THE CONNOLUX STUDIO LAMP

Designed specifically for conservation and museum professionals, The Connolux Studio Lamp provides optimum illumination for a broad range of activities, including examination of artworks and museum collections, conservation treatment, photography, and other related tasks.

The Connolux Studio Lamp has exceptional color appearance and accuracy, making it ideal for use when inpainting. The color temperature of the light source is 3950 K (±75 K), which can be adjusted with filters to emulate different exhibition lighting conditions. This informational document explains *why* this is the ideal color temperature range for inpainting, and how this neutral light source minimizes the problems of metamerism and low color contrast.

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ILLUMINATION FOR INPAINTING: SELECTING AN APPROPRIATE COLOR TEMPERATURE

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When inpainting, it is important to use a source of illumination that allows the conservator to distinguish very fine differences in appearance when matching colors. The challenge is to match colors so that they appear the same across a broad range of lighting conditions.

METAMERISM AND MISMATCHED COLORS

North light is the preferred source for many conservators. North light has a very high color temperature and appears very cool (typically 8000-12000 K). In contrast, many museums and galleries use very warm (2700-3000 K) light sources, such as halogen lamps or warm LEDs. As a result, a color match completed at a high color temperature may not match at a low color temperature. As Sarah Staniforth noted, "the matching of blue pigments has proved to be particularly difficult" under such circumstances.[1]

Metamerism is the term used to describe the phenomenon observed when colors with different spectral reflectance curves match under one type of illumination source, but do not match under other illumination conditions.

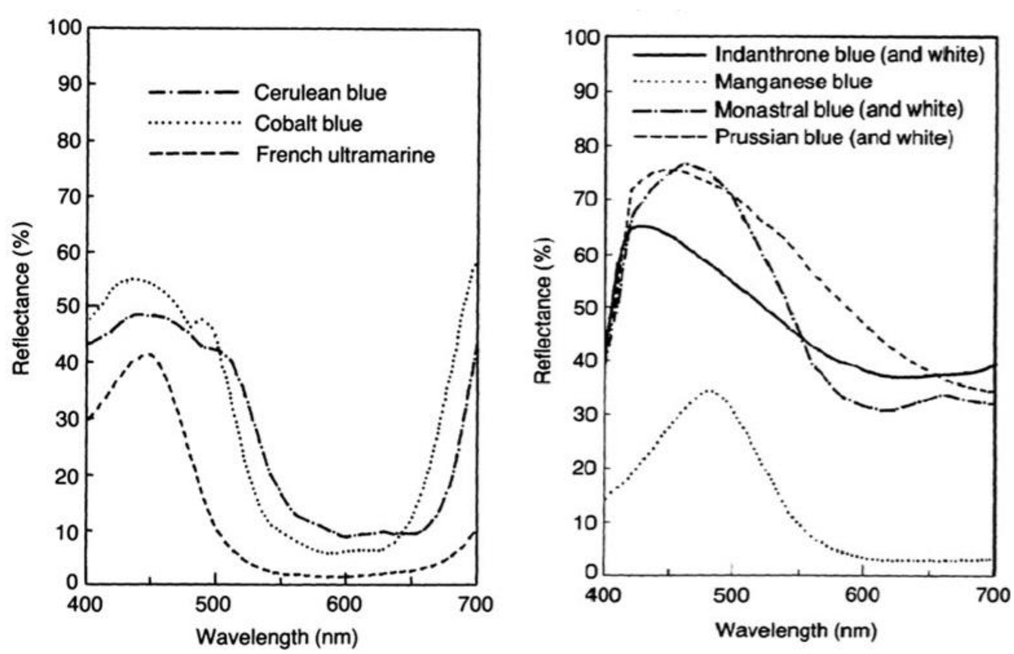

Fig. B.1. Spectral Reflectance Curves of blue pigments with high red reflectance (*left*) and low red reflectance (*right*) properties. As illustrated in Staniforth 1985 (Figs. 4a, b).[1]

The problem of metamerism is demonstrated by the spectral reflectance curves of different blue colorants (Fig. B.1.). At a high color temperature, it may be possible to match a pigment with a high red reflectance (e.g. Cobalt blue) using a blue pigment with a low red reflectance. Since the high color temperature source has a low proportion of red-to-blue radiation, the red portion of Cobalt blue is not evident, so the colors will match. At a low color temperature, the warmer light with a high proportion of red-to-blue will bring out the red quality of Cobalt blue and the colors will not match.

