Using Color

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Hue, Saturation and Value

- Hue – angle around the color wheel

  0° = red, 60° = yellow, 120° = green,

  180° = cyan, 240° = blue, 300° = magenta

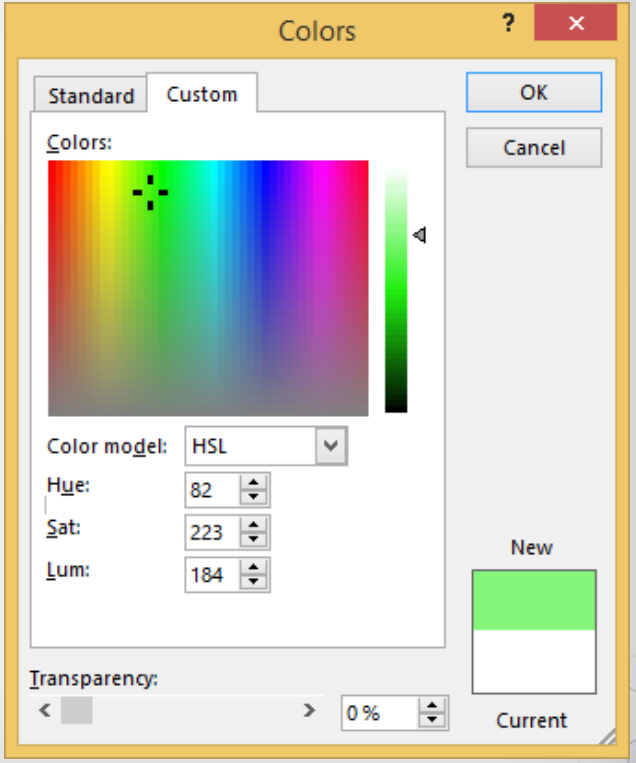
- Saturation – distance from gray

how intense

- Value – distance from black

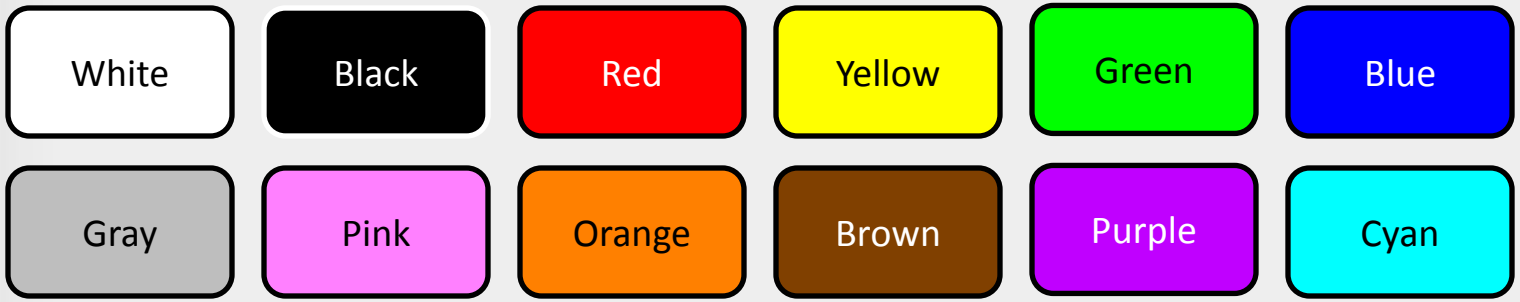
how bright

```
//Convert R,G,B to H,S,V
V = max(R,G,B)
D = V - min(R,G,B)
S = D/V
if (V == R) then H = (G-B)/D
else if (V == G) then H = (B-R)/D
else H = (R-G)/D
H = (60*H) mod 360
```



