Tone Sandhi in Lahu Nyi

วรรณยุกต์สนธิในภาษาลาหู่แดง

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Abstract

This study was conducted to determine if tone sandhi exists in Lahu Nyi. Lahu Nyi, a 7 tone language, is one of the Lahu dialects, a member of the Central Loloish branch of the Lolo-Burmese subgroup of Tibeto-Burman languages (Matisoff, 2003). Tone sandhi, a phenomenon occurring in some tone languages, refers to a phonological change from one tone to the other triggered by tone of adajacent words or morphemes. A word list specifically designed to elicit tone sandhi data was presented to research participants in a picture naming task. Five native speakers of Lahu Nyi who were residents of Chiang Doa District, Chiang Mai Province, Thailand, produced the target words in a soundproof room. Their production was transcribed and submitted to a detailed

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acoustic analysis. The obtained acoustic values such as F0 patterns and duration of the targeted vowel portion of a monosyllabic word and word in targeted context were compared. The results showed that tone sandhi occurs in three experimental conditions: compounding, color naming and causativisation (that is “to feed” is a causative verb derived from a transitive verb “to eat”). In compounding, the pattern of tone change from the citation value to new word is mid to high; in color naming, from mid to high-rising; and in causativisation, from high to low. These results confirmed the presence of tone sandhi in Lahu Nyi and the similarity between Lahu Na and Lahu Nyi dialects.

Keywords: tones, tone sandhi, Lahu Nyi, acoustics

บทคัดย่อ

จุดประสงค์ของงานวิจัยนี้คือตรวจสอบว่ามีวรรณยุกต์สนธิในภาษาลาหู่แดงหรือไม่ ภาษาลาหู่แดงมีเสียงวรรณยุกต์ 7 หน่วยเสียง เป็นสำเนียงหนึ่งของภาษาลาหู่ที่อยู่ในกลุ่มภาษาโลโล-พม่าของตระกูลจีน-ทิเบต (Matisoff, 2003) วรรณยุกต์สนธิคือวรรณยุกต์แปรรูปอย่างหนึ่ง โดยที่หน่วยเสียงวรรณยุกต์ดั้งเดิมเปลี่ยนไปเป็นอีกหน่วยเสียงวรรณยุกต์เนื่องจากเสียงวรรณยุกต์หรือหน่วยคำที่อยู่ใกล้ ปรากฏการณ์นี้เกิดขึ้นในภาษาที่ใช้เสียงวรรณยุกต์บางภาษาเท่านั้น ในงานวิจัยนี้ เจ้าของภาษาลาหู่แดงห้าคนจากอำเภอเชียงดาว จังหวัดเชียงใหม่ ประเทศไทย ได้อ่านรายการคำศัพท์ที่ออกแบบมาเพื่อทดสอบวรรณยุกต์สนธิ ในห้องอัดแบบกันเสียง หลังจากนั้นนักวิจัยได้ถอดเสียงและทำการวิเคราะห์ทางเสียง โดยเปรียบเทียบข้อมูล อาทิ รูปแบบของความถี่มูลฐาน และความยาวของเสียงสระ ของเสียงวรรณยุกต์ดั้งเดิมและเสียงวรรณยุกต์ในบริบทที่อาจทำให้เกิดวรรณยุกต์สนธิ ผลของงานวิจัยแสดงว่า

วรรณยุกต์สนธิเกิดในบริบทสามบริบท คือ คำประสม การเรียกชื่อสี และคำกริยาการีต เช่น คำว่า ให้กิน เป็นกริยาการีต และ คำว่า กิน เป็นสกรรมกริยา ในการสร้างคำประสม วรรณยุกต์เปลี่ยนรูปจากเสียงกลางเป็นเสียงสูง ในการเรียกชื่อสี เปลี่ยนจากเสียงกลางเป็นสูงขึ้น และในการสร้างกริยาการีต เปลี่ยนจากเสียงสูงเป็นต่ำ ผลวิจัยนี้ยืนยันว่ามีวรรณยุกต์สนธิในภาษาลาหู่แดงและภาษาลาหู่สำเนียงแดงและสำเนียงดำมีความคล้ายคลึงกัน

คำสำคัญ: วรรณยุกต์ วรรณยุกต์สนธิ ภาษาลาหู่แดง กลสัทศาสตร์

Introduction

Lahu language is a member of the Central Loloish branch of the Lolo-Burmese subgroup of Tibeto-Burman languages (Matisoff, 2003). It is spoken by a mountain minority group living in Northern Southeast Asia (Bradley, 1979). Lahu language is also used as a lingua franca among ethnic minorities in Yunnan Province, China, and in the Golden Triangle area. Lahu people were originally located in China's Yunnan Province and during the 19th century they began moving southwards into territories which are now part of Burma and Laos and, subsequently, into the northern Thailand. Lahu people migrated to the hills of Thailand territory and settled in Thailand since 1880s (Walker, 1980). Thai people call this hilltribe group “Musher” /musəə/, but Lahu people call themselves Lahu. Currently, the number of Lahu speakers worldwide is estimated to be over 750,000 (Ethnologue, 2018). Approximately 425,000 Lahu speakers live in Southwestern China, 250,000 in Myanmar, 20,000 in Laos as well as 2,000 in the USA. They also live in Northwestern Vietnam and Northern Thailand.

102,876 Lahu people were reported to live in 11 provinces of Thailand in 2015 (IMPECT, 2015).

The Lahu language subdivides into many dialects and all Lahu dialects have seven tones (Bradley, 1979: 73). In Thailand, all known Lahu communities fall into four major groups: Lahu Na (Black), Lahu Nyi (Red), Lahu Shehleh and Lahu Shi (Yellow) (Matisoff, 2006). However, both Bradley (1979) and Matisoff (2006) contend that there are actually two main subdivisions: Black and Yellow, based on linguistic criteria. Lahu Na, Nyi and Shehleh are grouped under the great Lahu Na (Black Lahu group) while Lahu Shi (Yellow) constitute the other group due to notable differences in tones, vowels and consonants and grammar (Matisoff, 2006).

Lahu Nyi (Red Lahu) is the dialect focused in this study. It is primarily used as a spoken language by older generations. The number of Lahu Nyi speakers has dwindled. Many adults had left to work outside the village and left their children with older relatives. Elder villagers usually claim themselves as having improper pronunciation. Some children understand few words or cannot speak the language at all. The young generation is more fluent in Thai as it is the official language at school. Studying the sound system of this language is one way to help preserve Lahu Nyi language, history of the people, their rites and rituals and unique culture.In comparison to Lahu Na which has been well documented (Matisoff, 2006; Lewis, 1986), Lahu Nyi is the lesser known and under studied dialect. Bradley (1979) and Sirisai (1986) describe Lahu Nyi sound inventory including the seven-tone system based on impressionistic data. Approximately 40 years after that, Jangjamras et al. (2019) conducted the first acoustic study on the

Lahu Nyi tone system. They presented pitch contour data and revealed that Lahu Nyi has five long tones in open syllables and two short tones in syllables closed with a glottal stop.

Tone sandhi is a type of tonal change motivated by the grammar of the language, not by surface coarticulatory effects. The existence of tone sandhi in Lahu Nyi has been unclear. While Bradley (1979) mentioned this phenomenon, Sirisai (1986) did not. This current acoustic study aimed to investigate the existence of tone sandhi in Lahu Nyi. If tone sandhi in Lahu Nyi can be verified, it would support the claim that Lahu Na and Nyi are the same dialect (Bradley, 1979; Matisoff, 2006).

Research Questions

Does tone sandhi exist in Lahu Nyi?

Hypothesis

Tone sandhi exists in Lahu Nyi.

Literature Review

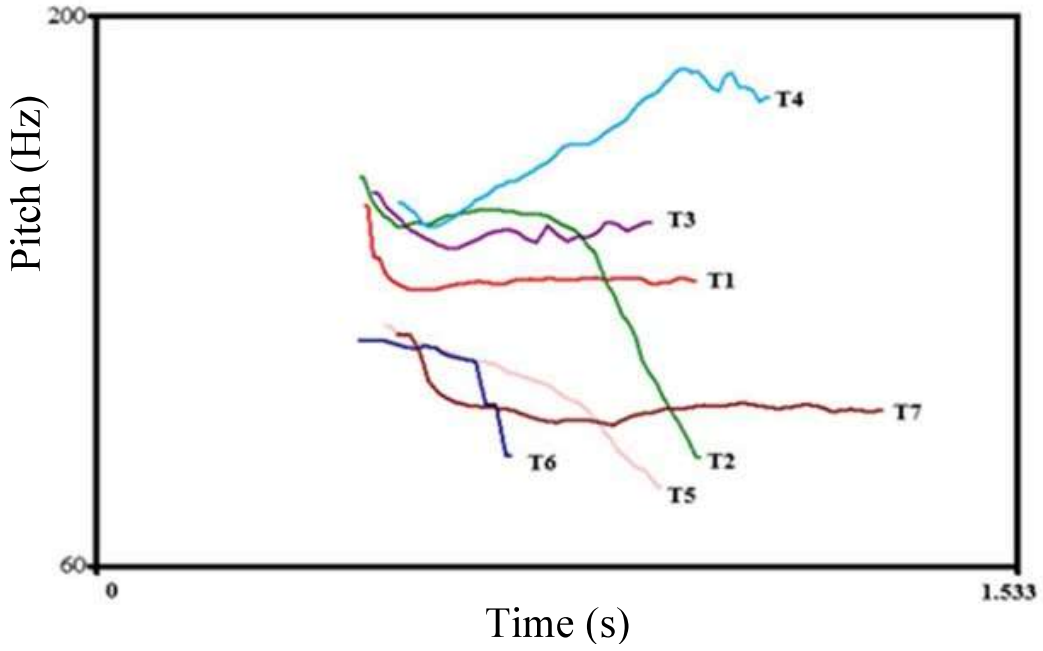
1.Lahu Nyi Tone Description

The Lahu Nyi language spoken in Chiang Rai, Thailand, has 28 consonants, 9 monophthongs and 6 diphthongs with C(C)V(V)T syllabic structure where C stands for consonant, V for vowel and T for lexical tone (Sirisai, 1986). Lahu Nyi tone features include not only pitch, but also glottalization and vowel duration (Bradley, 1979; Sirisai, 1986; Jangjamras et al., 2019). Based on pitch contour analysis (Jangjamras et al., 2019), the Lahu Nyi seven-tone system has two glottalized tones and five non-glottalized tones, level and contour, as shown in Figure 1, in which T stands for tone. Detailed description of

each tone is presented in Table 1. In the pitch value column, pitch value 1 is the lowest pitch and 5 the highest (Chao, 1930).

