

Declination and boundary effect in Cantonese declarative sentence

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Abstract

This paper investigates declination and boundary effect in Cantonese declarative sentences. Each sentence is composed of syllables of the same tone category, which is embedded in a dialogue as stimuli. The results show that the magnitude and slope of declination is independent of lexical tone category. The results also reveal that there is a boundary effect in Cantonese declarative sentences, which is proposed as the suspension of final lowering. The suspension of final lowering may be used to transfer the connotation of confirmation.

Index Terms: declination, Cantonese, boundary effect, tone category

1. Introduction

There is a general downward trend of speech fundamental frequency (f_0) found in many languages [1]. The downward trend can be attributed to several different factors, such as declination, downstep, tone terracing, and final lowering [2]. Some of the factors are phonological processes. Downstep, for example, is a process where a high (H) tone is realized in a lower pitch immediately following a low (L) tone than the one before the L tone. Declination is different from these factors and can be treated as a phonetic effect [2, 3]. Some authors treated declination as an automatic process and have proposed some explanations [1]. Most of the explanations are based on the idea that there is an automatic declination mechanism. For instance, Lieberman [4] suggested that declination is caused by the gradual drop of subglottal pressure (P_s).

Since downtrend is contributed by various factors, to study declination exclusively one has to manipulate other factors. It is easier to study declination in tone languages than in languages of other word prosody types. The lexical pitch specifications in tone languages enable speakers to have finer control over the f_0 curve. In Yoruba, Connell and Ladd [2] proposed an experimental design that can minimize the effect of downstep and study only the declination component. In this design, sequences composed of same tone syllables are used as test sentences. Another experimental design puts the same-tone sequence in a sentence frame, which can be seen as a modified version of the former one [5].

Cantonese is a Chinese dialect distributed in Guangdong Province and Hong Kong. There are nine tones in Cantonese, which are usually treated as six tone categories as listed in Table 1. The three checked tones have the same tone levels as the three level tones, and have thus been categorized together with the three level tones. There are three level tones (T1, T5, T6), two rising tones (T3, T4), and one falling tone (T2). A complete description of Cantonese phonology can be found in [6]. Cantonese intonation has been extensively studied and

Cantonese intonation system has been described within different frameworks, such as the autosegmental-metrical phonology [7] and the command-response model [8]. It is claimed that there are two components in Cantonese intonation, being utterance body intonation and utterance final intonation [9]. It is an interesting issue how lexical tones and intonation interact in Cantonese. Many researchers have studied the effect of utterance final intonation to lexical tone in Cantonese [10, 11, 12, 13]. In Cantonese, the sentence final syllable of the declarative sentence displays final lowering [10] and the final syllable of the interrogative sentence shows f_0 rising [12]. Even if the tone distinction of final syllable is preserved in declarative sentence, several distinctions are lost in interrogatives. Studies concerning primarily with declination in Cantonese are relatively few. Johnson [14] manipulated the length of the test sentences and the discourse position and found no effect of final lowering but the presence of declination. Zhang [15] investigated declination of Cantonese in speech and songs and found that declination is present in speech but absent in songs. The sequences of same tone are used by several studies. In Zhang [15], same tone words are used as test materials and in Fox et al. [9], same tone sequences of three tone categories are used. It appears that there is no study using same tone sentences for all the six tone categories in Cantonese to study the issue of declination. It is also contentious as to whether there is final lowering in Cantonese. The present study will use sentences composed of same tone syllables of all the six lexical tone categories as test materials. It is hoped that the present study will shed some light on the issues of declination and final lowering in Cantonese.

