

Information Visualization

Interactive Views

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Lect 8/9/10, 30 Jan & 4/6 Feb 2020

<https://www.cs.ubc.ca/~tmm/courses/436V-20>

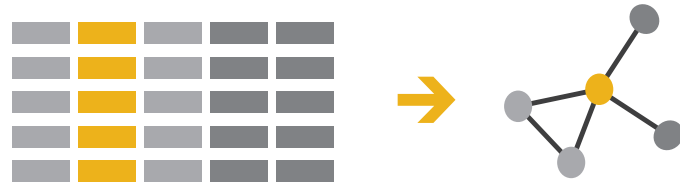
Upcoming

- Foundations 3: out Thu Jan 30, due Wed Feb 5 6pm
- Programming 2: out Thu Jan 30, due Wed Feb 12 6pm
- D3 videos/readings week 4
 - The General Update Pattern of D3.js [60 min]
 - Interaction with Unidirectional Data Flow [16 min]
 - Read: Reusable D3 Components
- Quiz 4, due by Fri Jan 31, 8am

Interactive Views

How to handle complexity: 1 previous strategy + 3 more

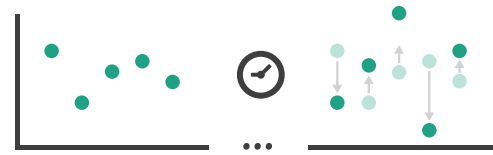
→ *Derive*



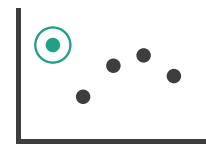
- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate

→ Change



→ Select

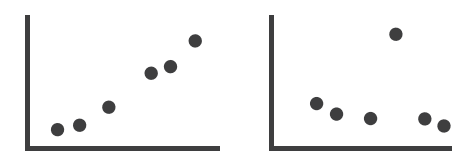


→ Navigate

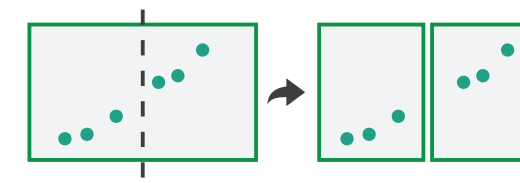


Facet

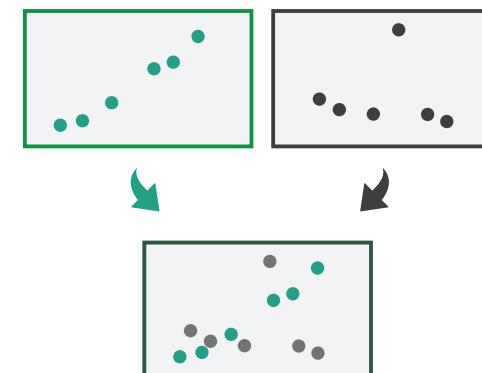
→ Juxtapose



→ Partition

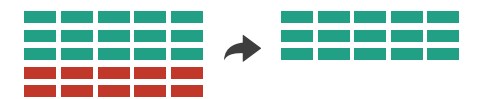


→ Superimpose

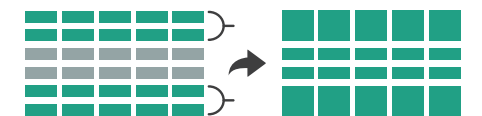


Reduce

→ Filter



→ Aggregate

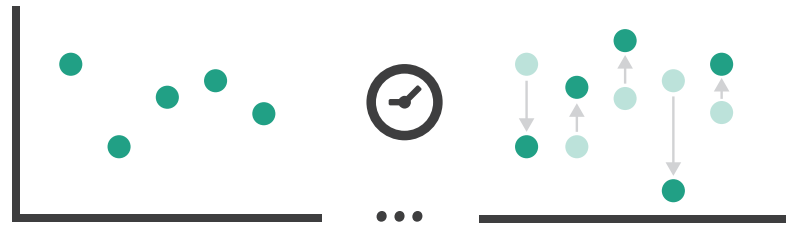


→ Embed

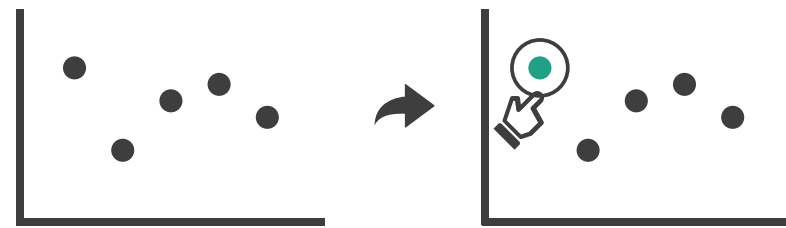


Manipulate

➔ Change over Time



➔ Select

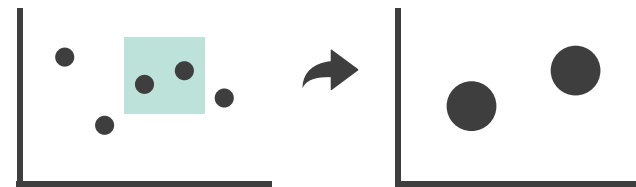


➔ Navigate

➔ Item Reduction

➔ Zoom

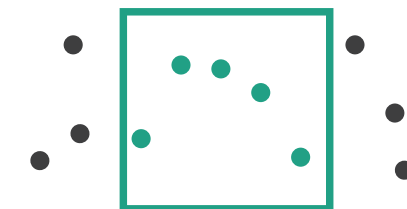
Geometric or *Semantic*



➔ Pan/Translate



➔ Constrained

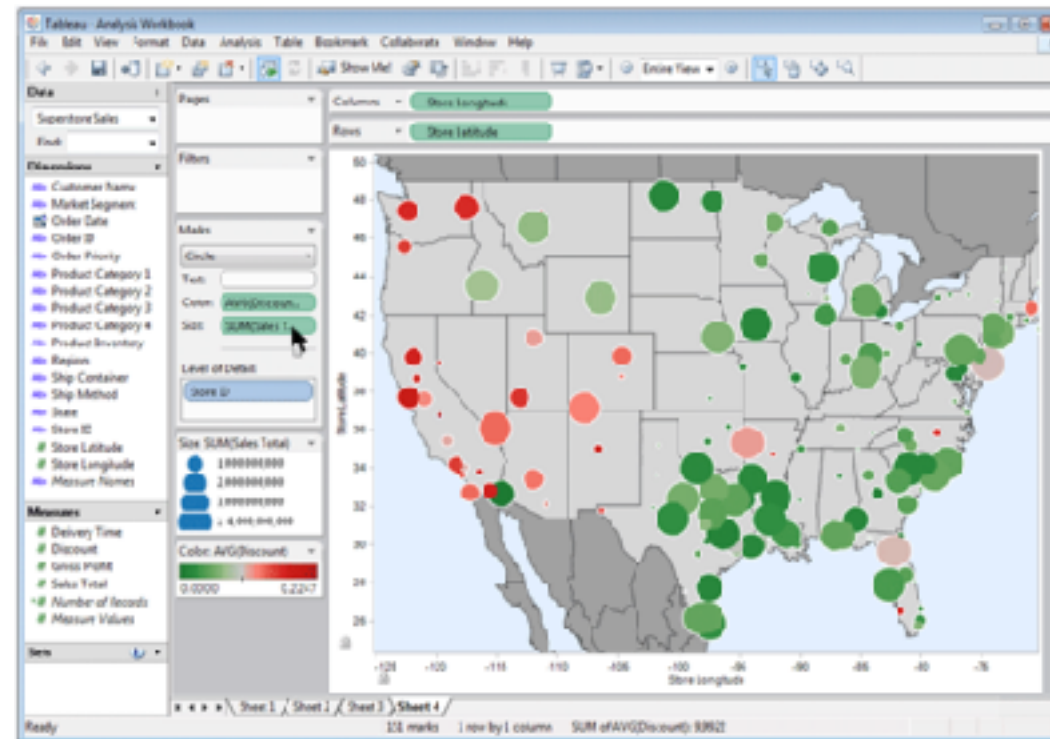
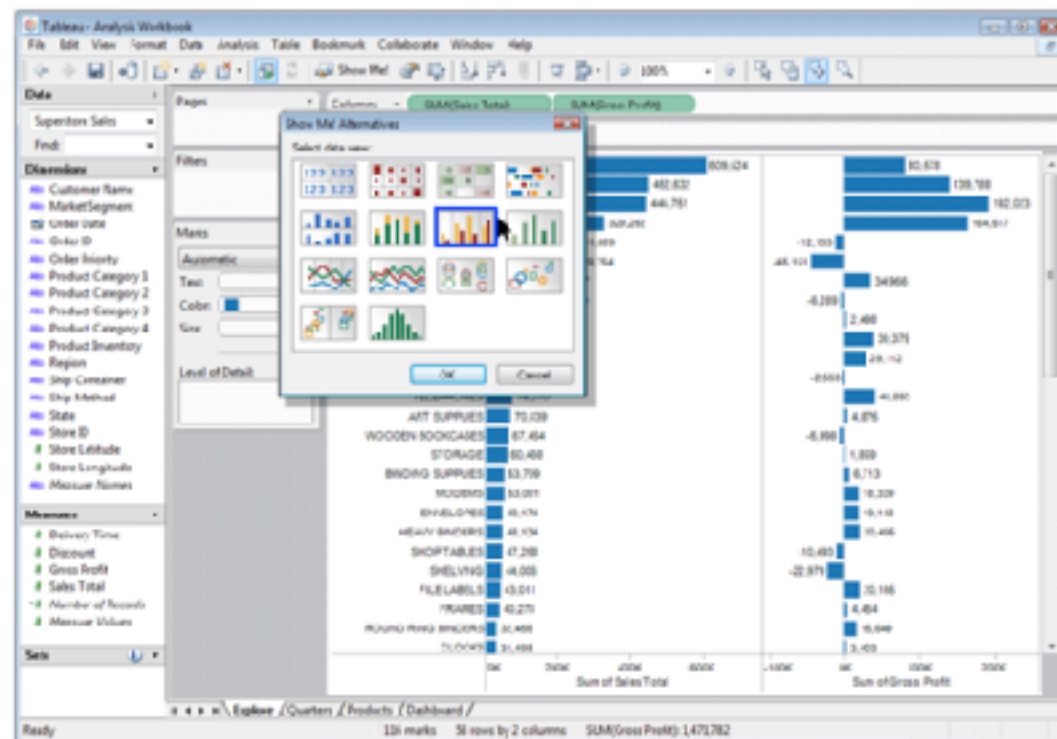
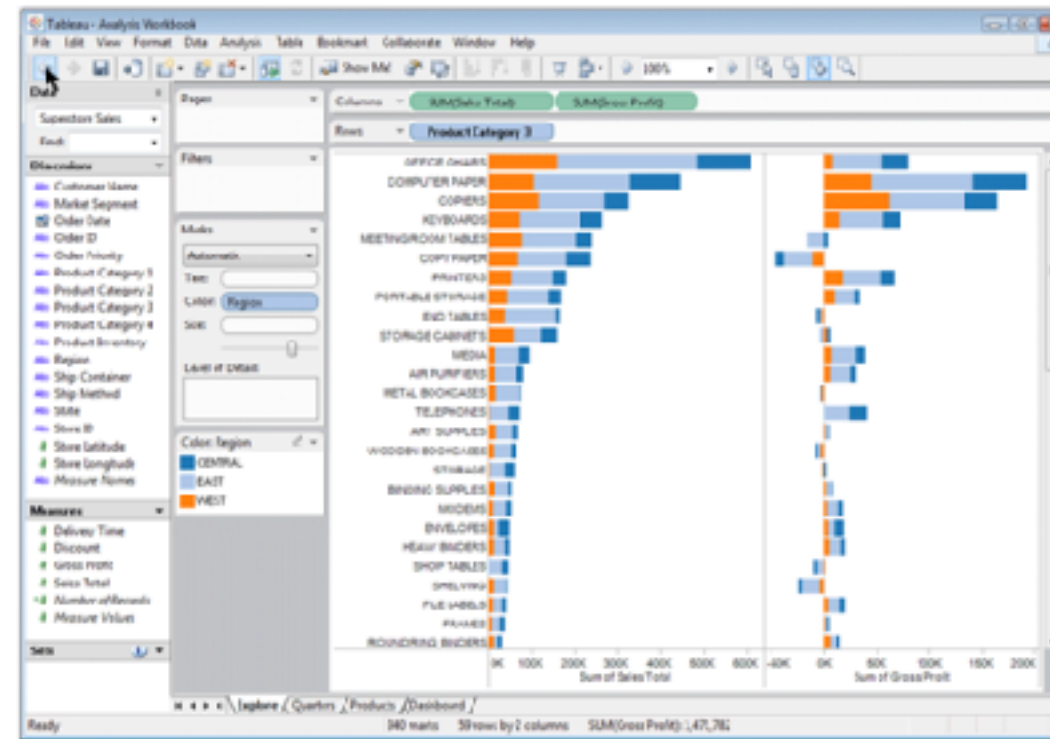
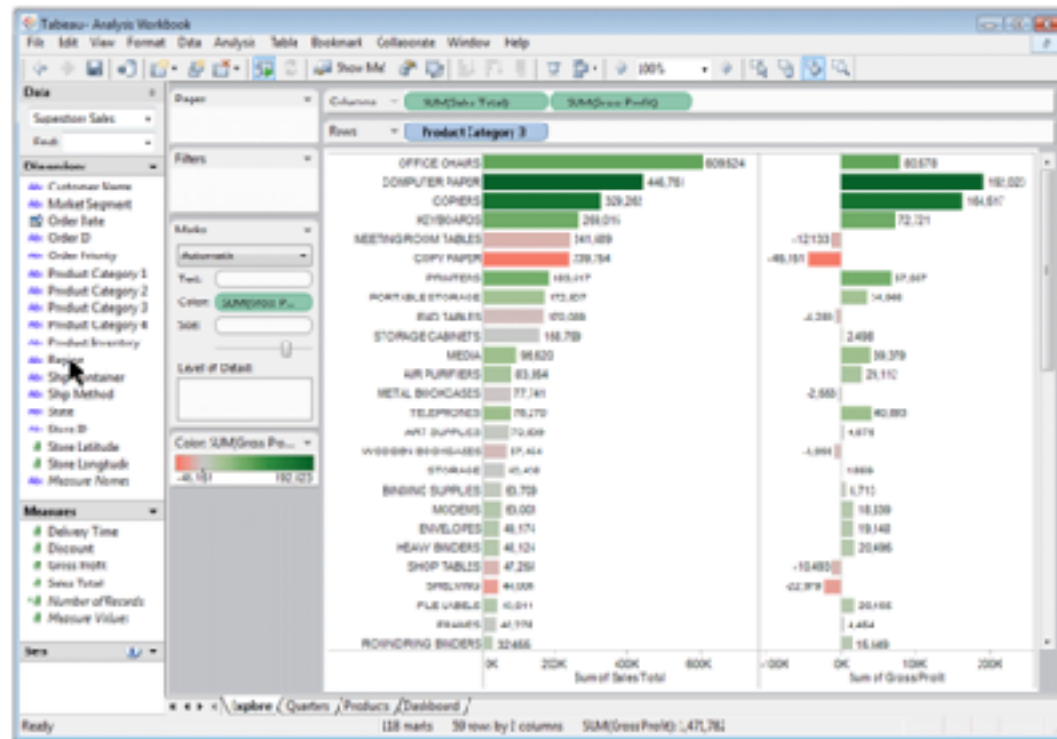


Change over time

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

Idiom: Re-encode

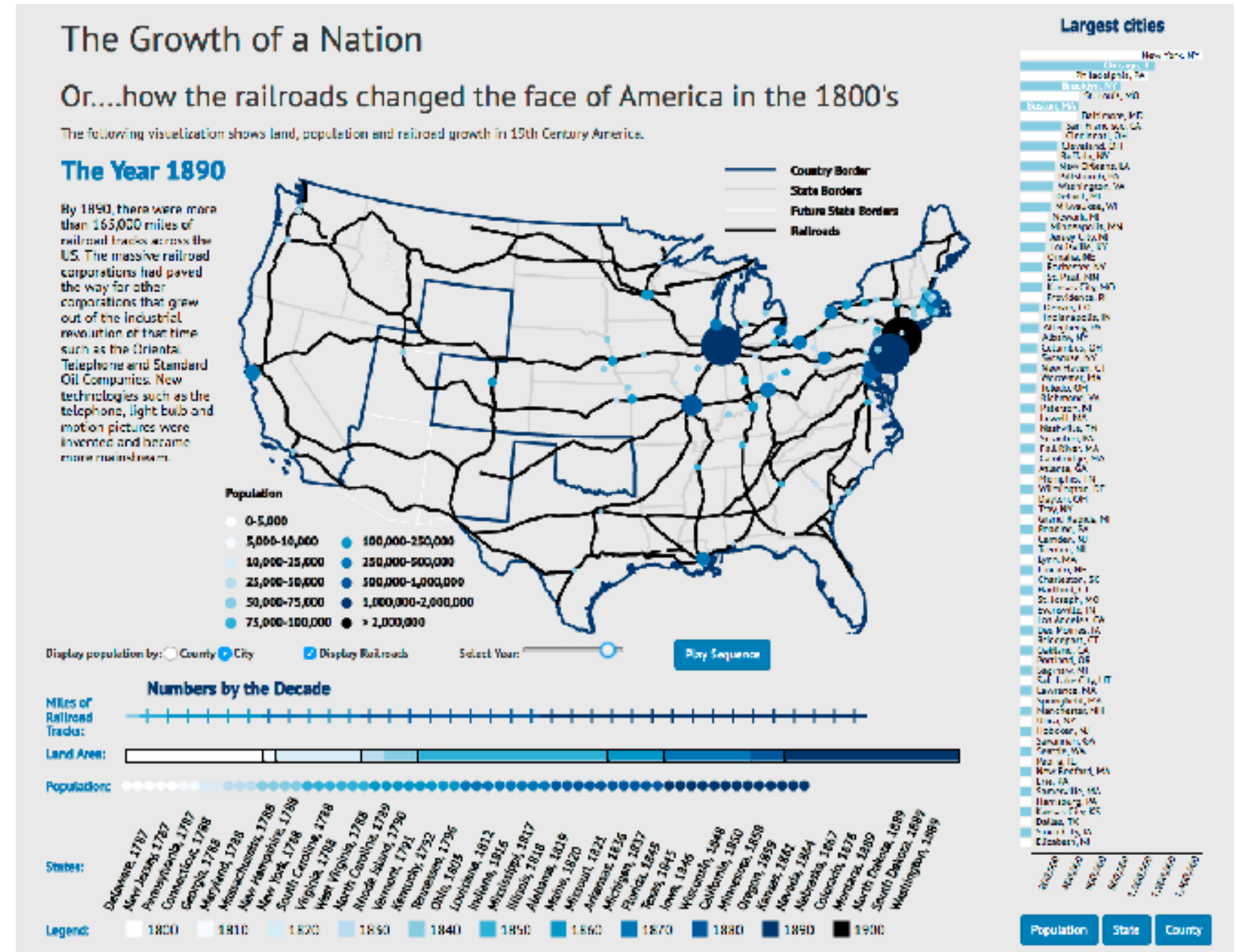
System: Tableau



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

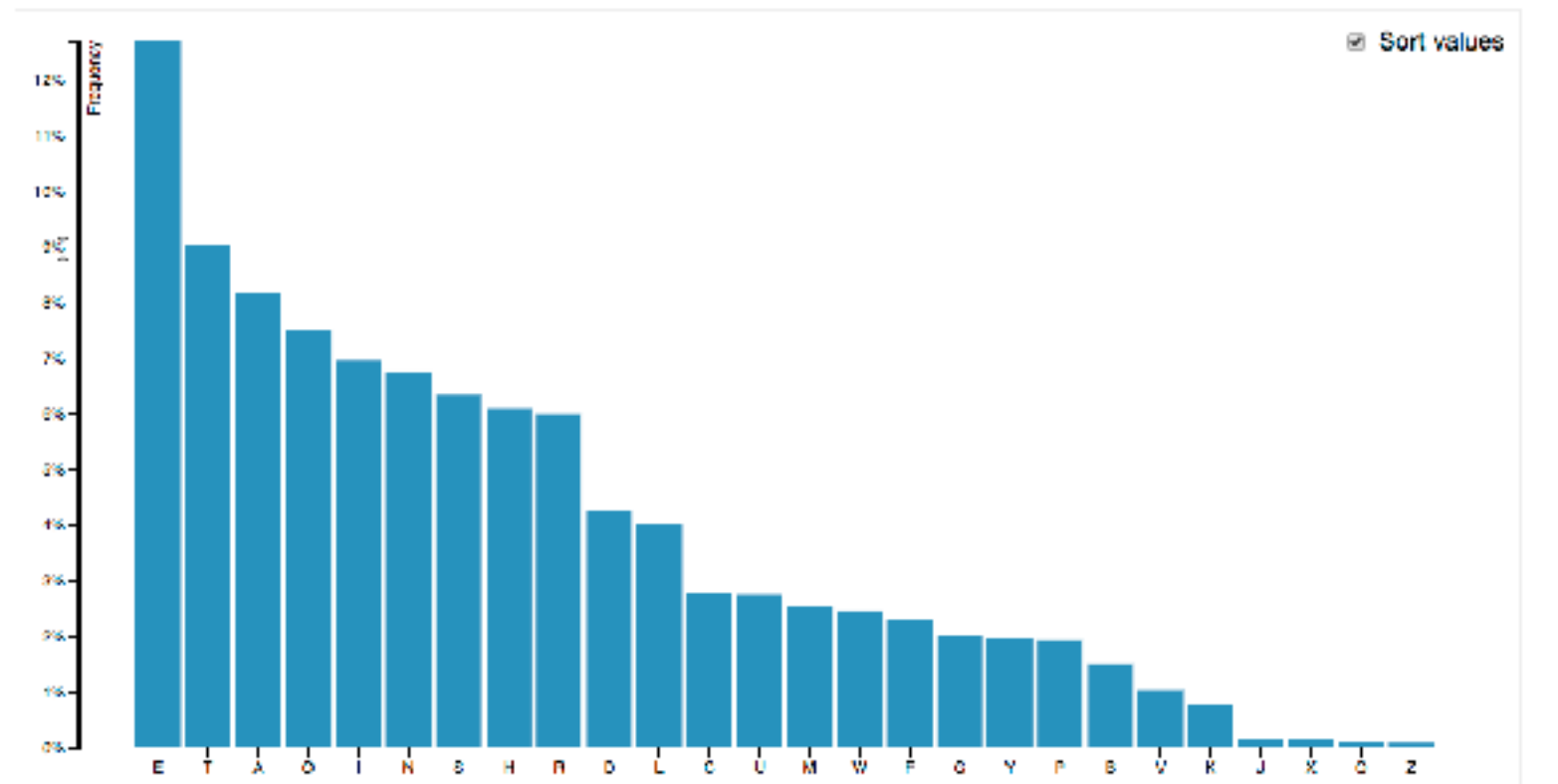
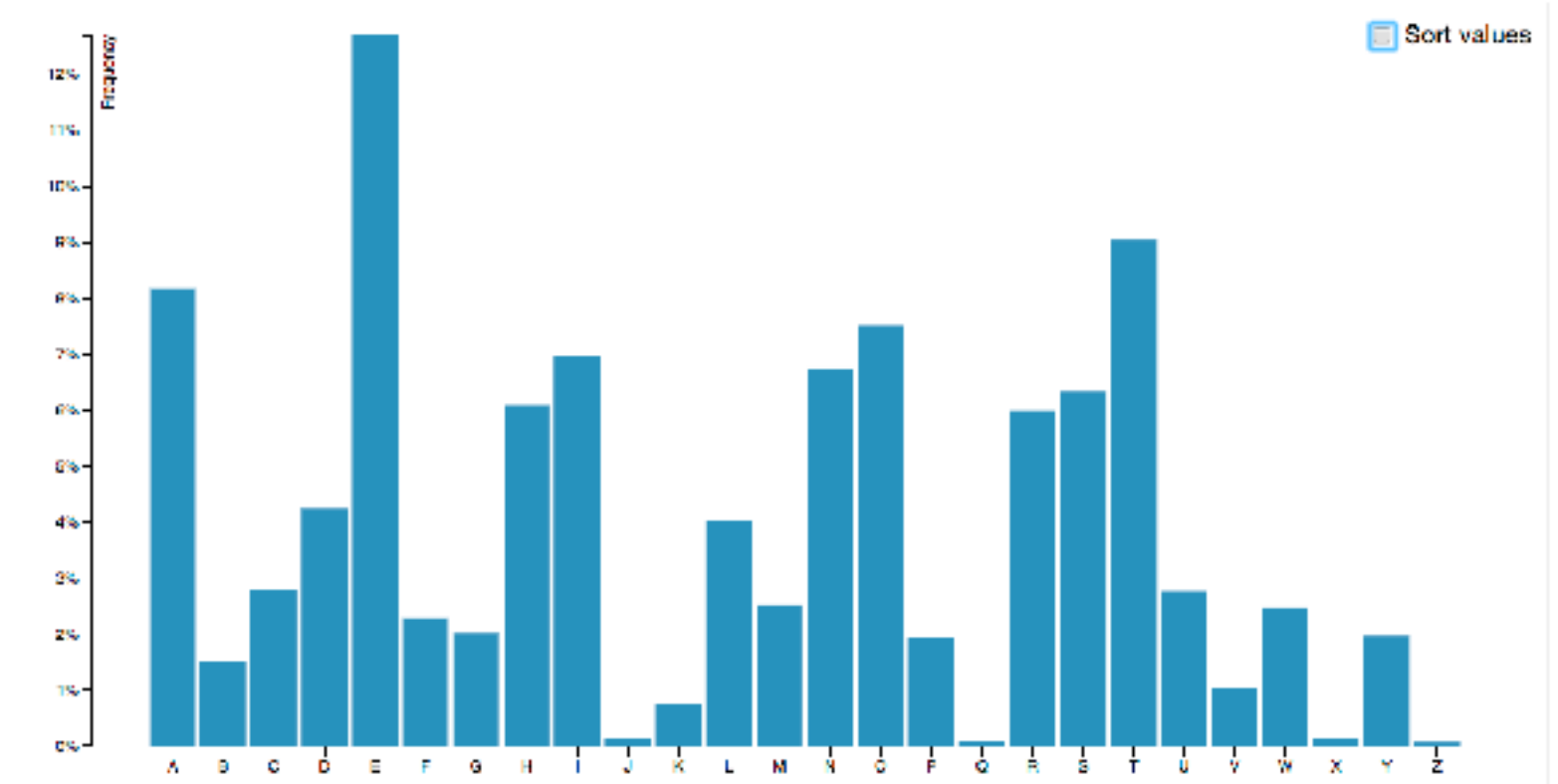


