Ch 7/10: Tables, Color
Paper: D3

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CPSC 547, Information Visualization
Week 4: 1 October 2019

http://www.cs.ubc.ca/~tmm/courses/547-19

News

- marks out for week 2 & 3
  - mostly 5 (full credit)
  - some 4s (comments don't show depth of understanding of material)
  - a few 0s (didn't hand in)

This Time

- wrap up Decoding exercise (from last time)
- 3 shorter in-class exercises
  - Two Numbers
  - Bars/Radial
  - Color Palettes
- paper types (carryforward from last time)
- paper: D3
  - system context
- chapters: Tables, Color
  - some new material, not just backup slides
- pitches: expectations

Paper: D3 System

Paper: D3

- paper types
  - design studies
  - technique/algorithm
  - evaluation
  - model/taxonomy
  - **system**

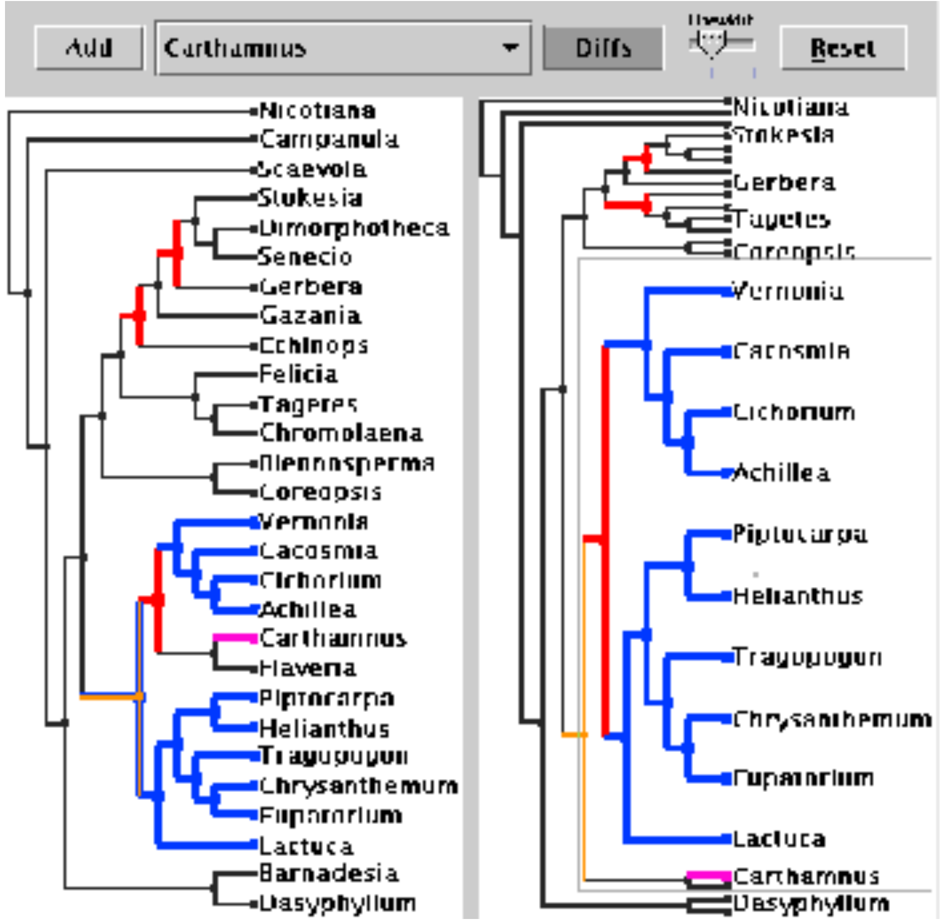
[D3: Data-Driven Documents. Bostock, Ogievetsky, Heer. IEEE Trans. Visualization & Comp. Graphics (Proc. InfoVis), 2011.]

Toolkits

- imperative: how
  - low-level rendering: Processing, OpenGL
  - parametrized visual objects: prefuse
    - also flare: prefuse for Flash
- declarative: what
  - Protoviz, D3, ggplot2
  - separation of specification from execution
- considerations
  - expressiveness
    - can I build it?
  - efficiency
    - how long will it take?
  - accessibility
    - do I know how?

WebGL/OpenGL

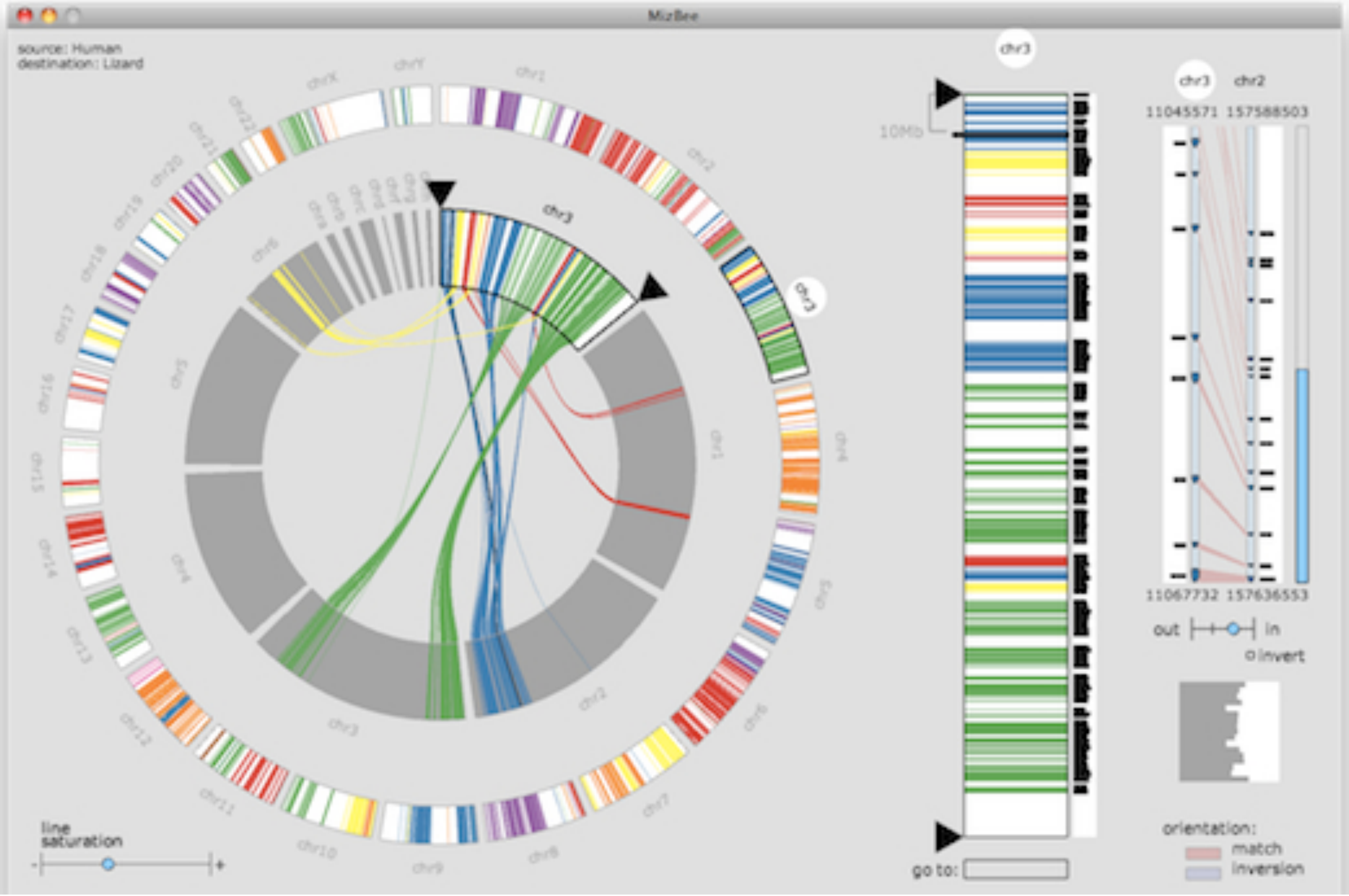
- graphics library
  - pros
    - power and flexibility, complete control for graphics
    - hardware acceleration
    - many language bindings: js, C, C++, Java (w/ JOGL)
  - cons
    - big learning curve if you don't know already
    - no vis support, must roll your own everything
  - example app: TreeJuxtaposer (OpenGL)



[Fig 5. Munzner et al. TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Proc SIGGRAPH 2003, pp 453-462.]

Processing / p5.js

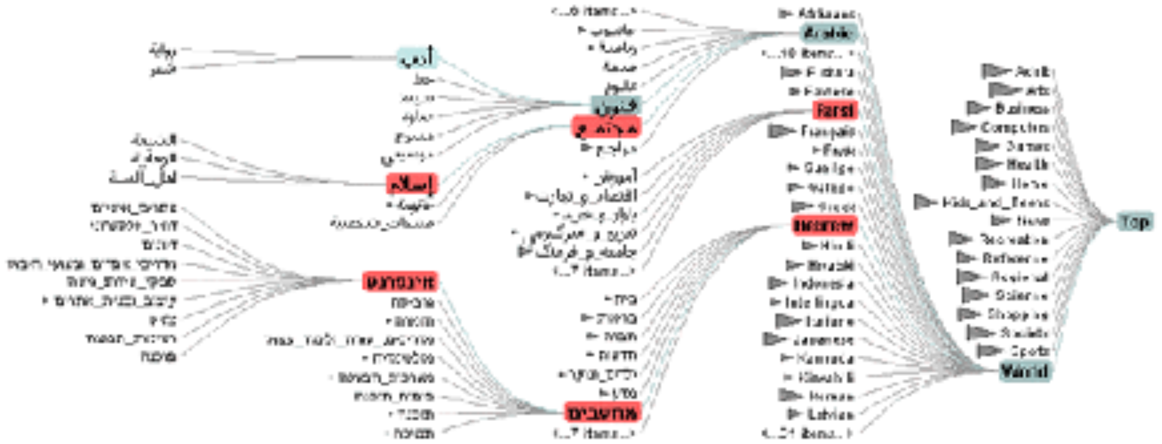
- layer on top of Java/OpenGL, Javascript/WebGL
- visualization esp. for artists/designers
- pros
  - great sandbox for rapid prototyping
  - huge user community, great documentation
- cons
  - poor widget library support
- example app: MizBee



[Fig 1. Meyer et al. MizBee: A Multiscale Synteny Browser. Proc. InfoVis 2009.]

prefuse

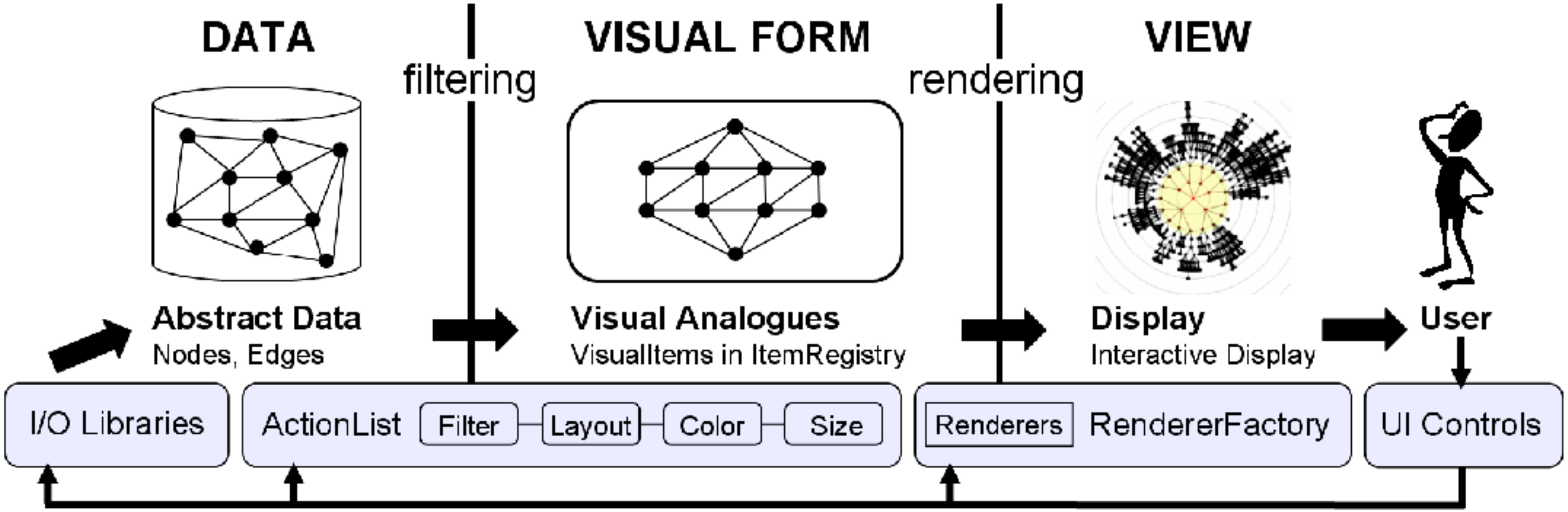
- infovis toolkit, in Java
- fine-grained building blocks for tailored visualizations
- pros
  - heavily used (previously)
  - very powerful abstractions
  - quickly implement most techniques covered so far
- cons
  - no longer active
  - nontrivial learning curve
- example app: DOITrees Revisited



[DOITrees Revisited: Scalable, Space-Constrained Visualization of Hierarchical Data. Heer and Card. Proc. Advanced Visual Interfaces (AVI), pp. 421–424, 2004.]

prefuse

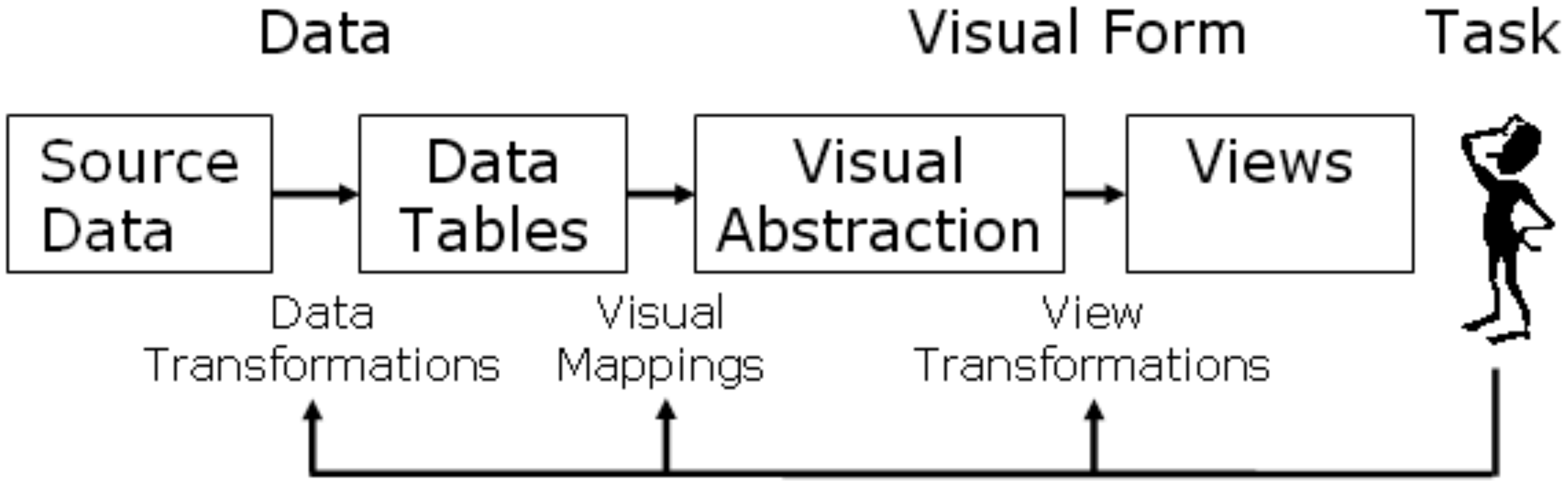
- separation: abstract data, visual form, view
  - data: tables, networks
  - visual form: layout, color, size, ...
  - view: multiple renderers



[Fig 2. Heer, Card, and Landay. Prefuse: A Toolkit for Interactive Information Visualization. Proc. CHI 2005, 421-430]

InfoVis Reference Model

- conceptual model underneath design of prefuse and many other toolkits
- heavily influenced much of infovis (including nested model)
  - aka infovis pipeline, data state model



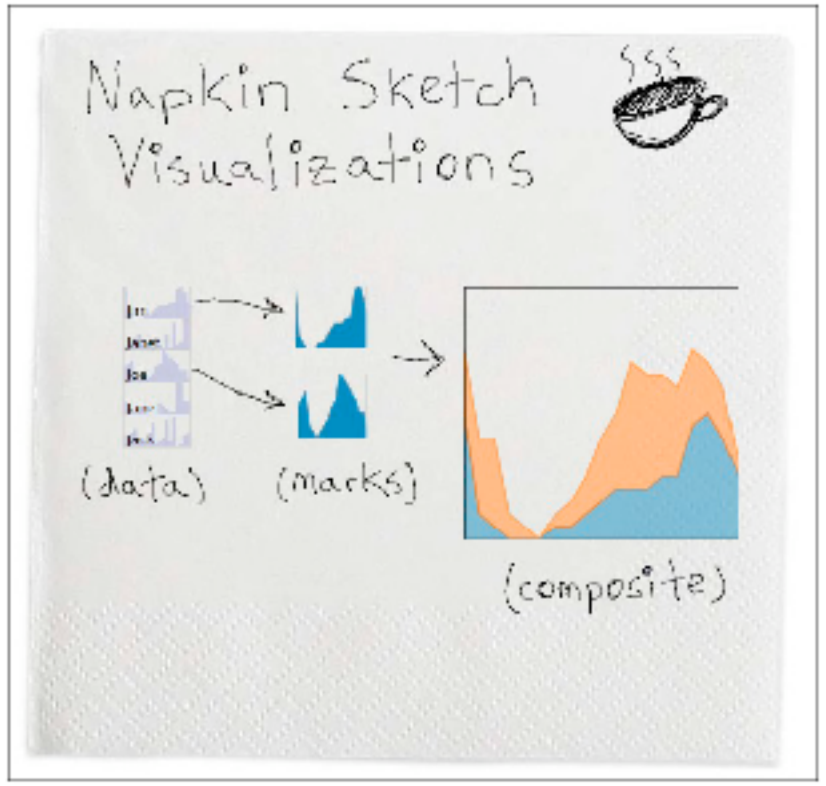
[Redrawn Fig 1.23. Card, Mackinlay, and Shneiderman. Readings in Information Visualization: Using Vision To Think, Chapter 1. Morgan Kaufmann, 1999.]

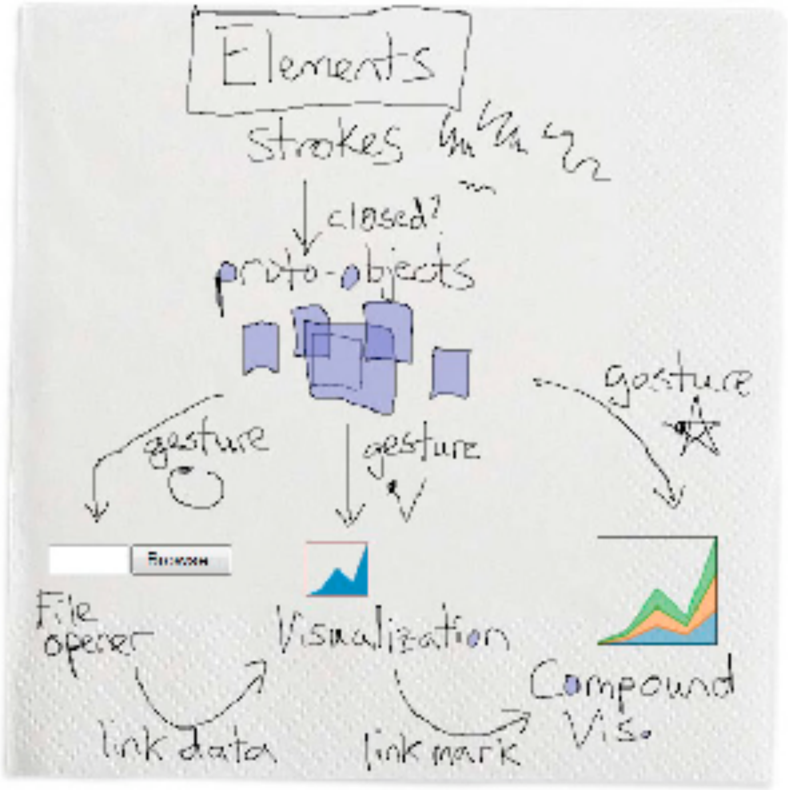
Declarative toolkits

- imperative tools/libraries
  - –say exactly **how** to do it
  - –familiar programming model
    - OpenGL, prefuse, ...
- declarative: other possibility
  - –just say **what** to do
  - –Protovis, D3

Protovis

- declarative infovis toolkit, in Javascript
  - also later Java version
- marks with inherited properties
- pros
  - runs in browser
  - matches mark/channel mental model
  - also much more: interaction, geospatial, trees,...
- cons
  - not all kinds of operations supported
- example app: NapkinVis (2009 course project)





[Fig 1, 3. Chao. NapkinVis. http://www.cs.ubc.ca/~tmm/courses/533-09/projects.html#will]

Protovis Validation

- wide set of old/new app examples
  - expressiveness, effectiveness, scalability
  - accessibility
- analysis with cognitive dimensions of notation
  - closeness of mapping, hidden dependencies
  - role-expressiveness visibility, consistency
  - viscosity, diffuseness, abstraction
  - hard mental operations

[Cognitive dimensions of notations. Green (1989). In A. Sutcliffe and L. Macaulay (Eds.) People and Computers V. Cambridge, UK: Cambridge University Press, pp 443-460.]

D3

- declarative infovis toolkit, in Javascript
- Protovis meets Document Object Model
- pros
  - seamless interoperability with Web
  - explicit transforms of scene with dependency info
  - massive user community, many thirdparty apps/libraries on top of it, lots of docs
- cons
  - even more different from traditional programming model
- example apps: many

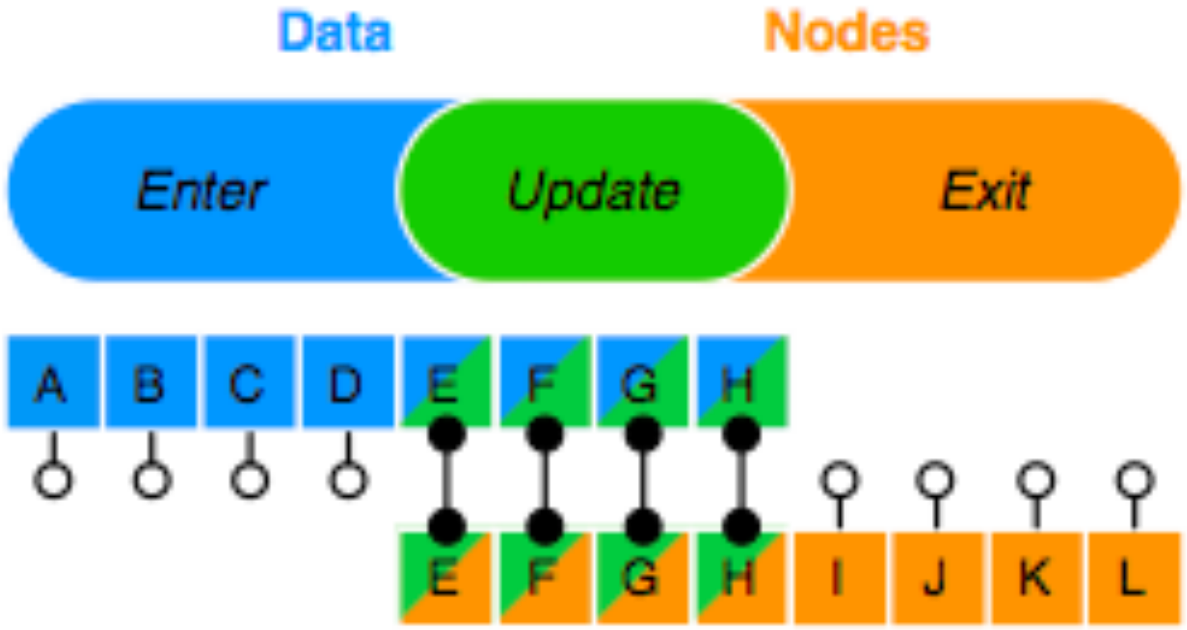
D3

- objectives
  - compatibility
  - debugging
  - performance
- related work typology
  - document transformers
  - graphics libraries
  - infovis systems
    - general note: all related work sections are a mini-taxonomy/typology!

[D3: Data-Driven Documents. Bostock, Ogievetsky, Heer. IEEE Trans. Visualization & Comp. Graphics (Proc. InfoVis), 2011.]

D3 capabilities

- query-driven selection
  - selection: filtered set of elements queries from the current doc
    - also partitioning/grouping!
  - operators act on selections to modify content
    - instantaneous or via animated transitions with attribute/style interpolators
    - event handlers for interaction
- data binding to scenegraph elements
  - data joins bind input data to elements
  - enter, update, exit subselections
  - sticky: available for subsequent re-selection
  - sort, filter



[D3: Data-Driven Documents. Bostock, Ogievetsky, Heer. IEEE Trans. Visualization & Comp. Graphics (Proc. InfoVis), 2011.]

D3 Features

- document transformation as atomic operation
  - scene changes vs representation of scenes themselves
- immediate property evaluation semantics
  - avoid confusing consequences of delayed evaluation

- validation
  - performance benchmarks
    - page loads, frame rate
  - accessibility
  - (adoption)
    - everybody has voted with their feet by now!

Ch 7: Arrange Tables

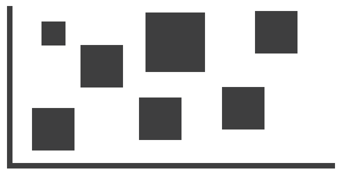
VAD Ch 7: Arrange Tables

Encode

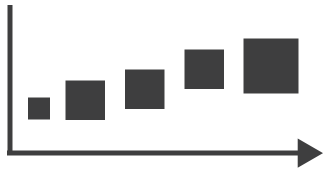
➔ Arrange

- ➔ Express

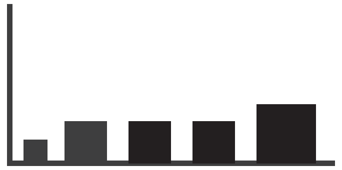
- ➔ Separate



- ➔ Order



- ➔ Align



- ➔ Use

How?

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, ...

Manipulate
- Change
- Select
- Navigate

Facet
- Juxtapose
- Partition
- Superimpose

Reduce
- Filter
- Aggregate
- Embed

What?

Why?

How?

Encode tables: Arrange space

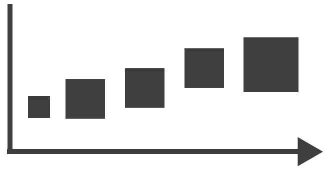
Encode

➔ Arrange

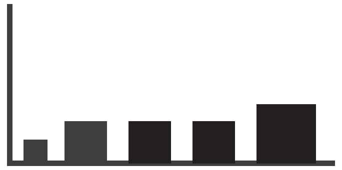
➔ Express

➔ Separate

➔ Order



➔ Align

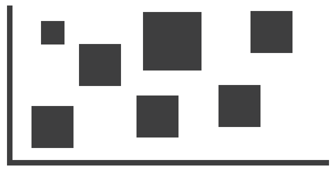


Arrange tables

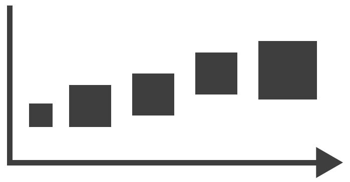
➔ Express Values

➔ Separate, Order, Align Regions

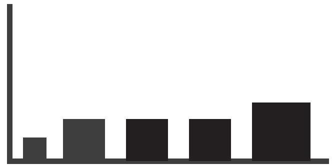
➔ Separate



➔ Order

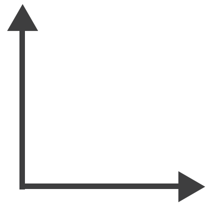


➔ Align

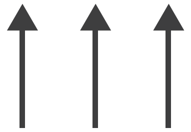


➔ Axis Orientation

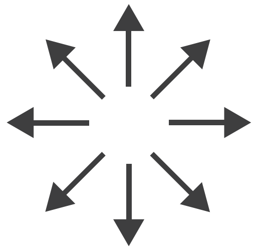
➔ Rectilinear



➔ Parallel

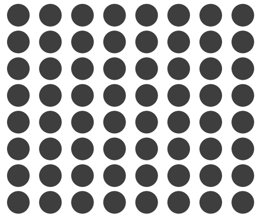


➔ Radial



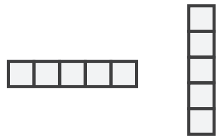
➔ Layout Density

➔ Dense

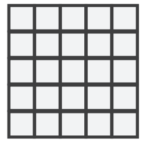


➔ Space-Filling

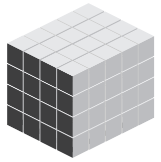
➔ *1 Key*
List



➔ *2 Keys*
Matrix



➔ *3 Keys*
Volume

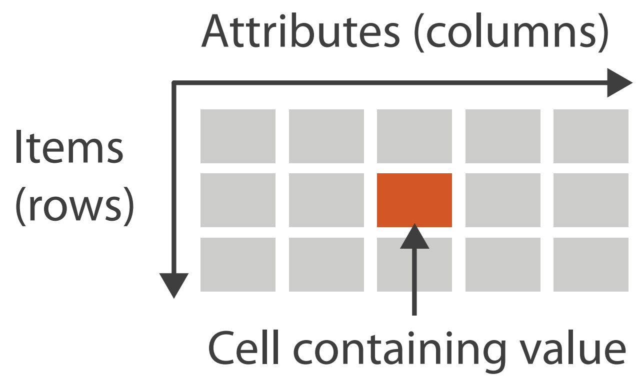


➔ *Many Keys*
Recursive Subdivision

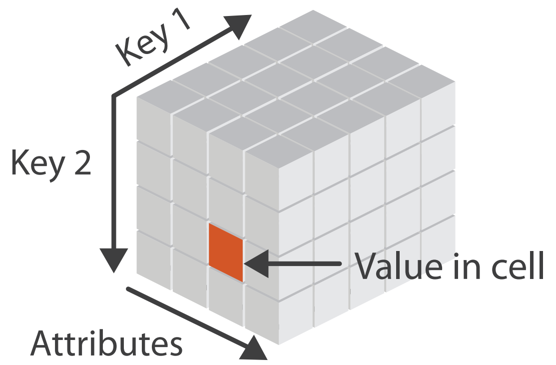
Keys and values

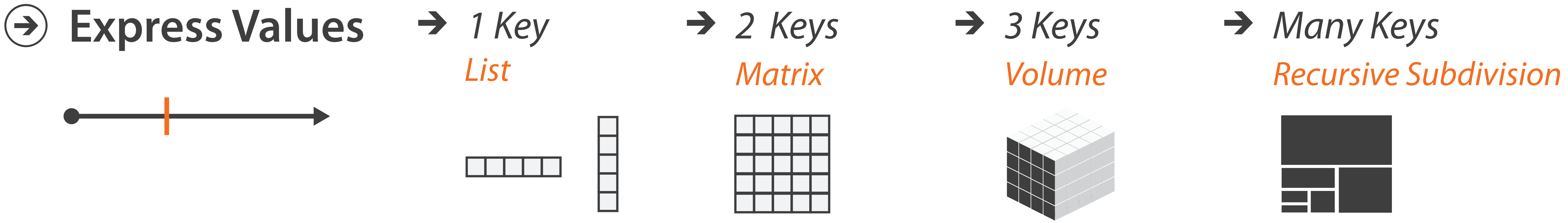
- key
  - independent attribute
  - used as unique index to look up items
  - simple tables: 1 key
  - multidimensional tables: multiple keys
- value
  - dependent attribute, value of cell
- classify arrangements by key count
  - 0, 1, 2, many...

