Two types of pre-stopping in Kaytetye

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1 Introduction

Kaytetye is an Arandic language of central Australia with approximately 200 speakers. As shown in Table 1, Kaytetye contrasts plain nasals with pre-stopped nasals, an unusual feature for an Australian language. Pre-stopping of both nasals and laterals is common in Australian languages, but it is not typically contrastive (Butcher, 2006; Dixon, 2002). Existing materials on Kaytetye do not report pre-stopping, whether contrastive or not, in laterals. In this paper, we show that Kaytetye does have non-contrastive pre-stopping in laterals.

	Labial	Dental	Alveolar	Retroflex	Palatal	Dorsal
Stop	p	t̪	t	ʈ	c	k
Nasal	m	n̪	n	ɳ	ɲ	ŋ
Pre-stopped Nasal	^{p}m	^{t}n̪	^{t}n	^{t}ɳ	^{c}ɲ	^{k}ŋ
Lateral		l̪	l	ɭ	ʎ	
Tap			ɾ			
Continuant	w			ɻ		ɰ

Table 1: Kaytetye consonantal inventory.

2 Methodology

In this study, we examine data collected from seven female Kaytetye speakers, aged 38-62, residents of Stirling and Neutral Junction, NT who participated in an acoustic and articulatory study investigating the Kaytetye coronal series. The speakers engaged in an elicited imitation task, where they were presented with an image depicting a target word and an audio prompt, pre-recorded by a native female speaker of Kaytetye. The audio prompts consisted of a carrier phrase and the target word X, illustrated in (1).

(1) *angke -ne = nge X*
say -IMP = 2SG X
'(You) say X!'

Participants were then asked to repeat the utterance, while audio and articulatory data from their speech were recorded. The acoustic signal was recorded using

a Behringer C-2 condenser microphone connected to an M-Audio DMP3 preamplifier. Both articulatory and acoustic signals were recorded onto a Sony mini-DV DCR-TRV103 digital camcorder. In this paper, the acoustic recordings from the relevant subset of the recorded data are considered. The target words contained the coronal nasals /n, ɳ, n̪, ɲ/, pre-stopped nasals /ᵗn, ᵗɳ, ᵗn̪, ᶜɲ/, and laterals /l, ɭ, l̪, ʎ/, all in a /#V_V/ context. The target coronal segments were preceded by word-initial /a/ and followed by a primary stressed tonic /a/ or /ə/ vowel (e.g. aᵗnə́mə 'yamstick').

3 Results

Unless otherwise stated, all comparisons below were performed using a linear mixed model, with Speaker, Item, and Repetition as random factors. Linear mixed effect modelling was accomplished using the lme4 package for R (Bates *et al.*, 2012), with p-values estimated using from the languageR package (Baayen, 2013).

3.1 Plain nasals and pre-stopped nasals

The phonemic contrast between pre-stopped and plain nasals demonstrated an extremely high correspondence with the respective presence or absence of initial closure. Of 323 tokens of plain nasal phonemes, 315 (97.5%) were realized without initial closure, and only 8 (2.5%) were realized with initial closure. Consistent with Maddieson & Ladefoged's (1993, p. 292) observation that "Arrernte prestopped nasals almost always contain a voiceless stop closure portion," 236 of 243 tokens of pre-stopped nasal phonemes (97.1%) were realized with initial closure, and only 7 (2.9%) were realized without. This essentially binary distribution suggests that plain nasal realizations are the canonical realizations for plain nasal phonemes, and that pre-stopped nasal realizations are the canonical realizations for pre-stopped nasal phonemes.

As shown in Figure 1, pre-stopped realizations of nasals were significantly longer than their plain counterparts by 66ms ($\beta = 72.25, t = 18.51, p < 0.0001$).

3.2 Plain laterals and pre-stopped laterals

The distribution of pre-stopped and plain lateral realizations differed from that of pre-stopped and plain nasal realizations on a number of parameters. First, the distribution of pre-stopped and plain lateral realizations does not support a distinction between canonical and non-canonical realizations. Of 332 tokens of laterals, 154 (46.4%) demonstrated measurable closure duration, while the remaining 178 (54.6%) did not. Second, as Figure 2 demonstrates, the distribution of pre-stopped lateral realizations was highly variable between speakers. Furthermore, place of articulation was not a significant predictor for the presence of initial closure (repeated measures ANOVA with proportion of laterals having closure as the dependent variable and Place as an independent variable, and Speaker as error factor; $F(3, 18) = 1.511, p = 0.2460$).

