Dialect specific patterns of gestural timing? Evidence from lateral clusters.

Emily Gorman[1]

[1]*Lancaster University*
e.gorman@lancaster.ac.uk

Abstract

This study explores the relationship between articulatory variation and speech timing, focussing on patterns of onset cluster timing in articulatorily distinct productions of /l/. Motivated by findings of variable cross-linguistic patterns of lateral cluster timing, this study compares lateral onset clusters across two closely related dialects of British English which differ in lateral darkness. Durational measures are used to determine the stable intervals and temporal movements across singleton and cluster pairs. Unexpectedly, the study finds no effects of lateral darkness on lateral onset cluster timing. Possible explanations for these results are explored.

Keywords: Speech Timing; Laterals; Consonant Clusters; C-centre; Articulatory Data

1. Introduction

What conditions cluster timing? Syllable structure and language are among the factors shown to influence patterns of cluster timing (e.g., Marin and Pouplier, 2010; Shaw et al., 2011). For other factors, such as the intrinsic properties of segments, their effects on timing remains more tentative. One such example is the proposed effect of lateral darkness on cluster timing (Marin and Pouplier, 2014). The lateral segment is one of considerable complexity and variation. Within British English dialects alone, acoustic and articulatory realisations of /l/ differ markedly (e.g., Turton, 2014). Such within language variation provides a test case for measuring the effects of lateral darkness on cluster timing.

1.1. Patterns of lateral cluster timing

The C-centre pattern, regarded the common timing pattern for onset clusters within branching languages, (Browman and Goldstein, 1988) describes the presence of a stable temporal relationship between the centre of the consonantal unit and the following vowel across singleton and cluster contexts, as illustrated in Figure 1. For this to occur, relative to the singleton context, C1 of the cluster must shift leftwards away from the vowel, and C2 must shift rightwards towards the vowel. For a C-centre pattern to emerge, the temporal shifts of C1 and C2 must be equal. Explanations for C-centre timing patterns have been offered, most notably by proponents of a coupled oscillator approach to speech timing (e.g., Browman, Goldstein, et al., 1995). From this perspective, a C-centre patterns arises due to competing phase relationships. Both C1 and C2 are coupled in-phase with the vowel; however, both consonants cannot be produced concurrently with the vowel. The anti-phase relationship between C1 and C2 thus facilitates a compromise solution whereby consonants shift equally around the consonant centre, thus preserving the global relationship between consonant and vowel segments.

For lateral clusters, previous studies have reported typical C-centre patterns for lateral onset clusters in American English (Browman and Goldstein, 1988; Marin and Pouplier, 2010), Romanian (Marin and Pouplier, 2014), and Italian (Hermes, Mücke, and Grice, 2013). Challenging these results, however, are findings for non C-centre patterns in lateral onset clusters in English (Goldstein et al., 2009), German (Brunner et al., 2014) and Montreal French (Tilsen et al., 2012). For example, in an analysis of English speakers, Goldstein et al. (2009) observed an asymmetrical shift pattern in lateral clusters, such that in a /p/ + /l/ + V structure, /l/ shifted less than /p/.

The timing pattern predicted for coda clusters of branching languages is a sequential or local pattern (Browman and Goldstein, 1988). Within this pattern, the transition from a singleton coda to a coda cluster involves the simple addition of a second consonant, with no temporal effect on the previous consonant. Again, explanations for the sequential timing patterns of codas can be gained from the coupled oscillator model of speech timing. From this perspective, a sequential timing pattern arises due to non-competitive anti-phase coupling relationships between segments. Findings for the timing patterns of lateral coda clusters, as with onsets, are varied. While a predictable sequential timing pattern has been observed for lateral coda clusters in German (Pouplier, 2012), non sequential timing patterns have been reported for lateral coda clusters in American English (Marin and Pouplier, 2010). For American English speakers, Marin and Pouplier (2010) found that /l/ shifted leftward towards the preceding vowel within a V + /l/ + C2 sequence, relative to its timing in a singleton context, (V + /l/).

