# Thinking outside the paint box

## Basic color theory for better scenery painting

**BY SEAN O'SKEA**

YOUR KINDERGARTEN teacher lied to you. Well, perhaps not lied so much as gave you an oversimplified explanation of color theory. Experienced scenic artists know there is a lot more to mixing colors than simply "red and blue make purple."

Beginning painters can have frustrating, time-consuming, and expensive failures trying to mix specific colors. For example, why can't you get a pretty purple when you mix red and blue? And if yellow and blue are supposed to make a solid green, why the resulting dull avocado instead? Not to mention, why does adding black to yellow make split pea soup? Understanding all this requires information your kindergarten teacher left out. For less frustration and better

All the colors on the CMYK color wheel above were mixed from cyan, yellow, and magenta, resulting in 12 secondary and tertiary colors that are better aligned to their actual complement than the six-color wheel.

scenery, let's explore some basic color theory and paint mechanics.

### Additive vs. subtractive mixing

First, let's review the definition of primary colors. Primary colors are defined as the (always three) colors you can mix to get all the other colors, and those colors are different for light mixing versus paint mixing.

You may know the terms additive and subtractive mixing. Additive mixing is done with light — think stage lighting, for example — using the primary colors of light: red, green, and blue — or RGB. With additive stage light mixing, you start with black (darkness) and add colors of light. Each new color adds visible wavelengths of light. Mix two primary colors of light together, and you will see a secondary color of light. Red + blue = magenta, blue + green = cyan, and green + red = yellow. Mix all three primary colors of light, and you get white.

It's somewhat the reverse with paint. Pigment is matter, which absorbs, reflects, and transmits light to varying degrees. Based on which wavelengths get absorbed versus reflected, the pigment appears to have a certain color. White pigment reflects almost all the light into our eyes, while black pigment absorbs almost all the light. That's why an actor in a white dress appears so much more prominent onstage than an actor in a black dress. With subtractive mixing, you add more pigment to the paint bucket, but the resulting mix absorbs or *subtracts* visible wavelengths of light.

### Hue, value, and chroma

Here are a few other basic but important terms you may already know: hue, value, and chroma. Hue is simply what we think of as the "color" of the pigment. Value is almost as easy to understand. It's the relative measure of white or black in that color. If you add white to red, you get the tint of pink. If you add black to red you get a brick-red shade. Each individual color has a wide range of different values you can give it by adding white or black.

Chroma is a bit trickier. Also known as intensity, saturation, vibrance, or colorfulness, chroma refers to the purity of the color. On one end of the gamut is the intense, unaltered rainbow version of the color. On the other end is a grey-black neutral. To lower a hue's chroma, you add that hue's color complement.

Take red, for example. If you add yellow pigment to red, you make a new hue: orange. If instead you add blue, you get a form of purple. But there is no amount of green that you can add to red to make a new hue. All you get is a duller, darker tone of red until you hit a midway point between red and green, where, in theory, you would have black. (In reality, due to all the other ingredients in paint besides pigment, you tend to get a dark grey-puce.) Keep adding green to low-chroma red past the 50/50 point, and you'll swing over to the other side of the color wheel and start making low-chroma greens.

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But why green? Remember the primary colors of paint are red, blue, and yellow — at least in the elementary school version. According to this model, how do you make green? Mix blue and yellow. So, when you add green to red you are adding both blue and yellow, which means you've got all three traditional primaries. So (in theory), with subtractive mixing, when you perfectly mix all three primaries, you get black. This will become very important in a bit.

With paint, there is no way to raise a color's chroma. You can place other colors next to it to create the illusion of higher intensity, but otherwise the best you will get is straight out of the can. This is one of the many reasons why high-quality paints are important, especially if you intend to mix colors.

