Wh-scope reading in (4) below.

Target sentence

(1) hokenzyo-wa [kanzyatati-ga nani-o tabeta-ka] tasikametandesu ka?
health.dept.$_{TOP}$ patients-$_{NOM}$ what-$_{ACC}$ ate-$_{COMP\text{-}Q}$ confirmed -$_{COMP\text{-}Q}$

a. Subordinate Wh-scope reading:
"Did the health department. confirm [what$_1$ the patients had eaten t$_1$]?"
b. Matrix Wh-scope reading:
"What$_1$ was such that the health department confirmed [whether the patients ate it$_1$]?"

(3) Dialogue for subordinate Wh-scope reading

Journalist: It's been 4 hours since you started interviewing the patients of the food poisoning. We need to know whether you finally identified the cause.
Spokesman: We are not ready to announce the name of the item yet.
Journalist: You don't have to tell us what it is. We simply would like to know if you have already identify the cause. <<**TARGET** (a. "Did the health department confirm [what$_1$ the patients had eaten t$_1$]?")>>
Spokesman: Oh, yes. That we did.

(4) Dialogue for Matrix Wh-scope reading

Journalist: I heard that you have already identified the food item that caused the mass food poisoning. Tell us what it is. <<**TARGET (b.** "What$_1$ was such that the health department confirmed [whether the patients ate it$_1$]?")>>
Spokesman: Let me answer that question. It was bean sprouts.

The thirteen pairs of dialogues were divided into two lists. In addition to the dialogues with the target experimental sentences with Wh-scope ambiguity, thirteen dialogues with various types of questions without a scope ambiguity were created as filler items, and were inserted between experimental dialogues. The same filler dialogues were used in the two sets. Both sets (= both versions of each experimental sentence) were read by all subjects.

Subjects (speakers) Four native Tokyo Japanese speakers (graduate students from Tokyo, Kanagawa, Saitama, or Chiba prefecture) participated in the production experiment. Besides the four subjects, one of the experimenters (Yoshihisa Kitagawa, YK) also participated in the recording. His utterances were to be used in the comprehension study to follow, together with the utterances of one of the participants of this production study. Since the purpose of the production study was to examine the difference in the prosodic patterns in the two different Wh-scope readings in speakers who are naïve about the purpose of the study, only the results from the four recruited subjects (speakers A, B, C and D) are discussed. (The data from YK will be also presented italicized on the fifth raw in the tables without analysis for comparison.)

Procedure First, in the screening session, the subjects were shown all experimental dialogues in pairs so that they can compare and familiarize themselves with the two contrasting Wh-scope readings. The subjects were told to compare the two dialogues and to make sure if the target sentence (indicated by an underline) made sense in each context. The purpose of this session was to screen out the subjects in case they disapprove of either or both of the Wh-scope readings. With respect to our subjects, all four of them agreed that the target Wh-questions made sense in both versions of the context. After this screening session, the subjects took a short break, and then were given one of the lists for the recording session. In the recording session, they were instructed to skim through each dialogue in the list again before they start reading the sentences aloud. They were told to start only after they understand the whole dialogue. The target sentences were always indicated by an underline. When they made a speech error, they were asked to repeat from the point prior to the target (indicated by the experimenter). After they read through all the sets of dialogues, they took a short break, and repeated the same set of dialogue for the second time. They were asked to come back at least one day later to read the other list.

This time, the subjects did not go through the preview session but went straight to the recording session (since they have checked all the experimental sentences in both versions on the first day). The procedures for the recording session for the second set of items were the same as those of the first set. Only the second recordings for all dialogues were used for the analyses.

The target sentences in the collected recordings were subject to the F0 measurements. The F0 peak values were measured at four positions: the item preceding the Wh-phrase, the Wh-phrase itself, the subordinate verb, and the matrix verb (in the case of example (1), *kanzyata'ti-ga* ("patients-$_{NOM}$"), *na'ni-o* ("what-$_{ACC}$"), *ta'beta-ka* ("ate-COMP") and *tasika'metandesu-ka* ("confirmed-COMP"), respectively).

In all versions of the prosody-scope correlation of Wh-interrogatives discussed by Deguchi and Kitagawa (2002), Ishihara (2002, 2003) and Hirotani (2004)[3], the important information about the Wh-scope domain is considered to be encoded in the prosodic cue to signal the end of the focus domain. The purpose of our production study is to examine if this is true across naïve speakers, and to investigate if there are any other cues at other positions in the sentences that are also encoded for the scopal distinction.

