Introduction

Bora is a Witotoan language spoken by about 750 people in the Amazon jungle of Peru and 100 in Colombia. It appears to have a contrast between central and back high unrounded vowels /i/ and /u/ (Thiesen and Weber 2012). A three-way backness contrast would challenge phonological models that limit vowel systems to two degrees of backness (e.g., Duano 2016). We investigate lip positions for these vowels and conclude that Bora /i/ and /u/ are not distinguished by rounding, but that /i/ involves lingual-dental contact. Several productive morphophonemic alterations and phonotactic constraints (vowel harmony and consonant palatalization) confirm the phonological classification of /i/ u/ as front, central, and back, respectively.

Figure 1: Scatterplot of mean F1 and F2 frequencies (in Hz) for 6 female speakers (error bars indicate 95% confidence intervals). (Parker 2003)

Phonetic study of /i/ and /u/ in Bora

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Bora is a Witotoan language spoken by about 750 people in the Amazon jungle of Peru and 100 in Colombia. It appears to have a contrast between central and back high unrounded vowels /i/ and /u/ (Thiesen and Weber 2012). A three-way backness contrast would challenge phonological models that limit vowel systems to two degrees of backness (e.g., Duano 2016). We investigate lip positions for these vowels and conclude that Bora /i/ and /u/ are not distinguished by rounding, but that /i/ involves lingual-dental contact. Several productive morphophonemic alterations and phonotactic constraints (vowel harmony and consonant palatalization) confirm the phonological classification of /i/ u/ as front, central, and back, respectively.

There are two back vowels /a/ and /o/ which are not distinguished by rounding, but that /i/ and /u/ are consistently different in the vertical lip dimension but not the horizontal lip dimension, consistent with a jaw height difference. /i/ is regularly produced with lingual-dental contact.

Data analysis

Audio was segmented at the word and phone levels using a modified Penn Phonetics Lab Forced Aligner (Yuan and Liberman 2008) and hand-corrected in Praat (Boersma and Weenink 2007).

Vowel formant frequencies were measured using Praat.

Video frames during vowel intervals were extracted using avconv and analyzed in R.

Vertical and horizontal lip distances were measured from dot locations and normalized.

Tongue/teeth contact in all vowels was visually coded.

Multitaper spectra from the middle 50% of vowels were analyzed in order to explore differences related to lingual/dental contact.

Acoustic results

/i/ has slightly higher F2 and F3 than /u/, as previously observed by Parker (2001).

/i/ and /u/ also have more prominent formant peaks than /u/.

Figure 2: Scatterplot of mean F1 and F2 frequencies (in Hz) for 6 female speakers (error bars indicate 95% confidence intervals). (Parker 2003)

Figure 3: Representative images for a female speaker. From top left: /apă/, /ts/ab/, /ts/ah/, /apă/le/, /ts/ah/ka/opa/, /ts/ah/ko/opa/, showing lingual/dental contact in [e] and raised jaw for [u].

Articulatory results

/u/ is not rounded. The only consistent difference involving the horizontal lip dimension is between /o/ and all other vowels. /i/ and /u/ are consistently different in the vertical lip dimension but not the horizontal lip dimension, consistent with a jaw height difference. /i/ is regularly produced with lingual-dental contact.

Discussion and Conclusions

All three Bora high vowels are unrounded. /i/ and /u/ are produced with measurably different lip positions, and this appears to be associated with jaw height and lingual/dental contact. /o/ is the only rounded vowel in Bora.

The tongue regularly contacts the upper and lower teeth in /i/ and at least the lower teeth in /i/ and /u/ is produced with the teeth together.

/i/ has higher F2 and F3 than /u/. In addition, /i/ has more prominent formants than /u/. Prominent formants in /i/ and /u/ may be related to the lack of a front cleft in these vowels.

Figure 4: F1 and F2 frequencies at vowel midpoint. Left: a female speaker. Right: medians for all ten speakers, showing a consistent but small F2 difference between /i/ and /u/.

Figure 5: F2 and F3 frequencies at vowel midpoint. Left: a female speaker. Right: medians for all ten speakers.

Figure 6: Left: averaged multitaper spectra for a female speaker, showing more prominent formant peaks for /i/ than /u/. Right: speaker medians for two measures of formant prominence, showing that /i/ and /u/ (and sometimes /o/) have more prominent and/or narrower formants than the other vowels.

Figure 7: Left: normalized vertical and horizontal lip dot distances for a female speaker, showing vertical lip difference between /i/ and /u/. Right: medians for all speakers.

Figure 8: Lingual-dental contact visual coding based on video frames for speakers with appropriate vertical approximations.

Acknowledgments

Data analysis for this project was supported by the NSC41 College of Humanities and Social Sciences.

Bibliography