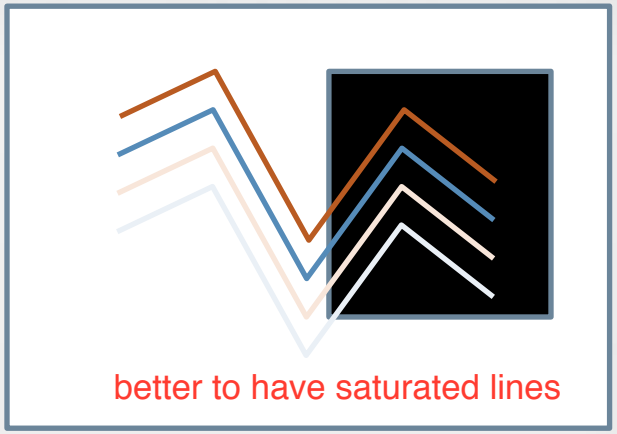
Hues

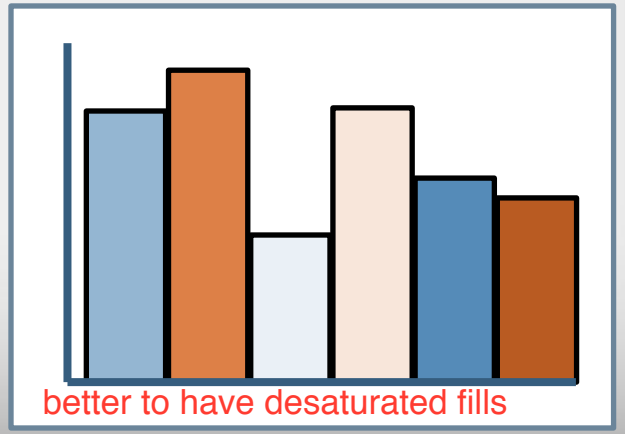
- Observers can rapidly differentiate between only five to ten hues [Healy, “Choosing effective colors for data visualization” Proc. Visualization, 1996]
- Twelve colors (6 + 6) recommended by Ward’s “Information Visualization”
- Based on Berlin & Kay, “Basic Color Terms” (plus cyan)



Saturation

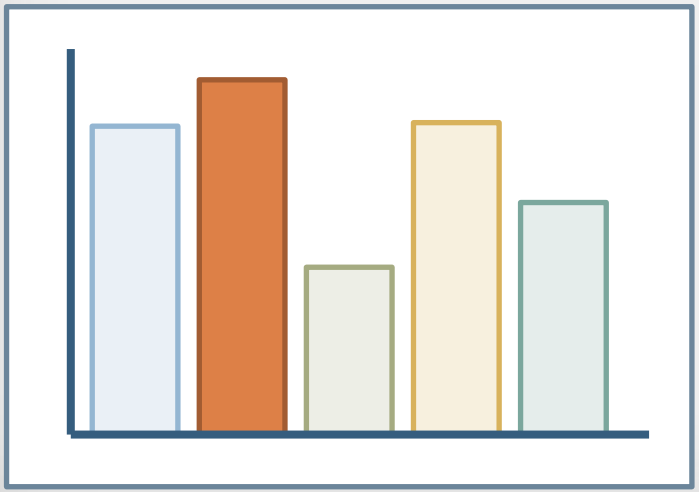
- Use saturated colors for points, strokes and symbols
- Use desaturated colors for fills and larger areas
- Desaturation blends with white, increases luminance
- Perceptual issues with color constancy and lateral inhibition





Contrast

- Use higher luminance contrast to gain attention



- Make sure text has sufficient luminance contrast

Here is some sample text to demonstrate the need for luminance contrast instead of color contrast. The hue of the text is complementary to the hue of the background, but as the background changes its luminance from less than the text to greater than text, the text becomes significantly harder to read.

