



Tai Khamti stop phonation contrasts: Historical origins and phonetic documentation

Ryan Gehrman^a and Douglas Inglis^a

^aLinguistics Department, International College, Payap University, Thailand

ABSTRACT

Whereas most Tai languages contrast three series of oral stops, Tai Khamti, an endangered Southwestern Tai language of Myanmar and India, is described as having just two: plain voiceless and voiceless aspirated. To the best of our knowledge, we present here the first acoustic phonetic analysis of this contrast, examining voice onset time (VOT) in 245 tokens from fieldwork recordings of two native speakers. The results reveal a robust plain/aspirated contrast with a mean VOT difference of 47.5 ms and a very large effect size (Cohen's $d = 3.03$). We also trace the historical origins of this two-way contrast through comparison with the onset inventory of Proto-Tai: the plain voiceless series reflects a merger of Proto-Tai voiced and voiceless stops, the voiceless aspirated series has a dual origin in Proto-Tai fricatives and certain onset clusters, and Proto-Tai voiced implosive stops have lenited to nasal stops. We further show that Proto-Tai voicing contrasts are continued in Tai Khamti via tonal innovations. The synchronic acoustic and historical phonological analyses presented here document a previously underdescribed contrast, laying a foundation for future investigation into tonogenesis in Tai Khamti and in the Tai languages more broadly, where innovations affecting both onset laryngeal contrasts and existing tonal contrasts must be traced.

KEYWORDS

Tai, Khamti, Tai languages, phonetics, voice onset time, tonogenesis

CORRESPONDENCE

Ryan Gehrman (ryan_g@payap.ac.th)

Douglas Inglis (douglas_i@payap.ac.th)

INTRODUCTION

Tai Khamti (or Khamti; ISO 639-3: [kht]) is a vulnerable Southwestern Tai language spoken in Myanmar and India. Qualitative descriptions of the language agree on a two-way contrast in the oral stop onset inventory between plain voiceless and voiceless aspirated stops. This is typologically unusual for Tai languages, in which a three-way stop phonation distinction is typical. While the historical phonological origins of Khamti's two stop phonation categories are retrievable using the comparative method, no study has yet laid out this derivation explicitly, nor has the resulting contrast been described in phonetic terms, as far as we are aware.

In this paper, our goal is to investigate Khamti onset phonation contrast from two complementary perspectives. Firstly, we explain Khamti's aberration from the expected onset phonation categories of a modern Tai language in diachronic terms, tracing the historical origins of Khamti's two onset stop phonation series. We show that (1) the plain voiceless stops are the result of a merger between Proto-Tai voiceless and voiced stops, (2) the voiceless aspirated stop series was innovated via sound changes affecting Proto-Tai fricatives and onset clusters, (3) the voiced implosive stops of Proto-Tai have lenited

to nasals, and (4) tonogenetic processes have transphonologized Proto-Tai onset voicing contrasts into tonal contrasts. Secondly, we document how modern Khamti's two-way onset phonation contrast is realized. Using fieldwork recordings of two native speakers, we provide acoustic phonetic documentation of Khamti's stop aspiration contrast, focusing on voice onset time (VOT) as one important cue, and leaving other potential cues (e.g., f_0 , voice quality) to future work. Together, the two analyses presented here establish a foundation for future acoustic investigation into the broader, interrelated network of laryngeal and tonal contrasts in Tai Khamti and into the language's tonogenetic history.

LITERATURE REVIEW

Qualitative descriptions of Khamti show a consensus regarding its oral stop onset inventory, which features a binary contrast between voiceless unaspirated and voiceless aspirated stops. While this agreement is longstanding, spanning from early historical accounts to modern linguistic descriptions, the available descriptions of this contrast are qualitative and impressionistic (Brown, 1837; Harris, 1976; Inglis, 2017, 2024; Morey, 2005, 2008; Robinson, 1849; Weidert, 1977). We are not aware of any instrumental acoustic analyses of Khamti onset phonation contrasts.

A two-way phonation distinction is typologically unusual for stop onsets in Tai languages, most of which feature a three-way distinction. Standard Thai contrasts voiceless, voiced, and voiceless aspirated stop series (Lisker & Abramson, 1964, p. 389), and as a large and well-documented language, its three-way contrast is frequently included in broader typological works, investigating the differential phonetic properties associated with onset phonation categories across languages and their interaction with tone (e.g., Abramson & Whalen, 2017; Cho et al., 2019; Kirby, 2018). Indeed, the available phonetic descriptions of Tai and related Kra-Dai languages tend to focus on tonal analysis, with interrelated issues of onset laryngeal properties receiving less attention (Burroni, 2023; Edmondson et al., 2004; Edmondson & Solnit, 1997; Harris, 1972; Harris & Noss, 1972).

VOT differences are the most widely investigated acoustic correlate of onset laryngeal contrasts cross-linguistically (Cho & Ladefoged, 1999; Keating, 1984, p. 290; Lisker et al., 1977; Lisker & Abramson, 1964; McDonough & Wood, 2008), and are consistently cited as the primary correlate in Tai languages, though secondary laryngeal articulations such as breathy release for voiced stops are also found (Kirby & Pittayaporn, 2025).

In the documentation of endangered languages, the presentation of phonological inventories is typically prioritized, while the phonetic properties of laryngeal contrasts often go uninvestigated. Khamti serves as a prime example: despite a longstanding qualitative consensus on its two-way stop contrast, no instrumental acoustic analysis of this contrast has previously been undertaken. As Ladefoged (2003, p. 94) stresses, VOT analysis should be treated as a basic component of an adequate phonetic description. We present this acoustic analysis of Khamti stops in response, recognizing that the phonetic analysis of phonological structures should be an integral part of the language documentation process (Bhaskararao, 2004, p. 220).

ORIGIN AND DEVELOPMENT OF KHAMTI ONSETS AND TONES

The initial consonant inventory of Khamti is presented in Table 1 (Inglis, 2017; Morey, 2008). The system of consonant contrasts makes no use of contrastive voicing, and the only laryngeal contrast is of stop aspiration. The coda inventory similarly lacks voicing contrast, including only voiceless stops /p t k/ and voiced nasals /m n ŋ/.

