EXPLAINING UNIVERSAL COLOUR CATEGORIES THROUGH A CONSTRAINED ACQUISITION PROCESS[1].

Joris Bleys [a] Tony Belpaeme [b]

[a] *Vrije Universiteit Brussel, Artificial Intelligence Lab, Pleinlaan 2, 1050 Brussels*
[b] *University of Plymouth, A318 Portland Square, Plymouth, PL4 8AA, UK*

1 Introduction

Colour categories, for example the thing you think of when hearing "red", are special compared to other categories and concepts, in the sense that they seem to be *universal*. No matter who you are —a tribal hunter-gatherer in the forests of Papua New Guinea or an highly educated Belgian— or where you live —on the barren Alaskan tundra or between lush jungle vegetation— , if you have normal colour vision you will have colour categories that resemble the colours designated by the English terms white, black, red, green, yellow, blue and so forth. This tendency was first reported by [1] and later reconfirmed in large-scale study called the world color survey [2].

The fact that the same colour category typology is found across all cultures has often been explained as a genetically determined universal. As humans across the world share the same "hardware" (everyone having normal colour vision has trichromatic colour perception and has the same neural pathway configuration), it is only to be expected that the same colour categories are found across the world. However, this has recently been challenged. There is quite some variance in colour categories: the number and location of our fingers is genetically determined and, except for mutations, never varies. This is not so with colour categories: they do vary; only when studied from a meta-level a certain universal pattern can be observed in colour category typology. Even more, some studies have shown that colour categories are under the influence of language [3]. The language you speak, and specifically the colour terms in that language, seem to have an influence on your colour categories.

As a yardstick for the cognitive model we present here, we use the results of Kay and Regier [2] who have compiled overview statistics of field data of the World Color Survey (WCS). During the WCS informants from 110 non-industrialised societies were asked to name a set of colour cards. From those experiments a chart was compiled giving an overview of linguistic colour categories across those 110 societies. Figure 1 shows a histogram: the floor plane is an ordered colour chart (ranging from red, over yellow, green, blue to purple on the hue axis, and ranging from light to dark colours on the value axis) and the z-axis shows the number of informants having a colour category for a particular colour.

2 The model and simulations

We have built a computational model to study the hypothesis that the universal character of colour categories is *not* caused by a genetic coding mechanism, but instead caused by a cultural acquisition process: one learns colour categories from one's peers. This is controversial, as cultural acquisition is considered to be arbitrary: every society is expected to have different colour categories. So it is seems counterintuitive to explain the universality of colour categories with an acquisition process.

The model is agent-based and builds on the *language game* paradigm [4]: agents acquire colour categories and colour terms while communicating with each other about colour. The agents develop a set of categories and a repertoire of terms with which they can communicate about colour. During the learning fase, the language is allowed to influence the categorisation and vice versa (see also [5]).

[1]This is an extended abstract of Belpaeme, T. and Bleys, J. (2005) Explaining universal colour categories through a constrained acquisition process. *Adaptive Behavior*. 13(3). In press.

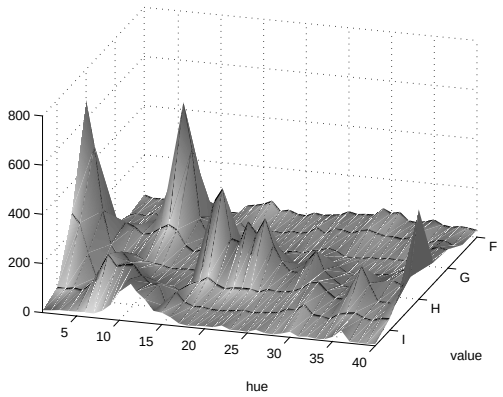

Figure 1: Overview of the World Color Survey, data from [2].

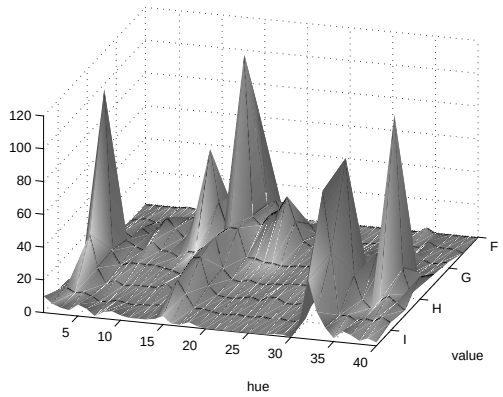

Figure 2: Simulation result.

We have run 105 simulations, each started with a different random seed. One might think of this as 105 different societies, each developing their own categories and language for representing colour. Next, we collect all results of the simulation and apply a statistical procedure identical to the one used in the WCS [2]. Figure 2 shows one of the resulting histograms. The peaks in the histogram are testimony to the fact a cultural acquisition can also produce non-arbitrary structure. Naively one would expect the histogram to be flat as culture is typically arbitrary. These results suggest that the universality of human colour categories has been wrongly interpreted as a genetically driven process. Instead, the phenomenon could also be explained as a cultural acquisition process on top of slight, universal biases.

References

[1] B. Berlin and P. Kay. *Basic Color Terms: Their Universality and Evolution*. University of California Press, Berkeley, CA, 1969.

[2] P. Kay and T. Regier. Resolving the question of color naming universals. *Proceedings of the National Academy of Sciences*, 100(15):9085–9089, 2003.

[3] D. Roberson, I. Davies, and J. Davidoff. Color categories are not universal: replications and new evidence from a stone-age culture. *Journal of Experimental Psychology: General*, 129(3):369–398, 2000.

[4] L. Steels. Language games for autonomous robots. *IEEE Intelligent Systems*, sept-oct 2001:17–22, 2001.

[5] L. Steels and T. Belpaeme. Coordinating perceptually grounded categories through language. A case study for colour. *Behavioral and Brain Sciences*, 24(8):469–529, 2005.