Color and color mixing

Introduction

Many artists seem to spend some time learning about color, and then kind of get lost. It's a tough subject to get your brain around. You see some version of a color wheel; learn a bit about how colors on opposite sides of the wheel (complementary colors) are supposed to behave, and so on.

Then you start to try to mix paints, and you realize that there is a lot of important stuff that conventional color theory doesn't handle very well. It's confusing, and I'm here to tell you that it's not you. Colors shift all over the place when mixed together, in ways that the color wheel doesn't predict. Some colors seem to have two or more mixing complements. Other colors, that should theoretically be complementary, don't mix to make a neutral. White and black cause colors to become chalky or dull, so how do you make colors darker or lighter? How the exactly does brown fit in? The outside of the color wheel has some light colors and some dark colors—what's with that? Secondary colors don't seem very secondary. How exactly do you make a dark yellow? Do the primaries, secondaries, and complements reflect some underlying reality of color vision, or is that just an arbitrary convention?

Inadequacies of most color theory for artists

Color theory, as found in most art books and art classes, doesn't actually help a working painter all that much. You may find that whenever you try to mix a specific color, you get "mud." You might cope by just getting a lot of tubes of paint so that you rarely have to do much mixing. Seeking clarity, you might buy a book like 'Blue and Yellow Don't Make Green," which promises a new approach to color, but is based on concepts invented in the 1700's. (And written in an irritable, repetitive, pretentious, repetitive, finicky, repetitive style. By a guy who doesn't know. How to construct grammatical sentences. But I digress.)

Or you find something like the Munsell color system, which does a good job describing color, but doesn't show how to mix those colors after you identify them. Reading books and looking around on the internet gets you a little closer, but mostly, by trial and error, you just figure out what works, using a small subset of available pigments. You memorize some useful mixing recipes. A lot of the time, you muck around with paint until you get something that looks about right. If you delve more deeply, you find that the subject of color is incredibly complex, because it requires reconciliation of the physics of light with the messy, non-linear neuroanatomy of the human retina, optic nerves, and visual cortex. Most of what's written about color is not for painters, and most of what's written for painters is by people who've learned to mix paint, but don't actually understand color that well.

One excellent resource is the Handprint web site, where the author, Bruce MacEvoy, has done incredible amounts of reading, research, and testing with watercolor paints. But the stuff he has on color goes on and on, and on and on, so it's hard to find the real practical stuff (it's there, and it's worth looking for, but oy!).

So, while I don't pretend to have a really thorough understanding of color as it pertains to painting, I thought I'd try to boil down what I do think I have a clue about. It's a little easier for me, since when I was in graduate school I did a bunch of work with the psychology of visual perception (I'm even published in the field). I will not, however, subject you to complex equations, the details of opponent process color vision theory, or technical color space specifications that are designed to meet the needs of the print, computer monitor, and motion picture industries (you're welcome). I'll try to stick with what you need to know in order to describe and mix colors.

Yes, the color wheel does suck

To start out, we need to dump the standard color wheel. It was a useful innovation back in Isaac Newton's time, but we've moved on since then. The biggest problem with it as a tool for painters is that it's trying to do two different things at the same time, and it does both of them poorly.

First, it tries to provide a model of human color vision, including how the eye processes complementary colors—whatever those are. But when you test how actual vision works, you find that the color wheel is a terrible model of color vision and that much more accurate models have existed for well over a century.

Second, it tries to provide a guide to color mixing. It does that quite badly as well, because real color mixtures don't fit the standard color wheel model in any coherent way.

It's become apparent to me that we must divide the topic of color for painters into two: (1) a way to describe color as it is found in the natural world and as the eye perceives it; and (2) a way to conceptualize how to mix desired colors using particular combinations of paints. There is no system that does both of those tasks, so let's just dispense with the standard color wheel and start over with two separate (albeit related) topics.

Describing color with Munsell

Although we often still see the standard three-primary color wheel in books about painting and color mixing, as a practical tool it went out of date in the late 19th century, when guys like Ogden Rood demonstrated that it pretty much stinks for describing color accurately. There is nothing in the way humans perceive light to support the idea of three unmixable primary colors (red, yellow, blue), each of which is complementary to a specific mixable secondary color (red and green, yellow and violet, blue and orange). In fact, it is more reasonable to say that there are no special primary colors at all, whether the traditional artist's primaries (red, yellow, blue), the printer's primaries (cyan, magenta, yellow), or anything else.

A number of more accurate ways of describing color have been developed. Many of them are designed primarily to support the needs of the print industry, the dye industry, manufacturers of video equipment, and other commercial ventures. They are needlessly complex for our purposes. The best system that is comprehensive enough, but not too complex to be easily understood, is the Munsell color system. It was first developed in the early part of the 20th century and has been updated a few times since then, although the original structure remains. Any such system represents a series of compromises, so there are ways in which Munsell is imperfect, but overall it suits our purposes better than any other that I am aware of.

Rather than a color wheel, Munsell is built around a three-dimensional color space. This space takes the shape of an irregular cylinder. Munsell uses three properties of color: value, hue, and chroma. A good summary of Munsell is found in **this Wikipedia article.** Go read it now. I'll wait.

Back? Excellent. From here on in I'll assume that you have an understanding of how Munsell is structured. For those of you who didn't bother with that and just kept reading, come back here when you start to get confused.

What's Munsell good for?

