

Information Visualization

Manipulate Interactive, Facet into Multiple, Scalable Insets

Ex: Complexity Families

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Week 9, 2 Nov 2022

<https://www.cs.ubc.ca/~tmm/courses/547-22>

Plan for today

- small group exercises
 - Complexity Families
- backlog reading Q&A
 - W6, W7
- this week reading Q&A
 - chap: Manipulate Interactive, Multiple Views. paper: ScalableInsets
- reminder: post-class office hours
 - if you want discussion of your project proposal feedback
 - especially if I told you to talk with me!
 - all of you should have gotten written comments by email

Upcoming

- next week (W10): reading week. no class, no readings, no async discussion
 - work on projects!
- week after (W11)
 - **light async reading/discussion**
 - 1 reading: Ch 13, Reduce
 - due Tue 3pm: project updates
 - in class: project peer reviews
 - each team will be matched with one other, will post on Piazza before Tue 3pm
 - read other team's written update before class
 - first A critiques B; then B critiques A
 - record discussion/thoughts in gdoc
 - in class: mini-lecture & Q/A catchup

Upcoming

- week after that (W12)
 - async: last week of readings / discussion
 - Ch 14: Embed - Focus+Context
 - paper: Visualizing Dataflow Graphs of Deep Learning Models in TensorFlow.
Kanit Wongsuphasawat, Daniel Smilkov, James Wexler, Jimbo Wilson, Dandelion Mané, Doug Fritz, Dilip Krishnan, Fernanda B. Viégas, and Martin Wattenberg.
IEEE TVCG (Proc. VAST 2017) 24(1):1-12, 2018.
[type: design study]
 - in class: post-update meetings with Tamara
 - oral feedback on project progress, after I've read them
- last week of classes (W13)
 - async: no readings/discussion
 - in class: lecture on research process and final writeup expectations
- final presentations (W15)

Q&A / Backup Slides

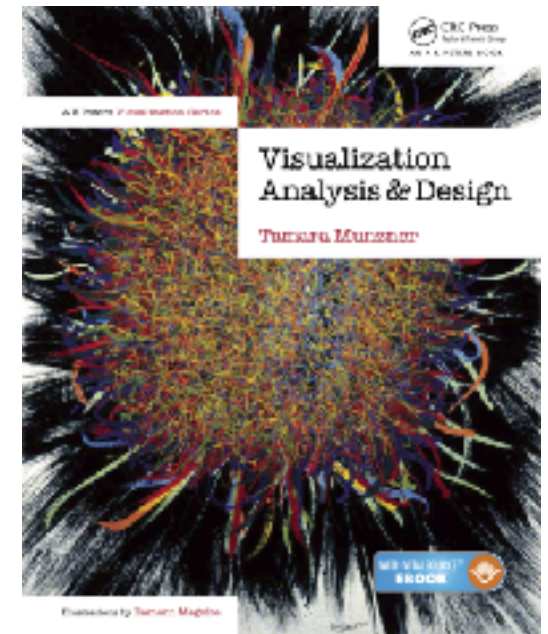
Visualization Analysis & Design

Interactive Views (Ch 11/12)

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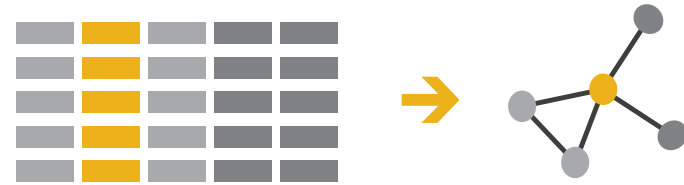
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How to handle complexity: I previous strategy

→ *Derive*



- derive new data to show within view

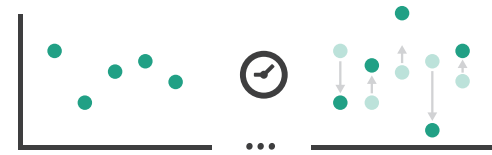
How to handle complexity: 1 previous strategy + 2 more

→ *Derive*

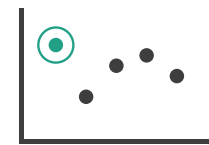


Manipulate

② Change



② Select

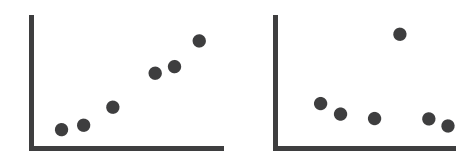


② Navigate

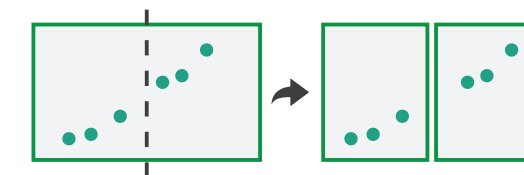


Facet

② Juxtapose



② Partition



② Superimpose



- derive new data to show within view
- change view over time
- facet across multiple views

Manipulate View

Manipulate

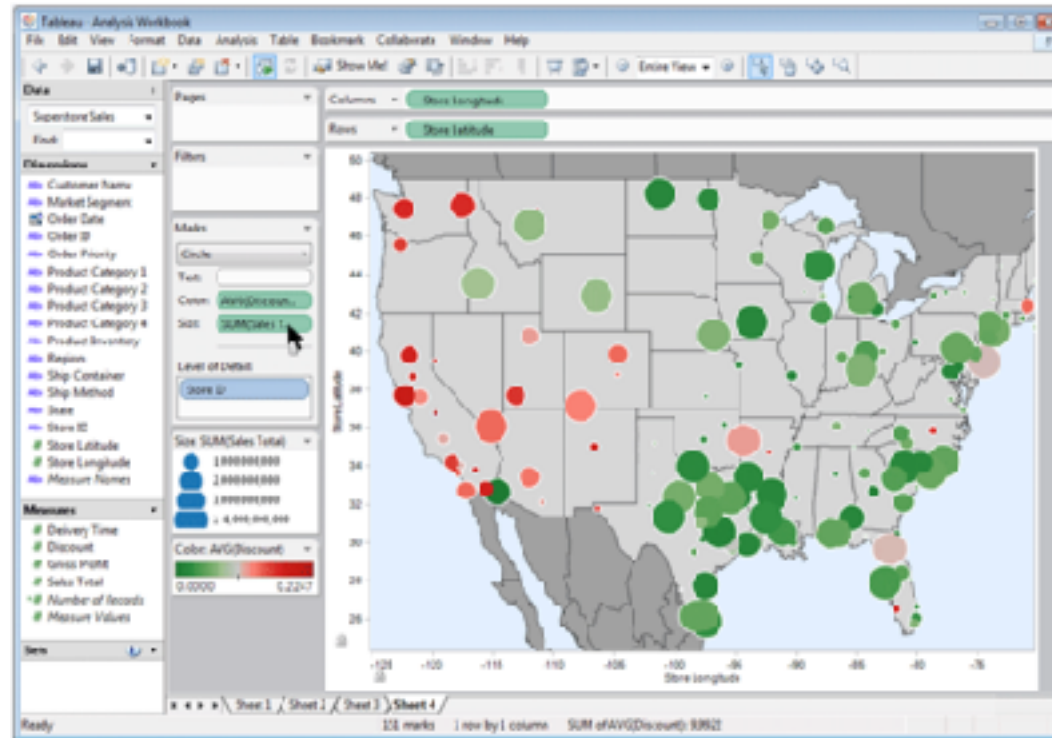
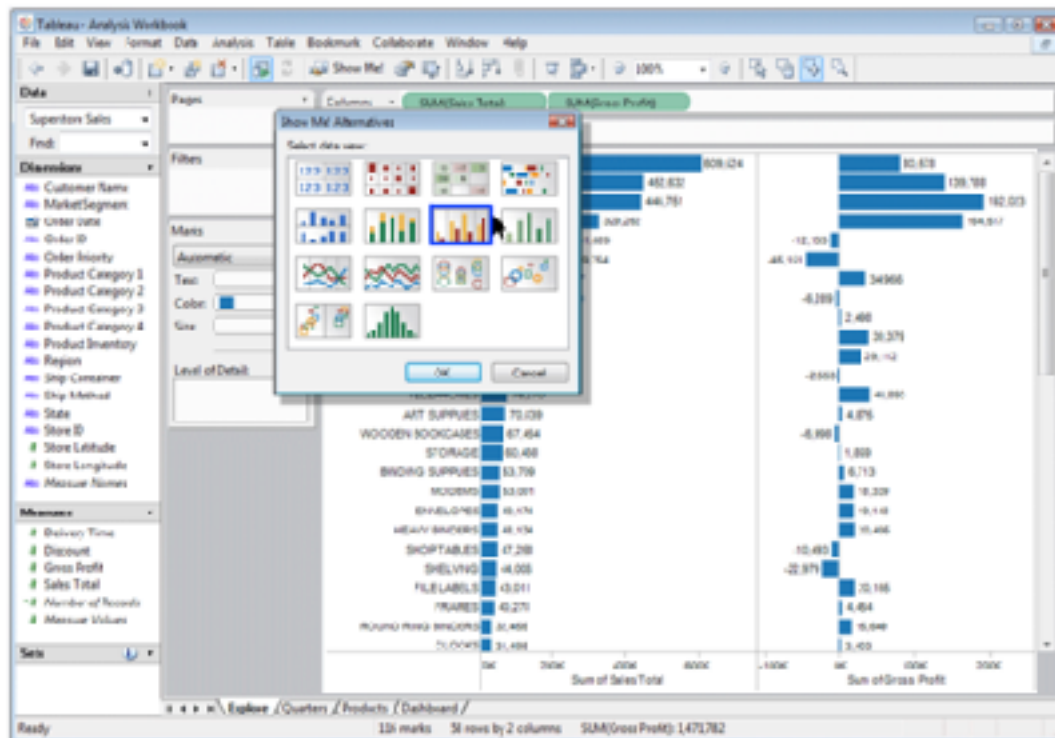
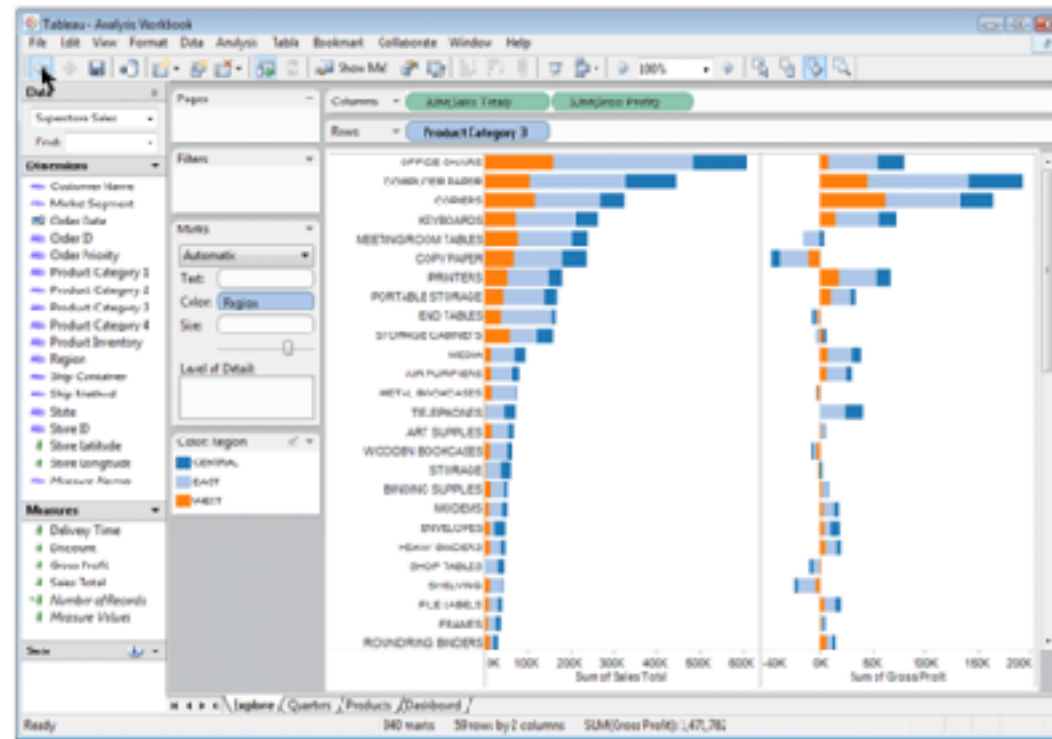
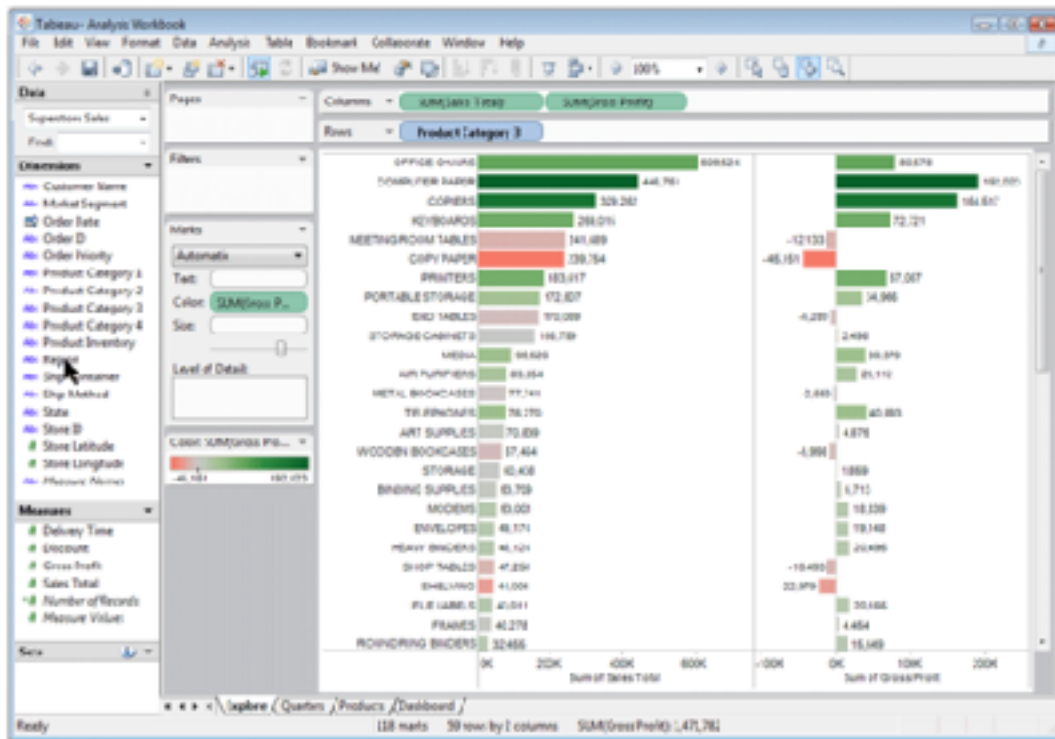
➔ Change over Time



