Color fidelity of chromatic distributions by triad illuminant comparison

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Background

- Color constancy has been a major topic in color research for several decades

- Stable object appearance, despite illumination changes
- Key issue: separation of illumination and reflectance from the product that enters the visual/vision system

Different lines of research

- Perceptual (human vision) and computational (computer vision)
- Perceptual : goal is to measure, characterize and model human color constancy, i.e. perceived object color
- Computational: estimate the illuminant, to recover object reflectance or to allow color correction

Problem

- Performance measures for color constancy are very different

    - perceptual : color constancy index

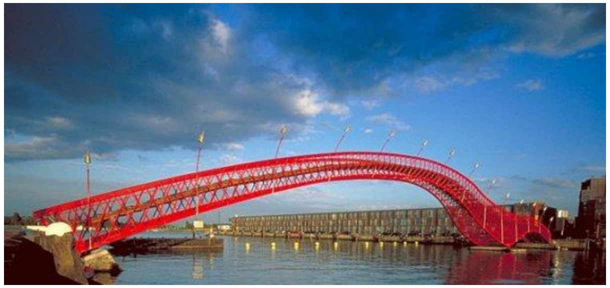
        local, stability of perceived object color

    - computational - computer vision : angular error

        global, accuracy of the estimated illuminant

- Can we bridge the gap?

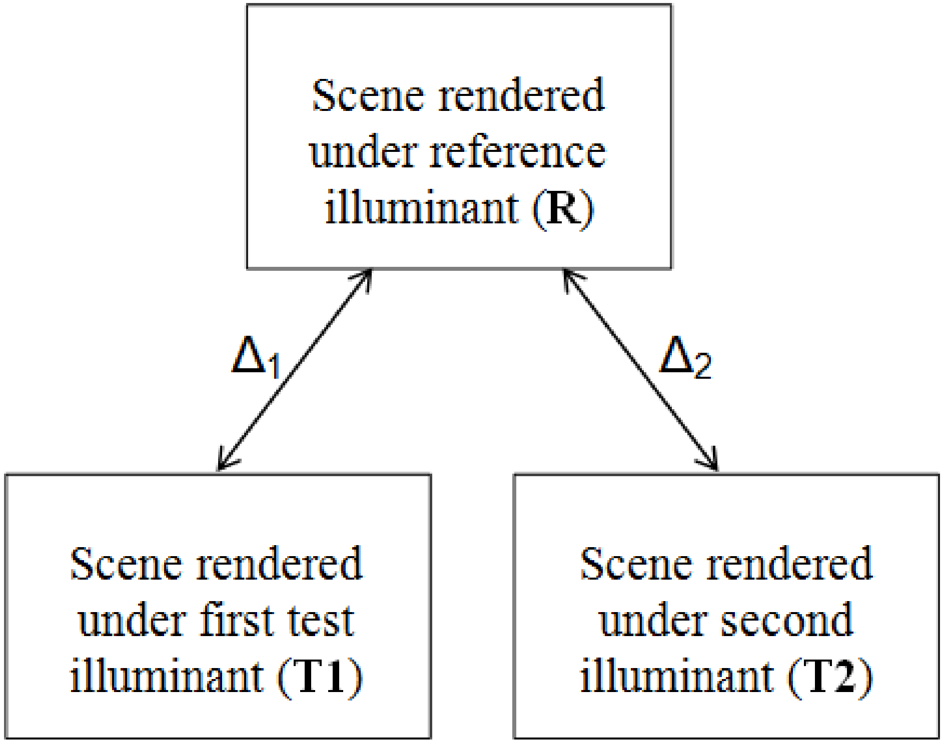
JOSA A (26), 2243-2256, 2009



Global image comparison

- We propose a psychophysical method that measures the global color fidelity of visual scenes rendered under different illuminants

- Triad illuminant comparison:



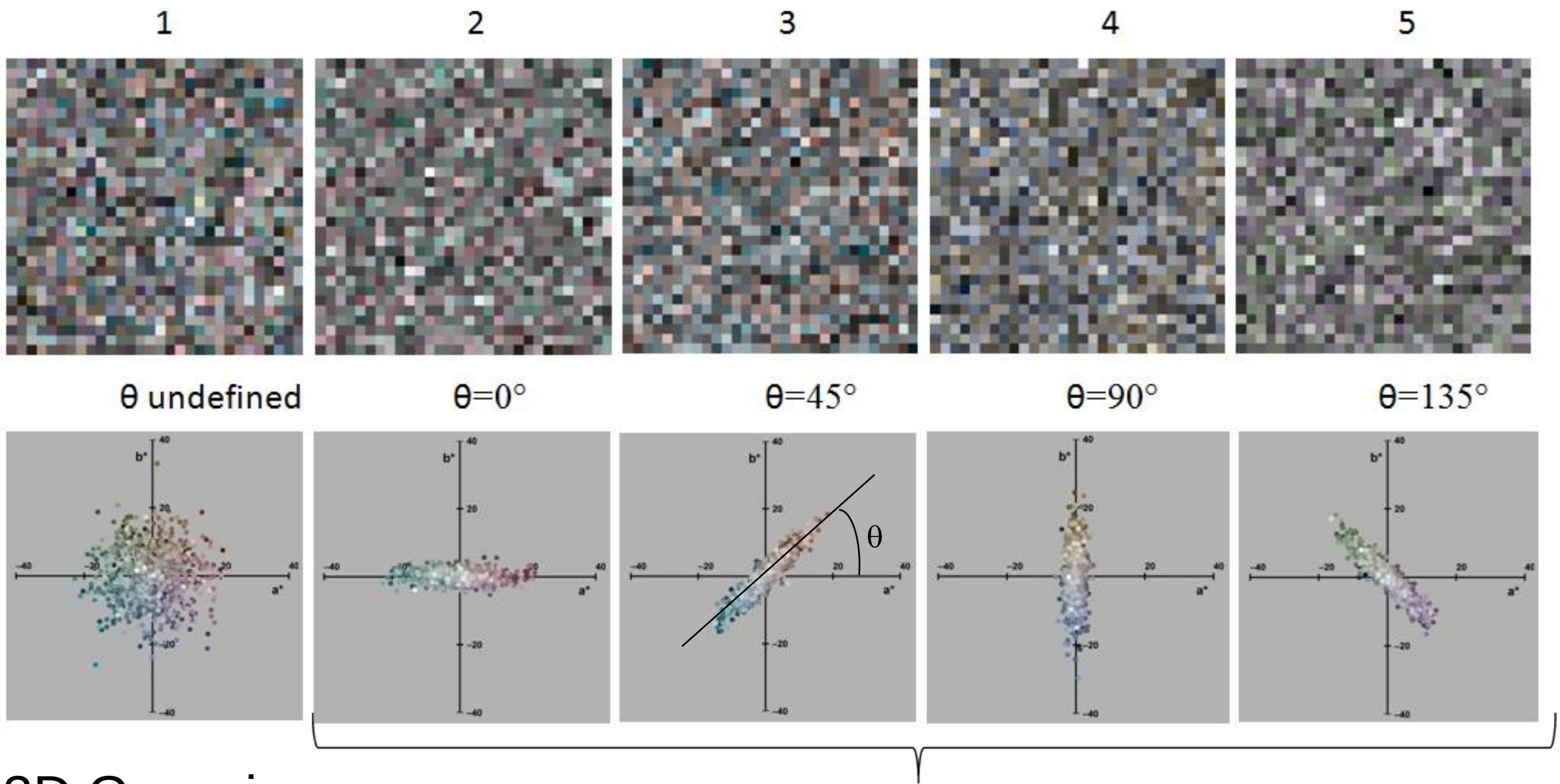
Example

Approach

- Spectral simulation of illuminant changes, shown on a calibrated color display
- Selection of test scenes, reflectances, and illuminants

