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AN ACOUSTIC STUDY OF TONE, TONE SANDHI AND NEUTRAL TONE IN LIAN-YUN-GANG (连云港) DIALECT OF CHINESE

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1. Introduction

Lian-Yun-Gang city is located in the northeastern corner of Jiang-Su (江苏) province in China, facing north to Shan-Dong peninsula, and east to Huang-Hai (Yellow Sea).

The language spoken there is included in the Northern Guan-Hua (Northern Mandarin) group in a broad sense taxonomy of Chinese dialectology, and among the Northern Guan-Hua group, falls under the Jiang-Huai group, as well as Nan-Jing and Yang-Zhou, in a narrower sense (J-H Yuan 1960). An outline of phonetic characteristics for the present language was reported in "JIANG-SU-SHENG HE SHANG-HAI-SHI FANG-YAN GAI-KUANG" (General survey for dialects in Jiang-Su province and Shang-Hai city, 1960).

During our field survey carried out in 1980, several characteristics of tonal phenomena were observed, which can be resolved into the following three points:

1. Glottalized syllable associated with "Yin-Ping" tone
2. Three types of "Neutral tone"
3. Tone sandhi, i.e. changed tones observed in the tone sequences

A detailed description for these characteristics and collected materials will be forthcoming. The aim of this paper is to show acoustic evidence for the tonal phenomena of this language.

2. Procedure

In our survey four native speaker of Lian-Yun-Gang dialect co-operated with us as main informants, referred to as Speaker A, B, C, and D respectively in the present paper. The speakers other than D are male. Speaker A was a student of Chinese Literature in Nan-Jing University, and was then twenty-five years old. The other speakers were all in their forties, and had lived in Lian-Yun-Gang city since their birth. Recording was mainly done in Nan-Jing University as for speaker A, and at a hotel in Lian-Yun-Gang city as for the other speakers. In the present analysis, however, test materials used are mainly from Speaker A, the other speakers providing supplementary materials, because the quality of recording is better in Speaker A than the others.

In the experiment the speech signals were lowpass-filtered to 5 kHz, sampled at 10 kHz and digitized in 10 bits. Pitch contours were extracted by using SIFT algorithm (simplified inverse filter tracking algorithm) (Markel 1972, Markel and

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Gray 1976). The input data was analyzed at 10 ms intervals using a 40 ms sliding window. The analysis covers a range of frequency, from 64 Hz to 400 Hz.

For some data formant frequencies were estimated based on Linear Prediction Analysis. The analysis was made every 10 ms for Hamming-windowed speech of 20 ms. The order of analysis was 12.

3. Isolated Tones (Tones in monosyllables)

Lian-Yun-Gang dialect has five lexical tones chiefly distinguished by the pitch contour of each tone, as is represented below using Chao's five point system (Y-R Chao 1930).

I	Yin-Ping	214
II	Yang-Ping	35
III	Shang-sheng	41
IV	Qu-sheng	45
V	Ru-sheng	24

Those terms noted as Yin-Ping, Yang-Ping and so on are introduced to show a correspondence to the historical tone category. What should be noted here is that this dialect preserves tone V (Ru-sheng), which is lost in northern dialects like Pekinese but is also preserved in other dialects within the Jiang-Huai group.

3.1 Glottalized syllable associated with Yin-Ping tone

What is paramount interest among the five types of pitch contours is that a syllable with tone I (Yin-Ping) is strongly glottalized after a low-falling and before a high-rising contour. Thus it is quite probable that a hearer who is unfamiliar with this dialect hears a syllable with tone I as if it were two syllables with a glottal stop in between; V ʔ V.

Fig. 1 (A) shows the extracted pitch contour of tone I together with speech envelope. The pitch contour is superimposed with the line-up point at the articulatory release for nasal stop [m]. The fundamental frequencies can not be detected during some periods after a slight falling of low contour. Fig. 1 (B) shows the speech wave for the same utterance shown in (A). A remarkable diminution of speech waves is observed for about 100–130 ms in the syllable.

From a physiological point of view, absence of fundamental frequency is presumed to be produced by a prominent supra-glottic laryngeal constriction with the closed glottis, thus preventing the glottal vibration (Iwata et al. 1979, 1981b).

3.2 Other tones

Fig. 2 shows each of the extracted pitch contours for tone II-V, together with tone I shown in Fig. 1. Each pitch contour is superimposed with the line-up point at the release of the preceding oral (for tone V)/nasal (for tones other than tone V) stop. Tone III has a high falling pitch contour, which is similar to the tone IV in Pekinese. Each of the other three tones, tone II, IV and V has rising pitch contour. Tone IV has the highest pitch range among all of the five tones. The pitch patterns of tone II and V show a remarkable resemblance, only distinguished with each other by a slight higher initiation and rising for tone II in some other samples.

