Articulatory-based subfeatural representations: tongue-tip perturbation made by high vowels

Hayeun Jang (*University of Southern California*)

Using qualitative simulations, this study shows how the articulation of high vowels /i, u/ affects an overlapping coronal constriction. In order to capture the cross-linguistic implicational hierarchy among high vowels as triggers of coronal palatalization on the basis of phonological effects of the tongue-tip perturbation, I propose a subfeature ⟦*x* distributed⟧.

Cross-linguistically, high vowels tend to trigger coronal palatalization and non-front high vowels trigger palatalization only on coronal consonants (Bateman 2007, 2011; Bhat 1978; Kochetov 2011). In the traditional tongue-body-based view of vowels, coronal palatalization is understood as a rearward shift in the contact point of the tongue tip from the dental or alveolar to the palatal region. This naturally leads to an expectation that non-front high vowels with a position farther back on the tongue body will trigger coronal palatalization more frequently than front high vowels would. In fact, however, non-front high vowels trigger coronal palatalization only when front high vowels are also triggers in the same language (Bateman 2007). As shown in Table 1, there is no language in which only non-front high vowels trigger coronal palatalization. This leads to an implicational hierarchy among high vowels as triggers of coronal palatalization: if non-front high vowels trigger coronal palatalization, then so will front high vowels. The tongue-body-based features of vowels ([±high], [±back]) cannot handle this typological implicational hierarchy.

Table 1. Trigger vowels of coronal palatalization and languages

High		Languages
Front	Non-front	
✓		Apalai, Basque, Carib, Fongbe, Hausa, Nupe, Romanian
✓	✓	Coatzospan Mixtec, Maori, Sentani, Tohono O'Odham
	✓	None

This study used a biomechanical 3D tongue model of Artisynth (Lloyd et al. 2010) to show perturbing influence of the following /i/ and /u/ on an overlapping alveolar constriction. An alveolar constriction and the following vowel were simulated to begin synchronously (Löfqvist & Gracco 1999) and the activation duration of tongue muscles for the following vowel was set to double the length of that of an alveolar constriction (Fowler 1980). The simulations were conducted by manipulating the activation values of tongue muscles in the static jaw-hyoid-tongue model of Artisynth. Tongue muscles were selected based on anatomical studies of the tongue (Hardcastle 1974; Epstein et al. 2002).

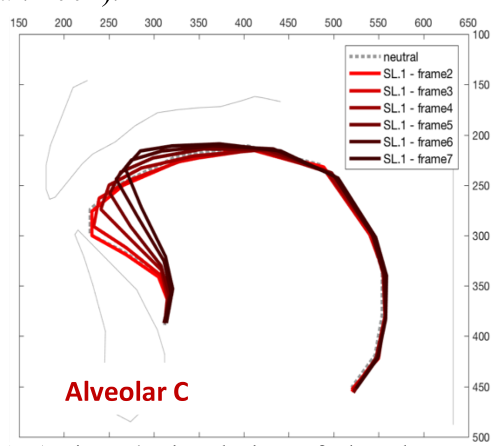

Figure 1. Artisynth simulation of alveolar constriction

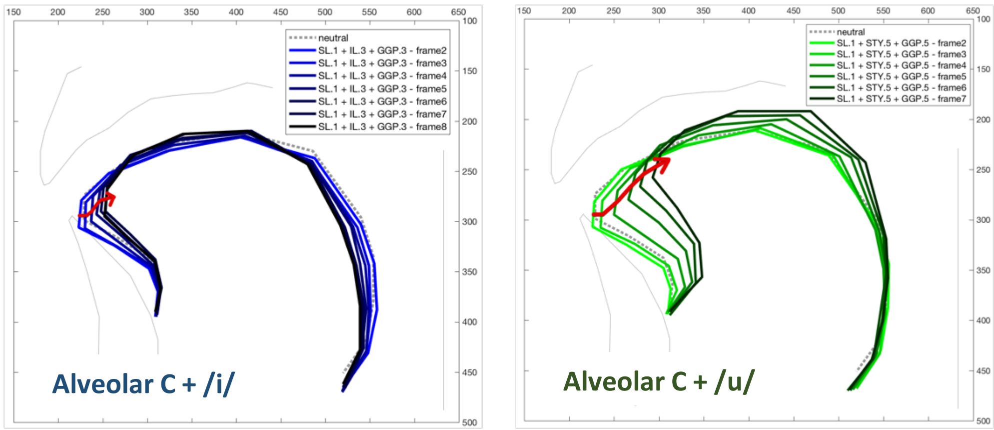

Figure 2. Artisynth simulations of alveolar constriction with the following /i/ vs. /u/

The simulated tongue configurations were compared at the maximum point of alveolar constriction. Figure 2 shows the effects on alveolar constriction of additional activated tongue muscles for the following /i/ and /u/. The movement trajectory of the tongue tip in the corresponding alveolar constriction is represented by red arrows. Compared to the isolated alveolar constriction in Figure 1, the movement angle of the tongue tip becomes smaller in both following vowel contexts, but the degree of change is greater when an alveolar constriction is followed by /i/ than by /u/. The tongue tip position is more anterior with the following /i/ than with /u/ due to different tongue body positions as articulatory targets of the vowels.

The simulation results imply that the articulatory motivation of coronal palatalization triggered by high vowels can be explained as tongue tip perturbing influence of the high vowels: lowering the tongue tip. The asymmetry of high vowels as triggers of coronal palatalization is explained on the basis of different degrees of perturbing influence on a coronal constriction: the additional activations of tongue muscles for the articulation of /i/ show a greater degree of tongue tip lowering compared to those for the articulation of /u/.

Since the asymmetry of high vowels as triggers of coronal palatalization is emergent from coarticulatory effects (competition of overlapping coronal and vocalic constrictions), subfeatural representations could be a good featural approach to account for the asymmety of high vowels. Unlike the perceptual subfeatures for outputs in Lionnet (2016, 2017), the subfeature proposed in this study ⟦x distributed⟧ (0< x <1) for high vowels is articulatorily distinct and it is assumed to be specified in the underlying representations of segments. Featurally, both front and non-front high vowels are unspecified for [distributed]. Subfeaturally, however, they are ⟦distributed⟧ and the subfeatural values of front high vowels are higher than those of non-front ones as in (1).

(1) [+high, -back]⟦x distributed⟧ & [+high, +back]⟦y distributed⟧, where $x \succ y$

The implicational hierarchy of high vowels as triggers of coronal palatalization (front high vowels > non-front high vowels) can be explained by subfeatural co-occurrence constraints in (2) that refer to subfeatural values of high vowels in (1) in a stringent way.

(2) *⟦<1dist⟧⟦≥x dist⟧ No ⟦dist⟧ sequences with values lower than 1 and equals/exceeds x.
*⟦<1dist⟧⟦≥y dist⟧ No ⟦dist⟧ sequences with values lower than 1 and equals/exceeds y.

Inasmuch as articulatory properties of segments are specified in input representations, the proposed subfeature can be seen as a type of Gradient Symbolic Representations (Smolensky & Goldrick 2016). The gradient symbolic representations for high vowels like $/i/_{[dist].7}$ and $/u/_{[dist].3}$ are assumed to be emergent from muscular activations as subsymbolic representations.