

# ACOUSTIC ANALYSIS OF TONE IN BENNA HANI: TONE SANDHI AND NEUTRALIZATION IN AN ATYPICAL TIBETO-BURMAN LANGUAGE

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## ABSTRACT

We present the first acoustic analysis of the tone system of Benna Hani, a poorly documented and potentially endangered non-standard variety of Hani (China: Southeastern Tibeto-Burman, Ngwi). Benna Hani is unusual for a Ngwi language in that it shows complex tone sandhi and tone neutralization. Benna Hani has only three contrastive tone categories (T1, T2, and T3), but sandhi patterns show a profusion of phonetically arbitrary variants for each category. 33 Benna Hani speakers (17 female) recorded 47 monosyllables and 36 disyllables in isolation and embedded in a carrier phrase. 10,118 tokens were extracted and normalized in semitones relative to mid level pitch. We plot mean F0 trajectories with 95% confidence intervals for monosyllables and disyllables. Acoustic analysis results cohere with native speaker intuition, namely that T1 and T3 neutralize in monosyllables and in the first syllable in a disyllabic compound, but are distinguished in the second syllable of disyllables.

**Keywords:** tone neutralization, tone sandhi, Tibeto-Burman, Ngwi, Hani

## 1. INTRODUCTION

The Hani language [ISO 639-3: hni], spoken in Yunnan Province, China, has 740,000 speakers [1] and comprises several topolects, including standard Hani spoken in Lüchun County [2] and Benna Hani of Honghe County. Benna Hani is spoken in the upper reaches of the Benna River by approximately 24,000 speakers in Luo'en and Jiache districts (see Figure 1 for map). Though intergenerational transmission of the language has been strong in previous generations, the number of speakers is expected to decrease dramatically in the next generation due to decreasing language use among today's young people. Benna Hani has recently begun to be documented [3], but analysis of this threatened, non-standard dialect of Hani is only in the beginning stages. This paper presents the first acoustic analysis of the Benna Hani tone system. The current study shows that Benna Hani has a highly distinctive tone system, notable for its extensive neutralization and the phonetic arbitrariness of its tone sandhi patterns.

Figure 1: Map of Benna Hani area (in grey).



All Benna Hani tones have modal phonation, and duration is non-contrastive. All syllables, with a few exceptions, are specified for tone. Syllable structure is (C)V or syllabic nasal. The tone system has three contrastive tone categories, labelled as T1 (“High”), T2 (“Low”), and T3 (“Mid”). These categories transparently correspond to historical Proto-Ngwi (PN) tone categories [4]; modern reflexes of PN tone categories in Lüchun Hani [5] and Benna Hani are compared in Table 1. There are two major points of divergence with Lüchun Hani: 1) Benna Hani has lost contrastive tense phonation, leading to a merger of Proto-Ngwi \*H with T3 and \*L with T2, respectively; 2) unlike Lüchun Hani, Benna Hani tones show extensive, though predictable, variation according to context (discussed below).

Table 1: Proto-Ngwi, Lüchun and Benna Hani tone

Proto-Ngwi	Lüchun Hani	Benna Hani
*T1 High	T1 /High/, [high level]	T1 /High/, [various]
*T2 Low	T2 /Low/, [mid falling]	T2 /Low/, [various]
*T3 Mid	T3 /Mid/, [mid level]	T3 /Mid/, [various]
*H Mid, tense	[mid level, tense]	merged with T3
*L Low, tense	[mid falling, tense]	merged with T2



Benna Hani is atypical for a Ngwi language in that each tone category shows a different surface form in

almost every disyllabic environment, and none of those forms correspond to the monosyllabic form. Underlying tonal representation is therefore not at all straightforward. We propose labels “T1=High,” “T2=Low,” and “T3=Mid” that match certain aspects of both the synchronic and diachronic forms. The perceptual salience of contour in this tone system is unclear as of yet. In monosyllables in connected speech, T1 and T3 neutralize to [mid], while T2 surfaces as [high]. Neutralization of the High and Mid tone to [mid] in isolated monosyllables is also found in Yongning Na (Tibeto-Burman, Naic) [6].