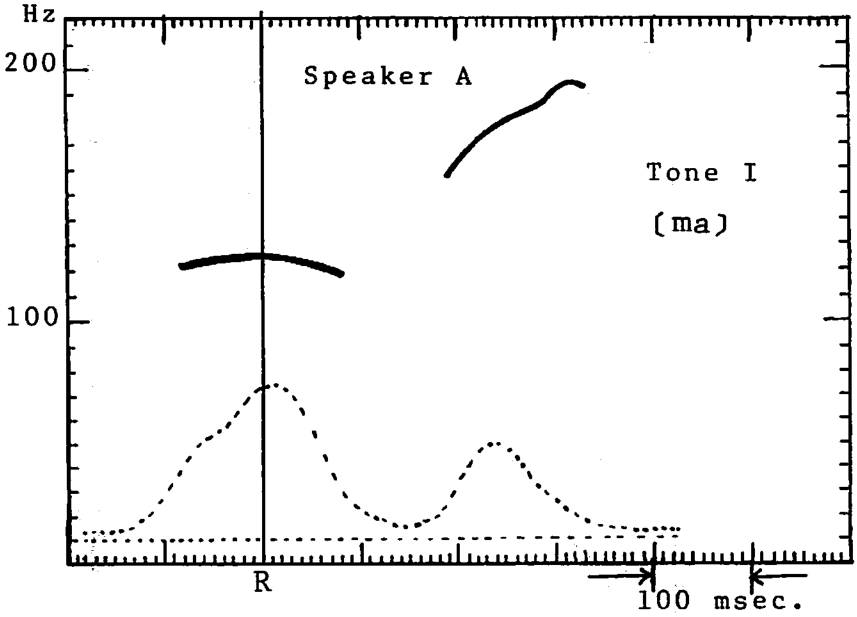

Fig. 1 (A) *Typical contour of the fundamental frequency for the syllable [ma] with tone I. The lower curve is speech envelope.*