2.2 Results (F0 analyses)

The maximum F0 converted to semitones for the four points of measurement for each subject are shown in Table 1 below for both Wh-scope readings, together with the results of t-tests comparing the mean F0 peak values (in Hz) at the Wh-item and the matrix verb (no significant diffrence was found in any speaker at other positions).

Table 1. Peak F0 values (in semitones) at the four positions in the target sentences (pre-Wh-phrase, Wh-phrase, subordinate verb, and matrix verb) with the results of the t-tests (t- and p-values) comparing the means at Wh-phrase and matrix verb.

Subject		Pre Wh	Wh-item	Subord. V.	Matrix V.
A	Matrix	17.41	18.70	11.54	8.03
	Subord.	17.82	18.01	11.89	18.53
	t-value		0.64		20.01
	p-value		p> 0.5		p< .0001***
B	Matrix	16.57	20.52	13.01	11.48
	Subord.	16.69	17.91	11.90	14.65
	t-value		3.73		2.60
	p-value		p< .005**		p< .05*
C	Matrix	14.77	17.27	9.95	8.54
	Subord.	14.85	14.85	10.12	14.85
	t-value		4.70		7.14
	p-value		p< .001**		p< .0001***
D	Matrix	16.84	18.48	13.76	13.88
	Subord.	17.40	18.89	14.20	17.72
	t-value		2.20		5.03
	p-value		p= .052+		p< .0005***
YK	Matrix	*14.20*	*22.09*	*10.90*	*5.19*
	Subor*d.*	*13.57*	*16.14*	*11.32*	*15.85*
	t-value		*7.72*		5.03
	p-value		*p< .0001****		*p< .0001****

For all four speakers, the F0 peak height for the matrix verb was significantly higher for the subordinate Wh-scope reading, as expected. In addition to this, for two of the subjects (speakers B and C), the F0 height at the Wh-phrase was significantly higher when the matrix Wh-scope was intended compared to

[3] According to Hirotani (2004), the scopal difference should be, at least partially, reflected in the formation of Major phrases. In our study we do not examine the phonological status of the observed difference to answer the question as to whether the prosodic difference is a phenomenon at the surface pitch contour or it is directly related to the prosodic structure. See Kubozono (2007) for relevant discussions.

when the subordinate Wh-scope was intended. This difference was not observed for the other two speakers (speakers A and D, although the difference was marginal for speaker D). No significant difference was observed at other positions for any speaker.

2.3 Factors contributing to the speaker's Wh-scope distinction

Based on the F0 and the durational measures, linear stepwise discriminant analyses were conducted for all target utterances from the four subjects in order to examine which prosodic cues mainly contribute to the prosodic distinction between the two distinct Wh-scope readings. The discriminant factor was the intended Wh-scope reading (1 = matrix, 0 = subordinate). The following eight independent factors were considered in the analyses: F0 peak of the pre-Wh phrase (in semitones), F0 peak of the Wh-phrase (in semitones), F0 peak of the matrix verb (in semitones), Silence interval preceding the Wh-phrase, Silence interval following the subordinate COMP, Final segment duration of the pre-Wh-phrase, Final segment duration of the subordinate COMP. [4] Table 2 below shows the details of the best discriminant function for each subject to account for the relationship between the subject's intended Wh-scope and the prosodic characteristics of the utterances under consideration.

Table 2. Summary of Stepwise Discriminant Analyses for the prosodic cues for individual speakers

Subject	Wilk's Lambda of the function	p	contributing variables by the order of the relative size
A (N=22)	.047	<.001	F0 peak of matrixV pre Wh-phrase silence interval
B (N=26)	.438	<.001	F0 peak of matrixV F0 peak of Wh-phrase
C (N=26)	.196	<.001	F0 peak of matrixV F0 peak of Wh-phrase
D (N=26)	.442	<.001	F0 peak of matrixV

The results showed that the F0 peak height of the matrix verb was indeed the most powerful for all subjects and it was the only independent factor that was always included in the best discriminant function across subjects.

Overall, both the phonetic analyses on the collected utterances and the discriminant analysis suggest that the F0 peak height of the matrix verb is the prosodic cue that the speakers most consistently manipulate to encode the Wh-scope domain in their speech. In addition to this, F0 peak height of the Wh-item itself seems to characterize the Scopal difference for some subjects.

