

The Effect of Intonation on the Citation Tones in Cantonese

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Abstract

The paper investigates the F_0 contours of the nine citation tones [55, 33, 22, 21, 25, 23, 5, 3, 2] in Hong Kong Cantonese that occur on the test syllables in the sentence-final position in the declarative and question sentences. Results show that (i) the citation tones in the declarative context are noticeably different from the same tones in the question context; (ii) the differences between the same citation tones in the declarative context and question context are in F_0 level and F_0 contour; (iii) in all the cases, the F_0 contours of [33, 22, 21, 25, 23, 3, 2] on the sentence-final test syllables in the question context are rising, and for the F_0 contours of [55, 5], there is a slight upward deflection and a pronounced increase in F_0 level; and (iv) the differences in F_0 contour and F_0 level between the tones in the declarative context are reduced in the question context in some cases and in other cases they have disappeared due to neutralization.

1. Introduction

It has been reported ([1, 2, 3, 4, 5]) that in Cantonese the pitch of citation tones on the component syllables, the final syllable in particular, of a declarative sentence are lowered progressively due to the effect of F_0 declination. Despite the effect, different citation tones on the sentence-final syllable of a declarative sentence can be distinguished ([1]). Similarly, the pitch of the citation tones on the component syllables of a question sentence, which contains a question word or particle, is also lowered progressively ([4, 5]). However, where a question sentence is without a question word, the citation tone on the sentence-final syllable is materialized as a rising F_0 contour, in a way substituting the missing question word ([4, 5, 6]). Some of the modified citation tones in the question context differ extensively from their original citation forms.

This paper is an acoustic analysis of the F_0 contour of each of the nine citation tones [55, 33, 22, 21, 25, 23, 5, 3, 2] in Hong Kong Cantonese (HKC, henceforth) on the sentence-final syllable of a declarative sentence and of a question sentence without a question word, in order to determine how the citation tones on the sentence-final word of a question sentence are modified.

2. Method

In this study, the meaningful monosyllabic words, including [si⁵⁵] ‘poem’, [si³³] ‘to try’, [si²²] ‘matter’, [si²¹] ‘time’, [si²⁵] ‘history’, [si²³] ‘city’, [tsit⁵] ‘to press’, [sit³] ‘tongue’, and [sit²] ‘loss’, associated with the nine different citation tones [55, 33, 22, 21, 25, 23, 5, 3, 2] in HKC were used as test words. Each of these test words occurs in the sentence-final position of the carrier sentence [lei⁵⁵ kɔ³³ tsi²² tuk² ___], a declarative sentence, meaning ‘this word read ___’, *i.e.*, ‘This word is pronounced as ___’. The carrier sentence can also be a question sentence, *i.e.*, ‘This word is pronounced as ___?’, given that the tone contour on the test word in the sentence-final position is rising. It will be shown that the F_0 values for

any one of the level tones on the non-final component syllables [lei⁵⁵ kɔ³³ tsi²² tuk²] of the carrier declarative and carrier question sentences are similar, so that the only difference between the two is the pitch contour of the sentence-final word.

The 18 test sentences, *i.e.*, the carrier sentence plus the sentence-final test word, were randomized in a wordlist. Four native speakers of HKC, 2 male and 2 female, all undergraduate students and in their early twenties, provided the speech data. Digital recordings of three repetitions of each test sentence were performed in a sound proof booth (IAC). The speech analysis was carried out, using CSL4400 (Computerized Speech Lab) by Kay Elemetric for obtaining F_0 contours of the tones on all the component syllables of the test sentences.

3. Results

Table 1 shows the mean F_0 values (in Hz) for the three repetitions of a level tone [55, 33, 22] or [2] on one of the component syllables [lei⁵⁵ kɔ³³ tsi²² tuk²] of the 27 test declarative sentences (9 different sentence-final test syllables x 3 repetitions) and 27 test question sentences for each of the four speakers in the study. The F_0 values were measured at the mid point of the F_0 contours of the level tones. Results of the ANOVA analysis for each speaker show that the difference in mean F_0 value for each of the level tones on the non-sentence-final component syllable in the 27 test declarative or question sentences is non-significant ($p > 0.05$). And, the results of the grouped two-tailed t-test analysis for each speaker show that the difference in mean F_0 value between the level tone on the non-final-component syllable of the carrier declarative sentences and the same level tone on the non-final-component syllable of the carrier question sentences is also non-significant ($p > 0.05$), although the mean F_0 value is approximately 5 Hz to 15 Hz higher for the level tones on the non-final-component syllables of the question sentences than the declarative sentences. This shows that the F_0 contours of the test declarative and question sentences, without the test word in the sentence-final position, are generally similar.

