FOCUS AND BOUNDARY IN CHINESE INTONATION

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ABSTRACT

Based on the previous studies on Chinese intonation and our own production data, we propose a model of Chinese intonation in which the surface f_0 contours of a prosodic phrase (PP) can be modeled by the combined effects of focus stress and boundary tones. The observed patterns are based on the statistical analysis of the data. Experiment results indicate that narrowly focused syllables have a significantly higher f_0 peak in Tones 1, 2 and 4, and a lower f_0 trough in Tone 3. They are represented as [+RAISEH] and [+LOWERL]. Broad focus does not raise f_0 peak, and the pitch range at the end of PPs is expanded. Declarative and interrogative intonation are distinguished intonationally by different boundary tones, which either raise or lower the *whole* tone of the PP-final syllable. Their features are [+RAISETONE] and [+LOWERTONE]. We conclude that the proposed feature-based model captures the significant pitch events related to focal prominence and boundary tones in Chinese intonation, and that Chinese intonation can be adequately described in the framework of intonational phonology.

Keywords: Chinese intonation, focus, boundary

1. INTRODUCTION

In spoken language communication, speakers are able to effectively convey focus information of the intended meaning and attitudinal information such as making a statement, asking a question, issuing a command or expressing exclamation. Such pragmatic functions can be expressed through intonation, which, cross-linguistically, is realized in time-varying f_0 contours corresponding to syllables in accented position and at the prosodic boundaries. Chinese intonation, however, presents an interesting challenge since as a tone language every syllable carries one of the four lexical tones. Tones are realized as f_0 changes over a syllable. In his classic study of English and Chinese intonation, Chao [1] noted that "[i]t is necessary therefore to disentangle one from the other in order to see what is speech intonation (p.111)."

In this paper we propose a feature-based model of Chinese intonation in which focal prominence and boundary tone play a key role in shaping the surface f_0 contours of the sentences. We present results from two experiments: the first one on the effect of two kinds of focal prominence on the f_0 contours in a prosodic phrase, and the second one on the effect of boundary tones in declarative and interrogative intonation. We identify main acoustic correlates and define intonational features for the focal prominence and the boundary tones.

In the following discussion, we adopt the hierarchical prosodic phrase grouping theory developed in [12]: prosodic units are organized in the order of syllable, prosodic word (PW), prosodic phrase (PP) and utterance. All the prosodic units discussed in this paper contain one PP.

2. FOCAL PROMINENCE

We identify two kinds of focal prominence, introduced by narrow focus and broad focus, in Chinese intonation. Narrow focus generally falls on the part of the PPs highlighted by either wh-questions or a contrast in the discourse. Broad focus occurs in PPs that carry normal stress. We are not concerned with the grammatical means by which focus is marked.

Previous studies of Chinese intonation showed that both narrow focus and broad focus induce changes in f_0 contours. For example, Xu [15] observed pitch range expansion on the focused syllable, followed by the pitch range compression on the post-focus syllable. Jia, Xiong and Li [3] found that narrow focus raised the pitch of Tone 1, Tone 2 and Tone 4 and lowered the pitch of Tone 3, where Tones 1, 2, 3 and 4 are the four lexical tones in Mandarin Chinese. Broad focus seems to have different effect. In their study of trisyllabic words/phrases, Yan and Lin [16] noticed that the lower bound of the pitch range is gradually declining, with the last syllable having more complete f_0 contours. Liu and Xu [8] examined the role of focus in question intonation.

