# CANTONESE TONES AND MUSICAL INTERVALS

*Suki S.Y. YIU*

Linguistics Department, University of Hong Kong

syutji@hku.hk

## ABSTRACT

This paper looks into how linguistic tones can be understood as musical tones. It provides a demonstration of the relationship between linguistic tone and musical intervals (MIs), which is especially relevant for Chinese languages since they mostly have relatively complex tonal systems, with more than a two-way tonal distinction, and contour tones. It tests whether MIs gives any insight into the use of tone in human language.

Tones in the Cantonese spoken in Hong Kong (HKC) are used as a test case. Six HKC speakers balanced for biological gender are selected for this project. The fundamental frequencies of the tones traditionally classified in the same tonal category are extracted with Praat, then time-normalized across syllables at 10% interval points of the rhymes. The mean values of the interval points of two relatively level tones are expressed in terms of ratio which is then used to match with the closest MI on the musical scale. A compatible treatment of contour tones is also provided for the two rising tones in HKC.

Through demonstrating that MI is a viable way to interpret linguistic tone on a musical scale, it is found that contour tones can be compatible with the analysis of the relatively level tones. Also, MIs can possibly serve as a referential indicator of tone merger.

**Keywords:** Tone, music, musical interval, frequency ratio, and Cantonese

## 1. INTRODUCTION

This paper explores how linguistic tones can be understood as musical tones in terms of musical intervals (MIs). This is especially relevant for Chinese languages since they mostly have relatively complex tonal systems such as the Cantonese spoken in Hong Kong (HKC), which has six lexical tones.

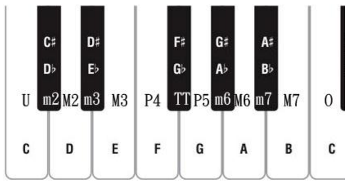
The principle phonetic characteristic of lexical tone is the fundamental frequency (F0). When represented phonologically, a tone scale with five values from 1 to 5 is usually adopted, especially for Chinese languages, following Chao [5]. Chao's 5-level transcription of tonal pitch variation (五度標記法) is a method developed to record the pitch value of linguistic tone with a sliding-pitchpipe ([6]). When the pitch of the pitchpipe matches the pitch of the linguistic tone, the pitch values of a linguistic tone (the starting and ending points, also a turning point between the two if any) can be notated on a staff.

Wee [17] revisited the idea by calculating the ratios between the highest and lowest F0 of linguistic tones for twenty Chinese languages. It questioned the musical range of an augmented fifth for the tonal scale as assumed in Chao [5] and suggested a wider musical range. Yiu and Wee [21] proposed the musical interval (MI) as a possible indicator of tone merger. Only one tone-pair of one HKC speaker merged in MI terms, despite F0 profiles suggestive of merger in the speech of male subjects generally.

From the musical perspective, MI is a perceptual distance of pitch, expressed in form of ratio to show the distance between two notes on a chromatic scale with twelve equal parts. The minimal distance between two notes is a semitone. The distance of two semitones adds up to a whole tone. MI is particularly useful to establish the link between musical pitch and linguistic pitch. After transforming the absolute pitch in music to MIs, the pitch of one note is relative to the pitch of another. For example, the distance from C to E and from E to G♯ is the same: the MIs are both major thirds, with four semitones in between. Since relativity of pitch is a core characteristic of phonemic tone, MI provides a platform to compare musical tones and linguistic tones.

Figure 1 shows a chromatic scale on a piano keyboard. With the leftmost C as an anchor key, one step up counts as one semitone. Moving from C to C♯ involves one semitone, and its MI is a minor second. Likewise, two semitones/one whole tone are/is involved moving from C to D, and the corresponding MI is a major second. The longer the distance from C, the more the semitones involved, the higher and the greater the MI. If there is no semitone between two keys, i.e. from C to C, the MI is unison (U). Different MIs are expressed in abbreviated forms: major (M), minor (m), perfect (P), tritone (TT), and octave (O).

**Figure 1:** MI from C on piano keyboard




For linguistic tones, MIs can be obtained by frequency ratios, a method particularly useful for describing intervals in both Western and non-Western music. The absolute pitch of one tone is expressed in the form of a ratio to another tone. The ratios can then be matched with the closest MI on the musical scale.