Figure 1

Lahu Nyi Tones Produced by a Male Speaker



Note. Reproduction from Jangjamras et al. (2019).

Table 1

Lahu Nyi Tone Description

Tone	Pitch value	Description	Words in context	Gloss
1	33	A mid-level tone	ta^{41} **tɕa^{33}** te^{33}	Don't do it.
2	41	A high-mid falling tone	**tɕa^{41}** ve^{33}	to eat
3	44ʔ	A high-mid short tone + glottalization	ʔa^{41} **tɕa^{44ʔ}** kʰɛɛ^{33}	robe

Tone	Pitch value	Description	Words in context	Gloss
4	45	A high-rising tone	**tɕa^{45}** da^{33} ve^{33}	to attach
5	21	A low-falling tone + slightly breathy	**tɕa^{21}** tɕɛɛɛ^{21}	rice plant
6	21ʔ	A low-falling short tone + glottalization	**tɕa^{21ʔ}** k^{h}ɤɤ^{33}	machine
7	22	A low-level tone + slightly breathy	**tɕa^{22}** la^{41}-a^{33}	to feed

Note. Adapted from Jangjamras et al. (2019).

Glottalized tones (Tones 3 and 6) occur in short syllables ending with a glottal stop. These two glottalized tones are shorter than the five non-glottalized tones. Tones 1 and 7 are level while tones 2, 4 and 5 are contour tones. Lahu Nyi does not have a vowel length distinction. In addition, tones 5 and 7 are slightly breathy at the end (Jangjamras et al., 2019).

2. Tone Sandhi

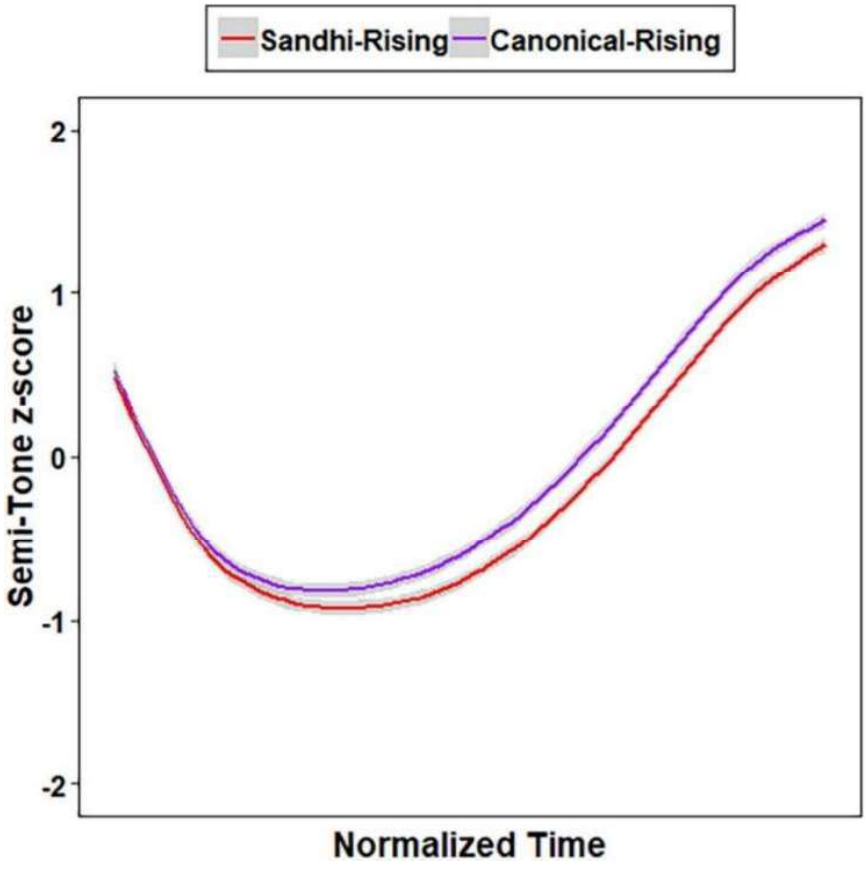
The main acoustic correlate of lexical tone is fundamental frequency or F0. It refers to the lowest frequency component of a complex signal and correlates physically to the vibration rate of the vocal folds. Each vibration or one cycle of opening and closing of the vocal folds generates one energy pulse in the acoustic signal. The frequency of these pulses is measured in Hertz (Hz); with 1 Hz equals to 1 pulse per second. The F0 values, contours and height of tones in connected speech can be changed in the context of neighboring tones.

This tonal variation could be either tonal coarticulation or tone sandhi. Tonal coarticulation refers to phonetic modification of F0 contours due to the non-lexical effect of preceding or following tones which occurs cross-linguistically (e.g., Abramson, 1979; Gandour et al., 1992; Potisuk et al., 1997; Xu, 1997; Zhang & Liu, 2011). The influence is characterized as anticipatory when the F0 of the following tone influences that of the preceding tone, or perseverative or carryover, when the preceding tone exerts its influence on the following tone. In addition, the coarticulatory patterns can be either assimilatory where F0s of the two tones become more similar or dissimilatory when they become more different. In contrast, tone sandhi initially refers to "phonetically conditioned morphotonemic alteration at the juncture of words or morphemes" but is extended overtime to also include "a number of related phenomena, including allotonic variations, intonational effects, and morphologically or syntactically conditioned tone changes" (Chen, 2000, p. xi). Unlike tonal coarticulation, tone sandhi is conditioned by grammar of the language and can be motivated by phonology (prosodic) or morphosyntactic environment (Zhang, 2014). Tone sandhi patterns are language specific.

Tone sandhi phenomena are pervasive in language families such as Sino-Tibetan and Hmong-Mien (Kirby & Brunelle, 2017). One of the most recognized tone sandhi patterns is the third-tone sandhi in standard Mandarin Chinese, in which tone 3 [213] becomes tone 2 [35)] when followed by another tone 3. For example, /ni213 hau213/ → [ni35 hau213] "hello". Examples of F0 contours (in semi-tone z-scores) of the underlying tone 2 and the sandhi derived tone 2 in 10 minimal pairs of disyllabic words produced by 10 female and 10 female speakers of Mandarin from Tu and Chien (2021) is shown in Figure 2.

Figure 2

Mean Semi-Tone Z Scores of the Underlying Tone 2 (purple) and the Sandhi Derived Tone (red) Produced by 10 Male and 10 Female Speakers of Mandarin



Note. Reproduction from Tu & Chien (2021).

While the majority of tone sandhi in Chinese dialects is motivated by phonology, evidence from Tibeto-Burman languages, such as Lisu, Akha and Lahu Na suggested that tone sandhi in these languages is morphologically conditioned. (Bradley, 2003; Hansson, 2003; Lewis, 1986).

For example, in Lisu, a member of the Lolo-ish group of Tibeto Burma languages, tone sandhi occurs in forms such as counting

numbers with a classifier. Specifically, there are six tones in Lisu: high level /^{55}/, rising /^{35}/, higher-mid creaky /$\_^{44}$/, mid non-creaky /^{33}/, low falling /^{21}/, and low falling with final glottal stop /^{21ʔ}/. However, the numbers /sa^{44}/ '3'and /li^{44}/ '4' when preceding the general classifier [mɑ^{44}] surface as [sa^{21}] and [li^{55}] (Bradley, 2003: 228) as in:

[ɑ^{55}	nɑ^{21}	sɑ^{21}	tu^{33}	t^{h}i^{21}	ɲ̃jɑ^{33}	li^{55}	ts^{h}ɳ^{33}	ku̲^{44}	mɑ̲^{44}]
dog		3	1000	1	100	4	10	9	CL
3,149 dogs									

In Akha, a language belonging to the southern part of the Burmese-Yipho (or Lolo-Burmese) subgroup of the Tibeto-Burma, some of the sentence particles, with high tone for non-past and low tone for past, have mid tone as sandhi (Hansson, 2003, p.238) as shown in the example below. The grave accent denotes low tone, and the acute accent high tone, while the mid tone is unmarked.

High + High > High + Mid	lámɛ́	> lá mɛ	*"he is coming"*
Low + Low > Low + Mid	dzà mɛ̀	> dzà mɛ	*"he ate"*

In addition, the underlying low tone of the possessive noun particle (NP) /ə/ becomes mid when preceded by a low tone as shown in the example below (Hansson, 2003, p.245).

[xhà-là	ə	dɔ̀-mì]	[ŋɑ̀q	ə	àmɑ]
tiger	NP	tail	I	NP	mother
tiger's tail			*my mother*		

Lahu Na, the most studied Lahu dialect, exhibits tone sandhi conditioned by some adjacent tones and morphemes. (Bradley, 1979; Lewis, 1986). Four instances of tonal change in Lahu Na were described by Lewis (1986, pp. 11-12).

