

Spotlight on Color Theory and Brightness

B E H I N D *the* S C E N E S

A TECHNICAL DISCUSSION FROM POTLATCH

Chromaticity Diagram

Full Spectrum

The CIE (Commission International de l'Éclairage) chromaticity diagram of color space provides a universal reference for all the colors of light visible to the human eye.

Matched Color Spectrum

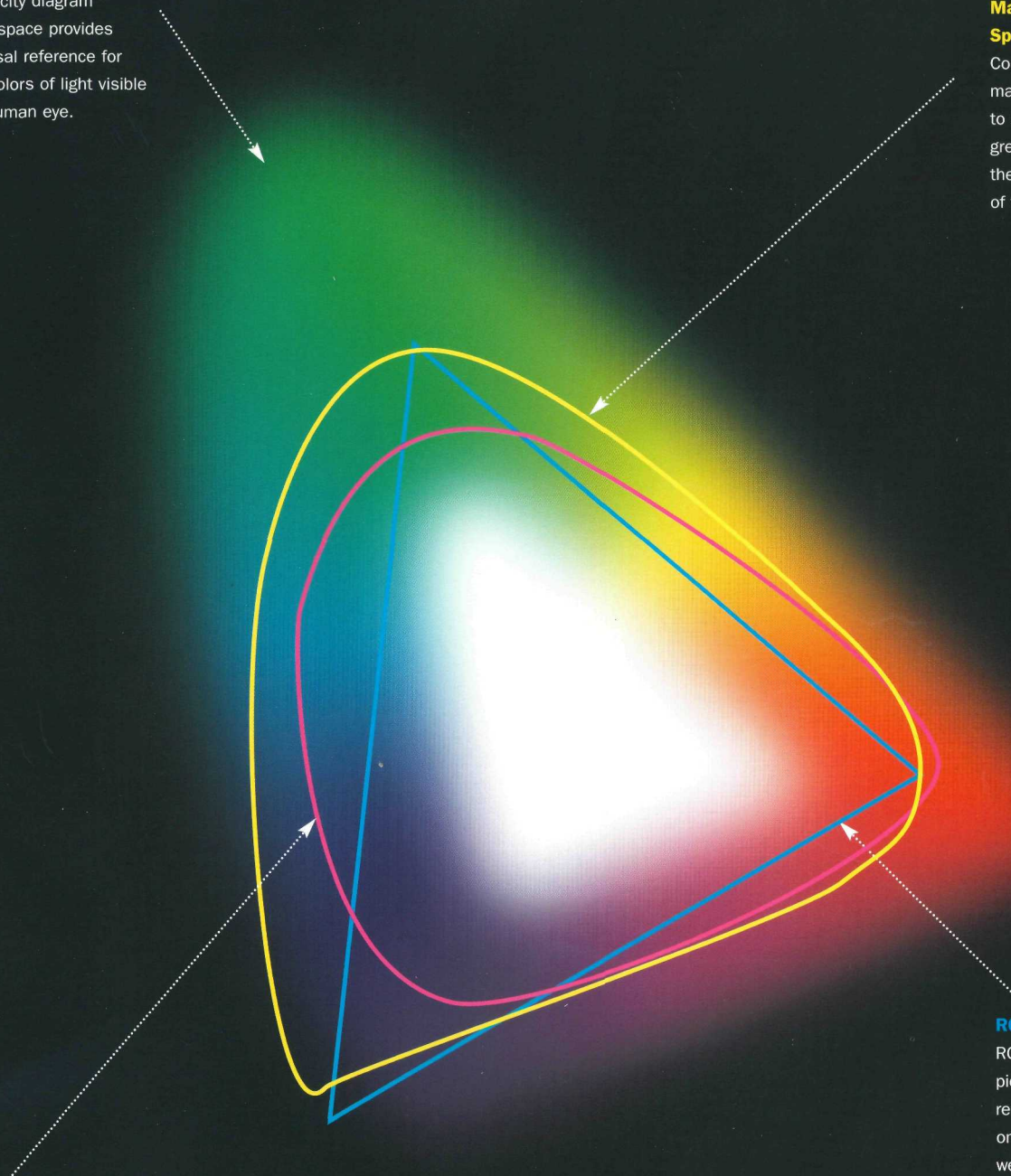
Commonly used color-matching systems tend to be shifted into the green range while omitting the very pure portions of the visible spectrum.

