Testing the Acoustic Adaptation Hypothesis with GIS and spatial regression models

Christophe Coupé, Laboratoire Dynamique du Langage, CNRS – University de Lyon

As other scientific fields, linguistics is witnessing the advent of big data. Databases like the WALS (Dryer & Haspelmath, 2011), PHOIBLE (Moran McCloy & Wright, 2014) or LAPSyD (Maddieson et al., 2013) have led to a burst of investigations based on hundreds if not thousands of languages. In some, correlations and possible causal relationships are studied between non-linguistic and linguistic variables. Departing from a classical perspective of language as an autonomous system, these studies emphasize that it is actually rooted in biological, social and ecological settings, and display adaptation to them: the distribution of tonal languages may be explained by climatic factors (Everett, Blasi & Roberts, 2015) or specific haplotypes (Dediu, 2011), language overall complexity by social structure (Lupyan & Dale, 2010), the size of phonemic inventories by speakers' group size (Hay & Bauer, 2007, but see Donohue & Nichols, 2011), or the presence of ejective consonants by altitude (Everett, 2013). Atkinson (2011) also proposed that the distribution of phonemic diversity on the planet derived partly from *Homo sapiens*' colonization of the continents, which led to controversy. These authors build on former approaches in linguistics (Munroe, 1996; 2009; Nettle, 1996) and anthropology (Nettle, 2009).

In these studies, statistical approaches have to take into account the genealogical and spatial relationships between languages, which undermine the independence of statistical units. Considering random effects (Jaeger, Graff, Croft and Pontillo, 2011) or looking for correlations between genealogical, geographic and typological distances (Dediu & Ladd, 2007) is possible, yet these techniques seem to better address the grouping of languages into families than their spatial distribution.

We present a test of the "acoustic adaptation hypothesis" (AAH) to illustrate the use of spatial regression, which has gained popularity in fields such as econometrics (Anselin, 2010). The AAH suggests that the structure of vocal communication signals is adapted to the animals' habitat to limit degradation during propagation, and has been tested in various species (Ey & Fischer, 2009). Maddieson (2011) has argued for AAH in humans based on a positive correlation between i) temperate climate and ii) consonant inventory and syllable complexity. We revisit his proposal with a precise investigation based on 429 languages, their phonemic inventories, the tree coverage of their geographic areas, their number of speakers and amount of language contact. We focus on various spatial models, some with random effects, and how they may support a small but significant acoustic adaptation.

(396 words)

Preference: oral presentation (and poster if not possible)

References:

Anselin, L. (2010). "Thirty years of spatial econometrics". *Papers in Regional Science* 89(1): 3–25.

Atkinson, Q. D. (2011). Phonemic diversity supports a serial founder effect model of language expansion from Africa. *Science* 332: 346–349.

Dediu, D. (2011). Are Languages Really Independent from Genes? If Not, What Would a Genetic Bias Affecting Language Diversity Look Like? *Human Biology* 83(2):279-296.

Dediu D. & Ladd, D. R. (2007). Linguistic tone is related to the population frequency of the adaptive haplogroups of two brain size genes, ASPM and Microcephalin. *PNAS* 104(26): 10944–10949.

Donohue, M. & Nichols, J. (2011). Does phoneme inventory size correlate with population size? *Linguistic Typology* 15(2): 161-170.

Dryer, M. S. & Haspelmath, M. (2011). *The World Atlas of Language Structures Online*. Available at http://wals.info/.

Everett, C. (2013). Evidence for direct geographic influences on linguistic sounds: The case of ejectives. *PLoS ONE* 8(6):e65275.

Everett, C., Blasi, D. E. & Roberts, S. G. Roberts (2015). Climate, vocal folds, and tonal languages: Connecting the physiological and geographic dots. *PNAS* 112(5): 1322–1327.

Ey, E. & Fischer, J. (2009). The “acoustic adaptation hypothesis” – A review of the evidence of birds, anurans and mammals. *Bioacoustics: The International Journal of Animal Sound and its Recording* 19(1-2): 21-48.

Hay, J. & Bauer, L. (2007). Phoneme inventory size and population size. *Language* 83: 388–400.

Jaeger, T. F., Graff, P., Croft, B. & Pontillo, D. (2011). Mixed effect models for genetic and areal dependencies in linguistic typology: Commentary on Atkinson. *Linguistic Typology* 15(2): 281-319.

Lupyan, G. & Dale, R. (2010). Language structure is partly determined by social structure. *PLoS ONE* 5(1): e8559.
Hay, J. & Bauer, L. (2007). Phoneme inventory size and population size. Language 83: 388–400.

Maddieson, I. (2011). Phonological complexity in linguistic patterning. *Proc. of the 17th International Congress of Phonetic Sciences*, Hong Kong, China, August 17-21.

Maddieson, I., Flavier, S., Marsico, E., Coupé, C. & Pellegrino, F. (2013). LAPSyD : Lyon - Albuquerque Phonological Systems Database. *Proc. of the 14th Interspeech Conference,* Lyon, France, August 25-29.

Moran, S., McCloy, D. & Wright, R. (eds.) (2014). *PHOIBLE Online*. Leipzig: Max Planck Institute for Evolutionary Anthropology. (Available online at http://phoible.org, Accessed on 2015-02-05).

Munroe, R. (1996). Cross-cultural correlates of the consonant-vowel (CV) syllable. *Cross-Cultural Research* 30: 160-83.

Munroe, R. L., Fought, J. G. & Macaulay, R. K. S. (2009). Warm Climates and Sonority Classes: Not Simply More Vowels and Fewer Consonants. *Cross-Cultural Research* 43(2): 123-133.

Nettle, D. (1996) Language Diversity In West Africa: An Ecological Approach. *Journal of Anthropological Archaeology* 15: 403-438.

Nettle, D. (2009). Ecological influences on human behavioural diversity: A review of recent findings. *Trends Ecol. Evol.* 24(11): 618–624.