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 only two degrees of backness (e.g., Duannu 2016). We investigate position in Bora vowels using video data.

Data collection

- We are analyzing audio/video recordings of 10 native Bora speakers (5 females and 5 males) collected in Bora villages in 2011.
- Four brightly colored dots were placed on each speaker’s lips, forming a diamond (Figure 3)
- 13 Bora words were elicited, including some minimal pairs (Figure 2). Each item was pronounced five times by each speaker, embedded in the frame /'i:_ /Say __/.

Table 1: The vowel inventory of Bora (Thiesen and Weber 2012)

<table>
<thead>
<tr>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>/i/</td>
<td>/u/</td>
</tr>
<tr>
<td>High open</td>
<td>/ɪ/</td>
<td>/ʌ/</td>
</tr>
<tr>
<td>Mid open</td>
<td>/ɪ/</td>
<td>/ʌ/</td>
</tr>
<tr>
<td>Low</td>
<td>/ɪ/</td>
<td>/ʌ/</td>
</tr>
</tbody>
</table>

| ts’aa-hu/ | ‘one’ (noun classifier) |
| ts’aa-hi/ | ‘one’ (etc.) |
| ts’aa-mu/ | ‘one’ |
| ts’aa-mi/ | ‘one’ |
| ts’aa-hi/k’opa/ | ‘one large’ |
| ts’aa-hi/ɪk’opa/ | ‘one large’ |
| u/k’u/ | ‘to get, obtain’ |
| ih/k’u/ | ‘species of bird (icterus chryscephalus)’ |

Table 2: Sample minimal pairs involving /i/ and /u/.

Data analysis

- Audio was segmented and 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 avascov and analyzed in R.
- We focus on vertical lip constriction (the distance between the ‘N’ and ‘S’ dots in Figure 3) and horizontal lip dimension (the distance between ‘W’ and ‘E’). All distances were normalized by speaker.

Results

- We observe the F2 difference between /i/ and /u/ previously observed by Parker (2001) (Figures 4, 7).
- The only consistent difference involving the horizontal lip dimension is between /i/ and all other vowels (Figures 5-7).
- /i/ and /u/ are consistently different in the vertical lip dimension but not the horizontal lip dimension (Figures 5-7).

Discussion and conclusions

- Bora /i/ and /u/ are produced with measurably different lip positions, in the vertical dimension, distinct from the rounding that is observed in /a/.
- The vertical lip difference between /i/ and /u/ is comparable to the vertical lip difference between /a/ and /i/ and it appears to correlate with jaw height.
- Linguistic data would be informative. Without information about tongue position, it is hard to know whether the observed lip jaw difference between /i/ and /u/ is the primary articulatory correlate of the phonological contrast, (2) a way of enhancing a lingual difference by changing the size of the lip opening, or (3) a way of facilitating a lingual difference by changing the height of the jaw.

Figures

- Figure 1: Scatterplot of F1 and F2 frequencies (in Hz) for 6 female speakers [error bars indicate 95% confidence intervals] (Parker 2001)
- Figure 2: A map showing where Bora is spoken in Peru (Lewis et al. 2015).
- Figure 3: The four yellow dots are identified from pixel color values
- Figure 4: F1-F2 plots for one female speaker (left) and one male speaker
- Figure 5: Vertical and horizontal lip dot distance for the same female speaker (left) and the same male speaker. More negative values indicate more lip constriction.
- Figure 6: Representative lip/jaw positions for another pair of speakers. Top row: /ɪ’aa-hi/ɪk’opa/, /ɪ’aa-hi/, /ɪ’aa-hu/, and /ɪ’aa-hi/ɪk’opa/; Bottom row: /ɪ’aa-ha/ɪk’opa/, /ɪ’aa-ha/, /ɪ’aa-hu/, and /ɪ’aa-ha/ɪk’opa/.
- Figure 7: Speaker medians. Lines connect each speaker’s /i/ and /u/.

Bibliography

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Acknowledgments

The project for this paper has been supported by the NC State College of Humanities and Social Sciences.

Acoustics 17 Boston, June 26, 2017