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Pitch and Voice Quality Characteristics of the Lexical Word-Tones of Tamang, as Compared with Level Tones (Naxi data) and Pitch-plus-Voice-Quality Tones (Vietnamese data)

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Abstract
The tones of Tamang (Sino-Tibetan family) involve both F₀ and voice quality characteristics: two of the four tones (tones 3 and 4) were reported to be breathy in studies from the 1970s. For the present research (thirty years later), audio and electroglottographic data were collected from 5 speakers of the Risiangku dialect in their 30s or 40s. Voice quality is estimated by computing the glottal open quotient. The present results bear on 788 syllables (from a corpus of 6,500). They show that in the speech of three speakers (M2, M3, M5), tones 3 and 4 have a higher open quotient (which provides an indirect cue to the degree of breathiness) than tones 1 and 2, with tone 3 more clearly so than tone 4, especially for speaker M2. The difference in open quotient between the four tones for the other two speakers is negligible or inconsistent.

The Tamang data are compared with similar data from Naxi, which possesses level tones, and from Vietnamese, which possesses pitch-plus-voice-quality tones. The comparison brings out the great variability of Tamang tones in terms of F₀, as well as in terms of open quotient. The present results appear to confirm that Tamang tones possess several correlates; they offer an insight on ongoing change in the prosodic system of Tamang.

1. Introduction
The tones of the Bodic language group (Sino-Tibetan family), and of the Tamang language in particular, raise a challenge for theories of tone, and for prosodic typology: (i) their domain is the prosodic word, not the mora or the syllable; (ii) their phonetic realisation is highly variable—across speakers, and within the speech of the same speaker—and involves several features [4, 5]. The present research focuses on the latter issue, and, more specifically, on F₀ and voice quality (the mode of vibration of the vocal folds).

Tamang possesses four tones, hereafter referred to as T₁, T₂, T₃ and T₄ (see figures 1, 4 and 5, on the last page). In studies from the 1970s, breathiness was described in two Tamang dialects, Risiangku and Sahugaon, and in other languages of the Tamangish branch: Gurung and Thakali) as one of the features of T₃ and T₄, the tones that are lowest in terms of F₀ [4, 5 and references therein]. As already pointed out in [4], it appears useful to explore Tamang tones experimentally in order to gain new insights into these complex tones.

As nearly two generations have elapsed since the investigations mentioned above, the present experiment (conducted in 2005) also offers an opportunity to reflect on language change. Variability in the realisation of breathy voice quality is well documented across languages [1], both diachronically (breathy voice quality frequently transphonologises to tonal contrasts or vowel contrasts) and synchronically (cross-dialect and cross-speaker variation in the realisation of the feature of breathiness is known to be considerable, as compared to other phonological features).

Data from two other languages (also recorded first-hand, using a similar experimental setup) are used as points of reference in the interpretation of the results: these languages are Naxi, which possesses level tones [9], and Vietnamese, which possesses pitch-plus-voice-quality tones [7, 8].

2. Method
The investigation relies on electroglottography (EGG), combined with audio recordings and spectrographic analysis.

2.1. Corpus and speakers
The 136 target morphemes are monosyllabic. They are divided into two sets: on the one hand 49 nouns and grammatical words (namely the particles /ću/ ‘as for’ and /će/ ‘only’; the deictic /ću/; and the 3rd person pronoun /će/), on the other hand 87 verbs, including stative verbs (e.g. /će/ ‘to be’). The nouns and grammatical words were placed inside the following carrier sentence:

\[
\text{ću-ri } \text{here target noun}
\]
e.g. ću-ri ‘Here [is] grease’ (tone is indicated as a superscript figure before the first syllable of the phonological word that carries it: /će/ ‘grease’, carries T2).

The verbs were placed inside another carrier sentence:

\[
\text{ću-ri } \text{here target verb} \text{-pa}
\]
e.g. ću-ri ‘Here, [he is] planting’ (/ću-ri/ ‘as for’ and /će/ ‘only’; the deictic /ću/; and the 3rd person pronoun /će/).

Tamang morphemes have a complex syllabic structure; the present investigation is limited to CV syllables made up of a nonaspirated stop /p, t, k, c, s/ followed by a nondiphthongised vowel /a, i, j, u, o, y, e/.

