

## Palatalisation can be quantity-sensitive: Dorsal Fricative Assimilation in Liverpool English<sup>1</sup>

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This paper shows that the Liverpool English dorsal fricative, derived through the lenition of /k/, is subject to place of articulation assimilation, driven by the preceding vowel. This 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 and also provide new detail in the description of Liverpool English (including a proposal for the featural analysis of its vowel system).

KEYWORDS: Dorsal Fricative Assimilation, Liverpool English, palatalisation, quantity-sensitivity

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## 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 type of patterning which has not been previously reported. We thus expand our understanding of the range of possible palatalisation patterns. 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 second 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.

The article is structured thus: [Section 2](#) explains why LE offers relevant palatalisation data – it features a process which derives dorsal fricatives; [Section 3](#) considers the type of palatalisation that dorsal fricatives often engage in – Dorsal Fricative Assimilation – and also issues related to the acoustic identification of the relevant fricatives; [Section 4](#) sets out our new data describing the patterning of Dorsal Fricative Assimilation in LE; [Section 5](#) considers how we analyse the LE results; 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 the source of these fricatives.

The variety that we consider is typically described 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 (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 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, b, c), Marotta & Barth (2005), Pace-Sigge (2010), Cardoso (2011, 2015), Crowley (2012), Honeybone & Watson (2013), Watson & Clark (2013, 2015), and Juskan (2016, 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 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 for our purposes 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), showing that – while the full environmental patterning is complex at both prosodic and melodic levels and 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 because they are not relevant to our precise concerns. As our focus is on fricatives, final and medial positions are relevant, and in order to direct our focus and to control for other factors, we focused only 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/. It is notable that lenition of /k/, although variable, is very common finally – Watson (2007b) found, in his corpus of elicited speech from 16 adolescent LE speakers, that /k/ is realised as a fricative 94% of the time in utterance final position, meaning that for those speakers it is almost categorical. Not all LE speakers lenite quite so much – in a different sample of LE speakers, Marotta & Barth found that 43% of pre-pausal occurrences of /k/ were lenited (although this average may hide inter-speaker differences). The 12 speakers that we focus on 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 who were recorded for Cardoso (2015). Four of them did not lenite at all. 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 LE dorsal fricatives derives from a fleeting observation in Honeybone (2001). After mentioning that underlying /k/ can be realised at a range of places of articulation in LE, that piece observes 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. (Honeybone 2001: 241–242)

This claim does not specify a precise pattern 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 aiming to model consonant–vowel interactions, such as Clements (1985), Lahiri & Evers (1991), Halle, Vaux & Wolfe (2000), and/or 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 (2007, 2011) detailed survey of palatalisations distinguishes between two fundamental types: ‘full palatalisation’, in which segments’ entire place of articulation 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).<sup>2</sup> 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<sup>3</sup> back dorsal fricative. Such back dorsals are typically transcribed as /x/, but may in fact be either velar by default (as in Standard Russian and Greek), or (pre-)uvular by default (as in Standard German and Northern Standard Dutch – see e.g. Kohler 1977, 1999; 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~χ~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 among back dorsals).

In DFA, dorsal fricatives take their surface place of articulation 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 i ε/ (the precise set naturally depends on the language) co-occur with the front dorsal [ç], and other vowels (such as /a o/) co-occur 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’, [ziχ] *zich* ‘self’ and [laχ] *laag* ‘low’, [buχ] *boeg* ‘ship’s bow’, irrespective of the place of the adjacent vowel. DFA is, however, quite common. It can proceed in either direction: in Standard German (henceforth simply German) and Scots, the assimilation is

[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.

perseverative, while in Modern Greek and Chilean Spanish, it is anticipatory. All this is shown in (1), where the vowel relevant to the assimilation is underlined.<sup>4</sup>

(1) *German*

[zi: <u>ç</u> ]	<i>siech</i>	‘ill’
[zi <u>ç</u> ]	<i>sich</i>	‘self’
[bu: <u>x</u> ]	<i>Buch</i>	‘book’
[da <u>χ</u> ]	<i>Dach</i>	‘roof’

*Scots*

[dri: <u>ç</u> ]	<i>driech</i>	‘bleak’
[ni <u>ç</u> t]	<i>nicht</i>	‘night’
[sas <u>Λ</u> na <u>χ</u> ]	<i>Sassenach</i>	‘English’
[l <u>o</u> x]	<i>loch</i>	‘lake’

*Greek*

[e <u>ç</u> i]	<i>έχει</i>	‘s/he or it has’
[ <u>ç</u> eri]	<i>χέρι</i>	‘hand’
[ex <u>o</u> ]	<i>έχω</i>	‘I have’
[x <u>o</u> ni]	<i>χώνει</i>	‘s/he or it thrusts’

*Chilean Spanish*

[ <u>ç</u> iro]	<i>giro</i>	‘turn’
[mu <u>ç</u> er]	<i>mujer</i>	‘woman’
[xu <u>o</u> ]	<i>juro</i>	‘I swear’
[mex <u>o</u> r]	<i>major</i>	‘better’

In some patterns, non-vocalic segments also trigger the assimilation (some such aspects of the German case are discussed below) but in LE only vowels are relevant as drivers of assimilation, so we focus on vowels as sources of palatality here.

How does assimilation of this type occur? DFA provides 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 using fundamentally the same features for consonants and vowels, so that PoA can spread from vowels to consonants. 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

[4] The transcriptions in (1) are our own transcriptions, apart from the Greek, which is from Newton (1961), Mackridge (1985) and Nina Topintzi (personal communication), 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.

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 well-known in the phonological literature because 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, the question of accuracy in transcription, the status of ‘structure preservation’ in phonology, and the modelling of assimilation in Optimality Theory (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).

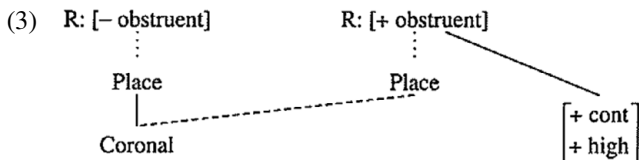
- (2) [manç] *manch* ‘some’  
 [zɔlç] *solch* ‘such’  
 [dʊʁç] *durch* ‘through’

The dorsal fricatives following /r/ show a degree of opacity, as /r/ is realised in this environment 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 [na:χ] *nach* ‘after’), but there is evidence (from alternations, for example) that the vocalisation of /r/ is synchronic,<sup>5</sup> and this opacity can be straightforwardly accounted for in either derivational or representational terms. Dorsal fricatives also occur initially in German (as in [çɛmi:] *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). Fricatives ARE derived after an /l/ (100% of /lk/ sequences result in a fricative), but those following /l/ are not in a palatalisation environment.

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.

[5] See e.g. Hall (1993). We use the transcriptions /r/ and [ʁ] 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.

The most thorough consideration of relevant data for the German case is Robinson (2001), who proposes the spreading convention reproduced here in (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. 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 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 straightforwardly 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 LE fricatives that are derived through the lenition of /k/. 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~ç] 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. Knowles briefly describes dorsal fricatives as the realisation of /k/ (‘true fricatives do occur in the velar position’) but does not focus on the issue of their PoA in detail. He includes some relevant transcriptions, however (Knowles 1973: 252), reproduced here in (4).

- (4) [snɛix+] *snake*  
 [nɛx] *neck*  
 [bux+] *book*  
 [klɔx-] *clock*

The precise intention of these transcriptions is not fully explained. Knowles (1973: 90) writes 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 frontness or backness. The transcription [x-] is a back dorsal, which could be a notational variant of [ç] – this seems quite secure because Knowles (1973: 252) further mentions that ‘the retracted fricative [x-] is often accompanied by uvular



scrape'. Wells (1982: 371) 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 discuss 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 (from Watson, Marotta & Barth, and ourselves), so it is possible that the situation that we describe has arisen in LE since the 1960s.

