# AN ACOUSTIC ANALYSIS OF HMONG ("KAIJUE MIAO") TONE[1]

**Kathy L. Sands**
University of California at Santa Barbara

## 1. Introduction

Languages use pitch in a variety of ways to encode linguistic meaning. Most familiar to English speakers is the intonational use of pitch, in which phrase-level patterns signal a variety of interactional meanings (semantic information) and the affective state of the speaker. Languages may also utilize pitch tonally. In these languages, pitch patterns, or "tones," extend over one syllable or word only and convey morphemic information, creating lexical and sometimes grammatical distinctions.

Pitch, whether linguistic or non-linguistic, is distinguished from fundamental frequency (Rose 1988). Pitch is perceptual, referring to the auditory sensation of ordering sound from high to low. Fundamental frequency is acoustic, referring to the physical reality underlying this ordering, specifically the number of complete variations in air pressure per second produced by the vocal folds opening and closing. Higher fundamental frequency values correlate to a large extent with higher perceived pitch, but they lack a one-to-one mapping due to other factors involved in the perception of pitch, such as vowel quality and amplitude (Couper-Kuhlen 1986:6; Durrant and Lovrinic 1995:278). Fundamental frequency and pitch are thus distinct, though related, concepts.

In a linguistic context, fundamental frequency (and pitch) plays a primary role in distinguishing between the different tones of a language. However, linguistic tone is not limited to fundamental frequency (and pitch), as the term would have one believe, but may encompass other features as well, such as duration, amplitude, and phonation type. In some languages, these features demonstrate distinctive patternings as well, supplying secondary or even primary phonetic information for tonal discrimination (Whalen and Yi 1992; Ratliff 1992:12).

Rigorous acoustic research is needed to determine the roles of fundamental frequency and other features in discriminating between tones in various tonal languages. Researchers such as Tseng (1990) and Howie (1976) have investigated the acoustic basis of tonal categories, particularly for Mandarin and dialects of Mandarin, providing much-needed insights and an empirical basis for subsequent studies. Many questions into the complex acoustic correlates of tone remain, pending further empirical research, particularly in non-Mandarin languages.

The language of focus in the research presented here is a previously unresearched Hmongic variety of southern China which I refer to as Kaijue

Miao.[1] The Hmongic languages, hereafter referred to as Miao,[2] are noted for their large tone inventories, often exhibiting six to eight lexical tones (*Zhongyang Minzu Yanjiusuo* 1987:2-4). Within the Eastern Guizhou branch, the branch to which Kaijue Miao belongs, eight lexical tones are common. My analysis of Kaijue Miao confirmed the presence of an eight-tone system in this variety as well. Sets of eight words composed of identical segmental sequencing of consonant and vowel but which nevertheless expressed eight distinctive meanings were found (see below). These distinctive meanings corresponded to eight distinctive tones, demonstrating the presence of eight lexical tones.

While Kaijue Miao clearly has eight distinct lexical tones, they could be distinctive for a number of different reasons acoustically. The objective of this present research was to examine the acoustic signal of each of the eight tones of Kaijue Miao in order to determine the distinctive acoustic features which are correlated with each tone. Specific research questions were as follows:

1. What are the duration and fundamental frequency patterns of Kaijue Miao tones?
2. Are there eight distinct duration patterns associated with the eight tones of Kaijue Miao?
3. Are there eight distinct fundamental frequency patterns associated with the eight tones of Kaijue Miao?

Eight distinct fundamental frequency patterns emerged, associated with the eight tones. Eight distinct duration patterns were not found. This study therefore concluded that fundamental frequency, but not duration, serves as a primary acoustic correlate of the eight lexical tones of Kaijue Miao. Phonation type,[3] while relevant to Miao, was beyond the scope of this present study, as was amplitude and the combined contribution of some or all of these features.

## 2. Data and Methodology

Data for this research were collected in Guizhou, China in 1993. The speaker was a well-educated Miao man from Kaijue village who was employed in the provincial capital. Gathering data from multiple speakers was not possible.

Two minimal sets of words were recorded which demonstrate the eight tones of Kaijue Miao. Tone Set 1 is based on the segmental sequence [tɔ] whereas Tone Set 2 is based on [tʃuo]. Tone Set 1 in isolation as well as in a frame, with all its tonal variations, provided the basis for this analysis. Tone Set 2 supplemented the findings. For Tone Set 1, twelve tokens in isolation and nineteen in a frame were analyzed. For Tone Set 2, six tokens in isolation were analyzed.

Orthographic representation, category number, and shape representation follow conventions used by Chinese researchers of Miao. Orthographically, Miao tones are indicated by choice of word-final consonant. These consonants correlate with tone category numbers, which represent historical similarity between different Miao varieties but not actual shape. The actual shape of each tone in a given variety is represented schematically by the five-point time-pitch graph system developed by Chao (1968).

