

Lectures 1&2: Manipulate & Interact

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DSCI 532: Data Visualization II

Lectures 1&2: 20 & 22 March 2017

https://github.ubc.ca/ubc-mds-2016/DSCI_532_viz-2_students

What's when

- 8 lectures in 4 weeks
 - Mon & Wed, 11am-12:20pm (80 min), Mar 20 - Apr 12, ORCH 3058
- 4 labs
 - Mon, 2-4pm, Mar 20 - Apr 12, ESB 1042
 - start work Mon 2pm, due next Mon 9am, 12.5% each
- 2 quizzes: Week 3 (Mon Apr 3) & week 5 (Thu Apr 20)
 - 2-2:30pm, 25% each
- my (optional) office hrs are in ICICS/CS X661
 - Mondays 5:30-6:30pm, Mar 20 - Apr 10
 - or by appointment

Reading

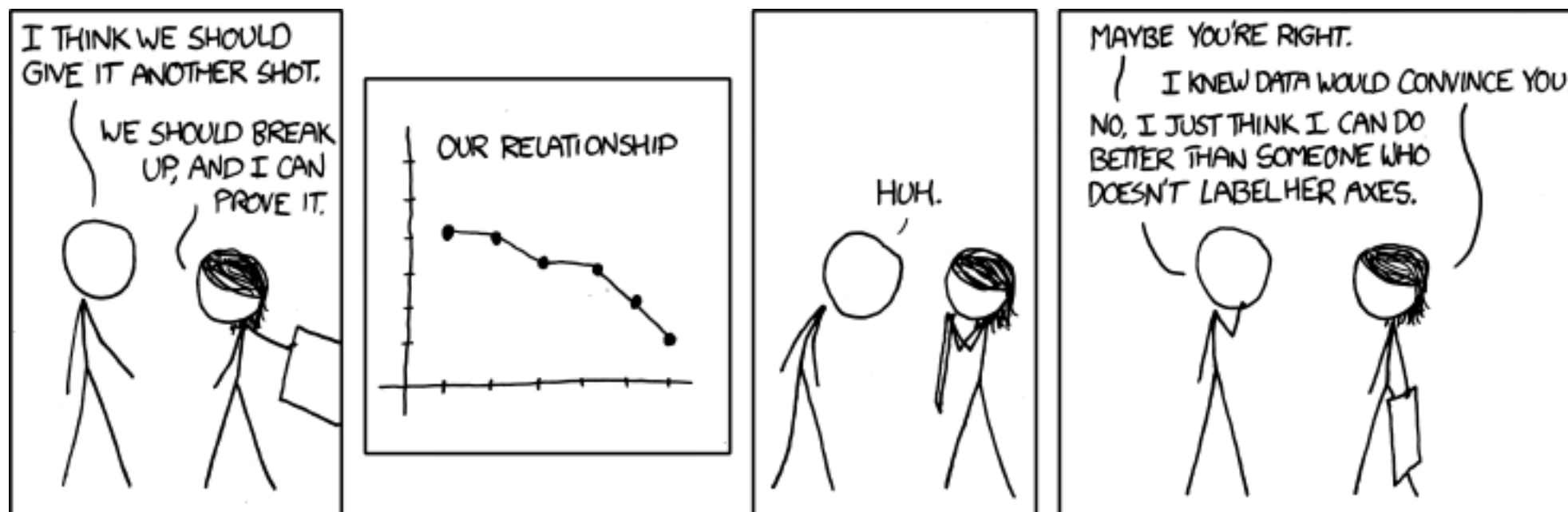
- same as before
- core foundational material covered in lectures
- textbook as backup to lectures
 - Tamara Munzner. *Visualization Analysis and Design*. CRC Press, 2014.
 - library has multiple ebook copies for free
 - to buy yourself, see <http://www.cs.ubc.ca/~tmm/vadbook/>

Topics

- Lectures 1&2
 - Manipulate View
 - Change over Time, Select, Navigate
- Lectures 3&4
 - Facet Into Multiple Views
 - Juxtapose, Partition, Layer
- Lectures 5&6
 - Reduce Items & Attributes
 - Filter, Aggregate, Embed
- Lectures 7&8
 - Usability/Validation & Case Studies

Labs

- make visualizations as self-documenting as possible
 - meaningful & useful title, labels, legends
 - axes and panes/subwindows should have labels
 - and axes should have good mix/max boundary tick marks
 - everything that's plotted should have a legend
 - and own header/labels if not redundant with main title
 - use reasonable numerical format
 - avoid scientific notation in most cases



[<https://xkcd.com/833/>]

How?

Encode

→ Arrange

→ Express



→ Separate



→ Order



→ Align



→ Use



→ Map

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

→ Color

→ Hue



→ Saturation



→ Luminance



→ Size, Angle, Curvature, ...



→ Shape



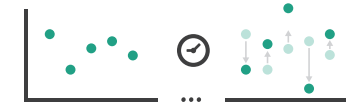
→ Motion

Direction, Rate, Frequency, ...

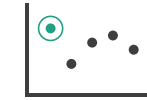


Manipulate

→ Change



→ Select



→ Navigate

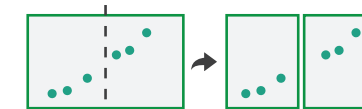


Facet

→ Juxtapose



→ Partition



→ Superimpose



Reduce

→ Filter



→ Aggregate



→ Embed



What?

Why?

How?

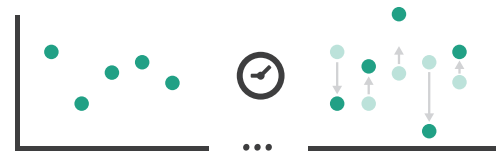
How to handle complexity: 1 previous strategy + 3 more

→ *Derive*

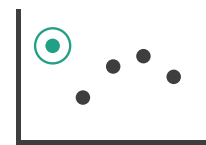


Manipulate

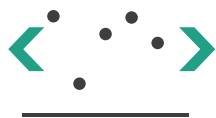
→ Change



→ Select

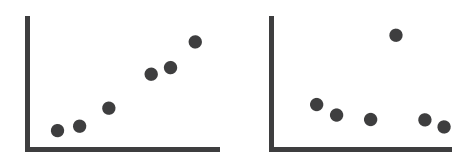


→ Navigate

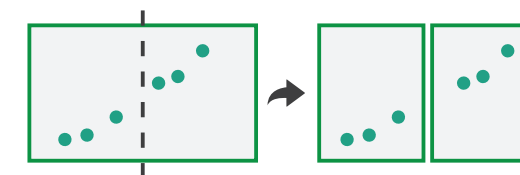


Facet

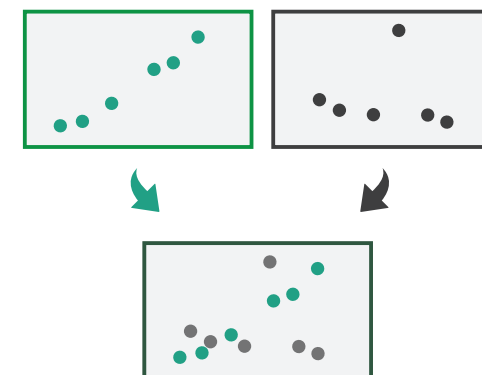
→ Juxtapose



→ Partition

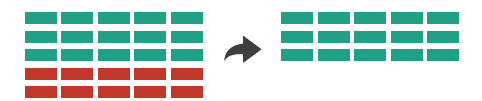


→ Superimpose



Reduce

→ Filter



→ Aggregate



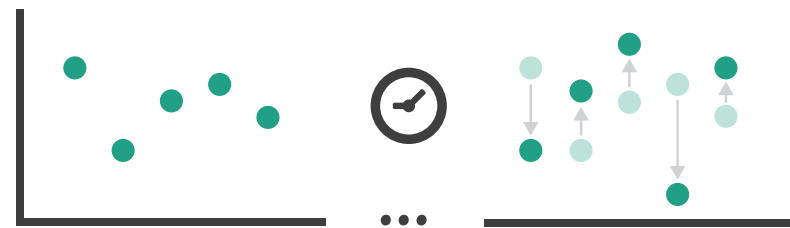
→ Embed



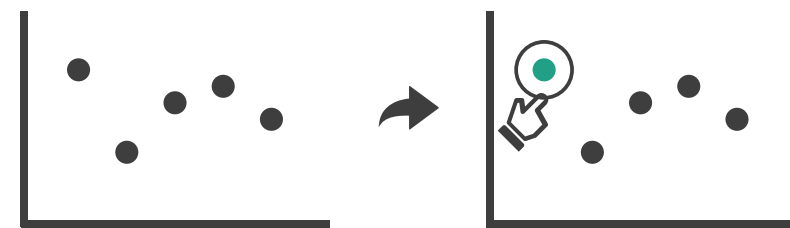
- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate

