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Research Article

Phonetic variation in Scottish Gaelic laterals

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ABSTRACT

This paper is an acoustic investigation of laterals in contemporary Scottish Gaelic. Scottish Gaelic is described as having three phonemic laterals /l̪ˠ l̪ʲ l/, which have previously been the subject of small-scale acoustic and static palatographic work. I expand on previous acoustic studies, including static and dynamic formant measures, and consider data from the diverse contemporary Gaelic-speaking population including [1] older speakers in a Gaelic-heartland area, [2] middle-aged speakers living in Glasgow, [3] adolescent speakers in immersion education in a heartland area, [4] adolescents in immersion education in Glasgow. Results suggest overall maintenance of the triple lateral system, but with substantial variation in the production of (phonemically) palatalised laterals in particular, which some young Glaswegians do not produce. These results are discussed with reference to language change in language revitalisation contexts, language contact, and modes of acquisition in revitalisation contexts.

1. Introduction

This paper has two aims, firstly to provide an account of phonetic variation in a context of language obsolescence and revitalisation, and in doing so, secondly, to contribute a descriptive account of laterals in contemporary Scottish Gaelic. The language is described as having three distinct lateral phonemes (Borgstrøm, 1940; Dorian, 1978; Hamp, 2010; Ladefoged, Ladefoged, Turk, Hind, & Skilton, 1998; Oftedal, 1956; Ó Dochartaigh, 1997;Shuken, 1980; Ternes, 2006), but this typologically unusual system has, as yet, been subject to little acoustic phonetic investigation. The three described laterals are a dental velarised lateral /l̪ˠ/, a dental palatalised lateral /l̪ʲ/, and an alveolar lateral /l/. Here, auditory, static acoustic, and dynamic acoustic analyses are presented describing these laterals in word-initial and word-medial position and I examine the phonetic justification for three distinct laterals in previous descriptions of the language.

The main aspect to this paper is to examine lateral production in the social context of Scottish Gaelic obsolescence and revitalisation. Previous studies of such language contexts have described rapid and extensive language change with different generations of speakers producing differing language systems (Dorian, 1981, 1989; Jones, 1998). Here, lateral productions are investigated among different groups of speakers designed to represent some of the increasingly diverse social groups existing within the Scottish Gaelic-speaking community. The speakers considered are [1] older speakers living in a rural Gaelic-heartland community, the Isle of Lewis, [2] middle-aged speakers from the Isle of Lewis working in Glasgow, [3] adolescent speakers living in the Isle of Lewis and attending Scottish Gaelic-immersion schooling, [4] adolescent speakers living in Glasgow and attending Scottish Gaelic-immersion schooling.

In the remainder of this section I provide an introduction to previous phonetic studies of lateral sounds, specifically focussing on Scottish Gaelic and closely related Irish. A more general introduction to the social context of Scottish Gaelic is then provided, and the specific research questions addressed in this paper (Section 1.3). Section 2 describes the general method used in this study including recruiting participants and recording setup. Section 3 describes the initial auditory analysis and results, Section 4 describes the static acoustic analysis, and Section 5 describes the dynamic acoustic analysis. Section 6 gives a results summary, then Section 7

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discusses these results and provides some explanations for patterns in the data. Finally, Section 8 concludes the paper and provides some directions for future research.

The language 'Scottish Gaelic' is referred to as 'Gaelic' [galɪk] throughout the rest of this paper, as is customary in the Gaelic-speaking community.

1.1. Articulation and acoustics of lateral sounds

Laterals have been described a complex set of articulations, characterised by airflow around a central tongue occlusion (e.g. Laver, 1994, 306 and Ladefoged & Maddieson, 1996, 182). Laterals are mostly produced with tongue tip or blade contact in the dental or alveolar region (Ladefoged & Maddieson, 1996, 183), although some languages also exhibit post-alveolar, palatal and velar laterals. Articulatory studies note that in a lateral articulation, the tongue is compressed inwards creating a convex tongue body shape (Narayanan & Alwan, 1997; Oliveira, Martins, Teixeira, & Sá-Couto, 2011).

Scottish Gaelic is described as having three phonemic lateral sounds /l̪ˠ l̪ʲ l/ (Borgstrøm, 1940; Dorian, 1978; Hamp, 2010; Ladefoged et al., 1998; Oftedal, 1956; Shuken, 1980; Ternes, 2006). This is part of a historical alternation between velarised and palatalised consonants, which extends across the consonant system of Scottish Gaelic and Irish. In Old Irish, there was a four-way contrast between laterals. This consisted of a dental velarised lateral and a dental palatalised lateral, which were realised as an alveolar velarised lateral and an alveolar palatalised lateral respectively in mutation environments (Ní Chasaide, 1999). 'Mutation' here refers to the morphophonological alternations occurring in the Celtic languages, see for example Ball and Müller (2009). In modern Irish and modern Scottish Gaelic, the two velarised laterals merged to a dental velarised lateral, and the alveolar palatalised lateral lost its palatalisation (Ní Chasaide, 1979, 1999). This is schematised in Fig. 1.

The dental velarised lateral is said to involve substantial tongue body retraction, similar to results found in studies of 'dark' /l/ (e.g. Carter & Local, 2007; Gick, Campbell, Oh, & Tamburri-Watt, 2006; Narayanan & Alwan, 1997; Recasens, 2004; Recasens & Espinosa, 2005; Recasens, 2012; Sproat & Fujimura, 1993). Similar to descriptions in Recasens and Espinosa (2005), static palatographic studies of Gaelic /l̪ˠ/ have shown this sound involves dental tongue tip contact (Ladefoged et al., 1998; Shuken, 1980).

Previous research found Gaelic /l/ to be produced with a more retracted tongue tip contact, and little or no audible tongue body retraction (Ladefoged et al., 1998; Shuken, 1980). This lateral is similar to descriptions of 'clear' /l/ in other languages, which is described as having little tongue body retraction/raising (e.g. Gick et al., 2006; Sproat & Fujimura, 1993). In the case of Gaelic /l̪ʲ/, palatal and dental contact is noted in Shuken's (1980, 279) static palatographic study, leading Shuken to conclude this lateral is indeed palatalised rather than palatal. This approach is also followed in Ladefoged et al. (1998). Some variability in place of articulation for this sound is noted in the transcriptions of Ó Dochartaigh (1997, 128), but in this study I follow Shuken and Ladefoged's descriptions in referring to this lateral as palatalised, rather than palatal.

Formant values of Scottish Gaelic, and closely related Irish Gaelic, laterals are collected in Ní Chasaide (1979), Shuken (1980) and Ladefoged et al. (1998). Ní Chasaide's study refers to data from Gaoth Dobhair (Donegal) Irish, and the two others studies consider Outer Hebridean (Lewis and Harris) Gaelic. These studies all find a consistent pattern with Gaelic velarised /l̪ˠ/ having the highest *F*1 and lowest *F*2 of the three lateral sounds, palatalised /l̪ʲ/ having the lowest *F*1 and highest *F*2, and alveolar /l/ lying in between these two extremes. *F*3 was not found to vary substantially between the lateral categories. These results are consistent with previous studies of lateral acoustics such as, for example, Sproat and Fujimura (1993) and Carter and Local (2007). A diagram showing sample *F*1, *F*2 and *F*3 values from the different laterals in this study is in Fig. 2. All tokens in this figure were produced by a middle-aged Lewis speaker living in Glasgow.

1.2. Context of Scottish Gaelic

Scottish Gaelic is currently spoken by approximately 58,000 people, just over 1% of the Scottish population (2011 UK Census). Although traditionally associated with the rural north-west Scottish Highlands and Islands, approximately half of Gaelic speakers now live in lowland Scotland (2011 UK Census). Gaelic has previously been considered in a well-known study of language obsolescence, Dorian (1981), and is classified by UNESCO as 'definitely endangered'. This social context is changing, and Gaelic is now undergoing intense revitalisation (McLeod, 2006). One widely-used way of revitalising Gaelic is the introduction of Gaelic immersion education, also known as Gaelic-medium education, where children receive their education in Gaelic without necessarily having a Gaelic-speaking background at home (Nicolson & MacIver, 2003). In the majority of cases, Gaelic-medium classes are delivered in an otherwise English-medium school. There is, however, one entirely Gaelic-medium secondary school in Glasgow.

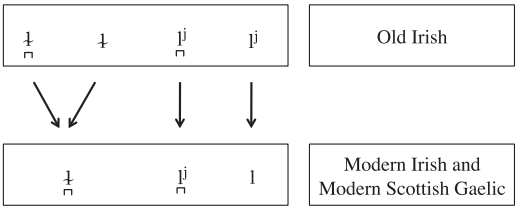

Fig. 1. Schematic representation of the change from the Old Irish lateral system to the contemporary Scottish Gaelic and modern Irish laterals.

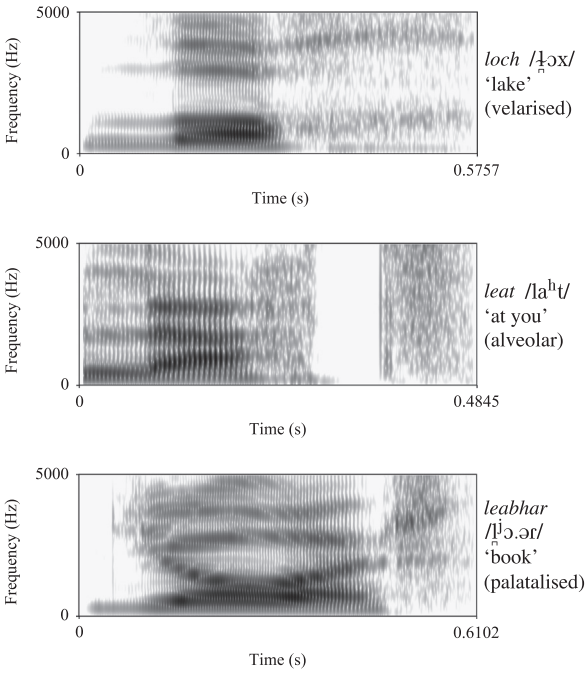

Fig. 2. Sample spectrograms from the dataset for the three Gaelic laterals produced by a middle-aged Lewis speaker living in Glasgow.

In a context of language obsolescence and language revitalisation, widespread and rapid language change is commonplace (Dorian, 1981, 151; Jones, 1998, 1). Multiple reasons are suggested for such rapid and extensive variation and change such as contact with local varieties of the dominant language (Dorian, 1981; Jones, 1998; King, Watson, Keegan, & Maclagan, 2009; Morris, 2013; Thomason, 2001;), functional reasons for language change (Dorian, 1981; Jones, 1998; King et al., 2009; Maguire, 1991), and differing home language backgrounds of young speakers of the obsolescing/revitalised language (Gathercole & Thomas, 2009; Mougeon, Rehner, & Nadasdi, 2004; Morris, 2013).

