Vowel Modification in Pre-lateral Environments

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INTRODUCTION

The acoustic and articulatory characteristics of the continuum of productions referred to as clear and dark /l/ have been thoroughly described for English [11, 20, 8]. These studies describe a bigestural articulation that has a gradient of syllabically conditioned variants, from the consonantal and primarily apical gesture of onset clear /l/ to the dorsal vocalic gesture of prepausal dark /ɫ/.

Dark /ɫ/ has a maximal degree of articulatory constraint (DAC) and therefore has a large impact on preceding vowels. This is due largely to the biomechanical properties of the dorsal gesture [17,18, 19]. However, this effect on vowels has not been as extensively examined as the dark /ɫ/ articulation itself (however, see [1, 2, 10, 7]). Impressionistic and objective evidence suggests that the short front vowels are maximally affected by a following dark /ɫ/ due to the physical incompatibility of the required gestures and the propensity of short vowels to embrace co-articulatory effects [16]. The long high front vowels are, however, affected differently as they, like dark /ɫ/, have maximal DAC [18]. Researchers have commented on the antagonistic effect of a rime comprising /i/ (or front rising diphthongs) and dark /ɫ/, the percept of which may be a bisyllabic structure [2, 10, 4]. Attempts have been made to explain this with reference to moraic theory and gestural conflict. Borowsky [4, 5] suggests that this is related to the preference for English syllables to be maximally bimoraic. Gick and Wilson [10] suggest that a number of different strategies can be employed by speakers to resolve the conflict between competing tongue root configurations including excrescent schwa and tense vowel laxing. Bradley [3] describes a similar process to tense vowel laxing with the loss of the length contrast in AusE between the pairs (i, ɪ) and (u, ʊ) in pre-lateral environments.

Dark /ɫ/ has the potential to affect preceding vowels to such an extent that loss of phonemic differentiation can result [12]. In AusE this is most clearly seen in the modification of /oʊ/ such that "doll" and "dole" become almost homophonous [1].

The present study examines the phenomenon of vowel modification and convergence in pre-lateral environments through an acoustic analysis of vowel formant structure. The results of this analysis have implications for phonological theories of syllabic structure and provide evidence that individuals may differ in the strategies used to comply with higher-level restrictions on syllabic constituency.

AIMS

- to examine the effect of dark /ɫ/ on the acoustic structure of preceding vowels
- to determine the extent of vowel convergence
- to identify strategies used by speakers in maintaining phonemic contrasts
- to suggest explanations for the resulting strategies

METHOD

Twenty 15 year-old girls from a total sample of 200 high school students from regional NSW were selected for the present analysis. All speakers were born in Australia, had lived in their current local area for over 10 years and were speakers of general AusE. Speakers read the 18 AusE vowels in /hVd/ and /hVl/ contexts, and additionally the 10 monophthongs and dipthongs from the set in the /hVl/ context, three times in random order.

Speech data was sampled at 20 kHz with 16bit resolution and annotated by means of established acoustic analysis procedures used in SHLRC [13]. The single target for monophthongs and the two targets for diphthongs were established for all vowels in the /hVd/ and /hV/ contexts and potentially all vowels in the /hVl/ context. For the /hVl/ context, there were some diphthongs for which a second target could not be established, particularly /aʊ/ and /oʊ/ (as described in Bernard [1]). Durations for /hVd/ environments were determined from vowel onset to consonant closure. Durations for /hVl/ environments were determined from vowel onset to consonant end.

Discrete Cosine Transforms were calculated to describe the characteristics of the dynamic formant trajectories [15]. DCT 2 provides an indication of slope and DCT 3 provides a measure of "peakiness"; important variables in the assessment of dynamic structures.

Repeated measures ANOVA p value was used to examine the effects of phonetic context on the acoustic characteristics of vowels.

