Palatalisation can be quantity-sensitive: Dorsal Fricative Assimilation in Liverpool English[1]

Amanda Cardoso
University of British Columbia

Patrick Honeybone
University of Edinburgh

Abstract

This paper shows that the Liverpool English dorsal fricative, which is derived through the lenition of /k/, is subject to assimilation in terms of place of articulation, driven by the preceding vowel. This assimilation is similar to the vowel-driven aspects of typical perseverative Dorsal Fricative Assimilation (a type of palatalisation), as found, for example, in the German *ich-Laut~ach-Laut* alternation, where (among other things) a preceding front high or mid vowel is followed by the front dorsal [ç], and other vowels are followed by a back dorsal. However, the majority Liverpool English pattern differs from previously described cases of Dorsal Fricative Assimilation in that [ç] only occurs following *long* front high vowels, while a back dorsal remains after their short congeners. This type of quantity-sensitive pattern in assimilation has not been reported before. We use Centre of Gravity measurements to investigate this pattern of place assimilation, and argue for the use of an innovative normalisation technique for consonant measurements, based on measurements of /k/ aspiration in a linear regression model. We thus both expand the taxonomy of what is known to be possible in phonology, using a novel technique for acoustic measurement, and also provide new detail in the description of Liverpool English (including a proposal for the featural analysis of its vowel system). We furthermore show that, while the quantity-sensitive pattern is robust for the majority of individuals in our data, some speakers show other patterns in terms of the place of their dorsal fricatives. We argue that this is evidence that a small set of grammars (which are minimally different in this regard) are available to speakers of Liverpool English, we connect this to other research which assumes the same for other cases of variation, and we show how this situation may have developed diachronically.

Keywords: Palatalisation; Dorsal Fricative Assimilation; Liverpool English; quantity-sensitivity; inter-speaker variation.

1. Introduction

Palatalisation is a canonical term in phonology, used to describe a range of phenomena in which non-palatal consonants acquire a specification for palatality. We describe in this paper a case of palatalisation which has an intriguing patterning of a type which has not been previous reported. We thus expand our understanding of what is possible in the patterning of palatalisation. The process is more interesting than just that, however. We show that it involves a segmental process in which a spreading (or agreement) phenomenon is sensitive to the quantity of the source of the specification that spreads (or drives the agreement). Quantity-sensitivity in phonology is usually considered in relation to prosodic phenomena, so the recognition of any quantity-sensitive *segmental* pattern is noteworthy. Furthermore, while a small number of other quantity-sensitive patterns have been reported from the segmental domain, all cases of which we are aware have the opposite patterning to that reported here: a preceding short vowel is required to trigger a process, and a long vowel blocks it. In the main pattern that we present here, a preceding long vowel is necessary to trigger the process, and a short vowel blocks it. Our observations thus extend our knowledge of what is possible in phonology, mixing subsegmental and prosodic specifications in a way which is rarely described.

A secondary goal of this paper is to expand our phonological understanding of the variety of English which has this palatalisation: Liverpool English (LE). This dialect has received some descriptive attention, but the phonological details of LE phenomena which differ from those found in reference varieties of English (like RP and General American) remain poorly described, as for most varieties of English. Our analysis of LE goes beyond the description of its palatalisation, however. In order to adequately describe it, we offer a full and novel analysis of LE's vowel system.

Our data furthermore shows that LE has more than one grammar for palatalisation. While individuals are consistent in their pattern of palatalisation, a minority of speakers show a different pattern to that which we focus on. We argue that this type of inter-speaker variation is not surprising in situations like that found in LE and consider other, related cases with similar patterning.

The article is structured as follows: in section 2 we discuss the reason why LE offers interesting palatalisation data to consider – it features a process which derives dorsal fricatives; in section 3 we focus on the type of palatalisation that dorsal fricatives often engage in (Dorsal Fricative Assimilation) and issues related to the acoustic identification of the fricatives involved; in section 4 we set out our new data describing the patterning of Dorsal Fricative Assimilation in LE; in section 5, we consider how the LE results should best be analysed (also considering the variation involved, and the likelihood that our data shows recent change in LE) and we compare the pattern to other similar segmental phenomena; and section 6 concludes.

2. Liverpool Lenition creates palatalisable dorsal fricatives

The dialect of English spoken in the northern English city of Liverpool (and closely surrounding areas) has several phonological characteristics which set it apart from its neighbours. Later in this article, it will be necessary to describe aspects of LE segmental phonology in some detail, but we focus here on one of these characteristics which enables our central descriptive focus: unlike most varieties of English, LE has dorsal fricatives. After a brief description of the variety in general, we explain in this section the source of these fricatives.

The variety that we consider here is typically referred to in linguistics as 'Liverpool English' (as we do here) or 'Merseyside English' (after the conurbation of which Liverpool is part). Colloquially it is known as 'Scouse'. LE ranks high in studies of people's awareness of distinct dialect areas in Britain, such as Montgomery (2007a, 2012). It usually fares badly in studies of sociolinguistic stigma (Coupland & Bishop 2007, Montgomery 2007b), but there is evidence that it ranks higher in certain positive characteristics, such as 'friendliness' (Watson & Clark 2015). Despite its social status, Watson (2006, 2007a) argues that LE is not taking part in dialect levelling to the same degree as many other varieties of English, showing that it has high local covert prestige. Watson & Clark (2017) find that levelling is still generally resisted in Liverpool (with the exception of TH-fronting for which they find some evidence of geographical diffusion into LE). Furthermore, Trudgill (1999) assumes that it will be the centre of a future dialect region of England. In a similar vein, McNeill (2009) surveyed 402 future education students from six establishments in Merseyside and found that 64% believe that an accent gives a sense of belonging, and that 76% believe Liverpudlians are proud of LE even outside of Liverpool. A fair amount of previous linguistic work has considered the variety in various ways, including Knowles (1973), de Lyon (1981), Honeybone (2001, 2007), Sangster (2001), Watson (2006, 2007a, 2007b, 2007c), Marotta & Barth (2005), Pace-Sigge (2010), Watson & Clark (2011), Cardoso (2011, 2015), Crowley (2012), Honeybone & Watson (2013), Juskan (2016, 2017), and Honeybone, Watson & van Eyndhoven (2017).

There are clear contact-related explanations for some of the phonological characteristics that set LE apart from neighbouring varieties, which Honeybone (2007), in part following Knowles (1973), links to a scenario of new-dialect formation in the nineteenth-century, related to some of the principles of such contact effects that Trudgill (1986, 2004) proposes (see Crowley 2012 for an alternative view of the timeline and ways in which linguistic contact played out in LE, and Cardoso 2015 for a rebuttal of Crowley's points). Some of the variety's other characteristics are, naturally, due to endogenous developments, and we consider one of these in this article. We are not aware of any possible exogenous source for the pattern that is our major focus in sections 4 and 5 in any lect which was involved in the development of LE (nor indeed are we aware of any phonological phenomenon with identical patterning in any language).

One crucial point is that LE features synchronic, variable obstruent lenition. This derives surface affricates and fricatives from underlying stops (that is, stops can synchronically progress two stages down a lenition trajectory of the type discussed in many places, including Lass 1984 and Honeybone 2008). A fair amount of work has investigated Liverpool Lenition (including Honeybone 2001, Sangster 2001, Marotta & Barth 2005, Watson 2007b), and this shows that while the full environmental patterning is complex at both prosodic and melodic levels, and that the process is variable (which is unsurprising as LE is a stigmatised non-standard variety), some broad phonological generalisations are clear: fricatives are common realisations of underlying stops in final and (foot-/word-) medial positions (and affricates are also possible in these positions), while affricates (and stops) but not fricatives are common in initial positions. There are many aspects of Liverpool Lenition that we do not consider here as they are not relevant to our precise concerns. As our focus is on fricatives here, it is fundamentally final and medial positions which are relevant, and in order to direct our focus and to control for other factors, we focused on final position in our data collection, as described in section 4.

Lenition is possible in stops at all places of articulation, but Watson (2007b) shows that it is most common for /t/, /d/ and /k/. In what follows, we will focus on the place of articulation of fricative realisations of /k/, and it is notable that lenition of /k/, although variable, is very common finally – Watson (2007b) found that, in his corpus of elicited speech from 16 adolescent LE speakers, /k/ is realised as a fricative 94% of the time in utterance final position, meaning that for these speakers it is almost categorical. Not all LE speakers lenite quite so much – in a different sample of LE speakers, Marotta & Barth found 43% of pre-pausal occurrences of /k/ were lenited (although this average may hide inter-speaker differences). The 12 speakers that we consider in this paper lenited 89% of word-final occurrences of /k/ overall. Not all speakers of English from Liverpool have lenition in their phonology – this is not surprising, as it is a variable feature which is clearly associated with the city's dialect (and some speakers may want to avoid that association). As we explain in section 4, the speakers included in our sample are extracted from a group of 26 speakers from Liverpool who were recorded in connection with the data collection for Cardoso (2015). Four of these speakers did not feature lenition at all in their speech. In the 22 speakers who showed any lenition at all, 66% of occurrences of word-final /k/ were lenited.

The lenition-derived fricatives in LE pattern like underlying fricatives in that they have no closure, and feature high frequency noise throughout their realisation. Crucial for our purposes is that the dorsal fricative realisations of /k/ can engage in palatalisation of the type that is often described as Dorsal Fricative Assimilation (DFA). We consider this in the next section.

3. Dorsal fricatives and Dorsal Fricative Assimilation

Our interest in the dorsal fricatives of LE derives from a fleeting observation in Honeybone (2001). After mentioning that underlying /k/ can be realised with a range of place of articulations in LE, that piece observes (2001, 241— 242) that '[t]his process of dorsal fricative place assimilation is similar to, but not quite the same as, that which is found in many varieties of German …. Front high vowels … can cause assimilation to [ç], but it seems likely that the length of the preceding vowel affects the likelihood of assimilation.' This claim does not specify a precise pattern, however, and relies on informal observation, inviting the serious study that we present in this article.

DFA is a kind of palatalisation. Palatalisation has been studied in some detail, both in typological work such as Bhat (1978) and Bateman (2007, 2011) and in research on segmental structure driven by attempts to model consonant-vowel interactions, such as Clements (1985), Lahiri & Evers (1991), Halle, Vaux & Wolfe (2000), and research in the Dependency and Government Phonology traditions (such as Anderson & Ewen 1987 and Kaye, Lowenstamm & Vergnaud 1990). Several 'overview' pieces also exist, such as Kochetov (2011) and Krämer & Urek (2016).

Bateman's detailed (2007, 2011) survey of palatalisations distinguishes between two fundamental types: 'full palatalisation', in which the entire place of articulation of a segment is shifted from non-palatal to palatal (typically due to the palatality of an adjacent vowel), and 'secondary palatalisation', in which a secondary palatal specification is added to segments which retain their primary place of articulation.[2] DFA is a type of full palatalisation, as the entire place of articulation of a fricative is shifted from back dorsal to palatal – canonically, it occurs in languages which have an underlying fortis[3] back dorsal fricative. Such back dorsals are typically transcribed as /x/, but may in fact be either typically velar by default (as in Standard Russian and Greek), or typically (pre-)uvular by default (as in Standard German and Northern Standard Dutch – see, for example, Kohler 1977, Collins & Mees 2003, van Oostendorp & Sebregts 2017). As none of these languages contrast velar and uvular fricatives, the precise place of back dorsals is often ignored, and we do not push this point here – our interest is in where front dorsals of the [ç] type can occur, on the assumption that these are categorically distinct from back fricatives, as is the consensus in the literature. We thus differentiate categorically between (i) a 'front' dorsal of the [ç] type, at the canonical palatal place of articulation, and (ii) 'back' dorsals from the velar to (pre-)uvular places of articulation, of the type [x~x̠~χ˖~χ]; we thus view any transcription of the [x] or [χ] type as being, phonologically, the same thing (at least for the languages that we consider here, where there is no question of contrast being involved).

In DFA, dorsal fricatives take their place of articulation at the surface at least in part from adjacent vowels, so that ‘palatal vowels’ (to use the terminology of, for example, Jakobson 1968 and Crothers 1978) of the front-high type, such as /i, ɪ, ɛ/ (the precise set naturally depends on the language) correlate with the front dorsal [ç], and other vowels (such as /a, o/ etc) are associated with a back dorsal, such as [x] or [χ˖].

DFA is not universal in languages with dorsal fricatives: Northern Standard Dutch (henceforth simply Dutch) has, for example, [fliχ] *vlieg* ‘fly’, [zɪχ] *zich* ‘self’ and [laχ] *laag* ‘low’, [buχ] *boeg* ‘ship’s bow’, irrespective of the place of the adjacent vowel. DFA is, however, quite common in languages. It can proceed in either direction: in Standard German (henceforth simply German) and Scots, the assimilation is perseverative, while in Modern Greek and Chilean Spanish, it is anticipatory, all of which is shown in (1), where the vowel which is relevant to the assimilation in each case is underlined.[4] In some patterns, non-vocalic segments also trigger the assimilation (some such aspects of the German case are discussed below) but in the case that we discuss from LE, only vowels are relevant as drivers of assimilation, so we focus on vowels as sources of palatality in this article.

(1) German

[z<u>iː</u>ç]	*siech*	‘ill’
[z<u>ɪ</u>ç]	*sich*	‘self’
[b<u>uː</u>x]	*Buch*	‘book’
[d<u>a</u>χ]	*Dach*	‘roof’

Scots

[dr<u>i</u>ç]	*driech*	‘bleak’
[n<u>ɪ</u>çt]	*nicht*	‘night’
[sasʌn<u>a</u>χ]	*Sassenach*	‘English’
[l<u>ɔ</u>x]	*loch*	‘lake’

Greek

[eç<u>i</u>]	‘he has’
[ç<u>e</u>ri]	‘hand’
[ex<u>o</u>]	‘I have’
[x<u>o</u>ni]	‘he thrusts’

Chilean Spanish

[ç<u>i</u>ɾo]	*giro*	‘turn'
[muç<u>e</u>r]	*mujer*	‘woman’
[x<u>u</u>ɾo]	*juro*	‘I swear’
[mex<u>o</u>r]	*major*	‘better’

How does assimilation of this type occur? Well-known patterns of DFA are some of the evidence that has been used to argue (in the literature on segmental structure cited above) that place of articulation (PoA) must be modelled in the same way in consonants and vowels (using fundamentally the same features), so that PoA can spread from a vowel to a consonant. The German case (often called the *ich-Laut~ach-Laut* alternation) is one of the closest analogues to what we describe for LE in section 4, because fundamentally parallel segments are involved: both have a tense-long/lax-short contrast in front high vowels which are involved in driving a perseverative assimilation, and both have a front [ç]-type fricative alternating with a back [x∼χ]-type fricative (which can go all the way to uvular). Although the languages are closely related, the DFA patterns have developed completely independently – German dorsal fricatives are overwhelmingly either inherited Proto-Germanic /x/ (which English has lost) or emerged due to the High German Consonant Shift, which did not affect English. LE dorsal fricatives are overwhelmingly derived by Liverpool Lenition (it may be possible to argue that some are borrowed, for example in names like *Bach*).

The German case is also well-known in the phonological literature as it has been implicated in theoretical debate a number of times (with reference to whether morphological information should be used in phonemic analysis and/or the opacity that morphological boundaries can invoke, with reference to the question of accuracy in transcription, with reference to the status of 'structure preservation' in phonology, and with reference to the modelling of assimilation in OT – see, among others, Bloomfield 1930, Kohler 1977, 1990, Hall 1989, Iverson & Salmons 1992, Merchant 1996 and Noske 1997). As well as the vowel-driven alternation shown in (1), in German, [ç] also occurs after /n, l, r/, as in (2).

(2)	[manç]	*manch*	'some'
	[zɔlç]	*solch*	'such'
	[dʊɐç]	*durch*	'through'

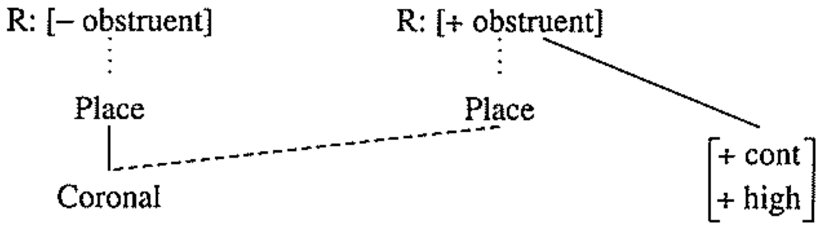
The dorsal fricatives following /r/ show a degree of opacity, as /r/ is realised as a low vowel at the surface in many varieties of German, as shown in (2), and low vowels are typically followed by the back fricative (as in [naːχ] *nach* 'after', but there is evidence (from alternations, for example) that the vocalisation of /r/ is synchronic,[5] so this opacity could be straightforwardly accounted for in either derivational or representational terms. Dorsal fricatives also occur initially in German (as in [çɛmiː] *Chemie* 'chemistry' and the bound morpheme *–chen* [çən] 'diminutive'), although as Robinson (2001) shows, the precise details of what is possible in initial position are contested and vary from variety to variety. These complications do not apply to the LE case: Liverpool

Lenition does not canonically derive fricatives initially, and our analysis in section 4 predicts that assimilation after consonants would not occur. Watson (2007b) shows that fricatives cannot be derived from /k/ after a nasal (only 1% of /ŋk/ sequences result in a fricative in his data). They *are* derived after an /l/ (100% of /lk/ sequences result in a fricative), but those following /l/ are not in the environment for palatalisation.

Many analyses have been proposed for German DFA, some taking /x/ as the underlier (e.g. van Lessen Kloeke 1982, Lass 1984), some taking /ç/ (e.g. Bloomfield 1930, Merchant 1996) and some taking a segment which is specified for dorsality, but is underspecified for its precise place of articulation (e.g. Hall 1989, Wiese 1996). Contemporary analyses adopt autosegmental spreading or OT-type alignment of a feature which inheres in relevant preceding segments, and perhaps also some default filling-in of features for fricatives which are not in a position to get a suitable specification from a preceding segment.

The most thorough consideration of relevant data for the German case is Robinson (2001), who proposes the spreading convention reproduced here in (3) to account for German DFA.

(3)



In Robinson's analysis, [Coronal] spreads from a preceding sonorant to derive [ç] from a segment which would otherwise surface as [x]. The precise nature of the phonologically active feature is the basis of much of the theoretical discussion of palatalisation mentioned above, and we return to this issue in section 5, where we present our analysis of the LE case. There will be a close parallel to the German case in our discussion of LE, but certain facts seem clearer in LE than in German. As well as the absence of initial dorsal fricatives, or those relevant to the data given in (2), LE derives its dorsal fricatives synchronically from a segment which patterns otherwise like a standard /k/ in English, so the derived fricatives can be assumed to have the same PoA as /k/ at some level of analysis.

3.1 *Place of articulation in previous reports of LE dorsal fricatives*

A number of previous reports mention the PoA of fricatives that are derived in the lenition of /k/ in LE. None of them make the precise observation reported at the start of section 3, but many corroborate the claim that /k/ can be realised as both a back dorsal, of the [x~χ] type, and as a front dorsal, of the [ç] type.

The serious study of LE began with Knowles (1973), which aims to provide a broad overview of the variety. He briefly describes dorsal fricatives as the realisation of /k/ ('true fricatives do occur in the velar position') but does not focus the issue of their PoA in detail. He includes some relevant transcriptions however (Knowles 1973, 252), reproduced here in (4).

(4)	[snɛɪx+]	*snake*
	[nɛx]	*neck*
	[bux+]	*book*
	[klɒx-]	*clock*

The precise intention of these transcriptions is not fully explained. Knowles writes (1973, 90) with reference to vowel transcription that '[f]ronting ... is marked by a plus sign ... and retraction by a minus sign', which is essentially the IPA convention, and this is surely also the basis of the transcription that Knowles used for consonants, too: the fricatives are all dorsal, with some degree of variation in terms of its front or backness. The transcription [x-] is a back dorsal, which could be a notational variant of [χ] – this seems quite secure as Knowles (1973, 252) further mentions that 'the retracted fricative [x-] is often accompanied by uvular scrape'. Wells (1982, 371) also reinterprets Knowles' data in this way, writing that, in LE '[t]he /k/ fricative is sometimes uvular rather than velar, and may have a degree of uvular scrape: [nɛχ] *neck*, [klɒχ] *clock*'. This makes the LE back dorsal fricative analogous to that found in, for example, Dutch, German and (especially North) Welsh in tending towards uvularity (and this tallies with our own observations, too). It seems clear that back fricatives are intended for *neck* and *clock*, but the intent of [x+] is not fully clear. If we assume that Knowles would have transcribed a palatal [ç] if he had heard one, as he is fully conversant with the IPA, we should most reasonably assume that [x+] in *snake* and *book* is a somewhat fronted back dorsal, likely driven by variable coarticulation with the preceding vowel as it is not categorically fronted (as we discus in section 5.1, the vowel in *book* is somewhat fronted in LE). This is very little data, but we note here that *neck*, which has the front DRESS vowel, is not transcribed as fronted at all, despite some degree of phonetic fronting clearly being possible. We note further that Knowles' transcriptions are based on data collected in 1968-69 and thus represent the LE of 30-40 years before that described in the remaining material considered here (those of Watson, Marotta & Barth, and ourselves), so it is possible that the situation that we describe has arisen in LE since the 1960s.