RGB Spectrum

RGB computer monitors pick out some of the red and violet ranges omitted by CMYK but fall well short of the spectrum included in matched color systems.

CMYK Spectrum

The range of the standard four process colors, or CMYK, is also restricted when it comes to pure reds and greens and comes up particularly short in the violets.



UNDERSTANDING COLOR THEORY

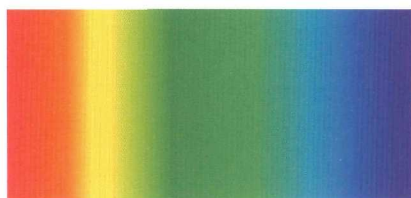
In the printing process, color begins with a transparency or illustration and ends as a printed image. Depending on your light source, monitor, proofing system and paper choice, this same image can look dramatically different. That's why it's so important to understand color theory and how it applies to the various parts of the reproduction process. It's also critical to know the mechanics of whiteness and brightness and the roles they each play in translating an image to the printed page.

ADDITIVE AND SUBTRACTIVE COLOR THEORY

Every photograph, every catalog, every image broadcast to your television is reproduced through one of two means. The first is called additive color formation; it relies on the mixing of light and is used in prepress operations. The second method is subtractive color formation; it relies on the absorption of light by colorants and dominates the printing process.

Additive Color

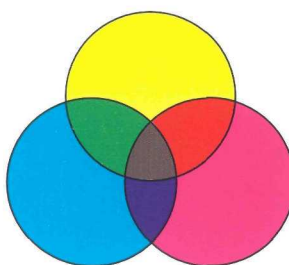
The next time the sun shines while it rains, you'll find an example of additive color formation. That's because a rainbow contains the three light-radiating primary colors—red, green and blue, or RGB. By mixing any two primaries, the secondary colors of light result. Where blue and green overlap, cyan is produced; red and blue produce magenta; and red and green give us yellow. When all these colors overlap, we perceive white.



Computer monitors create images using additive color formation, specifically through the optical blending of glowing dots of red, green and blue phosphor.

Subtractive Color

Four-color process printing depends on subtractive color. According to subtractive color theory, pigmented surfaces and materials absorb certain wavelengths of the light that illuminates them and thereby reflect other parts. When combined, the light wavelengths that are absorbed and reflected create a spectrum of color.



The subtractive primary colors are cyan, magenta and yellow—in printing jargon, CMYK, with K for black. Cyan pigment absorbs red and reflects blue and green light, magenta absorbs green and reflects red and blue, and yellow absorbs blue and reflects red and green. Black absorbs all colors.

Although, neither system is inherently superior, the incompatibility of additive and subtractive color systems may affect your perception of color quality. Because RGB monitors produce color by electronically “exciting” phosphor dots until they emit light, the overall color quality will tend to be sharper and more vivid than CMYK color. On the other hand, paper surface characteristics have a dramatic impact on CMYK color quality.

COLORS BY DESIGN

The Rolling Stones had it right when they sang, “You can’t always get what you want.” Much as we’d like to believe that the full-color spectrum is our stage, more than 75% of the visible spectrum, as defined by the “chromaticity” diagram (shown at right) developed by the Commission International de Éclairage (CIE), is beyond the reach of CMYK color. In printing, in computer design, even in matched color systems, you just can’t reproduce the colors that your miraculous little ol’ eye can spy.

Here’s why. Computer monitors, like television screens, depend on RGB additive colors, which come together as little dots to form images. Printing, however, uses a subtractive color system called, as you know, CMYK—the four-color standard process that uses cyan, magenta, yellow and black inks.

Both methods do a pretty good job of rendering real life. But, let’s be truthful: No system can reproduce the vivid colors that we can see in elaborate costumes and set designs.

