Fukuoka Japanese wh prosody in production and perception

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Abstract

The relationship between wh prosody and wh scope in Tokyo Japanese has been both empirically and theoretically controversial. This paper examines the production and perception of wh prosody in the Fukuoka dialect. Results confirm that the characteristic wh prosodic contour and the relationship between wh prosody and wh scope identified in earlier impressionistic and small-scale empirical studies can be observed in the speech of young-adult, linguistically naive speakers of this dialect. However, wh prosody and the prosody/scope relationship show variation both within and between speakers. In particular, the relationship between wh prosody and wh scope is not necessarily the same in perception and production, even for the same speaker; this is consistent with previous findings from Tokyo Japanese.

1. Introduction

The Tokyo dialect of Japanese shows a relationship between the prosody and the syntactic/semantic scope of wh questions (see, e.g., Deguchi and Kitagawa 2002; Ishihara 2002, 2003, 2007; Hirotani 2005, to appear). That is, main-clause wh scope (tends to) correlate with main-clause wh prosody, while embedded-clause wh scope (tends to) correlate with embedded-clause wh prosody. However, the specifics of this prosody/scope relationship have been both empirically and theoretically controversial. Some researchers have argued that the relationship is mandatory, at least at the level of linguistic competence (Deguchi and Kitagawa 2002; Ishihara 2003, 2007), while others have demonstrated that Tokyo speakers show some variation in whether or not the prosody/scope relationship is realized, both in production and in perception (Hirotani 2005, to appear; Hirose and Kitagawa 2011; Kitagawa and Hirose to appear). The implications of the Tokyo pattern for models of the syntax-phonology interface have also been a topic of debate. In particular, the Tokyo wh prosody/scope facts have been used to argue for a Multiple Spell-Out model of the syntax-phonology interface (Ishihara 2002, 2003, 2007); moreover, they have implications for any theory of a constrained interface between syntax and phonology (Hirotani 2005, to appear).

This paper is concerned with a similar wh prosody/scope relationship that has been reported for the Fukuoka dialect of Japanese (Hayata 1985; Kubo 1989 et seq.). In the context of the debates over the Tokyo pattern, it is of considerable interest to investigate the Fukuoka pattern. First, unlike in Tokyo, Fukuoka wh prosody is *different* from focus prosody; it involves not (only) focus prosody, but also a phenomenon of pitch-accent deletion.[1] This means that wh prosody in Fukuoka cannot be seen only as a subcase of focus prosody, as has been proposed for Tokyo (Deguchi and Kitagawa 2002; Ishihara 2002, 2003, 2007). As a consequence, Fukuoka provides an even stronger argument that wh features are relevant to the syntax/phonology interface (see Smith 2011 for additional discussion and theoretical implications). Second, determining whether the wh prosody/scope relationship in Fukuoka is mandatory or allows for variation might provide perspective on that aspect of the Tokyo pattern, and will certainly have implications for how wh effects are to be treated in a model of the syntax/phonology interface.

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[1] Igarashi (2007) demonstrates that focus in Fukuoka Japanese involves F_0 extrema, as in Tokyo Japanese, and not the accent deletion that is observed in wh contexts, confirming that wh prosody in Fukuoka is distinct from non-wh focus prosody. See also Kubo (2010) on this point.

Previously, the Fukuoka case has been investigated largely through introspective judgments and with speakers born in the 1960s or earlier. This project is an empirical investigation of wh prosody in twelve young-adult, linguistically naive Fukuoka speakers. The results of this study show that pitch-accent deletion, the key characteristic of Fukuoka wh prosody as described by Hayata and Kubo, is observed at least half the time for at least seven of the experiment participants. Furthermore, in those utterances that do exhibit accent deletion, evidence for a wh prosody/scope relationship is also found. However, the results show a certain amount of variation both within and between speakers, in line with Hirotani's (2005, to appear) findings for Tokyo. Moreover, a comparison of the results of the production task and a pilot perception task suggests that speakers do not show the same prosody/scope relationships in both tasks; in particular, there appears to be a bias for embedded-scope interpretations in perception that overrides the prosody/scope relationship for some of the study participants. This finding parallels results found in perception tasks for Tokyo speakers by Kitagawa and Fodor (2003), but may require a different explanation from that put forward for Tokyo by Hirose and Kitagawa (2011).

An overview of pitch accent and prosody in Fukuoka, with reference to prior work on Tokyo, is given in §2. The experiment design and methodology for the production study are presented in §3. Results and analysis of the production study for accent deletion and the wh prosody/scope relationship are discussed in §4 and §5 respectively. A pilot production study and its results are described, and compared to the production results, in §6. General conclusions and implications are given in §7.

2. Pitch accent and prosody in Fukuoka Japanese

This section presents a basic description of pitch accent and intonation in Fukuoka Japanese, as described by Kubo (1989 et seq.; see also Hayata 1985).

The overall pitch accent and intonation system resembles Tokyo, on which see, e.g., Pierrehumbert and Beckman (1988); Venditti (1997, 2005). Pitch accent, which is realized as a fall in pitch (fundamental frequency, F_0) from high to low, functions at the word level: nouns may be accented or unaccented (a matter of lexical contrast),[2] whereas verbs and adjectives are predictably accented except in certain deaccenting contexts. A phrase (usually) begins low, and a phrase containing no pitch accents that would introduce an abrupt pitch fall surfaces with high, gradually falling tone.

These basic characteristics of Fukuoka pitch accent and intonation can be seen in the pitch track for the declarative sentence in (1), produced by participant s12. The utterance contains three accented nouns, and the pitch accents are clearly visible as pitch falls. However, the verb phrase *yarareta to* is unaccented (the sentence-final particle *to* is a deaccenting context for verbs), so no pitch fall is observed in this region of the sentence.

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2 Older descriptions of the Fukuoka dialect (e.g., Hirayama 1951 and Kindaichi 1967, as cited by Hayata 1985) indicate that there is no contrast between unaccented and final-accented nouns; if a noun does not have an accent on a pre-final syllable, it is realized with no pitch fall in final position and before genitive *-no*, and as accented on the final syllable before all other monosyllabic case markers. Hayata (1985) confirms this pattern for his informants who were born before 1930 (although he determines that the pattern holds only when the final syllable is light; heavy final syllables do allow for an accentedness contrast). Crucially, however, Hayata (1985: 29, 113) explicitly reports that his young informants, born in the late 1950s, do have a contrast between unaccented and final-accented nouns, and that this contrast is realized in all contexts except before *-no*. The participants in the study reported here are considerably younger still, being born in the late 1980s, and indeed, as seen in §4.2, they all distinguish accented from unaccented nouns even before the case particles used in the stimulus sentences.

(1)   Pitch accents and intonation in Fukuoka Japanese:
       Declarative sentence with accented nouns

       Imanísi-ga   doyóobi   aomúsi-ni   yarareta   to.
       Imanishi-NOM   Saturday   caterpillar-by was.done   PRT
   'Imanishi was affected by caterpillars on Saturday.'

| Imanisi-ga | doyoobi | aomusi-ni | yarareta | to. |
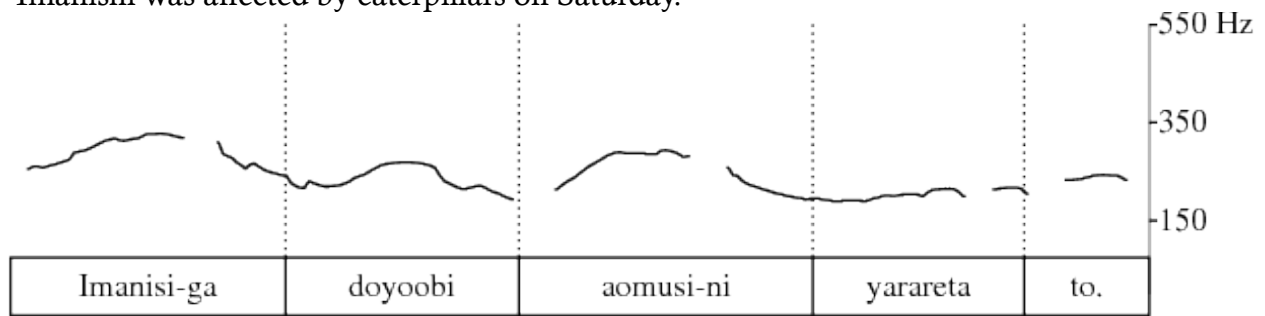
However, wh constructions (and certain semantically related constructions[3]) show a special prosodic contour. This wh prosody was first described by Hayata (1985) as a high flat tone, and it has been described by Kubo (1989 et seq.) as correlating with wh scope, as in Tokyo. Kubo's recent (2001, 2005) phonological interpretation of this wh prosody is as follows: The wh element triggers accent deletion on all words inside the wh prosody domain. The extent of this domain correlates with the wh scope; that is, it begins at the wh phrase and ends at the associated complementizer (Cwh). If the associated complementizer is null and sentence-final, then the entire wh span is realized as one single unaccented phrase. Otherwise (in particular, in the case of an embedded wh complementizer), a default accent is inserted on the penultimate mora of the wh domain, but the wh–C span still contains no other accents, not even lexically expected ones. In either case, the phrase containing no pitch accents that spans the string between the wh element and the complementizer is what creates the characteristic wh "high flat tone".

An example of wh prosody, produced by the same talker as in (1), is shown in (2). This wh question has the same structure and nearly the same lexical content as the declarative sentence in (1), except that the proper name *Imanisi* has been replaced by the wh word *dare* 'who'. Instead of the pitch accents visible in (1), this sentence has a flat pitch contour that extends up to the sentence-final rising tone (which signals a matrix wh question).

(2)   Fukuoka Japanese wh prosody:
       wh question showing high flat tone plus final rise (participant s12)

       dare-ga   doyoobi   aomusi-ni   yarareta   to   **Ø**?
       who-NOM   Saturday   caterpillar-by was.done   PRT   Cwh
       'Who was affected by caterpillars on Saturday?'

| dare-ga | doyoobi | aomusi-ni | yarareta | to? |

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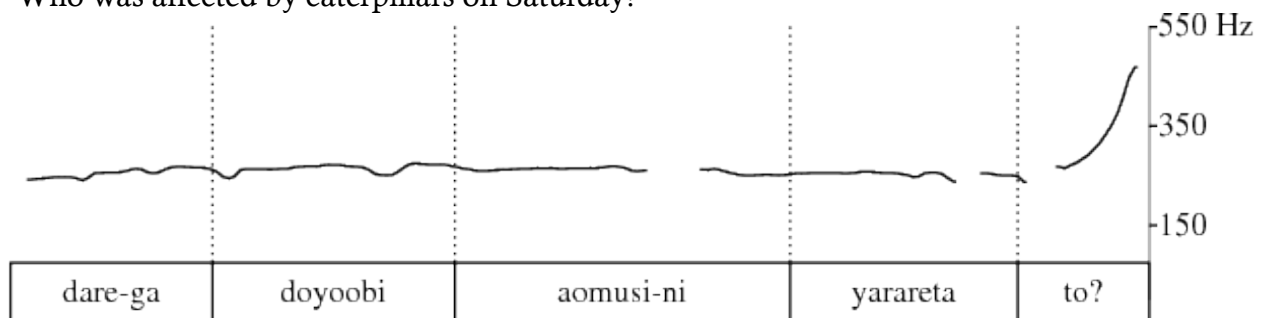
3 See also Kuroda (2005) for a discussion of the prosody of indeterminate phrases as a more general case of wh prosody in Tokyo Japanese.

The goal of this paper is to examine two of the crucial generalizations behind Kubo's analysis of Fukuoka Japanese wh prosody with an empirical investigation of production and perception by young-adult, linguistically naive speakers of this dialect. First, is wh prosody consistently realized with accent deletion? Second, for speakers who realize wh prosody with accent deletion, is there a relationship between wh scope and wh prosody in production and/or perception?

These questions are interesting both empirically and theoretically. Empirically, these findings present evidence that the largely impressionistic descriptions of Fukuoka wh prosody from previous work by Hayata and Kubo can be quantitatively confirmed for some of the speakers in the study, although no study participant is consistent with Kubo's descriptions in all utterances. Theoretically, this study provides a point of comparison with previous investigations of wh prosody in Tokyo Japanese.

3. Production experiment: Participants and materials

This section presents the participant information and design for the production experiment. The results of this experiment are discussed in the following two sections: accent deletion in §4 and the wh scope/prosody relationship in §5.

3.1 Participants

Twelve young-adult speakers of Fukuoka Japanese participated in the production experiment, which was conducted at the Hakozaki campus of Kyushu University in Fukuoka. All participants were born and raised in western Fukuoka prefecture and were self-identified as frequent users of the Fukuoka dialect when speaking with family and close friends. They were paid a nominal amount for their participation.

Participant information[4] is given in Table 1; participants are listed according to their place of origin within western Fukuoka prefecture, ordered from north to south.

Participant	Place of origin	Age	Gender	Deaccenting?
s02	Munakata city	(undergraduate)	female	few
s10	Fukutsu city	21	female	many
s11	Hisayama town	21	female	most
s03	Kasuya district	22	female	few
s01	Fukuoka city	21	female	inconclusive
s04	Fukuoka city	21	female	few
s05	Fukuoka city	20	female	most
s07	Fukuoka city	20	female	many
s12	Fukuoka city	22	female	most
s08	Ogoori city	21	female	many
s09	Ogoori city	20	female	many
s14	Ookawa city	20	male	inconclusive

Table 1. Participant information for the production experiment.

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4 Participant s02 did not report a precise age. Participant codes are not numbered consecutively because two additional Fukuoka speakers, s06 and s13, were recorded only as part of an experiment that is not reported here.

The last column in Table 1 indicates the extent to which each participant's utterances show noun deaccenting in the wh context (discussed in detail in §4 below). Only speakers with deaccenting in most or many items are included in the prosody/scope analysis (discussed in §5). Whether or not a participant shows frequent deaccenting does not seem to be closely correlated with geography.

3.2 Materials

The production experiment consisted of three sets of sentences: wh items, baseline items, and focus items. Only the wh items and the wh-relevant baseline items are analyzed here (see Appendix for a complete list of these items), but the three types were combined into one set of stimuli that was presented to participants in a pseudo-random order.

The wh items involved seven different syntactic structures. The first six structures (coded *w1–w6* in the Appendix) were all unambiguous strings with either matrix or embedded scope expected for each wh item, as shown in (3). Each structure was instantiated with two different lexical frames (coded *x* and *y*), and each lexical frame was used once with accented nouns and once with unaccented nouns (coded *a* and *u* respectively); thus, item *w1xa* is wh structure *1* with lexical frame *x* and an accented noun.

(3)　　Syntactic structures used in unambiguous wh items

　　w1　Single wh item in simple clause (matrix scope)
　　w2　Single wh item in embedded clause, embedded scope
　　w3　Single wh item in embedded clause, matrix scope
　　w4　Two wh items in simple clause (matrix scope for both)
　　w5　Two wh items in embedded clause, embedded scope for both
　　w6　Two wh items in nested wh construction: wh_1 in matrix clause with matrix scope, wh_2 in embedded clause with embedded scope

A seventh wh structure, coded *w7*, was also used. This was an ambiguous string, with a single wh item in an embedded clause that was compatible with either embedded or matrix scope (see §5.1 for details). In this case, the codes *x* and *y* do not represent distinct lexical frames, but instead indicate the discourse context in which the ambiguous string was presented (*x* for embedded-scope context; *y* for matrix-scope context). Again, there were both accented-noun (*a*) and unaccented-noun (*u*) versions of these items. Thus, overall there were 7 structures × 2 lexical frames (or scope contexts) × 2 accent classes = 28 wh items. Moreover, each item was produced two times, for a total of 56 wh utterances per participant.

The baseline (non-wh) items had four syntactic structures, coded *n1–n4*. These items matched the wh syntactic structures *w1-w4*, except that they had non-wh words or phrases in place of the wh words or phrases in the wh items. As with the wh items, each baseline structure *n1–n4* was instantiated with two different lexical frames. One of the lexical frames was the same as one frame from the corresponding wh structure, and was coded *x* or *y* accordingly. The other frame, coded *z*, was different because it was designed to be compared with the focus items, which are not analyzed here; accordingly, these *n_z* items are not included in the analysis reported in §4. Finally, as with the wh items, each structure+lexical frame combination had a version with accented nouns (coded *a*) and a version with unaccented nouns (coded *u*). Overall, there were 4 structures × 2 lexical frames × 2 accent classes = 16 baseline items (8 wh-baseline items and 8 focus-baseline items). Again, each item was produced twice, for a total of 32 baseline utterances per participant.

For the analyses reported here, the wh-baseline items were used in order to measure the F_0 decrease in accented versus unaccented nouns in non-wh contexts, so that this could be compared to the F_0 decrease in lexically accented nouns in wh contexts (see §4). The wh items were investigated at two different points.

