Phonetically prestopped laterals in Australian Languages: A preliminary investigation of Warlpiri

Deborah Loakes¹, Andrew Butcher², Janet Fletcher¹, Hywel Stoakes¹

¹School of Languages and Linguistics, The University of Melbourne, Australia
²Department of Speech Pathology & Audiology, Flinders University, Australia
dloakes@unimelb.edu.au, andy.butcher@flinders.edu.au, janetf@unimelb.edu.au, hstoakes@unimelb.edu.au

Abstract
Phonologically prestopped nasals occur primarily in central and southern Australian languages. Phonetically prestopped nasals on the other hand, occur in a large number of Australian languages and are not isolated to one particular region. Phonetically prestopped nasals have been analysed as a preservation of spectral characteristics at vowel-sonorant boundaries in languages which have a comparatively large number of sonorant contrasts. In this paper we describe acoustic, articulatory and durational characteristics of rarely mentioned phonetically prestopped laterals, in the Australian language Warlpiri. We conclude that like prestopped nasals, prestopped laterals are likely to be the outcome of a coarticulatory avoidance strategy to preserve the left-edge of the sonorant. While not auditorily salient, we report on the frequent distribution and very distinctive phonetic characteristics associated with prestopped laterals.

Index Terms: phonetics, laterals, Australian Languages, EPG

1. Introduction and Background

1.1. Warlpiri

Warlpiri is spoken to the north-west of Alice Springs in the Northern Territory, Australia. It is typical of Australian languages in having few vowel contrasts, no fricatives, and rich place of articulation distinctions amongst stops and sonorants [e.g. 1]. Warlpiri has the syllable structure CV(C), with the optional coda being a sonorant. This (C) is only allowed syllable finally and word medially; no Warlpiri words end in a consonant. Word medially, Warlpiri has three contrasting lateral phonemes /l/ (VLV, VLC) but word initially this contrast is neutralized to /l/ (#IV). Also relevant for this investigation, in terms of the environments in which laterals occur, is the fact that Warlpiri has only three vowels /i/ and /u/, each with a length contrast. Accentual prominence in Warlpiri is described as occurring on morpheme initial syllables, and there is additional prominence on subsequent odd-numbered syllables [see e.g. 2].

1.2. Phonetic prestopping

A prestop is a relatively short oral stop produced at the beginning of a sonorant consonant. Phonologically prestopped nasals occur primarily in central and southern Australian languages. Phonetically prestopped nasals on the other hand, occur in free variation in many Australian languages and have been analysed as the outcome of a coarticulatory avoidance strategy, i.e. to preserve the spectral properties of vowel-sonorant boundaries [3]. That is, because Australian languages have a large number of sonorants which often contrast at adjacent places of articulation, preserving the spectral characteristics of these contrasts is crucial for maintaining perceptual distinctions. Phonetically prestopped nasals have also been linked to phonetically long consonants, which are associated with stressed syllables [3].

Phonetically prestopped laterals appear to be a rare phenomenon in the world’s languages, although they are reported to occur in the indigenous North American language Montana Salish [4, 5] which has four lateral phonemes /l1 l l t/. All of these can also occur as geminates, hence giving eight contrasts in total [4]. The first three of these laterals tend to be prestopped (and the affricate has an initial stop phase by definition). Prestopping in Montana Salish is also reported to be especially common when the laterals double [4], indicating an association with phonetically long consonants, as is the case with the prestopped nasals in Australian languages. Along with prestopped nasals, prestopped laterals have also been reported by Hercus [6] in the south central group of Australian languages, where some detail about the distribution of these sounds is documented. Hercus observed that prestopped laterals in Arabana-Wangkanguru occur only word medially, at the beginning of the second syllable of a word. Unlike Warlpiri, Arabana-Wangkanguru allows words to begin with vowels, although prestopped laterals only occur in words beginning with a consonant. Hercus notes that in Arabana-Wangkanguru the alveolar lateral is most prone to prestopping, especially when occurring as the onset of a second syllable in a word. She also notes that prestopping is most common following the high vowels /i/ and /u/, and rare following /a/. Hercus suggests that these prestopped laterals have arisen from ‘gemination and subsequent differentiation of the geminate consonant’ – once again associating prestopped sounds to long consonants.

We first observed phonetically prestopped laterals in a corpus of Biniŋ Gunj-Wok, and have also observed the phenomenon in Iwaidja (both Northern Australian languages). In this paper, we focus on Warlpiri, for which we have clear controlled speech, and accompanying EPG data.

2. Method

2.1. Recording

Recording took place in 2006 at Alice Springs, Northern Territory, and was carried out by the second author. EPG data were acquired using the Reading Electropalatograph with Articulate Assistant. Acoustic data were recorded simultaneously. The EPG data were recorded at a sampling rate of 100 Hz. Focus tokens were produced following the carrier words, "say …", or "panu" "many ...". Tokens were produced
along with two other focus words, and repeated ten times by the speaker. For example *mayi kinki* [kinki] “devil”, *mayi nini* [nini] “mouse”, *mayi nyilji* [niŋki] “to aim at”.