HERE *you* ARE
READY *to* DELIVER
the **PERFORMANCE**
of **YOUR LIFE.**

The lights are up and trained on you so the audience can take in your every gesture, each exquisite detail of your costume, and all the rich colors and textures of the set. You are ready to shine.

But what would happen if you were cloaked in darkness instead? Your performance would lack visual pop, be drained of energy and result in less effective communication. Your audience would shrug their shoulders and, more than likely, seek a refund on their tickets. In a word, your play would flop.

In many ways, theater is just like paper. Put simply, paper allows you and the designer to perform. Whether you choose a sheet that's white and brilliantly bright for a show-stopping performance, or a lackluster sheet, can make all the difference. And there is quite a difference.

Introducing Shade and Brightness, part of Behind the Scenes by Potlatch. What follows is a useful guide to paper optics. It covers everything from whiteness and brightness to the basics of color theory, ways to measure color and how ink works. You'll learn what makes a white sheet white, what makes it bright, and how transparent inks make colors dazzle on the page.

Why does it matter? Simple. Because it's your business to be an expert on all matters involving paper. Because it's your job to make sure that ink performs at its very best, whether in design or on press. Because it's your knowledgeable service that attracts customers to your printing plant. And because the qualities of paper play a huge role in makeready and time to color, and that means money.

NOW,
it's **TIME**
to **RAISE THE CURTAIN...**

BETTER MAKE *it* BRIGHT

TARGETING BRIGHTNESS

Simply put, what makes a bright sheet bright is the amount of light it reflects at a wavelength set by industry standards: 457 nanometers.

What's that mean? Let's back up for a quick review of color physics: A nanometer is a unit of wavelength of electromagnetic radiation. Visible light waves are categorized by length, and a wave's length determines the colors we see. Violet wavelengths, at about 400 nanometers, are the shortest and red wavelengths, at about 700 nanometers, are the longest waves of the visible light spectrum. At 457 nanometers, our brightness measurement falls within the blue wavelengths. This explains why we perceive bluer sheets to be, in fact, brighter.

In the premium coated paper industry, brightness levels typically range from 88 to 98, with 100 percent representing the ultimate in brightness.

For your reference, Potlatch McCoy™, the sheet you're holding, has a 96 brightness rating. It's the brightest domestic coated sheet available. Vintage® Gloss has a 91 brightness rating.

American Forest and Paper Association (AFPA) Quality Levels

Premium	G.E. Scale 88 and above
No. 1	85.0 thru 87.9
No. 2	83.0 thru 84.9
No. 3	79.0 thru 82.9
No. 4	73.0 thru 78.9
No. 5	72.9 and below

Brightness Measurements of Imported Papers

Imported Papers	ISO Scale*	G.E. Scale
Premium 110 lb. - Japan	99	87.0
Premium 110 lb. - U.K.	96-98	91.9
Premium 100 lb. - Germany	94	90.5
Gloss 80 lb. - U.K.	92-94	87.0
Dull 80 lb. - U.K.	87-88	86.6

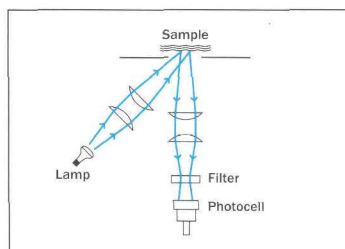
When reviewing brightness claims, make sure the numbers are G.E. Brightness. *ISO geometry with high U.V. light source.

G.E. VS ISO: A BRIGHT DIVIDE

Brightness is measured two ways: directional (also known as G.E.) and nondirectional (ISO). Directional rating is the standard used in the United States. Nondirectional rating is popular in Europe and Asia. The brightness ratings that result are often difficult to reconcile, so it's important to remember that paper quality is more than just a number. Other factors, including smoothness and opacity, also play important roles.

Directional Ratings

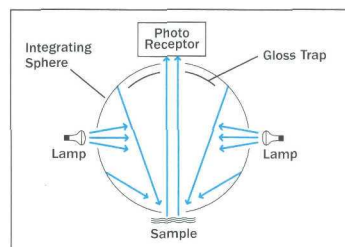
A sheet is illuminated with a tungsten bulb directed at it from a specified angle—in this case, 45 degrees. The light that reflects off the sheet is then measured by a photo receptor placed opposite it. This measurement is used to control the brightening agents added to pulp during the paper-making process.



