Color Matching: Exploring Proper Tools, Methods & Procedures

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Many garment decorators are faced with the challenge of matching a color that a customer has provided. There are many aspects of color, and many ways to steer your color matching efforts through color space. Understand that color matching can be as easy as it is hard, and there will be colors that are very easy to match and others that will be very difficult to match. Success is largely based on the gamut of the ink system you are using. Each manufacturer uses their own pigment and raw material suppliers for their own product line formulations, so you really need to understand those variables when matching color. You also need to have a really good understanding of color theory, and how to navigate through color space when formulating.

Reproducing Colors

The color you see on a computer monitor cannot always be reproduced in print. Computer monitors display a very large number of colors (approximately 16 million), and some just can't be reproduced with inks we use. Using a four-color process (CMYK) ink set, you can reproduce a few thousand colors. Spot color mixing systems can also match several thousand colors.

Lighter colors require small amounts of darker colors to make them darker. Dark colors require large amounts of lighter colors to make them lighter. For example, yellow requires very little blue to make a yellow-green. Blue will require a lot of yellow to make a yellow-shade green. Yellow-shade red will require more blue to make a violet versus using a blue-shade red.

It's also important to understand the range of colors your mixing system will provide. The Pantone Matching System (PMS) is very commonly used in the industry to specify color. You hear the horror stories involved with colors like PMS 011, PMS 012, PMS 032 and PMS 185 because they're just really hard to match.

There also needs to be a consistent chain of color communication between printer and customer so that expectations are understood, and there are not any surprises

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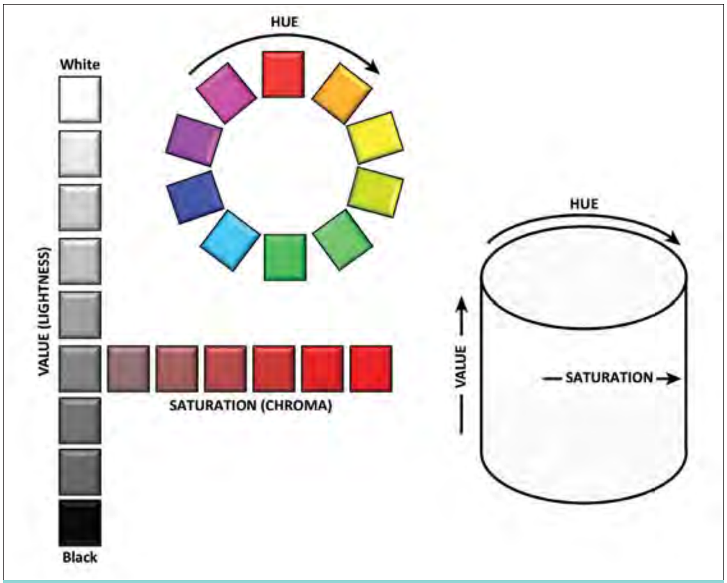

Figure 1: The three dimensions of color that help communicate information about its appearance

