Wide-domain r*-effects in English*[*]

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Abstract

Many cases of segmental licensing can be shown to have a broader prosodic scope than is suggested by established syllabic analyses. Non-rhoticity is one of a collection of *r*-related effects in English that illustrate this point. Some of these effects have to do with the licensing of *r* itself, including in positions that can be specified syllabically only by enriching prosodic theory in undesirable ways. Others have to do with the influence *r* exerts on neighbouring segments, particularly coronal consonants and preceding stressed vowels. Specifying the phonological context of these segmental effects requires explicit reference to the foot and the word rather than the syllable.

1 Introduction

It is often noted that the ability of a particular phonological position to support segmental contrasts is determined by its location within some prosodic domain. The domain most familiarly associated with this effect is the syllable: the set of contrasts licensed in onsets is typically greater than that licensed in codas. Non-rhoticity is widely cited as a textbook example. In non-rhotic English, for example, historical *r* weakens to a glide or zero in preconsonantal and word- or utterance-final positions, as in **ca~~r~~d** and **ca~~r~~**. According to a by-now standard analysis, these two positions can be subsumed under a single syllabic context, namely the coda. In non-rhotic systems, *r* is thus said to be licensed in onsets but not in codas.

Over the years, the notion of segmental licensing by syllabic position has been applied to an impressively wide range of phenomena. Recently, however, the whole approach has been called into question, mainly on the basis of two types of evidence. There are phenomena for which the domain defined by established syllabic analyses is arguably too broad, while for certain others it is too narrow.

The first type of evidence involves cases of segmental licensing that are claimed to be more locally conditioned than is suggested by analyses based on syllabic constituency. In these instances, the relevant phonological contexts are arguably

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better defined in terms of immediately adjacent segments and word boundaries, whose licensing potential depends on the relative robustness with which they allow segmental cues to be projected onto the speech signal (Steriade 1999, 2001, Jun 2004).

The second type of evidence involves cases of segmental licensing that can be shown to have a broader prosodic scope than is implied by syllabic analyses. As I will try to show here, non-rhoticity is one of a collection of *r*-related effects in English that illustrate this point. Some of these 'wide-domain' effects have to do with the licensing of *r* itself, including in positions that can be specified syllabically only by enriching prosodic theory in undesirable ways. Others have to do with the influence *r* exerts on neighbouring segments, particularly coronal consonants and preceding stressed vowels. The central claim of this paper is that specifying the domain of these segmental effects requires explicit reference not to the syllable but rather to the foot and the word.

It has been acknowledged for some time that the foot plays at least some role in conditioning segmental regularities (see for example Kiparksy 1979, Yip 1980, Nespor & Vogel 1986, Harris 1994). Evidence is accumulating in support of the conclusion that this role is much more extensive than was originally thought, encompassing segmental phenomena that were formerly attributed to syllabic conditioning. The scope of this evidence reaches far beyond English and the collection of *r*-related effects discussed here (see for example Harris 1997, 2004).

To get an initial idea of how *r*-effects in English can extend beyond the core coda context, consider 'broad' non-rhotic dialects in which *r* weakens not just in the familiar 'narrow' non-rhotic positions (before a consonant or pause) but also before an unstressed vowel, as in **ve~~r~~y, she~~r~~iff, Ca~~r~~olina**. Consonant weakening in general is cross-linguistically widespread in this position (see Harris 1997, Harris & Urua 2001). Other examples from English, to be discussed below, include the deletion of *h* and the tapping and glottalling of *t*. In the face of data of this sort, a coda-based analysis can only be maintained by allowing the intervocalic consonant to be captured into the coda of the syllable occupied by the vowel on its left. In the case of broad non-rhoticity, coda weakening thereby affects historical *r* in **ve~~r~~y** just as in **ca~~r~~** and **ca~~r~~d**. However, as we will see below, the device of coda capture not only is unnecessary but also makes false predictions about phenomena beyond those for which it was initially designed.

In any event, an analysis of broad non-rhoticity based on the foot and word is at once simpler and more general than one based on the coda. In the broad system, the positions where *r* is licensed can be described as initial in the foot or word. This analysis is simpler in that it dispenses with the derivational and representational machinery associated with coda capture. It is more general in that it connects the specific case of non-rhoticity with a range of other segmental phenomena in English, including the other *r*-related effects to be discussed here.

The presentation runs as follows. §2 compares coda-based and wide-domain approaches to segmental licensing by showing how each treats the extension of non-rhoticity to intervocalic position. Subsequent sections describe how the location of *r* within the foot or word conditions the neutralisation of preceding vowel contrasts (§3), the spread of *r*'s secondary resonance characteristics to surrounding vowels (§4) and the effect *r* can have on preceding coronal non-continuants and dental fricatives (§5). §6 concludes with the claim that the segmental licensing role attributed here to the foot cannot be reinterpreted in terms of some more locally defined notion of prominence.

2 Syllabic versus wide-domain analyses of segmental licensing

2.1 *r, h, t*

Non-rhoticity is often held up as a prime example of the coda's diminished ability to license segmental contrasts compared to onsets. According to this approach, *r* in a non-rhotic system is supported in syllable onsets but excluded from codas. This analysis has been applied to a wide range of languages exhibiting categorical or variable non-rhoticity, including Cibaeño Spanish (Harris 1983), Danish (Torp 2001), Dutch (van den Heuvel & Cucchiarini 2001), German (Wiese 2001), Quebec French (Sankoff *et al.* 2001) and English.

The familiar distinction between rhotic and non-rhotic dialects of English is illustrated by the systems labelled R1 and R2 in (1). Here a plus sign indicates a consonantal reflex of historical *r*, typically involving some form of tongue-tip constriction.[1] A minus indicates a vocalised or deleted reflex. Each data row exemplifies a particular phonological environment (v́ and v̆ stand for stressed and unstressed vowels respectively).

[1]Other constriction locations for English *r* include uvular and labio-dental (Wells 1982: 368 ff., Williams & Kerswill 1999, Foulkes & Docherty 2000).

