TEMPORAL MODELLING OF GESTURES IN ARTICULATORY ASSIMILATION

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ABSTRACT

Gestural trajectories for consonants in coronal + velar clusters were derived using EPG contact data from speakers of English and Russian. Evidence from rapid speech indicates a variety of articulatory strategies available to speakers of the two languages, with notably a high-level discrete assimilation process found only in the same utterances by the English speakers. The remaining data involve partial loss of the coronal gesture, and therefore are not susceptible to description within conventional phonological formalisms. The weakening of coronal gestures in certain contexts appears only as an arbitrary stipulation within the theory of Articulatory Phonology. It is argued that the theory requires further elaboration to allow the behaviour of the coronals to be modelled adequately.

1. CORONALS IN CC CLUSTERS

A number of studies have drawn attention to the tendency of alveolar and dental stops and nasals to assimilate to the place of articulation of a following non-coronal obstruent. The process is attested as source of phonological change in many languages, and gives rise, for example, to the presence only of homorganic intramorphemic NC clusters in English. The process has typically been formulated within the apparatus afforded by phonological theory in terms resembling those in figure 1, either, as in (a), in the linear formalism of early Generative treatments or as in (b), employing an autosegmental treatment of those features specifying place of articulation.

In this paper, however, I shall present evidence and arguments from rapid speech indicating that the formulations of fig. 1 are insufficiently revealing both of the phonetic facts obtaining in both English and Russian, and of the knowledge to which a native speaker of either language must have access in order correctly to produce sequences such as those under discussion.

2. ALVEOLARS IN ENGLISH

I have reported [1] an investigation into CC clusters in rapid speech in English, where C1 is an alveolar stop or nasal and C2 a velar stop, with an intervening mora.

[+ ant] [+ cor] [− ant] [− cor]

Figure 1: conventional phonological representations for alveolar and dental assimilation

are insufficiently revealing both of the phonetic facts obtaining in both English and Russian, and of the knowledge to which a native speaker of either language must have access in order correctly to produce sequences such as those under discussion.

3. QUANTITATIVE INVESTIGATIONS OF ARTICULATORY GESTURES

Further insight into patterns of articulatory activity may be gained by a consideration in terms of the trajectories of individual articulatory subsystems, recently restored to the phonetician's armoury through the development of the concept of the gesture in the paradigm of Articulatory Phonology developed by Brownman and Goldstein [3]. In the work reported in the present paper gesture trajectories were approximated from time-varying summaries of EPG contact data, and a number of measures devised by which temporal aspects of the various articulatory strategies might be compared. Figures 3 and 4 show gestural trajectories for the nasal + plus stop sequence [ng] in the phrase hand grenade. From the data values were obtained for (a) the duration of the alveolar and velar closures (DAC, DVC); (b) the overall duration of the coronal and dorsal gestures (DCG, DDO); (c) the place of lingual displacement, corresponding to the height of the peaks for the two gestures (CMAX, DMAX); and (d) the interval between onsets of the two closures, or, in the case where no alveolar closure was formed, between the peak in the coronal gesture and the onset of velar closure (INT).
4. DENTALS IN RUSSIAN

A consideration of the behaviour of speakers of Russian in similar contexts reveals some significant differences. The sound system of Russian differs from that of English in two significant respects: in general the requirement that NC clusters should be homorganic within the morphone does not apply, and there is no surface contrast between dental and velar nasals. A large body of data from two speakers of Russian was subject to the same qualitative and quantitative investigation as the data from English. To begin again with qualitative observations, two points are immediately evident:

(i) in the case of CC clusters where C₂ is a stop, no reduction can be observed in the magnitude of the coronal gesture as speaking rate increases (CMAX remains constant at 100%);
(ii) the range of contexts in which complete assimilation (i.e. a velar nasal) is encountered is very narrow, and apparently not sensitive to speech-rate. The cases involved were words such as sanksia/ and funktsia/, in which the nasal and the following stop must be partally delinked. g rs

These forms showed [ŋ] even in slow, careful speech.

In the remainder of cases (where the n and the following stop are heterosyllabic) the forms recorded typically reveal a fully articulated dental nasal in slow speech, and a fast speech a reduction in the magnitude of the coronal gesture, generally leading to the absence of a complete dental closure.

Applying the same quantitative measures as for English to the Russian data reveals further cross-linguistic differences. In the fast speech examples from the Russian speakers in the experiment, the reduction in magnitude of the coronal gesture is not accompanied by a corresponding lengthening in the duration of the dorsal gesture (CMAX decreases but DDG remains constant, or even undergoes a slight reduction typical at increased rates of speech), and while INT decreases, the velar closure is nonetheless formed after the peak in the coronal gesture. Thus while the phonological formulation of fig. 1b was seen to be roughly appropriate to the articulariry patterns found in English, with weakened alveolars and lengthened velars suggesting a partial implementation of the phonological processes of assimilation, the data suggests that such interpretation applies similarly for the patterns found in Russian-speakers.

It is appropriate instead, I would argue, to view the weakening of the Russian dentals as the manifestation of a process more phonetic than phonological; that is, more representative of the natural constraints acting on the articulatory apparatus than of the principles of phonological organisation which may be discerned in the English data found in English, with weakened alveolars and lengthened velars suggesting a partial implementation of the phonological processes of assimilation, the data suggests that such interpretation applies similarly for the patterns found in Russian-speakers.

Two important consequences emerge: that some aspects of the speaker's knowledge of how their language is pronounced are involvef more specific decisions than conventional phonological theories are not equipped to represent; and that language-specific knowledge of pronunciation extends to the operation or blocking of natural low-level processes.

6. CORONALS IN ARTICULARY PHONOLOGY

The paradigm of Articulatory Phonology [3] appears well-equipped to accommodate the variety of low-level phonetic detail which, as I have argued, falls within the subject-matter of a comprehensive theory of phonology. Gestural trajectories correspond to high-level phonological representations, and the operation of the task-dynamic model yields a spatio-temporal representation in terms of gestural trajectories in which the non-discrete application of phonetic and phonological processes may be formalised. In addition, the application of gestures to the regulation of relationships of phase between gestures accounts for much of the data we have observed, in which the velar gesture is responsible for the 'masking' of the coronal gesture.

What is still lacking in current formulations of the theory is a convincing account of the facts of coronal-gesture weakening. That gestures weaken in casual speech is stipulated somewhat axiomatically, and in no sense can be said to emerge from the mathematical properties of the model. Moreover, there appears to be no way, in a model which treats all gestures as formally identical objects, in which it can be shown that coronal gestures specifically are subject to elision in CC clusters. At the heart of the matter is the modelling of gestures as the critically-damped attraction of the active articulator towards its target. Thus for an articulator to fail during its target during the execution of a gesture seemingly requires the target itself to be reprogrammed. Within existing versions of the theory it would seem to be necessary to abandon the assumption of critical damping (such that an articulator always reaches its target) in order to accommodate gestural weakenings, and other undershoot phenomena. A more drastic revision of the model would be to abandon the modelling of gestures in terms of attraction, in favour of a model in which the articulator is pushed rather than pulled towards its target. But this would be to abandon entirely the mathematical content of the theory.

The issue of gestural weakening clearly remains a problem for the development of the theory: it seems clear that evidence of the kind presented in this paper will be of relevance in seeking a solution.

REFERENCES