Red-Green Versus Blue Tactical Light

A Direct, Objective Comparison

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ABSTRACT

Background: Success in Special Operations Forces medicine (SOFMED) depends on maximizing visual capability without compromising the provider or casualty when under fire. There is no single light that has been deemed "ideal" for all SOFMED environments. **Methods:** We used the Farnsworth-Munsell (FM) hue test to determine color vision of normal subjects under white, red-green, and blue flashlights to determine color discrimination. Then we used a timed color-determination visual test to determine how quickly normal subjects can identify color correctly. We had subjects perform a simulated surgery illuminated by a normal white-light source, then by red-green or blue light-emitting diode (LED) tactical light. **Results:** The total error score for white light was 49.714, 272.923 for red/green light, and 531.4 for blue light. The subjective perception of simulated trauma wounds was not substantially different with red-green LED tactical light when compared with white LED light. However, simulated surgery under the blue LED was more difficult compared with simulated surgery under the red-green LED light. **Conclusion:** Red-green was a superior light source for SOFMED and military first responders in this study, especially, where light was required to allow accurate and efficient application of Tactical Combat Casualty Care to injured personnel.

Keywords: *night vision; tactical combat casualty care; TCCC; LED flashlight; Special Operations Forces medicine; SOFMED*

Introduction

Military first responders require enough light to allow accurate and efficient application of Tactical Combat Casualty Care (TCCC) to injured personnel. First, there is the issue of balancing the benefits of providing the luminance required for task completion against the risk for tactical compromise associated with higher illumination. Second, when an individual quickly transits from ambient/daytime illumination to low-level/night light, the visual system needs time to adapt to the new dark conditions (i.e., dark adaption).

In this study, we evaluated red-green and blue tactical lighting compared to white light to determine the quality of illumination specifically for TCCC. The study hypothesis was that red-green light would provide better color discrimination than blue light-emitting diode (LED) illumination and possibly would reduce dark adaption time.

Materials and Methods

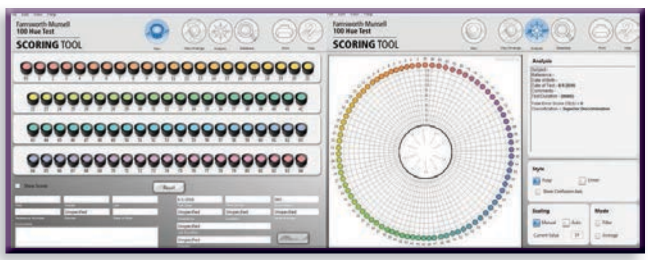
Fourteen normal-vision volunteers (8 men and 6 women), ages 18–65 years, gave informed consent before participating in a color-vision study that was approved by the Colorado Multi-Institutional Review Board (clincaltrials.gov listing NCT01927536, https://clinicaltrials.gov/ct2/results?term=NCT01927536&pg=1). Each subject performed a quantitative and qualitative color-vision test, using the FM test under white flashlight conditions (Tomahawk NV; First-Light USA, https://www.firstlight-usa.com) and two tactical illuminations provided by the red-green LED flashlight (Red-Green Tomahawk MC; First-Light USA; Figure 1) compared with another popular, tactical blue LED flashlight (Blue Tomahawk NV; First-Light USA).

The FM test is a qualitative and quantitative evaluation of color vision consisting of 85 colored papers mounted in plastic caps. The 85 different color caps are selected to represent equal steps in color difference around a complete color circle. The caps are divided into four groups, with each group assigned to a separate test tray representing a quadrant of the color circle. The test subject was given appropriate time to sort 85 color circles in order of perceived differences along a color gradient. The test administrator then determined the total number of errors and their position on the color circle. Scores deviating from normal were taken as a diagnosis

Figure 1 *Tomahawk MC Red-Green light with Molle Tactical Retention System (TRS).*

of color-vision deficit and as a measure of the severity. The FM test is scored by the total error score (TES; Figure 2).

Figure 2 *Farnsworth-Munsell software scorecard.*



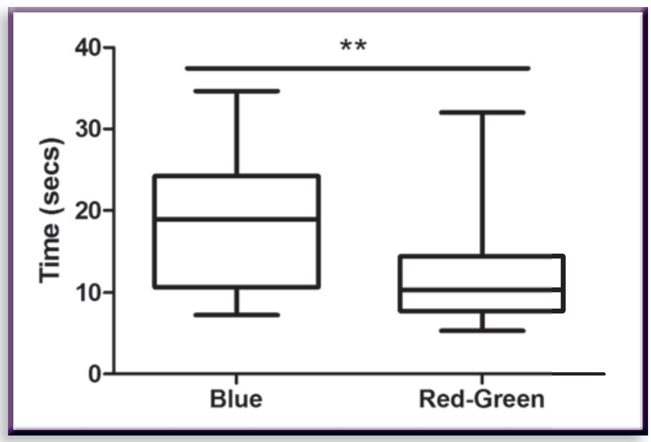
A timed color-matching exercise was performed by a new set of 20 medical students with normal color vision and a group of volunteers at Strategic Operations who self-identified as red-green colorblind. As quickly as possible, the subjects matched colors similar to those seen in traumatic situations, such as oil, blood, and camouflage, to a template of colors in a blackout box in which the only illumination came from the red-green or blue flashlights. The participants were timed to correct completion of the task.

