Sentence Prosody and *Wh*-indeterminates in Taiwan Mandarin

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Abstract

We report results of a speech production experiment about the intonation of three sentence types in Taiwan Mandarin, and discuss our results with implications for focus acoustics, and semantic-syntactic theories of sentence final particles and *wh*-indeterminates. *Wh*-indeterminates refer to *wh*-phrases that are ambiguous between interrogative and indefinite readings. In Mandarin, different interpretations of *wh*-indeterminates are not morphologically marked, but can be disambiguated in specific sentence contexts marked by sentence final particles. In this study, we systematically examined the intonation of *wh*-questions and *yes/no* questions by using declarative sentences as the baseline. The results show that both *wh*- and *yes/no* questions exhibit F0 prominence, and lengthening effects on regions containing sentence-final particles and *wh*-phrases, but the effects were stronger in *wh*-questions. Examining the duration and F0 range, we found that *wh*-phrases and sentence final particles together formed specific acoustic patterns to distinguish questions from declarative sentences. The findings suggest that the prosodic organization interacts with other internal structural organization.

Index Terms: sentence prosody, *wh*-indeterminate, sentence final particle, focus prosody, Taiwan Mandarin

1. Introduction

Cross-linguistically, one interesting and important research question has been on how linguistic ambiguity is resolved and how tone languages express intonation of different types of sentences. In this study, we examined the acoustic nature of a special lexical category – *wh*-indeterminates (i.e., *wh*-phrases that are ambiguous between interrogative and indefinite readings but are disambiguated in specific sentence types), which has been attested in many languages ([1], [2]). Mandarin *wh*-phrases like *shenme* 'what' can be interpreted as an interrogative in a *wh*-question (1a), or an indefinite in a *yes/no* question (1b). Previous syntax-semantic studies have identified the occurrence of sentence final particles (henceforth SFPs) *ma* for *yes/no* questions as one of such *wh*-indefinite-licensing contexts ([3], [4]). While most linguistic studies have focused on sentences like (1a-b), we notice that in declarative sentences like (1c) with the SFP *ba* (indicating weak epistemic judgment [5]), *shenme* therein is also interpreted as an indefinite noun.

(1) a. Zhangsan   mai-le   shenme   ne?
        Zhangsan   buy-ASP   what   WH-PARTICLE
        'What did Zhangsan buy?'
     b. Zhangsan   mai-le   shenme   ma?
        Zhangsan   buy-ASP   what   Y/N-PARTICLE
        'Did Zhangsan buy something/anything?'
     c. Zhangsan   mai-le   shenme   ba.
        Zhangsan   buy-ASP   what   S-PARTICLE

'Zhangsan probably bought something/anything.'
Examples in (1) show that Chinese *wh*-indeterminates not only are lexically ambiguous but are also relevant to structural ambiguity, given that SFPs often are not obligatory in Chinese.

Considering prosody as one of the disambiguation devices [6], some studies have reported that *wh*-indeterminates while functioning as *wh*-interrogatives manifest more acoustic prominence than *wh*-indefinites in languages like Korean [7], Japanese [8], [9] [10], and German [11]. Yet, some reported that no acoustic differences on *wh*-indeterminates that distinguished interrogative from indefinite readings (e.g., [12]).

Different results were also reported for *wh*-indeterminates in Mandarin. Hu [13] studied *wh*-subject *shei* 'who' and *shenme* 'what' and reported that Mandarin speakers expressed *wh*-interrogatives acoustically different from *wh*-indefinites, i.e., *wh*-phrases had higher mean F0 in *wh*-questions, and the verb phrase of a sentence showed higher mean F0 in *yes/no* questions. In this study, only descriptive statistics were reported for mean F0, duration and amplitude (with SD), and some inter-participant differences were found. For Taiwan Mandarin (henceforth TwM), Shyu and Tung [14] reported two different findings; first, based on eight tokens (from a corpus [15]), they reported some differences between *wh*-interrogatives and indefinites, but the syntactic and phonetic contexts where these eight tokens occurred were different; second, their production study showed that speakers did not acoustically disambiguate *wh*-indeterminates; however, since participants responded to the same two items for one context, it is difficult to draw a general conclusion for TwM. Thus far, the findings about Mandarin *wh*-indeterminates seem not yet to be conclusive.

