Figures for "Vectorial Color." Copyright 2006, James A. Worthey.

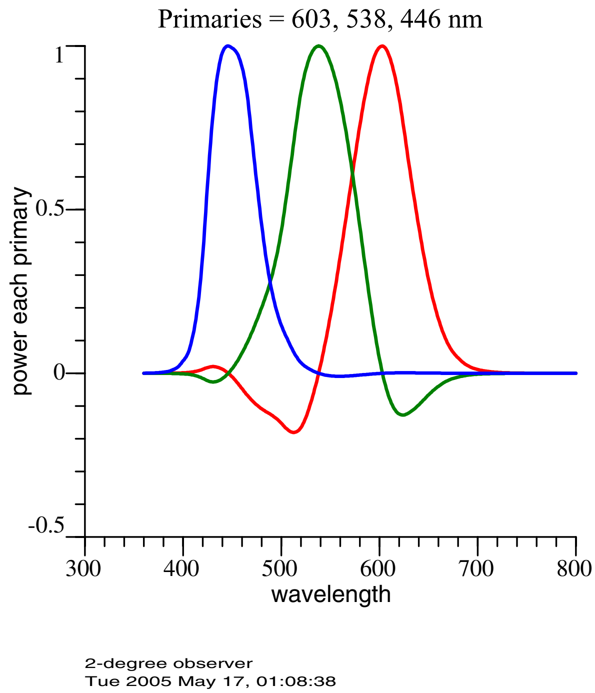


Figure 1a. Color matching functions that the 2 degree observer would give for narrow-band primaries at wavelengths of 603, 538, and 446 nm. That is, a test light of wavelength is stepped through the spectrum and the observer adjusts the amplitudes of these red, green, and blue primaries so that their sum gives a match. As usual, a negative amplitude indicates one primary being added to the test light.

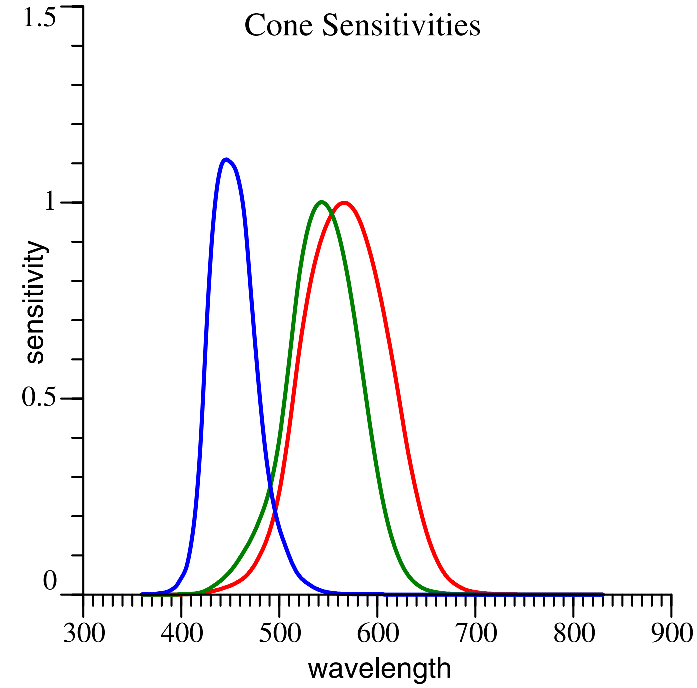


Figure 1b. A version of human cone sensitivities, but calculated to be consistent with the 2 observer.

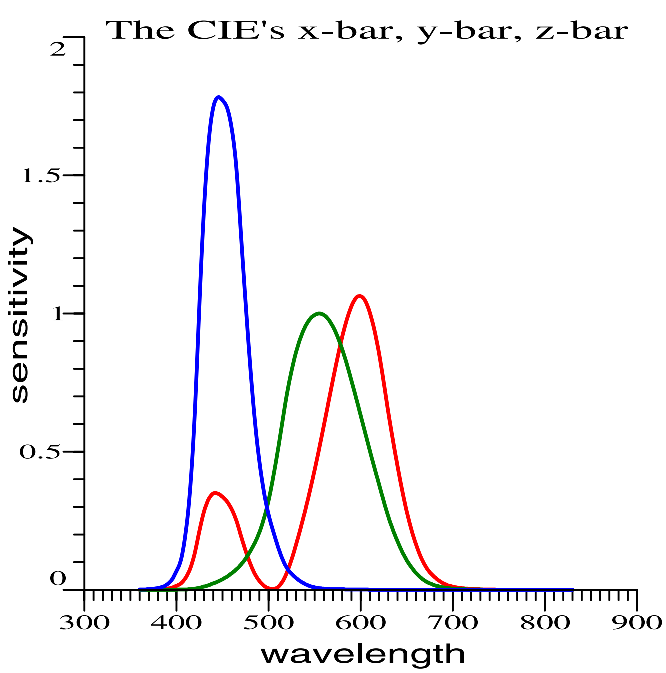


Figure 1c. The standard presentation of the 2-degree observer: functions x-bar (red), y-bar (green), and z-bar (blue).

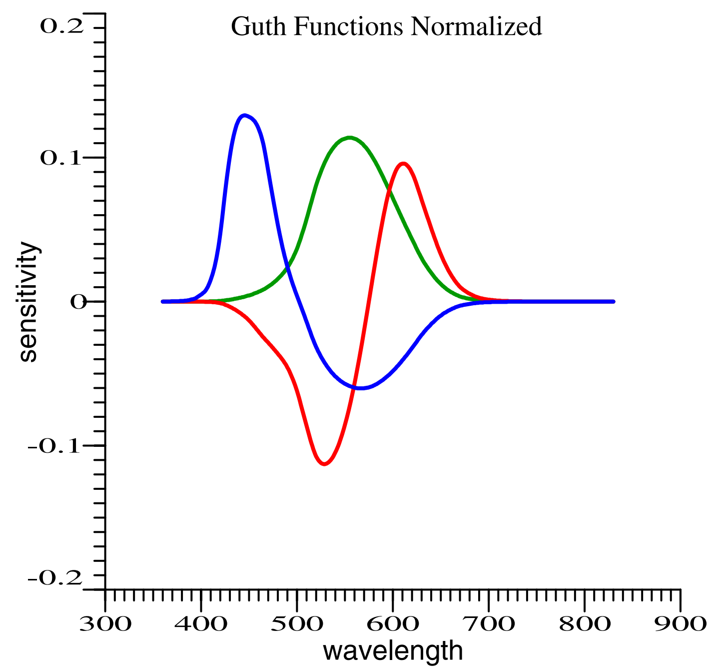


Figure 1d. These opponent functions are essentially Guth's 1980 model, but made consistent with the usual 2-degree observer and also normalized. That is, each amplitude is adjusted so that the summed square of the function equals 1, losing Guth's amplitude.