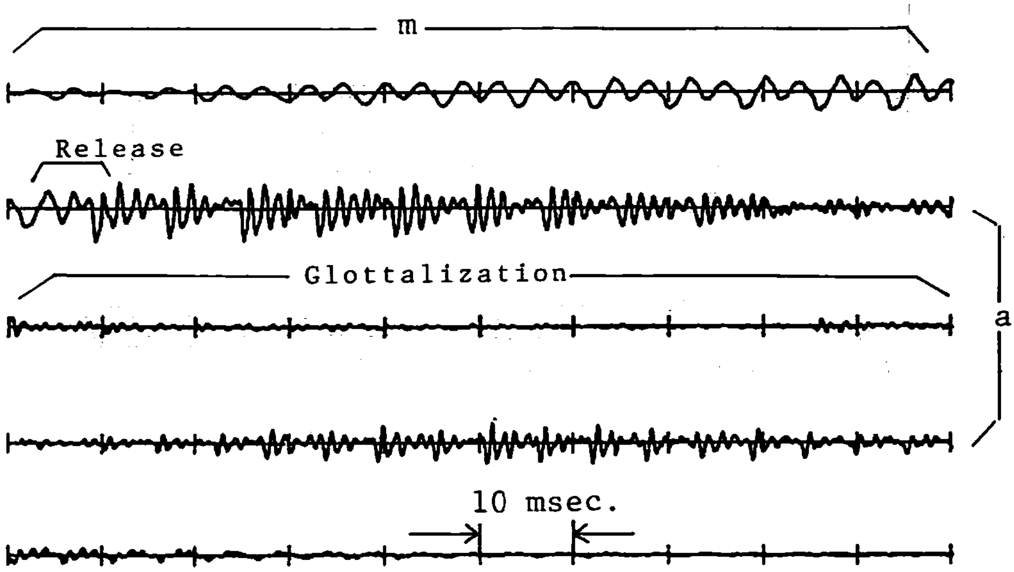

Fig. 1 (B) *Speech wave for the same utterance shown in Fig. 1 (A).*

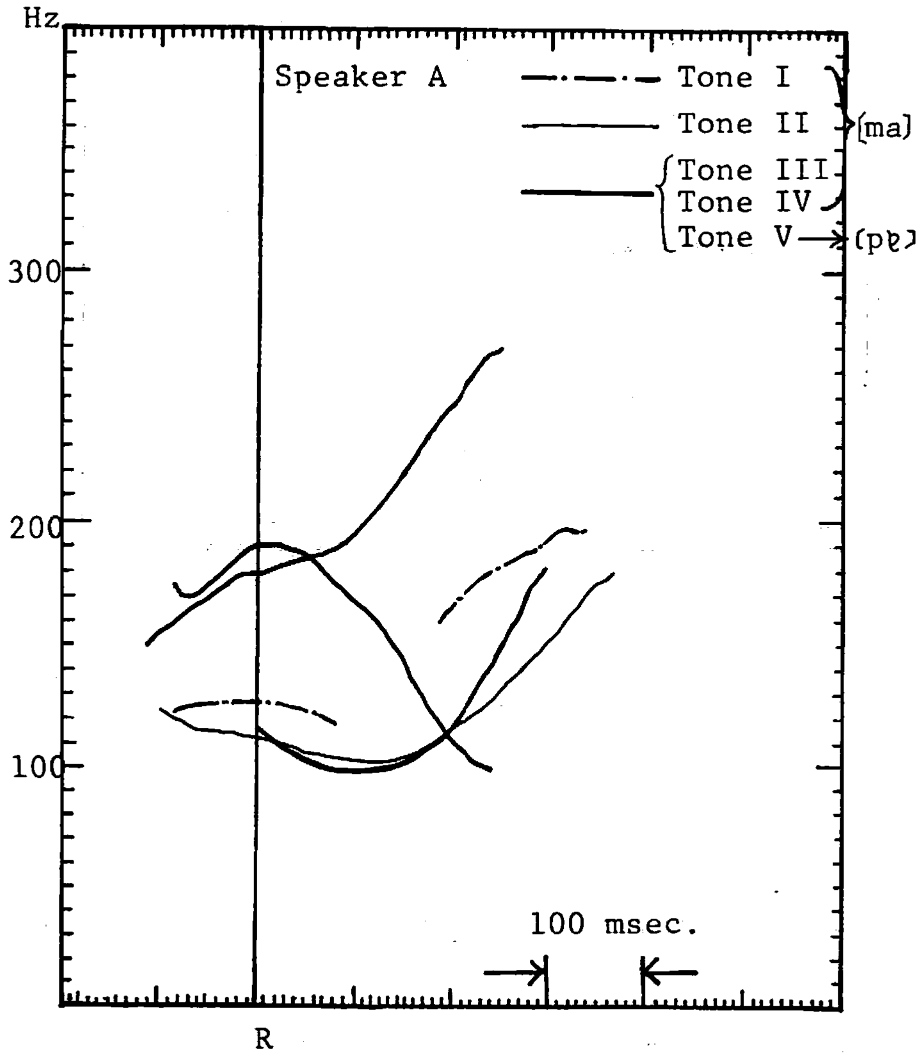

Fig. 2 *Typical contours of the fundamental frequency for the syllable [ma] or [pɐ] with each of five tones. A broken line represents the pitch contour for tone I, thin line for tone II and thick lines for tone III, IV and V.*

3.3 Duration and quality of the vowel

Syllables associated with tone II and V seem to be distinguishable mainly in terms of segmental components, i.e. duration and the quality of the vowel.

Duration of the vowels–[a, ɐ]–associated with each of the five tones was measured as to the utterance of speaker A. The number of samples is four for each of five tones. It is revealed that the syllables with tone I and II are consistently longer than those with the other tones. There is a tendency that the syllables with tone II are longer than with tone I. Among III, IV and V, no significant difference can not be observed.

The quality of the vowels show a complementary distribution vis-a-vis tonal categories; [ɐ, iə, uə] etc. are associated with tone V, whereas [a, i, u] etc. associated with tones other than tone V.

4. Tone Sandhi and Neutral Tone (tones in bisyllables)

Tones in monosyllables, however, undergo tone sandhi when they are uttered in polysyllables. Because sandhi rules for trisyllables or more can basically be considered as combinations of those for bisyllables, rules governing the latter will be clarified in the present investigation.

It is noted that the term "tone sandhi" used here has two implications; one is the tone change of each lexical tone in the first syllable, and another is tonal neutralization in the second syllable, usually referred to as "neutral tone". Four types of tone sandhi are discriminated in the bisyllables of this language, and roughly grouped into two types with respect to the distinction of each lexical tone in the second syllable. In Type A the distinction of each lexical tone is preserved in the second syllable, in other words, the tone change does not take place in the second syllable. In Type B, C and D, on the other hand, the distinction of each lexical tone is lost, i.e. neutralized, in the second syllable. Pitch contours in the second syllable for each of Type B, C and D are presented below, with the tonal values in parentheses:

Type B: high-falling (41), exclusive of the second syllable preceded by tone III
Type C: low-short (2)
Type D: low-short (2), when preceded by tone III
high-short (4), when preceded by tones other than tone III

In each of these three types of tone sandhi, the pitch contour for the second syllable is uniquely determined with the exception of the syllable preceded by tone III. Those sequences which have tone III in the first syllable do not cause B type sandhi, but cause C and D type. In the latter types no distinction can be observed in the second syllable, while the distinction is maintained in the first syllable; unchanged in Type D and changed to high-level in C.

Each of the three types of tone sandhi other than Type A can be interpreted as "neutral tone" type in the sense that the distinction of five tones in monosyllables is neutralized in the second syllable. The neutral tone in Type B, however, can not be regarded as such in the same sense as that in Pekinese, in which the neutral tone may be defined as a tone which is predictable from the syllable specified "unstressed". Because the second syllable is "stressed" in Type B tone sandhi in accordance with Type A, but in contrast with Type C and D in which the second syllable is "unstressed" and pronounced short.

In what follows we will observe the pitch contours of both the preceding and following syllables which undergo tone sandhi in the bisyllables. In comparing each subset of tone sequences, it is desirable to use segmentally homophonous words. Except for a few subsets, however, homophonous pairs could not be obtained in our survey. In the present experiment, the vowels in each subset was chosen to have a similar quality for the sake of comparison.

