

Lecture 5

Colour

DTS204TC Data Visualisation



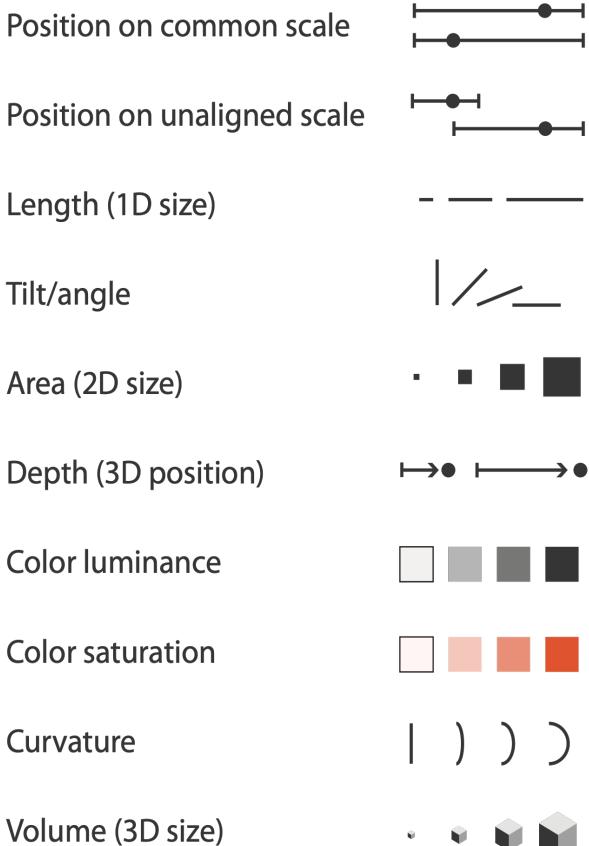
Outline

- Colour
 - Colour Channels in Visualisation
- Colour Design
 - Colour Palettes
 - Colour Deficiency
 - Colour Spaces
 - Colour Contrast & Naming

Colour

- What's up with Colour

⇒ **Magnitude Channels: Ordered Attributes**



⇒ **Identity Channels: Categorical Attributes**



Colour

- Decomposing Colour

Colour

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 - first rule of Colour: do not (**just**) talk about colour!
 - Colour is confusing if treated as monolithic

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 - decompose into three channels
 - ordered can show magnitude
 - **luminance**: how bright (B/W)
 - **saturation**: how colourful
 - categorical can show identity
 - **hue**: what colour



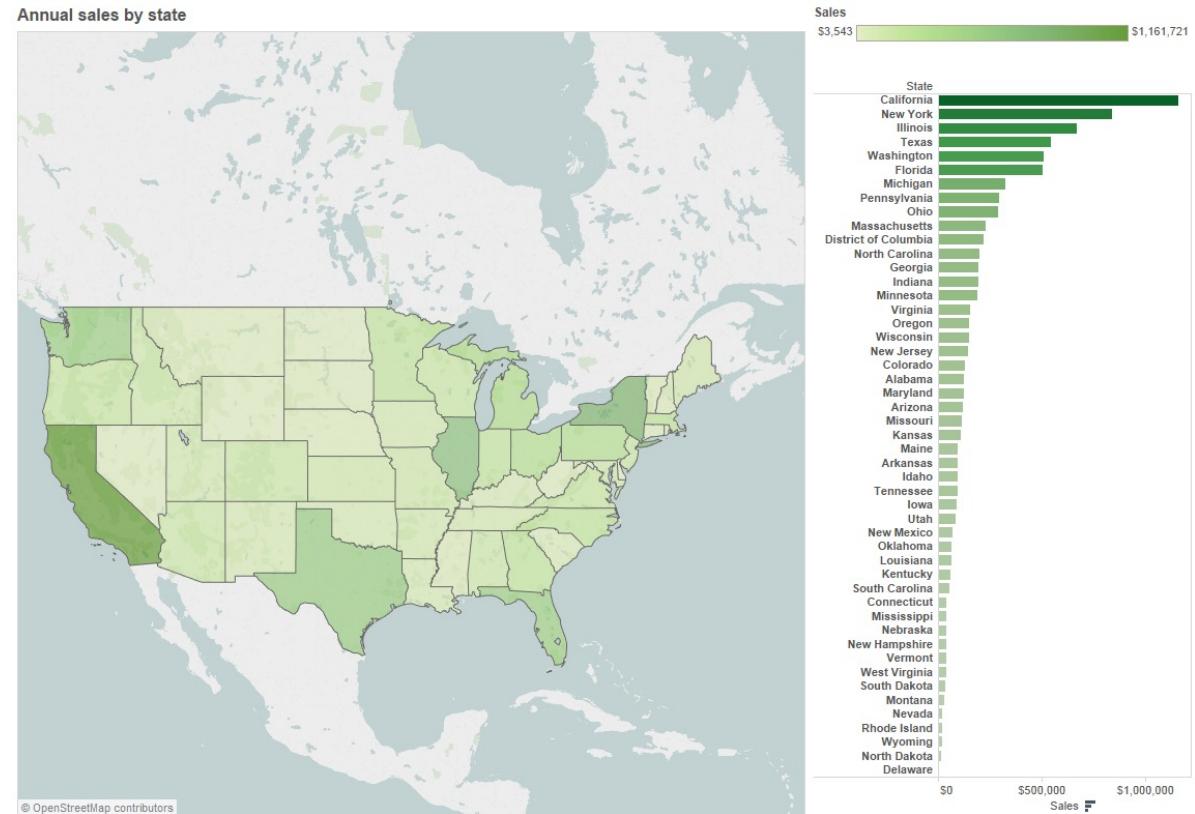
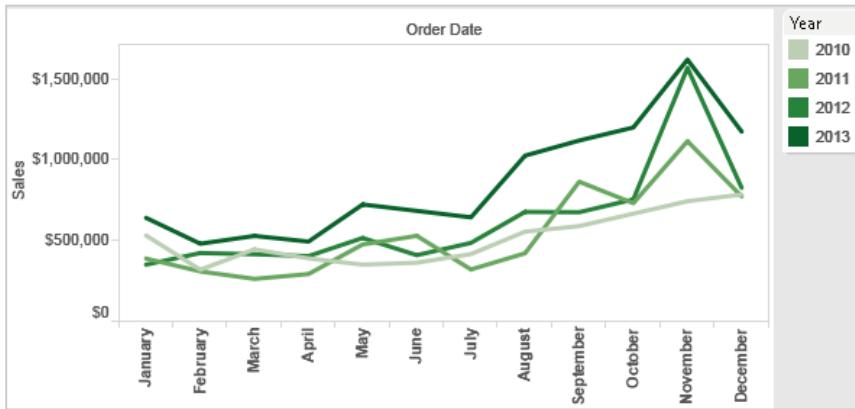
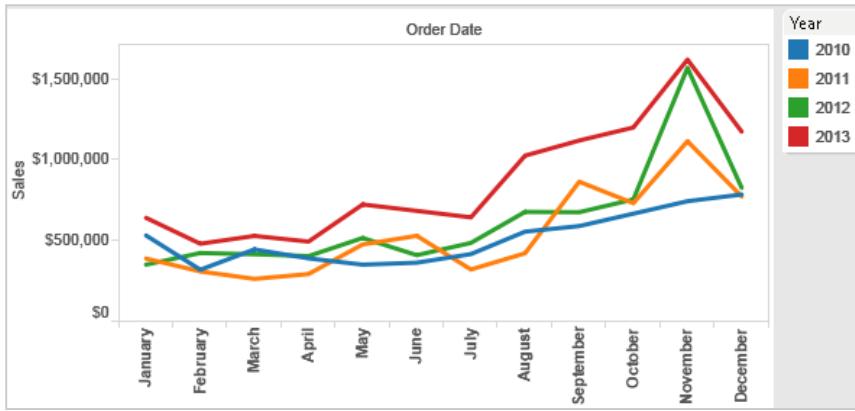
Colour

- Decomposing Colour
 - first rule of Colour: do not (**just**) talk about Colour!
 - Colour is confusing if treated as monolithic
 - decompose into three channels
 - ordered can show magnitude
 - **luminance**: how bright (B/W)
 - **saturation**: how colourful
 - categorical can show identity
 - **hue**: what colour
 - channels have different properties
 - what they convey directly to perceptual system
 - how much they can convey
 - how many discriminable bins can we use?



Colour

- Colour Channels in Visualisation
 - Categorical vs ordered colour

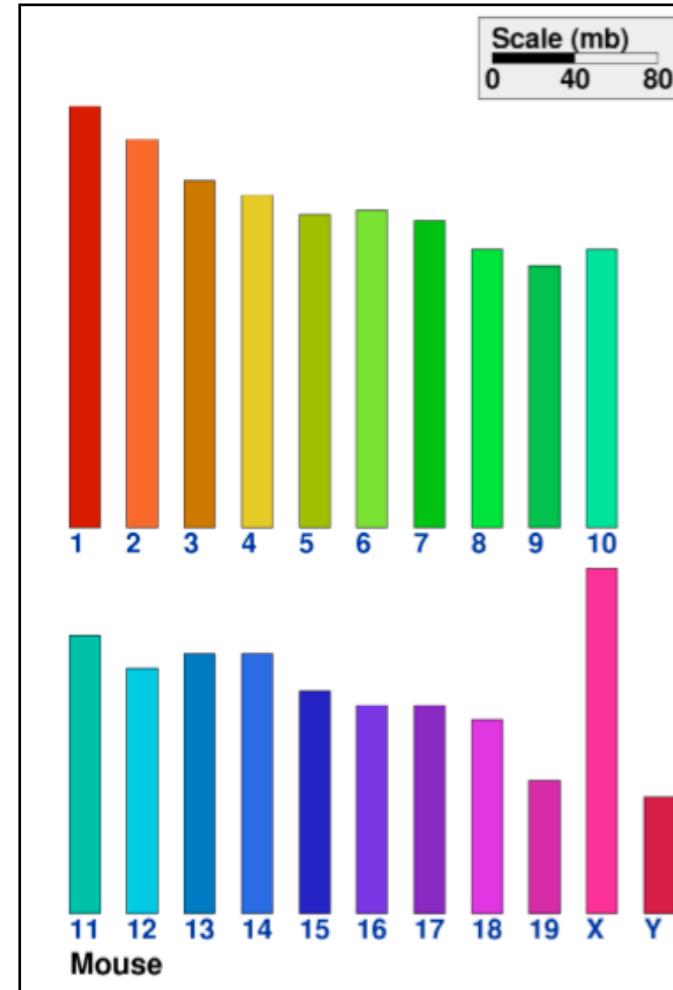


Colour

- Categorical Colour: limit number of discriminable bins
 - human perception built on relative comparisons

