ABSTRACTNESS IN PHONOLOGY AND EXTRINSIC PHONETIC INTERPRETATION: THE CASE OF LIQUIDS IN ENGLISH.

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ABSTRACT

This paper proposes constraints on the phonetic interpretation of liquids in English. Resonance categories usually associated with laterals are shown to be associated also with rhotics. It is shown that the implementation of clear/dark alternations in liquids is not only structure-dependent but also dialect-specific.

Data were collected from a representative selection of British varieties of English. A distinction is drawn between absolute clearness or darkness of liquids within any given variety and the relationships of clearness and darkness each liquid enters into in its phonological system. Distinct patterns were found for rhotic versus non-rhotic varieties, reflecting differing systems of contrast.

Questions are raised regarding phasing of gestures in different varieties of English. A gestural model relies on intrinsic interpretation of phonological units with reference to limited structural information; the data presented here support the need for structural information but challenge the validity of intrinsic interpretation.

1. INTRODUCTION

The experiment reported here was designed to test two sets of findings in the light of additional data from other varieties of English:

- the gestural phasing of laterals in English [1];
- the phonological relationship between laterals and rhotics, which is often analysed simply as [±lateral] (though not always [2]) but which also has consequences for secondary articulation or resonance quality [3,4].

This paper uses the terms 'clear' and 'dark', as they are often used in the context of laterals in English, to refer to particular resonance qualities evident in the liquids. Observations of resonance quality were made which took into account the identity of the liquid (whether the liquid is lateral or rhotic), its position within the syllable and the variety of English concerned.

The structure of the data set is outlined in Section 2.

2. BRITISH ENGLISH LIQUID DATA

The data were recorded in a sound studio onto DAT then resampled at 11025Hz into a Silicon Graphics Indy computer running Entropic's *ESPS* and *xwaves* analysis package.

Section 2.1 describes the speakers used in the experiment and the varieties of English they speak. Section 2.2 outlines the word list used for the experiment.

2.1. Speakers

The speech of four speakers was examined. All speakers were males in their twenties, educated to university level, with British regional varieties chosen to be representative of wider dialect groups within the language. These varieties, summarised in Table 1, differ in rhoticity and in the clearness or darkness of their initial laterals.

Initial lateral	Nonrhotic	Rhotic
Clear	Wearside (NE England)	Tyrone (N Ireland)
Dark	SE Lancashire (NW England)	Fife (E Scotland)

Table 1. Varieties of English examined.

2.2. Word lists

A subset of the data collected was used for the experiment reported in this paper. This subset contained 16 lexemes, all of which are monosyllabic actually-occurring words of English. The data set included both monosyllables containing initial liquids and monosyllables containing final liquids. Vocoids varied systematically in height and backness so that a spread of contexts was analysed and the identity of the vocoids would not skew the results.

The lexemes were embedded in the frame '*Say ... again*' and recorded in blocks of ten in combination with filler words included to avoid effects of list prosody. Two tokens of each lexeme were elicited from each speaker.

3. SPECTRAL ANALYSIS

F2 frequencies were used as a correlate of clearness/darkness in laterals [5,6]. Autocorrelation spectra with a 25ms hanning window were used to compile values for F2 in Hertz in the liquid portion of each lexeme at a relatively steady state in the formant trajectory or (where there was no evidence of a steady state) at the mid-point of the liquid. All measurements were checked by visual inspection of wideband spectrograms: where autocorrelation-derived values differed greatly from the spectrogram, estimates of formant frequencies were taken from DFT spectra.

The F2 frequencies were subsequently bark-scaled. The results obtained are discussed in Sections 3.1 (for nonrhotic varieties) and 3.2 (for rhotic varieties).

3.1. Nonrhotic varieties

Table 2 shows the means of the bark transform of F2 in initial liquids for nonrhotic varieties. Nonrhotic varieties have no contrast in the liquid system in syllable-final position. There is therefore no legitimate comparison to be made between liquids at this place in structure.

The clear initial lateral variety (Wearside) has a relatively clear lateral (higher F2) and a relatively dark rhotic whereas the dark initial lateral variety (SE Lancashire) has a relatively dark lateral (lower F2) and a relatively clear rhotic. SE Lancashire laterals are darker than Wearside laterals; SE Lancashire rhotics are clearer than Wearside rhotics.

Variety	Mean F2: initial lateral	Mean F2: initial rhotic	Significance of difference
Wearside	10.801	7.992	p<0.001
SE Lancashire	8.295	9.720	p<0.001

Table 2. Means of bark-scaled F2 in initial liquids; nonrhotic speakers.

