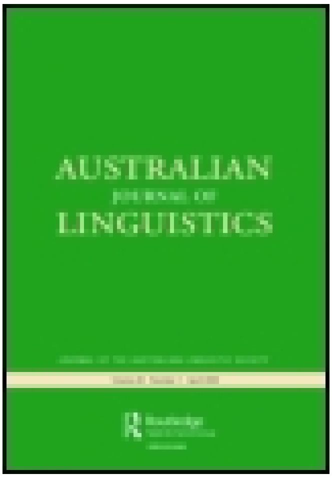

Australian Journal of Linguistics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/cajl20

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Published online: 17 Apr 2015.

To cite this article: Mark Harvey, Susan Lin, Myfany Turpin, Ben Davies & Katherine Demuth (2015): Contrastive and Non-contrastive Pre-stopping in Kaytetye, Australian Journal of Linguistics, DOI: 10.1080/07268602.2015.1023170

To link to this article: http://dx.doi.org/10.1080/07268602.2015.1023170

Australian Journal of Linguistics, 2015
http://dx.doi.org/10.1080/07268602.2015.1023170

Contrastive and Non-contrastive Pre-stopping in Kaytetye*

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(*Accepted 20 November 2014*)

Kaytetye is one of the few Australian languages for which pre-stopping is contrastive for nasals. This paper provides the first quantitative data on the phonetic realization of contrastive pre-stopping for any Australian language. It also provides data on the hitherto unreported non-contrastive pre-stopping of laterals in Kaytetye. The findings demonstrate that contrastive nasal pre-stopping and non-contrastive lateral pre-stopping differ on three parameters: (a) the conditioning on the distribution of plain vs. pre-stopped realizations; (b) the comparative overall durations of pre-stopped realizations compared to plain realizations; and (c) the duration of pre-stopping.

Keywords: Arandic; Kaytetye; Phonology; Nasals; Laterals; Pre-stopping

1. Introduction

Pre-stopping is a process where sonorants, most commonly nasals and laterals, are preceded by a period of complete homorganic closure. Cross-linguistically, it is not a commonly reported phenomenon. However, it is attested in a geographically and typologically diverse range of languages across the world (see Butcher and Loakes (2008) and Durvasula (2009) for surveys of pre-stopping). In nearly all cases, pre-stopping is non-contrastive, i.e. pre-stopped nasals are allophones/variants of plain nasals and pre-stopped laterals are allophones/variants of plain laterals. Non-

*We gratefully acknowledge Alison Nangala Ross for providing stimulus recordings, transcription and assistance in the field. We also thank the Kaytetye people who worked with us: Amy Ngamperle, Eileen Ampetyane, Janie Ampetyane, Lena Ngamperle, Carol Thompson, Harry Janima, Elsie Numina, Michael Hayes, Rachel Dinny, Rebecca Numina, Lucy Price, Michael Tyapeyarte and Bronwyn Young. This research was supported by the Australian Institute of Aboriginal and Torres Strait Islander Studies [G2011/7654].

contrastive pre-stopping of nasals and laterals is reported from a range of languages across Australia (see Butcher and Loakes (2008), Dixon (2002: 597) and Hercus (1972, 1994: 37–43) for indicative surveys).

Contrastive pre-stopping, however, is very rare, and there are no reports of contrastive *lateral* pre-stopping. The only well-established examples of contrastive *nasal* pre-stopping come from two areas of Australia: Central Australia—the Arandic language family, which includes Kaytetye (Breen 2001; Breen & Pensalfini 1999; Henderson 1998); and Cape York—Olkola and Oykangand (Dixon 1970; Hamilton 1998; Sommer 1969). There is one other report of potentially contrastive nasal pre-stopping in a Sepik language, Urim (Luoma 1985). However, there is some debate about the phonological analysis of [stop-nasal] sequences in Urim. Seiler (1988: 142) suggests that [stop-nasal] sequences in Urim 'could conceivably be analysed as having an underlying schwa'.

In analysing any phonetic/phonological phenomenon, it is important to have quantitative data so that the significance of factors potentially relevant to the phenomenon may be assessed. There are quantitative data on *non-contrastive* pre-stopping. Butcher and Loakes (2008) and Loakes *et al.* (2008) examine non-contrastive nasal pre-stopping in Gupapuyngu, and non-contrastive lateral pre-stopping in Warlpiri. They report considerable variation in the presence vs. absence of non-contrastive pre-stopping for both nasals and laterals (pre-stopping presence—Gupapuyngu nasals: /m/ 19%, /n/ 38%, /rn/ 26%, /nh/ 47%, /ny/ 12%, /ng/ 0%; Warlpiri laterals: /l/ 34%, /rl/ 17%, /ly/ 17%). They also report that non-contrastive pre-stopping typically has a duration of approximately 15–30 ms for both nasals and laterals (mean durations—Gupapuyngu nasals: /m/ 17 ms, /n/ 17 ms, /rn/ 21 ms, /nh/ 17 ms, /ny/ 20 ms; Warlpiri laterals: /l/ 29 ms, /rl/ 16 ms, /ly/ 21 ms).

However, as far as we are aware, there have been no quantitative studies of *contrastive* pre-stopping. There is some indication in the existing literature that the contrastive vs. non-contrastive parameter may be important in the quantitative phonetics of pre-stopping. Maddieson and Ladefoged (1993: 292) provide the following description of the phonetics of contrastive pre-stopping in Arrernte.

> Arrernte prestopped nasals almost always contain a voiceless stop closure portion. When this is released by lowering the velum, the resulting burst is voiceless and quite loud. The nasal portion that follows this is voiceless for approximately half its duration, with the second half voiced.

Maddieson and Ladefoged support this description with a spectrogram of the Arrernte form *pmware* 'coolamon' (Maddieson & Ladefoged 1993: 293), which involves an initial contrastive pre-stopped nasal. They then provide a very different description of non-contrastive pre-stopping in Eastern Arrernte—'the prestopped nasals are variants of plain nasals and are voiced throughout' (Ladefoged & Maddieson 1996: 129). They support this description with spectrograms of *arreme* 'louse' and *are-me* 'see-PRES' (Ladefoged & Maddieson 1996: 240). These forms involve phonologically plain nasals, and the observed pre-stopping is non-contrastive.

