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

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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 /ʊl/ at 25% through the vowel in F1 x F2 space in Cowlitz County, WA
  - Did not compare prelateral /ol/ and /ʊl/ 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

- Squizzero (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

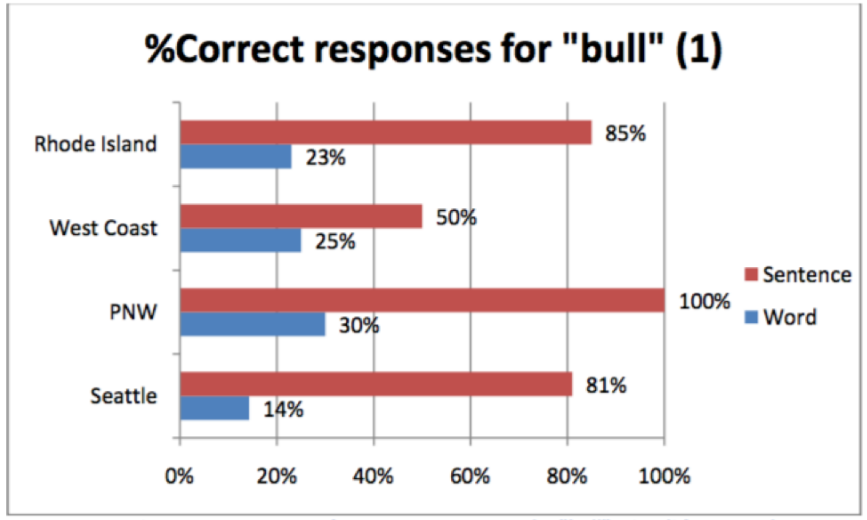


Figure 7: Percentage of correct responses to the "bull" stimuli from speaker 1

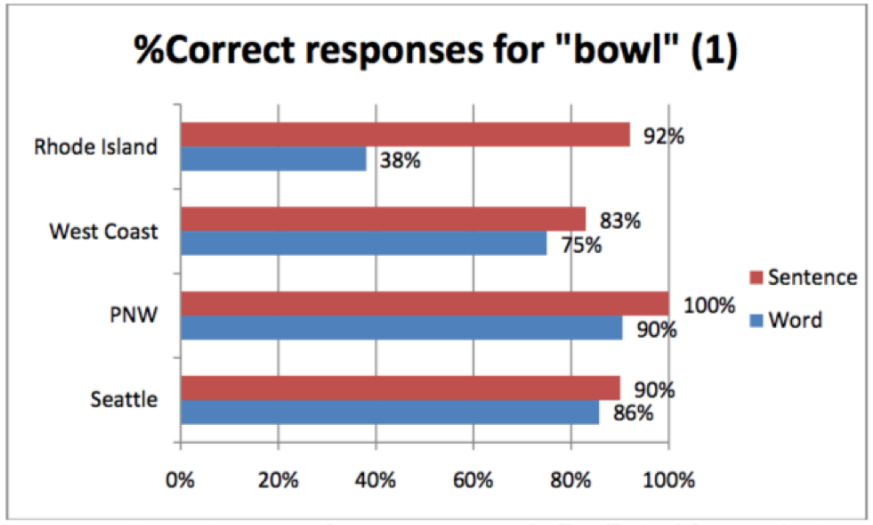
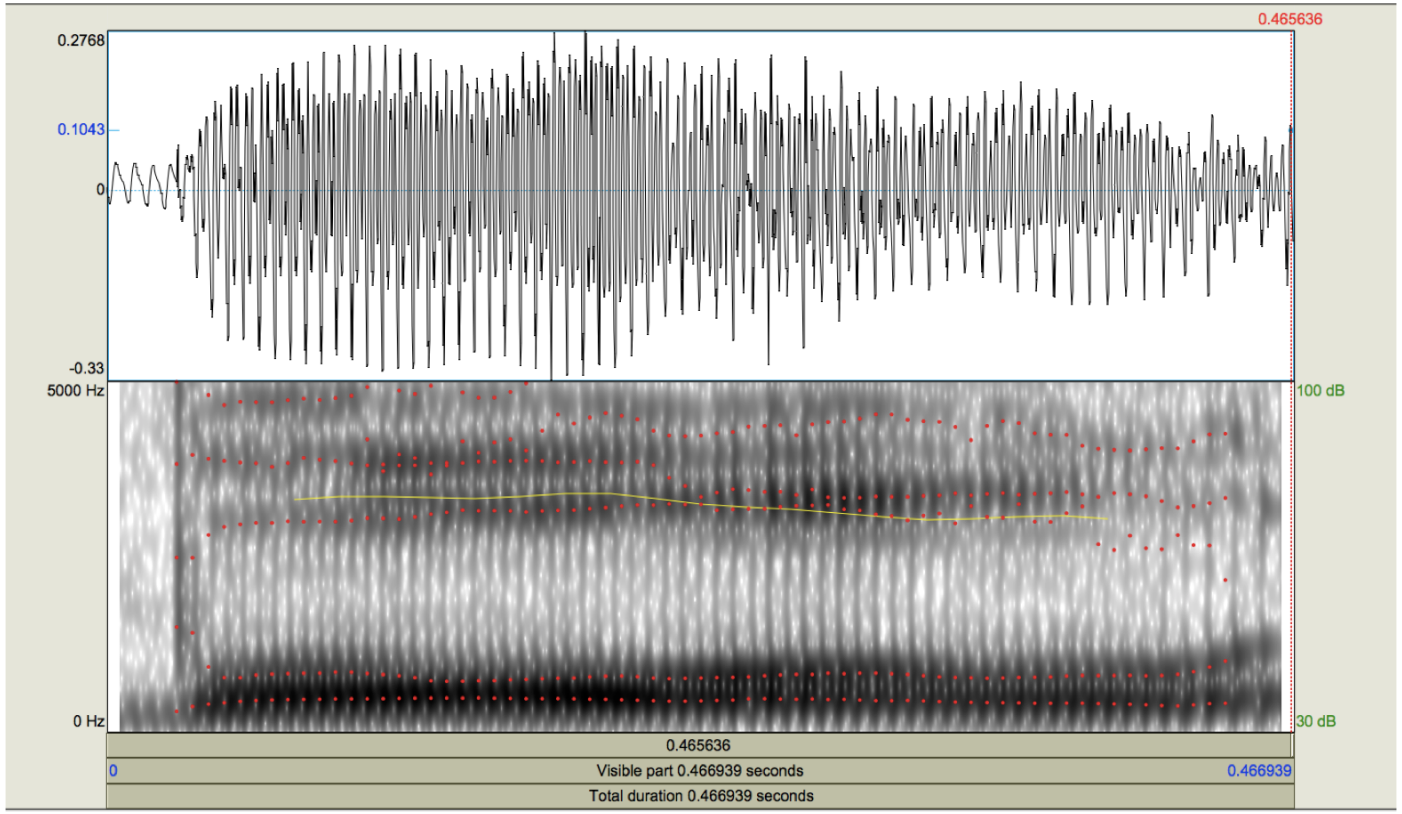


