

# AN ACOUSTIC STUDY OF VOWELS IN NORTHERN LISU

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## ABSTRACT

This study provides a formant analysis of the ten monophthongal vowels /i, y, e, ø, ε, ʊ, u, ʌ, o, a/, of Northern Lisu, a Tibeto-Burman language spoken around the borders of China, Myanmar and India. Word-list recordings were made of 8 native speakers from Yunnan province in China (4 female and 4 male). Results show differences in vowel realization between the male and female speakers, with female speakers and not male speakers merging the contrast between /e/ and /ø/. However, both sets of speakers show evidence of merger between /u/ and /y/, and /ʊ/ and /ʌ/. This study provides evidence for the instability of the secondary cardinal vowels in a complex monophthongal vowel space.

**Keywords:** Acoustic phonetics, Tibeto-Burman languages, Northern Lisu, vowels.

## 1. INTRODUCTION

Lisu is a Tibeto-Burman language, spoken in North-east India, Northern Myanmar, Southwest China, and Thailand [8]. The main dialects of Lisu are Northern, Central, and Southern, and it is related to the languages Lahu, Jingphaw, and Yi [3].

Northern Lisu is spoken in and around the Nujiang Lisu Autonomous Prefecture, in Western/Northwestern Yunnan Province, China [2]. Maximally, the Lisu vowel system has ten monophthongal vowels /i, y, e, ø, ε, ʊ, u, ʌ, o, a/, in Central Lisu [3][6]. Northern Lisu displays merging of the front rounded vowels with others; /y/ > /u/ and /ø/ > /e/, while the distinction between /ʊ/ and /ʌ/ is marginal in this variety [3].

This study presents an acoustic phonetic analysis of the vowel space of Northern Lisu. The front rounded vowels have been treated as separate in the analysis, to see to what degree this merger is present.

## 2. METHOD

### 2.1. Data Collection

Data were collected from eight participants (4 female and 4 male) in Kunming, the capital of Yunnan Province in China. All participants were native speakers of Northern Lisu, from Nujiang Lisu Autonomous Prefecture. They were all university educated, living and studying in Kunming, and aged between 20 and 22 years.

Recordings were made in a quiet room, using an H4n Zoom with a sampling rate of 48kHz, with one exception where the battery had run low and the Zoom auto-lowered the sampling rate to 44.1kHz. Participants were asked to give three repetitions of each word in a list obtained from the Dictionary of the Northern Dialect of Lisu [2]. Due to participants occasionally producing either more or fewer repetitions of a target word than was requested, in total 920 vowel tokens were analysed for this study.

### 2.2. Segmentation and Analysis

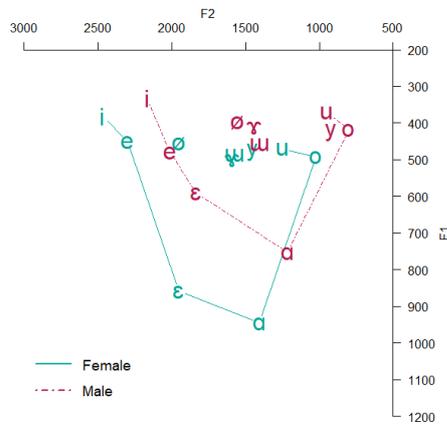
The recordings were manually segmented and labelled using Praat [1].

Using the emuR package [7] in R [5], formant values were extracted at vowel midpoints and then plotted with the phonR package [4]. Outliers, such as where a formant was listed as 0Hz, were double-checked manually and corrected using Praat, where this was required.

## 3. RESULTS

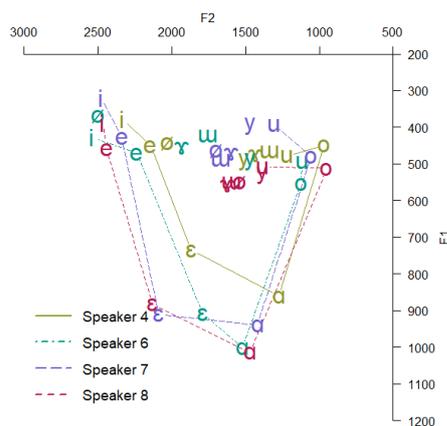
Figure 1 shows the average female and average male speakers on the one plot. However, the shapes and relative locations of each vowel in the space is generally similar. One point to note, here is the relative lowering of /ε/ for female speakers. A similar phenomenon can be seen for female speakers of Central Lisu [6].