We therefore found no phonetic evidence for suggesting either plain or pre-stopped lateral realizations as the canonical realization of lateral phonemes in tonic position in Kaytetye. In this respect, however, we note that further data from other prosodic positions might provide evidence for an overall canonical realization of

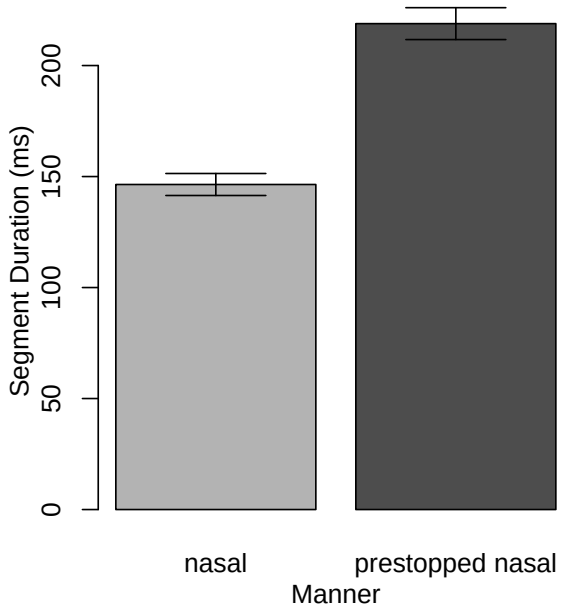

Figure 1: Mean durations of plain and pre-stopped nasals.

lateral phonemes. For example, Loakes *et al.*'s (2008) survey of the realization of laterals in Warlpiri reported that, over a range of prosodic positions, a majority (70%) of laterals were realized as plain laterals, supporting plain laterals as the canonical realizations of lateral phonemes in Warlpiri. Further, in our study, pre-stopped laterals were not found to be significantly longer than plain laterals ($\beta = 7.214, t = 1.588, p = 0.1133$), as is shown in Figure 3.

3.3 Characteristics of initial closure in pre-stopped realizations

Another aspect that varied between nasals and laterals was closure duration. Our data revealed closure in pre-stopped laterals to be significantly shorter than closure in pre-stopped nasals ($\beta = -35.23, t = 3.387, p = 0.0007$), with estimated means of 28ms and 63ms respectively. This is demonstrated visually in Figure 4.

Our data on closure duration in pre-stopped nasal realizations contrasts with that of Butcher & Loakes (2008), who examined non-contrastive nasal pre-stopping in Gupapuyngu. They found mean durations for pre-stopping in coronal nasals to be on the order of 20ms (alveolar 17ms; retroflex 21ms; dental 17ms; and palatal 20ms). This is substantially shorter than the 63ms of nasal pre-stopping produced by our Kaytetye speakers. Butcher & Loakes (2008) also report mean closure durations for non-contrastive lateral pre-stopping in Warlpiri: 21ms, 16ms, and 30ms for alveolar, retroflex, and palatal laterals respectively. This aligns closely with our findings on the duration of initial closure in pre-stopped lateral realizations in Kaytetye. We suggest that it may not be a coincidence that closure duration in both Gupapuyngu pre-stopped nasals and Warlpiri pre-stopped laterals are similar to those we found for Kaytetye pre-stopped laterals. In all three cases, pre-stopping is not phonemically contrastive, synchronically. By contrast, Kayteyte pre-stopped

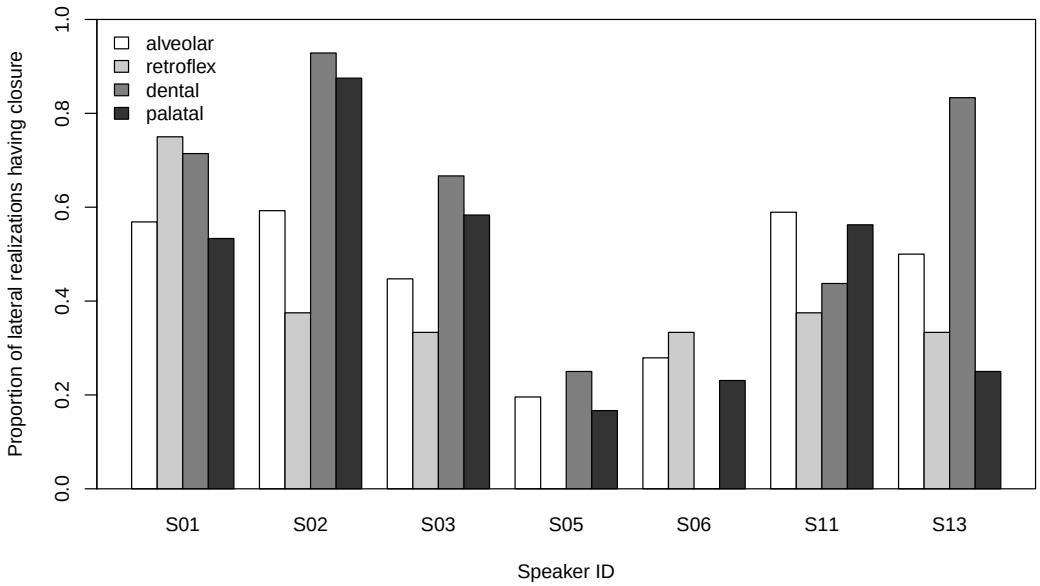

Figure 2: Proportion of lateral realizations having initial closure, by place and speaker.

nasals are phonemically distinct from plain nasals.