First, the F0 decrease in lexically accented nouns was examined and compared with that in accented and unaccented nouns in the equivalent structural positions in the baseline sentences, as just described (see §4). Second, the items with wh elements inside embedded clauses (structures *w2, w3, w5, w6,* and *w7*) were examined to determine whether the domain of wh prosody was limited to the embedded clause or not, based on the F0 decrease at the end of the embedded clause (see §5).

Items were presented to participants one at a time, in a different pseudo-random order for each participant. Each item was preceded by a description of a context that was designed to facilitate the intended semantic interpretation, such as the intended scope of the wh element. Participants were asked to read the context silently and then produce the target utterance as if they were uttering it in the given situation, repeating it twice (or more if they made an error, until two usable repetitions were recorded). Each item, with its context, was printed on a card in Japanese orthography.[5] An example of a question with (an English translation of) its context is given in (4).

(4)   Example question and context

Your brother brought his daughter Noriko to a party. Everyone is taking turns looking after Noriko, but you suddenly get confused about whose turn it is, so you ask:

Dare-ga	[	Noriko-ga	doko-de	asobi-yoo	ka]	wakaru	to	Ø?
who-NOM		*Noriko-NOM*	*where*	*playing-is*	*Cwh*	*know*	*PRT*	*Cwh*

'Who knows where Noriko is playing?'

There were as many focus items as baseline items, so the total number of sentences recorded was 28 wh + 16 baseline + 16 focus = 60 items (each repeated twice). Each participant took approximately 30 minutes to complete the task.

The experiment was carried out in a sound-attenuated room on the Hakozaki campus of Kyushu University in Fukuoka city. Responses were recorded with a Marantz PMD 660 digital recorder (sampling rate 44.1 kHz) and a Radio Shack 33-3012 head-mounted microphone.

4. Production experiment: Accent deletion analysis

One of the goals of the production experiment is to determine whether accent deletion (the absence of an expected lexical pitch accent) is observed in wh contexts, in accordance with Kubo's descriptions. This can in principle be done by examining wh sentences containing lexically accented nouns to see whether any pitch accent is actually realized on the nouns. However, to determine whether a pitch accent is phonetically realized, a diagnostic for accentedness is needed. Such a diagnostic, known as the F0 decrease score, is proposed in §4.1. The accent deletion analysis for the nouns in wh contexts in the production experiment is then presented, with an explanation of the measurement procedure in §4.2, results in §4.3, and discussion in §4.4.

4.1 A diagnostic for accentedness: The F0 decrease score

As seen in §2, a pitch accent in Fukuoka Japanese is realized as a pitch fall from high to low. However, there are three reasons why it is not trivial to determine whether a given noun is phonetically accented or

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5   These preceding contexts were written out in standard (Tokyo) Japanese, in a smaller font, while the utterance to be produced was written in Fukuoka Japanese, in a larger font and surrounded by a box. While having the context written in standard Japanese does introduce a factor that might lead participants to code-switch, discussion with native-speaker linguists suggested that this would be less disruptive to the experiment overall than if the context paragraphs were presented in Fukuoka dialect, which is not usually encountered in written form. In future work, presentation of the context auditorily as spoken by a Fukuoka dialect speaker might be advisable.

unaccented: declination, potential interspeaker differences in pitch levels, and potential interspeaker differences in lexical accent location. The diagnostic for accentedness proposed here, the F_0 decrease score, is designed to compensate for these complications.

Declination is a phenomenon, observed in many if not all languages, whereby the pitch level decreases gradually across an utterance (see, e.g., Ladd (1984) for a cross-linguistic review; Poser (1984) on declination in Tokyo Japanese). If pitch level has a tendency to decrease, then a noun that is several moras long may well end on a pitch lower than where it began, even if it is unaccented. The crucial question, therefore, is not whether there is a pitch fall at all, but whether any observed pitch fall is large enough to qualify as an accent.

Furthermore, there is evidence that the minimum size of a pitch fall required to count as an accent may vary from speaker to speaker. Hayata (1985: 8) reports that when he played a recording of one of his elderly Fukuoka speakers to a roomful of young northwestern Kyushu dialect speakers, opinions varied as to the location of the pitch accent. Briefly, in the place name *kami-gohukumati*, there was a small pitch fall on *ku* and a larger one on *ma*. For Hayata himself (a Tokyo speaker), and for younger speakers from Kitakyushu and Iizuka (in northeastern and central Fukuoka prefecture), as well as for his elderly Fukuoka city speakers, the pitch fall on *ku* was not large enough to be perceived as an accent, so accent was perceived to be on *ma*. However, for younger speakers from Fukuoka city (western Fukuoka prefecture), as well as younger speakers from Saga and Nagasaki prefectures further to the south and west, the smaller pitch fall on *ku* was large enough to qualify as an accent. It is particularly noteworthy that Fukuoka city speakers of different generations patterned differently with respect to this phenomenon.

The third complicating factor is the potential for interspeaker lexical differences in the lexical pitch accent of a given morpheme. Fukuoka speakers are exposed to Tokyo-dialect-based prescriptive norms and to other regional dialects, so it is entirely possible for different Fukuoka speakers to have lexicalized the same (expected) "accented" Fukuoka words with accent on different moras, or no accent at all.

What is needed, then, is an empirical diagnostic for accent that can be established on a speaker-by-speaker basis, but which does not depend on any a priori assumptions about the location of the accent or the size of the F_0 fall. The diagnostic proposed here is the **F_0 decrease score**, which is determined as follows. (Example calculations are given in (6), following the initial presentation of the procedure.)

First, the vowel portion of each mora of a word (or, in the case of the moraic nasal, the entire nasal) is demarcated; here, this was done using the TextGrid feature in Praat, version 5.1.11 (Boersma and Weenink 2009). For each of these vocalic mora intervals, the average F_0 in the interval is then recorded[6] (6a). Next, for each pair of adjacent moras in the word (μ_1, μ_2), the ratio μ_2/μ_1 is calculated (6b). This ratio shows the amount and direction of change: if μ_2 has the same F_0 as μ_1, then the ratio is 1; if μ_2 has a higher F_0 than μ_1 (the pitch rises), than the ratio is greater than 1; and if μ_2 has a lower F_0 than μ_1 (the pitch falls), then the ratio is less than one. The advantage to expressing the relationship between F_0 levels as a ratio, rather than as a difference, is that this normalizes across individual differences in the overall pitch range. Then, the natural logarithm (ln) of the μ_2/μ_1 F_0 ratios is calculated (6c). Since human pitch perception is more nearly logarithmic than linear, the logarithm of the F_0 ratios better represents the perceptual salience of the size of the change in F_0 than the ratios themselves would do. The ln transformation is also conceptually convenient in that equal F_0 values will give $\ln(\mu_2/\mu_1) = 0$, while a pitch rise will give $\ln(\mu_2/\mu_1) > 0$ (positive values) and a pitch fall will give $\ln(\mu_2/\mu_1) < 0$ (negative values). The final step in the calculation of the F_0 decrease score is to sum all and only the *negative* $\ln(\mu_2/\mu_1)$ values for a

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6   Average F_0 values for these intervals were recorded using a Praat script. All Praat scripts used in the course of this project are modified versions of basic scripts made available by Mietta Lennes at <http://www.helsinki.fi/~lennes/praat-scripts/>. All F_0 measurements returned by scripts were hand-checked for apparent pitch-halving or pitch-doubling errors; the few such apparent errors that were found were confirmed by visual inspection of the F_0 contour and corrected by hand.

word (6d). Values are summed over the word so that it is not necessary to know in advance which mora is the locus of the pitch fall; this procedure even takes into account the possibility that the accent's pitch fall may be realized slowly, over the course of three moras rather than two. However, only negative values are added together so that any pitch *rise* that may occur at the start of the word (which would be likely to occur if the word were realized at the beginning of a phonological phrase, for example; see §2) does not cancel out or attenuate the effect of a pitch fall due to a pitch accent.

The result of this calculation, i.e., the sum of all negative $\ln(\mu_2/\mu_1)$ values for a word, is the F_0 decrease score for that word.

Here are two examples of the F_0 decrease score calculation, performed on the lexically accented noun plus particle *aomusi-ni* 'by caterpillars' as produced in the same wh context by two different speakers, s12 and s07. (The pitch track for participant s12 in (5a) is repeated from (2) above.) Impressionistically, s12 appears to have produced *aomusi-ni* (and the surrounding context) with no pitch accents, while s07 appears to have a pitch accent on *aomusi-ni* (as well as on the preceding word *doyoobi* 'Saturday').
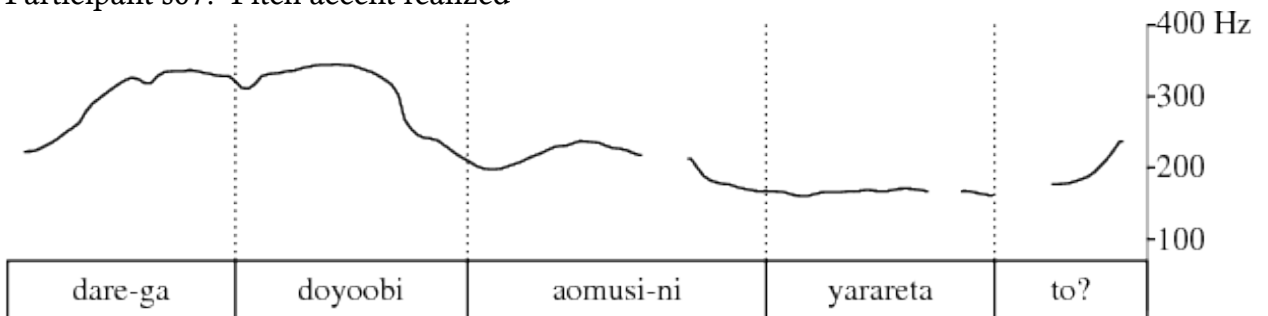
(5)   Two sample pitch tracks

dare-ga	doyoobi	aomusi-ni	yarareta	to	Ø?
who-NOM	Saturday	caterpillar-by	was.done	PRT	Cwh

'Who was affected by caterpillars on Saturday?'

(a)   Participant s12: Pitch accent not realized
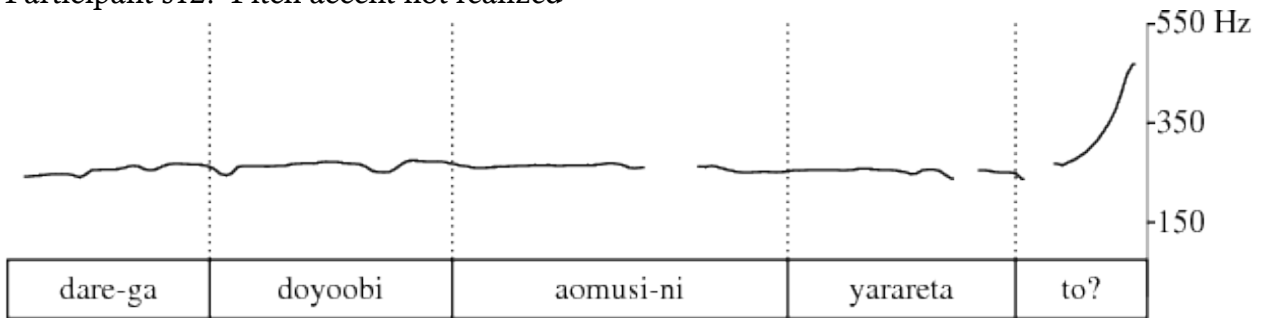
(b)   Participant s07: Pitch accent realized

The calculation of the F_0 decrease score for these two utterances of *aomusi-ni* proceeds as in (6).

(6) Calculation of F$_0$ decrease scores

(a) Mean F$_0$ of the vowel portion of each mora (Hz)

	μ_1	μ_2	μ_3	μ_4	μ_5
Participant	*a*	*o*	*mu*	*si*	*ni*
s12	261.95	264.87	266.04	263.02	251.72
s07	202.87	224.89	226.49	196.39	169.87

(b) F$_0$ ratios between adjacent moras

	μ_2/μ_1	μ_3/μ_2	μ_4/μ_3	μ_5/μ_4
Participant	*a→o*	*o→mu*	*mu→si*	*si→ni*
s12	1.011	1.004	0.989	0.957
s07	1.109	1.007	0.867	0.865

(c) ln of mora ratios

	$\ln(\mu_2/\mu_1)$	$\ln(\mu_3/\mu_2)$	$\ln(\mu_4/\mu_3)$	$\ln(\mu_5/\mu_4)$
Participant	*a→o*	*o→mu*	*mu→si*	*si→ni*
s12	0.011	0.004	-0.011	-0.044
s07	0.103	0.007	-0.143	-0.145

(d) Sum of negative ln values only = F$_0$ decrease score

	$\ln(\mu_2/\mu_1)$	$\ln(\mu_3/\mu_2)$	$\ln(\mu_4/\mu_3)$	$\ln(\mu_5/\mu_4)$	**F$_0$ decrease score**
Participant	*a→o*	*o→mu*	*mu→si*	*si→ni*	
s12	N/A	N/A	-0.011	-0.044	**-0.055**
s07	N/A	N/A	-0.143	-0.145	**-0.288**

Consistent with the impressionistic characterization of participant s12's utterance of *aomusi-ni* as unaccented, but participant s07's utterance as accented, we see that the F$_0$ decrease score for s12 is close to zero, while that for s07 has a larger negative magnitude. (To anticipate the results shown in (14) below, the full analysis of nouns in wh contexts based on F$_0$ decrease scores does indeed classify these two productions as unaccented and accented respectively.)

Speaking more generally, the predictions of an F$_0$ decrease score analysis are as follows. If all test words are of a consistent length, which is the case in this production experiment,[7] then accented words, with their phonologically relevant pitch fall, should have a larger F$_0$ decrease score than unaccented words (with no phonologically relevant pitch fall). That is, the F$_0$ decrease score should be able to distinguish between accented and unaccented words. Furthermore, this measure should also be applicable for diagnosing accent in nouns that occur in a wh context, on the basis of whether their F$_0$ decrease scores are in the range shown in non-wh contexts by unaccented words or accented words.

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7 All words in this experiment used to calculate F$_0$ decrease scores for the accent deletion analysis were four moras long, with the exception of two proper names that were three moras long.

4.2 Measurement procedure

A subset of the overall materials for the production experiment (§3, Appendix) was relevant for the accent-deletion analysis, which required the calculation of F_0 decrease scores for unaccented and accented nouns in non-wh contexts and for accented nouns in wh contexts.

The unaccented and accented nouns in non-wh contexts were taken from the eight wh-baseline items (§3.2). All of these stimuli are shown in (31) and (32) in the Appendix; representative examples are given in (7) below. The noun+particle whose F_0 decrease score was calculated in each sentence is underlined here and in the Appendix. Since there were two repetitions for each item, each participant provided F_0 decrease scores for eight unaccented tokens and eight accented tokens in the non-wh condition.

(7)   Stimuli with nouns in non-wh contexts; full list in (31)–(32)

　　(a)　Unaccented noun
　　　　Imanisi-ga　　doyoobi　　<u>marariya-ni</u>　　yarareta　　to.
　　　　Imanishi-NOM　Saturday　　malaria-by　　　was.done　　PRT
　　　　'Imanishi was hit by malaria on Saturday.'

　　(b)　Accented noun
　　　　Imanisi-ga　　doyoobi　　<u>aomusi-ni</u>　　yarareta　　to.
　　　　Imanishi-NOM　Saturday　　caterpillar-by　was.done　　PRT
　　　　'Imanishi was hit by caterpillars on Saturday.'

The accented nouns in wh contexts were taken from the fourteen accented wh items; since there were two repetitions of each item, each participant provided 28 F_0 decrease score measurements in the wh condition. Again, the full set of relevant stimuli is shown in (33) in the Appendix and an example is given in (8) below. Underlining indicates the noun+particle whose F_0 decrease score was calculated.

(8)   Accented nouns in wh contexts; full list in (33)

　　dare-ga　　doyoobi　　<u>aomusi-ni</u>　　yarareta　　to　　Ø?
　　who-NOM　Saturday　　caterpillar-by　was.done　　PRT　C$_{wh}$
　　'Who was hit by caterpillars on Saturday?'

4.3 Results

For at least ten of the twelve participants in the study, the F_0 decrease score successfully distinguished accented from unaccented nouns in non-wh contexts, and served as a diagnostic for accentedness in wh contexts. The analysis was carried out as follows, separately for each speaker.