The tone shapes presented below are similar to those given for the Yanghao variety of Miao, the chosen standard for the Eastern Guizhou branch (Zhang and Xu 1989), with modifications made to capture the unique shapes of Kaijue Miao tones. Kaijue Miao's chief departure from the standard is a switch in the shapes of Tones 3 and 5 (Jing Ping Li, personal communication). In addition, Tone 4 is heard as a mid-low level rather than a low level and Tone 7 as a high-low fall rather than a high-mid fall. Whether the Kaijue Miao shapes of these latter two tones represent an actual linguistic departure from the standard or simply a difference in notation is not known. The basic shapes of Tones 1 and 6 in Kaijue Miao are somewhat unclear based on fundamental frequency patterns observed in the data (to be discussed later) as well as inherent difficulties in determining "basicness" (Chan 1986), They are thus marked with a question mark.

Tones 4, 6, 7, and 8 are accompanied by distinct phonation.

**TONE SET 1**

| | | | |
|---|---|---|---|
| Tone 1: ˧? | [tɔ] | dob[4] | 'girl's name' |
| Tone 2: ˥ | [tɔ] | dox | 'to be hunchbacked' |
| Tone 3: ˦ | [tɔ] | dod | 'to cut, to chop' |
| Tone 4: ˨ | [tɔ] | dol | 'to bump against' |
| Tone 5: ˧˥ | [tɔ] | dot | 'man's name' |
| Tone 6: ˩˧? | [tɔ] | dos | 'with' |
| Tone 7: ˥˩ | [tɔ] | dok | 'to take, hold, grasp' |
| Tone 8: ˧˩ | [tɔ] | dof | 'a small bench for one' |

**FRAME**

˥ ˧ ˥ ˧? ˨

[moŋ] [fʰɑɪ] __________ [tʃiɪ] [xʊ] [tʲʊ]

Mongx hfaid jiix hveb diel.

You translate become language Chinese.

Please translate __________ into Chinese.

**TONE SET 2**

| | | | |
|---|---|---|---|
| Tone 1: ˧? | [tʃuo] | job | 'to teach' |
| Tone 2: ˥ | [tʃuo] | jox | 'root' |
| Tone 3: ˧ | [tʃuo] | jod | 'back of the knee' |
| Tone 4: ˨ | [tʃuo] | jol | 'a treadle-operated tilt hammer for hulling rice' |
| Tone 5: ˧˦ | [tʃuo] | jot | 'tight' |
| Tone 6: ˩˧? | [tʃuo] | jos | 'to pry something open or raise something up, using a lever' |
| Tone 7: ˦˨ | [tʃuo] | jok | 'to tie, fasten' |
| Tone 8: ˧˩ | [tʃuo] | jof | 'twisted, misshapen' |

The voice data were recorded on a Sony WM-60 professional quality cassette tape recorder using a Crown PZM Sound Grabber microphone. The recordings were digitized using WaveLite digitizing software and analyzed on a Sun computer using Waves acoustic analysis software.

Waveforms and fundamental frequency ($F_0$) files were created for each tone and its tokens. Each token was then marked for the beginning and endpoints of the tone using the waveform and by listening to selected portions of the word. Fundamental frequency and duration measurements were collected, using a computer program developed for these purposes (Kibre 1996). The duration of each token was measured from the points marked and the average duration for each tone was determined. Fundamental frequency was measured by sampling every 5% along the length of the tone, beginning at 15% and ending at 85%. Percentage intervals rather than time intervals were used in the sampling of fundamental frequency values in order to control for duration variability, and sampling was limited to the 15% to 85% range of the length of the tone in order to control for consonant influence. Average fundamental frequency values for each point were determined and composite representations of each tone were created. Standard deviations for duration and fundamental frequency means were calculated, capturing the range of values between which 66.66% of the data fall.

## 3. Results

### 3.1 Duration

Upon examining the duration patterns of the eight tones of Kaijue Miao together with their standard deviation values, eight distinct duration patterns correlating with the eight tones did not emerge (Charts 1, 2, 3). Only Tone 8 could be clearly distinguished from every other tone on the basis of duration, as shown in Charts 1 and 2, but this distinction did not hold when placed in the frame (Chart 3). Tone 7 was marginally distinct from several tones other than Tone 8, but without consistency. Tones 1 – 6 were never distinguished from each other on the basis of duration. Note that the scale has been adjusted in Chart 3 to better represent the duration of the tones when in the frame, overall much shorter. Actual duration measurements for each tone may be found in the Appendix. Duration is measured in milliseconds (ms.), or thousandths of a second.