In recognition of the fact that in many contexts of language obsolescence and revitalisation some influence of the community-dominant language (English in the case of Gaelic) is expected, I here give a brief review of previous work on laterals in Lewis English and Glasgow English. English is commonly thought to have one lateral phoneme (e.g. Sproat & Fujimura, 1993). Unlike many varieties of English, /l/ is described as 'clear' in all syllable positions in Lewis English (Wells, 1982, 413; Shuken, 1984, 160). In Glasgow English, on the other hand, /l/ is described as velarised or pharyngealised in all syllable positions, with sociolinguistic variation present (Wells, 1982, 411; Braber & Butterfint, 2008; Lambert, Alam, & Stuart-Smith, 2007; Macafee, 1983, 33; Stuart-Smith, Timmins, & Alam, 2011; Stuart-Smith, 1999;). In syllable codas, Glasgow English /l/ is often vocalised (Braber & Butterfint, 2008; Stuart-Smith, Timmins, & Tweedie, 2006; Stuart-Smith, Timmins, & Tweedie, 2007).

This study considers data from both older traditional speakers who learned Gaelic exclusively in the home environment, and young speakers who learned Gaelic mainly through immersion education. Two young Glaswegians also speak Gaelic with one of their parents at home (see Section 2.1). Immersion education as a method of acquiring Gaelic is now the norm even in Gaelic-heartland communities, and it is now the case that very few, if any, young people acquire Gaelic without attending immersion schooling (Munro, Taylor, & Armstrong, 2011). Immersion school pupils who do not speak the language at home have been considered sequential bilinguals (e.g. Bialystok, Peets, & Moreno, 2014), or advanced L2 learners (e.g. Mougeon et al., 2004). Previous studies of such speakers report transfer from the home language into the immersion school language both at the phonetic and phonological level (Anderson, 2004; Hecht & Mulford, 1982; Piper, 1984; Yavaş, 2002). Due to the near lack of intergenerational transmission for Gaelic, young immersion school pupils such as those described here represent the only group of young Gaelic speakers. Unlike many studies of language contact, heritage speakers, or second language acquisition, there are no age-equivalent speakers acquiring Gaelic primarily in the home and speaking primarily Gaelic in the community, to whom immersion school pupils can be compared. Following recent studies of minority language immersion school pupils, I refer to the young people in this study as 'new' speakers of Gaelic (O'Rourke & Ramallo, 2013; Robert, 2009; Timm, 2010).

1.3. Remaining questions

This paper investigates the typologically unusual triple lateral system of Scottish Gaelic. Previous acoustic studies of Scottish Gaelic laterals have been small-scale: four speakers in Shuken (1980), and nine speakers in Ladefoged et al. (1998). This study expands on these previous acoustic studies, and also considers dynamic properties of the lateral within its syllabic context. I consider data from a wider background of speakers, reflecting current social developments in Gaelic such as the introduction of Gaelic-immersion

schooling, and the spread of the language to non-traditional areas such as the city of Glasgow. The specific research questions addressed in this paper are as follows:

1. Is there phonetic evidence for three distinct laterals in Gaelic?
2. Do different groups of speakers in the diverse Gaelic-speaking community produce three phonetically distinct laterals?
3. Is there variation within each of the lateral categories among different groups of speakers?

2. Method

2.1. Speakers

This study presents data from 23 fluent Gaelic-speakers split into four groups: [1] older speakers aged 70–85 living in a rural part of the Isle of Lewis in the Outer Hebrides, [2] middle-aged speakers from Lewis aged 40–55 living and working as Gaelic teachers in Glasgow, [3] adolescent speakers from Lewis in Gaelic-medium secondary education aged 13–14, and [4] adolescent speakers from Glasgow in Gaelic-medium secondary education aged 13–14. These speakers were chosen to represent the diversity of Gaelic-speakers today including older traditional speakers, migrants to Glasgow from traditional areas, adolescents in Gaelic-heartland areas such as Lewis, and adolescents in new areas such as Glasgow. All speakers in this study were female; the number of participants and the number of tokens analysed per speaker is in Table 1, Section 2.2.

The older speaker groups ([1] and [2]) grew up in entirely Gaelic-speaking communities and learned English when they went to school. All reported speaking Gaelic wherever possible with friends and family. The middle-aged Lewis speakers were Gaelic-medium teachers working at the Gaelic-medium secondary school in Glasgow. The young people in Lewis and Glasgow grew up in English-dominant communities, and reported speaking English as a peer-group and social language, although the majority of their education was conducted in Gaelic. Two of the young people from Glasgow spoke Gaelic with one of their parents. None of the young people analysed came from entirely Gaelic-speaking households. This linguistic background is not unusual in the Gaelic-speaking context, where intergenerational transmission has been described as 'broken' (Munro et al., 2011, 12). No older or middle-aged Glasgow speakers are included in this study as the school in Glasgow is relatively new (opened in 2006), so there is no equivalent older non-immigrant Gaelic-speaking population to whom young Glasgow speakers can be compared.

2.2. Data

The word list for this study contained two word-initial laterals per lateral phoneme, and two word-medial laterals per lateral phoneme (12 words). In designing the word-list I chose the closest to minimal triplets possible, although this was very difficult as Gaelic has few minimal pairs or triplets generally (Ladefoged et al., 1998; Shuken, 1980), and secondly, the velarised laterals tend to be associated with back vowels, and the palatalised and alveolar laterals with front vowels. This is due to the historical system of palatalised and velarised consonant contrasts which extends across Gaelic consonants, discussed in Section 1.1. Each word was presented on a computer screen accompanied by a picture representing the word. Pictures were included as many older Gaelic speakers have limited literacy skills in the language. The words containing laterals were presented three times in random order alongside 34 distracters, which formed part of a larger corpus collected for several analysis purposes. The total number of tokens and participants is in Table 1, and the word list used is in Table 2.

Table 1
Participants and token counts in the analysis of Gaelic laterals.

Speaker group	Participants	Word-initial	Word-medial	Total
Lewis old	3	53	52	105
Glasgow teachers	3	54	53	107
Lewis young	5	89	87	176
Glasgow young	12	218	214	432
Total	23	414	406	820

Table 2
Word-list used in the analysis of Gaelic laterals.

Phonemic category	Word-initial			Word-medial		
	Gaelic	IPA	English	Gaelic	IPA	English
Velarised	latha	l̪ˠa.ə	Day	salach	sal̪ˠəx	Dirty
	loch	l̪ˠɔx	Lake	balach	pal̪ˠəx	Boy
Alveolar	liosta	lɪsʰtə	List	baile	palə	Town
	leat	laʰt	At you	duilich	t̪ulɪç	Sorry
Palatalised	leabhar	l̠ʲɔ.ər	Book	cailleach	kʰal̠ʲəx	Old woman
	leugh	l̠ʲev	Read	duilleag	t̪ul̠ʲak	Page

Recordings were made onto laptop computer using a Beyerdynamic Opus 55 headset microphone and a Rolls LiveMix pre-amplifier, at a sampling rate of 44,100 Hz. The recordings were made in a quiet room at the participant's school (in the case of the young people and teachers), or in the participant's home (in the case of the Lewis older speakers). Data were transcribed in ELAN (Sloetjes & Wittenburg, 2008), and then converted to Praat (Boersma & Weenik, 2012).

2.3. Analyses

Three analyses were conducted: an initial auditory analysis (Section 3), a static acoustic analysis (Section 4), and a dynamic acoustic analysis (Section 5). Due to the different methods used in each of these analyses, they are presented separately.

2.4. Statistical testing

Mixed effects regression modelling was conducted on the auditory and static acoustic data in R (R Core Team, 2012). The exact models run are described in the appropriate sections within the results, below. The alpha level for significance was set at $p<0.05$, and p values were calculated via Markov Chain Monte Carlo modelling (Baayen, 2008, 248). In each case, general-to-specific modelling was carried out, where non-significant predictors were removed from the models until an optimum model was found, as advocated in Baayen (2008, 205). Predictors were judged as non-significant and removed on the basis of the MCMC p values. All values reported are rounded to 2 decimal places unless otherwise stated. Mixed effects modelling has many benefits over fixed effects modelling, detailed in, for example, Baayen (2008). Specific to this study, mixed effects modelling can control for unbalanced samples, such as the unbalanced speaker numbers described in Table 1 (Field, Miles, & Field, 2012, 860).

When investigating the phonetic differences between groups of speakers (Models 6–8, Section 4.1), the Lewis older speakers were selected as a baseline group, and the three other speaker groups compared to them. This modelling strategy was selected as the teachers from Lewis living in Glasgow do not represent an older generation of Glasgow speakers. This study is therefore not a comparison of two generations in two locations. Due to the fact that only two young speakers had one Gaelic-speaking parent in one of the young speaker groups, this factor was not included in the statistical analyses. Instead, I discuss individual production patterns and observe whether home language background might aid in explaining some of the variation present.

In the case of the dynamic analyses, I present visual results of the Smoothing Spline ANOVAs fitted with Bayesian confidence intervals (following Simonet, Rohena-Madrazo, & Paz, 2008). This is detailed further in Section 5.

3. Auditory analysis

On listening to the data, it became clear that there was substantial variation in the production of the phonemically palatalised laterals in particular, with some tokens including no audible laterality. In order to ensure comparable tokens were included in the acoustic analyses, I conducted an initial auditory analysis of the data. Coding was done primarily on an auditory basis, backed up by spectrogram reading. Four distinct variants were present in the palatalised lateral data, which were coded in Praat.

1. Palatalised lateral.
2. Lateral with no palatalisation.
3. Palatal glide (no lateral).
4. Lateral followed by palatal glide.

Spectrograms of these four variants are shown in Fig. 3. Each panel shows the word *leabhar* ‘book’, produced by young speakers from Glasgow.

3.1. Auditory analysis results

All productions were coded as being one of the variants listed above. All of the phonemically velarised or alveolar laterals were produced with audible laterality. Among the phonemically palatalised laterals on the other hand, 57/274 laterals were produced as palatal glides with no audible laterality. These tokens were excluded from the acoustic analyses (below), but are included here. The Lewis older speakers only produced audibly palatalised laterals for the phonemically palatalised laterals. This was also the case in the vast majority of the tokens produced by the Lewis/Glasgow teachers. Variability was present in the tokens produced by the young speakers from Lewis and Glasgow, shown in Fig. 4.

