Lectures 5-6:
Spatial Data, Color

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DSCI 531: Data Visualization 1
Lecture 5: 29 November 2016
Lecture 6: 5 December 2016

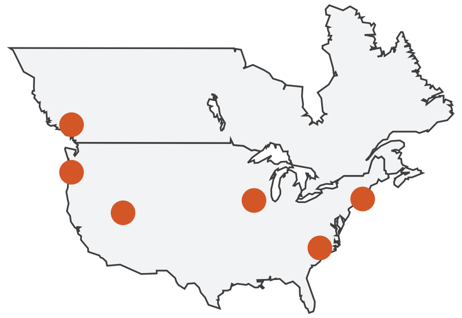
https://github.ubc.ca/ubc-mds-2016/DSCI_531_viz-1_students

Spatial Data

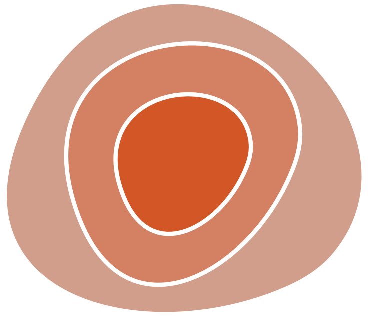
VAD Chap 8: Arrange spatial data

➔ Use Given

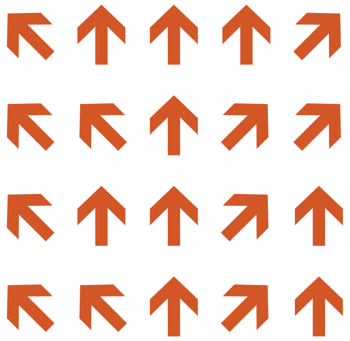
- ➔ Geometry
  - ➔ *Geographic*
  - ➔ *Other Derived*



- ➔ Spatial Fields
  - ➔ *Scalar Fields (one value per cell)*
    - ➔ *Isocontours*
    - ➔ *Direct Volume Rendering*

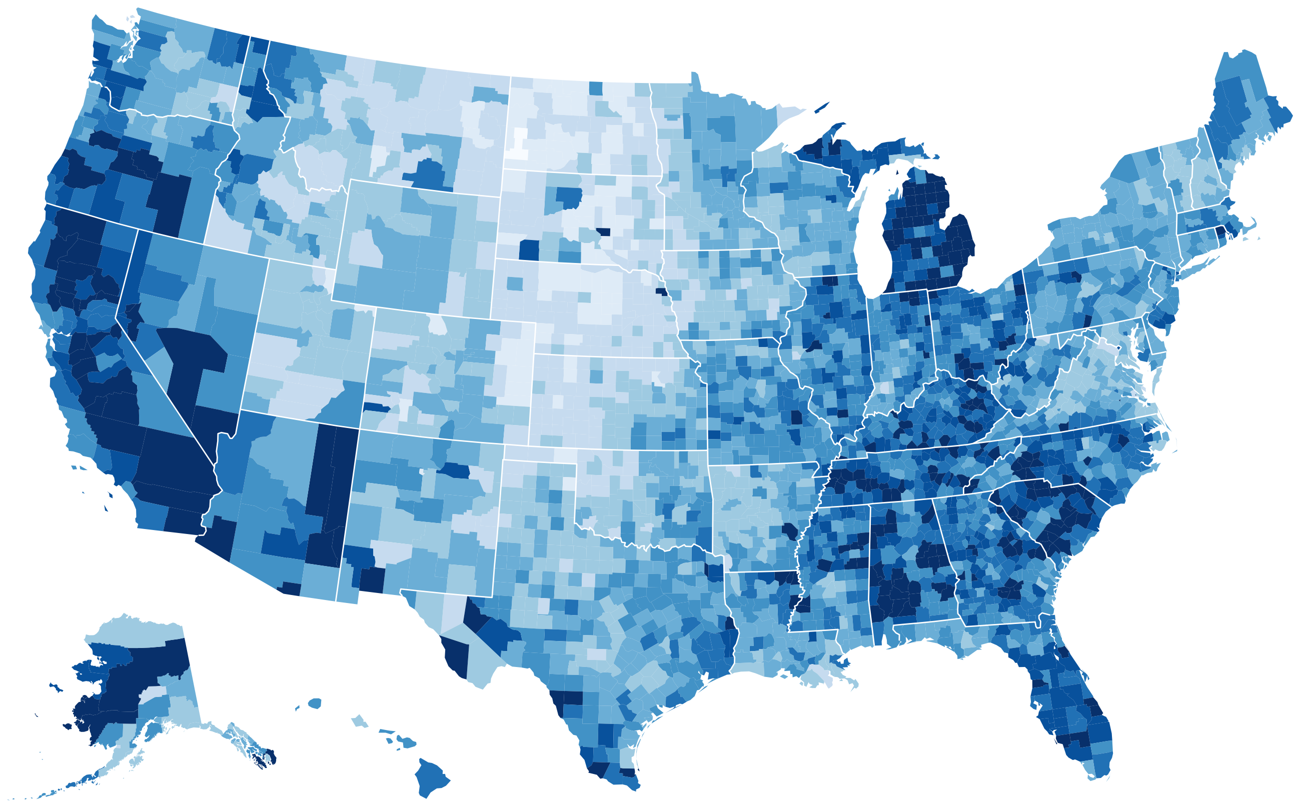


  - ➔ *Vector and Tensor Fields (many values per cell)*



Idiom: **choropleth map**

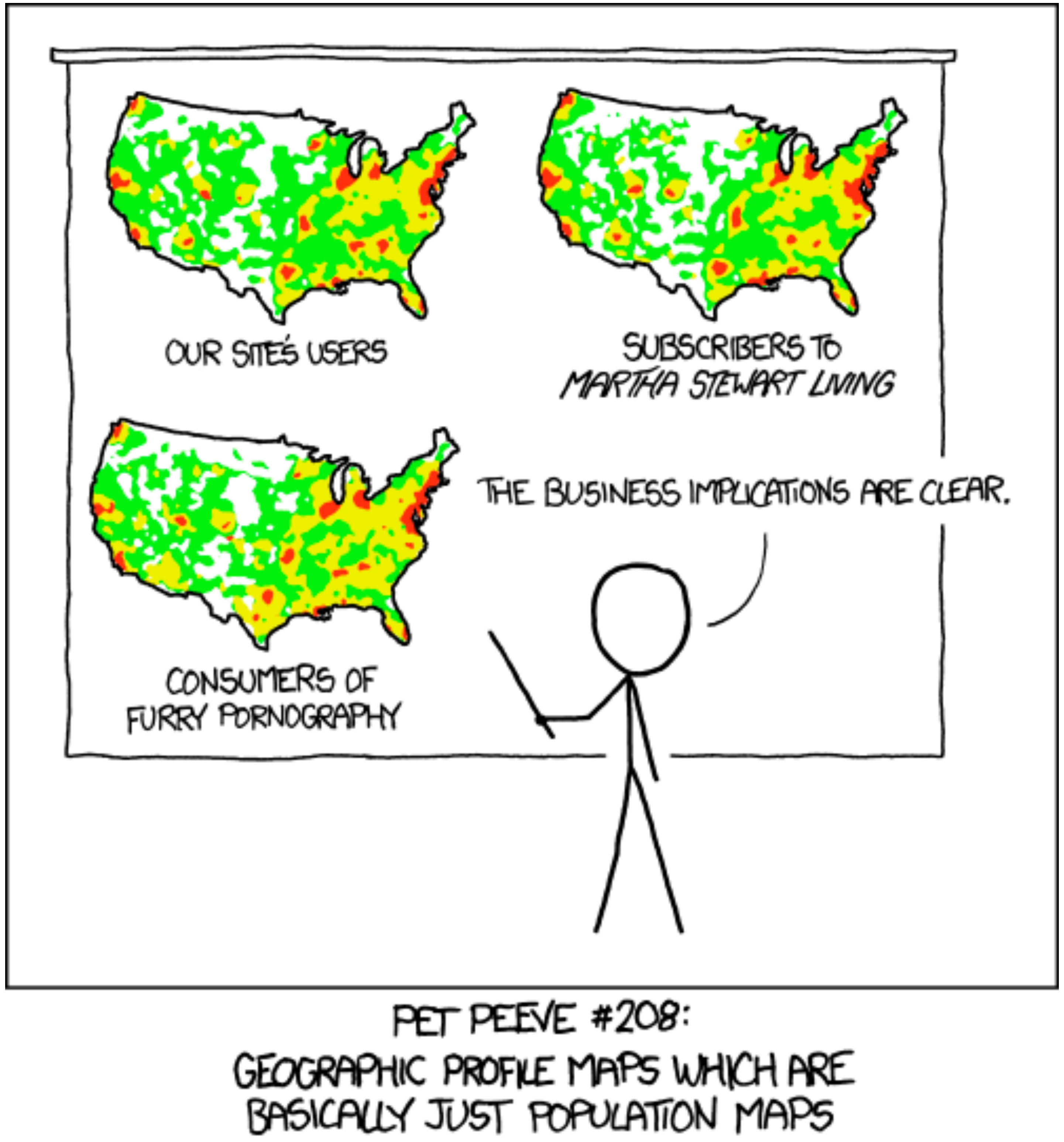
- *use* given spatial data
  - when central task is understanding spatial relationships
- data
  - geographic geometry
  - table with 1 quant attribute per region
- encoding
  - use given geometry for area mark boundaries
  - sequential segmented colormap
- trickiness
  - small regions are less visually salient



http://bl.ocks.org/mbostock/4060606

Population maps trickiness

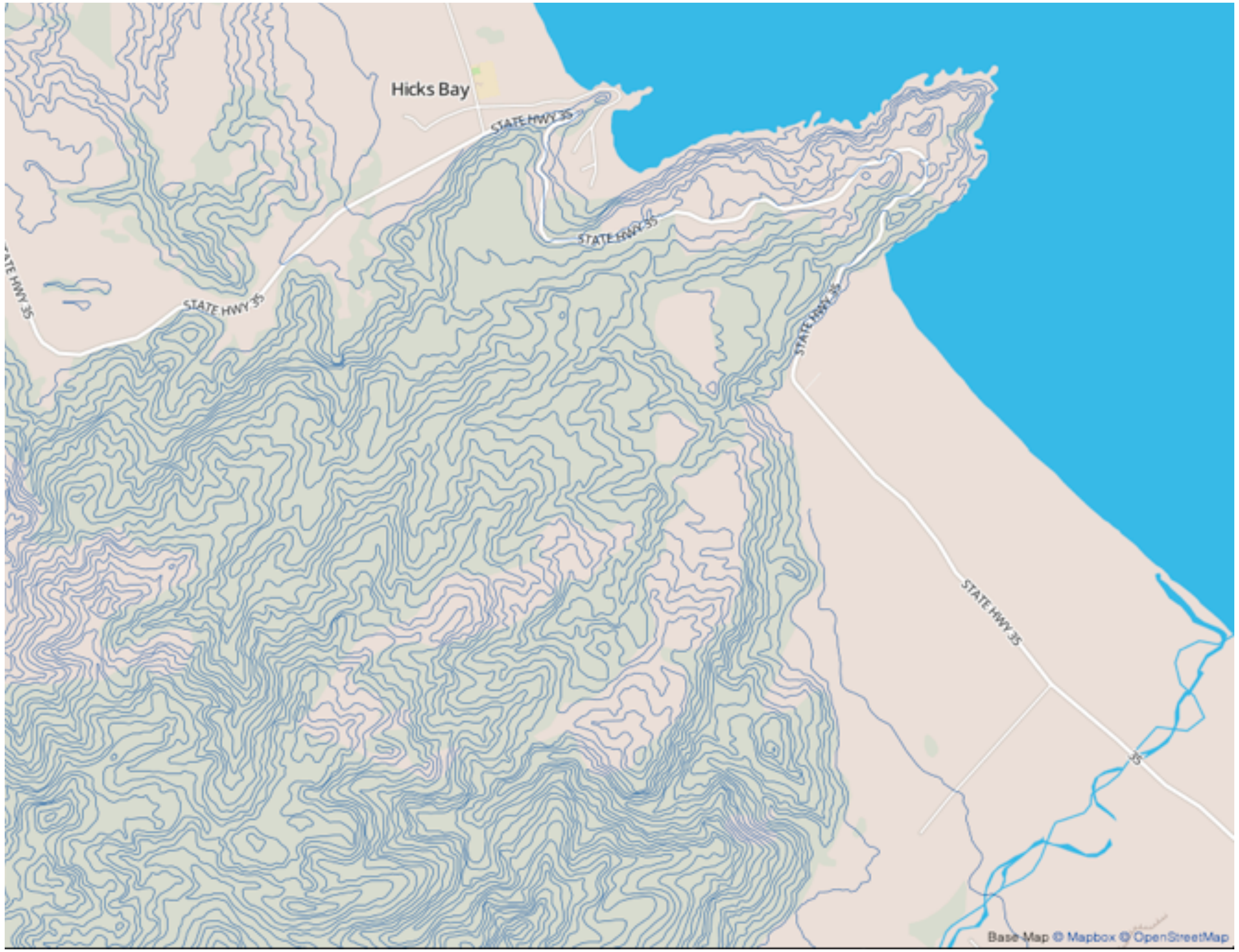
- beware!
- absolute vs relative again
  - population density vs per capita
- investigate with Ben Jones Tableau Public demo
  - http://public.tableau.com/profile/ben.jones#!/vizhome/PopVsFin/PopVsFin *Are Maps of Financial Variables just Population Maps?*
    - yes, unless you look at per capita (relative) numbers



[https://xkcd.com/1138]

Idiom: **topographic map**

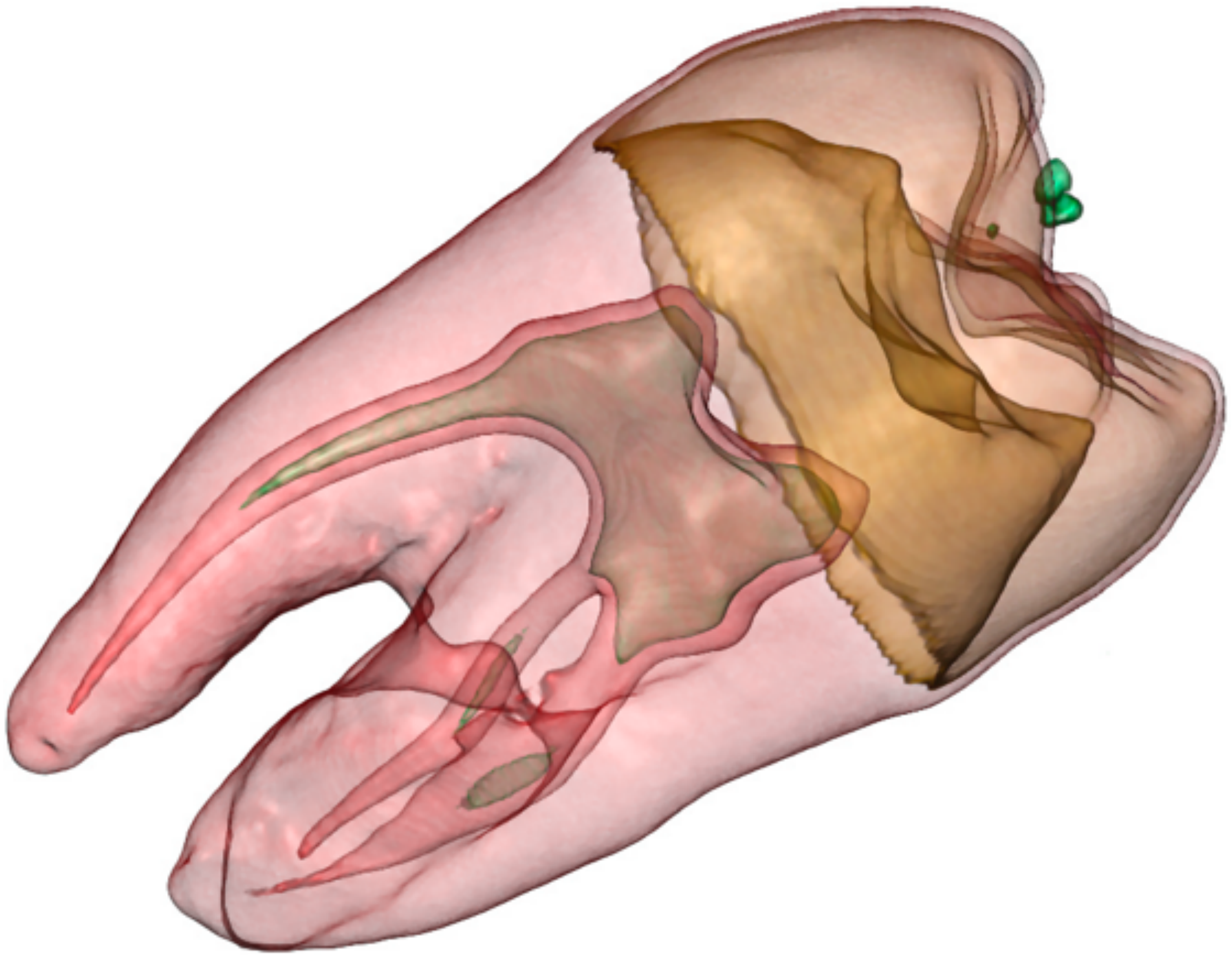
- data
  - –geographic geometry
  - –scalar spatial field
    - 1 quant attribute per grid cell
- derived data
  - –isoline geometry
    - isocontours computed for specific levels of scalar values