**Figure 1:** Northern Lisu vowel spaces for males and females



Figures 2 and 3 show the vowel spaces of female and male speakers of Northern Lisu.

**Figure 2:** Northern Lisu vowel space for female speakers



As can be seen in figure 2, the vowel /e/ is lower and further back in the vowel space than /i/, for all speakers. Its rounded counterpart, /ø/, however, doesn't always pattern with /e/. For speaker four, /ø/ is produced very near to /e/. Speaker six produces /ø/ higher than both /i/ and /e/. For the other two speakers, seven and eight, /ø/ is produced more centrally, patterning near to /ɜ/ and /u/.

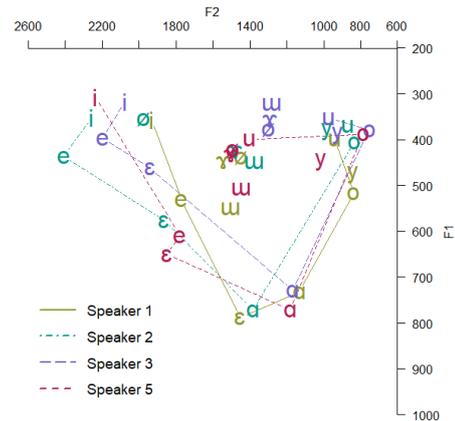
The vowels /ɛ/ and /a/ are both noticeably lower than /e/, with /a/ lower again and further back in the vowel space.

The vowel, /o/ is much higher in the vowel space than /a/, clustering just below and slightly further back in the vowel space where most speakers' productions of /u/ sits.

The vowel, /y/ sits back in the vowel space, for all of the female participants. However, it appears to be produced slightly further forward than /u/.

The vowels /ɜ/ and /u/ are both produced quite centrally. Additionally, speakers four, seven, and eight produce both these vowels in very similar areas, while speaker six separates the two only slightly.

**Figure 3:** Northern Lisu vowel space for male speakers



The vowel spaces for the male participants is similar to the females' vowel spaces. For all speakers, /i/ is higher than /e/. The vowel /ø/ is quite central for most male speakers, except for speaker five, who produces it further forward in his vowel space, but still back from his production of /e/.

Both the vowels, /ɛ/ and /a/ are noticeably lower than /e/, for speakers one and five. However, speakers two and, in particular, three, produce an /ɛ/ which is closer to their production of /e/. All male speakers produce an /a/ which is further back in their vowel space than their /ɛ/. And, while most speakers produce /a/ lower than /ɛ/, speaker one's /ɛ/ is the lower of the two.

The vowel, /o/ is higher and further back in the vowel space than /a/, for all speakers. And it is a little lower and further back than all male speakers' productions of /u/.

As with the female speakers, /y/, sits further back in the vowel space than /i/, with all male speakers producing this vowel very similarly to /u/. However, speaker one produces this vowel slightly closer to /o/ than /u/.

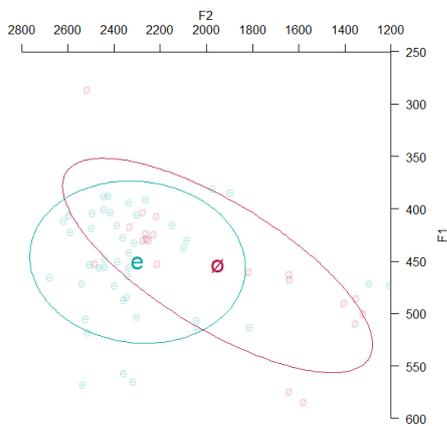
The vowel /ɜ/ is produced quite centrally for all speakers, with speaker three producing this vowel slightly further back and higher than the other three male speakers. However, unlike the female speakers, the close, back, unrounded vowel, /u/ doesn't

pattern for the male speakers as closely to /ɤ/. The location of this vowel for each speaker is fairly central in a front/back sense, but varies in height, with speaker three producing this vowel almost as high as his /i/, speaker two producing a lower /ɤ/ than speaker three, and speaker five lower than speaker two, with, finally, speaker one producing /ɤ/ lowest of the four male participants.

