# LIQUID POLARISATION IN AUSTRALIAN ENGLISH

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## ABSTRACT

Carter & Local [3] report acoustic data showing that in two varieties of British English, the liquids /l/ and /r/ are polarised in terms of 'darkness' along the F2 dimension; Leeds English has dark onset /l/ (low F2) and a light onset /r/ (high F2), and Newcastle English has the opposite pattern. Here we report data on liquid polarisation for Australian English, a variety reported to show a very dark (perhaps pharyngealised) /l/ [15].

The results show that Australian English has a neutral /l/ compared with Leeds and Newcastle English, and a very dark /r/. Polarisation does exist, with Australian English showing more extreme differences in /l/-/r/ F2 than Leeds English, but less extreme than Newcastle English. Differences in F2 in /r/ are hypothesised to be due to the rise of a 'labiodental' /r/ in British English.

**Keywords:** laterals, rhotics, Australian English, liquid polarisation

## 1. INTRODUCTION

Laterals and rhotics – here referred to as liquids – exhibit crosslinguistic and diachronic patterns which suggest some kind of affinity. Spanish *blanco* 'white' corresponds to Portuguese *branco*, Māori *rua* 'two' corresponds to Hawai'ian *lua*, and in both Latin and Georgian, stems containing /r/ take a derivational suffix containing /l/ and vice versa, e.g. Georgian *inglis-uri* 'English' vs. *german-uli* 'German'. These patterns find a phonetic parallel in recent work on liquids in varieties of British English [3].

English /l/ is well-known to vary in its realisation across syllable positions; onset /l/ is typically 'lighter' with a higher F2 than the 'dark' (velarised) coda /l/ [8, 9, 13]. Across varieties too, variation in the phonetic details of /l/ realisations is found. Onset /l/ is relatively dark in Yorkshire, Australia, and North America and relatively light in Tyneside, Ireland, and RP [9, 15].

This regional variation in /l/ has been shown to condition a 'polarisation' with /r/ along the F2 dimension in two varieties of British English. Whereas Leeds English exhibits a dark onset /l/ with a low F2 and a light onset /r/ with a relatively higher F2, Newcastle English exhibits a light onset /l/ and a dark onset /r/ [3]. Polarisation along the F2 dimension can be regarded as a kind of contrast dispersion [1, 6, 10], and is not unexpected if /l/ and /r/ share some phonetic affinity. Synchronic polarisation patterns in liquids should occur in other varieties of English and in other languages. A better understanding of liquid polarisation will inform explanations for crosslinguistic phonetic differences in comparable contrasts, contribute to an understanding of liquid perception, and indicate possible mechanisms of sound change involving liquid dissimilation.

This paper presents the results of an acoustic analysis of F2 polarisation in Australian English liquids in syllable onsets. Little detail is known about the acoustic structure of Australian English /r/. Australian English /l/ is also under-researched, with studies tending to focus on /l/ vocalization (cf. [4] and references therein) and the coarticulatory effects of /l/ on adjacent vowels ([11] and references therein). The studies by Loakes *et al.* e.g. [11, 12] comment on diachronic data that reveal that Australian English /l/ has become increasingly dark since the 1960's. The results of the present study will enhance our understanding of the extent to which polarisation operates in other systems contrasting /l/ and /r/, as well as providing novel acoustic data about the realisations of onset /l/ and /r/ in Australian English.

## 2. METHOD

Five female speakers of Australian English in their 20's were recorded reading carrier phrases which contained the test words 'rip', 'rush' and 'rash' for word-initial onset /r/, and 'lip', 'lush', and 'lash' for word-initial onset /l/. The carrier phrase was 'Whisper X again', so all consonants of interest were preceded by a schwa vowel. Following vowels were /ɪ/ (phonetic [i]), /æ/, and low central /ɐ/. The phrases were pseudorandomly dispersed between two blocks of similar phrases containing filler words. Six repetitions of each block were elicited, and five tokens of each word were selected for analysis.

Recordings were made in quiet environments in Australia and in the UK using a Sony ECM-16T electret condenser microphone and a Sony TCD-D8 portable DAT recorder (sampling rate: 48 kHz). Recordings were re-digitised at 22,050 Hz and band-pass filtered 60-9500 Hz (20 Hz smoothing) using *Praat* [2] to remove background noise.

The frequencies of F1, F2, and F3 were measured manually using *Praat* running on a Toshiba PC laptop running Windows Vista (connected to an external 18 inch monitor) from 50 ms spectra centred at the approximate midpoint of the consonant (C) and the following vowel (V). In cases where the spectrum provided no clear indication of a formant, recourse was made to dynamic formant movements visible in the spectrogram window. Most occasions on which this strategy was adopted involved resolving apparent mergers of F2 and F3 in the /ɪ/ vowel in 'rip' (phonetically [i]). Measures reported here relate to average values of F2 for the consonants for each vowel context. Statistical analysis was undertaken using SPSS. Acoustic measurements for a given target word were averaged across repetitions for each speaker. The data was subjected to a two-way repeated measures analysis of variance with the factors Liquid (/r/, /l/) and Vowel Context (/ɪ/, /æ/, /ɐ/).

