

# A PRELIMINARY EXPLORATION OF TONES IN PAITE

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## ABSTRACT

In this paper, we report the results of a series of experiments carried out on tones in Paite (ISO 639-3: pck) and provide an acoustic analysis of its tones. Paite is an endangered and under-documented Tibeto-Burman language spoken primarily in Manipur, India. This study confirms the presence of three contrastive tones in Paite. We built a linear mixed-effects models of  $f_0$  and duration to examine the tonal contrast using the likelihood ratio test which shows statistically significant contrast for  $f_0$  and confirms the presence of three contrastive tones in Paite.

Further, an examination of consonant-tone interaction suggests the presence of a fourth tone which occurs in a restricted environment. We conclude that Paite has three contrastive tones: rising, level and falling, and a fourth tone, arising from the interaction of a contour tone with final stops. We refer to the fourth tone as a low checked tone.

**Keywords:** Paite, tone, consonant-tone interaction.

## 1. INTRODUCTION

Paite (ISO 639-3: pck) belongs to the Northern Kuki-Chin sub-group of the Tibeto-Burman family [1], [2], [3], [4]. It is primarily spoken in the state of Manipur in India by about 79,500 speakers [5]. As Manipur is home to about 33 Tibeto-Burman languages, there is pressure from larger neighbouring languages and other sociolinguistic influences such as language contact between multiple similar languages which is causing decline in intergenerational transmission. Consequently, this study is a preliminary attempt devoted to investigating tones in Paite, an under-documented language.

In the previous literature, conflicting claims have been made regarding the number of tones found in Paite [6], [7], [8], [9]. It is also observed that none of the accounts were backed by instrumental evidence. Moreover, the previous literature also does not provide lexical items which are contrastively specified for tones.

In order to establish the tonal contrasts in Paite, we prepared a list of homophonous words exhibiting tonal contrast and this was primarily done by the first author who is a native speaker of Paite. After consulting with many speakers and analysing the

lexicon in these dictionaries [10], [11], we were convinced that there are three linguistically-contrastive tones in the language. This study also looks into the nature of the consonant-tone interaction found in Paite which triggers the occurrence of a fourth tone.

## 2. ACOUSTICAL ANALYSIS OF PAITE TONES: METHODOLOGY

A production experiment was conducted with 7 sets of minimal tone triplets ( $7 \times 3 = 21$  unique words). The word was embedded in a medial position in a carrier sentence of the type “I ‘x’ said”, x being the target word. 10 native speakers (7 male and 3 female, aged between 25 to 40) of Lamzang variety from Churachandpur district of Manipur participated in the experiment. All the participants spoke Paite as their first language and could also speak English. There were 3 iterations each resulting in 630 tokens. The target words in the dataset were of CV, CVV, and CVC syllable types.

Word	Gloss	Tone
/bêl/	pot	falling
/bēl/	shelter	level
/běl/	early	rising
/pôl/	straw	falling
/pōl/	mingle	level
/pöl/	colourful	rising

**Table 1:** Examples of tone minimal triplets considered for the experiment.

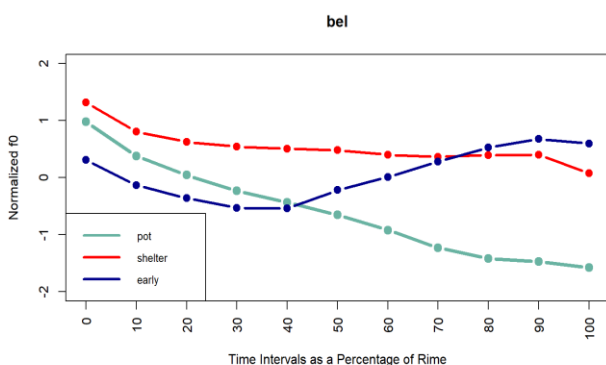
Sentence	Gloss	Tone
/kēn bêl tsī/	I ‘pot’ said	falling
/kēn bēl tsī/	I ‘shelter’ said	level
/kēn běl tsī/	I ‘early’ said	rising
/kēn pôl tsī/	I ‘straw’ said	falling
/kēn pōl tsī/	I ‘mingle’ said	level
/kēn pöl tsī/	I ‘colourful’ said	rising

