The Location of F0 Offset Targets for Taiwanese Long Tones

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Abstract

This paper presents the alignment of offset targets for five Taiwanese long tones, HH, LH, HL, ML, and MM, in different contexts. The location and value of offset target, in terms of f0 turning point, peak and valley, relative to the tone-bearing syllable was studied. Corpus was sentences with five syllables. Tonal values of the second, third, and fourth syllables in these sentences were varied, while the tonal values of first and fifth (final) syllables were controlled. F0 data were extracted from 5%, 20%, 40%, 60%, 80% and 95% points into the duration of second, third and fourth syllables. Results showed that f0 turning points for HH and MM tones located before offset boundaries of the second and third syllables; f0 targets for LH, HL and ML tones at the second syllables located after the offset boundaries. The turning points for HH tone in the penultimate syllables occurred after the offset boundaries, while the turning points for MM tone occurred before the boundaries. At the penultimate and antepenultimate syllables, the location of offset targets of HL and ML tones depended on the following tonal onsets. When followed by M onset, the targets occurred after the offset boundary of the syllables; when followed by H onset, the tonal targets occurred before the boundaries. There is a systematic relationship between offset tonal target and offset boundary of tone-bearing syllable in Taiwanese.

1. Introduction

The study of intonation often faces the difficulty of separating apart the contribution of global and local effect on f0. Chinese tonal language with its lexical tones clearly described locally for each syllable is an ideal candidate for studying the contribution of local tone and global intonation to surface f0. Among the Chinese tone languages, the surface realization of Mandarin lexical tones, in terms of f0, was well investigated. Studies show that both global and local effects influenced f0 contours. Global effects such as declination and downstep were found to influence f0 scaling in Mandarin (Shih, 1997, 1998). Local effects, such as focus and tonal context also affected f0 scaling and alignment of lexical tonal targets (Jin, 1996; Xu, 1997, 1998, 1999). The f0 range of narrow focused Mandarin syllable was expanded, while tonal context affected f0 direction, i.e. anticipatory and preservatory, and f0 height, i.e. assimilation and dissimulation. Xu (1999) investigated the alignment between tonal target and syllable offset and found that the H target for H tone occurred right before the offset, the f0 peak for R tone occurred after the offset, f0 peak for F tone occurred before syllable offset.

Besides Mandarin, Taiwanese is a tone language of which the surface f0 realization of lexical tone has received some attention. There are seven lexical tones in Taiwanese, including five long tones i.e. high level tone (HH), mid level tone (MM), high falling tone (HL), mid falling tone (ML), low rising tone (LH) and two checked tones. Following Shih's (1988) convention, two tonal targets are assigned for each lexical tone as indicated in the parenthesis. Taiwanese lexical tones has a recursive sandhi rule as shown in the following:

$$LH \rightarrow MM \rightarrow ML \rightarrow HL \rightarrow HH \rightarrow MM.$$

According to the sandhi rule a syllable carry its sandhi tonal value if not placed before tonal group boundary. The original underlying tonal value surfaces on juncture position before tonal group boundary.

Tonal context was a local effect that affects surface f0 formation in Taiwanese. Both preservatory and anticipatory f0 assimilation were observed (Lin, 1988, 1989; Peng, 1997). However, there was no systematic study of tonal environment, neither was there study on the alignment of between Taiwanese lexical tonal targets and tone-bearing syllable. This study intended to study the placement of onset and offset tonal targets relative to its tone-bearing syllable in Taiwanese. The major focus was on how location of tonal target was modulated according to context. With a clear specification for the location of onset and offset targets relative to the boundary of tone bearing unit, surface f0 can be precisely synthesized to improve recognition of lexical meaning.

2. Method

2.1. Corpus

Eighty Taiwanese sentences consisted only of vowel or sonorant were used to ensure a clear observation of continuous f0. There were five syllables in each sentence. Tonal values of the first and fifth syllables were under control, while the tonal values of the second, third, and fourth syllables were varied. The first syllable carried mid level (MM) tone with mid f0 register to provide a reference mid-point. The second syllable carried either one of the five tones, i.e. HH, LH, HL, ML or MM. The third and fourth syllables carried only four tones, i.e. HH, HL, ML or MM. The absence of LH tone in the third and fourth syllables was due to constrain of tone sandhi rule which required a sandhi tone, not an original tone, to surface in the third and fourth syllables. Since LH tone was not a sandhi tone, it was not used in the third and fourth syllables. The tone value for the fifth syllables was HL tone following HH, ML, and MM tones in the fourth syllables. However, the fifth syllable carried MM tone following HL tone at the fourth syllable. There were all together 240 sentences (5 tone on second syllable X 4 tones on third syllable X 4 tones on fourth syllable X 3 repetitions), as shown in table 1. The first and second syllable formed a surname; the third syllable was a verb, while the fourth and fifth syllables formed a noun. Though each word was semantically meaningful, the sentences formed by these words were not necessarily meaningful. The corpus used here is part of a larger corpus with 960 sentences varying four focus conditions

on each sentence, i.e. broad focus, narrow focus on subject, narrow focus on verb and narrow focus on object. The sentences investigated in this study carried broad focus. They were randomized and written on a list.