The standard Cantonese tonal inventory is comprised of six phonemic tones ([14]), as listed in Table 1. The pitch trajectories of each tone were reported by numeric values. Tone values 5 to 1 denote the highest to lowest pitches. Notably, the low falling tone can also be recognized by its phonetic variant as an extra low level tone [2].

**Table 1:** Cantonese tonal inventory ([14])

| Tone | Tone value | Tone category |
|---|---|---|
| high level | 55 | **T1** |
| high rising | 35 | **T2** |
| mid level | 33 | **T3** |
| low falling | 21 | **T4** |
| low rising | 23 | **T5** |
| low level | 22 | **T6** |

The central issue of this paper is to see how linguistic tones can be understood as and expressed in musical terms.

It demonstrates a musical treatment of linguistic tone via MI in Cantonese. If this approach turns out to be viable, MIs may be especially useful to understand the tonal system of Chinese languages which mostly have relatively complex tonal systems, with more than a 2 or 3-way tonal distinction.

Section 2 offers a brief review of the recent studies concerning tone and music in Chinese languages. Section 3 describes the methodology adopted to elicit the F0 of the Cantonese tones of the speakers. Section 4 presents and discusses the results. Section 5 ends the paper with the conclusions and implications.

## 2. LINGUISTIC TONE AND MUSICAL TUNE

To explore the relationship between musical tone and linguistic tone, two logical starting points are music and language. Musically, the tonal transition of speech in music is relevant. Linguistically, one way is to figure out how linguistic tones can be understood musically.

The relationship between language and music is multifold. Concerning tone and tune, the conformity between lexical tone and melody in vocal songs has been the focus of recent works like [1, 4, 7, 10, 11, 15, 16, 17, 19].

Speaking and singing share a lot of similarities, for example, both involve vocalization and manipulation of pitch. However, composition of songs sometimes requires fixed pitch notation while pitch in speech tones is a relative concept in principle. Depending on the pitch of the adjacent, or even neighboring, tones in speech, the interpretation of tones may vary. If the pitch of the adjacent or neighboring tones is lower, the target tone will be perceived as a higher tone. Likewise, higher pitch of the adjacent or neighboring tones makes the target tone a lower tone ([8]).

Huang [12] and Ho [11] observed that MIs and tonal target transitions (TTTs) are correlated with each other. TTT refers to the transition of pitch from the tonal target (i.e. offset) of a syllable to the next. When the mapping between the MI and TTT is optimal, the sung words can be perceived correctly. Chow [7] revisited the tone-melody relationship in Cantopop and pointed out that the correspondence between MIs and tonal transitions in Cantonese speech can be crucial to tone perception in sung melody, though the overall meaning can still be deduced given the right melodic and semantic contexts even if the tone and tune do not match perfectly. Based on Huang [12] and Ho [11], Table 2 displays the combined and revised optimal MIs of tonal transitions in vocal songs from Chow [7]. The TTTs are expressed in tonal values.

**Table 2:** Optimal MIs of tonal transitions ([7])

| TTT | Optimal MI | No. of semitones |
|---|---|---|
| 1-2 | M2 or M3 | 2 or 4 |
| 1-3 | m3 or P4 or m6 | 3 or 5 or 8 |
| 1-5 | P5 or M6 or m7 or O | 7 or 9 or 10 or 12 |
| 2-3 | m2 or m3 | 1 or 3 |
| 2-5 | m3 or P4 or m6 | 3 or 5 or 8 |
| 3-5 | M2 or M3 | 2 or 4 |

Wee [16] examined the relationship between tone and sung melodies in Mandarin Chinese by identifying headship. The head feature of the contour of each tone is identified by phonetic lengthening, which is then assigned a tone feature of either +H or –H. For example, [H] and [LH] are assigned +H whereas [L] and [HL] are assigned –H, implying that the final point of the contour is more prominent than its initial counterpart. Preservation of the contrast between features on the head position would allow listener of Mandarin songs to reconstruct the lyrics despite unfaithful preservation of tones in tune. There will be more discussion on which points along the tone contour are more prominent for HKC contour tones in Sections 3.3 and 4.3 with reference to the phonetic evidence.

## 3. METHODOLOGY

### 3.1. Subjects

Six Cantonese speakers balanced for gender were chosen as subjects in the project. They were all born after 1980 and raised in Hong Kong. Their age ranged from 21 to 32 years old, representing young adult speakers of HKC.

