

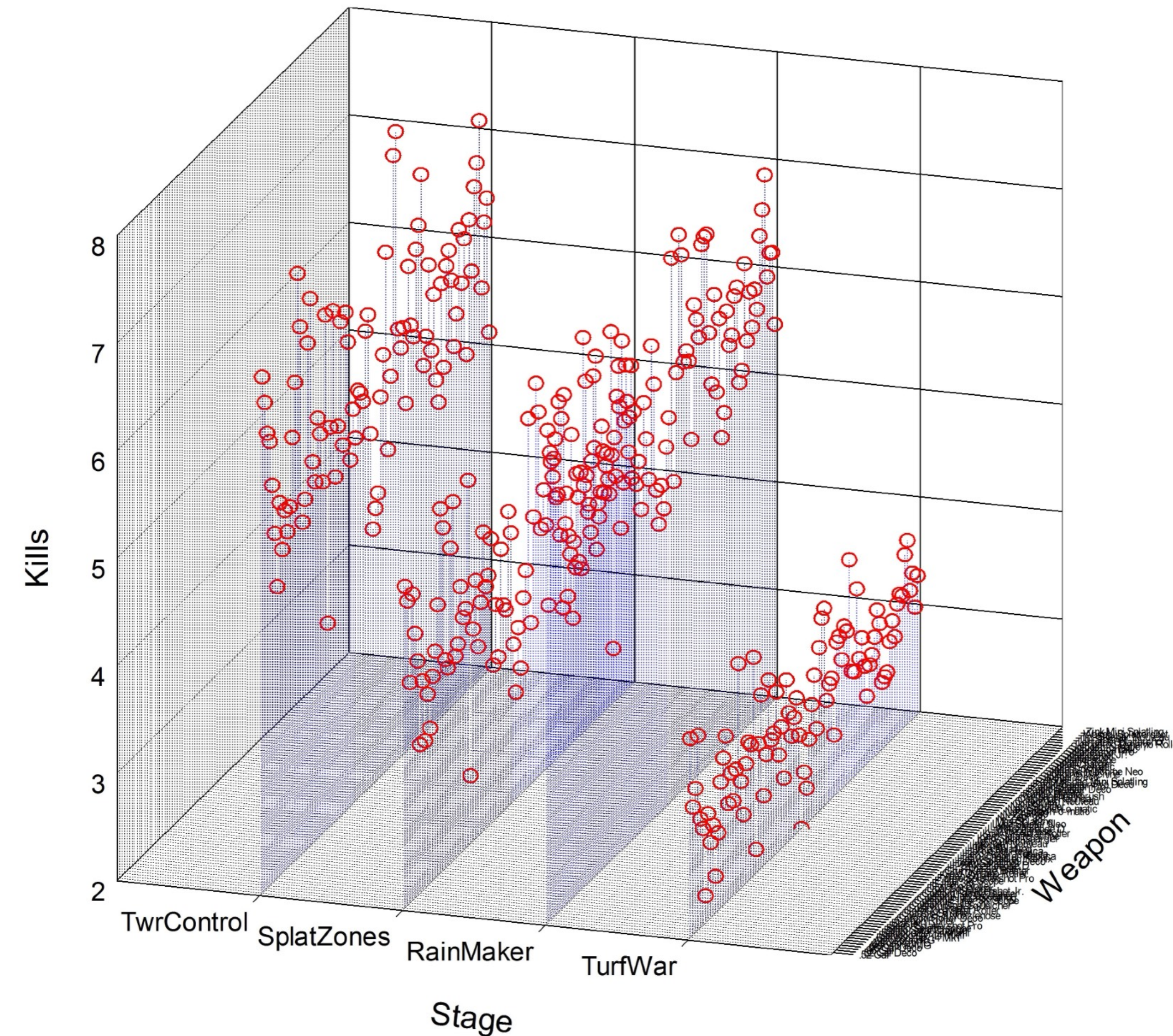
Data Visualization (CSCI 627/490)

Interaction

Dr. David Koop

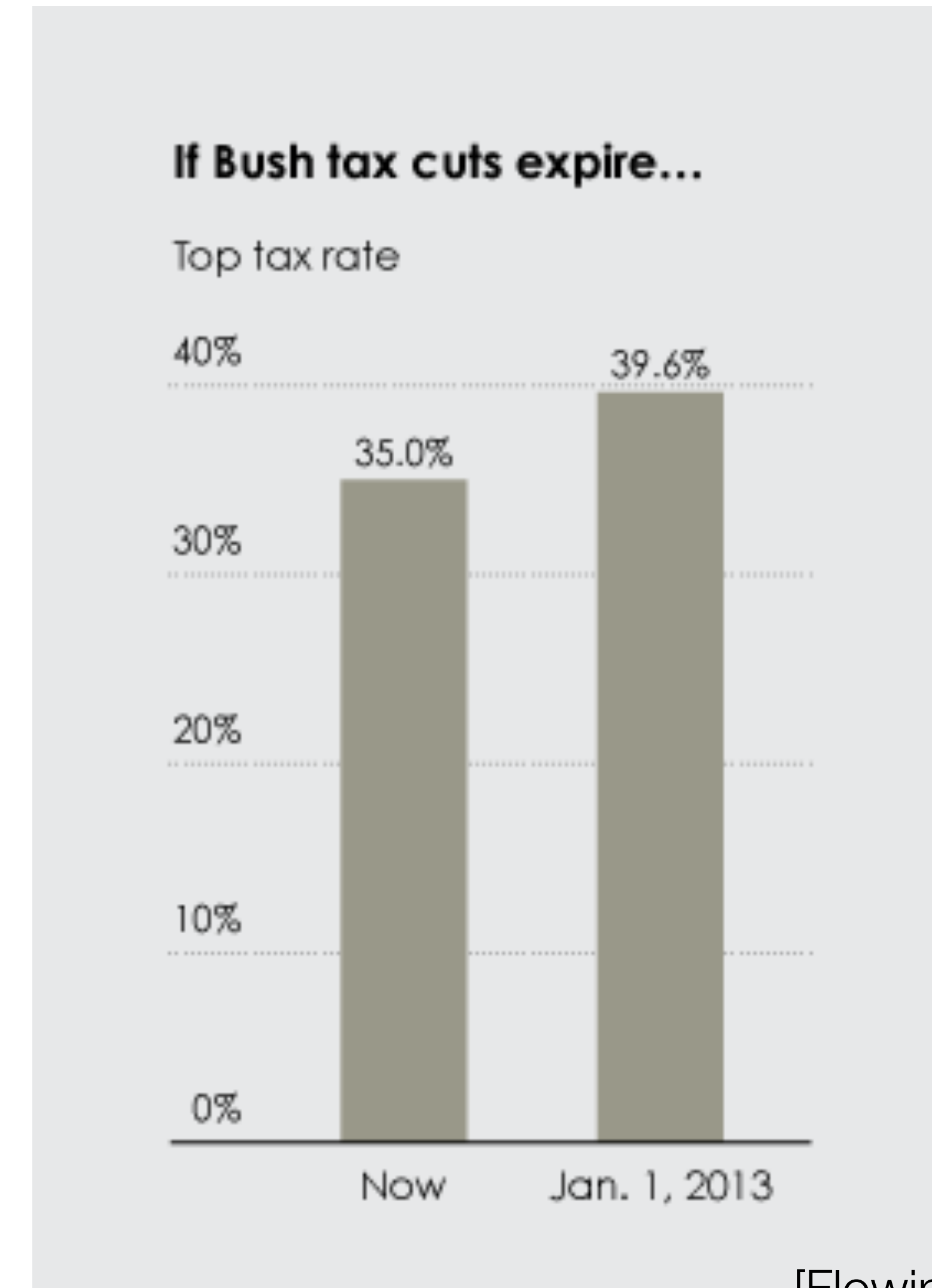
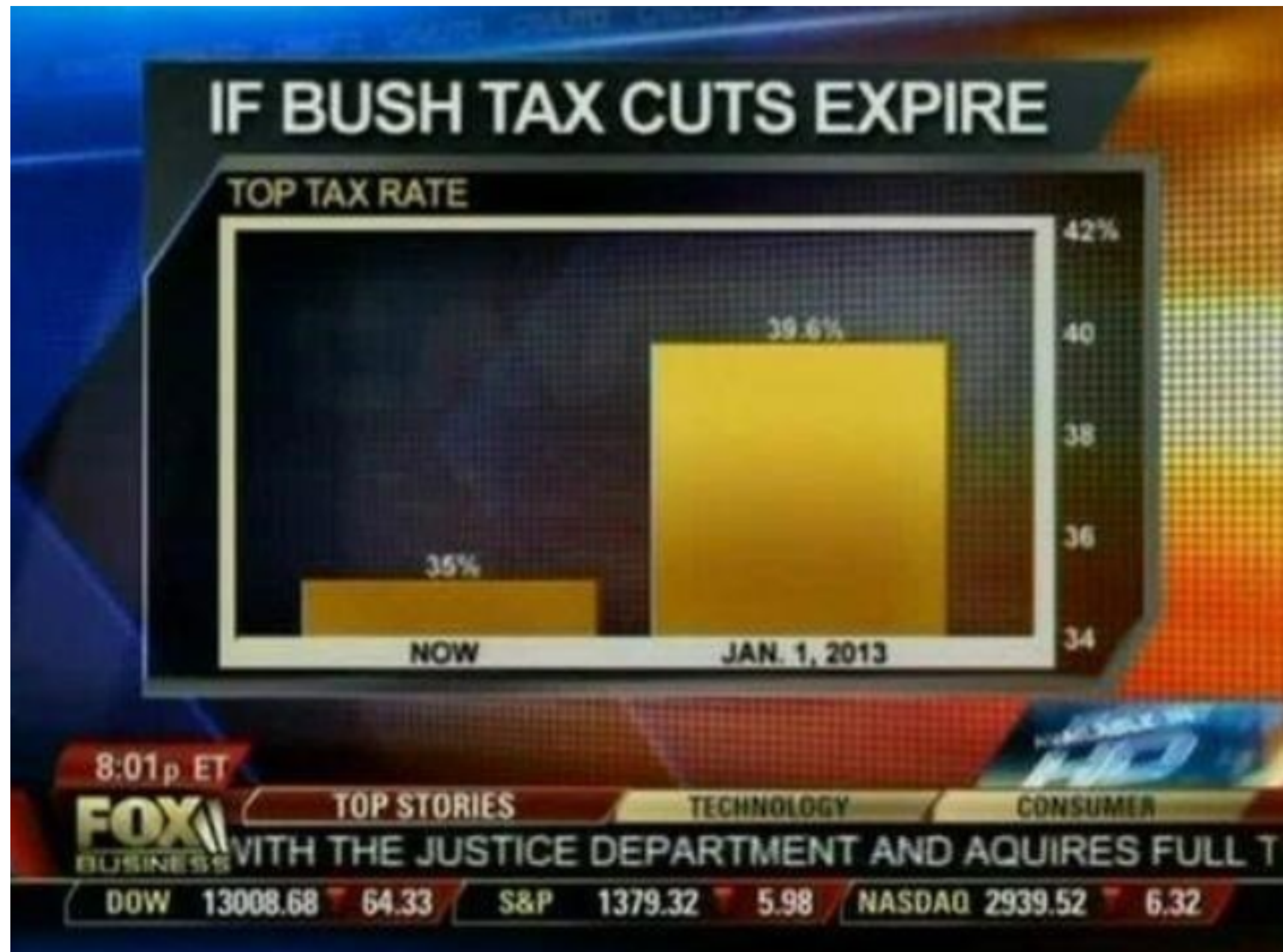
What is wrong with here and how can it be fixed?

