White Balance : Warmth vs Color Temperature

Robert Stone February 2024

White balance (WB) should play a leading role early in your RAW editing workflow. Why is this? Color casts[1] affect the hue and tone of every color in your image. Clicking the WB eye-dropper tool on a neutral object in your image instantly corrects color casts. You can see how the sliders are moved and the color temperature adjusted. Making WB adjustments late in your workflow may have a negative effect on earlier color adjustments done with the Color Mixer, Point Color or Color Grading panels. For this reason, Adobe intentionally placed the white balance controls at the top of Lightroom's Develop panel and the Color section of Adobe Camera Raw's panels. While Adobe suggests that the tools and panels are in an appropriate order, it does not, unfortunately, enforce a strict order.

As a nature and landscape photographer I realize not all color casts should be corrected! I routinely seek out the vibrant hues of both blue hour and golden hour and will likely enhance rather than 'correct' them. Sometimes though, accurate color balance is important. Subjects like flowers, insects and wildlife when photographed in shaded locations may have a blue color cast from the blue-sky illumination, and those under a forest canopy may have a green color cast. These may need accurate color correction.

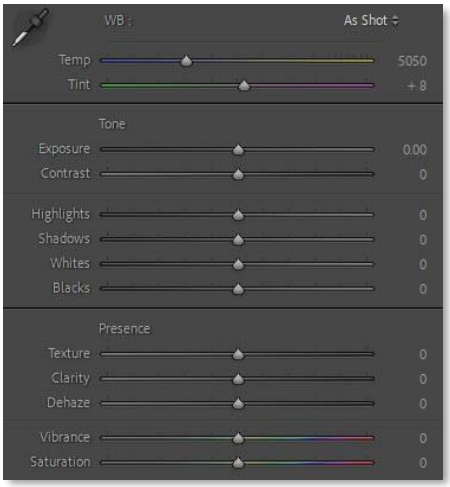
The WB panels you see when editing RAW files are shown. At the top, near the eye-dropper tool, you will find the words 'As Shot'. This is the initial entry in a picklist which offers additional options: 'Auto', 'Daylight', 'Cloudy', 'Shade', 'Tungsten', 'Fluorescent', 'Flash', and 'Custom'. These represent light sources (illuminants) that are the cause of some color cast problems. If the light source for your digital image was from one of these, using this picklist may help correct a color cast in your picture. Your camera also has WB options that are nearly identical to this list. Choosing the appropriate option may eliminate a color cast before you start shooting.

Adobe Camera Raw

The 'Auto' and 'Custom' options have a deeper meaning. The 'Auto' option tells us that your camera, LrC and ACR are all capable of attempting to evaluate and correct color casts. Many photographers choose this option on their camera because they know the results will often be very good and can be 'tweaked' in LrC and ACR if necessary[2]. Later in this document, I will mention a situation where 'Auto' is not a good choice.

The 'Custom' option in LrC and ACR lets you dial in a specific *color temperature* value. Your camera may include menu options to establish a precise color temperature using a gray card under your current illuminant.

Understanding what these color temperature numbers mean will help you get better color accuracy in your photographs and place your color correction and enhancements on a firm foundation. As you might expect from my writings, there's some physics here.



Lightroom Classic

Color temperature has a specific meaning in physics. It is based on the color of light emitted by objects at a specific temperature. This is called 'Black Body Radiation', based on the idea that an object that absorbs all colors equally would be black. Surprisingly, the hotter something gets, the more blue it becomes! You've likely seen this color effect without appreciating it. If you look closely at a candle flame, you may see blue light at the bottom. Near the

[1] See the Wikipedia entry: Color Cast

[2] The in-camera 'Auto' settings for color cast and exposure are based on machine learning, now called artificial intelligence or AI. The manufacturer of one of my first digital cameras stated that it was trained using 30,000 images. A later model was trained on 300,000 images. I believe the number is much higher now.

wick oxygen is plentiful, combustion more complete, and the flame hotter. Above the wick, oxygen has become depleted, and the temperature lower. In the kitchen, gas stove flames are blue and hotter because they are designed for better oxygen mixing. On an electric stove the heating elements start to glow dark red, then orange and finally almost yellow as they get hotter. Astronomers categorize stars by color; blue giants are the hottest. The energy of a photon increases with shorter blue wavelengths.[3]

Color temperatures are reported on the Kelvin scale, where '0' is absolute zero. Room temperature, 72°F, is 295K. Traditional studio lights have a yellowish color temperature at 3,200K, about the same as the ordinary household incandescent bulbs. Electronic flash units mimic midday sunlight at about 5,500K. On overcast days, daytime sky will have slightly more blue at 6,500K and the blue sky at the north pole as high as 25,000K. Modern LCD bulbs may be 'Warm' or 'Daylight' mimicking these illuminants. Film photographers often used color correction filters so images made with daylight film under studio lights would be color correct[4]. (Note that Kelvin numbers are not written with the ° symbol.)

Color temperature is single number, but not a single color. Each illuminant has a broad spectrum of colors with a dominant peak. The rainbow[5] is the full, colorful spectrum of the sun at a color temperature of about 5,500K. Color temperature outdoors changes from minute to minute depending on the position of the sun and cloudiness. Shadows may have a blue color cast as they have only blue sky illuminating them. Under forest canopy, everything may have a green color cast. The colors of nearby buildings or canyon walls can also add a color cast. Changing the color temperature value affects every hue in your image across that spectrum.