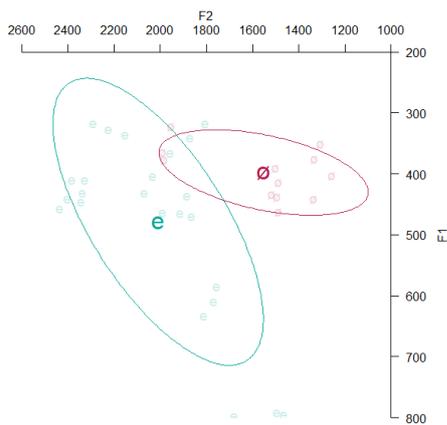
### 3.1. Vowel Mergers

Figures 4 and 5 display the ellipse plots of participants' productions of /e/ and /ø/.

**Figure 4:** Ellipse plot of female Lisu speakers' production of /e/ and /ø/



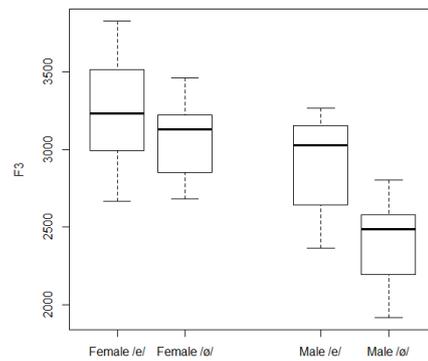
**Figure 5:** Ellipse plot of male Lisu speakers' production of /e/ and /ø/



It is clear that, despite the apparent distance between these two vowels for female speakers in figure 1, there is a large degree of overlap for these vowels in the F1/F2 plane. Meanwhile, Male production of /ø/ is comparatively retracted in the vowel space

from /e/. However, to get a fuller picture of the similarity of these two vowels, we must also consider F3, as this correlates to degree of lip rounding, and that is the typical difference between vowels /e/ and /ø/.

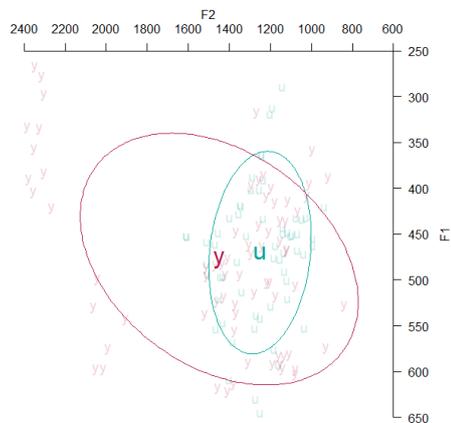
**Figure 6:** Box plot of F3 values of Lisu speakers' production of /e/ and /ø/



It can be seen in figure 6 that the F3 for these vowels has a high degree of similarity for female speakers. The male speakers, however, appear to differentiate /e/ and /ø/ in both the F1/F2 plane and in F3. Male production of /ø/ is comparatively retracted in the vowel space from /e/, and displays lower F3 values, which may be expected to correlate with lip rounding.

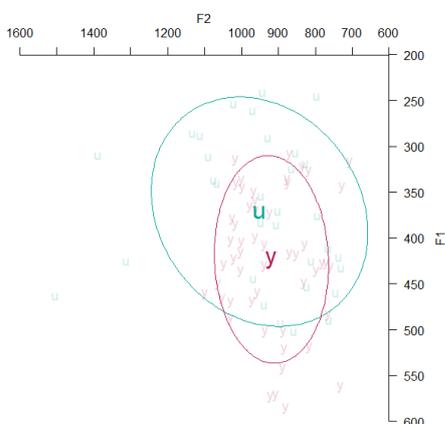
Figures 7 and 8 are the ellipse plots of participants' production of /y/ and /u/.