[Growth of a Nation](http://laurenwood.github.io/)

slide inspired by: Alexander Lex, Utah

Idiom: **Change order/arrangement**

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

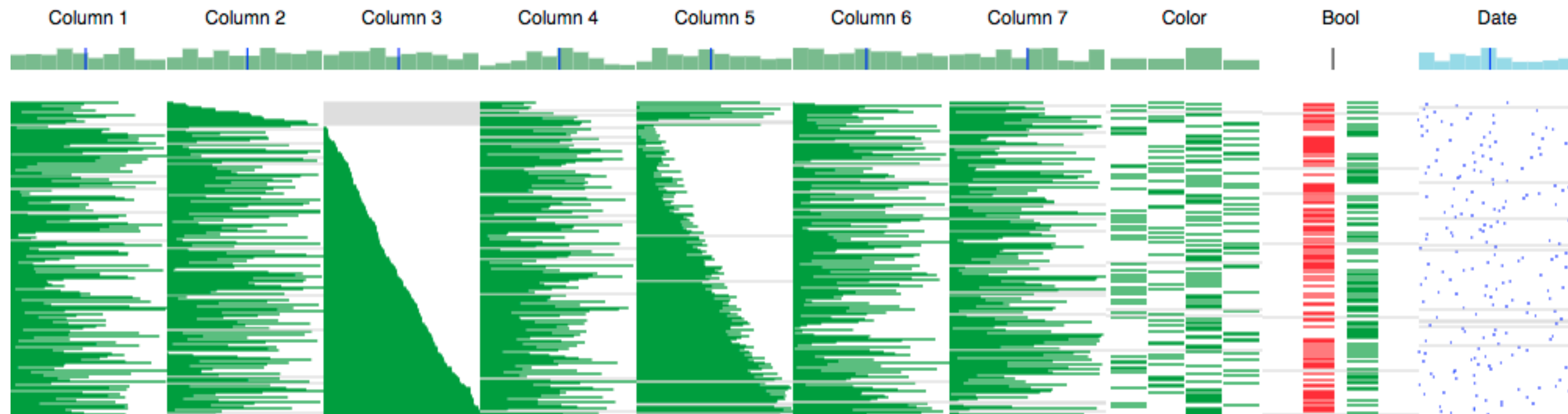


[Sortable Bar Chart](<https://bl.ocks.org/mbostock/3885705>)

Idiom: **Reorder**

System: **DataStripes**

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

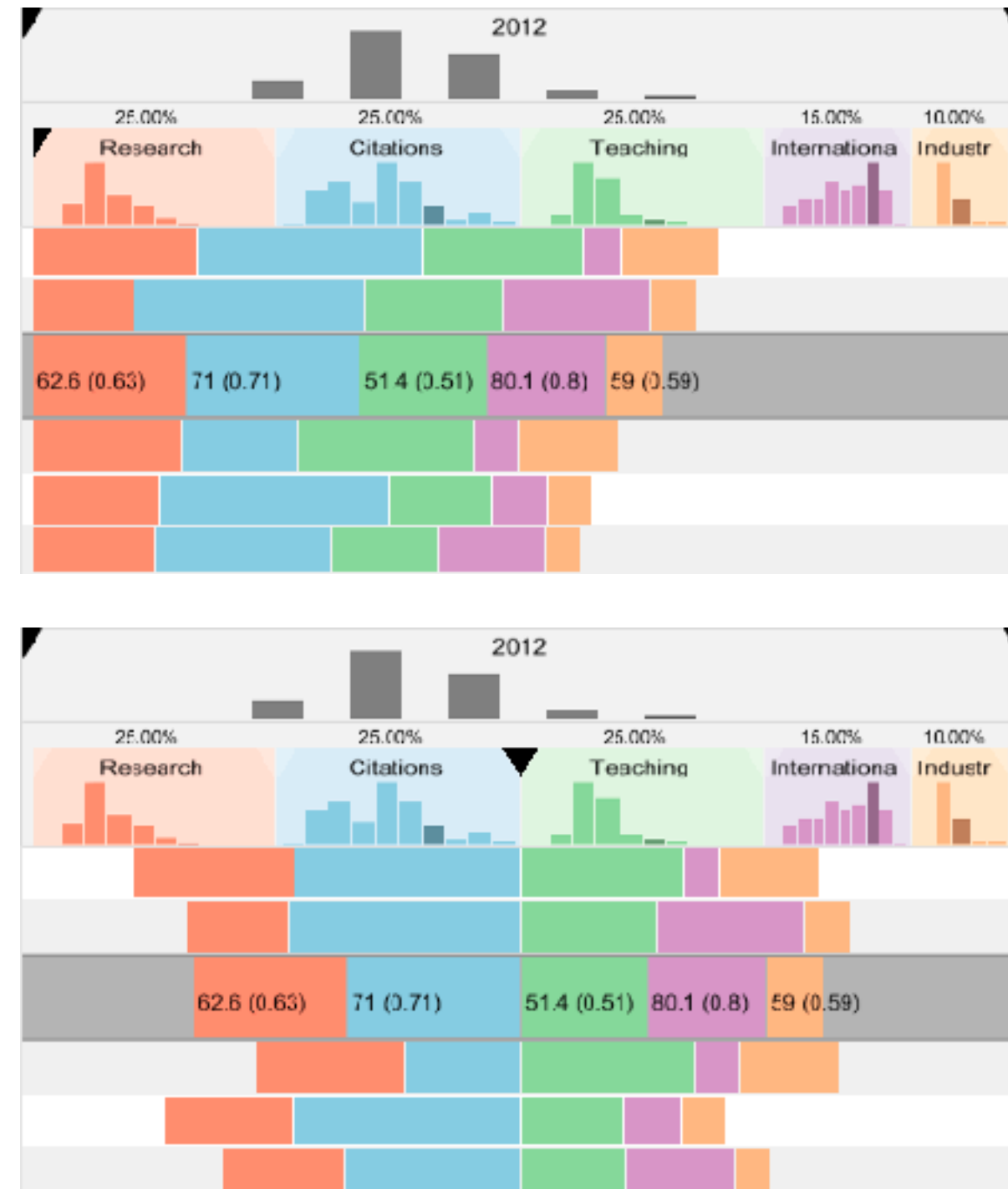


[\[http://carlmanaster.github.io/datastripes/\]](http://carlmanaster.github.io/datastripes/)

Idiom: **Change alignment**

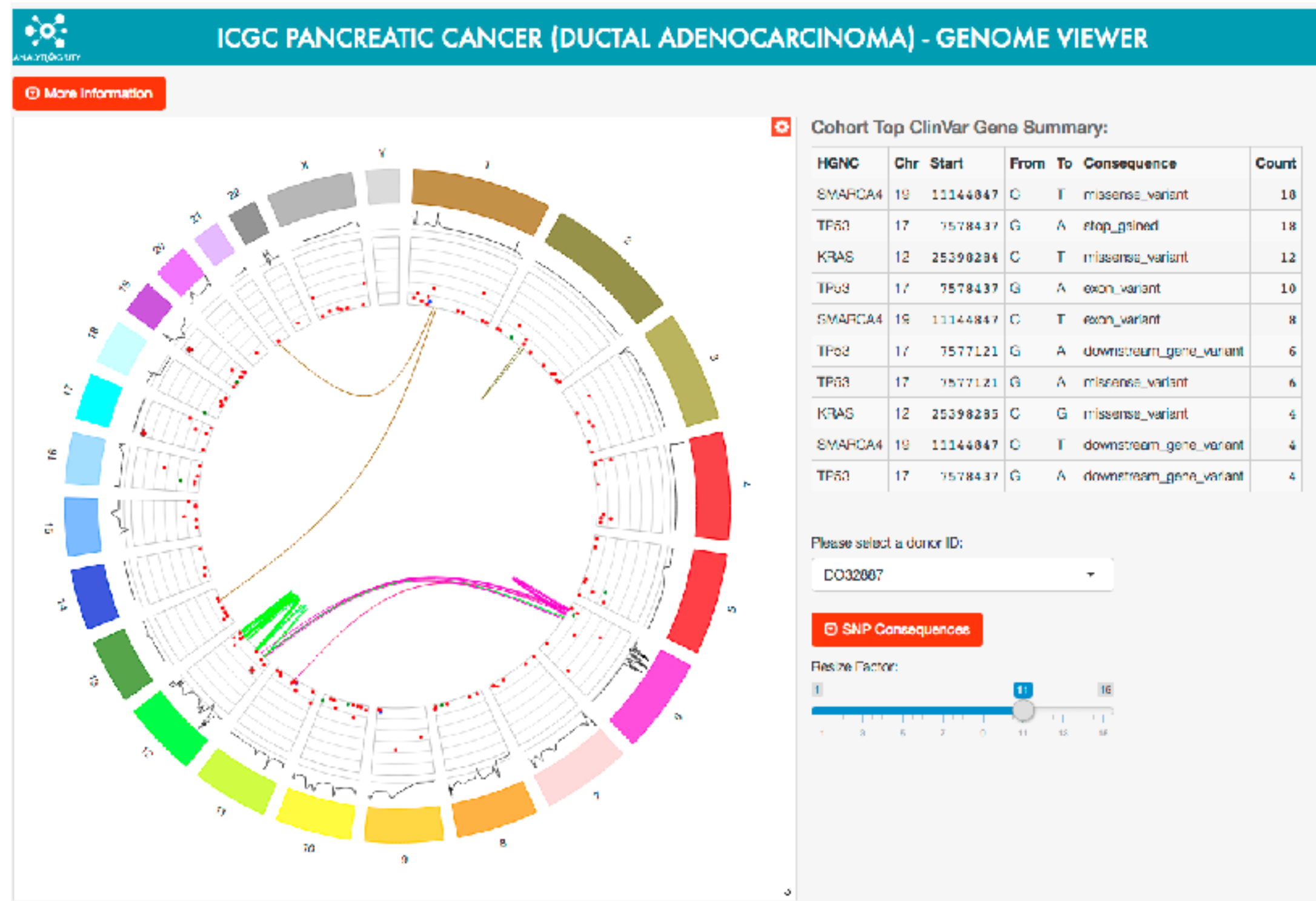
- stacked bars
 - easy to compare
 - first segment
 - total bar
- align to different segment
 - supports flexible comparison

System: **LineUp**



Shiny example

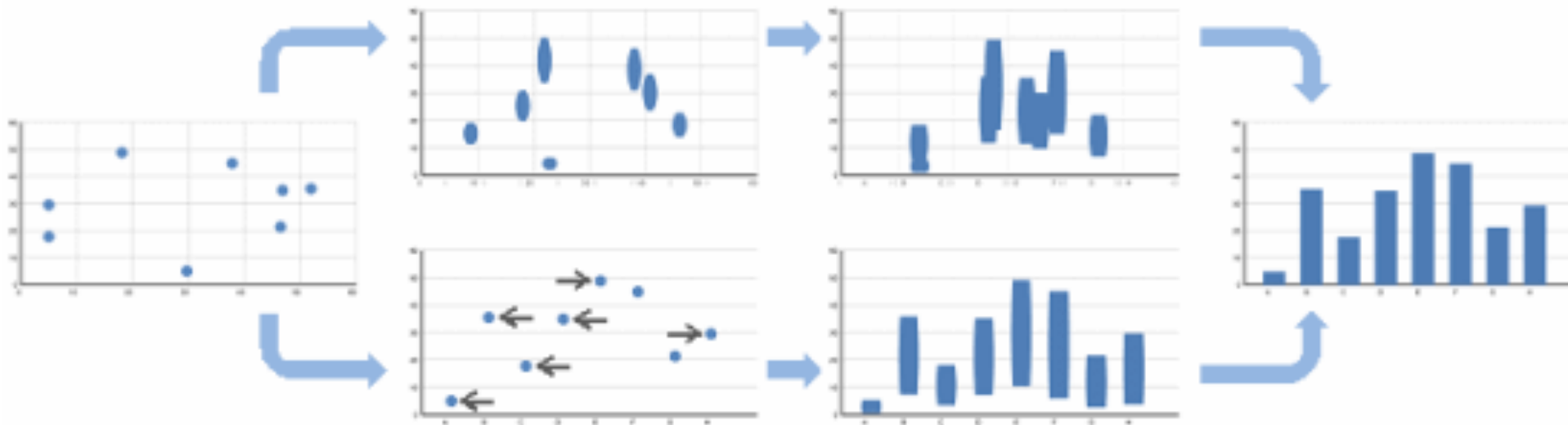
- APGI genome browser
 - tooling: R/Shiny
 - interactivity
 - tooltip detail on demand on hover
 - expand/contract chromosomes
 - expand/contract control panes



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

Idiom: **Animated transitions**

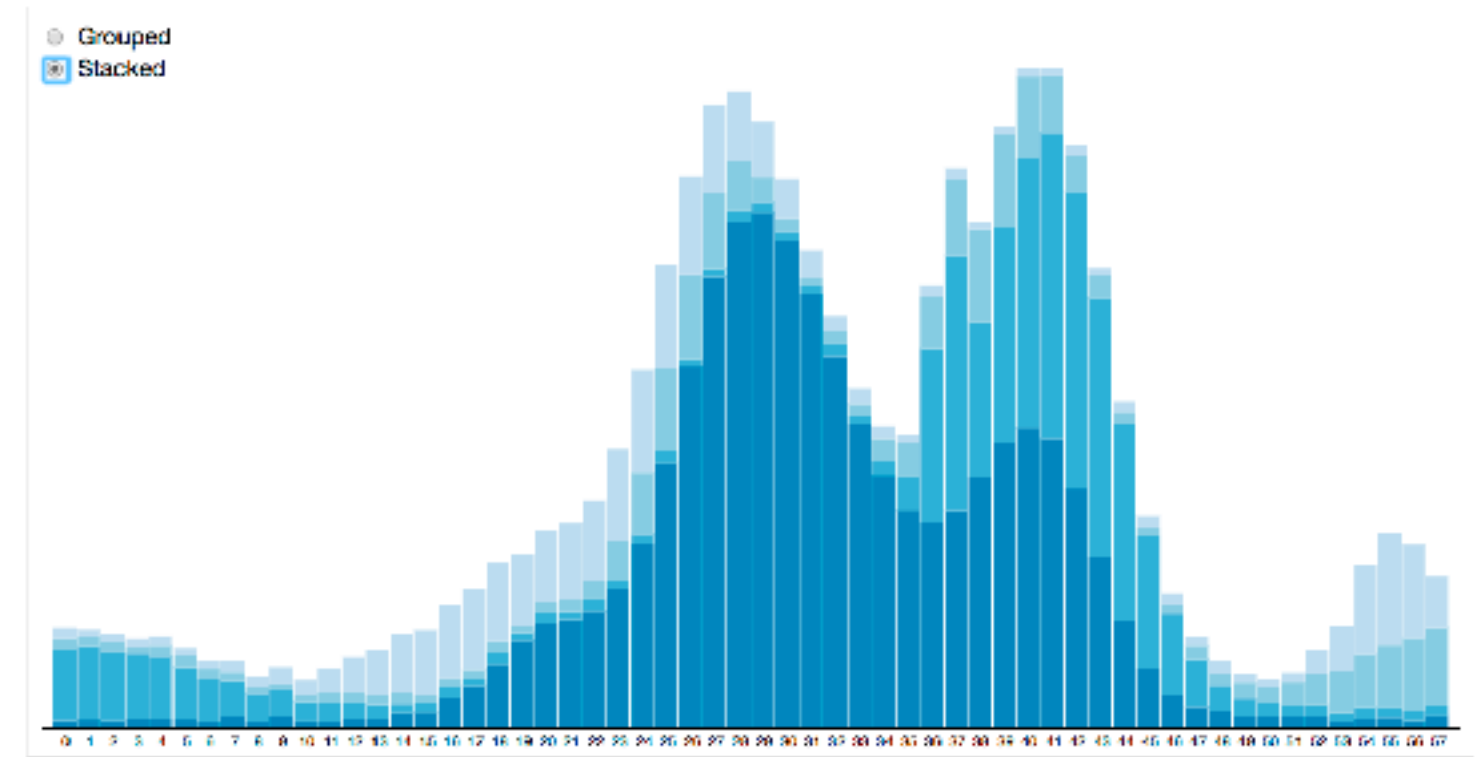
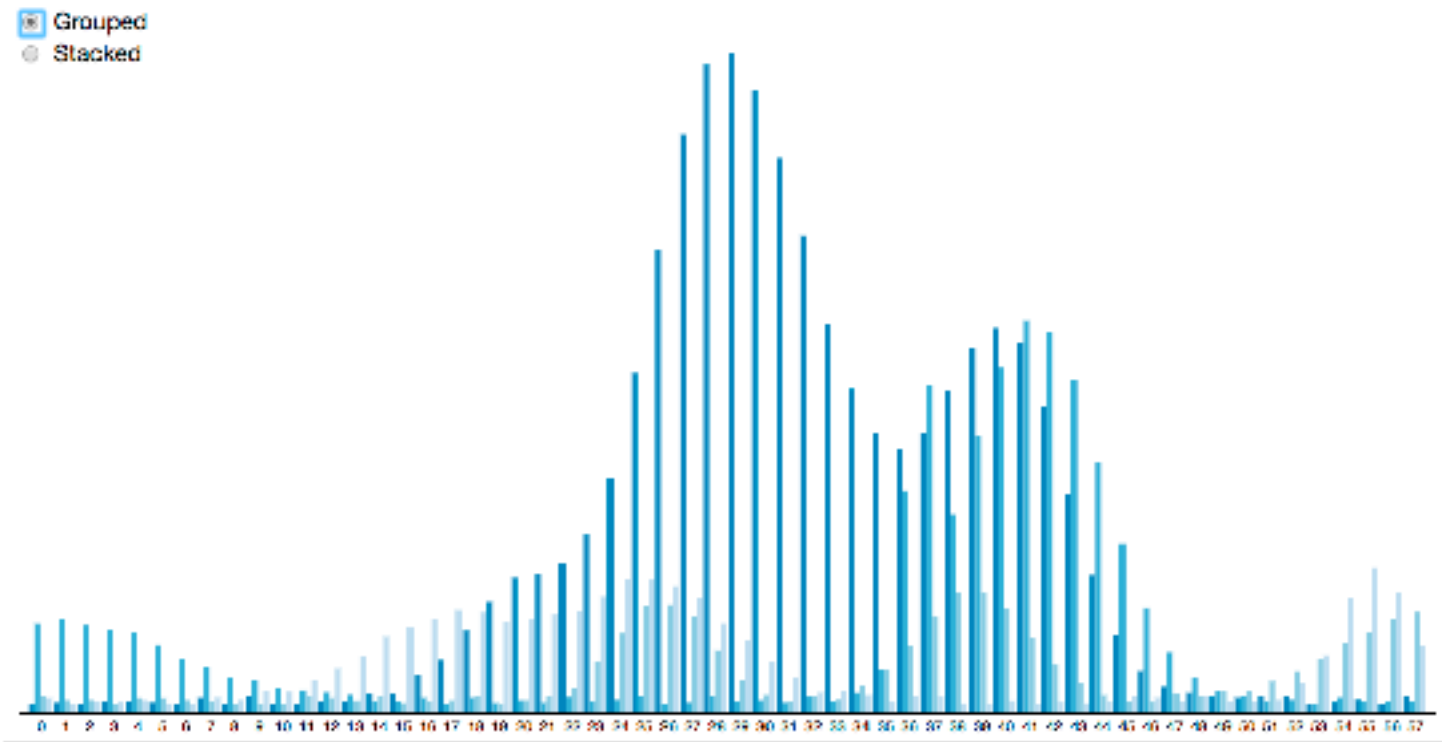
- smooth interpolation from one state to another
 - alternative to jump cuts, supports item tracking
 - best case for animation
 - staging to reduce cognitive load
- example: animated transitions in statistical data graphics



video: vimeo.com/19278444

Idiom: **Animated transitions** - visual encoding change

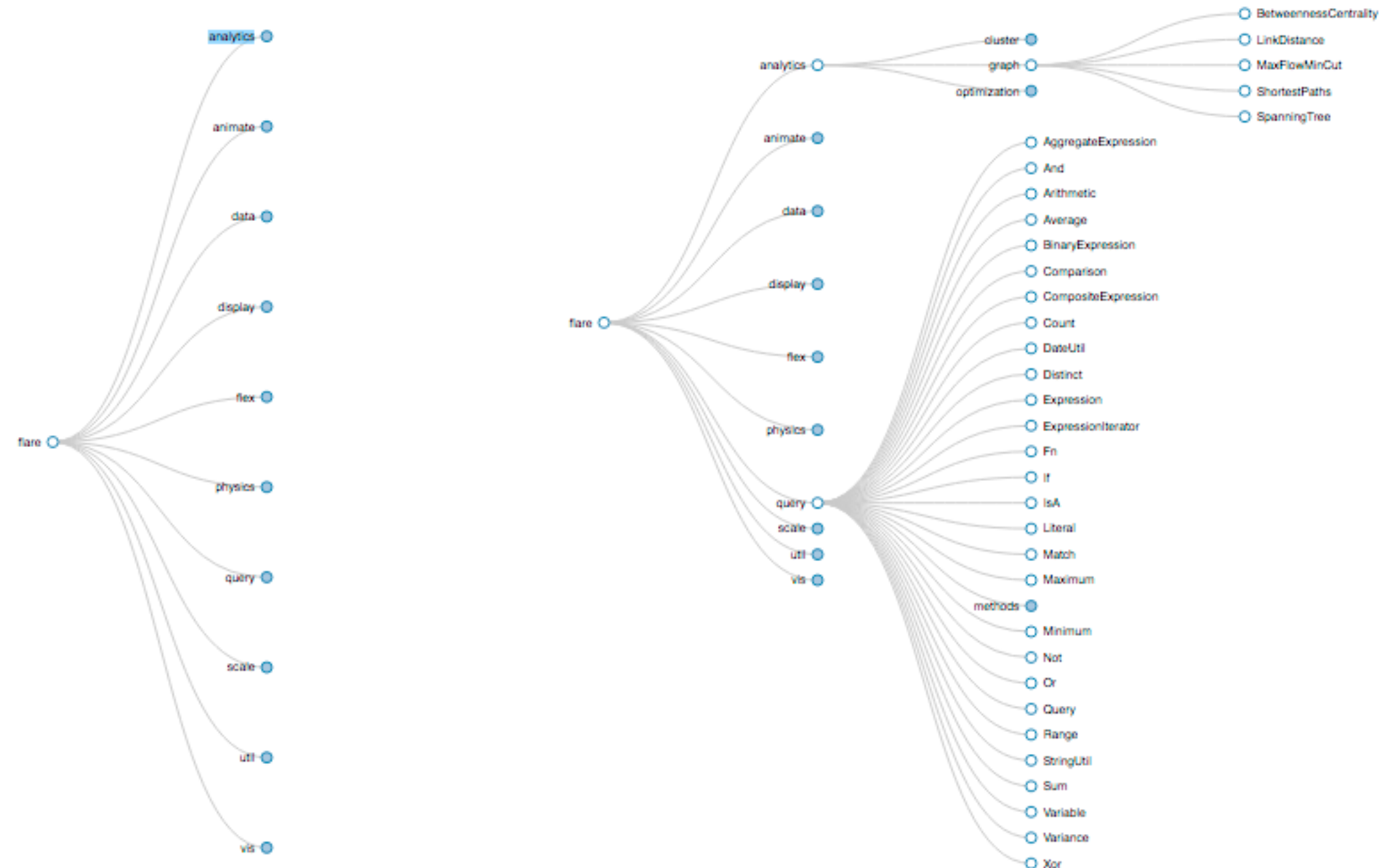
- smooth transition from one state to another
 - alternative to jump cuts, supports item tracking
 - best case for animation
 - staging to reduce cognitive load