First, it was determined whether the unaccented and accented nouns in non-wh contexts, as in (7), had distinct ranges for F_0 decrease scores. These values are plotted as "unacc N" (○) and "acc N" (●) in the graphs that follow, with unaccented items at the top of the graph and accented items at the bottom; vertical position (slightly higher or lower) within each category is not meaningful and was varied only to make it easier to see multiple points near the same value. The F_0 decrease scores are plotted along the horizontal axis, indicating the magnitude of the pitch fall. In some cases, an expected unaccented word had an F_0 decrease score that was of greater magnitude than that of the unambiguously *accented* word with the least decrease, or, conversely, an expected accented item had an F_0 decrease score that was of smaller magnitude than that of the unambiguously *unaccented* item with the largest decrease. In these cases, it is assumed that the speaker had actually produced the item as a member of the opposite accent class. Such

points are plotted as × in the graphs and are excluded from further analysis. As an example, unaccented and accented noun points and excluded points for participant s02 are shown in (9). The excluded (×) points reflect the fact that the leftmost two items from the "accented noun" category and the rightmost two items from the "unaccented noun" category were apparently produced as though they were members of the other category.
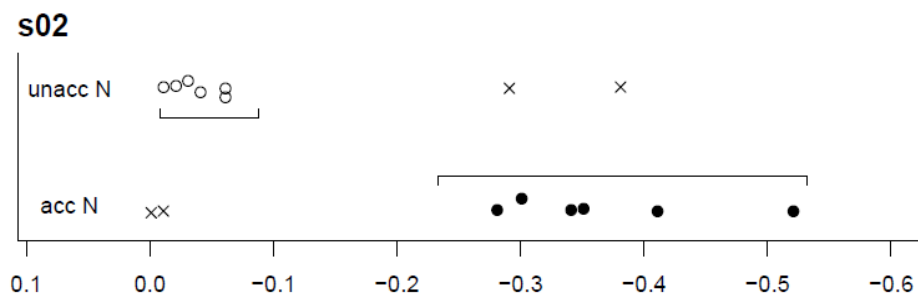
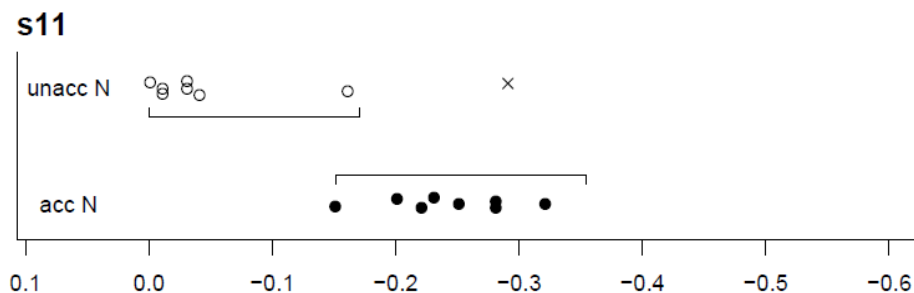(9)   Unaccented and accented nouns, and excluded items
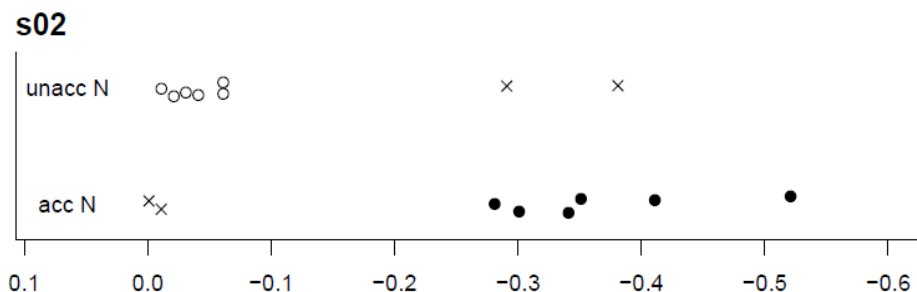
Next, as a way of modeling the *range* of F_0 decrease scores for unaccented words and for accented words for each speaker, 95% confidence intervals (from a gamma distribution that was fit by maximum-likelihood estimation) were determined for the unaccented ($\circ$) points and the accented ($\bullet$) points. These confidence intervals are shown in the graphs as horizontal brackets beneath the unaccented points and above the accented points respectively, as shown in (10) for participants s02 and s11. As will be seen in the full set of participants' results in (11)–(13) below, in nearly all cases, these ranges were either distinct as in (10a), or overlapped only slightly as in (10b). This indicates that the F_0 decrease score is a useful way of empirically distinguishing unaccented from accented nouns, and furthermore confirms that the participants in the experiment do distinguish the two types of nouns in their productions.

(10)   Range of expected F_0 decrease scores for unaccented and accented nouns: 95% confidence intervals

        (a)   Unaccented, accented ranges are distinct

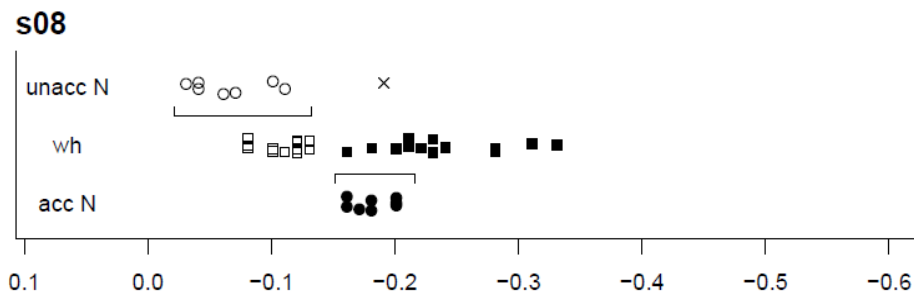(b)   Unaccented, accented ranges overlap slightly[8]

s11

The last step in the analysis was to use the range of expected F_0 decrease scores for unaccented and accented nouns to diagnose whether lexically accented nouns in wh contexts were realized as unaccented. In (11)–(13), F_0 decrease scores for expected accented nouns in a wh context, as in (8), are plotted as squares in the region of the graph between the unaccented and accented points (again, variation in vertical position within the category is for visual clarity only and is not meaningful). Those "wh" points that fall within, or even closer to zero than, the 95% confidence interval for unaccented nouns are categorized as unaccented (or "probably unaccented"; see the explanation of (14) below for this distinction) and are plotted as white squares (□). Those wh points that have an F_0 decrease score of greater magnitude than (to the right of) this limit are categorized as accented (or "probably accented") and are plotted as black squares (■).

For six of the twelve participants (s02, s03, s04, s08, s10, and s14), shown in (11), the unaccented and accented ranges for F_0 decrease scores in non-wh contexts are completely distinct. Participants s08 and s10 show moderately frequent accent deletion (11a), which is defined as having 50% to 75% of the accented nouns in wh contexts realized as unaccented or "probably unaccented." Participants s02, s03, and s04 show accent deletion in the wh contexts much more infrequently (11b), with a majority of accents being realized.

(11)   Distinct unaccented and accented ranges classify wh points

(a)   Moderately frequent accent deletion for nouns in wh contexts

s08

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8   It is notable—in this example of a participant whose unaccented and accented ranges as determined by the F_0 decrease score analysis actually overlap—that the greatest (rightmost) unaccented point and the smallest (leftmost) accented point are near each other and are somewhat separated from the other points in their category. This pattern suggests that one of the two similar mid-range points actually belongs to the other category (i.e., should be ×), which would make the ranges distinct. (In fact, similar situations obtain for the other participants with overlapping ranges, as seen in (12) and (13) below.) But what is crucial here is that the decision of which mid-range point to reclassify cannot be made on the basis of the F_0 decrease scores alone. This is precisely the concept that the use of the 95% confidence intervals is intended to model: F_0 decrease scores in the interval where the ranges overlap cannot be *automatically* classified by this procedure as belonging to the unaccented or accented category (even though other sources of information, such as perception judgments by native speakers, might be able to classify such values). Nevertheless, the fact that for all but one speaker there is at most a very small range of overlap in the ranges shows that the F_0 decrease score analysis is overall a successful method for automatic classification of accentedness category.

s10
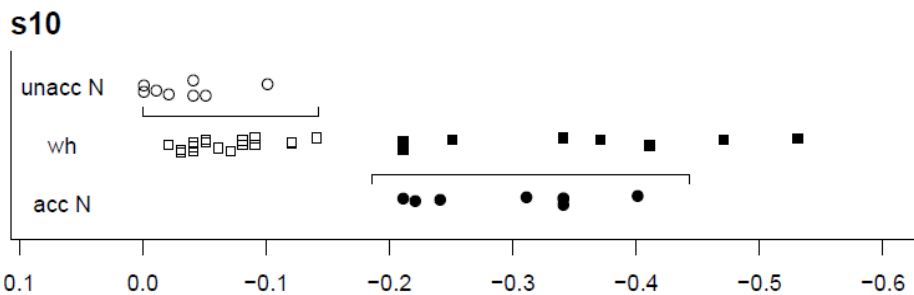
(b) Infrequent accent deletion for nouns in wh contexts

s02

s03

s04
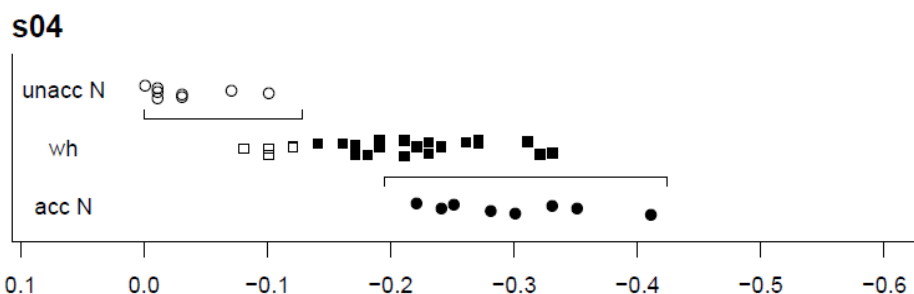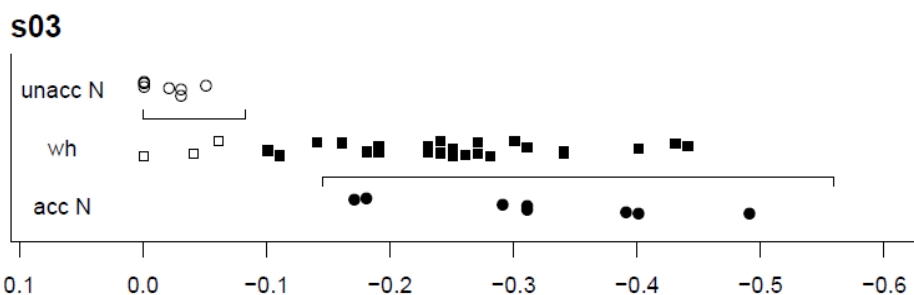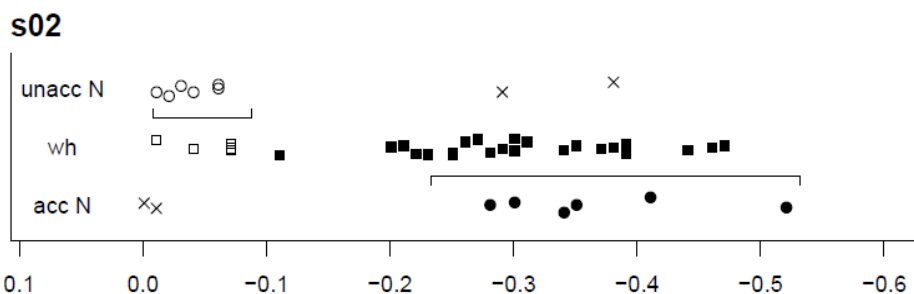
(c) Difficult to interpret

s14
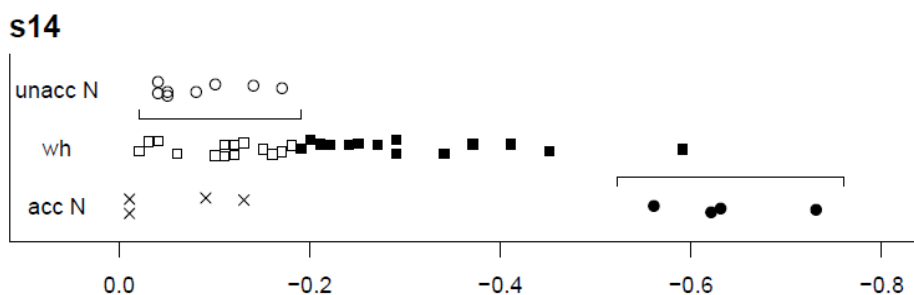
Participant s14 (11c) is somewhat difficult to classify. By the categorization developed above, he shows deaccenting in exactly half of the wh items. On the other hand, visual inspection of the graph in (11c) actually indicates that nearly all of his wh items have F_0 decrease scores that are distinct from his accented non-wh items; a number of the wh points seem to form a sort of continuum with those that are

13

classified as unaccented, and this might be evidence that the cutoff for the unaccented category should be further from zero, allowing for a larger F_0 decrease score. And yet, impressionistically, s14's productions do not sound particularly typical for a Fukuoka speaker, and an F_0 decrease score of 0.4 or even 0.3 is considerably larger than is seen in unaccented items for any of the other speakers (recall that, because the F_0 decrease score involves a ratio, absolute differences in pitch ranges between speakers have already been normalized to some extent).[9] For this reason, participant s14 has been grouped with the infrequent deaccenters and excluded from the prosody/scope analysis in §5. It might also be relevant that this participant's place of origin, Ookawa, is considerably more distant from Fukuoka city proper than any of the other locations in Table 1 above.

For five more participants (s05, s07, s09, s11, and s12), shown in (12), there is a small amount of overlap between the non-wh unaccented and accented ranges. However, the ranges are for the most part distinct, and very few of the wh points actually fall in the zone where the ranges overlap. This means that the accentedness status of the nouns in wh contexts is still fairly clearly established on the basis of the F_0 decrease score analysis. Among these speakers, s05, s11, and s12 show highly frequent accent deletion (75% or more), and s07 and s09 show moderately frequent accent deletion (between 50% and 75%).

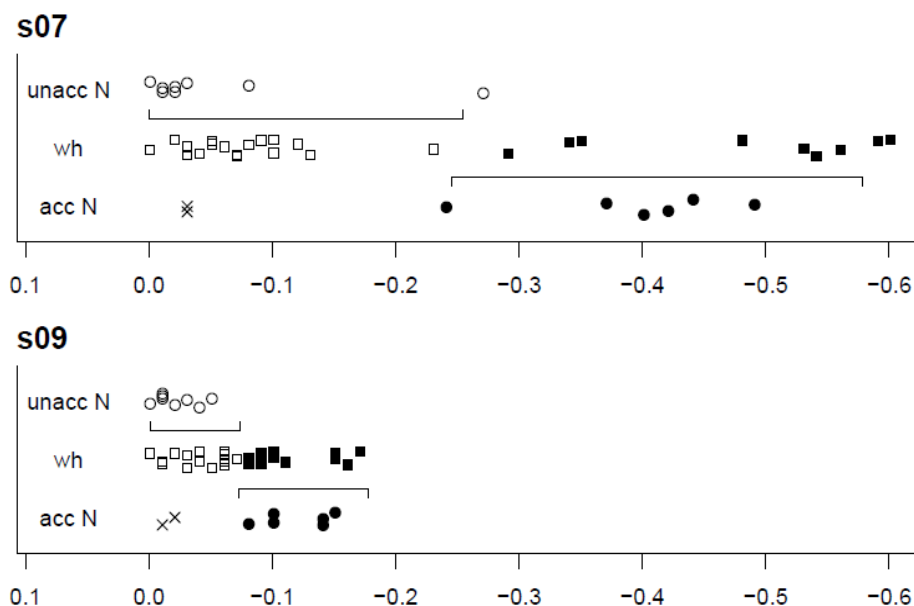(12)   Unaccented and accented ranges overlap slightly, but most wh points clearly classifiable

(a)   Highly frequent accent deletion for nouns in wh contexts


<hr>
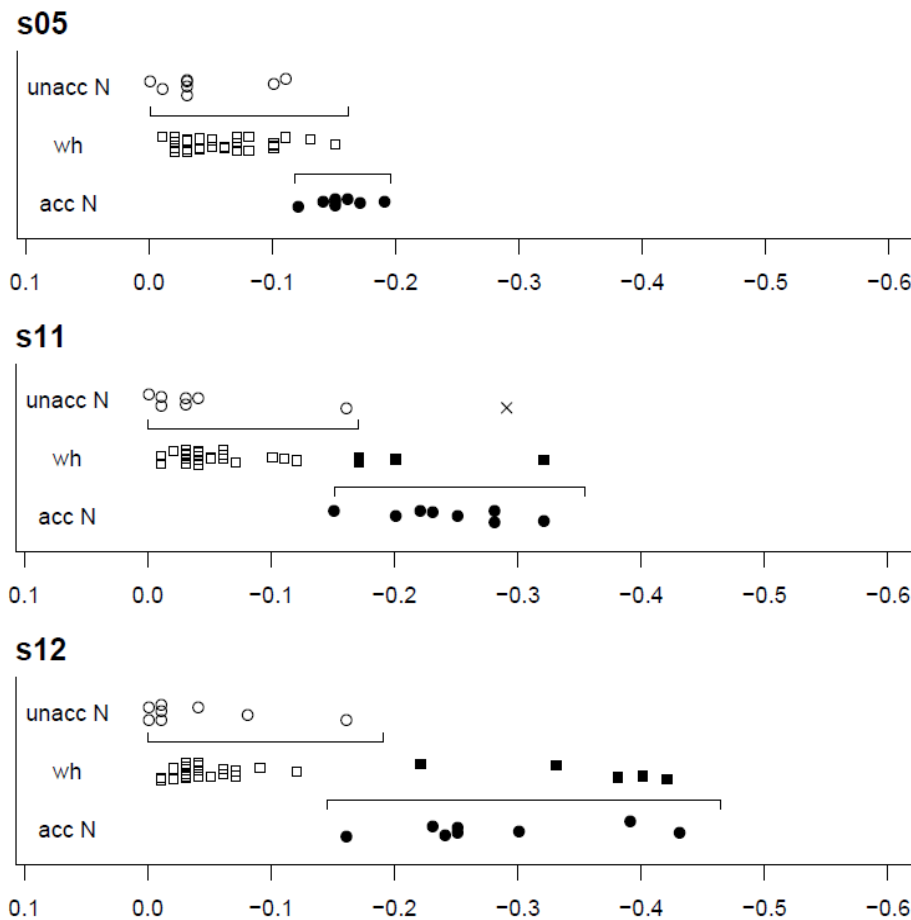
9   The horizontal scale on the graph for participant s14 has a higher maximum magnitude than the other graphs. This is because s14 has larger F_0 decrease scores for accented items than were recorded for any other participants.