→ Change over Time



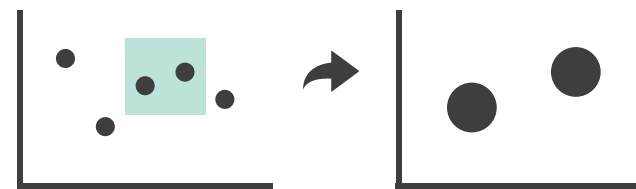
→ Select



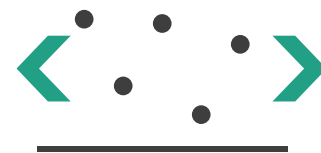
→ Navigate

→ Item Reduction

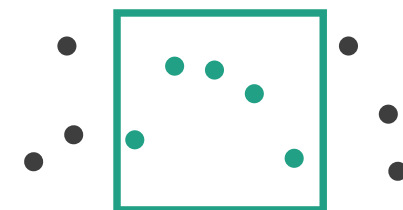
→ Zoom
Geometric or *Semantic*



→ Pan/Translate

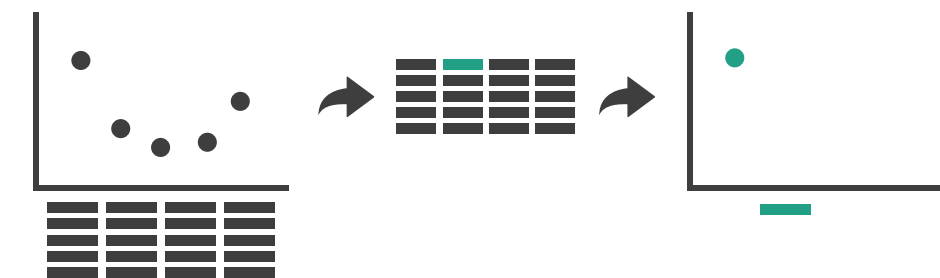


→ Constrained

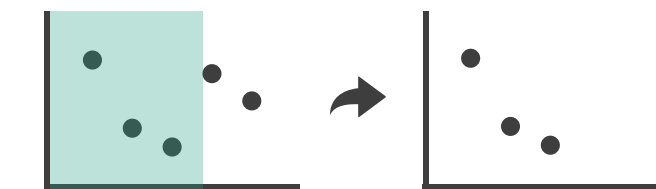


→ Attribute Reduction

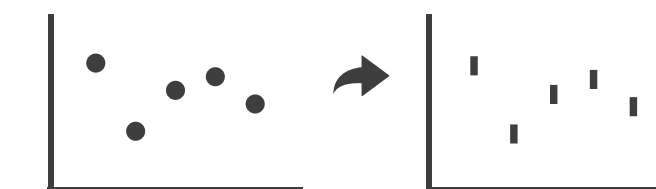
→ Slice



→ Cut



→ Project

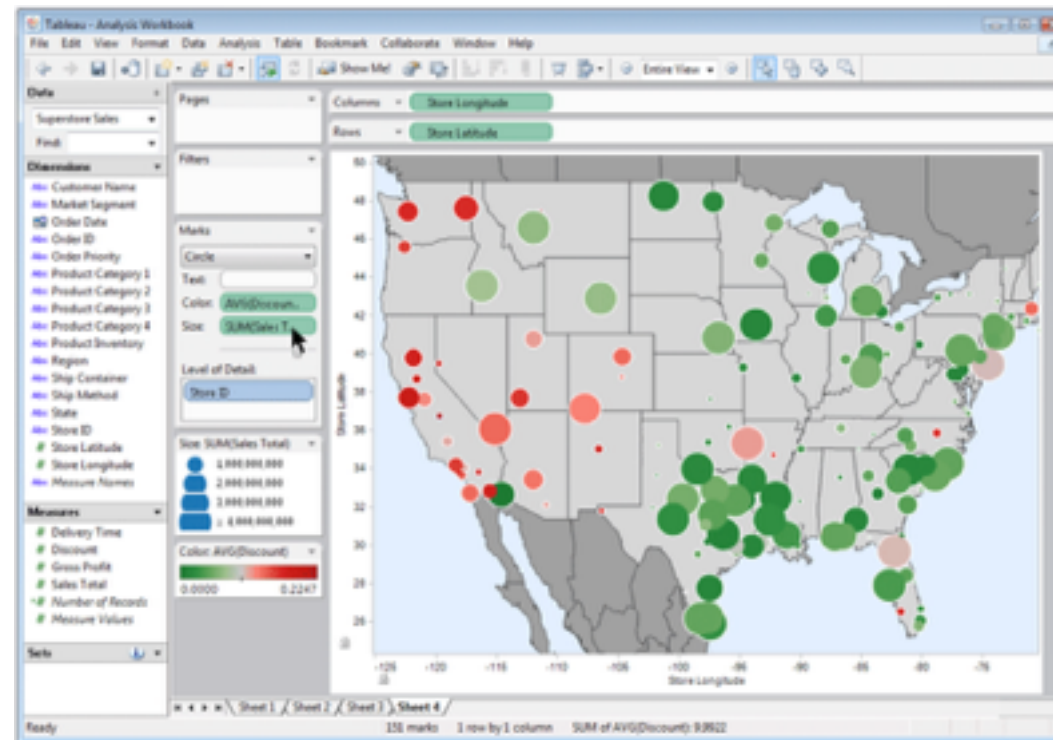
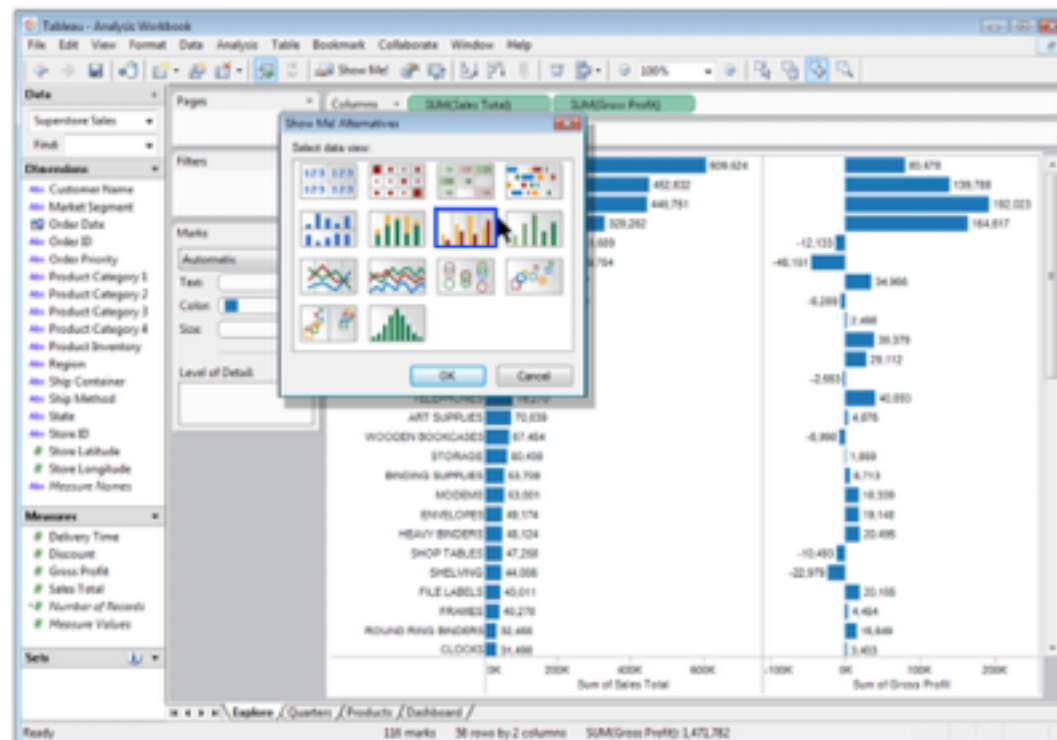
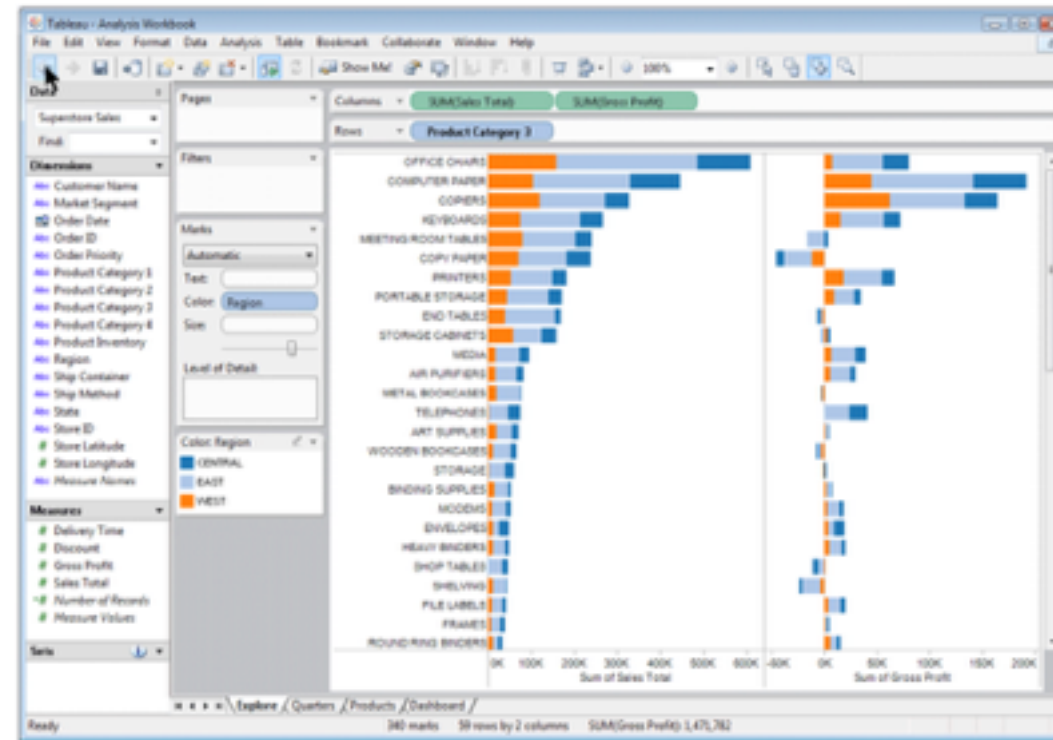
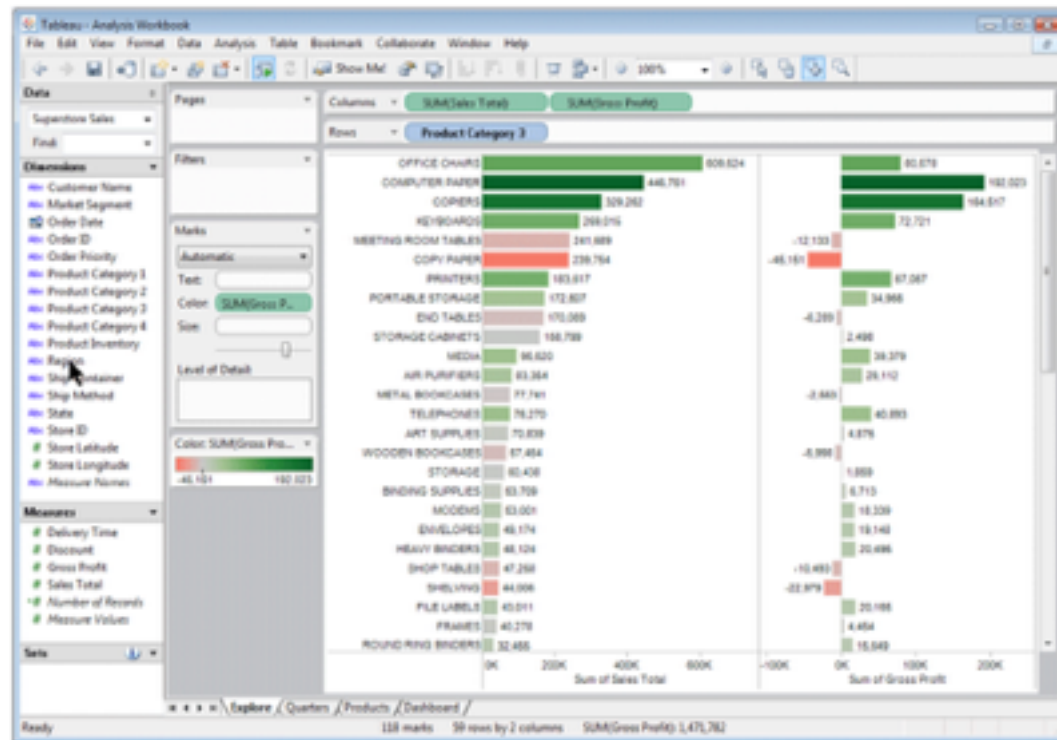