[Stacked to Grouped Bars](<http://blocks.org/mbostock/3943967>)

Idiom: **Animated transition** - tree detail

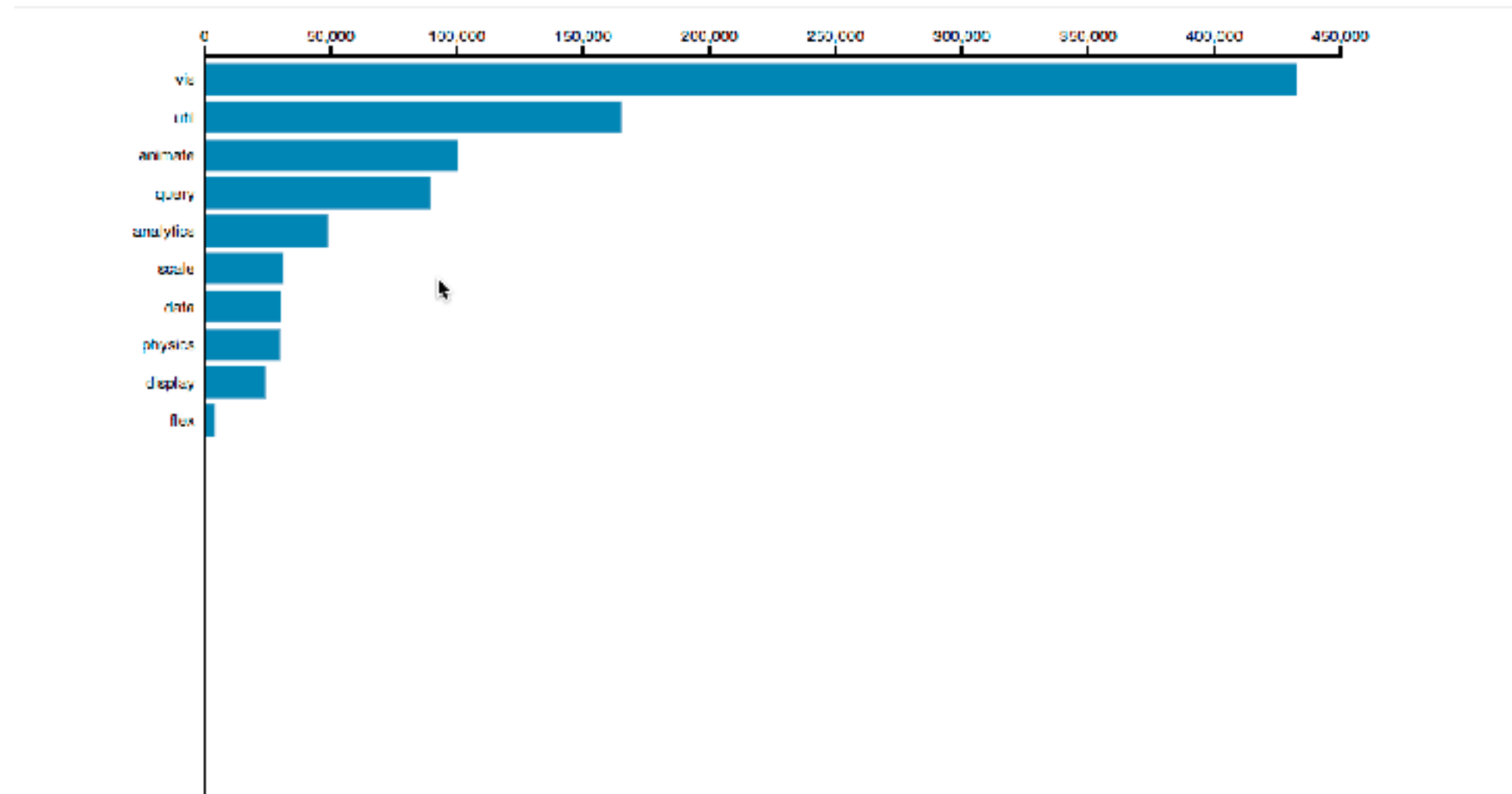
- animated transition
 - network drilldown/rollup



[Collapsible Tree](<https://blocks.org/mbostock/4339083>)

Idiom: **Animated transition - bar detail**

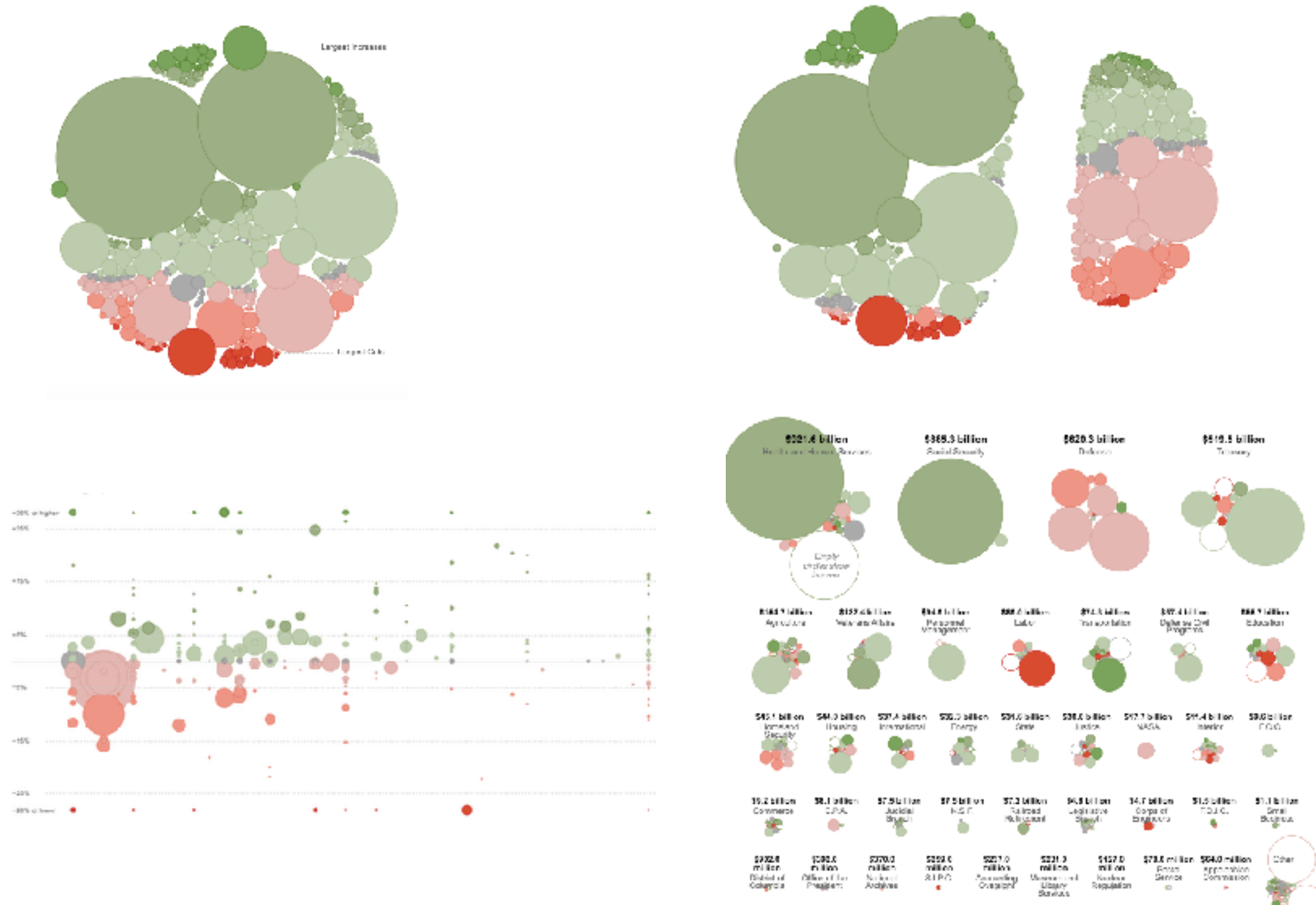
- example: hierarchical bar chart
 - add detail during transition to new level of detail



[Hierarchical Bar Chart](<https://blocks.org/mbostock/1283663>)

Interactive transitions quiz: 4 Ways Budget

- what changed?



Interaction technology

- what do you design for?
 - mouse & keyboard on desktop?
 - large screens, hover, multiple clicks
 - touch interaction on mobile?
 - small screens, no hover, just tap
 - gestures from video / sensors?
 - ergonomic reality vs movie bombast
 - eye tracking?

slide inspired by: Alexander Lex, Utah



Data visualization and the news - Gregor Aisch (37 min)
vimeo.com/182590214

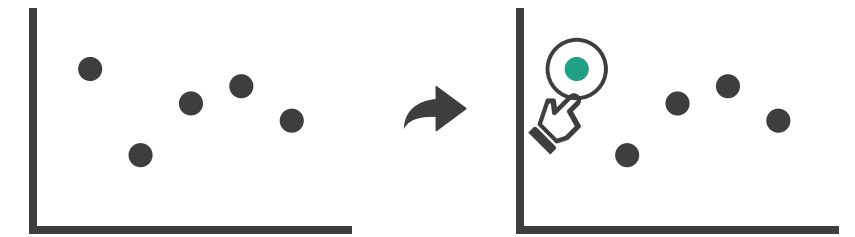


I Hate Tom Cruise - Alex Kauffmann (5 min)
www.youtube.com/watch?v=QXLfT9sFcbbc

Selection

- selection: basic operation for most interaction
- design choices
 - how many selection types?
 - interaction modalities
 - click/tap (heavyweight) vs hover (lightweight but not available on most touchscreens)
 - multiple click types (shift-click, option-click, ...)
 - proximity beyond click/hover (touching vs nearby vs distant)
 - application semantics
 - adding to selection set vs replacing selection
 - can selection be null?
 - ex: toggle so nothing selected if click on background
 - primary vs secondary (ex: source/target nodes in network)
 - group membership (add/delete items, name group, ...)

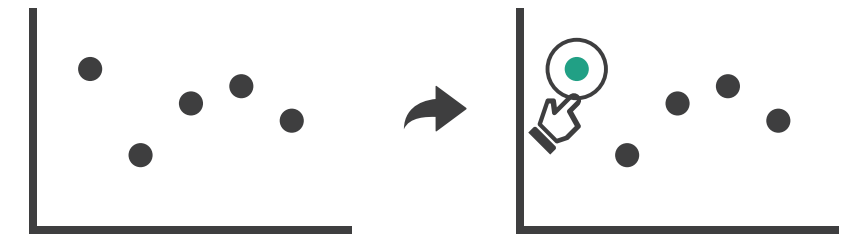
➞ Select



Highlighting

- highlight: change visual encoding for selection targets
 - visual feedback closely tied to but separable from selection (interaction)
- design choices: typical visual channels
 - change item color
 - but hides existing color coding
 - add outline mark
 - change size (ex: increase outline mark linewidth)
 - change shape (ex: from solid to dashed line for link mark)
- unusual channels: motion
 - motion: usually avoid for single view
 - with multiple views, could justify to draw attention to other views

➞ Select



Tooltips

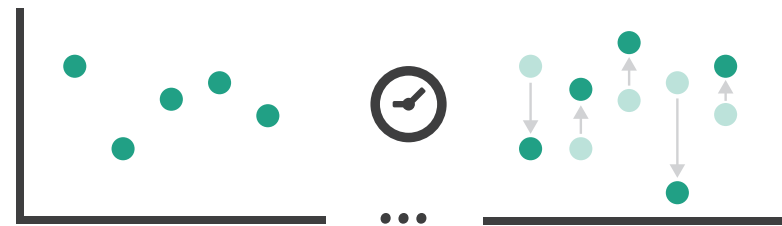
- popup information for selection
 - hover or click
 - can provide useful additional detail on demand
 - beware: does not support overview!
 - always consider if there's a way to visually encode directly to provide overview
 - “If you make a rollover or tooltip, assume nobody will see it. If it's important,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

Rule of thumb: **Responsiveness is required**

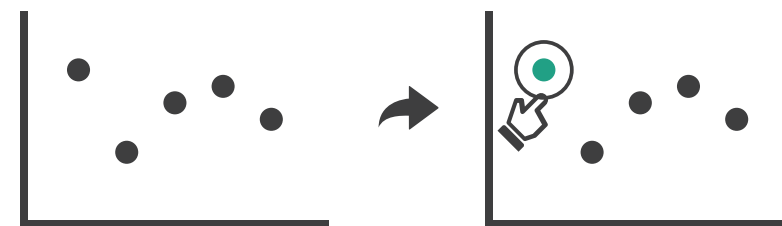
- *visual feedback: three rough categories*
 - *0.1 seconds: perceptual processing*
 - subsecond response for mouseover highlighting - ballistic motion
 - *1 second: immediate response*
 - fast response after mouseclick, button press - Fitts' Law limits on motor control
 - *10 seconds: brief tasks*
 - bounded response after dialog box - mental model of heavyweight operation (file load)
- **scalability considerations**
 - highlight selection without complete redraw of view (graphics frontbuffer)
 - show hourglass for multi-second operations (check for cancel/undo)
 - show progress bar for long operations (process in background thread)
 - rendering speed when item count is large (guaranteed frame rate)

Manipulate

➔ Change over Time



➔ Select



➔ Navigate

➔ Item Reduction

➔ Zoom

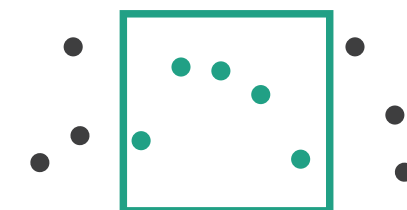
Geometric or *Semantic*



➔ Pan/Translate



➔ Constrained



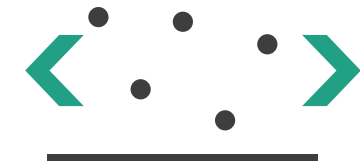
Navigate: Changing viewpoint/visibility

- change viewpoint
 - changes which items are visible within view
- camera metaphor
 - pan/translate/scroll
 - move up/down/sideways

➞ Navigate

➞ Item Reduction

➞ *Pan/Translate*



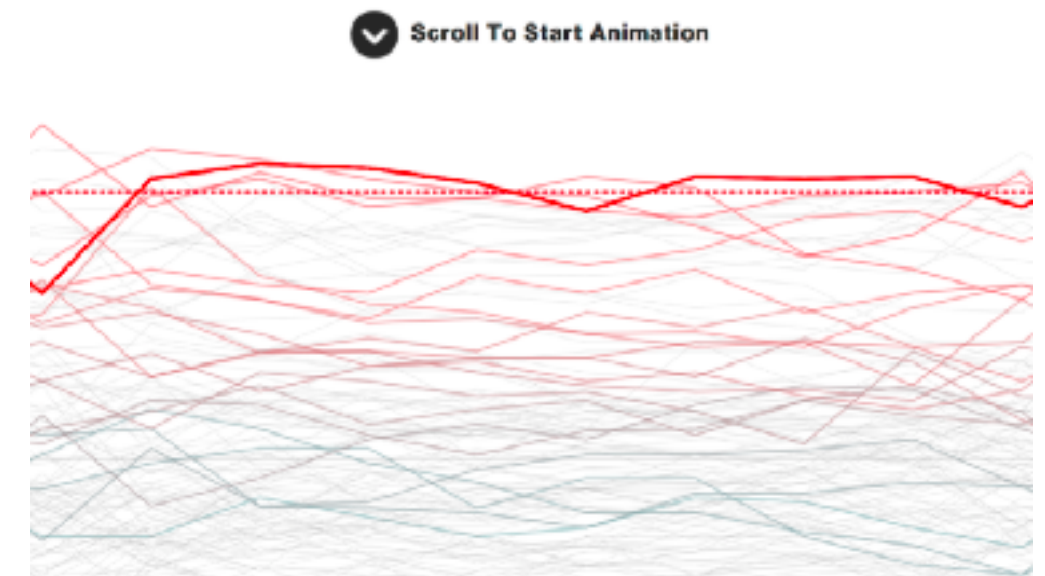
Idiom: Scrollytelling

- how: navigate page by scrolling (panning down)
- pros:
 - familiar & intuitive, from standard web browsing
 - linear (only up & down) vs possible overload of click-based interface choices
- cons:
 - full-screen mode may lack affordances
 - scrolljacking, no direct access
 - unexpected behaviour
 - continuous control for discrete steps

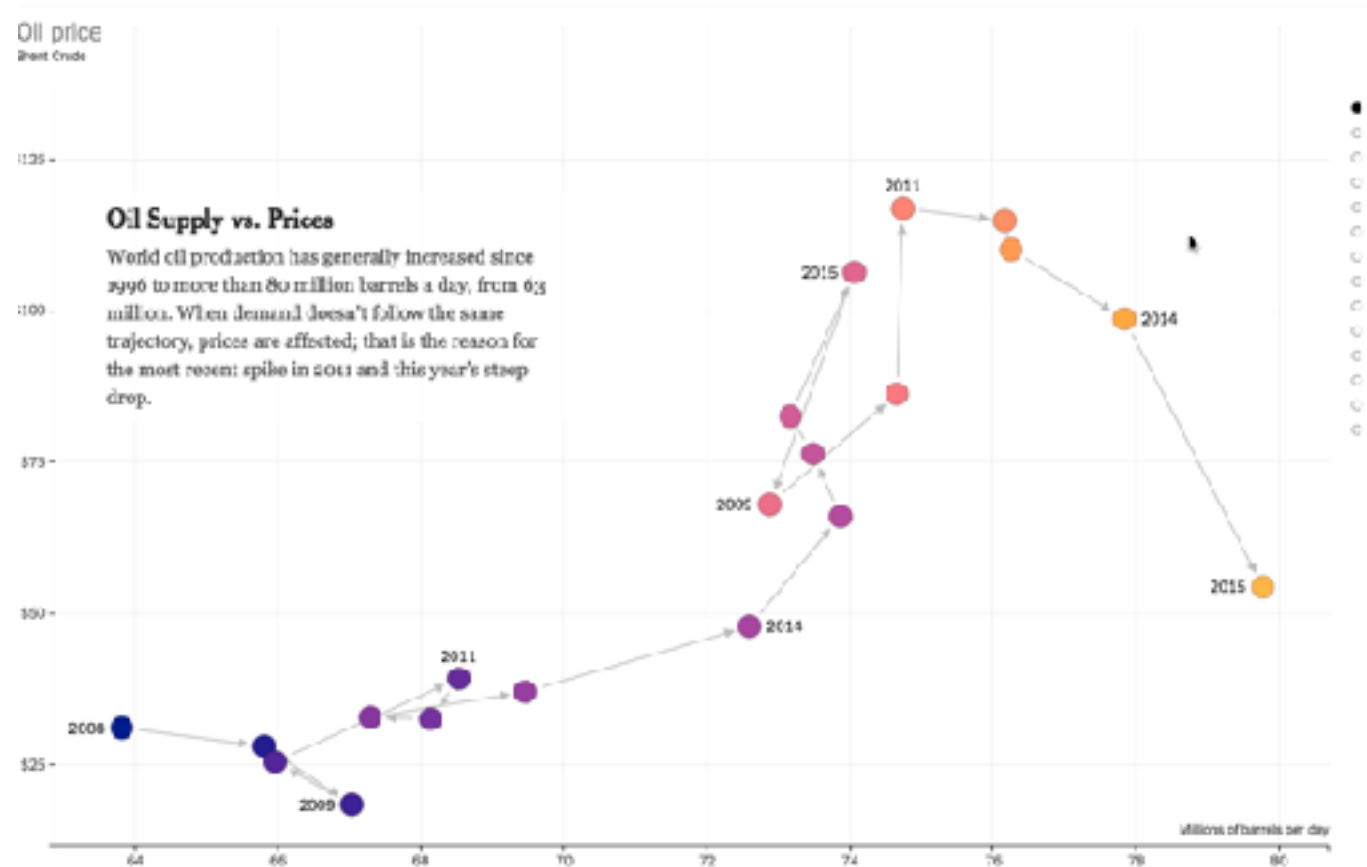
<https://eagereyes.org/blog/2016/the-scrollytelling-scourge>

[How to Scroll, Bostock](<https://bost.ocks.org/mike/scroll/>)

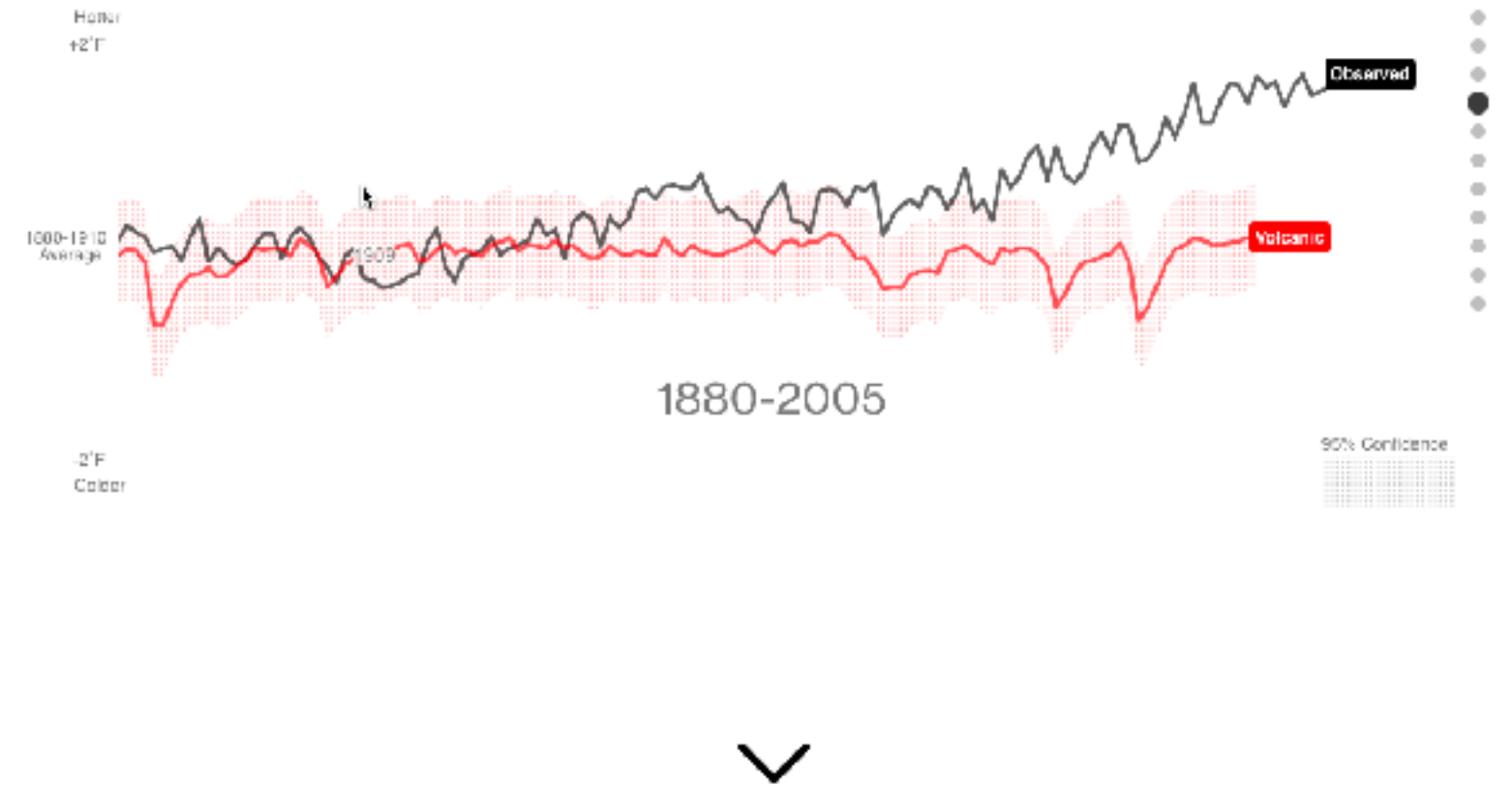
[slide inspired by: Alexander Lex, Utah](#)



Scrollytelling examples



https://www.nytimes.com/interactive/2015/09/30/business/how-the-us-and-opeac-drive-oil-prices.html?_r=1



<https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

slide inspired by: Alexander Lex, Utah

Navigate: Changing viewpoint/visibility

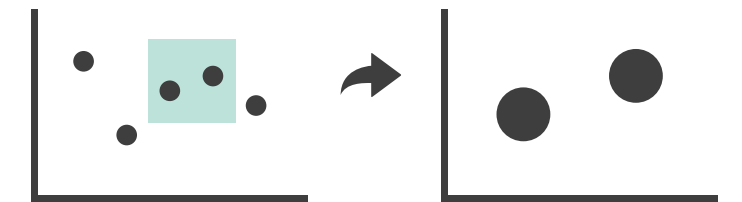
- change viewpoint
 - changes which items are visible within view
- camera metaphor
 - pan/translate/scroll
 - move up/down/sideways
 - rotate/spin
 - typically in 3D
 - zoom in/out
 - enlarge/shrink world == move camera closer/further
 - geometric zoom: standard, like moving physical object