Figure 9: Percentage of correct responses to the "bowl" stimuli from speaker 1

(Squizzero, 2009)

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 /ʊl/
  - H10: Formant trajectories of /ol/ and /ʊl/ will not be significantly different (Stanley, 2017)
  - H1a: Formant trajectories of /ol/ and /ʊl/ 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

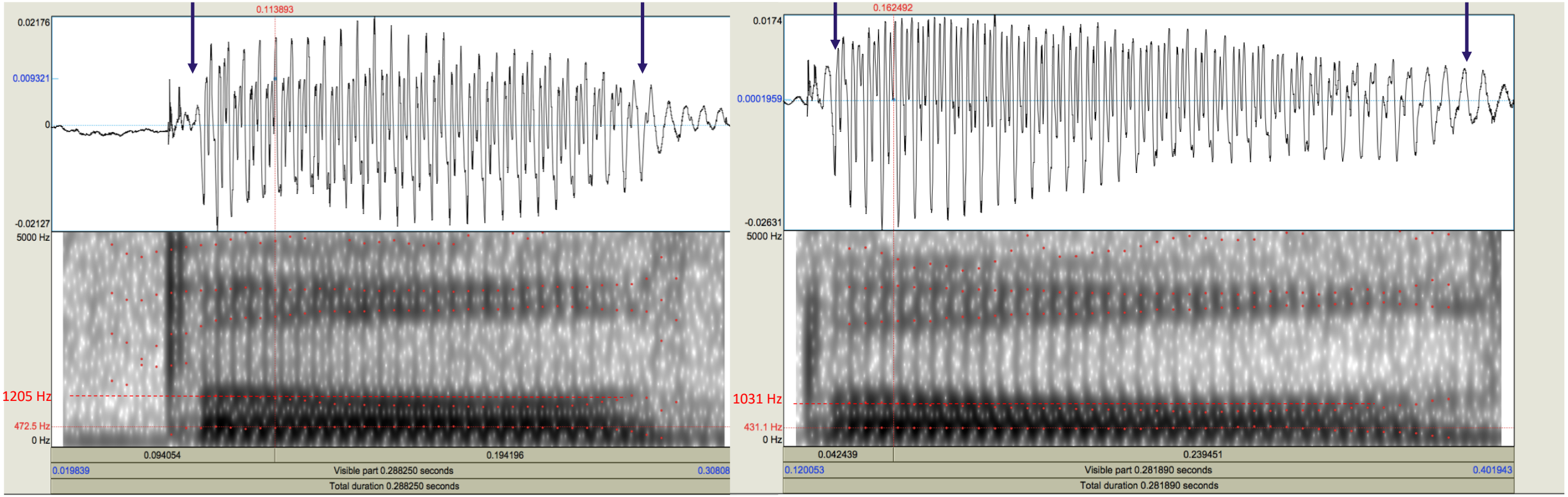
Methods

- 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/__d,t and /ʊ/__ d,t and the vocoid for /ol/ and /ʊl/
  - Praat measurement script adapted from Wassink & Koops (2013)