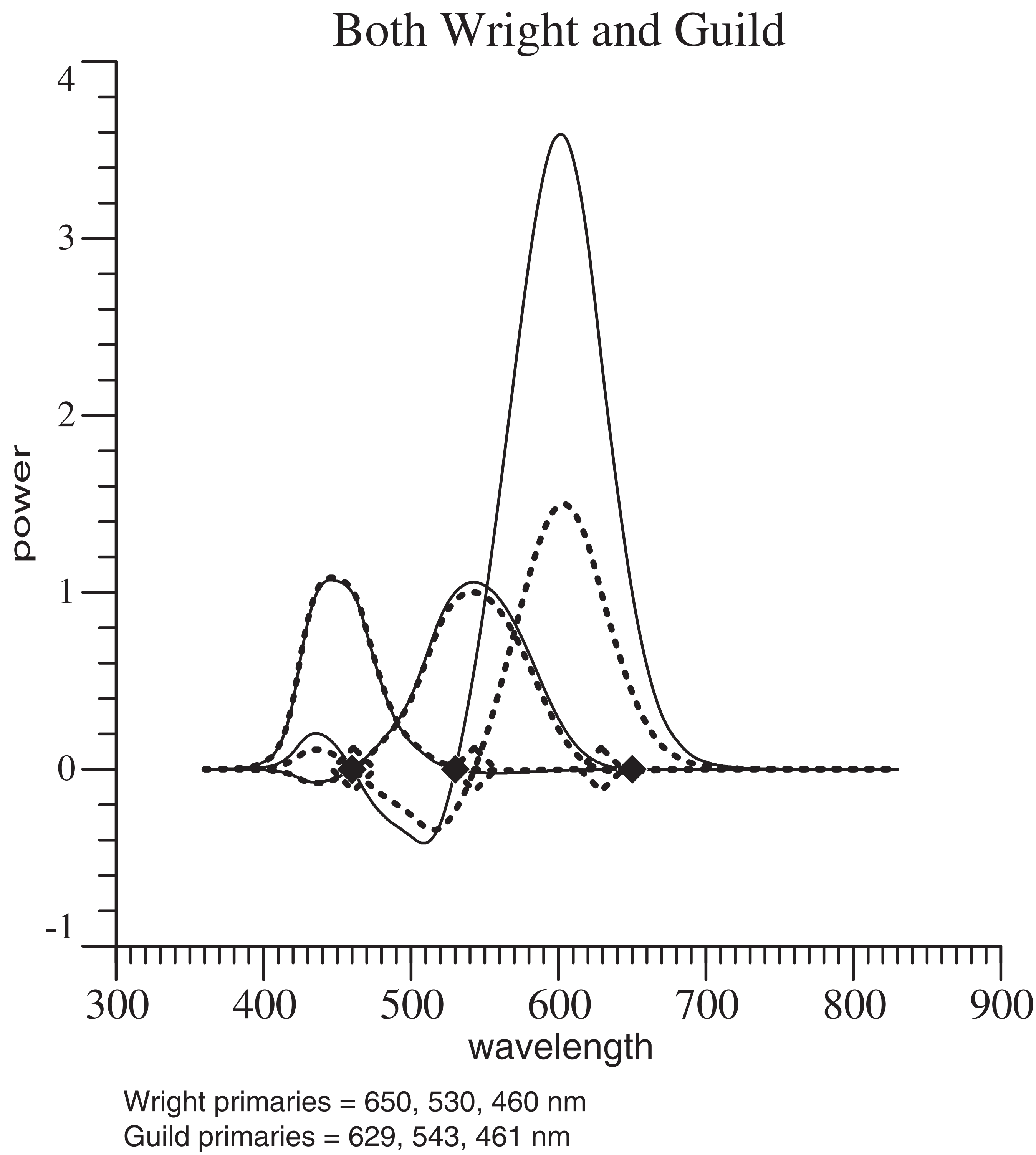


Figure 2. Approximations to the color-matching data collected by Wright and Guild in their separate experiments. The graphs are pseudo-historical data created from the 2-degree observer, but illustrate how different primaries give different results.

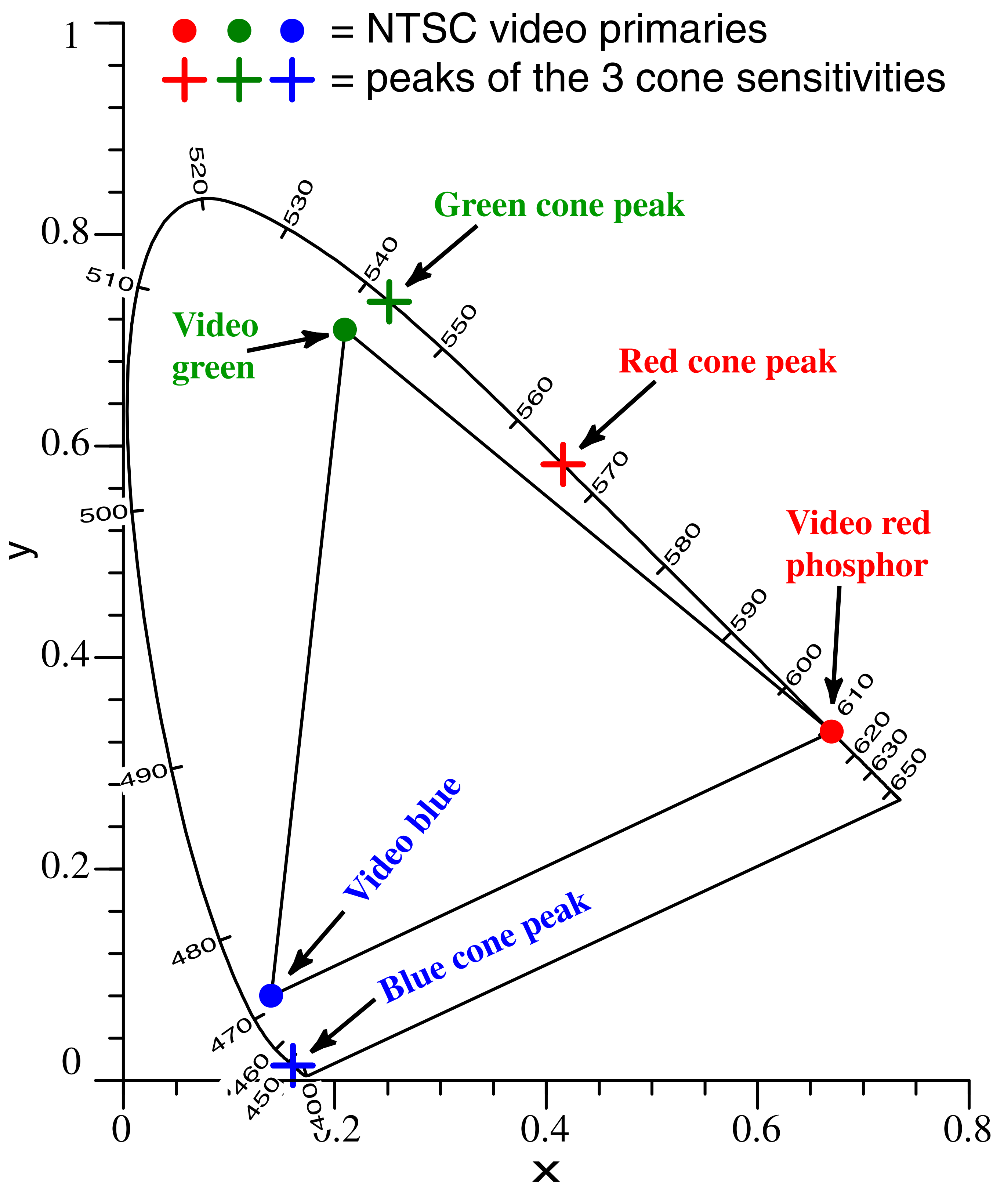


Figure 3. A traditional chromaticity diagram. Based on the cone functions of Fig. 1b, the peaks of those cone sensitivities are plotted on the spectrum locus by + signs. The NTSC video phosphors are indicated by filled circles, and by a triangle.

