

Prosodic context effects on acoustic differentiation of coronal stops in Wubuy

Introduction

Articulatory phonology (AP: Browman & Goldstein, 1986; 1989; 1990) proposes that speech is composed of hierarchically organised and precisely coordinated articulatory gestures. The execution of these gestures is coordinated such that a CV coupling is tighter, i.e., more in-phase than a VC coupling, which is executed in anti-phase (Nam, Goldstein & Saltzman, 2009).

Within an AP framework, prosodic boundary strength is also posited to systematically affect the degree of gestural coordination (see Figure 1). In particular, it has been claimed that CV coupling is *strengthened* by prosodic boundaries, and as a consequence it is predicted to be tighter for word-initial but phrase medial CVs (V#CV) than word-medial VCVs, and tightest for both word and utterance-initial CVs (##CV) (Byrd & Choi, 2009; Goldstein, Byrd & Saltzman, 2006).

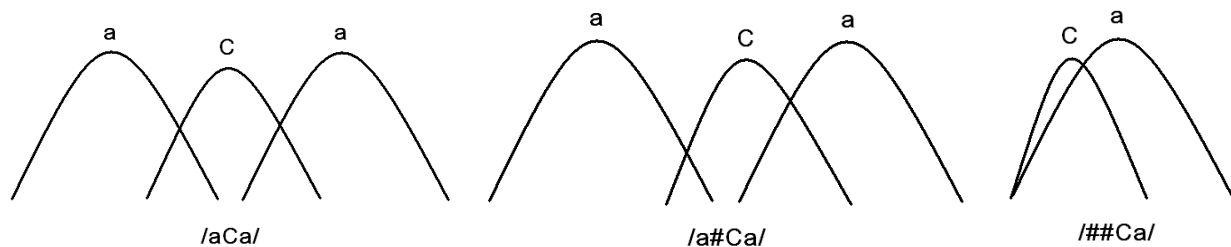


Figure 1: Schematic model of differences in gestural overlap in three different prosodic contexts: word-medial (/aCa/), word-initial but phrase medial (/a#Ca/), and word- and phrase initial (##Ca/).

Conversely, the AP framework predicts that VC coupling is *weakened* by prosodic boundaries, thus is lesser in V#CV than VCV contexts. In this context, tighter coupling represents greater gestural overlap (in other words, the gestures are executed more in-phase), hence the acoustic effects of coordination might be thought to be greater, the tighter the coupling. However, coordination effects are also strongly moderated by the identity of the consonants and vowels involved.

Coronals have been found to display the highest resistance to coarticulation (Recasens, 1985) and, conversely, to exert the greatest effects on neighbouring vowels, among which /a/ is least resistant to coarticulation (Fowler & Saltzman, 1993). Therefore, in coronal-rich languages, where pressure to maintain coronal contrasts is high, coronal consonants should leave the clearest traces of perseverative (passive) coarticulation in the acoustics of a following /a/ in ##CV context, with the weakest traces in VCV, and intermediate effects in V#CV. However, given that anticipatory effects are greater than carryover effects, the most significant coarticulation effects should be found in *preceding* vowels, due to active anticipatory coarticulation of the C, with VCV showing greater acoustic effects than V#CV (Fowler & Saltzman, 1993).

It is typically claimed that the only robust cues for retroflexes exist in the VC transition, and not in the CV transition. Further, it has been suggested that this is the reason for the cross-linguistically common pattern of apical neutralisation in word-initial contexts (see, for instance, Steriade, 2001). Retroflex stops, such as /ɭ/, thus offer a unique testing ground for the predictions of AP that prosody affects gestural coordination and thereby coarticulatory effects leading to the preservation of contrasts. This contrasts with other frameworks, such as psycho-acoustic perspectives, which do not integrate prosody in predictions for contrast maintenance. In particular, AP predicts that CV coupling may serve to differentiate retroflexes from alveolars and dentals, just when coupling is increased by prosodic strengthening.