### 3.2 Fundamental Frequency

Fundamental frequency corresponds physiologically to the rate at which the vocal folds open and close, and is measured in cycles per second, or Hertz. Upon examining the fundamental frequency values with their standard deviations for the eight tones of Kaijue Miao, eight distinct patterns emerged which correspond to the eight tones. Fundamental frequency is thus a primary acoustic correlate in Kaijue Miao. These patterns distinguished between tones by creating tones of different shapes and of different ranges. Actual fundamental frequency measurements may be found in the Appendix.

DURATION PATTERNS IN ISOLATION (Tone Set 1)

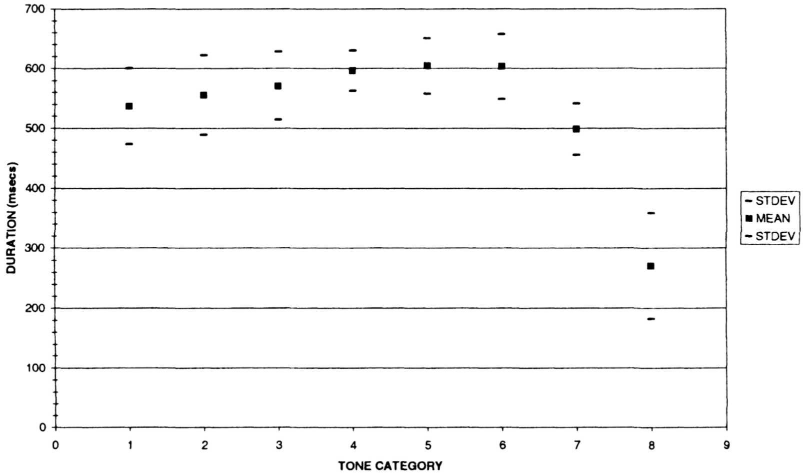


Chart 1. Plot of duration (on $y$ axis) as a function of tone category (on $x$ axis). Vertical bars denote ± 1 standard deviation.

*DURATION PATTERNS IN ISOLATION (Tone Set 2)*

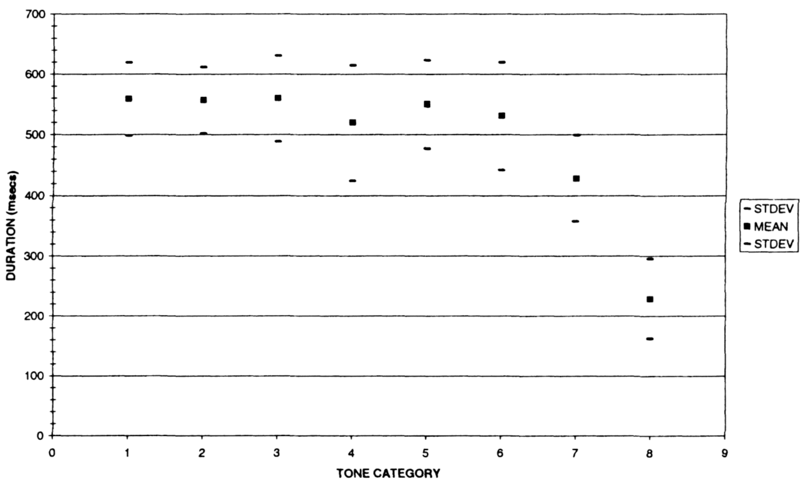


Chart 2. Plot of duration (on $y$ axis) as a function of tone category (on $x$ axis). Vertical bars denote ± 1 standard deviation.

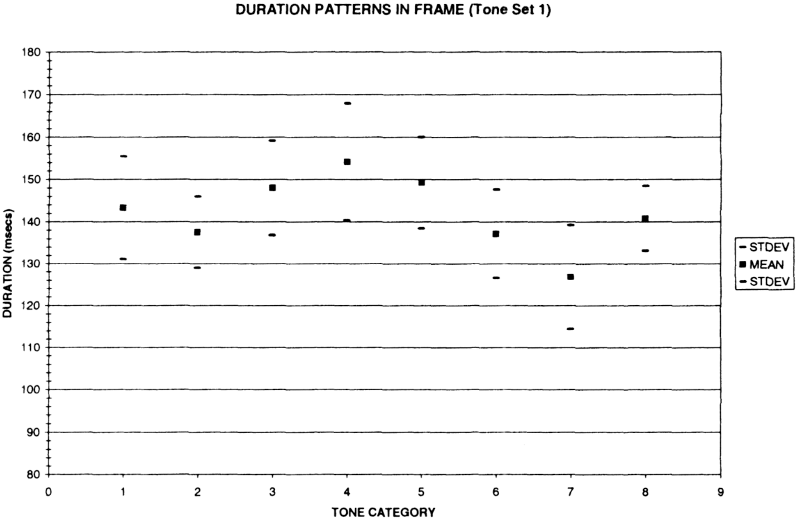


Chart 3. Plot of duration (on $y$ axis) as a function of tone category (on $x$ axis). Vertical bars denote ± 1 standard deviation.

