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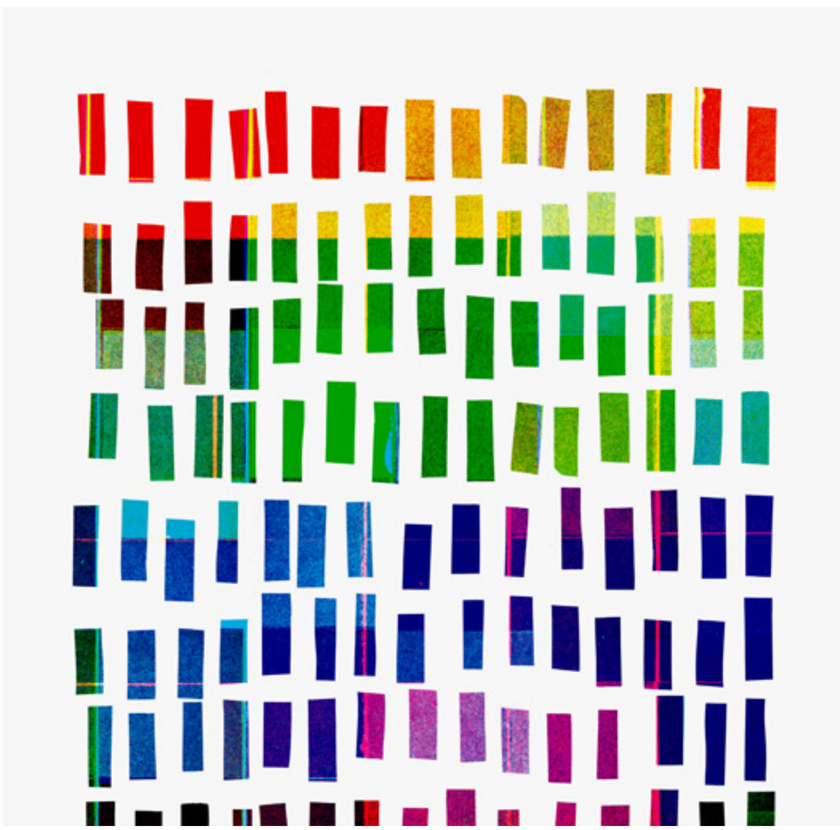
The crayola-fication of the world: How we gave colors names, and it messed with our brains (part I)

Khalil Cassimally)

14-17 minutes

> "Who in the rainbow can draw the line where the violet tint ends and the orange tint begins? Distinctly we see the difference of the colors, but where exactly does the one first blendingly enter into the other? So with sanity and insanity."
>
> —Herman Melville, *Billy Budd*



Spectral Rhythm. Screen Print by Scott Campbell.

Editor's Selection

In Japan, people often refer to traffic lights as being blue in color. And this is a bit odd, because the traffic signal indicating 'go' in Japan is just as green as it is anywhere else in the world. So why is the color getting lost in translation? This visual conundrum has its roots in the history of language.

Blue and green are similar in hue. They sit next to each other in a rainbow, which means that, to our eyes, light can blend smoothly from blue to green or vice-versa, without going past any other color in between. Before the modern period, Japanese had just one word, *Ao*, for both blue and green. The wall that divides these colors hadn't been erected as yet. As the language evolved, in the

Heian period around the year 1000, something interesting happened. A new word popped into being – *midori* – and it described a sort of greenish end of blue. Midori was a shade of ao, it wasn't really a new color in its own right.

One of the first fences in this color continuum came from an unlikely place – crayons. In 1917, the first crayons were imported into Japan, and they brought with them a way of dividing a seamless visual spread into neat, discrete chunks. There were different crayons for green (midori) and blue (ao), and children started to adopt these names. But the real change came during the Allied occupation of Japan after World War II, when new educational material started to circulate. In 1951, teaching guidelines for first grade teachers distinguished blue from green, and the word midori was shoehorned to fit this new purpose.

Reconstructing the rainbow. Stephanie, who blogs at 52 Kitchen Adventures, took a heat gun to a crayola set.

In modern Japanese, midori is the word for green, as distinct from blue. This divorce of blue and green was not without its scars.

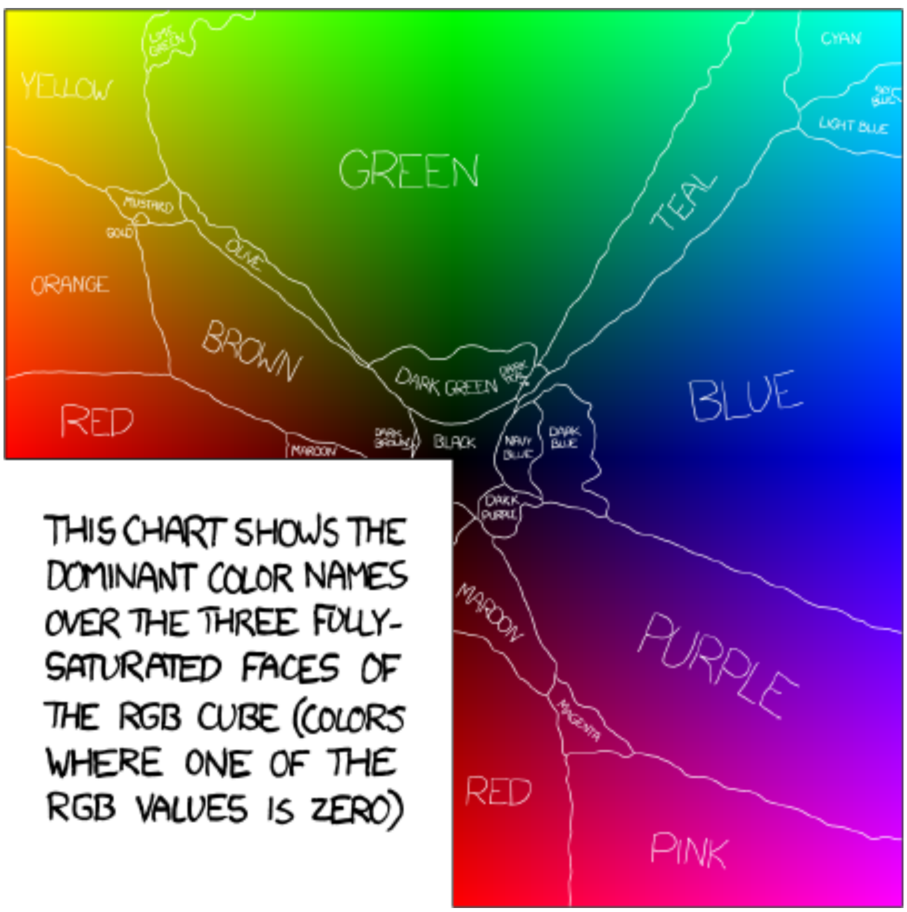
There are clues that remain in the language, that bear witness to this awkward separation. For example, in many languages the word for vegetable is synonymous with green (sabzi in Urdu literally means green-ness, and in English we say ‘eat your greens’). But in Japanese, vegetables are ao-mono, literally blue things. Green apples? They’re blue too. As are the first leaves of spring, if you go by their Japanese name. In English, the term green is sometimes used to describe a novice, someone inexperienced. In Japanese, they’re ao-kusai, literally they ‘smell of blue’. It’s as if the borders that separate colors follow a slightly different route in Japan.