Results

A total of 14 volunteers took the FM test; however, only seven were tested with the blue light (Figure 3). The TES for white light was 49.714 (n = 14); for red-green light, 272.923 (n = 14); and for blue light, 531.4 (n = 7).

A second set of 21 medical-student volunteers completed a timed color-matching exercise in which subjects matched colors in a blackout viewing box under the red-green light versus the blue light (Figure 4). The matching exercise was performed significantly more quickly with the red-green tactical light compared with the blue tactical light (p = .0038).

Figure 4 *Whisker plot of time taken to complete color arrangement under Red-Green Tomahawk MC or Blue Tomahawk NV flashlight. Analysis was performed using two-tailed paired Student's t test. **p = .0038.*



Last, a small group of the same medical-student volunteers at Strategic Operations performed a simulated abdominal wound surgery in a blackout situation, using cut suits (Strategic Operations, http://www.strategic-operations.com/). Simulated blackout surgery was performed

Figure 3 *Color discernment with normal-vision subjects under different lighting conditions.* **(A)** *White flashlight;* **(B)** *Red-Green Tomahawk MC light; and* **(C)** *Blue Tomahawk NV light.* **(D)** *Whisker plot of represented TES, using. one-way analysis of variance with Tukey post hoc test. ***p < .001.*

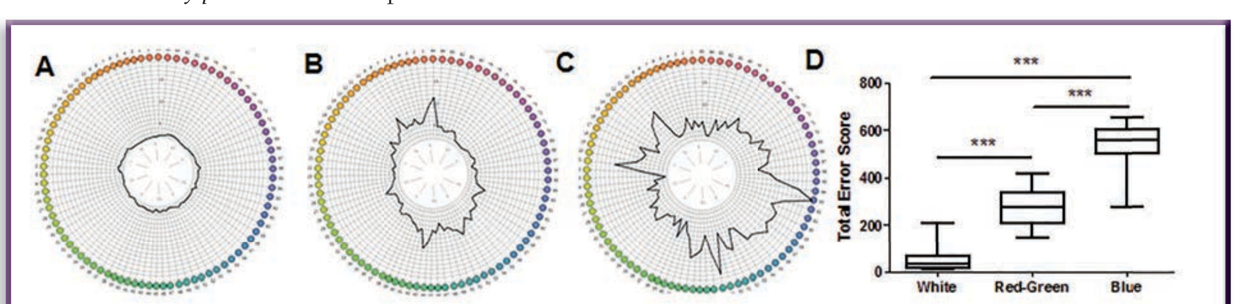
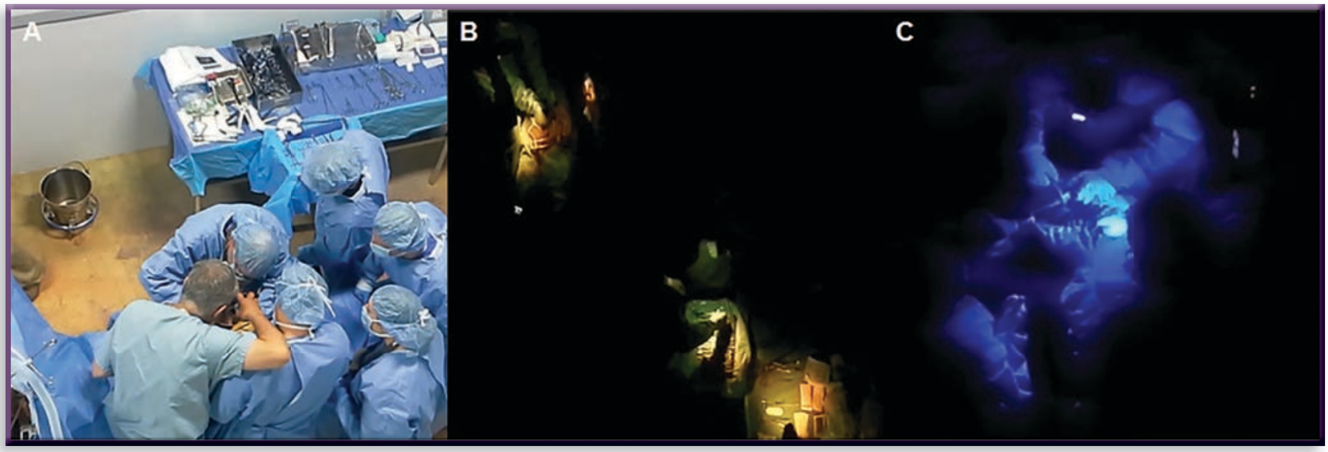


Figure 5 *Simulated surgery under the following conditions:* **(A)** *white light;* **(B)** *Red-Green Tomahawk MC light; and* **(C)** *Blue Tomahawk NV light.*



under the red-green LED light or the blue LED light to evaluate how well these tactical lights work in this environment (Figure 5).[1] Future studies are planned also. The subjects were surveyed and preferred the red-green Tomahawk MC light to the blue Tomahawk NV light (data not shown). Figure 6 demonstrates a Cut Suit® simulating wounds photographed with white light and the red-green Tomahawk MC light, demonstrating that color rendering is similar between the two.