Watson (2007b, c) 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 gives corroboration that there is now DFA in LE, writing (2007c: 353) that 'palatal fricatives can be found following the close front monophthong [i:] and closing diphthongs [eɪ, aɪ]<sup>6</sup> ... 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 the product of /k/ lenition 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) | [wi:ç]                       | <i>week</i>                |
|     | [laɪç]                       | <i>like</i>                |
|     | [tʰeɪç]                      | <i>take</i>                |
|     | [meɪçən]                     | <i>making</i> <sup>7</sup> |
|     | [bax]                        | <i>back</i>                |
|     | [tʰʊx]                       | <i>took</i>                |
|     | [klɛux, k <sup>h</sup> lɛux] | <i>cloak</i>               |

[6] Watson actually gives [eɪ aɪ] as the representative transcription of the diphthongs, but this is a typo (confirmed by Watson, personal communication) – elsewhere in his piece [eɪ aɪ] are used. 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 [meɪçən̩] because the final nasal has assimilated to a following /ð/ (the start of the word *the*), as would be expected in English. We omit this detail here and elsewhere in this article because it is orthogonal to our concerns.

[dɒχ]	<i>dock</i>
[ʃaːx]	<i>shark</i>
[maːxɪh]	<i>market</i>

Watson (2007c) transcribes the word *cloak* in two slightly different ways – as fully velar or somewhat advanced (this is possible because it occurs multiple times in ‘The North Wind and the Sun’, 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 [χ] 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 gives 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 as /a aɪ aː eː eɪ ɛː ɪ ɒ uː ɔː əʊ uː/, and all of the palatal fricatives that he identifies 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 LE lenition of /k/, and transcribes a wide range of variants: [k k<sup>h</sup> k<sup>x</sup> x<sup>k</sup> kx xk x<sup>k</sup> k<sup>x</sup> χ x~h h ? 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 LE lenition. 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<sup>x</sup>] → [χ], 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 [sməʊx].

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, following 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. The above transcriptions from recent descriptions of LE – from Watson (2007c), as in (5) above, 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 /t/ 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 assume the latter, as briefly discussed at the end of Section 4.1). We are left with fair grounds for a hypothesis that the LE pattern of DFA is like that described for 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 previous descriptions of LE dorsal fricatives were 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, because, 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 from 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 fricative PoA (see Strevens 1960, Jassem 1962, Wrench 1995, Gordon, Barthmaier & Sands 2002, Alwan, Jiang & Chen 2011),<sup>8</sup> but cross-linguistic studies have established

that the Centre of Gravity (CoG) measurement is the most accurate diagnostic measure for PoA in fortis fricatives (Forrest et al. 1988, Jongman, Wayland & Wong 2000, Gordon et al. 2002, Jones & Nolan 2007, Alwan et al. 2011).<sup>9</sup> 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 (e.g. 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, and palatals have higher average CoG than back fricatives. Table 1 presents figures from previous work describing fricative CoG measurements, extracting their results for velar fricatives (to show the range of

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 (averaged across all speakers in the sample) for PoA.

[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, the basis of the measurements or their use to provide a reliable distinction between fricatives are not discussed, so we cannot evaluate them. In any case, Marotta & Barth focus on whether closure is present, and 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 fricative PoA. CoG has been shown to be less accurate in establishing the place of /s/, but that is not relevant for our purposes.

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.

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 palatals were 4416 Hz and 4648 Hz respectively, whereas for velars, they were 4209 Hz and 4364 Hz respectively. Kemp (2011) found much higher average COG values for both palatals (6256 Hz) and velars (5207 Hz). 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 show the interspeaker and intraspeaker variation in averaged CoG values, given in Table 2. For example, 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 to 503 Hz between the two PoAs (equivalent figures were not given for German in Kemp 2011). 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 interspeaker 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).

The phonological pattern closest to that of LE from these languages is that described for German by Kemp (2011). However, while Kemp (2011) finds the same general trends in CoG as the other studies, her raw average CoG measurements are fairly different and the individual speakers are more variable. This could be a result of the methodology used, as speakers were asked to read nonce words in her study. Nonce words are potentially more variable than existing words because 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

Language	[ç] average CoG		[x] average CoG		Difference [ç] – [x]	
	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 and the difference between CoG values for palatal and velars.

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, too, 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).<sup>10</sup> 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 for velars is completely robust. A further conclusion 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 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 or back with the acoustic measurements, confirming the way to map CoG measurements to PoA. This could then be used to objectively identify 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 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. We focused on two vowels, which we transcribe below, following Watson (2007c), as [ɪ] and [i:], in order to compare the realisations of /k/ that occur following a short front high vowel and long front high vowel, keeping all other phonological parameters as similar as possible. These are widely referred to as the *KIT* and *FLEECE* vowels, following the system of keywords for lexical sets proposed to describe English vowel phonology 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

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[10] A referee 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 /ʃ/). Finally, intensity is affected by a wide range of factors unrelated to fricative production (e.g. speaker's f<sub>0</sub>, stress). Intensity measurements were also taken for our informants, but did not prove to be a reliable predictor for PoA for all but one speaker.

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 that we used.<sup>11</sup>

- (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 for completeness. 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<sup>12</sup> are not unreasonably massive (they are as small as is possible given the lexicon of English).

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

FLEECE-VOWEL words	Overall frequency	Frequency per million	KIT-VOWEL words	Overall frequency	Frequency per million
<i>seek</i>	2147	120	<i>sick</i>	1237	69
<i>teak</i>	20	0	<i>tick</i>	216	12
<i>cheek</i>	822	46	<i>chick</i>	92	5
<i>peak/peek</i>	541/68	30/4	<i>pick</i>	3418	191
<i>leak</i>	250	18	<i>lick</i>	218	12
Average per million:		43.6			57.8

Table 3  
 Frequency counts for words tested.

[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*.

We focus only on word-final realisations of /k/ in order to control for any 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 DFA can only occur in this position, however. Palatals can certainly also occur medially (for example, Watson 2007c transcribes *making* as [meiçən]) 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 [laiçə] *Leiche* ‘corpse’ vs. [laçə] *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.<sup>13</sup> All speakers have lived in Liverpool for all of their lives (apart from M04, who has lived outside of Liverpool for one year, and F03, who has lived away for three 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’ (Y) category), there were also two informants in their forties (seen as ‘older’ (O)). Class was determined on the basis of the occupation of informants’ parents because most informants were students (‘no information’ in Table 4 means

ID	Gender	Age	Location	Class	Lenite /k/
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%
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%
Total	F = 7 M = 5	Y = 10 O = 2	N = 10 S = 2	M = 3 W = 7	

Table 4

Details of informants used in this study; the numbering of speakers reflects the order of recording.

[13] Classifying informants into living in the north or south is somewhat problematic, as informants described all the areas they had lived in Liverpool and most have lived in both the north and south at different points in their lives.



either that an informant did not give information about their parents' occupation or their parents were described as 'retired').

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 (as shown in Figure 1). There were very few cases that were ambiguous, but any that were ambiguous were removed from the final analysis.