And it’s not just Japanese. There are plenty of other languages that blur the lines between what we call blue and green. Many languages don’t distinguish between the two colors at all. In ~~Vietnamese~~ the Thai language, *khiaw* means green except if it refers to the sky or the sea, in which case it’s blue. The Korean word *purueda* could refer to either blue or green, and the same goes for the Chinese word *qīng.* It’s not just East Asian languages either, this is something you see across language families. In fact, Radiolab had a fascinating recent episode on color where they talked about how there was no blue in the original Hebrew Bible, nor in all of Homer’s Illiad or Odyssey!

(*Update: Some clarifications here. Thanks, Ani Nguyen, for catching the mistake about Vietnamese. See her comment below about how the same phenomenon holds in Vietnamese. Also, the Chinese word qīng predates modern usage, and it mingles blues with greens. Modern Chinese does indeed distinguish blue from green. Thanks to Jenna Cody for pointing this out, and see her insightful and detailed comment below.*)

I find this fascinating, because it highlights a powerful idea about how we might see the world. After all, **what really is a color? Just like the crayons, we're taking something that has no natural boundaries – the frequencies of visible light – and dividing into convenient packages that we give a name.**

Imagine that you had a rainbow-colored piece of paper that smoothly blends from one color to the other. This will be our map of color space. Now just as you would on a real map, we draw boundaries on it. This bit here is pink, that part is orange, and that's yellow. Here is what such a map might look like to a native English speaker.

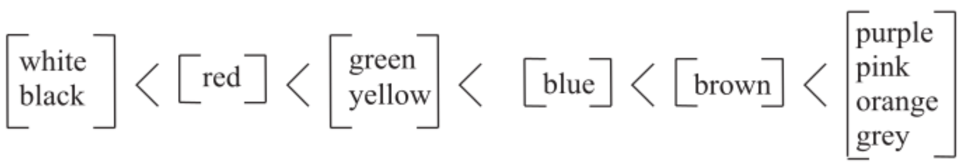


A map of color for an English speaker. Results of the XKCD Color Survey. Randall Munroe.

But if you think about it, there's a real puzzle here. ***Why should different cultures draw the same boundaries?*** If we speak different languages with largely independent histories, shouldn’t our ancestors have carved up the visual atlas rather differently?

This question was first addressed by Brent Berlin and Paul Kay in the late 1960s. ***They wanted to know if there are universal, guiding laws that govern how cultures arrive at their color atlas.***

And here’s what they found. Languages have differing numbers of color words, ranging from two to about eleven. Yet after looking at 98 different languages, they saw a pattern. It was a pretty radical idea, that there is a certain fixed order in which these color names arise. This was a common path that languages seem to follow, a road towards increasing visual diversity. And they suggested that the road looked like this:



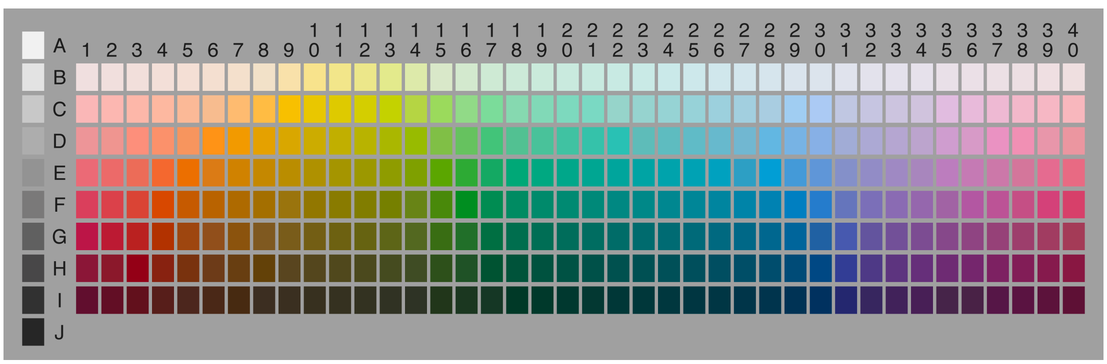
A picture worth many words. The path to a more colorful language, according to Berlin and Kay (1969).

The figure above is really telling a story. What it says is this. If a language has just two color terms, they will be a light and a dark shade – blacks and whites. Add a third color, and it’s going to be red. Add another, and it will be either green or yellow – you need five colors to have both. *And when you get to six colors, the green splits into two, and you now have a blue.* What we’re seeing here is a deeply trodden road that most languages seem to follow, towards greater visual discernment (92 of their 98 languages seemed to follow this basic route).

Critics of Kay and Berlin said they were reading too much from too little. Some argued that their study was too small, that they surveyed too few people from each language. They also said that study was skewed, as most the languages were from industrialized societies with written scripts. And to top it off, their methods weren't very quantitative.

To respond to these criticisms, the authors launched what they called the [World Color Survey], a project that started collecting data in the late 1970s. This was a survey of 110 languages, all spoken by pre-industrial societies, many that have no written script.

