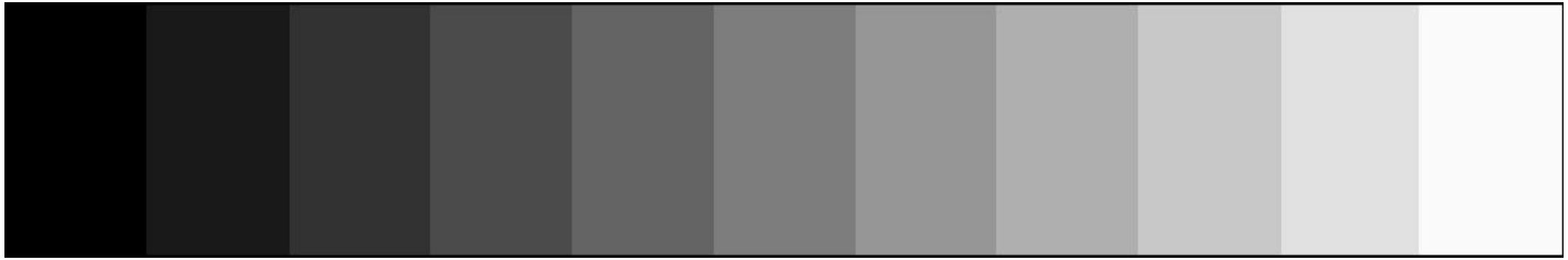
Understanding F-stops

our eyes and our photographic materials

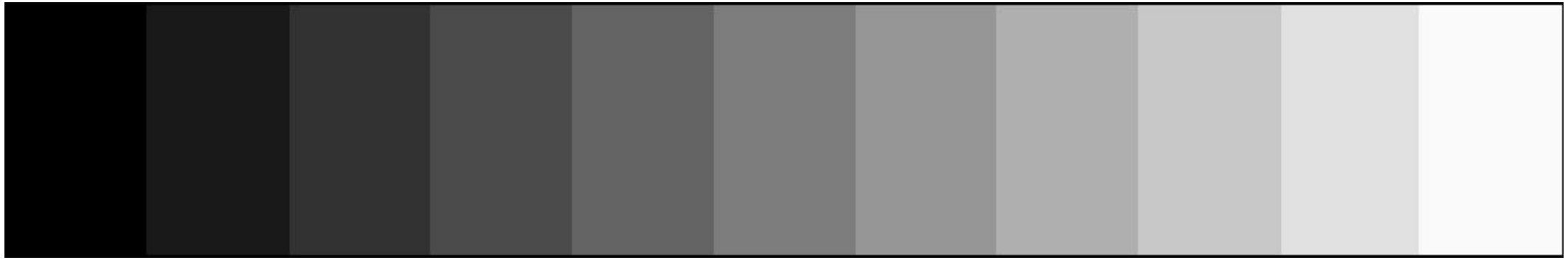
Ken Reek

A gray scale



Our eyes perceive this as uniform increases in brightness from each step to the next.

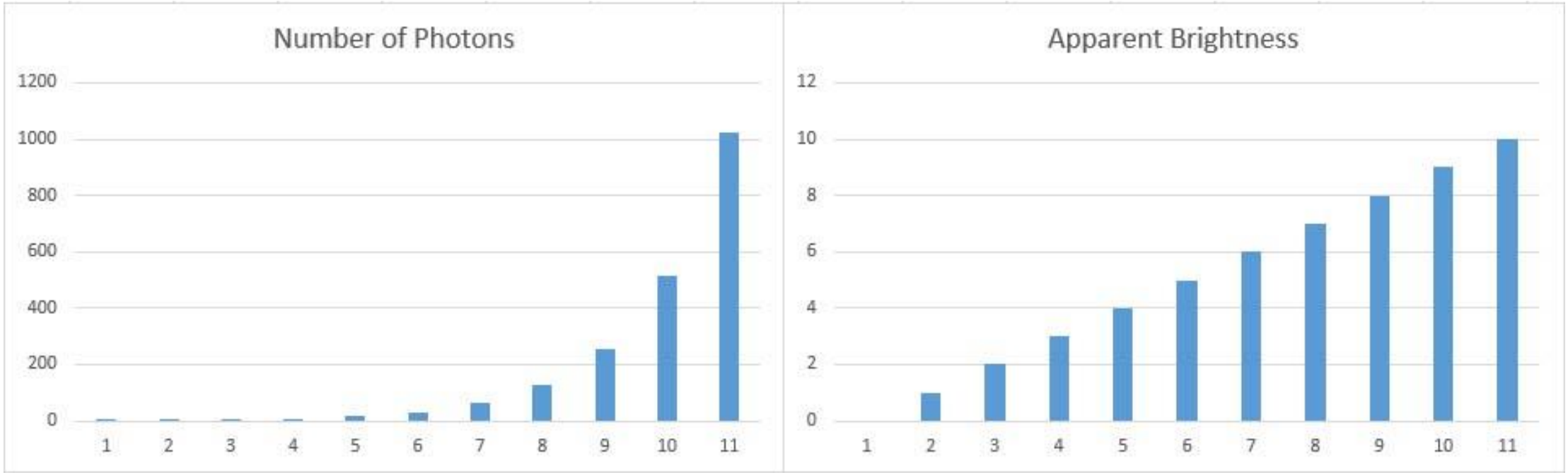
A gray scale



Our eyes perceive this as uniform increases in brightness from each step to the next.

- However, there are twice as many photons coming from each step compared to the previous step.
- Our eyes respond *logarithmically* to the photons.