Variety	Mean F2: initial lateral	Mean F2: final lateral	Significance of difference
Wearside	10.801	7.911	p<0.001
SE Lancashire	8.295	7.913	NS

Table 3. Means of bark-scaled F2 in laterals; nonrhotic speakers.

Both nonrhotic varieties have a final lateral which is darker than their initial lateral (Table 3), though the difference is less pronounced in the dark initial lateral variety than in the clear initial lateral variety. This effect may be due to an extremes of resonance effect (in this case a lower limit on darkness applying in the dark initial lateral variety): if initial laterals are dark, then there is not much acoustic space in which to squeeze a final, darker, lateral.

The longer-domain effects reported by Kelly and Local [3,4] are also supported here in that Wearside vocoids have a higher F2 after a lateral than after a rhotic while SE Lancashire vocoids have a lower F2 after laterals than after rhotics (Table 4).

Variety	Mean F2: vocoid following lateral	Mean F2: vocoid following rhotic	Significance of difference
Wearside	11.035	10.187	p<0.05
SE Lancashire	10.456	10.613	NS

Table 4. Means of bark-scaled F2 in vocoids following liquids; nonrhotic speakers.

3.2. Rhotic varieties

Tables 5-8 show the means of the bark transform of F2 in liquids for rhotic varieties. F2 patterns associated with liquids in rhotic varieties are different from those associated with liquids in nonrhotic varieties. In nonrhotic varieties, the F2 patterns differ depending on whether the initial lateral is clear or dark; in rhotic varieties, the (absolute) quality of the initial lateral makes no difference to the pattern of relationships in resonance quality. Syllable-final liquid qualities are appropriately included here since rhotic varieties do have liquid contrasts at that place in structure.

Variety	Mean F2: initial lateral	Mean F2: initial rhotic	Significance of difference
Tyrone	11.545	9.577	p<0.001
Fife	9.117	8.718	p<0.05

Table 5. Means of bark-scaled F2 in initial liquids; rhotic speakers.

Variety	Mean F2: initial rhotic	Mean F2: final rhotic	Significance of difference
Tyrone	9.577	10.145	NS
Fife	8.718	11.170	p<0.001

Table 6. Means of bark-scaled F2 in rhotics; rhotic speakers.

Variety	Mean F2: final lateral	Mean F2: final rhotic	Significance of difference
Tyrone	9.820	10.145	NS
Fife	9.238	11.170	p<0.001

Table 7. Means of bark-scaled F2 in final liquids; rhotic speakers.

Variety	Mean F2: initial lateral	Mean F2: final lateral	Significance of difference
Tyrone	11.545	9.820	p<0.001
Fife	9.117	9.238	NS

Table 8. Means of bark-scaled F2 in laterals; rhotic speakers.

The rhotic speakers have darker initial rhotics than initial laterals (Table 5) and final rhotics which are clearer than both initial rhotics (Table 6) and final laterals (Table 7). In rhotic varieties, the nonrhotic pattern [3,4] does not hold: initial rhotics in the dark initial lateral variety are not clearer than the initial laterals (as they are in the dark initial lateral variety of SE Lancashire). Differences in F2 are minimised in the rhotic dark initial lateral variety (Fife), with the exception that final rhotics are considerably clearer than other liquids. Once again, this could be due to the extremes of resonance effect (Section 3.1) since syllable-initial laterals are dark.

In vocoids following liquids in both rhotic varieties, F2 is higher when following a lateral than when following a rhotic (Table 9). This is the same pattern as is found in the clear initial lateral nonrhotic variety (Table 4).

Variety	Mean F2: vocoid following laterals	Mean F2: vocoid following rhotics	Significance of difference
Tyrone	10.682	10.345	p<0.05
Fife	11.642	10.887	p<0.05

Table 9. Means of bark-scaled F2 in vocoids following liquids; rhotic speakers.

3.3. Summary of F2 space analysis

There are three major results stemming from the analysis of the F2 space:

- Initial laterals are clearer than final laterals;
- Nonrhotic varieties pattern as Kelly & Local [3,4] suggest;
- Rhotic varieties have a fixed pattern of resonance qualities.

Two principles can be drawn from these findings: Extrinsic Phonetic Interpretation (Section 3.3.1) and Maximal Differentiation (Section 3.3.2).

3.3.1. Extrinsic Phonetic Interpretation (EPI). These data support the notion of extrinsic interpretation of phonological categories. In a rhotic dark initial lateral variety, a syllable-initial lateral counts as phonologically 'clear' because it contrasts with a dark rhotic in the same system. Yet this same lateral is phonetically dark: there is no sense in which the lateral is intrinsically clear. Such patterns of phonetic detail which interact with phonological categories in a partly absolute and partly relative fashion demand an extrinsic interpretation function.

