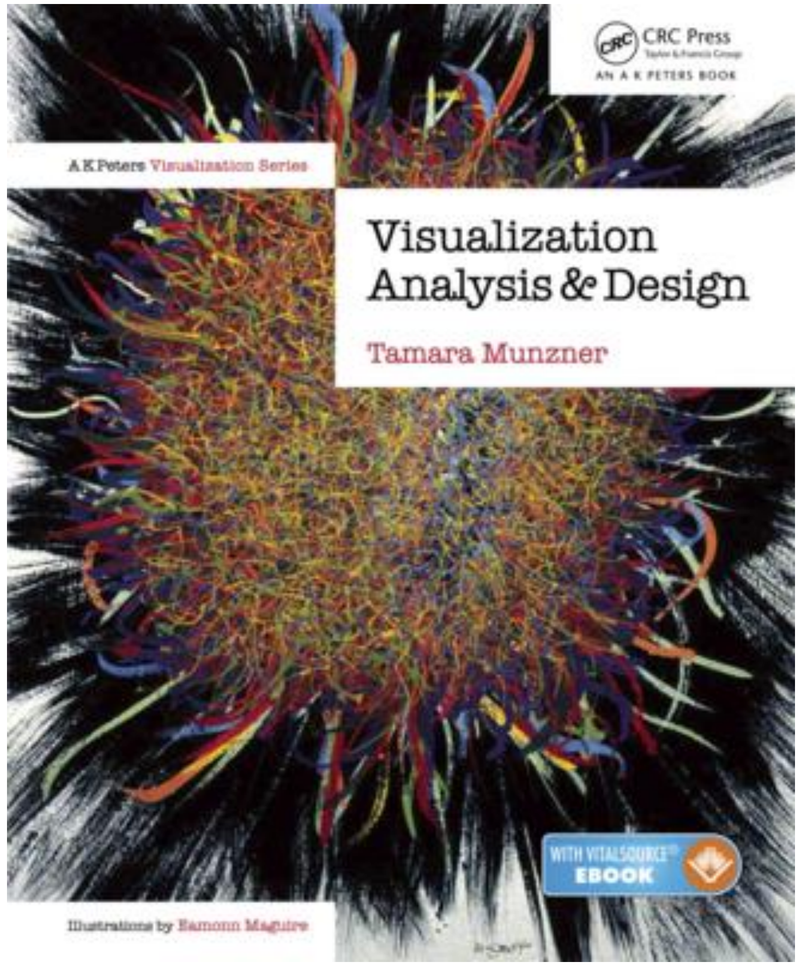
Interaction

Yu-Shuen Wang, CS, NCTU



- Slides refer to https://www.cs.ubc.ca/~tmm/

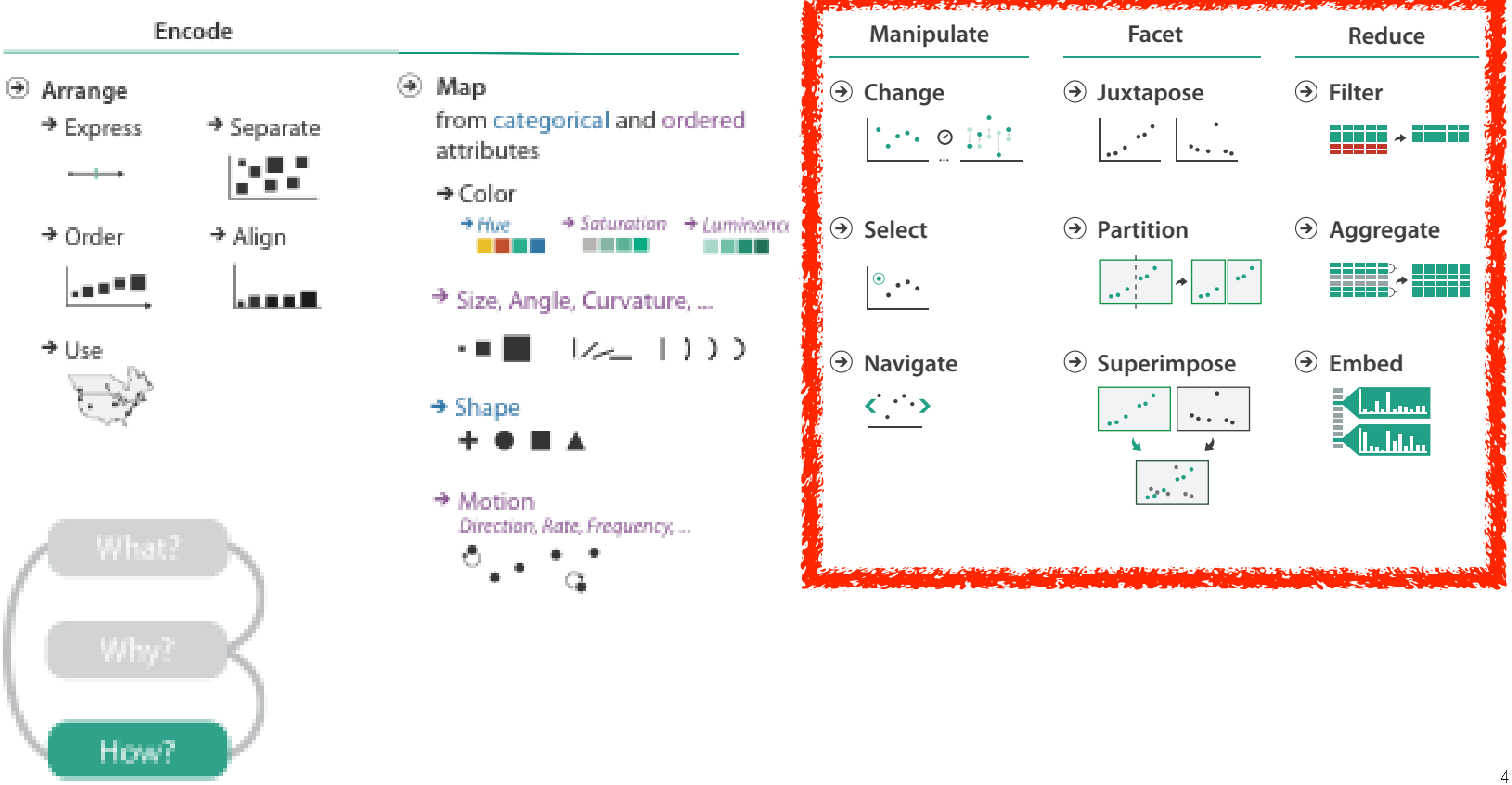
Color & Interaction

- Manipulate: Change, Select, Navigate (Ch. 11)

- Facet: Juxtapose, Partition, Superimpose (Ch. 12)

Manipulate: Change, Select, Navigate

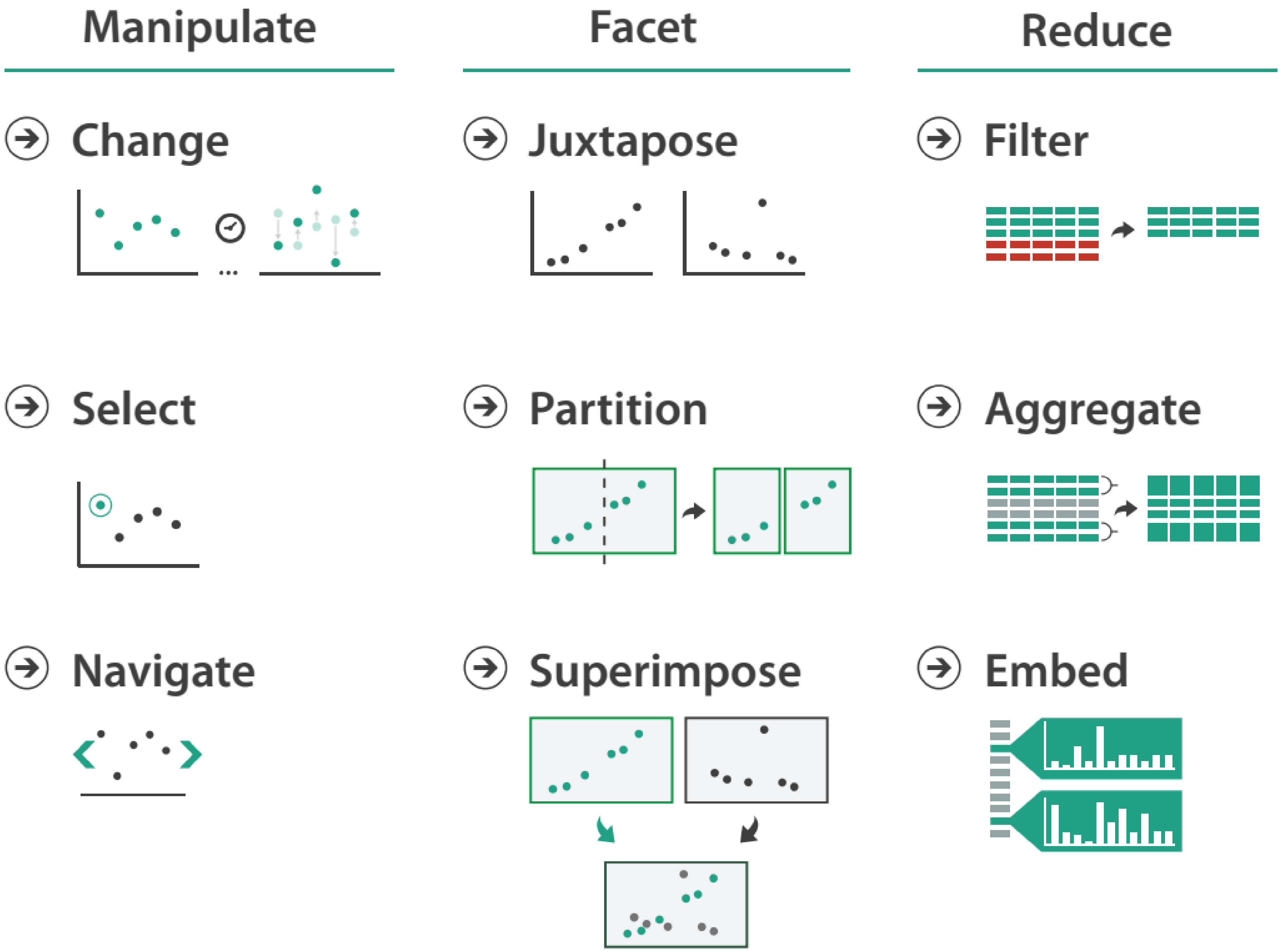
How?


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, ...
What?
Why?
How?
Manipulate
Change
Select
Navigate
Facet
Juxtapose
Partition
Superimpose
Reduce
Filter
Aggregate
Embed

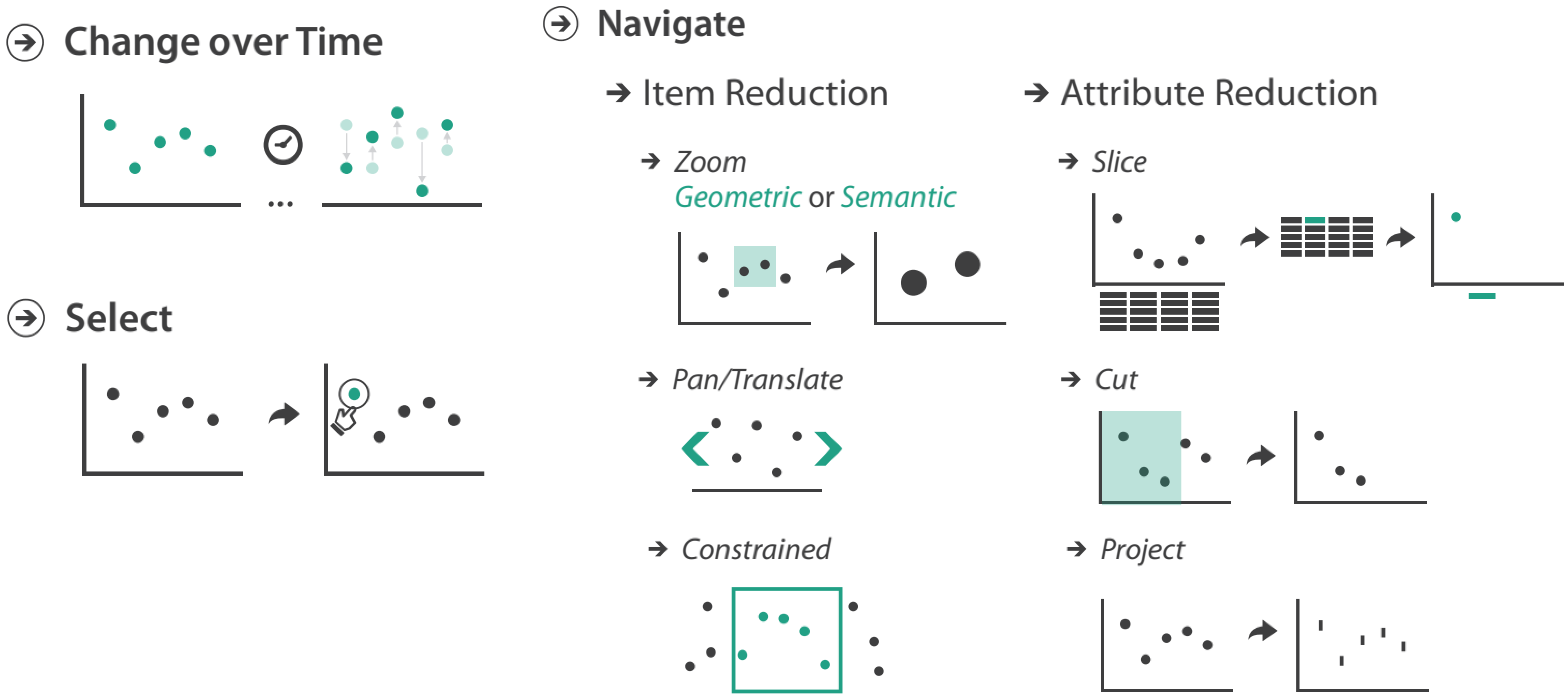
How to handle complexity: 1 previous strategy + 3 more

➔ *Derive*

- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view
- embed focus and context



Manipulate

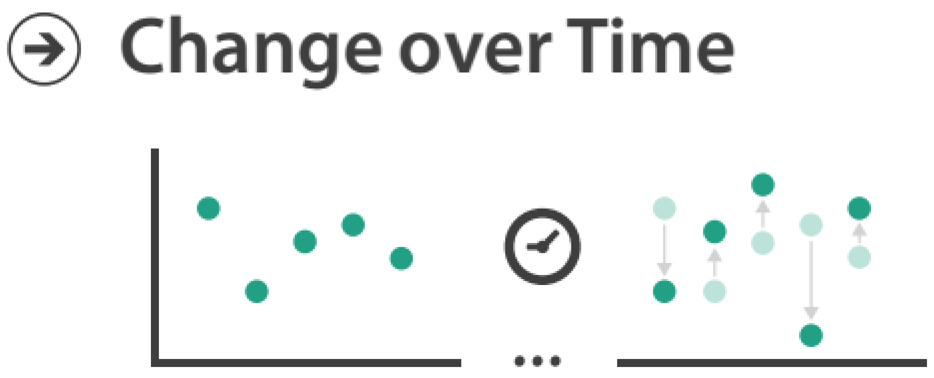


Change over Time
Select
Navigate
Item Reduction
Zoom
Geometric or Semantic
Pan/Translate
Constrained
Attribute Reduction
Slice
Cut
Project

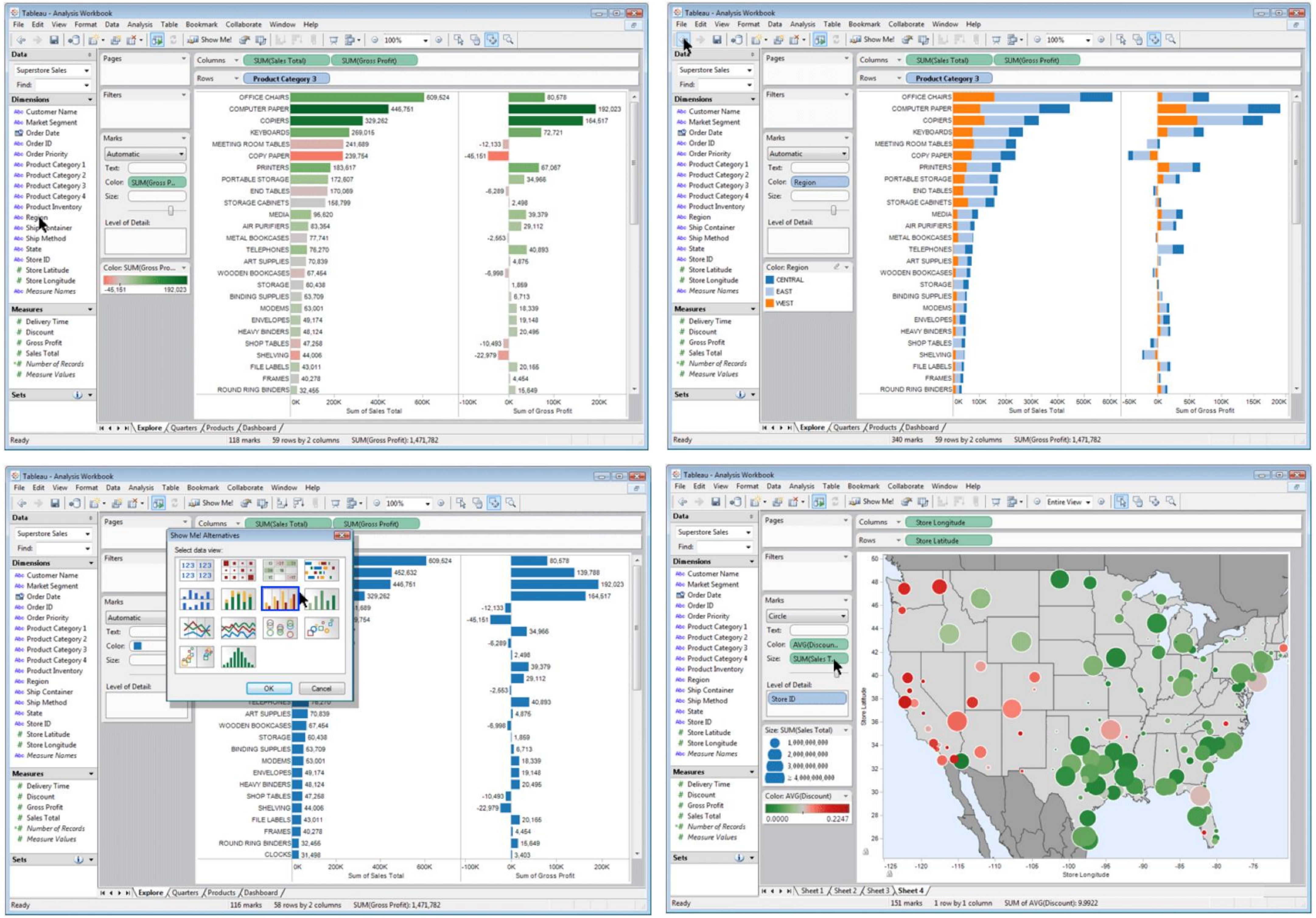
Change over time

- change any of the other choices
  - encoding itself
  - parameters
  - arrange: rearrange, reorder
  - aggregation level, what is filtered...

