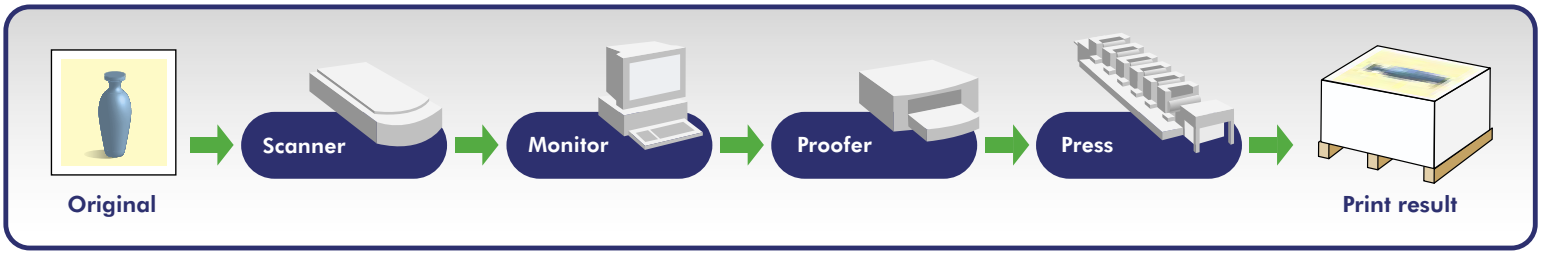
Color Management White Paper 2

Hardware & Human Factors Influence Color Management

In the digital imaging workflow, a document is commonly processed by a series of computer peripherals. Because these peripherals all differ from one another in the way they display, process, and reproduce color, discrepancies can appear between the original and the reproduced colors. The issue of reliable color reproduction is further impacted by human factors. The aim of this document is to explore some of the key reasons why color reproduction discrepancies appear and to outline some ways through which they can be minimized.



1. HARDWARE/SOFTWARE FACTORS: HOW RELIABLY CAN PERIPHERALS DISPLAY COLORS?

Basic color reproduction issues can easily be identified in common computer environments by comparing the way a given RGB value appears. For instance, when blue (R:0, G:0, B:255) is displayed on several computer monitors, the result is often as many shades of blue as there are available monitors.

There are several reasons for this:

MONITOR TECHNOLOGY DIFFERENCES

While flat panel displays are based on liquid crystal panels that use color filters to produce color, tube monitors (also called CRTs) use phosphors instead. Even among flat panel displays, the differences in liquid crystal technology types such as IPS, VA and TN families can cause differences in the way the same RGB value is displayed.

MONITOR SETTINGS

Luminance, brightness, contrast, and color temperature differ from one product to another depending on their usage. The end-user can also change the factory settings to adjust monitor behavior to their personal preferences. Both factory and user settings have a direct influence on monitor colors.

MONITOR AGING

The performance of a monitor varies with its age. As time goes by, for example, the maximum intensity of the backlights in a flat panel display can diminish, thus changing the way that the most saturated colors appear. Therefore, contrary to common belief, RGB color representation is not absolute, but essentially device-dependent.

While graphic artists need to display their work on monitors when processing documents, they also need to print or prepare them for printing. Unfortunately, monitors and printers differ in the way they produce color.

- Monitors are additive devices that represent colors by adding red, green, and blue values.

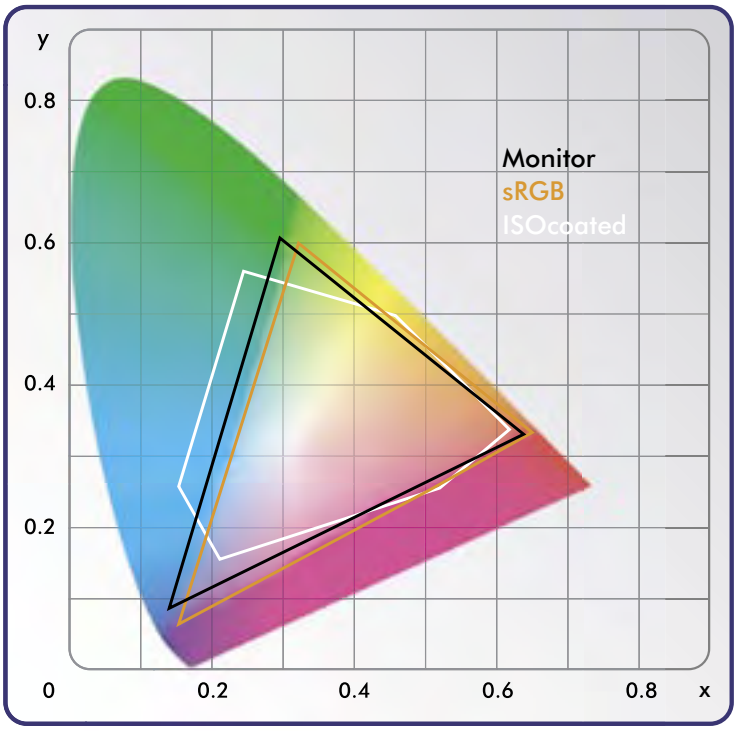
- Printers, on the other hand, are subtractive devices that rely on reflected light to render colors. Color is produced by the progressive subtraction of light by successively applying cyan, magenta, yellow, and black inks on paper.