1. The tones for number *three* and *four* change from high-short glottalized and high to mid and low level tones, respectively, before the high-falling tone on the classifier (CL) "leh$^{\vee}$" as shown in the example below.

"te$^{\vee}$,	nyi$^{\vee}$,	sheh$^{\wedge}$,	aw$^{\vee}$,	nga$^{\vee}$"
one	*two*	*three*	*four*	*five*
"te$^{\vee}$ ma$_{\vee}$,	nyi$^{\vee}$ ma$_{\vee}$,	sheh leh $^{\vee}$,	aw_ leh $^{\vee}$,	nga$^{\vee}$ ma$_{\vee}$"
one CL	*two CL*	*three CL* (mid)	*four CL* (low level)	*five CL*

2. Occasionally, the mid tone changes to a high rising tone before the high tone, as in:

"heh",	"g'a$^{\wedge}$"	"heh^{-} g'a$^{\wedge}$"
forest	*chicken*	*jungle fowl*
(mid)	(high rising)	(high, high rising)

3. The mid tone on a noun referring to colors, becomes a high tone when the "-eh$_{\vee}$" particle is added, as in:

red "nyi" (mid) and *reddish* "nyi^{-} –eh$_{\vee}$" (high, low-falling)

4. A high-falling tone becomes a low tone when intransitive verbs become causative verbs, as in:

awake	"naw$^{\vee}$ (ve)"
to *wake someone up*,	"naw_ (pi$^{\vee}$ ve)"

Lahu Na is considered to be mutually exclusive with Lahu Nyi (Bradley, 1989; Matisoff, 2003). Bradley (1989) describes similarities between Lahu Na and Lahu Nyi phonological system and concludes that these two dialects are "substantially identical" (p.90). While the status of tone sandhi in Lahu Nyi has not yet been investigated, it is very likely that it has tone sandhi as well. This is the main hypothesis of the current research.

Research Methodology

1. Data Collection

The data collection took place from July 2018 to June 2020. All language informants and participants were recruited by the snowball method. Five Lahu Nyi speakers, between 31-70 years of age from Mueang Na Sub-district, Chiang Dao District, Chiang Mai Province, Thailand, joined the recording session at the Faculty of Humanities, Chiang Mai University between May – June 2020. Prior to the recording session, the researcher learned the basics of the Lahu script written in Romanized alphabets.

2. Research Participants

To locate and verify Lahu Nyi language speakers and to construct the wordlist, the researcher visited three Lahu communities:

- Baan Meuang Na Sub-district, Chiang Dao District, Chiang Mai Province (July 2018-2020)
- Baan Chayee Village, Patheaung Sub-district, Mae Chan District, Chiang Rai Province (January 2019 – November 2019)

- Baan Nongkheaw, Mueang Na Sub-district, Chiang Doa, Chiang Mai Province (September 2019 to November 2019.

Table 2 presents demographic information of each Lahu native speaker. Each speaker was assigned a code. M1, F1 and F2 are Lahu-Thai bilingual while M2 and M3 are Lahu monolingual. M1 and M2 can read Lahu script. M2 was a Lahu language teacher who taught Lahu script to the researcher. He also met Paul Lewis when he was young.

Table 2
Lahu Nyi Speakers

Partici -pants	Gender	Age	Languages	Occupation
M1	Male	43	Lahu, Thai, Yunnan Chinese	Owner of filtered water factory, village priest
M2	Male	70	Lahu	Lahu language teacher
M3	Male	56	Lahu	Lahu music teacher and farmer
F1	Female	31	Lahu, Thai	House wife
F2	Female	55	Lahu, Thai, Cantonese	Shop owner

Before collecting any form of language data, the participants were requested to complete the formal consent form approved by Chiang Mai University. The researcher mainly used Thai to communicate with Lahu informants who were fluent in

Thai. When interacting with Lahu monolinguals, the researcher asked other bilingual Lahu-Thai speakers to be an interpreter.

3. Recording Procedures

A picture naming task was used to elicit Lahu Nyi word production. The recordings were done in a soundproof room at the Faculty of Humanities, Chiang Mai University. Each speaker sat comfortably in the room where they could see pictures presented on the computer screen. Figure 3 presents some of the pictures used in the experiment. Each speaker was asked to produce three repetitions of each word in citation form, in noun/verb phrases and in compounds. Recordings were made on a digital recorder (Marantz, PMD661) with a head-mounted microphone (Shure SM10A) at 44.1 kHz sampling rate and 16-bit amplitude resolution. Each target word was excised from its carrier sentence and stored as separate files for further acoustic analysis.

Figure 3

Picture Naming Task to Elicit Verbs Meaning "to carry on one's back" and "to help others to carry on his back"

Note. Left picture from Greg Waite (n.d.)
Right picture from ladyxoxo.com. (n.d.).

4.Wordlist

Criteria for selecting the target words were based on Lewis' description of tonal change in Lahu Na (1986) since Lahu Na and Lahu Nyi are considered to be nearly identical dialects (Bradley, 1989; Matisoff, 2003).

A combination of a base word and a potential tone sandhi triggering word were elicited in the picture elicitation task. This grouping of words is called "condition" in the experiment.

As shown in Table 3, there were four conditions, and each condition consisted of two sets of words. For example, in condition 2, set A includes nouns in citation form such as *chicken* "g'a$^{\wedge}$" and *forest* "heh" while set B includes words predicted to carry sandhi tone such as *jungle fowl* which combines the bases *chicken* and *forest* together. In addition to the target words, some control words such as *pig* "va$_{\wedge}$", *boar* "heh$_{\vee}$ va$_{\wedge}$", *bean* "naw$^{\wedge}$ shi_"and *wild beans* "heh naw$^{\wedge}$ shi_" were included. Note that the English glosses precede the corresponding Lahu words written in Lahu script.

Table 3
Wordlist Used in the Tone Sandhi Experiment

Condition	Set A	Set B
1	**Number**	**Number + CL**
	one "te$^{\vee}$", two "nyi$^{\vee}$", three "sheh", four "aw_", five "nga$^{\vee}$"	one lime "maphasue **te**$^{\vee}$ shi_" lime one CL (and count two to five limes)

Condition	Set A	Set B
2	**Noun in citation forms**	**Noun Compounds**
	chicken “g'a˄” forest “heh” foot “hkui sheh” to clamp “nu˄ ve”	jungle fowl “heh¯ g'a˄” shoes “hkui¯ nu˄ ”
3	**Colors**	**Diminutive Adjectives**
	red “nyi” white “hpu”	reddish “nyi¯ –eh˅” whitish “hpu¯ -eh˅”
4	**Instransitive verbs**	**Causative verbs**
	awake “naw˅ (ve)” carry, “pfuh˅ (ve)” *(ve) = a case marker for verbs	wake someone up, “naw_ (pi˅ ve)” to help others carry, “pfuh_ (pi˅ ve)” *(pi˅ ve) = a causative verb case marker

5. Predictions

If Lahu Na and Lahu Nyi are the same dialects as claimed by Bradley, 1989; Matisoff, 2003), the following sandhi patterns are predicted.

5.1 For Condition 1: When counting with a classifier, tone sandhi will be observed for numbers 3 and 4 but not for numbers 1, 2, 5. Specifically, the high-short, glottalized tone in the word *three* “sheh˄ ” will become the mid level tone in *(lime) three* CL “sheh leh˅,” and the high tone in the word *four* “aw˅ ” will become the low level tone in *four* CL “aw_ leh˅.”

5.2 For Condition 2: When a compound is created, tone sandhi will be observed in the first word. Specifically, the mid tone in the word “heh” and “hkui” will become the high rising tone in the compound *jungle fowl* “heh¯ g'a^” and “hkui¯ nu^” (high-rising + high).

5.3 For Condition 3: When the particle “–ehv” is added after the colors, tone sandhi will be observed. Specifically, the mid tone in the word *red* “nyi” and *white* “hpu” will become the high tone in the word *reddish* “nyi¯ –ehv” (high + low-falling) and *whitish* “hpu¯ ehv ” (high + low-falling).

5.4 For Condition 4: When an intransitive verb becomes causative, tone sandhi will be observed. Specifically, the high-falling tone in intransitive verbs *to be awake* “nawv ve” and *to carry* “pfuhv (ve)” will become the low tone in causative verbs *to wake others up* “naw_ piv ve” and *to help others carry* “pfuh_ (piv ve).”)

6. Data Analysis

6.1 Acoustic Measurement

The researcher listened to and analyzed all the elicited words. The word pairs in set A and set B that exhibited tonal change were noted. A total of 288 syllables that showed tonal change were extracted from the original recording and were submitted to detailed acoustic analysis. A text grid was created for each target sound file using Praat (6.2.23) (Boersma & Weenink, 2022) to label vowel-onset and vowel-offset. Using both the waveform and the spectrogram displays, vowel onset was defined as the onset of the first full glottal pulse and vowel-offset was defined as the end of the last glottal pulse, excluding

creak, if any, to avoid F0 tracking errors. F0 values and vowel duration were then automatically extracted from 20 time-intervals between vowel onset and vowel offset using ProsodyPro (Xu, 2013).

6.2 Tone Sandhi Identification

A comparison of each tone in isolation and in each sandhi condition produced by each speaker was done aurally and visually, as seen on spectrograms. Each detected tone sandhi token was manually recorded on an Excel sheet. The acoustic data of tone sandhi tokens such as F0 values in Hz, normalized F0 on 20 points, semi-tone values (mean, max, min) and vowel duration were plotted. Due to the small number of tone sandhi sample size, the results will be descriptively rather than statistically reported.

