HIGH BACK VOWELS IN SCOTTISH GAELIC

Claire Nance

University of Glasgow
c.nance.1@research.gla.ac.uk

ABSTRACT

This study provides an acoustic phonetic analysis of some of the vowels in an endangered language with little phonetic documentation, Scottish Gaelic. It tests previous mainly impressionistic analyses which claim Scottish Gaelic has phonemic vowel length, and contrasts four high back vowels /u ɯ o ɤ/. Results suggest four vowels are indeed contrasted, and that phonemic /u/ is divided into two phonetically distinct allophones. Phonemic vowel length is robustly maintained, but younger and older speakers differ in some areas for vowel quality: for younger speakers one allophone of /u/ is moving closer to /i/, and the other allophone of /u/ has merged with /o/.

Keywords: Vowels; sociophonetics; Scottish Gaelic; language change; vowel length.

1. INTRODUCTION

Previous impressionistic analyses of Scottish Gaelic (henceforth Gaelic) have identified nine short monophthongs and nine long monophthongs [1, 14]. These early descriptions did not use modern IPA, but an acoustic study has interpreted four high back vowels: /u ɯ o ɤ/ [9]. This is a highly unusual system and is only found in one other world language, Apinayé [9]. The reported vowels in Gaelic also vary substantially according to consonantal context, especially the backing of /u/ allophones preceding a velarised sonorant.

Approximately half of the current 58,000 speakers of Gaelic live in the traditional heartlands of the language in the far north and west of Scotland. The majority of the others live in urban central Scotland. The language is in decline, but undergoing intense revitalization efforts. All speakers of Gaelic are now bilingual in English and Gaelic, and in many cases English is slowly encroaching over language domains traditionally occupied by Gaelic [13]. This paper examines six speakers from a traditional Gaelic speaking area, the Isle of Lewis, in the Outer Hebrides.

Previous studies of bilingual speakers in situations of language decline indicate a loss of contrasts not maintained in the dominant language (English in this case), and a general tendency towards simplification of the system [2]. English vowels are distinguished by a combination of length and quality, rather than length or quality, and /ɯ ɤ/ are not phonemic vowels in English. This section of the Gaelic vowel space is therefore an interesting area to investigate the possibility of language change.

The research questions addressed here are: Does Gaelic contrast four high back vowels /u ɯ o ɤ/ for length and also for quality? Is this system undergoing change?

2. METHODS

2.1. Participants

Recordings were obtained from six native speakers of Lewis Gaelic. Three were aged 20-24, and three were aged 44-55. The younger speakers and two of the older speakers were female, and one older speaker was male.

2.2. Recordings

Recordings were made in a noise-attenuated sound studio using a Sennheiser cardioid condenser microphone, at 44,000Hz sampling rate with 16bit quantization. Words containing all of the reported 18 stressed vowels in Gaelic in a variety of consonantal contexts were couched in a carrier phrase and presented on a computer screen. Three repetitions of each word were elicited. 720 words containing vowel tokens were taken from these recordings.

2.3. Analysis

Vowel onset and offset were segmented on the waveform in Praat. Formant and durational analyses were conducted in Emu/R [6]. Vowel formants were extracted using a 35ms Blackman window. The LPC analysis order was 38 for back vowels and 32 for front vowels. All formant tracks were checked and approximately 25% of the tokens required some hand correcting.

The first two formants were measured at vowel midpoint. These formant values were normalized in NORM using the Watt and Fabricius (modified) method in order to reduce the effects of physiological differences between the speakers and allow sociolinguistic comparison [4]. This method of normalization uses formant values from /i/ and /a/ as reference points and normalizes F1 and F2 values only. Formant frequencies were converted to Bark in R. Durations were measured using the Emu package in R.

Statistical testing was carried out in SPSS: durational differences were tested within speakers via t-tests, and the effect of following consonantal context on duration was tested with a multiple linear regression model. Formant values were analysed via mixed design ANOVAs on the vowel contrasts of interest: F2 for the high back unrounded vowels compared to their rounded counterparts. Phonemic Vowel and Vowel Length were within subjects factors, and Age Group was a between subjects factor. Multiple linear regression models were constructed to investigate which consonantal contexts influenced vowel formants. Nothing following the vowel was set as the baseline context. The extent to which younger speakers displayed vowel mergers in contexts identified from the vowel plots was tested using MANOVAs with F1-F2 as dependent variables, and quantified using Pillai-Bartlett statistics [5, 8].

3. RESULTS

3.1. Durational

T-tests confirmed that phonemically long vowels are longer for each speaker. Durations are displayed in Table 1.