So how is Munsell more useful to a painter than the old three-primary color wheel? First, it dispenses with the confusing idea of primaries and secondaries while more accurately identifying useful complementary color relationships. Second, as you become more familiar with Munsell, you can begin to think about colors in terms of how they relate to each other within the color space. If you are looking

at a blue wall, for example, and you are thinking in Munsell terms, you can figure out where the color lies and how to accurately describe it. What is its hue? How chromatic is it? What value is it? How do those parameters compare to other colors you are trying to work with? How do the hue, chroma, and value of the wall relate to the hue, chroma, and value of the blob of paint you are trying to use to represent it? Some artists pre-mix a set of colors on their palette in Munsell value steps. If you have a set of Munsell chips, you have an absolute reference for colors that you can use for comparison and mixing. That can be incredibly valuable.

There isn't much in Munsell that helps you figure out what color you will get if you mix two paints together—that's not what it's for. What it does do is help you decide what color you are trying to get to. And for that, it's really excellent.

Practical Color Mixing: Value

Value is the most important component of color, because the human visual system prioritizes value information over other color information. The most important characteristic of color to learn how to mix is value, so that's what I'll discuss first. Later, I'll talk about controlling hue and chroma. Of course, since they are so closely interrelated, in each discussion of one of the three components I'll also have to talk about the other two.

Getting the Value Right

If you're having trouble mixing a color with exactly the right hue, chroma, and value, concentrate on at least getting the value right. There are any number of paintings out there with weird hues and no consistent use of chroma, but they work because the values work. (That's not to say that hue and chroma aren't important—they are—but value is the most important of the three for a beginning or intermediate painter to concentrate on.)

Value should be considered at two levels in realist painting. First, you need to consider the value structure of the painting as a whole. Do you want most of the painting to be light (a high key painting), most of it to be dark (a low key painting), or for there to be some kind of balance across a wide value rang (a full key painting). What is the range from darkest dark to lightest light? It's useful to establish that range early, because every object will be rendered in relation to that key.

Overall Value Range

As you think about this, you need to be aware that the value range of paint has only a small portion of the value range of human vision. Consider a painting of a sunset. That sun is much, much brighter than your highest-value white (which you'll need to tone down in order to get the right hue and chroma). In order to give an impression of that brightness, you will need to make the rest of the scene quite a bit darker than you otherwise might. You are choosing a value scheme that represents the value relationships most important to the composition. That means that you won't be able to have much contrast in the darks, because their value range is compressed in order to emphasize that very strong light. On the dark side as well, the blackest black on your palette reflects more light than a really dark shadow does. There are times when you need to compress the lights in order to show a full range of contrasts in the shadows.

(Of the painting media, by the way, oil paint has the widest value range, particularly in terms of really dark darks. So it's easier to create believable three-dimensional form with oil paint, and that's one reason why it's so popular.)

Therefore, in making decisions about the key of a painting, you need to accept that you are necessarily working with a limited value range, and you need to make intelligent choices about how you use it.

There is no such thing as "paint what you see" in this calculation. Artists often manipulate the value range to achieve a specific effect. Rembrandt and Caravaggio, for example, both painted low key paintings. But more than that, they made the darks very, very dark, the midtones quite dark, and the lights very light. That creates a marvelous dramatic effect, but there's nothing realistic about it. It is worth looking at a lot of paintings and thinking about what choices the artists made regarding value range, because those are the same choices you're going to have to make every time you paint. Trying to go for a middle road, in which the lights are fairly light, the midtones are fairly medium, and the darks are fairly dark, is not always the best choice, because it isn't very interesting and because it's often not the right way to represent the emotional content of the scene.

Don't think that hue and chroma are the primary determinants of the way your painting feels, because often the real money is where the value is.

Light and Shadow

Within the overall value scheme of your painting, you'll need to consider value as you work on each object or passage. Often, it's good to think in terms of two, three, or (maximum) four values in the mass areas each object depicted. On the Munsell value scale from 0 to 10, for example, you might paint the shadow side of a house at value 3 and the light side at value 5. A head might be represented at value 5. 5 in the upper lights, value 5 in the darker lights (sometimes called the "halftones"), value 3. 5 around the terminator (the shadow edge), and value 4.5 in the reflected lights. You could mix these tones on your palette before you start, lay them down in the appropriate areas, and then blend as desired. You could then add highlights at value 6.5 and dark accents at value 3. Doing it in such a methodical way can be much easier than figuring it out as you go.

To get these values right, it's sometimes easier to think about relationships than it is to think about matching the actual value of the object you're trying to paint. So if the overall key of your painting sets the value of the light side of a cube at value 7, the thing to do is to observe and think about how much darker the shadow side of that cube is. What value in paint best reflects the value relationship you are observing in real life? Is it a 5? 4.5? It takes a lot of practice to get these kinds of relationships right across an object, and then to keep those relationships right across many objects in a single painting (many beginner paintings seem to be keyed differently in different parts of the picture).

One useful exercise is to do a series of paintings in a single hue. If you do it in shades of grey, it is called a grisaille (pronounced *gree-zai*). A 50/50 mixture of black and burnt umber is a good base tone for a grisaille that you can mix with different amounts of white to get the desired value. Doing a series of grisaille studies can help develop your ability to judge and paint value. For each stroke of paint you put down, think about whether it should be darker or lighter than the paint surrounding it, and by how much. Over time, you'll achieve a much greater sensitivity to value.