  - interaction entails change



Idiom: **Re-encode** System: **Tableau**



made using Tableau, http://tableausoftware.com

Idiom: **Change parameters**

- **widgets and controls**

  sliders, buttons, radio buttons, checkboxes, dropdowns/comboboxes

- **pros**

  clear affordances,

  self-documenting (with labels)

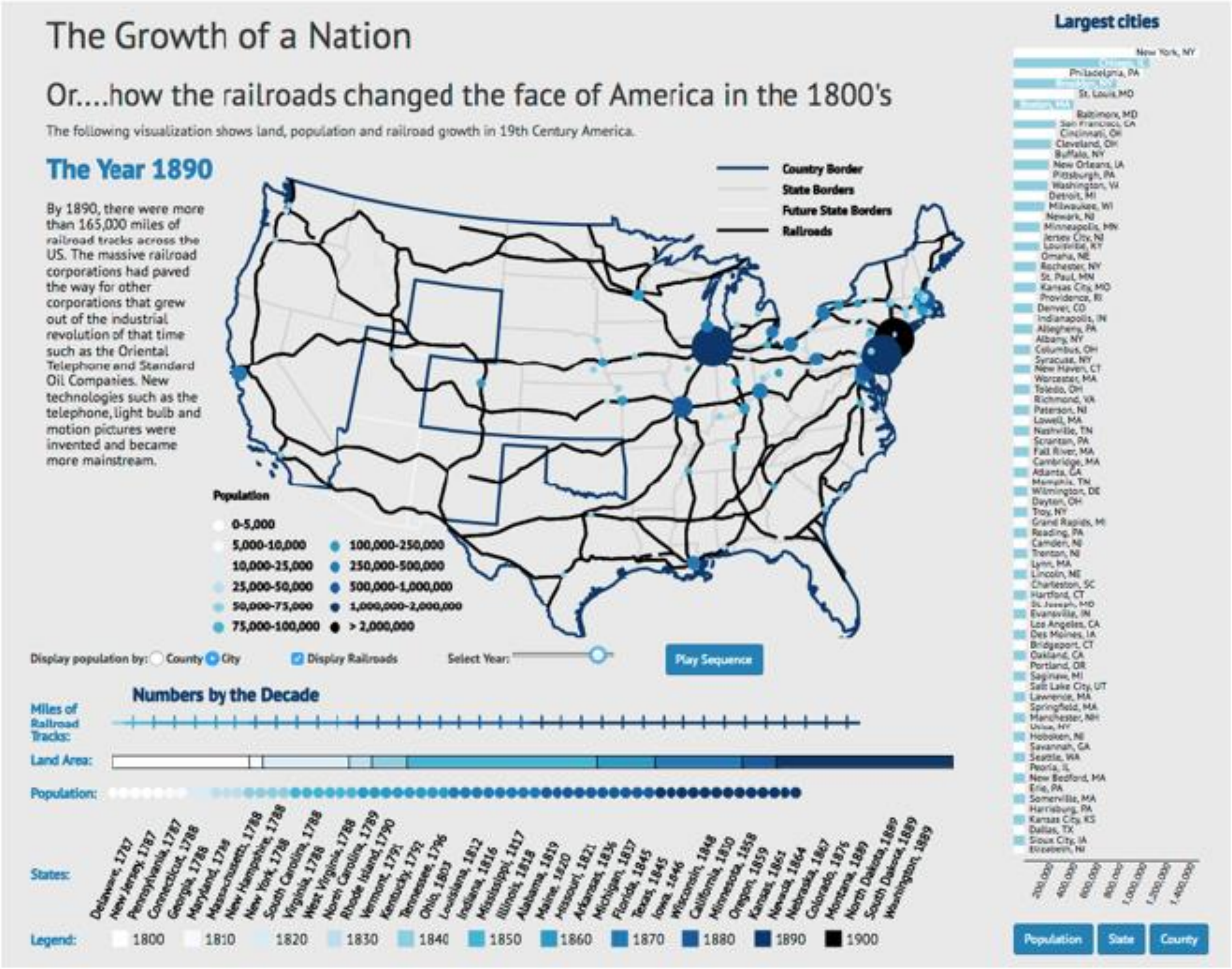
- **cons**

  uses screen space

- **design choices**

  separated vs interleaved

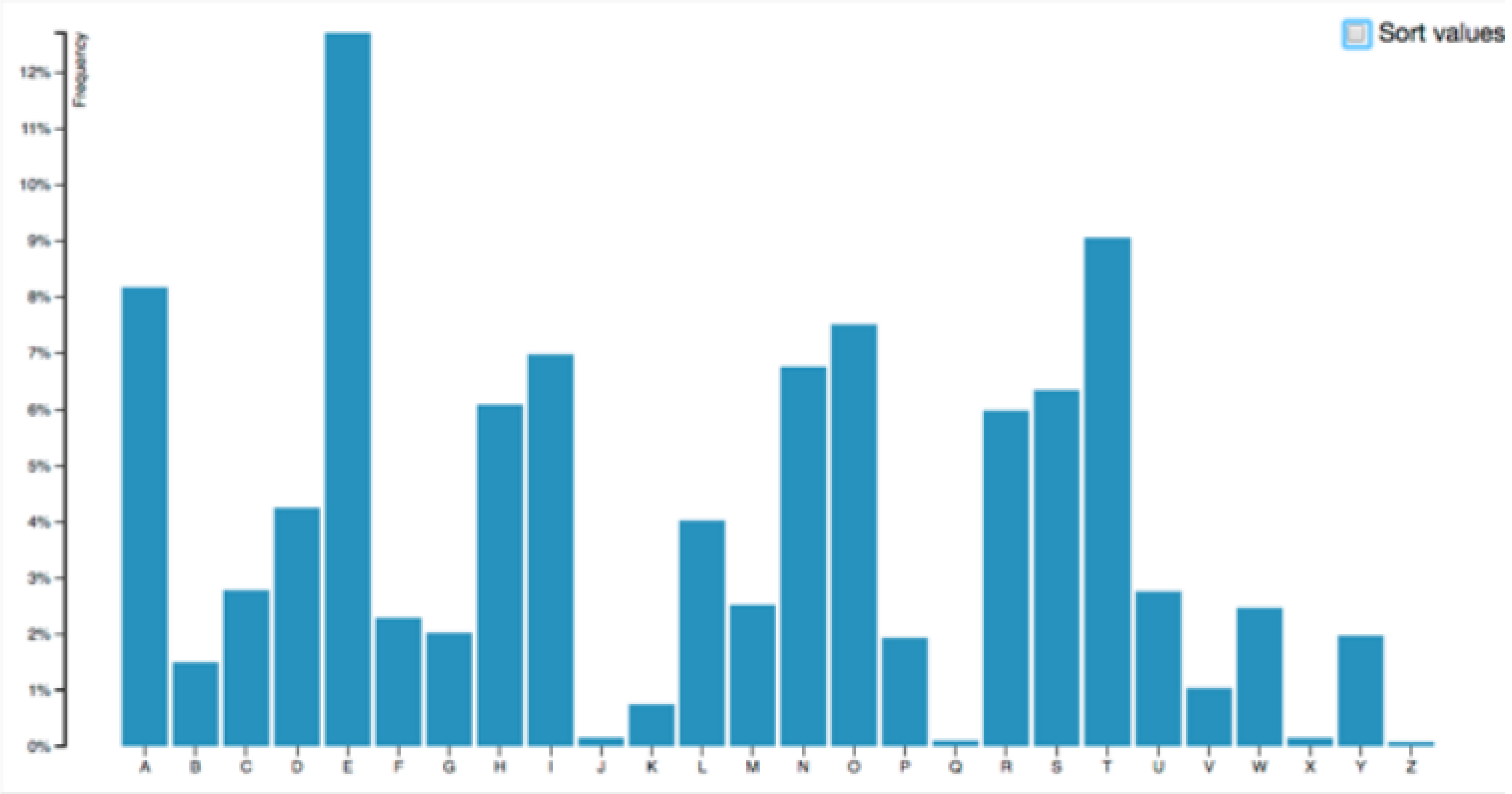
    controls & canvas

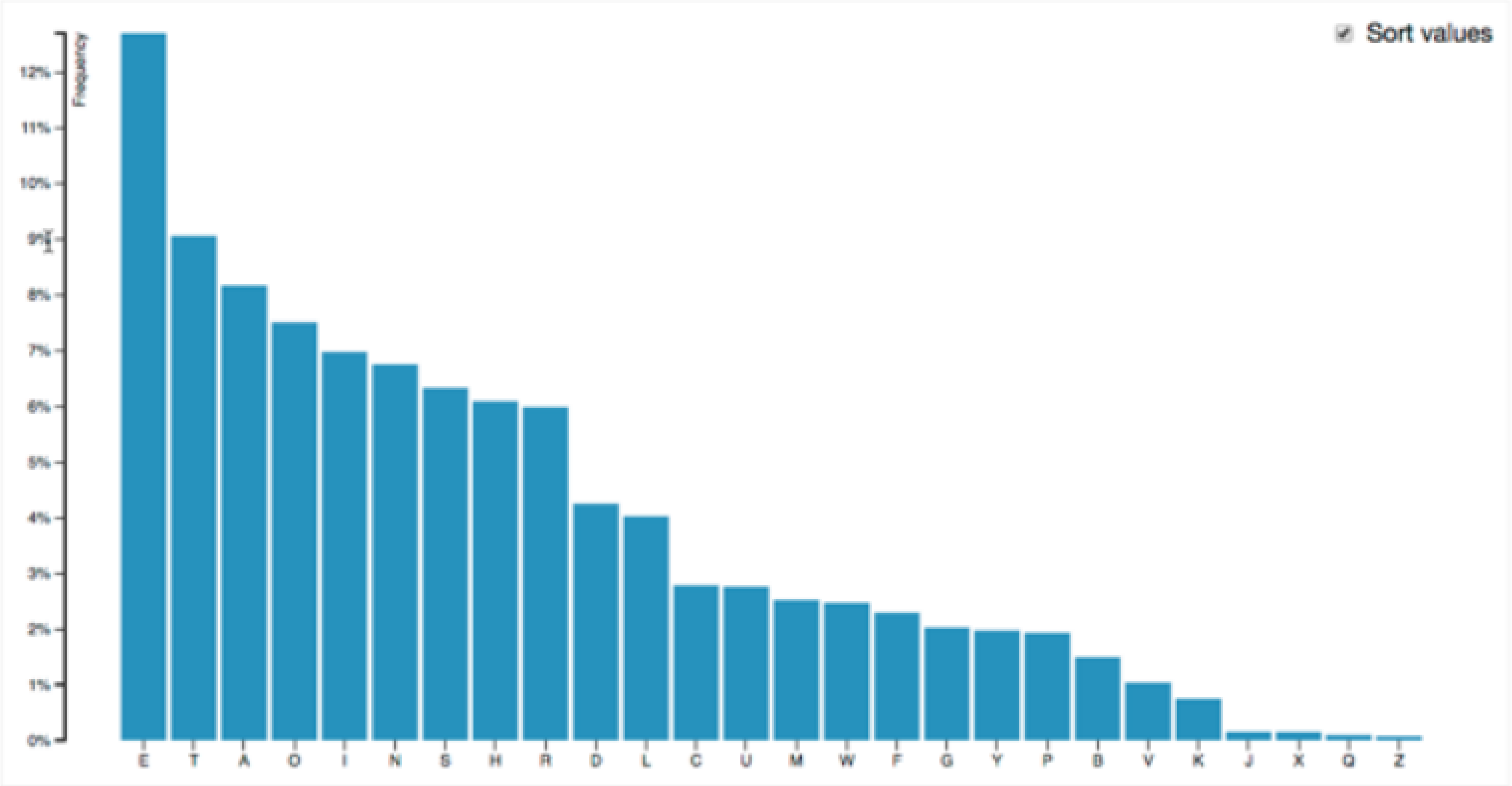


[Growth of a Nation](http://laurenwood.github.io/)

Idiom: Change order/arrangement

- what: simple table
- how: data-driven reordering
- why: find extreme values, trends



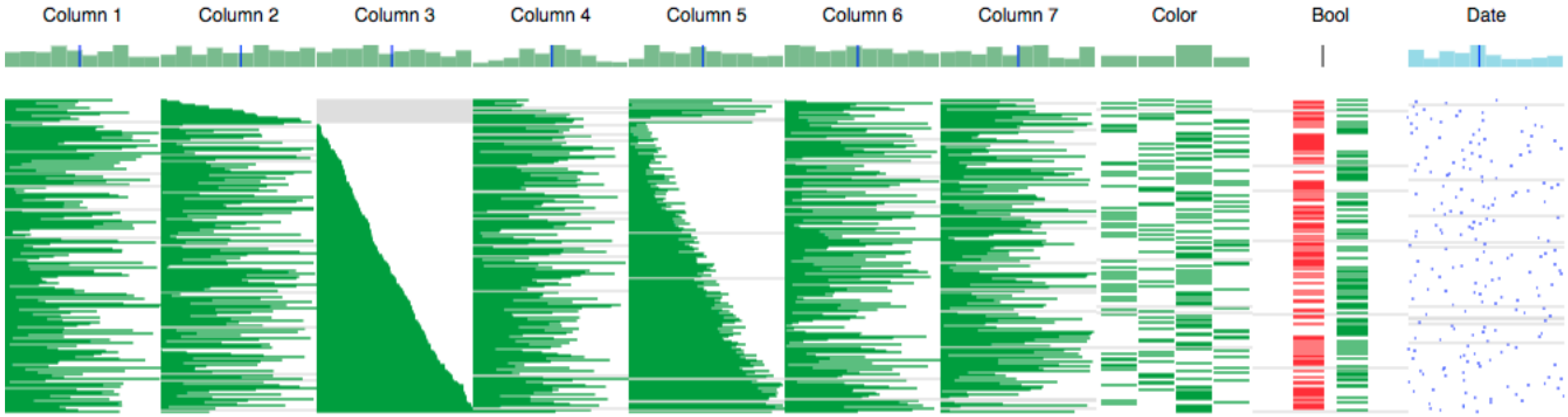


https://observablehq.com/@d3/sortable-bar-chart

Idiom: Reorder

System: **DataStripes**

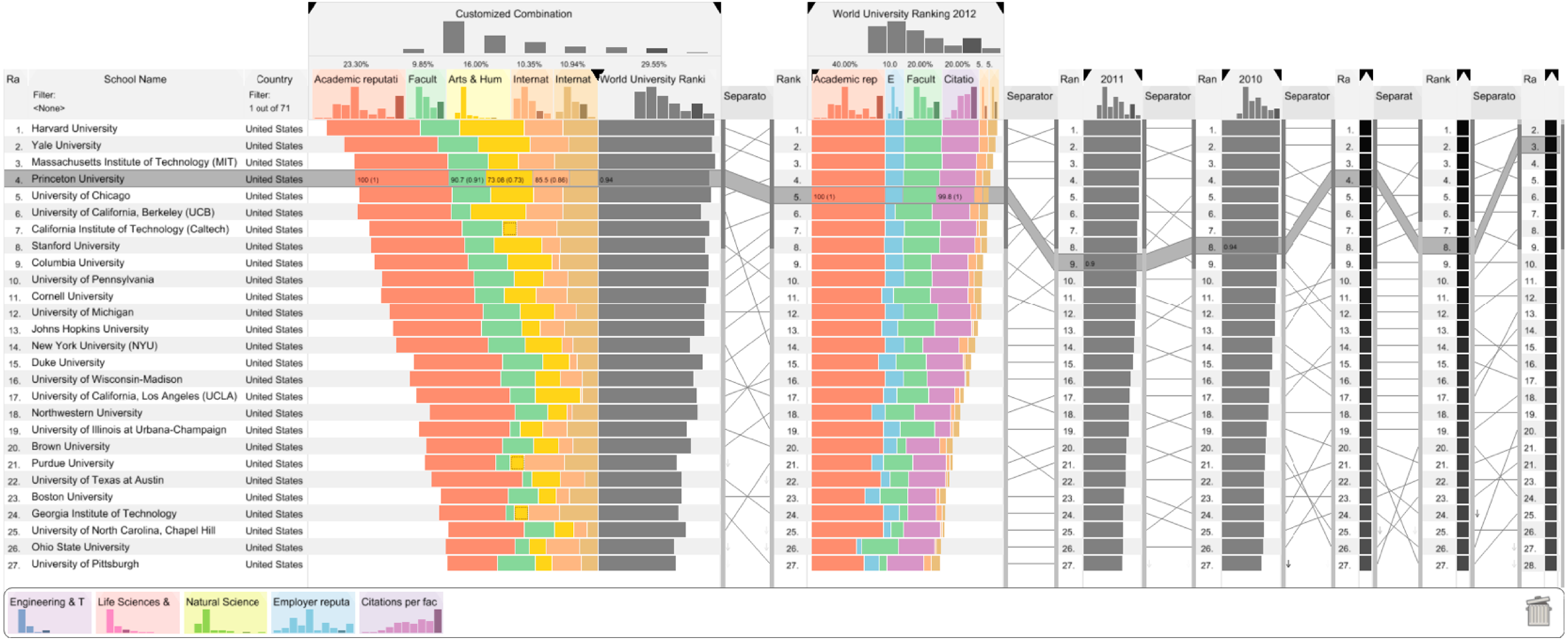
- what: table with many attributes
- how: data-driven reordering by selecting column
- why: find correlations between attributes