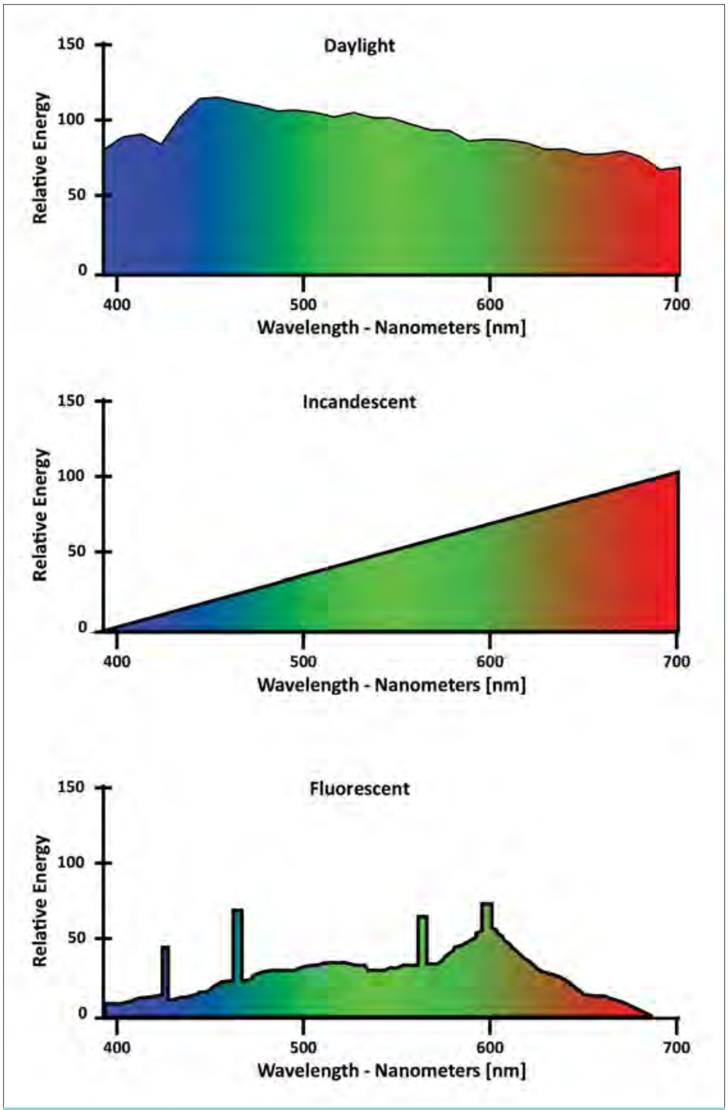

Figure 2: The wavelength distribution of common light sources

in the end. You should also try to work on calibrated monitors. Often, customers bring in artwork they put together on their computer system, but if the monitor is not calibrated, the color may look different on the monitors in use by the printer.

Talking in Terms of Color

It's also important to speak in color terms. Try to avoid terms like "pop" or other subjective terms; instead, use very objective terms: Warm or cool; red or blue; dark or light; saturated or unsaturated. These terms are more appropriate when talking about color.

Common specific color terms include hue, value and saturation. Hue is the actual color itself (e.g., red, blue, green, yellow). Value describes the lightness or darkness of a color, sometimes also referred to as brightness. Saturation reflects how much gray the color has. Less gray means higher saturation. Saturation is also referred to as chroma. You also need to understand color space, which is a defined range of colors. Some common color space models include RGB, CMYK and L*a*b*. The term color gamut is the range of colors attainable with a given set of colorants. Figure 1 provides a visual organization of color space based on the terms discussed: Hue, chroma and value.

The lack of color matching and mixing procedures can create unnecessary challenges for a shop. Establish standard operating procedures for mixing and matching color. Documentation is priority, and the procedures and documentation need to be followed. When you are matching a color, use the same parameters as will be used during production: Same mesh and stencil, same shirt color/fabric, same squeegee durometer, printed in the same sequence for overprints (Consider if there will be an underlay). You also need to have a scale that measures to the hundredth decimal place. All these variables will have an impact on the resulting color.

Perceiving Color

We all learn in grade school that color is light. All color is produced from mixtures of red, green and blue wavelengths of electromagnetic energy, and white light is produced when equal amounts of red, green and blue light are present. You see "black" because there are very few wavelengths of light reflected back to your eyes. Color is also a perception, a function of our brain and really depends on three things: A light source, the object being viewed and the observer. If any of these factors change, so does the color. Because color is perception, it can be affected by many things including where we live, the stress level in our lives, our income level, food and drugs we consume, and our gender and age.

The viewing conditions for color approval should also be considered. This needs to be standardized in your shop to avoid approving color under different light sources, because they each impact color differently. A lightbox is a great tool to have for viewing color in a controlled setting.