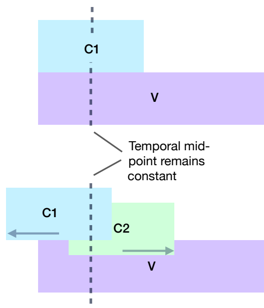

Figure 1: *Schematic illustration of C-centre timing pattern for onset cluster. A singleton, C1 + V, context is shown on top, and a cluster, C1 + C2 + V context is show on the bottom.*

The picture then for lateral cluster timing is varied. One explanation is that lateral cluster timing may be mediated by lateral darkness (Marin and Pouplier, 2010, 2014). Pursuing this hypothesis further, Marin and Pouplier (2014) investigated the timing patterns of liquids /l/ and /r/ in Romanian, which differ in darkness. This aim of their study was to ascertain whether articulatory darkness affected timing patterns of liquid coda clusters. Indeed, results of their study were suggestive of such an interaction, with the dark coda /r/ of Romanian speakers patterning similarly to the dark coda /l/s of American English speakers (Marin and Pouplier, 2010).

While there is some cross-linguistic evidence that differences in lateral cluster timing can be explained by the articulatory composition of the lateral, the potential confounds presented by cross-linguistic evidence prevents any firm conclusions from being drawn. In response to this problem, this study explores lateral darkness in two closely related dialects of a single system (British English). While sharing the phonotactic constraints of a single system, dialects differ in articulatory patterns of lateral darkness. It is hoped that this design will facilitate an explicit test of the effects of lateral darkness on lateral cluster timing.

2. This Study

Lateral clusters were compared in two dialects of British English, namely Standard Southern British English (hereafter, SSBE), and Lancashire / Manchester English. Dialects were selected on the grounds of reported differences in lateral darkness between these dialects. While SSBE speakers are reported produce a clear /l/ in onset position, and a dark /l/ in coda position (e.g., Turton, 2014), Lancashire /Manchester speakers are reported to have dark /l/s in all positions (e.g., Hughes, Trudgill, and Watt, 2012).

3. Research Questions and Hypotheses:

Using dialect as a proxy for onset lateral darkness, the research question and hypotheses for this study are as follows:

RQ: How does lateral darkness interact with patterns of lateral onset cluster timing?

Hypotheses: Differences in lateral darkness will correlate with differences in lateral onset cluster timing. Specifically, clearer onset /l/ clusters (SSBE) are predicted to correlate with a non-C-centre timing pattern, given findings for non C-centre patterns in German where /l/ is relatively clear (Brunner et al., 2014). Darker onset /l/ clusters (Lancashire /Manchester) are rather predicted correlate with a C-centre timing pattern, given findings for C-centre patterns in American English where /l/ is relatively dark (Marin and Pouplier, 2010).

4. Method

Audio-synchronised electromagnetic articulography data was collected using the Carstens AG501 articulograph, recorded at 1250 Hz, and downsampled to 250 Hz. Audio data was recorded using a DPA 4006A microphone. Data was collected from 8 SSBE and 6 Lancashire / Manchester speakers. Acoustic and articulatory data was recorded while participants read sentences aloud from an adjacent screen. Sensors were attached mid-sagittally to approximately 1cm behind the tongue tip, the tongue dorsum (as far back as was comfortable for the participant), and the tongue body, which was positioned equidistant between the tip and the dorsum. Further sensors were attached mid-sagittally to the upper and lower lips and the gumline of the lower incisors. Reference sensors were also used to correct for head movements; these were attached to non-mobile structures including, the bridge of the nose, behind each ear, and the gumline of the upper incisors. Ear and nose sensors were secured to clear goggles which were worn by the participant throughout the experiment. Finally, a bite plate was use to rotate sensor movements to the occlusal plane.

Stimuli consisted of target words within the carrier phrase *"Say tea xx again"*. Target words contained /l/ within an onset cluster (/p l/ or /k l/) or a singleton context (/l/ + V), giving 4 cluster - singleton pairs. For each pair, vocalic context varied between front and back vowels, see Table 1. Each target word was repeated four times.

Cluster	**Singleton**
Plug	Lug
Plick	Lick
Club	Lug
Clip	Lip

Table 1: *Target token pairs.*

Acoustic segmentation was performed using Montreal Forced Aligner (McAuliffe et al., 2017) in Praat (Boersma, 2011). Gestural maxima for /p, b/, /k, g/ and /l/ were defined as the time point when the relevant displacement measure reached its velocity minimum. The relevant measure for /p, b/ was the lip aperture in the horizontal/vertical dimension, for /k, g/, it was the tongue dorsum displacement in the vertical dimension, and for /l/, it was tongue tip displacement in the verticl dimension. The velocity minima were identified automatically using a function for finding peaks in "pracma" package (Borchers, 2022). Checks for accuracy were performed, and adjustments were made to parameters such as the search window and minimum peak height where necessary.

