

Color threshold formula LABJNDS 1985 (JND=just noticeable difference)

$$\Delta E_{JND}^* = Y_0 [(\Delta Y)^2 + (a_0 \Delta a'' \cdot Y)^2 + (b_0 \Delta b'' \cdot Y)^2]^{1/2} / (s + q \cdot Y^g)$$

$$a = x/y \quad a_n = x_n/y_n \quad b = -0,4 z/y \quad b_n = -0,4 z_n/y_n$$

$$a'' = a_n + (a - a_n) / (1 + 0,5 |a - a_n|) \quad n = D65 \text{ or } A \text{ (surround)}$$

$$b'' = b_n + (b - b_n) / (1 + 0,5 |b - b_n|)$$

$$Y = (Y_1 + Y_2) / 2 \quad \Delta Y = Y_1 - Y_2 \quad \Delta a'' = a_1'' - a_2'' \quad \Delta b'' = b_1'' - b_2''$$

$$s = 0,0170 \quad q = 0,0058 \quad g = 1,0$$

$$a_0 = 1,0 \quad b_0 = 1,8 \quad Y_0 = 1,5 \quad \text{surround D65}$$

$$a_0 = 1,0 \quad b_0 = 1,7 \quad Y_0 = 1,0 \quad \text{surround A}$$

Just noticeable difference (JND) in four colour directions

$$\Delta Y = \text{const} (s + q \cdot Y^g) / Y_0 \quad \text{in luminance direction } WN$$

$$\Delta a'' \cdot Y = \text{const} (s + q \cdot Y^g) / (Y_0 \cdot a_0) \quad \text{in chromaticity direction } RG$$

$$\Delta b'' \cdot Y = \text{const} (s + q \cdot Y^g) / (Y_0 \cdot b_0) \quad \text{in chromaticity direction } YB$$

$$\Delta c_{ab}'' \cdot Y = \text{const} (s + q \cdot Y^g) / (Y_0 \cdot [a_0^2 + b_0^2]^{1/2}) \quad \text{in any chromaticity direction } c_{ab}$$

1-000030-L0

UE100-3N

Color threshold formula LABJNDS 1987 (JND=just noticeable difference)

nonlinear color terms	name and relationship with tristimulus value Y and chromaticity (a, b)	notes
WN-response or scaling function T^*_L	response in white-black direction $T^*_L = \pm A_1/A_7 \cdot \log(1+A_7 \cdot Y_{1,2}-Y_n \cdot F_Y)$ with $Y_1 = Y - 0,5 \cdot \Delta Y$ $Y_2 = Y + 0,5 \cdot \Delta Y$	$F_Y = 1/(1+A_2 \cdot Y)$ is identical for the three responses Y_n tristimulus value of the surround (n)
RG-response or scaling function T^*_A	response in red-green direction $T^*_L = \pm A_5/A_3 \cdot \log(1+A_3 \cdot a_{1,2}-a_n \cdot Y \cdot F_Y)$ with $a_1 = a - 0,5 \cdot \Delta Y$ $a_2 = a + 0,5 \cdot \Delta Y$	$a = x/y$ $b = -0,4 \cdot (1-x-y)/y$ $c = \{ [a-a_n]^2 + [b-b_n]^2 \}^{1/2}$
YB-response or scaling function T^*_B	response in yellow-blue direction $T^*_L = \pm A_6/A_4 \cdot \log(1+A_4 \cdot b_{1,2}-b_n \cdot Y \cdot F_Y)$ with $b_1 = b - 0,5 \cdot \Delta Y$ $b_2 = b + 0,5 \cdot \Delta Y$	(a_n, b_n) chromaticity of the surround (n)
radial physiological response or scaling function T^*_C	physiological response in radial direction $T^*_C = \text{const} \cdot [\log(1 + A_2 \cdot Y + A_r \cdot c_{1,2}-c_n \cdot Y) - \log(1 + A_2 \cdot Y)]$ $T^*_C = \text{achromatic} + \text{chromatic response} - \text{achromatic response}$	$A_1=58, A_2=0,39, A_3=0,85, A_4=0,37, A_5=31, A_6=19, A_7=0,015$ physical: amplitude modulation