➔ Tables

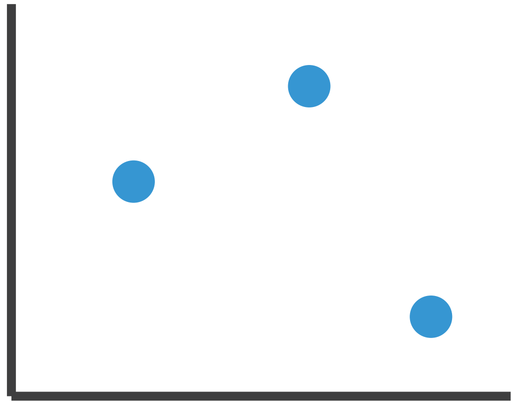


➔ *Multidimensional Table*

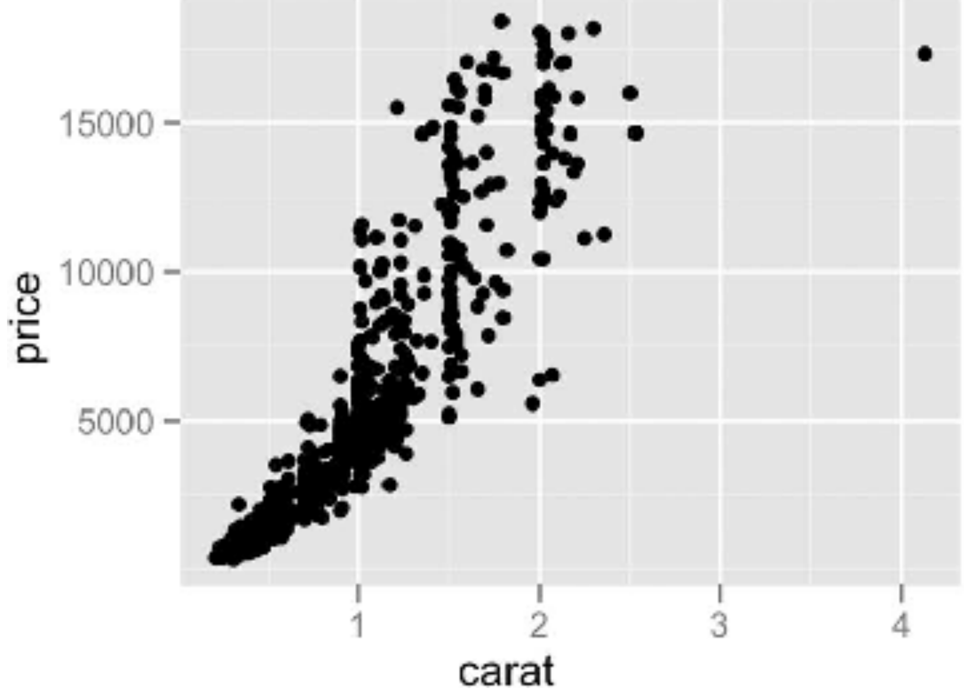


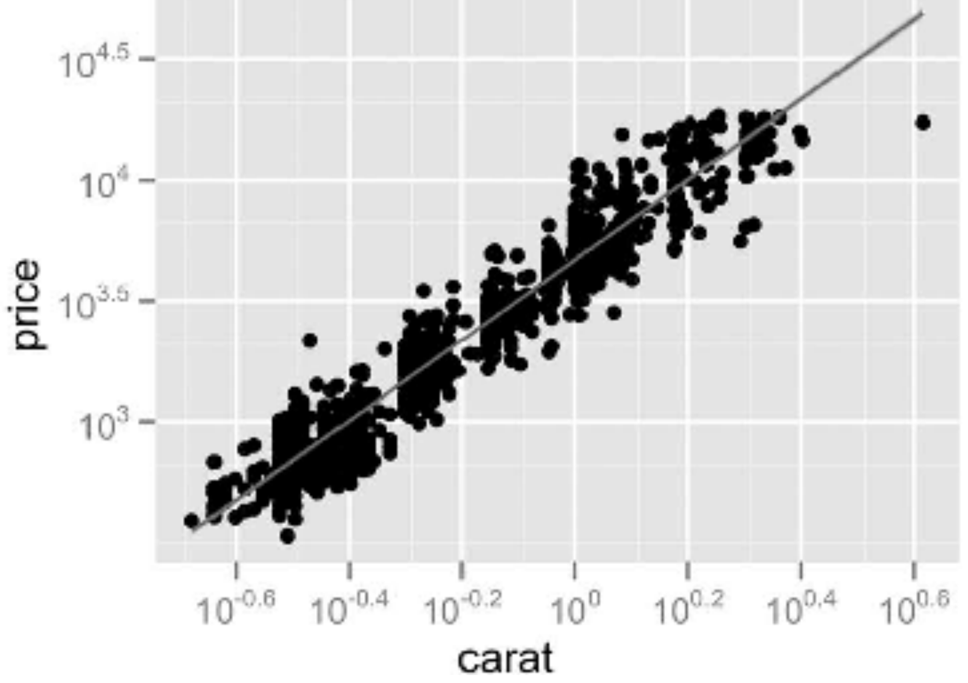


Idiom: **scatterplot**



- ***express*** values
  - quantitative attributes
- no keys, only values
  - data
    - 2 quant attribs
  - mark: points
  - channels
    - horiz + vert position
  - tasks
    - find trends, outliers, distribution, correlation, clusters
  - scalability
    - hundreds of items



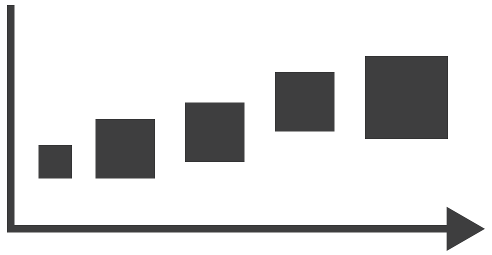


[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]

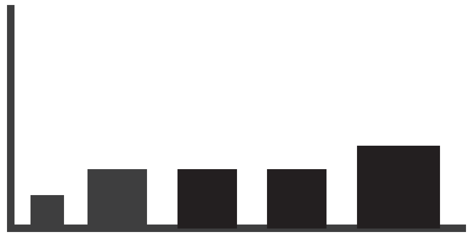
Some keys: Categorical regions

➔ Separate

➔ Order

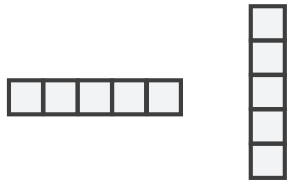


➔ Align

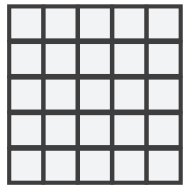


- **regions**: contiguous bounded areas distinct from each other
  - using space to ***separate*** (proximity)
  - following expressiveness principle for categorical attributes
- use ordered attribute to ***order*** and ***align*** regions

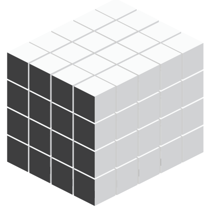
➔ *1 Key*
List



➔ *2 Keys*
Matrix

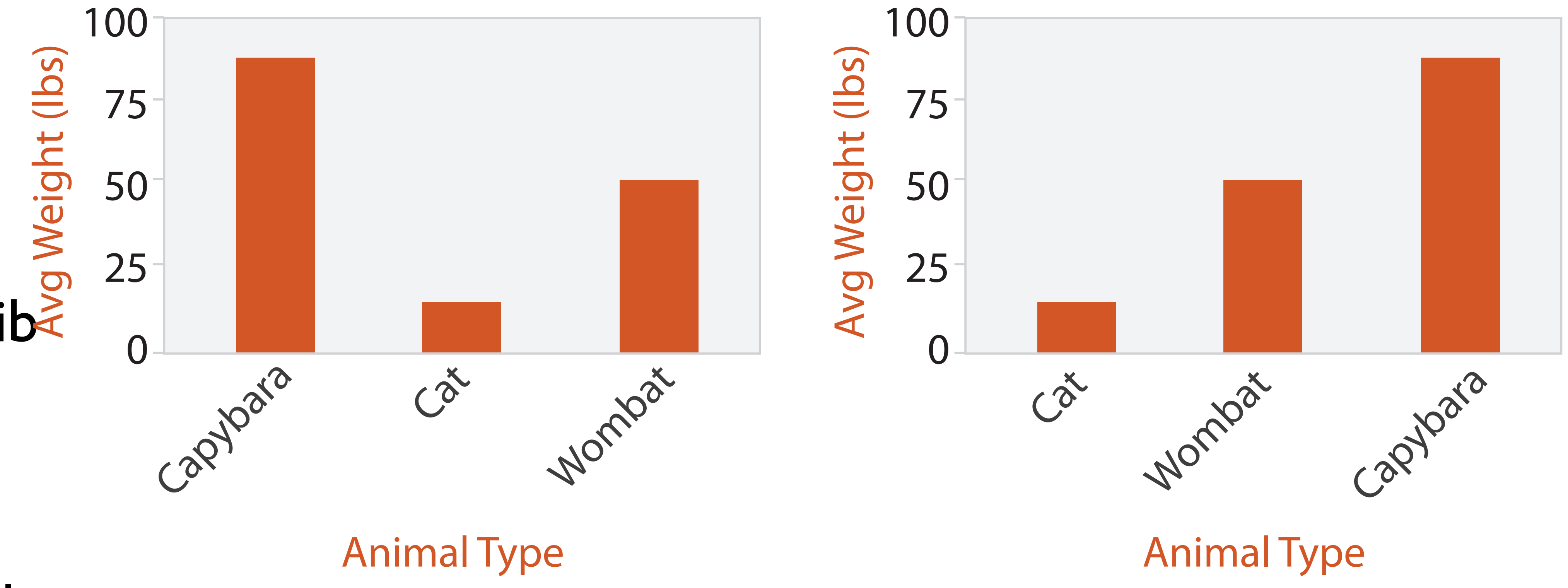


➔ *3 Keys*
Volume



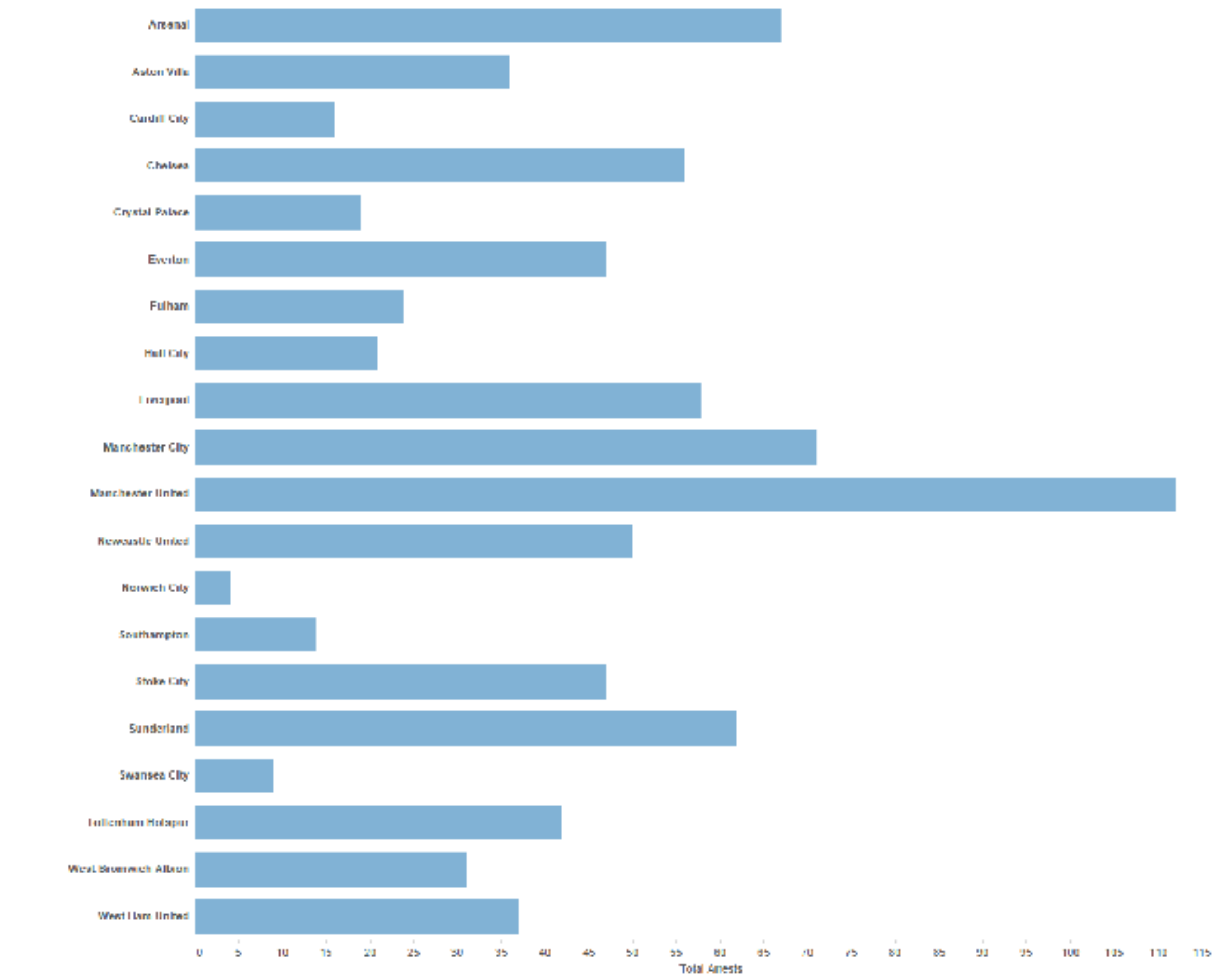
➔ *Many Keys*
Recursive Subdivision

Idiom: **bar chart**



- one key, one value
  - data
    - 1 categ attrib, 1 quant attrib
  - mark: lines
  - channels
    - length to express quant value
    - spatial regions: one per mark
      - separated horizontally, aligned vertically
      - ordered by quant attrib
        - » by label (alphabetical), by length attrib (data-driven)
  - task
    - compare, lookup values
  - scalability
    - dozens to hundreds of levels for key attrib

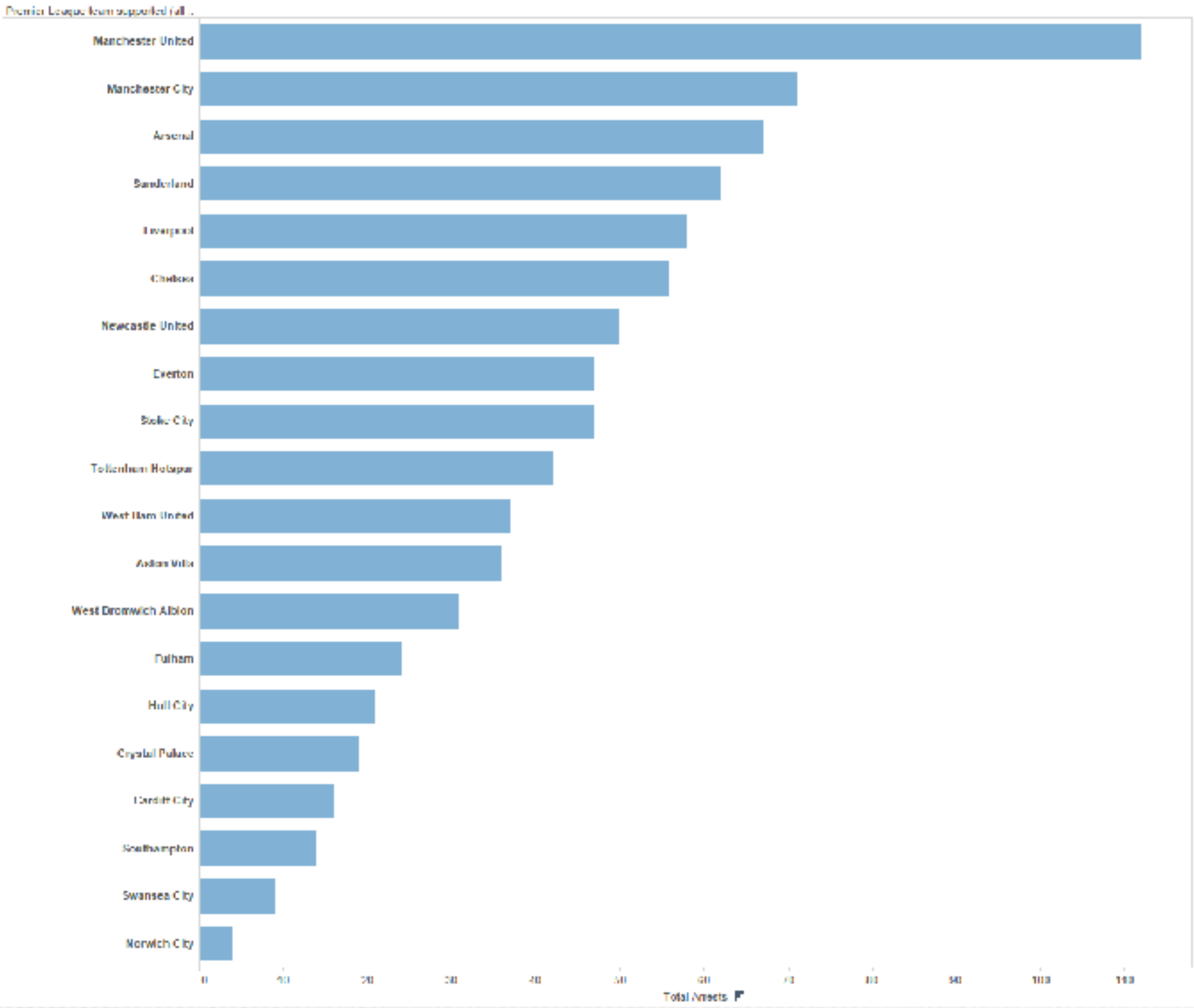
Separated and Aligned but not Ordered



LIMITATION: Hard to know rank. What's the 4th most? The 7th?

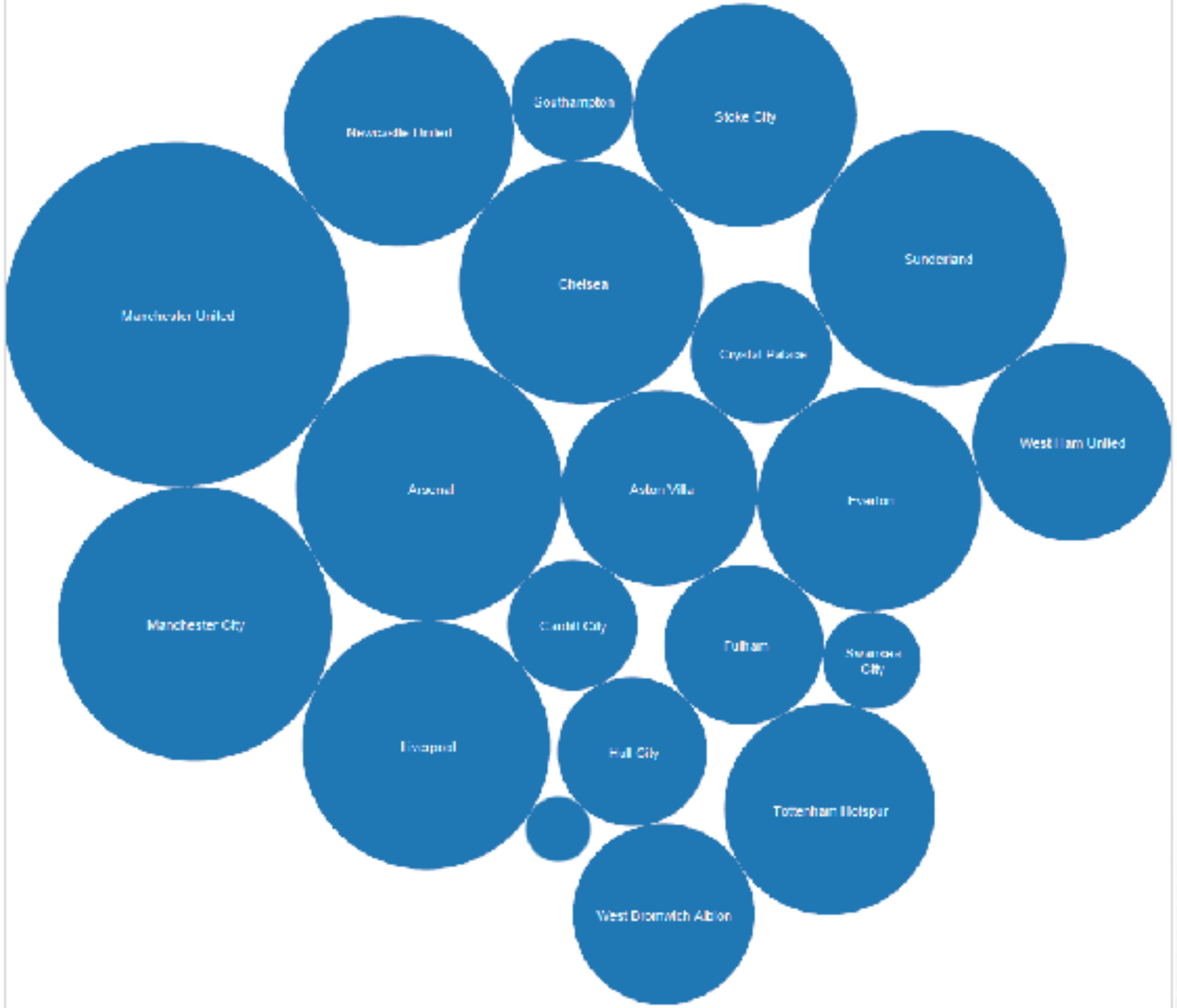
[Slide courtesy of Ben Jones]

Separated, Aligned and Ordered



[Slide courtesy of Ben Jones]

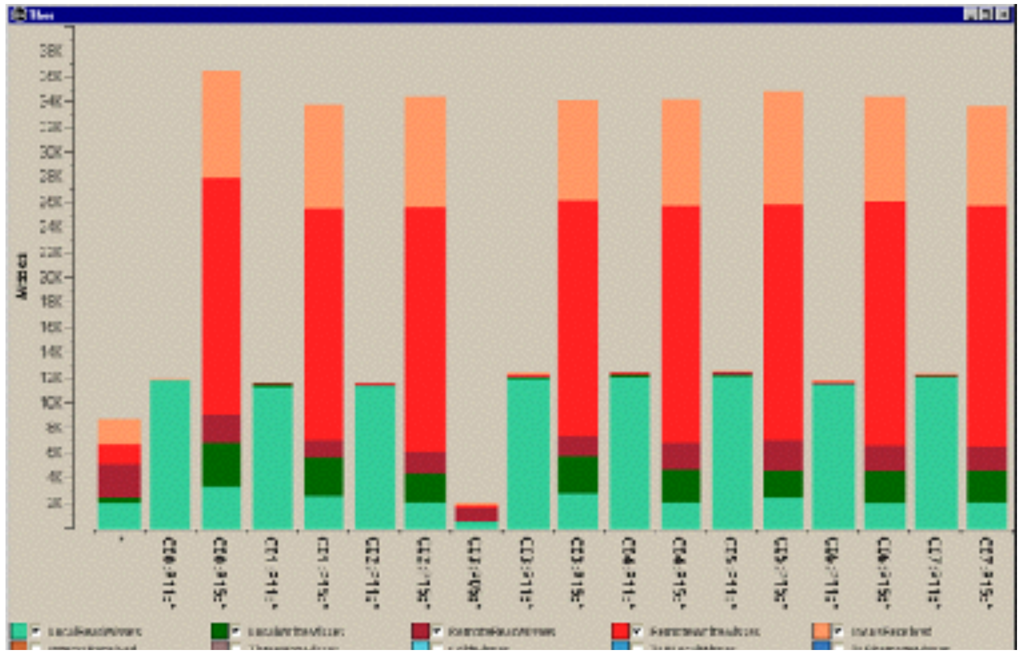
Separated but not Ordered or Aligned



LIMITATION: Hard to make comparisons

[Slide courtesy of Ben Jones]

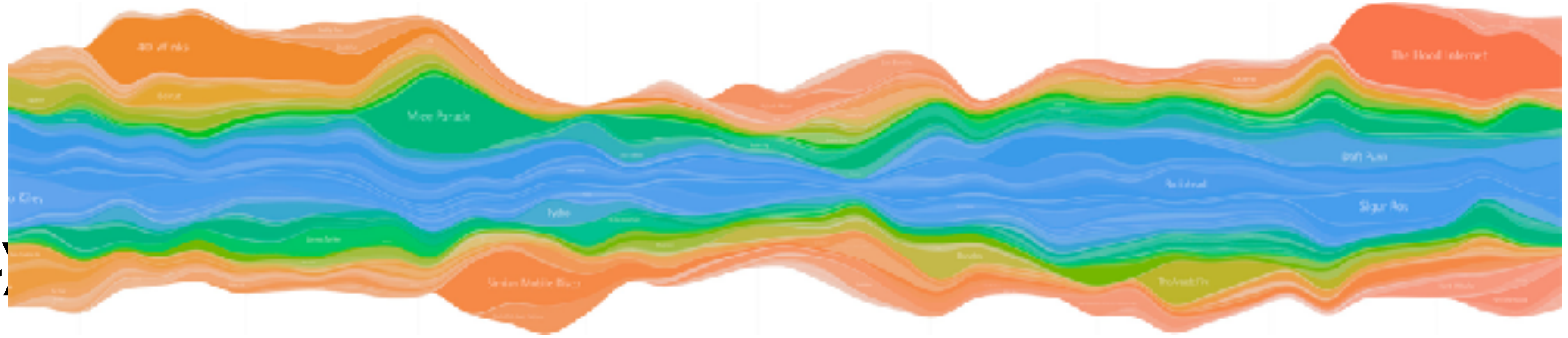
Idiom: **stacked bar chart**



- one more key
  - data
    - 2 categ attrib, 1 quant attrib
  - mark: vertical stack of line marks
    - **glyph**: composite object, internal structure from multiple marks
  - channels
    - length and color hue
    - spatial regions: one per glyph
      - aligned: full glyph, lowest bar component
      - unaligned: other bar components
  - task
    - part-to-whole relationship
  - scalability
    - several to one dozen levels for stacked attrib

[Using Visualization to Understand the Behavior of Computer Systems. Bosch. Ph.D. thesis, Stanford Computer Science, 2001.]

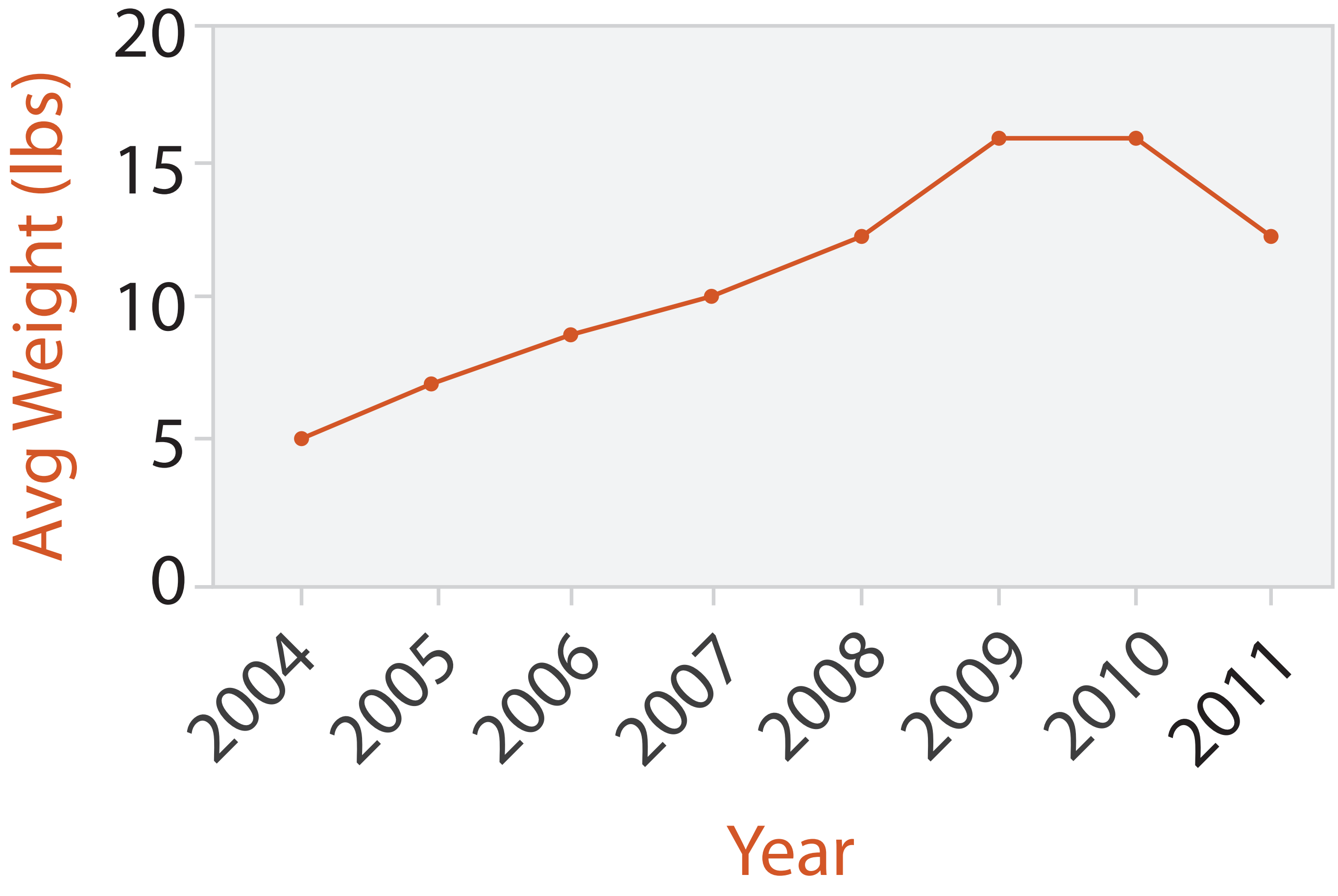
Idiom: **streamgraph**



[Stacked Graphs Geometry & Aesthetics. Byron and Wattenberg. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14(6): 1245–1252, (2008).]