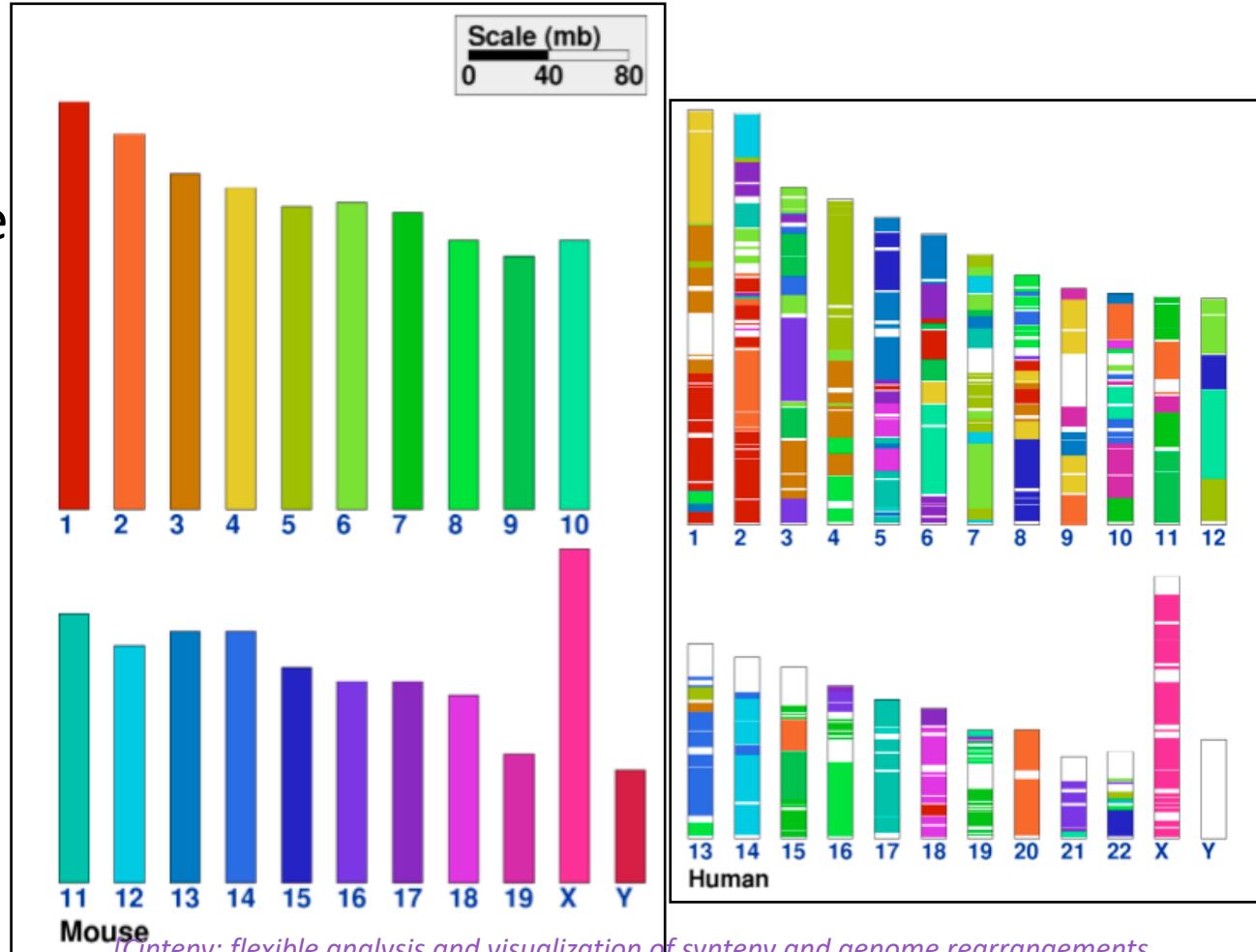
Colour

- Categorical Colour: limit number of discriminable bins
 - human perception built on relative comparisons
 - great if colour contiguous



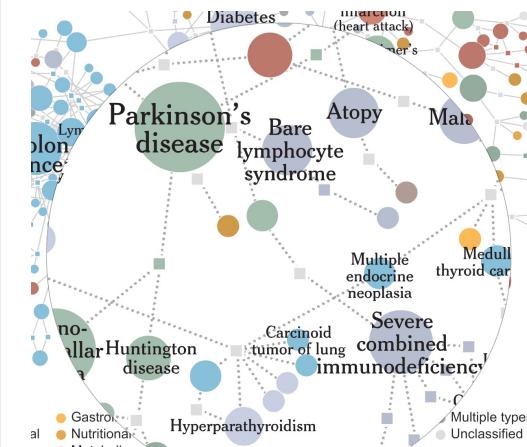
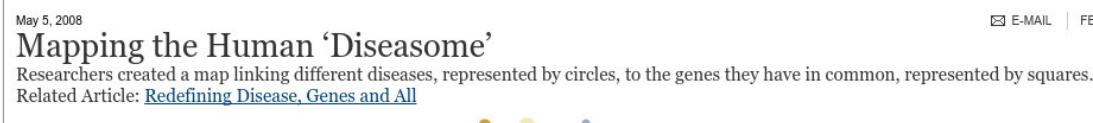
Colour

- Categorical Colour: limit number of discriminable bins
 - human perception built on relative comparisons
 - great if colour contiguous
 - surprisingly bad for absolute comparisons
- non-contiguous small regions of colour
 - fewer bins than you want
 - rule of thumb: 6-12 bins, including background and highlights



Colour

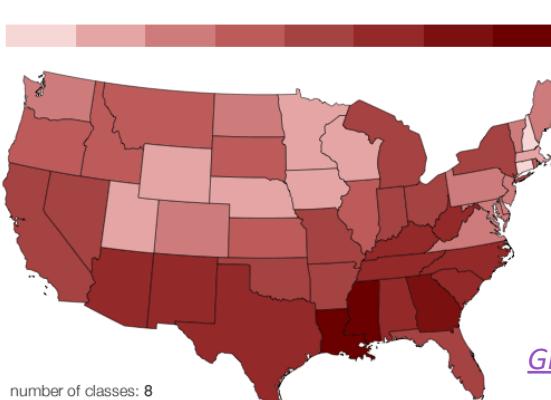
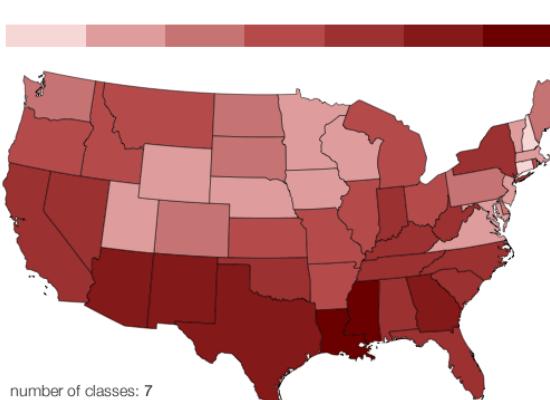
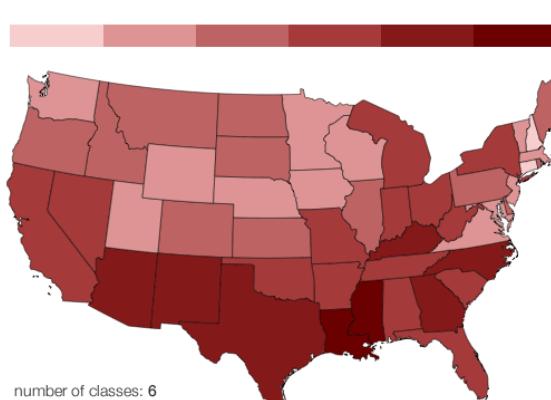
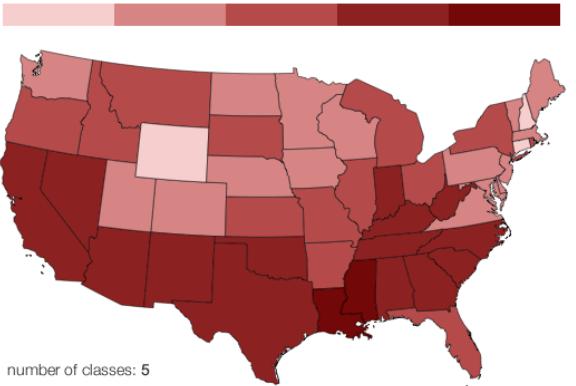
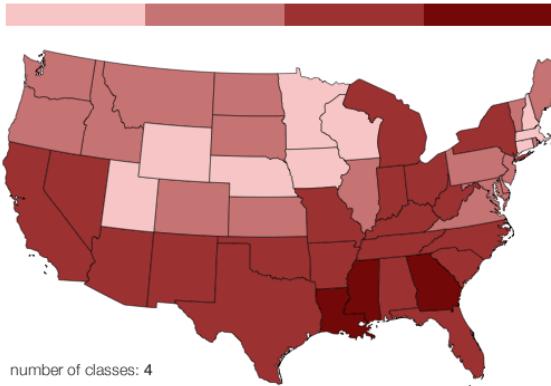
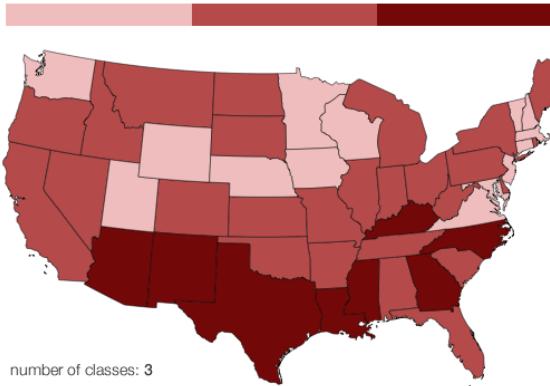
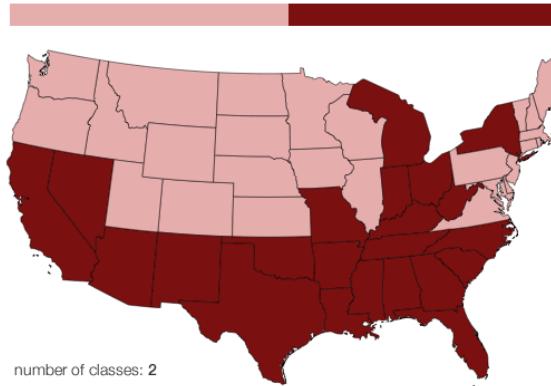
- Categorical color: limited number of discriminable bins



https://archive.nytimes.com/www.nytimes.com/interactive/2008/05/05/science/20080506_DISEASE.html

Colour

- Ordered colour: limited number of discriminable bins



Gregor Aisch, vis4.net/blog/posts/choropleth-maps/

Colour

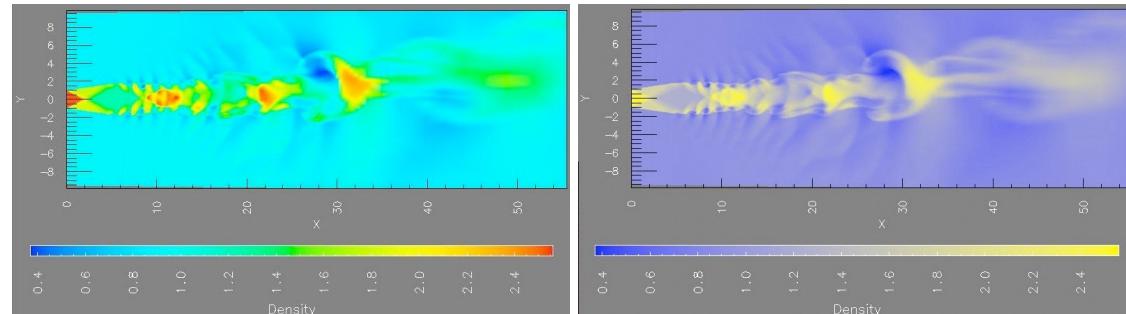
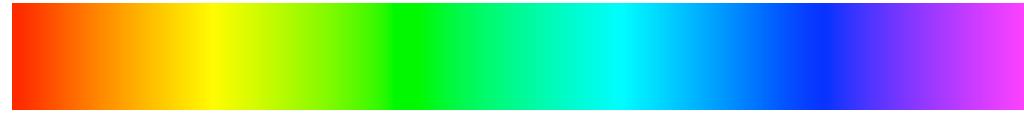
- Ordered colour: Rainbow is poor default