Land Information New Zealand Data Service

Idiom: **isosurfaces**

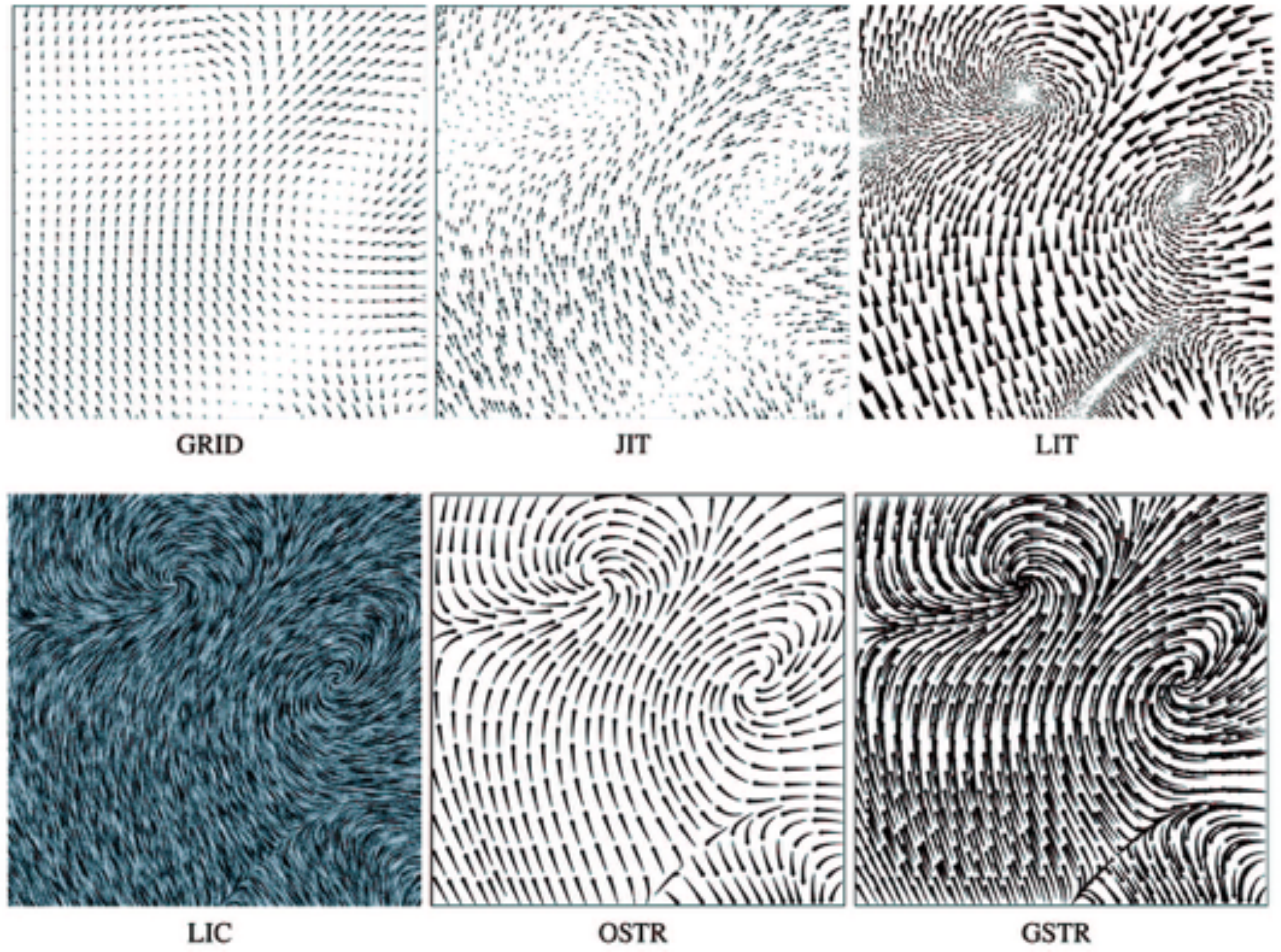
- data
  - –scalar spatial field
    - 1 quant attribute per grid cell
- derived data
  - –isosurface geometry
    - isocontours computed for specific levels of scalar values
- task
  - –spatial relationships



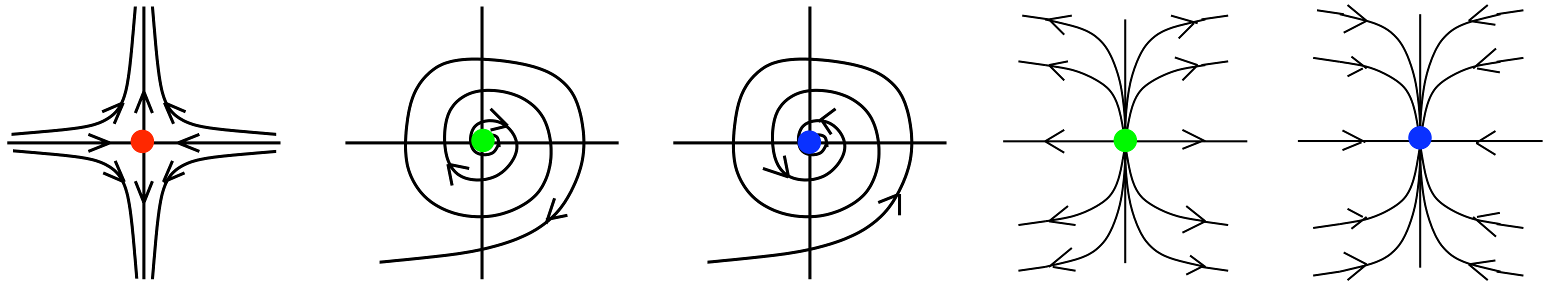
[Interactive Volume Rendering Techniques. Kniss. Master's thesis, University of Utah Computer Science, 2002.]

Vector and tensor fields

- data
  - many attribs per cell
- idiom families
  - flow glyphs
    - purely local
  - geometric flow
    - derived data from tracing particle trajectories
    - sparse set of seed points
  - texture flow
    - derived data, dense seeds
  - feature flow
    - global computation to detect features
      - encoded with one of methods above



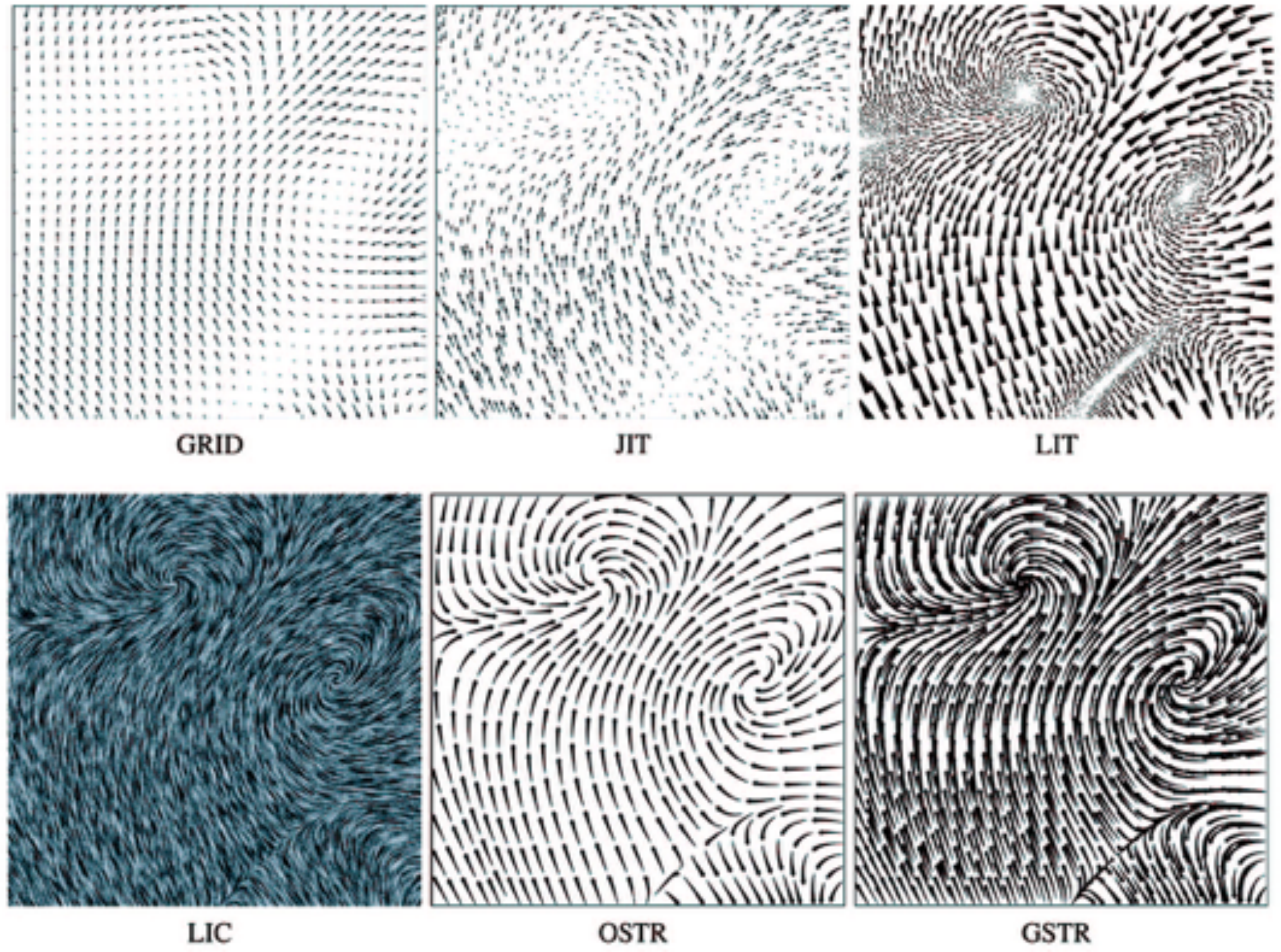
[Comparing 2D vector field visualization methods: A user study. Laidlaw et al. IEEE Trans. Visualization and Computer Graphics (TVCG) 11:1 (2005), 59–70.]



[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

Vector fields

- empirical study tasks
  - finding critical points, identifying their types
  - identifying what type of critical point is at a specific location
  - predicting where a particle starting at a specified point will end up (advection)



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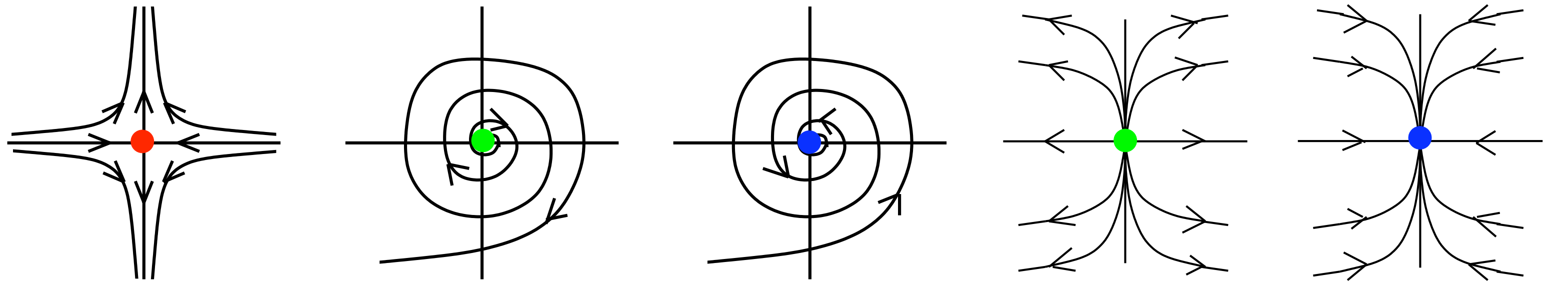
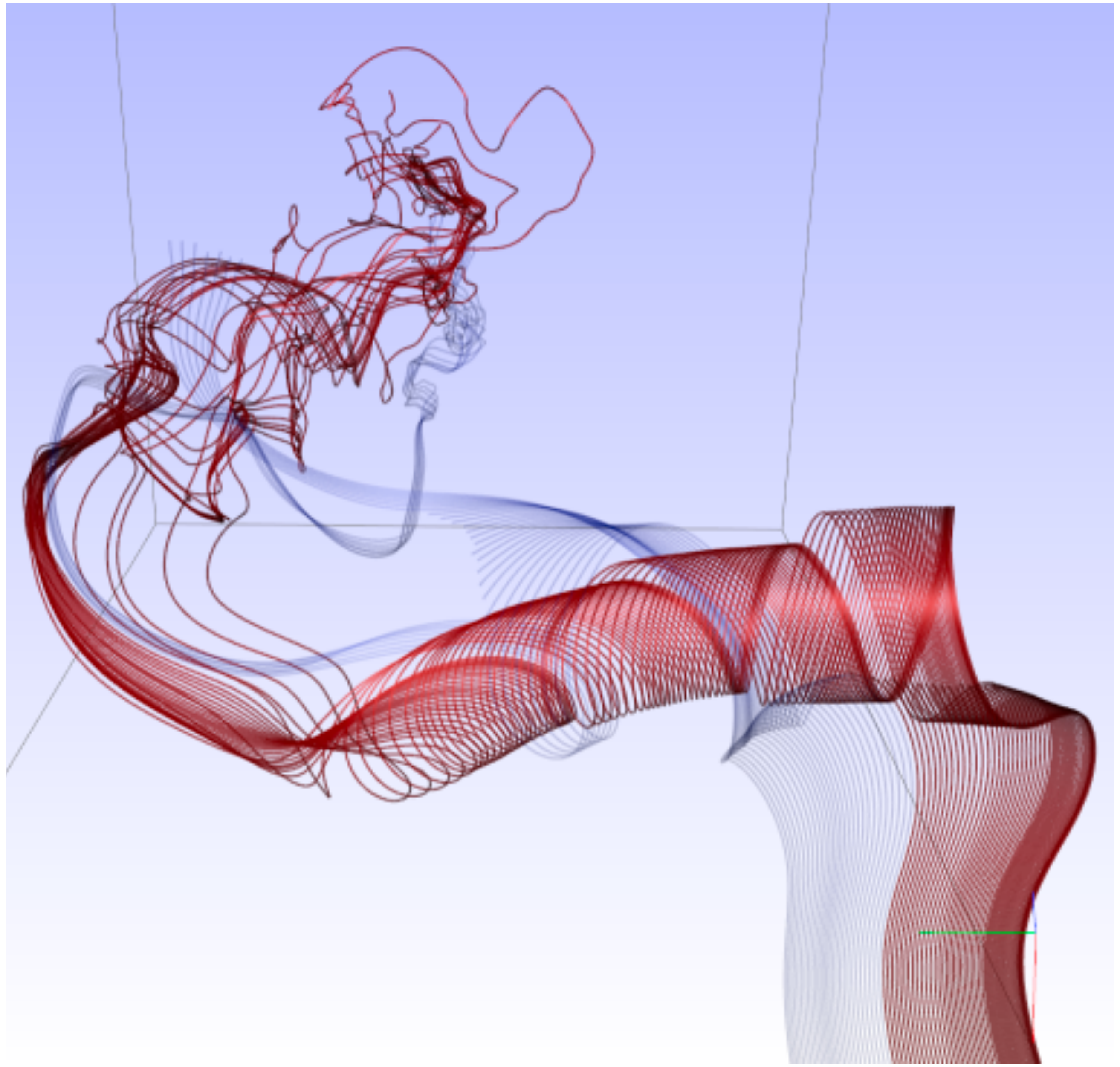


[Topology tracking for the visualization of time-dependent two-dimensional flows. Tricoche, Wischgoll, Scheuermann, and Hagen. Computers & Graphics 26:2 (2002), 249–257.]

Idiom: **similarity-clustered streamlines**

- data
  - 3D vector field
- derived data (from field)
  - streamlines: trajectory particle will follow
- derived data (per streamline)
  - curvature, torsion, tortuosity
  - signature: complex weighted combination
  - compute cluster hierarchy across all signatures
  - encode: color and opacity by cluster
- tasks
  - find features, query shape
- scalability
  - millions of samples, hundreds of streamlines

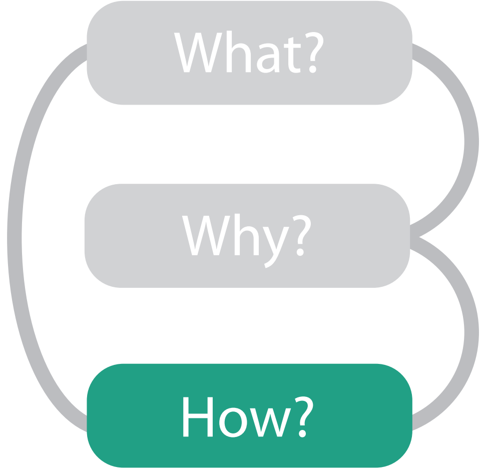


[Similarity Measures for Enhancing Interactive Streamline Seeding. McLoughlin,. Jones, Laramee, Malki, Masters, and. Hansen. IEEE Trans. Visualization and Computer Graphics 19:8 (2013), 1342–1353.]

Color

Idiom design choices: Encode

Encode

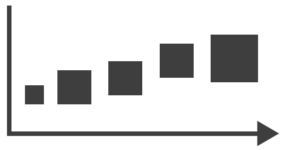


Arrange

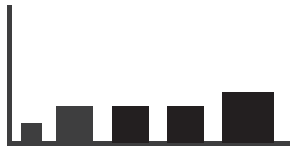
→ Express

→ Separate

→ Order



→ Align



→ Use

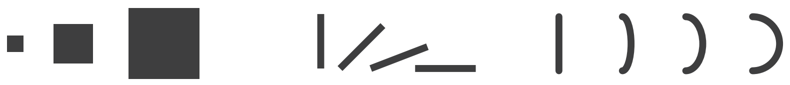
Map

from categorical and ordered attributes

→ Color

→ *Hue* → *Saturation* → *Luminance*

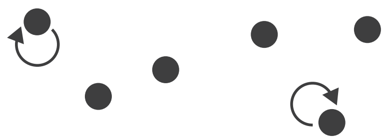
→ Size, Angle, Curvature, ...