Table 1: Vowel durations (ms) for each speaker: mean (standard deviation) number of words.

Speaker	Short vowel	Long vowel	*t*	*p*
Y1	96.3 (21.6) 24	233.3 (34.2) 16	-15.6	< .001
Y2	82.9 (23.5) 24	165.2 (37.1) 17	-8.07	< .001
Y3	71.5 (18.9) 24	177.4 (32.2) 16	-13.1	< .001
O1	98.3 (36.8) 24	245.0 (43.3) 17	-11.7	< .001
O2	109.4 (31.2) 24	255.3 (55.2) 17	-10.9	< .001
O3	84.4 (24.9) 24	230.7 (43.8) 17	-12.4	< .001

The final multiple linear regression model investigating vowel duration according to context is reported at Table 2: long vowels were longer, vowels with a following /h/ were longer, vowels with a following palatalized, nasal or velar consonant were shorter, and younger speakers produced shorter vowels.

Table 2: Best regression of vowel duration

Adj. R^2 = 0.77	Coefficient	*t*	*p*
Constant	31.32	2.79	.006
Length	118.02	21.88	< .001
Palatalised	-24.10	-3.15	.002
Nasal	-29.30	-3.11	< .001
Velar	-31.14	-4.07	< .001
/h/	14.90	-3.92	< .001
Younger	-29.96	-6.61	< .001

3.2. Formant analysis

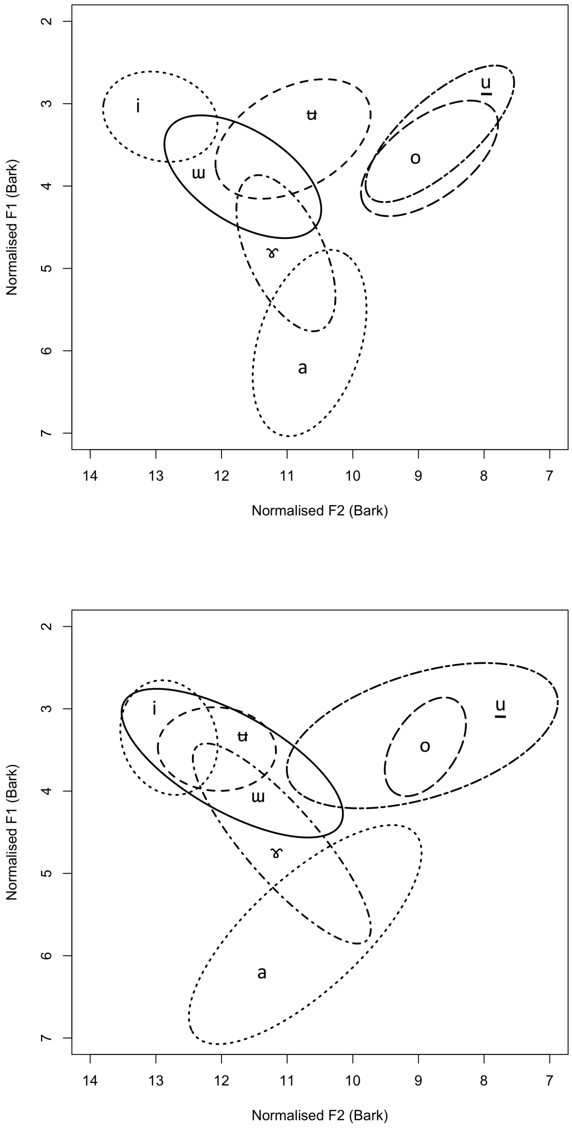
3.2.1. Vowel system

Vowel plots for the speakers are displayed in Figures 1 and 2. Ellipses show 95% confidence intervals. A visual inspection of the vowel data indicated the following: firstly the vowels labeled as /ɯ ɤ/ do display separate distributions from the back rounded vowels and are relatively central in the acoustic space. Secondly, /u/ is distributed into two very distinct spaces. These are considered separately within the statistical analysis following [9]. /u/ is most commonly central [ʉ], but preceding velarised consonants it is retracted [u̠]. Thirdly, there are differences by age: for younger speakers central [ʉ] is further forward towards /i/, and retracted [u̠] is merged with /o/.

This paper firstly asks whether the vowels described as high back unrounded are distinct from their rounded counterparts. A mixed design ANOVA of F2 values compared /ɯ/ and [u̠] and secondly /ɤ/ and /o/. /ɯ/ and [u̠] are significantly different for F2 ($F(1,4) = 31.58$, $p = .005$). A significant interaction between vowel quality and length indicated that short [u̠] has a higher F2 (more central) than long [u̠] ($F(1,4) = 20.88$, $p = .01$). Overall /ɤ/ and /o/ are different from each other ($F(1,4) = 8.99$, $p = .04$). A significant interaction between vowel quality and length indicated that short /o/ has a higher F2 than long /o/. ($F(1,4) = 33.59$, $p = .004$).

