# Modelling Change in the Liquid System in Tyneside English

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## ABSTRACT

Liquids in varieties of English are distinguished not only by F3 but also by the local and temporally-distributed characteristics of the spectrum below F3. We present an analysis of [l] and [ɹ] in the speech of young Tynesiders which reveals an ongoing change in typical sub-F3 spectral characteristics. The acoustic changes we identify are dependent on innovations in the liquid system having to do with labiodental ([ʋ]) rhotic productions and with prosodic structure. We deduce that medial liquids are ambisyllabic and that the sub-F3 distinctions in Tyneside English are primarily associated with liquids in syllable onsets, where the two liquids contrast with one another. We therefore suggest that the exploitation of this phonetic resource is connected with phonological contrast.

## 1 INTRODUCTION

Kelly and Local ([1]) describe varieties of English which have either clear initial [l] and dark initial [ɹ], or dark initial [l] and clear initial [ɹ]. Liquid consonants are particularly of interest for the study of phonological and phonetic constraints since, phonologically, they straddle the border between consonants and vowels ([2], [3]) and, phonetically, they are made up of multiple gestures with complex acoustic output.

### 1.1 LIQUID RESONANCE CHARACTERISTICS

An important dimension of variation in liquids involves *resonance* characteristics. Clear and dark resonance is conventionally associated with lateral articulations in English phonetics and phonology. We argue that these resonance attributes apply equally well to rhotics and that different dialects have different patterns of clear or dark [l] or [ɹ]. F2 frequency is an important correlate of clearness/darkness ([4], [5], [6]). F1 is also implicated ([7]): auditorily, dark [l] tokens which have a relatively high F1 sound darker.

### 1.2 AIMS

We report on part of a study which investigated the general resonance patterns associated with [l] and [ɹ] in two representative varieties of British English (Tyneside and West Yorkshire). The study explored the interaction of systemic linguistic phonological and physiological constraints on the phonetic characteristics of the resonance of liquids. Experiments were designed to elicit a representative range of speech data with liquids in different syllable positions and metrical structures. Speakers' productions of a set of phonologically-balanced core words were analysed using a variety of acoustic measures and statistical techniques.

## 2 METHODS

### 2.1 MATERIALS

A corpus of words was constructed. The materials on which we report comprised read lists of words in the frame 'It uttered . . . '. Pairs of words were included which differed only in whether they contained a lateral or a rhotic. Each word included one liquid in syllable-initial, intervocalic or syllable-final position. Vocalic contexts and metrical and morphological structure were systematically varied.

### 2.2 SPEAKERS

We report on the speech of eight Tynesiders from a Community College on the outskirts of Newcastle: four men and four women of student age. All speakers produced appropriately localised varieties of regional English.

### 2.3 PROCEDURE

**2.3.1 DATA ACQUISITION:** Word-lists were randomised into blocks of ten in combination with several dummy filler words. We report on data from five different randomisations of the word lists. Data sets were recorded in sound studios via a Sennheiser MD46 microphone onto a Sony TCD-D8 DAT recorder. The recordings were then resampled at 16000 Hz into a Toshiba Satellite Pro 4600 laptop computer. A core dataset of 100 tokens per speaker was extracted.

**2.3.2 LABELLING:** Initial, medial and final liquids were hand-labelled using the xlabel attachment to ESPS/xwaves. For the purposes of the analysis, the liquid boundary was defined in terms of F2 transitions. We labelled the start of any vowel preceding a liquid, the start of the F2 transition into the liquid, the end of the F2 transition into the liquid, the start of the F2 transition out of the liquid, the end of the F2 transition out of the liquid and the end of any vowel following the liquid. A subset of the data was labelled independently by both authors; no major

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inconsistencies between the two were found.

**2.3.3 AUDITORY ANALYSIS:** Speakers in both groups varied in the extent to which they produced rhotics as [ʋ]. We therefore conducted an auditory phonetic analysis of the rhotics produced by our speakers, quantifying the degree of labial/labiodental usage ([8]).

**2.3.4 NORMALISATION:** The labels were used as the basis for time normalisation. Figure 1 schematically exemplifies this procedure for initial liquids.

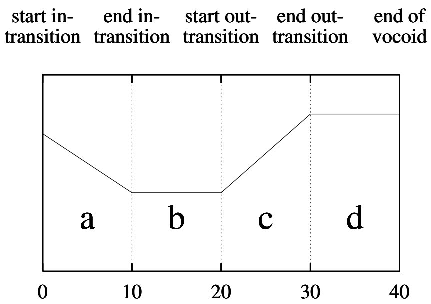


**Figure 1:** Representation of the labelling of F2 trajectories for analysis and time-normalisation for initial liquids. The solid line represents a schematised formant frequency.