### 3.2. Data elicitation and recording procedures

The data was elicited using carefully constructed stimuli to provide a comprehensive coverage of the tonal inventory, varying over three cardinal vowels [i], [u] and [a] in HKC. 18 target words were randomized with 18 fillers during elicitation.

The subjects were asked to produce each word three times in a row so that the basic position (initial, medial or final) of each target item in a non-contextual utterance was controlled. The list of words was recorded twice to ensure that backup was available in case either of them is unsuitable for F0 extraction due to unexpected technical errors.

A total of 1296 items were recorded. Since half of them were fillers, 648 items would be relevant for data analysis. Each of the subjects contributed 108 items (= 6 tones x 3 target items x 3 repetitions x 2 sets) to the data pool.

Recordings were made with Praat (ver. 5.3.39) with a sampling frequency of 22050Hz in a sound-proofed recording booth at HKBU Phonology Laboratory.

### 3.3. Method of analysis

F0 of the items in the final position were extracted with Praat (ver. 5.3.39) and then time normalized at 10% interval points across utterances corresponding to syllables that have been traditionally classified in the same tonal category with Praat script ProsodyPro (ver. 3.5).

The mean F0 of the interval points of the four relatively level tones (T1, T3, T4 and T6) are expressed in terms of ratios relative to each other.

For the two rising tones (T2 and T5), each tone has two tonal points by definition. All ten interval points of the T2 contour were used for analysis. The F0 for each point of T2 was turned into a ratio with the corresponding interval point for T5. By doing this, both the F0 of the tonal targets, and the smallest and largest MIs can be captured. The F0 of the final interval point (100%) would be used for calculating the MI since it was expected that the last point would give the largest ratio, an essential cue to perceive the correct tone (see data in Section 4.3).

The MI of each tone pair is then used to match with the closest MI on the musical scale. For the sake of accuracy, the MIs are expressed in numbers for comparison.

## 4. RESULTS AND DISCUSSION

This section begins with an overview of the results. Then it moves on to discuss the F0 range in speech in terms of MI, applicability of using MI as a means to capture contour tones, and as an indication of tone mergers.

### 4.1. Interpreting the results

The speech tones of all six speakers can be transformed to MIs successfully. The data of F2 is used as an example here.

**Table 3:** MIs of speaker F2

| $\overline{T}x$:$\overline{T}y$ | $\overline{T}x$ (Hz) | $\overline{T}y$ (Hz) | $\overline{T}x/\overline{T}y$ | Closest MI | Closest MI ref. value | no. of semitones |
|---|---|---|---|---|---|---|
| **T1:T3** | 289.6875 | 239.454 | 1.209783 | m3 | 1.2 | 3 |
| **T1:T6** | 289.6875 | 215.8672 | 1.341971 | P4 | 1.333333 | 5 |
| **T1:T4** | 289.6875 | 187.5193 | 1.544841 | P5 | 1.5 | 7 |
| **T3:T6** | 239.454 | 215.8672 | 1.109265 | M2 | 1.125 | 2 |
| **T3:T4** | 239.454 | 187.5193 | 1.276957 | M3 | 1.25 | 4 |
| **T6:T4** | 215.8672 | 187.5193 | 1.151173 | M2 | 1.125 | 2 |

Table 3 shows all possible combinations of ratios for the relatively level tones, T1, T3, T4 and T6, of F2. The first column ($\overline{T}x$:$\overline{T}y$) is filled with the ratio to which each row of data corresponds. The second and third columns ($\overline{T}x$ and $\overline{T}y$) are the mean F0 of the ten interval points on the tonal contour for each tone in Hz. The column $\overline{T}x/\overline{T}y$ shows the ratios in numbers. The ratios are then matched with the closest MI in the next column, followed by the actual ratio values for each MI. The last column shows the number of semitones present for the MIs classified.

Let us take T1:T3 as an example. The mean F0 of T1 and T3 are 289.6875 Hz and 239.454 Hz respectively. Their ratio is 1.209783 (=289.6875 Hz/239.454 Hz), closest to a minor third in terms of MI which has a ratio of 6:5, i.e. ratio value of 1.2, with 3 semitones in between.