Analysis: spectrograms characteristic of /ʊl/ and /ol/



bull

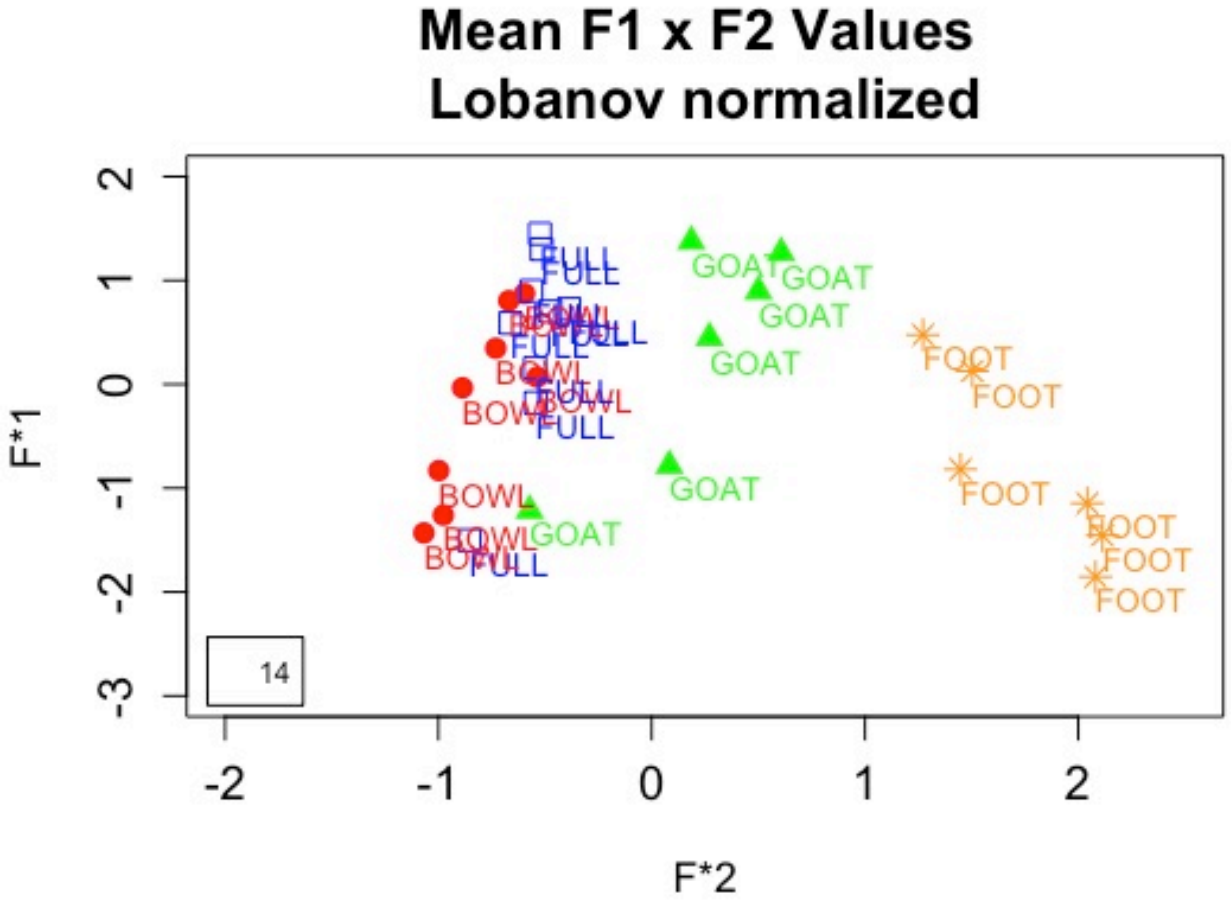
bowl

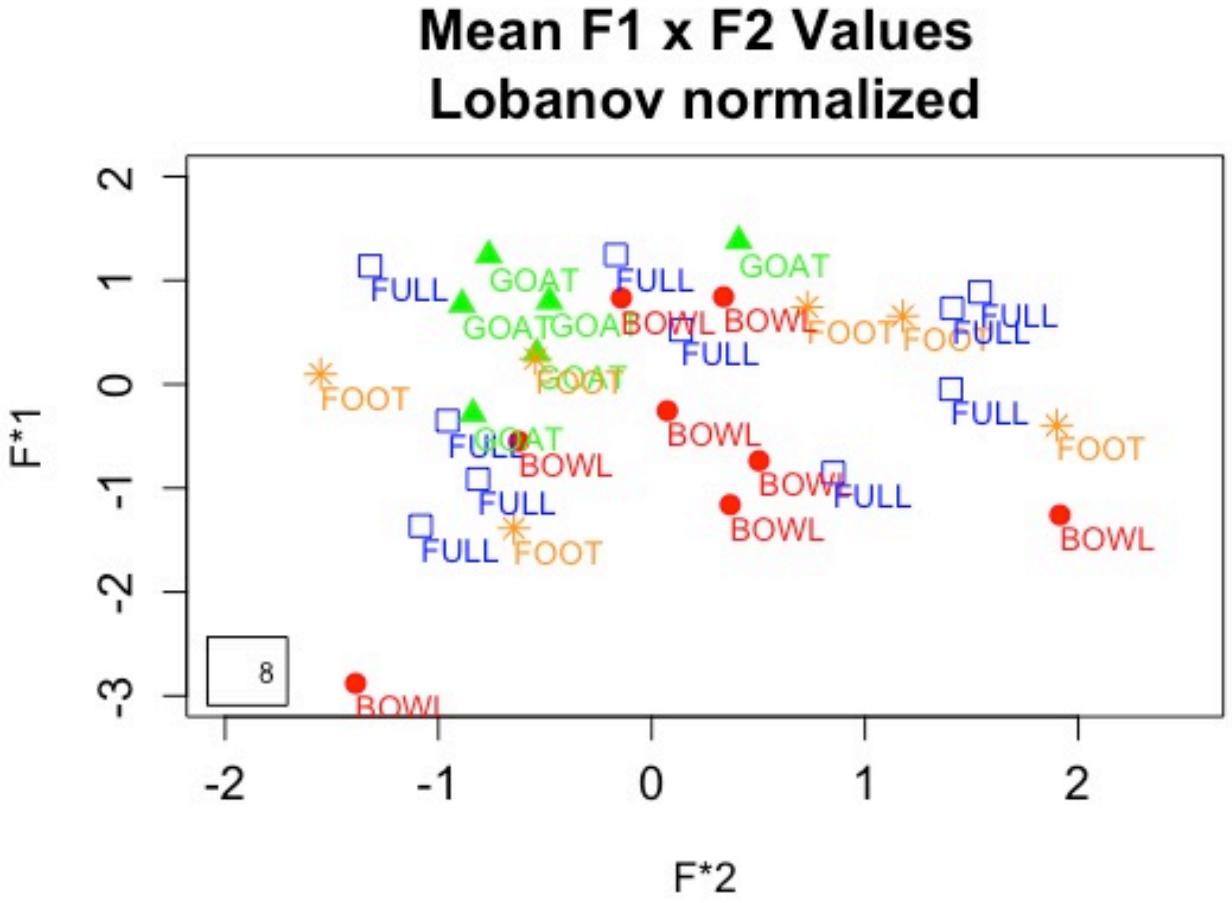
- No acoustic correlates of a ”clear” final /l/ - these appear dark, or velarized
- Similar, but not identical formant values
  - F1 difference of 42 Hz, F2 difference of 170 Hz
- Difference in duration: bull 182ms vs. bowl 244ms (bull 74.5% of bowl)

