Towards a Computational Articulatory Model of Spanish Phonology

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Many aspects of Spanish phonology remain poorly described within feature-based frameworks, in part because it is not well understood to what extent phonological features are grounded in the phonetic domain. In this paper, we introduce a computational model of Spanish phonology based on articulatory primitives (Browman & Goldstein 1992) that is currently being developed as an extension of the Task Dynamics Application (*TaDA*: Saltzman & Munhall 1989; Nam et al. 2004). Under this model, lexical items are represented as molecules of coordinated gestures. Hypotheses about phonological representations are tested by comparing the results of articulatory and acoustic simulations against phonetic data acquired from Spanish speakers producing the same utterances. Two phenomena of particular interest in Spanish phonological theory that have been examined using this methodology are intervocalic stop lenition and liquid neutralization.

A wide range of realizations are observed in the production of the Spanish stop series /b-d-g/ and /p-t-k/. This allophony is influenced by factors including speech rate, stress, context and individual speaker variation (Cole et al. 1999; Soler & Romero 1999; Ortega-Llebaria 2004), and has proven difficult to describe in terms of features. Under the articulatory framework proposed here, Spanish stops are modeled as a class of segments sharing a 'closed' constriction degree (that is, beyond the point of articulator contact) but differing in their exact target. The realized constriction degree is prone to variation as a result of articulatory and prosodic factors. TaDA simulations have demonstrated that intervocalic stop lenition can result from reduction of activation duration, such as that found in fast speech (Parrell 2009). The variable spirantization observed in Spanish intervocalic stop production can be modeled in TaDA as the result of undershoot when there is insufficient time to approximate the constriction target of the supraglottal or glottal articulators. The model also incorporates the finding that nasal assimilation is categorical for non-coronal nasal + consonant clusters, while gradient for coronals (Honorof 1999). This is currently implemented at the lexical phonological level; however, we discuss the possibility that such phenomena might also be modeled as the result of blending of invariant gestures at the implementation level.

Turning to liquid consonants, a variety of features have been proposed to describe the shared phonological behavior of Spanish /l-ɾ-r/, including [lateral], [trill] and [liquid] (Walsh-Dickey 1997), yet none of these primitives has proven adequate to capture the members of the class or describe the range of processes which these consonants participate in (Proctor 2009). The alternative hypothesis being examined in our work is that the Spanish liquids are best characterized as segments produced through the coordination of consonant-like tongue-tip gestures and vocalic tongue-body gestures (Giles & Moll 1975; Browman & Goldstein 1995). TaDA simulations based on these representations have successfully modeled /ɾ-r/ allophony (Hualde 2005) as variation in tongue tip stiffness, coda liquid neutralization (Quilis 1999) as variation in dorsal constriction location, and post-vocalic liquid deletion, coloring and lengthening (Quilis 1999) as resulting from the blending of co-produced tongue body gestures. Simulated articulatory and acoustic data are compared with those obtained in an ultrasound study of five speakers of American Spanish (Proctor 2010).

These experiments are described in the context of the broader research program whose goal is the development of a formal model of a Spanish articulatory phonology. We believe that Spanish TaDA provides a unique suite of tools with which to test and refine hypotheses about the phonology of Spanish against actual phonetic data.

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