Most of the theoretical studies about Chinese sentence prosody assumed the sentence final position being the locus of nuclear stress (cf. [16]). Therefore, some researchers proposed that sentence final position does not attract acoustic prominence, since Chinese languages use lexical tones and clausal types are already expressed by syntax ([17], [18]), while some studies reported that *wh*-questions had higher overall F0 contours than that of statements ([19], [20]).

With respect to focus prosody, much fewer studies on the *wh*-phrases themselves that induce focus interpretations [21]; most studies about Chinese focus prosody have examined the acoustic prominence on the answer to a *wh*-question (with no SFP) (e.g., [22] [23]). While different Chinese varieties and languages may use different acoustic devices to express focus, it has been consistently reported for Chinese languages that focus units show on-focus F0 rising and lengthening [24] [25] [26] [27]. And, to the best of our knowledge, even less research has investigated the prosodic function of SFPs in Chinese languages [28], and no research is about the impacts of SFPs on focus prosody and sentence intonation. Given that the majority of prosody work has been on Beijing Mandarin, and that the phenomenon of *wh*-indetermintates (e.g., (1)) provides us a new

and ideal acoustic context to systematically examine theoretical claims and experimental findings, we used this context to first, study how the sentential prosodic organization interacts with the system of focus marking and the influences from syntax [29]; second, to contribute to the research field with an interesting but relatively understudied Mandarin variety, TwM.

We used a speech production experiment to study whether and how TwM speakers use prosody to disambiguate *wh*-indeterminates, to examine whether sentence final position in specific syntactic constructions can bear focus acoustic prominence, and to explore whether and how SFPs signal the sentence types and interact with the system of focus marking.

2. Method

2.1. Stimuli

We examined the prosody of *wh*-questions and *yes/no* questions containing *wh*-indeterminates by using declaratives as the baseline, as shown in Table 1. Target sentences were constructed in the same tonal format, i.e., a monosyllabic subject pronoun in Tone3 (i.e., 你 *ni3* 'you' and 我 *wo3* 'I') followed by a disyllabic auxiliary 可以 *ke2yi3* 'can', and they were followed by a disyllabic helping verb or a disyllabic sentential adverb in the same Tone1-Tone2 sequence (e.g., 幫忙 *bang1mang2* 'help', or 今年 *jin1nian2* 'this year'). The main verb immediately before the target *wh*-phrase was a Tone4 monosyllabic verb (e.g., 帶 *dai4* 'bring', 要 *yao4* 'ask for'). These choices were due to lexical limitation while we considered the need of having enough parallel stimuli across sentence types and of maintaining the same tonal contexts that hosted the *wh*-indeterminates. Right after the main verb was the *wh*-phrase target and it was immediately followed by a Tone1 SFP indicating one of the three sentence types (i.e., 呢 *ne* for *wh*-Q, 嗎 *ma* for *yes/no*-Q, and 吧 *ba* for declaratives).

Table 1: *Examples of target sentences with 'what'.*

Sentence Types	Format of Target Sentences					
	T3 subj	T2-T3 'can'	T1-T2 (Ad)V	T4 V	Wh phrase	T1 SFP
Wh-Q	你	可以	幫忙	帶	什麼	呢？
	'What can you help [me] to bring?'					
Yes/no Q	你	可以	幫忙	帶	什麼	嗎？
	'Can you help to bring [me] something?'					
Declarative	我	可以	幫忙	帶	什麼	吧。
	'I probably can help to bring [you] something.'					