## 3. RESULTS

The mean F2 frequencies of /l/ and /r/ across vowel context are shown in Figure 1 for each speaker. All individuals produced /l/ with a higher F2 frequency than /r/, but for some subjects the degree of separation is greater than for others. Overall, the mean F2 frequency of /l/ (1398 Hz) is higher than that of /r/ (1115 Hz). This is confirmed statistically, with the effect of Liquid being significant ($F(1,4) = 13.549$, $p = 0.021$).

The mean F2 frequencies of /l/ and /r/ for each of the three vowel contexts averaged across speakers are shown in Figure 2. Vowel context appears to affect the liquids in different ways, with the mean values of the F2 frequency across each vowel context being more tightly clustered for /r/ (ranging between 1099 Hz and 1139 Hz for the /æ/ and /ɪ/ contexts respectively; difference = 40 Hz) than /l/ (ranging between 1307 Hz and 1521 Hz for the /ɐ/ and /ɪ/ contexts respectively; difference = 214 Hz). The main effect of Vowel Context is significant ($F(2,8) = 6.200$, $p = 0.024$), but pairwise comparisons with the Sidak correction show no significant differences among the levels of the factor. However, the interaction between Liquid and Vowel Context is significant, ($F(2, 8) = 6.385$ $p = 0.022$) and contrasts breaking down this interaction show significant differences when comparing /r/ and /l/ for both /ɪ/ versus /ɐ/ ($F(1, 4) = 9.342$, $p = 0.038$) and /æ/ versus /ɐ/ ($F(1, 4) = 10.096$, $p = 0.034$). There is no significant difference when comparing /r/ and /l/ for /ɪ/ versus /æ/ ($F(1, 4) = 3.364$, $p = 0.141$). This confirms the pattern suggested by Figure 2 whereby F2 values for /r/ vary much less with vowel context than those of /l/.

**Figure 1:** Graph showing separation of average F2 per subject (all vowel contexts). In each case, the lower bar represents the average F2 for /r/ across vowel contexts, and the upper bar the average F2 for /l/ across vowel contexts. Error bars (± standard error) are included.

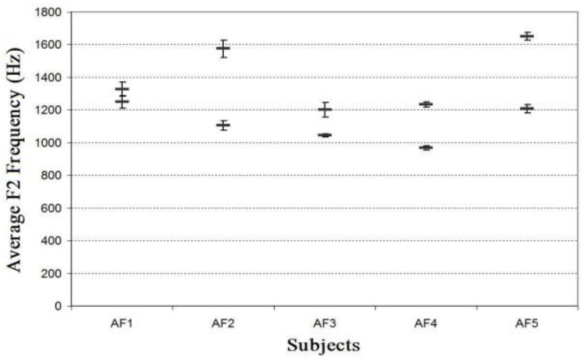
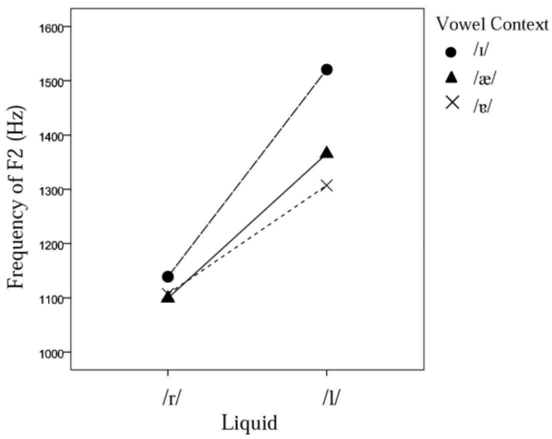



**Figure 2:** Graph showing mean frequency of F2 for the liquids /r/ and /l/ in the vowel contexts /ɪ/, /æ/, and /ɐ/ across the group of speakers.




## 4. DISCUSSION

The results show that for the speakers examined here Australian English onset /l/ can hardly be regarded as definitively 'dark' in comparison with other varieties of English, despite the possibility that it sounds dark enough to be considered pharyngealised. The average F2 frequency of 1398 Hz (all speakers, all contexts) is considerably higher than that of around 1045 Hz reported for female speakers of American English /l/ in word-medial position [8] and higher than that of 1194 Hz reported for word-initial onset /l/ for female speakers of Leeds English [3]. By comparison, the F2 for 'light' word-initial onset /l/ for female speakers of Newcastle English reported in [3] was 1675 Hz. By this criterion, Australian English appears to have a fairly neutral /l/ realisation. This finding casts doubt on the claim that F2 alone is a reliable indicator of impressionistic 'darkness' [3] (though it may still correlate with syllable position effects [8]).