The use of nonsense words did not appear as a valid option, because Tamang does not have a written tradition. The words used were selected from a Tamang dictionary...
breathy voice, each glottal cycle can still be divided into a (so-called) ‘closed’ and an ‘open’ phase. Despite the fact that the airflow baseline is not at zero in inside each glottal cycle, as some air leaks out constantly.

The detection of the glottal opening and closing peaks are consistently observed (this phenomenon is not uncommon: for a discussion see [2, page 1324-1327, 3]; \( O_q \) was nonetheless calculated, using a barycentre method (about this and other methods, see http://voiceresearch.free.fr/egg/, where our software is available for download, with some documentation).

3. Results

3.1. Comparison of the degree of variability with that observed in Naxi and Vietnamese

Figure 1 shows average \( F_0 \) and \( O_q \) curves for the four tones as realised on monosyllables by speaker M3. (All the rhymes represented come from the first repetition of the carrier sentence, in order to control for the effect of the position of the utterance within the series of two.) The error bars show a considerable standard deviation for \( F_0 \) and \( O_q \); the ranges of variation of the four tones overlap to some extent. This is especially clear by comparison with Naxi data (figure 2): Naxi is a textbook example of level tones (High, Mid and Low, plus a rising, Low-to-High tone), that are not specified in terms of voice quality (a fact which is straightforwardly reflected in the higher variation coefficient for \( O_q \) than for \( F_0 \)). Three Vietnamese tones are plotted in figure 3: they are much less variable than Tamang tones, both in terms of \( F_0 \) and of \( O_q \).

For the sake of visual clarity, the curves in figures 4 and 5 are plotted with only half their actual standard deviation, for \( F_0 \) and for \( O_q \).

3.2. Description of the four tones

Tones 1, 2, 4 (from highest to lowest) are decreasing over the syllable. T3 is rising. As for \( O_q \), M5 has a comparable mean \( O_q \) on T3 and T4, higher than on T1 and T2; M2 has a clearly higher \( O_q \) on T3, with T4 also slightly above T1 and T2. The range is markedly different across speakers: overall, M5 has a much higher mean \( O_q \) than M2, i.e. a more breathy voice; this confirms that tone-specific variation in voice quality is relative, not absolute. M3 exhibits the same \( O_q \) pattern as M2; the differences are of smaller amplitude, however.

M1 and M4 do not show any variation in \( O_q \) across tones. Correlatively, M1 has less variability in \( F_0 \) curves than other speakers, but this is not true of M4.

From figure 1, it appears that differences in \( O_q \) across tones tend to be strongest on the first half of the syllable; from figure 4, it further appears that this difference (like the difference in \( F_0 \)) is much stronger on the first than on the second syllable of disyllables (recall that, from a phonological point of view, the domain of tone in Tamang is the phonological word, which may be mono- or polysyllabic). This explains in part why the \( O_q \) values shown in table 1 and in graph 1, which are averaged over entire syllables, do not bring out a clear contrast between the four tones: the time course of \( O_q \) curves appears no less important than that of \( F_0 \) curves. (The values in table 1 and graph 1 do not include the second syllable of disyllables, in view of the fact that \( O_q \) differences on the second syllable are generally much smaller than on the first.)
both of the parameters measured here (F0 and Oq) show emerges for speakers M2, M3 and M5, in whose realisations terms of far from transparent. Indeed tends to be shorter than T2, and T2 tends to have a intermediate stage in the transphonologisation of consonantal linguistic trait (typically, in the Sino-Tibetan domain, an This tends to confirm the transitory nature of breathiness as a partic does contribute to the observed variance in F0 and Oq: speaker; tone; segments (especially vowel length); and F0 of the preceding syllables (i.e., realisation of the carrier sentence).

4. Discussion

4.1. Cues to tones rather than tonal features?

Speaker-specific variability is observed in all three languages. In the face of such variability, it seemed advisable to look for patterns of least variability, e.g. in Naxi there is some variability in F0 within each tonal category, but F0 varies less than Oq (reflecting the fact that voice quality plays no distinctive role in Naxi); in Vietnamese, Oq varies less than F0, reflecting a strict control on voice quality, which plays a distinctive role. The comparison brings out the great variability of Tamang tones in terms of F0, as well as in terms of Oq. The present results appear to confirm that Tamang tones are highly variable in terms of pitch, and possess several correlates. They also suggest differences between the speech of the language consultants of this study and those who participated in earlier studies [4, 5], some two generations ago. This tends to confirm the transitory nature of breathiness as a linguistic trait (typically, in the Sino-Tibetan domain, an intermediate stage in the transphonologisation of consonantal contrasts to pitch contrasts).