http://carlmanaster.github.io/datastripes/

Idiom: **Reorder** System: **LineUp**

- data: tables with many attributes
- task: compare rankings

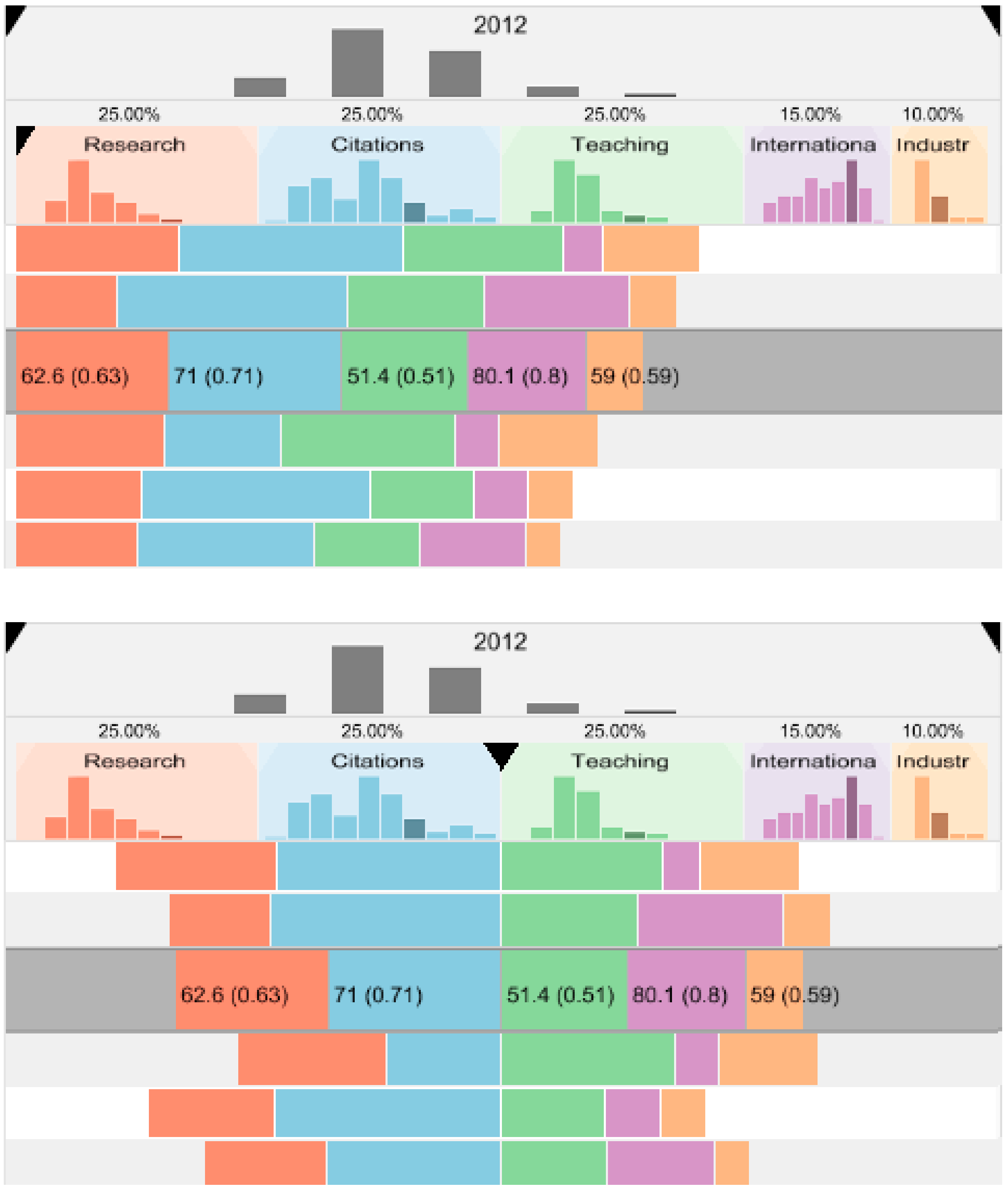


[LineUp: Visual Analysis of Multi-Attribute Rankings. Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.] video

Idiom: **Realign**

System: **LineUp**

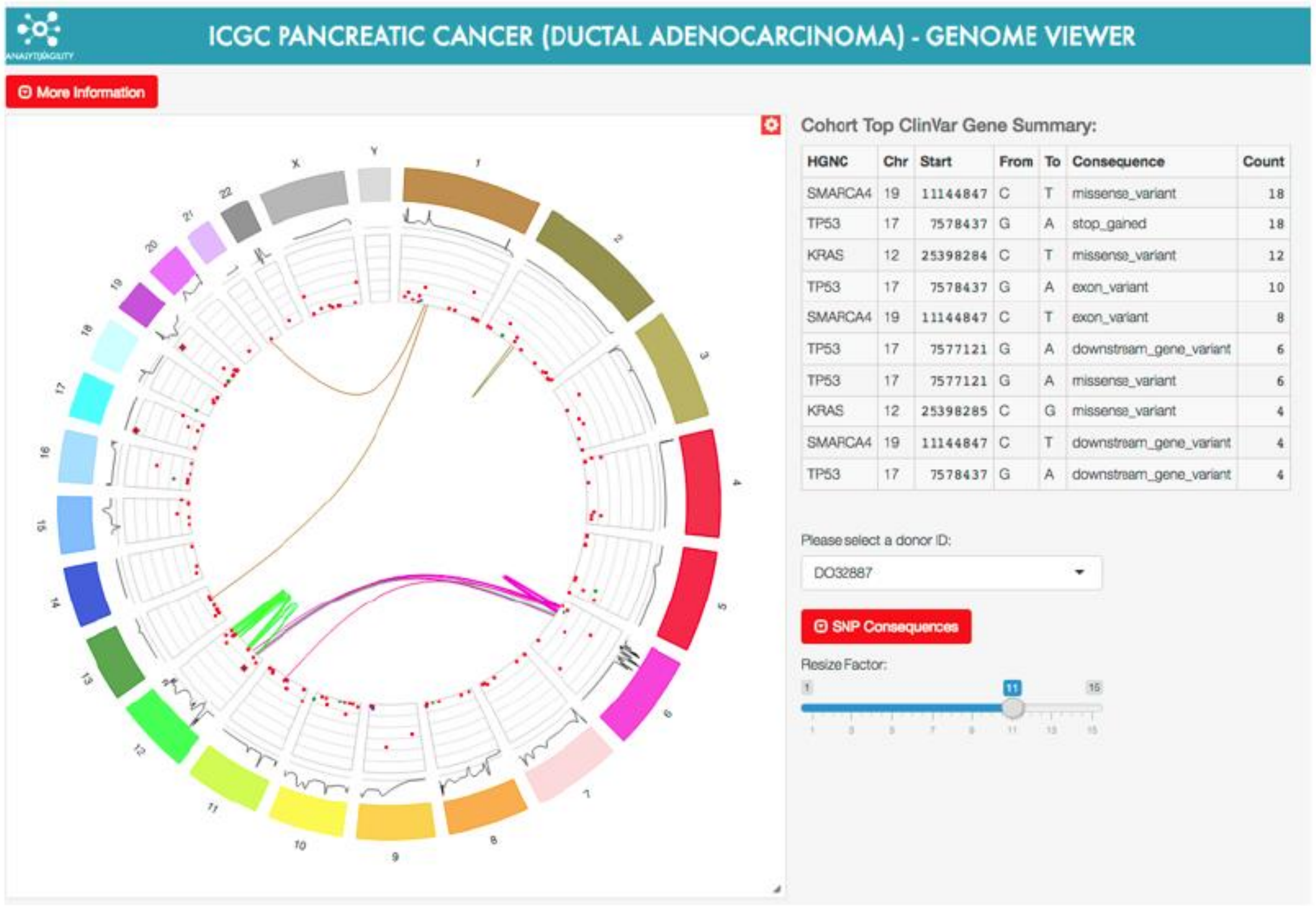
- stacked bars
  - –easy to compare
    - first segment
    - total bar
- align to different segment
  - –supports flexible comparison



[LineUp: Visual Analysis of Multi-Attribute Rankings.Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

Shiny example

- APGI genome browser
  - tooling: R/Shiny
  - interactivity
    - tooltip detail on demand on hover
    - expand/contract chromosomes
    - expand/contract control panes



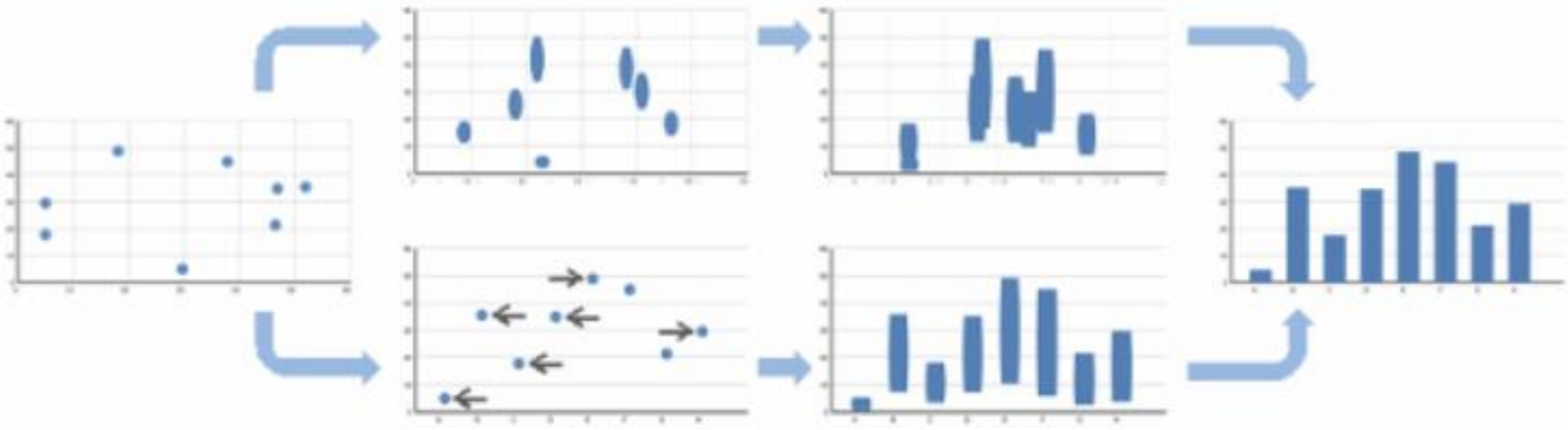
https://gallery.shinyapps.io/genome_browser/

30

Idiom: **Animated transitions**

- smooth transition from one state to another
  - –alternative to jump cuts, support for item tracking
    - Best case for animation
  - –Staging to reduce cognitive load

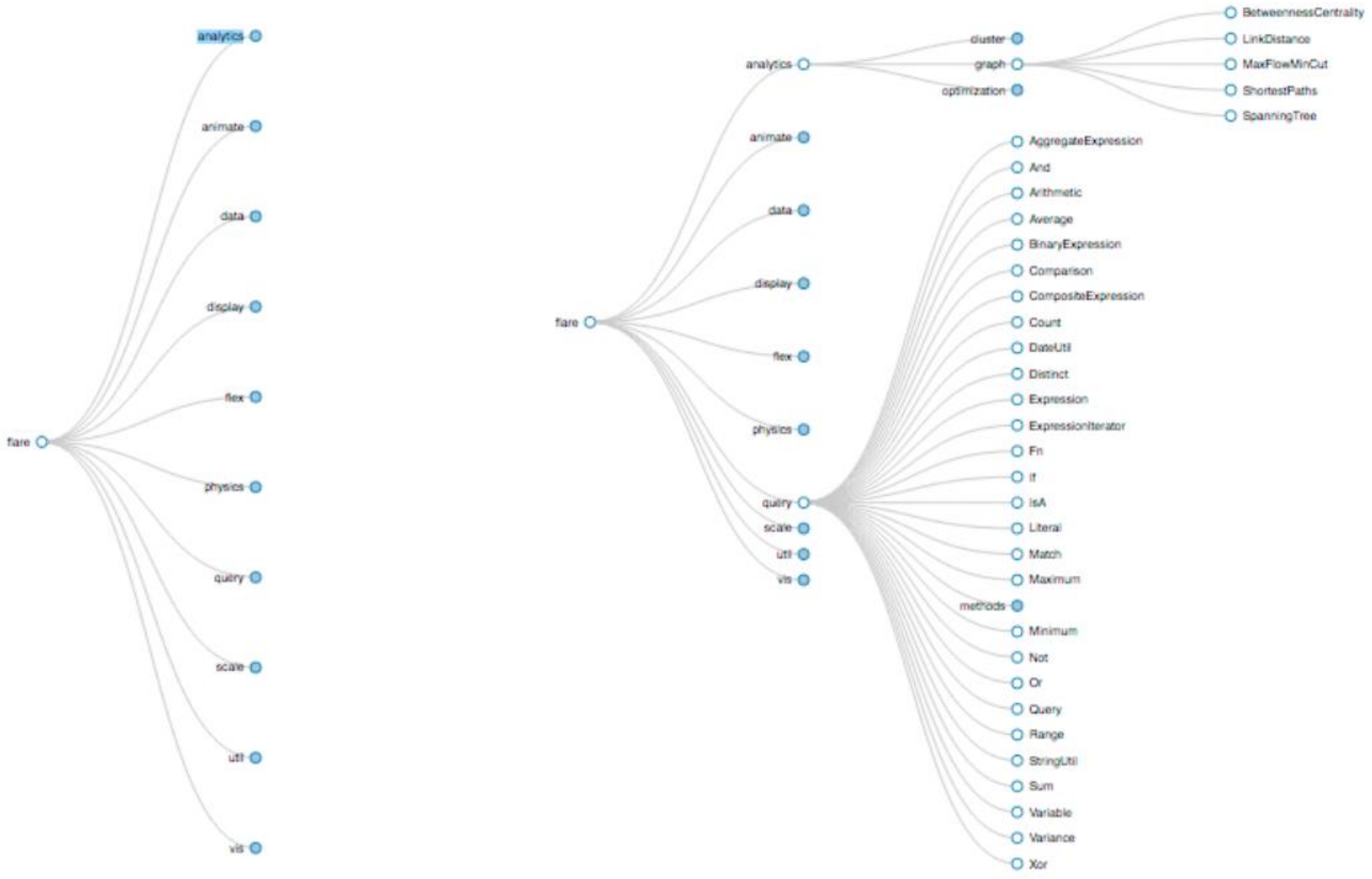
  - –example: animated transitions in statistical data graphics