2.2. Labelling and Corpus

Segmental labelling was carried out using the waveform, spectrogram and EPG window in The EMU Speech Datababase System [7]. Across the corpus there are between 8-20 repetitions of a large number of focus words, and in this paper we focus only on those containing a lateral consonant.

The majority of focus words in our analysis are repeated 10-20 times, although one word *langa* (ear) was produced 20 times. In some instances, the EPG trace did not track correctly and these tokens were excluded from analysis, meaning that some words were analysed only 8 or 9 times. Overall, we analysed 188 lateral phonemes in various contexts, as follows: *#li* (20 tokens), *#lu/ (20), *hi/i* (9), *i/ì* (19), *i/ì* (9), *la/* (10), *a/ (8), *u/ (9), *u/ (9), *u/ (9), *u/ (10). *í/í* (10), *í/i* (10). *í/í* (9). We note that due to variation in the speaker’s production of the carrier phrase, word initial tokens were sometimes preceded by a vowel, and sometimes preceded by a pause. This is taken into account in the analysis in section 3.2. Finally, we note that laterals in our corpus are observed in both accented syllables (initially and as a coda in medial clusters, e.g. *lì/làk* [lì/kà] “to stare at”), and unaccented syllables (medial singleton laterals which occur as the onset of a syllable, e.g. *kà/là* [kà/là] “but”).

3. Results

3.1. Acoustic description of prestopped laterals

Prestopped laterals are in many cases not auditorily perceptible, as noted by Butcher with respect to prestopped nasals [3]. However, acoustic cues, which we describe in this section, are clear. Firstly, a dramatic drop of loudness and intensity compared to the preceding vowel and the following lateral is clear. Additionally, very brief tap-like closure and release characteristics as would be expected following articulatory closure can be seen spectrographically. This is evident in Figure 1, where an arrow points to the prestopped portion of an initial prestopped lateral in the phrase *mayi lírli* [li[i] (“don’t know to look after”).

Figure 2: Prestopped initial /l/ in “mayi lírli” (waveform and spectrogram view, window set to 5000Hz)

We note here that while the characteristics of prestopped laterals are tap-like in duration (see section 3.4), and differ in terms of articulatory properties of the lateral (see section 3.3), we use superscript [d] to transcribe the prestopped portion, e.g. [l] [l] [l]. This is in accordance with Butcher [3] and Ladefoged and Maddieson [4].

3.2. Distribution of prestopped laterals in Warlpiri corpus

In this section, we describe the environments in which prestopped laterals occur across our corpus. Firstly, we note that 57 of the 188 laterals, or approximately 30%, were prestopped. This includes 38 prestopped /l/, 8 prestopped /r/ and 11 prestopped /s/.

We turn now to the frequency of medial prestopped laterals according to both place of articulation of the lateral, and the preceding vowel. This information is presented in Table 1.

<table>
<thead>
<tr>
<th>preceding vowel</th>
<th>%</th>
<th>%</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>78</td>
<td>37</td>
<td>63</td>
</tr>
<tr>
<td>a</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>u</td>
<td>40</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

This table shows that prestopped laterals in medial position occur most commonly for /l/, followed by /s/. Additionally, the overwhelming tendency is for prestopping to occur following high vowels, particularly /i/. This distribution accords with Hercus’ observations for Arabana-Wangkanguru described in 1.2. Table 2 shows further detail regarding the contexts in which laterals are prestopped.

<table>
<thead>
<tr>
<th>position in word</th>
<th>prestop</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>#lv</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>vlv</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>vlcv</td>
<td>20</td>
<td>54</td>
</tr>
</tbody>
</table>

This table shows that of the 57 prestops in the corpus, there is an almost even distribution according to position in the word. However, analysing the actual proportion of prestops presented in the final column shows that prestopped laterals occur most typically in medial clusters (when the lateral is the coda of a syllable following an accented vowel); over half of the laterals in this context were prestopped. Additionally, 28% of initial laterals were prestopped, while 22% of medial laterals were prestopped. This is in contrast to Hercus’ observations for Arabana-Wangkanguru, where laterals which are onsets of the second syllable in a word are most prone to prestopping. The phonotactic constraints of Warlpiri, which do not allow word initial vowels like Arabana-Wangkanguru, might explain this difference.

As mentioned in 2.2, the segment preceding initial prestopped laterals varied across the corpus depending on whether the speaker paused between the carrier and focus words. We now describe the preceding segment for the 17 initial prestopped alveolar laterals presented in Table 3. Here we see that again, the highest number of prestopped laterals occur following /l/, including three tokens following a sequence of /l/ and a pause. Interestingly, we also see 4 tokens following a sequence of /l/ plus a pause.
The analysis in this section indicates that prestopped laterals are common in Warlpiri in environments known to trigger prestopping: following high vowels and in accented syllables. We have also seen that prestopping can occur in other environments, but less frequently.