In the present paper, we provide quantitative data on *contrastive nasal* pre-stopping in Kaytetye, and in doing so provide the first quantitative data on contrastive nasal pre-stopping in any language. The currently available materials on Kaytetye do not mention the non-contrastive pre-stopping of laterals (Turpin 2000; Turpin & Ross 2011). Our recordings show that Kaytetye speakers often produce non-contrastive pre-stopping of *laterals*. We therefore also provide quantitative data on lateral pre-stopping in this paper.

Kaytetye is one of the few languages documented as having both contrastive and non-contrastive pre-stopping. Given the rarity of contrastive pre-stopping, Kaytetye therefore provides a valuable opportunity to compare the *contrastive* pre-stopping of nasals with the *non-contrastive* pre-stopping of laterals. We show that the phonetic patterns of non-contrastive lateral pre-stopping in Kaytetye accord with the patterns reported for non-contrastive pre-stopping of both laterals and nasals elsewhere in Australia.

We further show that the phonetic patterns of *contrastive nasal* pre-stopping differ from those of *non-contrastive lateral* pre-stopping on at least three parameters: (a) the degree of variation in the proportion of segments realized with pre-stopping; (b) the difference in total duration between plain and pre-stopped realizations; and (c) the duration of closure in pre-stopped realizations. When *non-contrastive*, the appearance of pre-stopping is highly variable with no evident phonological conditioning, there is no significant durational difference between plain and pre-stopped realizations, and pre-stopping is short (29 ms). When *contrastive* pre-stopping is consistently present, there is a significant durational difference between plain and pre-stopped realizations, and pre-stopping duration is long (63 ms). These issues are detailed below.

2. The Phonological Status of Pre-stopped Nasals in Kaytetye

Kaytetye is an Arandic language spoken 300 km north of Alice Springs with approximately 200 speakers. The Kaytetye consonantal phoneme inventory is shown in Table 1 (Harvey 2011; Turpin 2000).[1]

Table 1 Kaytetye consonantal inventory

		Coronal				
	Labial	Dental	Alveolar	Retroflex	Palatal	Dorsal
Stop	p	t̪	t	ʈ	c	k
Nasal	m	n̪	n	ɳ	ɲ	ŋ
Pre-stopped nasal	ᵖm	ᵗ̪n̪	ᵗn	ᵗɳ	ᶜɲ	ᵏŋ
Lateral		l̪	l	ɭ	ʎ	
Tap			ɾ			
Continuant	w			ɻ		ɰ

[1] Koch (1997) and Turpin (2000) recognize an additional consonant series, called 'prepalatals'. However, we analyse these as consonant clusters (Harvey 2011).

Table 2 Stop vs pre-stopped nasal vs nasal contrast

	Stop			Pre-stopped nasal			Nasal		
Labial	*apele*	apələ	‘kangaroo fat’	*apmelerre*	a^{p}mələrə	‘always’	*amele*	amələ	‘shallow hole’
Dental	*athe*	at̪ɐ	‘grass’	*atnhe*	a^{t}n̪ɐ	‘emu down’	*anhe*	an̪ɐ	‘that’
Alveolar	*ate-*	atə	‘step on’	*atne-*	a^{t}nə	‘stand’	*ane-*	anə	‘sit’
Retroflex	*arte-*	aʈə	‘chop’	*artne*	a^{ʈ}ɳɐ	‘scrub’	*arne*	aɳɐ	‘coolamon’
Palatal	*atye*	acɐ	‘1sg.ERG’	*atnyeme*	a^{c}ɲəmə	‘witchetty grub’	*anye*	aɲɐ	‘this’
Dorsal	*ake-*	akə	‘cry’	*akngenpe*	a^{k}ŋənpə	‘fresh’	*ange-*	aŋə	‘dig’

Table 2 lists (sub-)minimal triplets which illustrate the three-way root-level contrast between stops, pre-stopped nasals and plain nasals (Turpin & Ross 2011).[2]

As illustrated in Tables 1 and 2, [stop+nasal] sequences are analysed as unitary pre-stopped segments in Kaytetye, and in the other Arandic languages (Henderson 1998: 25). However, there has been no detailed discussion in the existing literature as to the advantages of this phonological analysis as against two other potential phonological analyses of [stop+nasal] sequences: (a) as unitary nasally released stops; and (b) as homorganic clusters.

We therefore compare the three possible analyses of [stop+nasal] sequences below to explicitly detail the advantages of the ‘pre-stopped nasal’ analysis.

Potential analyses of [stop+nasal] sequences:

(a) A homorganic stop + nasal cluster /t/ + /n/.
(b) A pre-stopped nasal /^{t}n/.
(c) A nasally released stop /t^{n}/.

General analyses of complex segments are one factor in the choice between these three analyses. There is considerable variation in the analysis of complex segments. However, analyses agree that if the phonetic realization is temporally ordered, then the components of the sequence must be homorganic (Kehrein 2002; Sagey 1990). If Kaytetye [stop+nasal] sequences included heterorganic sequences, such as [pn], then this would be a strong argument against a complex segment analysis. The [stop +nasal] sequences in Kaytetye are all homorganic. Consequently, the pre-stopped nasal and nasally released stop analyses, as set in (b) and (c) above, do accord with general analyses of complex segments.

Another central factor in the choice of analysis is the overall phonotactic patterning of consonants in the language. Excluding [stop+nasal] sequences from consideration for the moment, tautomorphemic biconsonantal clusters in Kaytetye may be divided into two classes: homorganic and heterorganic. The homorganic inventory is set out in Table 3 (Harvey 2011: 85). The inventory of heterorganic biconsonantal C_1+C_2 clusters is set out in Table 4 (Harvey 2011: 103). The inventory of triconsonantal $C_1+C_2+C_3$ clusters is set out in Table 5.

2 Verb roots require further substantive suffixation in Kaytetye. This is indicated in Table 2 with a final hyphen. Nominal roots may appear without substantive suffixation.