The tones in isolation provide very straightforward evidence for the eight distinct fundamental frequency patterns. Beginning with the Tone Set 1 tones in isolation, we find that the level tones of Chart 4 are distinguished from the rising tones of Chart 5 as well as the falling tones of Chart 6 on the basis of shape (change in fundamental frequency or lack thereof over the course of the tone). Rising tones are similarly distinguished from the falling tones. Within each tonal shape, we find that each tone occupies its own unique fundamental frequency space and is thus distinguished from the other tones of the same shape. For example, in comparing the level tones, we find that the fundamental frequency of Tone 1 remains around 149 Hz., while Tone 2 has a typical fundamental frequency of around 195 Hz. Tone 3 remains around 168 Hz. and Tone 4 demonstrates a consistent fundamental frequency value of around 125 Hz. These fundamental frequency values and their standard deviations clearly distinguish these four tones of the same shape.

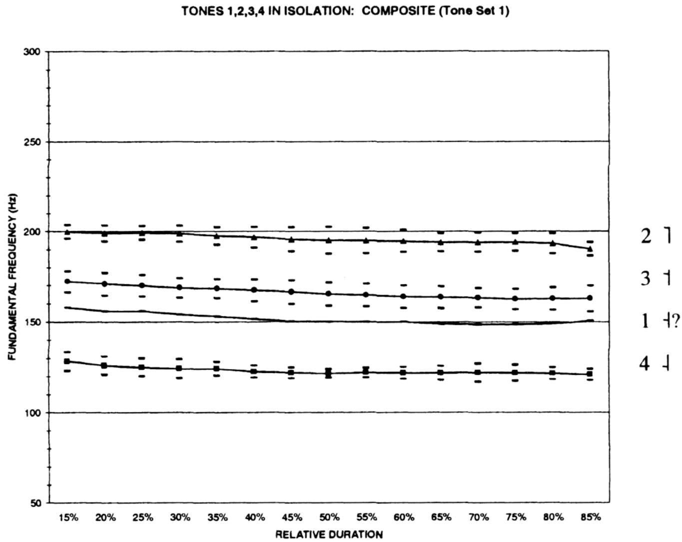


Chart 4. Plot of fundamental frequency (on *y* axis) as a function of relative duration (on *x* axis). The line curves correspond to the tone categories indicated on the right hand *y* axis.

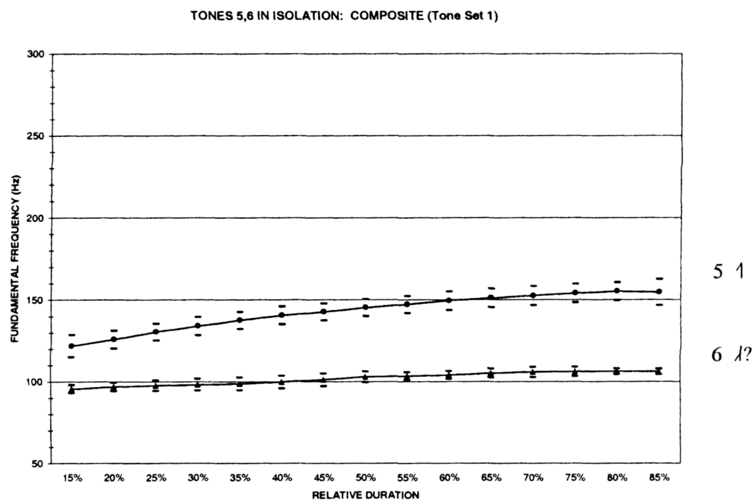


Chart 5. Plot of fundamental frequency (on *y* axis) as a function of relative duration (on *x* axis). The line curves correspond to the tone categories indicated on the right hand *y* axis.

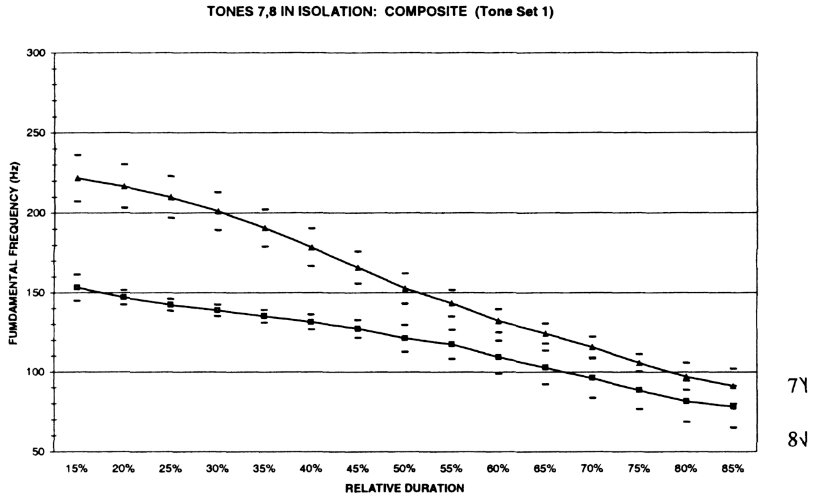


Chart 6. Plot of fundamental frequency (on *y* axis) as a function of relative duration (on *x* axis). The line curves correspond to the tone categories indicated on the right hand *y* axis.