One of the typical mistakes that beginners make is to focus on hue and chroma at the expense of value. They might be trying to paint a figure, for example, and mix up some "flesh tone" (or they might have a tube labeled "flesh"). They proceed to paint the whole figure that color, then timidly throw in a slightly darker tone for shadows and edges. The figure looks flat and unconvincing. If you are going to concentrate on a particular subject, and you want it to look dimensional, you need a fairly wide value range within that subject. If that means compressing the lights or darks so that background elements have less contrast, that's OK. If you're painting a figure, the shadows on that figure should be a significantly darker than the lights.

It is only with a wide dynamic range that you can create the illusion of three dimensional form. I remember when I was first taking painting classes, my teacher would look at my figures, sit down with my palette, and make the darks a good two value steps darker than I had made them (and I thought they

were pretty dark). It was a painful experience, but it showed me how to create a successful illusion of form.

White and Black

So how do you make paint darker or lighter? You can, of course, simply add black to darken and white to lighten. If you're only concerned with value that will always work. But both of those colors will, under many circumstances, distort hue and chroma. White, of course, is a critical mixing color; it is the dominant pigment in many paintings. As you add white, however, the color tends to drop in chroma and will often shift hue. Hue shifting isn't too hard to deal with; you can add a touch of a warm or cool color (usually warm) to correct the hue.

Dulled chroma is harder to fix (that's one reason why white paint isn't used in traditional watercolor technique). One strategy is to avoid titanium white when you don't need a really bright opaque white. Both flake white and zinc white are less overpowering and have fewer tendencies to kill the chroma in mixing. Zinc, especially, is good for this purpose (although recent studies suggest that it is prone to cracking in oil paint, so use it very sparingly). Another strategy is to use glazing, rather than mixing, to adjust hue and chroma.

But it is the case that some high-chroma colors are very hard to approximate with paint. So when you are deciding on a value scheme for your painting, one important consideration is whether you will need to showcase any very high chroma colors. If that is the case, you may need to adjust the key of the painting so that those intense colors are the right value without having to lighten or darken them much. So, for example, you might use a higher-chroma, slightly less bright light and it will read as very bright in contrast to the relatively darker, duller colors elsewhere.

I think of black as being one of the less important colors on my palette. Some painters never use it, claiming that is is a deadening color, that there is no black in nature, and that excessive use of it makes your painting look like it has a hole in it. That's hogwash. Take a look at paintings by guys like Leonardo da Vinci, Diego Velazquez, or Carravagio. They relied heavily on black. Can you really say that their paintings would have been vastly better if they had only known that some modern painters think black makes a painting look damaged? "That Leonardo guy, if only he'd known to avoid black, he might have made a name for himself!" Yeah, right. And don't think they didn't know how to darken colors without black, because they certainly did. They chose to use black because it was the color that worked best for what they were trying to accomplish.

That being said, it is true that mixing a color with black will reduce chroma, and that black is best used with care. Sometimes, strong chroma reduction is exactly the effect you are looking for, so that's when to use black. Black also causes color shifts. Mix black with a bright yellow (such as cadmium yellow light). Do you get dark yellow? No, you get an olive green (which can be quite useful). Under many circumstances, black acts like a very, very dark blue. Black is often best used the way it was usually used in the 15th century, to darken (and reduce the chroma of) earth colors and other low-chroma colors. Black can also be useful when you need a really dark dark for the darkest shadows. As I'll discuss later, black can also be useful when you are mixing a string of grays in order to reduce chroma by first mixing the right hue and value, then mixing in a neutral gray of the same value.

Controlling Value

So, if we need to be careful with white for lightening and if black is of limited use in making colors darker, how do we manage value? Carefully. Take a look at a color wheel, particularly the colors on the outside of the wheel (the highest chroma pigments in each hue). You'll notice that warm colors. like yellow, are quite high in value. By contrast, cool colors like purple are relatively dark. So your value

mixing strategy will need to depend, to some degree, on what part of the color wheel you're working with.

For example, how do you make a dark yellow? Do you look on the other side of the color wheel, find that a violet is the complement of yellow, and mix that in? That doesn't work very well, because many warm colors don't have a true mixing complement (they don't mix to a neutral grey). So violet added to yellow produces a severe color shift away from the yellow hue. Fortunately, there are dark yellows already available—browns are basically dark yellows. As artists have been doing for many centuries, you don't try to mix a dark yellow. You just use a dark yellow earth color.

If you want to depict a gradation from a light yellow to a dark yellow, you blend in a series of brown colors: cadmium yellow to yellow ochre to raw sienna to burnt umber, for example.

Of course, if you don't like earth colors, it's perfectly possible to mix similar ones. Some artists like to use a very limited palette of only high-chroma colors. A palette of cyan, magenta, and yellow is popular, for example. With those and white, you can mix colors very similar to yellow ochre, raw sienna, and burnt umber. Personally, I find it much easier to simply use the earths.

How do you make a dark purple? Easy. Purple pigments are already dark, so all you have to do is adjust the chroma (if needed). If you need it even darker, you can mix it with dark transparent colors that are near to it on the color wheel (a transparent dark blue like Prussian blue and a transparent dark red like pyrol ruby, for example). You could even add a touch of black.

How do you make a light purple? You're probably going to have to use some white. If you need a light, high-chroma purple, you may have some trouble, because the white is going to knock the chroma down. So you may need to start with the highest-chroma purple you can find (such as dioxazine violet), so the final result remains relatively chromatic. As noted earlier, you might also want to use zinc, or a zinc-flake mix. If you need a light, low-chroma purple, on the other hand, then mixing with white, then making slight adjustments to hue by mixing in small amounts of other colors, will probably work just fine.