Table 2 summarizes disyllabic tone sandhi alternations using pitch numbers [7] (1=low, 5=high) and H(igh), M(id), L(ow). Table 3 gives lexical examples of each pattern. All word classes show identical patterns. T1 and T3 neutralize not only in monosyllables but also as the first syllable in a disyllabic compound. Their contrast is only recoverable in the final syllable of disyllables. Interestingly, acoustic analysis results in Figure 4-F suggest that, when preceding T3, the neutralization of T1 and T3 is incomplete.

Many of the patterns are phonetically arbitrary, and the system is not easily classified as either left- or right-dominant [8]. While surface forms for T3+T1 /M+H/ and T2+T3 /L+M/ relate transparently to the proposed underlying tone representation, most other patterns show both non-final and final tone alternations. For example, T1+T2 /H+L/ > L+H is a case of tonal reversal. H, M, and L falling contours only appear in the final syllable, similar to other languages surveyed in [9] that show a preference for prosodic-final syllables as carriers of contour. Any tone preceding a falling contour neutralizes to H; this matches right-dominant sandhi systems’ tendency for paradigmatic neutralization of nonfinal tones [8].

**Table 2:** Tone sandhi alternations in Benna Hani:

Following tone 	+T1 H	+T2 L	+T3 M
Preceding tone 			
T1 H	33 44	21 44	44 42
T3 M	M+H	L+H	H+M
T2 L	44 52	44 32	22 33
	H+H	H+L	L+M

**Table 3:** Tone sandhi examples in Benna Hani:

	+T1 H	+T2 L	+T3 M
T1 teo <sup>34</sup> ‘exist’	+sa <sup>1</sup> ‘easy’ [teo <sup>33</sup> sa <sup>44</sup> ] ‘comfortable’	+sa <sup>2</sup> ‘difficult’ [teo <sup>21</sup> sa <sup>44</sup> ] ‘painful’	+nu <sup>r3</sup> ‘day’ [teo <sup>44</sup> nu <sup>42</sup> ] ‘rest day’
T3 nu <sup>34</sup> ‘day’	+ɔ <sup>1</sup> ‘daytime’ [nu <sup>33</sup> ɔ <sup>44</sup> ] ‘daytime’	+mu <sup>r2</sup> ‘good’ [nu <sup>21</sup> mu <sup>44</sup> ] ‘lucky day’	+ha <sup>3</sup> ‘hard’ [nu <sup>44</sup> ha <sup>42</sup> ] ‘bad day’
T2 sa <sup>52</sup> ‘meat’	+ts <sup>h</sup> y <sup>1</sup> ‘fat’ [sa <sup>44</sup> ts <sup>h</sup> y <sup>52</sup> ] ‘fatty meat’	+ky <sup>2</sup> ‘tendon’ [sa <sup>44</sup> ky <sup>32</sup> ] ‘tendon’	+k <sup>h</sup> u <sup>3</sup> ‘dry’ [sa <sup>22</sup> k <sup>h</sup> u <sup>33</sup> ] ‘meat jerky’

## 2. METHODOLOGY

### 2.1. Subjects

33 native Benna Hani speakers (M=16, F=17) were recruited from Luo’en District, Honghe County. All subjects grew up in Luo’en and had at least one parent from Luo’en. Subjects’ ages are fairly evenly distributed across a range from 16 years (guardian approval obtained) to 84 years; mean and median ages are both 45. Several older subjects are monolingual in Hani or strongly prefer Hani. No subjects are literate in standard Hani orthography.

### 2.2. Materials and procedure

The materials for the acoustic analysis consist of 47 monosyllabic words and 36 disyllabic words. Each tone category is represented by 15-16 monosyllabic words and each tone sequence by 4 disyllabic words; voiced, voiceless unaspirated and voiceless aspirated initial consonants were included. All recordings were conducted in subjects’ homes or the first author’s home using a Sony Linear PCM recorder (PCM-M10) at a sample rate of 48.00 kHz. The screening interview and recording procedure were conducted in Benna Hani by the first author. Because no subjects are literate in the Hani orthography, the first author used Benna Hani to orally prompt subjects. There is a possibility that the first author’s pronunciation of the stimulus words may have influenced subjects’ pronunciation, but in the fieldsite context this was unavoidable. Each word was repeated three times in isolation and once in the carrier phrase [ŋa<sup>34</sup> \_\_ le<sup>0</sup> so<sup>44</sup>tɔ<sup>44</sup> ɛ<sup>44</sup>va<sup>42</sup>] ‘I say \_\_ thus three times.’ /le<sup>0</sup>/ ‘thus’ is a toneless clitic; the tonal offset of the preceding tone extends on to /le<sup>0</sup>/, resulting in contour levelling. Six older subjects did not understand the request to record the carrier phrase, so they only recorded the words in isolation form.

