WHAT SPEAKERS OF AUSTRALIAN ABORIGINAL LANGUAGES DO WITH THEIR VELUMS AND WHY:
THE PHONETICS OF THE NASAL/ORAL CONTRAST

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ABSTRACT
Pre-stopped nasals, either as phonemes, or as major allophones of nas al consonants, are a well-documented feature of certain Australian languages - mostly concentrated in the southern and central areas of the continent. A study of nasality in connected speech in a wide variety of Australian languages, with and without phonologised pre-stopping, shows the same tendency is even more widespread at a phonetic level. This kind of perseverative velar closure, apparently well established in Australia, is rare in the world context. This paper considers the putative phonetic origins of this phenomenon in terms of unusual parameter settings for velopharyngeal control: a higher degree of stiffness for the opening gesture and a closer resting position. A possible perceptual explanation for these settings may be found in the need to preserve clear spectral cues to the place of articulation of postvocalic consonants in languages with up to seven places of articulation for nasals.

1. PRE-STOPPING OF NASALS
Pre-stopped nasals have been found to occur in a number of Australian languages. The geographical distribution of these languages leads to the conclusion that this is an areal phenomenon. With a few exceptions, such as Kunjen in the Cape York Peninsula and Lidjgal and Yugaral around the Queensland/New South Wales border, they are concentrated in central and southern Australia, amongst the Arandic languages and the ‘Lake Eyre languages’, extending south into the Yura group. In the case of most of the Arandic dialects, these sequences can be analysed as unitary phonemes, and are clearly in contrast with both oral stops and plain nasals, with which they are in parallel distribution preceding stressed vowels:

(1) Eastern/Central Arremte [1]:
/np/ 'gum tree' /na/ 'nest' /nma/ 'camp'
/np/ 'cut' /nap/ 'crow' /np/ 'carried'
/nt/ 'hurrying' /nam/ 'staying' /nam/ 'yamstick'
/nt/ 'built' /nt/ 'for a stick' /nt/ 'cried'
/nt/ 'ground up' /nt/ 'watered' /nt/ 'hit (o)'
/nt/ 'mo's fa' /nt/ 'father' /nt/ 'fell'

In the southern languages, the pre-stopped nasals are either in complementary distribution or in free variation with the plain nasals. In this case the pre-stopped allophones occur after the first (stressed) vowel; the plain nasals occur elsewhere.

(2) Nukunu [2]:
/pa/ [pe] 'he, she, it' /pu/ [po] 'two'
/ka/ [ke] 'rock' /ka/ [ka] 'arrogant'

Pre-stopping in these languages is often optional, however. Cognates in related languages outside the pre-stopping area - and often in place names and archaic song language within it - typically retain the plain long nasal.

There is thus very strong evidence that these sounds arise from an original lengthened or geminated nasal [3], through a process of rightward ‘oral spreading’, whereby the velar closure of the preceding vowel is carried into the articulatory closure of the original postvocalic nasal consonant. The conditions governing both the diachronic development of pre-stopped nasal phonemes, and the synchronic occurrence of pre-stopped allophones are strikingly similar across all of these languages. The first of these conditions is that the nasal segment must be phonetically long. This, in turn normally means it should be adjacent to a stressed short vowel. In Alyawarr, for instance, they are restricted to the first consonantal position of a word - i.e. the onset of the syllable bearing the primary stress. Thus a reduplicated form such as /apamam/ - [pehwehweh] ('mushy'), from /apam/ -
pre-stopping only in the first element [4]. In the Southern languages there are also cases of variable pre-stopping of nasals even in stressed syllables in long (i.e. four-syllable plus) words - e.g. Arabana-Wangkanguru: /kini tiok/ - [giɲuŋ tok] or [giɲiŋ tok] ('scorpion') [5]. This too might well be due to the reduction in length of segments in this context. Similarly, pre-stopping has not normally occurred in nasals following a long vowel, presumably since these too would be phonetically of insufficient length - e.g. Nukunu: /qiua/ - [gi³u³u³] ('foot'), but /wiŋa/ - [wiŋa] ('white chalk') [2]. The second condition applying to pre-stopping (both synchronic and diachronic) in all of these languages is that the process is blocked by the presence of a preceding nasal in the same word:

(3) Adnyamathanha:

/beda/ [ve³da] 'scent' /ŋaŋa/ [ŋaŋa] 'who'
/aŋaŋa/ [vŋa] 'rock' /ŋaŋa/ [ŋaŋa] 'bindweed'

The (phonetic) pre-stopping of (phonologically) plain nasals has also been noted in Eastern Arunta [7], where, as we have seen, the plain nasals are already in contrast with a full set of (phonologically) pre-stopped nasals. In fact the pre-stopping of nasal consonants is a widespread phenomenon at the synchronic phonetic level in many Australian languages, and is certainly not restricted to central Australia. Figure 1 shows an example of phonetic pre-stopping in Gupapuygu, a language not closely related to any of the languages so far discussed, spoken in north-eastern Arnhem Land, some 1,000 km further north than Arrernte. The word is /cipaka/ ('inside', 'underneath'), here pronounced [tʃ³ɲɛk⁴u⁴]. As already surmised, the phenomenon appears to arise through an asynchrony in the formation of the articulatory closure and the lowering of the velum. The latter appears to be delayed relative to the former - the velo-pharyngeal port is not sufficiently open for the production of a nasal consonant until after the formation of the articulatory closure - and an epenthetic (but often inaudible) oral stop closure results. The oral 'pre-stop' in the Gupapuygu example illustrated above is barely audible to the untrained ear. Once again the process appears to be particularly associated with phonetically long nasals, and nasal lengthening in turn appears to be associated with stressed syllables. And once again the process is inhibited by the presence of a preceding nasal in the word.

2. DENASALISATION AS A CONNECTED SPEECH PHENOMENON

The velum is generally regarded as a relatively sluggish mover, compared with some other articulators. Thus in connected speech in many languages of the world nasality may not be confined to a single segment in the way that it is assumed to be in the citation form, as the velum is lowered before the articulation of that segment begins, or fails to close in time to coincide with its completion. A common manifestation of this timing shift between oral and velar articulation is often referred to 'left-to-right' or 'perseverative assimilation of nasality'. In connected speech there is often no differentiation in nasality within a consonant cluster, where in the corresponding citation form a nasal is differentiated from a following homorganic oral stop. This appears to be just as common in Australian indigenous languages as it is in Australian and American English:

(4) Burarra:

/ŋuŋuŋmaŋka/ 'we get it' [ŋuŋumɛŋŋe]→ [ŋuŋumɛŋŋa]

Pitjantjatjara:

/ŋampaŋma/ 'our food' [ŋammbömön] → [ŋammbömön] → [ŋammbömön]

Thus as regards perseverative assimilation of nasality, Australian languages appear to behave much as languages from elsewhere in the world. The more common form of nasal assimilation found in the world's languages, however, is a right-to-left or anticipatory assimilation [8], whereby the velum lowers during a preceding oral segment (usually a vowel) in preparation for an upcoming nasal consonant. This is generally regarded as a universal process, but it seems that Australian languages have a particular aversion to anticipatory coarticulation of nasality. Both auditorily and through the visual inspection of spectrograms it is quite apparent that in vowel + nasal sequences speakers avoid lowering the velum until the latest possible instant. As we have seen in the word-internal case, the lowering of the velum is often 'left too late', with the result that orality perseverates into the nasal consonant. The ultimate extension of this phonetic oral spreading, is reached in rapid casual speech when the avoidance of premature velum lowering can lead to no lowering at all. In other words, there is clearly a synchronic connected speech process of perseverative denasalisation operating in some Australian languages:

(6) Warlpiri

/ŋanaŋaŋaŋ /I am just going' [ŋananaŋn̥]→ [ŋananaŋn̥]

Kunbaralang

/ki³tanjiŋn̥uŋi/ 'they would name' [ŋtanjiŋn̥uŋi]→[ŋtanjiŋn̥uŋi]

