Contextual Variability of Third-Tone Sandhi in Taiwan Mandarin

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Abstract

This study investigates the phonetic property of Third-Tone Sandhi in Taiwan Mandarin and the effects of contextual variability. The goal of this study is to provide empirical evidence for the description of Tone 2 (T2) and Tone 3 (T3) in Taiwan Mandarin and further to account for the phonetic features of T2 and T3 in Third-Tone Sandhi Contexts. The results show that isolated T2 is different from isolated T3 in Taiwan Mandarin. Interestingly, the phonetic T2 (\(<\)/T3/) derived from Third-Tone Sandhi Rule in Sandhi Context has more raising effect than the underlying T2 in the same Sandhi Context. The greater raising effect of the T3 (> T2) in Sandhi Context was supported by its longer vowel duration. Third-Tone Sandhi Rule turns T3 into T3 in Taiwan Mandarin and further to account for the phonetic realization of Third-Tone Sandhi. The study aims to provide empirical evidence for the description of T2 and T3 in Taiwan Mandarin and further to account for the phonetic features of T2 and T3 in Third-Tone Sandhi Contexts. Physical measures of T2 and T3 in different contexts were made to capture the tonal identity of Taiwan Mandarin and the variability of Third-Tone Sandhi.

2. Background of Third-Tone Sandhi

Mandarin Third-Tone Sandhi is generally predictable, and the application of Third-Tone Sandhi rule is phonological obligatory, when only two third-tone syllables are strung together. The phonetic realization of the Third-Tone Sandhi becomes more complicated when more than two third-tone syllables come together. Cheng [2] claims that all third-tone syllables except the last one may change when many T3 syllables appear, and the various possible changes depend on speech tempo.

Thus far, phonological status of Third-Tone Sandhi Rule is ascertained, whereas the phonetic realization of Third-Tone Sandhi may vary.

2.1. Mandarin Third-Tone Sandhi Rule

In Sandhi Contexts, T3 alternates with T2 when another T3 follows. In other words, Third-Tone Sandhi Rule turns a low T3 into a rising tone when followed by another T3. But a T2 (rising tone) does not change its phonetic property when followed by another T2. Earlier studies [3][4] provide phonological account for sandhi domain, and Chen [4] further proposes stress-foot as sandhi domain in diverse Chinese dialects. Mandarin Third-Tone Sandhi Rule was treated as a dissimilation process on a register level [5]. When two syllables with identical tones come together, the first one changes. Shih [3][6] proposes that three-tone structures function similarly to disyllabic feet. No matter whether the added syllable is to the right or to the left, Third-Tone Sandhi Rule applies without fail. Coster and Kratochvil [7] have investigated T3 Sandhi in connected speech and claimed that the occurrence of tone sandhi in spontaneous speech is not governed by the phonological tone sandhi rule, either in its conventional form or in its restricted form.

Phonetically, Shih’s [6] study captures a significant phonetic distinction between T2 and T3. T3 stays low much longer than a T2; in the beginning of a rhyme, the pitch of a T2 typically falls slightly as well, giving it an overall falling-rising shape; however, by the time T2 begins to rise, T3 still remains low and continues to fall, reaching a lower level than a T2 and then rises. However, the phonetic property of T2 and T3 in Sandhi contexts was not investigated in her study. In the present study, both isolated and connected T2 and T3 in Third Tone Sandhi Context were examined.

2.2. The Effect of Contextual Tonal Variation

The magnitude and directional has been important issues in the study of contextual tonal effect. Gandour et al. [8] have found that Thai tones were more influenced by carry-over coarticulation than by anticipatory coarticulation. Carry-over coarticulation affected a greater number of Thai tones and extended farther into adjacent tones. On the other hand, the findings on Mandarin tonal variation have been mixed. Anticipatory and carryover effects were found to be comparable in magnitude of effect, and it was concluded that the bi-directional effects are symmetric [9][10]. It was also observed that tonal coarticulation in Mandarin was unidirectional, and each tone in Mandarin was affected either by a carry-over effect, or by an anticipatory effect [11]. Furthermore, data from Mandarin and Thai suggest that the anticipatory tonal influence is dissimilatory rather than...
assimilatory [8][11][12]. The anticipatory effect (also called anticipatory raising or regressive H-raising) is that f0 height of a tone is raised when followed by a low tone [8][13]. Anticipatory raising effect may in fact be the real mechanism underlying downstep [11]. Xu [11] concludes that anticipatory effects are mostly dissimilatory: a low onset value of a tone raises maximum F0 value of a preceding tone.