**Table 2:** Examples of target tone minimal triplets embedded in carrier phrase.

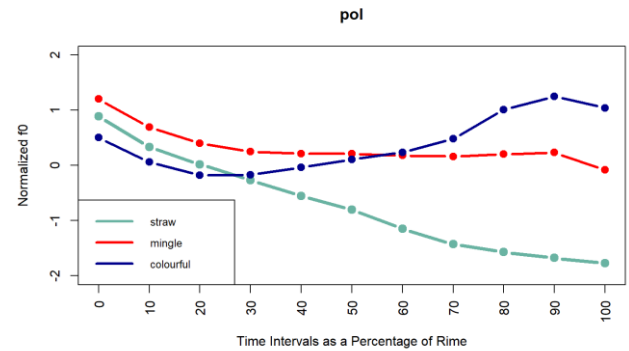
The recordings were carried out at the Phonetics and Phonology Lab, IIT Guwahati in a sound proof recording booth using a Tascam DR-100 MKII recorder. Four tier TextGrid files were created in Praat [12]. The tiers were TBU, individual phonemes, words, and sentences. The pitch of the onset (the point of initiation) and offset (the point of termination) of the TBU was observed in Praat. TBUs in Paite are the syllable nucleus or the entire rhyme if the coda is a sonorant. A Praat script was run to extract the pitch values at every 10% of the total duration of the TBU. Thus, there were 11 consecutive points at which the pitch was calculated, starting from the onset at 0% till the offset at 100%. Each point represented 10% of the total length of the pitch track. We did two measurements i) Averaging of percentage-wise pitch values for all iterations and ii) Z-score normalization of all raw pitch values using the formula  $Z = (f0_i - x) / SD$ , where  $f0_i$  is the sampling point,  $x$  is the average  $f0$  of all the sampling points, and  $SD$  representing the standard deviation of all the sampling points. The percentage-wise pitch values in Hz were normalized and averaged across all the tokens of all the speakers for all the 11 points and plotted on a graph to observe the distinct pitch contours.

### 2.1. Acoustical analysis of f0

The minimal tone triplets were examined to understand the possible tonal contrasts in Paite. The normalised pitch values of all iterations of all speakers at 11 consecutive points were used to draw line diagrams for visual examination. Figure 1 & 2 display the contrastive tones.

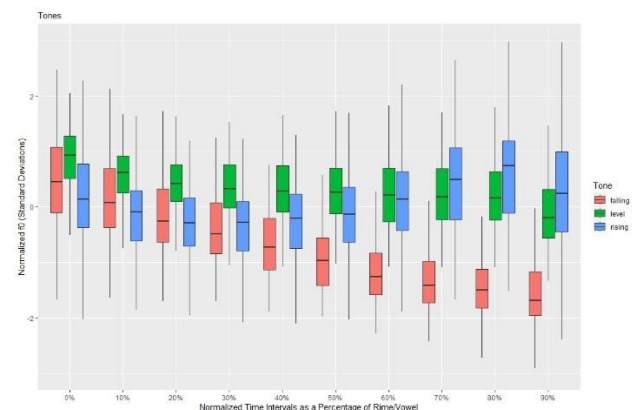


**Figure 1:** Normalized f0 interval contrast for the tonal triplet bēl ‘pot’, bēl ‘shelter’ and bēl ‘early’.



**Figure 2:** Normalized f0 interval contrast for the tonal triplet pōl ‘straw’, pōl ‘mingle’ and pōl ‘colourful’.

The y-axis in figures 1 & 2 represent the normalized f0 values and the x-axis represents the time interval at 11 consecutive points of the rime. The graphs show a clear contrast between the f0 of falling, level and rising tones. The f0 contour of the three tones are significantly different from each other.