Here's where the confusion starts. Even if you have done your color cast removal with the WB tool, it's common to move the Temp slider to warm or cool an image. This exactly reflects how we feel about warmth in an image: cool blues for icy icebergs or arctic weather, warm yellows under the hot summer sun. But when the temperature slider moves into yellow, the color temperature number goes up! These Kelvin numbers run from 2,000 at the slider's blue end to 50,000 on the yellow end. Yet a true color temperature of 50,000K would be a strong blue, not yellow! This seems backward from what we learned just about color temperature: higher number should be bluer! LrC and ACR seem to tell you that warmer colors have a higher temperature.

So let's get theoretical: A color neutral object, say a photographer's gray card, should look neutral gray in your image no matter what light source was providing illumination. However your camera, LrC and ACR know nothing about your image: not the actual content of your image, what, if anything, in the image is neutral gray, and not the color of the light source(s). Clicking the eye-dropper is simply telling the software where a neutral object is in your image.

So what is the eye-dropper tool actually doing? It asks two questions. First, "If this really is a neutral tone, what must have been the color temperature of the illuminant?" Second, "What would be the color temperature of the correct illuminant?" For a tungsten illuminated gray card, the color cast would be yellowish. The WB tool would determine that the illuminant should have been more blue. (Blue is opposite yellow on the color wheel and can be considered minus yellow.) The new color temperature number shown is not the color temperature of the image or anything in it; it's the color temperature of the correcting illuminant.

The software doesn't know anything about your image or your artistic choices about warmth. As you move the WB slider toward yellow the software is still calculating the theoretical color of a correcting illuminant. This is why

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[3] Wikipedia : Black Body Radiation, Color Temperature, Candle, Hertzsprung-Russell Diagrams and Photon Energy

[4] Back in the day, using daylight film indoors resulted in sickly yellow skin tones. While color films came in two varieties, 'Daylight' and 'Tungsten', changing film types mid-roll was awkward. Photographers purchased just one of these types and used an appropriate color correction filter for the other type. The Wratten blue 80B filter will balance daylight film under tungsten lighting, while the yellow 85B filter will balance tungsten film under midday lighting.

[5] Wikipedia : ROYGBIV

the color temperature number increase. The image would need more blue if correction is needed.

Clever tool, that eye-dropper! Automatic color temperature correction! But it is more sophisticated than simple point-and-click. It displays the RGB values of pixels under the eye-dropper beneath the histogram. In LrC, the WB eye-dropper also displays large a 5x5 pixel grid with the RGB values at the bottom. ACR doesn't use the grid but has a Color Sampler tool (the eye-dropper at the lower right corner) that opens the Color Sampler Toolbar at the top of the screen. It has room for up to 9 targeted triplet RGB values. The grid or RGB samplers values may help finding a neutral target. LrC and ACR can display either LAB or RGB numbers.

After all this technical information on color temperatures when editing RAW files, you will notice that both ACR and LrC sometimes show simple numbers. These typically run from -100 to +100. In ACR, you will see this when you use Adobe Camera Raw as a filter on a pixel layer or Smart Object. In LrC, the color temperatures are shown when you start editing RAW files, but later use the simple numbers as you start working with TIF or PSD versions. In these situations, your are working in a specific color space, sRGB, Adobe RGB or ProPhoto RGB. Your adjustments are changes to the R, G and B values of that color space. (LrC uses ProPhoto RGB internally but may use a different color space system for output images, e.g. sRGB for the web. Commercial photo printing may accept only sRGB, or both sRGB and Adobe RGB.) This is another reason why getting WB right needs to be done early in your workflow.

Here's a tip: Include a gray card[6] in the first image at a location to serve as a WB target. Only needed once as long as the lighting conditions remain fairly constant. Great when under foliage or in blue shadows. Interesting during Blue Hour or Golder Hour.

If you had a project requiring color matching across multiple images and video sequences, physical color correction CC filters[7] might be used, or a Macbeth Color Checker[8] included in a reference image. Calibrite[9] and Datacolor[10] have small color checker devices that fit in a camera bag. Included software will help color balance your files. Both have a gray card or patch.

Gotcha #1: Using in-camera 'Auto' WB can cause problems in panoramas. My very first panorama was a football game with the Catskill Mountains in the background. Different amounts of blue sky and green grass resulted in different color temperatures in each frame. Very hard to color correct! Instead, choose as fixed option, say daylight, for panoramas. Each frame will have the same WB, and easily adjusted in LrC, ACR or Photoshop.

Gotcha #2: Even when you have your camera set to a fixed value as above, it *might* not, *often* not, be the perfect correction. This is why I use a gray card; a neutral target that can be used with the WB eye-dropper.

Gotcha #3: The Calibration panel sliders in LrC and ACR also affect hues across all colors, not as the single RGB pixel values the panel seems to suggest. I have as PDF on this alone; look for "Color and Calibration" on the same page where you downloaded this document.

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[6] When I was doing 4x5 B&W photography I used a Kodak gray card as an aid to proper exposure. When I started to use it as a neutral target in color photography, I discovered it had a slight purple color cast! It caused an unwanted color shift in my images. Today, I use Michael Tapes WhiBal, which is color neutral across the full visual spectrum.

[7] See the Wikipedia entries: MIRED and Wrattan Number

[8] Wikipedia : Color Checker

[9] Color Checker Passport

[10] Spyder Checkr