The procedure for taking CoG measurements differs slightly in each previous study 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

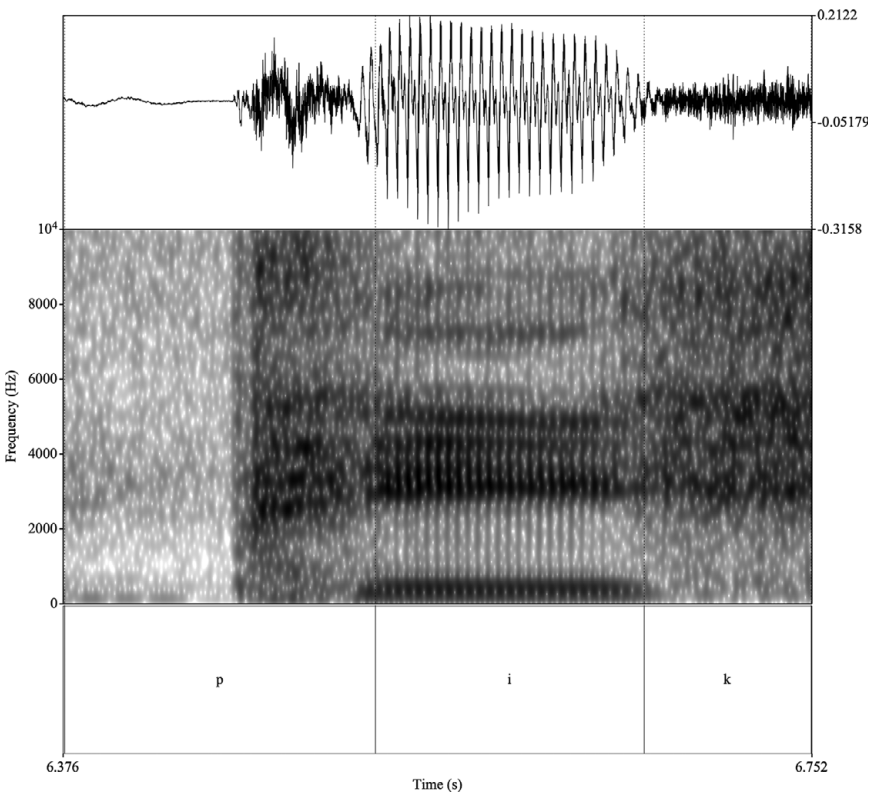


Figure 1

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/.

0.05 seconds.<sup>14</sup> 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. As 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 measurements can be comparable, as gender and speaker-specific vocal tract differences are known to affect 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; notable exceptions are Drager & Hay (2010) and Hay & Maclagan (2010). The lack of previous work on consonant normalisation means that there is no standard method for normalising consonant measurements. We used a model similar to the one in Hay & Maclagan (2010).

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 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 e.g. Dorman, Studdert-Kennedy & Raphael 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 0.01 second-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, and 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).

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[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.

#### 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, comparing realisations of *seek*, with a FLEECE vowel, and *sick*, with KIT).

The average CoG values, including all measurements from all speakers, show a clear difference between 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. M02) and some speakers do not (e.g. M03).

A clearer way to look at the difference between the CoG values is to inspect the distribution of the 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 4, 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 median are the same for ‘cat1’, but not for ‘cat2’ and ‘cat3’, because 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 Figure 3, the density plot portion demonstrates

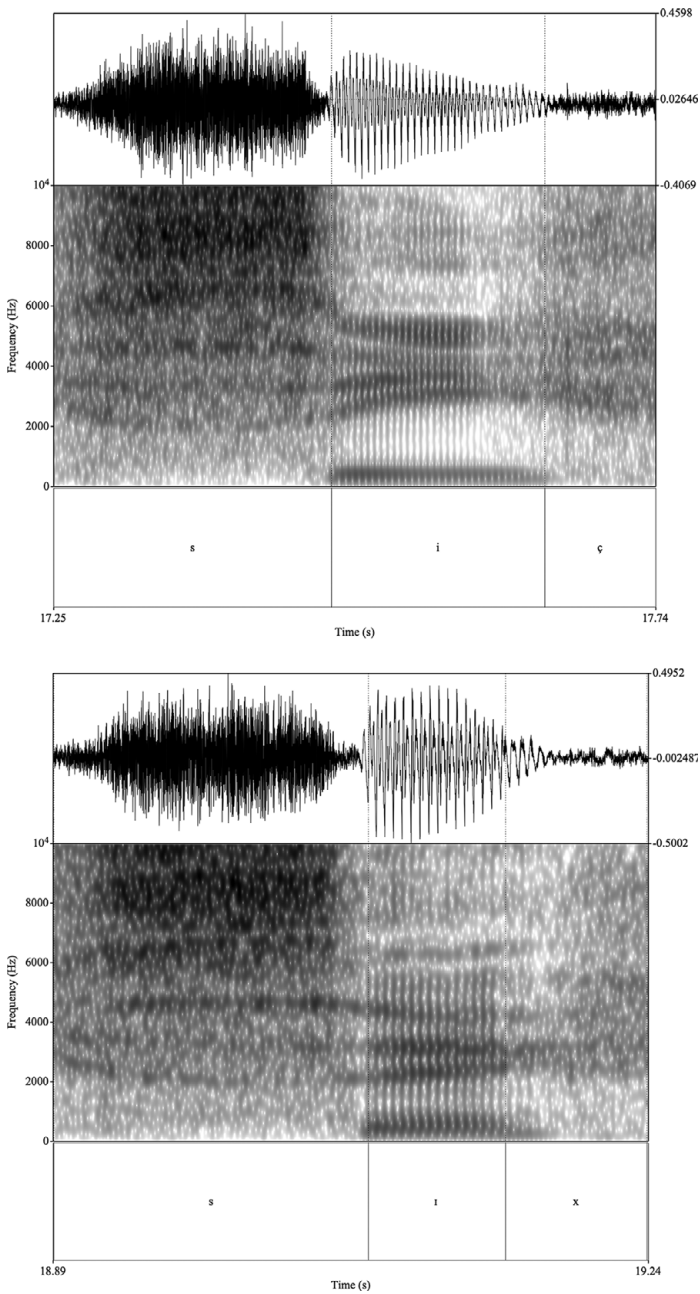


Figure 2

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

DORSAL FRICATIVE ASSIMILATION IN LIVERPOOL ENGLISH

Informant	Post-FLEECE average CoG	Post-KIT average CoG	Maximum CoG	Minimum CoG
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
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
Overall:	4922	4088	7459	2770

Table 5  
CoG measurements per speaker and overall.

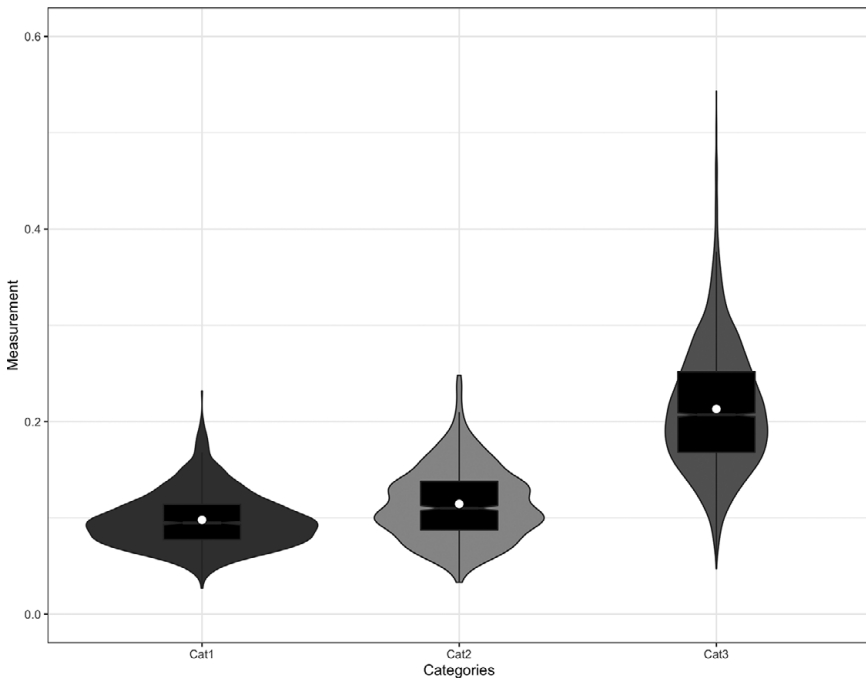


Figure 3  
Example violin plot.

