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VARIATION AND CHANGE
OF THE PHRAE PWO
KAREN VOWELS AND
TONES INDUCED BY
LANGUAGE CONTACT
WITH THE TAI
LANGUAGES

Chommanad Intajamornrak

Abstract

This paper aims to analyze and compare the acoustic characteristics of the vowels and tones in the Phrae Pwo Karen spoken by three generations. The data was collected at Khangchai Village in Wang Chin District, Phrae Province. A wordlist of Pwo Karen vowels and tones was recorded directly on to computer using Adobe Audition version 2. Fifteen female informants were divided into three groups: those over 60 years old, those 35-50 years old and those under 25 years old. The total number of test tokens was 405 for vowel analysis, and 810 for tone analysis. The fundamental frequencies and formant frequencies were measured using Praat version 5.1.43.

The results show that there are nine monophthongs in Phrae Pwo Karen, namely /i, e, ə, a, o, ə/. Considering the vowel spaces, it is noticeable in the over-60 group that front vowels /i, e, ə/ occur very close to each other, i.e., with only a little difference in the tongue height position (F1). Whereas the back vowels /u, o/ occur close to each other, the vowel /a/ appears close to the vowel /ə/. In the 35-50 group and the under-25 group, the vowel /ə/ moves downward and the vowel /a/ moves upward. There are 4 tones, namely, the high tone, mid tone, low tone and falling tone. In the over-60 group, the high tone begins at a high pitch and stays level until the end. The mid tone starts at a mid pitch and stays level until the end. The low tone starts at a mid pitch and falls to a low pitch. The falling tone begins at a high pitch and then rises slightly before sharply falling to a low pitch. For the 35-50 group, the acoustic characteristics of the 4 tones are similar to those of the older group; however, the high tone behaves differently. The onset of the high tone is lower and rises slightly until the end. The change of the high tone is clearer in the under-25 group. It starts from a mid pitch and rises sharply to a high pitch.

In conclusion, the acoustic characteristics of the vowels and tones as spoken by three generations suggest that Phrae Pwo Karen is changing because of the variation among the three groups. The variation and change seems to be caused by language contact with Tai Yuan and Standard Thai.

1. Introduction

Pwo Karen is one of the six Karen languages spoken in Thailand. The other five are Sgaw, Pa-O, Kayan, Kayah, and Kayaw. Pwo Karen and Sgaw Karen are the two languages with the greatest number of speakers. Pwo Karen can further be subdivided into dialects on the basis of classical criteria such as their degree of lexical similarity (or mutual intelligibility) and geographic distribution. The three examples below provide a glimpse into cross-dialect differences which including the presence of some non-cognate words and differences in consonants, vowels and tones between

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1 Lecturer, Faculty of Humanities, Naresuan University
cognates. ‘Sangkhla’ refers to the dialect of Sangkhla District, Kanchanaburi Province, ‘Omkoi’ for that of Omkoi District, Chiangmai Province (Phillips 2009), and ‘Khangchai’ for the variety spoken in Khangchai Village, Wangchin District, Phrae Province.

Sangkhla      Omkoi      Khangchai    Gloss
\[\theta a^1\]   [\theta a^2]   sa^3     ‘heart’
na^21ku^5   ne^14   na^21   ‘ear’
phlɔ^51   ke^13ma^45   ?añ^klaŋ^45   ‘to give’

The present study focuses on the third of these dialects: Khangchai. It belongs to the Phrae Pwo Karen dialect of Pwo Karen, which is also known as North-eastern Pwo (Lewis 2009). The speakers of Pwo Karen in Phrae Province have been settled in this area for at least 150 years (National Archives of Thailand 1999). Pwo Karen speaking people outnumber those of the other non-Tai ethnicities, e.g. Hmong, Akha, Lisu, and Mlabri. Khangchai Village is one of fourteen Pwo Karen speaking villages (in two districts) and almost all the speakers are bilingual. They can speak Phrae Tai Yuan, with the exception of some elderly speakers who are passive bilinguals. The young generation can also speak Standard Thai very well, since they have been educated in school.

The factors which bring about language variation and change can be distinguished into two groups, internal and external. Internal factors deal with features of a language itself, for example, vowel shifting in English, whereas external factors usually deal with language contact and social factors, e.g. age, gender, social class, etc. Weinreich (1968: 3) explains that among the extra-linguistic factors which must be considered in a language contact situation, some are inherent in the bilingual speakers’ relation to the languages they come into contact with. These include, for example, the speakers’ facility of verbal expression in general and their ability to keep the two languages apart, their relative proficiency in each language and specialization in the use of each language by topic and interlocutor. In addition, there are certain features of bilingual groups such as size, demographic facts, and political relations.

Furthers, Thomason (2001:60) also concluded that the results of language contact can be classified into three types: contact-induced change, extreme language mixture, and language death. Contact-induced change is varied in the kind and degree of change by two predictors: social factors and linguistic factors. Social factors include intensity of contact, presence vs. absence of imperfect learning and speakers’ attitude. Linguistic factors include universal markedness, the degree to which features are integrated into the linguistic system, and typological distance between source and recipient languages. The next type of result of language contact is extreme language mixture. This level leads to pidgins, creoles, and bilingual mixed languages. The last type is language death. This occurs through attrition or the loss of linguistic material and grammatical replacement.

Many scholars have studied tonal variation and change in Southeast Asian languages (Akharawatthanakun 2002 and 2009, Intajamornrak 2011, L-Thongkum 1994, Teeranon 2002) and found that acoustic characteristics of tones are influenced both by internal factors and by external factors. There are also generational differences in acoustic characteristics of vowels (Cox 1999, Decker and Mackenzie 2000,
Jacewicz, Fox and Salmons 2011). As the language used by different generations can provide insights into variation and change, this paper aims to analyze and compare the acoustic characteristics of the vowels and tones of Phrae Pwo Karen as spoken by three generations.

2. Phonological system of Phrae Pwo Karen (Khangchai Village)

Fieldwork data collected in 2010-2011 show that the Pwo Karen dialect spoken at Khangchai Village has 21 consonant phonemes. Only /ʔ/ and /ŋ/ can occur in final position. There are 9 monophthongs and 4 diphthongs, without vowel length distinction. The tonal system comprises 4 tones in non-checked syllables and 2 tones in checked syllables.

### Consonants

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stop</strong></td>
<td>p h</td>
<td>t h</td>
<td>e h</td>
<td>k h</td>
<td>?</td>
</tr>
<tr>
<td><strong>Nasal</strong></td>
<td>m n</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fricative</strong></td>
<td>s x</td>
<td></td>
<td></td>
<td></td>
<td>h</td>
</tr>
<tr>
<td><strong>Approximant</strong></td>
<td>w j</td>
<td>l j</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lateral</strong></td>
<td></td>
<td></td>
<td>j</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Vowels

<table>
<thead>
<tr>
<th>Monophthongs</th>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>i</td>
<td>i</td>
<td>u</td>
</tr>
<tr>
<td>Mid</td>
<td>e</td>
<td>e</td>
<td>o</td>
</tr>
<tr>
<td>Low</td>
<td>e</td>
<td>a</td>
<td>o</td>
</tr>
</tbody>
</table>

| Diphthongs   | ai    | ɔi     | ai   | au   |

### Tones

**Non-checked syllable (CV/CVN):**


/falling/ [41]

**Checked syllable (CV?):**

/midʔ/ [332 ~ 33] /fallingʔ/ [442 ~ 42]²

² /ʔ/ is marked for tones that occur in checked syllables. It does not mean a glottalized tone
3. Methodology

The data was collected at Khangchai Village in Wangchin District, Phrae Province. Because of the variation among Pwo Karen dialects, the 1,000 vocabulary items were collected in the first fieldwork. The vocabulary included action verbs, stative verbs, body parts and secretion, natural objects and phenomena, manmade objects and constructions, kinship terms, numerals, colors, time, direction and location, pronouns, and questions. After that, a wordlist for acoustical measurement of vowels and consonants was chosen from among these vocabulary items.

The words for acoustical measurement of the nine monophthongs are all mid tone and occur in non-checked syllables. The initials are voiceless aspirated stops which prevent the acoustic analysis from being affected by phonation. A wordlist for vowels is shown below.

Vowels

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Thai</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>/i/</td>
<td>khi³³</td>
<td>‘tick’</td>
</tr>
<tr>
<td>/e/</td>
<td>kheŋ³³</td>
<td>‘cricket’</td>
</tr>
<tr>
<td>/ɛ/</td>
<td>thɛ³³</td>
<td>‘to crack’</td>
</tr>
<tr>
<td>/ɨ/</td>
<td>phɨ³³</td>
<td>‘short’</td>
</tr>
<tr>
<td>/ɐ/</td>
<td>khəŋ³³</td>
<td>‘to dig’</td>
</tr>
<tr>
<td>/a/</td>
<td>khaŋ³³</td>
<td>‘calf’</td>
</tr>
<tr>
<td>/ʊ/</td>
<td>khuŋ³³</td>
<td>‘smoke’</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>thoŋ³³</td>
<td>‘bag’</td>
</tr>
<tr>
<td>/œ/</td>
<td>thoŋ³³</td>
<td>‘blood vain’</td>
</tr>
</tbody>
</table>

The words for acoustical measurement of tones occur both in non-checked syllables and checked syllables and also have voiceless aspirated stops as initial consonants. A wordlist for tones is shown below.

Tones

Non-checked syllables

<table>
<thead>
<tr>
<th>Tone</th>
<th>Thai</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>/high/</td>
<td>khəŋ⁴⁵</td>
<td>‘chopping board’</td>
</tr>
<tr>
<td>/mid/</td>
<td>khəŋ³³</td>
<td>‘to dig’</td>
</tr>
<tr>
<td>/low/</td>
<td>thanj²¹</td>
<td>‘comb’</td>
</tr>
<tr>
<td>/falling/</td>
<td>phəŋ⁴¹</td>
<td>‘hole’</td>
</tr>
<tr>
<td>/high/</td>
<td>thanj⁴⁵</td>
<td>‘gizzard’</td>
</tr>
<tr>
<td>/mid/</td>
<td>thanj³³</td>
<td>‘exit’</td>
</tr>
<tr>
<td>/low/</td>
<td>thanj²¹</td>
<td>‘to hit’</td>
</tr>
<tr>
<td>/falling/</td>
<td>phəŋ⁴¹</td>
<td>‘lance’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tone</th>
<th>Thai</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>/high/</td>
<td>phoŋ⁴⁵</td>
<td>‘abdomen’</td>
</tr>
<tr>
<td>/mid/</td>
<td>thoŋ³³</td>
<td>‘bag (shoulder~)’</td>
</tr>
<tr>
<td>/low/</td>
<td>thoŋ²¹</td>
<td>‘turn upside down’</td>
</tr>
<tr>
<td>/falling/</td>
<td>thoŋ⁴¹</td>
<td>‘to turn back’</td>
</tr>
</tbody>
</table>

Checked syllables

<table>
<thead>
<tr>
<th>Tone</th>
<th>Thai</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>/midʔ/</td>
<td>thauʔ³³</td>
<td>‘to polish’</td>
</tr>
<tr>
<td>/fallingʔ/</td>
<td>theʔ⁴¹</td>
<td>‘to fall’</td>
</tr>
<tr>
<td>/midʔ/</td>
<td>thaiʔ³³</td>
<td>‘thigh’</td>
</tr>
<tr>
<td>/fallingʔ/</td>
<td>thaʔ⁴¹</td>
<td>‘needle’</td>
</tr>
</tbody>
</table>

³ The Thai and English gloss for collecting the vocabulary was conducted by Prof. Dr. Theraphan L-Thongkum, the head of the “Karen Linguistics” project.

⁴ The word khəŋ⁴⁵ ‘chopping board’ is a loanword from Thai, but it has been used for a long time. The older speakers also use this word. Even though it is a loanword, it doesn’t affect the tone shape since it is integrated in the native lexicon. The word thoŋ³³ ‘bag (shoulder~)’ is not borrowed from Thai word thuŋ²⁴ ‘plastic or paper bag’ because Pwo Karen also has the word ta²¹ saŋ³³, which means ‘plastic bag’.
Variation and Change of the Phrae Pwo Karen Vowels and Tones

/midʔ/ phaiʔ ‘skin’
/fallingʔ/ thuʔ ‘pig’

The wordlist of Pwo Karen vowels and tones was recorded directly on to computer using Adobe Audition version 2. Fifteen female informants were divided into three groups: those over 60 years old, those 35-50 years old, and those under 25 years old. The informants were asked to pronounce each test-word three times randomly for each list, with a three-to-five second break between each word. The total number of test tokens was 405 (9 words x 3 times x 15 informants) for vowel analysis, and 810 (18 words x 3 times x 15 informants) for tone analysis.

The formant frequencies were measured at every 10 millisecond interval between 25% - 75% using Praat version 5.1.43. Then, the variation of each vowel within its space was plotted by vowel plot program on a graph for each speaker.

The fundamental frequencies were measured at every 10% of normalized duration using Praat version 5.1.43. The measured fundamental frequencies in Hertz were converted into semitone values. The formula was semitones = 3.32 x 12 x Log (Hz to be translated / Hz reference level). This is to help minimize the variation among the pronunciation of the five female speakers in each group. Microsoft Excel 2007 was used to analyze and plot graphs of the semitone values.

4. Results

4.1 Vowels

The results show the vowel spaces of the nine monophthongs in Phrae Pwo, Karen namely /i e ɛ i ə a u o ɔ/. The formant frequencies of the Phrae Pwo Karen vowels were divided into 3 groups, the over-60 group, the 35-50 group, and the under-25 group, as shown in Figures 1, 2, and 3.

Figure 1 shows that the overall space of the nine monophthongs as spoken by five speakers of the over-60 group is similar. The front vowels /i e ɛ/ occur very close to each other, i.e., with only a little difference in the tongue height position or the first formant frequency (F1) especially for speakers 1, 2 and 4. The central vowel /ɨ ǝ/ and the back vowels /u o ɔ/ occur close to each other, whereas the vowels /a/ appears close to the vowel /ɔ/. Concerning the tongue height position, there are only two low vowels, which are /a/ and /ɔ/.

In terms of the tongue advancement or the second formant frequency (F2), there are front vowels /i e ɛ/, central vowels /ɨ ǝ a/, and back vowels /u o ɔ/. The front vowels occur quite separately from the central and back vowels. It also appears that the vowels /a/ and /ɔ/ occur close to each other, with only a little difference in the tongue advancement position.

5 Only female informants were selected because different gender affects acoustical measurement.
6 Created by Mr. Patavee Chanvivit and thanks to Ms. Supaporn Phalipat for her help in drawing the graphs from the vowel plot program.

7 See the formant frequencies of each vowel in Appendix 1.
Figure 1 Vowel spaces of Phrae Pwo Karen vowels as spoken by five speakers of the over-60 group
Variation and Change of the Phrae Pwo Karen Vowels and Tones

**Figure 2** Vowel spaces of Phrae Pwo Karen vowels as spoken by five speakers of the 35-50 group
Figure 3 Vowel spaces of Phrae Pwo Karen vowels as spoken by five speakers of the under-25 group
Figure 2 shows that the overall space of the nine monophthongs as spoken by five speakers of the 35-50 group seems to be different from that spoken by the over 60 group. Even though the front vowels /i e ɛ/ occur close to one another, it can be clearly seen in speakers 1, 3, and 4 that the vowel /ɛ/ moves downward separately from the vowels /i e/. This means that the difference of tongue height position or the first formant frequency (F1) is wider in these three speakers. The central vowels /ɨ ǝ/ occur close to each other separately from the vowel /a/. It is also noticeable that the back vowel /ɔ/ moves upward in the data from speakers 4 and 5. It can be said that these speakers move the tongue height position higher than the other speakers.

Considering the tongue advancement or the second formant frequency (F2), the tongue position of the vowels /a/ and /ɔ/ occurs separately from each in all of the speakers except for speaker 3. It clearly shows that for the vowel /ɔ/, the back of the tongue moves to a similar position as the vowels /u o/. It is noticeable that the vowels /a/ and /ɔ/ of speaker 3 occur close to each other, with only a little difference in the tongue advancement position which is similar to the over-60 group.

In Figure 3, the overall space of the nine monophthongs as spoken by five speakers of the under-25 group looks similar to that spoken by the 35-50 group. Considering the front vowels, the vowel /e/ moves downward, whereas the vowel /ɔ/ moves upward in the vowel area. The difference of the tongue height position of the vowels /i e ɛ/ is clearer, except for speaker 1. As for the vowel /a/, the tongue moves to the higher position in all of the speakers.

In conclusion, the vowel /e/ moves downward in speakers 3 and 5 of the over-60 group (see Figure 1), in speakers 1, 2, and 4 of the 35-50 group (see Figure 2), and in speakers 2, 3, 4, and 5 of the under-25 group (see Figure 3). The vowel /ɔ/ moves upward in the vowel area as seen in Figure 2 in which the vowel /ɔ/ moves upward in speakers 1, 2, 4 and 5. In Figure 3, the vowel /ɔ/ moves upward in all of the speakers. It looks as if the variation and change occur in Phrae Pwo Karen vowels as clearly seen in the 35-50 group and the under-25 group.

### 4.2 Tones

There are 4 tones in Phrae Pwo Karen, namely, the high tone, mid tone, low tone and falling tone with an allotone in the mid tone and falling tone. Phonetically, the high tone is high level and high rising [44 ~ 45], the mid tone is mid level [33], the low tone is low falling [21], and the falling tone is high falling [41]. The mid tone in checked syllables is [332 ~ 32] and the falling tone is [442 ~ 42].

The semitones converted from fundamental frequencies of each tone as spoken by five speakers of each group were plotted using Microsoft Excel 2007 as shown in Figures 4, 5, and 6.

---

8 See the fundamental frequencies of Phrae Pwo Karen tones of each speaker in each group in Appendix 1 and Appendix 2.
Figure 4 shows that in the over-60 group, in non-checked syllables, the high tone begins at a high pitch and stays level until the end. The mid tone starts at a mid pitch and also stays level until the end. The low tone starts at a mid/low pitch and falls to a low pitch. The falling tone begins at a high pitch and then rises slightly before sharply falling to a low pitch.

In checked syllables, the mid tone starts at a mid/low pitch and stays level before falling slightly at 80% of the duration. The falling tone begins at a high pitch and then sharply falls to a low pitch.

In checked syllables, the mid tone starts at a mid/low pitch and stays level before falling slightly at 80% of the duration. The falling tone begins at a high pitch and then sharply falls to a low pitch.

For the 35-50 group as shown in Figure 5, the acoustic characteristics of the 4 tones are similar to those of the over-60 group. In non-checked syllables, the high tone begins at a high pitch and rises slightly until the end. The mid tone starts at mid pitch and also stays level until the end. The low tone starts at a mid pitch and falls sharply to a low pitch. The falling tone begins at a high pitch and then sharply falls to a low pitch at 50% of the duration. However, it is noticeable that the high tone behaves differently from that of the over-60 group.

In checked syllables, the mid tone has a similar contour as in non-checked syllables. It starts at mid pitch and also stays level until the end. The falling tone begins at a high pitch and stays level until 60% of the duration before falling to a mid pitch.

In Figure 6, in non-checked syllables, the change of the high tone is clearer in the under-25 group. It starts from a mid pitch and rises sharply to the highest pitch of the scale. The acoustic characteristic of the mid tone is mid level starting at a mid pitch and staying level to the end of the duration. The low tone is low-falling starting at a mid pitch and falling sharply to a low pitch. The falling tone is high-falling starting at a high pitch and slightly rising before sharply falling at 60% of the duration.

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9 Solid line represents a non-checked syllable. Dotted line represents a checked syllable.
10 The mid/low pitch means a mid pitch which moves to a low pitch.
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In checked syllables, the mid tone starts at a mid pitch and stays level before falling slightly at the last 10% of the duration. The falling tone begins at a high pitch and stays level until 70% of the duration before falling to a mid pitch.

It looks as if the acoustic characteristics of Phrae Pwo Karen tones as spoken by the 35-50 group and the under-25 group have changed, i.e., the contour of the high tone in non-checked syllables has changed from high level to mid-rising.

5. Conclusion and discussion

The acoustic characteristics of the vowels and tones in the Phrae Pwo Karen spoken by three generations are shown below;

5.1 Vowels

As mentioned in the Introduction, there are nine monophthongs in Phrae Pwo Karen, without length distinction: /i e ɛ i ə a u o ɔ/. The front vowels /i e ɛ/ occur very close to one another, i.e. with only a little difference in tongue height position (F1). The central vowels /i u/ and the back vowels /a o/ occur close to each other, whereas the vowel /a/ appears close to the vowel /o/. See Figure 7.

In Figure 7, it is noticeable that the vowel /o/ starts to move upward in the 35-50 group and obviously changes its position in the under-25 group. This situation might be explained in terms of external factors. If the overall space of Standard Thai vowels (Intajamornrak 2002) and of Tai Yuan vowels is considered, the tongue height position (F1) of the vowel /ɔ/ is similar to the low front vowel /ɛ/ (see Figure 8). Contact with Standard Thai or Tai Yuan might cause the vowel /ɔ/ to shift upward. This evolution is at its clearest in data from speakers 4 and 5 of the 35-50 group (see Figure 2) and also in speakers 3, 4, and 5 of the under-25 group (see Figure 3). A noticeable evolution also affects the front vowel /ɛ/, which moves downward in speakers 1 and 4 of the 35-50 group (see Figure 2) and also in speakers 3 and 4 of the under-25 group (see Figure 3). Speakers 1 and 2 in the under-25 group are not included because their vowels /ɛ/ and /ɔ/ do not have the same tongue height position, and the vowel /ɔ/ also appears close to the vowel /a/.

Figure 6 Semitones of Phrae Pwo Karen tones as spoken by the under-25 group

11 Standard Thai speakers are 45-60 years old. See the word list in Intajamornrak 2002.
12 Only long vowels are considered because the duration of vowels in Phrae Pwo Karen is phonetically similar to the duration of long vowels in Standard Thai and Tai Yuan.
Figure 7 The overall space of Phrae Pwo Karen vowels as spoken by three groups of speakers.

Figure 8 The overall space of Standard Thai long vowels (left) and of Tai Yuan long vowels (right).

The Tai Yuan long vowels were spoken by three female Tai Yuan (Phrae) native speakers between 35-50 years old which can be compared with Standard Thai from Intajamornrak 2002 and this age represents language in the present. The methodology for acoustical measurement of Tai Yuan vowels is the same as for Phrae Pwo Karen vowels. See the wordlist below.

/i:/ /ii/ 'year' /ii/ 'to be' /uu/ 'ditch'
/e:/ /ee/ 'to pour' /oo/ 'big'
/ɛɛ/ 'raft'
/a:/ /aa/ 'to paint' /ɔɔ/ 'neck'

* For the words ‘thee’ ‘thəə’ ‘too’, the informants use these words sometimes and pronounce them with Tai Yuan tones.
Variation and Change of the Phrae Pwo Karen Vowels and Tones

Figure 8 shows the overall space of Standard Thai long vowels and Tai Yuan long vowels. The position of the vowel /ɔ:/ for both Standard Thai and Tai Yuan is closer to the other back vowels /u: ø/ than the vowel /a:/.

Considering the F1, the vowels /ɛ:/ and /ɔ:/ appear in the same tongue height position. Additionally, with regard to the tongue advancement, the vowel /a:/ is a central vowel, while the /ɔ:/ is a back vowel. In language-contact situations, the difference between a language spoken by a majority group and a language spoken by a minority group is one of the factors which bring about language variation and change. Karen is said to be a minority language whereas Tai Yuan is a majority language in Phrae as is Standard Thai, which is a majority language of the country. Thomason (2001: 66) explains that if one of two groups in contact is much larger than the other, the smaller group’s language tends to acquire features from the larger group’s language.

5.2 Tones

Recall that there are four tones in Phrae Pwo Karen, namely the high tone, mid tone, low tone and falling tone. However, based on the over-60 group, the acoustic characteristics of each tone reveal that: the high tone is high level starting at a high pitch and staying level to the end of the normalized duration; the mid tone is mid level starting at a mid pitch and then slightly falling over 75% of the duration; the low tone is mid-falling starting at a mid pitch and sharply falling to a low pitch; the falling tone is high-falling starting at a high pitch and sharply falling to a low pitch. In checked syllables, the mid tone is mid level with the same contour as those in non-checked syllables; the falling tone is high-falling with less degree of pitch change than for those occurring in non-checked syllables.

However, the shape or contour of the four tones as spoken by each group of speakers is very similar except for the high tone. Figure 9 shows that the tonal contour changes from level to rising. In the over-60 group, it begins at a high pitch and stays level to the end point. The high tone of the 35-50 group also starts at a high pitch but continually rises which can be seen in the difference from the onset to the offset. The change is clear in the under-25 group, where it becomes a rising tone with an obvious degree of pitch change or pitch contour. Moreover, the tonal onset is lowered from a high pitch to a mid-high pitch. The acoustic characteristics of the high tone in the under-25 group and some speakers of the 35-50 group seem to be very similar to the high tone of Standard Thai. The Tai Yuan high tone is high-level (Intajamornrak 2011) which is similar to the high tone of the over-60 group. Therefore, in this situation it might not influence the Pwo Karen high tone.