  - –https://vimeo.com/19278444

Idiom: **Animated transitions – tree detail**

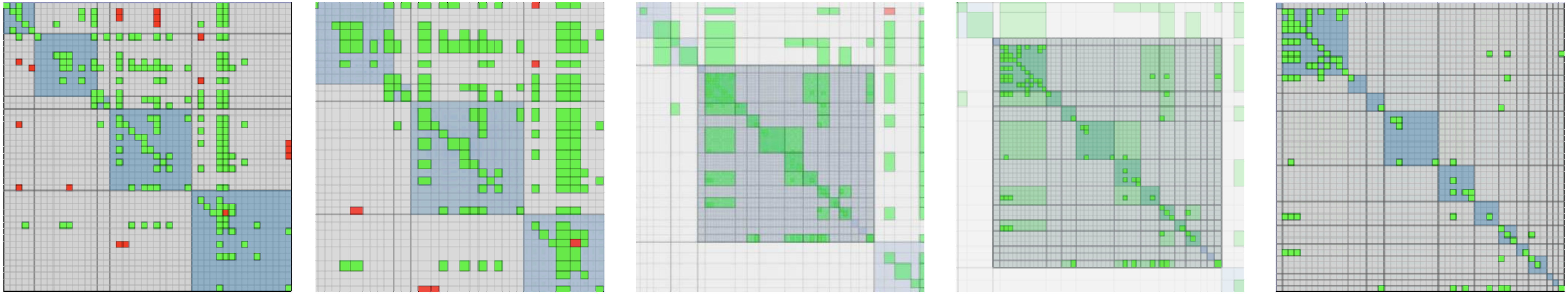
- animated transition
  - –Network drilldown/rollup



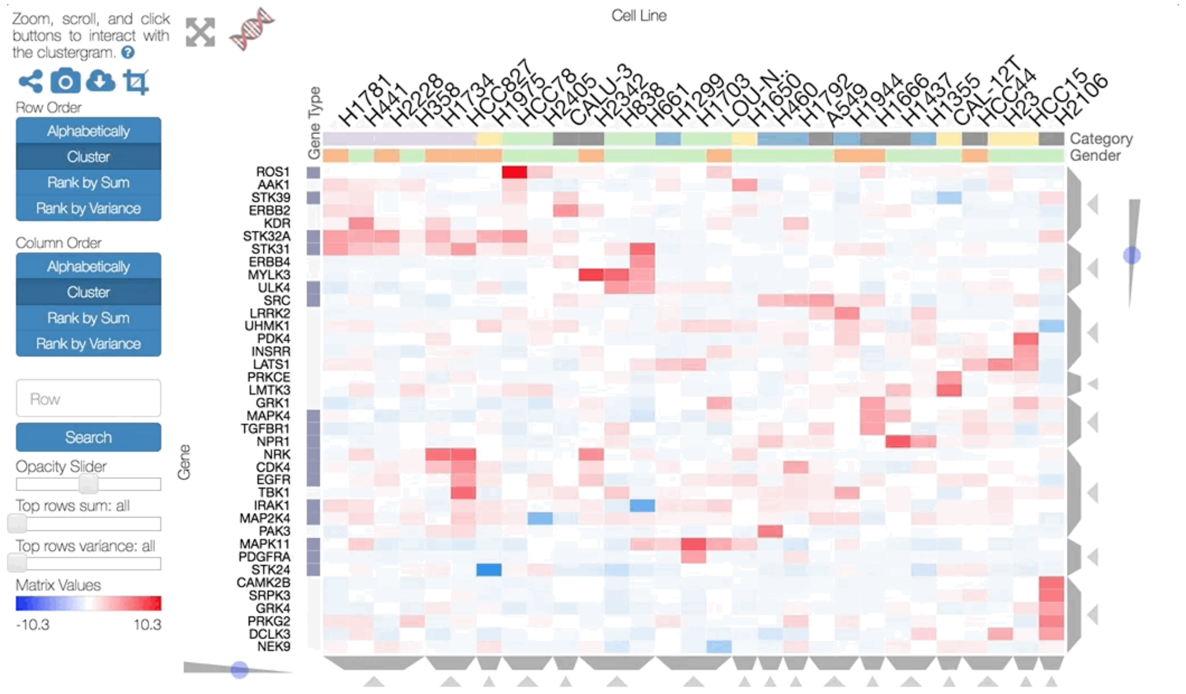
Collapsible Tree

https://observablehq.com/@d3/collapsible-tree

An interactive heatmap visualization



[Using Multilevel Call Matrices in Large Software Projects. van Ham. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 227–232, 2003.]

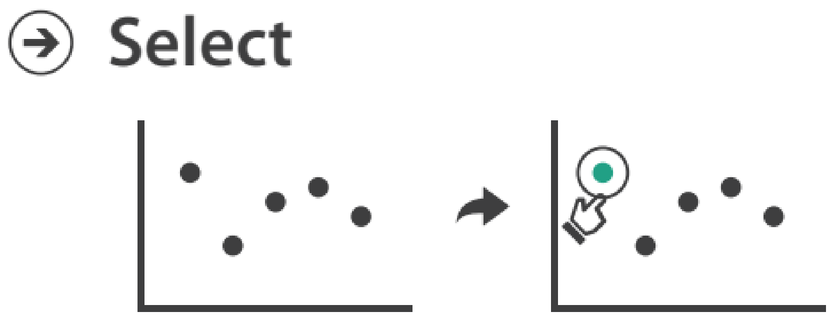


https://github.com/MaayanLab/clustergrammer

[Fernandez, N. F. et al. Clustergrammer, a web-based heatmap visualization and analysis tool for high-dimensional biological data. Sci. Data 4:170151 doi: [10.1038/sdata.2017.151](https://doi.org/10.1038/sdata.2017.151) (2017).]

Select and highlight

- selection: basic operation for most interaction
- design choices
  - –how many selection types?
    - Click/tap vs hover: heavyweight, lightweight
    - primary vs secondary: semantics (e.g., source/target)



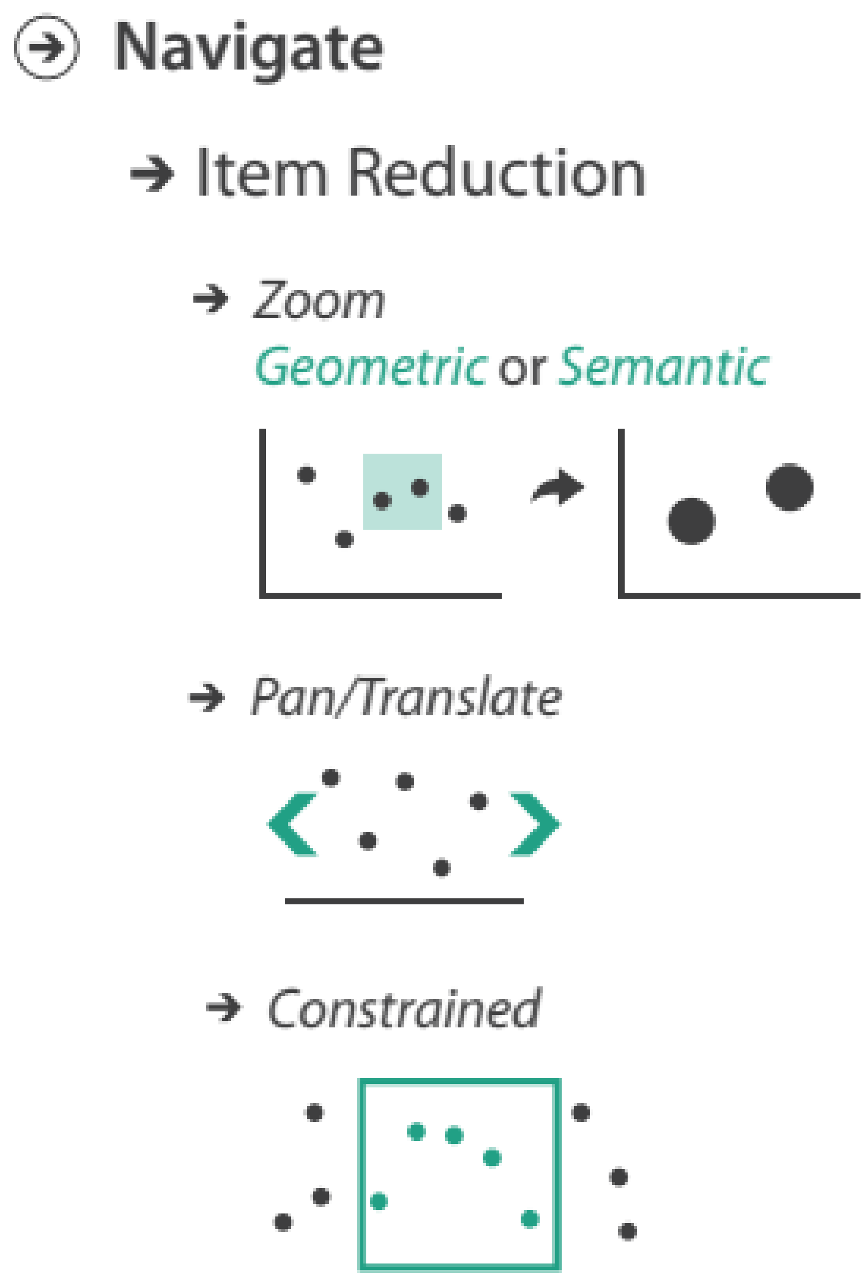
- highlight: change visual encoding for selection targets
  - –color
    - limitation: existing color coding hidden
  - –other channels (e.g., motion)
  - –add explicit connection marks between items

Tooltip

- popup information for selection
  - hover or click
  - can provide useful additional detail on demand
  - beware: does not support overview!
    - always consider if there’s a way to visually encode directly to provide overview
    - “If you make a rollover or tooltip, assume nobody will see it. If it's important, make it explicit. “
      - Gregor Aisch, NYTimes

Navigate: Changing item visibility

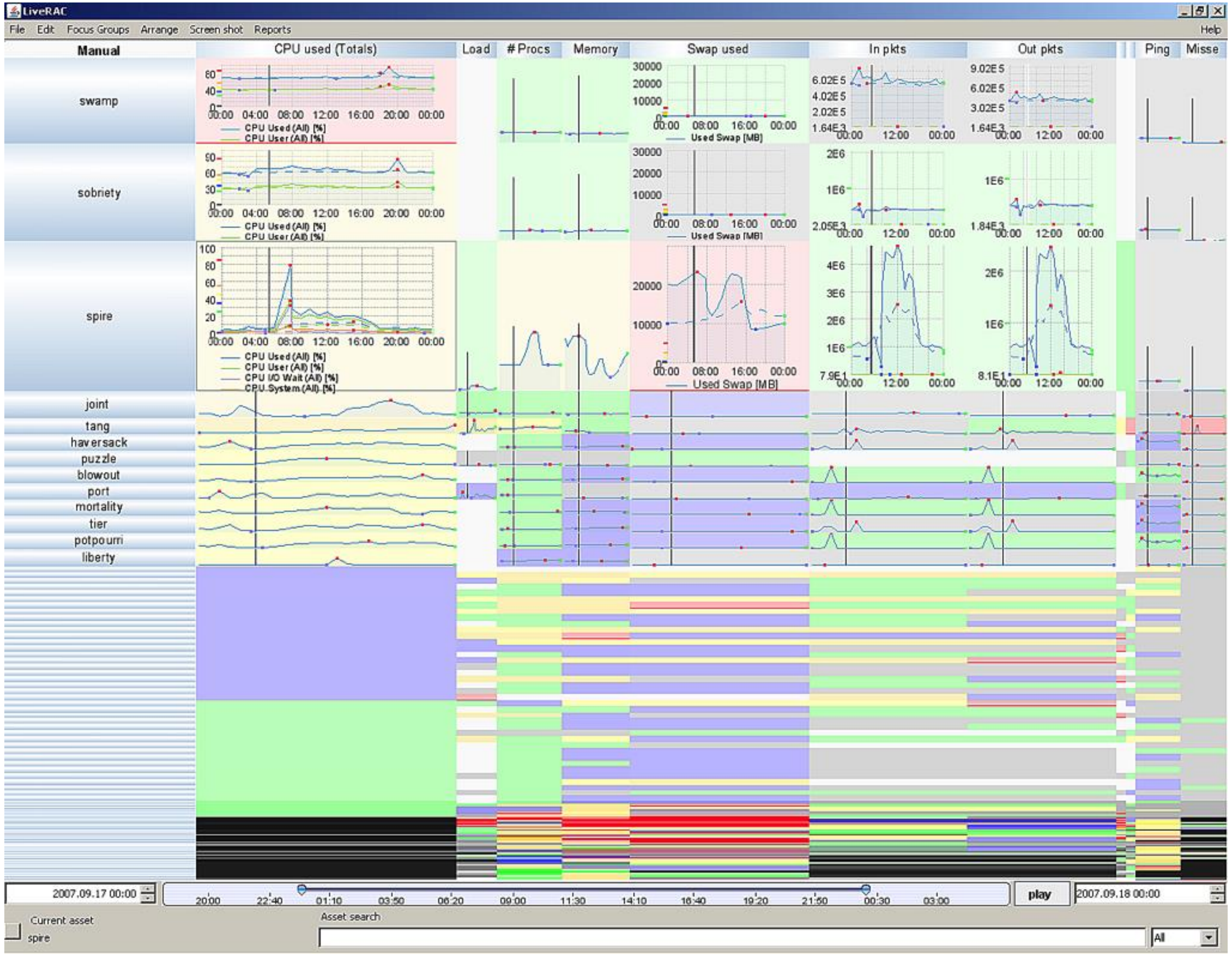
- change viewpoint
  - –changes which items are visible within view
  - –camera metaphor
    - zoom
      - –geometric zoom: familiar semantics
      - –semantic zoom: adapt object representation based on available pixels
        - » dramatic change, or more subtle one
    - pan/translate
    - rotate
      - –especially in 3D
  - –constrained navigation
    - often with animated transitions
    - often based on selection set



Idiom: **Semantic zooming**

System: **LiveRAC**

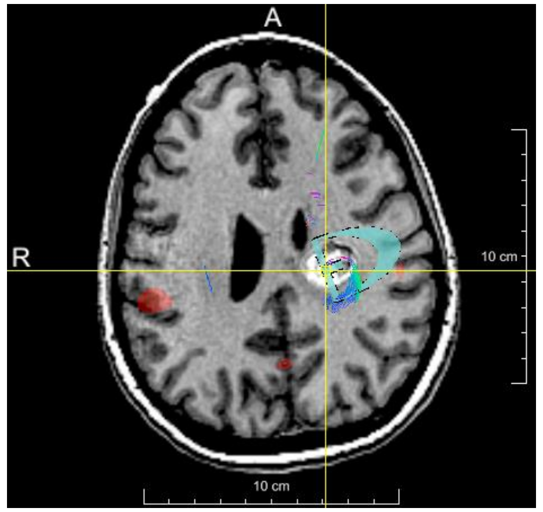
- visual encoding change
  - –colored box
  - –sparkline
  - –simple line chart
  - –full chart: axes and tickmarks

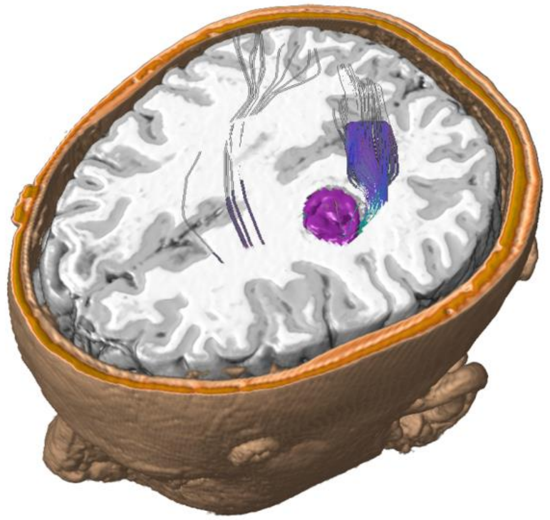


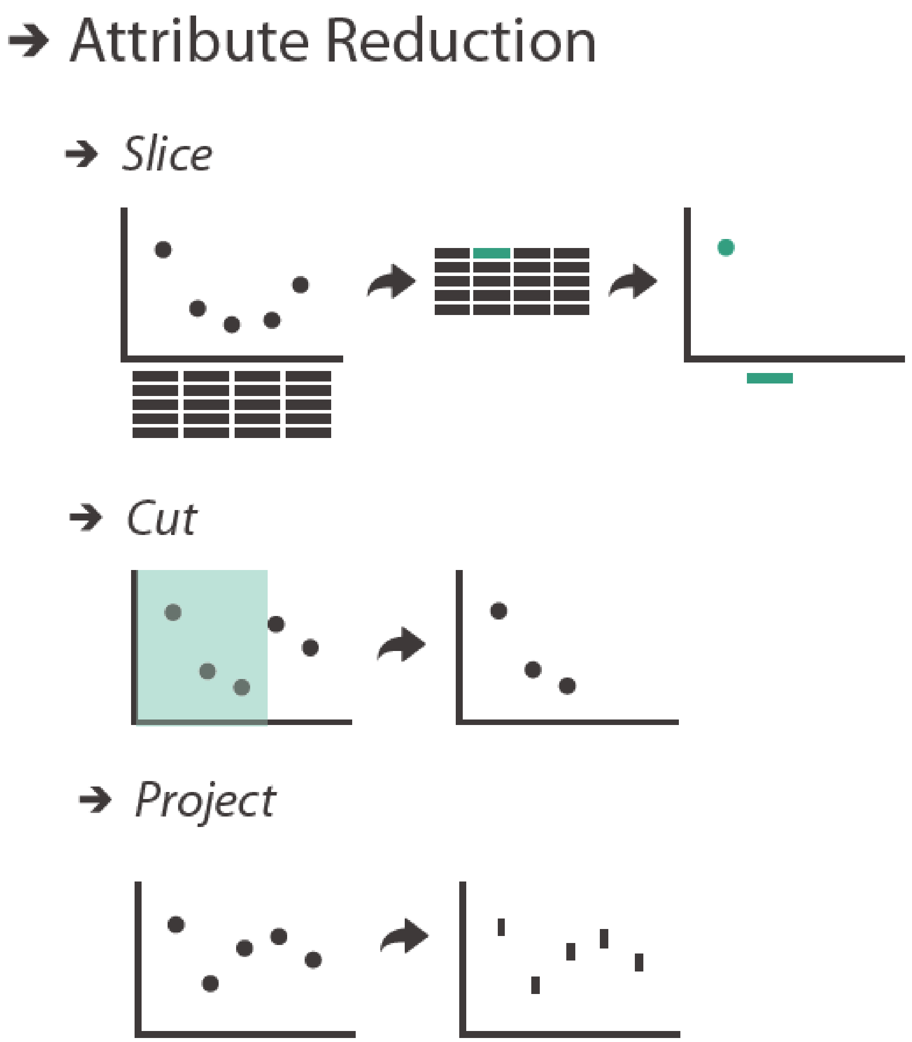
[LiveRAC - Interactive Visual Exploration of System Management Time-Series Data. McLachlan, Munzner, Koutsofios, and North. Proc. ACM Conf. Human Factors in Computing Systems (CHI), pp. 1483–1492, 2008.] video

Navigate: Reducing attributes

- continuation of camera metaphor
  - slice
    - show only items matching specific value for given attribute: slicing plane
    - axis aligned, or arbitrary alignment
  - cut
    - show only items on far slide of plane from camera
  - project
    - change mathematics of image creation
      - orthographic
      - perspective
      - many others: Mercator, cabinet, ...



