

# The Key Phonetic Properties of Vietnamese Tone: A Reassessment

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## ABSTRACT

Tone in Vietnamese is usually equated to pitch. There are eight tones in standard North Vietnamese: *ngang* (high level), *huyen* (low level), *sac1* (rising), *nang1* (dropping), *nga* (broken), *hoi* (falling-rising), *sac2* (rising, short), and *nang2* (falling, short). Phonologically, these tones are said to fall into two registers: high (*ngang*, *sac1*, *hoi*, and *sac2*) and low (*huyen*, *nang1*, *nga*, and *nang2*). However, there is a serious mismatch: phonologically, *hoi* is high but, phonetically, it is low, and *nga*, is the opposite, phonologically low but phonetically high. Experimental evidence from an acoustic study that examined phonation types shows that breathiness and creakiness rather than pitch height are the primary perceptual cues of tone. This study resolves the apparent anomaly with *hoi* and *nga* and casts serious doubts on the simple equation of tone to pitch.

## 1. INTRODUCTION

In the literature on tone languages pitch height is usually considered to be the primary and sometimes only phonetic correlate of tone. However, this view creates a problem in Vietnamese, namely a mismatch between the phonetic realization of tone and its phonological patterning. If ‘tone’ refers to a contrastive phonological category, that category may not in fact be pitch height. It may be that pitch height is not the basic tonal feature and that pitch register is not an adequate phonological feature for representing Vietnamese tones. This research shows that the laryngeal features of creakiness and breathiness are primary in signaling tone and that pitch height is derived from these features and from features describing tonal shape.

## 2. VIETNAMESE

Northern Vietnamese, the standard variety of the language, has eight tones: *Ngang*, *huyen*, *sac1*, *nang1*, *hoi*, *nga*, *sac2*, and *nang2*. *Ngang*, *huyen*, *sac1*, *nang1*, *hoi*, and *nga* occur in open or sonorant-final syllables. Only *sac2* and *nang2* occur in stop-final syllables. The standard position in the literature, reflected in the orthography, is that there are only six tones with final consonants distinctive in manner. In this view *sac1* and *sac2* and *nang1* and *nang2*

are allophones in complementary distribution. This research rejects this view in favor of adopting an approach with eight discrete tones: rather than being predictable variants of *sac* and *nang* in non-stop-final syllables, *sac2* and *nang2* in stop-final syllables are phonologically distinct from the two tones. It is the manner of the final consonant that is conditioned by tone.

## 3. THE MISMATCH PROBLEM

Phonologically, Vietnamese tones have been grouped into two registers on largely phonetic criteria: a high register (*ngang*, *sac1*, *nga*, and *sac2*) and a corresponding low register (*huyen*, *nang1*, *hoi* and *nang2*). There is considerable evidence for this classification in such processes as reduplication, neutralization, assimilation of borrowings, etc. However, *hoi* and *nga* behaves exceptionally in such processes in that *hoi* behaves like a high tone and *nga* behaves like a low tone. Such behavior has prompted the postulation of ad hoc adjustment rules such as Concave Tone Reversal [3] and Register Flip-Flop and Creakiness Acquisition [1]. This is not a satisfactory solution.

## 4. A NEW ACOUSTIC STUDY

Because there are very few acoustic studies of Vietnamese tone (see particularly [4] and [5]), a new study was undertaken to investigate the fundamental frequency (F0) of all the tones and the spectral characteristics of phonation types such as creakiness and breathiness. Nine speakers, three males and six females, were asked to read controlled lists of words of CV or CVC syllable form using only the vowel [a]. The initial consonants included the nasal /m/, two stops /t, k/, and two fricatives /s, z/, and the final consonants were stops and nasals. 112 items were randomized three times and presented to each speaker individually. Each speaker read all items and there were 3,024 tokens altogether. The study measured phonation types through the use of digital sound spectrography [2]. Signalyze TM was used to produce spectrograms and Excel was used to graph pitch. In addition to F0, both creakiness and breathiness were clearly present in the waveforms and were also examined. When the tone was heavily breathy, a low pass Butterworth filter was used to suppress the high frequency components.