(1)

			R1	R2	R3
(a)	[*r*v́	**red, rack, rude**	+	+	+
(b)	[*r*v̆	**ravine, revolt, resort**	+	+	+
(c)	C*r*	**tray, agree, petrol**	+	+	+
(d)	V*r*v́	**Corinne, terrain, carouse**	+	+	+
(e)	*r*v̆	**very, parent, sheriff**	+	+	–
(f)	*r*]v̆	**bear a, before a, poor again**	+	+	–
(g)	*r*]v́	**bear up, before eight, poor Eva**	+	+	–
(h)	*r*C	**board, cart, source**	+	–	–
(i)	*r*]C	**bear to, before nine, poor man**	+	–	–
(j)	*r* ‖	**bear, before, poor**	+	–	–

System R1 is rhotic: *r* is preserved in all the phonological contexts in which it was historically present. It appears before a vowel (as in (1)a-g), a consonant (as in (1)h-i) and a pause (indicated by ‖ in (1)j). System R2 is non-rhotic: *r* is preserved prevocalically ((1)a-g) but suppressed preconsonantally ((1)h, i) and prepausally ((1)j).[2] R1 occurs in most of North America, Ireland, Scotland, parts of the Caribbean and to a diminishing extent in the west and south of England. R2 occurs in most of England, in parts of the eastern and southern United States and in the southern Hemisphere (see Wells 1982). System R3 we'll consider presently.

Under a syllabic analysis, the specific contexts that together host non-rhoticity in system R2 are unified under the coda. In other words, the only location where historical *r* is retained in this system is a syllable onset; this includes the cross-word context, where *r* is assumed to syllabify into an onset when a vowel follows, as in (1)f-g. A wide range of other segmental effects display the same combination of contexts and are standardly treated in the same coda terms. Examples include *l*-vocalisation in English Wells 1982: 258 ff.), *s*-debuccalisation, liquid-vocalisation and nasal depalatalisation in Central American Spanish (Harris 1983) and obstruent devoicing in a whole range of languages (see Lombardi 1999 for discussion and references). Indeed, it was the ability to subsume these two contexts under a single syllabic position that provided one of the main motives for integrating syllable structure into phonological representations in the first place (Kahn 1976, Selkirk 1982, Harris 1983).

There is in fact a third phonological context that often acts in unison with preconsonantal and prepausal positions as a weak segmental licensor. It involves a combination of conditions that seems somewhat unwieldy when defined in traditional linear terms: intervocalic, where the second vowel is either (i) unstressed within the same word or (ii) in a different word (in which case stress is irrelevant). The contexts

[2] R2 comes in two varieties, differentiated according to whether or not cross-word linking *r* extends to etymologically *r*-less words, as in **law[*r*] and order**. This difference need not concern us here.

can be illustrated by the distribution of non-rhoticity in R3 in (1), the broad non-rhotic system identified in the introduction. It occurs in parts of the American South.[3] Like narrow non-rhotic system R2, R3 suppresses constricted *r* preconsonantally (see (1)h, i) and prepausally (see (1)j). However, it extends non-rhoticity to intervocalic position, but only if the following vowel meets the conditions just mentioned: either the vowel occurs within the same word and is unstressed (compare (1)e with (1)d); or the vowel is initial in a following word, in which case it can be either unstressed (as in (1)f) or stressed (as in (1)g).

The extended context just described is not peculiar to non-rhoticity. Other phonological effects that are sensitive to essentially the same set of conditions in English include the defective distribution of *h* in standard pronunciation and the glottalling or tapping of *t* in various dialects.

The pattern for *h* is illustrated in (2) (see Borowsky 1986). Besides word-initially (see (2)a, b), the consonant can appear internally before a stressed vowel (see (2)c). However, just like *r* in non-rhotic systems, *h* is barred from appearing preconsonantally and word-finally (see (2)e, f; an asterisk indicates an absence of examples). (There are varieties in which *h* can appear in these positions.) Moreover, just like *r* in non-rhotic system R3 in (1), *h* is also barred from appearing before an unstressed vowel (see (2)d).

(2)	(a)	[*h*v́	**hat, heat**	+
	(b)	[*h*v̆	**hilarious, historical, hysterical**	+
	(c)	V*h*v́	**behind, prohibit, vehicular**	+
	(d)	V*h*v̆	**prohibition, vehicle**	–
	(e)	*h*C	*	–
	(f)	*h*]	*	–

As for *t*, the situation is summarised in (3), where we can compare glottalling system T1 with tapping system T2.

[3] The description of R3 given here is based on my own observations. For other descriptions, see Morgan (1970) and Wells (1982: 543-544).

(3)

			T1	T2
(a)	[*t*v́	**time, tear**	t^h	t^h
(b)	[*t*v̆	**together, tomato**	t^h	t^h
(c)	V*t*v́	**retain, batik**	t^h	t^h
(d)	*t*v̆	**city, letter**	ʔ	ɾ
(e)	*t*]v̆	**got a, set of**	ʔ	ɾ
(f)	*t*]v́	**get on, set off**	ʔ	ɾ
(g)	*t*C	**atlas, Atlantic**	ʔ	*t*
(h)	*t*]C	**got bored, set down**	ʔ	*t*
(i)	*t* ‖	**got, set**	ʔ	*t*

T1 is well established in Great Britain. T2 occurs in North America, Australia and parts of Ireland (see Wells 1982, Harris 1994). In both systems, *t* occurs as an aspirated plosive word-initially (as in (3)a, b) and before a stressed vowel within the same word (as in (3)c). Elsewhere, it appears in system T1 as a glottal stop and in system T2 as either a tap or an unreleased stop. The elsewhere set of conditions includes the familiar preconsonantal and prepausal positions (see (3)g–i). And it includes prevocalic position where the vowel occurs either within the same word, in which case it must be unstressed (as in (3)d), or in the following word, in which case stress is irrelevant (see (3)e, f).