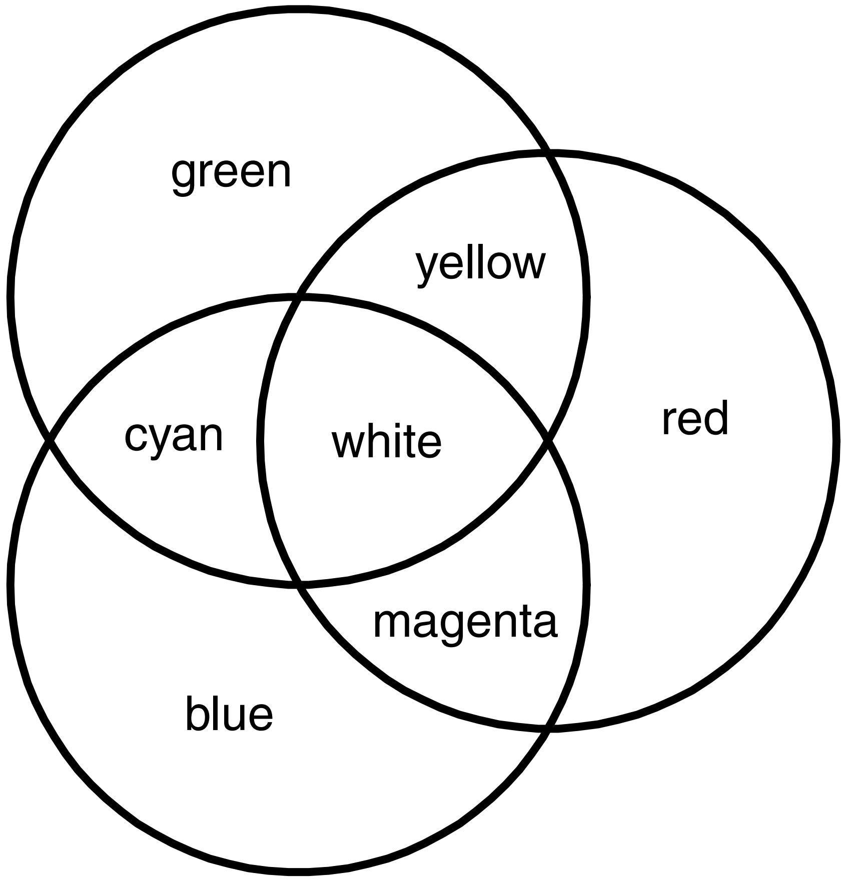


Figure 4. A traditional pictorial scheme for additive color.

Red Cone Sensitivity minus Green Cone Sensitivity

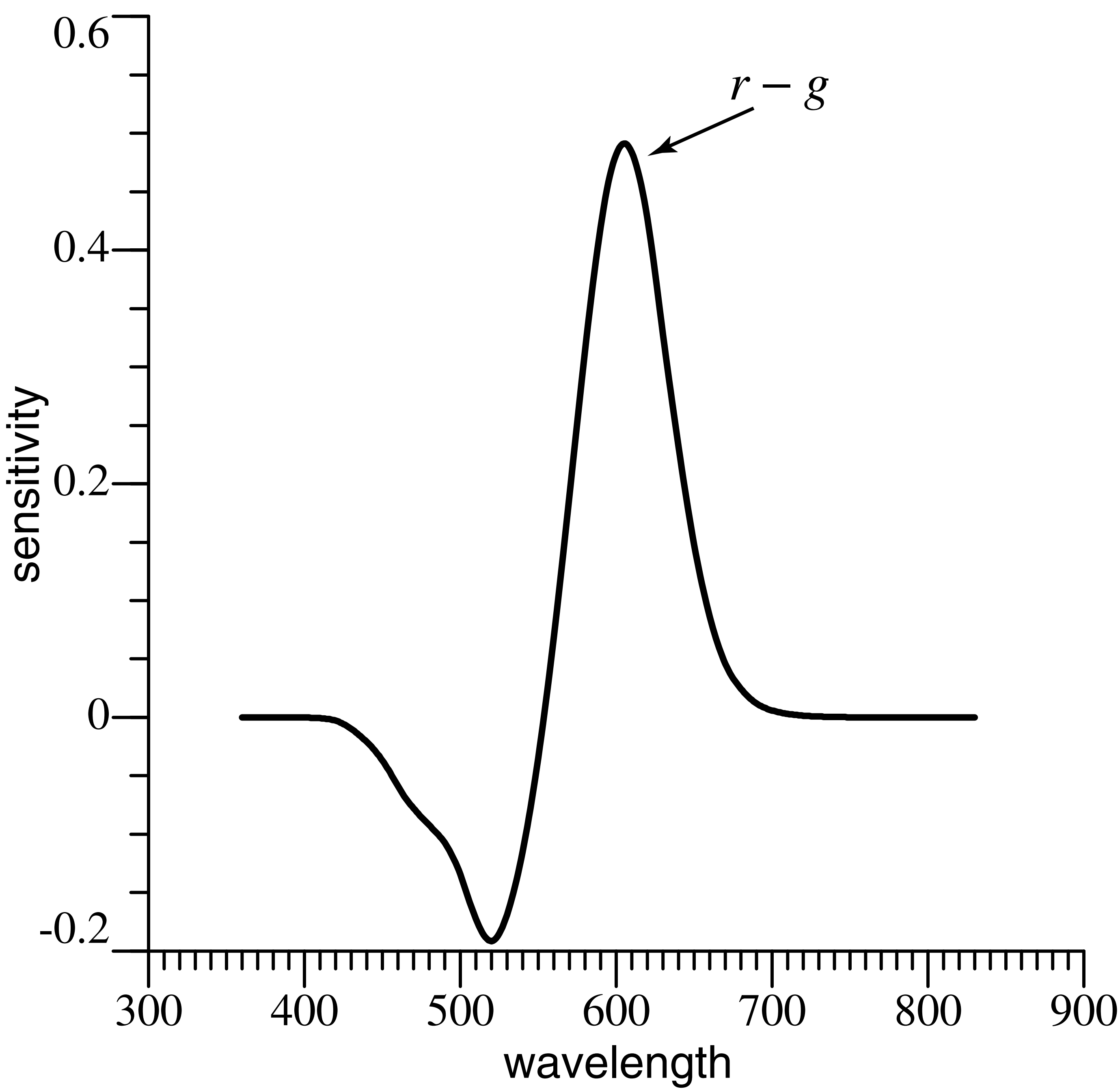


Figure 5. The red cone function minus the green cone function, with coefficients of 1.0 on both functions.