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

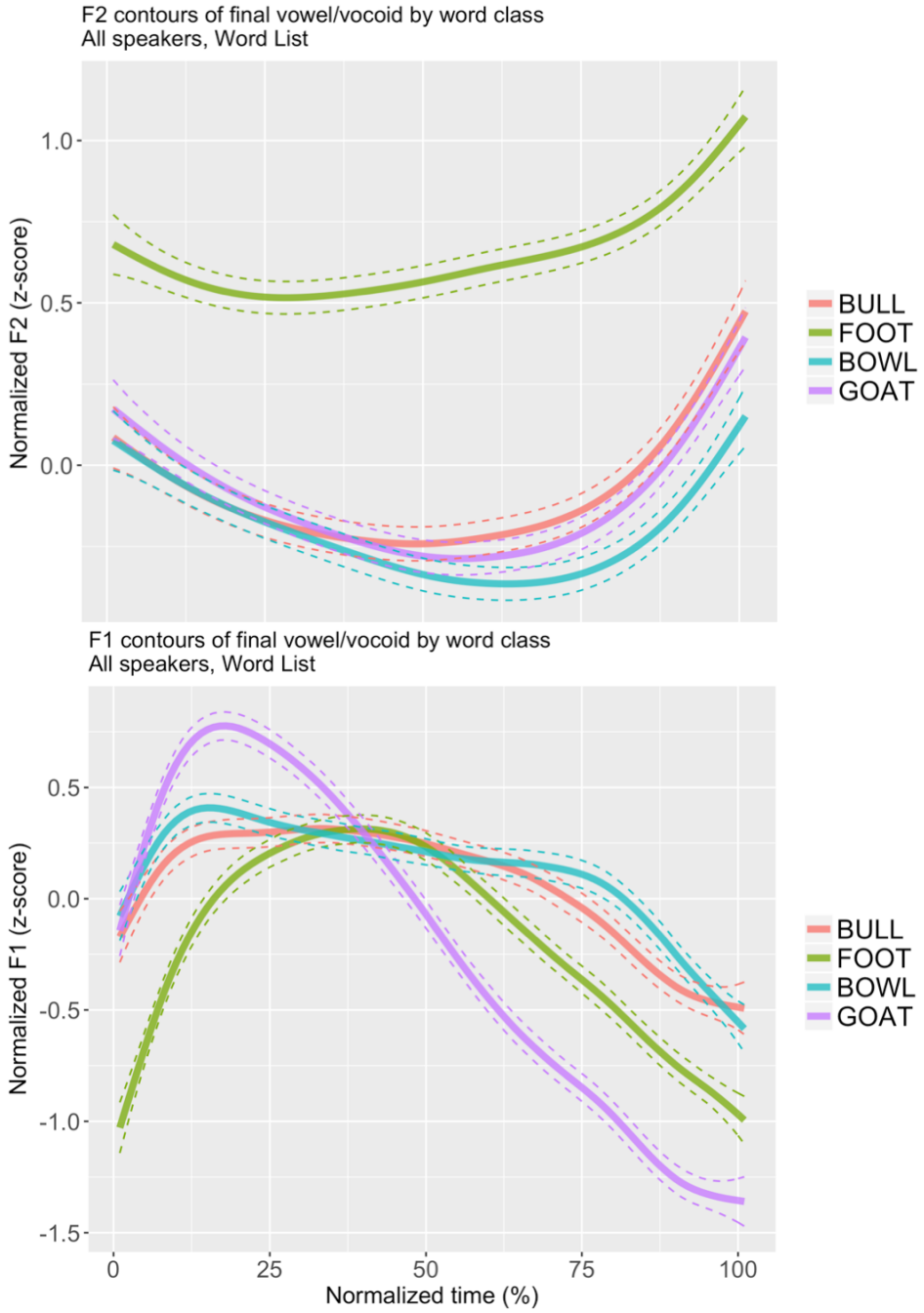
- Using lme4 for R (Bates et. al, 2015)
- normalizedF1 ~ HWC + task + stepNumberTime + HWC:stepNumberTime + stepNumberTime:task + (1|speakerNumber)
- normalizedF2 ~ HWC + task + stepNumberTime + stepNumberTime:task + (1|speakernumber)
- Gender and generation factors did not improve the models

F1 Fixed Effects	Estimate	Std. Error	t value	p <
HWC BOWL /ol/	0. 145	0.218	.667	.552
HWC BULL /ʊl/	-.009	0.154	-0.640	.567
HWC FOOT /ʊ __t,d/	-0.709	0.172	-4.104	.026*
HWC GOAT /o__t,d/	-0.152	0.173	-0.876	.445
Task LX2	-0.059	0.256	-0.231	.838
Task WL	-0.351	0.213	-1.646	.241

F2 Fixed Effects	Estimate	Std. Error	t value	p <
HWC BOWL /ol/	0.247	0.203	1.216	.310
HWC BULL /ʊl/	0.033	0.016	2.004	.138
HWC FOOT /ʊ __ t,d/	0.811	0.018	43.917	.00002**
HWC GOAT /o__t,d/	0.058	0.018	3.157	.0509
Task LX2	-0.080	0.275	-0.294	.796
Task WL	-0.158	0.214	-0.739	.947

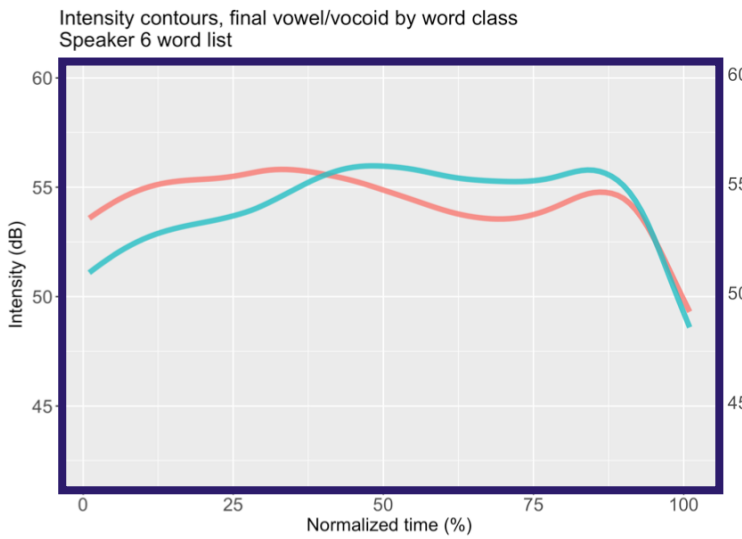
Formant trajectories

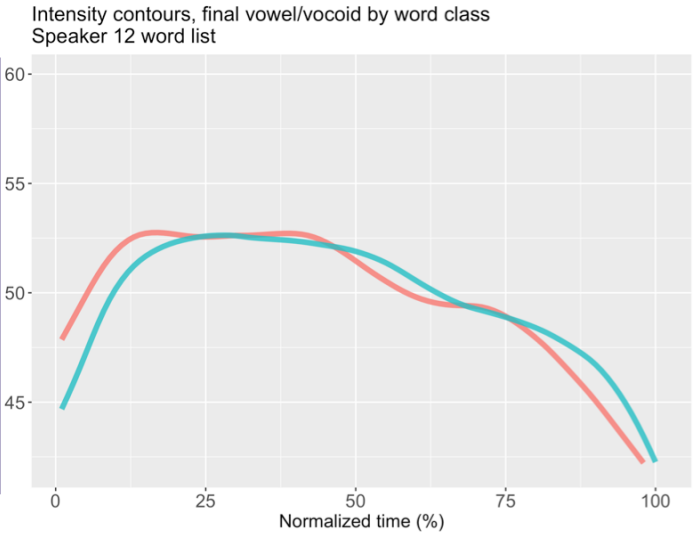
- Smoothing-Spline ANOVA (Gu, 2014) used for visualization purposes
- Merger in F2 for BULL/BOWL/GOAT
- F1 values of BULL & BOWL not significantly different
- Note the centralizing effect of /l/ in the F1 plot