2.2 Coda capture

Accommodating the intervocalic context within the coda analysis can only be achieved by resorting to resyllabification. Under 'basic' or unmarked syllabification, a single intervocalic consonant belongs to the onset of the second syllable, in accordance with the 'onset-first' principle. Under resyllabification, this consonant is captured into the coda of the first syllable (see for example Kahn 1976, Selkirk 1982, Wells 1990, Borowsky 1986, Hammond 1999). Depending on the particular version of the analysis, the consonant either loses its basic affiliation to the second syllable (crisp capture as in (4)b) or retains it, in which case it becomes ambisyllabic (as in (4)c).

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(4) (a) Basic        (b) Crisp capture      (c) Ambisyllabicity
        σ     σ          σ     σ                σ     σ
        |    /|          |\    |                |\   /|
        V  C  V          V  C  V                V  C  V
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(In what follows, I will use CODA CAPTURE as a cover term for both (4)b and (4)c.) Coda capture succeeds in unifying intervocalic position with preconsonantal and word-final positions, defining a single context where, for example, *r* and *h* can be deleted and *t* glottalled.

In earlier analyses, coda capture takes the form of a transformational rule. Because of this, the very term 'capture', like resyllabification, retains a certain procedural flavour. However, the same representational result can be achieved non-procedurally. In more recent analyses based on ranked constraints, it is achieved by allowing a candidate output form with the structure VC.V to be judged more optimal than one with V.CV (syllable boundaries indicated by points). How the VC.V result is derived is irrelevant here. What is at issue is the status of the VC.V structure itself. In what follows, I will review a range of reasons for rejecting coda capture outright. The evidence involves stress, weight, segmental phonology and native speaker judgements.

It needs to be borne in mind that coda capture, whether implemented by rule or constraint, represents a considerable enrichment of syllabic theory. Any serious model of syllabification must accommodate an onset-first analysis of VCV. (Apart from anything else, that is the parse required for languages that lack codas altogether.) As a null hypothesis, we may take this to be the only universally possible parse. The claim that syllabic theory must also accommodate a captured-coda analysis of VCV can thus be described a research hypothesis. Under normal circumstances, the onus would be on advocates of a theory with coda capture to adduce evidence that would force us to reject the simpler theory without it. This point is of such scientific generality that it might seem odd to be making it here. However, coda capture in particular and resyllabification in general are so deeply ingrained in the descriptive phonological tradition that they are often used as though they had pretheoretical observational validity. For this reason, it is worth spelling out why the null hypothesis in this case should not be rejected.

An observationally adequate formulation of coda capture has to make reference to stress in some way or another. For example, resyllabification must be prevented from applying where the following vowel is stressed within the same word, so as not to feed *r*-deletion in forms such as **carouse**, *h*-deletion in **behind**, and *t*-glottalling/tapping in **retain**. In earlier analyses, this was achieved by specifying [stress] values directly in the relevant rules (as in Kahn 1976 for example). It is now generally agreed that relations of stress prominence should not be coded in terms of an independent [stress] feature. This is partly because of the multifariousness of the phonetic variables involved, including changes in fundamental frequency, amplitude, duration and spectral shape. Instead, prominence is now viewed as the phonetic expression of metrical structure (Liberman & Prince 1977, Hayes 1995). In particular, the occurrence of stress on a syllable indicates that is it the head of a metrical foot. In other words, coda capture has to be made sensitive to foot structure. (Indeed, this is explicitly built into later rule-based implementations of the coda analysis; see for example Borowsky 1986.) The leftwards directionality of capture reflects the fact that feet in English are left-dominant, i.e. trochaic. However, the very reference to the foot suggests that coda capture is superfluous, at least as a device for specifying the context for segmental regularities. It is much simpler to specify the relevant context directly in terms of the foot, without having to engage the additional representational and derivational machinery needed for resyllabification. For example, *h* in standard English is suppressed when it is non-initial in the foot; compare **pro(hibit)** with **(pro~~h~~i)(bition)** (feet parenthesised).

The coda capture analysis becomes even less attractive when we compare consonant weakening with stress-related regularities involving vowel quality. Vowel reduction is like consonant weakening in neutralising contrasts in prosodically non-prominent positions. Coda capture leads to an contradictory situation where consonants targeted by weakening are pushed into prominent syllables, the very location where vowels resist reduction.

It might be countered that coda capture is motivated by facts that are quite independent of the segmental effects under discussion here – in particular, by evidence relating to weight and native-speaker judgements on syllabification. But here too the case for coda capture is far from convincing. The objections have been spelt out elsewhere (see especially Harris 1994, 2004 and Jensen 2000), so let me just summarise the main points here.

Capturing every intervocalic consonant into the coda of a preceding stressed syllable has the effect of rendering all stressed syllables heavy in English. In other words, the analysis implies that the stress-to-weight principle is active in English in the same way as it is in quantity-determined languages such as Italian and Norwegian. The ambisyllabic version of coda capture also implies that English has weight-bearing geminate consonants. The geminates are in this case covert; that is, they show no phonetic evidence of extra duration, unlike the overt equivalents in Italian and Norwegian. Moreover, regardless of whether it results in ambisyllabicity or crisp capture, leftward resyllabification freely produces superheavy syllables, such as in the *pawd* of **powder** (see Kahn 1976, Borowsky 1986 and Wells 1990 for example). This is quite unlike the situation in true quantity-determined languages, where vowels are consistently short in closed syllables. Depending on the nature of the consonant, many of the superheavy syllables are not even independently attested in English itself. The nearest equivalent sequence is VVC in word-final position, but here the consonant behaves extrasyllabically and extrametrically rather than as a coda (see Hayes 1982, Harris & Gussmann 2002).

In response, it might be proposed that, while superheavy syllables are tightly restricted at an underlying level in English, they are freely allowed at some more superficial (perhaps late lexical or post-lexical) level. On this analysis, the effects of coda capture are visible only later in derivation or in particular prosodic or morphological domains (cf. Myers 1987). As with coda capture itself, increasing the power of syllable theory in this way cannot be taken as a null hypothesis. There is no compelling reason to abandon the more restrictive assumption that the same set of syllabic structures is preserved across all domains.