The researchers set out to map the color boundaries for each culture. To do this, they showed people a set of colored tiles in 10 different shades of 40 different hues. In all, 400 tiles of color that represent the building blocks of our visual world.

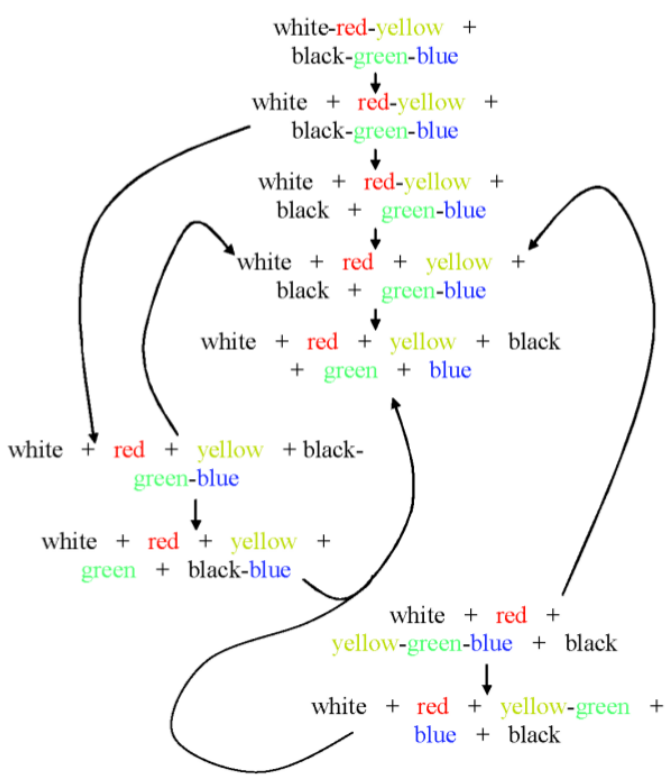


Crayons for science. How many colors can you name from these tiles? Most English speakers would come up with around 11 (including black and white). This number is a window into the linguistic history of your culture.

They then asked native speakers of these 110 different languages, many from remote tribal cultures, to painstakingly name the color of each tile. After tallying up what people said, they could divide these tiles into islands of color, similar to the map of color from before. Here's what they learnt.

First, cultures are quite different in how their words paint the world. Take a look at this interactive map. For the 110 cultures, you can see how many basic words they use for colors. To the Dani people who live in the highlands of New Guiniea, objects comes in just two shades. There's *mili* for the cooler shades, from blues and greens to black, and *mola* for the lighter shades, like reds, yellows and white. Some languages have just three basic colors, others have 4, 5, 6, and so on. There's even a debate as to whether the Pirahã tribe of the Amazon have any specialized color words at all! (If you ask a Pirahã tribe member to label something red, they'll say that it's blood-like).

But there's still a pattern hidden in this diversity. You might be wondering what happened to the cartoon picture of languages. Is there still a main road? Or are there languages that travel off the beaten path? The answer is yes, to both questions.



Goodbye yellow brick road. A more refined picture of how languages name colors.

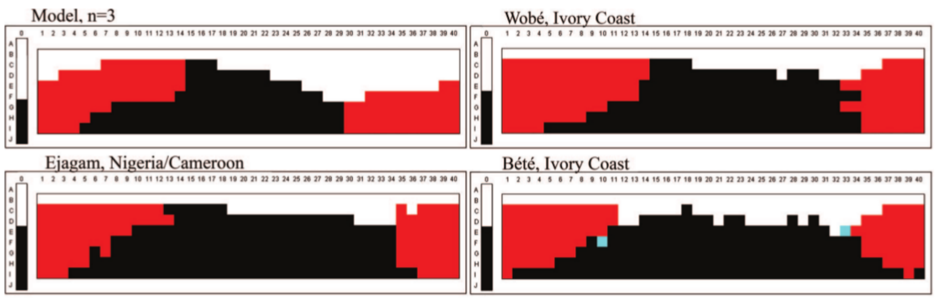
The picture looks like a mess, but keep in mind that **five out of six languages surveyed follow the central route**. So here's the story. You start with a black-and-white world of darks and lights. There are warm colors, and cool colors, but no finer categories. Next, the reds and yellows separate away from white. You can now have a color for fire, or the fiery color of the sunset. There are tribes that have stopped here. Further down, blues and greens break away from black. Forests, skies, and oceans now come of their own in your visual vocabulary. Eventually, these colors separate further. First, red splits from yellow. And finally, blue from green. The forest unmingles from the sky. *In the case of Japan, that last transition essentially happened in modern history!*

Something eerily powerful is at work here. These cultures have largely independent histories, yet they somehow gravitate towards the same choices for how to slice up the visual cake. So you might ask, **is there something special about the colors that they choose?** With the color maps made available from the World Color Survey, researchers were able to take a stab at this question. The work that follows was spearheaded by Terry Regier, in collaboration with Paul Kay and Naveen Khetarpal.

Imagine doing an experiment. Let's say you want to take the color tiles that represent the visual space, and divide them into four different patches. What's the best way to do this? Well, you'd like your colors to be quite different from each other, so that people can easily tell them apart. However, you also want each color to contain a whole bunch of very similar shades, so that it's easily recognizable. The researchers programmed these two conflicting tasks into a computer. They then let the algorithm fight out these conflicting instructions, until it reached some happy compromise.