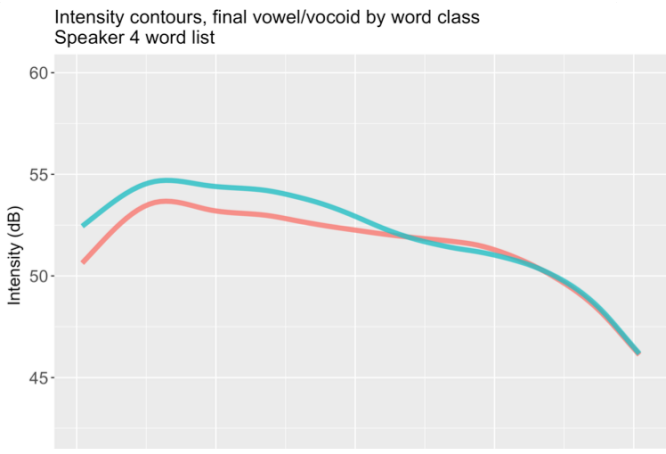


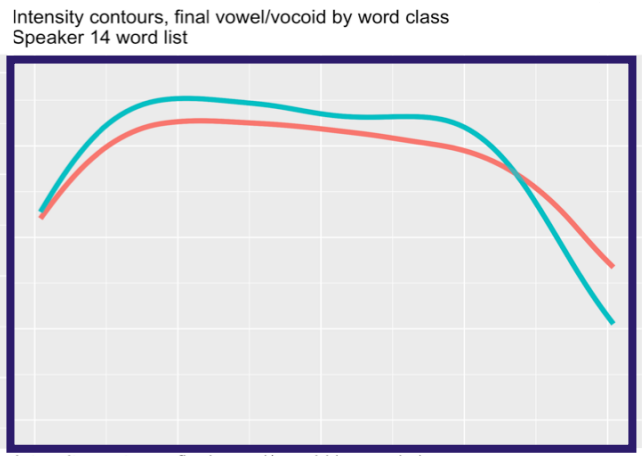
Intensity

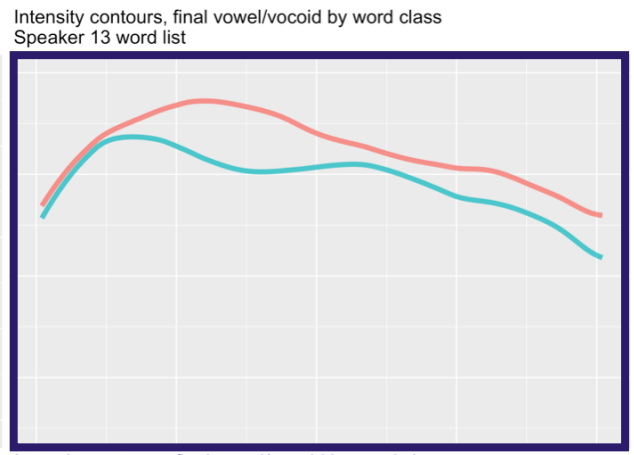
BULL & BOWL classes

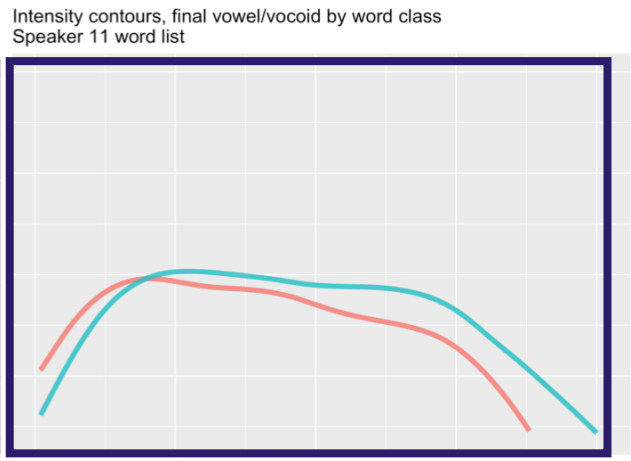


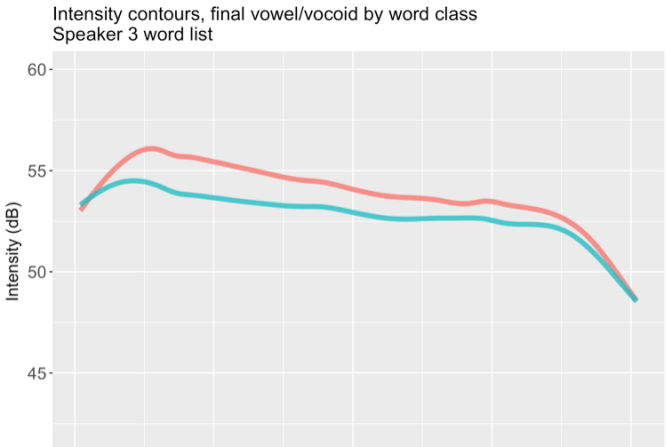


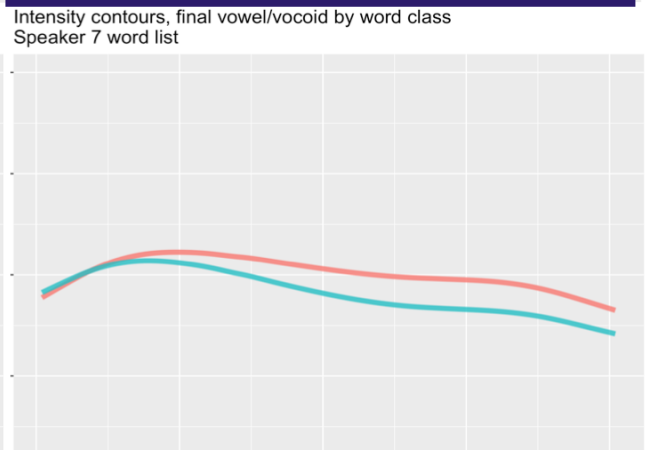