1-000030-L0

UE100-7N

Colour spaces CIELAB 1976, sRGB, & elementary Ostwald space oRGB_e

nonlinear color terms	name and relationship with tristimulus value Y	notes
lightness CIELAB aLAB	$L^*_{\text{CIELAB}} = 116 (Y/Y_n)^{1/3} - 16 \quad (Y > 0,8)$ approximation: $L^*_{\text{aLAB}} = 100 (Y/Y_n)^g \quad (Y > 0)$	$g = 1/2, 4 = \text{gamma}$ CIELAB 1976 $Y_n = 100$
triangle brilliance sRGB _d , see IEC 61966-2-1	$T^*_{\text{sRGB},d} = 100 (Y/Y_{0,d})^g \quad (Y > 0; 7 <= Y_{0,d} <= 100)$ $= 100 (Y/Y_n)^g \cdot (Y_n/Y_{0,d})^g$ $= L^*_{\text{aLAB}} \cdot (Y_n/Y_{0,d})^g$	sRGB _d , $Y_{0wd} = 100$ $Y_{\text{sRGB},d} = 22, 71, 7$ $Y_{\text{sCMY},d} = 78, 29, 93$ $d = \text{device colours}$
triangle brilliance oRGB _e , see CIE R1-57	$T^*_{\text{oRGB},e} = 100 (Y/Y_{0,e})^g \quad (Y > 0; 7 <= Y_{0,e} <= 100)$ $= 100 (Y/Y_n)^g \cdot (Y_n/Y_{0,e})^g$ $= L^*_{\text{aLAB}} \cdot (Y_n/Y_{0,e})^g$	oRGB _e , $Y_{0we} = 100$ $Y_{\text{oRGB},e} = 41, 62, 19$ $Y_{\text{oCMY},e} = 45, 26, 84$ $e = \text{elementary colours}$
luminance difference threshold $dT^*_{\text{oRGB},e} = 1$	$dT^*_{\text{oRGB},e} / dY = dL^*_{\text{aLAB}} / dY \cdot (Y_n/Y_{0,e})^g$ $= 100 g (Y/Y_n)^{g-1} \cdot (Y_n/Y_{0,e})^g$ $dY = \text{const} \cdot (Y/Y_n)^{1-g} \cdot (Y_{0,e}/Y_n)^g$	$o = \text{optimal colours of Ostwald of maximum chromatic value } C_{ab}$ see CIE R1-57

1-000030-L0

UE101-3N

Elementary colour space with Ostwald colours oRGB_e and colours tRGB_e

nonlinear color terms	name and relationship with tristimulus value Y, and the chromaticity values (x,y)	notes
triangle brilliance oRGB _e , see CIE R1-57	$I^*_{\text{oRGB},e} = 100 (Y/Y_{0,e})^g \quad (Y > 0; 7 <= Y_{0,e} <= 100)$ $= 100 (Y/Y_n)^g \cdot (Y_n/Y_{0,e})^g$ $= L^*_{\text{aLAB}} \cdot (Y_n/Y_{0,e})^g$	oRGB _e , $Y_{0we} = 100$ $41, 62, 19 <= Y_{\text{tRGB},e} <= 100$ $45, 26, 84 <= Y_{\text{tCMY},e} <= 100$ $e = \text{elementary colours}$
triangle brilliance tRGB _e of top color solid	$I^*_{\text{tRGB},e} = 100 (Y/Y_{t,e})^g \quad (Y > 0; 7 <= Y_{t,e} <= 100)$ $= 100 (Y/Y_n)^g \cdot (Y_n/Y_{t,e})^g$ $= L^*_{\text{aLAB}} \cdot (Y_n/[Y_n + p_{co}(Y_{0e} - Y_n)])^g$	$o = \text{optimal colours of Ostwald of maximum chromatic value } C_{ab}$, see CIE R1-57
luminance difference threshold $dI^*_{\text{tRGB},e} = 1$	$dI^*_{\text{tRGB},e} / dY = dL^*_{\text{aLAB}} / dY \cdot (Y_n/Y_{t,e})^g$ $= 100 g \cdot (Y/Y_n)^{g-1} \cdot (Y_n/Y_{t,e})^g$ $dY = \text{const} \cdot (Y/Y_n)^{1-g} \cdot ([Y_n + p_{co}(Y_{0e} - Y_n)]/Y_n)^g$	$t = \text{colours on top of colour triangle}$ $p_{eo} = (x - x_n)/(x_o - x_n)$ $= \text{rel. excitation purity}$
chromaticity difference threshold	$dI^*_{\text{tRGB},e} / da = L^*_{\text{aLAB}} \cdot d[(Y_n/Y_{t,e})^g] / da$ $da = L^*_{\text{aLAB}} \cdot ([Y_n + p_{co}(Y_{0e} - Y_n)]/Y_n)^{g-1} [Y_{0e} - Y_n]/Y_n$	$p_{co} = p_{eo} \cdot y_o / y$ $p_{coa} = (a - a_n)/(a_o - a_n)$

1-000030-L0

UE101-7N

TUB-test chart UE10; Colour thresholds and colour spaces
LABJNDS 1985&87, oRGB_e, tRGB_e, and line elements

input: w/rgb/cmyk -> w/rgb/cmyk-
output: no change