BY **MIKE WOOD**

Communicating color

LAST ISSUE, I WROTE ABOUT A PROPOSAL for a draft PLASA standard to facilitate communicating color information from a lighting control desk to luminaires. It's a problem we've had for a long time, but luminaire technology has never been powerful enough to address. Until a luminaire could make exactly the color you asked for, the need for an accurate way of communicating that color was moot. Now we are starting to manufacture calibrated luminaires, so precise color information becomes a realistic need. The proposed standard is very simple, just an agreed language to communicate the hue and saturation point of a color unequivocally. That's not all the information you could send about a color—to be comprehensive you'd also need to send the spectral makeup—but it's a good start and a lot better than we have now.

Human color language

Thinking about the minimal color information we could communicate to luminaires got me wondering about how we communicate the nuances of colors between people. Unlike attributes such as mass and size, color is a completely perceived attribute that has no reality outside our minds. Physics knows nothing about color. It can describe the wavelength of electromagnetic radiation, it can describe the spectrum of a mix of wavelengths, but the step of giving that complex mix a single name as a color is 100% in our eyes and brain. We don't even know for certain that what I see and call "red" appears the same to me as the mix of wavelengths that you see and call "red" (although research seems to suggest that it is highly likely that we do perceive the same thing). If we look back in human history and the development of language, how and when did we start naming colors and do different cultures come up with the same divisions between colors?

Which color is named first?

Once I started digging I found that a large amount of research has been done on the history and etymology of colors and color names, with early work from Berlin and Kay at Berkeley in the 1960s and most recently in a 2012 paper, "On the Origin of the Hierarchy of Color Names," and interestingly, it appears that just about all cultures come up with names for the same colors in the same order. Not too surprisingly, as a culture and language develop, the first areas of illumination to get names are dark/cool and light/warm. These terms cover a slightly wider distinction than simply black and white, but are essentially words for the presence or absence of light, with a slight distinction for the color temperature. No distinct color names yet. The first real color to get a name, and it appears to be common to just about every culture, is red. No matter where in the world this was, whether the language developed in Europe, Asia, Africa, Americas, or Australasia, the first color that humans name in the development of proto languages is red. Why is that?

> **How and when did we start naming colors?**

Seminal research by Berlin and Kay in 1969 suggests cultures develop color language in seven stages, with basic Stage I languages having only the colors black (dark–cool) and white (light–warm), while languages that have reached Stage VII have eight or more basic color terms. This includes English, which has 11 basic color terms: black, white, red, green, yellow, blue, brown, orange, pink, purple, and grey. Interestingly, some other European languages such as Italian, Modern Greek, and Russian have 12 color terms as they distinguish blue and azure (where azure is the sky-blue color half way between blue and cyan). This doesn't mean that English speakers can't see or describe the difference between blue and azure, of course. All it means is that, in English, azure is not a basic color term, and instead we might say bright-sky-blue instead, while pink is a basic color term because English speakers do not normally say "light-red."

Berlin and Kay theorized that, as languages evolve, they acquire new basic color terms in a common chronological sequence. If a basic color term is found in a language, then the colors of all earlier stages should also be present.
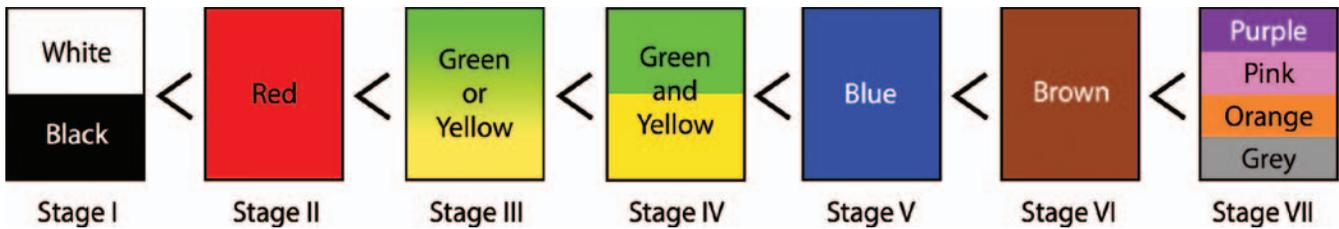
Figure 1 – Stages in color names

To explain this table, take it stage by stage. What it says is that if a language has just two color terms, they will be a dark and a light. When a language adds a third color, it's going to be red. Add a fourth, and it will be either green or yellow, five colors gives us both. When you get to six colors, the green region splits into two, and you now have blue. This appears to be a constant in human development that most languages seem to follow, towards finer and finer color divisions (of the 98 languages that Berlin and Kay studied, 92 seemed to follow this basic route).