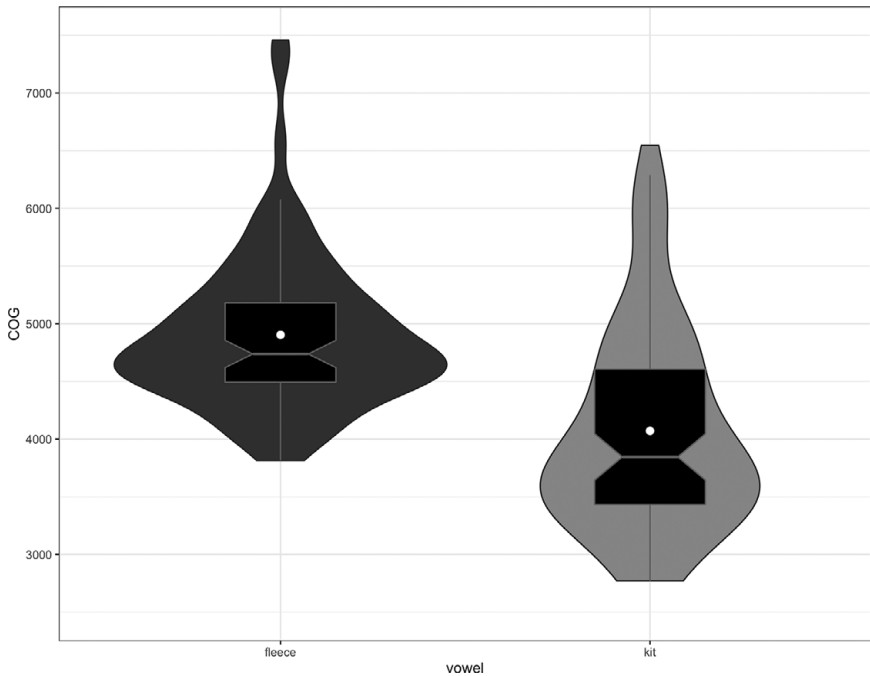


Figure 4  
Distribution of CoG measurements by vowel across all speakers.

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 4 presents a violin plot for the results 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, there is clearly a massive non-overlapping difference between the CoG averages for the two types of fricative.

In order to ensure that this effect was not being driven by specific tokens, we considered the CoG measurements across all tokens for each word across all speakers, as presented in Figure 5. These results corroborate our findings: all 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 categorically higher than those for post-KIT tokens.

Finally, we used a linear regression model to see if our results are statistically significant and to test whether the results are due to speaker-specific vocal tract features. In the linear regression model, the dependent variable was CoG measurements, and the predictors were preceding vowel and the normalisation of CoG

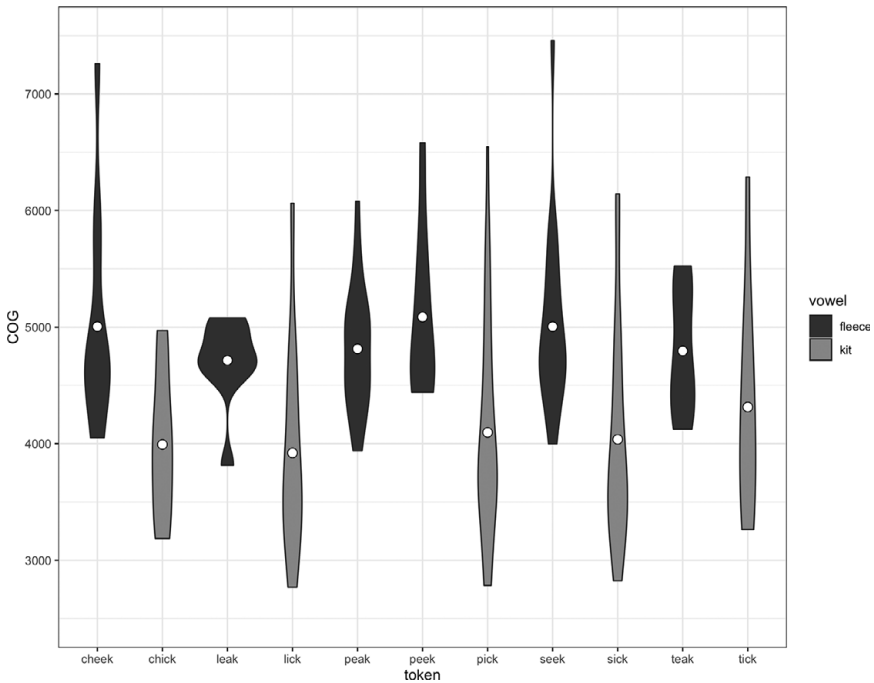


Figure 5

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.)

Coefficients

	Estimate	Std. Error	t-value	Pr(>  t )	Signifi.
(Intercept)	4915.3319	80.6857	60.919	< 2e-16	***
vowel <sub>KIT</sub>	-850.8399	114.1307	-7.455	4.64e-12	***
Norm	0.8411	0.2131	3.947	0.000117	***

Table 6

Results from the linear regression model showing that the difference in terms of the two vowels' CoG measurements (named 'vowel<sub>KIT</sub>') is statistically significant.

measurements. Random intercepts for speaker were also included in the model. The vowel came out as a highly significant predictor for CoG measurements, as shown in Table 6. In other words, there is a statistically significant difference between the CoG measurements for post-FLEECE and post-KIT fricatives.

If we compare these results to those found for other languages (in the studies mentioned in Table 1 above) our results are much closer 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, 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 [zi:ç] *siech* 'ill' and [ziç] *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 consider our results at a speaker-specific level. Table 5 shows that some speakers have a robust categorical difference between the CoG measurements after FLEECE and KIT. This is further shown in Figure 6, which represents the results for speakers F02 and M02. On the other hand, certain other speakers have more overlapping CoG measurements, as shown in Figure 7 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 6) operate on a tighter scale (approximately 2000 Hz) than the speakers with overlapping distribution (as in Figure 8).<sup>15</sup> 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 8 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.

[15] We thank an anonymous referee for pointing this out, and for pointing out that it is interesting in itself.