Each of the regions in (labelled *a* to *d* in Figure 1) between each sequential pair of labels was normalised in the time domain by dividing into tenths, giving 41 sample points in total for each token of initial liquids. Intervocalic liquids had an additional 10 sample points at the beginning (corresponding to the preceding vowel).

**2.3.5 FORMANT TRACKING:** The ESPS formant tracker was run over each file, tracking every millisecond with a 25 ms hamming window, and a preemphasis of 0.96. Gross errors in the formant tracking were corrected by hand using wideband spectrograms, DFT spectra and resynthesis of the original signal using the corrected formant trajectories. Formant frequencies were transformed into the bark scale.

**2.3.6 REGRESSION TREES:** Regression trees were employed to partition the speech data using linguistic criteria. All word tokens were coded for sex of speaker, liquid-type (lateral or rhotic), metrical structure and surrounding vowel contexts.

## 3 RESULTS

### 3.1 REGRESSION TREES

In Figure 2, the decision tree should be read from top to bottom, with the binary decisions represented by horizontal separation; a relatively long vertical line before the next (horizontal) split indicates that the previous decision has resulted in a relatively important split, with low deviances.

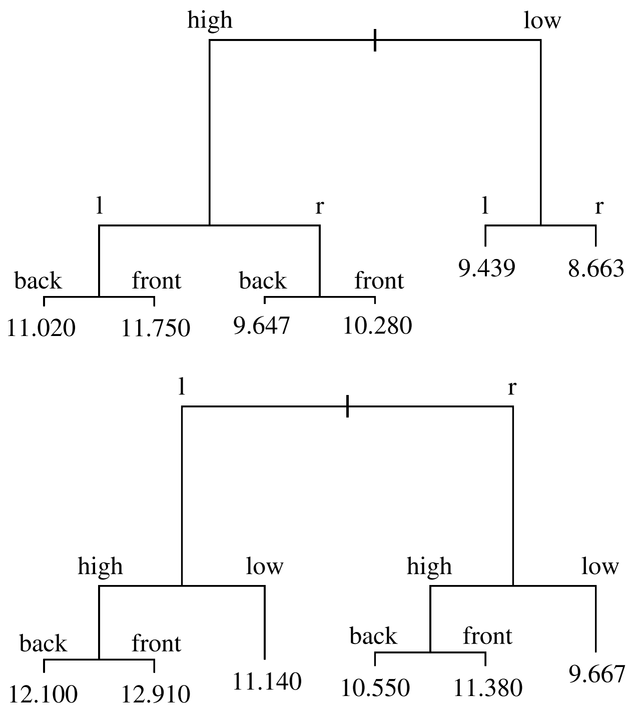


**Figure 2:** Regression trees predicting F2 frequency (bark) at the midpoint of the F2 steady state in liquids. Upper: male; lower: female.

### 3.2 FORMANTS IN INITIAL LIQUIDS

Auditory phonetic analysis indicated that the speakers produced initial tokens of [l] with clear resonance and initial tokens of [ɹ] with dark resonance. Figure 3 shows a time-normalised representation of the first four formants for initial [l] and [ɹ].

Analysis of formant frequencies at the midpoint of the F2 steady state in the liquid is presented below. Where t-statistics are reported we make a conservative estimate of significance based on the Welch modification to the degrees of freedom.

F2 is higher in [l] than in [ɹ] for both male ($t(154.307)=5.5883$, $p<0.0001$) and female ($t(157.92)=9.3463$, $p<0.0001$) speakers. This is unlike the state of affairs for the West Yorkshire speakers, for whom F2 was lower in [l] than in [ɹ]. F3 is lower in [ɹ] than in [l] both for males ($t(141.907)=13.382$, $p<0.0001$) and females ($t(125.412)=14.104$, $p<0.0001$). This is consistent with descriptions of liquids in the literature ([9]). Similarly, F4 is lower in [ɹ] than in [l] for male ($t(137.702)=10.6199$, $p<0.0001$) and female ($t(150.799)=7.3657$, $p<0.0001$) speakers. For female speakers F1 is higher for [l] than for [ɹ] ($t(146.209)=3.0497$, $p=0.0027$); there is no signif-