Watson (2007b, 2007c) provides a much fuller description of LE dorsal fricatives than Knowles, largely based on auditory analysis of the corpus described in section 2, and intending in Watson (2007c) to provide a representative description of the basic segmental phonetics and phonology of the variety. He provides corroboration that there is now DFA in LE, writing (2007c, 353) that 'palatal fricatives can be found following the close front monophthong [iː] and closing diphthongs [eɪ, aɪ][6] ... and more dorsal fricatives are attested following low and back vowels.... These dorsal fricatives can be velar or uvular.' Unlike Knowles, Watson is explicit in using [ç] to describe a palatal for the product of the lenition of /k/ in the environment that he describes and in using 'back dorsal' fricative transcriptions elsewhere. Watson (2007c) gives representative transcriptions for LE forms in a number of places, reproduced here as (5).

(5) [wiːç] *week*
[laɪç] *like*
[tˢeɪç] *take*
[meɪçən] *making*[7]
[bax] *back*
[tˢʊx] *took*
[klɛʉx, kʰlɛʉx̟] *cloak*
[dɒχ] *dock*
[ʃaːx] *shark*
[maːxɪh] *market*

Watson (2007c) transcribes the word *cloak* in two slightly different ways – it is transcribed as variably fully velar or somewhat advanced (this is possible because it occurs multiple times in 'the North Wind and the Sun', which is the passage used for the representative transcription in Watson 2007c). Given that Watson is unambiguous in transcribing a front dorsal as a palatal, we see the advanced velar variant as a fundamentally back fricative, which is subject to some degree of coarticulation. The fact that this is variable (as both [x] and [x̟] are transcribed for the final /k/ of *cloak*) reinforces this assumption, as coarticulation is inherently variable.

Watson (2007b, 178) suggests that there may be a gendered pattern to the DFA because in his corpus of nine females and seven males, palatals are only produced by male speakers. He presents some quantitative results for the number of fricatives at specific places of articulation following a number of vowels, but he did not expressly consider our key topic of interest – whether vowel quantity determines fricative place. In section 4, we present the results of an acoustic investigation of the issue which provides clear results, and we also interpret some of Watson's quantitative results there (and in section 5, too). For now, we note that Watson (2007b) considered dorsal fricatives following LE vowels that he transcribes there as /a, aɪ, ɑː, e, iː, eɪ, ɛː, ɪ, ɒ, uː, ɔː, əʊ, uː/, and all of the palatal fricatives that he identifies (in Watson 2007b) occur following /aɪ/

or /iː/, apart from one single token following short /ɪ/ (the ‘KIT vowel’, out of a total of 37 tokens), with no tokens of a palatal following what he transcribes as short /e/ (the ‘DRESS vowel’, out of a total of 31 tokens of dorsal fricatives following that vowel).

A few other texts of which we are aware mention something relevant. De Lyon (1981) considers lenition of /k/ in LE, and transcribes a wide range of variants: [k, k^h, k^x, ^xk, kx, xk, x^k, ^kx, χ, x~h, h, ʔ, ø], where [χ] = ‘strong fricative’ and [x~h] = ‘weak fricative’, which may imply a front fricative. However, de Lyon does not present results according to phonological environment, and so her results cannot contribute to our analysis. Marotta & Barth (2005) provide an acoustic description of some aspects of lenition in LE. They write (2005, 395) that ‘[t]he lenition trajectory for /k/ comprises two stages only; from the stop to the affricate and then to the fricative: [k] → [k^x] → [x], or [ç]. The fricative can be realized as velar or palatal, depending on the preceding vowel.’ They do not specify which vowels are involved, however, and say nothing else of relevance to our concerns, except that the one transcription that they provide of a fricative derived from /k/ is of *like*, which has the /k/ realised as [ç]. Ogden (2009, 134) briefly describes LE dorsal fricatives, explaining that they range ‘from palatal through to uvular articulations, depending on the preceding vowel: a more forward place of articulation with front vowels, a backer place of articulation with back vowels, as in ‘week’, [wiːç], ‘back’, [bax], ‘dock’, [dɒχ]’. The only other relevant information that Ogden gives is a transcription for the word *smoke* as [sməʉx].

The previous reports considered here are compatible with the claim at the start of this section that ‘it seems likely that the length of the preceding vowel affects the likelihood of assimilation’ of a dorsal fricative in LE. That claim was based on anecdotal observation of considerable experience of LE that [ç] is common as a realisation of /k/ only after long/tense front high vowels and after diphthongs which end in a front high position. All the above transcriptions from recent descriptions of LE – from Watson (2007c), as in (5), from Marotta & Barth (2005) and from Ogden (2009) – fit well with this: DFA from a back dorsal to [ç] is only transcribed in these representative transcriptions following long vowels (including diphthongs) which are either fully front high or which end in a front high position – it is never given following a short vowel (of any quality). The absence of evidence is not evidence of absence, of course, but nonetheless, only one token ever reported in previous literature goes against this pattern – the single token of [ç] following /ɪ/ in Watson (2007b). This should give us pause, but it invites further consideration because of its rarity – it is so rare that it could be due to a performance error or be explicable on other grounds (we return to it in section 5.4). We are left with fair grounds for a hypothesis that the pattern of DFA in

LE is like that described above for in German to the extent that the vowel preceding the fricative conditions it (with a front fricative occurring only following vowels which end in a non-back/low position), but is unlike the German pattern in that the quantity of the preceding vowel also conditions the DFA: it does not occur if the vowel is short. We test this hypothesis in section 4. We first describe our basis for the objective identification of fricative place.

3.2 *Identifying dorsal fricatives*

Almost all of the previous description of LE dorsal fricatives was based on auditory analysis. While this can lead to subtle and accurate description, acoustic analysis can offer an important check and an objective way to discriminate between phonological categories as long as identifiable acoustic correlates can be established for them. This can be especially helpful in cases like that in focus here, as in principle articulation is possible in dorsal fricatives anywhere along the cline from [ç] to [χ], and auditory analysis may not always be able to distinguish the PoA clearly. In order to test the hypothesis set out at the end of the last section, we used a detailed acoustic analysis to ensure the accuracy of our classification of the PoA of a set of specially-collected tokens, controlled for phonological environment, of lenition-derived dorsal fricatives in specially-collected data from 12 LE speakers.

Previous research has considered a number of acoustic correlates for the PoA of fricatives (see Strevens 1960, Jassem 1962, Wrench 1995, Gordon et al. 2002, Alwan at al. 2011),[8] but, cross-linguistic studies have established that the Centre of Gravity (CoG) measurement is the most accurate diagnostic measure of PoA in fortis fricatives (Forrest et al. 1988, Jongman et. al 2000, Alwan et al. 2011, Gordon et al. 2002, Jones & Nolan 2007).[9] CoG measurements have been used compellingly to determine the PoAs of fricatives shared by most varieties of English (Forrest et al. 1988, Jongman et al. 2000), and to compare the PoA of fricatives cross-linguistically (for example, in Gordon et al. 2002). We follow this body of work in using CoG to identify the PoA of the dorsal fricatives which derive from the lenition of /k/ in LE.

CoG is the spectral mean or the average of the frequency range. In other words, CoG provides a measurement for on average how high the frequencies are for a given spectrum. Lower frequencies are associated with constrictions further back in the mouth as the vocal cavity is longer (Kent & Read 2002, Johnson 2003, Ladefoged 2006). Higher CoG frequencies correspond to articulations that are further front. There is, however, cross-linguistic, interspeaker, and intraspeaker variation in the CoG measurements, producing a wide range of frequency values for palatal and/or 'back' measurements. This means that it is not completely straightforward to ascribe a frequency range to each PoA. Table 1 shows this variation in previous work, but also areas of clear agreement: there is a consistent difference in the average CoG for each PoA, with palatals having a higher average CoG than back fricatives. Table 1 presents figures from previous work that has described CoG measurements for fricatives, extracting their results for velar fricatives (to show the range of values ascribed to that PoA) and for palatals for those languages which have them. All languages surveyed show the average CoG for palatals to be higher than velars.

Language	Palatal (ave. CoG)	Velar (ave. CoG)	Source
Gaelic	4416	4209	Gordon et al. (2002)
Western Aleut	4648	4364	
Western Apache	-	4347	
Hupa	-	4228	
Toda	-	4231	
North Welsh	-	2586	Jones & Nolan (2007)
German	6256	5207	Kemp (2011)

Table 1. Summary of cross-linguistic studies on CoG measurements for PoA. The CoG measurements are averaged across all speakers in the sample.

Gordon et al. (2002) considered two languages with both palatal and velar fricatives: Gaelic and Western Aleut. Table 1 shows that the average CoG values over all speakers for palatal fricatives were 4416 Hz and 4648 Hz respectively, whereas for velar fricatives, they were 4209 Hz and 4364 Hz respectively. Kemp (2011) found much higher average COG values for both palatal (6256 Hz) and velar (5207 Hz) realisations. These cross-linguistic differences are only on the raw values for CoG frequencies, however: the raw frequency values may differ, but the general pattern of a higher average CoG for palatal fricatives than for velars is consistent.

These studies also give the interspeaker and intraspeaker variation in averaged CoG values, as shown in Table 2. For example, in Gaelic, speakers' average CoG values for palatal fricatives ranged from a minimum of an average of 4185 Hz for one speaker to a maximum of an average of 4792 Hz for another speaker, whereas velars ranged from 3976 Hz to 4617 Hz. Furthermore, speakers varied in the length of intermission between the palatal to velars; the speakers had from 101 Hz – 503 Hz between the two PoAs (equivalent figures were not given for German in Kemp 2011, from which we have taken this data). Fricative PoA and consequently CoG measurements are influenced by the size of the vocal tract, similar to vowel production, so it is not surprising to find inter- and intraspeaker variation in these measurements. In order to ensure that statistical significance is not contingent on the individual speaker values, we normalised our own data (as described in section 4).

	[ç] average CoG		[x] average CoG		Difference [ç] – [x]	
Language	Min	Max	Min	Max	Min	Max
Gaelic	4185	4792	3976	4617	101	503
West Aleut	4393	4830	4183	4444	182	513
German	4777	6697	4563	6188	-	-

Table 2. Inter-/Intraspeaker variation: showing the minimum and maximum averaged CoG values for speakers as well as the difference between CoG values for palatal and velars.

In terms of this previous work, the phonological pattern which is closest to that of LE is that described for German by Kemp (2011). It seems, however, that while Kemp (2011) finds the same general trends in CoG as the other studies, her raw average CoG measurements are fairly different from the other studies and the individual speakers are more variable. This could be a result of the methodology used, as speakers were asked to read nonce (non-existent) words in her study. The nonce words are potentially more variable than existing words as speakers may not have been fully confident in their reading of them, which could lead to over-exaggerated speech in some cases. Secondly, the actual make-up of the fricative system in German could affect this. Most of the languages described by Gordon et al. (2002) had a number of dorsal fricatives (for example, contrasting palatals, velars and uvulars, as in Western Aleut). In comparison to this, German has comparatively few dorsal fricatives. The more dorsal places of articulation, the more fine-grained the frequency differences will have to be, and if a language has fewer dorsal fricatives, a wider range of frequencies can be used for each PoA. This may be expected for LE dorsal fricatives, as there are comparatively few dorsal fricatives in the variety. Previous studies that feature acoustic analysis of /k/-lenition in LE use less reliable measures, such as intensity (Marotta & Barth 2005).[10] This means that we do not have any evidence of what to expect in terms of CoG measurements in LE.

Despite the variation that occurs in CoG measurements across previous studies, the consistent result of higher average CoG for palatals and lower average CoG for velars is completely robust. A further conclusion from the above is, however, that there is no simple way to map precise CoG measurement frequencies to specific PoAs. We tackled this for our data from LE by comparing our acoustic data with an auditory analysis. Both authors considered and classified the fricatives, prior to taking the acoustic measurements, into two fundamental categories: front (that is, fully palatal) and back (velar-uvular). There was a large degree of agreement across our auditory judgements, and we compared the typical CoG of fricatives which had been identified auditorily as unambiguously palatal and back with the acoustic measurements, confirming the way to map CoG measurements to PoA in LE. This basis could then be used to identify (in an objective way) the PoA of fricatives which were less clearly characterisable on an auditory basis. The following section describes our methodology, and results, in detail.

4. Quantity-sensitive DFA in Liverpool English

In order to investigate our hypothesis that quantity drives assimilation in the PoA of LE dorsal fricatives, we recorded twelve speakers producing words which were chosen to compare realisations of /k/ preceded by vowels which have the same fundamental PoA, but which differ in terms of their phonological length (i.e. their quantity). We focused on two vowels, which we transcribe below, following Watson (2007c), as [ɪ] and [iː], in order to compare the realisations of /k/ that occur following a short front high vowel and long front high vowel, keeping all phonological parameters other than those we aim to focus on as similar as possible. These vowels are widely referred to as the KIT and FLEECE vowels, following the system of keywords for lexical sets proposed to describe the vowel phonology of English in Wells (1982), and we adopt these labels here.

The data collection for this study was integrated into that for a larger study on an unrelated feature in LE (Cardoso 2015), with the words that we chose for this study included as some of the distractor tokens in wordlist fieldwork for that study. For our purposes, the other 330 words in the wordlist (which were necessary for the purposes of Cardoso 2015) count as distractors, so there was no chance that informants would be aware of what we were interested in. The words were randomly presented in the carrier sentence *'Say X here'*.

There are only a few minimal pairs of the type that we required, featuring words which are both relatively frequent and well-known. The words in (6) are those used in the current study.[11]

(6) *sick* : *seek*
tick : *teak*
chick : *cheek*
pick : *peek*
lick : *leak*

The frequency counts for these words are given in table 3. These were taken from CELEX and show both the COBUILD overall frequency and the COBUILD frequency per million words. These figures are fundamentally the same (the latter is 17 times the former), but we give them both to provide as much information as possible. While there are differences in terms of the relative frequency, table 3 shows that these do not all go in the same way, and the differences between the two members of a pair[12] are not unreasonably massive (they are as small as is possible given the lexicon of English).

FLEECE-vowel words	overall frequency	frequency per million	KIT-vowel words	overall frequency	frequency per million
seek	2147	120	*sick*	1237	69
teak	20	0	*tick*	216	12
cheek	822	46	*chick*	92	5
peak/peek	541/68	30/4	*pick*	3418	191
leak	250	18	*lick*	218	12
average per million		43.6			57.8

Table 3. Frequency counts for words tested

The words were repeated between 1 and 3 times, but each member of a minimal pair was repeated the same number of times as the other member of that minimal pair in the experiment (although, due to speakers' errors and repetitions, some speakers may have produced the target words fewer or more times than was included in the stimuli).

We chose to focus in this empirical part of our study only on word-final realisations of /k/ in order to control for any potential other factors which might influence the realisation of the segment, so that we can clearly test whether preceding vowel quantity has an effect. This should not be taken to imply that it is only in this position that Dorsal Fricative Assimilation can occur, however. Palatals can certainly also occur medially (for example, Watson 2007c transcribes *making* as [meɪçən]) and from anecdotal observation we think a similar pattern of assimilation to that found word-finally applies in that environment (as it does, *mutatis mutandis*, in German DFA, as in [laɪçə] *Leiche* 'corpse' vs [laχə] *Lache* 'puddle').

Cardoso (2015) recorded 28 informants, and we consider here results from only those who robustly lenite /k/ (at least 60% of the time), in order to be sure that they would produce enough tokens following both vowels to compare. In fact, most of the informants in the current study lenite much more than 60% of the time, as shown in table 4, which also gives a summary of informants' metadata. We thus report on data from seven female and five male speakers, who come from both the northern and southern areas of Liverpool.[13] All speakers have lived in Liverpool for all of their lives (apart from M04, who has lived outside of Liverpool for 1 year, and F03, who has lived away for 3 years, both as adults). There is also a mix of working and middle class speakers and while most speakers were around 20 (fitting into a 'younger' category), there were also two informants in their forties (seen as 'older'). Class was determined on the basis of the occupation of informants' parents because most informants were students ('no information' in table 4 means either that an informant did not give information about their parents' occupation or their parents were described as 'retired').

ID	Gender	Age	Location	Class	Lenite /k/
M01	Male	20	North	Working	94 %
M02	Male	23	North	Working	100 %
M03	Male	21	North	no information	82 %
M04	Male	22	North	Working	88 %
M05	Male	21	South	Middle	63 %
F01	Female	40	South	Working	100 %
F02	Female	18	North	Working	100%
F03	Female	28	North	Working	75 %
F04	Female	47	North	Middle	100 %
F05	Female	19	North	Middle	100 %
F06	Female	19	North	Working	75 %
F07	Female	21	North	no information	88 %
Total	F= 7	Y= 10	N= 10	M= 7	
	M= 5	O= 2	S= 2	W= 3	

Table 4: details of informants used in this study; the numbering of speakers (M01-M05 and F01-F07) reflects the order of recording

We considered all of these speakers' fricative realisations of /k/, first auditorily and then on the basis of their CoG (as described in section 3.2). Tokens were classified as a fricative if the silence that corresponds to the occlusion of stops was absent, as in Marotta & Barth (2005) and Watson (2007b). In such cases, the waveform and spectrogram show frication from the end of the preceding vowel to the beginning of the next vowel (as shown in the example given in Figure 1). There were very few cases that were ambiguous, but any that were ambiguous were removed from the final analysis.

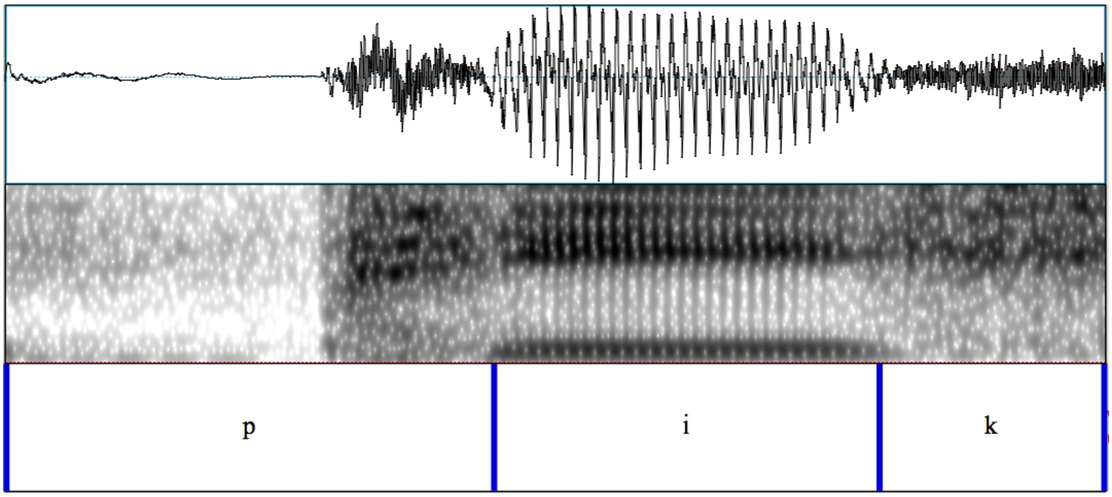


Figure 1: Example spectrogram & waveform from speaker F01 for the word *peek* (note that the transcription is for the UR), showing aperiodic waveform and high frequency frication in the realisation of /k/; no stop closure occurs in /k/, unlike in the realisation of /p/.

