Prosody and *wh*-scope in Osaka Japanese

HITOMI MINAMIDA
Cornell University

1. Introduction

It has been claimed that (Tokyo) Japanese is sensitive to *wh*-islands if the appropriate prosody is assigned (Deguchi and Kitagawa 2002, Ishihara 2003, *a.o.*). In (1), for example, the *wh*-word *dare* 'who' is normally bound by the embedded Q-marker *ka*, yielding a matrix yes/no question **(embedded scope (ES) reading)**. Under the right prosodic conditions, however, the association between the *wh*-word and the matrix Q-marker *ka* is claimed to be possible, which gives us a matrix *wh*-question **(matrix scope (MS) reading)**. The two associations are schematized in (2).

(1) *Tokyo Japanese*
Jiro-wa [Marina-ga *dare*-o yonda**-ka**] itta**(-ka)**?
Jiro-TOP Marina-NOM who-ACC called/invited-Q said-Q
ES reading: 'Did Jiro say [who$_i$ Marina called/invited t_i]?'
MS reading: 'Who$_i$ did Jiro say [whether Marina called/invited t_i]?'

(2) [... [... *wh* ... +Q] ... +Q]?

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Deguchi and Kitagawa's and Ishihara's claim is that there is a one-to-one mapping between prosody and interpretation in Tokyo Japanese. However, these researchers did not conduct any perception experiments to support this claim, as pointed out by Hirotani (2005). Hirotani (2005) did conduct a series of perception experiments on the construction in (2) in Tokyo Japanese. Her experiments were a forced-choice task; participants listened to each recorded question with ES or MS prosody in Tokyo Japanese and they chose either the yes/no answer or the *wh*-answer shown on the screen. Hirotani (2005) found the following things. First, with ES prosody, yes/no answers are preferred. This is expected because ES prosody is the prosody for yes/no questions. Second, with MS prosody, there is no preference between the two types of answers. This is surprising because MS prosody is the prosody for *wh*-questions. As a consequence, Hirotani (2005) concluded that (2) is unambiguous with ES prosody, while it is ambiguous with MS prosody.

In Tokyo Japanese, *wh*-scope is marked by the range of F0 pitch compression (Deguchi and Kitagawa 2002, Ishihara 2003, *a.o.*).[1] The F0 peaks of *wh*-words are boosted because they are semantically focused words (*P(rosodic)-focalization* in Ishihara's (2003) terminology). P-focalization reduces the F0 peaks of the words in the *wh*-scope domain (*Post-FOCUS reduction* in Ishihara's (2003) terminology).

Disambiguation of (2) by prosody has been reported to be observed in Fukuoka Japanese and Korean. However, these languages use different strategies for *wh*-scope marking from Tokyo Japanese. Fukuoka Japanese and Busan Korean[2] use "an exceptional high flat F0 contour" (Hwang 2015: 37; see also Hwang (2006), *a.o.* for these varieties). Hwang (2009) also reports Seoul Korean data; she claims that boundary tones are the cues to disambiguate (2).

In this paper, I present new findings from my two pilot experiments on the interaction of *wh*-scope and prosody in Osaka Japanese, a variety hitherto unstudied for this phenomenon. Section 2 discusses the differences between Tokyo and Osaka Japanese in terms of how *wh*-interrogatives are pronounced. Section 3 shows that Osaka Japanese uses F0 pitch compression to mark *wh*-scope with my data from a mini production experiment. Section 4 presents my pilot survey data, which show results similar to Hirotani's (2005) experiments. I claim that (2) is unambiguous, but allows what I call "pragmatic" answers. Section 5 compares my Osaka Japanese data with Hwang's (2015) Tokyo Japanese, Fukuoka Japanese, and Busan Korean data and sug-

[1] The range of F0 pitch compression can be understood in terms of prosodic phrasing (see Hirotani 2005). See the results of my production experiment in Section 3. See also the discussion in Kitagawa and Hirose (2012).

[2] Hwang (2015) calls this variety "South Kyŏngsang Korean", but I will call it "Busan Korean" in this paper for convenience.

gests a possible explanation for the difference in acceptability of (2) with MS prosody across these languages. Section 6 concludes the paper.

