Variability of articulatory dimensions relates to their role in distinguishing phonological categories for individual speakers

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The articulatory and acoustic properties of any one phonological segment can vary substantially from token to token, both between speakers and within a single speaker (e.g., [1],[2]). Previous research has demonstrated that the amount of variability permitted in the realization of a given articulatory dimension varies across segments in a language, with a link proposed between the importance of a dimension for differentiating contrasting segments and its ability to vary across contexts ([3], [4]). However, most work examining the relationship between variability in the realization of particular articulatory dimensions and phonological contrast has been highly context-specific, examining how variation along a specific dimension is or is not constrained for certain segments in specific phonetic environments. Despite recent work demonstrating that the effect of linguistic context on speech production differs across individuals (e.g., [5]) and that speakers differ from one another in their reliance on particular articulatory dimensions to produce specific phonological contrasts (e.g., [6]), little is known about the extent to which individual speakers differ in the overall amount of variability they exhibit in their production of an articulatory dimension, or how these differences may be related to their use of that dimension to differentiate contrasting segments. The study presented here tests the hypothesis that speakers who exhibit a smaller amount of variability along a particular articulatory dimension will use this dimension to differentiate contrasting pairs of segments to a greater extent than more variable speakers.

Kinematic data from 9,606 tokens of word-initial and -final /s/, /ʃ/, /l/, and /ɹ/ were analyzed from sentences read by 40 native speakers of American English in the Wisconsin XRMB Corpus [7]. Velocity trajectories of pellets placed on the upper and lower lips (UL and LL) and on the tongue tip (TT), blade (TB1), body (TB2) and dorsum (TD) were used to find the time of movement extremum for the articulatory gesture(s) used to form each segment, and the constriction location, degree, and orientation was extracted for all gestures in each consonant at the time of movement extremum. The contribution of these measurements to the production of the /s/~/ʃ/ and /l/~/ɹ/ contrasts was evaluated using logistic regression models fit to each speaker's data separately, with standardized coefficients from these models interpreted as indicating the extent to which each articulatory measure reliably differentiated the pair of contrasting segments. The coefficient of variation (CoV), a standardized measure of variability, was additionally calculated for each measurement in every segment for all speakers individually. To assess the relationship between variability in the production of a particular articulatory dimension and the use of this dimension to distinguish a contrasting pair of segments, a series of Mann-Whitney U tests were first used to determine whether CoV values for a specific dimension differed significantly between speakers for whom the dimension was a significant predictor of the contrast and speakers for whom it was not. Pearson's product-moment correlation was subsequently used to evaluate whether a more continuous relationship was observed between the size of the standardize regression coefficient and CoV values.

The results of this experiment indicate that there is co-variation in the extent of the variability observed along particular articulatory dimensions for specific segments and the contribution of these dimensions to differentiating the examined pairs of contrasting segments examined. Individual speakers differed substantially from one another in both the amount of variability they exhibited along specific articulatory dimensions, as indexed by CoV values, and in these dimensions' contribution to segment differentiation, as indexed by both the dimensions' significance and the size of its corresponding standardized logistic regression coefficient within the model. Speakers for whom a dimension was a significant predictor of a contrast tended to have significantly lower CoV values for that dimension than speakers for whom the dimension was not a significant predictor ($p < 0.05$ for 13/16 comparisons), suggesting that speakers who distinguish segments along an articulatory dimension are less variable in their production of that dimension (Fig. 1). Additionally, a significant correlation was observed between CoV values and regression coefficient size across speakers for the majority of articulatory dimensions in the examined segments, with speakers who were less variable in their production of a dimension tending to have larger regression coefficients for that dimension (Fig. 2). Overall, the results of these analyses provide strong support for a relationship between interspeaker differences in articulatory variability and the use of dimensions to differentiate contrasting segment pairs, and specifically suggest that speakers are less variable in their production of dimensions that play a larger role in differentiating contrasting segment pairs.

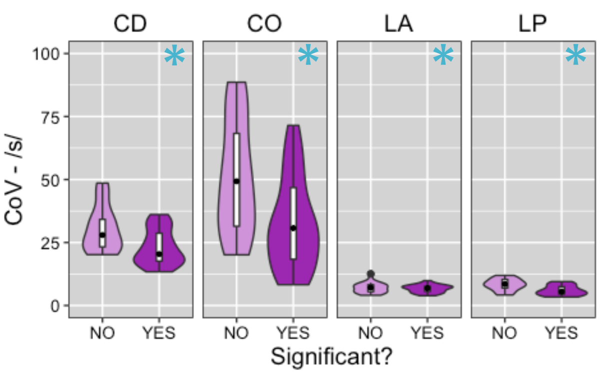

Fig. 1: Comparison of CoV values for /s/ across speakers for whom dimensions were (dark purple) and were not (light purple) predictors of the /s/~/ʃ/ contrast (* = significant difference at $\alpha = 0.05$).

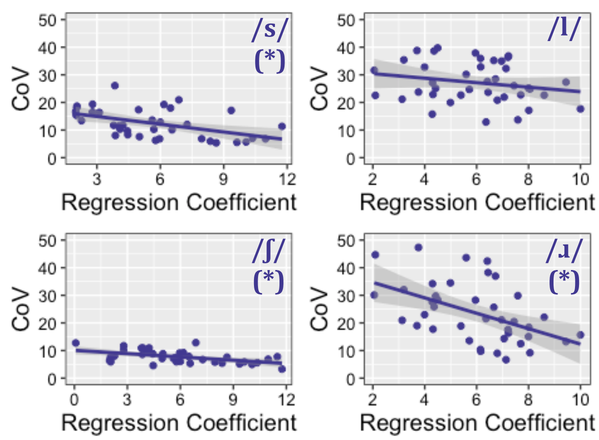

Fig. 2: Relationship between CoV and regression coefficients across speakers for constriction location in each segment (* = significant correlation at $\alpha = 0.05$)

References:

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