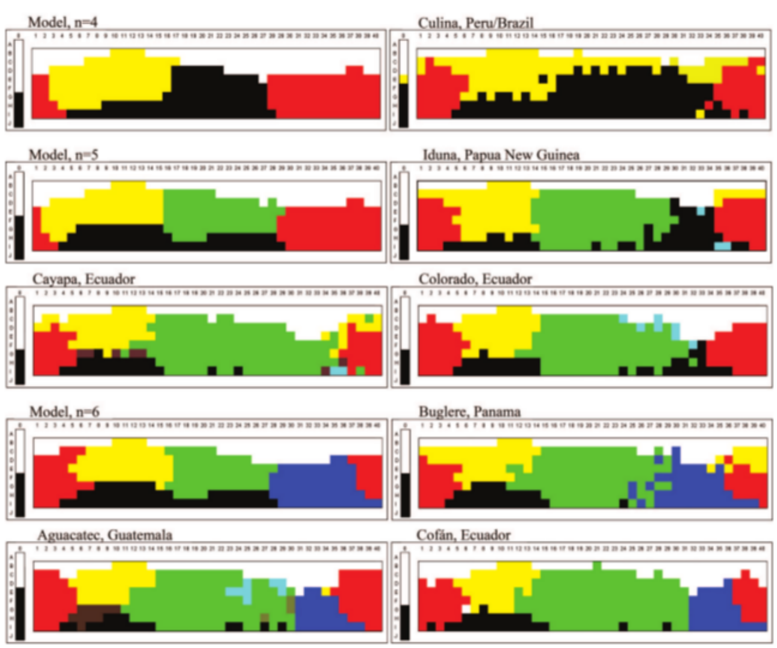
They were on the hunt for an optimal color map, if such a thing even existed.

Here's the map their computer model came up with. It takes the colored tiles and paints them, in broad strokes, into four different shades. Next to it are some of the *real* color maps for languages that have four basic color names.



Look similar? That's the point. The researchers make the case that the islands of color that we carve the world into are, in some sense, the best choice.

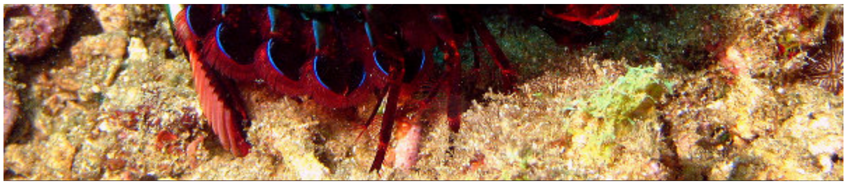
Next, here are some examples from cultures with four, five and six different words for colors. The predictions of the computer model are shown next to the data.



It's a little uncanny how closely well these models seem to match the data. But there are plenty of languages that don't line up quite as well. Nonetheless, the researchers argue that there is something special about the colors that we choose. If you try to move the borders around, your new colors will actually be less optimal, in a sense that they make precise.

The picture that's emerging is that colors aren't quite random slices of the visual pie. They're somewhat basic categories that humans from different cultures gravitate towards, and must have to do with how the biology of how we see the world. In other words, **rainbows have seams**. We can distill a rainbow into its basic visual ingredients, and a handful of colors come out. But if you were to ask a dog, a rainbow has fewer ingredients. The result is a little more boring, less rich than the visual spectacle we experience.

But don't feel too proud. If you were a mantis shrimp, your rainbow would be unimaginably rich, with thousands, maybe tens of thousands of colors that blend together, stretching from deep reds all the way to the ultraviolet. To a mantis shrimp, our visual world is unbearably dull. (Another Radiolab plug: in their episode on Color, they use a choir to convey this idea through sound. A visual spectrum becomes a musical one. It's one of those little touches that makes this show genius. </fanboy>)



DEAR MORTAL, YOUR RAINBOW IS PUNY. LOVE, MANTIS SHRIMP. Image by Perry Aragon.

That's all for part one of this post, on how we gave colors names. In the next part, I'll talk about some pretty surprising studies that show how giving a color a name can, quite literally, mess with our brains. So stay tuned for the next mind-bending chapter.

Update:* Part two *is up.

~~***Update (June 11): If you really enjoyed this post, I could use your help. Please consider* voting for it *in the annual 3QuarksDaily Science Writing Prize. Voting will close on SATURDAY, so get your vote in today. Thanks!***~~

Update: *This post received editor's selections at ScienceSeeker (by Cristy Gelling), ResearchBlogging (by Krystal D'costa), on the Scientific American Incubator Blog (by , and on Bora Zivkovic's and Ed Yong's picks of the week.*

Update: *It's been an exciting past few weeks. I'm blown away by the overwhelming response to this post. Here's a manual trackback of links. It was mentioned on the Browser, on the literary blog of the New Yorker, Andrew Sullivan's blog at the Daily Beast, Erza Klein's blog on the Washington Post, Maria Popova's tumblr blog Explore. Its also been tweeted by @BrainPicker and @HariKunzru, among others, and been featured on Hacker News, Reddit, Metafilter and Kottke. And to top it off, it won first place in the 3 Quarks Daily annual science writing prize, judged by Sean Carroll.*

Update: *Thanks to a reader suggestion, I updated the image of the colored tiles to a more accurately colored image from the World Color Survey website.*

References

Regier T, Kay P, & Khetarpal N (2007). **Color naming reflects optimal partitions of color space.** Proceedings of the National Academy of Sciences of the United States of America, 104 (4), 1436-41 PMID: 17229840

Kay, P., & Maffi, L. (1999). **Color Appearance and the Emergence and Evolution of Basic Color Lexicons** American Anthropologist, 101 (4), 743-760 DOI: 10.1525/aa.1999.101.4.743

Brent Berlin, & Paul Kay (1991). **Basic Color Terms: Their Universality and Evolution** (1969, Reprint) Center for the Study of Language and Information : Amazon Link