5. Tone Sandhi in Type A

In Type A sandhi, tones in the second syllable are not changed, but all tones in the first syllable are changed with the exception of tone sequences, I + III, IV. Tonal values of each changed tone for the first syllable are shown in Table 1 using Chao's five point system.

Table 1 *Tonal value of each changed tone for the first syllable; the tone category of the first syllable is represented in the column with the tonal value of the inherent tone in parenthesis.*

<table>
<tr><th>2nd syl. / 1st syl.</th><th>I</th><th>II</th><th>III</th><th>IV</th><th>V</th></tr>
<tr><td>I (214)</td><td colspan="3">11</td><td colspan="2">unchanged
‖
214</td></tr>
<tr><td>IV (45)</td><td colspan="3" rowspan="2">22</td><td colspan="2"></td></tr>
<tr><td>V (24)</td><td></td><td rowspan="3">55</td></tr>
<tr><td>II (35)</td><td colspan="4" rowspan="2">55</td></tr>
<tr><td>III (41)</td></tr>
</table>

Each of the pitch contours for the first syllable is observed below.

The distinction of tone II and III appears to be lost and both of them are changed into high-level tone in the first syllable, irrespective of the tone category of the subsequent syllable. Tone V is also changed to high-level when followed by tone IV. In Fig. 3 is shown the typical contours of the fundamental frequency for the sequences of tone II, III + II and tone V + IV. In the figure, the pitch contours are superimposed with the line-up point at the articulatory release for nasal [m] in II, III + II, and voice onset of the first syllable in V + IV.

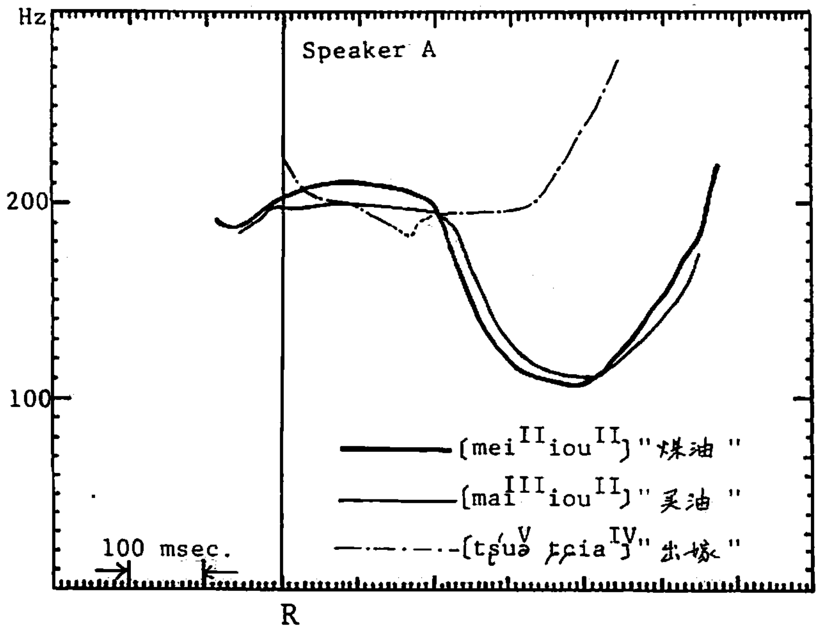

Fig. 3 *Typical contours of the fundamental frequency for the sequences of tone II + II; III + II and V + IV. In V + IV, the initial consonant [tɕ] in the second syllable is judged "voiced" and shown by dotted line in the figure.*

The distinction between tone I and IV seems to be lost in the syllable preceding tone III or IV. Fig. 4 shows the typical contours of fundamental frequency for the tone sequences, I, IV + IV. In the figure, each pitch contour is superimposed with the line-up point at the oral release for the initial stop [t] in the second syllable. Notice that initial [t] in the second syllable is judged to be voiced in both utterances and the closure periods are shown by dotted lines, estimated visually by formants and speech wave. It is observable in the figure that tone I and IV show almost identical pitch contours; tone IV in the first syllable is changed into a low concave contour, while tone I is slightly changed and having higher pitch contour than the monosyllabic one. It should be noted here that the disappearance of fundamental frequency found in monosyllabic tone I is not observed here.

Idiolectal variation can be observed for the same sequences of tones in Subject B, whose range of voice is lower than speaker A. As is shown in Fig. 5, the first syllable shows a slight falling low contour but without rising contour in both tone I and IV.

The pitch contours for tone I and IV show a resemblance with each other when followed by tone I, II and V. In the majority of the pitch contours for these sequences, the distinction between tone I and IV in the first syllable appears to lie in the presence of the periods without fundamental frequency. As is shown in Fig. 6 (C), a prominent diminution of speech wave is observed for the first syllable of the word, [uaŋ^{I}t'aŋ^{II}], in contrast with that of [uaŋ^{IV}k'ui^{II}]. The pitch contours shown in Fig. 6 (A) correspond to the speech waves shown in Fig. 6 (C). In Fig. 6

