

# Alveolar stops exhibit greater coarticulatory resistance than Retroflexes and Dentals in Malayalam

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**Background:** Malayalam geminates exhibit an extensive three-way place contrast in the intervocalic context which gives rise to V1<sub>̄</sub>V2, V1<sub>̄</sub>:V2, and V1<sub>̄</sub>:V2 sequences. In this study, we examine these contrasts in an ultrasound study of tongue contours to understand the nature of coarticulatory resistance and aggressiveness. Degree of Articulatory Constraint (DAC) predicts that articulatory complexity mitigates the nature of coarticulatory resistance cross-linguistically (Recasens and Espinosa, 2009). Coarticulatory aggressiveness is also understood to be consequent to articulatory complexity. Due to tongue tip and tongue dorsum gestures associated with the retroflex coronals, these stops can be expected to offer greater coarticulatory resistance and aggressiveness to neighboring segments. Studies on the effect of phonological neighborhood density on coarticulatory resistance and aggressiveness also predict higher degree of resistance for low density contrasts (Scarborough, 2004). Alveolars in Malayalam exhibit low neighborhood densities which may indeed govern coarticulatory resistance and aggressiveness of this place of articulation. We discuss the implications of our findings for DAC and propose that sparse lexical representation coerces coarticulatory resistance in tight coronal place contrasts.

**Methods:** Two female subjects were chosen for this study. Subjects were native speakers of Malayalam who were fluent readers of the script, aged between 20 and 24. Seventy-six items were chosen for this study, the majority of which were bi-syllabic words. Items had a V<sub>1</sub>C:V<sub>2</sub> sequence. V<sub>1</sub> was from the set /ə, o, i, u, e/, and V<sub>2</sub> was from the set /ə, a, i, o, u, e/. The block of seventy-six words was repeated twice. Ultrasound data was collected on the Articulatory Assistant Advanced (AAA) system, with a 10 mm radius probe, 5-8 MHz frequency and an FOV of 156°. All splines were automatically detected, and then hand-corrected. For each segment, six evenly spaced frames were extracted, with 42 coordinates detecting the tongue shape.

**Results and discussion:** Findings from our study of ultrasound tongue contours are contrary to the predictions of the DAC. The expectation of the DAC is that the directionality of coarticulatory resistance and aggressiveness will be V<sub>1</sub><sub>̄</sub>:V < V<sub>1</sub><sub>̄</sub>:V < V<sub>1</sub><sub>̄</sub>:V. We find that the order of coarticulatory resistance is V<sub>1</sub><sub>̄</sub>:V < V<sub>1</sub><sub>̄</sub>:V < V<sub>1</sub><sub>̄</sub>:V.

First, an analysis was conducted by choosing the frames corresponding to the constriction. The following table lists the coordinates that showed the highest variance for tongue height ((x<sub>1</sub>, y<sub>1</sub>) is the point closest to the front of the mouth):

Participant	Place of Articulation	X-Y coordinates	Variance in Y values
F1	Dental	x19, y19	35.71
F1	Alveolar	x17, y17	43.42
F1	Retroflex	x18, y18	35.14
F2	Dental	x10, y10	10.38
F2	Alveolar	x23, y23	16.04
F2	Retroflex	x13, y13	15.09

Table 1: Locations in the tongue splines that show the highest variance

For each participant, the alveolar splines showed highest values.

Comparisons of fitted models to tongue contours for the three coronals also showed that alveolars exhibit greater variability in tongue constriction location than in retroflex and dentals. The following figures plot the distribution of the splines (shaded portion), along with the predicted spline (bold line), for each place of articulation:

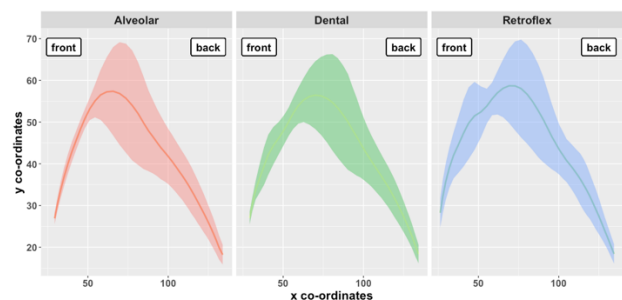


Figure 1: Plots for participant F1. The shaded portion shows the distribution of the splines

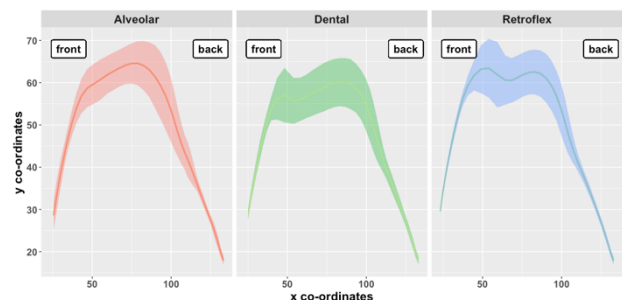


Figure 2: Plots for participant F2. The shaded portion shows the distribution of the splines

The results indicate that the effects of phonological neighborhood density mitigates the effects of the DAC.

## References

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