Following a methodology adapted from Marin and Pouplier (2010), two sets of timing measures were calculated: (i) lateral to anchor lags, and (ii) stability timing measures. Lateral to anchor lags measured the duration between the target achievement of the lateral, and the target achievement of the post-vocalic consonant, or the "anchor" consonant. For example, in the *"plug / lug"* pair, the lateral to anchor lag was the time of target achievement of /g/ (the anchor consonant) minus the time of target achievement of /l/. Lateral to anchor lags were compared between singleton and cluster tokens of each word pair. Stability measures were then used to calculate the most stable interval across the singleton and cluster tokens of each word pair. Intervals included the duration of the C-centre to anchor for both the singleton and cluster tokens, and two additional measures for cluster tokens only. For singleton tokens, the C-centre was defined as the target achievement of the singleton consonant. For cluster tokens, the C-centre was defined as the temporal midpoint between the targets of C1 and C2. Cluster only lags included a left-edge to anchor lag (target of anchor to the target of C1), and a right edge to anchor lag (target of anchor to the target of C2). See Figure 2 for a schematic illustration of stability intervals in singleton / cluster pairs. Model comparisons were used to determine the degree of similarity between singleton and cluster intervals; details of the model structures are provided in Section 5.2.

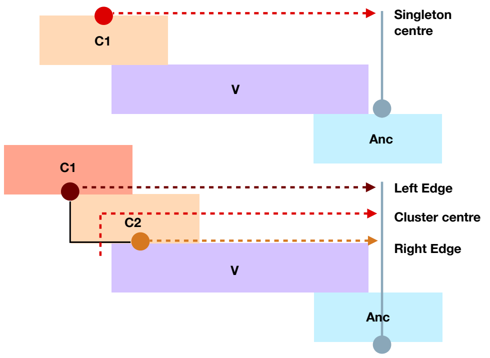

Figure 2: *Schematic illustration stability lag intervals.*

5. Results

5.1. Lateral to anchor lags

Figure 3 shows lateral to anchor lags for each singleton cluster pair, with dialect indicated by colour. A C-centre effect predicts the duration of the lateral to anchor lag will be shorter within the cluster context compared to the singleton context. This is because, C1 in a cluster must shift leftwards away from the vowel, and C2 must shift right towards the vowel. From Figure 3, we can see the the cluster context, on the left of each panel has a shorter lateral to anchor lag than the singleton context, on the right hand side of the panel. This is the case for each word pair, and for each dialect. While there is greater variation within the lag durations of SSBE, there are no qualitative differences between dialects.

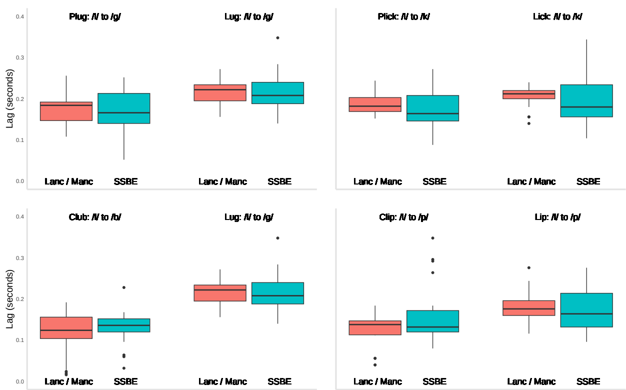

Figure 3: *Figure showing lateral to anchor lags in (s) for singleton - cluster pairs. Each panel shows a different pair.*

5.2. Stability measures

To determine the most stable interval across each singleton-cluster pair, and the effect of dialect on interval duration, linear mixed effects models were performed using the “lme4" package (Bates et al., 2015). For each word pair, three models were performed. Model (1) included the singleton centre lag and cluster centre lag; model (2) included the singleton centre lag and cluster left-edge lag; model (3) included the singleton centre lag and cluster right-edge lag. This structure enabled an explicit comparison between the singleton centre lag, and each of cluster lags. The cluster interval which was not significantly different to the singleton centre interval was considered the most stable interval across a word pair. Models included fixed effects of dialect and consonant structure (i.e., a term to test whether there was a significant difference between the duration of the singleton and consonant intervals included within the model), an interaction term between dialect and consonant structure, a random intercept of speaker, and a by-speaker random slope for consonant structure.