- problems
 - perceptually unordered
 - perceptually nonlinear

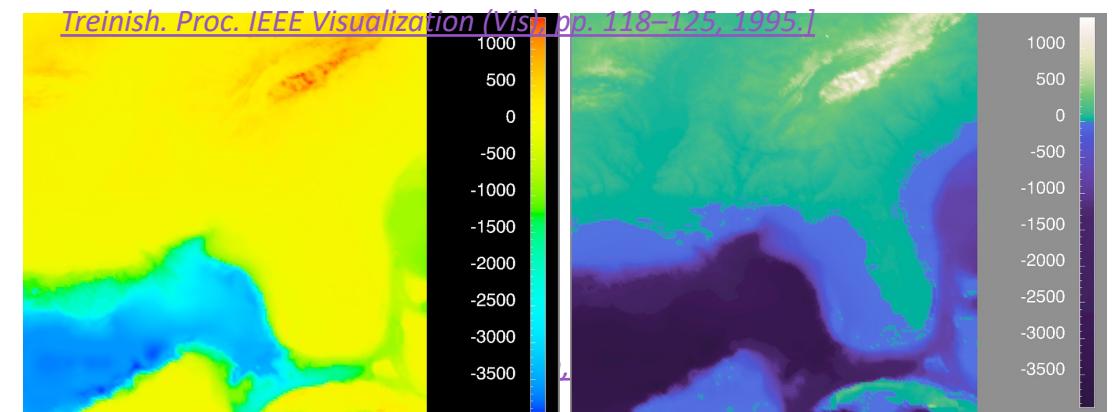


Colour

- Ordered colour: Rainbow is poor default
 - problems
 - perceptually unordered
 - perceptually nonlinear
 - benefits
 - fine-grained structure visible and nameable



[A Rule-based Tool for Assisting Colormap Selection. Bergman., Rogowitz, and. Treinish. Proc. IEEE Visualization (Vis), pp. 118–125, 1995.]

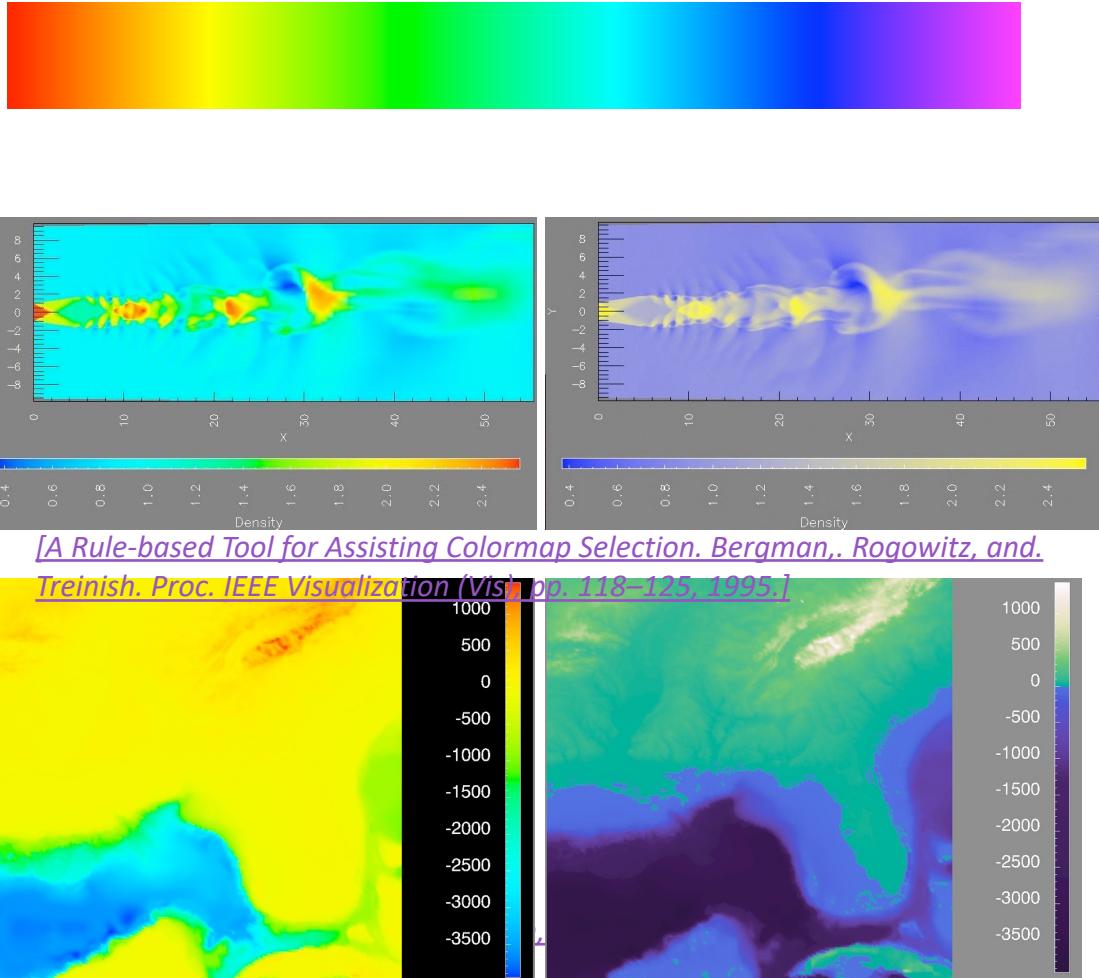


[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998.]

<http://www.research.ibm.com/people/l/lloyd/color/color.HTM>

Colour

- Ordered colour: Rainbow is poor default
 - problems
 - perceptually unordered
 - perceptually nonlinear
 - benefits
 - fine-grained structure visible and nameable
 - alternatives
 - large-scale structure: fewer hues
 - fine structure: multiple hues with monotonically increasing luminance [eg viridis]



[*A Rule-based Tool for Assisting Colormap Selection.* Bergman., Rogowitz, and.

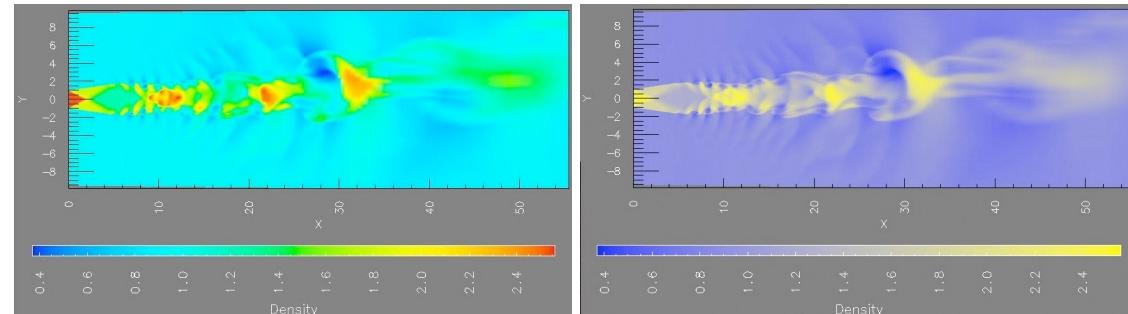
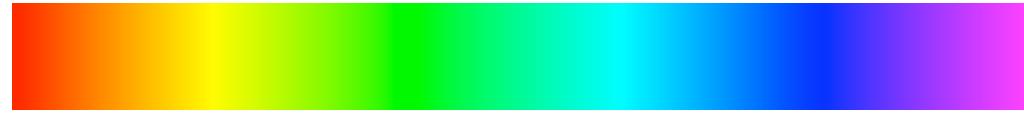
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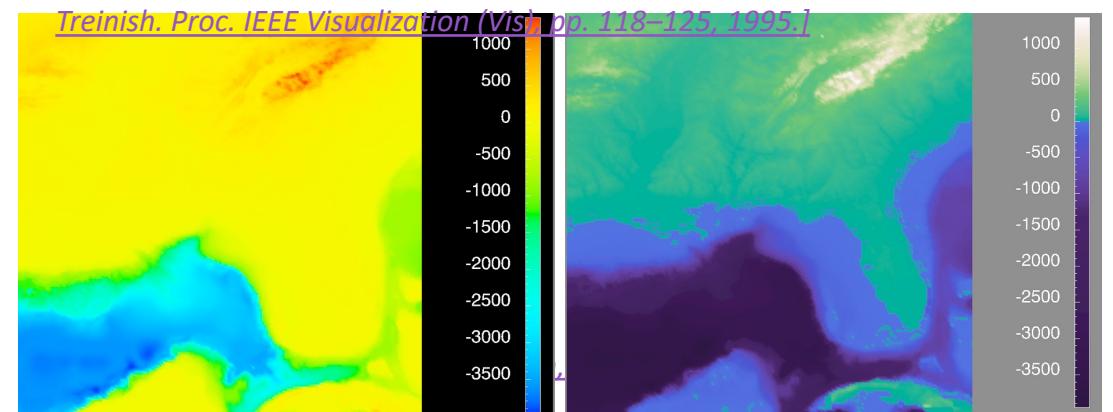
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Colour

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 - benefits
 - fine-grained structure visible and nameable
 - alternatives
 - large-scale structure: fewer hues
 - fine structure: multiple hues with monotonically increasing luminance [eg viridis]
 - legit for categorical
 - segmented saturated rainbow is good



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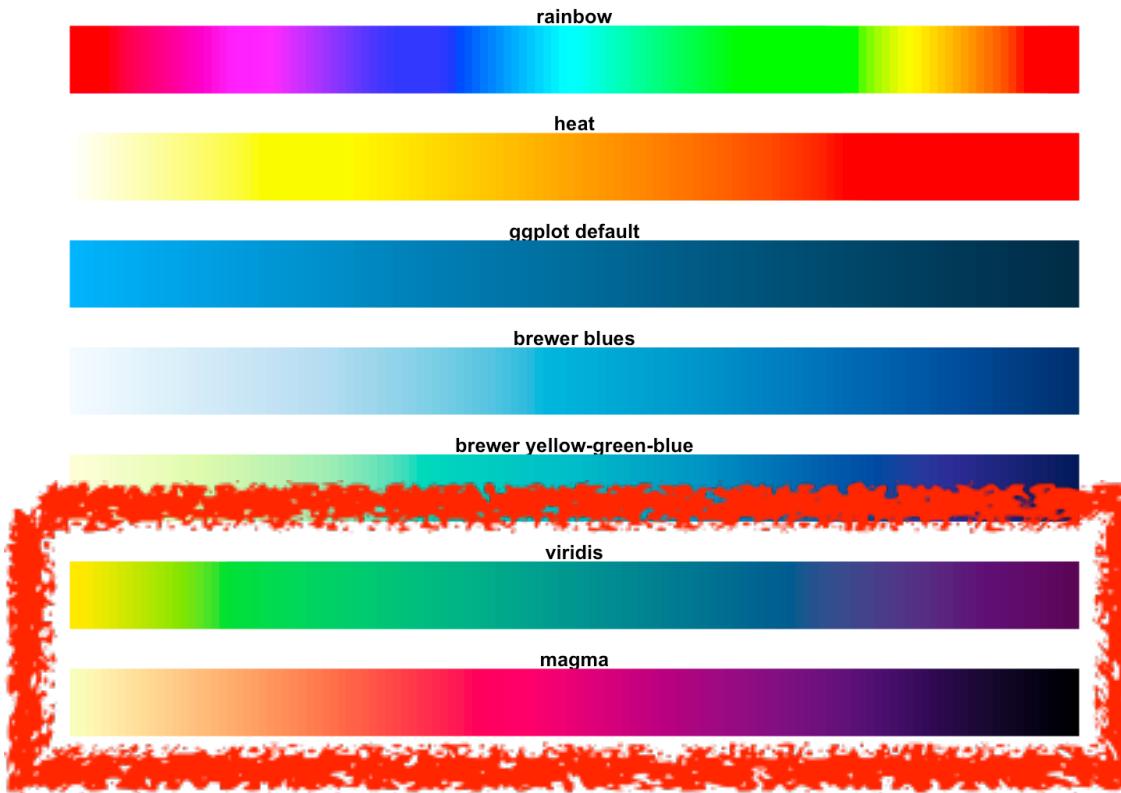