Findings

Predictions were borne out in three out of four conditions tested, namely Conditions 2 (compounding), 4 (causativization) and 3 (color).

The descriptive results of sandhi tone will be presented first, followed by the unborned predictions in Condition 1 (counting with a classifier).

1.Sandhi Conditions

Sandhi tones were produced in the compounds *jungle fowl* "heh¯ gˈa^" /hɛ45 ɣa44ʔ/, *shoes* "hkui¯ nu^" /kʰɯ45 nu44ʔ/; causative verbs *to wake others up* "naw_ pi˅ ve" /nɔ21 pi45 ve33/, and *to carry things for others* "pfuh_ pi˅ ve" /pʌi43 pi45 ve33/. Tables 4 and 5 present the words in citation form and their

derived forms with sandhi tone which are marked with an asterisk (*). The Chao number system is used to transcribe F0 levels and F0 contours of the tone, with 5 representing the height F0 level and 1 the lowest. The narrow transcription of each tone production is used.

Table 4
Tone Sandhi in Compounding

Word Form	Lahu script	Transcription	Meaning	Speakers
citation	heh	[hɛ33]	field	M1, M2, M3, F1, F2
compound	*heh‾ gˈa^	[hɛ45 ɣa44ʔ]	jungle fowl	M1, M2, M3, F2
citation	hkui sheh	[kʰɯ33 ʃɛ33]	foot	M1, M2, M3, F2
citation	hkui hkaw	[kʰɯ33 kʰɔ21]	foot	F1
compound	*hkui‾ nu^	[kʰɯ45 nu43ʔ]	shoes	M1, M2, M3, F1, F2

* denotes sandhi tones.

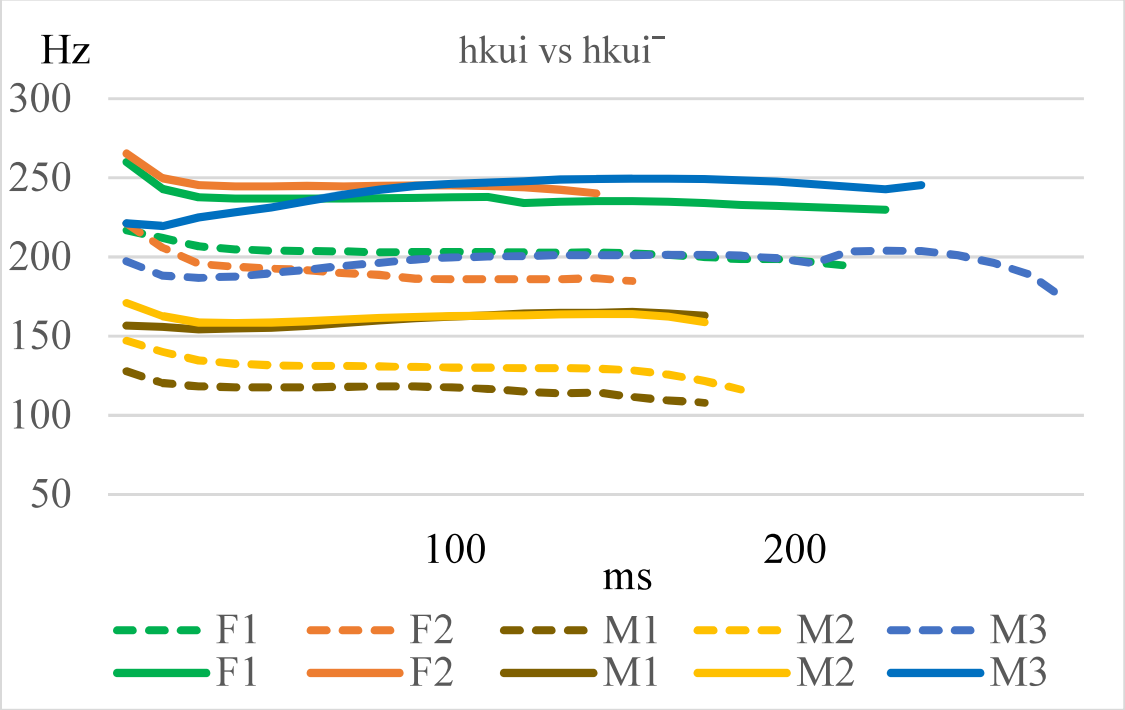
In a compound, the mid- level tone [33] becomes the high-rising tone [45]. That is, the word “heh” *field* surfaces as [hɛ45], the sandhi tone, in the compound “heh‾ gˈa^” *jungle fowl*. Note that F1 did not know the word *jungle fowl* in Lahu, thus, only 4 speakers were listed. The same tonal change was observed in the compound “hkui‾ nu^ ” *shoes*. The mid level tone of the word “hkui” [kʰɯ33] *foot* becomes the sandhi tone [45] in the word “hkui‾ nu^ ” *shoes* [kʰɯ45 nu43ʔ]. In this case,

both sandhi tones occur before the high-mid short glottalized tone [44ʔ] or [43ʔ] in the second word of the compound.

Figure 4a presents the approximate F0 contours and duration of tone in the word "hkui" [kʰɯ33] *foot* and "hkui¯" [kʰɯ45] from the word *shoes* produced by five speakers. Each line shows the average F0 value of three repetitions of each tone production by a speaker. Each dotted line represents a non-sandhi production whereas each solid line represents a sandhi production. The Y axis shows F0 value in Hertz (Hz) and the X axis shows the duration of the measured vowel in millisecond (ms).

Figure 4a

Mean F0 Contours of the Non-Sandhi Syllable "hkui" and the Sandhi Syllable "hkui¯" Produced by Five Speakers of Lahu Nyi



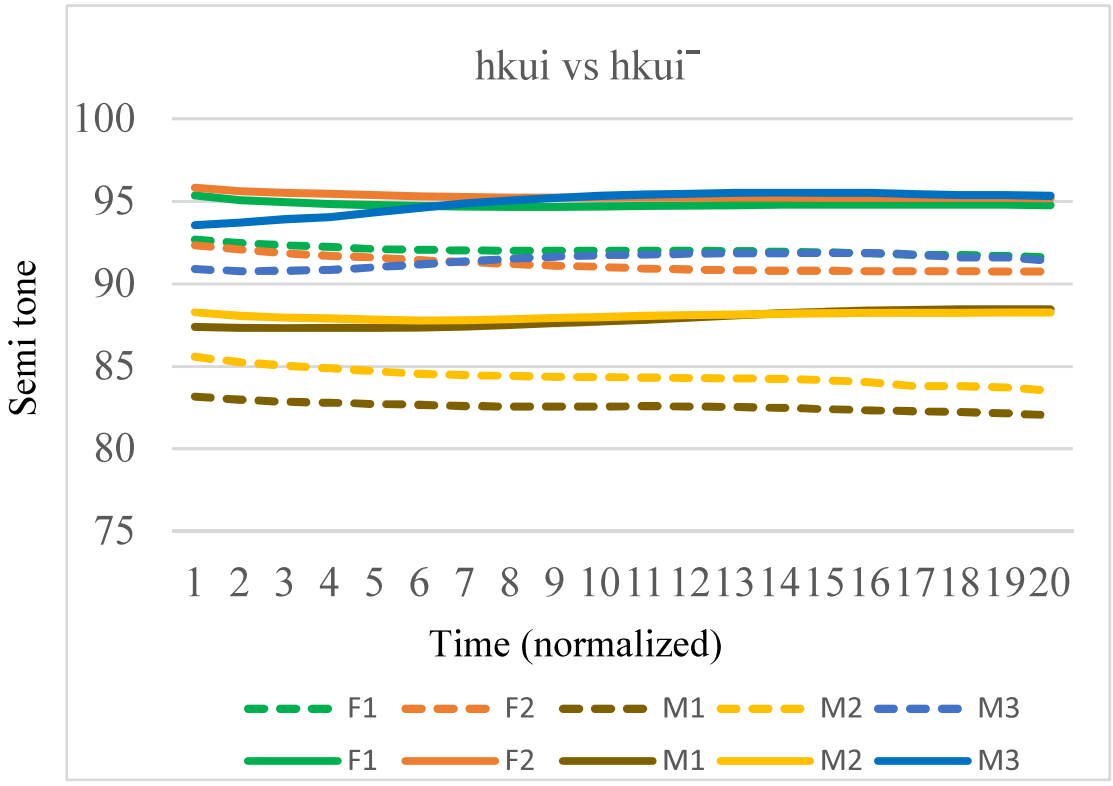
The mid (dotted line) and high-rising tones (solid line) contrast in the onset height and the direction of their offsets.

First, the onset of the mid-level tone [33] starts around 120-220 Hz while that of the high-rising tone [45] range from 150-250 Hz. Secondly, the F0 contours produced by five speakers in "hkui" stay level during the mid portion and slightly fall at the offset while the F0 contours in "hkui¯" from the word *shoes* show a gradual rise from the mid portion to the offset. The mid-level tone [33] is longer than the high-rising tone based on 15 samples (5 speakers x 3 repetitions) of each tone. The average duration of the mid tone is 174.40 ms (SD = 51.03) and that of the high-rising tone is 162.111 ms (SD = 37.10).

To better visualize F0 contours of the non-sandhi "hkui" and the sandhi "hkui¯" tones across the five speakers, time-normalized F0 values in semi-tone are plotted in Figure 4b.

