

Color by the Numbers

Topics: How to analyze an image to locate any values that can't be correct, and how to fix them with curves.

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Author's comment: If any one of these columns can be called an industry-changer, this is it. In 1994, few photographers had professional-level computers in their studios, and if they did, they didn't know how to make global color corrections with them. CMYK was king in 1994, and few photographers were comfortable with it. My assertion that 90 percent of color correction could be handled by monkeys became an icon of the desktop revolution. Direct descendants of this column, though expanded, appear in every edition of *Professional Photoshop*.

This archive, to be released over several years, collects the columns that Dan Margulis wrote under the *Makeready* title between 1993 and 2006. In some cases the columns appear as written; in others the archive contains revised versions that appeared in later books.

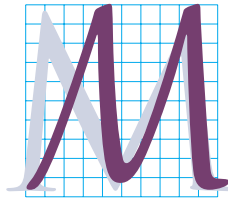
Makeready in principle could cover anything related to graphic arts production, but it is best known for its contributions to Photoshop technique, particularly in the field of color correction. In its final years, the column was appearing in six different magazines worldwide (two in the United States).

Dan Margulis teaches small-group master classes in color correction. Information is available at <http://www.ledet.com/margulis>, which also has a selection of other articles and chapters from Dan's books, and more than a hundred edited threads from Dan's Applied Color Theory e-mail list.



Color Correction By the Numbers

When looking at an image for the first time, we often see what we perceive to be many small problems. Normally, they are all part of one bigger problem, which can be solved in a single stroke of Photoshop's most powerful tool.



Monkeying around with the color balance of photographic images is not a sport for the timid, or so goes the conventional wisdom. Believing this, people go through the most simian sorts of shenanigans trying to make their color look believable. They select this area, sharpen that one, call up histograms, apply strange filters, and generally try to demonstrate that if an infinite number of art directors employ an infinite number of digital tweaks somebody somewhere may throw them a banana.

And yet, most color correction could be handled by monkeys. This chapter and the next introduce a numerical, curve-based approach calling for little artistic judgment. To be sure, one can go much farther, but all the advanced techniques are based on these surpassingly simple ones.

The by-the-numbers rules can be stated in a single sentence.

Use the full range of available tones every time, and don't give the viewers any colors that they will know better than to believe.

Figures 2.1 and 2.2 show how this deceptively simple concept is supposed to work. The corrected version is more detailed and has greater contrast everywhere. Furthermore, a piece of tinted Saran Wrap appears to have been lifted off the original version.

In principle, it's easy to see how this was done. The “full range of tones” means from white to black. The horses' foreheads are white; their blinders are black. Or at least they are in Figure 2.2.

“Colors that they will know better than to believe” includes, among other things, pink horses.

In fairness, one need not be particularly skilled to notice that there's something wrong with the horses of Figure 2.1. But

Figure 2.1 The pink horses below are clearly wrong, but are merely the most obvious of many problems.



what amateurs try to do to fix them usually ends up looking, well, amateurish.

First, many people would immediately select the horses and force them to become white. Such an action is to remove the horses from the context of the image and effectively paste them into a background to which they have no relation. The horses may be the most blatant things that are too pink in the original, but they aren't the only things.

Second, the pinkness is so pronounced that it can be detected on screen—or at least it can for a little while. People who try to correct to white based on what they see, however expensive and well-calibrated their monitors, invariably wind up with horses that aren't *as* pink, but aren't white either. Remember, our visual system is self-calibrating. The longer we stare at a monitor that is flooding our receptors with pinkness, the grayer these horses will seem.

This is why a monkey could do a better job on this image than many experienced people do. To be more provocative, this is the kind of image on which our agreeably adaptable color vision is actually a handicap.

Readers of previous editions will remember examples by Ralph Viola, the first color-blind person I ever trained to do this kind of work. Since that time, four color-blind men have taken my three-day courses, with results ranging from reasonable to spectacular. This is the kind of image they eat up but is a real handful for those with perfect color vision and the wrong mentality.

The color-blind, obviously, don't trust their eyes. They follow a recipe.

The Magic Numbers

In the following six chapters, we will be making global corrections only: no selections, no masks, no use of anything in the Photoshop toolbox. We will work in CMYK, although the methods translate easily into RGB, with one exception.

The cyan ink throws a monkeywrench into the CMYK works. It isn't very pure. It reflects considerable red light, which it wouldn't do in a perfect world. Because of this, we can't make good blues in CMYK, which is hard to adjust to, and the neutrality definition is different, which is easy with practice.

RGB users know that to create a neutral color—gray, white, black—the values of all three channels need to be the same. One would think that (ignoring black, which is neutral already) the same rule would apply in CMY. It doesn't. To make a neutral, magenta and yellow should be equal, but cyan higher. This explains the suggested shadow and highlight values below.

Make your images meet the following four requirements, and be prepared for some startling improvements.

- The **shadow** is the darkest significant neutral area of an image. Around 99 percent of images have *something* we can use for a shadow.

In principle, the shadow should be the heaviest value we believe that the output device can hold with detail. Sheetfed presses are fairly good at this, and can handle a shadow value higher than in web-printed jobs like this book, which in turn should be higher than for a newspaper. If unsure, use what's used here: $80^C70^M70^Y70^K$. One or more of these numbers can be higher in a deep

color. Navy blue, for instance, might be $95^C65^M15^Y50^K$.

Most commercial printers impose a limit on the sum of all four inks, to avoid drying problems. The better the conditions, the higher the number they'll accept. SWOP, the industry-standard Specifications for Web Offset Publications, mandates a 300 maximum, which most magazines tweak down to 280. My $80^C70^M70^Y70^K$ suggestion sums to 290, close enough.

Figure 2.2 A corrected version has less magenta in the horses, but more in the background flags.



However, 290 is not close enough when preparing images for a newspaper, which is apt to ask for 240, or even for some desktop printers. If a lower number is necessary, we reduce the CMY colors and increase black in roughly equal amounts.

People don't have good color perception in areas this dark, so, if need be, we can take liberties with one or two of the ink values. Don't do this without a good reason, though. An unbalanced shadow often is a symptom of a color cast that may be subtly hurting other parts of the image.

- The **highlight** is the lightest significant part of the image, with two qualifications. First, it cannot be a reflection or a light source. These things are called *speculars*, or *catchlights*. We ignore them. Second, it must be something that we are willing to represent to the viewer as being *white*. Assuming that all these requirements are met, use a value of $5^C 2^M 2^Y$.

Other experts suggest different values. They may say $4^C 2^M 2^Y$, $3^C 1^M 1^Y$, $5^C 3^M 3^Y$, or $6^C 3^M 3^Y$. But everyone agrees that magenta and yellow should be equal, and cyan a couple of points higher to maintain neutrality. Such universal agreement exists because this highlight value is critical. We humans are quite sensitive to light colors. A variation of three or four points in any ink could result in an unacceptable cast.