Table 1: *The tone system of Cantonese*

tone category	tone value	symbol
Yinping (阴平)	55	T1
Yangping (阳平)	21	T2
Yinshang (阴上)	35	T3
Yangshang (阳上)	13	T4
Yinqu (阴去)	33	T5
Yangqu (阳去)	22	T6

2. Methodology

This experiment investigates the declination of Cantonese declarative sentence using sentences composed of same tone syllables. In this experiment, six test sentences are constructed. Each sentence is made of syllables of the same tone category. The six sentences are all of the length of seven

syllables. The structure of the sentences is simple SVO structure with an adverbial intervening between subject and verb. The subject, object and the adverbial are all disyllabic words, while the verb is monosyllabic. To avoid the local perturbation of f_0 due to consonants, obstruents are avoided as much as possible. The target sentences are embedded in a dialogue as a confirming answer to a question. The answer has the same content as the question, to make sure that all the information in the target sentence is old information and no explicit prominence is given to any particular component of the target sentence. An example can be seen in (1), where the target sentence is italicized. As a result, the desired target sentence is subject only to the effect of declination, while immune to any other effect of prominence or downstep.

The recording was carried out in a sound-booth during late April 2018. Fourteen native speakers (seven male and seven female) from Guangzhou or Zhongshan volunteered to take part in the recording. The recordings were sampled at the rate of 16000 Hz and digitized at 16 bit using the AKG C4000B microphone through the Behringer XENYX X1832USB console. The test sentences were presented to the subjects as a dialogue and the subjects were instructed to pronounce the dialogue as naturally as possible.

The materials were manually annotated. The materials of one male speaker (M6) were discarded as being too emotional. To avoid the effect of consonantal perturbation to f_0 , the measurements of f_0 were taken from voiced parts of the sentences. During each syllable, f_0 of 10 points were extracted equidistantly. The durations of the syllables were also extracted.

- (1) - 姑妈今朝返苏州咩?
 ku1 ma1 kem1 tʃeu1 fan1 su1 tʃou1 mɛ1?
 Is auntie going back to Suzhou today?
 - 喺啊, 姑妈今朝返苏州。
 hei3 a1, ku1 ma1 kem1 tʃeu1 fan1 su1 tʃou1.
 Yes, auntie goes back to Suzhou today.

3. Results

In this section, we will first briefly inspect the intonation pattern of the sentences, and then we will present the results of utterance body intonation and utterance final intonation, separately.

Figure 1 illustrates the f_0 curves of the sentences composed of the six tone categories, separately. The f_0 curves are averaged across different speakers for male and female, respectively. The abscissa represents at which point the f_0 is extracted. Since there are ten values of f_0 extracted within a syllable, the positions are coded as 1.05, 1.15, 1.25, etc., where the integer stands for the syllable position and the floating point represents the time proportion within the syllable.

It can be seen at first glance that the f_0 curves all have a downward trend. The red curves for females and the blue curves for the males are almost parallel to each other. The f_0 curves of the three level tones (T1, T5, and T6) and the low falling tone (T2) are nearly linear, with small perturbations due to consonantal effects. However, within each grid in the panels of the two rising tones (T3 and T4), the f_0 curves show a rising trend. This is good proof that Cantonese lexical tone shapes are well reserved in sentences. What is unexpected is that apart from the two rising tones, the final syllables of two level tones (T1 and T5) and one falling tone (T2) all have a

rising tail. The final syllable of the low level tone (T6) shows a sustention of f_0 without abrupt drop. A rough inspection of the figure also shows that for the rising tones (T3 and T4), the rising excursion of the last syllable is at least equal to that of the preceding syllables. The rising excursions of the female speakers are even greater than the preceding syllables. This phenomenon suggests for all the tone categories, there is virtually no final lowering, but rather a boundary effect present in the sentence which causes the final f_0 to rise or at least to sustain.