Table 1: Corpus: phoneme between / / , Surface tone between [ ] , meaning between ‘ ‘

Subject		Verb	Object	
Syllable 1	2	3	4	5
	/ me / [HH] / mo / [LH]	/ lam / [HH] ‘ hug ’	/ lyu / [HH] ‘ button’	/ a / [HL]
/ a / [MM]	/ ma / [HL] / mai / [ML] / lun / [MM]	/ lyam / [HL] ‘ pinch ’ / ma / [ML] ‘ scold ’ / law / [MM] ‘ save ’	/ a / [HL] ‘ duck ’ / lwa / [ML] ‘ comb ’ / niu / [MM] ‘ silk-worm ’	/ ləŋ / [MM] ‘ egg ’

2.2. Subjects

Four male native Taiwanese speakers participated in the experiments, cys, hyh, lws and lyk. They were students at National Chiao Tung University in Taiwan at time of recording.

2.3. Recording

Recording was done in a sound treated booth with a TEV TM-728II unidirectional dynamic microphone placed 40 cm in front of the subject. Signals were bypassed through a TEAC 860R cassette deck and then recorded by SONY MZS-R4ST MD in digital quality.

Since the data elicitation process was incorporated into a large framework for eliciting different focus conditions on each sentence, there was an experimenter present in the sound booth asking questions to ensure focus fall on the right location. For data used in this study, subject saw the sentences on the lists, then experimenter would ask ‘what happened?’ to elicit production with broad focus on the entire sentence. Only after subject heard the question did they replied with the sentence they read on the list.

2.4 Data analysis

Signals were recorded from MD into a PC through fiber optical cable to ensure digital quality. F0 was generated using ESPS Waves+ program.

Data was transcribed using EMU label program (Cassidy, 1996) to mark the onset and offset of each syllable on the spectrograms. After segmentation of the syllables, f0 values of each syllable at the 5%, 20%, 40%, 60%, 80% and 95% points in time were extracted using EMU query program.

To observe the location of onset and offset tonal targets relative to the boundary of tone bearing syllable, the f0 characteristic for each tonal target must be defined first. For low rising (LH) tone, the onset f0 target was the lowest f0 value during the tone bearing syllable, while the offset targets were peak f0 after the f0 valley. For high falling (HL) and low falling (ML) tones, the onset targets were the highest f0 peak during the tone bearing unit, while the offset target was the tuning point at which f0 began to rise again. For high level (HH) and mid level (MM) tones, the onset tonal target was the minor f0 rise that occurred at the boundary between initial consonant and following vowel. The offset target was the turning point following the onset target at which point the pitch contour began to move to an opposite direction.

Average f0 contours without normalization of f0 range or smoothing of local f0 perturbation was compared to locate the f0 turning point, peak, and valley for each tonal target. The boundary between vowel and consonant was taken form spectrogram display.

3. Results

Average f0 contours for sentences with 20 different tonal combinations were shown in Figure 1. The legends on top of each panel indicated the tonal combination of second, third and fourth syllables.

The onset boundary of HH tone was located before syllable boundary regardless of the syllable position. For HH tone at the second syllable, the offset tonal target which is the turning point following onset tonal target was located before offset boundary as shown in figure 1.1.1., 1.1.3., 1.1.4., and 1.1.5. For HH tone at the position of the third syllable, following HH, LH, HL tones, the offset target was before the offset boundary as shown in figure 1.1.1., 1.2.1., and 1.3.1, while the offset target of HH tone at the third syllable after ML tone was around the syllable boundary, as shown in 1.4.1. The offset target of HH tone at the fourth syllable was after the syllable boundary as shown by solid line in every figure.

For LH tone at the position of the second syllable, the onset target which is the f0 valley is located before the syllable boundary, while the f0 peak occurred after the offset boundary of the tone-bearing syllable, as shown in figure 1.2.1., 1.2.3., 1.2.4., and 1.2.5.