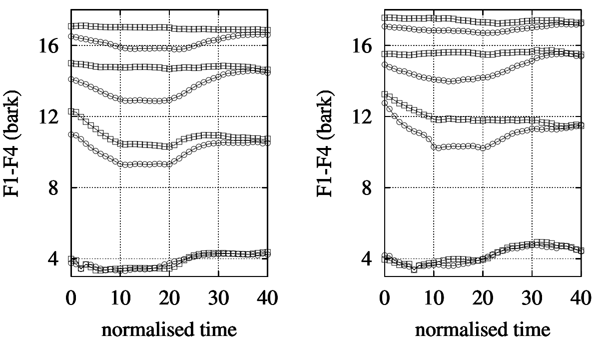


**Figure 3:** Time-normalised mean (bark) frequencies for the first four formants for onset liquids. Left: male; right: female. Squares: [l]; circles: [ɹ]. The F2 steady state corresponds to normalised-time points 10–20.

icant difference for male speakers (t(154.323)=0.5257, p=0.5999). There are no differences in F1, F2 or F2–F1 in the vowels following the liquids for either male or female speakers.

### 3.3 SYLLABLE POSITION EFFECTS

Figure 4 plots F2 frequencies at the midpoint of the F2 steady state in initial medial and final liquids in the context of high front vowels.

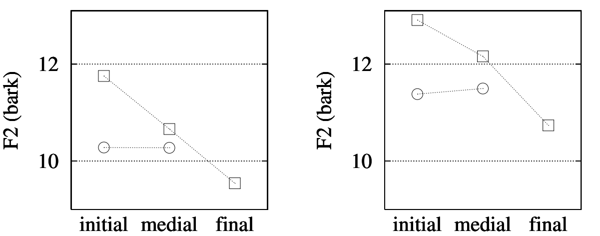


**Figure 4:** Mean F2 frequency (bark) for initial, medial and final liquids. Left: male; right: female. Squares: [l]; circles: [ɹ].

For males, F2 for initial [l] is higher than medial and final [l]. All comparisons are significant: initial/medial (t(23.738)=3.5183, p=0.0018); initial/final: (t(34.637)=4.4246, p<0.0001); medial/final: (t(21.464)=2.6797, p=0.0138). For males, F2 in initial [ɹ] is not significantly different from [ɹ] in medial position (males: t(26.069)=0.0155, p=0.9878). For males F2 for medial [l] is higher than medial [ɹ] (t(73.462)=2.3166, p=0.0233). For females, F2 in initial [l] is higher than medial and final [l]. All comparisons are significant: initial/medial (t(22.299)=3.7025, p=0.0012); initial/final: (t(34.406)=6.4987, p<0.0001); medial/final: (t(20.774)=5.1206, p<0.0001). For females, F2 in initial [ɹ] is not significantly different from medial [ɹ] (t(38.229)=0.4863, p=0.6295). For male speakers, vowels following the medial liquids are differentially affected by [l] and [ɹ]. F2 is higher when the vowel follows [l] than when it follows [ɹ] (t(74.311)=3.735, p=0.0003). This effect is not statistically significant for female speakers (t(71.975)=1.7548, p=0.08355).

### 3.4 PROSODIC EFFECTS

The clear/dark distinction between liquids is lost in trochaic words but maintained in iambic words (in comparison, Leeds speakers maintain the clear/dark distinction in both contexts). Figure 5 exemplifies this for female speakers. At the midpoint of the liquid (normalised-time point 25) for Newcastle females in iambic contexts, F2 is higher in [l] than in [ɹ] (t(76.305)=7.0462, p<0.0001); in trochaic contexts there is no difference (t(78)=1.0617, p=0.2917). However, for Leeds females the clear/dark distinction is maintained in both iambic (t(47.754)=5.2205, p<0.0001) and trochaic contexts (t(55.374)=13.8665, p<0.0001).

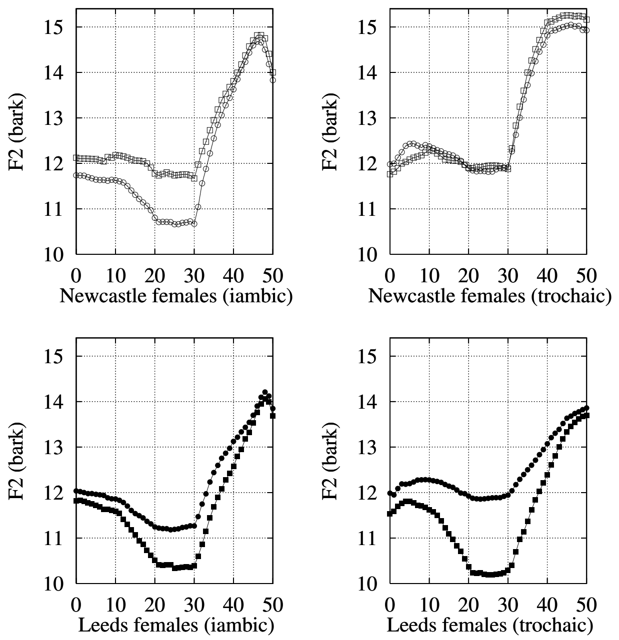


**Figure 5:** Mean F2 frequency (bark) in iambic and trochaic contexts for Newcastle and Leeds female speakers. Squares: [l]; circles: [ɹ]. The F2 steady state corresponds to normalised-time points 20–30.