The World Color Survey

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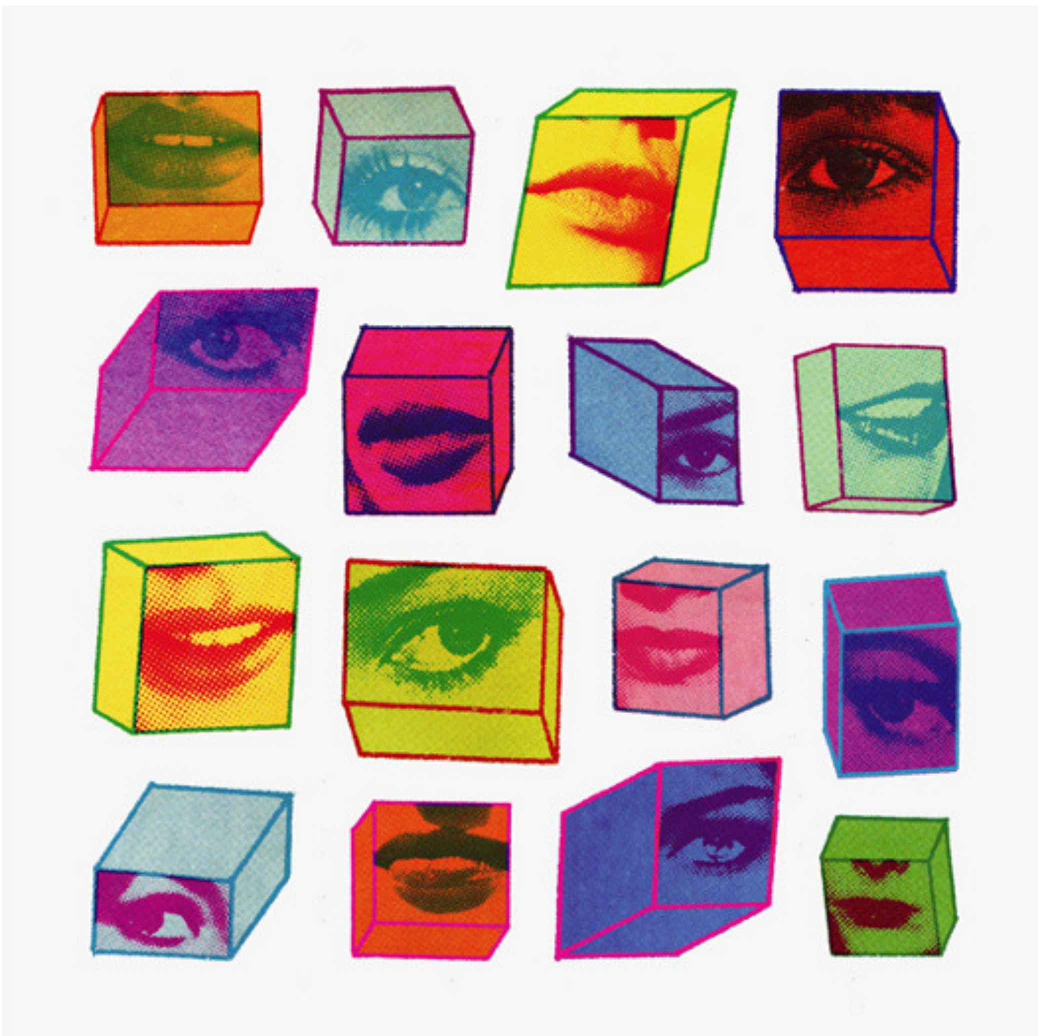
The crayola-fication of the world: How we gave colors names, and it messed with our brains (part II)

13-16 minutes



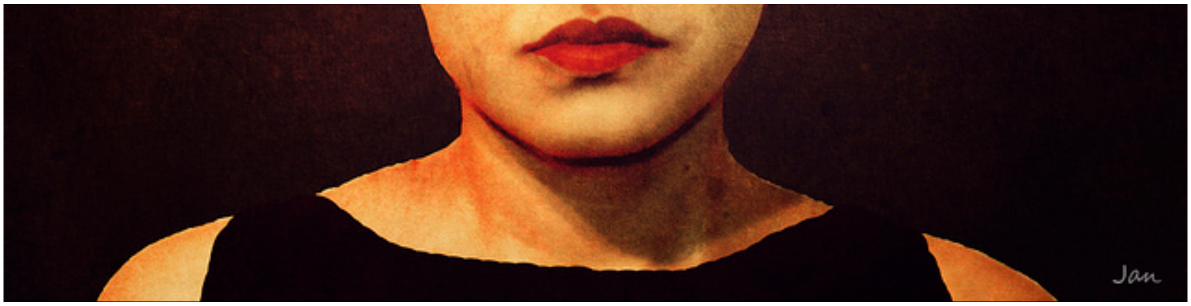
Untitled (Cubes) by Scott Taylor

Update: This post was an Editor's pick by [Cristy Gelling](#) at Science

Seeker, and was included in Bora Zivkovic's top 10 science blog posts of the week.

Lately, I've got colors on the brain. In part I of this post I talked about the common roads that different cultures travel down as they name the colors in their world. And I came across the idea that color names are, in some sense, culturally universal. The way that languages carve up the visual spectrum isn't arbitrary. Different cultures with independent histories often end up with the same colors in their vocabulary. Of course, the word that they use for red might be quite different – red, rouge, laal, whatever. Yet the *concept* of redness, that vivid region of the visual spectrum that we associate with fire, strawberries, blood or ketchup, is something that most cultures share.

So what? Does any of this really matter, when it comes to actually navigating the world? Shakespeare famously said that a rose by any other name smells just as sweet. ***So does red by another name look just as deep?*** **And what if you didn't have a name for red? Would it lose any of its luster?** Would it be any harder to spot those red berries in the bush?