Table 3 Kaytetye homorganic tautomorphemic biconsonantal clusters

Labial	Dental	Alveolar	Retroflex	Palatal	Dorsal
mp	n̪t̪	nt	ɳʈ	ɲc	ŋk
	l̪t̪	lt	ɭʈ	ʎc	

The comparative distributions of plain nasals and plain stops may be summarized as follows:

(a) Plain nasals may appear as either C_1 or C_2 in biconsonantal clusters. In triconsonantal clusters, they appear only as C_2.
(b) Plain stops may only appear as the final members of consonant clusters, i.e. C_2 in biconsonantal clusters, and C_3 in triconsonantal clusters.

The [stop+nasal] sequences show the following distribution.

(a) The first two members of a triconsonantal sequence, e.g. the verb root aʈɳpə́ 'run'.
(b) The last two members of a triconsonantal sequence, e.g. the verb root ajtnə́ 'spear'.
(c) The medial two members of a quadriconsonantal sequence, e.g. the verb root ajtnpə́ 'winnow'.
(d) Not as the first two or the last two members of a quadriconsonantal sequence.

It may be noted that if [stop+nasal] sequences are analysed as pre-stopped nasals, then their phonotactic distribution matches that of plain nasals. They appear as C1 and C2 in biconsonantal clusters, and C2 in triconsonantal clusters. If analysed as nasally released stops, then their distribution does not match to that of plain stops, which occur only in C2 and C3 positions.

The phonotactic distribution of [stop+nasal] sequences cannot be accommodated by analyses which account for the other consonantal sequences in Kaytetye. Some

Table 4 Kaytetye heterorganic tautomorphemic biconsonantal clusters

	C1					
C2	n	ɳ	l	ɭ	ɾ	j
p	np	ɳp	lp	ɭp	ɾp	jp
m	nm	ɳm			ɾm	jm
k	nk	ɳk	lk	ɭk	ɾk	jk
ŋ	nŋ	ɳŋ			ɾŋ	jŋ
c	nc				ɾc	
ɲ					ɾɲ	
t̪					ɾt̪	jt̪
t						jt
n						jn
l						jl

Table 5 Kaytetye tautomorphemic triconsonantal clusters

	C1+C2			
C3	jl	jn	jm	jŋ
p	jlp	jnp	jmp	
k	jlk			jŋk
t	jlt	jnt		

additional analytical machinery is required. The question is where the 'cost' of this additional machinery is to be borne. The cost could be borne in the segmental analysis by proposing complex segments, with the benefit that no additional machinery is required in the phonotactic analysis. Alternatively, the cost could be borne in the phonotactics, with the benefit that no additional machinery is required in the segmental analysis.

The analysis of [stop+nasal] sequences as nasally released stops may be rejected as it does not offer advantages in either segmental or phonotactic analysis. Under this complex segment analysis, [stop+nasal] sequences should pattern phonotactically with plain stops. However, as discussed, they do not. Consequently, additional machinery is required for both segmental and phonotactic analyses.

The choice is therefore between the cluster and pre-stopped nasal analyses. In terms of theoretical machinery, the two analyses would appear to be equivalent. The cluster analysis has a more complex phonotactics, with the advantage that no additional segmental analysis is required. The pre-stopped nasal analysis has a more complex segmental inventory, with the advantage that no additional phonotactic analysis is required.

It is therefore necessary to consider these two analyses from the wider perspective of general Kaytetye phonological patterns. We take as a baseline an analysis of Kaytetye which does not include the [stop+nasal] sequences. We consider the generalizations that can be drawn about Kaytetye phonological patterns with this dataset (i.e. not including [stop+nasal] sequences). We consider the two potential analyses of [stop+nasal] sequences in terms of the following three criteria: (a) the ease with which generalizations about [stop+nasal] sequences can be integrated into the baseline analysis; (b) the extent to which generalizations about the segmental inventory and consonant cluster phonotactics in the baseline analysis have to be modified; and (c) the extent to which generalizations in other phonological domains of the baseline analysis have to be modified.

The fact that [stop+nasal] sequences and plain nasals show the same distribution in Kaytetye is an important generalization. Under the pre-stopped nasal analysis, the [stop+nasal] sequences are a class of nasal sonorants. Therefore, the common patterning of [stop+nasal] sequences and plain nasals may be captured by standard phonotactic analyses. By contrast, under a cluster analysis, this common patterning cannot be represented by standard phonotactic analyses.

If the segmental inventory is analysed as not including pre-stopped nasals, then there are three manner generalizations that can be made about that inventory: (a) [voice] is not a contrastive feature; (b) the inventory does not include any [+continuant, –sonorant] segments (affricates, fricatives); and (c) the [–continuant] categories show a six-way place opposition. The pre-stopped nasal analysis posits an additional manner category within the segmental inventory. This does not affect the existing manner generalizations.

By contrast, if [stop+nasal] sequences are analysed as clusters, then this does affect existing generalizations. It would not be possible to generalize about stops, as these would appear in any cluster position. Generalizations about nasals would be more complex. They would appear in biconsonantal clusters as C1 or C2, in triconsonantal clusters as C2 or C3, and in quadriconsonantal clusters as C3.

The choice of analysis for [stop+nasal] sequences evidently has implications for syllabification in Kaytetye. If we leave [stop+nasal] sequences aside, then the following generalizations may be drawn about syllabification in Kaytetye.

(a) Syllabification follows standard patterns. The Sonority Sequencing Generalization [SSG] holds syllable internally. The Syllable Contact Constraint [SCC], that a coda should be of equal or greater sonority than a following onset, holds across syllable boundaries (Murray & Venneman 1983).
(b) There are no complex onsets, and the only complex codas are /j/ + /nasal/ (e.g. *ajmpe* 'lap' [ajm][pe]).