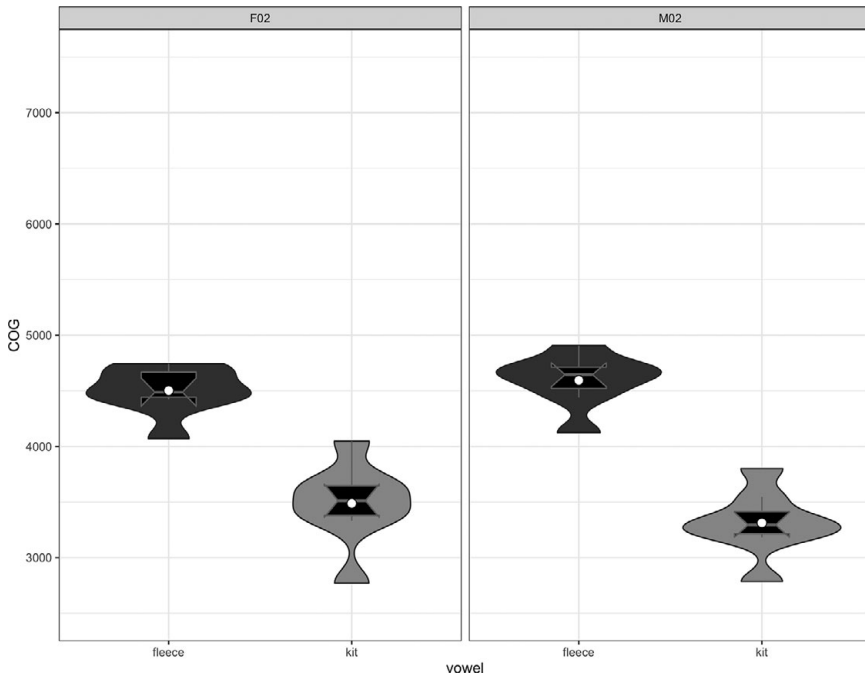


Figure 6

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

A summary of the results reported in this section is given in Table 7, which shows that while all 12 speakers show DFA, two 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 7).

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

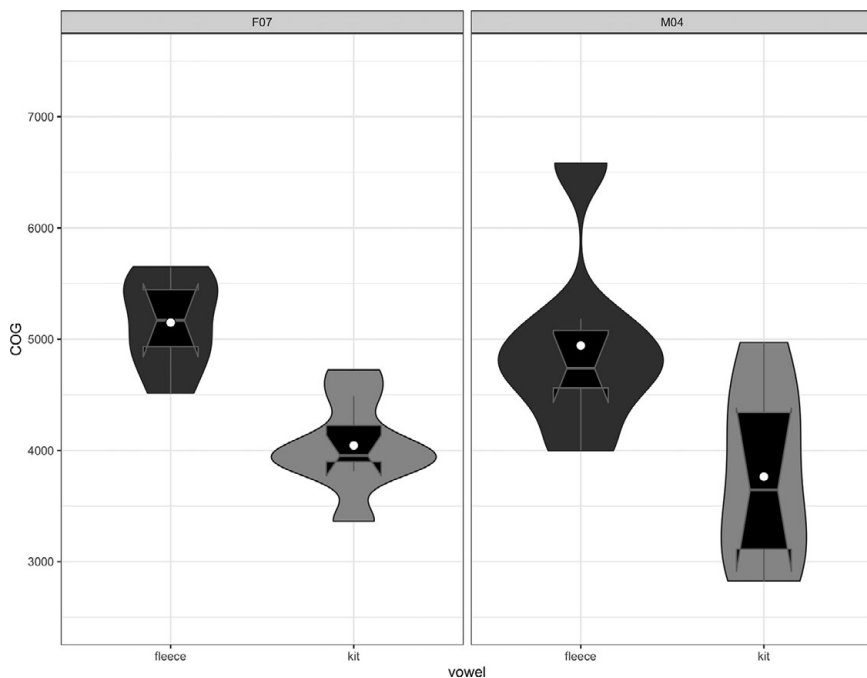


Figure 7  
Speakers with quantity-sensitive DFA, but overlapping CoG measurements.

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.

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 above), 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 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.

We lack the space in this article to examine why these three distinct groups of speakers exist. For present purposes, we simply assume that the existence of speakers such as those in (7a, b) (especially those in (7b)) show beyond doubt that quantity-sensitive DFA is possible, and that it exists in the majority of our

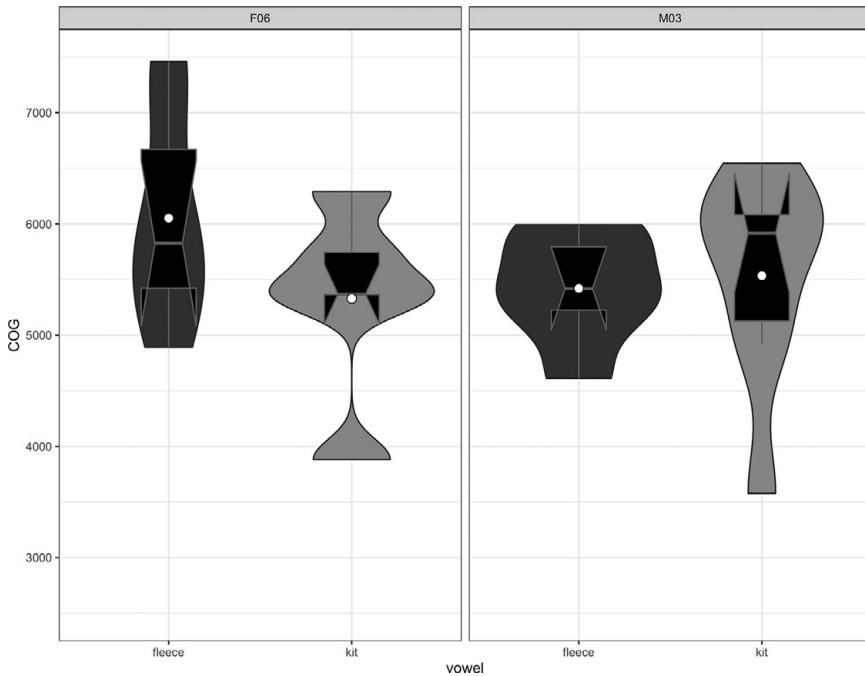


Figure 8  
Speakers without quantity-sensitive DFA.

speakers. We present a phonological analysis of this pattern in Section 5. An earlier version of this article included an account of the relationship between the three groups of speakers in (7). This will now appear as Cardoso & Honeybone (to appear) due to length constraints on the current article (in a nutshell, our analysis is that (7a–c) represent diachronic stages of development of the phenomenon, frozen as individual differences in grammars within the current speech community).

## 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 this pattern, in several steps. Section 5.1 provides 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.

Informant	Assimilation	Quantity- sensitive	Overlapping
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
M01	Yes	Yes	Yes
M02	Yes	Yes	No
M03	Yes	No	n/a
M04	Yes	Yes	Yes
M05	Yes	Yes	No

*Table 7*

Summary of patterns of DFA found in the 12 speakers.

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

It is clear from Section 4 above that the nature of a preceding vowel can determine the PoA of a following dorsal fricative in LE. As we have seen, this is similar to DFA patterns in other languages, and while an analysis of the German DFA pattern is given in (3) above, this cannot simply be transferred to LE – aside from the quantity-sensitivity, there is no LE DFA in environments that are not preceded by a vowel. If we assume that the PoA patterning of LE dorsal fricatives is, however, similarly derived – by assimilation driven by some aspect of the featural composition of preceding segments – then we need an analysis of the featural make-up of LE vowels and of 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.