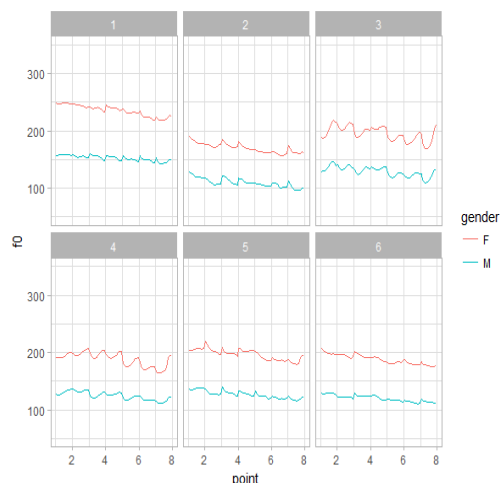


Figure 1: The f_0 (in Hz) curves of the six sentences composed of same tone syllables of six tone categories, with the panel labels representing the tone categories

With the boundary effect, it is hard to decompose declination or final lowering from the surface f_0 . A better approach may be to follow Fox et al. [9] and to treat utterance body intonation and utterance final intonation separately. In this study, the boundary effect seems to influence only the last syllable. Therefore, the intonation of the syllables except the last one is treated as utterance body intonation, and the intonation of the last syllable is treated as utterance final intonation.

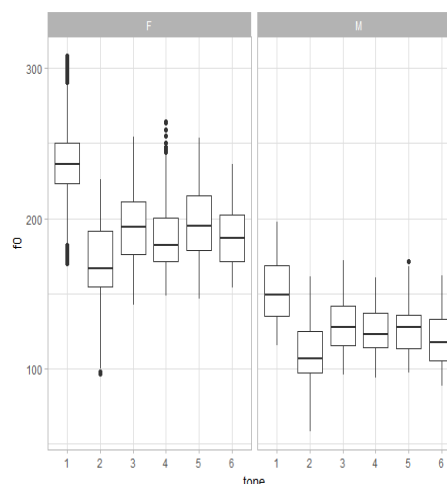


Figure 2: The distribution of the f_0 values of the utterance body intonation for the six sentences (left: female; right: male)

Figure 2 shows the distribution of the f_0 values of the utterance body intonation for the six sentences. Since each sentence contains syllables only of one tone category, the numbers on the abscissa represents different tone categories. It is clear that different sentences occupy different areas of the pitch range. The high level tone (T1) lies in the top of the pitch range, while the low falling tone (T2) lies in the bottom. For the two rising tones and the mid and low level tones, the difference is not that drastic. The distribution for these four tones is also in accord with their tone level. The high rising tone (T3) lies above the low rising tone (T4), and the mid level tone (T5) also lies above the low level tone (T6). This is clear indication that tone level is preserved in Cantonese sentences. It is natural to ask if the scaling of different tone categories influence the magnitude and the slope of declination. The magnitude of declination is calculated by subtracting the mean f_0 of the penultimate syllable from the mean f_0 of the first syllable. A two-way ANOVA finds that the magnitude of declination is not significantly different between tone categories ($F(5,66) = 1.866, p > 0.05$), while the difference between gender is significant ($F(1,66) = 13.184, p < 0.00$). The interaction between tone category and gender is also not significant ($F(5,66) = 0.767, p > 0.05$). This reveals that the magnitude is influenced by gender but is independent of tone category. The magnitude of declination is around 40 Hz for females and 10 Hz lower for males. Yet the magnitudes of declination in semitone do not differ significantly between tone categories or genders. The magnitude of declination is approximately 2.5 semitone. Concerning the slope of declination, we assume there is a linear relationship between f_0 values and the point at which the value is extracted. To see if the slope differs between different tone categories, a two-way ANOVA with an interaction is performed on the data for each gender. It is found that there is no interaction between point and tone category for both male ($F(5, 2148) = 0.784, p > 0.05$) and female ($F(5, 2508) = 0.251, p > 0.05$). This shows that the slopes of different tone categories are not significantly different from each other. Another two-way ANOVA is performed on the data to see if there is interaction between point and gender. The result shows that the interaction between point and gender is significant ($F(1, 4676) = 8.752, p < 0.01$). It reveals that the slope of declination does not differ between different tone categories but differ between different genders. Using the semitone scale removes the difference between genders. Evidences from these two dimensions (magnitude and slope of declination) collectively suggest that declination is an automatic process in Cantonese, which is independent of tone category. Declination is hardly influenced even if the same tone sentences occupy different parts of the pitch range and the tone distinctions are reserved. However, the results show that gender has an effect both on the magnitude and on the slope of the declination. In addition, the semitone scale has good performance in removing the inter-gender variations.