Change over time

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

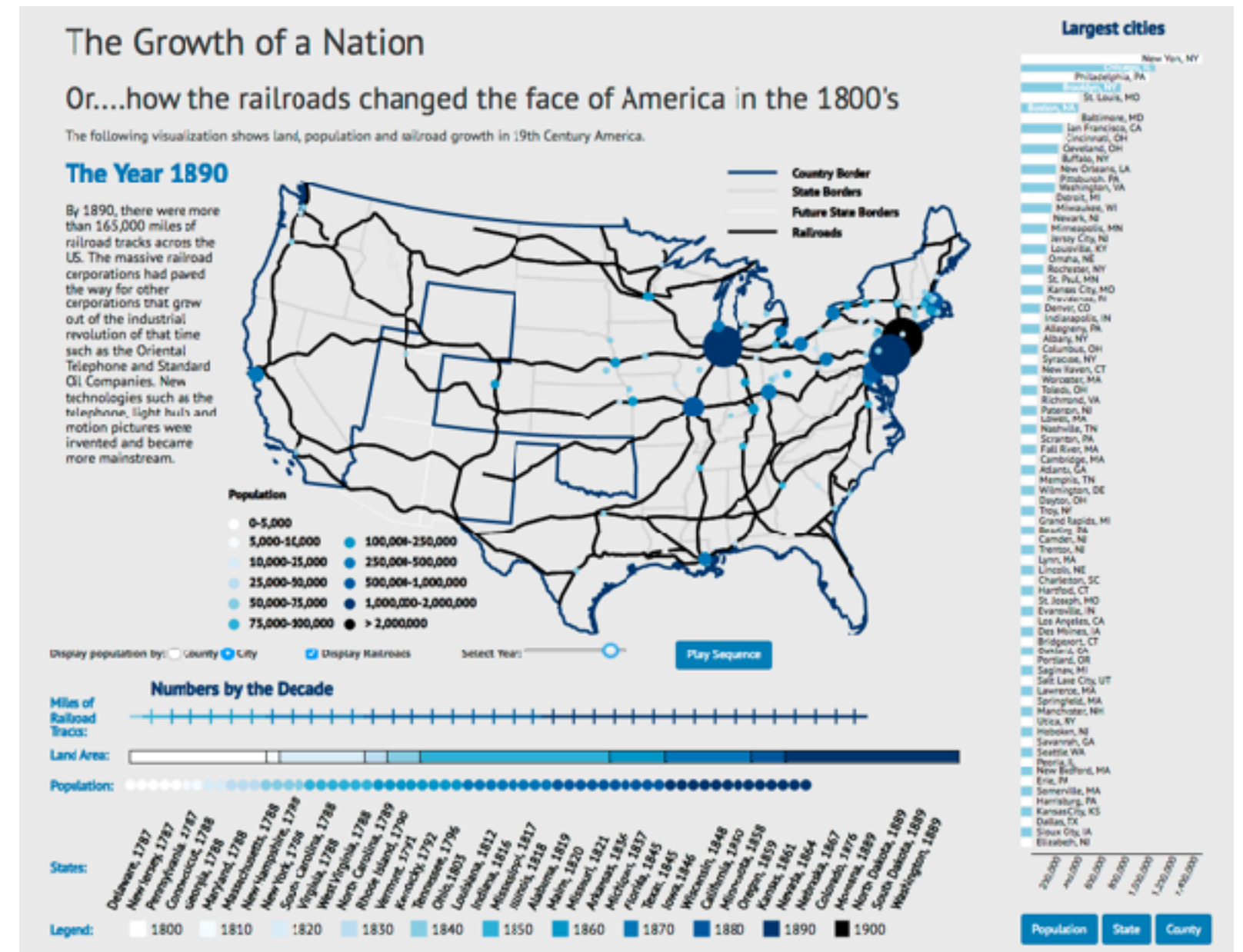
Idiom: Re-encode



made with Tableau, <http://tableausoftware.com>

Idiom: Change parameters

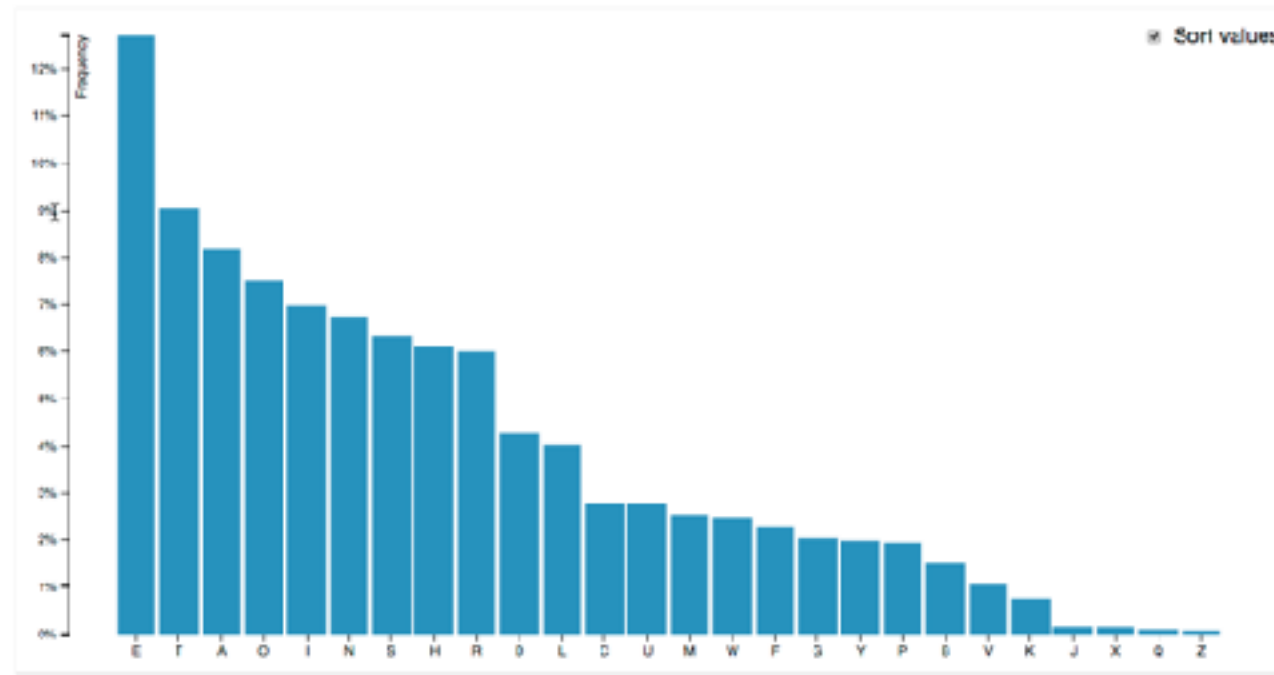
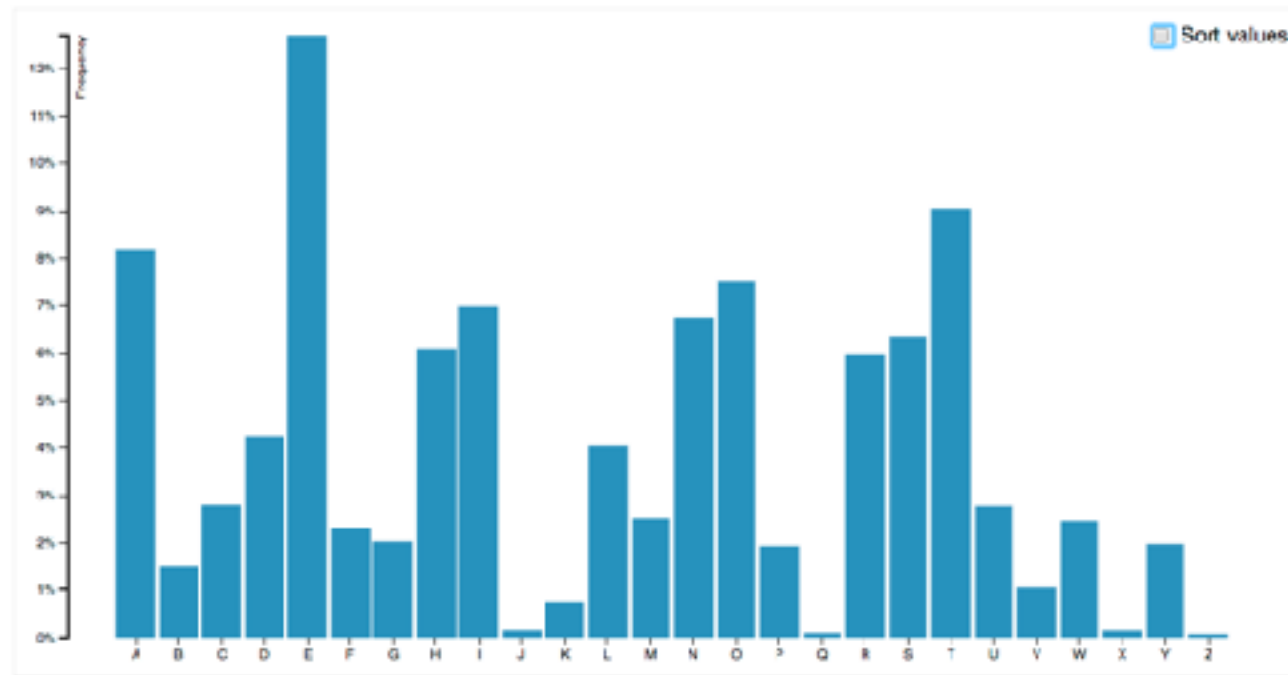
- widgets and controls
 - sliders, buttons, radio buttons, checkboxes, dropdowns/comboboxes
- pros
 - clear affordances, self-documenting (with labels)
- cons
 - uses screen space
- design choices
 - separated vs interleaved
 - controls & canvas



[Growth of a Nation](<http://laurenwood.github.io/>)
made with D3

Idiom: **Change order/arrangement**

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



[Sortable Bar Chart] <https://observablehq.com/@d3/sortable-bar-chart>

made with D3

Idiom: **Reorder**

System: **DataStripes**

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



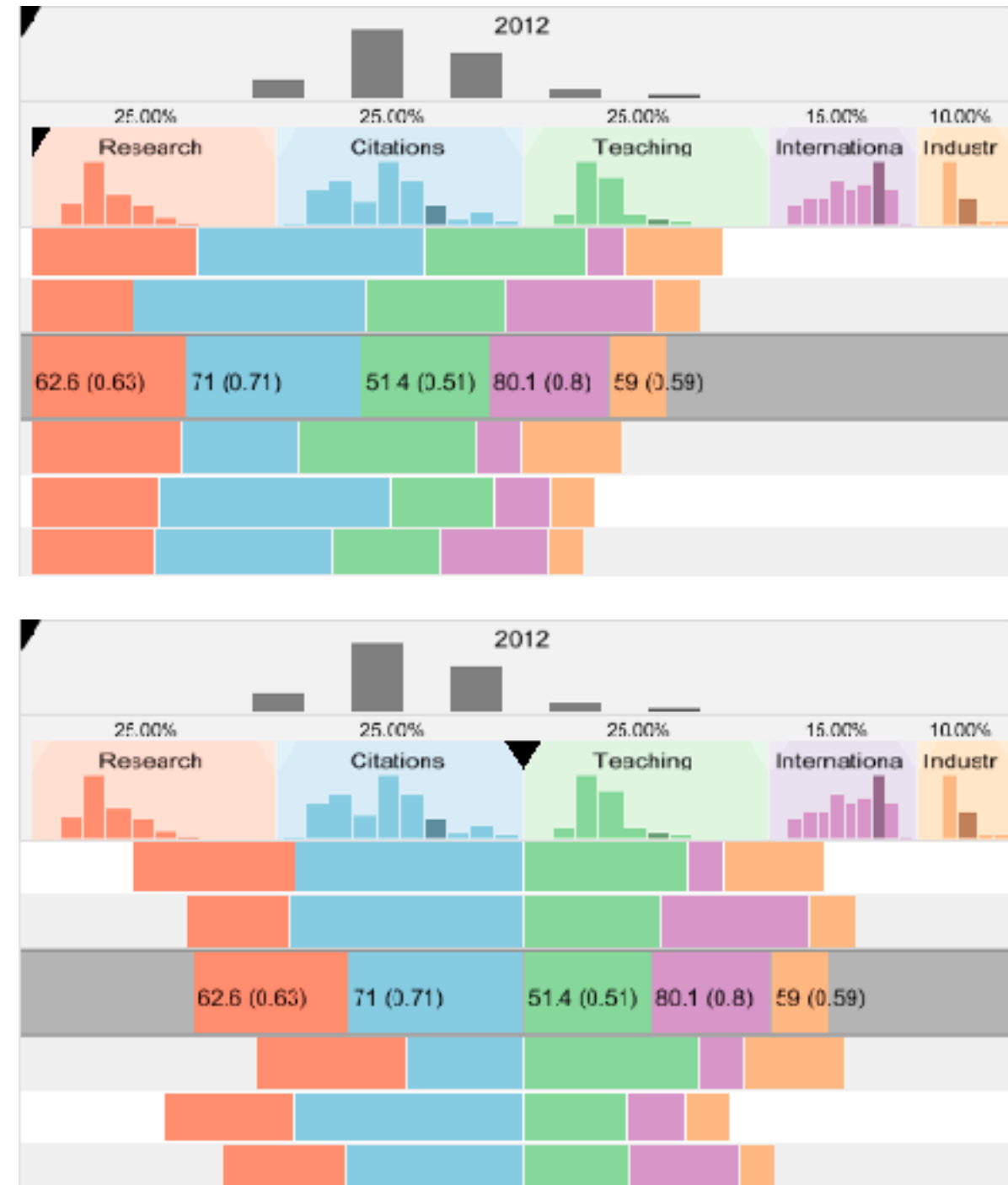
[\[http://carlmanaster.github.io/datastripes/\]](http://carlmanaster.github.io/datastripes/)

made with D3

Idiom: **Change alignment**

System: **LineUp**

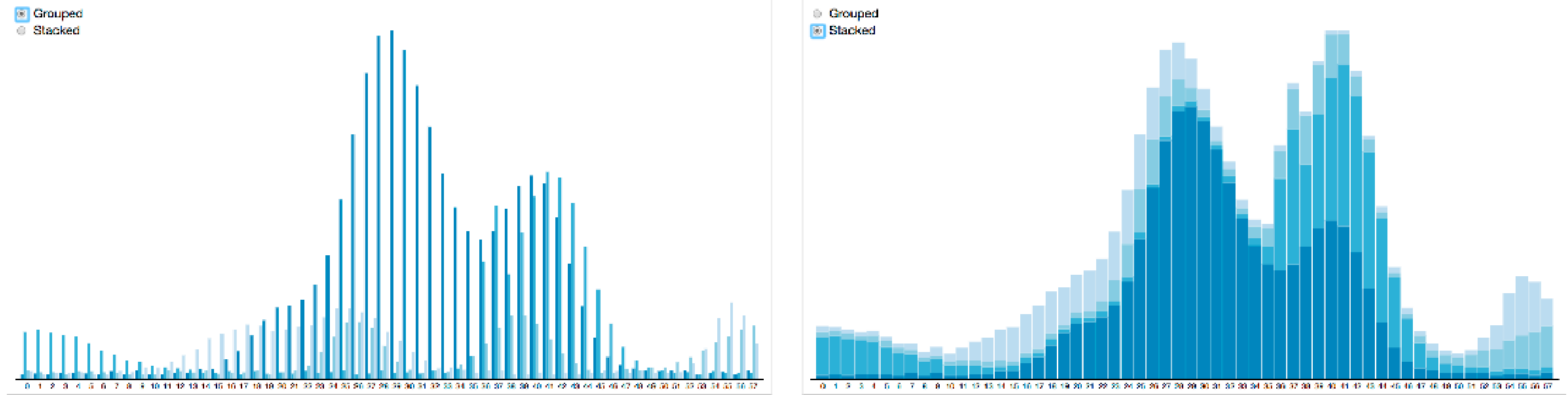
- stacked bars
 - easy to compare
 - first segment
 - total bar
- align to different segment
 - supports flexible comparison



[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.]