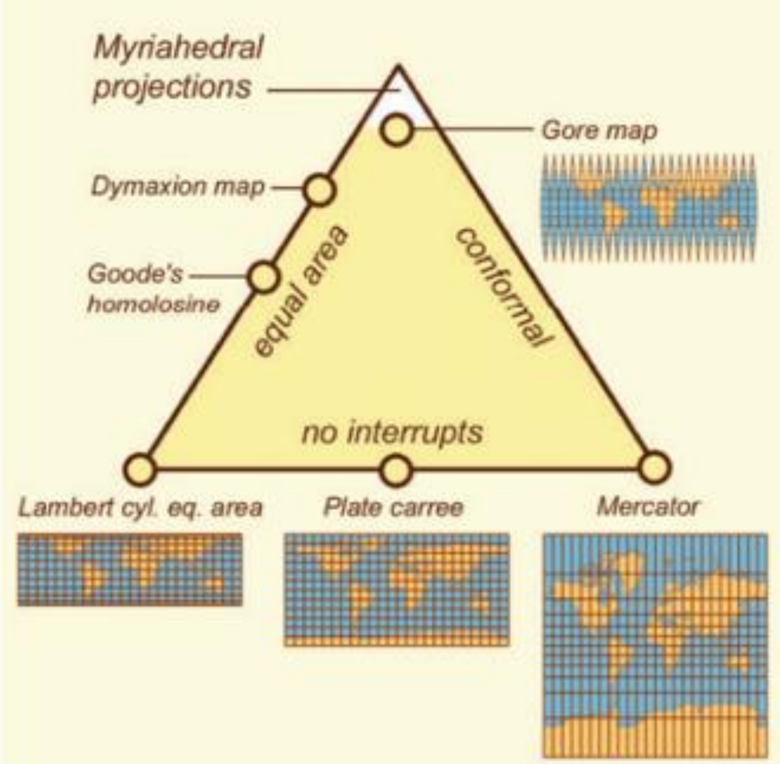




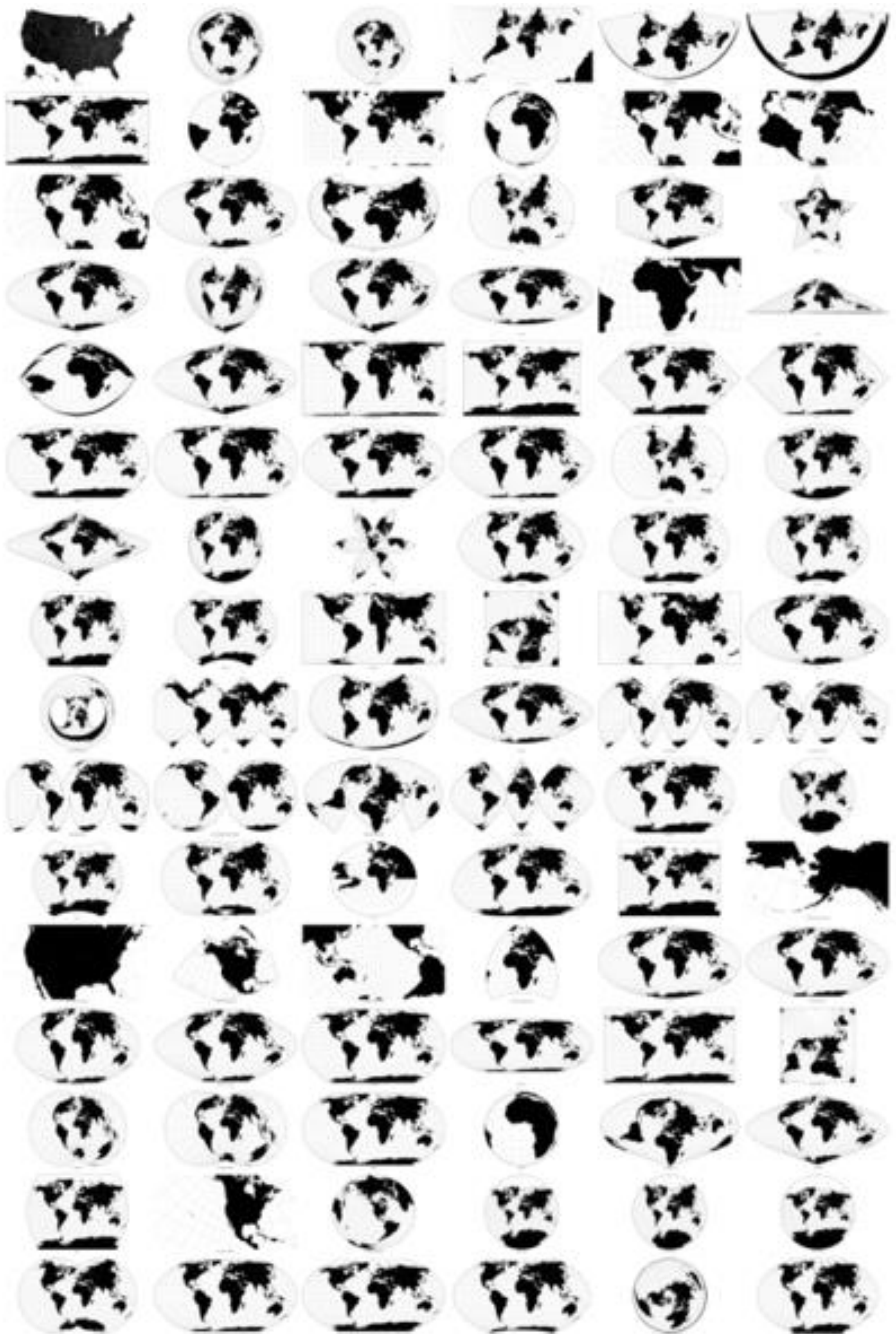
[Interactive Visualization of Multimodal Volume Data for Neurosurgical Tumor Treatment. Rieder, Ritter, Raspe, and Peitgen. Computer Graphics Forum (Proc. EuroVis 2008) 27:3 (2008), 1055–1062.]

Navigate: Reducing attributes

- project from 2D sphere surface to 2D plane
  - can only fully preserve 2 out of 3
    - angles: conformal
    - area: equal area
    - contiguity: no interruptions



https://www.win.tue.nl/~vanwijk/myriahedral/



[Every Map projection] (*https://bl.ocks.org/mbostock/29cddc0006f8b98eff12e60dd08f59a7*)

Interaction benefits

- **interaction pros**
  - major advantage of computer-based vs paper-based visualization
  - flexible, powerful, intuitive
    - exploratory data analysis: change as you go during analysis process
    - fluid task switching: different visual encodings support different tasks
  - animated transitions provide excellent support
    - empirical evidence that animated transitions help people stay oriented

Interaction limitations

- interaction has a time cost
  - sometimes minor, sometimes significant
  - degenerates to human-powered search in worst case
- remembering previous state imposes cognitive load
  - rule of thumb: eyes over memory
    - hard to compare visible item to memory of what you saw
    - ex: maintaining context/orientation when navigating
    - ex: tracking complex changes during animation
- controls may take screen real estate
  - or invisible functionality may be difficult to discover (lack of affordances)
- users may not interact as planned by designer
  - NYTimes logs show ~90% don't interact beyond scrollytelling - Aisch, 2016

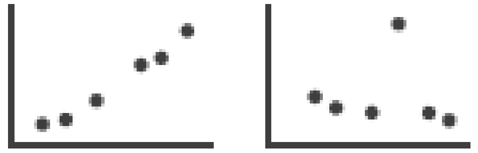
Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - *Chap 11: Manipulate View*
- *Animated Transitions in Statistical Data Graphics.* Heer and Robertson. IEEE Trans. on Visualization and Computer Graphics (Proc. InfoVis07) 13:6 (2007), 1240– 1247.
- *Selection: 524,288 Ways to Say "This is Interesting".* Wills. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 54–61, 1996.
- *Smooth and efficient zooming and panning.* van Wijk and Nuij. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 15–22, 2003.
- *Starting Simple - adding value to static visualisation through simple interaction.* Dix and Ellis. Proc. Advanced Visual Interfaces (AVI), pp. 124–134, 1998.

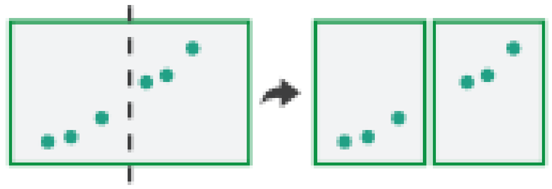
Facet: Juxtapose, Partition, Superimpose

Facet

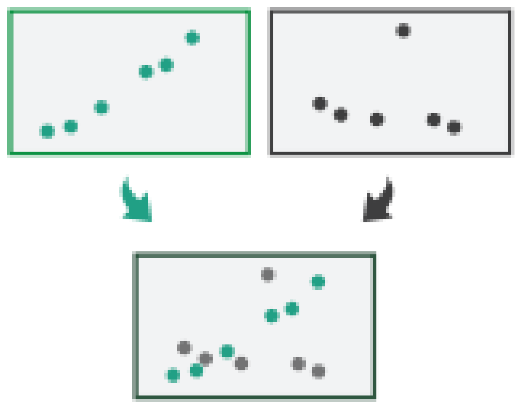
- Juxtapose



- Partition



- Superimpose



Juxtapose and coordinate views

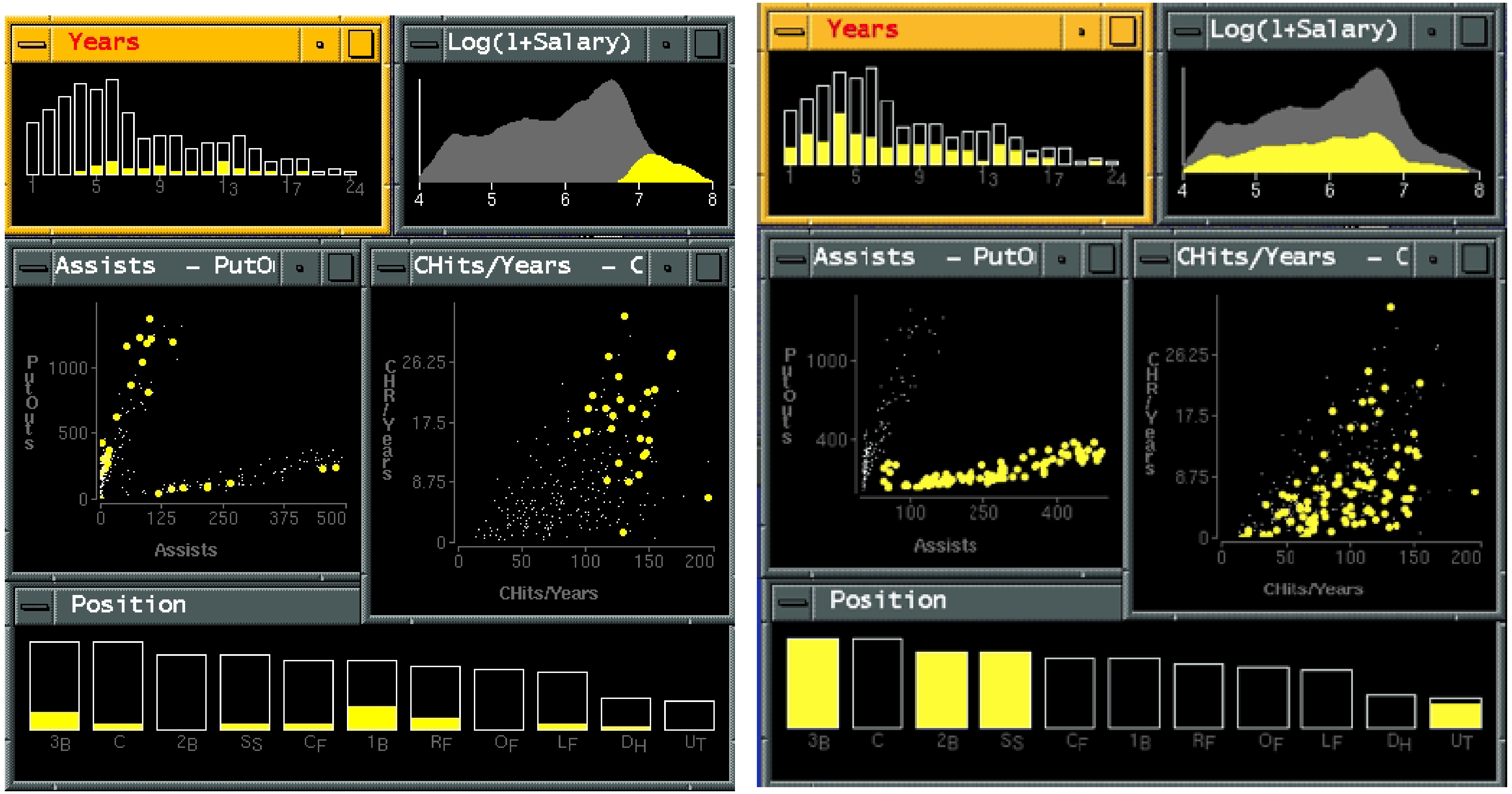
- Share Encoding: Same/Different
  - *Linked Highlighting*

- Share Data: All/Subset/None

- Share Navigation

Idiom: **Linked highlighting** System: **EDV**

- see how regions contiguous in one view are distributed within another
  - –powerful and pervasive interaction idiom
- <u>encoding: different</u>
  - –*multiform*
- data: all shared



[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

Idiom: **bird's-eye maps**

System: **Google Maps**

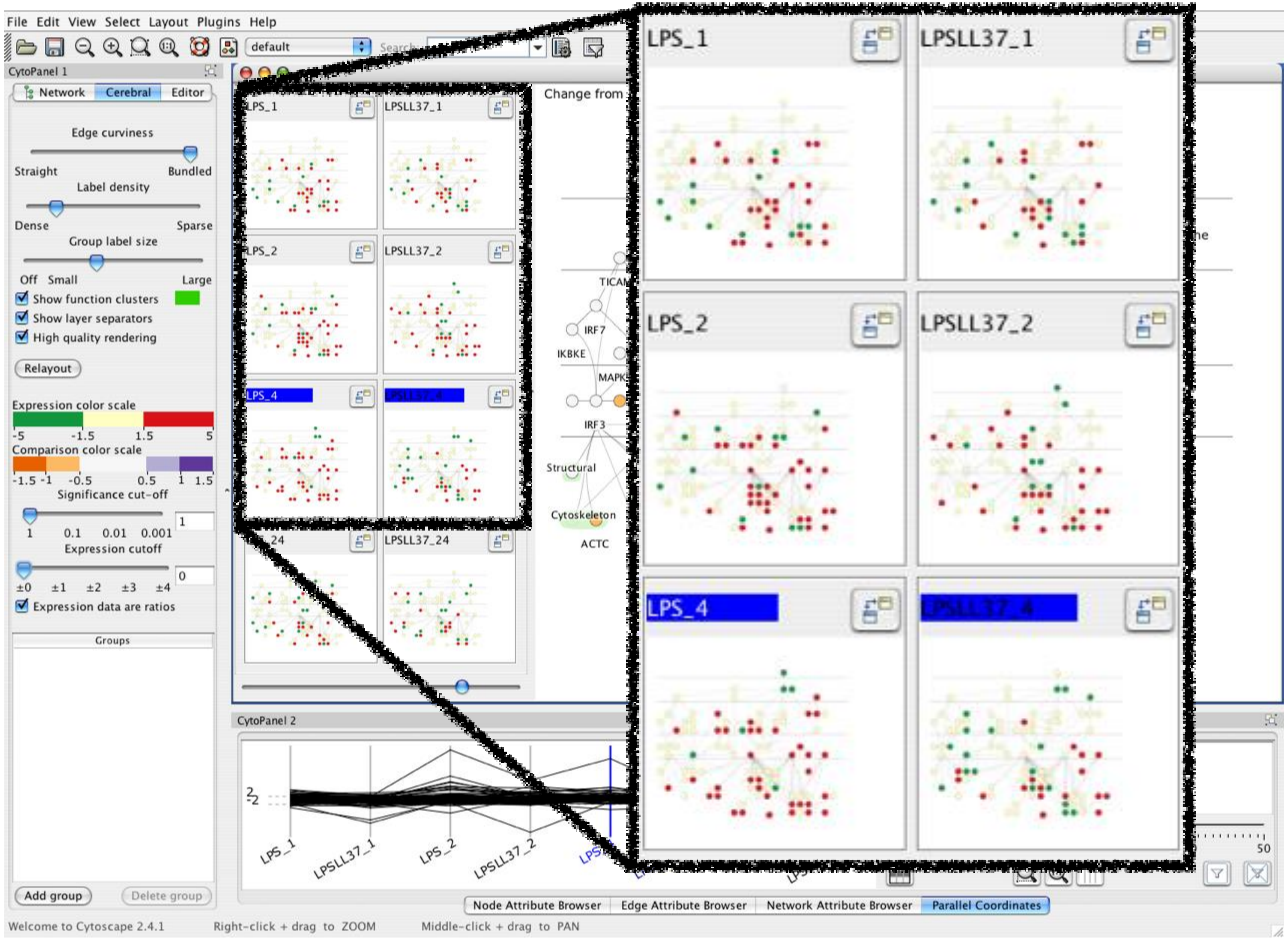
- encoding: same
- data: subset shared
- navigation: shared
  - –bidirectional linking
- differences
  - –viewpoint
  - –(size)
- *overview-detail*

[A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.]