The difference in these two processes and representations of color creates a requirement for a translation mechanism from the first to the second. This translation is generally managed, among others, by software called CMM that is embedded in the graphic application's software, operating system and/or hardware drivers used. Since the CMM is most often proprietary, the way colors are translated ultimately depends on which software, OS, and hardware are used.

In addition to these concerns, a fundamental issue affecting all color reproduction processes is the difference in the range of colors that each device can produce, also called gamut. While it is beyond the scope of this document to describe mathematical color representations, a common graphical

1- While this White Paper focuses on monitors and printers, the same issue affects scanners. The range of colors that are distinguishable by a scanner also varies from one model to the next.

representation of gamut relies on a xy-diagram similar to the one represented in the following graph, which compares the gamut of common monitors and printing devices.



In this diagram, the larger 'horseshoe' shape represents the entire range of colors that can be perceived by the human eye. Additionally, the gamuts of several devices are represented by the triangle shapes, which encompass all of the colors those specific devices can reproduce. As seen in the diagram above, some colors can easily be displayed on a computer monitor but not printed, and some can easily be printed but not displayed on monitors. This is inherently related to the differences between ink technology and monitor technology.

While advancements in technology bring hope to minimize such differences, it is probable that gamut differences will continue to exist for the foreseeable future.

In summary, different devices use different types of technologies and have different gamuts. Furthermore, the gamut of one device can change as it gets older, and color reproduction can further vary as a result of factory and user settings. Rather than a single "color space" for all peripherals, there is a range of color spaces, each a little different from the next—requiring proper translation mechanisms.

As a consequence, a given image (for instance, a digital photograph) will not necessarily appear exactly the same on different monitors and printouts.

If these discrepancies are not properly managed, they may be a source of considerable obstacles in productivity for digital professionals, resulting in unnecessary, time-consuming color adjustments and degradation in document quality rather than improvements.

2. HUMAN FACTORS: HOW RELIABLY DO OUR EYES & BRAINS PROCESS COLOR?

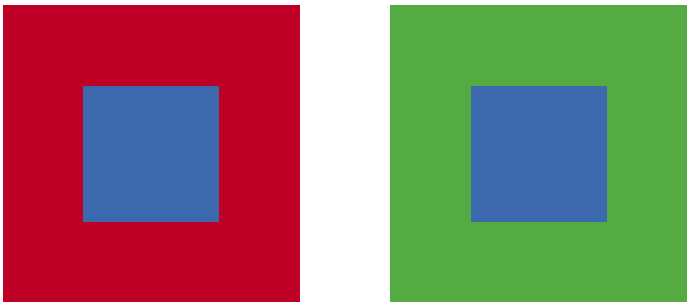
People may perceive the same color in completely different ways. There are several causes for this:

SPECTRAL SENSITIVITY VARIES FROM PERSON TO PERSON

The way eyes perceive colors can vary according to the age, condition and mood of the observer.

INFLUENCE OF SURROUNDING COLORS

A blue patch in a red square will look different from the same patch in a green square.