Table 1. Khamti initial consonant inventory

p p ^h	t t ^h	c [ts]	k k ^h
m	n	ɲ	ŋ
	s		h
w		j	
	l		
	r		

The laryngeal contrasts of Proto-Tai initials, presented in Table 2 (Pittayaporn, 2009), differ markedly from those of Khamti. Voicing contrast is pervasive among the Proto-Tai onsets, including the stops (e.g., *t vs. *d), fricatives (e.g., *s vs. *z), nasals (e.g., *^hn vs. *n), and other sonorants (e.g., *^hl vs. *l). No aspiration contrast is posited for stops, but a contrast of airstream mechanism / glottalization is reconstructed for the voiced stops (i.e., plain voiced *b *d *j vs. glottalized / implosive *ɓ *ɗ *ɟ).¹

Table 2. Reconstructed Proto-Tai initial consonant inventory (Pittayaporn, 2009)²

p ɓ	t ɗ	c ɟ	k ɡ	q ɠ	ʔ
^h m m	^h n n	^h ɲ ɲ	(^h ŋ) ŋ		
	s z	(ɕ) (ʐ)	x ɣ	χ	h
^h w w					
	^h l l				
	^h r r				

Clearly, the Khamti consonant inventory has undergone significant simplification with respect to its reconstructed ancestor Proto-Tai. Khamti's tone inventory (see Table 3), on the other hand, has increased relative to that of Proto-Tai. Three tones are reconstructed for syllables ending in a sonorant coda or vowel in Proto-Tai, which are labeled by convention *A, *B and *C. A fourth category, *D, represents syllables closed by an oral stop, in which environment tone was not contrastive. On a phonological level, this reconstruction is uncontroversial and has been long accepted in Tai studies (Gedney, 1972; Li, 1977), though opinions continue to differ concerning the phonetic reconstruction of *A, *B and *C (Liao & Gehrman, 2025; Pittayaporn, 2009; Sagart, 2019).

For Khamti, at least two different tone inventories have been described. As summarized by Dockum (2019, pp. 124–138), Khamti varieties in Arunachal Pradesh, India are analyzed by Harris (1976) as contrasting five lexical tones, while Dockum himself posits four lexical tones for Khamti varieties in the upper Chindwin River valley in Myanmar. Inglis’s (2017) inventory of Khamti varieties in what he calls the Irrawaddy Confluence Area in Myanmar appears to match well with Harris’s, as they both have five-tone inventories, but as will be demonstrated below, the tones do not match up etymologically in a straightforward manner. Harris’s and Inglis’s inventories are summarized in Table 3.

Table 3. Khamti tone inventory

Harris (1976)		Inglis (2017)	
¹	Mid	¹	Low [21]~[22]
²	Low	²	Rising [34]
³	Falling	³	Mid [42]
⁴	High	⁴	Falling [53]
⁵	Rising	⁵	High [44]~[55]

The reduction in onset laryngeal complexity and the increase in tone complexity between Proto-Tai and modern Khamti are not independent processes. In the remainder of this section, we will demonstrate the patterns of onset laryngeal contrast merger and tonal innovation.

Onset phonation contrasts from Proto-Tai to Khamti

It is beyond the scope of this paper to provide a thorough diachronic analysis of onset evolution from Proto-Tai to modern Khamti. Nevertheless, the thematic developments are apparent in the data available to us. We have aligned modern Khamti reflexes from Harris (1976) as reproduced by Inglis (2004) with their Proto-Tai precursors as reconstructed by Pittayaporn (2009) to produce the tables of lexical evidence below. The consonantal developments in question are shared by all modern Khamti varieties as far as we are aware (Morey, 2008). We will not devote space here to explaining the motivations underlying the phonological reconstructions of Proto-Tai onsets, which include sesquisyllabic structures that no longer exist in modern Tai languages in many cases. We encourage those who are interested in the intricacies of how these complex onsets developed and simplified across the Tai language family to consult Pittayaporn (2009).

The examples in Table 4 show that Proto-Tai voiced stops have become devoiced in modern Khamti (Proto-Tai *b, *d, *j, *g > Khamti /p t ts k/), resulting in phonetic merger with the etymologically voiceless Proto-Tai stops, which remain voiceless (Proto-Tai *p *t *c *k > Khamti /p t ts k/). Note that the merged reflexes of palatal stops *j and *c have become an alveolar affricate /ts/. Our database lacks any examples of words

that would have had Proto-Tai *b, but the pattern of development is clear from the examples at other places of articulation.

Table 4. Proto-Tai voiced and voiceless stop reflexes in Khamti

Correspondence	Gloss	Proto-Tai	Khamti
*p > /p/	‘year’	*pi: ^A	/pi ¹ /
	‘fish’	*pla: ^A	/paa ¹ /
	‘wing’	*pi:k ^D	/pik ⁴ /
*b > (/p/?)	–	–	–
*t > /t/	‘foot’	*ti:n ^A	/tin ¹ /
	‘cut’	*tac ^D	/tat ⁴ /
	‘liver’	*tap ^D	/tap ⁴ /
	‘eye’	*p.ta: ^A	/taa ¹ /
	‘die’	*p.ta:j ^A	/taai ¹ /
	‘full’	*k.tem ^A	/tem ¹ /
*d > /t/	‘belly’	*dwu:ŋ ^c	/tɔŋ ² /
	‘ashes’	*daw ^B	/tau ¹ /
*c > /ts/	‘heart, breath’	*cɣu: ^A	/tsay ¹ /
*j > /ts/	‘name’	*jɣ: ^B	/tsi ¹ /
*k > /k/	‘eat’	*kɤŋ ^A	/kin ¹ /
	‘old (living)’	*ke: ^B	/ke ⁴ /
	‘bite’	*kat ^D	/kat ⁴ /
	‘salt’	*klwɯə ^A	/kw ¹ /
*g/g > /k/	‘person’	*gwɯn ^A	/kon ³ /

For sonorants, it is the voiceless onsets that have been innovative. Proto-Tai voiceless sonorants have become voiced in modern Khamti (*^hm ^hn ^hɲ ^hw ^hl > m n j w l), merging with their Proto-Tai voiced counterparts (*m *n *ɲ *w *l > m n j w l), as the examples in Table 5 demonstrate.

Table 5. Proto-Tai voiced and voiceless nasal reflexes in Khamti

Correspondence	Gloss	Proto-Tai	Khamti
*^hm > /m/	‘dog’	* ^h ma: ^A	/maa ⁴ /
	‘fruit’	* ^h ma:k ^D	/maak ⁴ /
	‘fog’	* ^h mo:k ^D	/mɔk ⁴ /
	‘new’	* ^h mɤ:l ^B	/mau ⁴ /
*m > /m/	‘hand’	*mwa: ^A	/mu ³ /
*^hn > /n/	‘thick’	* ^h na: ^A	/naa ⁴ /
	‘skin’	* ^h naŋ ^A	/naŋ ⁴ /
	‘heavy’	* ^h nak ^D	/nak ⁴ /
*n > /n/	‘sit’	*naŋ ^B	/naŋ ¹ /
	‘one’	*nwa:ŋ ^B	/nuŋ ¹ /
	‘lie down’	*nwa:n ^A	/noŋ ³ /
*^hɲ > /j/	‘grass’	* ^h ɲwə ^c	/jaa ⁵ /
*ɲ > /j/	‘sew’	*ɲep ^D	/jap ¹ /
*^hŋ > (Ø?)	–	–	–
*ŋ > Ø	‘snake’	*ŋwa: ^A	/ŋu ³ /

The voiced glottalized / implosive stops of Proto-Tai remain voiced today, but they have lost their tense phonation and nasalized to merge with their corresponding plain voiced nasals (*^b *^d > m n). The comparative evidence in Table 6 suggests that sesquisyllabic clusters with a voiceless consonant in the presyllable position and a voiced stop in the main syllable position coalesced to merge with the implosives before both developed into nasals (*^C_◌b *^C_◌d > m n).