RESULTS

Monophthongs

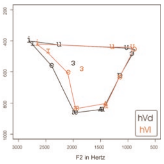

Figure 1: /hVd/ vs. /hVl/ monophthongs in the F1/F2 plane.

Significant differences were found for

- Target 1 F1 - /i, ɪ, e, ʌ, ɜ/
- Target 1 F2 - /i, ɪ, e, ʌ, ɔ, ʉ, ɜ/

Figure 1 illustrates the differences for monophthongs. It is clear that short front vowels /ɪ/ and /e/ are substantially affected as predicted. The most significant effect, however, is for /ʉ/ which is retracted to a position near /ʊ/ when followed by prepausal /ɫ/.

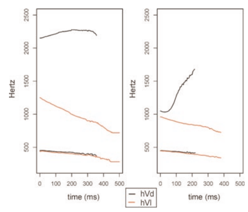

Figure 2: Averaged formant change over time for a) /ʉ/ and b) /ʊ/ in /hVd/ and /hVl/ environments.

Figure 2 compares the formant movement over time for /ʉ/ and /ʊ/ in /hVd/ and /hVl/. The convergence of /ʉ/ towards /ʊ/ before /ɫ/ is apparent. However, a significant formant 2 difference between the two persists and the length contrast is significantly retained. Therefore we cannot confirm Bradley's suggestion that /ʉ/ or /ʊ/ are homophonous before /ɫ/ [3].

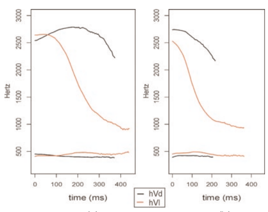

Figure 3: Averaged formant change over time for a) /i/ and b) /ɪ/ in /hVd/ and /hVl/ environments.

Figure 3 compares the two high front vowels /i/ and /ɪ/. Both vowels are affected by the prepausal /ɫ/ but in different ways. /ɪ/ and /i/ demonstrate the characteristic retraction of the target before /ɫ/ and the steeply falling F2 pattern with both vowels exhibiting movement consistent with schwa space excursion [10]. /i/ has been additionally affected in that the onglide and consequent delay of the target which are characteristic of AusE /i/ are reduced in the environment of prepausal /ɫ/. Loss of length contrast has not occurred here as indicated by a significant difference between vowel durations. The perception of syllabicity in the long vowel environment cannot be explained by the acoustic information provided here.

Diphthongs

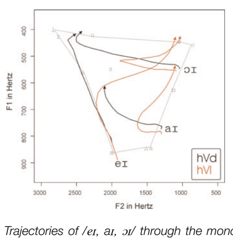

Figure 4: Trajectories of /eɪ, aɪ, ɔɪ/ through the monophthong space for /hVd/ and /hVl/.

Repeated measures ANOVA for prepausal consonant effect show

- Target 1 F1 - no significant effects
- Target 1 F2 - significant effects for /eɪ, ɔɪ, aʊ, oʊ/
- Target 2 - dipthongs /eɪ, aɪ, ɔɪ/ (/aʊ/ and /oʊ/ were not included in target 2 formant analysis due to the difficulties encountered in identification of target 2)
- F1 - significant effects present for /eɪ, aɪ, ɔɪ/
- F2 - significant effects present for /eɪ, aɪ, ɔɪ/

Target 2 of the front rising diphthongs is maximally affected. Figure 4 illustrates the very large impact of dark /ɫ/ on the diphthong trajectories and the magnitude of the second target reduction. Despite this reduction, an impression of bisyllabicity remains for these three diphthongs in this environment.

/oʊ/ and /ɒ/

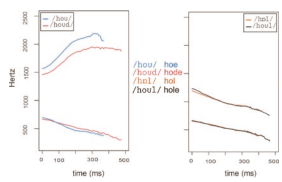

Figure 5: Averaged formant change over time for /oʊ/ and /ɒ/ in /hVd/, /hVl/ and /hV/ environments

In AusE, /oʊ/ preceding /ɫ/ bears a close resemblance to /ɒ/. Figure 7 shows the averaged formant change over time for "hoe, hode, hol, hole". The rising F2 in "hoe" and "hode" is very clear but "hole" and "hol" both display a falling F2 and have almost indistinguishable formant patterns. The durations between the monophthong and the diphthong are also significantly different with the diphthong maintaining its long vowel status.