Selected color distributions

- Test scenes are composed of 900 color patches

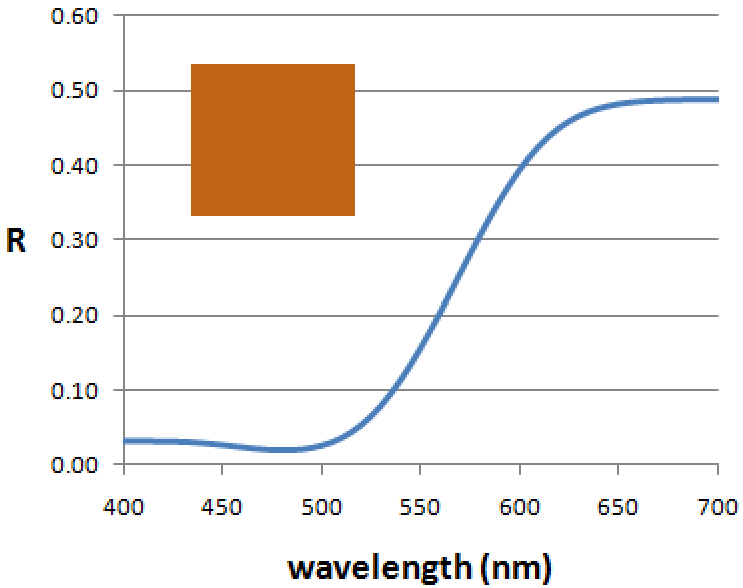


3D Gaussian

$\sigma_{major} = 5\ \sigma_{minor}$

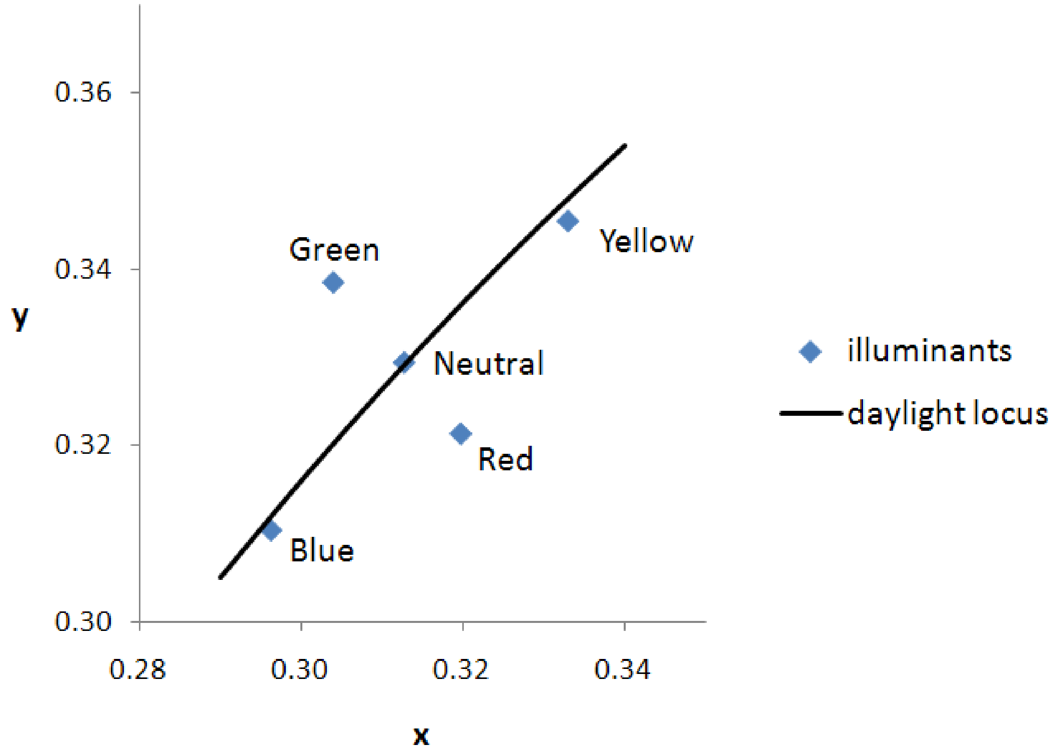
Deriving reflectance from L*,a*,b*

- Specifications in CIE L*,a*,b*
- For realistic color rendering we need spectral reflectance
- L*,a*,b* $\longrightarrow$ X,Y,Z $\longrightarrow$ R(λ)   many solutions possible
- We estimate the *smoothest reflectance function* that produces L*,a*,b* under D65