When viewed under each of three different, common light sources — incandescent, fluorescent and daylight — how color is perceived can change. Light from the sun (which we call daylight) has a very even distribution of electromagnetic energy. Incandescent bulbs emit a warm (red) light, which is comforting for use in our homes, therefore color viewed under incandescent light will have a warm, or red cast. Fluorescent lamps emit light energy at several wavelengths but typically cast a blue (or cooler) shade of light than the other common light sources (Figure 2). ISO Standard 3664:2000 "Viewing Conditions for Graphic Technology and Photography" specifies that viewing color should be done in a neutral setting with ambient room lighting, under a D50 (5,000° Kelvin) light source.

Of course, the object being viewed can also change the perceived color. When you look at a red apple, it is actually absorbing wavelengths of blue and green light, and reflecting wavelengths of red light. If the color of the apple changes, so does the reflected light.

Humans are trichromatic devices meaning we have three types of receptors in our eyes: Red, green and blue. Our visible spectrum ranges from approximately 400 to 700 nanometers (nm) on the electromagnetic spectrum. Humans can recognize roughly 2.3 million colors; however, some experts estimate that humans can distinguish perhaps as many as 10 million colors. Essentially, we can see many more colors than virtually any printing process can reproduce.

Color blindness is also a variable to take into account. Approximately eight percent of all males suffer from color blindness while only one half of one percent (0.5 percent) of females do so. Be sure whoever is matching color for your shop has been given a colorblindness test. Many can be found on the Web.

Color perception can also be influenced by the surrounding color as Figure 3 illustrates. The blue circle inside each section is actually the same shade of gray. The surrounding background color influences how we perceive the gray circle, making it appear different. So when viewing color it's important to remember the variables involved. Color perception is very much viewer-dependent, and if the viewer has color deficiencies, those should taken into consideration during the approval process.

Measuring & Specifying Color

Figure 4 represents L*a*b* color space. L*a*b* is a device-independent representation of color and contains three axes. The L* axis represents light and dark (value); the a* axis represents red to green, and the b* axis represents yellow to blue. The L* range is 0 to 100 where zero equals black and 100 equals white. The a* range is from -128 to +127. A negative a* is more green than red. A positive a* is more red than green. The b* range is also -128 to +127. A negative b* is more blue than yellow; a positive b* is more yellow than blue. Because L*a*b* color space is device-independent, it is a great tool for plotting and navigating color.

There are a few instruments that shops can purchase for measuring color. The first is called a spectrodensitometer, which reads reflected color and provides L*a*b* values. It can be used to measure target and batch mixes, but does not calculate the difference. These provide a more involved experience when trying to match a color. The other instrument is called a reflectance spectrophotometer. This is a device that measures, specifies and evaluates color. A database is created using various mixtures of the base inks. This information is then used as reference data when formulating a color by the accompanying software. The hardware measures the target color, and the software calculates a batch formula based on the database. Once mixed, the batch is measured and a correction formula (if needed) is generated.

Additive and subtractive color models are important to understand as they provide an additional component in efforts to navigate color. Additive color is simply the mixture of red, green and blue light. This color model is used by computer monitors, televisions, scanners, digital cameras, and of course, humans. The secondary colors created when additive colors are mixed (Figure 5) create the colors used in the subtractive color model: Green and red light make yellow; red and blue light make magenta; blue and green light make cyan. When all three additive colors are mixed in equal amounts, white light is created.

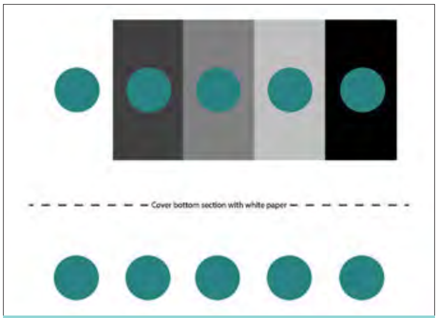

Figure 3: An illustration of the effect surrounding color has on color perception.

