StellaIQ™ task lamp “any color you want” white paper

Introduction

The StellaIQ™ lamp is the result of a partnership between Stella Lighting and Jasper Ridge, pioneer of the LuxIQ™, to provide a smart lamp with infinite colors. Its purpose is to improve visual performance and perceived contrast through choice of the optimum color and intensity of light. provides colored task lighting, with the objective of improving acuity, reducing eye strain, and increasing perceived contrast. These claims are based on both human studies and eye physiology. This white paper provides an overview of three things: the background study that led to the development of a task lamp with colored light, physiological aspects that contribute to improved visual performance when using colored task light, and methods to choose colors that optimize an individual’s visual performance.

Background study

A Veteran’s Administration researcher led a study in 2016 to assess what color subjects preferred to optimize the ability to read fine characters on a reading chart. This study was reported at the 2016 Envision Conference (G. Goodrich et. Al., Envision Conference, “Can Color Improve Perceived Acuity;” available on the Stella Lighting web site).

40 subjects were given an adjustable light box placed over a reading chart. The box had controls enabling the subject to adjust the color of light over most of the visible range, while keeping the intensity constant.

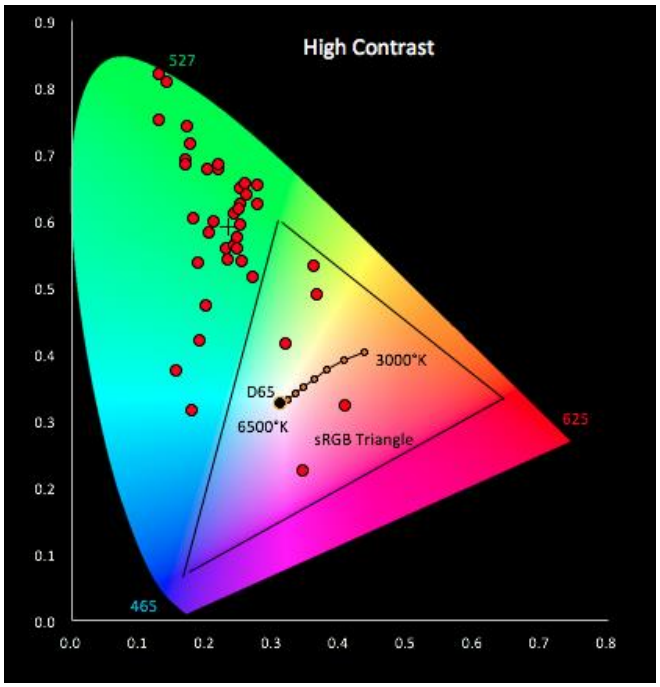


Figure 1: Results of the color study.

Figure 1 shows the results of this study for a high contrast chart (black characters on a bright white background). The figure shows the CIE color space, a map of the colors visible to the human eye. For reference, the triangle encloses the colors available on a conventional computer monitor. The line through the middle are whites, with the right end (3000°K) representing warm white typical of an incandescent light, and the left end representing cold white, typical of natural lighting or a the white in a computer display (D65, with approximately equal amounts of red, green and blue).

The red dots show the colors the subjects chose. 38/40 selected blue-green hues, two chose red-orange hues, and no one chose white. Interestingly, several of the subjects perceived the color they chose as white.

While the study did not assess why the subjects chose colored light over white, there are two likely reasons:

1. The colored light provides increased acuity and/or
2. The colored background reduces eye strain, making it easier to see features at the limit of visual acuity.

We will discuss these more fully in the next section.

Regardless of the cause, this study strongly suggests two things:

1. Using colored light in a task lamp can increase visual performance and
2. The optimum choice varies from person to person.

These observations are at the foundation of the Stella Lighting and Jasper Ridge Inc. collaboration that led to the StellaIQ technology. The lamp provides a colored light source with intensity appropriate for task illumination, and the app provides tools to optimize the color for an individual user, both for reading and performing functional tasks.

Physiological aspects

There are historical examples of using a colored background to reduce eye strain. For example, before the use of computers and spreadsheets, accounting ledgers used green paper to reduce eye strain when working with columns of small numbers. Engineering graph paper and lab notebooks also used green paper, probably for the same reason (see figure 2).

Indeed, blues and greens dominate in the outside environment (see figure 3, or just go outside and look around). White backgrounds are rare, except in the arctic. So, it is reasonable to expect that human eyes developed to see fine detail against a blue-green background.