If [stop+nasal] sequences are analysed as pre-stopped nasals, then all of these generalizations continue to hold, e.g. *ajtnpe-nke* 'winnow-PRES' [aj^{t}n][p-en][ke] (square brackets = syllable boundaries). If [stop+nasal] sequences are analysed as clusters, then a number of these generalizations no longer hold. The syllabification of forms such as *ajtnpe-nke* 'winnow-PRES' is somewhat uncertain under the cluster analysis. Presuming that the SSG is observed as far as possible, the initial syllabification would be [ajt]n[p-en][ke]. Given that extrasyllabic consonants are not permitted morpheme-medially under any analysis of syllabification, the nasal portion of the [stop+nasal] sequence must be syllabified. However it is syllabified there will be a violation of the SSG. Given the standard preference for onset maximization, the standard syllabification would be [ajt][np-en][ke]. This syllabification would involve an expansion of the class of complex codas to include /j/ + /stop/, and the positing of complex onsets. The SCC would also no longer hold consistently.

There is an alternative analysis of syllabification in Kaytetye as VC, following Breen and Pensalfini (1999). Under this analysis, there are no onsets, and consequently the SCC is not relevant. This analysis involves a more complex coda inventory, but this inventory still conforms to the SSG. If [stop+nasal] sequences are analysed as pre-stopped nasals, then the SSG still holds over the coda inventory, e.g. *aj^{t}npe-nke* 'winnow-PRES' [aj^{t}np][-enk][e]. If [stop+nasal] sequences are analysed as clusters, then the SSG no longer holds over the coda inventory: e.g. *ajtnpe-nke* 'winnow-PRES' [ajtnp][-enk][e].

Table 6 Pre-stopped nasal vs cluster analyses

Pre-stopped nasal	Cluster
Modification to the manner categories in segmental inventory, which does not affect existing manner generalizations	Modification to the cluster system with significant effects on existing generalizations about clusters
The common distributional patterning of [stop+nasal] sequences and plain nasals may be described by standard phonotactic analyses	The common distributional patterning of [stop+nasal] sequences and plain nasals cannot be described by standard phonotactic analyses
Does not affect generalizations about syllabification under either standard or VC analyses of syllabification	Affects generalizations about syllabification under both standard and VC analyses of syllabification

The differences between the two analyses are summarized in Table 6.

The pre-stopped analysis is favoured on all three criteria, and the cluster analysis is disfavoured on all three criteria. We therefore adopt a complex segment analysis of [stop+nasal] sequences as pre-stopped nasals.

3. Methodology

3.1. Subjects and Procedure

In this study, we examine data collected from seven female Kaytetye speakers,[3] aged 38–62. All were residents of Stirling and Neutral Junction, NT, and participated in a larger 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 below.

angke-ne=nge X

say-IMP=2sg X

'Say X!'

Participants were invited into a sound attenuated room and sat in front of the computer monitor. They heard the audio prompt as they looked at a pictorial drawing conveying the target word on the computer screen. They were then asked to repeat the utterance they had heard 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. Articulatory data were recorded using

[3] All Kaytetye speakers are bilingual in a variety of English and most also speak a neighbouring Aboriginal language, as Kaytetye is a minority language in the region. Some of the speakers in our study speak a significantly more mixed variety of Kaytetye with Anmatyerr and/or English (S05, S11, S13 in Table 7).

ultrasound imaging, for which the transducer was held under the participants' chins by the experimenters (the second and last authors) during the task. No stabilization headset or strap was used to fix the transducer to the participants' heads, thus mandibular movement was not restricted by constant upward pressure of the transducer against the participants' chins. Both articulatory and acoustic signals were recorded onto a Sony mini-DV DCR-TRV103 digital camcorder. In this paper, only the acoustic recordings from the relevant subset of the recorded data are considered.

3.2. Stimuli

Although Kaytetye contrasts six places of articulation (Table 1), we restrict our focus to the coronal places of articulation, as only these show the full range of manner contrasts: oral stops, plain nasals, pre-stopped nasals and laterals.

The target words, listed in Appendix A, contained the coronal stops /t, ʈ, t̪, c/, nasals /n, ɳ, n̪, ɲ/, pre-stopped nasals /ᵗn, ᵗɳ, ᵗn̪, ᶜɲ/ and laterals /l, ɭ, l̪, ʎ/, all in a /#V_V/ context. We include the oral stops in this discussion to provide comparative data on the duration of oral stop closure (i.e. the duration of simultaneous oral and nasal closure). The target coronal segments were preceded by word-initial /a/ and followed by a primary stressed /a/ or /ə/ vowel (e.g. aᵗnə́mə 'yamstick'). All items were randomized and presented to each participant for five or six repetitions. Table 7 lists, for each speaker, the number of total elicited items (including repetitions) by manner of articulation.

Audio files were later extracted digitally, at 48 kHz from the resulting DV tapes using Final Cut Pro X (version 10.0). We examined the waveforms and spectrograms in Praat (Boersma & Weenink 2012), marking the onset and offset of each target segment, as well as the onset and offset of any closure visible in the waveform and spectrogram, as shown in Figure 1. The beginning of the consonants of interest were marked at the zero crossing closest to the point of noticeable change within the shape, complexity or regularity of the waveform and/or spectrogram following the end of the initial vowel (end of F2) of the target word.

When these acoustic landmarks were ambiguous or not available in the waveform, evidence from the spectrogram was used. For plain nasals and laterals, this was accompanied by the appearance of anti-formants in the spectrogram, while in stops

Table 7 Number of elicited utterances for each speaker, by manner of articulation

Speaker	Age	Stop	Nasal	Pre-stopped Nasal	Lateral
S01	62	72	54	32	51
S02	64	57	42	39	54
S03	60	57	41	30	38
S05	38	65	43	31	46
S06	54	55	43	33	43
S11	45	87	54	46	56
S13	45	64	46	32	44
TOTAL		457	323	243	332