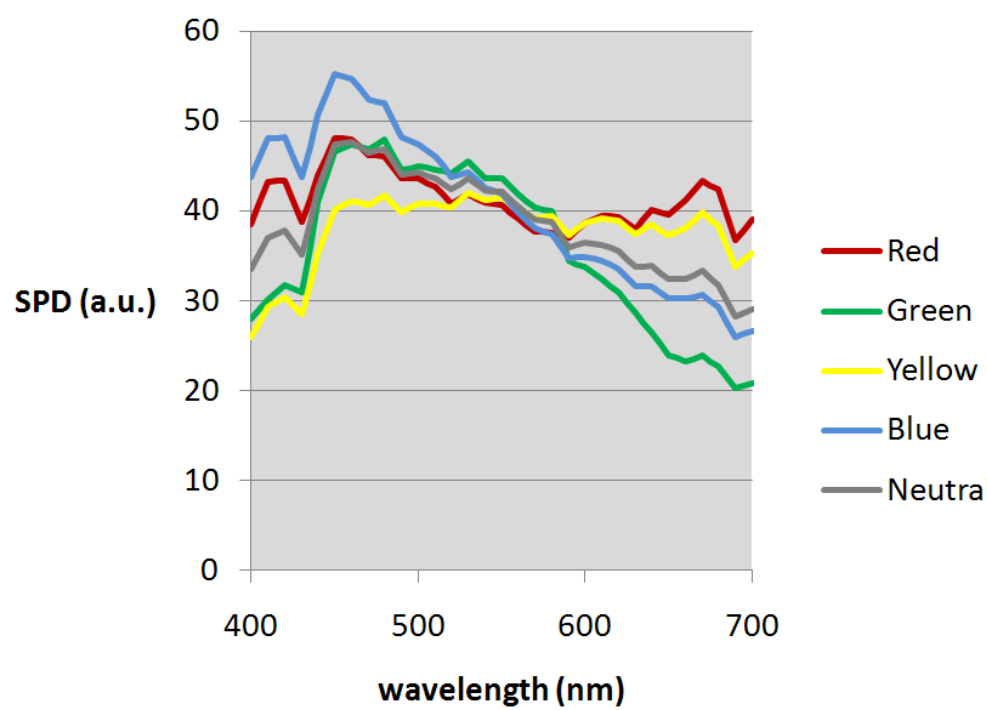
Selection of illuminants

- D65 = neutral reference
- B and Y along the daylight locus
- R and G perpendicular



Spectra of selected illuminants

- Spectra composed of the CIE basis functions for variations in natural daylight



- Distance to the neutral point was adjusted to obtain equal physical shifts in the reflected light signal when changing illumination from D65 to R,G,Y or B.