The procedure for taking CoG measurements differs slightly in each of the previous studies on fricative PoA. Our procedure most closely follows that of Kemp (2011). All CoG measurements were taken in Praat with the default spectrogram settings. The procedure was as follows: in order to limit co-articulation effects the spectral slice was taken 0.0075 seconds after the vowel for a duration of 0.05 seconds.[14] The lenited /k/ fricatives are not of the same duration as non-lenited fricatives and therefore we could not use a spectral slice of 0.2 seconds (which Kemp 2011 used). The CoG measurement was calculated from this spectral slice by Praat with a power of 1 or weighted by an absolute spectrogram. These measurements were then recorded for each informant. As was found in previous studies, the raw CoG measurements were not consistent across speakers. In order to ensure that specific informant measurements and the specific vocal tract differences are not responsible for statistical significance, we have normalised the CoG measurements.

Vowel normalisation is a commonly used procedure in acoustic analyses in order to ensure that vowel measurements can be comparable, as gender and speaker-specific vocal tract differences are known to affect the vowel formant measurements. On the other hand, consonant acoustic measurements are rarely normalised, despite the fact that many of those measurements will be influenced by vocal tract configurations in a similar way to vowels; notable exceptions are Hay & Maclagan (2010) and Drager & Hay (2010). The lack of previous work on consonant normalisation means that there is no standard method for normalising consonant measurements. For the present purposes, we used a model similar to the one used in Hay & Maclagan (2010) to normalise our CoG measurements.

Hay & Maclagan (2010) discuss the degree of *r*-ness in intrusive /r/ contexts using f3 measurements. In order to normalise for vocal tract differences, they took f3 measurements for 'regular' /r/ productions in the word *Sarah* and included this mean f3 measurement in a linear regression model. This measurement should then account for the speaker-specific vocal tract differences. Similar to f3 measurements for /r/ in Hay & Maclagan (2010), the fricative frequency range is influenced by differences in vocal tract length.

In order to normalise our fricative CoG measurements, we took measurements of /k/ aspiration. As dorsal fricatives do not generally occur in non-postvocalic positions in Liverpool English, we were not able to take CoG measurements for 'regular' dorsal fricative productions in the same way that Hay & Maclagan (2010) did. However, there is a potential workaround in our case. It is generally accepted that 'burst frication is essentially the same as a short duration fricative produced at the same place of articulation as the stop' (Flemming 2002, 23). Furthermore, stop release bursts have been shown to provide reliable PoA discriminations (see, for example, Dorman et al. 1977). Therefore, we used CoG measurements of the release burst for initial /k/ to control for vocal tract length. We used Praat to calculate the spectrum of a 10ms long slice taken immediately following the stop closure. The CoG measurement was then calculated with a power of 1 in Praat. These values were then included in the linear regression model used in the final analysis. As in Hay & Maclagan (2010), this acted as a normalisation for the CoG measurements of lenited /k/. If the PoA of lenited /k/ is not affected by the preceding vowel, the /k/ burst predictor should account for most of the variation in the model (see Hay & Maclagan 2010 for a more detailed description of this normalisation method).

4.1 *Results*

Overall, we found a clear difference between the realisations of lenited /k/ following the FLEECE and KIT vowels in both the auditory and acoustic analysis. The acoustic analysis produced robust results for a quantity-sensitive DFA pattern in LE, as discussed below, and indeed the spectrograms are often visually different for palatals and back fricatives (see Figure 2 for a clear example of this difference, comparing realisations of *seek*, with a FLEECE vowel, and *sick*, with KIT).

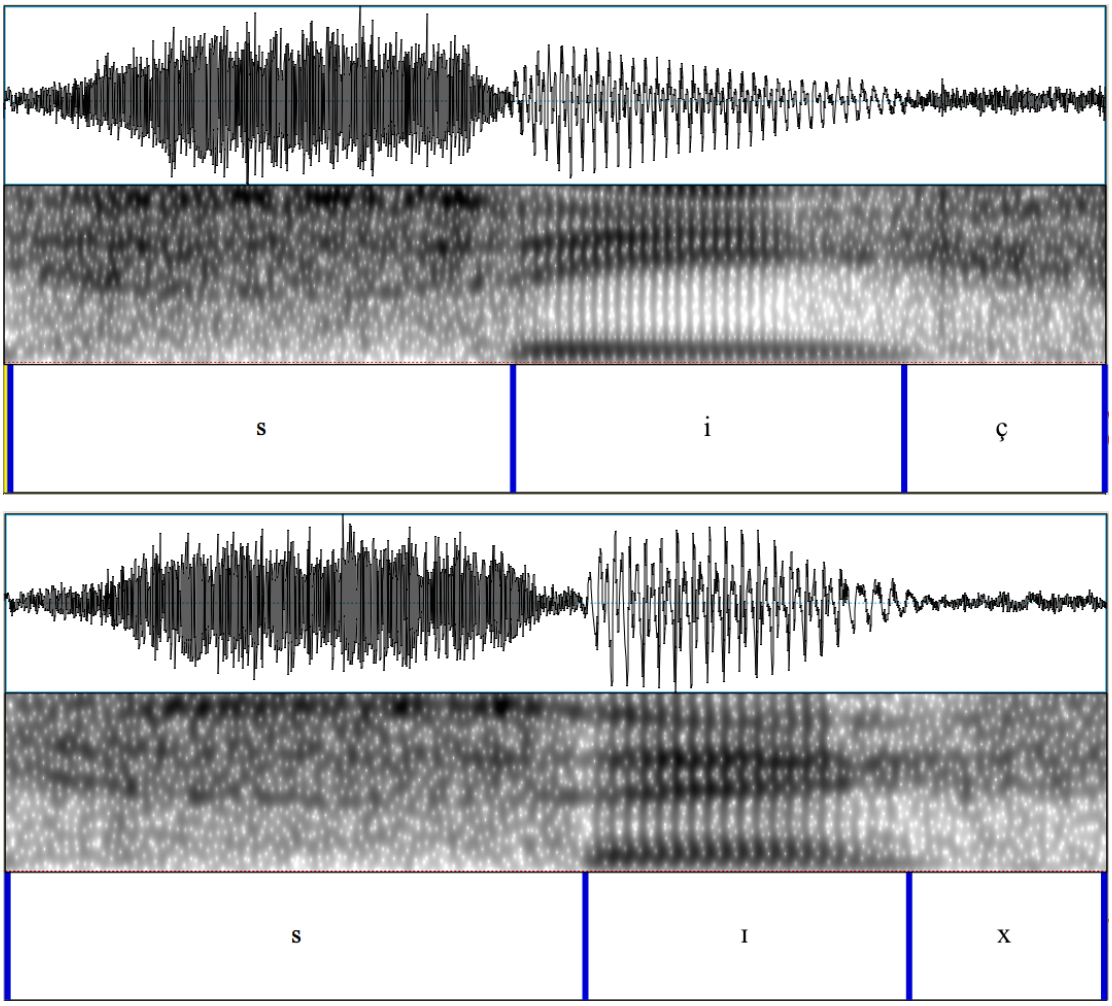


Figure 2. Comparison of a palatal and back fricative for speaker F01 in the words *seek* and *sick*. Note that IPA symbols are used here as approximate surface transcriptions.

The average CoG values, including all measurements from all speakers, show a clear difference between those dorsal fricatives following FLEECE (with an overall average of 4922 Hz) and those following KIT (with an overall average of 4088 Hz). Table 5 gives results of the CoG measurements for each individual speaker. Note that some have a big difference between the average CoG for post-FLEECE fricatives and that for post-KIT fricatives (e.g. speaker M02) and some speakers do not (e.g. M03). We return to the implications of this below.

informant	post-FLEECE average CoG	post-KIT average CoG	maximum CoG	minimum CoG
M01	4396	3524	4919	2818
M02	4594	3312	4906	2784
M03	5420	5534	6546	3577
M04	4942	3763	6580	2825
M05	4885	3970	5291	3688
F01	4591	3701	4812	2814
F02	4502	3487	4743	2770
F03	4472	3582	4941	3301
F04	4851	4023	5142	3327
F05	5207	4790	5611	4404
F06	6051	5329	7459	3880
F07	5149	4044	5650	3364
Overall	**4922**	**4088**	**7459**	**2770**

Table 5. CoG measurements per speaker and overall.

A clearer way to look at the difference between the CoG values for fricatives following the two vowels is to inspect the distribution of the CoG values overall in a density plot, as in figure 4, which shows a clear distinction (a bimodal distribution) between the CoG measurements even when all speakers are grouped together. Figure 3, like other results below, uses the graphical type of representation called ‘violin plots’. Violin plots are a combination of a box plot and density plot (Hintze & Nelson 1998). Box plots show a distribution of values based on five values: the minimum, first quartile, median, third quartile, and the maximum. The line in the centre of the boxes indicates the median values. The notches in the sides of the boxes show whether the medians of the boxes differ. In other words, if two boxes’ notches do not overlap that is taken as ‘strong evidence’ that their medians are different (Chambers et al. 1983). Note that the notches are only used as visual aids and the effects that we report on were checked using standard statistical procedures, as described below. The box plots shown in violin plots also indicate the mean, which is represented by a white dot. Figure 3 is an example plot, to show how they should be interpreted. In it, the median of all three categories likely differ from one another, as none of the notches overlap. Furthermore, the figure demonstrates that the mean and the median are the same for ‘cat1’, but are not the same for ‘cat2’ and ‘cat3’, as the line in the middle of the boxplot and the white dot align for ‘cat1’, but not for ‘cat2’ and ‘cat3’.

Density plots are similar to histograms, as the frequency distribution of a feature is shown along a continuous dimension. Therefore, density plots demonstrate the distribution of measurement values in relevant categories in a data set, such as the preceding vowel. The example plot in figure 3, shows that the distribution for ‘cat3’ is much wider than the distribution of the other two categories, and that ‘cat1’ and ‘cat3’ have a more normal distribution than ‘cat2’, as shown by the bumps in the distribution of ‘cat2’. Density plots are difficult to interpret when there are more than two categories and do not provide information about differences in average measurements across categories. Therefore, violin plots are preferable to either density plots or box plots alone. In the example plot in figure 3, the density plot portion demonstrates that the distribution of ‘cat1’ and ‘cat2’ overlap to a large extent, despite the differences demonstrated by the box plots in terms of the medians, means, and overlap of boxes. The plots have the relevant groups or categories plotted along the x-axis, with the y-axis showing the measurement.

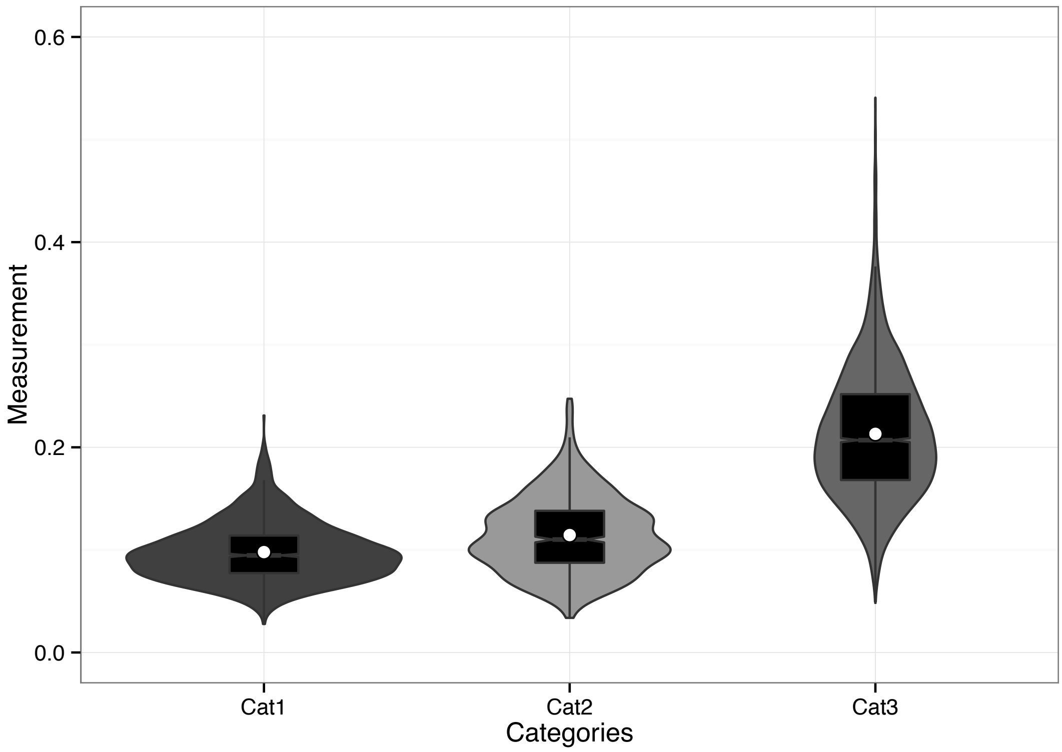


Figure 3. Example violin plot.

Figure 4 presents a violin plot for the results given in table 5, showing the average CoG measurements for all speakers together, for post-FLEECE fricatives (labelled ‘fleece’) and post-KIT fricatives (labelled ‘kit’). Although there is some difference in terms of the behaviour of individuals (which we analyse and explain below), there is still clearly a massive non-overlapping difference between the CoG averages for the two types of fricative.

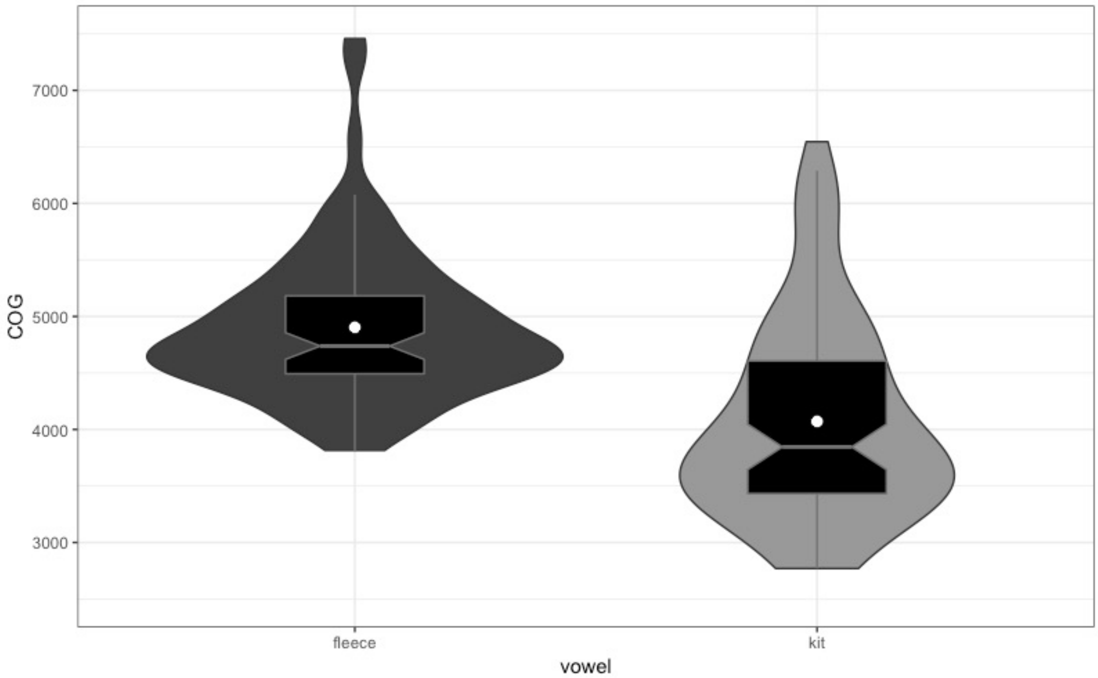


Figure 4. Distribution of CoG measurements by vowel across all speakers.

In order to ensure that this effect was not being driven by specific tokens, we considered the CoG measurements across all of the tokens for each word across all speakers, as presented in figure 5. These results corroborate our findings in that all of the tokens within each vowel can be seen to be behaving as a group. The tokens of lenited /k/ in post-FLEECE environment *all* have CoGs that are essentially categorically higher than those for the post-KIT tokens.

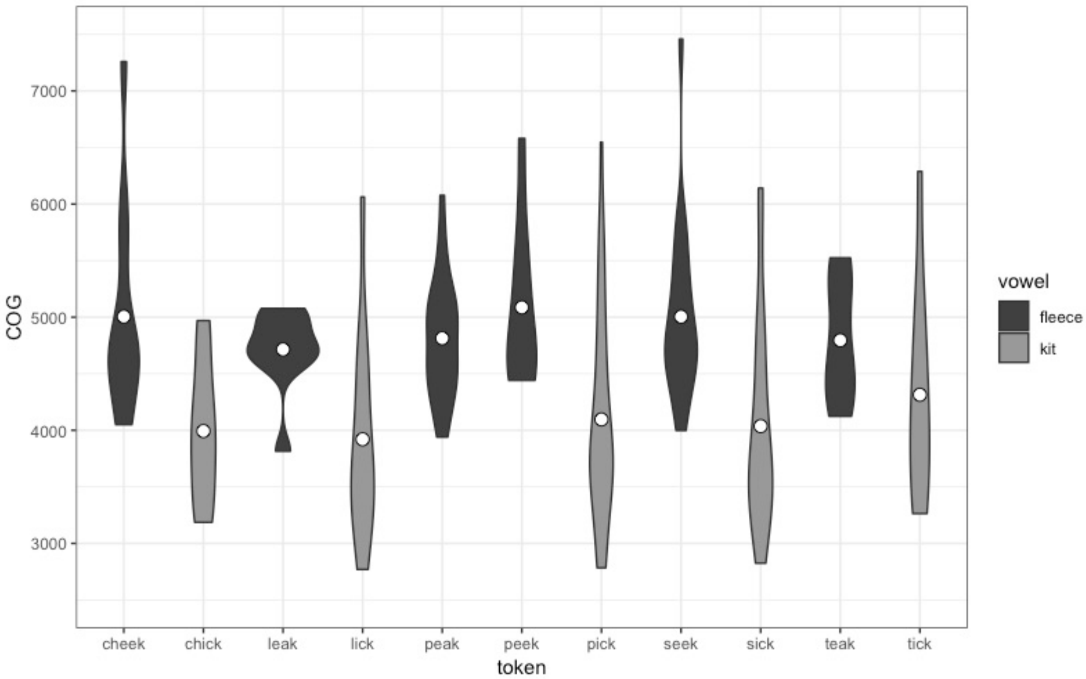


Figure 5. CoG measurements across all speakers by token. FLEECE is dark grey, KIT is light grey. (Boxplots are not included in this graph because the plots are too small.)

The final step of this aspect of our analysis was to complete a linear regression model to ensure that our results are statistically significant and not due to speaker-specific vocal tract features. In the linear regression model, the dependent variable was CoG measurements, and the predictors were which vowel was involved and the normalisation of CoG measurements. Random intercepts for speaker were also included in the model. The vowel came out as a highly a significant predictor for CoG measurements, as shown in figure 6. In other words, there is a statistically significant difference between the CoG measurements for post-FLEECE and post-KIT fricatives.

Coefficients					
	Estimate	Std. Error	t value	Pr(> |t|)	Signfi.
(Intercept)	4915.3319	80.6857	60.919	< 2e-16	***
vowelKIT	-850.8399	114.1307	-7.455	4.64e-12	***
norm	0.8411	0.2131	3.947	0.000117	***

Figure 6. Results from the linear regression model showing that the difference in terms of the two vowels' CoG measurements (named 'vowelKIT') is statistically significant.

If we compare these results to those found for other languages (in the studies mentioned in table 1) our results are much closer in average values to what was found for Gaelic and Western Aleut (by Gordon et al. 2002) than to the German results (from Kemp 2011). The CoG distinction between post-FLEECE and post-KIT fricatives is comparable to the distinction in Gaelic and Western Aleut, and the post-KIT fricatives have a CoG around or between that found in other languages for a back dorsal ([x-χ]). However, the range of variation that we found seems to be more like that found in Kemp (2011), in that there are some speakers with very large frequency ranges for CoG, such as F06.

Overall, therefore, we see that our results are clear: even though both FLEECE and KIT are front high vowels, the dorsal fricatives that follow FLEECE have an average CoG which is around 1000 Hz higher than the dorsal fricatives that follow KIT. This difference is analogous to the difference found for palatal and back (velar-uvular) dorsal fricatives in other languages, and it maps onto a distinction that we noted in our initial auditory classification into palatal and back dorsals: the fricatives following FLEECE tend to sound like canonical palatals, while those following KIT tend to sound velar-uvular. As hypothesised, it is the difference in quantity of the vowel which determines whether the fricative assimilates to a preceding front high vowel. This kind of pattern is by no means expected. We are not aware of any report of a similar pattern in previous literature, even in closely-related languages which also feature dorsal fricatives: German has consistent [ç] following both long and short front high vowels (as in [ziːç] *siech* 'ill' and [zɪç] *sich* 'self'), and [x-χ] following non-front-high vowels (as in [daχ] *Dach* 'roof'), as shown in (1), while Dutch does not have DFA at all, with [x-χ] following [i], [ɪ] and [a] (as in *vlieg* 'fly', *zich* 'self' and *vraag* 'question').