➞ Navigate

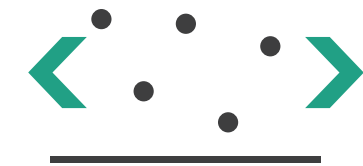
➞ Item Reduction

➞ Zoom

Geometric



➞ Pan/Translate



Navigate: Unconstrained vs constrained

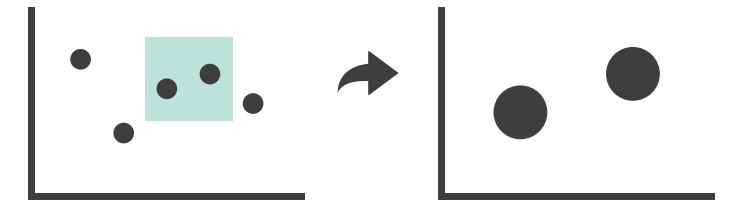
- unconstrained navigation
 - easy to implement for designer
 - hard to control for user
 - easy to overshoot/undershoot
- constrained navigation
 - typically uses animated transitions
 - trajectory automatically computed based on selection
 - just click; selection ends up framed nicely in final viewport

➞ Navigate

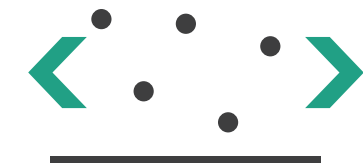
➞ Item Reduction

➞ Zoom

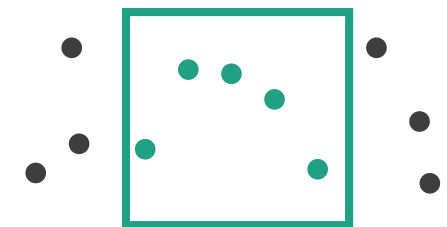
Geometric or *Semantic*



➞ Pan/Translate



➞ Constrained



Idiom: **Animated transition + constrained navigation**

- example: geographic map
 - simple zoom, only viewport changes, shapes preserved

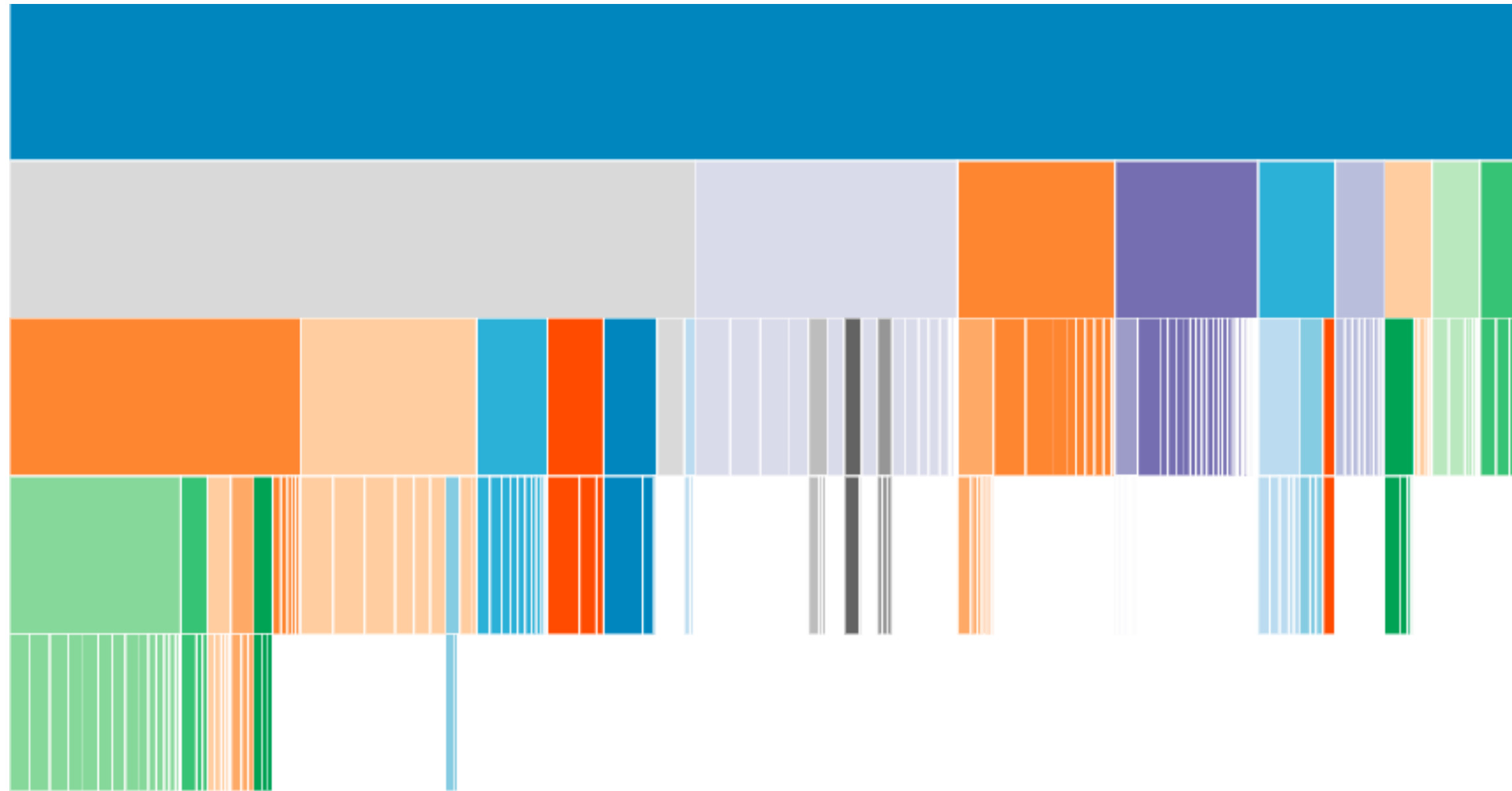
Zoom to Bounding Box



[Zoom to Bounding Box](<https://blocks.org/mbostock/4699541>)

Idiom: **Animated transition + constrained navigation**

- example: icicle plot
 - transition into containing mark causes aspect ratio (shape) change



[Zoomable Icicle](<https://bl.ocks.org/mbostock/1005873>)

Interaction benefits

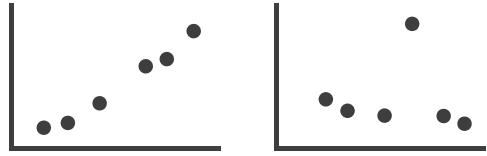
- interaction pros
 - major advantage of computer-based vs paper-based visualization
 - flexible, powerful, intuitive
 - exploratory data analysis: change as you go during analysis process
 - fluid task switching: different visual encodings support different tasks
 - animated transitions provide excellent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

Interaction limitations

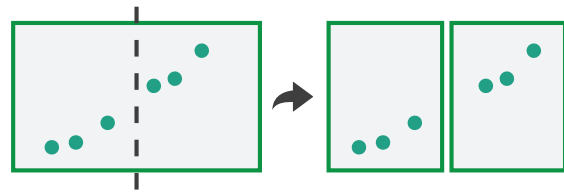
- interaction has a time cost
 - sometimes minor, sometimes significant
 - degenerates to human-powered search in worst case
- remembering previous state imposes cognitive load
- controls may take screen real estate
 - or invisible functionality may be difficult to discover (lack of affordances)
- users may not interact as planned by designer
 - NYTimes logs show ~90% don't interact beyond scrollytelling - Aisch, 2016

Facet

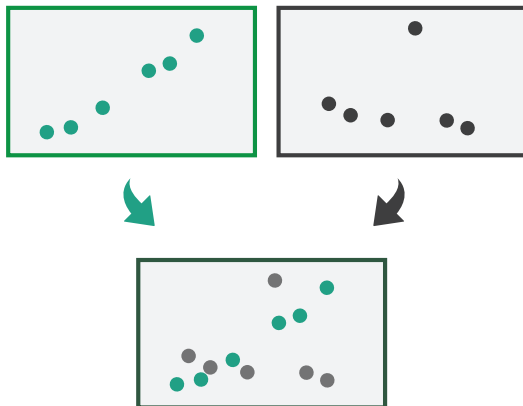
➔ Juxtapose



➔ Partition



➔ Superimpose



Juxtapose and coordinate views

→ Share Encoding: Same/Different

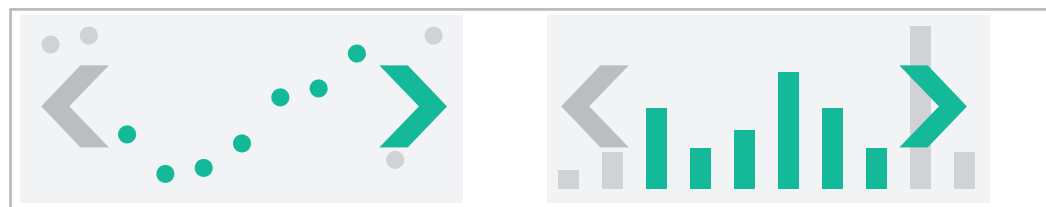
→ *Linked Highlighting*



→ Share Data: All/Subset/None



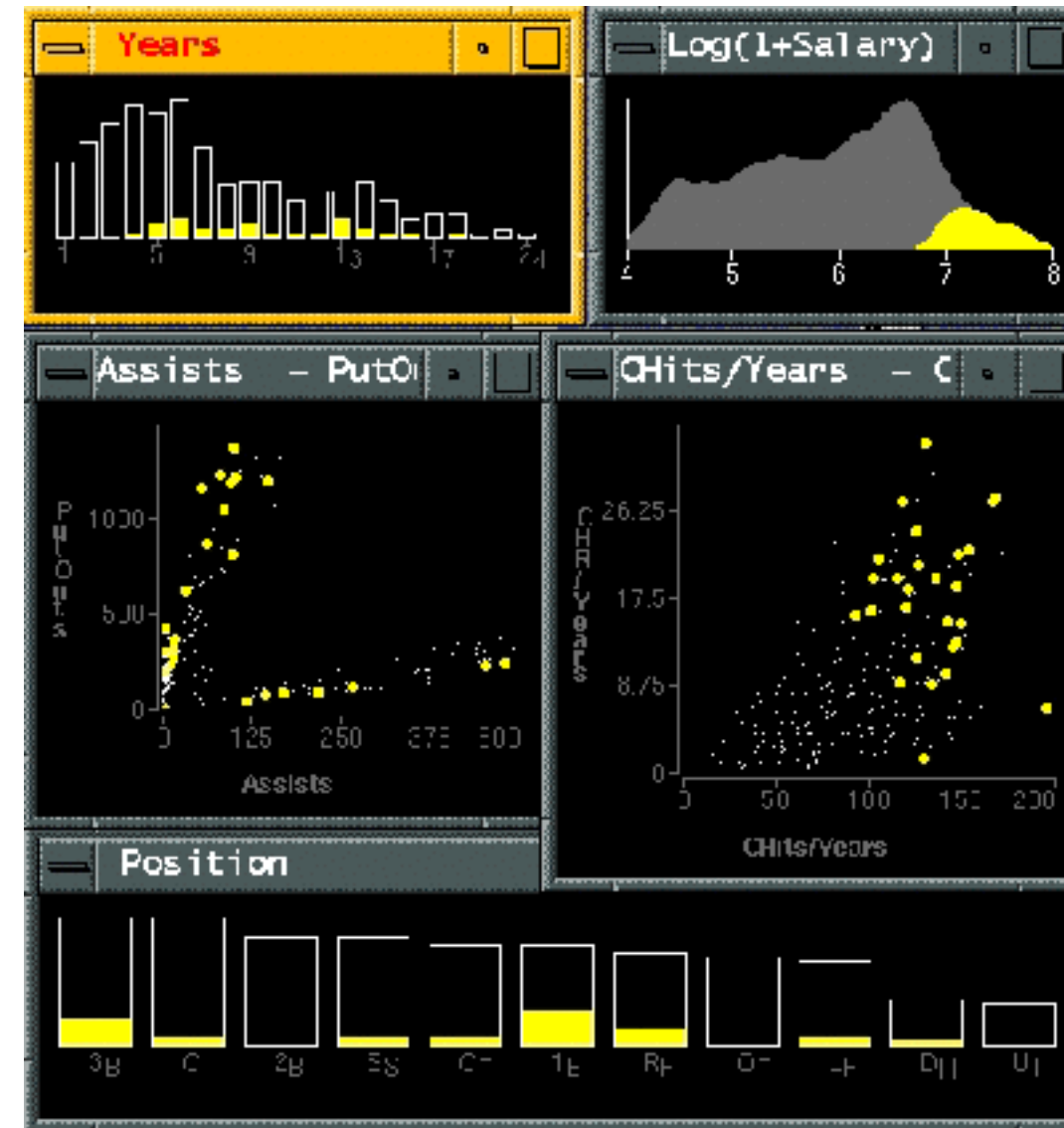
→ Share Navigation



Idiom: **Linked highlighting**

System: **EDV**

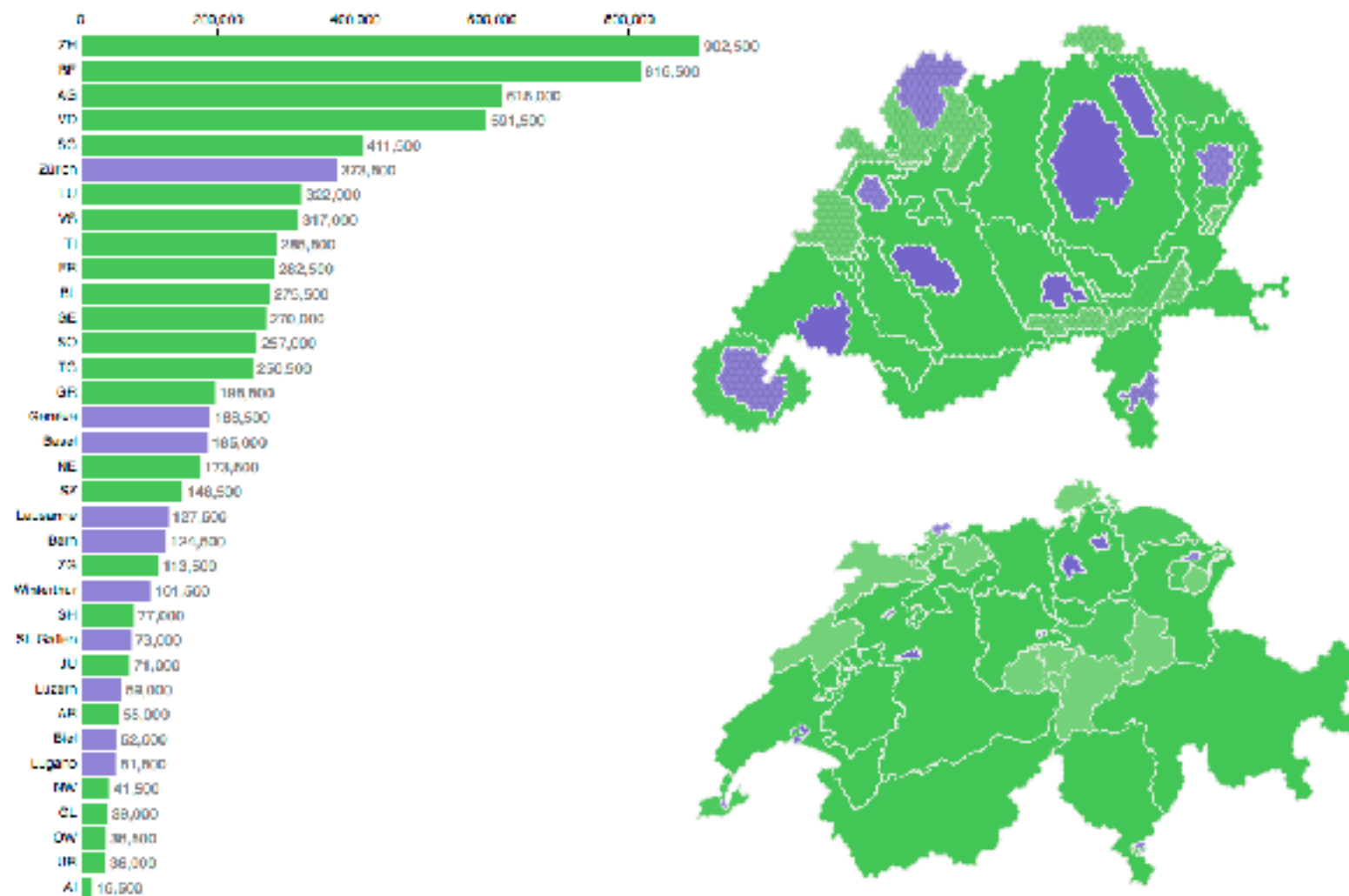
- see how regions contiguous in one view are distributed within another
 - powerful and pervasive interaction idiom
- encoding: different
 - ***multiform***
- data: all shared
- aka: brushing and linking



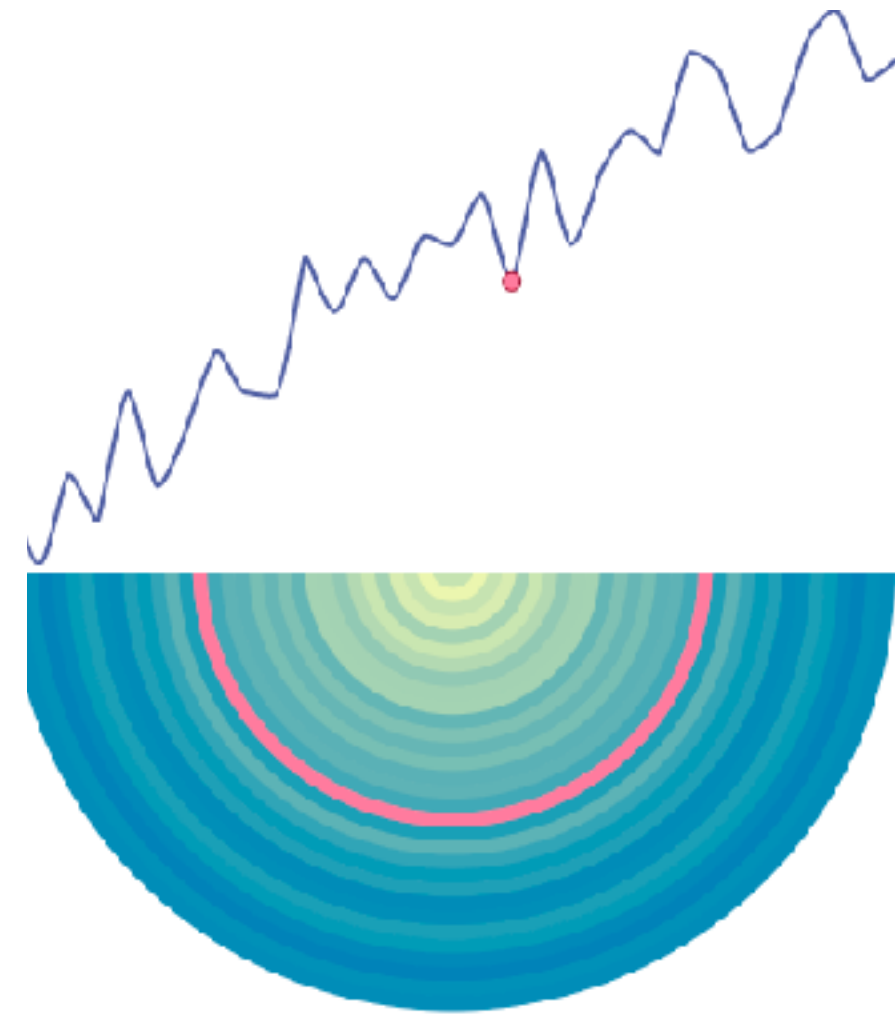
[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

Linked views

- unidirectional vs bidirectional linking



<http://www.ralphstraumann.ch/projects/swiss-population-cartogram/>



<http://peterbeshai.com/linked-highlighting-react-d3-reflux/>

Linked views: Multidirectional linking

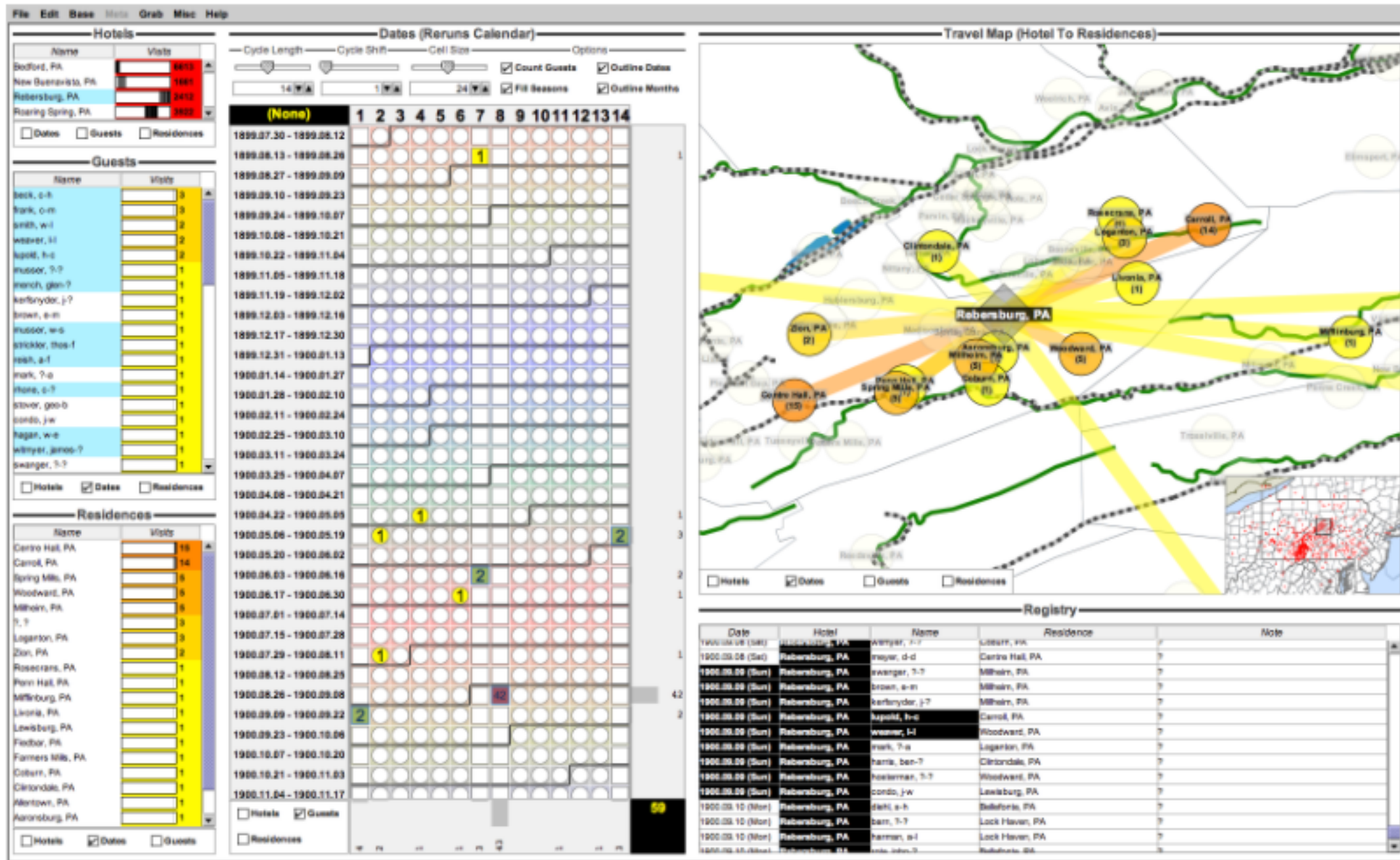
System: **Buckets**



<http://buckets.peterbeshai.com/>

<https://medium.com/@pbesh/linked-highlighting-with-react-d3-js-and-reflux-16e9c0b2210b>

