Finding a boot to fit:

Acoustic measures of vowel quality in a real-time corpus of Glaswegian vernacular

GULP

Jane Stuart-Smith, Tamara Rathcke, Claire Timmins

Glasgow University Laboratory of Phonetics, United Kingdom

Background

/u/ is fronting towards /i/ in the acoustic vowel space in Standard Southern British English (Harrington et al. 2011), American English (Labov et al. 2006), New Zealand English (Maclagan et al 2009).

What about Scottish English? Auditorily, /u/ has been reported to be fronted, and/or central in the vowel space for a long time (McAllister 1938, Macaulay 1977, Johnston and Speitel 1983). Recent acoustic and articulatory analysis suggests that /u/ is fronted and lowered (Scobbie et al. forthcoming).

Is there evidence for fronting of Scottish English /u/ over the past 40 years, and/or has it started to lower?

Research outline

We start to tackle this question using the analysis of a real-time corpus of naturally-occurring spontaneous speech. We draw on recordings of Glaswegian vernacular speech made in 2003 (Stuart-Smith 2006) and 1972 (Macaulay 1977). The recordings were made using different equipment and various scenarios. Previous research has shown that formant measures are sensitive to a number of factors, including recording equipment (e.g. Decker and Nycz 2011), microphone placement (e.g. Plichta 2004), measurement technique (e.g. McDougall and Nolan 2007), and LPC algorithm applied (Harrison 2004).

We look at the relative placement of /u/ in the auditory space defined by formant frequencies of /i/, /a/, /u/ in Bark (cf. Harrington et al. 2011), and compare the performance of three LPC algorithms in this corpus.

Methodological issues: data quality, automatic measurement, error rates

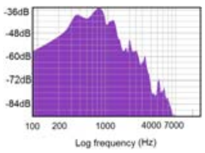


Fig. 1: Spectral energy in most of the recordings made in the 00s.

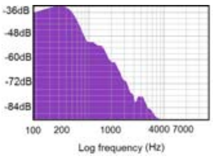


Fig. 2: Spectral energy in some poor quality recordings made in the 70s.

Tab.1: Default settings of LPC algorithms tested

Factors	Praat	EMU	SFS
Down-sampling	10 kHz	no (44kHz)	10 kHz
Filtering	no	no	high-pass at 75 Hz
Time steps	6.25 ms (25%)	5 ms (20%)	10 ms (25%)
Window length	25 ms	25 ms	50 ms
Pre-emphasis	50 Hz (+ 6dB/ octave)	500 Hz (+ 6dB/ octave)	15 kHz (- 6dB/ octave)
LPC order	10	44	10

Tab.2: Percentage of "errors" in the automatically measured formant data

Expected values	Praat	EMU	SFS
F1	57%	47%	63%
/i/ 200-450 Hz	66%	25%	19%
/a/ 700-950Hz	97%	96%	75%
/u/ 400-650 Hz	21%	21%	72%
F2	44%	59%	61%
/i/ 2000-2400 Hz	54%	75%	94%
/a/ 1200-1600 Hz	19%	36%	40%
/u/ 1300-1700 Hz	57%	64%	60%
F3 all vowels 1800-3500 Hz	2%	14%	6%

Formants can be taken *statically* (i.e. from the vowel midpoint) or *dynamically* (an average of a formant track). Dynamic measures in EMU increase the error rates by about 3% but in Praat and SFS, error rates in dynamic values are smaller (Praat by 6%, SFS by 3%)

Preliminary results: formant frequencies and Euclidean distances across the decades (based on static measures taken in Praat)

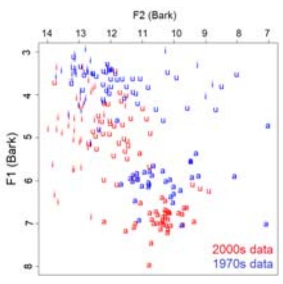


Fig. 3: F2/F1 formant plot of all tokens measured (n_1=n_2= 2 male subjects)

