Disambiguating Low-registered Tones in Taiwan Southern Min

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Abstract

The study explores the inherent and prosodic challenges within the low-register tonal domain of Taiwan Southern Min (TSM) through both fieldwork and acoustic analysis, focusing on the tones ST7, CT3, and Q-ST5. By comparing the fundamental frequency (F0) variations across these three surface low tones, the study concludes that ST7 and CT3 should be classified as ML (Mid-Low), whereas Q-ST5—previously underexplored—warrants categorization as LL (Low-Low). Furthermore, the paper highlights the non-cyclic nature of tone sandhi in TSM, a critical feature of the language's tonal behavior. The research also addresses the influence of dialectal variation on the directionality of tonal marks that undergoes tone sandhi, which serves as evidence for tonal reconstruction. Ultimately, the study aims to enrich our understanding of the tonal systems in TSM and, by extension, the tonal dynamics within the broader family of Chinese languages.

1 Introduction

Taiwan Southern Min (TSM) is the variant of Min dialects in Taiwan. In the past, Taiwanese was the lingua franca of Taiwan; currently, it is still one of the primary languages in Taiwan, second to Taiwan Mandarin (TM) in terms of the number of speakers. TSM has many unique characteristics and phonological features valuable for linguistic research, one of which is the phonological operations and variations of tones.

The issue of the tones of TSM has become one of the centerpieces of discussion among phoneticians and phonologists. Observing the discussion of TSM tones and tone sandhi issues, it is not difficult to find that the phonological operation in the low register is particularly intricate. The effect of dialectal variations on TSM also makes the patterns more complicated. Therefore, results from perceptual judgments by researchers cannot be taken for the preliminary reconstructions of TSM low registered tones all the time.

	Contour	Value	Mark	
T1	High-level	55/44	hr, HH	HH
T2	High-falling	53/42	hr, HL	HM
T3	Low-level/ Low-falling	21/11	lr, LL/HL	LL/ML
T5	Low-rising	13/24	lr, LH	LM
T7	Mid-level	33/32	lr, HH	MM

***hr**=high register; **lr** = low register

Table 1: TSM Tonal System (To be revised).

Previous researchers have divergent arguments about the phonological marks of low-registered tones in TSM, in which T3 is the most problematic one. Some consider it a low-level tone (LL), while some argue that the F0-falling beginning of T3 makes itself more like a falling tone. Essentially, the tonal ambivalence and opacity is not the patent of TSM, but are also considered to be an issue in several Chinese dialects (Chuang 2023, 2024; Chuang and Liao 2024). On account of the complexity and the counter opinion, the paper investigates low-registered tones in TSM.

2 TSM Tones

As a tone language, TSM has a rich tonal and prosodic system compared to other Chinese dialects. There are seven lexical tones in TSM, five of which are non-checked tones (including T1, T2,

T3, T5, T7) and two of which are checked tones (T4, T8). See more detailed descriptions and discussions in Fon and Khoo (2025).

In terms of tone-bearing unit (TBU) (Goldsmith 1976) and moraic theory for the phonological weight (Hyman 1985), non-checked tones can be linked to two TBUs. In contrast, it is difficult for a stop consonant to carry a tone, so a checked syllable is connected to only one TBU. When a TSM tone is followed by an XP (i.e., non-sentence-final positions), namely when two lexical tones (T_a, T_b) are adjacent to each other, T_a will be pronounced as a sandhi tone (ST), instead of its citation tone (CT), which can be summarized as the rule of $CT_a \rightarrow ST_a$ / ___ T_b.

3 Tone Sandhi & Variations

TSM has two dialects, Chiang dialect and Quan dialect. Low-registered tone sandhi and the variations are as follows: T7 is a mid-level tone, of which ST is perceptually like CT3. As for T5, its tone sandhi is relatively complicated with two dialectal variants. For Chiang TSM speakers, T5 undergoes tons sandhi, thus with the contour of T7, namely mid-level; for Quan TSM speakers, T5 is perceptually like T3 and in the low tonal domain. With the flow, the (apparently) surface representations of T3 can be three: (1) Sandhi tone of T7, (2) Sandhi tone of T5 in Quan dialect (Q-ST5), and (3) Citation tones of T3 (CT3). Considering the difference in their underlying origins, we are heading to discrimination and examination of the surface and the apparent T3.

