Supporting Appendix

Contains an outline of our notation scheme and statistical calculations.

I. Data

I.1. Color systems

$\mathbf{M} = (m_{1j}, m_{2j}, m_{3j})$: coordinates of Munsell chip (Hj Vj/Cj) [1]

on the following Cartesian coordinate axes

Axis-1 represents V, white (top) to black (bottom)

Axes-2 and -3 are vertical and horizontal axes in (H, C) plane,

Axis-2 (R/BG): 5R (top) to 5BG (bottom)

Axis-3 (Y/PB): 10Y (right) to 10PB (left)

$\mathbf{L} = (L^*_j, a^*_j, b^*_j)$: the Commission International de l'Eclairage 1976 L*a*b* color space (1) [2]

I.2. Matrices and a vector on spectrum, μ is code number representing a wavelength λ

$\mathbf{S} = (s_{ju})$: spectral reflectance of Munsell chips j [3]

$\mathbf{E} = (e_{\mu})$: spectral power distribution of standard illumination D65 [4]

$\mathbf{C} = (c_{q\mu})$: spectral sensitivities of cones q, q = L, M, S, [5]

Stockman and Sharp (2)

$\mathbf{G} = (g_{j\mu})$: excitation of lateral geniculate nucleus cells j caused by

monochromatic light μ, De Valois et al. (3) [6]

II. Two plots in Fig.2

target $\mathbf{Z} = (z_{j\mu})$ [7]

regression of **Z** on **C** $\mathbf{Z} \approx \hat{\mathbf{Z}} = \left(\hat{z}_{j\mu} \right)$

$$\hat{z}_{j\mu} = a_j + \sum_q b_{jq} c_{q\mu}^{\;0.33} , \quad q = L, M, S \qquad [8]$$

normalization

$$B_{jq} = \frac{b_{jq}}{\sum_q \left| b_{jq} \right|} \qquad [9]$$

plots: $(B_{jM},\ B_{jL})$

II.1. Right B: in Eq. **7**, $z_{j\mu} = s_{j\mu} e_\mu$

Munsell chips j = 1 – 1,269, μ = 1 – 12 (λ = 420 ~ 670nm)

II.2. Left A: in Eq. **7**, $z_{j\mu}$ = ((sum of $g_{j\mu}$ of 3 intensity levels) e_μ)

LGN cells $j = 1 – 147$, $\mu = 1 – 12$ ($\lambda = 420 \sim 670$nm)

III. Fig. 4

(B_{jq}) in II.1 ($j = 1 – 1{,}269$, $q = L, M, S$), j is changed to (H V/C)

($B(H\ V/C)_q$), [10]

$H = 2.5, 5, 7.5, 10$ H, H=R, YR, Y, GY, G, BG, B, PB, P, RP

$V = 2, 2.5, 3, 4, 5, 6, 7, 8, 8.5. 9$

$C = 2, 4, 6, 8$

$q = L, M, S$

Sums of cone coefficients = $\sum_{V,C} \left| B(HV/C)_q \right|$

Means = mean (over V,C) of $B(H\ V/C)_q$

IV. Fig. 5

A: plot of (m_{2j}, m_{3j}) of **M** in Eq. **1**

B, C, D:

Regression **M** on **X**: $\mathbf{M} \approx \hat{\mathbf{M}} = \left(\hat{m}_{\alpha j}\right)$, $\alpha = 1, 2, 3$, $j = 1 - 1{,}269$

$$\hat{m}_{\alpha j} = a_{\alpha} + \sum_{k} b_{\alpha k} x_{\alpha k} \qquad [11]$$

plot: $(\hat{m}_{2j},\ \hat{m}_{3j})$

B: $\mathbf{X} = (L^*_k,\ a^*_k,\ b^*_k)$ in Eq. **2**, $k = 1 - 1{,}269$

C: $\mathbf{X} = (x_{qk})$, $q = L, M, S$, Munsell chips $k = 1 – 1{,}269$

$$x_{qk} = \sum_{\mu} \left(s_{k\mu} e_{\mu} c_{q\mu}\right)^{0.33}, \quad \mu = 1 – 12 \ (\lambda = 420 \sim 670\text{nm})$$

D: $\mathbf{X} = (x_{qk})$, $q = L, M, S$, LGN cells $k = 1 – 441$ (147 by three intensity levels)

$$x_{qk} = \sum_{\mu} \left(g_{k\mu} e_{\mu} c_{q\mu}\right)^{0.33} \quad g_{k\mu} \text{ in } \mathbf{G} \text{ Eq. } \mathbf{6}, \quad \mu = 1 – 12 \ (\lambda = 420 \sim 670\text{nm})$$

1. Wyszecki, G. & Stiles, W. S. (1982) *Color Science: Concepts and Methods, Quantitative Data and Formulae*, 2nd edition. (Wiley, New York), p. 168.
2. Stockman, A. & Sharpe, L. T. (2000) *Vision Res.* **40**, 1711–1737.
3. De Valois, R. L., Abramov, I., & Jacobs, G. H. (1966) *J. Opt. Soc. Am.* **56**, 966–977.