Modeling self-organization in consonant inventories

Jan-Willem van Leussen <j.w.vanleussen@uva.nl>, University of Amsterdam

Although the phonemes employed by different languages vary considerably in number and quality, many striking patterns (*universals*) have also been found in phoneme inventories. In recent years, increasingly sophisticated computer simulations (e.g. Liljencrants and Lindblom 1972, De Boer 2001) have shown that many universal properties of vowel systems can be explained through anatomical and communicative constraints, rather than innate preferences.

These computer models have yielded phonetically accurate results for vowel systems, but accurate modeling of consonant universals has proven less successful. Most computational models of consonant systems use simplified or phonologically-based representations of segments (e.g. Lindblom and Maddieson 1988, Mielke 2005). Boersma and Hamann (2008) show that common sibilant inventories arise from a tension between ease of articulation and auditory distinctiveness, and suggest that this tension is also responsible for other consonant universals. Van Leussen (2009) described a computer model of consonant inventories, based on the articulatory synthesizer of Boersma (1998), in which inventories of maximally distinct [əCə] words were synthesized. The results of simulations performed in this model suggest that common consonantal patterns cannot be fully explained as emergent from articulatory ease and auditory distinctiveness.

I therefore propose an extended version of the model of van Leussen (2009), in which simulated speakers (*agents*) play a consonant 'imitation game', inspired by the vowel simulations of de Boer (2001). The agents do not explicitly aim to maximally differentiate their segment inventories, but simply try to minimize the number of misapprehensions when imitating one another. Using this model, the influence of additional factors, such as learnability and reuse of certain muscle gestures and the concept of *quantality* (Stevens 1972), is explored with respect to consonant inventories.

Bibliography

- de Boer, B. (2001). *The origins of vowel systems.* Oxford University Press.
- Boersma, P. (1998). *Functional phonology.* Holland Academic Graphics, Den Haag.
- Boersma, P. and Hamann, S. (2008). The evolution of auditory dispersion in bidirectional constraint grammars. *Phonology*, 25(02): 217–270.
- van Leussen, J.W. (2009). *Investigating consonant inventories with acoustic and articulatory models*. Master's thesis, University of Amsterdam. Available at http://www.fon.hum.uva.nl/theses.html
- Liljencrants, J. and Lindblom, B. (1972). Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language*, 48:839–862.
- Lindblom, B. and Maddieson, I. (1988). Phonetic universals in consonant systems. In *Language, speech and mind. Studies in honour of Victoria A. Fromkin*, chapter 6, pages 62–78.
- Mielke, J. (2005). Modeling distinctive feature emergence. In *Proceedings of the West Coast Conference on Formal Linguistics*, volume 24, pages 281–289.
- Stevens, K. (1972). The quantal nature of speech**.** In: EE David, Jr and PB Denes, (Eds), *Human communication: a unified view,* pages 51–66. McGraw-Hill Companies.