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

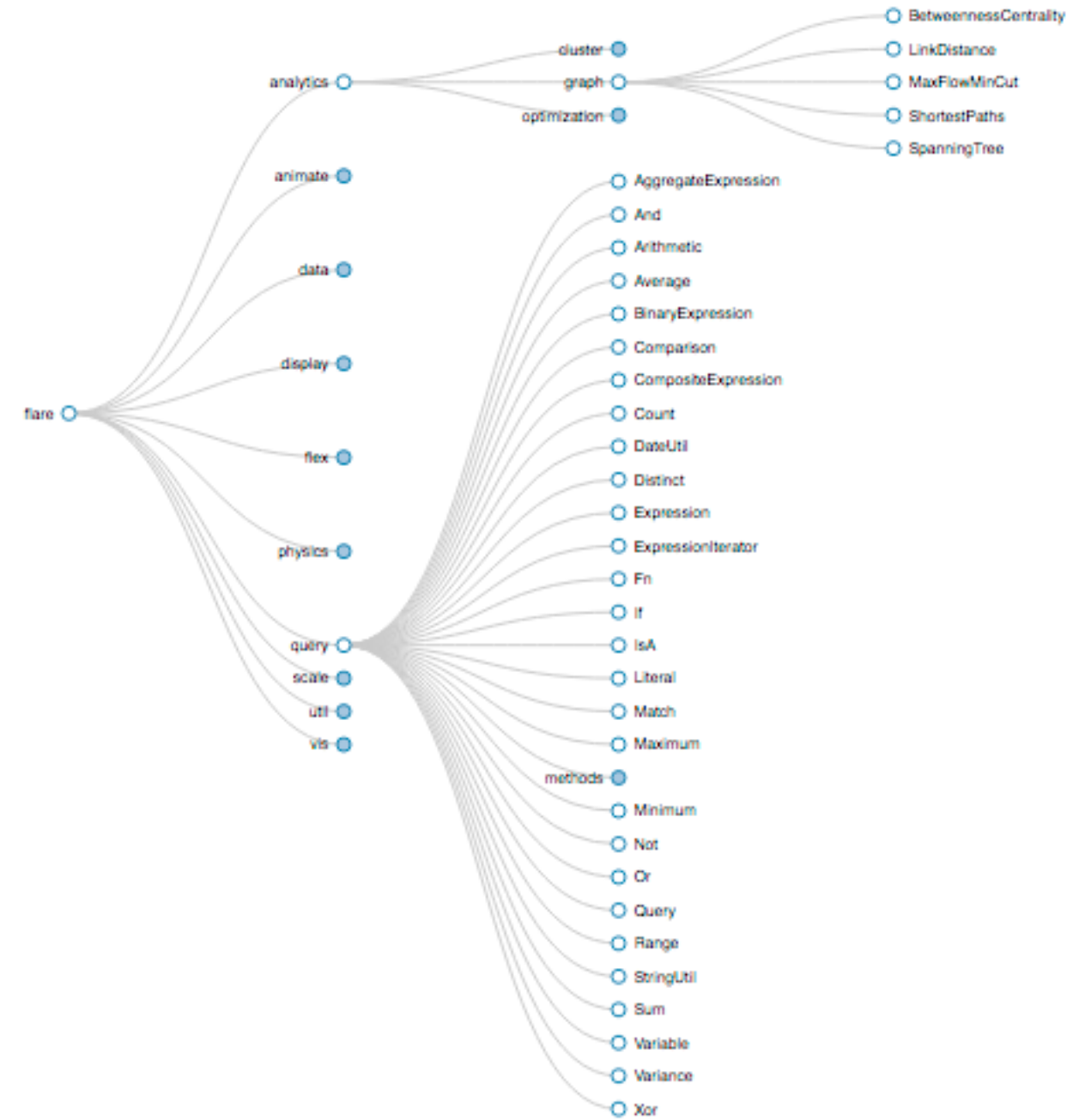
- smooth transition from one state to another
 - alternative to jump cuts, supports item tracking
 - best case for animation
 - staging to reduce cognitive load



[Stacked to Grouped Bars] <https://observablehq.com/@d3/stacked-to-grouped-bars>

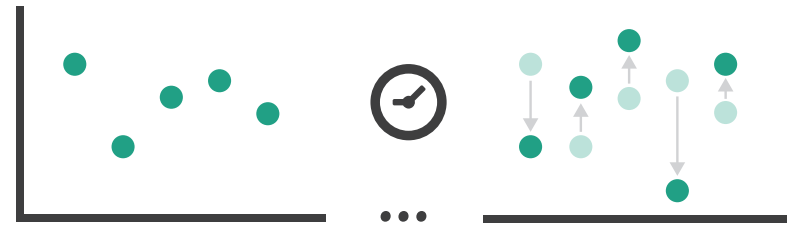
Idiom: **Animated transition** - tree detail

- animated transition
 - network drilldown/rollup

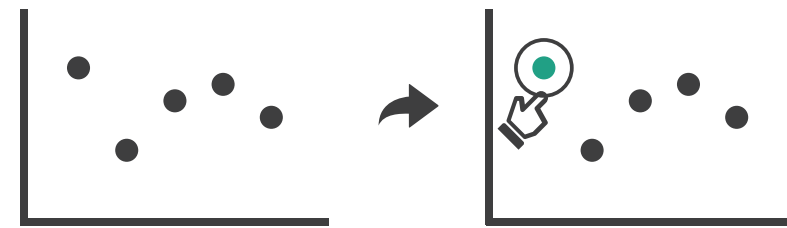


Manipulate

➔ Change over Time

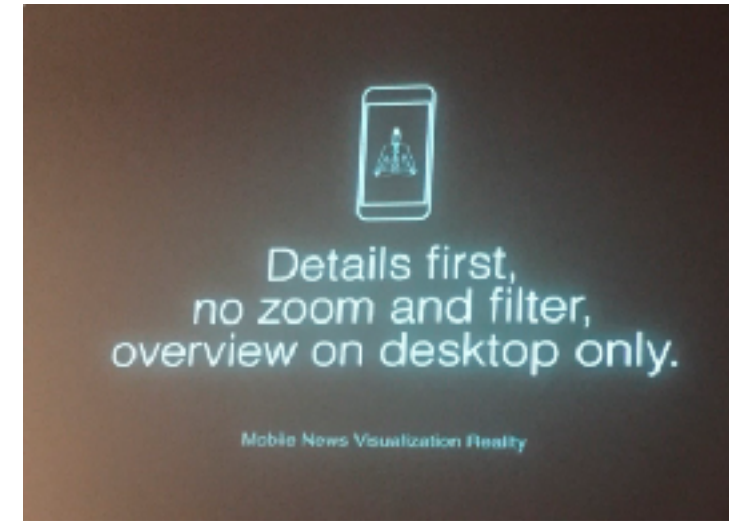


➔ Select



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?



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

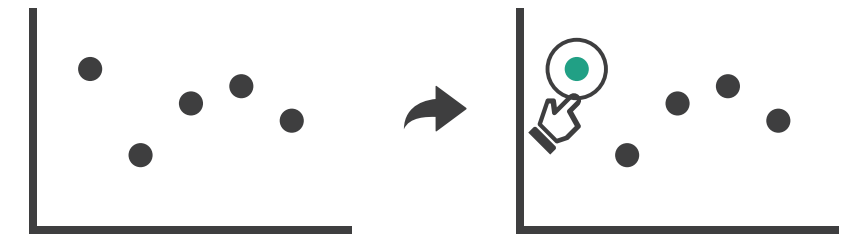


I Hate Tom Cruise - Alex Kauffmann (5 min)
www.youtube.com/watch?v=QXLfT9sFcbb

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, ...)

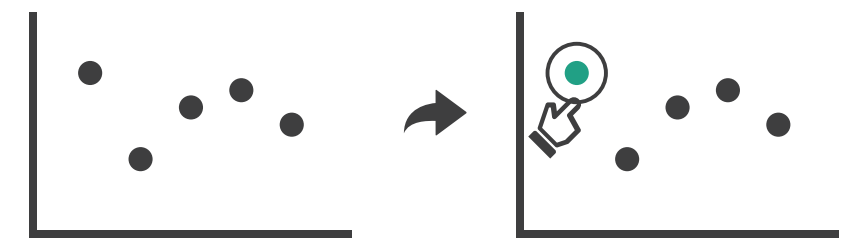
➞ Select



Highlighting

➞ Select

- 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

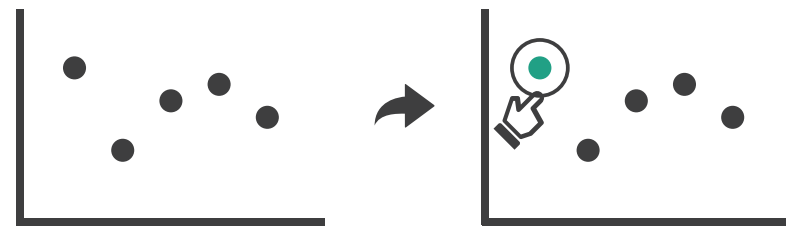


Manipulate

➔ Change over Time



➔ Select

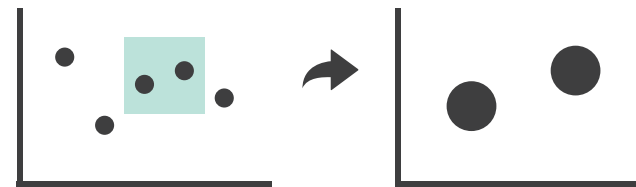


➔ Navigate

➔ Item Reduction

➔ Zoom

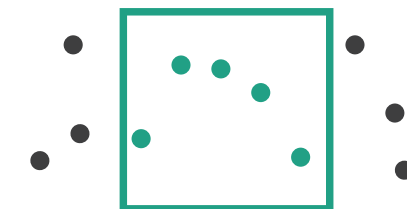
Geometric or *Semantic*



➔ Pan/Translate

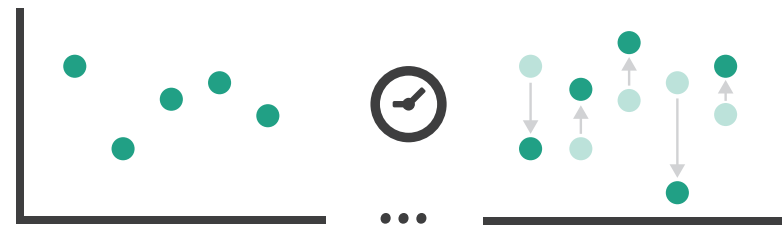


➔ Constrained

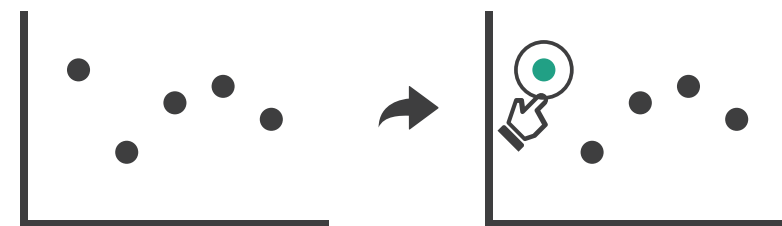


Manipulate

➔ Change over Time

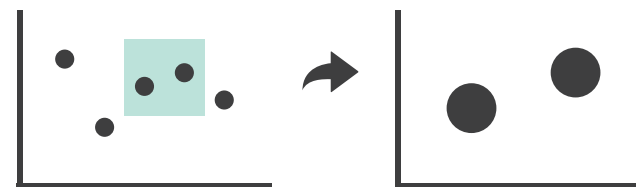


➔ Select



➔ Navigate

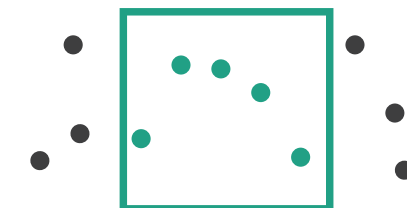
➔ Zoom
Geometric



➔ Pan/Translate



➔ Constrained

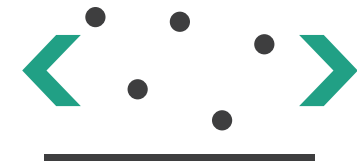


Navigate: Changing viewpoint/visibility

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

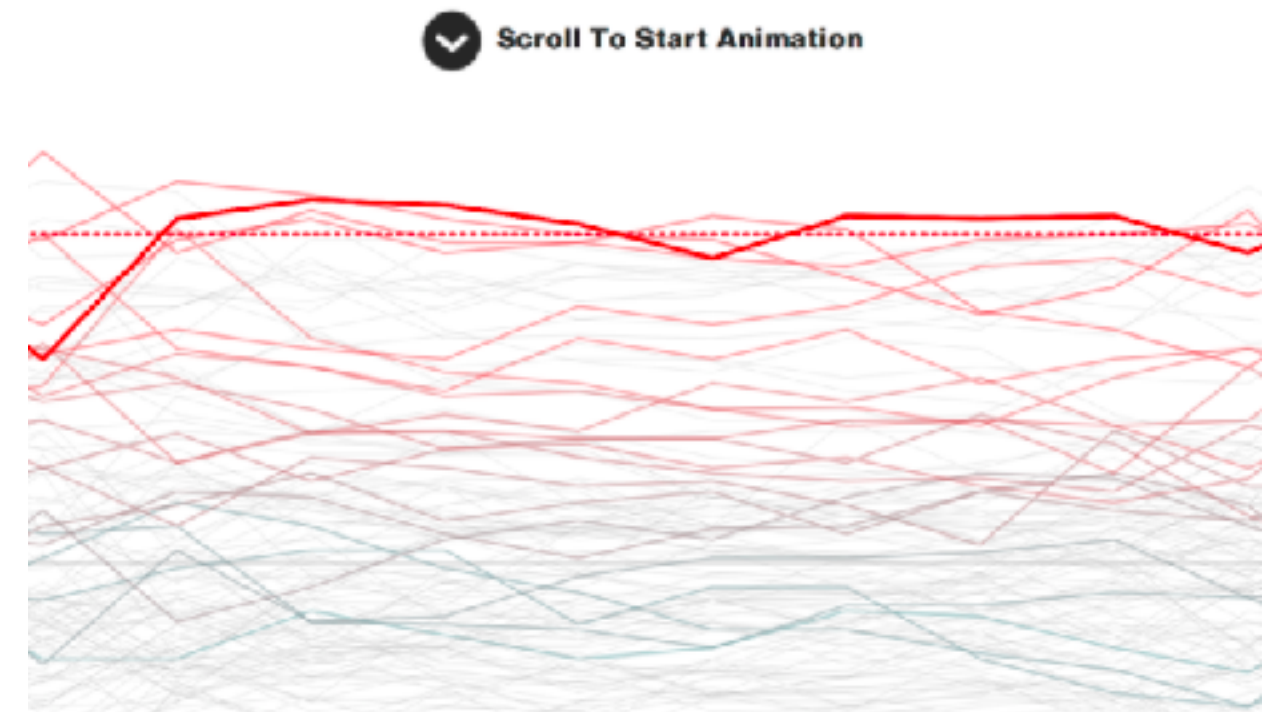
➞ Navigate

➞ *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



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

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

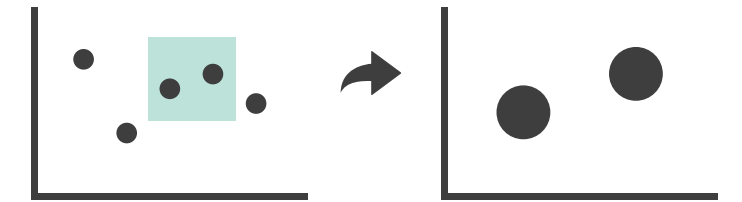
Navigate: Changing viewpoint/visibility

- 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

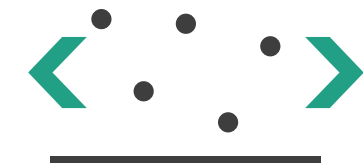
➞ Navigate

➞ Zoom

Geometric



➞ Pan/Translate



Navigate: Unconstrained vs constrained

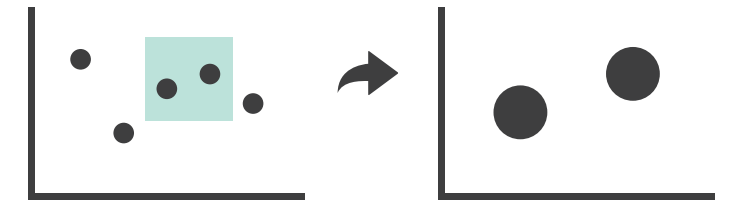
- unconstrained navigation
 - easy to implement for designer
 - hard to control for user
 - easy to overshoot/undershoot
- constrained navigation
 - typically uses animated transitions
 - trajectory automatically computed based on selection
 - just click; selection ends up framed nicely in final viewport