Directional Rating Method

Nondirectional Ratings

Measurements are made from all the ambient light that is reflected. As a result, nondirectional ratings often register higher brightness even though, by directional measurements, the sheet is really no brighter.



Nondirectional Rating Method

WHITE + BRIGHT = DAZZLING COLOR

Whiteness and brightness really come together when ink hits the sheet. It is then that the degree of whiteness will either limit or amplify your sheet's quality and spectral range. And brightness, like a dimmer switch, will either go on lackluster and low or come on strong and bold.

What does all this mean for the printed page? From a color reproduction standpoint, the more light—both white and bright—reflected from the paper, the better. Why? Because a brighter, whiter sheet improves contrast range for full color, halftone and line reproduction.

I INK, THEREFORE I AM

Of course, this entire discussion comes down to one question—How do shade and brightness affect ink performance? The answer is, a lot.

True-to-life color reproduction requires high-quality coated paper that equally and vibrantly reflects all wavelengths of the visible light spectrum. Whiteness and brightness—and their ability to reflect light—not only amplify characteristics of the ink, but they impact the appearance and performance of the end product.

And that's what it's all about: Producing a spectacular printed piece that your client, and your client's client, will applaud. Which is why Potlatch makes the broadest line of quality coated paper available anywhere. Exceptionally bright and in a range of shades and finishes. Delivering unsurpassed performance—every time.

PUTTING INK *on* PAPER

Because the inks on paper are transparent, paper acts as a backlight reflector and filter that reflects light through the ink. For accurate rendition of color, proper proportions of the three primary colors of light—red, green and blue—must exist in the light illuminating the ink film. This calls for a bright, white sheet.

LET THERE BE LIGHT

What makes a white sheet white? It all comes down to light.

White light contains all colors. So what makes a sheet white is, in effect, its ability to reflect equal amounts of red, green and blue light—the entire visual spectrum. It's really less a matter of being "white" than of containing all color.

A truly white sheet reflects the entire visual spectrum in equal amounts. The more white, the higher degree of color reflectance and the greater possible spectral range. The lower the whiteness, the less complete the spectrum of reflected light, which can result in dull, lackluster color.

SHADES OF WHITE

But we in the printing industry are an accommodating lot, welcoming paper shades that run the gamut under an umbrella we call "white." In truth, warmer sheets contain, and hence reflect, greater amounts of yellows and reds. Neutral sheets absorb all colors or wavelengths in equal amounts. And the blue-white sheets so popular these days really sing the blues.

Are these bluer shades less white? Technically speaking, yes. But to our modern eyes, we've grown to register blue-white sheets as white and bright, while warm whites seem almost creamy.

MEASURING PAPER SHADE

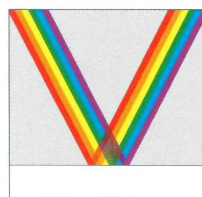
Whiteness—in all its colorful glory—is measured in a variety of ways. CIE, an international organization that sets standards for color measurements, designed a formula commonly referred to as CIE *L,a,b*. Another popular tool is known as the 1947 Hunter *L,a,b*, developed by Dr. Richard Hunter.

Put simply, these two formulas attempt to measure the dimensions of color by defining its primaries. On a three-dimensional scale, *L* indicates luminosity, or the degree of lightness from black (zero) to perfect white (100); *a* measures redness when positive and greenness when negative; and *b* measures yellowness when positive and blueness when negative.

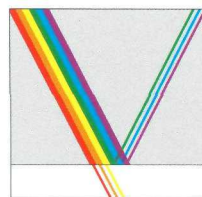
Here's a good way to remember these scales: For *L*, think of a light bulb; high *L* values mean the bulb is very bright and

therefore indicates high luminosity, while low *L* values dim the bulb or turn it off altogether. For *a* values, imagine tasting an apple: positive *a* values indicate redness, which is sweet and thus a positive experience, while negative *a* values describe a bitter, unripe green apple, surely a negative taste (unless you like the Granny Smith variety). For *b*, contemplate your moods: positive *b* values show off your positively sunny, hence yellow, side; negative values give you the blues, a negative experience indeed.