Doubt the impact of an incorrect highlight? Figure 2.3 shows how Photoshop's Image: Adjustments>Auto Levels can betray the beginners who deploy it.

That command is the simplest form of automated color correction. It maximizes contrast by forcing every channel to its full range. Ordinarily, this results in a distinct white point and black point, which are ordinarily very good things to have.

Here, however, the lightest point is in the man's left hand. Turning that white was not exactly crowned with success. By forcing it away from its natural yellow, the command makes everything too blue and basically torches the whole image.

A monkey, let alone a human being, could see that the hands and the belt buckle are not supposed to be white, which leaves the question of what numbers to set them to, the answer to which frustrates those readers who only want sure things.

If they really were white, then we'd want their typical value to be $5^C 2^M 2^Y$. By context, however, they are obviously yellow. How yellow are they? I have no more idea of this than you do. Perhaps it should be 15^Y and perhaps it should be 75^Y .

In these circumstances, where logic doesn't assist us, we guess. And we guess on the basis of what looks best to us on the screen. We'd like more reliable guidance than that, but we take what we're given.

The other two values, however, are no guess. They should be $5^C 2^M$ just as before. After all, this area is the lightest significant part of the image. If it were white, it would be $5^C 2^M 2^Y$, and it surely isn't green, blue, aqua, red, or purple, which are the only colors that would require mandate extra cyan or magenta.

Guessing is what we do when we aren't sure. And because we hate being tossed about in a sea of guesses, we always have to be on the lookout for anchors, sure things. The most common such anchor is a color that logic tells us must be neutral.

Looking for the Sure Thing

- For an area that is supposed to appear **neutral**, that is, white, black, or any shade of gray, the magenta and yellow values



Figure 2.3 Choosing the wrong highlight can be fatal. The right-hand version was corrected using the Auto Levels command, which assumed that the man's left hand was white, with disastrous results.

should be equal and the cyan higher. How much higher is an open question; two or three points ought to do it in the highlights, six or seven in the midtones, nine or ten in the shadows.

I used to think that if there was a problem meeting this requirement, it is better to be too heavy in the cyan than either of the other colors, since bluish grays are less obtrusive than greenish or reddish ones. I've changed my mind; the grays themselves may be more believable, but overall the image is likely to be worse. Even slight cyan casts are disagreeable. Slight casts in the direction of a warm color are often pleasing.

The statue of Figure 2.4 is gray. Our logic tells us so, even if we've never seen it in person. So, here I've made it a nearly perfect gray. I've measured a point in the neck as $20^C15^M15^Y$; other points are comparable.

But is this the only possibility? Could this not be yellowed with age as well, or perhaps brownish? Here's a quiz. Let's reduce each ink, in turn, by 5%. There are a total of six possibilities, counting combinations of two inks. For example, $20^C10^M10^Y$

would imply a slight cyan cast. $15^C15^M15^Y$ doesn't have the extra cyan that's needed for neutrality. It is therefore a reddish, or warm, or brownish feel, because it's unbalanced in favor of magenta and yellow, which combine to make red.

The other four possible permutations are $20^C15^M10^Y$, $20^C10^M15^Y$, $15^C15^M10^Y$, and $15^C10^M15^Y$. They yield (but not in this order; you have to figure it out) yellow, green, magenta, and blue.

That part is so easy that I won't waste space on the answers. The harder question is, which, if any, of these six possibilities do you think is a reasonable alternative to pure gray? Come up with a response before you turn to Figure 2.5.

- **Fleshtones** should have at least as much yellow as magenta, and up to a third again as much in extreme cases. Where the yellow is equal to or only slightly higher than the magenta, this implies a very light-skinned person, such as a small child or a blond. For Caucasians, the cyan value should be a fifth to a third as heavy as the magenta, depending upon how bronzed a

person is. For someone dark-skinned, $15^C50^M65^Y$ will do; lighter-skinned Caucasians can go $6^C30^M35^Y$ or even lower.

Persons of Hispanic or Asian parentage share a skintone range that's smaller than Caucasians as a whole. Yellow is always significantly higher than magenta, commonly 10-15 points in those of Asian descent. Cyan begins at $\frac{1}{4}$ the magenta value and can be greater even than $\frac{1}{3}$.

The race commonly referred to as black or African-American exhibits more diversity than any other ethnic group. Lighter skinned individuals compare to Hispanics, with yellow distinctly higher than magenta. However, as this group's skintone gets darker, the difference compresses, so that very dark-skinned African-Americans often have equal magenta and yellow. As for cyan and black, there is no limit.

Finding an image's typical fleshtone is easy enough with experience, but if you haven't tried it before, there are some snares to avoid. Measure only areas that are in normal lighting, not a shadow or a semi-reflection. Also, avoid any area where there's likely to be makeup, such as a woman's cheeks. You may wish to make a small selection of what seems like an appropriate area, use Filter: Blur>Gaussian Blur at a high value to make the selection take on a

more uniform color, and then measure that before cancelling the blur.

Except in persons of African descent, it isn't customary to have black ink in a fleshtone, but it sometimes happens, particularly when using nonstandard GCR settings (see Chapter 7 for more on this). If there *is* black, count it as additional cyan, because it does the same thing: it pushes the color away from red and toward gray.

Writing Curves: A First Step

To start, we open the image and check the ink values, using the Info palette, in the highlight and shadow areas, plus fleshtones and any area you are certain is close to neutral. First, though, click on the eyedropper tool and set its sampling to 3×3 rather than the default single pixel, which, due to noise in the image, can give a false view of what is going on.

In simple pictures, we can keep these numbers straight in our heads, but as they get more complex, writing down the density values and what we propose to do with them can be helpful. To the extent the image does not meet our target numbers, we apply curves to force it closer to them.

To do so, open Image: Adjustments>Curves. Ignore the default, or master curve. Go directly into the individual channels. To agree with the examples in this book, please be sure that shadows are set to the right and highlights to the left. This is Photoshop's default for CMYK, but not for RGB. Most people who work in both find it extremely confusing to find that raising the curve darkens the image in CMYK but lightens it in RGB. So I recommend you pick one or the other. To toggle your current setting, click on the light-to-dark bar at the bottom of the curves panel.



Figure 2.4 *This garden statue surely should be gray—approximately. But should it be gray exactly? This one is, according to measurements in the neck. Turn the page to see some other possibilities.*

A Plan for Using this Book and Its CD

To jump-start your effort to correct by the numbers, here's some advice, as well as some common problems readers have run into over the three previous editions of *Professional Photoshop*.