2. *Wh*-interrogatives in Tokyo and Osaka Japanese

In Tokyo Japanese, when *wh*-words are used as interrogative words, they are all accented (Kitagawa 2005, Shimoyama 2006). This pitch accent along with semantic focus are considered to cause F0 pitch compression (Kitagawa 2005). (3) shows the tone patterns of some *wh*-interrogatives in Tokyo Japanese. In (3), apostrophes represent pitch accent, which is indicated by a sharp F0 fall (H*+L), following McCawley's (1968) notation. Thus, the words in (3) are all realized as HL.

(3) Wh-*interrogatives in Tokyo Japanese*[3]
da're 'who', *na'ni* 'what', *do'ko* 'where', *i'tu* 'when', etc.

In Osaka Japanese, in contrast, *wh*-interrogatives are all unaccented.[4] There are two big differences between Osaka and Tokyo Japanese (McCawley 1968, Haraguchi 1977, Kori 1987, Pierrehumbert and Beckman 1988). First, unlike in Tokyo Japanese, where all words begin in L unless the first mora is accented, words begin either in H or L in Osaka Japanese. Second, in low-beginning unaccented words, the final mora is realized as H when the words are pronounced in isolation or occur before another low-beginning word; when the words appear before a high-beginning word, all the moras in the low-beginning words are realized as L.[5]

(4) shows how *wh*-interrogatives are pronounced in Osaka Japanese. Following McCawley's (1968) notation, an apostrophe in front of the word indicates that the word is low-beginning, but that does not mean that low-beginning words are "preaccented" in McCawley's sense. The high-beginning *wh*-interrogatives in (4a) are realized as HH, while the low-beginning *wh*-interrogatives in (4b) are realized as LH when they are pronounced in isolation or when they occur before a low-beginning word.

[3] The data here are from Shimoyama's (2006) (5).

[4] In this paper, "Osaka Japanese" refers to the varieties spoken in the Osaka metropolitan area or *Kei-Han-Shin* (Kyoto-Osaka-Kobe). Osaka Japanese data in this section are from the author's observations as a native speaker.

[5] In Tokyo Japanese unaccented words, on the other hand, only the first mora is realized as L (McCawley 1968, Haraguchi 1977, Pierrehumbert and Beckman 1988, *a.o.*).

(4) Wh-*interrogatives in Osaka Japanese*

a. *High-beginning words*
dare 'who', *doko* 'where', etc.

b. *Low-beginning words*
'nani 'what', *'itu* 'when', etc.

3. *Wh*-scope marking in Osaka Japanese

I ran a mini production experiment to verify how *wh*-scope is marked in Osaka Japanese. The data show that Osaka Japanese uses the same strategy as Tokyo Japanese: it uses F0 pitch compression (or prosodic phrasing).

3.1. Procedure

In this experiment, I tested how the structure in (5) is disambiguated by prosody in Osaka Japanese. I used the complementizer *-te*[6] (*-tte* in Tokyo Japanese) as the embedded complementizer. Since *-te* is the so-called quotative complementizer, it is [±Q], depending on the prosody. It is [+Q] when ES prosody is assigned, while it is [−Q] when MS prosody is assigned. I will call the structure in (5) the ***te*-construction**. I did not test the structure in (2) because whether it allows the MS reading is controversial. I will call the structure in (2) the ***ka*-construction** because the embedded complementizer is *-ka*, which is always [+Q].

(5) [... [... *wh* ... ±Q] ... +Q]?

The experiment took place in March 2019 in the Phonetics Lab at Cornell University. I had one female native speaker of Osaka Japanese as a participant. She lived in Ithaca, New York, United States at the time of the recording. She is a non-linguist and was naïve about the purpose of this experiment.

The stimuli are the two sentences in (6) and (7). They include *dare* 'who' and *'nani* 'what' to compare how high-beginning and low-beginning *wh*-interrogatives mark *wh*-scope. Following the similar experiments by researchers such as Hirotani (2005) and Hwang (2015), the words in the stimuli except for the *wh*-words are all accented to see F0 pitch compression clearly. The procedure is almost the same as the procedure of Hwang (2015). I told the participant that (6) and (7) can have two interpretations and be uttered with two prosodic patterns. I showed her the two contexts and two model answers for each sentence at the same time in written text in Osaka Japanese, given in

[6] This *-te* is different from the one that occurs in gerundive forms, which are called *te*-forms in L2 grammar.