## 5. FINDINGS

The spectrographic characteristics of Vietnamese tones are quite clear. Three have modal voice: *ngang*, *sac1*, and *sac2*; three have breathy voice: *huyen*, *hoi* and *nang2*; and two have creaky voice: *nang1* and *nga*. These characteristics are also quite consistent across speakers. *Ngang* has modal voice with periodic, regular glottal pulses and moderate amplitude. *Huyen* has breathy voice with regular glottal pulses and reduced amplitude. *Sac1* has modal voice with regular glottal pulses and moderate amplitude. *Nang1* has a glottal stop or creaky portion close to the end of the tone with irregular, widely spaced pulses sometimes interrupted by one or two irregular pulses, together with the complete closure of the vocal folds resulting in a glottal stop, or partial closure resulting in creakiness. *Hoi* is breathy after about 40ms and breathiest from 70 to 120ms with regular pulses and reduced amplitude. *Nga* has a glottal stop or creakiness in the middle of the tone with irregular, widely spaced pulses from about 70 to 130ms and gaps in the spectrogram. *Sac2* has modal voice with regular pulses and reduced amplitude but it is also very short because of the final stops and ends before 120ms. *Nang2* has some breathiness after 60ms with regular pulses and reduced amplitude but it is also very short because of the final stops and ends before 120ms. Its F0 is very close to that of *huyen*.

The results also show a relationship between F0 and phonation type: tones with creaky or breathy voice have low F0, either throughout the whole tone, e.g., *huyen* and *nang2*, or at some point, e.g., *nang1*, *hoi*, and *nga*. This result is not surprising since the faster the vibration of the vocal folds the higher the tone, and in breathy voice the vocal folds vibrate more slowly than they do in modal voice.

Breathiness and creakiness are found in *huyen*, *hoi*, *nang1*, and *nga*. The F0 of pitch is also variable within and across speakers and in many cases provides no information that allows listeners to distinguish between tones when two different tones are compared. Tonal length and tonal height also vary from speaker to speaker, from form to form, and from token to token.

A phonetics feature that is invariant across and within speakers is a primary feature. If the F0 of pitch is not a primary feature of Vietnamese tones, there must be something else that is more stable and reliable.

## 6. DISCUSSION

The characteristic phonetic features of the eight tones are as follows:

<i>ngang</i>	<i>huyen</i>	<i>sac1</i>	<i>nang1</i>	<i>hoi</i>	<i>nga</i>	<i>sac2</i>	<i>nang2</i>
level	level	rise	fall	(curve)	curve	rise	fall
modal	breath	modal	creak	breath	creak	modal	breath
H	L	H	L	L	L	H	L

The first row shows Tone, second row Contour, third row Register, and fourth row Pitch. The parentheses around the curved feature in *hoi* show that this feature varies from speaker to speaker. The last row (Pitch) does not show pitch as it is classified traditionally but shows how Register predicts pitch height, i.e., how breathiness predicts lowness in the tone throughout, as in *huyen*, or at a certain point, as in *hoi*.

As noted earlier, *hoi* is classified traditionally as a phonetic low tone but patterns phonologically as a high tone, and *nga* is classified traditionally as a phonetic high tone but patterns phonologically as a low tone. However, depending on which point in the tone is deemed relevant, *hoi* can be regarded as low and *nga* as high, or vice versa. *Hoi* is breathy and *nga* is creaky. If *nga* is creaky in the middle, this part is lower in *nga* than in *hoi*, since both breathiness and creakiness lower the tone, however, creakiness produces a lower tone than does breathiness. Therefore, *hoi* cannot be lower than *nga* because of the latter's creakiness. If *nga* has a glottal stop in the middle, then the F0 comparison is impossible, because there is no phonation during the glottal stop. *Nga* is usually treated as a high tone because it ends very high. This end is said to make the tone high 'overall'. However, the end of *nga* can be either high or low and varies greatly. A high pitch ending is not a good criterion for classifying it as a high tone. There is an alternative constant to consider: contour, which is a distinctive feature of Vietnamese tones. *Hoi* and *nga* are the two curved tones. *Nga* without the middle part would be like *sac1*, a rising tone. *Hoi* without the middle part would be like *huyen*, a falling tone. Therefore, in a comparison of *hoi* and *nga* the middle point is critical: *nga* must be curved and lower with creakiness in the middle.

All previous accounts classify *sac1* as a high-rising tone and *huyen* as a low-level tone. However, the pitch trajectories show that *huyen* starts higher than *sac1* and gradually goes down. *Sac1* starts lower than *huyen*, goes flat, and then rises higher than *huyen* only at the very end. Therefore, if overall pitch height is the criterion needed to classify tonal height, the high-rising *sac1* would be low and the low-level *huyen* would be high. If tonal height is instead reconceived as 'overall shape', it is possible to challenge the traditional classification.