The onset f0 peak target of HL tone at the second, third and fourth syllable position all occurred before the offset boundary of tone bearing unit. For HL tone at second syllable, the f0 offset target was located after the syllable boundary, as shown in figure 1.3.1., 1.3.3., 1.3.4., and 1.3.5. The offset target of HL tone at the third syllable was around the syllable offset boundary when followed by HH and HL tones; but the f0 valley was located after the offset boundary when followed by ML and MM tones. In other words, the location of f0 valley depended on the onset tonal targets of the following (fourth) syllable. The f0 valley of HL tone at the fourth syllable was located after the offset boundary of tone-bearing syllable, as shown by the long dash line in every figure. It should be noted here that HL tone in the fourth syllable was the only tone followed by MM tone, and not by HL tone.

For ML tone, the onset f0 peak target was located before the syllable boundary at the second and third syllables, so was the location of onset f0 peak of ML tone at the fourth syllable preceded by HH an HL tone. However, there was no onset f0 peak at all for ML tone at the fourth syllable preceded by ML and MM tones. The f0 contour of ML tone at MM_HL and

ML_HL tonal contexts was rising, as shown by dotted line in figure 1.1.4., 1.1.5., 1.2.4., 1.2.5., 1.3.4., 1.3.5., 1.4.4., 1.4.5., 1.5.4., and 1.5.5. For ML tone at the second syllable, the offset target which was the turning point that f0 valley began to rise again occurred after the offset boundary, as shown in figure 1.4.1., 1.4.3, 1.4.4., and 1.4.5. For ML tone at the third syllables, the offset target which was the turning point occurred before the offset boundary followed by HH and HL tones as represented by solid line and long dash line respectively in figure 1.1.4., 1.2.4., 1.3.4., and 1.4.4., and 1.5.4. For ML tone at the third syllable followed by ML and MM tone, the turning point was around the offset syllable boundary, as indicated by dotted line and dash dot line in figure 1.1.4., 1.2.4., 1.3.4., and 1.4.4., and 1.5.4. Like high falling (HL) tone, the location of offset target for low falling (ML) tone depended on the register of following tonal target. When followed by H target the offset target of ML tone was before the offset boundary. When followed by M tonal target the offset target was around the offset syllable boundary. For ML tone at the fourth syllable preceded by HH and HL tones, the f0 valley was located before the offset boundary, as shown by the dotted line in every figure. For ML tone at the fourth syllable preceded by ML and MM tone the f0 contour was rising instead of falling as expected for low falling. Not only was there no onset f0 peak target, there was no offset f0 turning point at which f0 began to rise again.

For MM tone, the onset target occurred before the offset boundary of the syllable regardless of the syllable position. The offset target of MM tone at the second syllable which was a turning point that f0 began to move to an opposite direction occurred before the offset boundary of the syllable when followed by HH and HL tones, but around the boundary when followed by MM and ML tones, as shown in figure 1.5.1., 1.5.3., 1.5.4., and 1.5.5. For MM tone at the third syllable, the offset target was the turning point when f0 began to rise. It was located around the offset boundary when followed by HH and HL tone, but after the offset boundary when followed by MM and ML tones, as shown in figure 1.1.5, 1.2.5., 1.3.5., 1.4.5., and 1.5.5. The offset target of MM tone at the fourth syllable was the f0 peak located after the offset boundary, as shown by dash-dot line in every figure.

4. Discussion

The alignment between f0 targets and the tone-bearing syllable is systematic. For level tones, HH and MM, at the position of second and third syllables, f0 turning point occurs before the offset boundary of tone bearing unit. However, at the fourth (penultimate) syllable, the location of turning point is different between HH and MM tones. For HH tone at the penultimate syllable, the turning point is located after the offset boundary, while the turning point is located before the offset boundary of tone-bearing syllable.

For the rising and falling tones, i.e. LH, HL, and ML, at the second syllable, the f0 target occurs after the offset boundary of the tone-bearing unit. At the third syllable, the location of f0 target for rising and falling tones depends on the tonal onset of following tone. When followed by an H tonal onset in the fourth syllable, i.e. HH and HL tones, the location of f0 target fall before the offset boundary of the third syllable. When followed by a M tonal onset at the fourth syllable, as in ML and MM tones, the location of f0 target fall after the offset boundary of the third syllable. Similar situation could be found at the location of tonal targets for rising and falling tones at the fourth syllable. When the following fifth syllable began with an M onset, the f0 valley of HL tone at the fourth syllable falls after the offset boundary. When the following fifth syllable began with an H onset, the f0 valley of ML tone at the fourth syllable is located before the offset boundary.

