City Research Online

City St George's, University of London

Citation: Mukherjee, A., Baronchelli, A., Loreto, V., Puglisi, A. & Tria, F. (2010). Aging in the Emergence of Linguistic Categories. In: Fellermann, H., Dörr, M., Hanczyc, M. M., Laursen, L. L., Maurer, S. E., Merkle, D., Monnard, P-A., Støy, K. & Rasmussen, S. (Eds.), Artificial Life XII: Proceedings of the Twelfth International Conference on the Synthesis and Simulation of Living Systems. (pp. 589-590). USA: MIT Press. ISBN 9780262290753

This is the published version of the paper.

This version of the publication may differ from the final published version. To cite this item please consult the publisher's version.

Permanent repository link: https://openaccess.city.ac.uk/id/eprint/13928/

Copyright and Reuse: Copyright and Moral Rights remain with the author(s) and/or copyright holders. Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge, unless otherwise indicated, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way. For full details of reuse please refer to City Research Online policy.

City Research Online: http://openaccess.city.ac.uk/ publications@citystgeorges.ac.uk

Aging in the Emergence of Linguistic Categories

A. Mukherjee[1], A. Baronchelli[2], V. Loreto[1,3], A. Puglisi[4,3] and F. Tria[1]

[1]Complex Networks Lagrange Laboratory, ISI Foundation, Torino, Italy
[2]Departament de Fisica i Enginyeria Nuclear, Univ. Politecnica de Catalunya, Barcelona, Spain
[3]Sapienza University of Rome, Physics Department, Rome, Italy
[4]CNR-INFM-SMC, Rome, Italy

Extended Abstract

Categories are fundamental to recognize, differentiate and understand the environment. They are meant to provide a coarse-grained description of the world we perceive. For instance, few "basic color terms", present in natural languages, coarse-grain the infinite number of different colors that humans can possibly perceive. An important question is whether categories are a manifestation of an underlying structure of nature or an emergent property of the complex interactions among individuals themselves as well as with the environment. The current work attempts to seek for an answer to this question by modeling a population of individuals who co-evolve their form-meaning repertoire by playing elementary language games.

The Category Game is a computational model designed to investigate how a population of individuals can develop a shared repertoire of linguistic categories, i.e. co-evolve their own system of symbols and meanings, by playing elementary language games (Puglisi et al., 2008). Consensus is reached through the emergence of a hierarchical category structure made of two distinct levels: a basic layer, responsible for fine discrimination of the environment, and a shared linguistic layer that groups together perceptions to guarantee communicative success. The only parameter of the model is the Just Noticeable Difference (JND) of the agents defined as the average detectable difference between two stimuli. Remarkably, the number of linguistic categories turns out to be finite and small, as observed in natural languages, even in the limit of an infinitesimally small JND.

The Category Game also allowed to focus on the question of the origins of *universal* categorization patterns across cultures. In this framework, it has recently been possible to reproduce the outcomes of the World Color Survey (WCS) (Baronchelli et al., 2010). Through the Category Game model, a certain number of non-interacting populations has been simulated, each one developing its own synthetic language. Universal categorization patterns have been discovered among populations whose individuals are endowed with the human JND function, describing the resolution power of the human eye to variations in the wavelength of the incident light (Long et al., 2006). It turns out that a simple perceptual constraint shared by all humans, namely the human Just Noticeable Difference (JND), is sufficient to trigger the emergence of universal patterns that unconstrained cultural interaction fails to produce.

A wide open question about the emergence of linguistic categories, and more generally of shared linguistic structures, concerns the role of the timescales. How to reconcile the apparent static character of most of the linguistic structures we learn with the evidences of a fluid character of modern communication systems? Here we report about preliminary studies that suggest how the structure of linguistic categories undergoes *aging* (Henkel et al., 2006): at relatively early stages changes are very frequent but they become progressively more rare as the system ages; a phenomenon whose intensity increases with the population size. From this point of view shared linguistic conventions would not emerge as attractors of a language dynamics, but rather as metastable states.

References

Baronchelli, A., Gong, T., Puglisi, A., and Loreto, V. (2010). Modelling the emergence of universality in color naming patterns. *PNAS*, 107:2403–2407.

Henkel, M., Pleimling, M., and Sanctuary, R. (2006). Statistical physics of ageing phenomena and the glass transition. *Journal of Physics: Conference Series*, 40(1).

Long, F., Yang, Z., and Purves, D. (2006). Spectral statistics in natural scenes predict hue, saturation, and brightness. *PNAS*, 103(15):6013–6018.

Puglisi, A., Baronchelli, A., and Loreto, V. (2008). Cultural route to the emergence of linguistic categories. *PNAS*, 105:7936.