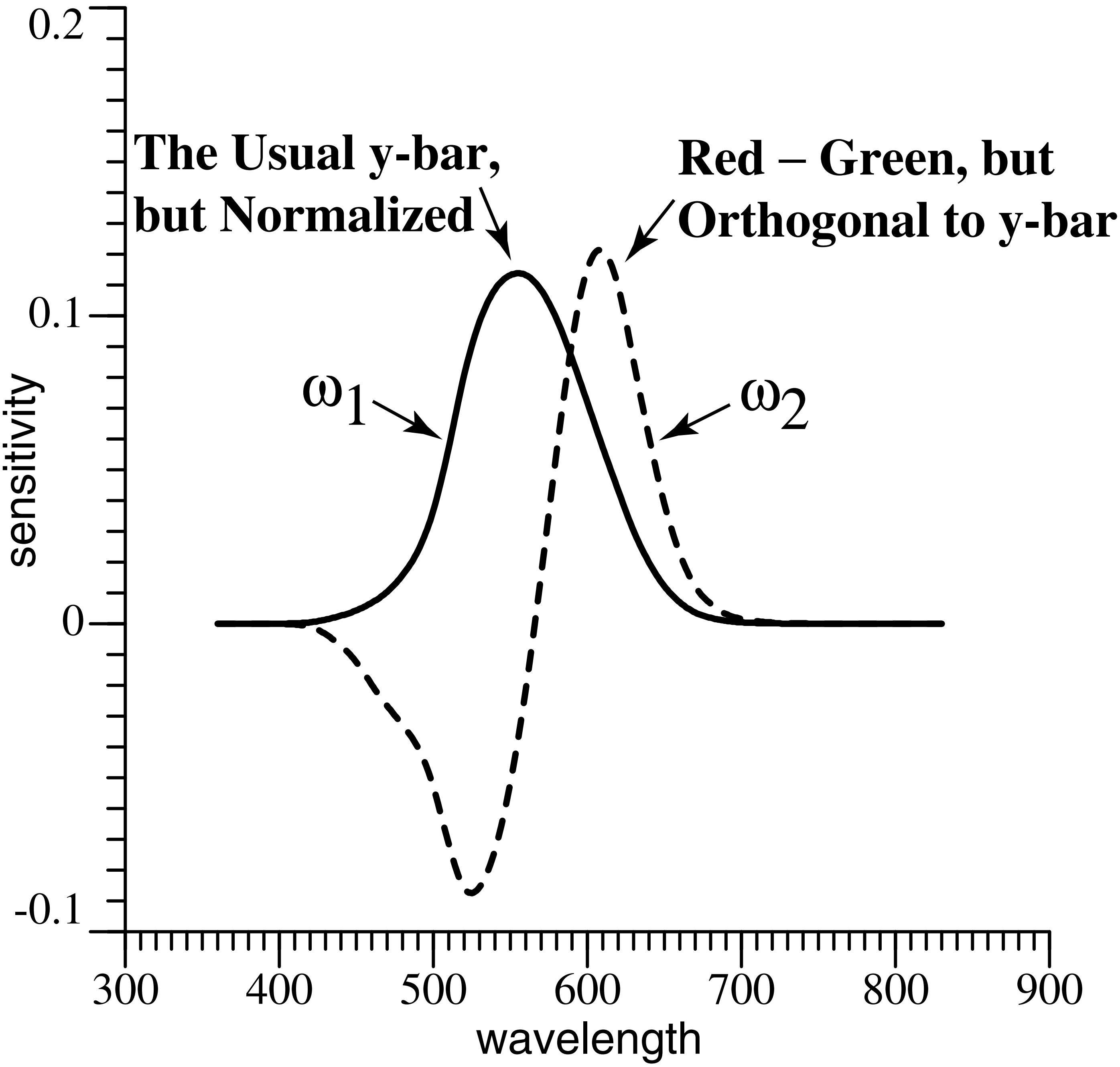


Figure 6. Orthonormal functions ω1 and ω2. The solid line indicates function ω1, which is proportional to the usual y-bar, but normalized. The dashed line is ω2, a red-green function that is orthogonal to ω1, and also normalized.

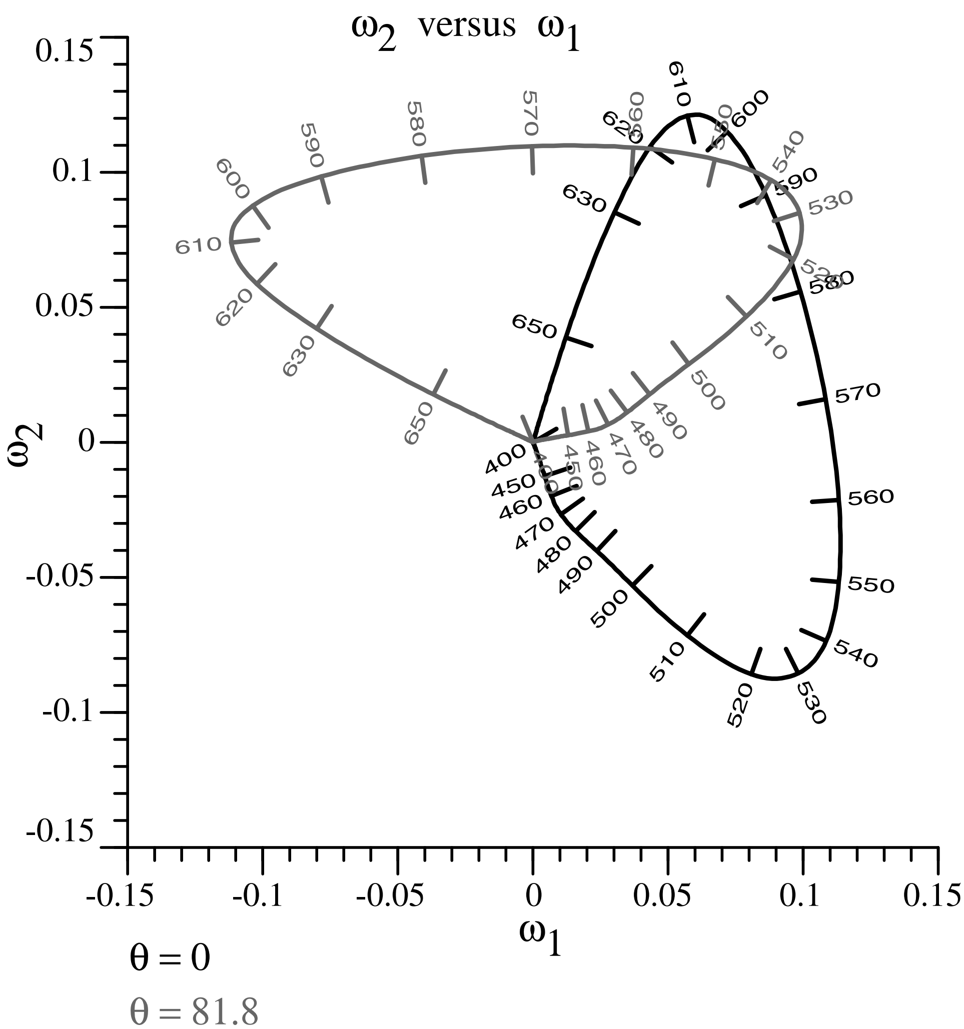


Figure 7. Plotting ω2 versus ω1, wavelength by wavelength, generates the black curve. Transforming to a different pair of functions that are still orthonormal generates the gray graph, showing that the shape is invariant (except for a possible reflection), so long as the functions are orthonormal.

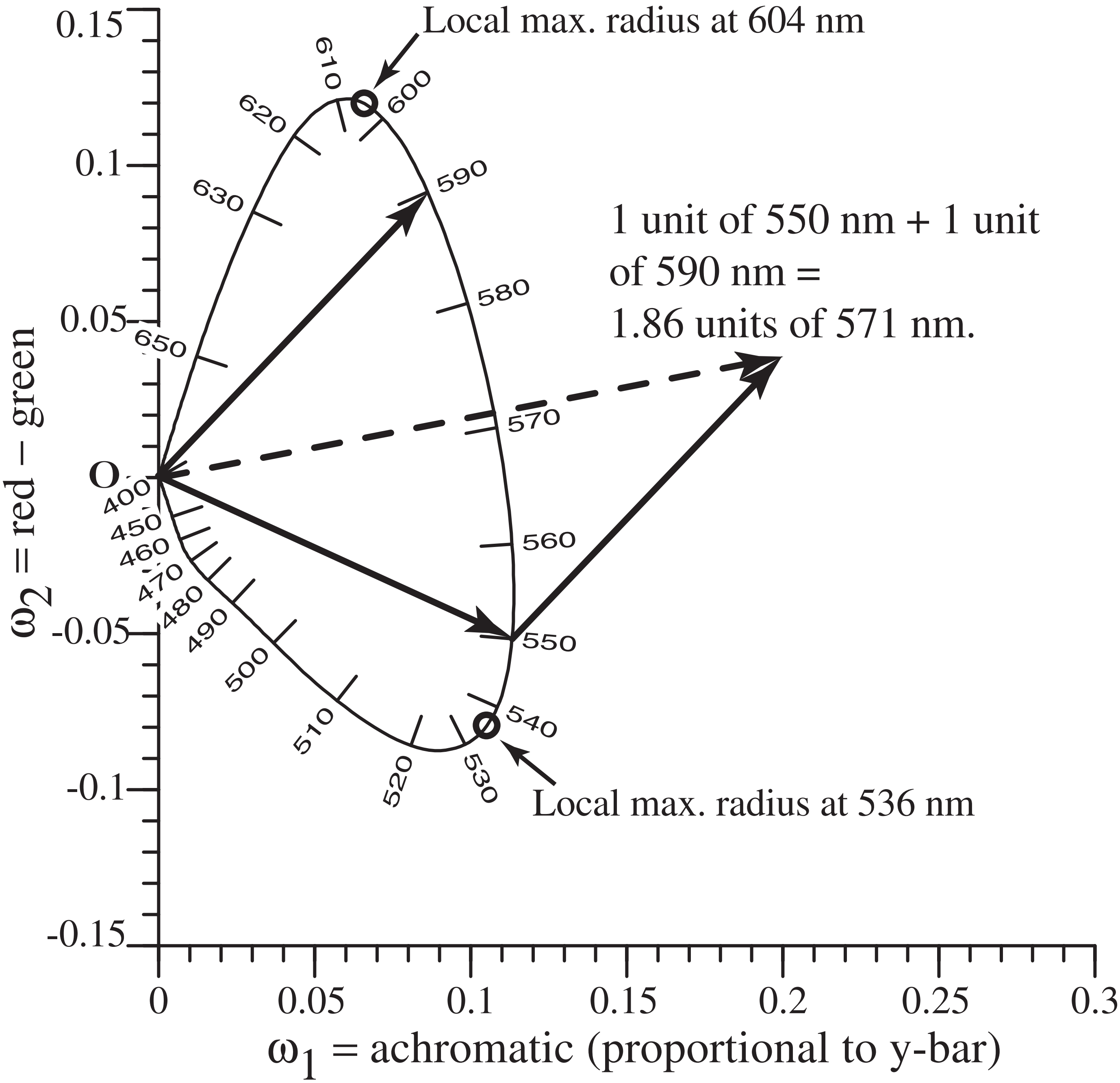


Figure 8. Reverting to the original ω1 and ω2, we see how addition of vectors describes color mixing. The local maxima of radius indicate strongly acting wavelengths.