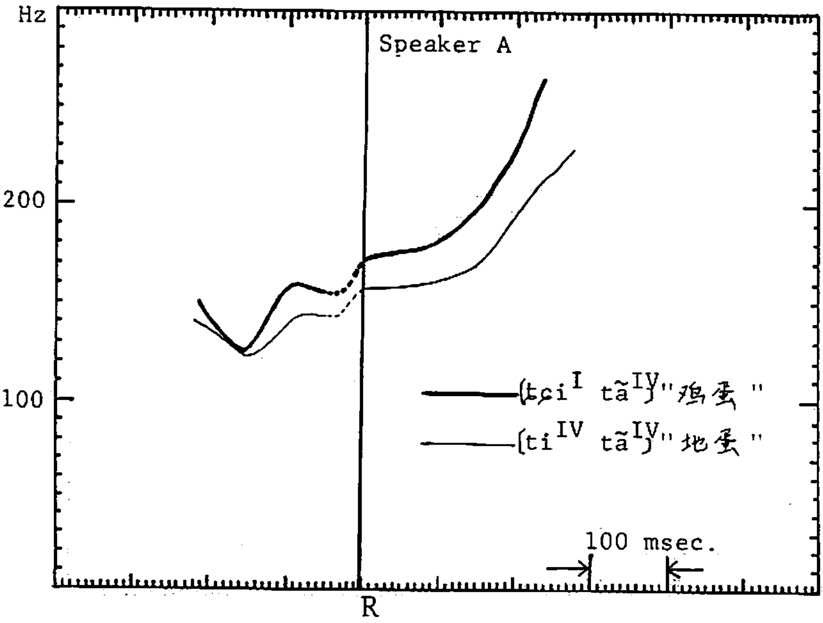

Fig. 4 *Typical contours of the fundamental frequency for the sequences of tone I + IV and IV + IV. Dotted lines represent the closure periods for [t] in the second syllable.*

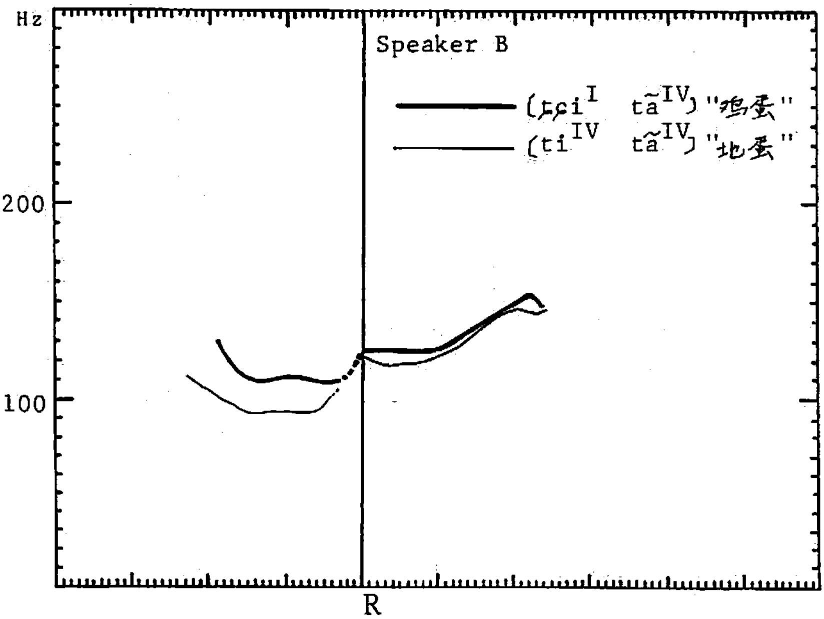

Fig. 5 *Pitch contours for the sequences of tone I + IV and IV + IV uttered by speaker B.*