Within the resyllabification approach, the creation of novel superheavy syllables could be prevented by making coda capture sensitive to the weight of the captor syllable, such that it applies only after short vowels (as proposed by Giegerich 1992 and Hammond 1999 for example). However, this undermines the segmental analyses for which coda capture was originally designed. It predicts that phenomena such as *r*-deletion, *h*-deletion and *t*-glottalling/tapping should be sensitive to the weight of the preceding syllable. This is incorrect: *t*-glottalling, for example, applies as much after long vowels (e.g. **liter**) as after short (e.g. **city**).

What of the suggestion that coda capture reflects speakers' intuitions about syllabification? The intuitions are supposedly revealed in metaphonological tasks where speakers are required to transpose syllables or insert pause-breaks between them. Ambisyllabicity is claimed to be reflected in responses such as **pity** being chunked as *pɪt* plus *ti* (see for example Fallows 1981, Giegerich 1992, Rubach 1996, Hammond & Dupoux 1996). The experimental methodology behind these tasks is flawed, however, because subjects' responses are naturally guided by explicit exposure to some prior definition of the syllable. The exposure can occur through previous experience (most likely in education), in which case the validity of the assumed definition is unverifiable. Or the exposure can occur through some training procedure associated with the experiment itself, in which case the results are prejudiced.

In any event, pause-break tasks almost certainly reveal more about feet and words than about syllables. There are good grounds for assuming that the smallest utterable unit of language is the minimal phonological word (cf. Bloomfield 1933: 178). This is likely to be the unit that corresponds to the individual chunks produced by speakers in pause-break tests. In English, as in many other languages, the minimal word consists of a single bimoraic foot (McCarthy & Prince 1986). Against this background, it is hardly surprising that an English speaker should choose *pɪt* rather than *pɪ* as the first chunk of **pity**. Being monomoraic, *pɪ* is too small to form a foot and therefore a minimal utterable word of English. In producing speech, it is of course possible to suppress language-specific phonological restrictions. There is after all no phonetic injunction against uttering *pɪ* in isolation; indeed it is phonologically well-formed in languages where words can be smaller than feet. An utterance produced under these conditions, however, no longer reveals anything about the phonology of English.

2.3 Wide-domain analysis of *r, h, t*

It has been demonstrated elsewhere that the parallel distribution of *h* and aspirated plosives in systems such as those described in §2.2 can be expressed in terms of suprasyllabic domain structure, without having to invoke coda capture (see Harris 1994, Davis & Cho 2003). Specifically, *h* and aspirated plosives can appear initially in the foot or word but not elsewhere. The parallel is illustrated in (5), which also shows how the occurrence of constricted *r* in a broad non-rhotic system can be specified in the same terms.

(5) (a) Broad non-rhoticity

	WORD	
FOOT	Initial	Non-initial
Initial	[*r*]**ed**	**a**[*r*]**ise**
Non-initial	[*r*]**avine**	**car⃥, car⃥d, ver⃥y**

(b) Defective *h*

	WORD	
FOOT	Initial	Non-initial
Initial	[*h*]**it**	**be**[*h*]**ind**
Non-initial	[*h*]**istorical**	**veh⃥icle**

(c) *t*-glottalling

	WORD	
FOOT	Initial	Non-initial
Initial	[t^h]**in**	**re**[t^h]**ain**
Non-initial	[t^h]**omorrow**	**bi**[*ʔ*], **a**[*ʔ*]**las**, **pi**[*ʔ*]**y**

(Following a generally accepted analysis (see for example Hayes 1982, 1995), I assume (i) that the metrical foot in English takes the form of a minimally bimoraic trochee and (ii) that a word-initial unstressed syllable is unfooted, as in **to(morrow)**, **de(ny)** (feet parenthesised).)

The domain-initial condition illustrated in (5) be satisfied by the foot alone (as in **a(rise)**), by the word alone (as in **ra(vine)**) or by both domains simultaneously (as in **(red)**). The elsewhere condition covers any position that is non-initial within the foot, whether final (as in **(car⃥)**), preconsonantal (as in **(car⃥d)**) or prevocalic (as in **(ver⃥y)**).

Situating the segmental regularities in (5) in relation to the foot and word confirms the close affinity between these two domains. The affinity is well established on the basis of factors quite independent of segmental phonology, in English most notably word minimality (see McCarthy & Prince 1986).

A formal statement of the distribution of constricted *r, h* and aspiration can be centred on either the domain-initial or the elsewhere context. Under a 'positional faithfulness' account of broad non-rhoticity, for example, a general constraint banning *r* from all environments would be outranked by a positional constraint requiring *r* to be preserved when initial in the foot/word (cf. Beckman 1998). Alternatively, adopting a 'positional markedness' approach, we could posit a specific constraint banning *r* from positions that are non-initial within the foot/word (cf. Zoll 1998). Which of these or indeed other approaches we adopt is not at issue here. What is important is that the overall distributional pattern can be specified in terms of foot/word structure.

The data in (5) show how the beginning of the foot or word acts as a strong segmental licensor, protecting consonants from deletion and lenition processes they are susceptible to elsewhere. It is still necessary to have some formal way of referring to different positions within the foot itself, however this is expressed. For example, in order to distinguish the narrow non-rhotic system from the broad, it is necessary to refer to the presence and identity of the segment following the *r*-deletion site. In system R2 in (1), the segment that excludes a preceding *r* is a consonant. It is a moot point whether CONSONANT here is to be interpreted syllabically or not. Under a traditional syllabic interpretation, it refers to a coda position (but crucially not a captured one). Alternatively, it can be identified by means of prosodic licensing relations between syllabic positions (see Scheer 2004). Under an interpretation that either plays down or rejects the syllabic dimension altogether, preconsonantal position can be viewed as a weak segmental licensing context on the grounds that the consonant potentially obscures auditory-perceptual cues to the identity of any preceding consonant (see Steriade 1999).

An advantage claimed for the coda-capture approach is that it defines a unique prosodic environment for segmental effects such as those under discussion here. It might be objected that, in having to invoke the foot-word conjunction, a wide-domain approach fails in this respect. However, it is important to bear in mind that, as autonomous metrical and morphological entities, the foot and word are fully motivated by evidence that is quite independent of segmental phonology. Coda capture, on the other hand, has no real motivation beyond the segmental facts for which it was originally devised, as we saw above. Unlike the foot and word, the device cannot adequately accommodate prosodic phenomena involving weight and stress.