Images that are included on the accompanying CD have an icon next to the uncorrected image. Although, in deference to those readers who demanded it, images from most chapters are included, I recommend that you *not* use the CD for Chapters 2–6. You should use your own. The techniques in these chapters apply to almost all images. I think you'll be more impressed if you apply them to ones you're more familiar with. Later, particularly in Chapters 16–18, which show techniques that are right for certain images and not for others, you should probably use the ones on the CD. Also, in those images I used a lot of blending percentages that are essentially personal preference, as opposed to the curves in earlier chapters, which yield if not the absolutely best numbers, something real close. By working on these blend images yourself, you can get a good idea of what the other options are, should you decide you don't like my choices.

This and the next three chapters assume CMYK files. For the moment, never mind how they got into CMYK. This is discussed in Chapter 7. Also, ignore the possibility of correcting in RGB or LAB. These options are discussed beginning in Chapter 8. The reason for this organization is that if you are preparing files for print, knowledge of CMYK correction is indispensable. A CMYK-only workflow isn't smart, but one can get by with it. A CMYK-never philosophy is another story. For those whose files begin and end in RGB, it shouldn't be too tough to follow the CMYK corrections.

If you are converting your own files into CMYK and trying to follow the numbers, you'll have a problem if you use Photoshop defaults, which will give you strange shadow values. The quick fix is to enter Edit: Color Settings>Working CMYK and choose Custom CMYK. Skip ahead to Figure 7.1 on Page 116 and copy its values. You'll need to know why later on, but it's not important now.

To maintain your sanity, I strongly recommend that you make a decision as to which side of the curves dialog should represent lightness and which darkness. By default, Photoshop sets lightness to the left in CMYK, but to the right in RGB. This has blinded generations of users to the essential similarity of the two colorspaces. If you make these settings uniform, the shape of the correction curve in the cyan channel of CMYK will be very similar to what it would be in the red if you did the work in RGB. The green correction would resemble the magenta and the blue the yellow. Because my background is CMYK, I've set lightness to the left in both colorspaces throughout the book. It doesn't hurt to reverse this if you are more comfortable with it, but then you have to reverse my curves in your mind. To reverse the orientation of the curve, click on the gradation line beneath the horizontal axis of the curve.

Many sets of images have circular color swatches inset, with their CMYK values indicated. This may help you start to visualize what colors various CMYK combinations produce. The swatch represents an important color in the image. The swatches in the corrected version(s) show what that same color has been changed to.

Finally, you should commit the basic colors to memory, ignoring black, which is neutral. If there are two strong CMY channels and one weak one, this creates red, green, or blue. If only one is strong and two are weak, the overall color is cyan, magenta, or yellow. Thus, 20^C90^M90^Y is a red; 20^C20^M90^Y is yellow; 20^C70^M90^Y is a yellowish red; and 20^C40^M90^Y is a reddish yellow.



Figure 2.5 Even when the precise color of a near-neutral object is unknown, logic and experience can exclude certain possibilities. Obviously, this garden statue could be gray, but it might have a slight color. Here are six possibilities, all generated by five-point increments in the CMY values at a certain point in the neck. Clockwise from top left: red, magenta, blue, cyan, green, and yellow casts. Which ones do you think are plausible? If you encounter one of the others, correct it!



The horizontal axis of the curve represents the original values of the image. The vertical axis is the values the curve will cause the image to take when we click OK.

The default curve is no curve at all, but a straight line at a 45-degree angle. If we decide to change it (and we may well decide to leave it alone), we can keep it a straight line by changing one or both of the end-points. Normally, though, we insert one or more intermediate points and adjust them up and down. If we do so, the straight line will become a curve.

If the entire new curve falls below the

original 45-degree straight line, the corrected image will be lighter than the original, and vice versa. Most of the time, we will want curves that fit neither description, but that make some parts of the image darker and others lighter.

Parts of any curve will end up steeper than 45 degrees. To compensate, other parts have to become flatter. Areas falling in its steeper parts will gain contrast. Objects having the misfortune to be found in flatter parts will lose out.

To locate highlight and shadow, I personally prefer to run the cursor over several

likely areas and watch the Info palette. This lets me choose the second-lightest area as a highlight, if I decide that the real lightest area isn't important to the image.

If you're uncomfortable with this, you can open Image: Adjust>Threshold and move its slider until it becomes obvious where the light and dark points are. Remember, though, to look for the lightest and darkest *significant* areas, which are often

a far cry from the areas that are literally the lightest and darkest.

Before clicking OK, we run the cursor across the neutral areas of the picture, if we're sure there are any. Ideally, they should have equal magenta and yellow and slightly more cyan; if not, we will have to make further adjustments to the curves.

If major work went into these curves, we should take advantage of the Save option in

Avoiding the Impossible: How the Pros Know the Numbers

There's a popular misconception that the best retouchers know exactly what numbers to shoot for no matter how esoteric the subject matter. In real life, the key is more to avoid numbers that can't possibly be right. If we find any such in the image, we have to twist curves or whatever to avoid them. Here's a brief guide to familiar colors, starting with the easiest.

GREENS are nominally equal combinations of cyan and yellow, with much less magenta. In practice most greens favor their yellow neighbor. Cyanish greens are rare. Often yellow is as much as half again higher than cyan. In the natural "green" of a plant, equal cyan and yellow would be impossible. On the other hand, if the cyan is so low that it's closer to the magenta value than the yellow, then it's a greenish yellow rather than a yellowish green. That's impossible, too. If we discover either situation in our picture, we have to correct. We may not get the right color, but it has to be better than an impossible one.

REDS are, in principle, equal combinations of magenta and yellow, with much less cyan. If the magenta is slightly higher than yellow, it's a rosier red. If yellow is higher, it's an angrier, more orange color. Faces are close to equal, but when they aren't, it's always a yellowish red. Reddish yellows, and magentaish red, are impossible in faces. In other things that are red, anything goes.

BLUES would, in a perfect world, have equal amounts of cyan and magenta. Photoshop commands like Hue/Saturation and Selective Color that are capable of targeting "blues" in fact make this assumption. The sad fact is that equal cyan and magenta makes purple, so any real blue will have decidedly more cyan. The color of most skies is even more heavily skewed; many skies are better described as bluish cyan than cyanish blue.

Intelligent retouchers therefore look at suspect areas of an image and ask, are these color values even *possible*? If they are, we don't try to mastermind the operation by guessing at how they might be better. But if the colors are impossible, we have to change them, even if we aren't positive of what to change them to.

For example, if you were asked to define the hair color known as *blond*, you would probably say it was yellow. Pure yellow, in the sense of equal cyan and magenta, is in fact possible. More commonly, though, the hair is a *reddish* yellow, meaning yellow first, magenta second, cyan third. A greenish yellow, with cyan higher than magenta, is impossible. If the image features greenish yellow hair, this has to be changed. I can't tell you to what, but you can't let it stay green.

the Curves dialog box before doing anything else. If we do this and then decide that a slight modification is necessary (or, heaven forbid, if we make some big mistake and are forced to File: Revert to the last saved version of the image) we can cancel the changes, then reopen the dialog box and choose the Load option to reinstate the curves. Or, we can save the curves within an Adjustment Layer, which will allow us to change the curves later even if there are other intermediate changes, such as airbrushing and/or cloning.