Four *wh*-phrases (*shei* 'who', *shen.me* 'what', *na.li* 'where', and *shen.me-dong.xi* 'what thing') were used to construct each type of sentences with five versions of Tone4 verbs. In total, 60 target sentences (3 sentence types x 4 *wh*-phrases x 5 verb) and 40 filler sentences (in different sentence structure with no SPFs) were used. Each target trial consisted of a pre-recorded context (25 character long) (A), and a target sentence (B) that participants used to respond. The contexts were pre-recorded by a female speaker of Mandarin from Taiwan, as shown in (2-4).

(2) *Wh*-question
A: 我等會兒要出去買飯。有沒有人需要我順路辦事或者帶飯的？ *'I am about to go to buy my meal. Does anyone need me to run simple errands or to buy a meal on the way?'*
B: 你可以幫忙帶什麼呢？ *'What can you help me bring?'*

(3) *Yes/no* question
A: (The leading context same as the one in the *wh*-question)
B: 你可以幫忙帶什麼嗎？ *'Can you help bring something?'*

(4) Declarative sentence
A: 星期六我們要去大湖邊野餐。有沒有人有空幫忙帶些東西呢？ *'This Saturday we are going on a picnic by the big lake. Can anyone help to bring some stuff for the picnic?'*
B: 我可以幫忙帶什麼吧。 *'I probably can help to bring [us] something.'*

2.2. Participants

The ethics approval and basic demographic information were obtained before the experiment. 10 female native Mandarin speakers born and raised in Taiwan (mean age ± SD: 20.1 ± 0.83 years), who were university students in Hong Kong, joined our study. None reported any history of hearing problems. Based on a 7-point selfreport scale, 4 reported non-fluency in Taiwanese Min (1-3 points), and 6 reported intermediate fluency (4-5 points); As for Cantonese, 8 reported non-fluency (1-3 points), and 2 reported intermediate fluency (4-5 points). Participants were paid HK$50 after the experiment.

2.3. Procedure

The experiment was conducted in Hong Kong in a sound-attenuated lab with a Focusrite Scarlett 2i2 sound interface, and a Telefunken M-80 dynamic microphone calibrated to measure intensity. Each participant first signed a consent form and filled out a background questionnaire. Participants were seated in front of a computer screen and wore headphones. Stimuli were presented one at a time (self-paced) on the screen. The order of trials was pseudo-randomized, such that no similar target item occurred immediately adjacent. Participants were asked to first listen to the leading context, and then read the target sentence aloud as casually and naturally as possible; no instructions were given regarding emphasis. Participants produced each sentence twice, and additional repetitions were allowed in cases of mispronunciation or hesitation. Productions were recorded in .wav format at a sampling rate of 44.1 kHz with 16-bit quantization. There were three practice trials before the main trials. Each experiment lasted about 30 minutes.

2.4. Acoustic measurements

The acoustic measurements were generated by ProsodyPro 5.7.6 [30] for duration, fundamental frequency (F0) range and time normalized F0. Syllable boundaries were determined by using both visual (the waveform and spectrogram) and auditory information. The vocal pulses were manually checked and corrected when there were pitch halving or doubling and creaky voice. F0 was time-normalized across tokens by dividing each syllable into 10 intervals equal in time and the trimmed F0 values were calculated. The graphical analysis of F0 was performed by Smoothing Spline ANOVA (SS-ANOVA) [31]. When the Bayesian 95% confidence intervals indicated by transparent ribbons around the means do not overlap, the F0 curves are significantly different from each other.

Linear Mixed Effects models were conducted on duration and F0 range using the lme4 package [32] in R [33]. The model first included random intercepts for item and speaker and also by-speaker, by-ITEM, by-SPEAKER-ITEM-interaction random slopes for SENTENCE TYPE (declaratives, *wh*- and *yes/no* questions). SENTENCE TYPE was then added as a potential fixed effect. The significance of the main effect was evaluated by

likelihood ratio test. The post-hoc Tukey's comparisons were conducted by *multcomp* in R [34].