3 Comprehension study 1

A comprehension study was also conducted using the same set of items recorded by two native Tokyo speakers. The aim of the study was to examine how well the speakers' intention (regarding the Wh-scope interpretation) is conveyed to listeners based upon the prosodic patterns they encoded into their utterances.

3.1 Method

Materials The same thirteen pairs of items with the Wh-scope ambiguity in two versions were recorded. Of them, eleven pairs of sentences were used in the comprehension study, two items having been excluded due to a presentation error. Additional 44 filler items of various types of interrogative

[4] The duration of silent intervals and phrase-final segments were also measured separately. Although those data are not discussed in 2.2, they are included in the linear discriminant analysis presented in 2.3.

sentences were prepared, half of which were ungrammatical. The target items were divided into two lists. The filler items were the same across the lists. Recordings from two speakers were used. The speakers included Y.K., one of the authors, and one of the subjects in the production study above (speaker A).

As can be seen in Table 1, the peak F0 on the Wh-phrase was significantly higher, and that on the matrix verb was significantly lower for the matrix reading for YK, in contrast to speaker A's recordings in which the F0 difference was only found for the matrix verb. As is obvious in the comparison between the data from YK and speaker A, the difference between the two Wh-scope reading is more emphasized for YK.

Subjects Twenty-eight native Tokyo speakers participated in the experiment. The subjects were divided into two groups for each speaker block. Within the speaker block, the subjects were further divided into two lists.

Procedure The utterances were played out one-by-one. Each item in the written form was also projected onto the screen simultaneously (although the subjects were instructed to focus mainly on the auditory stimuli). The subjects were asked to make a forced-choice judgment on a possible answer to the question. In addition to the two kinds of possible answers (each corresponding to the matrix- and subordinate-Wh-scope readings, respectively), there was also an option to reject the question sentence as ungrammatical. The example choice set (as in (1)) is as follow. The order between the two possible answers to the question was alternated across items:

a. The question itself was ungrammatical
b. “Yes, they have already confirmed it”
c. “It was bean sprouts.”

3.2 Results

The percentage of the responses in which the subject chose an answer consistent with the matrix Wh-scope reading is shown in the Table 3. The rejection rate for the target sentences is presented in Table 4.

Table 3. Percentage accepted with matrix Wh-scope

	intended reading	
Speaker	subordinate Wh-scope	matrix Wh-scope
YK	9	30
A	2	12

Table 4. Percentage rejection of the target sentences

	intended reading	
Speaker	subordinate Wh-scope	matrix Wh-scope
YK	0	19
A	0	7

For the speaker block YK, the percentage of matrix Wh-scope interpretation was significantly higher when the speaker had intended matrix-Wh-scope reading ($t_1(13)=2.58$, $p< .05$, $t_2(10)=2.81$, $p< .05$,). The rejection rate of the target sentences was 19% when the matrix Wh-scope reading was originally intended, compared to 0% when the subordinate Wh-scope reading was intended. For the block for speaker A, the percentage of matrix Wh-scope interpretation was significantly higher in the subject analysis and when the speaker had intended the matrix-Wh-scope reading and the difference was nearly significant for the item analysis (t_1 (13)=2.88, $p< .05$, t_2 (10)=2.18, $p= .054$). The target sentences were rejected 7% of the cases when the matrix Wh-scope reading was originally intended. No rejection occurred when the subordinate Wh-scope reading was intended. Overall, the results suggest that the

speaker's intention reflected in the prosodic pattern influenced the listeners' interpretation when the responses to the two versions of the sentences were compared to each other in relative terms. However, the overall proportion of the matrix Wh-scope reading was noticeably low.

4 Comprehension Study 2

To investigate the relative importance of the prosodic information on the Wh-item and the post-COMP item for the listeners in making the scopal judgment, a forced choice comprehension study was conducted with the selected sentences. The peak F0 height of the Wh-item and the post-COMP item were independently manipulated in an artificial way. In this study, we focused on the relative impact of the F0 cues on these two positions that potentially contribute to the Wh-scope determination.

4.1 Method

Materials Two sentences were selected from the items recorded by YK in the production study described above. Those two items were interpreted with a matrix Wh-scope in at least 30% in the comprehension study, so it is expected that the generally dispreferred matrix Wh-scope reading was at least available, even if it was not dominant. The items are called the "hokenzyo set" (presented in (1)) and the "kosinzyo set" ((5) below) hereafter.