### 4.2. From m2 to P5 for speech tones

Using the same method for each subject as in the above section, Table 4 shows the MIs identified for all 6 subjects. F/M1 to M/F3 represent fe/male speakers number 1 to 3 respectively.

**Table 4:** MIs of all subjects

| Speaker / Tx:Ty | M1 | M2 | M3 | F1 | F2 | F3 |
|---|---|---|---|---|---|---|
| **T1:T3** | m3 | | | M2 | m3 | M2 |
| **T1:T6** | M3 | | | m3 | P4 | M3 |
| **T1:T4** | P4 | P5 | | M3 | P5 | TT |
| **T3:T6** | m2 | | | | M2 | m2 |
| **T3:T4** | m2 | m3 | M3 | M2 | M3 | |
| **T6:T4** | m2 | M2 | m3 | m2 | M2 | |

The MIs of all subjects fall within the range of minor second to perfect fifth. A minor second is the shortest distance that two musical tones could have on a keyboard. A perfect fifth is the distance from C to G (cf. keyboard in Figure 1), with seven semitones in between. T3:T6 is the tonal pair with the smallest MI (minor second or major second) whereas T1:T4 is the pair with the biggest MI (major third to perfect fifth) across subjects. Other tonal pairs came within this minor second to perfect fifth range. The near unanimity of MIs (minor second or major second) for T3:T6 confirms that the interval between these tones corresponds to a semitone, as has been observed in studies of tone-melody mapping ([7, 11]). Meanwhile, the more flexible MIs (major third, perfect fourth, triton and perfect fifth) for T1:T4 reflects that a wider range of MIs are allowed as long as there is no confusion.

Speaker M1 has a relatively narrow MI range from minor second to perfect fourth. Speakers M2 and M3 have the largest range among all subjects, both from minor second to perfect fifth. F1 has the smallest MI range, from minor second to major third. Though the whole range is within one to four semitones, the tones are still distinctive from each other in MI terms. F2 does not have a minor second. F2's smallest MI is a major second, meaning that her closest tones are farther apart from each other than the other subjects. The range of MIs is similar for F2 and F3, just that F3's range begins with a smaller interval (minor second) and ends with a smaller interval (tritone, as opposed to perfect fifth).

### 4.3. Applicability of MI for contour tones

The treatment of rising tones to obtain MIs is different from the other relatively level tones because rising tones have a rising contour comprised of the onset and offset points, making the F0 averaging method inappropriate to get a meaningful MI from the ratio. Matthews and Yip [13] suggested that contour tones are distinguished by the pitch level to which they rise or fall. Wong and Diehl [19], Huang [12], Ho [11], Chow [7] and Wee [16] basically all agreed that the ending pitch level is crucial for the mapping of tones and tune. That said, it is still worthwhile to have a closer look at the tonal contour with the phonetic data available.

**Table 5:** T2 & T5 of speaker F2

| Interval point | 10% | 20% | 30% | 40% | 50% |
|---|---|---|---|---|---|
| **T2** (Hz) | 197.5375 | 192.883 | 187.526 | 183 9081 | 184.5237 |
| **T5** (Hz) | 209.6067 | 200.8321 | 194.4692 | 189 9673 | 188.6777 |
| **T2:T5** ***(T5:T2)*** | *1.061098* | *1.041212* | *1.037025* | *1.032947* | *1.022512* |
| **Closest MI** | m2 | m2 | m2 | U | U |
| **Closest MI ref. value** | 1.066667 | 1.066667 | 1.066667 | 1 | 1 |
| **Interval point** | **60%** | **70%** | **80%** | **90%** | **100%** |
| **T2** (Hz) | 187.7816 | 195.7321 | 215.3493 | 247.6582 | 281.0722 |
| **T5** (Hz) | 190.228 | 197.5776 | 206.5612 | 219.408 | 236.4949 |
| **T2:T5** ***(T5:T2)*** | *1.013028* | *1.009429* | 1.042545 | 1.128756 | 1.188491 |
| **Closest MI** | U | U | m2 | M2 | m3 |
| **Closest MI ref. value** | 1 | 1 | 1.066667 | 1.125 | 1 2 |

Table 5 illustrates how MIs for T2 and T5 are obtained. The MIs of F2 show that T2 and T5 are barely distinguishable from each other until the 80% interval point. The interval points have a larger MI towards the end of the contour. The same trend holds for the remaining five subjects. As the farthest MI of T2 and T5 is located at the last interval point, the MI of the last point (100%) is selected to create a row for T2:T5 comparable with the other relatively level tones as shown in Table 6.

