BY MIKE WOOD

How bright is bright

HOW BRIGHT IS BRIGHT? We studiously examine the light output figures for lighting fixtures trying to determine if 10,000 lumens is enough for this or if fixture A is better than fixture B because it has 20 more footcandles at 25 feet. In fact, the ESTA Technical Standards Program publishes ANSI standards describing ways of measuring all these values. But how do these figures actually relate to the real world and your eyes? What do you see as bright?

Of course, this is a trick question (no fun in writing an article about it otherwise!). Light output and brightness are difficult parameters to measure scientifically as they are not absolute values but always have to be related back to how the human eye behaves. Most physical values are well defined—a volt is a volt, a second is a second, and a kilogram is a kilogram. It doesn't matter who's measuring them or how, you should always get the same answer.

The photometric measurement of light on the other hand is as much statistical as it is physical. All the common measurements and units we use daily such as footcandles, lumens, lux, candela, etc. are based on statistical tests of many different people to come up with what the "standard observer" with "standard vision" would see.

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(Note: there are absolute ways of measuring light too—that is radiometric measurement rather than photometric and uses familiar units such as watts rather than lumens. It's the only way to do it when trying to measure light that a human can not see such as ultraviolet or infra-red.)

Thus our fundamental measurement of light depends on one big assumption, that what you see and what I see are the same. People differ in so many ways that it isn't at all obvious that this should be the case. Fortunately many tests have established that, within reasonable statistical errors, you can reliably and repeatedly measure and define a response curve for the standard human eye. *(Note the word human; other animals see the world and light very differently from us. A lumen for a cat or dog would likely be very different from the human one.)* If we accept all these statistics then it seems reasonable that if I see something as red and bright then so will you.

"So what's the problem?" you may ask. "That's the main hurdle climbed. If everyone sees essentially the same way then can't we conclude that 100 footcandles looks the same everywhere?"

Unfortunately the answer is still a resounding NO!

Perception is the key.

The photometric system of measurement and the standard observer curve is only the beginning of the story. These statistical tests are all done in dark rooms in highly controlled conditions. The real world is a whole lot more complicated and those observation conditions make a significant difference to our perception.

Perception—that's the key word—as we said at the beginning of this article, our vision system is by no means an absolute, precise measuring instrument. Rather it's an incredibly flexible system which is continually adjusting to give you the best view at any moment. Just consider what it has to deal with—you walk out from a dimly lit theatre into a street with full sunlight and your vision copes, you drive along a road where the sun keeps appearing and disappearing behind buildings as you go in and out of shadows and your vision copes, you look at someone who is heavily backlit standing in front of a sunlit window and your vision copes. Most of the time you do not even notice the huge changes in illumination your eyes deal with all the time, but try any of these scenarios with a camera and it will fail miserably. Overexposed, underexposed, blurred streaky images….

The range of illumination we can see well in is huge—something like 10 million to one—in photographic terms that's a range of about 24 f-stops! However, more importantly for the subject at hand, at any moment when viewing a single scene we can distinguish a contrast range of somewhere between 10,000:1 and 100,000:1. *(To put that in perspective most cameras are capable of not much better than 100:1 while a high quality HD video camera with a top quality prime lens might make 1,000:1 on a good day.)* This is a hint to where we are going and is really the key point of this whole article: **The human eye sees contrast differences not absolute values.**

If you come away from reading this article retaining just this one piece of information then I consider it worthwhile. This is incredibly important but non-intuitive and is something that, as lighting practitioners, we should fully understand and utilize. Our vision processing system is set-up to see contrast differences rather than flat lighting levels. The combination of eye and brain is always looking for edges and changes while ignoring areas of flat illumination or low contrast. In fact a lot of the time the brain does not even bother analyzing the data from flat areas and makes assumptions about what is there, filling in the blanks with a logical guess as to the contents.

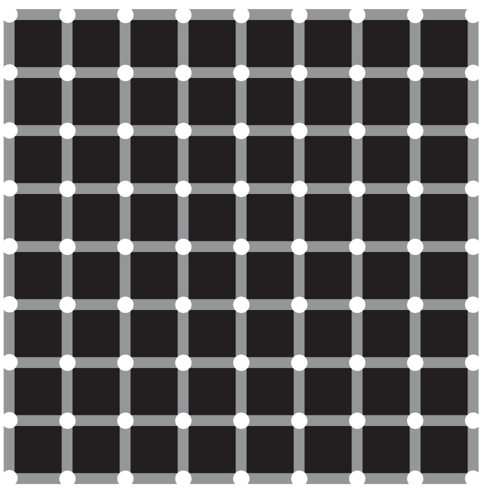

Figure 1

Figure 1 is an example of this process—look at the regular pattern of squares. You can probably see small black dots in the intersections which disappear when you try and look at them. They are not there at all of course—your vision system sees the black grid and the high contrast edges between the squares and the small white circles. It does not bother with looking in the circles and, instead, makes an assumption about what must be inside them. In this case we have fooled the brain and it fills them in with the wrong color. As soon as you look directly at one and bring it into the high processing area in the center of your vision the brain realizes the error and corrects.