Change over time

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

Idiom: Change encoding

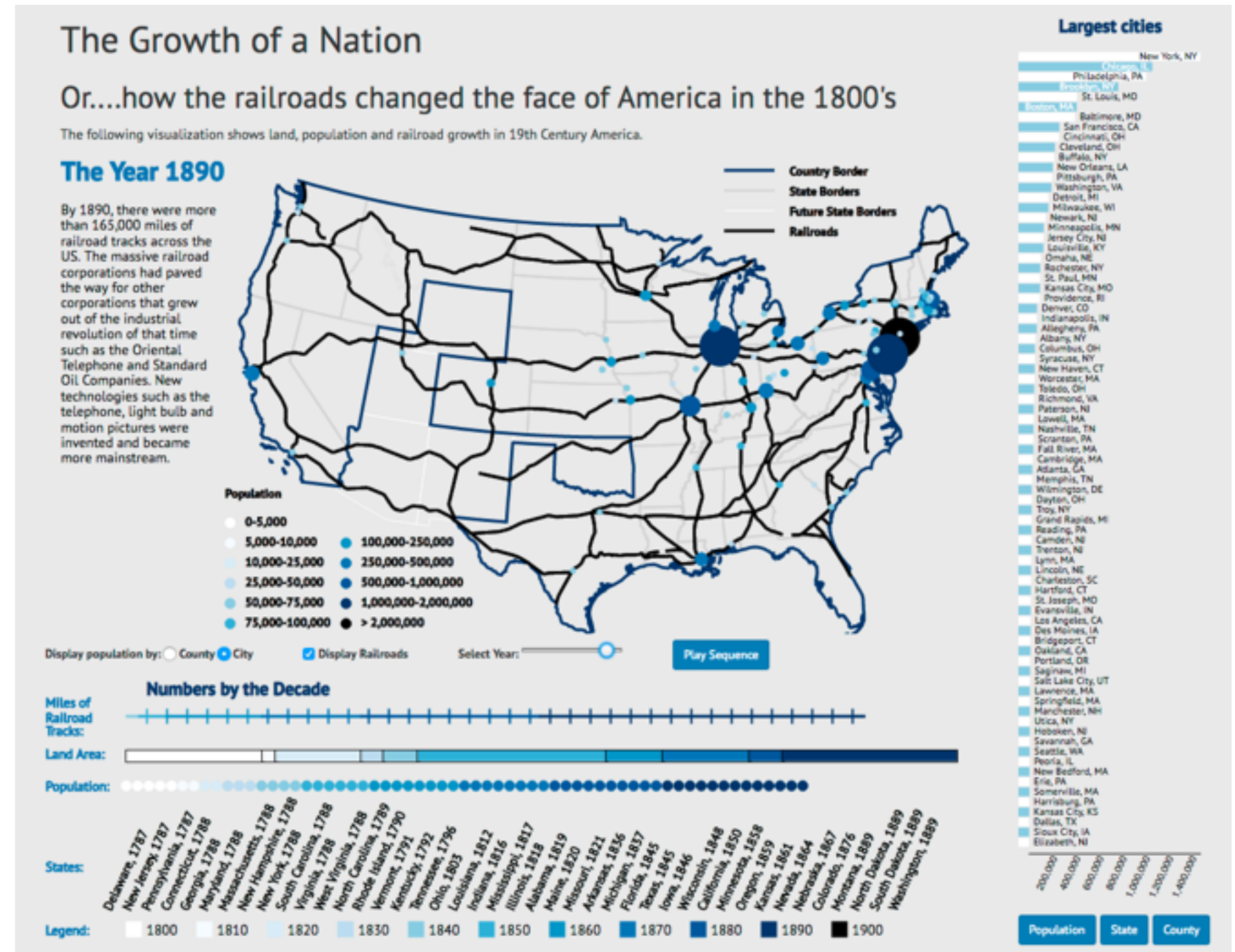
System: Tableau



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

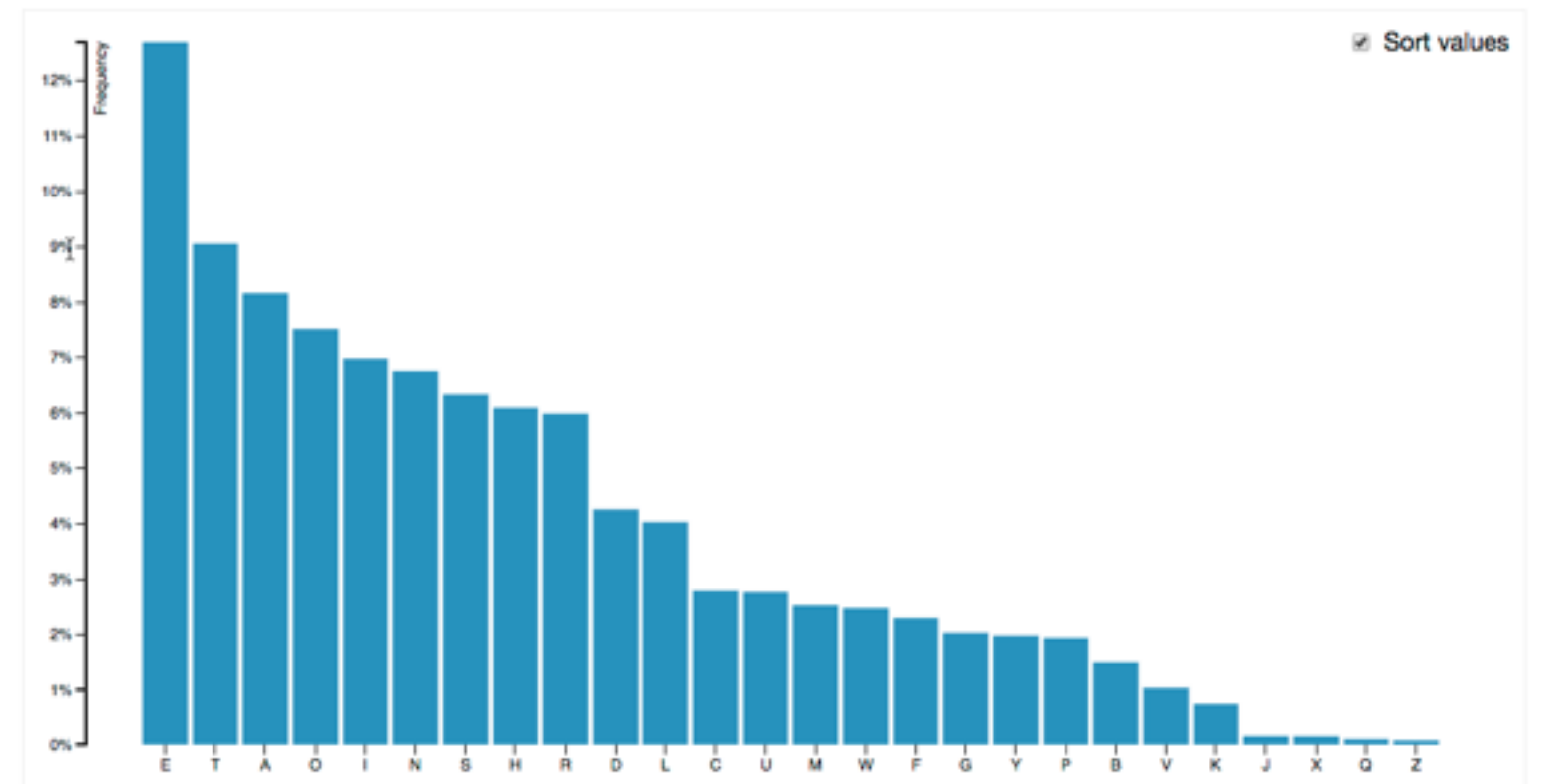
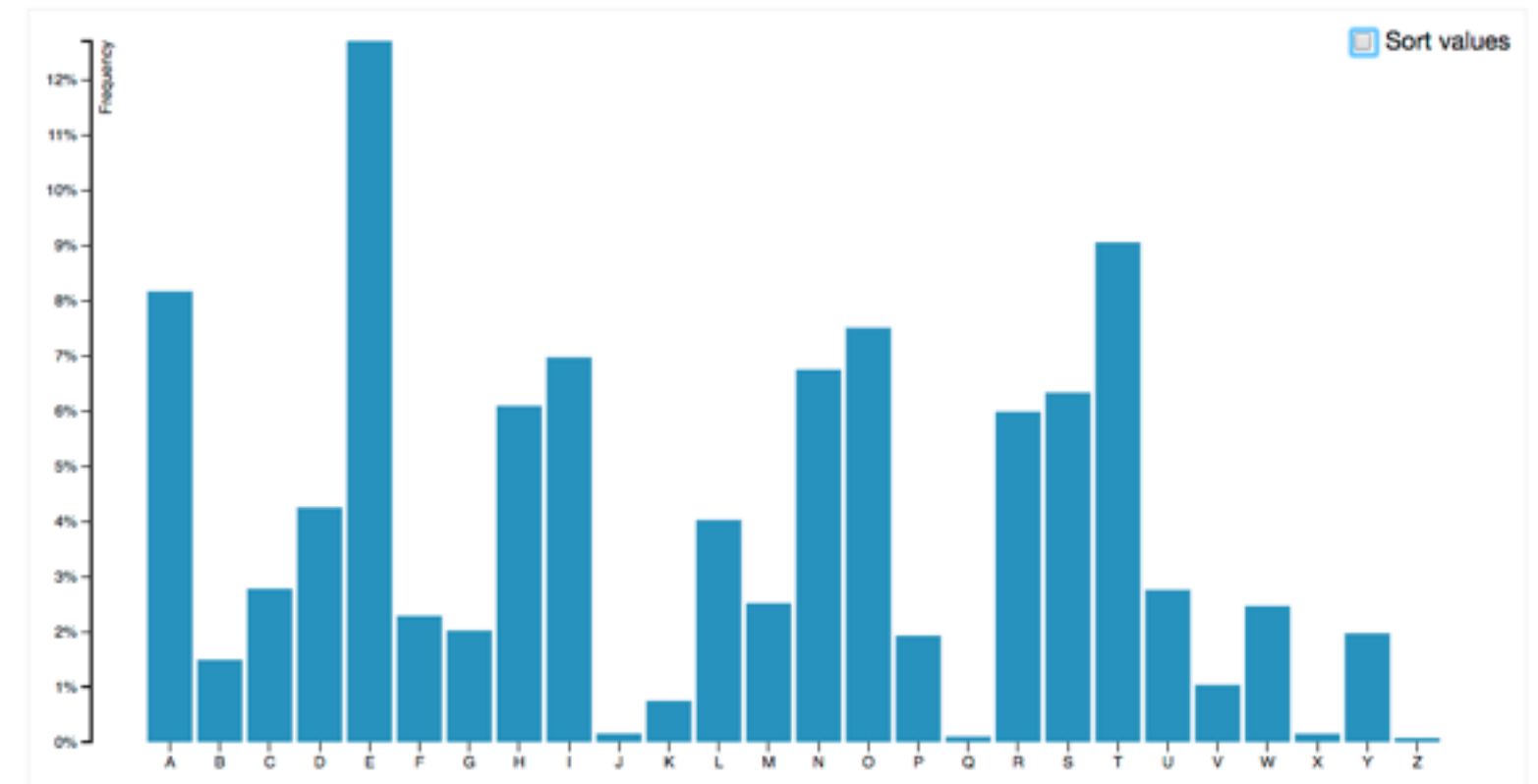


[Growth of a Nation](<http://laurenwood.github.io/>)

slide inspired by: Alexander Lex, Utah

Idiom: **Change order/arrangement**

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

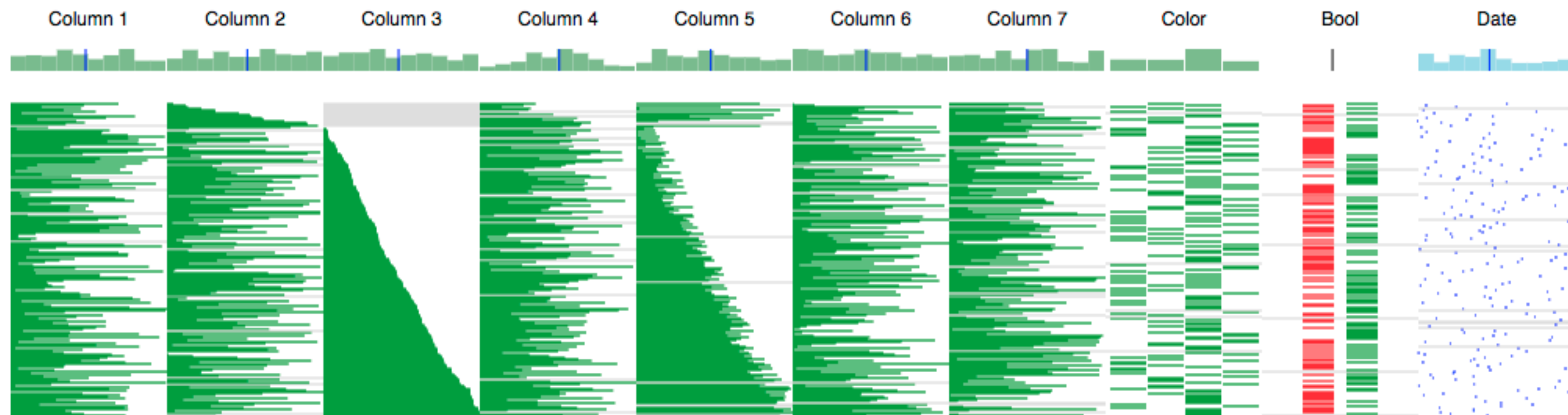


[\[Sortable Bar Chart\]\(https://blocks.org/mbostock/3885705\)](https://blocks.org/mbostock/3885705)

Idiom: **Reorder**

System: **DataStripes**

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

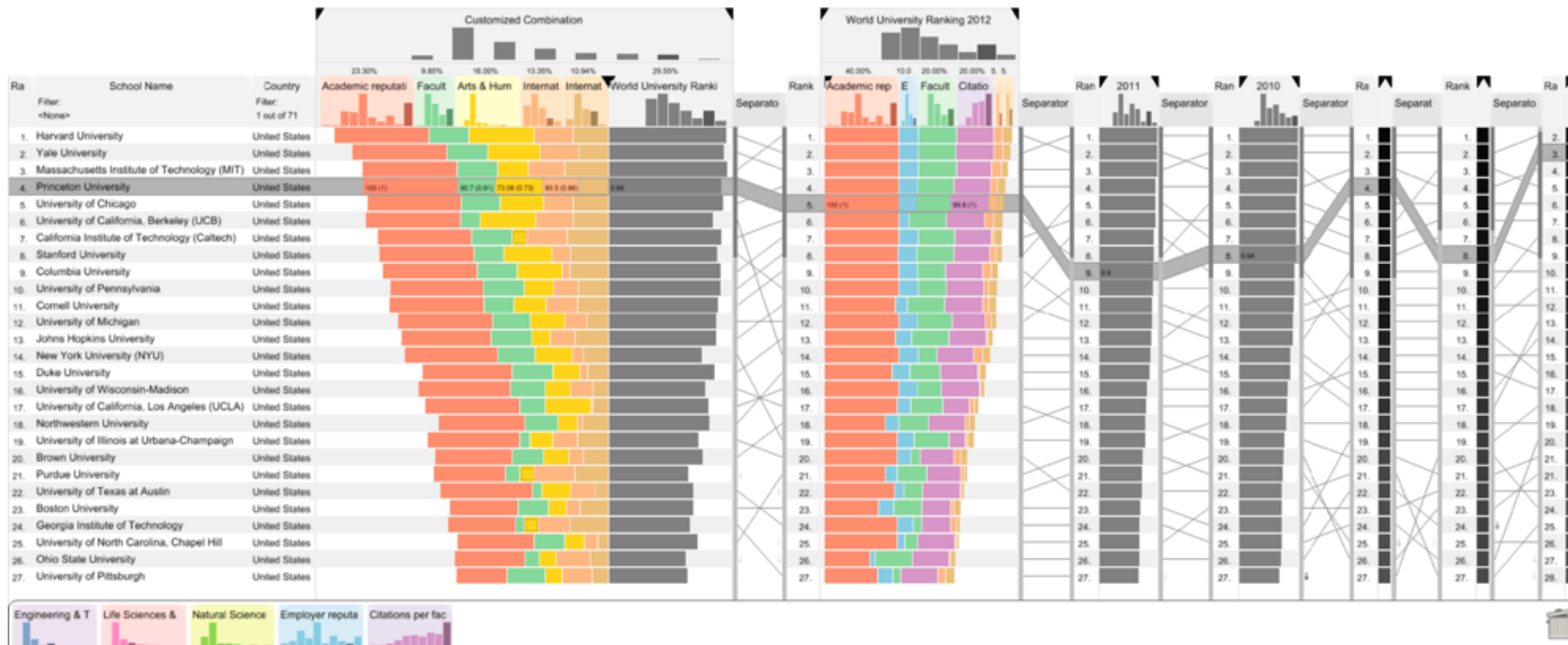


[\[http://carlmanaster.github.io/datastripes/\]](http://carlmanaster.github.io/datastripes/)