/aʊ/ and /æ/

/aʊ/ is a diphthong that exhibits a great deal of variation in AusE. It is one of the broadness marker vowels with broader speakers presenting a raised and fronted first target and a longer first element [6]. Impressionistic examination of the present speech data revealed that the speakers in this study displayed a range of variation consistent with broadness variation for this vowel. Therefore speakers were assigned to two groups based on the broadness of this dipthong [13]. 7 speakers produced broader /aʊ/ (subsequently identified as having a greater than 250Hz difference between /æ/ and /aʊ/ F2) and 13 speakers produced more general /aʊ/ (less than 250Hz difference between /æ/ and /aʊ/ F2).

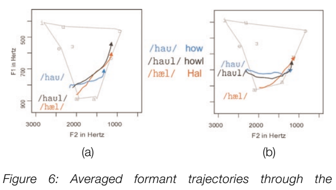

Figure 6: Averaged formant trajectories through the monophthong vowel space for /æ/ and /aʊ/ in /hVd/, /hVl/ & /hV/. a) Speakers who produce a general /aʊ/, b) Speakers who produce a broader /aʊ/.

Figure 6 illustrates that speakers make use of different strategies for managing /aʊ/ before /ɫ/. All speakers have undifferentiated "howl" and "how" at target 1 and this is separate from "Hal". For the 13 general speakers (Fig. 6a), "howl" and "how" become detached and it can be seen that "howl" and "Hal" converge on their trajectory towards the /ɫ/. This indicates that these speakers display second target reduction of "howl" and the second element of the diphthong is absorbed into the /ɫ/. The 7 broader speakers maintain the difference between /æ/and/aʊ/ vowel difference but do not appear to acoustically separate "howl" and "how". For both groups, /æl/ in "Hal" maintains its short vowel status as it has a significantly shorter duration than the rime in "howl" and "how". As /aʊ/ is the longest of the AusE vowels [6], these modifications may be related to syllabic limitations.

CONCLUSIONS

This analysis of vowels preceding prepausal /ɫ/ has shown that:

- front vowels are substantially affected in this environment
- there is a reduced onglide and earlier target for /i/ in the HVL environment and that both /i/ and /ɪ/ appear to have similar glides passing through "schwa space" although only /i/ is perceived to have a bisyllabic structure.
- the front rising diphthongs /eɪ, aɪ, ɔɪ/ undergo significant reduction in the second target. A question remains as to whether there is a relationship between the degree of reduction and the perception of bisyllabicity
- the contrast between /oʊ~ɒ/ and /ʉ̆~ʊ/ is reduced but the length differences remain. The near merger of /oʊ/ and /ɒ/ before /ɫ/ is interesting because the /oʊ/ vowel in non /ɫ/ environments bears little resemblance to its pre-lateral counterpart. Historically in English, the first target of /oʊ/ was more closely related to /ɒ/, and the second target was related to a high back vowel. This would have led to a coalescence of the second target in pre-lateral environments. This pre-lateral variant has been maintained in AusE [12, 14]. However, the non-lateral allophones have changed [6].
- Data from /aʊ/ and /æ/ has shown that dialect type can have an impact on vowel modification. Both processes discussed above relate to the coalescence of the second target of /aʊ/ and the /ɫ/ and may be in response to restrictions on syllabic structure. Gick, Kang & Whalen [9] show that there are close articulatory correspondences between American English dark /ɫ/ and the vowel /ɔ/. This vowel is similar to the second target of /aʊ/ in AusE.

