

Mysteries of Photography #7: Why 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, etc.?

I am certain you recognise this number series. Back when dinosaurs (and rangefinder and DSLR cameras) roamed the land, the barrels of your camera lenses would have been marked with f-stops marked with these numbers. Now these numbers still show in the digital viewfinders as we decide our exposure settings on our digital cameras even though most current lens do not have any aperture markings whatsoever.

Have you ever wondered why these numbers and not something sensible like 1, 2, 3, 4, etc.?

Also, why do the numbers get bigger as the aperture gets smaller?

These are usually (and correctly) shown as “f/” (e.g. f/2, f/4, etc.), being the relative light collected by a lens corrected for the focal length where “f” refers to the focal length (see Mysteries #6).



Now let's focus on our number series. Firstly, it is easiest to think of it as starting at 1 (i.e. 1, 1.4, 2, 2.8, 4, 5.6, 8, etc.). These f-stops give us a series of (more or less) equal steps in EV (exposure values) as our eye/brain combination perceives light intensity. Why and how can 1 to 1.4 and 1.4 to 2 give equal steps not to mention 5.6 to 8, etc.?

If we think back to the city of Bradford, England, in 1930, some 30 or so stolid Yorkshiremen (and zero women!) participated in what has become the definitive study in human light and colour perception. On this foundation the whole massive edifice of colour reproduction rests. (Ever heard the expression about building your house on sand?)

They found that to human perception, for what appeared to us to be equal steps in light intensity, the amount of light actually increased by a factor 2.2.

To see what this means for our ability to see in a wide variation of light levels, let's take a series of eight numbers starting at 1 *simplifying it by using a factor of 2 instead of 2.2*. If each successive number is double the previous (approximately mimicking our visual apparatus), we get 1, 2, 4, 8, 16, 32, 64, 128. Do this for series of 14 numbers and we are over 16,000.

In fact, I have been told by a highly reputable source that the range of human perception covers approximately 14 EV (about 16,000x difference between completely black to completely washed out). Our visual apparatus responding like this to different light intensities and thus enables us to discern visual details over a very wide range of luminosity.

Now while we should be factoring with 2.2 for every step in EV if we wanted to be completely accurate in modelling human perception, we instead simplified it by using 2 and this simplification is what is used in camera construction.

Let's bring it back to f-numbers and see what this looks like visually with this Wikipedia illustration (above) of the aperture of a lens set to different f-numbers with the **area** of each differing by a factor of **2** from the next in the series.

Ok, we are mimicking the progression in human perception but where do the actual values of the f-numbers come from?

Remember aperture is a measure of diameter of the lens aperture. Diameter is twice the radius of circle. The area of a circle is π multiplied by the radius squared ($\pi \times r^2$). Hence with the standard f-numbers, to obtain the next number in the series we multiply by the square root of 2 (approximated to 1.4).

So this is where the series of f-numbers 1.4, 2, 2.8, 4, 5.6, 8, 11, 16 come from. Nothing strange, mysterious or arbitrary at all about it.

I can see that, with most of you, your eyes have glazed over. Entirely understandable. But don't worry, the take home message is simple:

- 1) Your camera is set to use steps in exposure (or Exposure Values) that approximate to the way our eyes (or more correctly *our brains*) perceive light.
- 2) It is comprises a series of approximations (on top of approximations) but it works well enough.

In practical terms, you have probably gained nothing from reading and/or understanding this article but, just in case you ever wondered about the reason for the standard progression of f-numbers, you can now explain it when someone asks (especially if you want to bore them to tears).

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