3D Category Scatter



[WTF Visualizations, 2017]

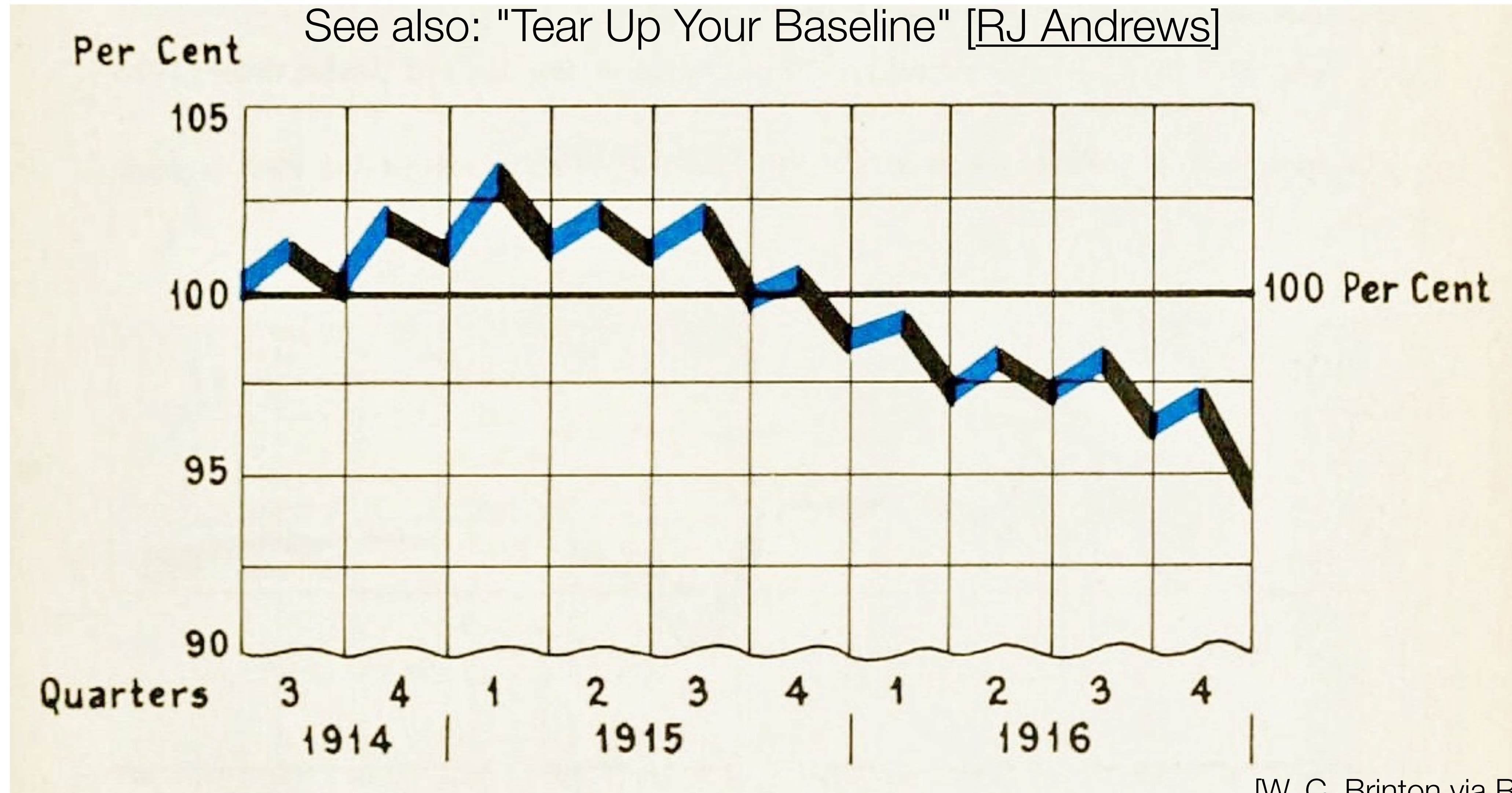
Good: Data magnitude $\Leftarrow \Rightarrow$ Mark magnitude



[Flowing Data, 2012]

Show when the baseline is not zero

See also: "Tear Up Your Baseline" [[RJ Andrews](#)]

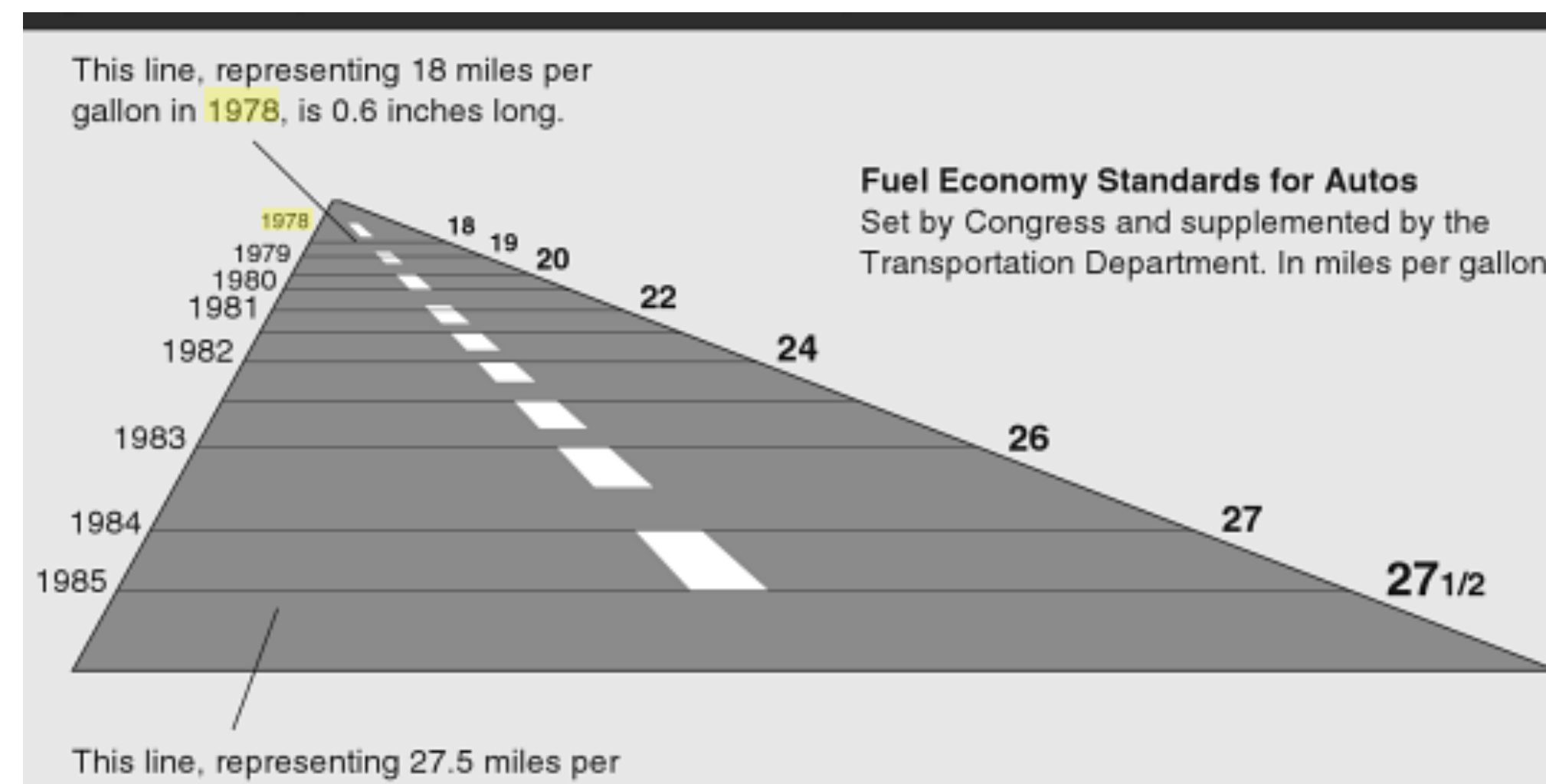


[W. C. Brinton via [RJ Andrews](#)]

