Is English /u/ becoming German /y/? A cross-linguistic, physiological and acoustic analysis.

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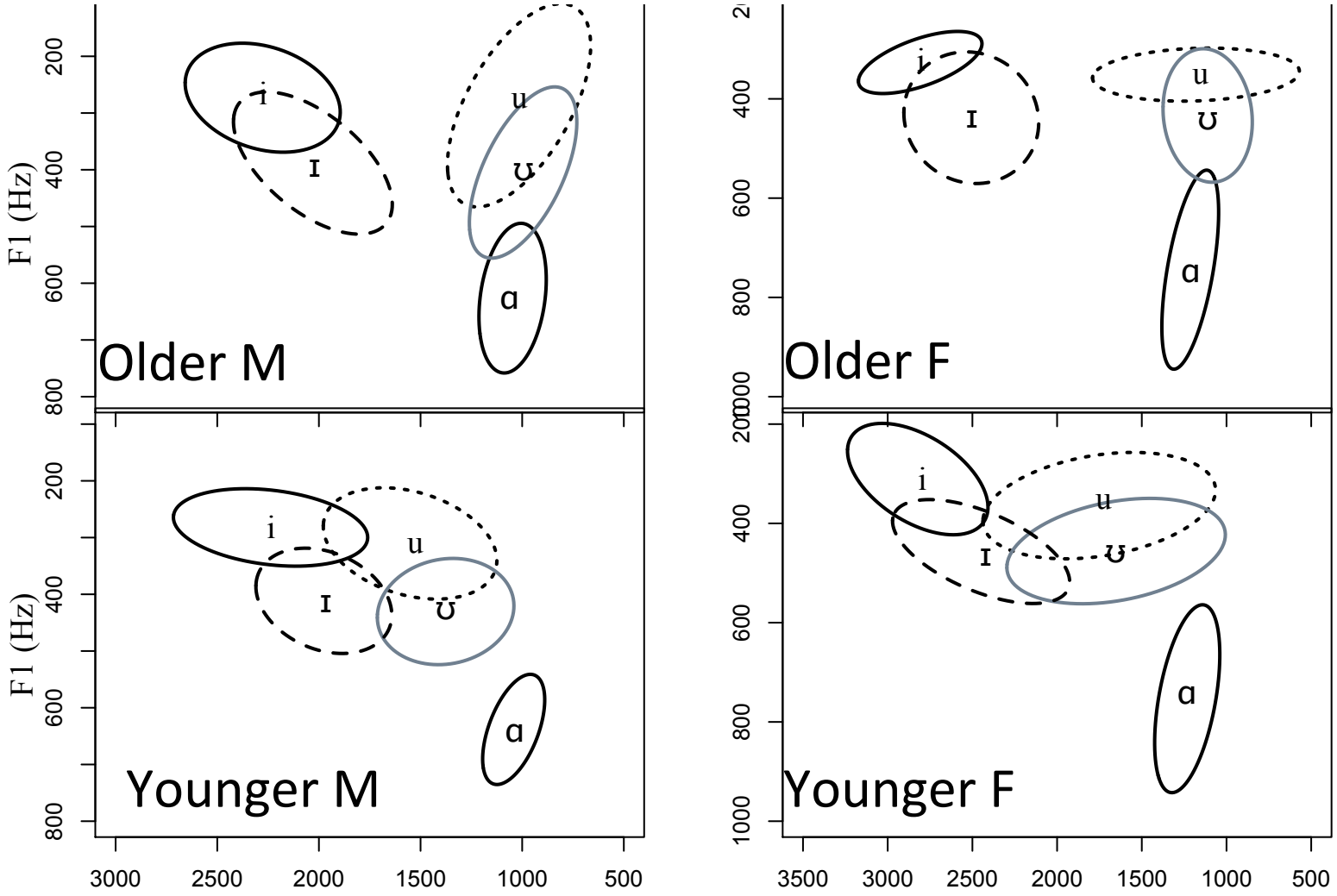
Background: Diachronic /u, ʊ/ fronting in SSB

Standard Southern British speakers

Older
n = 17;
mean age
69.2 years

Younger
n = 14;
mean age
18.9 years



Harrington, Kleber, Reubold (2008), *J. Acoust. Soc. Am.*

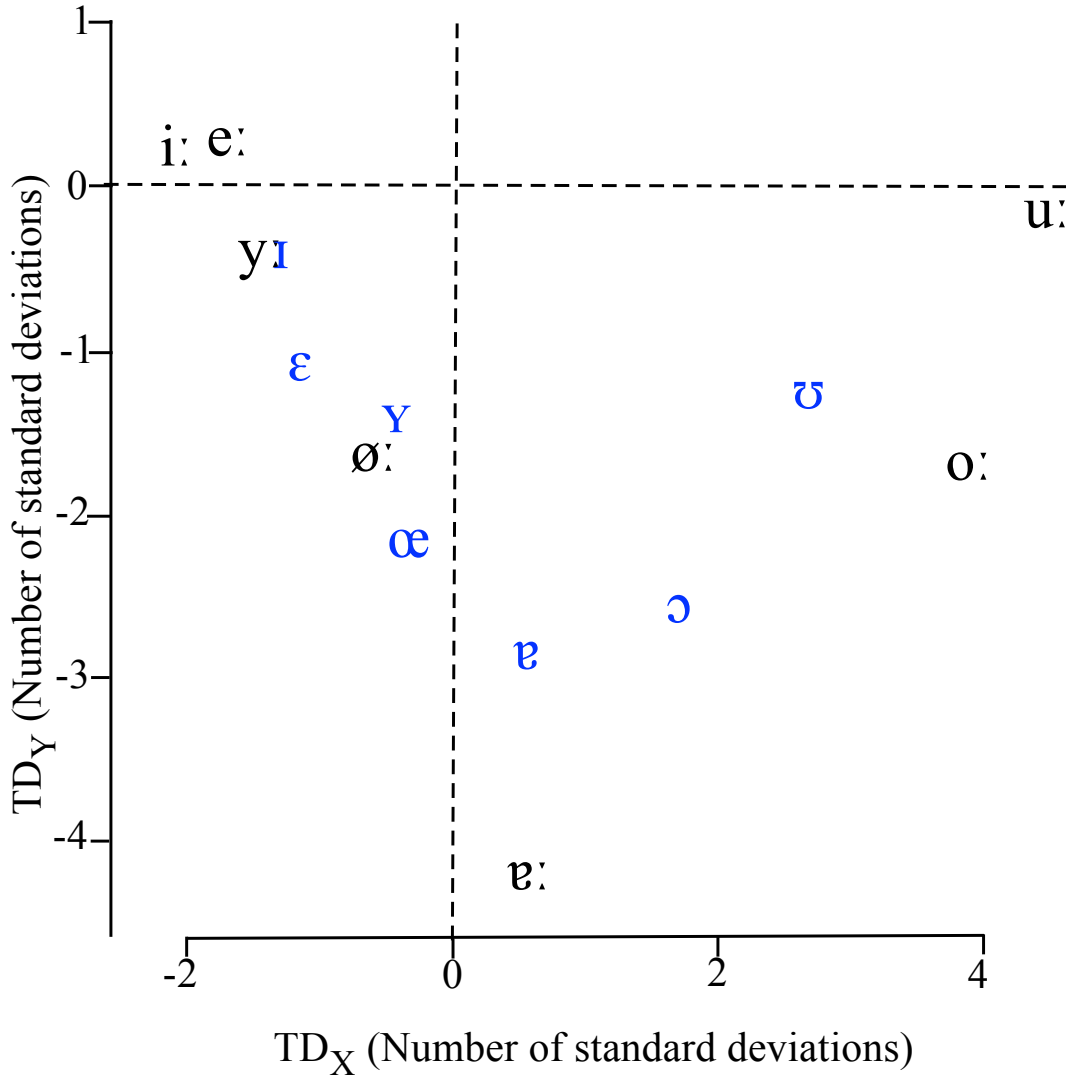
General principles of back vowel fronting