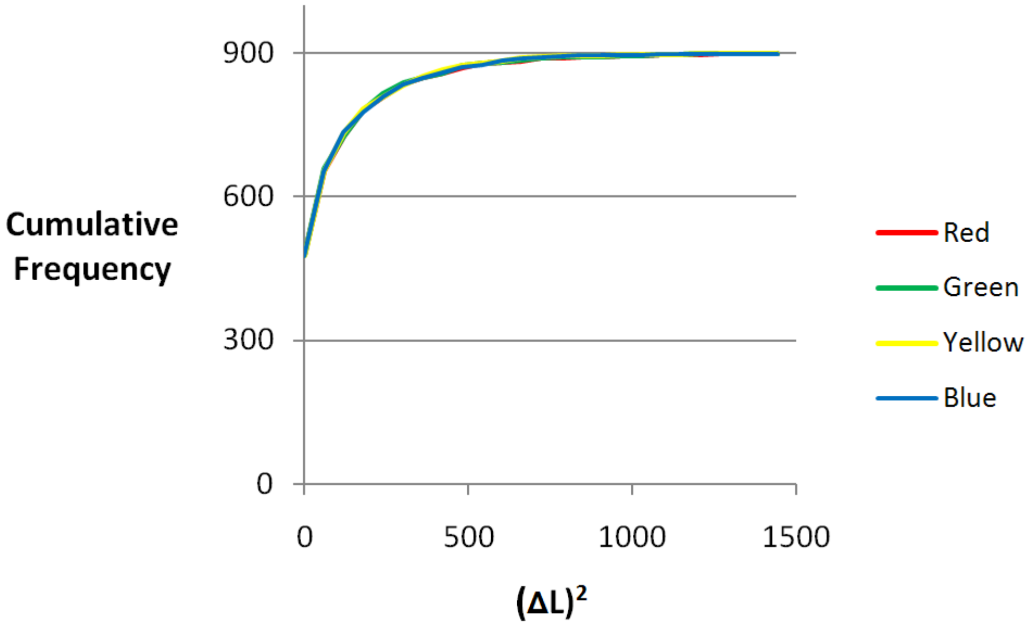
Equal illuminant shifts from D65

- Reflected light signal from a patch with reflectance $\rho(\lambda)$

$$L = \int_{\lambda} E(\lambda)\,\rho(\lambda)\,d\lambda$$

- Changing illumination : $\Delta L = L_2 - L_1$

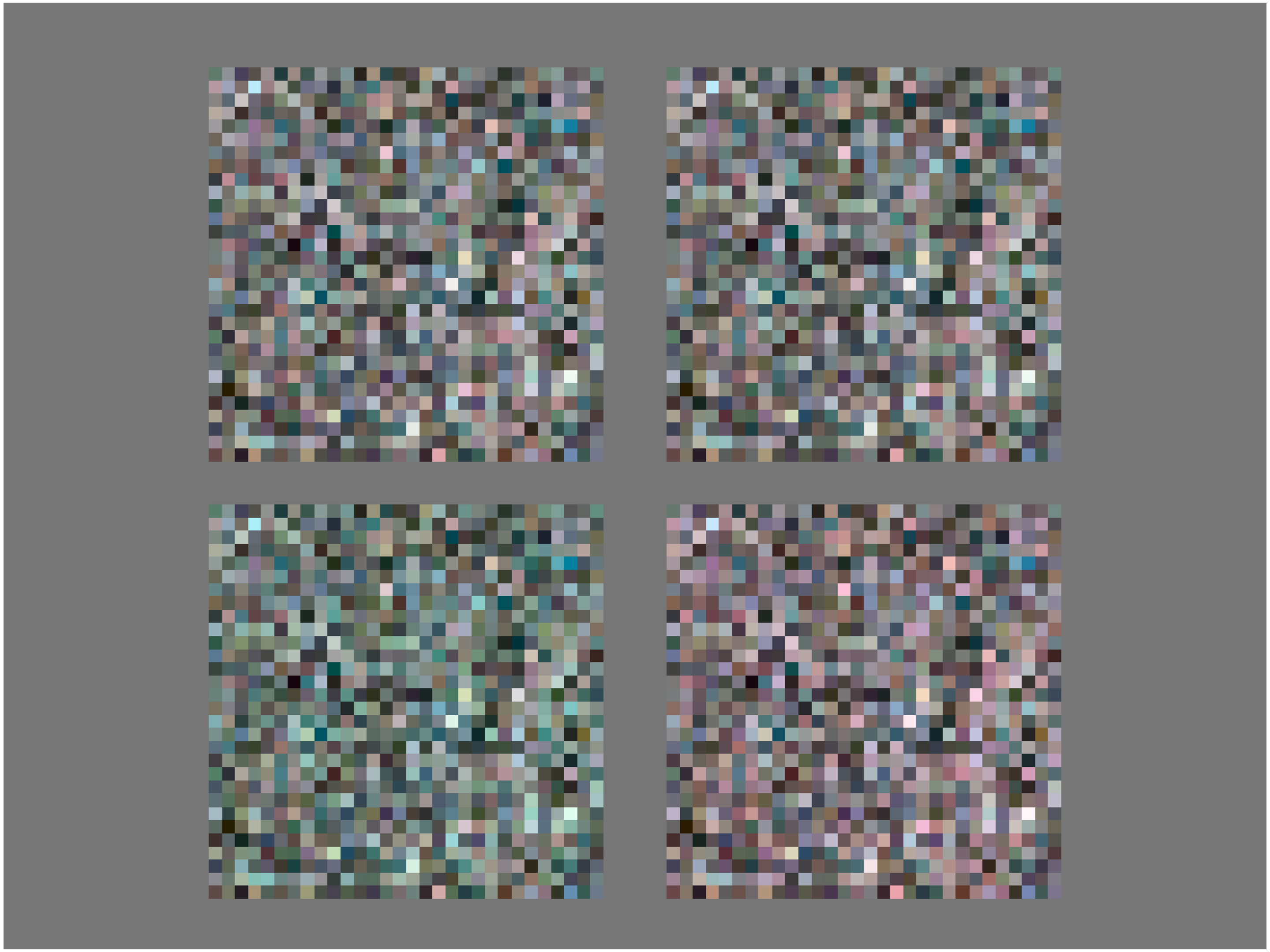
- Equal distributions of ΔL for the chromatic illuminants