Figure 4b

Time-Normalized Contours of the Non-Sandhi Syllable "hkui" and the Sandhi Syllable "hkui¯" Produced by Five Speakers of Lahu Nyi



The pitch tracks on the spectrograms in Figures 5a and 5b below illustrate the change of tone production by M3. In Figure 5a, the level tone in the word "hkui" [kʰɯ33] has the F0 mean of 198.78 Hz and F0 maximum value of 203.83 Hz. In contrast, the high-rising tone in the word "hkui¯" [kʰɯ45] in Figure 5b has the mean F0 of 242.17 Hz. The onset of this contour tone was 220.20 Hz, and its F0 contour rise sharply after the mid portion of the tone to the maximum F0 value of 251.32 Hz.

Figure 5a

The F0 Contour of the Non-Sandhi Syllable "hkui" [kʰɯ33] in the word *foot* "hkui sheh" by M3

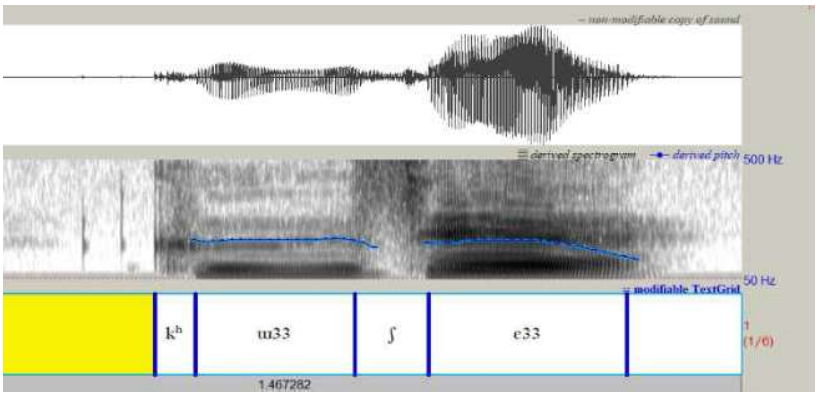
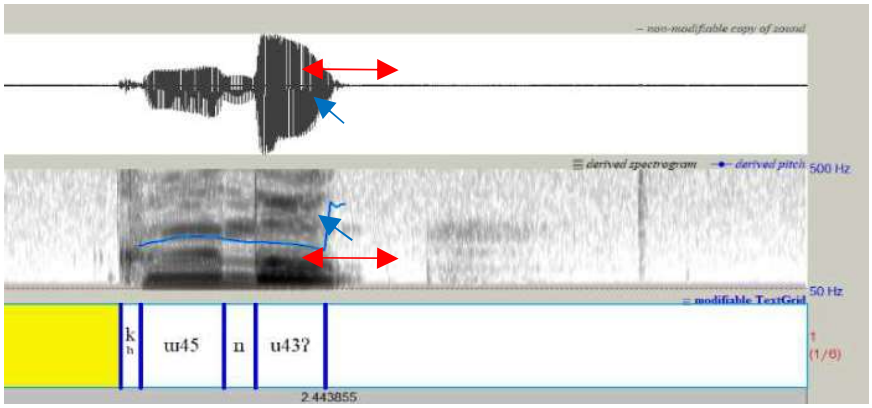


Figure 5b

The F0 Contour of the Sandhi Syllable "hkui¯" [kʰɯ45] in the word *shoes* "hkui¯ nu^" by M3



It is important to note the existence of the glottalized tone on this spectrogram. The word [nu43ʔ], the second member of the compound *shoes* [kʰɯ45 nu43ʔ], carries the high-mid, short, glottalized tone. The presence of a glottal stop realized with irregular voicing (indicated by the arrows) supports the description of glottalized tones in Lahu Nyi.

Tone sandhi was also observed in Condition 4, causative verbs. Table 5 presents the tonal alteration pattern between two verb types. The high falling [43] of intransitive verb becomes the low tone [21] in the causative verb counterpart.

Table 5
Tone Sandhi in Causativization

Verb Type	Lahu Word	Transcription	Meaning	Speakers
intransitive	naw$^{\vee}$ ve	[nɔ43 ve33]	to be awake	M2,
	naw_ ve	[nɔ21 ve33]	to be awake	F2
intransitive	naw$^{\vee}$ la ve	[nɔ43 la33 ve33]	to be awake other people up	M1, M3, F1
causative	*naw_ pi$^{\vee}$ ve	[nɔ21 pi45 ve33]	to wake other people up	F2, M2

Verb Type	Lahu Word	Transcription	Meaning	Speakers
causative	*naw_ tu ve	[nɔ21 tu33 ve33]	to wake other people up	M1, M3
causative	*naw_ tu la$^{\vee}$ ve	[nɔ21 tu33 la43 ve33]	to wake other people up	F1
intransitive	pfuh$^{\vee}$ ve	[pfʌi43 ve33]	to carry on the back	M1, M2, M3, F1, F2
causative	*chi$^{\vee}$ pfuh_ ve	[ʃi44 pfʌi22 ve33]	to lift stuff for others to carry on his back	M1
causative	pfuh$^{\vee}$ pi$^{\vee}$ ve	[pfʌi43 pi44 ve33] (no tonal change)	to help others carry stuff on his back	M1, M2, M3, F1
causative	*pfuh_ pi$^{\vee}$ ve	[pfʌi22 pi44 ve33]	to help others carry stuff on his back	F2

* notates sandhi tones.

In other words, when the subject of the verb is the agent or the performer of the action in the sentence, the verb carries a high tone as in "naw^{V} ve" [nɔ43 ve33] *to be awake*. When the agent in the sentence causes other people to perform an action, the low tone is used as in "naw_ pi^{V} ve" [nɔ21 pi45 ve33] *to wake other people up or to cause other people to be awake*. Figures 6a-e show the F0 contours of the first syllable of the "naw^{V} ve" and "naw_ pi^{V} ve" produced by the five speakers. Each dotted line represents a non-sandhi production whereas each solid line represents a sandhi production. The Y axis show F0 value in Hertz (Hz) and the X axis shows the normalized time (20 points) where each F0 value was measured.

Figure 6a

F0 Contours of Each Repetition of "naw^{V}" (Non-Sandhi) and "naw_" (Sandhi) by F1

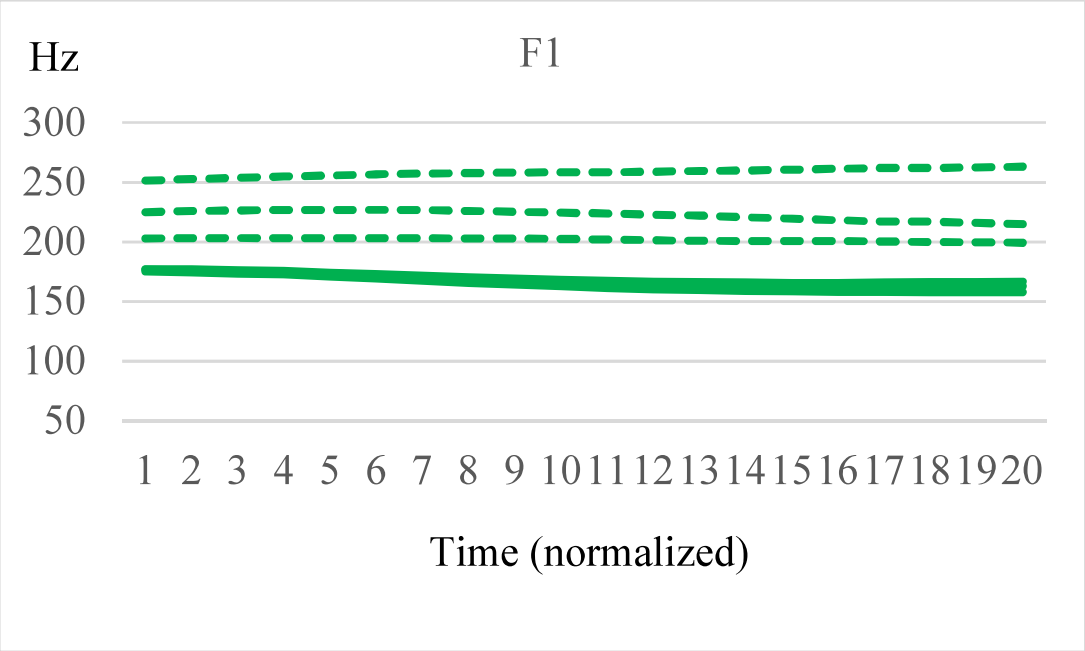


Figure 6b

F0 Contours of Each Repetition of "naw^{V}" (Non-Sandhi) and "naw_" (Sandhi) by F2

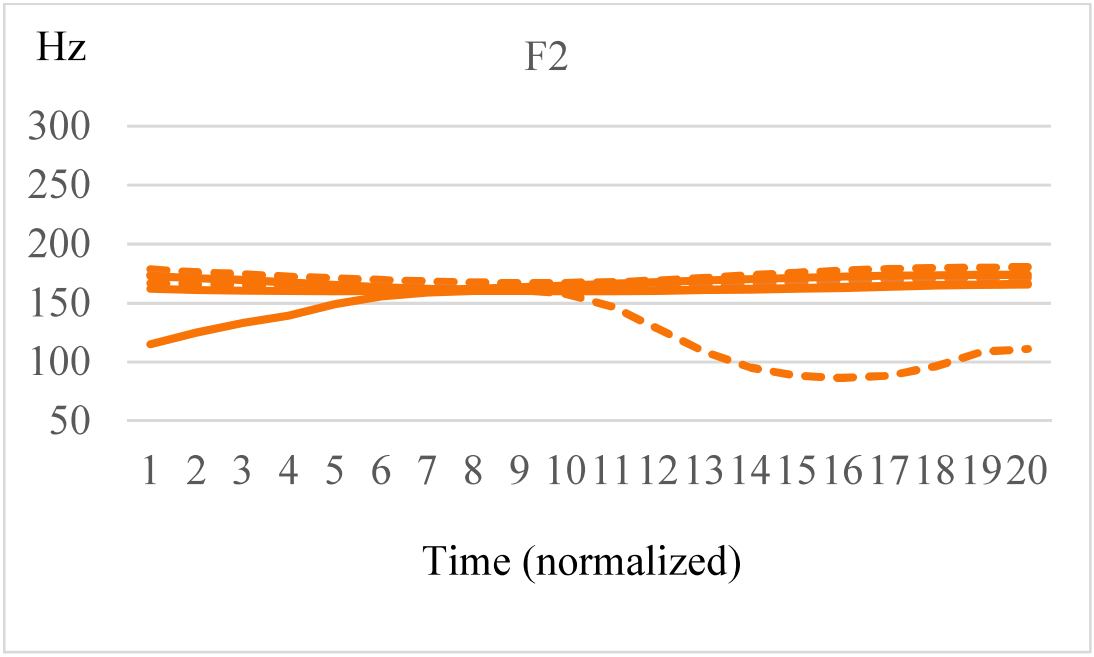


Figure 6c

F0 Contours of Each Repetition of "naw^{V}" (Non-Sandhi) and "naw_" (Sandhi) by M1