(b)   Moderately frequent accent deletion for nouns in wh contexts

The only participant for whom the F_0 decrease score analysis does not adequately distinguish accented and unaccented nouns is s01 (13). This participant has a large amount of overlap between the accented and unaccented ranges, and many of the wh points fall into this overlapping interval.

(13)   Large overlap in unaccented and accented ranges
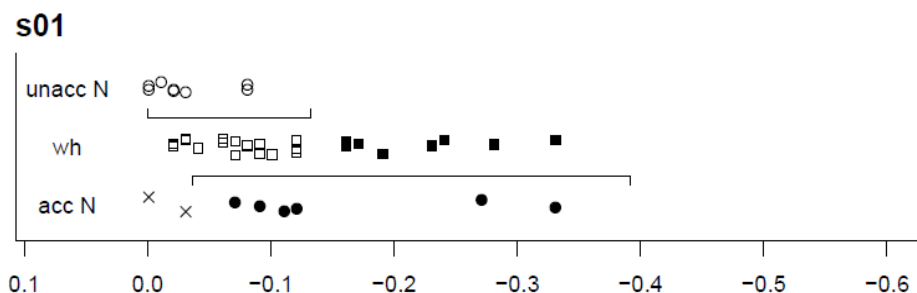
Even here, a look at the actual F_0 decrease scores for this speaker's non-wh items shows that the scores do actually fall into two distinct clusters, with the unaccented items and many of the (expected) accented items having F_0 decrease scores smaller than 0.15, and the remaining accented items having F_0 decrease scores greater than 0.25. This suggests that the difficulty with the analysis in this specific case may stem from this speaker having realized a large proportion of the expected accented nouns as unaccented. If this is so, then even participant s01 would actually have distinct ranges for accented and unaccented words.

Thus, the F_0 decrease score method presented in §4.1 does distinguish unaccented and accented nouns in non-wh contexts quite well for all participants except (possibly) s01. This method also allows accented nouns in wh contexts to be classified as to whether or not they show accent deletion.

4.4 Discussion

The chart in (14) summarizes the results of the accent-deletion analysis, allowing for an evaluation of how much accent deletion is shown by the participants in the study and whether it is evenly distributed across the various syntactic structures that were tested (as enumerated in (3)). Each cell in the chart shows the results of the F_0 decrease score analysis for the two repetitions of one experimental item as produced by

15

one participant. Participants are listed from top to bottom in decreasing order of proportion of accent deletion, while items are likewise listed from left to right in decreasing order of proportion of accent deletion when only the highly frequent and moderately frequent deaccenters' productions are considered.

(14) Classifying accented nouns in the wh domain

			item code — *structure type annotation*													
			w3 ya	w5 ya	w3 xa	w1 ya	w2 ya	w1 xa	w6 xa	w4 ya	w5 xa	w6 ya	w2 xa	w7 ya	w4 xa	w7 xa
participant *(# accented)*			*1m*	*2e*	*1m*	*1s*	*1e*	*1s*	*2m*	*2s*	*2e*	*2m*	*1e*		*2s*	
highly frequent deaccenters	s05	*(2)*	..	..	.|	..	..	..	..	|.	..	..	..	..	..	..
	s11	*(4)*	..	..	..	..	..	..	..	..	..	..	..	|A	..	|A
	s12	*(5)*	..	..	..	..	..	..	..	..	A.	..	AA	..	AA	..
moderately frequent deaccenters	s10	*(9)*	..	..	..	..	..	AA	..	..	A.	..	AA	..	AA	AA
	s07	*(11)*	..	..	..	.A	AA	..	..	..	AA	AA	..	AA	..	AA
	s09	*(12)*	..	..	.A	..	..	AA	AA	AA	..	A.	..	AA	AA	..
	s08	*(14)*	..	..	..	.A	..	..	AA	AA	.A	AA	AA	.A	.A	AA
total # accented			*0*	*0*	*1*	*2*	*2*	*4*	*4*	*4*	*5*	*5*	*6*	*6*	*7*	*7*
infrequent deaccenters (and other excluded participants)	s14	*(14?)*	..	a.	..	..	aa	aa	..	Aa	a.	.a	.a	aa	..	aa
	s01	*(??)*	||	.|	|.	||	..	||	|A	||	AA	AA	.|	A|	AA	||
	s02	*(23)*	AA	..	aA	Aa	AA	AA	AA	AA	AA	a.	AA	Aa	aA	..
	s04	*(23)*	aa	.a	aa	..	Aa	..	AA	AA	Aa	AA	aa	AA	AA	AA
	s03	*(25)*	..	aA	AA	AA	.a	AA	AA	AA	AA	AA	AA	AA	aA	AA

Symbols representing accentedness category are defined as follows; the symbols are chosen to be visually iconic, in that greater accentedness correlates with a larger, more visually salient symbol. Tokens that fall inside (or even closer to zero than) the 95% confidence interval for unaccented non-wh-context nouns, and are *not* inside the 95% confidence interval for accented non-wh-context nouns, are classified as "unaccented" (.). Tokens that fall inside the unaccented 95% confidence interval, but *also* inside the accented 95% confidence interval, are classified as "probably unaccented" (|); this category is only relevant for participants whose accented and unaccented ranges overlap (12),(13). Tokens that fall outside the unaccented confidence interval and inside (or even further from zero than) the accented confidence interval are classified as "accented" (A). Finally, tokens that fall further from zero than the unaccented confidence interval, but closer to zero than the accented confidence interval—in other words, between the two ranges—are classified as "probably accented" (a); such points are not directly assigned to either category by the F_0 decrease score analysis, so classifying them as "probably accented" is a conservative labeling strategy chosen to avoid inflating the count of instances of accent deletion with these uncategorizable cases. It is worth noting that, aside from participant s14 (discussed above), almost all the "probably accented" tokens were produced by participants who tend not to delete accents in general.

An examination of the accent-deletion results by stimulus item indicates that, with one exception, no particular syntactic structure seems to impede deaccenting more than any other. The exception is the *w7* structure, which is the ambiguous case (where the same surface string is compatible with both matrix and embedded wh scope); both sets of *w7* sentences had among the highest numbers of productions that showed no deaccenting.

The other six structures *w1–w6* (each with two lexical frames *x* and *y*; all have *a* codes, indicating accented nouns) are further annotated in (14) with a *1* or *2* to show number of wh elements in the sentence plus *s* (simple clause), *e* (embedded wh scope), or *m* (matrix wh scope for a wh item in an embedded clause). There is no indication that items with simple clauses versus embedded wh scope versus matrix wh scope were consistently more likely to resist deaccenting.

One factor that may have affected accent deletion, however, is the distinction between single-wh and multiple-wh structures; items with two wh elements appear to have been somewhat less likely to show accent deletion than items with only a single wh element, as seen by the fact that the *1s/e/m* items in (14) tend to fall further to the left in the chart than the *2s/e/m* items. This is interesting to consider in light of the fact that, impressionistically, the sentences that do not show accent deletion often seem to contain a disfluency or phrase break of some kind, signaled by lower pitch, glottalization, or an elongated vowel (described as characteristics of disjuncture in Tokyo Japanese by Venditti 2005: 185). Perhaps the increased processing complexity of the multiple-wh structures[10] results in a greater likelihood of disruption in the prosodic structure of the utterance, leading to failure of the accent-deletion process that would otherwise characterize wh prosody. Further investigation of such disfluencies and phrase breaks in these materials, and their relationship to accent deletion or the lack thereof, is planned.

Finally, participants who show accent deletion in very few of the utterances, especially s02, s03, and s04, may simply not be using a phonological grammar that has an accent-deletion rule for wh prosody. It would be interesting to see if these participants show characteristics that have been described for the wh prosody of Tokyo-dialect speakers.

In summary, the results of the accent deletion analysis show that, for seven out of the twelve young-adult speakers of Fukuoka Japanese who participated in the study, lexically accented nouns were phonetically unaccented more than half the time when they occurred after a wh element. This finding confirms that at least some young-adult Fukuoka speakers show wh accent deletion in at least some utterances, consistent with Kubo's descriptions of Fukuoka wh prosody. It is these seven speakers whose productions are examined in the prosody/scope analysis discussed in the following section.

5. Production experiment: Prosody/scope analysis

In order to determine whether there is a relationship between wh prosody and wh scope in Fukuoka Japanese, the crucial comparison is between sentences where the semantic scope of the wh element ends at an embedded complementizer (C), and sentences of otherwise similar structure where the semantic scope of the wh element extends to the end of the matrix clause. Kubo's generalizations predict accent near the end of the embedded clause in the case of embedded scope, but no accent at that position in the case of matrix scope. The quantitative prediction, then, is that there should be a larger F_0 drop at the end of the embedded clause in embedded-scope sentences than in matrix-scope sentences.

This prediction was tested with two sets of materials: ambiguous sentences, where the same surface string is compatible with both matrix and embedded scope (§5.1); and unambiguous sentences, where each sentence string is compatible with either only embedded scope or only matrix scope, but embedded and matrix sentences of similar structure can be compared (§5.2). The results are presented in §5.3 and discussed in §5.4.

Seven participants were included in the prosody/scope analysis: those who were classified as highly frequent deaccenters (s05, s11, s12) or moderately frequent deaccenters (s07, s08, s09, s10) in the

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10 The reason why such complex structures were used in this study is because Kubo's (1989) description makes specific claims about prosody in multiple-wh constructions (see Smith (2011) for some of the theoretical implications of these claims), and future analyses are planned that will test those claims using these materials.

accent-deletion analysis presented in §4. Additionally, any individual utterances in which accent deletion has not taken place—those that are classified as "accented" or "probably accented" in (14)—are excluded from the prosody/scope analysis, because such utterances are (by definition) not produced with prototypical Fukuoka wh prosody as described by Kubo (1989 et seq.). For this reason, the exact number of points plotted per scope condition in the graphs in (18)–(22) below will vary between speakers.

5.1 Sentences with ambiguous wh scope

The most direct comparison of the prosody associated with embedded-scope versus matrix-scope wh interpretations can be had from sentences with morphosyntactically ambiguous wh scope. For these items, the surface string is syntactically and semantically compatible with either scope interpretation, embedded or matrix; the intended scope (and, by hypothesis, the prosody) is determined by the discourse context.

The ambiguous sentences in the production experiment (structure *w7*; see (38) in Appendix for the full set of stimuli) were each presented in two different discourse contexts, facilitating embedded scope and matrix scope respectively.

(15)   Examples: Ambiguous sentence with disambiguating contexts

(a)   Context that facilitates embedded scope interpretation

At the store where you work part time, only designated people are allowed to sell things like nigiri sushi and alcohol. It seems that this is not the case for sushi rolls, but in order to make sure, you ask:

[**Dare**-ga   norimaki-o   ut-te   **mo**]   ii   to   Ø ?
who-NOM   sushi.roll-ACC   sell-TE C_{wh} okay   PRT   C
'Is it okay, no matter who sells sushi rolls?'

(b)   Context that facilitates matrix scope interpretation

The only people at work are Hanako, Yôko, and Junko. One of them has to sell sushi rolls. But when you ask the manager who will do it, you get these answers: "Not Hanako." "Not Yôko either." "Not Junko either." Even though one of the three has to do it! You're a little annoyed, so you say to the manager:

Dare-ga   norimaki-o   ut-te   mo   ii   to   **Ø** ?
who-NOM   sushi.roll-ACC   sell-TE   C   okay   PRT C_{wh}
'For whom is it okay, even if they sell sushi rolls?'

If wh prosody extends only to the end of the embedded clause, then a pitch accent should appear on the penultimate mora of the embedded clause (Kubo 1989, 1990a). On the other hand, if wh prosody extends into the matrix clause, then no accent should appear in that position. The pitch tracks in (16), from utterances by participant s12, are impressionistically clear examples of this distinction.

(16)   Ambiguous sentence with two different prosodic contours

(a)   Embedded-scope context; accent at *utté-mo*

dare-ga	norimaki-o	utte	mo	ii	to?
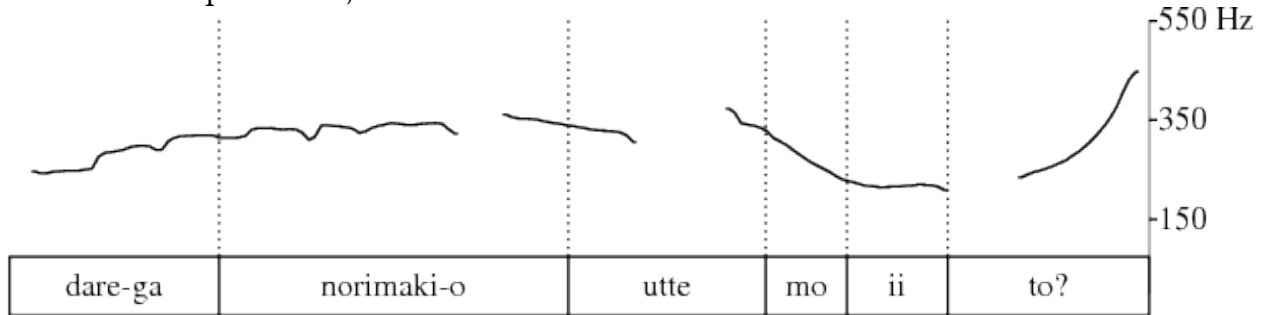
(b)   Matrix-scope context; no accent at *utté-mo*

dare-ga	norimaki-o	utte	mo	ii	to?
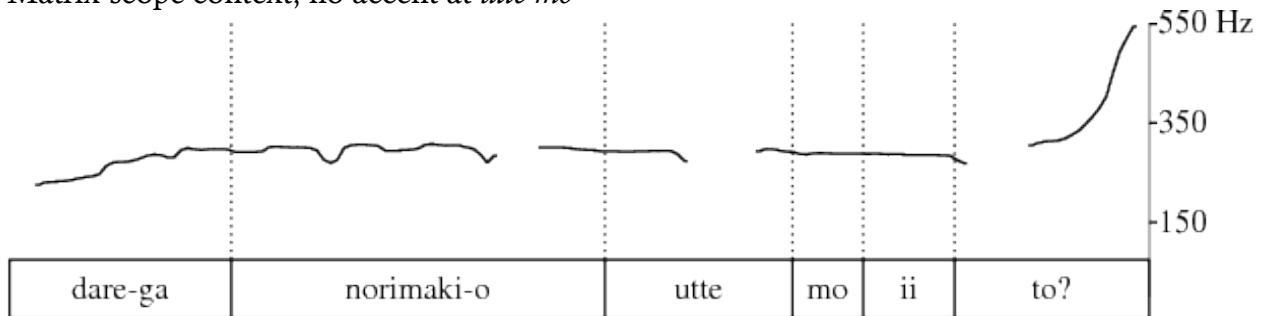
Thus, in order to determine whether wh prosody corresponds with wh scope, it is necessary to see whether there is a pitch fall in the vicinity of the end of the embedded clause.

