The $F_0$ Patterns of Tones in Hakka Chinese

Yuk-Man Cheung

Phonetics Laboratory, Department of Chinese, Translation and Linguistics, City University of Hong Kong
y.m.cheung@student.cityu.edu.hk

Abstract

This paper investigates the patterns of the $F_0$ contours for the two level tones [44, 11], two falling tones [52, 31] and two short tones [5, 1] on syllables that associated with vowels [i, a, u] in Meixian Hakka, which is one of the Chinese dialects. Results show that (i) the $F_0$ contours of the two level tones are level as expected and the difference in $F_0$ value between the two tones is around 50 Hz; (ii) the $F_0$ values of the ending points of the $F_0$ contours for the two falling tones are similar. The two tones are acoustically differentiated by the starting point, the highest point and the shape of the $F_0$ contour; (iii) the high short tones tend to be level, whereas the low short tones tend to be falling; and (iv) the differences between the $F_0$ patterns of the tones on syllables with different vowels are due to the influence of the initial consonants.

1. Introduction

Meixian Hakka is a dialect of the Hakka group of the Chinese language. Meixian Hakka is a tonal language in which difference in tone indicates lexical contrast. The Meixian Hakka tones have been extensively studied on their historical development and phonological perspective in the past studies (Huang, 1988; 1989; 1992; Xie, 2003; Xie, 1994; Zhou, 1998). Nevertheless, there is no acoustic data presented in any of the past studies.

It is generally agreed among the authors of the past studies of the language that there are six citation tones in Meixian Hakka. (Huang, 1992; Xie, 1994; Yuan, 1960) They are two level tones, two falling tones and two short tones, which are characterized by tone level (high and low), respectively. There are differences in the descriptions of the six citation tones in Meixian Hakka in terms of the tone value among the past studies. It is assumed that the differences are due to each author’s individual impression on the tone contours and levels. In this study, the transcription of Meixian Hakka tones in Yuan’s study (1960) was used as reference and the six citation tones are [44, 11, 52, 31, 5, 1].

This study is an acoustic analysis of the six citation tones in Meixian Hakka. The main purpose of this study is to investigate the $F_0$ values and $F_0$ contour of each of the six citation tones [44, 11, 52, 31, 5, 1] in Meixian Hakka. In this study, each of the six citation tones was associated with vowels [i], [a] and [u]. The tone-vowel interaction found in this study will also be briefly discussed.

2. Methodology

2.1. Speakers

The speech data were provided by 2 male and 2 female speakers. All of them are native speakers of Meixian Hakka who were born and grew up in Meixian that located in the northeast Guangdong Province of China. They were aged between 50 and 70 year-old with no history of speech or hearing disorders.

2.2. Test materials

In this study, the test words were composed of vowels [i, a, u] that associated with each of the 6 citation tones [44, 11, 52, 31, 5, 1] in Meixian Hakka. For syllables superimposed by the level and falling tones, those associated with vowel [i] were spoken in isolation, whereas those with vowels [a, u] were preceded by syllable-initial [tsʰ]. For syllables superimposed by the short tones, vowel was followed by syllable-final [t]. Each of the test words was embedded in a carrier sentence [jɔ11 tʰuk5 ____ pun35 mɔ11 tʰap44] “I read ____ for you (to) listen.”. The order of the test monosyllabic words was randomized and four readings of the word list were recorded. The speakers were instructed to read the word list at a normal rate of speech and audio recordings were conducted in a quiet room.

2.3. Data Analysis

The $F_0$ values and $F_0$ contour of each of the six citation tones were captured and measured using Praat 4.3.19 speech analysis software. For each of the six citation tones, 11 percentage points were sampled from the overall duration of the $F_0$ contour (0% - 100%). The onset of the $F_0$ contour was the first data point (0%) and the subsequent points were sampled at every 10% of the overall duration of the $F_0$ contour. The mean $F_0$ values of the 11 data points for each of the citation tones were measured and plotted in a figure for comparison.

3. Results

As mentioned, there are two level tones [44, 11], two falling tones [52, 31] and two short tones [5, 1] in Meixian Hakka. In the following sections, the mean $F_0$ values (in Hz) of the 11 data points for the 4 repetitions of each of the six citation tones will be presented using figures. For each figure, the X-axis represents the duration of the $F_0$ contour in millisecond (ms), whereas the Y-axis represents the $F_0$ values in Hertz (Hz). It should be noted that, for figures (1d and 4d) showing the $F_0$ contours of the two level tones [44, 11] and two falling tones [52, 31] on syllables that associated with vowel [i] for Female Speaker 2, the maximum duration of X-axis is 700 ms. Whereas for other figures, the maximum duration of X-axis is 500 ms. The results of the two level tones, two falling tones, and two short tones in Meixian Hakka that associated with vowels [i, a, u] will be presented separately.