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 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)
i: <i>heed</i>	FLEECE
ɪ <i>hid</i>	KIT
e: <i>heard</i> (also <i>hair, her</i> )	NURSE/SQUARE
ɛ <i>head</i>	DRESS
a <i>had</i>	TRAP/BATH
ɑ:/ɑ: <i>hard</i> <sup>16</sup>	PALM/START
ɒ <i>hod</i>	LOT/CLOTH
ɔ: <i>hoard</i>	THOUGHT/FORCE/NORTH/CURE
ʊ: <i>who'd</i> (also <i>book</i> ) <sup>17</sup>	GOOSE
ʊ <i>hood</i>	FOOT/ STRUT
ə <i>about</i>	<i>letter/comma</i>
eɪ <i>hay</i>	FACE
aɪ <i>high</i>	PRICE
ɔɪ <i>boy</i>	CHOICE
ɛʌ <i>hoe</i>	GOAT
aʊ <i>how</i>	MOUTH
ɪɛ <i>beer</i>	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 FLEECE and KIT (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 proposes the transcription /ʊ:/ 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 e.g. Labov, Ash & Boberg 2005, Ferragne & Pellegrino 2010). 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 /ʊ:/ 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

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

[17] The vowel in *book* is long/tense in traditional LE (a feature shared with many other varieties from the north of England); in terms of Wells' (1982) lexical sets, *book* has the GOOSE vowel, like 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.

northern English variety: there are contrasting vowels in KIT, DRESS, TRAP and LOT, but the same vowel occurs 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 /e:/ 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 for vowels. We follow Watson’s (2007c) description closely, but Watson does not analyse the featural phonology of the segments. In doing that here, we are influenced by the search for pattern congruity and economy, by the aim of capturing how the segments behave in the phonology of the language, as well as by the search 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 accounting for phonological patterning and processes).

We use a small set of privative features, 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’ in consisting 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) below.

(9) Specifications	ET	FG	PSM	<i>SPE</i>
palatality	I	Coronal	V-place [coronal]	[-back]
lowness	A	[+low]	V-manner [open]	[+low]
dorsality	U	Dorsal	V-place [labial]	[+back]

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, 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’.<sup>18</sup> 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).<sup>19</sup> 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.

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 need to commit to answers to these questions as they do not weigh on the phenomenon discussed.

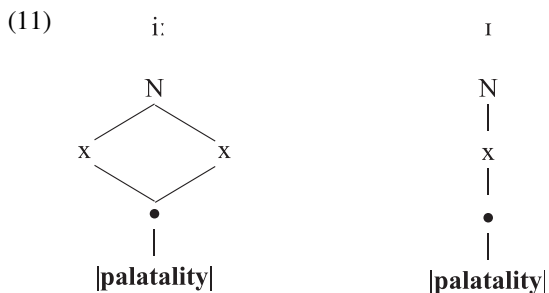
We make one further representational assumption: that there is headedness in segmental melody. This assumes that all melodic entities need a head (as discussed widely in the tradition of segmental representation that we build on, for example in Backley 2011: 42). We mark a head in segmental representations, such as those given in (10) for the set of LE monophthongs set out in (8) above, using bold type.

(10)		Head	Dependent	Quantity
	i: FLEECE	<b> palatality </b>		Double
	ɪ KIT	<b> palatality </b>		Single
	e: NURSE/SQUARE	<b> lowness </b>	palatality	Double
	ɛ DRESS	<b> lowness </b>	palatality	Single
	ɑ:/ɑ: PALM/START	<b> lowness </b>		Double
	ʌ TRAP/BATH	<b> lowness </b>		Single
	u: GOOSE	<b> dorsality </b>	palatality	Double
	ʊ FOOT/STRUT	<b> dorsality </b>		Single
	ɔ: THOUGHT ( <i>etc.</i> )	<b> lowness </b>	dorsality	Double
	ɒ LOT/CLOTH	<b> lowness </b>	dorsality	Single
	ə <i>letter/comma</i>			Single

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

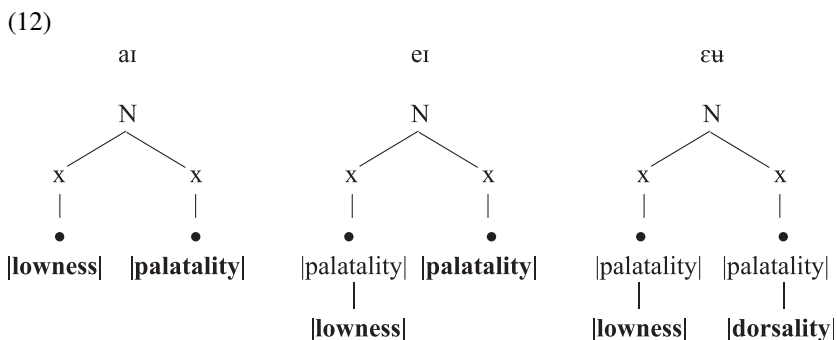
[19] The PSM assumes that segments are not necessarily represented in the same way across languages, so the equivalence in (4) is based on the use of PSM specifications to define a system like that of LE, following Iosad’s (2012) analysis of Pembrokeshire Welsh, which has a very similar system (in stressed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

The specifications in (10) assume that quantity is indeed fundamental, with the FLEECE and KIT vowel, for example, consisting of the same featural specifications, but linked to either one or two skeletal units. More explicit representations are given in (11), which are in line with those of Backley (2011: 47), for example. ‘N’ represents a nucleus, and ‘x’ represents 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 we discuss further 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.

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).<sup>20</sup>



[20] A referee 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 /aɪk/ and /i:lk/ are not); and they also pattern alike in terms of syllable weight in stress assignment.



As (12) shows, we assume that each part of a diphthong has its own head. This seems right because, for example, the GOAT vowel /ɛʌ/ 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/ + /ʌ/. The placement of a head in a representation has no relevance; for consistency, we always place it lowest.

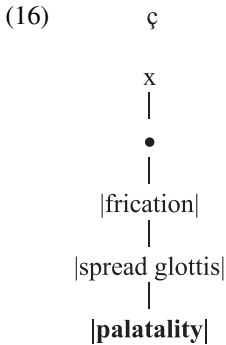
The specifications for the PoA of LE vowels in (10) above are quite straightforward once the set of specifications set out in (9) is adopted. In a simple vowel system of the type /i a u/, each vowel contains only one specification, and each of the three specifications produce a distinct vowel. In a linguistic 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, as we discuss in Section 5.2.

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 /ɛ:/, 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 /ɛ:/, but the overall analysis of the vowel system in (10) seems most compelling, for reasons that we touch on below. Our headedness assumptions do not follow from a principle, but they fit best with the patterning that LE shows. 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), given in (8) and (10), are arranged into the system suggested here in (13a) below. We continue to use these symbols below for the sake of transcriptional tradition, but we acknowledge



(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).



We can now present a formalisation of the patterning of LE DFA which was shown to exist in Section 4. We do this in Section 5.3 below. 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 position.

## 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 LE KIT 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 9 is a plot of LE vowels from our data which shows the relevant placement of

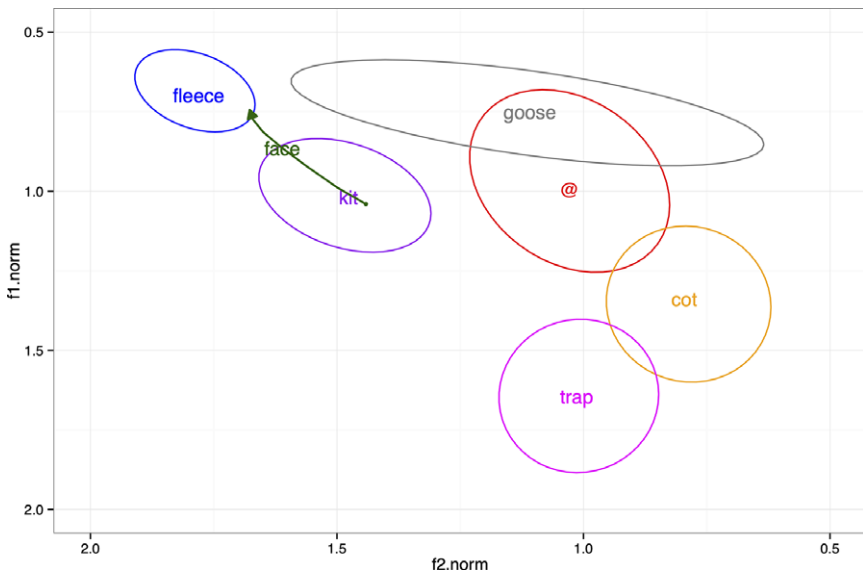


Figure 9

F1–F2 plot showing the phonetic realisation of LE vowels.

a number of LE vowels in the standard F1–F2-plot approximation of the vowel space.<sup>21</sup>

While schwa (represented by ‘@’) is rather high in Figure 9, 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 9 shows that KIT is fundamentally in the front-high quadrant of the vowel space in LE, between FLEECE and DRESS, and overlapping with FACE.