Teeranon and Rungrojsuwan (2009) analyzed the high tone of Standard Thai and found that there are three variants of high tone as spoken by the under-20 group: high level [34], rising with slightly falling [322] and rising [334]. The variant that has the highest frequency distribution is rising [334] (78%) (see Figure 10). Moreover, the pitch height of the high tone

over-60 group  35-50 group  under-25 group

Figure 9 The high tone as spoken by three groups of speakers
as spoken by the under-20 group moves downward from high to mid. Since the young generation studies Standard Thai in school, the high tone of Standard Thai may influence the native high tone.

![High level: Rising with slightly falling Rising](image)

**Figure 10** The high tone variants in the under-20 group (adapted from Teeranon and Rungrojsuwan 2009: 41)

However, if the fundamental frequencies of Phrae Pwo Karen high tones as spoken by each speaker of the group are considered (see Appendix 2), the variation seems to occur in middle age as seen in speakers 1 and 2. It is possible that some Karen speakers at this age went to school and also work in the Khangchak Women’s Weaving Group, so they have a chance to use Tai Yuan and Standard Thai frequently.

In conclusion, the acoustic characteristics of the vowels and tones as spoken by three generations suggest that Phrae Pwo Karen is in the process of changing because of the variation among the three groups. The variation and change seems to be caused by language contact with Tai Yuan and Standard Thai. As Weinreich (1968) said, the bilingual speaker’s relation to the languages that come into contact must be considered in language contact situations. Here, contact with Tai Yuan and Standard Thai is a factor that brings about variation and change in Pwo Karen because of being the majority language of Phrae and the national language. However, as the high tone shows, the situation occurs differently among the different groups of speakers. The over-60 group seems to be more familiar with Tai Yuan than Standard Thai, whereas the speakers of the 35-50 group have a chance to use Standard Thai, so tonal variation can be seen in the latter group. In the under-25 group, they are definitely familiar with Standard Thai because they use it in school and they are also very good at Tai Yuan. Therefore, their language seems to be influenced by both Standard Thai and Tai Yuan.

**Acknowledgements**

I would like to express my gratitude to the Thailand Research Fund (TRF) for financial support of my research through the research project on “Karen Linguistics” and Naresuan University for my travel grant. I would also like to thank Professor Dr. Theraphan Luangthongkum, the head of the project, for her valuable suggestion of my research, Dr. Pittayawat Pittayaporn and Dr. Alexis Michaud for their very useful comments. Last but not least, many thanks go to my Karen informants for their kindness and cooperation.

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### Appendix 1

#### Table 1 The formant frequencies of Phrae Pwo Karen vowels: the over-60 group

<table>
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<th>e</th>
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<th>i</th>
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<th>ə</th>
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<th>u</th>
<th>o</th>
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#### Table 2 The formant frequencies of Phrae Pwo Karen vowels: the 35-50 group

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#### Table 3 The formant frequencies of Phrae Pwo Karen vowels: the under-25 group

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#### Table 4 The fundamental frequencies (Hz) of Phrae Pwo Karen tones: the over-60 group

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#### Table 5 The fundamental frequencies (Hz) of Phrae Pwo Karen tones: the 35-50 group

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#### Table 6 The fundamental frequencies (Hz) of Phrae Pwo Karen tones: the under-25 group

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H = high tone, M = mid tone, L = low tone, F = falling tone
Mʔ = mid tone in checked syllable, Fʔ = falling tone in check syllable
Appendix 2

Figure 1 Fundamental frequencies of Phrae Pwo Karen tones as spoken by the over-60 group
Figure 2 Fundamental frequencies of Phrae Pwo Karen tones as spoken by the 35-50 group
Figure 3 Fundamental frequencies of Phrae Pwo Karen tones as spoken by the under-25 group
FORMANT TRANSITIONS AS EFFECTIVE CUES TO DIFFERENTIATE THE PLACES OF ARTICULATION OF BAN PA LA-U SGAW KAREN NASALS

Karnthida Kerdpol

Abstract

The Sgaw Karen dialect of Ban Pa La–u, Amphoe Hua Hin, Thailand, has four nasals: /m/, /n/, /ɲ/, and /ŋ/, that appear in syllable–initial position. Review of the relevant literature indicates that initial /ɲ/ has been less studied acoustically due to the lack of palatal nasals in the consonant systems of most languages. Thus, this Sgaw Karen dialect is suitable for investigating the place of articulation of nasals.

The acoustic characteristics examined include the duration, intensity, and frequencies of the formants (resonances) of the nasal murmurs as well as the frequencies of the formant transitions into the following vowels /a/ and /ɔ/. The significance of each acoustic characteristic as a place cue has been statistically tested with ANOVA and Tukey’s HSD.

The results confirm the previous findings (Liberman, Delattre, Cooper and Gerstman 1954, Malécot 1956, Recasens 1983, Harding and Meyer, 2003) that transitions provide better cues for differentiating place of articulation for nasals. Furthermore, this study found that among the formant frequencies in a formant transition, the F2 transition provides the most effective cue to identifying the places of nasal articulation, i.e. /ɲ/ has the highest F2 frequency value at the nasal–vowel juncture, followed by /n/, /ŋ/, and /m/, respectively. The relational pattern between F2–F3 transitional directions can also aid in differentiating nasal articulation places; however, the pattern of transitional direction depends on vocalic context. The F2–F3 transitional patterns among the places of articulation clearly differ in the /ɔ/ context. In the case of a following /a/, the F2–F3 transitional patterns for /n/ and /ŋ/ are very similar and do not act as a place cue. Although the second nasal formant (NF2) evinces consistent relational patterns, differences among /m/, /n/, and /ɲ/ are not statistically significant, implying their similarity. Likewise, neither intensity nor duration of nasal murmurs can be used as cues to differentiate place of articulation for nasals.

1. Introduction

In the production of nasal sounds, the oral and nasal cavities are coupled by the lowering of the velum. As a result, the acoustic characteristics of nasal sounds are more complex than those of purely oral sounds. In the case of nasal

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1 This paper was presented at the RGJ Seminar Series LXXXII: Southeast Asian Linguistics organized by The Royal Golden Jubilee Ph.D. Program (RGJ), Thailand Research Fund and Research Institute for Languages and Cultures of Asia, Mahidol University on August 5, 2011. I would like to express my gratitude to Dr. Chutamanee Onsuwan who was the discussant of the session for her valuable comments and suggestions.

2 Ph.D. Candidate, Department of Linguistics, Faculty of Arts, Chulalongkorn University.
consonants, there is an obstruction in the oral cavity, but the velum is lowered, allowing air to flow through the nasal cavity. The nasal cavity acts as the main resonator, while the oral cavity acts as a side branch, absorbing sound energy. According to Ohala (1975), since the nasal cavity is fixed in shape and size, the nasal formants caused by resonance in the nasal cavity are similar for the various places of articulation. The first nasal formant (NF1) is very low in frequency. Formants above the first nasal formant are low in energy. On the other hand, the antiformant corresponding to sound energy being absorbed in the oral cavity varies from one place to another. The shorter the oral tract is, the higher the antiformant frequency value becomes. The antiformant can, then, serve to differentiate place of articulation for the various nasal stops.

Place contrast for nasals has been acoustically and perceptually studied to find what the best cue to place of articulation is. Some studies have found that nasal murmurs consisting of nasal formants and the antiformant act as place cues. Others have argued that transitions provide better cues. However, due to the limited number of languages being examined, only three places of articulation have commonly been investigated, i.e., bilabial, alveolar, and velar. The database compiled by Maddieson and Precoda (1984) reveals that the bilabial nasals are found most frequently in world languages, followed by velar, alveolar, and palatal, in descending order of frequency. Study of palatal nasals has been rare. Fortunately, nasal sounds in the Sgaw Karen of Ban Pa La–u in Hua Hin District are articulated in four places of articulation, i.e., bilabial, alveolar, palatal, and velar, thus offering an excellent opportunity to examine the cross–linguistically rare nasal /ŋ/.

According to Matisoff (2008), the Sgaw Karen language belongs to the Karenic branch of the Tibeto–Burman language family. In Thailand, Sgaw Karen people are mostly found in the northern and western provinces. In this study, the Sgaw Karen dialect spoken at Ban Pa La–u, located in Hua Hin District, Prachuap Khiri Khan Province, has been examined. The population of Ban Pa La–u numbers one thousand one hundred and is made up of Sgaw, Pwo, and Thais. Most of the Karen people are Christian, although some are Buddhist. Their birth places vary; some were born in the village, some in Myanmar and some around the Myanmar–Thailand border. My Sgaw Karen informants speak both Thai and Sgaw. See the sound inventory of the Ban Pa La–u Sgaw Karen in Table 1 and 2.

To find nasal place cues, both nasal murmurs and formant transitions have been widely examined. Some studies have examined data from natural speech, while others have conducted experiments using synthetic speech. The results of these previous studies suggest that formant transitions provide better cues for differentiating place of articulation; however, nasal murmurs also play a place–contrastive role. The relational patterns among the nasal formants and antiformants of nasal murmurs and the formant frequencies of formant transitions reported in these various studies have been fairly consistent.
Table 1 Sgaw Karen Consonant System

<table>
<thead>
<tr>
<th>Manner</th>
<th>Place</th>
<th>bilabial</th>
<th>alveolar</th>
<th>palatal</th>
<th>velar</th>
<th>glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>stop</td>
<td>ph</td>
<td>p</td>
<td>b</td>
<td>th</td>
<td>t</td>
<td>d</td>
</tr>
<tr>
<td>nasal</td>
<td>m</td>
<td>n</td>
<td>j</td>
<td>ɲ</td>
<td>η</td>
<td></td>
</tr>
<tr>
<td>fricative</td>
<td>s</td>
<td></td>
<td>x</td>
<td>ɣ</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>trill</td>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approximant</td>
<td>w</td>
<td>l</td>
<td>j</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Only /ʔ/ can occur in final position.

Table 2 Sgaw Karen Vowel System

<table>
<thead>
<tr>
<th>Height</th>
<th>Advancement</th>
<th>front</th>
<th>central</th>
<th>back</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>i</td>
<td>i</td>
<td>u</td>
<td></td>
</tr>
<tr>
<td>mid</td>
<td>e</td>
<td>ə</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>ε</td>
<td>a</td>
<td>ɔ</td>
<td></td>
</tr>
</tbody>
</table>

Two diphthongs, /ai/ and /au/, are found.

There are four tones in Sgaw Karen:

Tone 1 is a mid tone with the phonetic realization [33] in non–checked syllables.

Tone 2 is a low tone with the phonetic realization [21] or [21] in non–checked syllables.

Tone 3 is a high tone with the phonetic realization [44] in non–checked syllables.

Tone 4 is a falling tone with the phonetic realization [452] in non–checked syllables.
1.1 Nasal murmurs

Nasal murmurs have been found to be potential cues in differentiating the places of articulation in some studies (Malécot 1956, Recasens 1983). Nasal murmurs occur during the closure phase of nasal stop production and consist of nasal formants (NF) and an antiformant (NZ). Nasal formants arise from resonance in the nasal cavity, which functions as the main resonator. Ohala (1975) has argued that nasal formants tend to be stable across different places of articulation due to the fixed size and volume of the nasal cavity. Ohala (1975), Recasens (1983), and Harding and Meyer (2003) state that the first nasal formant (NF1) occurs at about 200–300 Hz and has more energy than other nasal formants, which occur at higher frequencies. Furthermore, the disappearance of energy at certain frequencies is the result of energy absorption in the oral cavity. According to Ohala (1975), the antiformant frequency is inversely proportional to the length of the oral cavity. A longer oral cavity produces a lower antiformant frequency. Comparisons of the nasal murmurs for different places of articulation have shown that the highest to lowest frequency values for NF1 run from /ŋ/ through /ɲ/ and /n/ to /m/. As for the antiformant, /ŋ/ likewise has the highest frequency value, followed by /p/, /t/, and /m/. Moreover, the antiformant lies close to a particular nasal formant at each place of articulation, i.e., NZ is close to NF2 of /m/, NF3 of /n/, NF4 of /p/ and NF4 or higher of /ŋ/. Furthermore, perceptual studies such as Dukiewicz (1967), House (1957), Nakata (1959), Henderson (1978) (as cited in Recasens 1983: 1346), Malécot (1956) have found that the murmurs of /m/ and /n/ were quite effective in allowing identification of place of articulation, with /m/ receiving the highest correct score due to its having the lowest nasal formant and antiformant of all the nasal stops, and Ohala (1975) and Recasens (1983) have claimed that /ŋ/ is distinguishable from /n/ and /ɲ/ due to its higher NF1 value and the lack of an antiformant in the middle of the nasal spectrum.

1.2 Formant transitions

Formant transitions have been proven to be effective cues in distinguishing place of articulation for nasals, especially with respect to the second formant (F2). Formant transitions start from the release of the consonant and move toward the more–or–less steady state of the vowel. F2 has been the focus of place cue studies since its transitional direction and frequency value at the nasal–vowel juncture has proven to be a cue in many acoustic–perceptual studies. Studies on the contrastive role of transitions have shown that transitions following nasal initials differ by places: a rising transition follows /m/; a flat or falling transition depending on vowel type follows /n/ (Liberman et al. 1954, Recasens 1983) a falling (Liberman et al. 1954) or a slightly rising, falling, or flat transition follows /ŋ/ and a falling transition follows /ɲ/ (Recasens 1983). Additionally, some studies have found that the first formant (F1) and third formant (F3) aid in differentiating place of articulation (Recasens 1983, Narayan 2008).

Although F1 is not usually examined because all final nasals show the same falling transition, various studies (Recasens 1983) have found that the degree of fall
differs among the various place of articulation. F1 transitions fall the farthest for /ɲ/ and the least for /ŋ/, with /m/ and /n/ lying in between. This means that /ŋ/ has the highest F1 value at the nasal–vowel juncture, followed by /m/–/n/ and /ɲ/, in that order.

Narayan (2008) has found that the F3 value at the nasal–vowel juncture helps to distinguish between /n/ and /ŋ/, which have similar F2s. Furthermore, Recasens (1983) has found that F3 falls between /n/ and a vowel, while it rises after /ŋ/. However, results for F3 transitions vary from study to study. Some have found that the F3 transition falls for /m/, /n/ and /ŋ/ after vowels and rises for /ŋ/ (Magdics 1969, Vagges, Ferrero, Caldognetto–Magno, and Lavagnoli 1978, Dukiewicz 1967 and Fant 1960, all cited in Recasens 1983: 1347), but Recasens (1983) has found that the F3 transition after vowels falls for /m/ and /ŋ/ but rises for /n/ and /ɲ/.

This study aims to find effective cues for differentiating place of articulation of four initial nasals: /m/, /n/, /ɲ/, and /ŋ/, in the Sgaw Karen dialect of Ban Pa La–u, with the primary focus being the palatal nasal /ɲ/, which has been less studied acoustically. The acoustic parameters that were taken into account were the intensity, duration, and formant frequency of the nasal murmurs and the formant frequency of the formant transitions of /a/ and /ɔ/. Although, a review of the relevant literature shows intensity and duration to be considered generally poor place cues, they were examined in this study to verify the previous claims. The hypotheses of this study are (1) that formant transitions, especially F2, provide better cues for distinguishing place of articulation for nasal stops and (2) that of the four nasals, /n/ and /ŋ/ share the most similar acoustic characteristics.

2. Methods

2.1 Participants

Seven Sgaw Karen females aged between 19 and 43 were recorded. All speakers had Sgaw parents; however, their birth places varied. Some had been born on the Thai–Myanmar border, some had been born in Prachuap Khiri Khan Province, and one had been born in Myanmar. Females were chosen to avoid variation between genders; however, the participants’ ages varied because of the difficulty in finding participants and the limited working time. Given the eight–day time limit, it was hard to find ideal participants since most Sgaw Karen people had to go to work. Therefore, in order to complete the field record on time, I controlled age range as much as possible, and most participants were between 30 and 43 years old, with one speaker of 19 and another of 24. Despite the wide age range, analysis showed that age did not affect the acoustic results.

2.2 Corpus and setup

The corpus consisted of two word lists, one containing words with the vowel /a/ and the other words with /ɔ/. These were chosen because /a/ and /ɔ/ were the only two vowels that co–occurred with all 4 initial nasal stops. In both lists, the four nasals /m/, /n/, /ɲ/, and /ŋ/ were in syllable–initial position. Here are

\[ /ɲ/ \text{ indicates a palatal nasal with an offglide.} \]
the test words with their meanings: in /a/ context, ma1 ‘do’ or ma3 ‘wife’, na1 ‘you’ or na3 ‘ghost’, me2/na1 ‘front’, ηa1/lo2/na1 ‘hire’; in the /ɔ/ context, mɔ3 ‘bite (classifier)’, nɔ3 ‘older sister’, ɲɔ3 ‘easy’ and ɲɔʔ2 ‘dumb’.

In the /a/ context, ma3 and na3 were substituted for ma1 and na1 in case the recorded sound of words with a mid level tone was not of good quality. Although three test words were disyllabic, the syllable under examination in all these words, except ɲɔʔ2, was stressed, which was assumed to have characteristics similar to those of monosyllabic words. Word lists were recorded in mono through a Sony ECM–719 microphone via a Creative USB Sound Blaster Play into a Lenovo notebook at a sampling rate of 16 kHz using Praat version 5.2.2.6. The Praat program was suitable for recording in this study due to the limited time and the surrounding environment. The data were collected over eight days of fieldwork, and the short time and noisy environment, where uncontrolled sounds from rain, animals, passing vehicles, etc. could not be avoided, were not ideal for recording. Therefore, sounds recorded with Praat had to be checked immediately to see if they were clear enough for further measurement and analysis. The speakers were asked to hold the microphone about 5″ from their lips, which pretesting revealed to be the optimal distance, and to pronounce each word in the list at least 5 times. The total number of recorded test words was 280 (8 words × 5 times × 7 participants).

2.3 Acoustic analysis

Two characteristic parts of the acoustic signal were examined: nasal murmurs and formant transitions of the following vowels. Segmentation was based on waveform and wide–band spectrogram. Nasal murmurs were measured from the first periodic pulse to the beginning of the subsequent vowel, which was signalled by a high–amplitude periodic pulse. Formant transitions were measured from the nasal murmur offset to the beginning of the vocalic steady state, signalled by the end of F2 distortion. See Figure 1 for an example of segmentation.

In the nasal murmur phase measurement were taken of acoustic characteristics including intensity, duration, and nasal formant frequency. Murmur intensity was measured at three positions: 0%, 50%, and 100%. These positions were chosen because the transitional directions in all nasal contexts were the same; therefore, it was not necessary to measure at additional positions. Murmur duration, corresponding to the period from the point where the nasal murmurs began with the first periodic pulse to the beginning of the vowel, was measured. Only nasal formants in the /ɔ/ word list were examined due to sound quality. The first, second, and third nasal formants (NF1, NF2, NF3) were measured at 25%, 50%, and 75% of the total nasal murmur duration to ensure that the frequency values truly belonged to the nasal formants. In the formant transition phase, the first, second, and third formants (F1, F2,
Formant Transitions as Effective Cues

**Figure 1** Segmentation of nasal murmurs /n/, transition signalled with ‘t’ and /ɔ/ vowel

![Image of Figure 1](image)

**Table 3** Mean ($\bar{x}$) and Standard Deviation (SD) Values for Intensity (dB) during Murmurs

<table>
<thead>
<tr>
<th>Vocalic Context</th>
<th>Position</th>
<th>Value</th>
<th>Place of Articulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>m</td>
</tr>
<tr>
<td><strong>a</strong></td>
<td>0%</td>
<td>$\bar{x}$</td>
<td>53.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>6.69</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>$\bar{x}$</td>
<td>58.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>$\bar{x}$</td>
<td>62.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>8.83</td>
</tr>
<tr>
<td><strong>ɔ</strong></td>
<td>0%</td>
<td>$\bar{x}$</td>
<td>47.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>4.88</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>$\bar{x}$</td>
<td>54.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>4.54</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>$\bar{x}$</td>
<td>59.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>7.20</td>
</tr>
</tbody>
</table>
F3) were each measured at five positions: 0%, 25%, 50%, 75%, and 100% of the total formant transition duration. These positions were chosen to enable transitional direction graph plotting. The frequencies of the nasal murmur formants and of the formant transitions were obtained automatically using Praat’s formant tracker (LPC analysis).

2.4 Statistics

The significance of each acoustic characteristic as a cue in differentiating place of articulation for nasal stops was statistically tested with ANOVA (analysis of variance) and Tukey’s HSD, a multiple comparison test. ANOVA provides the means to test whether several groups differ significantly. It is suitable only for comparing more than 2 groups. The T–test was not chosen because it is suitable only for comparing 2 groups, resulting in a higher chance of committing an error. However, ANOVA only tells us whether there are statistically significant differences among groups. It cannot identify which pair is significantly different. Therefore, Tukey’s HSD is required to find out which pairs differ significantly.

3. Results

3.1 Intensity

Intensity was not a cue for differentiating place of articulation since it showed no regular pattern either within a vowel or between two vowels. See the mean and SD values for intensity (dB) measured from 0%, 50% and 100% of nasal murmurs in Table 3.

The measurements were submitted to ANOVA and Tukey’s HSD. ANOVA revealed no statistically significant difference among nasal places of articulation in the /a/ context, but there was a statistically significant difference among nasal places at the 50% and 100% position in the /a/ context with p < 0.01. The results of Tukey’s HSD revealed that the intensity values of /m/ were significantly greater than those of /ɲ/ with p < 0.05 at the 50% and 100% position. The intensity value of /m/ was significantly greater than that of /ŋ/ with p < 0.05 at 50%, and the intensity value of /n/ was significantly greater than that of /ɲ/ with p < 0.01 at 100%.

Although some statistically significant differences were found in the /a/ context, they were not consistent across every position in both vocalic contexts. Moreover, when compared with studies examining the acoustic characteristics of stops and nasals with different places of articulation (Trongdee 1987, Tarnsakun 1988), the intensity results showed no regular relational pattern of intensity in different places. Therefore, intensity could not distinguish nasal places of articulation. This result accords with intensity not usually being examined as a potential place cue. This may be due to the great variation in speakers’ speech volume, which is very hard to control.

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6 Nasal formants can be studied by measuring spectra based on observation of nasal formant frequencies or relative spectral energy changes in low– and high–frequency ranges at the nasal release; however, due to time consumption in obtaining the values, spectra measurements were not attempted in this study.
3.2 Duration

The results show that duration was not a place cue. There was no regular pattern of real–time duration across four nasals in two different vocalic contexts. Durations in milliseconds (msec) of nasal murmurs for nasal stops at four different places of articulation are shown in Table 4.

In both vocalic contexts, /ɲ/ had the highest duration value. In the /a/ context, the /ɲ/ duration value was followed by those for /ŋ/, /m/, and /n/, in descending order. In the /ɔ/ context, on the other hand, the duration of /ɲ/ was followed by /n/, /ŋ/, and /m/, in that order. ANOVA revealed no statistically significant difference in the /ɔ/ context; however, the /a/ context produced a statistically significant difference among nasal places of articulation with p < 0.05. Tukey’s HSD then showed that, in the /a/ context, the duration value for /ɲ/ was significantly higher than those for /m/ and /n/, with p < 0.05. These inconsistent results of relational patterns and statistical differences suggest that duration does not distinguish place of articulation for nasal stops. Furthermore, comparison with other works (Trongdee 1987, Tarnsakun 1988, Narayan 2008) did not show a consistent pattern. This confirms the fact that duration is not usually investigated as a potential cue to place differentiation. The variation found across vowels may have been affected by speech rate. The difference in speech rate may lengthen or shorten the duration of nasals in a non–systematic way.

3.3 Nasal formants

Due to sound quality, only nasal formants during nasal murmurs from the /s/ word list were examined. However, the NF3 of nasals preceding /s/ could possibly be noise formants. Of the three nasal formants, only NF2 produced a consistent relational pattern: at all three measurement positions /n/ > /ɲ/ > /m/ > /ŋ/. The mean values for NF2 at different points in the nasal murmur are shown in Table 5.

ANOVA showed some statistically significant differences among nasal places, with p < 0.001 for NF1 and p < 0.01 for NF2, but there was no statistically significant difference among nasal places for NF3. Furthermore, Tukey’s HSD revealed that only the NF2 values for /n/ and /ɲ/ were significantly higher than those of /ŋ/, with p < 0.05 for every measurement position. At 75%, the NF2 value for /n/ was significantly higher than that of /m/, with p < 0.01. As for the other two nasal formants, NF1 and NF3 did not produce regular relational patterns across three different positions. However, Tukey’s HSD revealed some patterns for NF1. The NF1 values for /ŋ/ were significantly greater than those for /m/ and /n/, with p < 0.05 for every measurement position. Moreover, at 50% and 75%, the NF1 values for /ŋ/ were significantly higher than those for /ɲ/, with p < 0.05. The mean values for NF1 at different points are shown in Table 6.