(6) and (7). I gave her time to think and practice. After that, I asked her to repeat each sentence eleven times. I discarded the first recording and analyzed the rest of the ten recordings, following Kubozono (2007). Apostrophes in (6) and (7) show the location of pitch accent and high/low-beginningness.

(6) *High-beginning* dare

Ji'ro-wa [Ma'rina-ga *dare*(-o) 'Mino'h-ni yo'nda**-te**] (
Jiro-TOP Marina-NOM who-ACC Minoh-to invited-C/Q
Go'ro-ni) yu'uta**(-ka)**?
Go'ro-to said-Q

ES reading: 'Did Jiro say (to Goro) [who$_i$ Marina invited t_i to Minoh]?'
MS reading: 'Who$_i$ did Jiro say (to Goro) [that Marina invited t_i to Minoh]?'

a. *ES reading*
Answer: うん、言うたで。('Yes, (Jiro) said.')
Context: まりなは昨日誰かを箕面に呼んで、次郎はそのことを五郎に言うたやんな？
('Marina invited someone to Minoh yesterday, and Jiro told Goro about it, right?')

b. *MS reading*
Answer: 太郎。('Taro.')
Context: まりなは昨日誰かを箕面に呼んで、次郎はそのことを五郎に言うたけど、私、まりなが誰（を）呼んだか知らんねん。（だから、聞くで。）
('Marina invited someone to Minoh yesterday, and Jiro told Goro about it, but I do not know who Marina invited. (So I will ask you.)')

(7) *Low-beginning* nani

Ji'ro-wa [Ma'rina-ga *'nani*(-o) 'Naga'o-ni mo'rota**-te**] (
Jiro-TOP Marina-NOM what-ACC Nagao-from received-C/Q
Go'ro-ni) yu'uta**(-ka)**?
Go'ro-to said-Q

ES reading: 'Did Jiro say (to Goro) [what$_i$ Marina received t_i from Nagao]?'
MS reading: 'What$_i$ did Jiro say (to Goro) [that Marina received t_i from Nagao]?'

a. *ES reading*
Answer: うん、言うたで。 (‘Yes, (Jiro) said.’)
Context: まりなは昨日何かを長尾に貰うて、次郎はそのことを五郎に言うたやんな？
(‘Marina received something from Nagao yesterday, and Jiro told Goro about it, right?’)

b. *MS reading*
Answer: 本。 (‘A book/books.’)
Context: まりなは昨日何かを長尾に貰うて、次郎はそのことを五郎に言うたけど、私、まりなが何（を）貰うたか知らんねん。（だから、聞くで。）
(‘Marina received something from Nagao yesterday, and Jiro told Goro about it, but I do not know what Marina received. (So I will ask you.)’)

3.2. Results

I analyzed the data with Praat (Boersma and Weenink 2018). Figures 1 and 2 present the pitch tracks of (6), which involve the high-beginning *wh*-interrogative *dare* ‘who’ with ES and MS prosody, respectively. *Go’ro-ni* ‘Goro-to’ was not recorded because the participant could not figure out how to utter the sentence with it.[7] The figures show that the F0 peak of the *wh*-word is boosted and that the F0 peaks of the words in *wh*-scope are lowered, which indicates that Osaka Japanese uses the same strategy as Tokyo Japanese to mark *wh*-scope. Recall that *wh*-interrogatives in Osaka Japanese are all unaccented, unlike their Tokyo Japanese counterparts. The data show that even unaccented words can cause F0 pitch compression.

I measured the F0 peaks of the *wh*-word and the matrix verb in each prosodic pattern. The results of the two sample t-test are in Table 1, which shows that the mean F0 peaks of the matrix verb and the *wh*-word are significantly different between the two prosodic patterns at the 0.05 significance level.

