



# Metrical Structure and Tone Sandhi: Evidence from Ei Tonal Reduction

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## Abstract

This study examines the interaction of metrical structure and tone sandhi in Ei (an endangered language spoken in Rongshui, Guangxi Province, China), focusing on tonal reduction conditioned by a foot-like prosodic structure. Our analysis shows that within a disyllabic domain, Ei tone sandhi, mainly in the form of tonal reduction, applies only to the first syllable and the second syllable remains unchanged, suggesting a tone sandhi domain that exhibits a weak-strong metrical structure regardless of morpho-syntactic structures. The tonal reduction process leads to a low-register tone of variable and gradient pitch values in the non-head position. This interaction pattern between metrical structure and tone sandhi in Ei differ from other cases of metrically-conditioned tone sandhi in Chinese, such as New Shanghai and Beijing Mandarin, contributing to the typology of prosodically-conditioned tone sandhi. As the first phonological analysis of Ei tone sandhi, this study also enriches our understanding of an understudied and endangered language.

**Index Terms:** Ei language, tone sandhi, tonal reduction, metrical structure

## 1. Introduction

Previous studies on the relation between metrical structure and tone sandhi show that (i) a tone sandhi domain may be determined by metrical structure [1,2], and (ii) the head-syllable tends to keep its original tone while the non-head syllable changes or loses tone [1,3,4]. In some cases, the interaction between metrical structure and tone sandhi can be affected by morpho-syntactic factors, e.g. Shanghai and Taiwanese [2].

Most phonological analyses on the relation between metrical structure and tone sandhi in Chinese draw evidence from (i) some Wu Chinese dialects, such as New Shanghai, where the tone of the head-syllable spreads to a non-head syllable that has lost its original tone,<sup>1</sup> and (ii) Beijing Mandarin neutral tone sandhi, where the unstressed syllable is much shortened, loses its original tone, and its surface tone is influenced by the tone of the stressed syllable.

In this study, we present a case study of Ei tone sandhi, where the right-headed metrical domain is the tone sandhi domain, in which tonal reduction occurs in the non-head syllable, but no tone spread occurs and there is no influence from the head-syllable tone on the non-head syllable. Instead, the reduced tone surfaces as a low-register tone with variable phonetic pitch values that seem to reflect some residual phonetic properties of the original tone.

<sup>1</sup> Some Wu Chinese dialects, such as New Shanghai or Mainstream Shanghai spoken in Shanghai city, exhibit these patterns, as discussed in [2]. Thanks to Yiya Chen, Carlos Gussenhoven and Jie Zhang for pointing out the lack of tone spread in some Shanghai dialects.

Ei is an endangered language spoken in Rongshui, Guangxi Province, China by a group of people who call themselves Ei people. Rongshui County is located at the northeast area of Guangxi Province, where Han Chinese people live together with minorities such as Miao, Yao, Zhuang, Dong, and Shui. Ei was also called Wusehua ('five-colored language') because it shares linguistic characteristics with five languages: Zhuang, Dai, Dong, Shui (minority languages) and Tuguaihua (a Chinese language). In this paper, we use the term Ei to refer to the language spoken by Ei people.

Previous studies on Ei focused on the typological classification of the language [5,6,7,8]. Lexical tones are mentioned in these studies as evidence to support their views on the typological classification of Ei, not as studies on tones per se, and the pitch values are based on impressionistic transcriptions. A more recent study [9] provides the first acoustic study of Ei lexical tones and disyllabic tonal sequences. Our phonological analysis is based on the data from this acoustic study.

In what follows, we first introduce Ei lexical tones and tone sandhi in disyllabic sequences (§2) before presenting our phonological analysis of Ei tonal reduction (§3). A discussion comparing Ei tone sandhi with New Shanghai tone sandhi and Beijing Mandarin neutral tone sandhi is given in §4, which is followed by conclusion in §5.

## 2. Ei lexical tones and disyllabic tone sandhi

According to the detailed acoustic description of Ei tones in [9], there are seven lexical tones in Ei and tonal reduction is the major tone sandhi process.

### 2.1. Lexical tones

There are seven lexical tones in Ei, as shown in Table 1. The normalized results are given in Chao tone numbers [10], with 5 indicating the highest pitch and 1 the lowest. For the phonological representation, H and L represent high and low registers respectively, and h and l the high and low tonal values respectively [11]. A superscript c indicates a checked tone.