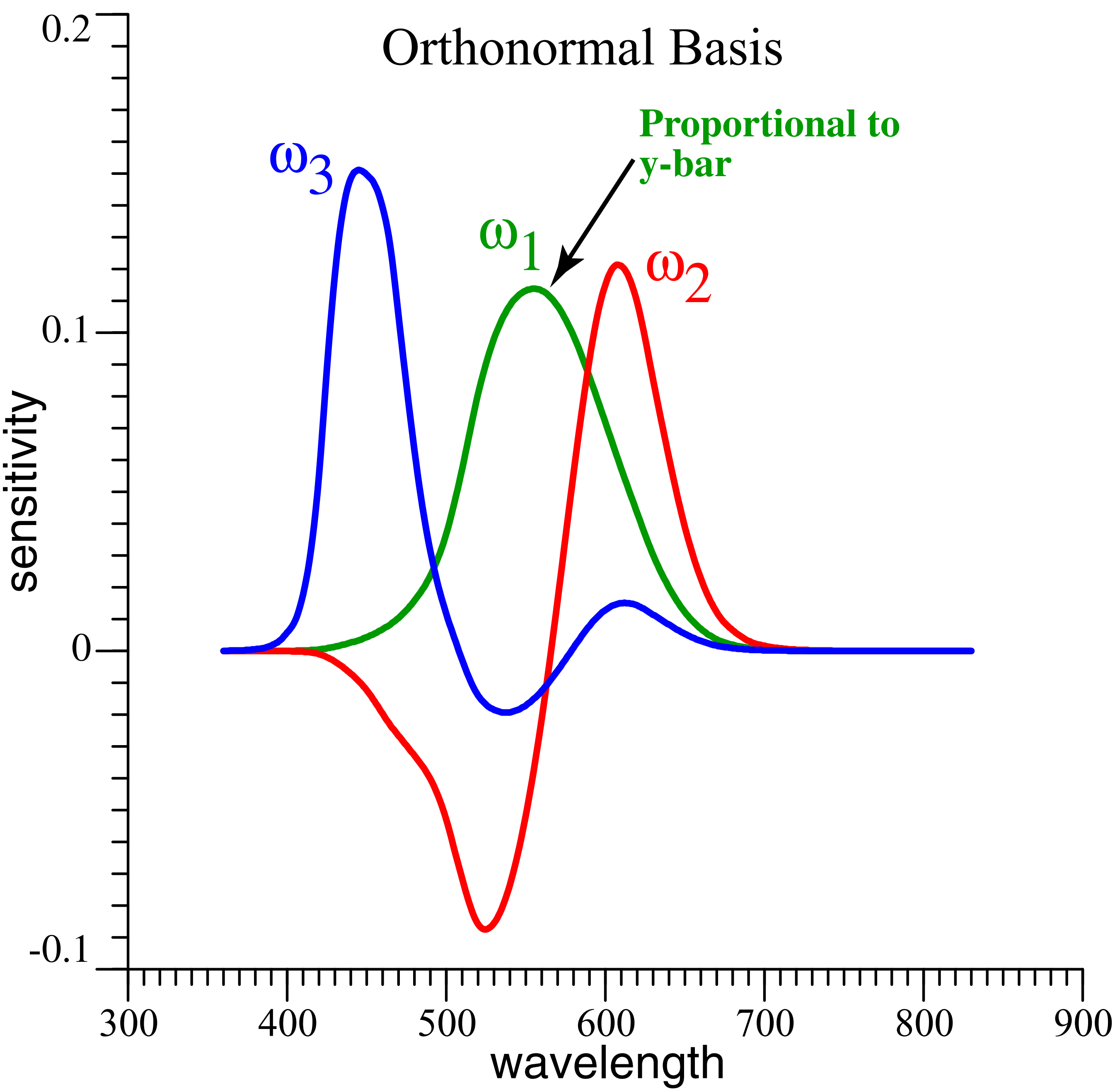


Figure 9. Orthonormal color matching functions based on the 2-degree observer.

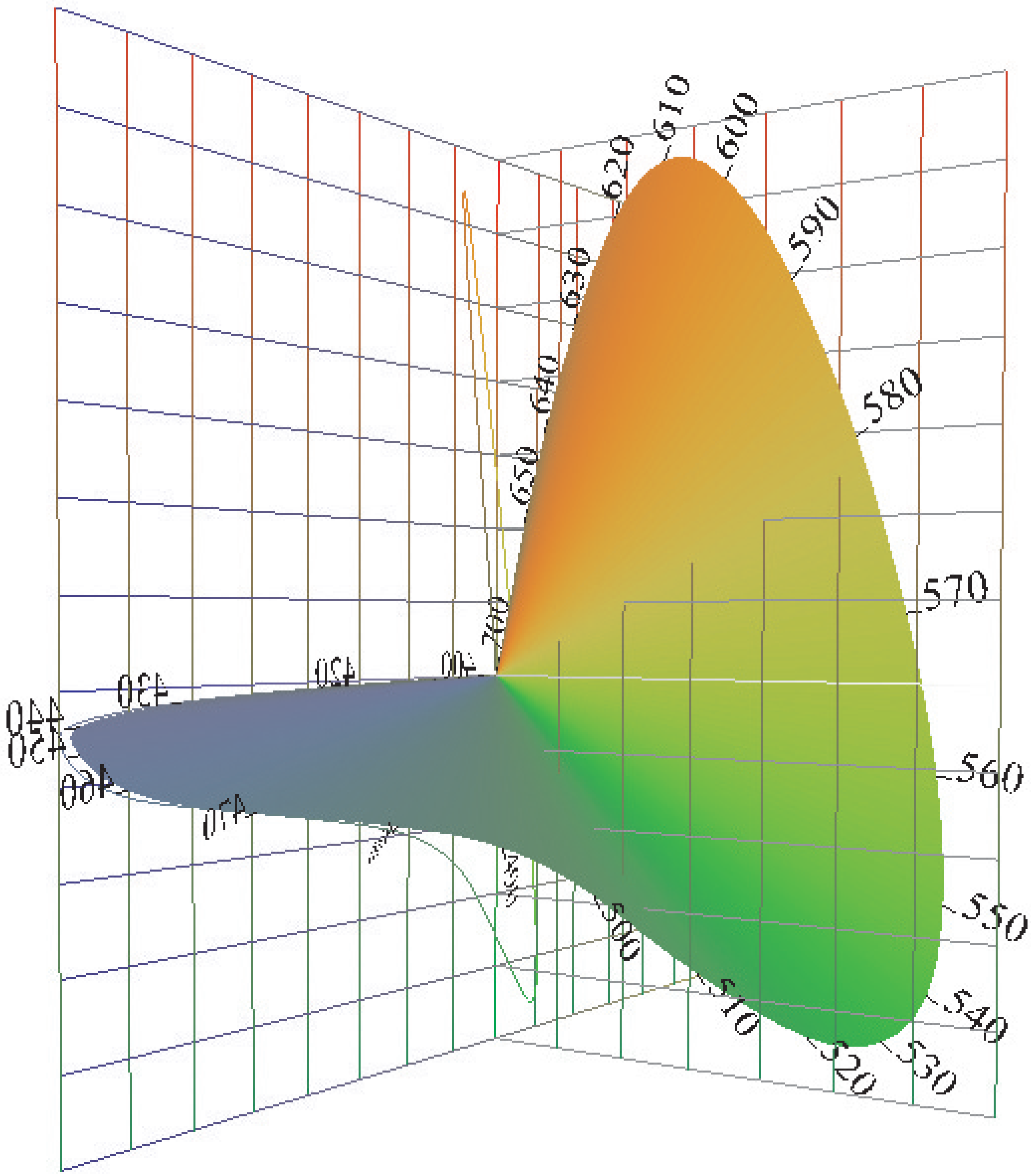


Figure 10. The orthonormal functions from Fig. 10 are combined into a 3-dimensional graph as the 2 functions were combined to make the 2-dimensional graph of Fig. 7. The graph, meaning the edge of the colored surface, is Cohen's Locus of Unit Monochromats.