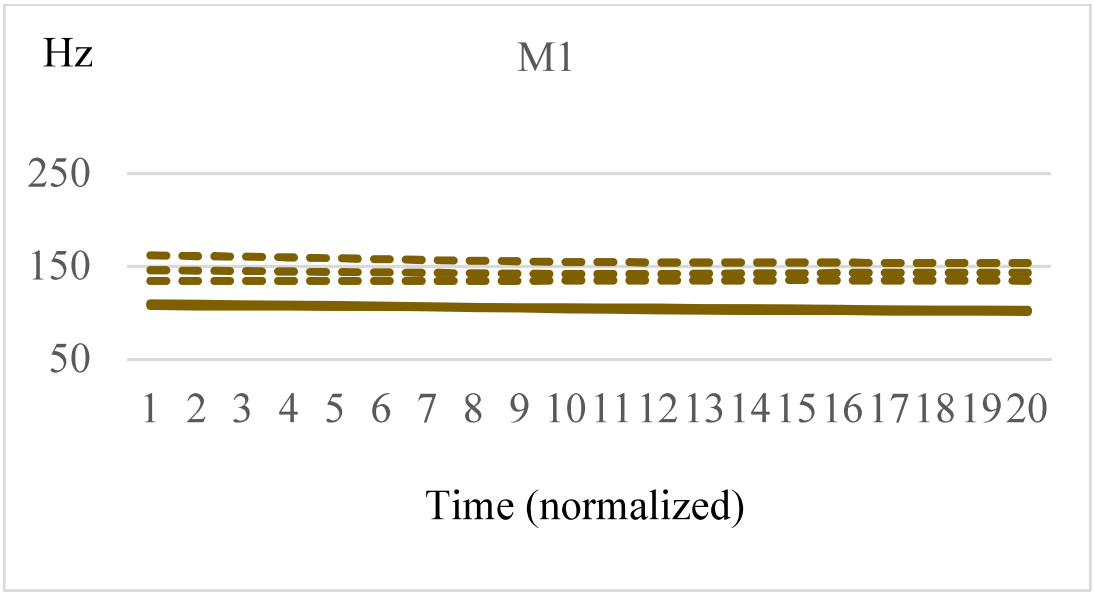


Figure 6d

F0 Contours of Each Repetition of "naw^{V}" (Non-Sandhi) and "naw_" (Sandhi) by M2

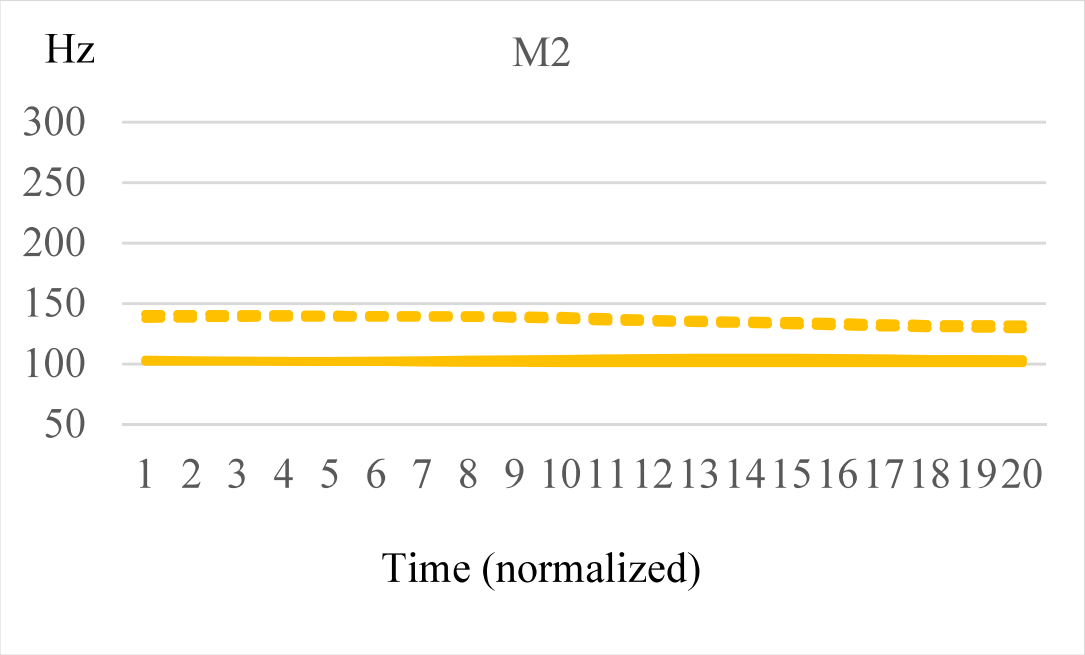
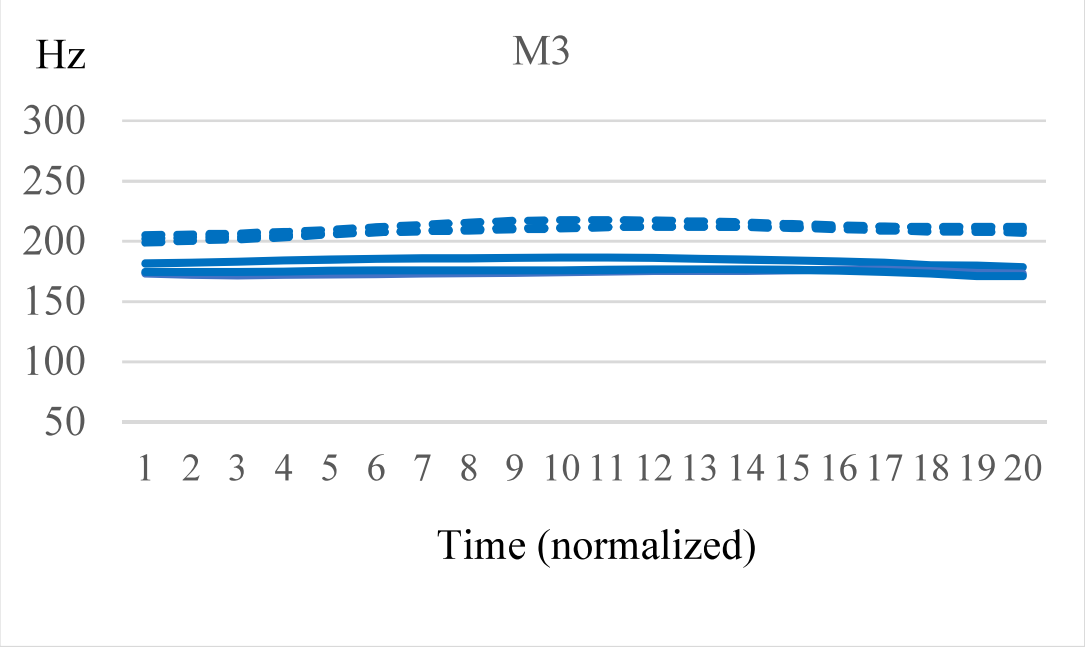


Figure 6e

F0 Contours of Each Repetition of "naw^{V}" (Non-Sandhi) and "naw_" (Sandhi) by M3



While the shape of both non-sandhi and sandhi tones appears similar, their onset originates at different F0 values. The high-falling tone [43] starts at the higher F0 values than the low level tone [21]. In the syllable "naw^{v}" the onset of F0 ranges from 150- 250 Hz on the Y axis while that of "naw_" starts at the lower F0 range, 100-180 Hz.

Unlike other speakers who produced "naw^{v} ve" as [nɔ43 ve33] on the intransitive verb, F2 produced the low tone [21] instead. That is F2 produced a low tone [21] in both intransitive and causative verbs (See Figure 6b). Note that F0 values at the bottom dotted lines are missing because they could not be reliably extracted due to F2' s creaky voice.

No difference in vowel duration was observed between the mid tone, non-sandhi, "naw ve" and the high-falling tone, sandhi, "naw^{v} ve". The duration of mid tone by F1 and M3 are longer than their high falling tone while the duration of these two tones by M1 and M2 are of equal duration. The average duration of non-sandhi tone across the five speakers is 174.40 ms (SD = 51.03) and that of sandhi tone is 162.11 ms (SD = 37.11).