**Figure 7:** Ellipse plot of female Lisu speakers' production of /y/ and /u/



As these plots show, there is a large degree of overlap in production of /y/ and /u/, for both male

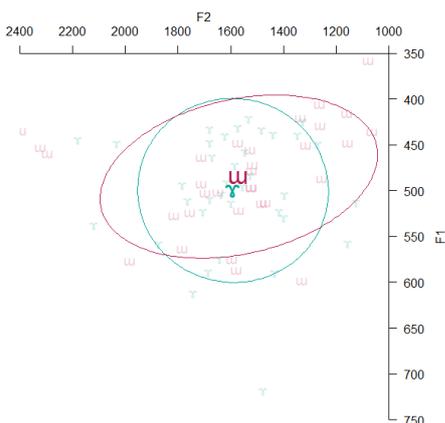
**Figure 8:** Ellipse plot of male Northern Lisu speakers' production of /y/ and /u/



and female speakers of Northern Lisu. F3 values for these vowels display little difference for both female and male speakers. The mean F3 for female speakers' /u/ is 2,767Hz with a standard deviation of 224.5Hz and for /y/ is 2,851Hz with a standard deviation of 196.9Hz. The mean F3 for male speakers' /u/ is 2,483Hz with a standard deviation of 184.1Hz and for /y/ is 2,517Hz with a standard deviation of 269.3Hz.

Figures 9 and 10 are the ellipse plots of participants' productions of /u/ and /ɤ/.

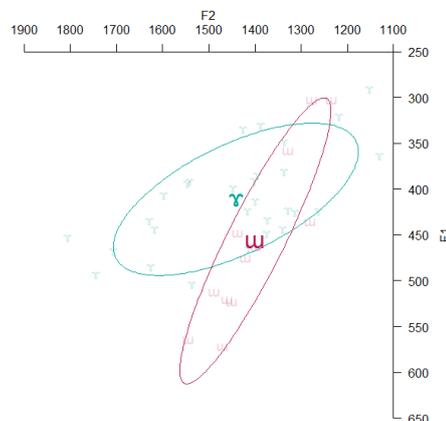
**Figure 9:** Ellipse plot of female Northern Lisu speakers' production of /u/ and /ɤ/



It is clear from figure 9 that there is very little difference in production of /u/ and /ɤ/ for all female participants involved in this study. F3 measurements for female speakers also show little difference in lip-rounding between the two vowels. The mean F3 for /ɤ/ is 2,879Hz with a standard deviation of 186.7Hz,

while the mean F3 for /u/ is 2,880Hz with a standard deviation of 136.7Hz.

**Figure 10:** Ellipse plot of male Northern Lisu speakers' production of /u/ and /ɤ/



As can be seen by figure 10, there is some overlap in the production of these two vowels. However, it is not as great as the female speakers' production. F3 measurements for male speakers show little difference in lip-rounding between the two vowels. The mean F3 for /ɤ/ is 2,441Hz with a standard deviation of 265.1Hz, while the mean F3 for /u/ is 2,486Hz with a standard deviation of 231.5Hz.

#### 4. CONCLUSION

The acoustic properties of the vowel spaces for male and female Northern Lisu speakers have been presented. Plots displaying the degree of overlap in the vowels /e/ and /ø/ indicate that this merger is very nearly complete for female speakers, but male speakers appear to still maintain a distinction on these two vowels. Plots displaying the degree of overlap in the vowels /y/ and /u/ indicate that this merger appears to be complete for both female and male speakers, though there are some outliers in /y/ production for female speakers. Finally, plots displaying /u/ and /ɤ/ indicate that this marginal distinction described in [3] appears to be merging for female speakers, while male speakers appear to maintain a marginal distinction. However, perceptual research is needed in order to better understand the extent.

#### 5. ACKNOWLEDGEMENTS

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