Color management is one area where you can't believe your own eyes. If you want a match, you need to measure.

The eyes don't have it

One important goal of color management is to view digital images on your display with accurate and consistent color previews. You want the preview to match the prints you make from your digital files. The first step toward achieving this match is calibrating and profiling your display.

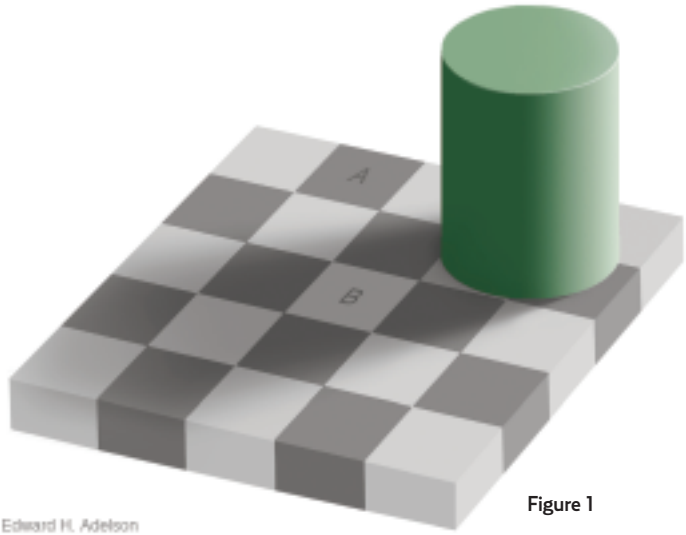
Not only do displays radically differ from one another, they also change as they age. But in color management, consistency is key. Calibration places a device into a known, specified condition based on predetermined target values, such as the display's *white point*, the color of the whitest white sent to the display; the luminance of the display, or the intensity of the white; and the *tone response curve*, which we specify as a gamma value. Once you've successfully calibrated your monitor, you can generate an ICC device profile that describes this known, specified condition in your color management system.

A digital image is a huge collection of pixels, with each pixel being a solid color defined by a set of numbers. Unless you alter those numbers, the image's color appearance should remain the same. Digital images do not age or change by themselves, so the colors in the images you preview today should look the same if you preview them a year from now. For this reason alone, consistency in display calibration is essential.

In theory, the way in which displays are calibrated and profiled is rather simple. Calibration software sends known colors to the display, one solid color at a time. Think of this as one giant color pixel with a known numeric value. We can use our eyes, or better yet, an instrument such as a colorimeter to measure this color while we adjust the display controls to reach the necessary calibration target values as best we can. After the calibration, the software sends another series of solid colors to the display to be measured with an instrument. The result is an ICC profile that defines how this device behaves. The color management system then uses the ICC device profile to preview our images.

There are a number of software-only, visual calibration products that allow you to calibrate a display using only the two instruments on either side of your nose—your eyes. For years, Adobe made a utility called Adobe Gamma that was used to visually calibrate and profile displays. The display control panel in the Macintosh operating system uses visual calibration that works in a similar fashion. But there's an inherent problem with these visual solutions; due to the influence of many psychophysical conditions, the human visual system simply isn't adequate to consistently place a device into a repeatable state. Immune to such influences, measuring devices are the ideal tools for calibrating and proofing our devices.

The human visual system is excellent at seeing colors and tone in context. We can view an image and determine whether we want it to be lighter or darker, or if



Edward H. Adelson

Figure 1

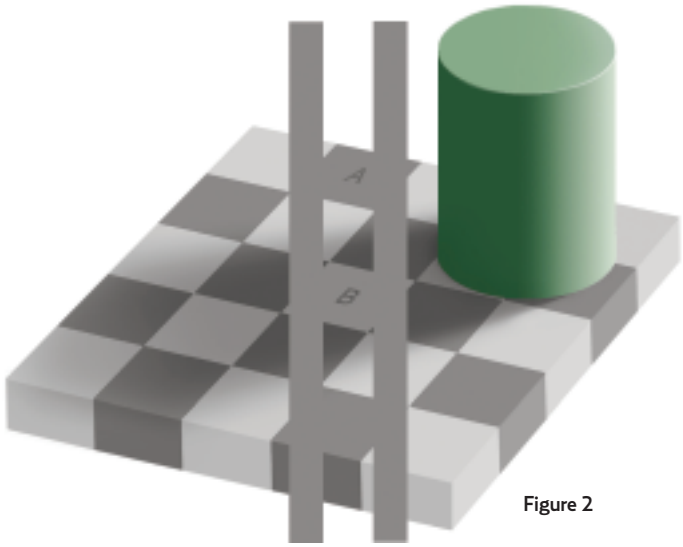


Figure 2

there's a colorcast that needs to be removed. No device can do this. Images are far too complex. The instruments used to measure digital devices are only useful for measuring a single color and comparing that measurement to a known reference.

To illustrate how visual calibration can be problematic, I ask that you examine **Figure 1**. Trust me when I tell you that squares A and B are identical, although they look quite different. That's my point. In **Figure 2**, the two solid gray bars of the same value make it apparent that, indeed, the two squares are identical. This graphic of an effect called simultaneous contrast was created by Edward H. Adelson, a professor of vision science at MIT. It illustrates just one of the optical illusions to which we're susceptible. The surrounding colors influence how we perceive colors, and the result is an illusion we can't control. A measuring device would provide identical values for each color. This and a host of other such mind-boggling illusions can be found at http://web.mit.edu/persci/gaz/#. I recommend you examine other optical illusions on this site, if only to validate the need for precision measuring devices.

Chromatic adaptation is another phenomenon that can fool our visual system. For example, an apple looks red to us, whether it's illuminated by sunlight, candlelight, fluorescent light or tungsten light. Our eyes actually adapt to the white in any scene, regardless of the color of the light. As photographers, we know we have to specify the desired white balance for the light source we're shooting under, because no chromatic adaptation is being automatically applied.

Examine two sheets of different brands of white paper under different light sources. Separately, each looks white, no matter the color of the light. In the same field of view you might notice that one is bluer or more yellow than the other. We can't help but see the whitest item in our field of view as white, even if it's not white.

We can estimate such qualities as speed, distance and temperature, but we rely on proper instruments of measure if we need to be accurate. In the context of color management, our measurement devices are colorimeters and, occasionally, spectrophotometers, which measure color based on the spectral properties. With the price of colorimeters and software for handling display calibration and profiling now falling under $100, you have to question the efficiency of using "eye-ball calibration."

Ask yourself if accuracy and repeatability in viewing digital images is important. If your lab sends you a file and reference print for adjusting your display to match, it will be clear that eyeball calibration is to be avoided at all costs. Not only are you being asked to use the wrong instruments to match the two medias, you've guaranteed that any ICC-aware application like Adobe Photoshop will produce inaccurate previews of all your digital files. ■

Don't miss Andrew Rodney at Imaging USA in Austin, Texas. His presentation, "Color Management from A-Z," explains how Photoshop can be set up easily to accurately preview digital images and get predictable color output. Monday, January 23, 9:15-10:45 a.m. Register at www.imagingusa.org.