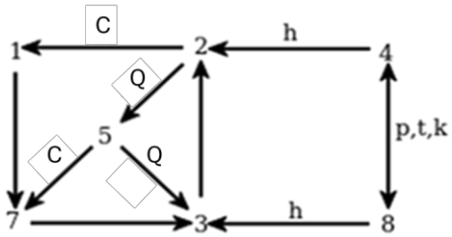

Fig. 1: Tonal operation in TSM
C= Chiang dialect; **Q**= Quan dialect;
h: applicable when the coda is [h];
p,t, k: applicable when the coda is [p, t, k]

4 Literature Review

After reviewing the previous accounts, I found two major tracks for the low-register tones in TSM. Some consider LL is the only way to go for CT3 and ST7, while some assume ML is the key to them. By considering two major opinions, a new possibility of the coexistence of LL and ML in TSM is presented.

4.1 LL

From the perspective of generative phonology, Ang (1997), Tsay and Myers (1996), and Hsiao (1991) assume CT3 and C-ST7 are low-registered low-level tones (l, LL), namely low-level tones (LL). Such phonological analysis is mainly based on perceptual judgment rather than acoustic measurement or analysis, so the results of the proposed tonal reconstructions may not be proper. Besides, F0 in the low-registered domain is already in a low-frequency band, which is difficult to perceive, so the auditory judgment may be interfered with by other phonetic factors. Lack of convincing for the low-level tone may thus be caused. At the same time, it is also difficult to explain CT3 as LL. ST3 is a high-falling tone (HM). Once we consider CT3 to be LL, it is hard to say why the tone sandhi of T3 contributes to a register sandhi from low register to high register as well as a tone sandhi from a level tone to a falling tone. The proposal is not economical and requires a complex tonal transfer with tone sandhi and register sandhi. Therefore, the LL analysis may be open to question.

4.2 ML

Chen (2018) conducted acoustic experiments on TSM tones, measuring the tone contour and pitch of five non-checked tones and their variant tones as tone sandhi. Results of F0 contour showed the changes in its pitch with raising/falling contours. To minimize the individual difference, the study used the normalized F0 as a reference for the analysis. In both young and old TSM speakers' pronunciations, CT3 and ST7 move from the mid-point to the low-pitch band. They are falling, heading to a low pitch. Despite the final low pitch position of the ST7 is slightly higher than that of the former, it was hypothesized by Chen (2018) to be the priming effect of citation tones in tone sandhi. Since CT7 is higher than ST7, it is possible that ST7 being slightly higher is a residual influence. No matter how CT3 and ST7

end differently in a slight manner, the general inclination of pitch-falling is doubtless.

In fact, M. Y. Chen (1987) has already proposed a similar idea. Peng (1997) also used similar acoustic experimental results to illustrate that CT3 and ST7 are in a descending pitch, only that the result of Fig. 3 was analyzed to be 21 at that time. Kuo (2013) corrected the experimental analysis of Peng (1997) and pointed out that the result should have been analyzed to be 31, which suggests they be ML.

4.3 Summary & New Possibility

Summarizing the above results, it is obvious that empirical studies have mostly compared CT3 and ST7 to the low-registered falling tone (ML). Acoustic measurements often do not support the analyses of LL. This further suggests that the phonological representation of TSM low-registered tones needs revising to match the actual situation. According to the acoustic data, CT3 and ST7 basically share the same tuning mode and tuning value. In terms of analysis, it is reasonable to include them in the same type of phonological structure. In other words, either LL or ML is appropriate for the analysis.

In addition, previous literature on TSM low-registered tones has been inclined to Chiang dialect, as it is the advantageous dialect in Taiwan compared to the Quan dialect. So far, nearly no acoustic measurements have been made on Q-ST5. Studies in the past usually do not show Q-ST5 for it is often considered to be the same with ST7 and CT3.