3.4 Formant transitions

Measurements at 0% and 25% were subjected to ANOVA and Tukey’s HSD since the values
### Table 4 Duration of Murmurs in Milliseconds

<table>
<thead>
<tr>
<th>vocalic context</th>
<th>value</th>
<th>place of articulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>m</td>
</tr>
<tr>
<td>a</td>
<td>̅x</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>67</td>
</tr>
<tr>
<td>o</td>
<td>̅x</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>37</td>
</tr>
</tbody>
</table>

### Table 5 Mean and Standard Deviation Values for NF2 during Murmurs

<table>
<thead>
<tr>
<th>vocalic context</th>
<th>position</th>
<th>value</th>
<th>place of articulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>m</td>
</tr>
<tr>
<td>o</td>
<td>25%</td>
<td>̅x</td>
<td>1157.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>227.77</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>̅x</td>
<td>1146.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>181.57</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>̅x</td>
<td>1108.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>148.18</td>
</tr>
</tbody>
</table>

### Table 6 Mean and Standard Deviation Values for NF1 during Murmurs

<table>
<thead>
<tr>
<th>vocalic context</th>
<th>position</th>
<th>value</th>
<th>place of articulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>m</td>
</tr>
<tr>
<td>o</td>
<td>25%</td>
<td>̅x</td>
<td>274.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>78.66</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>̅x</td>
<td>292.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>108.79</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>̅x</td>
<td>317.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>121.21</td>
</tr>
</tbody>
</table>
Formant Transitions as Effective Cues

at both positions were the two closest to the initial nasals and, therefore, had the better potential for displaying the different acoustic characteristics of the four nasals. Consistent relational patterns were found for F2 across nasal places. The F2 values for /ɲ/ were the highest, followed by /n/, /ŋ/, and /m/. Mean values for F2 in all four places of articulation are shown in Table 7.

ANOVA revealed that all four places differed significantly in both vocalic contexts with p < 0.001. However, statistical results for /ɔ/ and /a/ contexts differ according to Tukey’s HSD. In the /ɔ/ context, almost every nasal pair differed significantly, with p < 0.001, except for the /ŋ/-/m/ pair, where /ŋ/ was significantly greater than /m/, with p < 0.05. The statistically significant difference among nasal places in the /ɔ/ context reflects the potential for F2 being a place cue. However, while almost every nasal pair differed significantly in the /a/ context, with p < 0.001, /n/ and /ŋ/ did not differ significantly, reflecting their similarity. The scatter plots in Figure 2 and Figure 3 show F2 and F3 at the 0% position in both vocalic contexts.

As for F1, consistent relational patterns were found at 0% for both vowels and at 25% in the /a/ context. The F1 values for /m/ were higher than those for /n/, /ŋ/, and /ɲ/, in descending order. At 25% in the /ɔ/ context, /n/ values were higher than those for /m/, /ŋ/, and /ɲ/, once again in descending order. However, this did not necessarily lead to significant differences since /n/ and /n/ did not differ significantly. ANOVA revealed a statistically significant difference among nasal places in both vocalic contexts, with p < 0.01. Furthermore, Tukey’s HSD revealed that the F1 values for /m/ and /ŋ/ were significantly higher than those for /ɲ/ at both positions in both vocalic contexts, with p < 0.05. Moreover, the F1 values for /ŋ/ were significantly higher than those for /ɲ/ in the /a/ context, with p < 0.01. At 25% in the /ɔ/ context, the F1 values for /n/ were significantly higher than those for /ŋ/, with p < 0.001. However, the fact that the F1 values for /m/, /n/, and /ŋ/ did not differ significantly, except for one significant difference between /n/ and /ŋ/ at 25% in the /a/ context, shows that F1 cannot be a cue for distinguishing places of articulation.

Furthermore, the F3 values did not show regular relational patterns across nasal places in either vowel context. ANOVA indicated a statistically significant difference among nasal places in the /a/ context and at 0% in the /ɔ/ context, with p < 0.001. Also, Tukey’s HSD revealed that the F3 values of /ɲ/ were higher than those for /ŋ/, /n/, and /m/ at 0% in the /a/ context, where /ɲ/ was significantly higher than the others, with p < 0.001, and /ŋ/ and /n/ were significantly higher than /m/, with p < 0.001. At 25%, the /ɲ/ values were higher than those for /n/, /ŋ/, and /m/; every sound was significantly higher than /m/, with p < 0.01, and /ɲ/ was significantly higher than /ŋ/, with p < 0.05. The relational patterns at both positions in the /ɔ/ context did not show the same pattern within vowels or between two vowels. Tukey’s HSD revealed that at 0%, the /ɲ/ value was significantly higher than those for /m/, /ŋ/, and /n/, with p < 0.001, and that /m/
was significantly higher than /n/, with p < 0.05. At 25%, the /m/ value was higher than those for /ŋ/, /n/, and /ɲ/, but the differences were not statistically significant. The inconsistent relational patterns in both positions, with /m/ having a high F3 value, differing from the patterns in the /a/ context, resulted from high F3 values for /m/ obtained from two informants. If those values were discounted, the relational patterns at each position would be similar to those found in the /a/ context. Additionally, Figures 2 and 3 show that the F3 values at 0% of the formant transitions in both vocalic contexts are very close. The irregular patterns of the F3 frequency do not make F3 a good place cue.

Apart from formant frequency comparisons, F2 and F3 transitional directions were compared across different nasals in both vocalic contexts. The results show that the relation between F2 and F3 transitional directions in the /ɔ/ context helped in distinguishing place of articulation better than in the /a/ context, where F2 and F3 had the same falling transitional directions for /n/ and /ŋ/. Graphs showing F2 and F3 transitional directions for each vowel can be found in Table 8.

Table 8 shows outstanding patterns for /m/ and /ɲ/, namely, F2 and F3 transitions rise for /m/ and fall significantly for /ɲ/. The F2 and F3 transitional directions for /n/ and /ŋ/ are very similar in the /a/ context; however, in the /ɔ/ context, F2 falls in formant transition after /n/, while it rises only a little after /ŋ/, making it look rather flat. F3 rises after /n/, while it rises only a little after /ŋ/, once again making it look rather flat. From these results, it can be concluded that F2 and F3 transitional directions depend on vocalic context.

4. Discussion

The results appear to confirm previous studies’ claims that formant transitions are better cues (Malécot 1956, Delattre, Liberman, and Cooper 1955). Comparisons with other studies reveal that F2 and F3 formant transitional directions after different nasal places were found to have a regular pattern in most studies (Liberman et al. 1954, Delattre et al. 1955, Recasens 1983). On the other hand, formant patterns within the nasal murmur were inconsistent both within this study at different positions and between this study and others (Recasens 1983, Trongdee 1987). In addition, even though the relational patterns for NF2 were regular in all three measurement positions and the NF2s for /n/ and /ŋ/ were significantly higher than those for /ŋ/, the lack of statistically significant difference among /m/, /n/, and /ɲ/ reflects the similarity of NF2 for these nasals. Therefore, NF2 is not considered a good cue to differentiate the places of articulation. This might be explained by the anatomical characteristics of the nasal cavity. According to Ohala (1975), the nasal formants correspond to resonance in the nasal cavity, which is fixed in size and volume; hence, the frequencies resonating in the nasal cavity tend to be very close regardless of place of articulation. Therefore, nasal murmurs probably do not provide place cues. Apart from the results themselves, another difficulty in the attempt to use nasal formants as place cues is that it is complicated to measure nasal formants in natural speech. The nasal formant frequencies appearing on
Table 7 Mean and Standard Deviation Values for F2 (Hz) during Formant Transitions

<table>
<thead>
<tr>
<th>vocalic context</th>
<th>position</th>
<th>value</th>
<th>place of articulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>n</td>
</tr>
<tr>
<td>a</td>
<td>0%</td>
<td>$\overline{x}$</td>
<td>1533.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>285.93</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>$\overline{x}$</td>
<td>1590.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>254.77</td>
</tr>
<tr>
<td>o</td>
<td>0%</td>
<td>$\overline{x}$</td>
<td>1006.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>152.14</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>$\overline{x}$</td>
<td>1032.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>146.12</td>
</tr>
</tbody>
</table>

**Figure 2** F2 and F3 at 0% of formant transitions in the /a/ context

**Figure 3** F2 and F3 at 0% of formant transitions in the /o/ context

In Figure 2, the F2s of /n/ and /ɲ/ overlap greatly. In Figure 3, there was a clearer grouping of F2s for each place of articulation; however, although /ɲ/ somewhat overlapped with /m/, the statistic result indicated their difference.
Table 8 Mean Values of F2 and F3 during Formant Transitions and F2 and F3 Transitional Directions Following Four Initial Nasals in the /a/ and /o/ Contexts

<table>
<thead>
<tr>
<th>place of articulation</th>
<th>vocalic context</th>
<th>formant frequency (Hz)</th>
<th>position of formant transition</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0%</td>
<td>25%</td>
</tr>
<tr>
<td>m</td>
<td>a</td>
<td>F3</td>
<td>3136.61</td>
<td>3223.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>1533.37</td>
<td>1590.03</td>
</tr>
<tr>
<td></td>
<td>o</td>
<td>F3</td>
<td>3319.62</td>
<td>3402.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>1006.97</td>
<td>1032.57</td>
</tr>
<tr>
<td>n</td>
<td>a</td>
<td>F3</td>
<td>3407.83</td>
<td>3400.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>1987.82</td>
<td>1977.05</td>
</tr>
<tr>
<td></td>
<td>o</td>
<td>F3</td>
<td>3121.43</td>
<td>3326.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>1608.90</td>
<td>1532.44</td>
</tr>
<tr>
<td>ŋ</td>
<td>a</td>
<td>F3</td>
<td>3669.07</td>
<td>3498.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>2620.41</td>
<td>2514.19</td>
</tr>
<tr>
<td></td>
<td>o</td>
<td>F3</td>
<td>3651.34</td>
<td>3312.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>2697.74</td>
<td>2464.24</td>
</tr>
<tr>
<td>ŋ</td>
<td>a</td>
<td>F3</td>
<td>3465.31</td>
<td>3386.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>1986.07</td>
<td>1975.36</td>
</tr>
<tr>
<td></td>
<td>o</td>
<td>F3</td>
<td>3385.39</td>
<td>3388.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F2</td>
<td>1150.80</td>
<td>1161.45</td>
</tr>
</tbody>
</table>
the spectrum were neither clear nor consistent throughout the nasal murmur phase, and it was hard to separate noise frequencies from those of nasal formants.

F2 being an effective cue is consistent with other works (Delattre et al. 1955, Recasens 1983, Harding and Meyer 2003). Acoustic–perceptual studies have found the presence of certain F2 transitional directions at each place of articulation to be essential for correct place identification. The transitional direction rises after /m/, falls after /n/ and /ŋ/, and either falls or lies rather flat after /ɲ/, depending on which vowel follows. The F2 transitional directions of labial, alveolar, and velar nasal consonants arrived at in my research agree with previous studies on transitional directions of corresponding stops (Delattre et al. 1955, Pickett 1980).

The frequency values for F2 at the nasal–vowel juncture in the /a/ context in the present study were similar to the results achieved by Recasens (1983), in which /ɲ/ had the highest value, /m/ had the lowest value, and the values for /n/ and /ŋ/ fell in between. The difference is that, in Recasen’s study, /n/ and /ŋ/ were differentiated because the F3 of /ɲ/ rose before vowels. In contrast, I found the F3 of /ɲ/ to fall in a manner similar to /n/. However, the F2 values for /n/ and /ɲ/ in the /ɔ/ context differed significantly. Both the F2 values and transitional directions, then, aid in contrasting places of articulation. F3 showed more than one pattern. This can be seen in the case of the F3 transitional directions of /ɲ/ which differed in the /a/ and /ɔ/ contexts. Moreover, the F3 values of /n/ and /ɲ/ which helped distinguish both nasal places in Narayan (2008) did not differ significantly in the present study. Therefore, it could not help differentiate alveolar and velar places of articulation.

F1 is not an effective cue because the patterns are not consistent across studies. A comparison of F1 relational patterns between the present study and the literature review in Recasens’s study (1983) shows different patterns. In Recasens’s paper, /ɲ/ had the highest F1 value, followed by /m/ or /n/ and /ŋ/. In the present study, in contrast, /n/ had the highest F1 value, followed by /ɲ/, /ŋ/, and /ŋ/ in descending order. These inconsistent patterns may reflect language–specific traits or the ineffectiveness of F1 as a place cue. However, the lowest F1 value of /ɲ/ can be explained by the oral constriction/F1 rule which says that “the frequency of F1 is lowered by any constriction in the front half of the oral part of the vocal tract, and the greater the constriction, the more the F1 is lowered.” (Pickett 1980). In producing a palatal nasal /ɲ/, the tongue moves towards the hard palate, forming a constriction at the palate; hence, the F1 value decreases. Furthermore, the rising of the F1 during formant transitions after nasals likewise accords with the oral constriction/F1 rule, which also applies to constriction at the lips or teeth. In producing nasal consonants, oral constrictions occur in the front half of the mouth or at the lips, whereas there is no constriction in the oral cavity when producing vowels. Therefore, F1 is lower in nasals than in vowels, and the transitional direction is upward.

The transitional directions of F2 can be explained by the relationship between F2
and vocal--tract length. A sound produced in a longer vocal tract has a lower formant frequency. In producing /n/, /ɲ/, and /ŋ/, there is an obstruction within the oral cavity, causing the resonating chamber to be shorter; thus, the F2 rises. On the other hand, during vowel production, there is no obstruction, so the vocal tract is longer. Therefore, the F2 of a vowel is lower than that of nasal consonants. Consequently, when a vowel follows a nasal stop, F2 falls during the transition phase. This is true in the /a/ context but not in the /ɔ/ context. In the /ɔ/ context, the F2 rises only a little after /ŋ/, making it look rather flat. This might be because in producing both /ɔ/ and /ŋ/, the tongue moves toward the velum, even touching it for /ŋ/, so their places of articulation are rather similar. This may result in only minor changes of the vocal tract, so the F2 values for /ɔ/ and /ŋ/ are close, producing a flat transition. In the case of /m/, the resonating chambers of /m/ and vowels seem to have close to the same vocal--tract length, so the length of the vocal tract may not be the reason why the F2 of /m/ is lower than that of the following vowel. This may, instead, be explained by the lip closure which results in a lowering of formant frequencies (Ladefoged 1993). Hence, the F2 of /m/ is lower than that of the following vowel. Consequently, the formant rises from low to high, during the nasal--to--vowel transition phase.

To obtain more concrete results, future research should study both formant transitions in more vocalic contexts and stops at corresponding places of articulation. This would help confirm the general characteristics of each place of articulation found in nasal place cue studies. Additionally, formant transitions are noticeably easier to analyze due to the clarity of formant frequencies during formant transitions. In contrast, nasal murmurs are much less clear due to sound quality and the characteristics of the nasal murmurs themselves. Nasal formants are hard to determine since the formant frequencies shown on the spectrogram are not continuous and they can be altered by noise formants. Moreover, the location of antiformants cannot be specified due to sound quality. This situation can probably be overcome by using extra--high--quality recording equipment; however, recording during fieldwork makes it hard to avoid surrounding noise.

**Acknowledgements**

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**References**


INITIAL CONSONANT VOICING PERTURBATION OF THE FUNDAMENTAL FREQUENCY OF ORAL VOWELS AND NASAL VOWELS: A CONTROVERSIAL CASE FROM BAN DOI PWO KAREN

Phanintra Teeranon

Abstract

This paper aims to analyze the acoustic characteristics of initial consonant voicing perturbation of the fundamental frequency of oral vowels and nasal vowels of Ban Doi Pwo Karen. Three age groups of informants were selected: over-sixty years old (>60), middle aged (35-45), and under-twenty years old (<20). The acoustic analysis method was employed to analyze the mean vowel duration (msec), mean vowel amplitude (dB), and mean vowel fundamental frequency (Hz). The results show that voiceless initial consonants tend to cause a lower fundamental frequency than that of the voiced initial consonants. This has excited controversy concerning the tonogenesis theory of initial voicing perturbation on vowels. However, it was later found that the vowels followed by voiceless initial consonants were breathy and it was the voice register of vowels that caused the low fundamental frequency values. In contrast to other studies, the nasal vowels were not always higher in fundamental frequency when compared to oral vowels. In all age groups, nasal vowels following either voiceless or voiced consonants were found to be higher in fundamental frequency than oral vowels, except in the younger age group where the fundamental frequency of nasal vowels following voiced consonants was lower than that of the oral vowels following voiced consonants.

1. Introduction

According to linguistic classification (Grimes 1988), the languages spoken in Southeast Asia (SEA) can be grouped into five language families: Tai-Kadai (e.g. Thai); Miao-Yao (e.g. Miao, White Hmong); Sino-Tibetan (e.g. Chinese, Burmese); Austroasiatic or Mon-Khmer (e.g. Vietnamese, Mon, Khmer); and Austronesian (e.g. Malay, Javanese). The languages in these five families contain 3 main variations and are classified as the following: tonal languages (e.g. Thai, Chinese); non-tonal languages (e.g. Malay, Indonesian); and register languages (e.g. Chong, Mon). The distinctive feature of Tai-Kadai, Miao-Yao and Sino-Tibetan is tone. In contrast, most of the Mon-Khmer and Austronesian languages are non-tonal languages. At present, however, a number of non-tonal languages and register languages, such as some of the languages of New Caledonia in the Austronesian family and some Khmer dialects in the Mon-Khmer family, have been found to have changed from a stage of tonelessness to that of a tonal language. Some of the present tonal languages have also been found to have shifted their number of tones, that is to say, increasing the number of tones or decreasing the number of tones. This process of transformation is widely discussed as tonal evolution or the tonogenesis theory (Matisoff 1973).

In the year 1954, Haudricourt (1954) claimed that the Vietnamese language,
which is tonal, had derived its tones from its non-tonal ancestral language. Therefore, he proposed that Vietnamese should be classified as a language in the Mon-Khmer family, not as it had previously classified, Sino-Tibetan. He argued that the main influences causing tone birth in the Vietnamese language had been the loss of initial and final consonants (See Table 1). Since then, Haudricourt’s proposal has been broadly verified by linguists (Matisoff 1973, Maddieson 1984, L-Thongkum 1988, L-Thongkum et al. 2007, Thurgood 2007, etc.). Following this, others have proposed new influences that give birth to tones, for instance, the influence of the high-low dimension of vowels. Up to the present, linguists have discovered the various influences of consonants and vowel quality on the tonal evolution of the five Southeast Asian language families. These influences are: 1. Internal factors, (i) monosyllabicization (ii) initial consonants (iii) vowel quality (iv) final consonants, and 2. external factors. Both internal and external factors have been claimed, seemingly, as universal phenomena.

Data from published studies proves SEA languages to have developed tones by a similar influence of consonants and vowels. The most established factor causing tone birth and development is initial consonant voicing; the voiced consonant changing to a voiceless consonant causing a low pitch or low tone in the later state. This is accepted to be a universal phenomenon by linguists studying SEA languages. However, an uncommon phenomenon has emerged from a dialect of Cantonese, T’iensin, in which a high tone was found to have developed from an initial voiced consonant. This was reported in 1977 (Li 1977). In the Pwo Karen of Ban Doi, Chiangrai, the identical phenomenon seems to be appearing in some words. It has been observed that an initial voiceless consonant has initiated a lower tone, while a voiced initial consonant has initiated a higher tone. This corresponds to what had been found in T’iensin. Therefore, the objective of this study is to attest to the fundamental frequency behaviour of vowels influenced by initial consonant voicing in Ban Doi Pwo Karen. This study intends to investigate pitch behaviour in the vowels following voiceless and voiced initial consonants, i.e to investigate whether or not the voiceless consonant induces a high pitch, while the voiced consonant induces a low pitch.

2. Literature review

Tonogenesis is the study of tone evolution or tone development in languages, especially in Southeast Asian languages. Prior to linguistics publishing linguistic results, many comparativists tried to reconstruct a proto-language to demonstrate that languages may form more contrastive pitches—that is, tones—through changes in the initial and final consonant features in their parent languages. This concept was first introduced by Przyluski (1924). A classical model of tonal evolution has been proven in the Vietnamese language by Haudricourt (1954) and has later been clarified by Matisoff (1973).

According to Table 1, the Vietnamese language in the early 6th century was a non-tonal language. Its syllables during this period were of (i) the open type, ending in a vowel /*-∅/ or a nasal consonant /*-N/, and (ii) the closed type, ending in a fricative /*-ʔ/ or a glottal stop /*-ʔ/. There were, in addition, two types of voicing distinction for initial consonants:
voiceless /p-/ and voiced /b-/. The loss of final consonants, */-N/, */-h/, */-ʔ/, caused phonologically distinctive pitches or tones to emerge, namely level, falling and rising tones, as shown in Table 2.

By the end of the 12th century, the number of tones had increased to six through the loss of initial consonant voicing, as shown in Table 3. As the voiced initial consonants lost their voicing, */b-/ > */p-/, low and high tones emerged to avoid homophones. Tones emerged to replace consonant voicing and to differentiate word meanings. That is to say, when */p-/ became /p/, a high tone resulted, and when */b-/ became /p/, a low tone resulted.

The study of tonal evolution or tonogenesis has developed into a long progression, following the statement of the theory of consonant effect on the development of contrastive tones in the Vietnamese language.

Recently, Thurgood (2007) revised the model of Haudricourt (1954); explaining that pitch assignment occurs not from the consonant-based account but from the laryngeal-based or voice quality. This is due to instability in assigning pitch to the syllable from initial consonant types and final consonants.

In the case of initial consonants, it is argued, it is not Haudricourt’s initial consonant types but the voice quality, breathy voice, tense voice and clear voice, that assigns pitch to the syllable. Mostly, a breathy voice induces low pitch, a tense voice high pitch and a clear voice mid pitch.

Considering final consonants, laryngeal features and final consonants are considered to give birth to pitch contour. Glottal fricatives, */-h/ or glottal stops, */-ʔ/ alone are not the primary cause of falling or rising pitch but abrupt glottal stops [-ʔ abrupt] and [-h nonbreathy] relate to the raising of pitch or to a high pitch and a creaky glottal stop [-ʔ creaky] and a breathy final -h [-h breathy] relate to the lowering of pitch or a low pitch (Thurgood 2007).

In short, linguists have become aware of many universal phenomena which are thought to give birth to tones: 1. internal factors, (i) monosyllabization (ii) initial consonants (iii) vowel quality (iv) final consonants, and 2. external factors.

2.1 Internal factors

2.1.1 Monosyllabization

According to Matisoff (1973), languages whose basic syllable structures are monosyllabic in form are likely to develop tones. Most of the words in a language consist of stressed and unstressed syllables. An unstressed syllable tends to drop more than a stressed one (Thach 1999). This may possibly result in the creation of monosyllabic words and even bring homophones into a language. However, languages create tones to distinguish word meanings and also to avoid having homophones. Several studies have regarded monosyllabization as the source of tone birth in the five language families of SEA (Henderson 1982, L-Thongkum 1984, Matisoff 1973, Teeranon 2008, Thach 1999, Thurgood 1999). Table 4 examines monosyllabization in the Kiengiang Dialect of the Khmer language. In the case of the unstressed syllable, the first syllable of each word tends to drop and may result in monosyllabic words.
Table 1 Tonal development of the Vietnamese language in the early 6th century (non-tonal)

<table>
<thead>
<tr>
<th>Initial consonants</th>
<th>Final consonants</th>
<th>/<em>-∅/, /</em>-N/</th>
<th>/*-ʔ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless /*-p/-</td>
<td>pa, paN</td>
<td>pah</td>
<td>paʔ</td>
</tr>
<tr>
<td>Voiced /*-b/-</td>
<td>ba, baN</td>
<td>bah</td>
<td>baʔ</td>
</tr>
</tbody>
</table>

(adapted from Haudricourt 1954 and Matisoff 1973)

Table 2 Three tones of the Vietnamese language around the 12th century

<table>
<thead>
<tr>
<th>Initial consonants</th>
<th>Tones</th>
<th>Level</th>
<th>Falling</th>
<th>Rising</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless /*-p/-</td>
<td></td>
<td>pa</td>
<td>pa</td>
<td>pa</td>
</tr>
<tr>
<td>Voiced /*-b/-</td>
<td></td>
<td>ba</td>
<td>ba</td>
<td>ba</td>
</tr>
</tbody>
</table>

(adapted from Haudricourt 1954 and Matisoff 1973)

Table 3 Six tones in the Vietnamese language by the end of the 12th century

<table>
<thead>
<tr>
<th>Tones</th>
<th>Level</th>
<th>Falling</th>
<th>Rising</th>
</tr>
</thead>
<tbody>
<tr>
<td>/<em>-p/- &gt; /</em>-p/- &gt; High tone</td>
<td>pa</td>
<td>pa</td>
<td>pa</td>
</tr>
<tr>
<td>/<em>-b/- &gt; /</em>-p/- &gt; Low tone</td>
<td>pa</td>
<td>Pa</td>
<td>pa</td>
</tr>
</tbody>
</table>

(adapted from Haudricourt 1954 and Matisoff 1973)

Table 4 Monosyllabicization in the Kiengiang Dialect of the Khmer language

<table>
<thead>
<tr>
<th>Standard Khmer</th>
<th>Kiengiang Dialect</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ciɲcra:m</td>
<td>cram</td>
<td>‘to chop’</td>
</tr>
<tr>
<td>cɑngkra:n</td>
<td>kra:m</td>
<td>‘kitchen’</td>
</tr>
</tbody>
</table>

(adapted from Thach 1999: 84)

Table 5 A model of the influence of initial consonants on the development of tone

<table>
<thead>
<tr>
<th>Proto-language, Non-tonal language</th>
<th>Non-tonal language</th>
<th>Tonal language</th>
</tr>
</thead>
<tbody>
<tr>
<td>*pv</td>
<td>&gt; pv</td>
<td>&gt; pvv</td>
</tr>
<tr>
<td>*bv</td>
<td>&gt; bv</td>
<td>&gt; pvv</td>
</tr>
</tbody>
</table>
Linguists such as Abramson (2004), Brunelle (2005), Matisoff (1973), and Michaud (2012) have also revealed that monosyllabicization results in tonal contrast across Southeast Asian language families.