Tone Set 2 tones (isolation) demonstrate similar patterning to those of Tone Set 1 tones in isolation (Charts 7, 8, and 9).

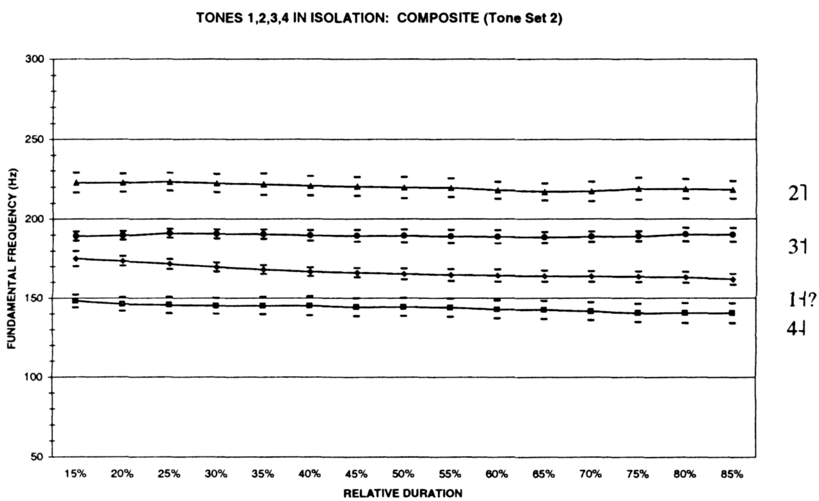


Chart 7. Plot of fundamental frequency (on *y* axis) as a function of relative duration (on *x* axis). The line curves correspond to the tone categories indicated on the right hand *y* axis.

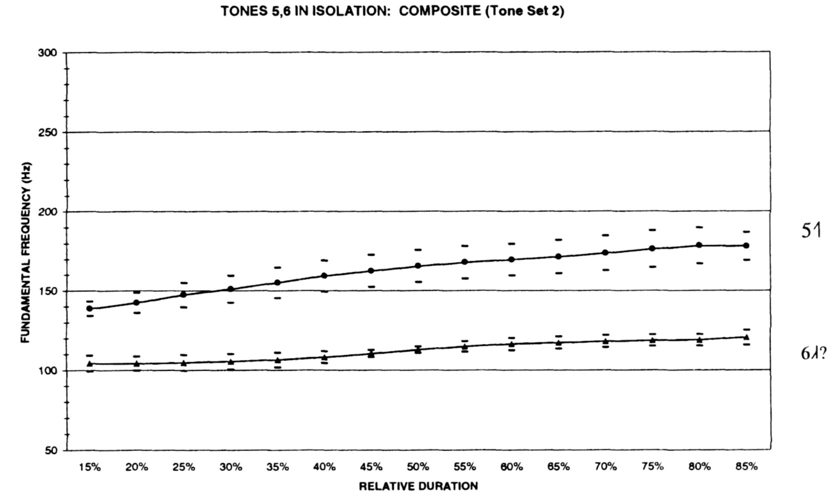


Chart 8. Plot of fundamental frequency (on $y$ axis) as a function of relative duration (on $x$ axis). The line curves correspond to the tone categories indicated on the right hand $y$ axis.

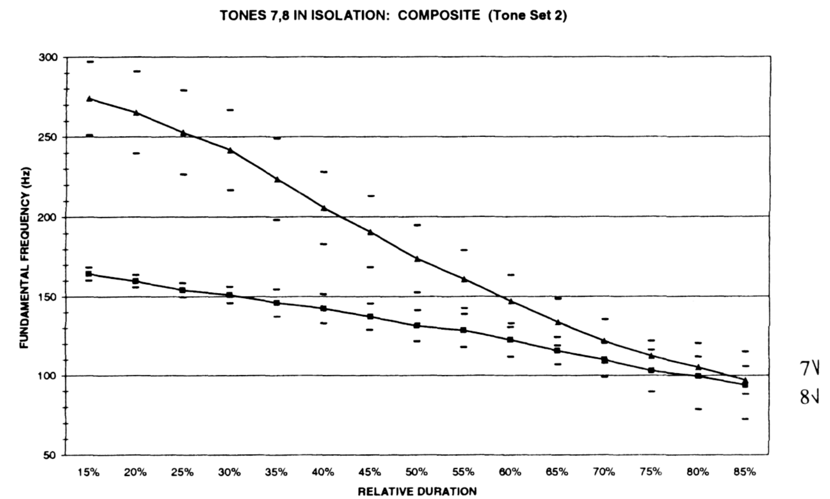


Chart 9. Plot of fundamental frequency (on $y$ axis) as a function of relative duration (on $x$ axis). The line curves correspond to the tone categories indicated on the right hand $y$ axis.