3. Results

3.1. F0 contours

The time-normalized F0 contours of statements, *wh-* and *yes/no* questions with four *wh-*phrases are in Figure 1. In general, *wh-*questions and *yes/no* questions were realized similarly in terms of F0, which contrasted with declarative sentences. The difference between statements and questions emerged quite early (at around the first three syllables), that is, the statements had higher F0 than the questions. Such tendency was more prominent in sentences with 'who', 'where' and 'what thing', as for sentences with 'what', the differences was prominent at the first syllable.
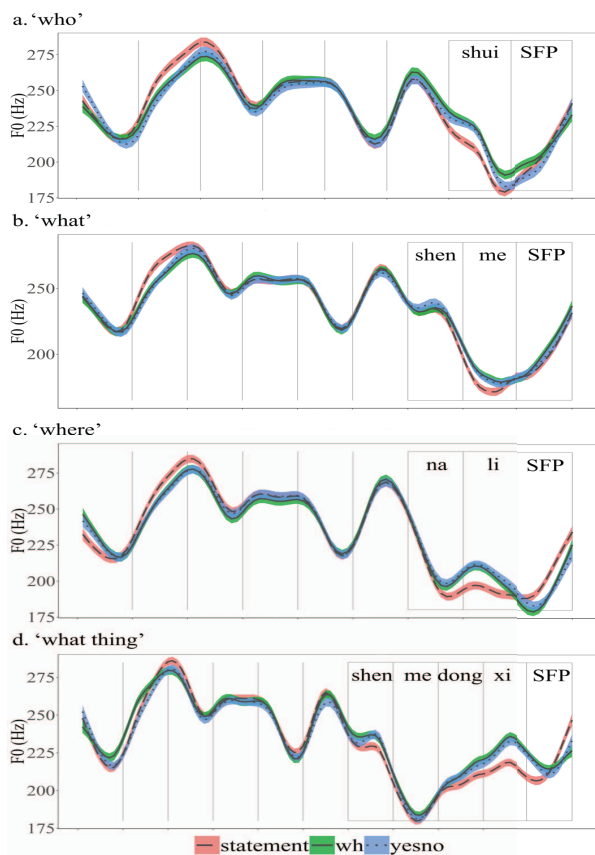

Figure 1: *SS-ANOVA plots of F0 contours.*

The most noticeable divergence across sentence types was found toward the end of the sentences, where the F0 contours differed greatly in the region of *wh-*phrases and SFPs (marked by the inner boxes inside of the SS-ANOVA plots). Specifically, both the *wh-* and *yes/no* questions had overall higher F0 than statements on the *wh-*phrases, and more complex F0 transitions in the syllable of SFPs. The more it was closer to the end of a sentence, the more prominent the modulation of F0 range was. While the two types of questions largely overlapped with each other across the four *wh-*phrase conditions, interestingly, in sentences with 'who' and 'what thing', the F0 of *wh-*questions was overall significantly higher than that of *yes/no* questions. Yet, in sentences with 'where', both questions

showed lower F0 toward the end; the F0 curve of *wh-*questions was slightly lower than that of *yes/no* questions.

3.2. Duration and F0 range

Figure 2 shows the mean and the distribution of the duration and the F0 range of each syllable of *wh-*phrases and of SFPs in three sentence types. The asterisks indicate significant difference between conditions in post-hoc comparisons. One interesting finding is that no matter how many syllables the *wh-*indeterminates have, the duration and the F0 range differ significantly between statements and questions mainly in the last syllable of the *wh-*indeterminates and in SFPs.
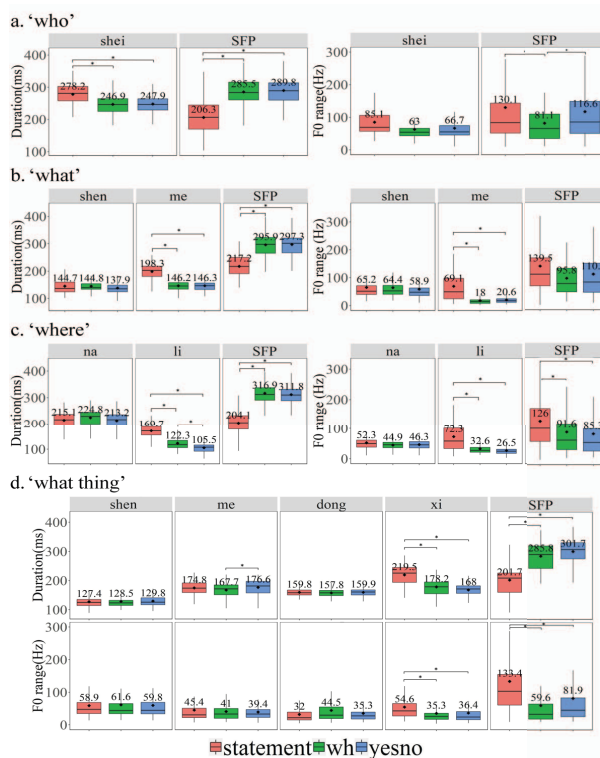

