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Impact of Tai Lue on Muak Sa-aak phonology

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Abstract

The Austroasiatic language Muak Sa-aak belongs to the Angkuic branch of the Palaungic subgroup. Speakers live primarily in eastern Shan State of Myanmar. This analysis is based on the variety of Wan Fai village. Although Burmese and Chinese are influential, their primary contact language is the Tai Kadai language Tai Lue. Borrowing from this language is extensive, even to the extent of replacing their numerals with Tai Lue. Although Muak Sa-aak underwent the Germanic shift typical of Angkuic languages, replacing proto-voiced initials with voiceless ones, it still retains some voiced initials. There is some evidence that language contact may have resulted in a three-tone system, where pitch would otherwise have been largely predictable. For the majority of rhotic-initial loan words, borrowing shows a direct correspondence of Muak Sa-aak /r/ with initial /h/ in Tai Lue. Some evidence from Assamese Tai languages suggests that rather than being a replacement, this might reflect a time when Tai Lue possibly still had a rhotic.

Keywords: Palaungic, Angkuic, phonology

ISO 639-3 language codes: tlq, khb, aho, aio, mya, cmn, huo, uuu, kjg, lbn

1. Introduction

Muak Sa-aak is an Austroasiatic language, belonging to the Angkuic subgroup of the Eastern branch of the Palaungic languages. They are also called Loi, or Tai Loi. This term however encompasses various languages which are not mutually comprehensible. Muak Sa-aak varieties are spoken in Eastern Shan State in Myanmar, primarily Mong Yawng Township, and also across the border in China. The estimated population total is 4,460 in Myanmar and China (Hopple 2007). This paper is based on the variety spoken in the village of Wan Fai in Eastern Shan State of Myanmar. A wordlist of 1,643 items was collected in whole or in part from three male mother-tongue speakers, aged between 42 and 55, who came from that village and had spent most of their lives there. None had any formal education.

The Muak Sa-aak are exposed to three major non-Austroasiatic languages: Tibeto-Burman Burmese, Chinese, and the Tai-Kadai language Tai Lue. Burmese, the national language of Myanmar where the majority of the Muak Sa-aak are located, has been used as a language of education in the government schools but many people in that part of Myanmar do not speak it due to lack of formal education. Like other adults in their community, none of the speakers interviewed for this research could speak Burmese. However, some Muak Sa-aak children in Wan Fai and other Muak Sa-aak villages have attended Burmese language schools. Recently many of the children have begun to attend schools with Chinese, the second contact language, as the language of instruction, especially in border areas. Speakers from Wan Fai village also report that their children watch Chinese television and that Chinese traders come through their village.

The most influential contact language is Tai Lue, classified as Tai Kadai, Kam Tai, Tai, Southwestern (Lewis, Simons and Fennig, 2013). Tai Lue is the major language of wider communication used in the Muak Sa-aak area of Shan State. Muak Sa-aak speakers do not seem to draw an ethnic or linguistic distinction between the Tai Kadai languages Shan and Lue. They will refer to both by the same ethnic group name, Shan, but they speak only Tai Lue as a second language, not Shan. In recent generations there has been intentional borrowing: one speaker in his fifties reported his parents teaching that not borrowing words from Tai Lue would be like eating food with no salt. Nevertheless, Muak Sa-aak parents still speak their mother tongue to their children and children continue to learn Muak Sa-aak first. The children may also use Tai Lue, Chinese, or Burmese at home.

Muak Sa-aak has borrowed extensively from the surrounding Tai Lue. Out of the initial wordlist of 1,643 items, 518 words or 32%, include Lue morphemes. In order to evaluate any effects of borrowing from Tai Lue on Muak Sa-aak, a brief sketch of the phonologies of both languages will be presented, followed by a comparison and analysis of loan words.

2. Comparison of Muak Sa-aak and Tai Lue phonology

The Muak Sa-aak phonology given below is based on Hall (2013). Muak Sa-aak is a tonal language. Words are sesquisyllabic, which means some words have reduced initial syllables made up of a consonant /p, p^h, t, k, k^h, m, s/ with a predictable vowel or the reduced vowel alone. Tone is not contrastive in reduced syllables.