Idiom: Reorder

System: LineUp

- what: tables with many attributes; derived rankings based on weights
- task: compare rankings
- how: reorder by interactively changing weights



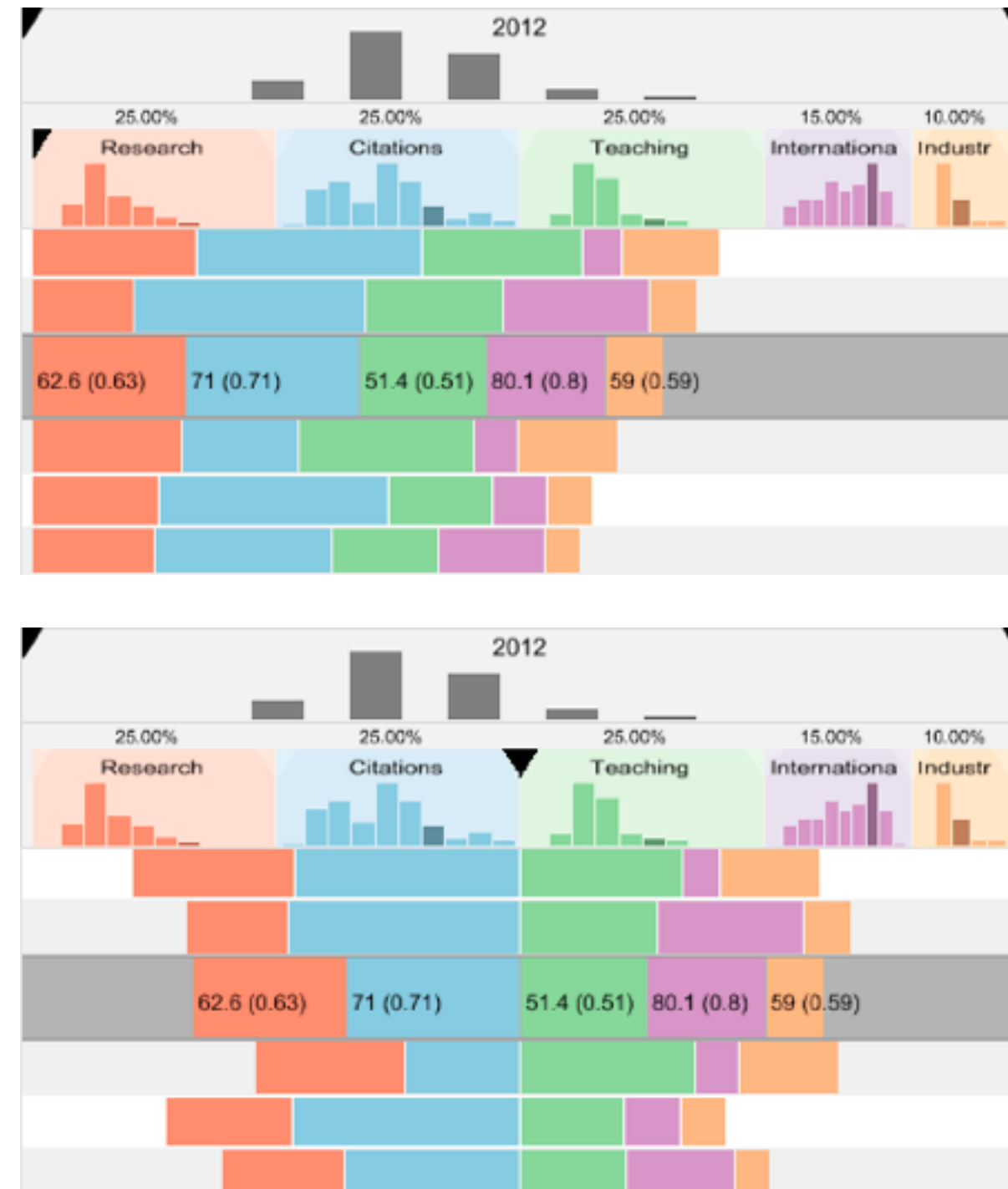
[LineUp: Visual Analysis of Multi-Attribute Rankings. Gratzl, Lex, Gehlenborg, Pfister, and Streit. IEEE TVGC (Proc. InfoVis 2013) 19:12 (2013), 2277–2286.]

[LineUp Demo](<https://lineup.caleydoapp.org>)

Idiom: **Change alignment**

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

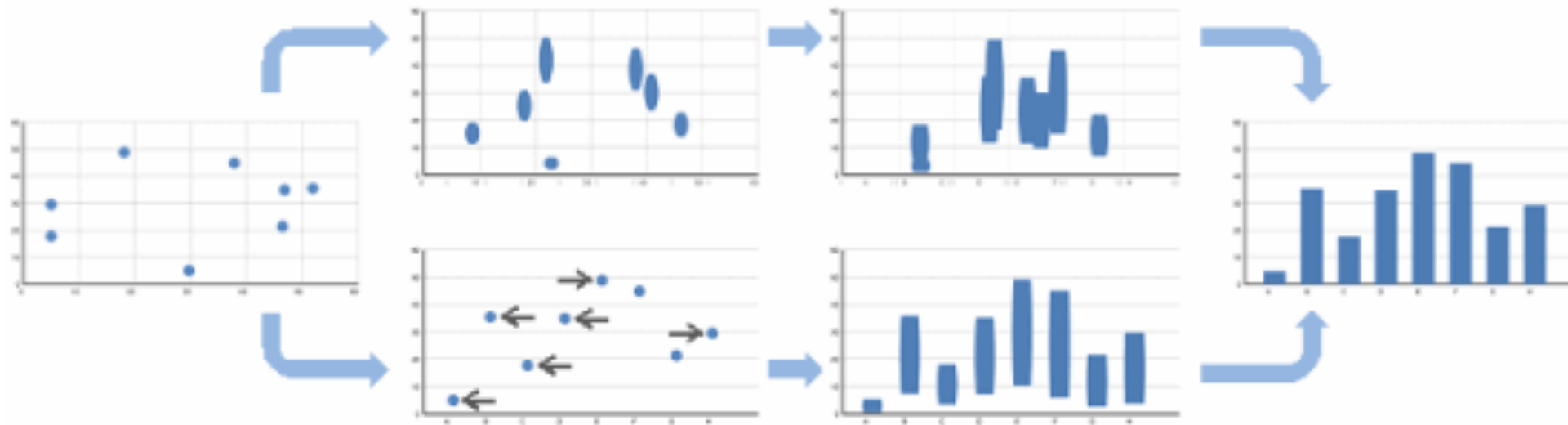
System: **LineUp**



[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**

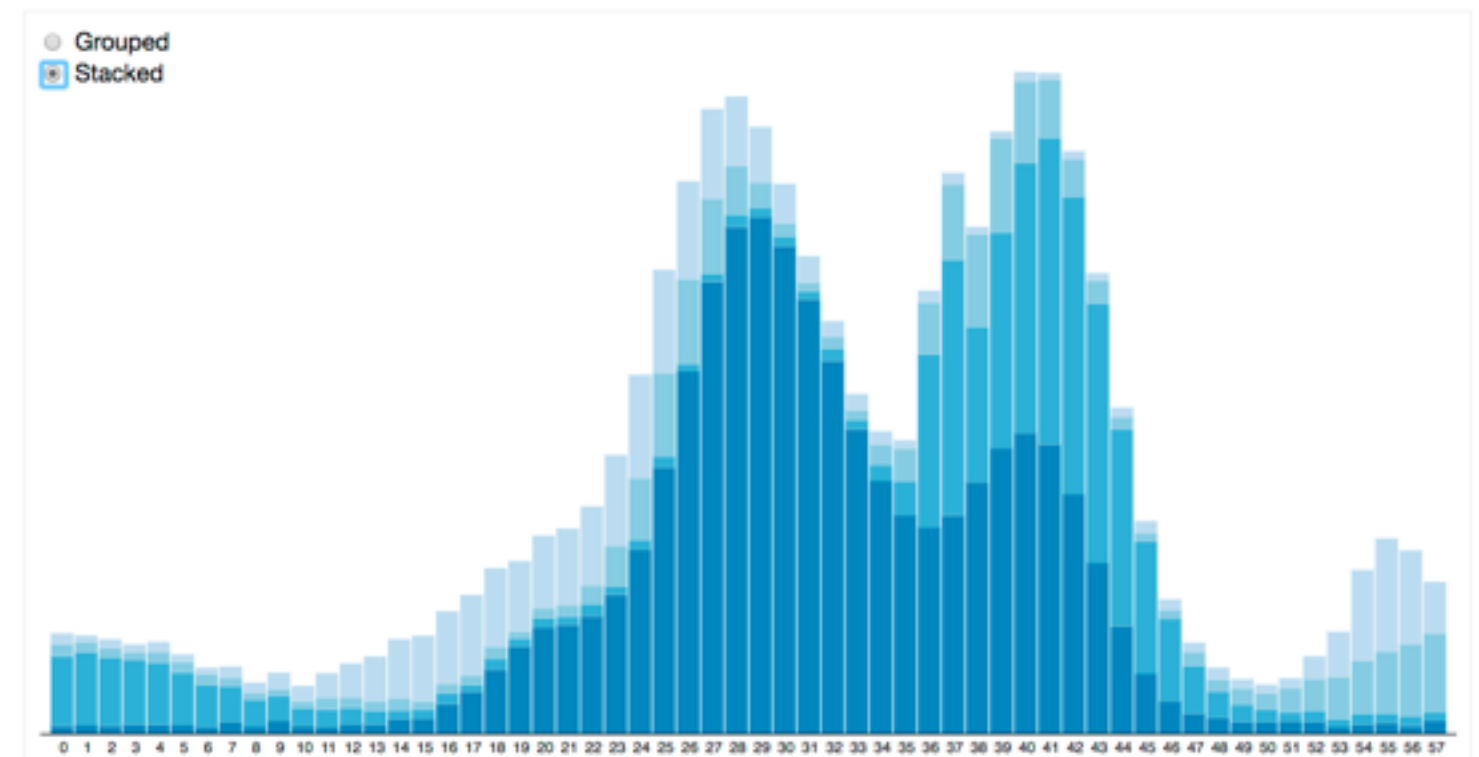
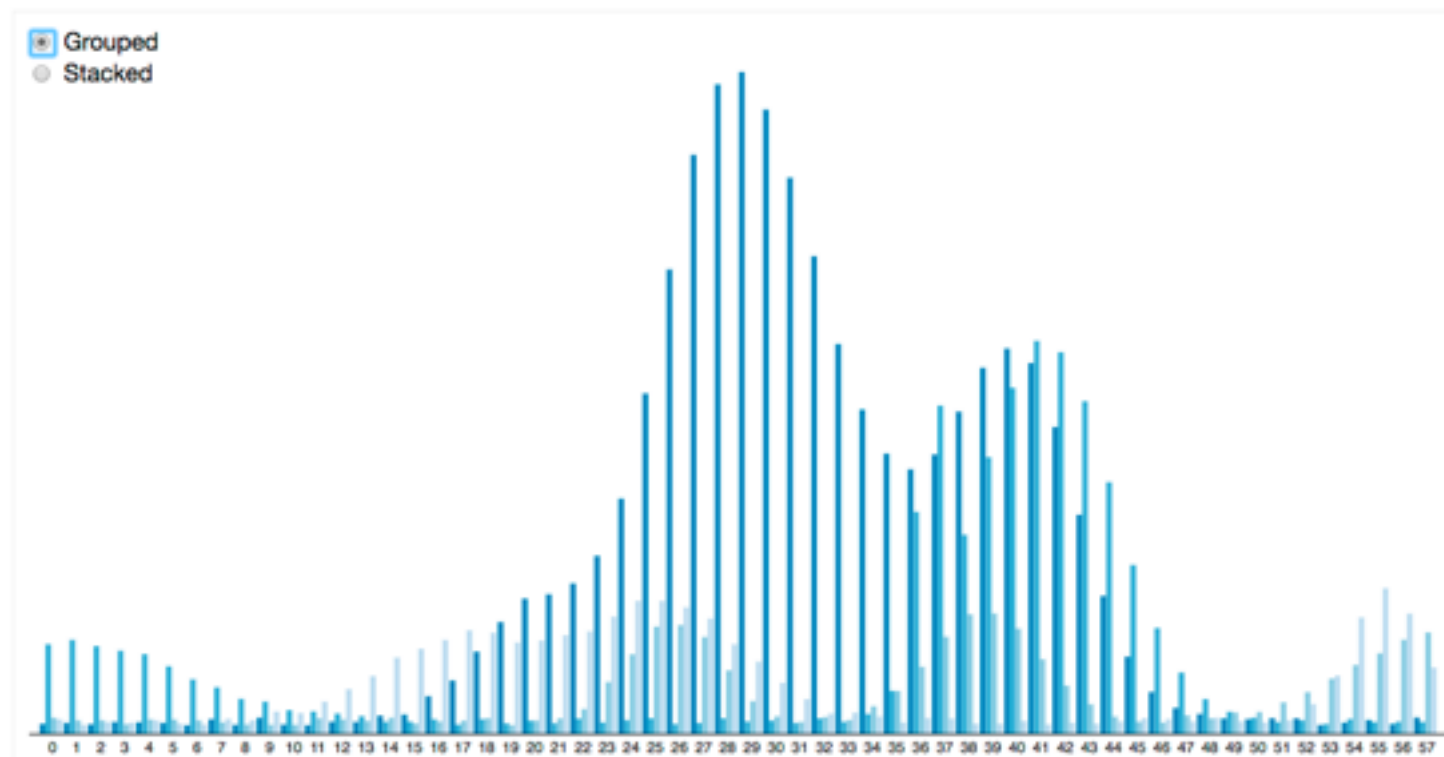
- smooth interpolation from one state to another
 - alternative to jump cuts, supports item tracking
 - best case for animation
 - staging to reduce cognitive load
- example: animated transitions in statistical data graphics