There is nothing wrong with using house paint on a set, but be careful trying to mix with it. House paint formula is designed for you to take that can home and paint it directly onto your walls, not mix it with other paint. A lot of paint-store black, for example, is actually a very deep purple or blue. So, when you stir a spoonful of "black" house paint into yellow to darken or neutralize it, you're really adding blue. What happens when you add blue to yellow? Instead of the muted butterscotch shade you were hoping for, you inadvertently shift toward green and get split pea.

### Color bias or temperature

But even more important is the concept of color bias or color temperature. There are warm and cool colors, right? Red, orange, and yellow are considered warm, while blue, green, and purple are cool. But, we can have cool reds and warm blues. Beyond the oversimplified, six-color, Trivial Pursuit color wheel we have all seen, there are infinite subtle variations between the pure spectrum hues. Half of green is a form of blue, while the other half is a form of yellow. So how can that be a "cool" color? Same goes with purple. In fact, lighting designers know how useful lavenders are in lighting, due to their dual nature as both warm and cool.

Color bias is why paint companies have more than one of each color. Rosco, for example, makes Lemon

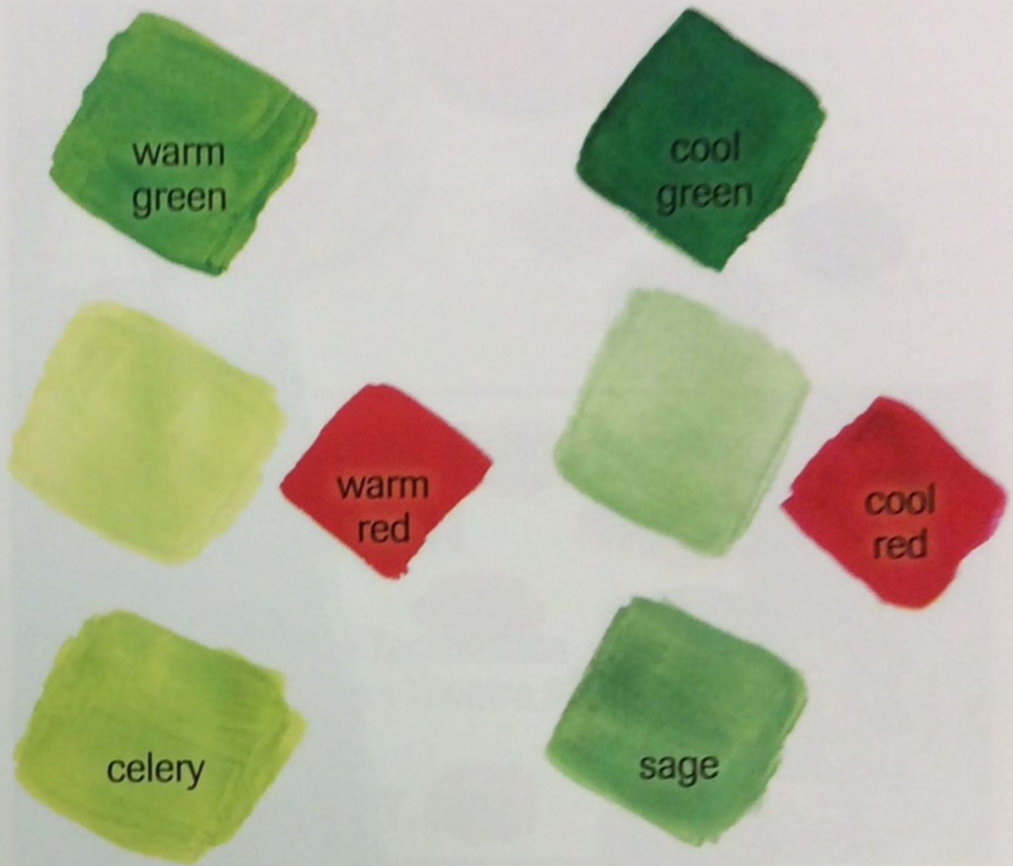
Yellow and Golden Yellow. Lemon is cool, or blue-biased, with a slightly green tint. While Golden, as the name suggests, leans toward orange (red bias). The scenic paint brand Artist's Choice sells 28 colors. In addition to Magenta and Royal Purple, they make three different reds: Dark, Rich, and Bright. Rich Red is blue-biased and the Bright is yellow-biased, while Dark, as the name suggests, works well at lower values.