Both syllable position and tonal context influence the location of tonal target relative to the offset boundary of tone-bearing syllable.

5. Conclusions

This research concentrated on the relationship between offset tonal target and offset tonal boundary. For future study, the relationship between onset tonal target and onset boundary should be investigated to model the location and value of tonal target relative to boundary of tone-bearing unit in different utterance. Moreover, both global effect, such as declination and prosodic boundary, and local effect, such as tonal context and focus, should be investigated. A complete portrait of Taiwanese surface f0 could be revealed after a thorough study of all the prosodic factors.

6. References

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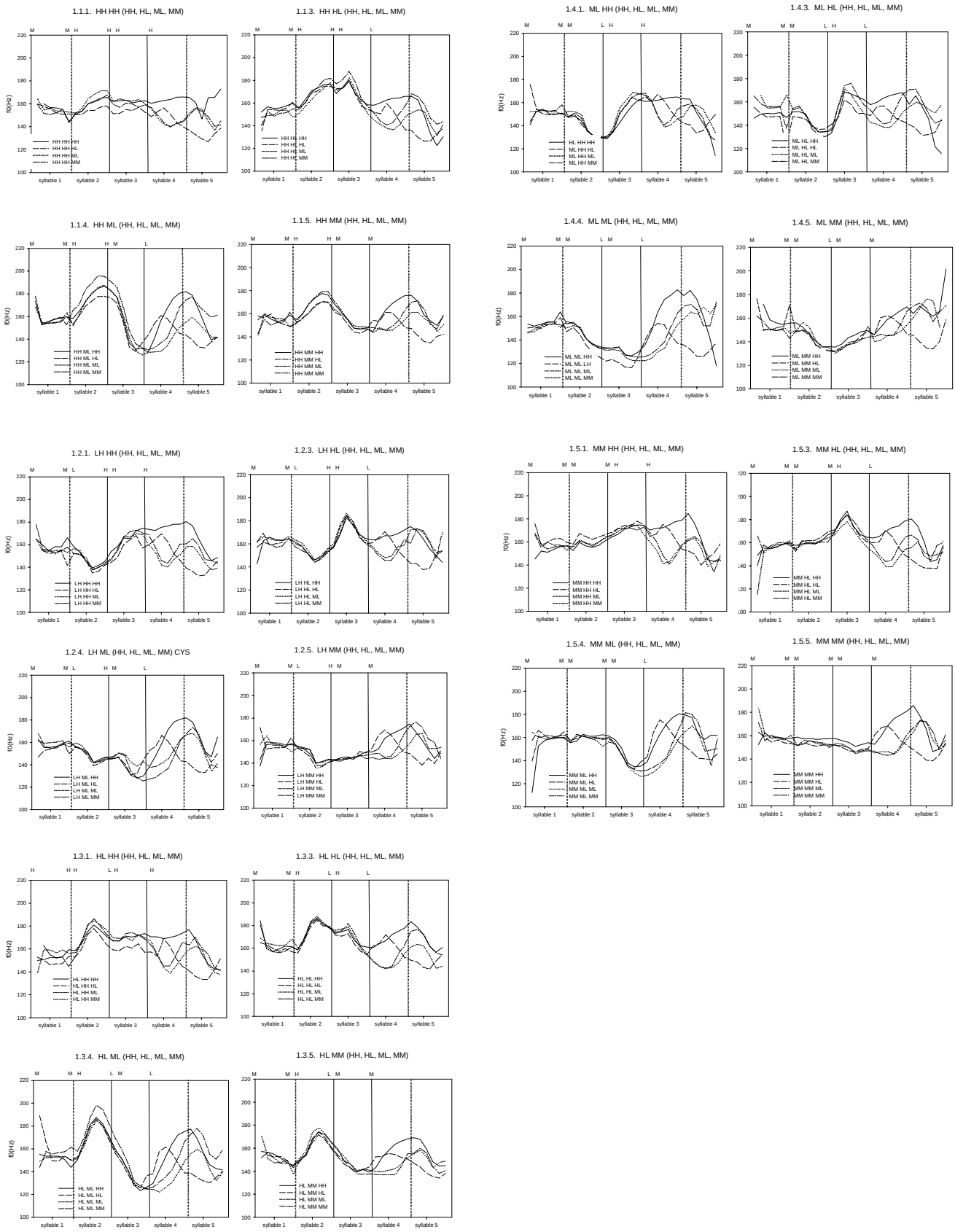

Figure 1: Average f0 contours.