### 3.5 TIMING

Speakers of the two varieties appear to show longer transitions into the dark liquids than the clear liquids in trochaic context. The Newcastle speakers have longer F2 transitions for [ɹ] than for [l] into the liquid (t(99.231)=4.121, p<0.0001) (the Leeds speakers have longer F2 transitions into [l] than [ɹ]). Durations of F2 transition into liquids in trochaic words are longer than those into iambic words (t(112.31)=6.466, p<0.0001). Liquids are longer in iambic words than in trochaic ones (t(98.369)=2.8431, p=0.0054).

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F2 transitions out of liquids are longer in iambic words than in trochaic words ($t(81.375)=6.933$, $p<0.0001$).

# 4 DISCUSSION

For Newcastle speakers the clear/dark distinction is lost in trochaic contexts; Leeds speakers preserve the distinction in both iambic and trochaic contexts. Loss of clear/dark differentiation for Newcastle speakers would seem to indicate a significant change in the sound patterns since Kelly and Local ([1]) reported that it was specifically in trochaic items that the clear/dark distinction was most obvious and impacted on both preceding and following vowels.

We can account for the innovating situation in Newcastle medial liquids by reference to ambisyllabicity and headedness. The liquids in both trochaic and iambic words are ambisyllabic ([2]). However, their relationship to each syllable depends on the head-status of the syllable in its foot. In iambic words the first syllable is a (weak) non-head whereas the second syllable is a (strong) head. In contrast, in trochaic words the first syllable is the head. Although the liquids are ambisyllabic, they associate predominantly with the syllables that are heads of feet. So liquids in iambic contexts associate predominantly with the following strong syllable and are therefore predominantly initial rather than final and display a similar resonance effect to initial liquids (and have relatively long transitions into the stressed syllable). Liquids in trochaic contexts associate predominantly with the preceding strong syllable and are therefore predominantly final rather than initial (and have relatively long transitions out of the stressed syllable). In final position there is no contrast between [l] and [ɹ] (since the variety in question is non-rhotic) and there is therefore no motivation for maintaining a distinction between [l] and [ɹ]. Evidence in favour of the ambisyllabicity of liquids includes the fact that there is an F2 effect in the vowel of the second (weak) syllable of trochaic words (males: $t(74.558)=4.42053$, $p<0.0001$; females: $t(61.923)=2.4493$, $p=0.0172$) despite the lack of an effect in the liquid itself, demonstrating that the liquid has residual initial characteristics despite being predominantly final. Moreover, as with monosyllables, there is no F2 effect in the second syllable of iambic words (males: $t(76.794)=1.7106$, $p=0.0912$; females: $t(77.947)=0.6345$, $p=0.5276$). In non-head syllables the clear/dark liquid effect is observed in the vowel as well as in the liquid portion.

### 4.1 LABIODENTAL R

There appears to be change in progress in respect of the production of [ɹ] as labial/labiodental ([ʋ]). Previous discussions of [ɹ] tokens (e.g. [8]) have indicated an association of higher F3 frequencies with [ʋ] variants. Quantification of the incidence of [ʋ] in our data reveals that [ʋ] also has a higher F2 at the midpoint ($F(1,158)=47.211$, $p<0.0001$). There is a subtle interaction between prosodic context and the incidence of [ʋ]. For female speakers we find an increased incidence in trochaic contexts. This means that in these contexts F2 frequency is also higher and approximates more closely to the F2 frequency for laterals. This provides another possible account for the loss of the clear/dark distinction in trochaic contexts (Section 3.4) in Figure 5. However, males also show a difference between trochaic and iambic contexts for the clear/dark liquid distinction but no significant difference in the incidence of [ʋ]. Following vowel context may have a differential impact on the occurrence of [ʋ]. Both male and female speakers strongly favour the production of [ʋ] where a high vowel follows (males: $t(75.718)=7.0529$, $p<0.0001$; females: $t(73.778)=4.8146$, $p<0.0001$).


# ACKNOWLEDGEMENTS

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