Figure 3 plots the f_0 curves of the last syllables for the six tones. The shapes of lexical tones are generally reserved although almost all the tones have a slightly rising tail. The rising tail is yet too slight to support the hypothesis that there is a rising boundary tone in Cantonese declarative sentences. It will be better to turn to the rising tones (T3 and T4) for some inspiration. We find that the rising excursion of the last syllable is equal to the preceding ones, if not greater. The finding is based on rough eye inspection. Post-hoc analyses are performed on the data of the two rising tones to see if the

finding is really valid. In T3, for male speakers, it is found that the difference between the excursions of the last syllable and that of any preceding syllable is not significant ($p > 0.05$ for all pairs, Tukey HSD). This is also true for T4 of male speakers ($p > 0.05$ for all pairs, Tukey HSD). For female speakers, the difference is also not significant for T4. However, the difference in T3 is significant for all the preceding syllables ($p < 0.00$, Tukey HSD) except for the sentence-initial one ($p > 0.05$, Tukey HSD). This suggests that the boundary effect is simply the suspension of final lowering. This proposal can be supported by the behavior of T6. We fitted a linear model to the utterance body intonation of T6 using mean f_0 as independent variable and syllable position as dependent variable. The predicted mean f_0 of the last syllable is slightly lower than the observed one. This indicates the final lowering really is suspended and the final f_0 level is slightly raised.

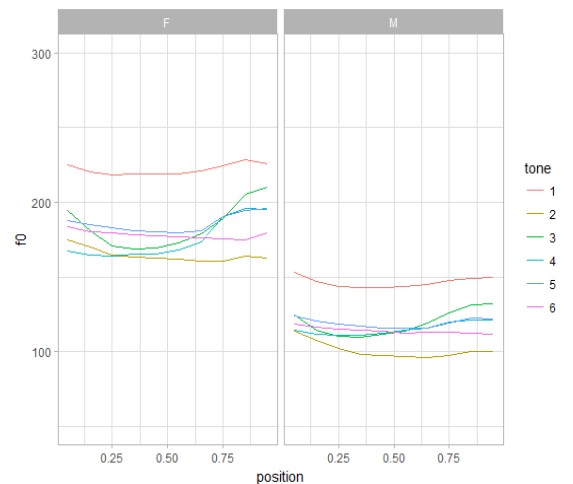


Figure 3: The f_0 (in Hz) curves of the last syllables for the six tones (left: female; right: male)

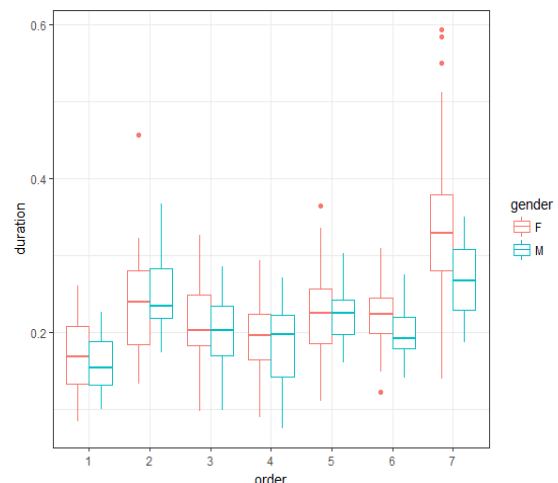


Figure 4: The durations (in second) of syllables at different positions of the sentence

In the main body of the f_0 curve, the shapes of the lexical tones are well preserved. Only in the latter half of the syllable is there rising in T1, T2 and T5. It seems that the boundary effect is successively added (Chao's phrase) to the lexical

tones. An inspection of the durations of the syllables supports this hypothesis. The durations of different syllables can be seen in Figure 4. The numbers on the abscissa represents the position of the syllable in the sentence. The duration of the last syllable is substantially greater than preceding ones ($p < 0.000$ for all the pairs of final and non-final syllables, Tukey HSD). A final lengthening is obviously present in these sentences and the boundary effect is realized on the lengthened part.