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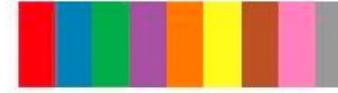
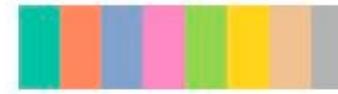
Colour

- Sequential color maps
 - monotonically increasing luminance, perceptually uniform
 - colorful, colorblind-safe
 - D3.js



Colour Design

- Colour palettes: univariate
 - categorical
 - aim for maximum distinguishability



Colour Design

- Colour palettes: univariate
 - diverging
 - useful when data has meaningful "midpoint"
 - use neutral colour for midpoint
 - white, yellow, grey
 - use saturated colours for endpoints
 - sequential
 - ramp luminance or saturation
 - if multi-hue, good to order by luminance

diverging sequential



Colour Design

- Colour palettes: univariate

→ Categorical



→ Ordered

→ *Sequential*



→ *Diverging*



→ Cyclic



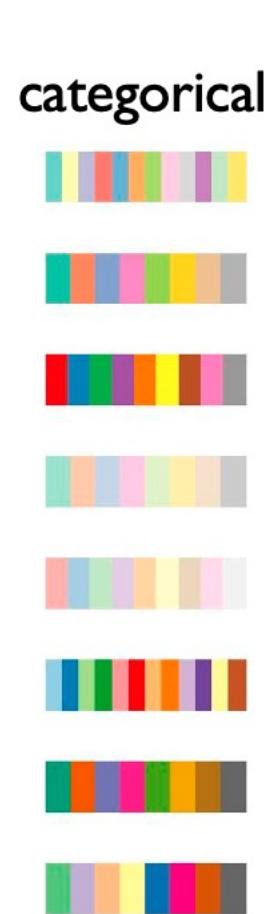
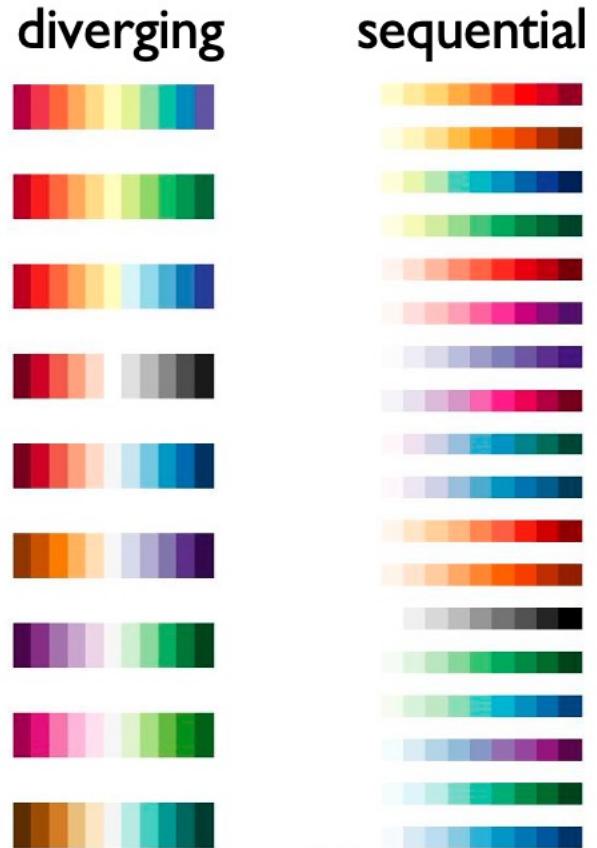
cyclic multihue



<https://github.com/d3/d3-scale-chromatic>

Colour Design

- Colour palettes: univariate segmented



- segmented or continuous?
- diverging or sequential or cyclic?
- single-hue or two-hue or multi-hue?
- perceptually linear?
- ordered by luminance?
- colorblind safe?

Colour Design

- Colour maps: bivariate

→ Categorical



→ Ordered

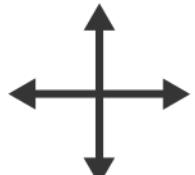
→ *Sequential*



→ *Diverging*

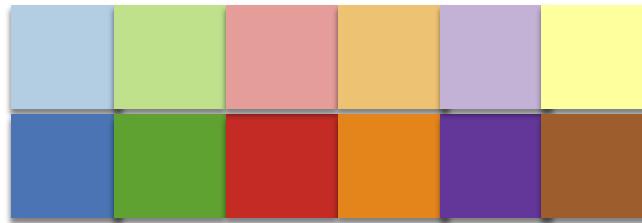


→ Bivariate



Colour Design

- Colour maps: bivariate
 - best situation
 - one of the directions is binary

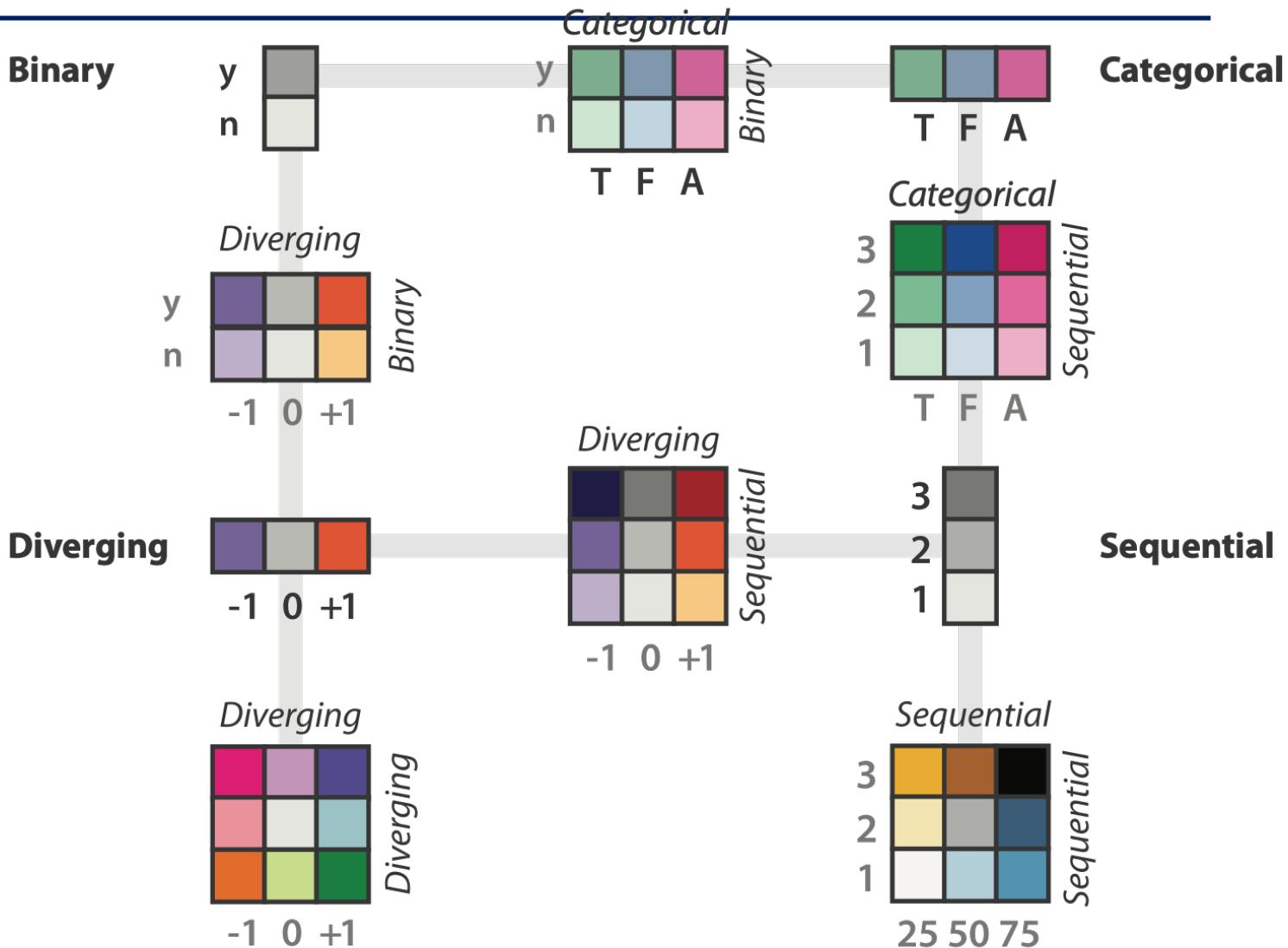


binary saturation

categorical hue

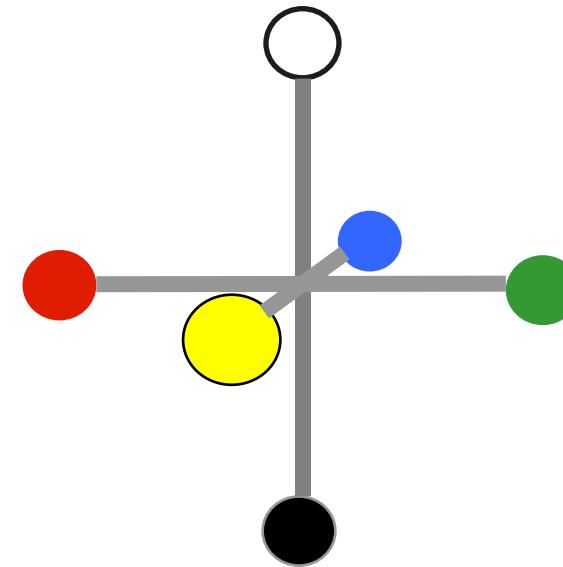
Colour Design

- Colour maps: bivariate
 - best situation
 - one of the directions is binary
 - bivariate can be very difficult to interpret
 - when multiple levels in each direction