➞ Navigate

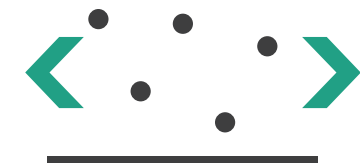
➞ Item Reduction

➞ Zoom

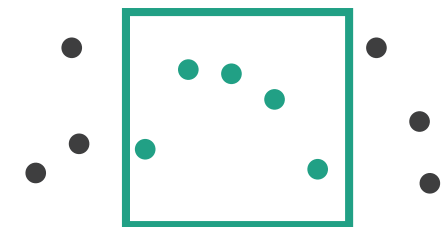
Geometric or *Semantic*



➞ Pan/Translate



➞ Constrained



Idiom: **Animated transition + constrained navigation**

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

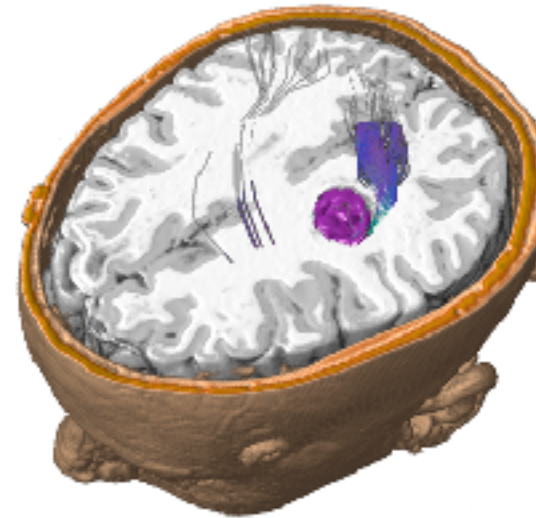
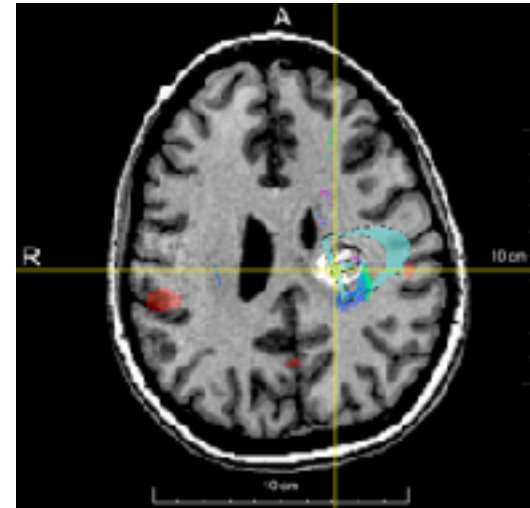
Zoom to Bounding Box



[Zoom to Bounding Box] <https://observablehq.com/@d3/zoom-to-bounding-box>

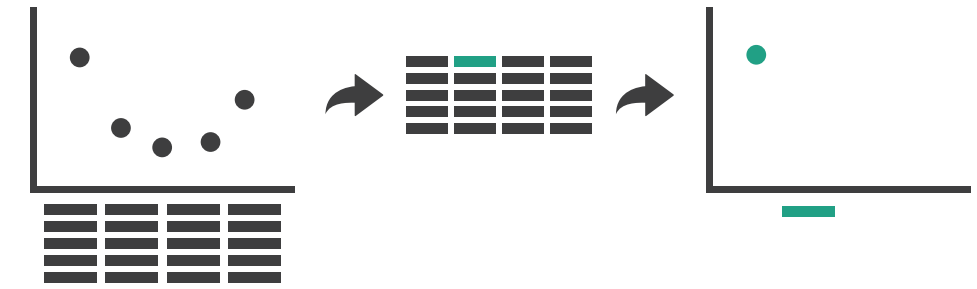
Navigate: Reducing attributes

- 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 side of plane from camera
 - project
 - change mathematics of image creation
 - orthographic
 - perspective
 - many others: Mercator, cabinet, ...

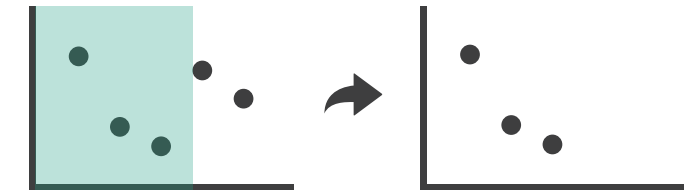


→ Attribute Reduction

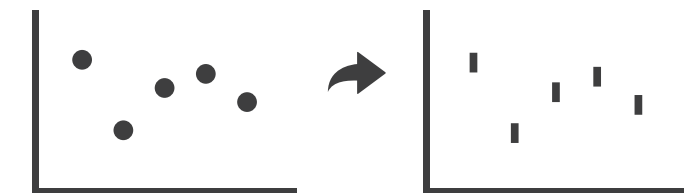
→ Slice



→ Cut



→ Project



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

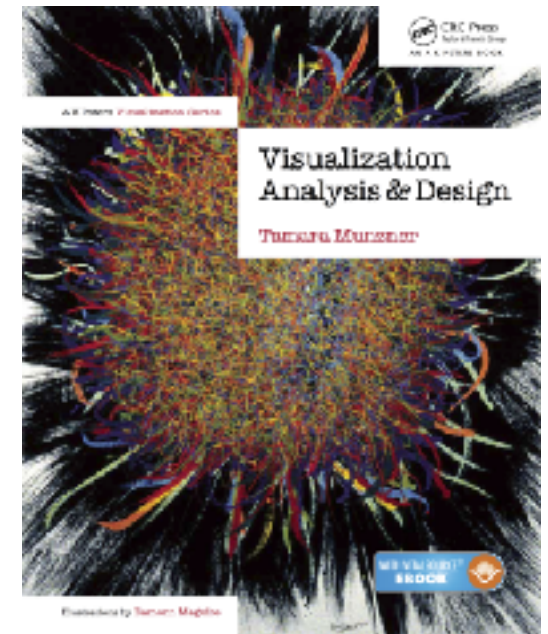
Visualization Analysis & Design

Interactive Views (Ch 11/12) II

Tamara Munzner

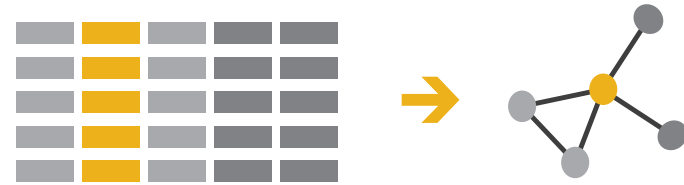
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How to handle complexity: 1 previous strategy + 2 more

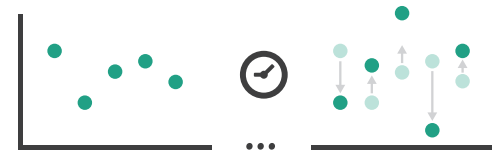
→ *Derive*



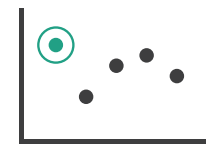
- derive new data to show within view
- change view over time
- facet across multiple views