(5) kosinzyo-wa [Kanno-san-ga dare-to uwakisiteiru-ka] sirabeteirundesu ka?
Detective service.$_{TOP}$ Ms. Kanno-$_{NOM}$ who with have an affair-$_{COMP\text{-}Q}$ investigating -$_{COMP\text{-}Q}$

a. Subordinate Wh-scope reading:
"Is the private detecvie investigating [who$_1$ Ms. Kanno is having an affair with t_1]?"
b. Matrix Wh-scope reading:
"Who$_1$ is such that the the private detective is investigating [whether Mr. Kanno is having an affair with him$_1$]?"

The F0 peak of the Wh-item and the matrix verb were resynthesized by using *Praat* 4.6.35. The sentence originally utterered with the subordinate Wh-scope intended was used as the source. Its peak F0 of the Wh-item was raised, and the peak F0 of the matrix verb was lowered, both in steps of 20Hz. That resulted in 35 (7 steps for the Wh-item and 5 steps for the matrix verb) combinations for the hokenzyo set and 49 (7 steps x 7 steps) for the kosinzyo set. In addition to those resynthesized items, the original utterances with each scopal interpretation were also included in each set. The total number of tokens was therefore 37 for the hokenzyo set, and 51 for the kosinzyo set.

Table 5. Peak F0 values (in Hz) at the four positions in the target sentences (pre-Wh-phrase, Wh-phrase, subordinate verb, and matrix verb) of the original utterances for Hokenzyo set and Kosinzyo set, respectively.

Hokenzyo set	Pre Wh item	Wh-item	Subord. V.	Matrix V.
Original (subordinate scope intended)	162	143	97	179
Matrix scope intended	177	250	114	91
Kosinzyo set	**Pre Wh item**	**Wh-item**	**Subord. V.**	**Matrix V.**
Original (subordinate scope intended)	166	151	116	200
Matrix scope intended	151	250	112	97

Table 5 above presents the peak F0 values (Hz) of the four positions of the original utterance (recoreded with the subordinate scope intended) from which the resynthesized tokens were created. The F0 values for the other original recorded utterance (with Matrix Wh-scope intended) are also presented in Table 5.

Subjects Ten subjects were selected among the participants of the comprehension study 1 above. The selected participants correctly interpreted the experimental items intended with matrix Wh-scope

more than 30 % throughout the comprehension study, thus confirming that the matrix Wh-scope reading was available for them with a proper prosody.

Procedure The two item sets were presented in separate blocks. In each block, the items were presented from a laptop computer in a randomized order without fillers. Each subject was asked to select the appropriate answer from the two options displayed on the screen, each associated with the two scopal readings as in the Comprehension Study 1. The same answer set was used within the blocks. Given the procedure of the experiment and the subjects' experience in participating in the comprehension study, it is reasonably assumed that the subjects were all aware of the scope ambiguity involved in the sentence and that they were trying to make conscious efforts to tune in the subtle difference among items to give intuitive judgments.

4.2 Results

Linear stepwise discriminant analyses were conducted for each item set to examine which F0 cues contribute to the listeners' interpretation of Wh-scope. The discriminant factor was the intended Wh-scope reading (1 = matrix, 0 = subordinate), and the two independent factors considered here were the F0 peak value of the Wh-item and the matrix verb. The results of the stepwise discriminant analyses, the discriminant functions, and the relative strength of the power of the relevant independent factors for the data from the 10 subjects are presented in Table 6 and 7 below, separately for each item set.

Table 6. Summary of Stepwise Discriminant Analyses for the Hokenzyo set (N=370)

Step	variable added	Wilk's Lambda	p		
1	Wh-item F0	.781	.000		
2	matrixV F0	.642	.000		
Function		Eigenvalue	Wilk's Lambda	Chi-square	p
1		.558	.642	162.755	.000
		Standardized canonical discriminant coefficient			
Wh-item F0		.778			
matrixV F0		-.708			

Table7. Summary of Stepwise Discriminant Analyses for the Kosinzyo set (N=510)

Step	variable added	Wilk's Lambda	p		
1	Wh-item F0	.693	.000		
2	matrixV F0	.641	.000		
Function		Eigenvalue	Wilk's Lambda	Chi-square	p
1		.559	.641	225.089	.000
		Standardized canonical discriminant coefficient			
Wh-item F0		.938			
matrixV F0		-.456			

In both item sets, the listeners' judgment of the Wh-scope reading was best explained by the combination of the both F0 cues (the higher the F0 on the Wh-item and the lower the F0 on the matrix verb, increased the matrix WH-scope interpretation). However, the results further demonstrated that the F0 information of the Wh-item was more influential compared to the F0 information of the matrix verb, as can be seen in the relative size of the standardized discriminant coefficients. The dominance of the F0 information at the Wh-item was more significant in the Hokenzyo-set.