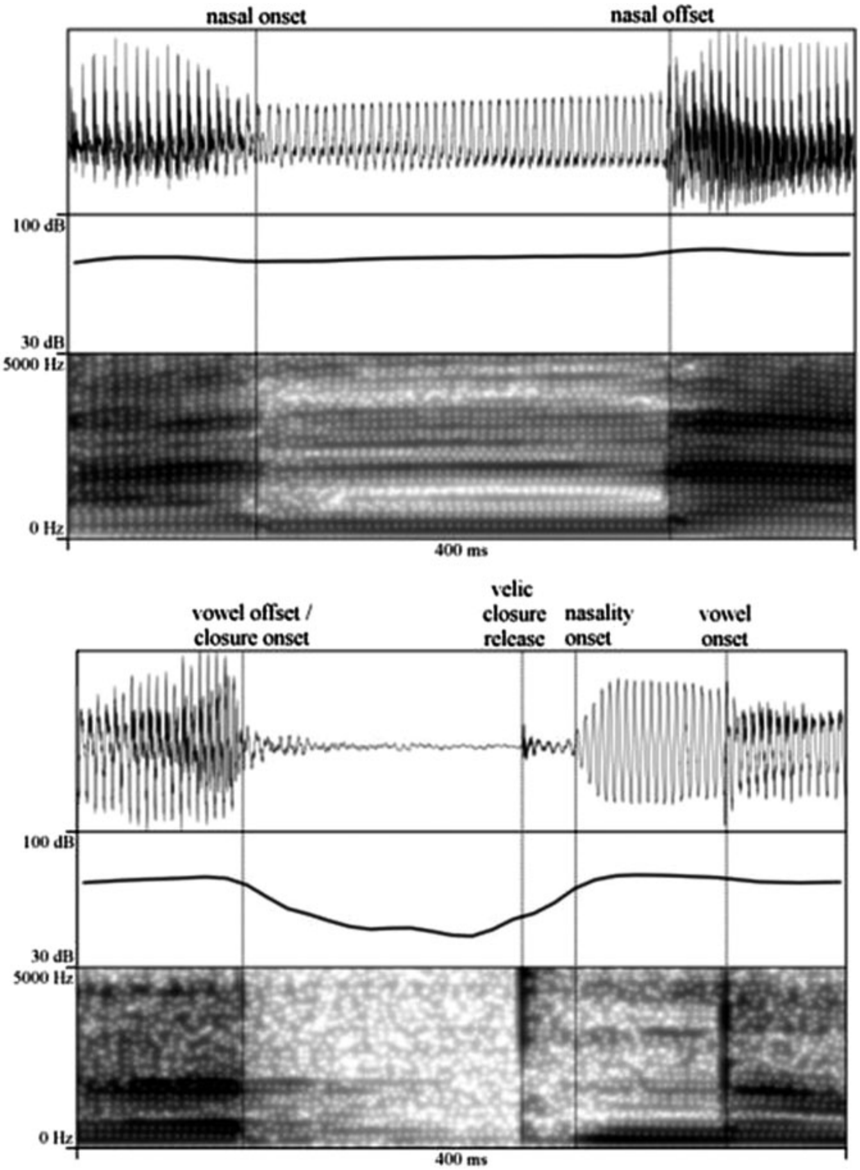

Figure 1 Waveform, audio intensity level, and spectrogram from a production of *aname* 'invalid' (top), showing marking of the onset and offset of the nasal /n/ (top), and from a production of *atneme* 'yamstick' (bottom), showing marking of the closure, burst and sonorant portions of the pre-stopped nasals /^{t}n/

and pre-stopped consonants this was accompanied by the loss of formant structure. The end of closure in stops and pre-stopped consonants was marked immediately before the first burst of energy following closure, on the waveform or spectrogram. Segment and closure durations were then automatically extracted for analysis.

4. Results

Unless otherwise stated, all comparisons below were performed using a linear mixed model, with Manner (in Section 4.1: oral stop, nasal stop, pre-stopped nasal) or Pre-stopping (in Section 4.2: yes, no) and Place (alveolar, dental, retroflex, palatal) as fixed factors, and Speaker, Item and Repetition as random factors. Linear mixed effect modelling was accomplished using the lme4 package for R (Bates *et al.* 2012), and *p*-value estimation provided by the lmerTest package set of convenience functions (Kuznetsova *et al.* 2014).

There is a considerable difference in older and younger people's speech such that the terms 'old' and 'new' Kaytetye are used within the community. The new variety is characterized by a number of lexical differences and phonological processes, such as elision of initial vowels and vowel epenthesis to break consonant clusters. Despite this, statistical analysis of our dataset found no significant correlation between the distribution of pre-stopping and age. A correlation with the degree of fluency in Kaytetye was found. Consequently, three additional speakers are excluded from the current analysis (S04, S07 and S09).

4.1. Plain Nasals and Pre-stopped Nasals

The phonological contrast between pre-stopped and plain nasals demonstrated an extremely high correspondence with the respective presence or absence of initial oral stop closure. Of 323 tokens of plain nasal phonemes, 315 (97.5%) were realized without initial closure, and only eight (2.5%) were realized with initial closure. Of 243 tokens of pre-stopped nasal phonemes, 236 (97.1%) were realized with initial closure, and only seven (2.9%) were realized without. This essentially binary distribution indicates 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.

The minimal departures from complete correspondence which do exist suggest a modest preference for pre-stopping in apical nasals. All phonologically plain nasal tokens which did show phonetic pre-stopping were apical. Among phonologically pre-stopped nasal tokens, only the alveolar category showed 100% realization with phonetic pre-stopping.

It is typical for the members of consonantal sequences to be shorter in sequences than they would be when appearing as singletons. However, the precise patterns of shortening vary considerably. Byrd (1996) found that articulatory reduction is correlated with three main factors. These are: (a) the type of sequence (stop-stop sequence, stop-fricative sequence); (b) the position in the syllable (onset, coda); and (c) the extent of linguo-palatal contact. Riehl (2008) showed that that acoustic shortening in nasal+obstruent sequences was confined essentially to the obstruent component (2008: 281–288). She also found that sequences analysed phonologically as complex singleton segments were significantly shorter than the equivalent sequences analysed as clusters (2008: 265). Similarly, Tzakosta and Vis (2009) report

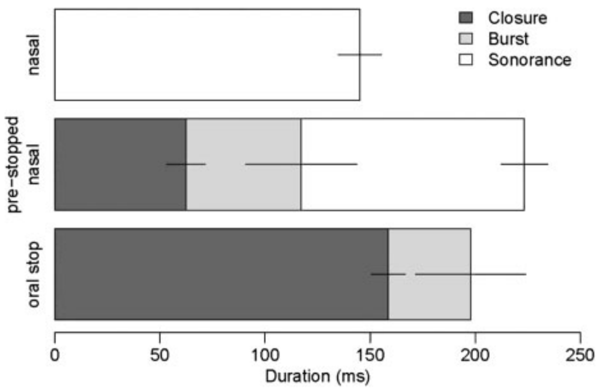

Figure 2 Estimated mean durations of closure in oral stops and pre-stopped nasals (dark grey), burst in oral stops and pre-stopped nasals (light grey), and nasal sonorance in plain and pre-stopped nasals (white). Error bars represent standard error as generated by the linear mixed effects models described in the text

for Greek that /s/ is significantly shorter in the homorganic sequence [ts], analysed as an affricate, than in the heterorganic sequences [ps] and [ks]. There are evidently many factors which affect component duration in consonantal sequences, and the precise roles of these various factors remain to be established.