Figure 2: *Duration and F0 range of wh-indeterminates and sentence final particles.*

The results of mixed models are summarized in Table 2. In sentences with 'who', the main effect of SENTENCE TYPE was significant on the duration of the SFPs and of the last syllable of *wh-*phrases. The duration of SFPs and the syllable before SFPs in statements was significantly different from that of questions. The main effect of SENTENCE TYPE was also significant on the F0 range of the SFPs, and marginally significant on the last syllable of *wh-*phrases. *Wh-*questions had narrower F0 range than statements and *yes/no* questions in SFP.

In sentences with 'what', the analysis confirmed that the main effect of SENTENCE TYPE was significant on the duration of SFPs and on the last syllable of *wh-*phrases. The post-hoc comparison showed that the duration of the SFPs in *wh-* and *yes/no* questions were longer than statements, whereas the duration of the syllable before the SFPs in questions was shorter than that in statements. However, the two questions did not significantly differ in terms of duration. The main effect of SENTENCE TYPE was marginally significant on F0 range of SFPs and was significant on the last syllable of *wh-*phrases. The F0 range of *wh-*question and *yes/no* question was narrower than

statements in the syllable right before the SFPs, while the overall F0 range of the two types of questions was similar.

Regarding sentences with 'where', the main effect of SENTENCE TYPE was significant on the duration of the SFPs and of the last syllable of *wh*-phrases. The duration of questions was longer than that of statements in the SFPs. Noticeably, the duration of the syllable before the SFPs was the longest in statements, and such syllables in *wh*-questions were longer than those in *yes/no* questions. The main effect of SENTENCE TYPE was significant on the F0 range of the SFPs and of the last syllable of *wh*-phrases. Questions had narrower F0 range than the statements in the SFPs and in the syllable before SFPs.

In sentences with 'what thing', the main effect of SENTENCE TYPE was significant on the duration of the SFPs and on the last syllable of *wh*-phrases and on the second syllable of *wh*-phrase ('me' region). *Yes/no* questions had duration longer than *wh*-questions in the second syllable of *wh*-phrases. Compared with statements, lengthened SFPs and shortened final syllable of *wh*-phrases were found in both questions. The main effect of SENTENCE TYPE was significant on the F0 range of SFP and of the last syllable of *wh*-phrases, where the differences was found significantly between questions and statements, but not between the two question types.

Table 2: *The main effect of SENTENCE TYPE.*

		Duration			F0 range		
		$\chi2$	df	*p*	$\chi2$	df	*p*
Who	shei	9.898	2	.007*	5.975	2	.050
	SFP	20.107	2	<.001*	7.446	2	.024*
What	shen	3.267	2	.195	1.366	2	.505
	me	16.061	2	<.001*	8.835	2	.012*
	SFP	20.600	2	<.001*	5.924	2	.052
Where	na	3.028	2	.220	3.234	2	.199
	li	22.698	2	<.001*	12.984	2	.002*
	SFP	27.992	2	<.001*	6.942	2	.031*
What thing	shen	.321	2	.852	.187	2	.911
	me	6.553	2	.038*	.874	2	.646
	dong	.423	2	.810	2.852	2	.240
	xi	20.866	2	<.001*	7.102	2	.029*
	SFP	22.291	2	<.001*	12.212	2	.002*