Tone Set 1 tones in the frame demonstrate again that eight distinct fundamental frequency patterns exist which correlate with the eight tones (Charts 10, 11, 12). Three tones warrant some brief comments. The uneven contour charted for Tone 7 on Chart 12 is due to an increase in glottalization on this tone when in the frame, making extraction of fundamental frequency values difficult. Tones 1 and 6 show variations in shape when in the frame. Tone 1, a level tone in isolation, drops by 39 Hz. in the frame (or 23 Hz. measured from 30% in, to further control for consonant influence). It is thus charted with the clear falling tones on Chart 12. Tone 6, a rising tone in isolation, rises only slightly in the frame (+5 Hz., starting 30% in), bringing into question its status as a rising tone. The increased perceptibility of small variations of fundamental frequency in the lower ranges (Durrant and Lovrinic 1995:270) may compensate for the slightness of the rise. It continues to be charted as a rising tone here. Regardless of choice of basic shape for Tones 1 and 6 and the factors which create the variations observed, these tones are still clearly distinct from all other tones on the basis of fundamental frequency.

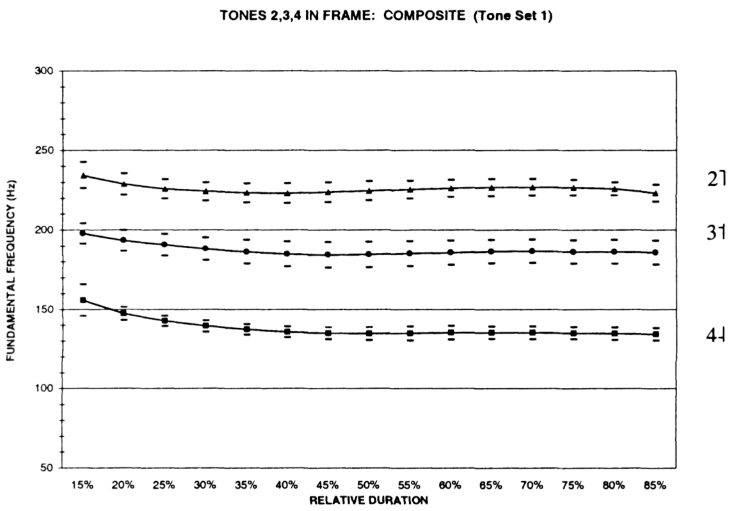


Chart 10. Plot of fundamental frequency (on $y$ axis) as a function of relative duration (on $x$ axis). The line curves correspond to the tone categories indicated on the right hand $y$ axis.

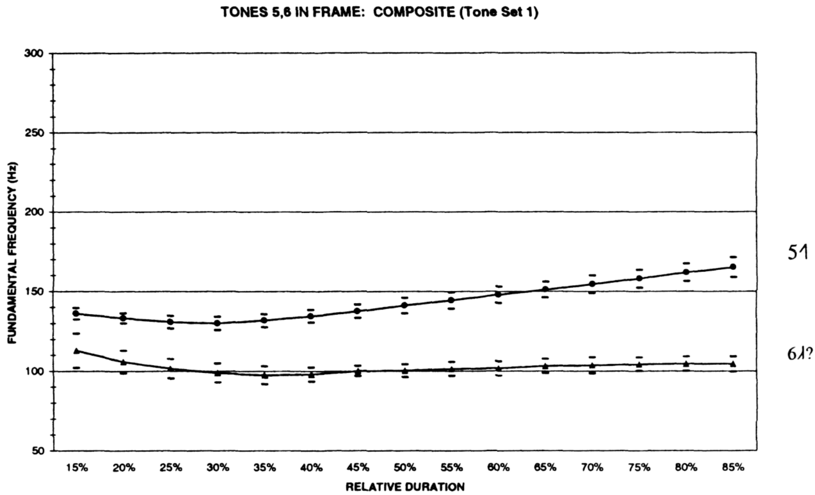


Chart 11. Plot of fundamental frequency (on *y* axis) as a function of relative duration (on *x* axis). The line curves correspond to the tone categories indicated on the right hand *y* axis.

