Language, thought, and color: Recent developments

Paul Kay*
International Computer Science Institute
University of California, Berkeley
paulkay@berkeley.edu

Terry Regier*
University of Chicago
regier@uchicago.edu

Abstract: The classic issue of color naming and color cognition has been re-examined in a recent series of articles. Here, we review these developments, and suggest that they move the field beyond a familiar rhetoric of 'nature versus nurture', or 'universals versus relativity', to new concepts and new questions.

The language-and-thought debate in the color domain has been framed by two questions:

1. Is color naming across languages largely a matter of arbitrary linguistic convention?
2. Do cross-language differences in color naming cause corresponding differences in color cognition?

In the standard rhetoric of the debate, a 'relativist' argues that both answers are Yes, and a 'universalist' that both are No. However, a number of recent studies, when viewed in aggregate, undermine these traditional stances. These studies suggest instead that there are universal tendencies in color naming (i.e. No to question 1) but that naming differences across languages *do* cause differences in color cognition (i.e. Yes to question 2). These findings promise to move the field beyond a conceptually tired oppositional rhetoric, toward a fresher perspective that suggests a number of new questions. Here, we review these recent studies, the clarification they bring to the debate, and the further questions they raise.

'Universalist' beginnings

Color naming varies across languages; however, it has long been held that this variation is constrained. Berlin and Kay found that color categories in 20 languages were organized around universal *focal colors* – those colors corresponding to the best examples of English "black", "white", "red", "yellow", "green", and "blue". Moreover, a classic set of studies by Eleanor Rosch found that these focal colors were also remembered more accurately than other colors, across speakers of languages with different color naming systems. Focal colors seemed to constitute a universal cognitive basis for both color language and color memory.

* PK and TR contributed equally to this work. Correspondence may be addressed to either author.

The 'relativist' challenge

Recently, however, Debi Roberson and colleagues [1,2] failed to replicate Rosch's results. They compared speakers of three languages – English, Berinmo, a language of Papua New Guinea, and Himba, a Bantu language – and did *not* find privileged memory, similarity judgments, or paired associates learning in the latter two languages at the proposed universal foci. Instead, they found that these cognitive variables are well predicted by the *boundaries* of each language's color categories: a form of categorical perception of color.[1] Since these boundaries vary across languages (Figure 1, top), speakers of different languages apprehend color differently. Moreover, these linguistic differences seem to actually cause, rather than merely correlate with, cognitive differences [3], confirming and extending earlier findings by Kay and Kempton. These results call into question the cognitively privileged status of the universal focal colors. And they provide an answer to question 2 above: language differences do cause differences in color cognition.

Roberson and colleagues have gone further, to propose that universal foci play no central role in color *naming* either (question 1). They argue that color categories are determined at their boundaries by language, and that best examples of categories are mere epiphenomena of this process [1]. The one universal constraint they do acknowledge is "grouping by similarity" – the very general principle that similar colors will tend to receive the same name. Lucy [4] also argued against universals of color naming. He suggested that Berlin and Kay's finding of universality was based on hopelessly subjective methodology: the data had been analyzed largely by human inspection, rather than objective test. If these claims about color naming turn out to be well founded, the overall picture would be a clearly 'relativist' one: a Yes answer to both of our framing questions.

Current status of the debate

But it is here that the traditional stances break down. For despite the clear recent evidence that language affects color cognition, there is also new evidence for color naming universals. Kay and Regier [5] conducted the first comprehensive objective tests of color naming universals – in part in response to the 'relativist' claims above – and found strong statistical evidence of universal tendencies in color naming across both written languages and the 110 unwritten languages of the World Color Survey (WCS). Moreover, there is evidence specifically for universal focal colors in naming. Regier, Kay and Cook [6], extending earlier work by MacLaury [7], found that best examples of color terms in the WCS tend significantly to cluster near the proposed focal colors (Figure 1, bottom). This pattern would not be predicted if the only major universal force in color naming was "grouping by similarity". Webster and Kay [8] found that the foci vary somewhat in placement across languages – but much less than the variation across

[1] Categorical perception is said to occur when stimuli that straddle a category boundary are perceived as more distinct than equivalently-spaced stimuli within a category.

speakers within a language. The overall picture is that color categories appear to be organized around universal foci (No to question 1) – and at the same time, differences in color naming do induce differences in color cognition (Yes to question 2).