It is also the case that, for many cooler colors like blues and violets, mixing with a small amount of white will increase the chroma. For example, in oil paint, ultramarine blue with a bit of white added is more chromatic than plain ultramarine. But adding a lot of white decreases the chroma. Warmer colors are tend to be at their maximum chroma straight out of the tube. The easiest overall mixing situation is when you are trying to reduce chroma at the same time you are adjusting value. If the color has a mixing complement, then, typically, that color will reduce value and chroma at the same time.

Mix the Value First

When mixing two colors, it's often a good strategy to first get both of those colors to the intended final value. Then, when you mix them together, it's much easier to judge hue and chroma. If you have a clear idea of what colors you'll be working with in a painting session (and you should), it can be useful to mix up a series of paint strings. One string is a single hue/chroma along a series of values. So, for example, a useful flesh tone is a neutral mixture of cadmium green and cadmium red. You might create that neutral brownish color on your palette, then mix in different amounts of white to make a series of gradations from very light brown to the base cad green/cad red mixture. You could then make darker tones along the same string by adding different amounts of raw umber. Now you have a string of one hue and chroma, but different values. Another string might be based on yellow ochre as a base tone, mixed with different amounts of white to make lighter tones and different amounts of raw sienna and burnt umber for darker tones. As you paint, if you need a hue that is in between the two strings, it's easy to mix paint from each string at the same value to get the right hue. Working with a set of pre-mixed values is called a *set palette.*

Some artists take it to extremes, always mixing up a pre-set group of value strings before staring to paint. If you do this habitually, it helps to mix a lot of each paint value in advance and put them into tubes—that way, you don't spend half of each painting session mixing strings of paint. I don't do that, but I do typically mix two or three strings at the beginning of a painting session and work from them.

Practical color mixing: chroma

After value, the human visual system emphasizes chroma. Always get the chroma right before you worry about hue.

Identifying chroma

As with value and hue, the simplest way to identify chroma is often in terms of relationships. How intense is the color you're looking at compared with the intensity of other colors around it? Chroma can be hard to separate out from value; light colors sometimes look more intense than they are, and dark colors sometimes look less intense. You get better with practice. If you have Munsell color chips, then of course you have a great absolute reference to work from.

Chroma cluelessness

Many artists—mostly amateurs, but also some professionals—seem to have trouble identifying chroma correctly. They often paint at a higher chroma than what they see, and they often seem unaware that they are doing so.

Let me give you an example. I was browsing through art books in a bookstore the other day and found one about the painting techniques of the impressionists. It's a very well written book, based on lots of research on the individual methods of many 19th century artists. There are a number of demonstrations in which the author copies a section of an impressionist painting, using the methods of the original artist. In every single case, throughout the entire book, the author gets the chroma badly wrong and pretty much everything else right. In particular, almost every color is one or two chroma steps higher than the corresponding color in the original. Impressionists were not known for making dull pictures, but the author felt the need to "improve" the originals by bumping the chroma, even though she was clearly making a serious attempt to use the same or similar pigments and techniques. What's more, I don't think she knew she was doing it. I think she believed she was doing precise copies, but failed to see chroma differences right in front of her face. That's just a guess on my part; some of the pigments used in the typical impressionist palette were fugitive, so she might have been deliberately compensating for their tendency to fade. But if that's the case, I couldn't find where she told us that, and she was certainly increasing the chroma even in areas corresponding to those painted with lightfast pigments. So either the reproductions in the book are badly messed up (or no one caught it) or this artist has a remarkable insensitivity to chroma.

I see similar errors on internet forums in which amateur artists post copies of old master works. The chroma is usually too high—often much, much too high. That might have something to do with how the work has been photographed, digitized, and presented on computer monitors, but in case after case, the posted copy appears consistently more chromatic than the original, even when the artist has shown them side by side. The artists usually seem unaware of this difference, and sometimes have trouble seeing it even when it is pointed out to them.

There is, of course, nothing wrong with deliberately pushing chroma for dramatic or decorative effect. I do it myself sometimes. My concern is with artists who do this unthinkingly, either because they just have an unconscious bias toward "brighter" color, or because they think that chromatic colors are always better or prettier. I think part of the problem is that we have been conditioned to think about

pictures in terms of photography. Many artists work from photographs, and even those who do not have spent a lot of time looking at photographs. Most color films and developing methods are deliberately designed to push the chroma, and most consumer digital cameras are designed to do so as well. That makes the scene more "colorful," and many people seem to think that a "good" snapshot is one that has a lot of chroma, regardless of how chromatic the original scene was. Over time, we've become accustomed to looking at pictures with lots of color intensity. That's what we think pictures are supposed to look like. And, I suppose, many of those who buy art think that way as well, so there may be a commercial incentive to paint very "colorful" pictures.

If you are looking to make a painting that seems like it is full of color, the problem is this: if you are looking at an array of high-chroma colors, the visual system habituates. We see chroma (and other aspects of color) in terms of relationships at least as much as we see absolute values. A whole bunch of intense colors looks lurid, but it doesn't give the impression of a really colorful scene. The better impressionist painters, for all of their emphasis on a modern palette of intense colors, understood this. They used chroma carefully, calculating the effect of one color against another. They were able to get high chroma colors to really stand out by juxtaposing them against much duller colors or dull optical mixtures, deliberately creating a strong visual contrast. That's something the author of that book on impressionist technique didn't seem to understand, for all of her impressive technical knowledge of impressionist methodologies. She's looked at hundreds of impressionist paintings and copied dozens of them, yet she fails to see how those artists used chromatic contrast. Her copies, as a result, are much less interesting than the originals.