REFERENCES

[1] Bernard, J. R. L. (1985). Some local effects of post-vocalic [l]. In Clark, J. E. (ed.) The Cultivated Australian. Festschrift in Honour of A. Delbridge. Hamburg: H. Buske. pp. 319-332.
[2] Bladon, R.A. W. & Al-Bamerni, A. (1976). Coarticulation resistance in English /l/. Journal of Phonetics, 4, 137-150.
[3] Bradley, D. (1989). Regional dialects in Australian English phonology. In Collins, P. & Blair, D. (eds.) Australian English: The Language of a New Society. St Lucia: University of Queensland Press. pp. 260-270.
[4] Borowsky, T. (2001). The vocalisation of dark l in Australian English. In Blair, D. & Collins, P. (eds.) Varieties of English Around the World: English in Australia. Amsterdam: Benjamins. pp. 69:88.
[5] Borowsky, T. & Horvath, B. (1997). L-Vocalisation in Australian English. In Hinskens, F., van Hout, R., & Wetzels, W. L. (eds.) Variation, Change and Phonological Theory. Amsterdam: Benjamins. pp: 101-123.
[6] Cox, F. (1996). An Acoustic Study of Vowel Variation in Australian Vowels. Unpublished PhD. Thesis, Macquarie University.
[7] Cox, F., Palethorpe, S., Carey, M. & Squires, S. (2003). The border effect: Evidence for vowel differences across the NSW/Victorian border. Paper presented at the Australian Linguistic Society meeting, Newcastle.
[8] Gick, B. (in press). Articulatory correlates of ambisyllabicity in English glides and liquids. In Local, B., Ogden, R. & Temple, R. (eds.) Papers in Laboratory Phonology VI: Constraints on Phonetics Interpretation. Cambridge: Cambridge University Press.
[9] Gick, B., Kang, Min A.& Whalen, D. H. (2002) MRI evidence for commonality in the post-oral articulations of English vowels and liquids. Journal of Phonetics, 30, 357-371.
[10] Gick, B. & Wilson, I. (to appear). Excrescent schwa and vowel laxing: Cross-linguistic responses to conflicting articulatory targets. In Papers in Laboratory Phonology VIII: Varieties of Phonological Competence.
[11] Giles, S. B. & Moll, K. L. (1975). Cinefluorographic study of selected allophones of English /l/. Phonetica, 31, 206-227.
[12] Gimson A. and Cruttenden, A. (1994). Gimson's Pronunciation of English. London: Arnold.
[13] Harrington, J., Cox, F. & Evans, Z. (1997). An acoustic phonetic study of broad, general and cultivated Australian English vowels. Australian Journal of Linguistics, 17, 155-184.
[14] McMahon, A. Foulkes, P. & Tollfree, L. (1994) Gestural representation and lexical phonology. Phonology, 11, 277-316.
[15] Palethorpe, S., Watson, C. & Barker, R. (2003). Acoustic analysis of monophthong and diphthong production i n acquired severe to profound hearing loss. Journal of the Acoustical Society of America, 114, 1055-1068.
[16] Perkell, J.S. (1969) Physiology of Speech production: Results and Implications of a Quantitative Cineradiographic Study. MA: The MIT Press.
[17] Recasens, D. (1999) Lingual Coarticulation. In Hardcastle, W. J. & Hewlett, N. (eds.) Coarticulation: Theory, Data and Techniques. Cambridge: Cambridge University Press. pp. 80 -104.
[18] Recasens, D. (2002). An EMA study of VCV coarticulatory direction. Journal of the Acoustical Society of America, 111, 2828-2841.
[19] Recasens, D., Fontdevila, J. & Pallarès, M. D. (1996). Linguopalatal coarticulation and alveolar-palatal correlations for velarized and non-velarized /l/. Journal of Phonetics, 24, 165-185.
[20] Sproat, R. & Fujimura, O. (1993). Allophonic variation in English in /l/ and its implications for phonetic implementation. Journal of Phonetics, 21, 291-311.

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