	ES (Hz)	**MS (Hz)**	**p-value**
***Wh*-word**	266.42	301.81	$p < 0.0001$ ($t = 7.56$, $df = 13.74$)
Matrix verb	283.13	151.41	$p < 0.0001$ ($t = -13.7$, $df = 11.86$)

TABLE 1 Results of the two sample t-test on (6)

[7] However, this does not mean that (6) with *Go’ro-ni* ‘Goro-to’ is ungrammatical because another Osaka Japanese speaker (my consultant) was able to include it in her speech.

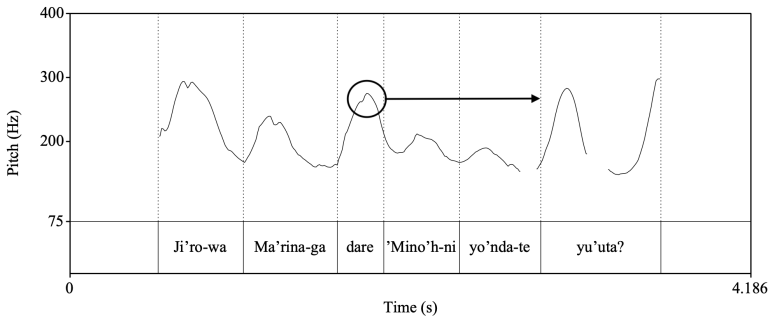

FIGURE 1 High-beginning *dare* 'who' (6) with ES prosody

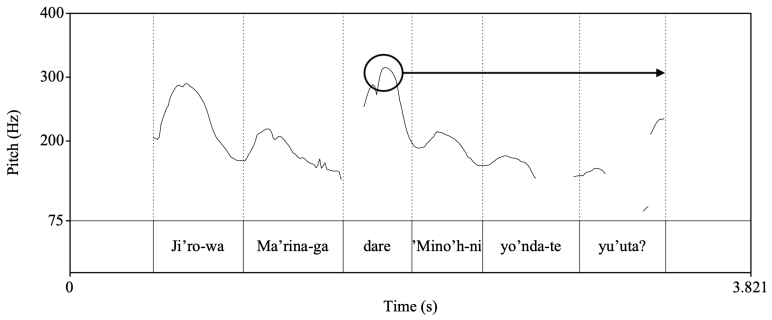

FIGURE 2 High-beginning *dare* 'who' (6) with MS prosody

Figures 3 and 4 are the pitch tracks of (7), where the *wh*-word is the low-beginning *'nani* 'what'. Again, *Go'ro-ni* 'Goro-to' was not recorded for the same reason mentioned above. The figures tell us that low-beginning *wh*-words also cause F0 pitch compression. This fact is interesting. Recall that *'nani* is low-beginning unaccented, which is realized as LH. The data show that the H tone on the second mora of *'nani* 'what' is raised due to the semantic focus of the word and reduces the F0 peaks of the words in the domain. However, the F0 pitch compression effect is small in Figure 3 because there are some bumps in the *wh*-domain.

As I did for the high-beginning *dare* 'who', I measured the F0 peaks of the *wh*-word and the matrix verb in both prosodic patterns. I applied the two sample t-test to the data and Table 2 shows the results. The data show that the mean F0 peaks of the matrix verb and the *wh*-word are significantly different between the two prosodic patterns at the 0.05 significance level.

	ES (Hz)	MS (Hz)	p-value
***Wh*-word**	278.95	295.02	$p = 0.0005$ ($t = 4.28$, $df = 17.41$)
Matrix verb	349.36	165.64	$p < 0.0001$ ($t = -17.16$, $df = 13.74$)

TABLE 2 Results of the two sample t-test on (7)