To study the effect of narrow focus and broad focus, we selected 132 sentences from the two well-known Chinese language and linguistics textbooks [13, 14]. The stress position of each sentence has been marked in the two books. Four college students, two males and two females, from the Broadcasting Department of Communications University of China read all the test sentences in a sound-proof recording room, generating a total of 528 sentences (132 sentences *x* 4 speakers) for acoustic analysis. The speakers were instructed to read some of the test sentences with a narrow focus and the others with a broad focus. For example, 这儿凉快 "*zher4* liang2kuai0" ('Here is cool') was read with narrow focus on the locative "zher4". (The numbers '1, 2, 3, 4' and '0' after the pinyin transcription of the sentence correspond to the four lexical tones and the neutral tone of Mandarin Chinese respectively.) 今天星期三 "jin1tian1 xing1qi1san1" ('Today is Wednesday') was read with broad focus, where normal stress is perceived at the end of the sentence. The same sentence could also be read with narrow focus on the subject "jin1tian1". The speakers were able to do it without any difficulty, which indicates that this is part of their linguistic knowledge. Their readings were verified by the authors before being used in the analysis. Segmentation and prosodic labeling were done with Praat, following C-ToBI proposed in [5]. For the purpose of our study, we are only concerned with the acoustic consequences of the two kinds of focus.

2.1.   Narrow focus and its features

It is found that when the narrow focus falls on the syllables in Tone 1, Tone 2 and Tone 4, the f_0 peak is raised prominently, hence expanding its overall pitch range. The resulting f_0 curve of the whole prosodic phrase looks like a convex because of the high f_0 peak. Figures 1 and 2 illustrate the waveforms, pitch contours and the relative duration of the syllables in the following four PPs:

1. 花儿干死了 "huar1 *gan1*si3le0"
   'Flowers withered and died'
2. 一道白光射出
   "yi12dao4 *bai2guang1* she4chu1"
   'A beam of white light is shooting out'
3. 他可以写得好 "ta1 ke32yi3 *xie3*de0 hao3"
   'He can write well'
4. 弟弟看了一眼 "di4di0 *kan4*le0 yi14yan3"
   'Little brother peeked at it'

The four PPs are produced with a narrow focus on one or two syllables which are italicized. The tones of the syllables are represented by the numbers. For the syllables with two tone numbers, the first one indicates the original tone and the second one indicates the tone it changes into due to the tone sandhi process. The boxes shown in the diagrams of the pitch contours are used to demarcate the division of the PWs in the PPs. The pinyin transcriptions of the PPs are provided at the bottom of the figures.

Figure 1: The waveforms (top), pitch contours (middle) and relative duration (bottom) of the syllables in "*huar1* gan1si3le0" (left) and "yi1dao4 *bai2guang1* she4chu1" (right).
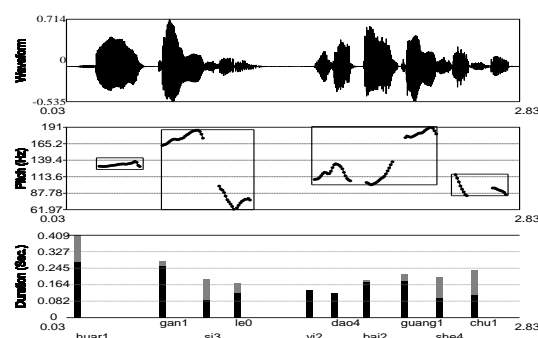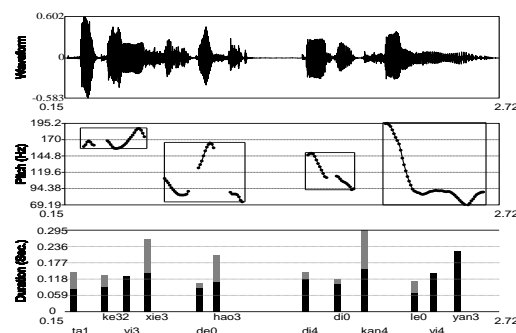

Figure 2: The waveforms (top), pitch contours (middle) and relative duration (bottom) of the syllables in "ta1 ke32yi30 *xie3*de0 hao3" (left) and "di4di0 *kan4*le0 yi14yan3" (right).

