

color palettes matter

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color palettes matter

using RGB or HSV to select colors for a palette does not yield optimal results

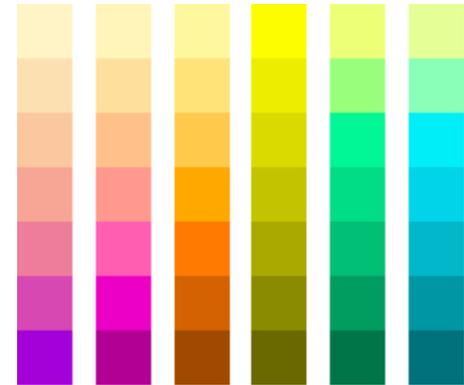
palette colors should be

- perceived as equally important

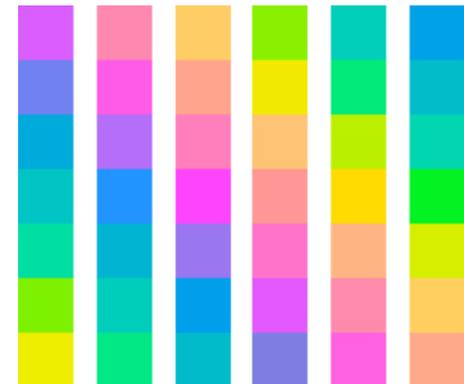
- perceived as equally distant

- perceived to have a natural order (if applicable)

neither RGB or HSV spaces take into account color perception



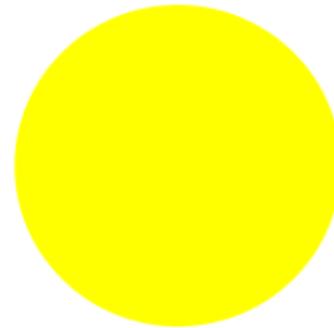
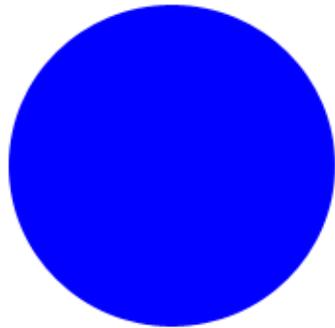
SEQUENTIAL PALETTES