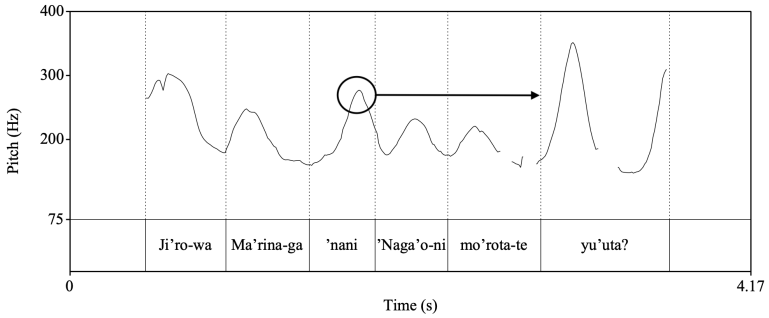

FIGURE 3 Low-beginning *'nani* 'what' (7) with ES prosody

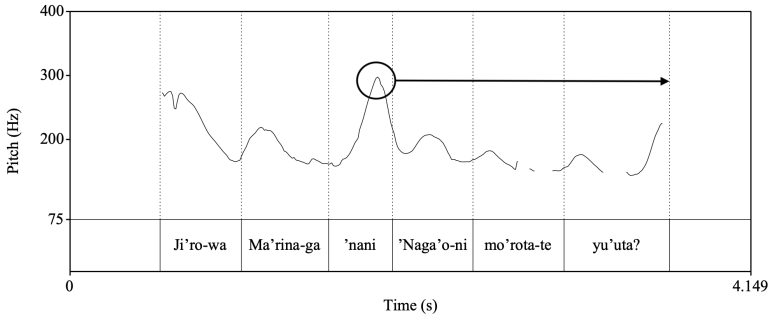

FIGURE 4 Low-beginning *'nani* 'what' (7) with MS prosody

3.3. Discussion

I showed that Osaka Japanese uses F0 pitch compression in *wh*-scope marking. Recall that *wh*-interrogatives in Osaka Japanese are all unaccented, unlike their Tokyo Japanese counterparts and that the pitch accent in *wh*-interrogatives causes F0 pitch compression in Tokyo Japanese (Kitagawa 2005). My data support Pierrehumbert and Beckman's (1988) claim that any H+L sequence can work as pitch accent in Osaka Japanese.[8] However, the effect of F0 pitch compression was smaller in Figure 3. It is possible that

[8] In my stimuli, the *wh*-words are followed by L (*'Mino'h* and *'Naga'o*: LHL).

prosodic phrasing rather than F0 pitch compression is what is operative for disambiguation (Hirotani 2005). The data also showed that the F0 peak of the *wh*-word is higher in the MS reading than in the ES reading in both (6) and (7), replicating the results in Kitagawa and Hirose (2012) for Tokyo Japanese.

4. Perception study

This section presents the data from my pilot perception experiment. My data show similar results as Hirotani's (2005) data for Tokyo Japanese. I argue that the structure in (2) is in fact unambiguous and that it looks ambiguous because it allows pragmatic answers.

4.1. Procedure

I conducted an online survey, using PsyToolkit (Stoet 2010, 2017). Ten Osaka Japanese speakers participated in the survey.[9] As a control, I compared the *ka*-construction in (2) and the *te*-construction in (5). As I mentioned in Section 3, the difference between the two constructions is the embedded complementizer. In the *ka*-construction, it is *-ka*, which is [+Q], while in the *te*-construction, it is *-te*, which is [−Q]. The example sentences are in (8) and (9). Apostrophes indicate the location of pitch accent.

(8) Ka-*construction in Osaka Japanese*
Ji'ro-wa [Ma'rina-ga *dare* yo'nda**-ka**] yu'uta**(-ka)**?
Jiro-TOP Marina-NOM who.ACC called/invited-Q said-Q
ES reading: 'Did Jiro say [who$_i$ Marina called/invited t_i]?'
MS reading: 'Who$_i$ did Jiro say [whether Marina called/invited t_i]?'

(9) Te-*construction in Osaka Japanese*
Ji'ro-wa [Ma'rina-ga *dare* yo'nda**-te**] yu'uta**(-ka)**?
Jiro-TOP Marina-NOM who.ACC called/invited-C/Q said-Q
ES reading: 'Did Jiro say [who$_i$ Marina called/invited t_i]?'
MS reading: 'Who$_i$ did Jiro say [that Marina called/invited t_i]?'

