Rod – Lcone color matching in complex images

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Rod and L-cone interactions generate color appearances. This paper measures color appearances in complex scenes above and below M- and S-cone thresholds. The paper test target was a Munsell ColorChecker viewed in tungsten light, 1 wax candle and 625 +546 nm light. Firelight is an ideal illuminant for Rod-Lcone color. The observers' task was to adjust RGB digits in LCD computer display to match the appearance of the ColorChecker papers. With the tungsten illumination, above L-,M-,& S-cone thresholds, the color matches for the reflective ColorChecker and the emissive LCD were reasonably close. With long-wave rich illumination, the below M- and S-cone threshold ColorChecker showed different color matches. A 4-D color space is not required because all colors were matched to above cone threshold colors, sharing information with other color channels. The color appearances are not consistent with rods sharing S-channel alone, or M-channel alone. The colors are not consistent with the rods desaturating all three channels. Under these conditions, the colors are consistent with the rod spatial comparisons sharing both the M- and the S-cone channels.

Outline

1.Crosstalk controls the range of colors in an image. [Figure 9]

2. Recent low-light experiments measured small color ranges using sub-optimal illuminants.
(Shin, 2004 [6500˚K]; Cao,2005 [5000˚K]).

3. The experiments in this paper used optimal spectral illuminants [Figure 1, (McCann, 2006a,b)].
Here, we measured a wide range of colors from rod and Lcone interactions .

4. The experiments matched 24 paper color squares [FIgure 2]
(ColorChecker in low light) with (LCD display with 24 adjustable squares, above M- & S-cone thresholds).

5. Color matching data [Figures 3 – 8] show:
   A. Wide range of rod/Lcone colors fall on red cyan line
   B. Colors consistent with rod information sharing both M- and S-channels.

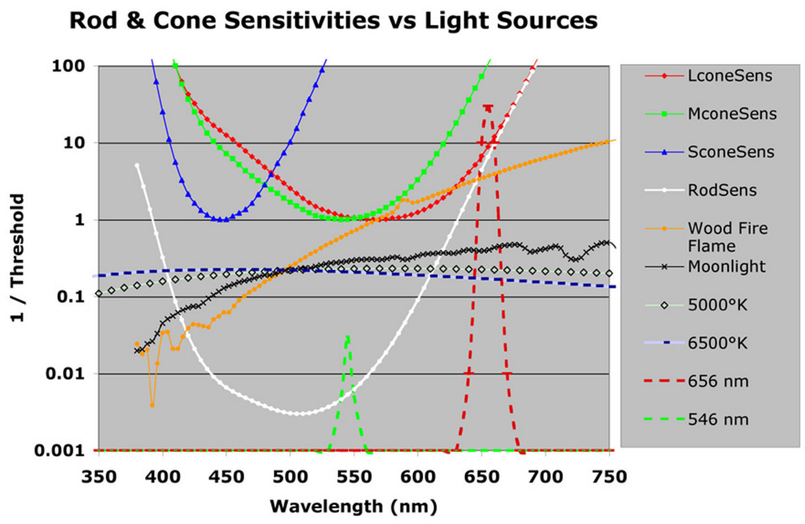


Figure 1 compares specta of receptor sensitivities with illuminants.

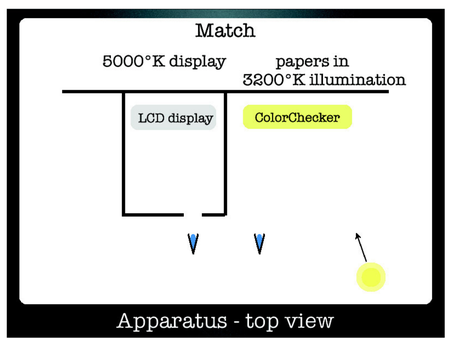


Figure 2. Experiment: Observers viewed all 24 papers with their right eye. Alteratively, they viewed all areas on the the LCD display with their left eye, while adjusting each squares color.
The first pass took ~ 30 min. Observers continued matching until all areas are the best match, ~ 60 min.

