Bull or bowl?
A production study of prelateral back vowel mergers in Pacific Northwest English

Rob Squizzero
University of Washington
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Background

- Wassink (2015, 2016) published detailed results of linguistic variants characteristic of the Pacific Northwest
  - Discussion of high back vowels fronting, but no discussion of back vowels preceding /l/
- McLarty, Kendall & Farrington (2016) treated /ul/ and /ol/ separately in their study of Oregon vowels
- Stanley (2017) reported merger between /ol/ and /ul/ at 25% through the vowel in F1 x F2 space in Cowlitz County, WA
  - Did not compare prelateral /ol/ and /ul/ to vowels in other environments
  - Did not include an analysis of low-level phonetic cues
- DiPaolo & Faber (1990) found that pairs of Utah tense/lax prelateral pairs, such as FOOL/FULL, were distinguished acoustically by differences in phonation
Background: Perceptual Study

- Squizzeraro (2009) identified potential mergers of /ol/ and /ʊl/
- Cross Dialectal Comprehension (CDC) style perception study (Ash, 1988)
  - Subjects listen to a word in isolation, write down what they think they hear
  - Subjects then listen to the same word in the context of the sentence in which it originally appeared and again write what they think they hear
Background: Vowel Deletion

- Stimuli vowels spoken by the speaker (born between 1900-1950) showed near-merger in F1 and F2 at midpoints
- Stimuli vowels spoken by another speaker (born between 1951-1975) showed F1 and F2 merger at midpoint, but there was evidence of a difference in intensity contours
- Spectrograms show acoustic correlates of syllabic /l/ and not /l/-vocalization

Waveform and Spectrogram of the “bowl” stimulus you just heard
Goals of the present study

- Preliminary investigation intended to clarify time-varying vowel quality, intensity, and duration of /ol/ and /ul/
  - H10: Formant trajectories of /ol/ and /ul/ will not be significantly different (Stanley, 2017)
  - H1a: Formant trajectories of /ol/ and /ul/ will indicate differences in F1 and/or F2
  - H20: Intensity does not distinguish these vowel classes
  - H2a: BOWL class items show two intensity peaks, one in each half of the vocoid, while BULL class items show a single peak in the first half (Squizzero, 2009)
  - H30: Duration does not distinguish these classes; the underlying vowels have been deleted (Squizzero, 2009)
  - H3a: BOWL class items show a longer duration than BULL class items
  - H3b: BULL class items show a longer duration than BOWL class items

- Is this a change in progress? Is this sensitive to sociolinguistic style shifting?
Methods: Speakers

- 10 native Seattleites
- 5 males, 5 females
- 3 females born before 1950 (generation 1)
- All other speakers born between 1951-1975 (generation 2)
- 7 Caucasians, 2 African-Americans, 1 Japanese-American
  - Ethnicity not expected to play a role based on stimuli from the perception experiment
Methods

- Data source: Pacific Northwest English Study (Wassink, 2016)
- Word list: 4 prelaterals, 4 precoronals, 3 repetitions (n=24)
  - Subjects read words in the frame “Write ____ today”
- Semantic differential test: 3 prelaterals, 2 repetitions
Analysis

- Comparing a vowel + lateral to a vowel before a consonant
  - Auditory impression: no clear difference in vowel quality between nominal “vowel portion” and “lateral portion” of the vocoids (n=190)
  - Proportional measurement will indicate possible change in formants or intensity

- Proportional Measurement (Koops, 2010, Risdal & Kohn, 2014)
  - Vowel/vocoid onsets and offsets hand-marked
  - First and second formants and intensity measured at 101 points along the vowel for /o/ and /ʊ/ and the vocoid for /ol/ and /ul/
Analysis: spectrograms characteristic of /ʊl/ and /ol/

- No acoustic correlates of a ”clear” final /l/ - these appear dark, or velarized
- Similar, but not identical formant values
  - F1 difference of 42 Hz, F2 difference of 170 Hz
  - Difference in duration: bull 182ms vs. bowl 244ms (bull 74.5% of bowl)
Analysis

- Normalized measures
  - F1 and F2 Lobanov normalized
  - Within-speaker durations z-score normalized

- Excluded African American speakers from interspeaker analyses due to noticeably different formant trajectory patterns

- Included Japanese American speaker
  - Japanese Americans leading in Washington sound changes (Wassink, 2016)
Results – vowel 25% points