Table 1. *The pitch values and phonological representation (PR) of the seven lexical tones*

Tones	T1	T2	T3	T4	T5	T6 <sup>c</sup>	T7 <sup>c</sup>
Pitch values	52	31	55	45	24	54 <sup>c</sup>	24 <sup>c</sup>
PR	H hl	L hl	H h	H lh	L lh	H hl	L lh

The Ei lexical tonal inventory includes five unchecked tones (tones in syllables that end with a vowel or sonorant): T1(52) and T2(31) are falling tones, one in the high register and the other in the low register, T4(45) and T5(24) are rising tones, one in the high register and the other in the low register, and T3(55) is a high level tone. T6<sup>c</sup>(54<sup>c</sup>) and T7<sup>c</sup>(24<sup>c</sup>) are

checked tones (tones in syllables that end with a stop): one is rising and the other falling.

## 2.2. Disyllabic tone sandhi

The disyllabic tone sandhi patterns are summarized in Table 2. The raw Hertz results were obtained first, and then normalized in a 0-5 numerical scale according to the formula in (1)[12], with 0–1, 1–2, 2–3, 3–4, and 4–5 corresponding to 1-5 in Chao numbers respectively.

$$F0_{\text{normalized}} = \{[\text{Log}_x - \text{Log}_{\min}] / [\text{Log}_{\max} - \text{Log}_{\min}]\} \times 5a. \quad (1)$$

Table 2. Ei disyllabic tone sandhi patterns

Tonal combinations	Base forms		Sandhi forms	
	1st 6	2nd 6	1st 6	2nd 6
T1+X	52	X	33, 32, 22	X
T2+X	31	X	22, 21, 11	X
T3+X	55, 44	X	44, 55	X
T4+T4	45	T4	44	T4
T4+other tones	45	X	45, 34	X
T5+X	24	X	32, 23, 22, 21	X
T6 <sup>c</sup> +X	54 <sup>c</sup>	X	54	X
T7 <sup>c</sup> +X	24 <sup>c</sup>	X	32, 22, 23, 21	X

In Table 2, X represents any tone, and the X in the base form and the corresponding X in the sandhi form indicate that the tone remains the same. Although the phonetic pitch values of the sandhi tone vary, they are all in the lower pitch range from 1 to 3, and therefore phonologically, they can all be classified as a low-register tone.

Of the 49 disyllabic sequences, tone sandhi applies to 29 disyllabic tonal combinations; that is, 20 sequences do not undergo tone sandhi. The tonal change does not apply to high tones T3(55) and T6<sup>c</sup>(54<sup>c</sup>), as shown in (2ab). T4(45) is lowered to become a mid or mid-high level tone before another T4(45); otherwise, it remains unchanged when followed by other tones, as shown in (2cd).

- a. T3+T1 tam55 paŋ52 “weave” (2)  
 b. T6<sup>c</sup>+T2 mjok54<sup>c</sup> luei31 “bud”  
 c. T4+T2 mai45 p<sup>w</sup>ən 31 “wooden basin”  
 d. T4+T4 mai45 tɛ<sup>h</sup>iu45 → mai44 tɛ<sup>h</sup>iu 45 “tree top”

T1(52), T2(31), T5(24) and T7<sup>c</sup>(24<sup>c</sup>) in the first syllable are reduced to a low-register tone before any tone, and the second syllable remains unchanged, examples of which are given in (3). This tonal reduction process is the focus of the present study.

- a. T1+T1 pju52 soi52 → pju 32 soi52 “shuttle” (3)  
 b. T2+T3 nan31 fai55 → nan11 fai55 “sad”  
 c. T5+T4 mɯ24 kyn45 → mɯ11 kyn45 “sty”  
 d. T7<sup>c</sup>+T1 ɕiok24<sup>c</sup> hwən52 → ɕiok21 hwən52  
 “acquaintance”

As shown in Figures 1-4, the second tone does not have phonological effects on the output of tonal reduction. For example, when the underlying tone of the first syllable is T1(52), it changes consistently to a low-register tone no matter what the second tone is. Some examples are given in (4).