Why does this matter for mixing? Let's say we want to mix a nice rich, royal purple. Easy, right? Red and blue. But when you mix the paint, instead of the toga-purple you were hoping for, you get something that looks like a bruise. What happened? If you're after a high-chroma Crayola purple, you could mix the blue-biased Artist's Choice Rich Red and a red-biased ultramarine to make a rich violet. Neither color has much yellow in it to lower the chroma of the resulting purple.

If instead you reach for the (orangish) Bright Red and add a (greenish) cerulean blue, then your mix is getting a double-dose of yellow bias. Now you have all three traditional primaries in the bucket and all that yellow will seriously damage the resulting color, resulting in an unpleasant brown. But that's a judgement based on the hope for a vibrant violet. In another context, a neutral, brownish purple might be exactly what you wanted. You can add some white to that color and get pretty tints of old rose or amethyst.

The warm, Bright Red mixed with a cool blue won't get you violet either, but you will get a lovely lavender, a lower-chroma (more neutral) purple because of the yellow-biased. Tweak the value and you discover a full range of lovely pale purples, from lilac to periwinkle to heather.

It's true in the other direction as well. Bright Red mixed with Golden Yellow will make a hot, pumpkin orange — both colors are already biased toward orange. But mix Rich




Mixing celery and sage are almost identical recipes. The only difference is the color biases or temperature of the greens and reds used.

Red and Lemon Yellow, and you will get brown. Add some white or black, and you'll find a gamut of earth tones, all lovely in their own right, but nothing close to the flame orange you get by mixing the two orange-biased colors.

As described earlier, you can adjust a color's hue, value, and chroma simultaneously while mixing. Look at another example. Celery and sage are two popular colors. Look closely at celery and notice how yellow it is. It's awfully high-value too, meaning that it requires some white. Sage is also a high-value tint (requiring white) but is much cooler, or blue-biased, than the celery. Let's try mixing each one separately.

Start with the celery. You will want a yellow-biased green, perhaps Rosco Emerald, to start. You know that to raise its value, you must add white. That gets you a kind of radioactive green. To neutralize this, you need to lower its chroma slightly. That means adding a tiny bit of red — so little that the exact red may not be too important, but, for this one, err toward yellow-bias when in doubt. Now we have a warm green that has been significantly raised in value by adding white but also lowered in chroma by adding a little of green's traditional complement, red.

For the sage, let's start with a phthalo green — a teal (blue-biased) green. Add white, and you get mint. Lower its chroma by adding a bit of red — this time go with Deep Red — and you get sage. The two recipes are almost identical, except for the opposite color biases.

These four purples were mixed with different combinations of warm and cool reds and blues. The top result is from a mix of ultramarine (warm blue) and cool red. The next is ultramarine and a warm red. The extra yellow from the orange-biased red has lowered the chroma of the result. While cool (green-biased) blue and cool red make a nice lavender, cool blue and warm red have way too much yellow to get anything but a muddy mauve.

## Now, forget everything you learned

There is another way to look at mixing that involves giving up your elementary school red, yellow, and blue color wheel altogether. There are all kinds of reasons we have the spectrum colors we are accustomed to, many of which have more to do with Isaac Newton and 18th century pigments than with sound color theory. That's a fascinating story, but too long for this article.

The truth is that red, yellow, and blue are not primary colors of either printing or paint mixing. Instead, those primaries are cyan, yellow, and magenta (the secondary colors of light mixing). In this model, red and blue are secondary colors, meaning that they can be derived from mixing two other (primary) colors. The magazine you are holding and every printer in the world, from the inkjet on your desk to the finest German press, uses this CMYK color system. If you put the photos on this page under a microscope, you'd see tiny halftone dots of cyan, yellow, magenta, and black (the K in CMYK represents black). Depending on the density of the dots, our eyes perceive various colors, just as George Seurat and the other pointillists discovered 140 years ago.