It was also observed from the plots that /u/ divides into two distinct allophones. These two allophones, [ʉ] and [u̠], are significantly different along the F2 dimension ($F(1,4) = 10.37$, $p = .032$). A significant interaction between vowel length and vowel quality indicated that short [u̠] has a higher F2 than long [u̠] ($F(1,4) = 102.79$, p = .001).

Figure 1: Short vowels: older speakers (top); younger speakers (bottom).



3.2.2. Contextual variation

The final regression models of formant values and following consonantal context are in Table 3 (F1) and Table 4 (F2). The models indicate that a velar or alveolar following context raises F1; a nasal, labial, or lateral context raises F2; and a velarised, velar or vowel following context lowers F2.

Table 3: Best regression of F1 according to context.

Adj. $R^2 = 0.20$	Coefficient	*t*	*p*
Constant	3.66	54.79	< .001
Palatalised	0.30	1.81	.072
Velar	0.40	2.37	.019
Alveolar	1.48	7.97	< .001

Figure 2: Long vowels: older speakers (top); younger speakers (bottom).

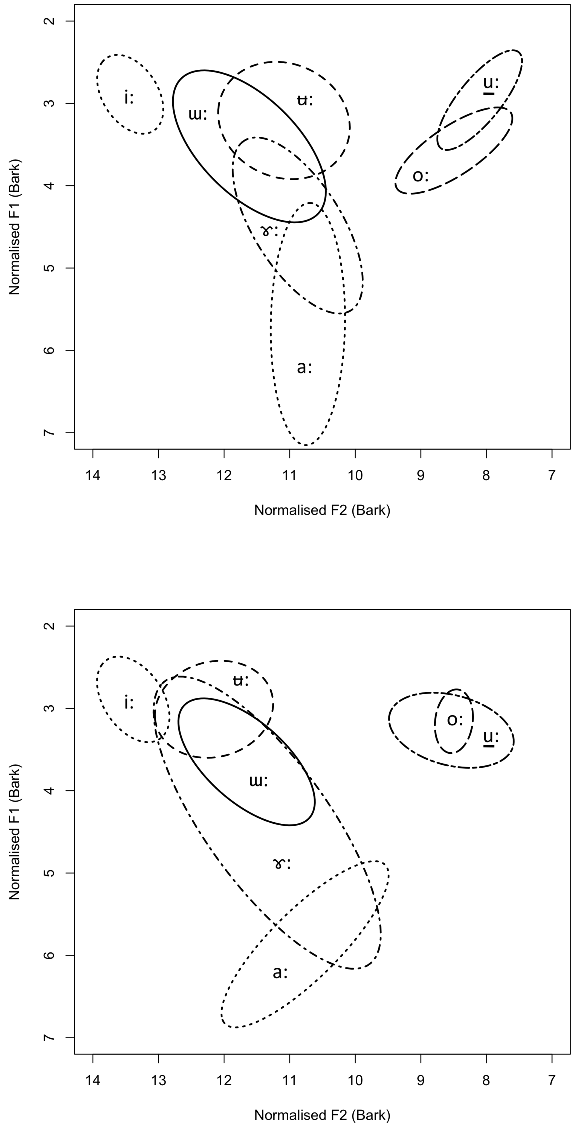


Table 4: Best regression of F2 according to context.

Adj. $R^2 = 0.36$	Coefficient	*t*	*p*
Constant	10.43	41.09	< .001
Velarised	-2.60	-7.91	< .001
Nasal	1.50	3.99	< .001
Velar	-1.08	-4.41	< .001
Labial	1.15	5.04	< .001
Lateral	0.85	3.06	.003
Vowel foll.	-0.96	-3.61	< .001
Younger	0.32	2.09	.037

Also, younger speakers have overall a higher F2 than older speakers.