Idiom: **Small multiples**

System:

- encoding: same
- data: none shared
  - different attributes for node colors
  - (same network layout)
- navigation: shared

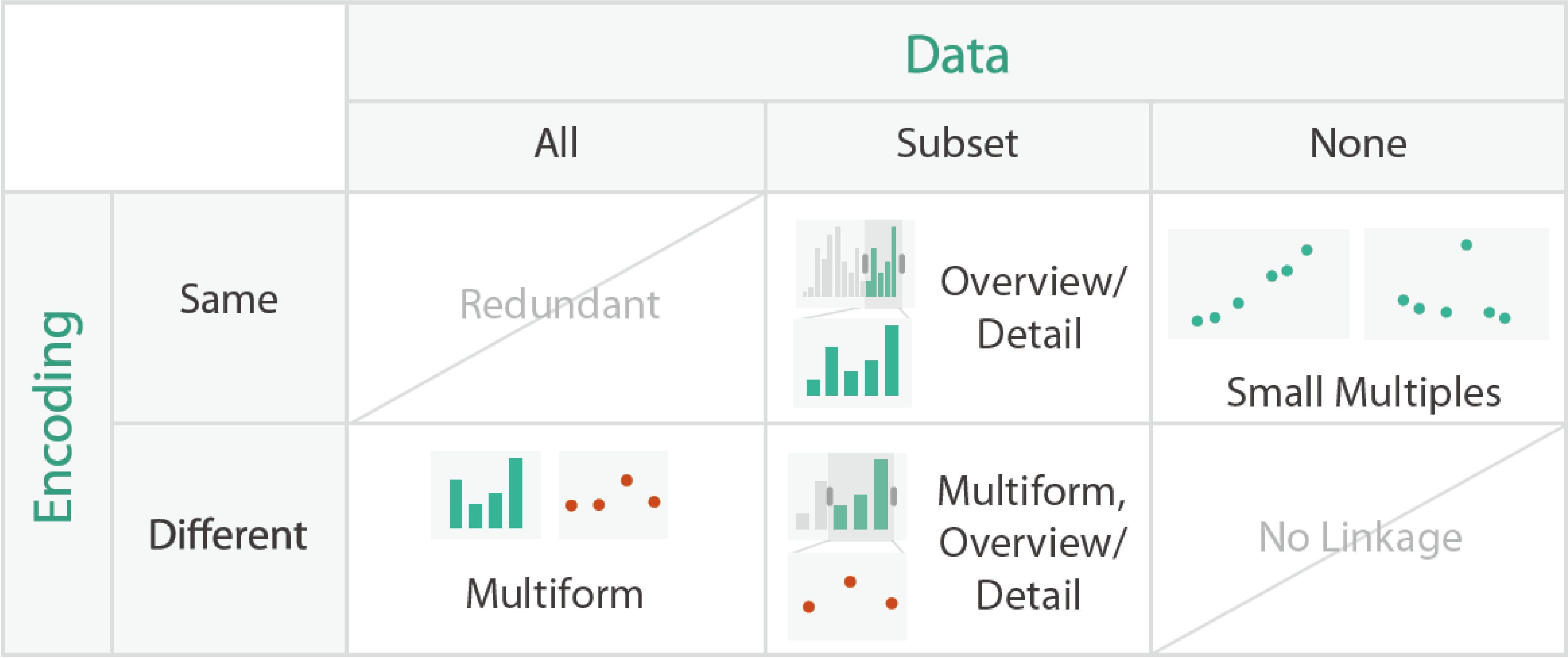


[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]

Juxtapose design choices

- View count
  - few vs many
    - How many is too many? Open research question
  - View visibility
    - Always side by side *vs* temporary popups
  - View arrangement
    - User managed *vs* system arranges/aligns

Coordinate views: Design choice interaction

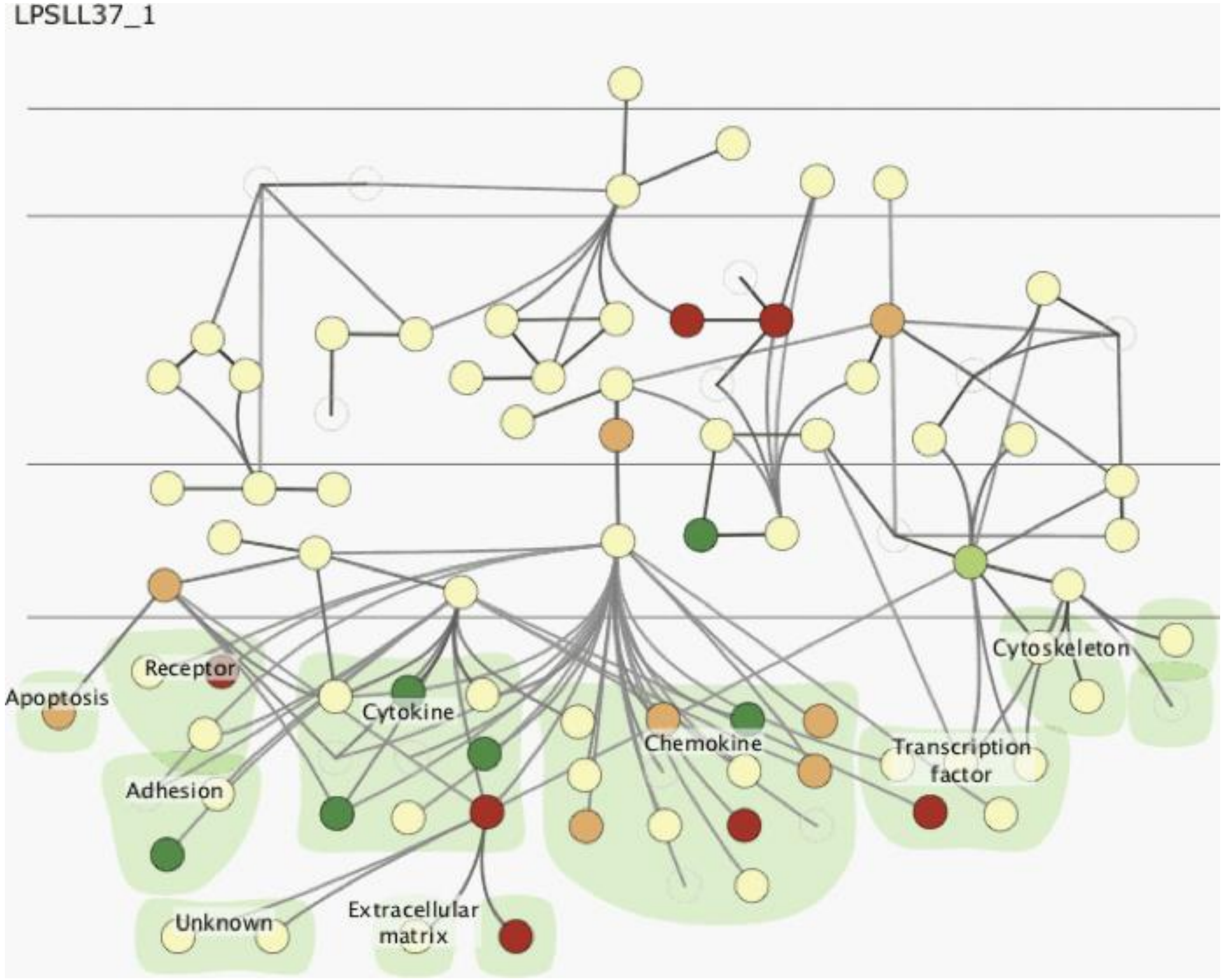


- why juxtapose views?
  - –benefits: eyes vs memory
    - lower cognitive load to move eyes between 2 views than remembering previous state with single changing view
  - –costs: display area, 2 views side by side each have only half the area of one view

Why not animation?

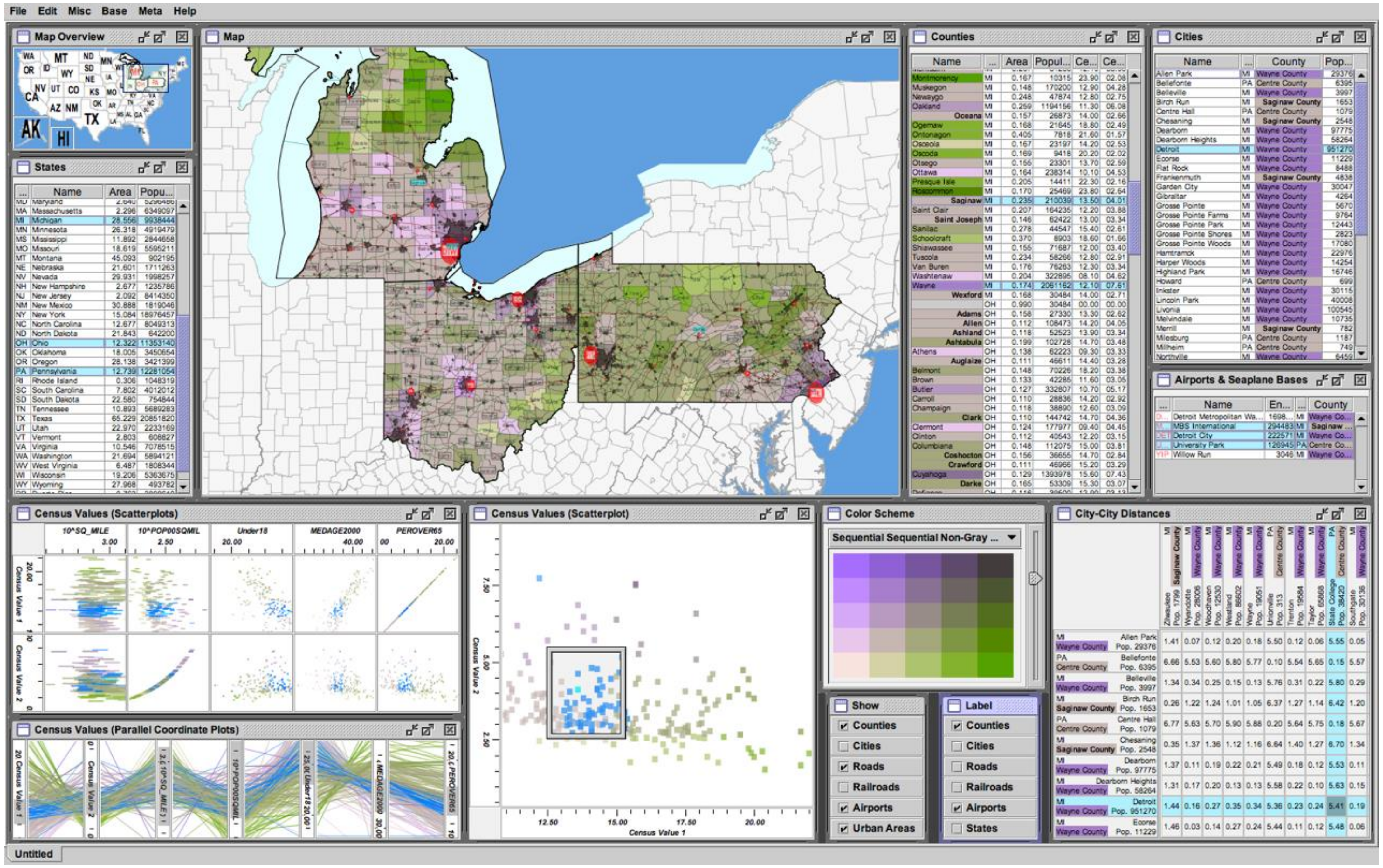
- disparate frames and regions: comparison difficult
  - –vs contiguous frames
  - –vs small region
  - –vs coherent motion of group

- safe special case
  - –animated transitions



System: **Improvise**

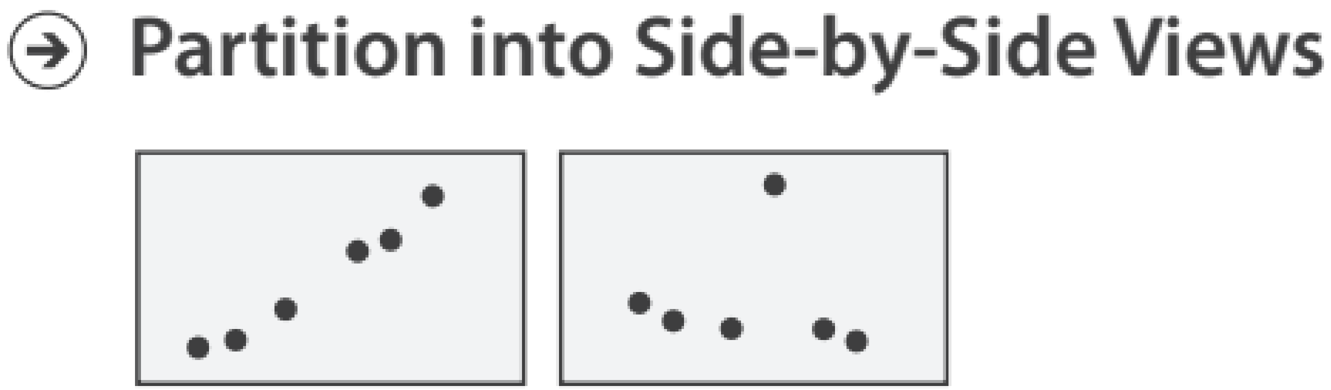
- investigate power of multiple views
  - pushing limits on view count, interaction complexity
  - how many is ok?
    - open research question
  - reorderable lists
    - easy lookup
    - useful when linked to other encodings