At the end of this paper, a possibility will be raised, where the bias of past analyses is actually an insight into the LL-ML dispute for TSM. With reference to the formal analyses and acoustic surveys presented in the previous section, we suggest that a potential analysis would be that CT3 and ST7 are ML, whereas ST5 in Quan is LL. This is, ML and LL co-exist, yet distributed in different tonal contexts. Difficulties in perceptual interpretation between them may be a source of analytic disagreement in the past.

5 Fieldwork

5.1 Speakers

Seven speakers were initially invited to the reading task in fieldwork, including four male Chiang-TSM (C-TSM) speakers and three male Quan-TSM (Q-TSM) speakers. Their ages ranged from 43 to 71 (Mean = 57.7; SD = 10.54). In this survey, C-TSM speakers were defined as those with ST5 as MM, while Q-TSM speakers were defined as those with ST5 as ML/LL, either falling or level. C-TSM speakers mainly come from C-accented areas along the north coast of New Taipei City (e.g., Wanli, Jinshan, etc.), while Q-TSM speakers come from two Q-accented areas, including Dacun, Changhua City and Muzha, Taipei City.

5.2 Reading List

Before this fieldwork, the researcher designed a corresponding word list for the speakers to read out when recording. The word list mainly consists of 30 disyllabic words A+B. Under normal circumstances, A will be pronounced in the sandhi tone and B in the citation tone. Among the words, A may be ST7 and ST5, and B can be CT3. Each target tonal representation was repeated 10 times in the word list and will not be used in the same word. The word list was provided to the speakers in a randomized manner, with the researcher assisting with word guidance if necessary.

5.3 Acoustic Measurement

In order to obtain the acoustic data of the tones, the measurement mainly focuses on the F0 of the target syllable. Twelve sampling points were extracted to investigate the F0 contour in a row, in which the first sampling point was discarded. The total number of valid sampling points was 11 (t_1...t_{11}). After setting the start and end points, any insufficient sampling points will be compensated by interpolation to construct reasonable data for the gap.

In order to further investigate the acoustic differences, a two-tailed t-test was performed to analyze the different tones at the start (t_1), middle (t_6), and end (t_{11}) points. For statistical analysis, the data will be normalized, and the normalized data includes the F0 height and duration. The main purpose of this operation is to eliminate the effect of individual differences on F0.

6 Results

First of all, this study will report the preliminary F0 data that have not yet been formalized. After that, the researcher will analyze the data of the target tones, by comparing the similarities and

differences among the three target tones. Finally, based on the data, we will propose the possibility of phonological analysis.

6.1 ST7

From the mode of F0, it is clear that ST7 has a falling contour. The maximum average F0 of ST7 is 109.6 Hz, the average midpoint value is 86.4 Hz, and the minimum value is 78.9 Hz. The average span of pitch-dropping is 30.7 Hz, with the average drop of the front section being 23.2 Hz, and that of the back section being 7.5 Hz. The settling of the F0 in the front section is more pronounced, while that in the back section is more moderate.

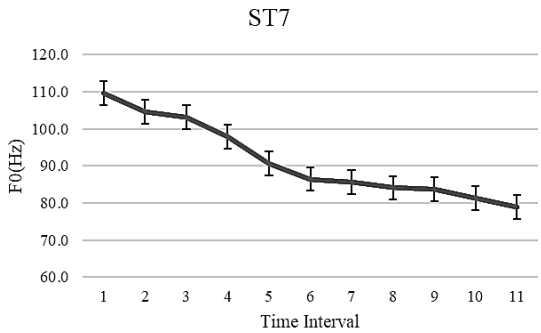

Fig. 2: F0 result of ST7

6.2 CT3

A preliminary analysis of the data reveals that CT3 is a falling key. The maximum average F0 of this key is 99.2 Hz, the average midpoint value is 83.9 Hz, and the minimum value is 77.0 Hz. The average pitch decreases by 22.2 Hz, with an average drop of 15.3 Hz in the front section and 6.9 Hz in the back section. The sinking of the F0 in the front section is pronounced like ST7, and that in the back section is relatively flat.