**Table 6:** MI of speaker F2 (cf. Table 3)

| $\overline{T}x$:$\overline{T}y$ | $\overline{T}x$ (Hz) | $\overline{T}y$ (Hz) | $\overline{T}x/\overline{T}y$ | Closest MI | Closest MI ref. value | no. of semitones |
|---|---|---|---|---|---|---|
| **T1:T3** | 289.6875 | 239.454 | 1.209783 | m3 | 1.2 | 3 |
| **T1:T6** | 289.6875 | 215.8672 | 1.341971 | P4 | 1 333333 | 5 |
| **T1:T4** | 289.6875 | 187.5193 | 1.544841 | P5 | 1.5 | 7 |
| **T2:T5** | 281.0722 | 236.4949 | 1.188491 | m3 | 1.2 | 3 |
| **T3:T6** | 239.454 | 215.8672 | 1.109265 | M2 | 1.125 | 2 |
| **T3:T4** | 239.454 | 187.5193 | 1.276957 | M3 | 1.25 | 4 |
| **T6:T4** | 215.8672 | 187.5193 | 1.151173 | M2 | 1.125 | 2 |

Adding the ratio data of T2:T5 to Table 3 gives a complete picture of the MIs of F2 in Table 6. Using the same method to calculate the MIs of T2 and T5 for the remaining subjects gives us Table 7. The MIs for T2:T5 ranges from m2 to m3.

**Table 7:** MIs of all subjects (cf. Table 4)

<table>
<tr><th>Speaker / Tx:Ty</th><th>M1</th><th>M2</th><th>M3</th><th>F1</th><th>F2</th><th>F3</th></tr>
<tr><td>T1:T3</td><td colspan="3">m3</td><td>M2</td><td>m3</td><td>M2</td></tr>
<tr><td>T1:T6</td><td colspan="3">M3</td><td>m3</td><td>P4</td><td>M3</td></tr>
<tr><td>T1:T4</td><td>P4</td><td colspan="2">P5</td><td>M3</td><td>P5</td><td>TT</td></tr>
<tr><td>T2:T5</td><td colspan="2">M2</td><td>m2</td><td>M2</td><td colspan="2">m3</td></tr>
<tr><td>T3:T6</td><td colspan="4">m2</td><td>M2</td><td>m2</td></tr>
<tr><td>T3:T4</td><td>m2</td><td>m3</td><td>M3</td><td>M2</td><td colspan="2">M3</td></tr>
<tr><td>T6:T4</td><td>m2</td><td>M2</td><td>m3</td><td>m2</td><td colspan="2">M2</td></tr>
</table>

## 4.4. MI as indicator of tone merger

Bauer et al [3] found that there were tone mergers in T2&T5, T3&T5, or T3&T6 in the speech of Cantonese speakers, resulting in various five-tone systems. With a larger sampling size, Fung [9] found cases of full merger in T2&T5, partial merger in T3&T6, and near merger in T4&T6 in Cantonese, moving towards a 4-tone system with three level tones and one rising tone.

Yiu and Wee [21] suggest that the tones in HKC which seem to have merged at phonetic level are still clearly distinctive from each other under a musical treatment of the F0 of the tones. In other words, those linguistic tones are not merged at the musical level, and so probably not at the phonological level likewise.

From Table 7, the smallest MI is a minor second, which means there is still one semitone difference separating two tones, no matter how close those two tones seem to be. In other words, no cases of tone merger in MI terms are reported for the subjects in this study.

## 5. CONCLUSIONS AND IMPLICATIONS

When doing linguistics fieldwork eighty years ago, modern handy tools for recording and analyzing sound were still not around. Chao used a sliding-pitchpipe to record linguistic tone. With more advanced technology, the F0 of the tones can now be recorded, digitalized and analyzed. However, current phonetic studies on tone seem largely to employ precise F0 measurement without paying much attention to the relative characteristics of linguistic tone. As pointed out by Chao [6], the F0 provided by instruments only provide raw materials for tone value analysis, but not the tone values, and hence the tone system.