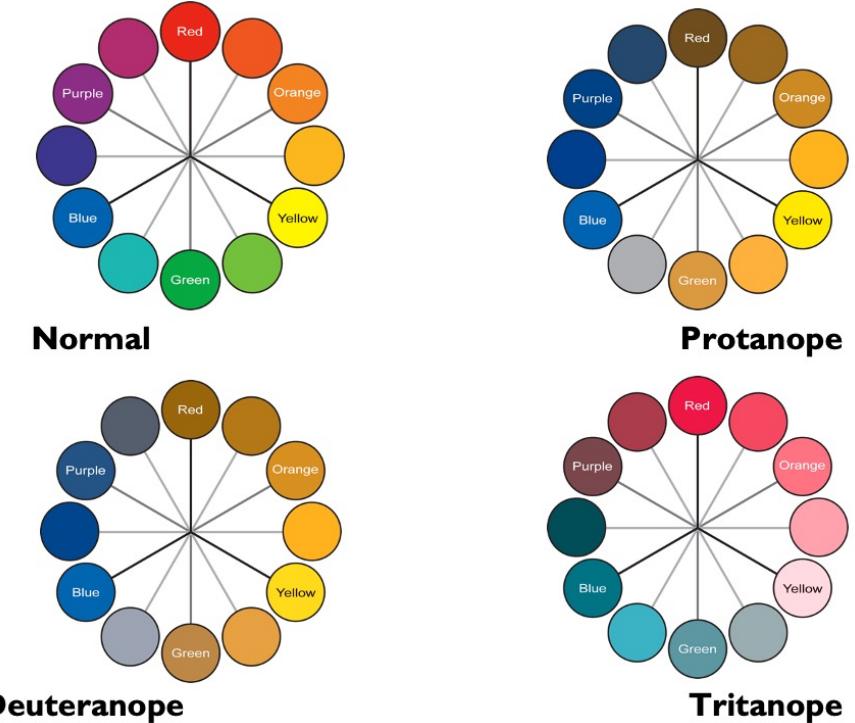
Colour Design

- Colour deficiency
 - opponent color
 - one achromatic luminance channel (L^*)
 - edge detection through luminance contrast
 - 2 chroma channels
 - red-green (a^*) & yellow-blue axis (b^*)
 - “colorblind”: degraded acuity, one axis
 - 8% of men are red/green colour deficient
 - blue/yellow is rare



Colour Design

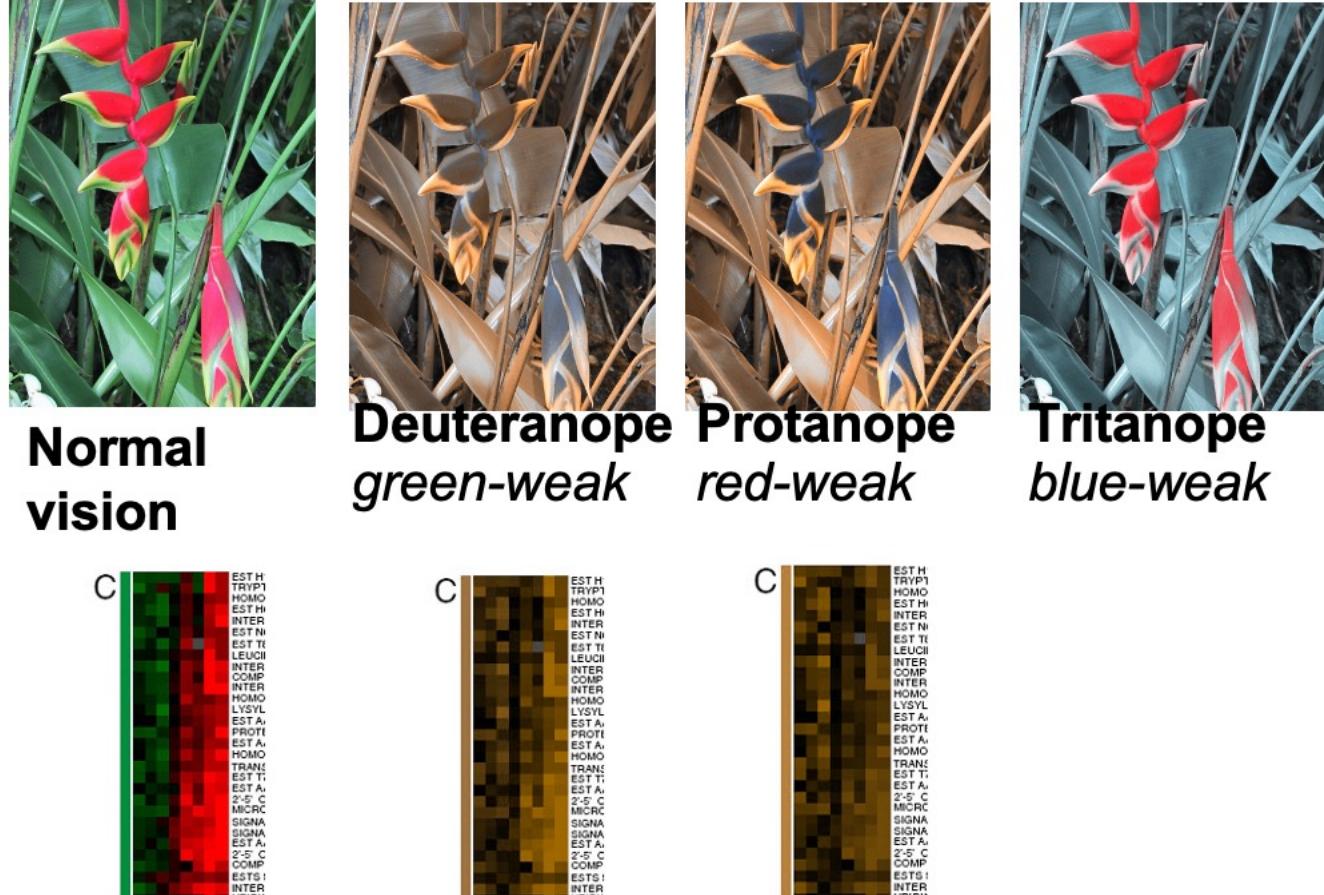
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[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

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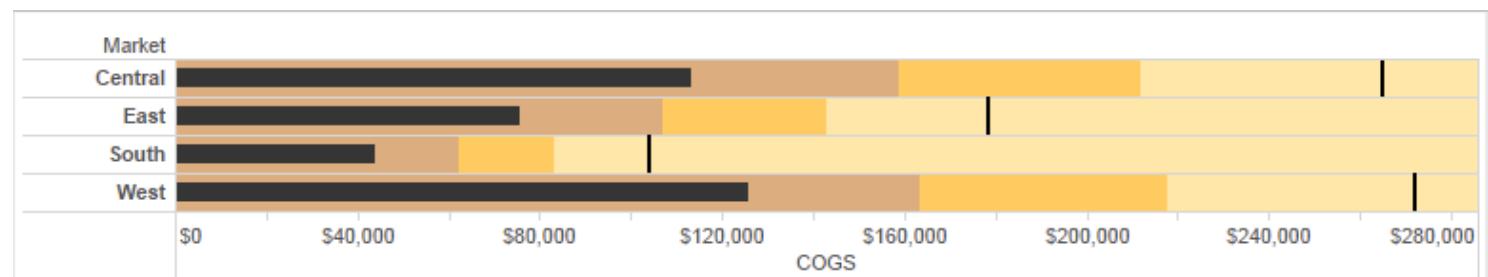
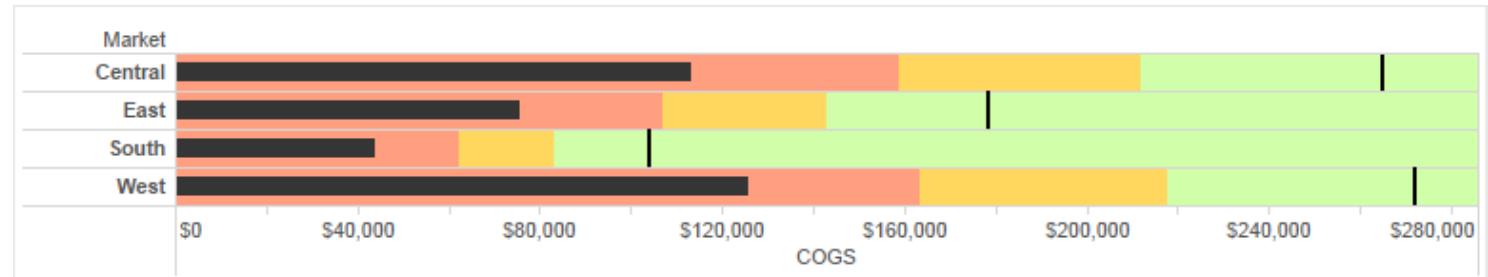
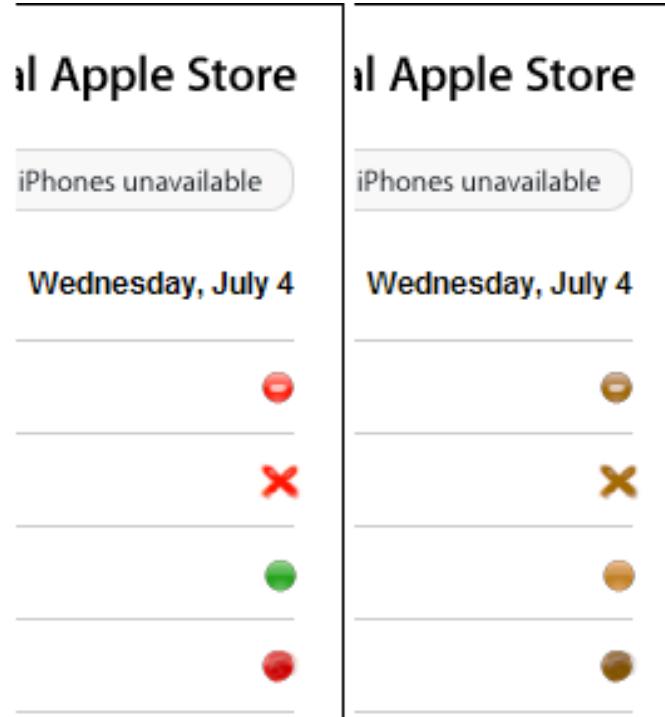
- Colour deficiency
 - Design for colour deficiency
 - check with simulator



[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

Colour Design

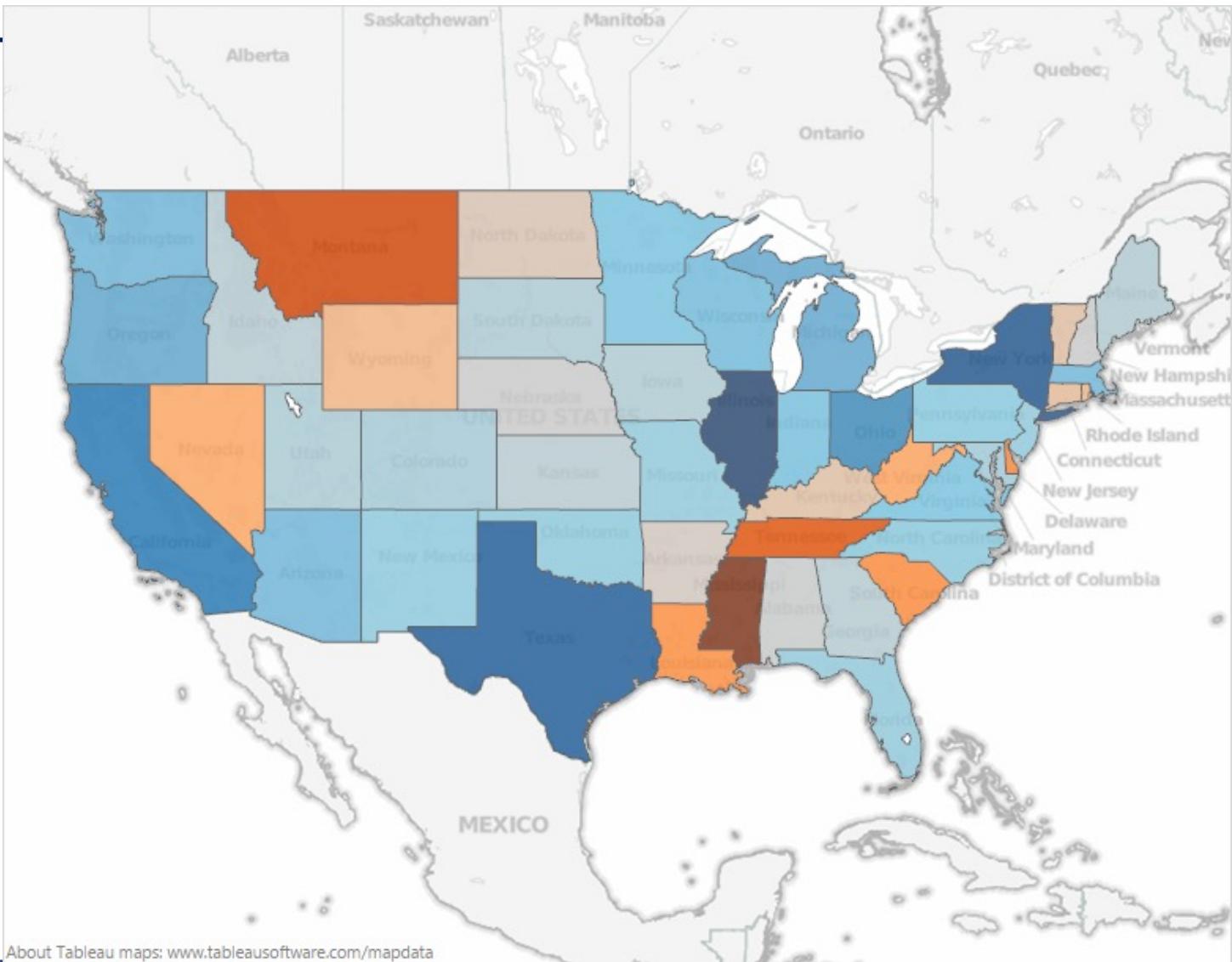
- Colour deficiency
 - Design for colour deficiency
 - Avoid encoding by hue alone
 - redundantly encode