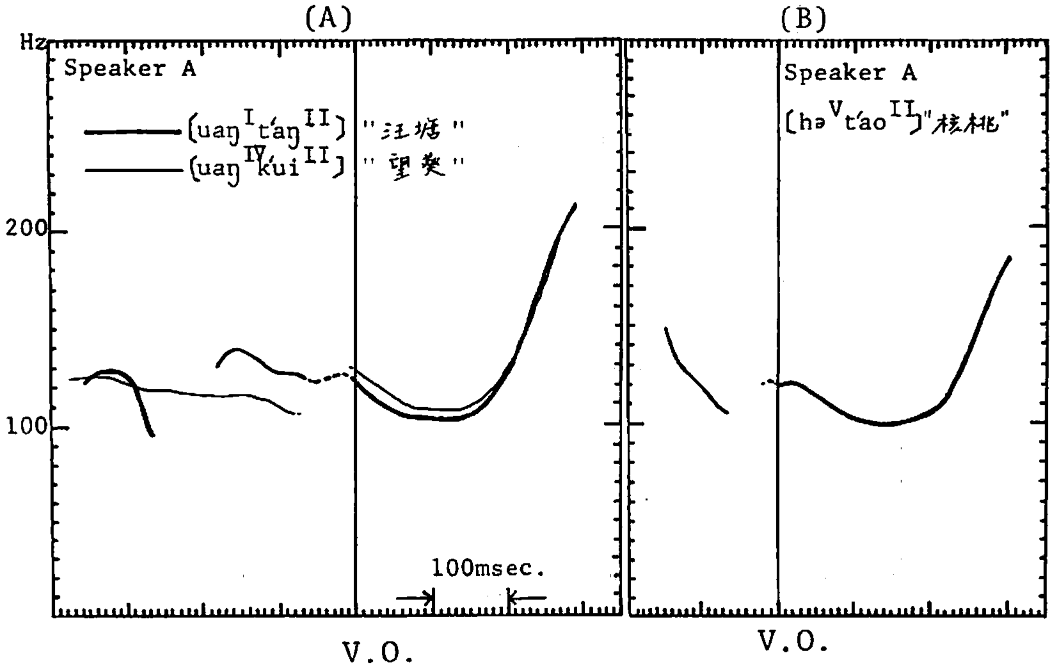

Fig. 6 (A), (B) *Typical contours of the fundamental frequency for the sequences of tone I + II and IV + II in (A), and V + II in (B). Each contour is superimposed with the line-up point at the vowel onset (V.O.) of the second syllable.*

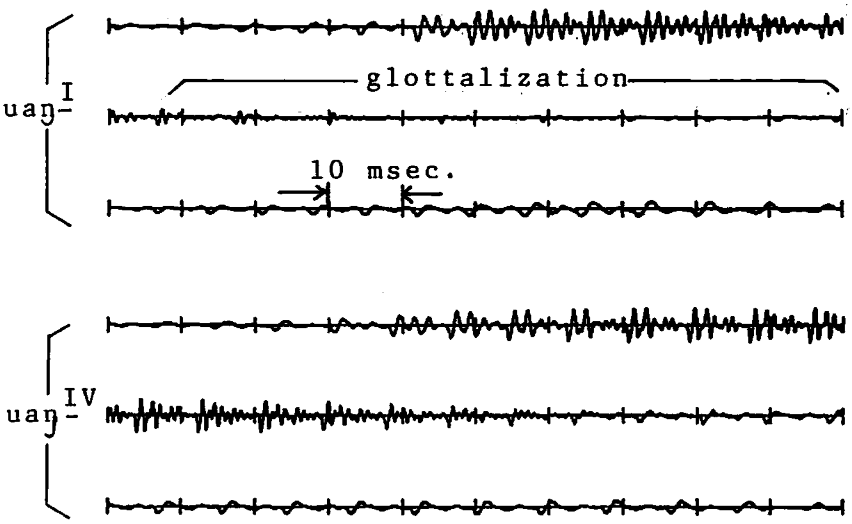

Fig. 6 (C) *Speech wave for the same utterances shown in Fig. 6 (A).*

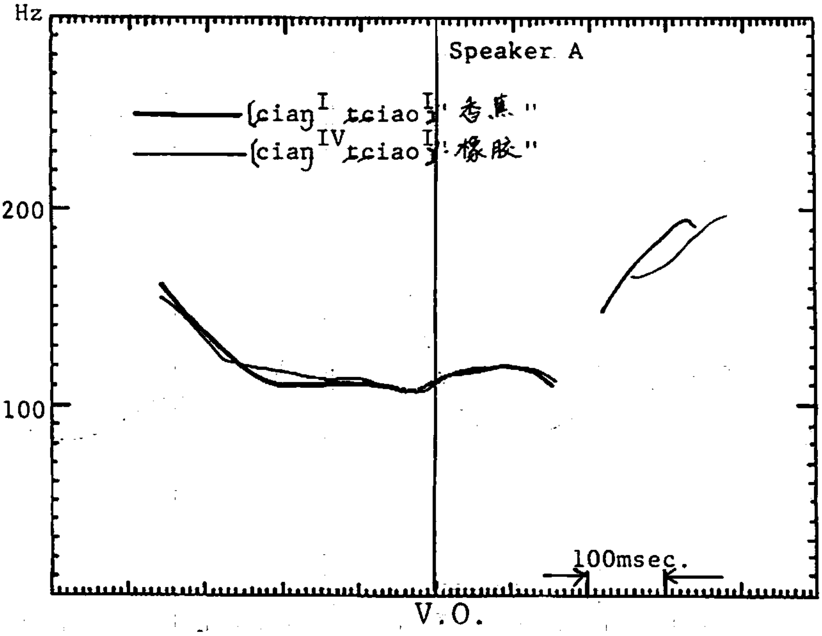

Fig. 7 *Minority type of the pitch contours for the sequences of tone I + I and I + IV. Each contour is superimposed with the line-up point at the vowel onset of the second syllable.*