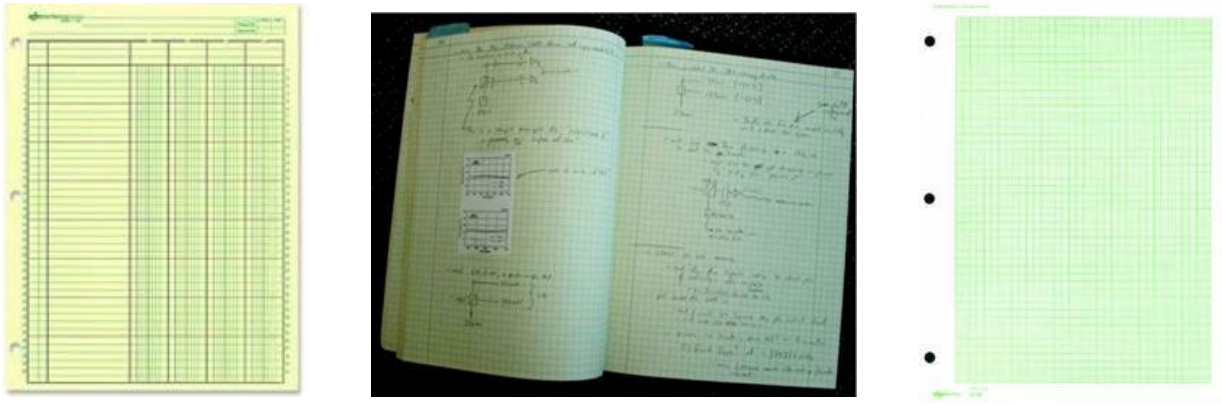


Figure 2: Examples of specialty paper with green background to reduce eye strain. From left to right: accounting ledger, laboratory notebook, engineering graph paper.

Figure 3: Outdoor scenes showing abundant green and blue hues.

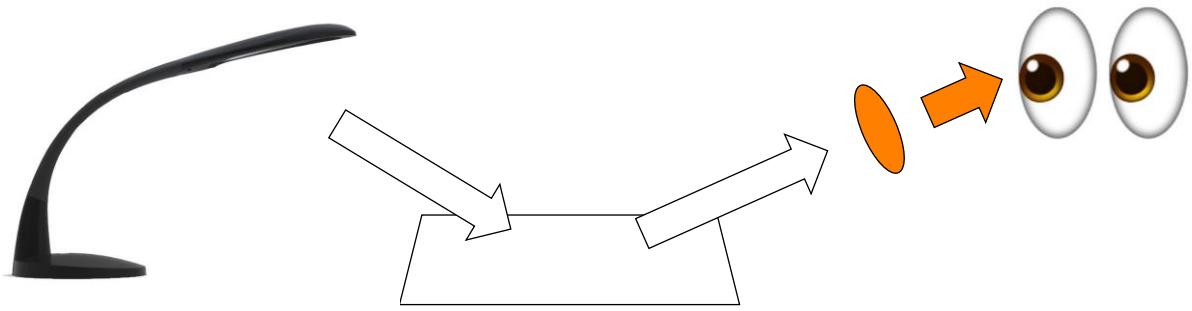
Another factor is chromatic aberration in the ocular media (lens and vitreous). The lens in the eye focuses an image onto the retina. The focal power of the lens varies with the wavelength of the light, with the focal point for blue light nearer to the lens and the focal point for red light further from the lens. This variation across the visible spectrum is about 1.5 diopters, about equal to a pair of low magnification reading glasses.

White light has equal amounts of red, green and blue primary colors, so it presents all wavelengths to the eye. Consequently, the chromatic aberration will be greatest for letters on a white background. Restricting the range of wavelengths reduces this distortion. The eye is most sensitive to green light, so using wavelengths near the green will result in a sharper focus and a greater perceived contrast between the black letters and the background.

Simulating color filters

A lamp with colored light can simulate the effect of reading or performing a task while wearing tinted lenses or color filters. The benefit is that one does not need a tinted lens for many indoor tasks, and a single lamp can simulate several filters appropriate for different tasks.

Figure 4 shows how this works. Imagine a lamp that shines white light onto a page. The white light reflects from the page, passes through a tinted lens and to the eye, as in the upper portion of figure 4. If a lamp emits light with a color equal to the light that passes through the tinted lens, the eye sees the same effect, but without needing the tinted lens, as shown in the lower portion of figure 4.



