INTONATION OF CANTONESE INTERROGATIVE SENTENCES WITH AND WITHOUT SENTENCE FINAL PARTICLE

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ABSTRACT

This paper describes the intonation of Cantonese interrogative sentences with and without sentence final particle (SFP). Sentences of like-tone sequences are used as test sentences. Interrogative sentences without SFP are elicited in the form of echo question. For interrogative sentences with SFP, test sentences are formed by adding SFPs of different lexical tones to the like-tone sequences. In interrogative sentences without SFP, Functional Data Analysis (FDA) is conducted to fit the F0 curve of the last syllable. The results suggest that even if the distinctions between lexical tones are largely influenced by the boundary tone, subtle differences still exist. In interrogative sentences with SFP, the results reveal that SFPs are different from the last syllable of interrogative sentences without SFP, yet are not fully determined by intonation. This study deepens the understanding of the interplay between tone and intonation in lexical tone languages.

Keywords: Cantonese, interrogative sentences, SFP, intonation, tone.

1. INTRODUCTION

Lexical tone and intonation employ the same acoustic parameter, namely, fundamental frequency (F0), while lexical tones are used to distinguish lexical meaning and intonation non-lexical meaning [7, 9]. There are various views upon the question of how tone and intonation interact. Chao [3] proposes that in Mandarin Chinese, the intonational tones can be added to the lexical tones either simultaneously or subsequently. In the generative model of intonation proposed by Gårding [5], a grid is generated according to the sentence type and prominence relations, after which lexical tones are realized within the range of the grid. Based on cross language data, Hyman and Monaka [8] suggests that there can be three possibilities concerning the interaction between intonation and tone, being accommodation ("peaceful coexistence"), submission ("surrender"), and avoidance ("blockage"). Apart from the complex interaction between lexical tone and intonation, what one language expresses by intonation can be expressed in another language by sentence particles. The most well-known examples, of course, are question particles and focus particles [9].

Cantonese is a tone language, which makes use of both intonation and sentence particles to express post-lexical meaning. Cantonese is a Chinese dialect, whose population is distributed among Hong Kong, Guangdong Province in China, and various other areas. A general description of Cantonese phonology can be found in [20]. There are nine lexical tones in Cantonese, six of which are unchecked tones and three of which are checked tones. Checked tones can only occur in syllables ending with [p,t,k], while unchecked tones can only occur in open syllables. Since the three checked tones have the same pitch height as the three level tones of unchecked tones, it is generally accepted that Cantonese has six lexical tone categories. The six lexical tones and the symbols used in this paper is shown in Table 1. Apart from the lexical tones, various intonational tones of Cantonese are proposed by Wong et al. [15]. The most well recognized boundary tone is the H boundary tone for yes-no question. In additional to intonational tones, Cantonese has an abundant inventory of Sentence Final Particles (SFP). The number of SFPs in Cantonese are claimed to be over 40 [4]. These SFPs can not only be used in questions, but also in statements. More strikingly, these SFPs are said to have their own lexical tones.

Some acoustic studies have been conducted to address the effect of boundary tone to lexical tone in Cantonese [10, 11]. It is found that at the final position of questions, the pitch contours of all six tones of Cantonese become rising. Due to this situation, it is of doubt if the native speakers of Cantonese can identify the lexical tone of the final syllable in questions. A perception study finds that although T1 and T5 can be identified with high accuracy, a large portion of T2, T4, and T6 are misperceived as T3 [11]. Another perception study asks if listeners can discriminate between different tone pairs at the end of questions. The results show that the pairs T3 and T4, T3 and T6, T3 and T4 are hard to discriminate [12]. The results of these two studies are in general consistent, and the slight discrepancy can be attributed to differences in experimental designs.

Several studies are concerned with SFPs in Cantonese [16, 17, 22]. One of the studies finds that SFP is in complementary distribution with the H boundary tone in questions, and proposes that H boundary tone in Cantonese is a segmentless SFP [22]. The other study compares the F0 contour of SFP in question with the SFP in statement and the last syllable in echo question. It is found that the F0 of SFP is an amalgam of lexical tone and intonation [17].