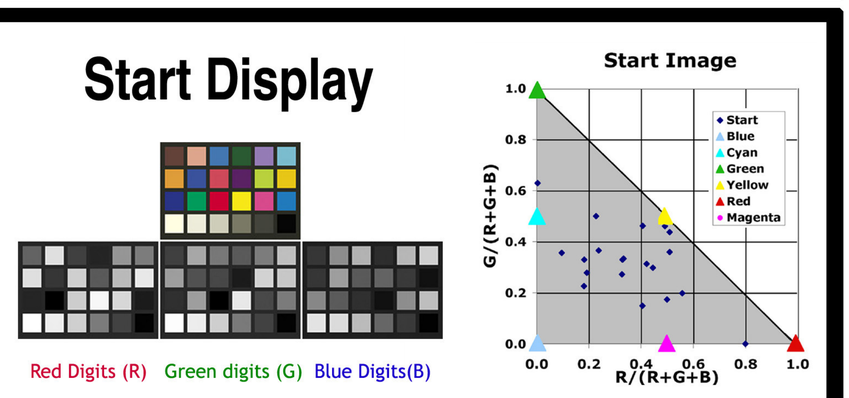


Figure 3 Data Analysis: We used display digits to calculate display chromaticitities.
(left) Start image on display with R, G,B separations.
(right) Triangles plot the display gamut
Diamonds plot 24 starting colors.

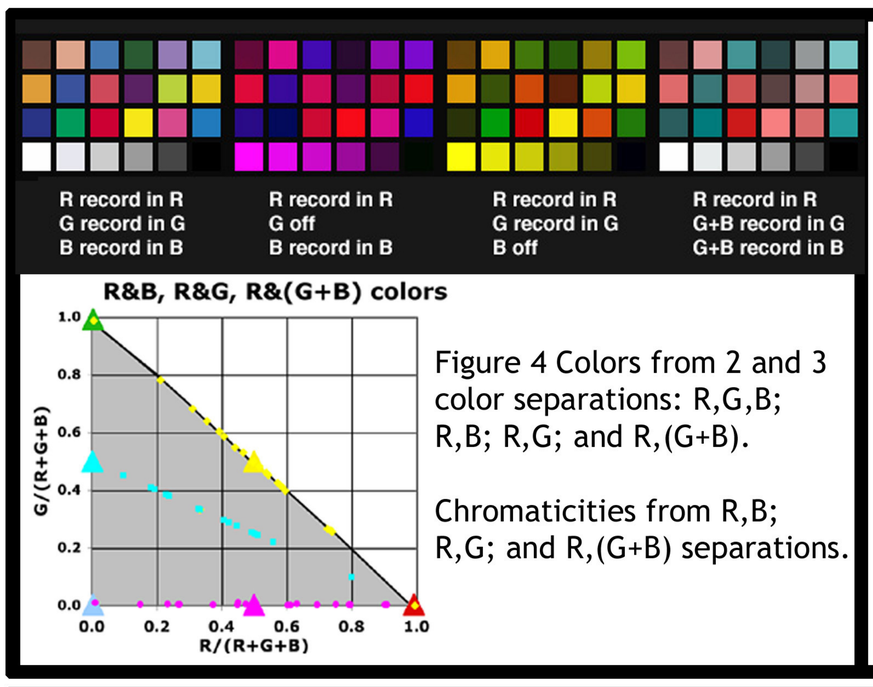


Figure 4 Colors from 2 and 3 color separations: R,G,B; R,B; R,G; and R,(G+B).

Chromaticities from R,B; R,G; and R,(G+B) separations.

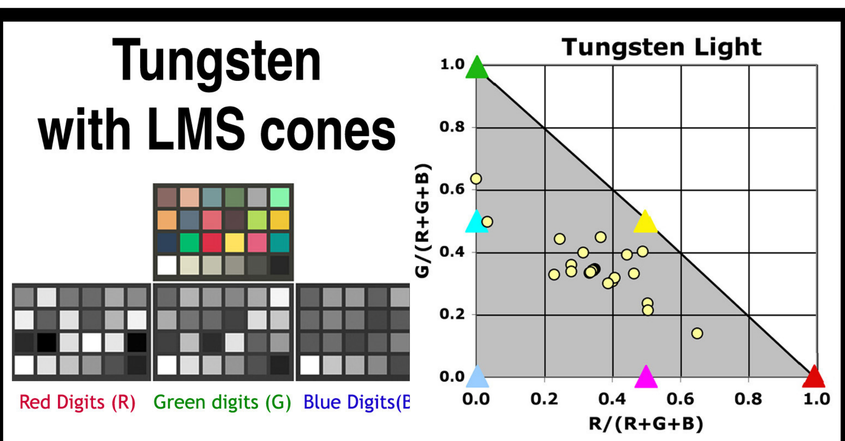


Figure 5 Matching digits for bright tungsten light.