Labov (1994): back→front vowel diachronic change is more likely than front→back

Left-right asymmetry in the distribution of vowels in the languages of the world (Schwartz et al, 1997) i.e. languages tend to have /i, u, a/ but /u/ is more likely to be absent than /i/

A possible physiological basis of this asymmetry is the very peripheral tongue dorsum position of high back vowels in relation to the speaker's vowel space (Harrington, Hoole, Kleber, Reubold (2011, *Jphon*)

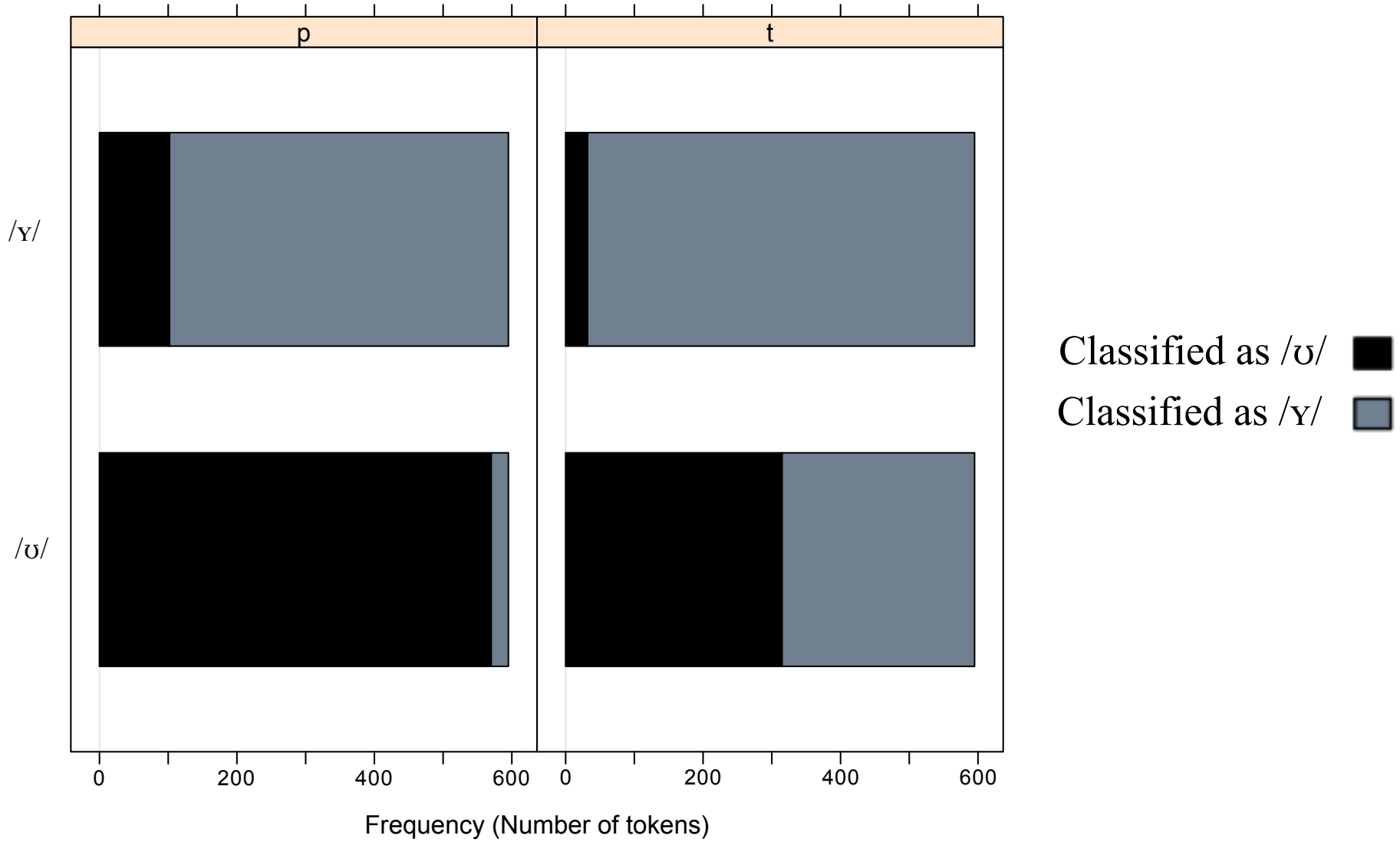
TD_X x TD_Y, 7 speakers, German vowels in /gəCVCə/



[0, 0]: speaker-mean [TD_X,TD_Y]

Perception experiment

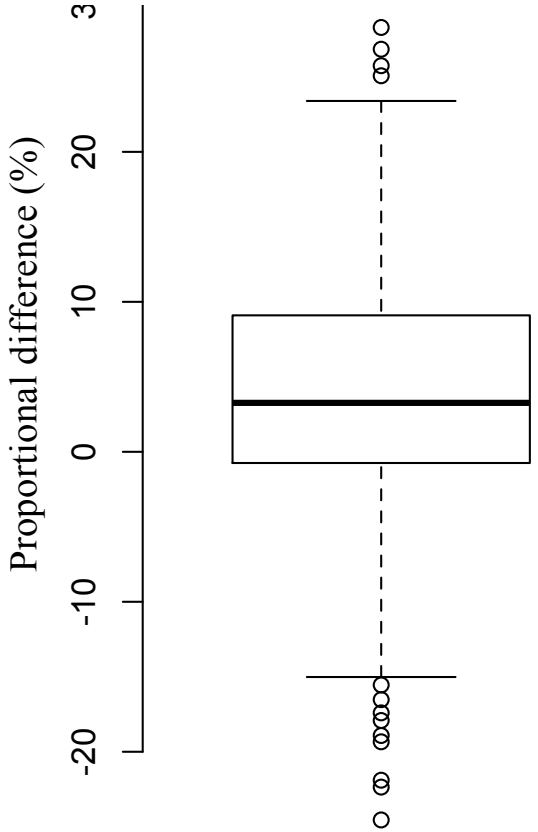
There were many more /ʊ/→/ʏ/ than /ʏ/→/ʊ/ misclassifications when these were spliced from two contexts are presented to listeners in a forced-choice classification task



Analysis of UPSID

The 375 languages that have both high front and high back vowels contain more *acute* consonants (that are likely to induce back-vowel fronting) in their inventory than *grave* consonants (that are likely to induce front-vowel backing).