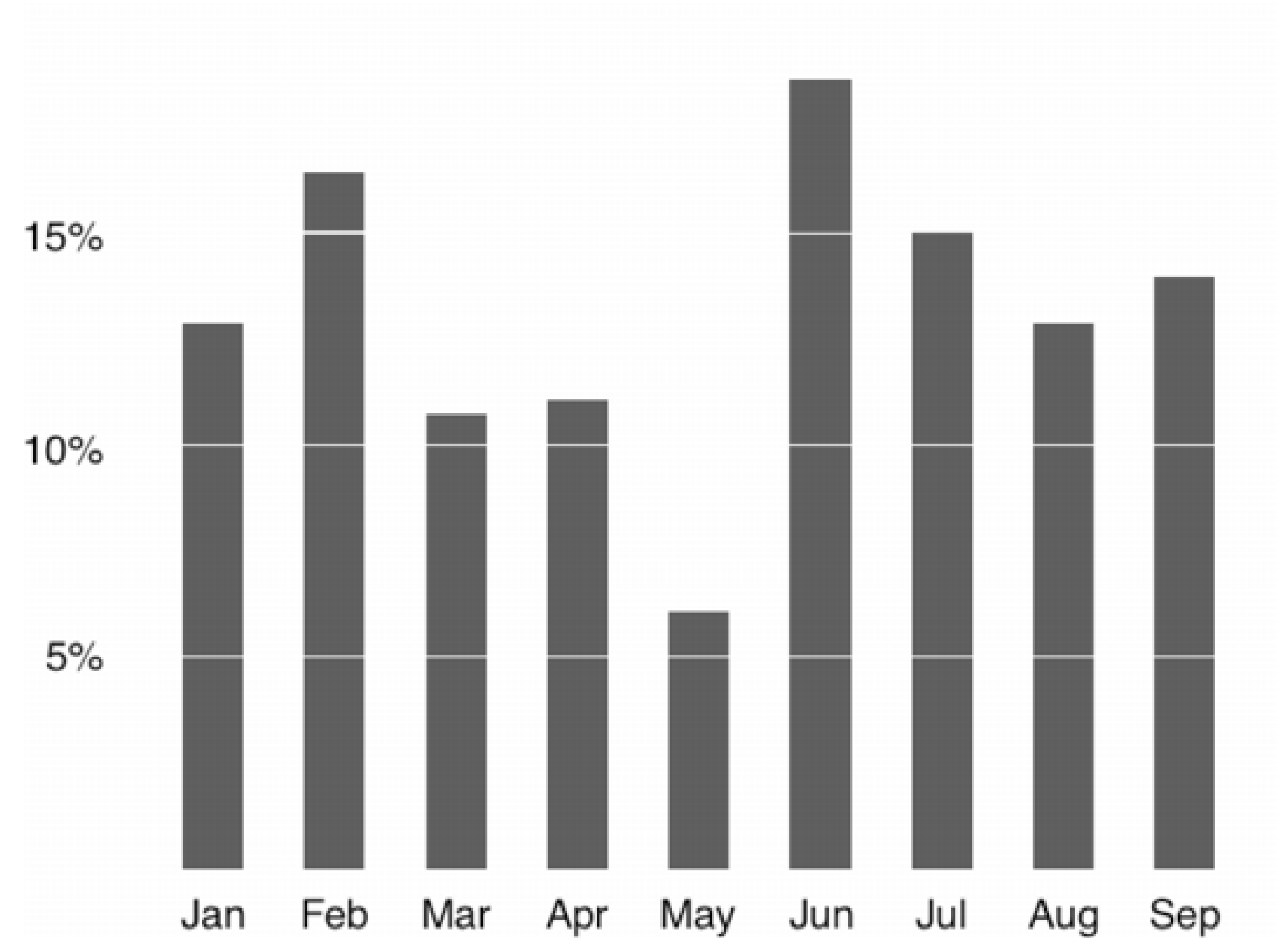
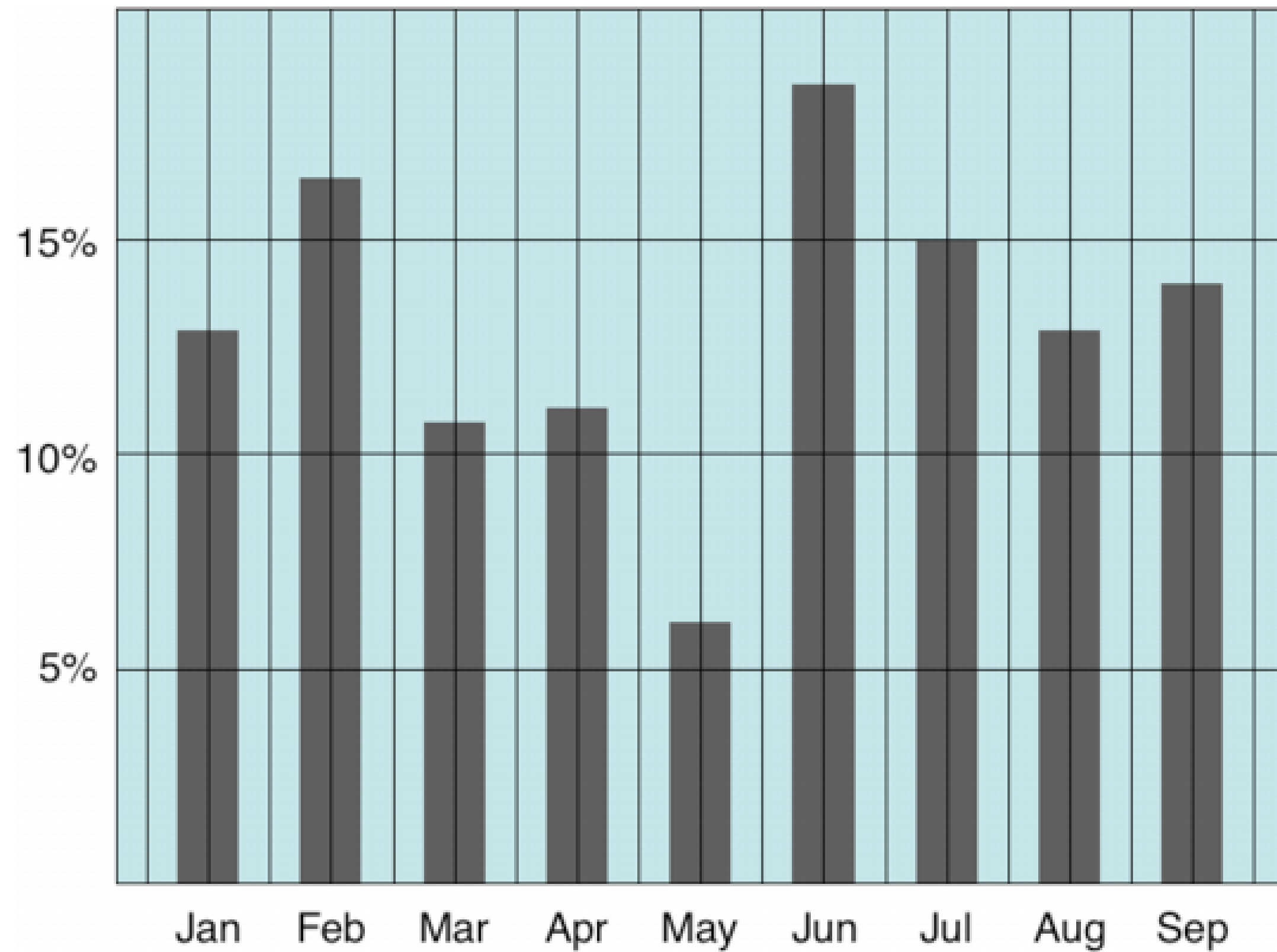
Tufte's Lie Factor

- Size of effect = (2nd value - 1st value) / (1st value)
- Lie factor = (size of effect in graphic) / (size of effect in data)
- In the graphic:

$$\text{Lie Factor} = \frac{\frac{5.3 - 0.6}{0.6}}{\frac{27.5 - 18}{18}} = 14.8$$



