Statistical relationships in distinctive feature models and acoustic-phonetic properties of English consonants

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The relationship between segmental contrasts, often modeled as being composed of distinctive features, and actual acoustic-phonetic properties is complex and many-to-many. Contrasts may be cued by a multiple acoustic-phonetic properties, and acoustic-phonetic properties often cue multiple contrasts. This paper presents a hierarchical multivariate statistical model of the relationship between a suite of 11 acoustic measurements and various target feature systems. Measurements are taken from 10 repetitions of 16 English singleton consonants by 20 young adult native speakers of English in both onset and coda position in nonsense monosyllables, comprising a corpus of 6400 syllables. We fit and compare maximum likelihood models embodying three different category representations: 1) a model in which each consonant constitutes its own category; 2) a more general model with fewer degrees of freedom, in which consonants are represented as specifications of six features, and 3) a model in which consonants are represented as places on an ordinal, three dimensional space of manner, place, and voicing. The statistical model enables analysis of within-speaker and between-speaker sources of variability in consonant production, and constitutes a principled statistical method for comparing these different distinctive feature models.

Evaluating the model fits using the Bayesian Information Criterion, which balances goodness of fit against number of degrees of freedom in each model, indicates that the more specific, segmental model exhibits a goodness of fit increase which outweighs penalties associated with the increase in degrees of freedom in the segmental model. Examining the patterns of segment locations in various acoustic dimensions indicates two types of reasons for the overall results. 1) There are numerous segmental peculiarities across segmental categories. While some of the orthogonal feature structure can be found in the multidimensional acoustic space, there are pervasive peculiarities in individual segments which do not fit the expectations of the featural model. These results indicate a pervasive interaction between feature specifications which gives rise to acoustic peculiarities for each individual segment. 2) Within category structure also exhibits pervasive differences across segments, and thus the covariance structure between acoustic measures within one segment often does not generalize to other segments.

We will exemplify these patterns, discuss ways in which the more general models might be made to perform better, and discuss some implications the results have for the relationship between acoustic structure and phonological generalization.