Concerning the contrast between T1 and T2, which has been described as ‘ballistic’ (T1) vs. ‘controlled’ (T2), T1 indeed tends to be shorter than T2, and T2 tends to have a slightly more level curve, though here again, the results are far from transparent. This raises issues in the description of Tamang tones in terms of features. No obvious hierarchy among features emerges for speakers M2, M3 and M5, in whose realisations both of the parameters measured here (F0 and Oq) show consistent patterns of tone-specific variation. Speakers M1 and M4 apparently rely on pitch, not on voice quality. There appears to be multiple cues, rather than a hierarchy of features, the one primary, the others secondary.

4.2. On the hypothesis of relations of compensation

Synchronically, it has been hypothesised [6] that a relation of compensation may obtain between pitch and breathiness for Risiangku Tamang T4, such that when a token is pronounced at the bottom of T4’s F0 range, breathiness is often absent. While it is marginally verified that M1, who uses no breathiness cues, has the largest separation of tones in terms of F0 (i.e., has least F0 variability), no relation of compensation between F0 and Oq emerges from the present data: the T3 and T4 tokens with lowest Oq (least breathiness) are not those with lowest F0. If the relation of compensation at issue exists in the language, it did not come into play under the experimental setup chosen—or perhaps the cues to ‘breathiness’ partly lie in parameters other than Oq: this leads to the issue of the enlargement of the scope of research, addressed in the ‘Perspectives’ below.

5. Conclusion and perspectives

Within a fairly homogeneous group of Tamang speakers, individual strategies in the realisation of tone differ sharply, two of the five informants appearing not to make consistent use of voice quality differences to contrast tones. From a synchronic point of view, these data appear to call for speaker-dependent modelling, and for modelling in terms of a bundle of multiple acoustic correlates: F0, length, voice quality, and allophonic variation of consonants (not studied here). These results confirm and complement description by ear: (i) T3 and T4 show clear hints of breathiness (in the speech of three speakers), more clearly so for the former than for the latter; and (ii) the cross-linguistic evidence adduced shows that the degree of variability observed (in F0 and Oq) is higher than would be expected on the basis of speaker-specific and phoneme-conditioned variability alone, i.e. this variability is a characteristic of Tamang tones.

From a diachronic point of view, it might be that Tamang is evolving towards an all-pitch tone system; neighbouring languages certainly have a bearing on this evolution, however: the influence of Nepali, the (non-tonal) national language of Nepal, is towards a simplification of the tone system. With a view to contributing to the study of language change, and more specifically of the evolution of tonal systems, our ongoing research is now directed to the issue of the other cues to tone, in particular the variation in the realisation of syllable-initial consonants in relation to the phonemic tones. Lastly, further experiments are called for to verify the hypothesis of a relation of compensation among cues to tones.

6. Hyperlink

Supplementary materials are available at:


7. References


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**Tamang. Large variation of F0 and Oq.**

Stars: tone 1, squares: tone 2, line: tone 3, circles: tone 4

**Naxi. Small variation of F0, large variation of Oq.**

High tone

Rising tone (squares)

Mid tone (circles)

Low tone (stars)

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**Vietnamese. Small variation of both F0 and Oq.**

Tone D1 (line).

Nonglottalised.

Tone B2 (squares).

Glottalised.

Tone D2 (stars).

Nonglottalised.

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**Open quotient (%)**

Graph 1. Open quotient values for the four Tamang tones, averaged over 3,361 syllables with nonaspirated initials. These mean values do not bring out a clear contrast between the four tones, suggesting the necessity of studying the time course of open quotient values.

**Tamang disyllables. (Standard deviation halved.)**

Stars: tone 1, squares: tone 2, line: tone 3, circles: tone 4

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**Tamang disyllables. (Standard deviation halved.)**

Open quotient consistently higher on tone-3 syllables (indirect indication of breathiness)

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**Open quotient (%)**

Fig. 5. The 4 tones on disyllables by speaker M5, initial position, averaged over 134 syllables, nonaspirated initials.