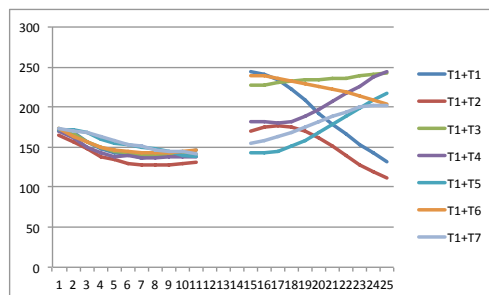


Figure 1. The raw Hertz results of T1(52)+X

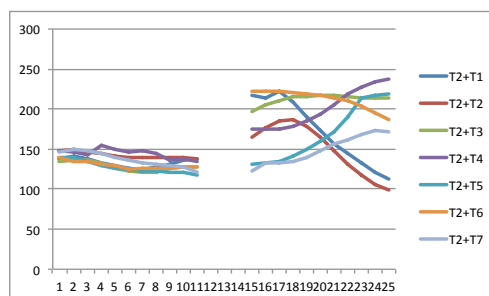


Figure 2. The raw Hertz results of T2(31)+X

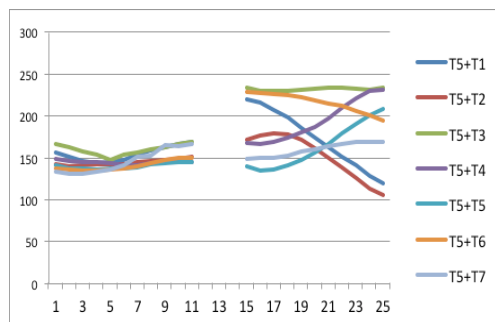


Figure 3. The raw Hertz results of T5(24)+X

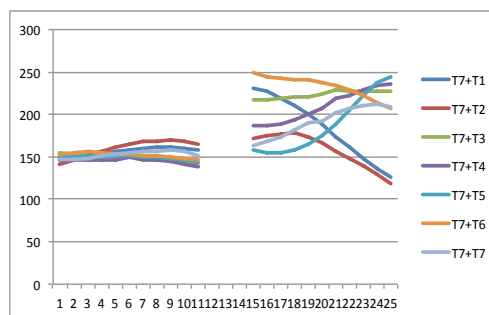


Figure 4. The raw Hertz results of T7<sup>c</sup>(24<sup>c</sup>)+X

- a. T1+T1 ey52 pau52 → ey32 pau52 “school bag” (4)  
 b. T1+T2 ɕio52 yən31 → ɕio32 yən31 “pills”  
 c. T1+T3 p<sup>h</sup>ja52 k<sup>h</sup>jau55 → p<sup>h</sup>ja32 k<sup>h</sup>jau55 “peak”  
 d. T1+T4 ɭan52 teŋ45 → ɭan22 teŋ45 “roof”  
 e. T1+T5 so52 pjo24 → so22 pjo24 “coir raincoat”  
 f. T1+T6 koŋ52 pat54<sup>c</sup> → koŋ22 pat54<sup>c</sup> “pen”  
 g. T1+T7<sup>c</sup> hwən52 wo:k24<sup>c</sup> → hwən 22 wo:k24<sup>c</sup> “adults”

## 3. Phonological analysis of Ei tonal reduction

The main generalizations about Ei tone sandhi are that (i) the tone of the first syllable is changed, (ii) the sandhi tone is a low-register tone with varying phonetic pitch values, (iii) the

second syllable retains its tone, and (iv) the tone of the second syllable does not have phonological influence on the reduced tone of the first syllable.

In the following subsections, we present an analysis in which (i) a right-headed disyllabic metrical domain constitutes the tone sandhi domain in Ei, (ii) the sandhi process is tonal reduction that may retain some remnant phonetic properties of the original tone, and (iii) there is no tonal spread or influence from the tone of the second syllable to the first.

### 3.1 The right-headed metrical domain

We propose that Ei disyllabic tone sandhi is prosodically conditioned by a foot-like right-headed metrical domain, as illustrated in (5).

$$\begin{array}{ccc} \text{weak} & \text{strong} & \\ \text{[syllable 1]} & \text{[syllable 2]} & \text{metrical domain} \end{array} \quad (5)$$

Even though Ei is not a stress language and it is usually difficult to assess if there is stress in a tone language, some phonological and phonetic facts point to the existence of this metrical structure in Ei (cf. Ayutla provided in [13] and Kera in [14]). First, this iambic pattern is indicated by disyllabic tone sandhi, with the second syllable unchanged and the first syllable reduced. In cases where prosodic structure and tone sandhi interact, there is a general agreement that the strong syllable keeps the original tone while the weak syllable undergoes tone sandhi, as observed in Shanghai, Taiwanese [2] and Lipu [4].