Multiplicative changes (e.g. *doubling*) in the number of photons appear to us as *linear* increases (e.g. *uniform steps*) in brightness.



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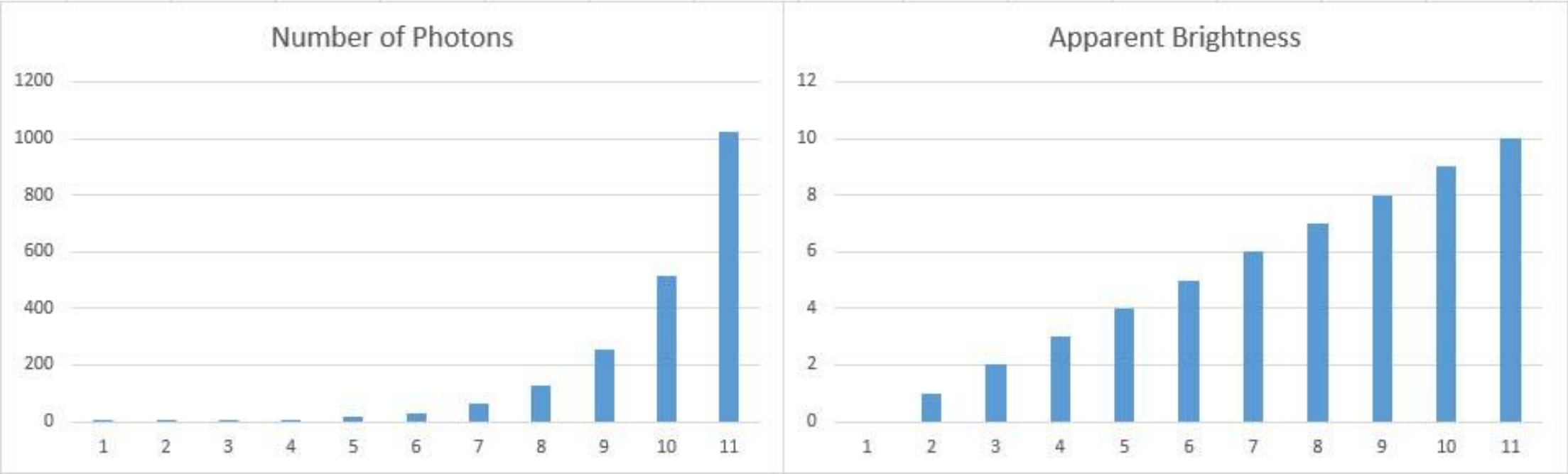


Photographic film responds to light the same way our eyes do:

- Doubling the amount of light that reaches the film produces what appear to us as linear increases in the brightness of the image.

The sensors in digital cameras count photons! They are inherently linear (not logarithmic).

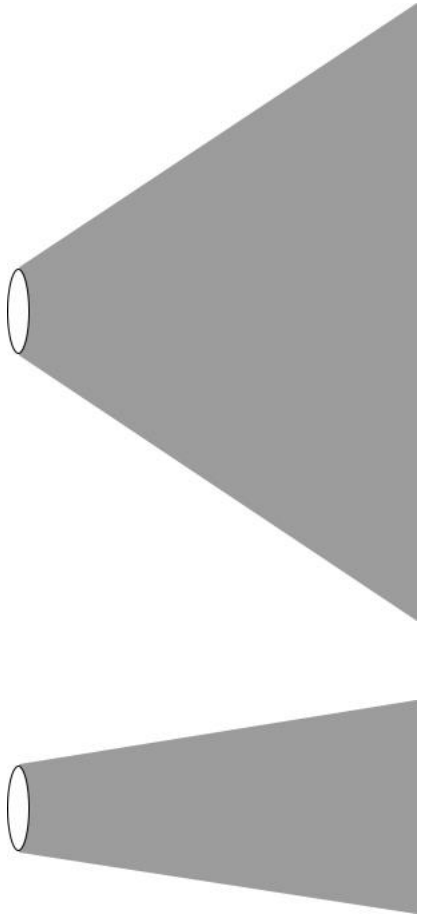
Therefore:

- The camera must process this linear data so that it appears the way we expect to see it.
- This processing is done when the image is converted to JPEG format.
- Shooting in RAW preserves all the original data from the sensor.
- Manipulating a RAW image in an image editing program gives you more possibilities in how you can change the photograph.

So where did these crazy f-stop numbers come from?

A wide angle lens sees a much larger field of view than a telephoto lens.

- There is more light coming from the wider field of view than from the narrower field.
- For a lens opening of any specific diameter, the wide angle lens will let in more light than the telephoto lens.
- If we were to measure lens openings in inches or millimeters, this would not directly relate to how much light is coming through the lens.



Instead, we measure the size of the opening in the lens as a ratio of its diameter to the focal length of the lens.

Technically, an f-stop is stated as a ratio, for example *f*/8, where *f* stands for the focal length of the lens.

- For a 50 mm lens, *f*/8 is an opening whose diameter is 6.25 mm.
- For a 200 mm lens, *f*/8 is an opening whose diameter is 25 mm.

This method compensates for the different amounts of light that each lens will gather.

1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, 45, 64

So why these particular numbers?

- F-stops are designed so that each lets in twice as much light—or half as much light—as its neighbors.
- The amount of light is determined by the area of the opening in the iris.
- The area of a circle is given by $Area = \pi R^2$ (where R is the radius).

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- The area of a circle is given by $Area = \pi R^2$ (where R is the radius).
- To double the area of a circle, its radius must be increased by $\sqrt{2}$ (about 1.4).
- So each number in the sequence is $\sqrt{2}$ times the previous number (and then rounded off a little bit).

Now you know!