Proportion *acute* minus proportion *grave* (375 languages)



acute: dental, dental/alveolar, alveolar

grave: bilabial, labiodental, retroflex, labial-velar, and uvular

(highly significantly different from zero)

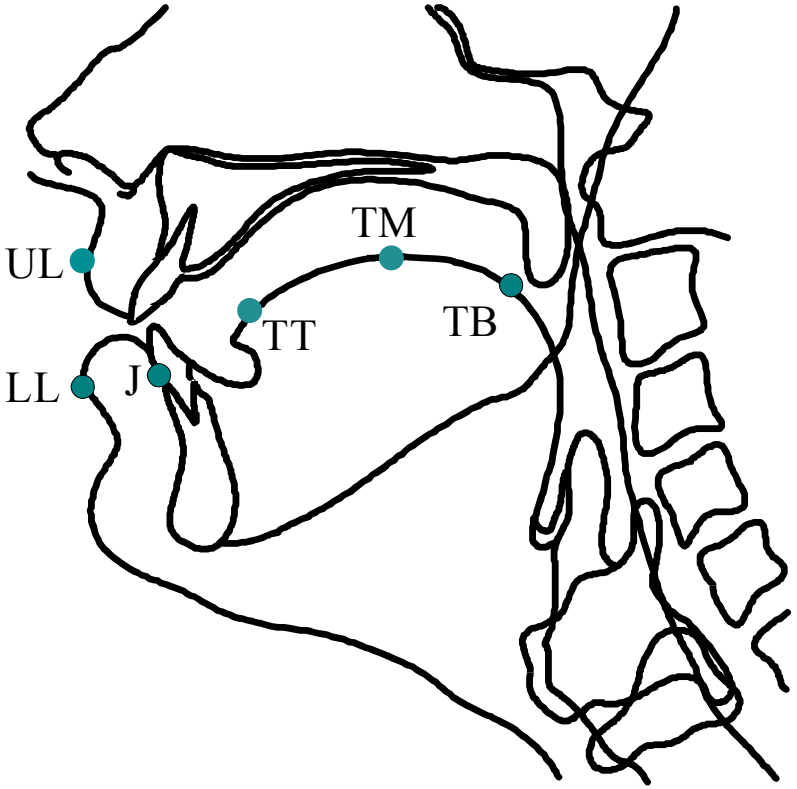
Harrington, Hoole, Kleber, Reubold (2011, Jphon)

Further background to /u, ʊ/ diachronic fronting in SSB

Wells (1997): 'Traditionally classified as back and rounded, these vowels [tense /u/ and lax /ʊ/] are not only losing their lip-rounding but also ceasing to be very back. Thus *spoon*, conservatively [spu:n], may now range to a loosely rounded [spʊ̟n] or even [spɪ̟n], while *good* /gʊd/ is often pronounced with a schwa-like quality '

EMA analysis

(3 F, 2 M) young (Alter 21-22)
SSB speakers



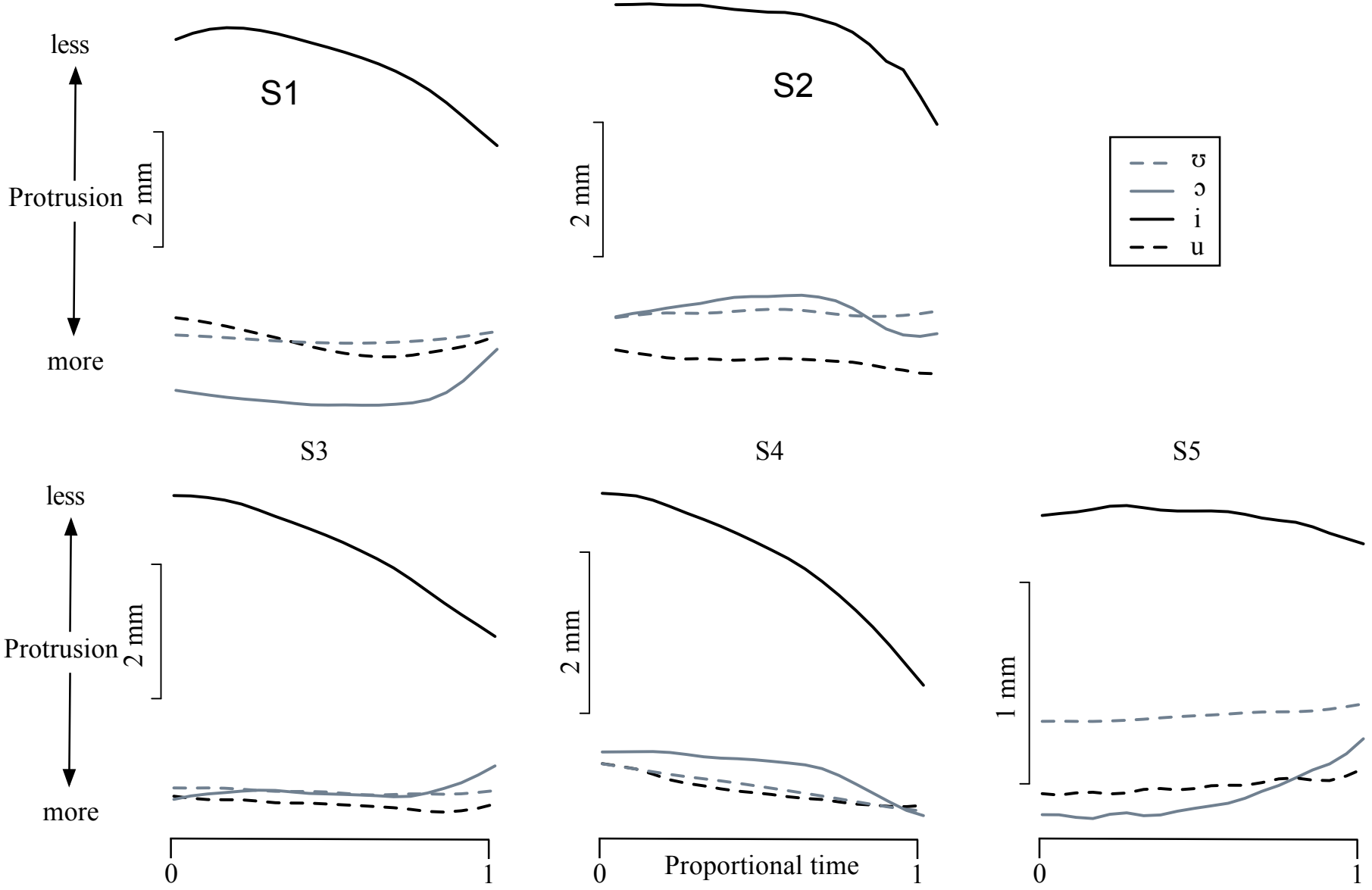
6 /hVd/ target words: *heed*, *hid*, *who'd*, *hood*, *hod*, *hoard* in n

/mɑ mɑ hVd/ (final) and /mɑ hVd S/ (medial, S = /hi, hɔ, mɑ/)

(Perkell et al, 1993)