Based on these previous studies, the present study intends to answer the following two questions:

1. Are lexical tones still distinctive under the influence of boundary tone?
2. Do SFPs have their own targets?

For the former, Functional Data Analysis is applied on the pitch track of the last syllable, which can capture the properties of the whole curve. The results can be submitted to Functional Principal Component Analysis to capture the differences across tones. For the latter, the tone of the syllable immediately preceding SFPs is manipulated to see if the phonetic realization of SFP is influenced by the preceding tone. In this paper, the tone target is defined to consist static and dynamic targets, which can be measures using F0 level and F0 direction.

Table 1: The lexical tone inventory of Cantonese

Tone	Tone value
T1 (Yinping)	55
T2 (Yangping)	21
T3 (Yinshang)	25
T4 (Yangshang)	23
T5 (Yinqu)	33
T6 (Yangqu)	22

2. METHODOLOGY

Sentences composed of syllables of the same lexical tone category are constructed as target sentences. For interrogative sentences without SFPs, the target sentences are embedded in the context so that the target sentence is produced as an echo question to a statement of the same content. An example is shown in (1a). The target sentence is in italic with a literate translation. This study does not consider the case of checked tones, so there are six sentences for six unchecked tones in total. Since in Cantonese, there is no SFP with T6 (22). For interrogative sentences with SFPs, SFPs of four lexical tones (T1, T2, T3, and T5) are selected. The SFP with T4 is not used due to the difficulty in constructing appropriate test sentence. The SFPs are each added to the sentences of T1 (55), T2 (21) and T3 (25), respectively, thus formed 4×3 = 12 sentences. An example of interrogative sentence with SFP is given in (1b). The SFPs and the connotations they convey are listed in Table 2.

The recording is carried out in a sound-treated booth. The sounds are sampled at 16000 Hz and digitized at 16 bit. Fourteen native speakers of Cantonese from either Guangzhou or Zhongshan volunteered to participate in the recording. There are seven male speakers and seven female speakers, all in their twenties. During the recording, speakers are instructed to produce the sentences as naturally as possible. In the case of interrogative sentences without SFP, speakers are asked to produce the test sentences as a dialogue. The same style is also applied to the interrogative sentences with SFP.

(1) a. - 姑妈今朝返苏州。
- Auntie will go back to Suzhou today.
- *姑妈今朝返苏州?*
- *Auntie today goes back to Suzhou?*

b. 姑妈今朝返苏州咩?
Will auntie go back to Suzhou today?

Table 2: The Sentence Final Particles (SFPs) used in the test sentences (according to [4])

SFP	Tone	Connotation
mɛ (咩)	55	Confirmation
a (呀)	21	Guess or reassuring
ka(㗎)	25	Doubt
ma(吗)	33	Requesting for information

The sounds are manually annotated, and the F0 tracks automatically generated by Praat [2] are checked manually. For the interrogatives without SFP, the pitch information during the voiced parts of the last syllable is submitted to the Functional Data Analysis. Functional Data Analysis (FDA) is an advanced statistical method that can represent curves or trajectories. FDA is especially useful for capturing the overall shapes of curves, which can later be submitted to Functional Principal Component Analysis (FPCA). FDA has been adopted to the study of acoustic studies of prosody [14, 21], vowel formant patterns [6], as well as studies of articulatory data [13]. More details concerning FDA will be given in the next section. For the interrogative sentences with SFP, the target of SFP can be measured by Final F0 and Final Velocity, according to early results on Mandarin [19]. To be specific, Final F0 measures the F0 level of SFP, which is the static aspect of the tone, while Final Velocity, calculated as the first derivative of the pitch curve, measures the dynamic aspect of the tone. Final F0 and Final Velocity are both extracted using the praat script ProsodyPro [18]. The two measures, Final F0 and Final Velocity, are in semitone and semitone/s, respectively

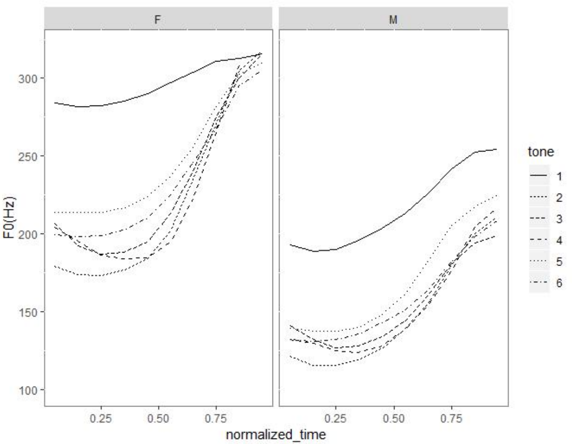
3. RESULTS

3.1 Interrogative sentences without SFP

In this section, we will illustrate the general pattern of boundary tones in interrogative sentences without SFP, and then briefly present the procedure of FDA, after which the results of FPCA will be provided.