We therefore see our results as establishing that LE does indeed feature quantity-sensitive DFA. However, table 5 shows that there is interspeaker variation in this phenomenon, so we need to investigate our results at a speaker-specific level. Table 5 indicates that some speakers have a robust categorical difference between the CoG measurements after FLEECE and KIT. This is further shown in figure 7, which graphically presents the results for speakers F02 and M02). On the other hand, certain other speakers have more overlapping CoG measurements (as shown in figure 8 for speakers F07 and M04). Note also that speakers with a categorical difference between CoG measurements in the post-FLEECE and post-KIT environments (as in figure 7) operate on a tighter scale (approximately 2000Hz) than the speakers with overlapping distribution (as in figure 8).[15] A final set of speakers do not, in fact, have a quantity-sensitive pattern of DFA at all, but rather have palatal realisation of the fricative with both vowels, as shown in figure 9 for speakers F06 and M03 – that is, the fricatives that follow both FLEECE and KIT vowels have CoGs at the high end of the Hz measurements produced in this study, which are comparable to the palatals which only follow FLEECE in other speakers (and which sound palatal in auditory analysis). The behaviour of this last group of speakers is most compatible with the assumption that their dorsal fricatives do undergo assimilation but that the assimilation is not quantity-sensitive.

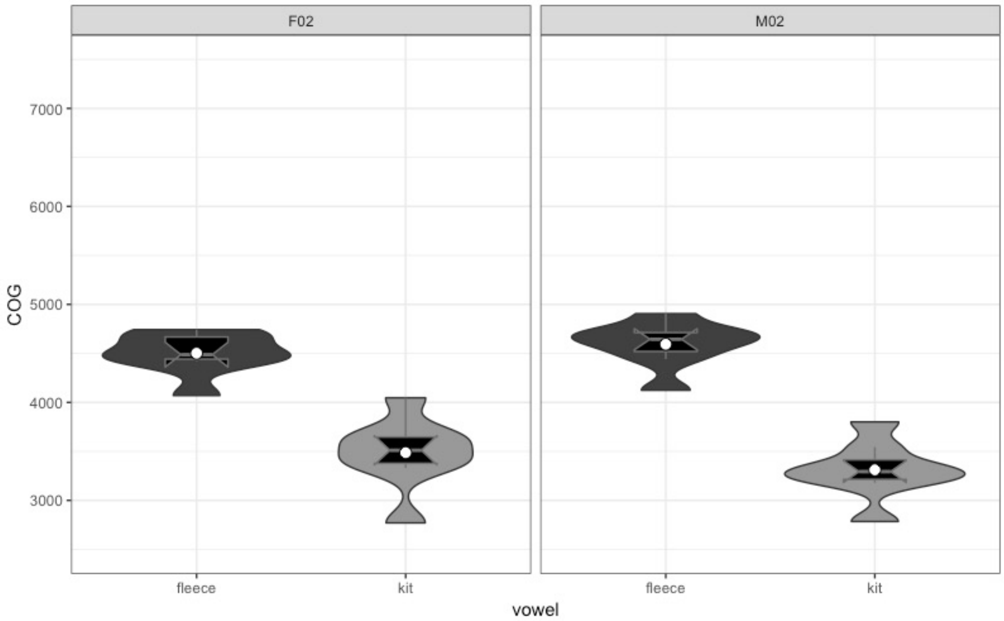


Figure 7. Speakers with a clear categorical difference between CoG measurements before FLEECE and KIT.

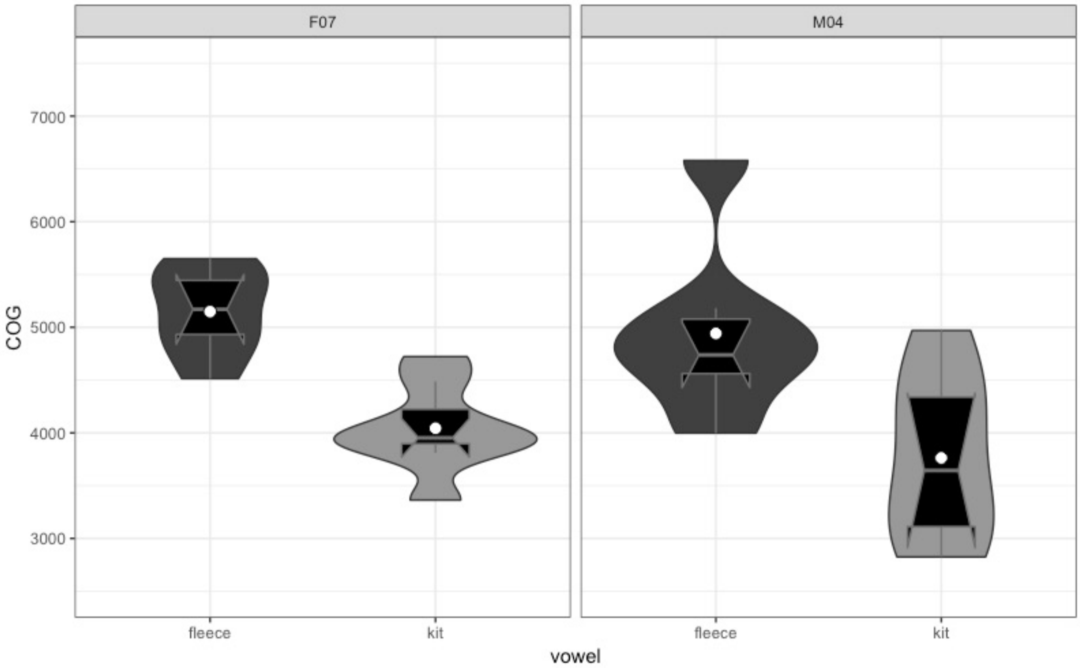


Figure. 8 Speakers with quantity-sensitive DFA, but overlapping CoG measurements.

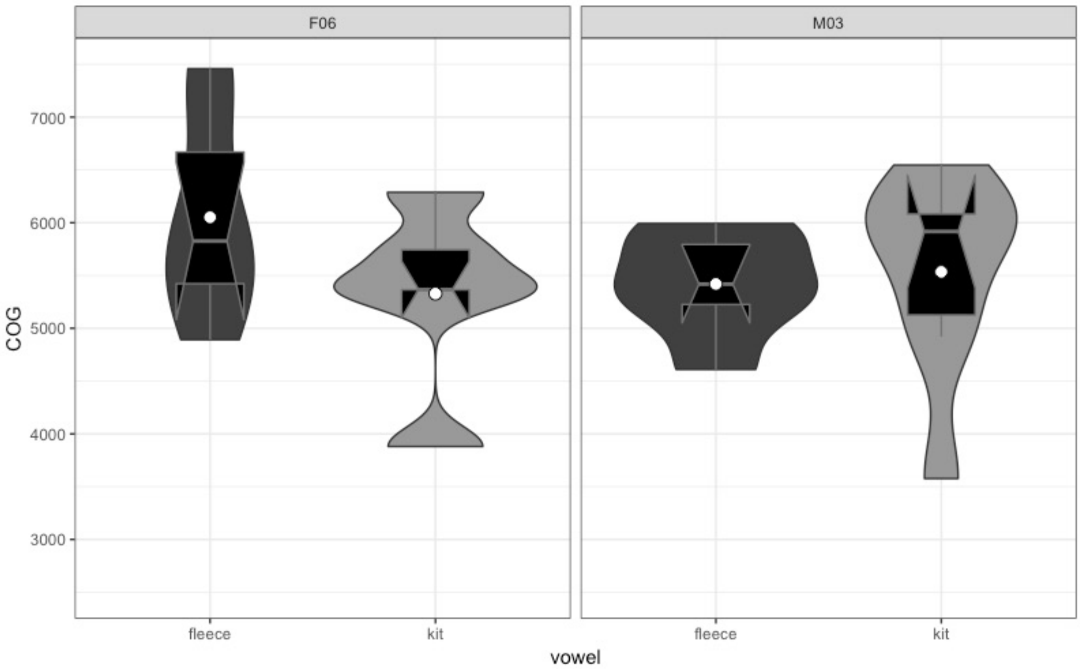


Figure 9. Speakers without quantity-sensitive DFA.

We consider the implications of this variation and present an analysis for it all in section 5. We first summarise our analysis of the results reported in this section. Our summary is given in table 6, which shows that while all 12 speakers show DFA, 2 speakers do not show a quantity-sensitive pattern. Of the 10 speakers who do show quantity-sensitivity, five show overlapping distributions for the two realisations in terms of CoG (and hence, we assume, precise PoA), while five do not have an overlapping pattern, showing clear categoriality in terms of the two realisations. The two speakers who have only one (assimilated) realisation of the fricatives naturally cannot have overlapping distribution (hence the 'n/a' in table 6).

Informant	Assimilation	Quantity-sensitive	Overlapping
M01	Yes	Yes	Yes
M02	Yes	Yes	No
M03	Yes	No	n/a
M04	Yes	Yes	Yes
M05	Yes	Yes	No
F01	Yes	Yes	No
F02	Yes	Yes	No
F03	Yes	Yes	No
F04	Yes	Yes	Yes
F05	Yes	Yes	Yes
F06	Yes	No	n/a
F07	Yes	Yes	Yes

Table 6. Summary of patterns of DFA found in the 12 speakers.

There are thus in fact three types of speakers in our data – that is, there are speakers with the three types of pattern/grammar shown in (7).

(7) (a) gradient DFA which is quantity-sensitive = M01, M04, F04, F05, F07
(b) categorical DFA which is quantity-sensitive = M02, M05, F01, F02, F03
(c) DFA which is not quantity-sensitive = M03, F06

This kind of interspeaker variation in terms of LE DFA has been reported before (although not in such detail). The transcriptions and descriptions for LE dorsal fricatives that Watson (2007b) gives indicate that the precise realisational possibilities vary from person to person. As noted above, Watson (2007b, 178) writes that '[t]he two 'most front' fricatives are provided [by] the male speakers only – there are no female tokens of the palatal', showing that in his data there is a gender-based pattern in terms of assimilation. We do not find this in our data, so there may have been a change since Watson investigated the phenomenon.

We cannot perceive any correlation between the three types of pattern in (7) and the age, gender or class of the speakers (as described in table 4), and while both speakers from the south of Liverpool are in category (7b), there is not enough data to show for sure that there is a geographical pattern as it may be that if we had more speakers from the south that there would be more variation in them. There is no real variation in terms of whether speakers' parents were from Liverpool, either (practically all parents were from Liverpool); both parents of the most exceptional speakers (M03 and F06) were from Liverpool, and there is nothing about the speakers that would pick them out as unusual based on the information that we collected from them. In section 5.3, we consider how this interspeaker variation might make sense, as part of an overall analysis of our results.

5. Analysis: Liverpool English vowels, consonants and DFA

The last section has shown that for the majority of speakers that we investigated, fricatives in words of the FLEECE lexical set assimilate, while fricatives in words of the KIT lexical set do not. What is responsible for this pattern? In this section, we offer an analysis of the patterns found in the data just described, in several steps. In section 5.1, we provide a featural analysis of the phonology of LE vowels and relevant aspects of LE consonants, in order to establish the groundwork for the formalisation of the quantity-sensitive assimilation pattern which is set out in section 5.3. Section 5.2 gives justification for some of the assumptions that prove crucial in section 5.1. Section 5.4 tackles head-on the fact that section 4 in fact identifies a *number* of patterns in terms of the PoA of LE dorsal fricatives (as summarised in (7), above), and section 5.5 considers the context for our claim that the majority pattern for DFA in LE is quantity-sensitive.

5.1 *Preliminaries to an analysis: LE vowels and consonants*

It is clear from the acoustic measurements and auditory analysis described in section 4 that the featural makeup of a preceding vowel can determine the PoA of a following dorsal fricative in LE. As discussed above, this is similar to the patterns of DFA that have been described for many other phonological systems, as set out in (1). An analysis of the German pattern was given in (3), and an explanation of one aspect of why this cannot simply be transferred to the LE is considered around (2) –

there is no DFA in environments that are not preceded by a vowel. If we therefore assume that the patterning of the PoA of LE dorsal fricatives is derived by assimilation which is driven by some aspect of the featural composition of preceding vowels, then we need an analysis of LE phonology which accounts for the featural make-up of vowels and for those aspects of consonantal PoA that interact with them. No such analysis has previously been provided. We offer one here. We take as our starting point the description of LE in Watson (2007c), which is the most comprehensive (if concise) recent discussion of LE segmental phonetics extant, and we use a theory of features which aims to be simple and broadly translatable across frameworks (as discussed below).

Watson (2007c) discusses the segmental contrasts of LE and their surface realisations, showing that LE has the same number of vocalic contrasts as most other varieties of English from northern England except in one specific case. Watson (2007c) sets out the LE vowel contrasts as in (8), with a segmental transcription and example words for each (in line with an IPA-related transcriptional tradition for English), to which we have added the relevant keyword from the system of lexical sets developed in Wells (1982).

(8)

Watson (2007c)		Wells (1982)
iː	*heed*	FLEECE
ɪ	*hid*	KIT
eː	*heard* (also *hair*, *her*)	NURSE/SQUARE
ɛ	*head*	DRESS
a	*had*	TRAP/BATH
ɑː/aː	*hard*[16]	PALM/START
ɒ	*hod*	LOT/CLOTH
ɔː	*hoard*	THOUGHT/FORCE/NORTH/CURE
ʉː	*who'd* (also *book*)[17]	GOOSE
ʊ	*hood*	FOOT/ STRUT
ə	*about*	*lett*ER/*comm*A
eɪ	*hay*	FACE
aɪ	*high*	PRICE
ɔɪ	*boy*	CHOICE
ɛʉ	*hoe*	GOAT
aʊ	*how*	MOUTH
iɛ	*beer*	NEAR

As (8) shows, Watson (2007c) analyses vowels as inherently long or short. Although we acknowledge the controversy regarding the underlying nature of the contrast in English between pairs of vowels such as the FLEECE and KIT vowels (Knowles 1973, for example, does not transcribe length for tense vowels at all, relying on a contrast between /i/ and /ɪ/ which could be described as tense/lax), we accept Watson's characterisations for the purposes of this paper. As we show in section 5.2, the phonetic instantiations of such vowels in LE do differ in duration, as has been described for many other (especially British) varieties, so length is presumably phonological at some level. We follow Watson in assuming that it is fundamental, as explained below. As (8) also shows, Watson (2007c) proposes the transcription /ʉː/ for the GOOSE vowel; that is, the vowel is not back at any level of analysis. This is not due to a recent variable fronting (unlike in many varieties of English, as shown in Labov et al. 2005, Ferragne & Pellegrino 2010, and the recent discussion in Jansen 2019). Rather, the GOOSE vowel has been non-back for as long as we have records for LE. Although Knowles does not overtly transcribe this, he does not disagree, writing (1973, 270) the '[c]lose central /u/ varies ... from front of centre to back of centre. At the front it overlaps with /i/, but is quite distinct from it on account of the auditory qualities and tongue-shape associated with rounding.' Watson's transcription /ʉː/ makes explicit the non-back quality of the vowel involved, so we adopt it here.

The set of contrasts in (8) also shows that LE has two contrasts less than the 'Maximal English' (Honeybone 2010) set of vowels. One of these is expected for a northern English variety: there are contrasting vowels in KIT, DRESS, TRAP and LOT, but the same vowel in the FOOT and STRUT sets. More unusually (but shared with the neighbouring Lancashire English), LE has the same vowel in the NURSE and SQUARE sets, so LE has one contrast less than most other English varieties of English in the set of vowels variously described as 'free', 'long' or 'tense'. We again follow Watson in using /eː/ to transcribe the LE NURSE/SQUARE vowel as this seems to indicate the typical frontness of the vowel in most current LE speakers. There is much else that could be said about the LE vowel contrasts, but most other points are not specific to LE, so we expect they do not need discussion here. We note further only that the LE FACE and GOAT vowels are typologically unusual for Northern English English as they are diphthongs, and that, as Cardoso (2015) shows, the PRICE and MOUTH vowels have complex patterns of realisation, so the transcriptions in (8) should be seen as 'default' or underlying forms.

We will need an understanding of the subsegmental make-up of these vowels in order to understand the pattern of DFA described above, so we offer a full analysis of the LE vowel system here. All that we will need for LE consonants is the specifications for certain places of articulation, and we consider those here too, in ways which lean heavily on that discussed here for vowels. We follow Watson's (2007c) description closely, but Watson does not offer an analysis of the featural phonology of the segments that he describes. In doing that here, we are influenced by the search for pattern congruity, economy and the aim of capturing how the segments behave in the phonology of the language, as well as for an appropriate degree of what Honeybone (2010) calls 'surface-respect' (that is, the segments' underlying specifications should reflect the phonetic space of their phonetic interpretation to a fair degree, to the extent possible while still being able to account for phonological patterning and processes).

We use a small set of privative specifications, following a practice adopted, for example, in Honeybone (2001, 2005) and Watson (2007b), which is in line with representational trends in segmental phonology, but which also aims for the specifications to be as translatable as possible into compatible frameworks. In this approach, segments may consist of single specifications, or may be 'complex' which means that they consist of more than one specification. In (9), we *name* the specifications that we use to characterise PoA relatively transparently, enclosing them in vertical slashes (borrowing a convention of Dependency Phonology). We use them to analyse the basics of the LE vowel system in (10). The specification names can be spelt out in various ways, as shown in (9), and so can largely be seen as straightforwardly interpretable in many frameworks (part of the point of using the cover-names for specifications is that the issue of quantity-sensitivity for a segmental process arises whatever model of features is adopted). The second column in (9) gives the formalism of the tradition which our set of specifications is most closely in line with: the tradition often referred to as the 'Dependency/Government' approach (e.g. in Carr, Durand & Ewen 2005), or 'Element Theory' (e.g. in Backley 2011), hence 'ET'.[18] This approach shares lines of argumentation with feature geometric approaches, for which specifications are given in the third column in (9). This follows work such as Sagey (1986), but is modified by arguments that front vowels are specified in the same way as coronal consonants, as in Clements (1991) and Lahiri & Evers (1991). We also give, in the fourth column, equivalent specifications from a recent influential development of such ideas: the Parallel Structures Model (Morén 2003, 2007).[19] The fifth column gives approximate equivalences to the specifications used here with the features used in the *SPE* tradition. As our approach assumes privativity, the translatability of specifications given in (9) is not completely straightforward, but to most intents and purposes, when we use particular specifications below in the representation of segments or formalisation of processes, they can be translated in this way.

(9)

specifications	ET	FG	PSM	*SPE*
|palatality|	I	Coronal	V-place [coronal]	[–back]
|lowness|	A	[+low]	V-manner [open]	[+low]
|dorsality|	U	Dorsal	V-place [labial]	[+back]

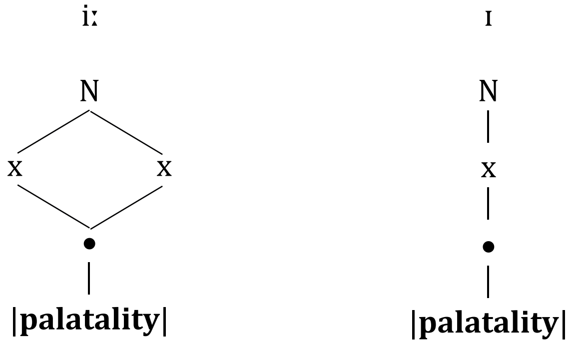
In aiming for translatability here, we ignore a number of complex issues in the representation of PoA (e.g. should labials and dorsals share some aspect of the same place of articulation; should palatals and coronals?). For the purposes of this paper, we do not think that we need to commit to answers to these questions as they do not weigh directly on the phenomenon discussed. We make one further representational assumption: that there is headedness in segmental melody. This assumes that all melodic entities need a head (as discussed widely in the tradition of segmental representation that we build on, for example in Backley 2011, 42). We mark a head in segmental representations, such as those given in (10) for the set of LE monophthongs set out in (8), using bold type.