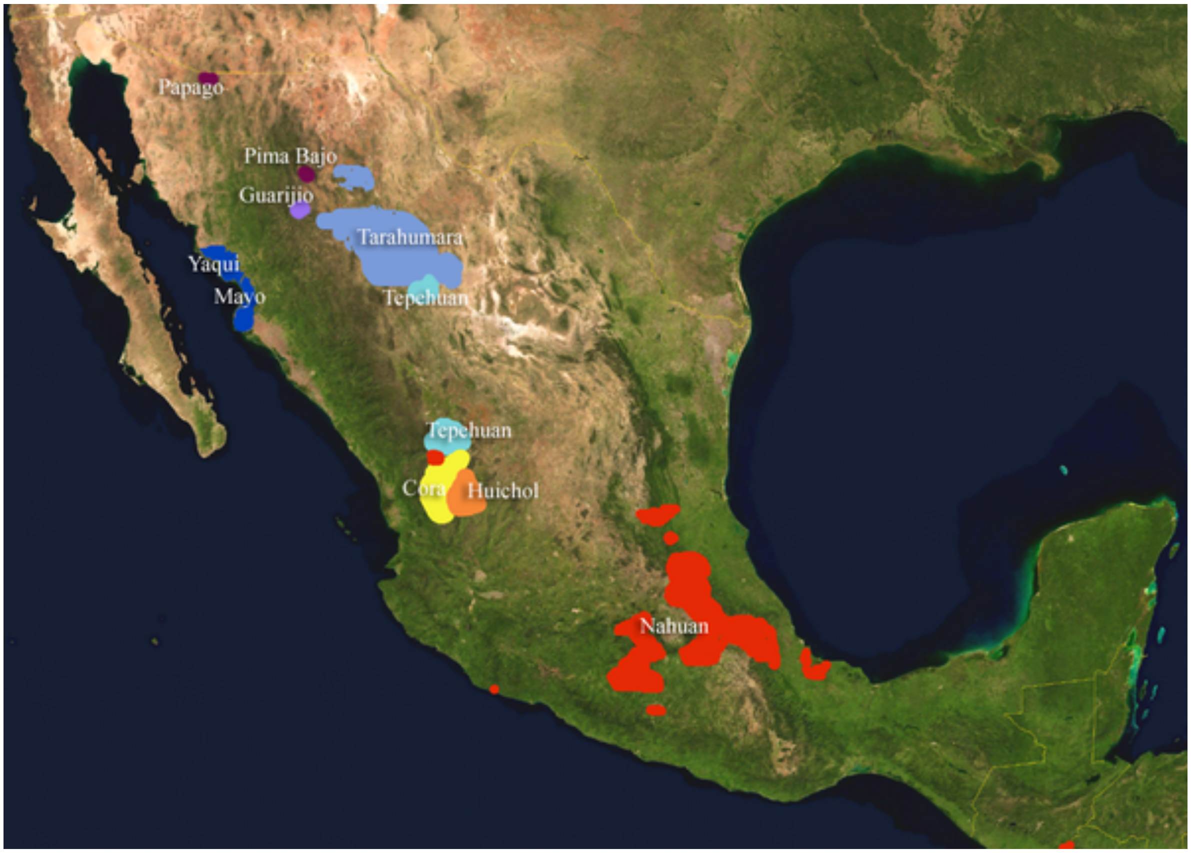
Rose coloured glasses by jan_clickr

This question goes back to an idea by the American linguist Benjamin Whorf, who suggested that our language determines how we perceive the world. In his own words,

> We cut nature up, organize it into concepts, and ascribe significances as we do, largely because we are parties to an agreement to organize it in this way—an agreement that holds throughout our speech community and is codified in the patterns of our language […] **all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar**

This idea is known as linguistic relativity, and is commonly described by the blatantly false adage that Eskimos have a truckload of words to describe snow. (The number of Eskimo words for snow probably tells you more about gullibility and sloppy fact-checking than it does about language.)

Hyperbole aside, color actually provides a neat way to test Whorf's hypothesis. A study in 1984 by Paul Kay and colleagues compared English speakers to members of the Tarahumara tribe of Northwest Mexico. The Tarahumara language falls into the Uto-Aztecan language family, a Native American language family spoken near the mountains of North America. And like most world languages, the Tarahumara language doesn't distinguish blue from green.

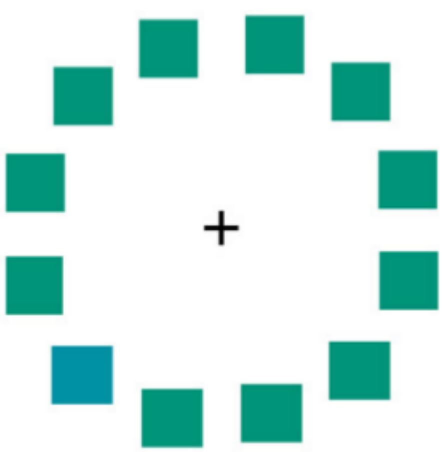


The Tarahumara language falls among the southern Uto-Aztecan languages. Image credit: Wikimedia Commons

The researchers discovered that, compared to the Tarahumara, English speakers do indeed see blue and green as more distinct. **Having a word for blue seems to make the color 'pop' a little more in our minds.** But it was a fragile effect, and any verbal distraction would make it disappear. The implication is that language may affect how we see the world. Somehow, the linguistic distinction between blue and green may heighten the *perceived* difference between them. Smells like Whorf's idea to me.

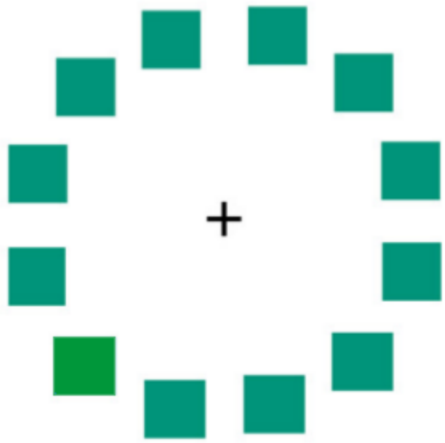
Do you see what I see? A young girl from the Tarahumara tribe, whose language doesn't distinguish green from blue. Photo credit: Fano Quiriego

That was 1984. What have we learnt since? In 2006, a study led by Aubrey Gilbert made a rather surprising discovery. Imagine that you're a subject in their experiment. You're asked to stare at the cross in the middle of the screen. A circle of colored tiles appear. One of the tiles is different from the others. Sometimes it will be on the left, and other times on the right. Your task is to spot whether the odd-color-out is on the left or on the right. Keep your eyes on the cross.

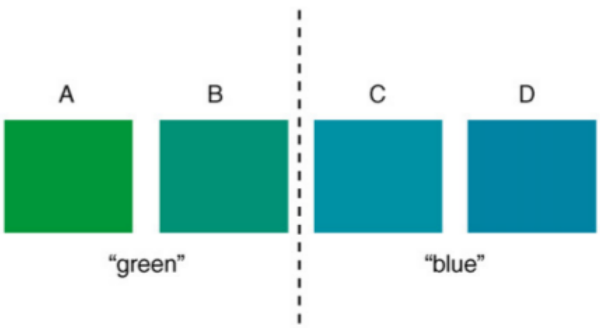


That's easy enough. What's the catch?

Well, sometimes you'll also get a picture that looks like this.



See the difference? In one case, English speakers have different words for the two colors, *blue* and *green*. So there's a concept that builds a wall between them. But in other cases like above, the two colors are conceptually the same.