### 2.3. Analysis

In Praat [10], the first author annotated the first two repetitions of isolation form and the single token in carrier phrase form. A total of 10,118 tone tokens were extracted, normalized and analyzed. F0 was extracted at 10 millisecond intervals across the vowel [11]. Tokens were time-normalized by dividing the raw duration into 200 equally spaced intervals, and normalized for pitch by converting F0 to logarithmic semitones and setting speaker’s mid level pitch as the baseline (=0), as in [12]. After normalizing, the mean pitch trajectories and 95% confidence intervals across all 33 speakers were plotted in Excel. Future research will examine co-

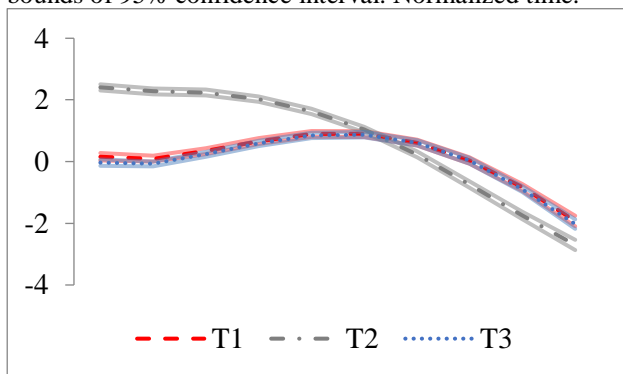
variation of tonal acoustics and speaker characteristics (age, gender, etc.)

### 3. RESULTS

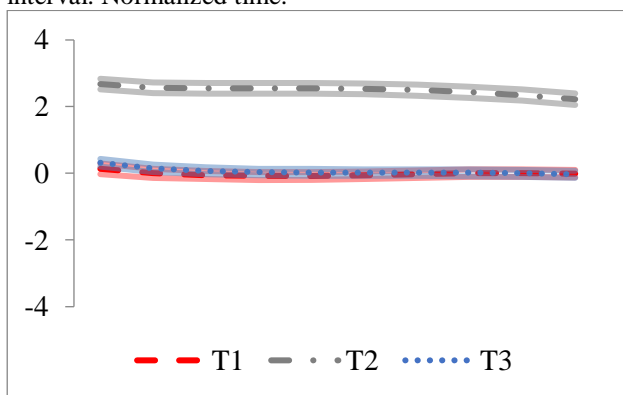
#### 3.1. Tone in monosyllables

Mean F0 trajectories and 95% confidence intervals for monosyllabic tone are shown in Figure 2 (isolation) and in Figure 3 (carrier phrase). T1 and T3 show near identical trajectories in both environments, suggesting neutralization. The contour leveling in carrier phrase form (Figure 3) is possibly due to the extension of the tonal offset of the target tone onto toneless clitic /le<sup>0</sup>/ in the carrier phrase. Future research should use a carrier phrase that avoids this extension effect.

**Figure 2:** Monosyllabic tone in isolation, n=3022. Dashed lines indicate mean F0 (normalized in semitones; speaker mid pitch = 0); Solid lines represent upper and lower bounds of 95% confidence interval. Normalized time.