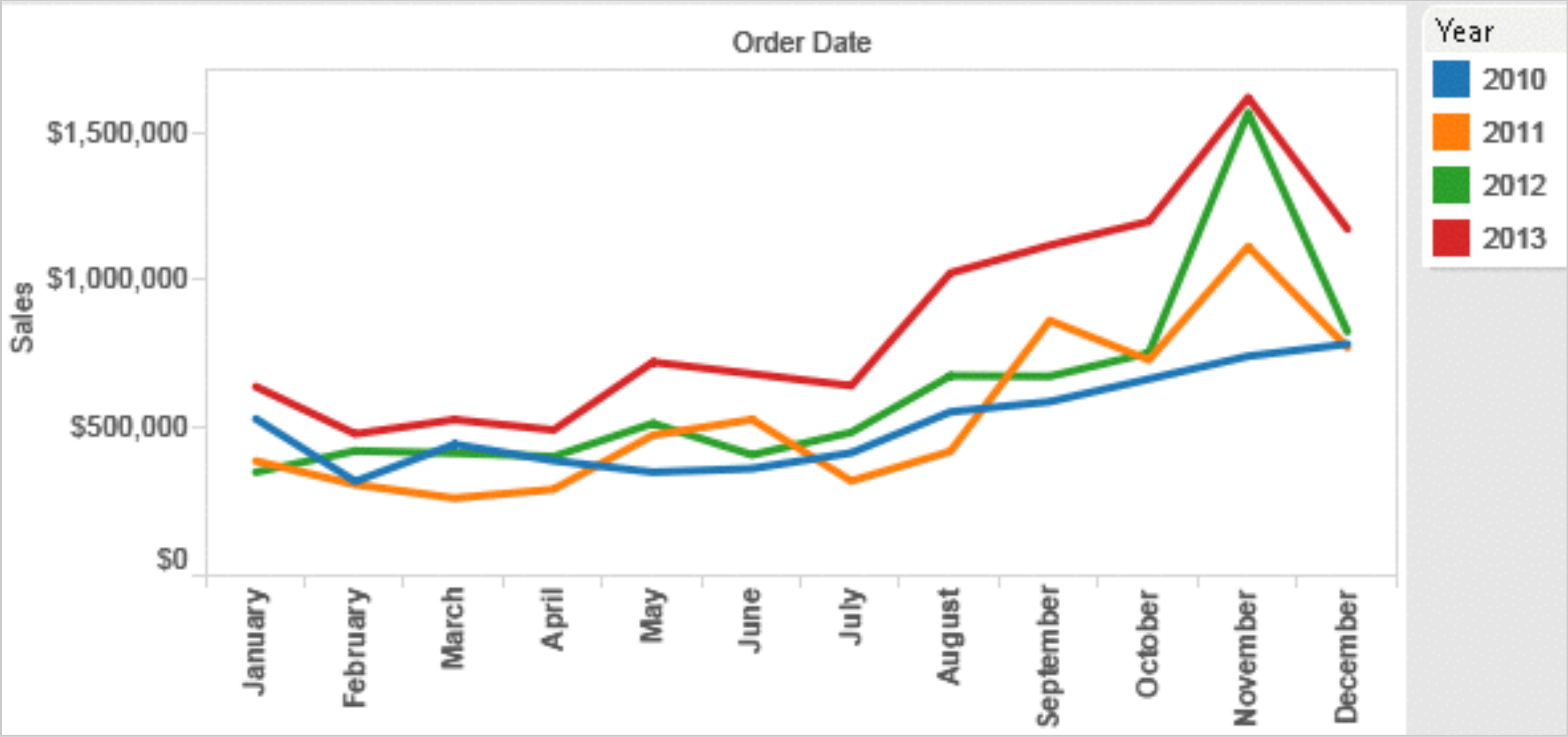
→ Shape

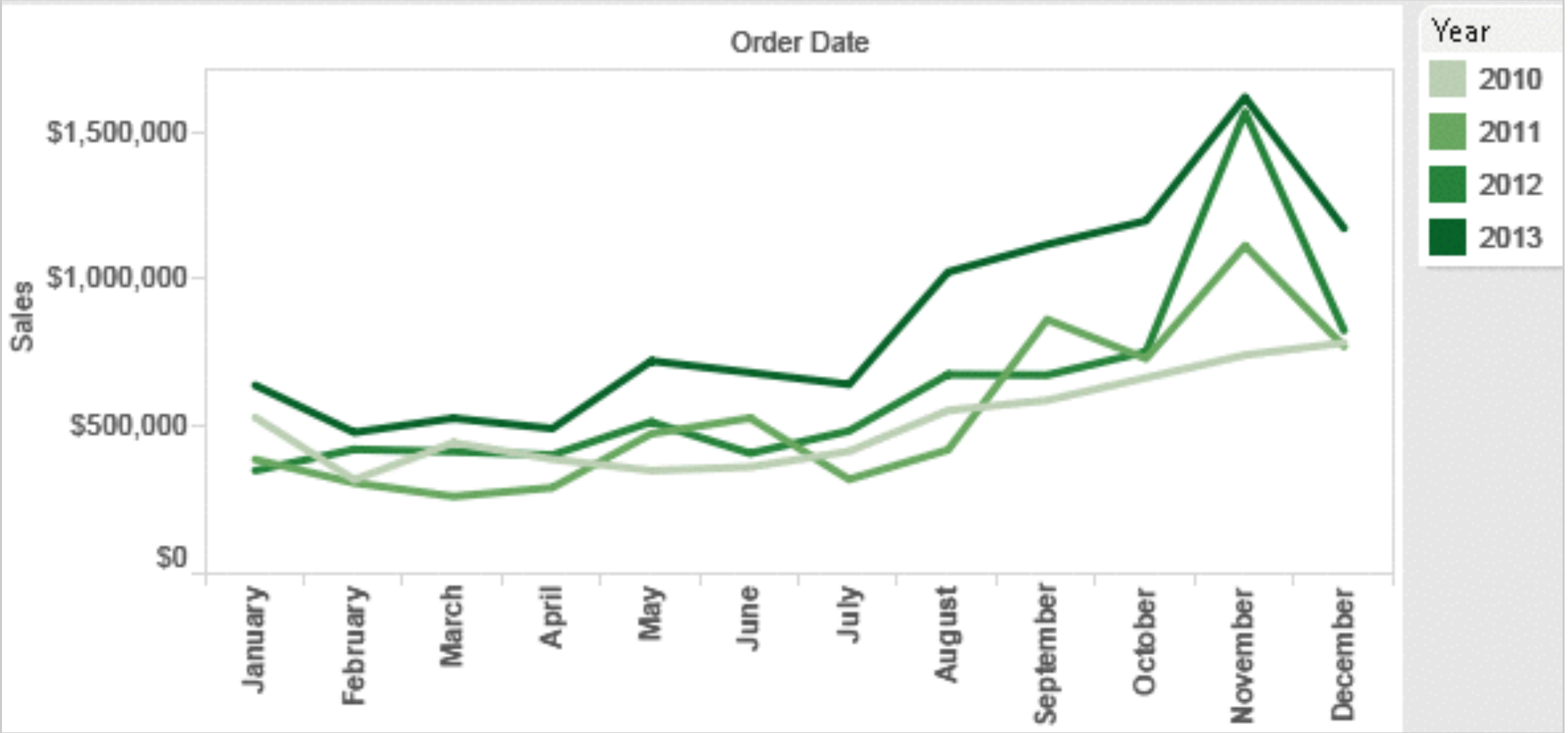
→ Motion

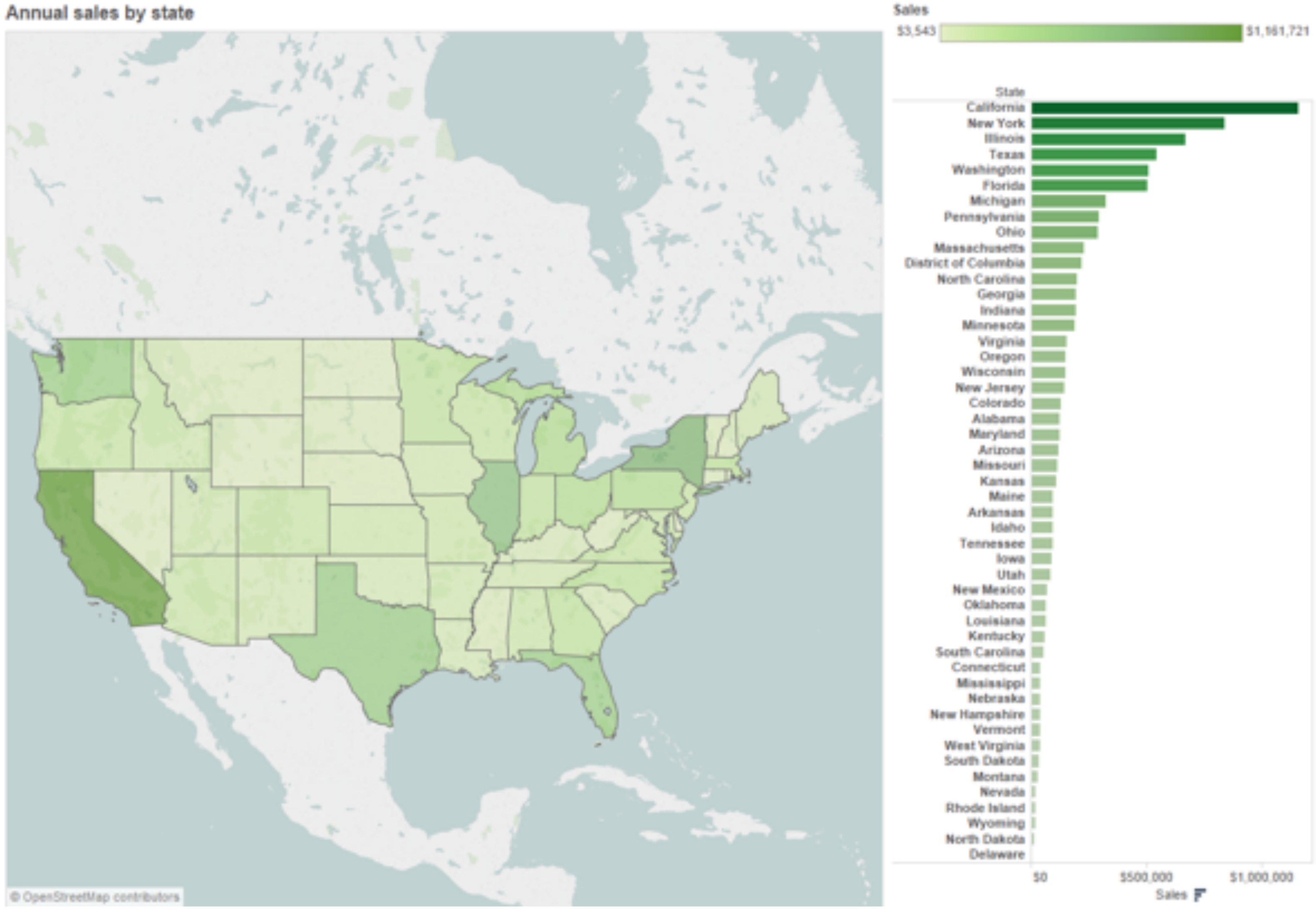
Direction, Rate, Frequency, ...



Categorical vs ordered color







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

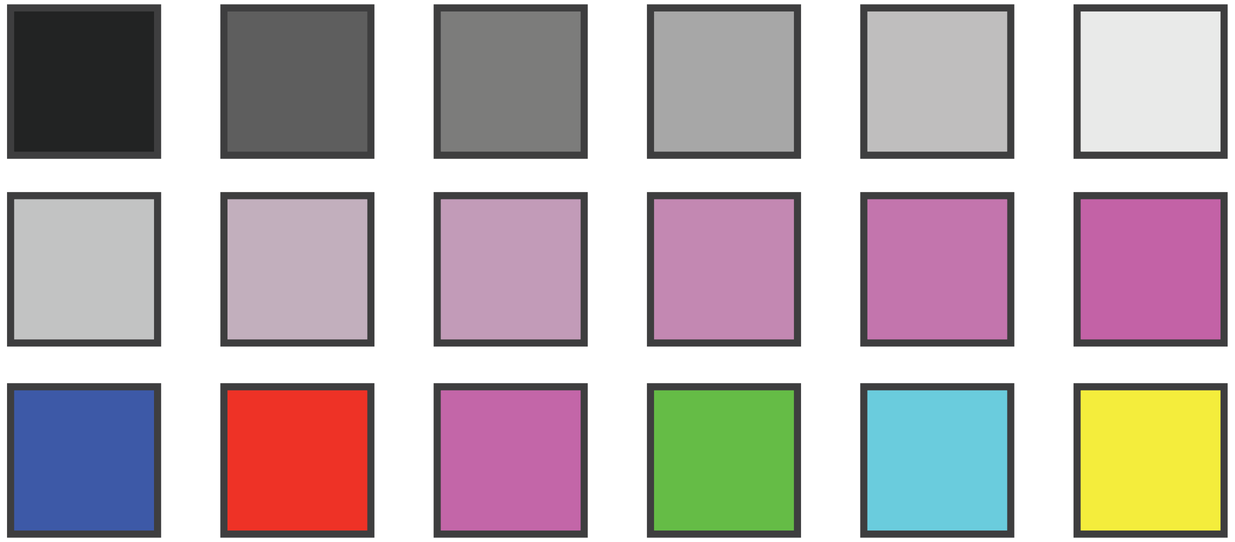
Color: Luminance, saturation, hue

- 3 channels
  - identity for categorical
    - hue
  - magnitude for ordered
    - luminance
    - saturation
- RGB: poor for encoding
- HSL: better, but beware
  - lightness ≠ luminance