video: vimeo.com/19278444

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

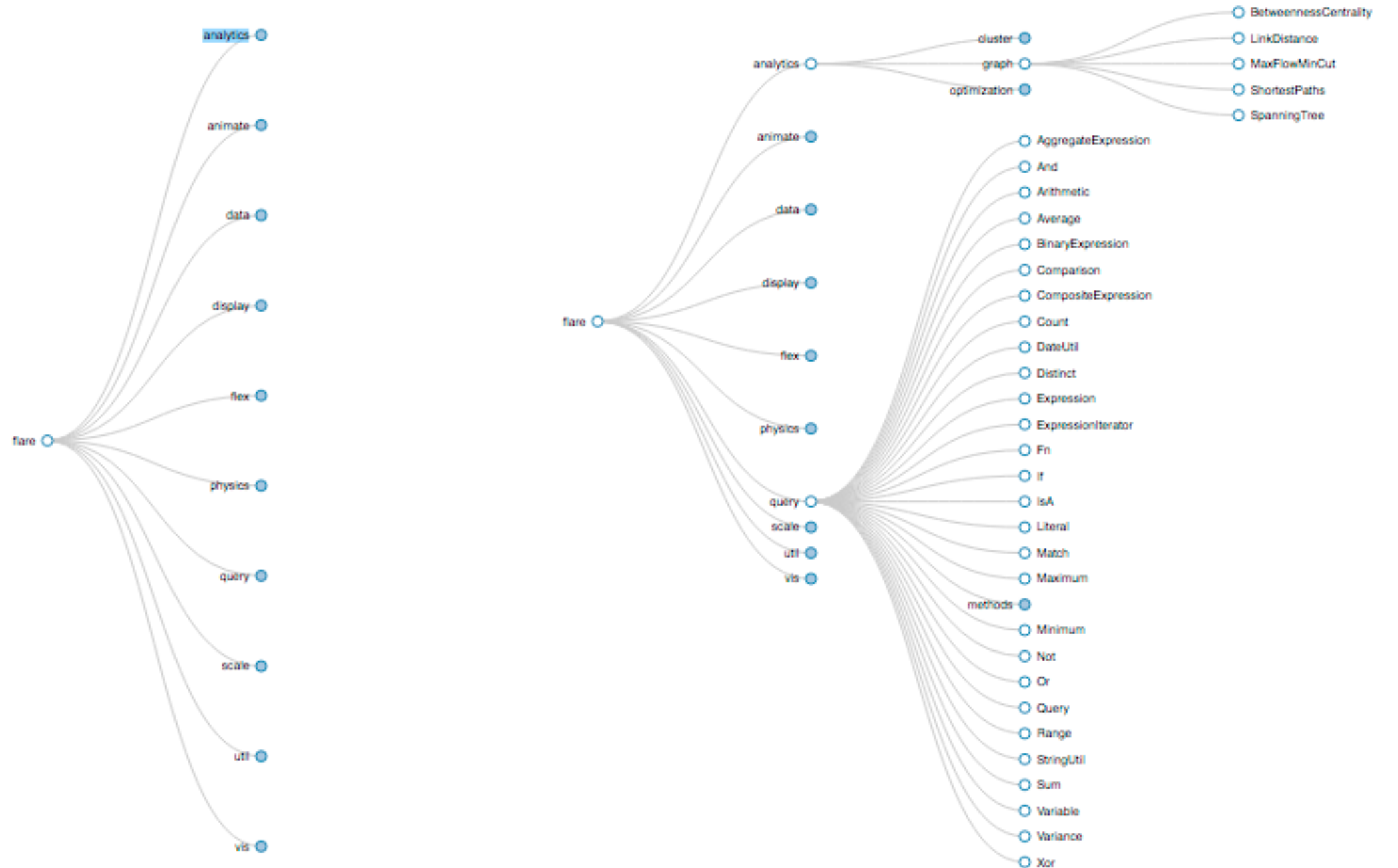
- smooth transition from one state to another
 - alternative to jump cuts, supports item tracking
 - best case for animation
 - staging to reduce cognitive load



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

Idiom: **Animated transition - tree detail**

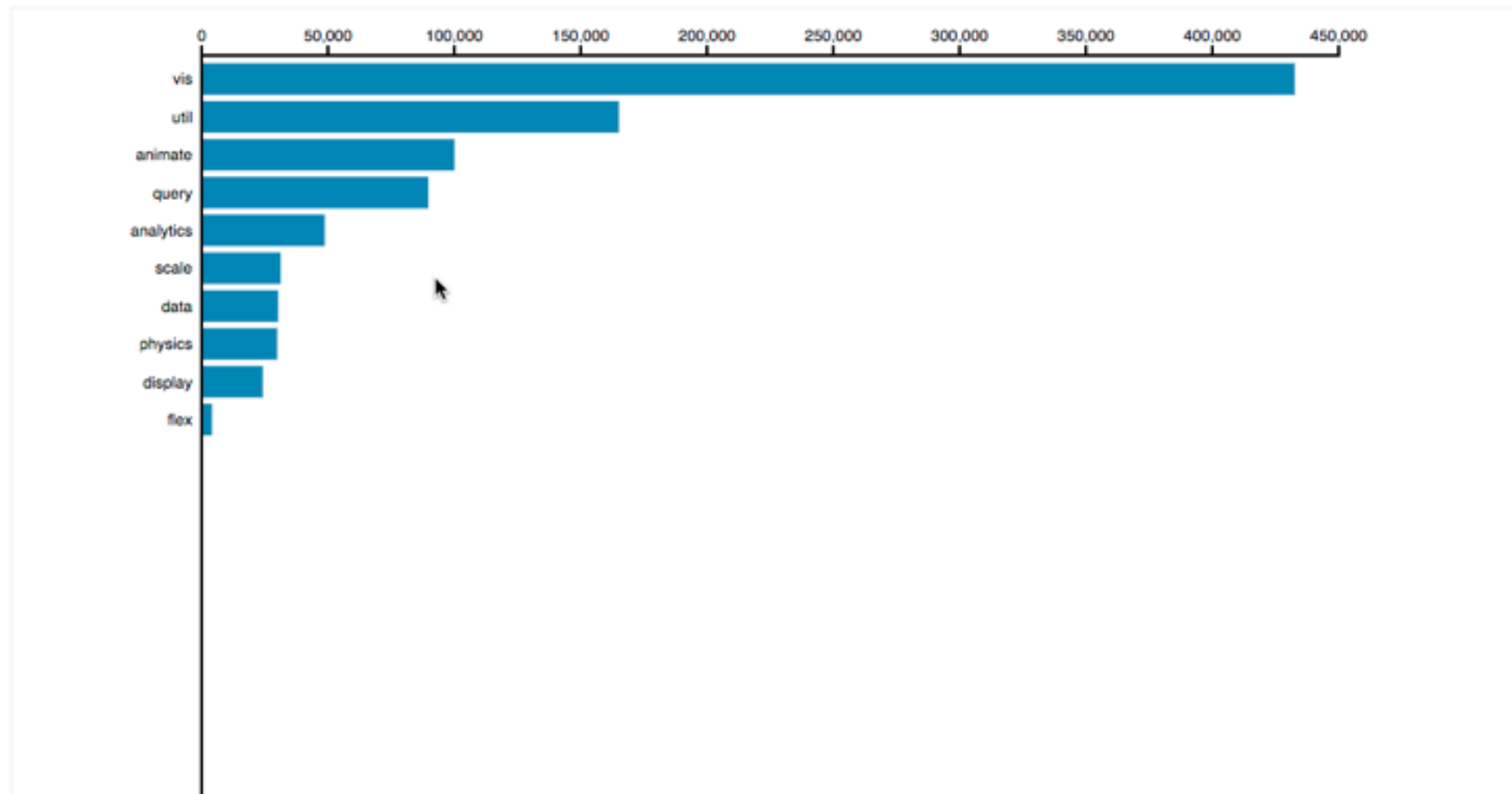
- animated transition
 - network drilldown/rollup



[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>)

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

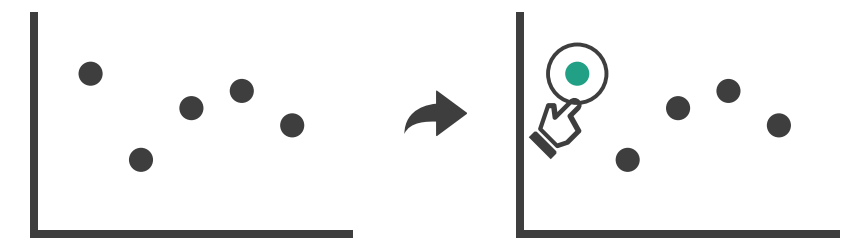


I Hate Tom Cruise - Alex Kauffmann (5 min)
www.youtube.com/watch?v=QXLfT9sFcbc

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, ...)