### 2.1.2 Initial consonants

One of the most documented studies of tonal evolution concerns the influence of initial consonants on the development of tones. An illustration of the influence of initial consonants on the development of tones in SEA can be found in Table 5. Symbol ‘p’ represents a voiceless initial consonant, ‘b’ represents a voiced initial consonant, ‘v’ represents a vowel, /̀/ is a low tone, and /́/ is a high tone.

Table 5 shows a loss of initial contrast and refers to the original initial consonants in the ancestral language (Proto-language). When the voicing distinction of the initial consonant in the Proto-language is lost, a higher tone /́/ seemingly appears in words formerly beginning with Proto-voiceless initial consonants as compared with words beginning with proto-voiced initial consonants accepting the result of the lower tone /̀/.

Matisoff (1973) often refers to examples from the Tai-Kadai language family. One of these, the Thai language, is depicted in Table 6:

Another interesting case of the influence of initial consonants on tone birth is found in the Khmer language. The Phnom Penh Khmer was discovered for the loss of its cluster /r-/ in /Cr-/ which also causes a falling-rising tone -- as in Table 7:


### 2.1.3 Vowel quality

#### 2.1.3.1 Voice register of vowels

Register is phonologically defined as a prosodic system (Henderson 1952), a contrast between phonation types. For example, the modal voice vowel and the breathy voice vowel in the Suai language spoken in Thailand:

**Modal voice vowel**

/luː/  ‘to howl’
/
luːm/  ‘a mouthful’

**Breathy voice vowel**

/luː/  ‘thigh; the lap’
/
luːm/  ‘to gobble chunks of food’

(adapted from Abramson, L-Thongkum, Nye 2004: 148)

Phonetically, register is called phonation type; it describes a cluster of laryngeal and supralaryngeal activities, one property of which may be dominant and the rest secondary. The term register is generally understood to mean a ‘register complex’, one property of which may be dominant and the rest secondary. The complex of phonetic characteristics typically includes such features as phonation type, pitch, vowel quality, vowel length, loudness and
perhaps others (Abramson, Thongkum, and Nye 2004: 147).

The register of vowels is regarded as the transcending stage (or middle point) for SEA non-tonal languages changing to tonal ones. Apparently, an example is derived from the Mon-Khmer language family dialects -- Khmu (Premsrirat 2003).

According to Table 8, the Eastern Khmu dialect retains its voicing distinction of initial consonants, whereas dialect 1 of Western Khmu shows the register distinction of vowels. However, dialect 2 and dialect 3 of Western Khmu drop both initial voicing distinction and the register of vowels. With the loss of these two features, dialect 2 has now substituted low tones.


2.1.3.2 High and low vowel dimension

In Southeast Asian languages, high vowels, e.g. /i/, have a higher pitch than low vowels, e.g. /a/, in non-tonal languages such as Malagasy (Whalen and Levitt 1995), an Austronesian language; in register languages such as Paroak (Watkins 2002), a Mon-Khmer language; and in tonal languages such as Thai (Mohr 1971, Zee 1980, Bunphan et al. 1982, Svantesson 1988, Rose 1997). All of the findings conclude that high vowels cause a higher fundamental frequency than that of low vowels.

However, Lehiste (1970) and Teeranon (2008) have revealed that the influence of initial consonants on the following vowels is much greater than the effect of the voice register of the vowel itself. It can be inferred that after the monosyllabicization process or the change of syllabic structure to the monosyllable (Matisoff 1973), tones occurred as the voicing states of initial consonants influenced by the pitch of the following vowels, not higher and lower pitches within the vowels.

2.1.3.3 Vowel length

Hu, a language of the Mon-Khmer family, has been confirmed to have 2 tones, i.e. high tone vs. low tone which developed from the loss of vowel length. According to Table 9, the ancestral language of Hu (Proto-Palaungic) had both short vowels and long vowels. In the middle stage of Hu tonal evolution, the short vowels remained short but the long vowels began to lose their length. Following this, the new short vowels merged with the original short vowels. To compensate for the loss of vowel length, two tones have developed in Hu as shown in Table 9. (Diffloth 1980, Svantessen 1991).

Over the past 20 years, the birth of tones in many minority languages of the Mon-Khmer (Diffloth 1980, Svantessen 1991) and Sino-Tibetan language families (Sun 2003) have been found to indicate this type of influence. Recently, SEA languages such as Tai-Kadai, Miao-Yao, and other unmentioned categories, have developed tones through the loss of vowel length (L-Thongkum et al. 2007).
Table 6 The influence of initial consonants on tones in the Thai language.

<table>
<thead>
<tr>
<th>Proto-Tai</th>
<th>Ancient Thai</th>
<th>Modern Thai</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>*hmaa</td>
<td>&gt; hmaa</td>
<td>&gt; mǎa</td>
<td>‘a dog’</td>
</tr>
<tr>
<td>*maa</td>
<td>&gt; maa</td>
<td>&gt; maa</td>
<td>‘to come’</td>
</tr>
</tbody>
</table>

(adapted from Robinson 1994: 16)

Table 7 The lost of cluster in the Phnom Penh Khmer

<table>
<thead>
<tr>
<th>Standard Khmer</th>
<th>Phnom Penh Khmer</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>pram</td>
<td>pʰeam</td>
<td>‘five’</td>
</tr>
<tr>
<td>triw</td>
<td>tʰǐw</td>
<td>‘correct’</td>
</tr>
</tbody>
</table>

(adapted from Guion and Wayland 2004: 1)

Table 8 The loss and the replacement of register distinction in Khmu dialects

<table>
<thead>
<tr>
<th>Non-tonal language</th>
<th>Register language</th>
<th>Tonal language</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Khmu</td>
<td>Western Khmu</td>
<td>Western</td>
<td>‘fermented rice’</td>
</tr>
<tr>
<td></td>
<td>Dialect 1</td>
<td>Khmu Dialect 2</td>
<td>‘to cut the trees’</td>
</tr>
<tr>
<td>buc</td>
<td>pʊːc</td>
<td>pʰʊːc</td>
<td>‘to chew’</td>
</tr>
<tr>
<td>bok</td>
<td>pok</td>
<td>pʰɔk</td>
<td>‘to weigh’</td>
</tr>
<tr>
<td>buːm</td>
<td>Ɂʊːm</td>
<td>pʰʊm</td>
<td>‘stone’</td>
</tr>
<tr>
<td>jaŋ</td>
<td>Ɂaŋ</td>
<td>cʰaŋ</td>
<td></td>
</tr>
<tr>
<td>glaːŋ</td>
<td>klaːŋ</td>
<td>kʰlaːŋ</td>
<td></td>
</tr>
</tbody>
</table>

(adapted from Premsrirat 2003: 25)

Table 9 The loss of vowel length in the Hu language

<table>
<thead>
<tr>
<th>Proto-Palaungic</th>
<th>Hu</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>*yam</td>
<td>&gt;</td>
<td>*yam</td>
</tr>
<tr>
<td>*yaam</td>
<td>&gt;</td>
<td>*yam</td>
</tr>
</tbody>
</table>
2.1.4 Final consonants

The influence of final consonants on the development of tones is widely observed in vowels preceded by a glottal stop consonant /*ʔ/ and a glottal fricative consonant /*h/*. The loss of /*ʔ/ tends to develop into a higher tone than those preceded by /*h/*. This phenomenon is often found in Middle Chinese (Hombert et al. 1979; Sagart 1993), Jingpaw spoken in Myanmar (Maran 1973) and Usat which is an Austronesian language spoken in Hainan (Thurgood 1996), and so forth.

However, not all languages conform to this hypothesis, for instance, in Eastern Chamic languages (Phu Van Han et al. 1992; Thurgood 1993) and some dialects of Tibetan (Mazaudon 1977; Sun 2003), the loss of the final /ʔ/ causes a low tone. As stated in Thurgood (2007) laryngeal features and final consonants are considered to give birth to pitch contour, so it is not only the final consonants that play a major role in pitch but also the phonation types of the vowels. This corresponds to the results found in L-Thongkum (1989, 1990) where it was pinpointed that the voice register of vowels plays a major role in causing tone birth.

Above all, the influence of final consonants, proven and verified, appears universally as a common phenomenon in SEA languages (Lohde 2003, Thavisak 2001, Watkins 2002).

2.2 External factors

The external factor, or language contact, is the only factor unlikely to be attested to within the frame of the tonogenesis theory. According to Matisoff (1973), the Chinese language is the only true tonal language in the whole of SEA. The Chinese language, through its own internal factors, has developed its tones. In other words, tones did not emerge out of language contact. On the other hand, Tai-Kadai, Miao-Yao and the Austronesian language families have been claimed to have developed tones by interweaving parts from internal factors with language contact.

A number of observations have also been made by Thurgood (1996, 1999). In Western Cham, an Austronesian Language, tones have developed following influence from the Khmer language and Eastern Cham or Phan Rang Cham is transforming into a tonal language through the influence of Vietnamese. Additionally, the Chamic language which is known as Usat, a language of Hainan, has given birth to tones with the presence of the Chinese language.

3. Methodology

3.1 Context and language

This research was conducted at Ban Doi (Doi Village), Tambon Chokchai (Chokchai Sub-district), Amphoe Doi Luang (Doi Luang District), Chiang Rai Province, Thailand. Pwo Karen is the main language spoken by the villagers. The approximate population is 693 (356 males and 377 females). According to the phonological study, the sound system of Pwo Karen of Ban Doi is as follows (See Table 10 and Table 11):

Synchronic analysis reveals that there are 4 tones in the smooth syllables, high, mid, rising and low. The other 2 allotones are in the checked syllables, low?, and high?.

46
Table 10  Pwo Karen of Ban Doi consonants

<table>
<thead>
<tr>
<th>Manners of articulation</th>
<th>Bilabial</th>
<th>Labiodental</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiceless un aspirated</td>
<td>p</td>
<td>t</td>
<td>c</td>
<td>k</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>voiceless as</td>
<td>ph</td>
<td>th</td>
<td>ch</td>
<td>kh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiced</td>
<td>b</td>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>voiceless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>j</td>
<td>x</td>
<td>h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>voiced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td>η</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td></td>
<td>j</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11  Pwo Karen of Ban Doi vowels

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>i</td>
<td>i, ī, u, ū</td>
</tr>
<tr>
<td>Mid</td>
<td>e, ē</td>
<td>a, ē, o, ō</td>
</tr>
<tr>
<td>Low</td>
<td>e, ē</td>
<td>a, ē, o, ō</td>
</tr>
</tbody>
</table>

/ai, au, ui, iə, ia, əu, əi, īa, əi/

Table 12  Mean duration values, Standard deviation (SD) and t-test of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Oral vowels (msec)</th>
<th>Nasal vowels (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Voiceless onset</td>
<td>Voiced onset</td>
</tr>
<tr>
<td>&gt;60</td>
<td>224.86 SD = .73</td>
<td>273.89 SD = .77</td>
</tr>
<tr>
<td>35-45</td>
<td>288.50 SD = .67</td>
<td>329.50 SD = .89</td>
</tr>
<tr>
<td>&lt;20</td>
<td>327.48 SD = .92</td>
<td>343.34 SD = .71</td>
</tr>
</tbody>
</table>
3.2 Wordlist

The wordlist used to attest to the influence of voiceless and voiced initial consonants followed by oral vowels contains 16 words; that is 8 words for voiceless initial consonants and 8 words for voiced initial consonants. Voiceless and voiced initial consonants followed by nasal vowels are represented by 8 words, i.e. 4 words contain voiceless initial consonants and 4 words voiced initial consonants. In the case of voiceless consonant onset, the glottal stop /Ɂ/ has been regarded as a voiceless stop like /p/, /t/, /c/, /k/. This is due to /Ɂ/ being classified as the same phonation type as the remaining sounds, voiceless, in that there is no vibration of the vocal folds (Ladefoged 1999: 609). Almost all of the vowels in the wordlist were low vowels to diminish vowel height effect on the pitch. Tones on the vowels are mid tone (no tone mark) to avoid pitch perturbation. Moreover, it appears that in the wordlist not only monosyllabic words were selected but also the last syllables of disyllabic and sesquisyllabic words because the last syllables receive a prominent sound or stress as in the monosyllabic words. The wordlist is as follows:

<table>
<thead>
<tr>
<th>Oral vowels</th>
<th>Voiceless</th>
<th>Voiced</th>
</tr>
</thead>
<tbody>
<tr>
<td>ke ‘to be’</td>
<td>me ‘birth scar’</td>
<td></td>
</tr>
<tr>
<td>?e ‘to love’</td>
<td>thàYe ‘chilli’</td>
<td></td>
</tr>
<tr>
<td>?a ‘much’</td>
<td>ba ‘cheap’</td>
<td></td>
</tr>
<tr>
<td>?aka ‘to grill’</td>
<td>lola ‘a kind of tree’</td>
<td></td>
</tr>
<tr>
<td>mapha ‘to rent’</td>
<td>?aña ‘meat’</td>
<td></td>
</tr>
<tr>
<td>sa ‘to breathe’</td>
<td>phaipà ‘skin’</td>
<td></td>
</tr>
<tr>
<td>?o ‘to have’</td>
<td>nâsàba ‘pity’</td>
<td></td>
</tr>
<tr>
<td>baco ‘wet’</td>
<td>kàdi ‘dull’</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nasal vowels</th>
<th>Voiceless</th>
<th>Voiced</th>
</tr>
</thead>
<tbody>
<tr>
<td>natâ ‘naughty’</td>
<td>sanâ ‘to forget’</td>
<td></td>
</tr>
<tr>
<td>mǐʔa ‘burn’</td>
<td>cham5 ‘to think’</td>
<td></td>
</tr>
<tr>
<td>sathâ ‘angry’</td>
<td>lal5 ‘piece’</td>
<td></td>
</tr>
<tr>
<td>kaik5 ‘crooked’</td>
<td>kheb5 ‘hip’</td>
<td></td>
</tr>
</tbody>
</table>

3.3 Language consultants and data collection

For the Pwo Karen of Ban Doi, twelve language consultants of both sexes, equally, who were >60 years of age, 35-45 years of age, and <20 years of age were chosen. The language consultants were asked to pronounce each word 5 times. The number of test tokens for oral vowels in each age group was 960 (4 language consultants x 3 age group x 16 words x 5 times). The overall number of test tokens for nasal vowels was 480 (4 language consultants x 3 age groups x 8 words x 5 times). Regarding the nasal vowels, the words were pronounced twice to produce an identical number with the oral vowels above. Therefore, the test tokens used were 960 for both oral vowels and nasal vowels. The recording was done with a SONY IC Recorder ICD-MS515.

3.4 Data analysis

The entire vowel (vocalic portion) of each token was measured in respect of vowel duration, vowel amplitude and fundamental frequency. In each vowel, the time was normalized at the following points: 0%, 25%, 50%, 75% and 100%, a total of 5 measurement points. The Praat program version 4.2.09 was used for the analysis. The duration of vowels was measured in milliseconds (msec) in the range of the beginning of the vowel onset (0%) to the vowel offset (100%). The
amplitude values were measured at each peak of the vowel. The fundamental frequency values were measured at 0-100 msec as it has been reported that the initial consonant voicing influences the following vowels from 0-100 msec (Hombert, Ohala, and Ewan, 1979). This range was normalized starting from the vowel onset or 0 msec to 100 msec into the following points: 0%, 50%, and 100%. Each point was averaged. Statistical analysis, Mean, Standard Deviation (SD) and \textit{t-test} were used. Then, bar and line graphs were drawn.

4. Results

The results detail mean vowel duration, mean vowel amplitude and mean fundamental frequency values comparing the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20).

4.1 Duration

Table 12 and Figure 1 show the mean duration values of oral and nasal vowels following voiceless and voiced initial consonants in the Pwo Karen of Ban Doi. The mean duration values of both types of oral and nasal vowels following voiceless initial consonant was significantly lower (\(p < .05\)) than that of voiced initial consonants for the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20), except that the nasal vowels following voiceless consonants were found to be insignificantly lower than that of the voiced consonant (\(p = .200\)). The mean duration values of nasal vowels were found to be inconsistently higher than those of the oral vowels. The size of the differences between the mean duration of the vowel following voiceless and following voiced consonant in each age group was not significantly different (\(p > .05\)).

4.2 Amplitude

Table 13 and Figure 2 show the mean amplitude values of oral and nasal vowels following voiceless and voiced initial consonants in the Pwo Karen of Ban Doi. The mean amplitude values of both oral and nasal vowels following voiceless initial consonants were insignificantly lower (\(p > .05\)) than those of voiced initial consonants for the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20). The mean amplitude values of nasal vowels were found to be higher than those of the oral vowels. The differences between the mean durations in each age group were not significantly different (\(p > .05\)). It was found that the size of differences between the mean amplitude of the vowel following voiceless and following voiced consonants in each age group was not significantly different (\(p > .05\)).

4.3 Fundamental frequency

Table 14 shows mean fundamental frequency values at the 3 measurement points: 0%, 50%, and 100%. Standard deviation (SD), and \textit{t-test} result or p-values of both oral vowels and nasal vowels following voiceless initial consonants and voiced initial consonants in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20) are also shown. In Table 14 and Figures 3-5, “pa” represents oral vowels following voiceless initial consonants, while “ba” represents oral vowels following voiced initial consonants. As for “pã”, it represents nasal vowels following voiceless initial consonants, while “bã” represents nasal vowels following voiced initial consonants.
Figure 1 Mean duration values of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20).

Table 13 Mean amplitude values, Standard deviation (SD), and t-test of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20).

<table>
<thead>
<tr>
<th>Age group</th>
<th>Oral vowels (dB)</th>
<th>Nasal vowels (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Voiceless onset</td>
<td>Voiced onset</td>
</tr>
<tr>
<td>&gt;60</td>
<td>77.19</td>
<td>79.83</td>
</tr>
<tr>
<td></td>
<td>SD = .99</td>
<td>SD = 1.24</td>
</tr>
<tr>
<td>35-45</td>
<td>76.27</td>
<td>77.49</td>
</tr>
<tr>
<td></td>
<td>SD = .82</td>
<td>SD = 1.79</td>
</tr>
<tr>
<td>&lt;20</td>
<td>80.95</td>
<td>81.02</td>
</tr>
<tr>
<td></td>
<td>SD = 1.05</td>
<td>SD = 1.63</td>
</tr>
</tbody>
</table>
Figure 2 Mean amplitude values of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20).

Figure 3 Mean fundamental frequency values of oral vowels and nasal vowels in the >60 years of age.
Table 14 Mean fundamental frequency values, Standard deviation (SD) and t-test of oral vowels and nasal vowels in the three age groups: the over-sixty group (>60), the middle group (35-45) and the under-twenty group (<20)

<table>
<thead>
<tr>
<th>Age group</th>
<th>&gt;60</th>
<th>35-45</th>
<th>&lt;20</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Fundamental frequency of oral vowels following voiceless initial consonant (pa)</strong></td>
<td>177.79</td>
<td>178.03</td>
<td>178.86</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>2.44</td>
<td>3.12</td>
<td>2.89</td>
</tr>
<tr>
<td><strong>Fundamental frequency of oral vowels following voiced initial consonant (ba)</strong></td>
<td>183.09</td>
<td>189.21</td>
<td>194.22</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>1.48</td>
<td>1.95</td>
<td>2.34</td>
</tr>
<tr>
<td><strong>t-test result (p)</strong></td>
<td>.089</td>
<td>.045</td>
<td>.042</td>
</tr>
<tr>
<td><strong>Fundamental frequency of nasal vowels following voiceless initial consonant (pã)</strong></td>
<td>198.65</td>
<td>197.52</td>
<td>197.20</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>5.65</td>
<td>3.36</td>
<td>4.12</td>
</tr>
<tr>
<td><strong>Fundamental frequency of nasal vowel following voiced initial consonant (bã)</strong></td>
<td>210.91</td>
<td>204.89</td>
<td>200.63</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>2.67</td>
<td>4.97</td>
<td>4.21</td>
</tr>
<tr>
<td><strong>t-test result (p)</strong></td>
<td>.038</td>
<td>.077</td>
<td>.095</td>
</tr>
</tbody>
</table>
Initial Consonant Voicing Perturbation

**Figure 4** Mean fundamental frequency values of oral vowels and nasal vowels in the 35-45 years of age

**Figure 5** Mean fundamental frequency values of oral vowels and nasal vowels in the <20 years of age
From Table 14 and Figure 3, all lines were level and both oral and nasal vowels following voiced consonants were clearly higher in pitch from 0%-100%. Regarding oral vowels, the vowels following voiceless initial consonants at 0% were found to be insignificantly higher in mean fundamental frequency values compared to those following voiced initial consonants but they were significantly higher at 50% and 100%. Regarding mean fundamental frequency values, those of the nasal vowels were higher than that of the oral vowels.

From Table 14 and Figure 4 in the 35-45 age group all lines were found to be level. Oral vowels following voiced initial consonants were insignificantly higher in mean fundamental frequency values than that of the voiceless vowels, while the nasal vowels following voiced initial consonants were significantly lower in mean fundamental frequency values compared to those following voiceless initial consonants. Regarding mean fundamental frequency values, those of the nasal vowels were higher than that of the oral vowels.

From Table 14 and Figure 5 mean fundamental frequency values of clear vowels following voiced initial consonants were insignificantly higher in pitch at the onset compared to those following voiceless initial consonants. However, at the midpoint and the offset, it was found to be insignificantly lower. In the case of nasal vowels, the vowels following voiceless initial consonants were found to be insignificantly higher in mean fundamental frequency values than those following voiced initial consonants at the mid point. All lines seem to be similar in pitch contour but different in pitch height. The size of the pitch differences seems to be larger in the >60 years of age and smaller in the 35-45 years of age, and <20 years of age, respectively. Moreover, for all vowel types, e.g. oral and nasal vowels, pitch contours were found to change from level to falling.

5. Discussion and conclusion

Linguists (Erickson 1975, Gandour 1974, Hombert et al. 1979, House and Fairbanks 1953, Lehiste 1970, Lehiste and Peterson 1961, L-Thongkum 1990, Maddieson 1984, Watkins 2002) have claimed many universal factors for the causes of tone development—initial consonant voicing, voiceless and voiced. These factors have caused the tones in all Tai languages (Li 1966), some Mon-Khmer languages such as Vietnamese and Plang (Diffloth 1980, Haudricourt 1954), Sgaw Karen and Cantonese in Sino-Tibetan (Haudricourt 1954, Li 1977, Sun 2003), and Cham in Austronesian (Thurgood 1999). However, there is one language reported not to have behaved in the same way, T’iensin, a dialect of Peking (Li 1977). Ban Doi Pwo Karen seems to be another language that presents the uncommon phenomenon of the fundamental frequency behaviour of vowels influenced by a voiced initial consonant being higher than the voiceless initial consonant. All of the three age groups displayed identical behaviour. The size of the fundamental frequency differences seems to be larger in the >60 years of age and smaller in the <20 years of age. Regarding all vowel types, e.g. oral and nasal vowels, the fundamental frequency contours were found to change in the same direction, level to falling. This means that pitch height may have been used as a cue to perceive tone differences. It can be inferred from this that voiced initial consonant tends to cause a high
tone, while voiceless initial consonants tend to cause a low tone. The phenomenon is an unusual case. However, when searching into the voice register of the vowels following some voiceless consonants, it was found that those vowels in the three age groups were pronounced with breathy voice vowels. As the voice register of vowels was found to play a major role in causing tone birth (L-Thongkum 1989, 1990, Thurgood 2007), so breathy vowels have prominently affected the mean fundamental frequency values causing low pitch in vowels following voiceless consonants.