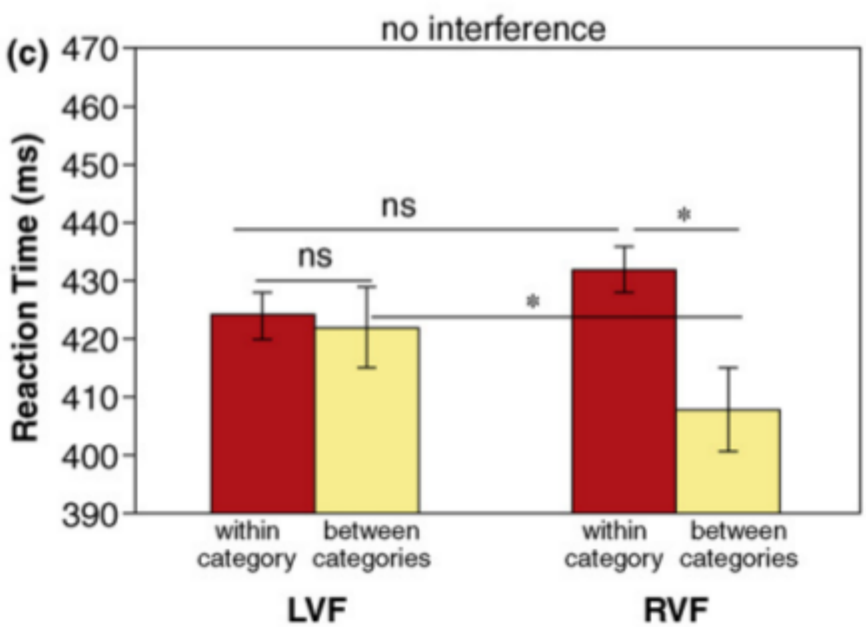


Here's what the researchers wanted to know. *If you have a word to distinguish two colors, does that make you any better at telling them apart?* More generally, does the linguistic baggage that we carry effect how we perceive the world? This study was designed to address Whorf's idea head on.

As it happens, Whorf was right. Or rather, he was *half right*.

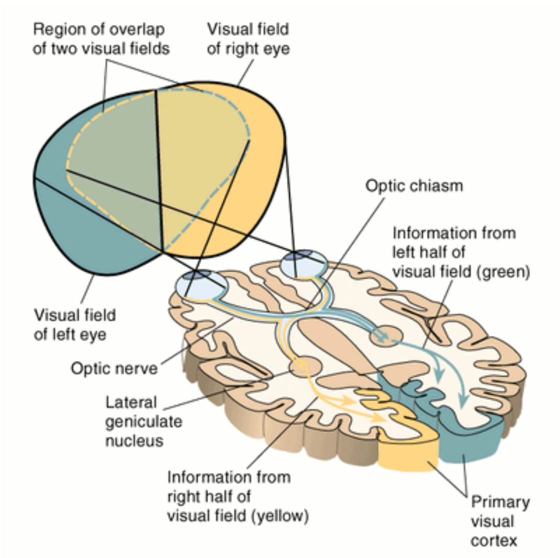
The researchers found that there is a real, measurable difference in how we perform on these two tasks. In general, it takes less time to identify that odd blue square compared to the odd green one. This makes sense to anyone who's ever tried looking for a tennis ball in the grass. It's not that hard, but I'd rather the ball be blue. In once case you are jumping categories (blue versus green), and in the other, staying with a category (green versus green).

However, and this is where things start to get a bit strange, this result only holds if the differently colored square was in the *right half of the circle*. If it was in the left half (as in the example images above), then there's no difference in reaction times – it takes just as long to spot the odd blue as the odd green. It seems that **color categories only matter in the right half of your visual field!**

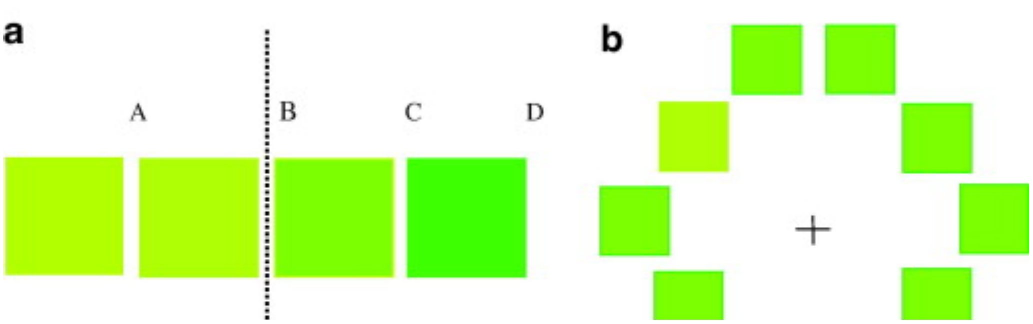


The graph above summarizes the results of this experiment. In red are the reaction times for making comparisons within a category (think green among greens). In yellow are comparisons where you straddle a category (think blue among greens). And what you see is that your performance on these two types of tasks differs in the right visual field (RVF), but not in the left visual field (LVF). **It's easier to tell apart colors with different names, but only if they are to your right.** Keep in mind that this is a very subtle effect, the difference in reaction time is a few hundredths of a second.

So what's causing this lopsidedness? Well, if you know something about how the brain works, you might have already guessed. **The crucial point is that everything that we see in the right half of our vision is processed in the left hemisphere of our brain, and everything we see in the left half is processed by the right hemisphere.** And for most of us, **the left brain is stronger at processing language.** So perhaps the language savvy half of our brain is helping us out.



It's not just English speakers that show this asymmetry. Koreans are familiar with the colors *yeondu* and *chorok.* An English speaker would call them both green (*yeondu* perhaps being a more yellowish green). But in Korean it's not a matter of shade, they are both basic colors. There is no word for green that includes both *yeondu* and *chorok*.



To the left of the dotted line is yeondu, and to the right chorok. Is it still as easy to spot the odd square in the circle?

