Articulatory variation in /Vl/ transitions within and across syllable boundaries

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Lateral consonants are produced with airflow along one or both sides of the tongue. Creating this side-branch for lateral airflow requires coordination of several parts of the tongue. The basic claim in past work is that laterals require the tongue tip to rise, the tongue middle to lower and the tongue back to retract relative to the position of the tongue for adjacent vowels. In many varieties of English, the timing and magnitude of these mid-sagittal movements has been shown to vary across phonetic environments, including as a function of syllable position (Giles & Moll, 1975; Sproat & Fujimura, 1993; Wrench & Scobbie, 2003) and preceding vowel (Espy-Wilson, 1992; Huffman, 1997; West, 1999). The articulatory studies mentioned above only recorded mid-sagittal movement. In this study, we examined how these articulatory variations in the mid-sagittal plane influence the sides of the tongue, expanding our understanding of /l/ production to lateral (i.e., para-sagittal) tongue dynamics.

To investigate the dynamics of lateralization during the production of /l/, we conducted a 3D electromagnetic articulography (EMA) study collecting both mid-sagittal and para-sagittal articulographic data. Three mono-lingual Australian English speakers (one male) were recorded. The numbers of valid tokens varied across speakers from 40-60 depending on how long the sensors remained attached. Three sensors were affixed mid-sagitally to the tongue tip, tongue middle and tongue back; two additional sensors were affixed para-sagitally to the sides of the tongue blade (Figure 1). Our materials varied the vowel preceding /l/, either /æ/ or /ɪ/, and the syllabic position of /l/, either as a syllable onset, as in the CVC.lVC frame, or as a syllable coda, as in the CVl.CVC frame. The vowels, /æ/ and /ɪ/, were chosen because of the different constraints that they place on the shape of the tongue preceding /l/ (Stone & Lundberg, 1996). The vowel /æ/ requires the opposite para-sagittal configuration as /l/. It usually has a complete groove tongue shape such that the sides of the tongue are curved up (instead of curved down in laterals). A vowel like /ɪ/, in contrast, does not conflict with the tongue shape required for /l/ to the same degree. Therefore, lateralization might have to start earlier in /æ/ than in /ɪ/ to achieve the /l/ target at the same time. By comparing /l/ in the context of these two vowels, we investigate how local variation in tongue shape impacts the time course of lateralization. By comparing /l/ across syllable positions, CVC.lVC vs. CVl.CVC frames, we investigate how known variation in the timing and magnitude of mid-sagittal movements (across syllable positions) are related to para-sagittal dynamics. Accordingly, we conducted two analyses of the data, a mid-sagittal analysis designed replicate past work and a para-sagittal articulatory analysis designed to explore the consequences of this variation for lateral side-branch formation.

For the mid-sagittal analysis, we measured the timing lag between the tongue tip and tongue back (timing lag = tongue tip extremum –tongue back extremum) to replicate Sproat & Fujimura's (1993) study. A negative value indicates that the tongue tip movement starts earlier than the tongue back; a positive value indicates that the tongue back movement starts first. For the para-sagittal analysis, we computed an index of lateralization that captures the degree to which the side of the tongue is higher or lower than the mid-sagittal plane and investigated the change of this index over time. The duration of the lateralization interval, reported below, indicates the time from the onset of lateralization to the point of most extreme lateralization as determined by the relative height of para-sagittal and mid-sagittal sensors.

Results for the mid-sagittal analysis (Figure 2) replicated past results. Timing lags in syllable onset position were either near zero or negative, indicating that the tongue tip moves with or before the tongue back. In coda position, in contrast, lags tended to be positive. Missing data are due to some subjects not producing /l/ with a tongue tip gesture in some environments, particularly before / ɪ / (making it impossible to calculate the lag measure). There were no effects of preceding vowel on the timing lag (where we could measure them). Results for the second analysis indicated that the lateralization interval remained stable across syllable positions, even as timing lag varied. There was, however, an effect of vowel on the lateralization index, particularly for subject M04. As predicted, lateralization intervals were longer when /l/ was preceded by /æ/, although this is only true of coda /l/. Overall, adding results from sides of the tongue offers a richer view of articulatory dynamics, especially for laterals.

Figure 1. *Schematic placement of tongue sensors.*

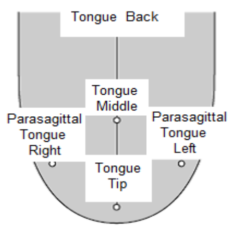


Figure 2. *TT-to-TB lag for /l/ words in onset and coda position in /æ/ and /ɪ/ contexts by speaker*

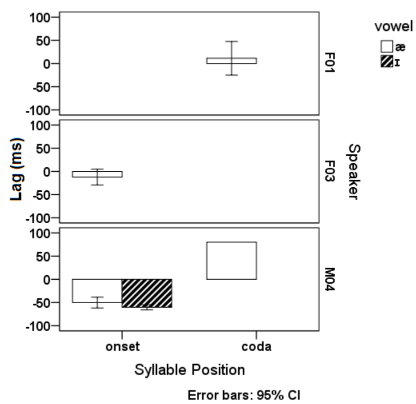
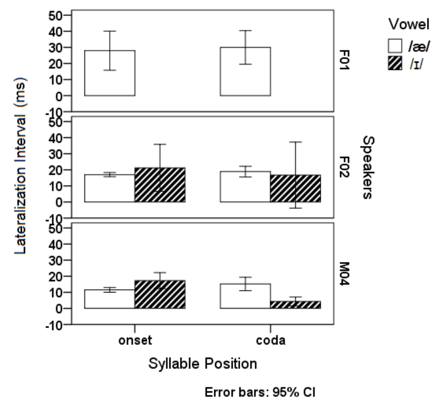


Figure 3. *The mean lateralization interval for words preceded by /ɪ/ and /æ/ across syllable position by speaker.*



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