Luminance

Saturation

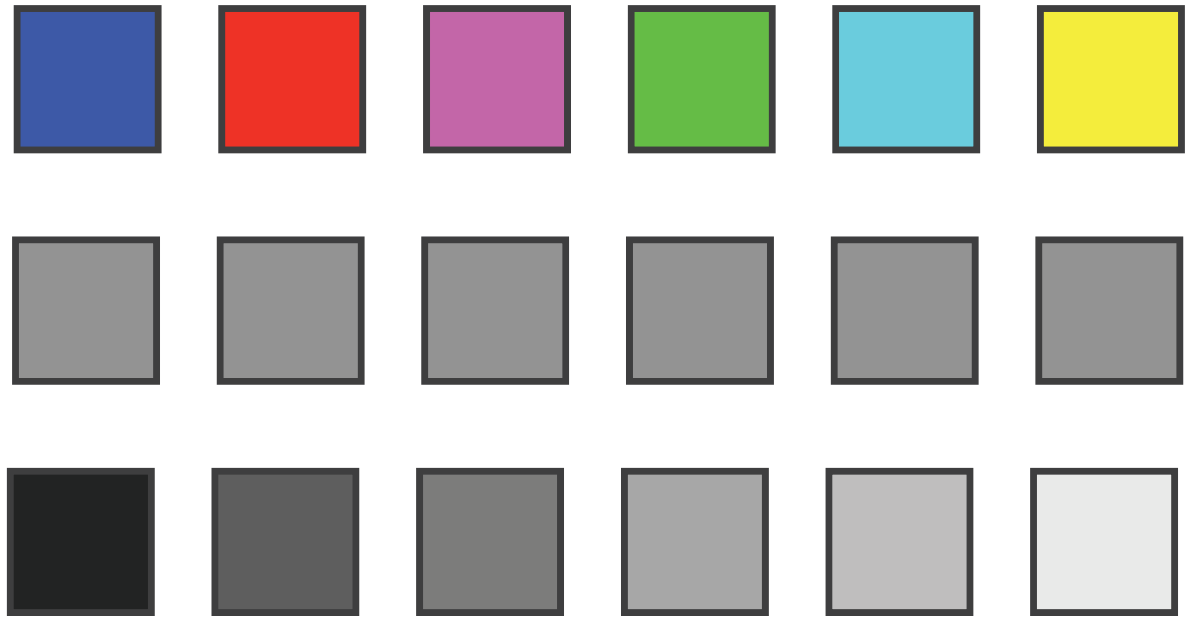
Hue



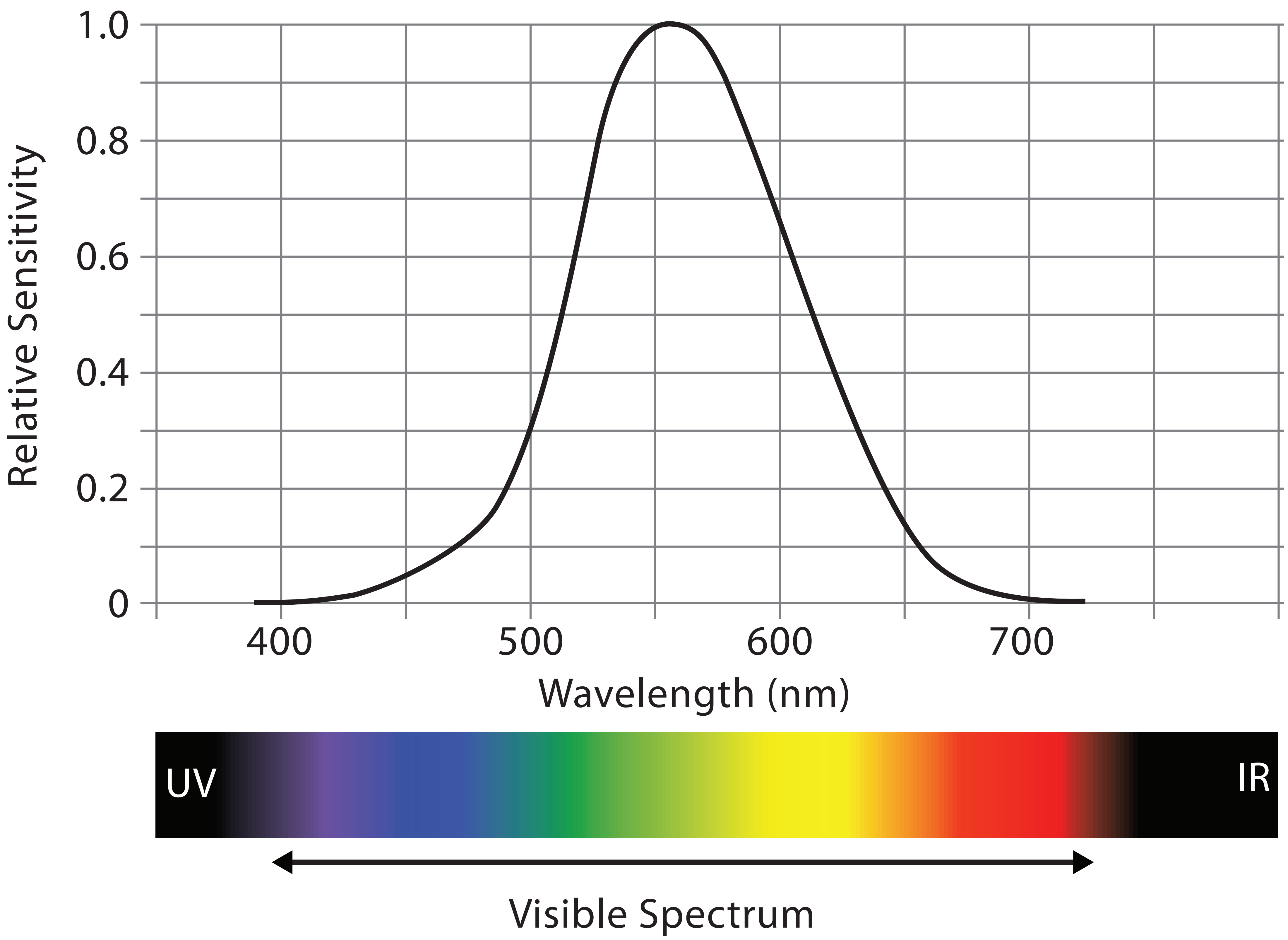
Corners of the RGB color cube

L from HLS
All the same

Luminance values

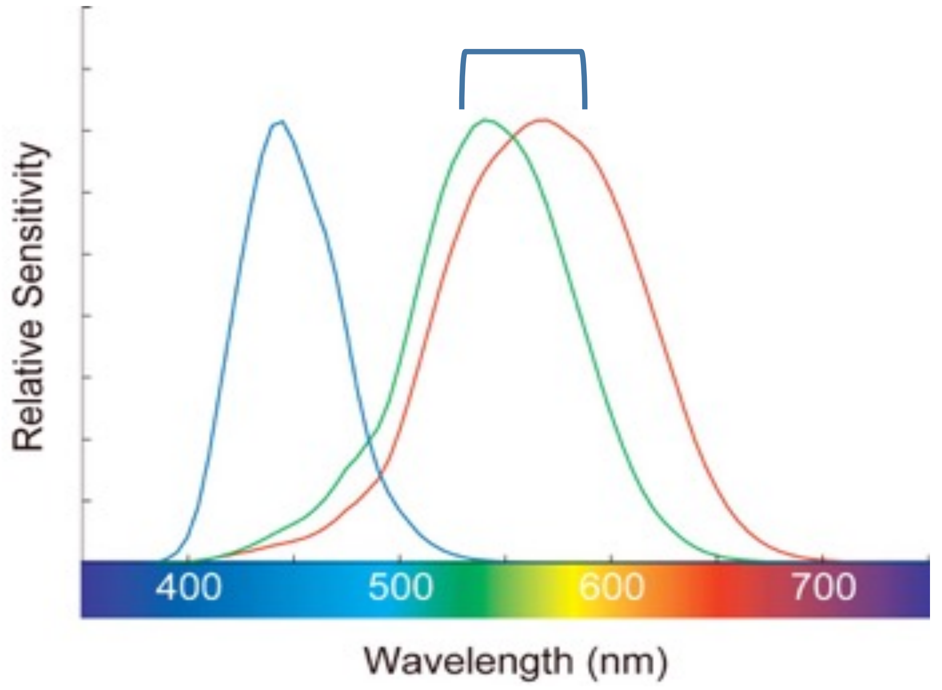


Spectral sensitivity



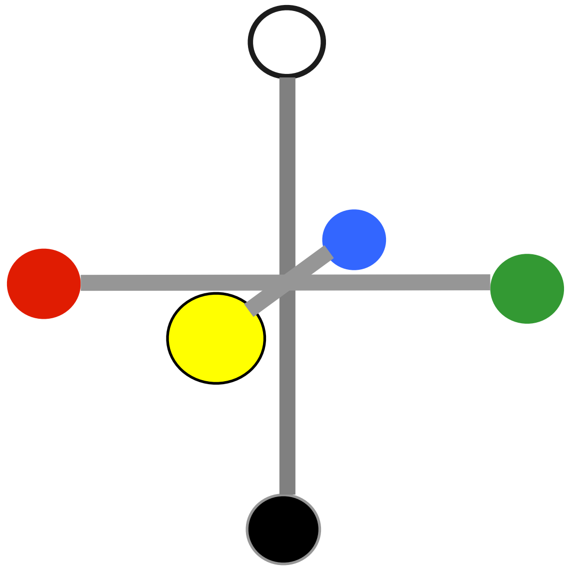
& three cone types

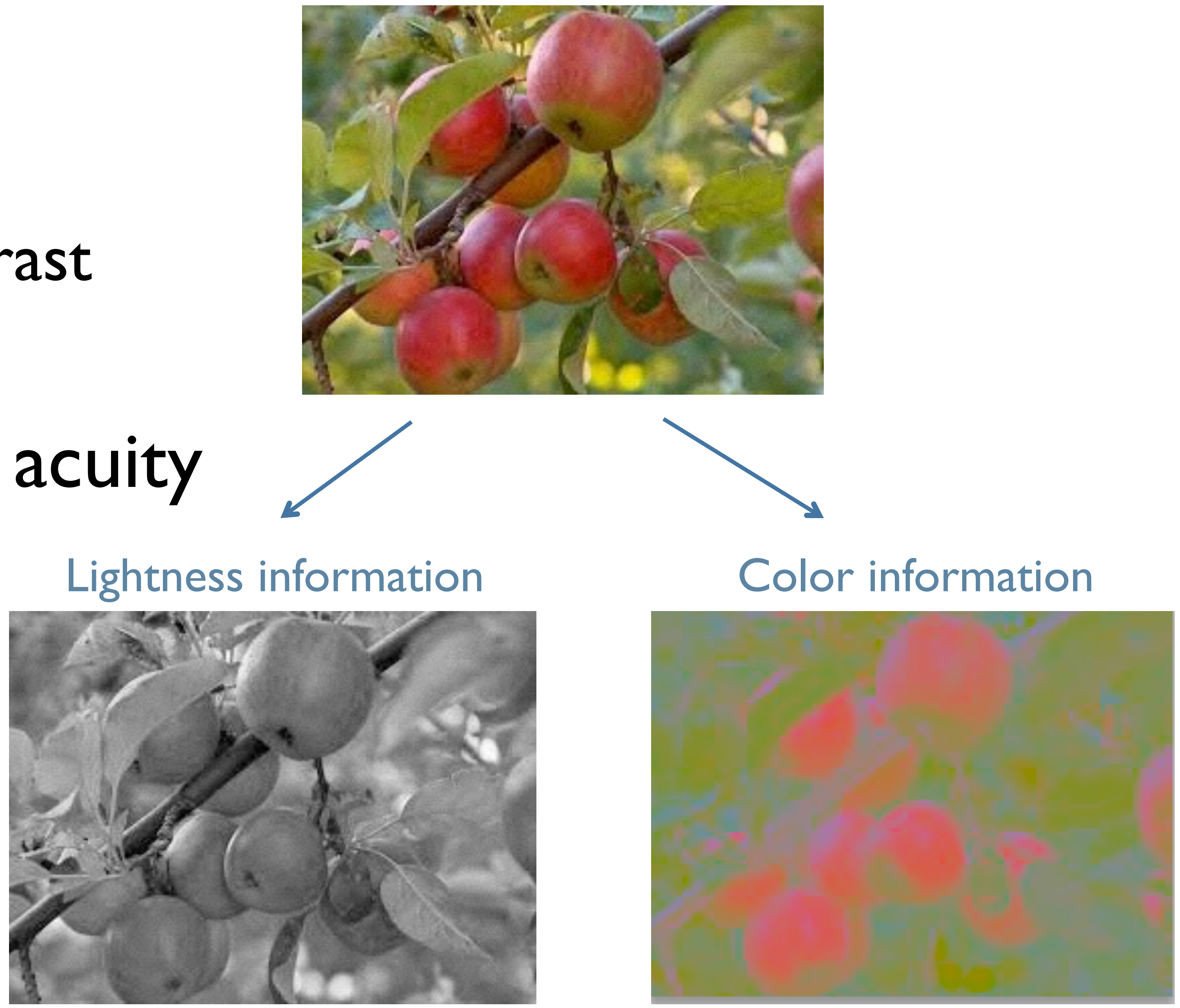
Small but important separation



Opponent color and color deficiency

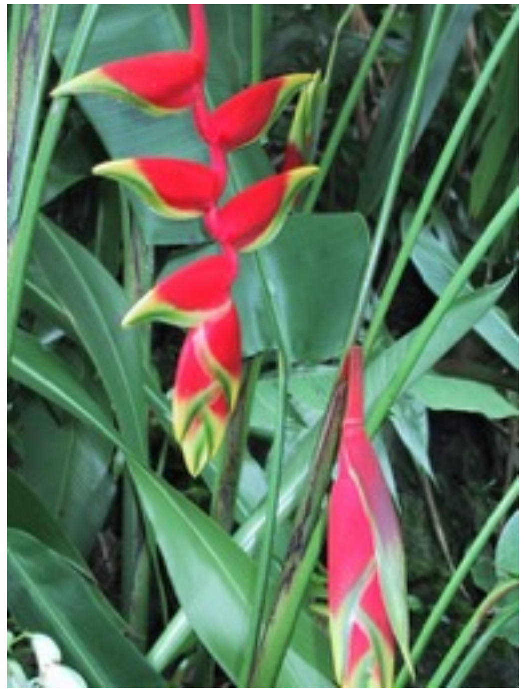
- 3 cones processed before optic nerve
  - one achromatic luminance channel L
    - edge detection through luminance contrast
  - two chroma channels, R-G and Y-B axis
- “color blind” if one axis has degraded acuity
  - 8% of men are red/green color deficient
  - blue/yellow is rare

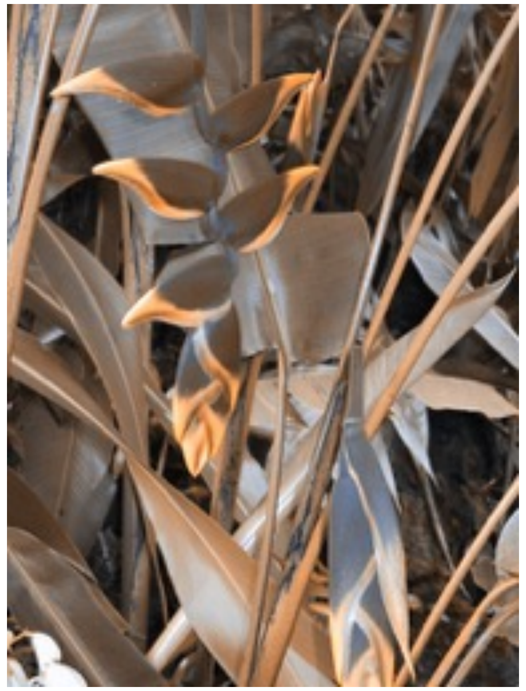


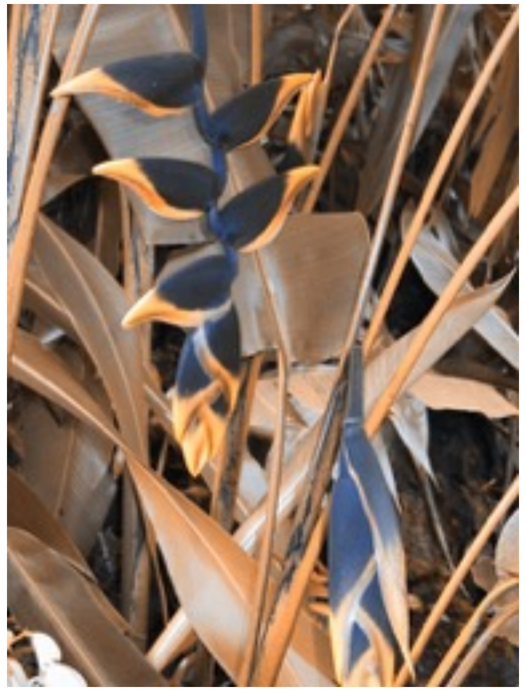


[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

Designing for color deficiency: Check with simulator

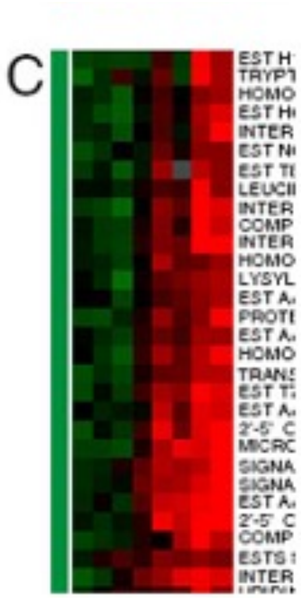

Normal vision


Deuteranope


Protanope


Tritanope

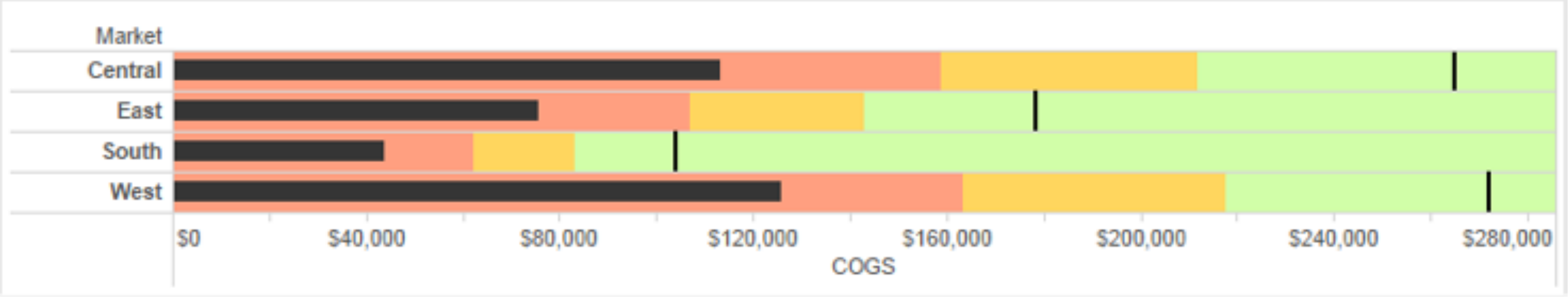
http://rehue.net

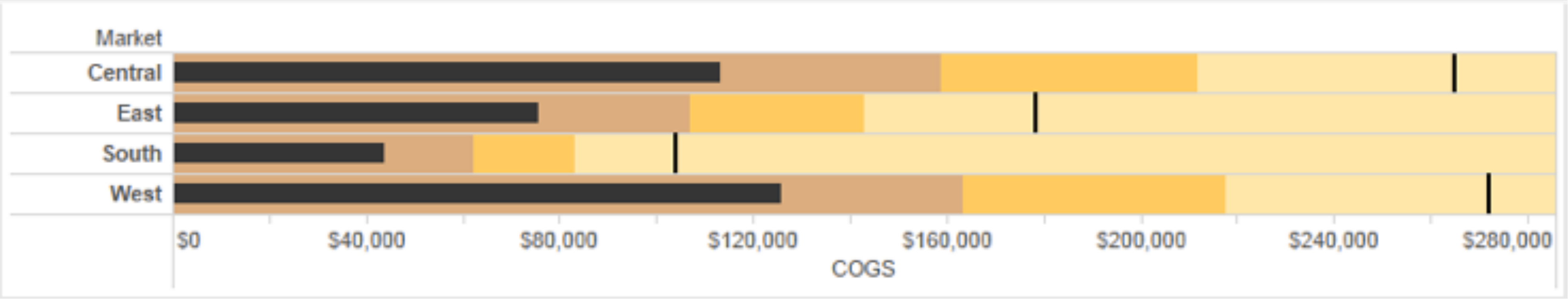


[Seriously Colorful: Advanced Color Principles & Practices. Stone. Tableau Customer Conference 2014.]

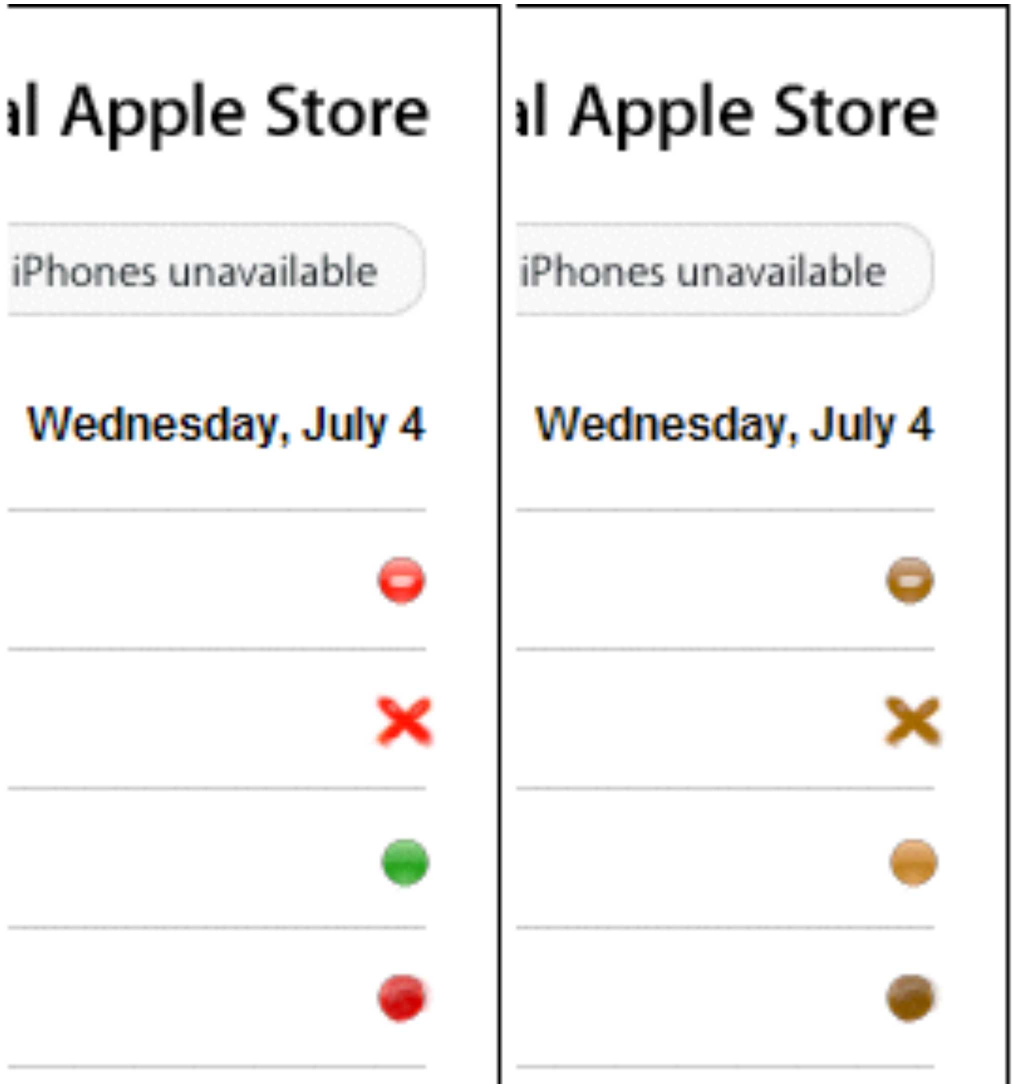
Designing for color deficiency: Avoid encoding by hue alone

- redundantly encode
  - vary luminance
  - change shape





Deuteranope simulation

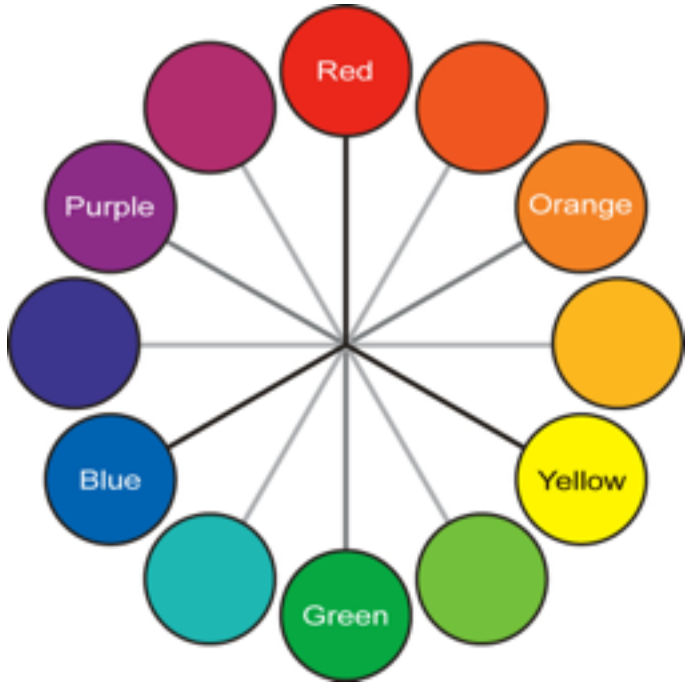


Change the shape

Vary luminance

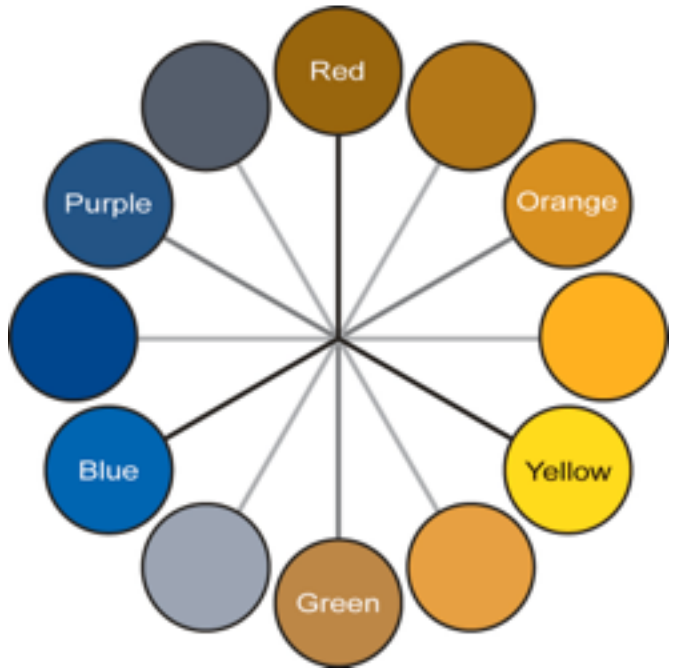
[Seriously Colorful: Advanced Color Principles & Practices. Stone. Tableau Customer Conference 2014.]