Photoshop's interface offers many ways to do the same thing. Nobody cares which method of establishing shadow values you use provided the result is accurate. If your correction looks good, nobody cares whether you used Adjustment Layers or saved curves or a trained baboon to get there. And nobody will care whether you constructed your curves by dragging points with the mouse, as I do, or by typing in numbers in the bottom left of the dialog.

Similarly, there are many ways to configure the critical Info palette, as shown in Figure 2.6. It's customary, and sensible, to have the top left box display Actual Color, which in this case is CMYK. The second

Figure 2.6 When a curve or other adjustment dialog is open, the Info palette shows before-and-after values, separated by a slash. Users also can define, using the color sampler tool, up to four fixed sample points, which will update continuously as the correction proceeds.



box is currently set to read total ink, just in case our values offend the ink police. Or we can change it, by clicking and holding the top right eyedropper icon. When correcting in an unfamiliar colorspace, like LAB, many people set the top right box to read the equivalent values in RGB or CMYK.

Using the color sampler tool, many people like to establish up to four fixed reference points whose changing values will be displayed during the correction. This is a good practice as long as it isn't taken too seriously: one shouldn't depend on a single point to evaluate shadow or highlight, but rather on several. This display, for example, which is taken from the Statue of Liberty image of Figure 2.7, shows a shadow value that's a bit high in the yellow. Not a problem here: other points in the same range, I found with the cursor, weren't as bad.

So much for theory. Let's roll up our sleeves and correct some color. Please remember that a lot of the high-octane stuff that you'll encounter in other chapters isn't in use yet. We will not consider sharpening, channel blending, false profiles, selections, masks, or layering shenanigans, or the use of any colorspace other than CMYK. Could some of those things make the corrected versions here even better? Undoubtedly. But this chapter is the foundation. Ignore it, and all those tools, powerful as they are, won't give you competitive results.

Picking Significant Points

The statue is straightforward. There are no fleshtones, leaving three issues.

- There are several candidates for shadow: the doors at the base, the large half-oval windows beneath the statue, or the dark area to the right of the base. They all measure about the same

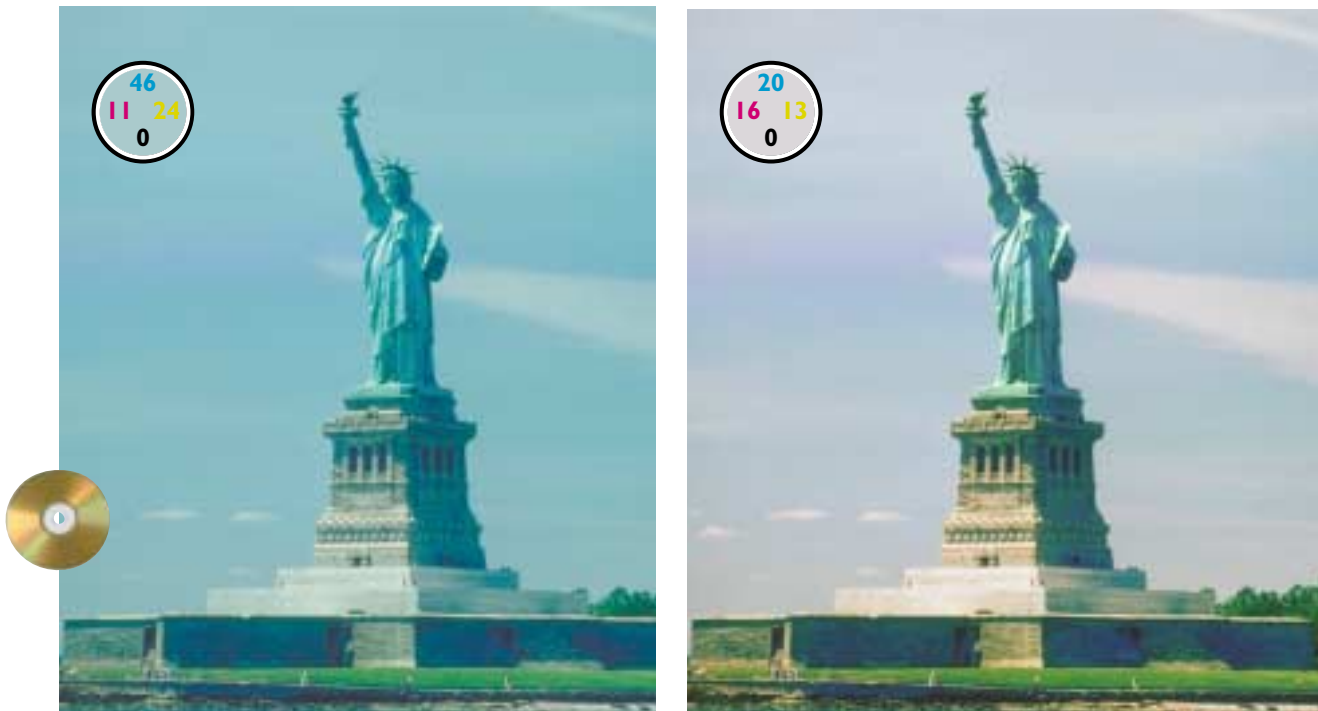
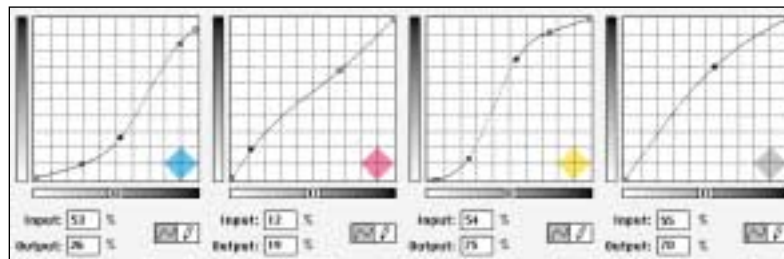


Figure 2.7 Correcting this image requires picking its lightest and darkest significant points and forcing neutrality into at least parts of the clouds. At right, the curves.



in the original. In such cases, we choose the one that seems most significant. Since I didn't care whether the doors closed up, I chose the far right window. It measured $85^C70^M56^Y53^K$, similar to the doors.

- Highlight is trickier. It illustrates the danger of taking things too literally. The lightest pixels of this image can be found, if we magnify enough, in the shirts that some of the strolling people are wearing, or in the whitecaps of New York Harbor. These all measure around $13^C1^M9^Y$. The only reasonable alternatives, Lady Liberty's scroll and the brightest parts of the base, are significantly darker.