Furthermore, identifying foot- and word-initial positions as strong segmental licensors is consistent with evidence that they enjoy special prominence in speech production and perception. For example, it has been shown that articulatory gestures are more extreme at the beginning of words and stressed syllables (see Pierrehumbert & Talkin 1992, Keating Cho, Fougeron & Hsu 2004). And these positions supply listeners with the most important cues for use in lexical access (see Nooteboom 1981, Hawkins & Cutler 1988, Hall 1992). Facts such as these are often cited as providing a functional basis for positional faithfulness in phonology (see Beckman 1998).

There is another, this time more specific reason for adopting a suprasyllabic account of non-rhoticity: defining its context in terms of the foot/word unites it with a range of other *r*-related phenomena, none of which readily submit to syllabic analysis. One of these, to which we now turn, has to do with the influence of historical *r* on preceding vowels.

3 Pre-*r* vowels

There is a strong tendency for vowel contrasts to neutralise before historical *r* in English, with individual dialects displaying the effect to different extents. The most far-reaching impact of this tendency is to be observed before historical *r* in absolute word-final position. The arrays in (6) illustrate different patterns of merger in three areas of the vowel system. As in Wells (1982), the lexical incidence of each historical vowel is indicated by a capitalised head-word.

(6)

<table>
<tr><th>(a)</th><th>(a.i)</th><th>(a.ii)</th></tr>
<tr><td>FIR</td><td>ɪr</td><td rowspan="3">əː^r</td></tr>
<tr><td>PER</td><td>ɛːr</td></tr>
<tr><td>FUR</td><td>ʌr</td></tr>
</table>

<table>
<tr><th>(b)</th><th>(b.i)</th><th>(b.ii)</th><th>(b.iii)</th><th>(b.iv)</th></tr>
<tr><td>WIRE</td><td>ayr</td><td>ayə^r</td><td rowspan="2">aə^r</td><td>ayə^r</td></tr>
<tr><td>FAR</td><td>aːr</td><td>aə^r</td><td rowspan="2">aə^r</td></tr>
<tr><td>HOUR</td><td>əwr</td><td>awə^r</td><td>awə^r</td></tr>
</table>

<table>
<tr><th>(c)</th><th>(c.i)</th><th>(c.ii)</th><th>(c.iii)</th><th>(c.iv)</th><th>(c.v)</th></tr>
<tr><td>POOR</td><td>ʉːr</td><td>ʊə^r</td><td rowspan="2">oə^r</td><td>ʊə^r</td><td rowspan="3">oə^r</td></tr>
<tr><td>FOUR</td><td>oːr</td><td>oə^r</td><td rowspan="2">oə^r</td></tr>
<tr><td>FOR</td><td>ɔːr</td><td>ɔə^r</td><td>ɔə^r</td></tr>
</table>

The *r* transcriptions in (6) are to be interpreted broadly (*ər*, for example, is typically realised as a fully rhotacised vowel). We will return to the phonetic details presently.

The sub-systems represented in (6) occur in various combinations in particular dialects. Details of the geographical distribution of the different patterns can gleaned from Kurath & McDavid (1961: ch 4) and Wells (1982: 153 ff.). Sub-system (i) in each of (6)a-c is represented by Scottish English. This makes a good reference system, since it has preserved not only historical *r* but also a near-maximal system of vowels before it. The raised *r* transcriptions indicate that vowel merger has affected both rhotic and non-rhotic dialects.[4]

The mergers illustrated in (6) suggest that *r* has somehow invaded the qualitative space of the preceding vowel. Historical *l* often exhibits similar behaviour. In London English, for example, there is extensive vowel neutralisation before vocalised *l*, producing mergers such as **pool = pull = Paul** (see Wells 1982: 313 ff.). In this respect, liquids are quite unlike other word-final consonants in English; plosives, for example, typically do not exert a neutralising influence on a preceding vowel.

Pre-*r* vowel merger is not restricted to word-final position. In many dialects, it extends to *r* in the onset of an unstressed syllable. This is illustrated by systems (ii) and (iii) in (7) (both well-established in North America). The extent of merger can be gauged by again taking Scottish English as a reference system (see (7)i).

(7)

<table>
<tr><th></th><th>(i)</th><th>(ii)</th><th>(iii)</th></tr>
<tr><td>SPIRIT</td><td>*ɪ*</td><td rowspan="2">*ɪə*</td><td rowspan="2">*ɪə*</td></tr>
<tr><td>INFERIOR</td><td>*iː*</td></tr>
<tr><td>MERRY</td><td>*ɛ*</td><td rowspan="3">*ɛə*</td><td rowspan="3">*ɛə*</td></tr>
<tr><td>MARY</td><td>*eː*</td></tr>
<tr><td>MARRY</td><td>*a*</td></tr>
<tr><td>SORRY</td><td>*ɒ*</td><td>*ɔə*</td><td rowspan="2">*oə*</td></tr>
<tr><td>GLORY</td><td>*oː*</td><td>*oə*</td></tr>
<tr><td>HURRY</td><td>*ʌ*</td><td>*əː*</td><td>*əː*</td></tr>
</table>

The reference to stress as a conditioning factor here indicates that, as with broad non-rhoticity, the domain of pre-*r* vowel neutralisation is larger than the syllable. Specifically, pre-*r* vowel contrasts potentially collapse when historical V*r*V is

[4]The relative chronology of vowel merger and *r*-loss is not a straightforward matter. Present-day changes in progress indicate that the two processes can occur simultaneously (see Harris 1994 for discussion and references).

contained within a foot, as in (**four**) = (**for**) and (**merry**) = (**marry**). No such effect is evident when the preceding vowel is separated from *r* by a foot boundary; hence the preservation of pre-*r* vowel contrasts such as *ow* versus *ɔː* in for example (**low**)(**rider**) versus (**law**)(**rider**).

