Why is blue tinted backlight better?

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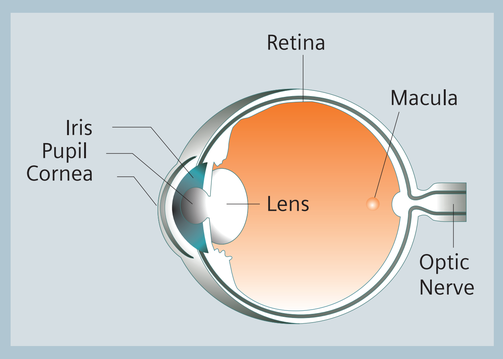
Introduction

Purpose is to explain the well-known property: blue images always look sharper than white images to the user, even if, objectively, the measurements are the same. For more than 100 years, lighting users have often found that their sense of brightness does not match with light meter values. Areas lit by lighting with bluish tint appear brighter than the same areas lit by lighting with more of an orange or reddish tint even though a light meter may indicate the opposite.
Recent scientific research can explain this feature, based on the eye's physiology. First, some pre-requisites from the visual system behavior are described. Then, the optimal viewing condition, especially for diagnosis, is explained. Finally, both information are used to explain why a blue tinted display offers accuracy and comfort advantages to its user.

1 – Eye Physiology

The retina, a light-sensitive membrane at the back of the eye, contains photoreceptors, called cones and rods (see fig. 1).



Photosensors performances

The rods are more numerous, some 120 million, and are more sensitive than the cones. They are incredibly efficient photoreceptors, adapted for the dark surrounding (scotopic vision). E.g. they can be triggered by individual photons under optimal conditions.
As a result, they allow for the ability to distinguish 2 kinds of dark gray levels for instance. When active, a better contrast resolution is achieved. Furthermore, they are better motion sensors than the cones.

The Fovea Centralis, center of the eye's sharpest vision, exclusively contains cones (see fig.2). That is why the cones visual resolution is much better.
Another reason is that the cone cells are connected to one ganglion cell only, whereas several rod cells are connected to one ganglion cell. The rods provide the resolution of details.

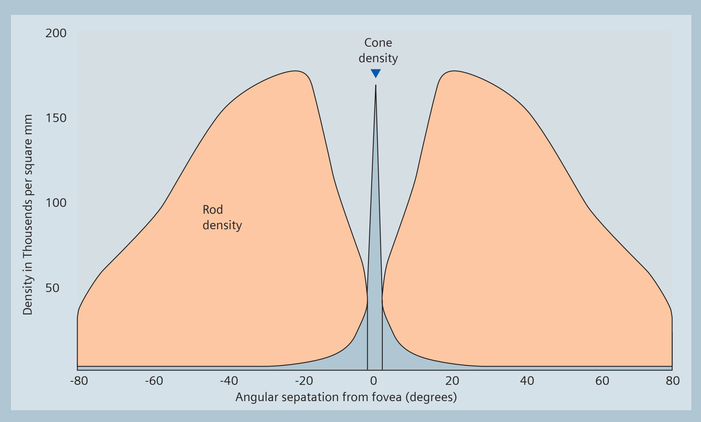


Fig. 2. Cones and rods repartitions, apart from the fovea.

Photosensors & blue light response

The cones can be divided into "red" (64%), "green" (32%), and "blue" cones (2%) based on measured response curves. They provide the eye's color sensitivity. (see fig. 3 (b)). The blue sensitivity of our final visual perception is at least comparable (and is even better) to that of red and green, suggesting that there is a somewhat selective "blue amplifier" somewhere in the visual processing in the brain.

As far as the rods are concerned, the light response of the rods peaks sharply in the blue. The rod sensitivity is shifted toward shorter wavelengths (507 nm) compared to daylight vision. (see fig. 3 (a)). For rod-dominated dark-adapted vision (scotopic vision), the rods response has a unique peak in the blue range.