For this analysis, the following measurement procedure was employed. First, the vowel portion of the mora in the complementizer (*mo*) was demarcated, using a TextGrid in Praat. Then, the vowel portion of the antepenultimate mora of the verb (*utte*) was likewise demarcated. As noted above, the expected pattern for embedded-scope wh prosody is a default accent on the penultimate mora of the embedded clause, which would be the final mora of the verb, i.e., [te]. However, in some cases the experiment participants instead indicated the end of the wh prosody domain by realizing the verb with its non-wh accent pattern, with accent falling in this case on the antepenultimate mora, [u]. Thus, the antepenultimate mora of the verb was chosen for this analysis because it would be at or before the pitch fall associated with either of these choices of accent location, and would represent the high-tone span before the pitch fall in either case.

The maximum F_0 in the verb mora and the minimum F_0 in the complementizer mora were recorded using a script in Praat. As was done for the F_0 decrease score described in §4.1 above, the ratio of these two F_0 values μ_C/μ_V was computed, to normalize for differences in pitch range between speakers, and then the natural logarithm of this ratio $\ln(\mu_C/\mu_V)$ was computed. If $\ln(\mu_C/\mu_V) > 0$ or $\ln(\mu_C/\mu_V) = 0$, then the pitch either rises or remains the same between the verb and the complementizer, indicating that there is no accent at the end of the embedded clause, and the wh prosody extends into the matrix clause. However, if $\ln(\mu_C/\mu_V) < 0$, then there is a pitch fall. A pitch fall of sufficient magnitude (see §5.3 for discussion) indicates that there is an accent at the end of the embedded clause, and the wh prosody ends at that point.

5.2 Sentences with unambiguous wh scope

While in some respects, sentences with ambiguous scope provide the most straightforward way to compare the prosody of embedded versus matrix scope utterances (since everything but the discourse context can be

held constant), ambiguous examples present complications of their own. For one thing, it is difficult to find natural examples of truly ambiguous strings.[11] For another, the context favoring embedded scope is often more natural or less contrived than the context favoring matrix scope (as can be seen in the example contexts given in (15) above), which may actually lead to uneven facilitation of embedded versus matrix prosody (see §6.3 for additional discussion).

Therefore, the production experiment also included examples of unambiguous sentences that were matched between embedded-scope and matrix-scope items for crucial aspects of the syntactic structure. All unambiguous sentences used in the prosody/scope analysis had an embedded clause containing at least one wh element, but they differed by two factors: whether the (outermost) wh element had embedded scope or matrix scope, and whether the sentences contained just one wh element or two. The full list of stimuli is given in the Appendix in (34)–(37); representative examples are shown in (17).

(17)   Examples: Unambiguous sentences

    (a)   1 wh in embedded clause, embedded scope (1wh-e); full list in (34) (structure *w2*)

        [**dare**-ga   doyoobi   aniyome-o   yondá   **ka**]   siran'yatta.
        who-NOM   Saturday   sis-in-law-ACC   called C_{wh} didn't.know
        '(I) didn't know who called (my) sister-in-law on Saturday.'

    (b)   1 wh in relative clause, matrix scope (1wh-m); full list in (35) (structure *w3*)

        nomiya de [**nan.de** Morioka-ni mukau] hito to   nomi-yotta   to   **Ø**?
        bar at   why   Morioka-to heading person with were-drinking   PRT C_{wh}
        'At the bar, who were you drinking with, identified by why they were going to Morioka?'

    (c)   2 wh in embedded clause, embedded scope (2wh-e); full list in (36) (structure *w5*)

        [**dare$_1$**-ga   doyoobi   **doko$_2$** de amaguri-o   yaitá   **ka$_{1,2}$**] wakaran.
        who-NOM   Saturday   where at chestnuts-ACC   roasted C_{wh} don't.know
        '(I) don't know who roasted chestnuts where on Saturday.'

    (d)   2 nested wh/C pairs, outer wh has matrix scope (2wh-m); full list in (37) (structure *w6*)

        dare$_1$-ga [Noriko-ga *doko$_2$* de asobi-yoo   **ka$_2$**] wakaru to   **Ø$_1$**?
        who-NOM Noriko-NOM where at is-playing C_{wh} know   PRT C_{wh}
        'Who knows where Noriko is playing?'

Like the ambiguous sentences discussed in §5.1, the unambiguous sentences were also presented along with a written paragraph that provided a discourse context, in order to make the sentences as natural as possible and to facilitate the intended semantic interpretation.

The measurement procedure applied to these sentences is equivalent to that described above for the ambiguous sentences, with one exception. The sentences in the single-wh/matrix scope condition (structure *w3* in the Appendix; see (35)) have no embedded complementizer, because this structure uses a relative clause modifying a head noun. Therefore, a mora in the noun immediately following the relative clause was used to provide a value for μ_C in the μ_C/μ_V F_0 ratio for these items. A position three moras

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[11] This is more difficult in Fukuoka Japanese than in Tokyo Japanese. In Tokyo, the complementizer *ka* in an embedded clause can be either [+wh] or [–wh] (see, e.g., Hirose and Kitagawa 2011). In Fukuoka, *ka* has only a [+wh] interpretation in embedded clauses for most speakers (T. Kubo, personal communication).

previous, which falls within the verb and on or before the expected location of the pitch accent of the verb, were it to have one, was used for the μv value. This means that the two measured moras are the same distance apart as for the sentences with embedded complementizers.

5.3 Results

If there is a relationship between wh prosody and wh scope, then we predict a pitch accent near the end of the embedded clause in the case of embedded wh scope and no such pitch accent in the case of matrix wh scope. Quantitatively, the prediction is that embedded-scope items in all three syntactic structure conditions—ambiguous, single wh, and multiple wh—should have a greater decrease in F_0 than matrix-scope items at the crucial region. The structure with nested wh words is classified as a case of matrix scope because, even though the innermost wh element does have embedded scope, this structure is still predicted to have matrix wh prosody because there is one wh element in the sentence with matrix wh scope (Kubo 1989).

The results of the $\ln(\mu_C/\mu v)$ measurements described in §5.1 and §5.2 above, which indicate the magnitude of the difference between the maximum F_0 in the verb mora and the minimum F_0 in the complementizer (or noun) mora, are displayed in (18)–(22). Each graph gives the results for one participant. The points are divided into three horizontal plots centered on a dashed line, one for each syntactic structure type: ambiguous sentences (*amb*), single-wh sentences (*1wh*), and multiple-wh sentences (*2wh*). Within each structure type, items in matrix-scope contexts or with unambiguous matrix-scope structures are plotted as white circles (○) just above the dashed line, while items in embedded-scope contexts or with unambiguous embedded-scope structures are plotted as black circles (●) just below the dashed line. (As above, vertical distance from the dashed line is not meaningful; the circles are vertically staggered so that individual values that lie very close together can be visually distinguished.) Values for the $\ln(\mu_C/\mu v)$ measurement are on the horizontal axis with positive values (pitch rises) toward the left and negative values (pitch falls) toward the right; thus, the further to the right a point lies, the greater the magnitude of the pitch fall between the verb and the complementizer (or noun) for that item. If there is a relationship between wh scope and wh prosody, then within each syntactic structure type, the black circles should lie to the right—have more-negative values than—the white circles.

For each participant, there is a maximum of four "ambiguous" tokens for each scope category (see (38)), and a maximum of eight tokens for each scope category for both the "1wh" and "2wh" structures (see (34)–(37)). However, as noted above, items in which deaccenting did not occur (see (14)) are excluded from the prosody/scope analysis, so the graphs for some of the participants show fewer than the maximum possible number of tokens plotted.
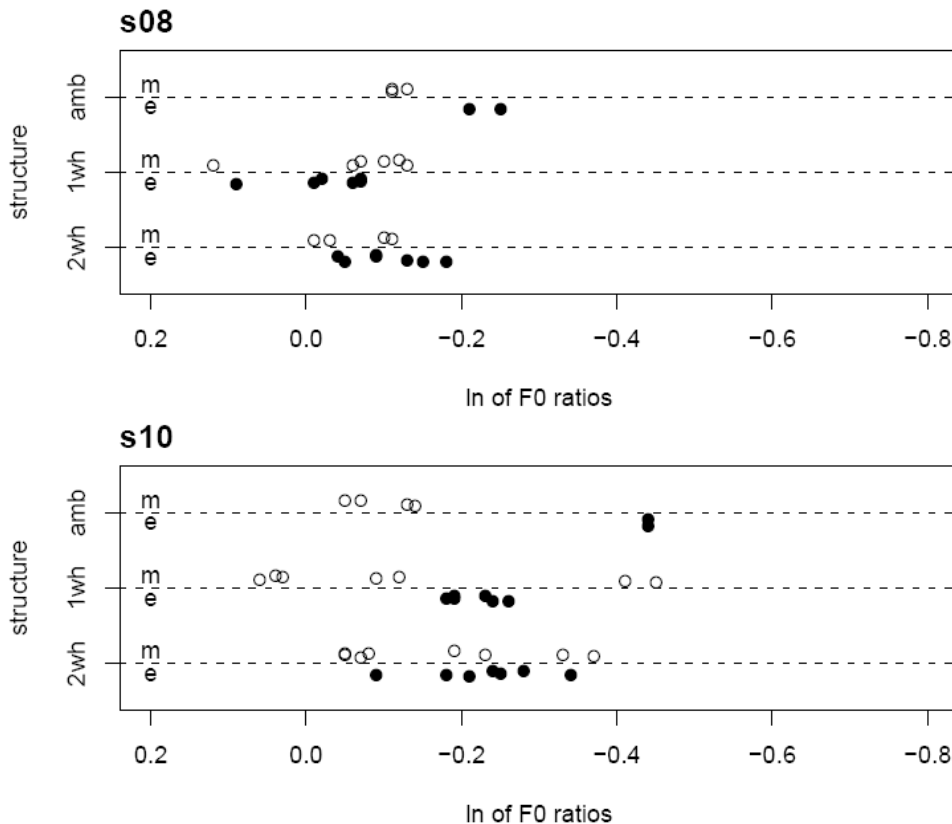
One participant (s12) shows a clear relationship between wh prosody and wh scope in all conditions. There was only one production that failed to follow the prosody/scope pattern (a single-wh item with embedded scope was produced with a pitch fall of the magnitude of the matrix prosody examples on one of two repetitions).

(18)   Relationship between prosody and scope for all structure types

s12
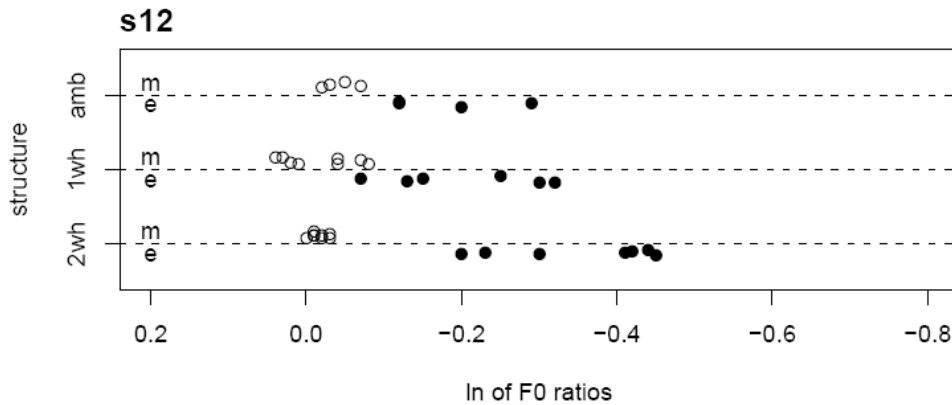
Two participants (s08, s10) show a relationship between wh prosody and wh scope for the ambiguous items, where prosody would serve to disambiguate the two meanings, but show a much less consistent relationship for the unambiguous items. In the unambiguous conditions, one of these participants (s08) seems to show a bias for matrix prosody, in that the points for embedded-scope items (●) are realized in the same range as the points for matrix-scope items (○) (compare the ranges of values seen for this participant in the ambiguous items, where the two scope conditions are distinguished). The other participant (s10) seems to show something of a bias for embedded prosody, in that the embedded-scope items are fairly consistent across the three structures, but some of the matrix-scope items lie within that range as well.

(19)   Relationship between prosody and scope for ambiguous items

s08

s10

One participant, s07, actually shows less of a prosody/scope relationship for the ambiguous items, where only prosody would have served to disambiguate the two meanings, than for the unambiguous

items, where the intended wh scope is already clear from the morphosyntax of the utterance. For the unambiguous items, s07 shows a clear prosody/scope relationship for the simpler single-wh sentences, but appears to show an embedded-prosody bias for the more complex multiple-wh sentences. This participant likewise seems to show an embedded-prosody bias for the ambiguous items.

(20)   Relationship between prosody and scope for unambiguous items
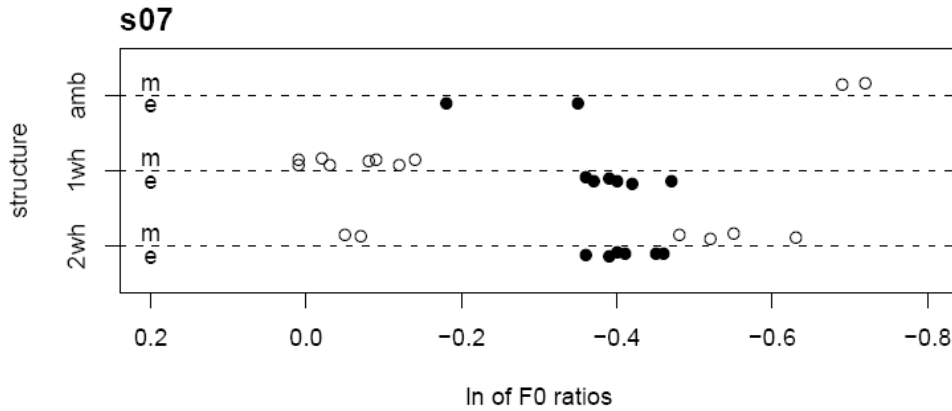
Participant s11 seems to show rather random behavior. There is some indication of a prosody/scope relationship for the ambiguous items, but the cases that do not match do not seem to show a consistent bias toward either matrix or embedded prosody. This participant's productions for the unambiguous cases are also difficult to classify consistently. Somewhat surprisingly, there is a very poor correlation between wh prosody and wh scope in the simpler single-wh sentences and a better match in the more complex multiple-wh sentences. Moreover, there appears to be a bias toward matrix prosody in the former, but toward embedded prosody in the latter.

(21)   Difficult to classify
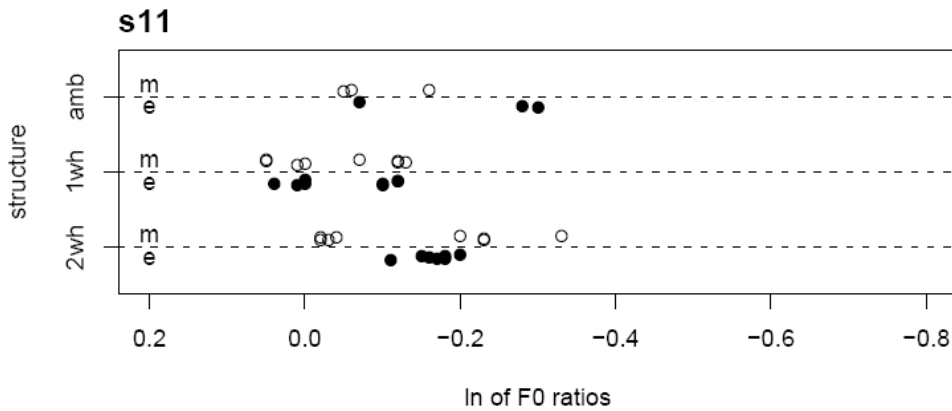
The last two participants (s05 and s09) show poor prosody/scope correlation in all structure types. Both of these subjects show very little pitch fall in the vicinity of the embedded complementizer, indicating a bias for matrix prosody in almost all items, independent of wh scope.