Manipulate

② Change



② Select

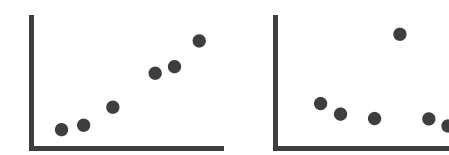


② Navigate

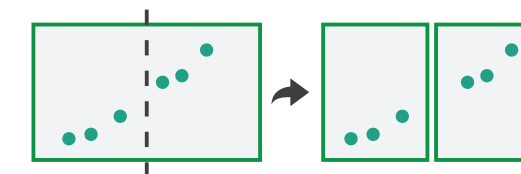


Facet

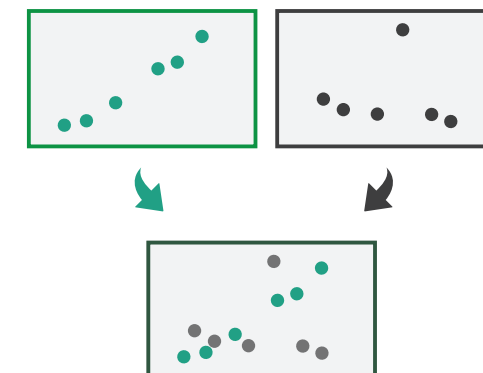
② Juxtapose



② Partition



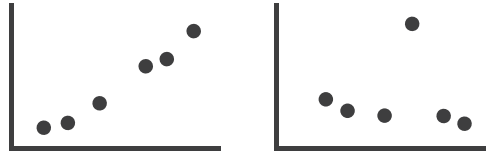
② Superimpose



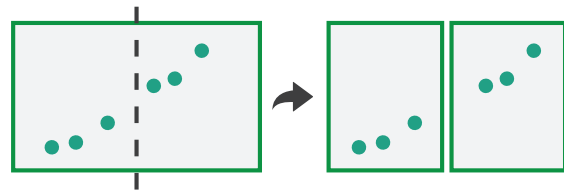
Multiple Views

Facet

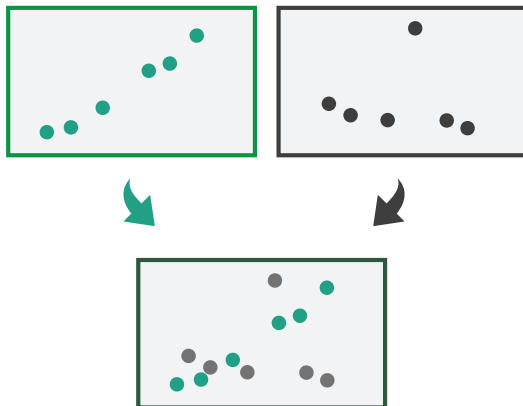
➔ Juxtapose



➔ Partition

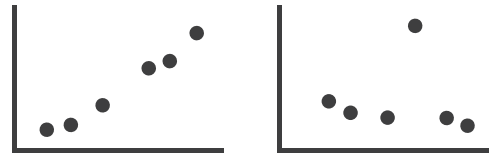


➔ Superimpose

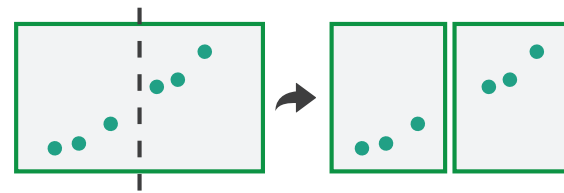


Facet

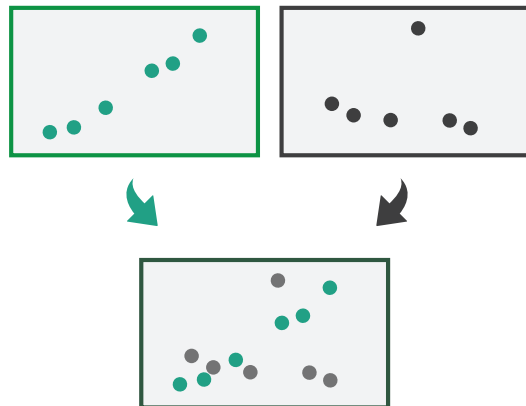
➔ Juxtapose



➔ Partition



➔ Superimpose



Juxtapose and coordinate views

→ Share Encoding: Same/Different

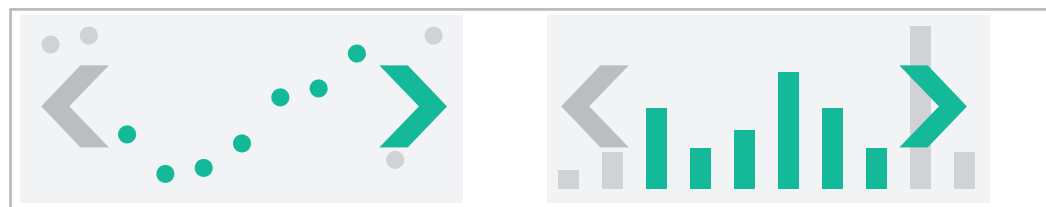
→ *Linked Highlighting*



→ Share Data: All/Subset/None



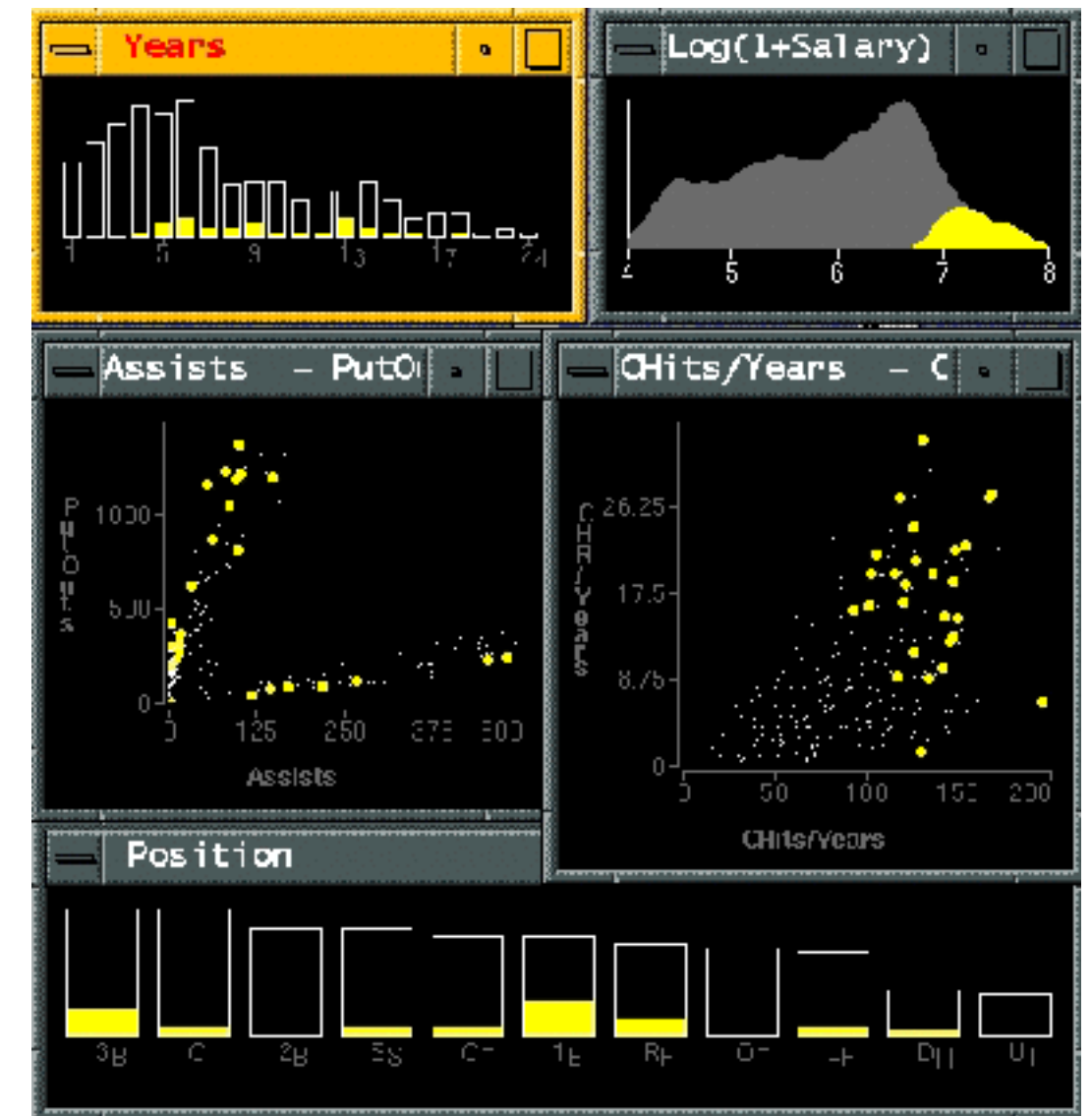
→ Share Navigation



Idiom: **Linked highlighting**

System: **EDV**

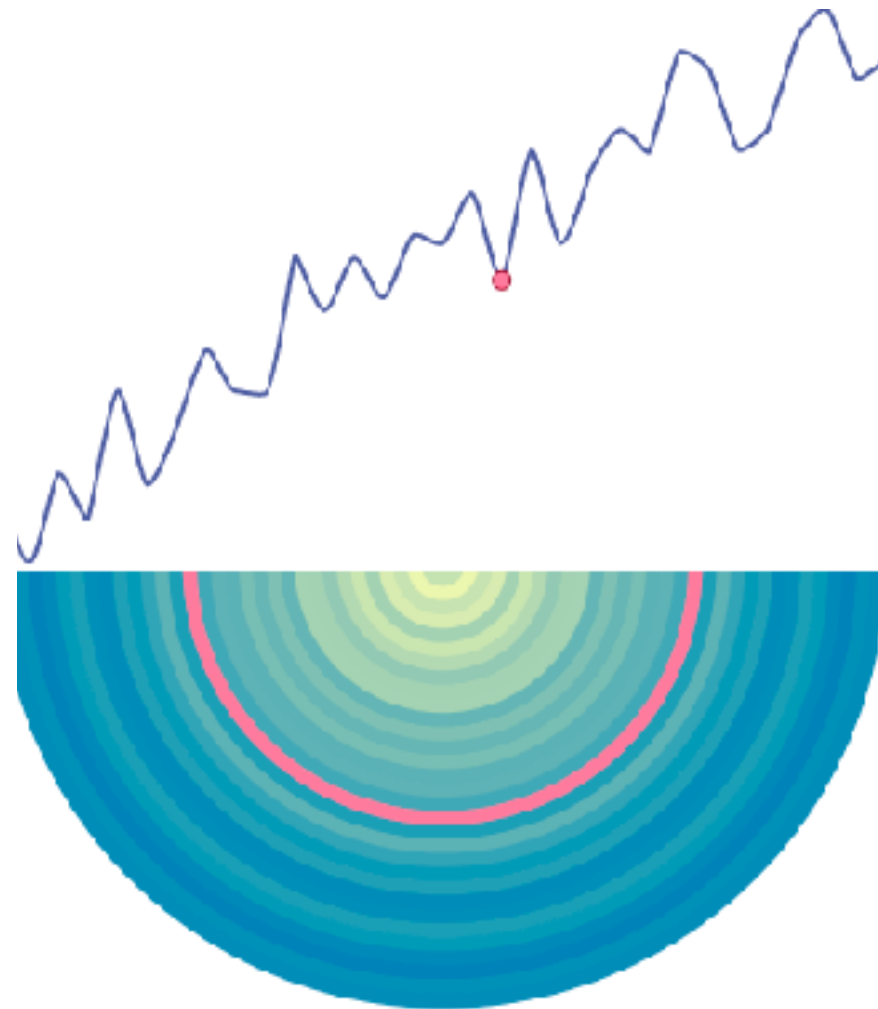
- see how regions contiguous in one view are distributed within another
 - powerful and pervasive interaction idiom
- encoding: different
 - *multiform*
- data: all shared
 - all **items** shared
 - different **attributes** across the views
- aka: brushing and linking



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

Linked views: Directionality

- unidirectional vs bidirectional linking
 - bidirectional almost always better!



<http://pbeshai.github.io/linked-highlighting-react-vega-redux/>

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

Idiom: **Overview-detail views**

- encoding: same or different
 - ex: same (birds-eye map)
- data: subset shared
 - viewpoint differences: subset of data items
- navigation: shared
 - bidirectional linking
- other differences
 - (window size)

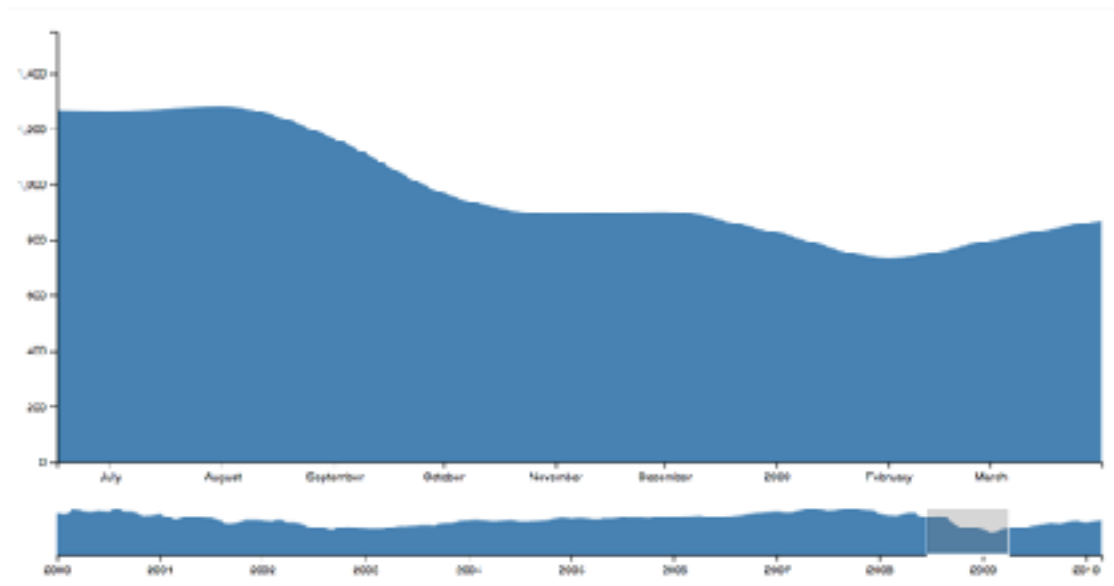
System: **Google Maps**



*[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 or different
- data: subset shared
- navigation: shared
 - unidirectional linking
 - select in small overview, change extent in large detail view



<https://observablehq.com/@uwdata/interaction>

Idiom: **Tooltips**

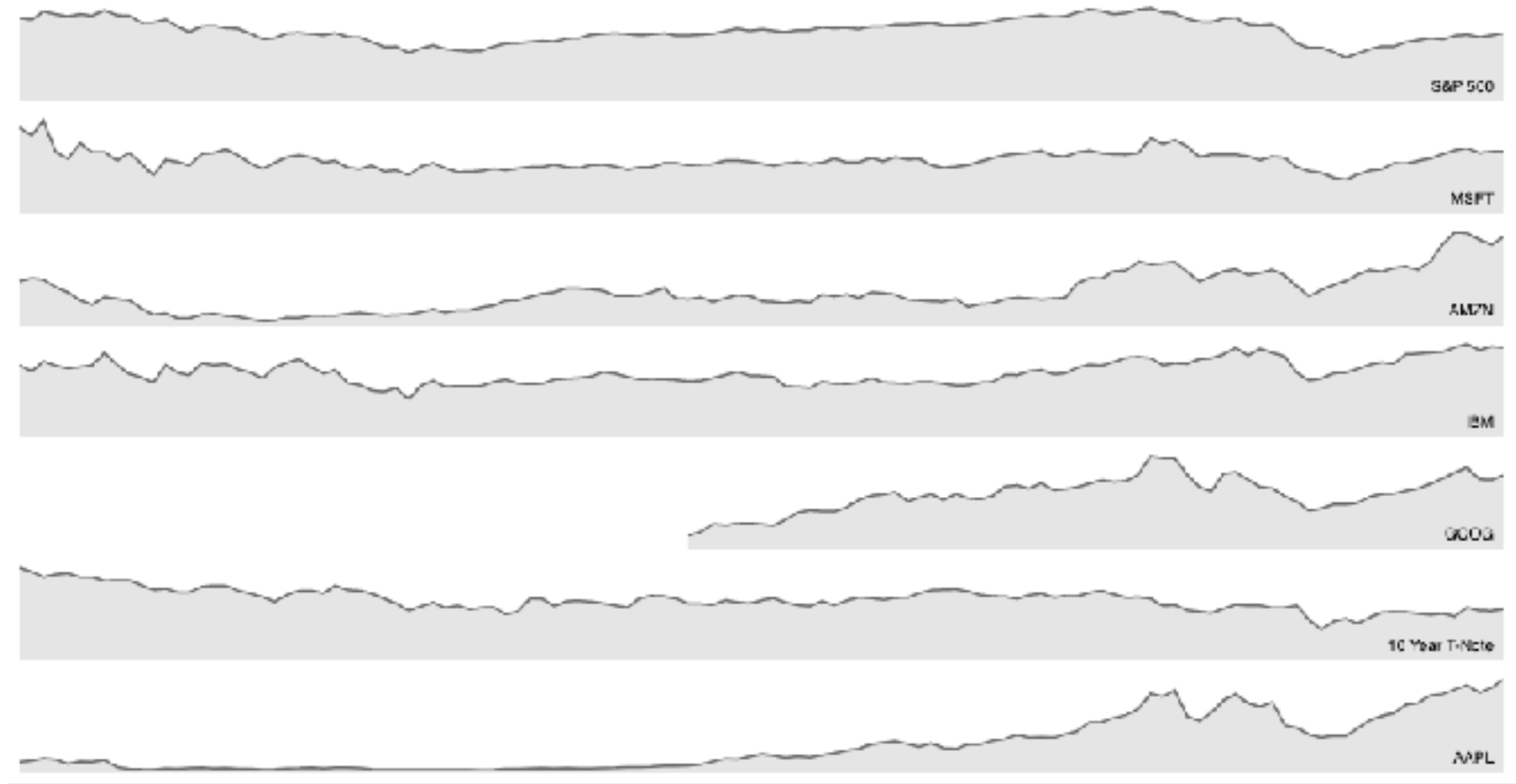
- popup information for selection
 - hover or click
 - specific case of detail view:
provide useful additional detail on demand
 - beware: does not support overview!
 - always consider if there's a way to visually encode directly to provide overview
 - “If you make a rollover or tooltip, assume nobody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



[\[https://www.highcharts.com/demo/dynamic-master-detail\]](https://www.highcharts.com/demo/dynamic-master-detail)

Idiom: **Small multiples**

- encoding: same
 - ex: line charts
- data: none shared
 - different slices of dataset
 - items or attributes
 - ex: stock prices for different companies



Interactive small multiples

- linked highlighting:
analogous item/attribute
across views
 - same year highlighted across all charts if hover within any chart

The Rise and Decline of Ask MetaFilter

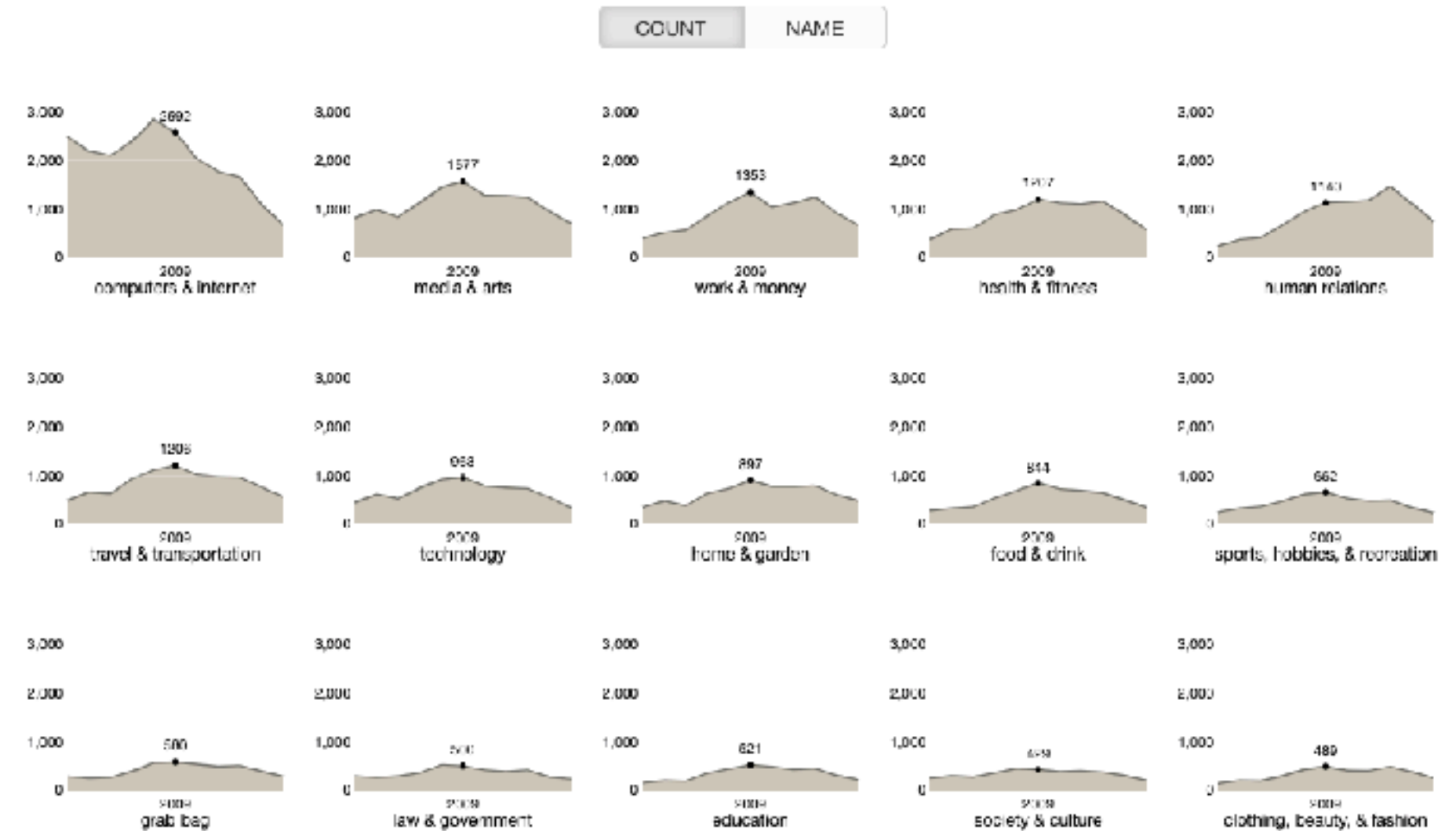
Metafilter's revenue has been on the decline, but has its content dried up as well?