Method

We tested the predictions of AP using Wubuy. Wubuy (also known as Nunggubuyu, see e.g., Heath, 1984) is an endangered Australian Aboriginal language, spoken in Eastern Arnhem Land. It has a four-way coronal stop contrast /t, t̪, t̺, c/ that is reportedly contrastive word-initially, and by implication utterance-initially. We recorded 3 female native speakers of Wubuy (ages 51-61 years), producing 5 repetitions of target Wubuy words containing the dental, alveolar and retroflex stops in a carrier phrase, in three prosodic contexts: word-medial, but syllable initial /aCa/, word-initial but utterance-medial /a#Ca/, and absolute utterance-initial /##Ca/. F1, F2, F3 values were extracted at 25%, 50%, 75% of both preceding and following vowels, as well as at consonantal closure and voicing onset as it has been claimed that information about retroflexation is carried on the preceding vowel.

The lamino-palatal series was excluded from this study for the following reasons. Researchers consistently report difficulty in distinguishing, on the one hand, apico-retroflex from apico-alveolar and, on the other, apico-alveolar from lamino-dental under certain conditions, and there is some acoustic work supporting these auditory impressions (see e.g. Hamilton, 1996). In many Australian languages, the contrast between apicals is reportedly neutralised in some environments, notably word- and morpheme-initially (see e.g. Dixon, 1980). In addition, there is some evidence for historical neutralisation of the contrast between lamino-dental and apico-alveolar in morpheme-initial positions in the genetic group which includes Wubuy (Harvey, 2003), as well as synchronically in Wubuy's neighbour and presumed congener, Anindilyakwa (Leeding, 1989). No researchers report difficulty in distinguishing the lamino-palatal series from any other contrastive place of articulation, to our knowledge.

Results

In *preceding* vowels (/aCa/, /a#Ca/), F3 distinguishes all three stops (see Figure 2). In the /aCa/ context, the retroflex is distinct from the other two stops in terms of F3 from 25% into the preceding vowel. In the /a#Ca/ context, the retroflex is distinct from the other two stops in F3 from 50% into the preceding vowel. At the onset of consonantal closure, the VC transitions distinguish all three stops in terms of F3 in both contexts.

In the *following* vowel, however, F2 distinguishes the stops differently in each environment (again, see Figure 2). In the /aCa/ context, F2 distinguishes the dental from the alveolar and retroflex in the first 25% of the vowel. In the /##Ca/ context, the retroflex is distinct from the dental in F2 throughout the vowel, and also from the alveolar at 25% and 50% of the vowel. In the intermediate /a#Ca/ context, F2 distinguishes all three stops at 50% of the vowel, while the retroflex is distinguished from the dental in F2 throughout the vowel.

Discussion

These patterns are consistent with AP predictions. The alveolar versus retroflex stops are clearly distinguished in the preceding vowel of /a(##)Ca/, but in the crucial /##Ca/ context, where prosodic strengthening is maximal, F2 distinguishes the retroflex from the two other stops throughout the first 50% of the *following* vowel.

We suggest that this is because of the greater gestural overlap associated with a tighter coupling of the consonant and vowel gestures in the utterance initial context. F2 does not distinguish the retroflex and alveolar in the CV transition of the /aCa/ context, where the preceding vowel transitions clearly distinguish all three stops. As predicted, /a#Ca/ shows intermediate characteristics. While the preceding vowel's F3 distinguishes among the three stops, distinctions also appear in the following F2, suggesting a greater degree of gestural overlap, though not as strong as in utterance initial context. All in all, the findings support the posited convergence of prosodic strengthening and gestural coupling on coronal stop distinctions.

While formant trajectories differentiate the stops to some extent in the preceding and the following vowel, we suspect that measures of closure duration, VOT, as well as the spectral properties of the burst, may also contribute to the maintenance of contrasts. In addition, though we have established that there are measurable differences in the vowel transitions for coronal stops, perceptual studies are an important direction for future research.