Color deficiency: Reduces color to 2 dimensions

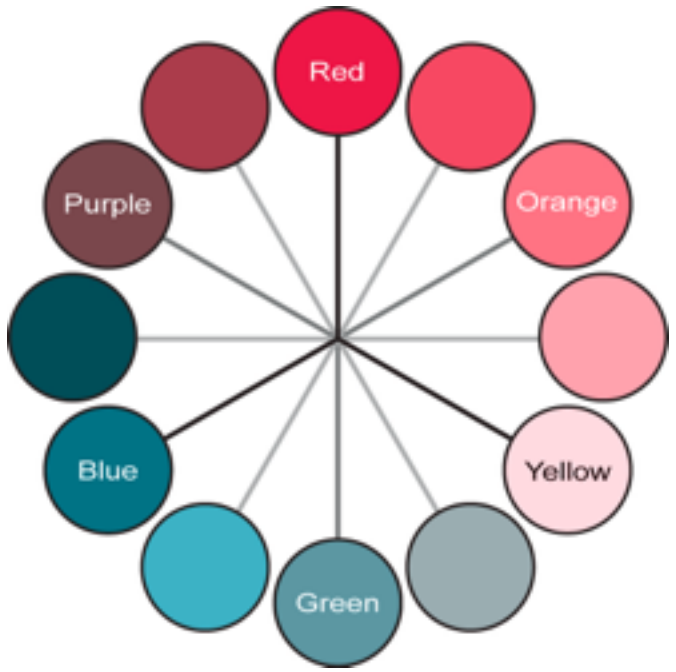


Normal

Protanope



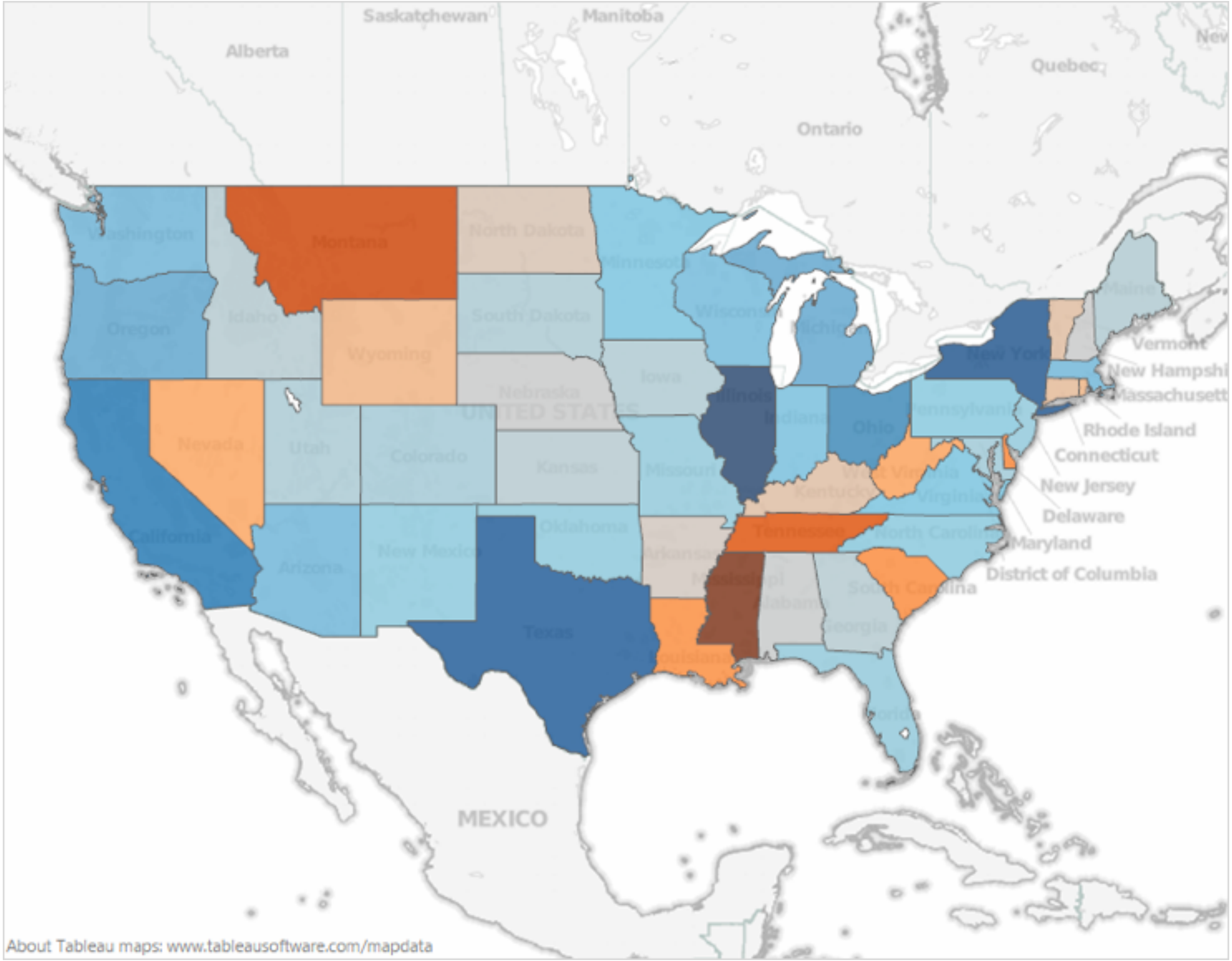
Deuteranope



Tritanope

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

Designing for color deficiency: Blue-Orange is safe



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Color/Lightness constancy: Illumination conditions

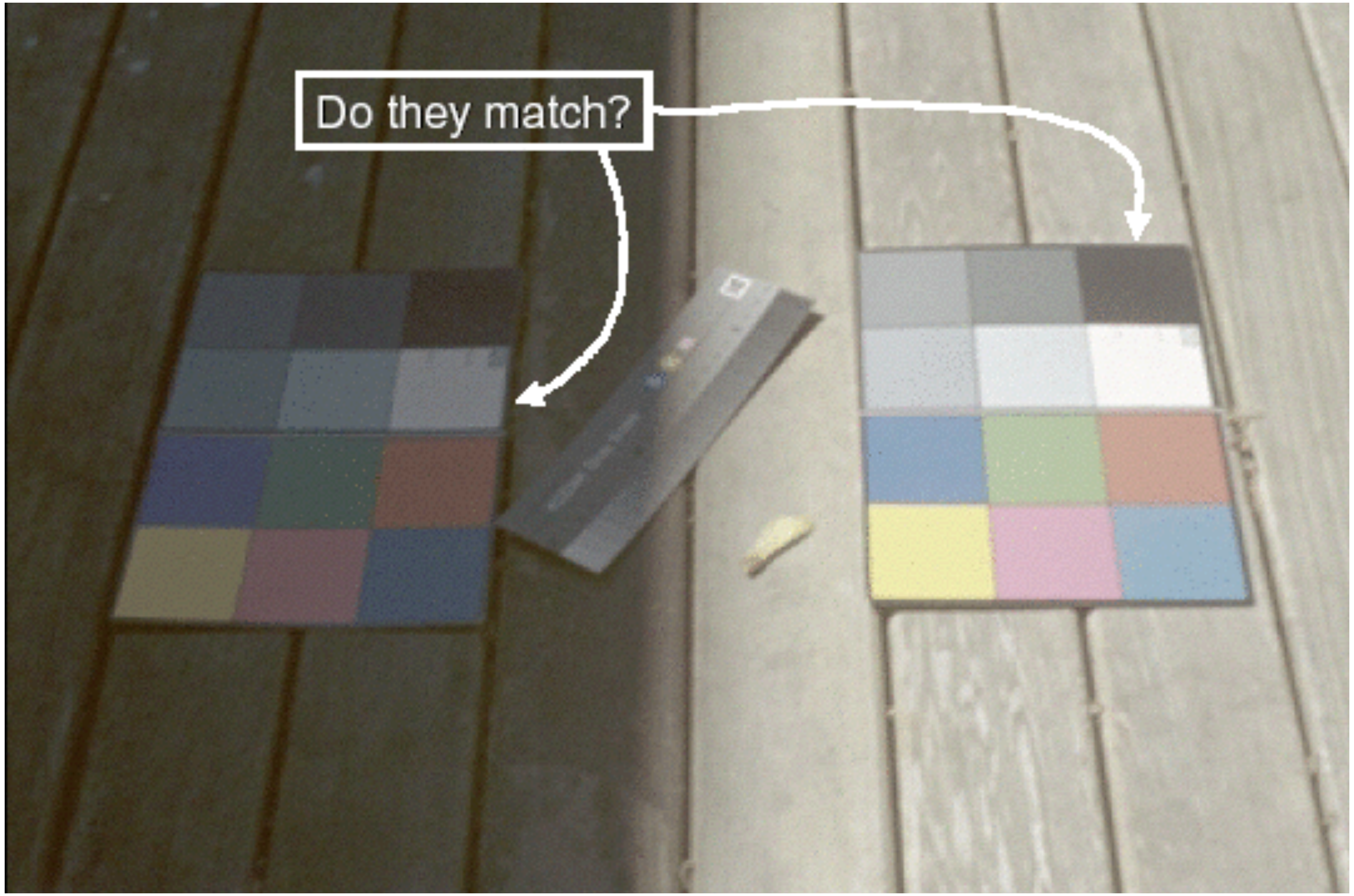

Image courtesy of John McCann

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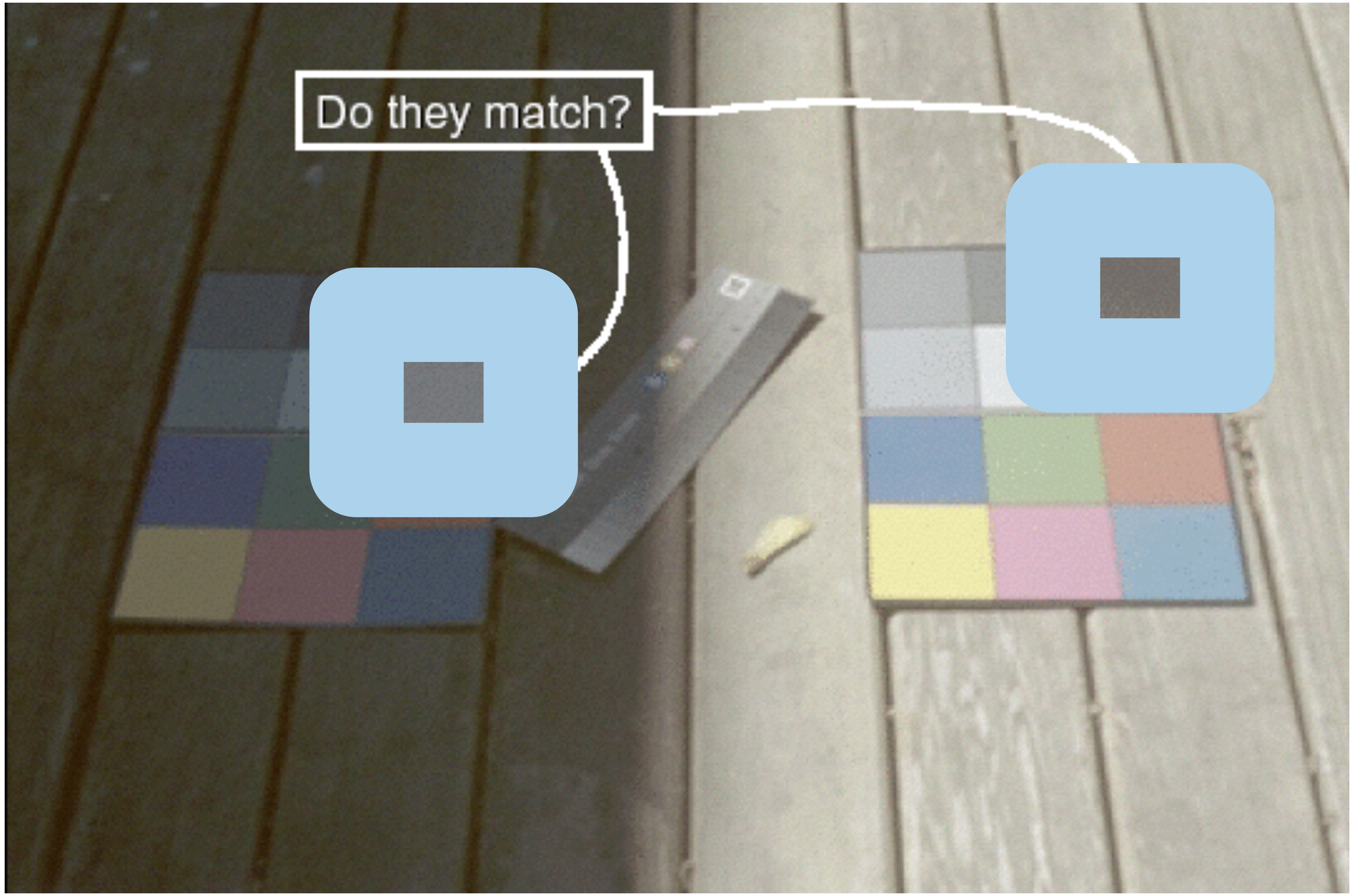
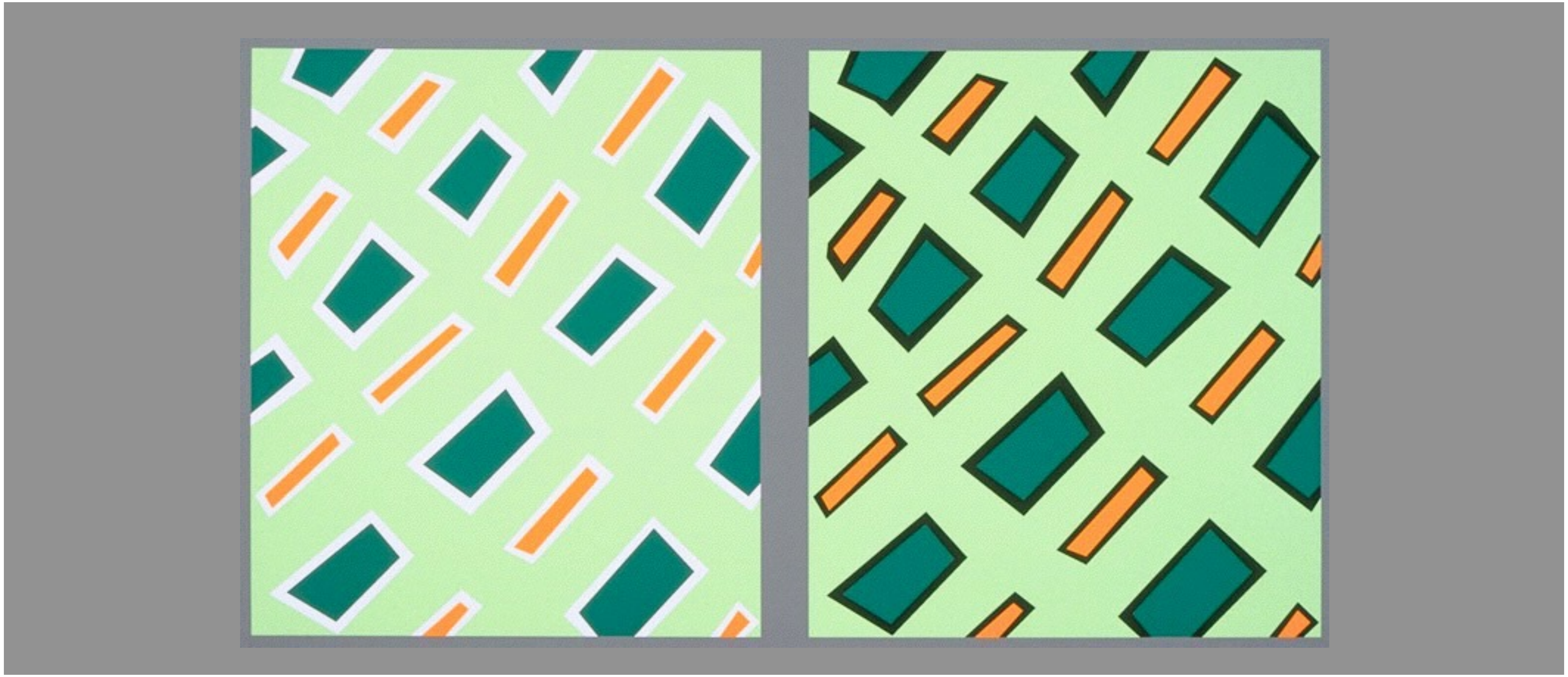


Image courtesy of John McCann

Bezold Effect: Outlines matter

- color constancy: simultaneous contrast effect



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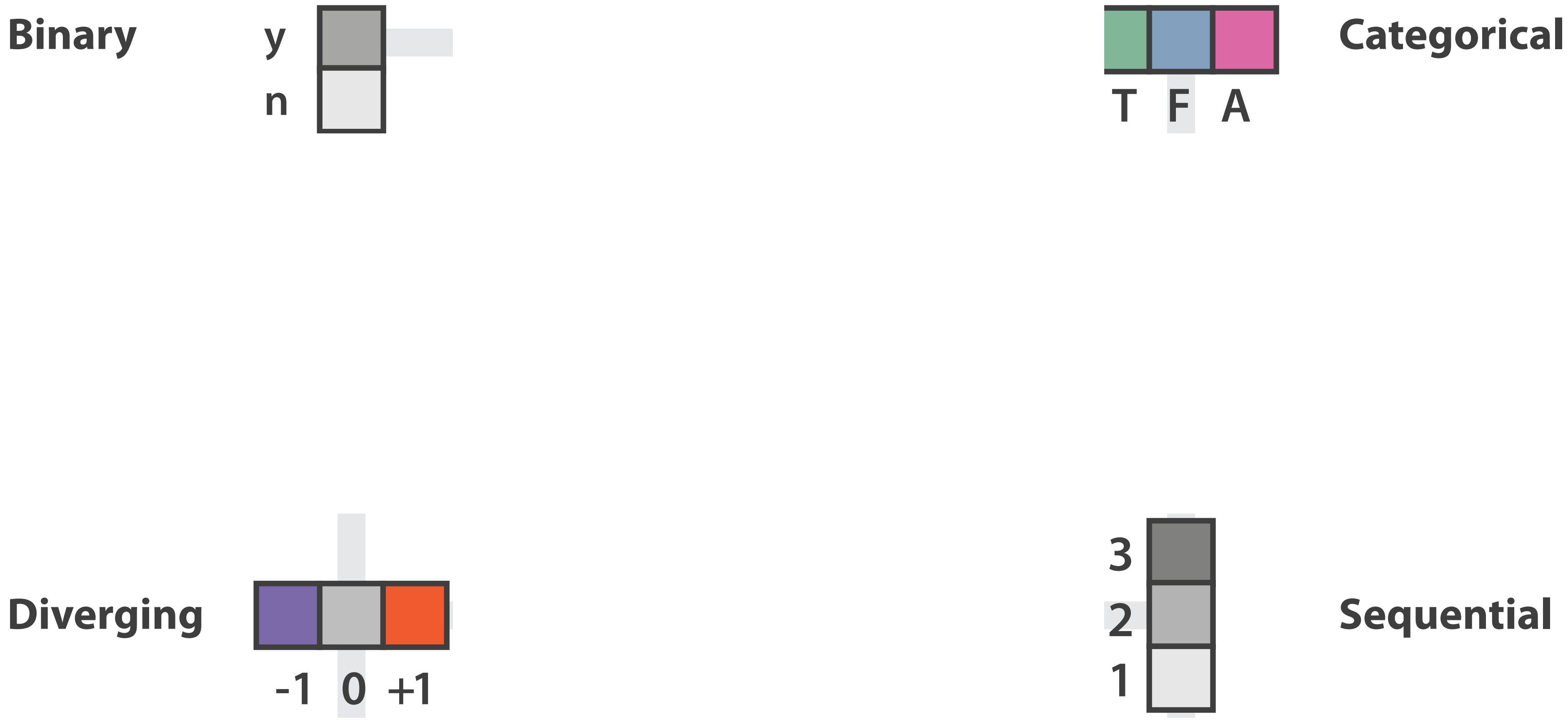
Colormaps