Here we look at new posts on Ask Metafilter by category.

Categories like computers & internet have been dropping in use for a long time, most likely due to competition like Stack Overflow.

Other smaller categories have had consistent use patterns until more recently.

Disclaimer: 2014 is included, even though the year is not over yet.



[\[https://bl.ocks.org/ColinEberhardt/3c780088c363d1515403f50a87a87121\]](https://bl.ocks.org/ColinEberhardt/3c780088c363d1515403f50a87a87121)

[\[https://blog.scottlogic.com/2017/04/05/interactive-responsive-small-multiples.html\]](https://blog.scottlogic.com/2017/04/05/interactive-responsive-small-multiples.html)

[\[http://projects.flowingdata.com/tut/linked_small_multiples_demo/\]](http://projects.flowingdata.com/tut/linked_small_multiples_demo/)

Example: Combining many interaction idioms

System: **Buckets**

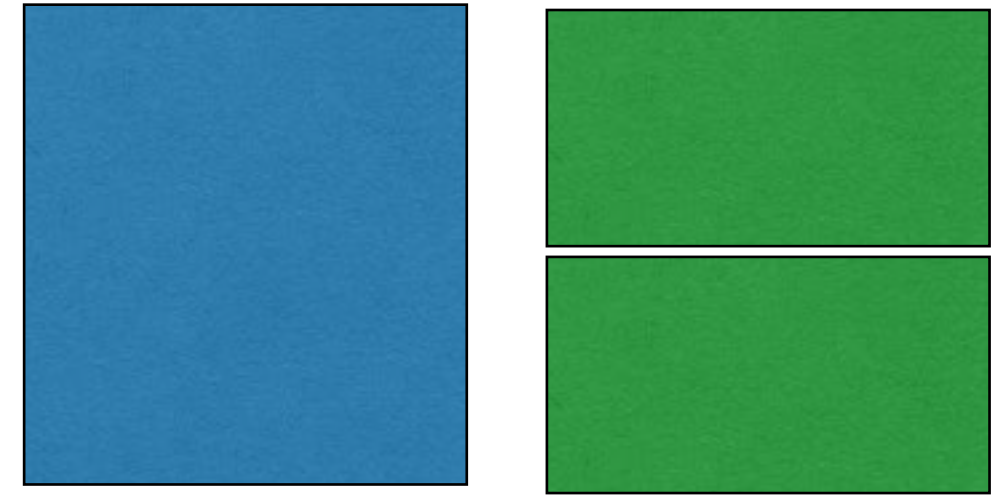


- multiform
- multidirectional linked highlighting of small multiples
- tooltips

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

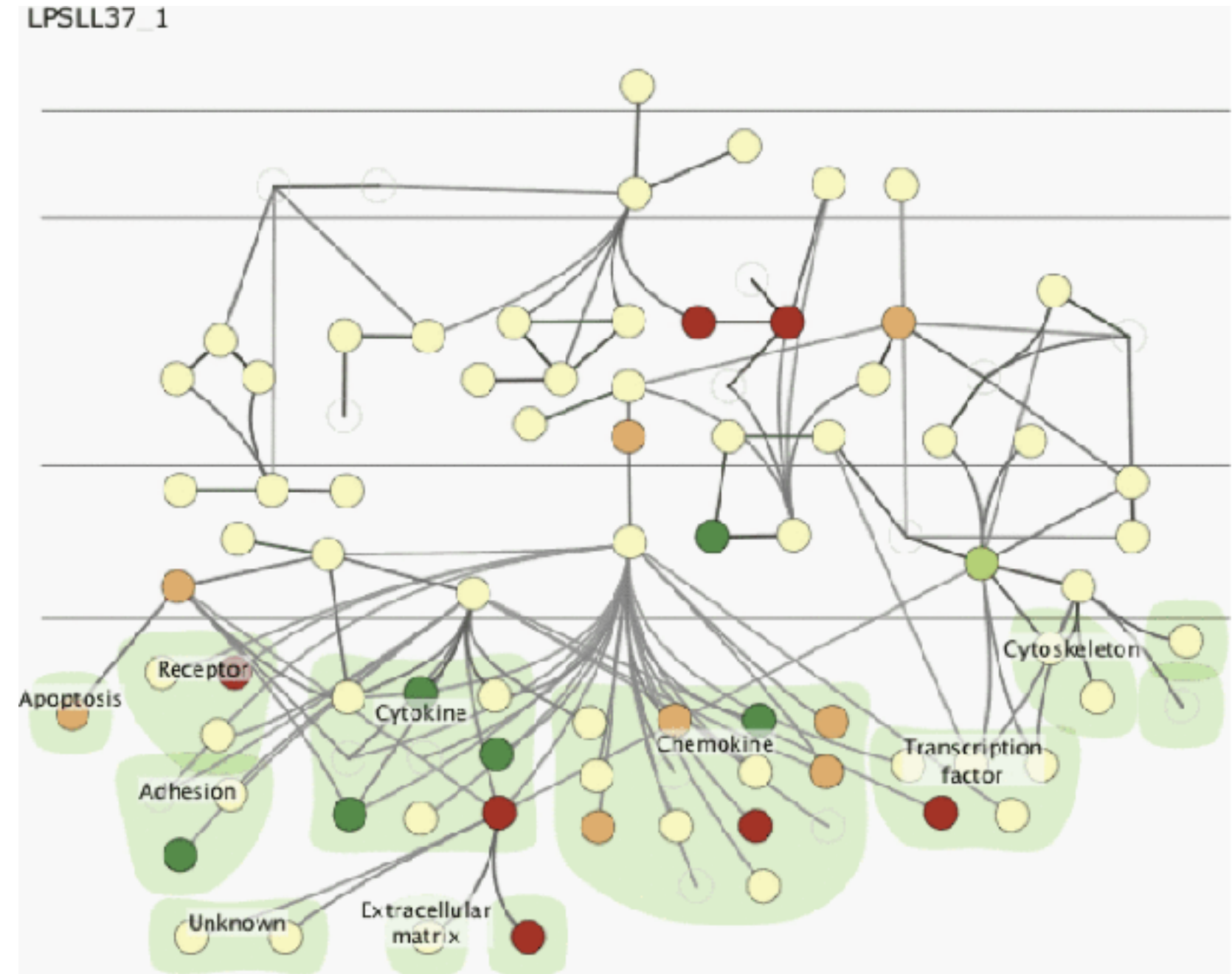
Juxtapose views: tradeoffs

- juxtapose costs
 - display area
 - 2 views side by side: each has only half the area of one view
- juxtapose benefits
 - cognitive load: eyes vs memory
 - lower cognitive load: move eyes between 2 views
 - higher cognitive load: compare single changing view to memory of previous state



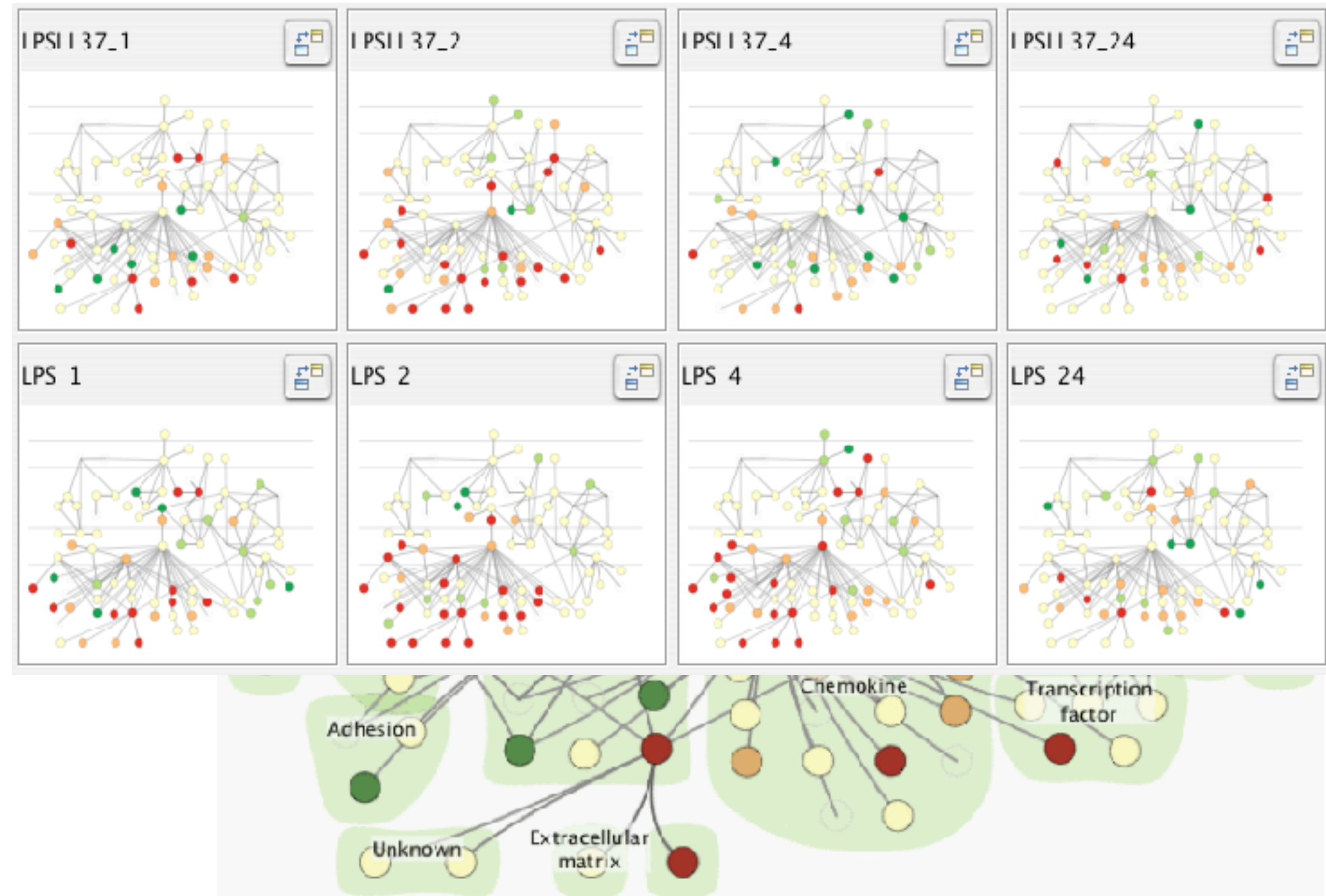
Juxtapose vs animate

- animate: hard to follow if many scattered changes or many frames
 - vs easy special case: animated transitions







Juxtapose vs animate

- animate: hard to follow if many scattered changes or many frames
 - vs easy special case: animated transitions
- juxtapose: easier to compare across small multiples
 - different conditions (color), same gene (layout)



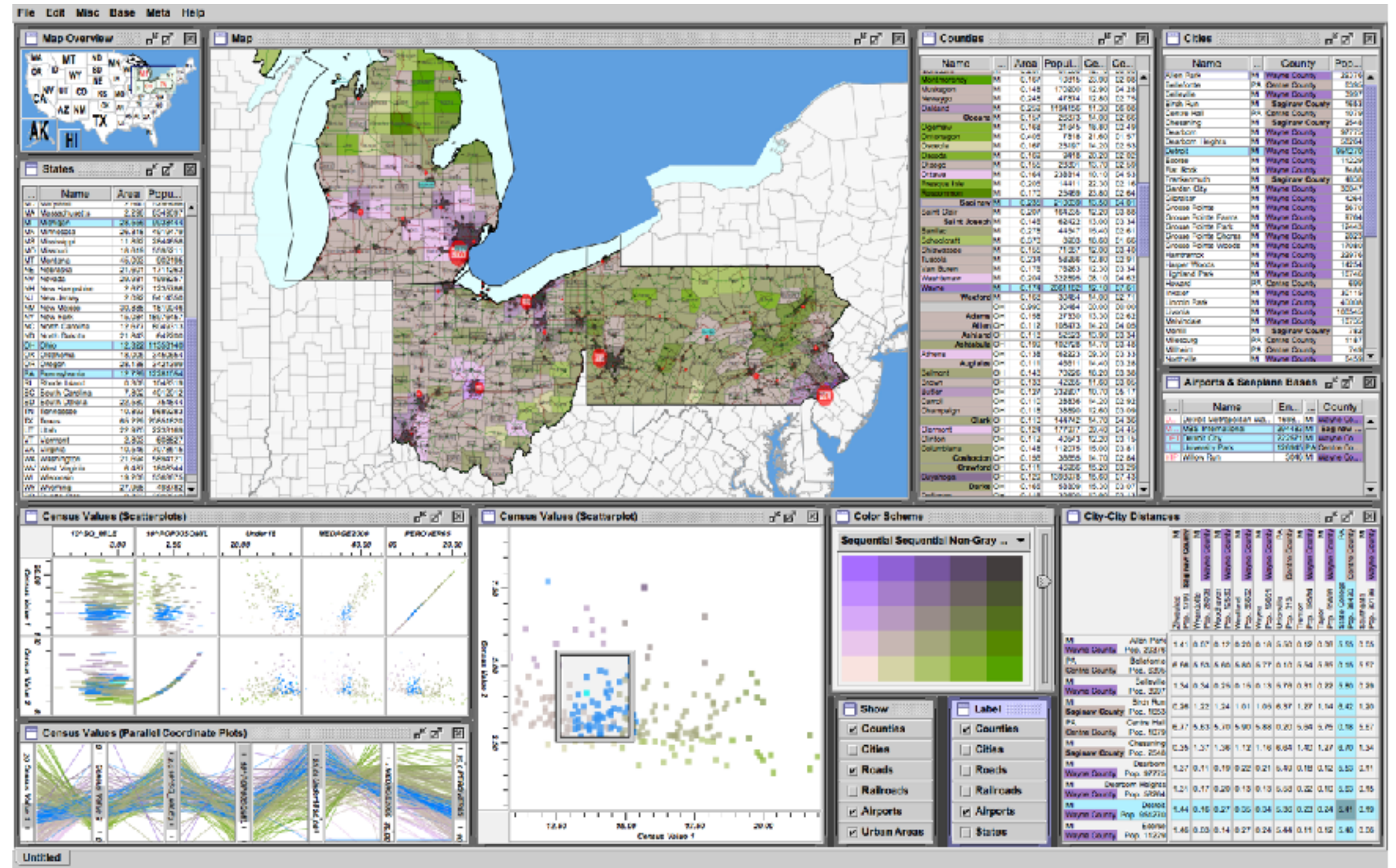
View coordination: Design choices

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

Idiom: Reorderable lists

System: Improvise

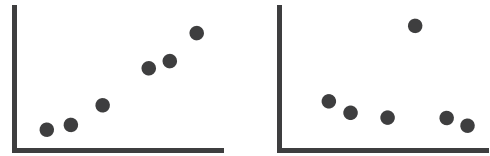
- list views
 - easy lookup
 - useful when linked to other views
- how many views is ok vs too complex?
 - open research question



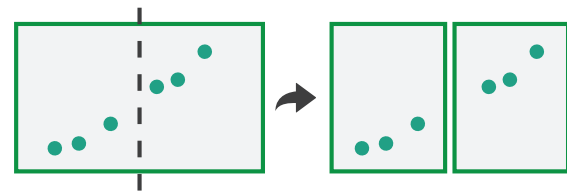
[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.]