**Figure 3:** Boxplot of normalized f0 intervals showing falling, level and rising tones.

The deviation from the mean of the three tones is visualized in the boxplot in figure 3 which shows the f0 contrast at every 10% of the total duration. The f0 for the three tones is plotted at each interval point clearly showing the movement of the pitch. The results of the acoustic experiment indicate the presence of three contrastive tones in Paite. All the three tones show a dynamic f0 contour.

### 2.2. Statistical Analysis

For statistical analysis, a linear mixed-effects model was built using lme4 in R [13].  $\text{Tone.model} = \text{lme4::lmer}(F0 \sim \text{Tone} + (1 + \text{Tone} | \text{Subject}) + (1 + \text{Tone} | \text{Word}), \text{data} = \text{tone})$  was the full model created. Normalized f0 and tone were the fixed effects. Speakers and words were random factors.

	Estimate	Std. error.	t value
Intercept	-0.3312	0.2204	-1.502
Level	0.7535	0.2789	2.701
Rising	0.3069	0.3570	0.860

**Table 3:** Fixed effects for normalized f0 contrast between falling, level and rising tones.

The fixed-effects results showed a distinction between the level tone, rising tone and f0 of the intercept which represents the falling tone. The estimate of the intercept is about -0.3312. A comparison of the full and null model using the likelihood ratio test [14] showed that tone affects pitch ( $\chi^2(1) = 6.8331$ ,  $df = 1$ ,  $p = 0.008948$ ), which reveals that the contrast is statistically significant.

	Estimate	Std. error.	t value
Intercept	259.93	16.887	15.393
Level	7.81	19.210	0.407
Rising	16.66	22.122	0.753

**Table 4:** Fixed effects for duration contrast between falling, level and rising tones.

The raw values of duration of each target word were measured to check if duration is a possible cue for tonal contrast. Duration.model = lme4::lmer(Duration ~ Tone + (1+Tone|Speaker) + (1+Tone|Word), data = dur) was the model created with duration and tone as the fixed effects. Random effects were gender and iteration. No significant difference for duration between the tones was found ( $\chi^2(1) = 4.8654$ ,  $df = 2$ ,  $p = 0.0878$ ). The level and rising tones are lengthened by a meagre 7.81 ms and 16.66 ms respectively when compared to the intercept which represents the falling tone.

### 3. CONSONANT-TONE INTERACTION IN PAITE LEAD TO A FOURTH TONE

Paite has a two-verb stem system where there is tonal and segmental alternation between the two verb forms. This phenomenon is observed in other Kuki-Chin languages such as Thadou [15], Vaiphei [16], Mizo [17] and Hakha Lai [18] as well. There is not enough linguistic work on Paite. There is hardly any literature that discusses its verbal morphology and we aim to explore this in future works. Verb-stem alternations may arise from various morphological and syntactic functions which are beyond the scope of this paper. This paper is limited to the interaction

between segments and tones involved in these alternations and how these processes suggest the presence of a fourth tone in Paite.

Our research shows how this verb-stem alternation necessitates segmental as well as tonal change. The difference between the two alternates can be observed tonally as the two forms carry different tones. We believe that stem II forms are derived from stem I forms as the distribution of stem II tones is considerably limited. Usually, the tone of stem II undergoes a process of lowering, along with a change in segment word finally. Stem II typically carries a low tone.

#### 3.1. Data sets

We present below in tables 5, 6 & 7 data sets to show how a low tone emerges as a result of the alternation. We followed the same process of data collection for the low tone as for the other tones. The previous 10 subjects recorded these words. The data set contained 6 words with 3 iterations each. A total of 180 tokens were considered. The falling tone is described as a sequence of high-low (HL) and the rising tone as low-high (LH).

HL tone	L tone	Gloss
/pân/	/pàt/	‘start’
/dîn/	/dît/	‘return’
/kêm/	/kèp/	‘keep’

**Table 5:** HL in verb stem I changing to L in verb stem II, along with nasals changing to final stops.

HL tone	L tone	Gloss
/bâa/	/bàt/	‘borrow’
/nâa/	/nàt/	‘pain’
/tûu/	/tùt/	‘sit’

**Table 6:** HL in verb stem I changing to L in verb stem II, along with the insertion of a final stop.

LH tone	L tone	Gloss
/t <sup>h</sup> öu/	/t <sup>h</sup> òʔ/	‘get up’
/löu/	/lòʔ/	‘pluck’
/zöu/	/zòʔ/	‘finish’

**Table 7:** LH in stem I changing to L in stem II. Additionally, there is glottal stop insertion along with a vowel change.