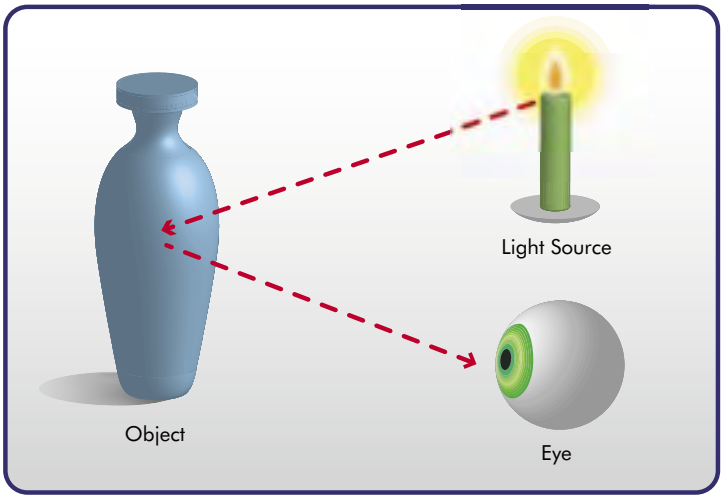


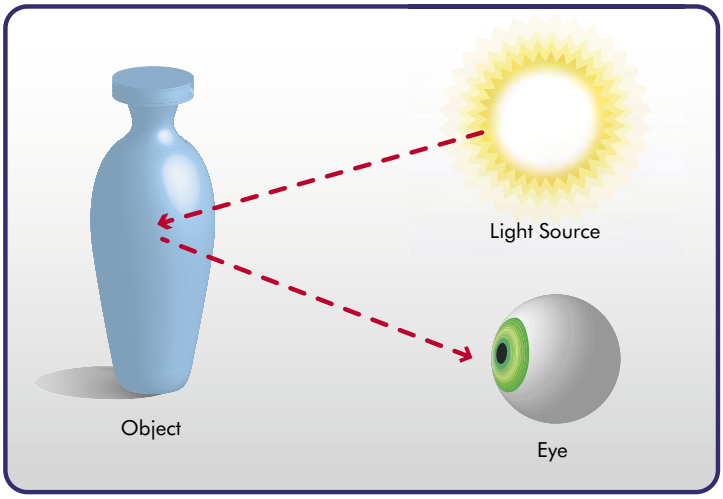
THE FORMAT AND SIZE OF THE COLOR DISPLAYED

A larger square with the same blue will look brighter and more powerful than a smaller square.

VARYING LIGHT SOURCES CAN
ALTER A COLOR'S APPEARANCE

A blue glass jar in daylight, under lamplight, and by candlelight will produce different color perceptions.





A light source that emits most of its energy in wavelengths of 570 nm (nanometers) can be described as emitting mostly "yellow" light. A light source that has a flat spectral distribution (equal energy emitted across the entire spectrum) will be described as gray.

3. NEED FOR A RELIABLE MANAGEMENT SYSTEM

As explained in this White Paper, there are several causes for color inaccuracies when processing digital documents in graphic arts, design and photography.

In order to address these issues, we recommend that you adhere to the following rules:

- Adapt your working environment to color management requirements. The ISO 3664 Standard recommends an ambient light that offers less than 64 lux luminance and has a neutral chroma. Use neutral lighting; protect your desktop and display from outside daylight influence; change your light bulbs, turn off your office lamps or reduce their intensity; shade any windows; etc.

- Build a clearly defined color management strategy and follow standard settings for your calibration and profiling: select white point, luminance and gamma settings according to your needs.

- Rely on measurement tools such as spectrophotometers and colorimeters rather than on your eyes with products specifically designed for color management, such as the LaCie blue eye pro calibrator, integrated in a comprehensive color management system.

- Calibrate every color sensitive peripheral (printer, scanner, monitor). In a reliable workflow, a color document must be reproducible by all different peripherals of the graphic chain with predictable and consistent results.

- Rely on monitors that can display accurate colors and are specifically designed for color management, particularly monitors that can be hardware calibrated such as the LaCie 300 Series.

Future White Papers in this series will explore other aspects of Color Management in further depth.

"Through a combination of cutting-edge technological engineering and a rich history of unique design aesthetics, LaCie continues as a firm leader in the color display industry. Established in the United States, Europe and Japan, LaCie is a leading worldwide producer of PC and Macintosh compatible peripherals, including a new generation of color LCD monitors. By providing top-of-the line tools for multimedia innovation, LaCie anticipates the needs of creative professionals such as graphic designers, photographers and filmmakers, who require genuine, practical solutions for accurate color management."

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