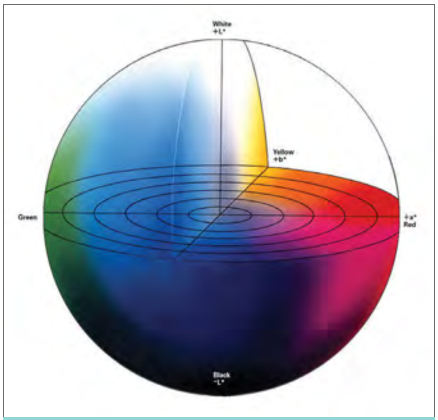

Figure 4: A visual representation of L*a*b* color space

Figure 5: Additive color is created by mixing red, green and blue light

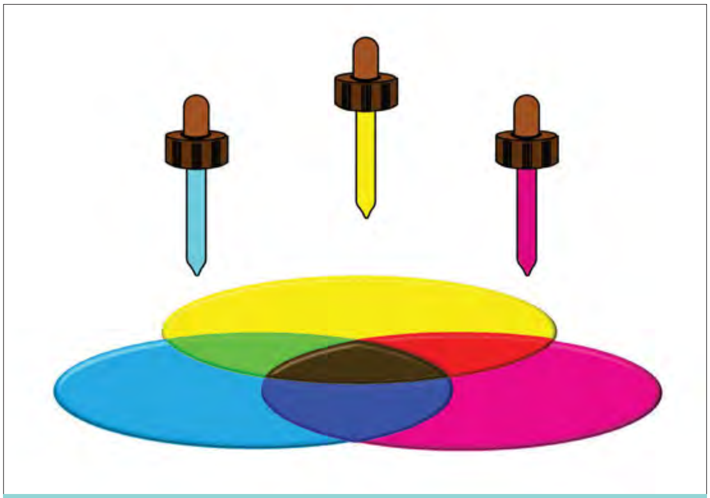

Figure 6: Subtractive color is the result of subtracting (absorbing) wavelengths of light.

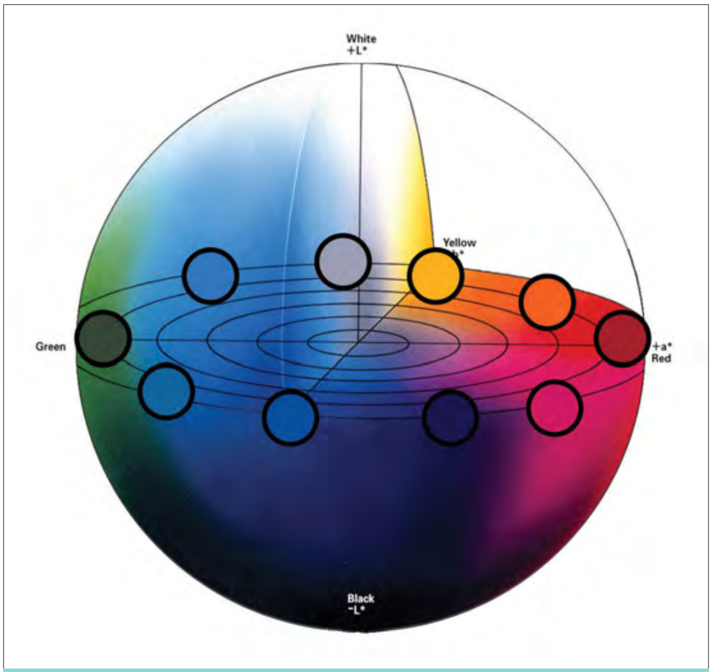

Figure 7: Common mixing colors arranged within L*a*b* color space

The subtractive color model (Figure 6) uses cyan, magenta and yellow colorants. Notice the colors produced when subtractive colors are mixed: Yellow and magenta produce red; magenta and cyan produce blue; and cyan and yellow produce green. When all three colors overlap, black is (theoretically) achieved; however, it's usually a dull brown because of the impurities of the pigments that are used. Subtractive color is used by print technologies like offset, inkjet, color laser or screen printing.