Table 6. Proto-Tai glottalized / implosive stop reflexes in Khamti

Correspondence	Gloss	Proto-Tai	Khamti
*b/C_ɔ.b > /m/	‘leaf’	*baw ^A	/maw ¹ /
	‘moon’	*blwən ^A	/nwn ¹ /
	‘flower’	*blo:k ^D	/mɔk ⁴ /
	‘thin’	*C _ɔ .ba:ŋ ^A	/maan ¹ /
*d/C_ɔ.d > /n/	‘nose’	*dɔŋ ^A	/hu ¹ nan ¹ /
	‘earth’	*dɪn	/nin ¹ /
	‘black’	*C _ɔ .dam ^A	/nam ¹ /
	‘mountain’	*C _ɔ .do:j ^A	/nɔi ¹ /
	‘red’	*C _ɔ .dwi:ŋ ^A	/nɛŋ ¹ /
	‘bone’	*C _ɔ .duk ^D	/nuk ⁴ /

Although voiceless aspirated stop onsets are common among modern Tai languages, Pittayaporn’s Proto-Tai is notably reconstructed without a voiceless aspirated stop series. Khamti’s voiceless aspirated stops are a post-Proto-Tai innovation, as are those of other Southwestern Tai languages (Pittayaporn, 2009, pp. 88–101). We will not discuss this topic in detail here, but a few sources of modern Khamti aspirated stops are evident, as the lexical evidence in Table 7 suggests.

Table 7. Proto-Tai sources for Khamti voiceless aspirated stops

Correspondence	Gloss	Proto-Tai	Khamti
*kr *qr > /k^h/	‘laugh’	*krwəw ^A	/kho ⁴ /
	‘egg’	*qraj	/khay ⁴ /
*x *χ *ʁ *q > /k^h/	‘white’	*xa:w ^A	/khaaw ⁴ /
	‘itch’	*yal ^A	/khe ⁴ /
	‘fang’	*χe:w ^c	/kheu ⁵ /
	‘sharp’	*ʁm ^A	/khom ¹ /
	‘smoke’	*ɣwan ^A	/khon ³ /
	‘horn’	*qaw ^A	/khau ⁴ /
*pr > /p^h/	‘burn (tr.)’	*praw ^A	/phau ⁴ /
	‘hair, head’	*prɤm ^A	/phom ⁴ /
*w > /p^h/	‘sky’	*wa: ^c	/phaa ² /
	‘fire’	*wɤj ^A	/phai ³ /
	‘rain’	*C _o wwn ^A	/phon ⁴ /

The labial /p^h/ has at least two sources: the Proto-Tai complex onset *pr via debuccalization of the rhotic medial consonant to voiceless aspiration and the labial glide *w via fortition to *v, devoicing to *f and further fortition to /p^h/. The latter development from *w to /p^h/ is shared with Shan and other Tai languages of Myanmar (Pittayaporn, 2009, p. 131). The velar /k^h/ also has two main sources. Complex onsets comprising a velar or uvular stop and a rhotic medial regularly develop into /k^h/ in Khamti in a process paralleling the *pr > /p^h/ innovation, and simple uvular onsets, both stop and fricative, have /k^h/ as their regular reflexes.

The alveolar /t^h/ only occurs rarely in the data available, and we were only able to align one example with a Proto-Tai lexeme. No modern reflex for this word, Proto-Tai *cm.ruk ‘to tie’, was found in Harris’s word list, but it is attested in other varieties as /p^huk/ or /t^hok/. Pittayaporn (2009, pp. 142–143) shows that *cr clusters tend to develop into /t^h/ in Tai languages via an intermediate *t^hr stage. The above analysis is summarized in Table 8.

Table 8. Onset phonation contrasts from Proto-Tai to Khamti

Proto-Tai	Khamti
*p *t *c *k	/p t ts k/
*b *d *j *g	/p t ts k/
*b/C _ɔ b *d/C _ɔ d	/m n/
*m *n *ɲ *ŋ	/m n j Ø/
* ^h m * ^h n * ^h ɲ * ^h ŋ	/m n j Ø/
*pr *w	/p ^h /
*cr	/t ^h /
*kr *qr *x *ɣ *χ	/k ^h /

Tone Contrasts from Proto-Tai to Khamti

Like most Tai languages, Khamti has not simply neutralized the historical onset phonation contrasts reconstructed for Proto-Tai; rather, those contrasts have been transphonologized into tonal contrasts, upholding the historical contrasts. This was accomplished via the standard tonogenetic model that is ubiquitous among the Tai languages and shared with many other, unrelated tonal languages of Mainland Southeast Asia (Haudricourt, 1954, 1961; Matisoff, 1973). According to this model, languages with a smaller number of historical tones undergo a doubling of their tone inventory under conditioning from historically contrastive onset voicing values. Once the tones are split, the burden of maintaining phonological contrast shifts from onset voicing to tone, permitting the gradual erosion of voicing distinctions without any loss of contrast in the overall system.

We have already introduced the three contrastive tones of Proto-Tai on syllables ending in a sonorant sound above (*A *B *C). These Proto-Tai tones are subject to splits not only from onset voicing differences, but from other phonation type or manner of articulation differences as well. Gedney (1972) proposed a standard tabulation (a tone box), as a tool for tracking tonal evolution across Tai languages (see Table 9). The tone box includes five columns, one each for *A *B and *C and two columns for *D. The two columns for D represent words with different vowel length values, because long and short vowels before coda stops condition different modern tonal outputs in many Tai languages. The four rows in the tone box represent different onset phonation configurations. Row 1 is for voiceless onsets characterized by aspiration or voiceless frication, which group together in terms of tonal conditioning. Row 2 is for the plain voiceless stops, Row 3 for the glottalized / implosive stops and Row 4 for plain voiced onsets of any manner (stop, sonorant, fricative). The tone box's utility is that it defines groups of words (lexical sets) that are expected to share the same tone value in modern Tai languages. The tool is based on the principle of regular sound change, whereby sounds in identical environments are expected to change and develop in parallel, all things being equal.

Table 9. Generic tone box structure (Gedney, 1972) used to analyze Tai tonogenesis

	*A	*B	*C	*DS	*DL
(1) vl aspirated / fricative onsets	A1	B1	C1	DS1	DL1
(2) plain vl stop onsets	A2	B2	C2	DS2	DL2
(3) glottalized / implosive onsets	A3	B3	C3	DS3	DL3
(4) plain vd onsets	A4	B4	C4	DS4	DL4

Each cell in the tone box may be referenced via its alphanumeric code. For example, the code A4 refers to the tone found on the group of words which had *A tone in Proto-Tai and was preceded by a plain voiced consonant. In Harris’s Arunachal Pradesh Khamti, the A4 lexical set developed into the modern falling tone /³/, as in Proto-Tai **gwun*^A ‘person’ and **ɲwan*^A ‘daytime’, which become modern /*kon*³/ and /*wan*³/.