(22)   Poor prosody/scope correlation in all structure types

s05

In of F0 ratios

s09

In of F0 ratios
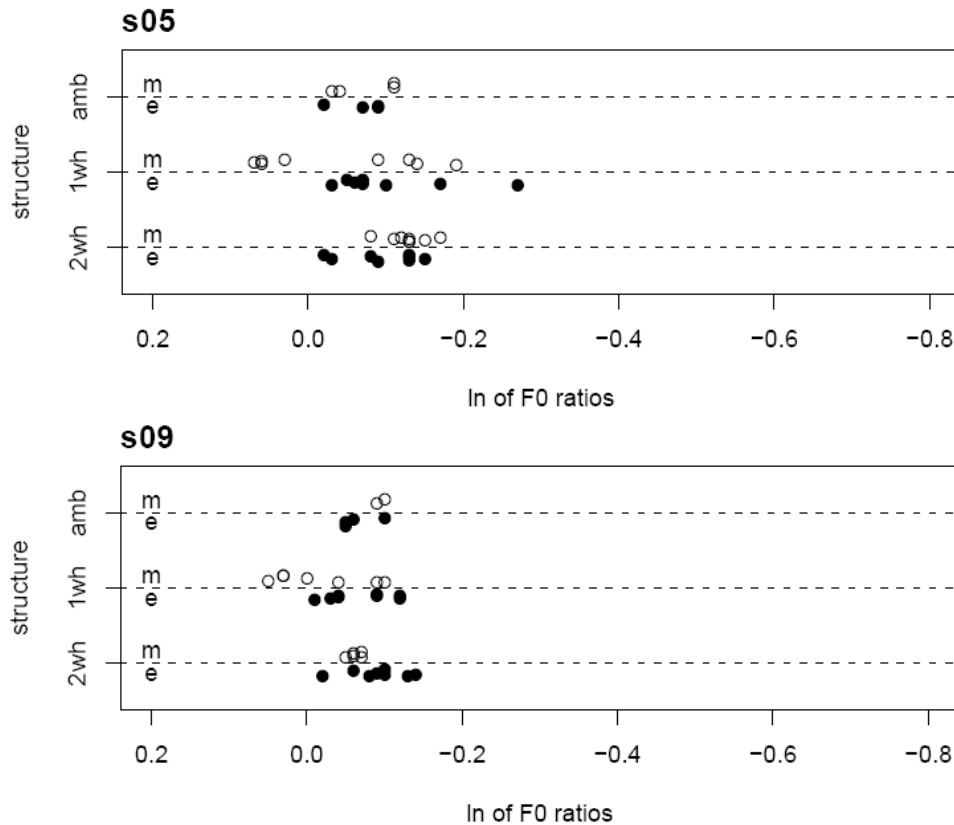
5.4 Discussion

The overall results for the prosody/scope analysis in the production experiment are summarized in the chart in (23). Participants' response patterns are classified as follows: If all or nearly all of the embedded-scope points (●) lie to the right of all of the matrix-scope points (○), the participant is said to have a *good* match between wh prosody and wh scope for that class of syntactic structures. If there is a recognizable matrix-scope cloud to the left and a recognizable embedded-scope cloud to the right, but more than one point from either group is mixed with the other, then the match between prosody and scope is said to be *medium*. If the embedded and matrix points are mixed together with no discernible separation into two clouds, then the match between prosody and scope is said to be *poor*. In medium and poor cases, a further judgment is made as to whether the non-matching responses seem to show a tendency toward patterning as unaccented (matrix prosody bias) or accented (embedded prosody bias), based either on the values for the embedded and matrix points for the same participant in other syntactic structures, or (for the case of matrix prosody bias) on a consistent trend toward values for the $\ln(\mu_C/\mu_V)$ measurements that are very close to zero.

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(23)   Summary: wh prosody/wh scope correlation in production

	Ambiguous *single wh*	Unambiguous	
		single wh	*multiple wh*
s12	good	good	good
s08	good	poor (matrix prosody bias)	poor (matrix prosody bias)
s10	good	medium (embedded prosody bias)	poor (embedded prosody bias)
s07	poor (reverse pattern)	good	medium (embedded prosody bias)
s11	medium	poor (matrix prosody bias)	medium (embedded prosody bias)
s05	poor (matrix prosody bias)	poor (matrix prosody bias)	poor (matrix prosody bias)
s09	poor (matrix prosody bias)	poor (matrix prosody bias)	poor (matrix prosody bias)

Only one participant, s12, shows a good prosody/scope match for all syntactic structure types, but in each syntactic structure condition there is at least one other participant (and sometimes several) who show either a good or a medium match between wh prosody and wh scope. Thus, there is evidence that some Fukuoka speakers are able to manifest a prosody/scope relationship in production.

For speakers whose performance differs between ambiguous and unambiguous sentences, the most common pattern has a better prosody/scope match in the ambiguous sentences, where prosody would be a non-redundant cue to wh scope, than in the unambiguous ones, where prosody would be redundant (see Hirotani 2005, to appear for similar findings with Tokyo speakers). However, one participant, s07, shows the opposite pattern, with a closer relationship between prosody and scope in the unambiguous items than in the ambiguous ones. It is unclear exactly why this would be the case, but it is worth noting that s07's response pattern for the ambiguous items shows neither a matrix-prosody bias nor an embedded-prosody bias. Instead, each of the ambiguous items was produced with the reverse of the expected prosody. This might indicate that s07 was simply not taking the provided discourse context into account—especially given that for the unambiguous items, where context was not necessary for determining the intended wh scope, this participant shows a *more* consistent scope/prosody match than all other participants except s12.

When participants have only a medium or poor relationship between prosody and scope, some are observed to have a consistent bias for embedded prosody (s10, and s07 in the unambiguous multiple-wh items). Studies of the Tokyo dialect have also shown that, for sentences with syntactic structures similar to those examined here, there is a general tendency toward a bias for embedded wh prosody or scope. Some of the factors discussed may relate more to perception than to production, and are discussed in §6.3 below. However, other factors are relevant for production as well. Kitagawa and Fodor (2003, 2006) note that an utterance with a long span of wh prosody in Tokyo Japanese, where wh prosody is realized as post-focus reduction—a region of generally low pitch—may be more highly marked than a shorter wh span, because it does not show the alternation between high and low (or strong and weak) that typically characterizes prosodic structure crosslinguistically. A similar interpretation may be available for Fukuoka, despite the differences in the phonetic realization of wh prosody as compared to Tokyo. Namely, a long span of wh prosody may be dispreferred in Fukuoka because it is a long span of relatively high pitch, i.e., just as undifferentiated as is the case for Tokyo. In addition, given that Kubo (2001, 2005) analyzes the wh

prosody domain in Fukuoka as consisting of one single phonological phrase, it may be the case that matrix wh prosody is more marked because such a long phonological phrase would violate maximality constraints on phrase size (Selkirk 2000).

Conversely, other participants are observed to have a bias for matrix prosody in production (s08, s05, s09). Hirotani (2005) finds a similar effect for Tokyo speakers; some make use of matrix wh prosody even when the semantic interpretation of the utterance clearly has embedded wh scope. Hirotani attributes this pattern to a processing preference in which a wh element is preferentially produced in the same phonological phrase as its associated complementizer; crucially, this generalization allows for cases where the phrase is larger still (as when matrix wh prosody is produced even though the scope of the wh element ends at the embedded complementizer).

6. Perception pilot study: wh prosody and wh scope

Hirotani (2005) has found that Tokyo speakers do not necessarily use the wh prosody/scope correlation in the same way in production and perception tasks. Similarly, Hirose and Kitagawa (2011, Kitagawa and Hirose to appear) find that the most consistent prosodic cues to wh scope produced by their talkers are not necessarily the cues most consistently used by listeners to determine wh scope in sentence processing.

In this study, a pilot perception experiment was carried out in order to investigate whether Fukuoka speakers show evidence of a wh prosody/scope relationship in perception, and more generally how the perception results correspond to the results from the production experiment. Because this was a small-scale study, the results are not conclusive, but they do suggest patterns as well as directions for future investigation. In particular, it seems that there is a strong tendency for subjects to assign an embedded-scope interpretation in perception, even in the presence of matrix prosody. Overall, it seems that a wh scope/prosody correlation is observed more strongly in production than in perception.

The design and materials for the perception study are outlined in §6.1, with results and discussion in §6.2, and a comparison of production and perception results in §6.3.

6.1 Materials and design

Three syntactic structure conditions (plus distractors) were used in the perception study; each sentence was presented both with "embedded" wh prosody (with a pitch accent before the embedded complementizer) and with "matrix" wh prosody (with the wh intonation span extending to the end of the matrix clause). One set of sentences was morphosyntactically ambiguous, compatible with either embedded or matrix wh scope and therefore predicted to be compatible with either pattern of prosody, as in (24). These items test the extent to which prosody influences the choice between available interpretations. The remaining two sets of sentences were morphosyntactically unambiguous, one with embedded wh scope as in (25), and one with matrix wh scope as in (26). These items test whether the interpretation of a sentence is influenced by having a match versus a mismatch between wh prosody and wh scope.

The materials were designed so that an embedded-scope wh interpretation would make the entire sentence a yes/no question, while a matrix-scope wh interpretation would make the entire sentence a wh question. Participants were instructed to listen to each question and then select an "appropriate" answer. There were always three answers provided: one that would be an answer to a yes/no question, one that would be an answer to a wh question, and a final option indicating that "neither answer is good." The participant's response would thus indicate whether the sentence was judged to have embedded wh scope, to have matrix wh scope, or to be ungrammatical (or have some other kind of interpretation altogether), respectively.
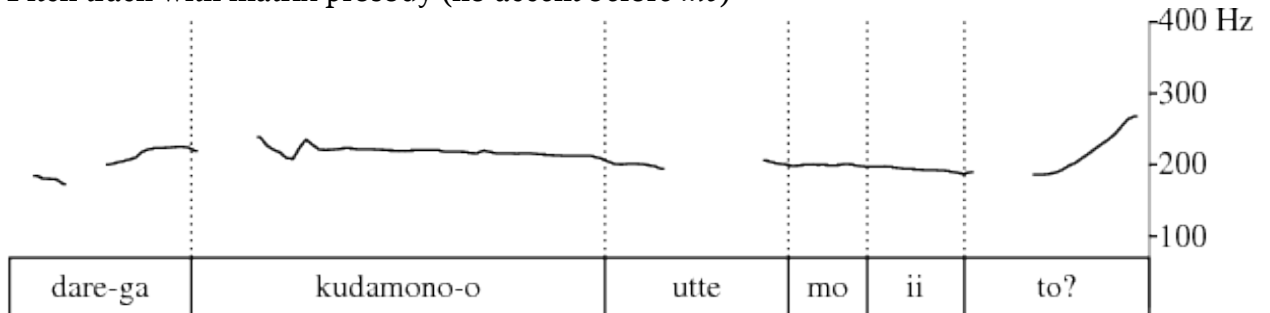
(24)   Example of ambiguous item; full list in (39)

Dare₁-ga   kudamono-o   ut-te **mo**_(1/2)_   ii   to   **Ø**_(2/1)_?
who-NOM   fruit-ACC   sell-TE C   good   PRT   C_{wh}
'Is it okay, no matter who sells fruit?' / 'For whom is it okay, even if they sell fruit?

(a)   Pitch track with embedded prosody (accent before *mo*)
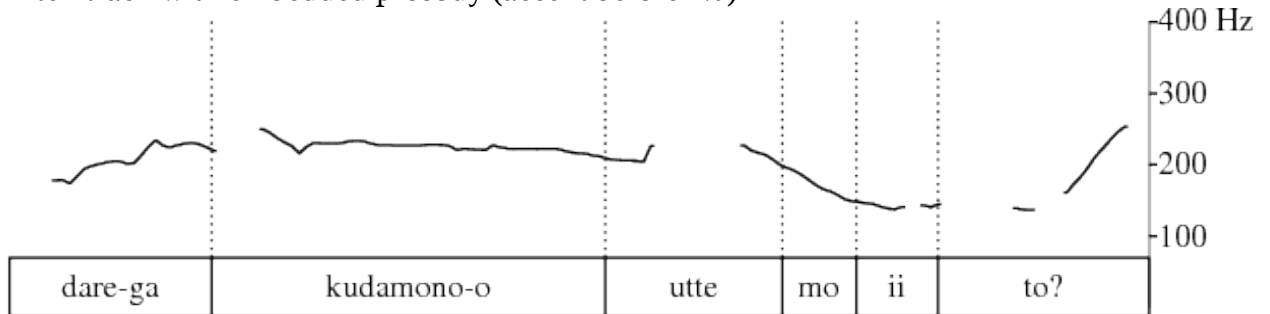
(b)   Pitch track with matrix prosody (no accent before *mo*)

(c)   interpretation with embedded wh scope:
          'Is it okay, no matter who sells fruit?'
       interpretation with matrix wh scope:
          'For whom is it okay, even if they sell fruit?'

(d)   Response options
       (i)   Right. It's fine.   *(yes/no answer; indicates embedded wh scope)*
       (ii)   Tarô.   *(wh answer; indicates matrix wh scope)*
       (iii) *neither answer is good*

(25)   Example of unambiguous item with embedded wh scope; full list in (40)

Naoya-wa   [Mariko-ga   **nan(i)**-o   katta   **ka**]   wakaran   to   Ø?
Naoya-TOP   [Mariko-NOM   what-ACC   bought   C_{wh}]   not.know   PRT   C
'Does Naoya not know what Mariko bought?'

(a) Crucial region of pitch track with embedded prosody (accent before *ka*)

| nan-o | katta | ka | wakaran | to? |

(b) Crucial region of pitch track with matrix prosody (no accent before *ka*)

| nan-o | katta | ka | wakaran | to? |

(c) interpretation with embedded wh scope:
  'Does Naoya not know what Mariko bought?'
(forced matrix wh scope interpretation, if any):
  # 'What doesn't Naoya know whether Mariko bought?'
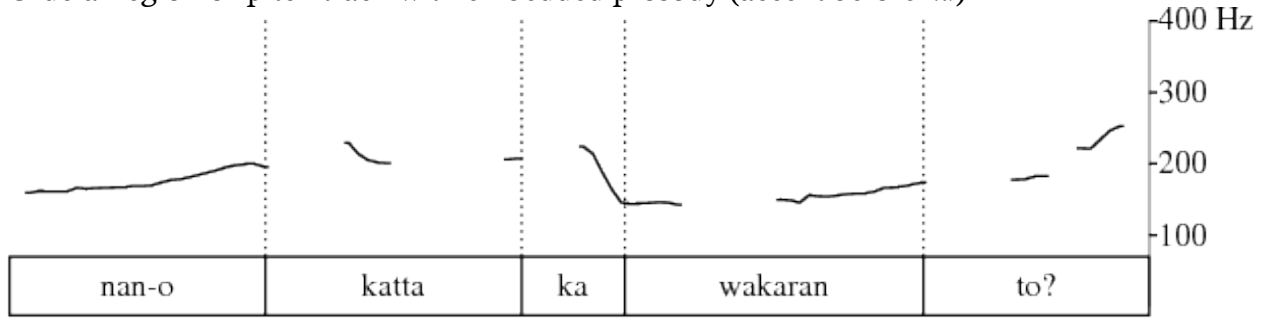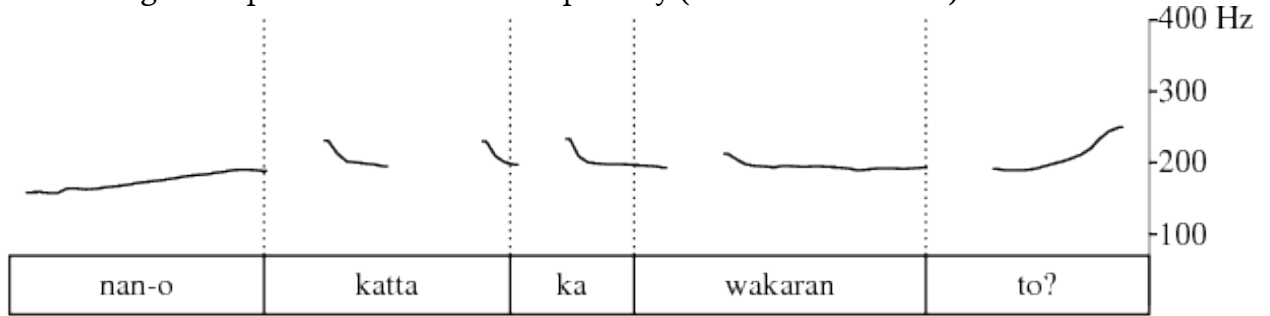
(d) Response options
  (i)   Right. (He) doesn't know.   *(yes/no answer; indicates embedded wh scope)*
  (ii) A coat.   *(wh answer; indicates matrix wh scope)*
  (iii) *neither answer is good*

(26) Example of unambiguous item with matrix wh scope; full list in (41)

Yoohei-wa [Emiko-ga   **nani₁-o**   nonda ka.doo.ka]   wakaran to   **Ø₁?**
Yoohei-TOP [Emiko-NOM   what-ACC drank C   ]   not.know PRT   Cwh
'What doesn't Yôhei know whether Emiko drank?'