There are three types of full syllables in Muak Sa-aak: open, checked, and smooth. Open and checked syllables can be short or long. In smooth syllables, when the vowel preceding a sonorant final is short, the sonorant is lengthened; when the vowel is long, the sonorant is short, so that the overall smooth syllable is always long. In full syllables, all consonants may occur in syllable-initial position. Initial consonant clusters include /pr, kr, p^hr, k^hr, pw, kw, p^hw, k^hw/. Final consonants are limited to /p, t, c, k, m, n, ɲ, w, j, l/. All full syllables carry one of the three contrastive tones. The low tone is labeled with 1, the constricted tone is labeled 2, and the falling tone is labeled 3. Tone 1 is found on all long syllable types. Tone 2 occurs on both long and short syllables, with a high allotone in short syllables and a falling allotone in long syllables. Tone 3 occurs only on long smooth syllables.

The 21 consonant phonemes and 18 vowel phonemes are shown in Tables 1 and 2.

Table 1. Muak Sa-aak consonant phonemes

<i>p^h p b</i>	<i>t^h t d</i>	<i>c^h c</i>	<i>k^h k</i>
<i>m</i>	<i>n</i>	<i>ɲ</i>	<i>ŋ</i>
<i>f</i>	<i>s</i>		<i>h</i>
<i>w</i>	<i>r l</i>	<i>j</i>	

Table 2. Muak Sa-aak vowel phonemes, Wan Fai variety

	Front	Back unrounded	Back rounded
Close	<i>i i:</i>	<i>u u:</i>	<i>u u:</i>
Close-mid	<i>e e:</i>	<i>ɤ ɤ:</i>	<i>o o:</i>
Open	<i>ɛ</i>	<i>a a:</i>	<i>ɔ</i>
Diphthongs	<i>ia</i>	<i>ua</i>	

A brief summary of Tai Lue phonology, based on Hudak (1996), is presented for comparison with Muak Sa-aak. Tai Lue has 22 consonant and 18 vowel phonemes, shown in Tables 3 and 4.

Table 3. Tai Lue initial consonants (adapted from Hudak 1996)

<i>p p^h b</i>	<i>t t^h d</i>	<i>c c^h</i>	<i>k</i>	<i>ʔ</i>
<i>f</i>	<i>s</i>		<i>x</i>	<i>h</i>
<i>m</i>	<i>n</i>	<i>ɲ</i>	<i>ŋ</i>	
<i>w</i>	<i>l</i>	<i>r</i>	<i>j</i>	

The velar fricative /x/ in Tai Lue is the equivalent of the aspirated velar stop /k^h/ in some Tai languages and in Muak Sa-aak. The phoneme /w/ is realized [v] initially. Initial consonant clusters according to Hudak include/ kw, tw, t^hw, xw, tr, t^hr/. Hudak (1996) includes the rhotic in his Tai Lue phoneme inventory, although it is only found in its written form, never spoken. Final consonants are limited to /p, t, k, m, n, ɲ, j, w/.

Table 4. Tai Lue vowels (Hudak 1996: xxiii)

	Front	Back unrounded	Back rounded
High	<i>i i:</i>	<i>u u:</i>	<i>u u:</i>
Mid	<i>e e:</i>	<i>ɤ ɤ:</i>	<i>o o:</i>
Low	<i>ɛ ɛ:</i>	<i>a a:</i>	<i>ɔ ɔ:</i>

Hudak identifies six tones for Tai Lue with slight differences in pronunciation according to two dialects, Chiang Hung and Muong Yong. Tones 3 and 6, low and mid-falling, are glottalized. The other tones are high, mid, low and falling.

As may be seen in Tables 1-4 above, there is a great amount of similarity in phonology between Muak Sa-aak and Tai Lue, including voicing contrast of initial stops, which Angkuic languages like Muak Sa-aak are expected to have lost. Major differences between the sound inventories of Muak Sa-aak and Tai Lue include the number of contrastive tones and the presence of a rhotic. The phoneme /r/, occurring only in written forms in Tai Lue, occurs widely in Muak Sa-aak, including as a medial consonant in clusters. Tai Lue, on the other hand, forms many consonant clusters with /w/ as the medial consonant, while Muak Sa-aak has only a few of these. In the vowels, this variety of Muak Sa-aak has two diphthongs /ia/ and /ua/, which Tai Lue does not have. In addition, the lateral /l/ and the palatal consonants /c, ɲ/ are found word-finally in Muak Sa-aak, but not in Tai Lue, suggesting that words with these finals are unlikely to be borrowed from Lue. Since data on borrowings with final /c, ɲ/ into Lue are not available, it is not possible to say how these might be adapted in Lue, which has only bilabial, alveolar and velar oral and nasal stops and the glides /w, j/ in syllable-final position.