If you want to choose these white areas as the highlight, fine. That'll make for a snappier picture. It isn't the best approach, though. You need to ask yourself whether

those points are really significant enough that you would care if they were lost altogether. The danger of forcing a highlight into a point other than the lightest in the image is that anything lighter will zero out, leaving a blank area on the printed page. That's usually bad. If this were a studio portrait of a man wearing a business suit, for example, it wouldn't do to have blown-out areas in the shirt. Some kind of dot, however light, is needed to retain the sensation of a fabric.

But here, suppose that there's no dot at all in these tiny shirts and whitecaps? Do you care? I don't. They're inconsequential. Therefore, I'd go with a point in the second base, at $15^C2^M19^Y$. I prefer something relatively neutral to the statue's scroll, which might be green. My curves, however, weren't



totally dogmatic: they changed the values to $5^C 4^M 7^Y$, which is slightly brownish, more in keeping with the base.

- Speaking of neutrals, the only thing we can be sure of is that parts of the clouds are white. Not every part, to be sure: the sky is cyan or blue, and the clouds could be picking up some of that. But some part of the cloud has to be white. Right now, no part is. The typical value of the clouds on both sides of the statue is $45^C 10^M 25^Y$.

Summing up: the highlights measure as cyanish green. The clouds are greenish cyan. The shadows are cyanish blue. These three findings indicate a cast favoring the cold colors, hardly what we'd want on a sunny day like this one.

In the highlights, the magenta goes up; the cyan and yellow go down. This forces neutrality, grayness, into the clouds. The yellow goes up especially sharply on the right side, to neutralize the shadow.

A common problem beginners have is to look for “the” neutral point of the image. There may not be one. We don't force neutrality into anything unless we're prepared to bet the image that we're right.

The reverse of this error is to ignore other areas of known neutrality once “the” neutral point has been found. That's what needs to be avoided in our next image.

Figure 2.8 *The highlight and shadow in the original, above, are obvious. But how many points can you find that should definitely be neutral?*



One Neutral After Another

We may have to accept a bluish cast every once in a while, but a desert shot is not the place to do it.

The picture of the SUV in Figure 2.8 is typical of much automotive advertising today. The original doesn't look that bad, until one compares it to the bottom version.

There's no problem identifying highlight and shadow. The metal wheels are plainly the lightest significant part of the image. They are virtually guaranteed to be a neutral gray. In the original, the lightest area measures $4^C1^M2^Y$, very nice.

The darkest significant area is surely the car's underbody. Detail there is vague, but we don't want it to close up any more than it already has. My sample point indicates $77^C67^M70^Y71^K$.

These values are nearly perfect. Indeed, the corrected version doesn't have the big hike in contrast that we saw in the image of the horses. The color issue, however, is what derails the original, perfect highlight and shadow notwithstanding.

An engineer for the Ford Motor Company might have an advantage over the rest of us in this correction. She might know the exact shade of yellow of this vehicle and be able to use that as a reference.

The rest of us can't do that, nor can we state whether the canyon walls behind it are gray or reddish. We should, however, be ready to bet the image that California license plates are white. In the original, the plate reads $44^C29^M26^Y$. That isn't far from being neutral but it is

definitely on the cyan side, inappropriate for the heat of the desert. A true neutral might be something like $37^C30^M30^Y$. I'd be inclined to add a couple points more magenta and yellow for that warm feel, and have done so in the curves of Figure 2.9.

Therefore, some messing around with the quartertones in all three CMY channels is a good idea. But we shouldn't leave it at that. Just because we've found one neutral point doesn't mean the hunt is over.

The Ford engineer might know what color the bumper is. I suspect that it's gray but am not willing to bet the image on it, for the same reason that I won't bet the image that the lighter part of the taillight is neutral. Both might have bluish casts in real life.

Although I am no Ford engineer, I have great confidence in the supposition that tires are black. At the outset, they measure $69^C51^M50^Y15^K$. This is a lot further off neutral than the license plate was.

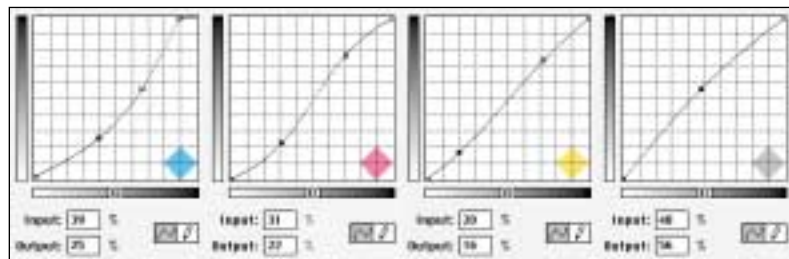
When the appropriate points are added to the three-quarter-tone area of the curve, the blue Saran Wrap comes off the picture.

What's Reliably Neutral?

It's not a big stretch to decide that tires or license plates or horses or marble statues are either neutral or very close to it. Sometimes, however, one has to surmise.

As with the SUV image, there's no trouble identifying the highlight and shadow

Figure 2.9 The curves that created the bottom version of Figure 2.8.





in Figure 2.10. A light cloud in the center of the sky starts out at $22^C11^M14^Y$. The base of the lower right cannon is the darkest significant part of the image at $77^C67^M70^Y64^K$.

In the bottom version, I corrected these in a way that is not recommendable, especially not in CMYK, but that some people find useful as they learn to work with curves.

In the bottom right of the Curves dialog box are three eyedroppers, representing highlight, shadow, and a real loose cannon, neutrality. By double-clicking on the highlight and shadow eyedroppers, one can enter the desired numbers for future reference. Then, with the highlight eyedropper active, click the appropriate point of the picture and repeat this process to select the shadow.

This creates four straight lines, rather than curves. The lower left and upper right endpoints of each curve are automatically moved in until the targets are reached.

The method is ugly, but the bottom version is much better than the top. It's more open, because the original's highlight was too dark and its shadow too light. Also, the bottom version has knocked out an annoying greenish feel. The original highlight value was cyan-green, not the neutral a light cloud should be.

Other than the highlight point itself, there isn't anything we can be

Figure 2.10 The highlight of the original, top, is too dark and too blue-green. The bottom image, done with straight-line curves, corrects this.

absolutely sure is neutral, but we have some suspects. In the original, as noted, the lightest part of the cloud was $22^{\text{C}}11^{\text{M}}14^{\text{Y}}$. Picking a slightly darker cloud in the lower right, I measured $40^{\text{C}}22^{\text{M}}18^{\text{Y}}$. An even darker one in the upper left corner of the image was $61^{\text{C}}40^{\text{M}}24^{\text{Y}}2^{\text{K}}$. The road was $48^{\text{C}}40^{\text{M}}45^{\text{Y}}2^{\text{K}}$ and the nearest cannon $64^{\text{C}}29^{\text{M}}44^{\text{Y}}3^{\text{K}}$.

The road starts almost neutral, but we have no reason to think that it has to stay that way: it could be brown or even yellow in real life. A purple road would be most weird, however. That's what we'd get if we forced the cannons to be neutral. So, I think we have to accept that the cannons are either made of weathered bronze or have been painted, and that their true color is somewhere between cyan and green.