4. Discussion and Conclusion

We studied whether Taiwan Mandarin speakers prosodically distinguish *wh*-interrogatives from indefinites, and whether sentential prosodic organization interacts with the systems of focus marking and syntax (as represented by the occurrence of SFPs). Our results show that the mechanism of sentential prosodic organization not only considers lexical tones, but also sentence types and focus marking, as target sentences across sentence types bear identical lexical tones, and yet, consistent patterns were found to distinguish statements from questions, and specific patterns of *wh*-focus were also observed.

Concerning focus marking, we observed that *wh*-phrases in *wh*-questions showed significantly higher F0 than *wh*-phrases in declaratives across all four types of *wh*-phrases. This finding is not only in line with previous studies on focus prosody, but also indicates that TwM speakers acoustically distinguished *wh*-interrogative (in *wh*-questions) from *wh*-indefinite phrases (in declaratives). Also worth noting is that while the overall F0

contours of *wh*-questions and *yes/no* questions were similar, the F0 of *wh*-phrases were significantly higher than that of *yes/no* questions in 'who', 'what', and 'what thing', and only when the *wh*-phrase was 'where', the F0 of *wh*-phrases was lower in *wh*-questions than when it was in *yes/no* questions, although such a difference did not reach statistical significance. This reversed pattern might be due to the lexical tone of 'where' which ends in a low tone. One possibility would be that unlike high tones units that mark focus through raising the F0, low tone units may do so by lowering the F0. We leave this point for future study.

Our results also show that sentence final position can bear acoustic prominence. The overall F0 analyses across sentence types show that declaratives exhibit sentence initial prominence with a gradual lowering toward the end of the sentence, whereas both questions more dramatically raise the F0 on *wh*-phrases and on the SFPs. This sentence-final rising of F0 observed in both questions may seem to suggest that TwM speakers do not distinguish the two readings of *wh*-indeterminates. However, considering that they did prosodically distinguish them in *wh*-questions and statements, we think that this sentence final similarity of both types of questions may be due to different reasons. For *wh*-questions, it is expected, because the *wh*-phrases are the second unit to the last in each target sentence. For *yes/no* questions, although it is not expected to see a rise of F0 of *wh*-phrases expressing the indefinite reading in *yes/no* questions, the syllable immediately following the *wh*-indefinite is SFP indicating the *yes/no* question status. Thus, the sentence final F0 rising may be due to the sentential focus marked by the SFP of *yes/no* questions (cf. similar but less prominent F0 rising, while comparing it with the SFP of *wh*-questions).

In addition to F0, our results show very interesting and consistent patterns of duration and F0 range, across four *wh*-phrase types. Unlike the on-focus lengthening effect reported in previous studies, in our study the last syllable of all four types of *wh*-phrases in both questions was significantly shorter than that syllable in declaratives. This may seem rather surprising until we looked at the SFPs (immediately followed the target *wh*-phrases), i.e., SFPs in both questions were significantly longer than the SFPs in declaratives. Considering the duration patterns of *wh*-phrases and SFPs, we think that these two units may cooperate in marking focus prosody. Interestingly, the patterns of F0 range were also consistent across all four types of *wh*-phrases. The F0 range of statements was wider than both types of questions in the SFPs and in the last syllable of *wh*-phrases. These suggest that the occurrence of SFPs explicitly defines the sentence types, and while maintaining the lexical tones, the syntactic information indicated by SFPs requires the prosodic organization to comply with focus marking, as shown by the acoustic patterns of Tone1 SFPs across sentence types.

In sum, our results suggest that the internal information at different structural levels interact with the sentential prosody. We expect to see similar interactions in other Mandarin varieties, and would like to testify such effects in different groups of Mandarin speakers (e.g., male speakers, and learners of Mandarin), and other (Sinitic) languages in the future, to further advance our understanding of the language system.

5. Acknowledgements

6. References

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