The tone box includes twenty cells, but there are no Tai languages with twenty contrastive tones. Instead, multiple cells tend to share the same tone, with different languages showing different patterns of tonal development. Comparativists speak of “splits” when cells under the same tone column have different tones and “mergers” when cells in different columns have the same tone. The most common split pattern crosslinguistically is between voiceless onsets (the first three rows of the tone box) and voiced onsets (row four), but further splits among the three voiceless categories are also common. The most common merger pattern for Tai languages is between the cells under tones *B and *D.

In Table 10, we compare tone boxes based on data from Harris’s Arunachal Pradesh Khamti and Inglis’s Irrawaddy Confluence Area Khamti. The two varieties’ tonal inventories have developed very similarly, but there are notable differences as well. Column *A shows the same three-way split in both lects, with the expected split between A4 and the rest, and a secondary split in the voiceless rows between A1 and A23. Column *C is also the same, with a standard voicing split of C123 and C4. The differences are localized to Columns *B and *D. The voiceless rows of *B and *D share the same tone in both varieties and, strikingly, both varieties show a merger of A1 with B123 and D123. The differences relate to cells B4 and D4. Arunachal Pradesh B4 is merged with A23, whereas Irrawaddy Confluence Area Khamti shows no split at all in the *B column. As for D4, Arunachal Pradesh Khamti merges this with B4 and A23, while Irrawaddy Confluence Area Khamti merges it with C4 alone. More detailed discussion on comparative Khamti tonality is presented by Dockum (2019).

Table 10. Comparative tone box: Arunachal Pradesh Khamti vs. Irrawaddy Confluence Area Khamti

Arunachal Pradesh Khamti (Harris, 1976; Dockum, 2019)				Irrawaddy Confluence Area Khamti (Inglis, 2024)			
*A	*B	*C	*D	*A	*B	*C	*D
1 (A1) High ⁴	(B1) High ⁴	(C1) Rising ⁵	(D1) High ⁴	(A1) High ⁵	(B1) High ⁵	(C1) Rising ²	(D1) High ⁵
2 (A2) Mid ¹	(B2) High ⁴	(C2) Rising ⁵	(D2) High ⁴	(A2) Mid ³	(B2) High ⁵	(C2) Rising ²	(D2) High ⁵
3 (A3) Mid ¹	(B3) High ⁴	(C3) Rising ⁵	(D3) High ⁴	(A3) Mid ³	(B3) High ⁵	(C3) Rising ²	(D3) High ⁵
4 (A4) Fall ³	(B4) Mid ¹	(C4) Low ²	(D4) Mid ¹	(A4) Fall ⁴	(B4) High ⁵	(C4) Low ¹	(D4) Low ¹

Inglis (2024) presents lexical evidence supporting the historical development of Khamti tone presented in Table 10 as an appendix. Dockum (2019) tabulates Harris’s results as shown here, and we have assembled lexical evidence corroborating it here in Appendix A. We were not able to find examples for every cell. As Dockum (2019, p. 126) notes, the A column is the most reliably reconstructed because A tone words tend to be more numerous and therefore better represented in wordlists across the family. Nevertheless, the examples that we did find correspond with Dockum’s tabulation neatly.

METHODOLOGY

Having traced the historical origins of Khamti’s onset and tone contrasts, we now turn to acoustic documentation of the resulting plain/aspirated stop contrast in the modern language.

Data Collection

The analysis is based on a dataset of 250 VOT measurements drawn from legacy audio recordings of two native speaker participants.³ Both participants are native speakers of Khamti who were born and raised in villages near the multilingual town of Putao in Myanmar, the heartland of the language group, which lies within the Irrawaddy Confluence Area. They are also fluent in Burmese and speak some Rawang. Participant M1 is male, 46 years old, and participant F1 is female, 21 years old.

Data collection took place in 2005 in an enclosed room in a house in Yangon, the capital city of Myanmar, on a trip the participants took outside their home area. Audio recordings were made on a Sony TCD-D3 DAT with a sampling rate of 22,050 Hz in uncompressed .wav file format.⁴ In addition to elicited word list items spoken in isolation, the audio data also include recorded language lessons and recordings of spontaneous narratives recounting personal experiences. The measured stop VOT examples were randomly drawn from all three types of data and each token was an independent and unique observation with no repeated lexemes.⁵

VOT Measurement

VOT, the temporal interval between stop release and the onset of voicing, was measured manually in milliseconds using Praat (Boersma & Weenink, 2011). Closure voicelessness was identified visually by the near-complete absence of energy in the formant frequency range, and stop release was marked at the point where an abrupt increase of energy was visible in the waveform and spectrogram (Ladefoged, 2003, p. 96; Lisker & Abramson, 1964, p. 389). In cases where more than one point in time might be identified as stop release, such as the double burst commonly found with the release of a velar closure, the first identifiable burst was selected. The onset of voicing was defined as the zero crossing at the end of the first recognizable cycle of regularly spaced vertical striations, which correspond to glottal pulses. VOT measurements reflect the difference between this zero-crossing and the stop burst. Each measurement was rounded to the nearest millisecond.

The VOT measurements were assembled in a database, in which each token was coded according to the following categorical variables: phonological onset stop series (aspirated vs. unaspirated), onset place of articulation (labial, alveolar, velar), position of the onset within an utterance (initial, medial), and speaker (M1, F1). The full factorial design of the study comprises 24 cells (2 aspiration $\times$ 3 place $\times$ 2 position $\times$ 2 speaker). Under a balanced design, each cell would contain approximately 10 tokens after outlier removal (see below); however, actual cell counts range from 1 to 17. Notably, five cells (21%) contain five or fewer tokens, with the most extreme case being the alveolar aspirated medial condition for Speaker M1, which contains just one token. This imbalance precludes reliable estimation of higher-order interactions. Consequently, the analysis focuses on main effects (primary hypothesis) and select two-way interactions (secondary considerations).

Outlier thresholds were calculated separately for aspirated and unaspirated tokens, with any measurement exceeding the within-category mean by more than three standard deviations removed. This yielded upper thresholds of 49.5 ms for unaspirated stops (mean 20.4 ms, SD 9.7 ms) and 142.5 ms for aspirated stops (mean 68.9 ms, SD 24.6 ms). Five tokens were removed: three unaspirated medial velar tokens (F1 $\times$ 1, M1 $\times$ 2) and two aspirated medial velar tokens (M1 $\times$ 2). The final dataset comprised VOT measurements for 245 tokens, the counts of which are summarized categorically in Table 11. Each token was randomly drawn from unique lexical items. Arrows ($\rightarrow$) indicate cells affected by outlier removal.⁶

Table 11. Token counts per cell after outlier removal

	Labial		Alveolar		Velar	
	-asp	+asp	-asp	+asp	-asp	+asp
F1, Initial	13	9	12	4	11	15
F1, Medial	7	10	12	9	→10	9
M1, Initial	16	10	4	4	12	15
M1, Medial	12	5	13	1	→17	→15

Statistical approach

We use Welch’s t-tests to evaluate differences in group means. Unlike the standard t-test, Welch’s method does not assume equal variances, avoiding the inflation of Type I error rates (i.e., false positives) that would result from the unequal variances observed in this dataset (Welch, 1947; Delacre et al., 2017).