Clouds are white in their lightest part. They get bluer as they get darker. This effect is indeed what is happening in the original, but the question has to be whether they are getting too blue too fast.

I think they probably are. As matters stand only the very lightest parts of the clouds are white. By dropping the quartertone points in the cyan and, to a lesser extent, the magenta, and adding to the yellow quartertone, the sky stays more neutral. The curves that do this and the final version are shown in Figure 2.11. One can now see that the bottom version of Figure 2.10 merely substituted a blue cast for a cyan one.

The Photographer's Intent

Everybody knows that when we're in a darkened room, our eyes adjust to the environment and become more sensitive. When somebody turns the light on suddenly, it dazzles us.

Not everybody realizes that the same thing takes place in color perception. Our brains want to reference everything to a

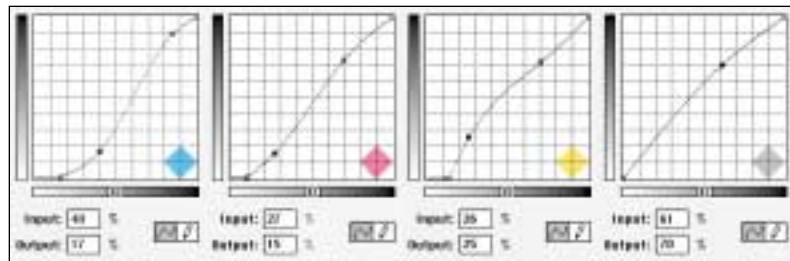
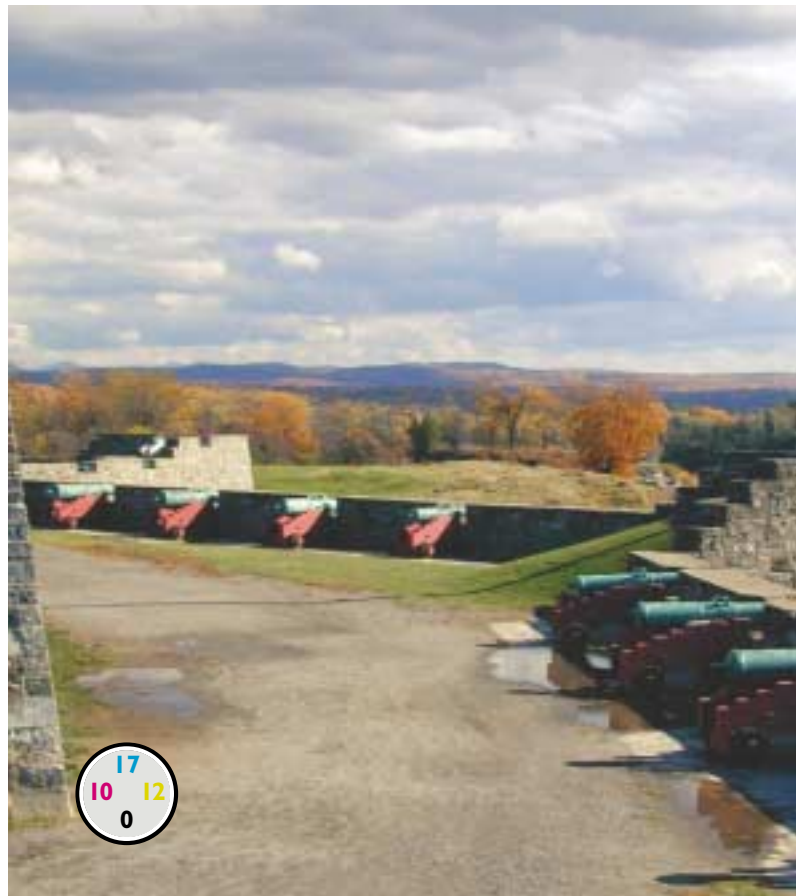
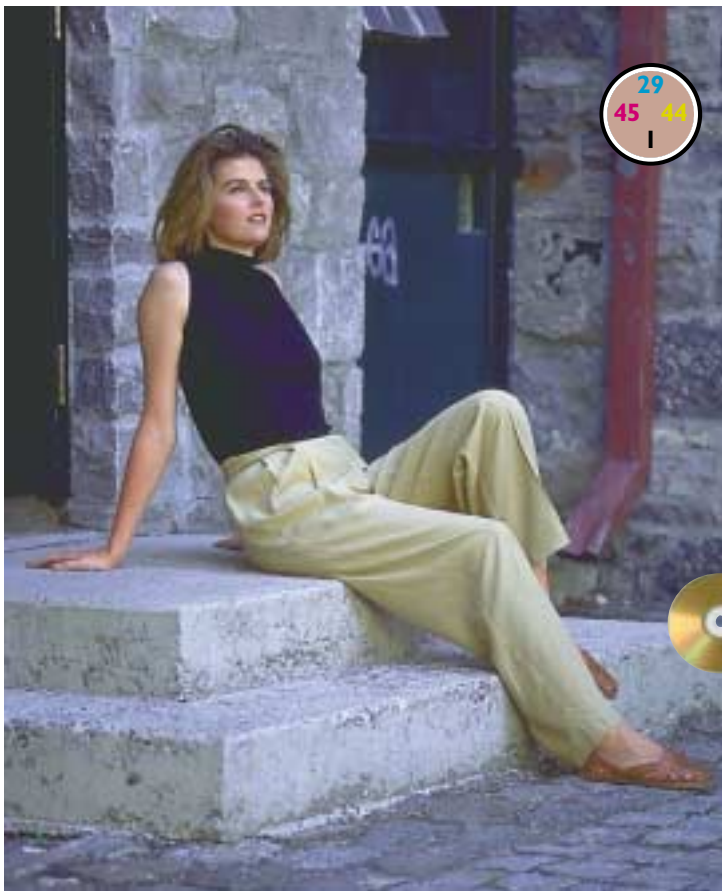


Figure 2.11 These curves, applied to the top version of Figure 2.10, produce the result below. Yellow is being forced into the sky as cyan and magenta are removed, keeping the clouds more neutral as they get darker.





neutral environment, so when we are flooded with light of one color, we compensate by making our eyes less sensitive to it—all unconsciously.

The quick summary of the last three images is that we followed our philosophy of correcting them to be more like what human observers would have seen had they been where the camera was. Humans ignore color casts. Cameras don't.

Perhaps you can think of a reason why the photographer might have wanted, for artistic reasons, the bluish feel of the original of Figure 2.10. I surely can't. Figure 2.12 might be something else again. The blue cast sets mood. I would like to think that the photographer did it on purpose.

But suppose that the decision is made that the cast is incorrect, that we are to do exactly what we did with the first two images of this chapter.