Statistical analysis was used to compare the number of palatalised lateral productions to other ways of producing a phonemically palatalised lateral in the different groups of speakers. Older Lewis speakers could not be included in this analysis, as they produced 100% palatalised laterals, so statistical analysis was not appropriate. A logistic mixed effects regression model was therefore run with the dependent variable of palatalised lateral/other production and independent variables of speaker group, word position, and speaker group$_*$word position. Speaker and word were random effects. The baseline was set as the Lewis young people, and the teachers and young people at the Glasgow school were compared to this baseline using treatment contrasts. The results of the final

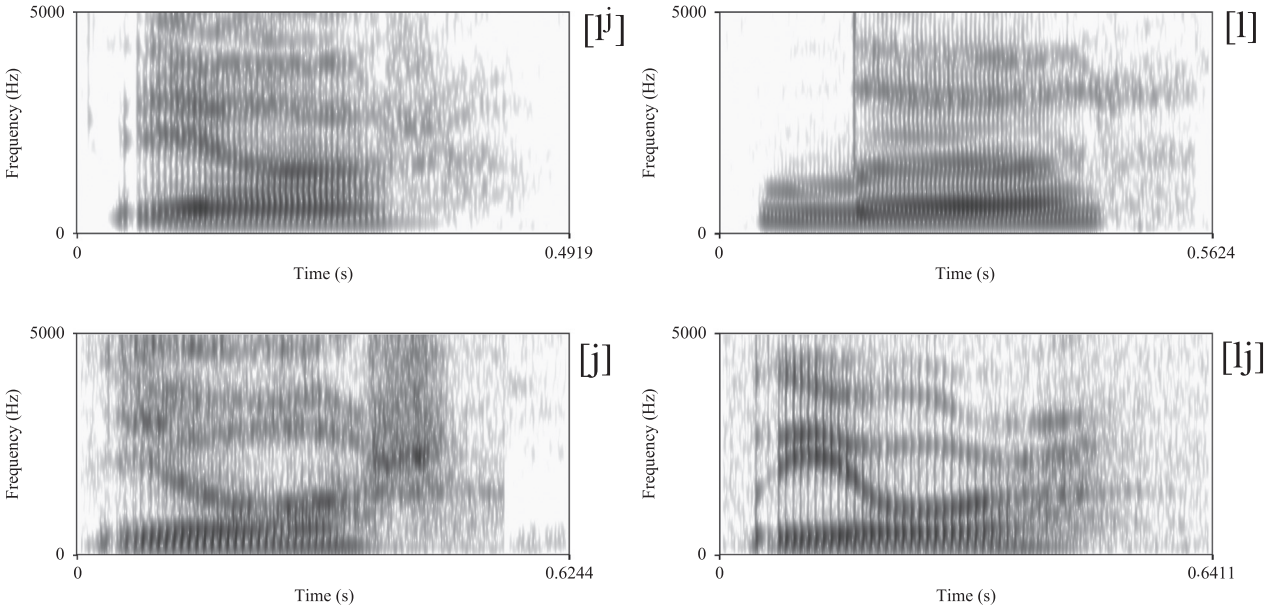

Fig. 3. Lateral variants. All are examples of young Glasgow speakers producing the word *leabhar* 'book' traditionally: [ʲɔ.ər]. The transcriptions here are broad reflecting my auditory coding categories: for example the analysis did not distinguish between [ʲ] and [ʲ], or [ˡ] and [l].

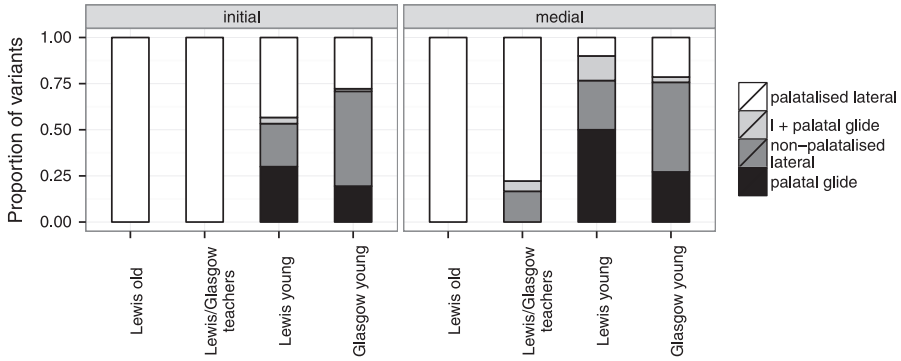

Fig. 4. Proportion of auditory variants in the palatalised lateral data from each group of speakers. Left panel, word-initial $n=138$; right panel, word-medial $n=136$.

Table 3
Final regression model comparing productions of phonemically palatalised laterals. Dependent variable is production as a palatalised lateral, compared to other productions. $n=238$.

Effect	β	SEβ	z	p
Intercept	−1.69	1.08	−1.56	0.11
Glasgow young	−0.34	1.10	−0.31	0.76
Lewis/Glasgow teachers	4.84	1.59	3.05	0.002

model are presented in Table 3. The dependent variable was coded so that positive coefficients in the model indicate more use of palatalised laterals, and negative coefficients indicate less use of palatalised laterals.

The model indicates that the teachers at the Glasgow school produced significantly more palatalised laterals than the young people at the Lewis school. There were no significant differences between the young people at the Lewis or Glasgow schools. This result indicates that the Glasgow young people were therefore significantly different from their teachers, but not from the other young speakers.

4. Static acoustic analysis

The acoustic analyses were conducted on all tokens that included audible laterality (763 tokens). The 57 tokens of palatalised laterals which included no audible laterality were not included in the acoustic analysis, but are discussed further in Section 7.2. Prior to analysis the data were low-pass filtered to 11,025 Hz and down-sampled to 22,050 Hz in Praat. The data were labelled for onset of lateral steady state,

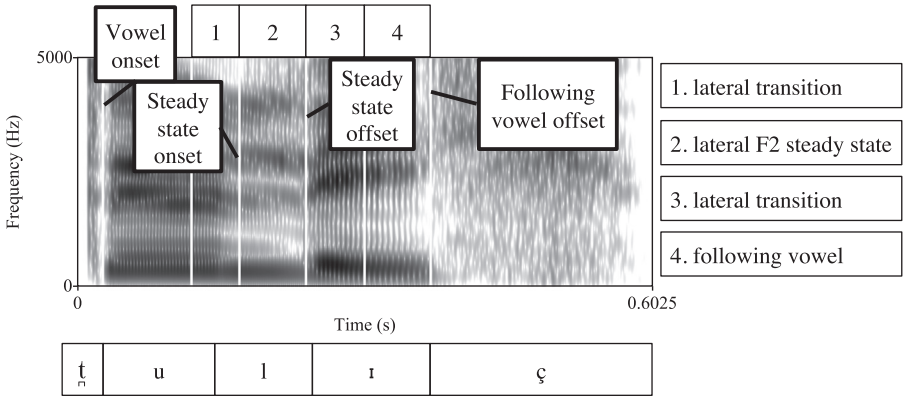

Fig. 5. Lateral phases in the word *duilich* 'sorry' as identified in Carter and Local (2007). Segmental divisions are shown below for comparison.

offset of lateral steady state, offset of following vowel, and in the case of word-medial laterals, onset of preceding vowel (Carter & Local, 2007). An example of this labelling in relation to the lateral phases identified in (Carter & Local, 2007) is shown in Fig. 5.

The static analysis described here concentrates on Phase 2, lateral steady state. The dynamic analysis described below includes Phases 1–4 as well as the vowel preceding the lateral in the case of word-medial tokens. In order to determine the labelling points I used information from the spectrograms looking for qualitative changes in *F*2 (Carter & Local, 2007). The Praat TextGrids were then converted to Emu files for formant analysis (Harrington, 2010). The first three formants were generated using Linear Predictive Coding with settings specific to each speaker. The most commonly used settings were an LPC order of 20 with a 45 ms Blackman window. All formant traces were visually checked for formant tracking errors and hand correction carried out in Emu. All further analyses were conducted in R (R Core Team, 2012).

Formant values were extracted at the temporal midpoint of the lateral steady state. The measure used to capture lateral production differences was *F*2−*F*1 in Bark (Traunmüller, 1990), similar to Sproat and Fujimura (1993), Simonet (2010), and Oliveira et al. (2011). In addition to capturing the relationship between *F*1 and *F*2, this measure is one aspect to the Bark Difference Metric (Syrdal & Gopal, 1986), and therefore normalises to some extent for differences in vocal tract length between speakers.

4.1. Static acoustic analysis results

4.1.1. Laterals overall

Overall, the data suggest different formant values for each of the lateral categories, as reported in the previous literature. The exact values of the first three formants in Hertz are tabulated in Table 4 for ease of comparison with other languages (Recasens & Espinosa, 2005). The greatest differences between the laterals are found in *F*2, and to a lesser extent in *F*1. This is consistent with previous studies (Ladefoged et al., 1998; Shuken, 1980). The Hertz values here are comparable to the results from Shuken and Ladefoged et al.'s studies, though there are some minimal differences, presumably due to the differing genders of the speaker samples. Fig. 6 shows the *F*2−*F*1 values (Bark) for the three laterals in word-initial (left panel) and word-medial (right panel) position.

Mixed effects regression was conducted on the overall dataset to ascertain whether each lateral phoneme's formant values were different from the others. The model contained the fixed effects of lateral phoneme and word position, and the interaction of phoneme$_*$word position. Speaker and word were included as random effects. Alveolar laterals were set as the baseline and the other laterals compared to this baseline using treatment contrasts. Word position and phoneme$_*$word position were non-significant so were removed from the model. The final model is in Table 5. The model indicates that the *F*2−*F*1 values in palatalised laterals were significantly higher than alveolar (1.63 Bark higher on average), and the *F*2−*F*1 for velarised laterals were significantly lower (3.40 Bark lower on average). These results suggest that, overall, the lateral phonemic categories are phonetically distinct in Gaelic.

Table 4
Hertz values for the first three formants of each Gaelic lateral in word-initial and word-medial position. Values are means, with standard deviations in brackets below, rounded to the nearest Hertz. Total $n=763$.

	Word-initial			Word-medial		
	Velarised	Alveolar	Palatalised	Velarised	Alveolar	Palatalised
*F*1	374 (128)	393 (114)	327 (82)	444 (142)	405 (142)	390 (131)
*F*2	1016 (227)	1560 (387)	2031 (576)	1079 (185)	1659 (451)	1875 (474)
*F*3	3263 (240)	3308 (278)	3360 (277)	3313 (249)	3265 (260)	3254 (223)

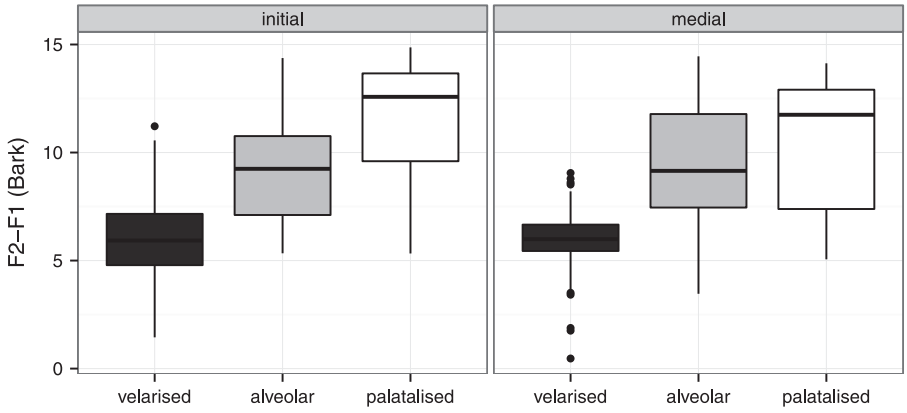

Fig. 6. *F2–F1* (Bark) values overall for the different lateral categories in word-initial position (left, $n=391$), and word-medial position (right, $n=372$).