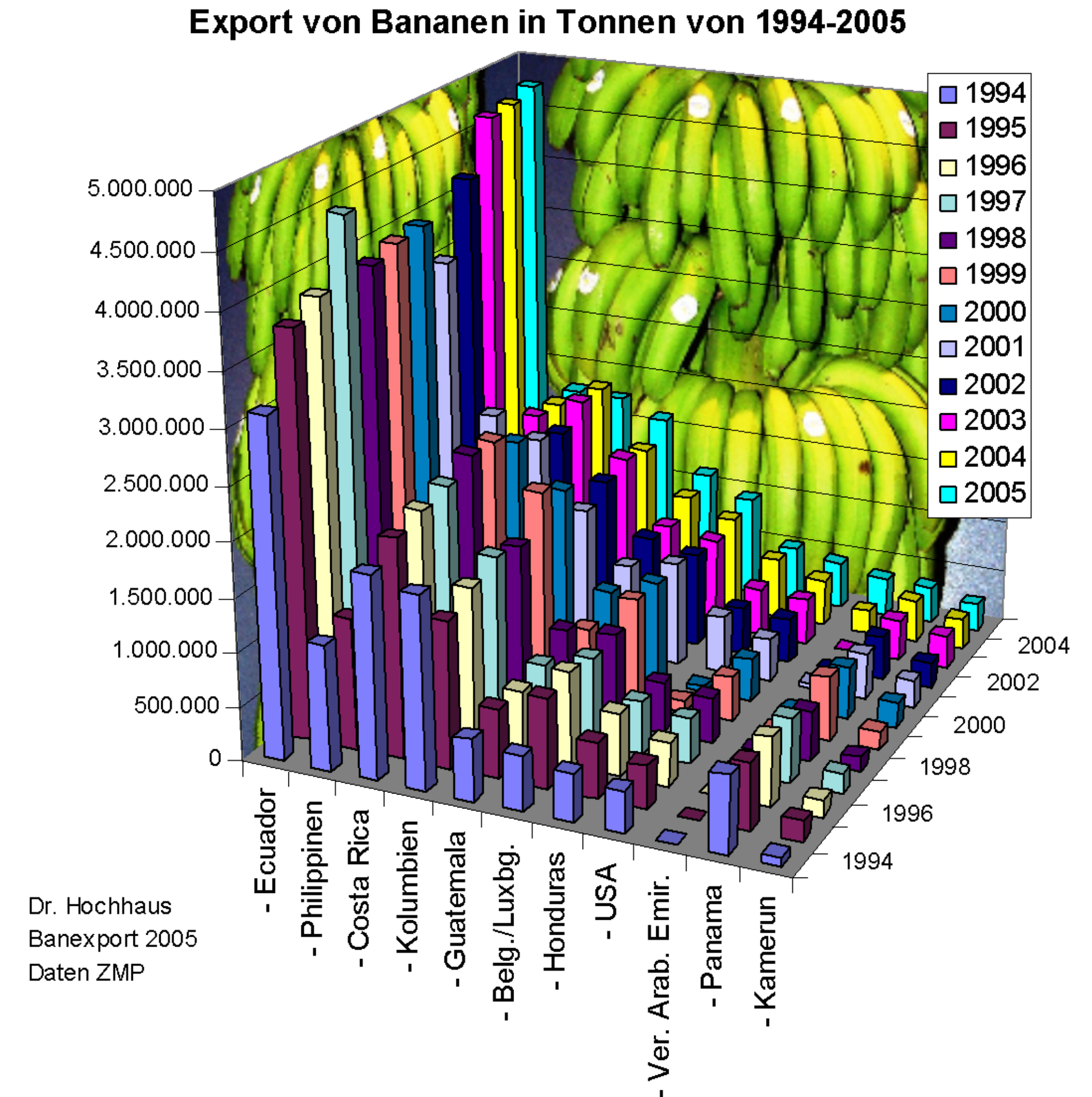
Avoid Chartjunk



[T. Brey via [A. Lex](#)]

No Unjustified 3D

- Occlusion hides information
- Perspective distortion dangers
- Tilted text isn't legible
- Can **help** with shape perception



Validation at each level

❗ **Threat** Wrong problem

☑ **Validate** Observe and interview target users

❗ **Threat** Wrong task/data abstraction

❗ **Threat** Ineffective encoding/interaction idiom

☑ **Validate** Justify encoding/interaction design

❗ **Threat** Slow algorithm

☑ **Validate** Analyze computational complexity

Implement system

☑ **Validate** Measure system time/memory

☑ **Validate** Qualitative/quantitative result image analysis

Test on any users, informal usability study

☑ **Validate** Lab study, measure human time/errors for task

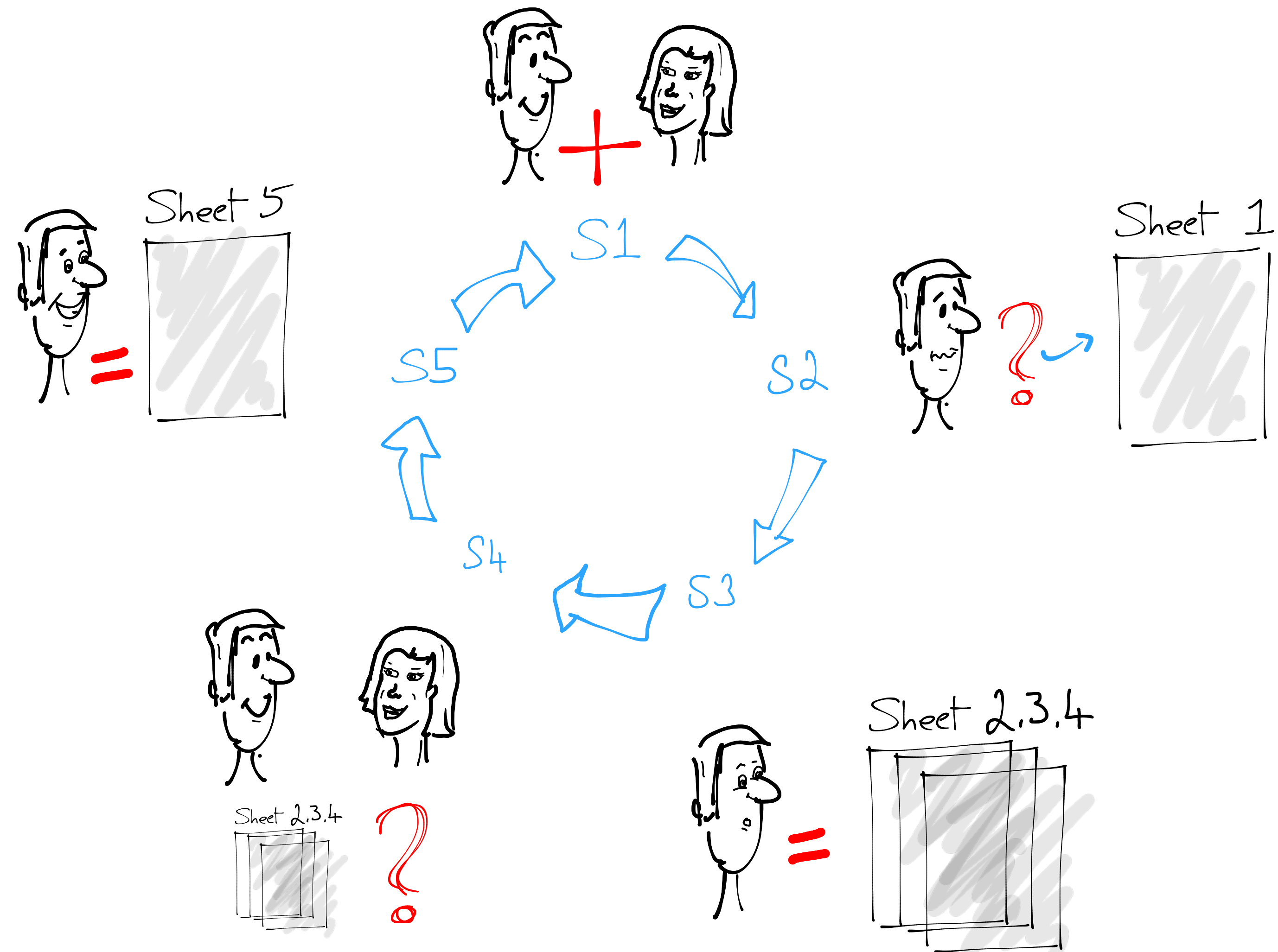
☑ **Validate** Test on target users, collect anecdotal evidence of utility