Video: Visual Analysis of Historical Hotel Visitation Patterns

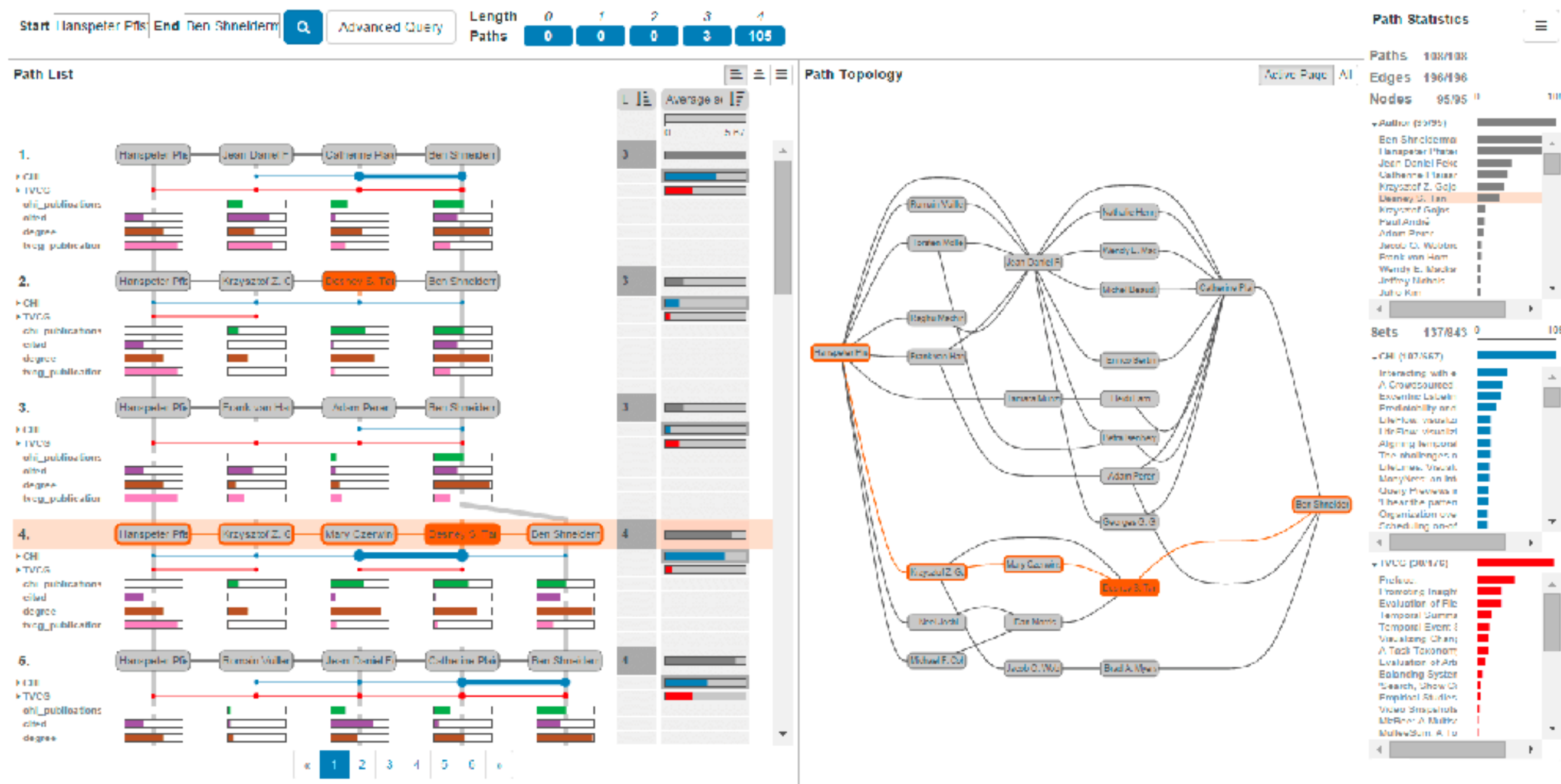


<https://www.youtube.com/watch?v=Tzsv6wkZoiQ>

<http://www.cs.ou.edu/~weaver/improvise/examples/hotels/>

Complex linked multiform views

System: Pathfinder



<https://www.youtube.com/watch?v=aZF7AC8aNXo>

Idiom: Overview-detail views

System: Google Maps

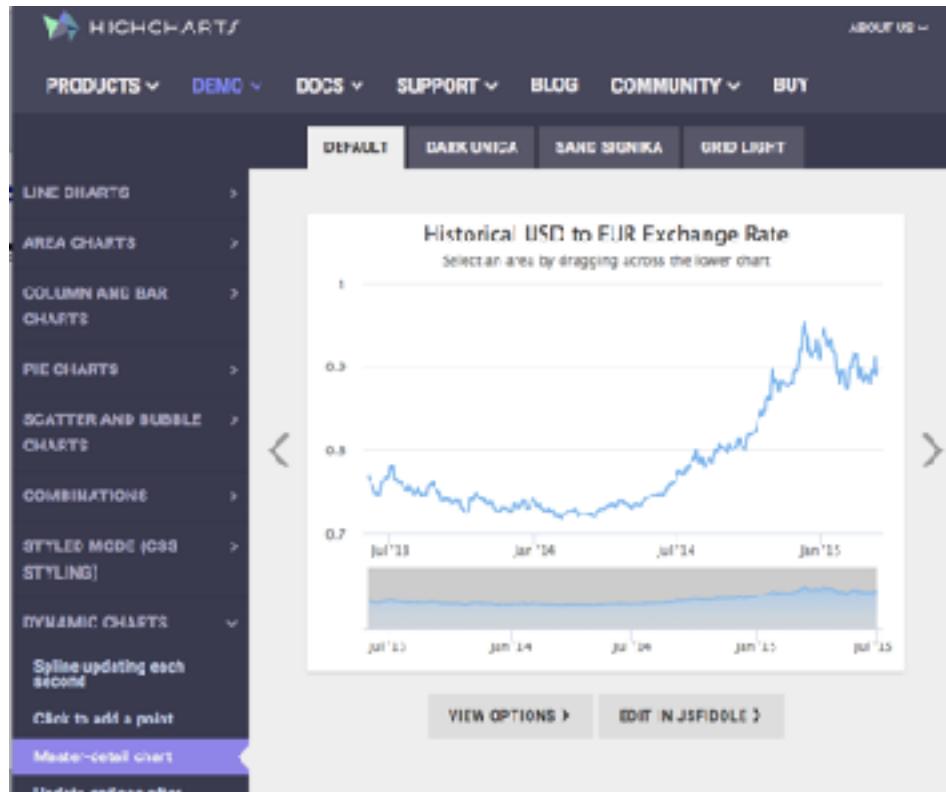
- encoding: same
- data: subset shared
- navigation: shared
 - bidirectional linking
- differences
 - viewpoint
 - (size)
- special case:
birds-eye map



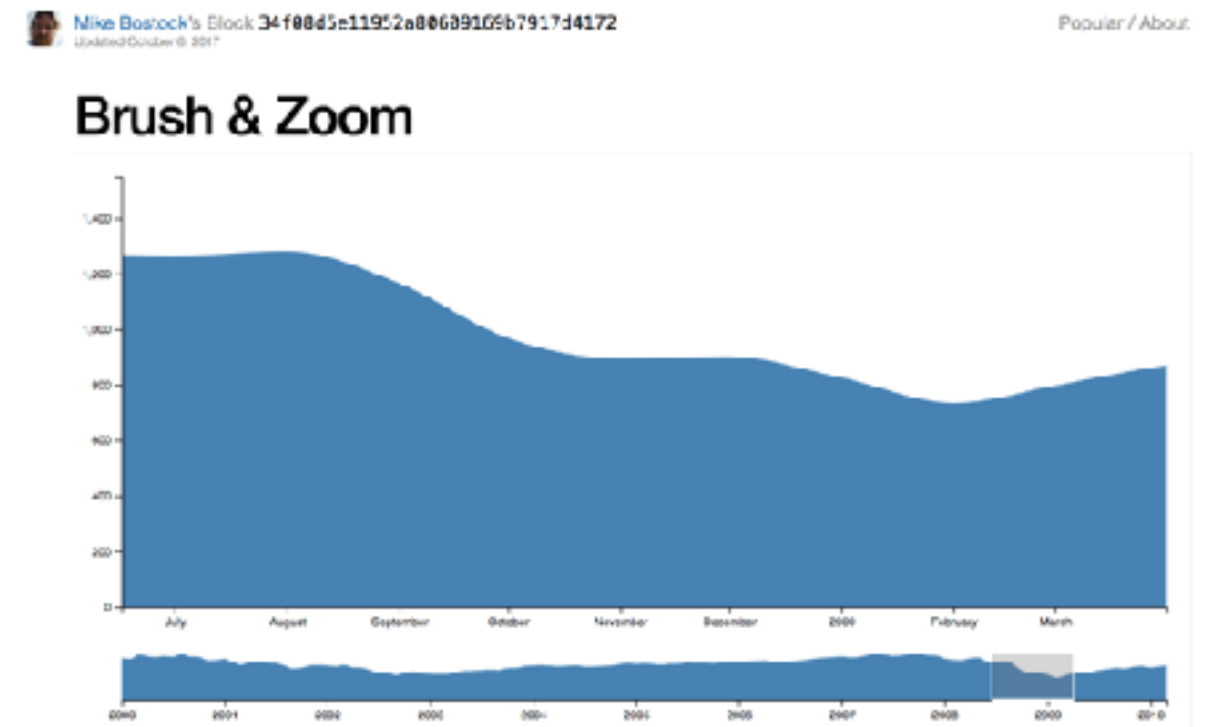
[A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. *ACM Computing Surveys* 41:1 (2008), 1–31.]

Idiom: Overview-detail navigation

- encoding: same
- data: subset shared
- navigation: shared
 - unidirectional linking
 - select in small overview
 - change extent in large detail view



<https://www.highcharts.com/demo/dynamic-master-detail>

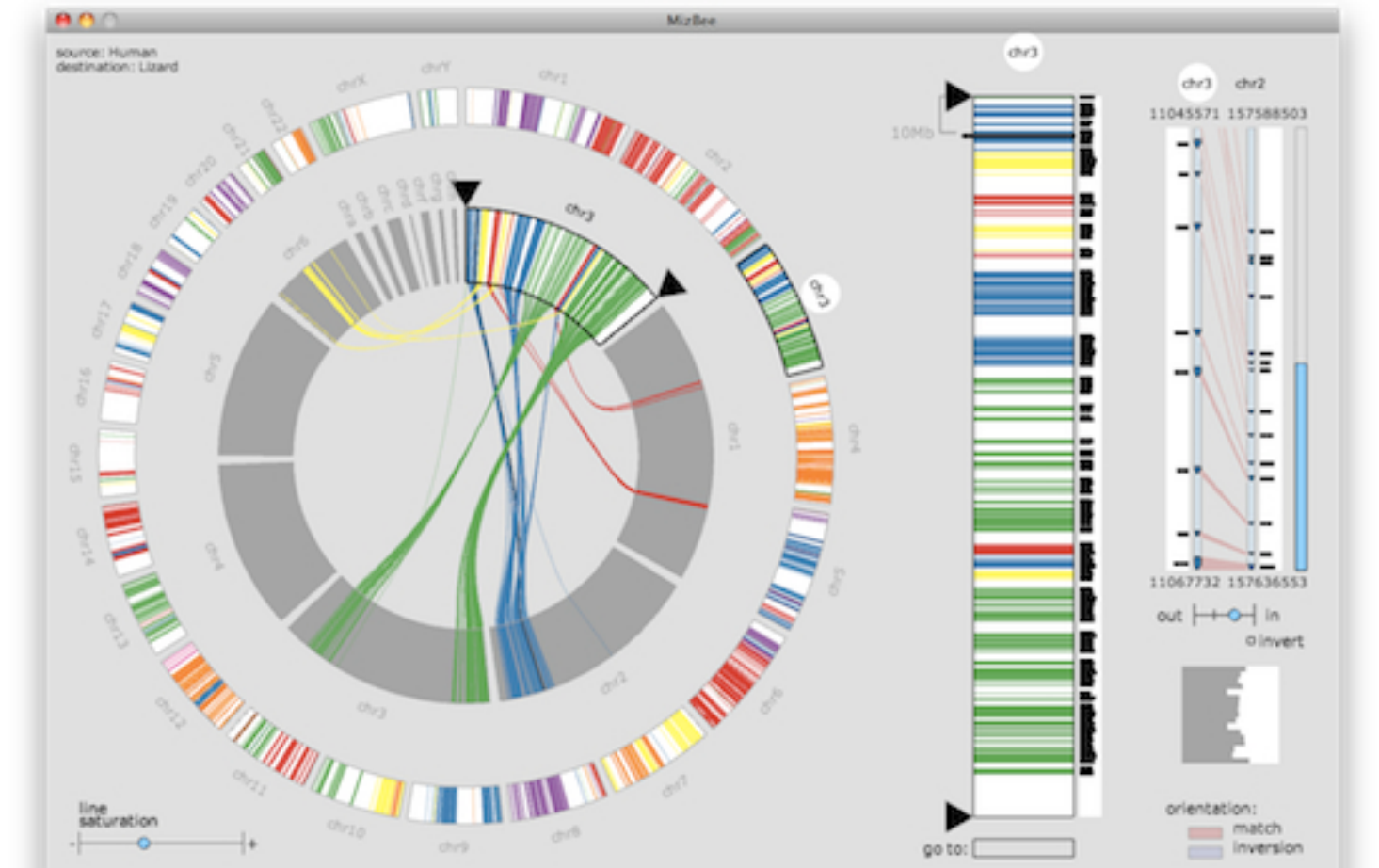


<https://bl.ocks.org/mbostock/34f08d5e11952a80609169b7917d4172>

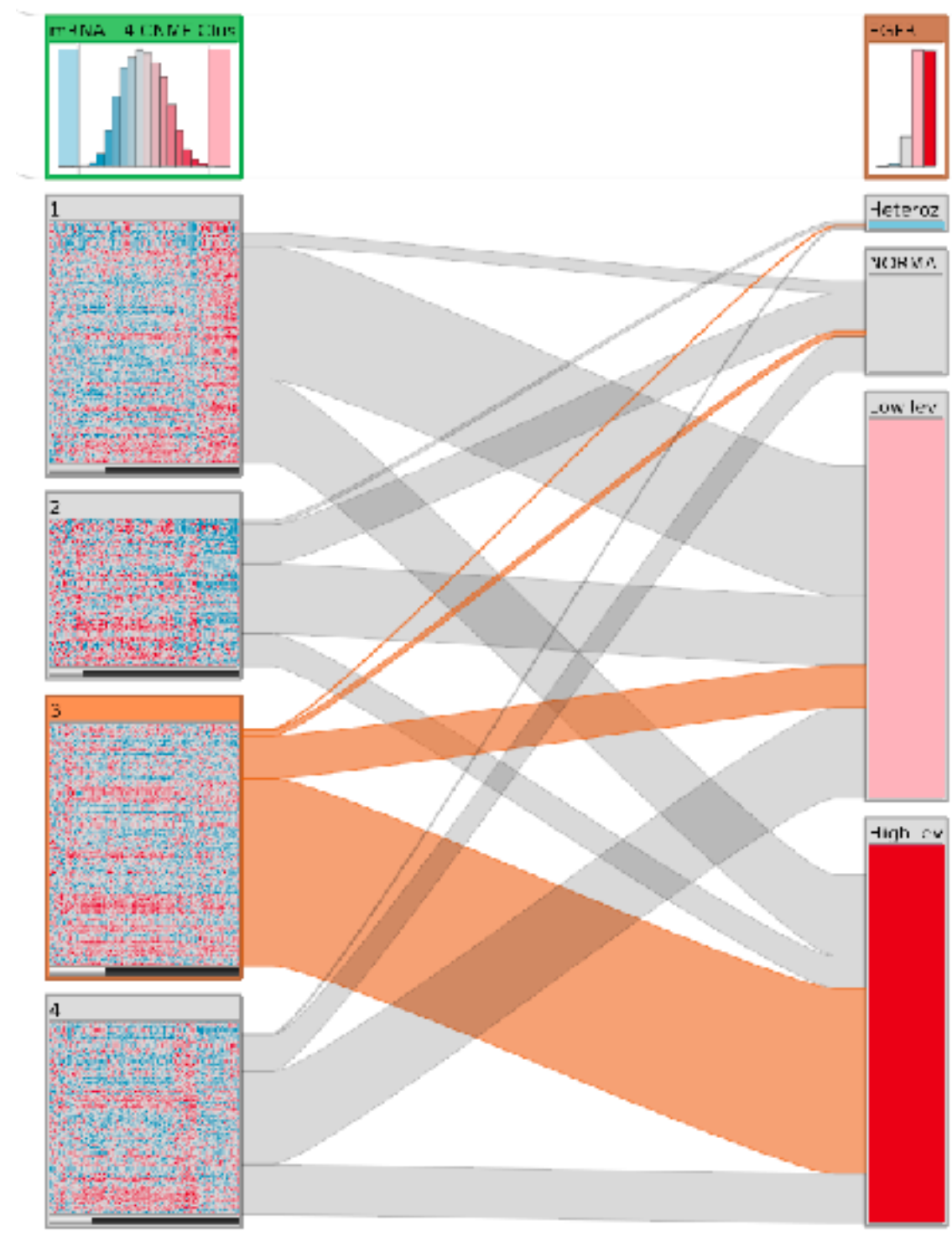
Overview-detail

- multiscale: three viewing levels
 - linked views
 - dynamic filtering
 - tooling: processing (modern version: p5js.org)

