A Phonetic Study of the Prosodic Properties of Bisyllabic Compounds in Hong Kong Cantonese

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Abstract

This paper reports on an investigation of the phonetic properties, including (i) duration, (ii) F_0, and (iii) intensity, of bisyllabic compounds in Hong Kong Cantonese. Results show that the values of duration, F_0, and intensity of the rimes in the compounds are determined primarily by the type of tone on the component syllables and secondarily the position of the syllables in the compounds. For the same syllable, the duration of the rime is longer when it occurs in second position than when it does in the first. However, the F_0 and intensity of the rime are higher when the syllable occurs in the first position. The duration of the syllable-initial consonant is longer in the second position when it is a sonorant. However, this is not true when it is a voiceless obstruent.

本文是作者对香港广州话双音节词的语音学特征的研究报告。研究的范围包括(i)时长、(ii)基频、及(iii)音强。结果显示，双音节词的三个韵律特征价值都跟音节的声调及其在词中的位置有关。就同一个音节来说，当它在词的第二位置出现时，其韵母的长度比同一个音节在第一个位置出现时为长。但是，在第二个位置出现时，韵母的基频和音强却比音节在第一个位置出现时为低。在词中第二位置出现的浊声母也比第一位置的长，清声母则不一定。

1 Introduction

Little work has been done on the prosodic characteristics of syllables in larger linguistic units, such as words or phrases in Cantonese. Our knowledge of the Cantonese phonological system is incomplete without a good understanding of the behaviour of the syllables in context. Accurate information about the prosodic properties of speech is also necessary for synthesizing speech units with a higher degree of naturalness. To these ends, an investigation of the prosodic properties, including duration, fundamental frequency (F_0), and intensity, of multi-syllabic compounds in Hong Kong Cantonese (HKC) has been carried out by the Department of Linguistics of the University of Hong Kong and the IBM China Research Lab. In this paper, we report on the results of the bisyllabic compounds.

2 Method

100 bisyllabic compounds in HKC (Table I) were analyzed for their prosodic properties, i.e., duration, F_0, and intensity. The compounds, all frequently used common words in Hong Kong, were selected as representatives of possible tone combinations. The citation tones in HKC are [55, 33, 22, 21, 25, 23] (the long series) and [5, 3, 2] (the short series). As [2] is associated with two different vowel lengths, two tone [2]s are distinguished, with [2a] representing the tone with a longer vowel and [2b] the tone with a shorter vowel.

2nd syllable / 1st syllable	[55]	[33]	[22]	[21]	[25]	[23]	[5]	[3]	[2a]	[2b]
[55]	叉烧	收购	兄弟	冰糖	删改	街市	分析	挣扎	收集	侵蚀
[33]	信封	计较	制订	著名	痛苦	爆满	庆祝	报答	碎裂	证实
[22]	冒充	面对	自大	奉承	谅解	治理	利息	效法	召集	病毒
[21]	盆栽	投诉	平静	神奇	皮草	憔悴	常识	纯洁	萝卜	提拔
[25]	取消	古怪	典范	枕头	死板	饱满	解释	反驳	表达	写实
[23]	冷清	奋斗	领导	奶茶	米粉	窈窕	满足	敏捷	拒绝	老实
[5]	菊花	足够	辐射	足球	质料	率领	出色	督察	复杂	北极
[3]	法官	作对	决定	折磨	拓展	尺码	脊骨	发作	发达	法术
[2a]	复苏	合并	服侍	实行	值钱	密码	特色	复发	实习	食物
[2b]	乐观	达到	杂乱	达成	立体	白领	袭击	邋遢	学习	习俗

Table I. The 100 test bisyllabic compounds in HKC.

One native female university student was asked to utter all the 100 test bisyllabic compounds at a normal rate of speech. The recording was performed in a sound-proof room. The speech materials were analyzed, using the CSL (Computerized Speech Lab) 4100 speech analysis software by Kay Elemetrics of USA. The durations of the syllable-initial consonant and rime of the two component syllables in the test bisyllabic compounds were measured directly from the speech waveforms, and the synchronized wideband spectrograms of the speech signals were referred to for verification where needed. The fundamental frequency or pitch contours and the intensity curves of the compounds were obtained, using the pitch synchronous method provided by the software.

3 Results

3.1 Duration

3.1.1 Duration of the rime

Based on the temporal data of the two component syllables in the 100 test bisyllabic compounds, it was found that the duration of the rimes of the component syllables are determined primarily by the syllables' tone categories, and secondarily by their position in a compound. The bisyllabic compounds did not exhibit any constant length, and the two component syllables did not show any compensation effect, i.e. there is no positive or negative correlation between the durations of the rimes of the first and second syllables. Table II shows the values of the mean duration and standard deviation for the rime of the each of the two component syllables associated with one of the ten citation tones in HKC in the 100 test bisyllabic compounds.