In our own data, both the stop and nasal components of pre-nasalized stops are significantly shorter than would be expected of a full singleton stop or nasal consonant. Pre-stopped realizations of nasals were on average 66 ms longer than their plain counterparts (β=66.21, t=4.971, p<0.0001). A large portion of this difference is due to the oral stop closure and burst components of pre-stopped nasals, which comprised 119 ms of the entire segment, on average. In comparison, as shown in Figure 2, the sonorant portion of pre-stopped nasals was 39 ms shorter than that of plain nasals, having estimated mean durations of 106 ms and 145 ms, respectively (β=−38.79, t=−3.546, p=0.0004). Similarly, as shown in Figure 2, the pre-stopped portion of pre-stopped nasals was significantly shorter than the duration of a full oral stop (β=−78.64, t=−6.404, p<0.0001). Place of articulation was a significant factor only when comparing duration of pre-stopping; the pre-stopped portion of retroflex pre-stopped nasals was significantly shorter than that of alveolar, dental or palatal pre-stopped nasals. However, no interactions between Manner and Place were found —in other words, this effect of Place was similar across all Manners of articulation.

4.2. 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, pre-stopped and plain lateral realizations of lateral phonemes are of roughly equal frequency. Of 332 tokens of laterals, 154 (46.4%) demonstrated measurable oral stop closure duration, while the remaining 178 (54.6%) did not. As such, it is not possible to analyse plain

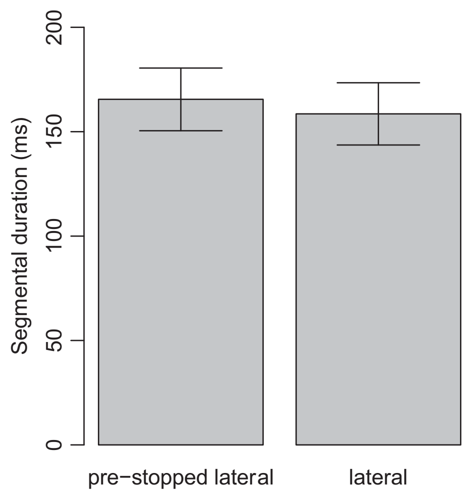

Figure 3 Total duration of pre-stopped and plain laterals, across all speakers. Error bars represent one standard error above and below estimated means

lateral realizations as the unmarked or canonical realizations of lateral phonemes, or to treat pre-stopped lateral realizations as marked or non-canonical realizations.

We note, however, that our data were limited prosodically to a /#V_V́_/ environment. Further data from other prosodic positions might provide evidence for an overall canonical realization of 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, suggesting that plain laterals could be analysed as the canonical realizations of lateral phonemes in Warlpiri.

Second, pre-stopped laterals were not significantly longer than plain laterals (β=7.21, t=1.588, p=0.1133), as is shown in Figure 3, and this non-significance persists through all places of articulation. There were no significant effects of Place or interactions between Place or Manner.

Third, as shown in Figure 4, the relative frequency of pre-stopped lateral realizations was highly variable between speakers.

The variation in our data is consistent with other types of variability reported for non-contrastive pre-stopping of both laterals and nasals in other Australian languages. As discussed in Section 1, Butcher and Loakes (2008) and Loakes *et al.* (2008) report significant variability in the appearance of non-contrastive pre-stopping depending on place of articulation. They also report variation depending on preceding vowel, and prosodic position. We did not examine these two factors. The variability in our data appears to be random, or potentially speaker-specific.[4]

[4] Note that speakers S05, S11, S13 all converse predominantly in Anmatyerr.

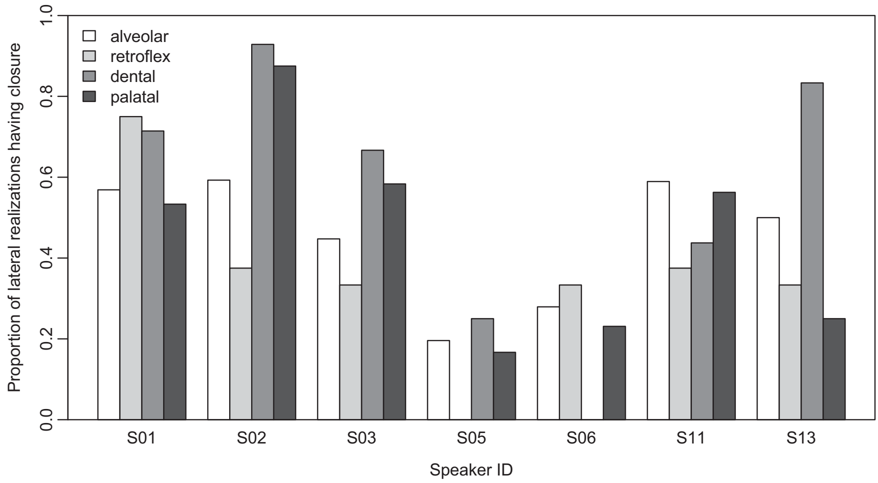

Figure 4 Proportion of lateral realizations having initial oral stop closure, by place and speaker

However, a more extensive dataset on Kaytetye would be needed to test for these other potentially interacting factors.