To test for the significance of dialect and consonant structure, model comparisons were performed using likelihood ratio tests. An effect was here considered significant if the model comparison was significant at $p < .05$. Full models were compared to partial models where an effect had been removed.

A C-centre pattern predicts a significant difference between models comparing the singleton centre lag and the cluster left-edge lag, and the singleton centre lag and the cluster right-edge lag. This is because across singleton and cluster pairs, these intervals are not held constant within a C-centre structure. Conversely, a C-centre pattern predicts a non significant difference between models comparing the singleton C-centre lag and the cluster C-centre lag, for these intervals are predicted to remain stable across singleton and cluster pairs.

For all word pairs, the effect of dialect on interval duration was non-significant, as was an interaction between dialect and consonant structure. However, each word pair differed regarding the interval of greatest stability. For *“plug / lug"*, a significant difference was found between the single centre interval and cluster left-edge lag ($p < .001$). This means that across the *“plug / lug"*, pair, the C-centre lag and the right-edge lags were both stable. For *“plick / lick"*, a significant difference was found between the singleton centre interval and all three cluster intervals, meaning that non of the intervals were stable across the singleton-cluster pair. For *“club / lug"*, a significant difference was found between the singleton centre lag and the cluster right edge lag only ($p = 0.016$), meaning that the C-centre and left-edge intervals were stable across the word pairs. Finally, for *“clip / lip"*, a significant difference was found between the singleton centre and the cluster left edge interval only ($p = 0.003$), meaning that the C-centre and right-edge intervals were stable across the word pair.

5.3. Results summary

Considering results from the lag measures and stability measures, no differences in lateral onset cluster timing were observed between dialects. In addition, stability measures showed that the C-centre was not typically the most stable interval across singleton and cluster pairs. The stability of the left-edge, right-edge, and C-centre intervals rather varied across word-pairs. For two of the word-pairs, *“plug / lug"* and *“clip / lip"*, the C-centre and right-edge were both stable. For *club / lug"* the C-centre and left-edge were both stable, while for *“plick / lick"* no interval was stable across the singleton/cluster word pair.

6. Discussion and conclusion

This study has examined the timing of lateral onset clusters across SSBE and Lancashire / Manchester dialects, where lateral darkness is reported to differ. Findings from the stability measures analysis showed that the C-centre was typically not the most stable interval across singleton and cluster pairs for either dialect. Though this ran counter to the hypothesis that the dark /l/s of Lancashire / Manchester speakers would yield a C-centre pattern in lateral onset clusters, this result was not entirely surprising, given considerable variability reported for onset cluster timing patterns (Mücke, Hermes, and Tilsen, 2020).

A more surprising finding, was that neither the lag analysis nor the stability analysis show a timing difference between dialects. This result was unexpected given: (i) previous findings for lateral darkness and lateral cluster timing to show an apparent pattern of covariation, as discussed within the introductory section, and (ii) the centrality of timing to articulatory accounts of lateral darkness (e.g., Sproat and Fujimura, 1993). To confirm that the speakers within this study indeed differed in lateral darkness, an additional articulatory analysis was performed. Analysis showed a clear dialectal difference in lateral darkness. Secure in the knowledge of dialectal difference in lateral darkness, we are then faced with an interesting question: How can a stable timing pattern occur in lateral onset clusters which differ in lateral darkness? There are several avenues which could be explored in response to this question. I will here only speculate on a few.

The first possibility I consider is the presence of compensatory strategies which preserve timing while accommodating differences in lateral darkness. One such strategy is higher velocity. For example, higher velocity could enable a spatially larger dorsal gesture to be achieved without incurring a further temporal cost. Another possible compensatory strategy is a reduction in vowel duration. Since lag measures in this study span from a point within the consonant onset to the target of the post vocalic anchor consonant, systematic changes in vowel duration could reasonably influence timing measures.

Another factor could be the use of the tongue tip gesture to define lateral timing. Since the dialectal differences in lateral darkness manifest in differences in tongue body vertical displacement, it may be the case that the timing of the tongue tip gesture is not the most informative point within the lateral in terms of capturing the interaction between lateral darkness and cluster timing. The timing of the lateral tongue body gesture may be more informative in this regard; however, this is difficult to obtain within vocalic contexts.

In conclusion, this study has compared lateral onset cluster timing across two varieties of British English which differ in lateral darkness. That no timing differences were found across these varieties poses an interesting question regarding how temporal stability can be maintained across lateral clusters which differ in lateral darkness.

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