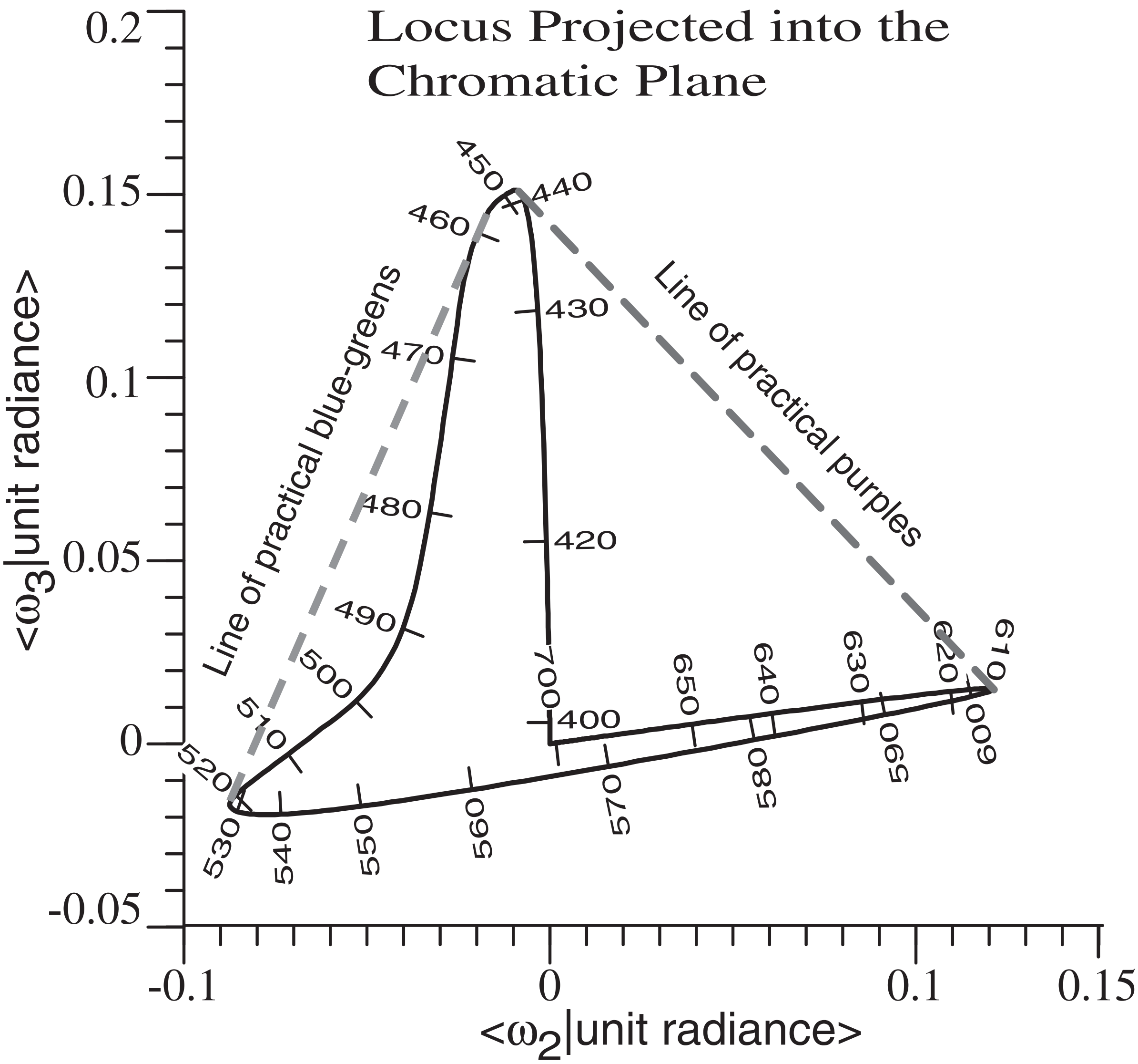


Figure 11. The Locus of Unit Monochromats is shown projected into the two chromatic dimensions, omitting the ω1 dimension.