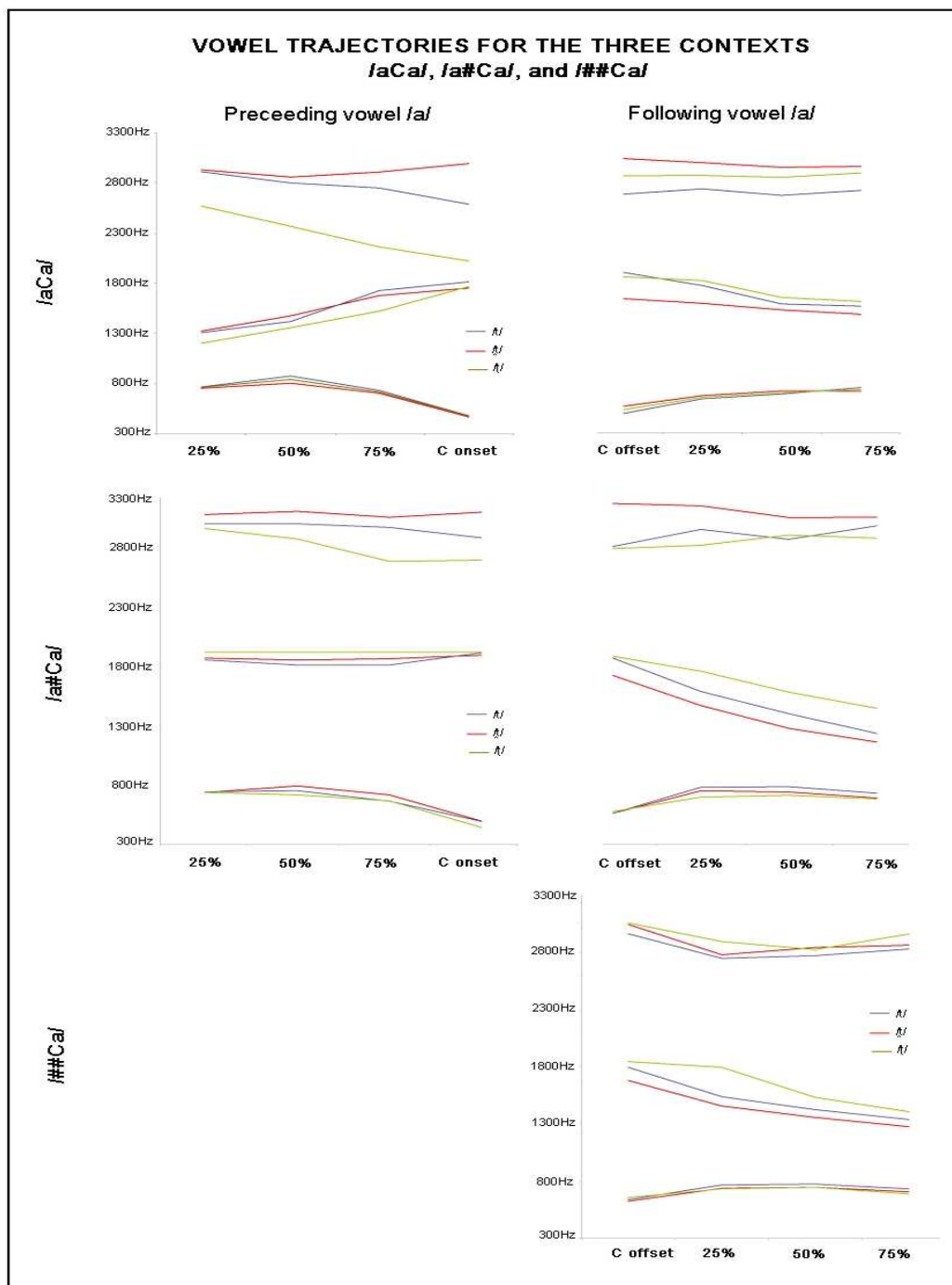


Figure 2: Averaged vowel trajectories for the vowels in /aCa/, /a#Ca/, and ##Ca/.

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