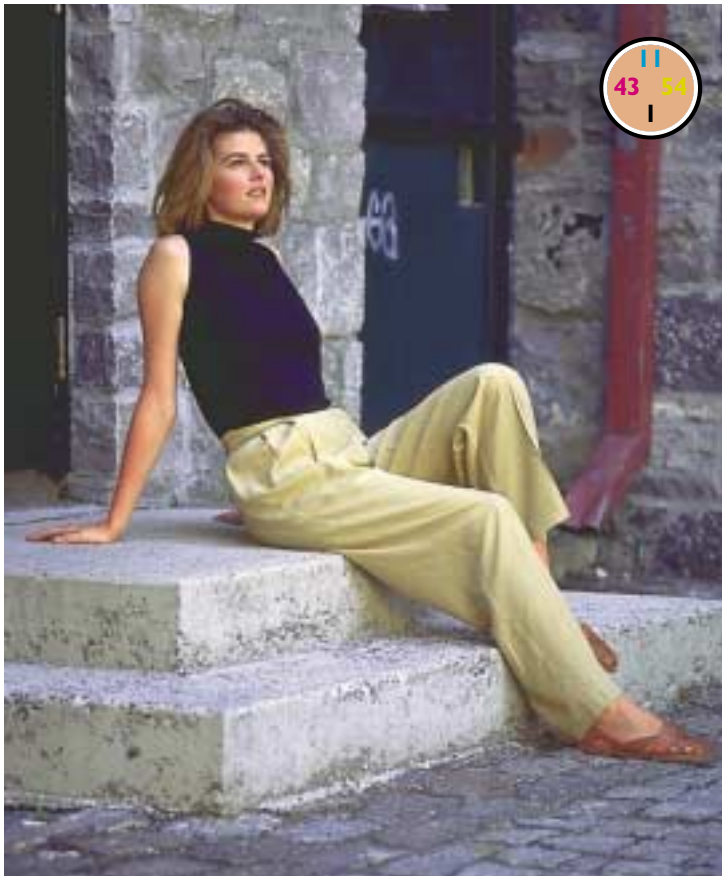
The analysis works the same way. Highlight? There isn't one. The pants are the lightest nonreflective thing in the image, and they aren't white.

Shadow? The black door to the left. Currently $81^C66^M68^Y68^K$, not bad.

Fleshtones? For sure. A typical value in the woman's arm is $29^C45^M44^Y1^K$. By the standards set out earlier, this is illegal, cyan being twice as high as it should be, and yellow being slightly low.

Neutrals? Yup, virtually everything that's made of stone. The front part of the first step reads $24^C9^M1^Y$, a heavy cyan cast, as if we didn't know.

Figure 2.12 In Figure 2.1, the cast was obviously undesirable. That isn't always the case. Is the blue cast above an aesthetic choice, or should we balance the image as at bottom?



What to do? That's easy. We have to blow away the cyan that contaminates the highlight. The yellow has to come up sharply in the lighter part of the image, and the magenta has to come down slightly, to get neutral stone. Note that both steps will also help correct the balance between magenta and yellow in the fleshtone. And the black plate is okay as is. These curves appear in Figure 2.13.

So, we now have an interesting blue cast version, and a nice-looking normally lit one. You can take your pick. But there's no need to limit yourself to these two choices. Using either layers or the Apply Image command, we can split the difference any way we like: 90–10, 50–50, whatever.

I am not a professional photographer myself, but I am given to understand by some of my friends who are that this business of shooting something with an intentional subtle cast is not as easy as a simian might think. If I were a photographer, and if I wanted the image to look more like the top half of Figure 2.12, I think I'd deliberately shoot the image too blue. Color-correcting a copy of it by the numbers and then blending the two versions together is a useful safety net to have.

And there's another plus for the curve-savvy photographer: certain difficult lighting conditions can now be ignored. For example, suppose you are shooting a hockey game. Odds are, you have to shoot through glass, which will donate a slight green cast to the image. For my money, it's a lot easier to apply curves in Photoshop later than to experiment with magenta filters.

Betting the Image

I use the horses image of Figure 2.1 in classes. Many students louse it up by misapplying the principles of this chapter. In their quest for known neutral colors, they assume that the building is one, and they force it to be gray.

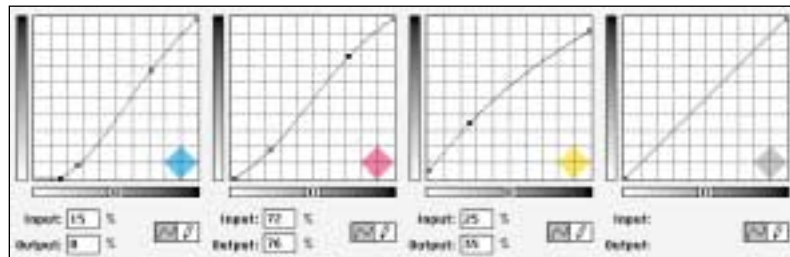
Readers from the New York City region will be familiar with the building's architectural material, which is indigenous to the area. It is called *brownstone*. We don't call it that because it's gray.

If we've never heard of brownstone, we should ask ourselves whether this building is really gray. The answer to that is yes—probably. Most such walls would be close to gray. But the next question is the big one: are we really ready to bet the image that we're right?

I'm not willing to bet that the building is neutral, but I am willing to risk the image that the horses are. I'll also gladly bet that the light parts of the flags are neutral and that the horses' blinders are too.

Figure 2.14 shows how to use—and misuse—the by-the-numbers method. At first glance it looks easier than any of the others, because there aren't known neutral colors, and the fleshtone areas are too small for us to get reliable measurements. It looks as though we can do nothing more than set highlight and shadow.

Figure 2.13 The curves used for the bottom version of Figure 2.12.



Fine. The highlight is obviously the back of the matador's collar, which starts out at a reasonable $6^C5^M2^Y$. The shadow, on grounds of significance, should be either the bull or the matador's hair in preference to

the background signs. The matador's hair is $64^C73^M98^Y43^K$. The bull's left shoulder is substantially darker, $81^C60^M80^Y62^K$.

That needn't be an obstacle. There's so little detail in the bull that we shouldn't worry about losing it by making it too dark. So let's suppose we choose the hair.



The bottom half of Figure 2.14 moves the collar to $5^C2^M2^Y$ and the hair to $80^C70^M70^Y70^K$. I guess it's better than the top version; there's more snap for sure. But it looks like something Ralph Viola might have done. Can you analyze why?

The bottom image looks much cooler. The dirt is gray, rather than the yellowish-brown of the original. This proves nothing. We've all seen gray dirt and we've all seen brown dirt. We can't bet the image that either one is correct.

But we've already placed a similar bet. The matador's hair might indeed be black. But the original $64^C73^M98^Y$ is a warm color, suggesting that the hair is really dark brown. Is that possible? I don't think we can bet the image against it.