- generalized stacked graph
  - emphasizing horizontal continuity
    - vs vertical items
  - data
    - 1 categ key attrib (artist)
    - 1 ordered key attrib (time)
    - 1 quant value attrib (counts)
  - derived data
    - geometry: layers, where height encodes counts
    - 1 quant attrib (layer ordering)
  - scalability
    - hundreds of time keys
    - dozens to hundreds of artist keys
      - more than stacked bars, since most layers don't extend across whole chart

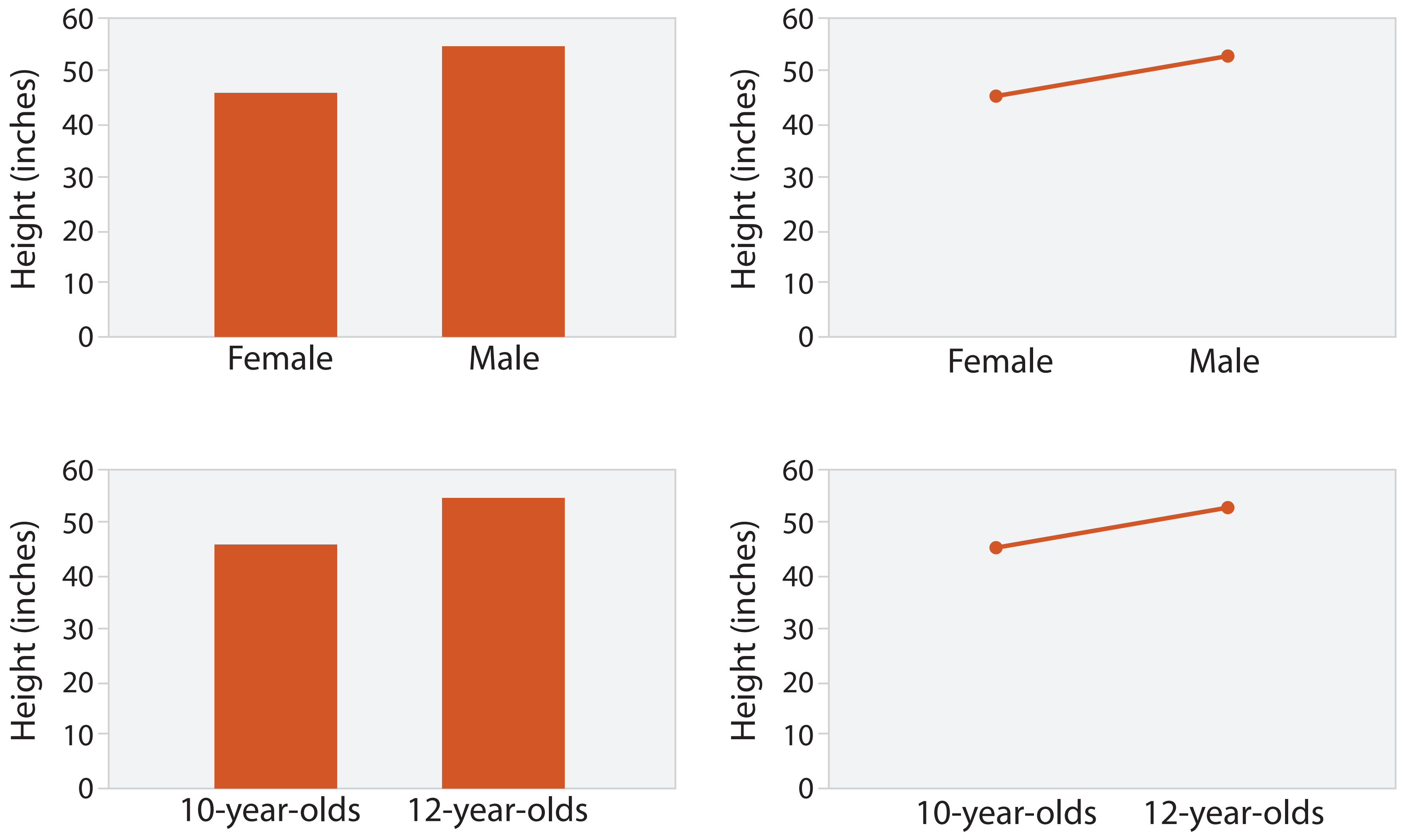
Idiom: **line chart / dot plot**



- one key, one value
  - data
    - 2 quant attribs
  - mark: points
    - line connection marks between them
  - channels
    - aligned lengths to express quant value
    - separated and ordered by key attrib into horizontal regions
  - task
    - find trend
      - connection marks emphasize ordering of items along key axis by explicitly showing relationship between one item and the next
  - scalability
    - hundreds of key levels, hundreds of value levels

Choosing bar vs line charts

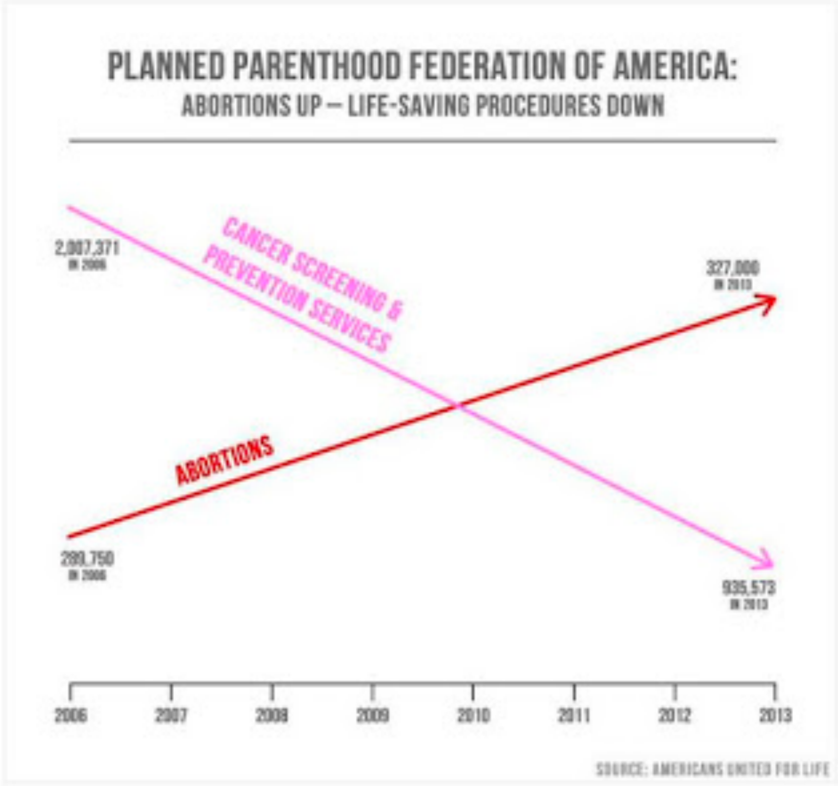
- depends on type of key attrib
  - bar charts if categorical
  - line charts if ordered
- do not use line charts for categorical key attribs
  - violates expressiveness principle
    - implication of trend so strong that it overrides semantics!
      - "The more male a person is, the taller he/she is"

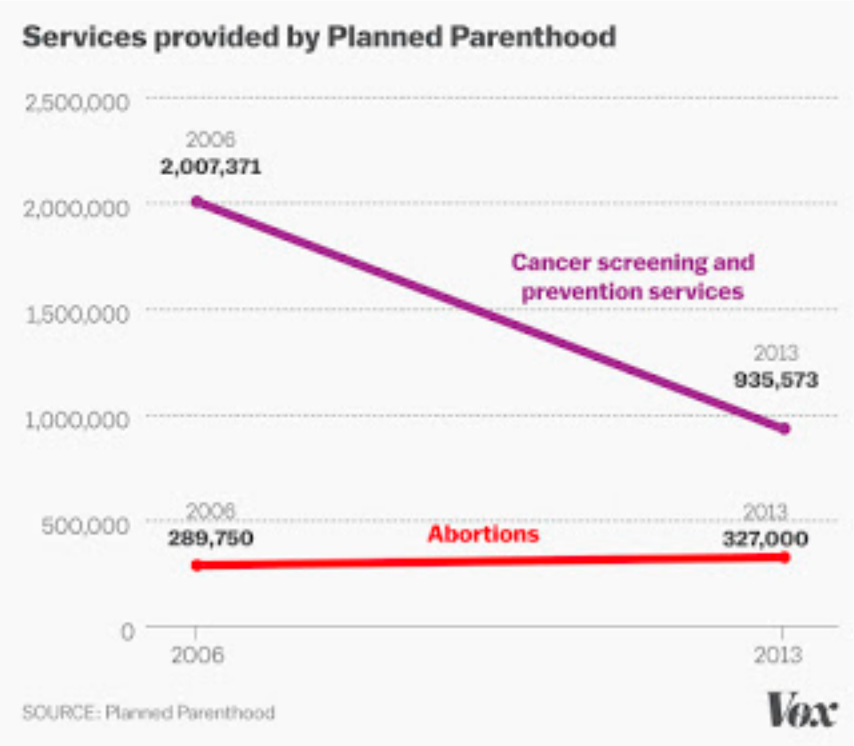


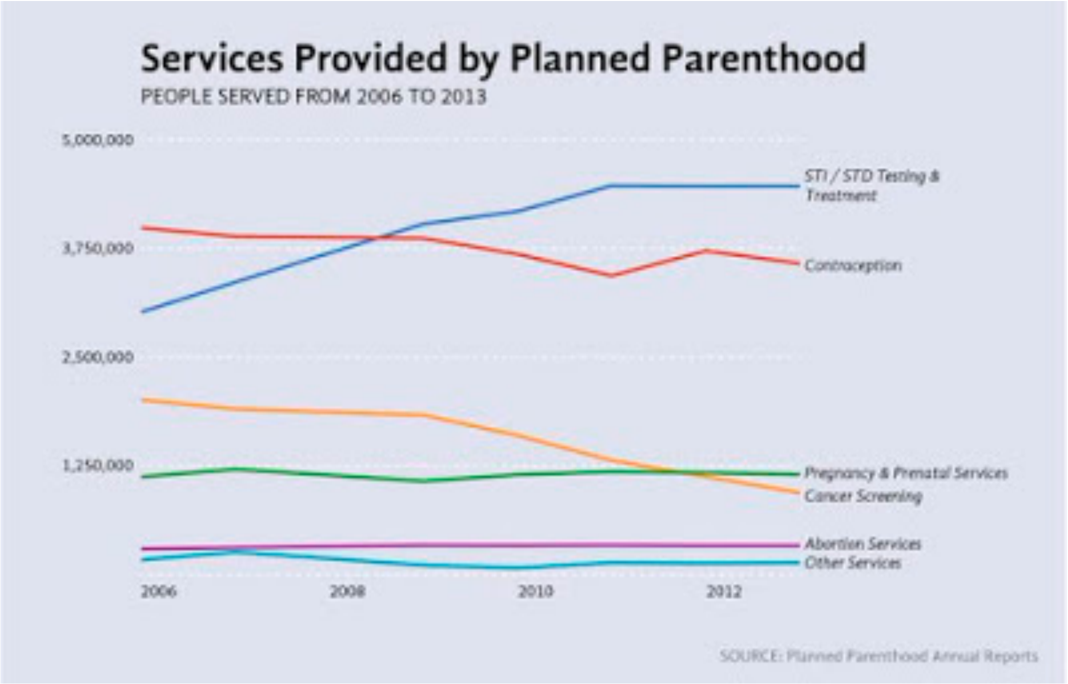
after [Bars and Lines: A Study of Graphic Communication. Zacks and Tversky. Memory and Cognition 27:6 (1999), 1073–1079.]

Chart axes

- labelled axis is critical
- avoid cropping y-axis
  - include 0 at bottom left
  - or slope misleads
- dual axes controversial
  - acceptable if commensurate
  - beware, very easy to mislead!



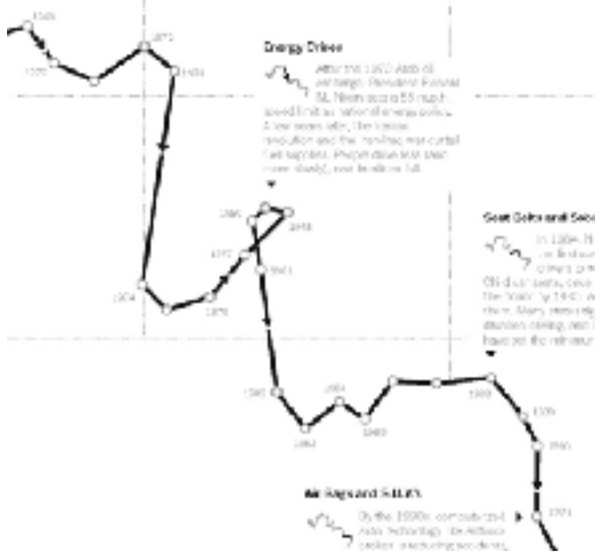


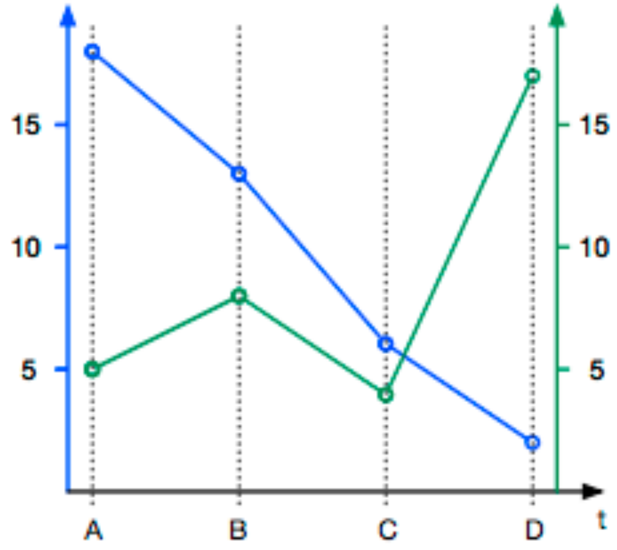


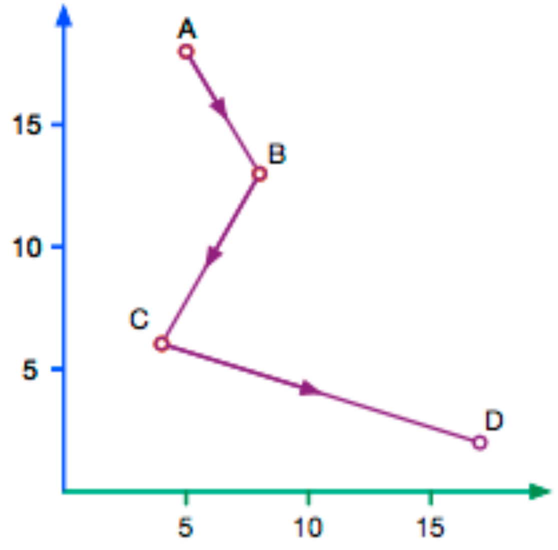
http://www.thefunctionalart.com/2015/10/if-you-see-bullshit-say-bullshit.html

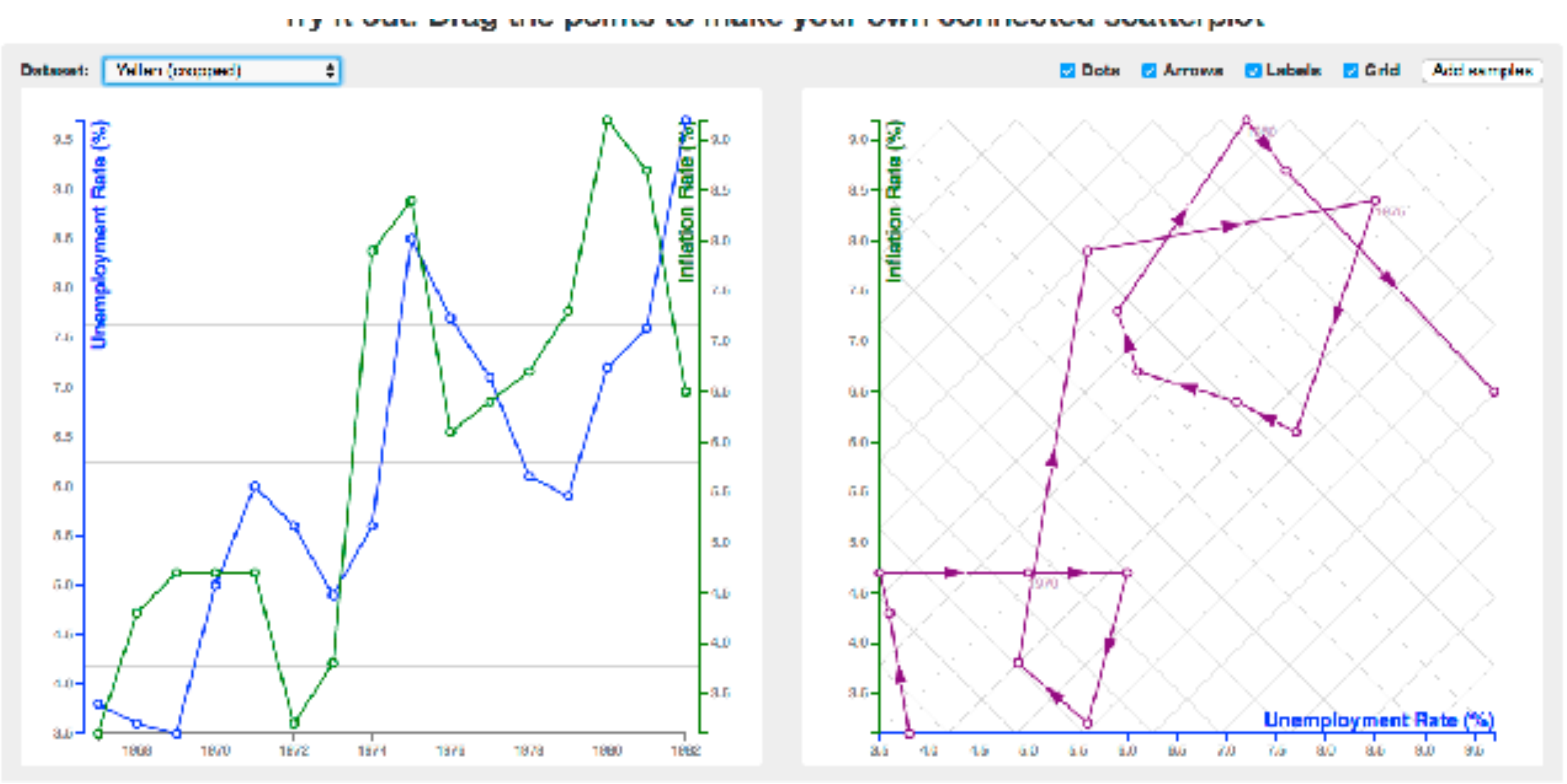
Idiom: **connected scatterplots**

- scatterplot with line connection marks
  - popular in journalism
  - horiz + vert axes: value attribs
  - line connection marks: temporal order
  - alternative to dual-axis charts
    - horiz: time
    - vert: two value attribs
- empirical study
  - engaging, but correlation unclear







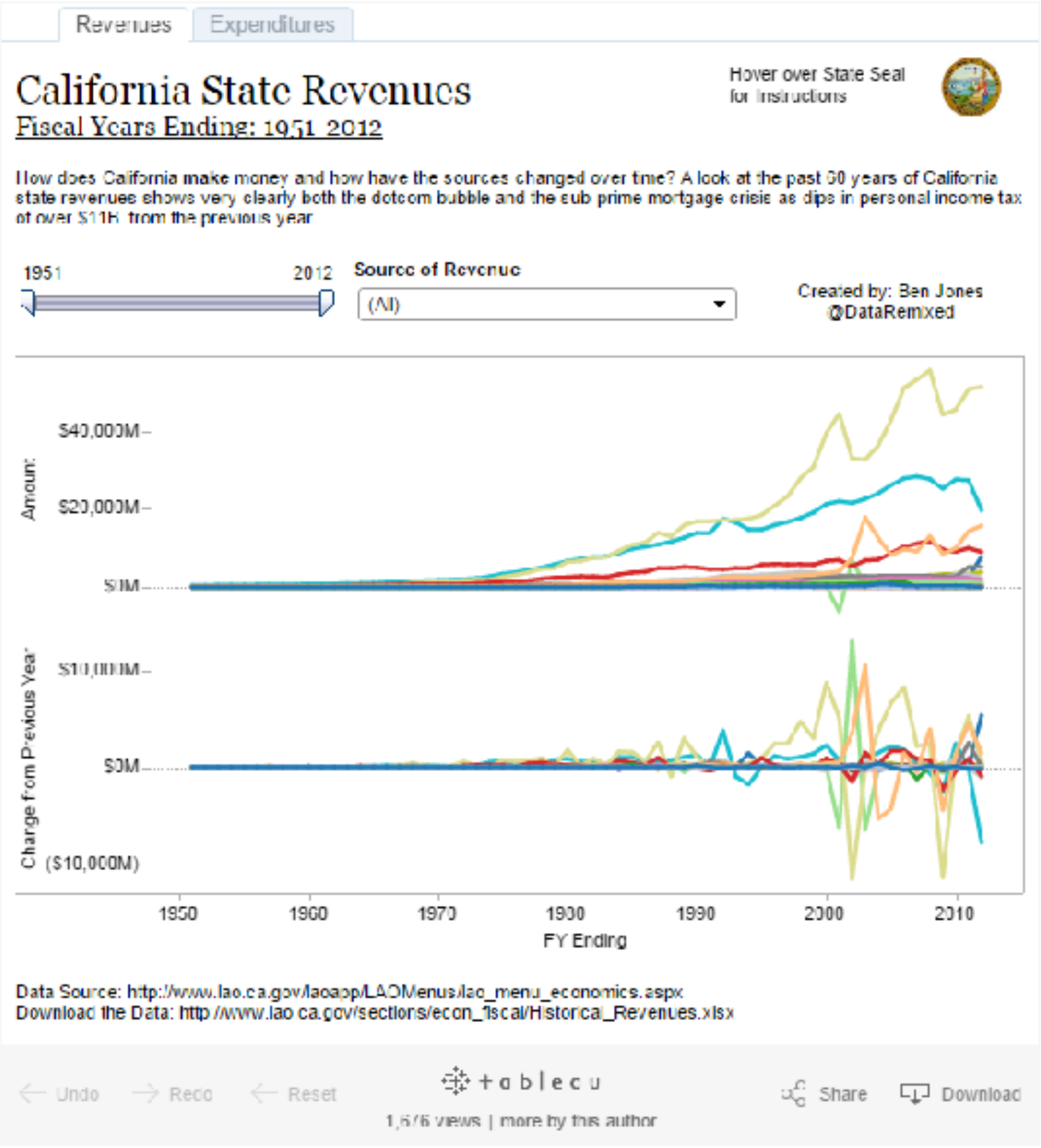


[The Connected Scatterplot for Presenting Paired Time Series. Haroz, Kosara and Franconeri. IEEE TVCG 22(9):2174-86, 2016.]

http://steveharoz.com/research/connected_scatterplot/

Idiom: **Indexed line charts**

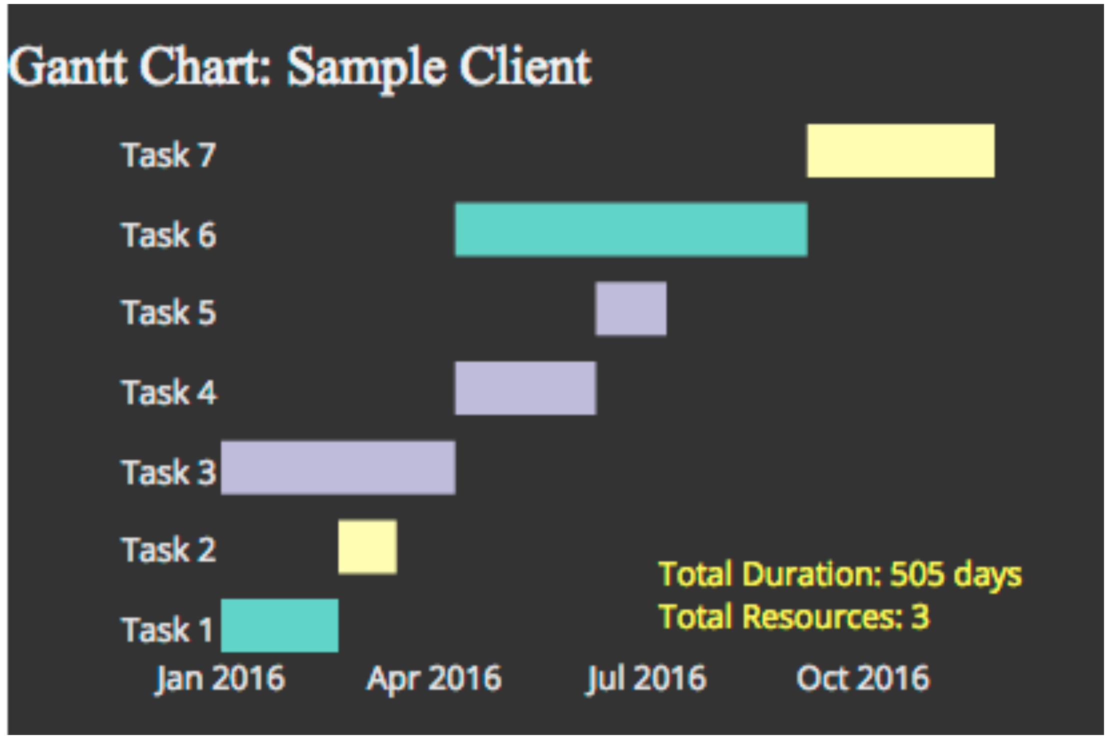
- data: 2 quant attires
  - 1 key + 1 value
- derived data: new quant value attrib
  - index
  - plot instead of original value
- task: show change over time
  - principle: normalized, not absolute
- scalability
  - same as standard line chart



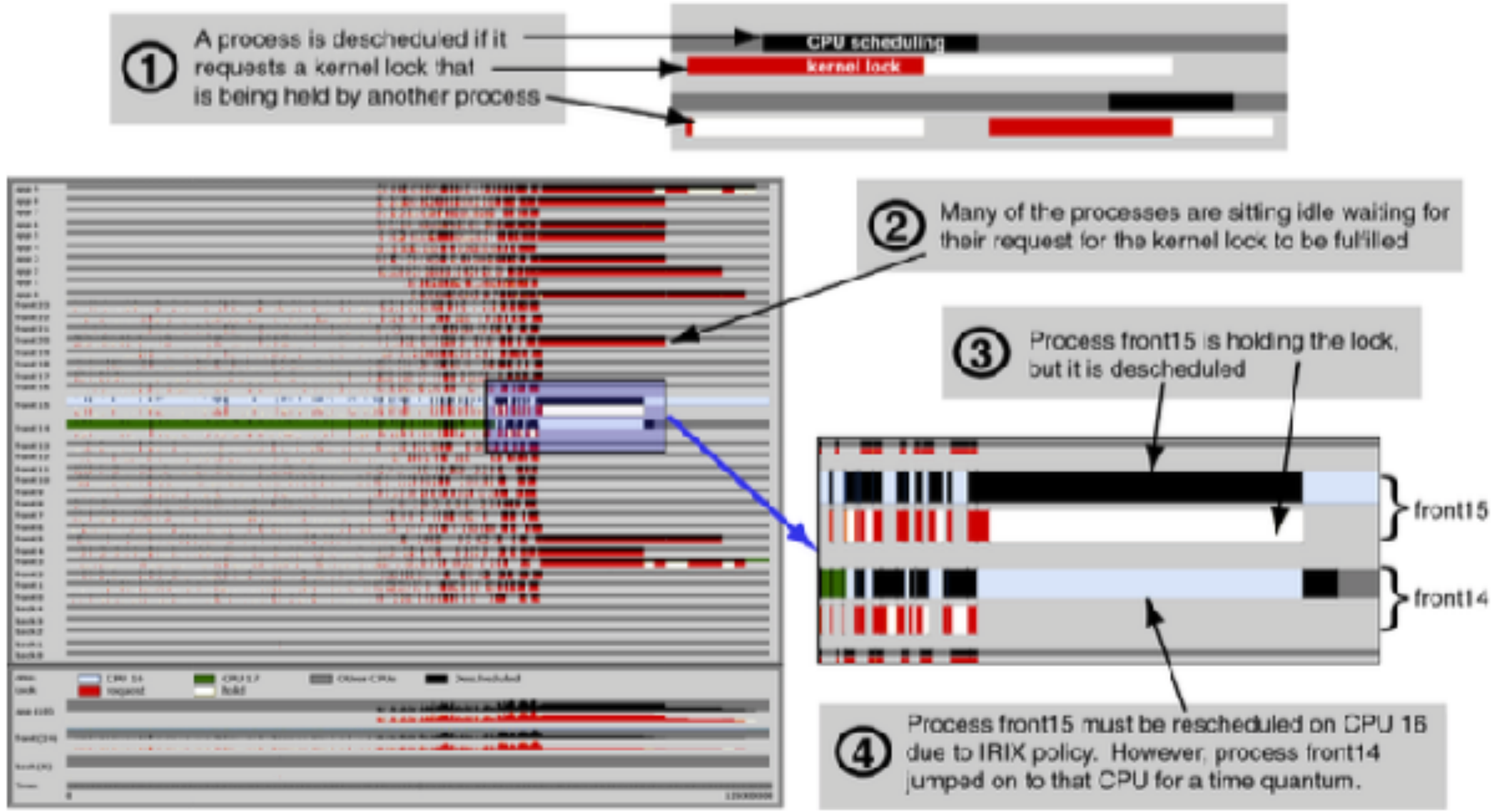
https://public.tableau.com/profile/ben.jones#!/vizhome/CAStateRevenues/Revenues

Idiom: **Gantt charts**

- one key, two (related) values
  - data
    - 1 categ attrib, 2 quant attribs
  - mark: line
    - length: duration
  - channels
    - horiz position: start /end times
    - horiz length: duration
  - task
    - emphasize temporal overlaps, start/end dependencies between items
  - scalability
    - dozens of key levels
    - hundreds of value levels



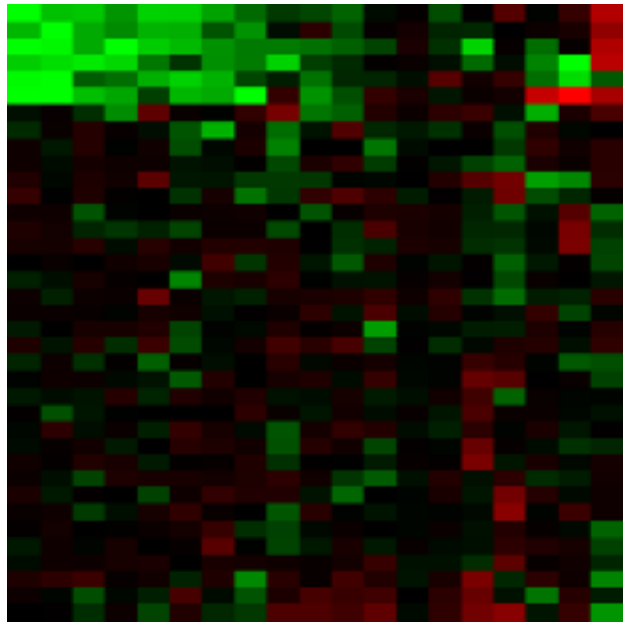
https://www.r-bloggers.com/gantt-charts-in-r-using-plotly/

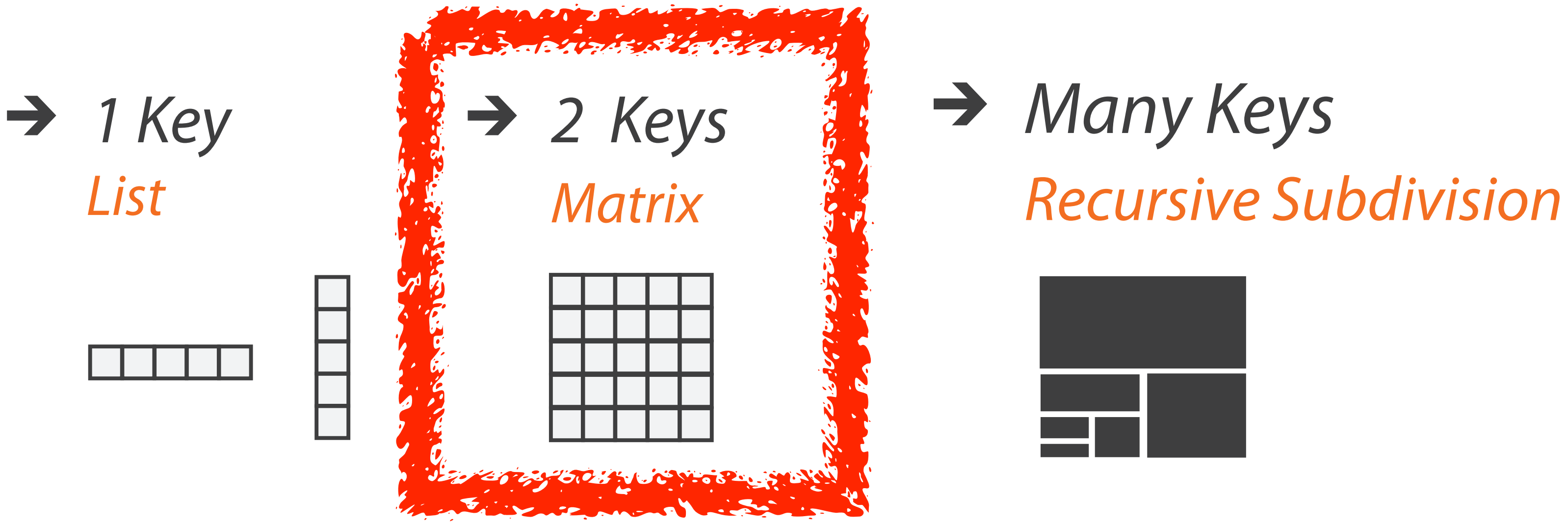


[Performance Analysis and Visualization of Parallel Systems Using SimOS and Rivet: A Case Study. Bosch, Stolte, Stoll, Rosenblum, and Hanrahan. Proc. HPCA 2000.]