If you like color, then learn how to identify the chroma you see around you. Learn how to mix and use subtle mixtures of neutral and near-neutral colors. If you like intense colors, learn how to create the visual impression of really high chroma by using contrast, rather than just blasting away with unmixed colors right out of the tube and hoping the viewer likes "colorful" art. Even today, with a viewing public accustomed to artificially enhanced color, there are plenty of really good artists who know how to use color more effectively, and they stand out from those who do not. So let's put an end to chroma cluelessness.

I'll close my little editorial rant here with this: *Enough with those bright orange skin tones already!* Even Caucasians who spend way too much time in tanning booths have skin that's much less intense than cadmium red mixed with yellow ochre, or any of the other ways to mix luridly awful skin tones.

Thank you very much. We'll now return to your regularly-scheduled paint mixing article.

Working with low-chroma color

Almost all paints are high in chroma right out of the tube. Since most of the world is low in chroma, the majority of a realistic painting will consist of neutrals and near-neutrals. So a realist painter is going to have to spend a lot of mixing time reducing the chroma of paint. How do you do that? At one level, it's easy because, most of the time, whenever you mix one blob of paint with another blob of paint, you end up with something lower in chroma. By that, I mean that the result is less intense than the brighter of the two colors. Often, it's less intense than either of them. So if you want to reduce the chroma of a paint color, pick another paint that's lower in chroma and smoosh them together. The problem, of course, is that if you also want to have control over hue and value, you're going to have to pick your mixtures carefully.

Reducing chroma with mixing complements

A common method of chroma reduction is to mix in a complementary or near-complementary paint. For example, if you want to reduce the chroma of a bright pthalo green, mix in a violet-red (i. e. , a

magenta). Complements will usually reduce both chroma and value. You also sometimes get hue shifts when mixing colors from the other side of the color mixing wheel—the mixture follows a curved path around the wheel rather than a straight path toward the center. Because of the peculiarities of individual pigments, there is no way to predict these hue shifts without just mixing two paints together and seeing what happens. You can pull the mixture back to the original hue, however, by adding a third paint that is complementary to the color you've mixed. Once you have the hue and chroma right, you'll need to check to see if the value has now been brought too low. Of course, if you add white to increase the value, the chroma will be decreased.

So the method of adding the complement can result in frustration as you try to chase the color of a mixture to the right combination of value, hue, and chroma. For low-chroma colors, I find this process much less frustrating when I start with fairly low-chroma paints, such as earth colors and a few others. That way, I do less chasing of color and less mixing overall. It's also easier if you mix each color to the correct value first, then mix them together for the desired hue and chroma. Yellows and violets, although they are on opposite sides of the color mixing wheel, don't work well as complements (the hues shift severely rather than mixing toward neutrals). To dull down a yellow, it is easiest to mix in a duller yellow or orange, such as raw umber or raw sienna. You can also mix in a neutral gray of the same value (see below). To get a dull violet, the easiest course is often to ignore violet pigments and mix your own violet. Because mixing reduces chroma, the right combination of red and blue will give you a violet of the desired degree of dullness. A good dark dull violet can be made with ultramarine blue and burnt sienna, for example.

Other than yellow and violet, it is very helpful to experiment with, and memorize, pairs of complementary colors. As a general rule, if you want to dull down an intense color, choose a dull complement. Blues have mixing complements in the range of warm yellows, oranges, and middle reds. Middle and cool greens have mixing complements in the range from middle reds to violets. Warm greens have mixing complements among the violets. Some of my favorite mixing complements include raw sienna/ultramarine blue, viridian/pyrol ruby, Prussian blue/Venetian red, and ultramarine blue/raw umber. I expect that most artists develop a set of strongly preferred mixing complements.

Reducing chroma with optical color mixing

If you put a bunch of small dabs of different colored high chroma paints next to each other, then step back far enough, they will blend optically and look like one color. The perceived color will resemble what you would get if you mixed all of those colors together—i. e. , it will be lower in chroma than the colors that go into it. If you take this approach to extremes, you get pointillism, which I don't personally find to be very attractive or effective.

Used with more subtlety, however, optical mixing can be one of the best ways to make neutrals, because by controlling the structure of paint blobs, you can create effects that are much more visually interesting than a flat region of neutral color. The eye sees the optical blend, but is also aware of the color variation. You can partially blend colors together, layer them on top of each other while allowing different amounts of lower colors to show through, create interesting textures, or use any of a number of techniques for optical color blending.

Reducing chroma with white

Almost all colors lose chroma when mixed with white (as I've already noted, a few dark cool transparent pigments show an initial increase in chroma when mixed with a little white, then drop chroma as they are lightened further). Of course, they also get lighter, but dull light colors are often exactly what you want. For example, imagine that you are painting a piece of blue cloth. The part of the

cloth that is highest in chroma will be the “midtones”—the part of the cloth that is illuminated, but is near the form shadow boundary (the terminator) and turning away from the light. As the form turns toward the light it gets lighter in value and also less chromatic. You can create the same effect with paint by mixing a blue color (cobalt blue, say) with more and more white as it turns toward the light. The paint becomes lighter and less chromatic, just as the blue cloth does. You may need to adjust the mixture to make the chroma, value, and hue changes exactly model what you are seeing in front of you, but just mixing with the appropriate amount of white gets you into the right ball park. Sometimes, you’ll find that white reduces chroma faster than you want it to. The mixture becomes “chalky. ” I’ll discuss how to deal with that problem below, when I talk about high chroma color mixing.