Discussion

As elucidated by Calvano et al.,[2] there are four categories of a lighting system. First, the output of the light source itself, as measured in watts, candelas, or foot-candles. Second is the light beam, or luminous flux, measured in lumens. The third quality is the illuminance, which represents the light falling on a surface, measured in lux or lumens/m^2 and proportionate to the distance from the light source to the target. Fourth is the luminance, or the light reflected from a surface, as expressed as candelas/m^2, foot-lamberts, or milli-lamberts.[2]

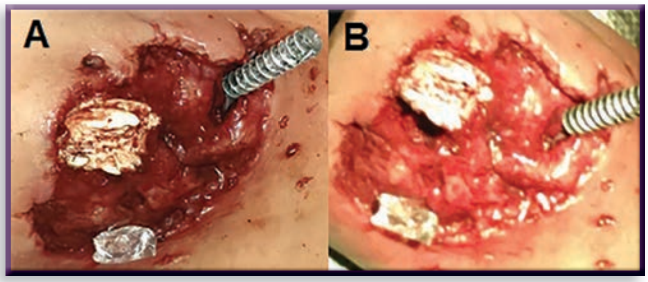
Additionally, there is some significant confusion regarding what components contribute to quicker dark adaptation, and unaided night vision is still a subject of controversy. A red light had been the traditional choice for retaining night vision since before the Second World War, when the military settled on red as the best choice, and the classic elbow flashlight was fit with a red filter. The myth of the red light has been suggested to go back to the photographic darkroom prior to the First World War. Also, for a long time, the earliest LED lights were only available in red, perpetuating the myth. Recently, there has been a move to green and blue-green light. However, total brightness, or illumination level, of the light has the most significant effect on night-vision retention more than the choice of color. The brighter the light, the more negative the impact on night vision, both in our capacity to see and how long it takes to recover night vision.

Human eyes are most sensitive to green wavelength light, so at the same level of low light, the visual perception would be better with green or blue-green when compared with red.[2] Pilots and aircrew often prefer green light to red, most likely because of perceived improved perception on aviation charts. Tactical medical personnel more often prefer red-free (visible green) light because the perception of blood “stands out” from the surroundings.

It is well known that both low illumination and small target size have adverse effects on color-task performance.[3,4] Also, fatigue has been shown to influence color perception in color-deficient individuals.[5] Satisfactory indoor illumination for most visual needs ranges from 50 to 100 foot-candles. This is only approximately 10% of the illumination present in the shade of a tree on a bright, clear day.[6]

There are several clinical color-vision tests available to detect anomalous color vision.[7] However, the FM test is one of the very few tests that can be used for both quantitative and qualitative evaluation of subjective color vision. It allows the grading of the performance of normal color-vision patients into superior, moderate, and poor hue discrimination. Results of this test can be used in the same way as one might grade stereoscopic acuity among patients who have stereopsis (depth perception). Additionally, there are many metrics of visual performance beyond simple visual acuity. Human eyes adapt to light, dark, and variation in image contrast.[8,9] This limitation in the current study is why further studies are planned to compare the red-green Tomahawk MC light with other color flashlights to evaluate recovery of night vision, visual acuity, and contrast sensitivity in low-light conditions after various flashlight exposure.

Figure 6 *Wound-simulation suits illuminated with* (A) *white flashlight and* (B) *Red-Green Tomahawk MC light.*



Conclusion

The choice of tactical lights for acute trauma response is based on the desire of the TCCC tactical first responder to deliver life-saving trauma medical response, maximizing visual acuity, color perception, and minimizing the time for dark adaptation. The FM test demonstrates that color perception is significantly better with red-green light than blue light. Color discrimination is quicker with the red-green versus blue light and the difference is perceivable to normal vision subject. Our study confirmed marked superiority of red-green LED over blue LED flashlights for a TCCC military first responder to assess acute trauma response.

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Disclosures

The authors have indicated they have no financial relationships relevant to this article to disclose.

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Related Internet Links

http://www.strategic-operations.com/
https://clinicaltrials.gov/ct2/show/study/NCT01927536?term=NCT01927536&rank=1

Ms Pedler is a professional research assistant in the Department of Ophthalmology at the University of Colorado Denver Anschutz Medical Campus. She has worked in medical research on the campus since 2003 after moving to the United States, and in Australia from 1995 to 2002 prior to that. She graduated with a bachelor of science with honors in medical science from the University of Adelaide in 1994.

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