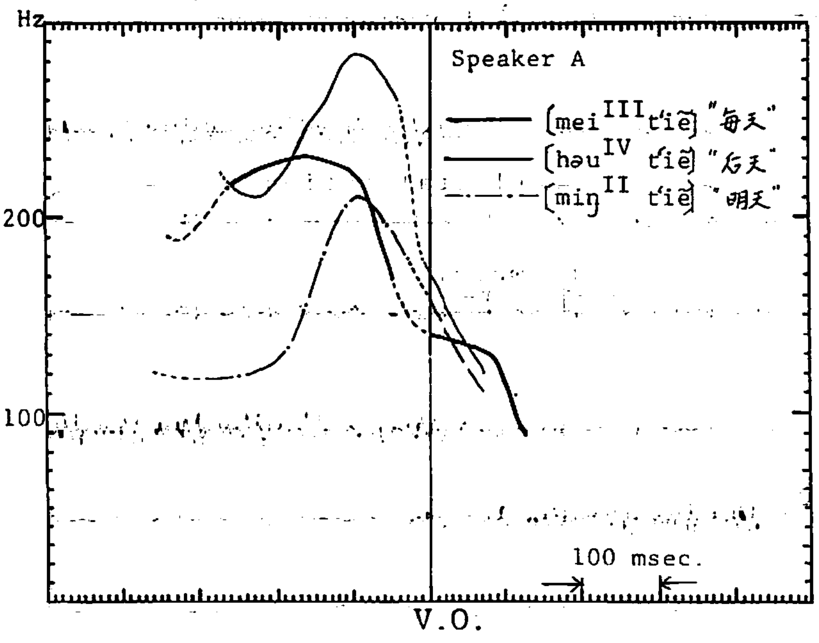

Fig. 8 *Typical contours of the fundamental frequency for sandhi type C. The contours are superimposed with the line-up point at the vowel onset of the second syllable.*

(B) is shown the pitch contour for the sequence of tone V + II.

In the minority of pitch contours, however, tone I and IV in the first syllable show almost identical pitch contours, as is shown in Fig. 7.

6. Tone Sandhi in Type B, C, D

As is mentioned above, in sandhi Type B, C and D, the distinction of each lexical tone is neutralized in the second syllable. Furthermore some of the tones in the first syllable also give rise to tone sandhi. In Table 2 is shown the tonal value of the first syllable for sandhi Type B, C and D.

Table 2 *Tonal value of the first syllable for Type B, C, D: "U" means that the tone does not undergo tone sandhi.*

Type of sandhi / 1st syl.	B	C	D
I (214)	214 (U)	214 (U)	214 (U)
II (35)	22	35 (U)	22
IV (45)	44	45 (U) (55)	44
V (24)	22	55	22
III (41)		55	41 (U)

In sandhi Type C, tone I and II do not undergo tone sandhi in the first syllable, while each of tone III and V is changed to a high-level tone. Tone IV is not changed in most words, but changed into high-level in a few words. Fig. 8 represents the pitch contours of unchanged tone II and IV and changed tone III in sandhi Type C.

Two evidences should be pointed out as for sandhi Type B and D. First, each changed/unchanged tone in Type B and D shows the identical pitch contour. The pitch contours of the first syllable for tone I, II and V are quite similar to each other in both Type B and D; all of them show low-level (usually with slight falling) contours. Tone I in the first syllable, however, appears to be distinguished from tone II and V by the absence of fundamental frequency as well as the rising contour in the syllable. It should be noted here that this type of similarity between tone I, II and V is parallel to that of tone I, IV and V in sandhi Type A. Fig. 9 and 10 represent the B and D type pitch contours of tone sequences which have tone I, II, V in the first syllable.

Affinity between Type B and D can also be exemplified by the alternative

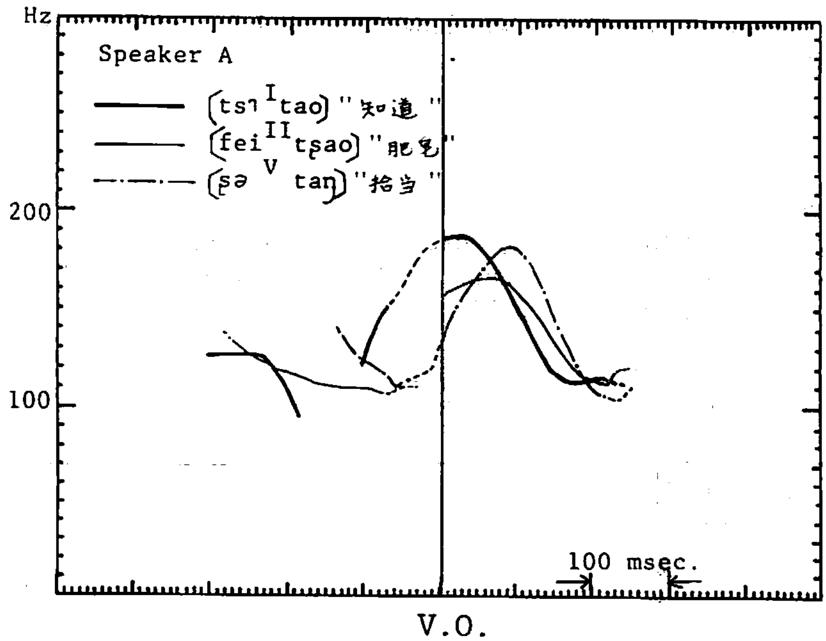

Fig. 9 *Typical contours of the fundamental frequency for sandhi Type B. Each contour is superimposed with the line-up point at the vowel onset of the second syllable.*