The reasons and logic behind the published research are complex, but the basic premise is simple, it seems that the order we name colors is, not surprisingly, directly linked to the color receptors in the eye, in particular to the specific sensitivity to small changes in color in different parts of the spectrum. **Figure 2** shows the minimum change (Just Noticeable Difference – JND) that's needed in the wavelength of a color before the human eye sees it as having altered.
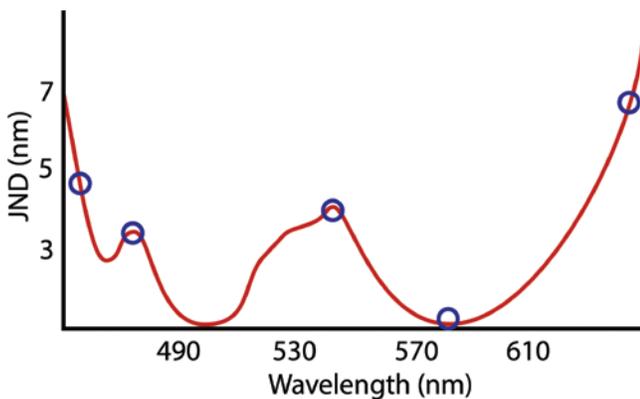

Figure 2 – Just Noticeable Differences for human color vision

This shows that we are most insensitive to changes in the color of red light, blue light, and pure green. Conversely, we are most sensitive to changes around cyan and yellow—the colors that overlap most sensors in the eye. If we turn this around and look at it from the opposite point of view of then it means that, if we are wondering which colors stand out as being the most similar to each other, and worthy of being given a single name then red is the leader. We are

insensitive to wavelength changes in red light, therefore most reds will look similar if not the same to us. That means it's an easy color when a language is developing to agree on. You can imagine two cavemen easily understanding and agreeing with each other that a flower, or blood, or fire, or a sunset is "red" whereas they may not agree that cyan is the same color at all. One may see it as blue while the other as green. As with communication between desks and luminaires, agreement is the key to language development. Once we agree we are all referring to the same thing then a name comes easily.

Red

If red is the first color to be named by all cultures, then where do we get the English word? Current thinking is that the first recorded ancestor was the Proto-Indo-European (an ancient culture rooted in Central Asia and Eastern Europe at around 4000 BC) word reudh in around 3500 BC. Over the millennia this word migrated, crossed the globe and became used in Sanskrit (an Indian continent language dating back to 2000 BC that forms a primary root for Hindu) as well as Proto-Germanic, where it became rod or rauthaz, which is one of the primary ancestors of English. It also made it to Greece where it became erythros, familiar to us in English as the medical name for red blood cells, erythrocytes. In Old English, reudh became read which eventually became the red we use today. (If your name is Reed, Reid, or Read—your name remains as Old English for red. Perhaps one of your ancestors had red hair?). Reudh also gave us ruddy, ruby, russet, rust, and other red words.

Green

The next color we give a name to is the green/yellow area. Not too surprisingly, the word green seems always to have been connected to the idea of growing things: indeed green and grow come from the same Germanic root, which, in turn came from the Proto-Indo-European words ghre and gro. The word has changed very little over the centuries; it's grun in German, green in English (by way of the Old English version grene or greene), and groen in Dutch. By the way, the original gro also gives us the modern word grow, so grow and green are still inextricably linked.

Yellow

It takes some time for cultures to distinguish green and yellow as separate terms, they are both natural plant colors and it was probably hard to agree where the division between them was. In Proto-Indo-European yellow was ghelwo which, depending on context, could mean both yellow and green along with ghre. Passing down the now familiar route through Proto-Germanic, it became gelwaz. Subsequent derivations of German had the word as gulr (Old Norse), gel (Middle High German), and gelo (Old High German). From those same roots, Old English developed geolu and geolwe, both very close in pronunciation to our current yellow.

Blue

Blue is such a common word in English that it's odd to discover that the original word for blue didn't mean the color blue at all. As always, we go back to Proto-Indo-Europeans where the word bhle was used to describe anything that was light-colored or shiny. In fact some researchers believe that bhle may have even meant yellow! As languages spread, so too did the words based on bhle. For example, here are just a few of the words that sprang from bhle:

    belyi – Russian for white
    blawr – Welsh for gray
    blanc – French for white or blank
    blavo – Old Spanish for yellowish-gray
    flavus – Latin for yellow
    phalos – Greek for white (The Greeks used the same word for bronze as they did for blue—it really just meant shiny)
    None of which mean blue!

It's unclear why a word for blue is so slow to develop, it seems so strong and clear to us as a division today, we have more blue gels than any other color. However, it's a color that doesn't appear too often in nature other than the sky, and it's a dye color that was very difficult to make. We call the sea blue, but very often it's green, and the distinction is difficult.