Table 5
Final regression model comparing *F2−F1* values across all lateral categories. Baseline lateral is alveolar, so the model indicates how the other laterals differ from this. $n=763$.

Number	Data	Effect	β	SEβ	t	p
1	All laterals	Intercept	9.36	0.52	17.92	<0.001
		Palatalised	1.63	0.63	2.57	0.02
		Velarised	−3.40	0.63	−5.39	<0.001

Table 6
Final regression models comparing *F2−F1* values across lateral categories within each group of speakers. Model 2, $n=152$; model 3, $n=105$; model 4, $n=107$; model 5, $n=399$.

Number	Data	Effect	β	SEβ	t	p
2	Lewis old	Intercept	11.05	0.70	15.84	<0.001
		Palatalised	1.72	0.72	2.37	0.01
		Velarised	−6.38	0.72	−8.81	<0.001
3	Lewis/Glasgow teachers	Intercept	11.29	0.64	17.54	<0.001
		Palatalised	1.91	0.80	2.39	0.005
		Velarised	−5.11	0.80	−6.41	<0.001
4	Lewis young	Intercept	10.50	0.87	12.09	<0.001
		Palatalised	1.52	1.22	1.25	0.07
		Velarised	−4.16	1.21	−3.45	<0.001
5	Glasgow young	Intercept	8.01	0.59	13.65	<0.001
		Palatalised	1.53	0.68	2.26	0.02
		Velarised	−1.98	0.67	−2.93	0.005

4.1.2. Lateral categories across groups

In order to investigate whether lateral categories were phonetically distinct within each group of speakers measured, separate models were run for each speaker group containing the fixed effects of lateral phoneme, word position, and phoneme$_*$word position. Speaker and word were included as random effects. In each case, word position and phoneme$_*$word position were not significant so were removed from the models. The baseline lateral category was set as alveolar. The final models are in Table 6, and the values are shown in Fig. 7. The models indicate significant differences between lateral categories among all groups of speakers, except Lewis young speakers who do not significantly distinguish alveolar and palatalised laterals. Although word position, and its interactions, were not significant in these models, from the plots it appears that the young people produce most phonetically distinct lateral categories in word initial position. Among the Glasgow young speakers, their word medial palatalised laterals were significantly different to the word medial alveolar laterals, however the boxplots show a low median value for the palatalised laterals. This is due to several young speakers producing palatalised lateral values which were very similar to their alveolar and indeed velarised lateral values. This finding is further explored below in Fig. 9.

4.1.3. Phonetic differences within groups

Boxplots comparing the productions of each group of speakers within lateral categories are in Fig. 8. Regression models were conducted on the data from each lateral with the fixed effects of word position, speaker group and a position$_*$group interaction. Speaker and word were included as random effects. Non-significant predictors were removed from the models. Speaker groups were coded as dummy variables with the Lewis older speakers as the baseline. The final models are in Table 7.

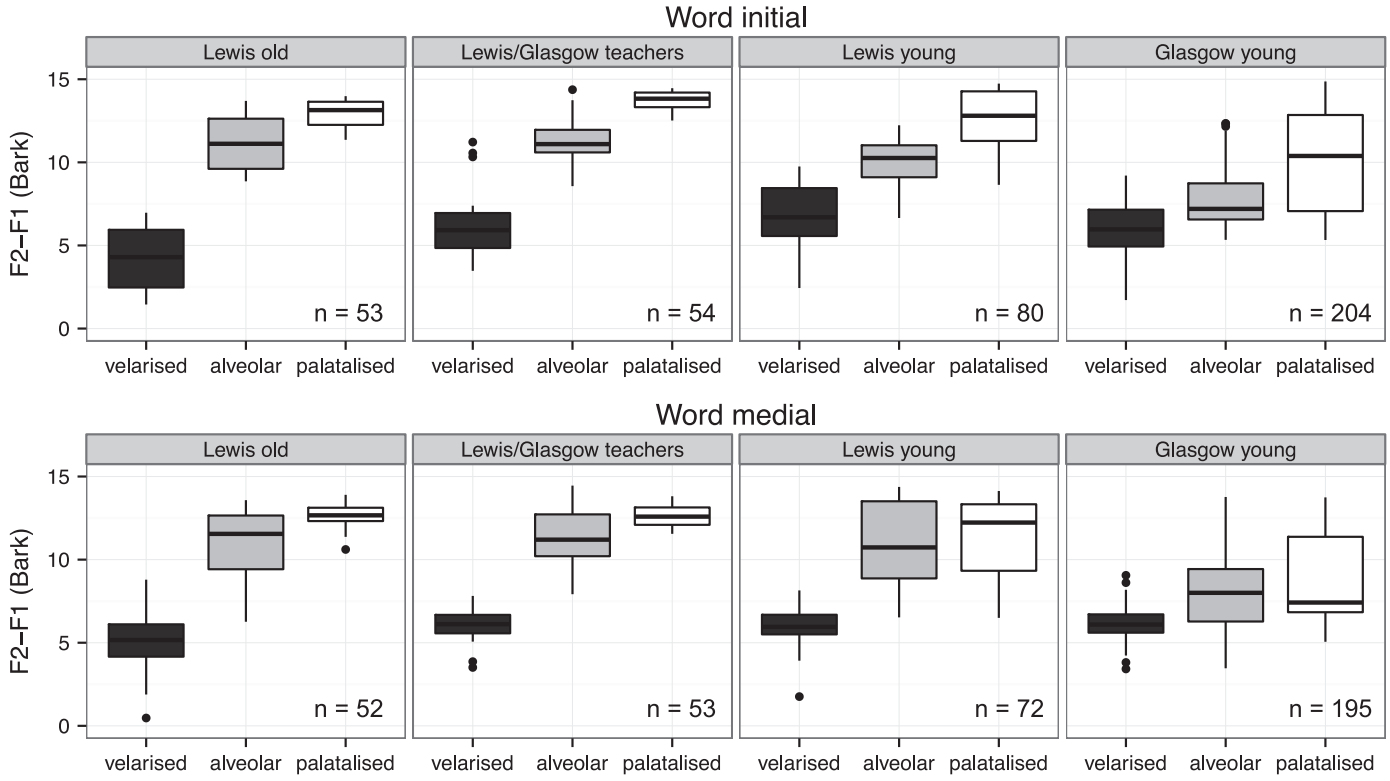

Fig. 7. Boxplots of *F2–F1* values for each group of speakers in word-initial position (top panel) and word-medial position (bottom panel).

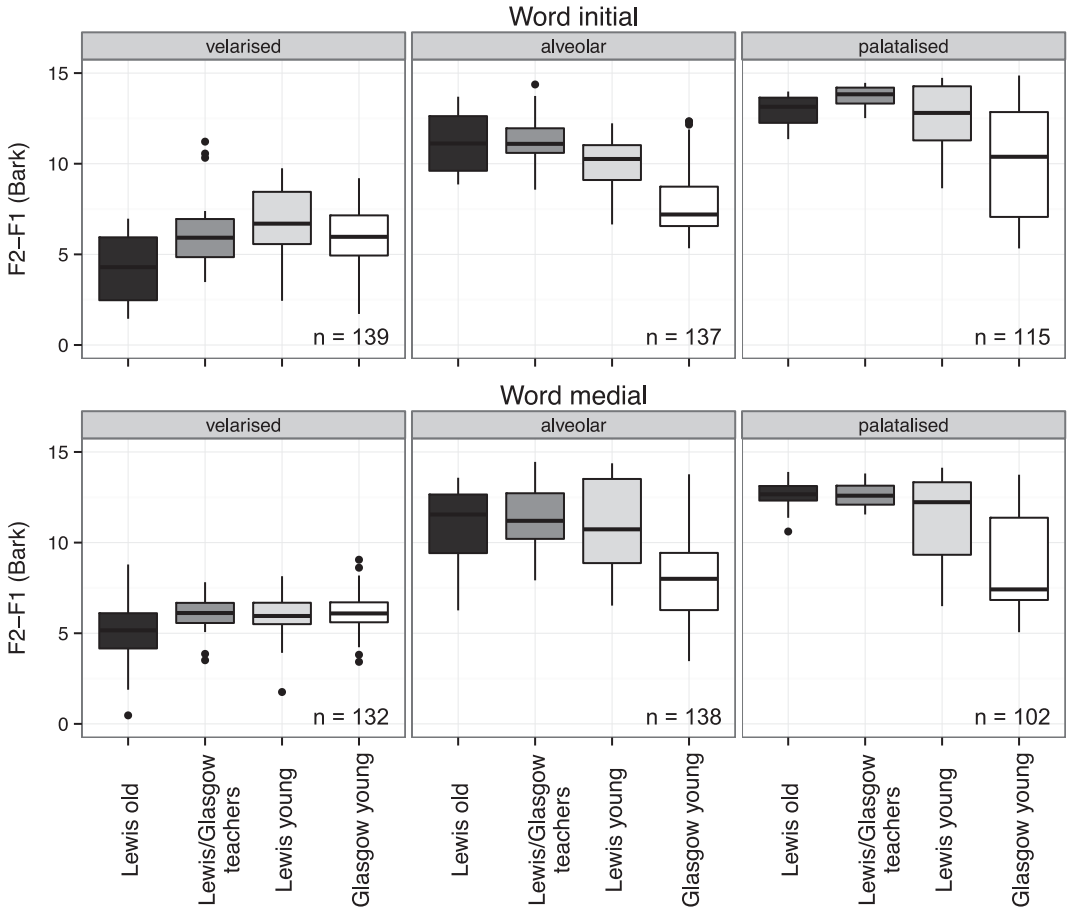

Fig. 8. Boxplots comparing *F2–F1* values for the different speaker groups across lateral categories.

Table 7
Final regression models comparing groups of speakers within each lateral category. Model 6, $n=271$; model 7, $n=275$; model 8, $n=217$.