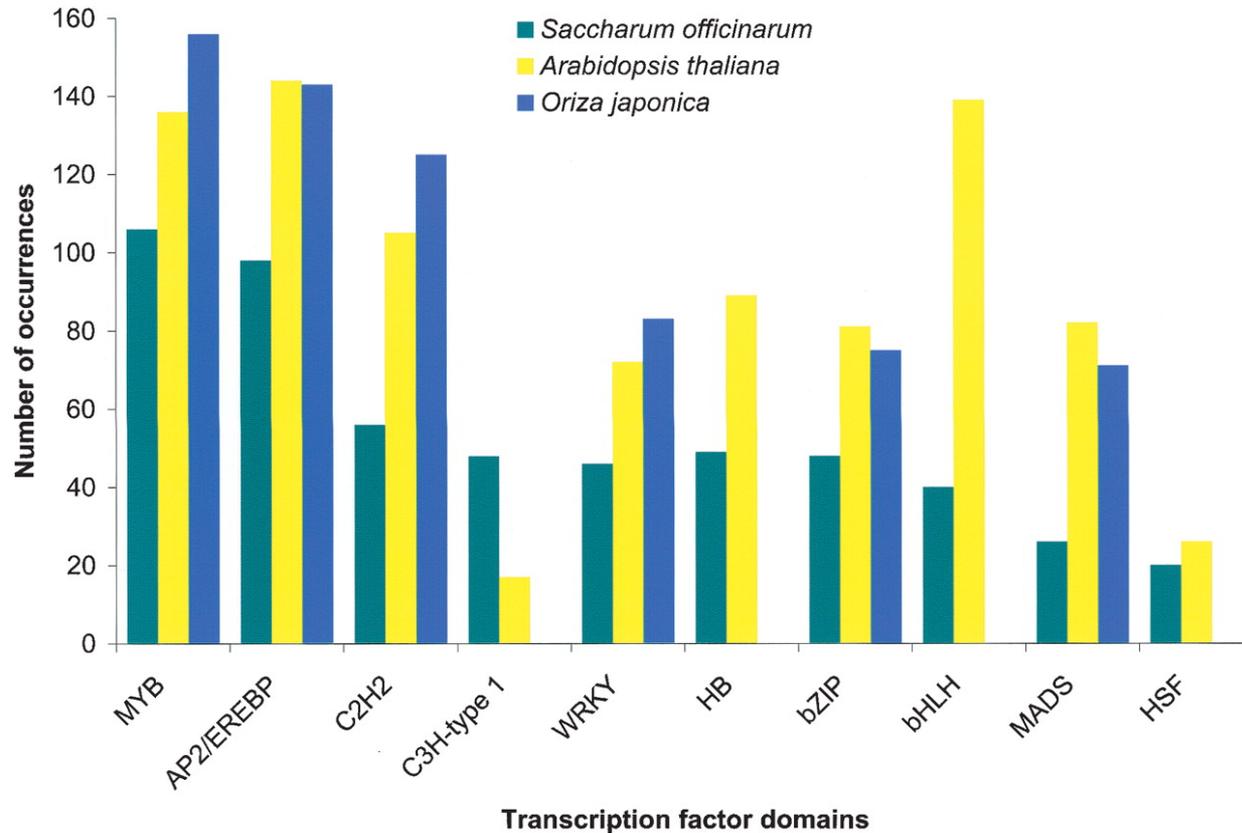
QUALITATIVE PALETTES

some hues appear brighter

yellow appears brighter

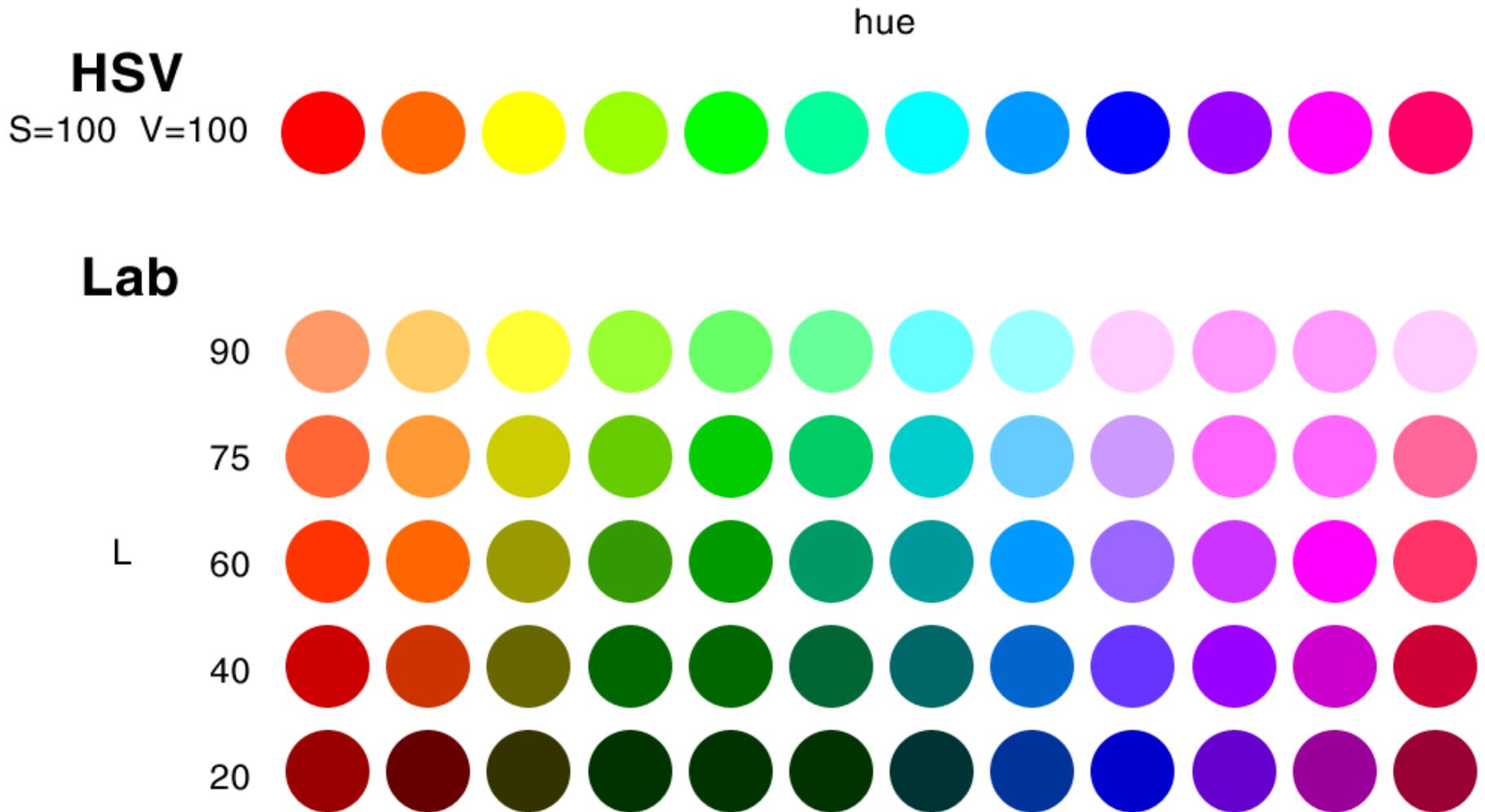


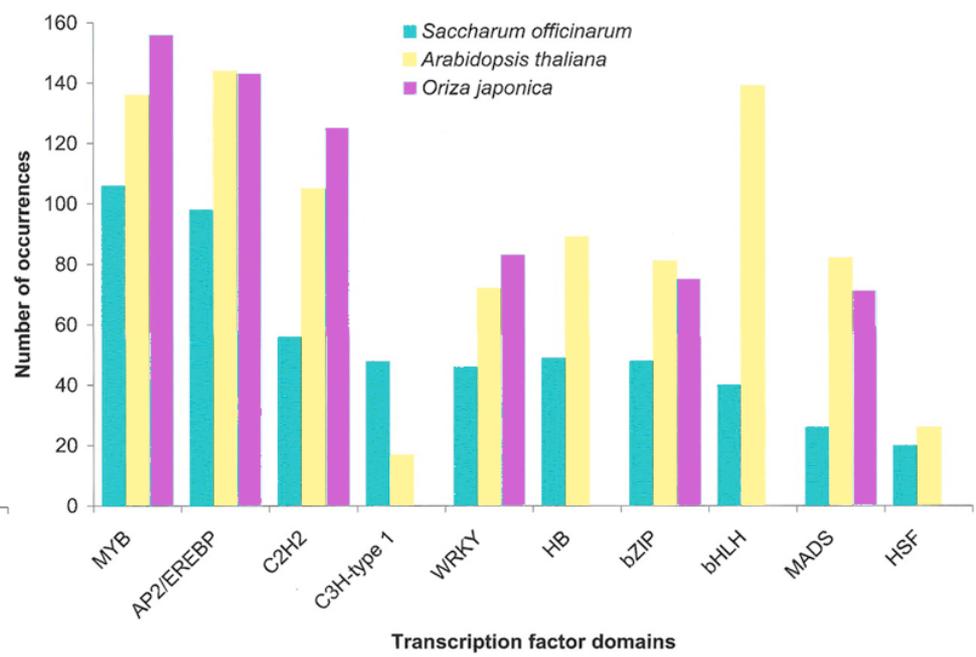
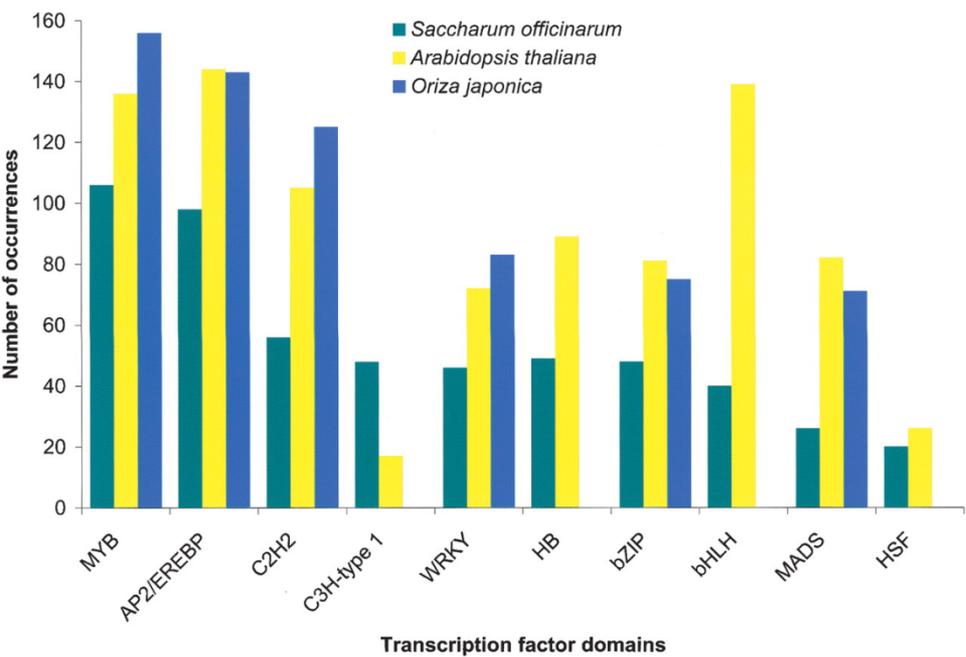
yellow commands attention



THE 10 MOST COMMON TRANSCRIPTION FACTOR PFAM DOMAINS IN SAS PROTEINS.

taking perception into account





ORIGINAL MODIFIED

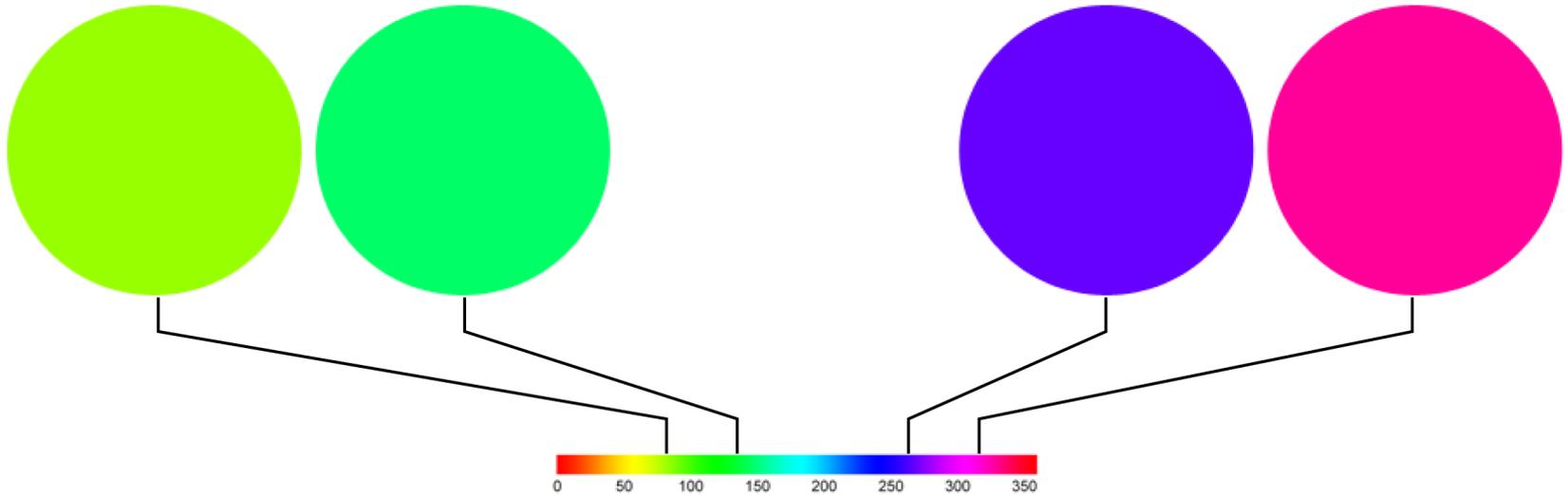
THE 10 MOST COMMON TRANSCRIPTION FACTOR PFAM DOMAINS IN SAS PROTEINS.

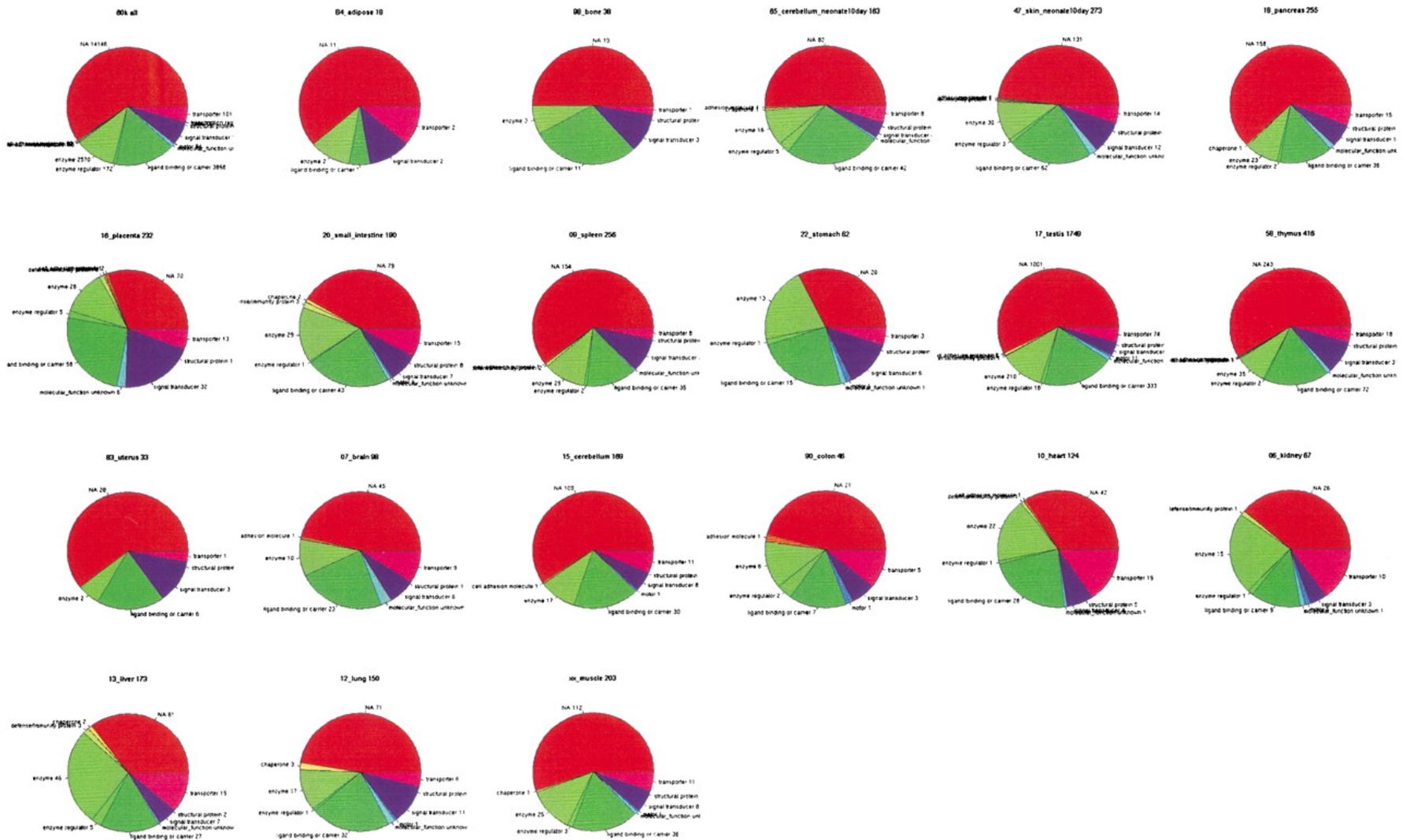
perceptual uniformity

DH=60

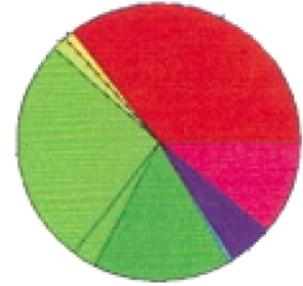
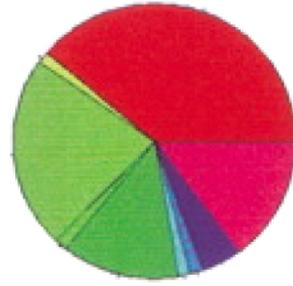
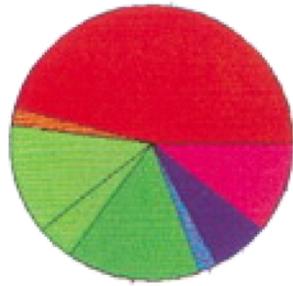
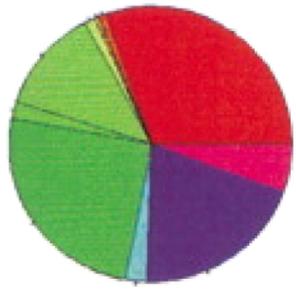
similar

different

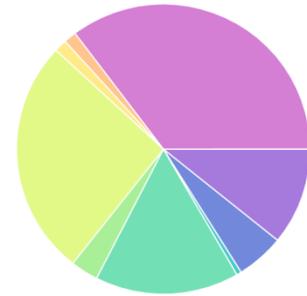
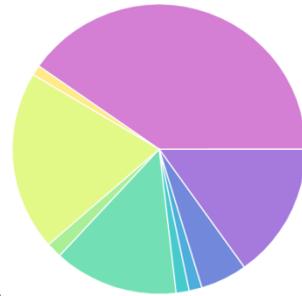
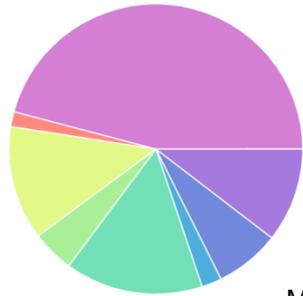
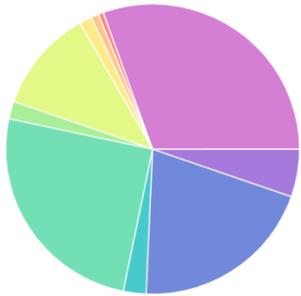




PIE CHARTS FOR TISSUE PROFILING BY GENE ONTOLOGY.