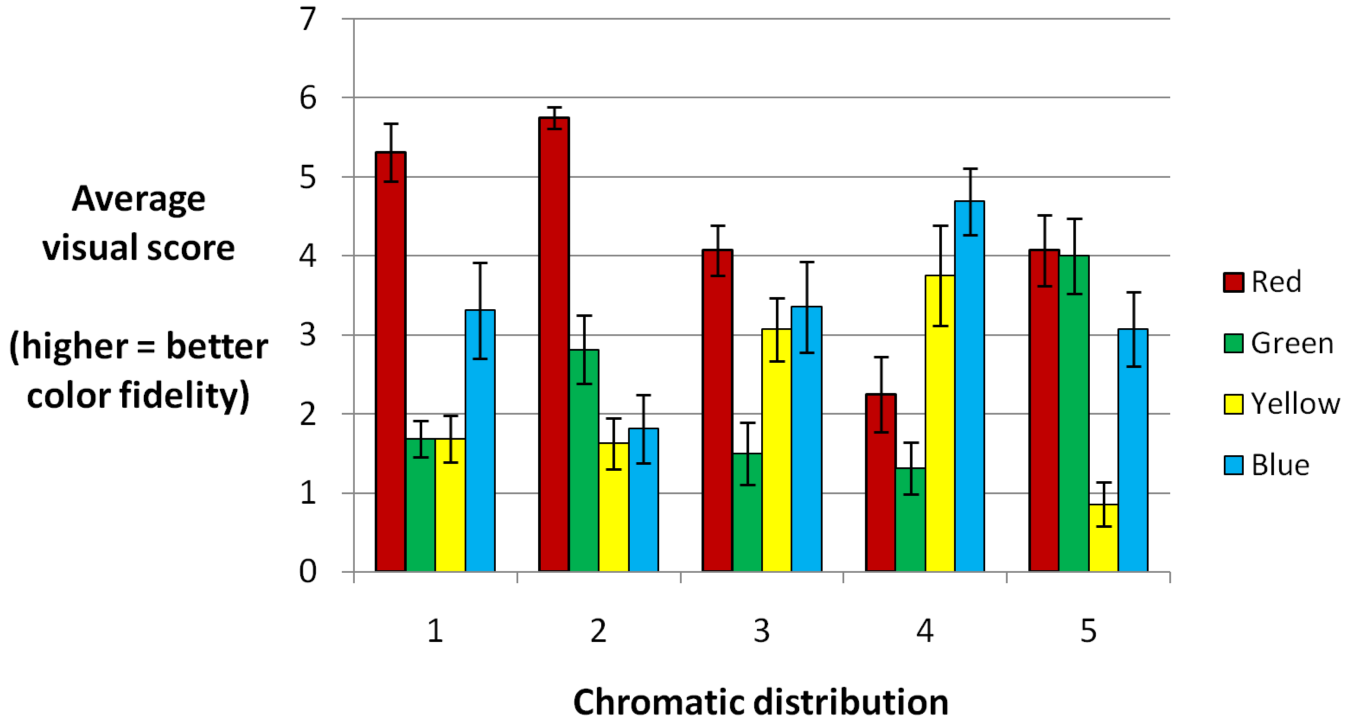
Experiment

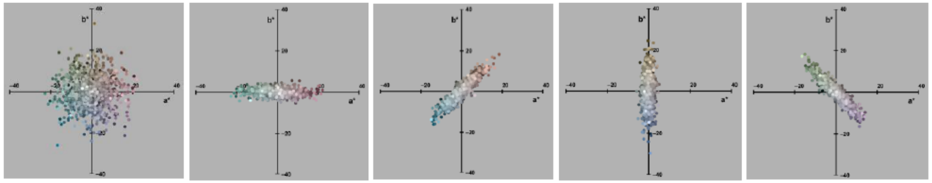
- 5 test scenes (chromatic distributions)
- 6 illuminant pairs (R-G, R-Y, R-B, G-Y, G-B, Y-B)
- 8 observers
- Full repetition
- 5x6x8x2=480 observer responses