Number	Data	Effect	β	SEβ	t	p
6	Velarised	Intercept	4.16	0.65	6.45	<0.001
		Lewis/Glasgow teachers	2.26	0.78	2.88	0.004
		Lewis young	2.74	0.70	3.91	<0.001
		Glasgow young	1.87	0.61	3.03	0.002
		Lewis/Glasgow teachers$_*$position	−1.53	0.61	−2.49	0.01
		Lewis young$_*$position	−2.07	0.56	−3.71	<0.001
		Glasgow$_*$position	−1.07	0.49	−2.18	0.03
7	Alveolar	Intercept	11.14	1.20	9.28	<0.001
		Glasgow	−3.19	0.55	−5.82	<0.001
		Lewis young$_*$position	0.85	0.40	2.13	0.04
8	Palatalised	Intercept	12.56	0.60	20.79	<0.001
		Glasgow	−2.99	0.70	−4.28	<0.001

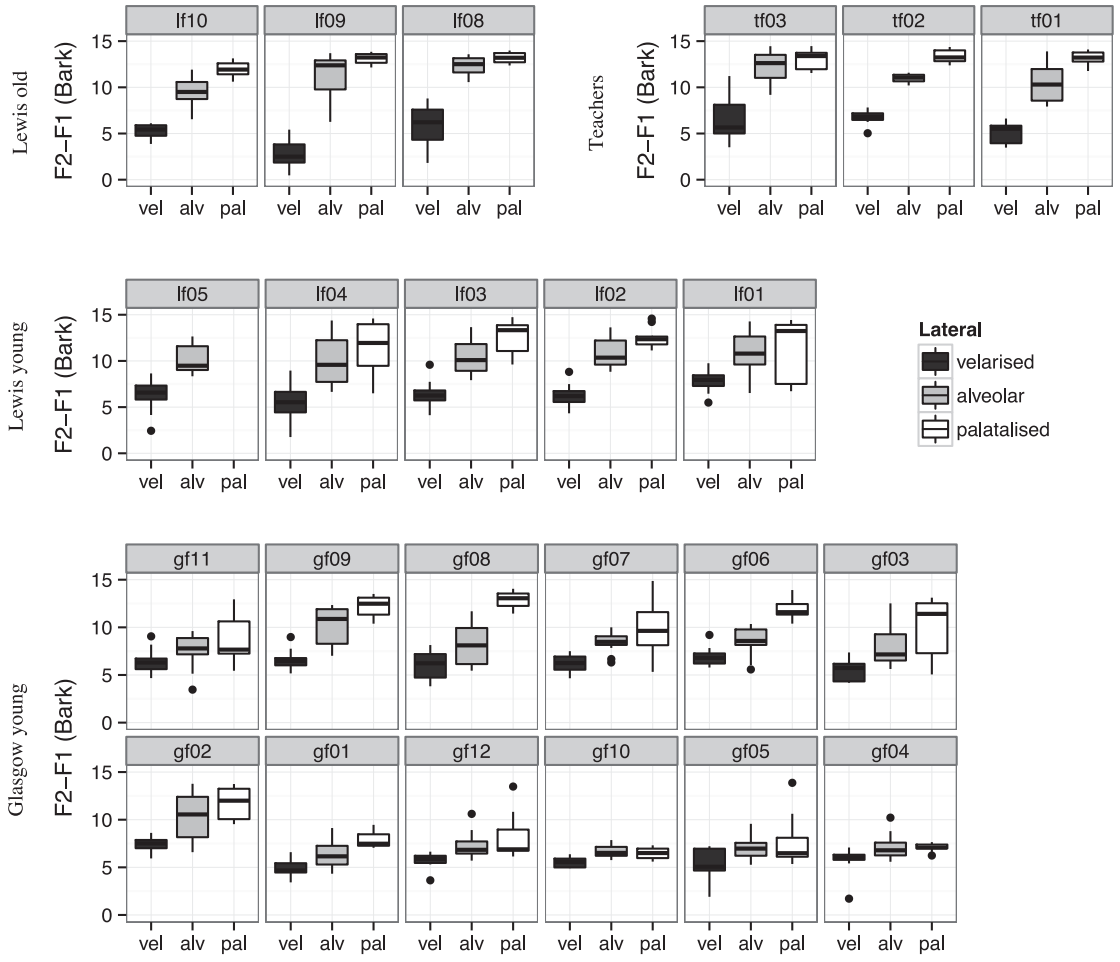

Fig. 9. Individual *F2–F1* values for each lateral phoneme. The two students with Gaelic-speaking parents are gf08 and gf12. Overall $n=763$.

In the velarised laterals, the Lewis/Glasgow teachers have significantly higher *F2−F1* than the Lewis old speakers, as do the Lewis young speakers and the Glasgow young speakers. However, a significant interaction with word position and visual examination of Fig. 8 suggests this is only the case in word-initial position. The Glasgow young speakers' regression coefficient is closer to the Lewis older speakers' baseline value than the coefficients of either the Lewis young speakers or the Lewis/Glasgow teachers, suggesting that on average the Glasgow young speakers' values may be closest to the Lewis older speakers. This is also apparent from the plots in Fig. 8, at least along with the Lewis/Glasgow teachers. Among the alveolar laterals, the Glasgow young speakers have significantly lower *F2−F1* than the Lewis older speakers in both word positions, and the Lewis young speakers are significantly lower in word-initial position only. In the palatalised laterals, the Glasgow young speakers have significantly lower *F2−F1* values than the Lewis older speakers in both word positions. What is also clear in the palatalised lateral data in Fig. 8 is that there is a large difference in distribution of the data among the younger and older speaker groups, with the younger speaker groups having a much wider spread of values than the older speakers.

The general picture emerging is that the Glasgow young people are significantly different from the Lewis older speakers in every condition, except word-medial velarised laterals. Lewis young speakers differ in the production of word-initial velarised laterals, and word-initial alveolar laterals. The Lewis/Glasgow teachers differ only in the production of word-initial velarised laterals. The Lewis older speakers had significantly lower *F*2−*F*1 velarised lateral values, but significantly higher palatalised lateral *F*2−*F*1 values than the young Glaswegians. This suggests a difference in the range of productions used to distinguish lateral phonemes. Using the coefficients from Models 6–7, the older Lewis speakers produced velarised laterals with a mean *F*2−*F*1 of 4.16 Bark, whereas the value for young Glaswegians was 6.03 Bark. The *F*2−*F*1 for older Lewis speakers' palatalised laterals was 12.56 Bark, but 9.57 Bark for the Glasgow young people. This gives a mean range of 8.4 Bark for the Lewis old speakers, and 3.54 Bark among the young Glasgow speakers.

4.1.4. Individual variation

*F*2−*F*1 values for each lateral phoneme per speaker are shown in Fig. 9. Analysis of individual production patterns reveals a variety of strategies in the production of palatalised laterals in particular: speakers gf12, gf10, gf05 and gf04 show almost complete overlap in the distribution of the alveolar and palatalised lateral tokens, and near or total overlap with the velarised tokens. These speakers are positioned at the end of the graph for ease of comparison. This result suggests that these speakers do not maintain the traditional triple lateral system of Gaelic. Speaker lf05 produced all her phonemically palatalised laterals as palatal glides. These tokens were therefore excluded from the acoustic analysis. Two of the Glaswegian young people reported speaking Gaelic with one parent: gf12 and gf08, who display very different formant distributions, suggesting that in these data at least, there is no clear link between home language background and lateral production.

5. Dynamic acoustic analysis

This paper investigates not only the static acoustic characteristics of laterals, but also examines the lateral in its syllabic context (Carter, 2003; Carter & Local, 2007; Plug & Ogden, 2003; Simonet et al., 2008). Dynamic formant analyses here are conducted on the lateral and following vowel, and, in the case of word-medial lateral, the preceding vowel as well. Carter and Local (2007) favoured segmenting the lateral and surrounding vowel(s) into discrete phases, and then conducting dynamic analyses within each discrete phase. The disadvantage to this method is that discrete labelling is required. As shown in Carter (2003) different laterals can have longer or shorter transition phases. This information would be lost by time-normalising each lateral phase separately. I therefore conducted a dynamic formant analysis of the entire vowel + lateral or vowel + lateral + vowel sequence. Formant trajectories were analysed using Smoothing Spline ANOVAs and Bayesian confidence intervals, similar to Simonet et al.'s (2008) study of coda liquids in Spanish.

A Smoothing Spline ANOVA (SS ANOVA) is a non-parametric regression technique for statistically analysing curves (Gu, 2002, 2). The smoothing spline works by finding the best possible balance between fitting the data points and producing a smooth curve (Van der Linde, 2000, 22). This optimal fit is found through a method known as cross validation (Craven & Wahba, 1979). Once smoothing splines are fitted to the data, different curves can be compared using the ANOVA component of the SS ANOVA. The ANOVA tests whether curves are different or not, but unless two curves are exactly identical across the entirety of the curves trajectory, the ANOVA is likely to return a significant result.

One method of seeing where and how curves differ is to plot them using Bayesian confidence intervals. If there is no overlap in the Bayesian confidence intervals fitted to an SS ANOVA, this indicates the curves are significantly different at the point in time where there is no overlap (Davidson, 2006). As the more interesting point here is where and how formant trajectories might differ, the graphical representations showing Bayesian confidence intervals are presented, rather than also detailing the output of the ANOVA. In order to calculate the Bayesian confidence intervals, the output equation of the SS ANOVA was used to generate formant values in a simulated dataset using the predict function in R. Standard errors from were calculated from this simulation, and Bayesian confidence intervals were generated from these standard errors (1.96_{*}standard error).

In each case formant measures were taken at 11 time-equal points in the lateral + vowel or vowel + lateral + vowel sequence. Initial analyses indicated very great differences between words due to the different vowels involved, so productions are compared using the three words that are the closest possible to minimal triplets:

- word-initial: *latha* ‘day’ /l̪ˠa.ə/; *leabhar* ‘book’ /l̪ʲɔ.ər/; *leat* ‘at you’ /laʰt/
- word-medial: *balach* ‘boy’ /palˠ̪ɔx/; *cailleach* ‘old woman’ /kʰalʲ̪ɔx/; *baile* ‘town’ /palə/

5.1. Dynamic acoustic analysis results

The results of SS ANOVAs on the overall dataset are shown in Fig. 10, split into word-initial position (left) and word-medial position (right).

These figures indicate significant differences between the vowel and lateral sequences in all of these words: crucially there is no overlap in the confidence intervals during the initial part of the lateral + vowel word-initially, and no overlap in the *F*2 confidence intervals in the middle of the vowel + lateral + vowel sequence word-medially. It is to be expected that there would be formant differences around the release of the tongue tip closure in laterals such as these Gaelic ones, which exhibit differences in terms of secondary articulations (e.g. Recasens & Espinosa 2005). The differences are especially notable in the second formant values, the

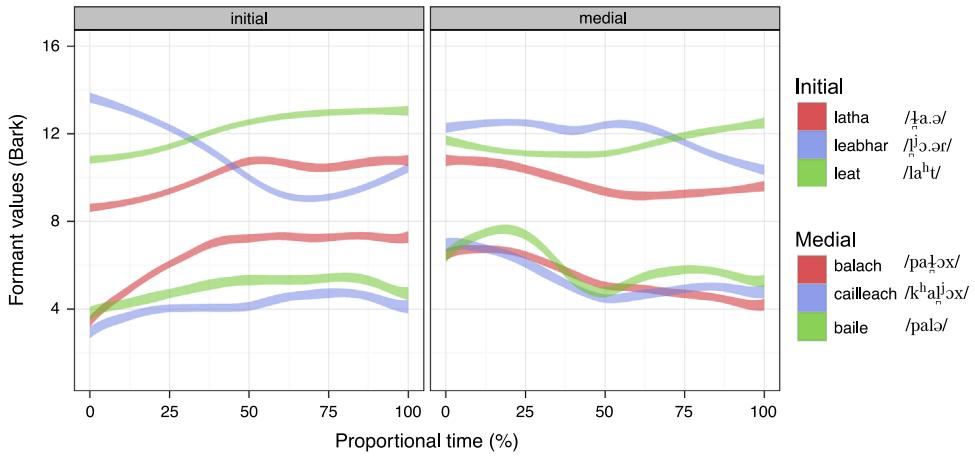

Fig. 10. SS ANOVA of the formant trajectories in three words with 95% Bayesian confidence intervals shown as a ribbon around the spline. Word initial trajectories show lateral+vowel; word medial trajectories show vowel+lateral+vowel. Red splines are velarised laterals, blue splines show palatalised laterals, green splines show alveolar laterals. Within each panel, the top splines show *F*2 and bottom splines show *F*1. Left panel shows word-initial lateral+vowel, $n=190$ words; right panel shows word-medial vowel+lateral+vowel, $n=190$ words. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