Effect sizes are reported as Cohen’s *d*, which quantifies the difference between two group means in pooled standard deviation units (Cohen, 1988). This enables cross-study comparisons and captures practical significance beyond mere statistical detectability (Lakens, 2013). Attending to practical significance is an important consideration in phonetics research, where differences may be statistically significant while remaining perceptually negligible. Conventional benchmarks are applied: *d* = 0.2 (small), *d* = 0.5 (medium), *d* = 0.8 (large).

Given five planned comparisons (aspirated vs unaspirated, labial vs alveolar, labial vs velar, alveolar vs velar, initial vs medial), the familywise false positive rate accumulates, increasing the risk of at least one spurious result. A Bonferroni correction is applied, adjusting the significance threshold from $\alpha = 0.05$ to $\alpha = 0.01$ (Dunn, 1961). This conservative adjustment reduces false positive risk at the cost of increased Type II error risk (i.e., false negatives) (Armstrong, 2014).

Interaction effects are examined through pairwise Welch’s t-tests for two-way interactions where cell sizes permit reliable estimation. Higher-order interactions are not pursued due to insufficient statistical power in several cells. Speaker patterns are reported descriptively only, as inferential statistics cannot be meaningfully applied to a two-speaker sample. Mixed-effects modeling is similarly precluded, as reliable estimation of variance components requires more random-effect levels than two speakers can provide.

Limitations of the study

Findings involving alveolar stops, particularly in medial position, must be interpreted with caution because of the sparseness of data. The findings of this study are limited to the two individuals in the study and cannot be generalized to broader subsets of the Khamti-speaking population, such as gender or age group. The absence of repeated measurements per token means that measurement reliability, such as inter-rater agreement, cannot be assessed, introducing potential unquantified error.

RESULTS

Figure 1 presents VOT distributions for Tai Khamti stops across four dimensions: aspiration (upper left), place of articulation (upper middle), syllable position (upper right), and speaker (lower right), with two-way interaction plots in the lower-left panels. The rightmost panel visualizes Cohen's *d* effect sizes for all contrasts, with dashed lines indicating conventional benchmarks (small = 0.2, medium = 0.5, large = 0.8) and bar shading reflecting effect magnitude: dark green = large, medium green = medium, light green = small, gray = negligible.

The data reveal no negative VOT measurements that would indicate a voiced stop series. There is robust evidence for a phonologically significant two-way laryngeal contrast between aspirated and unaspirated stops, with aspiration emerging as the primary dimension of variation. Results for each factor are reported in turn below.

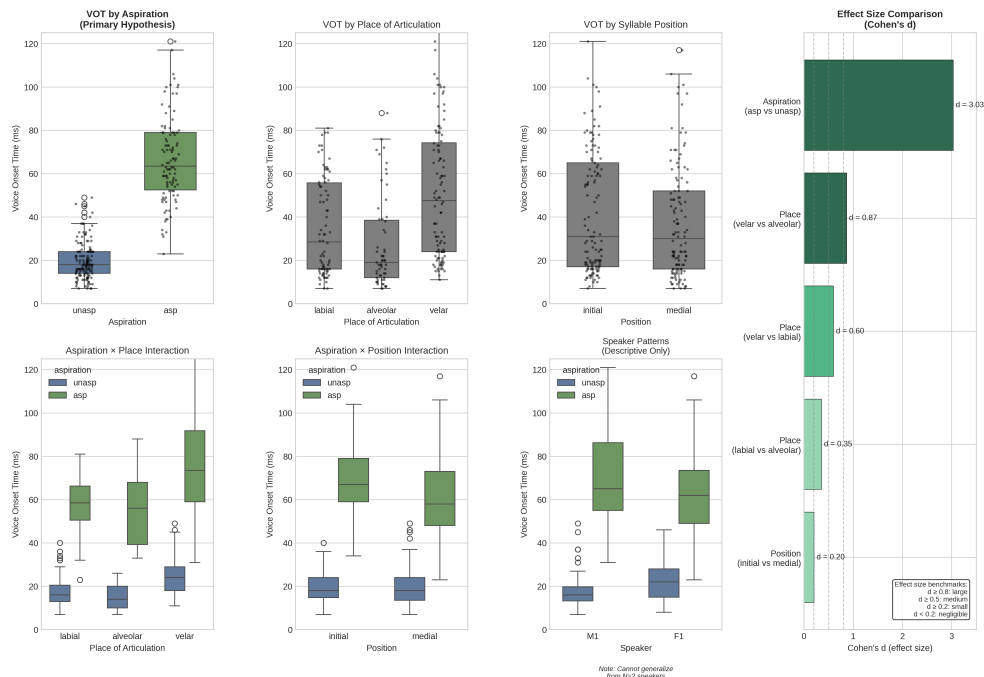


Figure 1. Boxplots of VOT distributions by aspiration, place of articulation, syllable position, and speaker, with Cohen's *d* effect size

Table 12 indicates the effect of aspiration as highly significant ($p < .001$), with aspirated stops exhibiting a mean VOT 47.5 ms longer than unaspirated stops. The effect size is large, $d = 3.03$. This finding strongly supports the primary hypothesis of a categorical aspirated/unaspirated VOT distinction.

Table 12. Aspiration (primary hypothesis)

	Mean	SD	N
Aspirated	67.2 ms	21.7	106
Unaspirated	19.7 ms	8.6	139

For secondary considerations, Tables 13 and 14 show comparisons with place of articulation. Velar stops show significantly longer mean VOT values (51.8 ms) than those of both labial stops (35.0 ms) and alveolar stops (27.3 ms). Pairwise comparisons show that velar stops differ significantly from both labial and alveolar stops, while labial and alveolar stops do not differ significantly from each other. Effect sizes are medium for the velar-labial comparison ($d = 0.60$) and large for the velar-alveolar comparison ($d = 0.87$).

Table 13. Place of articulation

	Mean	SD	N
Labial	35.0 ms	22.4	82
Alveolar	27.3 ms	21.0	59
Velar	51.8 ms	31.7	104

Table 14. Pairwise comparison for places of articulation

	VOT difference	d	p	Significant ($\alpha = .01$)?
Vel. vs Lab.	+16.7 ms	0.60	< .001	Yes
Vel. vs Alv.	+24.5 ms	0.87	< .001	Yes
Lab. vs Alv.	+7.7 ms	0.35	.038	No

Syllable position, as shown in Table 15, has no significant effect on VOT. The difference between the mean values for initial stops and medial stops is just 5.7 ms, resulting in a small effect size ($d = 0.2$) and a p value that is not significant ($p = .111$).

Table 15. Syllable position

	Mean	SD	N
Initial	43.1 ms	30.3	125
Medial	37.3 ms	26.0	120

Finally, in Table 16, both speakers show the expected aspiration contrast, with Speaker M1 showing a 12.8 ms larger aspiration effect than Speaker F1. The caveat is

that this difference cannot be attributed to gender, age, or individual idiolect as it represents individual variation between just two speakers.