Table 1: Mean F_0 values (in Hz) and standard deviations (in parentheses) for the level tones [55, 33, 22, 2] on the non-final component syllables [lei⁵⁵ kɔ³³ tsi²² tuk²] of the 27 test declarative and 27 test question sentences for the four speakers (D = declarative sentence; Q = question sentence).

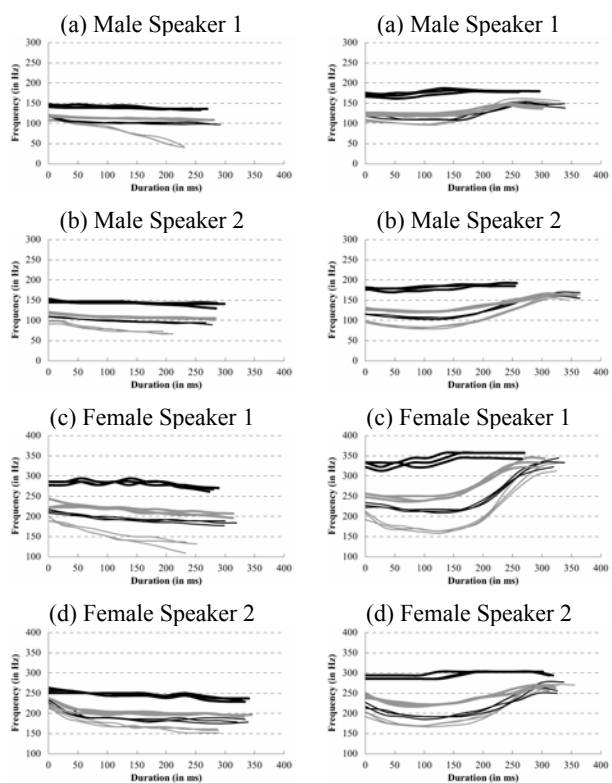
Component Syllable	Male 1		Male 2		Female 1		Female 2	
	D	Q	D	Q	D	Q	D	Q
[lei ⁵⁵]	164 (8)	185 (10)	158 (8)	170 (9)	332 (11)	339 (12)	298 (14)	311 (13)
[kɔ ³³]	147 (7)	161 (10)	142 (6)	153 (7)	287 (20)	285 (16)	244 (9)	260 (10)
[tsi ²²]	113 (5)	121 (6)	109 (3)	117 (5)	202 (5)	212 (5)	200 (5)	208 (4)
[tuk ²]	106 (4)	112 (5)	101 (4)	106 (5)	192 (5)	204 (5)	189 (5)	195 (4)

In the following sections, the F_0 contours of the nine HKC citation tones, consisting of the long [55, 33, 22, 21, 25 23] and short [5, 3, 2] tones on the test syllables in the sentence-final position of the carrier declarative and question sentences for the four speakers will be presented.

3.1. Citation tones [55, 33, 22, 21]

Figures 1a-1d show the F_0 contours of the citation tones [55] (in thick dark line), [33] (in thick grey line), [22] (in thin dark line), and [21] (in thin grey line) on the sentence-final test syllables of the declarative sentences for the four speakers. The F_0 contours of the four citation tones on the sentence-final syllables of the question sentences for the four speakers are shown in Figures 2a-2d.

(1) Declarative [55, 33, 22, 21] (2) Question [55, 33, 22, 21]



Figures 1a-1d and 2a-2d: The F_0 contours of the citation tones [55] (in thick dark line), [33] (in thick grey line), [22] (in thin dark line), and [21] (in thin grey line) on the sentence-final test syllables in the declarative and question contexts for the four speakers.