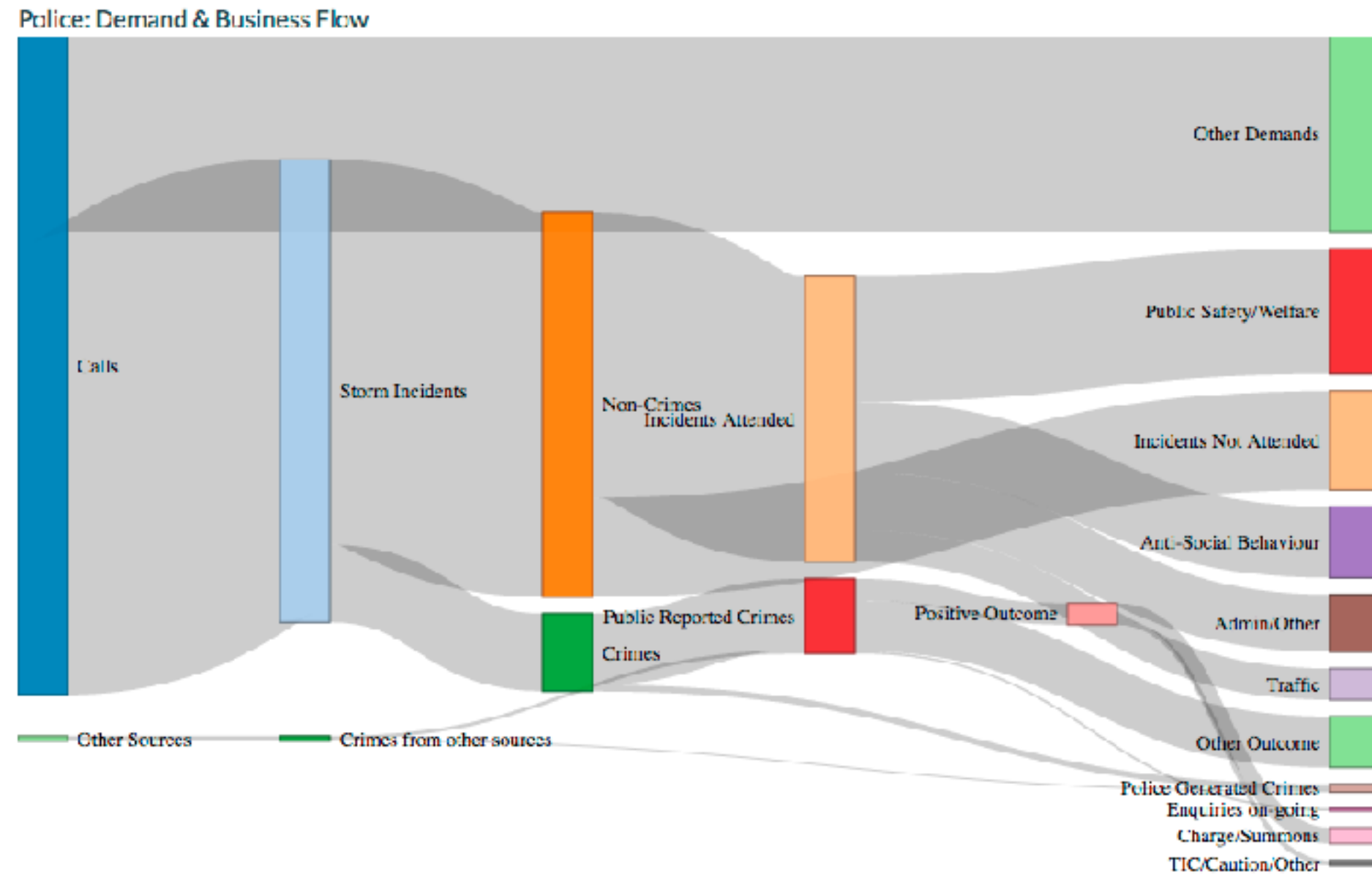
System: **MizBee**



<https://www.youtube.com/watch?v=86p7brwuz2g>

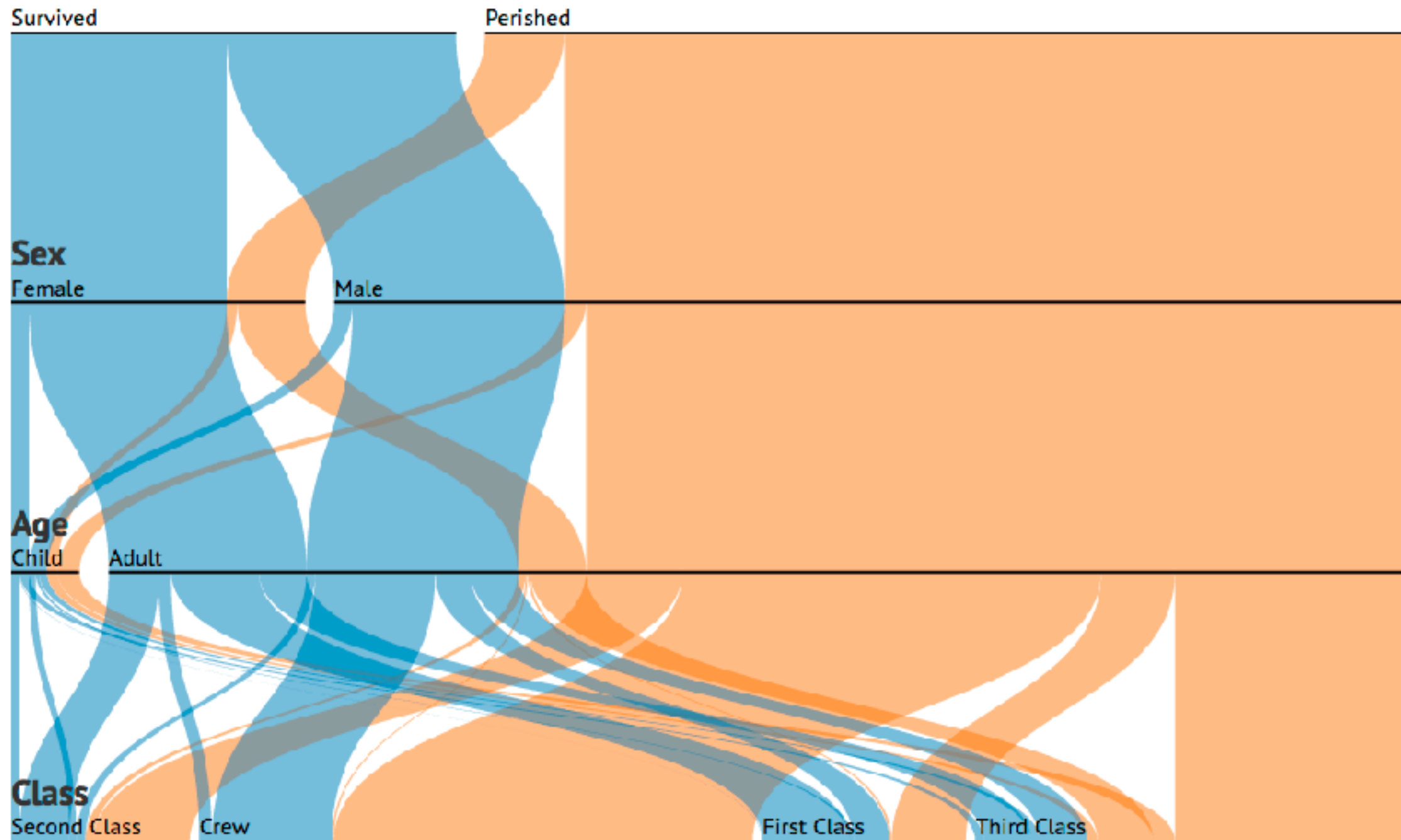


Flows: R/Shiny



<https://gallery.shinyapps.io/TSupplyDemand/>

Idiom: **Parallel sets**

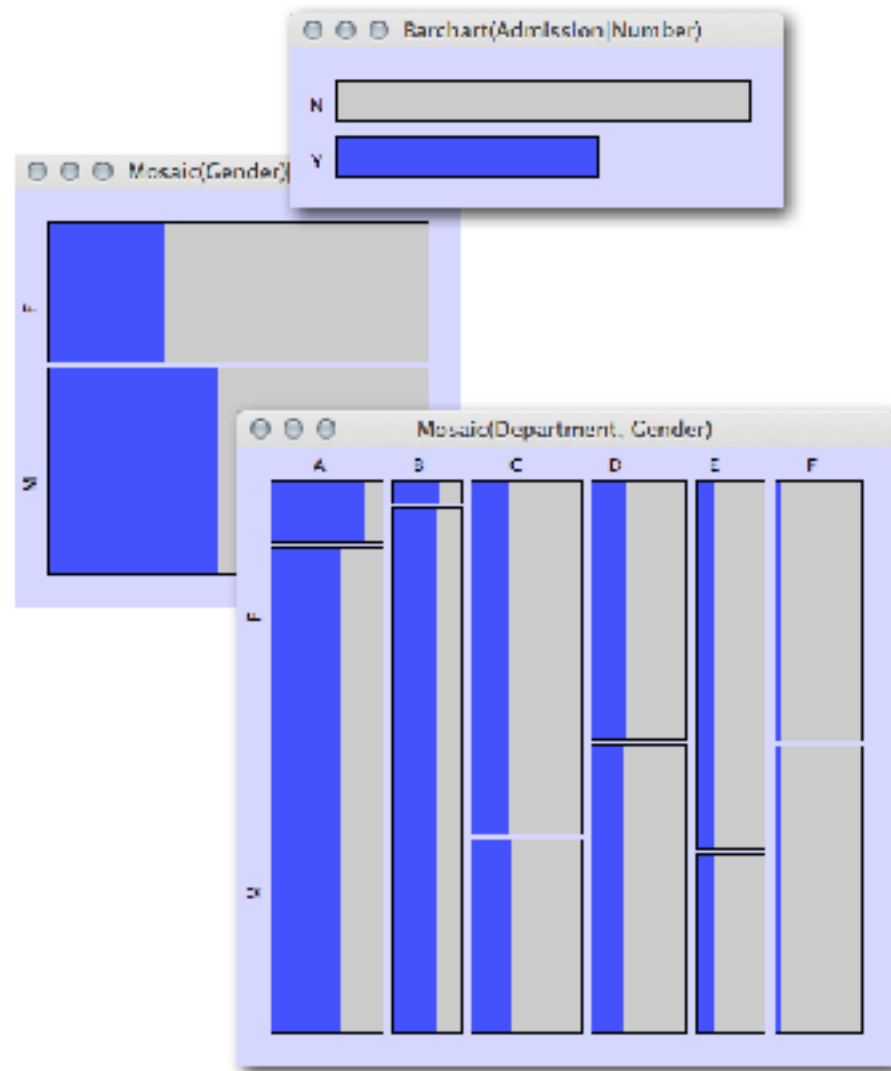


<https://www.jasondavies.com/parallel-sets/>

<https://eagereyes.org/parallel-sets>

Idiom: **Mosaic plots**

System: **Mondrian**



<http://www.theusrus.de/blog/understanding-mosaic-plots/>

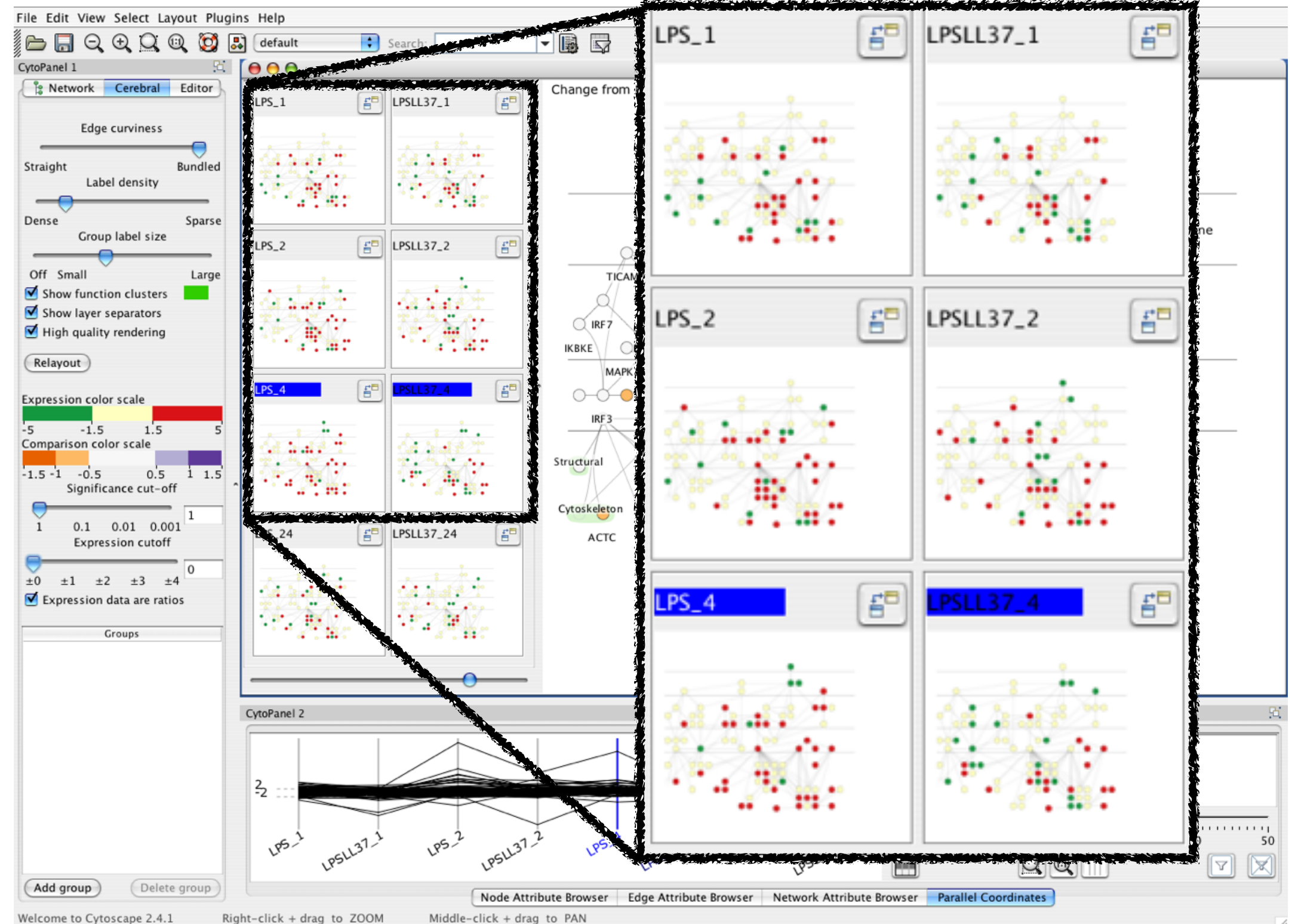
<http://www.theusrus.de/Mondrian/>

<http://www.theusrus.de/blog/making-movies/>

Idiom: Small multiples


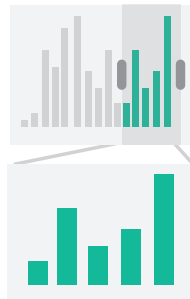
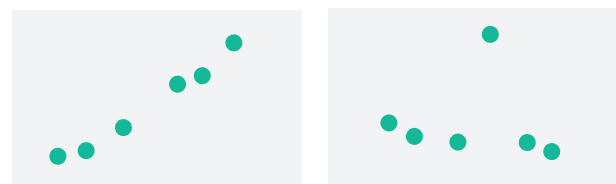



System: Cerebral

- encoding: same
- data: none shared
 - different attributes
 - different items**
 - (different condition keys,**
 - same gene keys),**
 - same attributes:**
 - expression values**
 - for node colors
 - (same network layout
 - for nodes=genes)**
- 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.]

Coordinate views: Design choice interaction

		Data		
		All	Subset	None
Encoding	Same	 <p>Redundant</p>	 <p>Overview/ Detail</p>	 <p>Small Multiples</p>
	Different	 <p>Multiform</p>	 <p>Multiform, Overview/ Detail</p>	 <p>No Linkage</p>

- why juxtapose views?

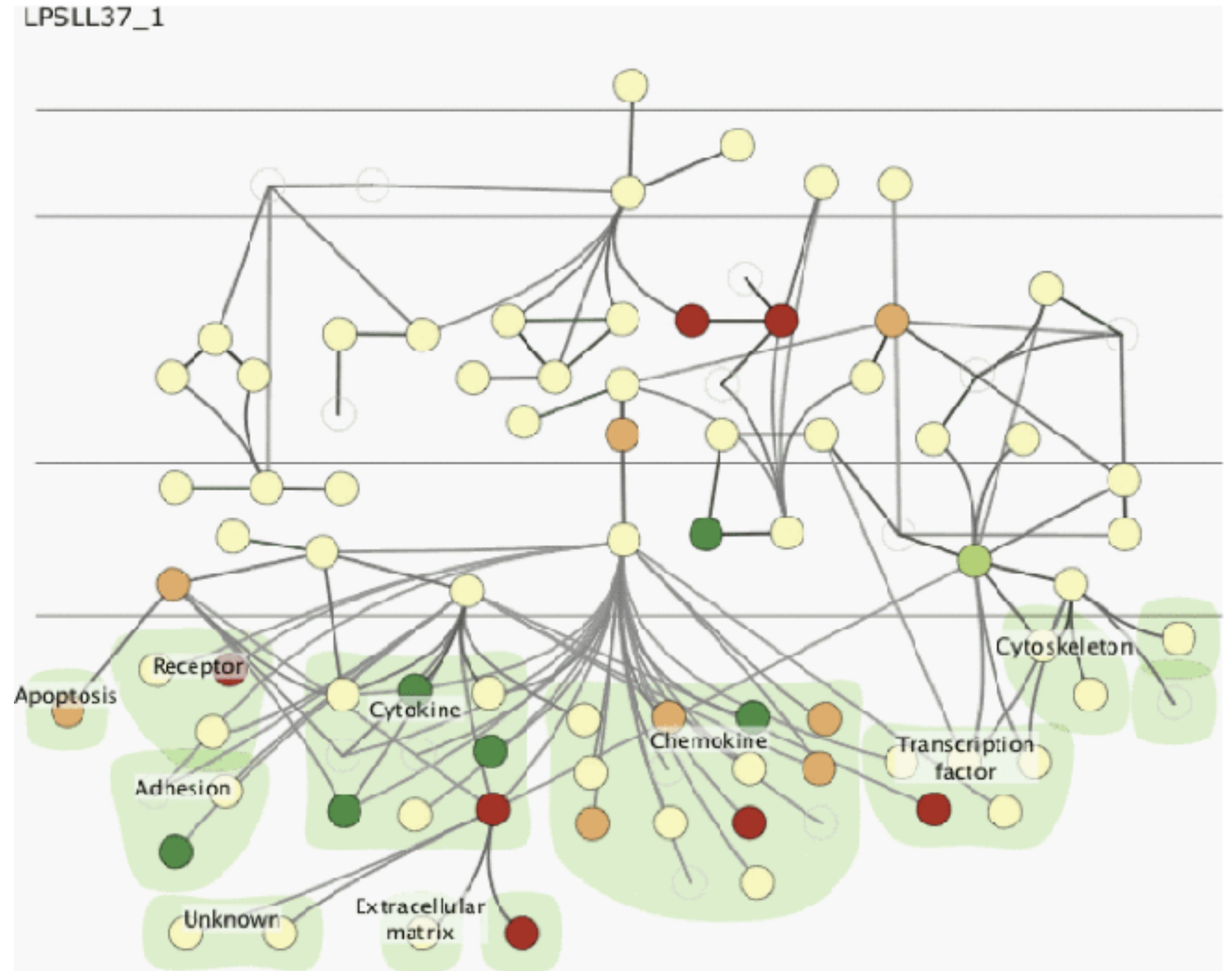
- benefits: eyes vs memory

- 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

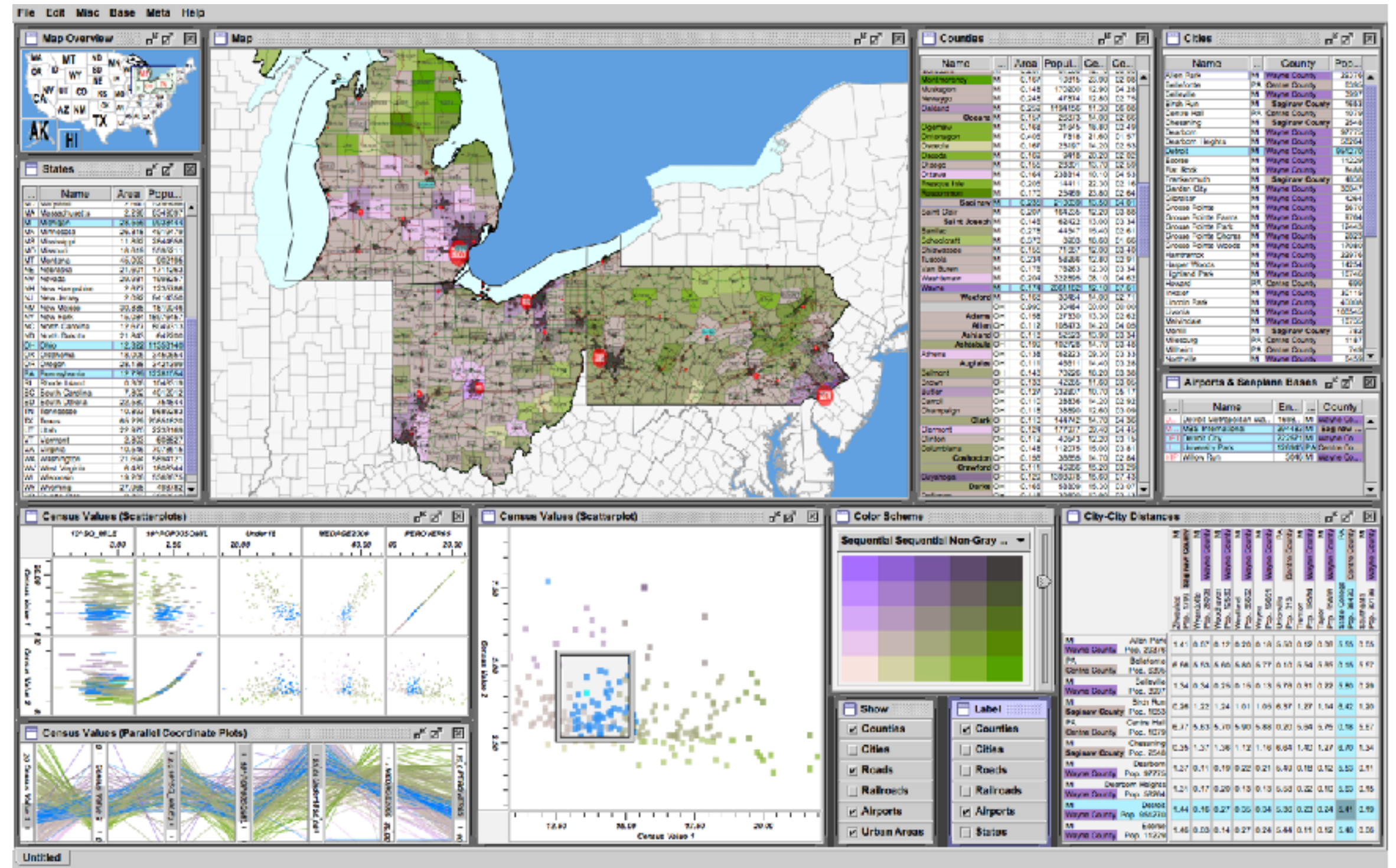
Why not animation?

- disparate frames and regions: comparison difficult
 - vs contiguous frames
 - vs small region
 - vs coherent motion of group
- safe special case
 - animated transitions



System: Improvise

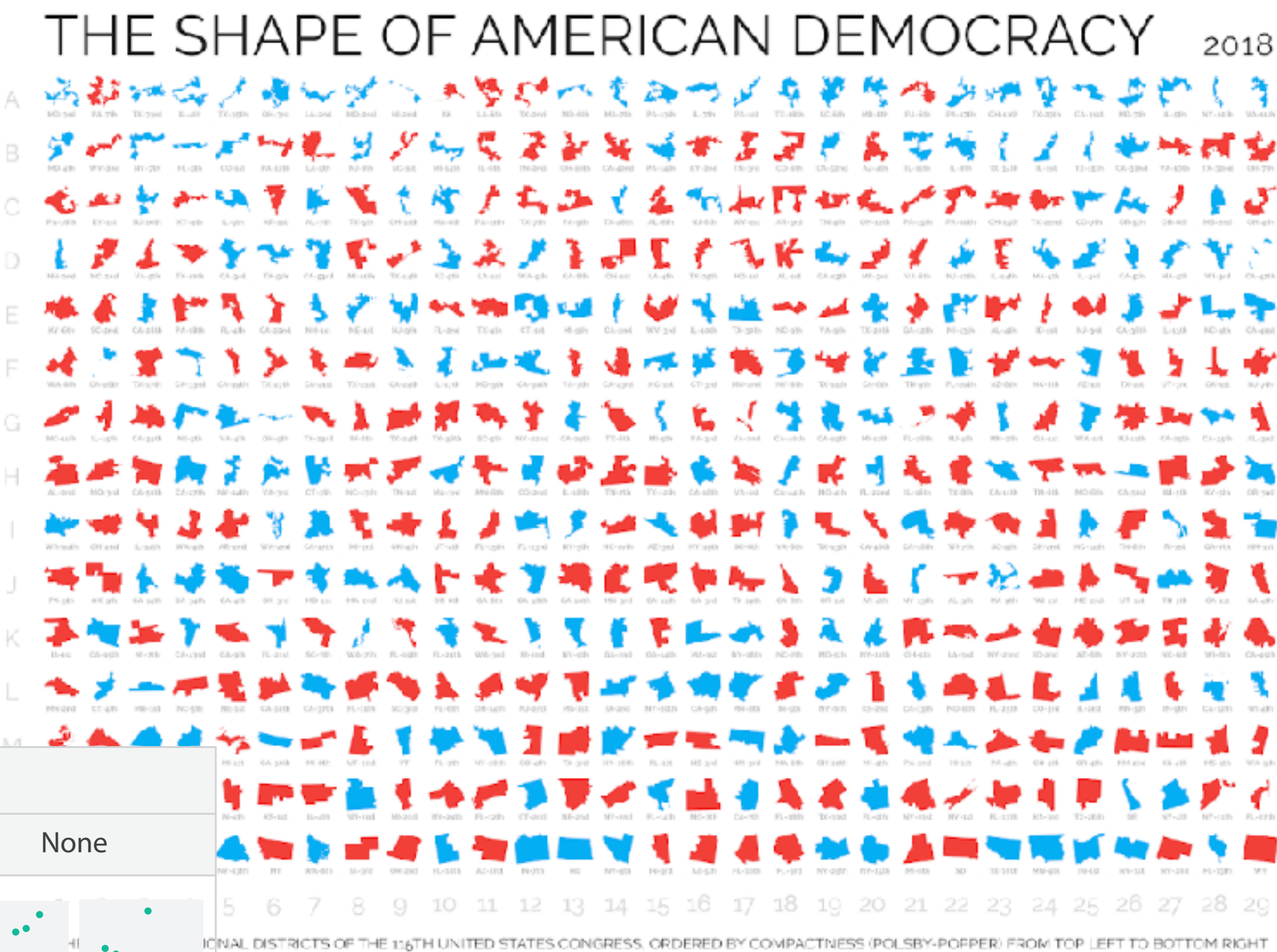
- investigate power of multiple views
 - pushing limits on view count, interaction complexity
 - how many is ok?
 - open research question
 - reorderable lists
 - easy lookup
 - useful when linked to other encodings




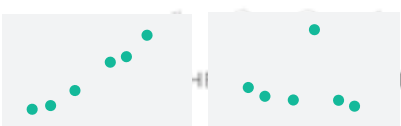

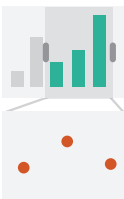
[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.]

Quiz: Multiple views

- gerrymandering




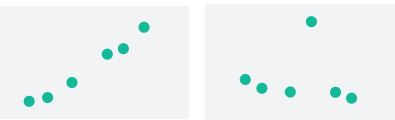


<http://www.statmapsnpix.com/2018/05/the-shape-of-american-democracy-v1.0.html>

		Data		
		All	Subset	None
Encoding	Same	Redundant	 Overview/ Detail	 Small Multiples
	Different	 Multiform	 Multiform, Overview/ Detail	No Linkage

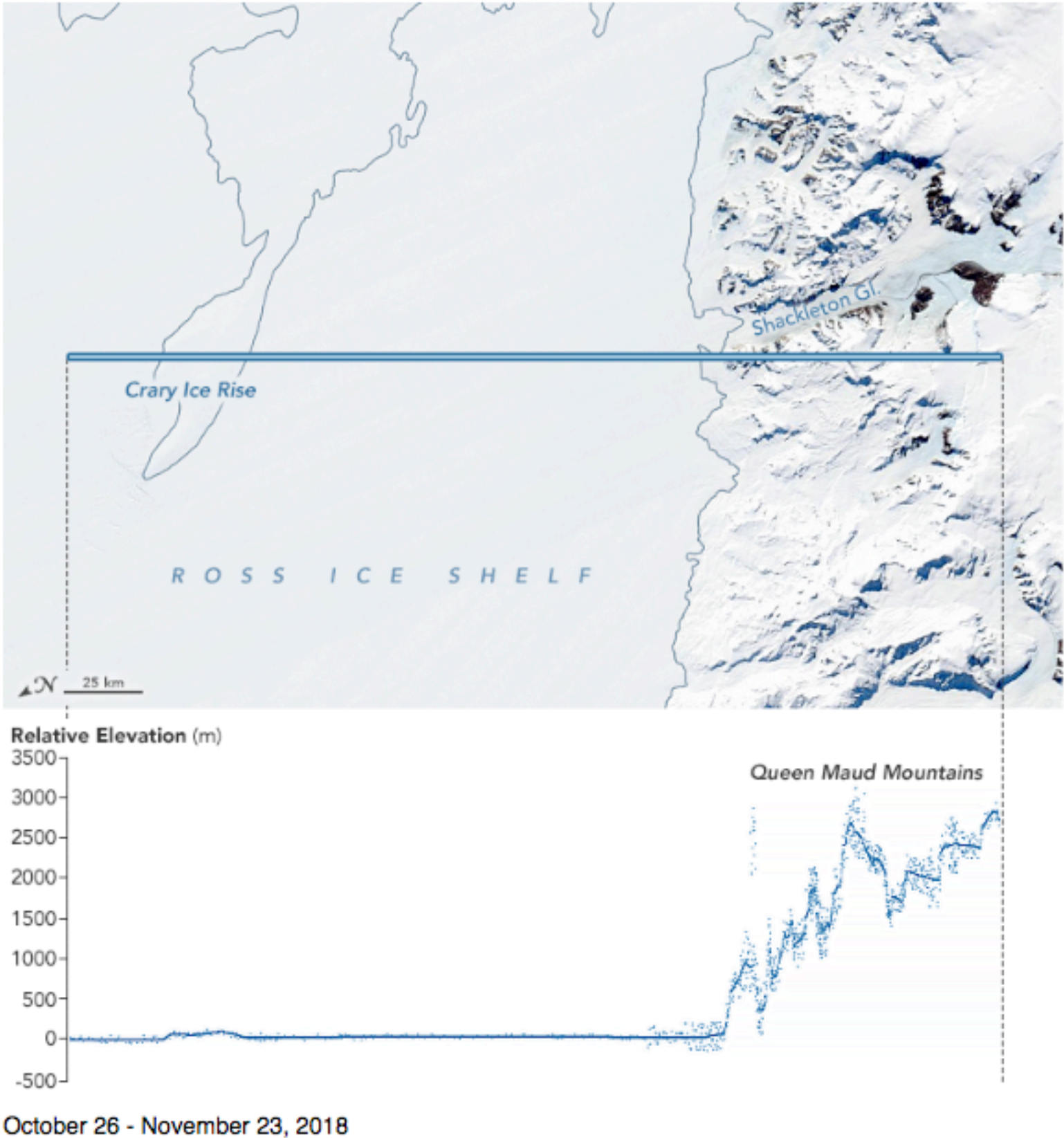
Quiz: Multiple views

- terrain

<https://earthobservatory.nasa.gov/images/144367/taking-measure-of-antarctic-terrain>


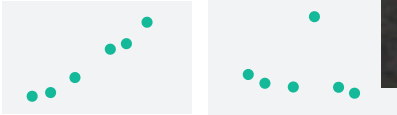


		Data		
		All	Subset	None
Encoding	Same	Redundant	 Overview/ Detail	 Small Multiples
	Different	 Multiform	 Multiform, Overview/ Detail	No Linkage

