

A Gradient Treatment of Contrast: Repercussions for Implicational Universals

This paper describes a computational model of the emergence of a new phoneme over time. It begins with the observation that palatalized variants tend to occur before high, front vowels, either in an allophonic relationship with underlyingly plain forms, or as the neutralizing products of an otherwise contrastive relationship (e.g., Japanese: [ʃi], [tʃi] versus *[si], *[ti]). From this distributional evidence the following typological generalization is made: if palatal variants exist in a given language, their environments *must* include the highest, frontest vowels. This “universal” is rooted in the phonetic details of articulation and perception (see Guion 1998, and references therein), and is also typically taken as the basis for sound changes that produce palatalized segments, such as the well-studied case of Jers deletion in Slavic (e.g., Townsend & Janda 1996).

The present model assumes such a sound change, represented by the hypothetical minimal pair in (1). The initial-state grammar is one of phonetic allophony. The (covert) phonetic palatalization on the velar stop adjacent to the high, front vowel /ɪ/ becomes a phonological feature once the conditioning environment is lost (e.g., Matthews 1960, Andersen 1976, Shevelov 1979).

(1) dak_ʊ > dak dak_ɪ > dak^j

Under categorical definitions of phonemehood, (1) establishes an immediate contrast between /k^j/ and /k/. This definition becomes less useful, however, when the full set of words in which the two sounds occur is considered. In fact, without additional changes, the distribution of /k^j/ is highly restricted, and to non-natural contexts. The present model supplies a full trajectory from this initial change to a set of possible end-state grammars by operating over lexicon-sized collections of tokens.

As above, it is assumed that novel phonemes arise through the transformation of pre-existing allophones. This transformation process is additionally modeled as an incremental re-categorization of a set of ambiguous tokens (cf. Ohala 1981). A competition takes place for inclusion in one phoneme category or the other (see, e.g., Luce and Galanter 1963, Nosofsky 1988). The choice will depend on the relative acoustic similarity of the velar token to previously classified members of the /k^j/ and /k/ phoneme categories (see Pierrehumbert 2003). Additionally, the learner’s phonotactic expectation for one segment over another in the given word environment asserts a (smaller) top-down influence (e.g., Dupoux et al. 1999, Vitevitch et al. 1999). This is the mechanism that allows the new palatal segment to spread to “non-natural” environments and thus, for a contrastive relationship to develop at all.

The model provides quantitative predictions regarding the exact outcome of the palatalizing sound change. This turns out to be a relatively simple function of the pre-change [k-Vowel] token distribution, namely, the ratio of the tokens containing naturally palatalizing vowels (i, ɪ, e), to those containing non-palatalizers. Probabilistic token-by-token sound change produces a gradient, rather than a categorical outcome. Assessing contrast along a continuum (see Hume and Johnson 2003, Hall 2009) allows a coarse-grained division of the space of possibilities. High numbers of both types of tokens lead to the most completely contrastive distribution (Lexicon A); a large ratio between non-palatalizing and palatalizing, to distributions approaching contextual neutralization (Lexicon B); and low numbers of non-palatalizing, to near complementarity (Lexicon C). See Fig. 1.

Unnatural and arbitrary phonotactic associations emerge, but are sharply limited both by the size of the lexicon and the local nature of the sound changes. “Anti-Natural” distributions which violate the implicational relationship in the categorical sense are absent. However, under a continuum interpretation of the universal, unpredicted asymmetries emerge regularly (e.g., greater numbers of k^j_ɪ than k^j_i tokens). The status of such a distribution, however, is unclear under the terms of generative theory. These simulations thus serve several goals of linguistic theory: providing typological predictions for a model of sound change, and forcing more explicit characterizations of proposed grammatical principles. Additionally, this work serves as an existence proof both for the falsifiability of emergentist theory, as well as non-UG based mechanisms for avoiding over-generation.

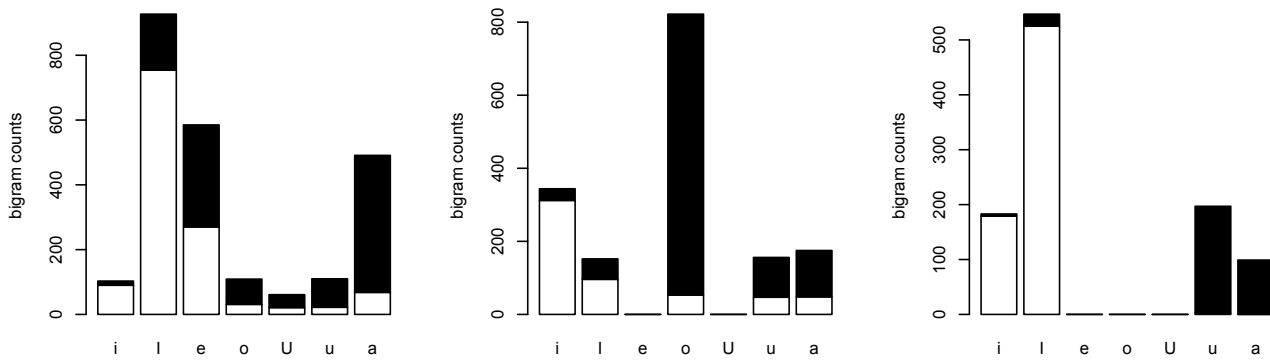


Figure 1: white bars: k^jV token counts; black bars: kV token counts. From left to right: Lexicon A; Lexicon B; Lexicon C

References

- Andersen, H. 1976. Perceptual and conceptual factors in abductive innovations. In *International Conference on Historical Phonology*, 1–22. Ustronie, Poland: The Hague.
- Dupoux, E., K. Kakehi, Y Hirose, C. Pallier, and J. Mehler. 1999. Epenthetic vowels in Japanese: a perceptual illusion. *Journal of Experimental Psychology: Human Perception and Performance* 25:1568–1578.
- Guion, S.G. 1998. The role of perception in the sound change of velar palatalization. *Phonetica* 55:18–52.
- Hall, Kathleen Currie. 2009. A probabilistic model of phonological relationships from contrast to allophony. Doctoral Dissertation, The Ohio State University.
- Hume, E., and K. Johnson. 2003. The impact of partial phonological contrast on speech perception. In *15th International Congress of Phonetic Sciences*.
- Luce, R.d., and E. Galanter. 1963. Discrimination. In *Handbook of mathematical psychology*, ed. R. D. Luce, R. R. Bush, and E. Galanter, 191–243. New York: John Wiley and Sons, Inc.
- Matthews, W.K. 1960. *Russian historical grammar*. University of London, Athlone Press.
- Nosofsky, Robert M. 1988. Exemplar-based accounts of relations between classification, recognition, and typicality. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 14:700–708.
- Ohala, J. 1981. The listener as a source of sound change. In *Parasession on Language and Behavior: Chicago Linguistics Society*, ed. C.S. Masek, R.A. Hendrick, and M.F. Miller, 178–203. Chicago.
- Pierrehumbert, J.B. 2003. Phonetic diversity, statistical learning, and acquisition of phonology. *Language and Speech* 46:115–154.
- Shevelov, G.Y. 1979. *A historical phonology of the Ukrainian language*. Heidelberg.
- Vitevitch, M.S., P.A. Luce, D.B. Pisoni, and E.T. Auer. 1999. Phonotactics, neighborhood activation and lexical access for spoken words. *Brain and Language* 68:306–311.