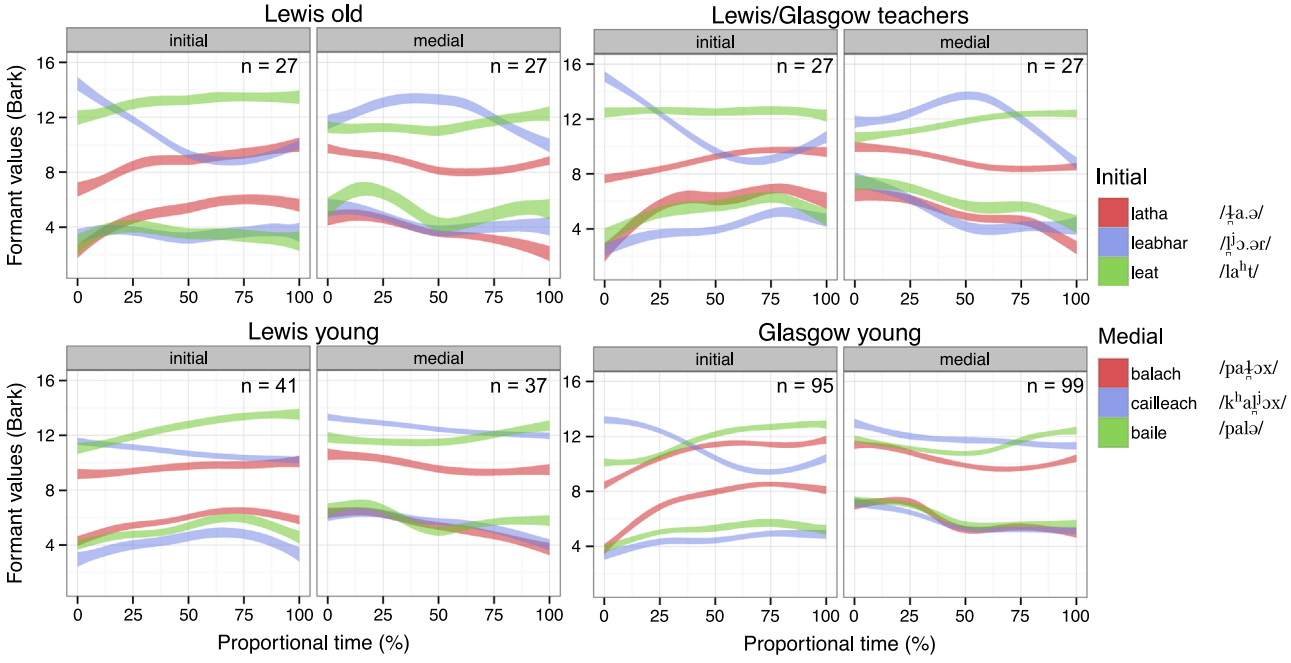

Fig. 11. SS ANOVA of the formant trajectories in three words with 95% Bayesian confidence intervals. Word initial trajectories show lateral+vowel; word medial trajectories show vowel+lateral+vowel. Red splines are velarised laterals, blue splines show palatalised laterals, green splines show alveolar laterals. Within each panel, the top splines show *F*2 and bottom splines show *F*1. Token counts refer to words. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

words containing the palatalised lateral, *leabhar* and *cailleach*, having the highest *F*2 values at onset, and velarised *latha* and *balach* the lowest at onset.

SS ANOVAs with confidence intervals for each of the groups of speakers are shown in Fig. 11. These figures show that there are significantly different curves for each lateral word in each group. There are, however, several different curves on display across groups, also shown in Fig. 12.

Fig. 12 allows comparison of the different groups of speakers across each lateral word. Among the palatalised laterals there are clear differences between the older speakers on the one hand, and the younger speakers on the other. *F*2 is significantly higher for the older speaker groups at the start of *leabhar*, and higher in the middle (lateral) portion of *cailleach*. There are clear distinctions between groups in the production of the alveolar laterals: the older speaker groups produced the lateral in *leat* with a significantly higher *F*2 than the younger speaker groups. The Glasgow young people produced *leat* with the lowest *F*2, and the Lewis young significantly higher, but lower than the older groups. In word-medial *baile*, the same pattern is present, but to a lesser extent. In the case of the velarised laterals, there are again distinctions between the older speaker groups on the one hand, and the younger groups on the other. In *latha* and *balach*, the younger speakers produced laterals with a higher *F*1 but also a higher *F*2.

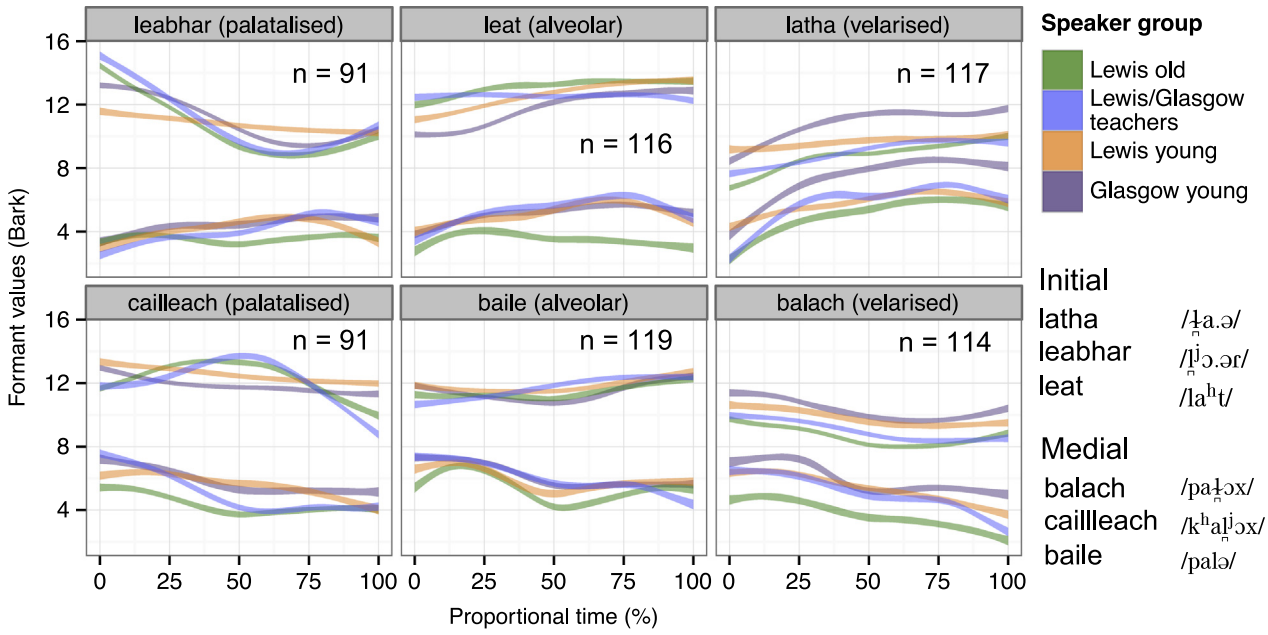

Fig. 12. SS ANOVAs for each group of speakers in each word. Top panels show word-initial laterals, bottom panels show word-medial laterals. Token counts refer to words.

6. Results summary

These results, overall, support previous studies of Gaelic which describe three distinct laterals. Overall, the lateral categories measured here were significantly different in static acoustic and dynamic acoustic measurements. Among the different groups of speakers there were significantly different lateral *F*2–*F*1 values, excepting the Lewis young speakers who did not significantly distinguish alveolar and palatalised laterals. The dynamic plots, however, suggest significantly different formant trajectories (Fig. 11). Overall, the data suggest that the older speaker groups maintain more phonetically distinct lateral categories than the younger speaker groups. This is supported by evidence from the range of coefficients in Table 7, and the range of values shown in the formant trajectories in Fig. 12.

There were phonetic differences between the groups in the production of each lateral category: the Glasgow young people were different from the Lewis older speakers in every lateral phoneme, Lewis young speakers differ in the production of word-initial velarised laterals, and word-initial alveolar laterals. The Lewis/Glasgow teachers differ only in the production of word-initial velarised laterals.

The greatest amount of variation in these data was present in the production of palatalised laterals. The auditory analysis showed that some speakers were producing laterals with no aspect of palatality, or palatal glides with no aspect of laterality. This was most common among the young Glaswegians, and significantly more common in the young speakers compared to the older speaker groups. The static acoustic analysis showed a greater spread of values among the young speaker groups compared to the older speaker groups in the production of the palatalised laterals (Fig. 8), suggesting a range of production strategies, compared to the consistency of the older speakers. The dynamic analysis suggests distinctively high *F*2 and low *F*1 values in the palatalised laterals among older speaker groups, but flatter formant trajectories among the young people (Fig. 12).

Examination of individual patterns in Fig. 9 suggests that some speakers are not distinguishing palatalised laterals from alveolar or velarised lateral at all, and instead producing one or two phonetically distinct laterals. There is no evidence here to suggest that home language background affects lateral production as the two young speakers in Glasgow who had a Gaelic-speaking parent displayed very different formant values, especially in the production of palatalised laterals.

7. Discussion

The Discussion is structured around the three research questions outlined in Section 1.3, and aims to discuss and explain the results described above.

7.1. Three laterals in Gaelic

Across the whole dataset, there is phonetic evidence for three distinct laterals in Scottish Gaelic. Using the static acoustic measure of *F*2–*F*1 at lateral midpoint, I have demonstrated that the phonemic laterals reported for Gaelic are phonetically distinct both in word-initial and word-medial position. When considered dynamically, the three laterals also show significantly different formant trajectories. This was most noticeable in the trajectory of *F*2, though *F*1 showed some differences as well. The static and dynamic analyses were conducted on near minimal triplets. The fact that these minimal triplets are acoustically distinct suggests separate laterals in the sound system of Gaelic, confirming earlier dialect descriptions (Borgstrøm, 1940; Oftedal, 1956; Ternes, 2006).