[Blue bracket pointing to the first two items] Change the shape
[Blue bracket pointing to the last two items] Vary luminance

Colour Design

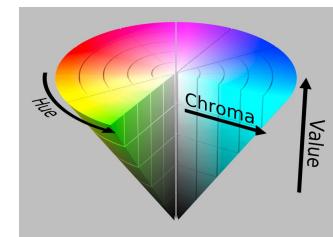
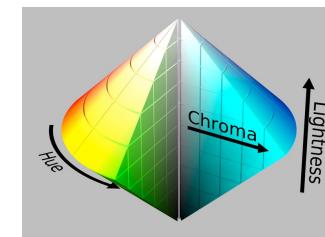
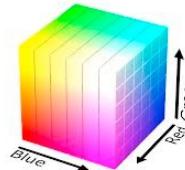
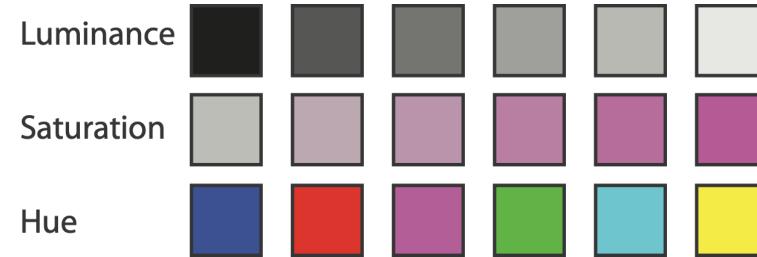
- Colour deficiency
 - Design for colour deficiency
 - Blue-Orange is safe



Colour Design

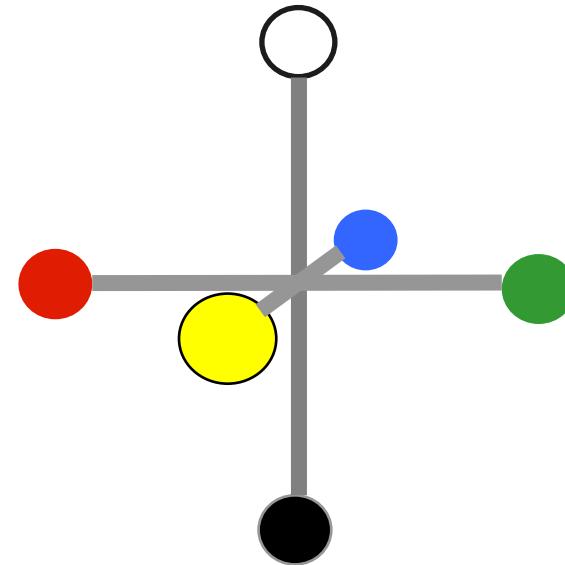
- Colour spaces

- Luminance (L^*), hue (H), saturation (S)
 - good for encode colour
 - but not standard graphics/tools colour space
- RGB
 - good for display hardware
 - poor for encoding
- CIE LAB ($L^*a^*b^*$)
 - good for interpolation
 - hard to interpret, poor for encoding
- HSL/HSV: somewhat better for encoding
 - hue/saturation wheel intuitive
 - beware: only pseudo-perceptual!
 - lightness (L) or value (V) \neq luminance (L^*)



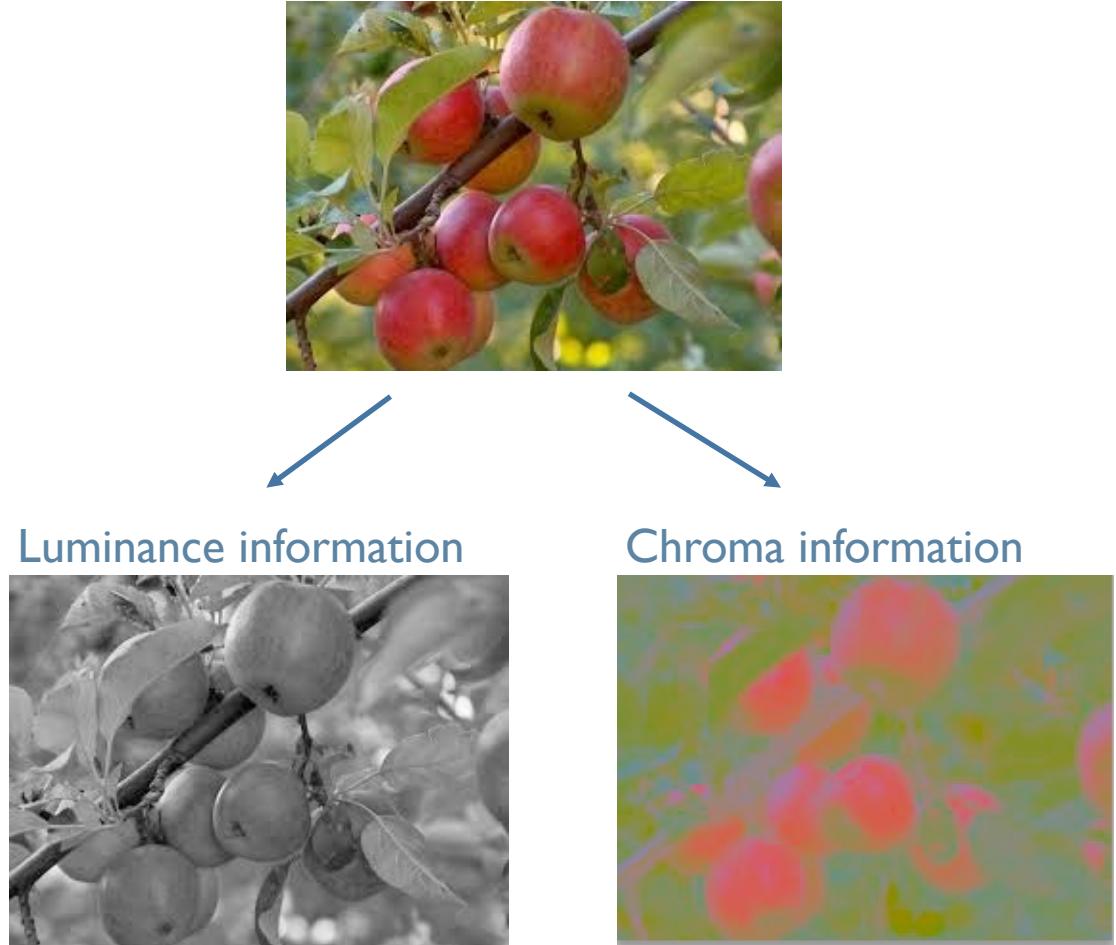
Colour Design

- Colour spaces
 - $L^*a^*b^*$
 - one achromatic luminance channel (L^*)
 - edge detection through luminance contrast
 - 2 chrome channels
 - red-green (a^*)
 - Yellow-blue (b^*a^*)



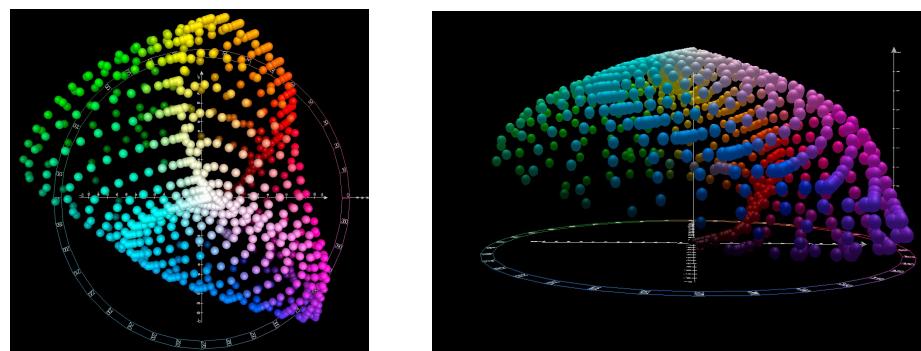
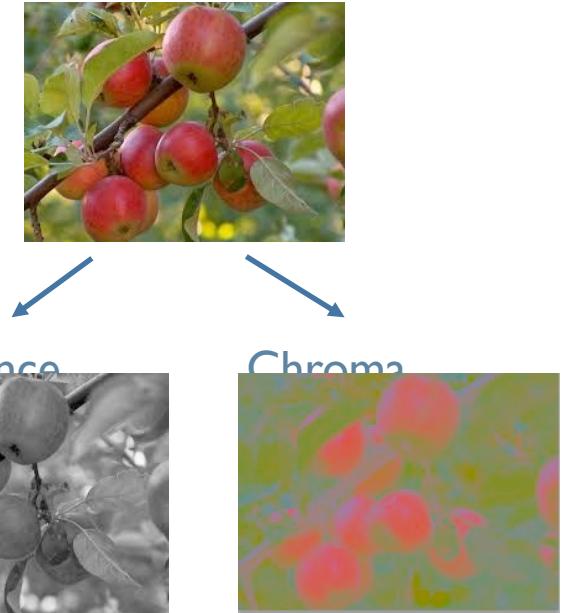
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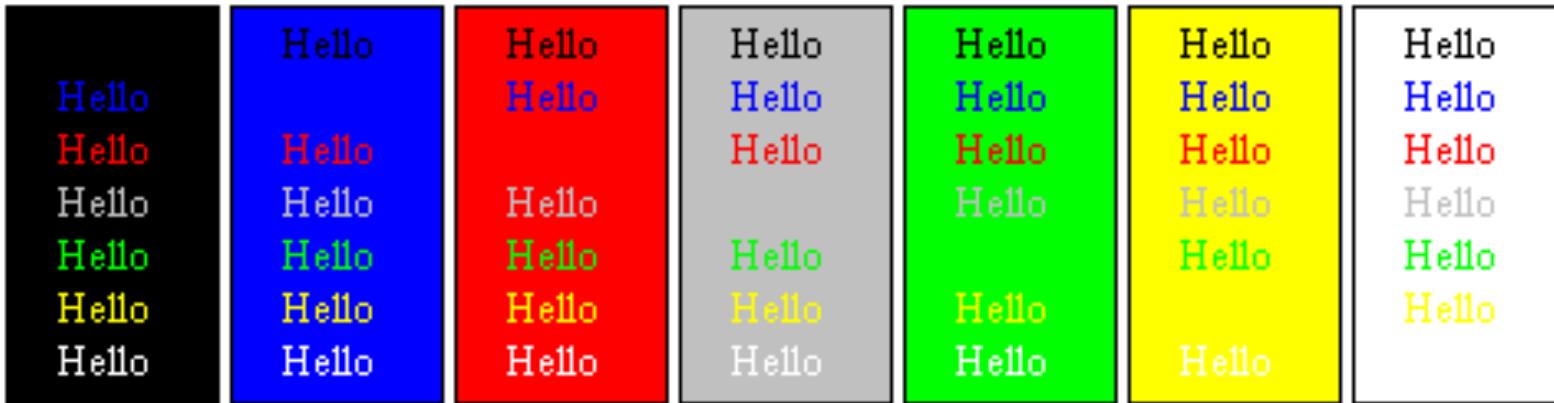
Colour Design