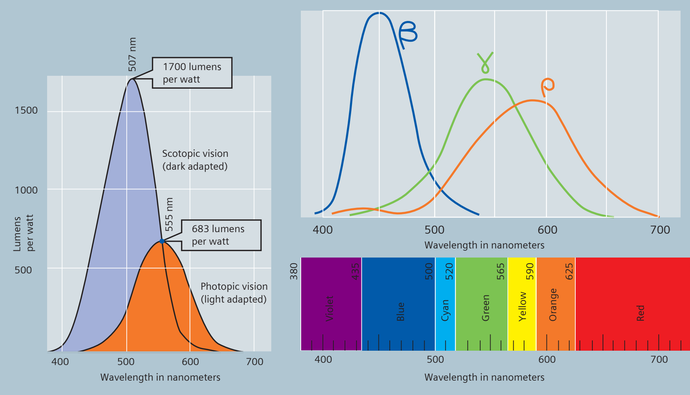


Fig. 3. Sensitivity curves: a) depending on the ambient condition (dark surrounding or not); b) Cones sensitivity curves for red, green and blue cones. c) wavelength scale.

Active in dark surrounding, rods improve the contrast resolution. Their response curve has a unique peak in the blue range. The cones permits the resolution of details and are responsible for day vision.

2 – Diagnostic Conditions: How does the Eye work?

Three vision types

- Scotopic vision, or vision "in the dark" (< 0.034 cd/m²): the eye uses rods to sense light. Since there is a single absorption maximum at a wavelength of 507 nm, the scotopic vision is color blind.
- Photopic vision: under normal lighting conditions, during the day (> 3.4 cd/m ² the cones are active.
- Mesopic vision is a combination between photopic vision and scotopic vision in low, but not quite dark, lighting situations (between 0.034 cd/m² & 3.4 cd/m²).

Fig. 4. repartition of the 3 vision types.

Consequences in medical viewing conditions

At interior light levels (mesopic vision), the rods are not disabled and are functioning quite well. They contribute to the perception of the brightness.

These findings correspond to the viewing conditions that are used in medical reading rooms or diagnostic rooms. For medical image reading, both photosensors, the rods and the cones, are active and combine their properties as far as how the image is perceived. They combine their performances and their sensitivity curves.

3 – Advantages of blue tinted backlight

More efficency

The combination of the higher total sensitivity of the rods for the blue range with the color perception through the cones results in a very strong appearance of bluish colors.

Reduce eye fatigue and lens error

The activation of the rods at typical interior light levels not only allows a better eye performance, but also permits reduction of visual fatigue.
The eyes automatically adapts (accommodates) in order to bring the viewed objects into focus: the shape of the lens is adjusted in order to bring the desired light rays into focus.
If the pupil of the eye gets smaller (muscle iris is strengthen), the net amount of accommodative work is reduced.
The most efficient way of achieving a smaller pupil, that is to say to reduce the eye's work and therefore eye fatigue, is to have the rods activated.
Furthermore, the iris reacts more to blue light and closes therefore better and faster. The "lens error" decreases if the pupil size decreases (the eye acts as a convergent lens). As a result, less lens error is achieved and so a sharper image is printed on the retina.

Conclusion

To have the ....

Optimal viewing conditions

- **Cones for details resolution**
- **Rods for contrast resolution**
  For less eye fatigue
  For fast/motion image adequate

Both sensors (rods and cones) have to be active

Rods & Cones are active

This happens **At interior light levels = best working conditions**

The total sensitivity is then a function of the cones' sensitivity curve and the rods' sensitivity curve.

Because the **Rods are blue-sensitive, only**

The highest total sensitivity is achieved when the eye is excited in the blue range.

The sensation of brightness is enhanced with the bluish light. Bluish pictures improve the efficiency of the viewing system, and the viewer's eye comfort (less eye strain)
This can be achieved with

Blue tinted backlight on Displays

Visual systems properties can be used in an optimized way:

- adapt the emission of your display system to work in the mesopic surrounding (dimmed environment)
- then your eyes will use both photosensors simultaneously which will provide
  - better contrast resolution (rods)
  - more detailed resolution (cones); and
  - more effective diagnostic ability

References

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