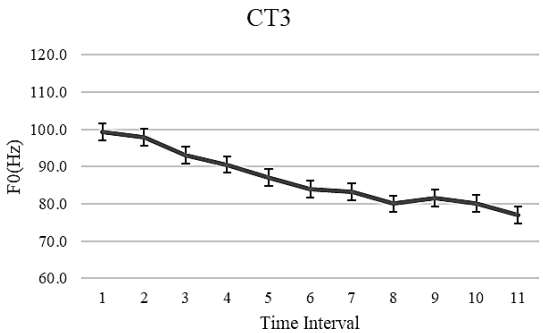

Fig. 3: F0 result of CT3

6.3 Q-ST5

From the F0 contour, Q-ST5 should be a level tone. The maximum average F0 of this key is 87.1 Hz, and the minimum is 81.1 Hz. The average drop of this key is 6.0 Hz, with an average drop of 4.8 Hz in the front section and -2.9 Hz in the back section. Overall, the tone has gentle ups and downs, with only a slight drop in the middle, which is similar to the flat tonal patterns observed in Chen (2018) for high-level and mid-level tones.

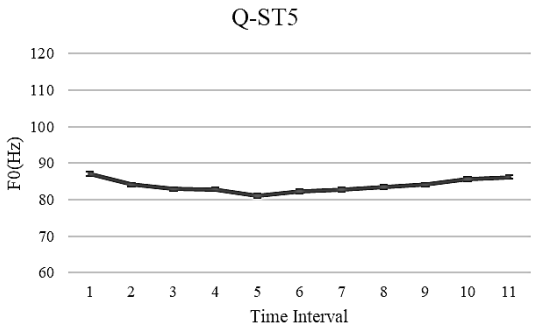

Fig. 4: F0 result of Q-ST5

6.4 Normalized F0

The normalized analysis can facilitate the comparison and difference analysis between the three low-register tones (ST7, CT3, Q-ST5). In the starting point, ST7 has the highest pitch, followed by CT3 and Q-ST5. The difference between the lowest one and the highest one is more than 0.5 units. The mid-point values for all converge and fall between 0.25 and 0.35. The end-point values are inverted and staggered somehow, but not significant with Q-ST5 being the highest value at the end, followed by ST7 and CT3.

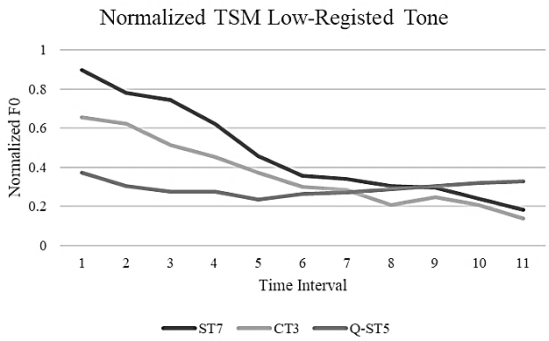

Fig. 5: Normalized F0 results in comparison

A statistical analysis of variance (One-Way ANOVA) was performed on the values of the start points, mid-points, and end points of three tones,

in order to see if there were any significant differences. First, the three sets of start point data were significantly different ($p<.01$) in between, including ST7 and CT3 ($p<.01$), CT3 and Q-ST5 ($p<.01$), and ST7 and Q-ST5 ($p<0.01$). Then, the three sets of midpoint data were not significantly different ($p>0.1$). For the endpoints, Q-ST5 was significantly different from ST7 and CT3 respectively ($p<0.1$), and there was no significant difference between ST7 and CT3 ($p>0.1$).

In general, the results show the representations of TSM tones in the low register are actually not the same. Assumed 0 and 1 to be the high and low boundaries of the low-registered domain, namely M and L, 0-0.5 can be regarded as the low-pitched domain of the low-pitched domain for L, while 0.5-1.0 is the high-pitched domain of the low-pitched domain for M. Summarizing the statistical analyses above, we consider that Q-ST5 is a low-level tone, with little difference in its overall changes, gentle ups and downs, and continuous operation in low-tone domain (L); while ST7 and CT3 should be a mid-falling tone, with both of them moving from the high-tone domain of the low-tone domain (M) to the low-tone one (M), as well as with a clear convergence of both, which suggests that the two of them should have the same tonal end-point target.