A color that has been lightened by mixing with white is called a tint. Tints are high in value and low in chroma. They are also called “pastels. “

Reducing chroma with grey

Instead of using mixing complements, it is possible to reduce the chroma of a mixture without having much effect on value or hue. To do that, use a neutral gray of the same value. The chroma will go down without significantly affecting the other parameters of color.

Black mixed with white does not make a neutral gray—it’s much too cool. A 50/50 mixture of ivory black and raw umber, however, is very close to neutral. Adjust the value of this mixture by adding whatever amount of white is required. You may want to mix up a string of neutral grays in advance and use them to easily adjust chroma.

So here’s a good way to work with low-chroma colors without driving yourself nuts. First, start with low-chroma colors such as earths. They will still be too high in chroma for a lot of purposes, but they are a lot closer than, say, a cadmium red light. Second, pre-mix strings of colors you’re likely to use. Each string is one hue, ranging in value from the lowest you will need to the highest. Also mix a string of neutral grays in the same value range. Small chroma adjustments are fairly easy with nudges of small amounts of complementary colors. When you need to pull the chroma down significantly, first mix the right hue and value from combinations of paint from your strings and, if needed, nudges of other colors on your palette. Then adjust the chroma downward by adding some of your neutral gray at the same value as the mixture you’re working with.

Reducing chroma with glazing

If you paint one color thinly over another color, you get an optical mixture. Blue glazed over yellow produces a green, for example. You can use this effect to reduce chroma, since an optical mixture is darker and duller than the colors that make it up. Michelangelo, for example, sometimes made a dark dull blue by glazing ultramarine over black.

The browns and the brown-ish

It’s worth briefly discussing brown colors. Brown doesn’t appear in the visual spectrum or in the named colors on the outside of a color mixing wheel. Colors labeled “brown” are yellows and oranges that are fairly dark and low in chroma. Brown, therefore, isn’t a color per se: it’s a zone within the overall color space. There are plenty of earth colors that start out in the zone of brown, and a few non-earths as well. To make a bright yellow or orange more brownish, it needs to be dulled down and darkened (mixing with white won’t do it; you get a pastel tint). If you mix a yellow or orange with a gray of equal value, you will usually get something you could call a brown. If you mix with black, you will almost always get a brown. Some yellows, when reduced in chroma with grey or black, shift their hue toward green. Just a touch of grey or black makes a green gold; more grey or black makes a

greenish umber-like color. Bright yellow-reds (oranges), if dulled down with grey or black, make more clearly brown colors, without those green tones. Bright reds, if dulled down with grey or black, make a maroon. A color that has been darkened by mixing with black is called a shade. So a mixture of cadmium red and black would be a shade of cadmium red.

Working with high-chroma color

For almost all colors, chroma is highest with paint straight out of the tube. Some pigments that are dark and transparent (such as Prussian blue or pthalo green) reach maximum chroma with the addition of a little white. Generally, however, if you want high really high chroma, the way to get it is to have a tube of paint with exactly the right hue and value, and just paint with that. Sometimes, you can make that work. At other times, you don't have quite the right color, or the right color just doesn't exist in pigment form. The highest chroma mixtures are blends of high-chroma paints of similar hue. If your cerulean blue is just a bit too greenish, don't mix it with red, mix it with a high chroma middle blue such as cobalt blue. You want to draw a line through the color mixing wheel that stays as close to the outside of the wheel as possible. So if you like to work with a lot of high chroma colors, then it's to your advantage to have many tubes of high-chroma paint. That way, when you want a particular color, you will usually have two colors that are similar enough to that color that you can mix them without taking too much of a hit to the chroma. Warm colors are at their highest chroma when they are fairly light (high in value). Cool colors are at their highest chroma when they are a bit darker. At maximum chroma, warm colors such as yellow are more chromatic than cool colors such as blue. But that's OK, because warm colors have higher maximum chroma in the real world as well. If you want cool colors to compete for the viewer's attention with warm colors, however, you'll need to keep that difference in mind.

Munsell complements

Yellow < — > purple blue
Yellow red < — > blue
Green < — > red purple
Blue green < — > red
Blue < — > yellow red

(These are visual complements, not necessarily mixing complements.)

Because of the way the visual system works, a color is usually perceived as more chromatic when it is placed next to its visual complement. The impressionists made frequent use of this principle. A bright magenta looks more intense when it is surrounded by a dull green. The complements identified in the Munsell color system more accurately reflect human color vision than those in the antiquated three primary color wheel.

Masstone and undertone

We like to pretend that pigments, paints, and colors are all the same thing. In reality, pigments have many characteristics separate from their "color. " Also, pigments behave differently in different binding media. One of the most important aspects of pigment variation is in masstone and undertone. Masstone is a pigment's color when it is applied thickly. Undertone is a pigment's color when it is applied in a thin layer. Lots of pigments display a huge difference between masstone and undertone, and that often has a lot to do with chroma. Most commonly, masstone is duller than undertone.

The difference is most marked with relatively transparent pigments, but many opaque pigments show significant differences as well. For example, I painted a self-portrait in which the background consists

of yellow ochre glazed thinly over white paint. Yellow ochre is generally described as a dull pigment, and in masstone that's true. But the background of the painting is quite intense. The hue is also much more orange than that of yellow ochre in masstone. We get so used to application of paint in thicknesses that make use of masstone that we often forget how paints behave when applied in very thin layers.

