A PRELIMINARY EPG STUDY OF STOP CONSONANTS IN ARRERNTE

Marija Tabain & Kristine Rickard

Linguistics Program, La Trobe University, Melbourne, Australia
m.tabain@latrobe.edu.au

ABSTRACT

The Australian Aboriginal language Arrernte has four coronal consonants in the stop, nasal and lateral series. This paper presents EPG data for the four coronal stops of Arrernte in inter-vocalic context for one female speaker of the language. Results show comparatively little variability in the laminal articulations, and comparatively greater variability in the apical articulations. An interesting finding suggests that a retroflex harmony may exist in the language, whereby a retroflex consonant later in the word may cause a previous alveolar consonant to harmonize.

Keywords: Aboriginal languages; EPG; coronal stops; retroflex harmony.

1. INTRODUCTION

Australian Aboriginal languages have up to six places of articulation in stop and nasal consonants, including up to four coronal places of articulation. However, there are very few articulatory studies of these languages. This paper presents some preliminary electropalatographic (EPG) data from the Arrernte language, which is spoken in and around Alice Springs in central Australia.

The particular focus of this paper is on describing coronal stop articulations across multiple inter-vocalic tokens for one speaker of Arrernte. The coronal stops in Arrernte are the lamino-dental /t̪/, written "th"; the apico-alveolar /t/, written "t"; the apico-post-alveolar, or retroflex /ʈ/, written "rt"; and the lamino-palatal /c/, written "ty". The distinction between laminal and apical articulations is phonologically important in Aboriginal languages, and hence the discussion in this paper will highlight some important differences between apical and laminal articulations.

2. METHOD

EPG recordings of two speakers of Arrernte were made at Macquarie University, Sydney. The speakers were mother and daughter, both teachers of Arrernte language in Alice Springs. Only results from the younger speaker, aged in her 30s, will be presented here. However, the broad observations made in this paper hold true for the older speaker as well.

The Reading EPG system was used for these recordings, interfaced with a UNIX machine. Time-synchronized acoustic recordings were also made. The acoustic data were sampled at 20 kHz and the EPG data were sampled at 200 Hz.

Stimuli consisted of real words from the Arrernte language. The word-list was designed by Andy Butcher and John Henderson, especially for use with EPG recordings (i.e. the words illustrated the lingual consonants in different positions in the word and in different vocalic contexts). The speakers repeated each word three times, and the list was read through twice.

The acoustic data were hand-labeled by a paid labeler using the EMU speech labeling toolkit. The EPG data were then extracted from the database, based on the acoustic labeling, using the EMU speech database system interfaced with the R statistical package.

EPG data were sampled at the temporal midpoint of the stop consonant. Only coronal stop consonants which were both preceded and followed by a central vowel were selected for the present study (i.e. there were no word-initial or word-final stops included). The two central vowels in Arrernte are /ɐ/ and /ə/, and these are the two most frequent vowels in the language (in fact, it can be argued that Arrernte has a 2-vowel system consisting of precisely these two vowels, since the other possible phonemic vowels, /i/ and /u/, have an extremely low functional load and limited phonotactic distribution).

The following EPG measures were calculated for the data [3]: Centre of Gravity (COG), which measures contact across the entire palate; Anteriority Index (AI) which measures contact in the first five rows of the palate (i.e. from the dental to the post-alveolar region); the Dorsopalatal Index (DI) which measures contact in the last three rows of the palate (i.e. from the pre-palatal to the pre-velar region); and the Centrality Index (CI) which measures the degree of contact in the central columns.

3. RESULTS

Figure 1 presents gray-scale summaries of the contact patterns, and figures 2-5 present the raw data for each token. Figure 6 presents box-plots of the COG, AI, DI and CI results.

Figure 1: Gray-scale summaries of Reading EPG contact patterns for one female speaker of Arrernte. "th" = lamino-dental stop; "t" = apico-alveolar stop; "rt" = apico-post-alveolar stop; "ty" = lamino-palatal stop. An empty cell denotes that the electrode was not contacted in any token, and a black cell denotes that the electrode was contacted in all tokens.