3.3.2. Maximal Differentiation. If categories are differentiated maximally in the phonetic space, laterals will be as different as possible from rhotics. For nonrhotic varieties there need be no reference to syllable position in this statement since there is no contrast syllable-finally. Syllable-initial and syllable-final systems are therefore different and so the phonetics of the final position has no bearing on the phonetics of the initial position. Given that resonance qualities exist, one liquid will be clear and the other dark, and it does not matter which is which. Maximal differentiation thus predicts the variation which is indeed found across nonrhotic varieties.

In rhotic varieties, laterals and rhotics contrast in both initial and final positions. If resonance quality is to be used to differentiate categories maximally in the phonetic space then for any given liquid, the other liquid in the same syllable position will contrast in resonance quality (to differentiate laterals from rhotics) and the same liquid in an opposite syllable position will also contrast in resonance quality (to differentiate syllable-initial position from syllable-final position). These two patterns are therefore predicted:

I {clear initial lateral & dark initial rhotic,
dark final lateral & clear final rhotic};

II {dark initial lateral & clear initial rhotic,
clear final lateral & dark final rhotic}.

Given that initial laterals are clearer than final laterals (ruling out pattern II), maximal differentiation predicts that the resonance quality pattern for rhotic varieties should be pattern I. Pattern I is indeed what is observed in the data.

4. TEMPORAL ANALYSIS

This section covers two temporal aspects of the data. Section 4.1 contains remarks on the duration of liquids; Section 4.2 examines the relative timing of articulatory gestures as reflected in the acoustic signal.

4.1. Durational analysis

There is no clear correlation in these data between duration of a liquid and its identity as a lateral or rhotic in a given syllable position. Nevertheless, there are some durational observations worth making.

Sproat & Fujimura [1] predict that initial laterals should be darker if they are of greater duration, since the dorsal gesture has more time to become prominent. This prediction has only in part been borne out by other work [7]. The prediction is upheld in the nonrhotic clear initial lateral variety, but the nonrhotic dark initial lateral variety has the opposite pattern: the greater the duration of the initial lateral, the clearer that lateral is (Figure 1). This is an indication that phonetic parameters related to liquids are phased in different ways in different varieties. An opposite pattern exists in the rhotics of these varieties.

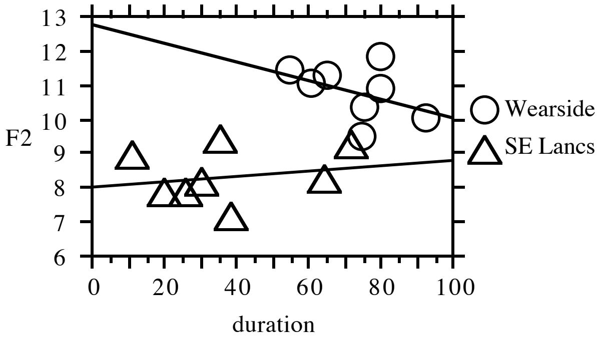

Figure 1. F2 (bark) against duration (ms) for initial laterals; nonrhotic speakers.

4.2. Relative timing of articulatory gestures

Table 10 shows the mean duration in milliseconds of the F2 transitions into and out of initial liquids in the nonrhotic varieties. The clear initial lateral variety (Wearside) has a longer transition into rhotics than into laterals. Conversely, the dark initial lateral variety (SE Lancashire) has a longer transition into laterals than into rhotics. The pattern is reversed in transitions out of liquids: the clear initial lateral variety has a shorter transition out of rhotics than out of laterals and the dark initial lateral variety has a shorter transition out of laterals than out of rhotics.

	LATERALS		**RHOTICS**	
	trans.in	*trans.out*	*trans.in*	*trans.out*
Wearside	59	51	76	44
SE Lancashire	94	63	53	68

Table 10. Mean duration in milliseconds of F2 transitions into and out of initial liquids; nonrhotic speakers.

Longer second formant transitions in liquids are likely to reflect relatively slow dorsal gestures while shorter transitions reflect relatively fast apical gestures [5]. Consequently, it seems that the clear initial lateral variety has approximately co-extensive apical and dorsal gestures in initial laterals. In contrast, the dark initial lateral variety has laterals with a dorsal gesture timed before an apical gesture (since transitions into the lateral are relatively slow and transitions out of the lateral are relatively fast). The SE Lancashire variety has shorter transitions into an initial rhotic than out of it; the Wearside variety has longer transitions into an initial rhotic than out of it.