4 Long-distance resonance effects in liquids

Why do liquids have a tendency to encroach on the quality of preceding vowels? A plausible answer is to be found in the notion that liquids are produced with two articulatory gestures – a primary stricture involving the tongue tip and a secondary stricture involving the tongue dorsum (cf. McMahon *et al.* 1994, Walsh-Dickey 1997, Alwan *et al.* 1997, Docherty & Foulkes 2001). Stricture tightness and inter-articulator coordination differ from one phonological position to another. Prevocalically, the primary stricture tends to be tight and the gestures closely synchronised. Postvocalically, the primary stricture is much looser and the gestures out of phase (see Krakow 1999 for discussion and references). The tendency is for the dorsal gesture to precede the apical (Sproat & Fujimura 1993, Gick 1999). Anticipation of a liquid's early dorsal gesture will inevitably affect the dorsal articulation of the preceding vowel (cf. Marshall Denton 2001 on early West Germanic). Pre-rhotic neutralisation can then be viewed as the phonologisation of this coarticulatory effect. Extensive loosening of the apical stricture leads to vocalisation.

The appearance of in-gliding schwa before historical *r* can thus be viewed as an anticipatory development of the consonant's dorsal articulation. The glide represents the sole synchronic residue of *r* once a system moves towards non-rhoticity. A similar story accounts for the *w*-glide outcome of *l*-vocalisation.

While it might be convenient to describe one of the articulations in a bi-gestural liquid as primary and the other as secondary, the relation between their associated qualities is not so obviously asymmetric in speech perception. The 'secondary' quality of a liquid can typically be identified as either clear (produced by a front-dorsal gesture) or dark (back-dorsal). The clear-dark distinction can act as an important auditory-perceptual cue to liquids, particularly in dialects of English where it correlates reliably with the contrast between *r* and *l* (see Kelly & Local 1986). In some dialects (predominant in North America and the north of England), *r* is consistently clear, while *l* is dark. In others (in parts of Ireland for example), it is *r* that is dark, while *l* is clear. The contrast is measurable in terms of the frequency of the second formant, with darker resonance being associated with lower F2 values. In word-initial position, Carter (1999) found mean F2 values for *r* to be significantly higher than for *l* in one northern English system (southeast Lancashire), while the reverse relation held in one Irish English system (Tyrone).

The coarticulatory influence that the dorsal component of liquids exerts on neighbouring vowels has been shown to extend over domains larger than the syllable (Hawkins & Slater 1994). This effect gives rise to long-distance resonance distinctions that can be exploited in speech perception (Kelly & Local 1986, Whalen 1990). West (1999) has shown that listeners can recover the *l-r* contrast when the liquids are replaced by noise in VCV sequences. Auditory-acoustic cues to the identification of *r* have a longer reach than corresponding *l* cues: *r* remains more reliably identifiable than *l* as progressively longer stretches of the surrounding context are obscured.

The smearing of rhotic resonance over stretches the size of VCV suggests the foot as the relevant domain, a claim explicitly made by Kelly & Local (1986). The stimuli used in the West (1999) study include both foot-internal liquids (e.g. **mallow, marrow**) and foot-initials (e.g. **alive, arrive**). Unfortunately for our purposes, these are not distinguished in her reported results. Nevertheless, the study does provide a window onto the kind of coarticulatory detail that is likely to have sown the seeds of the phonologically entrenched pre-*r* vowel mergers discussed in the previous section.

Although the smearing effect is bidirectional, any long-term neutralising impact can only be felt on stressed nuclei, since that is the locus of full contrastivity in English vowels (including before historical *r*). The potential for neutralising effects on unstressed nuclei is negligible, since most dialects support only a two- or three-way vowel contrast in that position anyway. Where the VCV window constitutes a trochaic foot, it is thus the first nucleus that will potentially show vowel merger before *r* – precisely the pattern evidenced by systems (ii) and (iii) in (7).

5 Rhotic–dental interactions in Irish English

5.0 In this section, we examine two sets of interactions between *r* and dental consonants in Irish English, one involving non-continuants (§5.1), the other continuants (§5.2). In both cases, the domain within which the interactions occur is the foot/word.

5.1 Dentalisation

In most dialects of English, the non-continuant coronals *t, d, n, l* are generally alveolar but assimilate to a following dental fricative, yielding [d̪] in **bad thing** for example. In conservative northern Irish English, the same consonants also show up as dentals before rhotics (see Gregg 1964, Harris 1985). The plosives *t* and *d* dentalise before an *r* within the same syllable onset (see (8)a). Under these circumstances the *r*, elsewhere realised as an approximant, appears as a tap.

(8)	(a)	**trip**	[*t̪ɾ*]**ip**	**drip**	[*d̪ɾ*]**ip**
		train	[*t̪ɾ*]**ain**	**drain**	[*d̪ɾ*]**ain**
		petrol	**pe**[*t̪ɾ*]**ol**	**bedraggle**	**br**[*d̪ɾ*]**aggle**
	(b)	**matter**	**ma**[*t̪ɚ*]	**manner**	**ma**[*n̪ɚ*]
		ladder	**la**[*d̪ɚ*]	**pillar**	**pi**[*l̪ɚ*]

All of the coronal non-continuants dentalise before an unstressed rhotic schwa (see (8)b).

While the alveolar-dental difference is not lexically distinctive, it is nevertheless surface-contrastive at the word level. This is because dentalisation is blocked when a level-2 morpheme boundary intervenes between the target of the process and a potential trigger.[5] Note how the monomorphemic examples on the left of (9) have dentals, while the examples containing level-2 suffixes on the right have alveolars.

(9)	Dental		Alveolar	
	matter	**ma**[*t̪*]**er**	**fatter**	**fa**[*t*]**er**
	ladder	**la**[*d̪*]**er**	**sadder**	**sa**[*d*]**er**
	manner	**ma**[*n̪*]**er**	**planner**	**pla**[*n*]**er**
	pillar	**pi**[*l̪*]**ar**	**filler**	**fi**[*l*]**er**

The blocking effect is also seen in level-2 compounds, as the examples containing alveolars in (10) illustrate.