I made four sentences each for the two constructions (4 × 2). Words were all accented except for the *wh*-words *dare* 'who' and *'nani* 'what'. I used the verbs *yo'nda* 'called/invited' and *mo'rota* 'received' for the embedded verb and the verbs *yu'uta* 'said' and *ki'ita* 'heard/asked' for the matrix verb. The *wh*-words were in direct object position. The eight sentences were assigned either ES or MS prosody in Osaka Japanese (8 × 2). The sixteen sentences

[9] Most participants were undergraduate students at Ritsumeikan University in Kyoto, Japan. I had eleven participants, but excluded the data from one participant because s/he stopped answering the questions in the middle of the survey and did the whole survey again.

were paired with either a yes/no answer or a *wh*-answer as in (10) (16 × 2).[10] I added sixty-four filler items to the thirty-two experimental items.

(10) *Two answer types*

a. *Yes/No answer*
うん、言うたで。 ('Yes, (Jiro) said.')

b. Wh-*answer*
太郎。 ('Taro.')

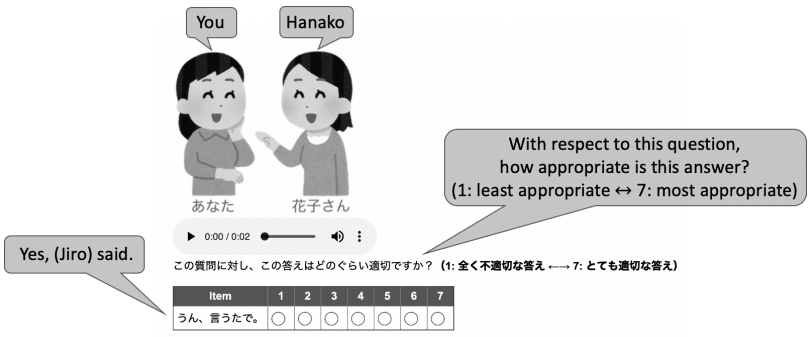

FIGURE 5 Survey screen

I asked my participants to listen to each question recorded by the author. They rated the appropriateness of the recorded question with respect to the yes/no answer or the *wh*-answer on the screen. I used a 7-point Likert scale, where 1 is the least appropriate and 7 is the most appropriate. This is a crucial difference with Hirotani's (2005) experiments, as hers were a forced-choice task, where participants were forced to choose either a yes/no answer or a *wh*-answer after listening to each question. Unlike her experiments, my survey tested how appropriate each combination is. I did not provide any context, except for the picture[11] in Figure 5, where "you" and Hanako are having a conversation and Hanako is asking you a question.

We have the following prediction. If Deguchi and Kitagawa's (2002) and Ishihara's (2003) analysis is correct, both the *ka*-construction and the *te*-construction would behave in the same way with both ES and MS prosody.

[10] The stimuli included "hybrid answers", which involve both a yes/no answer and a *wh*-answer (e.g. "Yes, Taro."). However, I decided not to use them as experimental items and treated them as filler items because I did not find anything interesting.

[11] I used a picture from *Irasutoya* (`https://www.irasutoya.com/`), following the terms and conditions. It is copyrighted by Mr. Takashi Mifune.

4.2. Results

I transformed the ratings into z-scores to eliminate scale bias and averaged them, but I did not test for statistical significance due to the small number of participants ($n = 10$). Figure 6 and Table 3 show that yes/no answers were strongly preferred in both constructions with ES prosody, which means that the two constructions behave similarly with ES prosody. Surprisingly, Figure 7 and Table 4 show that the two constructions behave differently with MS prosody; *wh*-answers were strongly preferred in the *te*-construction, whereas there was no strong preference in the *ka*-construction, as Hirotani (2005) found for Tokyo Japanese. Note that the error bars in the figures show standard deviation.