☑ **Validate** Field study, document human usage of deployed system

☑ **Validate** Observe adoption rates

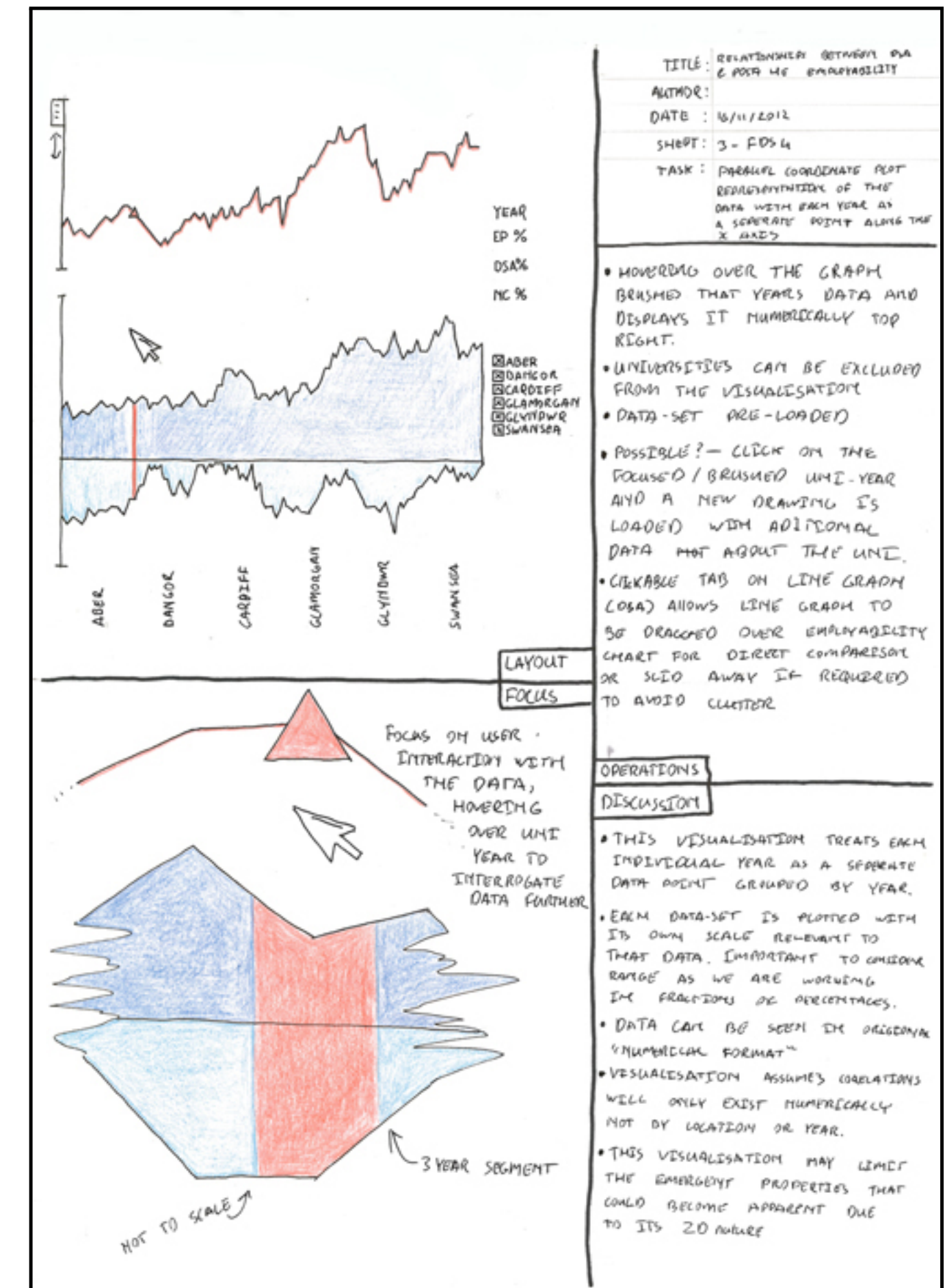
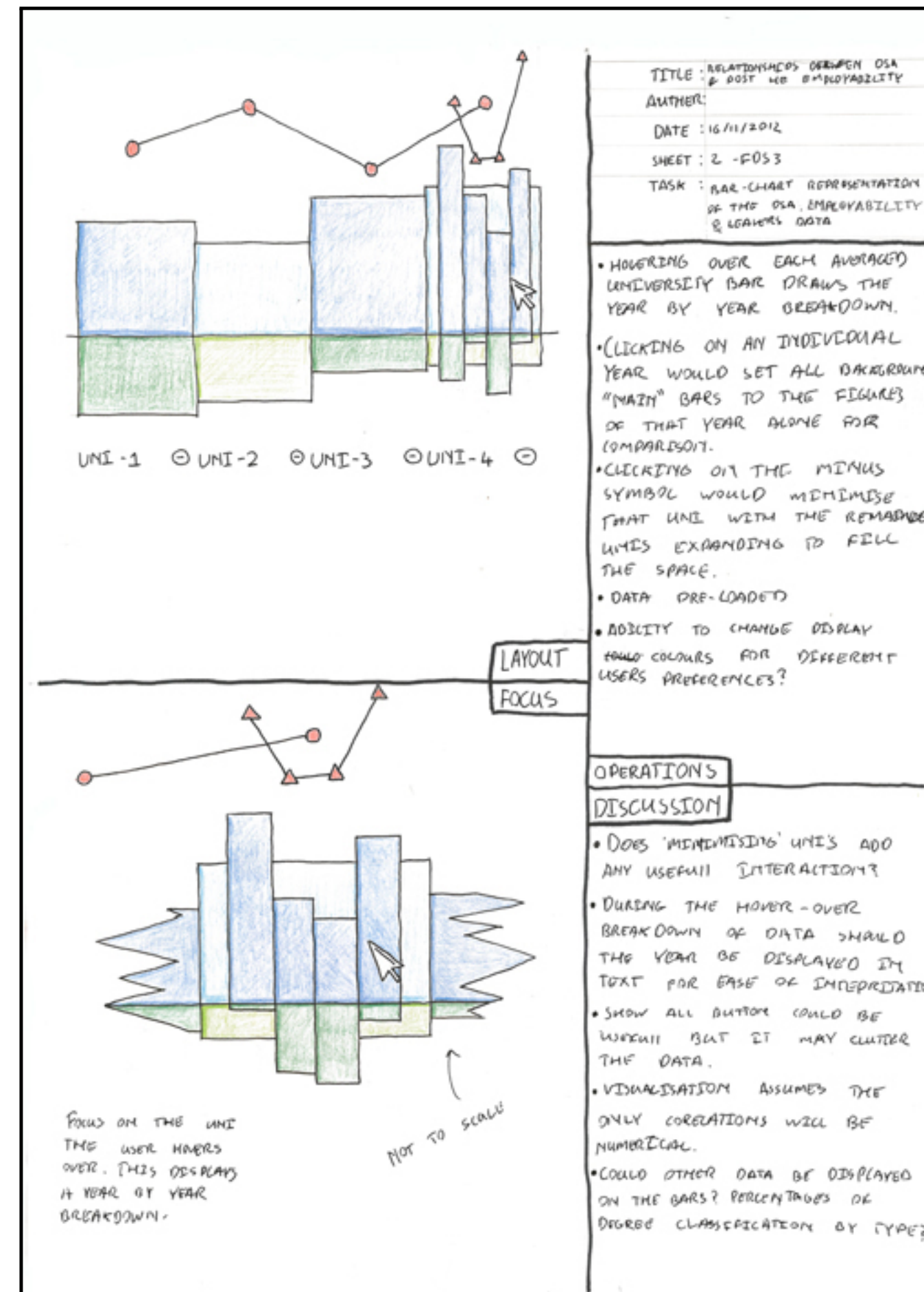
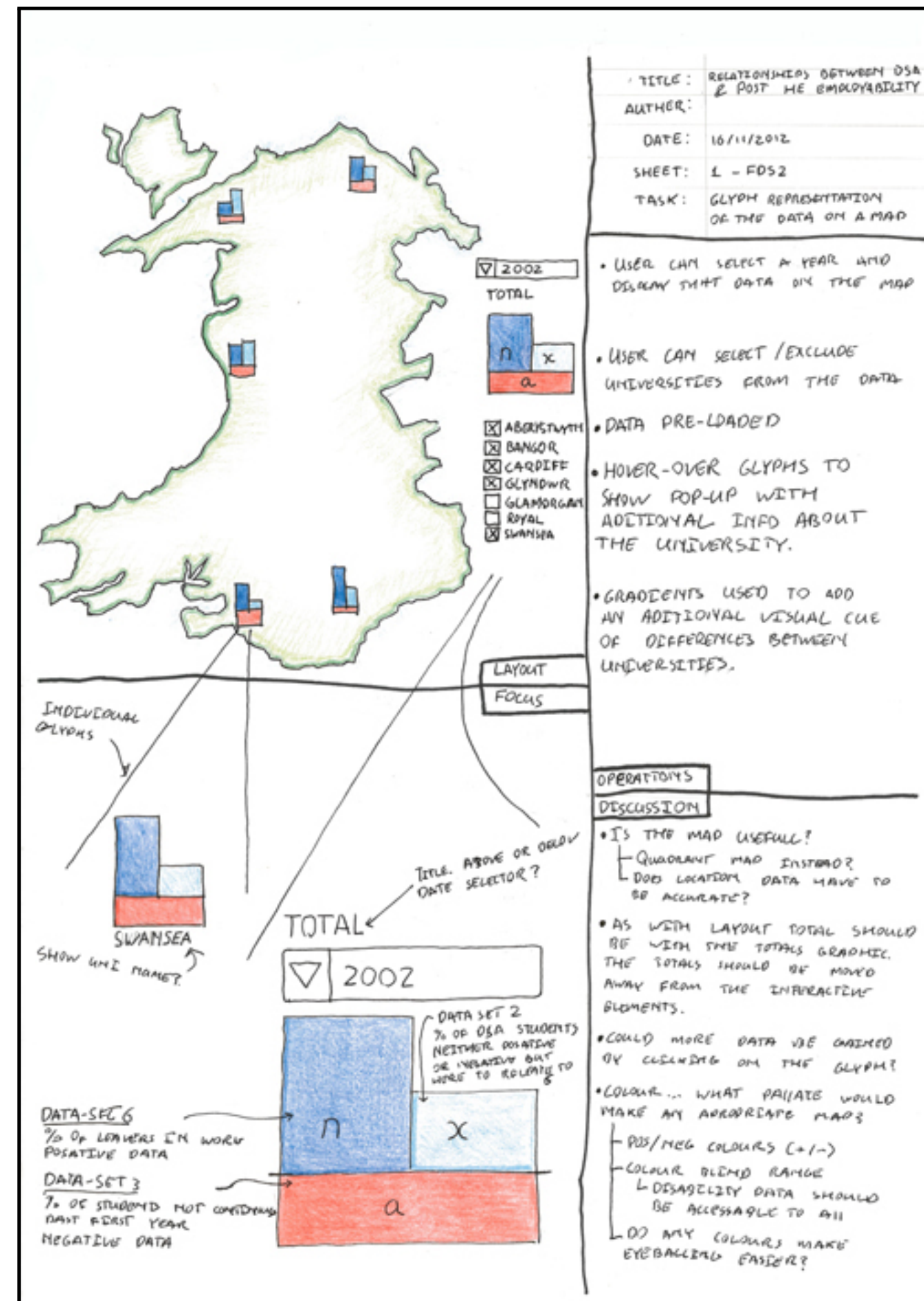
[Munzner, 2014]

Five Design Sheet Method



[J. Roberts et al., 2016]