(10)	**hat rack**	**ha**[*t*] **rack**	**sunrise**	**su**[*n*] **rise**
	bed rock	**be**[*d*] **rock**	**bullring**	**bu**[*l*] **ring**

The distributional differences between dentals and alveolars in Irish English exemplify what can be termed a 'derived contrast' (Harris 1990), one that only emerges when certain types of morphologically complex words are taken into account. Dentalisation 'underapplies' in forms derived by level-2 morphology: rather than obeying the phonological dictates of dentalisation, level-2 forms prefer to be segmentally faithful to their bases (cf. Benua 1997). For example, **lou**[*d*]**er** preserves the alveolar present in its base **lou**[*d*].

As to the process itself, dentalisation might look like a case of articulatory dissimilation, given that a dental consonant requires a more advanced tongue-tip position than *r*. However, once viewed in auditory-acoustic terms, the process shows itself to be assimilatory. Impressionistically, dental *t, d, n, l* can be described as darker

[5]Level-1 morpheme boundaries are transparent to dentalisation; hence the dentals in forms such as **po**[*l̪*]**ar**, **missio**[*n̪*]**ary**.

than their alveolar counterparts. The dark resonance can be attributed to a secondary back-dorsal gesture. This is in all likelihood mechanically connected to the fact that the dentals are produced with laminal articulation (cf. Ladefoged & Maddieson 1996: 20 ff.). In other words, the dental non-continuants are velarised or 'broad' (to borrow a term traditionally applied to the same sounds in Irish Gaelic).

Recalling from §4 that *r* in Irish English is also dark, we can now view dentalisation as a case of assimilation: a dental non-continuant anticipates the dark resonance of a following rhotic. Compared to undarkened alveolars, this effect would be expected to correlate acoustically with a skewing of energy towards the lower end of the spectrum. This can be quantified in terms of the spectral centre of gravity (the average frequency of a spectrum weighted by spectral power). A lowering of F2, the measure employed in the Carter (1999) study reported in §4, would contribute to this overall darkening effect.

A preliminary study of the consonants in question suggests that the dentals do indeed have a lower centre of spectral gravity than their alveolar counterparts. Measurements were made of the spectral transition from a vowel to a following *t* before rhotic schwa in two sets of words produced by a young adult male from County Down. The *tɚ* sequence contained an intervening level-2 suffix boundary in one set of words (e.g. **cutter**, the expected alveolar condition) but not in the other (e.g. **butter**, the expected dental condition). Measuring centre of gravity at the final pitch period of the preceding vowel allows pair-wise comparisons such as the following to be made: **butter** (321Hz) versus **cutter** (602Hz); **litter** (432Hz) versus **fitter** (588 Hz); **matter** (308Hz) versus **fatter** (504Hz). In each pair, the dental condition shows a lower centre of gravity than the alveolar. The *t* in **butter** thus has a bottom-heavier spectrum than the *t* in **cutter**.

Of course these preliminary results are no more than suggestive and await validation from a more extensive study. Nevertheless, they do indicate that measuring spectral centre of gravity is a viable way of getting a quantitative handle on the impressionistic notion of dark resonance.

Returning to the phonological context of dentalisation, we can describe the segmental trigger as follows: it must be (i) a rhotic segment of some kind and (ii) right-adjacent to a non-continuant coronal target. At first sight, it might seem odd that the trigger can either be a consonant (as in **trip**) or an unstressed vowel (as in **letter**). However, the reference to stress alerts us to the fact that the domain of dentalisation must involve the foot in some way or another. As illustrated by the underlined sequences in (11)a, dentalisation occurs when the target and trigger are adjacent within a foot. Moreover, as the level-2 compounds in (11)b show, it fails when the target and trigger are separated by a foot boundary.

(11)(a) DENTAL
(track), **(dream)**
(matter), **(ladder)**, **(manner)**, **(pillar)**

(b) ALVEOLAR
(hat)(rack), **(bed)(room)**, **(sun)(rise)**, **(bull)(ring)**

(c) DENTAL
tre(mendous), Dro(more) *d̪rəmóɚ*

Foot-internal adjacency is, however, not an exhaustive specification of the prosodic conditions under which dentalisation occurs. As illustrated by the forms in (11)c, the process also applies if the target and trigger are contained within an unfooted syllable at the beginning of a word. In the examples in (11)a and (11)b, feet coincide with words. What thus seems to be important for dentalisation is that the target and trigger must not be separated by a foot or word boundary. In the case of level-2 suffixes, the foot/word boundary established at the right edge of the base evidently acts as a barrier to dentalisation; hence the alveolars in for example **(fatt)-er, (madd)-er**.

5.2 *ðər*

If *r*'s darkening influence on non-continuants points to an affinity with dentality, there are other phenomena, this time involving dental continuants, that seems to point in the opposite direction. For example, in some dialects of English, historical *r* is deleted after *θ*, as in **th~~r~~ee, th~~r~~ough** (Wells 1982: 543-4). Another example, which we investigate here, involves voiced dental fricatives in broad northern Irish English. These elide before rhotic schwa, as illustrated in (12).

(12)	**mother**	*mʌɚ*	**northern**	*nɔɚn*
	weather	*wæɚ*	**together**	*təgæɚ*

The background to *ð*-deletion in Irish English is the well-known idiosyncratic phonological distribution of the consonant in English at large. In the case of lexical-category words, it can appear word-finally (as in **bathe, smooth**) and intervocalically (as in **mother, weather**). It occurs initially only in (typically unaccented) function words (such as **the, that, though**). In fact the intervocalic specification needs to be refined: the second vowel has to be unstressed. A familiar theme, this: yet again the foot makes an appearance in the structural description of a segmental regularity. The defective phonological distribution of *ð* in lexical-category words is highlighted when we compare it with its voiceless congener:

(13)

		θ	*ð*
NON-FOOT-INITIAL			
(a)	VC]	**bath, tooth**	**bathe, teethe**
(b)	VCv̆	**ether, brothel**	**either, mother**
FOOT-INITIAL			
(c)	[Cv́	**think, three**	*
(d)	VCv́	**athwart, cathartic**	*

θ can occur anywhere within a foot – finally (as in (13)a), medially ((13)b) or initially ((13)c, d). *ð*, in contrast, is barred from foot-initial position in lexical-category words.[6]

The historical background to *ð*'s defective distribution is well established (see Jespersen 1909: 199). Like the other voiced fricatives in English, *ð* was originally no more than a positional variant of its more widely distributed voiceless counterpart. In Old English, fricatives were predictably voiced when intervocalic within a foot. Two developments led to a phonemic split between *θ* and *ð*. One involved the loss of final unstressed vowels under certain conditions. This had the effect of leaving *ð* exposed at the end of words, where it now contrasted with *θ* (as in **bathe** versus **bath**). The other development involved the large-scale borrowing of words (mostly learned items from Greek) containing intervocalic *θ*, resulting in a word-internal contrast with *ð* (as in **ether** versus **either**).