(10)

		head	dependent	quantity
iː	FLEECE	**|palatality|**		double
ɪ	KIT	**|palatality|**		single
eː	NURSE/SQUARE	**|lowness|**	|palatality|	double
ɛ	DRESS	**|lowness|**	|palatality|	single
ɑː/aː	PALM/START	**|lowness|**		double
a	TRAP/BATH	**|lowness|**		single
ʉː	GOOSE	**|dorsality|**	|palatality|	double
ʊ	FOOT/STRUT	**|dorsality|**		single
ɔː	THOUGHT (*etc*)	**|lowness|**	|dorsality|	double
ɒ	LOT/CLOTH	**|lowness|**	|dorsality|	single
ə	*lett*ER/*comm*A			single

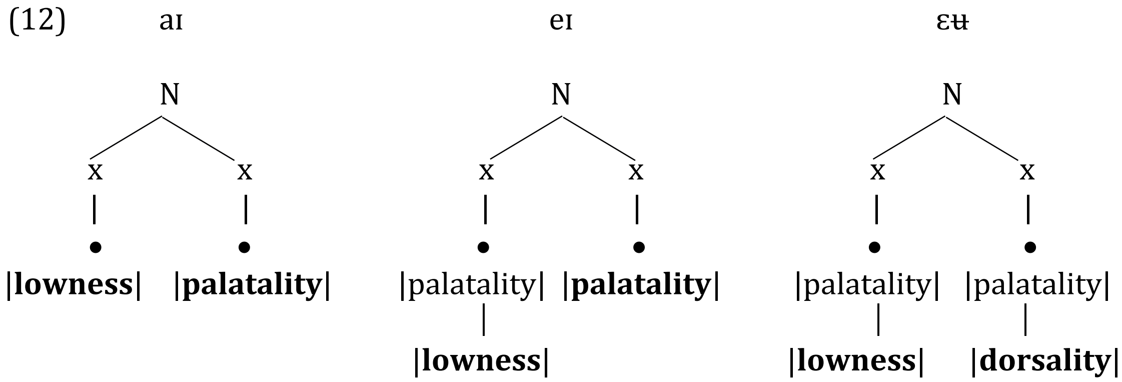
The specifications in (10) assume that quantity is indeed fundamental, with the FLEECE and KIT vowel, for example, consisting of the same featural specification, but linked to either one or two skeletal units. More explicit representations for this are given in (11), which are in line with those of Backley (2011, 47), for example. An 'N' is used to represent a nucleus, and an 'x' is used to represent a 'timing-slot', as in many representational models (a rhymal x-slot can be seen as analogous to a mora in mora-based approaches, which is something that we discuss in further detail in section 5.3). We assume here that the specifications attach, through root nodes, to skeletal timing slots and that the difference of articulation which is often described as tense/lax (e.g., that the FLEECE vowel is tense, and the KIT vowel lax) is a reflection of the realisation of the different phonological objects.

(11)



We assume, as is traditional in such representational approaches, that diphthongs of the type found in English are also represented with two x-slots, as in (12).[20] As (12) shows, we assume that each part of a diphthong has its own head. This seems right because, for example, the GOAT vowel /ɛʉ/ has multiple elements in each part of the diphthong. Diphthongs are thus simply specified as for two monophthongs, so PRICE = /a/ + /ɪ/ and GOAT = /ɛ/ + /ʉ/. The placement of a head in a representation has no relevance; for consistency, we always place it lowest in a representation.

(12)



The specifications for the PoA of LE vowels in (10) are quite straightforward once the set of specifications set out in (9) is adopted. In a simple vowel system of the type /i, a, u/, each vowel contains only one specification, and each of the three specifications produce a distinct vowel. In a linguistic system like LE, which has multiple heights, mid vowels are represented as complex, so, for example, the DRESS vowel is comprised of the specifications which independently make up the KIT vowel and the TRAP vowel. Kostakis (2015) offers a wide range of arguments in favour of such representations (from the behaviour of such vowels in a large number of diachronic developments in Germanic languages, of which LE is one) and against alternatives (such as non-specification for place in mid-vowels), and we see this as good evidence in favour of such representations.

Other aspects of (10) need some comment. The KIT vowel /ɪ/ cannot be left unspecified in terms of the features used here (as Youssef 2010 does in a PSM approach for Buchan Scots) as there is no evidence for any other feature to specify it distinctly from schwa, which can then itself be left unspecified (unlike for Buchan Scots, where Youssef argues that a feature [Lowered Larynx] is needed in the system). The representations in (11) fit the LE system, as we discuss further below, and they fit the phonetic facts, too, as we discuss in section 5.2.

As will be seen below, the notion that segmental representations involve headedness fits well with the analysis we propose for the LE pattern of DFA. In (10), we assume that |lowness| is head where it features in a segment. This has the effect that |palatality| is not head in complex vowels, an analytical assumption which is carried over into the representation of the GOOSE vowel /ʉː/, which we assume is specified with a dependent |palatality| because of the consistent and persistent long term phonetic placement of the vowel in the front-to-central section of the vowel space (this is clearly the target that speakers aim at). This does not make the GOOSE vowel a 'front' vowel, as it contains both |palatality| and |dorsality|, which pull the vowel both ways (both to the front and to the back, which in LE is resolved by realising the vowel as front-to-central); in fact, nothing in our analysis depends on this complex specification of /ʉː/, but the overall analysis of the vowel system given in (10) seems most compelling, for reasons that we touch on below. The assumptions in terms of headedness do not follow from a principle, but they fit best with the patterning that LE shows, as we explain below. They combine with the other assumptions above to provide an analysis of the LE monophthong inventory which sees it as a symmetrical system of vowel pairs, disturbed only at the back-high place, where there is no pair (only the FOOT/STRUT vowel is there) – instead, the GOOSE vowel is filling what would otherwise be a complete gap in the system: it is a high central vowel. The symbols suggested by Watson (2007c) for the transcription of LE, as given in (8) and (10), are arranged into the system suggested here in (13a). We continue to use these symbols below for the sake of transcriptional tradition, but we acknowledge that our analytical assumptions really imply that LE has a system of segments that would best be transcribed as set out in (13b), with the difference in the pairs being one of quantity, and with the mid-vowels specified with |lowness| as head. This latter point is in line with the observation that the LE NURSE/SQUARE vowel is in fact transcribed as /ɛː/, in much other work on LE (for example Watson 2007b, Honeybone, Watson & van Eyndhoven 2017).

(13) (a)

iː ɪ	ʉː	ʊ
eː ɛ	ə	ɔː ɒ
	ɑː a	

(b)

iː i	ʉː	u
ɛː ɛ	ə	ɔː ɔ
	aː a	

A final implication of all this is that the LE diphthongs would best be transcribed as set out in the last column in (14), in which the first two columns are from Watson (2007c), and the third column shows Wells' (1982) keyword for the relevant lexical set. As shown in (12), the first part of the FACE and GOAT diphthongs are analysed here as phonologically the same.

(14)

eɪ	*hay*	FACE	ɛi
aɪ	*high*	PRICE	ai
ɔɪ	*boy*	CHOICE	ɔi
ɛʉ	*hoe*	GOAT	ɛʉ
aʊ	*how*	MOUTH	au
iɛ	*beer*	NEAR	iɛ

We do not need to consider the segmental make-up of LE consonants in as much detail as its vowels, as only the place of articulation is really relevant to our purposes, and within PoA only those places relevant for DFA are necessary. We represent them as shown in (15), using some of the specifications from (9).

(15)

PoA	examples	place specification
palatal	j, ç	|palatality|
velar/back	k, x	|dorsality|

This means that we assume that [ç] is specified in terms of PoA only by |palatality|, not by (the equivalents of) both |palatality| and |dorsality|, which is what Robinson (2001) in fact assumes, together with his rule given in (3). It is translatable into the use of |coronal| to specify the place in [ç], as long as that feature is also used to specify place in front high vowels (as in Clements & Hume 1995 and much else, but not as in Sagey 1986 and other such work). Within |dorsality|, we assume that a range of precise articulations are possible ([x_{+}~x~χ_{+}]), likely driven in part by coarticulation.

Otherwise, in terms of consonantal structure, we assume only that fricatives include a specification |frication|, which can be seen as translatable into |h| in most varieties of Element Theory, as 'C-manner [open]' in the Parallel Structures Model, and as [+continuant] in a more traditional feature system. We therefore represent [ç] as in (16), where the specification for place is assumed to be head, as for vowels (although little hangs on this in terms of our analysis of DFA).

(16) ç

x
|
•
|
|frication|
|
|spread glottis|
|
|**palatality**|

We can now present a formalisation of the patterning of DFA which was shown to exist in LE in section 4. We do this in section 5.3. Some of the assumptions made in this current section will be crucial in that. It may be, however, that the reader will doubt some of these assumptions (are FLEECE and KIT really both front high vowels? and are they really differentiated as 'long' and 'short'?). In anticipation of such worries, we next present some clear evidence in favour of our assumptions.

5.2. *Are FLEECE and KIT really both front high vowels? And are they long and short?*

Section 5.1 argues that the LE FLEECE vowel, which triggers DFA to produce [ç] in the patterns described in (7), is phonologically different from the LE KIT vowel, which does not trigger DFA in the patterns in (7a) and (7b), only in that FLEECE is long and KIT is short. But is this really the case? A reader might assume that the vowel that we are transcribing as /ɪ/ in LE is actually not front and high at all (as in New Zealand English, Scots and in some environments in South African English), and that *this* is why no assimilation occurs after it. This is not the case, however: there are good reasons to see the KIT vowel as a front high vowel which is phonologically specified for the feature that can in principle induce palatalisation in DFA, in exactly the same way as the FLEECE vowel. While we do not expect to be able to read off phonological specifications from phonetic data in a simplistic manner, we expect some degree of 'surface respect', such that vowels that are specified by |palatality| will be in the front-high section of the vowel space. If LE KIT is central, as in some other varieties of English, we would not expect it to be specified by |palatality|. Figure 10 is a plot of LE vowels from our data which shows the relevant placement of a number of LE vowels in the standard F1-F2-plot approximation of the vowel space.[21] While schwa (represented by '@') is rather high in figure 10, this may be because final schwas can be raised in LE, and schwa is unspecified in terms of place, so may be expected to have a wide range of realisations. As assumed in section 5.1, affiliation to a double unit of length produces a more extreme articulation, and from what we know about practically all varieties of English, we would not expect both members of the FLEECE/KIT vowel pair to occur in exactly the same spot on the vowel space; nonetheless, figure 10 shows that KIT is fundamentally in the front-high quadrant of the vowel space in LE, between FLEECE and DRESS, and overlapping with FACE.

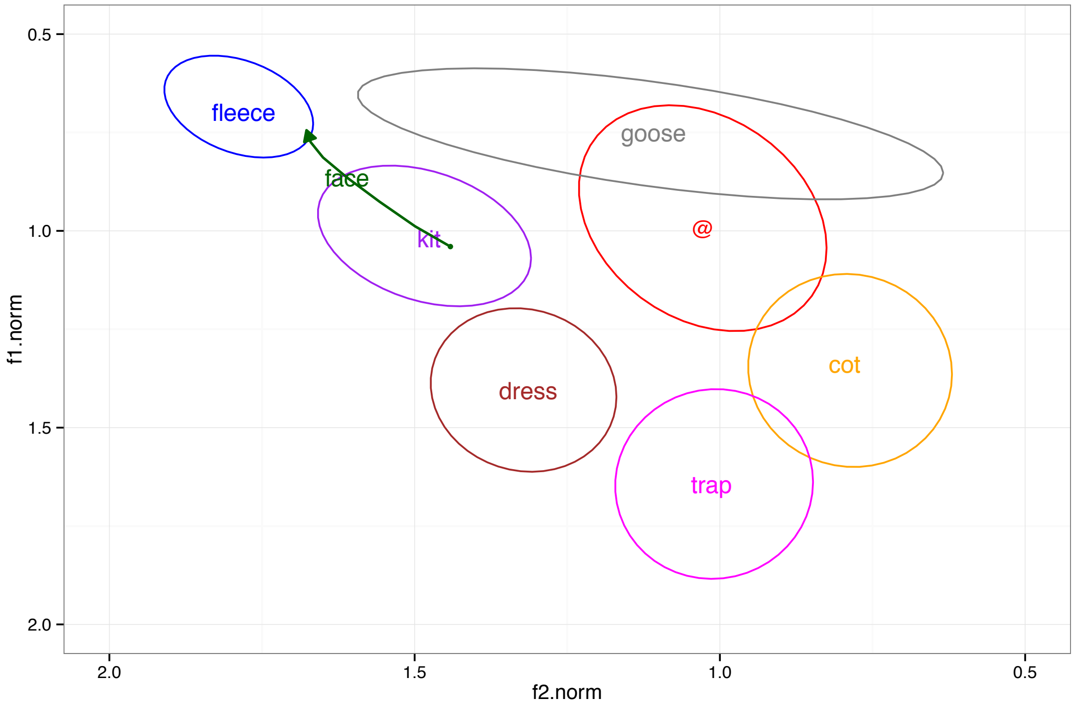


Figure 10. F1-F2 plot showing the phonetic realisation of LE vowels.

The placement of KIT in figure 10 is similar to its placement in the F1-F2 plot for Liverpool given in Ferragne & Pellegrino (2010), which compares such plots for a number of varieties of English, with KIT on a diagonal between FLEECE and DRESS. This is fundamentally the same as Ferragne & Pellegrino's findings for varieties of English from Birmingham, Cornwall, East Anglia, East Yorkshire, Lancashire, Newcastle upon Tyne, Dublin, and for 'Standard Southern English', but is different to what they find for Glasgow, Elgin in the Scottish Highlands, and Belfast, where KIT is clearly central. Given that LE patterns like the former set of varieties, a reasonable conclusion is that KIT is a front high vowel, like FLEECE, in LE if it is *anywhere* in English. If Liverpool patterned like the latter set of varieties, a case could be made that KIT was not a front high vowel in LE.[22]

The above shows, to the extent that phonetic data can, that both FLEECE and KIT are front high vowels in LE (of the type that we might expect to be characterisable using |palatality|), with their difference in the extremity of their articulation due to differences of implementation. But do they really differ in quantity? If so, we would expect that FLEECE would be realised with fundamentally longer duration that KIT, with FLEECE comparable to a diphthong like PRICE. Figure 11 shows that this is the case. The plots in figure 11, which show the measurements for the duration of these vowels in the data collected for this study and for

Cardoso (2015), indicate that FLEECE is fundamentally longer in its duration than is KIT, with no overlapping in the boxplots at all. On the other hand, FLEECE and PRICE are of overlapping, comparable length.

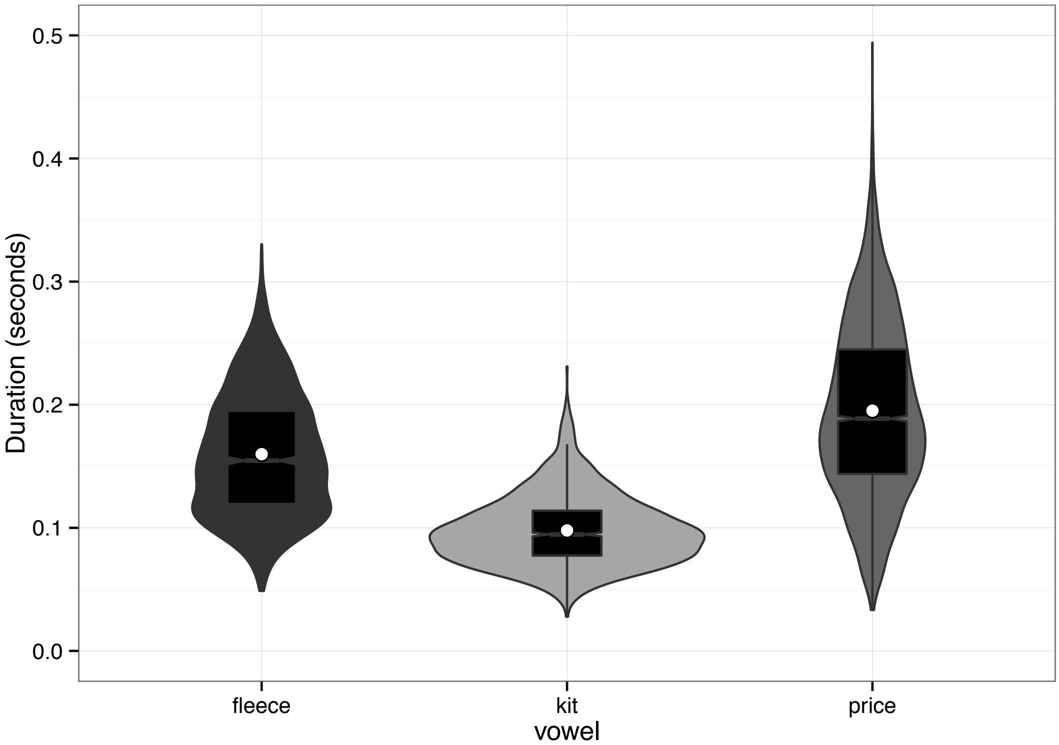


Figure 11. Duration of LE vowels.

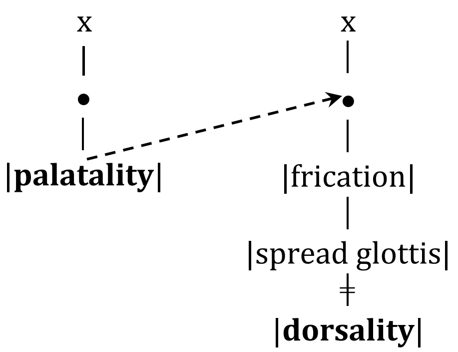
All the available phonetic evidence indicates that the basis of the difference assumed for FLEECE and KIT in section 5.1 is on the right lines. In any case, the minority of speakers of LE listed in (7c) have a grammar in which both FLEECE and KIT cause palatalisation, which implies that both vowels contain the specification which can cause the LE dorsal fricative to become a palatal. It seems, though, that in most speakers, KIT is prevented from passing on this specification. We turn to the reason for this now.

5.3 *Analysis: quantity-sensitive DFA in Liverpool English*

The basic PoA assimilation in the patterns of DFA described in (7) is nothing out-of-the-ordinary. As shown in (1), DFA in which a palatal fricative is adjacent to front high vowels (and sometimes front mid vowels) and a back fricative is adjacent to other vowels is common in languages, and can be modelled by the spreading of a feature which only front high/mid vowels have to the fricative, or by the forced agreement of the fricative's place features with those in the vowels. As will be clear from section 5.1, we assume here that this involves the transference of |palatality| from a vowel to a following dorsal fricative. The central question, which makes the data described here exceptional, is: why does the DFA in the majority of speakers only occur following long vowels? To answer this, we follow a lead given in Bye & de Lacy (2008), which links certain segmental patterns (which have something in common with the pattern of DFA in question here) to foot structure. The pattern described here has a fundamental difference to that described by Bye & de Lacy, however, as we explain below.

We model the basic assimilation involved as shown in (17). This is a simple representational conception of DFA as spreading, in which |palatality| spreads when it is the head of a segment (represented, as above, in bold) to a following back fortis fricative, which then loses its own place specification (|dorsality|), resulting in [ç]. The latter point could follow from the assumption that a segment can only have one head, and so |palatality| replaces |dorsality|, but this assumption is not absolutely necessary. (17) can be translated into whichever representational framework a reader prefers; indeed it could be seen as the addition of |palatality| to |dorsality| if that is the representation preferred for [ç]. The process in (17) could also be implemented OT-style as the satisfaction of a high-ranked AGREE(|palatality|) constraint which penalises a VF sequence in which members do not either both have or lack |palatality| (where 'F' refers to a dorsal fricative), or using a high-ranked constraint which bans a sequence of a back or low vowel followed by [ç], as in Merchant (1996). The precise means of implementing the part of the process given in (17) is not crucial.

(17)



The spreading process in (17) accounts for the non-quantity-sensitive pattern described in (7c). The majority pattern in the LE data, however, described in (7a) and (7b), *is* quantity-sensitive: DFA occurs if the preceding vowel (monophthong or diphthong) is long, but not if it is short (we deal with the difference between 7a and 7b in subsequent sections). Quantity-sensitivity is not normally a property that is associated with segmental phenomena, but Bye & de Lacy (2008) describe another phenomenon which can be seen in this way. Flapping in English (at the lexical level) typically occurs in intervocalic (or intersonorant) position, as long as the second syllable in the relevant sequence is not stressed. Bye & de Lacy (2008, 197) show, however, that post-stress flapping in New Zealand English (NZE) Acrolect has the patterning given in (18).