- ➔ Categorical

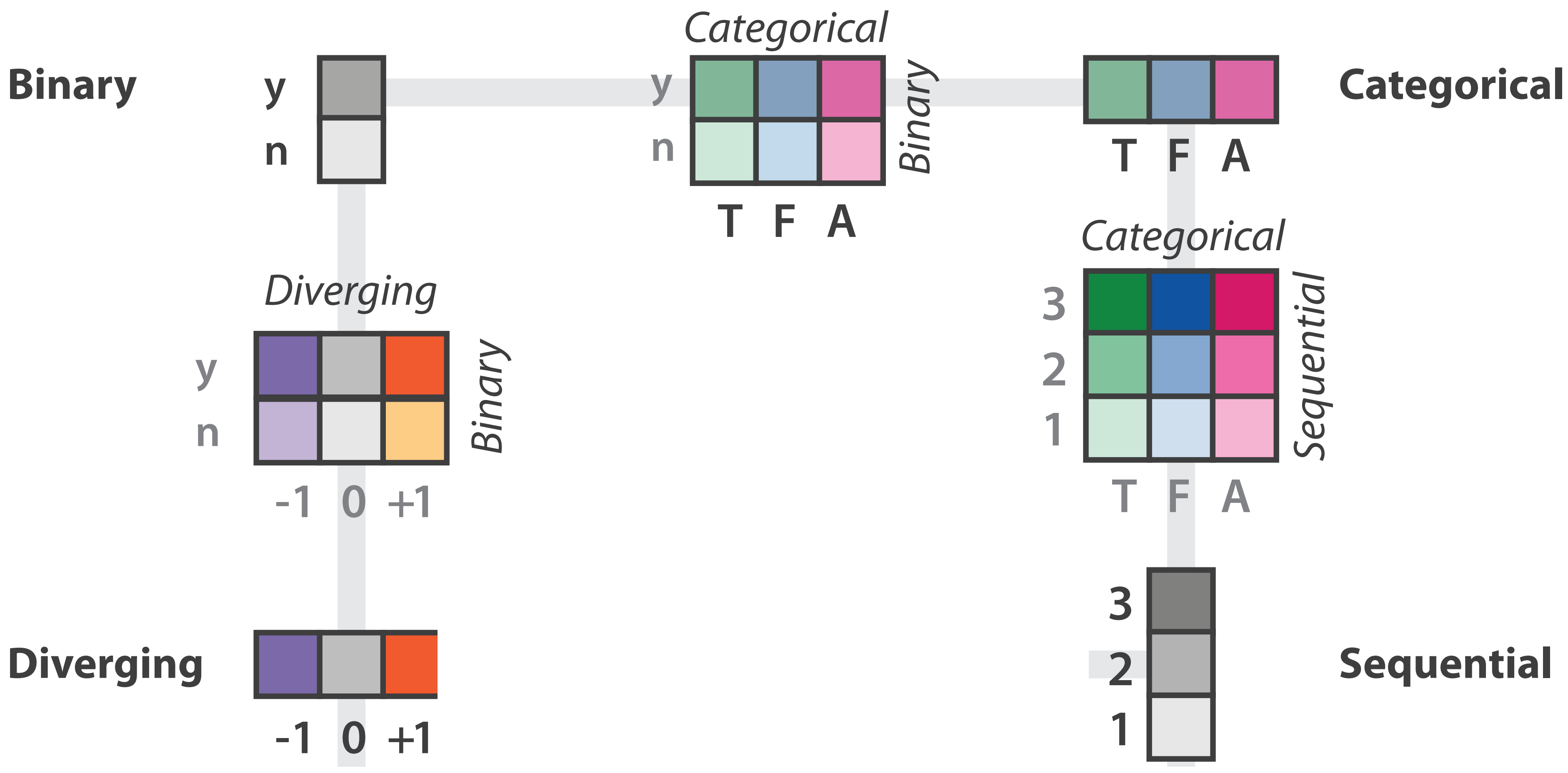
- ➔ Ordered
  - ➔ *Sequential*
  - ➔ *Diverging*



after [Color Use Guidelines for Mapping and Visualization. Brewer, 1994. http://www.personal.psu.edu/faculty/c/a/cab38/ColorSch/Schemes.html]

Colormaps

- Categorical
- Ordered
  - *Sequential*
  - *Diverging*
- Bivariate



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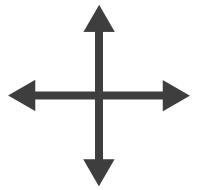
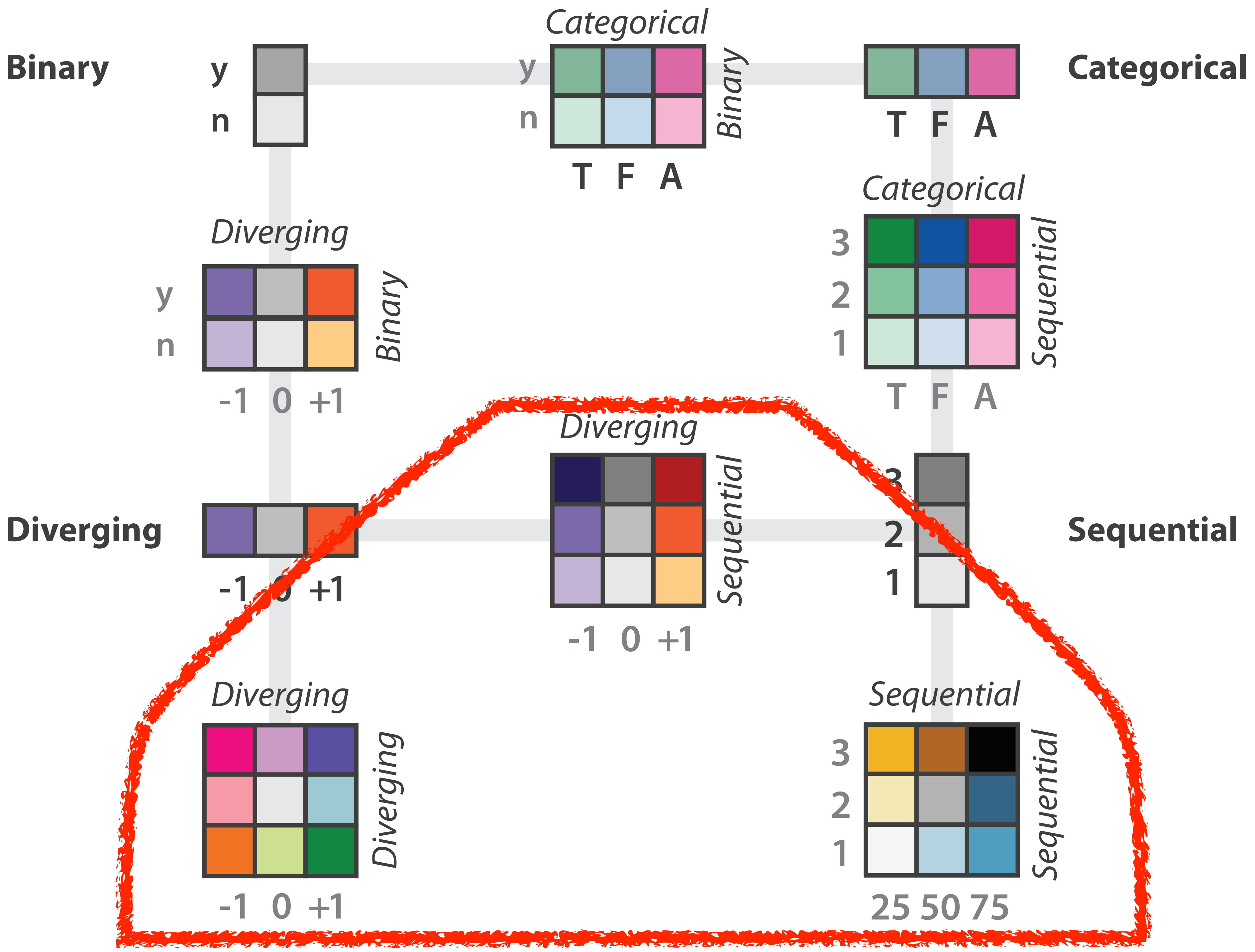


use with care!



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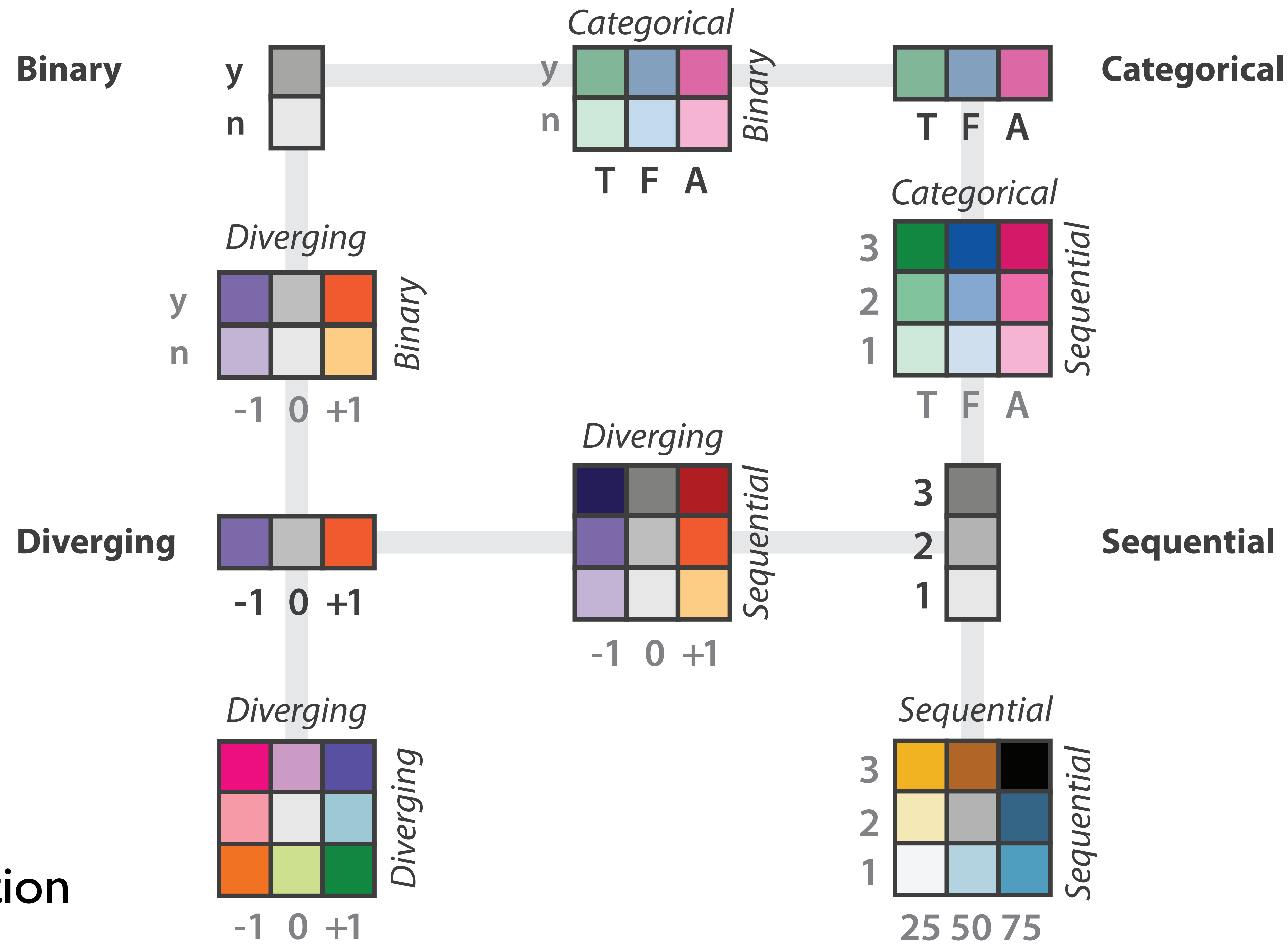

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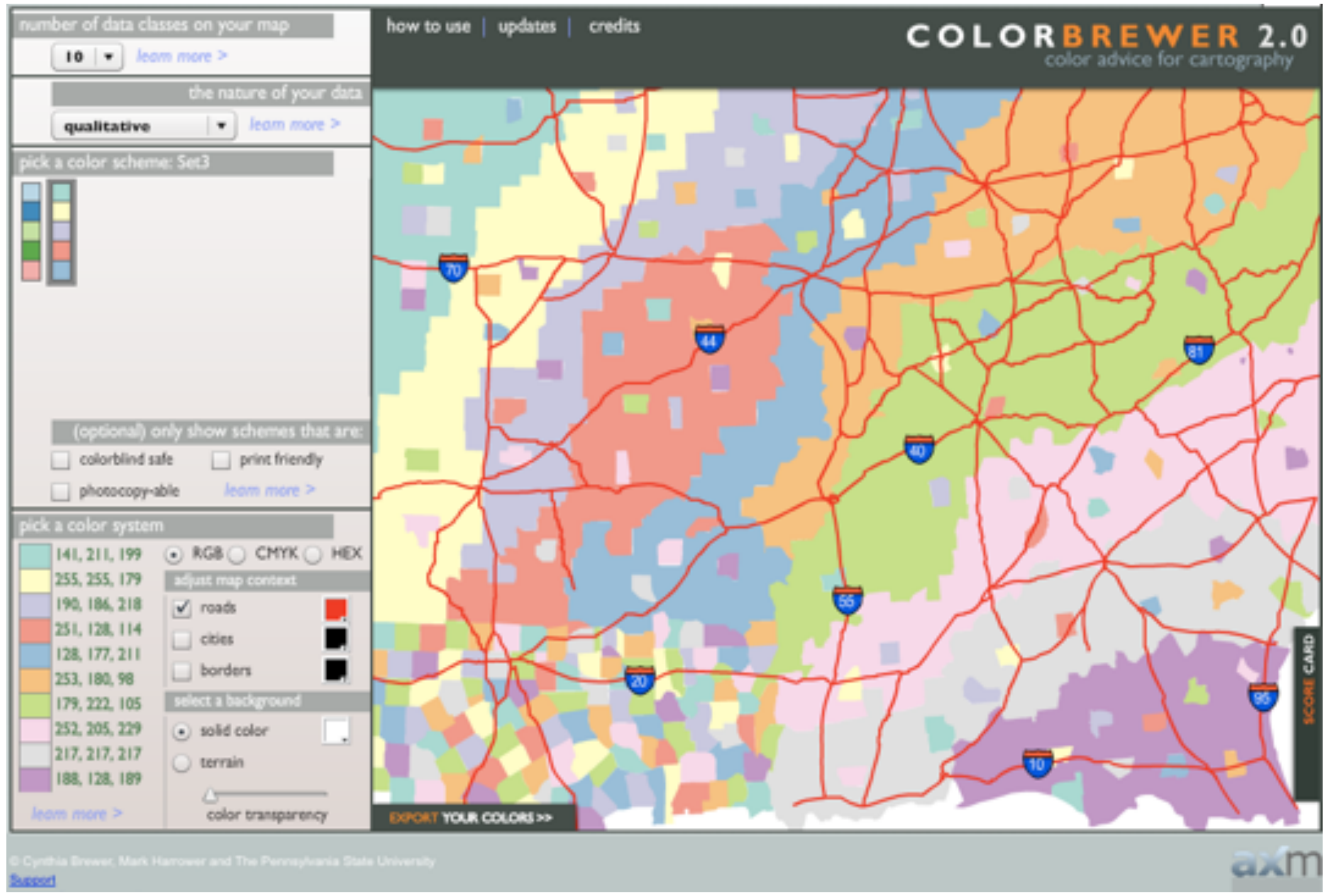
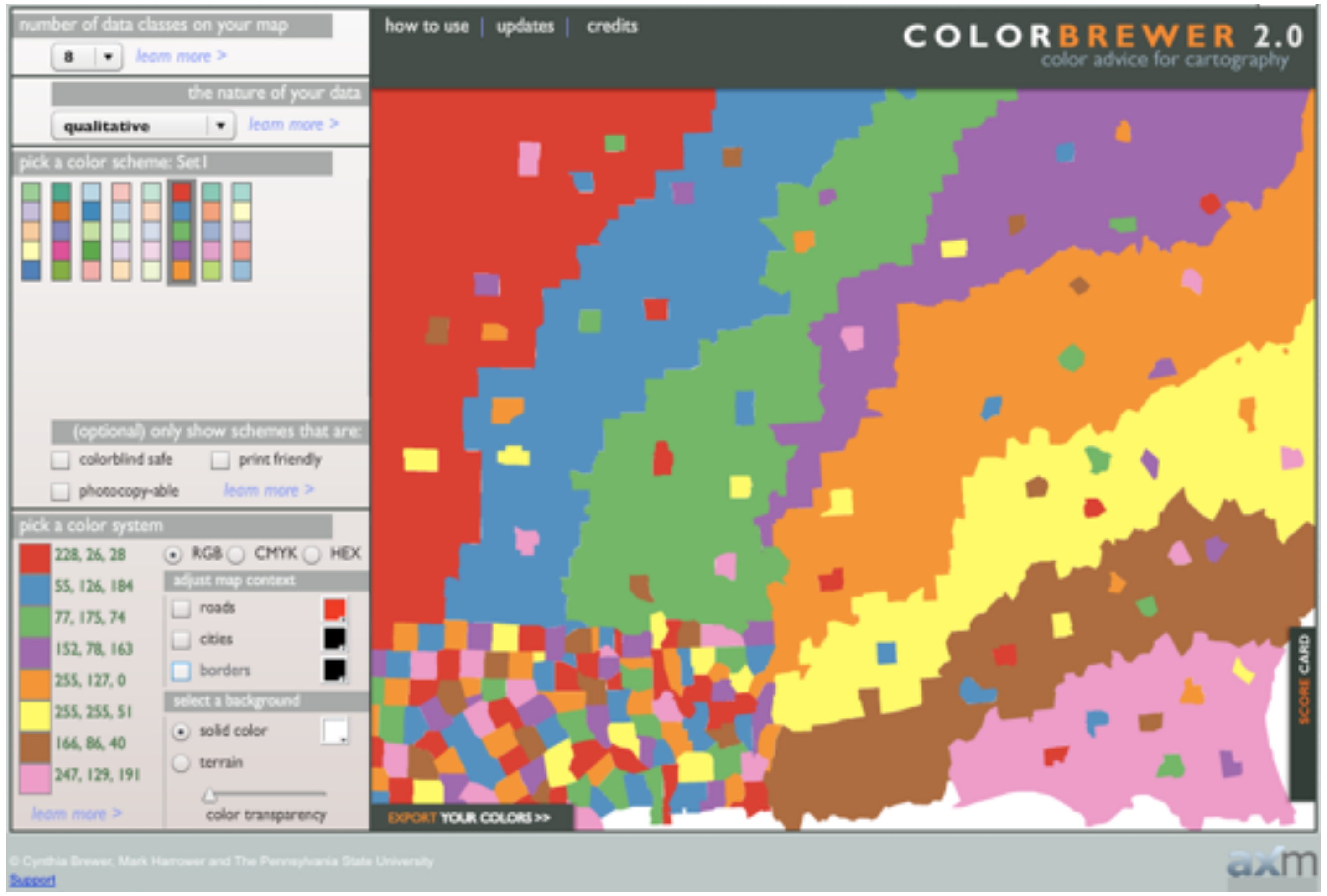
- color channel interactions
  - size heavily affects salience
    - small regions need high saturation
    - large need low saturation
  - saturation & luminance: 3-4 bins max
    - also not separable from transparency