Table 16. Speaker patterns

	Mean -asp	Mean +asp	Aspiration effect
M1	17.6 ms	71.6 ms	54.0 ms
F1	22.1 ms	63.4 ms	41.2 ms

CONCLUSION AND OUTLOOK

This study addresses a gap in the phonetic documentation of Khamti by providing, to the best of our knowledge, the first instrumental acoustic analysis of its VOT, confirming through quantitative means the two-way aspirated/unaspirated contrast that qualitative descriptions have long reported. Though we did not control for etymological voicing of stop onsets in the data collected for this project, we take the absence of any negative VOT measurements as supporting the hypothesis that historical voiced stops have indeed been completely devoiced in this Khamti lect. Velar onsets have a significant lengthening effect on onset VOT, and the place hierarchy identified in the mean VOT measures by place of articulation (velar > labial > alveolar) aligns with cross-linguistic typological trends in stop production. Syllable position effects are found to be negligible.

The small speaker sample ($N = 2$) precludes generalization to the broader Khamti speech community. Potential confounds, including vowel context and speech rate, are not controlled, which may influence the acoustic realization of the contrasts under investigation. Consequently, these findings must be interpreted within the context of the specific speakers and elicitation materials used.

Desiderata for future research growing out of this study include (1) a more thorough investigation of the historical phonological development of Khamti, informed by a broader base of comparative data and lexical evidence and (2) a targeted acoustic phonetic investigation into the phonetic realization of onset phonation beyond just stop VOT, investigating possible differences conditioned by historical onset phonation categories, modern tone categories, and interactions between the two.

ACKNOWLEDGEMENT

Special thanks go to the two mother-tongue speakers of Tai Khamti for this study, who wish to remain anonymous. We also want to thank the editor and anonymous reviewers for insightful comments improving the quality of this research. We take responsibility for any remaining errors.

DISCLOSURE STATEMENT

The authors have no competing interests to disclose.

NOTES

1. Pittayaporn's phonetic reconstruction of *ʔj as a glottalized palatal semivowel glide is based on its subsequent development and phonetic realization in modern Tai languages. However, because it behaves phonologically like the two implosive stops *ɓ and *ɗ (Pittayaporn, 2009, p. 72), he places this proto-consonant on the stops row in the slot that a palatal implosive stop *ɟ would be expected to occupy.
2. Parentheses reflect possible Proto-Tai consonants, which Pittayaporn reconstructs tentatively.
3. The data used in this research are from the fieldwork recordings of Douglas Inglis under the approved project "Documenting endangered languages: A community-based approach among the Tai Khamti", ID: Pro00010356_CLS5, with the IRB of the University of Alberta (Inglis, 2014, p. iv). Under this project the second author has access to the recordings, stored on his password protected computer, and is responsible for managing the files. Both Khamti language speakers have provided written informed consent to use these recordings.
4. This sampling rate is appropriate for the temporal measurements made here (stop release, voicing onset), which do not require spectral resolution above 11 kHz (Lisker & Abramson, 1964).
5. Legacy recordings are used because this is an initial untargeted documentation of VOT providing general results. As such, certain uncontrolled variables such as speaker gender and age remain for future targeted research.
6. M1/velar/unaspirated/medial: 19→17; M1/velar/aspirated/medial: 17→15;
F1/velar/unaspirated/medial: 11→10

REFERENCES

- Abramson, A. S. & Whalen, D. H. (2017). Voice onset time (VOT) at 50: Theoretical and practical issues in measuring voicing distinctions. *Journal of Phonetics*, 63, 75–86. <https://doi.org/10.1016/j.wocn.2017.05.002>
- Armstrong, R. A. (2014). When to use the Bonferroni correction. *Ophthalmic and Physiological Optics*, 34(5), 502–508. <https://doi.org/10.1111/opo.12131>
- Bhaskararao, P. (2004). Phonetic documentation of endangered languages: Creating a knowledge-base containing sound recording, transcription and analysis. *Acoustical Science and Technology*, 25(4), 219–226. <https://doi.org/10.1250/ast.25.219>
- Boersma, P. & Weenink, D. (2011). *Praat: Doing phonetics by computer*. Phonetic Sciences, University of Amsterdam. www.praat.org. Version 5.2.12
- Brown, Rev. N. (1837). Alphabets of the Tai language. *Journal of the Asiatic Society of Bengal*, 6, 17–21.
- Burroni, F. (2023). *Dynamics of F0 planning and production: Contextual and rate effects on Thai tone gestures* [PhD dissertation, Cornell University]. <https://doi.org/10.7298/tj8r-kg22>
- Cho, T. & Ladefoged, P. (1999). Variation and universals in VOT: evidence from 18 languages. *Journal of Phonetics*, 27(2), 207–229. <https://doi.org/10.1006/jpho.1999.0094>

- Cho, T., Whalen, D. H. & Docherty, G. (2019). Voice onset time and beyond: Exploring laryngeal contrast in 19 languages. *Journal of Phonetics*, 72, 52–65. <https://doi.org/10.1016/j.wocn.2018.11.002>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
- Delacre, M., Lakens, D. & Leys, C. (2017). Why psychologists should by default use Welch's t-test instead of Student's t-test. *International Review of Social Psychology*, 30(1), 92–101. <https://doi.org/10.5334/irsp.82>
- Dockum, R. (2019). *The tonal comparative method: Tai tone in historical perspective* [PhD dissertation, Yale University]. https://ling.yale.edu/sites/default/files/files/The_Tonal_Comparative_Method_.pdf
- Dunn, O. J. (1961). Multiple comparisons among means. *Journal of the American Statistical Association*, 56(293), 52–64. <https://doi.org/10.1080/01621459.1961.10482090>
- Edmondson, J. A., Esling, J. H., Harris, J. G. & Wei, J. (2004). A phonetic study of Sui consonants and tones. *Mon-Khmer Studies*, 34, 47–66. <http://sealang.net/sala/archives/pdf8/edmondson2004phonetic.pdf>
- Edmondson, J. A. & Solnit, D. B. (1997). Comparative Shan. In J. A. Edmondson & D. B. Solnit (Eds.), *Comparative Kadai: The Tai branch* (pp. 337–360). Summer Institute of Linguistics and the University of Texas at Arlington.
- Gedney, W. J. (1972). A checklist for determining tones in Tai dialects. In M. E. Smith (Ed.), *Studies in linguistics in honor of George L. Trager* (pp. 423–437). Mouton de Gruyter.
- Harris, J. G. (1972). Phonetic notes on some Siamese consonants. In J. G. Harris & R. B. Noss (Eds.), *Tai Phonetics and Phonology* (pp. 8–22). Bangkok.
- Harris, J. G. (1976). Notes on Khamti Shan. In T. G. Getting, J. G. Harris & P. Kullavanijaya (Eds.), *Tai linguistics in honor of Fang-Kuei Li* (pp. 113–141). Chulalongkorn University Press.
- Harris, J. G. & Noss, R. B. (Eds.). (1972). *Tai phonetics and phonology*. Bangkok.
- Haudricourt, A.-G. (1954). On the origin of tones in Vietnamese. *Journal Asiatique*, 242, 69–82.
- Haudricourt, A.-G. (1961). Bipartition and tripartition of tonal systems in some Far Eastern languages. *Bulletin de La Société de Linguistique de Paris*, 56(1), 163–180.
- Inglis, D. (2004). *Preliminary report: Khamti Shan wordlist and lexicostatistical results*. Payap University. https://www.academia.edu/7152885/Preliminary_report_Khamti_Shan_wordlist_and_lexicostatistical_results
- Inglis, D. (2014). *This here thing: specifying morphemes an³, nai¹, and mai² in Tai Khamti Reference-point constructions*. [PhD dissertation, University of Alberta].
- Inglis, D. (2017). Myanmar-based Khamti Shan orthography. *Journal of the Southeast Asian Linguistics Society*, 10(1), xlvii–lxi. <https://hdl.handle.net/10524/52404>
- Inglis, D. (2024). Basic grammar of Khamti Shan. *Journal of Southeast Asian Linguistics Society*, 17(2), 171–207. <https://hdl.handle.net/10524/52534>
- Keating, P. A. (1984). Phonetic and phonological representation of stop consonant voicing. *Language*, 60(2), 286–319. <https://doi.org/10.2307/413642>