4.3. *Characteristics of Initial Oral Stop Closure in Pre-stopped Realizations*

Another aspect that varied between nasals and laterals was the duration of oral stop closure. Our data revealed closure in pre-stopped laterals to be significantly shorter than closure in pre-stopped nasals (β=−35.23, t=−3.387, p=0.0007), with estimated means of 28 ms and 63 ms, respectively. This is demonstrated visually in Figure 5. Here again, there were no significant interactions between Place and Manner,

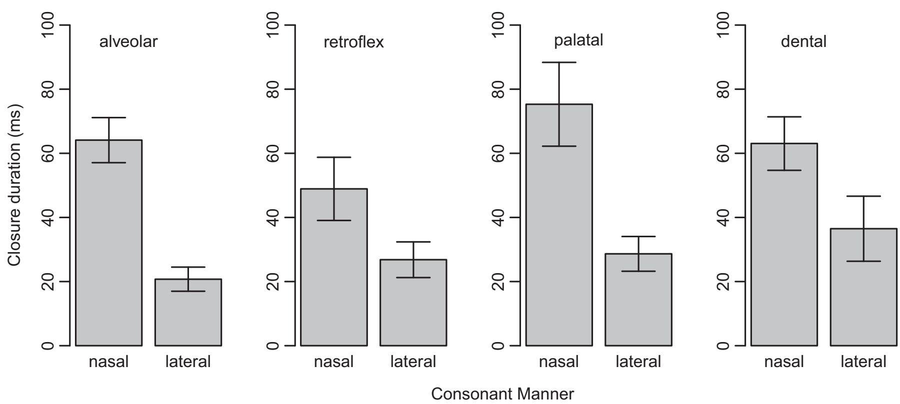

Figure 5 Duration of initial closure in realizations of pre-stopped nasals and laterals, separated by place of articulation, across all speakers

suggesting that this distinction is robust and holds throughout different places of articulation.

Our data on closure duration in pre-stopped nasal realizations contrast with that of Butcher and 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 20 ms (alveolar 17 ms; retroflex 21 ms; dental 17 ms; and palatal 20 ms). This is substantially shorter than the 63 ms of nasal pre-stopping produced by our Kaytetye speakers. Butcher and Loakes also report mean closure durations for non-contrastive lateral pre-stopping in Warlpiri: 21 ms, 16 ms and 30 ms for alveolar, retroflex and palatal laterals, respectively.

However, these values are quite similar to our findings for initial closure duration in pre-stopped *lateral* realizations in Kaytetye. We suggest that it is not 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. By contrast, Kaytetye pre-stopped nasals are phonemically distinct from plain nasals.

The pre-stopped *lateral* realizations in our data are therefore consistent with Butcher and Loakes's (2008) observation that non-contrastive pre-stopping is characterized by a 'brief tap-like closure and release'. Indeed, closure in some of the Kaytetye productions was short enough to make determining its presence not trivial. Figure 6 shows waveforms and spectrograms from three lateral productions. The lateral shown in Figure 6 (middle) has a clear period of initial closure indicated by a sharp decrease and increase in amplitude of the waveform followed by a release burst, whereas Figure 6 (top) shows neither initial closure nor a release spike. In contrast, the lateral in Figure 6 (bottom) shows clear evidence of a short and abrupt change in the waveform. Here, we took the break in the formant structure to indicate a very brief closure.

5. Determining the Extent of Non-contrastive Pre-stopping Cross-linguistically

Butcher and Loakes (2008) note that non-contrastive pre-stopped realizations are difficult to perceive auditorily, even by field researchers experienced in working with the languages in question. Our research anecdotally supports this observation. Members of our research team found non-contrastive lateral pre-stopping in Kaytetye difficult to perceive, but perceiving contrastive nasal pre-stopping was unproblematic.

Given these perceptual issues, it is plausible that there may be reports of the absence of non-contrastive pre-stopping in a particular phonological context, when it is in fact present but not perceived. In this paper, we demonstrated that at least one Arandic language, Kaytetye, shows non-contrastive lateral pre-stopping, contrary to statements in the literature (Hercus 1972: 293). By contrast, there seems little reason to doubt statements reporting the *presence* of non-contrastive pre-stopping. It is unlikely that researchers would perceive non-contrastive pre-stopping, if it were in fact absent.