Anticipatory raising effect may be a factor for the dissimilatory phenomena of T2 (<T3/>) in Third-Tone Sandhi Context. In the present study, all the target words were placed preceding a T3 with a low onset. Under the controlled phonetic environment, it was expected that the maximum F0 (usually offset) of a T2 would be raised by its following T3 (low onset). Particularly, one of the main concerns of the present study is to know whether the raising effect of T3 is significant in the tonal context of T2T3 (</T3T3/). with the application of Third-Tone Sandhi Rule. Namely, whether the T2 derived from Third-Tone Sandhi Rule has greater raising effect than the controlled T2 in the same context without the application of T3 Sandhi Rule. The static T2 is the product of Third-Tone Sandhi Rule, whereas T2 is a controlled one.

2.3. Rate Factor in Mandarin Speech

Shih [3] has noted that internal structures of three-syllable phrases are ignored or ‘flattened’ out in fast and causal speech. In allegro speech, for instance, three-syllable phrases are treated as intrinsically unstructured sequences of syllables. This indicates speech rate affects the identification of a prosodic foot and the application of the T3 Sandhi rule in three-syllable phrases. In Xu’s [14] instrumental study, it was found that duration at slower rate is longer and that the duration of the R (Rising) tone is the longest. It is clear that speech rate reduces the duration of a syllable. However, whether speech rate directly affects the phonetic realization of Third-Tone Sandhi needs further investigation.

In the present study, speech rate was considered as one of the parameters in the physical measures of F0 contour, one of the major phonetic correlates of the third-tone Sandhi features. Four groups were designed. Two are experimental, and two are controlled. Experimental groups are T3 in Tone Sandhi Context and T2 in Tone Sandhi Context. Controlled groups are Isolated T2 and T3. Each group is consisted of 30 tokens. Tokens in each group were produced at fast and normal rates. The total number of the tokens is 480 (N= 480).

In Mandarin, lexical items are monosyllabic. Each monosyllable is divided into a consonant initial and a rhyme (a single vowel, diphthong or a vowel plus a nasal coda). Vowel height was not controlled in the study, because the three-syllable phrases must be grammatical and the thirty grammatical phrases per condition could not be formed by only an identical vowel tone. Tone Sandhi Contexts are three-syllable phrases, with first or second-syllable T3, fixed last-syllable T3, and the target T2 or T3 inserted into the initial or the middle of the template to form a grammatical phrase. Target tonal syllables are in the form of T2 or T3 CV, in which C is a nasal, a lateral, or a glide. A target syllable X is placed at the first or second position of an internal prosodic foot in a three-syllable phrase context X T2 T3 or T3 X T3, in which the application of Third-Tone Sandhi Rule is obligatory. Experimental groups 1 and 2 are illustrated below.

- Group 1: T3 in Third-Tone Sandhi Context
  
- Group 2: T2 in Third-Tone Sandhi Context

Controlled groups 3 and 4 are shown below.

- Group 3: T3 in isolation
  
- Group 4: T2 in isolation

Two female native speakers of Taiwan Mandarin ages 25-28 participated in this study. None of them had hearing impairment history. Recording was conducted in a sound treated booth in the Department of Linguistics, University of Texas at Austin. Materials were randomized and presented to the subjects in a printed list in Chinese characters. None of the target words was marked or underlined. Subjects were instructed to read aloud each phrase or syllable at a normal rate. Then they were asked to read the list again at their fastest rate. The data recorded on the digital tapes was sampled at 20,000Hz using the Macquarier software.

Physical measures are vowel duration, f0 at onset and offset points, and pitch contour. Vowel duration was measured from each target syllable. Pitch contour (rising or falling) was obtained by subtracting onset from offset (Pitch Contour = f0 at Offset – f0 at Onset). Separate analyses of variances (ANOVAS) were performed on the f0 values at onset and offset, contour, and vowel duration to evaluate the extent of anticipatory effects in 480 tokens.