[Color image displays matching digits not appearance.]

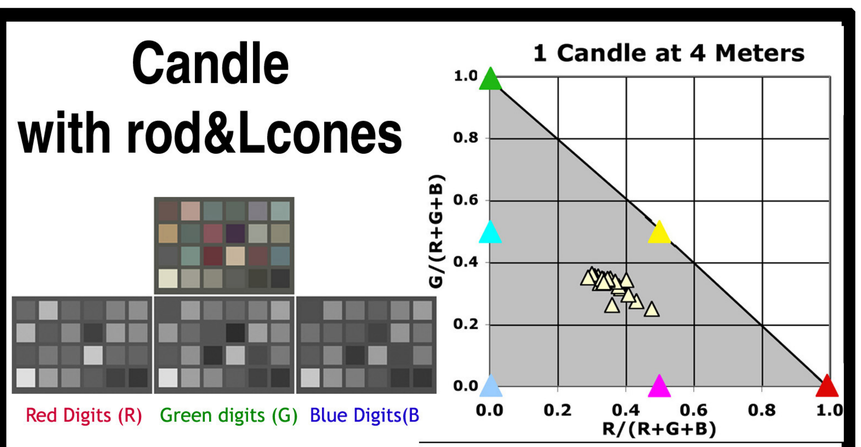
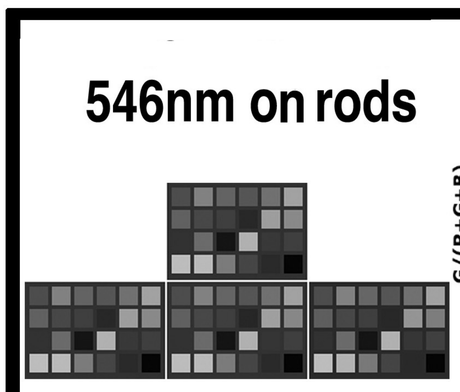


Figure 6 Matching digits for dim candle light.
Note similarity of G and B separations.

[Color image displays matching digits not appearance.]



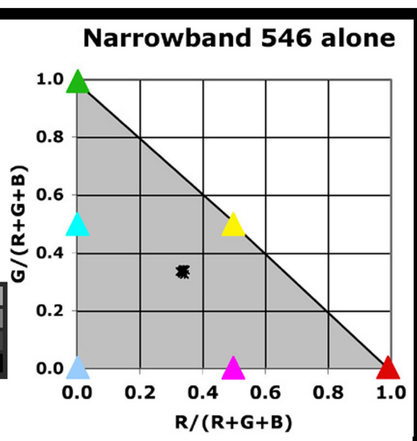
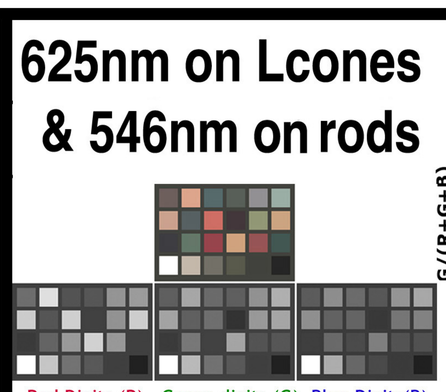


Figure 7 Matching digits for dim 546nm light that excites only the rods.

Note all RGB separations are the same.



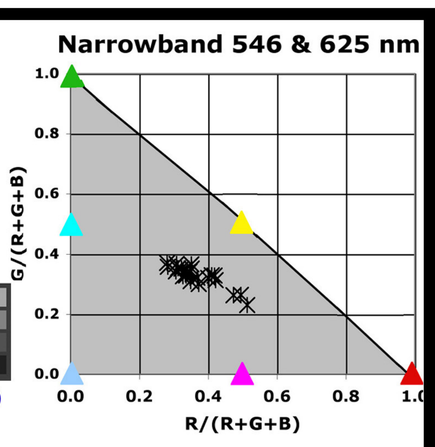


Figure 8 Matching digits for dim 625 & 546nm light.
A wide range of color matches fall on Red-Cyan line.