(18) a. Flapping after a short stressed vowel and before a vowel

[hǽɾə]	*hatter*	[kǽɾi]	*catty*
[ɹəgǽɾə]	*regatta*	[tʰæ̀ɾəməgútʃi] *Tatamagouchee*	

b. No flapping after a stressed long vowel or stressed diphthong

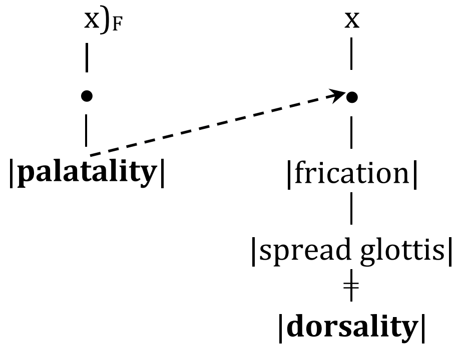
[báːtə]	*barter*	[míːtə]	*metre*
[kəmpjúːtə]	*computer*	[ɹáɪtə]	*writer*
[páʊtə]	*pouter*		

The distinction between examples like *hatter* [hǽɾə] and *barter* [báːtə] shows that, in NZE Acrolect, flapping *only* happens if the vowel which precedes the foot-internal /t/ is short. Flapping does not occur if the preceding vowel is long. Bye & de Lacy account for this by proposing that it is related to the different positioning of the /t/ in relation to foot structure. This relies on the assumption that the English foot is the moraic trochee, following a long line of work such as Hayes (1987, 1995). The footings given by this assumption, with the foot represented by parentheses, are [(hǽɾə)] and [(báː)tə], because short vowels and coda consonants each possess one mora, and long vowels possess two moras. The footings relevant here (and throughout this article) are the *initial* footings (it is likely that, later in a derivation, initially unfooted syllables are grouped into higher-level feet, or 'superfeet'). A mora is equivalent to a *rhymal x-slot* for our purposes, and we use the term 'mora' to refer to this type of structure below. This means that both the [æ] and [ə] from *hatter* are needed to form a foot, which in turn means that the /t/ in that word is foot-medial, whereas the [aː] vowel of *barter* contains two moras, so the /t/ in that word is not in the foot, and flapping is blocked. The precise implementation of Bye & de Lacy's account of flapping need not be considered here; their crucial insight is the role of foot-structure in conditioning it. Fundamentally, if the target for flapping is outside of the foot, flapping is blocked.[23]

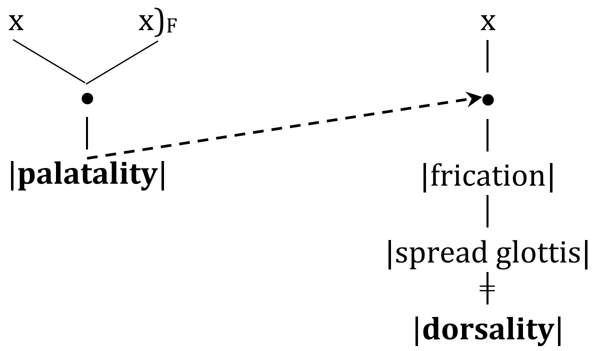
The pattern and process that Bye & de Lacy (2008) describe is similar to, but also notably different from, that described in this paper. The quantity-sensitive pattern of DFA in LE is, we propose, not blocked, but *triggered* if the target is outside of the foot. Thus, for speakers with quantity-sensitive DFA, we account for the difference between *teak*, where DFA occurs (following the FLEECE vowel), and *tick*, where it does not (represented here and below using [χ] to represent a back dorsal fricative), following the KIT vowel, as in (19), where foot structure is again represented using parentheses. The [ɪ] of *tick* has one mora, so the foot (which requires two moras) includes the following consonant, which is also moraic on classical assumptions (coda consonants are typically assumed to be moraic in Standard English for syllable-weight-based reasons, and this also applies to LE); the [iː] vowel of *teak*, on the other hand, has two moras itself and the following fricative (which is moraic itself as it is in a classical coda position) cannot be included in the bimoraic foot.

(19) *tick* [(tɪχ)]
teak [(tiː)ç]

We assume, therefore, that the quantity-sensitive DFA process, as found in the large majority of the LE speakers described in section 4, can be characterised as in (20), where foot structure is made explicit (the foot boundary is also marked with a subscript F for clarity).

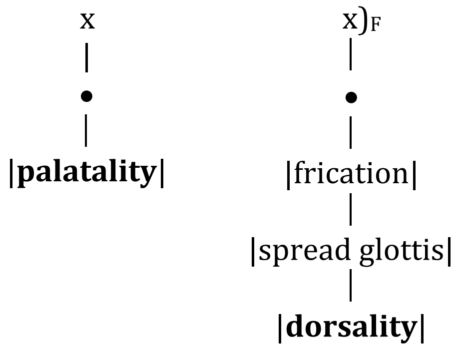
(20)


This should be read as requiring that a foot-boundary be present between the trigger and the target for the spreading to occur, and (as above) that |palatality| must be a head in order for it to spread. Another way of saying this is that the target dorsal fricative must be outside the basic bimoraic foot in order for it to assimilate. In line with the representations for LE vowels proposed in section 5.1, we think this makes exactly the right predictions. It shows that the DFA will occur in *teak*, and all words with that rhyme, as in (21), which represents the rhyme of such words.

(21)


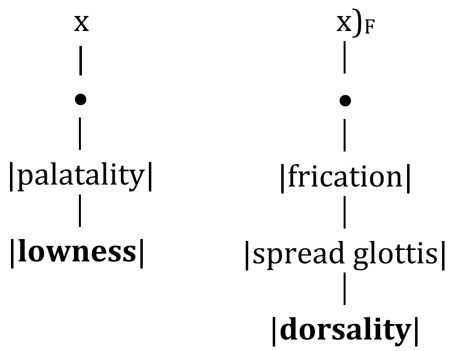
(20) prescribes that the (quantity-sensitive) DFA in question here will not occur in *tick* (or other words with that rhyme), as shown in (22), with the foot boundary not where it needs to be in order to trigger DFA. The potential target for the DFA is inside the foot that contains the potential trigger, so no DFA occurs.

(22)



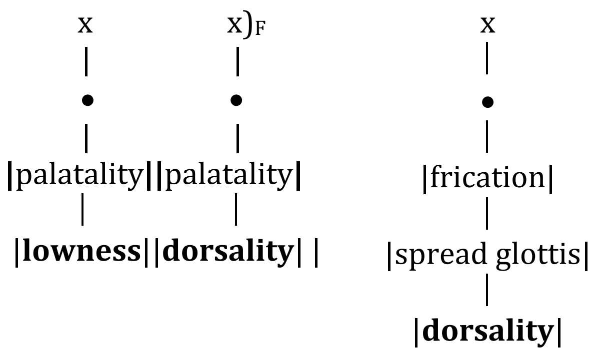
(20) makes further clear predictions as to where LE quantity-sensitive DFA should and should not occur. Clearly, we predict that there will be no palatal fricatives following vowels which do not contain |palatality| (low vowels, schwa, /ʊ, ɒ, ɔː/). DFA should also not occur in words with the DRESS vowel, such as *tech*, because neither the foot-structure nor headedness requirements are met, as shown in (23).

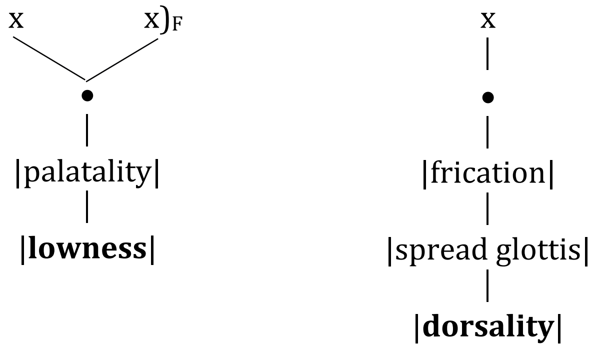
(23)



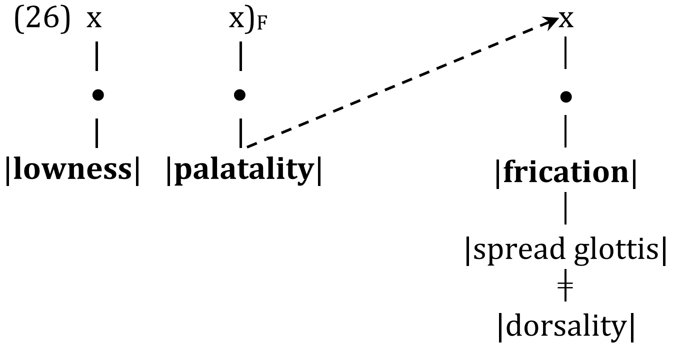
DFA should also not occur in fricatives following the GOAT vowel, as in *toke*, because the headedness requirement is not met, as shown in the rhyme in (24), nor will it occur in words with the NURSE/SQUARE vowel, such as *Turk*, as shown in (25).

(24)

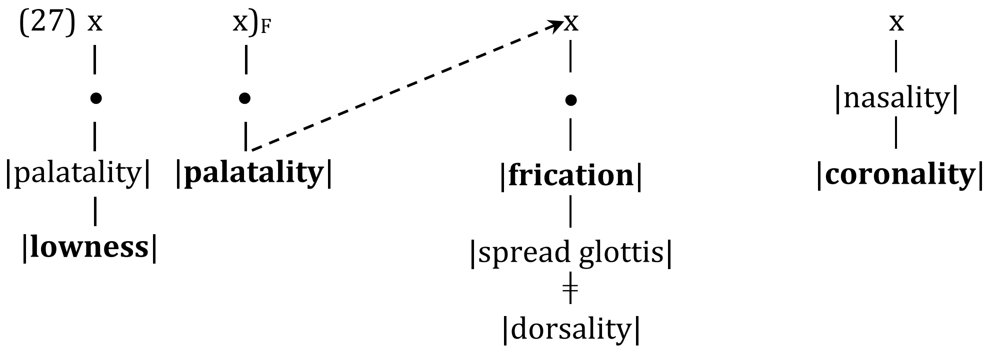


(25)


We predict that the process *will* occur, however, following the PRICE vowel, as in *tyke*, as shown in (26), and the same prediction holds for words like *take* (with the FACE vowel).

(26)


Finally, in this regard, we predict that LE quantity-sensitive DFA will also occur in a medial environment in words with a FLEECE, PRICE or FACE vowel, such as *taking* or (monomorphemic) *bacon* (which would be [(beɪ)çn̩]), as shown (minus the initial consonant) in (27), because the dorsal fricative is in the environment described in (20). DFA is predicted not to occur, however, in medial dorsal fricatives following a short vowel, including the KIT vowel, as in words such *ticking* or (monomorphemic) *chicken* (which would be [(t͡ʃɪχn̩)]), as shown (minus the initial consonant) in (28), because the fricative here is foot-internal.

(27)


```
(28)        x                    x                  x)F
            |                    |                  |
            •                    •              |nasality|
            |                    |                  |
      |palatality|          |frication|      |coronality|
                                 |
                          |spread glottis|
                                 |
                            |dorsality|
```

The predictions made here are empirical, but the full testing of them is beyond the scope of this paper. They can, however, be easily checked against all previous descriptions of dorsal fricatives in LE, as described in section 3.1. They hold up well in this light. As mentioned above, Knowles (1973) does not transcribe or describe palatals, possibly because his fieldwork was conducted before the pattern of DFA described here was innovated. The other representative transcriptions and descriptions that are based on first-hand phonetic analysis (we consider here Marotta & Barth 2005, Watson 2007c and Ogden 2009), fit well with what we predict here.[24] Watson's (2007c, 353) observation that 'palatal fricatives can be found following the close front monophthong [iː] and closing diphthongs [eɪ, aɪ]' is clearly compatible – it does not explicitly exclude palatals following short vowels, but we might expect that Watson would mention short vowels in this place if he had noticed palatals following them. None of the previous work discussed here happens to provide an example of a dorsal fricative following a short front high vowel that we could consider, apart from Wells (1982), which transcribes *neck* as [nɛχ] – if this is allowed as a relevant datum, it is compatible with what we predict.

The transcriptions discussed in section 3.1 unambiguously describe back dorsals following short vowels, as in [bax] *back* (given by Watson and Ogden), [dɒχ] *dock* (Watson and Ogden), [t^{s}ʊx] *took* (Watson); in terms of post-long-vowel fricatives, all data also fit our predictions, as in [ʃaːx] *shark* (Watson), [wiːç] *week* (Watson and Ogden), [laɪç] *like* (Watson and Marotta & Barth), [t^{s}eɪç] *take* (Watson), and also in terms of the GOAT vowel, as shown in [klɛʉx, k^{h}lɛʉx̟] *cloak* (Watson) and [sməʉx] *smoke* (Ogden), even though the authors transcribe the vowel slightly differently. All of this is as predicted above.

In terms of medial dorsal fricatives, our predictions also fit with the previous data. Watson (2007c) gives [maːxɪh] *market*, with a low vowel and hence no DFA, and [meɪçən] *making*, with a FACE vowel preceding the fricative, and hence a palatal. We have no data for post-medial-KIT-vowel dorsal fricatives, and this offers a crucial empirical prediction if our foot-related analysis is correct. We think it is relevant here that the pronunciation of *chicken* with (pre-)uvular fricatival scrape (i.e. with a back dorsal fricative) is a shibboleth for LE, doubtless because the uvular is strident/salient. This should become clear if the reader googles *Scouse chicken*, or the phrase 'chicken and a can of coke', which should bring up a large number of results (22,900 on 3rd July 2020 including http://www.wikihow.com/Talk-Like-a-Scouse-Teenager). While some of this material is playing with stereotypes, and may be insulting, we see it as nonetheless evidence that our prediction is met: the fricative in this environment is back, as no DFA can occur.[25]

5.4 *Individual differences in the grammar and innovation of LE DFA*

The last section focused mainly on the quantity-sensitive pattern found in the data discussed in section 4 – that is clearly the case in the speakers grouped in (7b), where the distinction between the palatal and the back dorsal fricatives is categorical, and it is also clearly relevant to those grouped in (7a), where there is an overlapping, phonetically gradient distinction between the two types of fricatives. However, our data also shows the small number of speakers grouped in (7c), which show non-quantity-sensitive DFA. In this section, we consider these inter-speaker microdifferences and the relationship between the patterns that they show.

We provided an analysis for speakers of both main types (7a,b and 7c) in section 5.1. The difference is in the structural description of the phonological process, not the segmental representations: for (7c)-type speakers, the DFA is not sensitive to foot-structure. We propose that the differences between speakers is best understood by assuming that these speakers show a number of stages in the *development* of LE DFA. Knowles (1973), discussed here in section 3.1, is transcribing LE from the late 1960s. He provides no evidence that dorsal fricatives assimilate – rather, in the forms given in (4), repeated here as (29), he seems to be transcribing (physiologically unavoidable) coarticulation, in which the precise place of articulation of the fricative is affected by the preceding vowels, just as the precise realisation of /k/ is widely described to be slightly variable in languages.

(29) [snɛɪx+] *snake*
[nɛx] *neck*
[bux+] *book*
[klɒx-] *clock*

This coarticulation is precisely the kind of precursor state which can lead to the development of a phonological process through a process of phonologisation (as in the broad swathe of literature on this topic, such as Hyman 1976, 2013). Once a phenomenon has become phonologised, it will be more exaggerated and consistent than any pattern of coarticulation – it is under cognitive control and can thus interact with other phonological entities. During the first stage after which a phenomenon has come under grammatical control, it is expected to be a phonetically gradient, regular process (as in the model of change known as 'life cycle of phonological processes' – see, among others, Bermúdez-Otero 2007, 2015, Ramsammy 2015, Sen 2016). This seems to be exactly what we have found in those speakers grouped as (7a) above, and the existence of this gradient stage in current speakers indicates that the phenomenon is indeed relatively recent in LE. Phonologisation models such as the 'life cycle' predict that the second stage, following an initial gradient stage, is for the process to become a 'standard' categorical phonological process. This seems to be exactly what we have found in those speakers grouped as (7b) above – indeed, that fact that speakers with a categorical distinction between CoG measurements in the post-FLEECE and post-KIT environments operate on a tighter scale than the speakers at the gradient stage also fits with this[26] – the categorical speakers have a more precise target, which is expected if their pattern is due to a stabilised phonological process. The coexistence of gradient and categorical speakers is no surprise if we assume that those with the categorical process are 'one stage further advanced' in the phonologisation of the phenomenon. If we assume that the quantity-sensitive DFA process has recently begun to become categorical in LE, we would expect to find variation within the speech community between some speakers with the original gradient pattern and some with the more advanced categorical pattern. The division into gradient and categorical speakers does not correlate with age: gradient speakers are 19, 20, 21, 22 and 47 years old, the same range as categorical speakers, who are 18, 21, 23, 28 and 40 years old, so this is truly a difference between individuals, some of whom are more advanced in terms of the adoption of the process than others. We did not find any speakers who do not assimilate at all in our data, but this seems to be what is transcribed by Knowles (1973), and it is also noteworthy that Watson (2007b) finds *some* speakers with assimilation and some without, so it seems likely that the assimilation is a recent innovation in LE. Watson's data suggests that males may have led the innovation of the process as he finds palatals only in male speakers, as discussed above. As our data shows palatals in as many females as males, it may be that the process is being taken up more broadly by the speech community now. However, as neither we nor Watson focused on this question, this must remain speculation.

The kind of situation that we assume here is not unusual when a process is being introduced into a language. It is found in pre-sonorant *s*-voicing in Quito Spanish by Strycharczuk (2012), where some speakers in the current speech community show a gradient voicing of /s/, while others have a categorical process of voicing; this can be interpreted, like in Liverpool, as the simultaneous presence of the initial, gradient stage of the process and its later, categorical stage in different members of a speech community (see also Bermúdez-Otero 2015); and the same is also found by Bermúdez-Otero & Trousdale (2012) in their analysis of Ellis & Hardcastle's (2002) articulatory study of *n*-assimilation in /n#k/ clusters (as in *ban cuts*), where some speakers show no assimilation, others show a gradient reduction of the alveolarity, and a further group of speakers show categorical absence of alveolarity – in these latter two groups of speakers, this again shows the simultaneous presence of speakers who have an early and a later stage of a process in the same speech community.

This is not all that is found in the Liverpool data, however. The pattern found in the two speakers grouped above in (7c) shows a subtly different patterning, in that it does not have the prosodic sensitivity of the majority pattern.[27] It is a categorical pattern, and it raises the possibility that a few speakers have gone one stage further even than those in (7b), that is, they have simplified/generalised the quantity-sensitive process, by losing the '$)_F$' specification in its formulation. This may be plausible: this kind of quantity-sensitive consonantal process is clearly quite rare – such a pattern has not been reported before in an assimilation – and this might imply that it is either difficult to acquire or easy to lose diachronically. On the other hand, the quantity-sensitive assimilation is the majority pattern in our data, and an alternative scenario is that the (7c) pattern has not gone through a (7b) stage, but is rather an alternative route to categoricality after a gradient stage such as (7a) – perhaps even a gradient stage which was not quantity-sensitive. Our current state of knowledge does not allow us to determine which scenario is correct, and it is likely that only further research over several decades will be able to show if the (7b) pattern is stable in the long-term; it may be that a range of grammars, such as we have found in our data, will simply remain in stable 'free' variation. LE is a stigmatised variety, but it nonetheless has high covert prestige, so many speakers are happy to 'sound Scouse'; there is, however, no clear 'standard' pattern to follow for LE – in part connected to this, the phenomena related to the assimilation, including the lenition process which creates the dorsal fricatives in the first place, are subject to variation, and seem likely to remain so.

What is clear is that the quantity-sensitive pattern currently exists in LE, and there is currently a period of variation in the speech community, with a range of grammars. Such individual differences in phonology are not often discussed, but are not rare (see Hall-Lew, Honeybone & Kirby, to appear, for an overview). For example, the several types of articulation used by various speakers to realised /r/ in American English ('bunched' and 'retroflex', for example) has long been documented (as in Delattre & Freeman 1968), and more recently, Baker, Archangeli & Mielke (2011) have shown that certain speakers of American English in some areas retract /s/ towards [ʃ] in *str-* and similar sequences much more than others; Jones (2015) argues that in words like *huge* and *human* in British English, some speakers retain an initial underlying /hj/ sequence, as they realise the sequences with voicing throughout, which suggests that the frication is not 'essential', while others produce purely voiceless frication throughout, suggesting an underlying /ç/. Teasing apart variation between speakers and variation within speakers is crucial in understanding the patterning of variable phenomena, and in all the cases discussed in this section, including LE dorsal fricative assimilation, slightly different (variable) grammars are found within one speech community.