3.2. The Correspondence of Offset and Pitch Contour

The results of f0 values at onset and offset points of each condition are given in Figure 1. F0 values at offset are higher than that at onset, except for T3 in isolation, and T3 in Sandhi Context has greater raising effect than T2 in Sandhi Context, indicated by the raising slope. There is not much pitch contour difference between T2 in Sandhi Context and T2 in isolation.

There is, however, significant pitch contour difference between T3 in Sandhi Context and T3 in isolation (p<0.0001). ANOVAs indicate a significant difference in f0 at offset of T3 and T2 in Sandhi Contexts [F (3, 236)= 135.94, p<0.0001]. The correspondence between offset and pitch contour is clear.
A t-test was conducted to confirm the contour distinction between T3 and T2 in Sandhi Contexts. Pitch contour of T3 in Sandhi Context has significant difference \( df=118, t=3.139, p<0.001 \) from T2 in Sandhi Context. T3 in Sandhi Context has more raising effect. The greater raising effect is significant \( F (3, 236)=175.42, p<0.0001 \). Pitch contour indicates the raising effect, because it was obtained from the subtraction.

The results indicate isolated T2 is different from isolated T3 in Taiwan Mandarin. The phonetic T2 (</T3/) derived from Third-Tone Sandhi Rule in Sandhi Context has more raising effect than the underlying T2 in the same Sandhi Context.

Note that the duration of T3 in Sandhi Context is the longest, much longer than the T2 tokens in the same Sandhi Context. It is clear that the greater raising effect of the T3 in Sandhi Context was supported by its longer vowel duration.

3.4. Speech Rate Affects Raising Effect

At fast speech rate, the distinction between T3 and T2 in Sandhi Contexts becomes less salient and not significant. F0 values at onset and offset points at fast rate were illustrated in Figure 3. Though the offset of T3 in Sandhi Context is slightly higher than that of T2 in Sandhi Context, the difference is not significant \( p=0.2175 \). This indicates speech rate affects raising effect, though it does not change the falling or rising pitch contour of the tonal tokens.

4. Contextual effects

Sandhi Context provides the application of Third-Tone Sandhi Rule. Pitch tracks of the isolated T2 and T3 [ma] tokens in the present study are given in Figure 4, whereas pitch tracks of T2 and T3 [ma] in Sandhi Context are given in Figure 5. Vowel duration in the figures was normalized.

As shown in Figure 4, T3 falls from the middle of the duration and has minimum f0 at offset point, whereas T2 rises and has the maximum f0 at offset point. On the other hand, both T2 and T3 in Sandhi Context have high f0 values at offset, as shown in Figure 5. The comparison between T3 in isolation and T3 in Sandhi Context indicates Sandhi Contexts trigger the application of Third-Tone Sandhi Rule in Mandarin and turn the underlying T3 into the phonetic T2. Isolated T2, T2 and T3 in Sandhi Context have rising pitch contour, whereas isolated T3 is a slightly falling tone or a low tone. It is clear that Sandhi Context is the prerequisite for the application of
Third-Tone Sandhi Rule, and phonetic contexts do affect the phonetic realization of T2 and T3 in Taiwan Mandarin.

While no significant difference was found in the onsets of T2 and T3 in Sandhi Context, higher offset and raising pitch contour are the direct evidence for the claim that T2 alternated with /T3/ due to Third-Tone Sandhi Rule has extra raising effect, given the same phonetic environment where anticipatory dissipimilatory effect occurs. Phonological, T2T3 (T3T3 > T2T3) due to Third-Tone Sandhi Rule is identical to underlying T2T3. Phonetically, however, derived T2T3 (T3T3 > T2T3) is distinct from underlying T2T3, because of the robust anticipatory raising effect in Sandhi Context, as well as the contextual variability of Sandhi. Third-Tone Sandhi Rule turns T3T3 into T2T3, and the anticipatory dissimilation enhances the raising effect on its preceding tone.

Speech rate, described in earlier studies as a ‘tempo’ [2], has found to be a factor for the phonetic realization of T3 in Sandhi Context. At fast rate, the raising effect of T2 and T3 in Sandhi Context did not show significant difference. Therefore, it is proposed in this study that fast speech rate reduces anticipatory raising effect in T3 Sandhi Context. It is not the case in this study that the occurrence of Tone Sandhi in fast speech is not governed by the phonological Tone Sandhi rule. Rather, the interaction between speech rate and anticipatory dissimilation is the account for the loss of robust raising effect.

6. References