By comparison with /l/, Australian English /r/ is relatively 'dark', with an average F2 of 1115 Hz. In Leeds and Newcastle English, /r/ is reported to have F2 values of 1376 Hz and 1331 Hz, respectively. Australian English /r/ appears to be particularly 'dark' when compared with these two varieties of British English. In American English, F2 for /r/ in adult females is similar to the Australian English data reported here: 1165 Hz [5]. A reviewer points out that Australian English /r/ is labialized, with a possible dorsal constriction. Both effects are also reported for approximant /r/ in other varieties of English, and so the relatively greater darkness of /r/ observed here requires explanation.

Differences in F2 frequency for Australian English /l/ and /r/ do therefore indicate that a polarisation effect is found. Averaged across all speakers and all contexts, the separation of F2 for /l/ and /r/ is 283 Hz in this Australian English data. In Leeds English, the F2 separation between /l/ and /r/ is 182 Hz and in Newcastle English the separation between /l/ and /r/ is 344 Hz [3]. Australian English therefore appears to have an intermediate degree of polarisation, with a more Newcastle-like pattern of relatively dark /r/ and relatively light /l/ (as judged from F2 alone). Polarisation need not entail maximum possible separation along a particular dimension. The liquids /r/ and /l/ are usually considered in isolation from /w/ and /j/; to account fully for the patterns, all approximants may need to be considered.

This separation varies across subjects and contexts. Maximum separation occurs in the 'rip-lip' context (average 382 Hz) and minimum separation occurs in the 'rush-lush' context (average 201 Hz), with 266 Hz in the 'rash-lash' context. The minimum separation with a single subject is 44 Hz (AF1, rush-lush) and the maximum separation within a single subject is 661 Hz (AF2, rip-lip). These values may reflect not just differences in liquid polarisation but also differences in coarticulatory effects due to adjacent vowels. More research is needed to separate these two influences.

The low F2 of the Australian English /r/ is remarkable given the similarity in F2 frequency found for /r/ in Leeds and Newcastle English. In these varieties, it appears that the laterals polarise relative to the cross-dialectally similar /r/ realisations which have a more 'fixed' position. How then, does polarisation work in Australian English? Is /l/ a fixed point (for some reason) relative to which /r/ polarises, or do both realisations shift outwards along the F2 dimension? Why should Leeds and Newcastle /r/ appear to be less mobile?

A rise in a 'labiodental' realisation of /r/ in British English [7] may be partly responsible for these observations. A speculative role for labiodental /r/ in affecting the /r/-/l/ polarisation patterns in Leeds and Newcastle "in some way" was identified by Carter & Local [3], but no precise details were given. A detailed hypothesis is proposed here for the differing F2 frequencies of /r/ across these varieties and possible constraints on /l/-/r/ polarisation. Labiodental /r/ has a relatively high F3, unlike apical approximant /r/ realisations [7]. A crossdialectal perceptual study of a synthetic /r/-/w/ continuum [14] found that British English subjects, who were assumed to have been exposed to high F3 labiodental variants of /r/, seemed to base their perceptual judgements for the /r/-/w/ boundary more on F2 than American English subjects, whose exposure to labiodental /r/ was assumed to have been minimal. The hypothesis put forward here is that with the reduction in reliability of low F3 as a cue to the /r/-/w/ contrast, F2 may be assuming a more primary role for distinguishing /r/ and /w/ in many British English varieties, and /r/-/l/ polarisation patterns along the F2 dimension may be being affected by this change. With no similar increase in high F3 labiodental /r/ realisations reported for Australian English, F2 is not being utilised as a more reliable cue to the /r/-/w/ contrast, and functions more to separate /r/ and /l/. So F2 in Australian English /r/ can adopt a lower frequency to polarise with /l/

without endangering the contrast with /w/. Further research is needed to support this hypothesis.

Regardless of the details, liquid polarisation does appear to operate at the level of speech production for this group of speakers of Australian English. Further work will examine the relationship between production patterns of /r/ and /l/ and coarticulatory effects, and investigate links between speech production and speech perception. As some speakers have such small differences in F2 between /l/ and /r/, if polarisation exists in their speech it must operate along another dimension. The impressionistically ‘dark’ nature of Australian English /l/ also runs counter to the results of F2 values presented here, and more work is needed to determine the precise acoustic origin of an impression of ‘darkness’ in liquid consonants.

## 5. CONCLUSIONS

Liquid polarisation patterns are found to exist in Australian English, though the degree of polarisation varies across contexts and subjects. Australian English /l/ has a neutral degree of darkness, as determined by F2 in comparison with previous studies of /l/ in other English varieties. Australian English /r/ has a decidedly low F2 compared with data on British English varieties, and this may be attributable to the role of F2 in signalling the /r/-/w/ contrast in British English as high F3 ‘labiodental’ realisations become more common. Further research into /r/-/l/ polarisation will need to consider possible effects of /w/.

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