Therefore, as well as the process of stiffening (for voiceless) and slackening (for voiced) the cricothyroid muscles, there might be low muscular tension with weak medial compression and medium longitudinal tension of the vocal folds causing the vibrations' frequency to be just below the value typical of the modal voice (Eckert and Laver 1994).

The mean amplitude of both types of vowel (oral vowel and nasal vowel) following voiceless initial consonants is lower than that of voiced initial consonants for the over-sixty group (>60), the middle group (35–45), and the under-twenty group (<20). The amplitude of the nasal vowel was found to be higher than that of the oral vowel. This is in line with previous research (Amelot and Rossatto 2007, Ladefoged 2003, Picket 1998, Whalen and Beddor 1989). However, the duration of the nasal vowel was found to be inconsistently higher than that of the oral vowel. This does not correspond with other research in which the duration of the oral vowels was found to be less than that of the nasal vowels (Amelot and Rossatto 2007, Ladefoged 2003, Picket 1998, Whalen and Beddor 1989).

In conclusion, the initial consonant voicing perturbation of the fundamental frequency of oral vowels and nasal vowels was in the same direction, that is, a voiceless initial consonant causing a lowering of mean fundamental frequency and a voiced initial consonant causing an increase in of mean fundamental frequency in Pwo Karen of Ban Doi. This challenges the tonogenesis universality claimed in previous research. The three age groups were reliable in showing a tone development tendency. However, physiological analysis should be initiated for further explanation.

**Acknowledgements**

I would like to express my deepest gratitude to Prof. Dr. Theraphan L-Thongkum for all her valuable support as a part of the Karen project funded by the Thailand Research Fund (TRF) throughout the year. I am also grateful to the anonymous readers of the Journal for all their fruitful comments.

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Thurgood, G. W. 1993. Phan Rang Cham and Utsat: tonogenetic themes and


BAN PA LA-U SGAW KAREN TONES: AN ANALYSIS OF SEMITONES, QUADRATIC TRENDLINES AND COEFFICIENTS\textsuperscript{1}

Sujinat Jitwiriyanont\textsuperscript{2}

Abstract

Each dialect of the Sgaw Karen language has a different tonal system. Despite the different number of tones, all of the previous studies agree on the fact that all tones of Sgaw Karen are level tones. However, according to my phonological analysis of the tonal system of Ban Pa La-u Sgaw Karen, this dialect has a contour tone. The tonal system comprises four tones, i.e. /low/, /mid/, /high/ and /falling/ occurring in non-checked syllables. The high and low tones also have allotones in checked syllables. To confirm my analysis of the tonal system and the new finding of a contour tone in this Sgaw Karen dialect, an acoustic analysis of the tones occurring in citation forms was attempted. The analysis included three parts: (1) semitones to illustrate the pitch shape and height; (2) quadratic trendlines to indicate the direction and degree of pitch change; and (3) coefficients to show the generalization of each tone and the discrimination among tones.

The fundamental frequencies in hertz of the four tones were measured and then converted into semitone values to help minimize the variations in the pronunciation of the six female speakers. In addition, time and semitone values were used to generate 2\textsuperscript{nd} degree polynomial or quadratic equations and trendlines for which coefficients were plotted to model the pitch contour shapes.

The results revealed that: the low tone was mid-falling or low-falling with an obvious degree of pitch change and curved or linear pitch movement; the mid tone was mid level with a less obvious degree of pitch change and wide curved or linear pitch movement; the high tone was mid-high level with a lesser degree of pitch change and wide curved or linear pitch movement; and the falling tone was high-falling with an obvious degree of pitch change and curved pitch movement. In checked syllables, the low and high tones were realized as low-falling and high-falling respectively. The low tone had a greater degree of pitch change than the other; however, both had curved pitch movement.

1. Introduction

Sgaw Karen is a tonal language belonging to the Karenic branch, which is an affiliation within the Tibeto-Burman languages. Sgaw Karen speaking people outnumber those of the other Karenic languages spoken in Thailand, i.e. Pwo, Pa-O, Kayan, Kayah, and Kayaw. Sgaw Karen speaking people are widely distributed throughout the country. The Karen in Thailand are generally called “Kariang” which roughly refers to all

\textsuperscript{1} This paper was presented at RGJ Seminar Series LXXXII on Southeast Asian Linguistics organized by the Research Institute for Languages and Cultures of Asia at Mahidol University. I am grateful to Dr. Chutamanee Onsuwan, the discussant of the session, for her comments and suggestions which have been useful for the revision.

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Karenic groups. At Ban Pa La-u, Tambon Huay Sat Yai, Amphoe Hua Hin, Changwat Prachuap Khiri Khan (a province in the western part of Thailand), some Karen identify themselves as “Kariang”, and others as “Karang”. Following the linguistic fieldwork, we found that Kariang is Pwo Karen while Karang is Sgaw Karen.

Each dialect of the Sgaw Karen language has a different number of tones. Previous studies have reported three to four tones in Sgaw Karen, i.e. /high/, /mid/ and /low/ (Jones 1961a, Ratanakul 1986b) or /mid/, /breathy high/, /breathy low/ and /creaky low/ (Dhananjayananda 1983) or /mid high/, /mid/, /mid-low/ and /low/ (Lar Baa 2001) in non-checked syllables and two in checked syllables, i.e. /high/ and /low/. In addition we observed in a Linguistic Field Methods class (November 2010 – February 2011) that the Sgaw Karen dialect spoken at Ban Huay Mi in Amphoe Pay, Changwat Mae Hong Son (a province in the northern part of Thailand) has two tones, i.e. /low/ and /high/. Despite the different number of tones, all of the previous studies agree on the fact that all tones in Sgaw Karen are level tones. However, according to my phonological analysis of the tonal system of Ban Pa La-u Sgaw Karen, this dialect of Sgaw Karen has a contour tone, i.e. a falling tone. The objectives of this research are to attest by acoustic study that the Sgaw Karen dialect spoken at Ban Pa La-u has four tones in non-checked syllables and two allotones in checked syllables and to investigate the acoustic cues to tonal discrimination. This research will provide a new finding about a contour tone in Sgaw Karen and prove the effectiveness of applying quadratic equations to analyze the acoustic characteristics of tones.

2. Phonological sketch of Ban Pa La-u Sgaw Karen

The Sgaw Karen dialect spoken at Ban Pa La-u has 23 consonant phonemes which occur in the initial position. Only /ʔ/ can occur in the final position. There are 11 vowel phonemes: 9 monophthongs and 2 diphthongs. The vowel length is not contrastive. The tonal system comprises 4 tones, i.e. /low/, /mid/, /high/ and /falling/ occurring in non-checked syllables. There are allotones of the high and low tones in checked syllables. The high and low tones occurring in checked syllables are analyzed as allotones of those in non-checked syllables instead of tonemes, for they are conditioned by syllable type.

3. Methodology

I collected the data for phonological analysis in order to find a minimal set of tones to use as test words for acoustic study at Ban Pa La-u, Tambon Huay Sat Yai, Amphoe Hua Hin, Changwat Prachuap Khiri Khan. The test words were pronounced three times by six female native speakers of Sgaw Karen.
ranging in age from 23 to 43. The total number of test tokens was 108 (6 speakers x 6 words x 3 times). The speakers were asked to say the test words in the sentence frame:\n
\[ /tɛ \ we \ ____ \ tɔʔ \ bɔ/ \]
\say COMP one time
\‘say the word _____ once’

The following are the test words of four lexical tones in non-checked syllables and two allotones in checked syllables:

**Non-checked syllables**
- Low tone (Low) /lɔ̓/ ‘play’
- Mid tone (Mid) /lɔ/ ‘down’
- High tone (High) /lɔ́/ ‘deceive’
- Falling tone (Falling) /lɔ̂/ ‘straw’

**Checked syllables**
- Low tone (Lowʔ) /nɔʔ/ ‘Ms (title)’
- High tone (Highʔ) /nɔʔ/ ‘grass’

The Praat program version 5.2.11 was used for recording and F0 measurement. A high-quality desktop microphone was placed approximately 30 cm from the speakers. Mono recordings and a default sampling frequency of 44,100 hertz were selected. Regarding pitch analysis, the standard pitch range setting, which was from 75 to 500 hertz, was adapted as all of the speakers were female. The floor was set to 100 hertz and the ceiling to 500 hertz.

Two F0 measurement tasks were done. The first was to analyze semitone values and the other to generate quadratic trendlines. Regarding the first F0 measurement task, the fundamental frequencies (F0) at 5 points of time for each vowel were measured at 0%, 25%, 50%, 75% and 100% from vowel onset to offset. Only 5 points of time, instead of 11 points, were measured because they did not show significant differences. Moreover, the elaborated pitch measurement was further done for the second F0 measurement task for which the fundamental frequency was measured every 0.01 second from vowel onset to offset.

The measured fundamental frequencies in hertz were converted into semitone values. In fact, there are a number of psycho-acoustic pitch scales, apart from semitones, such as mels, Bark and ERB-rate. Semitones were used in this study owing to their effectiveness. Nolan (2007) has done an experimental evaluation of pitch scales and the results reveal that semitones most

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4 To avoid the influence of initial and final consonants on pitch, I used a minimal set, of which I could find only one set due to the time limitations of the fieldtrip, for non-checked syllables which have four tones, for acoustic analysis. Therefore, only six words including two analogous pairs in checked syllables were used.

5 There is no tone sandhi in this dialect of Sgaw Karen so this sentence frame can be used for eliciting the data.

6 Checked syllables with the initial consonant /l/ could not be found for the minimal set. Therefore /h/ was chosen because they are both voiced alveolar sounds.

7 The glottal stops (?) are used to mark the allotones of the high and the low tones in checked syllables.

8 It was difficult to find male informants because they went out to work.
accurately reflect intuitions about the intonational equivalence of the subjects.

The formula was semitones = 3.32 x 12 x LOG(Hz to be translated/ Hz reference level). On account of the different purposes of converting hertz into semitones, the reference levels used for plotting the semitone-value line graph and the scatter plot for generating quadratic trendlines were different. The line graph of semitones was to illustrate the overview of the tone shapes and the comparison of the pitch height of all tones, so the reference level in the case of the semitone line graph was the lowest pitch point among all tones which, in this study, was always that of the low tone in the non-checked syllable (as an example of Speaker 4 in Table 1). The fundamental frequencies were converted into semitones and the lowest pitch was subtracted to zero to help minimize the variation in the pronunciation of the six female speakers, showing the different pitch height and range between each tone produced by the individual speaker and among the other speakers.

<table>
<thead>
<tr>
<th>Consonants</th>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plosive</td>
<td>p</td>
<td>t</td>
<td>c</td>
<td>k</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ph</td>
<td>th</td>
<td>ch</td>
<td>kh</td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td>ɲ</td>
<td>ŋ</td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>s</td>
<td>x</td>
<td>ɣ</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>Trill</td>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td>l</td>
<td>j</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Vowels</th>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monophthongs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>i</td>
<td>i</td>
<td>u</td>
</tr>
<tr>
<td>mid</td>
<td>e</td>
<td>ə</td>
<td>ə</td>
</tr>
<tr>
<td>low</td>
<td>ə</td>
<td>a</td>
<td>ə</td>
</tr>
<tr>
<td>Diphthongs</td>
<td>ai</td>
<td>au</td>
<td></td>
</tr>
</tbody>
</table>

**Tones** /low/ /mid/ /high/ /falling/

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9 The low tone is produced with a breathy voice, but the breathy voice is not marked because it can be predicted and phonation type is not contrastive in this language.
The other purpose of converting hertz into semitones was to show the degree of pitch change in each tone. Thus the reference level was the lowest pitch point of each tone (as an example of Speaker 4 in Table 2). When the lowest pitch point from each pitch measurement of each tone was normalized to zero, the maximum pitch became equal to the degree of pitch change. The normalized semitones showed the total amount of pitch change in each contour compared across tones and speakers. The scatter plots and the quadratic trendlines that best fitted the F0 measurements were generated by Microsoft Excel 2010. The 2nd degree polynomial or quadratic equation used to generate the trendline was \( y = ax^2 + bx + c \). The a- and b-coefficients for each trendline were saved to create a model based on the relationship of the a- and b-coefficients from the equations.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The semitone values of each tone produced by Speaker 4, prepared for a line graph. Zero was the reference level.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Low</th>
<th>Low?</th>
<th>Mid</th>
<th>High</th>
<th>High?</th>
<th>Falling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>4.782749</td>
<td>7.144141</td>
<td>2.657708</td>
<td>4.861412</td>
<td>7.349272</td>
<td>6.520224</td>
</tr>
<tr>
<td>50%</td>
<td>3.209767</td>
<td>6.529904</td>
<td>1.560691</td>
<td>4.668621</td>
<td>7.272468</td>
<td>5.546492</td>
</tr>
<tr>
<td>75%</td>
<td>1.818102</td>
<td>5.560063</td>
<td>1.442503</td>
<td>4.473226</td>
<td>6.549445</td>
<td>3.430742</td>
</tr>
<tr>
<td>100%</td>
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<td>3.208046</td>
<td>1.30989</td>
<td>4.140227</td>
<td>5.402263</td>
<td>2.37995</td>
</tr>
</tbody>
</table>

4. Results

4.1 Semitones

The semitones converted from the average fundamental frequencies of each tone produced by each Pa La-u Sgaw Karen speaker were plotted using line graphs illustrating the phonetic realization of the four lexical tones.

The six line graphs show the overview of the four tones in non-checked syllables and two in checked syllables. In spite of some differences in details among speakers, they reflect a similar pattern (see Figure 1).

In Figure 1, the result of the F0 measurements indicates that the four lexical tones in Pa La-u Sgaw Karen can be categorized by pitch height and contour. To begin with the non-checked syllables, the generalization was that the low tone was mid-falling or low-falling. It began at mid or low range, and fell steadily to the lowest point of the semitone scale. The mid tone was mid level or low level beginning at the mid or low range and staying level or falling slightly. The high tone was mid-high level. It began with mid or mid-high pitch and stayed relatively level in that it rose or fell for not more than one semitone scale except for that of Speaker 1. Despite three semitone scales of pitch contour, the high tone of Speaker 1 could be concluded to have a small amount of contour similar to the other
five speakers due to the widest pitch range. This is supported by the finding of Dilley (2005), suggesting that tone is relative in a dualistic way, one part of which is that tones are scaled relative to an individual’s pitch range. Moreover, although the high tone of some speakers began at the mid range similar to the low and the mid tone, it was noted that the pitch of the high tone from 25% to 100% was always higher than the other two tones. The falling tone was high-falling. It began at a high range then either fell to mid range (Speaker 1, 2 and 4) or rose to the highest point at 25% before falling to mid range (Speaker 3, 5 and 6). Furthermore, the pitch shapes of the allotones of the high and the low tones in the checked syllables were either falling or rising-falling. Although they shared a similar pitch contour, they were differentiated by the endpoint. The high tone always ended higher than the low tone.

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Low</th>
<th>Low?</th>
<th>Mid</th>
<th>High</th>
<th>High?</th>
<th>Falling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.905162</td>
<td>2.086838</td>
<td>1.061225</td>
<td>0.273398</td>
<td>1.858174</td>
<td>4.078882</td>
</tr>
<tr>
<td>0.01</td>
<td>3.819686</td>
<td>2.071617</td>
<td>0.911586</td>
<td>0.258577</td>
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<tr>
<td>0.02</td>
<td>3.632387</td>
<td>2.054405</td>
<td>0.514968</td>
<td>0.310423</td>
<td>1.617278</td>
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</tr>
<tr>
<td>0.03</td>
<td>3.477174</td>
<td>2.049013</td>
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<td>0.313052</td>
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<tr>
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<tr>
<td>0.09</td>
<td>2.094947</td>
<td>0.717159</td>
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<td>0.13</td>
<td>0.630345</td>
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<td>0.17</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2 The semitone values of each tone produced by Speaker 4, prepared for a scatter plot to generate the quadratic trendline. The zeroes were the reference level of each tone.
According to the semitones of the four lexical tones in both non-checked and checked syllables, the phonetic characteristics of many tones, i.e. the low tones in both non-checked and checked syllables, the high tone in checked syllables, and the falling tone were of a falling or convex shape. Moreover, it was speculated that duration was relevant to tonal identity. Among the tones with phonetically falling shape, the tone with shorter duration would fall more steeply than the longer counterpart. Nevertheless, the different durations of the tones were ignored in the semitone line graph owing to the normalized duration represented by the x-axis. Therefore, it was interesting to use the method proposed by Andruski and Costello (2004) to investigate the pitch contour cues for tone discrimination in Pa La-U Sgaw Karen as the method revealed the details of pitch contour and the durations of tone in real time. Andruski and Costello (2004) noted that “in languages with a crowded tonal space, multiple tones can have similar contours. Even in languages with few tones, details of contour shape may be used by listeners for tone identification.” They proposed the method of using polynomial equations to model pitch contour shape in lexical tones. Green Mong was used as a test case. In the paper, two kinds of polynomial equations, namely linear equations (1st degree polynomial equations) and quadratic equations (2nd degree polynomial equations) were used to test their hypothesis. It was found that discriminant analysis using the coefficients as predictor variables showed a greater effectiveness of using quadratic coefficients for tone classification than linear coefficients.

The method of using quadratic equations and trendlines to analyze lexical tones proposed by Andruski and Costello (2004) was adopted in this study in order to investigate the pitch contour cues for tone discrimination in Pa La-u Sgaw Karen.
4.2 Quadratic trendlines

A quadratic equation can be applied in order to analyze lexical tones, especially contour tones, in languages. The output of the quadratic equation is the trendline which can be used to describe and compare the details of contour shape across tones. The quadratic trendline shows the direction and the degree of pitch change, which pinpoints some interesting pitch contour cues compared with the semitone-value line graph. The information carried by the trendlines elaborates the phonetic realization of the lexical tones.

A quadratic equation is a polynomial equation of the second degree. The form of quadratic equation used in the study of Andruski and Costello (2004) was \( y = ax^2 + bx + c \). However, this current study followed the form of quadratic equation generally used in mathematic literature i.e. \( y = ax^2 + bx + c \) where \( a \) and \( b \) are coefficients. Therefore, the \( a \)-coefficient in this study was the \( c \)-coefficient in Andruski and Costello’s study. The trendline generated from a quadratic equation is a graph in the form of a parabola. The parabola can open either upward or downward as in Figure 2.

However in the case of analyzing tone or lexical pitch in languages, the quadratic trendline generated from the value of time and semitones is always half of the parabola. This is because the \( x \)-axis which represents time value is never negative.

![Figure 3 A half parabola due to the positive value of the x-axis representing duration](image)

In this paper, the values of time and semitones were used to generate 2nd degree polynomial or quadratic equations and trendlines for each actual pitch contour. As in the example of Speaker 1 in Figure 4, the \( y \)-axis shows the semitone scale for interpreting the direction and degree of pitch change while the \( x \)-axis shows the duration in seconds.

In the case of Speaker 1’s falling tone, the quadratic equation for generating this trendline was \( y = -178.1x^2 - 12.90x + 6.867 \) in the form \( y = ax^2 + bx + c \). The \( y \)-axis of the line graph (left) represents the level of pitch height whereas the \( y \)-axis of the scatter plot (right) represents the degree of pitch change. The line graph indicates that the pitch height of the starting point of the falling tone produced by Speaker 1 was approximately 12 semitones and the lowest point at the end was approximately 6 semitones. This conforms to the information conveyed by the trendline of the scatter plot in that the \( y \)-axis indicated an amount of
pitch change of approximately 6 semitones. While the x-axis of the line graph represents
the normalized duration, the other represents the real duration indicating a duration of
approximately 0.17 second. The semitone-value line graph and the trendline both
suggest a similar phonetic realization in
terms of the pitch shape of the falling tone
produced by Speaker 1 in that the line graph
illustrates the overall pitch shape of the
falling tone as high falling and the trendline
also shows the direction of the pitch
movement as a convex or falling contour.

As in Figures 5-10, it is important to note
that the y-axis of the quadratic trendline
graph on the right does not represent the
pitch height as it traditionally does in the
line graph of hertz or semitone values but
the degree of pitch change or contour.
Besides, the x-axis of the quadratic trendline
graph on the right represents real duration
(seconds) instead of normalized duration (5
equidistant timepoints) as in the line graph
of semitone values on the left.

The quadratic trendlines of the four lexical
tones produced by 6 speakers can be classified
into 3 groups based on the patterns. The main
difference is the pitch movement of the high,
mid and low tones in non-checked syllables.

The other tones, i.e. the falling tone in non-
checked and the high and low tones in checked
syllables, all had a convex pitch contour.

Pattern 1: Linear pitch movement (S1)

The uniqueness of the first pattern was that,
except for the falling tone, all tones in non-
checked syllables had a linear pitch
movement. In other words, the pitch
movement of the low, mid, and high tones in
non-checked syllables was a straight line
(see Figure 5).

As in Figure 5, the trendline on the right
shows that the falling tone had the largest
amount of pitch change and the mid tone
had the smallest. Although the low tone in non-checked syllables had the lowest starting point, illustrated by the semitone-value line graph on the left, the amount of pitch change was not the smallest. According to the trendlines, the pitch movement of the falling tone, the low, and the high tones in checked syllables was convex or falling. The pitch movement of the low tone, mid tone, and high tone in non-checked syllables was a straight line. This suggests that in spite of the contour shape of the low tone resembling the falling tone in the semitone-value line graph, the overall pitch movement was similar to that of the level tone. This was due to the different duration of the low and falling tones. The low tone had approximately 0.1 seconds of duration more than the falling tone. Longer duration caused the gradual pitch fall; consequently, the overall pitch movement was more like a level tone than a contour tone.

Pattern 2: Curved pitch movement (S2-S5)

All of the tones in the second pattern had a non-linear pitch movement. Like the other patterns, the falling tone and the two tones in checked syllables were convex. The low, mid, and high tones, in contrast to Pattern 1, had a curved pitch movement – both convex and concave. The different shape of curvature brought about an insignificant difference due to the small degree of pitch change (see Figures 6-9).

Figure 5 A comparison of semitones of the Pa La-u four lexical tones (left) and quadratic trendlines generated from semitones (right) produced by Speaker 1
As illustrated in Figures 6-9, the tones produced by Speakers 2 – 5 had nearly the same pitch-contour pattern. The trendlines illustrate that no tones had a pitch movement in an exact straight line. The semitone-value line graph shows that the overall tone shapes of the low tone and the falling tone in non-checked syllables were of a similar contour shape as for Speaker 1 in Figure 5. Nonetheless, unlike the linear trendline of Speaker 1’s low tone, the trendlines showing the pitch movement of the low tones of this pattern were convex. With regard to the other tones in non-checked syllables, the pitch movement of the mid tone was a wide concave (S2,S3,S4) or a wide convex (S5); and that of the high tone was a wide convex (S2,4,5) or an extremely wide concave which resembled a straight line but not exactly. (S3). However, the degree of the pitch change was less than 1 semitone, leading to an insignificant contour, and they were reasonably categorized as level tones conforming to the overall pitch shape in the semitone-value line graph. The falling tone was obviously realized as a falling contour. The pitch-change range was approximately 3-4 semitones except for Speaker 5. What differentiated Speaker 5’s falling tone from the low tone, which had nearly the same amount of pitch change, was a rise-fall pitch contour and shorter duration causing a steeper contour. In checked syllables, both the semitone-value line graph and trendline showed that the low and high tones were falling and the low tone had greater degrees of pitch excursion.

**Figure 6** A comparison of semitones of the Pa La-u four lexical tones (left) and quadratic trendlines generated from semitones (right) produced by Speaker 2
Figure 7 A comparison of semitones of the Pa La-u four lexical tones (left) and quadratic trendlines generated from semitones (right) produced by Speaker 3.

Figure 8 A comparison of semitones of the Pa La-u four lexical tones (left) and quadratic trendlines generated from semitones (right) produced by Speaker 4.
Figure 9 A comparison of semitones of the Pa La-u four lexical tones (left) and quadratic trendlines generated from semitones (right) produced by Speaker 5

Pattern 3: Mixed type (S6)

The last pattern combined Patterns 1 and 2 in that the mid and low tones in non-checked syllables had a straight-line pitch movement but the high tone in non-checked syllables had a curved pitch movement as shown in Figure 10.

As seen in Figure 10, the trendline of the falling tone shows the largest amount of pitch change and the pitch contour shape as high falling. Due to the small pitch change below 1 semitone and the relatively long duration compared to the other tones, the high tone was categorized as a level tone, conforming to the phonetic realization illustrated by the semitone-value line graph. The pitch movement of the low and mid tones in non-checked syllables was a straight line, suggesting the characteristics of a level tone. In checked syllables, the low tone had much more pitch excursion than the high tone; both were realized as falling.