4. Discussions

This study intends to shed some light on the issues of declination and final lowering in Cantonese declarative sentences using same tone sentences. We will first discuss declination in Cantonese declarative sentences and then turn to the boundary effect. The results of same tone sentences provide further proof that declination is present in Cantonese. Declination in Cantonese declarative sentences is independent to tone category, but it is influenced by gender. Both the magnitude and the slope of declination in Cantonese are influenced by gender. It is reviewed in the Introduction that there is an automatic mechanism responsible for declination. The result that the tone category does not have an influence on declination in Cantonese supports this opinion. The boundary effect, of sustention or slight rising of the f_0 of the last syllable, adds more complexities to this view. The influence of gender to declination also indicates that declination is influenced by physiological properties. Fuller understanding and explanation of declination should take all these factors into consideration.

The most interesting finding of this study is that even in the declarative sentences, there is the presence of a final rising in most of the tone categories. This boundary effect is better treated as the suspension of final lowering. It is pointed out in the Introduction that it is contentious as to if there is final lowering in Cantonese. The finding of the present study prefers the answer yes. If there is no final lowering in Cantonese, the f_0 curves of the level tones (T1, T5 and T6) should just sustain the f_0 level. Even if T6 sustains the f_0 level, the mean f_0 of the last syllable is slightly higher than predicted by the linear model fitting declination. This indicates that the lexical tones are influenced by some boundary effect apart from declination. The rising tones provide us with more evidence. The rising excursion of the last syllable is not significantly different from the preceding syllables. If there is final lowering, the rising excursion will be truncated and be less than the preceding ones. Otherwise, the rising excursion should be just the same as the preceding ones. But in some cases (T4 of female speakers), the rising excursion of the last syllable is greater. It is better to propose that there is final lowering in Cantonese, and the boundary effect found in our experiment is a suspension of final lowering. This suspension of final lowering will cause the final f_0 to be equal or a little bit higher than that of the preceding syllables.

Another explanation may be that for the high level and mid level tones, there is a universal tendency to rise at sentence final position. The evidence is that in Yoruba, the high level and the mid level tones both show f_0 rising at sentence final position [2]. Given the rarity of empirical data, this explanation is far too general to validate. Confined to the results of our data, it is better to suggest that there is final lowering in Cantonese declarative sentences and the boundary effect we find is simply the suspension of final lowering. Of course, more evidence is needed to validate this hypothesis.

This suspension of final lowering can perhaps be attributed to the experimental design. The target sentences are embedded in a dialogue as a confirming answer to the question. The suspension of final lowering may be an indicator of confirmation. In Wong et al. [7], they proposed seven boundary tones for Cantonese, but the suspension of final lowering is beyond their expectation. Fox et al. [9] put the same tone sentences in isolation. As a result, no effect of the context is detected. On the other hand, the boundary effect found in this study supports the theory of successive addition of Chao [16]. To reserve tone distinction under the influence of intonation, Cantonese employs the strategy of accommodation [17], where both lexical tone and intonation are preserved.

5. Conclusions

In this paper, the results suggest that there is declination in Cantonese declarative sentences. Declination is an automatic process in Cantonese. The slope and magnitude of declination do not differ in sentences composed of same tones sequences. A further finding is that the final lowering is suspended in our target sentences, which may be attributable to the confirmation mood triggered by the context. The present study has its constraints in only declarative sentences are used. More evidence will be presented in the subsequent studies concerning the boundary effect of Cantonese intonation, as well as declination in other sentence types, such as echo questions and narrow focus sentences.

6. Acknowledgements

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