3. Phonological changes due to borrowing

Tai Lue loan words are adjusted to, but also impact, Muak Sa-aak phonology as seen in the vowel system, the rhotic, voiced initials, and tone.

3.1 Adjustment of alien vowels

The Tai Lue vowels /ɔ:/ and /ɛ:/ are realized as the diphthongs /ia/ and /ua/ in the Wan Fai variety of Muak Sa-aak. This suggests that the Muak Sa-aak diphthongs are phonologically the equivalents of the missing long open vowels /ɛ:/ and /ɔ:/ which are found in other Muak Sa-aak varieties without diphthongs, such as the variety spoken in Wan Saw village. Thus, the Wan Fai Muak Sa-aak rendering of the Tai Lue monophthongs /ɛ:, ɔ:/ as /ia, ua/ suggests that these diphthongs developed from an older /ɛ:/ and /ɔ:/. Examples of borrowed words with the adjustment to Muak Sa-aak diphthongs are given in Table 5.

Table 5. Wan Fai Muak Sa-aak diphthongs in Tai Lue loanwords

Tai Lue	Muak Sa-aak	gloss
<i>pɛ:t²</i>	<i>piat¹</i>	‘eight’
<i>sip¹ sɔŋ¹</i>	<i>sip² suan³</i>	‘twelve’
<i>mɛŋ⁴ sa:p²</i>	<i>mian³ sa:p¹</i>	‘cockroach’
<i>lɛm¹</i>	<i>liam¹</i>	‘sharp-pointed’
<i>sɔɔk²</i>	<i>suak¹ tɔ²</i>	‘elbow’
<i>hɔn⁶</i>	<i>ruan²</i>	‘hot’

The number ‘two’ forms an exception as it is not pronounced consistently. As a monosyllable the vowel /ɔ:/ is retained, while in numeral compounds it is adjusted to Muak Sa-aak /ua/, as in *sip² suan³* ‘twelve’.

3.2 Correspondence of /h/ and a rhotic in Muak Sa-aak

Muak Sa-aak and Tai Lue differ in phonotactics. In Tai Lue, initial /r/ is found only in the written language and always realized as /h/ in the spoken language. In Muak Sa-aak, /r/ and /h/ are contrastive, with /r/ being more common. Initial /h/ in Tai Lue words is often replaced with /r/ in

Muak Sa-aak; for example, Lue *hok*² ‘six’ > Muak Sa-aak *rɔk*². This does not appear to be motivated by phonotactics or meaning. In addition to the replacement of /h/ with /r/, some apparent borrowings into Muak Sa-aak have initial consonant clusters /p^hr-/ or /pr-/, clusters which do not occur in Tai Lue: for example, Lue *p^hung*³ ‘bee’ > Muak Sa-aak *p^hrxŋ*². In some places where /r/ is found in Muak Sa-aak, /r/ is also found in standard Thai: Muak Sa-aak *ruan*² ‘hot’ > Thai *rɔ:n*, Muak Sa-aak *rx:n*¹ ‘[CLSF] house’ > Thai *ruan* ‘house’, Muak Sa-aak *rx*³ ‘boat’ > Thai *rua*. In other apparent loanwords containing /r/ in Muak Sa-aak, the /r/ does not occur in Thai either.

It is useful here to examine the Tai languages of Assam, India, specifically Tai Ahom and Tai Aiton which, like Tai Lue, are Southwestern Tai languages. These have retained /r/ in places that the other Tai languages do not, including consonant clusters with /r/. Ahom was spoken by people who originally came from Shan state of Myanmar (Tabassum and Morey 2009). The language is no longer spoken as a mother tongue, but is found in manuscripts. Initial clusters with /r/ do occur in the manuscripts, but it is not clear how many of these reflect actual clusters in the spoken language. Pronunciation today in religious usage may reflect hypercorrection. Tai Aiton, however, which is closely related to Ahom, is still spoken in northeast India and the rhotic may be heard there in spoken language, both as an initial and in initial consonant clusters (Tabassum and Morey 2009). Some Tai cognates found in Muak Sa-aak borrowings have initial /r/ or clusters with /r/ which are not found in Tai Lue or Tai, whereas Ahom or Aiton contain these rhotics; see Table 6 for examples. The numeral ‘five’ is included for contrast as an example of a word which does not have /r/ in any of these languages, showing that /h/ is not systematically being replaced with /r/. There must rather have been some other mechanism responsible for the occurrence of the rhotic in Muak Sa-aak loanwords from Tai Lue.

