Andrew Wedel
University of Arizona

Title: Simulating the evolution of patterns in lexical contrast

Systems of phonological contrast are constrained in a variety of ways, two of which will be of interest here: first, phonologies exhibit only a subset of cross-linguistically attested contrasts, formed from a subset of possible features in combination. Second, crosslinguistic and intra-lexicon frequencies are correlated, i.e., when a phonology allows a crosslinguistically rare element, that element tends to appear less frequently in the lexicon than the more common elements allowed by that phonology (Ferguson 1963, Greenberg 1966, Frisch 1996).

Optimality Theory (OT, Prince and Smolensky 1993) accounts for the first observation through language-specific ranking of Faithfulness over Markedness, defining the particular dimensions of the contrast-space that can be exploited by a given language (Kirchner 1997). However, as standard OT constraints are not sensitive to contrast, unconstrained ranking of OT constraints predict unattested grammars that allow little or no contrast. Within OT, Dispersion Theory (DT; Flemming 1995) addresses this issue through the introduction of contrast-sensitive Dispersion constraints, which are violated when the degree of contrast along a given dimension falls below a defined boundary. However, the mechanisms of OT and DT cannot easily account for the observation that even if a crosslinguistically rare element is allowed by a grammar, it tends to occur less frequently than crosslinguistically common elements.

This paper presents evidence that both of these patterns can be accounted for diachronically through indirect selection over phonetic variants (cf. Lindblom et al 1984). This work is based on the assumptions that 1) lexical categories are richly specified for phonetic detail that can be updated through experience (Pierrehumbert 2001), 2) a perceived utterance updates the content of a lexical category only if it is identified as an example of that lexical category (Pierrehumbert 2001), and 3) that usage of an articulatory motor program creates a positive feedback loop, i.e., deployment of an articulatory motor program in production increases the probability that that program will be used again in future productions (Browman and Goldstein 1988, 1990; Saltzman and Munhall 1989; Byrd 1995; Shadmehr and Bashers-Krug 1997). The value of exploring the third assumption has been suggested by results of a previous study (Wedel, to appear), in which abstract cross-category phonological similarity served to provide feedback to target assembly production.

The ramifications of these assumptions were investigated through computer simulation, in which a speaker/hearer pair (cf. Batali 2002) alternately communicate the contents of their lexicons to each other, where stochastic variation in production and perception provides the background variation upon which selection can act. When a hearer succeeds in categorizing an output, he/she is influenced to reproduce that category in a similar way in a subsequent round, resulting in eventual convergence of the two lexicons (cf. de Boer 2000). However, when a given output-shape is either far from any category, or too close to multiple categories, the consistency of its categorization is low from round to round, with the result that its influence on the production of any given category is diluted. This feedback loop between robust categorizability and subsequent production results in continuous, indirect selection pressure on lexical categories to be sufficiently contrastive.

In control simulations lacking articulatory motor feedback to production, the speaker/hearer lexical categories evolve ‘gratuitous contrast’, in which lexical forms range randomly over the entire contrast space provided in the simulation. However, when motor feedback is allowed to influence production patterns, the speaker/hearer lexical categories gradually evolve to share as many feature-types and sequences as possible, while preserving adequate contrast. Finally, when production or perception biases against certain features or feature combinations are introduced into the simulation, the pairs’ lexicons tend to evolve to avoid these ‘less-fit’ elements. However, when avoidance of all less-fit elements would result in insufficient contrast, the speaker/hearer lexicons evolve to exploit a subset of the available less-fit elements, but at a lower frequency than fitter elements.

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