ORIGINAL



MODIFIED



PIE CHARTS FOR TISSUE PROFILING BY GENE ONTOLOGY.

palette selection – color space

to take aspects of perception into account, palettes are chosen from a color space that is designed to model human vision

all color spaces that implement response of the eye are based on the CIE XYZ color space

the human eye contains three kinds of cones

S – short wavelength – blue

M – medium wavelength – green

L – long wavelength – red

the **tristimulus value** of a color is the amount of each primary color needed to match a test color

matching is done empirically, with large number of human subjects

tristimulus values are defined in **X,Y,Z** color space

XYZ – briefly

color matching was performed by
Herman Grassman

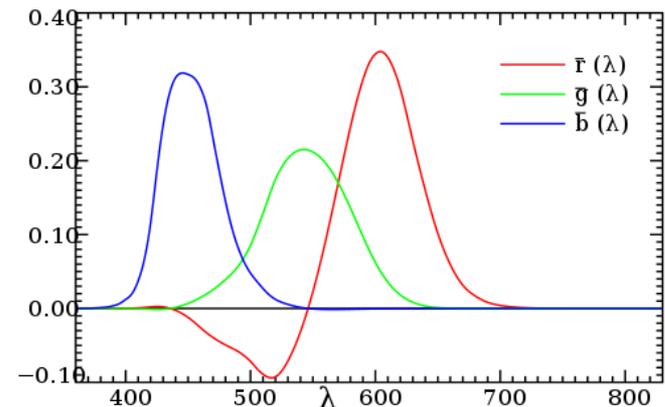
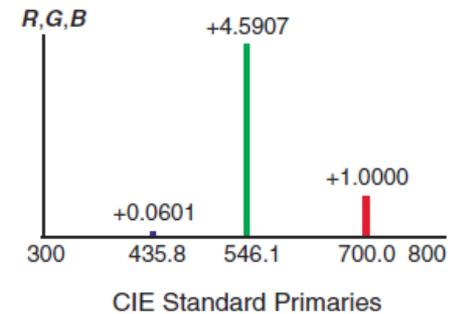
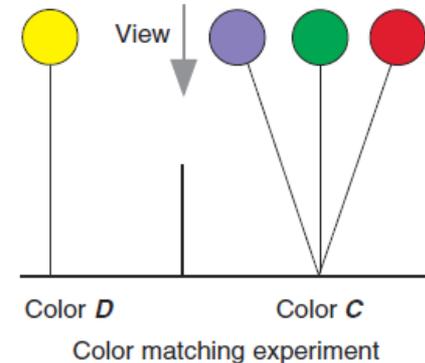
later, results were reinterpreted for
monochromatic primaries at
standardized wavelengths of 436,
546 and 700 nm (red, green, blue) .

the result were the CIE 1931 RGB
Color matching functions, giving the
amounts of primaries needed to
match the monochromatic test
primary

$$R = \int_0^{\infty} I(\lambda) \bar{r}(\lambda) d\lambda$$

$$G = \int_0^{\infty} I(\lambda) \bar{g}(\lambda) d\lambda$$

$$B = \int_0^{\infty} I(\lambda) \bar{b}(\lambda) d\lambda$$



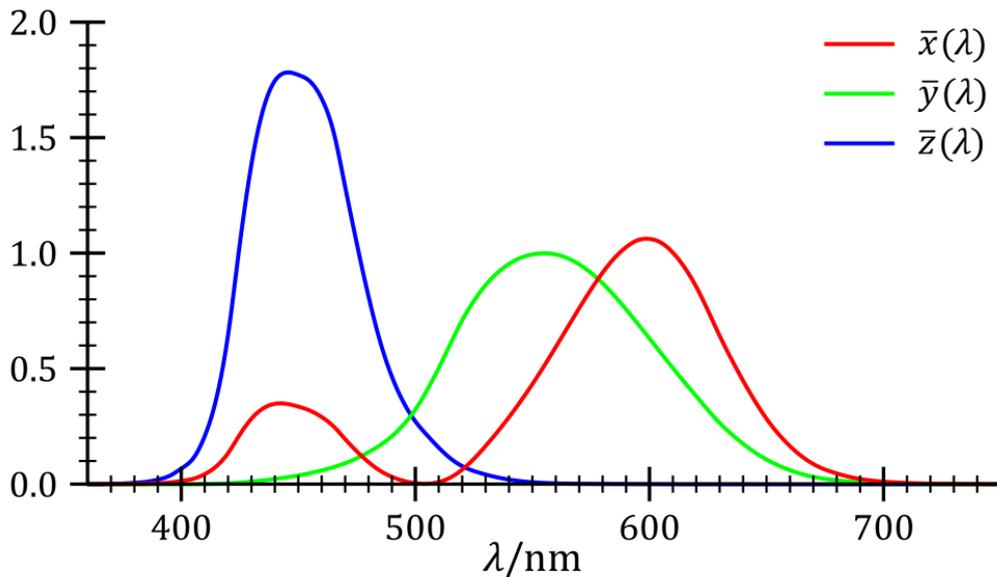
XYZ - briefly

CIE proposed to modify the color matching functions (essentially a change of basis)

everywhere greater than or equal to zero.

the color matching function would take into account the variation of perceived brightness with wavelength (Y component).

were be set to zero in certain regions for computational simplicity



$$X = \int_0^{\infty} I(\lambda) \bar{x}(\lambda) d\lambda$$

$$Y = \int_0^{\infty} I(\lambda) \bar{y}(\lambda) d\lambda$$

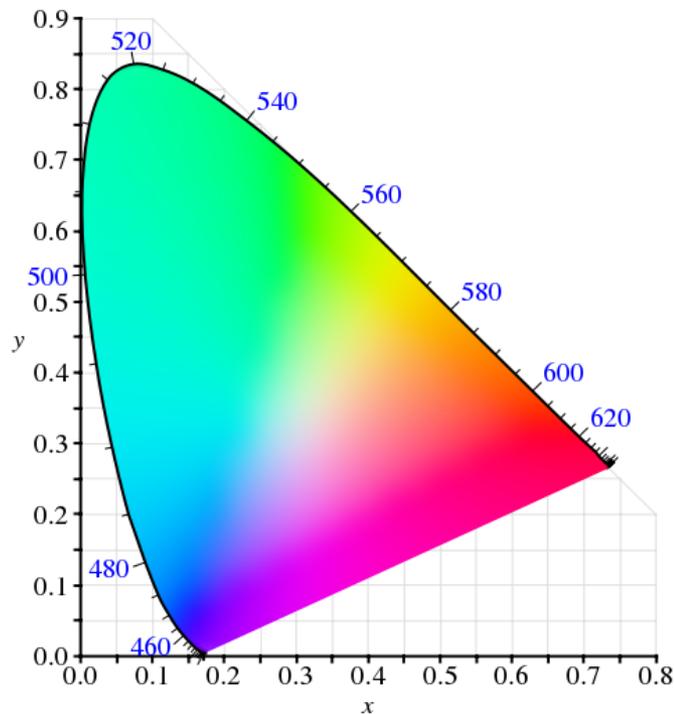
$$Z = \int_0^{\infty} I(\lambda) \bar{z}(\lambda) d\lambda$$

XYZ to xyY

color can be characterized by **brightness** and **chromaticity**

white and grey have the same chromaticity, but different brightness

$$x = \frac{X}{X+Y+Z}$$
$$y = \frac{Y}{X+Y+Z}$$
$$z = \frac{Z}{X+Y+Z} = 1 - x - y$$

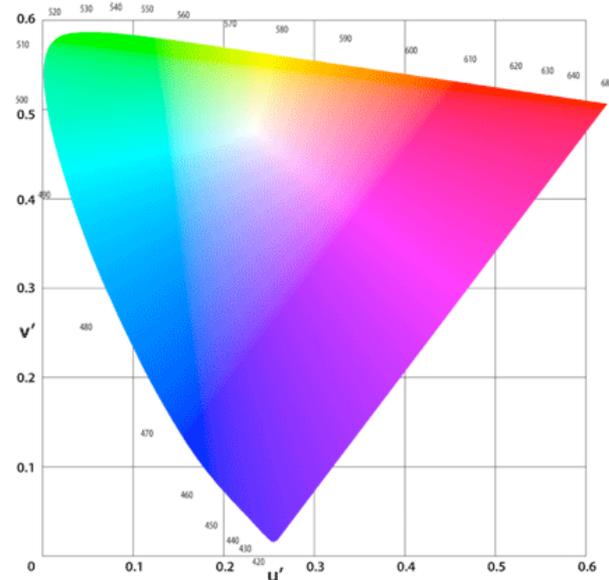
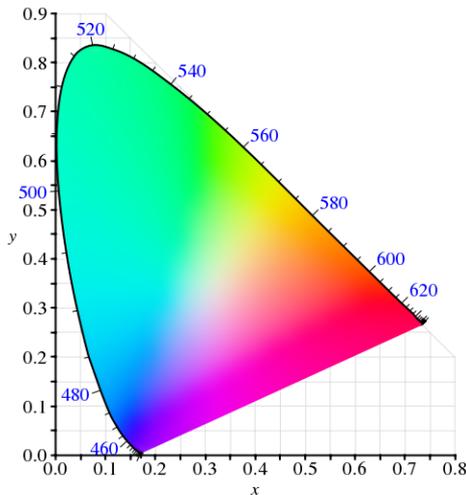


perceptual uniformity

XYZ space is not perceptually uniform

relative distances in XYZ space do not correspond to relative perceived differences