5.5 *Can palatalisation really pattern in this way? Can segmental processes really be quantity-sensitive? Why are they rare?*

The reader may be wondering whether consonantal processes of the type that we describe here for LE are really possible in language. In this final section we confirm that segmental processes certainly can have the kind of patterning that we describe for LE quantity-sensitive DFA. DFA is a kind of palatalisation, which is a well-studied type of process (see, for example, Bhat 1978, Bateman 2007, Krämer & Urek 2016). We are aware of no other pattern precisely like that described here, where the quantity of the segment that triggers assimilation is a constraining factor on whether or not the palatalisation occurs, but other similarly complex patterns exist. Bateman (2007) investigates palatalisation in a sample of 117 languages (intended to be representative and to avoid genetic, areal, and bibliographic biases) among which 58 languages have some form of palatalisation. None of the languages in her sample show a quantity-sensitive pattern of palatalisation but other languages have patterns which also seem initially surprising. For example, in Fanti, the fortis velar fricative assimilates to [ʃ] before front vowels (a common kind of palatalisation). However, the palatalisation is blocked not if the vowel is long, but if it is nasal (the fricative then surfaces with secondary palatalisation). All this is shown in (30), which is taken from Welmers (1946), Bateman's original source for the Fanti data, and slightly adapted (in part following Bateman), to update symbol choice and omit tone and other diacritics for clarity. This pattern of palatalisation is all the more surprising because other dorsal consonants, such as the stops, fully palatalise before both nasal and non-nasal front vowels in the language.

(30)	xira	[ʃ]ira	'earthen water pot'
	xe	[ʃ]e	'he located at (out of sight)'
	xiã	[xʲ]iã	'need' [with /i/ nasalised at the surface before /ã/]]
	ixen	i[xʲ]en	'boat' [with /e/ nasalised at the surface before /n/]

Patterns of palatalisation can thus clearly be more complex than those set out in section 3, and this is the full context for the interpretation of the LE pattern discussed here. We might well wonder, though: can segmental processes really be quantity-sensitive? The kinds of phenomena that are standardly assumed to be quantity-sensitive involve stress assignment or other prosodically-related phenomena such as syncope or prosodic morphology. We think that there is no doubt, however, that segmental processes can have this kind of patterning. While the DFA from LE that we describe above is the first report of which we are aware to show that an assimilation can be sensitive to quantity (through its sensitivity to moraically-dependent foot-structure), other phenomena have been previously reported involving other consonantal processes with the same type of patterning.

Bye & de Lacy's (2008) data from Acrolectal New Zealand English presented in (18), above, clearly demonstrates a consonantal phenomenon with analogous patterning. It is not unique. Balogné Bérces & Honeybone (2012) collate a number of cases of consonantal lenition which show the same fundamental patterning: a process involving a 'standard' type of consonantal change (spirantisation, 'voicing', flapping) is sensitive to the quantity of preceding material. For example, the same patterning that Bye & de Lacy report for Acrolectal NZE is also recorded in flapping from Northern England in Ellis (1889) (see also Broadbent 2008), and this is also reported as current in contemporary Blackburn English by Turton (2017). Also, the aspect of the High German Consonant Shift (HGCS) in which stops were left spirantised in medial positions (with West Germanic /p, t, k/ now having the reflexes /f, s, x/) is shown to be sensitive to preceding quantity in the Wermelskirchen dialect of German by Hasenclever (1905) (see also Iverson & Salmons 2006). The High German Consonant Shift is, overall, a complex matter (see, for example, Salmons 2012) which was innovated and lexicalised many centuries ago, but the data reproduced in (31) (from Hasenclever 1905, as in Balogné Bérces & Honeybone 2012) shows the point in question here clearly. (31) gives Hasenclever's data for Wermelskirchen German (except that the transcriptions are slightly updated, and they simplify the representation of length to use [ː] to reflect the vowel length that was present when the spirantisation occurred), the orthographic form from Standard German with the representation of the consonant in question in bold (which shows that the variety represented in that spelling had spirantisation following both short and long vowels – given that <ß> is one way of representing [s] and <ch> represents the dorsal fricative which undergoes DFA as discussed in section 3), and, in the third column, the English cognate, which retains the West Germanic consonants unchanged.

(31) Reflexes of West Germanic /p/

[ɔfən]	*o**ff**en*	'o**p**en'
[pɛfər]	*Pfe**ff**er*	'pe**pp**er'
[aːpə]	***A**ff**e***	'a**p**e' [28]
[diːpə]	*tie**f***	'dee**p**'

Reflexes of West Germanic /t/

[frjɛsən]	*verge**ss**en*	'forge**t**'
[vasər]	*Wa**ss**er*	'wa**t**er'
[ʃiːtən]	*schie**ß**en*	'shoo**t**'
[ʃtrɔːtə]	*Stra**ß**e*	'stree**t**'

Reflexes of West Germanic /k/

[brɛçən]	*bre**ch**en*	'brea**k**'
[kɔχən]	*ko**ch**en*	'coo**k**'
[ruːkən]	*rie**ch**en*	'ree**k**'
[zyːkən]	*su**ch**en*	'see**k**'

The HGCS was once a synchronic process which involved spirantisation. It patterned quite differently in different High German dialects, but the data in (31) show that, in Wermelskirchen at least, the spirantisation occurred only if the preceding vowel was short. This fits with the same basic analysis set out for LE DFA and the cases of flapping discussed above: the moraic trochee provides an environment that allows us to characterise the processes. Like in English, the moraic trochee is often recognised to be relevant in German (see, for example, Féry 1998), and on this basis we can see that the HGCS spirantisation only occurred in Wermelskirchen if a stop was within the foot: the cognate of *cook* is [(kɔxə)n], with spirantisation, and the cognate of *seek* is [(zyː)kən], without.

Given what we have seen in this article, we can now recognise a typology of processes in the relevant regard: those which are *triggered* and those which are *blocked* by being inside a foot. Wermelskirchen HGCS and the types of flapping discussed above are triggered if the target is within the foot; on the other hand, (majority pattern) LE DFA is blocked if the target is within the foot. It may make less intuitive sense for a process to be blocked by being inside a foot than to be triggered by it, but it seems that phonology is able to do this, so both 'post-short vowel' and 'post-long-vowel' environments need to be phonologically characterisable, in a way which might lead us to expect that they trigger a process. Our analysis of LE DFA in section 5.3 offers a suggestion for the latter; Bye & de Lacy's (2008) approach characterises only the former.

We refer in many places here to the length of a preceding vowel, but we assume in our analysis that this is simply because of the number of moras (that is, rhymal x-slots) that vowels of different phonological lengths provide, which means that a consonant must or must not be included inside a foot. It will be clear that our analysis could be recast in other theoretical clothing – in approaches where faithfulness is fundamental, it may be appealing to consider the idea that LE DFA involves *foot-internal faithfulness*, while the other processes considered here show foot-external faithfulness.

The quantity-sensitive pattern of DFA described here is unique in the literature as far as we are aware, but we naturally do not intend to imply that no other such phenomena exist. If we are right, other such patterns should be able to occur in language. Indeed, we hope that this article will generate awareness of other such patterns. It is clear that the pattern is rare, however, and it is worth considering why this might be. It makes good sense to us that quantity-sensitive DFA should be rare in the worlds' languages, because the set of conditions that are needed before it can be innovated are quite substantial. Firstly, a language needs a short-long contrast in vowels. While not rare, this is not exactly common across the world's languages (Gordon 2016). In addition to this, a language needs the moraic trochee as its foot-type (this is not the same thing as the previous issue – they are separate parameters as in some languages, only coda consonants make a syllable heavy). While again not rare, this is not the most common foot-type (Gussenhoven & Jacobs 2017). Furthermore, the language needs to innovate a palatalisation process – again, palatalisation is not unusual, but if Bateman's survey is representative, only 58 out of 117 languages have any kind of palatalisation, and many of those are cases of secondary palatalisation, not primary palatalisation of the type involved in DFA. Finally, a further factor is that the assimilation needs to be perseverative (rightward), not anticipatory (leftward). Studies of assimilations have established that anticipatory assimilation is much more common than a perseverative pattern (see, for example, Gordon 2016). If a language needs all this in order to be able to innovate a pattern of the type described here, it is not surprising that it is rare. (If, in addition to this, it is diachronically unstable, as in one possible scenario sketched in section 5.4, that is another reason why such a pattern may be uncommon.)

6. Conclusion

The majority of the speakers that we report on have a robust pattern in which the quantity of a preceding vowel constrains the application of assimilation. We are aware of no process with identical patterning to this in any other language, so we hope that the material discussed here is of interest. We hope that our discussion in section 4 and 5.2 has confirmed that this really is an authentic pattern, and that sections 5.4 and 5.5 show that the patterning in our data should not be so surprising after all. It is furthermore understandable that the pattern is rare. Nonetheless, palatalisation really can be quantity-sensitive, and phonology needs to be able to model this.

Authors' addresses

Amanda Cardoso,
Department of Linguistics,
Vancouver Campus,
Totem Field Studios (Main Department),
2613 West Mall,
Vancouver, BC Canada V6T 1Z4.

Patrick Honeybone,
Linguistics and English Language,
University of Edinburgh,
Dugald Stewart Building, 3 Charles Street,
Edinburgh, EH8 9AD, UK.

REFERENCES

Alwan, Abeer, Jintao Jiang & Willa Chen. 2011. Perception of place of articulation for plosives and fricatives in noise. *Speech Communication* 53(2), 195-209.

Anderson, John M. & Colin J. Ewen. 1987. *Principles of dependency phonology*. Cambridge: Cambridge University Press.

Anderson, John & Charles Jones. 1974. Three theses concerning phonological representations. *Journal of Linguistics* 10, 1-26.

Backley, Phillip. 2011. *An Introduction to Element Theory.* Edinburgh: Edinburgh University Press.

Baker, Adam, Diana Archangeli & Jeff Mielke. 2011. Variability in American English s-retraction suggests a solution to the actuation problem. *Language Variation and Change* 23(3), 347–374.

Balogné, Bérces, Katalin & Patrick Honeybone. 2012. Splitting 'intervocalic': expanding the typology of lenition environments. *Acta Linguistica Hungarica* 59, 27-48.

Bateman, Nicoleta. 2007. *A crosslinguistic investigation of palatalization*. University of California, San Diego PhD thesis.

Bateman, Nicoleta. 2011. On the Typology of Palatalization. *Language and Linguistics Compass* 5(8), 588-602.

Bermúdez-Otero, Ricardo. 2007. Diachronic phonology. In Paul de Lacy (ed.), *The Cambridge handbook of phonology*, 497-517. Cambridge: Cambridge University Press.

Bermúdez-Otero, Ricardo. 2015. Amphichronic explanation and the life cycle of phonological processes. In Patrick Honeybone & Joseph C. Salmons (eds), *The Oxford handbook of historical phonology*, 374-399. Oxford: Oxford University Press.

Bermúdez-Otero, Ricardo & Graeme Trousdale. 2012. Cycles and continua: on unidirectionality and gradualness in language change. In Terttu Nevalainen & Elizabeth Closs Traugott (eds), *The Oxford handboosk of the history of English*, 691-720. New York: Oxford University Press.

Bhat, D. N. S. 1978. A general study of palatalization. In Joseph H. Greenberg (ed.) *Universals of human language,* 47-92. Palo Alto, CA: Stanford University Press.

Bloomfield, Leonard. 1930. German ç and x. *Le Maître Phonétique* (3rd Series) 20, 27-28.

Botma, Bert. 2004. *Phonological Aspects of Nasality: an Element-Based Dependency Approach.* University of Amsterdam PhD thesis.

Broadbent, Judith. 2008. t-to-r in West Yorkshire English. *English Language and Linguistics* 12.1: 141–168.

Bye, Patrik & Paul de Lacy 2008. Metrical influences on fortition and lenition. In: de Carvalho, Joaquim Brandão, Tobias Scheer & Philippe Ségéral (eds). *Lenition and fortition*. Mouton de Gruyter, Berlin & New York, 173–206.

Cardoso, Amanda. 2011. *PRICE realisations and phonological change: Liverpool English.* University of Edinburgh unpublished MSc thesis.

Cardoso, Amanda. 2015. *Dialectology, Phonology, Diachrony: Liverpool English Realisations of PRICE and MOUTH.* University of Edinburgh PhD thesis.

Carr, Philip, Jacques Durand & Colin Ewen (eds.). 2005. *Headhood, Elements, Specification and Contrastivity*. Amsterdam: John Benjamins.

Chambers, John. M., William Cleveland, Beat Kleiner & Paul Tukey. 1983. *Graphical methods for data analysis.* Belmont, CA: Wadsworth.

Clements, George N. 1985. The geometry of phonological features. *Phonology Yearbook* 2, 225-252.

Clements, George N. 1991. Place of articulation in consonants and vowels: a unified theory. *Working papers of the Cornell Phonetics Laboratory* 5, 77-123.

Clements, G. N. & Elizabeth Hume, 1995. The Internal Organization of Speech Sounds. In John Goldsmith (ed.), *The Handbook of Phonological Theory*. Oxford: Basil Blackwell. 245-306

Collins, Beverly & Inger Mees. 2003. *The Phonetics of English and Dutch.* (5th edn.). Leiden: Brill.

Coupland, Nikolas & Hywel Bishop. 2007. Ideologised values for British accents. *Journal of Sociolinguistics* 11(1), 74-93.

Crothers, John. 1978. Typology and universals of vowel systems in phonology. In Joseph H. Greenberg (ed.). *Universals of Human Language*, vol. 2, 95-152. Stanford, CA: Stanford University Press.

Crowley, Tony. 2012. *Scouse: A Social and Cultural History.* Liverpool: Liverpool University Press.

De Lyon, Hilary. 1981. *A sociolinguistic study of aspects of the Liverpool accent*. University of Liverpool unpublished MPhil dissertation.

Delattre, Pierre & Freeman Donald. C. 1968. A dialect study of American English r's by x-ray motion picture. *Linguistics* 44, 28–69.

Dorman, Michael F., Michael Studdert-Kennedy & Lawrence J. Raphael. 1977. Stop consonant recognition: Release bursts and formant transitions as functionally equivalent, context dependent cues. *Perception & Psychophysics* 22, 109–122.

Drager, Katie & Jennifer Hay. 2010. A novice's guide to understanding mixed effects models. Paper presented at the *Workshop on Using Statistical Tools to Explain Linguistic Variation at NWAV 39*.

Ellis, Alexander. 1889. *On early English pronunciation*. London: Truebner and Co.

Ellis, Lucy & William J. Hardcastle. 2002. Categorical and gradient properties of assimilation in alveolar to velar sequences: evidence from EPG and EMA data. *Journal of Phonetics* 30 (3), 373-96.

Ferragne, Emmanuel & Francois Pellegrino. 2010. Formant frequencies of vowels in 13 accents of the British Isles. *Journal of the International Phonetic Association* 40(1), 1–34.

Féry, Caroline. 1998. German Word Stress in Optimality Theory. *The Journal of Comparative Germanic Linguistics*. 2(2), 101-142

Flemming, Edward. 2002. *Auditory Representations in Phonology*. Oxon: Routledge.

Forrest, Karen, Gary Weismer, Paul Milenkovic & Ronald N. Dougall. 1988. Statistical analysis of word-initial voiceless obstruents: Preliminary data*. Journal of the Acoustical Society of America* 84(1), 115-123.

Gordon, Matthew, Paul Barthmaier & Kathy Sands. 2002. A cross-linguistic acoustic study of voiceless fricatives. *Journal of the International Phonetic Association* 32, 141-174.

Gordon, Matthew. 2016. *Phonological typology*. Oxford: Oxford University Press.

Gussenhoven, Carlos & Haike Jacobs. 2017. *Understanding Phonology*. Fourth edition. London and New York: Routledge.

Hall, Tracy. 1989. Lexical Phonology and the distribution of German [ç] and [x].

Phonology 6(1), 1–17.

Hall, Tracy. 1993. Phonology of German /ʀ/. *Phonology* 10(1), 83-105.

Halle, Morris, Bert Vaux & Andrew Wolfe. 2000. On feature spreading and the representation of place of articulation. *Linguistic Inquiry* 31(3), 387–444.

Hall-Lew, Lauren, Patrick Honeybone and James Kirby. To appear. Individuals, communities, and sound change: a systematic review. To appear in a *Glossa* Special Collection on 'Individuals, Communities, and Sound Change'.

Harris, John. 1994. *English Sound Structure*. Oxford: Blackwell.

Hasenclever, Max 1905. *Der Dialekt der Gemeinde Wermelskirchen*. Elwert, Marburg.

Hay, Jennifer & Margaret Maclagan. 2010. Social and phonetic conditioners on the frequency and degree of 'intrusive /r/' in New Zealand English. In Dennis Preston & Nancy Niedzielski (eds.) *A Reader in Sociophonetics (Trends in Linguistics Studies and Monographs 219)*, 41-69. New York: De Gruyter Mouton.

Hayes, Bruce (1987). A revised parametric metrical theory. *Northeastern Linguistic Society* 17, 274-289.

Hayes, Bruce. 1995. *Metrical Stress Theory: Principles and Case Studies*. Chicago: The University of Chicago Press.

Hintze, Jerry L. & Ray D. Nelson. 1998. Violin plots: a box plot-density trace synergism. *The American Statistician* 52(2), 181–184.

Honeybone, Patrick. 2001. Lenition inhibition in Liverpool English. *English Language and Linguistics* 5, 213–249.

Honeybone, Patrick. 2005. Sharing makes us stronger: process inhibition and segmental structure. In Phillip Carr, Jacques Durand & Colin J. Ewen (eds.). *Headhood, Elements, Specification and Contrastivity: Phonological Papers in Honour of John Anderson*, 167-192. Amsterdam: John Benjamins.

Honeybone, Patrick. 2007. New-dialect formation in nineteenth century Liverpool: a brief history of Scouse. In Anthony Grant & Clive Grey (eds.)*. The Mersey sound: Liverpool's language, people, and places*, 106–140. Open House Press.

Honeybone, Patrick. 2008. Lenition, weakening and consonantal strength: tracing concepts through the history of phonology. In Brandão de Carvalho, Joaquim, Tobias Scheer & Philippe Ségéral (eds). Lenition and Fortition. Berlin:

Mouton de Gruyter, 9-93.

Honeybone, Patrick. 2010. How symmetrical are English vowels? *Yazyk i rechevaya deyatel'nost'* (*Language and Language Behavior). Journal of the Linguistic Society of St. Petersburg* 9 (issue dated 2006), 33-63.

Honeybone, Patrick & Kevin Watson. 2013. Salience and the sociolinguistics of Scouse spelling: Exploring the phonology of the Contemporary Humorous Localised Dialect Literature of Liverpool. *English World-Wide* 34(3), 305-340.

Honeybone, Patrick, Kevin Watson & Sarah van Eyndhoven. 2017. Lenition and T-to-R are differently salient: the representation of competing realisations of /t/ in Liverpool English dialect literature. In Joan Beal & Sylvie Hancil (eds.) *Perspectives on Northern Englishes*, 83-108. Berlin: De Gruyter.

Hualde, José I. 2005. *The Sounds of Spanish.* New York, NY: Cambridge University Press.

Hyman, Larry. 1976. Phonologization. In A. Juilland (ed*.), Linguistic studies presented to Joseph H. Greenberg*. Saratoga: Anma Libri. 407-418.

Hyman, Larry. 2013. Enlarging the scope of phonologization. In Alan C.L. Yu (ed.), *Origins of sound change: Approaches to phonologization*, 3-28. Oxford University Press.

Iosad, Pavel. 2012. Representation and variation in substance-free phonology: A case study in Celtic. PhD thesis, University of Tromsø.

Iverson, Gregory & Joe C. Salmons. 1992. The Place of Structure Preservation in German Diminutive Formation*. Phonology* 9, 137-143.

Iverson, Gregory & Joseph C. Salmons. 2006. Fundamental Regularities in the Second Consonant Shift. *Journal of Germanic Linguistics* 18(1). 45-70.