When specifying color in any art file, do not use custom or multiple pallets for spot color artwork. Always use Pantone solid coated pallets to specify color. When working with spot color matching, most mixing systems can be arranged as follows: Red, Orange, Yellow, Green, Blue, Indigo and Violet (ROY G BIV). Common shades mixing systems use include a blue-shade red, yellow-shade red, red-shade blue, green shade blue, etc. Figure 7 represents the base colors in a given mixing system, and where they would be plotted in L*a*b* color space (note the ROY G BIV order of the colors). This arrangement of color will help you stay focused and properly oriented when formulating color. If you do not keep color order, you will have chaos when trying to navigate through the color spectrum.

Pantone Matching System

The Pantone Matching System is a system commonly used for specifying color in our industry. It's made up of basic colors like Yellow 012, Orange 021, Rubine Red and so on. Pantone formulas use these basic colors in the Pantone system. The highest saturated color, or hue, appears in the middle of each page. As you move up on the page, colors become lighter (addition of white). As you move down the page, colors become darker (addition of black).

One of the easiest methods of color matching using the Pantone Matching System is to find the closest PMS color to the standard sample you are trying to match. Note the basic colors and their amounts used in the PMS formula. Match the Pantone colors in the formula to the base inks in your mixing system. Once the mixing colors are selected, start weighing each colorant using the Pantone formula ratios as a guide. You can also mentally place the color in L*a*b* color space, and look to either side to see what primaries are closest to that color. If the color is yellow, it's already a primary color. Pure colors make for a brighter color mixture, so don't use red and blue to make purple if you already have a purple in the mixing system. Start mixing with the primary colors chosen, and use L*a*b* as a navigation reference. For example, if we are trying to match PMS 185C — with an L* value of 50 an a* value of 76 and a b* value of 42 — we know that there is very little white or black, and that it is to the red side on the a* axis and to the yellow side on the b* axis. L*a*b* provides an easy way of knowing where the color falls in color space. It's also important to use the correct shade of each base colorant before starting, so over correction is not an issue. You can find the L*a*b* values by simply using the eyedropper tool in your graphic application software, selecting the PMS color, and locating the values in the color picker window.

The color of the fabric that will be printed should not be overlooked. White or light fabric will be easier to match color on; dark fabric may be a bit tougher. The opacity of your mixing system will really come into play here because opaque inks are less affected by fabric color. Transparent inks (e.g four-color process) are greatly influenced by fabric color.

Fluorescent inks are often used to fix mistakes in a formula, but are usually weak in terms of their impact, so their power and limitation should be considered. They cannot get rid of any undertones that may dirty a color and really only generate more excess colors in a formula. They are also very expensive, and can cause a domino effect. If the right primary colors are picked in the formula, then you'll have a much easier time managing a color match. Choosing the wrong primary colors initially may cause you to try to doctor the mixture with a fluorescent. If you must use fluorescent color, use only one in your formula.

There are many factors involved in color matching and those presented here should be taken into account. Successful color matching comes with knowledge of how to drive around in color space. It also will depend on the experience level and expertise of whomever is matching the color. Incorporating the proper tools, methods and procedures will result in more success with your color matching skills.

Johnny Shell has served as Vice President of Technical Services for SGIA for the past 15 years. In this role, he directs and coordinates the activities of the Technical Services department, and works to educate the industry on the capabilities and viability of specialty printing. Shell also teaches numerous workshops annually, and his technical writings appear regularly in several top industry publications in the US and Europe. In addition, he is a frequent speaker at industry events and trade show expositions both domestically and internationally. Shell has worked in the specialty imaging industry for the past 27 years, with experience ranging from optical media manufacturing to graphic and apparel printing. He has won numerous printing awards throughout his career, and is a member of the Academy of Screen & Digital Printing Technologies, an international body of experts which honors qualified individuals through election to membership for their distinguished, long-term contributions to, and application and promotion of, screen and digital printing and associated imaging technologies for graphic, textile, industrial and electronic printing applications.

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