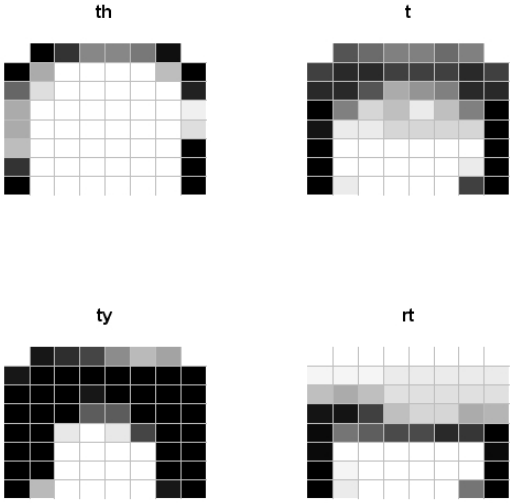


Figure 2: EPG plots of individual tokens, sampled at acoustic temporal midpoint, for the lamino-dental "th".

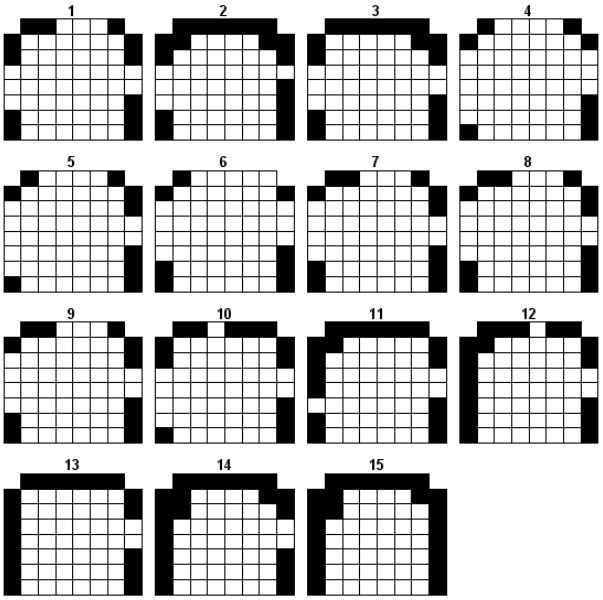


Figure 3: EPG plots of individual tokens, sampled at acoustic temporal midpoint, for the apico-alveolar "t".

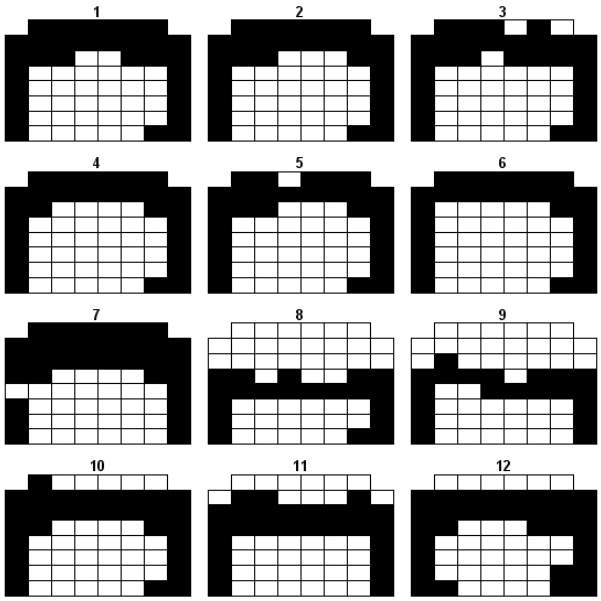


Figure 4: EPG plots of individual tokens, sampled at acoustic temporal midpoint, for the apico-post-alveolar "rt".