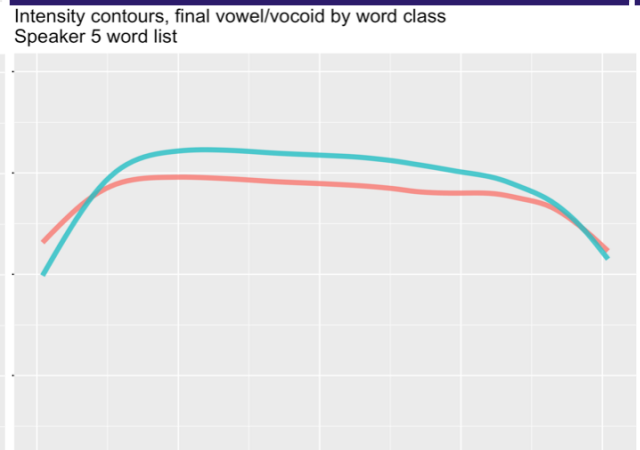


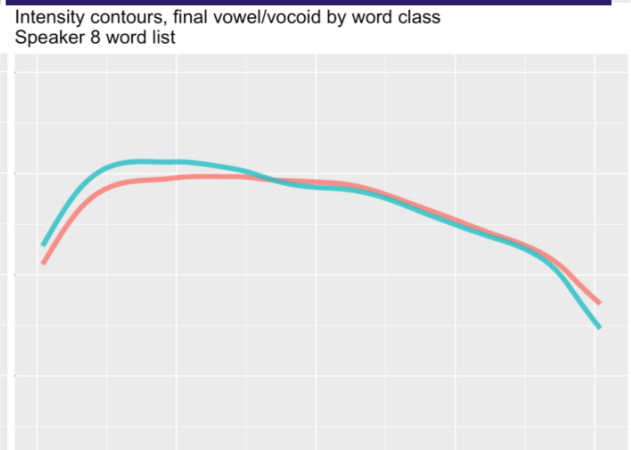




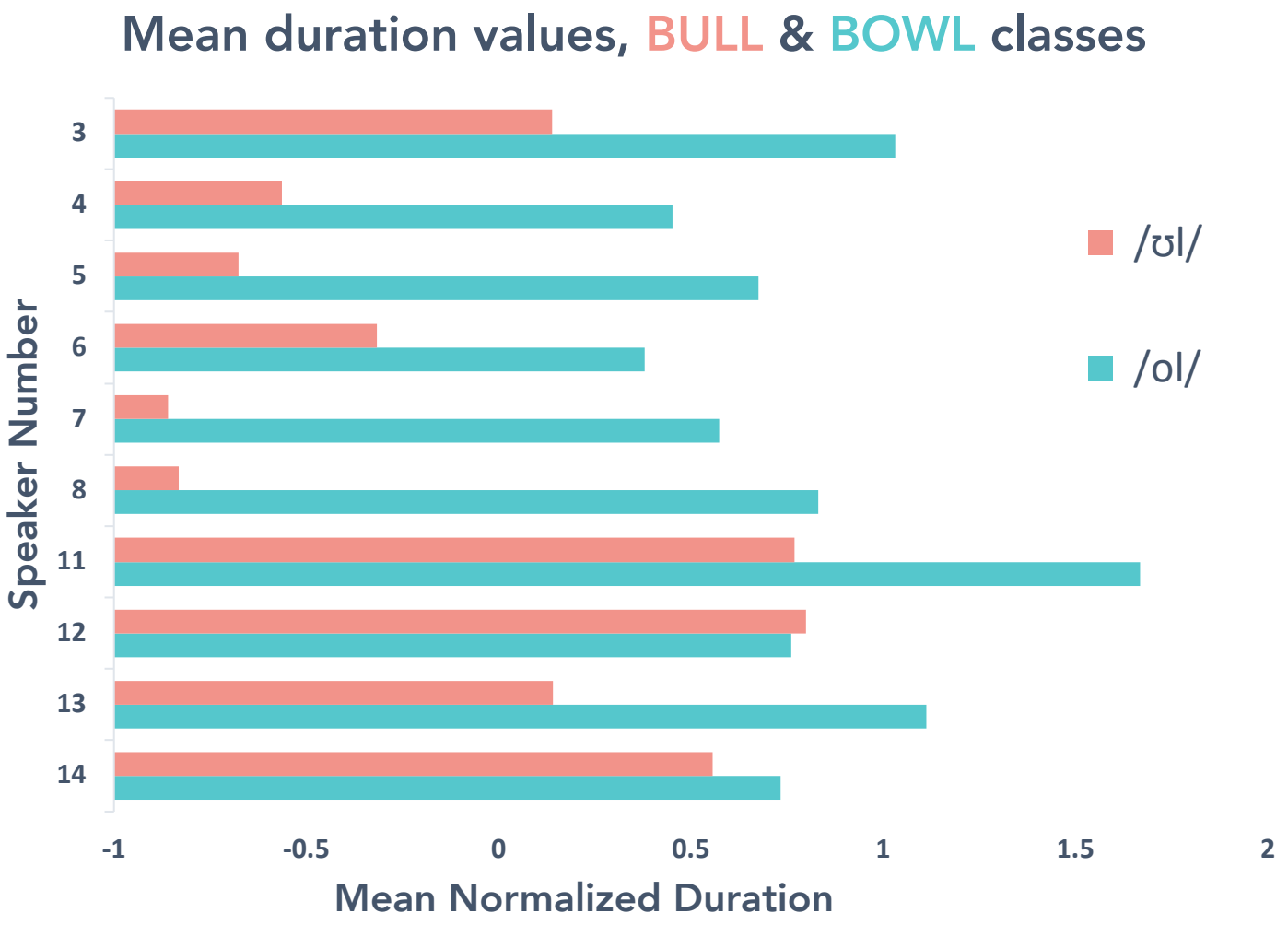








Duration



- 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/
  - Generalize to the greater region
  - Include respondents born after 1975
  - Articulatory study

