Understanding Color Perception

Most industrial color professionals understand the value of incorporating spectrophotometers into their color workflow for fact-based color management. But visual evaluation throughout the design, development, color formulation, production and quality assurance process still plays an important role in most industries.

While readings from a spectrophotometer may show that a process is running within specification, visual evaluation is still critical for several reasons. Customers who are buying a product – whether it is a new toy or a new car – make that purchasing decision based on what they see. Additionally, while instruments evaluate a specific color very accurately, they are unaffected by the surrounding colors, unlike the human eye. Customers looking at a product will see all of the surrounding colors, and their color perception will be affected by the way those colors interact with one another. During the development, production and quality assurance process, these effects can only be evaluated using visual assessment.

This white paper will discuss how color perception varies from individual to individual. And it will identify the steps industrial operations in plastics, textiles, paint & coatings, automotive and other industries can take to optimize the visual evaluation process to ensure optimal color quality, reducing waste, rework and cycle time.

Color Your Business Successful
How important is color to your business, or more specifically, how important is accurate color? When products reach the shelf or showroom, do they attract attention? Do they inspire confidence? Do they ensure immediate brand recognition?

Color is a factor in answering all of these questions. Studies show that as much as 70% of the buying decision is made at the shelf or in the showroom, and consumers will reach past a package or product that looks faded to get a "fresher" one with brighter colors.

Color Inspiration
Getting to great color starts with ideation. In this phase, product concepts are dreamed up, along with the colors that will make them stand out. Designers often use Pantone Reference Guides specific to their industry when selecting colors. They serve a valuable role, but they also must be cared for properly so that degradation over time is minimized. If they are exposed to contamination or too much light, colors will fade and/or be damaged, reducing their value in the color specification process. Well-cared-for Guides are a great starting point for color selection and can be used throughout the process for comparison purposes.

Conditions Affecting Color Vision
We often think of color as being a constant, but the truth is, everyone sees color differently. And individuals see color differently at different times based on a number of factors, including time of day, environmental conditions, retinal fatigue, and even the clothing they are wearing or how much sleep they got the night before.

Color vision deficiency, as opposed to total color blindness, is quite common. In fact, about one in every 13 men exhibits some type of color deficiency. For women, it’s much less, only about one in 300.
There are several common color deficiencies, but the most common is red-green colorblindness. Age can also be a factor in color vision. As we get older, our perception of color starts to fade. Carotene, a protein pigment, is responsible for this demise by invading the cornea and causing it to slowly turn yellow. You won’t notice it happening; but once it starts, it will continue.

Our eyes are also not exempt from life stressors that play a role in how our bodies function, such as stress, disease and medications. Even cultural, regional and ethnic influences can impact how we perceive color. Do your glasses have a UV coating? Are your contacts blue to help you find them when they fall on the bathroom floor? Although subtle, these tints can affect the way we see color.

These are some of the reasons why in color-critical environments, it is important for anyone involved with the visual evaluation of color to understand how accurately they actually see color. One solution is to periodically test color vision for both in-house and field staff who interact with color, especially if they are required to perform visual color evaluation as part of their job. The Farnsworth-Munsell 100 Hue Test (or FM100 Hue Test) is an easy-to-administer test and a highly effective method for measuring an individual’s color vision. A global standard that has been used by governments and industry for more than 40 years, the FM100 Hue Test evaluates and ranks color acuity.

Other strategies recommended by color scientists include:

• Rest your eyes before viewing, view quickly, and rest again before the next evaluation. A tired eye cannot make good color judgments, especially after being over-stimulated by a strong color.

• Always be aware of your environment. Surrounding colors can make a color look different. When judging color, use a light booth to ensure that nothing is clouding your view. And keep the light booth in an uncluttered state.

• Recognize the type of light that is illuminating your color. A light booth can help you control the lighting conditions and ensure consistency.

• To compare colors, view them side by side in a neutral environment, under controlled lighting conditions.

• Use a color measurement instrument to capture color data as a supplement to, visual evaluation. A colorimeter or spectrophotometer provides objective measurements rather than subjective evaluation, and it doesn’t even know surrounding colors exist.