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Another example, very relevant to lighting, is **Figure 2.** Stare fixedly at the black dot in the center of the image for at least ten seconds and you will see the rest of the image slowly fade away. The graded grey image does not change in contrast quickly enough to stimulate the eye's edge receptors so the brain gets bored with it as unimportant and just ignores it.

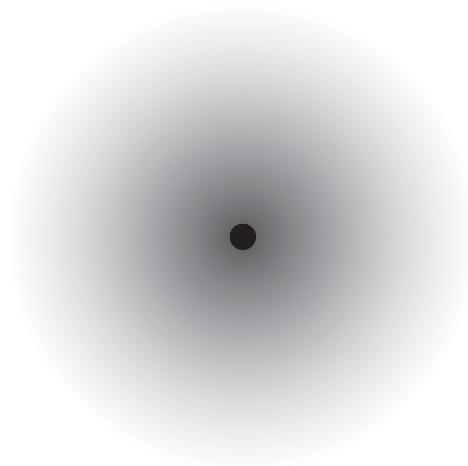

Figure 2

Introduce different backgrounds and the situation can get even more interesting. Our vision system makes contrast and brightness decisions based on the *entire* image it sees. It does not do spot measurements like a light meter does. Consequently it can be very difficult to judge the brightness in one part of a view. Everything you can see will influence your perception. **Figure 3** is a well-known optical illusion that relies on this simultaneous contrast effect. As you probably guessed the two sets of mid-grey bars in this image are exactly the same grey. Look at the whole image

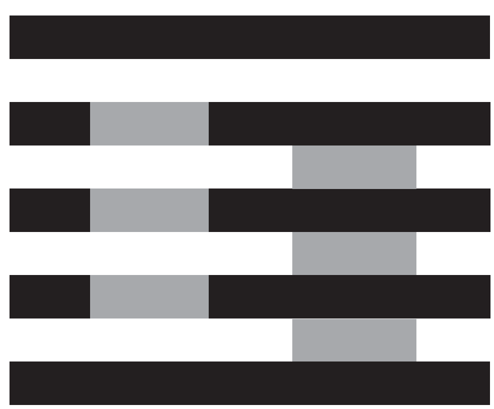

Figure 3

and the set on the left look significantly brighter. The eye has found the edges, evaluated the average contrast ratio of the scene and then makes judgments on flat brightness based on that. Now try covering up the right half of the image and just look at the left half for a few seconds, then switch and just look at the right half. Give your eye a few seconds to adjust each time. I think you will find, even though you are comparing them in memory, that the grey bars look much more similar this time. You are not getting confused by the whole scene.

What's this got to do with lighting?

Think of this in lighting terms—when you are looking at a stage that is brightly lit in some areas and darker in others with varying contrast scenery then the same thing is going to happen. You will be making incorrect judgments about what is bright and what is not.

Figure 4

One final example for this issue—**Figure 4** shows a similar effect but this time with a gradually changing background. This is something that we often see in real life, a wall or back cloth lit from one side or a cyc lit from the top will have a brightness profile very like the graded grey background. Now look at the grey rectangles—they all look different but are, of course, all exactly the same. If those were a row of people you just lit in front of that backcloth or cyc you would have a hard time judging when they were all evenly illuminated. In fact you would likely light the darker looking one on the left to a higher level than the one on the right to compensate. As long as you were lighting it for an audience who had much the same view as you then this would not matter—they would all see the scene the same way you did. The problem comes if some of your audience is viewing from a different position and does not see the same backing or, even worse, there are video cameras. Unfortunately (or fortunately depending on your point of view) video cameras will not see this in the same way—they are absolute devices where a lumen is a lumen and that's the end of it, so to a video camera all those grey rectangles would look the same.

As a final intangible when that same video image gets shown on a TV screen in someone's home and they view a long shot then the perception issues appear all over again; only this time exacerbated by however their room is lit—remember that the eye judges brightness by the whole view. What looks fine in close up may look all wrong in a long shot where the backing contrast comes into play.

This issue we have looked at some of the concerns with the human vision system and judging brightness and contrast. Next time we will try and apply this to lights and lighting to see if knowing how our own vision works can help us evaluate lighting. Later in this series we will look at color—which complicates things even more! ■

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