The placement of KIT in Figure 9 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

[21] The measurements for all vowels in Figure 9 apart from DRESS were taken from the data gathered for this study (and Cardoso 2015). 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 9 should be comparable.

to what they find for Glasgow, Elgin (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 LE patterned like the latter set of varieties, a case could be made that KIT was not a front high vowel in LE.<sup>22</sup>

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 than KIT, with FLEECE comparable to a diphthong like PRICE. Figure 10 shows that this is the case. The plots in Figure 10, 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 completely non-overlapping boxplots. On the other hand, FLEECE and PRICE are of overlapping, comparable length.

All 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 assimilation in the DFA described in (7) is nothing out-of-the-ordinary. As shown in (1), DFA in which palatal fricatives correlate with front high/mid vowels and back fricatives with other vowels is common, and can be modelled by spreading a feature which only front high/mid vowels have to the fricative, or by forced agreement of the fricative's place features with those in the vowels. As will be clear from Section 5.1, we assume that this involves the transference of [palatality] from a vowel to a following fricative. The key 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 to foot structure. The LE pattern has a fundamental difference to that described by Bye & de Lacy, however, as explained below.

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

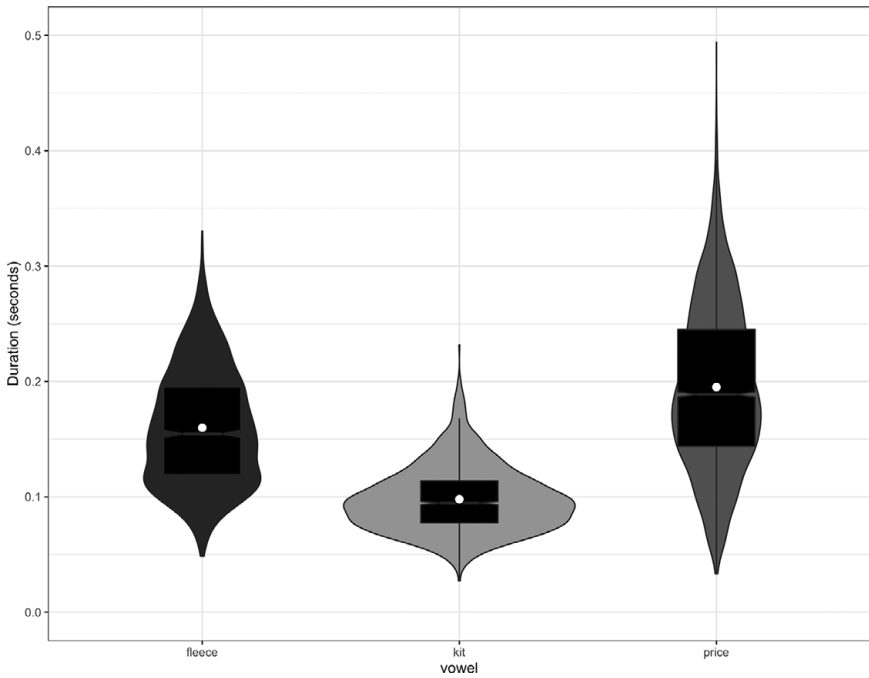
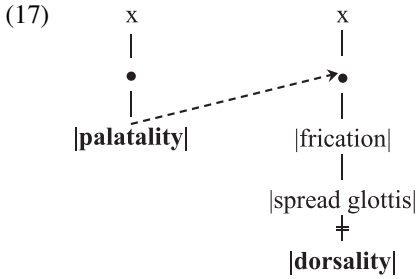


Figure 10  
Duration of LE vowels.

We model the basic assimilation as 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 penalising VF sequences 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 implementation of the part of the process in (17) is not crucial.



The representation in (17) accounts for the non-quantity-sensitive pattern in (7c). The majority pattern in the LE data, however, 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 Cardoso & Honeybone, to appear, viewing them as stages in the phonologisation of DFA). Quantity-sensitivity is not normally associated with segmental phenomena, but Bye & de Lacy (2008) describe another phenomenon which requires it. 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 in (18).

- (18) (a) Flapping after a stressed short vowel and before a vowel  
 [hæ:rə] *hatter*                      [kæ:ri] *catty*  
 [ɹæɟə:rə] *regatta*                      [tʰæ:rəmæɟʉtʃi] *Tatamagouchee*
- (b) No flapping after a stressed long vowel or stressed diphthong  
 [bá:tə] *barter*                      [mí:tə] *metre*  
 [kæmpjú:tə] *computer*                      [ɹáitə] *writer*  
 [páʊtə] *pouter*

The distinction between examples like *hatter* [hæ:rə] and *barter* [bá:tə] shows that, in NZE Acrolect, flapping ONLY happens if the preceding vowel is short. Bye & de Lacy account for this by proposing that it is related to the different positioning of the /t/ in the foot, assuming 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 [(hæ:rə)] and [(bá:)tə], because short vowels and coda consonants each possess one mora, and long vowels possess two. 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 [a:] vowel of *barter* contains two moras, so the /t/

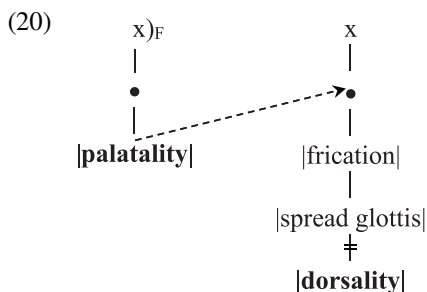
in that word is not in the foot, and flapping is blocked. The precise implementation of Bye & de Lacy's account of flapping need not be considered here; their crucial insight is the role of foot structure in conditioning it. Fundamentally, if the target for flapping is outside of the foot, flapping is blocked.<sup>23</sup>

The pattern that Bye & de Lacy describe is similar to, but also notably different from, that described in this paper. The quantity-sensitive pattern of LE DFA 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 FLEECE), and *tick*, where it does not (represented here and below using [χ] to represent a back dorsal fricative), following KIT, as in (19), with foot structure again represented using parentheses.

- (19) *tick* [(tɹχ)]  
*teak* [(ti:ç)]

The [ɹ] of *tick* has one mora, so the foot (which requires two moras) includes the following consonant, which is also moraic (coda consonants are typically assumed to be moraic in Standard English for syllable-weight-based reasons, and this also applies to LE); the [i:] 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.