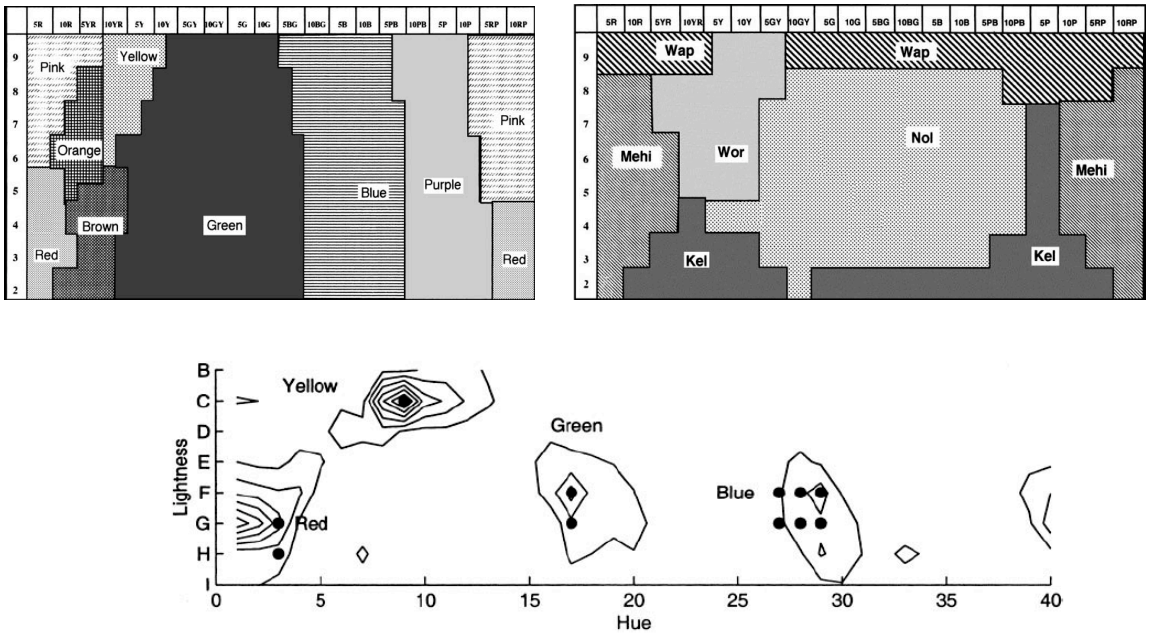

Figure 1. (Top) Color categories in English (left) and Berinmo (right), shown on the same standard array of colors [adapted from 1]. Color cognition varies across languages, in accordance with category boundaries.[2] (Bottom) But variation in color naming is constrained by universal foci [6]. The contour plot shows the number of best example choices for color terms across 110 unwritten languages, compared with those of English (black dots).

This non-traditional pair of answers to our two main questions suggests further questions that are currently under investigation. Most broadly: which aspects of color cognition shape language, and which are shaped by it? How do these reciprocal influences work together? Some initial answers are emerging, as we outline below.

What causes universal tendencies in color naming?

Several explanations for universals in color naming have been proposed. Kuehni [9] posits neurophysiological support for the cardinal colors red, yellow, green, and blue. Lindsey and Brown [10] proposed that languages spoken near the equator tend to lack separate terms for green and blue because excessive exposure to ultraviolet radiation

[2] We display category boundaries here but not best example choices; the latter may be found in [1]. The interpretation of best example data in Berinmo is contested [1,6].

from sunlight yellows the lenses of people living in this region. However, this theory has been challenged [11,12]. Shepard [13] suggested that the major phenomenal hue axes, especially blue-yellow, derive from evolutionary tuning to the predominant sources of natural illumination. Yendrikhovskij [14] showed that the sources of color naming universals may reside in evolutionary tuning to the most frequently occurring colors in the environment. Jameson and D'Andrade [15] argued that the universal focal colors are salience maxima in color space and that universals of color naming flow from a process that partitions color space in a way that maximizes information. Steels and Belpaeme [16] emphasize the role of inter-speaker communication, relying on simulations of interacting agents. In short, there is no lack of explanations for universals of color naming, some mutually consistent and some not.

What causes categorical perception of color?

It has been widely assumed that language is the cause of color categorical perception. This is suggested since – as we have seen – named category boundaries vary across languages, and categorical perception varies with them. However, Franklin and Davies [17] have found startling evidence of categorical perception at some of these same boundaries in pre-linguistic infants and toddlers of several languages. Thus, some categorical color distinctions apparently exist prior to language, and may then be reinforced, modulated, or eliminated by learning a particular language.