Type of tone on the syllables	Rime in the 1st syllable		Rime in the 2nd syllable	
	Mean	SD	Mean	SD
[55]	185.12	25.46	272.36	37.69
[33]	176.12	20.56	302.12	38.02
[22]	182.44	29.40	291.14	44.50
[25]	181.06	22.22	292.42	29.03
[23]	180.43	28.39	284.89	28.46
[21]	174.80	30.37	205.47	53.22
[3]	107.86	15.65	167.36	22.26
[2a]	107.37	18.31	146.55	14.16
[5]	65.87	18.54	107.76	16.69
[2b]	57.67	10.31	103.57	12.99

Table II. Mean durations (in msec) and standard derivations (SD) of the rimes of the first and second component syllables, associated with one of the ten citation tones in HKC, in the 100 test bisyllabic compounds.

As can be seen from the above table, the 10 citation tones can be grouped into several categories in terms of their durational characteristics. For the syllables in position 1 of the

compounds, the mean durations are similar for (i) the rimes associated with [55], [33], [22], [25], [23], and [21], (ii) the rimes associated with [3] and [2a], or (iii) the rimes associated with [5] and [2b]. The results of the single factor ANOVA analysis show that the difference in duration among the rimes in (i) ($p < 1.0$), in (ii) ($p < 1.0$), or in (iii) ($p < 0.25$) is non-significant.

For the syllables in position 2 of the compounds, the mean duration is similar for (i) the rimes associated with [55], [33], [22], [25], and [23], and (ii) the rimes associated with [5] and [2b]. The results of the single factor ANOVA analysis show that the difference in duration among the rimes in (i) ($p < 0.5$) or in (ii) ($p < 1.0$) is non-significant. The mean duration of the rime associated with [21] is shorter than the durations of the rimes associated with [55], [33], [22], [25], and [23]. The mean duration of the rime associated with [3] is slightly longer than that of the rime associated with [2a], and the difference in duration between them is significant ($p < 0.05$).

Taking both positions into account, we can group the 10 citation tones into four types in order of decreasing duration: Type I > Type II > Type III > Type IV. Type I includes the rimes associated with [55], [33], [22], [25], and [23], Type II the rimes associated with [21], Type III the rimes associated with [3] and [2a], and Type IV the rimes associated with [5] and [2b]. In all the bisyllabic compounds, for each tone type, the rime is always longer in the second position than in the first.

3.1.2 Duration of the syllable-initial consonant

Six types of syllable-initial consonants were analyzed. These include (i) the unaspirated stops [p, t, k, k^w], (ii) aspirated stops [p^h, t^h, k^h], (iii) unaspirated affricate [ts], (iv) aspirated affricate [ts^h], (v) fricatives [f, s, h], and (vi) sonorants [m, l]. In general, the durations of the syllable-initial consonants in (i), (ii), or (iii) are similar in the two positions. The results of the two-tailed grouped data t-test analysis show that the difference in duration (i) between the unaspirated stops in the first and second positions ($p < 0.5$), (ii) between the aspirated stops in the first and second positiions ($p < 0.5$), and (iii) between the unaspirated affricates in the two positions ($p < 1.0$) are non-significant.

The syllable-initial aspirated affricate [ts^h] is longer in first position than in second position, and the difference in duration is significant ($p < 0.05$). The syllable-initial fricative [f] or [s] is also longer in the first position than in second. The exceptional cases are (i) when [f] is followed by the vowel [u], (ii) when [s] followed by the vowel [i], and (iii) when [f] or [s] is preceded by a syllable with a stop-ending. In these cases, the duration of [f] or [s] is long, even though it occurs in second position. Excluding these cases, the results of the two-tailed grouped data t-test analysis show the difference in duration between [f] in first and second positions ($p < 0.05$) and (ii) between [s] in first and second positions ($p < 2.5E-05$) is significant. As for the syllable-initial fricative [h], since there was only one word containing such a fricative in second position, there was insufficient data to determine the variation in duration of [h] in the two positions.

As for the syllable-initial sonorants, the duration of the nasal [m] or the liquid [l] is shorter in first position than second. The results of the two-tailed grouped data t-test analysis show that the difference in duration (i) between [m] in first and second position ($p < 0.001$) and (ii) between [l] in first and second position ($p < 0.0025$) is significant.

Thus, in the bisyllabic compounds, (i) the sonorants are longer in second position, (ii) the aspirated affricate and fricatives are longer in first position, and (iii) the unaspirated stops, aspirated stops, or unaspirated affricate are similar in length in the two positions. The mean durations and standard deviations of the different types of syllable-initial consonants in the two positions are shown in Table III.

