**Idiom: choropleth map**
- use given spatial data
  - when central task is understanding spatial relationships
- data
  - geographic geometry
  - scalar spatial field
- derived data
  - 1 spatial attribute per grid cell
- sequential segmented colormap
- transparency
  - useful for creating visual layers
  - but cannot combine with luminance or saturation

**Other color spaces**
- RGB: poor choice for visual encoding
- HSL: better, but beware
  - lightness ≠ luminance

**Categorical color: Discriminability constraints**
- noncontiguous small regions of color: only 6-12 bins
  - 6-12 bins hex/color
  - far fewer if colorblind
  - 3-4 bins luminance/saturation
  - can heavily affect valence
  - use light saturation for small regions, low saturation for larger

**Colormaps**
- Geographical
- Sequential
- Diverging
- Categorical
- Continuous

**Idiom: topographic map**
- data
  - geographic geometry
  - scalar spatial field
- derived data
  - isovalue geometry
- isosurfaces computed for specific levels of scalar values

**Ordered color: Rainbow is poor default**
- problems
  - perceptually unordered
  - perceptually nonlinear
- benefits
  - fine-grained structure visible and meaningful
- alternatives
  - fewer hues for large-scale structure
  - multiple hues with monotonically increasing luminance for fine-grained segments

**Spectral sensitivity**
- Luminance values

**Map other channels**
- size
  - length accurate, 2D area ok, 3D volume poor
- angle
  - non-linear accuracy
  - horizontal/vertical/oblique diagonal
- shape
  - complex combination of lower-level primitives
  - many bins
- motion
  - highly separable among static
  - binary great for highlighting
  - use with care to avoid irritation

**Data**
- Movie Reviews
- Geographical
- Sequential
- Diverging
- Categorical

**Tableau Research**
- designer of Tableau color defaults
- co-author of A Field Guide to Digital Color
- creator of follow-up color slides excerpted from Seriously Colorful: Advanced Color Principles & Practices
- Tableau Customer Conference 2014 talk
Different colorings tell different stories

Four distinct categories

Ordered colors for ordered relationships

Contrasting color for emphasis

Perceived lightness: Fundamental to vision

Similar, but still distinctly different

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How do we define "lightness"?

Generated lightness: RGB, HSV, HLS
Perceived lightness:  L* (from CIELAB)

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Tools for perceived lightness

CIELAB, L*a*b*, Lab, etc.
Adobe Creative Suite (gray, Lab)
Gpick (www.gpick.org) Opensource, PC, Unix
DigitalColor Meter (L*a*b*) Apple desktop utility

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By default: Tableau 10 and 20

Default Medium Light

By default: Tableau 10 and 20

Default Medium Light

Size matters

OK large, Not so OK small

Tableau default

Large area color: Too bright

Size matters

OK large, Not so OK small

Tableau default

Large area color: Too bright
Summary: Understanding color
- Hue, chroma, lightness
- Generated vs. perceived
- Contrast and analogy: Tell your story
- Size, outlines, background all matter

Color vision deficiency (CVD)
- Affects 8-10% of men
- Red-green availability icons

Most CVD involves problems with red-green
- Small but important separation

When CVD is a problem
- As seen by a deuteranope

Named colors and CVD
- Red-green not the only problem

Encode with lightness
- Deuteranope simulation

Avoid encoding by color alone
- Change the shape
- Vary lightness

Tableau 10 and CVD
- Normal
- Mild
- Severe

Problem: Genes in Vischeck
- Extensive CVD (Vischeck simulation)

Similar perception of lightness
Blue-Orange is "safe"

Tableau and CVD: Colorblind palette

Making "traffic light" colors work

Tableau color design principles
Focus on data, not color design
Defaults encode best practices
Support multiple views, multiple mark types
Encourage best practices, allow personal expression

Overview
Discrete palettes and continuous ramps
Design of defaults and UX
Design alternative choices
Customized within the UX
Create your own with XML (preferences.tps)

CVD Simulation
Built into some Adobe tools
Coblis: http://www.color-blindness.com/coblis-color-blindness-simulator/

Discrete data: Palettes
Assign colors to items in categories

Default: Tableau 10 and 20
Automatic based on cardinality
Order is top-to-bottom, left-to-right

Disjoint Palettes Partition color space

Specials
Colorblind
Gray 5
Traffic Light

Ordered
Discrete ramps, distribute across domain

Multiple fields on color

Continuous data: Ramps
Assign colors to sequences of numeric values

DEMO: CATEGORICAL COLOR
Learn from Cartographers
From Cynthia Brewer
Large
Small
Large
Large
Zero
Sequential
Diverging
(grey & white centers)
Default for areas
(maps, treemaps, heatmaps…)
Light, for behind text
Light, for behind text
Specials for maps

Color Ramps

DEMO: QUANTITATIVE COLOR

Summary
Color vision and design principles
Tableau principles
• Focus on the data
• Design your color “story”
• Consider size, legibility
Don’t forget those with CVD

Further reading
  — Chap 10: Map Color and Other Channels
  — Chap 8: Arrange Spatial Data

Lab/Assignment 3
• Work through two Stevens tutorials
• Work through two Stone color demos
• Apply color principles to three datasets from previous two labs
• submit next week
  — by 9am Tue, email tmm@cs.ubc.ca with subject JOURN Week 3

Preferences.tps
<color-palette name='flame' type= 'ordered-sequential'>
  <color> #FFEF3A </color>
  <color> #FED724 </color>
  <color> #FEAC0A </color>
  <color> #ED6211 </color>
  <color> #E03D1A </color>
  <color> #CC0629 </color>
</color-palette>

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