

# Color naming and the effect of language on perception

Terry Regier; University of Chicago; Chicago, IL, USA

## Abstract

*A classic nature-versus-nurture debate in cognitive science concerns the relation between language and perception. The universalist view holds that language is shaped by universals of perception, while the opposing relativist view holds instead that language shapes perception, in a manner that varies with little constraint across languages. Over the years, consensus has oscillated between these two poles. In this talk, I argue that neither position is fully supported. I argue moreover that the universalist/relativist opposition itself should be resisted as a conceptual framework, since it paints with too broad a brush, and obscures interesting realities. I argue this general point using two case studies in the naming and perception of color.*

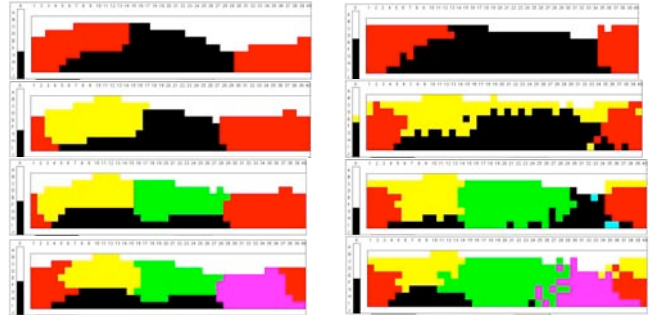
## Color naming is near-optimal

An influential universalist view of color naming holds that color categories across languages are organized around the universal focal colors *black, white, red, green, yellow, and blue* [1]. A recent relativist challenge holds in contrast that there are no such universal foci, and that color categories are instead defined at their boundaries by largely arbitrary linguistic convention [2]. Both of these views are partly supported by – and partly challenged by – existing data, which show universal tendencies in color naming [3], coupled with interesting cross-language variation in just where category boundaries are drawn [4].

In an attempt to resolve this tension, I argue for a third view, based on a proposal by Jameson and D’Andrade [5]: that color naming across languages reflects optimal or near-optimal partitions of an irregularly shaped perceptual color space [6]. My colleagues and I have formalized this proposal in terms of a *well-formedness* measure that captures the extent to which a given categorical partition of color space maximizes perceptual similarity within color categories and minimizes it across categories [7]. We propose that the color naming systems of the world’s languages correspond to maxima or near-maxima in well-formedness – i.e. to theoretically optimal color naming systems.

We used simulations to create such theoretically optimal color naming systems, with  $n=3,4,5,6$  categories. We initialized each simulation by randomly assigning each of a discrete set of points in perceptual color space to one of the  $n$  categories; we then adjusted these category labels through steepest ascent in well-formedness, until a maximum was reached. The results are displayed in Figure 1, together with selected languages from the World Color Survey (WCS) database [8]. Each color naming system is displayed on a standard color grid in which columns represent hues, and rows lightness. More broadly, we found that across the 110 languages of the WCS, color naming tended to be shaped in part by well-formedness. At the same time, our model also suggests where linguistic convention may get some wiggle room: there are often several similar but different partitions that

are roughly equally well-formed. Thus, the model suggests a specific middle ground between “nature” and “nurture” in color naming across languages – one that corresponds to neither the standard universalist nor the standard relativist account.



**Figure 1.** Model prediction (left) compared with selected WCS languages (right), for  $n=3,4,5,6$  categories.

## Whorf hypothesis in the right visual field

The Whorf [9] hypothesis, a classic relativist proposal, holds that language affects perception: when languages categorize reality differently, speakers of those languages should correspondingly perceive reality differently. There are a number of studies that support this idea, and a number that do not. I shall argue not for one side or the other of this existing debate, but instead for a novel proposal: that language affects perception primarily in the right visual field (RVF), and much less if at all in the left visual field (LVF). This idea, which is suggested by left hemisphere language dominance, is unanticipated by the traditional universalist/relativist framing of the debate.