Table 6. Muak Sa-aak loanwords with /r/ in comparison to Tai Lue, Tai Ahom, and Tai Aiton (Tabassum and Morey 2009).

Muak Sa-aak	Thai	Tai Lue	Tai Ahom	Tai Aiton	gloss
<i>ro</i> ³ <i>caj</i> ³	<i>hǔa caj</i>	<i>hoo</i> ¹ <i>caj</i> ¹	<i>ru u chau</i>		heart
<i>rɔk</i> ²	<i>hòk</i>	<i>hok</i> ²	<i>ruk</i>		six
<i>ha</i> ²	<i>hâ</i>		<i>ha</i>		five
<i>p^hrxŋ</i> ²	<i>p^hûŋ</i>	<i>p^hung</i> ³	<i>phrung, phreng</i>	<i>phruŋ</i> ³	bee
<i>prut</i> ²				<i>phrû</i> ⁹	sorcerer

The existence of the rhotic in other Tai languages suggests that Muak Sa-aak has not replaced /h/ with /r/ in some instances and kept the /h/ in others. Rather, it is likely that it has instead retained an initial /r-/ in loanwords from Tai Lue where the rhotic has subsequently been lost. Muak Sa-aak loanwords from Tai Lue containing clusters with /r/ are still found in Tai Ahom and Aiton, suggesting that Tai Lue also had those clusters when the respective cognates entered the Muak Sa-aak lexicon.

3.3 Voicing contrast of initial plosives

According to Svantesson, applying the historical Germanic shift to Angkuic languages (1991), the voicing contrast in Palaungic languages was replaced in the Angkuic languages with an aspiration contrast; that is, the proto-voiceless initials became aspirated and the proto-voiced initials became voiceless. Comparison of Muak Sa-aak initials with other Palaungic languages shows that Muak Sa-aak also underwent this so-called Germanic shift (Hall 2010). Table 6, taken from Hall (2010), compares Muak Sa-aak proto-voiceless and voiced initials with Hu and U, two other Angkuic languages. Three Mon-Khmer languages that do not belong to the Angkuic subgroup, Lamet, a Palaungic language, and Northern Khmu and Southern Khmu, Northern Mon-Khmer languages that belong to the Khmuic group, are included to demonstrate that the Germanic shift is an Angkuic innovation.

Table 7. Germanic shift in Muak Sa-aak initial consonants (adapted from Svantesson 1991)

Muak Sa-aak	Hu	U	Lamet	Northern Kammu	Southern Kammu	
<i>*voiceless</i>						
<i>p^hxj³</i>	<i>phjɲ</i>	<i>phèt</i>	<i>pjɲ</i>	<i>pjɲ</i>	<i>pjɲ</i>	‘to shoot’
<i>tam¹</i>	<i>thəɲ</i>	<i>thán</i>	<i>tá:ɲ</i>	<i>tá:ɲ</i>	<i>ta:ɲ</i>	‘to weave’
<i>k^ha:p¹</i>	<i>khàp</i>	<i>khap</i>	<i>ká:p</i>	<i>ká:p</i>	<i>ka:p</i>	‘jaw’
<i>*voiced</i>						
<i>pri²</i>	<i>pɕiʔ</i>	<i>qí</i>	<i>priüʔ</i>	<i>priʔ</i>	<i>briʔ</i>	‘forest’
<i>puɕ² ta:k¹</i>	<i>phltàk</i>	<i>ʔatǎʔ</i>	<i>pltà:k</i>	<i>ktá:k</i>	<i>kda:k</i>	‘palm (of hand)’
<i>ka:ɲ³</i>	<i>kàɲ</i>	<i>káã</i>	---	<i>kà:ɲ</i>	<i>ga:ɲ</i>	‘house’
<i>kak²</i>	<i>kák</i>	<i>kàk</i>	<i>kàk</i>	--	--	‘to bite’