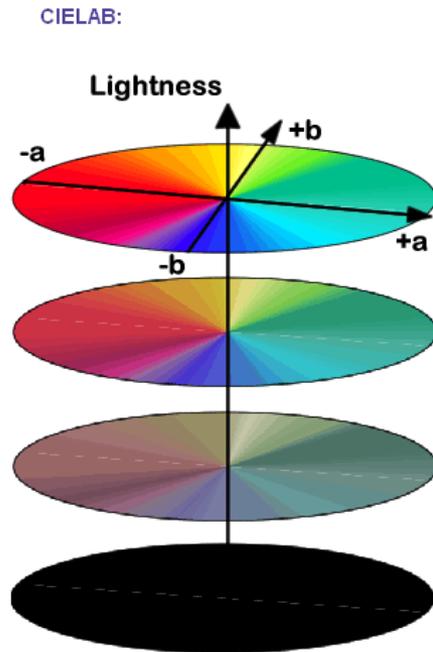
to include uniformity, XYZ is transformed to LUV
lightness and two chromaticities u, v



LUV to LCH

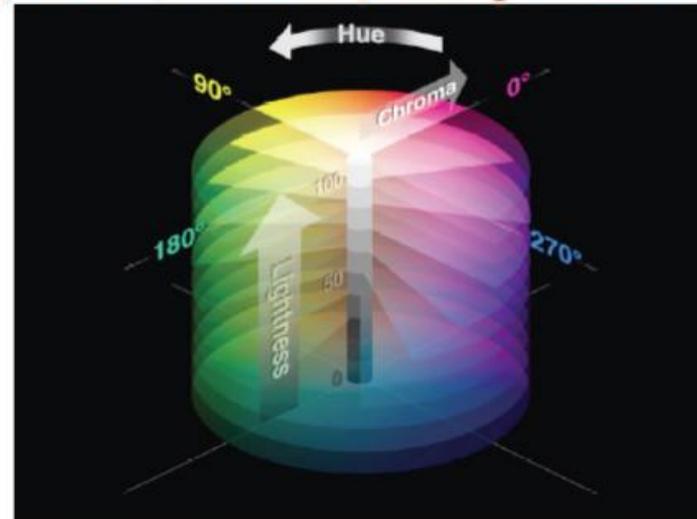
LUV u,v chromaticities are not intuitive (just like a,b in LAB).

cylindrical form remaps u,v to chroma and hue (c,h)



CIELCH - the Human Color Space

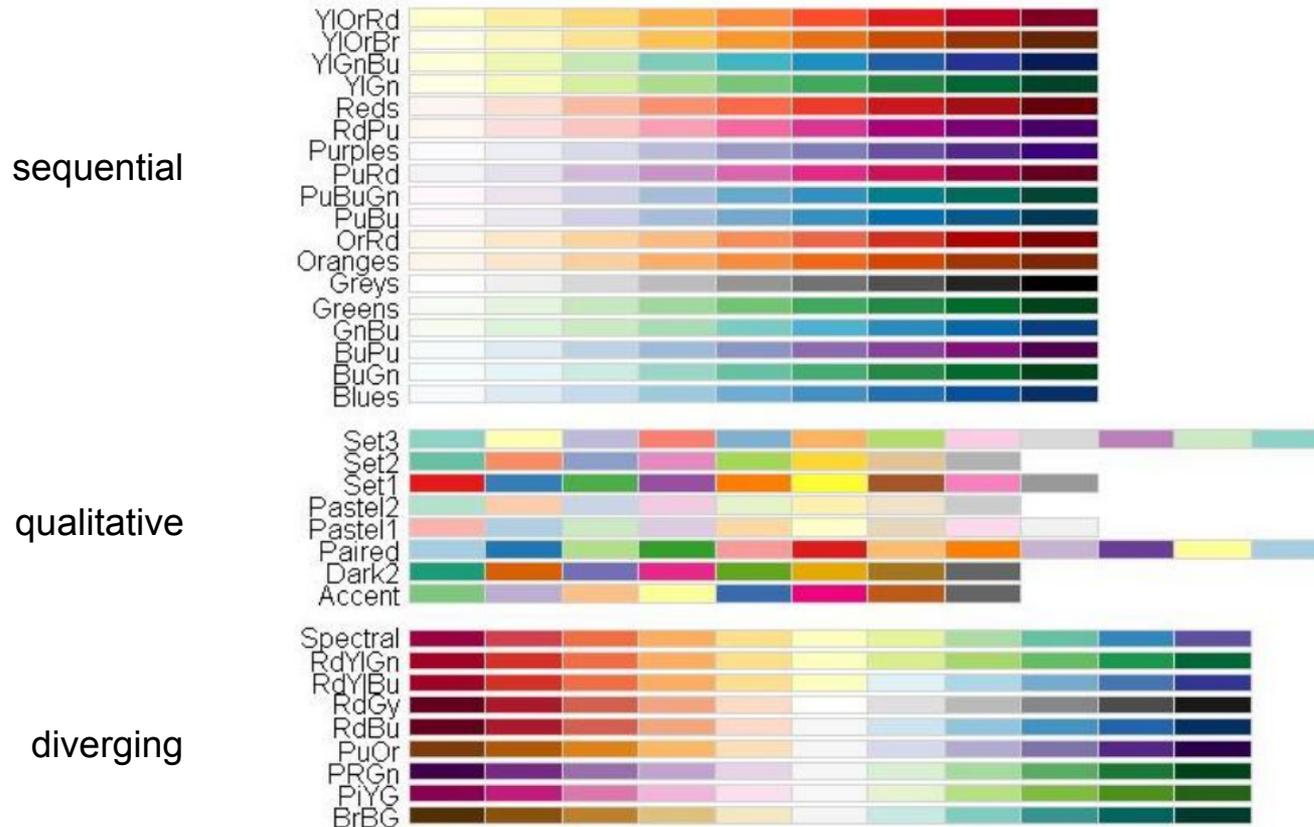
Easily-learned, user-friendly labeling of CIELab



Brewer palletes

hand-picked by Cynthia Brewer

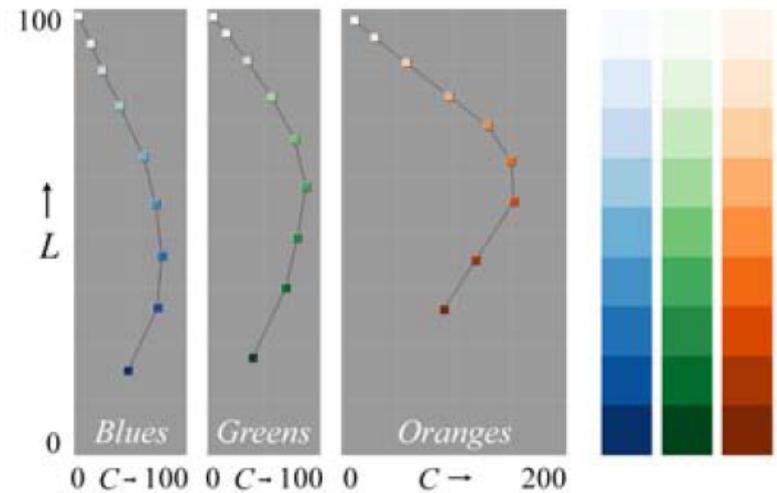
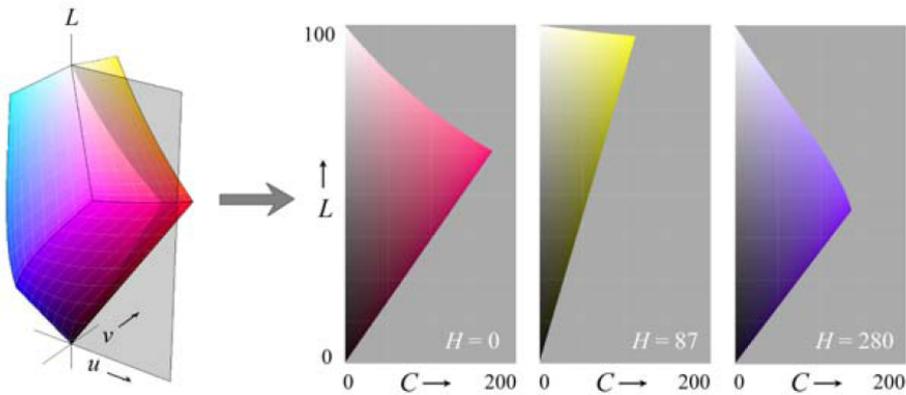
commonly used for their perceptual qualities



method by Wijffelaars *et al.*

the paper develops a method to select color palettes from LCH space to automate and extend Brewer's approach

below – three Brewer sequential palettes in LCH



method by Wijffelaars *et al.*

the paper develops a method to select color palettes from LCH space to automate and extend Brewer's approach