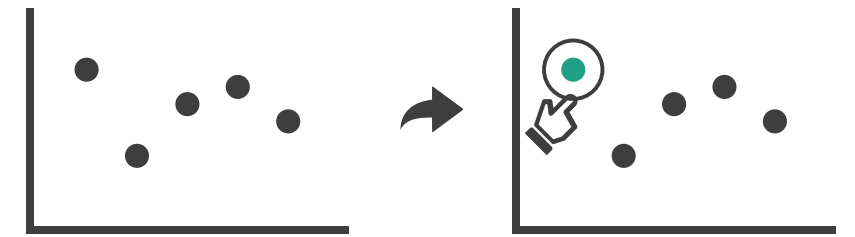
➔ Select



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

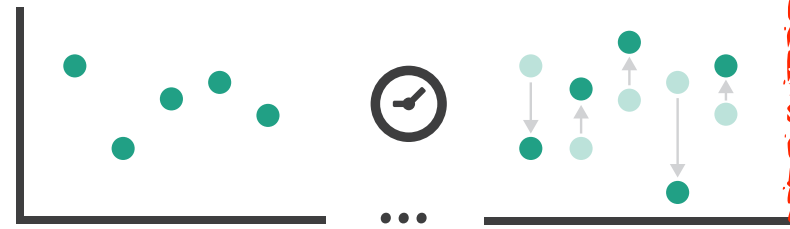
- popup information for selection
 - hover or click
 - can provide useful additional detail on demand
 - beware: does not support overview!
 - always consider if there's a way to visually encode directly to provide overview
 - “If you make a rollover or tooltip, assume nobody will see it. If it's important,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

Rule of thumb: **Responsiveness is required**

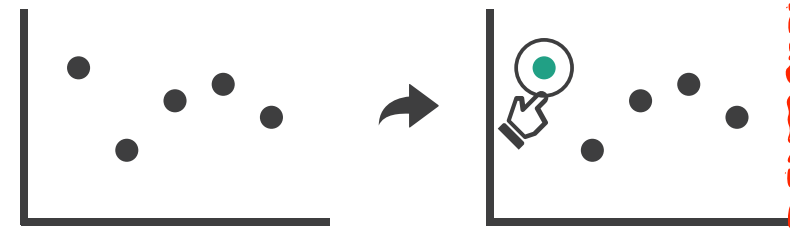
- *visual feedback: three rough categories*
 - *0.1 seconds: perceptual processing*
 - subsecond response for mouseover highlighting - ballistic motion
 - *1 second: immediate response*
 - fast response after mouseclick, button press - Fitts' Law limits on motor control
 - *10 seconds: brief tasks*
 - 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

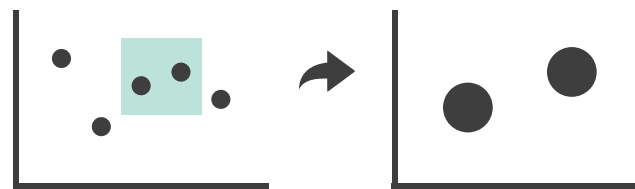


→ Navigate

→ Item Reduction

→ Zoom

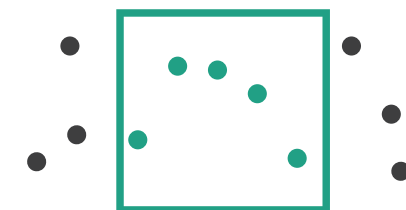
Geometric or Semantic



→ Pan/Translate

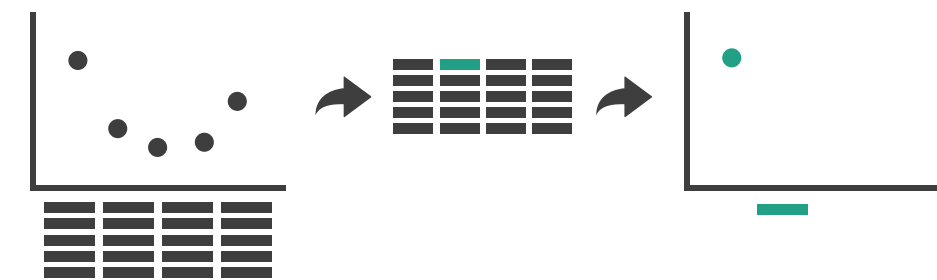


→ Constrained

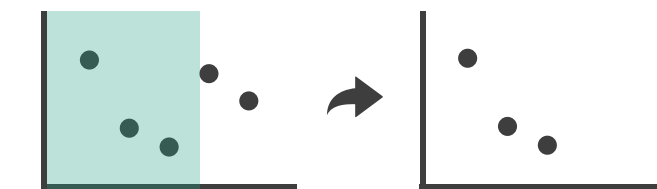


→ Attribute Reduction

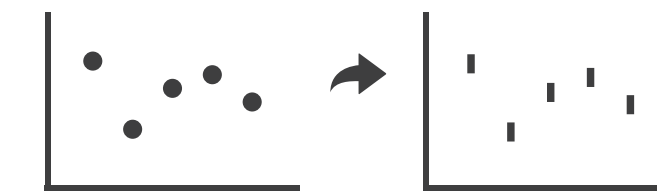
→ Slice



→ Cut



→ Project



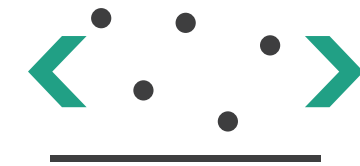
Navigate: Changing viewpoint/visibility

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

➔ Navigate

➔ Item Reduction

➔ *Pan/Translate*



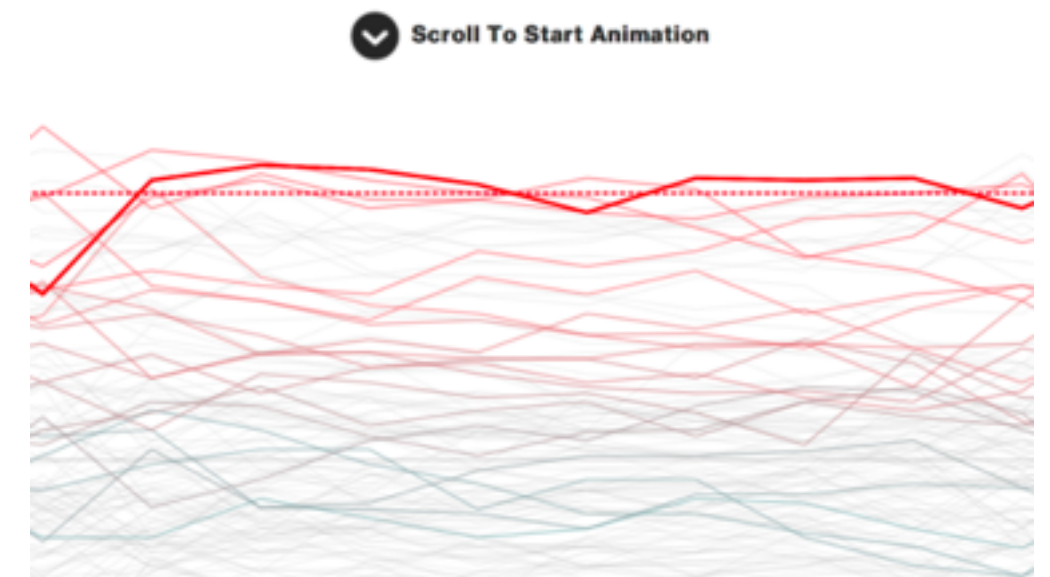
Idiom: Scrollytelling

- 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

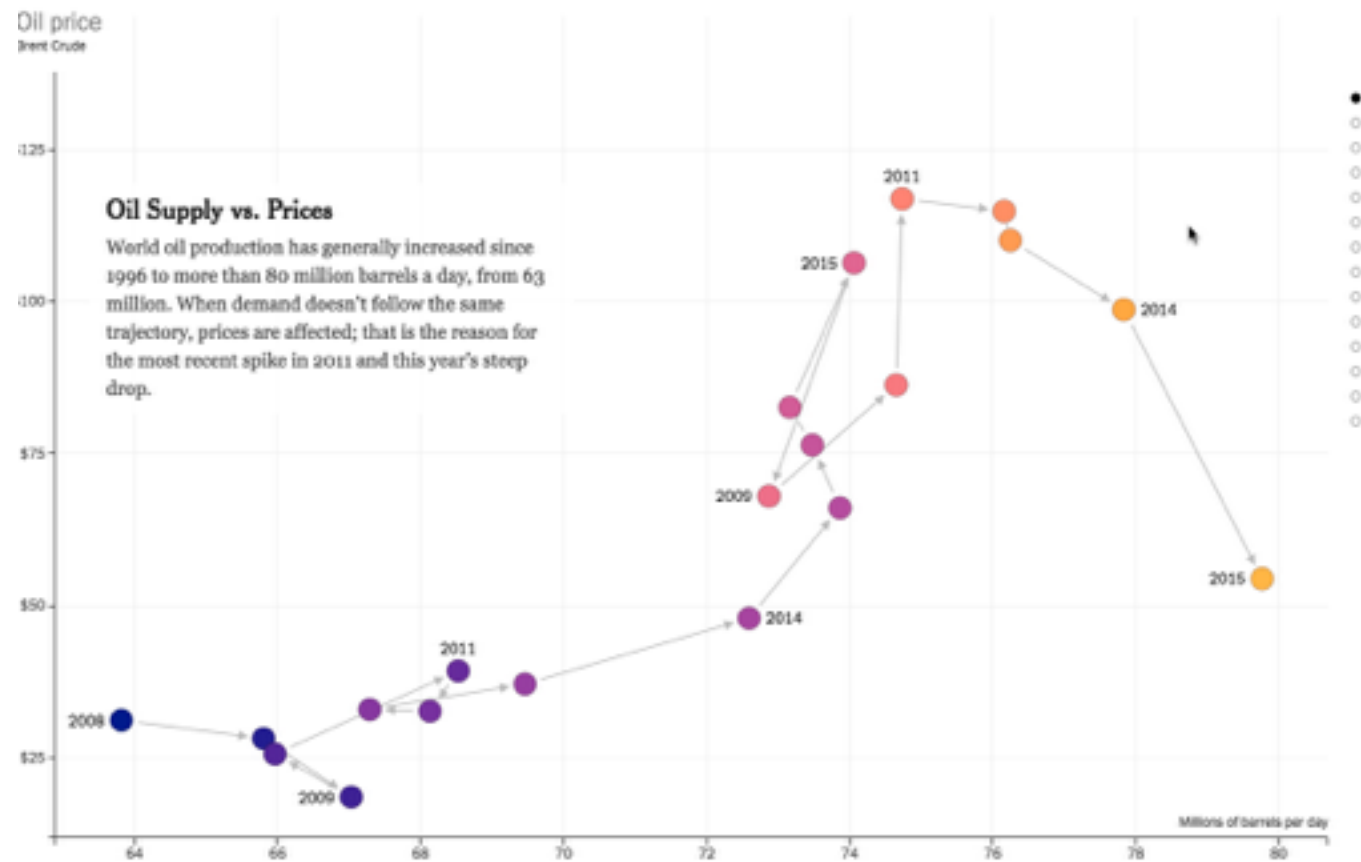
<https://eagereyes.org/blog/2016/the-scrollytelling-scourge>

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

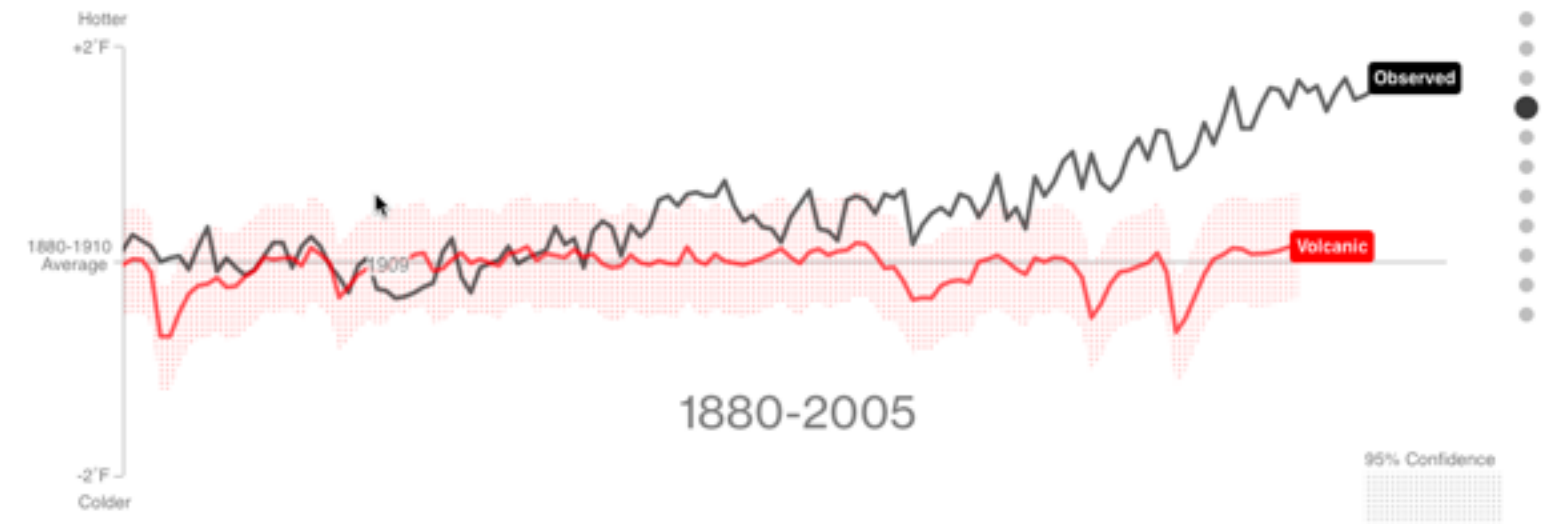
[slide inspired by: Alexander Lex, Utah](#)