Maintaining chroma by glazing

One effective way to maintain chroma is by glazing. If you apply paint very thinly over white, you can get a higher chroma than you could by mixing that paint to the same value using white. A transparent paint that is applied a little more thickly can be more chromatic at low values than you might be able to obtain with a mixture of the same hue.

Maintaining chroma at high values

With many pigments, it's hard to get high chroma at high values. Because white lightens the value of paint and also reduces chroma, mixtures with a lot of white become pastel tints. If that's not what you want, then you may consider the mixture to be "too chalky. " How do you avoid this chalky effect when you're trying to make light colors that have relatively high chroma? One way is to start with very high chroma paint. The chroma reducing effect of white is then balanced with a strong base chroma. It can also be a good idea to avoid titanium white, which tints very strongly and can have a greater effect on chroma than other whites. That's one reason I usually paint with lead white.

Practical Color Mixing: Hue

Identifying hue

Before you can mix the right hue, you need to figure out what hue you want to mix. That's often kind of hard, especially with the dull, low-chroma colors that predominate in most of the visual world. Look around you. What color is the wall? A yellow-green? Or is it more of a middle yellow? How about the cable leading to your monitor? Is it black, or some very dark greyish color? If so, is it a warm dark grey or a cool dark grey? If warm, is it a yellow or an orange? What about the shadow falling on the floor from your desk?

You get the picture. When I'm standing around waiting for something I find myself trying to identify the color of various things around me. And not just the color of the thing (the "local color") but the color of the shadow side, the light side, and so on. I think about value and chroma as well as hue, but the hue is often the hardest to figure out. As with any other attribute of color, it's best to think in terms of comparison of one color with others around it. Once I think I know what the color is, I consider how I would mix it. That seems like a pretty geeky thing to do (and it is) but it's a useful exercise. We think we know what color things are, but while it's easy to say that the sky is blue, it's a bit more of a challenge to determine that the part of the sky beyond those clouds is a green-blue, while the sky in between the clouds is slightly more purple.

Nudging

So once you know what hue you want, how do you get it? Well, if the hue is pretty close to a paint that's already on your palette, you might be able to just nudge it in one direction or another. Say you want a violet blue and you have ultramarine on your palette. Without having to think about color wheels or anything complex like that, you could simply add just a bit of a more purple color, such as dioxazine violet. That may well get you where you want to go, simply and easily. In doing this, the

thing to realize is that any given paint can only go in two directions from where the hue is right now—either clockwise or counterclockwise on the color circle. Ultramarine blue can be made more violet or more green. That's it. Cadmium orange can be made more yellow or more red. If you're just trying to nudge the hue around a little bit, all you have to decide is which direction to go and select a color next door on the color wheel to move it in that direction. Add only tiny amounts of the "nudging" color at a time, as it is easy to overdo it.

Using a mixing color wheel

The nudging strategy is great for small adjustments, but it starts to fall apart when you need to make a hue that isn't close to one of the paints you already have. At that point, it's useful to go back to the concept of a color mixing wheel. As I've pointed out previously, a color mixing wheel does not provide a precise guide to what you will get with any two pigment mixtures. Individual pigments are simply too idiosyncratic in their mixing properties to allow any kind of absolute prediction of how they will behave when mixed. But a color mixing wheel will help you to get into the approximate ballpark, at which point you will be close enough to use the nudging aproach described above.

Steven Quiller sells a useful color mixing wheel. Bruce MacEvoy at Handprint has a somewhat different one that you can print out for free (it's designed for watercolor, but I have found it to be reasonably useful for other media as well).

Say you need to mix a yellowish green, but don't have anything close to that on your palette. If you look at a color mixing wheel, the two colors on either side of green are blue and yellow. As we all know, you can mix a green from blue and yellow, and if you adjust the proportions correctly, you can pretty easily get a yellowish green. If you have any set of paints that are selected to fall at reasonable intervals across the color wheel (at least a cyan, magenta, and yellow), you can mix any desired hue using two or three paints. A traditional color wheel is set up so that all of the colors on the outside are as high in chroma as that hue goes (without regard to value). On the inside are less chromatic colors, arranged so that the closer to the center they are, the lower the chroma.

The basic mixing procedure goes like this: (1) identify a point within the color mixing wheel that represents the desired hue and chroma; (2) look for one or more lines between two paints that pass through (or near) the color you are trying to match; and (3) consider whether a third paint (typically one on the opposite side of the wheel from the desired color) might be needed to adjust the chroma downward. If the paints have equal tinting strength, you can figure out approximately how much of each paint you will use, based on where the desired color falls on the line between the two paints being mixed. If one paint is stronger, you'll need to adjust accordingly to account for that. As a general rule, put out some of the weaker paint and add the stronger paint to it. Alternately, put out the paint you will use the largest amount of and add the other paint to it. Add in small increments at a time—I find myself overshooting frequently if I'm not careful. With oil paint, it's best to mix with a palette knife rather than a brush. Once you're used to it, the knife is faster because you can clean it so quickly, and your paint piles don't become contaminated with other pigments.

Coordinating hue and chroma

Notice that if you draw a straight line between any two colors on the outside the wheel, every point on the line represents a lower chroma than those two colors. So mixing tends to reduce chroma. As a general rule, any mixture is duller than the brighter of the two paints being mixed, and often duller than either one. There are a very few exceptions (some warm pigments become a little more chromatic when mixed with each other and some cool pigments become more chromatic when mixed with a small amount of white), but chroma reduction is the usual effect of paint mixing.