The stepwise discriminant analysis performed for each subject revealed that there are considerable differences among individuals and items. For three out of the ten subjects, the responses for both Hokenzyo set and Kosinzyo set were best accounted for only by the F0 on the Wh-item. On the other

hand, there was one subject whose best discriminant function consisted only of the F0 on the matrix verb.

5 Discussion and Conclusion

The results of our production study was consistent with the previous findings in the literature that prosody-scope correspondence is established for Wh-interrogatives in Japanese. When these findings are combined with the outcome of our comprehension study, however, they cast doubt on the standard assumption that speakers' encoding and the listeners' decoding of the Wh-scope information are mediated by identical prosodic cues.

For production, the language users' appeal to the F0 peak height of the post-COMP item makes perfect sense since, for speakers, the most straightforward way to encode the Wh-scope in prosody would be to signal the end of the subordinate focus prosodic domain with the Post-COMP rise. It in fact seems to be the only position in which the terminal point of the syntactic constituent functioning as a subordinate Wh-scope domain is directly translated into prosody. Our comprehension study revealed, however, that this prosodic cue was not necessarily the primary information utilized by listeners to distinguish the two Wh-scope readings in the way the speakers had intended. Instead, listeners tended to rely more heavily on the relative F0 height of the Wh-item itself. This result implies that the marking of the subordinate Wh-scope domain by the F0 peak height of the post-COMP item may not be a critical factor playing any crucial role in sentence processing, contrary to what was claimed by Hirotani (2004), while it may still be regarded as a production phenomenon induced by grammatical derivation as proposed by Deguchi and Kitagawa (2002) and Ishihara (2003). It should also be noted that there were differences among individuals as to the relative weight of the two cues: the results of our comprehension study directly comparing the impact of the two cues implied that some listeners consistently relied on the F0 cue on the Wh-item across the two items sets whreas one speaker constantly utilized the F0 cue at the matrix verb. The nature of such individual difference should be investigated further in the future research.

One remaining question is why such a mismatch between speakers and listeners arises. Our tentative answer concerns the listeners' general interests in regard to the incremental processing. In on-line real time processing, upon encountering the Wh-item, listeners need to learn at which COMP the Wh-COMP dependency is meant to be resolved. For Wh-in-situ in a subordinate clause, the first candidate COMP item would be the subordinate COMP, but there is no way for listeners to know if there is another COMP to be encountered in the subsequent input. The processing preference, therefore, would be to resolve the Wh-COMP dependency at the earliest possible point (Miyamoto and Takahashi 2002), which, as we pointed out above, correctly predicts the preference towards the subordinate Wh-scope reading.

In this regard, the most informative prosodic cue encoded by the speaker at the first matrix item following COMP, i.e. the post-COMP F0 rise, is not necessarily the most useful in on-line processing. Listeners are under the pressure to make the decision about the Wh-domain in comprehension by resorting to a cue that appears as early as possible which would inform them if the Wh-phrase should NOT be associated with the first encountered COMP. So for the sake of timely decision, it would be ideal if the Wh-phrase itself contained some information which could provide a signal to the parser if it should override the default local dependency analysis. This, we believe, is a highly likely source of the mismatch between speakers' and listeners' cues.

As was discussed by Kitagawa and Fodor (2003, 2006), the strong preference towards the subordinate Wh-scope reading in a Wh-island construction in Japanese seems to be at least partly due to the direct effect of the processing preference towards the local Wh-COMP dependency. Based upon the experimental results and theoretical conjectures presented above, we now consider that the discrepancy between speakers' and listeners' strategies in encoding/decoding the Wh-scope information in prosody induced by this processing constraint provides an additional processing cause of the subordinate Wh-scope preference and hence another possible clue to resolve the controversy over the Subjacency effect in Japanese Wh-sentences.

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