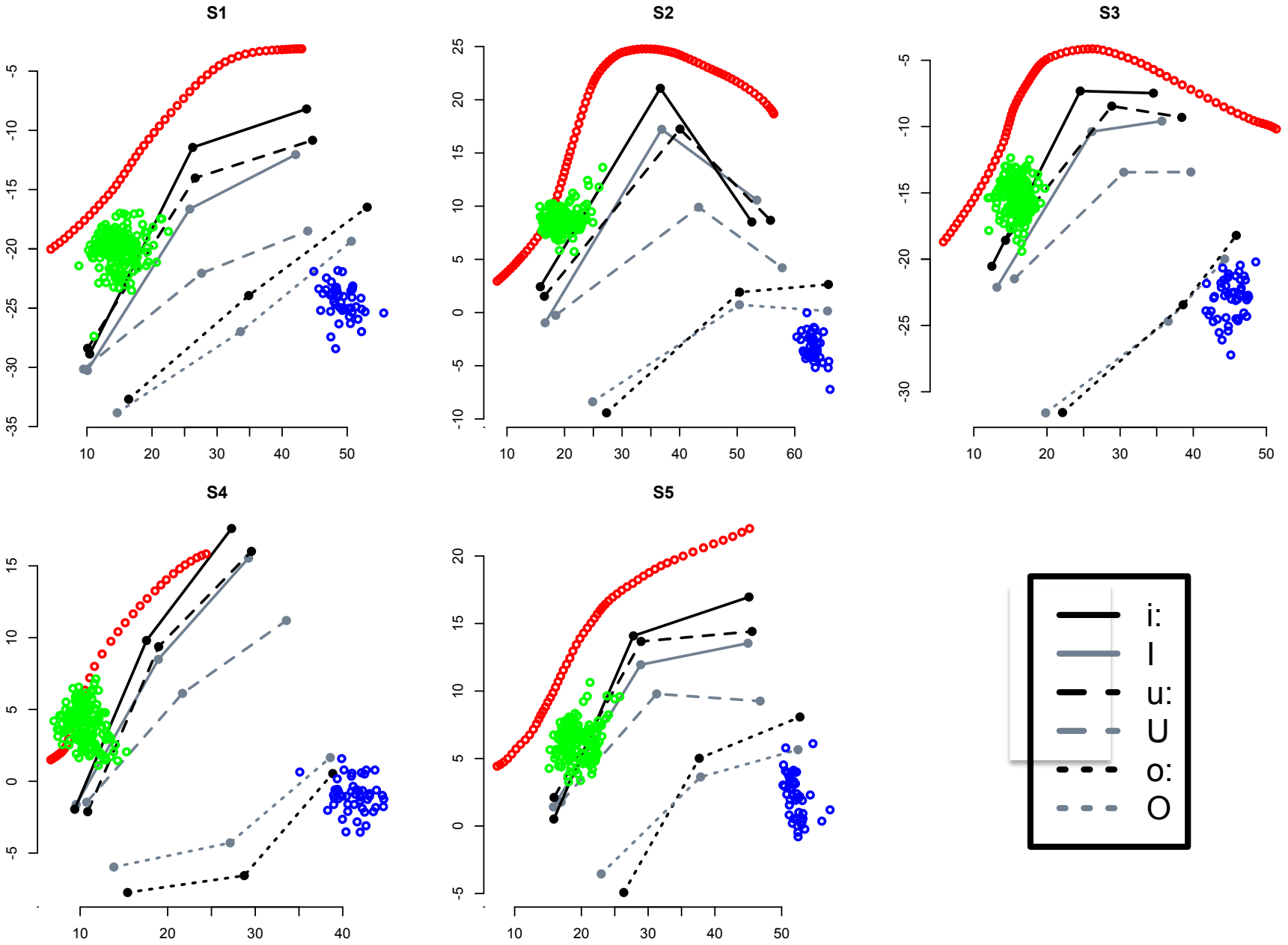
6 repetitions, 192 items per subject, randomised with distracters

LL_X, similar extent of lip-rounding in/u, ʊ/ as in /ɔ, ɒ/



(Harrington, Kleber, Reubold (2011), *J. Int. Phonetic Association*

tongue-dorsum X-Y data

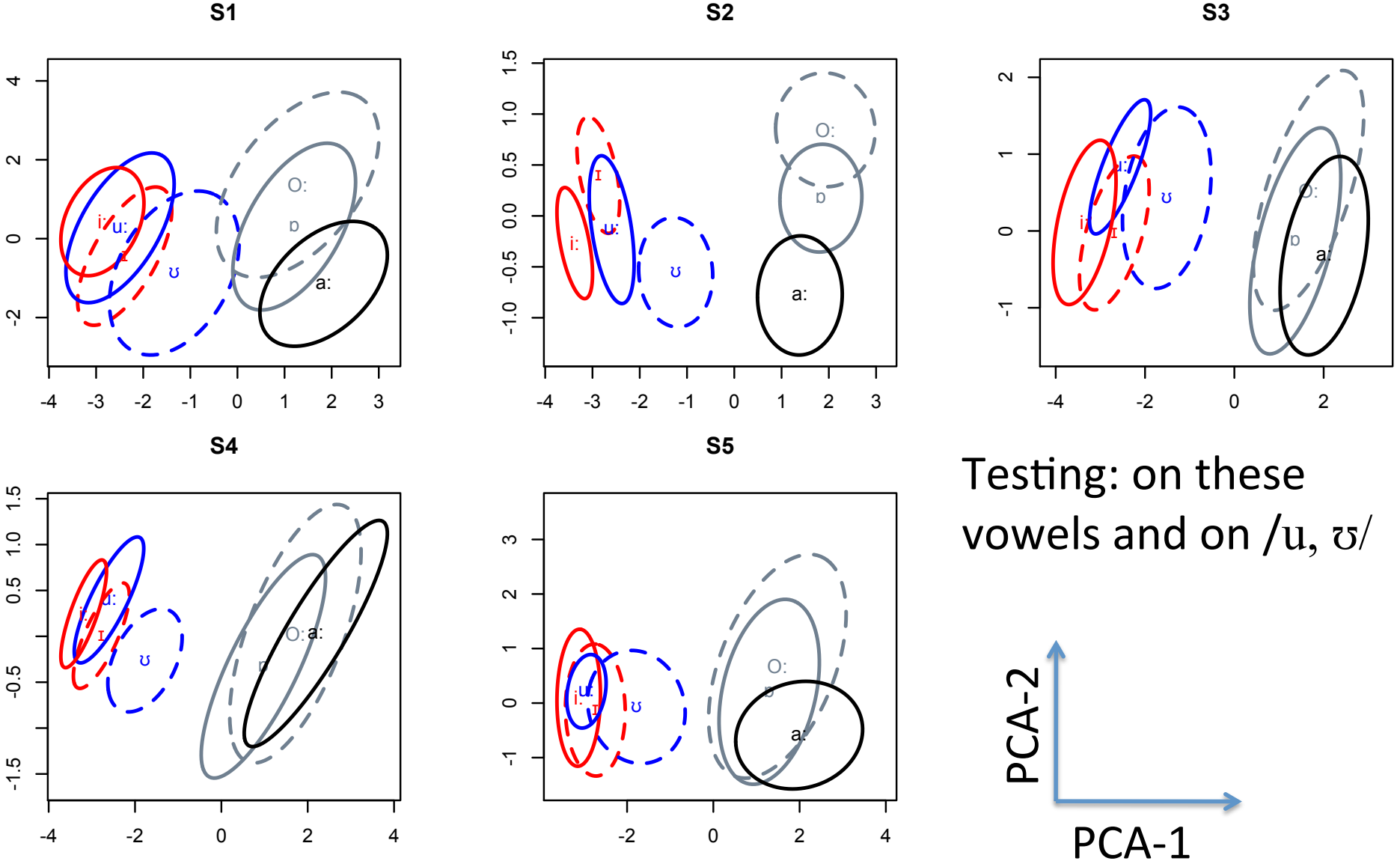


tongue tip /d/

tongue dorsum [a:]

Tongue positions of /u, ʊ/ very similar to those of /i, ɪ/

PCA analysis applied to the tongue data (6. dim) separately per speaker.
Training (calculation of eigenvectors) based only on /i, ɪ, ɔ, ɒ, a:/



Testing: on these vowels and on /u, ʊ/

Current investigation

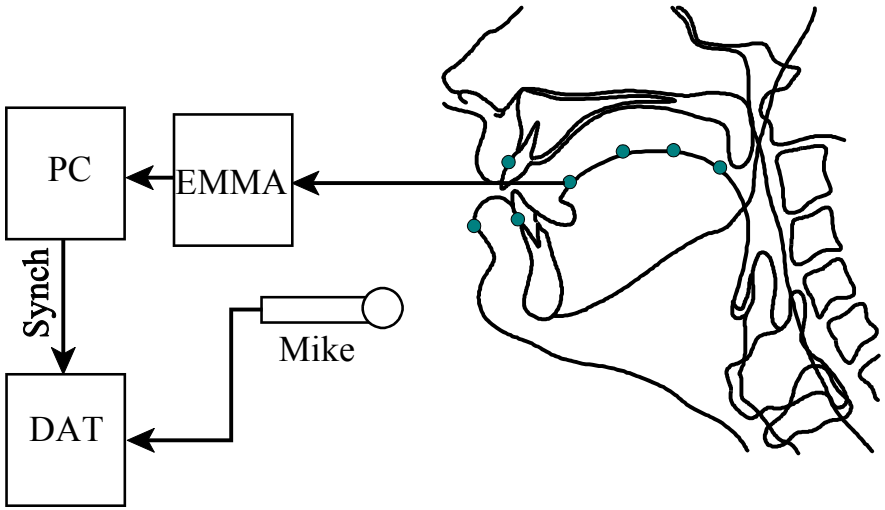
1. Are SSB /u, ʊ/ as close to /ɪ, i/ as German /ʏ, y/ are to /German /ɪ, i/?