- Kirby, J. (2018). Onset pitch perturbations and the cross-linguistic implementation of voicing: Evidence from tonal and non-tonal languages. *Journal of Phonetics*, 71, 326–354. <https://doi.org/10.1016/j.wocn.2018.09.009>
- Kirby, J. & Pittayaporn, P. (2025). Tone and voicing in Cao Bằng Tai: Implications for tonal evolution and change. *Diachronica*, 42(3–4), 357–381. <https://doi.org/10.1075/dia.24030.kir>
- Ladefoged, P. (2003). *Phonetic data analysis: An introduction to fieldwork and instrumental techniques*. Blackwell Publishing.
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, 4, 863. <https://doi.org/10.3389/fpsyg.2013.00863>
- Li, F. K. (1977). *A handbook of comparative Tai*. The University Press of Hawaii.
- Liao, H. & Gehrman, R. (2025). Kra-Dai tonogenesis in Austro-Tai perspective. *Diachronica*, 42(3–4), 382–405. <https://doi.org/10.1075/dia.24028.lia>
- Lisker, L. & Abramson, A. S. (1964). A cross-language study of voicing in initial stops: Acoustical measurements. *Word*, 20(3), 384–422. <https://doi.org/10.1080/00437956.1964.11659830>
- Lisker, L., Liberman, A. M., Erickson, D. M. & Mandler, R. (1977). On pushing the voice-onset-time (VOT) boundary about. *Language & Speech*, 20(3), 209–216. <https://doi.org/10.1177/002383097702000303>
- Matisoff, J. A. (1973). *A grammar of Lahu* (Vol. 75). University of California Press.
- McDonough, J. & Wood, V. (2008). The stop contrasts of the Athabaskan languages. *Journal of Phonetics*, 36(3), 427–449. <https://doi.org/10.1016/j.wocn.2007.11.001>
- Morey, S. D. (2005). *The Tai languages of Assam: A grammar and texts*. Pacific Linguistics.
- Morey, S. D. (2008). The Tai languages of Assam. In A. V. N. Diller, Jerold A. Edmondson, & Yongxian Luo (Eds.), *The Tai-Kadai Languages* (pp. 207–253). Routledge.
- Pittayaporn, P. (2009). *The phonology of Proto-Tai* [PhD dissertation, Cornell University]. <https://hdl.handle.net/1813/13855>
- Robinson, W. (1849). Notes on the languages spoken by the various Tribes inhabiting the valley of Assam and its mountain confines. *Journal of the Asiatic Society of Bengal*, 18(Part 1), 311–318, 342–349.
- Sagart, L. (2019). A model of the origin of Kra-Dai tones. *Cahiers de Linguistique Asie Orientale*, 48(1), 1–19. <https://doi.org/10.1163/19606028-04801004>
- Weidert, A. (1977). *Tai Khamti phonology and vocabulary*. Franz Steiner Verlag.
- Welch, B. L. (1947). The generalization of ‘Student’s’ problem when several different population variances are involved. *Biometrika*, 34(1–2), 28–35.

APPENDIX

Appendix A Tone Box Lexical Evidence

Cell	Tone	Gloss	Proto-Tai	Khamti
A1	/˥˥/	'rain'	*C ₂ wun ^A	/phon ⁴ /
		'itch'	*ɣal ^A	/khe ⁴ /
		'dog'	* ^h ma: ^A	/maa ⁴ /
		'thick'	* ^h na: ^A	/naa ⁴ /
		'skin'	* ^h naŋ ^A	/naŋ ⁴ /
		'laugh'	*krwəw ^A	/kho ⁴ /
		'ear'	*krwu: ^A	/hu ⁴ /
		'burn (tr.)'	*praw ^A	/phau ⁴ /
		'hair, head'	*prɤm ^A	/phom ⁴ /
		'horn'	*qaw ^A	/khau ⁴ /
		'three'	*sa:m	/saam ⁴ /
		'see'	*tran ^A	/han ⁴ /
		'louse'	*traw ^A	/hau ⁴ /
		'stone'	*tri:l ^A	/hin ⁴ /
		'head'	*truə ^A	/ho ⁴ /
A2	/˥˥/	'tail'	*trwɤ:ŋ ^A	/haaŋ ⁴ /
		'white'	*xa:w ^A	/khaaw ⁴ /
		'heart, breath'	*cɤw ^A	/tsay ¹ /
		'full'	*k.tem ^A	/tem ¹ /
		'salt'	*klwuə ^A	/kw ¹ /
		'eat'	*kwɤŋ ^A	/kin ¹ /
		'eye'	*p.ta: ^A	/taa ¹ /
		'die'	*p.ta:j ^A	/taai ¹ /
A3	/˥˥/	'year'	*pi: ^A	/pi ¹ /
		'fish'	*pla: ^A	/paa ¹ /
		'foot'	*ti:n ^A	/tin ¹ /
		'leaf'	*ɓauɥ ^A	/mau ¹ /
		'moon'	*ɓlwən ^A	/nwn ¹ /
		'thin'	*C ₂ ba:ŋ ^A	/maaŋ ¹ /
		'black'	*C ₂ dam ^A	/nam ¹ /
		'mountain'	*C ₂ do:j ^A	/noi ¹ /
		'red'	*C ₂ dwi:ŋ ^A	/neŋ ¹ /
		'nose'	*ɗaŋ ^A	/hu ¹ naŋ ¹ /
		'earth'	*ɗin	/nin ¹ /
		'star'	*t.na:w ^A	/naau ¹ /