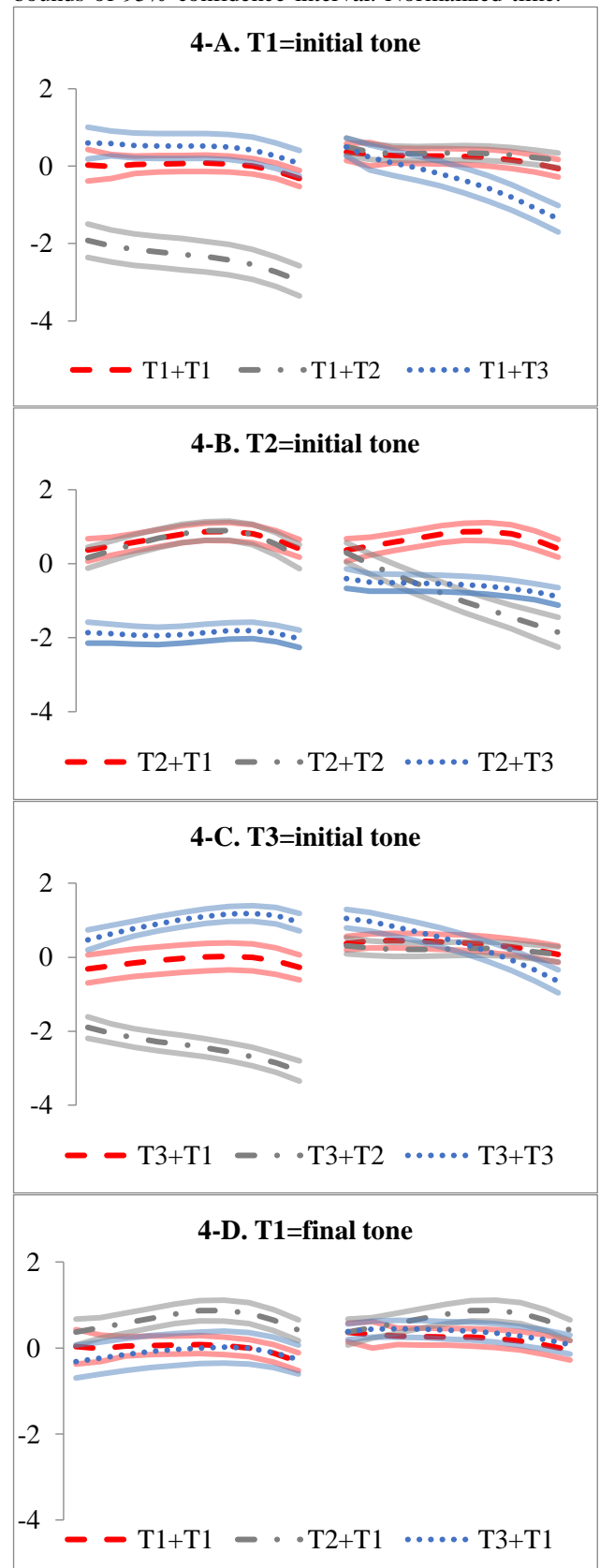
**Figure 3:** Monosyllabic tone in carrier phrase, n=706. Dashed lines indicate mean F0 (as above); Solid lines represent upper and lower bounds of 95% confidence interval. Normalized time.