2. Does the tongue position contribute to the acoustic separation between /i, u/ (and between /ɪ, ʊ/) in SSB – or is their acoustic distinction entirely due to lip-rounding?

3. SSB /i, u/ and German /i, y/ are almost certainly not the same (?), at least not in older SSB speakers (e.g. English *l**ea**f* vs. German *l**ie**f*). Are they different in younger speakers?

Physiology data in Standard German

7 speakers of standard German, all 15 monophthongs (8 tense, 7 lax) of German at two rates (fast and slow) and three consonantal contexts in a target word /gəCVCə/ (Hoole, 1999)

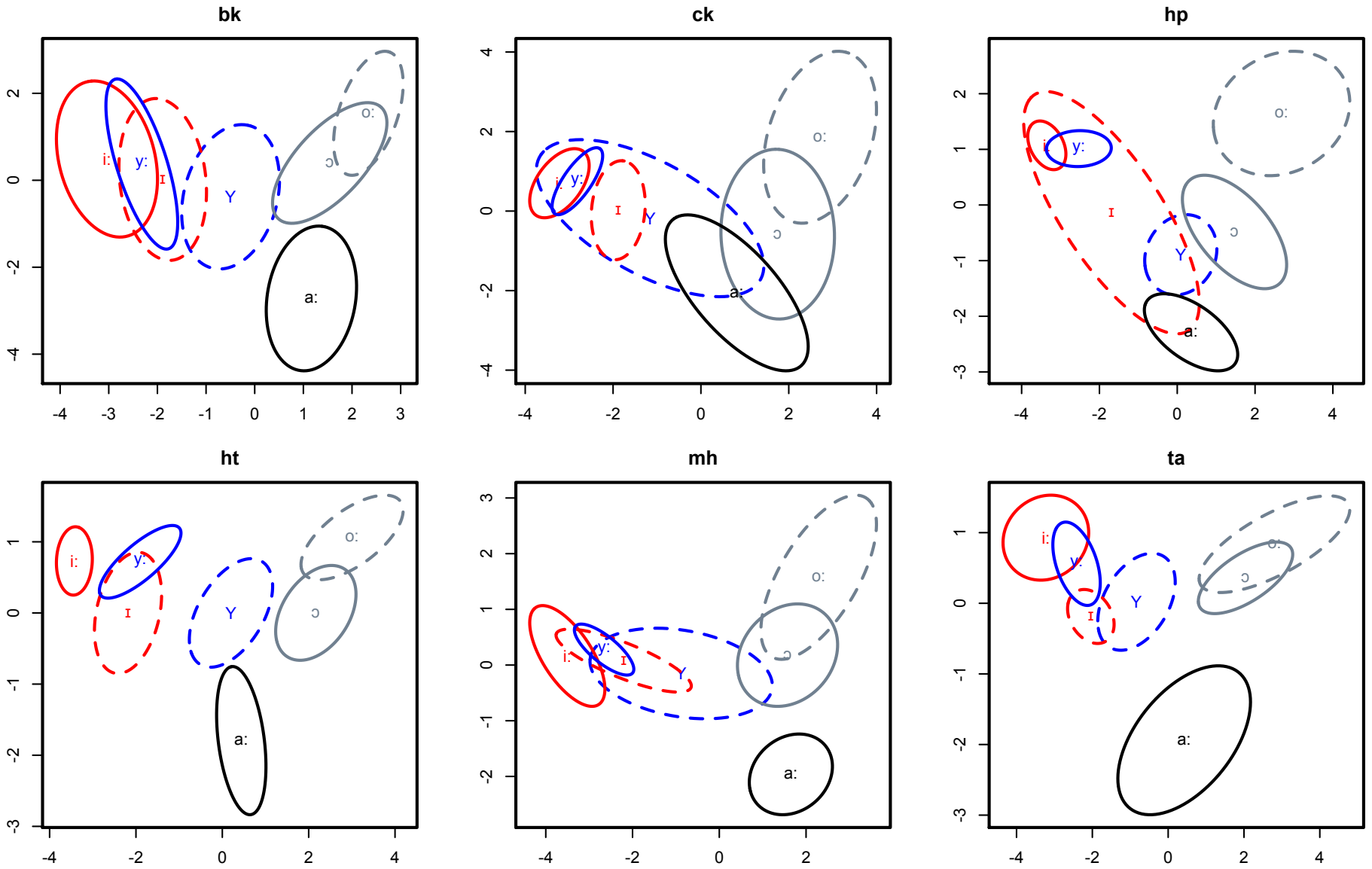


Recordings with 2D-EMMA

Analysis of tongue movement, /pVp/, V = /i:, ɪ, y:, ʏ, ɔ, o:, a:/

Speaker-specific PCA analysis on 4 tongue-X, tongue-Y positions.
Training on /i:, ɪ, ɔ, o:, a:/, testing on these vowels and on /y:, ʏ/

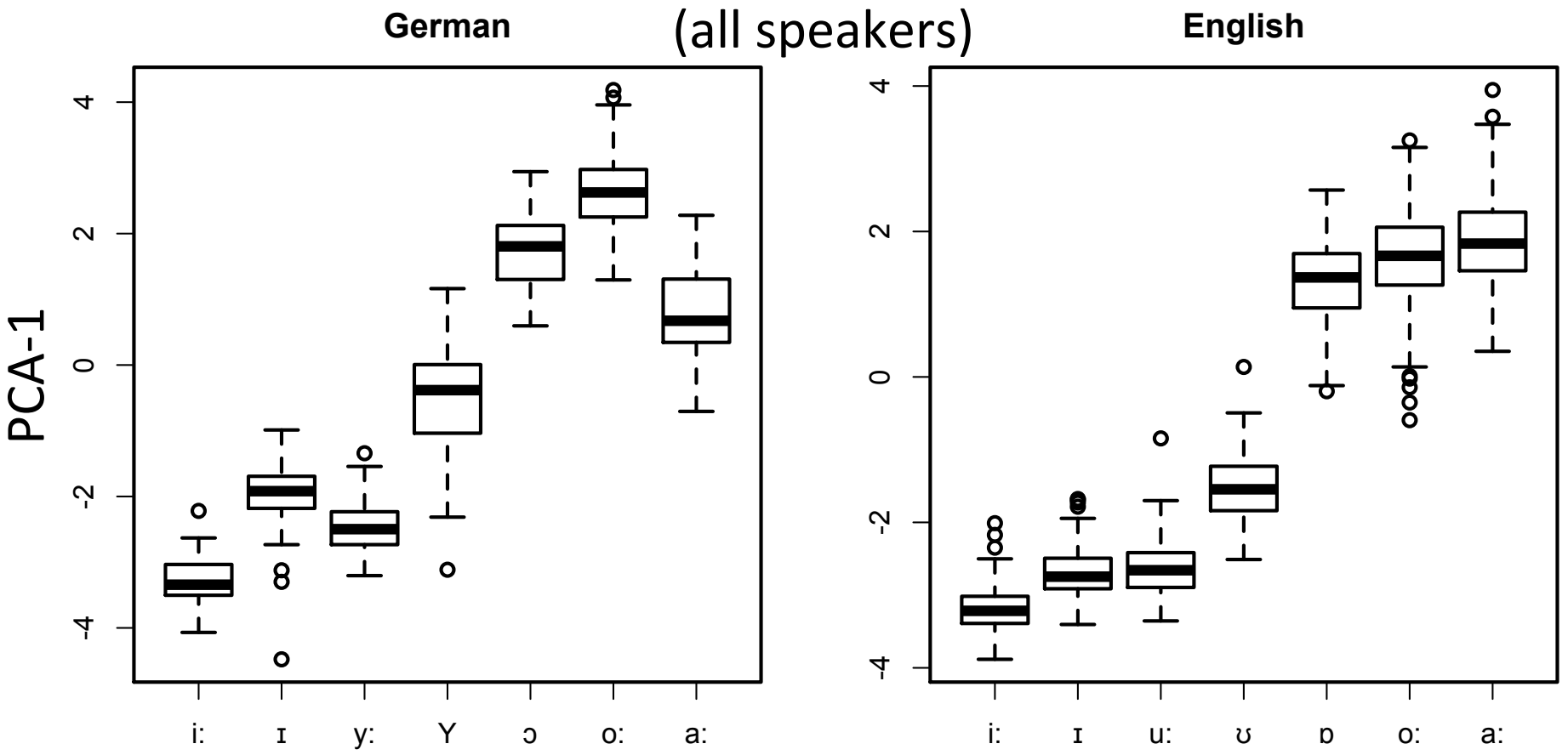
PCA-transformed tongue positions for German