Table 3. Number of prestopped laterals in word-initial position (#l), according to context

<table>
<thead>
<tr>
<th>preceding segment</th>
<th>following vowel</th>
<th>[‘l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>i#l</td>
<td>i</td>
<td>9</td>
</tr>
<tr>
<td>i pause#l</td>
<td>i</td>
<td>3</td>
</tr>
<tr>
<td>a#l</td>
<td>a</td>
<td>0</td>
</tr>
<tr>
<td>a pause#l</td>
<td>a</td>
<td>4</td>
</tr>
<tr>
<td>u#l</td>
<td>u</td>
<td>1</td>
</tr>
<tr>
<td>u pause#l</td>
<td>u</td>
<td>0</td>
</tr>
</tbody>
</table>

3.3. Articulatory properties of prestopped laterals

In this section we analyse the varying nature of the articulatory properties of prestopped laterals. We present EPG palatograms, illustrating the average amount of tongue palate contact during the onset of the prestop, compared to the midpoint of the following lateral. The data for prestopped alveolar laterals, averaged from the 38 tokens in all environments, are presented in Figure 3.

Figure 3 shows that across /l/, the tendency for occlusion is not in the anterior region for this speaker (i.e. the alveolar ridge), but the sides of the palate. In addition, this figure indicates a greater articulatory "seal" around the sides of the palate for the prestopped portion compared to the /l/. This is particularly evident on the right edge of the palatogram for [l], where less contact is seen overall, especially in the dorsal region. This is the pattern we would expect for a stop followed by a lateral.

Figure 4 shows similar data, this time for the 8 prestopped retroflex laterals. Again we see a greater degree of closure around the sides of the palate during the prestop compared to the retroflex lateral. Conversely there is less overall electrode contact on both sides of the palate during the lateral compared to the prestop. During the lateral portion we also see the dynamic nature of the retroflex consonant, where the tongue is moving forward from the initial contact giving a greater degree of tongue-palate contact overall.

3.4. Durational properties of prestopped laterals

We have so far described prestopped laterals as “tap-like”, and here we describe their durational properties. Figure 6 below shows the mean duration (ms) of prestopped laterals, according to both the prestopped and lateral portions. This gives some understanding of how brief the prestopped portion of these laterals is, and further illustration of the range of durational properties is presented in Figure 7.
absent from Flack’s analysis, our analysis supports this preceding vowels. While mention of prestopped laterals is behaviour is seen in vowels that laterals are right-anchored. That is, coarticulatory languages (including Warlpiri) [9], where it was concluded further supported by Flack’s analysis of laterals in Australian crucial for maintaining perceptual contrasts. This idea is (approximately 70% to 30%) [e.g. 8]. This in turn means that proportion of sonorants compared to obstruents in inventories of Australian languages have a relatively high means of preserving phonemic contrasts. The phonemic manner to prestopped nasals; with prestopping likely to be a We posit that prestopped laterals can be analysed in a similar better described as “flap-like” given the direction of tongue analysis (although the prestop in retroflex laterals would be [e.g. 4]. Thus, calling prestops “tap-like” is an appropriate analysis (although the prestop in retroflex laterals would be better described as “flap-like” given the direction of tongue movement).

4. Discussion

This posits that prestopped laterals can be analysed in a similar manner to prestopped nasals; with prestopping likely to be a means of preserving phonemic contrasts. The phonemic inventories of Australian languages have a relatively high proportion of sonorants compared to obstruents (approximately 70% to 30%) [e.g. 8]. This in turn means that the spectral transitions at vowel-sonorant boundaries are crucial for maintaining perceptual contrasts. This idea is further supported by Flack’s analysis of laterals in Australian languages (including Warlpiri) [9], where it was concluded that laterals are right-anchored. That is, coarticulatory behaviour is seen in vowels following laterals, and not in preceding vowels. While mention of prestopped laterals is absent from Flack’s analysis, our analysis supports this suggestion. That is, prestopping is another means of preserving the important left-edge of lateral consonants.

Finally, the tendency for prestopping of laterals in Montana Salish agrees with the idea that phonetic prestopping preserves spectral changes at vowel-sonorant boundaries. This is a language with an exceptionally large number of consonant phonemes, including eight lateral contrasts. The epenthetic prestop in Montana Salish could well occur for the same reasons as in Warlpiri, to protect the left-edge of the sonorant.

5. Conclusion

This study gives a preliminary description of prestopped laterals in a corpus of Warlpiri. In future work, we will investigate the spectral properties in surrounding vowels of the prestopped and canonical laterals, to determine the exact effect of the prestop in preserving vowel-lateral contrasts. Additionally, the reason that prestopping has been associated with long consonants is not clear from the literature. However, it is possible that this might be some form of articulatory fortition, with a greater degree of stricture during the prestop (which is especially clear when analysing laterals with EPG). In future work we will measure the length of laterals which are not prestopped, to determine whether the link between phonetically long consonants and prestopping applies in Warlpiri.

6. Acknowledgements

We would like to thank our language speaker, Bess Price Nungarrayi. This research was supported by an Australian Research Council Discovery Grant to Janet Fletcher and Andrew Butcher.

7. References