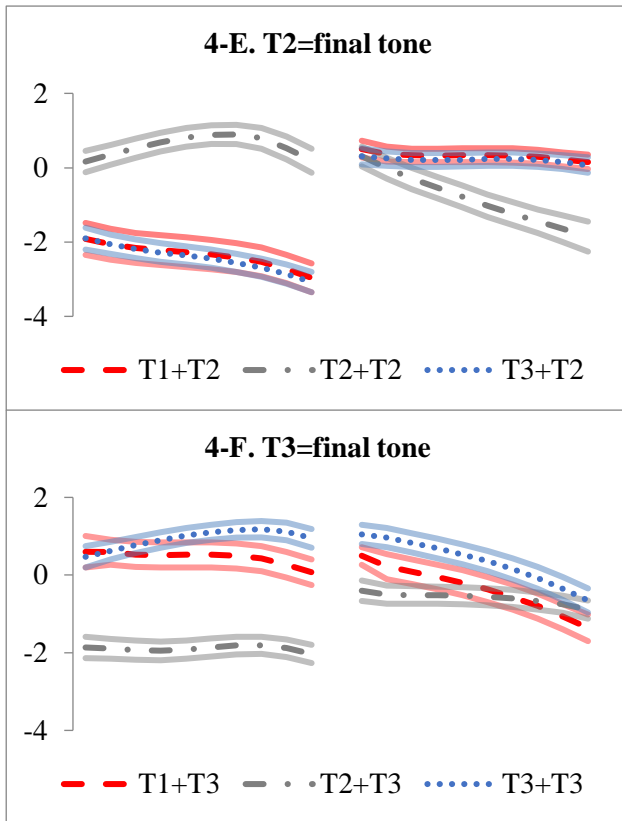


#### 3.2. Tone in disyllables

Figure 4 show acoustic analysis results for tone patterns in disyllables in carrier phrase form. Mean F0 trajectories and 95% confidence intervals are displayed for each tone category when occurring either as the initial tone (Figure 4-A, 4-B, 4-C) or the final tone (Figure 4-D, 4-E, 4-F).

**Figure 4:** Disyllabic tone sandhi patterns, carrier phrase form, n=1828. Dashed lines indicate mean F0 (as above); Solid lines represent upper and lower bounds of 95% confidence interval. Normalized time.





#### 4. DISCUSSION

The acoustic analysis matches the impressionistic analysis based on native speaker intuition, given in Table 2. What is striking about this tone system is the wide variation of surface forms for each tone category and the phonetic arbitrariness of the sandhi patterns. Also, neutralization of T1 and T3 is suggested by the overlap of the 95% confidence intervals of T1 and T3 as monosyllabic tone (Figures 2 and 3) and when preceding T1 (Figure 4-D) and T2 (Figure 4-E). At any point across the tone trajectory in carrier phrase form, the means only vary by a maximum of 0.182 semitones in monosyllables and 0.345 in disyllables. However, the 95% confidence intervals do not overlap in T1+T3 versus T3+T3 in Figure 4-F: initial tone T3 is higher than initial tone T1 by a maximum of 0.874 semitones. Whether T1 and T3 show complete or incomplete neutralization in the above contexts needs to be further tested statistically, as done for Taiwan Southern Min [13] and Fuzhou Min [14]. Additionally, perception tests are needed to determine if the tones are neutralized and to see if there are generational differences in perception of neutralization.

Similar to the levelling seen in carrier phrase form for monosyllables (Figure 3), the falling contour in the second syllable of disyllables (Figure 4) also shows decreased pitch excursion when

embedded in the carrier phrase. Whether this is due to the target tone's tonal offset extending onto following toneless clitic / $\text{le}^0$ / needs to be further tested. Using a different frame may alleviate this effect.

A difficult remaining question is, how did this phonetically arbitrary system come about? Zhang [15] suggests that a main reason synchronic sandhi patterns appear arbitrary is that diachronic changes have erased what was once the phonetic motivation for the sandhi tone. Comparing various Hani dialects, many of whom have never been described before, may reveal clues as to how the sandhi patterns developed.

#### 5. CONCLUSION

In many ways, Benna Hani fits the typological profile of Ngwi languages: analytic, monosyllabic, lexical tone specified on almost all syllables, moderately-sized tone inventory [16]. Benna Hani has three contrastive tones, similar to its neighbour, standard Hani of Lüchun County (excluding the rising tone from recent Chinese loanwords). However, the complexity and phonetic arbitrariness of Benna Hani's tone sandhi patterns set it apart from other Hani dialects and even from the other Tibeto-Burman languages described in [17].

T1 and T3 appear to neutralize in monosyllables and in the first syllable of disyllables; their contrast is only recoverable in the second syllable of disyllables. Thus, the three tone categories show only a two-way contrast in monosyllables and combine to only six tone patterns in disyllables, rather than nine. Acoustic analysis of pitch in both isolation and carrier phrase form coheres with the impressionistic analysis, but also reveals differences between T1 and T3's surface forms when preceding T3. Neutralization of tonal contrast in isolation is seen in several Tibeto-Burman languages such as Hakha Lai, Kuki-Thaadow [18] and Yongning Na [6], but is not common among Ngwi languages.

The distinctiveness of Benna Hani tone underlines the importance of documenting non-standard varieties of minority languages. There is an urgent need for this documentation in light of imminent language shift in the Benna Hani community.

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