/y, ʏ/ are lowered and/or retracted relative to /i, ɪ/ (as in Hoole, 1999 who used factor analysis)

English and German tongue positions

English /i, ɪ/ and /u, ʊ/ are as close to each other on PCA-1 (frontness separator) as German /i, ɪ/ and /y, ʏ/

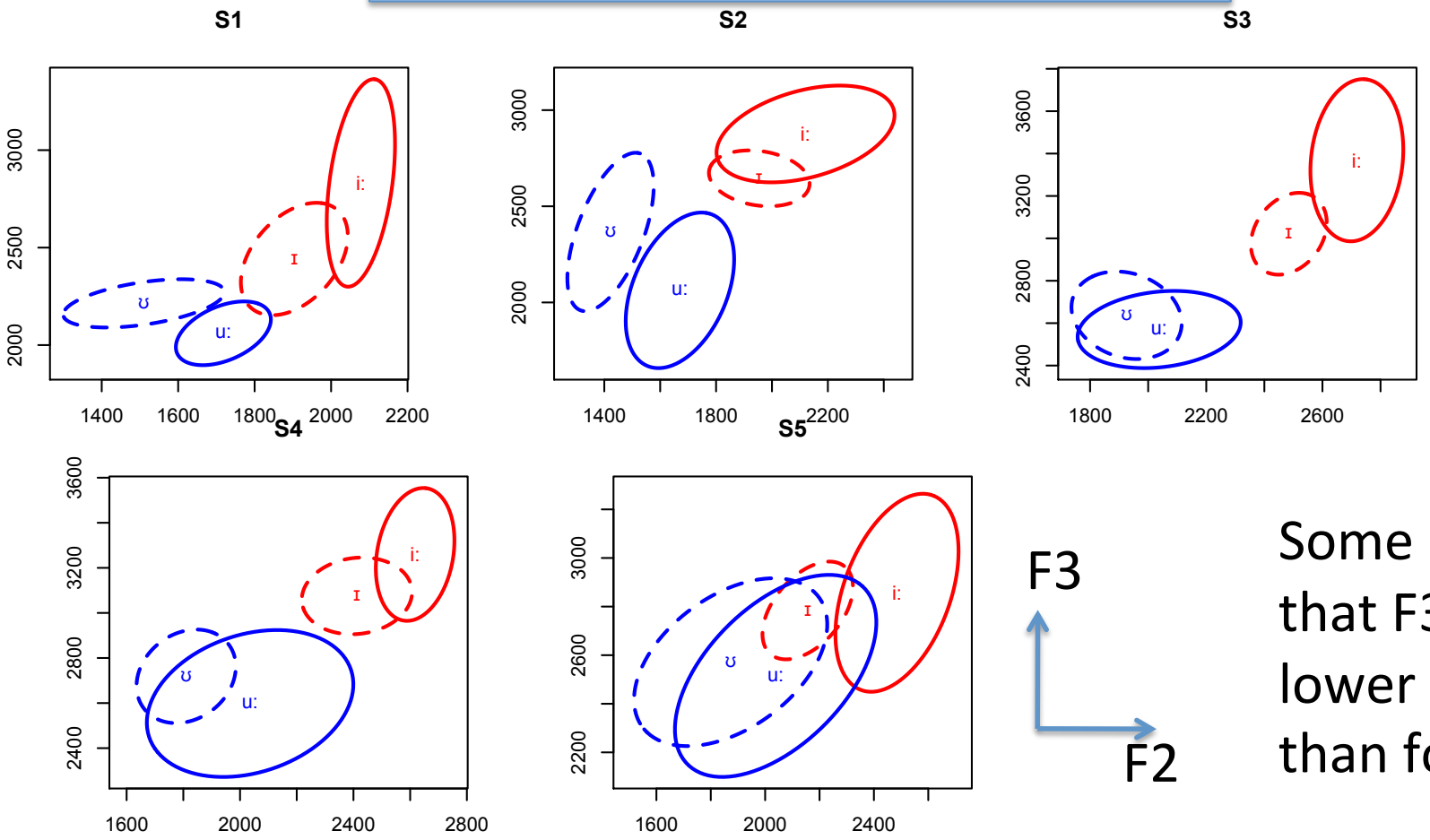


Acoustic-physiological analysis

2. Does the tongue X-Y position make any additional contribution to the acoustic /i, u/ or /ɪ, ʊ/ distinction beyond lip-rounding?

Wood (1986): "The consequences of a lower tongue body for [y] are thus to retain roughly the same F1 as for [i] and to decrease the interval between F1 and F2, reinforcing the spectra flattening. Without tongue body lowering, F1 would be lowered by the lip rounding of [y] and the total effect would be a simple downward transposition of the entire spectrum rather than spectral flattening."

Acoustic F2 x F3 formants, SSB



Some evidence that F3-F2 is lower for [u:, ʊ] than for [i:, ɪ]

Do the [i, ɪ] vs. [u, ʊ] tongue-differences enhance this acoustic distinction beyond the contributions already made by lip-spreading/rounding?

Method

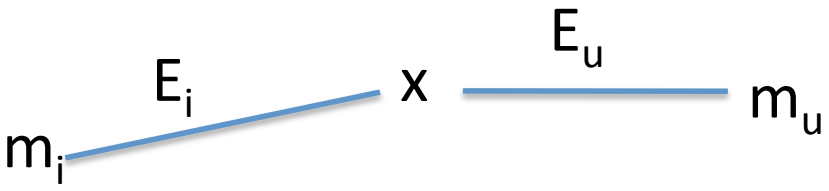
1. Determine the extent of acoustic [i, ɪ] vs. [u, ʊ] separation based on d_R, the log. Euclidean distance ratio (Harrington, Kleber, Reubold, 2008).

2. Calculate d_R in an articulatory space based on (a) only LL_X and (b) on a combination of LL_X and Tongue (PCA-1).

If the tongue position enhances the acoustic [i, ɪ] vs. [u, ʊ] separation *beyond the contribution already made by the lips*, then 1. should be better predicted from 2b than from 2a.