3. THEORETICAL IMPLICATIONS

I have elsewhere described the phonologies of Australian languages as having 'long thin' systems of contrasts, in terms of the traditional way of setting out these systems on the printed page [9] - i.e. they are relatively restricted in terms of manner-of-articulation distinctions (traditionally displayed in the vertical dimension) and rich in place-of-articulation distinctions (traditionally represented horizontally). This means that oppositions within Australian phonological systems are heavily reliant on systematic differences in formant transition patterns at vowel-consonant boundaries. Furthermore, the relative lack of manner distinctions is entirely within the domain of the obstruents: the majority of Australian languages have a single series of these, with no [voice] - [voiceless] contrast and no [stop] - [fricative] contrast. On the other hand, these languages have as rich a system of sonorant contrasts as any language in the world - and richer than most. This means that these systems have precisely the opposite proportion of obstructions to sonorants to that proposed as the normal tendency amongst the languages of the world [10]. A typical Australian inventory may thus consist of 70% sonorants
and only 30% obstruents. This in turn implies that spectral changes at vowel-sonorant boundaries must be crucial to the perception of an unusually large proportion of segmental contrasts in Australian languages. Among these contrasts would be a minimum of four nasals - /m/ /n/ /ŋ/ /ŋ/ (already a large number in world terms) and a maximum of at least six - /m/ /n/ /ŋ/ /ŋ/ /ŋ/ /ŋ/ /ŋ/. It is well accepted that perceptual information on the place of articulation of postvocalic nasals is conveyed by some formant transitions out of the vowel and by the nasal murmur itself [11]. Thus it would seem essential for a language with half a dozen place of articulation contrasts among the nasals to maintain clearly distinctive vowel transitions in the preceding vowels. However, in most languages vowels preceding nasal consonants are nasalised to varying degrees and therefore contain extra nasal formants and anti-resonances, the general effect of which is to flatten the spectrum and lower the overall amplitude, rendering place of articulation cues much less distinct [12].

Figure 2. Oral and nasal airflow (volume velocity) during the production of the words banner by a speaker of British English (top) and gana (‘with the eyes open’) by a speaker of Burarra (bottom).

It seems likely that the maintenance of clear spectral cues to place of articulation in the pre-nasal vowel would be facilitated by ensuring that the lowering of the velum for the nasal consonant is delayed as long as possible - optimally coinciding exactly with the formation of the articulatory closure. In phonological terms, this would require that, whereas the vowels of English are unspecified for nasality, the vowels of Australian languages must be specified as [-nasal] (or [+oral]). Thus, during the course of a vowel preceding a nasal consonant in English the velum commonly begins to be lowered at the outset, with a consequent steady increase in nasal airflow throughout (Figure 2a). The vowels of Australian languages, on the other hand, maintain a raised velum until the beginning of the articulatory closure, at which point it is lowered as rapidly as possible (Figure 2b). The only exception to this rule, is where there is a nasal consonant on both sides of the vowel, in which case complete closure of the velum is not attained before the beginning of the second nasal consonant, as evidenced by a small but steady flow of air from the nose throughout the vowel.

Figure 3. Schematic parametric representations of relative timing of velopharyngeal and articulatory gestures hypothesised for various CVNV- sequences in English and in Australian languages.

It seems clear from this that in Australian languages the basic velum lowering gesture must be a relatively rapid one or, in terms of task dynamics, one with a high degree of stiffness. The raising gesture, on the other hand, is usually gradual, as in other languages. Thus the main difference between a series of velar opening and closing movements in English and Australian languages can be schematised as in Figure 3. In English the movement is represented by a quasi-sinusoidal waveform, representing more or less equal stiffness in the opening and closing gestures, whereas in Australian the wave has more of a sawtooth shape. It may also be the case that the resting position for Australian languages is higher - i.e. nearer to the closed position - than in English. The effect of these differences on the production of a canonical 'CVNV-sequence is represented in Figure 3a and b.
One of the main manifestations of stress in most languages is the lengthening of the vowel of the stressed syllable. In Australian languages, on the other hand, stress is commonly manifested through a lengthening of the coda consonant of the stressed syllable - perhaps because the timing of these languages may be mora-based - usually with a corresponding shortening of the stressed vowel [13]. Unfortunately I have as yet no aerodynamic data on long vowels, but the acoustic data suggest that the prediction may indeed be correct. Figure 4 compares spectrograms of a subminimal pair of words in Warlpiri. The nasals following the short vowels are noticeably longer than those following the long vowels, the difference being particularly striking in the case of the stressed syllables. Furthermore, it seems likely that the substantial weakening of first formant amplitude in the final half to one third of the long vowel is due to nasalisation, an effect which is absent from the spectrum of the corresponding short vowel.

REFERENCES