Experimental trial



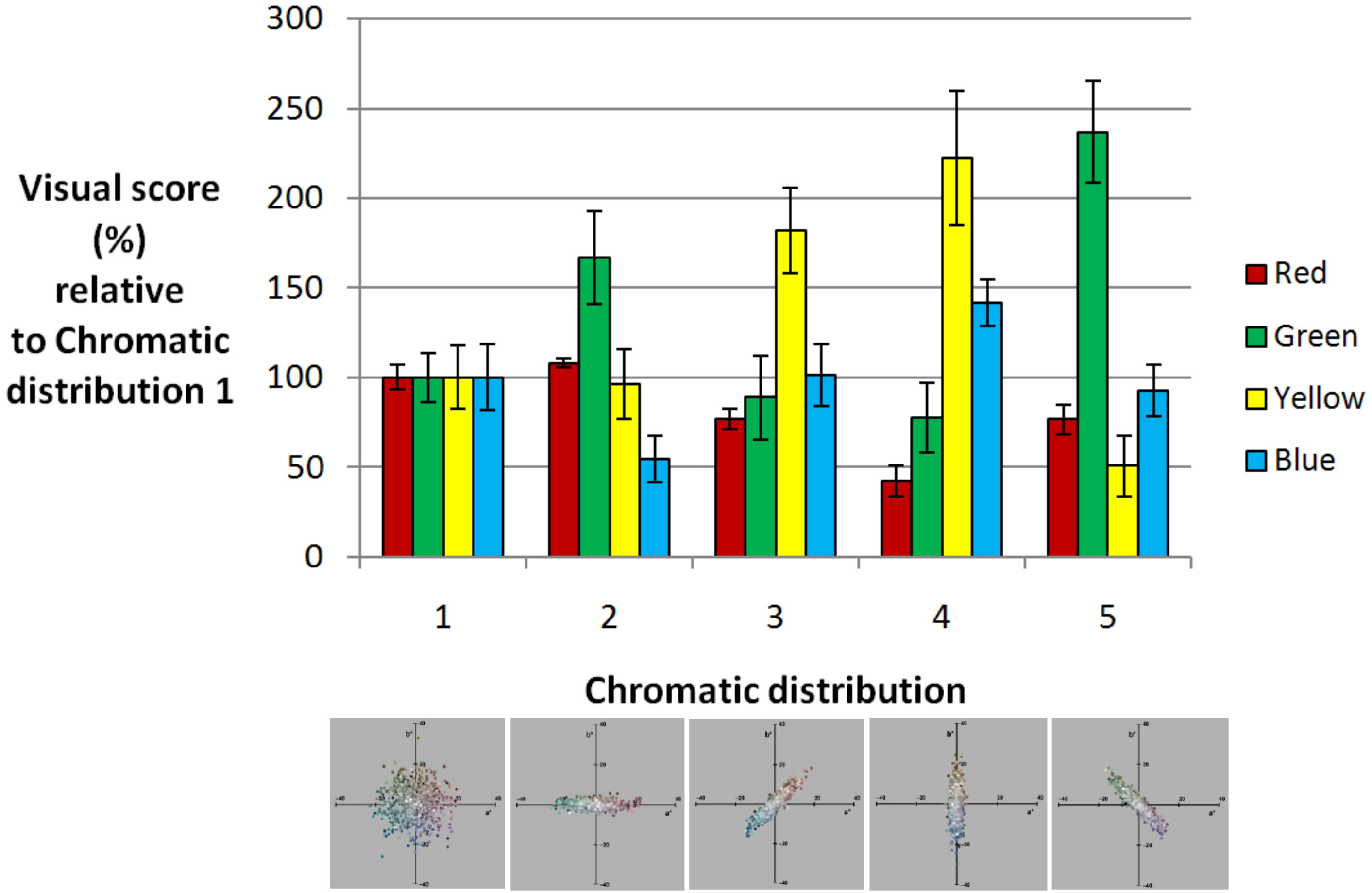
Results (average of 8 observers)





Color fidelity depends on the shape and orientation of the chromatic distribution in color space

Results



Color fidelity is better when the chromatic distribution is aligned with the illuminant change

Conclusion

- Triad illuminant comparison measures global color fidelity
- Color fidelity depends on the shape and orientation of the chromatic distribution in color space
- Color fidelity is better when the chromatic distribution is aligned with the illuminant change
- These findings may be used in CC algorithms to improve illuminant estimation (like grey world algorithm)