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 - L*a*b*
 - one achromatic luminance channel (L^*)
 - edge detection through luminance contrast
 - 2 chrome channels
 - red-green (a^*)
 - Yellow-blue (b^*)
 - CIE LAB
 - perceptually uniform
 - great for interpolating
 - complex shape
 - poor for encoding



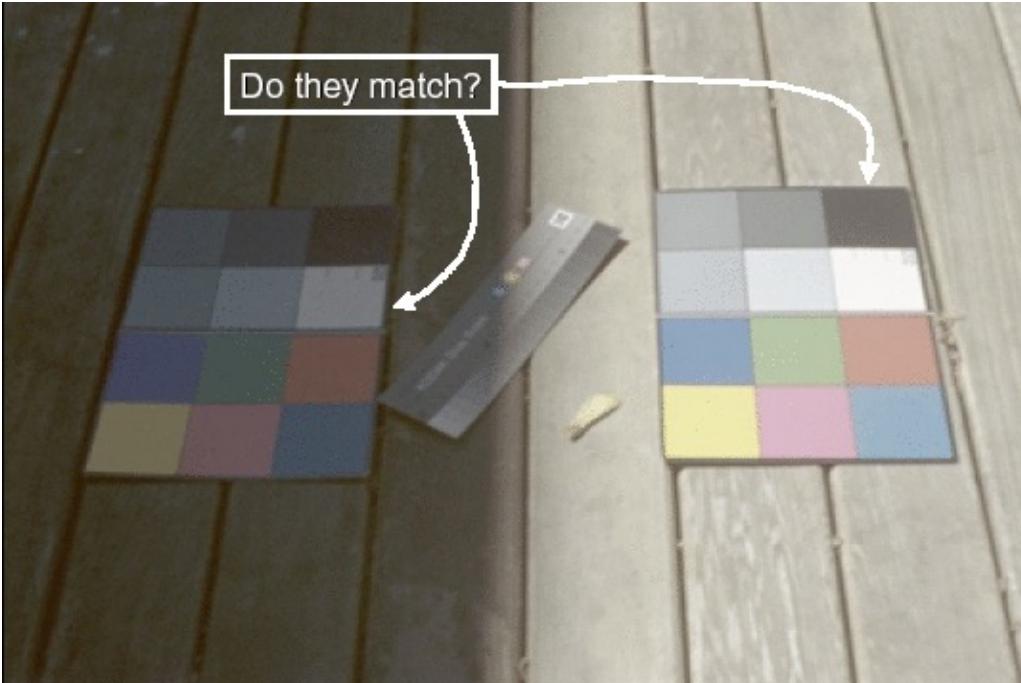
Colour Design

- Colour contrast
 - The difference between foreground and background colours determines legibility.
 - interaction with the background



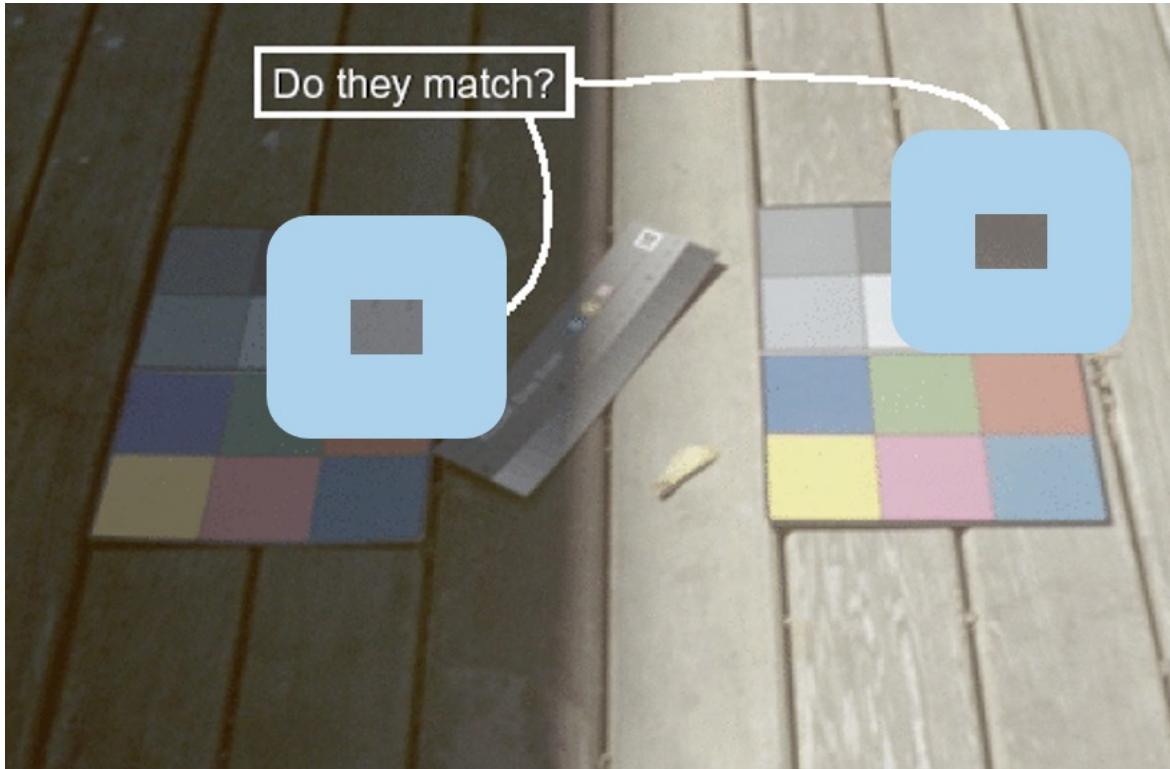
Colour Design

- Colour contrast
 - Colour/Lightness constancy: Illumination conditions



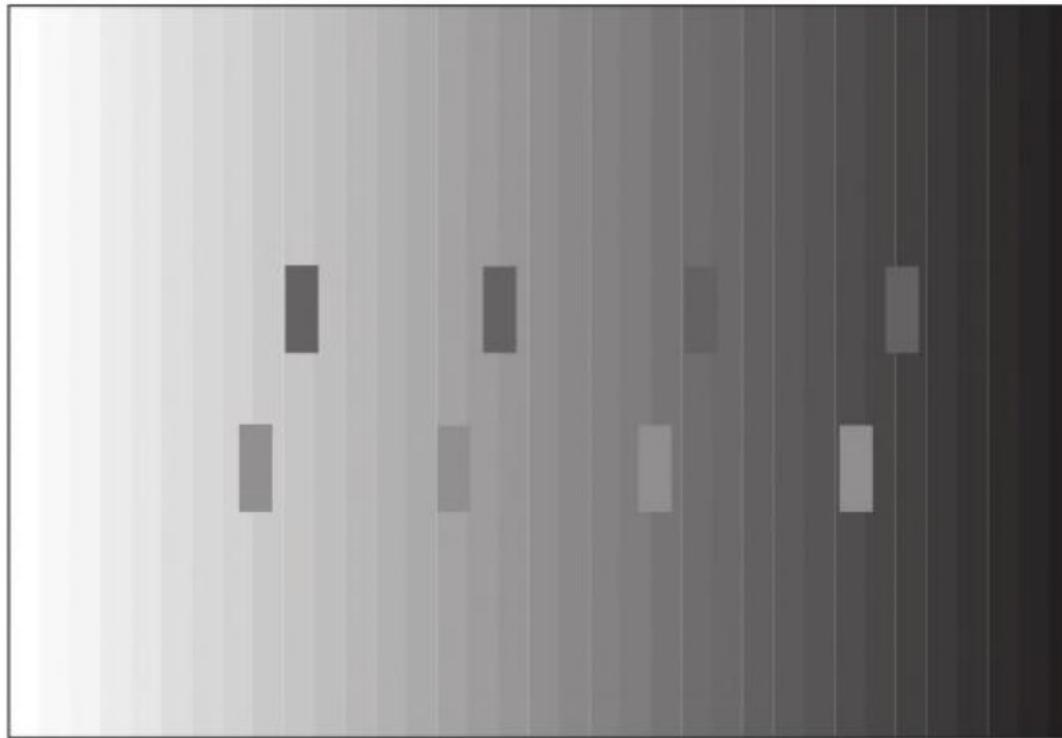
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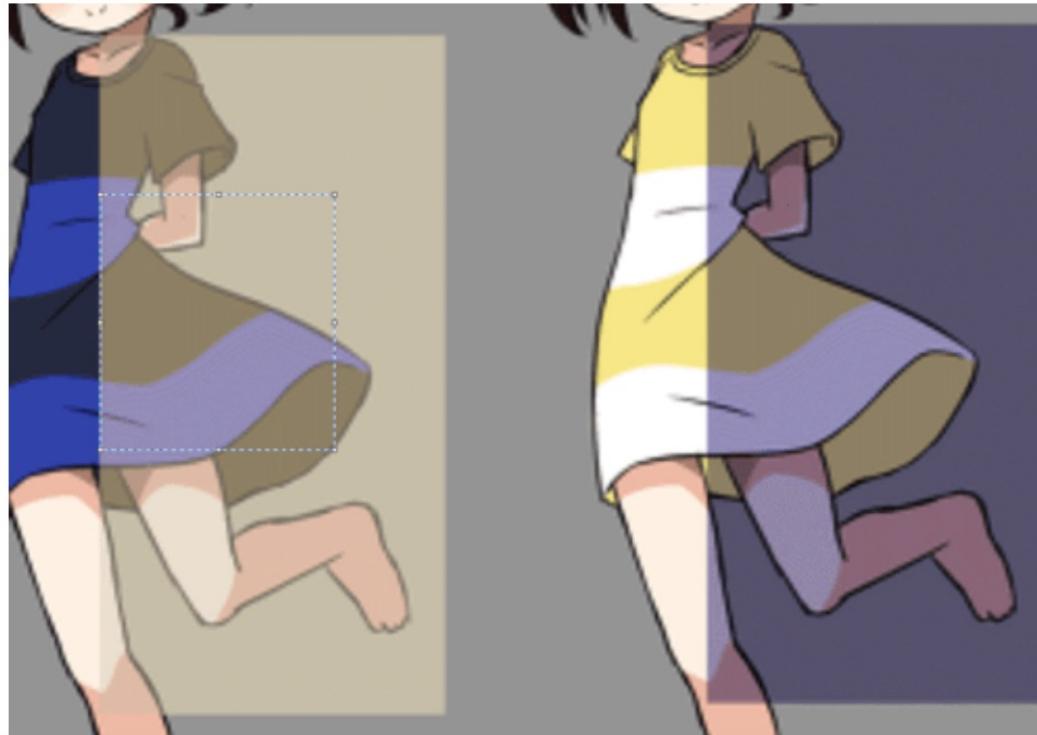
Colour Design