Cell	Tone	Gloss	Proto-Tai	Khamti
A4	/ə/	'smoke'	*ɣwan ^A	/khɔn ³ /
		'person'	*ɣwun ^A	/kon ³ /
		'hand'	*mwu: ^A	/mw ³ /
		'lie down'	*nww:n ^A	/nɔn ³ /
		'daytime'	*ɲwan ^A	/wan ³ /
		'snake'	*ɲwu: ^A	/ɲu ³ /
B1	/ə/	'fire'	*wɤj ^A	/phai ³ /
		'new'	* ^h mɤ:l ^B	/mau ⁴ /
		'egg'	*qraj	/khay ⁴ /
B2	(/ə/?)	'four'	*si: ^B	/si ⁴ /
B2	(/ə/?)	'old (living)'	*ke: ^B	/ke ⁴ /
B3	(/ə/?)	–	–	–
B4	/ə/	'ashes'	*daw ^B	/tau ¹ /
		'night'	*ɣam ^B	/kham ¹ /
		'name'	*jɤ: ^B	/tsi ¹ /
		'sit'	*nan ^B	/nan ¹ /
		'one'	*nw:ɲ ^B	/nuɲ ¹ /
C1	/ə/	'five'	*ha: ^c	/haa ⁵ /
		'give'	*haw ^c	/haw ⁵ /
		'grass'	* ^h ɲwə ^c	/yaa ⁵ /
		'near'	*k.raw ^c	/kau ⁵ /
		'intestine'	*saj ^c	/say ⁵ /
		'fang'	*ɣe:w ^c	/kheu ⁵ /
C2	(/ə/?)	–	–	–
C3	(/ə/?)	–	–	–
C4	/ə/	'water'	*C ₂ nam ^c	/nam ² /
		'belly'	*dwu:ɲ ^c	/tɔɲ ² /
		'tongue'	*li:n ^c	/lin ² /
		'sky, weather'	*wa: ^c	/phaa ² /
D1	/ə/	'fruit'	* ^h ma:k ^D	/maak ⁴ /
		'fog'	* ^h mo:k ^D	/mɔk ⁴ /
		'heavy'	* ^h nak ^D	/nak ⁴ /
D2	/ə/	'bite'	*kat ^D	/kat ⁴ /
		'wing'	*pi:k ^D	/pik ⁴ /
		'cut'	*tac ^D	/tat ⁴ /
		'liver'	*tap ^D	/tap ⁴ /
D3	/ə/	'flower'	*blo:k ^D	/mɔk ⁴ /
		'bone'	*C ₂ duk ^D	/nuk ⁴ /

Cell	Tone	Gloss	Proto-Tai	Khamti
D4	/ə/	'fingernail'	*C ₂ lep ^D	/let ¹ /
		'bird'	*C ₂ nok ^D	/nok ¹ /
		'root'	*C ₂ ra:k ^D	/haak ¹ /
		'child'	*lu:k ^D	/luk ¹ /
		'blood'	*luwət ^D	/nwt ¹ /
		'sew'	*nep ^D	/yap ¹ /
		'wash (cloth)'	*zak ^D	/sak ¹ /

Note. Cell shading groups the cells that share the same modern tone in Harris's (1976) Arunachal Pradesh Khamti, using the same colours as Table 10. A dash (–) marks a cell for which no example was found; a tone in parentheses with “?” is the expected value.

Appendix B VOT dataframe of 250 extracted measures (pre-outlier removal)

Spkr.	Pos.	Pl.	Asp.	n	VOT values (ms)
F1	init.	lab.	-asp	13	13, 19, 15, 12, 13, 28, 32, 40, 36, 17, 29, 12, 12
			+asp	9	62, 56, 71, 56, 59, 67, 78, 70, 50
		alv.	-asp	12	17, 13, 13, 8, 25, 22, 26, 24, 20, 11, 20, 20
			+asp	4	65, 60, 72, 39
		vel.	-asp	11	31, 18, 17, 33, 16, 24, 28, 29, 31, 25, 29
			+asp	15	67, 79, 42, 73, 75, 85, 100, 59, 78, 49, 60, 82, 80, 55, 82
F1	med.	lab.	-asp	7	29, 33, 22, 22, 13, 32, 34
			+asp	10	47, 81, 52, 47, 32, 23, 48, 73, 58, 62
		alv.	-asp	12	12, 14, 9, 20, 24, 12, 18, 11, 22, 18, 15, 18
			+asp	9	38, 33, 39, 44, 62, 48, 71, 57, 40
		vel.	-asp	11	24, 24, 21, 42, 28, 50 [†] , 24, 46, 24, 24, 24
			+asp	9	117, 67, 71, 49, 65, 79, 97, 71, 106
M1	init.	lab.	-asp	16	12, 10, 7, 16, 16, 11, 16, 15, 15, 20, 16, 14, 19, 17, 16, 24
			+asp	10	57, 50, 62, 64, 55, 63, 61, 54, 73, 79
		alv.	-asp	4	19, 14, 10, 18
			+asp	4	88, 55, 34, 76
		vel.	-asp	12	25, 18, 19, 13, 17, 19, 18, 21, 20, 20, 16, 19
			+asp	15	59, 66, 70, 91, 59, 47, 98, 101, 79, 104, 139, 121, 73, 140, 89
M1	med.	lab.	-asp	12	14, 12, 9, 16, 20, 7, 14, 16, 18, 16, 18, 14
			+asp	5	79, 63, 43, 54, 43
		alv.	-asp	13	10, 16, 7, 9, 10, 22, 11, 7, 14, 8, 8, 16, 9
			+asp	1	69
		vel.	-asp	19	18, 53 [†] , 33, 37, 53 [†] , 15, 15, 31, 11, 21, 37, 49, 45, 27, 37, 22, 22, 16, 15
			+asp	17	58, 81, 66, 48, 51, 52, 97, 101, 63, 52, 100, 74, 92, 145 [†] , 56, 31, 163 [†]

Note. Spkr. = speaker. Pos. = Position. Pl. = Place. Asp. = Aspiration. n = number of tokens before outlier removal (cf. Table 11). [†] Removed as an outlier (more than 3 SD above the category mean; see Methodology). F1 = female speaker; M1 = male speaker; unasp. = unaspirated; asp. = aspirated.

BIODATA

Ryan Gehrmann ( 0009-0007-8738-5415) is Head of the Linguistics Department, International College, Payap University. His research deals with the phonetics and phonology of Mainland Southeast Asian languages, particularly the historical phonology of Austroasiatic and the origins of tone and register, drawing on extensive primary data collection across the region.

Douglas Inglis ( 0000-0002-5325-6902) is a lecturer in the Linguistics Department, International College, Payap University. He works with grammatical description of minority languages of Mainland Southeast Asia.

How to cite this article:

Gehrmann, R., & Inglis, D. (2026). Tai Khamti stop phonation contrasts: Historical origins and phonetic documentation. *Journal of Language and Culture*, 45(2), 106-128.

Received: 13 April 2026

Revised: 27 June 2026

Accepted: 24 September 2026

© The Author(s) 2026. *Journal of Language and Culture* published by Research Institute for Languages and Cultures of Asia, Mahidol University. This article is open access under a Creative Commons Attribution 4.0 International License, permitting the use, sharing, adaptation, distribution, and reproduction in any medium or format. Users are required to provide appropriate credit to the original author(s) and the source, include a link to the Creative Commons license, and indicate if any changes were made. The images or other third-party materials included in this article fall under the article's Creative Commons license unless otherwise specified in a credit line. If the material is not covered by the article's Creative Commons license or if your intended use goes beyond what is permitted by statutory regulation, you must seek permission directly from the copyright holder.