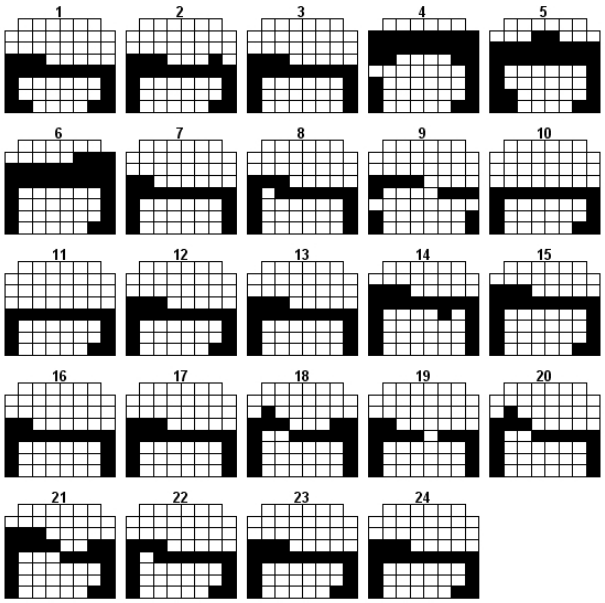


Figure 5: EPG plots of individual tokens, sampled at acoustic temporal midpoint, for the lamino-palatal "ty".

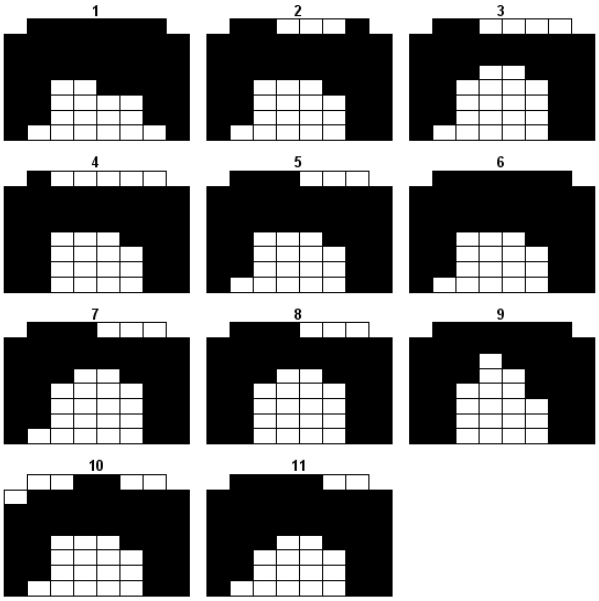
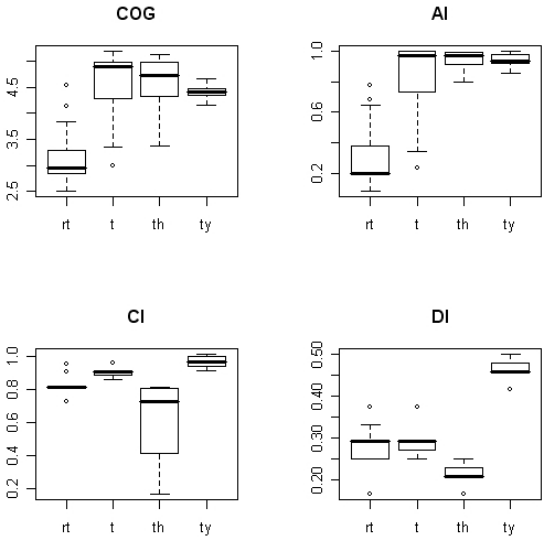


Figure 6: Box-plots summarizing the COG, AI, CI and DI measures for the four coronal stops.



As can be seen from figures 1-5, there is generally much less variability in the production of laminals ("th" and "ty") than apicals ("t" and "rt"). This is consistent with the view that laminal production involves much greater tongue raising than apical production, and hence is more resistant to coarticulation and prosodic sources of variability (since the stop tokens in this paper were always flanked by central vowels, the variability observed is most likely due to prosodic factors, which were not controlled).

The COG measure (Figure 6) separates the post-alveolar (or retroflex) "rt" from the other coronals, with a much lower value for this stop than for the other stops, suggesting a place-of-articulation which is much further back. The relatively high COG for the palatal is due to the fact that contact is quite extensive across the palate, with front rows also showing contact – by contrast, the post-alveolar tends to show contact no further forward than rows 3 or 4.

The AI measure also separates the post-alveolar from the other coronal stops, for reasons similar to those outlined for the COG measure. In this particular instance, COG and AI behave quite similarly.

The CI measure shows a tremendous amount of variability for the dental stop "th". This is most likely due to the fact that there is very little contact registering on the Reading EPG system for this stop, since most of the contact is between the

tongue and the teeth. As a result, the CI is quite low.