And, despite what your kindergarten teacher said, the same is in fact true for paint mixing. Mix cyan and magenta paint together, and you will get a deep, true blue. Meanwhile, magenta mixed with yellow paint makes fire engine red. This certainly departs from kindergarten wisdom, where primary colors of paint mixing were red, blue, and yellow. And it also may appear to contradict what you just read above about color biases and how pigments combining the complements of traditional primary colors (like magenta — a purple hue — and yellow) colors turn out "muddy."

The CMY primaries of pigment can be better understood through revisiting the primary colors of light: red, green, and blue. Mixed in the right pairs, these lights produce their secondary complements: cyan, magenta, and yellow. In painting, the model inverts: CMY are the primary colors, and RGB are the complements.

Here's how it works. When white light hits magenta pigment, the pigment absorbs only green light, reflecting a combination of red and blue, seen as magenta. Likewise, cyan pigment absorbs only red light, reflecting green and blue (cyan). And finally, yellow pigment absorbs blue light, reflecting red and green — remember, when you mix red and green light, you see yellow. Note that this set of complementary colors (magenta – green, cyan – red, yellow – blue) for paint mixing is quite different from the traditional set (green – red, yellow – purple, blue – orange).

So, mix cyan and magenta and you get blue. Why? Cyan absorbs red, and magenta absorbs green, so the remaining reflected light looks blue. Same goes with yellow + magenta (these absorb green and blue, leaving behind red). Finally, mix cyan with yellow (these absorb both red and blue), and what remains is a lovely, high-chroma green.

The simple CMYK wheel features 12 colors, while more advanced versions offer 20 or even 36 colors to help guide your mixing. Starting with CMY primaries and following this color wheel will create vivid, high-chroma hues. For example, mix a warm blue with magenta, and it's easy to get true purple. The high-chroma (secondary) red you get from mixing magenta and yellow can be combined with a little more yellow to make a flame orange.

Also, since cyan is a green-biased blue, when it's mixed with yellow, the resulting green will be much brighter than mixing say ultramarine blue and yellow. If you want more of a phthalo green, then just mix in a little more cyan to shift it into the tertiary blue-green slot.

The earth tones and greys you get mixing with the CMY color wheel also come out cleaner, since the complements are more precise. This is especially true in the blue/yellow and yellow-orange/cool-blue mixes, where you get all the Italian browns, like umber and sienna.

## Tips and tricks

Remember, different hues have different values as well. A 50/50 color ratio between red and green results in a pretty good neutral value. But you need the tiniest drop of blue or purple into yellow to find a color halfway between those two. Equal parts (non-magenta) purple and yellow will get you a slightly brown purple.

Mix in tiny quantities until you get the color you are after. You can scale up any measurements and stay consistent. One tablespoon of green, one of white, and a quarter of red can be scaled up to a quart of green and white and a cup of red. Add the darker color to the lighter color, add it slowly and mix thoroughly before adding more. Pour too fast or don't stir enough, and you can easily overshoot your target.

If you are mixing into paint store bases, check the amount of filler in the can you are mixing into. Most paint brands offer the following variations: a white or pastel base, a mid-tone, and a deep or accent base. The pastel base has a lot of chalk in it so that smaller amounts of pigment still cover the surface painted. Meanwhile, the accent base is more transparent. If you are going for a magenta, no amount of pigment stirred into the pastel base will make anything darker than a Pepto-Bismol pink.

You don't have to perfectly understand color theory to use it. Do a little experimenting. Color and color theory is vast and complicated, but the material covered in this article should not only improve your scenery painting but also provide a fascinating study for you and your students into the intersection of science and art. T