(a) Crucial region of pitch track with matrix prosody (no accent at *ka-doo-ka*)

| nani-o | nonda | ka- | doo- | ka | wakaran | to? |

28
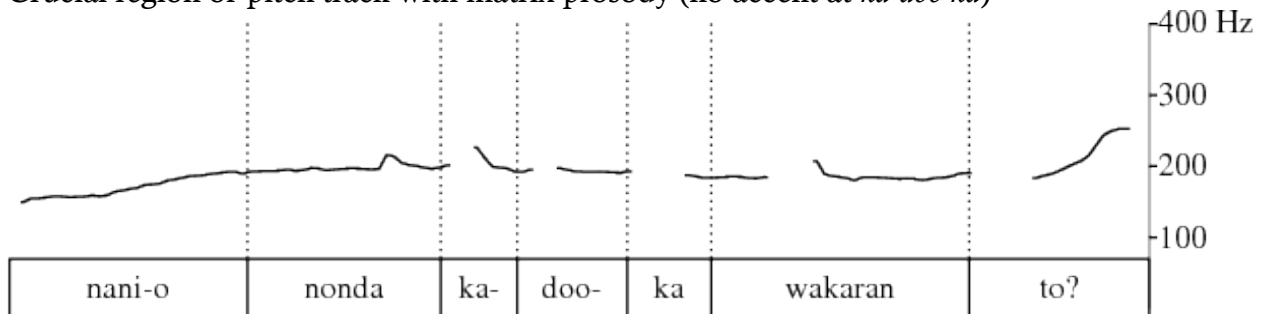
(b)   Crucial region of pitch track with embedded prosody (accent at *ka-doó-ka*)

| nani-o | nonda | ka- | doo- | ka | wakaran | to? |

(c)   interpretation with matrix wh scope:
          'What doesn't Yôhei know whether Emiko drank?'
        (forced matrix wh scope interpretation, if any):
          # 'Does Yôhei not know what Emiko drank?'

(d)   Response options
          (i)   Wine.   *(wh answer; indicates matrix wh scope)*
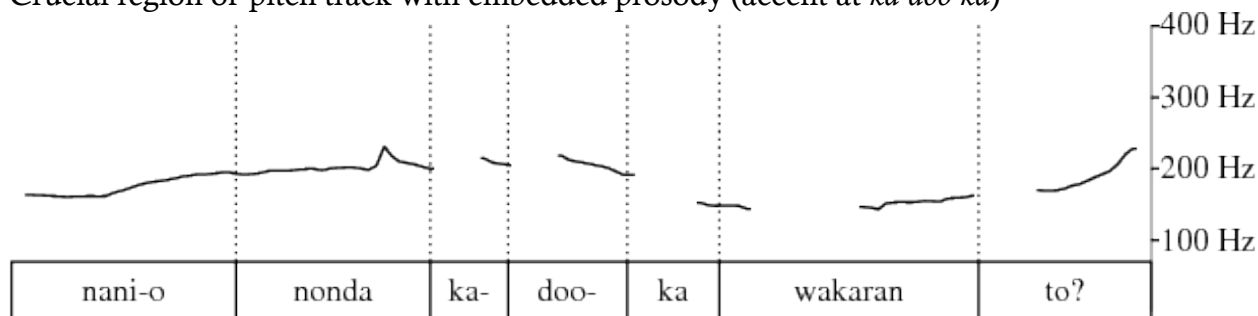   (ii)   Right. (He) doesn't know.   *(yes/no answer; indicates embedded wh scope)*
          (iii)   *neither answer is good*

There were 16 experimental items in total (see (39)–(41) in Appendix), along with eight distractor items. The distractor items were created from pairs of sentences in which one was an ordinary single-wh sentence with no embedded clause, which would be interpreted as a matrix wh question. The other sentence in the pair had the same structure except that the wh element had been replaced with the corresponding wh+*ka* indefinite expression (e.g., *dare* 'who' versus *dare-ka* 'someone'); this would cause the sentence to be interpreted as a matrix yes/no question. In this way, the distractor items still had participants choosing from among the same three types of question responses, but they did not require participants to choose among different possible interpretations of wh scope. Each item was presented to each listener only once; in a full-scale perception study, items could be repeated in order to assess the consistency of each listener's responses.

The experimental items and the distractor items were all recorded in a sound-attenuated room by a female young-adult speaker of Fukuoka Japanese, using a Marantz PMD 660 digital recorder (sampling rate 44.1 kHz) and a Radio Shack 33-3012 head-mounted microphone. After a few practice trials, the talker was able to produce the mismatching prosodic contours for the unambiguous experimental items in a way that sounded intonationally natural. (The sample pitch tracks in (24)–(26) are from these materials.)

The stimuli were stored as uncompressed audio files and were presented in a partially randomized order to each participant individually using the Praat software. (The same presentation order was used for all subjects; see §6.3 for more discussion of the stimulus presentation order and its possible effects.) Participants listened to the sound files over headphones in a quiet room. The three response options for each stimulus were presented on a paper questionnaire in Japanese orthography, and subjects were asked to mark their chosen responses directly on the questionnaire.

The participants in this experiment were a subset of the participants in the production experiment: s08, s09, s10, s11, and s12, all young-adult female speakers from western Fukuoka prefecture who self-identified as native speakers of the Fukuoka dialect and frequent users of the dialect. See Table 1 for additional demographic information for these participants.

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6.2 Results and discussion

All participants had high accuracy on responses to the distractor items, indicating that they understood the nature of the task and did not have particular wh-question or yes/no-question response biases overall.

Results for the ambiguous experimental items are shown in (27) below. The response chosen by the participant is coded as *e* for the answer compatible with an embedded-scope interpretation, *m* for the answer compatible with a matrix-scope interpretation, and ***** for the 'neither answer is good' response. A **bold underlined** symbol indicates a response where the selected scope interpretation matches the prosody of the stimulus, while a *light italicized* symbol indicates a response where the selected scope interpretation does not match the prosody. Item codes such as (*p1a*) can be matched with the stimulus items listed in (39)–(41) in the Appendix.

(27)   Perception results: Ambiguous items

	Embedded prosody				**Matrix** prosody			
	1 wh		*2 wh*		*1 wh*		*2 wh*	
	(p1b)	*(p2b)*	*(p3b)*	*(p4b)*	*(p1a)*	*(p2a)*	*(p3a)*	*(p4a)*
s08	**e**	**e**	**e**	**e**	*e*	*e*	*e*	*e*
s09	**e**	**e**	*	*	*e*	*e*	*	*e*
s10	**e**	**e**	*m*	**e**	*e*	*e*	*e*	*e*
s11	*m*	*m*	**e**	**e**	**m**	**m**	**m**	**m**
s12	**e**	**e**	**e**	**e**	**m**	**m**	*e*	*e*

For the ambiguous items, participants s08, s09, and s10 appear to have a response bias in favor of embedded scope, regardless of the prosody. Even participant s12's two cases of mismatch are both in the direction of a bias for embedded scope. On the other hand, an embedded-scope bias is not universal; participant s11 appears to have a weak bias for matrix scope. (A bias for embedded scope is defined as a pattern in which mismatching responses, where the scope does not match the prosody of the stimulus, favor *e*, in that the proportion of *m* responses given for the embedded-prosody category is smaller than the proportion of *e* responses given for the matrix-prosody category. A bias for matrix scope is likewise defined as a pattern in which mismatching responses favor *m*.)

The participants that come closest to showing a prosody/scope correlation in the perception of the ambiguous items in this experiment are s11 and s12, each of whom overcomes an apparent response bias in two cases where the non-preferred response was a better match to the prosody. However, none of the other three subjects show any evidence of taking prosody into account when choosing their responses.

Results for the unambiguous experimental items are shown in (28). Participant responses are coded as in (27) above, except that the columns in the chart that are grayed out indicate items where the wh scope and the wh prosody are mismatched. For these items, the response codes *e* and *m* are underlined when they match the prosody and *italicized* when they do not (recall that responses that do not match the prosody for these items do in fact match the morphosyntactically indicated scope).

(28)   Perception results: Unambiguous items

	Only **embedded** interpretation expected				Only **matrix** interpretation expected			
	embedded prosody		*matrix prosody*		*embedded prosody*		*matrix prosody*	
	(p5b)	*(p6b)*	*(p5a)*	*(p6a)*	*(p7b)*	*(p8b)*	*(p7a)*	*(p8a)*
s08	*m*	*m*	e	e	m	e̲	*	*
s09	**e̲**	**e̲**	e	*	e̲	e̲	*e*	*
s10	**e̲**	**e̲**	e	m	e̲	m	*e*	*e*
s11	**e̲**	**e̲**	m̲	m̲	m	m	**m̲**	**m̲**
s12	**e̲**	**e̲**	m̲	e	e̲	e̲	*e*	*e*

Again, we see evidence of a general response bias for embedded scope. Where the prosody matches the expected wh scope (white columns), the embedded-prosody cases show an embedded-scope response from all but one participant; conversely, the matrix-prosody cases show a matrix-scope response from only one participant. Indeed, three out of five participants actually show at least one *embedded*-scope response in the matrix-interpretation, matrix-prosody condition, even though this response is counter to both the prosodic and the morphosyntactic information in the utterance. In terms of individual participants, s09, s10, and s12 show an embedded-scope bias. On the other hand, s08 shows a possible matrix-scope bias (although in that light, s08's 'ungrammatical' response to the cases with matrix prosody and expected matrix scope is puzzling). Only s11 has responses that reflect prosody and expected scope interpretation in both the embedded and the matrix conditions.

For the cases where the prosody and the wh scope do not match (gray columns), the patterns are a little more complicated. Participant s11 shows a bias for matrix-scope responses, which is reminiscent of the weak matrix bias seen for this participant in the ambiguous-sentence condition in (27). Participant s10 appears to show random behavior when there is a prosody/scope mismatch. The other three participants once again appear to show an embedded-scope response bias for the mismatch cases, although s12 did give one matrix-scope response for a mismatch case with matrix wh prosody, possibly showing a sensitivity to prosody (although no such sensitivity is evident in s12's responses to the unambiguous items where prosody and morphosyntactic scope actually matched; there, an embedded-scope bias is observed).

The overall perception results for ambiguous and unambiguous items are summarized in (29).

(29)   Summary: wh prosody/wh scope correlation in perception

	Ambiguous	Unambiguous	
		prosody/scope consistent	*prosody/scope mismatch*
s08	poor match (**embedded** scope bias)	poor match (*matrix* scope bias?)	*, or **embedded** scope bias
s09	poor match (**embedded** scope bias)	poor match (**embedded** scope bias)	*, or **embedded** scope bias
s10	poor match (**embedded** scope bias)	poor match (**embedded** scope bias)	random?
s11	medium match (*matrix* scope bias)	good match	*matrix* scope bias
s12	medium match (**embedded** scope bias)	poor match (**embedded** scope bias)	prosody, or **embedded** scope bias

The most salient observation to be made here is that almost all subjects show a bias for embedded scope in perception in at least two out of the three conditions. Kitagawa and Fodor (2003, 2006) discuss several possible sources for such an embedded-scope bias observed in Tokyo Japanese speakers. One factor is that, since the wh element precedes all complementizers, assigning it embedded scope allows for fewer open dependencies in online sentence parsing and should be easier to process as a result (see also Miyamoto and Takahashi 2002). A second factor is that embedded-scope interpretations require less semantic or pragmatic complexity than matrix-scope interpretations (indeed, this difference can be observed in the relative naturalness of the disambiguating contexts for the ambiguous stimuli in the Fukuoka production experiment exemplified in (15) above). Related to this point, Hirotani (to appear) also discusses the possibility that the information structure (given versus new status for words in the question) is likely to be different for matrix versus embedded wh cases, further contributing to a bias for a prosodic phrasing pattern typical of that for embedded wh prosody. (See §6.3 below for a possible factor behind participant s11's apparent bias for matrix prosody in perception.)

It is also interesting to note that, of the few responses that actually indicate a judgment of ungrammatical (or some other, unexpected interpretation) for the stimulus, three out of four are for sentences with matrix prosody (though they did also have expected matrix scope, rather than having prosody incompatible with the intended scope). This is reminiscent of findings by, e.g., Hirotani (2005) and Hirose and Kitagawa (2011) for Tokyo Japanese, where matrix wh prosody leads to a higher rejection rate than embedded wh prosody, possibly due to the same sorts of factors that lead to a bias for embedded-scope interpretations as discussed above.

6.3 Discussion: wh prosody and scope in perception and production

Since five participants took part in both the production and perception studies, their results can be compared across the two tasks, as shown in (30). This comparison suggests that the relationship between wh prosody and wh scope does not necessarily operate the same way in production and perception for all Fukuoka Japanese speakers, a finding that is similar to those of Hirotani (2005) and Hirose and Kitagawa (2011, Kitagawa and Hirose to appear) for Tokyo Japanese.

(30)   Comparison of perception and production results

	Perception results			Production results		
	Ambiguous	Unambiguous		Ambiguous	Unambiguous	
		prosody/scope consistent	*prosody/scope mismatch*		*single wh*	*multiple wh*
s08	poor match (**embedded** scope bias)	poor match (*matrix* scope bias?)	*, or **embedded** scope bias	good match	poor match (*matrix* prosody bias)	medium (*matrix* prosody bias)
s09	poor match (**embedded** scope bias)	poor match (**embedded** scope bias)	*, or **embedded** scope bias	poor match (*matrix* prosody bias)	poor match (*matrix* prosody bias)	poor match (*matrix* prosody bias)
s10	poor match (**embedded** scope bias)	poor match (**embedded** scope bias)	random?	good match	medium (**embedded** prosody bias)	poor match (**embedded** prosody bias)
s11	medium (*matrix* scope bias)	good match	*matrix* scope bias	medium (random?)	poor match (*matrix* prosody bias)	medium (**embedded** prosody bias)
s12	medium (**embedded** scope bias)	poor match (**embedded** scope bias)	prosody, or **embedded** scope bias	good match	good match	good match

First, some participants show a difference in how closely prosody is related to scope between the two tasks. Participants s08 and s10 show a somewhat more consistent prosody/scope relationship for production than for perception, and this pattern is even more striking for participant s12, who has the most consistent prosody/scope relationship in production, but shows a strong bias for embedded scope in perception, especially in the unambiguous sentences. On the other hand, participant s11 actually seems to show a slightly more robust prosody/scope relationship in perception (at least for unambiguous sentences with consistent prosody and scope) than in production.

A second difference between the two tasks is that for conditions where participants show little or no relationship between wh prosody and wh scope, the direction of the response bias is sometimes different. In particular, participants s08 and s09 show at least a tendency toward an embedded scope bias in perception, but a consistent matrix prosody bias in production. Conversely, participant s11 is the only one to show a matrix-scope bias in perception; in production, a similar matrix-prosody bias appears for the single-wh items, but the multiple-wh items actually seem to show a bias for embedded prosody. Overall, it seems that more embedded-scope bias is seen in perception, while more matrix-prosody bias is seen in production. (Participant s10 shows a consistent bias for embedded scope in both perception and production, however.)

Previous work on Tokyo Japanese wh prosody and scope has also found mismatches between production and perception (Hirotani 2005; Hirose and Kitagawa 2011). These studies have found that for the Tokyo dialect, production of prosody is quite consistent for at least embedded-scope wh sentences (Hirotani 2005), or for both embedded-scope and matrix-scope wh sentences (Hirose and Kitagawa 2011; see also similar findings in Hirotani to appear, for circumstances where talkers were made aware of a potential difference in wh scope). On the other hand, more variability was found in perception. This is similar to the pattern of results found here for participants s08, s10, and s12, though not for participant s11

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(however, see below on the possibility that s11's response pattern in the perception study was an artifact of the stimulus presentation order).

On the other hand, one factor discussed by Hirose and Kitagawa (2011) concerning the discrepancies between production and perception in Tokyo Japanese wh scope is perhaps less relevant for the case of Fukuoka. For Tokyo, any potential wh prosody/scope correlation is signaled by the resumption of non-wh prosody after the embedded complementizer in the case of embedded scope but not in the case of matrix scope. Hirose and Kitagawa argue that this distinction is not particularly useful to listeners, because the prosodic cues that would disambiguate the two scope possibilities come after the embedded complementizer has been encountered, and therefore after the parser has had to make an initial hypothesis about wh scope. They suggest that this is why the prosody/scope relationship is more consistent for production than for perception. Crucially, however, in the Fukuoka dialect, embedded wh prosody is signaled by a pitch accent immediately *before* the embedded complementizer (as well as by a resumption of non-wh prosody, beginning with a phrase-initial F0 rise after the complementizer, as in Tokyo). In this dialect, therefore, prosody would provide potentially disambiguating scope information even *before* the embedded complementizer was encountered. Nevertheless, the prosody/scope relationship still seems to be stronger for production than for perception in Fukuoka. This suggests that the post-complementizer location of the disambiguating prosody in Tokyo may not be the sole source of the perception/production discrepancies in that dialect, either.

One final point to note is that it would be useful to attempt to replicate this perception study with additional speakers of Fukuoka Japanese. This particular experiment had a small number of participants and a small number of items. The questions used as stimuli were complex, and may have been difficult to process; a methodology like that in Kitagawa and Fodor (2006) and Hirose and Kitagawa (2011), where the sentences were presented orthographically as well as auditorily, might provide clearer results.

Additionally, there was an error in the procedure used to generate an intended pseudo-random presentation order for the stimuli, which resulted in most of the matrix-prosody items being presented before most of the embedded-prosody items. It is possible that this unintended near-blocking of the stimuli affected response patterns. However, it would seem that this presentation order would be most likely to lead participants into a matrix-scope response bias, and actually only one participant (s11) showed this pattern, so fortunately this particular error does not seem to have had a strong effect on the results of the study.