A comparison of the F_0 contours of the respective tones in the two figures shows that for all the four speakers, male and female, (i) the overall F_0 levels of the tones are raised in the context of question sentence, compared to the context of declarative sentence; (ii) in the question context, the F_0 levels of the [21], [22], [33] and [55] tones are all raised; (iii) the F_0 contours of all the tones deflect upward in the question context; and (iv) the degree of F_0 upward deflection varies according to the tone type, and the increasing order is [55], [33], [22] and [21]. Thus, in the question context, relative to the declarative context, the F_0 contour of all the tones on the sentence-final syllable become rising, in addition to its level being raised.

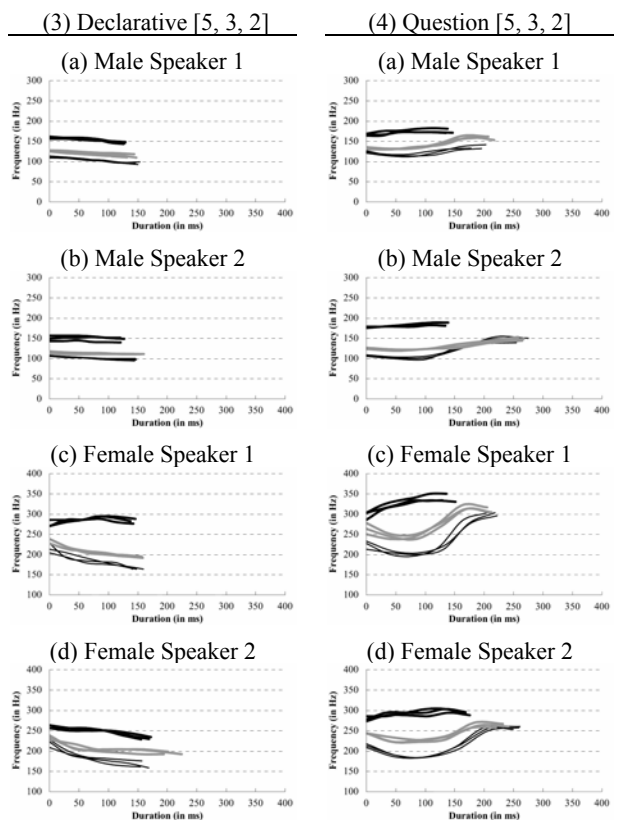
There are speaker variations in the question context. For Male Speaker 1, there is a tendency for the rising F_0 contours

of [33, 22, 21] on the sentence-final syllable to merge; for Female Speaker 1, the rising F_0 contours of the three tones are kept separated; and for Male Speaker 2 and Female Speaker 2 the rising F_0 contours are also kept separated but to a lesser degree in comparison with Female Speaker 1. Furthermore, there is a difference in F_0 contours of the three tones between the male and female speakers. For the two female speakers, the shapes of the F_0 contours of [33, 22, 21] are dipping, whereas for the two males speakers, they are basically rising.

As for the durations of the F_0 contours of [55, 33, 22, 21] on the sentence-final syllables in the declarative context, as shown in Figures 1a-1d, [21] is shorter than [55, 33, 22], and [33, 22] have a tendency to be slightly longer than [55]. Such a temporal pattern for [55, 33, 22, 21] is not maintained in the question context. A comparison of Figures 1a-1d and Figures 2a-2d shows that the duration of [21] is much lengthened in the question context and it becomes similar to the durations of [33, 22] (approximately 350 ms) also in the question context. The durations of [33, 22] in the question context are slightly longer than those in the declarative context, except for Female Speaker 2. As for [55], the difference in duration between the two contexts is minimal. Thus, compared with the tones in the declarative context, [33, 22, 21] in the question context have an appreciable increase in duration.

3.2. Citation tones [5, 3, 2]

Figures 3a-3d and Figures 4a-4b show the F_0 contours of the three short citation tones [5] (in thick dark line), [3] (in thick grey line), and [2] (in thin dark line) in HKC in two difference contexts, declarative and question, for the four speakers.



Figures 3a-3d and 4a-4d: The F_0 contours of the citation tones [5] (in thick dark line), [3] (in thick grey line), and [2] (in thin dark line) on the sentence-final test syllables in the declarative and question contexts for the four speakers.