3.1. Level tones [44, 11]

Figures 1a-1d show the $F_0$ contours of the citation tones [44] (in dark line) and [11] (in grey line) on syllables that...
associated with vowel [i] for the two male and two female speakers. The \( F_0 \) contours of the citation tones on syllables that associated with vowel [u] for the four speakers are shown in Figures 2a-2d, whereas the \( F_0 \) contours of the citation tones on syllables that associated with vowel [a] are shown in Figures 3a-3d.

A comparison of the \( F_0 \) contours of citation tones [44, 11] on vowels [i, a, u] for all four speakers in the three figures shows that the shape of the \( F_0 \) contours of the two level tones are similar in Meixian Hakka. The only difference between the two tones is the level of the \( F_0 \) contour. Despite the difference in quality among the associating vowels, there is an approximately 50 Hz difference in terms of \( F_0 \) value between the high level tone [44] and the low level tone [11]. Though the shapes of the \( F_0 \) contours for the two level tones are not necessarily level, the variation in \( F_0 \) value of the \( F_0 \) contour is limited and the \( F_0 \) contours of the two level tones are quite steady in most of the cases. Therefore, it is agreed that the two tones should be considered as basically level. In addition, it seems that there is no significant difference in duration between the high level tone [44] and the low level tone [11].

3.2. Falling tones [52, 31]

Figures 4a-4d show the \( F_0 \) contours of the citation tones [52] (in dark line) and [31] (in grey line) on syllables that associated with vowel [i] for the four speakers. The \( F_0 \) contours of the citation tones on syllable that associated with vowel [u] for the four speakers are shown in Figures 5a - 5d. The \( F_0 \) contours of the citation tones on syllable that associated with vowel [a] are shown in Figures 6a - 6d.

As shown in Figures 4a-4d, Figures 5a-5d and Figures 6a-6d, despite the difference in the associating vowels of the test syllables, results show that the level of the ending point of the \( F_0 \) contours for the two falling tone are similar for the four speakers. That is, there is no significant difference in \( F_0 \) value between the ending point of the \( F_0 \) contour for the high falling tone [52] and that for the low falling tone [31]. The acoustic differences between the high falling tone and the low falling tone are (1) the \( F_0 \) value of the starting point, (2) the \( F_0 \) value of the highest point and (3) the shape of the \( F_0 \) contour. For tone [52], the \( F_0 \) values of the starting-point and the highest point of the \( F_0 \) contour are higher than those for tone [31] in most cases. However, it should be noted that there is interspeaker variation on the \( F_0 \) values of the starting points of the \( F_0 \) contour for tone [52] and tone [31]. The \( F_0 \) values of the starting points of the \( F_0 \) contours for [52] and [31] are similar on syllables that associated with vowel [i] produced by Male Speaker 1 and Male Speaker 2 (Figures 4a and 4b).

A comparison of the Figures 5a-5d and Figures 6a-6d with Figures 4a-4b show that there is difference in the shape of the \( F_0 \) contour between the tones [52, 31] on syllables that associated with vowels [a, u] and those on syllables that associated with vowel [i]. Such difference will be discussed in the latter section. In general, results show that for tone [52], there is a steady state or a slight rise before the rapid fall and it covers about one-third of the overall duration of the \( F_0 \) contour, whereas for tone [31], a rapid fall is found immediately after the starting point of the \( F_0 \) contour. In addition, results show that the durations of the \( F_0 \) contour for tones [52, 31] on syllables that associated with vowel [i] (Figures 4a-4d) are longer than those on syllables that associated with vowels [a, u] (Figures 5a-5b and Figures 6a-6d) for the four speakers. The durations of the \( F_0 \) contour for [52, 31] on syllables with [i] range from 300 ms to 600 ms for
the four speakers, whereas those on syllables with [a, u] range from 250 ms to 380 ms. This may be due to the difference in syllable structure of the test syllables. For vowels [a, u], they were preceded by a syllable-initial consonant, whereas there is a zero initial for vowel [i] and it was spoken in isolation.

3.3. Short tones [5, 1]

Figures 7a - 7d show the F0 contours of the citation tones [5] (in dark line) and [1] (in grey line) on syllables that associated with vowel [i] for the four speakers. The F0 contours of the citation tones on syllable that associated with vowel [u] for the four speakers are shown in Figures 8a - 8d, whereas the F0 contours of the citation tones on syllable that associated with vowel [a] are shown in Figures 9a - 9d.