Log. Euclidean distance ratio

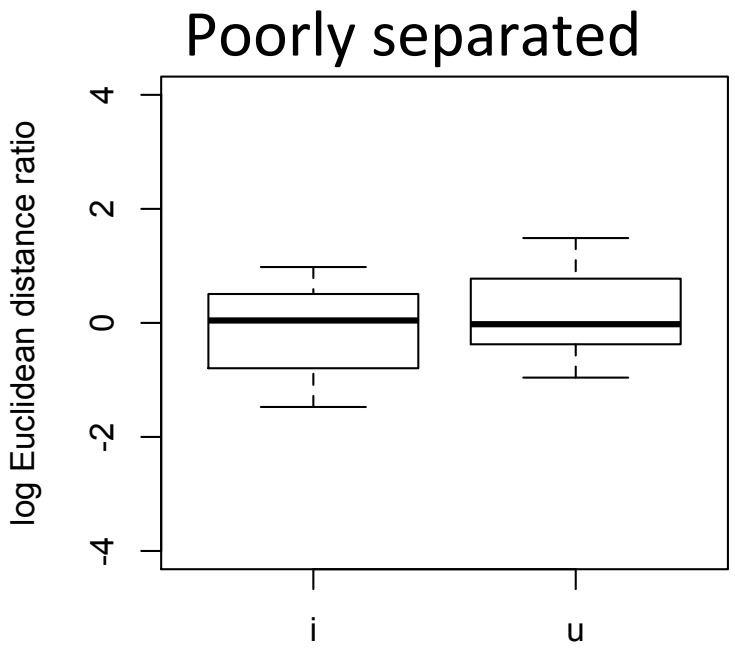
Parameter for measuring the extent to which two clusters overlap