ColorBrewer

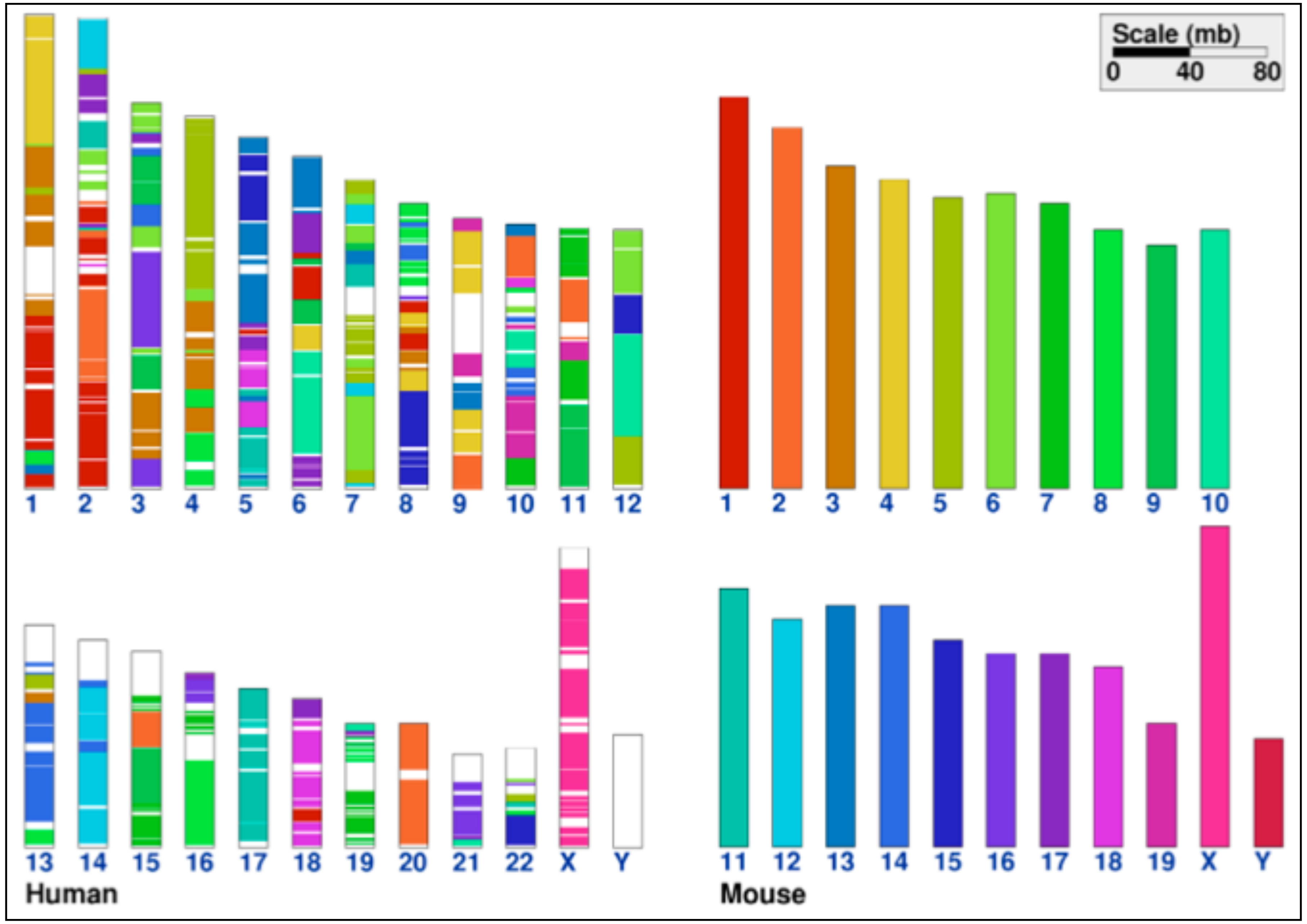
- http://www.colorbrewer2.org
- saturation and area example: size affects salience!





Categorical color: Discriminability constraints

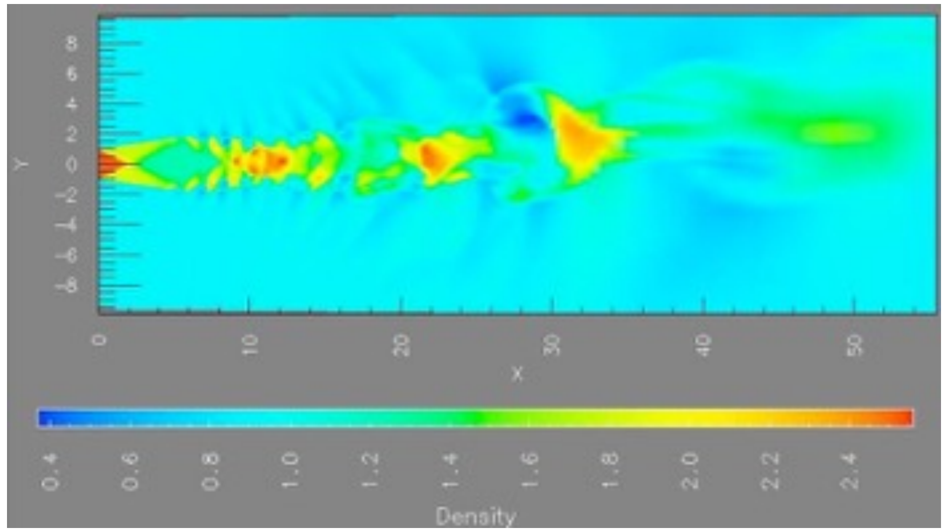
- noncontiguous small regions of color: only 6-12 bins



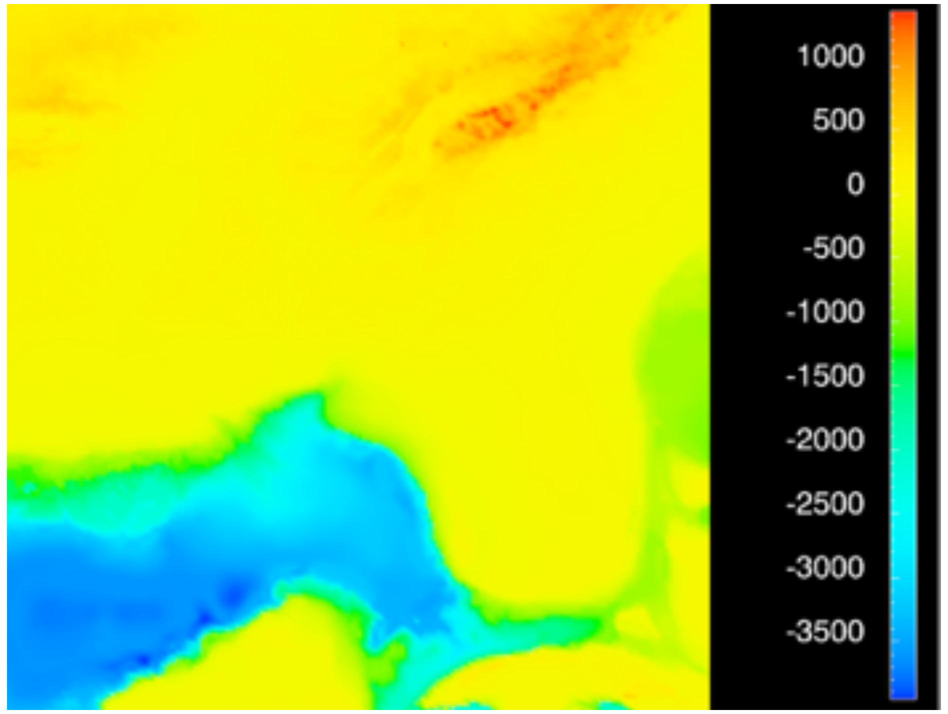
[Cinteny: flexible analysis and visualization of synteny and genome rearrangements in multiple organisms. Sinha and Meller. BMC Bioinformatics, 8:82, 2007.]

Ordered color: 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/lloydt/color/color.HTM]

[Transfer Functions in Direct Volume Rendering: Design, Interface, Interaction. Kindlmann. SIGGRAPH 2002 Course Notes]

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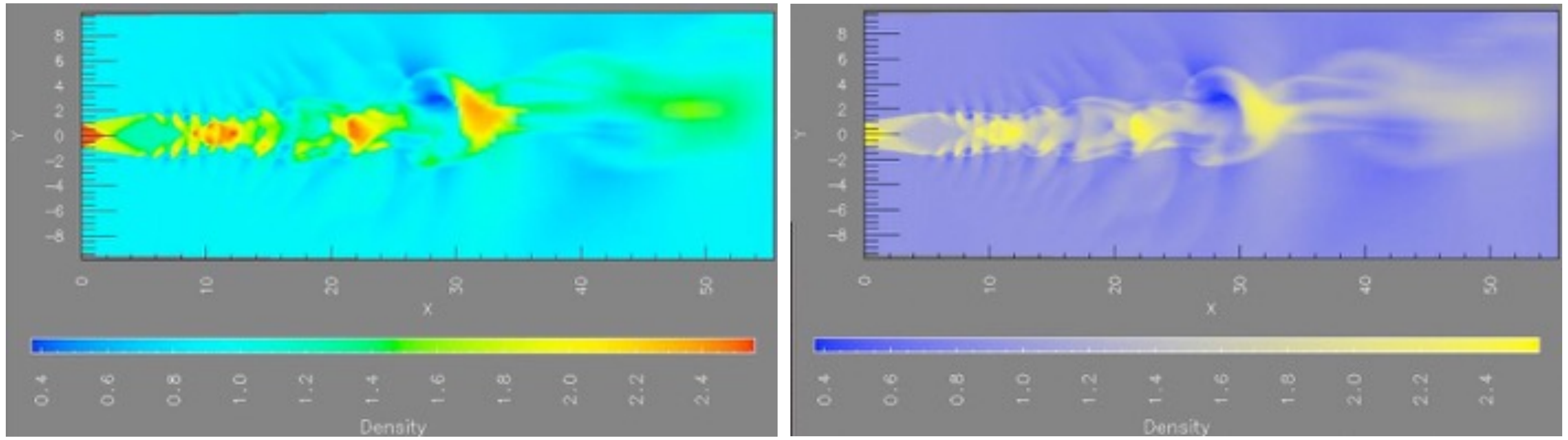
  - fine-grained structure visible and nameable
- alternatives
  - large-scale structure: fewer hues



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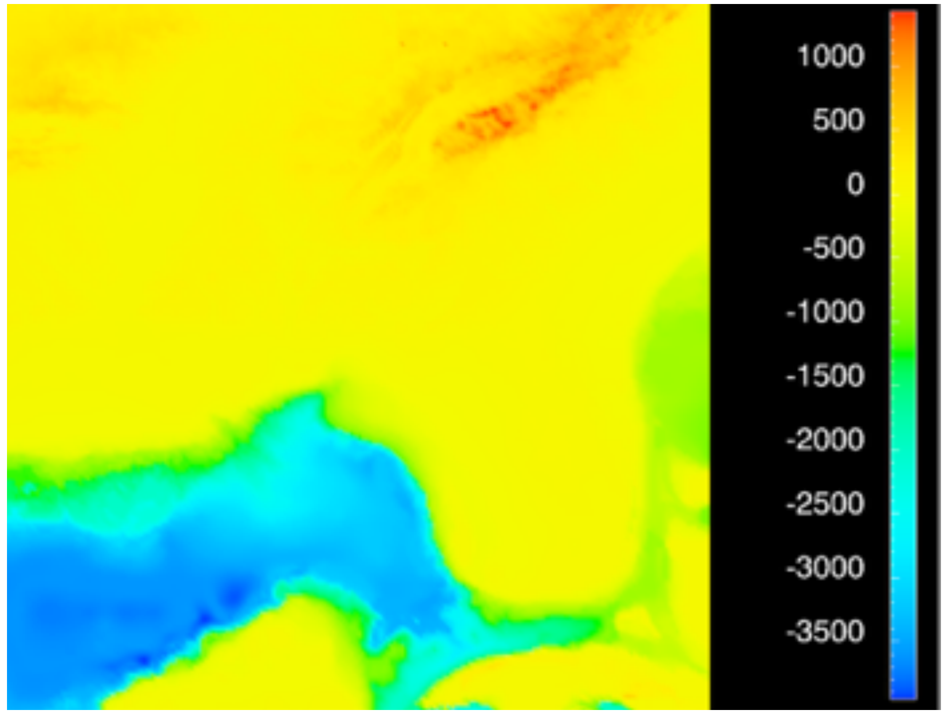

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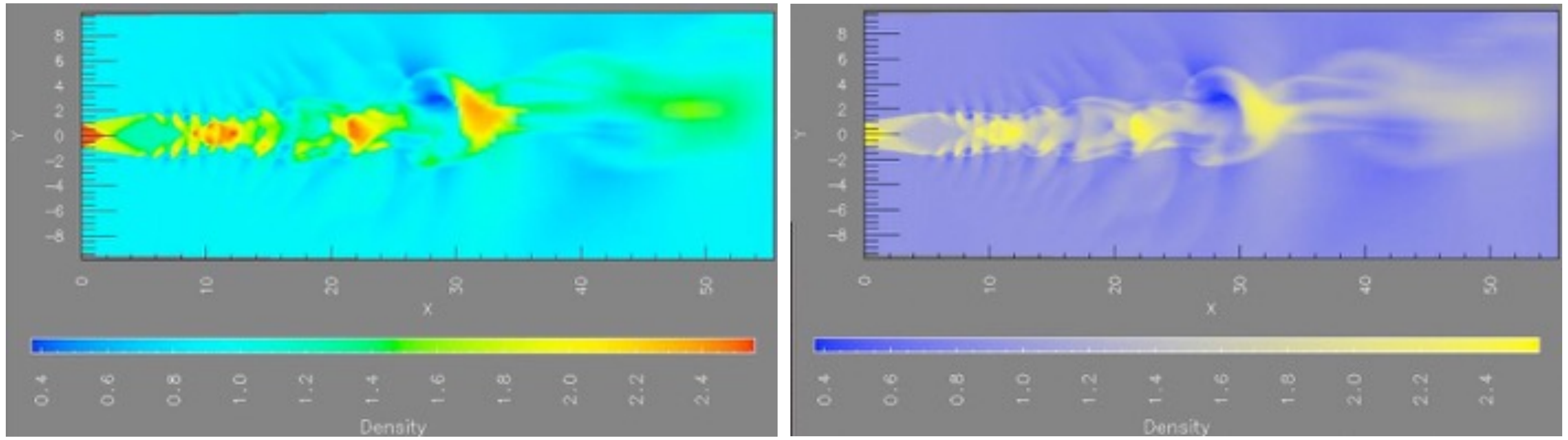
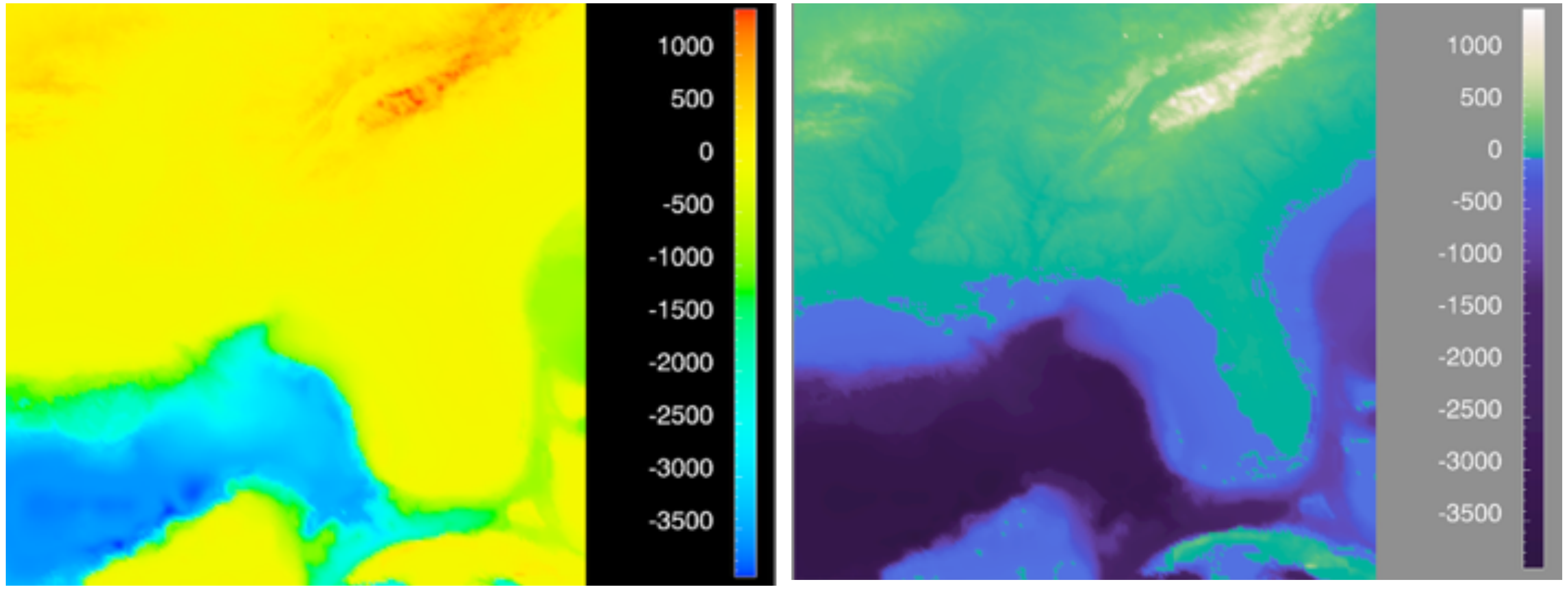
- alternatives
  - large-scale structure: fewer hues
  - fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]