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

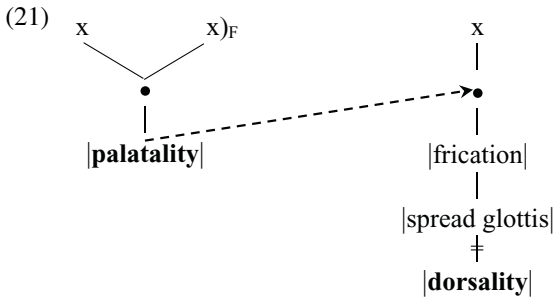


This should be read as requiring that a foot-boundary be present between the trigger and the target for the spreading to occur, and (as above) that [palatality] must be a head in order for it to spread. Another way of saying this is that the target dorsal fricative must be outside the basic bimoraic foot in order for it to assimilate. Given

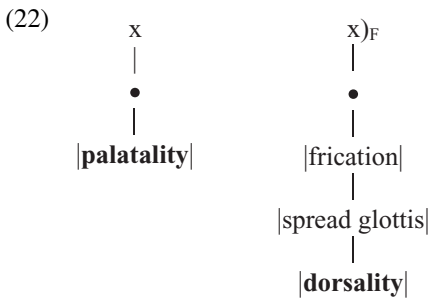
[23] Bye & de Lacy (2008) give further evidence for their claim: flapping also does not occur in NZE Acrolect if the potential target is between two unstressed vowels, as in *hospital* and *Terretton* (a placename), because this also places the relevant /t/ outside of the bimoraic foot: [(hɔspə)təl],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



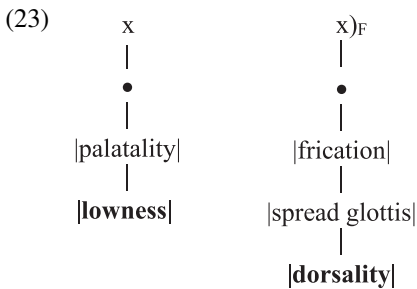
the representations proposed in Section 5.1, we think this makes exactly the right predictions. It shows that DFA will occur in *teak*, and all words with that rhyme, as in (21), which represents the rhyme of such words.



(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.

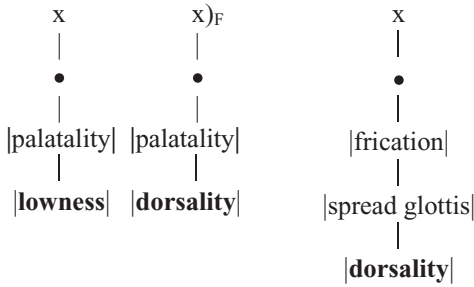


(20) makes further clear predictions as to where LE quantity-sensitive DFA should and should not occur. We predict that there will be no palatal fricatives following vowels which do not contain |palatality| (low vowels, schwa, /ʊ ɒ ɔ:/). DFA should also not occur in words with the DRESS vowel, such as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

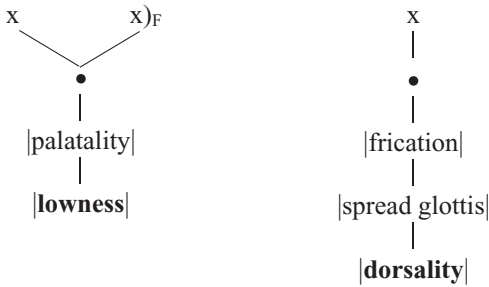


DFA should also not occur in fricatives following the GOAT vowel, as in *toke*, because the headedness requirement is not met, as in (24), nor will it occur in words with the NURSE/SQUARE vowel, such as *Turk*, as in (25).

(24)

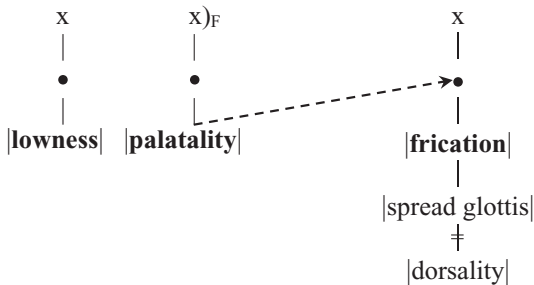


(25)



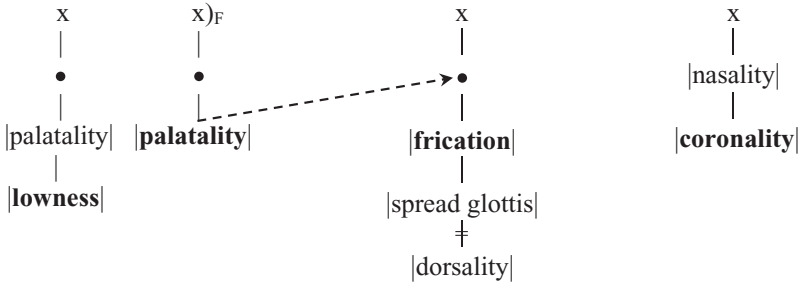
We predict that the process WILL occur, however, following the PRICE vowel, as in *tyke*, shown in (26), and this also holds for words like *take* (with FACE).

(26)

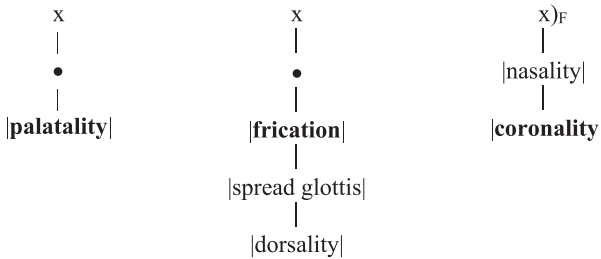


Finally, we predict that LE quantity-sensitive DFA will also occur in a medial environment in words with a FLEECE, PRICE or FACE vowel, such as *taking* or *bacon* (which would be [(bei)ŋ]), as shown (minus the initial consonant) in (27), because the fricative is in the environment described in (20).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

(27)



(28)



These predictions are empirical, but their full testing is beyond the scope of this paper. They can, however, be easily checked against all previous descriptions of LE dorsal fricatives, 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.<sup>24</sup> Watson’s (2007c: 353) observation that ‘palatal fricatives can be found following the close front monophthong [i:] 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 provides 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.

[24] A referee asks whether a different analysis to ours could also work: if the contrast between the FLEECE and KIT vowel were assumed 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.

The transcriptions discussed in Section 3.1 unambiguously describe back dorsals following short vowels, as in [bax] *back* (given by Watson and Ogden), [dɔx] *dock* (Watson and Ogden), [t<sup>s</sup>ɔx] *took* (Watson); in terms of post-long-vowel fricatives, all data also fit our predictions, as in [ʃa:x] *shark* (Watson), [wi:ç] *week* (Watson and Ogden), [laɪç] *like* (Watson and Marotta & Barth), [t<sup>s</sup>eɪç] *take* (Watson), and also in terms of the GOAT vowel, as shown in [klɛʊx, k<sup>h</sup>lɛʊx] *cloak* (Watson) and [sməʊx] *smoke* (Ogden), even though the authors transcribe the vowel slightly differently. All of this is as predicted above.

In terms of medial fricatives, our predictions also fit with previous data. Watson (2007c) gives [ma:xiɪh] *market*, with a low vowel and hence no DFA, and [meɪçən] *making*, with a FACE vowel, 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 fricative 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 evidence that our prediction is met: the fricative in this environment is back, as no DFA can occur.<sup>25</sup>

[25] A referee insightfully 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 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 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 the foot (so it could indeed be an interesting question whether DFA occurs here). 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 affects unstressed syllables such as the finals 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)ç] [(mju:zə)ç], with no possibility for DFA to occur as the ‘potential front-high vowel’ 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 such subtle environments invite future testing to discover if all the predictions of our analysis stand up.

## 6. CONCLUSION

The large majority of speakers that we report on in this paper 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 in any other language, so we hope that the material discussed here is of interest. Palatalisation really can be quantity-sensitive, and phonology needs to be able to model this.

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