Jakobson, Roman. 1968. *Child Language, Aphasia and Phonological Universals.* The Hague: Mouton.

Jansen, Sandra. 2019. Change and stability in GOOSE, GOAT and FOOT: back vowel dynamics in Carlisle English. *English Language and Linguistics* 23(1). 1-29.

Jassem, Wiktor. 1962. Noise spectra of Swedish, English, and Polish fricatives. *Proceedings of the Speech Communication Seminar, Stockholm, Royal Institute of Technology Speech Transmission Laboratory*, 1-4.

Jones, Mark. 2015. Individuals, Innovation, and ChangeIn Patrick Honeybone & Joseph C. Salmons (eds), *The Oxford handbook of historical phonology*, 400-409.

Oxford: Oxford University Press.

Jones, Mark J., & Francis J. Nolan. 2007. An acoustic study of North Welsh voiceless fricatives. *Proceedings of the XVIth International Congress of Phonetic Sciences*. Saarbrücken.

Jongman, Allard, Ratree Wayland & Serena Wong. 2000. Acoustic characteristics of English fricatives. *Journal of the Acoustical Society of America* 108, 1252-1263.

Johnson, Keith. 2003. *Acoustic and Auditory Phonetics* (2nd edn.). Blackwell Publishing.

Juskan, Marten. 2016. *Production and Perception of Local Variants in Liverpool English – Change, Salience, Exemplar Priming.* University of Freiburg PhD thesis.

Juskan, Marten. 2017. Scouse NURSE and northern happY: vowel change in Liverpool English. In Joan Beal & Sylvie Hancil (eds.) *Perspectives on Northern Englishes*. Berlin: Mouton de Gruyter.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud. 1985. The internal structure of phonological representations. *Phonology Yearbook* 2, 305-328.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud. 1990. Constituent structure and government in phonology. *Phonology* 7(2), 193-231.

Kemp, Renee. 2011. *The Perception of German Dorsal Fricatives by Native Speakers of English.* University of Georgia unpublished MA thesis.

Kent, Raymond D. & Charles Read. 2002. *Acoustic analysis of speech* (2nd edn.). London: Singular/Thomson Learning.

Kloeke, W. U. S. van Lessen. 1982. *Deutsche Phonologie und Morphologie*. Tübingen: Niemeyer.

Knowles, Gerald. 1973. *Scouse: the spoken dialect of Liverpool.* University of Leeds PhD thesis.

Kochetov, Alexei. 2011. Palatalization. In Colin Ewen, Elizabeth Hume, Marc van Oostendorp & Keren Rice (eds.). *The Blackwell companion to phonology*, 1666-1690. Oxford: Blackwell.

Kohler, Klaus J. 1977, *Einführung in die Phonetik des Deutschen* (Grundlagen der Germanistik 20), Berlin: Schmidt.

Kohler, Klaus J. 1990. Segmental reduction in connected speech in German: Phonological facts and phonetic explanations. In William J. Hardcastle & Alain Marchal (eds.). *Speech production and speech modelling,* 69-92. Dordrecht: Kluwer.

Kohler, Klaus J. 1999. German. In: *Handbook of the international phonetic association*, 87–89, Cambridge: Cambridge University Press.

Kostakis, Andrew. 2015. Height, frontness and the special status of /x/, /r/ and /l/ in Germanic language history. PhD thesis, Indiana University.

Krämer, Martin & Olga Urek. 2016. Perspectives on palatalization. *Glossa: a journal of general linguistics* 1(1): 31, 1-17.

Labov, William, Sharon Ash & Charles Boberg. 2005. *The atlas of North American English: Phonetics, phonology and sound change.* Walter de Gruyter.

Ladefoged, Peter. 2006. *A course in phonetics*. 5th edition. Chicago: University of Chicago Press.

Lahiri, Aditi & Vincent Evers. 1991. Palatalization and coronality. Phonetics and phonology. In Carole Paradis & Jean-François Prunet (eds.). *The special status of coronals: internal and external evidence,* Vol. 2, 79–100. London, San Diego: Academic Press Inc.

Lass, Roger. 1984. *Phonology*. Cambridge: Cambridge University Press.

Mackridge, P. *The Modern Greek Language* (Oxford 1985).

Marotta, Giovanna & Marlen Barth. 2005. Acoustic and sociolinguistic aspects of lenition in Liverpool English. *Studi Linguistici e Filologici Online*, 377-413.

McNeill, Jo. 2009. Acceptable accents: Do regional accents 'fit' within the discourses of higher education. Paper presented at *Widening Participation Research Centre Knowledge Exchange Seminar.*

Merchant, Jason. 1996. Alignment and fricative assimilation in German. *Linguistic Inquiry* 27, 709-719.

Montgomery, Chris. 2007a. *Northern English dialects: A Perceptual Approach*. University of Sheffield PhD thesis.

Montgomery, Chris. 2007b. Perceptions of Liverpool English. In Anthony Grant & Clive Grey (eds.). *The Mersey Sound: Liverpool's Language, People and Places*, 164–185. Open House Press.

Montgomery, Chris. 2012. Perceptions of dialects: Changing attitudes and ideologies. In Terttu Nevalainen & Elizabeth Traugott (eds.). *Handbook on the History of English: Rethinking and Extending Approaches and Methods*, 457-469. Oxford: Oxford University Press.

Morén, Bruce. 2003. The Parallel Structures Model of Feature Geometry. *Working Papers of the Cornell Phonetics Laboratory,* vol. 15.

Morén, Bruce. 2007. The division of labour between segment-internal structure and violable constraints. In Sylvia Blaho, Patrik Bye & Martin Krämer (eds.). *Freedom of Analysis*. Berlin: Mouton de Gruyter.

Newbrook, Mark. 1999. West Wirral: norms, self-reports and usage. In Paul Foulkes & Gerard J. Docherty (eds.). *Urban Voices: Accent Studies in the British Isles*, London: Arnold, pp. 90–106.

Newton, Brian. 1961. Rephonemization of Modern Greek. *Lingua* 10, 275-284.

Noske, Manuela. 1997. Feature spreading as dialignment: the distribution of [ç] and [x] in German. *Phonology* 14, 221–234.

Ogden, Richard. 2009. *An Introduction to English Phonetics*. Edinburgh: Edinburgh University Press.

Oostendorp, Marc van & Koen Sebregts. 2017. The velar fricatives /x/ and /ɣ/. *Taalportaal*. Retrieved from: http://www.taalportaal.org/taalportaal/topic/pid/topic_20150720150623493. (accessed 21 December 2017).

Pace-Sigge, Michael. 2010. *Evidence of lexical priming in spoken Liverpool English*. University of Liverpool PhD thesis.

Ramsammy, Michael. 2015. The life cycle of phonological processes: accounting for dialectal microtypologies. Langu*age and Linguistics Compass* 9(1), 33-54.

Robinson, Orrin. 2001. *Whose German? The ich/ach alternation and related phenomenon in 'standard' and 'colloquial'*. Amsterdam: John Benjamins Publishing.

Sagey, Elizabeth, C. 1986. *The representation of features and relations in non-linear phonology.* Massachusetts Institute of Technology unpublished PhD thesis.

Salmons, Joseph. 2012. A History of German. Oxford: Oxford University Press.

Sangster, Catherine. 2001. Lenition of alveolar stops in Liverpool English. *Journal of Sociolinguistics* 5(3), 401–412.

Schambach, Georg. 1858. Wörterbuch der niederdeutschen Mundart der Fürstenthümer Göttingen und Grubenhagen, oder Göttingisch-Grubenhagen'sches Idiotikon. Carl Rümpler: Hanover.

Schane, Sanford. 1984. The fundamentals of Particle Phonology. *Phonology Yearbook* 1, 129–155.

Schane, Sanford (2005). The aperture particle |a|: its role and functions. In Philip Carr, Jacques Durand & Colin Ewen (eds.). *Headhood, Elements, Specification and Contrastivity*. Amsterdam: John Benjamins.

Schütze, Johann Friedrich. 1800. *Holsteinisches Idiotikon*... Hamburg: Heinrich Ludwig Villaume.

Sen, Ranjan. 2016. Examining the life cycle of phonological processes: considerations for historical research. *Papers in Historical Phonology* 1, 5-36.

Strevens, Peter. 1960. Spectra of fricative noise in human speech. *Language and Speech* 3, 32-49.

Strycharczuk, Patrycja. 2012. Phonetics-phonology interactions in pre-sonorant voicing. PhD thesis, University of Manchester.

Trudgill, Peter. 1986. *Dialects in contact*. Oxford: Blackwell.

Trudgill, Peter. 1999. *The Dialects of England*. Second Edition. Oxford: Blackwell.

Trudgill, Peter. 2004. *New-Dialect Formation: The Inevitability of Colonial Englishes*. Edinburgh: Edinburgh University Press.

Turton, Danielle. 2017. t-flapping in present-day Northern English: implications for sociophonological change. Paper presented at the Third Symposium on Historical Phonology, University of Edinburgh.

Watson, Kevin. 2006. Phonological resistance and innovation in the north-west of England. *English Today*. 86, 55.

Watson, Kevin. 2007a. Is Scouse getting Scouser? exploring phonological change in contemporary Liverpool English. In Anthony Grant & Clive Grey (eds.). *The Mersey Sound: Liverpool's Language, People and Place*s, 215–241. Open House Press.

Watson, Kevin. 2007b. *The phonetics and phonology of plosive lenition in Liverpool English.* University of Lancaster PhD thesis.

Watson Kevin. 2007c. Liverpool English*. Journal of the International Phonetic Association* 37(3), 351-360.

Watson, Kevin & Lynn Clark. 2011. Capturing Listeners' Real-Time Reactions to Local and Supralocal Linguistic Features. Paper presented at *Variation and Language Processing Conference.*

Watson, Kevin & Lynn Clark. 2013. How salient is the NURSE~SQUARE merger? *English Language and Linguistics* 17(2), 297-323.

Watson, Kevin & Lynn Clark. 2015. Exploring listeners' real-time reactions to regional accents. *Current Issues in Language Planning* 24(1), 38-59.

Watson, Kevin & Lynn Clark. 2017. OLIVE: The Origins of Liverpool English. In Raymond Hickey (ed.). *Listening to the Past.* Cambridge: Cambridge University Press.

Wells, John C. 1982. *Accents of English*, Vol. 1. Cambridge: Cambridge University Press.

Welmers, William Everett. 1946. A descriptive grammar of Fanti. Language 22(3), 3-78. Language Dissertation No. 39.

Wiese, Richard. 1996. *The phonology of German*. Oxford: Clarendon.

Wrench, Alan. 1995. Analysis of fricatives using multiple centres of gravity. *Proceedings of the International Congress of Phonetic Sciences* 4, 460-463.

Youssef, Islam. 2010. Laryngeal assimilation in Buchan Scots*. English Language and Linguistics* 14(3), 321-345.

FOOTNOTES

[1] We have presented parts of this material at a number of venues and we are grateful for the comments and questions that we received there. We would like to especially thank Márton Sóskuthy for help with the normalization, and we would also like the thank the participants in the recordings and the anonymous reviewers (whose comments improved the article in multiple ways).

[2] A similar distinction was made by Bhat (1978) between palatalisations which shift place of articulation and those which involve the addition of a secondary articulation, but it is Bateman's terminology which has been taken up in recent work.

[3] Here and elsewhere in this article, we discuss only fortis fricatives. Some of the languages mentioned also feature lenis dorsal fricatives, but nothing that we consider hinges on laryngeal specification.

[4] The transcriptions in (1) are our own transcriptions, apart from the Greek, which is from Newton (1961) and Mackridge (1985), and the Chilean Spanish, which is from Hualde (2005) and Benjamin Molineaux (personal communication). Some cases of the relevant assimilations can be opaque, but that does not affect our reasoning here.

[5] See, for example, Hall (1993). We use the transcriptions /r/ and [ɐ] for the German rhotic for convenience and do not intend to make analytical claims with them – we simply represent the facts that German has an underlying rhotic which is subject to vocalisation in a coda.

[6] Watson actually gives [ei, ai] as the representative transcription of the diphthongs, but this is a typo (confirmed by Watson, pc); elsewhere in the piece [eɪ, aɪ] are used. In any case, there is no contrast between tense and lax diphthongs, so the two types of transcription can be taken as notational variants, and we use the more common transcription here. We return to issues of transcription for LE in section 5.1.

[7] In fact, Watson's transcription for *making* is [meɪçən̪] because the final nasal has assimilated to a following /ð/ (which occurs at the start of the word *the*), as would be expected at the surface in English. We omit this detail here and elsewhere in this article because it is orthogonal to our concerns.

[8] The one previous piece of work on LE to consider dorsal fricatives acoustically – Marotta & Barth (2005) – suggested that a lower frequency distribution of energy is related to productions of back fricatives and a low relative intensity is a diagnostic for [ç]. However, they provide no description of how these measurements were taken, or discussion of how such properties of the signal can allow for a reliable distinction between types of fricative, so we cannot evaluate it. In any case, their focus is on whether closure is present in the underlying stops, and they say little about PoA.

[9] For example, Gordon et al. (2002) used a number of acoustic measurements across seven languages: fricative duration, average acoustic spectra, and CoG, and found that CoG was the most accurate predictor of PoA of fricatives. The measure of CoG has been shown to be less accurate in establishing the place of /s/, but that is not relevant for our purposes as we focus on fricatives that are further back than /s/.

[10] A reviewer queries this. Intensity is a less reliable measure because very high-quality recordings with specific equipment would be required in order to get reliable measures of intensity, which is less of an issue for CoG. Furthermore, it is not clear how useful intensity is as a discriminator of fricatives, as it can really only discriminate between certain classes of fricatives (e.g. /s/ vs /f/). Finally, intensity is affected by a wide range of factors unrelated to fricative production (e.g. speaker's f0, stress). Intensity measurements were also taken for our informants, but did not prove to be a reliable predictor for PoA of fricatives for all but one speaker.

[11] The other possible minimal pairs have either one of the pair as an infrequent word (as in *keek* : *kick* (where *kick* has a frequency of 55 per million and *keek* does not register at all in a frequency count), or did not fit in with the requirements of the larger study into which they were embedded (as in *week : wick*, because /w/ was not allowed as an onset), or – in terms of *clique* : *click* – because the orthography of *clique* is potentially misleading.

[12] The words *peak* and *peek* are grouped together in table 3 as both were compared to *pick*.

[13] Classifying informants into living in the north or south is problematic in some ways, as informants described all of the areas they had lived in Liverpool and most have lived in both the north and south at

different points in their lives.

[14] A small number of tokens had to have a 0.04 s spectral slice as they had too short a duration for a 0.05 s spectral slice.

[15] We thank an anonymous reviewer for pointing this out, and for pointing out that it is interesting in itself (a point which we make in section 5.4).

[16] This low vowel varies in LE from front to back (front realisations are common in many speakers, but back realisations are also found).

[17] The vowel in *book* is a long/tense vowel in traditional LE (a feature which LE shares with many other varieties from the north of England); in terms of Wells' (1982) lexical sets, *book* has the GOOSE vowel, as do other *-ook* words, as the shortening which has led to these words having the FOOT vowel in most accents did not occur in the (ancestors of the) relevant dialects.

[18] The approach has been developed in the literature of Dependency Phonology (eg, Anderson & Jones 1974, Anderson & Ewen 1987), Particle Phonology (eg, Schane 1984, 2005) and Government Phonology (eg, Kaye, Lowenstamm & Vergnaud 1985, 1990), in part through independent development, and latterly through conscious cross-fertilisation (eg, Harris 1994, Botma 2004).

[19] The PSM assumes that segments are not necessarily represented in the same way across languages, so the equivalence in (4) is based on the use of PSM specifications to define a system like that of LE, following Iosad's (2012) analysis of Pembrokeshire Welsh, which has a very similar system (in stressed syllables) to that proposed for LE here.

[20] A reviewer asks if there is independent evidence that the LE diphthongs are long (that is, have two x-slots) and not short. The standard arguments from English for representations of these types hold for LE: for example, diphthongs pattern like long/tense monophthongs in rhymal phonotactics (e.g., only one non-coronal consonant may follow both in a rhyme, so, for example, /aɪk/ and /i:k/ are possible rhymes, but /aɪlk/ and /i:lk/ are not); and they also pattern alike in terms of syllable weight in stress assignment.

[21] The measurements for all vowels in figure 10 apart from DRESS were taken from the data gathered for this study (and for Cardoso 2015), as described in section 4. Tokens of DRESS were not included in that study, so have been taken from a pilot study for Cardoso (2015) that was completed shortly beforehand, using similar LE speakers. As all vowels have been normalised, all vowels in figure 10 should be comparable.

[22] LE is also the same as German in this respect: both have a contrast between vowels typically transcribed as /i:/ vs /ɪ/, and both have these realised with a 'tense/lax' distinction, with /ɪ/ lower and more central in terms of articulation (and in F1-F2 plots) than /i:/. In German, both vowels trigger DFA.

[23] Bye & de Lacy (2008) give further evidence for their claim: flapping also does not occur in NZE Acrolect if the potential target stop is between two unstressed vowels, as in *hospital* and *Terreton* (a placename), because this also places the relevant /t/ outside of the bimoraic foot, as in [(hɔ́spə)təl] and [(tʰɛ́ɹə)tən].

[24] A reviewer asks whether a different analysis to that which we propose could also work: if the contrast between the FLEECE and KIT vowel were taken to be made on the basis of tenseness (not quantity), and palatality were seen to spread from a high front tense vowel to /x/. We think that the fact that diphthongs which end in a front-high position also trigger the assimilation (as in *like*, *take*) is important here – these diphthongs would not standardly be analysed as [+tense], but yet do trigger assimilation. Our account predicts that they should trigger assimilation.

[25] A reviewer asks whether the dorsals in words like *because* or *economy* are affected by DFA because they are foot-initial, and hence inside the foot, and so the prediction is that DFA should not apply, even though a potentially front-high vowel precedes them. There is, however, typically no lenition in words with /k/ in this foot-initial phonological environment, so there is no dorsal fricative which could assimilate. We have also been asked (by Donald Morrison, at a talk which featured the analysis of DFA given in this article) whether the final dorsal in words like *atomic* or *music* undergoes DFA. This is an incisive question because lenition does occur in such final environments and the resultant dorsal fricative is outside of the foot, with a potentially front-high vowel preceding. In a word like *atomic*, precisely the environment set out in (20) is relevant, as the foot-boundary precedes the dorsal fricative,

while in *music* a further interesting environment occurs, with the fricative outside of the foot but 'further' outside than in *atomic* because the long vowel takes up all the space in the bimoraic foot, meaning that the whole second syllable is outside of the foot (so it could indeed be an interesting question whether DFA occurs here or not). However, LE is one of the varieties of English which has the 'Weak Vowel Merger' – that is: there is no "clear opposition between [ɪ] and [ə] before a final consonant" (Wells 1982, 167), so that the names *Lenin* and *Lennon* are homophones. This is relevant to unstressed syllables such as the final syllables in *atomic* and *music*. Classical LE has schwa in syllables of this type (or a syllabic consonant), not a front-high vowel, as in certain other accents, including RP (which Wells transcribes as the KIT vowel). This is seen in Watson's (2007c) transcription of *making* as [meɪçən], given here in (5), and also in Newbrook's (1999) description of the 'local' (that is, Liverpool) form of the vowel in the post-sibilant plural morpheme (as in *horses*) as /ə/. This means that surface forms for *atomic* and *music* would be [ə(tɒmə)χ] [(mjʉː)zəχ], with no possibility for DFA to occur as the 'potential front-high vowel' in these words is not front or high in LE. The prediction of our analysis is, therefore, that the dorsal fricative in words like *atomic* and *music* will be back fricatives. Many subtle environments invite future testing to discover if all the predictions of our analysis stand up.

[26] Thank you to the reviewer who pointed this out (as mentioned in footnote 15).

[27] It may be that the single token of a palatal following the KIT vowel that Watson (2007b) found, as mentioned above in section 3.1, is from a speaker of the (7c) type.

[28] As a reviewer rightly notes, the tonic vowel in this word was short in Old High German and is short in contemporary Standard German, too. As Hasenclever (1905, 37) explains, however, the word in Wermelskirchen German is one of a group which differ from Standard German in terms of their length, and this word definitely has a long vowel. Hasenclever assumes that "Low German influence is probable" in these cases, and indeed a long vowel is widely attested for this word in Low German, as in Schütze (1800), who records *Aap*, and Schambach (1858), who records *âpe* (both of these spellings for the relevant vowel indicate length).