White light from lamp passes through filter, eye sees colored light

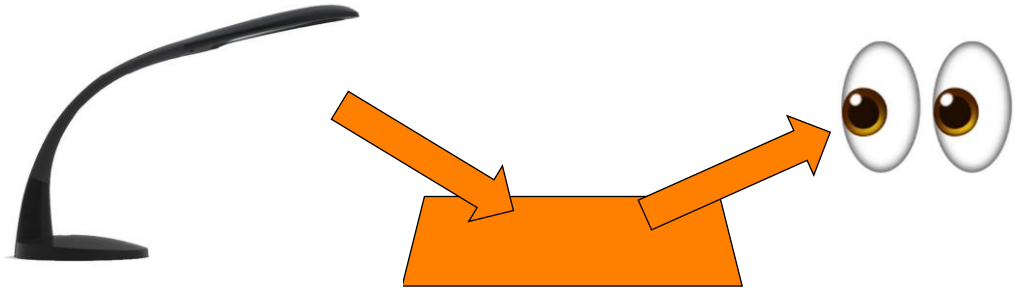


Figure 4: Simulation of the effect of a tinted lens. Top: white light and tinted lens. Bottom: colored light.

Optimizing the color for an individual

The optimum color varies from person to person and task to task. Several factors complicate color choice. These include:

- Retinal and eye disorders
- Age
- Colors that the task presents when optimizing color contrast
- Color vision defects (e.g., colorblindness)

For these reasons, it is necessary to have tools and guidance to select the best color for a task.

Users most often engage in two types of activities: *reading* and *functional tasks*:

- *Reading* most commonly involves viewing black characters on a white background for an extended period of time. Colored light has the effect of changing the color of the background. This has the potential to increase acuity and reduce eye strain. The acuity increase arises from the reduced range of wavelengths in the light, which improves the sharpness of focus on the retina. Additionally, there may be an increase in contrast between the letters and the page if the retina has increased sensitivity to the chosen color of light. The reduced eye strain arises from two factors:
    - The increase in acuity, which reduces the effort required to resolve the letters.
    - Choice of a background color that is perceived to be less harsh. For example, we have found that people with light sensitivity resulting from dry eye disease can tolerate twice the intensity of blue light compared to red light.
- *Functional tasks* are day-to-day activities such as fine arts and crafts where color may increase the perceived contrast of elements that might otherwise be hard to distinguish. For example, a red thread will be more visible under light with high red content, and a green background may be subdued using light with a low green content. This can help resolve fine details and reduce strain in extended activities.

Presets

Because thousands of colors are available, it is helpful to have a starting point. The app provides a range of presets, including standard colors, colors associated with certain conditions, and colors that simulate the effect of common filters. A good approach is to start with one of these settings and then do minor adjustments to optimize the color for the individual for either reading (next section) or functional tasks (two sections below).

Tools to select the best color for reading

Viewing a reading chart is the best way to determine an optimum background color. This can be done using a reading chart or sample of text under the lamp, or through use of the reading sections on the home screen of the app.

The reading chart and reading sections in the app provide two advantages. First, they are a calibrated reference and, second, they easily provide a way to test acuity with several sizes of text. For example, one can look at text at the limit of acuity to see if the ability to read fine text is improved, and text of normal size for reading to see if one can read with less strain.

Figure 5 shows the tools available on the home screen of the app. The reading section has two parts so one can compare color selections. For example, one finds a comfortable color, locks one section, and then adjusts the color to see if a better color can be found. The white/color button allows one to switch the background between white and the color selection to quickly see if the colored background is preferred to white. These tools are designed to provide an instant comparison in which one does not have to remember what a color looked like.

Figure 5: Home screen of StellaIQ app showing reading sections.

Tools to select the best color for functional tasks

For functional tasks (tasks other than reading), the benefits of colored light are to reduce eye strain during long duration tasks and to increase contrast to make objects more visible. Smart phones and tablets usually have a built-in camera, so it is easy to take a picture of a scene or task and work with the picture to find colors that highlight features.

Once a picture is displayed, the app recolors the picture to show how the scene would look under the lamp's illumination. This allows the user to adjust the color to highlight critical features. The app also has tools to show the color content of the picture and how the picture would look under the primary colors of red, green and blue.

Consider the example in figure 6, which shows a garden scene under red, green, blue and white light. The red and blue light highlight the flowers, which have red and blue content, while suppressing the green leaves. The green light highlights the leaves while minimizing the contrast between the flowers and the leaves. Clearly, if one wants to see the flowers standing out against the leaves, the best combination is light rich in red and blue, with reduced green.