The acoustic nature of the laterals is consistent with descriptions of their articulation: the palatalised lateral has the highest *F*2−*F*1 values, the velarised lateral has the lowest *F*2−*F*1, and the alveolar in between these two. These values suggest the Gaelic velarised lateral is produced with substantial tongue body retraction, and the alveolar with little or no tongue body retraction, and the palatalised lateral with tongue body raising in the palatal region. Previous descriptions and analysis of palatograms in Ladefoged et al. (1998) indicates that the velarised and palatalised laterals are produced with a dental articulation, while the alveolar lateral is alveolar. While it is difficult to confirm this result with the current acoustic data, future articulatory research could test the results of Ladefoged et al. (1998). Results from these data confirm that overall, Scottish Gaelic does maintain the typologically unusual triple lateral system. This system may, however, be subject to future change, which is discussed below.

7.2. Three laterals among different groups of speakers

This study considers data from four different groups of speakers representing different sections of the contemporary Gaelic-speaking population. Overall, the four groups of speakers maintained three phonetically distinct laterals. There are, however, differences between the groups of speakers, especially in the production of (phonemically) palatalised laterals. The auditory data suggest some speakers do not produce laterals, but retain aspects of palatality by producing a palatal glide. This particular strategy was adopted by speaker lf05 100% of the time. The younger speaker groups were more likely than the older speaker groups to produce sounds other than palatalised laterals in this phonemic category. Other young speakers do not produce their palatalised laterals differently from other lateral categories (Fig. 9). This particular production strategy only occurred among the Glasgow young speakers (4/12 speakers). These results suggest that the palatalised lateral category is undergoing change in two different directions: on the one hand some speakers drop the laterality and keep the palatal aspect, on the other hand some speakers keep the laterality and lose the palatal aspect. Either way there were significantly fewer palatalised laterals produced among the young speakers compared to the older generations.

Differences in the production of palatalised laterals cannot be linked to home language background in any straightforward way from these data since one of the speakers with near overlap of formant values across the lateral categories (gf12) spoke Gaelic with one parent at home, as did gf08, a speaker with very separate distributions of lateral formant values. It may be the case that there is not enough data here from young people with a Gaelic-speaking home background to confirm previous studies such as Mougeon et al. (2004), Gathercole and Thomas (2009), Morris (2013) which suggest that young people in immersion schooling with extensive contacts in the minority language-speaking community will produce more traditional language structures.

Another finding from the analyses comparing groups was that overall, younger speakers have less phonetically distinct lateral categories than the older speakers. This is shown in Fig. 12 in the dynamic formant traces, as well as in the coefficients from Table 7: the older Lewis speakers have the greatest range of values with the highest *F*2−*F*1 in palatalised laterals and the lowest *F*2−*F*1 in velarised laterals. This suggests that one phonemic category is not maintained by some young people and that overall phonemic categories are less distinct among younger speakers. This latter result was also found in a study of pre-aspiration in Gaelic (Nance & Stuart-Smith, 2013) who found that young Lewis speakers produced pre-aspiration with shorter duration than Lewis older speakers, and also qualitatively different pre-aspiration with fewer zero crossings. Similarly, although the models in Table 6 did not return significant effects of word position or its interactions, it does appear from the plots in Fig. 7 that the younger speakers maintain more distinct lateral categories in word initial position compared to word medial position. This may be evidence for domain initial strengthening (e.g. Fromkin, 1965; Fougeron & Keating, 1997). An interesting line for future enquiry could explore this suggestion in Gaelic. It may be the case that in a situation of limited language exposure (such as that of minority language immersion schooling), phonemic categories are most easily acquired and then reproduced where productions are exaggerated through domain initial strengthening.

These results may be indicative of a change in progress in the Gaelic lateral system. Such changes are not unexpected in a context of language obsolescence and revitalisation. Previous work such as Dorian (1981), Jones (1998), and King et al. (2009) suggest rapid and widespread change such as the loss or merger of phonemic categories as well as phonetic change due to influence from a community-dominant language (explored in Section 7.3). Such changes may be for a variety of reasons; here I explore functional reasons, language contact, and differing modes of acquisition in a context of language revitalisation. This latter factor is discussed mainly in Section 7.3.

Previous phonetic studies of Gaelic have noted that there are few minimal pairs or triplets in the language in general (Ladefoged et al., 1998; Shuken, 1980). In the case of laterals, and particularly the palatalised laterals, this is indeed the case, and led to near minimal triplets being used as stimuli in this study. In the case of laterals, the nature of the contrast is partially realised through vocalic context, velarised laterals being associated primarily with back vowels, and alveolar palatalised laterals with front vowels. This means it is unlikely, if not impossible, that any pair or triplet of words will be distinguished by the lateral alone. Taken together, this context suggests there is little communicative reason to maintain phonetically distinct categories, leading to the less distinct categories apparent among the younger speakers in this study, and loss of distinct palatalised laterals observed in some of the Glasgow data. Interestingly though, some young speakers chose to retain aspects of palatality by instead producing a palatal glide. One potential explanation for this is that young people might hear a palatalised lateral, then map it on to a near English equivalent, a palatal glide, rather than retaining the aspects of laterality. This could be evidence of equivalence classification (Flege, 1987), during the acquisition of another language in immersion schooling.

Younger speakers of Irish have been observed to not produce palatalised laterals in two previous descriptive studies: Maguire (1991, 197) and Ó Curnáin (2007, 414). In the case of Gaelic and Irish, the community-dominant language, English, does not have

a phonemically palatalised lateral, and the English lateral more closely resembles either the Gaelic/Irish alveolar or velarised lateral. This is potentially the reason why the palatalised lateral is subject to so much variability and change, instead of the other two laterals. In other words, the structure of the community-dominant language may influence the direction of change in a minority language (Thomason, 2001, 62; King et al., 2009).

7.3. Variation within each lateral category

There were some differences between the groups at the phonetic level within each lateral phoneme. Specifically, the Glasgow speakers produced velarised laterals with a higher $F2-F1$ than the Lewis older speakers, lower $F2-F1$ in alveolar laterals, and lower $F2-F1$ in the palatalised laterals. The Lewis younger speakers produced alveolar and velarised laterals with a higher $F2-F1$ than the Glasgow young people. Taking into account previous research into the phonetics of laterals in Glasgow English (Braber & Butterfint, 2008; Lambert et al., 2007; Stuart-Smith, 1999; Stuart-Smith et al., 2011; Wells, 1982, 411; Macafee, 1983), and Lewis English (Wells, 1982, 413; Shuken, 1984, 160), it is probable that the young speakers' laterals showed some contact-induced influence in the phonetics of their productions. The Glasgow speakers tended to produce all laterals more similar to Glaswegian velarised or pharyngealised laterals, and the Lewis young people tended towards productions consistent with a more prototypically 'clear' lateral. The current analysis does not distinguish between dental and alveolar tongue tip gestures across the different laterals under study here. Speakers also potentially vary in this aspect of production, which could form the basis of future work.

As discussed in Section 1.2, the young speakers in this study are new speakers, who have acquired Gaelic primarily, or uniquely, through immersion schooling. As such, they can be considered somewhere between sequential bilinguals and advanced second language learners. This mode of acquisition may explain some of the results detailed in this study. While all of the speakers here are bilingual, the younger speakers prefer to use English as a peer group language, and unlike the older groups of speakers, they were brought up in an English-dominant world. It is not unexpected that there will be some influence from community-dominant English in the speech of new speakers (Jones, 1998; King et al., 2009; Maguire, 1991). Previous phonetic and phonological studies of immersion speakers have noted both phonetic and phonological transfer into the language learned in the school context (Anderson, 2004; Hecht & Mulford, 1982; Piper, 1984; Yavaş, 2002). This appears to also be the case in these data: some young speakers collapse Gaelic lateral categories to resemble a system closer to English, and some young speakers produce laterals which are phonetically more similar to those reported for their dialect of English, than those of the older speaker groups who grew up in Gaelic-dominant environments. It is highly probable that the factors discussed here in combination (functional, language contact, modes of acquisition) explain the variation in these lateral data.

8. Conclusion

This study has considered data from the diverse contemporary Gaelic-speaking community including [1] older speakers from a Gaelic-heartland community, the Isle of Lewis; [2] middle-aged Lewis speakers working as teachers in Glasgow; [3] young Lewis speakers in Gaelic-immersion education; and [4] young people in Glasgow in Gaelic-immersion education. I have shown that there is phonetic evidence to confirm previous descriptions of the language claiming there are three distinct lateral phonemes (Borgstrøm, 1940; Dorian, 1978; Ladefoged et al., 1998; Oftedal, 1956; Shuken, 1980; Ternes, 2006). But this is not the case among all speakers; in particular some young people in Glasgow do not distinguish palatalised laterals. In general, younger speakers produced a narrower range of values across all laterals, suggesting that their phonemic categories are less distinct than those of the older speaker groups. There were also some phonetic differences between the groups, where the younger speakers tended to produce laterals with formant values more similar to those of the lateral reported in their variety of English (e.g. Shuken, 1984; Stuart-Smith, 1999). I suggest that these differences between speaker groups are explainable through a combination of contact-induced transfer, the small functional load of lateral contrasts in Gaelic, and the nature of language acquisition in an immersion school context. The variation in the production of (phonemically) palatalised laterals in particular may represent a change-in-progress towards eventual loss of this lateral in Gaelic phonology. As noted in Jones (1998, 1), however, change in a revitalisation or obsolescence context is no different to language change in any other context, but due to the social situation changes can become accelerated and more widespread. It must be taken into account that the word list used in this study represents a small proportion of the total Gaelic lexicon, so future work could expand to a larger word list or corpus of data.

These data contribute to studies of speech production of new speakers in revitalisation contexts, and also provide a descriptive account of laterals in the contemporary Gaelic-speaking community. Future work will consider articulatory aspects of Gaelic lateral production, analysis of palatalised laterals with a larger dataset, comparison of dental and alveolar tongue tip productions, and comparison with English data produced by the same speakers.

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References

Anderson, R. (2004). Phonological acquisition in preschoolers learning a second language via immersion: A longitudinal study. *Clinical Linguistics and Phonetics*, *18*, 183–210.

Baayen, R. H. (2008). *Analyzing linguistic data: A Practical introduction to statistics*. Cambridge: Cambridge University Press.

Ball, M., & Müller, N. (Eds.). (2009). *The Celtic languages* (2nd ed.). London: Routledge.

Bialystok, E., Peets, K., & Moreno, S. (2014). Producing bilinguals through immersion education: Development of metalinguistic awareness. *Applied Psycholinguistics*, *35*(1), 177–191.

Boersma, P., & Weenik, D. (2012). *Praat: Doing phonetics by computer* [computer program]. Version 5.3.23. URL: ⟨www.praat.org⟩.

Borgstrøm, C. (1940). *The dialects of the Outer Hebrides*, *Vol. 1*. Olso: Norsk Tidsskrift for Sprogvidenskap.

Braber, N., & Butterfint, Z. (2008). Local identity and sound change in Glasgow: A pilot study. *Leeds Working Papers in Linguistics and Phonetics*, *13*, 22–43.

Carter, P. (2003). Extrinsic phonetic interpretation: Spectral variation in English liquids. In J. Local, R. Ogden, & R. Temple (Eds.), *Papers in laboratory phonology VI: Constraints on phonetic interpretation* (pp. 237–252). Cambridge: Cambridge University Press.