Figure 1 is the F0 curves averaged across speakers of the same gender of the last syllable in the interrogative sentences without SFP. It can be seen quite clearly that all these curves are rising, while the curve of T1 is most remarkably different from the others. The curve of T1 starts at a relatively high level, and then rise abruptly. It is also clear that the curves of other tones are of delicate differences, yet all in a rising shape. For example, the curves of T3 and T4 have concave shape in the first half of the curves, while they differ in the magnitude of the concavity. With this observation, it seems FDA, as a technique which can capture the overall shape of the curve, is quite appropriate for answering the question that if different lexical tones remains distinctive under the influence of boundary tones.

Figure 1: F0 curves of the final syllable of the interrogative sentences without SFP (left: female; right: male)



To apply FDA to our data, we follow the procedure in [14]. The data, as is mentioned in the methodology section, are the pitch during the voiced segments of the last syllable. The data are originally in Hz scale, and are transformed into the semitone scale. Following the generalized cross-validation procedure, two parameters, namely, the number of knots and lambda, are chosen as 10 and -12, respectively. Since the data in this study is confined to the voiced segments of the last syllable, we do not apply Landmark Registration, as is also the case in [6]. The smoothed curves are then submitted to FPCA. Three principal components are calculated. The first Principal Component (PC1) explains 99.99% of the variance, while PC2 explains only 0.0072% of the variance. The distributions of PC1 scores and PC2 scores can be seen in the boxplots in Figure 2.

In the left panel, scores of PC1 of tones other than T1 are in approximately the same level, while the scores of T1 are remarkably different from the other tones. This suggests that PC1 mainly captures the difference between T1 and the other tones, which is in accordance with the pattern in Figure 1. A one-way ANOVA shows that PC1 is different across tones ($F(5,78)=3.724$, $p<0.01$). Scores of PC2, however, are also different for different tones. The distribution of the six tones is plotted in the PC1 × PC2 plane as in Figure 3, with results for female on the left panel, and the male on the right. There seems to be no clear pattern at first glance. However, T1 is clearly different from other tones, especially in females. The distribution of T5, even if more diversed than T1, also tends to cluster together. T2, T3 and T4 have a large degree of overlap. T6 seems to be the most variable tone, with no clear pattern of distribution.

Figure 2: The distributions of scores of PC1 (left) and PC2 (right) of different tones (T1 to T6 from left to right)

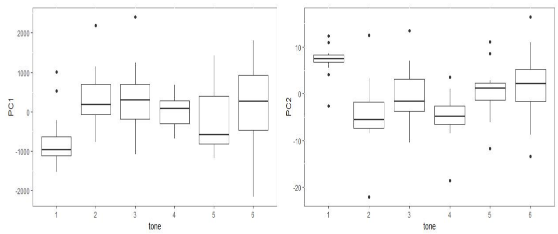
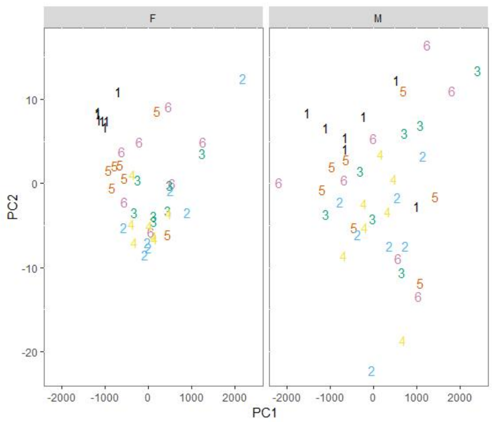


Figure 3: The distribution of T1 to T6 in PC1 × PC2 plane (left: female; right: male)