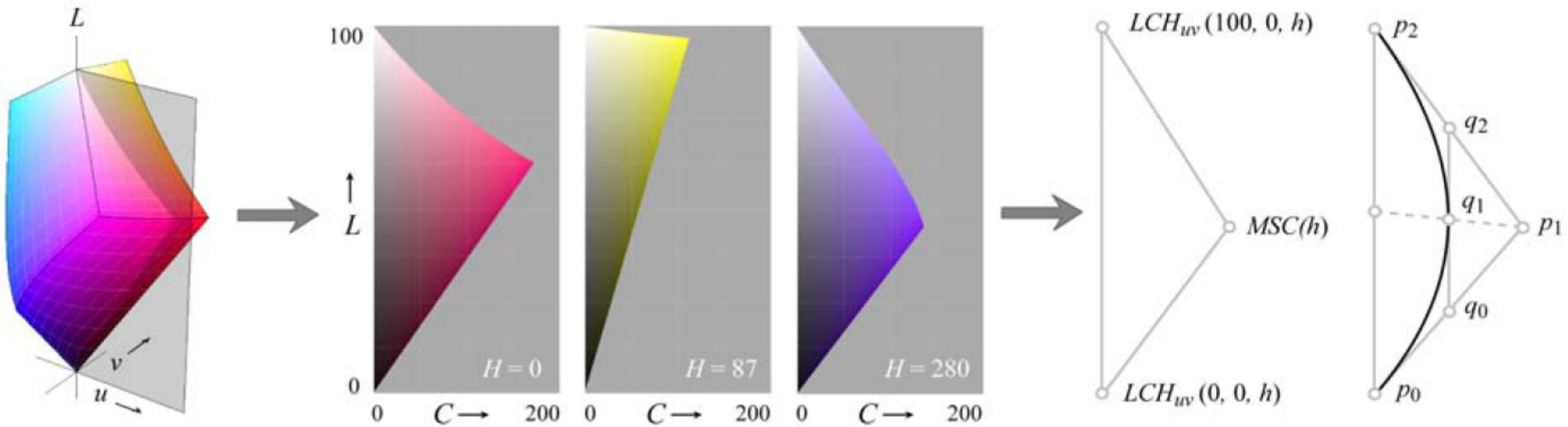
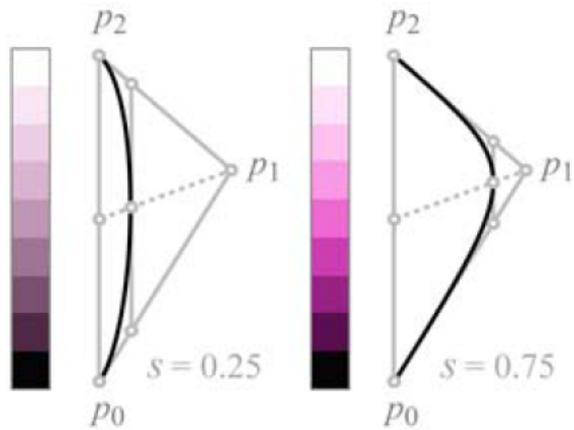
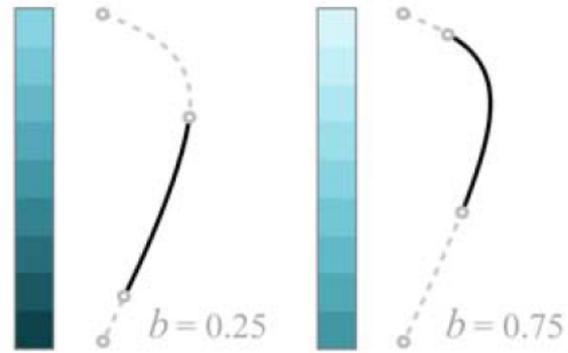


Figure 3: The volume of displayable colors in CIELUV space, three hue slices of CIELUV space generated with PaletteView and the triangle that approximates the boundary of the displayable colors of a hue slice

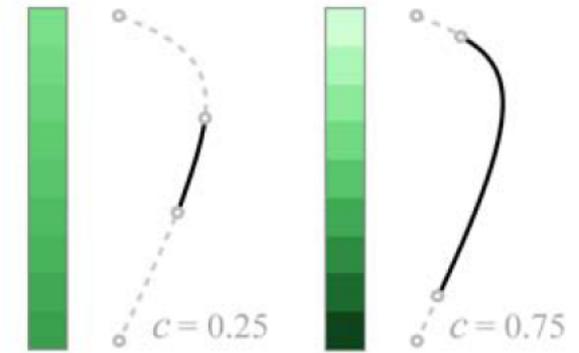
pallette parameters



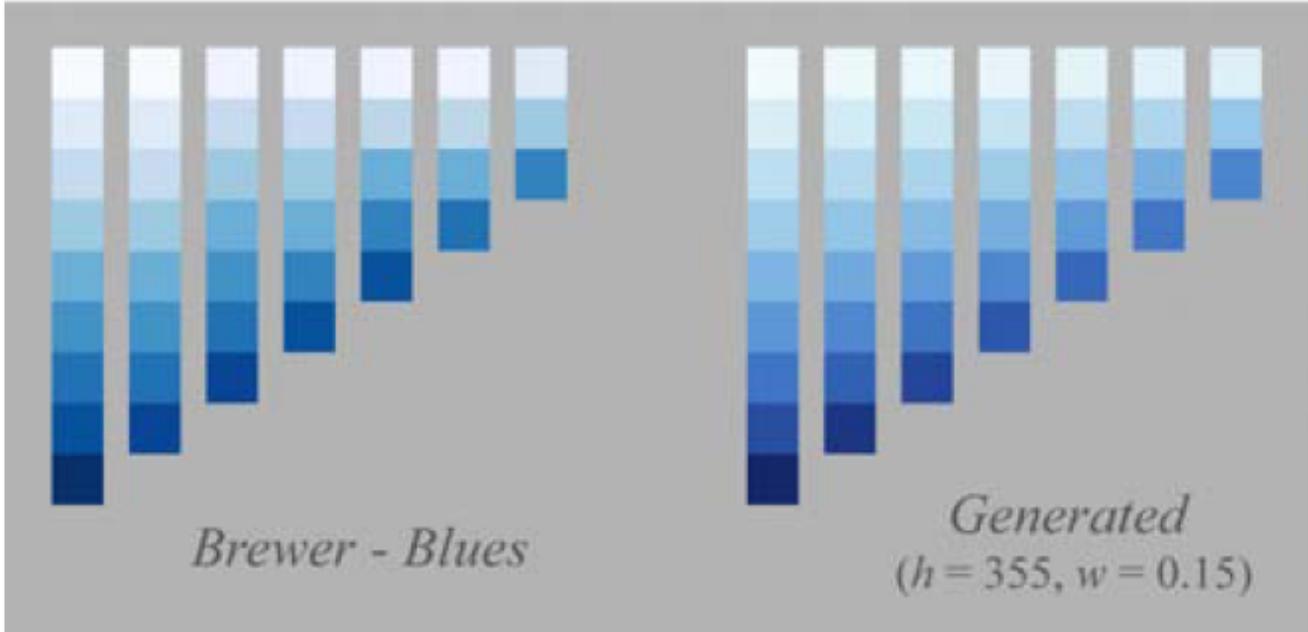
a. Saturation



b. Brightness



c. Contrast



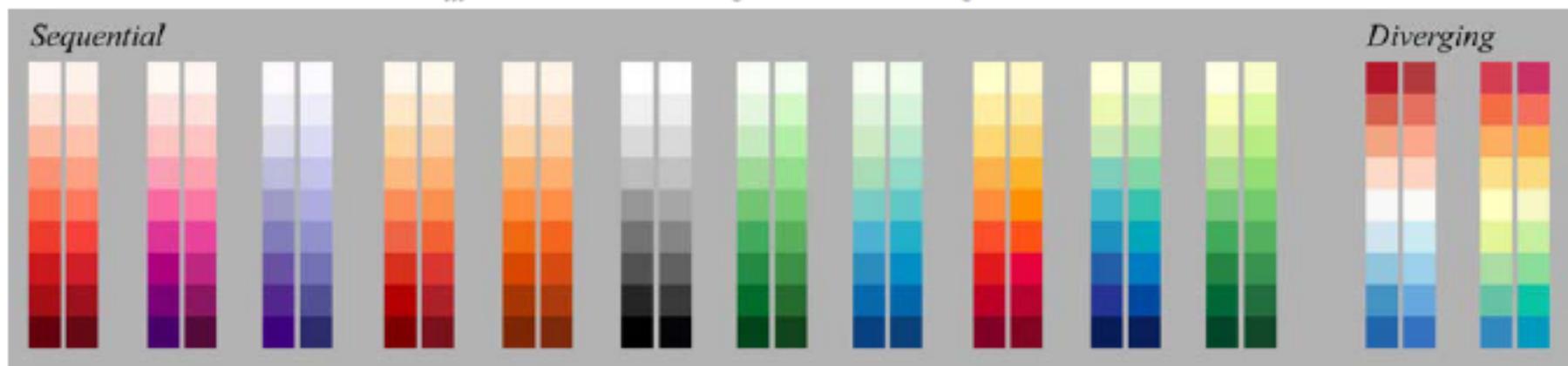


Figure 9: Pairs of palettes of which the left palettes are defined by Brewer, and the right palettes are generated with P_{seq} .

View Settings

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:

Ref. White:

Gamma:

Dist Func:

1 x 1 2 x 2

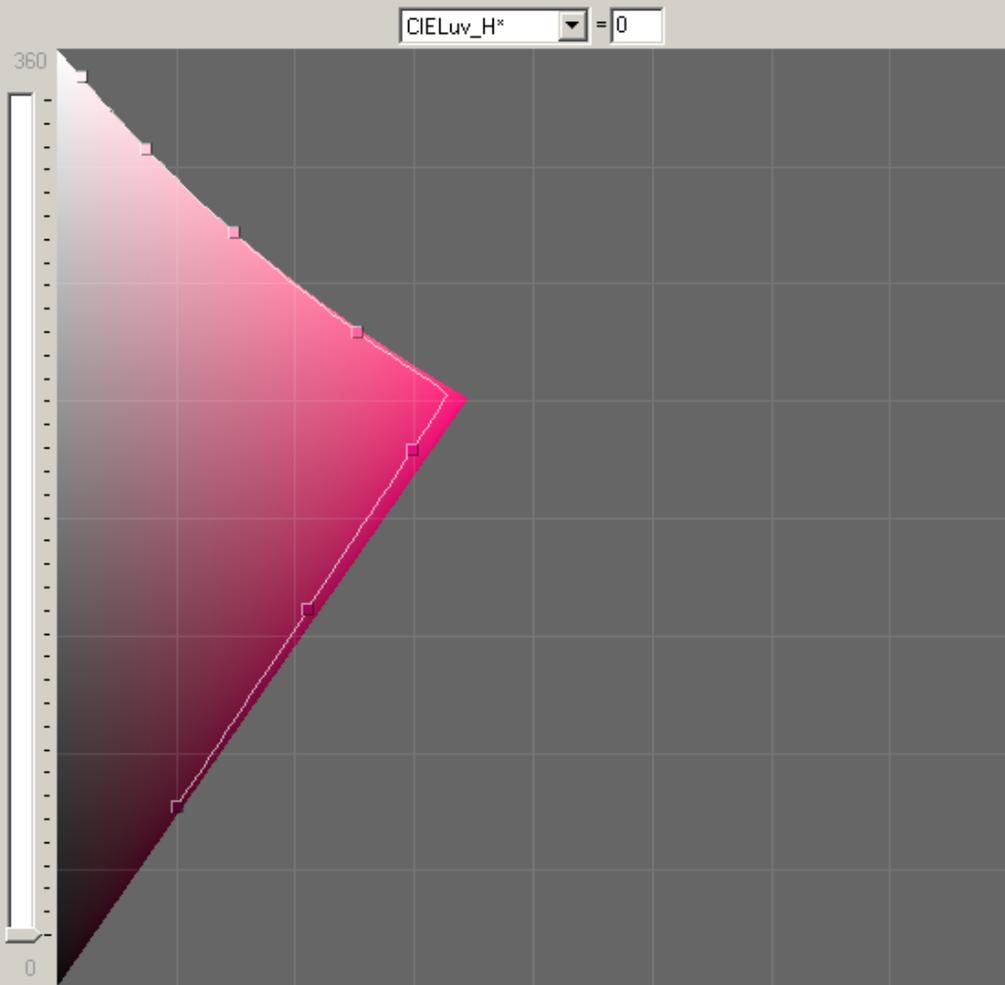
Color under cursor

R G B: 224 224 224

L* u* v*: 89 0 0

C* H*: 0 244

Previous colors



Custom Auto Brewer Extra

Num Colors:

Palette type: Sequential Qualitative

Hue:

Cold/Warm:

Brightness:

Saturation:

Contrast:

Palette colors

Show pixels out of range
 Show stored palettes

Avg: 82.7

83.33

83.33

76.84

78.76

84.79

89.03

View Settings

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:

Ref. White:

Gamma:

Dist Func:

1 x 1 2 x 2

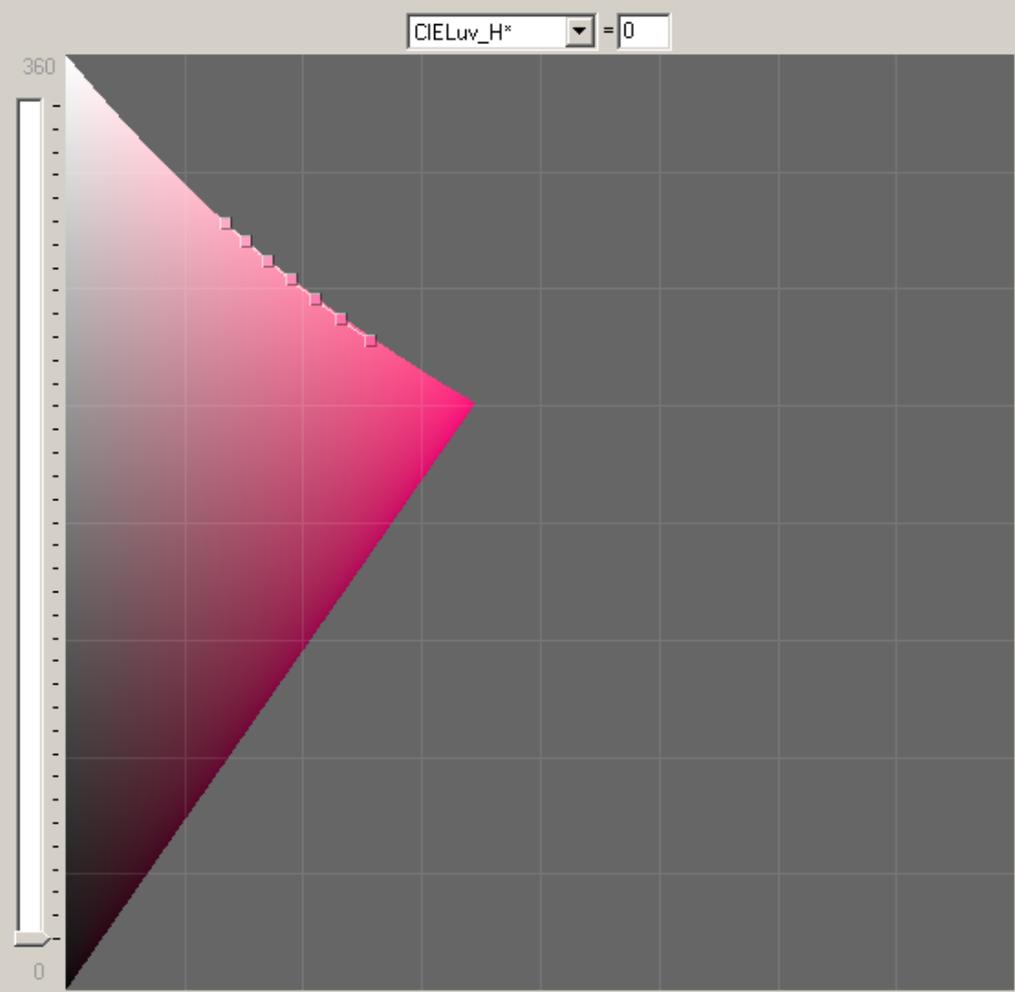
Color under cursor

R G B: 172 170 166

L* u* v*: 70 2 4

C* H*: 4 63

Previous colors



Custom Auto Brewer Extra

Num Colors:

Palette type: Sequential Qualitative

Hue:

Cold/Warm:

Brightness:

Saturation:

Contrast:

Palette colors

Avg: 15.8

15.02

15.41

15.74

16.03

16.29

16.52

Show pixels out of range

Show stored palettes

View Settings

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:

Ref. White:

Gamma:

Dist Func:

1 x 1 2 x 2

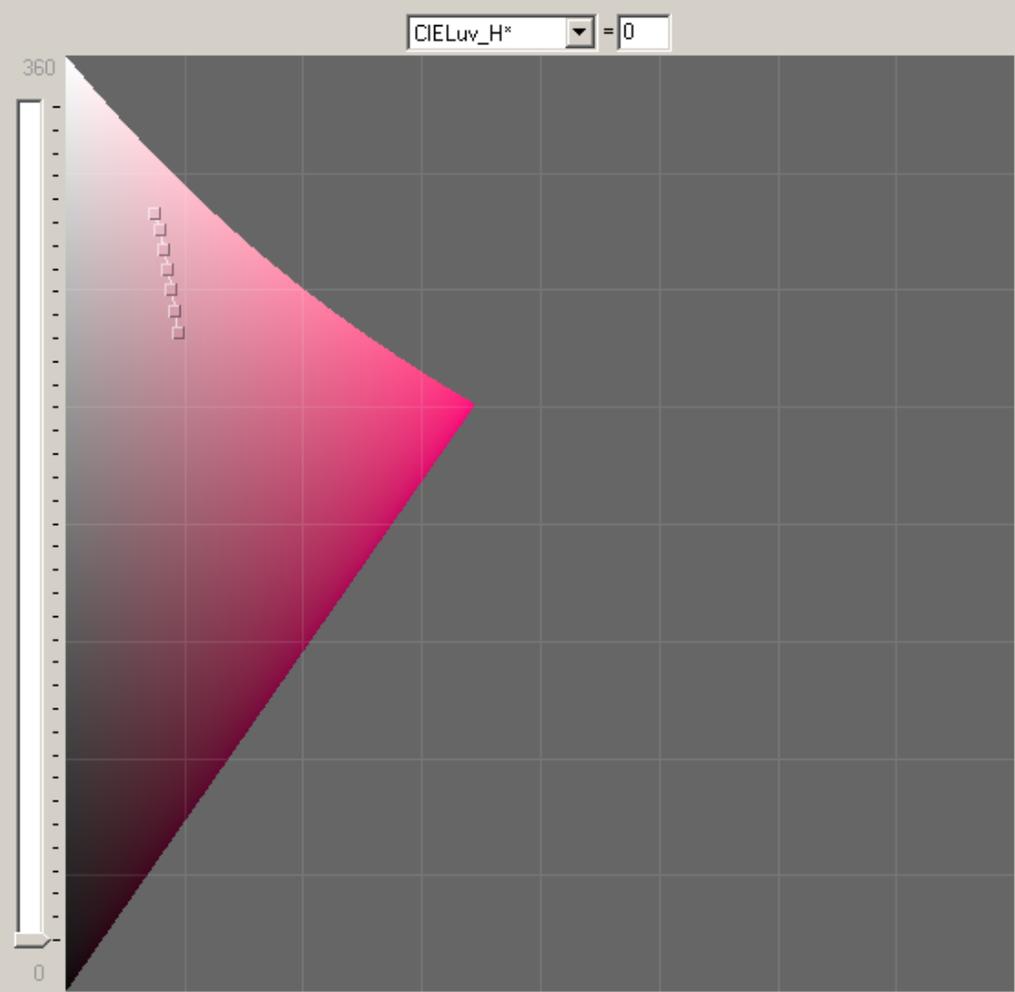
Color under cursor

R G B: 105 22 54 

L* u* v*: 26 65 0

C* H*: 65 0

Previous colors



Custom Auto Brewer Extra

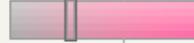
Num Colors:

Palette type: Sequential Qualitative

Hue: 

Cold/Warm: 

Brightness: 

Saturation: 

Contrast: 

Palette colors

Avg: 16.7

16.67

16.67

16.67

16.67

16.67

16.67

16.67

Show pixels out of range

Show stored palettes

View Settings:

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:
 Ref. White:
 Gamma:
 Dist Func:

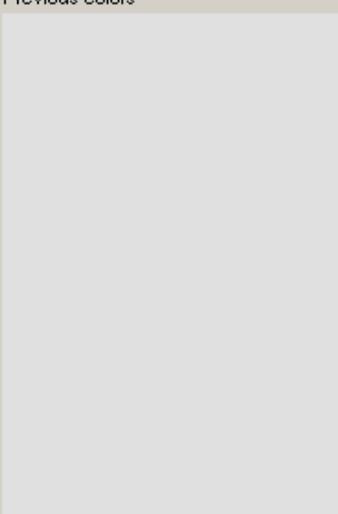
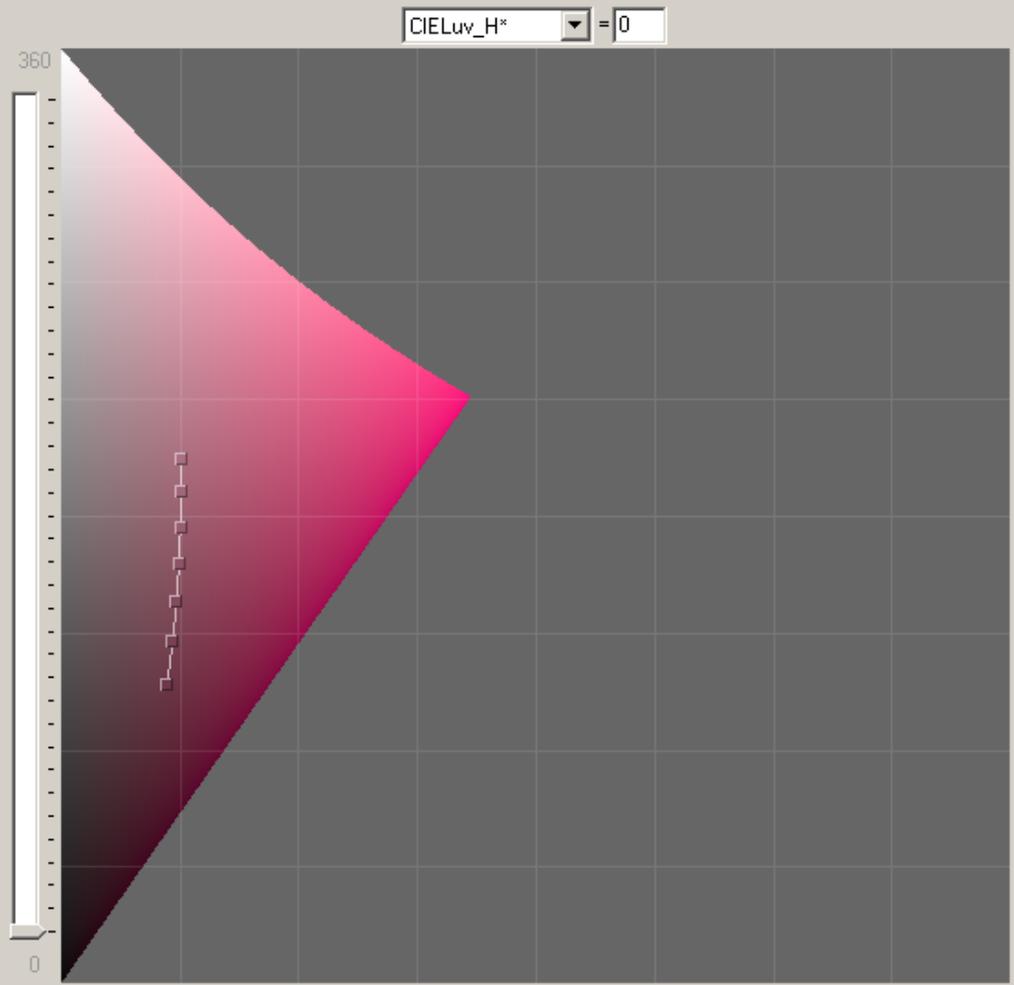
1 x 1 2 x 2

Color under cursor

R G B: 105 22 54
 L* u* v*: 26 65 0
 C* H*: 65 0



Previous colors

Custom Auto Brewer Extra

Num Colors:

Palette type: Sequential Qualitative

Hue: 

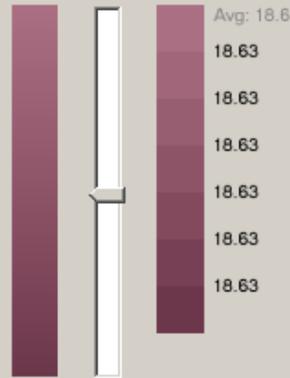
Cold/Warm: 

Brightness: 

Saturation: 

Contrast: 

Palette colors



Show pixels out of range
 Show stored palettes

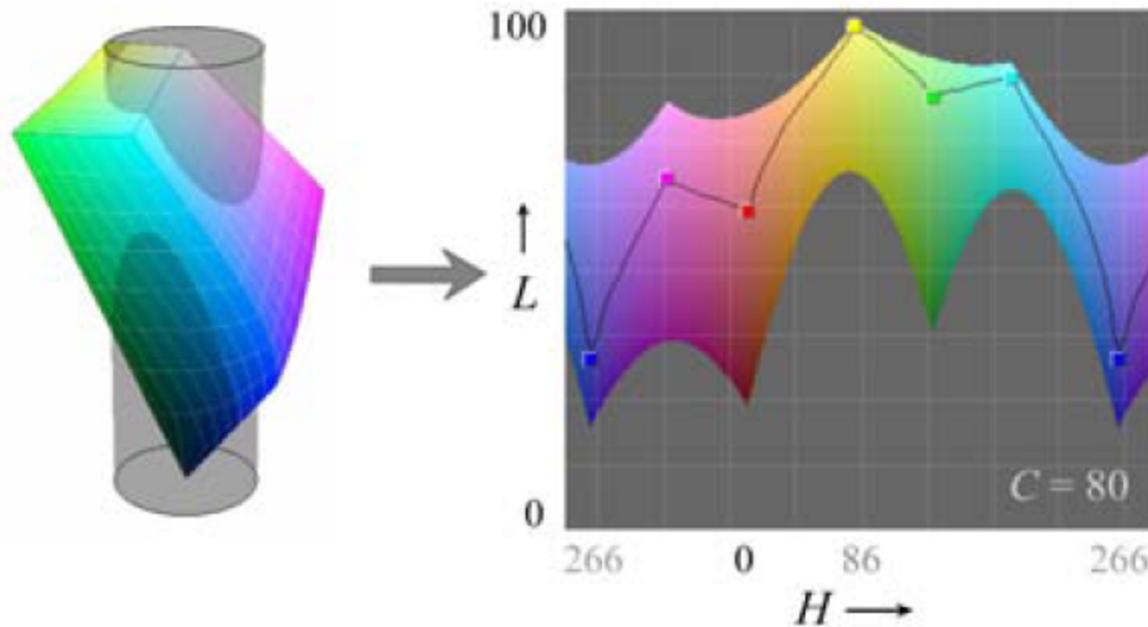


Figure 5: *Left:* the CIELUV displayable color volume with a cylinder that defines all colors of similar saturation. **Right:** the corresponding saturation slice generated with Palette-View. The path of the MSCs of all hues is shown, indicating the lightness of each MSC.

View Settings

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:

Ref. White:

Gamma:

Dist Func:

1 x 1 2 x 2

Color under cursor

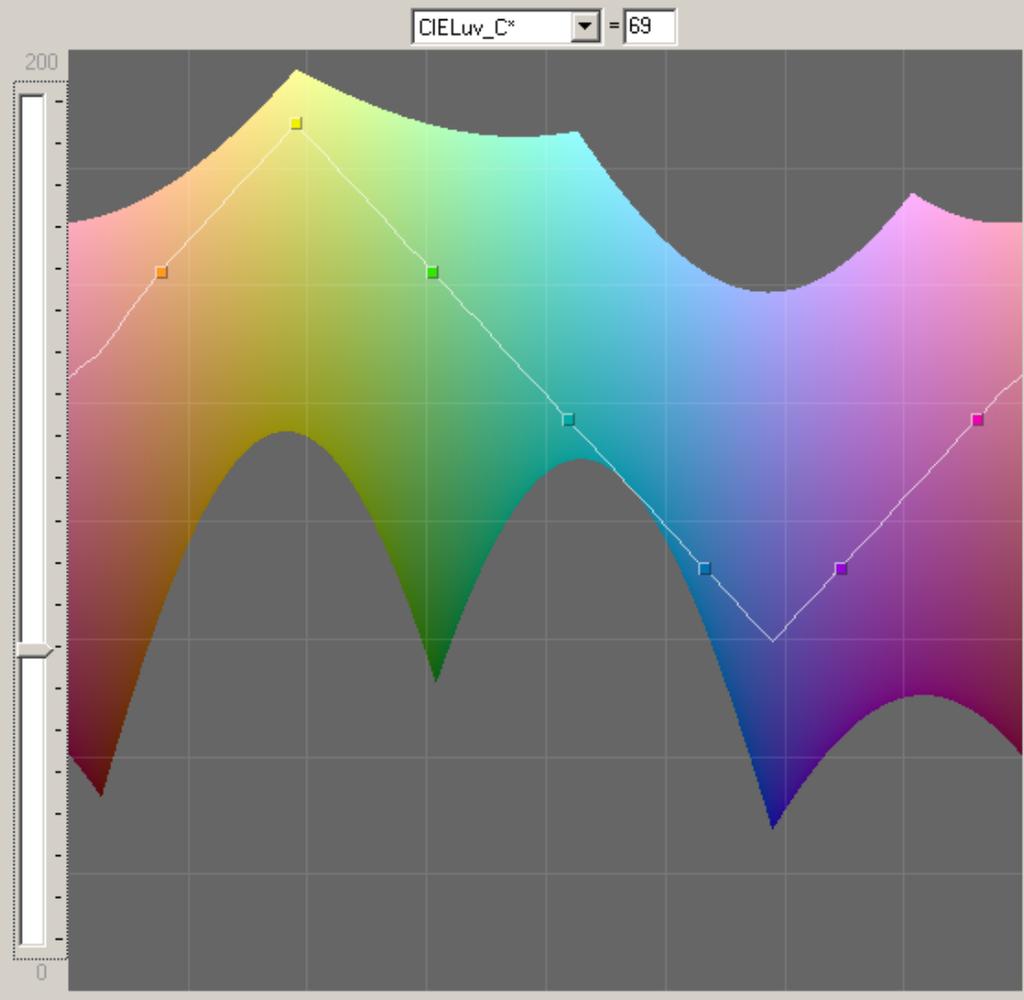
R G B: 17 54 140

L* u* v*: 24 -13 -68

C* H*: 69 259



Previous colors



Custom Auto Brewer Extra

Num Colors:

Palette type: Sequential Qualitative

Hue Shift: 

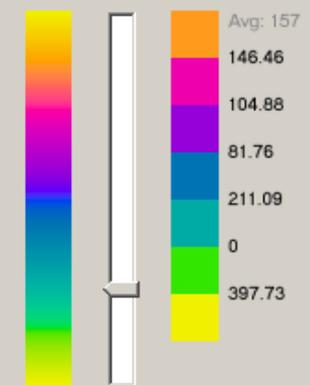
Hue Range: 

Brightness: 

Saturation: 

Contrast: 

Palette colors



Avg:	157
	146.46
	104.88
	81.76
	211.09
	0
	397.73

Show pixels out of range

Show stored palettes

View Settings

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:

Ref. White:

Gamma:

Dist Func:

