

## Using EMA to Explore Prosodic Strengthening in Persian

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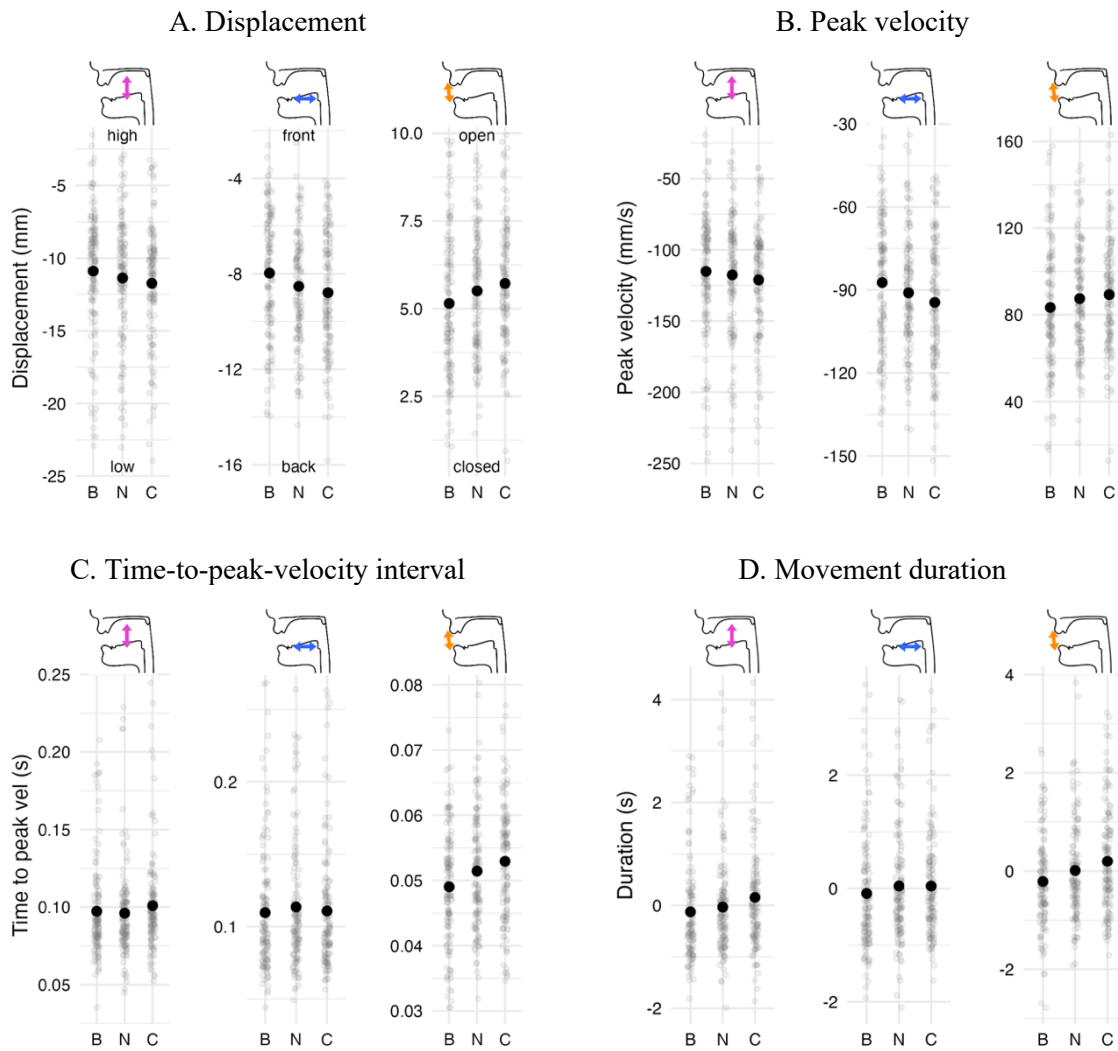
The expression of focus is an important function of prosody in many languages. A growing body of research shows that prosodic prominence patterns associated with focus can have a significant impact on the articulatory profiles of the lips and the tongue, e.g., [1], [2]. This paper reports results from the *first* articulometric study on prosodic strengthening in Persian. We concentrate on fine-grained differences in the marking of three focus types (broad, narrow, and corrective focus). Hence, we examine effects of prosodic strengthening between pitch-accented words with varying degrees of prominence, rather than comparing the more divergent conditions focused/accented and unfocused/unaccented.

Twelve native Persian speakers were recorded. They were residents of Germany, had grown up in Iran with Persian as their native language, and had lived outside Iran for only a relatively short time (mean: 3.5 years). The participants were involved in an interactive scenario with a virtual avatar and answered questions that triggered different focus structures. The target words were carefully selected and contained [a] in the syllable that is expected to bear the pitch accent, preceded by a syllable with the vowel [i]. We recorded the acoustic signal and simultaneously tracked the movements of the lips and tongue using a Carstens AG501 articulograph.

The results indicate that even within the subtle range of prominence differences of our focus conditions, speakers adjust parameters of the labial and lingual subsystems when articulating [a]; see results in Figure 1. Bayesian regression modeling provides strong evidence for systematic differences across the focus types. These differences are most consistent between broad and corrective focus, while narrow focus generally falls in between the two conditions (with a tendency to be more similar to corrective focus). Directly comparing corrective to broad focus, we find more extreme displacements and peak velocities in the vertical (high-low) and horizontal (front-back) movement dimensions of the tongue body, as well as in the lip aperture. In addition, the vertical dimension of the tongue body as well as the lip aperture both show longer movement durations. Solely the lip aperture shows longer time-to-peak-velocity intervals.

We interpret the findings through the lens of the gestural model of Articulatory Phonology (AP) and follow previous literature [1], [3] by explaining movement differences as arising from changes in the underlying dynamical parameters of the articulatory gestures. For the tongue body, the results are most consistent with a combined modulation of the gestural target and duration of the activation interval. For the lip aperture, we discuss a combined modulation of gestural target and stiffness as a possible interpretation.

The study contributes to our understanding of the direct influence of pragmatics and prosody on the supra-laryngeal articulatory system and broadens our knowledge of systematic variation in speech production processes in Persian.



**Figure 1:** Results for (A) displacement, (B) peak velocity, (C) time-to-peak-velocity interval related to stiffness, and (D) movement duration. In each plot, the left panel corresponds to the vertical (high-low) tongue body movement (TB Y), the center corresponds to the horizontal (front-back) tongue body movement (TB X), and the right panel corresponds to the lip aperture (LA). The mean is represented by the thick black dots, the smaller, transparent dots scattered around it are the raw data points. Note that displacements for the tongue dimensions are negative, since the tongue moves downward and backward from the preceding [i] to the [a]. This means that a smaller (more negative) displacement indicates a larger movement, and a smaller (more negative) peak velocity indicates a faster movement.

### References:

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- [3] T. Cho, "Manifestation of prosodic structure in articulatory variation: Evidence from lip kinematics in English," in *Laboratory phonology*, vol. 8, De Gruyter Mouton, 2006, pp. 519–548.