Gilbert, Regier, Kay, and Ivry [10] tested this idea in the context of color perception. We reasoned that if language affects perception primarily in the RVF, one would predict three things. First, discrimination of stimuli with different names (e.g. a hue of “blue” and one of “green”) should be faster in the RVF than in the LVF, since the difference in names will heighten perceptual differences in the RVF. Second, the discrimination of stimuli with the *same* name (e.g. two different hues of “green”) should be *slower* in the RVF than in the LVF, since the sameness of the name will impede perceptual discrimination in the RVF. And third, this overall pattern should be disrupted by concurrent tasks that interfere with verbal processing, but not by concurrent tasks of comparable difficulty that only interfere with non-verbal processing. We found support for all three predictions, in experiments with English-speaking subjects. Drivonikou et al. [11] have replicated these findings.

## Conclusions

Neither of these findings – that color naming is near-optimal, and that language affects color perception primarily in the RVF – is anticipated by the traditional universalist-versus-relativist framing of the debate over language and perception, and neither sits particularly comfortably with it. Instead, these findings suggest that the world is a more interestingly differentiated place than that framing might lead one to expect.

## Acknowledgments

I would like to acknowledge and thank my collaborators on this work: Aubrey Gilbert, Richard Ivry, Paul Kay, and Naveen Khetarpal. This work was supported by National Science Foundation Grants 0418283 (to TR) and 0418404 (to PK).

## References

- [1] Kay, P., & McDaniell, C. K. (1978). The linguistic significance of the meanings of basic color terms. *Language*, 54(3), 610-646.
- [2] Roberson, D., Davies, I., & Davidoff, J. (2000). Color categories are not universal: Replications and new evidence from a stone-age culture. *Journal of Experimental Psychology: General*, 129(3), 369-398.
- [3] Regier, T., Kay, P., & Cook, R. (2005). Focal colors are universal after all. *Proceedings of the National Academy of Sciences, USA*, 102(23), 8386-8391.
- [4] Roberson, D., Davidoff, J., Davies, I. R., & Shapiro, L. R. (2005). Color categories: Evidence for the cultural relativity hypothesis. *Cognitive Psychology*, 50(4), 378-411.
- [5] Jameson, K. A., & D'Andrade, R. G. (1997). It's not really red, green, yellow, blue. In C. L. Hardin & L. Maffi (Eds.), *Color Categories in Thought and Language* (pp. 295-319). Cambridge: Cambridge University Press.
- [6] Regier, T., Kay, P., & Khetarpal, N. (2007). Color naming reflects optimal partitions of color space. *Proceedings of the National Academy of Sciences*, 104, 1436-1441.
- [7] Garner, W. R. (1974). *The processing of information and structure*. Potomac, MD: L. Erlbaum Associates.
- [8] Cook, R. S., Kay, P., & Regier, T. (2005). The World Color Survey database: History and use. In H. Cohen & C. Lefebvre (Eds.), *Handbook of categorization in cognitive science* (pp. 223-242). Amsterdam: Elsevier.
- [9] Whorf, B. L. (1956). *Language, Thought, and Reality*. Cambridge, MA: MIT Press.
- [10] Gilbert, A., Regier, T., Kay, P., & Ivry, R. (2006). Whorf hypothesis is supported in the right visual field but not the left. *Proceedings of the National Academy of Sciences*, 103(2), 489-494.
- [11] Drivonikou, G. V., Kay, P., Regier, T., Ivry, R. B., Gilbert, A. L., Franklin, A., & Davies, I. R. L. (2007). Further evidence that Whorfian effects are stronger in the right visual field than the left. *Proceedings of the National Academy of Sciences*, 104, 1097-1102.

## Author Biography

Terry Regier received his BS in computer and communication sciences from the University of Michigan (1983) and his PhD in computer science from the University of California at Berkeley (1992). Since 1994 he has been on the faculty of the psychology department at the University of Chicago. His work focuses on the relation of language and thought.