	Citation Tone	Sandhi Tone	
		Chiang	Quan
T1	HH	MM	
T2	HM	HH	LM
T3	ML	HM	
T5	LM	MM	LL
T7	MM	ML	

Table 2: TSM Tonal System (Revised).

7 General Discussions

7.1 Revision of TSM tonal system

Based on the above results, the proposal of TSM tonal marks should be revised. This paper proposes to revise the original assumption that ST7 and CT3 are LL (Ang 1997; Tsay and Myers 1996; Hsiao 1991, 2000) to ML, which is low-registered HL. The revised system matches the empirical results of Chen (2018). In addition, based on the F0 pattern and acoustic characteristics of Q-ST5, this paper analyzes Q-ST5, which has rarely been studied in the past, as LL in the low tonal domain. In summary, the modifications of Taiwanese non-checked tones are listed as follows:

7.2 Non-cyclicity of TSM tone sandhi

By the tonal correspondences between citation tones and sandhi tones, we can see that TSM is not a cyclic tone-sandhi language. C-TSM seems to conform to the rules of cyclic modulation, while the tonal system of Q-TSM does not conform to cyclic tone sandhi and cannot be fully cyclic. With comparisons between C-TSM and Q-TSM, I argue that there is no such cyclic tone sandhi in TSM regardless of dialects, since it is impossible for the tonal system of a language to have cyclic and non-cyclic dialects at the same time, simply due to dialectal variations.

In addition, if a language is a cyclic tone-sandhi language, native speakers should have the ability to trace the citation tones from the sandhi tones. However, previous empirical studies on TSM speakers' linguistic knowledge do not support such a claim (Zhang, Lai, and Sailor 2011). This is indirect evidence for the non-cyclicity of tone sandhi in TSM.

7.3 Dialectal Variations

The dialectal difference between Chiang dialect and Quan dialect can be seen from the tone sandhi of T5, which is LM→MM for C-TSM and LM→LL for Q-TSM. The dialectal difference actually reflects the proposed tonal marks to be possible: In the low register, Q-TSM prefers the tone sandhi of the left-side tone, and thus L, which is on the left-side TBU, will be converted to M, resulting in MM. By contrast, C-TSM prefers the tone sandhi of the right-side tone within a syllable, and thus M, which is on the right-side mora, is converted to L, resulting in LL.

8 Conclusion

The study investigated the tonal problems in the low-registered domain in TSM through fieldwork and acoustic analyses. The major focus includes ST7, CT3, and Q-ST5. Based on the comparison of F0 contours among three surface low tones, it is concluded that ST7 and CT3 should be analyzed as ML, while Q-ST5, which has seldom been

investigated before, should be analyzed as LL. This paper further points out the property of non-cyclic tone sandhi in TSM. In addition, the paper discusses the fact that the C-Q dialectal differences are reflected in the directionality of tone marks that undergoes tone sandhi, which can be evidence for tonal reconstruction. It is hoped that the study contributes to a better understanding of the tonal systems of TSM, even of Chinese languages, since many Chinese dialects also have similar problems with low-registered tones.

In fact, tonal identification in the low-registered domain is an issue for many Chinese dialects, especially for the distinction between mid-falling and low-falling/level tones. This is, ML and LL cause problems in tonal identification. The present study suggests that ML and LL are hard to distinguish in perception for misleading assumptions in intuitive judgements by previous formal analyses, while they remain discernible in production as the acoustic analysis has shown in the present study. Such a mismatch in tonal identification predicts the potential tonal merger of TSM low-registered tones in the coming future, where ML and LL may be fused together.

Lastly, the study has some pedagogical implications. For heritage language learners of TSM, understanding the complexities of tone sandhi and the tonal distinctions between ML and LL tones could be especially challenging, as these learners may not have received formal instruction in TSM and may have limited exposure to tonal distinctions. It would be significant to create pedagogical materials that emphasize the restoration and correct usage of these low-register tones, providing exercises and practice specifically targeting L (ML vs. LL).

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