We observe that the final consonant is always either an oral or a glottal stop. In table 5, HL in verb stem I changes to L in verb stem II, along with nasals changing to final stops. In table 6, HL in verb stem I changes to L in verb stem II, along with the insertion of a final stop. In table 7, LH in stem I changes to L in stem II along with a glottal stop insertion. We observe that a fourth tone emerges as a result of the interaction between a final stop consonant and a contour tone (rising LH or falling HL) in the verb-stem II form. The resulting stem II tones are consistently low.

### 3.2. Low checked tone in Paite.

The f0 contour of the checked tone when compared to the other three tones has a lower pitch than the falling and level tones. It also exhibits a low-falling contour. An examination of figure 4 helps us visualize how the pitch of the tone that results from the consonant-tone interaction is invariably low.

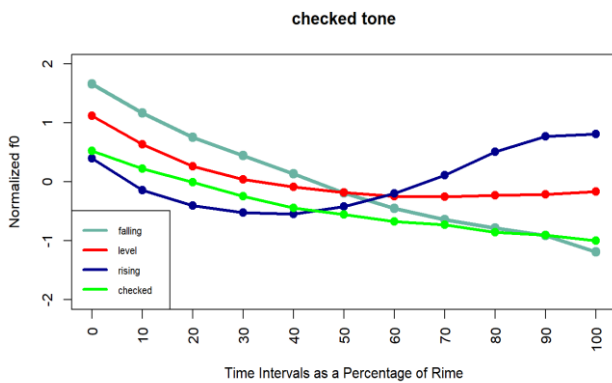


Figure 4: Normalized f0 of checked tone in contrast with falling, level and rising tones.

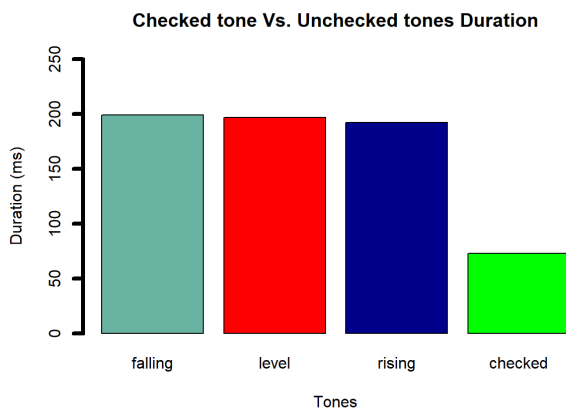


Figure 5: Duration of low checked tone compared to falling, level and rising tones.

This tone is observed to behave in a similar manner as the checked tones found in other tonal languages such as Taiwanese [19] and Xiapu Min [20] where the checked tones show a clearly distinct f0 contour. The low checked tone in Paite is also found to be significantly shorter in duration than the other three tones as shown in figure 5. In Burmese [21], Mandarin [22] and Taiwan Min [23] as well, checked tones are distinguished phonetically by a notably shorter duration.

## 4. CONCLUSION

Acoustic analysis performed on the recorded speech of 10 native speakers confirms the presence of three contrastive tones in Paite. This is further substantiated by likelihood ratio test results revealing that the f0 contrast between the three tones is statistically significant. On the other hand, it is found that duration does not play a role in providing a cue for tonal contrast. Further, a fourth tone is detected in Paite which occurs only with short vowels followed by either a final oral or glottal stop. It is also observed that the pitch of the fourth tone is consistently low. This tone is identified as a low checked tone. This tone is also significantly shorter in duration when compared to the other three tones. So, the results obtained in this study establish that there are three contrastive tones in Paite: falling, level and rising, and a fourth low tone that occurs in a restricted environment.

## 5. REFERENCES

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