Note the G and the B separations are the same.

Conclusions

In dim 546nm light matches fall on an achromatic point.

Add 625nm light to get a wide range of color matches.

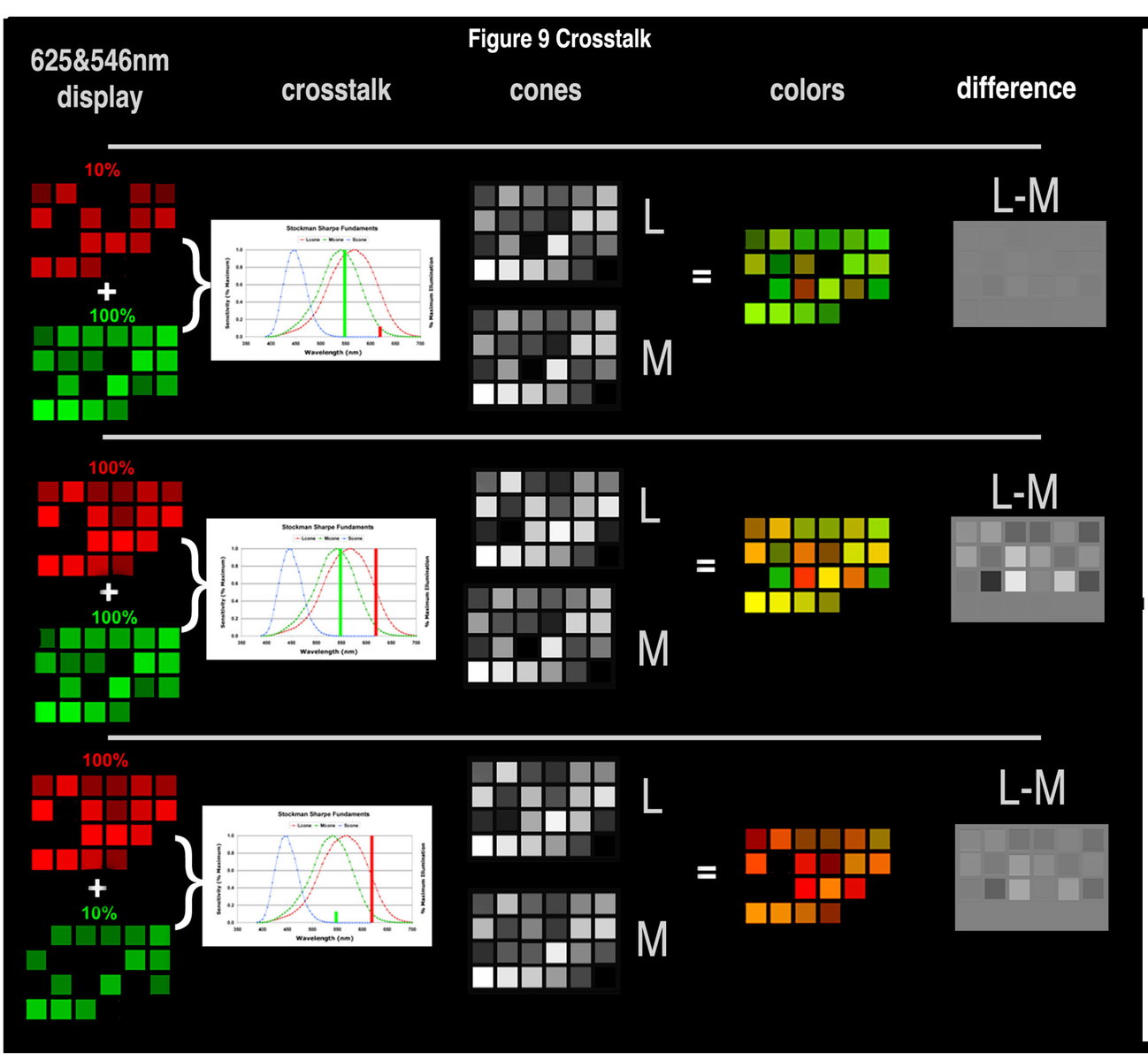
Color matches fall within LMS cone color space.

The matches fall on a chromaticity line (3-D plane).

That line defines the rod (546nm) information pathway.

Colors show rods share both M- and S-channels.

The same is true for firelight.



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