Figure 3 – Where does blue end and green begin?

The Greek phalos became pale in Old English, still well away from the color blue. Instead, Old English obtained the word blaw and then bleu with the meaning we know today from the French spoken during the Dark Ages, which had taken the original bhle on a different evolutionary path.

Even today there are modern languages that don't fully distinguish blue and green as primary terms. Korean, for instance, uses the word pureu-da to describe both colors. Similarly, the Thai word khiaw usually means green but can represent blue when describing the sky or the ocean.

In modern Japanese, the division into distinct terms for blue and green is very recent. In English, as in many other languages, we use the same or a similar word for vegetable as we do for the color green (as in eat your greens), but in Japanese, vegetables are ao-mono, which literally translates as "blue things." Apples in Japanese are also blue, as are the leaves of spring. It's the same when we look at the other English meaning for the word green we use when referring to a novice or somebody new to a task. In Japanese, those same novices are referred to as ao-kusai, or "they smell of blue." Blue and green have not been fully divided in Japanese and the meanings appear mixed to our ears. As a final example, in Japanese the traffic light color which means Go, is called ao that is again translated as blue. The traffic lights in Japan are the same color as they are everywhere else; it's the name for the color that's different, not the color itself. The word ao used to be the only word Japanese had for both blue and green, however the language did have a word for a particular greenish-blue, midori. As time has gone on, and Japanese has been mixed with Western culture so that word midori has now come to mean green in the same sense as we use it. This adoption of a distinct word for green is within living memory, perhaps only becoming widespread in the last 60 years since World War II.

Brown

Brown is an odd color; it's not part of the spectrum and, in reality, is a dark red or orange. However, it's very common in nature; earth and trees, stones and rocks. Once again we look back to Proto-Indo-European for the derivation of brown. The original term was bher that meant something that was both shiny and dark colored. It kept this same meaning through Proto-Germanic as its pronunciation shifted to brunaz. In Old English this became brun or brune, and the meaning shifted to mean shining and light (as opposed to shining and dark). This "shiny" meaning still persists in modern English in the word burnish meaning to polish while it comes down to us meaning the color in words like "brunette." The exact switch over in English to the word brown with a different connotation is hard to pin down, although it seems to be as late as the 13th century before it gained its current meaning. Even today the word brown has a very wide range of meanings. Everything from a pale taupe to a deep chestnut is called brown. Some of these colors are actually dark reds, while others are closer to a greyish yellow.

Now we get to the color terms that aren't essential, they are more words of convenience than distinct terms. The derivation of these is often much more recent.

Orange

Not a Proto-Indo-European word at all, in fact the color's name derives from the Sanskrit word for the fruit naranga. The color orange was named after the fruit, not the other way around. This mutated into the Arabic and Persian naranj, and to narange in Old French. In English we have a common habit of altering nouns that begin with an 'n' by moving the 'n' from the beginning of the word to the end of the indefinite article before it. Just like "a napron" became "an apron," "an otch" became "a notch," and "a nadder" became "an adder," so too did "a norange" became "an orange."

This moving of the "n" to the indefinite article can happen in the other direction as well, for example "an eke-name" became "a nickname," and "an ewte" became "a newt."

The word for the fruit didn't also become the word for the color in English until the 16th century. Before then, English referred to the color as geoluhread, which literally translates to "yellow-red." Just like pink was originally light-red, when a color becomes important enough it gains its own name rather than as a derivative of another type.

Purple

This word is also more recent. In Ancient Greek, the word was porphrya, a term for a shellfish-derived dye for a reddish-blue color that is more red than what we'd call purple today. The Romans adopted the Greek dye as purpura and occasionally used the name for the garment color as well, in those days this was an extremely expensive dye. Thus, it is associated with the purple robes of emperors and senators and has a derived association with upper class and royalty. In Old English, purpura became purpul from which the current root is clear, however it still meant a dye rather than the color. It wasn't until the 14th century that the color was named after the dye.

I don't know if you agree, but I find every aspect of color fascinating. The fact that it's completely imaginary and fundamentally incommunicable just adds to the intrigue. It's so important to us in our daily lives and in our professional lighting world, but is also ephemeral and difficult to measure. We may think we are slow in developing a standard for color in entertainment lighting, but if it takes four thousand years to come up with seven different fundamental color names, and we still don't agree on all of those, should we be at all surprised that it's taken a while? ■

Mike Wood runs Mike Wood Consulting LLC, which provides consulting support to companies within the entertainment industry on product design, technology strategy, R&D, standards, and Intellectual Property. A 35-year veteran of the entertainment technology industry, Mike is the Immediate Past Chair of the PLASA Governing Body and Co-Chair of the Technical Standards Council. Mike can be reached at mike@mikewoodconsulting.com.