4 Diachrony of pre-stopping

Cross-linguistically, pre-stopping is a comparatively rare phenomenon (Butcher & Loakes, 2008), and its historical development is therefore of interest. Several diachronic analyses propose that pre-stopping derives historically from post-tonic lengthening (Butcher, 1999; Hercus, 1972, 1994; Round, 2013). Post-tonic consonantal lengthening is attested in a number of environments in Australian languages (Butcher, 2006, p. 202-204). The hypothesis relating post-tonic lengthening and pre-stopping was originally proposed by Hercus (1972), with further data provided in (Hercus, 1994, p. 37-44).

The hypothesis proposes that the principal factors in the development of pre-stopped realizations are those illustrated in examples (2) - (4) from Arabana (Hercus, 1972).

(2)	snake	/wáma/	[wámma]	>	[wá^{p}ma]
(3)	nose	/mí̪la/	[mí̪̪lla]	>	[mí^{t}̪la]
(4)	Look!	/múɳa/	[múɳa] *[múɳɳa]	>	*[mú^{t}ɳa]

As illustrated in (2) and (3), a long post-tonic nasal or lateral develops a pre-stopped realization. If both tonic and post-tonic consonants are nasal, as in (4), then the post-tonic consonant is short and pre-stopping does not develop. A tonic nasal consonant does not affect pre-stopping in laterals, as illustrated in (3).

The lack of pre-stopping in (4) requires some further consideration. Hercus (1972, 1994) states that post-tonic nasals do not lengthen if the tonic consonant is

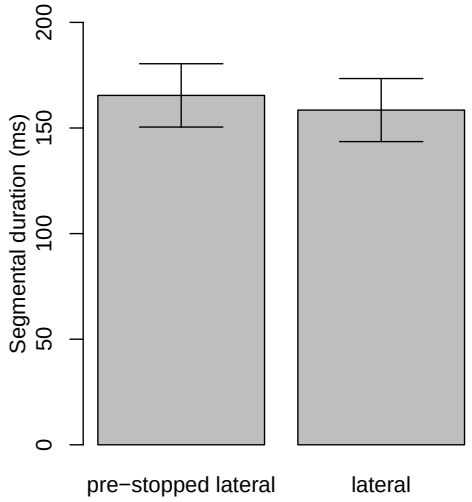

Figure 3: Total duration of pre-stopped and plain laterals, across all speakers. Error bars represent one standard error above and below estimated means.

nasal, and are therefore not subject to pre-stopping. However, the overall data on post-tonic lengthening in Arabana suggests that further investigation of this phenomenon is warranted. (Hercus, 1994, p. 44) reports that the retroflex nasal /ɳ/, and the stops /p, t, ʈ, t̪, c, k/, all fail to lengthen in any post-tonic environment. As such, it appears that the lack of post-tonic lengthening in (4) is not conditioned by the presence of an initial nasal. Further, it is not evident on general grounds why there should be a non-local relation between the manner of articulation of a tonic consonant and the duration of a post-tonic consonant.

(Maddieson & Ladefoged, 1993, p. 290-291) propose an alternative explanation for the exception in (4): that vowels in an N_N environment are nasalised. Consequently, the development of pre-stopping in (4) is articulatorily and aerodynamically disfavoured because it would require the insertion of a brief period of velic closure within a domain of continuous velic opening. This hypothesis is supported by Butcher's (1999) observation that in Burarra, tonic vowels in an N_N environment do involve nasal airflow. There is also evidence that a preceding nasalized vowel inhibits pre-stopping of nasals generally. (Durvasula, 2009, p. 100-105) reports that a preceding nasalized vowel inhibits pre-stopping of coda nasals in Jambi Malay, and in two languages of Brazilian Amazonia, Maimandé and Mundurukú. Given this cross-linguistic evidence, we adopt Maddieson & Ladefoged's analysis, and suggest that the absence of pre-stopping in (4) is not due to variations in the distribution of post-tonic lengthening.