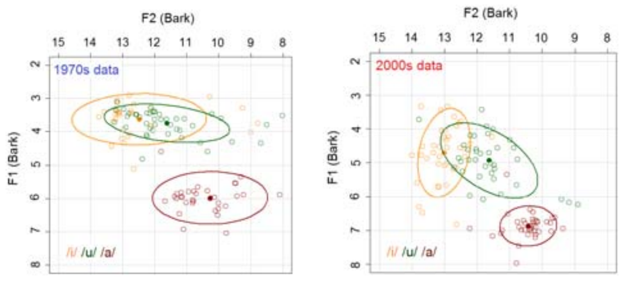
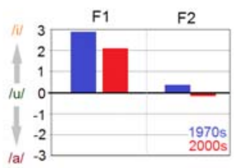


Fig. 4: F2/F1 formant plot of all tokens measured in the 70s-data (left panel, n_1= 2 male subjects) and 00s-data (right panel, n_2= 2 male subjects). Ellipses include 70% of the data.

Tab. 3: Euclidean distances between pairs of vowels calculated on the basis of F1 (close/open), F2 (back/front)

		i/a		u/a		i/u	
		70s	00s	70s	00s	70s	00s
F1	Hz	269	269	257	243	12	25
	Bark	2.35	2.2	2.23	1.93	0.12	0.23
F2	Hz	542	647	311	281	231	366
	Bark	2.22	2.6	1.35	1.20	0.87	1.38

Fig. 5: Mean d_u values calculated following the formula in Harrington et al. 2008: $d_u = log\ E_{u/a} - log\ E_{u/i}$ to visualise the averaged distance between /u/ and /i/, /a/ in the 70s and 00s



Preliminary discussion: Method

- Lower F1 values in all 70s-data were demonstrated using Praat, EMU, SFS. This may be caused by the different microphones used for the recordings (Plichta 2004). We may be able to correct this by applying a constant, if further analysis shows that the artefact is systematic and present in other vowels as well.
- None of the algorithms performs optimally by default on these data (Harrison 2004). We intend to establish a signal pre-processing/ enhancement procedure for the algorithms applied (adjust pre-emphasis factor, filter frequencies, sampling rate, the LPC-order). Our goal is to reduce error rates down to 10-20%, exclude erroneous data, and work with the remaining sample.

Preliminary discussion: Sound Change

- Can we infer sound change at this point? Comparison of the relative proximity measure d_u between 70s and 00s does suggest possible shift in /u/-quality but not fronting towards /i/ as in other varieties of English. These very preliminary results suggest lowering in real time (cf. the articulatory data for these vowels in Scobbie et al. forthcoming).
- The classic representation in terms of F2/F1 space does not include F3 which relates to lip rounding and is an important parameter for this contrast (Harrington et al. 2011). In future work, we intend to explore this vowel contrast beyond the F2/F1 space.

References De Decker and Nycz (2010): For the record: which digital media are good enough for sociophonetics? *Poster presented at NWAV 39, University of Texas-San Antonio.* Harrington, Kleber, Reubold, (2008). Compensation for articulation. *JASA 123*; Harrington, Kleber, Reubold (2011) The contributions of the lips and the tongue to the diachronic fronting of high back vowels in Standard Southern British English, *JIPA;* Harrison (2004): Variability of formant measurements. *MA thesis University of York*. Plichta (2004) Scobbie, Lawson, Stuart-Smith (forthcoming): The frontness of Scottish English /u/: a socially-stratified ultrasound tongue imaging study. *Italian Journal of Linguistics.* Macaulay, R. (1977), Language, Social Class and Education: A Glasgow Study.Johnston and Speitel 1983 Stuart-Smith (2007) : The influence of the media. In: Llamas, C., Mullany, L. and Stockwell, P. (eds.) McDougall and Nolan (2007) Discrimination of speakers using the formant dynamics of /u:/ in British English. Proceedings of the 16th ICPhS.

Acknowledgments The authors would like to thank Mark Huckvale and Michel Scheffers for their help with preparing the SFS and EMU data for comparative analysis.

The Leverhulme Trust