Not All Daylight Is Created Equal

Natural daylight is generally accepted as the only light source that does not distort color judgment. But the problem with “natural daylight” is that its appearance and spectral characteristics can change dramatically from day to day, season to season and even during a single day. An overcast day can appear gray and drab; and a crystal clear bright sky can appear very blue. Changes in daylight quality are affected by atmospheric conditions, the change of seasons, time of day, pollution, altitude and even whether you are in a city or in the country.

This image shows how perception of color can change based on time of day. At noon, the car definitely appears red, but at night, it can have a much bluer tone.

Walking out to the parking lot at high noon to evaluate a color sample is an unreliable (and inconvenient) approach to color quality control. For color-critical environments, the best solution is a light booth that delivers consistent lighting to the entire supply chain at all times. There are many light booth choices in the market, so it is also important to consider the types of lighting final products will encounter once they are out in the world and select a light booth that can accurately simulate those conditions. Are your products primarily for home use? Retail? Outdoors? All of the above? You should perform color evaluation using every light source under which the final product will be seen. For instance, if you’re producing plastic garden ornaments, you’ll want to make sure they look good under a daylight source, plus fluorescent store lighting.
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Or consider assembling headphones with parts that were manufactured in different plants. Achieving the same color on different materials is not easy. Just because the leather ear pads, foam head cushion and printed metal sides appear to match under factory lighting doesn’t mean they will match under the store’s fluorescent lights, outside in the sun, or in the new owner’s new family room.

Whiter than White

The other consideration in visual evaluation of color is the increasing use of optical brightening agents (OBAs) to achieve a “whiter-than-white” effect on a range of materials, including plastics, paints & coatings and paper. Adding these optical brighteners gives products a brighter, whiter appearance and compensates for the yellowing that can happen over time with white products.

The challenge for manufacturers using OBAs is accurately measuring and maintaining color consistency across their production processes. While adding OBAs makes for a brighter product, the addition of these brighteners fundamentally alters the way the color is perceived in the production process.

OBAs operate through the process of fluorescence. They absorb invisible ultraviolet (UV) radiation at wavelengths below 400 nanometers (nm) and, through an electro physical change, emit light mostly in the blue end of the visible spectrum at about 400 to 450 nm. When this light is emitted from products that have used brightening agents, they are perceived as having a color that is “whiter-than-white,” since the observed light from the brightened material is the total of the reflected and emitted light due to the fluorescence. Under an ultraviolet light source, such as a “black” light, you can clearly detect visible color differences in products that contain various amounts of OBAs. Products that contain more OBAs will appear lighter, while products with less OBAs will be darker. To properly assess the quantity and impact of OBAs, a lighting source with a UV component is required.

Companies like Ultimate Textiles have implemented controlled conditions to facilitate accurate visual evaluation. It’s President, Anthony Guarriello, understands that the lighting under which color is examined and measured is critical. To that end, he uses controlled lighting over the dyers’ desks and an X-Rite SpectraLight light booth in the lab. All of the lighting in the sample room, dyers’ office and lab are TL-84 narrow band 4,100K lights and all of those rooms are painted in Munsell Neutral Gray.

Malti Rugs of India takes lighting a step further with an X-Rite Harmony Room equipped with SpectraLight QC luminaires. Sometimes referred to as fit and finish areas, these custom-designed viewing rooms simulate the customer experience and allow for the evaluation of components and/or final product for color palette harmony and accuracy. Its Harmony Room has SpectraLight QC luminaires mounted throughout the ceilings and/or walls as well as mounted on mobile stands for optimum viewing conditions. In the case of Malti Rugs, the Harmony Room was constructed to 10 x 12 feet to accommodate rugs up to 8 x 10 feet. Malti Rugs also uses an X-Rite Judge II light booth in its dyeing room for quick checking of sample yarn hanks during the dying process, comparing them against approved samples examined in the Harmony Room. As a result, the company has been receiving first-shot approvals on its colors, saving a huge amount of time in the manufacturing process.

Getting to Great Color – And Staying There

As the leader in the art and science of color, X-Rite has a wealth of information that will help companies in the industrial sector ensure they have the best possible color management processes in place.

For more information about visual evaluation of color, controlled lighting systems, formulation solutions, color measurement instruments and more, visit www.xrite.com/resources.