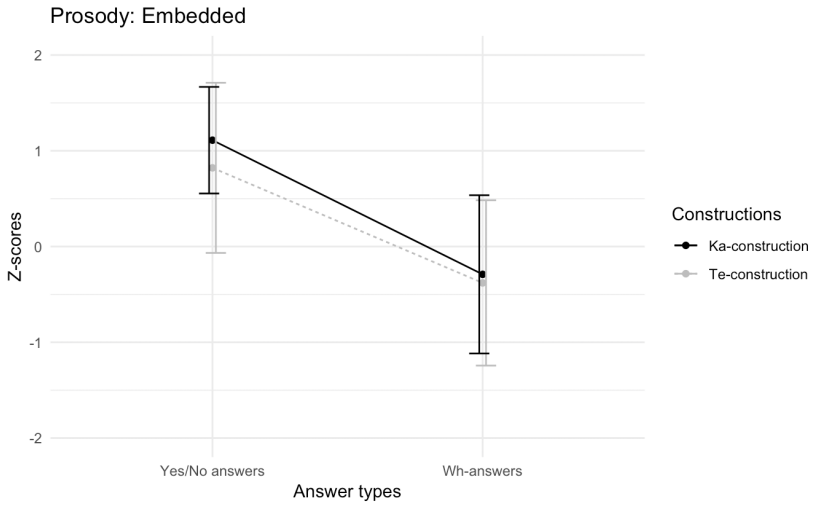

FIGURE 6 ES prosody

	Yes/No answers	***Wh*-answers**
***Ka*-construction**	1.11 (0.56)	−0.29 (0.83)
***Te*-construction**	0.82 (0.89)	−0.38 (0.86)

TABLE 3 ES prosody: Average z-scores (SD)

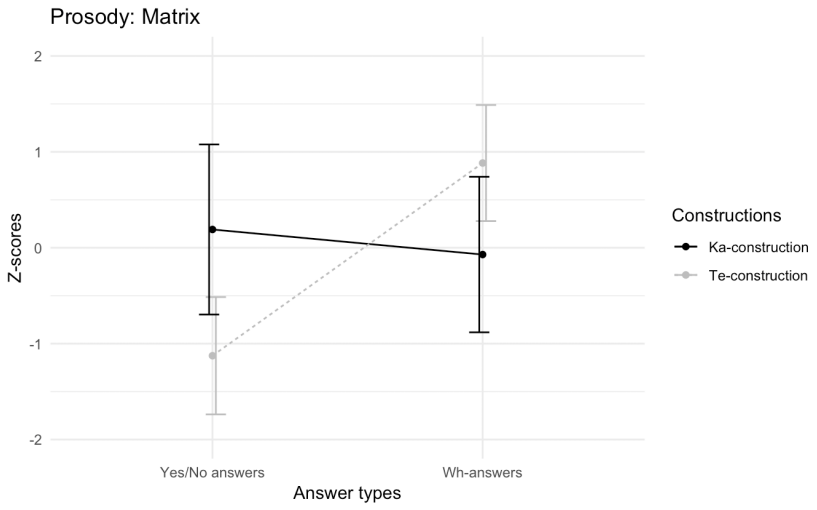

FIGURE 7 MS prosody

	Yes/No answers	***Wh*-answers**
***Ka*-construction**	0.19 (0.89)	−0.07 (0.81)
***Te*-construction**	−1.13 (0.61)	0.88 (0.61)

TABLE 4 MS prosody: Average z-scores (SD)

4.3. Pragmatics

I conducted a mini survey after the main survey to see if every combination between construction and prosody is well-formed. In this mini survey, the same ten participants listened to two sentences each for the three combinations (*-ka* + ES, *-te* + ES, and *-te* + MS) and four sentences for *-ka* + MS from the main survey. I asked them to rate the naturalness of the prosody, using a 7-point Likert scale (1: not natural at all and 7: very natural). The mean ratings were 6.75 for *-ka* + ES, 2.38 for *-ka* + MS, 5.4 for *-te* + ES, and 5.95 for *-te* + MS; *-ka* + MS was rated substantially lower than the other combinations.

This fact can explain why there was no preference between the two answer types in this condition. Since I did not tell my participants beforehand that some stimuli might sound unnatural or ill-formed, they may have made an effort to interpret the ill-formed questions, using the two strategies in (11). It is possible that the same explanation holds for Hirotani's (2005) Tokyo Japanese data.