To sum up, the generalization is that in non-checked syllables, the low tones whose phonetic realizations were mid falling or low falling, as the line graphs showing the semitones on the left of Figures 5-10 indicate, had three characteristics of trendlines: (1) the pitch movement was a straight line similar to the level tone; (2) the pitch movement was convex with wide curvature nearly similar to a straight line; (3) the pitch movement was convex but less obvious than the falling tone, which was relevant to the longer duration of the low tone. This suggests that the characteristics of the low tone were fairly level, similar to the impressionistic description.
The trendlines of the mid tone and the high tone, which were level tones, in non-checked syllables were not always a straight line. In spite of some curved trendlines, the range of the pitch change showing in semitones was narrow, resulting in a less obvious pitch contour. The contour was not significant when the degree of pitch movement was very little (not more than 1 semitone). Likewise, the results emphasize their realization as level tones. With regard to the falling tone, the semitone-value line graph together with the trendline unanimously confirmed the high-falling pitch contour.

In checked syllables the high tone and the low tone both had a falling pitch contour indicated by the direction and shape of the trendlines. The two tones were distinguished by the amount of pitch change. The pitch-change range of the low tones was larger than the other. The results support the conclusion that the trendlines illustrate more detailed information about contour shape.

Table 3 shows the phonetic realization of the four lexical tones by synthesizing the information conveyed by both semitone-value line graph and quadratic trendline.

4.3 Coefficients

As the trendlines of tones across speakers were not identical, the line graphs cannot show the generalization and discrimination of tones well. Therefore, the a- and b-coefficients of the quadratic equations were further used to generate a scatter plot in order to create a model for tonal identity. The model reflects the generalization of each tone and discrimination among tones.
Table 3: Phonetic realization of the four lexical tones

<table>
<thead>
<tr>
<th>Lexical tones</th>
<th>Overall shape</th>
<th>Starting point</th>
<th>Endpoint</th>
<th>Degree of pitch change</th>
<th>Duration</th>
<th>Pitch movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>falling</td>
<td>mid/low</td>
<td>lowest</td>
<td>Obvious(^{10})</td>
<td>long</td>
<td>linear / curved</td>
</tr>
<tr>
<td>Mid</td>
<td>level</td>
<td>mid</td>
<td>mid</td>
<td>less obvious</td>
<td>long</td>
<td>linear / wide curved</td>
</tr>
<tr>
<td>High</td>
<td>level</td>
<td>mid-high</td>
<td>high</td>
<td>less obvious</td>
<td>long</td>
<td>linear / wide curved</td>
</tr>
<tr>
<td>Falling</td>
<td>falling</td>
<td>high</td>
<td>low</td>
<td>obvious</td>
<td>short</td>
<td>curved</td>
</tr>
<tr>
<td>Low?</td>
<td>falling</td>
<td>high</td>
<td>higher than high?</td>
<td>more than high?</td>
<td>short</td>
<td>curved</td>
</tr>
<tr>
<td>High?</td>
<td>falling</td>
<td>high</td>
<td>lower than low?</td>
<td>less than low?</td>
<td>short</td>
<td>curved</td>
</tr>
</tbody>
</table>

This model is based on the relationship of the a- and b-coefficients from the quadratic equations reflecting the aspects of pitch contour shape distinguishing one tone category from another. The b-coefficient indicates the initial slope at the intercept. With the positive b-coefficient, the initial slope of the contour is upward, and the negative b-coefficient causes a downward initial slope (see Figure 11).

![Figure 11](image)

**Figure 11** Information carried by the b-coefficients, the dotted circle indicating the initial slope

\(^{10}\) The criterion for identifying the “obvious” pitch change was a pitch-change degree of more than 3 semitones for linear pitch movement and more than 1 semitone for curved pitch movement.

The a-coefficient indicates whether the pitch contour is concave or convex. A positive a-coefficient brings about a concave contour and a negative result in a convex contour. In addition, when the value of the a-coefficient is zero, its contour is a straight line. The amount of the absolute value of a-coefficients also indicates the size of the curvature. The larger the absolute value of a-coefficient, the steeper the pitch contour becomes (see Figure 12).

![Figure 12](image)

**Figure 12** Information carried by the a-coefficients

The a- and b-coefficients from all trendlines were plotted in the scatter plot to show the clustering and scattering of the tones suggesting the generalization of each tone and discrimination across tones (see Figure 13).
In Figure 13, the x-axis represents the b-coefficient, and the y-axis represents the a-coefficient. There are no tones in the upper right quadrant because positive a- and b-coefficients indicate a rising contour. The rising tone is not a phoneme in the tonal system of Pa La-u Sgaw Karen. Only the mid and high tones in non-checked syllables are level owing to the value of a-coefficients (y-axis) near zero. Although the high tone has a slightly upward initial slope whereas the mid tone has a slightly downward initial slope due to the different positive/negative values of b-coefficient, they both are categorized as level tones since the contour is slight and their overall shapes are relatively straight lines.

The model reflects the different falling or convex shapes of the low (in non-checked syllables) and falling tones. The low tones have a progressive fall indicated by negative b-coefficient values. Although one token of the low tones has a positive b-coefficient value, the absolute value is so small that it
The falling tones have a rise-fall pattern and a steep fall. The rise-fall pattern is specified by a positive b-coefficient value. Compared to the low tones, all of the falling tones have larger absolute values of a-coefficients, pointing out the steeper contours. In addition, having smaller absolute values of a-coefficients, the majority of the low tones fall very close to the same space occupied by the mid and high tones in non-checked syllables. Therefore, some of the low tones have a contour shape resembling the level tone. These values reflect the fact that the falling tone has a more obvious contour pattern than the low tone in non-checked syllables.

Of all the tones, the low and high tones in checked syllables show the most obvious rise-fall pattern. All have positive b-coefficient values and most have extreme negative a-coefficient values. However, the low tones have steeper contours as the absolute values of a-coefficients are larger.

5. Conclusion and discussion

Acoustic analysis confirmed the characteristics of Pa La-u Sgaw Karen’s four lexical tones consisting of three level tones and one contour tone. The line graph of semitones, the quadratic trendlines, and the model based on the relationships of coefficients indicate the complex of acoustic cues to tonal identity. Tones in the Pa La-u Sgaw dialect are well-defined by pitch shape, starting point, endpoint, degree of pitch change, duration, pitch movement, and slope.

This research supports the effectiveness of applying quadratic equations to analyze the acoustic characteristics of tones in language as suggested by Andruski and Costello (2004). In addition, the values of quadratic coefficients can further be plotted in a scatter plot to reflect the generalization of the individual tone together with the discrimination among tones by showing clustering and scattering in a particular area.

In fact, an acoustic analysis of the tones in connected speech was also performed but is not included in this paper because it did not show any significant pattern. The variability of the tones in connected speech could have resulted from different phonetic environments. Moreover, the data is too small and thus, inadequate for statistical analysis.

Acknowledgements

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References


USING GIS FOR EXPLORING KAREN SETTLEMENTS: A CASE STUDY OF WESTERN AND NORTHERN THAILAND IN THE VICINITY OF THE THAI-BURMESE BORDER

Sirivilai Teerarojanarat

Abstract

The Karen are one of the largest ethnic minority groups living in Thailand today, residing mostly in the mountainous ranges along the Thai-Burmese border. In most previous Karen studies, map presentation of Karen settlements has been disregarded. This paper explores the Karen from the spatial aspect. The study area covered 15 provinces in western and northern Thailand along the Thai-Burmese border. The scope of the study focused on the village locations of 6 Karen subgroups, namely the Sgaw, the Pwo, the Taungthu or Pa'O, the Kayah, the Kayan, and the Kayaw. A survey of these Karen subgroups settlements was performed via a questionnaire that was collected between 2011 and 2012. A spatial-based technique, the Geographic Information System (GIS), was used as a tool to develop a geographical database of Karen settlements. Further analysis was performed to explore the population numbers of Karen subgroups and their population change, settlement distribution, village size and the relationship of village locations to topography. The findings show that the Sgaw Karen are still the largest Karen-speaking group living in Thailand today. The population size of Karen villages varies largely but their average size is almost the same. According to the settlement pattern, Karen villages of the same subgroup tend to stay close together. A mixture of Karen subgroups in a village are found in small numbers. All subgroups are located on mountain peaks or at high elevations along the Thai-Burmese border or along the provincial boundaries. However, the Sgaw and the Pwo Karen tend to settle at a higher elevation than the Kayah and the Taungthu (Pa’O) Karen. The findings also suggest that the role of GIS is obvious, showing its great potential for advancing our understanding of Karen studies from the spatial aspect.

1. Introduction

Among non-Thai speaking peoples living in today’s Thailand, the Karen are the largest tribal group and they reside mostly in mountainous areas along the Thai-Burmese border. According to the recent demographic figures reported by Delang (2003), there are between four and six million Karen residing in Myanmar with a large number in the Shan States and there are over 400,000 Karen in Thailand. It has been estimated that there will be more than one million Karen in Thailand in 2011 if the Karen in refugee camps and the Karen from Myanmar who have come to work as alien labour are taken into account (Booranaprasertsook 2012). The Karen are believed to be one of the earliest ethnic groups to have migrated to Southeast Asia.
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from the northeast before 1000 AD ("The Karen Tribal Group of Thailand" 1969). According to Renard (1980) and Schliesinger (2000), the Karen living in Thailand came across the eastern border of Myanmar and first settled down in the vicinity of present-day Chiangmai during the eighth century. The migration of the Karen from Myanmar to Thailand occurred many times. However, a huge migration took place in the middle of the eighteenth century around the late Ayuthaya and early Ratanakosin period because of conflict and fighting with Myanmar. The Sgaw and the Pwo Karen formerly arrived to Thailand a long time ago. Both subgroups are known as people without a history because their movements cannot be traced back to their origins. Other subgroups that have recently migrated are the Taungthu (Pa'O), the Kayah, the Kayan and the Kayaw Karen. The Taungthu (Pa'O) emigrants escaped to Thailand from Myanmar after 1975 and later from the State Law and Order Restoration Council (SLORC) armies. It was reported that there were 4 principal Taungthu villages in Mae Hong Son province in 1996. The Kayah Karen illegally fled from the Kayah state of Myanmar to Thailand in small numbers in the 1940 and settled down in Mae Hong Son province. The Kayan fled from their homes in the Kayah state of Myanmar in 1988 and settled down in 3 border villages in Mae Hong Son province of Thailand. Finally, in 1994 the Kayaw Karen migrated from their homes in the Kayah state of Myanmar to Thailand as a result of the increase in the tourist attraction of Ban Nai Soi in Mae Hong Son province.

According to a report of the Center for Research in Social Systems (1970), the word Karen was first used by missionaries and British administrators in Myanmar in the early nineteenth century. Each Karen subgroup, however, refers itself in its own way, e.g., the so-called ‘Pga K’Nyaw’ by the Sgaw Karen and the so-called ‘Phloung’ by the Pwo Karen. All of these terms probably came from a Chinese origin and mean “men” or “human beings” (Schliesinger 2000; Laungaramsri 2003). The Karen tribe has its own way of life, speaks its own language and adheres to its own particular customs, traditions, rituals and rites. Up to now a number of pieces of research in Karen studies have been carried out, covering a wide variety of aspects including language, culture, beliefs, costumes and woven fabrics. Most of these pieces of research work, however, paid little attention to giving information about the precise location of Karen settlements. In these previous studies, maps, if provided, were usually drawn on paper by hand and the locations of data collection were roughly marked or ignored. The derived map information thus lacked reliability and could not be used further by other agencies.

In 2009, the Karen Linguistics Project was launched under the sponsorship of the Thailand Research Fund (TRF). The research project director is Professor Theraphan Luangthongkum, Ph.D. from the Department of Linguistics, Faculty of Arts, Chulalongkorn University. The key objective of the project is to analyze the diversity of languages spoken by 6 subgroups; namely the Sgaw, the Pwo, the Taungthu (Pa'O), the Kayah, the Kayan and the Kayaw. According to the linguistic study, the Karen are classified as a tribe that speaks in the Karenic division of the Tibeto-Burman speakers, a subgroup of
the Sino-Tibetan language grouping (Schliesinger, 2000). Each subgroup distinguishes itself from other groups on the basis of its communicating language, style of costume and personal decoration and hair style (The Karen Tribal Group of Thailand, 1969). The study area of the project focuses on Karen settlements covering 15 provinces in western and northern Thailand in the vicinity of the Thai-Burmese border.

In the project, linguistics, in terms of vowel system and acoustics, was mainly applied to study the Karen languages. Field surveys—interviewing and asking questions of a number of Karen people in upland Karen villages—were primarily conducted for Karen data collection. In doing the field surveys, however, the linguistic staff were hampered by the unavailability or inaccuracy of Karen location maps. This work was established, therefore, to facilitate the preparation of maps for this purpose.

This paper differs from most previous Karen studies because observing the Karen from the spatial aspect is the key focus. A spatial-based technique using GIS has been integrated with the aim of developing a geographical database of Karen settlements to map the locations of Karen settlements classified by the 6 Karenic groups at village level and to investigate the spatial pattern of the settlements as well as their relationship with topography.

In the next section, the background concepts of GIS and its application to Karen studies are briefly explained. The study area and its scope, the data source and methodology, results and discussion as well as conclusions are then given in turn.

2. GIS and its related application to Karen studies

The Karen study inevitably involves spatially-related work including field surveys, data collection and the recording, mapping, analyzing and displaying of location data. To present data on a map, two types of data—spatial and attribute—are mainly involved. Spatial data refers to the geographical location whilst attributes data constitute related descriptions of the location data e.g., collected Karenic language data and names of Karen villages. Spatial features are symbolized on a map in three forms; point, line and polygon. Their locations are defined by x and y coordinates in units of a geographical reference system such as degrees of longitude and latitude. Prior to today’s computerized maps, map making and cartographic display was always done manually. Drawing locations of data collection was roughly defined by hand. In addition, integrating maps using the overlay technique was traditionally performed by simply superimposing multiple paper maps by hand. Overlaying maps of different scales cannot be done.

The development of computer technology led to a big improvement in geographical technology in the 1960s. Geographical tools and technology for spatial data measurement, data collection and analysis was developed to be more powerful, especially in the handling of voluminous data and for performing complex spatial analysis. Among these technologies, the Geographic Information System (GIS) was mainly designed to manage digital geographic data. GIS comes with powerful functions for capturing, storing, querying, analyzing and displaying data that are linked
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to locations on the Earth’s surface. Differing from MIS (Management Information Systems) such as the tabular data of Microsoft Access, GIS provides a geographical database linking geographical features to their attributes. To manage many themes of maps in a study location, GIS uses the concept of “layer” to organize these themes. Each “layer” or theme is stored separately in a GIS database, for example, a layer of Karen settlement, a topography layer and a road layer. Displaying or retrieving these layers separately or in combination can be easily performed to serve different user requirements. GIS also provides a wide variety of basic and complex spatial analysis functions, including the extension module of geostatistics, 3-D surface and network analyses. Details of GIS principles, functions and capabilities are described extensively elsewhere, e.g., the textbooks of Tomlin (1990), Heywood et al. (2002), Longley et al. (2005) and Demers (2009). The derived spatially-related information of a GIS, as a result, has been primarily used for policy decision making and planning purposes. Because of its beneficial uses, GIS is nowadays widely applied in spatially-related work in the area of science, social science as well as humanity studies such as disaster management, agriculture, urban planning, and linguistic geography.

For less than a decade, GIS has been applied to the study of the settlements of minority groups in Thailand and its neighbouring countries. Masron et al. (2005) employed GPS (Global Positioning System) and GIS technologies to capture the coordinates of the locations of respondents, to develop a geographical database and to map the spatial patterns of dialectal variation spoken by Melanau speakers in Sarawak, Malaysia. A series of research works published by Luo et al. (2000), Wang et al. (2006), Luo et al. (2007), and Luo et al., (2010) integrated GIS mapping techniques and spatial analysis functions with linguistic and geophysical information to reconstruct the historical past settlement pattern of Tai minority groups in southern China and Southeast Asia. According to Luo et al., (2000), the spatial variation for the pronunciation of the word “rice” in the Tai Languages was mapped with topography to locate and reconstruct the settlement pattern. Their extension work used place names (Wang et al. 2006), kinship terms (Luo et al. 2007), and three Tai toponyms (Muang, Chiang and Viang) (Luo et al. 2010) to further explore the settlement patterns in the study location.

In the case of Thailand, Premsrirat et al., (2004) reported that over 60 ethnolinguistic groups had been found in this country. However, up to now, a handful of research works have paid attention to creating a map showing settlements of these ethnic groups. The oldest one, produced by “The Karen Tribal Group of Thailand” in 1969, is a map showing undetailed locations of 4 Karen tribes - the Sgaw, the Pwo, the Kayah (the so-called B’ghwe in the report paper) and the Pa’O (the so-called Taungthu in the report paper). Later, the research work of Premsrirat et al., (2004) produced maps at village level showing the language variation spoken by these ethnic groups found in the whole of Thailand. Their work was also the first to integrate GIS as a tool for storing and mapping the language distribution of all ethnic groups in Thailand. Another work was conducted by Cheewinsiriwat (2010)
to apply GIS for exploring the settlement patterns of ethnic groups residing in Nan province, Thailand. In her study, some terrain analysis functions were incorporated to examine the relationship between the settlement patterns and the physical environment. The work, conducted by Puginier (2000), applied a participatory land use planning approach using GIS as a tool to produce land use maps based on data collection at two Karen villages in Mae Hong Son Province, Thailand. The most recent research work was conducted by Burusphat et. al. (2011). The main aim of their work was to explore the language use and language attitudes of the ethnic groups in the western region of Thailand. Ethnolinguistic maps and a GIS database were constructed to help explain the locations of ethnic groups residing in the study location.

None of these previous works, however, recorded and gave details of the locations of Karen settlements classified by subgroup. In this paper, the main objective is to produce a map of Karen settlements of these subgroups at village level and explore the settlement patterns, population size and their relationship with topography. The result of the study, to some extent, will be a reference point for the settlement maps of Karen subgroups surveyed in 2011-2012.

3. Study area and scope of study

In this paper northern and western parts of Thailand in the vicinity of the Thai-Burmese border covering 15 provinces, including Chiang Rai, Mae Hong Son, Chiang Mai, Lamphun, Lampang, Phrae, Tak, Sukhothai, Kamphaeng Phet, Uthai Thani, Kanchanaburi, Suphan Buri, Ratchaburi, Phetchaburi and Prachuap Khirikhan, were chosen as the study area (see Figure 1).

Figure 1: Study area

Geographically, the northern region of Thailand is characterized by mountain ranges lying in north-south direction, natural forests and narrow, fertile valleys. There are different types of agriculture, including wet-rice farming in the valleys, swidden cultivation, temperate vegetables and fruit such as strawberries and lychees in the uplands. Similar to the North, the western region of Thailand is dominated by high mountain ranges and steep river valleys. Western Thailand, close to the Myanmar border, contains protected forest areas, including the world heritage Thung Yai Naresuan-Huai Kha Khaeng Wildlife Sanctuary. This region also contains major dams such as the Bhumibhol dam in Tak province, the Sirinakharin
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dam and the Wachiralongkorn dam in Kanchanaburi, the Kaengkrajarn dam in Phetchaburi and the Pranburi dam in Prachuap Khirikhan. Mining is an important industry in the area. In the study area, mountain ranges with an average height of approximately 1,600 meters above mean sea level border the northern and western part of the country and mostly high mountain ranges are close to the border of Myanmar. These mountain ranges lie in a north-south direction extending from the Daen Lao Range and the Thanon Thong Chai Range in the North to the Tanaosri Range in the western part of Thailand. For some villages, no roads but walking trails are the only way to visit. Water sources for the villages are creeks or small streams in high mountains.

The scope of the study focused on the village locations of 6 Karen subgroups, namely the Sgaw, the Pwo, the Taungthu or Pa'O, the Kayah, the Kayan, and the Kayaw. The photographs in Figure 2 show the 6 Karen subgroups wearing their traditional dress and personal adornments. The photos were obtained courtesy of the Karen Linguistics Project.

4. Data source and methodology

4.1. Data source

The data used in this study came from different sources. The first data source was Karen village data. A total of 1,896 pieces of Karen village data, obtained in 2002 courtesy of the Department of Social Development and Welfare, the Ministry of Social Development and Human Security, Thailand, was made available in a Microsoft excel spreadsheet containing information about village location and estimated Karen population. Village locations were recorded in the Universal Transverse Mercator (UTM) geographic coordinate system in the form of X and Y coordinates. The village names and information about the subdistrict (so-called Tambon in Thai), the district (the so-called Amphoe in Thai) and the province (the so-called Changwat in Thai) names where the villages are located also were included in the file. It should be noted that the X and Y coordinates of the village locations as well as information such as village names were originally read from the topographical paper maps of the Royal Thai Survey Department (RTSD). To do this task, an approximately 240 map sheets based on the available L7018 map sheets on a scale of 1:50,000 were used. The estimated Karen

Figure 2 Photographs of 6 Karen subgroups in their traditional costumes
population of each village had been surveyed and collected many times in the past (during the period 1985-1988, in 1995 and in 1997) and finally updated to produce the 2002 data.

Unfortunately, the document had no record of the population numbers of Karen subgroups. A questionnaire was thus constructed and sent by post for this study in April 2011 to all of the subdistricts in the study area. The respondents were selected from the informants or the officers of the Subdistrict Administrative Organization (SAO). The results of the questionnaire collection were then used as the second data source of the study. Data collection was completed within 10 months. The data used in this study was obtained from 68.1% of all the observed Karen villages in the study area from 14 provinces with the exception of Ratchaburi province. As a result, the map and the analysis will cover 14 provinces only.

The third data source was the administrative boundary maps. Thailand’s administrative boundary maps at subdistrict, district and provincial level, obtained courtesy of the Ministry of Transportation (MOT), were available in vector format in the form of a polygon shaped file in the latest version of 2011. These administrative boundary maps were mainly used for map display and error checking.

The final and last data source was topographical maps. Topographical maps of Thailand are available from the Royal Thai Survey Department (RTSD) at a scale of 1:50,000. However, for national security reasons, some sheets of topographical maps covering the areas bordering Thailand and its neighbouring countries, including the Thai-Burmese border, are not available to public and can not be sold by the Department. Therefore, other sources for topographical maps were sought. Finally, the topographical map of Thailand used in this study was obtained courtesy of the USGS (the U.S. Geological Survey), namely the SRTM (the NASA Shuttle Radar Topographic Mission) digital elevation data. The SRTM topographical map is considered to be a uniform representation of the Earth’s topography that is all-purpose to users and applications. It is stored in the raster form of a digital elevation model (DEM), covering a land area between 56 degrees South and 60 degrees North latitudes and constituting about 80 percent of the Earth’s landmass (Slater et al., 2006). The extraction of ground heights from the SRTM data was processed by the interpretation of Radar satellite data through the digital image processing technique of interferometry (Slater et al., 2006). In this study, the SRTM topographical map, specifically called DTED® Level 1, was available for use at a spatial resolution of 30x30 m. For more information about the SRTM data, visit the CGIAR-CSI website http://srtm.csi.cgiar.org/.

4.2. Preparation of a GIS database and cartographic presentation for a spatial analysis of Karen settlements

Based on the available data illustrated in the previous section, a geographical database of Karen settlements was created under a GIS environment. A spreadsheet file containing the village locations in the form of X and Y coordinates was converted and added as a vector map layer, represented as point
features. The village map produced contained information about village names including subdistrict, district, and province names. The administrative boundary maps, having more up-to-date information about administrative boundaries in 2011, were also overlaid with village locations to recheck and make corrections to subdistrict, district, and province names. Then, a file containing the number of population in each Karen subgroup village, derived from the questionnaire collection, was recorded and joined to the village map. The final map, as a result, had village locations and village information including the population of Karen subgroups. Figure 3 shows a map of all Karen villages in the study area. From the Figure, a total of 1,291 villages from the returned questionnaires, or about 68% of all Karen villages in the study area, were used for the analysis in this study.

Map presentation of Karen settlements was done in two ways. Firstly, the technique was to produce a map of the settlement of Karen classified by subgroups. In this technique, the Karen villages were symbolized in circles with different colours based on the Karen’s subgroups. The second technique was to produce a map of the settlement of Karen subgroups classified by population size. In this technique, the population size of Karen villages for each subgroup was classified and symbolized. For both techniques, a district map, in the form of polygon features, was superimposed on the village map to make the resultant map more complete and easily readable. However, due to unrest in the area along the Thai-Burmese border, map production with a reference coordinate system was omitted for security reasons.

Map results are shown and discussed in the next section.