/ʊ/ and /o/-fronting, but not for /ʊl/ or /ol/

merger at 25%
Linear Mixed Effects Model

- Using lme4 for R (Bates et al, 2015)
- \( \text{normalizedF1} \sim \text{HWC} + \text{task} + \text{stepNumberTime} + \text{HWC:stepNumberTime} + \text{stepNumberTime:task} + (1|\text{speakerNumber}) \)
- \( \text{normalizedF2} \sim \text{HWC} + \text{task} + \text{stepNumberTime} + \text{stepNumberTime:task} + (1|\text{speakerNumber}) \)
- Gender and generation factors did not improve the models

<table>
<thead>
<tr>
<th>F1 Fixed Effects</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
<th>p &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>HWC BOWL /ʊl/</td>
<td>0.145</td>
<td>0.218</td>
<td>.667</td>
<td>.552</td>
</tr>
<tr>
<td>HWC BULL /ʊl/</td>
<td>-.009</td>
<td>0.154</td>
<td>-0.640</td>
<td>.567</td>
</tr>
<tr>
<td>HWC FOOT /ʊ __ t,d/</td>
<td>-0.709</td>
<td>0.172</td>
<td>-4.104</td>
<td>.026*</td>
</tr>
<tr>
<td>HWC GOAT /ʊ __ t,d/</td>
<td>-0.152</td>
<td>0.173</td>
<td>-0.876</td>
<td>.445</td>
</tr>
<tr>
<td>Task LX2</td>
<td>-0.059</td>
<td>0.256</td>
<td>-0.231</td>
<td>.838</td>
</tr>
<tr>
<td>Task WL</td>
<td>-0.351</td>
<td>0.213</td>
<td>-1.646</td>
<td>.241</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F2 Fixed Effects</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
<th>p &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>HWC BOWL /ʊl/</td>
<td>0.247</td>
<td>0.203</td>
<td>1.216</td>
<td>.310</td>
</tr>
<tr>
<td>HWC BULL /ʊl/</td>
<td>0.033</td>
<td>0.016</td>
<td>2.004</td>
<td>.138</td>
</tr>
<tr>
<td>HWC FOOT /ʊ __ t,d/</td>
<td>0.811</td>
<td>0.018</td>
<td>43.917</td>
<td>.00002**</td>
</tr>
<tr>
<td>HWC GOAT /ʊ __ t,d/</td>
<td>0.058</td>
<td>0.018</td>
<td>3.157</td>
<td>.0509</td>
</tr>
<tr>
<td>Task LX2</td>
<td>-0.080</td>
<td>0.275</td>
<td>-0.294</td>
<td>.796</td>
</tr>
<tr>
<td>Task WL</td>
<td>-0.158</td>
<td>0.214</td>
<td>-0.739</td>
<td>.947</td>
</tr>
</tbody>
</table>
Formant trajectories

- Smoothing-Spline ANOVA (Gu, 2014) used for visualization purposes
- Merger in F2 for BULL/BOWL/GOAT
- F1 values of BULL & BOWL not significantly different
- Note the centralizing effect of /l/ in the F1 plot
Intensity

BULL & BOWL classes
Duration

- Within-speaker normalized
- Word list items only
- In general: /o/ longer than /ʊ/ in English
- Here: syllabic /l/ in BOWL longer than syllabic /l/ in BULL.
- Mean difference of unmerged speakers is 1.266 SD, or 47.25 ms (raw)
Conclusions

- Completed merger in F1 x F2 space
  - No significant effects of sociolinguistic factors
- Duration distinguishes BULL and BOWL class items
  - The contrast between /o/ and /ʊ/ appears to be maintained for most speakers by duration of syllabic /l/
- Difference in intensity between BULL and BOWL requires further study
- Future Directions
  - Investigation of /ʌ/
  - Include respondents born after 1975
  - Generalize to the greater region
  - Articulatory study
References


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- Thank you to Richard Wright, Anna Moroz, Nicole Chartier, and members of the UW Sociolinguistics Brown Bag for their feedback and support
Tasks: less formal $\rightarrow$ more formal $\rightarrow$ most formal*
African American Speakers

F2 contours of final vowel/vocoid by word class
Speaker 5, Word List

F1 contours of final vowel/vocoid by word class
Speaker 5, Word List

F2 contours of final vowel/vocoid by word class
Speaker 6, Word List

F1 contours of final vowel/vocoid by word class
Speaker 6, Word List