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

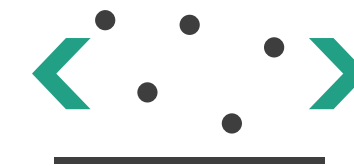
➔ Item Reduction

➔ Zoom

Geometric



➔ Pan/Translate



Navigate: Unconstrained vs constrained

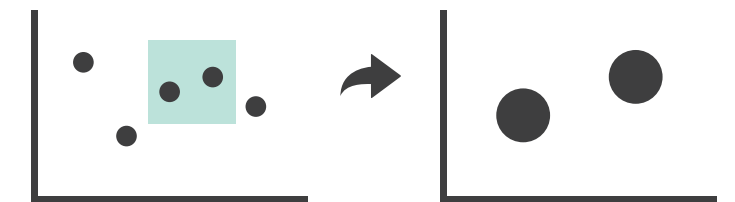
- unconstrained navigation
 - easy to implement for designer
 - hard to control for user
 - easy to overshoot/undershoot
- constrained navigation
 - typically uses animated transitions
 - trajectory automatically computed based on selection
 - just click; selection ends up framed nicely in final viewport

➔ Navigate

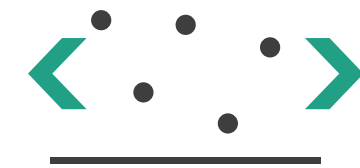
➔ Item Reduction

➔ Zoom

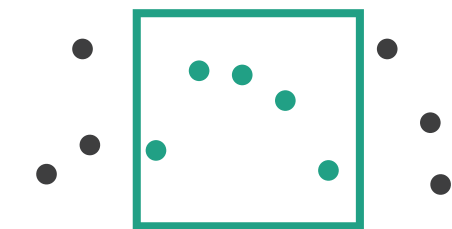
Geometric or *Semantic*



➔ Pan/Translate



➔ Constrained



Idiom: **Animated transition + constrained navigation**

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

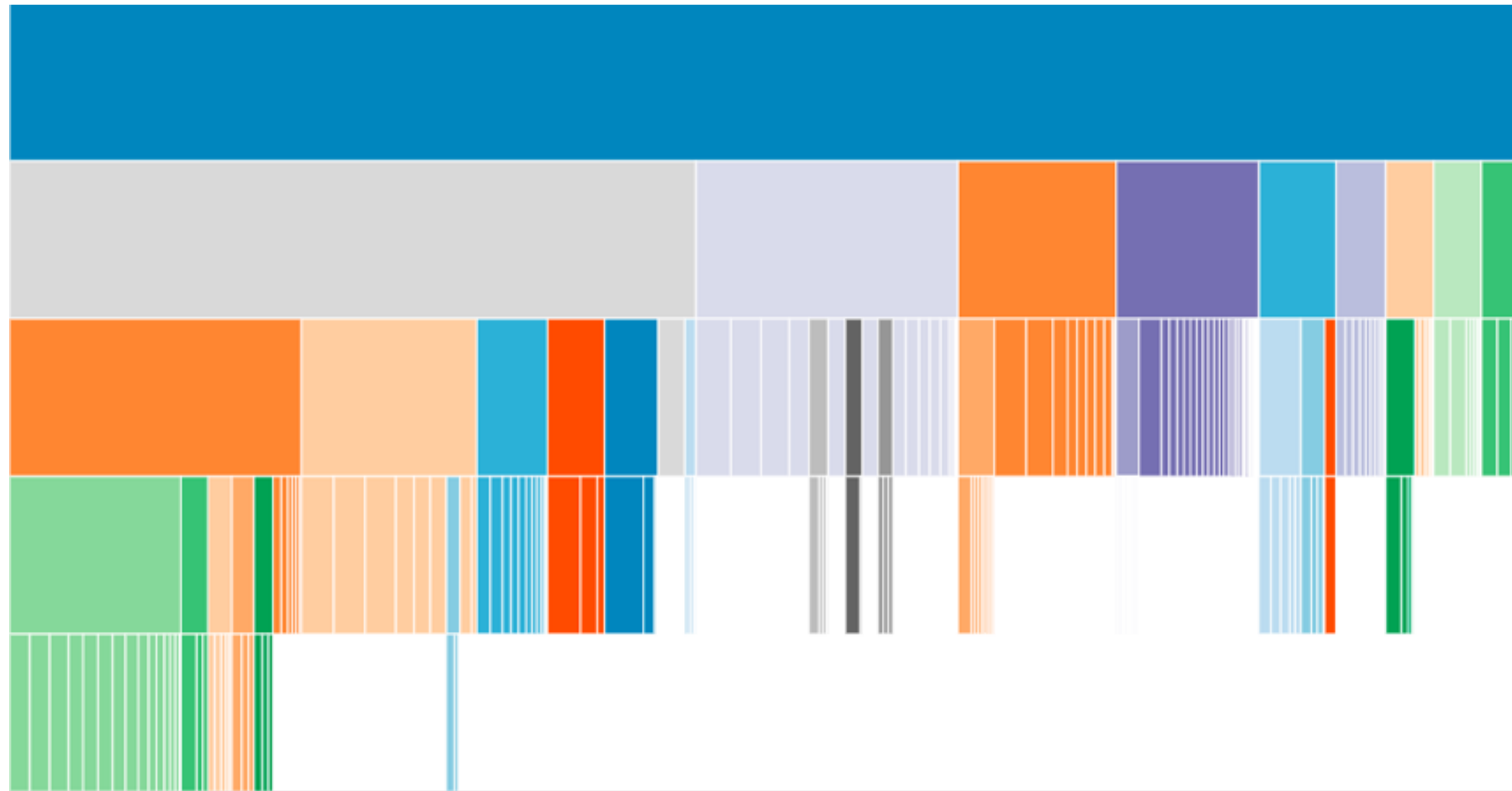
Zoom to Bounding Box



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

Idiom: **Animated transition + constrained navigation**

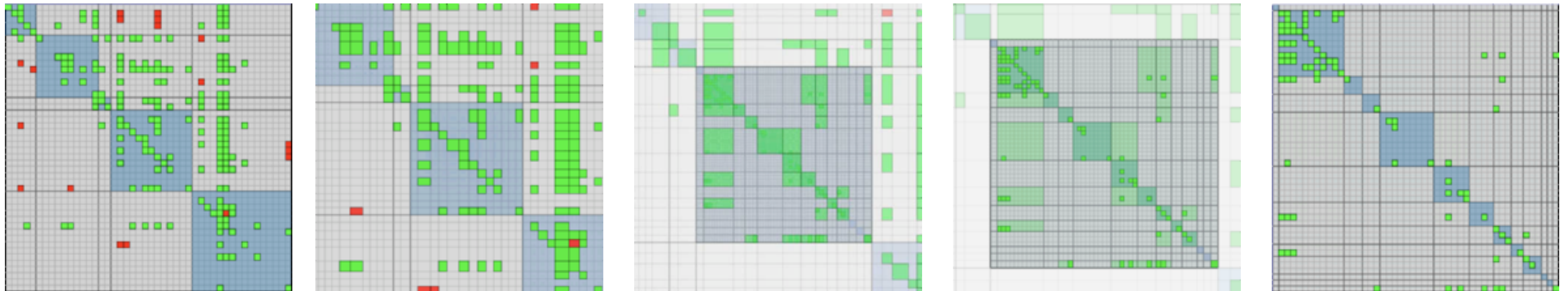
- example: icicle plot
 - add detail during transition into containing mark



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

Idiom: **Animated transition + constrained navigation**

- example: multilevel matrix views
 - add detail during transition
 - movie: <http://www.win.tue.nl/vis/home/fvham/matrix/Zoomin.avi>
 - movie: <http://www.win.tue.nl/vis/home/fvham/matrix/Zoomout.avi>
 - movie: <http://www.win.tue.nl/vis/home/fvham/matrix/Pan.avi>

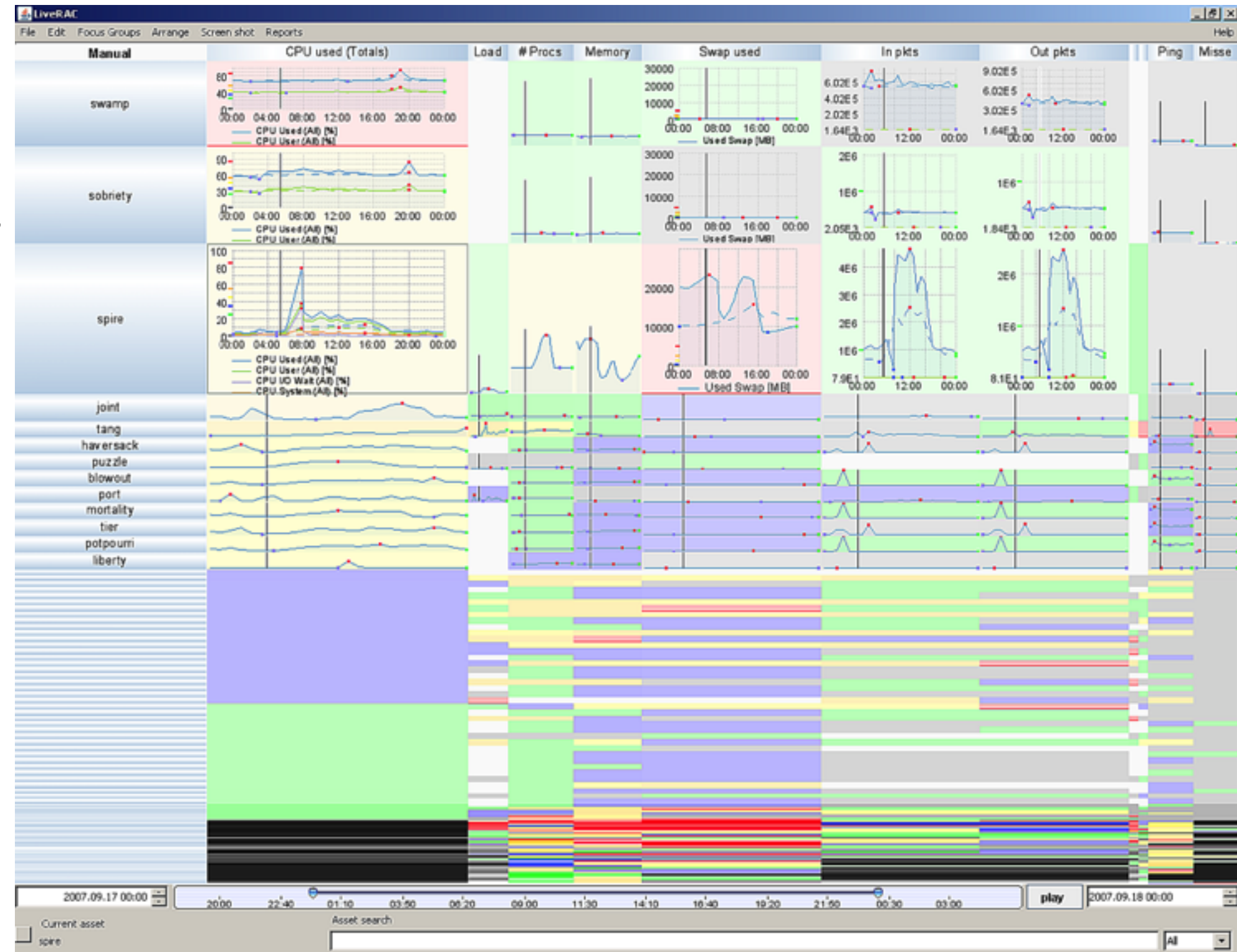


[Using Multilevel Call Matrices in Large Software Projects. van Ham. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 227–232, 2003.]