Syllable-initial consonant		Initial consonant of the 1st syllable			Initial consonant of the 2nd syllable		
		Mean	SD	N	Mean	SD	N
[p]		14.78	5.62	8	9.90	0.56	4
[t]		16.29	1.84	5	17.39	3.22	23
[k]		23.84	4.74	5	27.00	8.41	9
[k^w]		-----	-----	0	24.89	2.35	2
[p^h]		55.11	13.24	3	44.36	-----	1
[t^h]		66.88	11.25	4	49.37	12.88	5
[k^h]		69.73	2.51	2	77.20	17.86	3
[ts]		71.99	21.83	18	68.85	17.91	15
[ts^h]		106.31	12.75	6	91.39	6.96	6
[f]	before [u] or after a stop	-----	-----	0	125.76	5.84	3
	in elsewhere	105.94	12.80	13	91.36	5.77	4

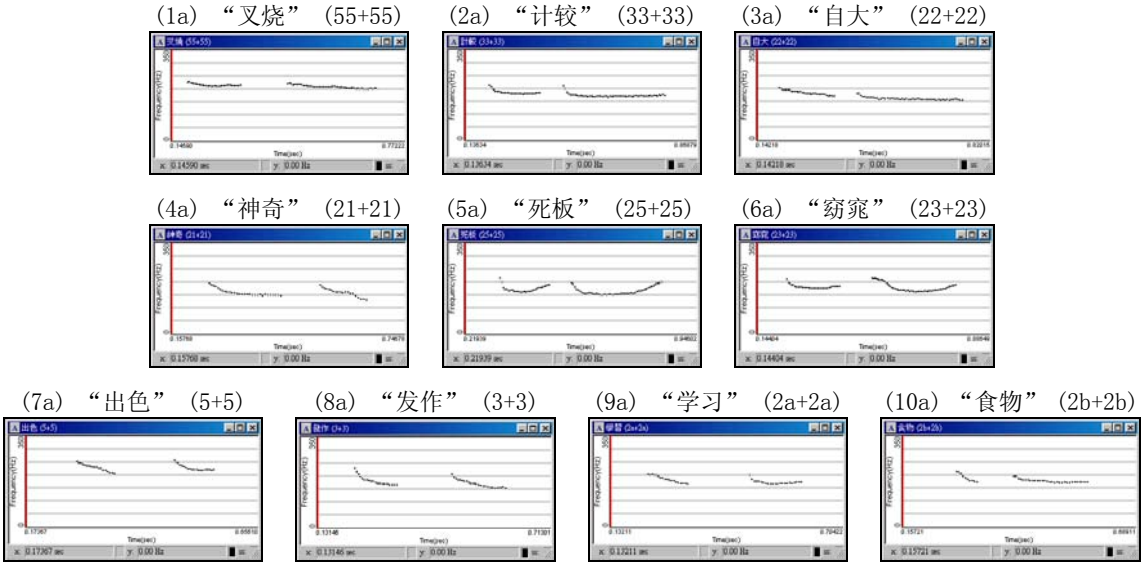
[s]	before [i] or after a stop	-----	-----	0	141.70	16.26	10
	in elsewhere	130.49	14.86	14	103.96	6.07	11
[h]		79.79	11.10	5	95.68	-----	1
[m]		45.45	14.58	7	71.11	7.86	7
[l]		40.35	10.68	10	62.52	13.04	6

Table III. Mean durations (in msec) and standard derivations (SD) of the different types of syllable-initial consonants in the first and second positions in the 100 test bisyllabic compounds ("N" = number of cases; "-----" = non-applicable).

3.2 Fundamental frequency (F_0)

The F_0 characteristics of the syllables in the two positions also depend on their tone type and their position in the compounds. Firstly, the variation in F_0 or pitch contour of the 10 citation tones in the two positions is not great. As far as the pitch characteristics of the rimes are concerned, (i) the F_0 contours of [55], [33], and [22] are generally level, (ii) the F_0 contours of [25] and [23] are rising, and (iii) the F_0 contour of [21] is falling. As for [5], [3], [2a], and [2b], their F_0 contours are slightly falling. It was found that for the same syllable in the same tone, the F_0 level is usually slightly lower when it occurs in second position than when it does in first position. In the case where the tone is a rising [25], the F_0 level of the beginning portion of the syllable is higher for the tone in position 1 than that in position 2. However, the pitch level of the upward deflection of the contour is slightly lower for [25] in first position than in second. This pattern is also true for [23], the other rising tone When the tone is a falling [21], the F_0 contour falls lower for the tone on the rime when the syllable is in second position.

Figures 1a-10a show the pitch contours of 10 bisyllabic compounds in which both syllables are of the same tone. As can be seen, the F_0 level is lower when the syllable occurs in second position.