The diachronic processes that have given rise to contrastive nasal pre-stopping in Kaytetye conform to the patterns illustrated in (2) - (4). There are three additional processes in the historical phonology of Kaytetye that are relevant to this discussion: initial consonant dropping, vowel reduction (unstressed vowels realized as schwa), and shift of stress from the first V to the first full CV. If the proto-form had an initial nasal (5), then the Kaytetye form lacks pre-stopping. If the proto-form did not have an initial nasal (6), then the Kaytetye form has pre-stopping (Koch, 2001, p. 76).

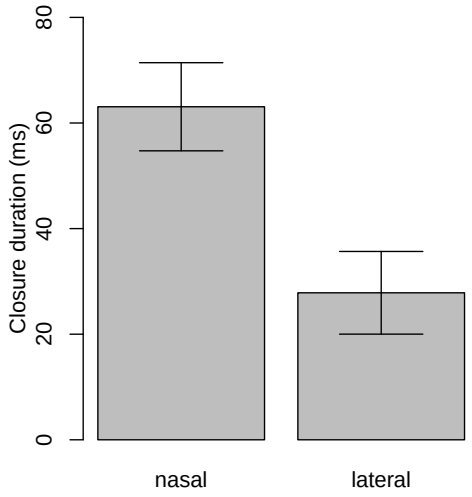

Figure 4: Duration of initial closure in realizations of pre-stopped nasals and laterals, across all speakers. Error bars represent one standard error above and below estimated means.

(5)	lie	*/ŋúna/	[ŋúna]	>	/unə́/
(6)	stand	*/t̪ána/	[t̪áᵗna]	>	/aᵗnə́/

It therefore appears that the contrast between plain and pre-stopped nasal phonemes in Kaytetye developed as a result of the loss of the initial conditioning consonant. This analysis requires post-tonic nasal lengthening to have occurred prior to the loss of the initial consonant as well as the stress shift. As a result, pre-stopped consonants in Kaytetye are no longer synchronically post-tonic.

As discussed in section 3.1, the pre-stopped nasals produced by the speakers in this study were significantly longer than their plain nasals. One may hypothesize that this length difference is a reflex of the diachronic roots of nasal pre-stopping - that is, pre-stopped nasals may be longer than plain nasals because they derive historically from geminate nasals. However, this length distinction between pre-stopped and plain realizations did not extend to laterals. This is problematic for existing diachronic hypotheses proposing that pre-stopping in laterals has the same (or parallel) historical origin as pre-stopping in nasals.

Following current diachronic hypotheses, there are two possible scenarios that could explain the Kaytetye lateral data. There are issues with both these scenarios. First, laterals could simply have a diachronic origin independent of post-tonic lengthening, where no conditional lengthening occurred in the first place, as suggested by Round (2013). Currently, it is not entirely clear what that distinct historical origin might be.

Second, if pre-stopping in Kaytetye did originate from post-tonic lengthening, perhaps pre-stopped lateral realizations were also longer than plain lateral realizations. Following the loss of the onset consonant during the development of modern Kaytetye, an independent change then collapsed the length contrast between pre-stopped and plain laterals, but conditionally preserved it between pre-stopped and

plain nasals in order to maintain their contrastive distinctiveness. Again, it is not clear at this point what might have prompted such a collapse.

5 Conclusions

While contrastive pre-stopping of nasals in Kaytetye has been previously attested, our recordings establish that modern Kaytetye speakers also produce pre-stopped variants of all laterals in the language. The distribution of these non-contrastive pre-stopped laterals does not appear to be phonologically conditioned synchronically. Analyses of the durations of these laterals compared to nasals (for which pre-stopping is phonemically contrastive) confirms that lateral pre-stopping and nasal pre-stopping are quite distinct in modern Kaytetye.

Nasal pre-stopping Kaytetye is phonemically contrastive, showing minimal variation in its distribution. In addition, pre-stopped nasal realizations are significantly longer than plain nasal realizations. By contrast, lateral pre-stopping is phonemically non-contrastive, showing considerable variation in its distribution that does not appear to be related to either place of articulation or speaker-specific factors. Neither are pre-stopped lateral realizations significantly longer than plain lateral realizations. Further, closure in pre-stopped nasal realizations is significantly longer than closure in pre-stopped lateral realizations, 63ms and 28ms, respectively.

These findings provide much needed acoustic evidence for the contemporary study of Australian languages. Current diachronic explanations for the development of pre-stopping are not able to adequately account for the differences between the contrastive pre-stopping in nasals and the non-contrastive pre-stopping in laterals in Kaytetye. Our findings therefore highlight the importance of further acoustic and perceptual phonetic studies for understanding both synchronic and diachronic processes in the phonology of Australian languages.

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