Carter, P., & Local, J. (2007). *F2* variation in Newcastle and Leeds English liquid systems. *Journal of the International Phonetic Association*, *37*, 183–199.

Craven, P., & Wahba, G. (1979). Smoothing noisy data with spline functions. *Numerische Mathematik*, *31*, 377–403.

Davidson, L. (2006). Comparing tongue shapes from ultrasound imaging using smoothing spline analysis of variance. *Journal of the Acoustical Society of America*, *120*, 407–415.

Dorian, N. (1978). *East Sutherland Gaelic: The dialect of the Brora, Golspie, and Embo fishing communities*. Dublin: Dublin Institute for Advanced Studies.

Dorian, N. (1981). *Language death: The life cycle of a Scottish Gaelic dialect*. Philadelphia: University of Pennsylvania Press.

Dorian, N. (1989). *Investigating obsolescence: Studies in language contraction and death*. Cambridge: Cambridge University Press.

Field, A., Miles, J., & Field, Z. (2012). *Discovering statistics using R*. London: Sage.

Flege, J. (1987). The production of 'new' and 'equivalent' phones in a foreign language: Evidence for the effect of equivalence classification. *Journal of Phonetics*, *15*, 47–65.

Fougeron, C., & Keating, P. (1997). Articulatory strengthening at edges of prosodic domains. *Journal of the Acoustical Society of America*, *101*, 3728–3740.

Fromkin, V. (1965). *Some phonetic specifications of linguistic units: In electromyographic investigation.* UCLA working papers in phonetics (Vol. 3, pp. 1–184).

Gathercole, V. M., & Thomas, E. M. (2009). Bilingual first language development: Dominant language takeover, threatened minority language takeup. *Bilingualism: Language and Cognition*, *12*, 213–237.

Gick, B., Campbell, F., Oh, S., & Tamburri-Watt, L. (2006). Towards universals in the gestural organization of syllables: A cross-linguistic study of liquids. *Journal of Phonetics*, *34*, 49–72.

Gu, C. (2002). *Smoothing spline ANOVA models*. New York: Springer Verlag.

Hamp, E. (2010). Scottish Gáidhlig liquids and nasals. In W. McLeod, A. Burnveat, D. U. Stiùbhart, T. O. Clancy, & R. Ó Maolalaigh (Eds.), *Bile ós Chrannaibh: A festschrift for William Gillies* (pp. 189–194). Ceann Drochaid: Clann Tuirc.

Harrington, J. (2010). *Phonetic analysis of speech corpora*. Oxford: Wiley-Blackwell.

Hecht, B., & Mulford, R. (1982). The acquisition of a second language phonology: Interaction of transfer and developmental factors. *Applied Psycholinguistics*, *3*, 313–328.

Jones, M. (1998). *Language obsolescence and revitalization: Linguistic change in two sociolinguistically contrasting Welsh communities*. Oxford: Clarendon Press.

King, J., Watson, C., Keegan, P., & Maclagan, M. (2009). Changing pronunciation in the Maori language: Implications for revitalization. In J. Rehner, & L. Lockard (Eds.), *Indigenous language revitalization: Encouragement, guidance and lessons learned* (pp. 85–96). Flagstaff, Arizona: Northern Arizona University.

Ladefoged, P., Ladefoged, J., Turk, A., Hind, K., & Skilton, S. J. (1998). Phonetic structures of Scottish Gaelic. *Journal of the International Phonetic Association*, *28*, 1–41.

Ladefoged, P., & Maddieson, I. (1996). *The sounds of the world's languages*. Oxford: Blackwell.

Lambert, J., Alam, F., & Stuart-Smith, J. (2007). Investigating British Asian accents: Studies from Glasgow. In *Proceedings of the 16th international congress of the phonetic sciences* (pp. 1509–1512). Saarbrücken.

Laver, J. (1994). *Principles of phonetics*. Cambridge: Cambridge University Press.

Macafee, C. (1983). *Glasgow*. Amsterdam: John Benjamins.

Maguire, G. (1991). *Our own language: An Irish initiative*. Clevedon: Multilingual Matters.

McLeod, W. (2006). *Revitalising Gaelic in Scotland: Policy, planning and public discourse*. Edinburgh: Dunedin Academic Press.

Morris, J. (2013). *Sociolinguistic variation and regional minority language bilingualism: An investigation of Welsh–English bilinguals in North Wales* (Ph.D. thesis). University of Manchester Manchester.

Mougeon, R., Rehner, K., & Nadasdi, T. (2004). The learning of spoken French variation by immersion students from Toronto, Canada. *Journal of Sociolinguistics*, *8*, 408–432.

Munro, G., Taylor, I., & Armstrong, T. (2011). *The state of Gaelic in Shawbost: Language attitudes and abilities in Shawbost*. Inverness: Bòrd na Gàidhlig.

Nance, C., & Stuart-Smith, J. (2013). Pre-aspiration and post-aspiration in Scottish Gaelic stop consonants. *Journal of the International Phonetic Association*, *43*, 129–152.

Narayanan, S., & Alwan, A. (1997). Toward articulatory-acoustic models for liquid approximants based on MRI and EPG data. Part I. The laterals. *Journal of the Acoustical Society of America*, *101*, 1064–1077.

Ní Chasaide, A. (1979). Laterals of Gaoth-Dobhair Irish and of Hiberno English. In D. Ó Baoill (Ed.), *Papers in Celtic phonology* (pp. 54–78). Coleraine: New University of Ulster.

Ní Chasaide, A. (1999). *Irish. In Handbook of the International Phonetic Association*. Cambridge: Cambridge University Press.

Nicolson, M., & MacIver, M. (Eds.). (2003). *Gaelic medium education*. Edinburgh: Dunedin Academic Press.

Ó Curnáin, B. (2007). *The Irish of Iorras Aithneach, County Galway*. Dublin: Dublin Institute for Advanced Studies.

Survey of the Gaelic dialects of Scotland. In C. Ó Dochartaigh (Ed.), Dublin: Dublin Institute for Advanced Studies.

O' Rourke, B., & Ramallo, F. (2013). Competing ideologies of linguistic authority amongst new speakers in contemporary Galicia. *Language in Society*, *42*, 287–305.

Oftedal, M. (1956). *A linguistic survey of the Gaelic dialects of Scotland. The Gaelic of Leurbost, Isle of Lewis*, *Vol. III*. Oslo: Norsk Tidsskrift for Sprogvidenskap.

Oliveira, C., Martins, P., Teixeira, A., & Sá-Couto, P. (2011). *An articulatory and acoustic study of the European Portuguese /l/. Proceedings of the 17th international congress of the phonetic sciences*. Hong Kong: City University Hong Kong.

Piper, T. (1984). Observations on the second-language acquisition of the English sound system. *Canadian Modern Language Review*, *40*, 542–551.

Plug, L., & Ogden, R. (2003). A parametric approach to the phonetics of postvocalic /r/ in Dutch. *Phonetica*, *60*, 159–186.

R Core Team (2012). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. URL: ⟨www.R-project.org⟩.

Recasens, D. (2004). Darkness of [l] as a scalar phonetic property: Implications for phonology and articulatory control. *Clinical Linguistics and Phonetics*, *18*, 593–603.

Recasens, D. (2012). A cross-language acoustic study of initial and final allophones of /l/. *Speech Communication*, *54*, 368–383.

Recasens, D., & Espinosa, A. (2005). Articulatory, positional and coarticulatory characteristics for clear /l/ and dark /l/: Evidence from two Catalan dialects. *Journal of the International Phonetic Association*, *35*, 1–25.

Robert, E. (2009). Accommodating new speakers? An attitudinal investigation of L2 speakers of Welsh in south-east Wales. *International Journal of the Sociology of Language*, *195*, 93–116.

Shuken, C. (1980). *An instrumental investigation of some Scottish Gaelic consonants* (Ph.D. thesis). University of Edinburgh Edinburgh.

Shuken, C. (1984). Highland and Island English. In P. Trudgill (Ed.), *Language in the British Isles* (pp. 152–167). Cambridge: Cambridge University Press.

Simonet, M. (2010). Dark and clear laterals in Catalan and Spanish: Inter-action of phonetic categories in early bilinguals. *Journal of Phonetics*, *38*, 663–678.

Simonet, M., Rohena-Madrazo, M., & Paz, M. (2008). Preliminary evidence for incomplete neutralization of coda liquids in Puerto Rican Spanish. In L. Colantoni, & J. Steele (Eds.), *Selected proceedings of the 3rd conference on laboratory approaches to spanish phonology* (pp. 72–86). Somerville, MA: Cascadilla Proceedings Project.

Sloetjes, H., & Wittenburg, P. (2008). (URL). *Annotation by category - ELAN and ISO DCR*

Sproat, R., & Fujimura, O. (1993). Allophonic variation in English /l/ and its implications for phonetic implementation. *Journal of Phonetics*, *21*, 291–311.

Stuart-Smith, J. (1999). Glasgow: Accent and voice quality. In P. Foulkes, & G. Docherty (Eds.), *Urban voices: Accent studies in the British Isles* (pp. 203–223). London: Arnold.

Stuart-Smith, J., Timmins, C., & Alam, F. (2011). Hybridity and ethnic accents. In F. Gregersen, J. Parrot, & P. Quist (Eds.), *Language variation: European perspectives III* (pp. 43–59). Amsterdam: John Benjamins.

Stuart-Smith, J., Timmins, C., & Tweedie, F. (2006). Conservation and innovation in a traditional dialect: L-vocalization in Glaswegian. *English World-Wide*, *27*, 71–87.

Stuart-Smith, J., Timmins, C., & Tweedie, F. (2007). Talkin Jockney'? Variation and change in Glaswegian accent. *Journal of Sociolinguistics*, *11*, 221–260.

Syrdal, A., & Gopal, H. (1986). A perceptual model of vowel recognition based on the auditory representation of American English vowels. *Journal of the Acoustical Society of America*, *79*, 1086–1100.

Ternes, E. (2006). *The phonemic analysis of Scottish Gaelic* (3rd ed.). Dublin: Dublin Institute for Advanced Studies.
Thomason, S. G. (2001). *Language contact: An introduction*. Edinburgh: Edinburgh University Press.
Timm, L. (2010). Language, culture and identity in Brittany: The sociolin-guistics of Breton. In M. Ball, & N. Müller (Eds.), *The Celtic languages* (pp. 712–752). London: Routledge.
Traunmüller, H. (1990). Analytical expressions for the tonotopic sensory scale. *Journal of the Acoustical Society of America*, *88*, 97–100.
Van der Linde, A. (2000). Variance estimation and smoothing-parameter selection for spline regression. In M. Schimek (Ed.), *Smoothing and regression: approches, computation, and application* (pp. 19–43). New York: Wiley.
Wells, J. (1982). *Accents of English*. Cambridge University Press.
Yavaş, M. (2002). Voice onset time in bilingual phonological development. In F. Windsor, M. L. Kelly, & N. Hewlett (Eds.), *Investigations in clinical phonetics and linguistics* (pp. 341–550). Mahwah: Erlbaum.