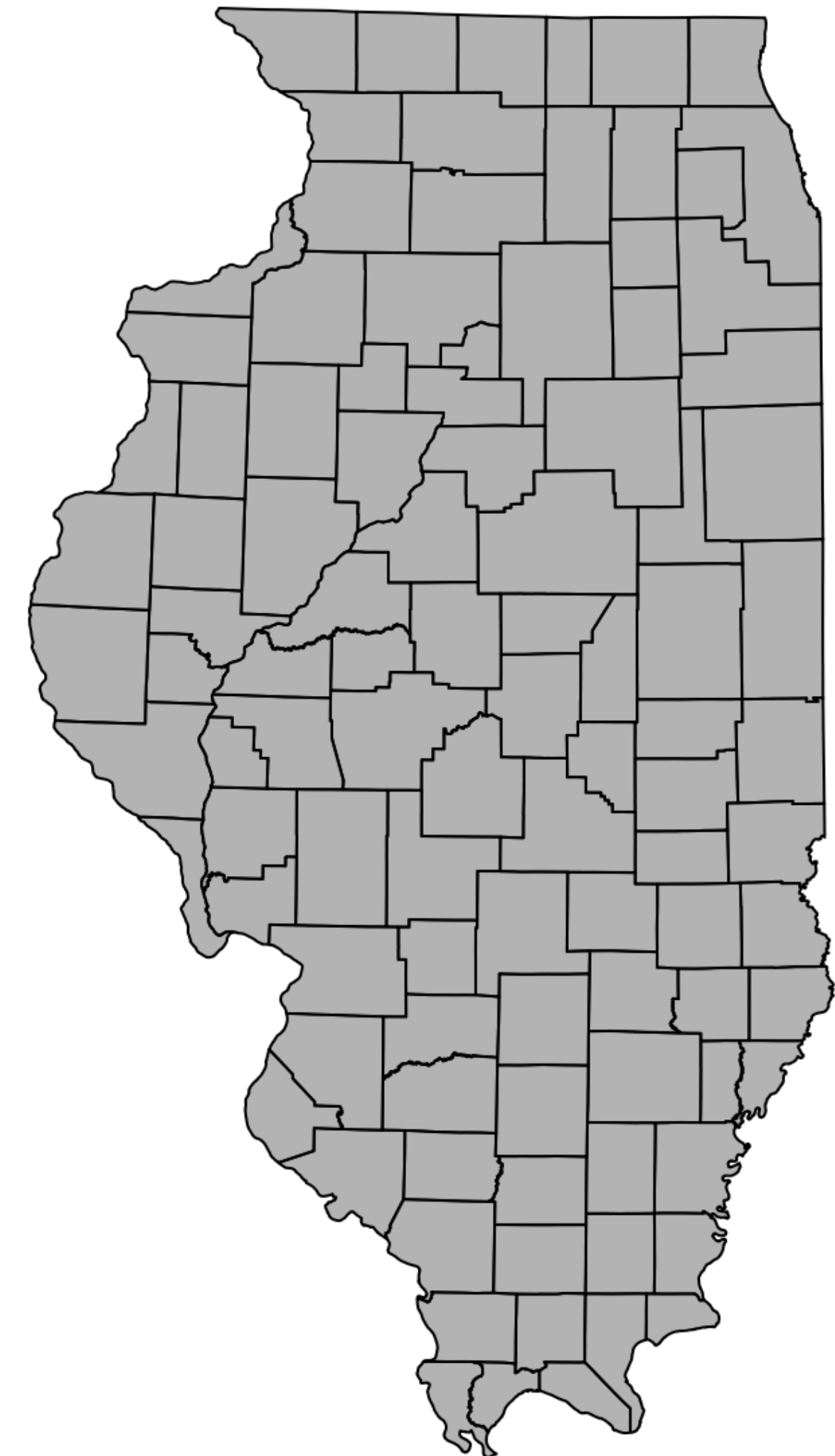
Sheets 2-4



[J. Roberts et al., 2016]

Assignment 4

- Maps, colormaps, and treemaps
- Due this week
- Colormapping courselet available



Project Designs

- Designs:
 - **Be creative!**
 - Tasks should drive your design
- Turn in:
 - Three Designs Sketches
 - One Bad Design
 - Progress on Implementation
- Due Wednesday, April 9

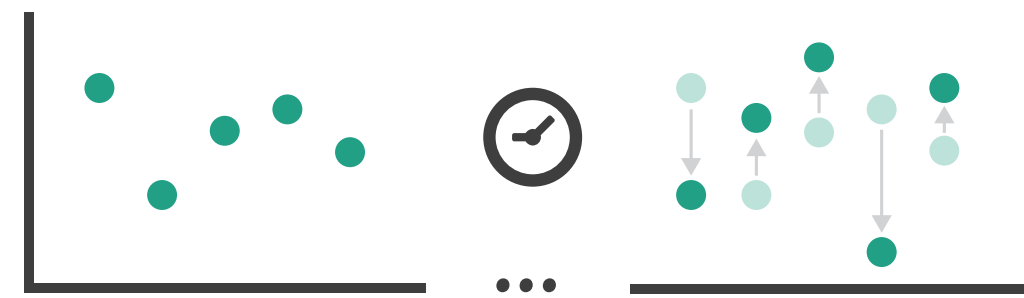
Guidelines for Interaction Design

Interaction

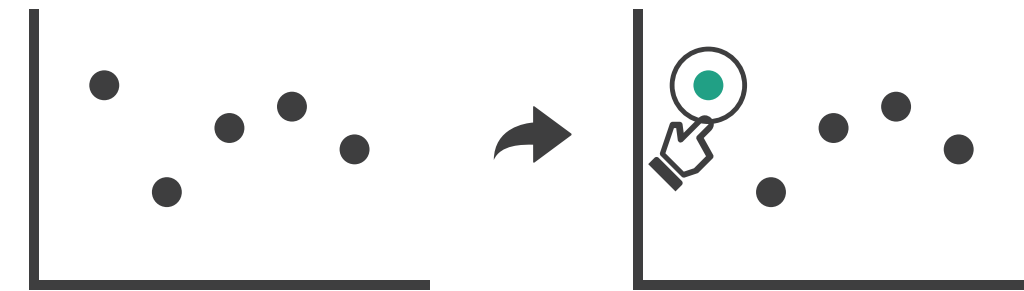
- The view changes over time
- Changes can affect almost any aspect of the visualization
 - encoding
 - arrangement
 - ordering
 - viewpoint
 - attributes being shown
 - aggregation level