Voiced initial plosives are not expected in an Angkuic language such as Muak Sa-aak, due to the established phonological correspondences of initial voiceless plosives with proto-initial voiced plosives. The preservation of a voicing contrast of bilabial and alveolar stops in Muak Sa-aak may therefore be the result of contact with Tai Lue. These voiced initials may be seen in borrowed words from Tai Lue: for example, Lue *bii¹* ‘gallbladder’ > Muak Sa-aak *bi:³*, Lue *bup¹* ‘hit’ > Muak Sa-aak *bup²*, Lue *daʔ¹* ‘kick’ > Muak Sa-aak *da:²*, Lue *dɤn¹* ‘month’ > Muak Sa-aak *dɤ:n³*, Lue *dɛn⁴* ‘border’ > Muak Sa-aak *dian³*.

Not all instances of voiced initials /b,d/ however, may be easily explained as borrowing from Tai Lue. The initials /b,d/ appear in some apparent Austroasiatic cognates as well. For example Muak Sa-aak *bil³* ‘forget’ may be found in U *pin* and has been reconstructed as proto-Mon-Khmer **[b]iir*; this may be seen in Palaung *bir* and Praok *pi[ɔm]*. Muak Sa-aak *dɤɲ³* ‘quiet’ has the proto-Mon-Khmer reconstruction **dǎk*, seen also in Palaung *dɔʔ* and Riang-Lang *dǎk*. Muak Sa-aak *bɔt²* ‘cloud’ may be linked to the proto-Mon-Khmer reconstruction **ʔut*, **ʔuut*, which does not contain the voiced initial, but the realizations of *ʔbɔt* in Bo Luang Lawa and of *pú:t* in Yunnan Khmu do have the bilabial initial (Svantesson 1988, Shorto, Cooper, Sidwell and Bauer 2006). These last two, ‘quiet’ and ‘cloud’, raise another possibility, that the voiced initials /b, d/ in Muak Sa-aak could be reflexes of earlier glottalized initials. This is an area for further research, as the data available at present is limited.

3.4 Impact of Tai Lue tone on Muak Sa-aak

Given the extensive amount of vocabulary borrowed from Tai Lue- even the numeral system has been borrowed essentially intact- it is worth asking to what extent this has affected the tones seen today.

Previously it has been suggested that tonogenesis in Muak Sa-aak was motivated primarily by final consonants and vowel length (Hall 2010). In native words, sonorant finals mostly occur with Tone 3 whereas checked syllables only occur with Tones 1 or 2. This suggests that final consonants have played an important role in tonogenesis.

This pattern is not entirely regular; in particular for nasal finals. Most of the words ending in nasals which match up to Svantesson’s (1988) Lamet list, and therefore do not appear to be loanwords, occur with falling Tone 3. However, there are a number of Muak Sa-aak words ending with nasal finals that carry low Tone 1 or constricted Tone 2. One possible explanation is that these words are largely borrowed words from Tai Lue. Words ending in palatal nasals are native Muak Sa-aak because Tai Lue does not have these. These Muak Sa-aak words always carry falling Tone 3; there are no occurrences with the other two tones.

Tai Lue also does not have the lateral approximant /l/ occurring in final position. Nearly all of those Muak Sa-aak words ending in /-l/ occur with Tone 3 as well; only a handful of exceptions in the corpus occur with Tone 1. These are: *pal¹ k.tit²* ‘(be) equal’, *mu:l¹* ‘boundary’, *jul¹ jil³* ‘crush to powder’, *pɤl¹* ‘fall’. Even though these words are not borrowings from Tai Lue, the rarity of Tone 1 and Tone 2 sonorant finals suggests that sonorant finals naturally carry Tone 3. The falling allotone

of Tone 2 on long syllables includes a number of words with final nasals. About half of those in the corpus collected for this study are Tai Lue cognates.

Another phenomenon to take into account is the small group of long open syllables occurring with constricted Tone 2. Generally this tone is found on short open syllables, and the majority of these exceptions are borrowed from Tai Lue. Examples are given in Table 8.