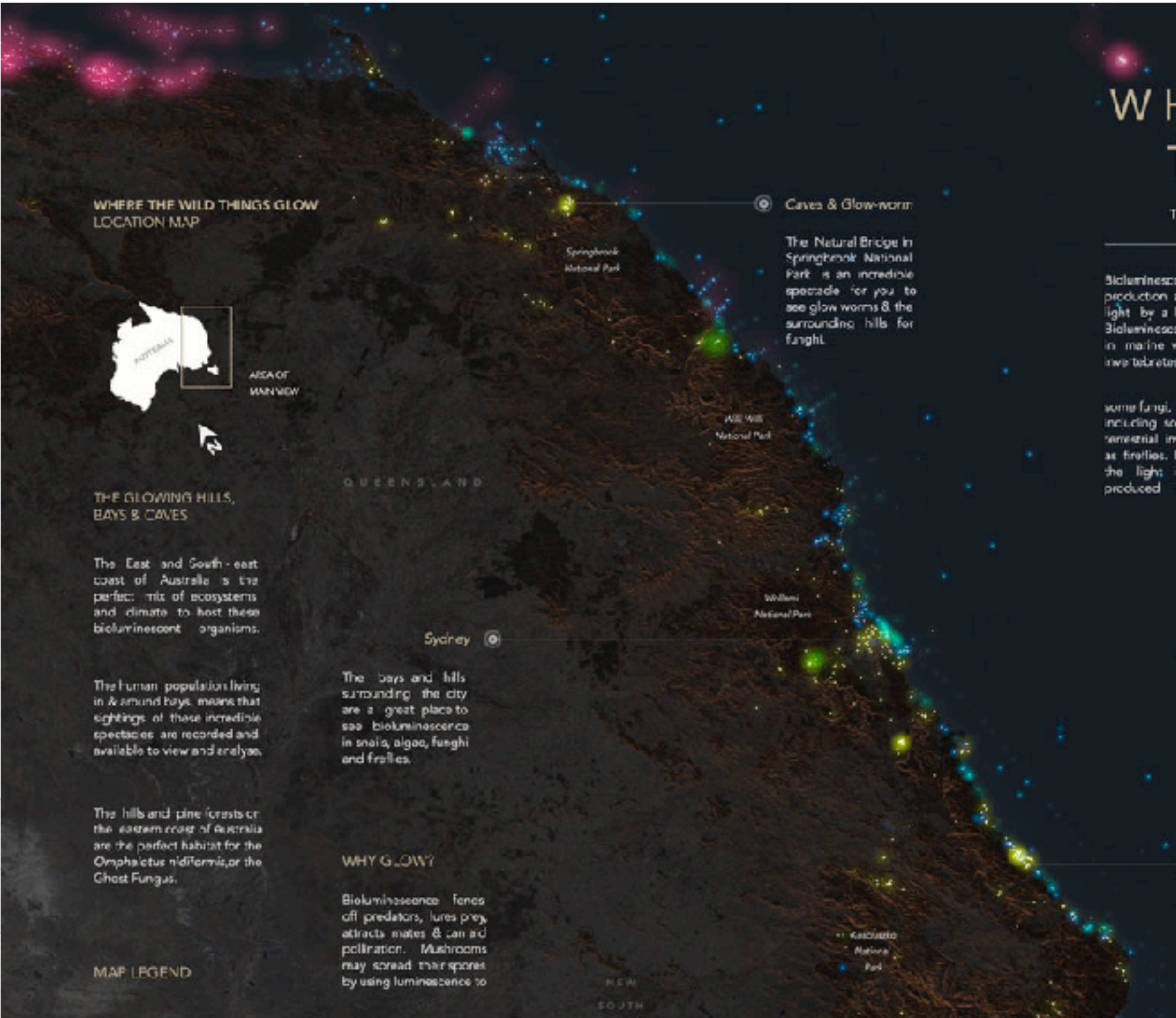
Taking Measure of Antarctic Terrain



Quiz: Multiple views

- where the wild things glow

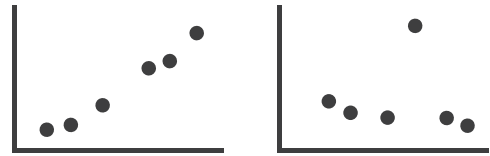
		Data		
		All	Subset	None
Encoding	Same	Redundant	 Overview/ Detail	 Small Multiples
	Different	 Multiform	 Multiform, Overview/ Detail	No Linkage



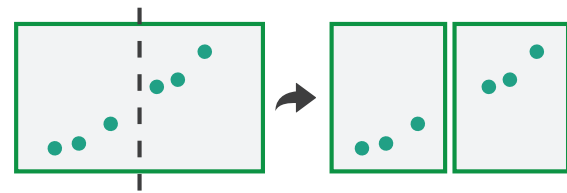
<https://public.tableau.com/profile/jonni.walker#!/vizhome/WhereTheWildThingsGlow/Tester>

Facet

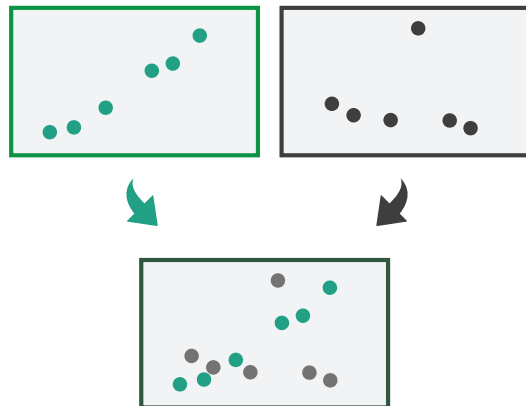
➔ Juxtapose



➔ Partition



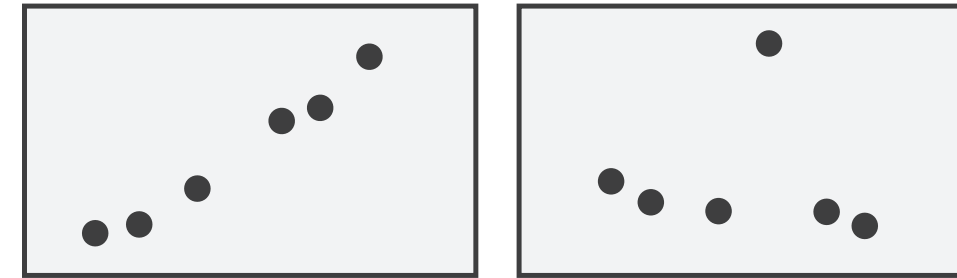
➔ Superimpose



Partition into views

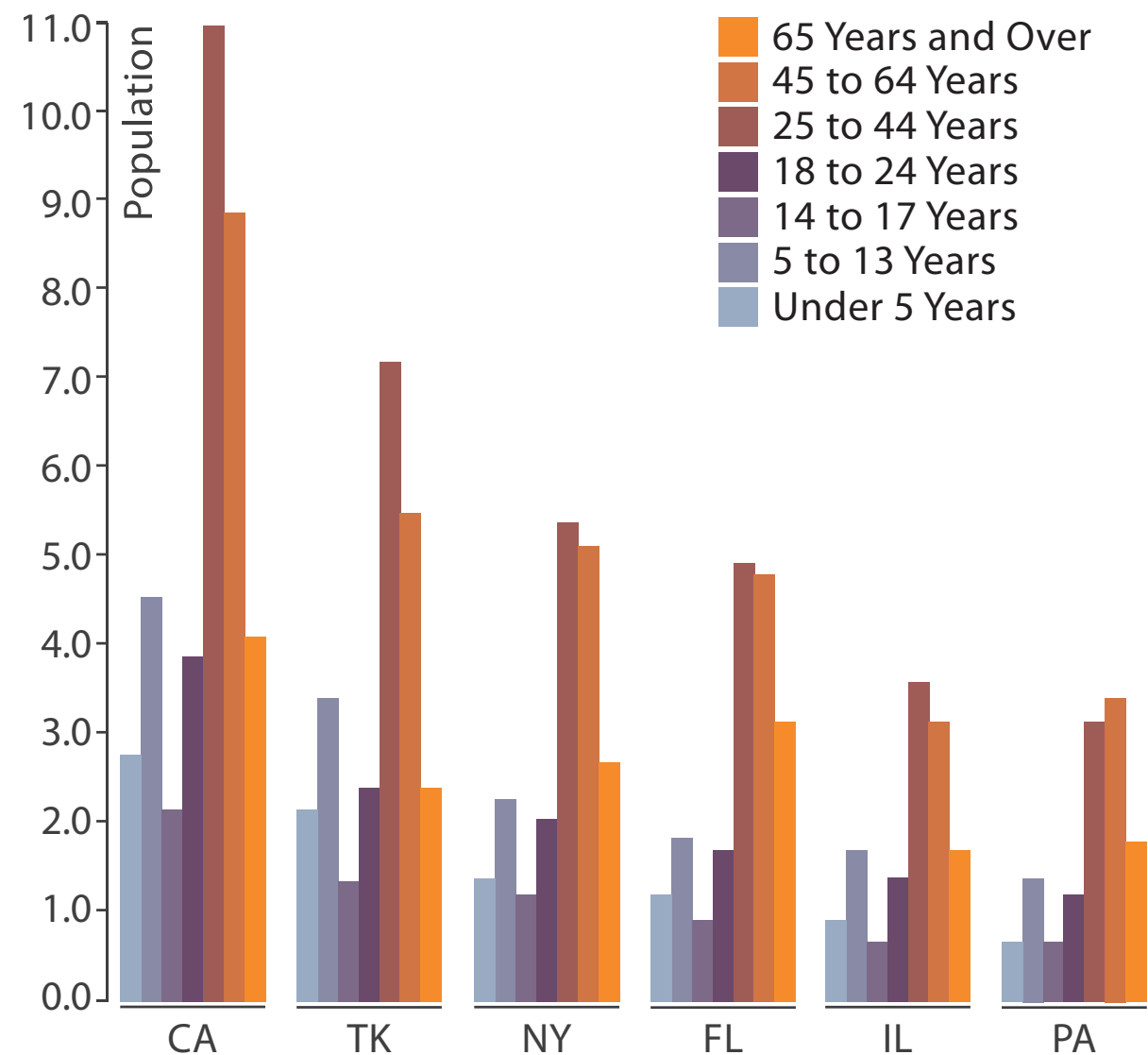
- how to divide data between views ➞ **Partition into Side-by-Side Views**

- split into regions by attributes
- encodes association between items using spatial proximity
- order of splits has major implications for what patterns are visible

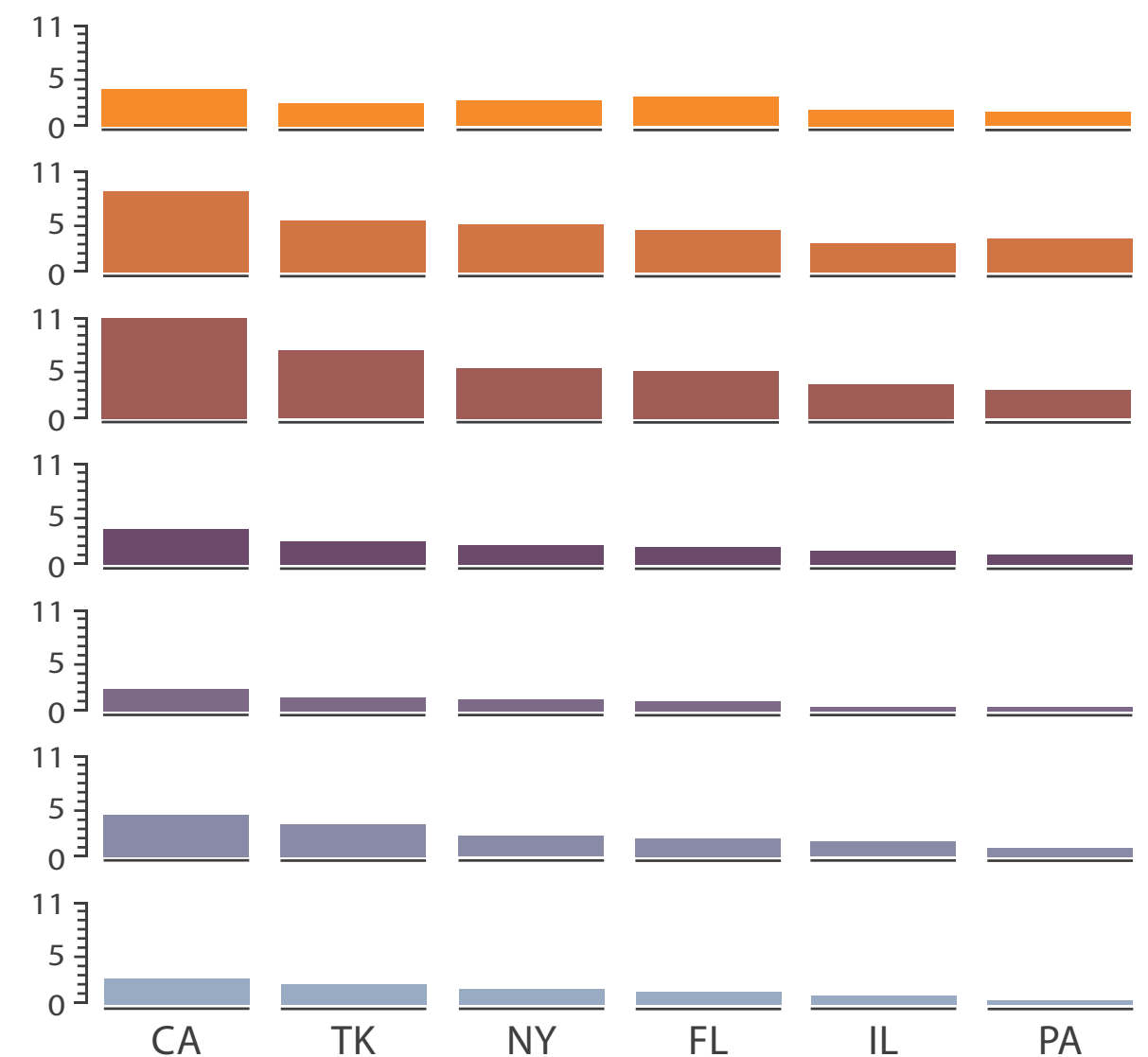


Partitioning: List alignment

- 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



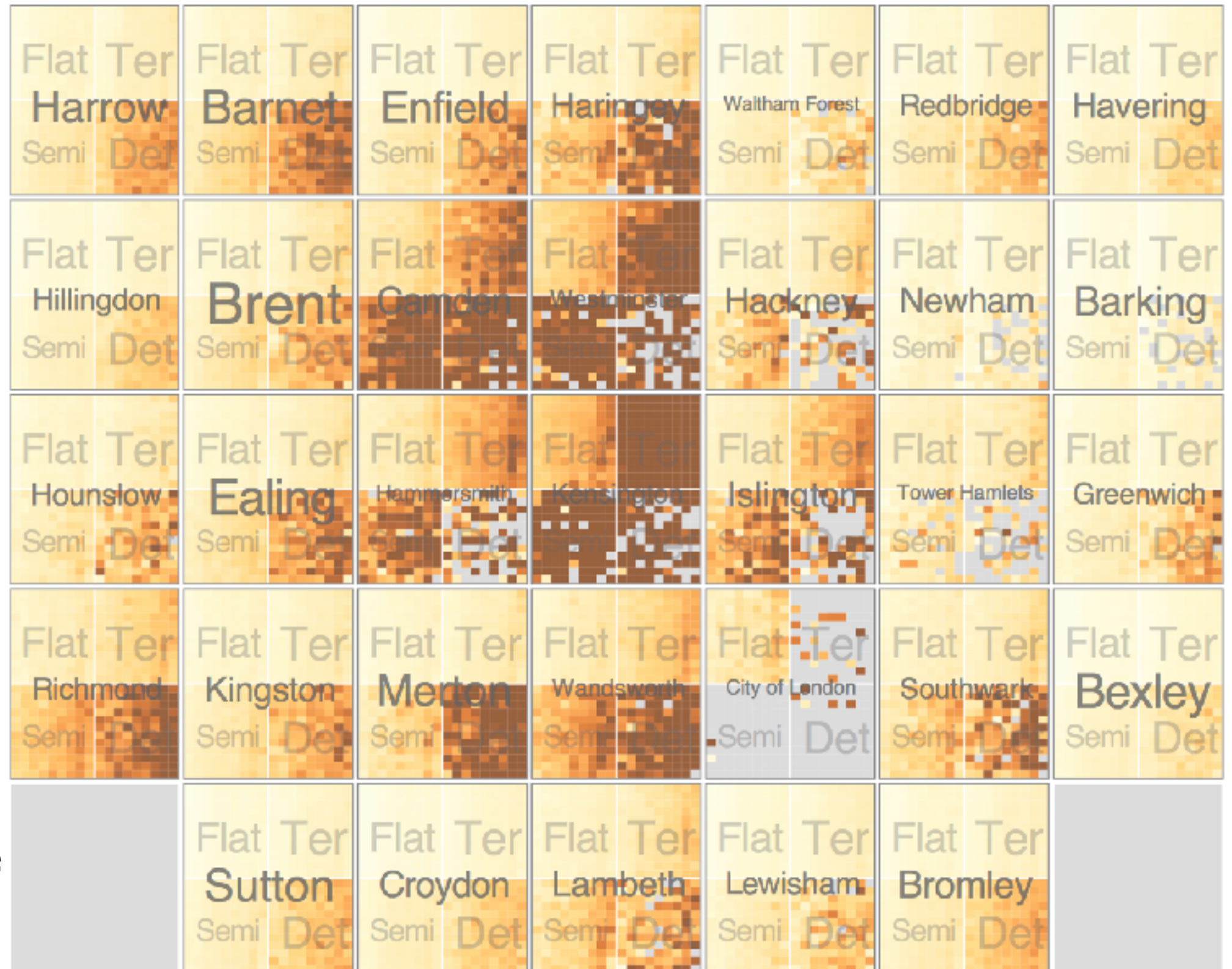
- small-multiple bar charts
 - split by age into regions
 - one chart per region
 - compare: easy within age, harder across states



Partitioning: Recursive subdivision

System: **HIVE**

- split by neighborhood
- then by type
 - years as rows
 - months as columns
- color by price
- neighborhood patterns
 - where it's expensive
 - where you pay much more for detached type



Partitioning: Recursive subdivision

System: **HIVE**

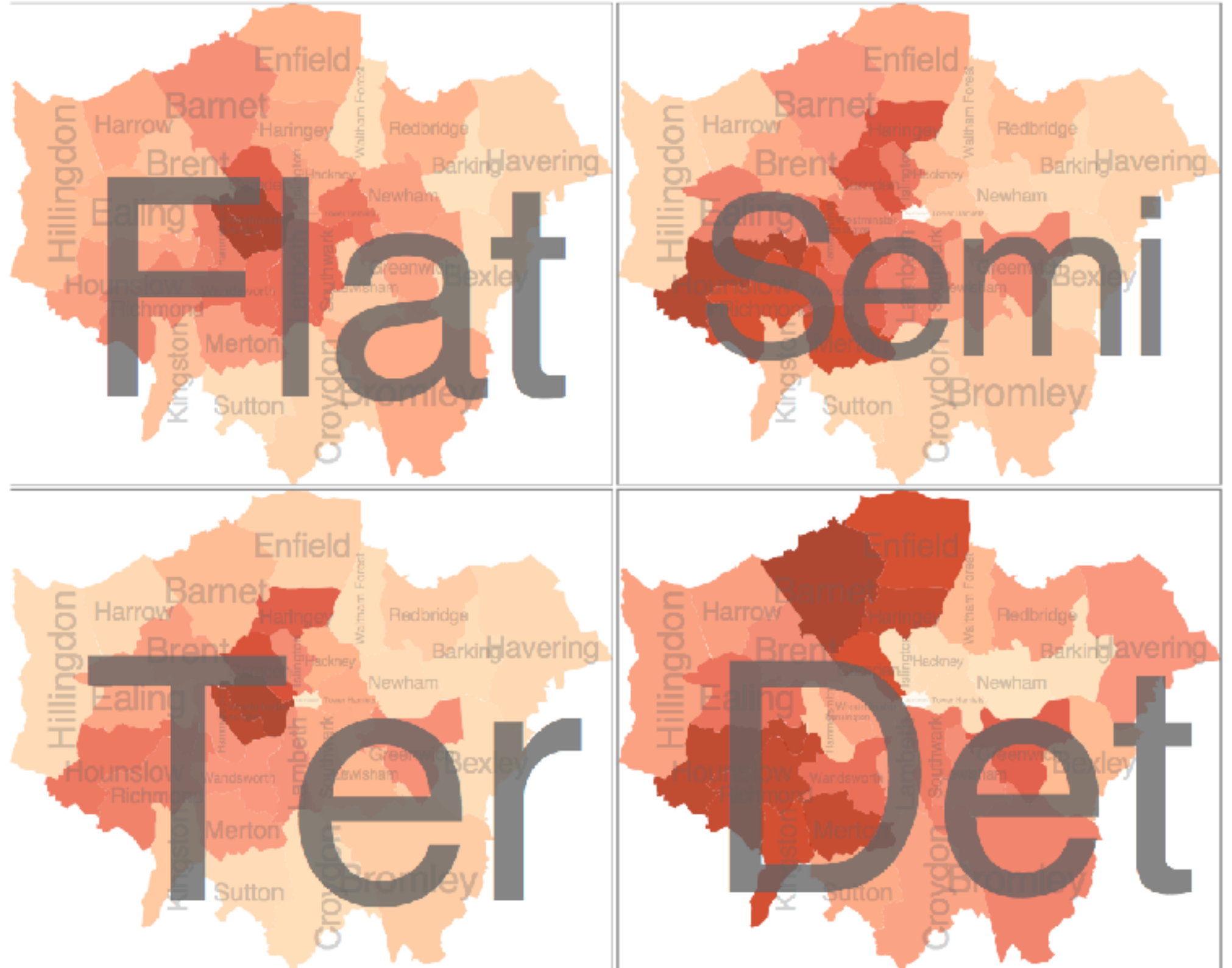
- switch order of splits
 - type then neighborhood
- switch color
 - by price variation
- type patterns
 - within specific type, which neighborhoods inconsistent



Partitioning: Recursive subdivision

System: **HIVE**

- different encoding for second-level regions
– choropleth maps

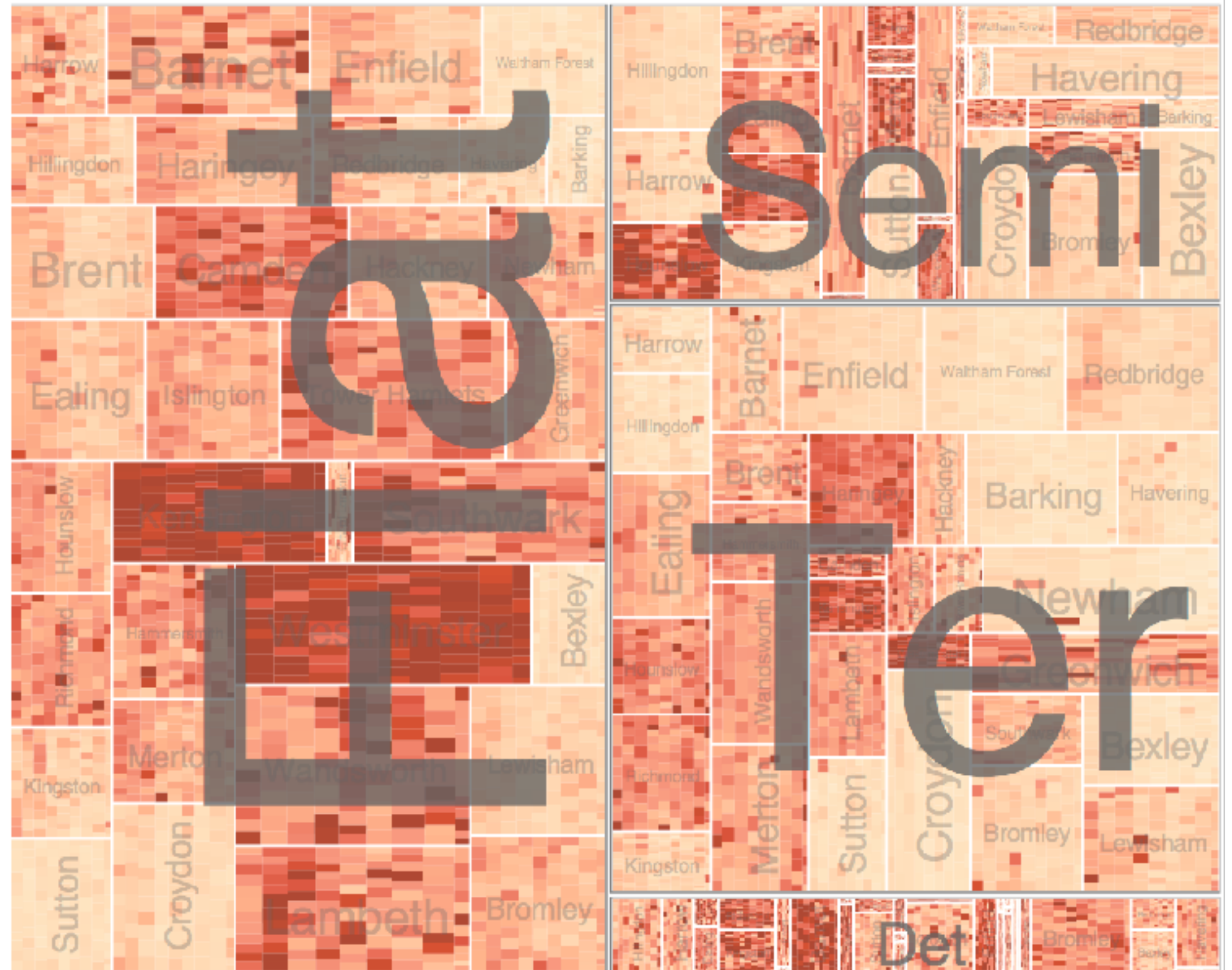


[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. *IEEE Transactions on Visualization and Computer Graphics* (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

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.]