Idiom: **heatmap**

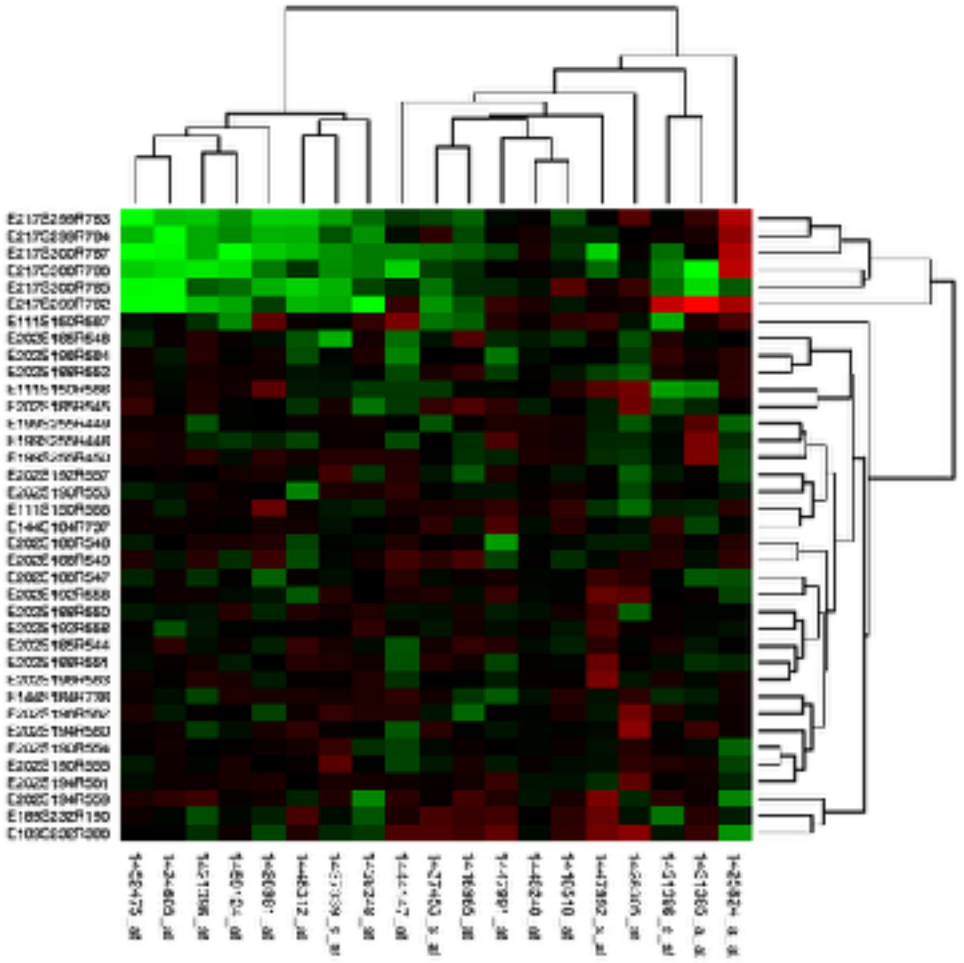
- two keys, one value
  - data
    - 2 categ attribs (gene, experimental condition)
    - 1 quant attrib (expression levels)
  - marks: area
    - separate and align in 2D matrix
      - indexed by 2 categorical attributes
  - channels
    - color by quant attrib
      - (ordered diverging colormap)
  - task
    - find clusters, outliers
  - scalability
    - 1M items, 100s of categ levels, ~10 quant attrib levels





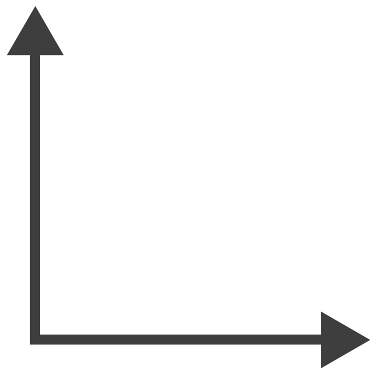
Idiom: **cluster heatmap**

- in addition
  - derived data
    - 2 cluster hierarchies
  - dendrogram
    - parent-child relationships in tree with connection line marks
    - leaves aligned so interior branch heights easy to compare
  - heatmap
    - marks (re-)ordered by cluster hierarchy traversal

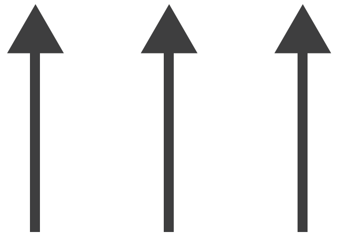


Axis Orientation

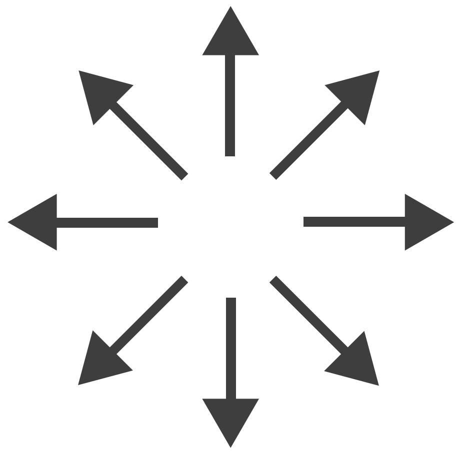
- Rectilinear



- Parallel

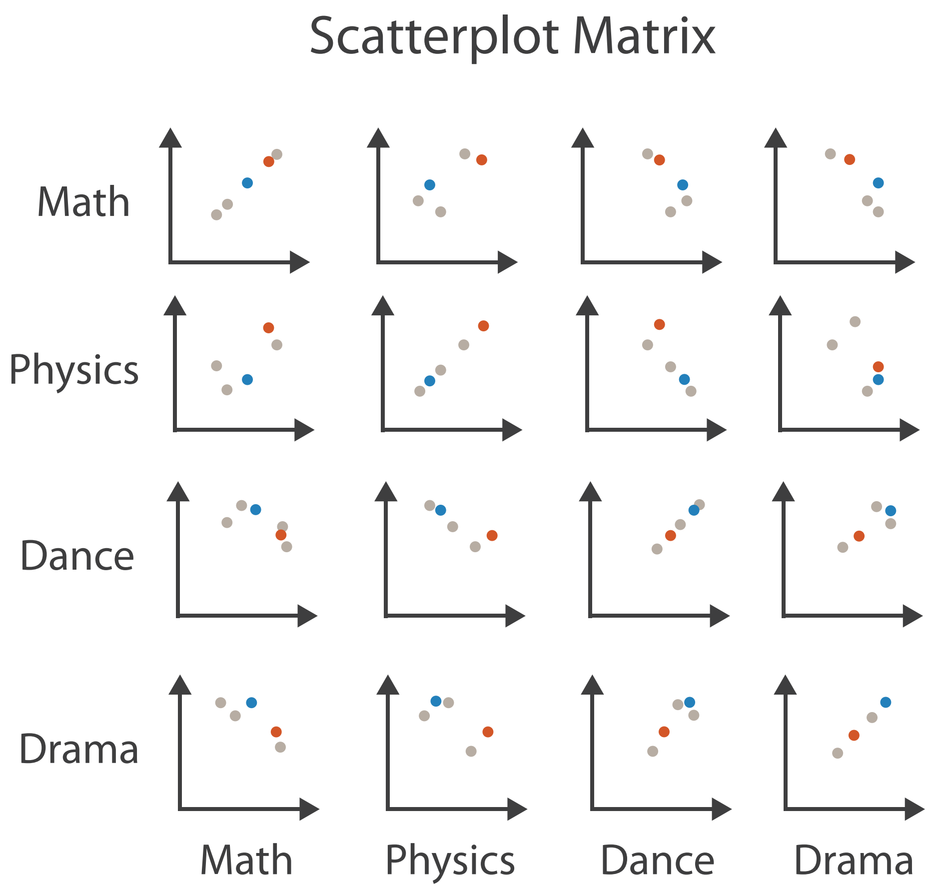


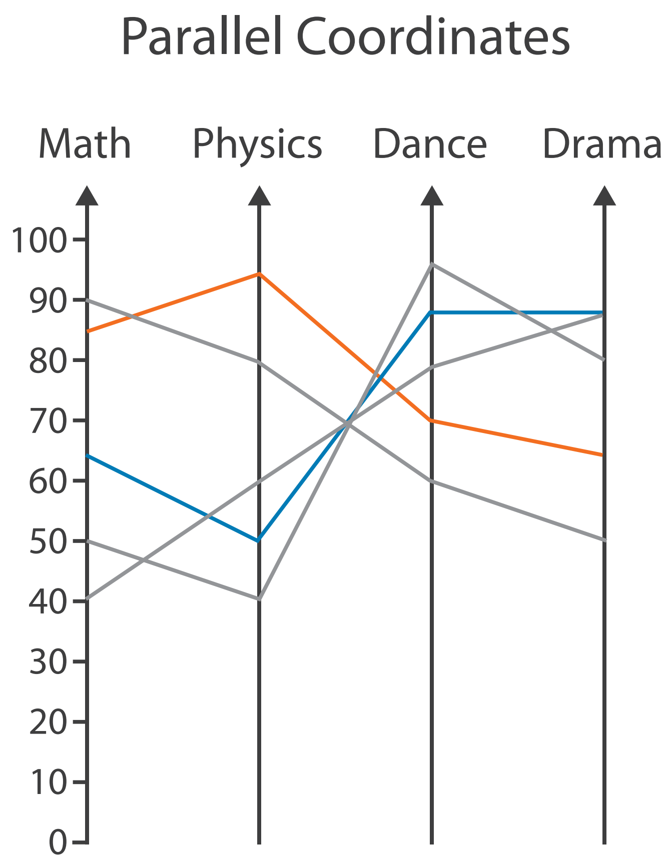
- Radial



Idioms: **scatterplot matrix, parallel coordinates**

- scatterplot matrix (SPLOM)
  - rectilinear axes, point mark
  - all possible pairs of axes
  - scalability
    - one dozen attribs
    - dozens to hundreds of items
- parallel coordinates
  - parallel axes, jagged line representing item
  - rectilinear axes, item as point
    - axis ordering is major challenge
  - scalability
    - dozens of attribs
    - hundreds of items





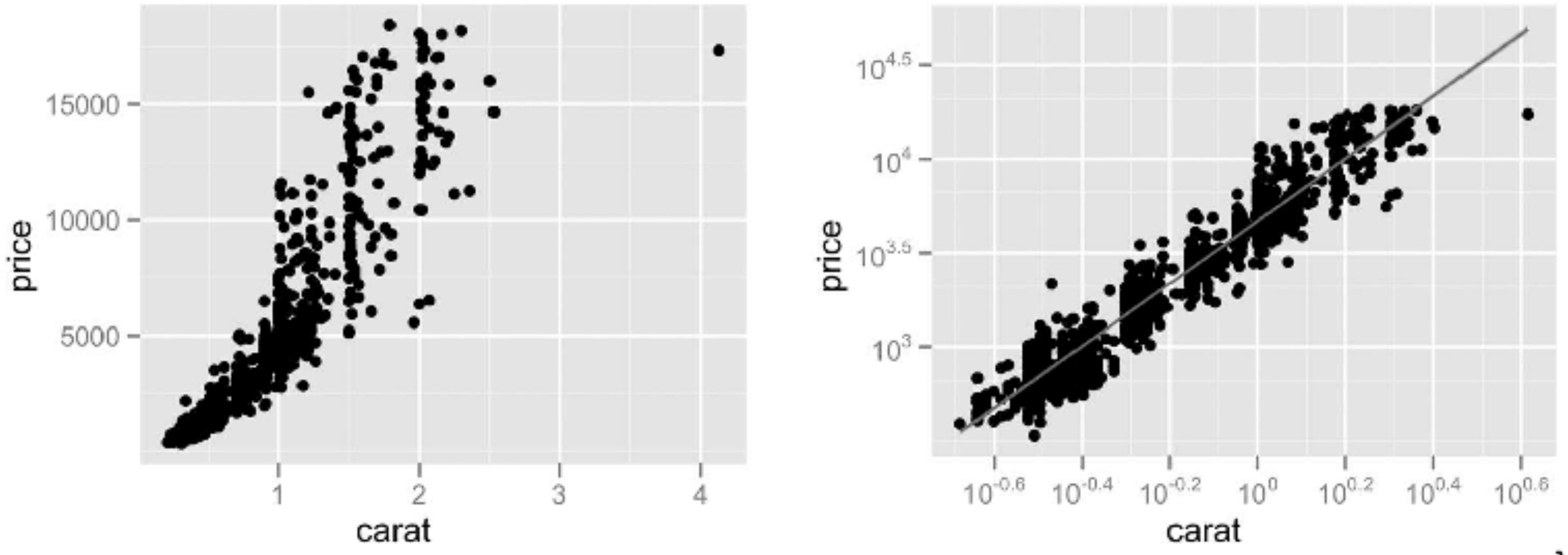
Table

Math	Physics	Dance	Drama
85	95	70	65
90	80	60	50
65	50	90	90
50	40	95	80
40	60	80	90

after [Visualization Course Figures. McGuffin, 2014. http://www.michaelmcguffin.com/courses/vis/]

Task: Correlation

- scatterplot matrix
  - positive correlation
    - diagonal low-to-high
  - negative correlation
    - diagonal high-to-low
  - uncorrelated
- parallel coordinates
  - positive correlation
    - parallel line segments
  - negative correlation
    - all segments cross at halfway point
  - uncorrelated
    - scattered crossings



[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]

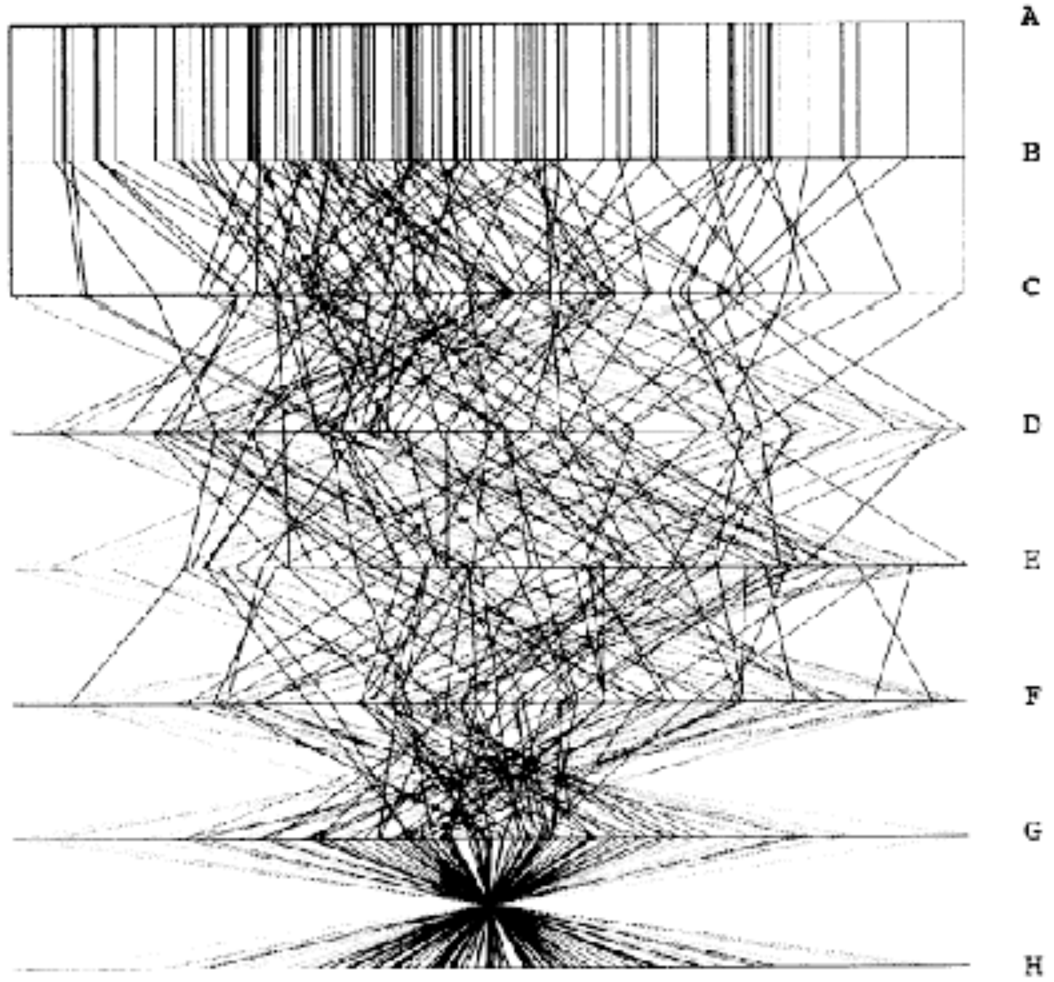
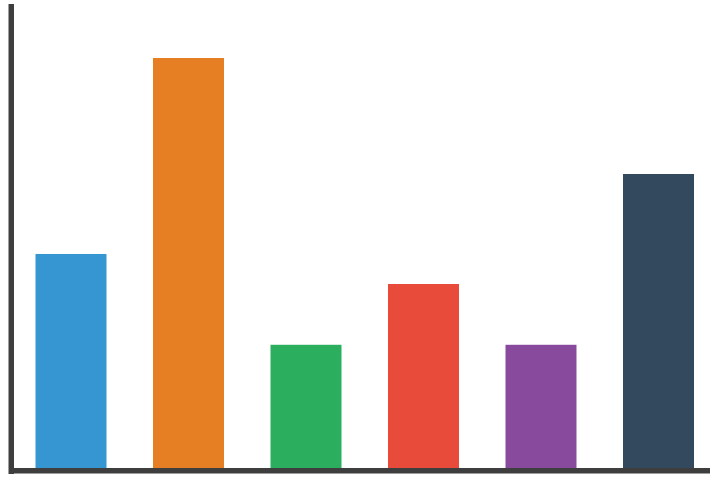


Figure 3. Parallel Coordinate Plot of Six-Dimensional Data Illustrating Correlations of ρ = 1, .8, .2, 0, −.2, −.8, and −1.

[Hyperdimensional Data Analysis Using Parallel Coordinates. Wegman. Journ. American Statistical Association 85:411 (1990), 664–675.]

Idioms: **radial bar chart, star plot**

- radial bar chart
  - –radial axes meet at central ring, line mark
- star plot
  - –radial axes, meet at central point, line mark
- bar chart
  - –rectilinear axes, aligned vertically



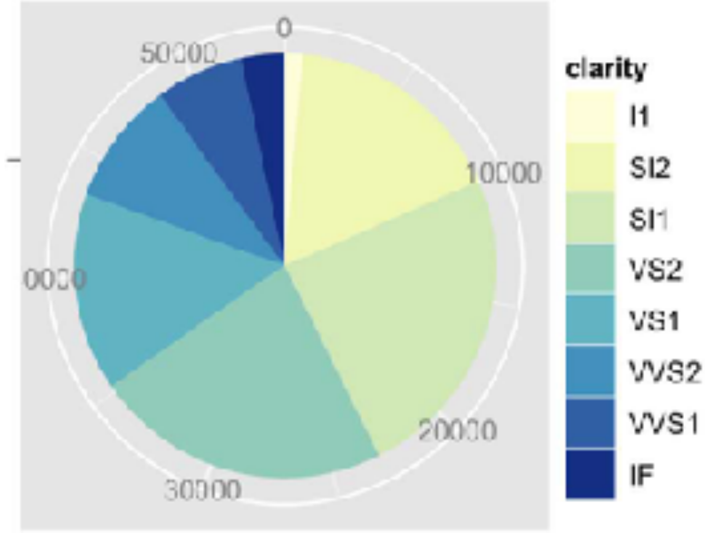
- accuracy
  - –length unaligned with radial
    - less accurate than aligned with rectilinear

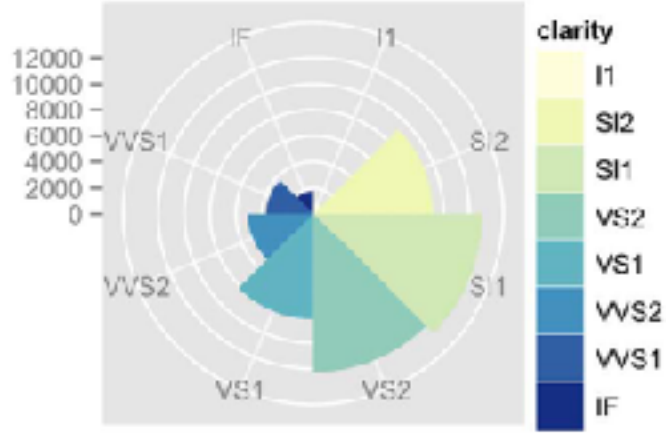
[Vismon: Facilitating Risk Assessment and Decision Making In Fisheries Management. Booshehrian, Möller, Peterman, and Munzner. Technical Report TR 2011-04, Simon Fraser University, School of Computing Science, 2011.]

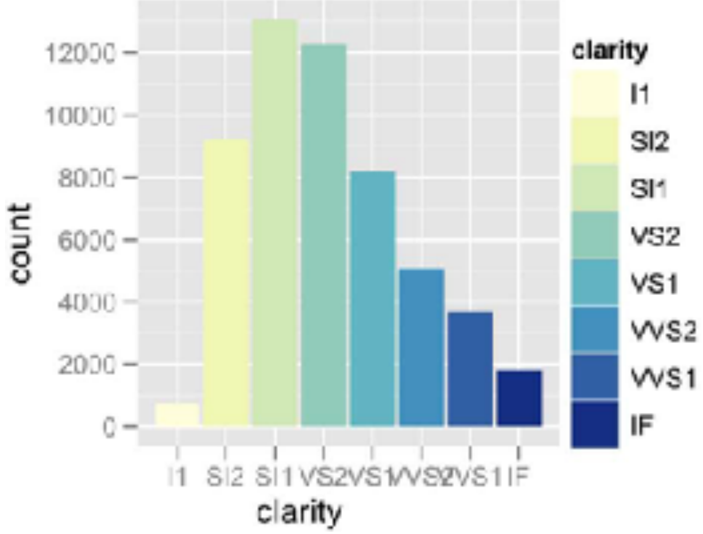
Idioms: **pie chart, polar area chart**

- pie chart
  - area marks with angle channel
  - accuracy: angle/area less accurate than line length
    - arclength also less accurate than line length
- polar area chart
  - area marks with length channel
  - more direct analog to bar charts

- data
  - 1 categ key attrib, 1 quant value attrib
- task
  - part-to-whole judgements



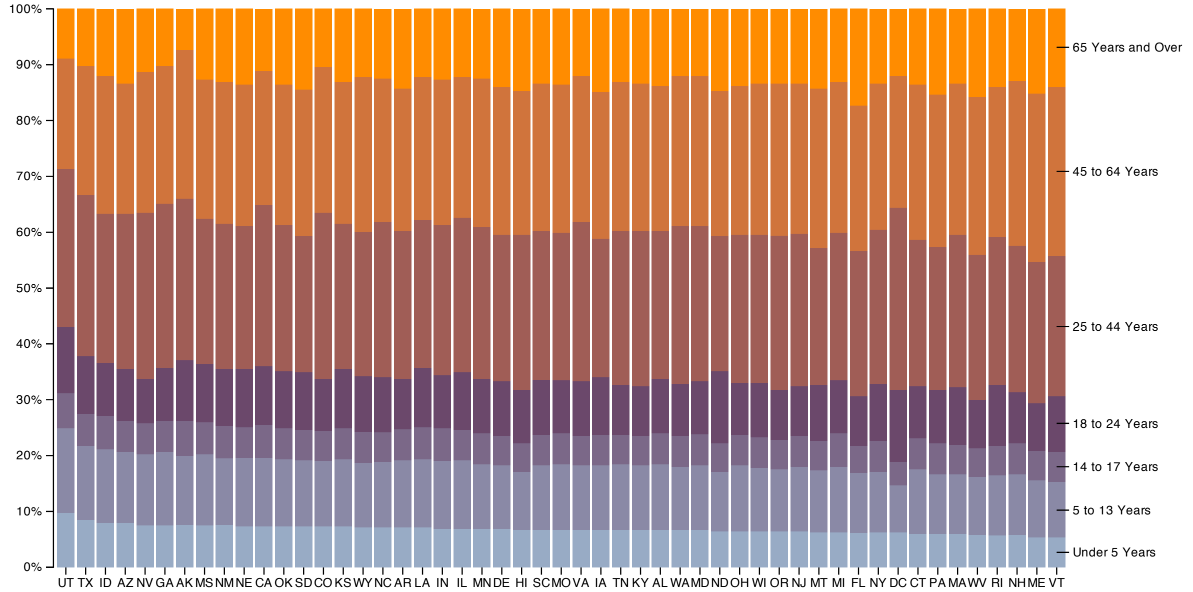


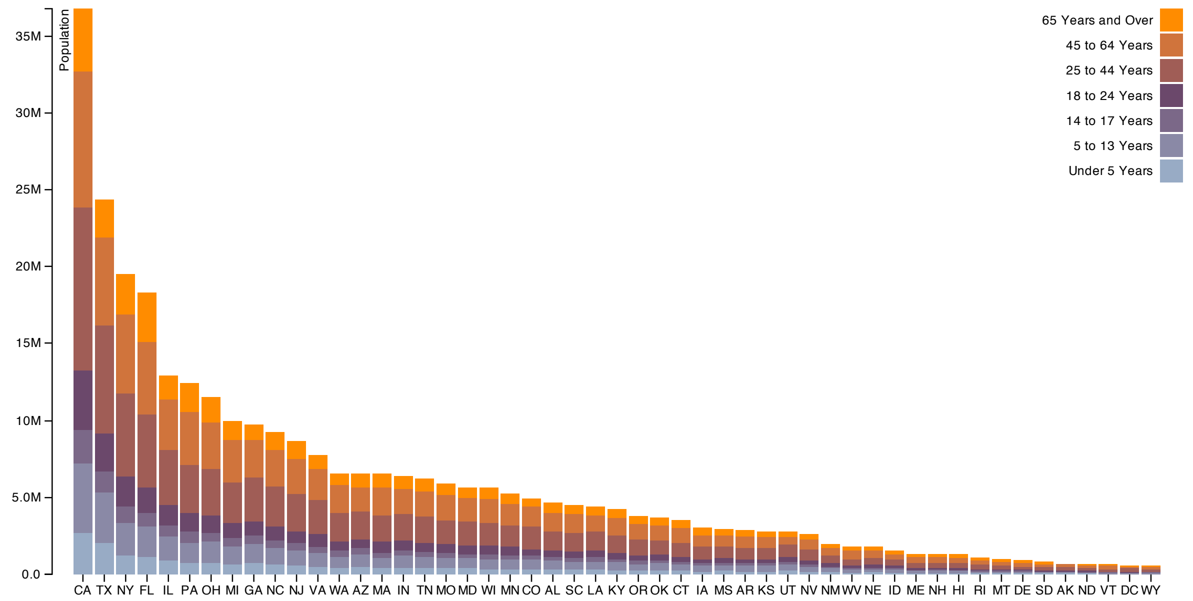


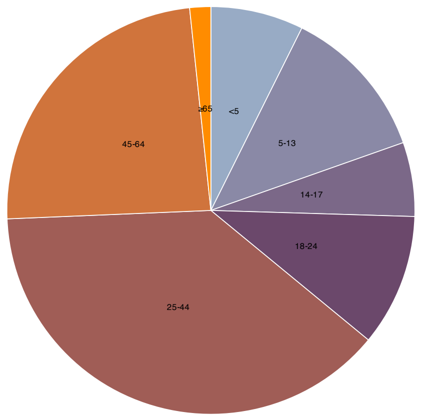
[A layered grammar of graphics. Wickham. Journ. Computational and Graphical Statistics 19:1 (2010), 3–28.]

Idioms: **normalized stacked bar chart**

- task
  - part-to-whole judgements
- normalized stacked bar chart
  - stacked bar chart, normalized to full vert height
  - single stacked bar equivalent to full pie
    - high information density: requires narrow rectangle
- pie chart
  - information density: requires large circle



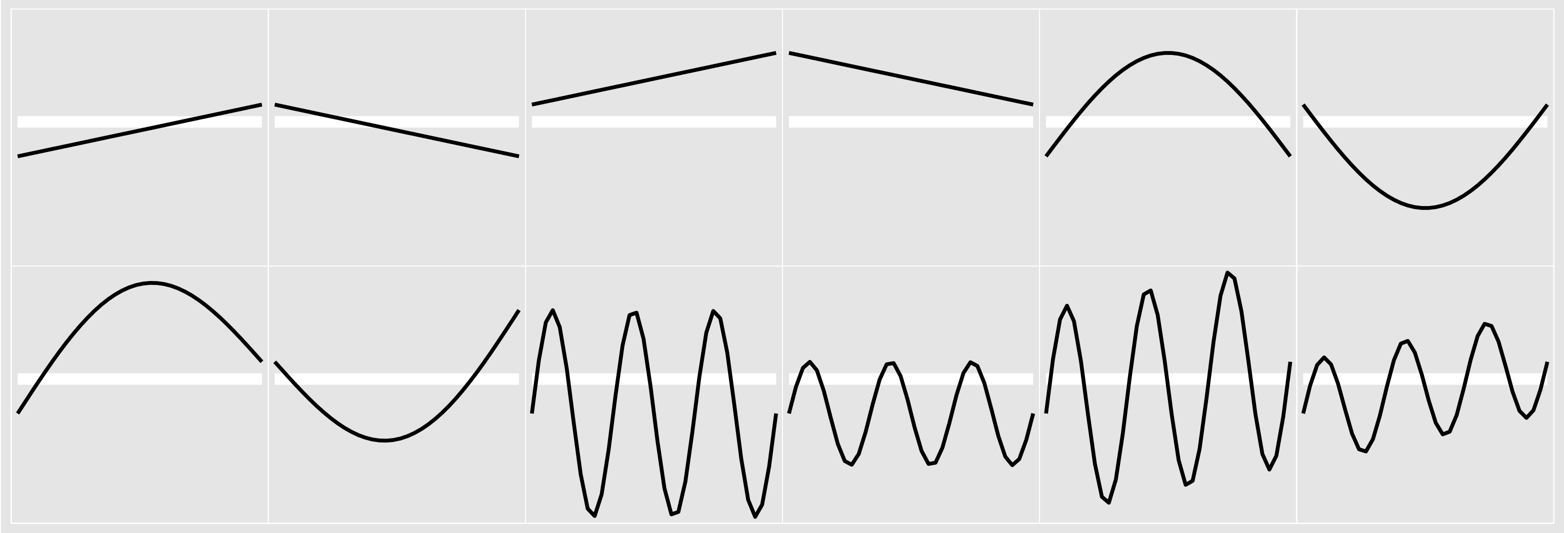




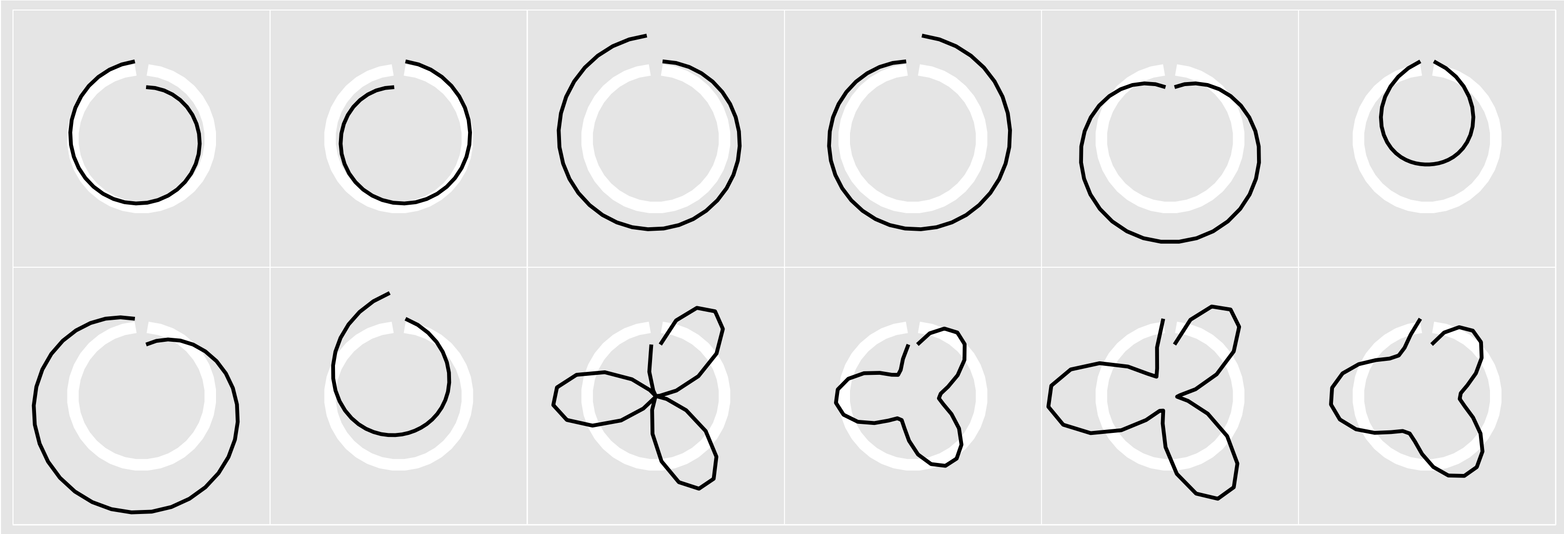
http://bl.ocks.org/mbostock/3887235,
http://bl.ocks.org/mbostock/3886208,
http://bl.ocks.org/mbostock/3886394.

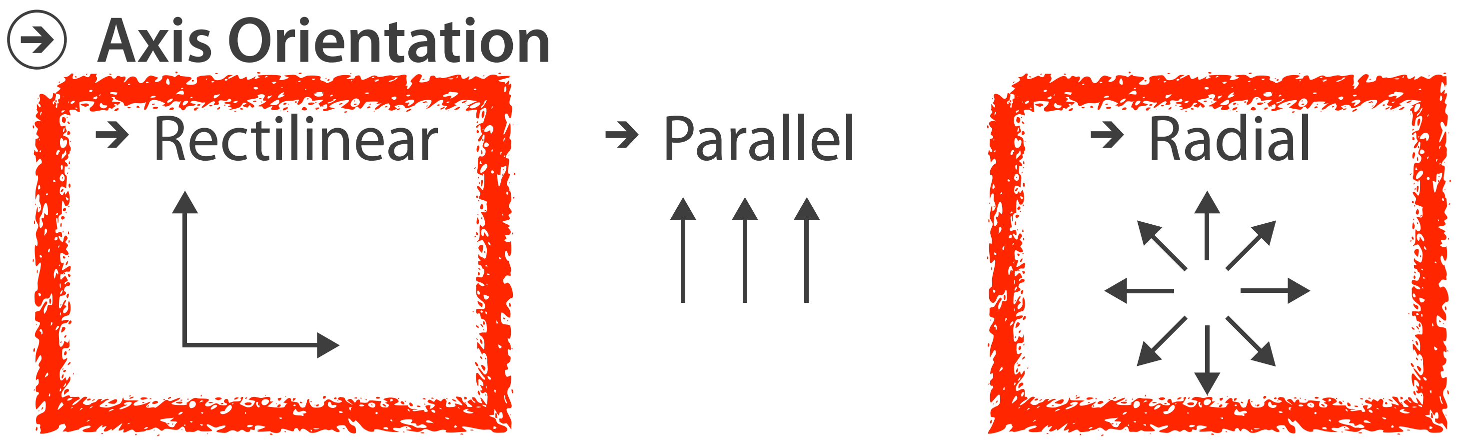
Idiom: **glyphmaps**

- rectilinear good for linear vs nonlinear trends



- radial good for cyclic patterns



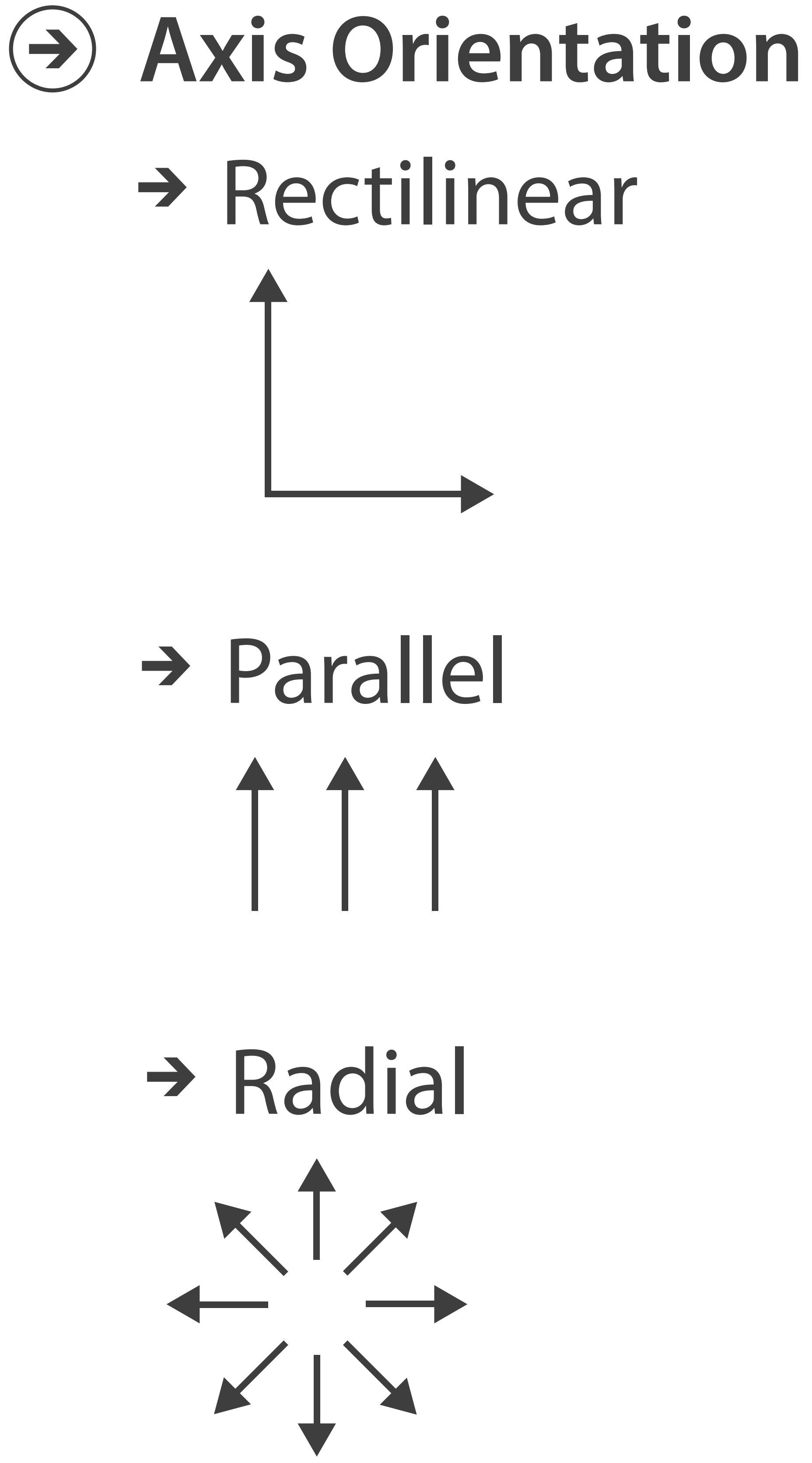


[Glyph-maps for Visually Exploring Temporal Patterns in Climate Data and Models. Wickham, Hofmann, Wickham, and Cook. Environmetrics 23:5 (2012), 382–393.]