Often, it's useful to have mixing reduce chroma, because in realist painting you are frequently trying to mix a color that is duller than the tube paints you have available. If you're trying to mix a flesh tone with bright cadmium colors, for example, any reduction in chroma is welcome (you've probably seen bad amateur portraits with bright orange flesh tones). But there are times when you are trying to mix a high-chroma color, and in that case the chroma reduction from mixing can be frustrating. Because of this effect, it's often a bad idea to just muck around with paint, hoping to get close to the color you're looking for. Every paint you add to the mix cuts the chroma down, so after awhile you are just mixing paint into a sort of nondescript grayish color—i. e. , you're mixing "mud. "

It's is much better to decide what color you want, choose two or three paints that you will use to get that color, and try to stick with those. Minor nudging with other paints is OK, but if the mixture goes radically in a direction you didn't expect, don't keep throwing additional paints in, hoping you'll eventually get to your desired color. Once you have mud, just scrape it off your palette (or use it as the basis of some nondescript color you need elsewhere) and start over. Take a step back and think again about what you're trying to accomplish and how you're going to get there. As noted above, many pigments fail to follow a straight line on the color wheel when mixed. In particular, some paint mixtures follow a circular mixing line. That means that, while the wheel predicts the correct hue, the chroma is higher than expected (this is particularly common with greens). In that case, go ahead and mix the hue you want, then tone it down (preferably by mixing with a neutral gray of the same value).

Coordinating hue and value

We've talked about getting to the right hue and chroma, but what about value? It would be easier to make this color mixing thing work if there were only two parameters to worry about, and many color mixing books kind of pretend that's the case. Earlier, when I discussed getting the value right when mixing, I suggested that the first thing you do when trying to make any particular color was to first mix the colors you are working with to the correct value. You can then mix them together and get the hue and value you are looking for—because the paints are already at the correct value, you don't have to think about that factor any more, greatly simplifying the problem you're trying to solve.

Mixing value first usually works, except when you can't get the right chroma and value because the white paint is pulling the chroma down too far. Under most circumstances, however, the "mix the value first" rule makes color mixing much easier to control.

Warmth and coolth

The idea of warm and cool colors has many implications for composition that don't belong in a discussion of color mixing. Warm colors are generally thought to include red, yellow red, and yellow, while cool colors are thought to include blue green, blue, and purple blue. (I'm using Munsell hue terminology here.) In between colors include green, green yellow, purple, and red purple (some people would label green and purple as warm and green yellow and red purple as cool). There are some aspects of the warm/cool division that are useful to include in a discussion of color mixing. If you reduce the chroma of a warm color, it appears less warm (raw umber is less warm than cadmium orange); if you reduce the chroma of a cool color, it appears less cool. The most chromatic warm colors are much higher in chroma than the most chromatic cool colors. Compare, for example, cadmium yellow light (a high chroma yellow) and pthalo blue (a high chroma blue). The yellow is much higher in chroma than the blue. Not only that, the yellow is also much lighter in value than the blue. Warm pigments can be very light (high in value) at high chromas. Cool pigments are much darker at their highest chroma.

Adding a lot of white to a cool pigment, to bring the value up near to that of cadmium yellow,

decreases the chroma still further. You can't have a high chroma, high value cool color—the physics of light and the structure of the eye don't allow it. These kinds of differences are why the Munsell color space is shaped like a bumpy, irregular cylinder.

Because of this effect, high chroma warm colors have more overall punch than high chroma cool colors. Many art books tell you that warm colors advance and cool colors recede. That's wrong, although it has a germ of truth. The eye looks for contrast. In most paintings, chromatic colors have more contrast with their surroundings. Higher value colors also have more contrast. Because warm colors are more chromatic and higher in value, they have more contrast, so they jump forward. If you drop the chroma and value of warm pigments to match those of cool pigments, they become brownish and don't have any extra punch at all. The warm/cool contrast can also be useful when you're trying to figure out what hue something has. It can be easier to ask whether a hue is warmer or cooler than a color near it than to try to figure out its hue directly. Any hue can be shifted either clockwise or counter-clockwise on the hue circle. You can think of this as shifting warmer or shifting cooler. For example, a yellow can shift toward green (cooler) or toward red (warmer). That is not to say that red is warmer than yellow (different people have different opinions on that issue), but that shifting toward red is shifting away from a cooler color (green is definitely cooler than red), so it's useful to think of that as "warmer" in this context. Similarly, a purple can be shifted toward red (warm) or toward blue (cool). As you are painting, you can think in terms of these comparisons. Is the hue on the light side of an object warmer or cooler than the hue on the shadow side? That comparison is an easier task than determining the absolute hue of the light side.

Wrap up

As I noted earlier, color and color mixing is very complex. It takes a lot of time to get all of this. Just understanding the concepts is only half the battle—you also need to practice color mixing, over and over, so that you can do it consistently. I've been working at this for several years now, and I still mess myself up. Usually, the answer is not

To keep mixing, but to scrape the paint away, figure out what went wrong and what the right strategy is, and begin again.

Also of interest

- The kitchen sink palette (7)
- More on chroma (0)
- Limited palettes (0)
- Chroma Cluelessness Syndrome (9)
- The color theory palette (2)

Tags: art technique, chroma, chroma cluelessness syndrome, color, complementary colors, flesh tones, glazing, limited palette, Munsell, paint mixing, palette, pigments