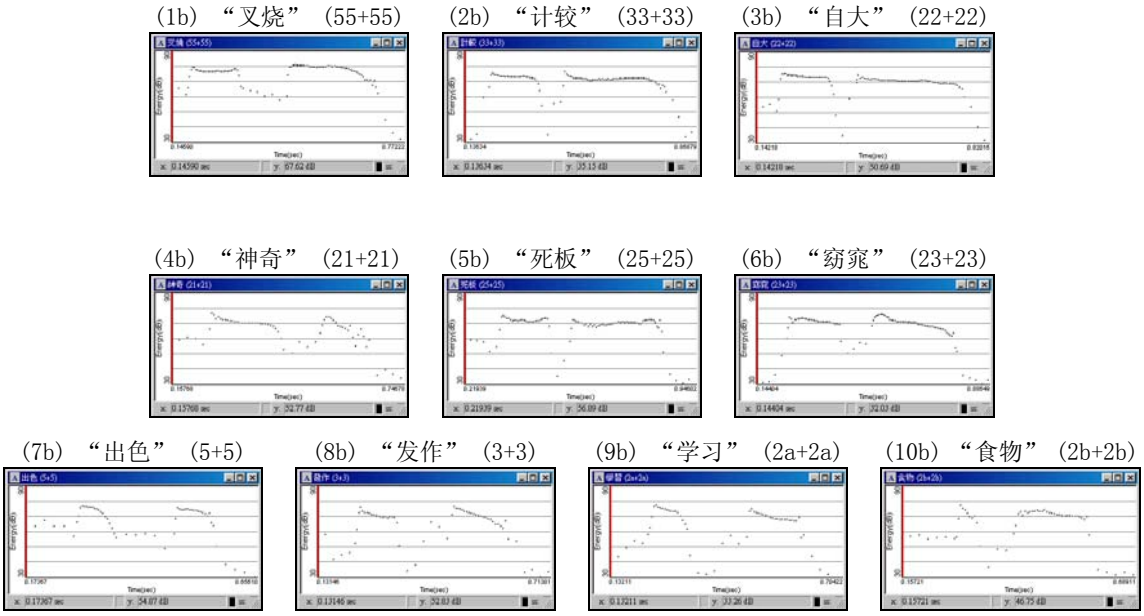


Figures 1a-10a. F_0 contours of 10 bisyllabic compounds in which the two syllables are of the same tone..

3.3 Intensity

With regard to intensity levels, it was found that the intensity of the syllables in the two positions also depends on tone type and position in the compounds. Figures 1b-10b show the intensity curves of the 10 bisyllabic compounds whose F_0 characteristics were presented in Figures 1a-10a in the previous section Recall that in these compounds, both syllables are of the same tone. A comparison of Figures 1a-10a and Figures 1b-10b shows that the intensity level of the syllables in the two positions is generally positively correlated with their F_0 levels. As can be seen in Figures 1b-10b, the intensity level is slightly lower in the second position than the first in most cases. In general, the difference in intensity level between the first and second positions is not great. The only exception is when one of the syllables in the compound is in a high tone ([55] or [5]) and the other in

a non-high tone ([33, 22, 21, 25, 23, 3, 2a, or 2].



Figures 1b-10b. Intensity curves of 10 bisyllabic compounds in which the two syllables are of the same tone.

4 Discussion and Conclusion

Taking the three prosodic properties (duration, F_0, and intensity) as variables, for any syllable in HKC, the determining factors for variation in its prosodic properties are primarily its tone type, and secondarily its position in a compound. In other words, a syllable’s duration, F_0, and intensity are determined in the first instance by its tone type. These characteristics are then subject to modification according to where the syllable occurs in a compound. However, there are strict limits on the extent of the variation. Thus, for example, a syllable whose inherent tone is [55] (tone type I) will always be substantially longer than a syllable whose inherent tone is [2b] (tone type IV), even when the former occurs in first position and the latter in second position (in spite of the fact that for the same syllable, its duration is generally longer in second position than in first). The reason for this appears to be that the phonological system of HKC demands that a syllable’s tonal characteristics be preserved and remain identifiable regardless of its positional context. The extent of positional modification is therefore kept within reasonable limits. It has been reported previously that in bisyllabic compounds of Beijing Mandarin, syllables in the second position tended to be longer than the same syllables occurring in first position. (Lin, et al., 1984) Also, a syllable’s full pitch contour (i.e. tone shape) tended to be better preserved in second position than in first. Acoustically, these findings are similar to those reported for HKC in this paper. In Beijing Mandarin, perceptually, in the majority of cases, syllables in second position were judged to be more prominent than those in first position, probably as a result of the longer duration and the relative fullness of tone shapes of syllables in second position. Whether the same applies to perception of prominence in HKC remains an open question.

Reference

[1]Lin, et al. 林茂灿, 颜景助, 孙国华 (1984). 北京话两字组正常重音初步实验. 《方言》1.57-73.