Against this historical background, it is hard to tell whether *ð*-deletion in Irish English is attributable to some specific antagonism between *ð* and rhotics, or whether it is part of some more general tendency for consonants to lenite in intervocalic position. The syncope of unstressed vowels just alluded to left v̆*r* untouched. The upshot is that the bulk of morphemes with intervocalic *ð* in modern English have some reflex of historical v̆*r* in the second syllable (rhotic or non-rhotic schwa, depending on the dialect). Words in which present-day *ð* occurs before some originally non-rhotic unstressed vowel (and for most dialects that boils down to *i* or *ɪ*) almost always contain a level-2 morpheme boundary (**smoothie**, for example). *ð*-deletion in Irish English does not occur in this environment. Indeed, just as with dentalisation, *ð*-deletion fails even when a rhotic trigger is present but is separated from its potential target by a level-2 boundary (as in **bather, smoother**). In short, there are no clean examples of simplex morphemes containing intervocalic *ð* that would allow us to determine whether the appearance of *r* in the structural description

[6]The northern Irish English system under discussion here has dental fricatives in all of the positions represented in (13) apart from the one where *ð*-deletion applies (in **either, mother**, etc.). The situation is different in certain southern dialects, where the historical fricatives show up as dental stops in all positions.

of *ð*-deletion is a matter of historical accident.

Whatever the original motivation for *ð*-deletion in Irish English, the synchronic legacy of the consonant's special history is that the ban on *ðɚ* operates within the foot.

6 Conclusion

The role of the syllable in conditioning segmental phenomena is almost certainly more limited than was once thought. On current evidence, some conditions previously attributed to syllabic structure are better defined more locally in terms of neighbouring segments or boundaries, while others are better viewed as having a wider, suprasyllabic scope. The various *r*-related phenomena discussed in this paper provide evidence of both types.

Certain aspects of non-rhoticity are amenable to the more local treatment. It is reasonable to assume that cues to constricted *r* are more robustly signalled before a vowel than before a consonant or a pause. The narrow non-rhoticity of system R2 in (1) can be viewed as phonologising this asymmetry by suppressing *r* altogether in positions with the lowest cueing potential.

Certain other *r*-related effects clearly involve domains larger than the syllable. Some of these, such as pre-*r* vowel merger, have a reach that extends over the foot. Others, such as dentalisation and *ð*-deletion, require adjacency between a target and its segmental trigger to be defined in terms of the foot or word.

It is necessary for us to consider whether an approach based on localised licensing by cue can be extended beyond segmental phenomena previously analysed in syllabic terms to wider-domain phenomena of the type discussed in this paper. Particularly relevant in this regard, in view of the involvement of stress, are segmental phenomena analysed here in terms of the foot. Might not these be explained non-prosodically in terms of the relative prominence of different linear positions? Cues to the identity of *r*, for example, are likely to be more readily recoverable before vowels bearing stress prominence than before those without. The disappearance of *r* from unstressed positions in broad non-rhotic system R3 in (1) would then be treated as the phonologisation of this asymmetry.

Without denying the importance of the relation between prominence and locally defined cueing potential, let me conclude by outlining grounds for continuing to recognise the foot as an indispensable part of the structural descriptions of many segmental regularities.

The primary phonetic exponents of stress prominence are traditionally defined in terms of loudness, duration and pitch. Any differences in segmental quality that accompany stress differences (such as vowel reduction) are then regarded as secondary. This is an essentially derivational view: surface quality effects are determined by an underlying stress relation. Even some professedly non-derivational approaches incorporate this view. It is inherent in the notion that certain phonological constraints require output forms to be segmentally faithful to their inputs specifically in positions bearing stress prominence (see for example Crosswhite 2001). From an authentically output-oriented perspective, however, the relation among all of the apparently diverse properties associated with prominence must be regarded as non-directional. That is, differences in segmental quality are as much a part of the expression of prominence as properties related to loudness, duration and pitch. According to this view, constraints regulate how all of these properties co-vary in output.

It is still of course necessary to have some way of defining the positions where particular values of all of these properties congregate. An abstract cover-term such as [stress] is unsuitable for this purpose: its close association with only a subset of the properties in question means that its use is intrinsically derivational. The only serious alternative is the foot. For example, particular ranges of values for segmental quality, loudness, duration and pitch can be specified as co-occurring in the head position of a foot. And, unlike the syllabic device of coda capture, the foot has metrical credentials that are quite independent of the segmental regularities it plays host to.[7]

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[7]It might have been tempting here to cite evidence from prosodic morphology as further independent support for the foot. The bisyllabic or bimoraic foot is often supposed to play an important role in defining such entities as the minimal word, the maximal stem, the reduplicative morpheme and the template for nicknames and abbreviations (McCarthy & Prince 1986). These entities often show up in the absence of what would traditionally be termed stress prominence – for instance, as stem templates or reduplicants in tone languages. Moreover, some languages of this type display segmental effects that are remarkably similar to those found in languages with stress feet (see for example Akinlabi & Urua 2002, Harris & Urua 2001). However, there are grounds for concluding that these bisyllabic or bimoraic entities are best defined in terms of prosodic conditions on canonical morpheme shape that are independent of the metrical foot (see especially Downing 2006).

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