The F0 of tone varies from token to token and from speaker to speaker. For example, *nga* can have a very high end point for one speaker but a low one for another and the end point can even differ from token to token for the same speaker. However, phonation type is quite consistent both within individuals and across speakers. The tones that have non-modal phonation are *huyen*, *nang1*, *nga*, *nang2*, and *hoi*. *Huyen*, *hoi*, and *nang2* are breathy. *Nang1* and *nga* are creaky. The breathiness in *huyen* is the only difference between the two level tones *ngang* and *huyen*. All speakers have breathiness in *huyen*. However, the degree of breathiness varies from speaker to speaker. A comparison of the waveforms and spectrograms of *nga* and *sac1* shows that *nga* with a little creakiness is higher in F0 than *sac1*. it would appear that although creakiness

is produced at low frequencies, low frequencies do not necessarily produce creakiness. This is very strong evidence that phonation predicts pitch height, not vice versa.

Without creakiness in the middle *nga* would lose its most important, distinctive cue. Pitch height is not critical because *nga* can have either a very high ending, making it partially higher than *hoi*, or a very low ending, making it lower than *hoi* throughout. Treating the rising part of *nga* as phonetic resolves the problem of which is higher, *nga* or *hoi*. The phonetic height varies randomly. All that is required is that the F0 rises a little to make a curve. Because creakiness and breathiness lower the tone, it is not surprising that marked (low register) tones are indeed low because each tone has either breathiness or creakiness at some point or throughout the tone and it is from these phonation types that the lowness is derived. They are [laryngeal] tones.

Since F0 varies to the point of not distinguishing between certain tones in many cases, it is not a reliable cue to differentiate tones. The laryngeal features of breathiness and creakiness are stable and provide more reliable auditory cues. Along with tonal shape, these features account for tonal height: where breathiness or creakiness occurs, the tone is low. In curved tones, breathiness and creakiness signal the lowest part. They are also found in all marked tones, i.e., *huyen*, *nang1*, *nga*, and *nang2*. *Hoi* is an unmarked (high register) tone but is breathy. The breathiness in this tone satisfies a requirement of the contour feature (to make a curve). *Nga* is usually classified as high because of its high ending, but this is a phonetic characteristic rather than a distinctive feature. In *nga* creakiness predicts curve but not vice versa.

The phonological and phonetic properties of Vietnamese tones can be summarized as follows:

<i>ngang</i>	<i>huyen</i>	<i>sac1</i>	<i>nang1</i>	<i>hoi</i>	<i>nga</i>	<i>sac2</i>	<i>nang2</i>
level	level	rise	fall	curve	curve	rise	fall
	breath		creak	(breath)	creak	[obst]	breath [obst]
H	L	H	L	L	L	H	L

The phonation types of creakiness and breathiness can be used reliably in Vietnamese to group tones into natural classes. Instead of pitch height, these laryngeal features are distinctive as the register features of Vietnamese tones. Tonal height is derived from the configuration of contour and register, i.e., tonal shape and phonation type. There is no phonetics-phonology mismatch.

## 7. CONCLUSION

Vietnamese tones are organized in a hierarchical structure, the laryngeal features of phonation are distinctive, pitch

height is not distinctive, and the features are grounded phonetically. The replacing of pitch height with phonation types and tonal shape also provides a natural and elegant account of reduplication, the most widely discussed evidence for the patterning of tones in the traditional literature. When the assumption that tone is solely pitch height is abandoned, there also emerges a new way to examine tone languages.

## ACKNOWLEDGEMENTS

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## REFERENCES

- [1] S. Burton. Reduplication and Representation of Tone. Unpublished manuscript, Brandeis University, 1992.
- [2] P. Ladefoged, I. Maddieson, M. Jackson. ‘Investing phonation types in different languages’, In O. Fujimara (ed.), *Voice Physiology: Voice Production Mechanisms and Features*. New York: Raven Press, 1988, pp. 297-317.
- [3] N. T. Ngo. *The Syllabeme and Pattern of Word-Formation in Vietnamese*. Doctoral dissertation, New York University.
- [4] V. L. Nguyen, J. Edmondson. ‘Thanh dieu chat going trong tieng Viet hien dai’, *Ngon ngu*, 1997, 1: 1-16.
- [5] B. H. Vu. ‘Ve dac trung co ban cua thanh dieu tieng Viet o trang thai tinh’, *Ngon ngu*, 1999, 6: 35-53.