This paper looks into how linguistic tones can be understood as musical tones. Transforming the F0 in speech tones to MIs opens a new window to understand how linguistic tones and musical tunes are linked to each other. Unlike most of the earlier works cited, the focus of this paper is not on how linguistic tones are realized in sung melodies, but on how linguistic tones in speech relate to musical tones. It has demonstrated that MI is a viable way to interpret linguistic tone on a musical scale. Not only does this hold for the relatively level tones which provide convenient F0 raw material for data processing and analysis, the treatment of contour tones is also compatible with the analysis of the level tones. Also, MI could possibly be a referential indicator of tone merger.

The scale of this project is small, yet it serves as an important test case for the proposed method to understand linguistic tone. It would be interesting to apply this method to more tonal languages with a larger sample, especially the Chinese languages which mostly have complex tonal systems.

## 6. ACKNOWLEDGMENTS

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## 7. REFERENCES


[1] Agawu, V.K. 1988. Tone and Tune: The evidence for Northern Ewe music. *Africa Journal of the International African Institute* 58(2), 127-146.

[2] Bauer, R.S., Benedict, P.K. 1997. Cantonese tones. In *Modern Cantonese Phonology*. Berlin; New York: Mouton de Gruyter, 109-250.

[3] Bauer, R., Cheung, K.H., Cheung, P.M. 2003. Variation and merger of the rising tones in Hong Kong Cantonese. *Language Variation and Change* 15(2), 211-225.

[4] Chan, M.K.M. 1987. Tone and melody interaction in Cantonese and Mandarin songs. *UCLA Working Papers in Phonetics* 68, 132-169.

[5] Chao, Y.R. 1930. A system of tone letters. *La Maître Phonétique* 45, 24-27.

[6] Chao, Y.R. (趙元任) 1956. **现代吴语的研究**. 科學出版社, 3, 4, 74.

[7] Chow, M.Y. 2012. *Singing the Right Tones of the Words the Principles and Poetics of Tone-melody Mapping in Cantopop*. (MPhil dissertation). HKU.

[8] Fok Chan, Y.Y. 1974. *A Perceptual Study of Tones in Cantonese*. Hong Kong: HKU.

[9] Fung, S.Y. 2012. *Tone mergers in contemporary Hong Kong Cantonese*. Presented at Departmental Seminar, HKU.

[10] Ho, V.W.S. 2006. The tone-melody interface of popular songs written in tone languages. *Proceedings of ICMPC9*, University of Bologna, Italy, 1414-1422.

[11] Ho, V.W.S. 2009. *Fine-Tuning Tone-Melody Constraints through the Investigation of Mismatches in Cantonese Pop Music*. Hong Kong: CityU.

[12] Huang, Z.H. (黄志華) 2003. **粵語歌詞創作談** [On Writing Cantonese Lyrics]. Hong Kong: Joint Publishing.

[13] Matthews, S., Yip, V. 1994; 2011. *Cantonese A Comprehensive Grammar*. London: Routledge.

[14] Peking University (北京大學). 1995. 中國語言文學系語言學教研室 (編), **漢語方言詞彙** (第二版). 北京: 語文出版社, 33.

[15] Sollis, M. 2010. Tune-tone relationships in sung Duna Pikono. *Australian Journal of Linguistics* 30(1), 67-80.

[16] Wee, L.H. 2007. Unraveling the relation between Mandarin tones and musical melody. *Journal of Chinese Linguistics* 35(1), 128-144.

[17] Wee, L.H. 2008. Inquiry into the musical nature of linguistic tone. In Hsiao, Y.C., Hsu, H.C., Wee, L.H., Ho, D.A. (eds.), *Interfaces in Chinese Phonology*. Taiwan: Institute of Linguistics, Academia Sinica, 139-160.

[18] Wee, L.H., Chan, Q.K.Y., Cheung, W.H.Y., Yiu, S.S.Y. 2013. *Tone Samples of Cantonese and English in Hong Kong*. Phonology Laboratory, HKBU.

[19] Wong, P.C.M , Diehl, R.L. 2002. How can the lyrics of a song in a tone language be understood? *Psychology of Music* 30(2), 202-209.

[20] Xu, Y. 2012. *Praat script ProsodyPro* (version 3.5).

[21] Yiu, S.S.Y., Wee, L.H. 2013. *Hong Kong Cantonese tones replication study*. Paper presented at the 13th Workshop on Cantonese (WOC 13), HKBU, Hong Kong.