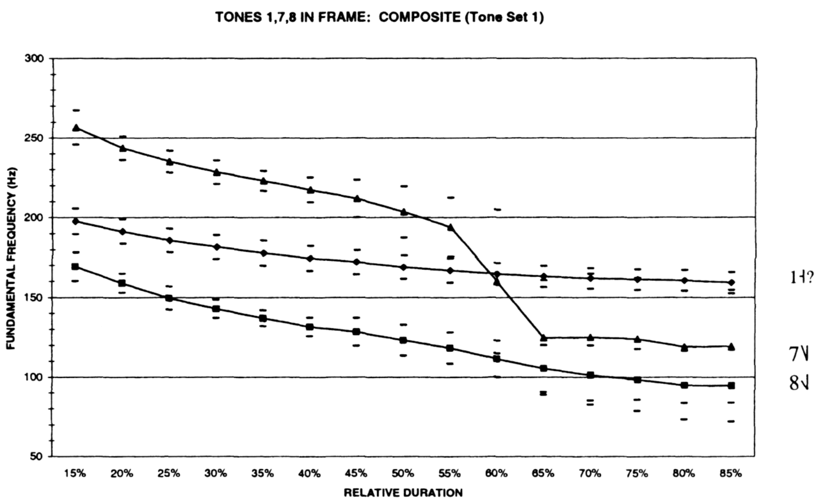


Chart 12. Plot of fundamental frequency (on *y* axis) as a function of relative duration (on *x* axis). The line curves correspond to the tone categories indicated on the right hand *y* axis.

# 4. Conclusions

This acoustic phonetic study of the eight tones of Kaijue Miao concluded that fundamental frequency but not duration is a primary acoustic correlate of tone in Kaijue Miao. Eight distinct fundamental frequency patterns were found which correlate to the eight tones. Eight distinct duration patterns were not found. Phonation type and amplitude, though relevant, were beyond the scope of this present study. Data from additional speakers of Kaijue Miao would serve to verify the conclusions of this research, presently a case study. While no claims can be made on the basis of this study regarding the roles of these acoustic features in the perception of tone, it seems highly plausible that they contribute significantly, given the correlation between the eight fundamental frequency patterns and the eight lexical tones.

In addition to contributing to our understanding of the acoustic phonetic basis of tone itself, studies such as this provide an empirical foundation for future in-depth investigations into the related areas of tone sandhi phenomenon, perception of tone, and the complex interactions between tone and other elements, such as segments, phonation types, and stress and intonation. Acoustic studies also have much to contribute to research into the typology of tonal systems, cross-dialectal comparisons, historical reconstruction, and theories of language change. Finally, as Asian tonal systems are less understood than their African counterparts, studies such as this which focus on Asian tone make a unique contribution to our understanding of tonal phenomenon.

## Notes

*Very special thanks to Mr. Li Jing Ping, my Miao language consultant, for his kind and able assistance, and to Guizhou University for providing opportunity for this research. I am also greatly indebted to my thesis advisor H.S. Gopal for his valuable guidance throughout this research project, to Stuart Milliken for his inspiration and assistance in initially formulating the research, and to my committee members Sandra Thompson and Carol Genetti, whose encouragement and input have been most valuable. I cannot thank Nicholas Kibre enough for his kindness in developing the software needed for this project, and for contributing, along with Simon Corston and others, the computer expertise and patient ongoing assistance that made this research possible. All shortcomings remain my responsibility.

[1]Hmong forms part of the Hmong-Mien (Miao-Yao) language family and is comprised of three main branches: Eastern Guizhou, Western Hunan, and

Sichuan-Guizhou-Yunnan, the latter encompassing varieties spoken outside China. Kaijue Miao (my term) forms part of Eastern Guizhou branch, Northern subdivision. It is spoken in Kaijue village, Xijiang Zhen, Leishan County, SE Guizhou Miao-Dong Autonomous Prefecture, Guizhou Province, P.R. China. Given the great diversity of Miao, even within linguistic subdivisions where substantial variation may not yet be reflected in designation, I have chosen to refer to this Miao variety by its village name, Kaijue, in order to uniquely identify and locate it.

[2]As I research varieties spoken in China, working alongside Chinese linguists, I have chosen to use the Chinese designation "Miao" rather than "Hmong," the preferred term outside China, though I certainly appreciate the reasons for the use of the designation "Hmong."

[3]Laryngeal features, such as "breathy" and "creaky" voice.

[4]Orthography in this paper is based on the standard system developed for the Eastern Guizhou branch of Miao, with slight modifications appropriate to Kaijue Miao phonology.