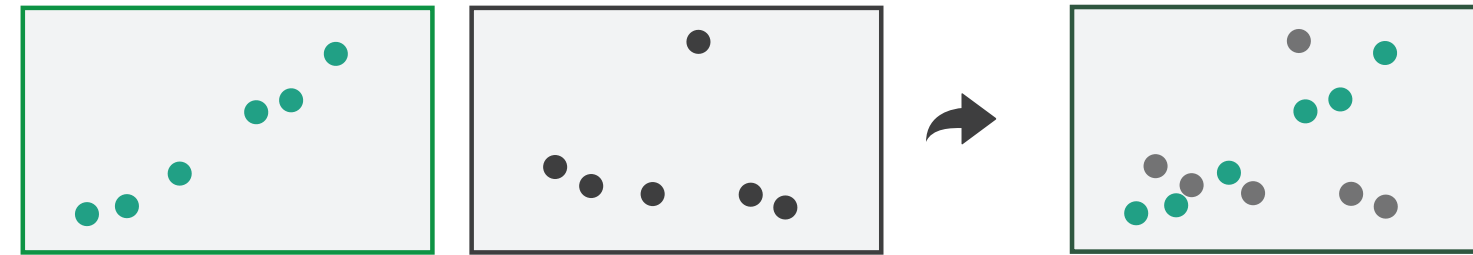
Superimpose layers

- **layer**: set of objects spread out over region
 - each set is visually distinguishable group
 - extent: whole view

➔ Superimpose Layers

- design choices

- how many layers, how to distinguish?
 - encode with different, nonoverlapping channels
 - two layers achievable, three with careful design
- small static set, or dynamic from many possible?



Static visual layering

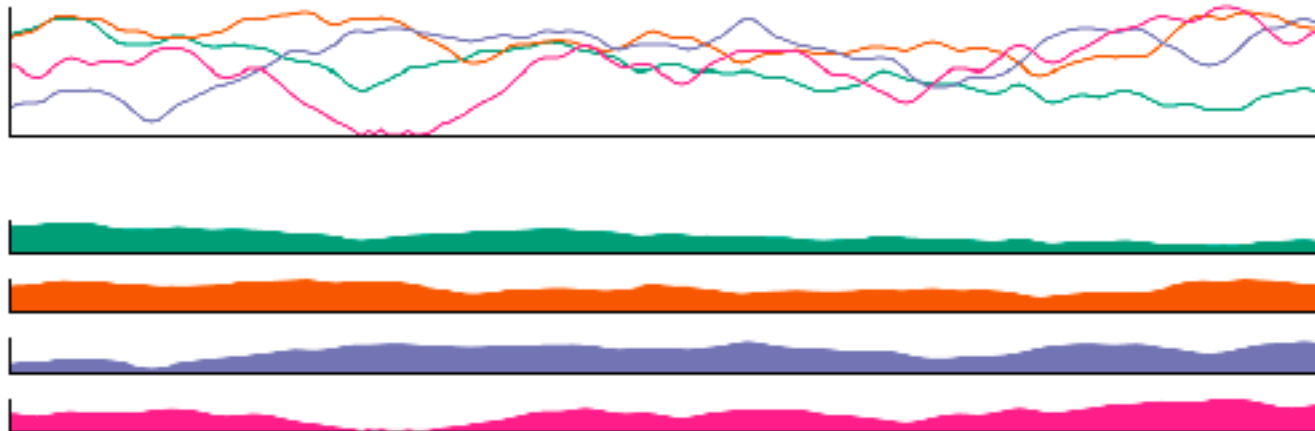
- foreground layer: roads
 - hue, size distinguishing main from minor
 - high luminance contrast from background
- background layer: regions
 - desaturated colors for water, parks, land areas
- user can selectively focus attention
- “get it right in black and white”
 - check luminance contrast with greyscale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



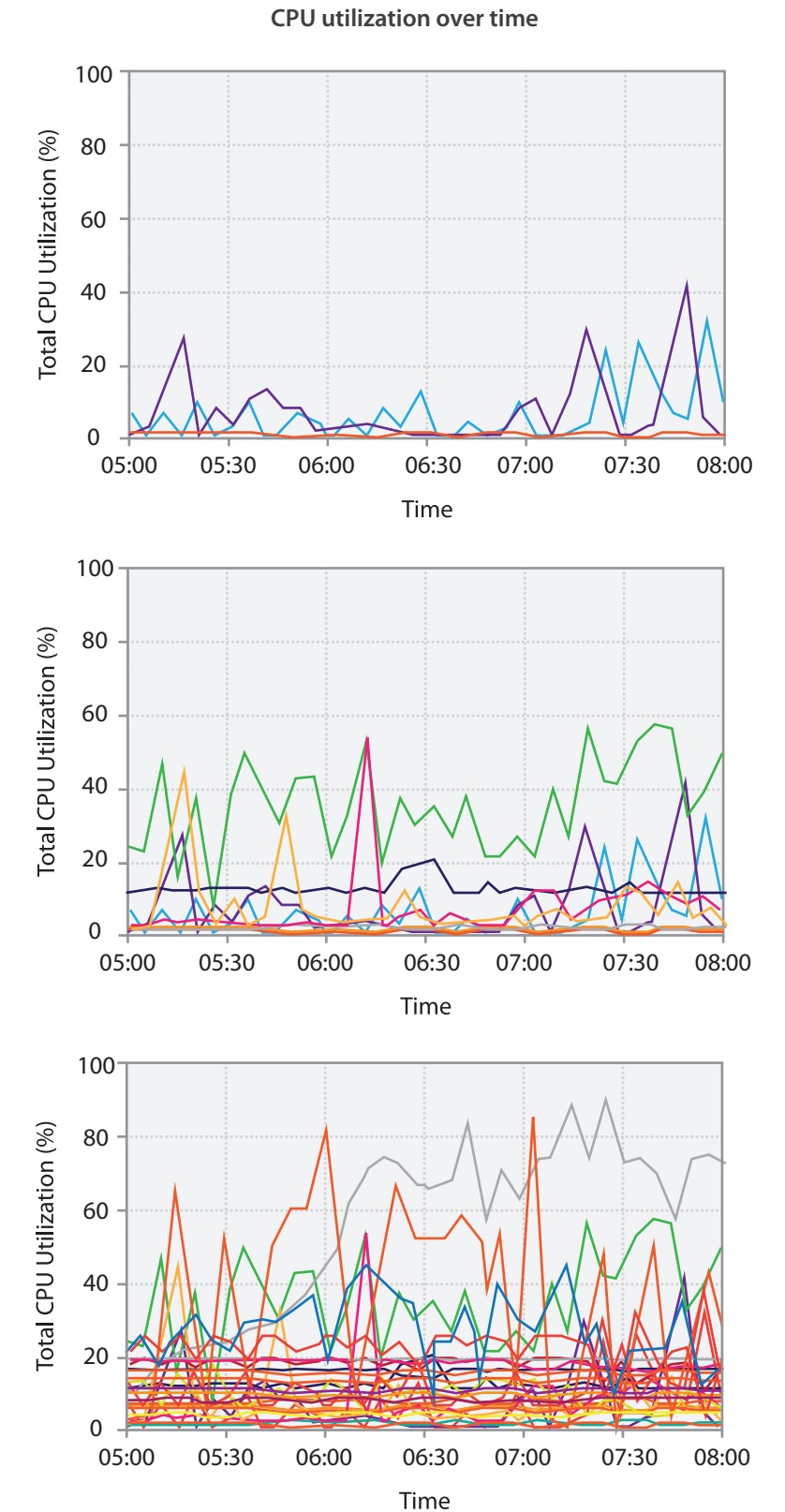
[Get it right in black and white. Stone. 2010.
<http://www.stonesc.com/wordpress/2010/03/get-it-right-in-black-and-white>]

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

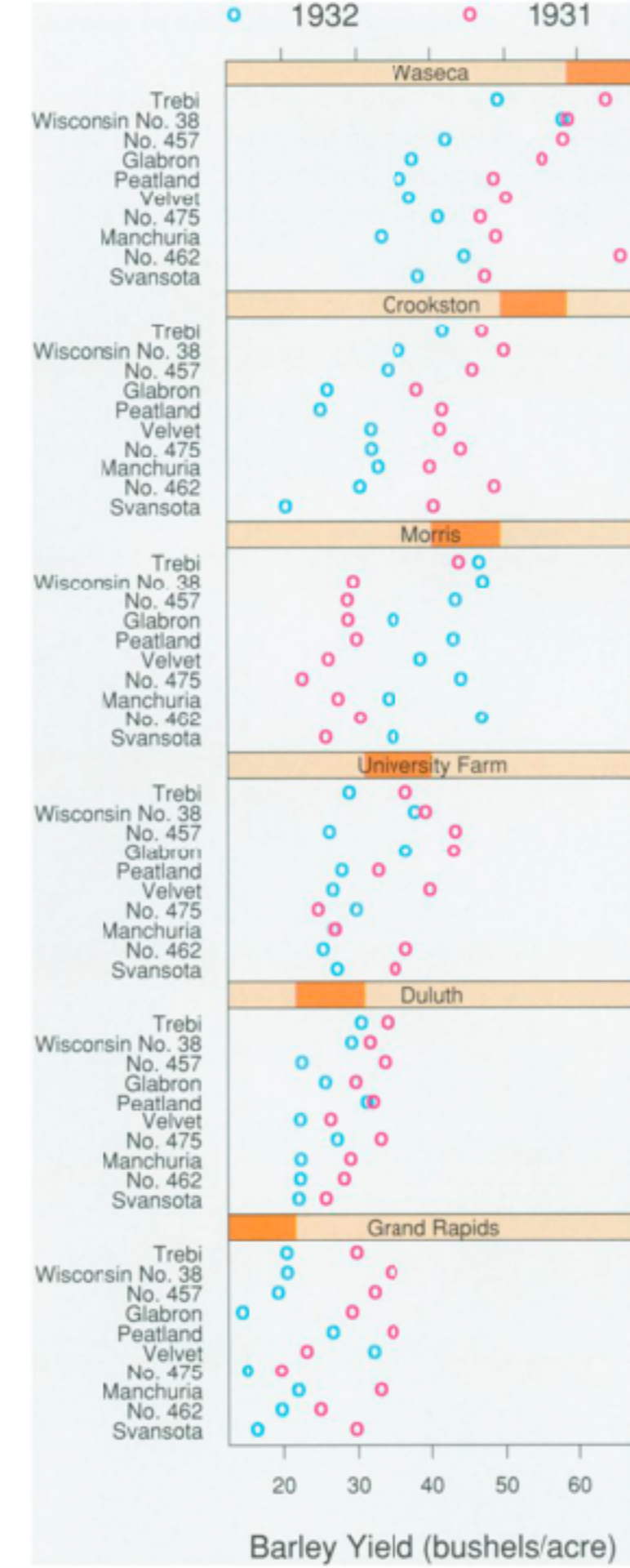


[Graphical Perception of Multiple Time Series. Javed, McDonnell, and Elmqvist. *IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010)* 16:6 (2010), 927–934.]



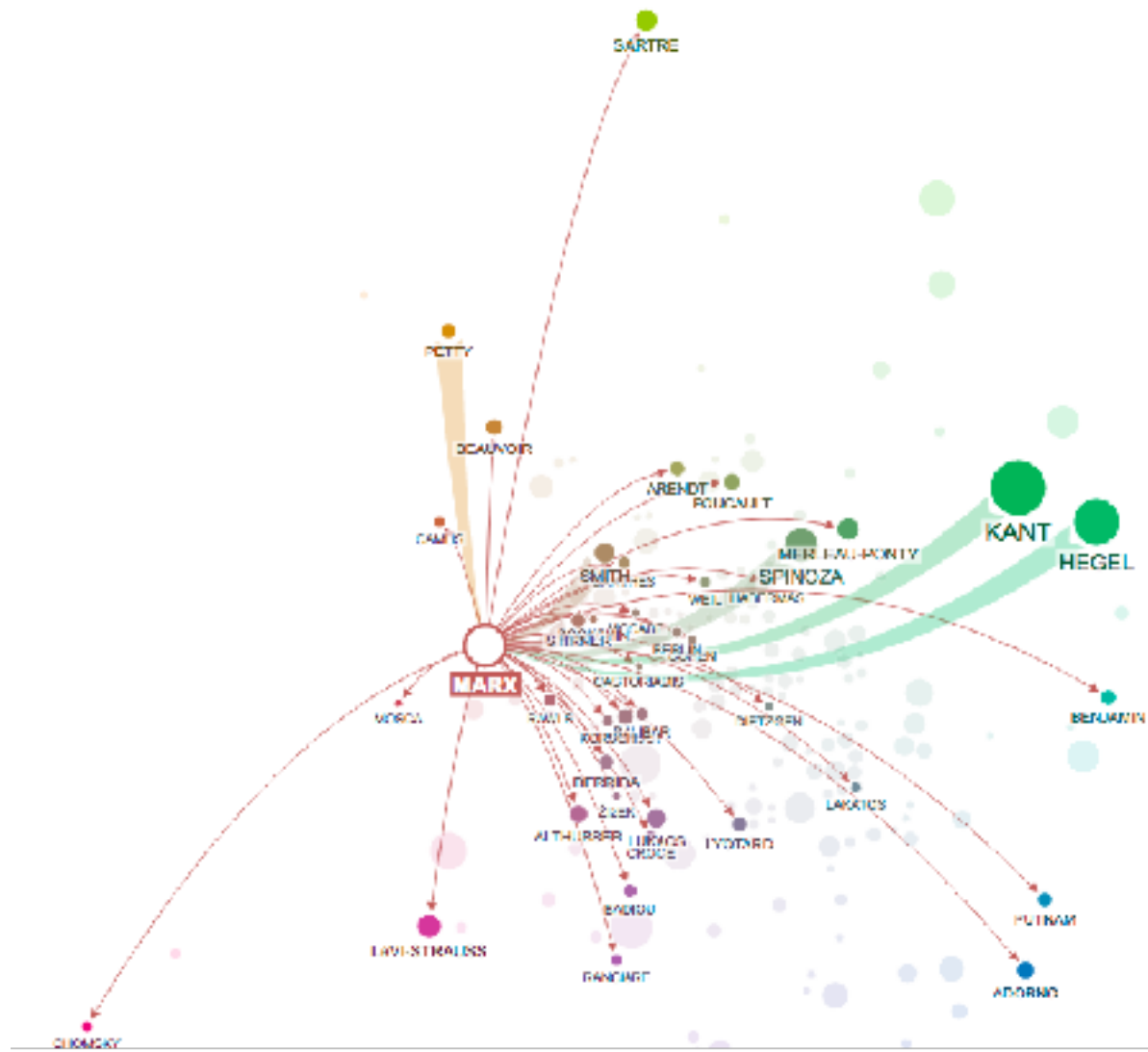
Idiom: **Trellis plots**

- superimpose within same frame
 - color code by year
- partitioning
 - split by site, rows are wheat varieties
- main-effects ordering
 - derive value of median for group, use to order
 - order rows within view by variety median
 - order views themselves by site median

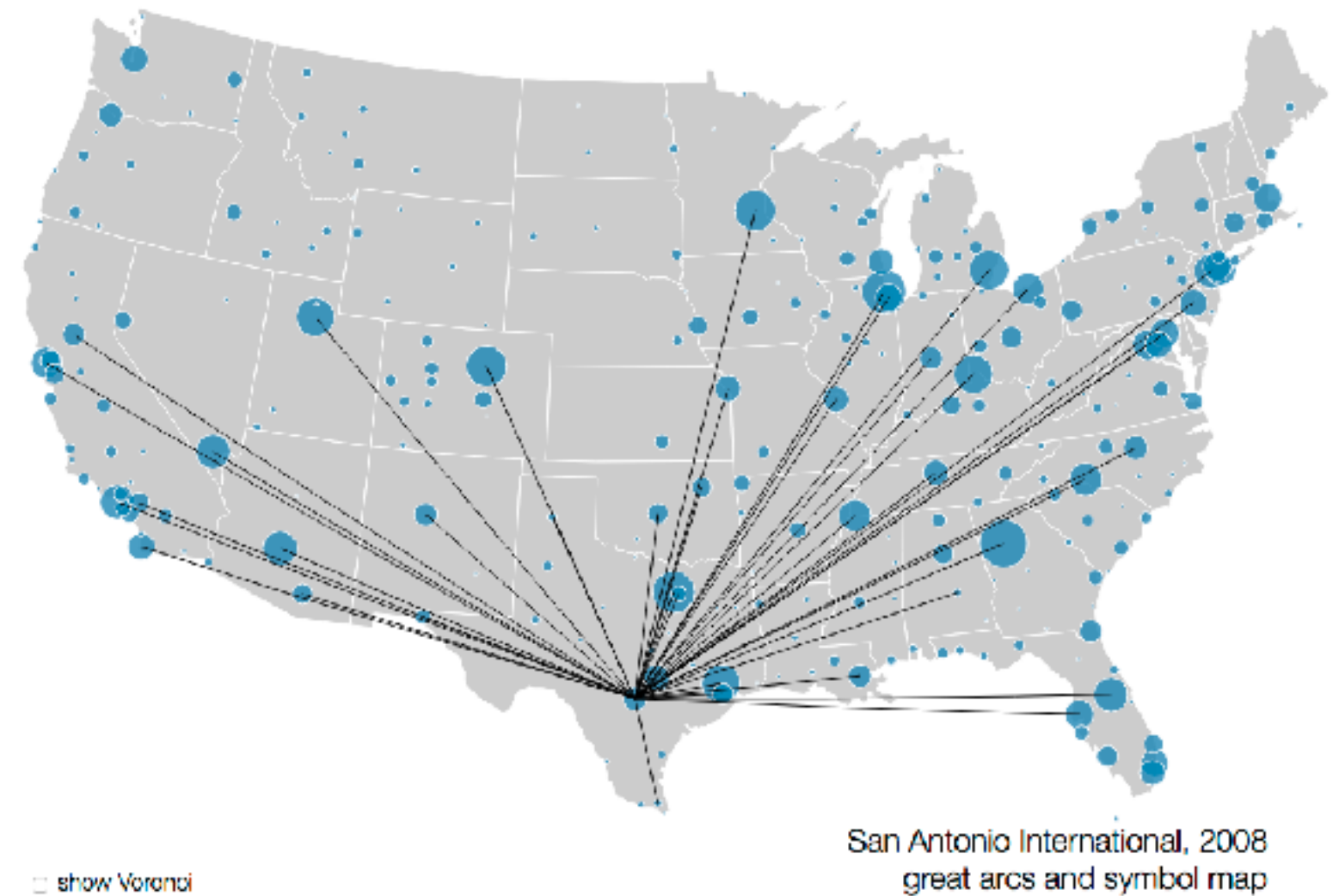


Dynamic visual layering

- interactive based on selection
- one-hop neighbour highlighting demos: click vs hover (lightweight)



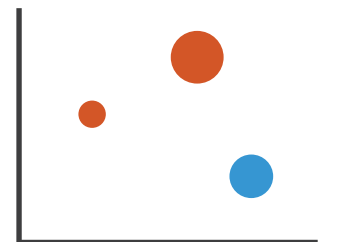
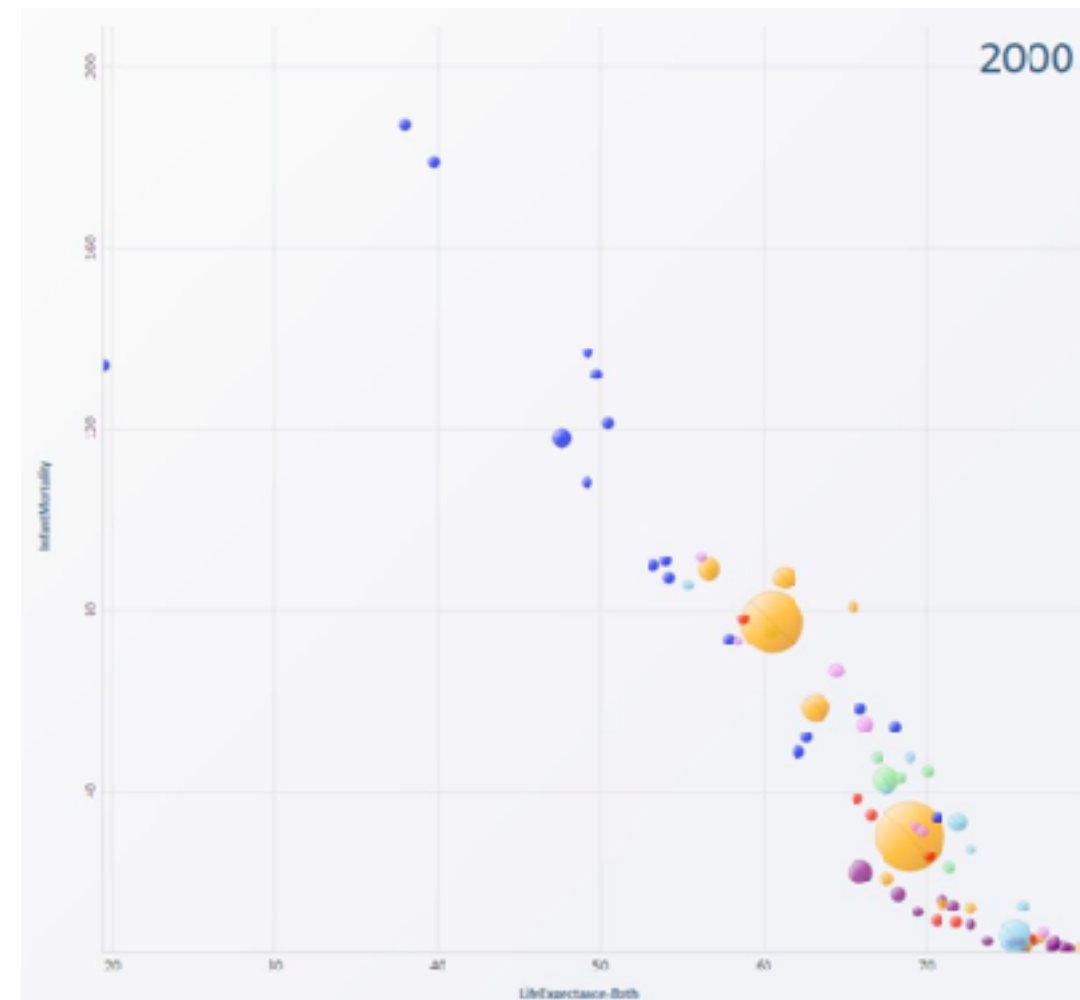
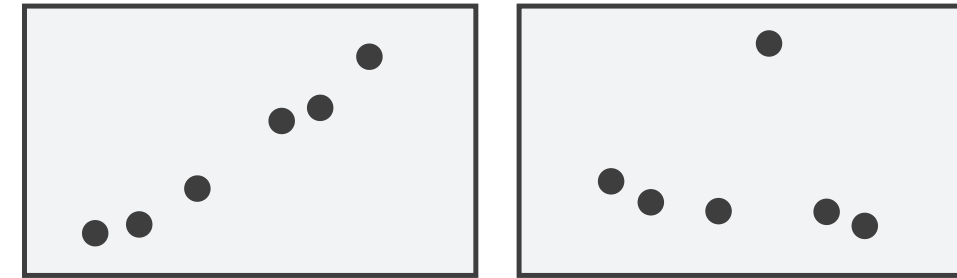
<http://mariandoerk.de/edgemaps/demo/>



<http://mbostock.github.io/d3/talk/20111116/airports.html>

Partition into views

- how to divide data between views ➞ Partition into Side-by-Side 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



How?

Encode

➔ Arrange

➔ Express



➔ Separate



➔ Order



➔ Align



➔ Use



➔ Map

from **categorical** and **ordered** attributes

➔ Color

➔ Hue



➔ Saturation



➔ Luminance



➔ Size, Angle, Curvature, ...



➔ Shape



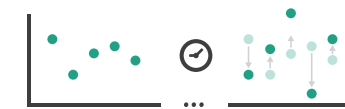
➔ Motion

Direction, Rate, Frequency, ...

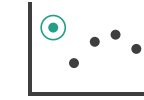


Manipulate

➔ Change



➔ Select



➔ Navigate



Facet

➔ Juxtapose



➔ Partition



➔ Superimpose



Reduce

➔ Filter



➔ Aggregate



➔ Embed



What?

Why?

How?

Credits

- Visualization Analysis and Design (Ch 11, 12)
- Alex Lex & Miriah Meyer, <http://dataviscourse.net/>
- Effectiveness of Animation in Trend Visualization.
George Robertson, Roland Fernandez, Danyel Fisher, Bongshin Lee, and John Stasko.
IEEE TVCG 14(6):1325-32 (Proc InfoVis 2008).
<https://www.cc.gatech.edu/~stasko/papers/infovis08-anim.pdf>