Facet

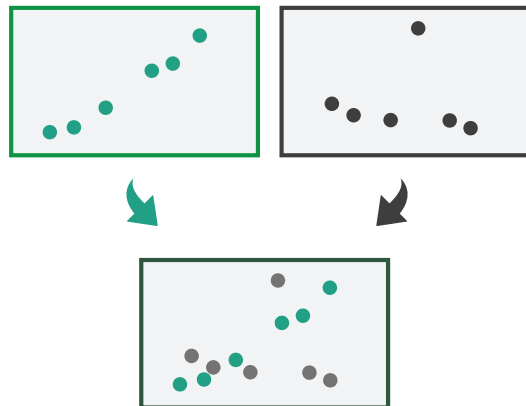
➔ Juxtapose



➔ Partition



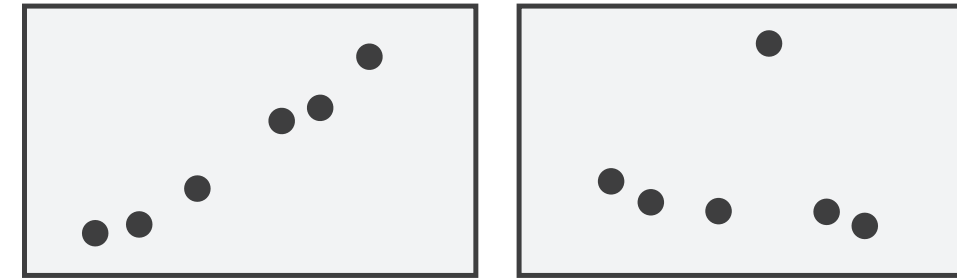
➔ Superimpose



Partition into views

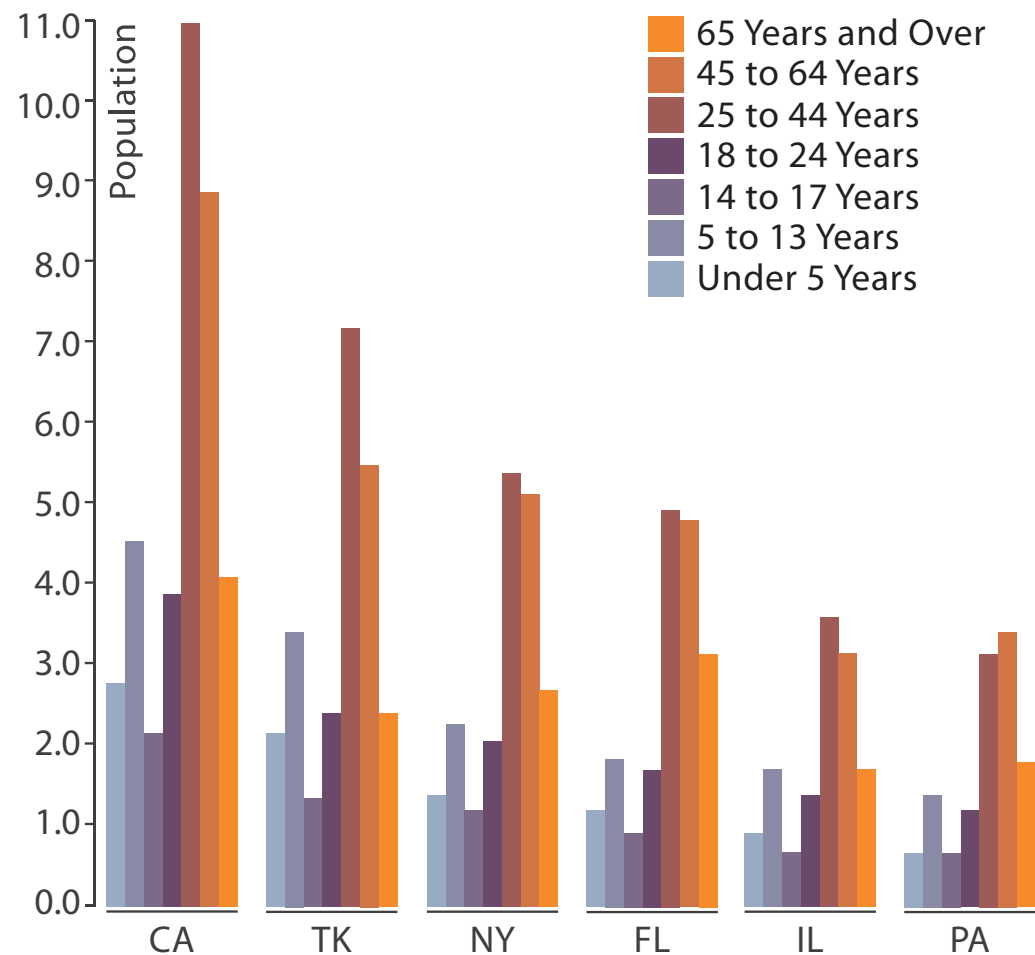
- how to divide data between views
 - split into regions by attributes
 - encodes association between items using spatial proximity
 - order of splits has major implications for what patterns are visible

➔ Partition into Side-by-Side Views



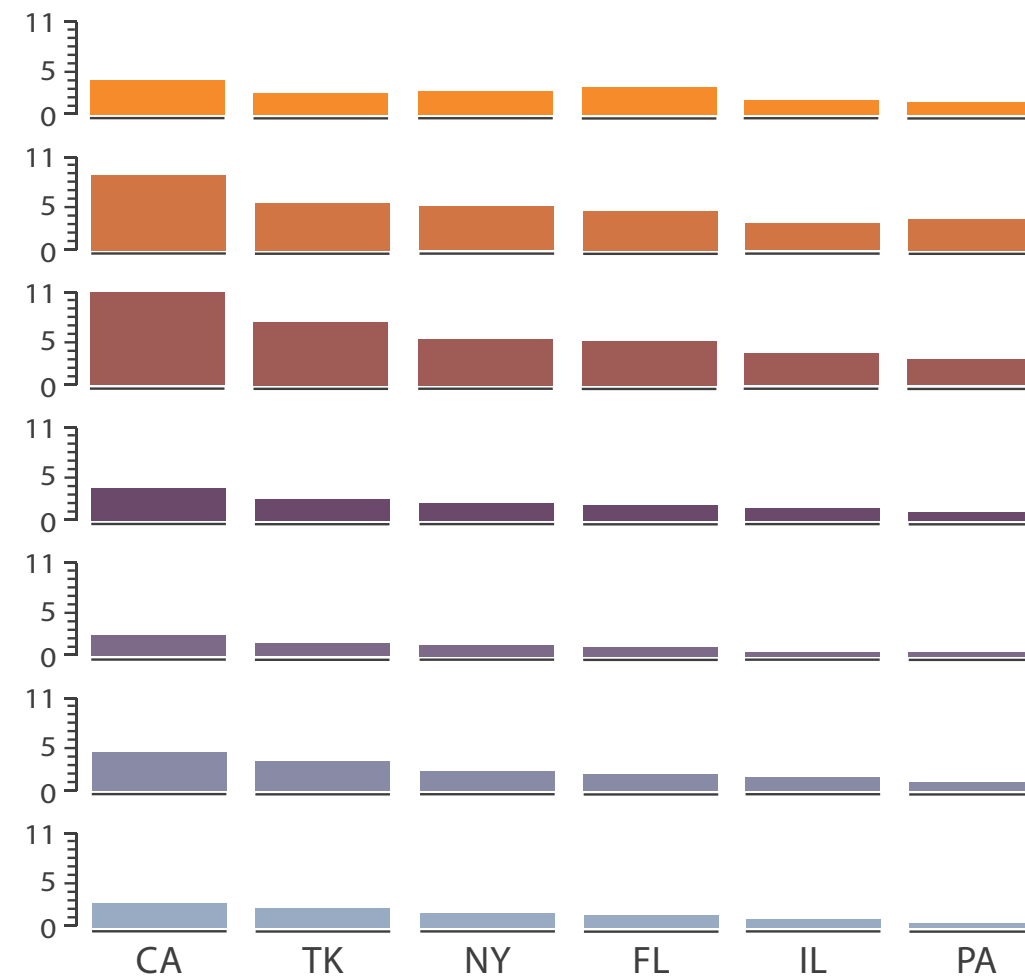
Partitioning: Grouped vs small-multiple bars

- 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



[<https://observablehq.com/@d3/grouped-bar-chart>]

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

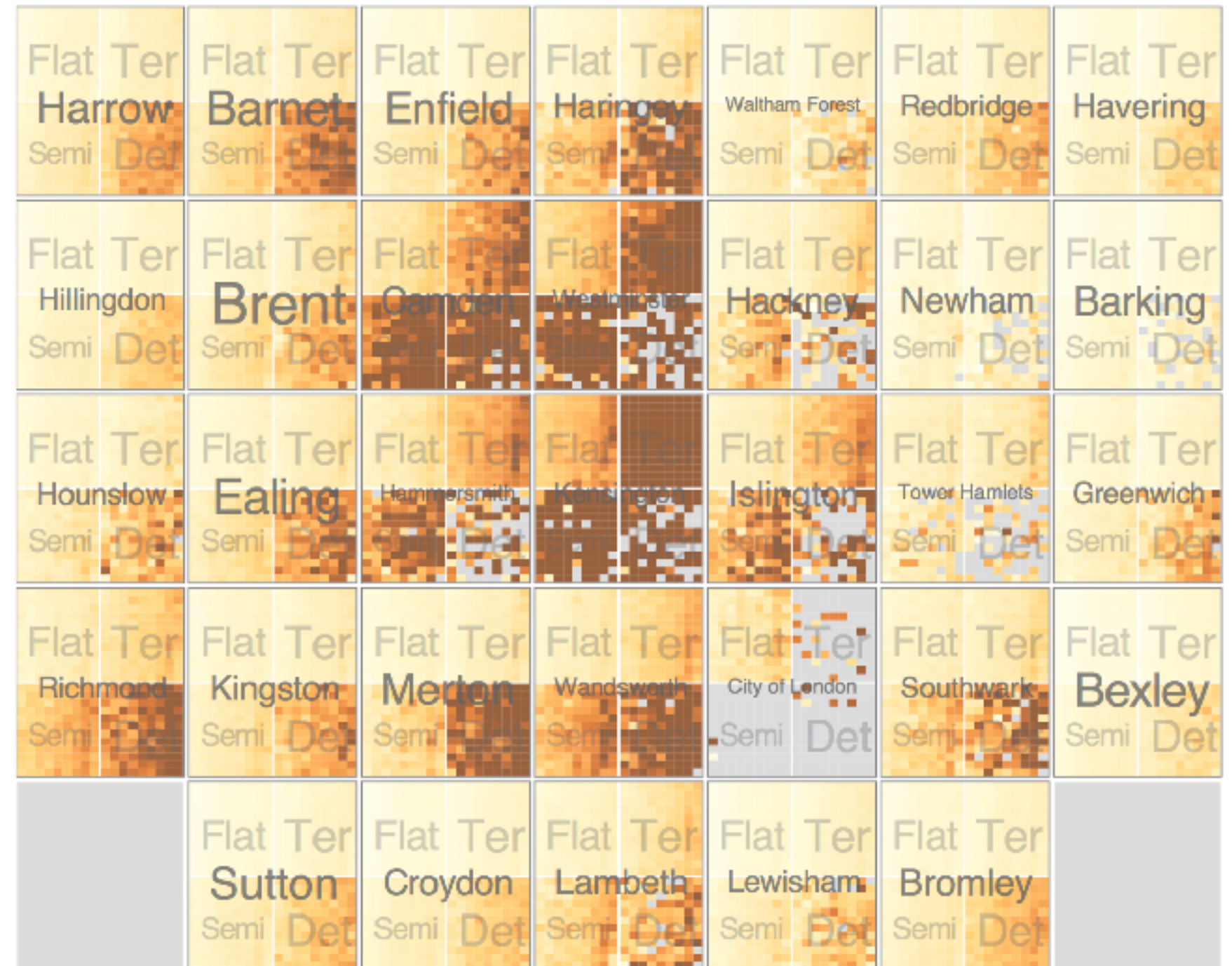


[<https://bl.ocks.org/mbostock/4679202>]

Partitioning: Recursive subdivision

System: **HIVE**

- split by neighborhood
- then by type
 - flat, terrace, semi-detached, detached
- 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