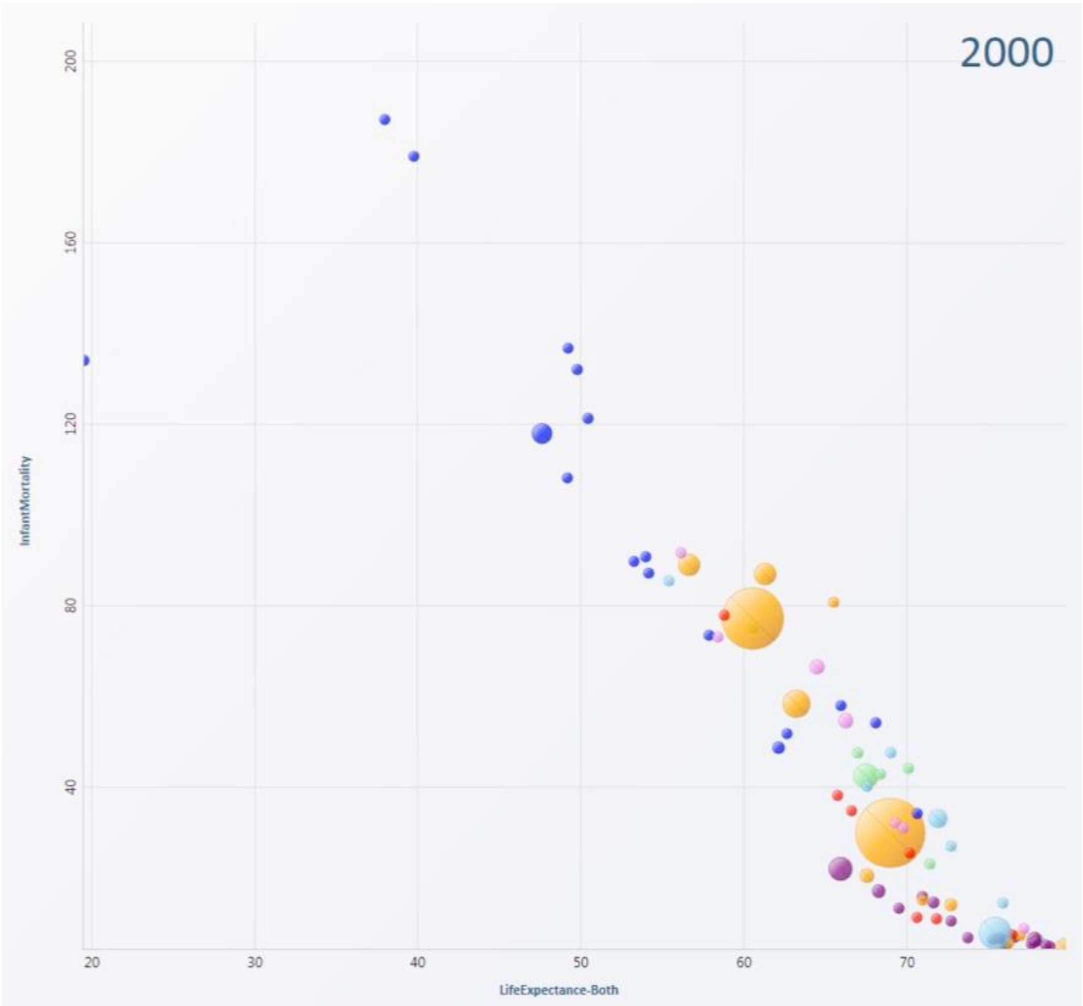


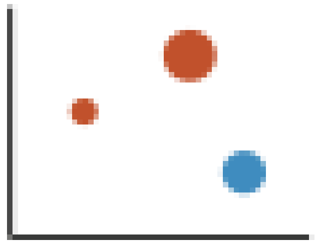
[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.] *video-census*

Partition into views

- how to divide data between views
  - split into regions by attributes
  - encodes association between items using spatial proximity
  - order of splits has major implications for what patterns are visible
- no strict dividing line
  - ***view**: big/detailed*
    - contiguous region in which visually encoded data is shown on the display
  - ***glyph**: small/iconic*
    - object with internal structure that arises from multiple marks

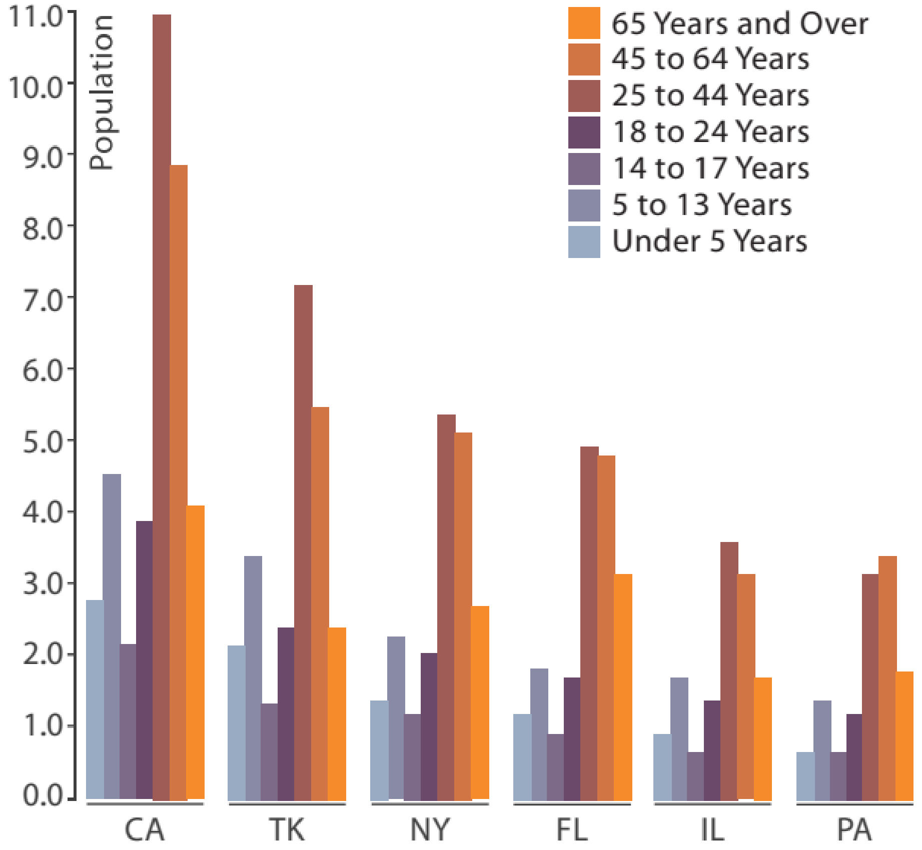




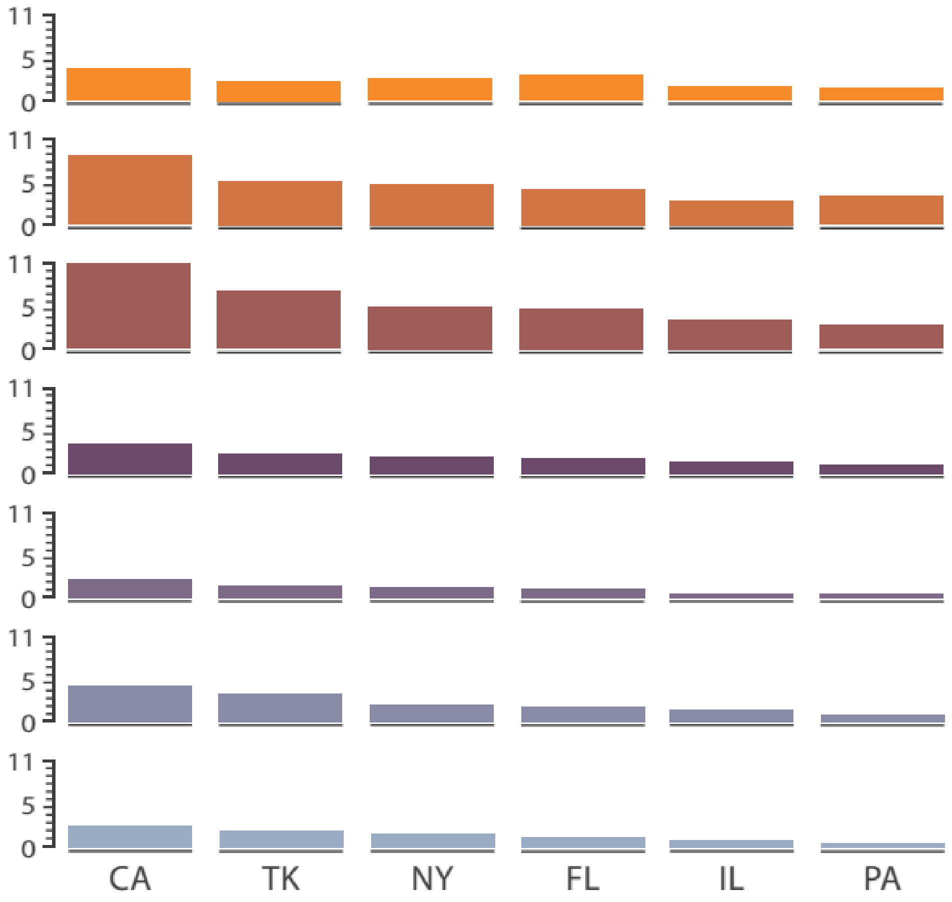


Partitioning: List alignment

- single bar chart with grouped bars
  - –split by state into regions
    - complex glyph within each region showing all ages
  - –compare: easy within state, hard across ages



- small-multiple bar charts
  - split by age into regions
    - one chart per region
  - compare: easy within age, harder across states

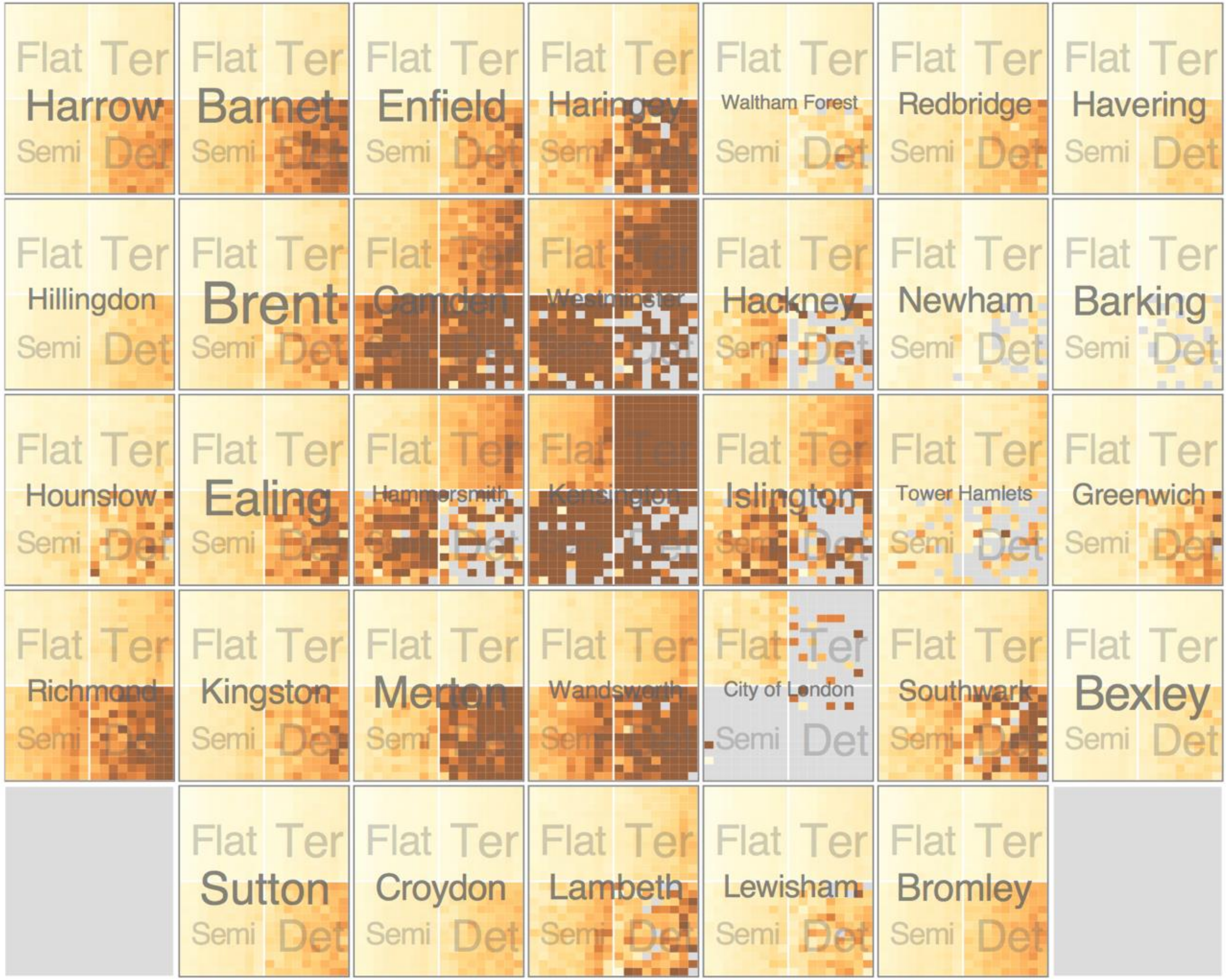


Partitioning: Recursive subdivision

System: **HIVE**

- split by neighborhood
- then by type
- then time
  - –years as rows
  - –months as columns
- color by price

- neighborhood patterns
  - –where it's expensive
  - –where you pay much more for detached type



[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.] [video]

Partitioning: Recursive subdivision

System: **HIVE**

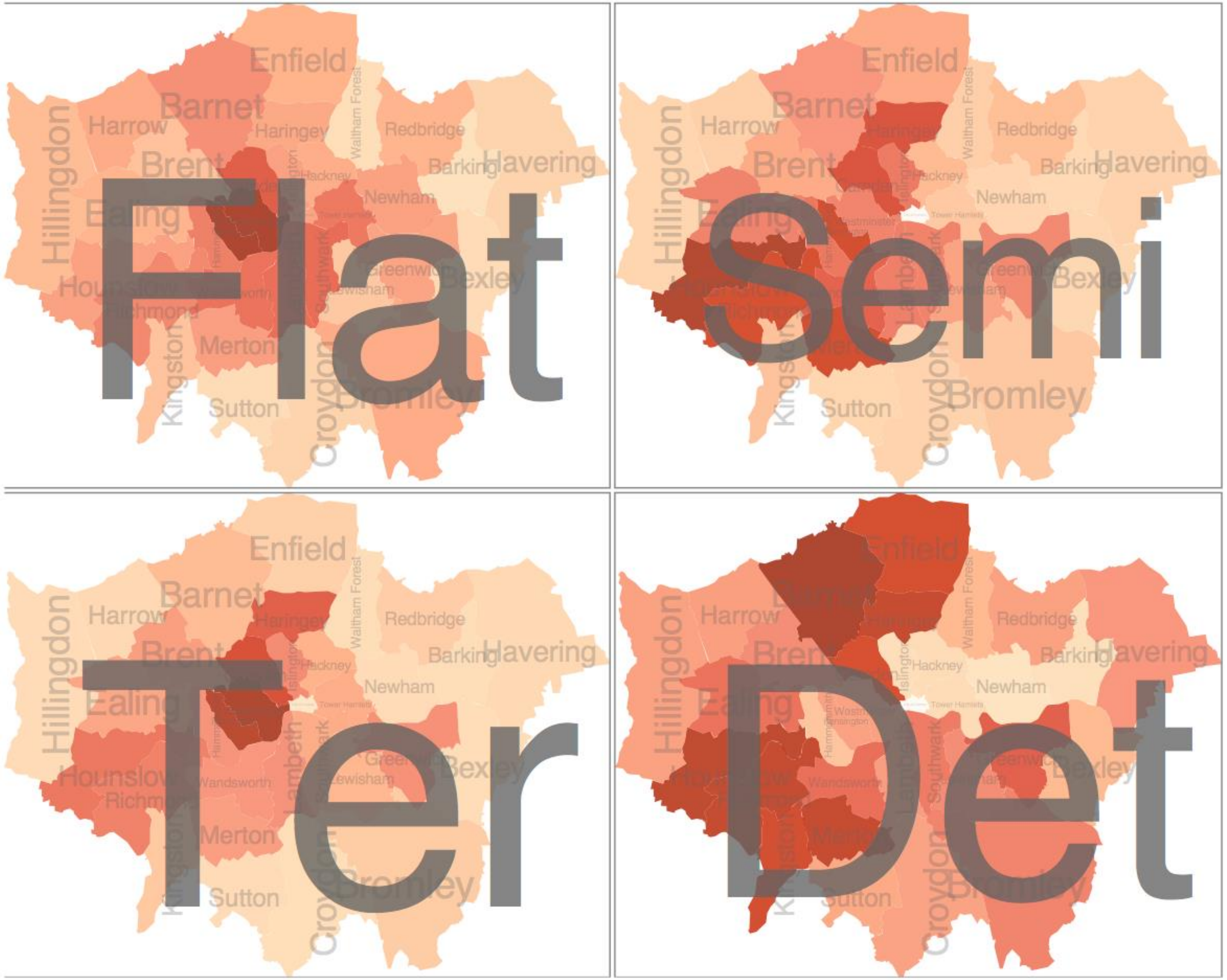
- switch order of splits
  - –type then neighborhood
- switch color
  - –by price variation