Is "categorical perception" of color really perceptual?

Much of the evidence for categorical "perception" of color comes from tasks that involve memory – thus the category effects could stem from memory rather than perception. Recently, however, Franklin, Pilling and Davies [18] found that both adults and infants respond categorically in a visual search task that minimizes the involvement of memory. They concluded that the effect was probably truly perceptual. This is a tentative conclusion that deserves further investigation. The perceptual status of 'categorical perception' of color is currently an object of inquiry, as is its status with respect to innateness, learning and unlearning.

Summary

The debate over color naming and cognition can be clarified by discarding the traditional "universals versus relativity" framing, which collapses important distinctions. There are universal constraints on color naming, but at the same time, differences in color naming across languages cause differences in color cognition and/or perception. The source of the universal constraints is not firmly established. However, it appears that nature proposes and nurture disposes. Finally, 'categorical perception' of color may be perception *sensu stricto*, but the jury is still out.

References

1. Roberson, Debi, Ian Davies and Jules Davidoff (2000). Color categories are not universal: Replications and new evidence from a stone age culture. *Journal of Experimental Psychology: General 129*: 369-398.

2. Roberson, D., Davidoff, J., Davies, I.R.L., Shapiro, L.R. (2005). Color categories: Evidence for the cultural relativity hypothesis. *Cognitive Psychology 50*: 378-411.

3. Roberson, D. & Davidoff, J. (2000). The categorical perception of colors and facial expressions: the effect of verbal interference. *Memory and Cognition 28:* 977-986.

4. Lucy, John A. (1997) The linguistics of color. In C.L. Hardin and Luisa Maffi (Eds.), *Color Categories in Thought and Language*. Cambridge: Cambridge University Press.

5. Kay, Paul and Terry Regier (2003). Resolving the question of color naming universals. *Proceedings of the National Academy of Sciences 100:* 9085-9089.

6. Regier,Terry, Paul Kay and Richard S. Cook (2005). Focal colors are universal after all. *Proceedings of the National Academy of Scienc*es *102:* 8386-8391.

7. MacLaury, R. E.(1997*) Color and Cognition in Mesoamerica: Constructing Categories as Vantages*. Austin: University of Texas Press.

8. Webster, Michael A. and Paul Kay (in press). Individual and Population Differences in Focal Colors. *The Anthropology of Color*, ed. by Robert E. MacLaury, Galina V. Paramei and Don Dedrick. Amsterdam: John Benjamins.

9. Kuehni, Rolf G., (2005) Focal color variability and unique hue variability. *Journal of Cognition and Culture 5:* 409-426.

10. Lindsey, D.T. & Brown, A.M. (2002) Color naming and the phototoxic effects of Sunlight on the eye. *Psychological Science 13:* 506-512.

11. Hardy, Joseph L., Christina M. Frederick, Paul Kay, and John S. Werner (2005).Color naming, lens aging, and grue: What the optics of the aging eye can teach us about color language. *Psychological Science 16:* 321-327.

12. Regier, Terry and Paul Kay (2004). Color naming and sunlight: Commentary on Lindsey and Brown (2002). *Psychological Science 15:* 289-290.

13. Shepard, Roger N. (1992) The perceptual organization of colors. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The Adapted Mind*. Oxford: Oxford University Press.

14. Yendrikhovskij, Sergej N. (2001). Computing color categories from statistics of natural images. *Journal of Imaging Science and Technology 45:* 409-417.

15. Jameson, K. & D'Andrade, R.G. (1997). It's not really Red, Green, Yellow, Blue: An inquiry into cognitive color space. In: C. L. Hardin and Luisa Maffi (Eds.) *Color*

Categorization in Thought and Language. Cambridge: Cambridge University Press.

16. Steels, Luc and Tony Belpaeme (in press). Coordinating perceptual categories through language: A case study for colour. *Behavioral and Brain Sciences*.

17. Franklin, A. & Davies, I.R.L. (2004). New evidence for infant color categories. *British Journal of Developmental Psychology 22:* 349-377.

18. Franklin, A., Pilling, M., & Davies, I. (2005). The nature of infant color categorization: Evidence from eye movements on a target detection task. *Journal of Experimental Child Psychology 91:* 227-248.