(11) *Two strategies*

a. **Strategy I**: Ignore MS prosody and interpret the questions with the embedded Q-marker *-ka* (= yes/no questions)
b. **Strategy II**: Ignore the embedded Q-marker *-ka* and interpret the questions with MS prosody (= *wh*-questions)

Also notice in Figures 6 and 7 and Tables 3 and 4 that although *wh*-answers are dispreferred with ES prosody, the ratings are slightly better than yes/no answers in the *te*-construction with MS prosody. I claim that this is what the previous studies have interpreted as ambiguity in the *ka*-construction in (2). Some speakers try to provide a "super-informative" answer to matrix yes/no questions. In English, for example, a speaker may answer a question like "Did Mary say who bought the book?" with "Yes, Bill.", providing a value for the variable associated with the embedded *wh*-word.

To sum up, the *ka*-construction in (2) is not ambiguous, but looks ambiguous because of pragmatics. Deguchi and Kitagawa (2002) and Ishihara (2003) claim that there is a one-to-one correspondence between prosody and interpretation and Hirotani (2005) argues against this claim. In fact, these two claims are partially correct; there is a one-to-one correspondence between prosody and interpretation, but the *ka*-construction in (2) with MS prosody is ill-formed.

5. Comparison with Tokyo Japanese, Fukuoka Japanese, and Busan Korean

Hwang (2015) conducted perception experiments on Tokyo Japanese, Fukuoka Japanese, and Busan Korean. Her experiments used a forced-choice task, like Hirotani's (2005): participants chose a yes/no answer or a *wh*-answer after listening to each question with ES or MS prosody in each variety. The embedded complementizer was *-ka* in Tokyo and Fukuoka Japanese and *-ci* in Busan Korean. She did not provide any context. (12) shows one of the stimuli in Busan Korean.

(12) *Busan Korean*

Kyengchal-un [kunal Yumi-ka *nwukwu*-lul mannassnun**-ci**]
police-TOP that.day Yumi-NOM who-ACC met-Q
mwuless-eyo**?**
asked-ending

ES reading: 'Did police ask [who$_i$ Yumi met t_i on that day]?'
MS reading: 'Who$_i$ did the police ask [whether Yumi met t_i on that day]?' (Hwang 2015: (6))

Hwang (2015) concluded that all three languages can overcome *wh*-islands with MS prosody. She found that all Busan Korean participants almost always chose *wh*-answers in this condition, which tells us that Busan Korean can override *wh*-islands with MS prosody.[12]

However, she reports that there was between-speaker variability as to how acceptable *wh*-answers were in the *ka*-construction with MS prosody in Tokyo and Fukuoka Japanese. In Tokyo Japanese, the acceptance rate ranged from 0% to 100%, which means that one speaker never allowed *wh*-answers, while another speaker always allowed *wh*-answers. I claim that the speaker with 0% acceptability consistently used Strategy I in (11a), while the speaker with 100% acceptability consistently used Strategy II in (11b). In Fukuoka Japanese, in contrast, the range was from 17.7% to 100%, which means that there were no Fukuoka Japanese participants who never allowed *wh*-answers in this condition. Why were there no Fukuoka Japanese participants who consistently used Strategy I? In other words, why do Fukuoka Japanese speakers tend to use prosody?

Recall that Fukuoka Japanese and Busan Korean use a high F0 plateau prosody to mark *wh*-scope (Hwang 2006, *a.o.*). As pointed out by Hwang (2015) herself, F0 pitch compression, which is used in Tokyo and Osaka Japanese, can be used to mark focus, but the high plateau prosody is exclusively used for *wh*-scope marking. I claim that the availability of the high plateau prosody prompts Fukuoka Japanese speakers to use prosody in *wh*-island violation contexts.

6. Conclusion

In this paper, I showed that Osaka Japanese marks *wh*-scope by F0 pitch compression and that the structure in (2) is unambiguous. (2) appears to be ambiguous because it yields a "super-informative" yes/no answer.

Acknowledgments

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[12] Probably, Seoul Korean can also overcome *wh*-islands with MS prosody (see Hwang 2009).

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Note: I did statistical analyses with R (R Core Team 2018). I used the ggplot2 package (Wickham 2016) to make Figures 6 and 7.