Table 8. Long open syllables with constricted Tone 2

Tai Lue	Muak Sa-aak	gloss
<i>na:</i> ³	<i>na:</i> ² <i>ɲa:</i> ^{j3}	‘face’
<i>k^ha:</i> ³	<i>k^ha:</i> ²	‘slave’
<i>ɲa:</i> ⁴	<i>t.ɲa:</i> ²	‘sesame seed’
<i>ju:</i> ⁶	<i>ju:</i> ²	‘push’

Three of these four examples occur with the Tai Lue glottalized tones 3 and 6; this constriction is being carried into Muak Sa-aak. Although *t.ɲa:*² ‘sesame seed,’ does not follow this pattern, there still appears to be a correlation between tone of borrowed words from Tai Lue and tone in Muak Sa-aak. Tai Lue words with a glottalized tone tend to occur with constricted Tone 2 in Muak Sa-aak. The first of the items in Table 8 is a tautological hybrid form: *na:*² ‘face’ coming from Tai Lue, and *ɲa:*^{j3}, ‘face’ or ‘eye’ from Muak Sa-aak.

To summarize, sonorant finals naturally carry Tone 3; if they carry Tone 2 they are likely to be Tai Lue loan words. Similarly, long open syllables usually carry Tone 1 or 3; those carrying the long allotone of constricted Tone 2 are mostly Tai Lue borrowings. The natural environment for Tone 2 appears to be either the short open syllable or the short checked syllable. Without these borrowings, tones on sonorant-final syllables would largely be predictable, based upon vowel length and final consonant. These predictable indigenous Muak Sa-aak tones correlate to the pitch accompanying register described for Lampang Lamet. In this variety, pitch appears to relate to the interaction of vowel length and final consonant type, or dead and live syllables (Narumol 1982). Svantesson also describes a similar distinction between final consonant types for U (1988). The reason Muak Sa-aak tones are not predictable may be found in this borrowing of long glottalized open or sonorant-final syllables, as well as the loss of some final consonants.

4. Summary and outlook

Borrowing is an interesting phenomenon in this language, as it has been heavily influenced by Tai Lue, a language of an entirely different family from which it has borrowed large amounts of vocabulary. Even the numeral system has been adopted essentially intact from Tai Lue. The effects of lexical borrowing from Tai Lue on Muak Sa-aak can be seen at several levels. The Muak Sa-aak variety under study has two diphthongs /ia/ and /ua/ and replaces Tai Lue /ɛ:/, /ɔ:/ with these diphthongs in borrowed words. Although Angkuic languages are expected to have lost their voicing contrast, Muak Sa-aak retains this contrast, which is found in Tai Lue as well. It did however, undergo the Germanic shift like other Angkuic languages. Further in-depth studies to investigate the possible motivation for retaining the old Mon-Khmer voicing contrast as well as developing aspiration in other Mon-Khmer cognates are needed. The borrowings appear to have influenced the tonal patterns of Muak Sa-aak, possibly furthering the development of tone in an otherwise largely predictable pitch system.

Despite the borrowing, the majority of lexical items and phonotactics stand out as native to Muak Sa-aak. This includes palatal final consonants and a final lateral consonant. One feature which may reflect something that has been lost in the surrounding Tai Lue but not in Muak Sa-aak is the phoneme /r/. The rhotic occurs frequently in Muak Sa-aak, both word-initially and in consonant clusters, while spoken Tai Lue does not have an /r/ in its phoneme inventory. In many words borrowed from Tai Lue, Muak Sa-aak actually replaces initial Tai Lue /h/ with the rhotic, which appears to reflect the existence of a former rhotic in these Tai Lue cognates, since rhotics are found in some Assamese Tai equivalents. Conversely, this particular variety of Muak Sa-aak shows at least one development which does not appear in Tai Lue, the development of diphthongs /ia/ and /ua/ from a former /ɛ:/ and /ɔ:/. These also may be seen in words originally borrowed from Tai Lue,

where they do not contain diphthongs, but in Muak Sa-aak usage the long monophthongs are replaced with a diphthong.

The exposure to the school languages could create further pressure on the Muak Sa-aak language. Together with the Chinese television programs, this could cause a shift in borrowing patterns, as the children growing up now use more Burmese and Chinese and less Tai Lue than their parents. Since the Muak Sa-aak community seems to be linguistically quite absorbent, future investigations of the lexicon and phonology promise to be of interest for the study of contact phenomena.

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