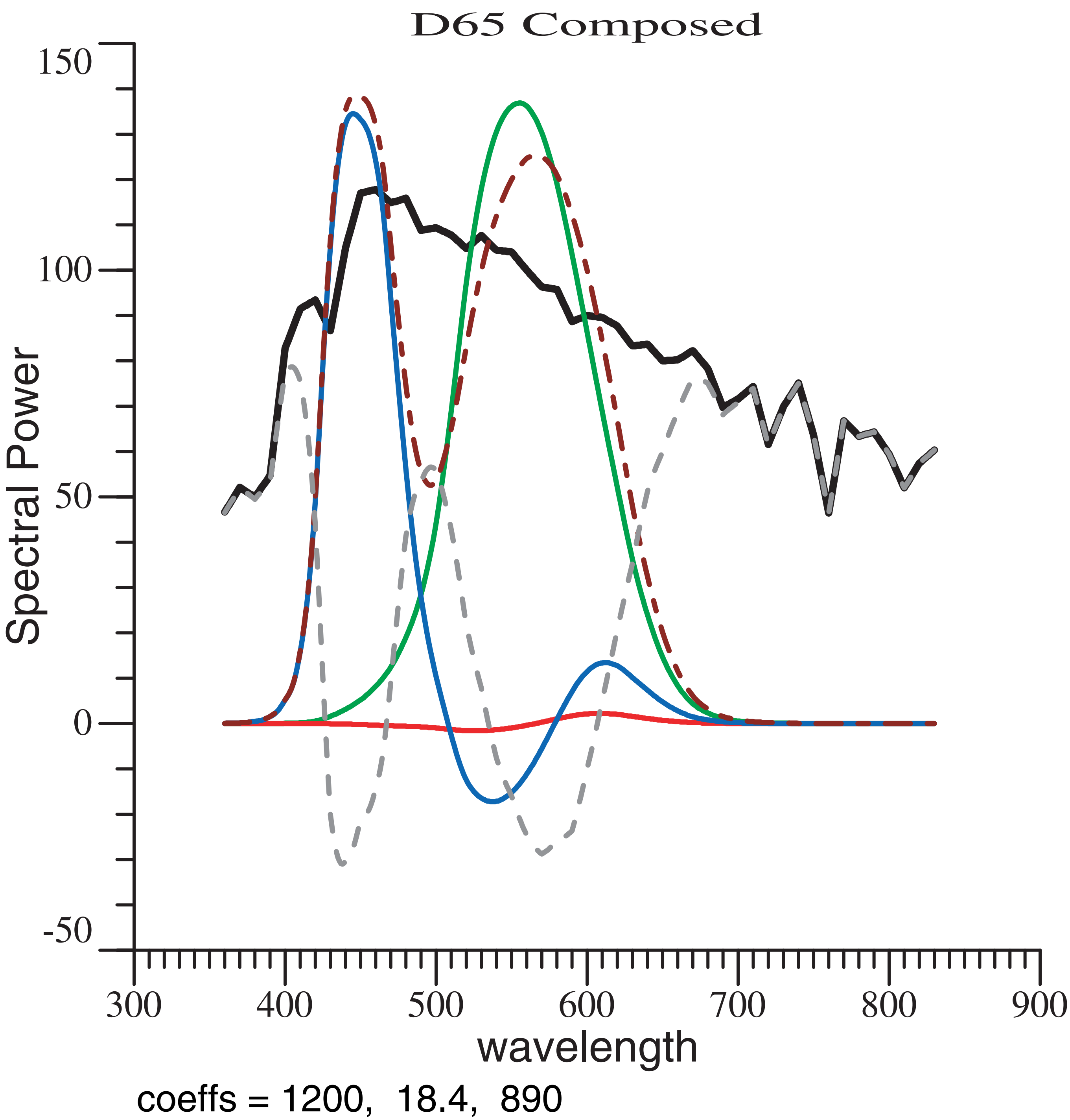
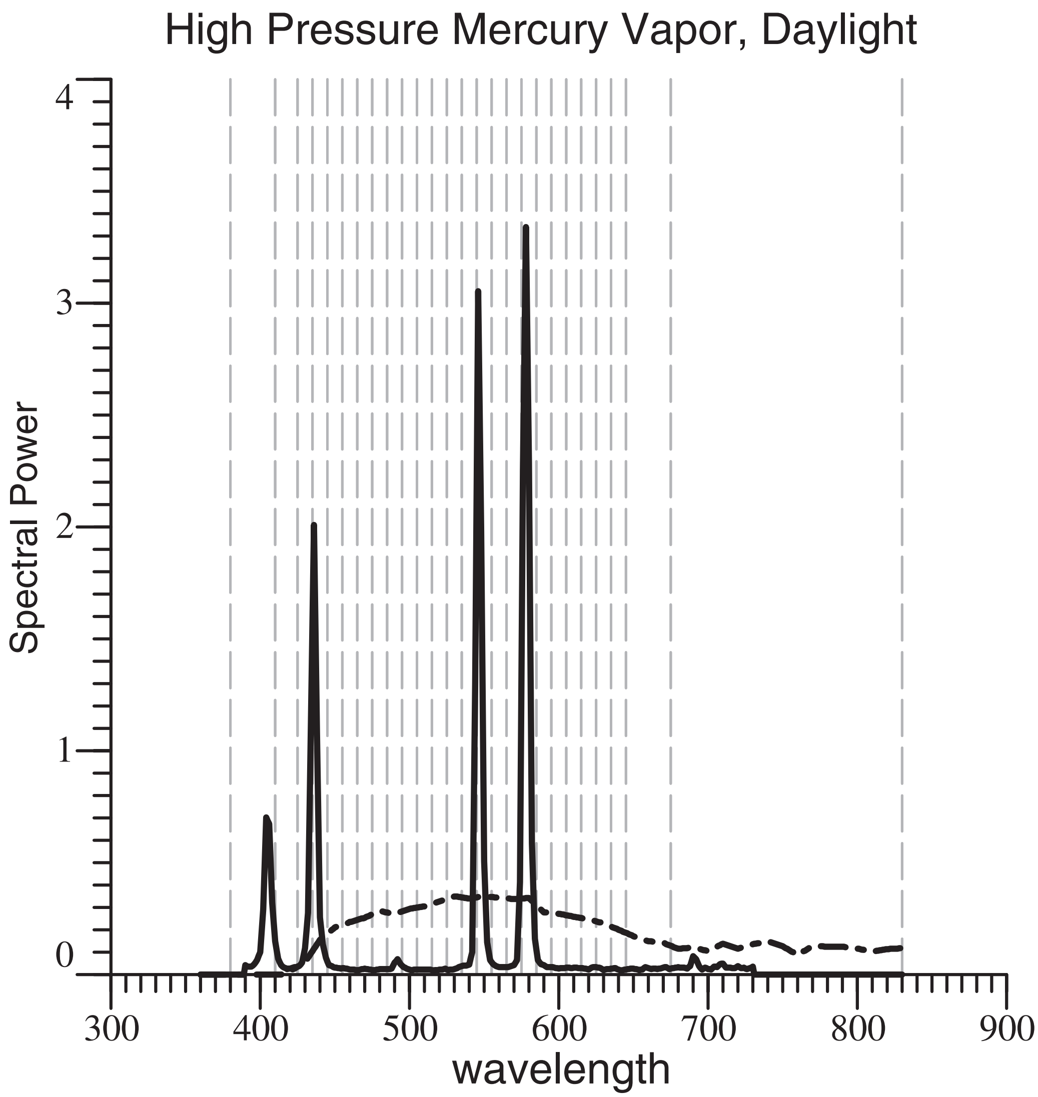


Figure 12. The heavy black curve is standard daylight D65. The maroon dash-dot curve is its fundamental metamer, D65*, which is the sum of $\omega1$, $\omega2$, and $\omega3$ components, green, red, and blue. The difference D65–D65* is the metameric black, gray dashes.



Vectors will be drawn according to indicated wavelength bins.
Original color version of this dwg is in
C:\science\omjim\OrthoModel

Figure 13. The solid curve is the measured spectrum of a mercury vapor light, while the dash-dot curve is a version of JMW daylight with the same tristimulus vector. The tristimulus match is not quite perfect. The vertical dashed lines indicate how the lights are chopped into narrow bands. In most cases, the center of the band is a round-number wavelength.

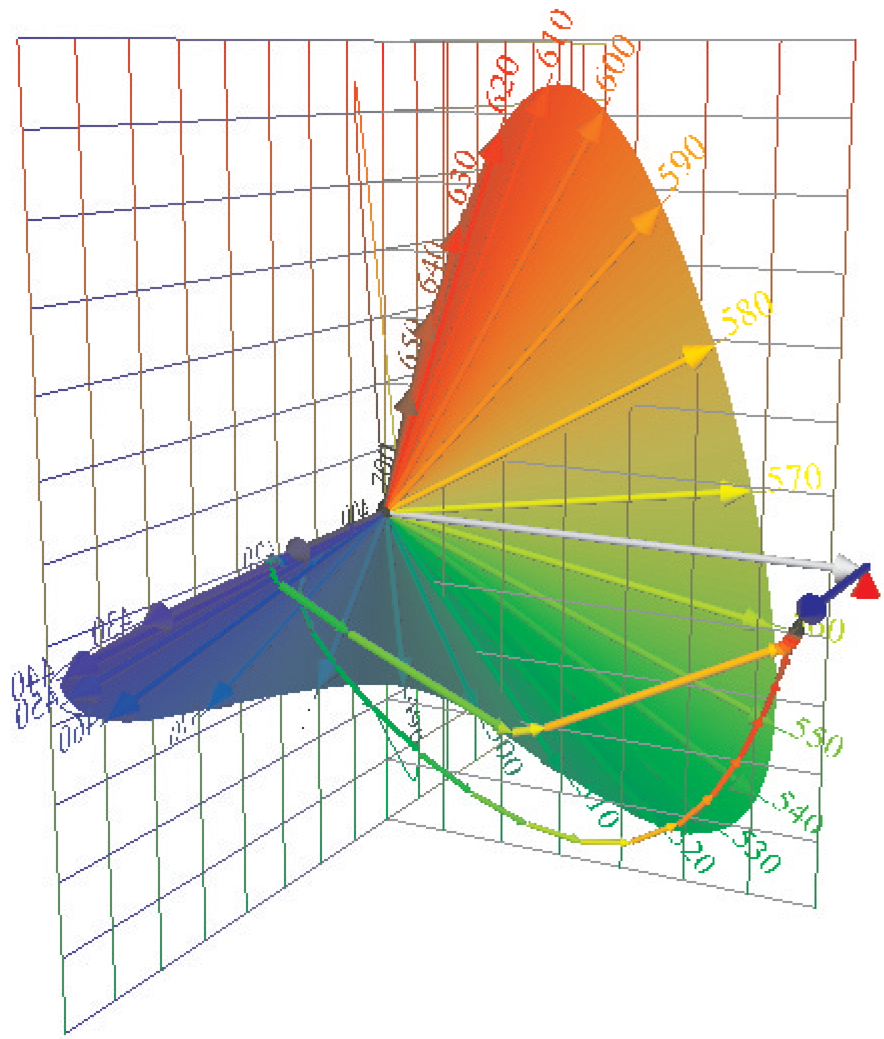


Figure 14. For each narrow band in Figure 13, and for each light, a stimulus vector is calculated. Those vectors are then chained tail-to-head in normal vector addition. The vector totals are virtually the same, but the mercury light takes a shortcut to the goal because it is poor in red and green.