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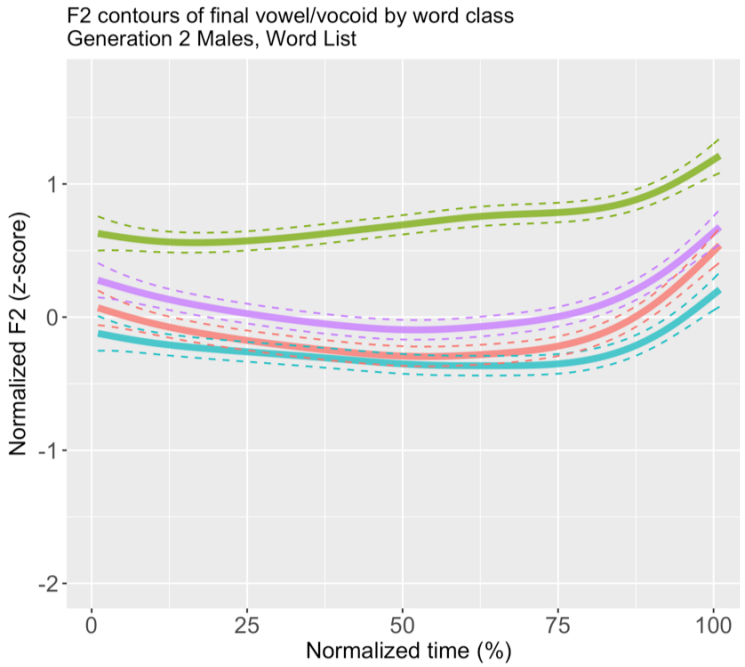
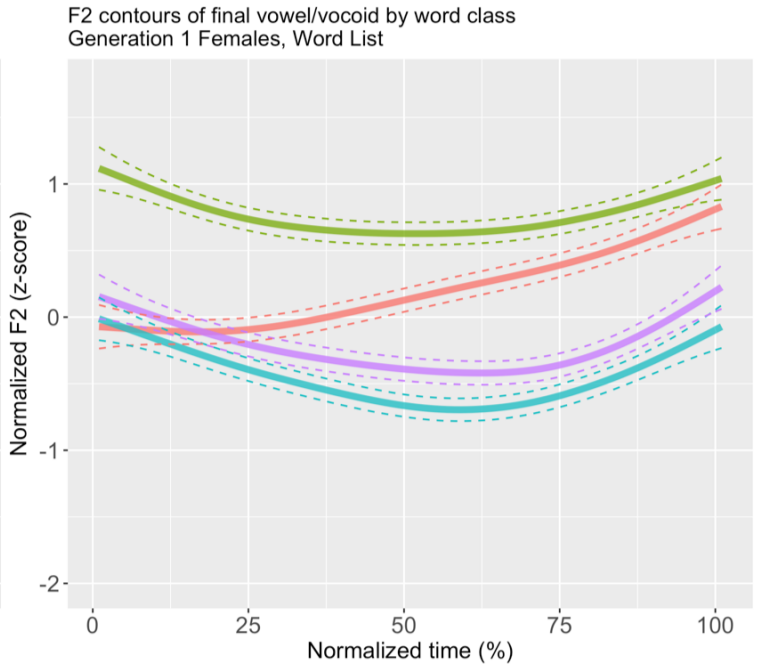
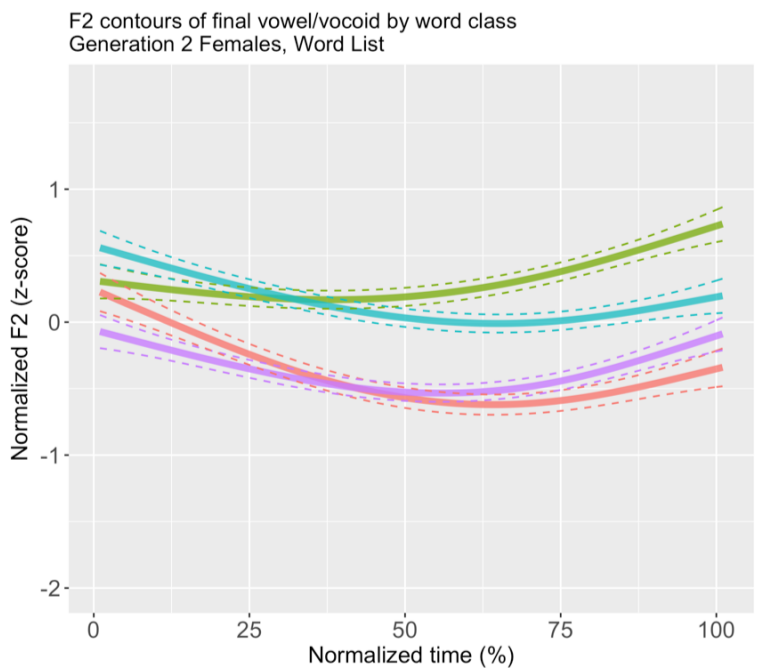
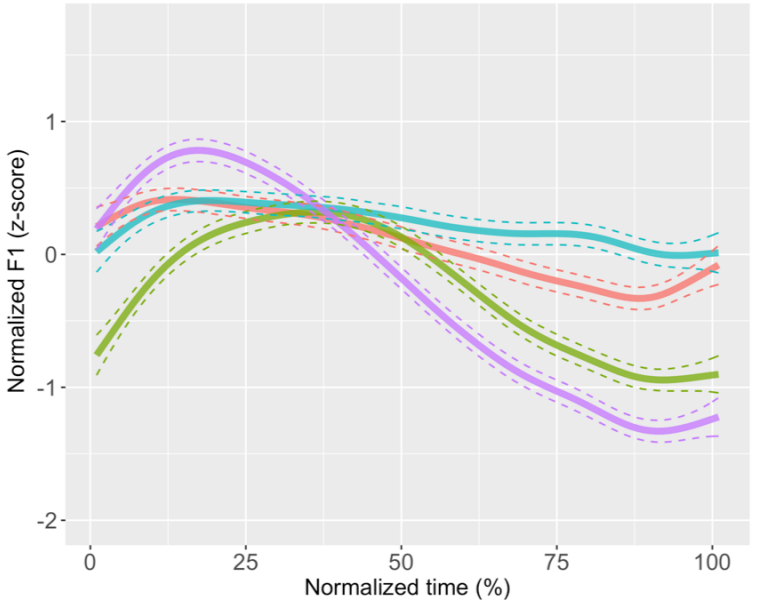
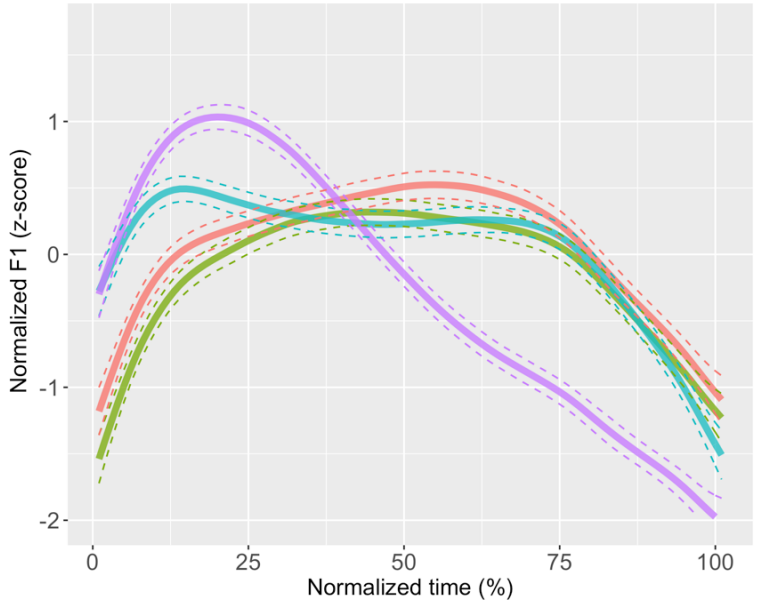
Gender & Generation