The DI separates both of the laminals from the apicals. The lamino-dental has a lower DI than the other stops (for the reasons outlined in the preceding paragraph), and the lamino-palatal has a higher DI than the other stops. The DI is high for the lamino-palatal because of the high degree of tongue body raising involved in the production of this consonant.

It is worth commenting on the individual tokens presented in Figures 2-5. As already mentioned, contact patterns for the laminals show little variability. For the dental, contact is strictly on the edges of the palate, in row 1 and columns 1 and 8. Often these rows and columns are not completely filled, suggesting contact with the teeth rather than the palate. For the palatal, central contact may extend from row 1 to row 5 (and always including rows 2 and 3), with significant lateral contact all along the palate.

However, there is much greater variability for the apical stops. For the apico-post-alveolar "rt", there is usually a single row of contact in row 5, though the contact may be a little further forward. Lateral contact is usually restricted to columns 1 and 8.

The apico-alveolar, by contrast, tends to have contact in rows 1 and 2, with lateral contact in columns 1 and 8. This contrasts with the much sparser and more forward contact for the lamino-dental. However, there are some important exceptions to this description of the apico-alveolar, as is seen in tokens 8-12 in Figure 3. Here, the contact patterns strongly resemble the post-alveolar contact patterns (tokens 8 and 9), or appear in-between the alveolar and post-alveolar contact patterns (tokens 10, 11 and 12). Tokens 8 and 9 are from the 2nd and 3rd repetitions of the word "aternnge" /ɐtənɳə/, and tokens 10-12 are the three repetitions of this same word on the second reading. (The auditory impression of the first repetition of the first reading of this word is of a more careful pronunciation, with subsequent repetitions being more fluent.) These tokens illustrate what appears to be a common pattern in this EPG database, namely, a retroflex harmony whereby a retroflex consonant (stop, nasal or lateral) later in the word may cause a preceding alveolar to become retroflexed as well. Interestingly, the first repetition of a word is often exempt from this coronal harmony, as the speaker produces the word more carefully. In the example mentioned here, the retroflex nasal later in the word causes the preceding apical stop to have a more retracted articulation. The auditory impression is that tokens 8 and 9 have a retroflexed oral stop [ɐʈənɳə], whereas tokens 10-12 do not.

4. DISCUSSION

The observations on laminal and apical articulations are mostly consistent with previous results in the EPG literature on such articulations in other languages (e.g. [5]), as well as with results from static palatography on Australian Aboriginal languages [1], [2]. The current results also support more quantitative acoustic studies on Aboriginal languages [6].

However, what is surprising in the current data is the evidence for retroflex harmony within the word. The apical harmony described for Arrernte [4] involves the first apical consonant (alveolar or retroflex) in the word causing subsequent apical consonants to become retroflexed, provided schwa is the only vowel to intervene. However, the current results suggest that this is not necessarily the case, and that a regressive harmony (whereby a preceding alveolar may become retroflexed) appears to be operating instead in the modern language. This is planned to be an area of further study with this EPG database.

5. ACKNOWLEDGEMENTS

This work was supported by an Australian Research Council Discovery Project Grant to the first author. We would like to thank our speakers for their time, and Gavan Breen for his support.

6. REFERENCES

[1] Anderson, V. 2000. *Giving weight to phonetic principles: the case of place of articulation in Western Arrernte.* PhD thesis, UCLA.

[2] Butcher, A. In preparation. *The Sounds of Australian Languages.* Oxford: OUP.

[3] Hardcastle, W., Gibbon, F., Nikolaidis, K. (1991). EPG data reduction methods and their implications for studies of lingual coarticulation. *Journal of Phonetics* 19, 251-266.

[4] Henderson, J. (1998). *Topics in Eastern and Central Arrernte grammar.* PhD thesis, UWA.

[5] Recasens, D. 1985. Coarticulatory patterns and degrees of coarticulatory resistance in Catalan CV sequences. *Language and Speech* 28, 97-114.

[6] Tabain, M., Butcher, A. 1999. Stop consonants in Yanyuwa and Yindjibarndi: a locus equation perspective. *J. Phon.* 27, 333-357.