Partitioning: Recursive subdivision

System: **HIVE**

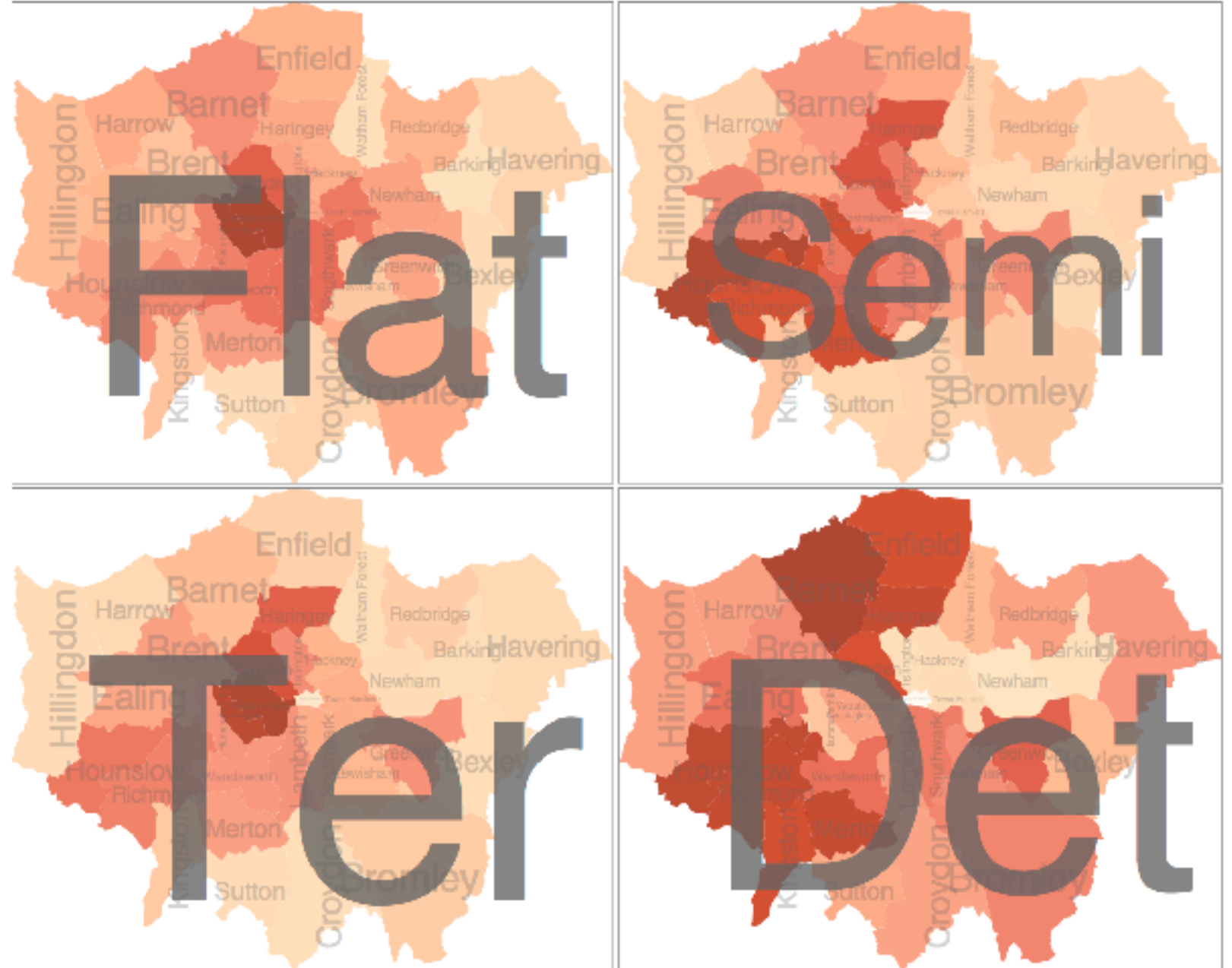
- switch order of splits
 - type then neighborhood
- switch color
 - by price variation
- type patterns
 - within specific type, which neighborhoods inconsistent



Partitioning: Recursive subdivision

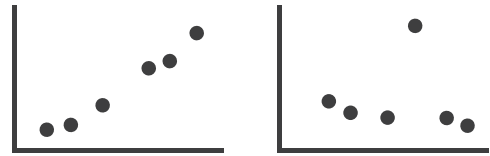
- different encoding for second-level regions
 - choropleth maps

System: **HIVE**

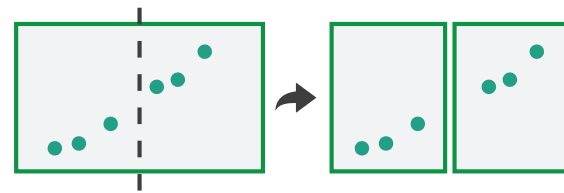


Facet

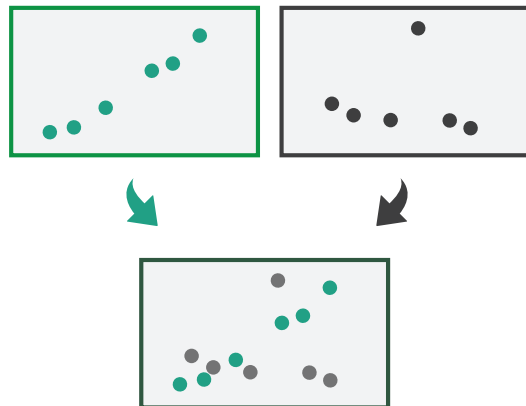
➔ Juxtapose



➔ Partition



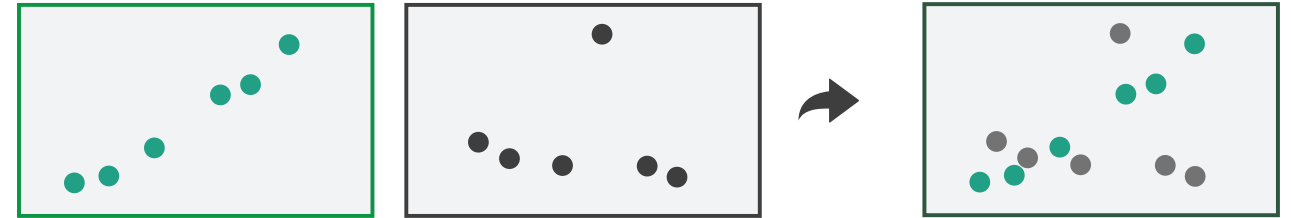
➔ Superimpose



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 achievable, three with careful design
 - small static set, or dynamic from many possible?

➔ Superimpose Layers



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

Idiom: **Trellis plots**

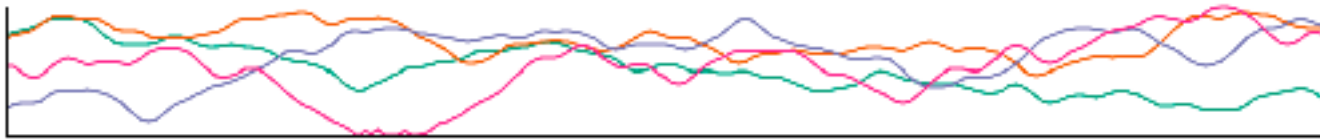
- superimpose within same frame
 - color code by year
- partitioning
 - split by site, rows are barley varieties
- main-effects ordering
 - derive value of median for group
 - order rows within view by variety median
 - order views themselves by site median

[The Visual Design and Control of Trellis Display. Becker, Cleveland, & Shyu.
Journal of Computational and Graphical Statistics 5(2):123-155 1996.]

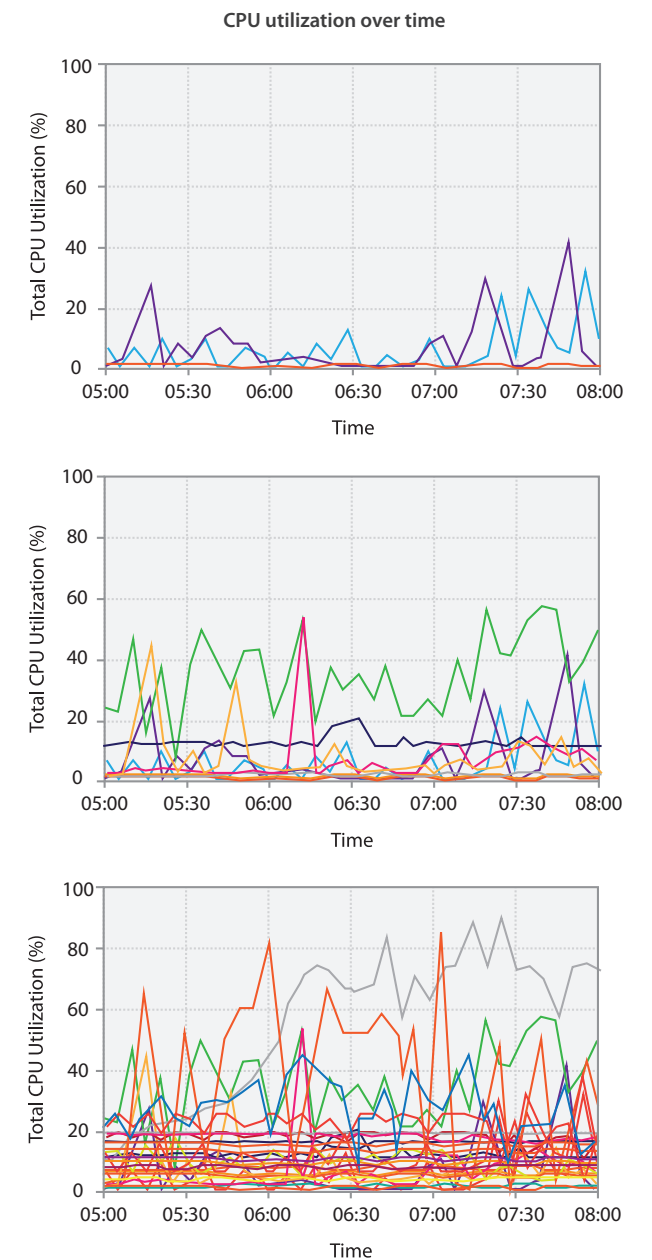


Superimposing limits (static)

- few layers, more lines
 - up to a few dozen lines
 - but not hundreds
- superimpose vs juxtapose: empirical study
 - same size: all multiples, vs single superimposed
 - superimposed: local tasks
 - juxtaposed: global tasks, esp. for many charts



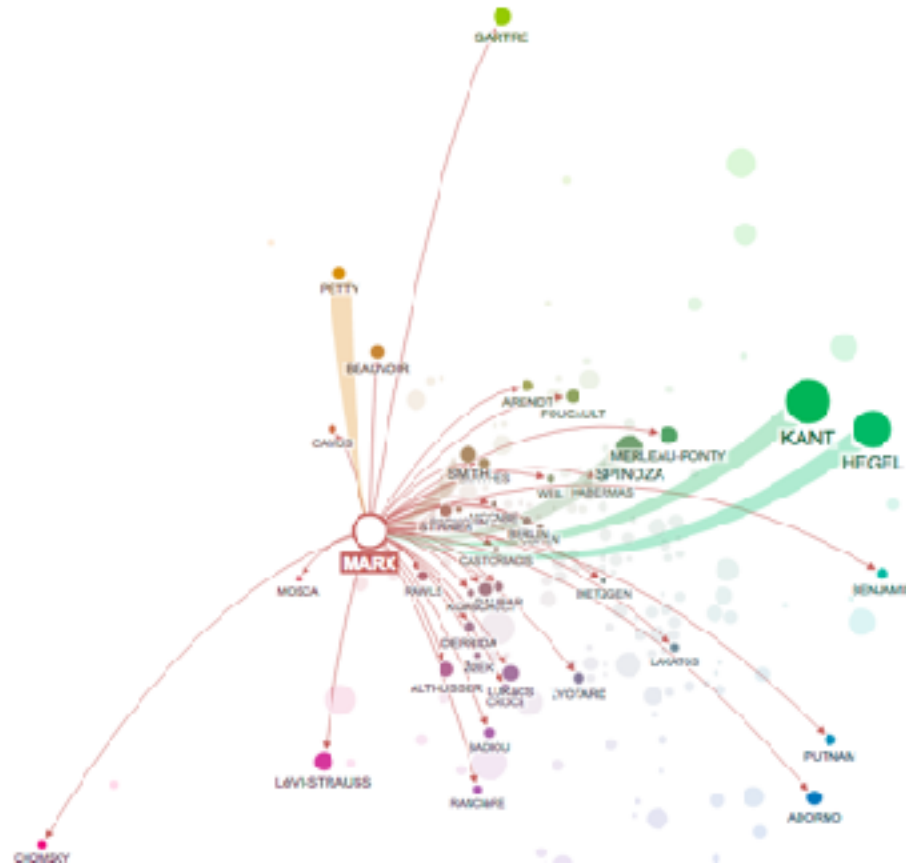
[Graphical Perception of Multiple Time Series.
Javed, McDonnell, and Elmqvist. *IEEE Transactions on Visualization and Computer Graphics* (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]



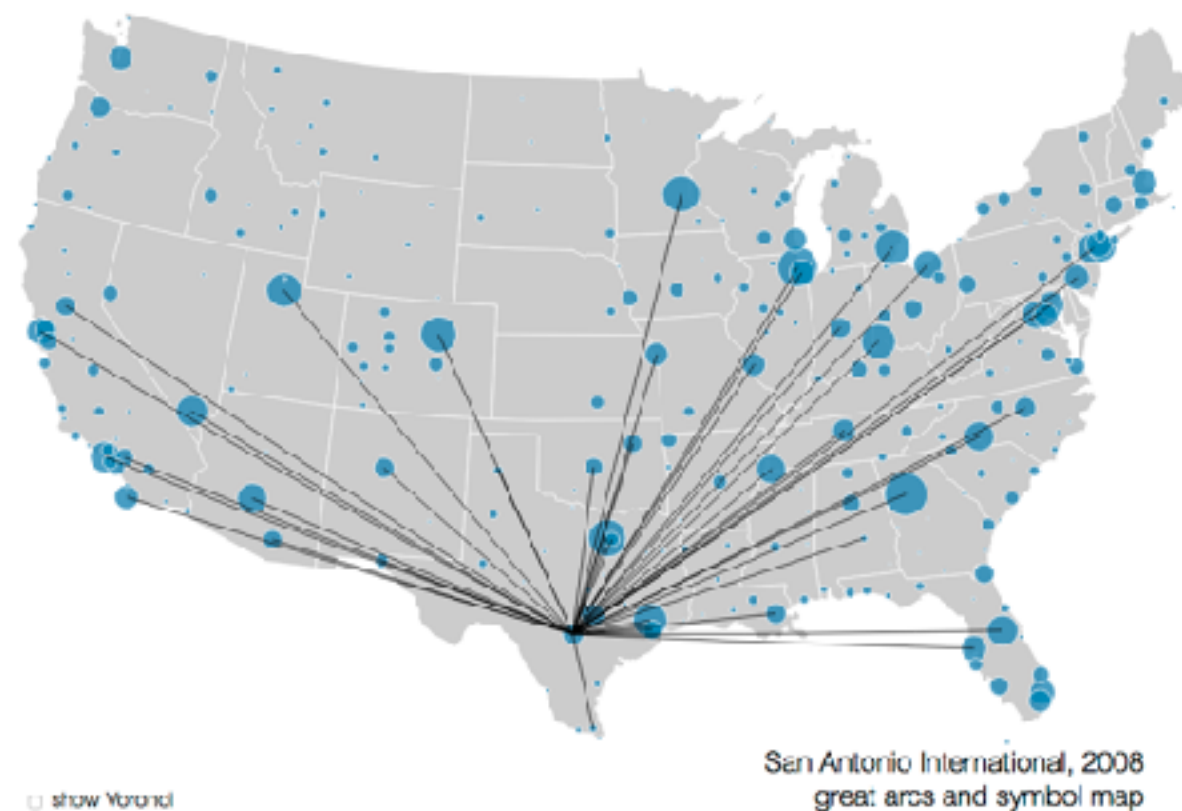
Dynamic visual layering

- interactive, based on selection
- one-hop neighbour highlighting

click (heavyweight)



hover (fast)



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

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

How?

Encode

➔ Arrange

➔ Express



➔ Separate



➔ Order



➔ Align



➔ Use



➔ Map

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

➔ Color

➔ Hue



➔ Saturation



➔ Luminance



➔ Size, Angle, Curvature, ...



➔ Shape



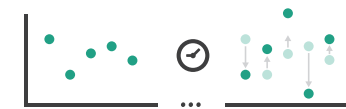
➔ Motion

Direction, Rate, Frequency, ...

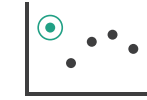


Manipulate

➔ Change



➔ Select



➔ Navigate

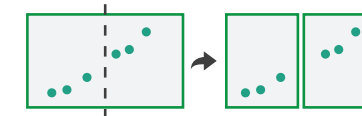


Facet

➔ Juxtapose



➔ Partition



➔ Superimpose



Reduce

➔ Filter



➔ Aggregate



➔ Embed



What?

Why?

How?