Some instances of tone sandhi, not a consensus, supported the prediction that tone [43] in an intransitive verb (e.g., [pfʌi43] in *to carry on one's back* "pfuh^{v} ve" [pfʌi43 ve33]) would become low level tone [22] in the causative form (i.e., [pfʌi22] *to help others carry stuff on his back*). Specificallly, F2 produced "pfuh_ pi^{v} ve" [pfʌi22 pi44 ve33] with the low tone on the target verb [pfʌi22] as described by Paul Lewis (1986: 12) while the rest: M1, M2, M3 and F1, produced [pfʌi43 pi44 ve33] with no tonal change. Interestingly, M1 produced the phrase "chi^{v} pfuh_ ve" [ʃi44 pfʌi22 ve33] with the

sandhi low tone [22] on“pfuh_”. According to M1 and Lewis (1986:449), “chi$^{\vee}$ (ve)” means *to lift.*

These results suggest that the high falling tone [43] becomes the low [22] sandhi tone in causative verbs, at least for some speakers. It was possible that M1 and M2 knew more Lahu Nyi words than other speakers as suggested by F1 and F2 during the language verification period. M1 was the “to bo” or *village priest* who performs the traditional Lahu Nyi rites in his village and M2 was a Lahu Nyi language teacher in the nearby village.

Figures 7a and 7b illustrate F0 patterns of the non-sandhi verb “pfuh$^{\vee}$ ve” and the sandhi verb “chi$^{\vee}$ pfuh_ ve” produced by M1. The maximum value of F0 in the vowel portion of the transitive verb “pfuh$^{\vee}$ ve” [pfʌi43 ve33] meaning *to carry on one’s back* by M1 is 152.98 Hz while that of the causative verb “chi$^{\vee}$ pfuh_ ve” [ʃi44 pfʌi22 ve33] meaning *to to lift stuff for others to carry on his back* by M1 is 101.83 Hz.

Figure 7a

The Non-Sandhi Verb “pfuh$^{\vee}$ ve” [pfʌi43 ve33] Meaning “to carry on one’s back” by M1

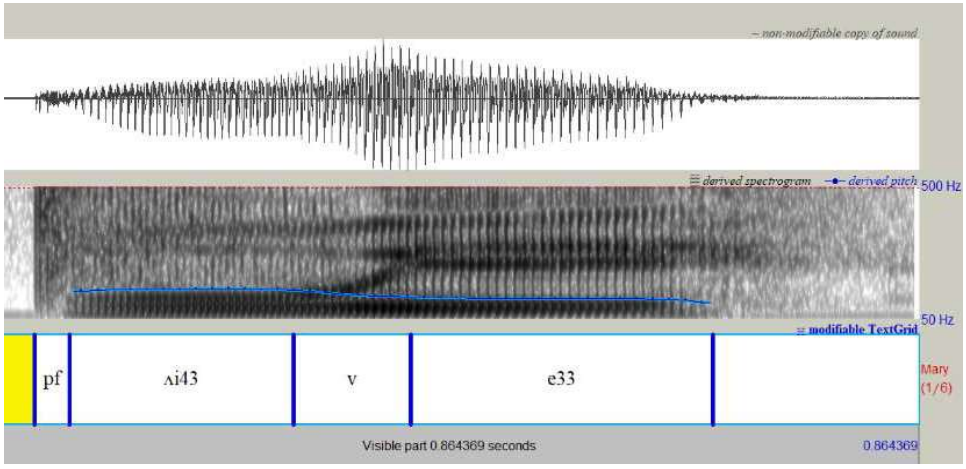


Figure 7b

The Sandhi Verb "chi^{v} pfuh_ ve" [ʃi44 pfʌi22 ve33] Meaning "to to lift stuff for others to carry on his back" by M1

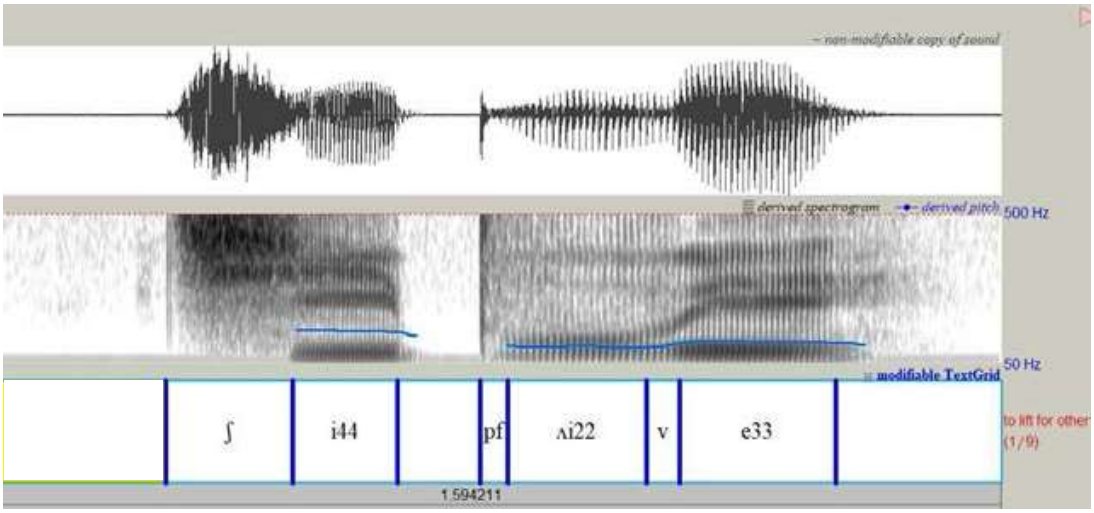


Table 6 presents target words in Condition 3: color naming.

Table 6

Tone Sandhi in Colors

Word Form	Lahu script	Transcription	Meaning	Speakers
citation	nyi	[ɲi33]	red color	M2
citation	nyi¯	[ɲi45]	red color	M1, M2, M3
citation	nyi¯ eh ve	[ɲi45 ə ve33]	red color	F2
derived form	*nyi¯ eh_ ve	[ɲi45 e22 ve33]	to be red	M2

Word Form	Lahu script	Transcription	Meaning	Speakers
derived form	nyi¯ eh_ ve	[ɲi45 e22 ve33]	to be red	M1, M3
derived form	nyi¯ eh_ ve	[ɲi45 e22 ve33]	red color	F1, F2

In Condition 3, it was challenging to elicit the target words *red* "nyi" and *reddish* "nyi¯ –ehᵥ" as well as *white* "hpu" *whitish* "hpu¯ ehᵥ" in the picture naming task. Firstly, the words *reddish* and *whitish* are subjective and difficult to depict with pictures as shown in Figure 8.

Figure 8

Pictures Used to Elicit Colors in Condition 3

Set A	Set B
	

Secondly, the meaning of the the particle "–ehᵥ" is unclear. Lewis (1986:12) defined it as an adverb forming particle but he glossed it as *-ish* as in *reddish* and *whitish.* Moreover, on page 254, the Lahu Na word entry "nyi¯ –eh_ ve" means *to be red* and at the buttom of the same page, the word that means *to be red (color)* has two forms "nyi" and "nyi¯ eh_ That is, there are two possible pronunciations, with mid [33] or high tone [45].

It was found that only M2 produced tone sandhi as predicted. That is the mid tone [33] in *red* "nyi" or *white* "hpu" becomes the high-rising tone [45] when the particle "-eh" is attached to the noun referring to these colors. To illustrate, the F0 contours of the words meaning *red* are displayed in Figures 9a and 9b. Figure 9a shows the non-sandhi mid tone [33] with the maximum F0 value of 131.9 Hz. Figure 9b shows the sandhi high-rising tone [45] with the maximum F0 value of 178.4 Hz.

However, the other four speakers did not exhibit tonal change. All of them produced the word meaning *red* or *white* with a high-rising tone whether or not they thought "nyi¯" or "nyi¯ -eh ve" had the same or different meaning, *red* or *to be red*.