I would be, however, prepared to bet the image that the bull isn't greenish yellow. That's what the original numbers say. Furthermore, although the color of the dirt is anybody's guess, the large letters in the sign at upper left are probably white or gray. I'm ready to bet the image that they aren't cyan, which is what happened in the bottom version of Figure 2.14.



Figure 2.14 The original, above, is flat. The corrected version, below, assumes that the highlight is in the matador's collar and the shadow in his hair. What do you think of the colors?



Stumbling Blocks: Misconceptions to Avoid

In learning color correction, everyone seems to have certain personal blind spots: the inability to grasp certain concepts that other people find clear. We've already alluded to a huge one: people who try to force things that should be approximately neutral to be absolutely neutral. Thanks to feedback from previous editions of this book, several chapters now include a box like this one, clarifying and restating points that some have found confusing. This chapter, unsurprisingly, is home to more such stumbling blocks than any other.

•**Overreliance on a single sampling point.** If the highlight, or whatever it is you're sampling, is so small that only one point can be measured, then you shouldn't be worrying about it at all. It's better to run the cursor over several adjacent values, or similar areas elsewhere in the image, before deciding that the one you've chosen is correct.

•**Making sure the highlights/shadows are significant.** If you don't care whether a certain light point is blown out or a certain dark point is totally plugged, choose different endpoints. You can maximize detail by choosing as highlight and shadow the lightest/darkest points in which you desire to hold detail, rather than the literally lightest and darkest points of the image.

•**The curve that can only be made one way.** If a point must be changed from, say, 70% to 80%, this does not require that one choose specifically the 70% point on the curve and raise it. Any curve that results in 70% becoming 80% is acceptable. Other shapes are often necessary.

•**The 70-80% CMY "limit."** Recommended shadow values of $80^C70^M70^Y$ don't mean that CMY inks can't be higher elsewhere. They're artificially low in shadows to stay within a total ink limit, usually 300% or so. A fire engine should be approximately $0^C100^M100^Y$, only 200% total ink as opposed to the 290% in the shadows.

•**Working in CMYK for RGB Output.** Nobody is advocating this, except in certain rare and complex cases. We use CMYK in these chapters because the principles are readily transferable to RGB, whereas the converse is not true. A professional today needs to be able to correct in either space, as well as LAB. Beginning in Chapter 8, the majority of correcting is *not* done in CMYK.

•**Originals with high black values in the shadows.** These often indicate files that were separated using too high a black ink limit. Forcing the CMY values to $80^C70^M70^Y$ in the shadows in such cases may cause problems. Either correct to a lighter CMY shadow or reparate the image using a proper setting.

•**My curves are not the gospel.** Quality results are impossible if the numbers are seriously off. But there are many ways to achieve the same or similar numbers. The way shown here is not guaranteed to be the best.

•**The magic fleshtone values.** The typical fleshtone values cited in this chapter are not target numbers for you to force all skin to match. Across all ethnicities, flesh can be light or dark. The relationship between the inks is what counts, not their exact values.

•**The power of positive guesswork.** The "by-the-numbers" philosophy looks for areas of known color, or where certain colors are inconceivable. Sometimes neither one is available. At such times, there is nothing to do but guess, based on feedback from the monitor.



Figure 2.15 A corrected version of Figure 2.14, using the bull as the shadow and maintaining neutrality in letters of the sign at top left.

Therefore, we balance the bull, not the hair. This may still be wrong: for all we know he's brown, not black. But it has to be better than leaving him yellow-green.

Figure 2.15 uses the bull for the shadow and deliberately maintains neutrality in the letters. There's also a little better contrast because, reasoning that the collar had no significant detail, I set a light highlight of 2^{C1M1Y} . ¡Olé!

Of Values and Judgments

We've now corrected half a dozen images in this chapter, with almost no "artistic" judgments. It was all numbers, numbers, numbers. There was no need even to use a color monitor. And every single change was made to the image as a whole.

In short, there is absolutely no reason that an orangutan could not get these results, once he got the hang of curves. Years of retouching experience, artistic

talent, and mathematical aptitude wouldn't hurt him, but they're not really needed.

Notice how these adjustments tend to help areas of the image that we never even thought about. Things like the reddish rock of the canyon, the flags behind the horse, the road in front of the fort, and the matador's cape.

Artists who worry their images to death tend to see such shortcomings immediately and plunge happily and vigorously into a morass of individual moves. They sponge out the flags and select the horses; they isolate the Statue of

Liberty and work on it; they apply Selective Color to the cape, and after eight hours or so of labor they have 12 layers, 18 extra channels, an 800-megabyte file, and an image that's not as good as what the curvewriting orangutan would have gotten in seconds.

Neutralizing our artistic judgment along with the color casts gave us images that came out much better than the originals—yet not as good as they might have been.

Determining that the horses are more important than the building, or that the statue is more important than the sky, are the kinds of logical decisions that are too difficult for either apes or calibrationists. In the next chapter, we will exploit our superior intellect, and with a combination of good numbers and curves that improve contrast in the critical areas of the image, we'll get the color correction monkey off our backs forever.



COLOR CORRECTION BY THE NUMBERS

- ✓ For 90 percent of the correction work we face, the rules can be stated in one sentence: Use the full range of available tones every time, and don't give the viewers any colors that they will know better than to believe.
- ✓ In each uncorrected image, we must find the highlight—the lightest white with detail—if there is one. Also, we must find the darkest area, or shadow. We will use curves to move these areas to the minimum and maximum values we expect to be able to hold detail with on press. Absent specific information to use different numbers, use $5^C2^M2^Y$ for highlight and $80^C70^M70^Y70^K$ for shadow.
- ✓ In choosing a highlight, speculars, meaning areas that are reflecting light or portraying a light source, should be ignored. Values of zero are acceptable for them. Similarly, dark areas without important detail can be allowed to print heavier than the recommended shadow values.
- ✓ Most pictures have some colors that are known to the viewer. The known colors are generally either fleshtones or areas that must logically be neutral.
- ✓ Neutral colors, of which there are plenty in nature, should have equal amounts of magenta and yellow, and slightly more cyan. The amount of black, if any, is irrelevant. If there is a slight cast, viewers prefer it to be a warm-color imbalance; if you must depart from this formula, a reddish gray may be better.
- ✓ The best highlight isn't necessarily the literal lightest nonspecular. Ask yourself: do I care if all detail in this area vanishes and it prints without a dot? If you don't care, choose some other point to be the highlight.
- ✓ Except in small children and other very light-skinned persons, yellow is always higher than magenta in fleshtones. Cyan is always at least a fifth of the magenta value. As skin tone gets darker, these imbalances increase. A dark-skinned individual may have a third more yellow than magenta, and cyan a third the strength of the magenta.
- ✓ Do not be seduced into a local selection of an area where the color is obviously wrong. Whatever is causing the undesirable color is also doing it in the rest of the picture, but it may not be apparent. Applying correction globally will often create overall improvements that you might not anticipate.