And so imagine taking the same color ID test, but this time with *yeondu* and *chorok* instead of blue and green. A group of researchers ran this experiment. They discovered that among those who were the fastest at identifying the odd color, English speakers showed no left brain / right brain distinction, whereas Korean speakers *did*. It's plausible that their left brain was attuned to the distinction between yeondu and chorok.

But how do we know that language is the key here? Back to the previous study. The researchers repeated the color circle experiment, but this time threw in a verbal distraction. The subjects were asked to memorize a word before each color test. The idea was to keep their language circuits distracted. And at the same time, other subjects were shown an image to memorize, not a word. In this case, it's a visual distraction, and the language part of the brain needn't be disturbed.

They found that when you're verbally distracted, it suddenly becomes harder to separate blue from green (you're slower at straddling color categories). In fact the results showed that people found this *more difficult* then separating two shades of green. However, if the distraction is visual, not verbal, things are different. It becomes easy to spot the blue among green, so you're faster at straddling categories.

All of this is only true for your left brain. Meanwhile, your right brain is rather oblivious to these categories (until, of course, the left brain bothers to inform it). The conclusion is that **language is somehow enhancing your left brain's ability to discern different colors with different names.** Cultural forces alter our perception in ever so subtle a way, by gently tugging our visual leanings in different directions. Whorf was right, but only when it comes to half your brain.

Floral Gaze. Screen print by Scott Campbell

Imagine a world without color names. You lived in such a world once, when you were an infant. Do you remember what it was like? [Anna Franklin] is a psychologist who is particularly interested in where color categories come from. She studies color recognition in infants, as a window into how the brain organizes color.

Here she is discussing her work in this incredible clip from a BBC Horizon documentary called '*Do you see what I see?*'. It's 8 minutes long, but definitely worth it. It starts off with infants, and then cuts to the Himba tribe who have a highly unusual color naming system. You'll see them taking the color wheel test, with very surprising results.

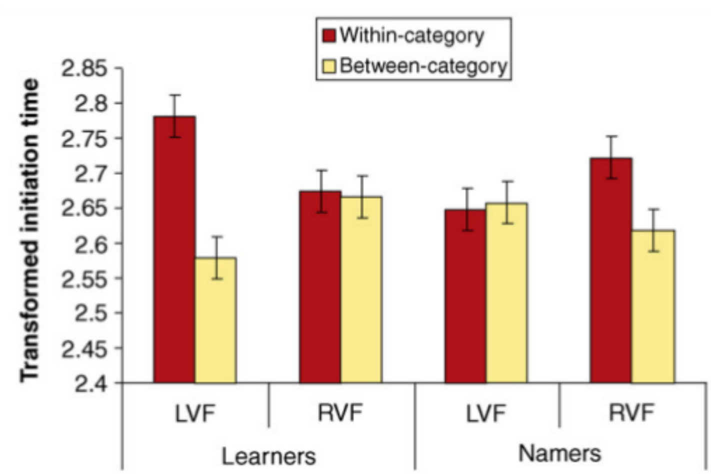
Surprisingly, many children take a [remarkably long time] to learn their color names. By the time they can name dozens of objects, they still struggle with basic colors. A two year old may know that a banana is yellow or an apple is red, but if you show them a blue cup, odds are even that they'll call it red. And this confusion can persist even after encountering hundreds of examples, until as late as the age of four. There have been studies that show that very young sighted children are as likely to identify a color correctly as blind children of the same age. They rely on their experience, rather than recognize the color outright.

Even Charles Darwin, who had a tendency to think of his children as in-house experimental subjects, was alarmed with their slow progress in this domain*.

> I attended carefully to the mental development of my young children, and with two, or as I believe three of them, soon after they had come to the age when they knew the names of all common objects, I was startled by observing that they seeed quite incapable of affixing the right names to the colours in coloured engravings, although I tried repeatedly to teach them. I distinctly remember declaring that they were colour-blind, but this afterwards proved a groundless fear. [..] **Therefore the difficulty, which young children experience either in distinguishing, or more probably in naming colours, seems to deserve further**

attention.

He was on to something here. The big question is **when children learn their color words, does their perception of the world change?** Anna Franklin (who we met in the video above) and colleagues took on this question. Working with toddlers aged two to four, they split them into two groups. There were the *namers*, who could reliably distinguish blue from green, and the politely-named *learners*, who couldn't. The researchers repeated the color circle experiment on these children. Rather than have them press a button (probably not a good idea), they tracked the infants' eyes to see how long it took them to spot the odd square.



As toddlers learn the names of colors, a remarkable transformation is taking place inside their heads. Before they learn their color names, they are better at distinguishing color categories in their right brain (Left Visual Field). In a sense, their right brain understands the difference between blue and green, even before they have the words for it. But once they acquire words for blue and green, this ability jumps over to the left brain (Right Visual Field).

Think about what that means. As infant brains are rewiring themselves to absorb our visual language, the seat of categorical processing jumps hemispheres from the right brain to the left. And it stays here throughout adulthood. Their brains are furiously re-categorizing the world, until mysteriously, something finally clicks into place. So the next time you see a toddler struggling with their colors, don't be like Darwin, and cut them some slack. They're going through a lot.

Footnote:

*At times, it was probably not much fun to be one of Darwin's children. He goes on to write:

> I will add that it formerly appeared to me that the gustatory sense, at least in the case of my own infants, and very young children, differed from that of grown-up persons. This was shown by their not disliking rhubard mixed with a little sugar and milk, which is to us abominably nauseous; and in their strong taste for the sourest and most austere fruits, such as unripe gooseberries and crab apples.

References:

Regier, T., & Kay, P. (2009). **Language, thought, and color: Whorf was half right** Trends in Cognitive Sciences, 13 (10), 439-446 DOI: [10.1016/j.tics.2009.07.001]

Gilbert AL, Regier T, Kay P, & Ivry RB (2006). **Whorf hypothesis is supported in the right visual field but not the left.** Proceedings of the National Academy of Sciences of the United States of America, 103 (2), 489-94 PMID: [16387848]

Franklin A, Drivonikou GV, Clifford A, Kay P, Regier T, & Davies IR (2008). **Lateralization of categorical perception of color changes with color term acquisition.** Proceedings of the

National Academy of Sciences of the United States of America, 105 (47), 18221-5 PMID: 19015521