Interaction Overview

➔ Change over Time



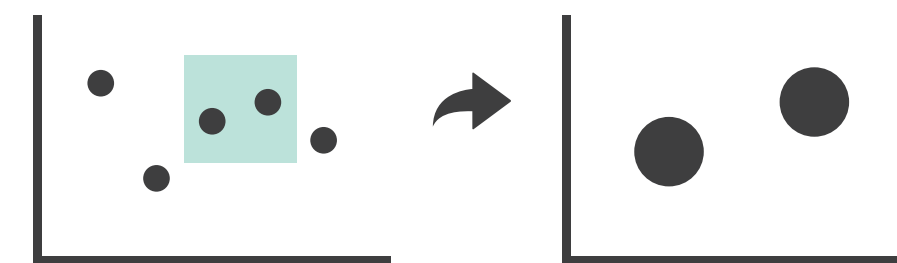
➔ Select



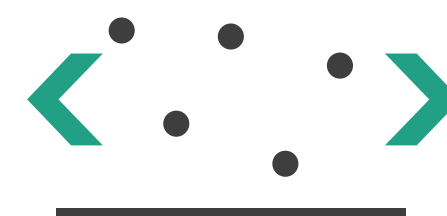
➔ Navigate

➔ Item Reduction

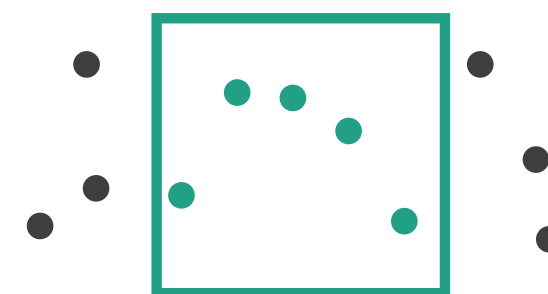
➔ Zoom
Geometric or *Semantic*



➔ Pan/Translate

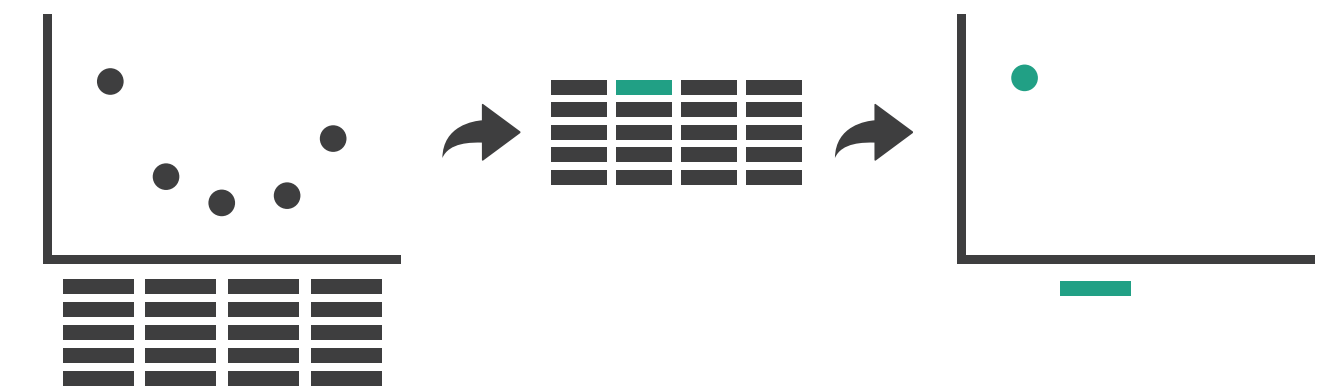


➔ Constrained

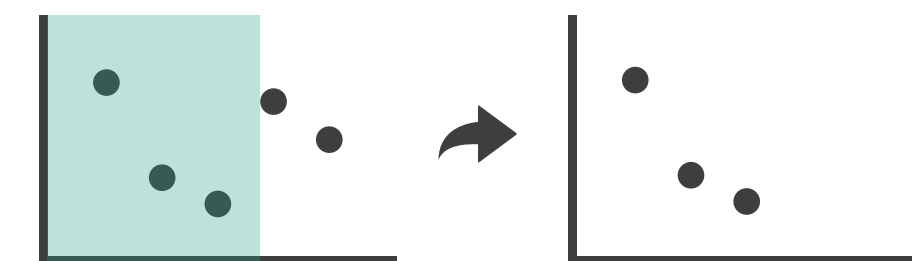


➔ Attribute Reduction

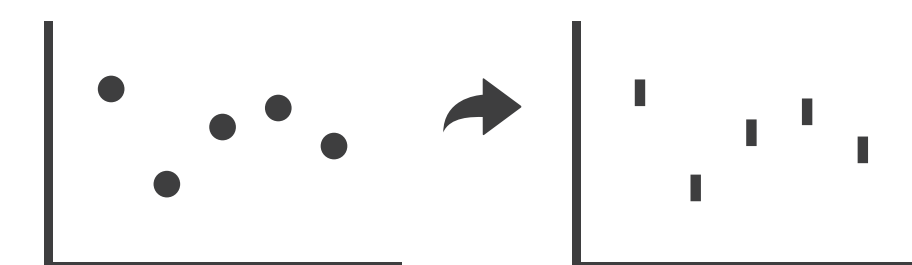
➔ Slice



➔ Cut



➔ Project

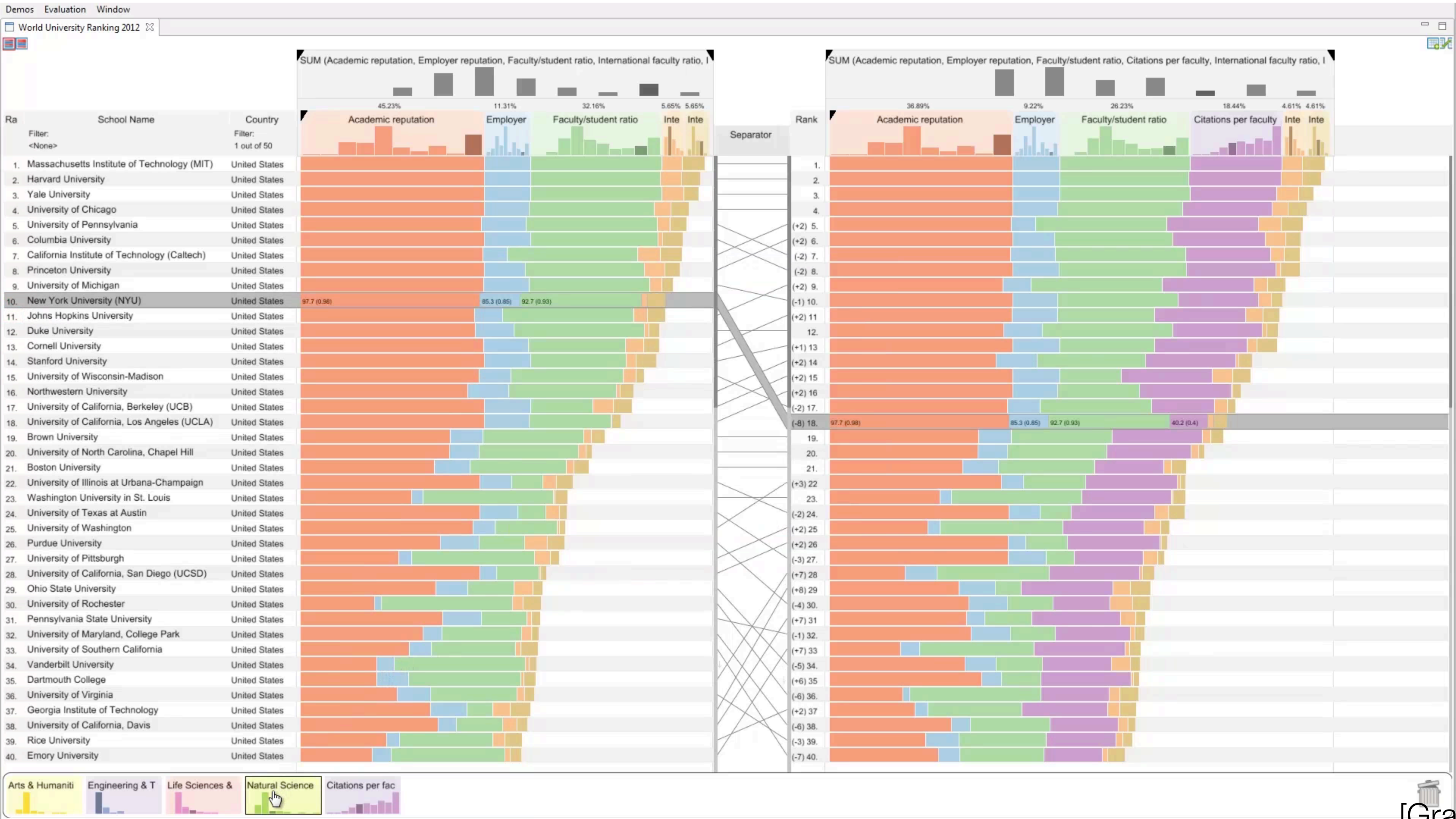


[Munzner (ill. Maguire), 2014]

Sorting

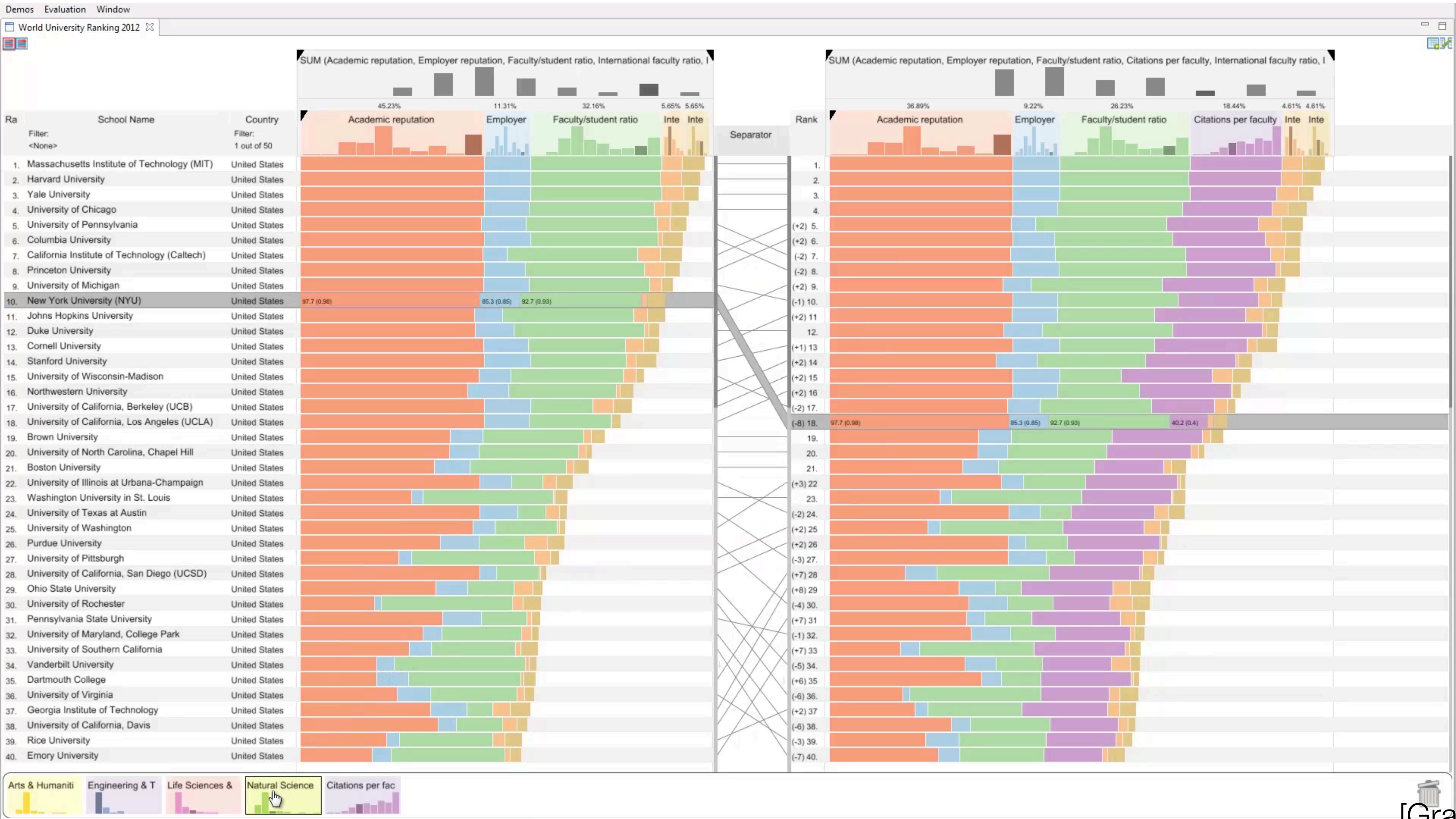
- Allow user to find patterns by reordering the data
- Do this with tabular data all the time
- Note that categorical attributes don't really need sorting
 - We can compare these attributes no matter what order
 - Instead, sort categorical attribute based on an ordered attribute

Example: LineUp



[Gratzl et al., 2013]

Example: LineUp



[Gratzl et al., 2013]

Slope Graphs

- Connection marks
- Link the same item appearing in different rows
- Show changes for different attributes (parallel coordinates idea) but with one highlighted item
- Also called bump charts