1 x 1 2 x 2

Color under cursor

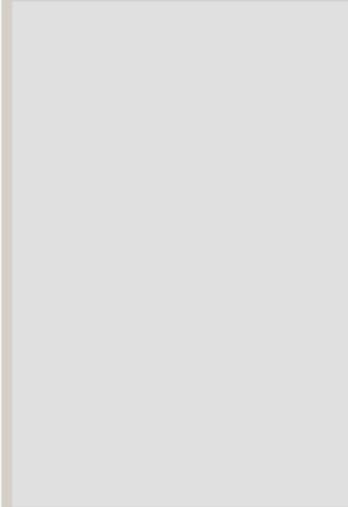
R G B: 135 49 92

L* u* v*: 37 68 -11

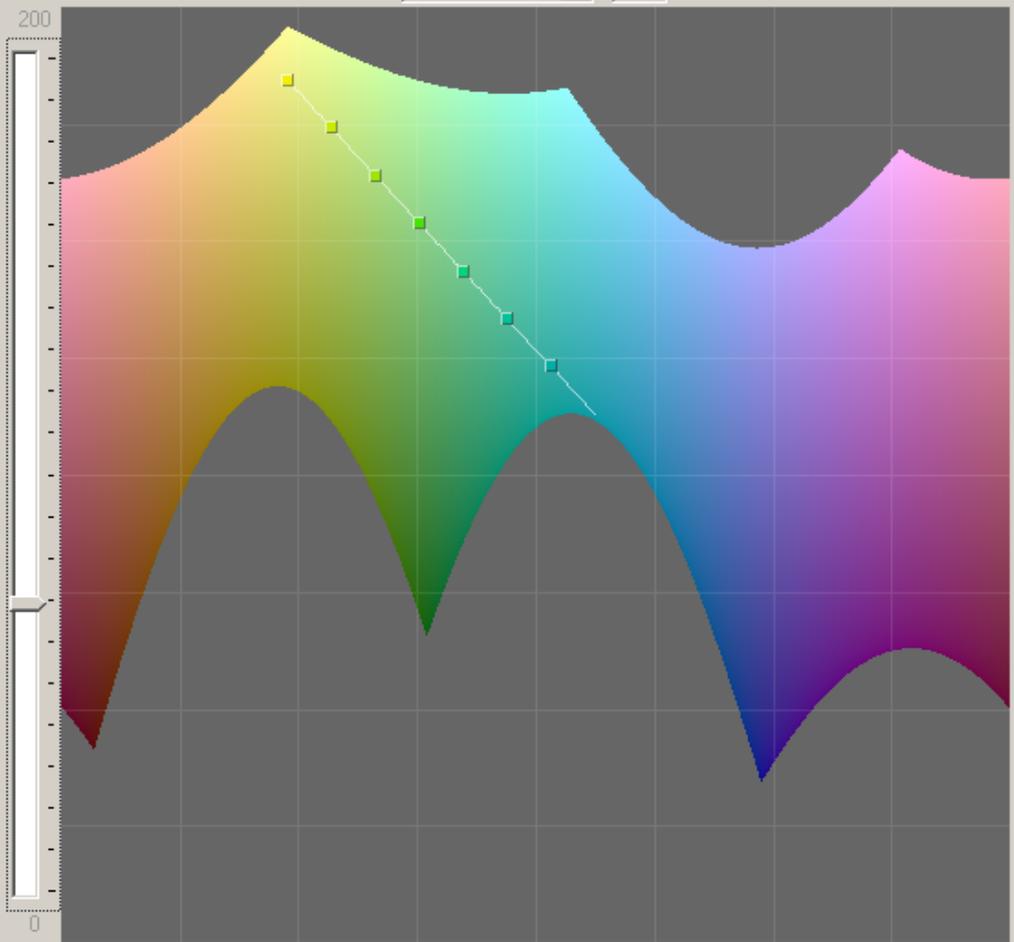
C* H*: 69 351



Previous colors



CIE Luv C* = 69

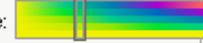


Custom Auto Brewer Extra

Num Colors:

Palette type: Sequential Qualitative

Hue Shift: 

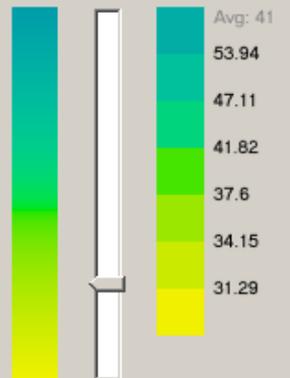
Hue Range: 

Brightness: 

Saturation: 

Contrast: 

Palette colors



Show pixels out of range

Show stored palettes

View Settings

- Show pixels out of range
- Draw grid lines
- Draw grid axes (red)
- Show draw time (MSec)
- Show color keys

RGB:

Ref. White:

Gamma:

Dist Func:

1 x 1 2 x 2

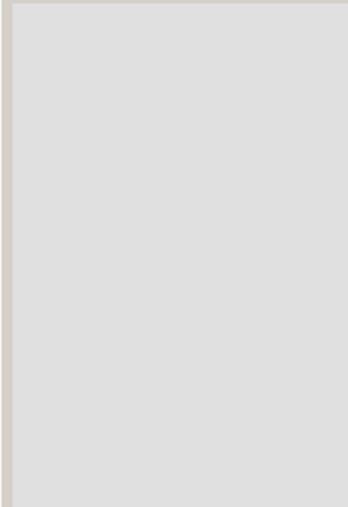
Color under cursor

R G B: 224 224 224

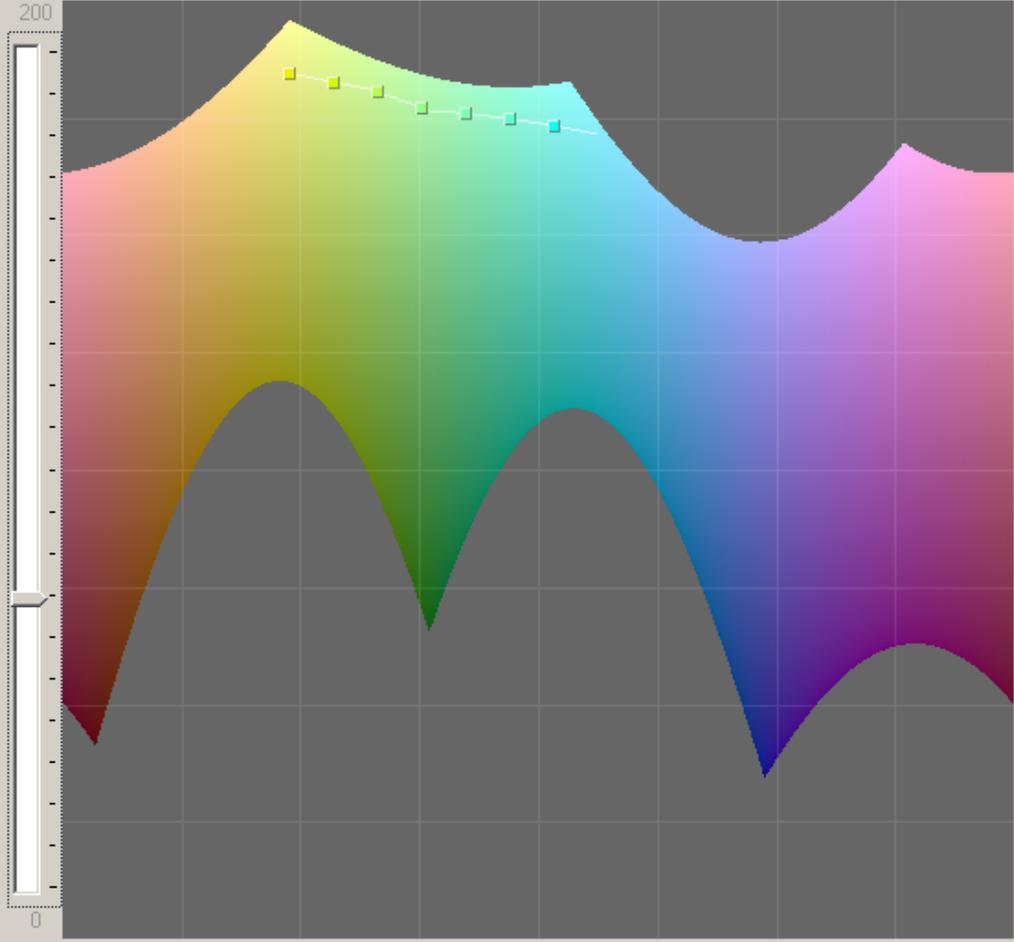
L* u* v*: 89 0 0

C* H*: 0 244

Previous colors



CIELuv_C* = 69



Custom Auto Brewer Extra

Num Colors:

Palette type: Sequential Qualitative

Hue Shift:

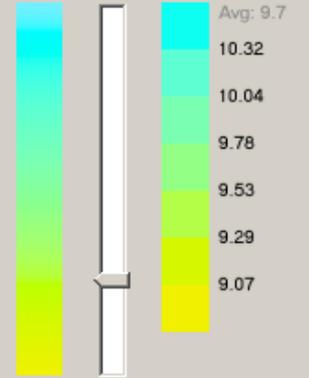
Hue Range:

Brightness:

Saturation:

Contrast:

Palette colors



- Show pixels out of range
- Show stored palettes
-

colorconvert – convert color spaces

I've created a script to convert a color from one color space to a list of popular spaces

```
> ~martink/work/colorconvert/current/colorconvert
using white point / rgb space D65 sRGB
could not initialize color - please us one of the available color spaces:
rgb rgb255 rgbhex hsv hsl cmyk yiq yuv lab luv lch xyz xyy
e.g. colorconvert -rgb 255,255,0
```

using a nice green RGB = 127,231,75 as default

```
rgb      0.498  0.906  0.294
rgb255   127   231    75
rgbhex   7FE74B
hsv      100   0.675  0.906
hsl      100   0.765  0.600
cmyk     0.408    0   0.612
yiq      0.775  0.006 -0.246
yuv      0.775 -0.210 -0.129
lab      83.004 -56.476  63.808
luv      83.004 -50.307  85.982
lch      83.004  99.618 120.332
xyz      0.386  0.622  0.166
xyy      0.329  0.530  0.622
```

> ~martink/work/colorconvert/current/colorconvert -lch 85,90,120

using white point / rgb space D65 sRGB

rgb 0.560 0.920 0.400

rgb255 143 235 102

rgbhex 8FEB66

hsv 101.525 0.566 0.920

hsl 101.525 0.766 0.660

cmyk 0.360 0 0.521

yiq 0.804 -0.000 -0.221

yuv 0.804 -0.185 -0.120

lab 85 -50.613 55.015

luv 85 -45 77.942

lch 85 90.000 120

xyz 0.433 0.660 0.230

xyy 0.327 0.499 0.660



RGB = 127 231 75 LCH = 83 100 120



RGB = 0 113 0 LCH = 40 90 120 HSB = 120 100 44



RGB = 53 152 0 LCH = 55 90 120 HSB = 99 100 60



RGB = 99 192 42 LCH = 70 90 120 HSB = 97 78 75



RGB = 143 245 102 LCH = 85 90 120 HSB = 103 58 96



RGB = 186 255 150 LCH = 100 90 120 HSB = 99 41 100



RGB = 231 255 197 LCH = 115 90 120 HSB = 85 23 100

colorbrewer.org to choose palettes

kuler.adobe.com to peruse/create attractive color combinations