Towards a measure of the optimization of natural vowel systems

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Computational simulations of the emergence and evolution of phonological systems have shown that, given sufficient time, organizations of the articulatory space emerge in which phonemes are optimally distinctive (e.g. Steels, 1997; de Boer, 2000; Oudeyer, 2005). However, there has been little investigation into the typological description of articulatory optimization across the world's languages. It is not known, for example, how optimized natural vowel systems actually are, or whether the vowels of, for example, English, are more or less distinctive than those of, for example, Swahili.

In this paper I introduce a methodology for measuring the optimization of vowel systems, which proceeds in four steps: first, we measure the formant frequencies of a language's monophthongs; second, we plot the vowels in a perceptual vowel space; third, following Liljencrants and Lindblom (1972), we calculate the potential energy in the system using the inverse-square law from theoretical physics; finally, we use Monte Carlo techniques to measure the non-randomness of the system.

Using audio recordings from the UCLA Phonetics Lab archive, this method has been applied to 100 languages. The results suggest that there is a high level of variation in the optimization of vowel systems. I also explore the potential for cross-linguistic correlational studies using this measure, which could reveal whether external social pressures affect the emergent state of vowel systems.

References

de Boer, B. (2000). Self-organization in vowel systems. *Journal of Phonetics*, 28(4):441–465.

Liljencrants, J. and Lindblom, B. (1972). Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language*, 48(4):839–862.

Oudeyer, P.-Y. (2005). The self-organization of speech sounds. *Journal of Theoretical Biology*, 233(3):435–449.

Steels, L. (1997). The synthetic modeling of language origins. *Evolution of Communication*, 1(1):1–34.