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

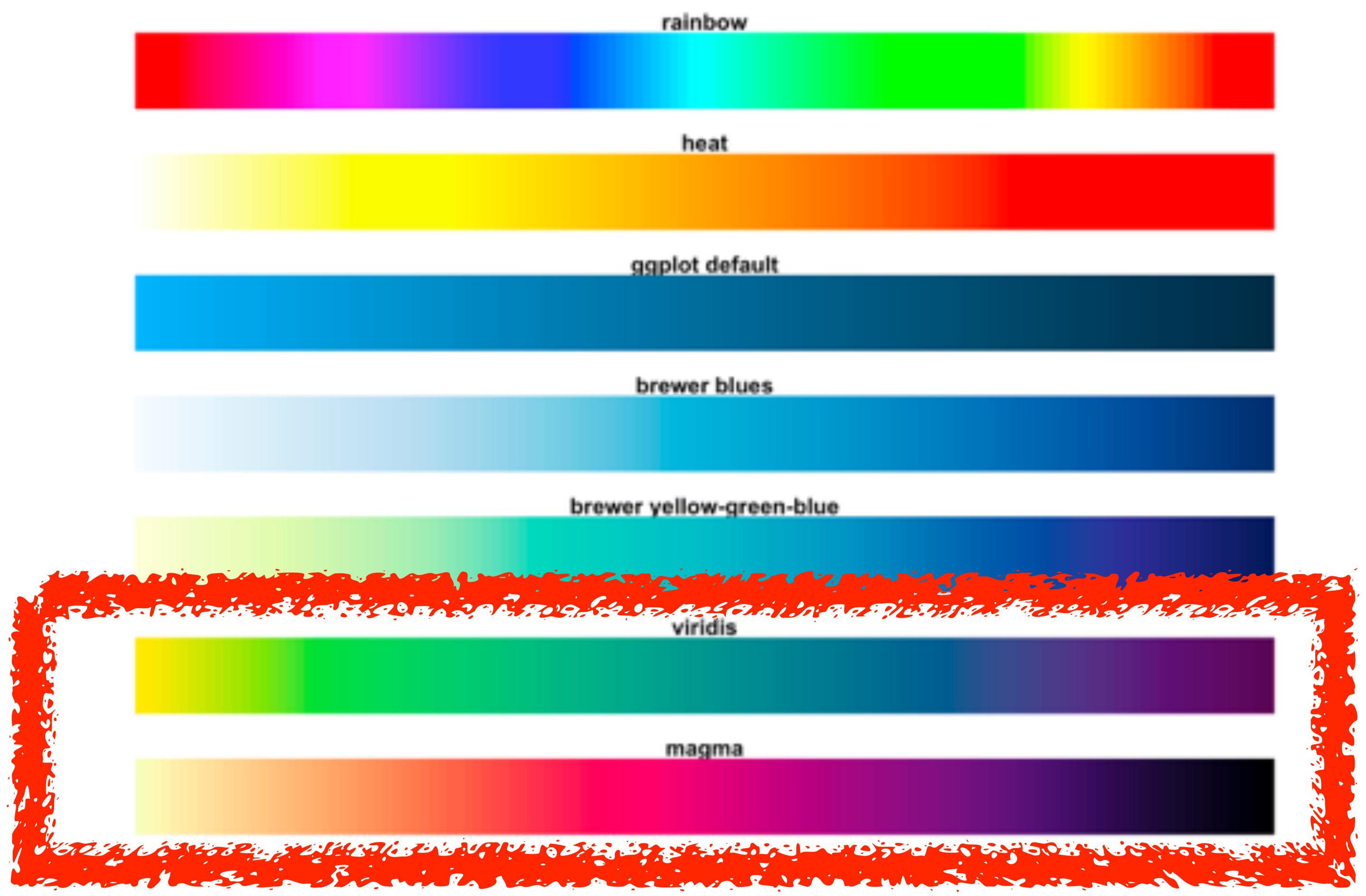


[Why Should Engineers Be Worried About Color? Treinish and Rogowitz 1998. http://www.research.ibm.com/people/l/lloydt/color/color.HTM]

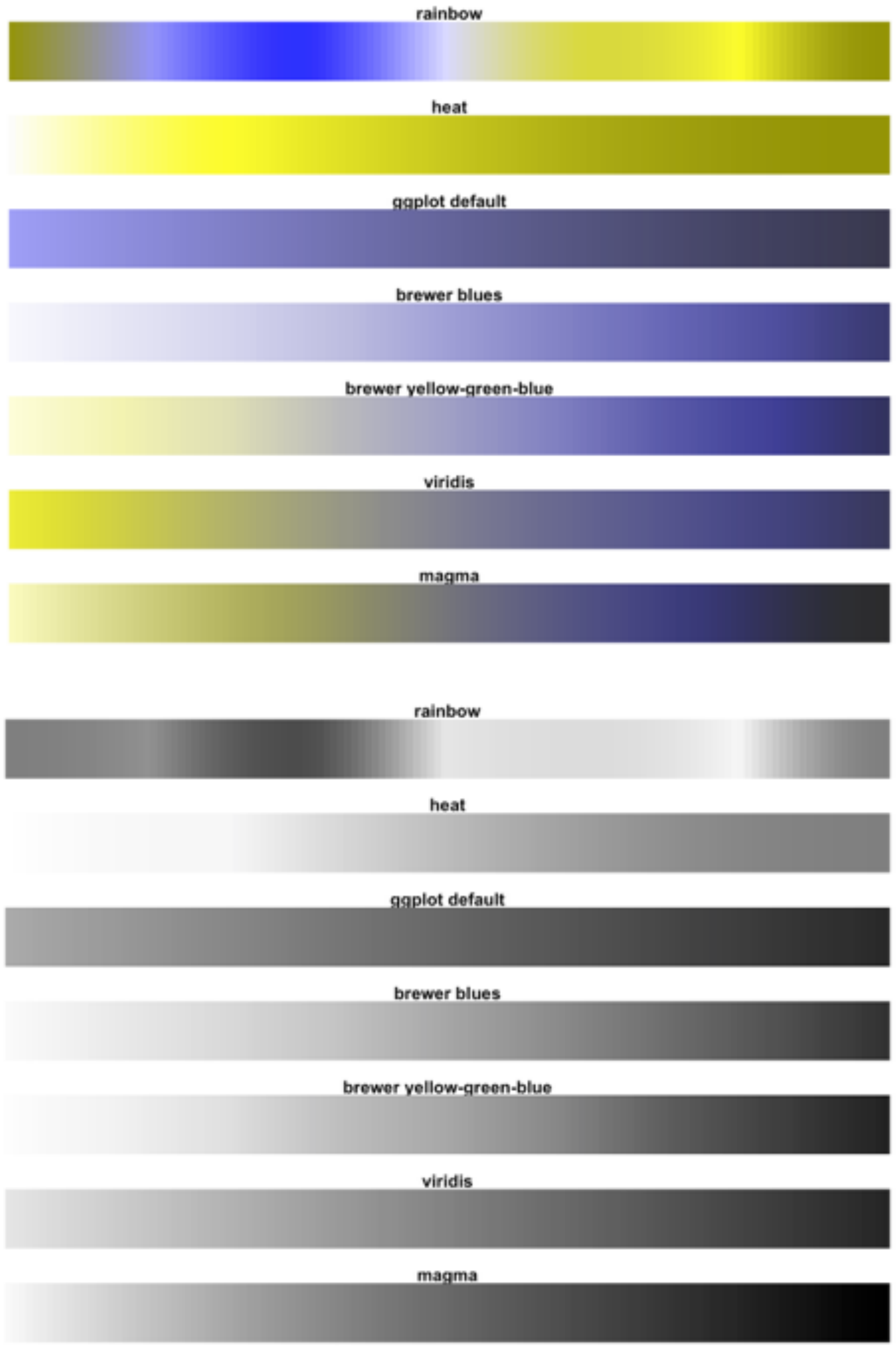
[Transfer Functions in Direct Volume Rendering: Design, Interface, Interaction. Kindlmann. SIGGRAPH 2002 Course Notes]

Viridis

- colorful, perceptually uniform, colorblind-safe, monotonically increasing luminance

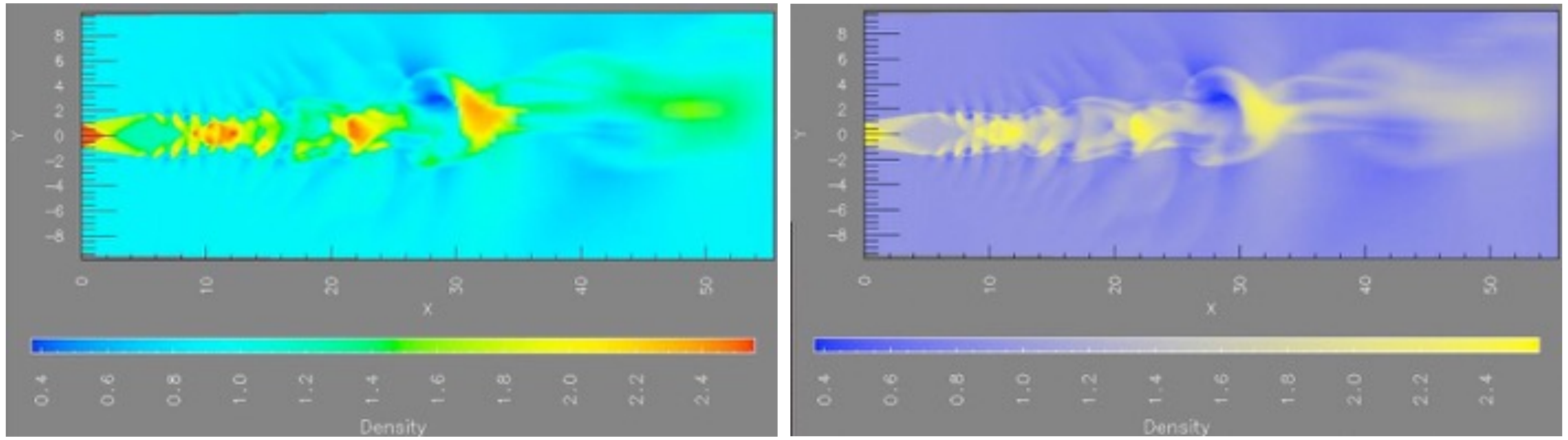


https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html



Ordered color: 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 R/python]
  - segmented rainbows for binned or categorical



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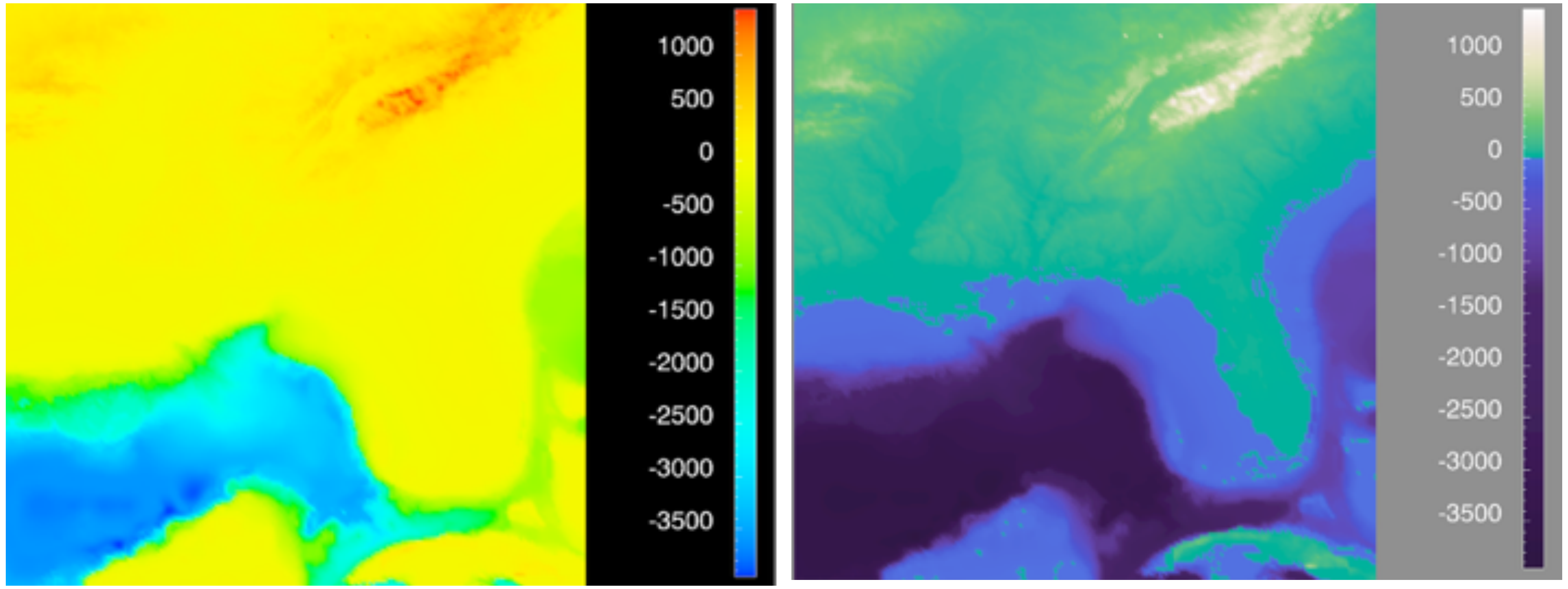

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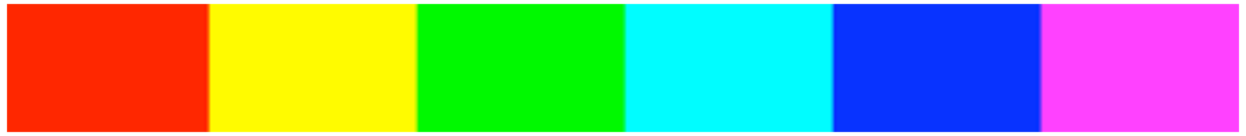
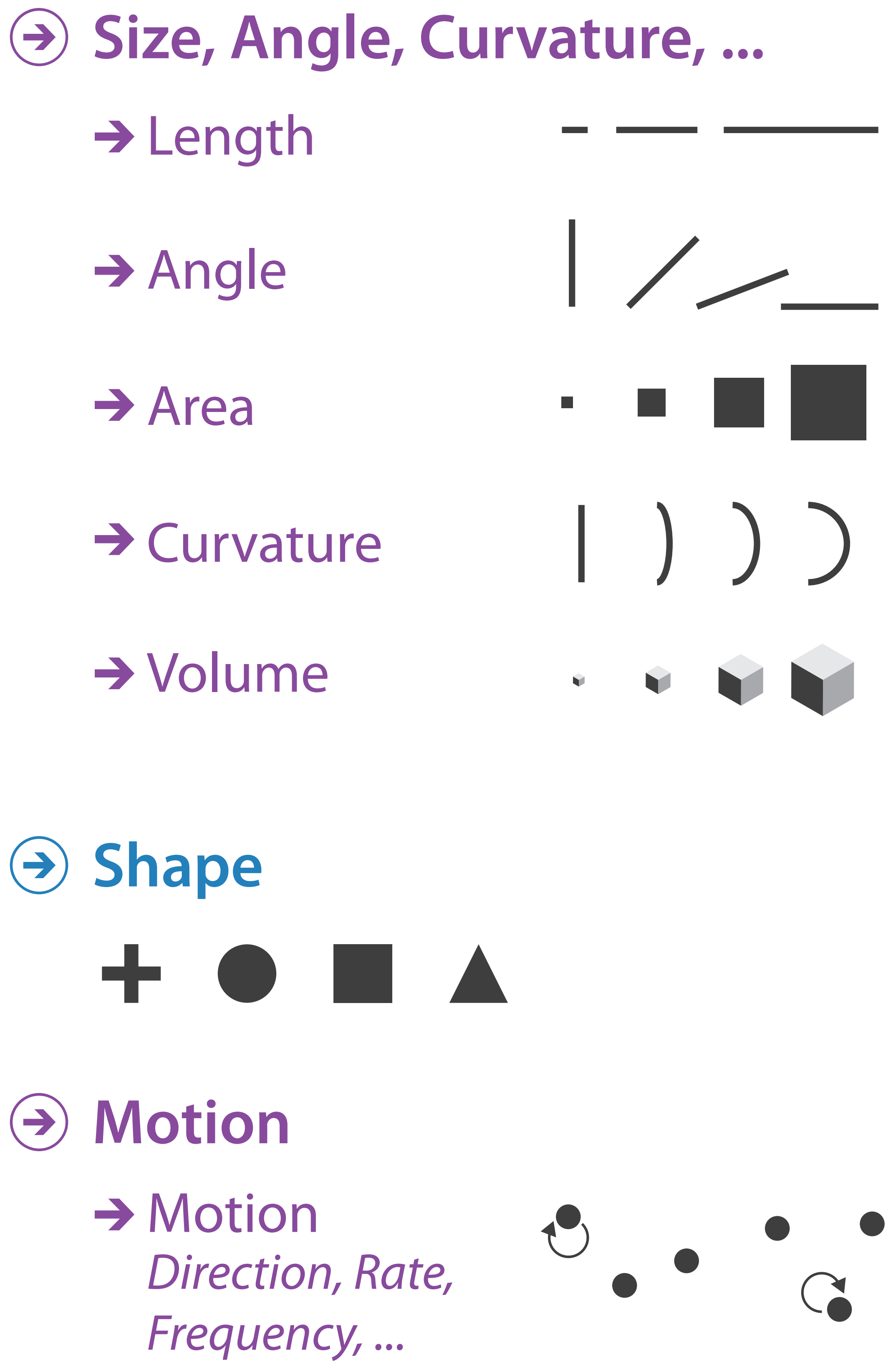
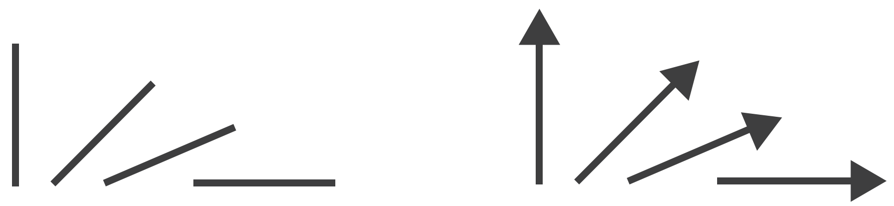


Map other channels

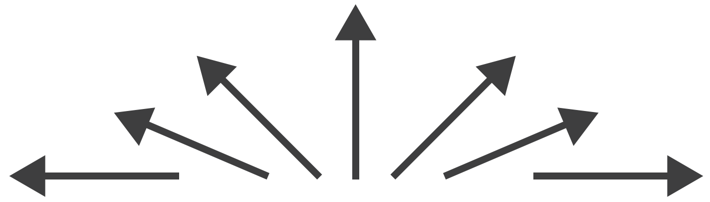
- size
  - –length accurate, 2D area ok, 3D volume poor
- angle
  - –nonlinear accuracy
    - horizontal, vertical, exact diagonal
- shape
  - –complex combination of lower-level primitives
  - –many bins
- motion
  - –highly separable against static
    - binary: great for highlighting
  - –use with care to avoid irritation



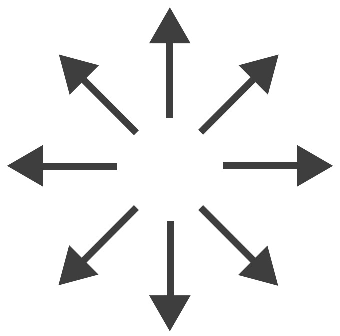
Angle



Sequential ordered
line mark or arrow glyph



Diverging ordered
arrow glyph



Cyclic ordered
arrow glyph