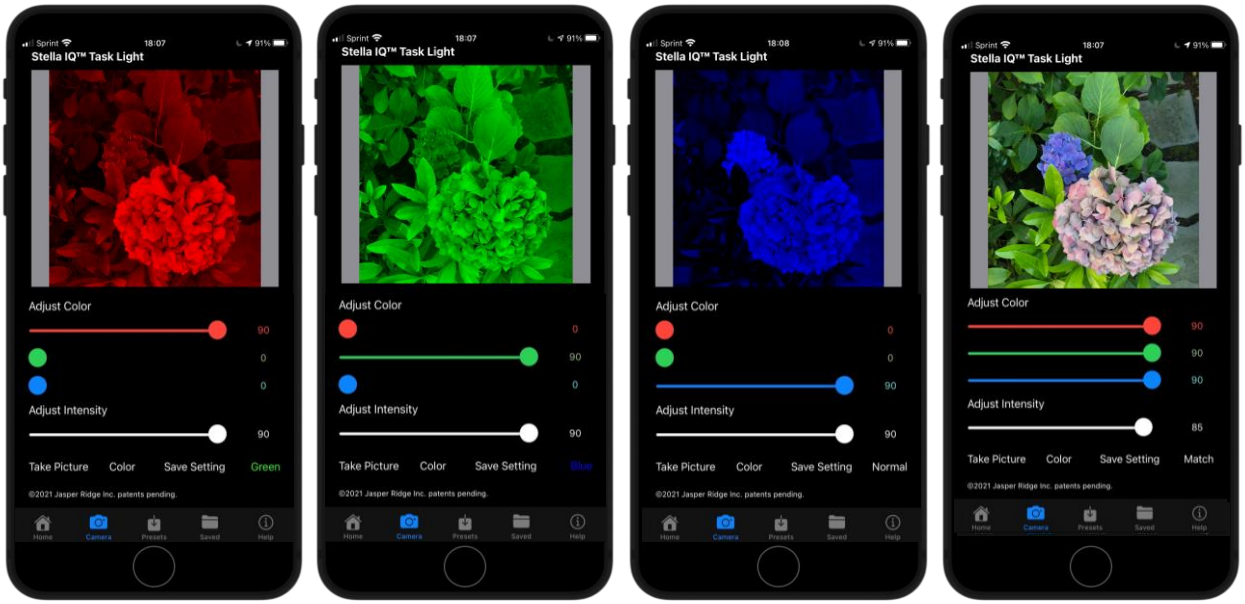


Figure 6: Scene viewed from left to light with red, green, blue and white illumination.

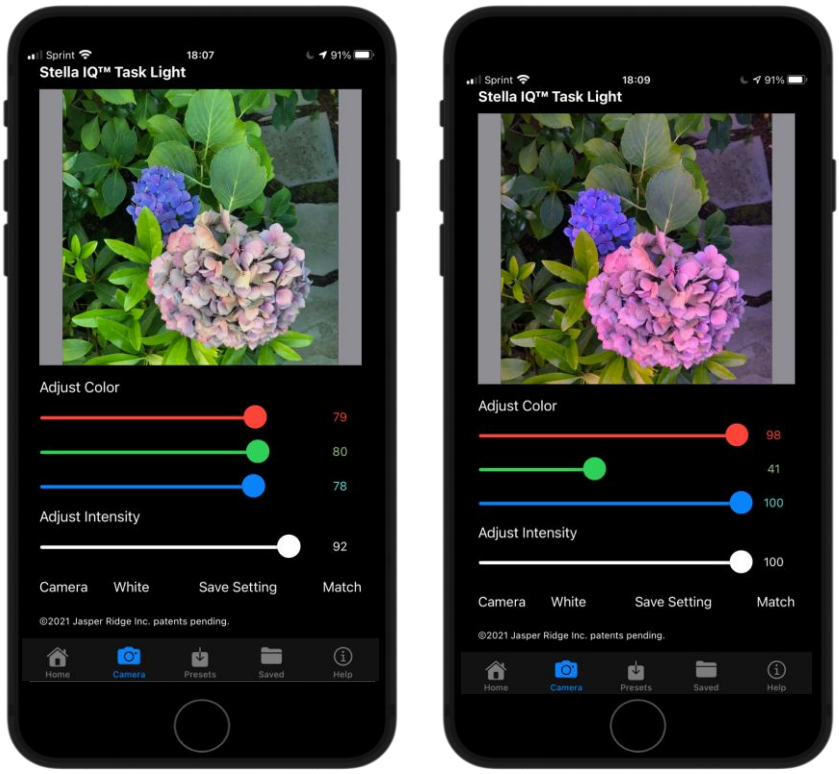


Figure 7: Scene viewed under white light (left) and reduced green (right) to subdue leaves relative to flowers.

Figure 7 shows this case (right) compared to white illumination (left). With the increased red and blue content, the flowers stand out while the leaves recede into the background.

This strategy maximizes color contrast to highlight fine objects. For example, using light that matches the color of a thread will cause the thread to be more visible against the background. This increase in color contrast will also lessen eye strain, as it is easier to see the thread.

Conclusion

The StellaIQ™ Task lamp's colored task lighting improves acuity, reduces eye strain, and increases perceived contrast. This white paper has shown how both human studies and eye physiology support these claims. We have also seen that, because of the wide range of available colors, it is essential to have the tools and methods available in the app to find the best color for a given task.