Towards a Dynamic Computational Model of Portuguese Liquid Consonants

Many aspects of Portuguese 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. The liquid consonants /l/-/ʎ/-/ɾ/-/ʀ/ in particular, resist characterization in terms of distinctive features because of the great variation in their acoustic and articulatory realization. It is unclear why such a diverse group of sounds patterns together in the phonological organization of Portuguese and other languages (Walsh-Dickey 1997); neither has it been established what phonetic properties the members of the class might share (Ladefoged & Maddieson 1996). Better knowledge of the phonetic characterization of this group of sounds is therefore critical to our understanding of the nature of phonological representation.

In this paper, I introduce a computational model of Portuguese consonant phonology based on articulatory primitives (Browman & Goldstein 1992) being developed as an extension of the Task Dynamics Application (*TaDA*: Nam et al. 2004). Under this model, lexical items are represented as molecules of coordinated gestures. Hypotheses about phonological representations may be tested by comparing the results of articulatory and acoustic simulations against phonetic data acquired from Portuguese speakers producing the same utterances. Most importantly, by modeling liquid consonants in a gestural framework, we can appeal to general principles of dynamic organization of task-directed primitives (Saltzman & Munhall 1989) to account for their phonological behavior. Three phenomena of particular interest in Portuguese phonology which are being examined using this methodology are rhotic variation, coda liquid neutralization, and gestural organization in stop-liquid clusters.

A variety of features have been proposed to describe the shared phonological behavior of liquid consonants, including [lateral], [trill], [sonorant] and [liquid] (Walsh-Dickey 1997; Mateus & Pardal 2000), yet none of these primitives has proven adequate to capture the members of the class or their behavior in Portuguese (Mielke 2008; Proctor 2009). Crucially, feature-based models do not offer a principled account of the dynamic organization of phonological primitives.

The alternative hypothesis being examined in our work is that liquid consonants are prototypically characterized as segments produced through the coordination of tongue-tip and tongue-body gestures (Giles & Moll 1975; Browman & Goldstein 1995). TaDA simulations based on these representations have so far been used to model a variety of phenomena relating to liquid consonants in Romance, Germanic, Dravidian and Slavic. The Spanish /ɾ-r/ contrast has been modeled as primarily resulting from differences in tongue tip stiffness. Russian /r^{j}-r/ and /l^{j}-l/ contrasts have been modeled as primarily resulting from differences in the specification of the dorsal constriction location. Phonological phenomena associated with post-vocalic liquids, such as coda deletion (Quilis 1999) and coloring and lengthening of nuclei (Wiese 2001) have been described as the result of blending of co-produced tongue body gestures.

Portuguese presents a special challenge for accounts of liquid representation because of the great variety of rhotics used in different varieties and by different speakers (Cruz-Ferreira 1995).

Varieties of Portuguese which use uvular rhotics are especially problematic for feature-based accounts of rhoticity. In the gestural model being developed here, each of the liquid consonants of Portuguese are characterized by the presence of an intrinsic tongue body constriction. These consonants differ in their specifications for constriction location and degree, and the way in which the tongue body is coordinated with tongue-tip gestures. Rhotic variation – both synchronic and diachronic – is argued to result from changes in gestural constituency and coordination. Coda liquid neutralization is modeled as a change in the organization of gestural primitives with respect to syllabic nuclei. Constraints on segmental organization in Portuguese clusters are argued to result from issues relating to production and recoverability of concurrent gestures.

TaDA simulations are presented which capture many of the fundamental acoustic and articulatory properties of Portuguese liquids, and compared with preliminary phonetic data. These models are described in the context of a broader research program whose goal is the development of a formal model of a Portuguese articulatory phonology.

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