Coarticulation in apical consonants: acoustic and articulatory analyses of Hindi, Swedish and Tamil

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Coarticulation in apical consonants: acoustic and articulatory analyses of Hindi, Swedish and Tamil

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Abstract
In Hindi, Swedish and Tamil, the place of articulation of retroflexes is more posterior at the beginning of the closure than at the release. Retroflex place of contact is also vowel-dependent whereas that of dentals is constant. F2 locus parameters fail to support the idea that the degree of vowel-consonant coarticulation varies with place and/or language. The main difference between dental and retroflex is provided by F3, and to a lesser degree F4. The contrast is larger at the VC than at the CV boundary.

Issues
1. Phonologically, Hindi and Tamil use dental and retroflex stops contrastively, whereas in Swedish they are combinatorial variants arising in sequences of an /r/ or a retroflex followed by a dental. Given that fact we looked for language-dependent effects in the time-course of retroflex production.

2. Locus equation parameters have been said to provide a context-independent way of specifying place of articulation (Sussman, McCaffrey and Matthews, 1991). The present results will be discussed in the light of that claim.

3. If two languages differ in the degree of retroflexion, how is tongue body coarticulation affected? On the basis of articulatory synergy (Lindblom, Pauli and Sundberg, 1975) it might be assumed that a more posterior retroflexion requires a tongue body which is also more posterior. Is such an expectation borne out by our data?

4. Hindi and Swedish retroflexes are apical/laminal. Tamil is reported to use sublaminal articulations (Ladefoged and Bhaskararao 1983), that is, contact patterns involving the tongue underside.

Those issues will here be examined with the aid of acoustic data and synchronized EPG records.

Experimental procedures
The present data come from two speakers of Hindi, three speakers of Swedish and two speakers of Tamil. Electropalatographic and acoustic records were obtained from all of them. The Hindi and Tamil speakers were asked to produce isolated words of either [aCV:] or [V:Ca] structure with V = /i/, /e/, /a/, /o/ or /u/. The Swedish utterances, prosodically similar to gul hatt, had symmetrical [V:CV:] structure, where V = /i/, /e/, /e/, /a/, /o/ or /u/. The test words were read five or six times.

Formant estimates were made from spectrograms and short-term spectra using the MIX software written by R Carlson (KTH). Formant frequencies were measured (1) in the first vowel 80 ms before closure; (2) at the last glottal pulse before closure (= VC boundary); (3) at the first glottal pulse of the second vowel (= CV boundary); and (4) in the second vowel 80 ms after the CV boundary. The EPG data were collected using the Reading system (Engstrand 1989).

Results
Figure 1 compares several aspects of the data. Average values are shown for three Swedish speakers, two Hindi speakers, and two Tamil speakers. The place of contact obtained from the EPG data is presented in mm from the incisors. For dentals, the place does not vary with vowel context, nor is there a change from the VC to the CV condition. However, for retroflex, the data differ in that the exact place does indeed depend on the vowel, front vowels having a more anterior variants of retroflexion. There are also marked differences between the VC and CV samples: during the closure the place of contact slides forward so that the contrast between dental and retroflex is larger at the VC than at the CV boundary. These results confirm earlier findings on Hindi (Dixit 1990).
Dental stops

<table>
<thead>
<tr>
<th>VC</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish</td>
<td>Hindi</td>
</tr>
<tr>
<td>Place (mm)</td>
<td>30</td>
</tr>
<tr>
<td>F2 of V1 (kHz)</td>
<td>3</td>
</tr>
<tr>
<td>F2-4 offset (kHz)</td>
<td>1</td>
</tr>
</tbody>
</table>

Retroflex stops

<table>
<thead>
<tr>
<th>VC</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish</td>
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<td>1</td>
</tr>
</tbody>
</table>

Figure 1. The top half of the figure pertains to dental, the lower half to retroflex observations. The columns to the left show measurements made at the VC boundary, to the right CV observations. The smaller panels (EPG) indicate place of stop closure (in mm from the incisors) and are paired with the plot of F2, F3 and F4 offset (VC) or onset (CV). The calibration of the x-axis is F2 of the first or second vowel. The data points represent the respective means for three Swedish, two Hindi and two Tamil speakers.
Figure 2. The upper panels show retroflex F2, F3 and F4 at the VC boundary plotted against corresponding dental values in three languages. The lower panel shows similarly plotted data at CV boundary.

F2, F3 and F4 onsets-offsets are plotted against F2 of the adjacent vowel (first vowel for VC and second vowel for CV). Locus equation lines are fitted to F2 data. A comparison of the slopes and intercepts of these equations reveals no major difference between dentals and retroflexes. This is in agreement with the results reported by Sussman, Hoemeke and Farhan (1993).

Since, theoretically, F2 ought to be associated with the cavity behind the closure, this finding appears to imply that dentals and retroflexes invoke similar coarticulation patterns with respect to tongue body configurations. If that is a correct assumption, a more posterior retroflexion does not necessarily presuppose a tongue body that is also more posterior. Sublaminal articulations are allegedly typical of Tamil retroflexes (Ladefoged and Bhaskararao 1983). They involve the tongue underside and might therefore be assumed to constrain the mobility of the tongue body even more severely than apical/laminal retroflexes and dentals. Krull (1988) has suggested that, for a given place of articulation, variations in the slope and intercept of locus equations could be seen as variations in degree of coarticulation.

However, the present investigation provides no basis for identifying significant differences in slopes and intercept values in the F2 of the
Swedish and Hindi apical/laminal retroflexes and Tamil sublaminal retroflexes.

The main difference between dentals and retroflexes is found in the relation of F3 onsets-offsets to F2 of the adjacent vowel: regression lines for retroflex F3 would be much steeper than those for dental F3 (see Fig. 1). In the case of Swedish, this is true also of F4 whereas in Hindi and Tamil F4 is very little affected by vowel context. The only difference between dentals and retroflexes lies in the generally lower onsets-offsets for retroflexes.

These differences are illustrated in Figure 2 where dental and retroflex onset-offset values are plotted against their dental counterparts. Points lying on the diagonal indicate identical values for a retroflex and a dental onset or offset in a given vowel context. Values above or below the diagonal indicate higher resp. lower retroflex values. Note that all distinctions are much more pronounced in the VC condition than in CV.

Conclusions

1. With respect to the time course of retroflex production, it was found that, in all three languages, retroflexes showed a more posterior articulation at the beginning of the closure than at the release. Also their exact place of closure is vowel dependent, whereas that of dentals is constant. (Fig. 1).

2. Do locus equation parameters provide invariant place correlates separating dentals and retroflexes in a vowel-independent manner (Sussman et al 1991)? The answer based on the present data is no with respect to F2. The main difference is found mainly in the relation of F3 onset-offset to the adjacent vowel.

3. Is there evidence of a more restricted tongue body variation (less coarticulation) in retroflexes than in dentals? Applying the reasoning of Krull (1988) we conclude that for the present analyses, the degree of coarticulation does not seem to be less in retroflexes.

4. We were unable to identify reliable articulatory or acoustic evidence for the apical/laminal variant of retroflexion supposedly characteristic of Hindi and Swedish as opposed to the sublaminal articulation of Tamil (Ladefoged and Bhaskararao 1983). That may be due to more fine-grained analyses than the ones undertaken so far.

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References