Orientation limitations

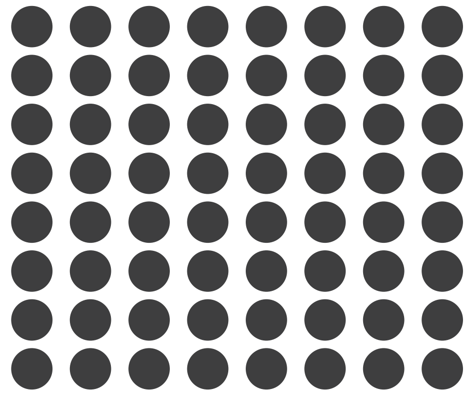
- rectilinear: scalability wrt #axes
    - 2 axes best
    - 3 problematic
        - more in afternoon
    - 4+ impossible
- parallel: unfamiliarity, training time
- radial: perceptual limits
    - angles lower precision than lengths
    - asymmetry between angle and length
        - can be exploited!

[Uncovering Strengths and Weaknesses of Radial Visualizations - an Empirical Approach. Diehl, Beck and Burch. IEEE TVCG (Proc. InfoVis) 16(6):935--942, 2010.]

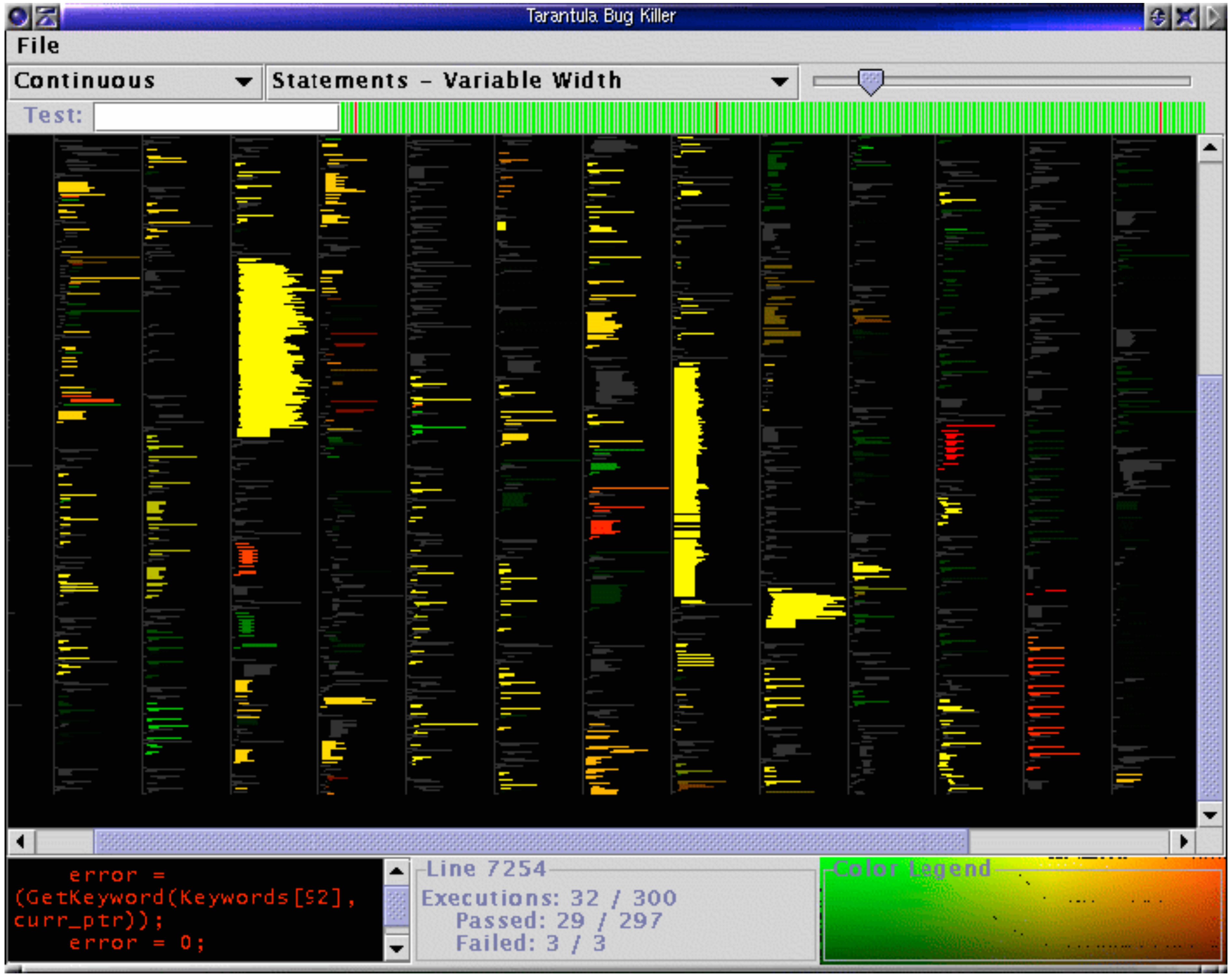


➔ Layout Density

➔ Dense



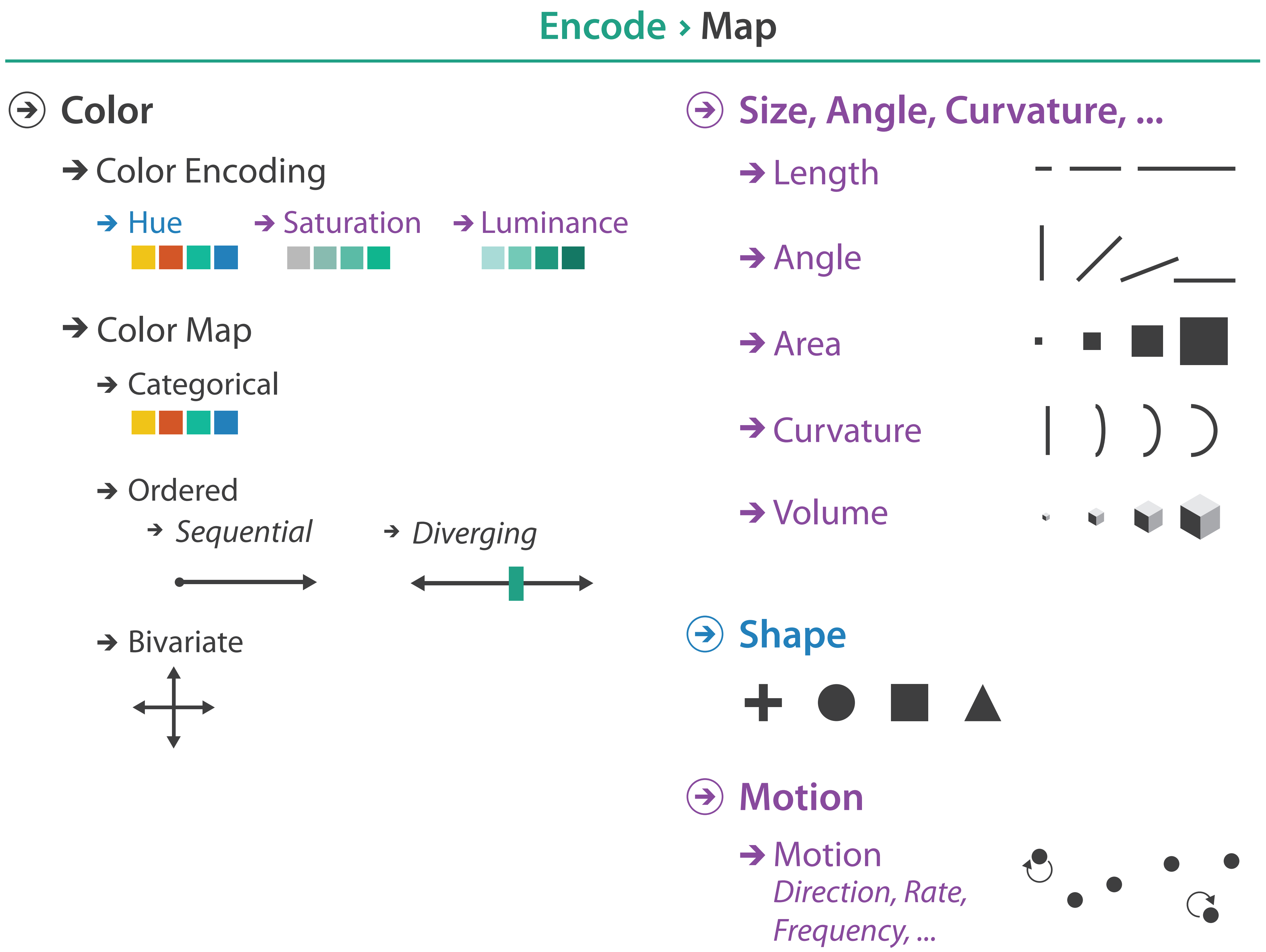
dense software overviews



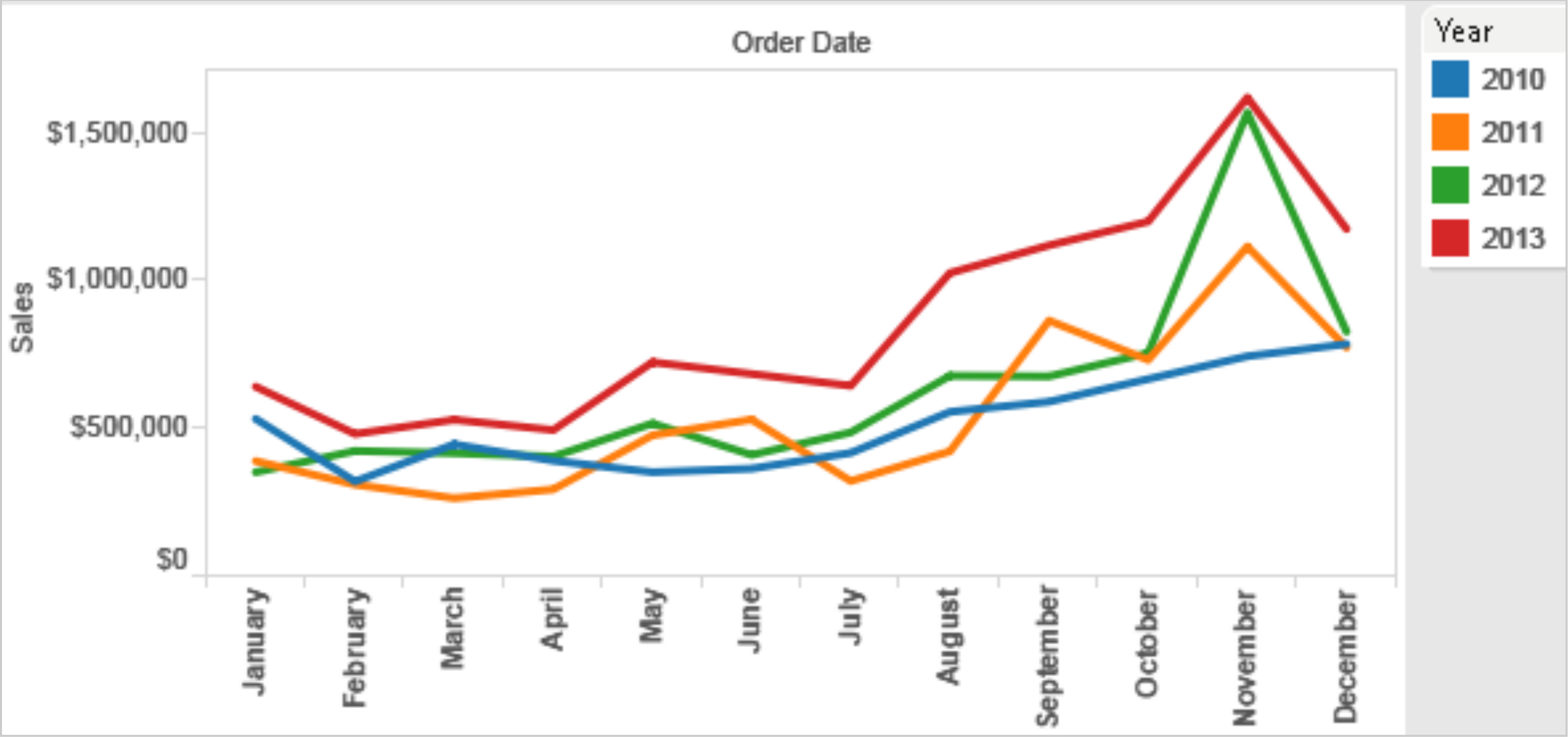
[Visualization of test information to assist fault localization. Jones, Harrold, Stasko. Proc. ICSE 2002, p 467-477.]

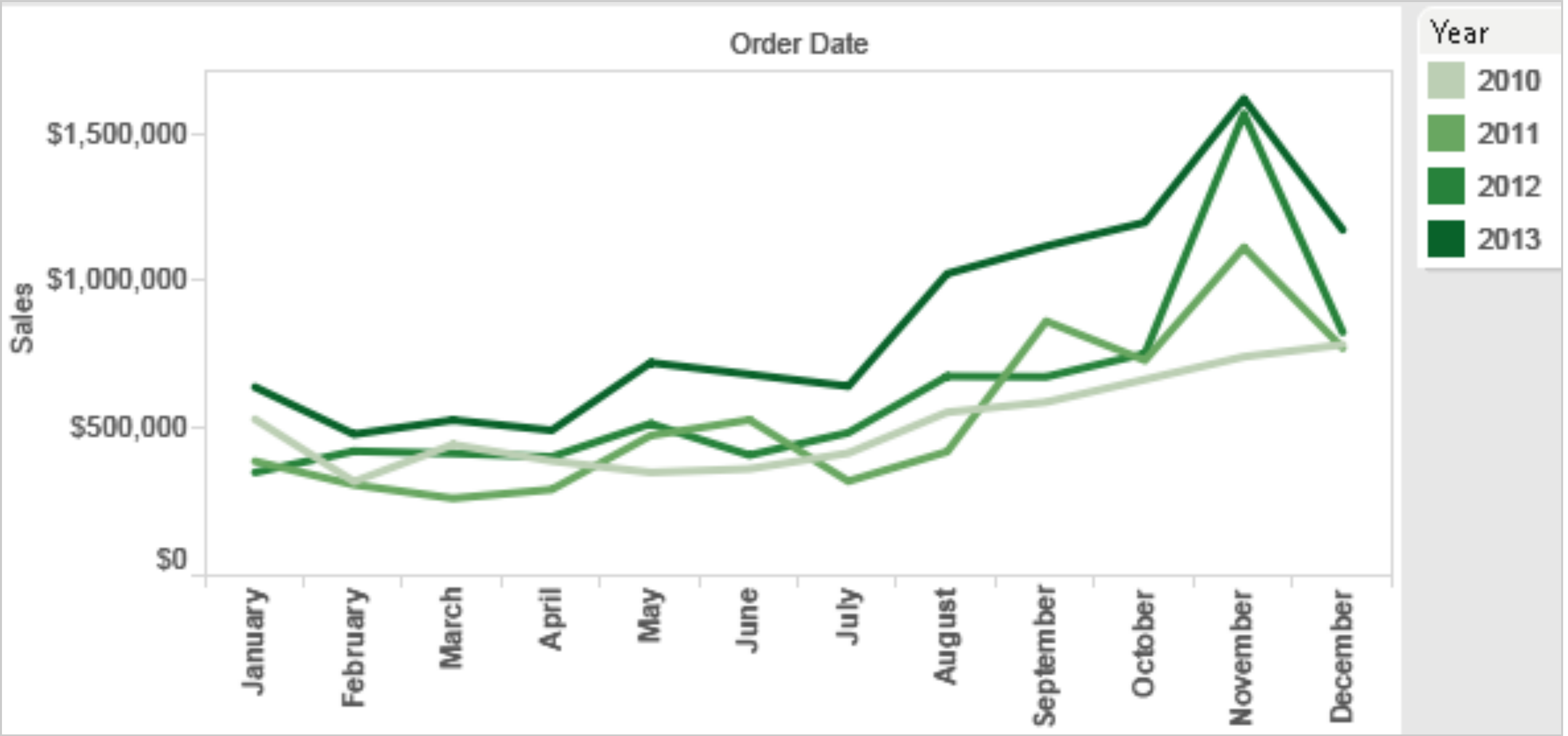
Ch 10: Map Color and Other Channels

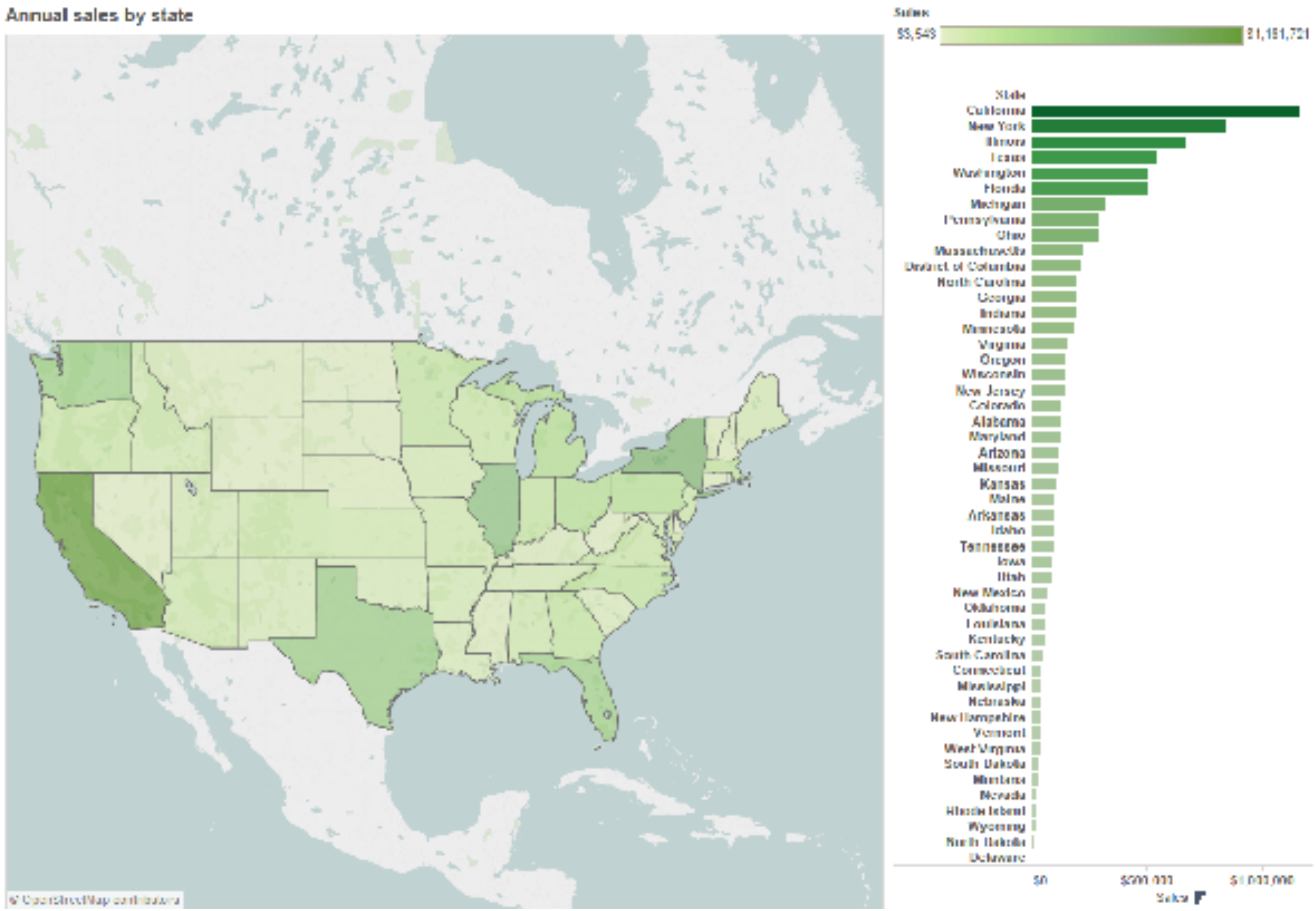
VAD Chap 10: Map Color and Other Channels



Categorical vs ordered color





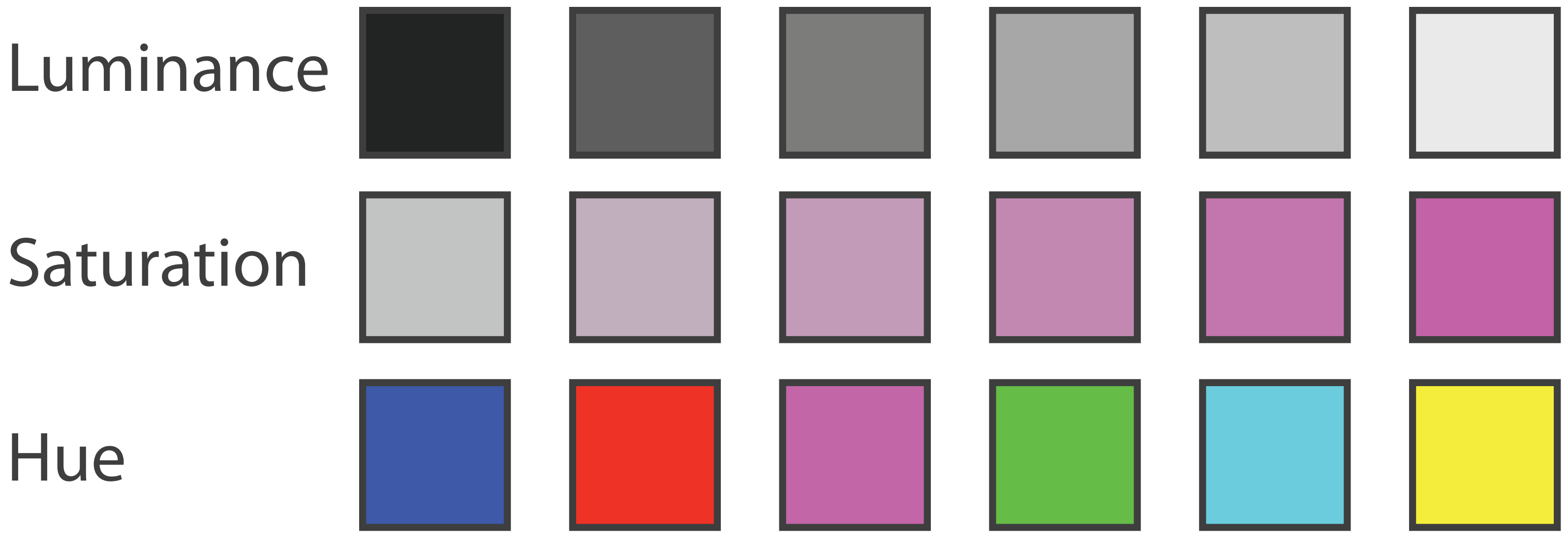


[Seriously Colorful: Advanced Color Principles & Practices. Stone. Tableau Customer Conference 2014.]

Decomposing color

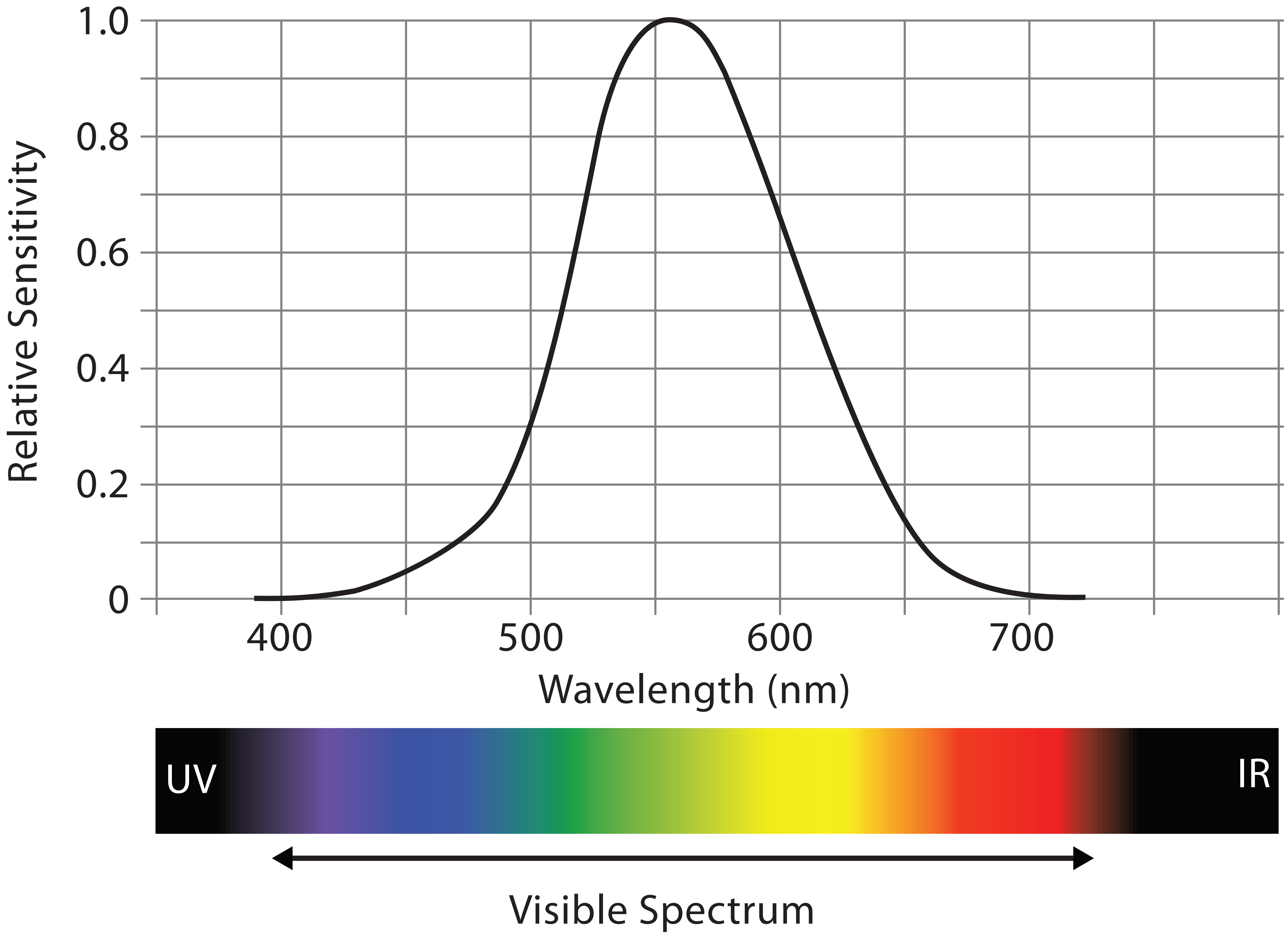
- first rule of color: do not talk about color!
  - color is confusing if treated as monolithic

- decompose into three channels
  - ordered can show magnitude
    - luminance: how bright
    - saturation: how colorful
  - categorical can show identity
    - hue: what color



- channels have different properties
  - what they convey directly to perceptual system
  - how much they can convey: how many discriminable bins can we use?

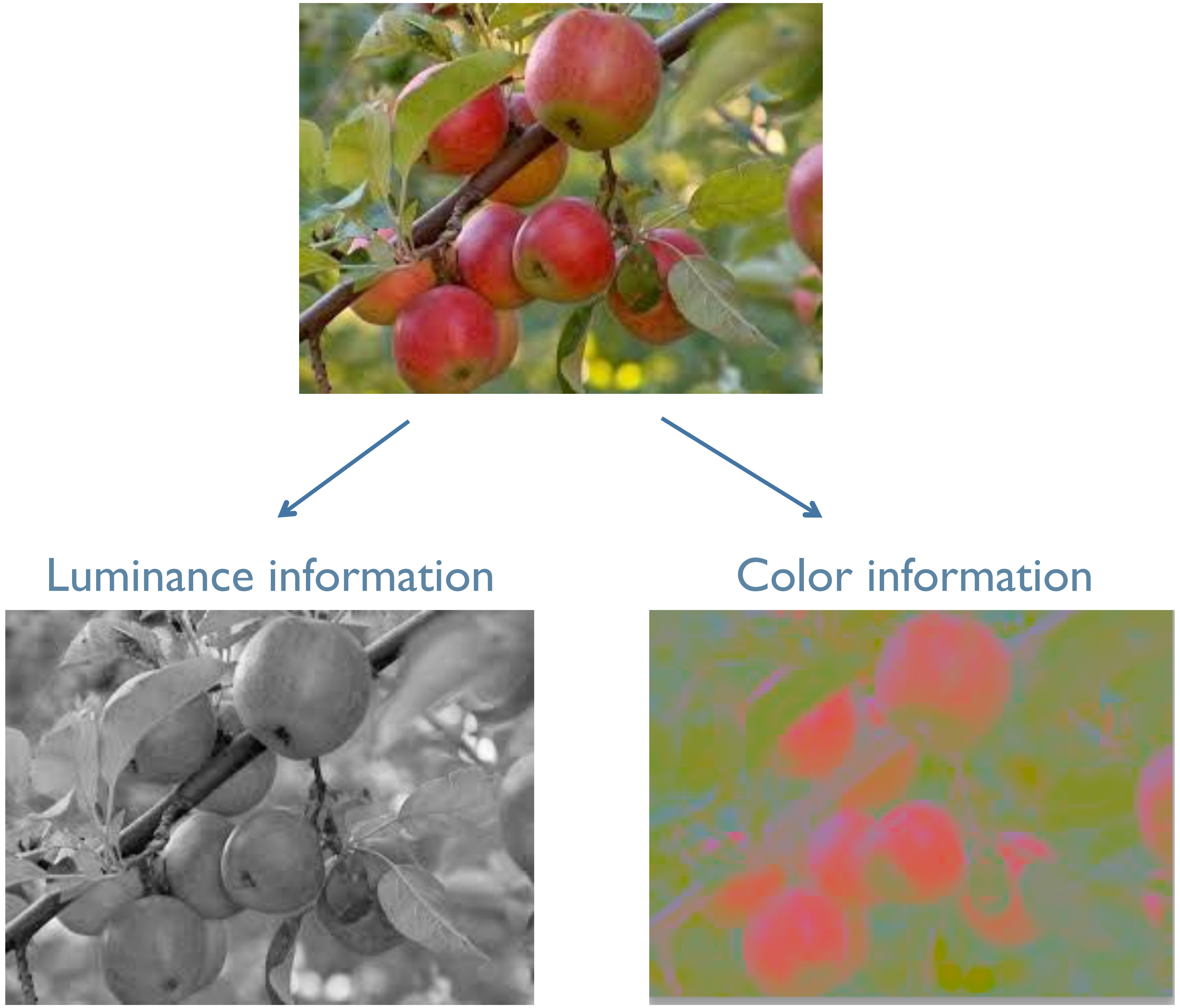
Spectral sensitivity



Luminance

- need luminance for edge detection
  - fine-grained detail only visible through luminance contrast
  - legible text requires luminance contrast!