In Figure 1, the syllables "gan1" in the sentence on the left and "bai2guang1" in the sentence on the right carry the narrow focus. Therefore their tones are realized with a significantly higher f_0 peak, contrasting sharply with the tones before and after. Similar pattern is observed in the sentence on the right in Figure 2, where "kan4" carries the narrow focus. The tones of the syllables "gan1", "bai2" and "kan4" are Tone 1, Tone 2 and Tone 4, which are traditionally represented as H, LH, and HL respectively in the tonal phonology of Mandarin Chinese. Thus, we propose that narrow focus is associated with an intonational feature, defined as

[+RAISEH], which will effectively raise the f_0 peak on the pitch curve, if present, of the narrowly focused syllable with a H-tone target. The defining tone feature is a L-tone target for Tone 3 in Mandarin Chinese. When the syllable in Tone 3 is focused, its f_0 goes downward, resulting in a concave pattern, as shown in the sentence on the left in Figure 2, where "xie3" carries the narrow focus. Our proposed intonational feature is defined as [+LOWERL].

2.2. Broad focus and its features

Broad focus does not highlight any particular part of the sentence prosodically. The normal stress is often perceived at the end of PPs. In contrast to PPs with narrow focus, it does not introduce any raising effect of f_0 peak on the pitch curve. The last one or two syllables at the end of PPs seem to have a lowered f_0, which might be due to the often observed f_0 declination effect [10]. The glottal vibration is becoming slack toward the end of the sentence when there is no active prosodic adjustment like narrow focus. Also irregular glottal vibration occurs frequently toward the end of a sentence [11]. Two examples of the PPs with broad focus are given in 5 and 6. Waveforms, pitch contours and relative durations of the syllables in the two PPs are shown in Figure 3.

5. 今天星期三"jin1tian1 xing1qi1san1"
   'Today is Wednesday'
6. 你不会外语"ni3 bu2hui4 wai4 yu3"
   'You can't speak a foreign language'

Figure 3: The waveforms (top), pitch contours (middle) and relative duration (bottom) of the syllables in "jin1tian1 xing1qi1san1" (left) and "ni3 bu2hui4 wai4yu3" (right).
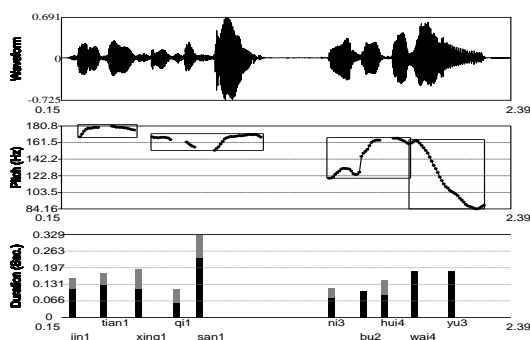
As shown in Figure 3, there are two PWs in each of the two PPs, with no prominent f_0 peak across the PWs. The pitch range of the last PW is the largest. This is a typical f_0 pattern for the PPs with broad focus.

In sum, narrow focus provides further adjustment to the resulting pitch curves through two intonational features, [+RAISEH] and [+LOWERL]. The former works on the H-tone target or the resulting f_0 peak of Tone 1, Tone 2 and Tone 4, and the latter on the L-tone target or the resulting f_0 trough of Tone 3. Broad focus does not introduce significant prosodic adjustment. The expanded pitch range at the end of a PP seems to be associated with the normal stress, which is often perceived at the end of the PP.

3. BOUNDARY TONES

In the model of intonational phonology [4, 9], boundary tones are L or H pitch events occurring at the end of a PP. Recent studies [6, 7] showed that the information distinguishing declaratives and interrogatives in Chinese is also carried by the boundary tones. We explore the relation between the four lexical tones and the boundary tones by comparing the f_0 contours of the syllables in isolation and the same syllables occurring at the end of the declarative and interrogative PPs. Each of the four students participated in this study produced the frame sentence 这个字读作 X, "zhe4ge4zi4 du2zuo4 X" ('This word is read as X'), in which X was one of four syllables: "cai", "da", "tao" and "zhai" said in four lexical tones respectively. Each sentence was read in both declarative and interrogative intonation. X was also read in isolation. Since no question particles are present, the only difference between the two readings resides in intonation. The data are presented in Table 1, with explanations below.