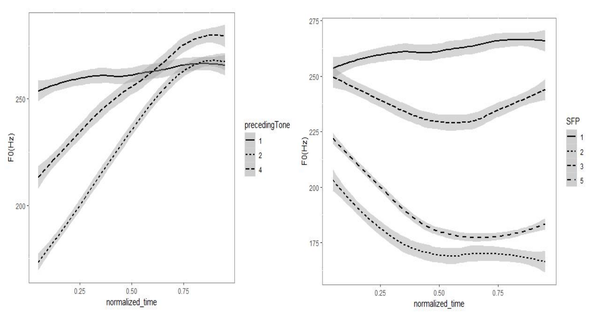


3.2 Interrogative sentences with SFP

Figure 4 shows average F0 curves of SFP of T1 (mɛ) following syllables of T1, T2 and T3 (left), and average F0 curves of different SFPs following T1, (right) for female. The left panel illustrates that even if the same SFP undergo coarticulation due to the preceding tone, the offset is quite stable and the pitch curve gradually approximates the same point in the pitch range. The right panel shows that different SFPs have different pitch curves even following the same tone. According to the final portion of the F0 trajectories, these SFPs are conspicuously different in F0 levels, yet the situation of the directions of F0 movement is less clear. The pitch curves nonetheless are consistent with the impressionistic transcriptions of the four SFPs as 55(mɛ), 21(a), 35(ka), 33(ma), regardless of the variation caused by the preceding T1. The F0 contours of these SFPs, however, are clearly different from the syllable at the final position of echo questions.

Statistical analysis of Final F0 agrees with these observations. A linear mixed model is fitted to the data of Final F0 using the lme4 package in R [1]. The tone of SFP and the tone of the preceding syllable are entered as fixed effects, while speaker and gender are entered as random effects. A significant effect is found for the tone of SFP ($\chi^2(1)=46.87$, $p<0.001$), while no such effect is found for the preceding tone ($\chi^2(1)=0.19$, $p>0.05$). A similar linear mixed model is also applied to Final Velocity. However, no significant effect is found for both the tone of SFP ($\chi^2(1)=0.23$, $p>0.05$) and the preceding tone ($\chi^2(1)=0.13$, $p>0.05$).

Figure 4: Average F0 curves of SFP of T1 after syllables of T1, T2, and T3 (left), average F0 curves of SFP of T1, T2, T3, and T5 after the syllable of T1 (right), both for female, with the gray shades indicating the standard errors



4. DISCUSSION AND CONCLUSION

For interrogative sentences without SFP, this paper studies the familiar question of Cantonese tone at the end of interrogative sentences using a new method, namely, FDA. The results agree well with the former results using the traditional methods and also the perceptual results. Even if the significant effect is found for both PC1 and PC2 calculated using FDA results, the different proportions of variation PC1 and PC2 explain suggest the situation is more complex. From the distribution of scores of PC1 for different tones, it is clear that PC1 mainly captures the difference between T1 and the other tones. Even if tone also has a significant effect in PC2, the small proportion of variance it explains suggest that difference between tones other than T1 is subtle. The distribution of these six tones in PC1 × PC2 plane suggests that T1 and T5 are different from the other tones, while the other tones have a great degree of overlap. The results are consistent with the perception studies of [11] and [12]. Due to the influence of the H boundary tone, the lexical tone distinction of the last syllable is largely neutralized.

For interrogative sentences with SFP, SFPs of various tone categories are attached to the like-tone sequences of various tones. The F0 contours of SFPs are different from the boundary tone in interrogative sentences without SFP in not having the abrupt rising F0 contour. The F0 contours of SFPs are influenced by the immediately preceding tone, which can be attributed to tonal coarticulation. The results suggest that SFPs of different tones are different in F0 level, but not different in the direction of F0 movement. This is accountable, and even is exactly what is expected. Three of the tones of SFPs are level (T2 (21) is usually treated as low level in the literature). The distinction between these tones is tone level rather than tone contour. The results thus confirm the traditional impressionistic transcriptions. The results also show that, neither Final F0 nor Final Velocity is influenced by the preceding tone. This is good evidence that the tonal targets of SFPs are quite stable.

Taken together, we can have a better understanding of the interplay between tone and intonation in Cantonese. Cantonese H boundary tone in questions can largely but not fully neutralize lexical tone contrast. It is possibly due to this conflict between lexical tone and intonation that Cantonese uses an abundant number of SFPs to convey post-lexical meanings. SFPs in Cantonese have stable tonal targets, which can be preserved under the perturbation of the preceding tone.

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