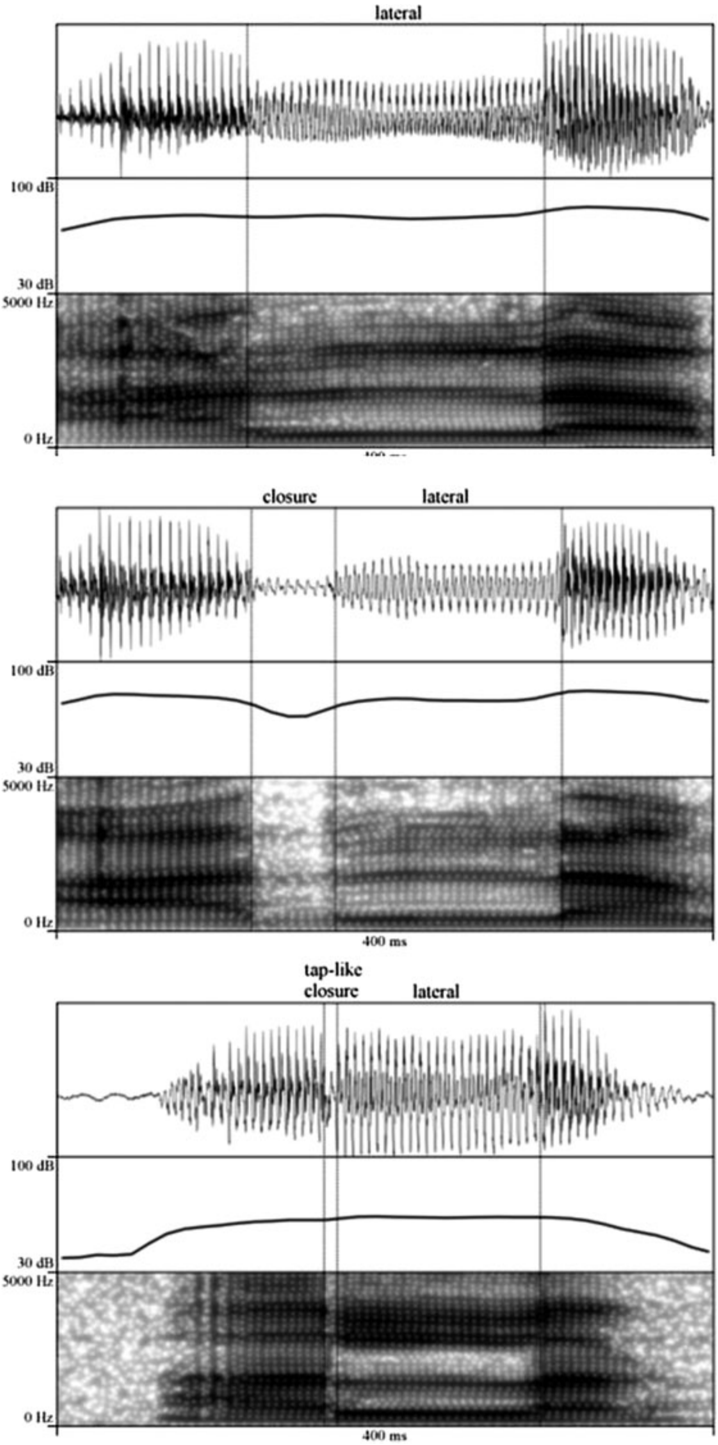

Figure 6 Lateral spectrograms showing clear lack of stopping (top), pre-lateral closure (middle) and very short pre-lateral closure (bottom)

However, much of the literature providing data on non-contrastive pre-stopping, including field grammars, contains only very limited discussion of most non-contrastive phonetic phenomena in general. As such, the absence of a statement about pre-stopping in a particular environment should not be interpreted as evidence that pre-stopping does not occur in that environment. For example, Austin (1981: 18–19) reports that Diyari shows pre-stopping of alveolar and dental nasals and laterals, but does not otherwise comment on pre-stopping. It would therefore be premature to conclude that pre-stopping is absent for other nasal and lateral phonemes. Similarly, Dench (1995: 27) reports that Martuthunira shows pre-stopping of coda laterals, but does not otherwise comment on pre-stopping. Again, this should not be taken as evidence that pre-stopping is absent for laterals in other positions, nor that pre-stopping is absent for nasals.

6. Conclusion

While contrastive pre-stopping of nasals in Kaytetye has been previously reported, 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 in Kaytetye is phonemically contrastive, with phonetic and phonological pre-stopping showing near total correspondence: 97.1% of phonologically pre-stopped nasal tokens show phonetic pre-stopping; and 97.9% of phonologically plain nasal tokens lack phonetic pre-stopping. In addition, pre-stopped nasal realizations (whether phonemically pre-stopped or not) are significantly longer than plain nasal realizations.

By contrast, lateral pre-stopping is phonemically non-contrastive. The relative frequency of plain and pre-stopped lateral realizations does not appear to be related to either place of articulation or speaker-specific factors. There is no significant difference in duration between pre-stopped lateral realizations and plain lateral realizations. Further, closure in pre-stopped nasal realizations is significantly longer than closure in pre-stopped lateral realizations (63 ms and 29 ms, respectively), likely making the pre-stopping in nasals easier to perceive.

These findings provide much needed acoustic evidence for the contemporary study of Australian languages. Further research is required into their implications for the general synchronic and diachronic analysis of pre-stopping.

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Appendix A: Stimulus Words

		Orthographic	Broad IPA	Gloss
Oral Stop				
dental	t̪	athenganenye	ɐ.ˈt̪ə.ŋa.ni.ɲə	'lay-NEG'
		athenge	ɐ.ˈt̪ə.ŋə	'grass-LOC'
		athepe	ɐ.ˈt̪ə.pə	'grass-FOC'
alveolar	t	atake	ɐ.ˈta.kə	'they'
		ateke	ɐ.ˈtə.kə	'fontanelle'
		atenganenye	ɐ.ˈtə.ŋa.ni.ɲə	'step on-NEG'
retroflex	ʈ	artenganenye	ɐ.ˈʈe.ŋa.ni.ɲə	'cut-NEG'
		artepe	ɐ.ˈʈe.pə	'back'
palatal	c	atyemeye	ɐ.ˈce.mi:	'mother's father'
		atyepe	ɐ.ˈcə.pə	'1sgERG-FOC'
Pre-stopped Nasal				
dental	ᵗ̪n̪	atnhepe	ɐ.ˈᵗ̪n̪ə.pə	'emu down-FOC'
alveolar	ᵗn	atneme	ɐ.ˈᵗnə.mə	'yamstick'
		atnenganenye	ɐ.ˈᵗnə.ŋa.ni.ɲə	'stand on-NEG'
retroflex	ᵗɳ	artnenge	ɐ.ˈᵗɳə.ŋə	'scrub-LOC'
palatal	ᶜɲ	atnyeme	ɐ.ˈᶜɲə.mə	'acacia sp.'
Nasal				
dental	n̪	anhamernarte	ɐ.ˈn̪a.mə.ɳa.ʈə	'that-PL-DEF'
		anhaperte	ɐ.ˈn̪a.pə.ʈə	'that-only'
alveolar	n	aname	ɐ.ˈna.mə	'invalid'
		anenganenye	ɐ.ˈnə.ŋa.ni.ɲə	'sit-NEG'
retroflex	ɳ	arnenge	ɐ.ˈɳə.ŋə	'coolamon-LOC'
palatal	ɲ	anyamernarte	ɐ.ˈɲa.mə.ɳa.ʈə	'this-PL-DEF'
		anyaperte	ɐ.ˈɲa.pə.ʈə	'this-only'
Lateral				
dental	l̪	alhekere	ɐ.ˈl̪ə.kə.ɹə	'dislike'
alveolar	l	aleke	ɐ.ˈlə.kə	'dog'
		aleme	ɐ.ˈlə.mə	'stomach'
retroflex	ɭ	arlemenye	ɐ.ˈɭə.mi.ɲə	'curled up'
		arlepe	ɐ.ˈɭə.pə	'elegant acacia'
palatal	ʎ	Alyeke	ɐ.ˈʎə.kə	a place name
		alyepe	ɐ.ˈʎə.pə	'softly, gently'