A comparison of Figures 1a-1d and Figures 3a-3d shows that for each of the four speakers the F_0 contours of the long tones [55, 33, 22] and those of the respective short tones [5, 3, 2] in the declarative context are generally similar in terms of F_0 level and F_0 shape. Due to the similarities, phonologically the citation tones [5, 3, 2] have been analyzed as the short variants of the long tones [55, 33, 22], respectively. The conspicuous difference between the two sets of tones is the duration. A comparison of Figures 2a-2d and Figures 4a-4d shows that for each of the four speakers the F_0 contours of the long tones [55, 33, 22] and the short tones [5, 3, 2] in the question context are also similar in terms of F_0 level and F_0 shape. The difference between the two sets of tones is again in duration.

For the F_0 contours of the tones [5, 3, 2] on the sentence-final test syllables in the declarative context for the male speakers shown in Figures 3a-3b, (i) the F_0 contours of [5] are slightly falling, and (ii) the space between the F_0 contours of [3] and [2] is smaller than that between the F_0 contours of [5] and [3]. For the female speakers (Figures 3c-3d), (i) the F_0 contours of [5] are slightly rising or slightly falling, (ii) the F_0 contours of [3, 2] are also falling and the degree of falling is larger than the F_0 contours of other tones, and (iii) the space between the F_0 contours of [3] and [2] is also smaller than that between the F_0 contours of [5] and [3].

As for the F_0 contours of the tones [5, 3, 2] on the sentence-final test syllables in the question context shown in Figures 4a-4d, (i) the F_0 contours of these tones all deflect upward, compared to the F_0 contours of the same tones in the declarative context (Figures 3a-3d); (ii) for the male and female speakers, the degree of upward deflection is much larger for [3, 2] than for [5]; and (iii) generally, the F_0 levels of the tones are raised. There is a difference in the shape of F_0 contours for the tones [3, 2] between the male and female speakers, i.e., for the male speakers the F_0 contours are rising, whereas for the female speakers they are dipping.

A comparison of Figures 1a-1d and Figures 2a-2d with Figures 3a-3d and Figures 4a-4d shows that (i) in the declarative or question context, the patterns of F_0 contours of [55, 33, 22] are similar to those of [5, 3, 2]; and (ii) the differences in the F_0 contours of [55, 33, 22] and those of [5, 3, 2] in the two contexts are similar.

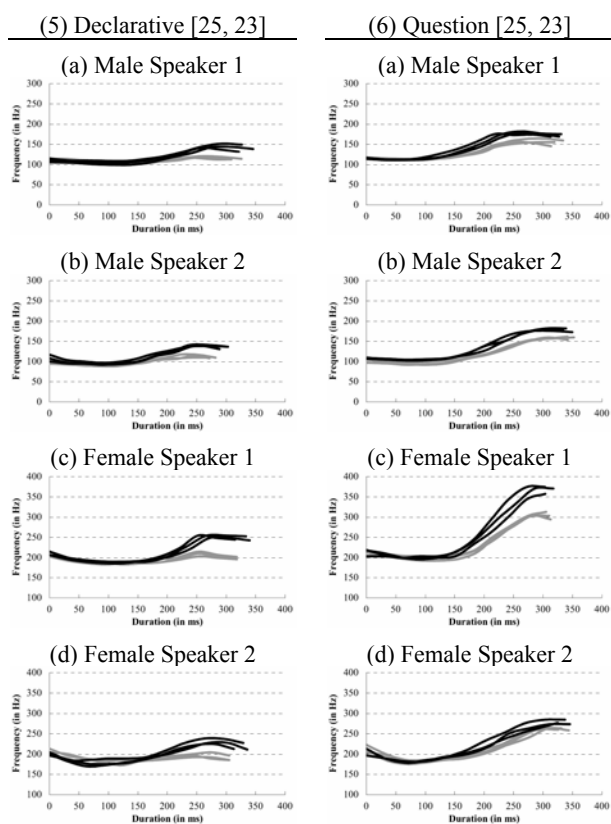
The durations of the F_0 contours of the tones [5, 3, 2] on the sentence-final test syllables in the declarative context range from 150 ms to 200 ms, and the tone [5] tends to be slightly shorter than the tones [3, 2]. This temporal pattern for the tones [5, 3, 2] is similar to that for the same tones in the question context, although the differences in duration between [5] and [3, 2] are larger in the question context, as a result of a substantial increase in the durations of [3, 2]. For the sentence-final test syllables in the question context, the duration of the F_0 contour of the tone [5] is about 150 ms, whereas the durations of the F_0 contours of the tones [3, 2] range from 200 ms to 250 ms.