3.2.3. *Differences between age groups*

The investigation of vowel change was focused on two areas identified from the visual analysis of the vowel plots: the movement of [ʉ] towards /i/ and the merger of [u̠] and /o/. Pillai-Bartlett statistics were used as a gradient measure of fronting and merger [5, 8]. The lower the Pillai-Bartlett statistic, the more advanced the merger and the less distinct the phonemic vowel categories. MANOVAs were run with F1 and F2 as dependent and Phonemic Vowel as independent variables, on [ʉ] and /i/, and on [u̠] and /o/. Different MANOVAs were run for younger, older, and for the individual speakers. Overall, all speakers display separate /i/ and [ʉ] F1-F2 distributions (younger V = .669, $F(2,38)$ = 37.5, p < .001; older V = .865, $F(2,38)$ = 124.7, p < .001). For [u̠] and /o/ only older speakers display significantly separate distributions (older V = .462, $F(2,38)$ = 12.9, p < .001). Pillai-Bartlett statistics in Table 4 indicate that in general younger speakers produce [ʉ] closer to /i/, and less distinct [u̠] and /o/.

Table 4: Pillai-Bartlett statistic for each speaker individually, and for each age group.

Speaker	Pillai-Bartlett value [ʉ] and /i/	Pillai-Bartlett value [u̠] and /o/
Old 1	.875	.704
Old 2	.856	.542
Old 3	.908	.288
Older	.865	.462
Young 1	.660	.250
Young 2	.655	.027
Young 3	.866	.166
Younger	.669	.057

4. DISCUSSION

The formant data here show that acoustically the high back unrounded vowels in Gaelic appear central. This may be due to the fact that they are produced with spread lips, as [1, 14] suggest, and this lowers F2 [12]. However, Gaelic /ɯ ɤ/ have a higher F2 than /ɯ ɤ/ in other languages e.g. Korean [10] and Beijing Chinese [11].

The four vowels /u ɯ o ɤ/ do display separate distributions and there is no evidence of differences between older and younger speakers here. Vowels in Gaelic can be distinguished by length as well as quality. The vowels examined here did vary according to consonantal context. The most striking variation is the two very distinct allophones of /u/: a back variant appears preceding phonemically velarised consonants, but the most commonly occurring variant is central [ʉ]. A velar or velarised consonantal environment did significantly lower F2 overall, in keeping with previous studies of velarisation [3].

This paper has identified differences between older and younger speakers in two areas: firstly, younger speakers display a merger between [u̠] and /o/. Secondly, [ʉ] is closer to /i/ indicating Scottish Gaelic is another example of a language exhibiting /u/ fronting [7].

5. CONCLUSION

Gaelic does contrast the four vowels /u ɯ o ɤ/ by quality and also by length, not a combination of the two as in English. The Gaelic vowel system is undergoing some changes: /o/ now appears to be the acoustically high back corner vowel for younger speakers, and central [ʉ] is moving towards /i/.

6. REFERENCES

[1] Borgstrøm, C. 1940. *The dialects of the Outer Hebrides*. Oslo: Norsk Tidsskrift for Sprogvidenskap.

[2] Campbell, L., Muntzel, M. 1989. The structural consequences of language death. In Dorian, N. (ed.), *Investigating obsolescence.* Cambridge: CUP.

[3] Carter, P., Local, J. 2007. F2 Variation in Newcastle and Leeds English liquid systems. *JIPA* 37, 183-199.

[4] Fabricius, A., Watt, D., Johnson, D. 2009. A comparison of three speaker-intrinsic vowel formant frequency normalization algorithms for sociophonetics. *Language Variation and Change* 21, 413-435.

[5] Hall-Lew, L. 2010. Improved representation of variance in measures of vowel merger. *Proc. of meetings on acoustics.* Baltimore.

[6] Harrington, J. 2010. *The phonetic analysis of speech corpora.* Oxford: Wiley-Blackwell

[7] Harrington, J., Kleber, F., Reubold, U. 2011. The contributions of the lips and tongue to the diachronic fronting of high back vowels in Standard Southern British English. *JIPA* 41, 27-48.

[8] Hay, J., Warren, P., Drager, K. 2006. Factors influencing speech perception in the context of a merger-in-progress. *Journal of Phonetics* 34, 458-484.

[9] Ladefoged, P., Ladefoged, J., Turk, A., Hind, K., Skilton, S-J. 1998. Phonetic structures of Scottish Gaelic. *JIPA* 28, 1-41.

[10] Lee, H. 1999. Korean. In *Handbook of the IPA.* Cambridge: CUP.

[11] Lee, W-S., Zee, E. 2003. Standard Chinese (Beijing). *JIPA* 33, 109-112.

[12] Lindblom, B., Sundberg, J. 1971. Acoustical consequences of lip, tongue, jaw, and larynx movement. *JASA* 50, 1166-1179.

[13] MacKinnon, K. 2010. Scottish Gaelic today. In Ball, M., Muller, N. (eds), *The Celtic languages*. London: Routledge.

[14] Oftedal, M. 1956. *A linguistic survey of the Gaelic dialects of Scotland.* Oslo: NT for Sprogvidenskap.