Conundrum

The dark shade of the moon

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Sivaprasad and Saleh seem to suggest that we misperceive the moon as white because contemplation of the skies is not what we evolved for. The latter claim is true, of course. For example, the sun and the moon look much the same size to us; yet the sun is 400 times as far away and 400 times as large as the moon, and by the rules of size constancy should appear as such. The reason why it does not is that we have no way to judge the relative distances of celestial bodies: it was earthly, not astronomical lengths that shaped our visual system.

This argument has no bearing on the perceived colour of the moon, though, as proven by an experiment conducted nearly 80 years ago.[1] In 1929, Adhemar Gelb suspended a disc of black paper in a darkened room, and illuminated it with a projector (a 'sun'). Exactly as the moon in nighttime, the disc appeared white. The fact that it was actually black became evident only when a larger surface of higher luminance, such as a sheet of white paper, was brought into the beam of light and placed behind the black disc. But as soon as the white paper was taken away the black surface went precipitously back to white, demonstrating that perception was impermeable to the knowledge of the 'real' colour of the disc.

The Gelb effect shows, as later experiments have confirmed,[2] that the highest luminance in a scene appears white. It follows that the moon looks white simply because it is the brightest region in the nocturnal sky. On earth, samples of moon rocks and dust look dark because the scene context has shifted – not from evolutionarily unnatural to natural, but from the dim surroundings to an ample range of luminances, some of which are higher than those of the moon pieces themselves.

The perceived shade of the moon changes very much depending on whether the moon is up there or down here, but is also affected more subtly by skylight and lunar altitude. A moon rising before sunset, when the sky is still quite bright, can be so faint that it is even difficult to detect. Besides, moonlight passes through nearly 40 times as much atmosphere at the horizon as it does at zenith, and for this reason moon luminance increases rapidly with altitude, from 2 cd/m^2 up to over 4000.[3] Accordingly, the moon can appear off-white, white, fluorescent, or luminous – variations that are not predicted by Retinex theory.

Both the colour and the mutable appearance of the moon are explained well by models based on luminance anchoring within a visual scene, such as the double-anchoring model of lightness.[4,5] In this model, the shade of grey (technically, the 'lightness') of any given region is computed by taking a weighted average of the ratios of the region's luminance to two 'anchors': the surround luminance and the highest luminance in the scene. Such anchors are both given a default value of white. As the brightest object in the night sky, at the highest-luminance anchoring stage the moon is always perceptually white, whatever its actual luminance. However, at the surround anchoring stage, it is lighter than white (and thereby perceptually glowing), and the extent of this component depends on the moon's luminance ratio to the surrounding sky. From the standpoint of anchoring models of lightness, the shade of the moon is a spectacular, but otherwise predictable, instance of the general principle that the achromatic colour of objects results from luminance anchoring within the visual scene.

References

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