3.3. Citation tones [25, 23]

Figures 5a-5d and Figures 6a-6d show the F_0 contours of the tones [25] (in dark line) and [23] (in grey line) on the sentence-final test syllables in the declarative and question contexts. As can be seen in Figures 5a-5d, the F_0 contours of the tones [25, 23] are rising in the declarative context. The difference between the F_0 contours of [25] and [23] is that the F_0 rise is larger for [25] than [23].

As shown in Figures 6a-6d, the F_0 contours of both [25, 23] on the sentence-final test syllables in the question context deflect further upward, relative to the F_0 contours of the tones in the declarative context (Figures 5a-5d). And, relatively, the

degree of upward deflection of the F_0 contour is larger for the tone [23] in the question context than the tone [25] also in the question context. This may be due to the fact that the level of the final portion of the F_0 contour of the tone [25] is already close to the upper limit of the pitch range for the speakers. As a result, the difference between the two F_0 contours the tones [23] and [25] in the question context is minimized and impressionistically neutralized. For Female Speaker 1, the upward F_0 deflection is substantial, in fact larger than that for the other speakers, i.e., Female Speaker 2 and the two male speakers. As for F_0 levels of the tones [25, 23] in the question context, there is a tendency for them to be raised slightly, relative to the F_0 contours of [25, 23] in the declarative context. This is true for the male and female speakers. As for duration, there is no significant difference between the F_0 contour of [25] or [23] in the declarative and question contexts, except for Male Speaker 2, for whom the durations of [25, 23] are shorter in the declarative context than in the question context. The durations of the F_0 contours of [25, 23] range from 300 ms to 350 ms for the four speakers.



Figures 5a-d & 6a-d: The F_0 contours of the citation tones [25] (in dark line) and [23] (in grey line) on the sentence-final test syllables in the declarative and question contexts for the four speakers.

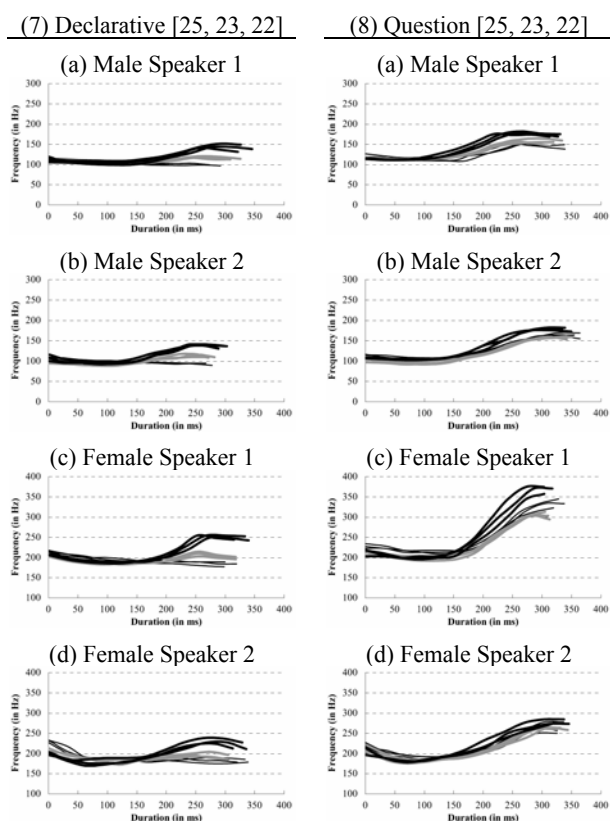
4. Discussion

In this section, I would like to refer to the perceptual study on a series of identification tests of the Cantonese tones which occur on the sentence-final syllables in question context carried out by Mai ([6]) and provide explanations for the results of these perceptual tests. Firstly, let me present a brief summary of the findings in this study. According to the F_0 data presented earlier, the F_0 contours of the nine citation tones on the test syllables in the sentence-final position in the declarative context are different in terms of F_0 shape, F_0 level, and/or duration (Figures

1a-1d, 3a-3d, and 5a-5d). However, when the nine citation tones occur on the sentence-final test syllables in the question context (Figures 2a-d, 4a-d, and 6a-d), the degree of differences is reduced or in some cases the difference disappears.