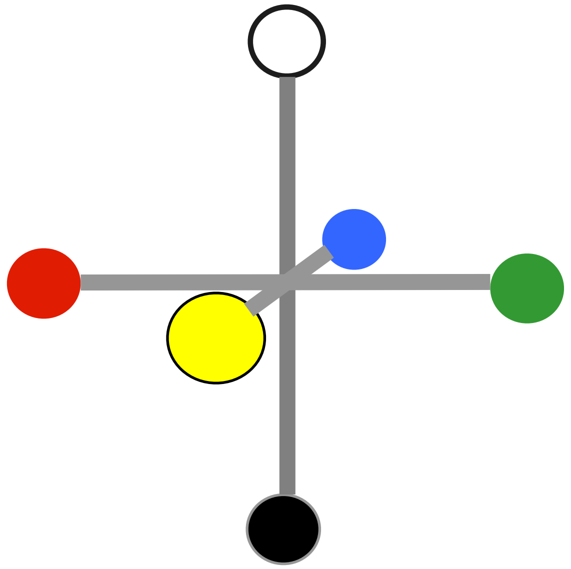
- intrinsic perceptual ordering

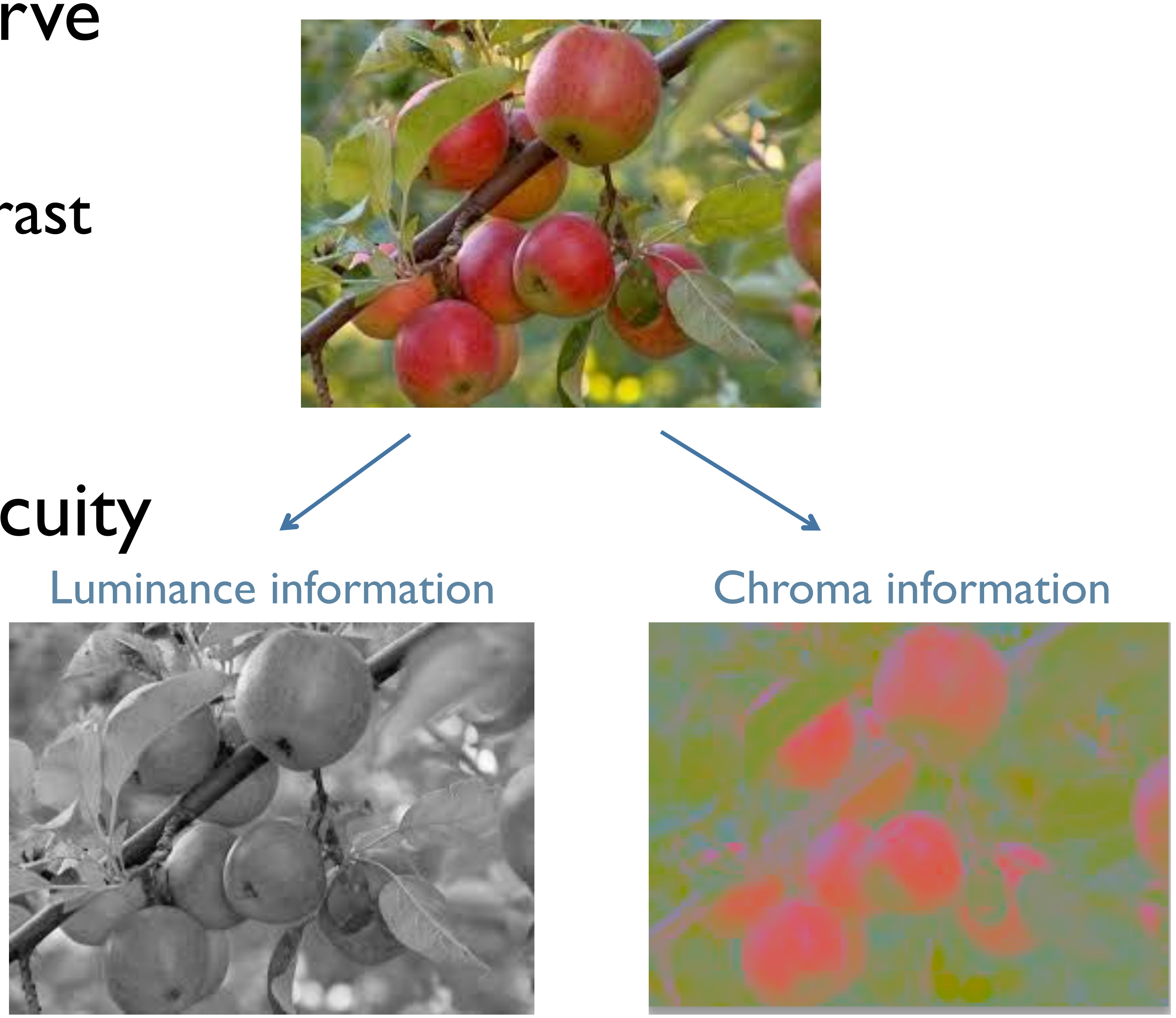


[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

Opponent color and color deficiency

- perceptual processing before optic nerve
  - one achromatic luminance channel (L*)
    - edge detection through luminance contrast
  - 2 chroma channels
    - red-green (a*) & yellow-blue axis (b*)
- "color blind": 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.]

Color spaces

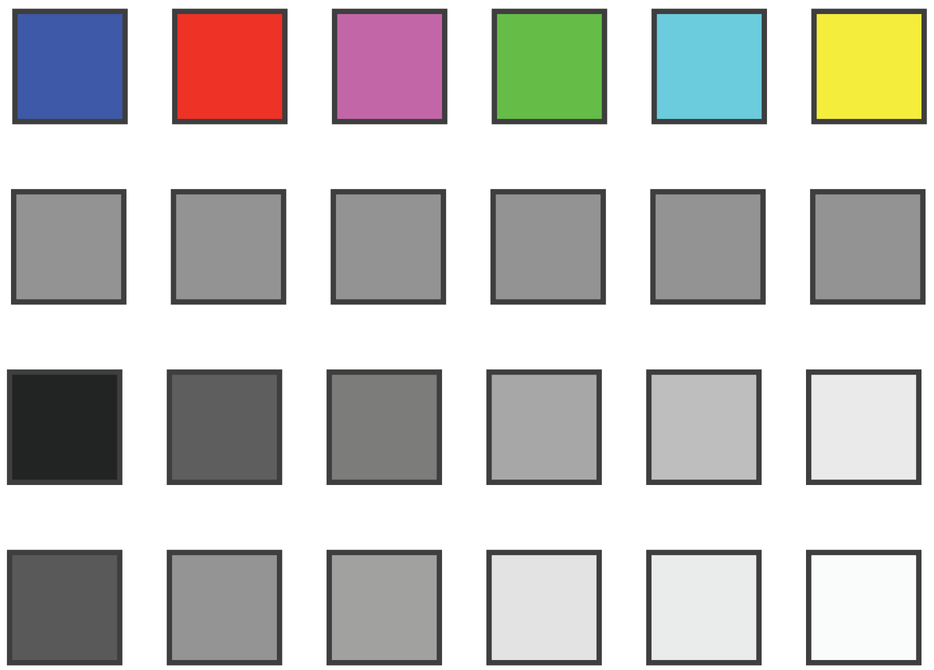
- CIE L*a*b*: good for computation
  - L* intuitive: perceptually linear luminance
  - a*b* axes: perceptually linear but nonintuitive
- RGB: good for display hardware
  - poor for encoding
- HSL/HSV: somewhat better for encoding
  - hue/saturation wheel intuitive
  - beware: only pseudo-perceptual!
  - lightness (L) or value (V) ≠ luminance or L*
- Luminance, hue, saturation
  - good for encoding
  - but not standard graphics/tools colorspace

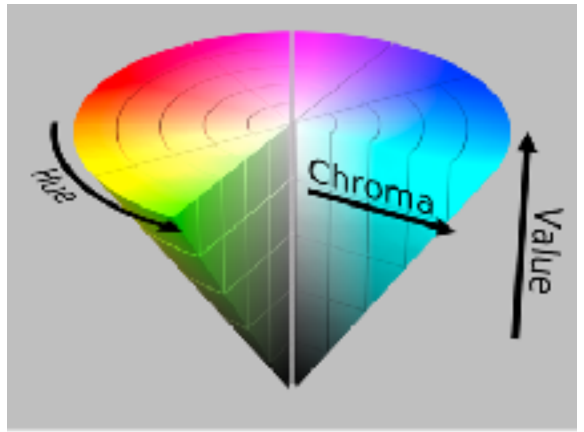
Corners of the RGB color cube

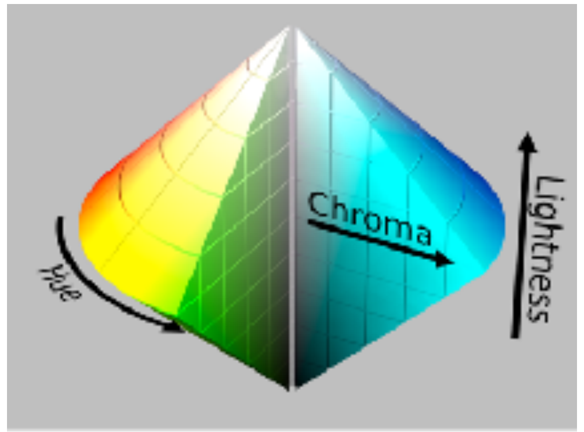
L from HLS
All the same

Luminance values

L* values



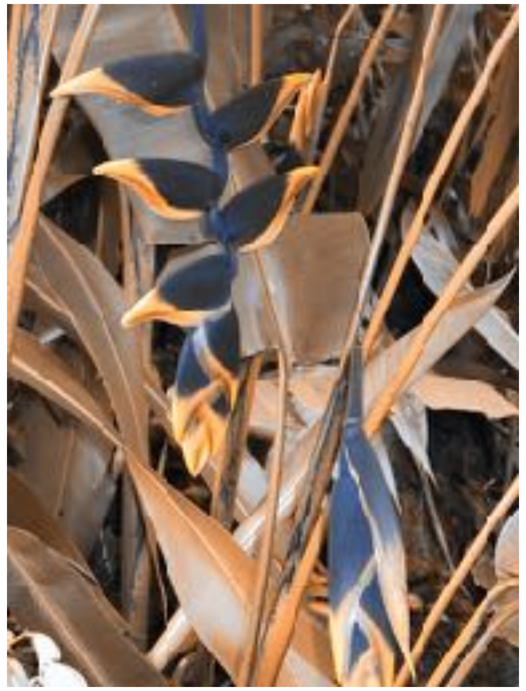




Designing for color deficiency: Check with simulator

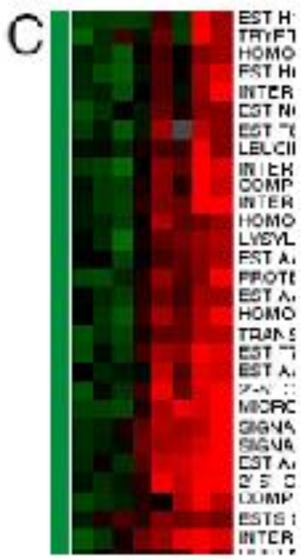
Normal vision

Deuteranope



Protanope

Tritanope

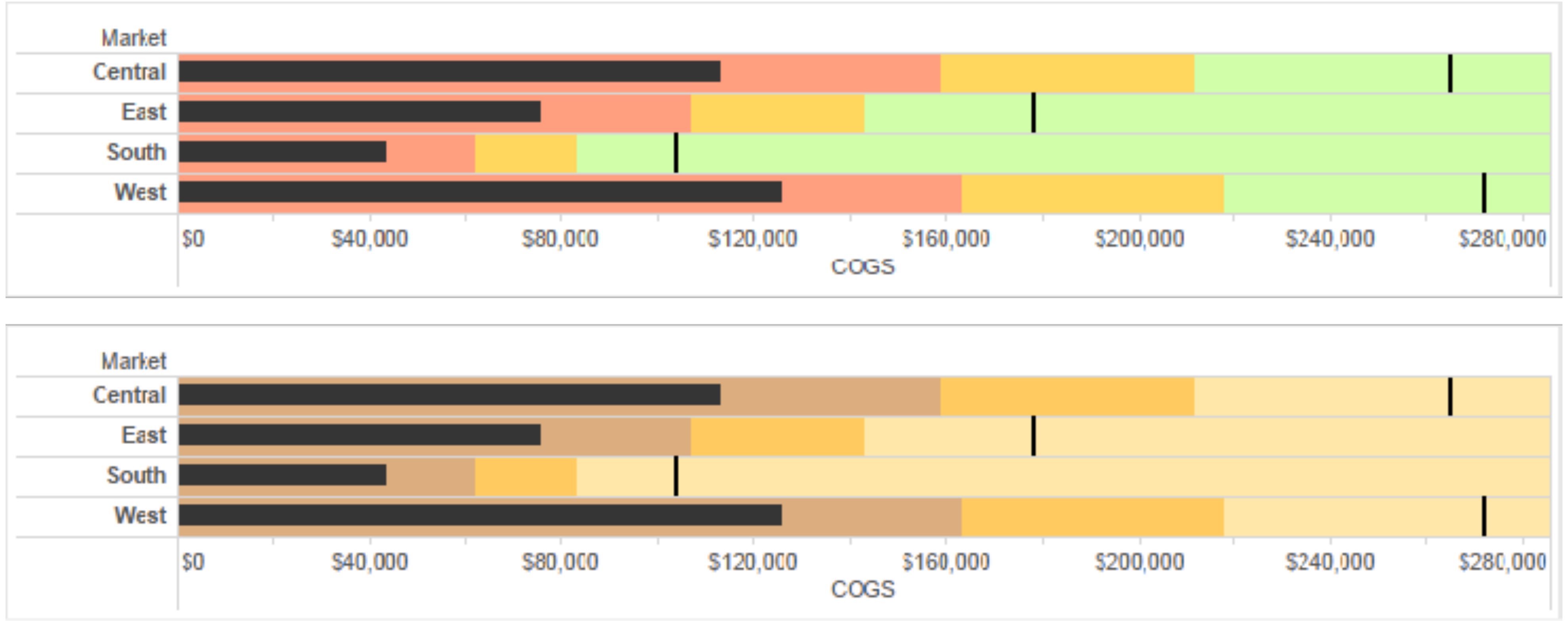


http://rehue.net

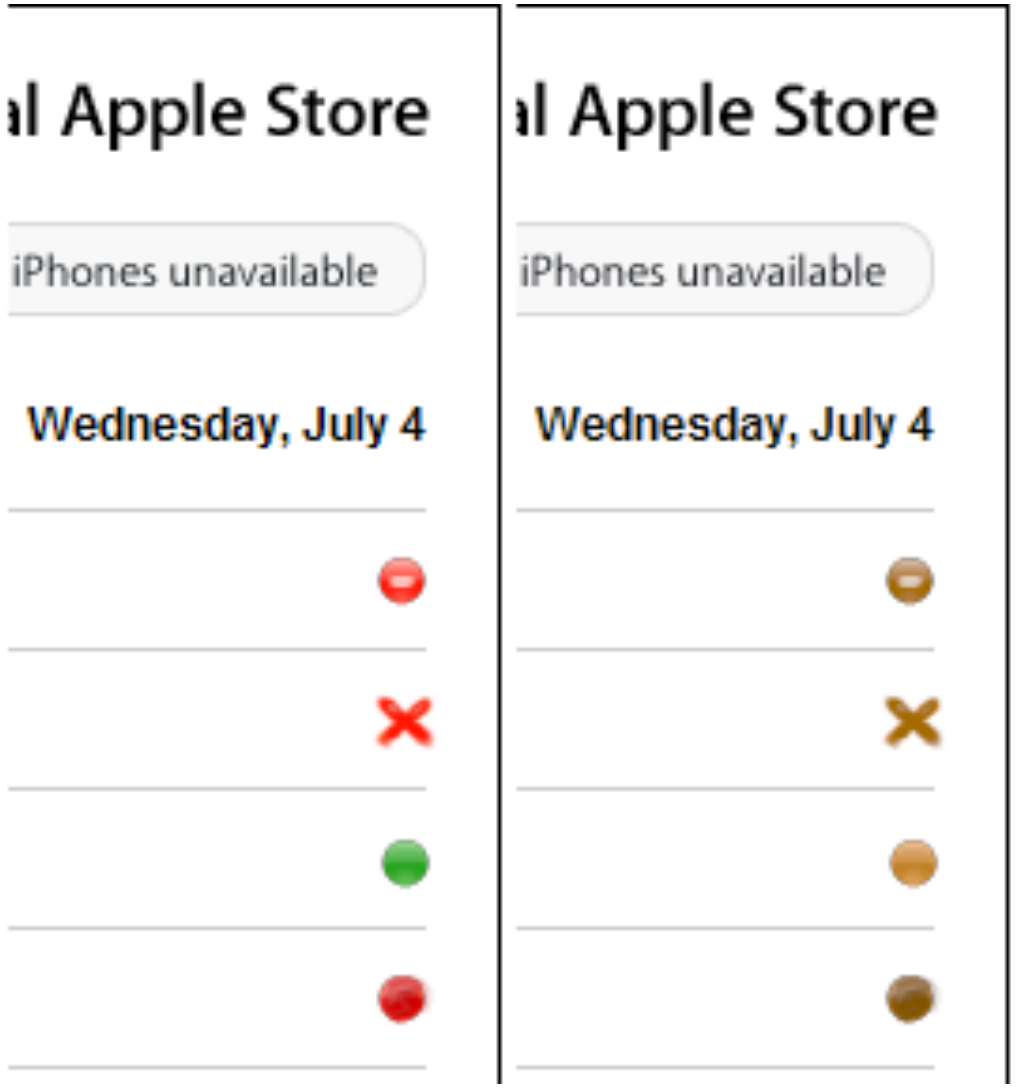
[Seriously Colorful: Advanced Color Principles & Practices. Stone.Tableau Customer Conference 2014.]

Designing for color deficiency: Avoid encoding by hue alone

- redundantly encode
  - vary luminance
  - change shape



Deuteranope simulation

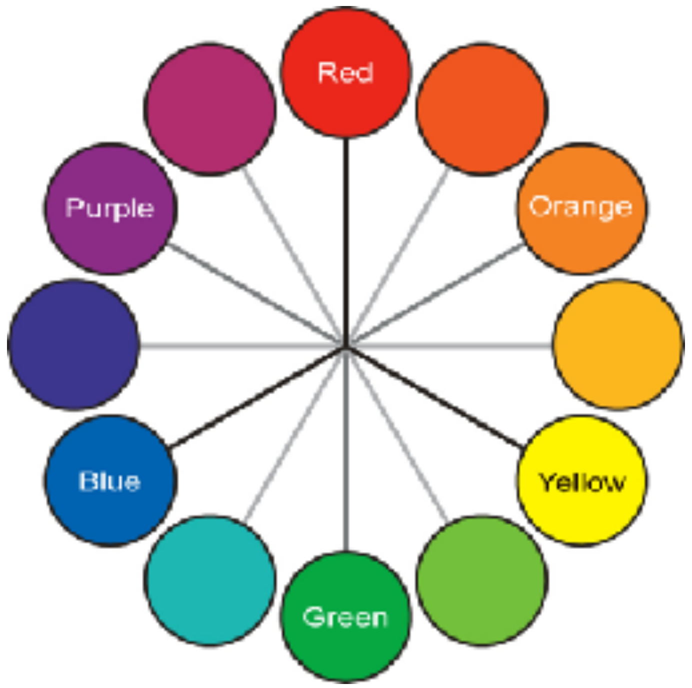


Change the shape

Vary luminance

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

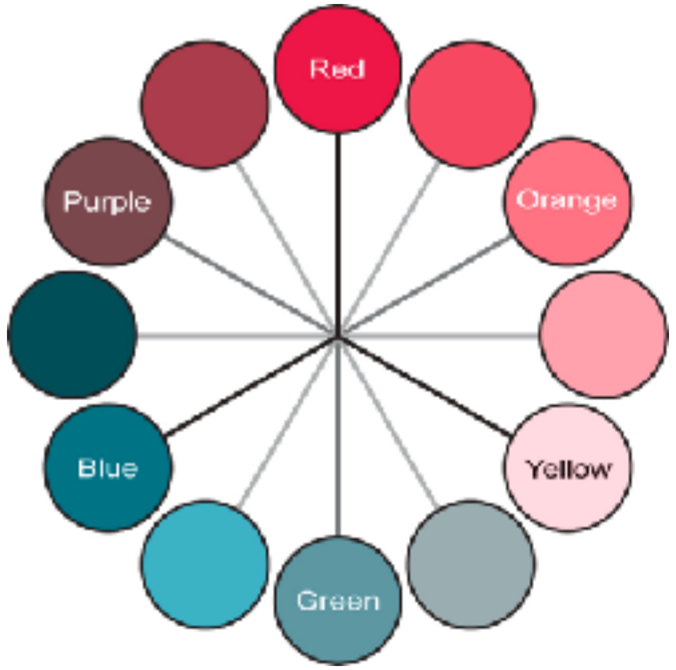
Color deficiency: Reduces color to 2 dimensions



Normal

Protanope

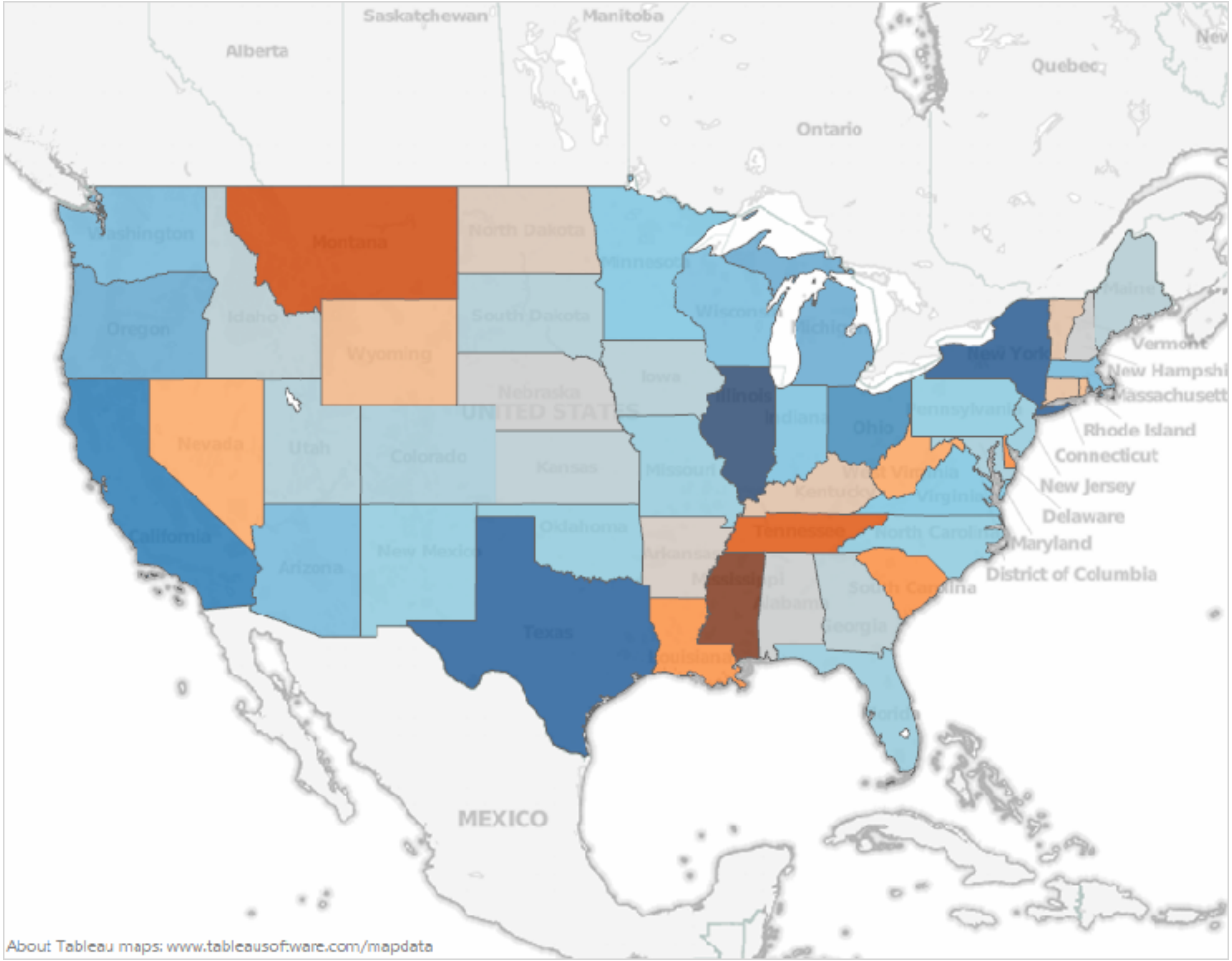
Deuteranope



Tritanope

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

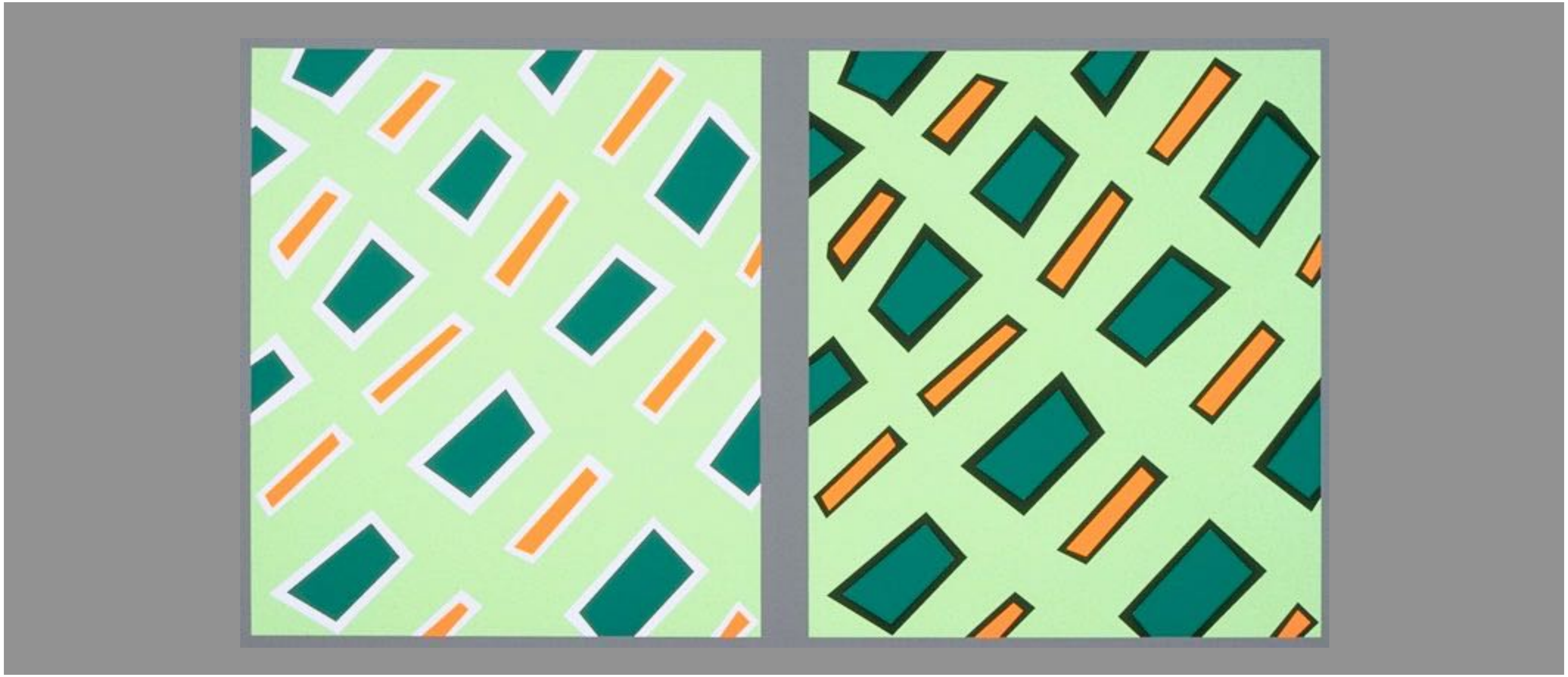
Designing for color deficiency: Blue-Orange is safe