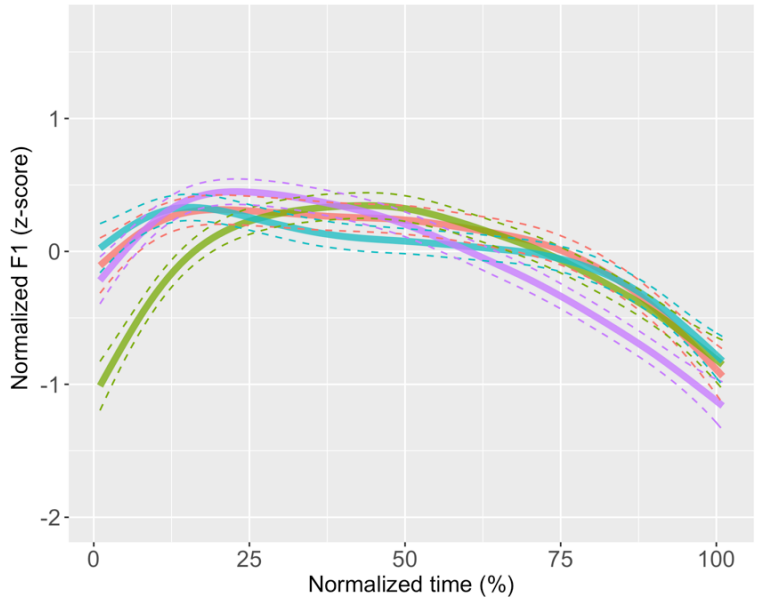




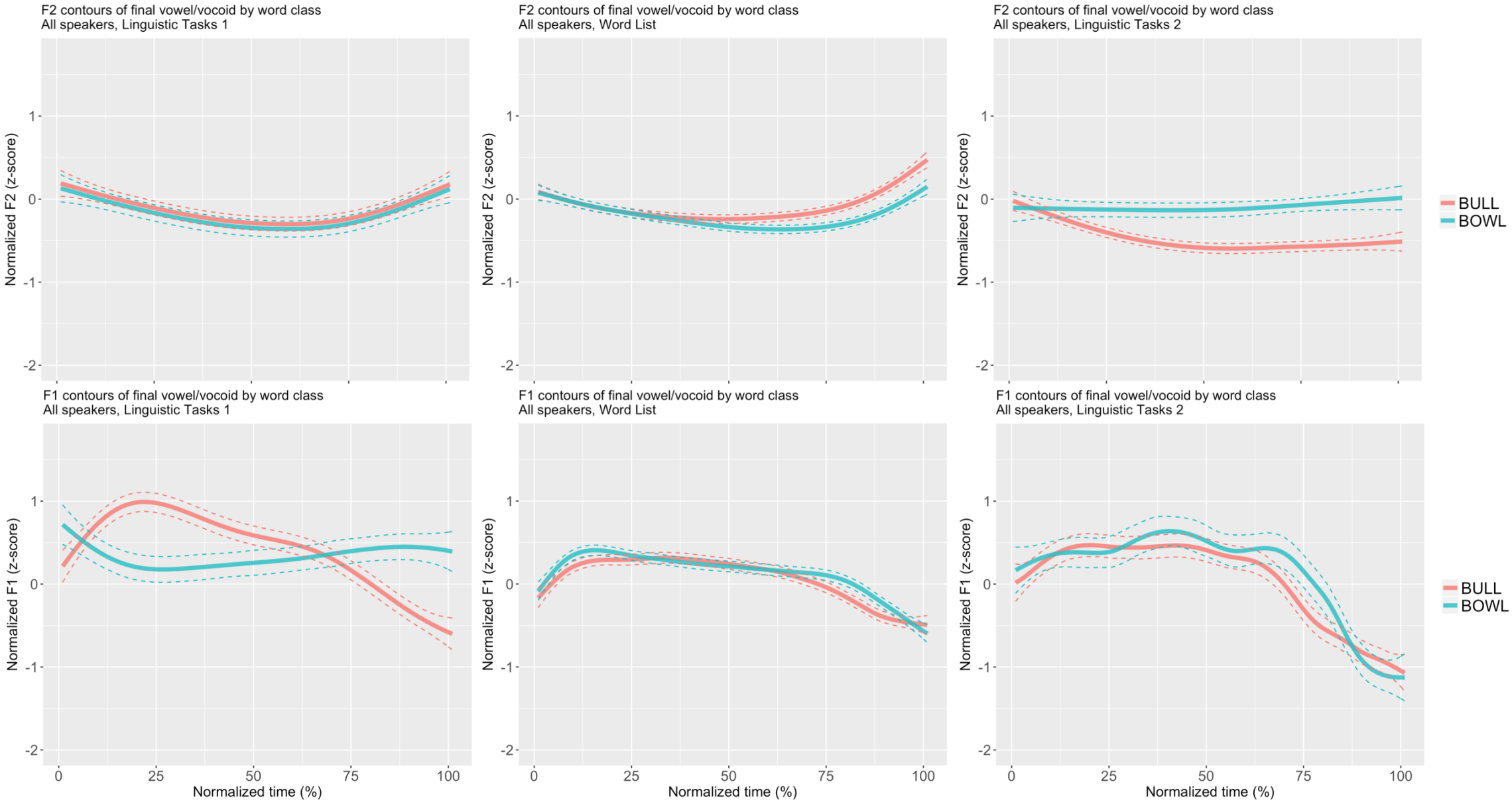








Tasks: less formal → more formal → most formal*



African American Speakers