Figures 7a-7d show that the F0 contour of the high short tone [5] on syllables that associated with [i] has a slight rising trend. There is a slight rise which covers more than half of the overall duration of the F0 contour before the fall for the low short tone [1]. Figures 8a-8d and Figures 9a-9d show that for [5] on syllables that associated with [a, u], the F0 contours are basically level for the four speakers, whereas the F0 contours tend to be falling for [1] on syllables that associated with [a, u]. In all cases, the F0 values of the starting points of the F0 contours for [5] and [1] are similar and their difference is small compared to the difference between the F0 values of the ending points of the F0 contours for [5] and [1].

Figures 4a-4d: The F0 contours of the citation tones [52] (in dark line) and [31] (in grey line) on syllables that associated with [a] for the four speakers.

Figures 5a-5d: The F0 contours of the citation tones [52] (in dark line) and [31] (in grey line) on syllables that associated with [i] for the four speakers.

Figures 6a-6d: The F0 contours of the citation tones [52] (in dark line) and [31] (in grey line) on syllables that associated with [u] for the four speakers.
with vowel [i] in this study were produced in isolation. As mentioned in the previous section, syllables that associated on syllables with [i] and [u], which are high vowels. In tones on syllables with [a] and [u] are similar but not tones of vowel [u] differs in both vowel height and backness from [a]. In order to further verify whether the difference between the F0 patterns of the citation tones on syllables with [i] and those on syllables with [a, u] is due to the influence of zero initial or preceding glide [j] of vowel [i], additional F0 data for tone [1] on vowel [a] with zero onset and syllable-final [p] were analyzed. Figures 10a-10d show the F0 contours of [1] with initial [tsʰ] (in dark line) and with zero initial (in grey line) for the four speakers. Results show that the F0 contours for [1] on [a] with zero initial show a similar pattern as those on [a] with initial [tsʰ]. As the F0 pattern for [1] on [a] with zero initial differs form the F0 pattern of the same tone on [i], it seems that the appearance of initial glide [j] results in the particular F0 pattern found in tones on syllables with [i].

4. Discussion

According to the F0 data presented earlier, the shapes of the F0 contour for the falling tones [52, 31] on syllables with [i] differ from those on syllables with [a, u]. On one hand, Figures 4a-4d show that there is a rise for more than half of the overall duration of the F0 contour, before the fall for [52] on syllables with [i] for the four speakers. For [31] on syllables with [i], there is a steady state for more than half of the overall duration of the F0 contour before the fall. On the other hand, Figures 5a-5d and Figures 6a-6d show that there is a very slight rise or a steady state before the fall for [52] on syllables with [a, u]. The F0 contours for [31] on syllables with [a, u] tend to be falling from the beginning of the syllables. In fact, similar phenomenon can be found in the F0 data of the short tones. Figures 7a-7d show that the F0 contour for [5] on syllables with [i] has a slight rising trend and the F0 contour for [1] has a very slight rise or a steady state for more than half of the overall duration. The F0 contour for [5] on syllables with [a, u] tends to be level, whereas that of [1] tends to be falling (Figures 8a-8d and Figures 9a-9d).

There are two possible explanations on this phenomenon. First, it may be due to the difference in the quality of the associating vowels of the test syllables that result in the difference in the F0 pattern of the citation tone. However, as vowel [u] differs in both vowel height and backness from vowel [a]. It would be hard to understand why the F0 pattern of tones on syllables with [a] and [u] are similar but not tones on syllables with [i] and [u], which are high vowels. In comparison, the second explanation may be more convincing. As mentioned in the previous section, syllables that associated with vowel [i] in this study were produced in isolation, whereas syllables that associated with vowels [a] and [u] were preceded by a syllable-initial consonant [tsʰ]. In that case, the difference in syllable-initial consonant of the test syllables may be the cause of the phenomenon. In Yuan’s study (1960), he claimed that vowel [i] in Meixian Hakka with zero initial was in fact preceded by a glide [j] and should be transcribed as [ji]. In order to further verify whether the difference between the F0 patterns of the citation tones on syllables with [i] and those on syllables with [a, u] is due to the influence of zero initial or preceding glide [j] of vowel [i], additional F0 data for tone [1] on vowel [a] with zero onset and syllable-final [p] were analyzed. Figures 10a-10d show the F0 contours of [1] with initial [tsʰ] (in dark line) and with zero initial (in grey line) for the four speakers. Results show that the F0 contours for [1] on [a] with zero initial show a similar pattern as those on [a] with initial [tsʰ]. As the F0 pattern for [1] on [a] with zero initial differs form the F0 pattern of the same tone on [i], it seems that the appearance of initial glide [j] results in the particular F0 pattern found in tones on syllables with [i].

5. Conclusions

In conclusion, this paper has presented the F0 contours of the six citation tones in Meixian Hakka and the results of this study provide useful data for further analysis.

6. References