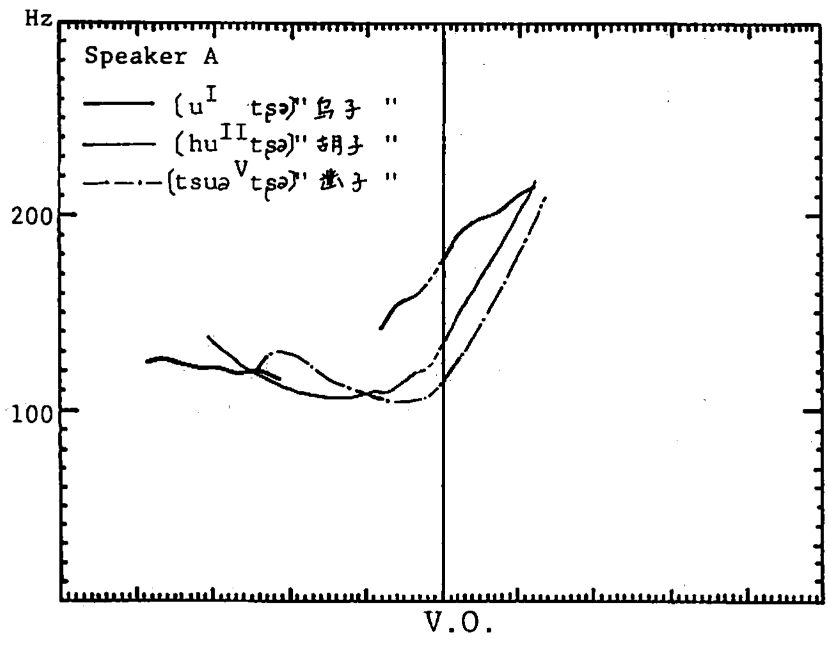

Fig. 10 *Typical contours of the fundamental frequency for sandhi Type D. The contours are superimposed with the line-up point at the vowel onset of the second syllable.*

pronunciation between the two types by different speakers and sometimes even by the same speaker. For instance, [ȶɕ'ü ȶɕ'ü] "cricket", which has tone V in the first syllable, was pronounced in Type B by speaker B, in Type D by speaker C and pronounced in both ways in speaker A and D. This type of alternative pronunciations, however, can be possible only in words whose first syllable takes tone I, II and V. When the first syllable takes tone III, alternatives can mainly be found between C and D, and between B and C when the first syllable is tone IV.

7. Concluding Remarks

In the present investigation tones in Lian-Yun-Gang dialect was examined for the extracted pitch contours.

Of all five kinds of tones in monosyllables, tone I (Yin-Ping) is worthy of special mentioning. The characteristic feature of tone I is the absence of fundamental frequency during some periods in the middle part of the syllable. This characteristic is supposed to be caused by a prominent supra-glottic constriction accompanied by a tense adduction of the vocal folds. The same findings were already reported as for the syllables with final stops (-p, -t, -k, -ʔ) in southern chinese dialects, like Fukienese and Cantonese (R. Iwata et al. 1979, 1981). In Fukienese, for instance, the glottalized gesture which is manifested by the adduction of false vocal folds, was observed throughout the whole periods of the syllable when the syllable ends in a glottal stop. From a comparative or historical point of view, however, the tone which corresponds to the glottalized tone in southern Chinese is tone V (Ru-sheng) in Lian-Yun-Gang dialect. The prominent feature of glottalization could not be observed in the syllable with tone V.

One of the significant characteristics of tonal phenomena for bisyllabic words or compounds is tone sandhi which can be observed in the first syllable. In sandhi type A, those tones which undergo tone sandhi can be roughly grouped into two types as far as pitch contours are concerned; a "high" type tone and "low" type, including a low-high concave tone. Among the "low" type tones, however, the syllabic feature of glottalization is still preserved for tone I in the majority of utterance types, when followed by tone I, II and V. Further experiments are needed to confirm whether each pair of tones in the first syllable which show identical or similar contours are really homophonous.

Sandhi Type B, C and D are set apart from Type A in that the distinction of each lexical tone is erased in the second syllable. The preceding syllables also cause tone sandhi in the former three types, and it is revealed that the distinction is preserved between tone I and II, V as to the presence of glottalized periods in Type B and D, as is also the case with the distinction between tone I and IV, V in sandhi Type A.

Acknowledgments

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References

Chao, Y-R. (1930); A system of "tone-letters". Le Maîttre Phonétique, troisième série, no. 30. Chinese translation appears in "Fang-Yan", 1980, vol. 2.

Iwata, R., M. Sawashima, H. Hirose and S. Niimi (1979); Laryngeal adjustments of Fukienese stops—Initial plosives and final applosives—. Ann. Bull. RILP, 13, 61-81.

Iwata, R., M. Sawashima and H. Hirose (1981); Laryngeal adjustments for syllable-final stops in Cantonese. Ann. Bull. RILP, No. 15, 45-54.

Markel, J.D. (1972); The SIFT algorithm for fundamental frequency estimation. IEEE transaction on audio and electroacoustics, vol. AU-20, No. 5.

Markel, J.D. and A.H. Gray (1976); Linear prediction of speech.