In Mai ([6]), a perceptual study was carried out to determine whether the native speakers of Cantonese were able to identify the impressionistically similar rising F_0 contours of the citation tones [33] and [22] or the rising F_0 contours of the citation tones [3] and [2] in the question context. It was reported that the Cantonese-speaking subjects were able to correctly identify the rising F_0 contours of the [33] and [22] tones or the rising F_0 contours of the [3] and [2] tones. However, Mai ([6]) was not able to provide an explanation for the results, as impressionistically the rising F_0 contours were very similar to him. My explanation for the results is that although both [33] and [22] or [3] and [2] become rising in the question context and their rising F_0 contours are similar, there is a difference in F_0 level, especially in the initial plateau portion of the rising F_0 contours, between the rising F_0 contours of [33] and those of [22] (Figures 2a-2d) or between the rising F_0 contours of [3] and those of [2] (Figures 4a-4d). Thus, the subjects are assumed to have relied on the difference in F_0 level rather than F_0 contour as a cue for the identification of the two rising F_0 contours.

Mai ([6]) also reported that the native speakers of Cantonese were not able to identify or discriminate the two rising F_0 contours of the tones [25, 23] on the sentence-final syllable in the question context. My explanation for the result is that the rising F_0 contours of the tones [25, 23] in the question context are so similar that in most of the cases they are considered merged as shown in Figures 6a-6d in this study.



Figures 7a-d & 8a-d: The F_0 contours of the citation tones [25] (in thick dark line), [23] (in thick grey line), and [22] (in thin dark line) on the sentence-final test syllables in the declarative and question contexts for the four speakers.

In Mai ([6]), it was also reported that both the tones [25, 23] in the question context are confused with the tone [22] also in the question context. The F_0 data in this study can explain why the subjects were not able to identify or distinguish the three tones in the question context. Figures 7a-7d and Figures 8a-8d show the F_0 contours of the citation tones [25] (in thick dark line), [23] (in thick grey line), and [22] (in thin dark line) on the sentence-final test syllables in the declarative and question contexts for the four speakers in this study. A comparison of Figures 7a-7d and Figures 8a-8d shows that there is a high degree of similarity among the F_0 contours of the tones [25, 23, 22] in the question context, as their rising F_0 contours overlap quite extensively. Thus, the F_0 data explain why these tones are confused in the question context.

To conclude, the F_0 contours of the tones in Cantonese in the question context explain and constitute evidence in support of the results of the perceptual tests in Mai ([6]).

5. Conclusion

The paper has presented the F_0 contours of the nine citation tones in HKC that occur on the test syllables in the sentence-final position in the declarative and question sentences. The F_0 data show that the citation tones in the declarative context are noticeably different from the same tones in the question context. The differences between the same citation tones in the declarative context and question context are in F_0 level and F_0 contour. In all the cases, the F_0 contours of the tones on the sentence-final test syllables in the question context are rising, which is expected, since the way to form a question sentence in Cantonese is to impose a rising F_0 contour on the sentence-final word in case a question word or particle does not occur. The degree of rising varies according to the tone type, e.g., for the [55] and [5] tones, the degree of F_0 upward deflection is only small; for the [33, 22, 21, 22] tones, the degree of F_0 upward deflection is large; and for the [25, 23] tones come in between. The differences in F_0 contour and F_0 level between the tones in the declarative context are reduced in the question context in some cases and in other cases they have disappeared due to neutralization, e.g., the difference in F_0 contour among the tones [22, 25, 23] ceases to exist in the question context. The F_0 production data in this study support the results of the perceptual tests in Mai ([6]).

6. References

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