- type patterns
  - –within specific type, which neighborhoods inconsistent

[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision

- different encoding for second-level regions
  - –choropleth maps

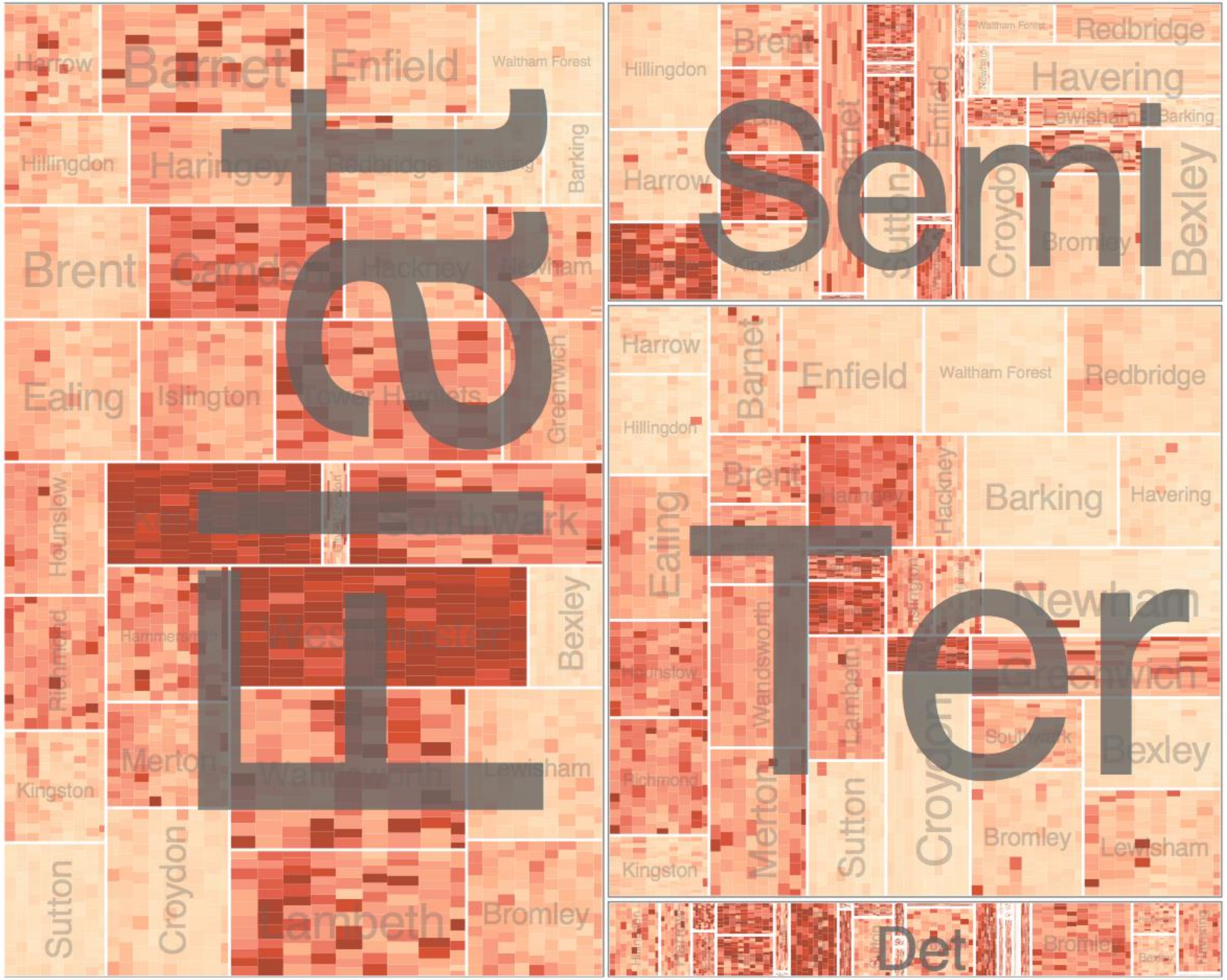


[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision

System: **HIVE**

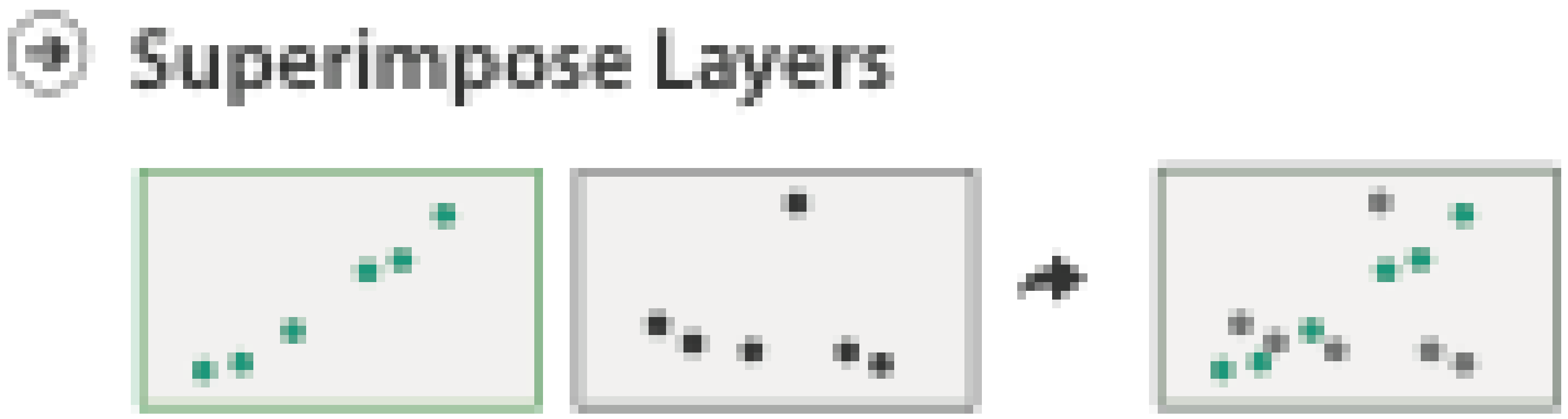
- size regions by sale counts
  - –not uniformly
- result: treemap



[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Superimpose layers

- *layer*: set of objects spread out over region
  - –each set is visually distinguishable group
  - –extent: whole view
- design choices
  - –how many layers, how to distinguish?
    - encode with different, nonoverlapping channels
    - two layers achieveable, three with careful design
  - –small static set, or dynamic from many possible?



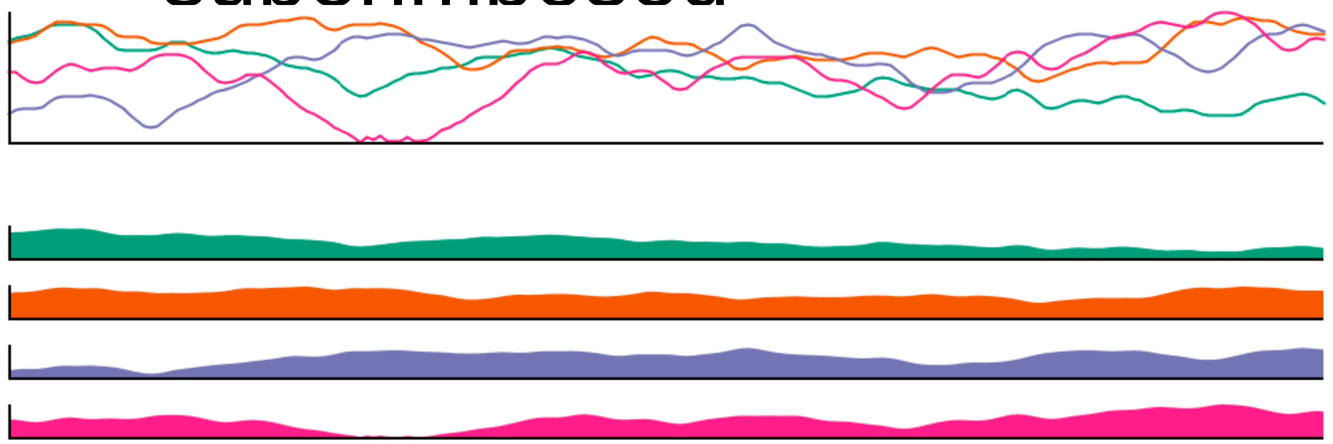
Static visual layering

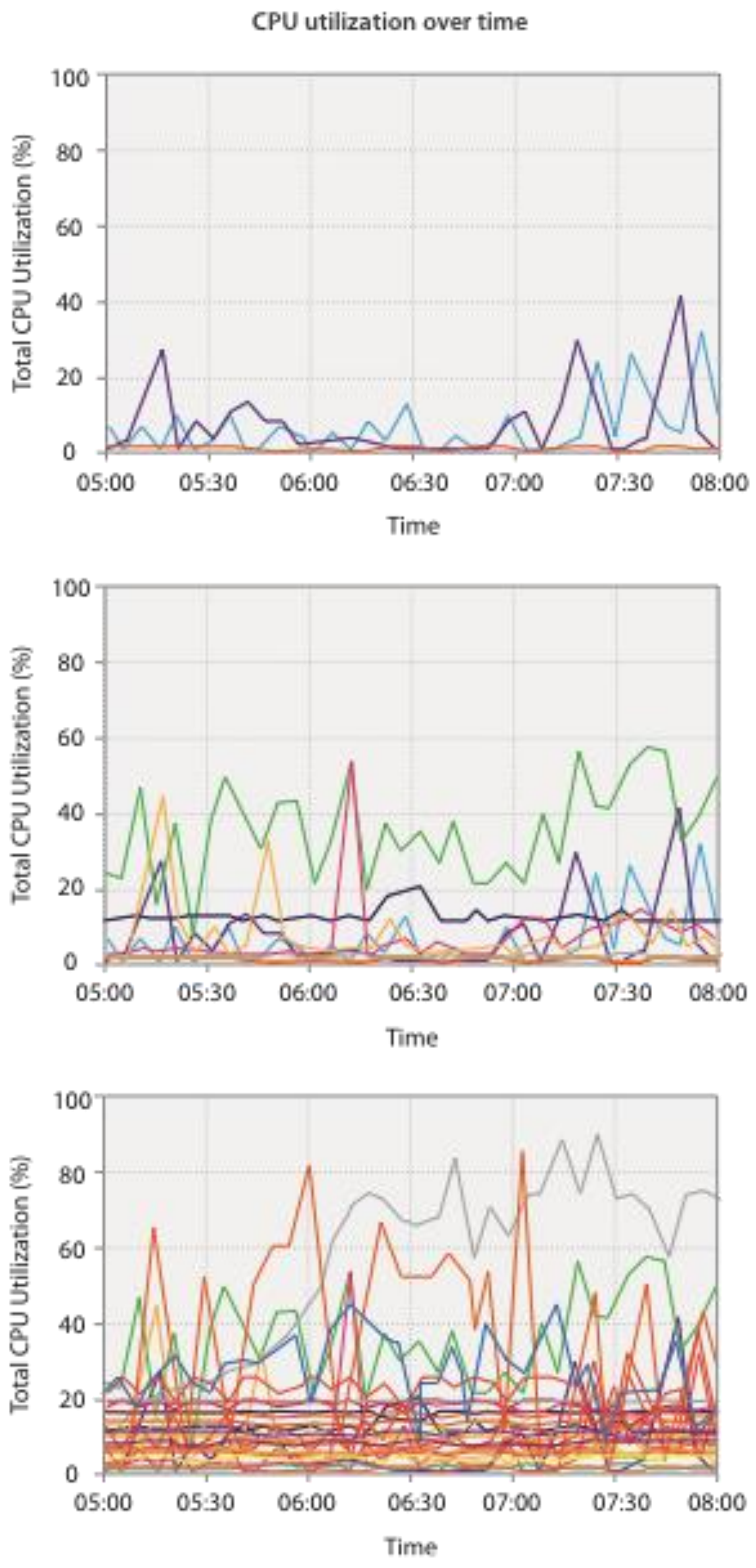
- foreground layer: roads
  - hue, size distinguishing main from minor
  - high luminance contrast from background
- background layer: regions
  - desaturated colors for water, parks, land areas
- user can selectively focus attention
- “get it right in black and white”
  - check luminance contrast with greyscale view

[Get it right in black and white. Stone. 2010. http://www.stonesc.com/wordpress/2010/03/get-it-right-in-black-and-white]

Superimposing limits

- few layers, but many lines
  - –up to a few dozen
  - –but not hundreds
- superimpose vs juxtapose: empirical study
  - –superimposed for local, multiple for global
  - –tasks
    - local: maximum, global: slope, discrimination
  - –same screen space for all multiples vs single superimposed



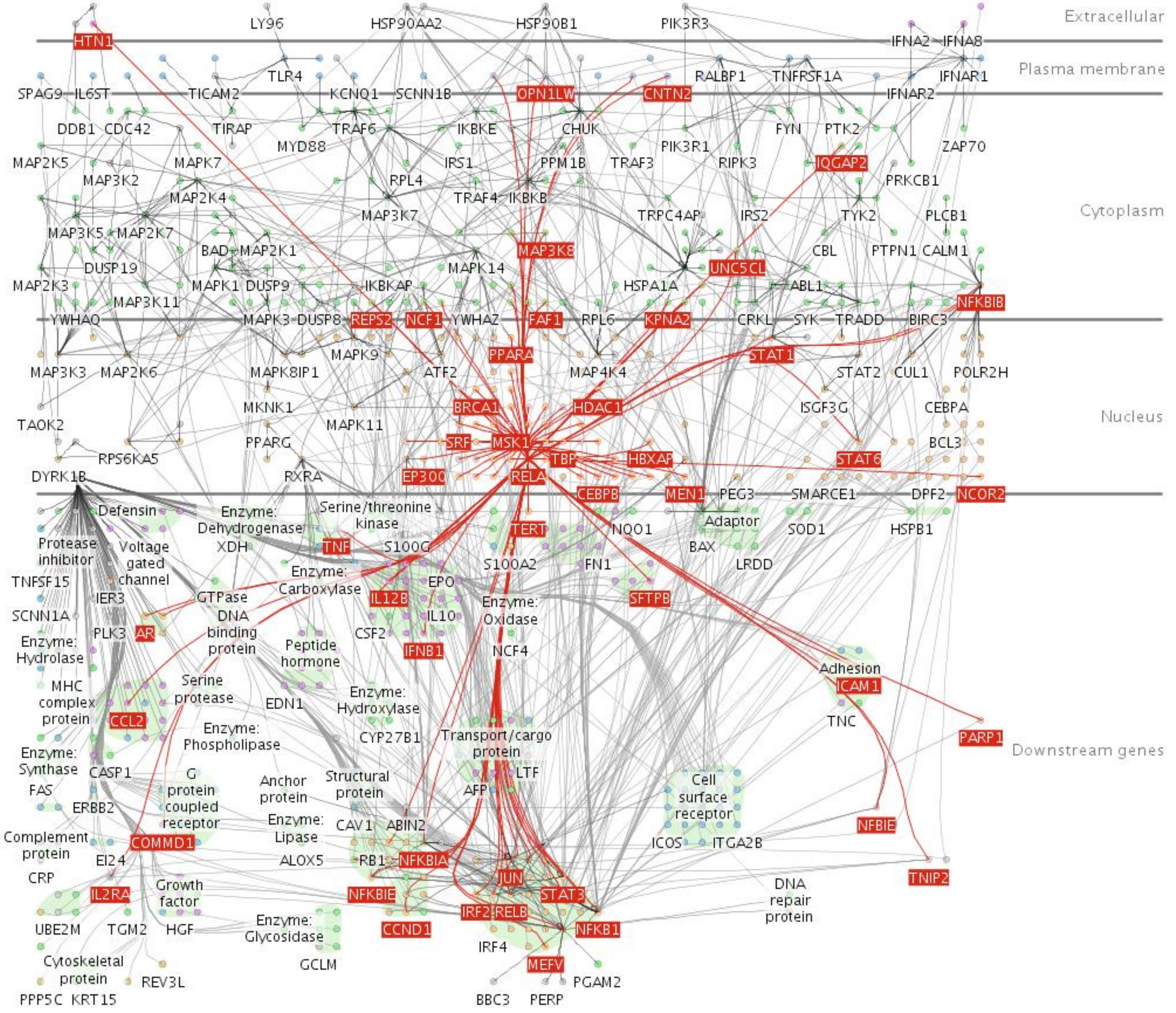


[Graphical Perception of Multiple Time Series. Javed, McDonnel, and Elmqvist. IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]

Dynamic visual layering

System: **Cerebral**

- interactive, from selection
  - lightweight: click
  - very lightweight: hover
- ex: 1-hop neighbors



[Cerebral: a Cytoscape plugin for layout of and interaction with biological networks using subcellular localization annotation. Barsky, Gardy, Hancock, and Munzner. Bioinformatics 23:8 (2007), 1040–1042.]

Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - *Chap 12: Facet Into Multiple Views*
- *A Review of Overview+Detail, Zooming, and Focus+Context Interfaces.* Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.
- *A Guide to Visual Multi-Level Interface Design From Synthesis of Empirical Study Evidence.* Lam and Munzner. Synthesis Lectures on Visualization Series, Morgan Claypool, 2010.
- *Zooming versus multiple window interfaces: Cognitive costs of visual comparisons.* Plumlee and Ware. ACM Trans. on Computer-Human Interaction (ToCHI) 13:2 (2006), 179–209.
- *Exploring the Design Space of Composite Visualization.* Javed and Elmqvist. Proc. Pacific Visualization Symp. (PacificVis), pp. 1–9, 2012.
- *Visual Comparison for Information Visualization.* Gleicher, Albers, Walker, Jusufi, Hansen, and Roberts. Information Visualization 10:4 (2011), 289–309.
- *Guidelines for Using Multiple Views in Information Visualizations.* Baldonado, Woodruff, and Kuchinsky. In Proc. ACM Advanced Visual Interfaces (AVI), pp. 110–119, 2000.
- *Cross-Filtered Views for Multidimensional Visual Analysis.* Weaver. IEEE Trans. Visualization and Computer Graphics 16:2 (Proc. InfoVis 2010), 192–204, 2010.
- *Linked Data Views.* Wills. In Handbook of Data Visualization, Computational Statistics, edited by Unwin, Chen, and Härdle, pp. 216–241. Springer-Verlag, 2008.
- *Glyph-based Visualization: Foundations, Design Guidelines, Techniques and Applications.* Borgo, Kehrer, Chung, Maguire, Laramee, Hauser, Ward, and Chen. In Eurographics State of the Art Reports, pp. 39–63, 2013.