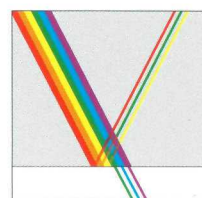
Brightness is the measure of light volume at a now-standard wavelength. So what does it do for paper? Bright paper makes colors dazzle. A high degree of brightness also enhances contrast, brilliance, snap and sparkle of the printed subject. It's all the difference between lighting a room with a 40-watt light bulb versus one that's 200 watts.



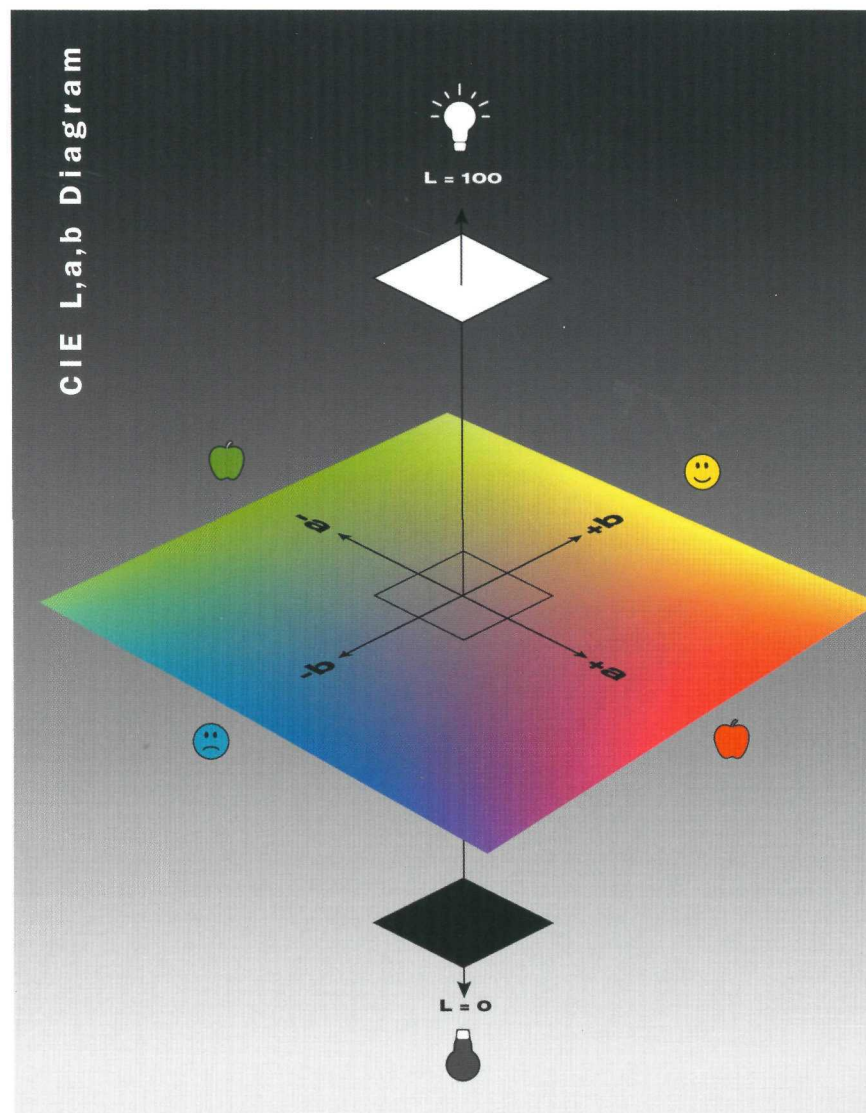
Neutral shade



Cool shade



Warm shade



Potlatch

WHERE PAPER IS JUST THE BEGINNING OF THE PARTNERSHIP
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