The best method to avoid metamerism is to use inpainting pigments with reflectance values similar to the original pigments used in the artwork. The selection of a light source that does not over-emphasize or under-emphasize spectral reflectance properties is likewise critical. High and low color temperature sources are problematic because they accentuate one part of the spectrum over another.

COLOR INCONSTANCY AND MISMATCHED COLORS

In his book, *Color Vision and the Visual Arts*,[2] Roy Berns discusses another issue regarding the viewing of colors at two significantly different color temperature conditions: *color inconstancy*. He writes:

> Another undesirable effect of altered lighting is color inconstancy, in which an object's color changes as lighting varies. This can occur, for example, when an artist's studio has natural daylight and a gallery uses incandescent lighting. Color relationships carefully crafted in the studio may not persist when the artwork is exhibited. (p. 99)
>
> Because most materials, including those used in artwork, are color inconstant, selecting a light's color is an important decision. "Cooler" lights tend to increase the vividness of blues and greens and decrease the vividness of reds and yellows; "warmer" lights tend toward the opposite. (p.111)

3000 K – Warm White | **4100 K – Neutral White** | **5000 K – Cool White**

Fig. B.2. The top row shows an apple and neutral background at three different color temperatures. The bottom row shows an apple and scenic background at three different color temperatures. (Image credit: https://www.hitlights.com/blog/what-is-color-temperature-choosing-the-right-color-led-lights/)

This concept is illustrated in Fig. B.2., which shows images of the same apple and backgrounds—either a neutral or scenic background—at three different color temperatures. The change in color appearance is a result of color inconstancy.

This sequence of images also underscores the difference between color inconstancy and metamerism. Color inconstancy refers to the difference in appearance of the same object under different color temperature conditions. Metamerism is due to the difference in the reflectance value of two colors that match at one color temperature and look different at another color temperature.

The best approach to minimizing color matching problems that result from color inconstancy is to choose a light source that has a “neutral” spectrum. This increases the probability that color matching completed in this balanced condition will match in both warmer and cooler illumination conditions.

THE PROPERTIES OF A NEUTRAL WHITE LIGHT SOURCE

The goal in choosing an appropriate color temperature for inpainting is to select a color temperature that renders colors accurately without exaggerating the appearance of warmth or coolness. But what color temperature range appears neither warm nor cool? Figure B.3. illustrates a series of light sources with different color temperatures, ranging from warm to cool.

Fig. B.3. The image shown above illustrates the transition in appearance between warm and cool light sources.

Research conducted by the National Institute for Standards and Technology[3] found that the correlated color temperature range of 3600K to 4500 K appears to be “neutral white.” This conclusion is based on the evaluation of the warmth or coolness of 25 color temperature points, ranging from 2200 K to 6300 K. Study participants were asked whether the appearance of a white tile appeared warm or cool, depending on the color temperature of the light reflecting off the tile.

Study participants judged color temperature points below 3660 K as warm 80- 100% of the time. Color temperature points above 4400 K were judged as cool 80- 100% of the time. The pooled average of all participants results identified a transition point of warm to cool around 4000 K.

Based on this research, it is probable that the most neutral color temperature appears to be in the range of 4000 K.

[1] Staniforth, S. 1985. “Retouching and Colour Matching: The Restorer and Metamerism.” *Studies in Conservation* 30: 101-111.
[2] Berns, R. S. 2016. *Color Science and the Visual Arts.* Los Angeles: Getty Publications.
[3] Davis, W., Weintraub, S., and Anson, G. 2013. “Perception of Correlated Color Temperature: The Color of White.” *Proceedings of the 27th Session of the CIE, Sun City, South Africa*: 197-202.