Figure 3 Map of all Karen villages covering 15 provinces in the study area

It should be noted that although a village database provides useful information about Karen settlements, there are some defects. Careless mistakes such as map reading errors or wrong entries with data input into the GIS database possibly occurred during the map input process. One inevitable error that should be highlighted was due to mismatch as well as misplacement between administrative boundaries and Karen village locations. As previously mentioned, Karen village data was obtained from the Department of Social Development and Welfare, the
Ministry of Social Development and Human Security, Thailand—a government organization that takes full responsibility for collecting Karen data. The Department mainly read the Karen village locations from 1:50,000 RTSD topographical maps. The RTSD maps have details of administrative boundaries at provincial and district level, but no details about subdistrict boundaries. Therefore, subdistrict data for all Karen villages was read from text-based information obtained from the Department of Provincial Administration (DOPA)\(^3\). In some areas, the subdistrict boundaries of some Karen villages had been changed and some newly established villages had been split administratively from old villages as a result of population increase. With the long reporting delay to other relevant government agencies, information about villages was not up-to-date. As a result, there were many cases where a village name labelled in one Tambon was located in a different Tambon or even a different Amphoe. Also, some newly established villages could not be found on the RTSD map. According to the study, errors involving mismatching and misplacing villages accounted for almost 2% of the study area.

4.3. Exploring the relationship between village locations and topography

To explore the relationship between Karen village locations and topography, the village location layer was overlaid with the village elevation layer. Spatial overlay analysis is commonly used among GIS applications. Basically when two map layers are overlaid, information can be extracted between these two layers using ‘union’ or ‘intersection’ operations. The ‘union’ operation can be considered to be the Boolean logic ‘OR’ while the ‘intersection’ operation can be considered to be the Boolean logic ‘AND’. In this study, the intersection overlay function was applied to extract the elevation of Karen village locations classified by Karen subgroup. Summarizing and interpreting the relationship between Karen villages and elevation was conducted using statistical functions within GIS software such as boxplot and histogram as shown in Figure 4 and Figure 5. The results of the investigation are given and interpreted in terms of tables and graphs in the next section.

5. Results and discussion

In this section, results based on data collection and maps produced are reported and discussed. Firstly, the population numbers of Karen subgroups in the study as well as the population change are investigated. Secondly, the distribution of Karen settlements classified by subgroup is examined. Villages of Karen subgroups classified by population size are also investigated. Finally, the relationship between Karen villages and topography is explored.

5.1 Exploring the population numbers of Karen subgroup and population change

5.1.1 Numbers of subgroup population by province

\(^3\) The Department of Provincial Administration (DOPA) is a government agency responsible for assigning and demarcating Tambon (subdistrict), Amphoe (district) and Changwat (province) boundaries in Thailand.
Using GIS For Exploring Karen Settlements

Figure 4 An example of a boxplot showing the relationship between the Sgaw Karen’s villages and elevations

Figure 5 An example of histogram showing the relationship between the Sgaw Karen’s villages and elevations
Table 1 lists the population numbers of Karen subgroups conducted in this study. The survey was performed based on the 15 provinces in 2011-2012. Ratchaburi was excluded from the observation because no questionnaire was returned from this province.

Overall, a total of 332,754 Karen from 1,291 villages were identified. Of all Karen subgroups, Sgaw accounts for 76.0%, Pwo 22.8%, Kayah 1.1% and Taungthu (Pa’O) 0.1%. No Kayan and Kayaw were found in the study area. Obviously, the majority of the Karen population in the vicinity of the Thai-Burmese border are Sgaw. The number of the Pwo population places them in the second place. The Kayah population accounts for third place and the Taungthu (Pa’O)’s population are found in small numbers. As previously mentioned in the data source section, the numbers here came back from the collection of about 68% of all observed Karen villages in the study area. Thus, the correct population numbers should be more than those indicated in the Table.

5.1.2 Exploring population change

Two available Karen population sources were used to compare the population numbers surveyed by the project. The first source was the survey work in 1995 compiled by Schliesinger (2000) and the second source was the survey data in 2002 obtained from the Department of Social Development and Welfare, the Ministry of Social Development and Human Security, Thailand.

The survey work compiled by Schliesinger (2000)\(^4\) estimated the population numbers of Karen subgroups in 1995. According to Schliesinger (2000)\(^4\), there were an estimated 245,000 Sgaw, 105,000 Pwo, 2,500 Kayah, 900 Taungthu (Pa’O), 500 Kayan (Padong), and 30 Kayaw in the whole of Thailand.

However, these population numbers could not truly compare to those surveyed by the project. This is due to the fact that Schliesinger did not give the population numbers of Karen subgroups classified by province. Also, details about the survey method such as how the data has been surveyed and collected were not given. More importantly, the survey conducted by the project was accomplished based on a collection of 68.1% of all Karen villages. For these reasons, population change could not be calculated. Nevertheless, the overall percentage of population for each subgroup between these two sources was compared to investigate the proportion of population among these subgroups. The result of the comparison is shown in Table 2. According to the Table, the proportion of population of these subgroups in the two data sources was relatively the same. The Sgaw Karen are the largest group. The smaller groups are the Pwo, the Kayah and the Taungthu Karen in that order. The population numbers of the Kayan and Kayaw Karen surveyed in 1995 were in small numbers and appeared as 0.0% in the Table while the survey in 2012 had no return from these two subgroups.

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\(^4\) Remark: the population numbers of the Kayan Karen was reported by Tribal Research Institute, Service and Publicity Section, Chiang Mai, in 1995 while the other subgroups were estimated figures.
Table 1 The population numbers of Karen subgroups in Northern and Western Thailand in the vicinity of the Thai-Burmese Border

<table>
<thead>
<tr>
<th>No.</th>
<th>Province</th>
<th>Population numbers of Karen subgroups (2012)</th>
<th>Total</th>
<th>Sgaw</th>
<th>Pwo</th>
<th>Taungthu (Pa’o)</th>
<th>Kayah</th>
<th>Kayan</th>
<th>Kayaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chiang Rai</td>
<td></td>
<td>7,108</td>
<td>6,460</td>
<td>594</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Mae Hong Son</td>
<td></td>
<td>92,160</td>
<td>63,648</td>
<td>18,701</td>
<td>260</td>
<td>2,001</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Chiang Mai</td>
<td></td>
<td>98,155</td>
<td>65,615</td>
<td>30,161</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Lamphun</td>
<td></td>
<td>16,276</td>
<td>13,812</td>
<td>2,454</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Lampang</td>
<td></td>
<td>3,313</td>
<td>2,036</td>
<td>220</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Phrae</td>
<td></td>
<td>8,158</td>
<td>519</td>
<td>6,276</td>
<td>0</td>
<td>1,363</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Tak</td>
<td></td>
<td>85,472</td>
<td>81,684</td>
<td>2,754</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Sukhothai</td>
<td></td>
<td>989</td>
<td>989</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Kamphaeng Phet</td>
<td></td>
<td>495</td>
<td>275</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Uthai Thani</td>
<td></td>
<td>3,284</td>
<td>0</td>
<td>3,284</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>Kanchanaburi</td>
<td></td>
<td>8,531</td>
<td>4,357</td>
<td>3,797</td>
<td>42</td>
<td>225</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Suphan Buri</td>
<td></td>
<td>1,504</td>
<td>0</td>
<td>1,504</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Ratichaburi</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>Petchaburi</td>
<td></td>
<td>4,788</td>
<td>495</td>
<td>2,882</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>Prachuap Khirikhan</td>
<td></td>
<td>2,521</td>
<td>2,521</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>332,754</strong></td>
<td><strong>242,411</strong></td>
<td><strong>72,627</strong></td>
<td><strong>368</strong></td>
<td><strong>3,603</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Remark:

1. Data source: questionnaire collection conducted by the project. The respondents were the informants or the officers of the Subdistrict Administrative Organization (SAO), Thailand in 2011-2012.
Table 2: The percentage of Karen population for each subgroup between the year 1995 and 2012 compared.

<table>
<thead>
<tr>
<th>Karen subgroups</th>
<th>1995 data¹</th>
<th>2012 data²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sgaw</td>
<td>69.3</td>
<td>72.8</td>
</tr>
<tr>
<td>Pwo</td>
<td>29.7</td>
<td>21.8</td>
</tr>
<tr>
<td>Kayah</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Taungthu</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Kayan</td>
<td>0.0⁴</td>
<td>0.0</td>
</tr>
<tr>
<td>Kayaw</td>
<td>0.0⁴</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
<td><strong>95.8</strong></td>
</tr>
</tbody>
</table>


2. Data source: the population numbers of Karen obtained from the questionnaire collection conducted by the project. The respondents were the informants or officers of the Subdistrict Administrative Organization (SAO), Thailand in 2011-2012.

3. Kayan population accounts for 0.0014%.

4. Kayaw population accounts for 0.0008%.

Although a comparison between subgroups could not be provided, overall population change could be observed by using the second source—the survey data obtained from the Department of Social Development and Welfare. As shown in Table 3, the population numbers of Karen previously surveyed in 2002 by the Department of Social Development and Welfare was comparable to the data surveyed by the project in 2012. From the table, it is quite clear that the numbers of Karen population increased in most provinces, except in Phrae and Uthai Thani. The degree of percent increase varied from 5.5% to 44.4%. Classified by 3 classes—below 20% increase, 20-30% increase and higher than 30% increase, conclusions can be made. The number of the Karen population in Chiang Mai, Tak, Lampang, and Lamphun increased at a low rate. The number of the Karen population in Mae Hong Son, Chiang Rai, Sukhothai and Kanchanaburi increased at a medium rate while Petchaburi, Suphan Buri and especially Prachuap Khiri Khan increased at a high rate. Overall, it can be concluded that in the last 10 years the number of the Karen population in the study area increased by 10%. In the case of Phrae and Uthai Thani, the percentage decrease could possibly have occurred due to the fact that an observed village had been divided into two or more villages as a result of population increase and some newly established villages were not included in the survey.

5.2. A map of the spatial distribution of Karen settlements

This research studied the spatial distribution of Karen subgroup settlements in 3 aspects—settlement distribution, village size, and the relationship between village location and topography.
Using GIS for Exploring Karen Settlements

Table 3 Population numbers of Karen between the year of 2002 and 2012 compared

<table>
<thead>
<tr>
<th>No.</th>
<th>Province</th>
<th>Year 2002(^1)</th>
<th>Year 2012(^2)</th>
<th>Difference (in percent )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chiang Rai</td>
<td>5,630</td>
<td>7,108</td>
<td>20.8</td>
</tr>
<tr>
<td>2</td>
<td>Mae Hong Son</td>
<td>73,650</td>
<td>92,160</td>
<td>20.1</td>
</tr>
<tr>
<td>3</td>
<td>Chiang Mai</td>
<td>92,766</td>
<td>98,155</td>
<td>5.5</td>
</tr>
<tr>
<td>4</td>
<td>Lamphun</td>
<td>13,099</td>
<td>16,276</td>
<td>19.5</td>
</tr>
<tr>
<td>5</td>
<td>Lampang</td>
<td>2,694</td>
<td>3,313</td>
<td>18.7</td>
</tr>
<tr>
<td>6</td>
<td>Phrae</td>
<td>8,298</td>
<td>8,158</td>
<td>-1.7</td>
</tr>
<tr>
<td>7</td>
<td>Tak</td>
<td>73,734</td>
<td>85,472</td>
<td>13.7</td>
</tr>
<tr>
<td>8</td>
<td>Sukhothai</td>
<td>741</td>
<td>989</td>
<td>25.1</td>
</tr>
<tr>
<td>9</td>
<td>Kamphaeng Phet</td>
<td>275</td>
<td>495</td>
<td>44.4</td>
</tr>
<tr>
<td>10</td>
<td>Uthai Thani</td>
<td>3,382</td>
<td>3,284</td>
<td>-3.0</td>
</tr>
<tr>
<td>11</td>
<td>Kanchanaburi</td>
<td>6,146</td>
<td>8,531</td>
<td>28.0</td>
</tr>
<tr>
<td>12</td>
<td>Suphan Buri</td>
<td>953</td>
<td>1,504</td>
<td>36.6</td>
</tr>
<tr>
<td>13</td>
<td>Ratchaburi</td>
<td>13,577</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>Petchaburi</td>
<td>3,338</td>
<td>4,788</td>
<td>30.3</td>
</tr>
<tr>
<td>15</td>
<td>Prachuap Khirikhan</td>
<td>1,278</td>
<td>2,521</td>
<td>49.3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>299,561</strong></td>
<td><strong>332,754</strong></td>
<td>-</td>
</tr>
</tbody>
</table>

Remark:

1. Data source: the population numbers of Karen surveyed in 2002 obtained from the Department of Social Development and Welfare, the Ministry of Social Development and Human Security, Thailand.

2. Data source: the population numbers of Karen obtained from the questionnaire collection conducted by the project. The respondents were the informants or officers of the Subdistrict Administrative Organization (SAO), Thailand in 2011-2012.
5.2.1 Exploring settlement distribution

A map of Karen settlements was produced as shown in Figure 6 to investigate settlement distribution. The Karen villages were symbolized in circles with different colors based on Karen subgroups, namely the Sgaw, the Pwo, the Taungthu or Pa’O, the Kayah, the Kayan and the Kayaw. It is obvious that a mixture of subgroups in the same village is hardly ever seen (see the magnified area ‘A’ in the Figure), except in Kanchanaburi (see the magnified area ‘B’ in the Figure). Overall, villages that contain only one subgroup account for about 89% of all observed Karen villages in the study area. That is, the mixture of subgroups in a village is found to be at about 11%. By considering them separately, villages containing only Sgaw people account for 93% of all villages where the Sgaw Karen reside. Villages containing only Pwo people account for 75% of all villages where the Pwo Karen reside, villages containing only Kayah people account for 73% of all villages where the Kayah Karen reside, and villages containing Taungthu people only account for 20% of all villages where the Taungthu Karen reside. In other words, the Taungthu people are found mostly mingling with other subgroups in a village. The finding thus confirms the Karen's social structure, as stated in the “The Karen Tribal Group of Thailand” (1969), in that there is much interaction among the same group and each tends to live independently from other groups. One suggestion, however, would be the case of Kanchanaburi province where a mixture of Karen subgroups in some villages such as Saphan Lao village, Dinso village, and Rai Pa village are found in almost the same proportion. This would be an interesting case for linguists and anthropologists to study as to whether the social and cultural change in the area has occurred or not.

5.2.2 Exploring village sizes

Village size reflects how many people live in a village. Table 4 gives a summary of village size observed for all Karen subgroups. According to the Table, the village size where the Sgaw Karen and the Pwo Karen reside varies largely. For example, villages containing the Sgaw Karen range from 1 to 1,840 people. The village size where the Kayah and Taungthu Karen reside has a smaller range compared to that of the Sgaw and the Pwo Karen. In spite of their range-size variations, however, one finding is that the average village size for all subgroups except Taungthu is almost the same. Approximately, the average size of a Karen village is 240-300 people in the study area.

Table 4 The village sizes of Karen subgroups found in the study area

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Population numbers of subgroups in a village</th>
<th>Mean average village size (S.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sgaw</td>
<td>1 – 1,840</td>
<td>247 people (238)</td>
</tr>
<tr>
<td>Pwo</td>
<td>1 – 1,249</td>
<td>298 people (236)</td>
</tr>
<tr>
<td>Kayah</td>
<td>4 - 572</td>
<td>240 people (240)</td>
</tr>
<tr>
<td>Taungthu</td>
<td>5 - 260</td>
<td>70 people (106)</td>
</tr>
</tbody>
</table>

5 Only 5 villages where the Taungthu Karen reside were found in the study area.
To explore the pattern of village size, the numbers of population in a village was classified. In the case of Thailand, up to now classification of village size has not been informally set. The National Village and Urban Community Fund Office, Thailand, has recently set criteria for village size using S-M-L classification to help allocate financial aid to rural villages and communities (The National Village and Urban Community Fund Office, 2012). A Small village is considered to have 500 people in a village, a Medium village having 501-1,000 people, and a Large village to have more than 1,000 people. Some researches such as a survey conducted by Yoshikatsu et al. (1996) have concluded that the average size of a rural village in Northeastern Thailand is about 500 – 1000 people. Based on the visual observation and statistics means applied in this study, the numbers of Karen in a village have been classified as 4 groups; a village of 1-250 people, 251-500 people, 501-1000 people, and a village of more than 1,000 people.

Table 5 gives a summary of classified village sizes by subgroup. Of all villages where the Šgaw Karen reside, for
example, villages containing Sgaw people of between 1-250 account for 66%, Sgaw people of between 251-500 account for 23%, Sgaw people of between 501-1,000 account for 9%. Villages containing more than 1,000 Sgaw people account for 2%.

According to the Table, it can be summarized that the majority of the village sizes for all subgroups is a village of 1-250 people, the smallest one. This size of village occupies approximately 65% of all observed Karen villages. A larger village size of 251-500 people is found in the second place. A village size of 501-1,000 people accounts for the third place while a village size of more than 1,000 people is hardly ever found.

Table 5 The classified village size of Karen subgroups

<table>
<thead>
<tr>
<th>Classification of the numbers of Karen in a village</th>
<th>Sgaw</th>
<th>Pwo</th>
<th>Kayah</th>
<th>Taungthu</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-250 people</td>
<td>66</td>
<td>63</td>
<td>53</td>
<td>80</td>
</tr>
<tr>
<td>251-500 people</td>
<td>23</td>
<td>23</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>501-1000 people</td>
<td>9</td>
<td>12</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 1000 people</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The distribution of settlement patterns based on population size of the 4 Karen subgroups was plotted on a map and symbolized with different dot sizes as shown in Figure 7. Overall, Karen villages of the same subgroup tend to stay close together.

As shown in Figure 7(a), villages where the Sgaw Karen reside are generally distributed over the study locations but one big group is mainly in the northern and western part of the study area. Their settlements are clearly in a linear pattern lying in a north-south direction of the study area. A clearer view of the classified Sgaw village sizes is shown in Figure 8. In spite of different village sizes, a similar pattern can be noticed. Villages cluster densely close to the Thai-Burmese border. This area mainly covers the southern part of Mae Hong Son, the western part of Chiang Mai, and the northern and western part of Tak. In Figure 8(c) in which a village size between 501-1,000 was plotted, village locations lie mainly along the provincial borders between Mae Hong Son and Chang Mai whereas villages in Tak lie along the border between the two countries.

Different from the Sgaw villages, villages where the Pwo Karen reside are found as a few clusters in the study area. A big cluster is located in the southern part of Chiangmai, Mae Hong Son, Lamphun and Lampang. Another cluster is located in the southern part of Tak and the northern part of Kanchanaburi. A smaller cluster can be found in Uthai Thani, the northern part of Kanchanaburi and is connected to Suphan Buri. When different village sizes were plotted separately as shown in figure 9, the settlement appears to be in a linear pattern lying in the east-west direction. Interestingly, larger villages (see Figure 9(d)) tend to be located farther from the country border than smaller villages (see Figure 9(a)).
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Figure 7 Map showing the population size of Karen villages classified by subgroup
Figure 8 Sgaw villages with different population size

Figure 9 Pwo villages with different population size
A total of 15 Kayah villages were found in the study area. Villages where the Kayah Karen reside are shown in Figure 7(c), small groups can be detected in the northwestern part of Mae Hong Son and in the southern part of Phrae. A few villages are also found in the western part of Kanchanaburi.

Only 5 Taungthu villages were found in the study area. Their village distribution, as shown in Figure 7(d), locates with no-pattern. However, they have all settled along the Thai-Burmese border. Among all Taungthu villages, the biggest village size, containing 260 Taungthu people, is located in the northern part of Mae Hong Son at Huai Cha Rob village. Of the 5 villages, this is only village that contains only Taungthu people.

When superimposing the Karen settlements with a topographical map in a 3-D view as shown in Figure 10, one noticeable point is that the clusters of settlements in all Karen subgroups are often on mountain peaks or at high elevations. The villages mainly lie linearly along the Thai-Burmese border or the provincial boundaries. Further investigation of the relationship between Karen village locations and topography will be examined in the next section.

5.2.3. Relationship between village locations and topography

In their physical setting, the Karen in Thailand commonly live in small villages in mountainous areas at elevations of between 600 and 1,500 meters above mean sea level (Delang 2003). The settlements, as reported by “The Karen Tribal Group of Thailand” (1969), have some variations ranging from small upland settlements placed around the activity of swidden agriculture (slash-and-burn technique) to larger permanent valley where villages are placed around wet rice cultivation. In this section, the relationship between village locations and topography for each Karen subgroup is examined.

Determining by the government agency of Thailand (Buddee 1985:19 in Delang 2003)), elevations below 200 meters above MSL are defined as ‘lowlands’, up to 500 meters above MSL are defined as ‘uplands’ and elevation exceeding 500 meters are referred to as ‘highlands’.

Based on the definition above, a topographical map was classified according to 3 classes. These classes were ‘lowland’, ‘upland’, and ‘highland’ areas. As shown in Figure 11, the classified map (see Figure 11(a) was superimposed with Karen villages (see Figure 11(b)) to observe the preference height of the Karen settlements. Overall, most Karen settlements are at an elevation exceeding 200 meters above MSL. The high elevation area (exceeding 500 meters above MSL) in the northern and western part of the study area comprises the thick pack of settlements as shown in the magnified area ‘1’ (see Figure 11(c)). The lower elevation in the southern part of the study area, as shown in the magnified area ‘2’ (see Figure 11(d)), has a lower concentration of settlements.
Figure 10 A topographical map superimposed with Karen villages
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(a) A classified topographical map, assigned as ‘lowland’, ‘uplands’, and ‘highlands’ area
(b) A classified topographical map draped with Karen villages
(c) Magnified area ‘1’
(d) Magnified area ‘2’

Figure 11 A classified topographical map superimposed with Karen villages
Statistical calculation was also performed to observe the relationship between Karen’s village locations and topography. The elevation ranges of settlements are illustrated as graphs in Figure 12 and Figure 13. Villages where the Sgaw Karen reside are located at elevations ranging from 72.0 – 1470.0 meters above mean sea level (MSL) with an average elevation of 692.2 meters above MSL. Villages where the Pwo Karen reside are located at elevations ranging from 47.0 and 1470.0 meters above MSL with an average elevation of 661.9 meters above MSL. The village locations of both the Sgaw and Pwo Karen can thus classify them as a ‘highland’ tribe.

![Figure 12 Graphs showing ranges of elevation occupied by Karen subgroup](image1)

![Figure 13 Graph showing cumulative numbers of village against elevation](image2)
Villages where the Kayah Karen reside locate at a lower elevation between 112.0 and 908.0 meters above MSL with an average elevation of 384.2 meters above MSL. Village locations of the Kayah Karen can thus be define them as an ‘upland’ tribe.

Compared to the other observed subgroups, villages where the Taungthu Karen reside are located at the lowest elevation between 103.0 and 414.0 meters above MSL. Their average elevation is 275.5 meters above MSL. Based on the examination, the village locations of the Taungthu Karen can also define them as an ‘upland’ tribe.

To sum up, the preferential topographical heights for these subgroups are different. The Sgaw and Pwo Karen mostly settle at high elevations in ‘highland’ areas while the Kayah and Taungthu (Pa’O) Karen locate at lower elevations in ‘upland’ areas. Since higher elevation implies less accessibility and more isolation of the villages, the Sgaw and the Pwo Karen who live at higher altitudes may better preserve the originality of their languages than the Kayah and Taungthu Karen. Such a finding may help linguists to further investigate the variation of languages in these subgroups more clearly.

6. Conclusion

In this study, a village database of Karen settlements of 6 Karen subgroups was produced with the main aim of facilitating linguists’ work. Locations of 6 Karen subgroups in western and northern Thailand in the vicinity of the Thai-Burmesian border are the main scope. The Geographic Information System (GIS), a spatially-based technique, was used as a tool to map the Karen village locations. Further analysis was conducted to explore the population numbers of Karen subgroup and their population change, settlement distribution, village sizes and the relationship of village locations and topography. Overall the key findings of the study can be summarized as follows.

Firstly, among all of the 6 Karen subgroups, the Sgaw Karen are still the largest Karen population residing in Thailand today. The second largest subgroup is the Pwo Karen. This finding is in agreement with most previous Karen surveys such as the study compiled by Schliesinger (2000).

Secondly, in the last 10 years the total number of the Karen population in the study area has increased by 10%. The numbers of Karen population in some provinces such as Kamphaeng Phet and Suphan Buri have increased at an alarming rate while the population numbers in two provinces—Uthai Thani and Phrae—have decreased slightly.

Thirdly, the findings show that the size of village of all subgroups varies greatly ranging from small to large ones. However, their average size is relatively similar—approximately 250 people per village. In addition, village size below this number (≤250 people) applies to over 60% of all Karen villages.