Table 1: Averaged pitch scale in semi-tone of the target syllables carrying boundary tones in interrogative reading, in isolation reading and declarative reading for the two male and two female speakers.

Tones	Readings	Male	Female
Tone 1	Interrogative	13.76	19.76
	Isolation	10.15	17.34
	Declarative	8.63	15.83
Tone 2	Interrogative	6.15	13.82
	Isolation	4.40	13.19
	Declarative	2.50	11.75
Tone 3	Interrogative	3.14	10.41
	Isolation	1.18	8.47
	Declarative	-2.0	3.98
Tone 4	Interrogative	11.71	18.81
	Isolation	8.35	16.16
	Declarative	6.49	14.33

The target syllables were produced in isolation, in interrogative and in declarative readings by the

two male and female speakers. Measurements of f_0 were made at ten equally-spaced points throughout the total duration of the target syllables. The averaged pitch scale in semi-tone over the ten points of the target syllables in the three readings is given in Table 1 above. The corresponding pitch contours of the target syllables for all the speakers in the three readings are plotted in Figure 4.

Figure 4: The averaged pitch contours of the target syllables in Tone 1, Tone 2, Tone 3 and Tone 4 in interrogative reading, in isolation reading and declarative reading for all the four speakers.
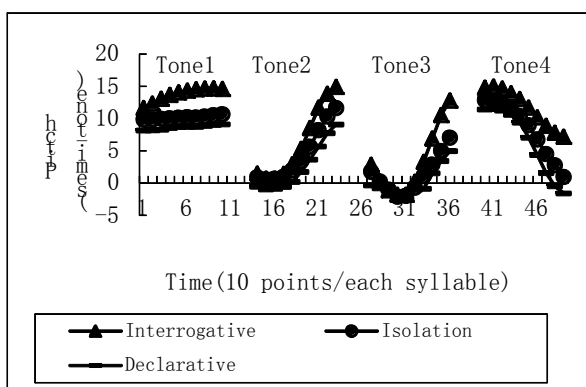
It can be seen from Table 1 that the averaged pitch scale of the target syllables has the highest value in interrogative reading and the lowest value in declarative reading. The isolation reading comes in between. The pitch contours in Figure 4 confirm the above observation. Note that it is the overall f_0 contours being raised in interrogative reading and lowered in declarative reading relative to the corresponding isolation reading. Following Lin [6, 7], we attribute the raising and lowering effects to the boundary tones in respective interrogative intonation and declarative intonation.

The boundary tones affect the *whole* tone rather than a part of the tone in the phonological representation of the four tones, and the effect is the same on all four tones. Therefore, we propose the following two features for the boundary tones: [+RAISETONE] in interrogative intonation and [+LOWERTONE] in declarative intonation.

4. CONCLUSION

The feature-based model of Chinese intonation consists of two key components: focal prominence and boundary tones. The features proposed for narrow focus and boundary tones are based on analysis of the acoustic correlates of these categories, and they are summarized below:

Narrow Focus: [+RAISEH] and [+LOWERL]
Interrogative boundary tone: [+RAISETONE]
Declarative boundary tone: [+LOWERTONE]

We conclude that the proposed feature-based model captures the significant pitch events related to focal prominence and boundary tones in Chinese intonation, and that Chinese intonation, like non-tonal languages, can also be adequately described in the framework of intonational phonology. The applicability of our model in speech synthesis is also confirmed by the synthesis of Cantonese F_0 curves with stress and sentence-final tone using Fujisaki's Command-Response model [2].

5.   REFERENCES

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