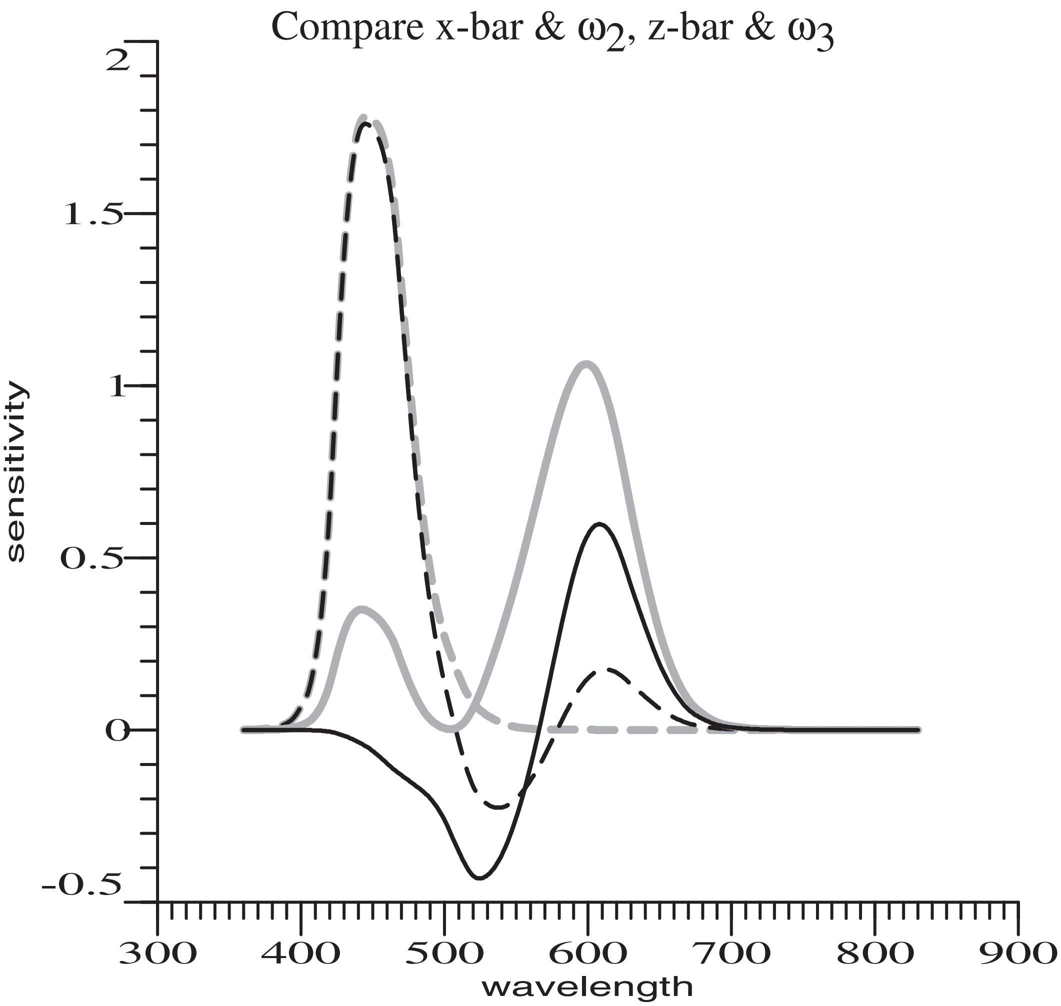


Fig. 15. The gray curves are two of the CIE functions:
gray dashed = z-bar; gray solid = x-bar.
The black curves are two of the orthonormal functions:
dashed black = ω_3 ; solid black = ω_2.

Figure 15. Comparison of old and new color matching functions. See text.

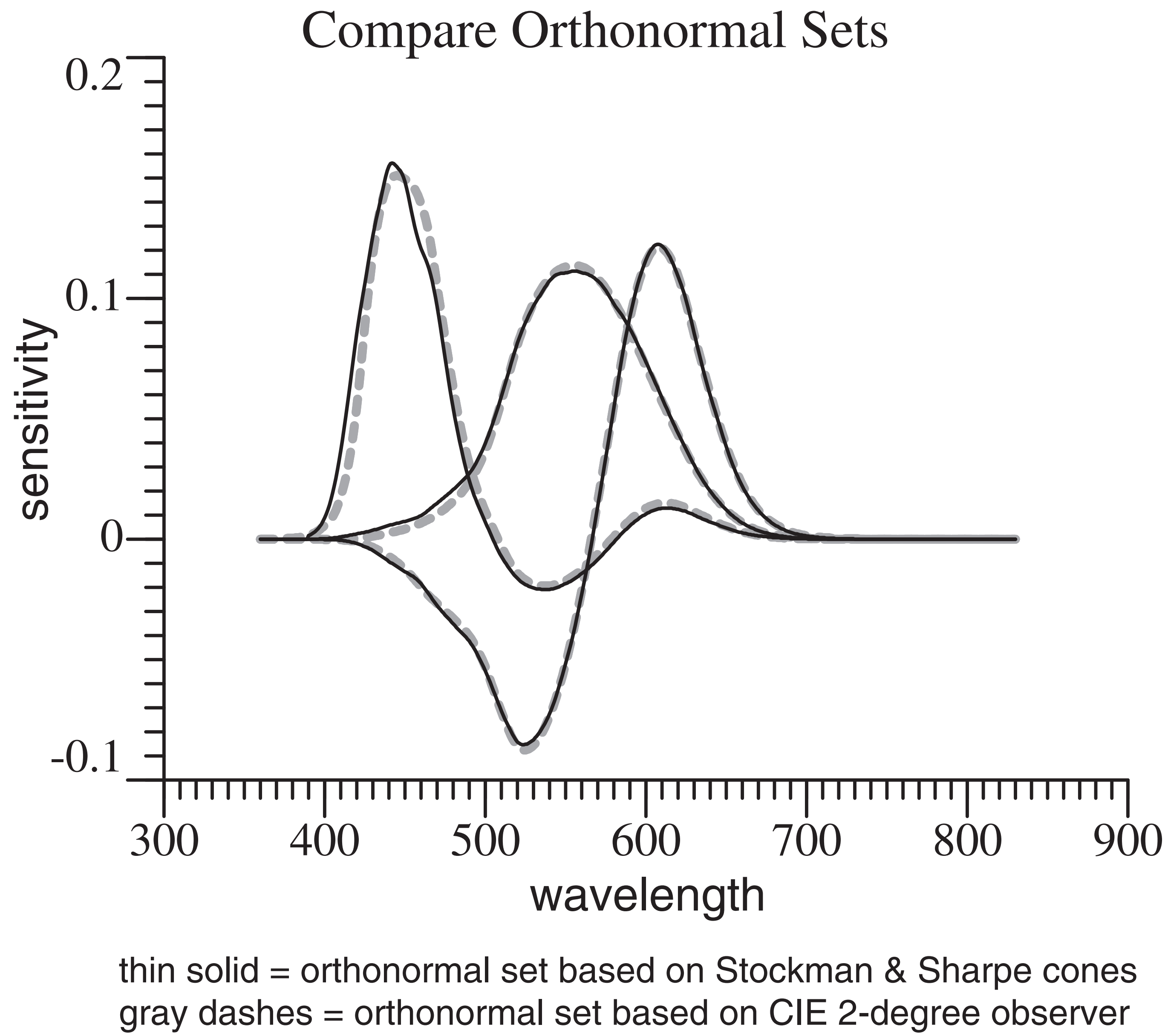


Figure C1. The thin solid lines are an orthonormal set based on Stockman and Sharpe cones. The gray dashes are an orthonormal set based on the CIE 2-degree observer.