Fourthly, the distribution of Karen villages is unique and totally different from Thai settlements. Each subgroup tends to live independently from other subgroups. The pattern of their settlement linearly lies along the Thai-Burmesian border or provincial boundaries due to their being confined by mountain ranges, hills, and valleys. For the Sgaw Karen, their settlements are found clustered mostly
close to the Thai-Burmese border. The Pwo Karen have settled closer to the mainland of the Thai Kingdom. The settlements of the Kayah and Taungthu Karen are distributed with no-pattern.

And finally, the elevation ranges of settlements occupied by Karen subgroups are approximately between 100 and 1,500 meters above MSL. The preferred topographical height for these subgroups is different. The Sgaw and Pwo Karen tend to settle at higher elevations in ‘highland’ areas whereas the Kayah and Taungthu (Pa’O) Karen locate at lower elevations in ‘upland’ areas.

The main result of the study, a GIS village database, provides very useful information in the spatial dimension and will be used as a reference map for the settlement of Karen subgroups surveyed in 2011-2012. Maps of Karen settlements can help linguists and relevant researchers to interpret and get a better knowledge of Karen studies from the spatial aspect. Also, this information will be useful for government agencies in performing rural planning and policy making as well as setting up action plans to mitigate problems in upland and highland areas.

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BOOK REVIEW

Ratanakul’s Ruam botkhwam wichakan lem 1: Kariang [Collected papers I: Karen]

This book is a collection of articles on the language and culture of the Sgaw Karen, an ethnic group now numbering over 400,000 (REF) living in the western part of Thailand. The product of Ratanakul’s laborious fieldwork from 1976 to 1981, it contains two papers written in Thai and six in English published or presented at various occasions in the early eighties. All of them, however, address issues in the linguistic and cultural study of the Karen people that are of interest to readers regardless of their linguistic background.

The first article, Ahan kariang or Karen food, written in Thai, describes different types of traditional food eaten by the Sgaw people of Huay Bong subdistrict, Mae Chaem district, Chiangmai province. Not only does the paper provide basic descriptions and recipes of common Karen dishes not generally known to outsiders but close reading also reveals interesting observations on Karen food culture. For example, Ratanakul observes that only one curry or soup dish [tà su] is served in combination with one spicy dipping dish [mì?sàtò] at each meal. She suggests that the relatively small meal set is related to the fact that Karen families are typically nuclear families in contrast to the extended families found in the other ethnic groups of Thailand. Particularly interesting ethnolinguistically is how types of meat are categorized. Unlike Thai, in which meats are classified binarily, Karen have a ternary classification: grilled meat [nə xo], fishy meat [nə chyî], and old-smelling meat [nə pya]. This article thus provides good documentation on one important aspect of Karen culture.

The second article, Phleng kariang or Karen songs, also written in Thai, is another piece of descriptive ethnological work included in this volume. Ratanakul starts off with a concise review introducing the different Karenic groups followed by the phonemic inventory of Sgaw Karen, necessary for a systematic transcription of the Karen songs recorded. Not only does this article describe the structure of the different song types and their usages in the community but it also documents traditional practices with which each type of song is associated, e.g. funerals, courting, nursery etc. Most valuable, perhaps, are the systematically transcribed and interlinearly-glossed samples of Karen songs included at the end. Of special interest are two modern Karen songs showing Karen-Thai code switching. As Ratanakul points out, these songs are clear manifestations of the dynamism of Karen culture.

Unlike the previous two, Wikhro kham wa (tà) nai phasa kariang sako or Analysis of Sgaw Karen tà, written in Thai, is a linguistic study. It examines the meaning of tà, one of the most functionally diverse grammatical morphemes in Sgaw Karen. Ratanakul identifies seven different usages of the morpheme and characterizes it as polysynymous. Furthermore, she groups the usages into two functions: 1) generic designator, and 2) impersonal pronouns. She concludes that [tà] has a rather vague core meaning as it denotes an entity generally without specifying its identity and is used in cases when the subject is deemphasized. In my opinion, tà as an impersonal pronoun is very interesting typologically. It is used with verbs denoting natural phenomena, e.g. rain,
thunder etc. as well as in sentences describing personal feelings, e.g. hunger, desire, pain etc. These usages are curiously reminiscent of dummy subjects and the impersonal se in Romance languages. This descriptive account of the Sgaw Karen morpheme is thus an important contribution to both Karen linguistics and linguistic typology in general.

The fourth article *Numeral classifiers in Sgaw Karen* presents, in English, the inventory of numeral classifiers and measure words in Sgaw Karen. It is, essentially, a catalogue of classifiers listed with examples of the nouns with which co-occur. In addition to the list of classifiers, this article also includes a brief discussion of the classifier constructions at the end. Ratanakul groups the eighty-some classifiers according to their etymological origins: 1) those functioning only as classifiers e.g. /di2/ for four-footed animals, 2) those derived from nouns e.g. /pa2/ from ‘side’ used with one side of things that typically come in pairs, and 3) those derived from verbs e.g. /khliʔ3/ from ‘to fold’ used with cloths and blankets. From an areal point of view, the last type is perhaps most intriguing as verb-derived classifiers are rather rare in Southeast Asia. In short, this article adds to our knowledge about the taxonomy of classifiers in the linguistic area.

The next article *Transitivity and causation in Sgaw Karen* describes different structures related to causitivity in Sgaw Karen. Ratanakul does not offer a working definition of causatives but seems to be very inclusive. She first shows that passivization is not possible in Sgaw Karen. She then proceeds to show that the main strategy for causitivization is using auxiliary verbs /maʔ/ ‘to do, to make’, /maʔeʔ/ ‘to cause’, /maʔ/ ‘to send, to use’, etc. In addition to the periphrasis, she also shows that verb serialization and cause-effect bi-clausal sentences are also used to convey causative meaning. As intended by Ratakul, these different ways of conveying causitivity shows that Sgaw Karen is highly analytic despite its Sino-Tibetan affiliation.

The sixth article *Prolegomena on traditional wisdom in Karen folklore* turns again to culture. It presents selected aspects of Karen culture including proverbs and sayings, traditional beliefs, view on life and death, and traditional entertainment. Ratanakul addresses these cultural issues by way of reflecting on key examples from oral texts collected in her fieldwork. A curious example is the Karen concept of “weird wicked” behavior, or [kčchú]. She cites examples like “to separate the little monkey from its mother, to fell too many trees in the forest is [kčchú],” and interprets them as showing that the Karen are non-acquisitive non-capitalist people. Even though alternative interpretations for the examples cannot be ruled out, the article successfully raises cultural issues that need to be further studied.

The last two articles are rather short pieces. The first one *Sgaw Karen color categories* is an ethnolinguistic one. It identifies and describes basic color terms in the language. The six categories claimed to comprise the set of Sgaw Karen basic colors are /wal/ ‘white, light’, /su/ ‘black, dark’, /γə/ ‘red’, /bɔʔ/ ‘yellow’, /laʔ/ ‘green’, and /lɨʔ/ ‘purple’. It then characterizes Karen as type 6 in Berlin and Kay’s typology (1969). The last article is a shorter presentation in English of the materials on Karen food presented in first
article of this volume. In the conclusion of the article, Ratanakul expresses concerns about the worrisome way Karen food culture is changing due to outside influences.

In short, Ratanakul’s *Collected papers I: Karen* is a great contribution to Karen studies as well as Southeast Asian Studies as whole. The papers each present invaluable materials on the language and culture of the Sgaw Karen not previously available. More importantly perhaps, this scholarly work will lead to public awareness of and respects for the cultural rights of ethnic minorities.

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ABSTRACTS IN THAI

VARIATION AND CHANGE OF THE PHRAE PWO KAREN VOWELS AND TONES INDUCED BY LANGUAGE CONTACT WITH THE TAI LANGUAGES
(การเปลี่ยนแปลงของสาระและวรรณยุกต์ภาษาขาวยะปอพร้อมที่จะเปลี่ยนจากภาษาไทย)
Chommanad Intajamornrak

วัตถุประสงค์ของการวิจัยคือเพื่อวิเคราะห์และเปรียบเทียบลักษณะทางสังคมศาสตร์ของสาระและวรรณยุกต์ภาษาขาวยะปอพร้อมที่จะเปลี่ยนโดยยุคที่ 3 ช่วงอายุ เกี่ยวกับสิ่งที่เกิดขึ้นที่บ้านต่าง ๆ จังหวัดเทพร โดยมีตัวชี้วัดการตัดสินใจของวัฒนธรรมสาระและวรรณยุกต์ด้วยคอมพิวเตอร์ที่โปรแกรม Adobe Audition เวอร์ชั่น 2 ตื่นตัวภาษาเป็นภาษาไทย แบ่งเป็น 3 กลุ่มคือ กลุ่มอายุมากกว่า 60 ปี กลุ่มอายุระหว่าง 35-50 ปี และกลุ่มอายุน้อยกว่า 25 ปี จำนวนรายการสังเกตุเหตุการณ์ทางสังคมศาสตร์แบ่งเป็นสองระยะ 405 คำ และวรรณยุกต์ 810 คำ จากนั้นจัดคำเป็นกลุ่มฐานและคำตกผลไม้ที่มีแนวโน้มที่จะเปลี่ยนแปลง

ผลการวิจัยแสดงให้เห็นแนวโน้มของสาระที่จำนวน 9 เสียง ได้แก่ / i, e, e, i, e, i, o, o, ə/ ซึ่งเมื่อพิจารณาบริบทที่ใช้ พบว่าในกลุ่มผู้สูงอายุมากกว่า 60 ปี สาระ /i, e, e/ เกิดในตำแหน่งใกล้กันมาก หมายถึงมีความแตกต่างของตำแหน่งสูงสุดที่ใช้ในการเปลี่ยนแปลง /u, o/ เกิดในตำแหน่งใกล้กัน และสาระ /ə/ ปรากฏในตำแหน่งใกล้กัน /a/ ในกลุ่มผู้สูงอายุ 35-50 ปี และกลุ่มอายุน้อยกว่า 25 ปี สาระ /e/ เกิดการเปลี่ยนแปลง ความมีตัวชี้วัดการเปลี่ยนแปลง /u, o/ ในกลุ่มผู้สูงอายุของ 35-50 ปี และกลุ่มอายุน้อยกว่า 25 ปี สาระ /e/ เกิดการเปลี่ยนแปลง

การเปลี่ยนแปลงของวรรณยุกต์ที่เกี่ยวข้องกับวรรณยุกต์ของ 810 คำ ในกลุ่มผู้สูงอายุมากกว่า 60 ปี วรรณยุกต์สุ่มที่ระดับเสียงสูงและระดับเสียงต่ำ เมื่อมีข้อมูลเกี่ยวกับการเปลี่ยนแปลง และระดับเสียงสูงและระดับเสียงต่ำ เมื่อมีข้อมูลเกี่ยวกับการเปลี่ยนแปลง วรรณยุกต์ของวรรณยุกต์ที่มีความแตกต่างกัน มันจะมีข้อมูลเกี่ยวกับวรรณยุกต์ที่ระดับเสียงต่ำกว่าและเพิ่มขึ้นเสียงสูงจึงสุ่มสูง การเปลี่ยนแปลงของวรรณยุกต์ที่เกี่ยวข้องกับข้อมูลของกลุ่มผู้สูงอายุน้อยกว่า 25 ปี กรณีที่ระดับเสียงสูงและระดับเสียงต่ำ

การเปลี่ยนแปลงของวรรณยุกต์ที่เกี่ยวข้องกับวรรณยุกต์ของ 810 คำ ในกลุ่มผู้สูงอายุมากกว่า 60 ปี วรรณยุกต์สุ่มที่ระดับเสียงสูงและระดับเสียงต่ำ เมื่อมีข้อมูลเกี่ยวกับการเปลี่ยนแปลง และระดับเสียงสูงและระดับเสียงต่ำ การเปลี่ยนแปลงของวรรณยุกต์ที่เกี่ยวข้องกับข้อมูลของกลุ่มผู้สูงอายุน้อยกว่า 25 ปี กรณีที่ระดับเสียงสูงและระดับเสียงต่ำ
FORMANT TRANSITIONS AS EFFECTIVE CUES TO DIFFERENTIATE THE PLACES OF ARTICULATION OF BAN PA LA-U SGAW KAREN NASALS

(การปรับเปลี่ยนของค่าความสัมพันธ์ระหว่างพจน์ ณ ช่วงorizontal ระหว่างคู่สัมพันธ์ของจากระดับคู่สัมพันธ์พยัญชนะในภาษาภูเขาดิน บ้านปะพลู)

Karnthida Kerdpol (ภาคที่สาม สกัดสด)

ภาษาภูเขาดิน บ้านปะพลู ด้ำนหัวชัย ไทย สังเกตุว่าเฉพาะที่ริเริ่มมีเสียงพพญัญชนะบก 4 รูปกรณ์ ได้แก่ รูปกรณ์อินฟอรา /m/ รูปกรณ์อินฟอรา /n/ รูปกรณ์พพญัญชนะบก และ รูปกรณ์พพญัญชนะบก /ŋ/ ที่เกิดในตำแหน่งดังกล่าว จากการทบทวนวรรณกรรมที่เกี่ยวข้องพบว่าเสียงพพญัญชนะบกพพญัญชนะบกในภาษาภูเขาดิน บ้านปะพลู ซึ่งเหมาะสมอย่างยิ่งสำหรับการศึกษาเสียงพพญัญชนะบก

ลักษณะทางกลต่อกลต่างๆที่ศึกษาในงานวิจัยนี้ได้แก่ ความเข้ม ค่าระยะเวลา และค่าความสัมพันธ์ระหว่างวัดในช่วงærนตรวจสอบ (nasal murmur) และค่าความสัมพันธ์ระหว่างวัดในช่วงærคุณค่าสัมพันธ์ Grammatical ถ้าเพราะว่าได้แก่ สาระ /a/ และ /e/ รวมทั้งโปรดปิดล็อกโดยข้อมูลพหุกิจ ANOVA และ Tukey’s HSD

ผลการวิจัยสะท้อนถึงบ้านงานวิจัยนี้ (Liberman et al. 1954, Malécot 1956, Recasens 1983, Harding and Georg 2003) ที่พบว่า ความสัมพันธ์ระหว่างพญัญชนะบกพพญัญชนะบกเป็นตัวอย่างฐานการ์ ที่สิ้นสุด กล่าวคือ ช่วง何度もระหว่าง /m/ กับ /a/ และ /e/ นี้ค่าความสัมพันธ์ระหว่าง 2 มากที่สุด รองลงมาคือ /n/ /ŋ/ และ /ŋ/ ต่ำสุด และกลุ่มเป็นความสัมพันธ์ระหว่างการทดสอบค่าความสัมพันธ์ระหว่าง /m/ กับ /a/ ที่ช่วงของการคุณค่าความสัมพันธ์พญัญชนะบกได้เอื้อ อย่างไรก็ตาม รูปแบบความสัมพันธ์

 Abstracts in Thai

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INITIAL CONSONANT VOICING PERTURBATION OF THE FUNDAMENTAL FREQUENCY OF ORAL VOWELS AND NASAL VOWELS: A CONTROVERSIAL CASE FROM BAN DOI PWO KAREN

(อิทธิพลของเสียงพยัญชนะสั้นในภาษาและประโยคที่มีต่อความถี่เสียงฐานของเสียงสระมนต์และสระนาค)

กรณีตีโดยจากภาษาท้องถิ่น

Phanintra Teeranon

BAN PA LA-U SGAW KAREN TONES: AN ANALYSIS OF SEMITONES, QUADRATIC TRENDLINES AND COEFFICIENTS

(วรรณยุกต์ภาษาท้องถิ่นสกาวกAREN การวิเคราะห์วรรณยุกต์ เสียงแย้มใหม่และอั้มประทวีชิ้นของสมการกัลลังการ)

Sujinat Jitwiriyanont

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博士สังกัดคณะและผลความสุ่มต่างของระดับเล็ก (2) เส้นแนวโน้มผลการก้าวส่งของสถานที่และระดับของการเปลี่ยนแปลงของระดับเล็ก และ (3) เส้นประสิทธิสมการก้าวส่งเพื่อแสดงความหมายของวรรณยุกต์ เหมาะกับการจัดทำวรรณยุกต์ที่ต่างกัน

ถ้าความสัมพันธ์ที่มีหน่วยเป็นเส้นทางของวรรณยุกต์ที่วัดได้ นำแนวทิศเป็นคำว่าไทยและต้องการ แสดงของการเปลี่ยนแปลงของระดับเล็ก และ (3) เส้นประสิทธิสมการก้าวส่งเพื่อแสดงความ หมายของวรรณยุกต์ที่ต่างกัน

ผลการศึกษาแสดงให้เห็นว่า วรรณยุกต์ดังกล่าว มีสัดส่วนลดที่ระดับเล็กสูงกว่า หรือ ต่ำกว่า โดยมีระดับ ของการเปลี่ยนแปลงระดับเล็กสูงและ นอกจากนี้ ผลของการเปลี่ยนแปลงระดับเล็กไม่ชัดเจน และมีการเปลี่ยนที่ ของระดับสัมพันธ์เป็นเส้นได้ทั้งหมดหรือส่วน วรรณยุกต์สูง มีสัดส่วนลดที่ระดับเล็กสูงกว่า หรือส่วนของวรรณยุกต์ที่สูงสุดที่สัดส่วนลดที่ระดับสัมพันธ์ของวรรณยุกต์สูงสุด โดยมีระดับของการเปลี่ยนแปลงระดับเล็กสูงและ มีการเปลี่ยนที่ ของระดับสัมพันธ์เป็นเส้นได้ส่วนใหญ่กว่าไว้ส่วนของวรรณยุกต์สูงสุดไม่ชัดเจน และมีการเปลี่ยนที่ของระดับสัมพันธ์เป็นเส้นได้ส่วนใหญ่กว่าไว้ส่วนของวรรณยุกต์สูงสุด

ผู้วิจัยสรุปได้ว่า การปรากฏของวรรณยุกต์ลดในพื้นที่ของภาษาไทยในบางพื้นที่อาจเกิดจากการสัมพันธ์ที่มีหน่วยที่จะทำให้เรื่องราวหมดไป (ะระเรื่อง) ที่จะได้รับจากแนวคำไทยและพื้นที่ดังกล่าว โดยเป็นที่ทราบกันดีว่าภาษาไทยในพื้นที่นี้มีวรรณยุกต์ลดในพื้นที่ปัจจุบัน

USING GIS FOR EXPLORING KAREN SETTLEMENTS: A CASE STUDY OF WESTERN AND NORTHERN THAILAND IN THE VICINITY OF THE THAI-BURMESE BORDER

(การใช้ระบบสารสนเทศภูมิศาสตร์เพื่อตรวจสอบการตั้งถิ่นฐานของชาวแห่งชาติ: การศึกษานาทีทางเหนือและภาค ตะวันตกของประเทศไทยในบริเวณใกล้ชายแดนไทย-มาเลย์)

Sririvilai Teerarojanarat

ในปัจจุบัน ชาวไทยเริ่มเป็นธรรมกันมากยิ่งขึ้นที่มีจิตใจยากที่จะสุ่มสิ่งต่างในประเทศไทย ส่วนใหญ่สิ่งที่ยังคงมีอยู่ บนพื้นที่มีแนวความหลากหลายไทย-พม่า ในภาษาไทยข้อมูลชาวพม่าหรือเชื้อที่ต่างถิ่น ซึ่งไทยยังคงไม่ให้ความ สนใจในการนำเสนอแผนที่แสดงการทำเมืองขึ้นของชาวพม่า บทความนี้เน้นการสำรวจข้อมูลชาวพม่าที่มีอยู่ในพื้นที่นี้ เพื่อที่จะทราบถึงความระดับ 15 จังหวัดในภาคตะวันตกและภาคเหนือของประเทศไทยตามแนว

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ฆ่าแผนไทย-พม่า กระบวนการศึกษาครอบคลุมเฉพาะพื้นที่ถิ่นโค้งบ้านกะเหรี่ยง 6 กลุ่ม ได้แก่ สะบอง โป ตองสุหรinstagram โต กาฉา กะยัง กะยะ การสำรวจข้อมูลแหล่งต้นฐานกระจายรอบตัว 6 กลุ่มดังนั้นการใดก็ตามสอบถามข้อมูลในกระบวนการศึกษา

เกี่ยวข้องระหว่างพ.ศ.2554 ถึง พ.ศ.2555 เทคนิคเชิงพื้นที่ ที่ชื่อว่า "ระบบสารสนเทศภูมิศาสตร์" ถูกนำมาใช้เป็นเครื่องมือในการพัฒนาฐานข้อมูลภูมิศาสตร์จากแหล่งต้นฐานกระจายรอบตัว นอกเหนือจากนี้ การวิเคราะห์เชิงลึกการสำรวจข้อมูลจานวนประชากรกะเหรี่ยงกลุ่มต่างๆและการเปลี่ยนแปลงจานวนประชากร การกระจายตัวของแหล่งต้นฐาน ขนาดหมู่บ้าน รวมถึงความสัมพันธ์ระหว่างที่ตั้งหมู่บ้านกับกลุ่มและภูมิประเทศผลการวิจัยแสดงให้เห็นว่ากระจายตัวของกลุ่มสะบองออกเส้นเป็นกะเหรี่ยงที่มีจานวนมากที่สุดที่อาศัยอยู่ในประเทศไทยในทุกวันนี้ จำนวนประชากรของหมู่บ้านกะเหรี่ยงมีขนาดแตกต่างกันไปมากถึงน้อยถึงร้อย แต่ต่างแต่ละขนาดหมู่บ้านโดยทั่วไปและในรูปแบบการดึงข้อมูล พบว่าหมู่บ้านกะเหรี่ยงกลุ่มเดิมกับกลุ่มที่จะอาศัยอยู่ให้ได้มากกว่ากลุ่มที่จะอาศัยอยู่ในหมู่บ้านเดิมกว่ามากนัก กระจายทุกกลุ่มจะตั้งต้นฐานอยู่บนยอดเขาหรือในพื้นที่สูงตามแนวชายแดนไทย-พม่าหรือตามแนวรอตองจังหวัด อย่างไรก็ตาม กระจายจะแตกต่างกันและกระจายไปเช่นนี้จะอาศัยอยู่บนพื้นที่ซึ่งมีระดับความสูงที่สูงกว่ากะเหรี่ยงระยะและของกะเหรี่ยง (ประโยชน์)ผลการวิจัยยังยืนยันถึงแนวทางการร่วมสร้างสารสนเทศภูมิศาสตร์ได้อย่างชัดเจน แสดงให้เห็นถึงความในการเพิ่ม

ความเข้าใจการศึกษาข้อมูลกระจายรอบตัวในภูมิศาสตร์พื้นที่
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BAN PA LA-U SGAW KAREN TONES: AN ANALYSIS OF SEMITONES, QUADRATIC TRENDLINES AND COEFFICIENTS
Sujinat Jitwiriyanont

Each dialect of the Sgaw Karen language has a different tonal system. Despite the different number of tones, all of the previous studies agree on the fact that all tones of Sgaw Karen are level tones. However, the finding of this study shows that Ban Pa La-u Sgaw Karen has a contour tone. The tonal system of this dialect comprises four tones, i.e. /low/, /mid/, /high/ and /falling/ occurring in non-checked syllables.

USING GIS FOR EXPLORING KAREN SETTLEMENTS: A CASE STUDY OF WESTERN AND NORTHERN THAILAND IN THE VICINITY OF THE THAI-BURMESE BORDER
Sirivilai Teerarojanarat

The Karen are one of the largest ethnic minority groups living in Thailand today, residing mostly in the mountainous ranges along the Thai-Burmese border. In most previous Karen studies, map presentation of Karen settlements has been disregarded. This paper explores the Karen from the spatial aspect, using GIS. The study area covered 15 provinces in western and northern Thailand along the Thai-Burmese border. The findings show that the Sgaw Karen are still the largest Karen-speaking group living in Thailand today. The population size of Karen villages varies largely but their average size is almost the same. Concerning the settlement pattern, Karen villages of the same subgroup tend to stay close together. All subgroups are located on mountain peaks or at high elevations along the Thai-Burmese border or along the provincial boundaries.

INITIAL CONSONANT VOICING PERTURBATION OF THE FUNDAMENTAL FREQUENCY OF ORAL VOWELS AND NASAL VOWELS: A CONTROVERSIAL CASE FROM BAN DOI PWO KAREN
Phinantra Teeranon

This paper aims to analyze the acoustic characteristics of initial consonant voicing perturbation of the fundamental frequency of oral vowels and nasal vowels of Ban Doi Pwo Karen. The results show that voiceless initial consonants tend to cause a lower fundamental frequency than that of the voiced initial consonants. This has excited controversy concerning the tonogenesis theory of initial voicing perturbation on vowels. In contrast to other studies, the nasal vowels were not always higher in fundamental frequency when compared to oral vowels. In all age groups, nasal vowels following either voiceless or voiced consonants were found to be higher in fundamental frequency than oral vowels, except in the younger age group where the fundamental frequency of nasal vowels following voiced consonants was lower than that of the oral vowels following voiced consonants.