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

Bezold Effect: Outlines matter

- color constancy: simultaneous contrast effect



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

Color/Lightness constancy: Illumination conditions

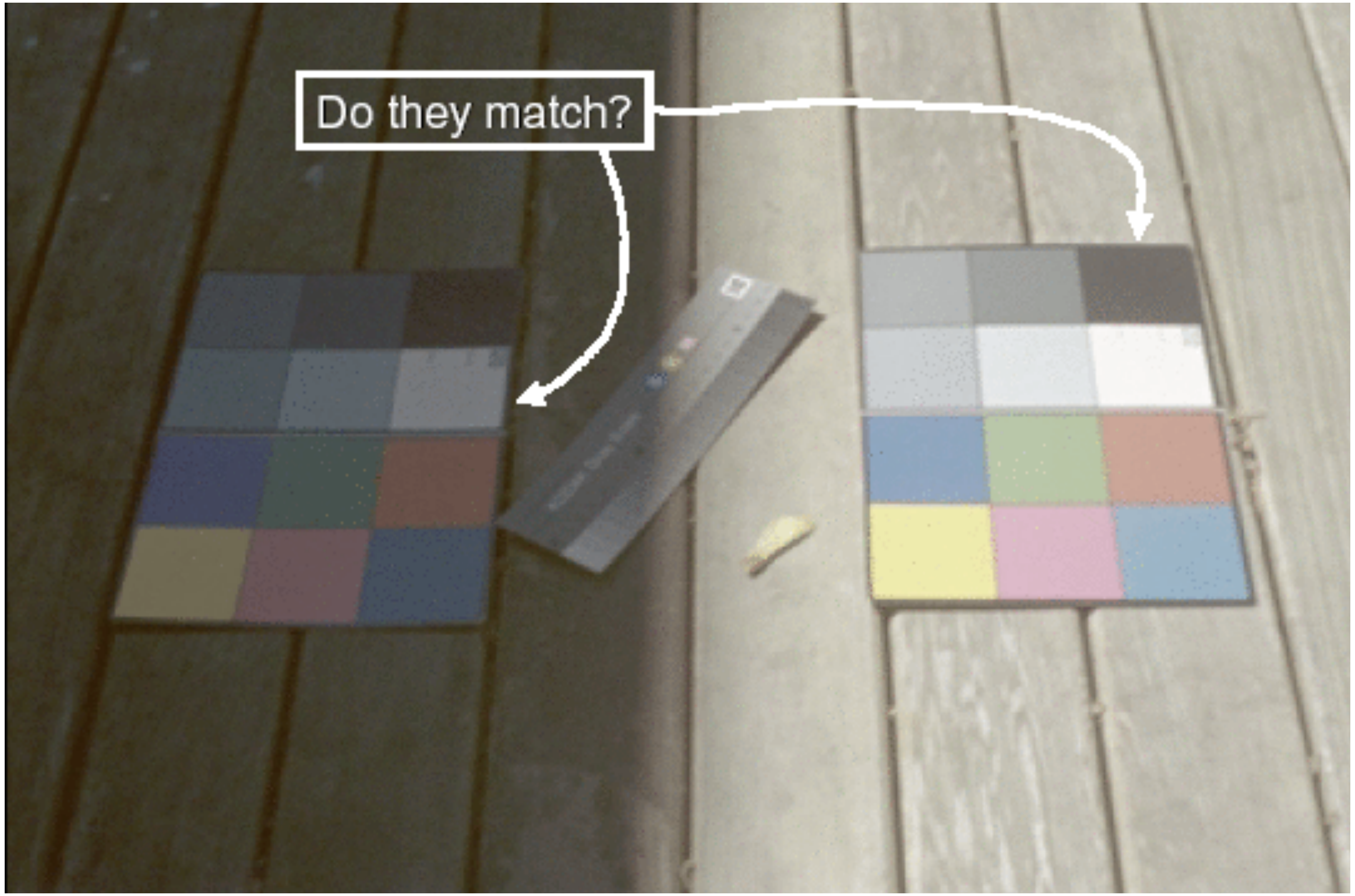


Image courtesy of John McCann

Color/Lightness constancy: Illumination conditions

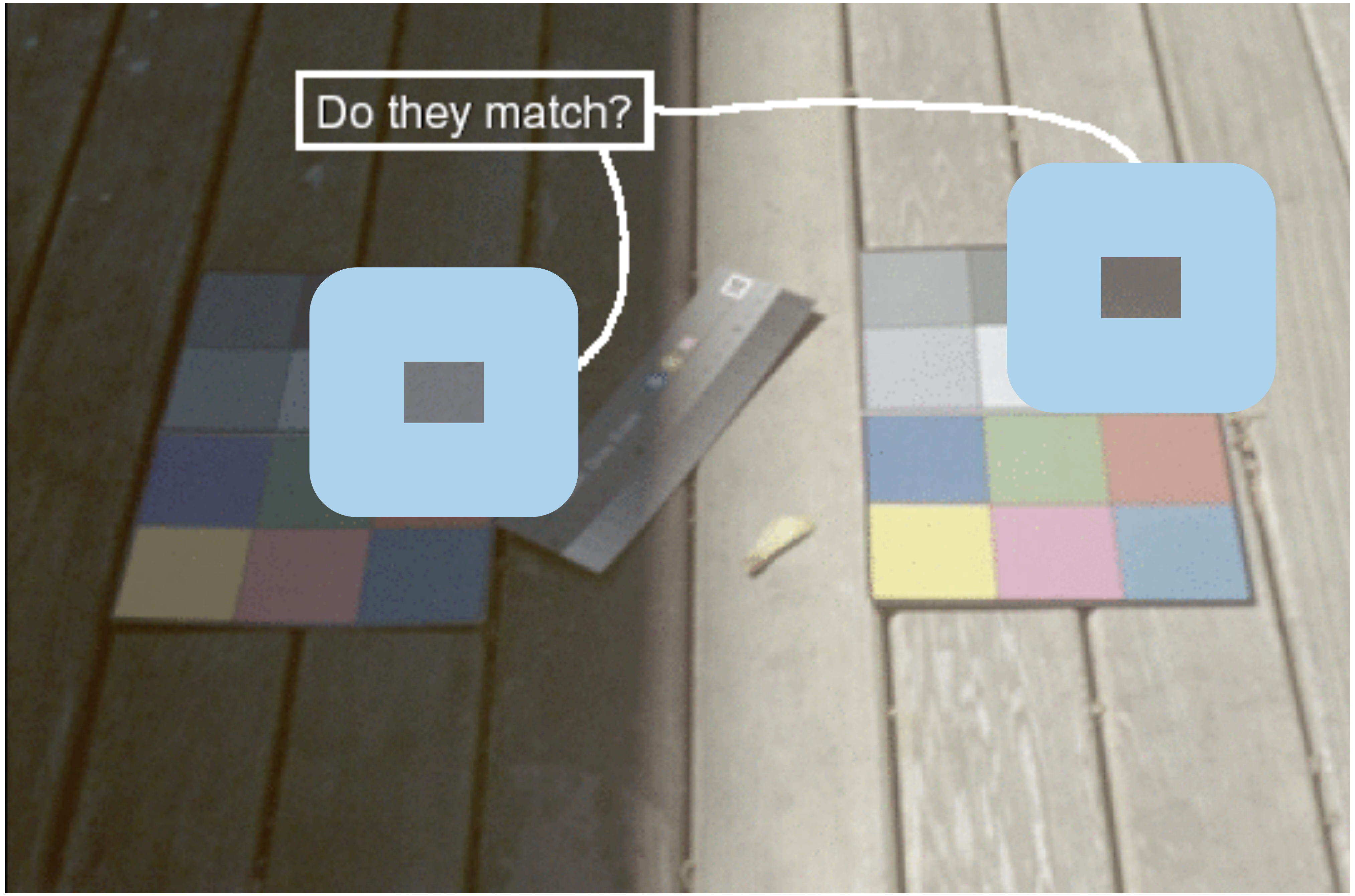
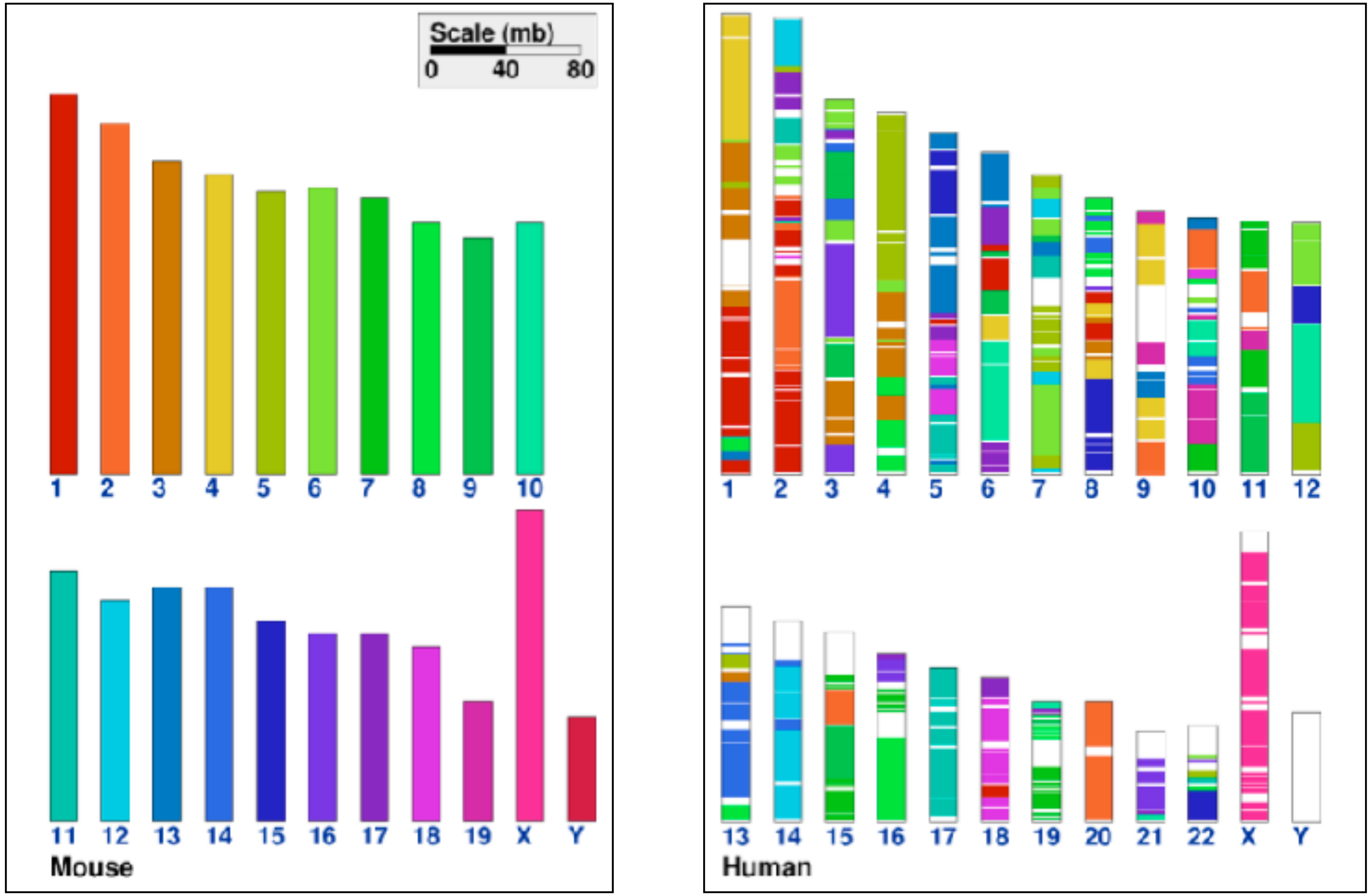


Image courtesy of John McCann

Categorical color: limited number of discriminable bins

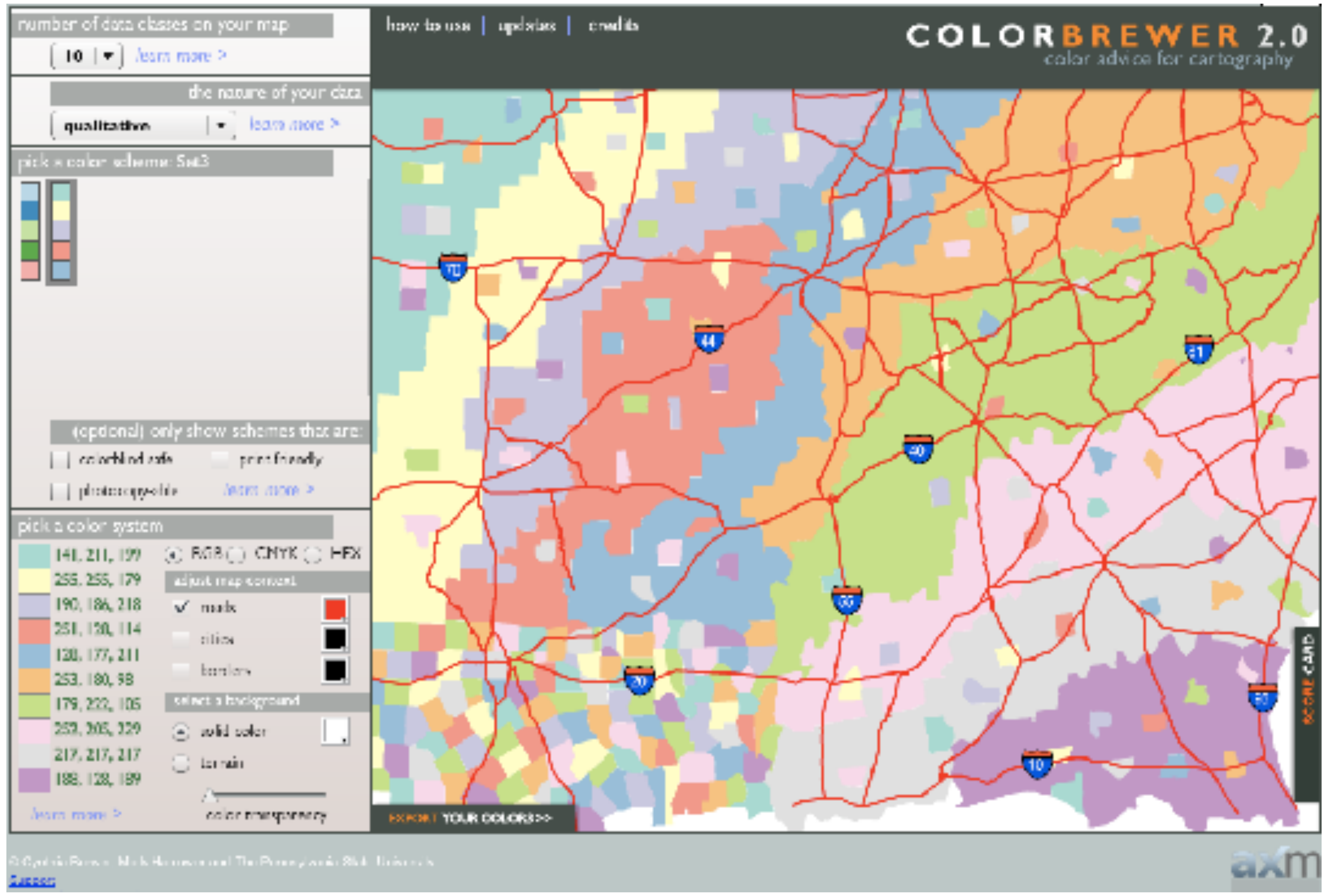
- human perception built on relative comparisons
  - great if color contiguous
  - surprisingly bad for absolute comparisons
- noncontiguous small regions of color
  - fewer bins than you want
  - rule of thumb: 6-12 bins, including background and highlights

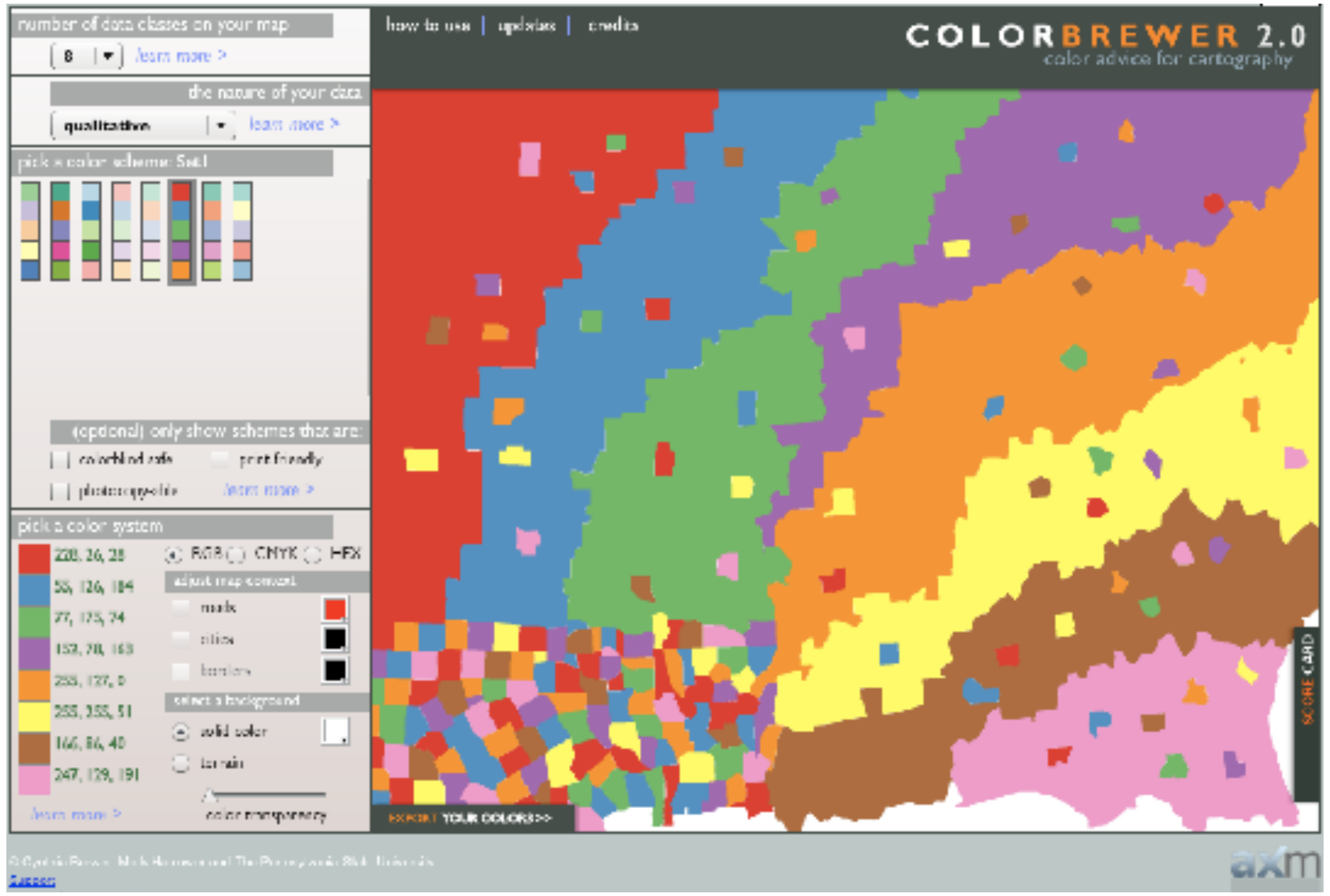


[Cinteny: flexible analysis and visualization of synteny and genome rearrangements in multiple organisms. Sinha and Meller. BMC Bioinformatics, 8:82, 2007.]

ColorBrewer

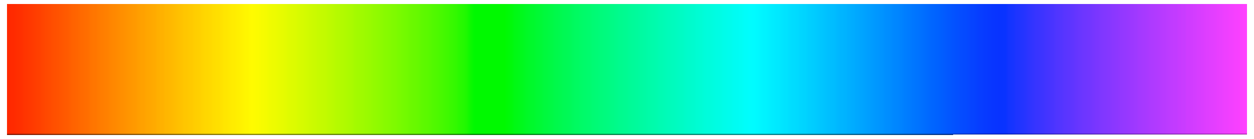
- http://www.colorbrewer2.org
- saturation and area example: size affects salience!

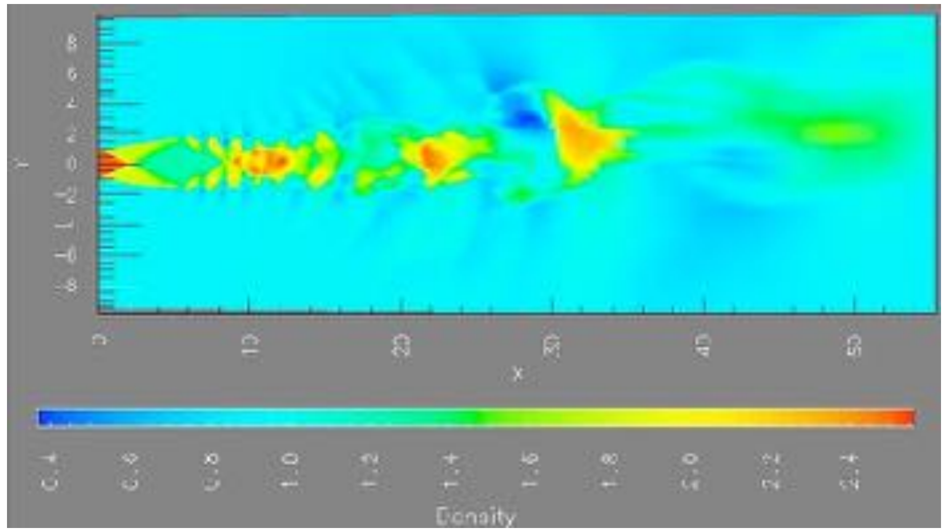




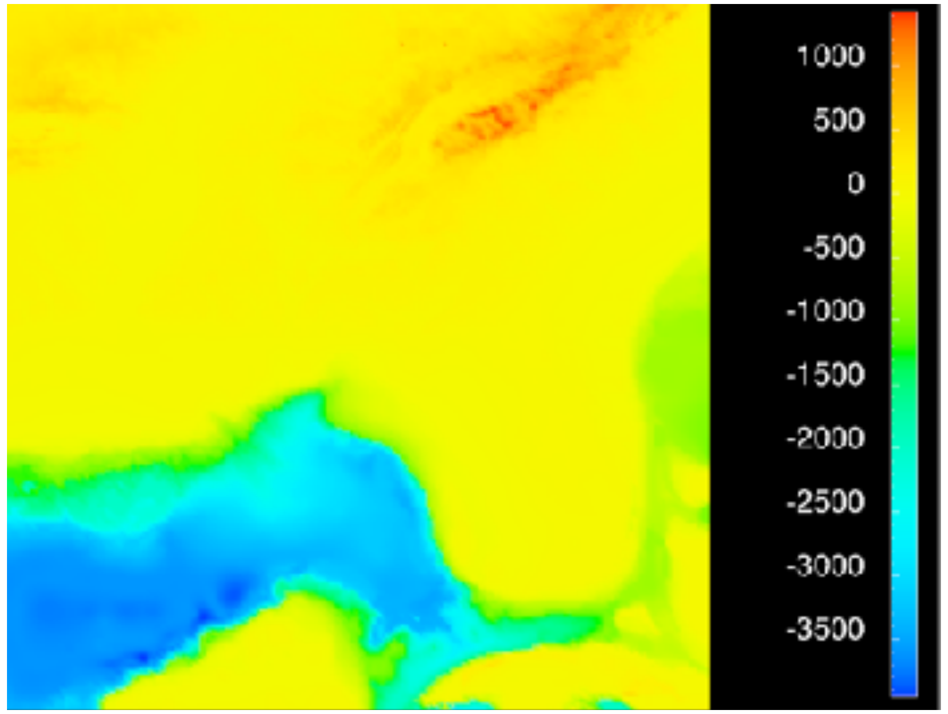
Ordered color: Rainbow is poor default

- 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]

Ordered color: Rainbow is poor default

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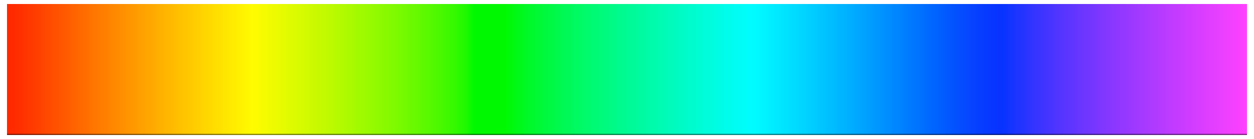
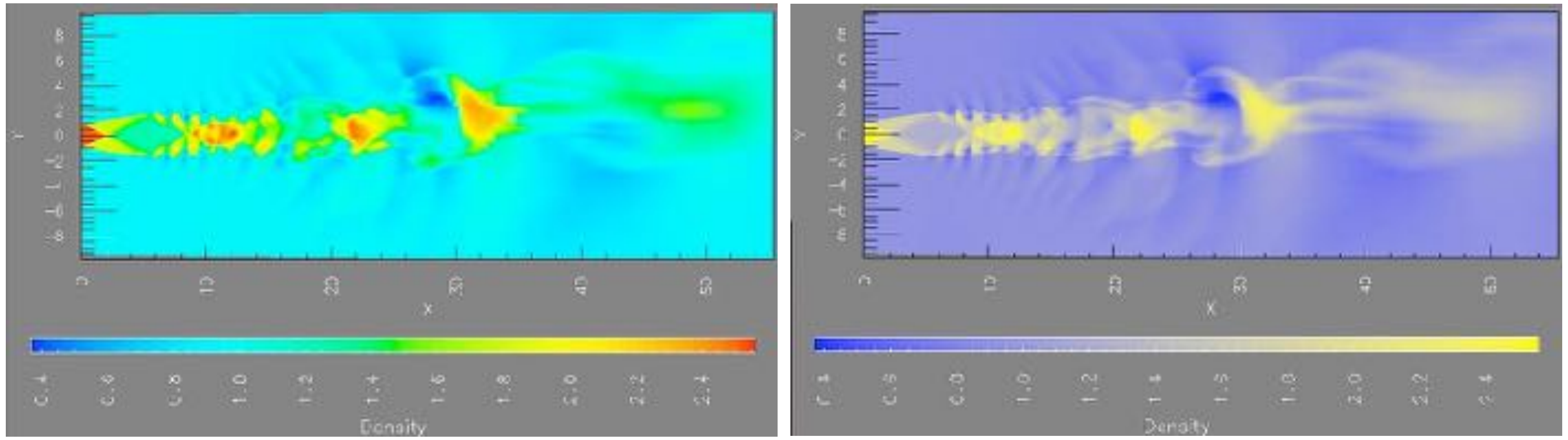
- benefits
  - fine-grained structure visible and nameable
- alternatives
  - large-scale structure: fewer hues





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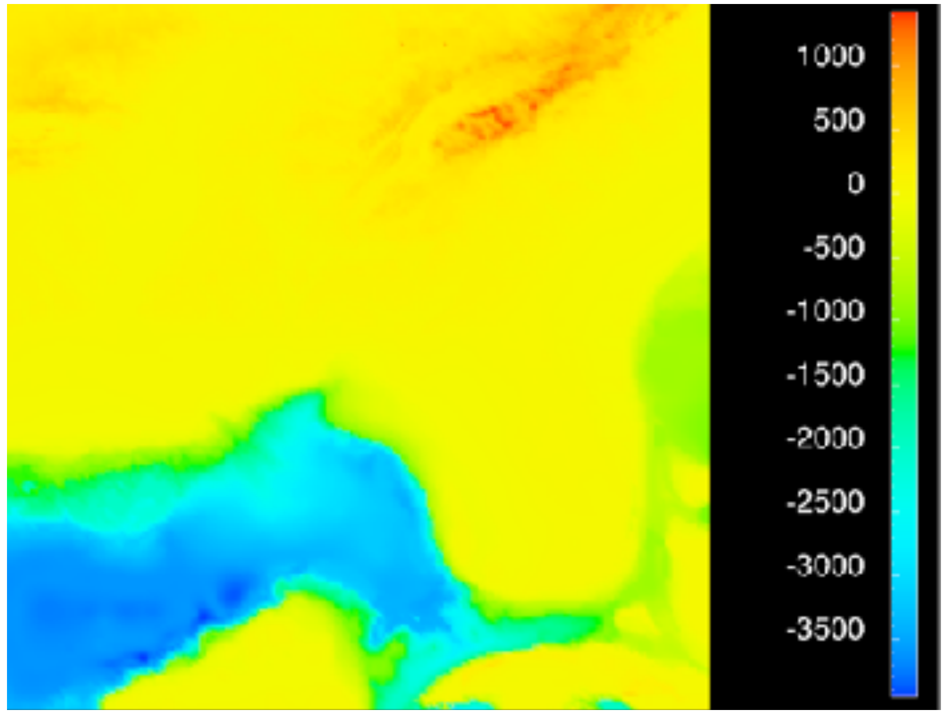

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Ordered color: Rainbow is poor default

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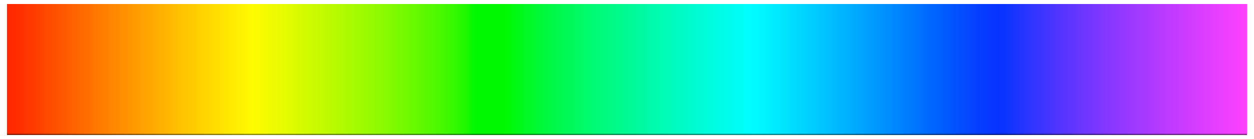
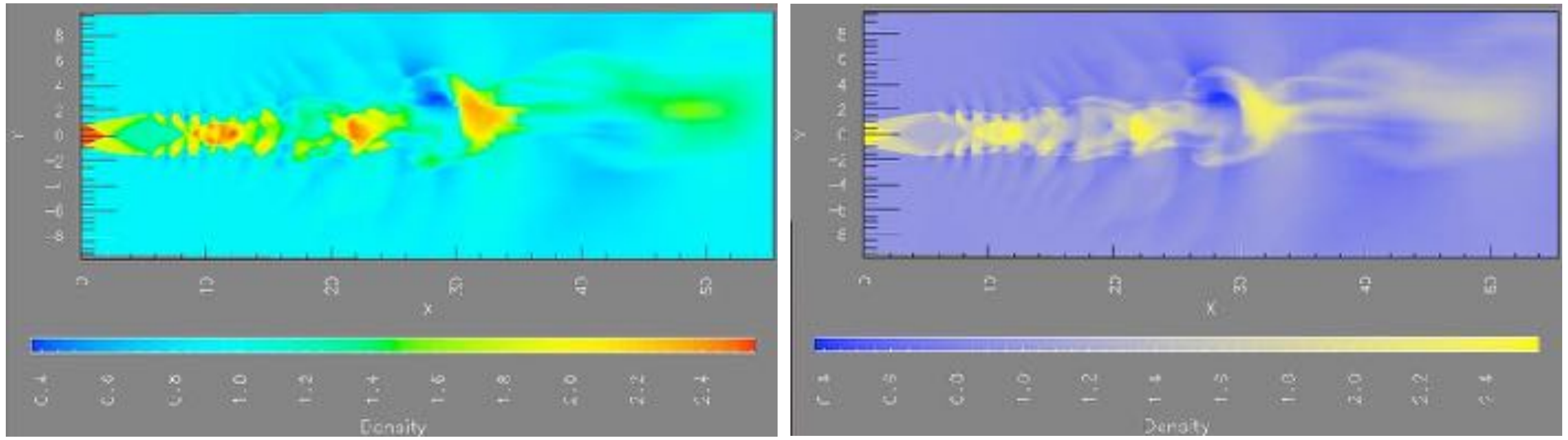
  - perceptually unordered
  - perceptually nonlinear
- benefits
  - fine-grained structure visible and nameable
- alternatives
  - large-scale structure: fewer hues
  - fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]





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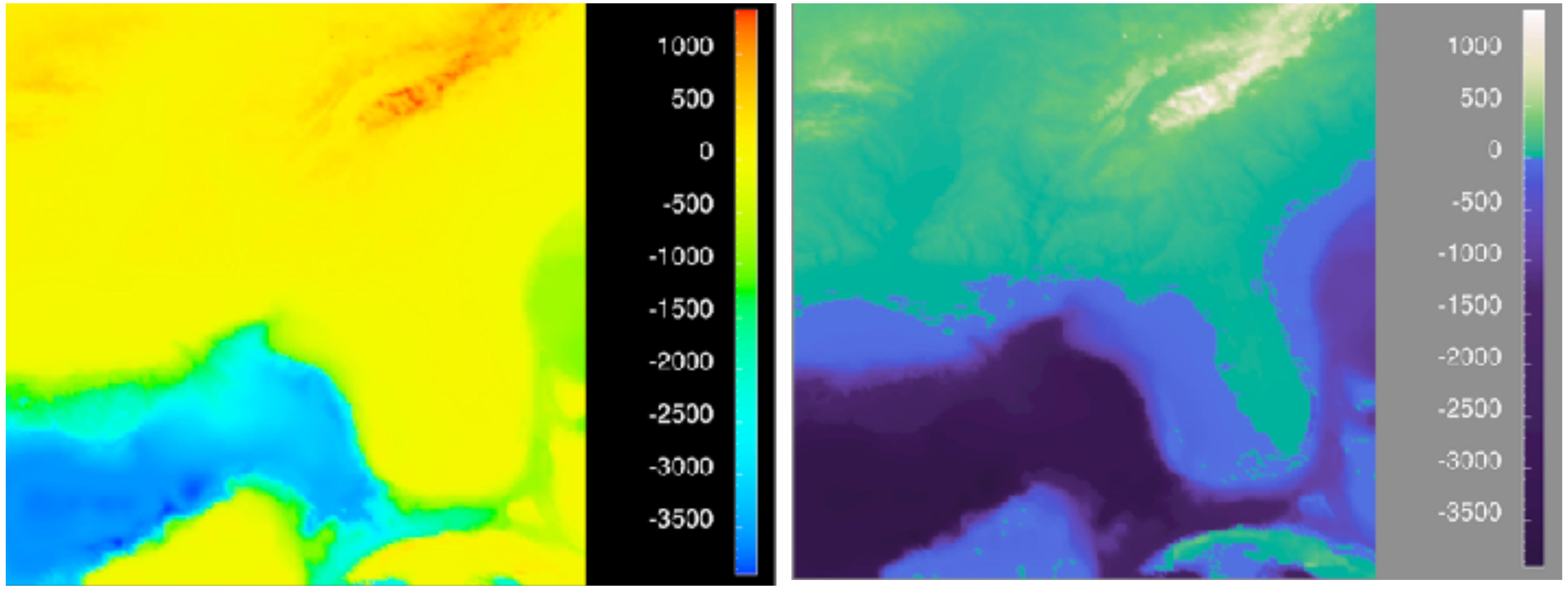

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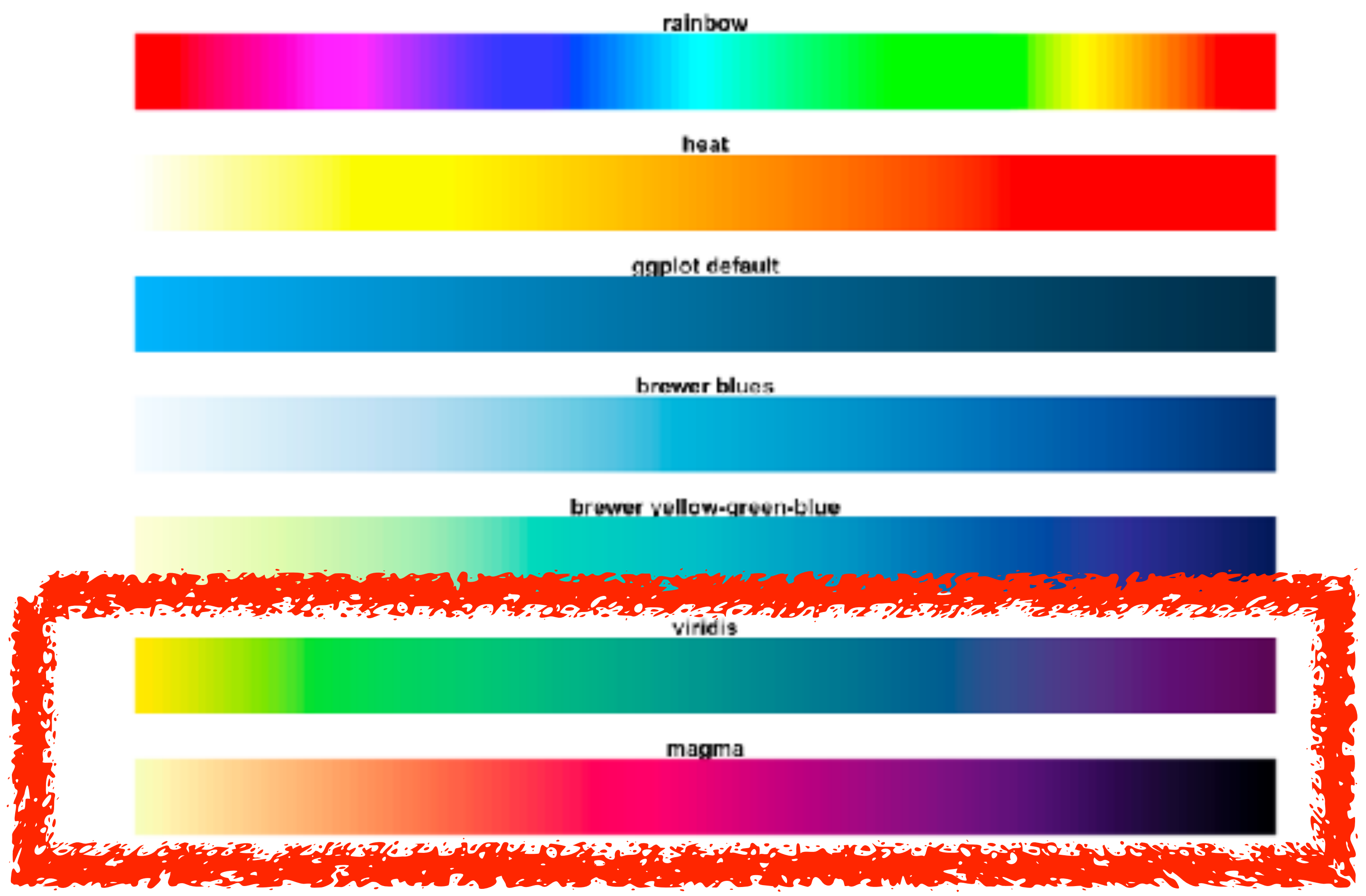
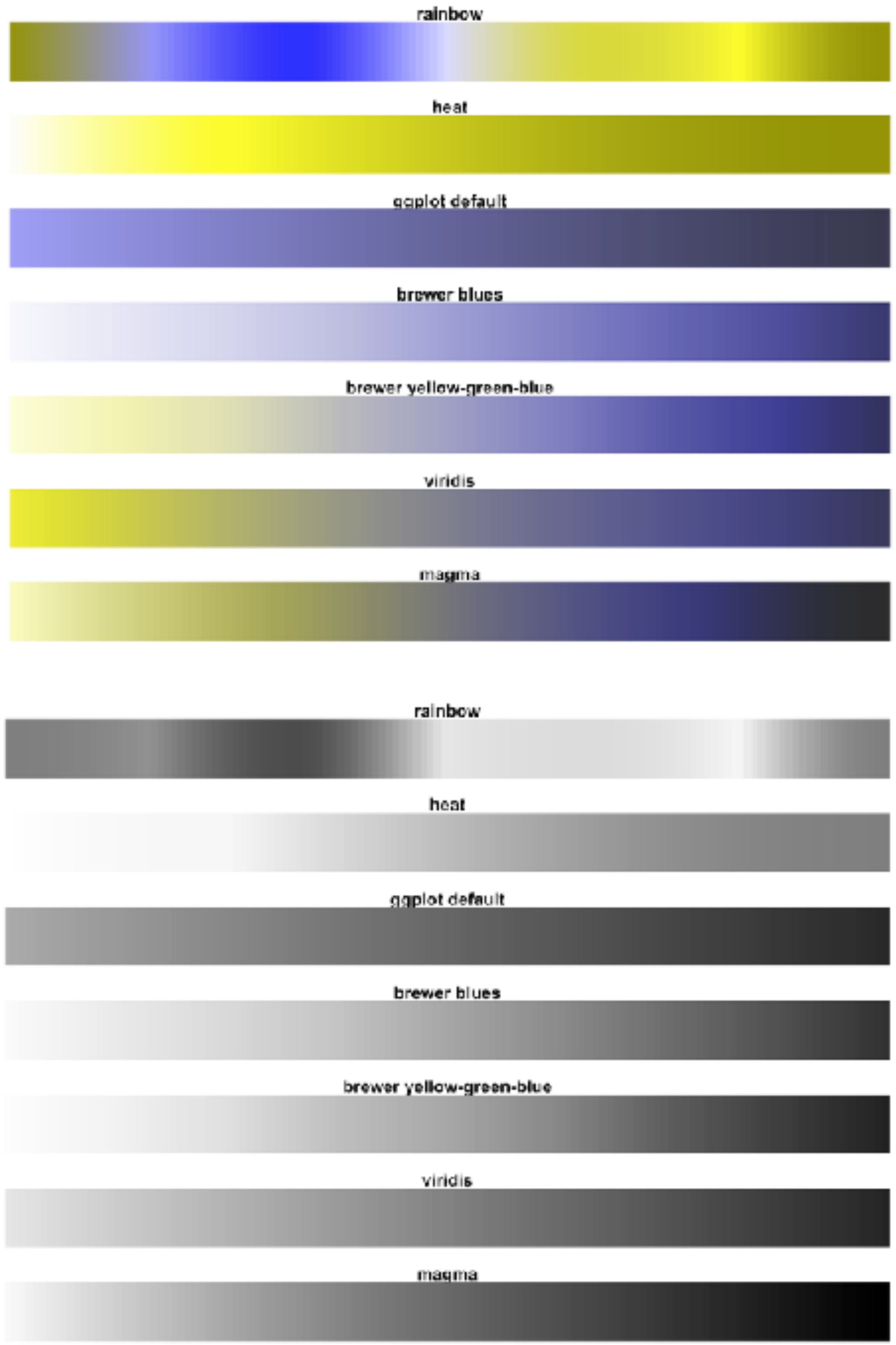
Viridis