Usage

- Density equivalent to value or brightness
- Use different hues for categories
  - Easier to make a hue reference
  - Brightness & saturation more susceptible to color constancy issues
- Can tell brighter, more saturated colors from darker, grayer colors
- Cannot really tell how much brighter or how much more saturated

Quantitative	Ordinal	Nominal
Position	Position	Position
Length	Density	Hue
Angle	Saturation	Texture
Slope	Hue	Connection
Area	Texture	Containment
Volume	Connection	Density
Density	Containment	Saturation
Saturation	Length	Shape
Hue	Angle	Length
	Slope	Angle
	Area	Slope
	Volume	Area
		Volume

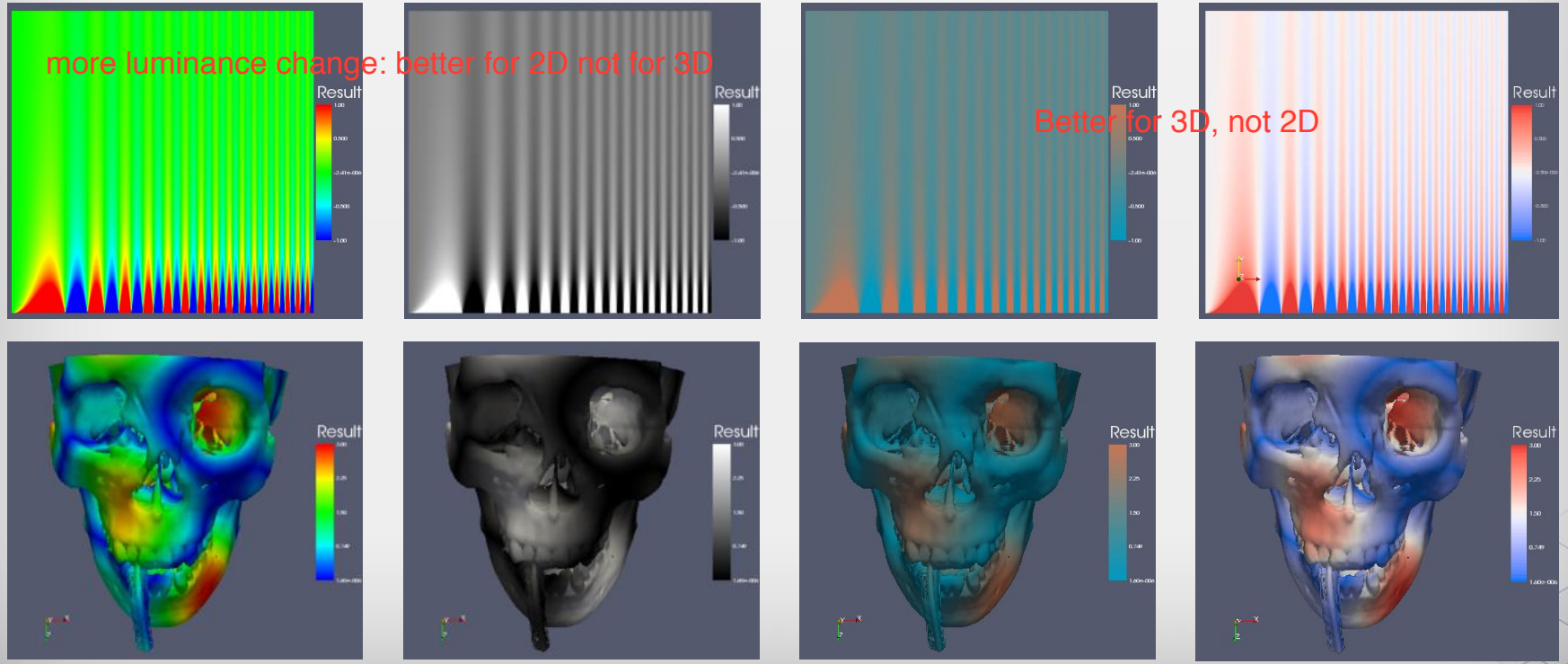
J. Mackinlay, Automating the Design of Graphical Presentations of Relational Information, ACM Transactions on Graphics 5(2), 1986

Quantitative Colormaps

- Colormap is a mapping between a quantitative variable and an array of corresponding colors
- Frequent luminance variation in color map helps with perception of detail in the data
- Avoid brightness and saturation mapping on illuminated 3-D surface renderings
- Brightness and saturation maps more error prone than hue maps

Some ParaView Color Maps

The left two colormaps work badly when representing 3-D;
The right two use uniform value(brightness), so that the result doesn't interfere with the lightning in 3-D



http://colorbrewer2.org/