Figure 9a
The Non-Sandhi Form *red* "nyi" by M2

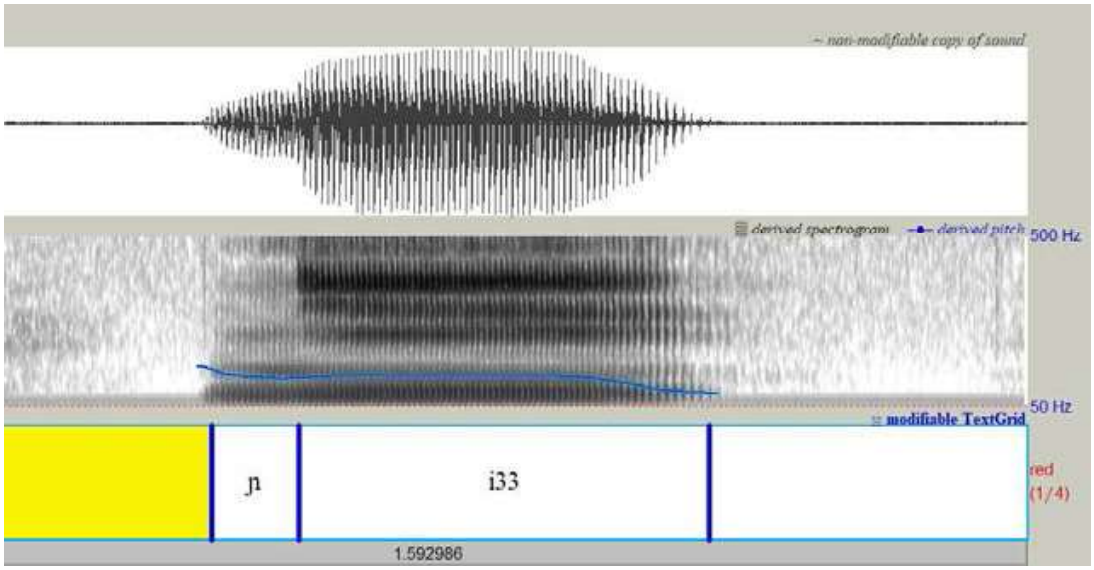
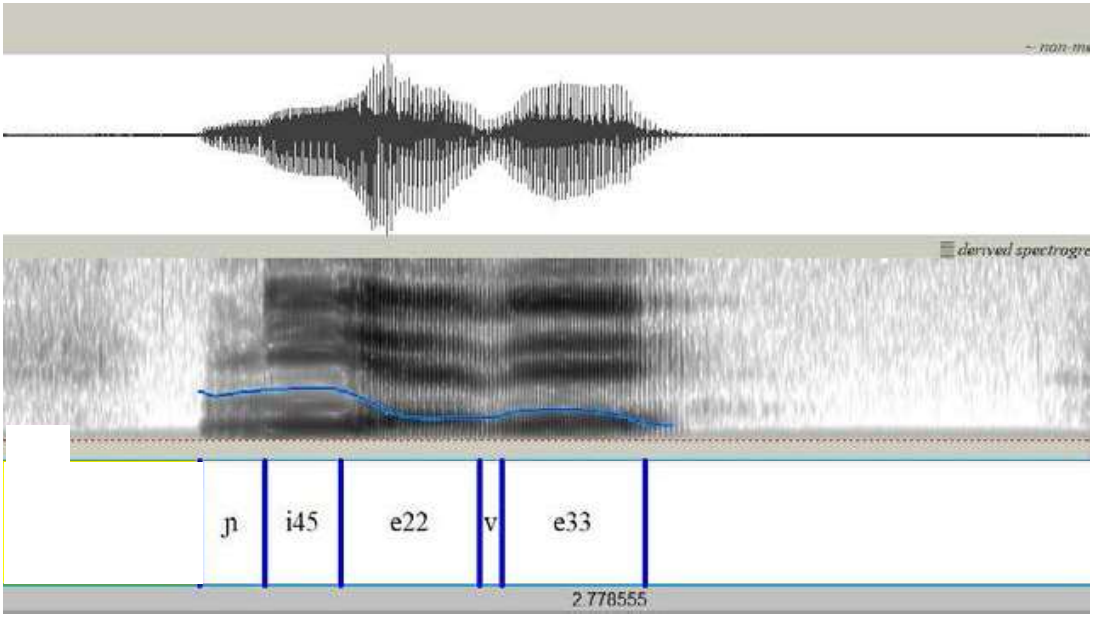


Figure 9b
The Sandhi Form *to be red* "nyi¯ –eh_ ve" by M2



2. Non-Sandhi Condition

Contrary to our predictions, tone sandhi could not be examined in Condition 1 because the target classifier "ma$_{V}$" or "leh^{V}" could not be elicited. According to F2, our first reader, these classifiers had not been used. Thus, the researcher elicited other classifiers such as "shi_" instead and asked her to count limes using this classifier. The classifier "shi_" is the specific classifier when counting a round item such as limes, pills or grains of rice. In contrast, the classifers "ma$_{V}$ or leh^{V}" are general classifiers for counting items or objects without implying its shape.

Discussion

Lahu Nyi tone sandhi occurs in a very limited set of words. It was found in three out of four tested conditions, namely, compounding, color and causativization. In compounding condition, only two

compounds *shoes* and *jungle fowl* exhibit the tonal change. The observed tonal change pattern is that mid tone [33] becomes high tone [45] in compounds. This is not found in other words like "heh va" [hɛ^{33} va^{33}] *boar or jungle pig* or "heh hpui^" [hɛ^{33} pʰɯ^{41}] *fox* or *dog living in a field*. Note that the word "hpui^" [pʰɯ^{41}] means *dog* and "va" [va^{33}] means *pig*. It could be postulated that the high-mid short, glottalized tone [44ʔ] in the second element of the compound (*chicken* g'a^ [ɣa44ʔ] and *to clamp* nu^ [nu43ʔ] triggers tone sandhi in this condition.

Results of the other two conditions did not yield a consensus. In the color naming condition, only one speaker, M2, produced the predicted sandhi tone (from the non-sandhi mid to the sandhi high tone) when the particle "-eh" was added, for example *red* versus *to be red* and other colors. Compared with other speakers, M2 is the most experienced speaker of Lahu Nyi language due to his age and language contact. M2 had lived and spent his adulthood in Myanmar before moving to Thailand. Moreover, he is a monolingual; he does not speak Thai or dialects of Chinese like M1 and F2.

In the causativization condition, F2's productions diverged from the others. While M1, M2, M3 and F1 produced the predicted sandhi tone pattern (the high tone [41] becomes the low tone [21]) on the verb pairs "naw^v" *to be awake* and "naw_" *to wake others up*, F2 produced no tonal contrast on these verb pairs. On the other hand, F2 produced tonal change on the verb "pfuh^v ve" *to carry on one's back* and "pfuh_ pi^v ve" *to help others carry stuff on his back* but produced no tonal change for the rest. Note that M1 produced tone sandhi in these verb pairs when he added the verb "chi^v" *to lift* as in "chi^v pfuh_ ve" *to lift stuff for others to carry on his back*. In this condition, F2 might have been influenced by her contact with other languages such

as Thai and Cantonese. She lived outside the Lahu Nyi community the most. She grew up in Bangkok as a child and worked in Hong Kong until she turned 40. It was possible that M1 and M2 knew more Lahu Nyi words than other speakers as suggested by F1 and F2. Nonetheless, these results suggest that the high falling tone [43] becomes the low [22] sandhi tone in causative verbs, at least for some speakers. This tonal alteration pattern also occurs in other pairs of verbs not used in this experiment e.g., verbs meaning "to eat" and "to feed."

The presence of tone alternation in this experiment supports the hypothesis that tone sandhi exists in Lahu Nyi in some speakers. It is not tonal coarticulation or coarticulatory effects as the sandhi tone matched up with other tones in the language. Moreover, the fact that the tonal change pattern can be predicted based on the meaning of the derived word suggested that tone sandhi exists in this language, albeit in limited contexts.

The characteristics of tone sandhi in Lahu Nyi are not the same as the phonologically conditioned tone sandhi phenomena in Mandarin (Zhang & Lai, 2010) or Wu's dialect (Rose, 1990). In Mandarin, there are two sandhi patterns which involve tone 3 [213]. Specifically, tone 3 becomes tone 2 [35] when followed by another tone 3, or tone 3 becomes half tone 3 [21] when followed by any other tones (Zhang & Lai, 2010). Both sandhi patterns are highly productive in Mandarin disyllables and phrases. In Northern Wu, tone sandhi occurs at the word level known as "high mountain" and the phrase level known as "cook soup" (Zhu & Wang, 2015: 11). At the word level, a pitch value or tone of the first syllable spreads rightward and determines the pitch pattern of the whole word. In disyllabic phrases, the first tone becomes a mid-level tone, regardless of

their original shape while the tone of the second syllable maintains its original value.

In contrast, tone sandhi in Lahu Nyi is motivated by morphology or word formation process. When the meaning is changed or a new word is created, tone changes its citation value to that of another tone in the language. In compounding condition, the pattern is mid to high and in causativisation from high to low. Considering some linguistically related languages in Tibeto-Burman branch of the Sino-Tibetan language family, the use of tone sandhi in Lahu Nyi is similar to Lisu and Akha. That is, their tone sandhi is conditioned by morpho-syntax as discussed previously. The term "tone change" is generally used by sinologists to refer to this type of tonal modification to distinguish it from phonologically conditioned tone sandhi (Chen, 2000). "One can think of tone change thus defined as an analog of ablaut and umlaut in English functioning as both inflectional (foot~feet, sing~sang~sung) and derivational devices (food~feed)" (Chen, 2000, p. 31). Examples of tone change in Bejing Mandarin offered by Chen (2000, p. 31) include: zhong55 'center' > zhong51 "to hit the center of the target"; yin55 "shade" > yin51 'to shelter"; hao214 "goo" > hao51 > hao51 "to like", and heng35 "horizontal" > heng 51 "cross-grained, hard to deal with."

The results found in this current study shed light on the similarity between Lahu Na and Lahu Nyi. Both Bradley and Matisoff claimed that Lahu Na and Lahu Nyi are actually the same dialect of Lahu language. The seven-tone system proposed in the current study and conditions triggering tone sandhi in Lahu Nyi appear to mirror those of Lahu Na described by Lewis (1986). However, to acoustically confirm the sandhi similarities

of these two Lahu dialects, future studies should reinvestigate the use of general classifer "ma$_{V}$"and "leh^{V}" by changing the elicitation method. In addition, the prefix could be a possible trigger in both Lahu dialects as it does in Lisu (Bradley, 2003). Future acoustic studies should also analyze tone sandhi data recorded by more Lahu Nyi speakers living elsewhere and Lahu Na speakers living in Northern Thailand in the present day.

Last but not least, some missing data such as the word meaning "fowl" and some classifiers in this current study reflect the fact that some words are disappearing or not known by the younger generation of Lahu Nyi speakers in the present days. More work should be done to help preserve the language.

Conclusion

This study confirmed the existence of morpho-syntactically conditioned tone sandhi in Lahu Nyi in some speakers. Two compounds represent the sandhi pattern: a mid to high, while causativization triggers the high-to-low sandhi pattern. The suffix particle "-eh" triggers tone sandhi in one speaker. Tone sandhi in Lahu Nyi is motivated by morphology and the results revealed similarities between Lahu Nyi and Lahu Na, dialects of Lahu Language. Absence of tone sandhi among some speakers awaits further investigation.

Limitations and Recommendation

Since this research study only included a small number of language informants, reporting statistical results on F0 or semi-tone values and duration may not be reliable. To increase statistical power, future studies should include more

participants, especially from different locations to verify results found in this current study.

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