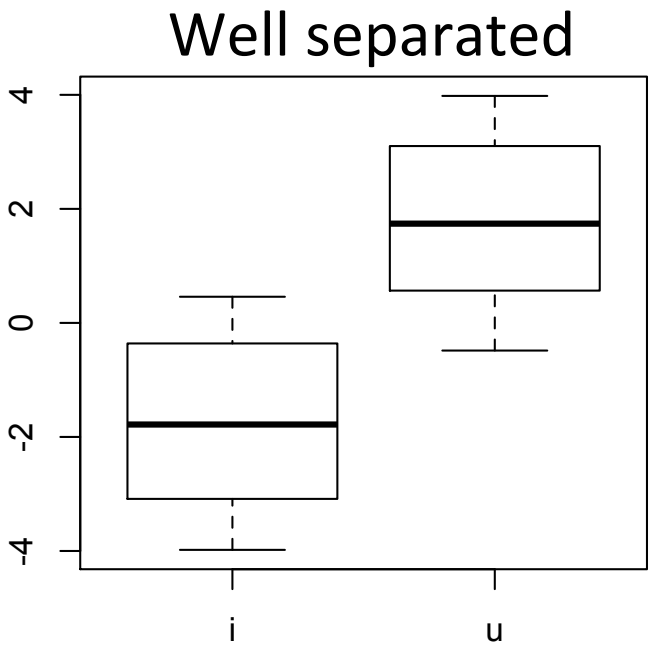


m_i, m_u, means of clusters for /i, u/

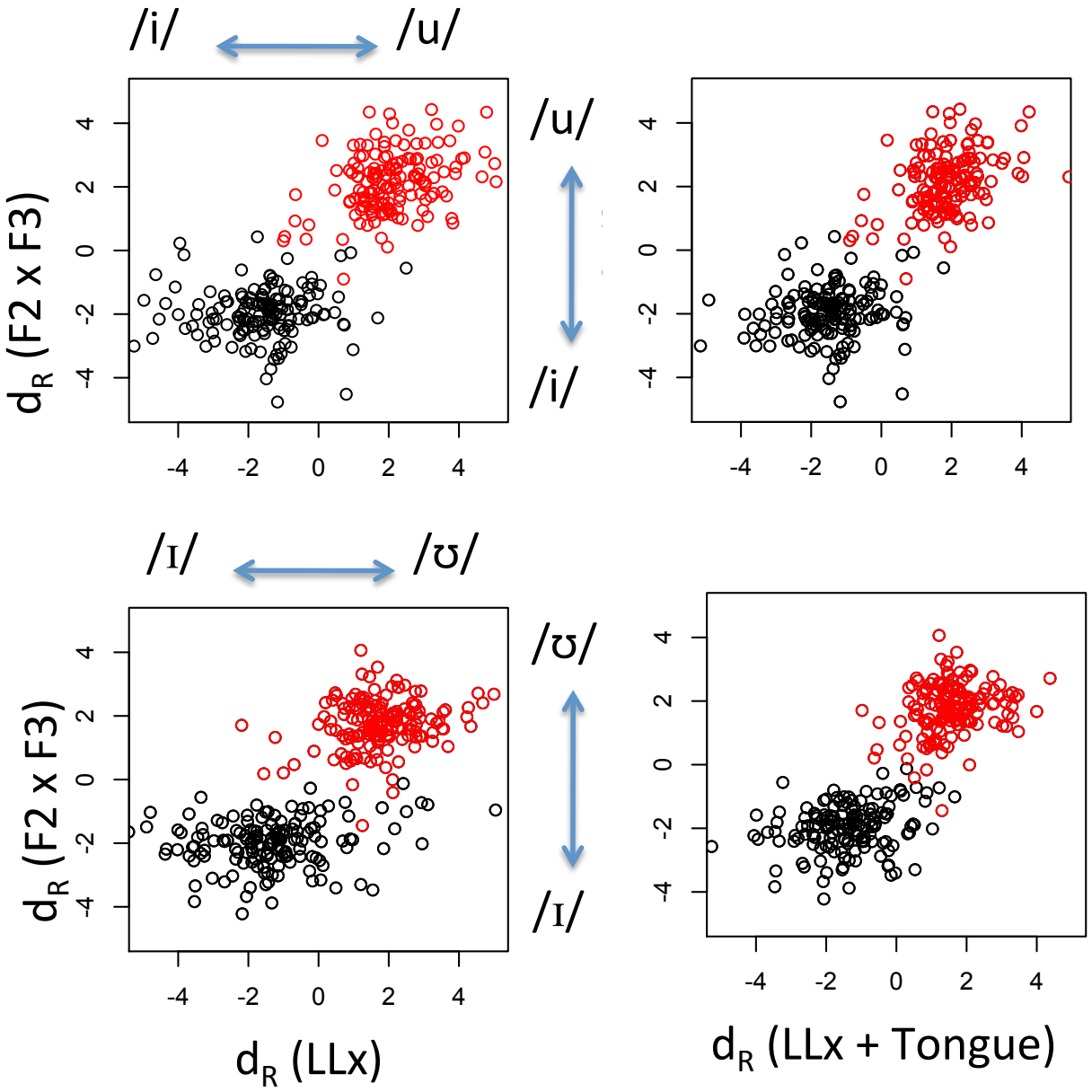
x are all the data points of /i, u/

log. Eucl. distance ratio (d_R) = $\log(E_i/E_u) = \log(E_i) - \log(E_u)$





Acoustic x Physiology distance spaces



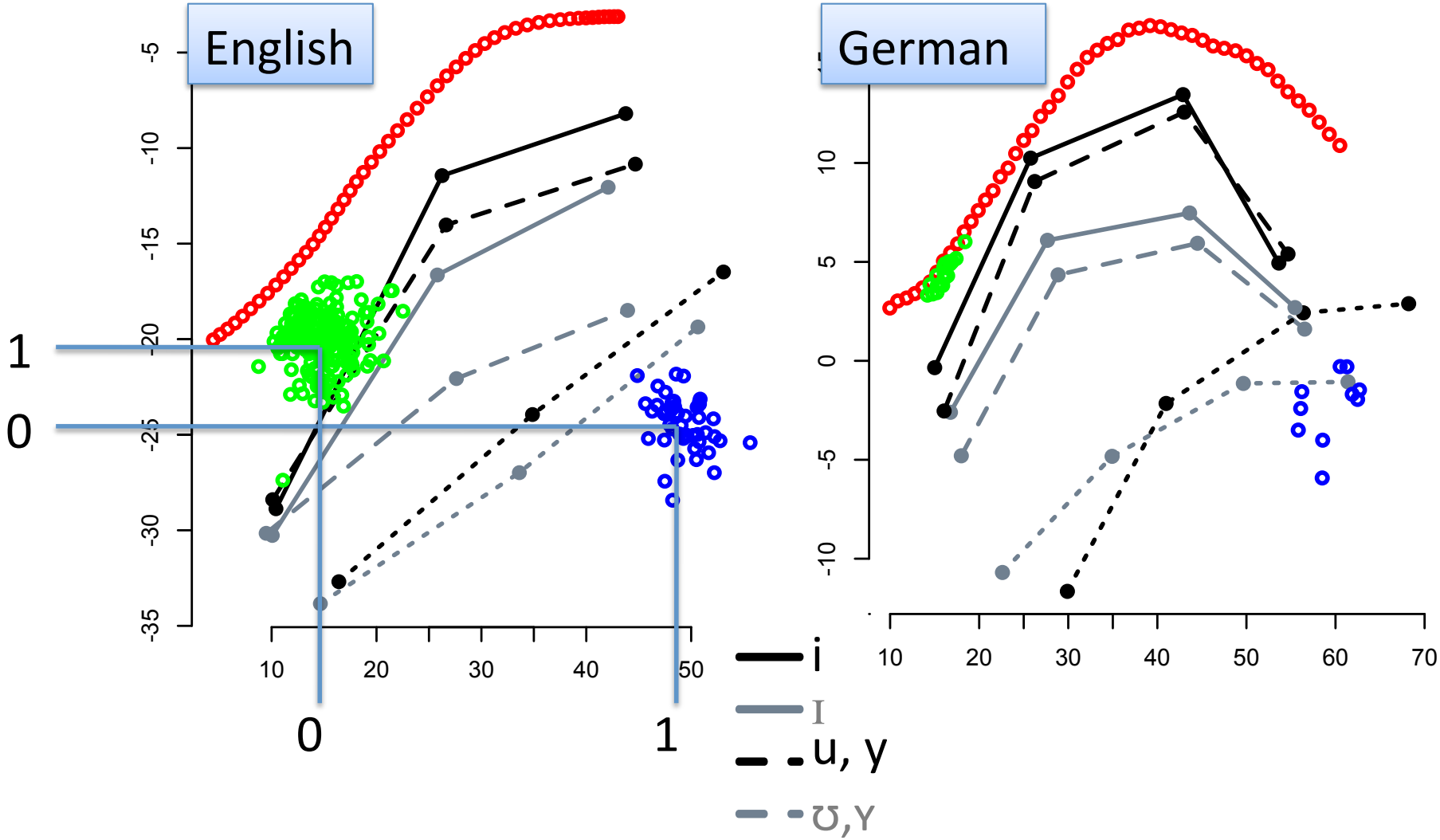
The tongue does not add any additional information to the acoustic /i, u/ or /ɪ, ʊ/ separation beyond that already provided by the lower lip in SSB

3. Differences between English /i, u/ vs. German /i, y/

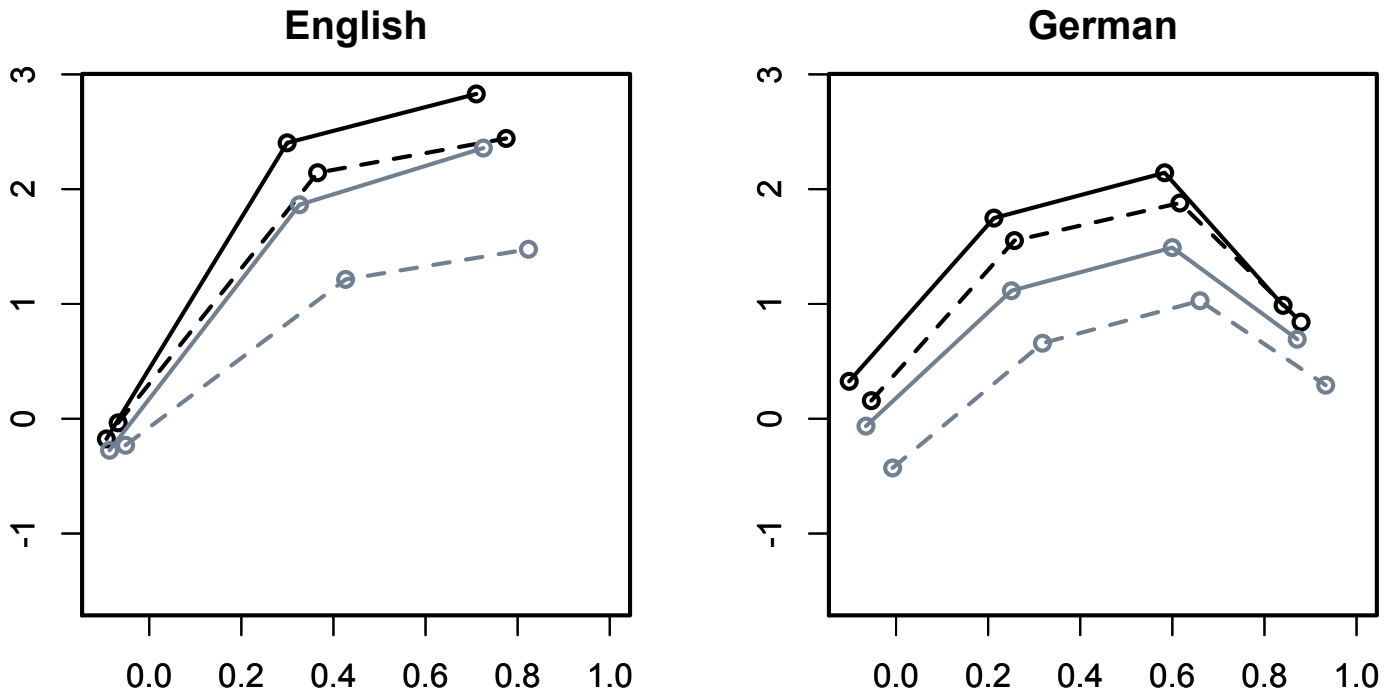
Linear rescaling of vowel space

relative to /d/ and /a:/

relative to /t/ and /a:/



Average tongue positions, all speakers



The tongue-back sensor is higher in relation to English /a:/ (0, 1) than it is in relation to German /a:/ (0, 1). Possibly "more tongue root advancement (and thus more bunching) in German" (P. Hoole, pers. comm). "But..."

...I need to think about it some more".

Preliminary conclusions

1. Are SSB /u, ʊ/ as close to /ɪ, i/ as German /ʏ, y/ are to /German /ɪ, i/?

Yes.

2. Does the tongue position contribute to the acoustic separation between /i, u/ (and between /ɪ, ʊ/) in SSB – or is their acoustic distinction entirely due to lip-rounding?

It seems to be entirely due to lip-rounding

3. SSB /i, u/ and German /i, y/ are almost certainly not the same (?), at least not in older SSB speakers (e.g. English *l**ea**f* vs. German *l**ie**f*). Are they different in younger speakers?

There may be more tongue-bunching indicative of a pre-palatal (German) vs. mid-palatal (English) position