

**ON THE ORIGIN OF UNIVERSAL CATEGORIZATION PATTERNS:
AN *IN-SILICA* EXPERIMENT**

ANDREA BARONCHELLI

*Departament de Física i Enginyeria Nuclear, Univ. Politécnica de Catalunya, C. Nord B4,
08034 Barcelona, Spain
andrea.baronchelli@upc.edu*

TAO GONG

*Dept. of Linguistics, Max Planck Institute for Ev. Anthropology, Deutscher Platz 6,
04103 Leipzig, Germany
tao_gong@eva.mpg.de*

VITTORIO LORETO

*Dip. di Fisica, Sapienza Università di Roma, P.le Aldo Moro 5, 00185 Roma, Italy
and Complex Networks Lagrange Laboratory, ISI, Torino, Italy
vittorio.loreto@roma1.infn.it*

ANDREA PUGLISI

*CNR-INFM-SMC and Dip. di Fisica, Sapienza Università di Roma, P.le Aldo Moro 5,
00185 Roma, Italy
andrea.puglisi@roma1.infn.it*

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, Baronchelli, & Loreto, 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. As in pioneering work on the coevolution of language and meaning (Steels & Belpaeme, 2005), finally, the shared categorization is reached through pure cultural negotiation, but in the Category Game the individuals, whose percep-

tual channel is for simplicity monodimensional, are additionally able to categorize a continuum environment. The analogy with color categorization is therefore natural (Steels & Belpaeme, 2005; Puglisi et al., 2008), even though of course computational modeling implies a large number of (even drastic) simplifications.

Here we focus on the (much debated (Lakoff, 1987)) question of the origins of *universal* categorization patterns across cultures. In particular, we report on an *in silico* experiment pointing out that cultural and linguistic interaction can induce universal patterns in categorization provided that human neurophysiology is taken into account (Baronchelli, Gong, Puglisi, & Loreto, 2009). We simulate, through the Category Game model, a certain number of non-interacting populations each one developing its own synthetic language. We find universal categorization patterns 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, Yang, & Purves, 2006). We furthermore show that, on the contrary, populations whose individuals' JND is uniform do not exhibit any signature of universality. In particular we repeat the same statistical analysis performed in (Kay & Regier, 2003) and we find that the difference between these two classes of simulated populations is in striking agreement with the difference between the experimental World Color Survey data and their randomized counterparts.

Remarkably, the model we present (i) incorporates a true feature of human neurophysiology (i.e. the human hue JND), and produces results (ii) testable against and (iii) in agreement with experimental data. In addition, the connection between the hypothesis and the results of the discussed experiment is particularly transparent, since the Category Game, originally inspired by experiments employing embodied robots, was designed to be as simple as possible.

References

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