Sproat & Fujimura [1] report an early dorsal gesture with final laterals and predict that initial laterals would have a relatively late (and relatively weak) dorsal gesture. This is evidently not the case for the SE Lancashire speaker, who has noticeably dark laterals in all positions. These temporal results coupled with the spectral analysis in Section 3.1 (Wearside laterals are clear and Wearside rhotics are dark while SE Lancashire laterals are dark and SE Lancashire rhotics are clear) strongly imply that early dorsality is a marker of darkness rather than of syllable-finality. All these results are generally reflected in the rates of transition as well as these durations of transition and may also account for the durational effect reported in Section 4.1 since longer SE Lancashire laterals would include more time for a later apical gesture to become more prominent, making the lateral clearer.

As is the case with the spectral data presented in Section 3.2, rhotic varieties seem to pattern with the clear initial lateral nonrhotic variety, whether or not their laterals are phonetically clear.

5. DISCUSSION

This section contains discussion of gestural timing, aspects of the phonetic interpretation of liquids in English and the alignment of features or attributes in the prosodic hierarchy.

5.1. Gestural timing

The results outlined in Section 4 suggest a model of gestural alignment closer to that sketched in Figure 2 than to that outlined by Sproat & Fujimura [1]. Early dorsality is a marker not of syllable-finality but of darkness. The arrangement of gestures is not intrinsic to the phonology of syllable structure since it is dependent not only on position in structure but also on dialect-specific phonetic interpretation.

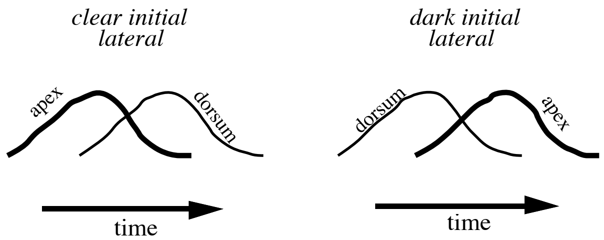

Figure 2. Gestural alignments for initial laterals.

5.2. Phonetic interpretation of liquids in English

The data pose problems for analyses based purely on articulatory dynamics. Previous results for laterals [1] are generally supported here (with reservations regarding the phasing of gestures in dark initial laterals). However, the fact that the interpretation of syllable-initial liquids in a given variety is dependent on whether that variety is rhotic challenges universalist articulatory explanations since interpretation requires knowledge of nonlocal but tautosyllabic systems of contrast in addition to gestural information. Future articulatory work needs to recognise abstract phonological entities as well as phonetic data in order to constrain more accurately predictions regarding phonetic interpretation.

5.3. Feature alignment in the prosodic hierarchy

Given a (non-segmental) phonology [8,9,10,11] where contrastive features or attributes are distributed across the prosodic hierarchy rather than being restricted to a terminal node or (auto-)segmental level, the issue of alignment of attributes in the hierarchy arises.

In an extrinsically-interpreted phonology, naming of attributes is arbitrary. It is a potential weakness of EPI that the phonetics is related arbitrarily to the phonology. However, the relationship is constrained by interpretation being not only arbitrary but also systematic. The patterning and interactions reported in this paper support the notion of a single liquid system with phonological attributes at more than one place in the syllable.

If liquids comprise both consonantal (apical) and vocalic (dorsal) gestures, the possibility arises that the consonantal and vocalic attributes of liquids might be separated, with vocalic attributes at rime level and consonantal attributes at coda level. This analysis is appealing since it would result in the rime carrying typically vocalic attributes and the coda consonantal ones. Since the phonetics of the rime begins earlier in time than the phonetics of the coda, this arrangement would make accurate predictions about phasing of gestures in syllable-final position, namely that the vocalic (rimal) dorsal gesture precedes the consonantal (coda) apical gesture. The absence of an intermediate level in the prosodic hierarchy between the onset and the syllable means that no such constraints are placed on the timing of gestures in initial position, predicting variability in syllable-initial position, which is indeed what is found cross-dialectally. Moreover, this separation of vocalic attributes from consonantal attributes also predicts ambisyllabicity data [12] in that coda gestures occurring later in time would have a greater affinity with the following syllable than would earlier rimal gestures, and so would vary more under conditions of ambisyllabicity.

6. CONCLUSION

Liquids participate in phonetic patterning and interact with syllable position: interpretation of onset liquids depends crucially on which system obtains in the rime. These phonetic facts support the notion of a single liquid system in operation at different points in structure. The analysis presented here provides systematic constraints on the phonetic interpretation of liquids in English.

The phonetic interpretation of this liquid system is both structure-dependent and dialect-specific. A phonetic interpretation intrinsic to the phonological representation cannot account adequately for the phonetic facts as they relate to the detail of complex articulations such as liquids in English. If there is to be any notion of a single liquid system across structure or of a pan-dialectal phonology then phonetic interpretation must be extrinsic.

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