## Appendix

1. Mean Duration (in milliseconds)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | ˧? | ˥ | ˦ | ˨ | ˧˥ | ˩˧? | ˥˩ | ˧˩ |
| Iso (Set 1) | 537 | 555 | 571 | 596 | 604 | 603 | 498 | 271 |
| Iso (Set 2) | 559 | 557 | 560 | 520 | 550 | 531 | 428 | 229 |
| Frame (Set 1) | 143 | 137 | 148 | 154 | 149 | 137 | 127 | 141 |

2. Mean Fundamental Frequencies (in Hertz)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | ˧? | ˥ | ˦ | ˨ | ˧˥ | ˩˧? | ˥˩ | ˧˩ |
| Iso (Set 1) | | | | | | | | |
| 15% | 153 | 200 | 172 | 128 | 122 | 96 | 222 | 153 |
| 85% | 145 | 190 | 163 | 121 | 155 | 106 | 91 | 78 |
| Change | -8 | -10 | -9 | -7 | +33 | +10 | -131 | -75 |
| Iso (Set 2) | | | | | | | | |
| 15% | 175 | 223 | 189 | 148 | 139 | 104 | 274 | 164 |
| 85% | 162 | 218 | 190 | 140 | 178 | 121 | 97 | 94 |
| Change | -13 | -5 | +1 | -8 | +39 | +17 | -177 | -70 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frame (Set 1) | | | | | | | | |
| 15% | 198 | 234 | 198 | 156 | 136 | 113 | 257 | 169 |
| 85% | 159 | 223 | 186 | 134 | 165 | 104 | 119 | 95 |
| Change | -39 | -11 | -12 | -22 | +29 | -9 | –138 | -74 |
| | | | | | | | | |
| 30% | 182 | | | 139 | | | 99 | |
| Change from 30% | -23 | | | -5 | | | +5 | |

## References


Chan, Marjorie K.M. 1986. On the status of "basic" tones. University of California working papers in phonetics 63.71-94.

Chao, Yuan-Ren. 1968. A grammar of spoken Chinese. Berkeley: University of California Press.

Couper-Kuhlen, Elizabeth. 1986. An introduction to English prosody. Forschung and Studium Anglistik 1. Tubingen: M. Neimeyer.

Durrant, John and Jean Lovrinic. 1984. Bases of hearing science, 2nd ed. Baltimore: Williams and Wilkins.

Howie, John. 1976. Acoustical studies of Mandarin vowels and tones. Cambridge: Cambridge University Press.

Kibre, Nicholas. 1996. In-house computer program for management of fundamental frequency and duration. University of California at Santa Barbara.

Ratliff, Martha. 1992. Meaningful tone: a study of tonal morphology in compounds, form classes, and expressive phrases in White Hmong. Northern Illinois University Center for Southeast Asian Studies, Monograph Series on Southeast Asia, Special Report No. 27.

Rose, Philip John. 1988. On the non-equivalence of fundamental frequency and pitch in tonal description. Prosodic analysis and Asian linguistics: to honour R.K. Sprigg, ed by D. Bradley, E. Henderson, and M. Mazaudon, 55-82. Pacific Linguistics C-104.

Shen, Xiao Nan. 1990. The prosody of Mandarin Chinese. Berkeley: University of California Press.

Shih, Chilin. 1988. Tone and intonation in Mandarin. Cornell phonetics lab working papers 3.83-109.

Tseng, Chiu-yu. 1990. An acoustic phonetic study on tones in Mandarin Chinese. Institute of History & Philology Academia Sinica, Special Publications No. 94. Taipei.

Wang, Fushi (ed.) 1985. *Miaoyu Jianzhi* [A sketch of the Miao language]. *Zhongguo Xiaoshu Minzu Yuyan Jianzhi Congshu* [Brief Account of the Languages of China's Minority Nationalities Series]. Beijing: Minzu Chubanshe [Nationalities Publishing House].

Whalen, Douglas, and Yi Xu. 1992. Information for Mandarin tones in the amplitude contour and in brief segments. Phonetica 49.1-23.

Xu, Yi. 1994. Production and perception of coarticulated tones. Journal of the acoustical society of America 95.2240-2253.

________. 1997. Contextual tonal variations in Mandarin. Journal of phonetics 25.61-83.

Zhang, Yong Xiang and Shi Ren Xu (eds.) 1989. *Hmub Diel Cif Dieex, Hveb Qeef Dongb. Miao-Han Cidian, Qiandong Yuyan* [Miao-Han Dictionary, Eastern Guizhou]. Guiyang, Guizhou: Guizhou Minzu Chubanshe [Guizhou Nationalities Publishing House].

Zhongyang Minzu Xueyuan Miaoyaoyu Yanjiusuo [Miao-Yao Language Research Institute of the Central Institute of Nationalities]. 1987. *Miaoyaoyu Fangyan Cihuiji* [Miao-Yao Dialect Glossary]. Beijing: Zhongyang Minzu Xueyuan Chubanshe [Central Institute of Nationalities Publishing House]