Second, in Ei, vowel duration changes in different positions in a disyllabic sequence: a short vowel in the first syllable becomes a long vowel when it is moved to the second syllable. For example, [mam24 hwai52] ‘beef’ becomes [hwaɪ52 ma:m24] ‘beef’. The word order of modifiers and nouns are quite free in Ei since nouns can be either preceded or followed by modifiers. In this example, the /a/ vowel is short when it is in the first syllable, but becomes long in the second syllable. As reported in [15], the vowels /a/, /e/, /ɛ/, /i/, /u/ have short versus long variants when they occupy the syllable nucleus, but the authors did not mention the condition of this variation. However, after checking about 1000 Ei disyllabic sequences, we found out that the short variant appears in the first syllable and the long one in the second syllable. The fact that the same vowel becomes long in the second syllable suggests a foot-like metrical structure with iambic lengthening [16].

Third, phonetic evidence from syllable duration also indicate that the disyllabic domain in Ei constitutes a right-headed metrical domain. According to [9], as shown in Table 3, where the tones in the first and second syllables are the same,<sup>2</sup> the average duration of the second syllable is consistently longer than that of the first syllable, although the duration of the first syllable is not so short as about half of the duration of the second. Since the tones in both syllables are the same, the influence from different tones on duration is minimized. Paired t-test indicates that there is a significant difference between the average durations of the two syllables ( $p < 0.05$ ). Since duration has important effects on the manifestation of stress, and is often used as a correlate of stress or metrical head in the study of Chinese languages [17,18], the phonetic evidence conforms to the suggestion that the disyllabic metrical domain in Ei is right-headed.

Table 3. The duration values (ms) of disyllabic combinations

	Syllable 1	Syllable 2
T1+T1	407	439
T2+T2	378	470
T3+T3	373	515
T4+T4	368	497
T5+T5	405	484
T6 <sup>c</sup> +T6 <sup>c</sup>	243	315
T7 <sup>c</sup> +T7 <sup>c</sup>	220	385
Average	342	443

Ei tone sandhi also demonstrate that this metrical domain is consistently right-headed regardless of morpho-syntactic structures. Some examples are given in (6), which show that the first syllable undergoes tonal reduction no matter what the syntactic structures are. In addition, parts of speech do not affect the location of tonal reduction either, as the examples in (7) show.

Structure type	Example	IPA	(6)
adjective+noun	dead fish	pjai52 p <sup>h</sup> ja52 → pjai32 p <sup>h</sup> ja52	
verb+adjective	rotten	au24 ŋau45 → au21 ŋau45	
verb+noun	receive a visitor	wei24 k <sup>h</sup> ek54 → wei23 k <sup>h</sup> ek54	
noun+noun	friend	pi31 noŋ45 → pi11 noŋ45	
adjective+adjective	how many	lai52 eiu55 → lai22 eiu55	

Parts of speech	Example	IPA	(7)
noun	bamboo woods	kwan52 lam31 → kwan32 lam31	
adjective	smart	tshoŋ52 meŋ31 → tshoŋ32 meŋ31	
verb	guess a riddle	sai52 ts <sup>h</sup> em45 → sai22 ts <sup>h</sup> em45	
pronoun	they	mo24 kjau52 → mo22 kjau52	

One interesting observation to note is that under normal circumstances, the non-head first syllable undergoes tonal reduction. However, very occasionally, when the first syllable is especially emphasized or focused in discourse contexts, its tone can be kept, and the second syllable instead becomes weak and has a reduced tone, which reflects focus-prominence alignment [19,20]. For example, with a special focus on the first syllable, [wok24 li:k24] becomes [wok24 li:k22] ‘the oldest son’. This seeming exception to the general tone sandhi process actually supports our view that the tone sandhi domain in Ei is a metrical domain since it allows only one head/strong syllable and tonal reduction only applies to the non-head/weak syllable.

In sum, the tonal reduction process and the phonological and phonetic duration data all suggest that a disyllabic sequence in Ei constitutes a right-headed metrical domain regardless of what the morpho-syntactic structure is.

<sup>2</sup> Since T6<sup>c</sup> and T7<sup>c</sup> are checked tones, their durations are much shorter than other tones.



## 7. References

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