Idiom: Semantic zooming

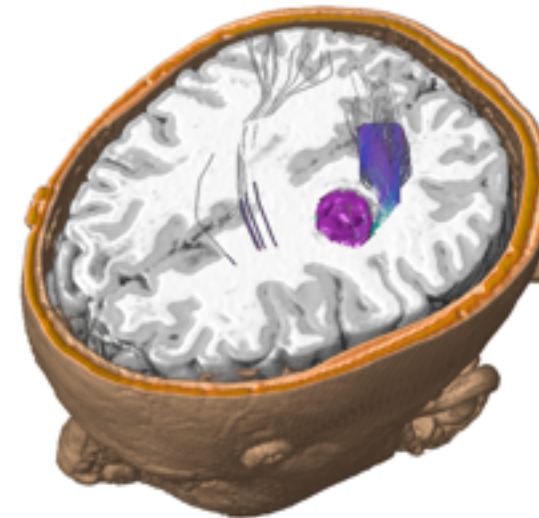
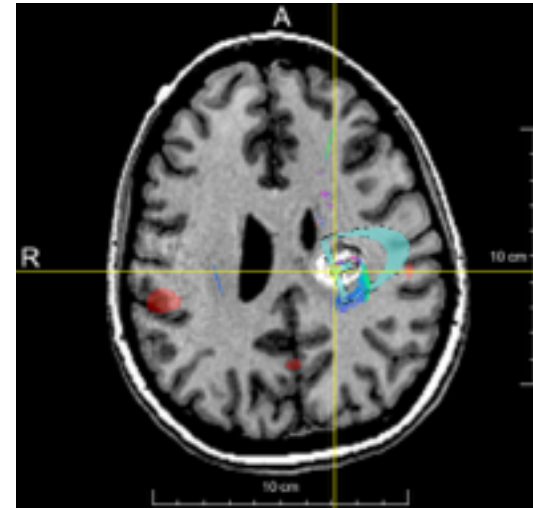
System: LiveRAC

- semantic zoom
 - alternative to geometric zoom
 - resolution-aware layout adapts to available space
 - goal: legible at multiple scales
 - dramatic or subtle effects
- visual encoding change
 - colored box
 - sparkline
 - simple line chart
 - full chart: axes and tickmarks



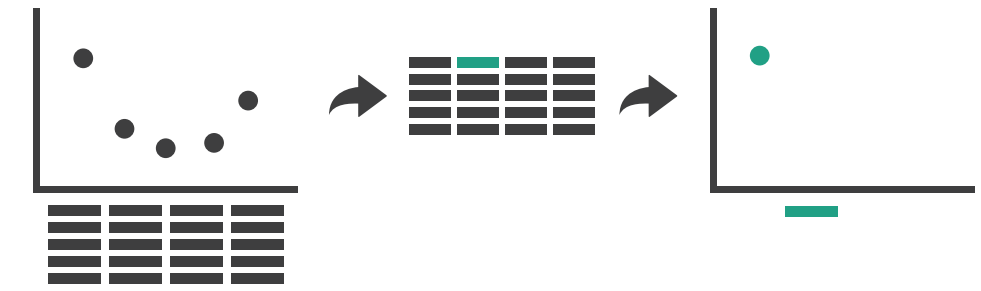
Navigate: Reducing attributes

- 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 (eliminate 3rd dimension)
 - perspective (foreshortening captures limited 3D information)

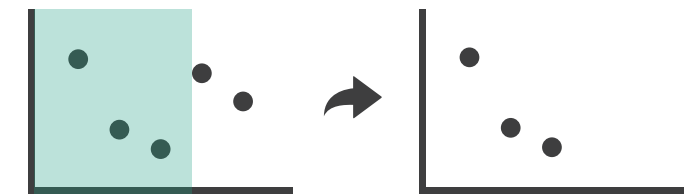


→ Attribute Reduction

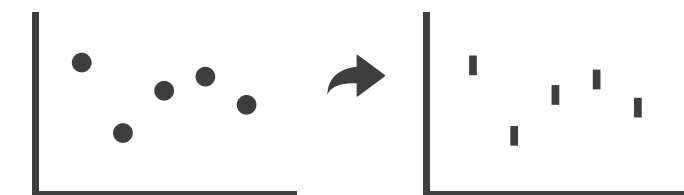
→ *Slice*



→ *Cut*

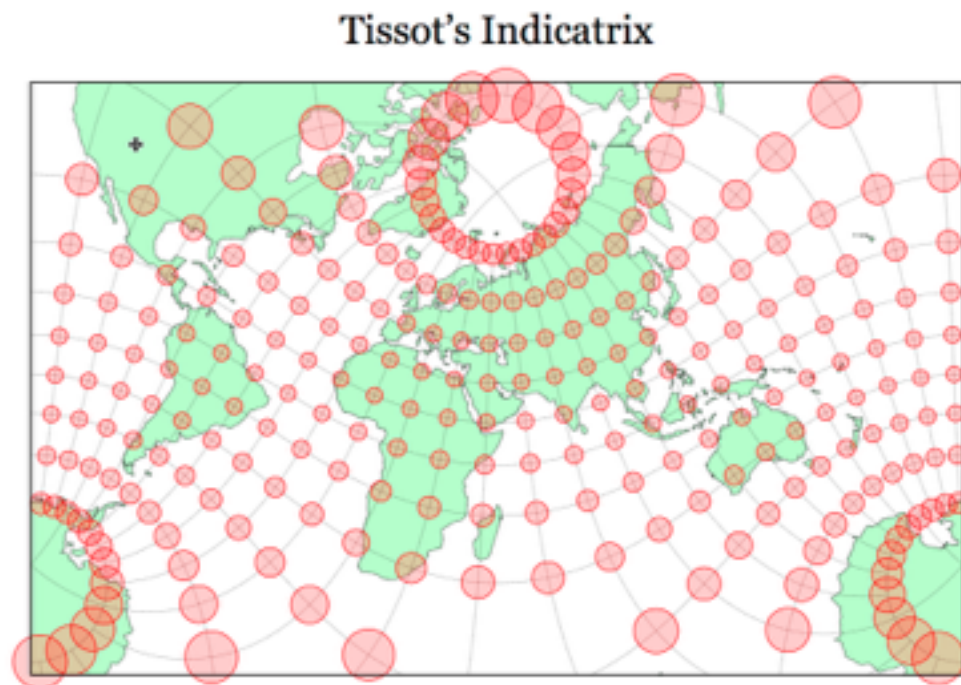


→ *Project*

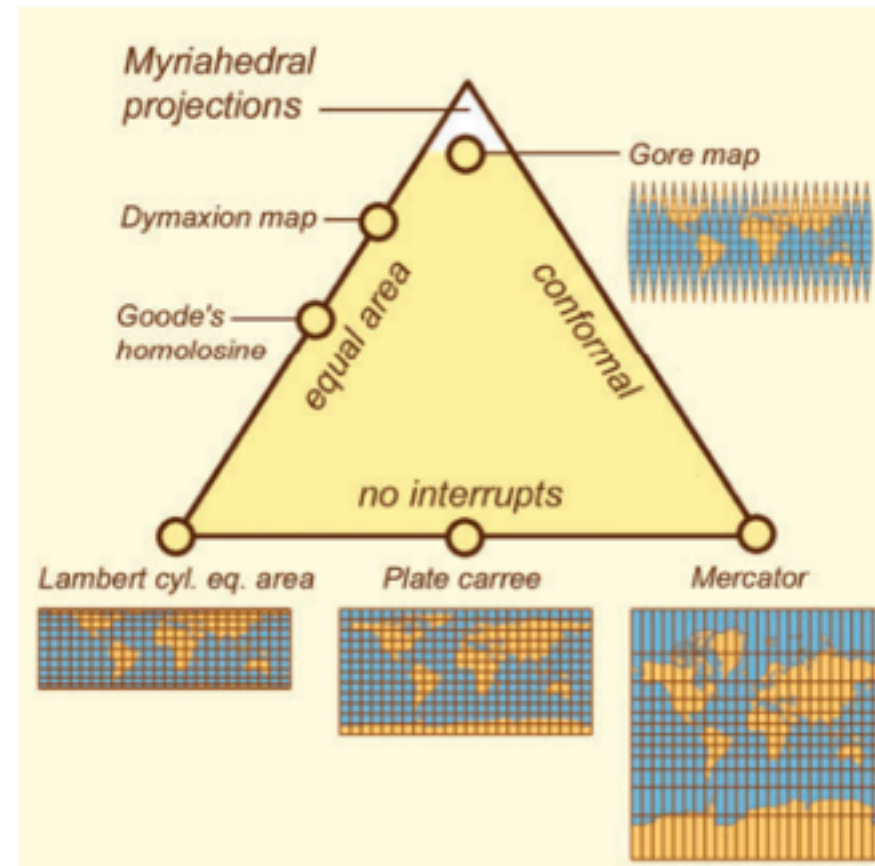


Navigate: Cartographic projections

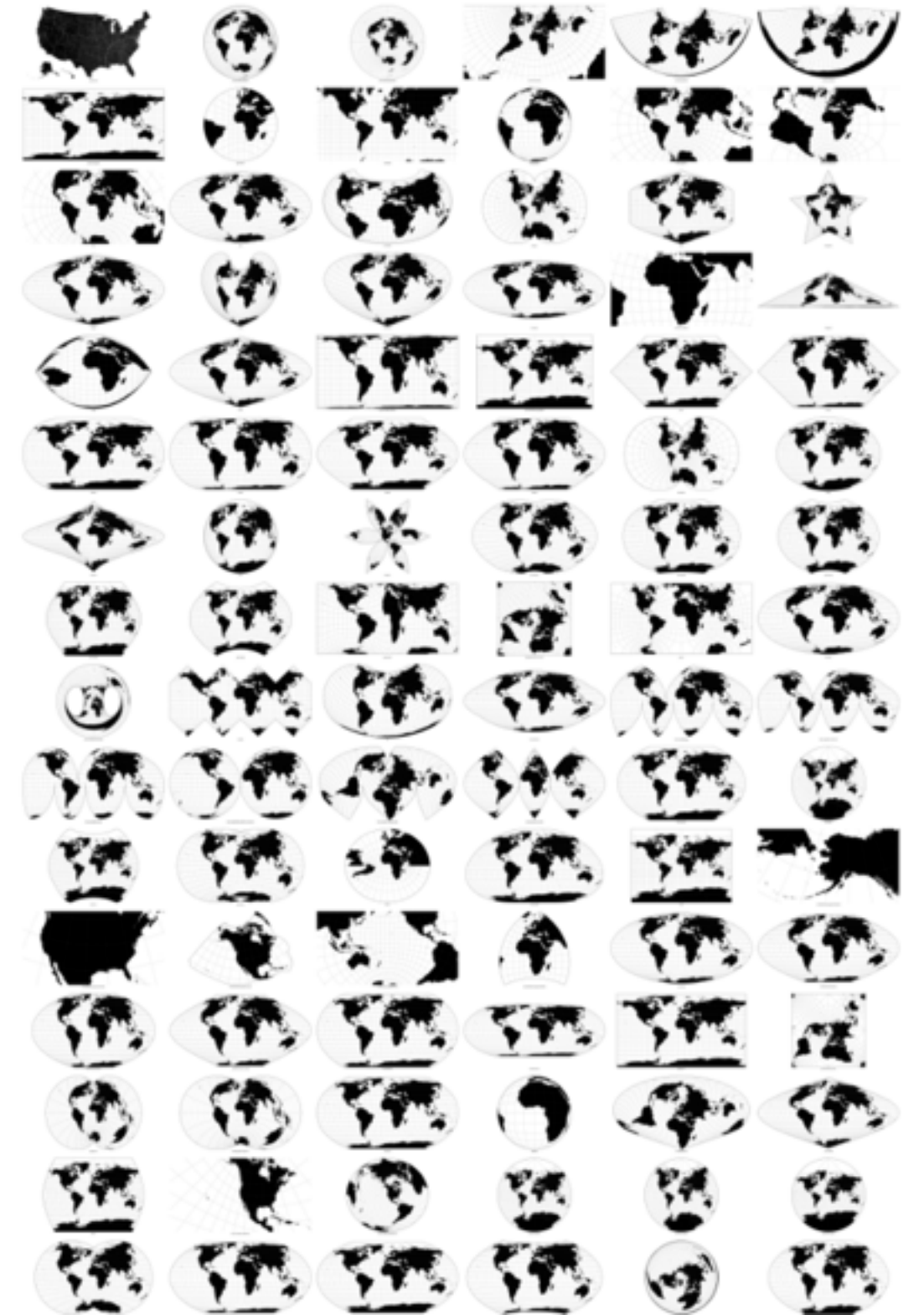
- project from 2D sphere surface to 2D plane
 - can only fully preserve 2 out of 3
 - angles: conformal
 - area: equal area
 - contiguity: no interruptions



<https://www.jasondavies.com/maps/tissot/>



<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.