- Colour contrast
 - Contrast with background



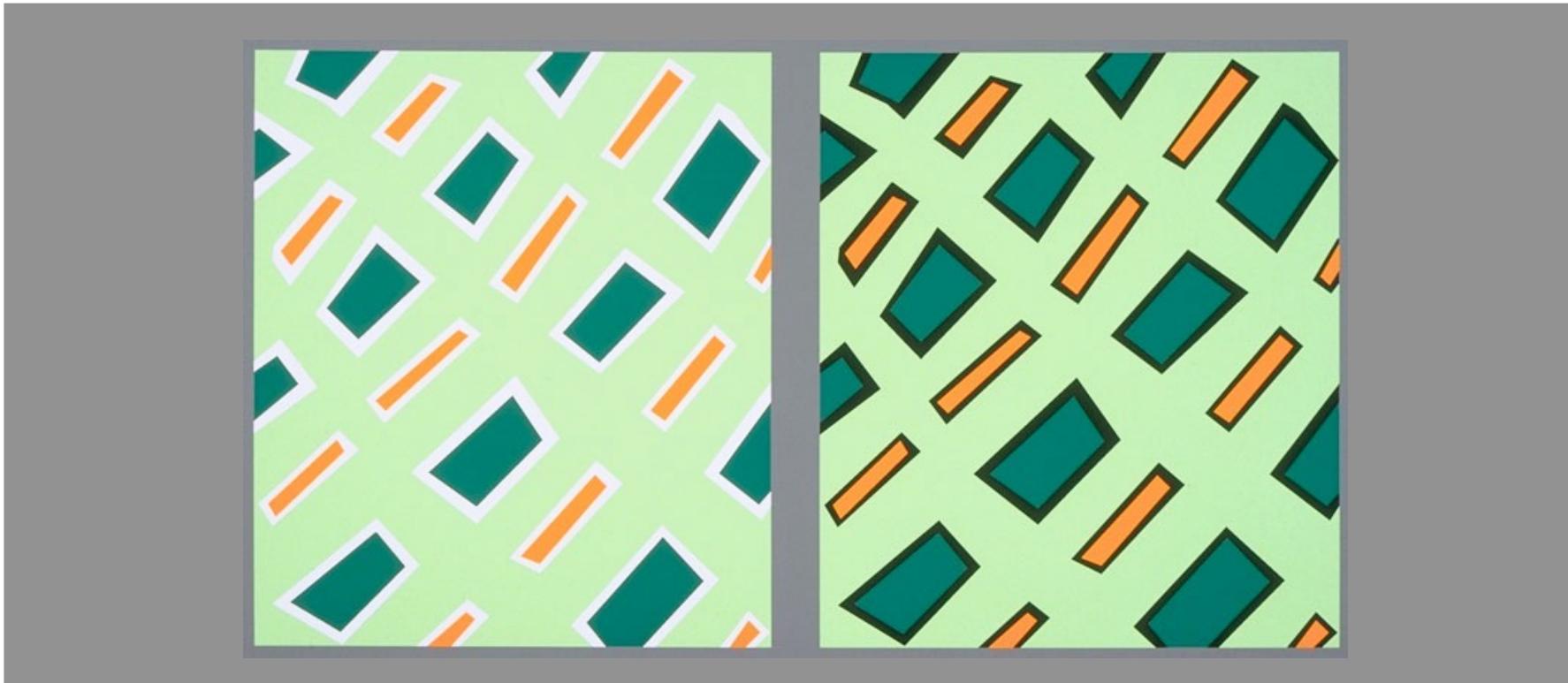
Colour Design

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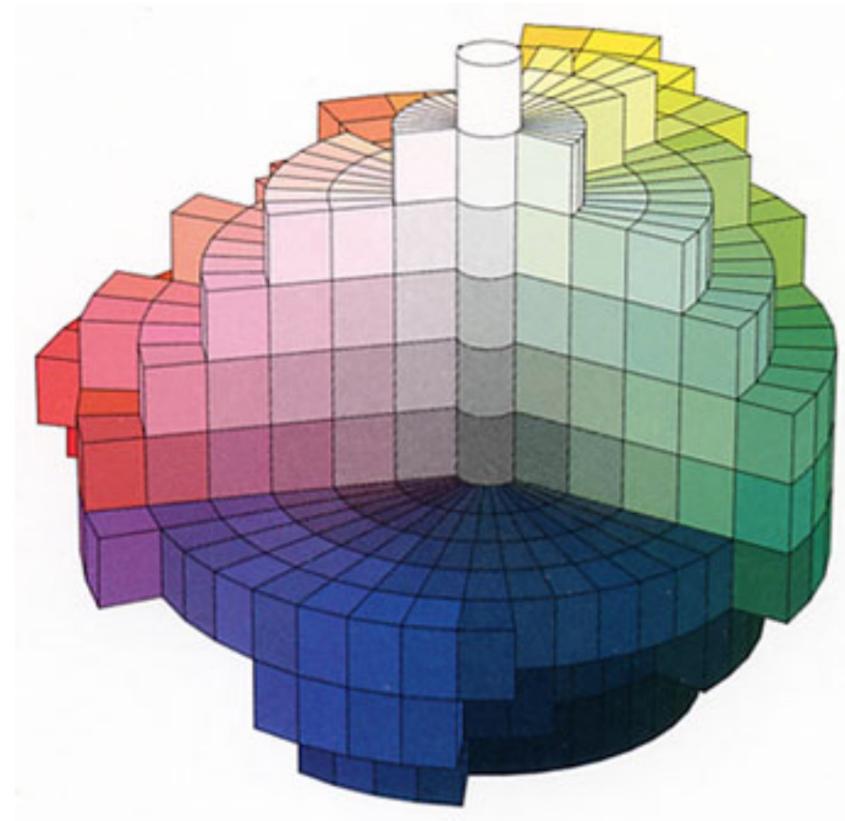
Colour Design

- Colour contrast
 - Bezold Effect: Outlines matter



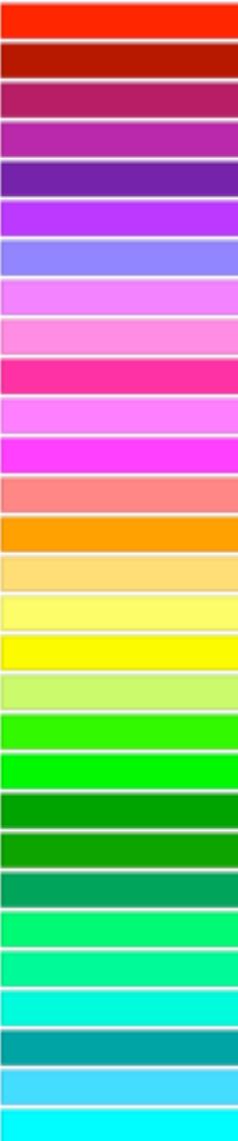
Colour Design

- Colour naming
 - Given $L\ a^*\ & b^*$, can we tell what color it is?
 - No, it depends
 - chromatic adaptation
 - luminance adaptation
 - simultaneous contrast
 - spatial effects
 - viewing angle



Colour Design

- colour naming

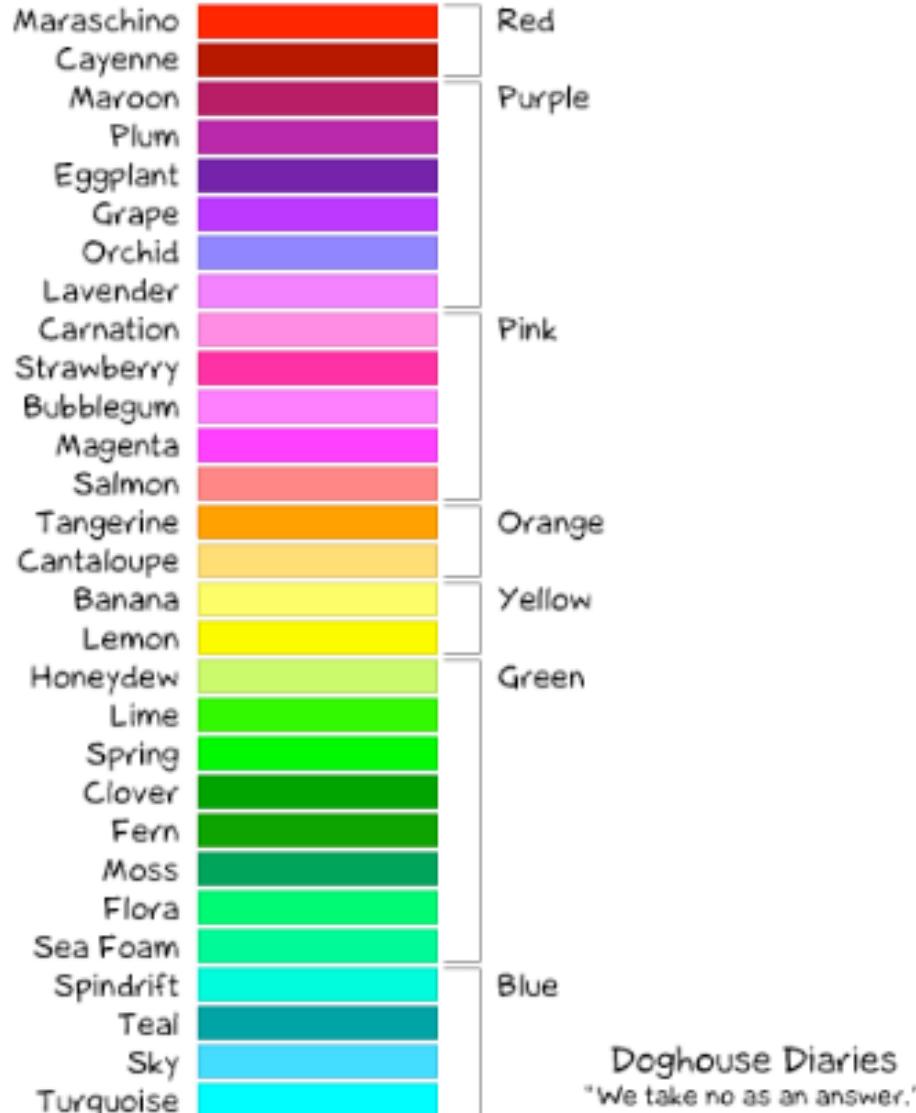


Colour Design

- colour naming

Color names if
you're a girl...

Color names if
you're a guy...



Colour Design

- colour naming

*Actual color names
if you're a girl ...*

*Actual color names
if you're a guy ...*



Colour Design

- colour naming
 - nameability affects
 - communication
 - memorability
 - can integrate into colour models
 - in addition to perceptual considerations

*Actual color names
if you're a girl ...*



*Actual color names
if you're a guy ...*