7. Conclusions and implications

The empirical investigation of Fukuoka Japanese wh prosody described here has found evidence for the basic patterns described for this dialect in previous impressionistic and small-scale empirical studies. However, the patterns are not found for all speakers in all utterances.

Specifically, some, but not all, of the participants in this study showed a strong tendency to deaccent in the wh domain. However, no speaker deaccented in every case (similar to the findings of Igarashi 2007 and Igarashi and Kitagawa 2007).

Several speakers showed evidence of a wh prosody/scope relationship to at least some extent, although this pattern was not consistent for most speakers. Moreover, the prosody/scope relationships observed in the production and perception tasks were not necessarily the same even for the same speaker, which is similar to results that have been found for speakers of the Tokyo dialect.

Now that some of the basic claims about Fukuoka prosody have been empirically confirmed, future work will use data from the experimental participants who show more consistent deaccenting and at least some degree of relationship between wh prosody and wh scope to explore some of the more complex

aspects of Kubo's (1989 et seq.) descriptions, such as those concerning the left edge of the wh prosody domain. Some of these further, more intricate predictions have potentially very significant implications for models of the syntax-phonology interface (see Smith 2011 for related discussion).

Acknowledgments

A preliminary version of some of these results is presented in Smith (to appear), but both the empirical analysis and the interpretation have been revised here.

Appendix: List of all stimuli and items measured

A.1 Materials for the accent deletion analysis (§4)

(31) Unaccented nouns (in non-wh contexts)
   • Moras in underlined nouns were measured to compute F_0 decrease score (see §4)

n1yu Imanisi-ga doyoobi <u>marariya-ni</u> yarareta to.
Imanishi-NOM Saturday malaria-by was.done PRT
'Imanishi was hit by malaria on Saturday.'

n2xu [Yoneyama-ga doyoobi <u>Muraoka-o</u> yonda tte] siran'yatta.
Yoneyama-NOM Saturday Muraoka-ACC called C didn't.know
'(I) didn't know Yoneyama called Muraoka on Saturday.'

n3xu Kyoo-wa [kinoo moratte.kita <u>yamaimo-o</u>] yaki-yotta to.
today-TOP yesterday received yams-ACC roasting-were PRT
'Today, we were roasting the yams we got yesterday.'

n4xu Naomi-ga omise de Minoru-ni <u>yamamori-o</u> moratta to.
Naomi-NOM shop at Minoru-DAT full.plate-ACC received PRT
'Naomi got a full plate from Minoru at the shop.'

(32) Accented nouns (in non-wh structures)
   • Moras in underlined nouns were measured to compute F_0 decrease score (see §4)

n1ya Imanisi-ga doyoobi <u>aomusi-ni</u> yarareta to.
Imanishi-NOM Saturday caterpillar-by was.done PRT
'Imanishi was hit by caterpillars on Saturday.'

n2xa [Yoneyama-ga doyoobi <u>aniyome-o</u> yonda tte] siran'yatta.
Yoneyama-NOM Saturday sister.in.law-ACC called C didn't.know
'(I) didn't know Yoneyama called (my) sister.in.law on Saturday.'

n3xa Kyoo-wa [kinoo moratte.kita <u>amaguri-o</u>] yaki-yotta to.
today-TOP yesterday received chestnuts-ACC roasting-were PRT
'Today, we were roasting the chestnuts we got yesterday.'

n4xa   Naomi-ga   omise de   Minoru-ni   <u>onigiri-o</u>   moratta   to.
      Naomi-ɴᴏᴍ   shop at   Minoru-ᴅᴀᴛ   rice.ball-ᴀᴄᴄ   received   ᴘʀᴛ
      'Naomi got a rice ball from Minoru at the shop.'

(33)   wh questions with lexically accented nouns
     •   Nouns measured for the F$_0$ decrease score analysis (§4) are underlined
     •   wh items and their associated complementizers are underlined and bolded (if there is a second pair, it is also italicized)

w1xa   **<u>nan.de</u>**   kyoo   <u>imomusi-ga</u>   ooi   to   **Ø**?
      why   today   hornworm-ɴᴏᴍ   numerous   ᴘʀᴛ   C$_{wh}$
      'Why are there so many hornworms today?'

w1ya   **<u>dare</u>**-ga   doyoobi   <u>aomusi-ni</u>   yarareta   to   **Ø**?
      who-ɴᴏᴍ   Saturday   caterpillar-by   was.done   ᴘʀᴛ   C$_{wh}$
      'Who was hit by caterpillars on Saturday?'

w2xa   [**<u>dare</u>**-ga   doyoobi   <u>aniyome-o</u>   yonda   **<u>ka</u>**]   siran'yatta.
      who-ɴᴏᴍ   Saturday   sister.in.law-ᴀᴄᴄ   called   C$_{wh}$ didn't.know
      '(I) didn't know who called (my) sister-in-law on Saturday.'

w2ya   [**<u>nan.de</u>**   kyoo   <u>norimaki-ga</u>   takusan aru   **<u>ka</u>**]   siran'yatta.
      why   today   sushi.roll-ɴᴏᴍ   many   exist   C$_{wh}$ didn't.know
      '(I) didn't know why there were so many sushi rolls today.'

w3xa   kyoo-wa   [**<u>itu</u>**   moratte.kita]   <u>amaguri-o</u>   yaki-yotta   to   **Ø**?
      today-ᴛᴏᴘ   when   received   chestnuts-ᴀᴄᴄ   roasting-were   ᴘʀᴛ   C$_{wh}$
      'Today, which chestnuts were (you) roasting, identified by when you received them?'

w3ya   nomiya de   [**<u>nan.de</u>**   <u>Morioka-ni</u> mukau]   hito to   nomi-yotta   to   **Ø**?
      bar at   why   Morioka-to   heading   person with   drinking-were   ᴘʀᴛ   C$_{wh}$
      'At the bar, who were (you) drinking with, identifed by why they were going to Morioka?'

w4xa   **<u>dare</u>**-ga   omise de   **<u>dare</u>**-ni   <u>onigiri-o</u>   moratta   to   **Ø**?
      who-ɴᴏᴍ   shop at   who-ᴅᴀᴛ   rice.ball-ᴀᴄᴄ   received   ᴘʀᴛ   C$_{wh}$
      'Who received a full plate from whom at the shop?'

w4ya   **<u>dare</u>**-ga   kyoo   **<u>doko</u>** de   <u>omawari-o</u>   kowagari-yotta   to   **Ø**?
      who-ɴᴏᴍ   today   where at   policeman-ᴀᴄᴄ   seem.afraid-were   ᴘʀᴛ   C$_{wh}$
      'Who was acting afraid of a policeman where today?'

w5xa   [**<u>dare</u>**-ga   doyoobi   **<u>doko</u>** de   <u>amaguri-o</u>   yaita   **<u>ka</u>**]   wakaran.
      who-ɴᴏᴍ   Saturday   where at   chestnut-ᴀᴄᴄ   roasted   C$_{wh}$ don't.know
      '(I) don't know who roasted chestnuts where on Saturday.'

w5ya   [**<u>dare</u>**-ga   kyoo   **<u>nan.de</u>**   <u>yamadera de</u>   moriagari-yoo   **<u>ka</u>**]   wakaran.
      who-ɴᴏᴍ   today   why   mountain temple at   having.fun-are   C$_{wh}$ don't.know
      '(I) don't know who is having fun why at the mountain temple today.'

w6xa   **<u>dare</u>**-ga   [<u>Noriko-ga</u>   ***<u>doko</u>*** de   asobi-yoo   ***<u>ka</u>***]   wakaru to   **Ø**?
      who-ɴᴏᴍ   Noriko-ɴᴏᴍ   where at   playing-is   C$_{wh}$ knows   ᴘʀᴛ   C$_{wh}$
      'Who knows where Noriko is playing?'

w6ya   **<u>dare</u>**-ga   [<u>Naoya-ga</u>   ***<u>itu</u>***   arawareru   ***<u>ka</u>***]   wakaran   to   **Ø**?
      who-ɴᴏᴍ   Naoya-ɴᴏᴍ   when   appear   C$_{wh}$ doesn't.know   ᴘʀᴛ   C$_{wh}$
      'Who doesn't know when Naoya will show up?'

w7xa   [**<u>dare</u>**-ga   <u>norimaki-o</u>   ut-te   **<u>mo</u>**]   ii   to   Ø?
      who-ɴᴏᴍ   sushi.roll-ᴀᴄᴄ   sell-ᴛᴇ   C$_{wh}$ good   ᴘʀᴛ   C

'Is it okay, no matter who sells sushi rolls?' *(embedded wh scope)*

w7ya **dare**-ga   [norimaki-o   ut-te   mo]   ii   to   **Ø**?
       who-NOM   sushi.roll-ACC   sell-TE   C   good   PRT C$_{wh}$
       'For whom is it okay, even if they sell sushi rolls?' *(matrix wh scope)*

A.2 Materials for the prosody/scope analysis

(34)   Single wh in embedded clause, embedded scope

    w2xa (see (33))

    w2xu [**dare**-ga   doyoobi   Murayama-o   yonda   **ka**]   siran'yatta.
          who-NOM   Saturday   Murayama-ACC   called   C$_{wh}$ didn't.know
          '(I) didn't know who called Murayama on Saturday.'

    w2ya (see (33))

    w2yu [**nan.de**   kyoo   waremono-ga   takusan aru   **ka**]   siran'yatta.
          why   today   breakables-NOM   many   exist   C$_{wh}$ didn't.know
          '(I) didn't know why there were so many breakables today.'

(35)   Single wh in embedded clause, matrix scope

    w3xa (see (33))

    w3xu kyoo-wa   [**itu**   moratte.kita]   yamaimo-o   yaki-yotta   to   **Ø**?
          today-TOP   when   received   yams-ACC   roasting-were   PRT C$_{wh}$
          'Today, which yams were (you) roasting, identified by when you received them?'

    w3ya (see (33))

    w3yu nomiya de   [**nan.de**   Momoyama-ni mukau]   hito to   nomi-yotta   to   **Ø**?
          bar at   why   Momoyama-to heading   person with drinking-were   PRT C$_{wh}$
          'At the bar, who were (you) drinking with, identifed by why they were going to Momoyama?'

(36)   Multiple wh in embedded clause, both with embedded scope

    w5xa (see (33))

    w5xu [**dare**-ga   doyoobi   **doko** de   yamaimo-o yaita   **ka**]   wakaran.
          who-NOM   Saturday   where at   yam-ACC roasted C$_{wh}$ don't.know
          '(I) don't know who roasted yams where on Saturday.'

    w5ya (see (33))

    w5yu [**dare**-ga   kyoo   **nan.de**   yamagoya de   moriagari-yoo   **ka**]   wakaran.
          who-NOM   today   why   mountain cabin at   having.fun-are   C$_{wh}$ don't.know
          '(I) don't know who is having fun why at the mountain cabin today.'

(37)   Multiple wh in clause (nested wh–C pairs); outer wh with matrix scope

    w6xa (see (33))

    w6xu **dare**-ga   [Naomi-ga   *doko*-de   asobi-yoo   *ka*]   wakaru to   **Ø**?
          who-NOM   Naomi-NOM   where-at   playing-is   C$_{wh}$ knows   PRT C$_{wh}$
          'Who knows where Naomi is playing?'

    w6ya (see (33))

w6yu **dare**-ga [Minoru-ga *itu* arawareru *ka*] wakaran to Ø?
who-NOM Minoru-NOM when appear C_wh doesn't.know PRT C_wh
'Who doesn't know when Minoru will show up?'

(38) Sentences with ambiguous wh scope

w7xa (see (33))

w7xu [**dare**-ga omamori-o ut-te **mo**] ii to Ø?
who-NOM amulet-ACC sell-TE C_wh good PRT C
'Is it okay, no matter who sells amulets?' (embedded wh scope)

w7ya (see (33))

w7yu **dare**-ga [omamori-o ut-te mo] ii to **Ø**?
who-NOM amulet-ACC sell-TE C good PRT C_wh
'For whom is it okay, even if they sell amulets?' (matrix wh scope)

A.3 Stimuli for perception experiment

In all cases, the stimuli with codes ending in *a* were produced with matrix prosody (no accent at the end of the embedded clause), while those with codes ending in *b* were produced with embedded prosody (default accent at the end of the embedded clause).

(39) Ambiguous strings: two meanings, two intonations

p1a matrix wh prosody
Dare-ga kudamono-o ut-te mo ii to **Ø**?
who-NOM fruit-ACC sell-TE C good PRT C_wh
'For whom is it okay, even if they sell fruit?

p1b embedded wh prosody
[**Dare**-ga kudamono-o ut-te **mo**] ii to Ø?
who-NOM fruit-ACC sell-TE C_wh good PRT C
'Is it okay, no matter who sells fruit?'

p2a matrix wh prosody
Nani-o torakku de hakon-de mo ii to **Ø**?
what-ACC truck by transport-TE C good PRT C_wh
'For what is it okay, even if (I) transport it by truck?'

p2b embedded wh prosody
[**Nani**-o torakku de hakon-de **mo**] ii to Ø?
what-ACC truck by transport-TE C_wh good PRT C
'Is it okay, no matter what (I) transport by truck?'

p3a matrix wh prosody
Ziroo-ga **nan**-no hi ni *dare* to atta *ka* wakaran to **Ø**?
Jirô-NOM what-GEN day on who with met C_wh don't.know PRT C_wh
'What day is it that (you) don't know who Jirô met (on that day)?'

p3b embedded wh prosody
[Ziroo-ga **nan**-no hi ni **dare** to atta **ka**] wakaran to Ø?
Jirô-NOM what-GEN day on who with met C_wh don't.know PRT C
'Do (you) not know [who Jirô met when]?'

p4a matrix wh prosody
Ayako-ga **doko** de *nani*-o wasureta *ka* wakaran to **Ø**?
Ayako-NOM where at what-ACC forgot C_wh don't.know PRT C_wh
'Where is it that (you) don't know what Ayako forgot (there)?'

p4b embedded wh prosody
[Ayako-ga **doko** de nani-o wasureta **ka**] wakaran to Ø?
Ayako-NOM where at what-ACC forgot C_wh don't.know PRT C
'Do (you) not know [where Ayako forgot what]?'

(40) Unambiguous strings with embedded wh interpretation

p5a matrix prosody (mismatch)
Naoya-wa Mariko-ga **nani**-o katta *ka* wakaran to Ø?
Naoya-TOP Mariko-NOM what-ACC bought C_(wh) doesn't.know PRT C_(?)
(potential forced matrix interpretation:) 'What doesn't Naoya know whether Mariko bought?'

p5b embedded prosody (match)
Naoya-wa [Mariko-ga **nani**-o katta **ka**] wakaran to Ø?
Naoya-TOP Mariko-NOM what-ACC bought C_wh doesn't.know PRT C
'Does Naoya not know what Mariko bought?'

p6a matrix prosody (mismatch)
Tieko-wa Kenzi-ga **dare** to odotta *ka* wakaran to Ø?
Chieko-TOP Kenji-NOM who with danced C_(wh) doesn't.know PRT C_(?)
(potential forced matrix interpretation:) 'Who doesn't Chieko know whether Kenji danced with (them)?'

p6b embedded prosody (match)
Tieko-wa [Kenzi-ga **dare** to odotta **ka**] wakaran to Ø?
Chieko-TOP Kenji-NOM who with danced C_wh doesn't.know PRT C
'Does Chieko not know who Kenji danced with?'

(41) Unambiguous strings with matrix wh interpretation

p7a matrix prosody (match)
Yoohei-wa Emiko-ga **nani**-o nonda ka.doo.ka wakaran to **Ø**?
Yôhei-TOP Emiko-NOM what-ACC drank C doesn't.know PRT C_wh
'What doesn't Yôhei know whether Emiko drank?'

p7b embedded prosody (mismatch)
Yoohei-wa Emiko-ga **nani**-o nonda ka.doo.ka wakaran to Ø?
Yôhei-TOP Emiko-NOM what-ACC drank C_(?) doesn't.know PRT C_(wh)
(potential forced embedded interpretation:) 'Does Yôhei not know what Emiko drank/whether Emiko drank something?'

p8a matrix prosody (match)
Minako-wa Yuuta-ga **dare** to kenka.sita ka.doo.ka wakaran to **Ø**?
Minako-TOP Yûta-NOM who with quarreled C doesn't.know PRT C_wh
'Who doesn't Minako know whether Yûta quarreled with?'

p8b embedded prosody (mismatch)
Minako-wa Yuuta-ga **dare** to kenka.sita ka.doo.ka wakaran to Ø?
Minako-TOP Yûta-NOM who with quarreled C_(?) doesn't.know PRT C_(wh)
(potential forced embedded interpretation:) 'Does Minako not know who Yûta quarreled with/whether Yûta quarreled with someone?'

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