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



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



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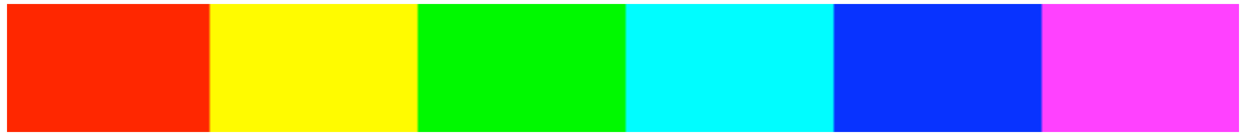
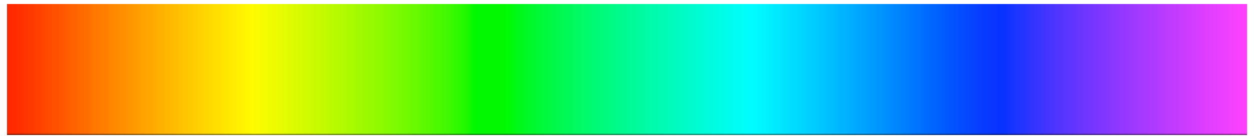
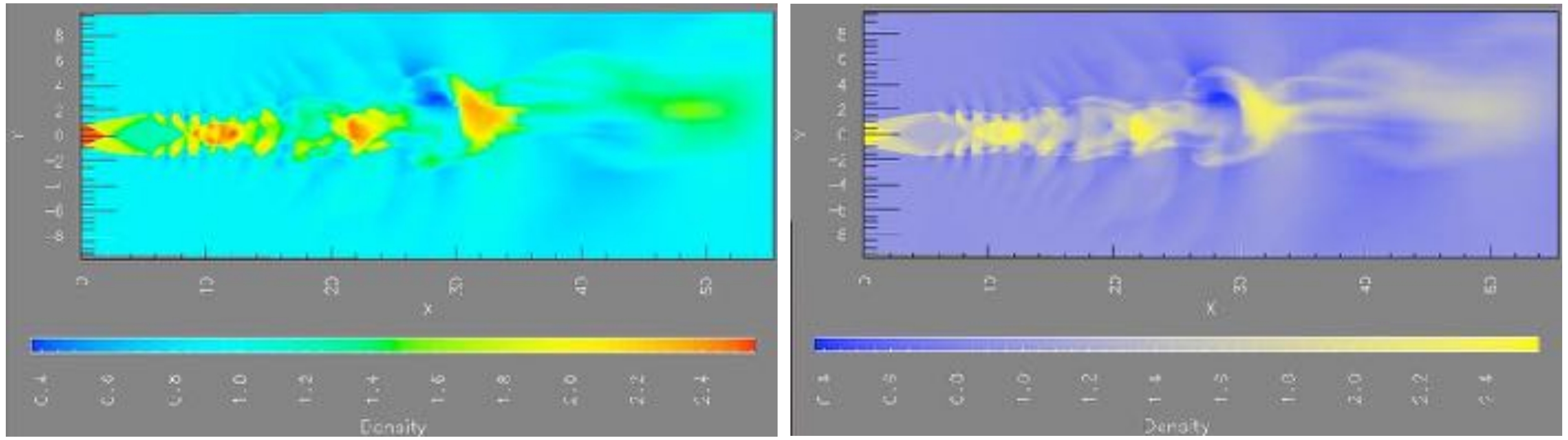
  - fine structure: multiple hues with monotonically increasing luminance [eg viridis R/python]
  - segmented rainbows for binned or categorical







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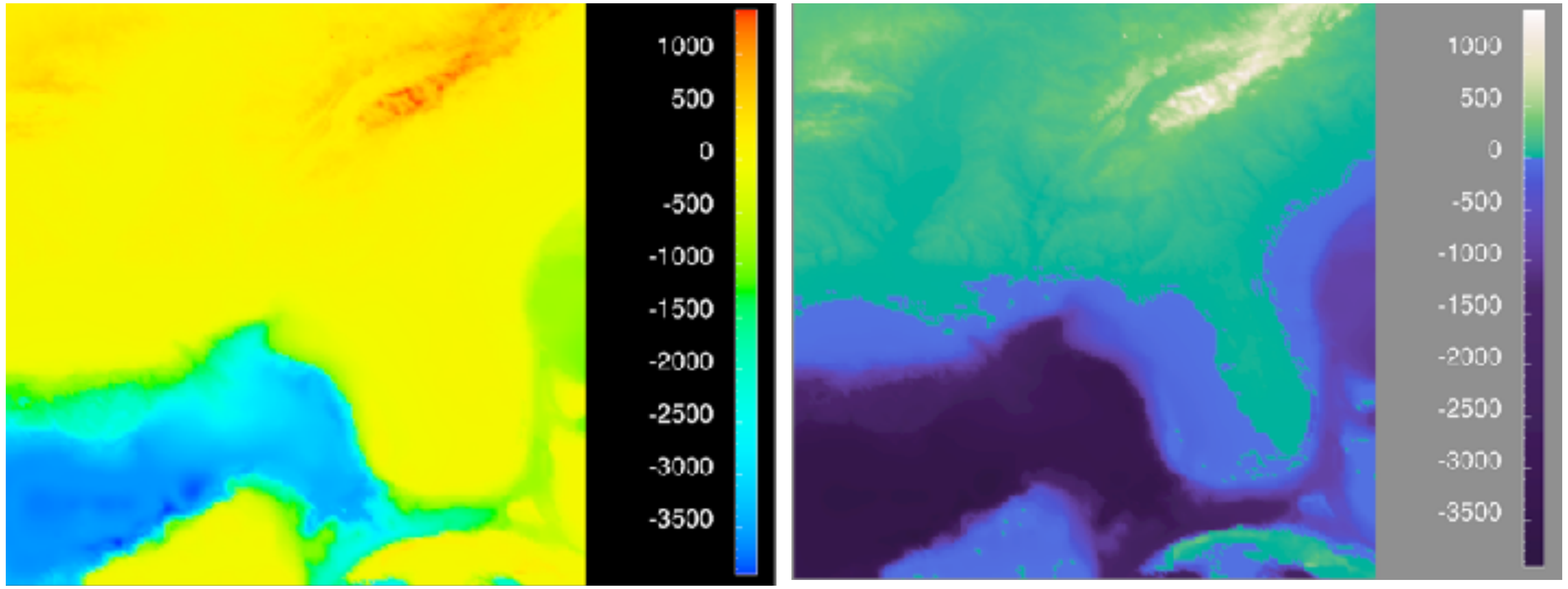

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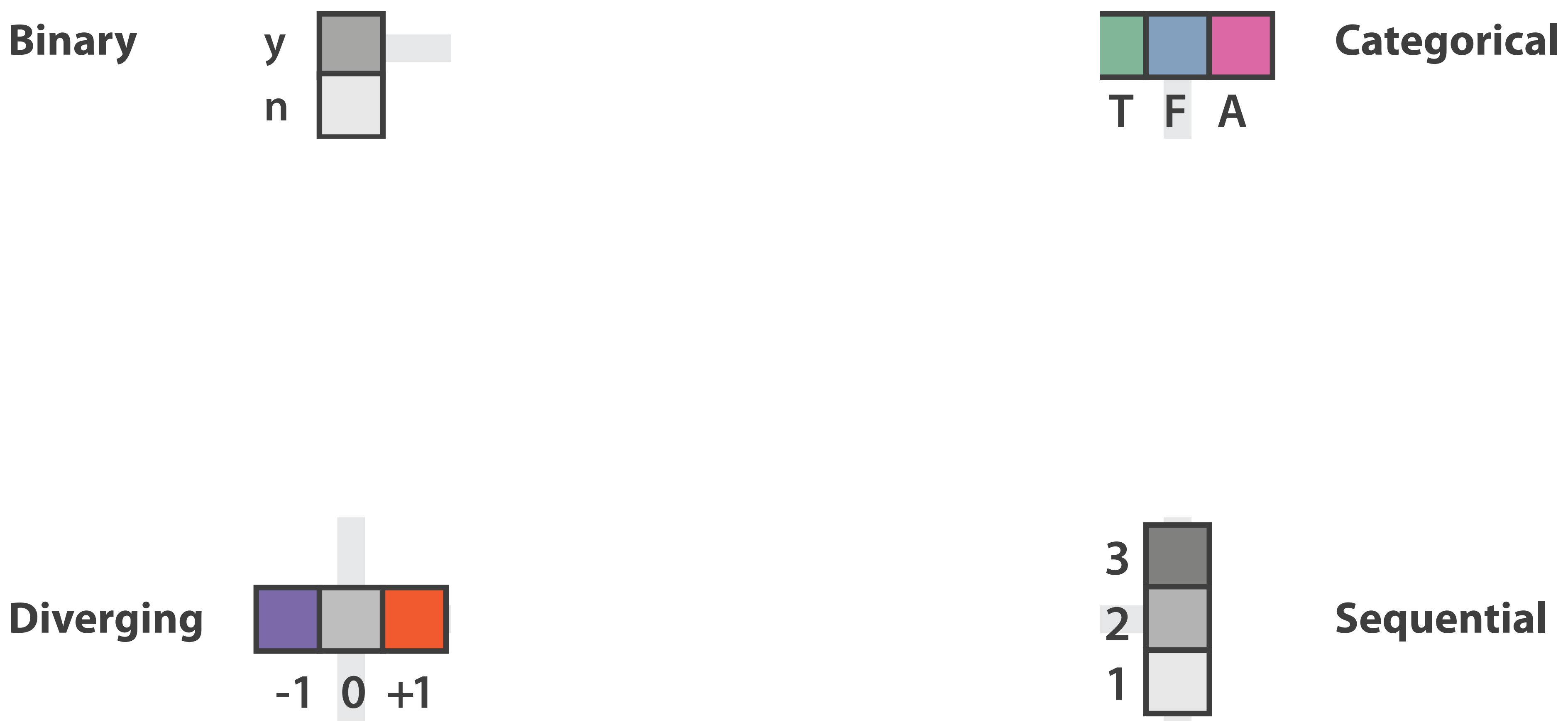
Colormaps

- Categorical

- Ordered
  - *Sequential*
  - *Diverging*



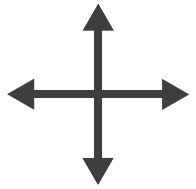
after [Color Use Guidelines for Mapping and Visualization. Brewer, 1994. http://www.personal.psu.edu/faculty/c/a/cab38/ColorSch/Schemes.html]

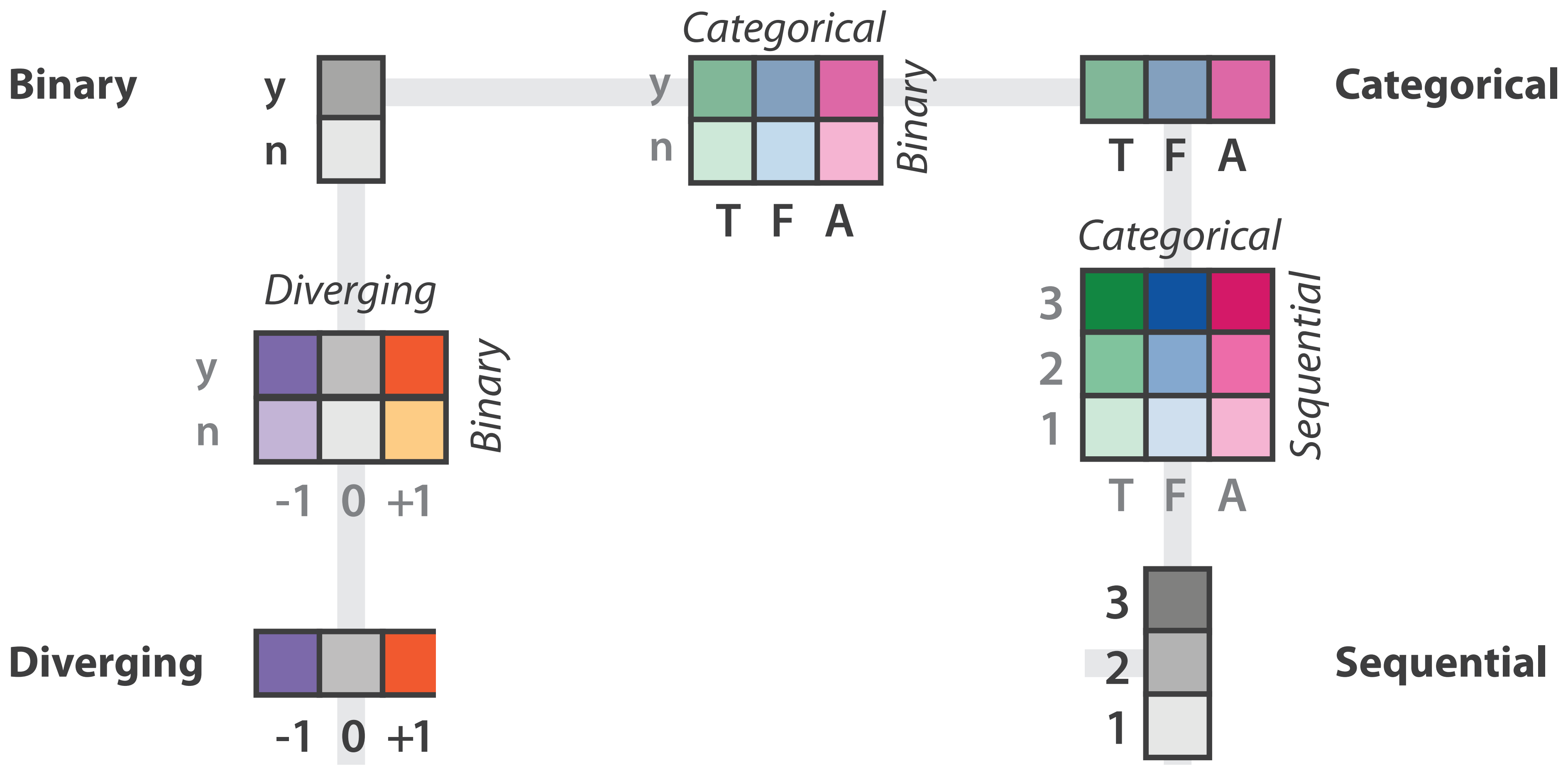
Colormaps

- Categorical

- Ordered
  - *Sequential*
  - *Diverging*

- Bivariate





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Colormaps

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  - *Diverging*
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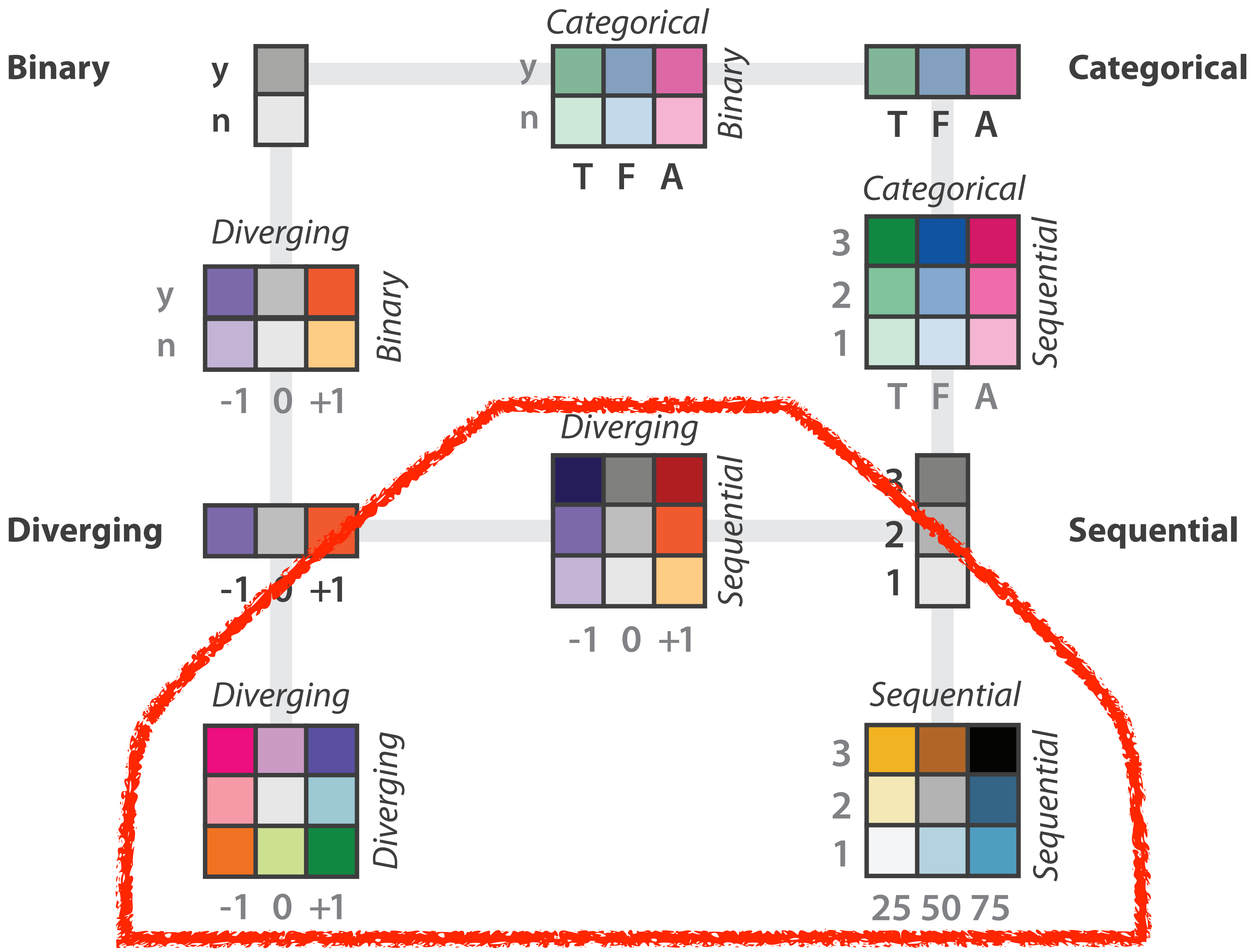
use with care!



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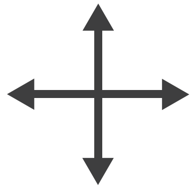
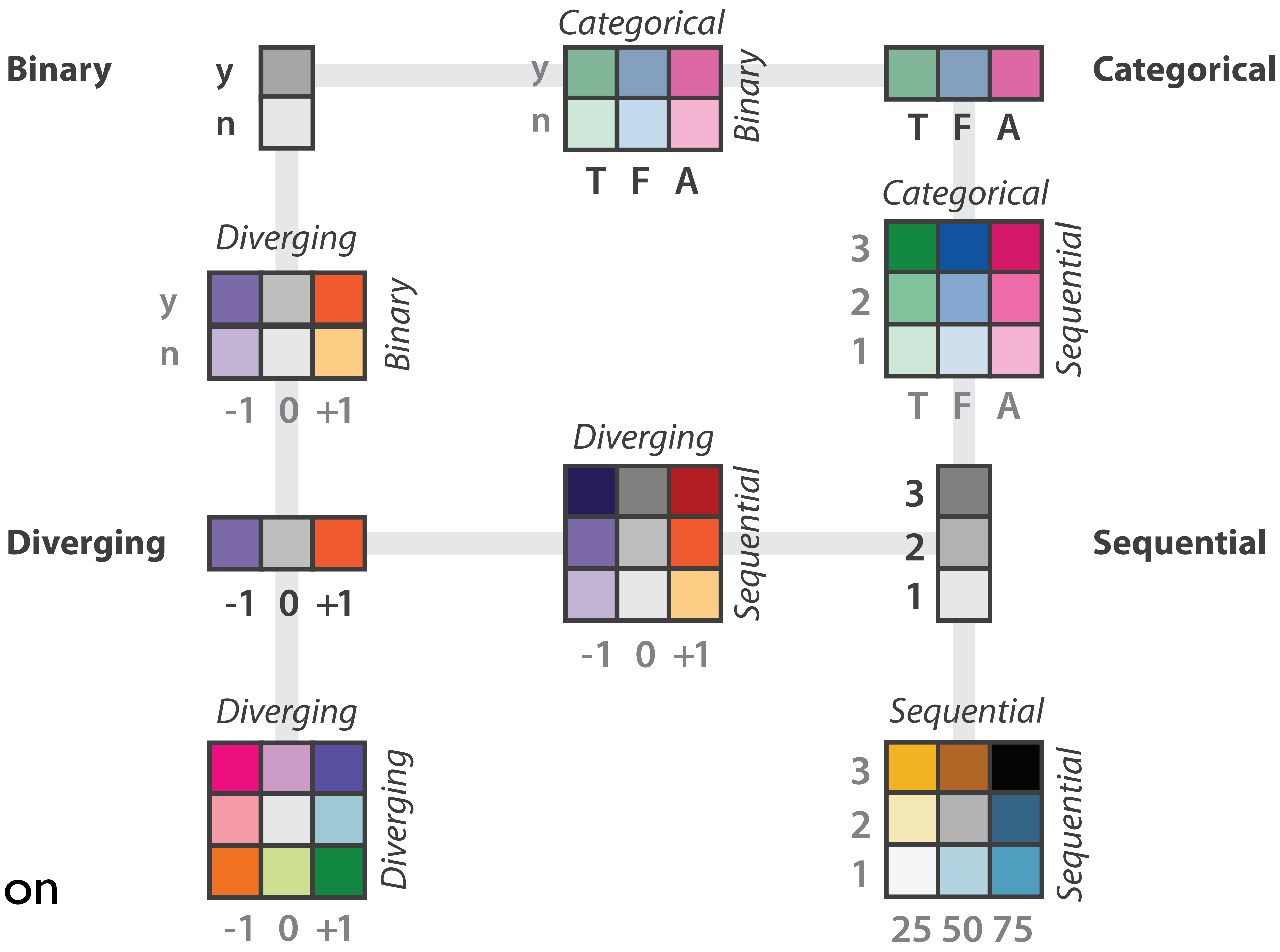


- color channel interactions
  - size heavily affects salience
    - small regions need high saturation
    - large need low saturation
  - saturation & luminance: 3-4 bins max
    - also not separable from transparency



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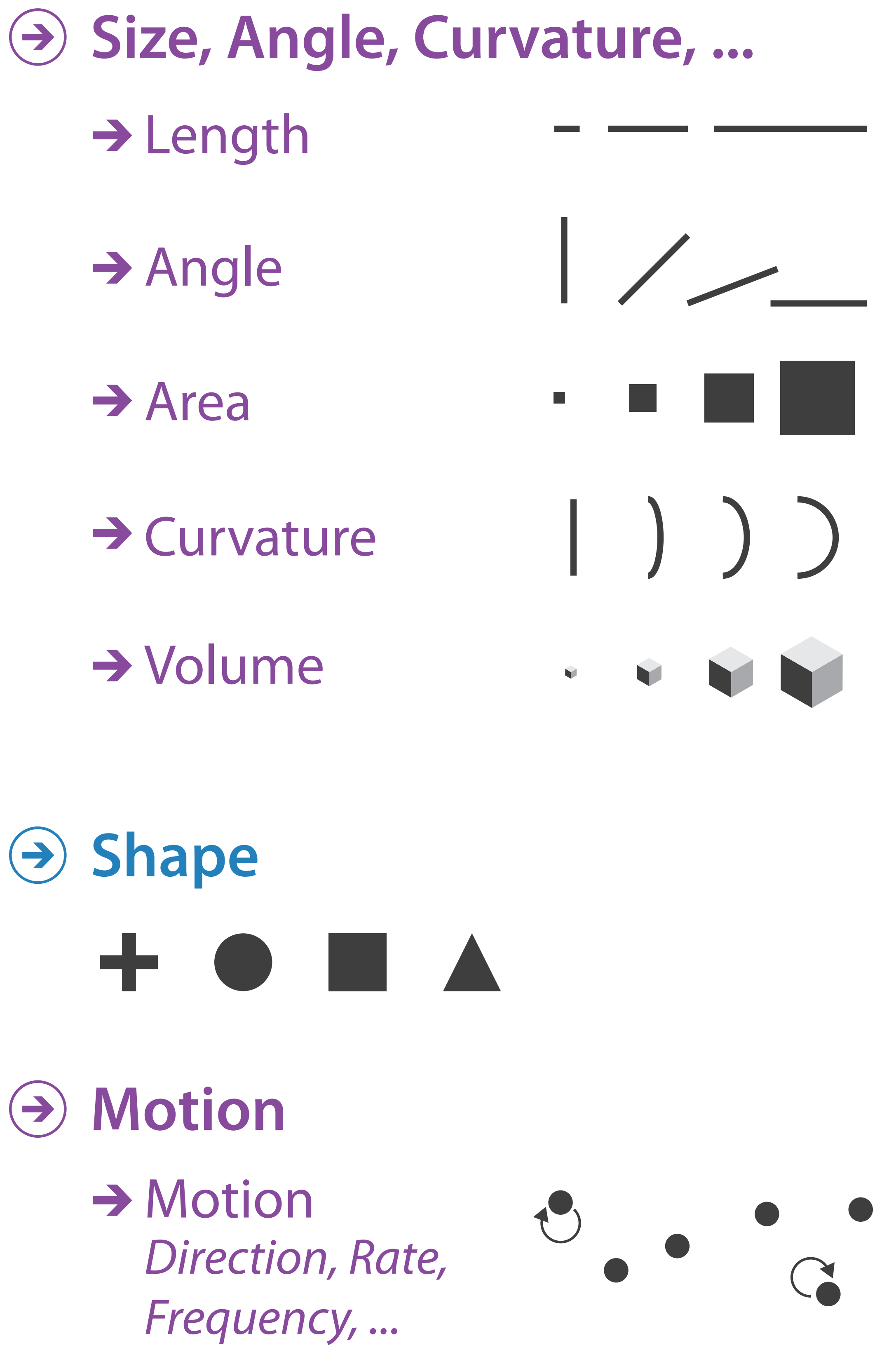
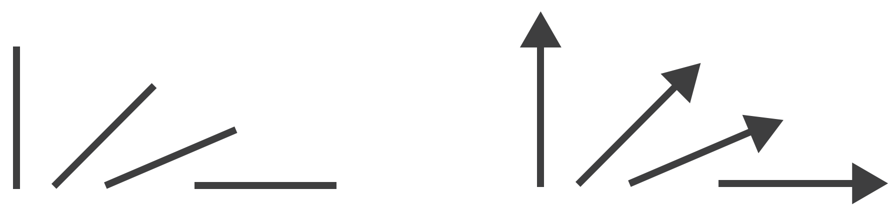
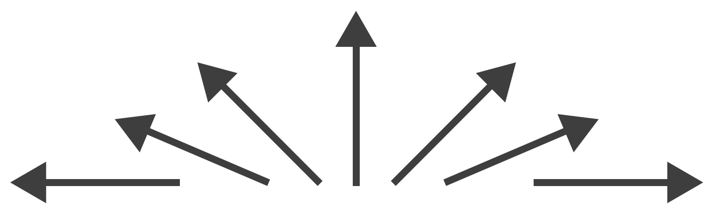
Map other channels

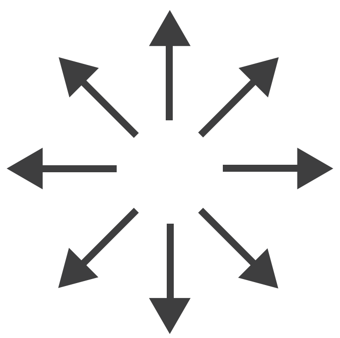
- size
  - length accurate, 2D area ok, 3D volume poor
- angle
  - nonlinear accuracy
    - horizontal, vertical, exact diagonal
- shape
  - complex combination of lower-level primitives
  - many bins
- motion
  - highly separable against static
    - binary: great for highlighting
  - use with care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



Angle







Sequential ordered
line mark or arrow glyph

Diverging ordered
arrow glyph

Cyclic ordered
arrow glyph

Next Time

- to read
  - VAD Ch. 8: Arrange Spatial Data
  - VAD Ch. 9: Arrange Networks
  - paper: ABySS-Explorer: visualizing genome sequence assemblies. *Cydney B. Nielsen, Shaun D. Jackman, Inanc Birol, Steven J.M. Jones. TVCG 15(6):881-8, 2009 (Proc. InfoVis 2009).*
    - [paper type: design study]
  - paper: Interactive Visualization of Genealogical Graphs. *Michael J. McGuffin, Ravin Balakrishnan. Proc. InfoVis 2005, pp 17-24.*
    - [paper type: technique]
- to prepare
  - project pitches (3 min each)

Pitches

- next time (Oct 8) everybody must do a 3-min project pitch
  - slides required by 1pm in PDF format
    - submit to Canvas as "Pitch Slides" Assignment
  - if you have already made decision about teaming up
    - tell me in advance so you're back to back, coordinate so more time for detail
- goals
  - help form teams
  - give everybody (me, fellow students) situational awareness of your project ideas
    - even if not on same team, good to know who's doing similar things
      - both topic & methods
  - deadline for coming up with some concrete project idea

Pitch Hints

- think of it like an "elevator pitch"
  - explain big idea
  - convince us that it's cool/worthwhile
  - give us a sense of how fleshed out it is
    - what you've figured out
    - what's TBD
- practice in advance!
  - 3 min is both slow and fast
- I encourage you to meet with me in advance to talk through your ideas
  - 2 of you already have, and have already achieved "project signoff"
  - today's office hours is a great time for that (right after class!)
  - or make specific appointment

Projects (Reminder)

- groups of 2, 3, or 4
  - amount of work commensurate with group size
  - permission for solo project granted in exceptional circumstances, by petition
- stages
  - milestones along the way, mix of written & in-class
    - pitches (data/task), proposals, peer project reviews
    - formative feedback
  - final versions
    - final presentations
    - final reports
    - summative written feedback for both

Projects (Reminder)

- programming
  - common case *(I will only consider supervising students who do these)*
  - four types
    - problem-driven design studies (target specific task/data)
    - technique-driven (explore design choice space for encoding or interaction idiom)
    - algorithm implementation (as described in previous paper)
    - interactive explainer (like distill articles)
- analysis
  - use existing tools on dataset
  - detailed domain survey
  - particularly suitable for non-CS students
- survey
  - very detailed domain survey
  - particularly suitable for non-CS students

Projects: Design studies (Reminder)

- BYOD (Bring Your Own Data)
  - you (or your teammates) have your own data to analyze
    - thesis/research topic
    - personal interest
    - dovetail with another course (sometimes works, but timing may be tricky)
- FDOI (Find Data Of Interest)
  - many existing datasets, see resource page to get started
    - http://www.cs.ubc.ca/group/infovis/resources.shtml
  - can be tricky to determine reasonable task

More info

- showcase project examples
  http://www.cs.ubc.ca/~tmm/courses/547-17F/projectdesc.html#examp
- resources (detailed list from 2015)
  http://www.cs.ubc.ca/group/infovis/resources.shtml
  - inspiration
  - **data repositories**
  - data wrangling & EDA
  - visualization design
  - sharing your work
- tools directory (updated regularly)
  https://www.visualisingdata.com/resources/