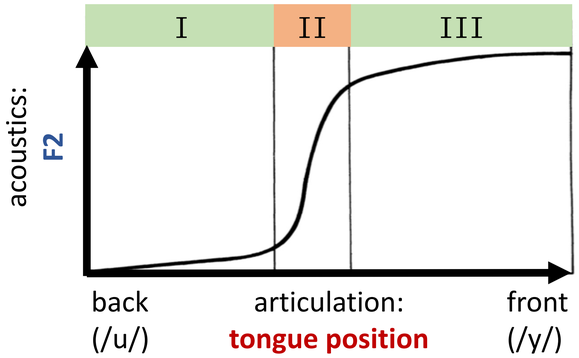
The crooked relationship between tongue shift and F2 in /u/-/y/-transitions

Rosa Franzke, Lia Saki Bučar Shigemori, Phil Hoole, Jonathan Harrington
Institute of Phonetics and Speech Processing, LMU Munich

This research is funded by European Research Council Grant no. 742289: *Human interaction and the evolution of spoken accent* (2017-2022)
Awarded to Prof. Jonathan Harrington

Background

Non-linear relationship between **articulation** & **acoustics** according to the Quantal Theory of Change (plot based on Stevens, 1989)

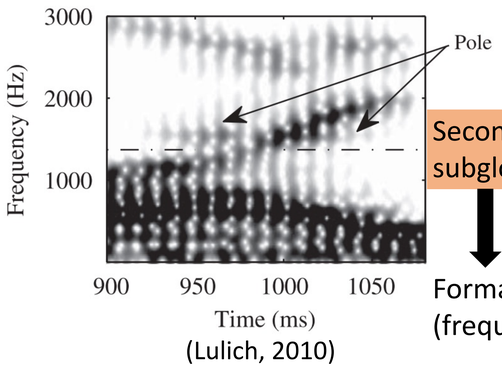


I + III
acoustically **stable region**:
change **F2**
<
change **tongue**

II
acoustically **unstable** region:
change **F2**
>
change **tongue**

Cause

Acoustic coupling between subglottal (bronchi, trachea) + oral cavities



(Lulich, 2010)

Second resonance of the subglottal system (SGR2)

affects

Formants (frequency + amplitude)

SGR as boundaries

	SGR1	SGR2
female	660	1513
male	554	1327

Mean values of 50 adult native speakers of American English from (Lulich et al., 2012)

Mapping between articulation and acoustics in the back ⇔ front dimension for female vs. male speakers?

Method

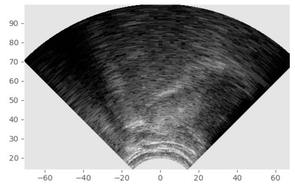
German speakers (11 f, 8 m) producing /u/-/y/- and /y/-/u/-continua

➢ Acoustics: Speech signal
F2 → manually corrected → smoothed
SGR2 → visually detected

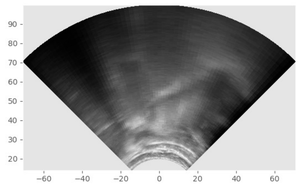
➢ Articulation: Ultrasound recordings of the tongue
Principal Component (**PC**) Analysis → raw image data → separately for each speaker → choose PC best reflecting /u/-/y/-contrast

Example from female continuum

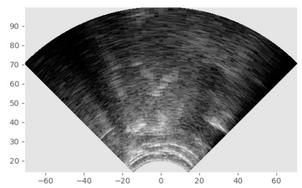
/y/ original, t = 0.5



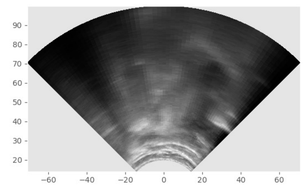
/y/ reconstructed, PC1 = 1778



/u/ original, t = 2.5



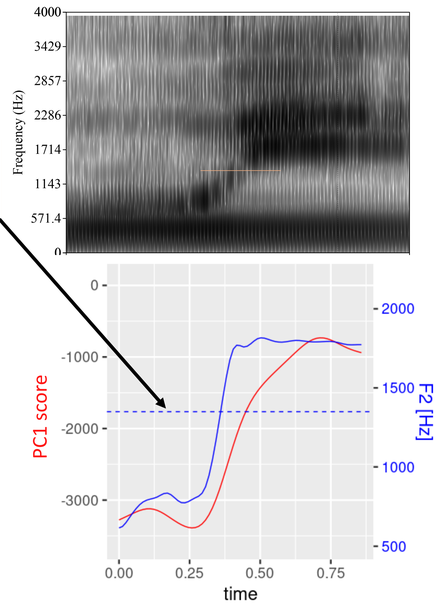
/u/ reconstructed, PC1 = -2011



Data (in progress)

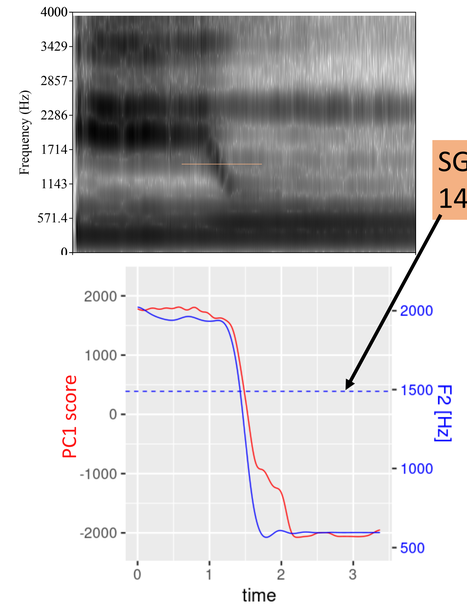
Male continuum

SGR2: 1350 Hz



Female continuum

SGR2: 1480 Hz



Discussion

Formant differences between female and male speakers explained by anatomical differences in the **vocal tract** and the **glottis** (=> f0 differences: sufficient contrast hyp.).

➢ **subglottal** anatomy?
→ **Boundaries** between vowel features are sex-specific based on different SGRs

⇒ Relation to sound change **/u/-fronting**?

➢ **During**: F2 of female speakers has to change more from back to front to skip the unstable region based on **SGR2**

➢ **Before**: in a very back vowel (like German /u/) **F2** could additionally be unstable based on **SGR1** for females,

e.g. F2 increase due to coart. fronting (f: 660 Hz vs. m: 554 Hz)

References

Lulich, S. M. (2010). Subglottal resonances and distinctive features. *Journal of Phonetics*, 38(1), 20–32. ||| Lulich, S. M., Morton, J. R., Arsikere, H., Sommers, M. S., Leung, G. K. F., & Alwan, A. (2012). Subglottal resonances of adult male and female native speakers of American English. *The Journal of the Acoustical Society of America*, *132*(4), 2592–2602. ||| Stevens, K. N. (1989). On the quantal nature of speech. *Journal of Phonetics*, *17*, 3–45.