Animation: Jump Cut vs. Animated Transitions

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Side-by-side views

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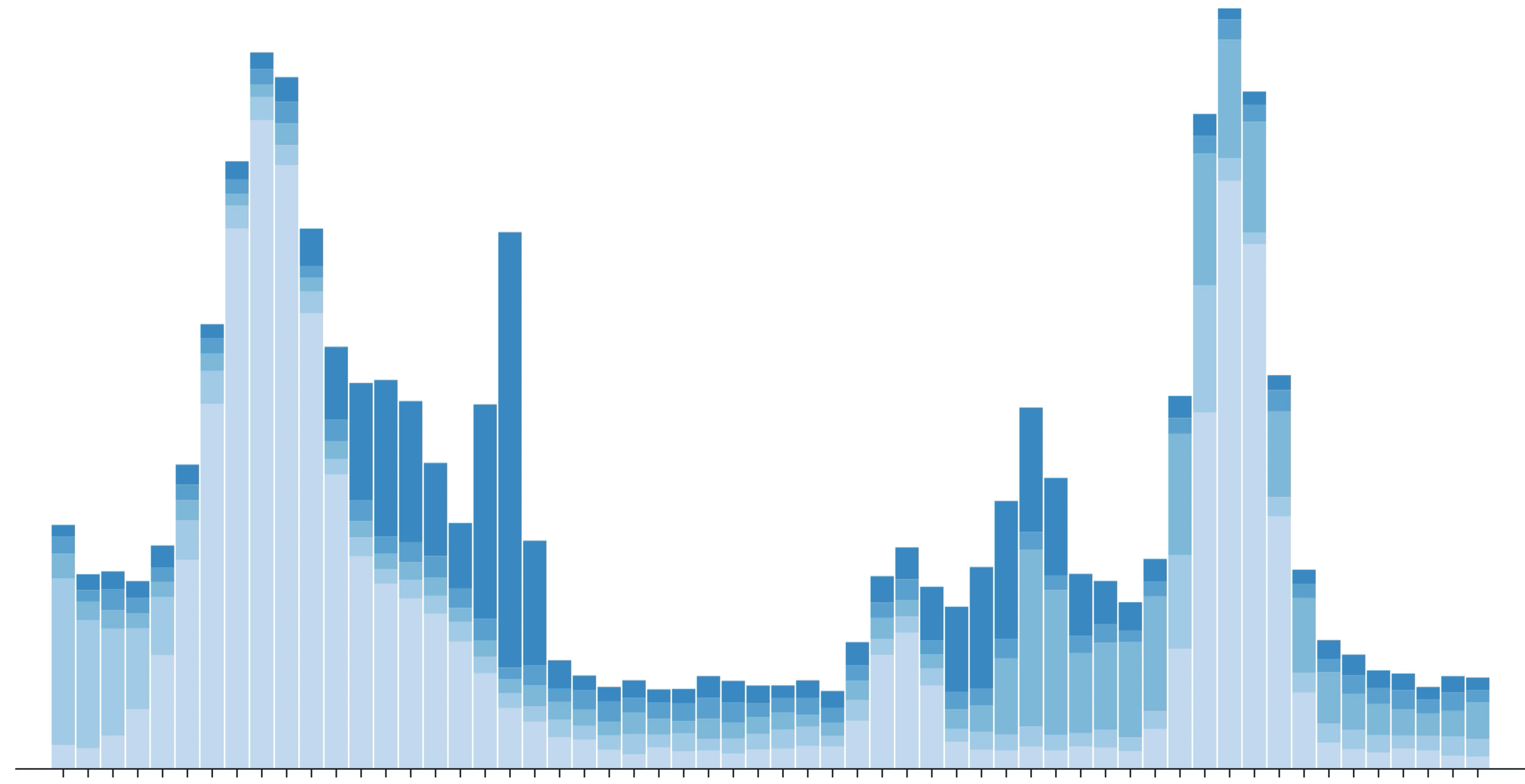
Side-by-side views

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Animated Transitions

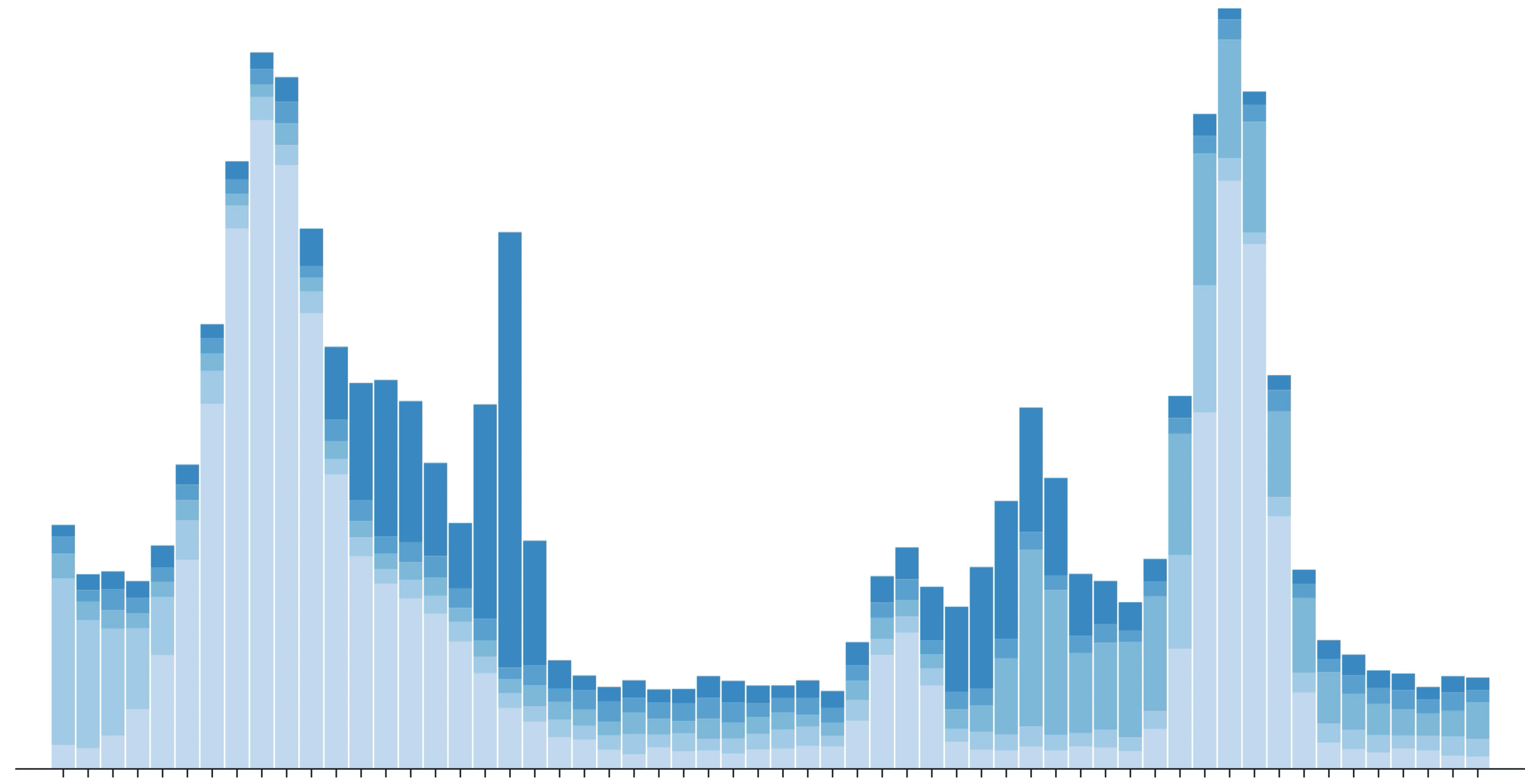
☐ Stacked ☒ Grouped



[M. Bostock]

Animated Transitions

☐ Stacked ☒ Grouped

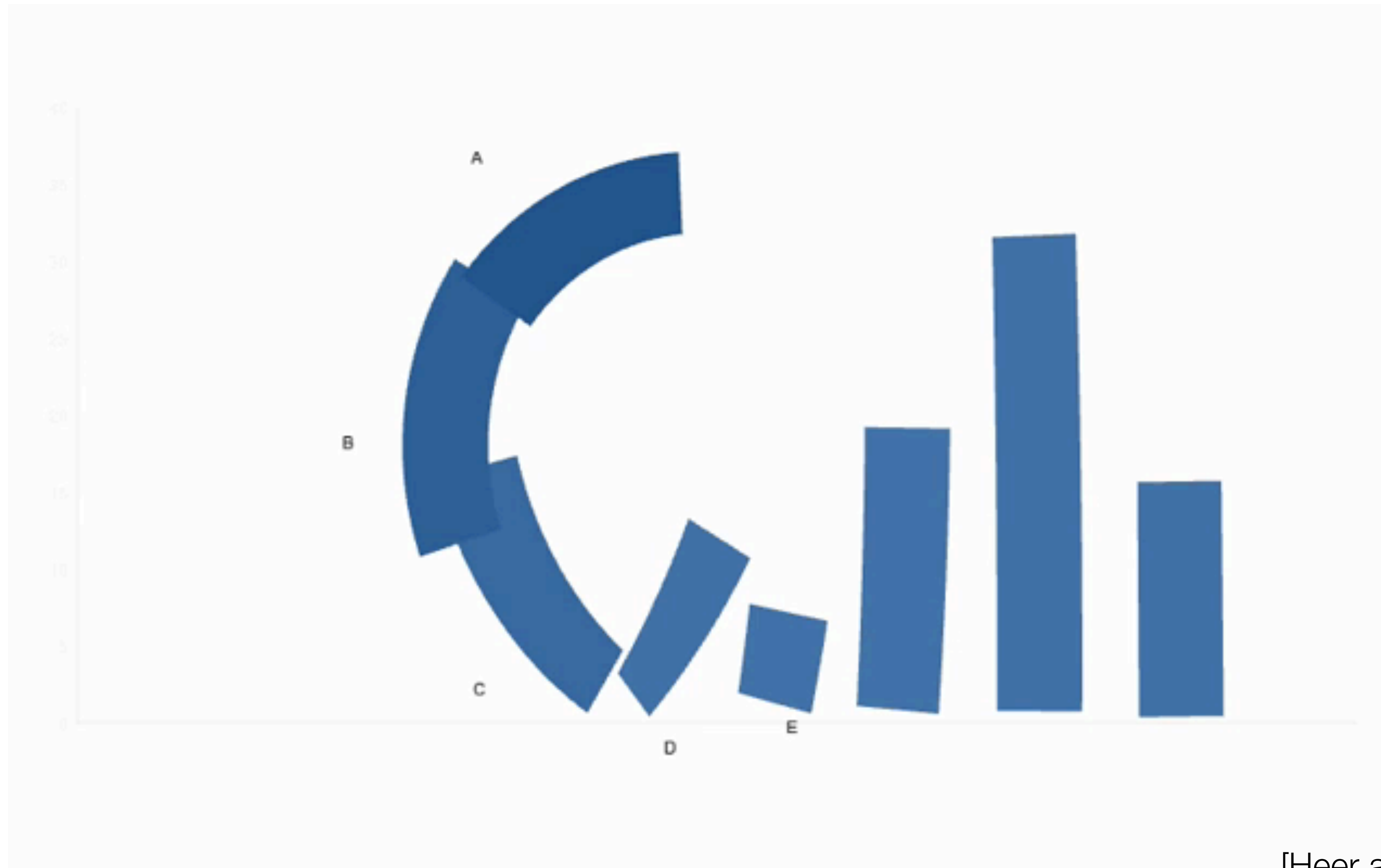


[M. Bostock]

Animated Transitions

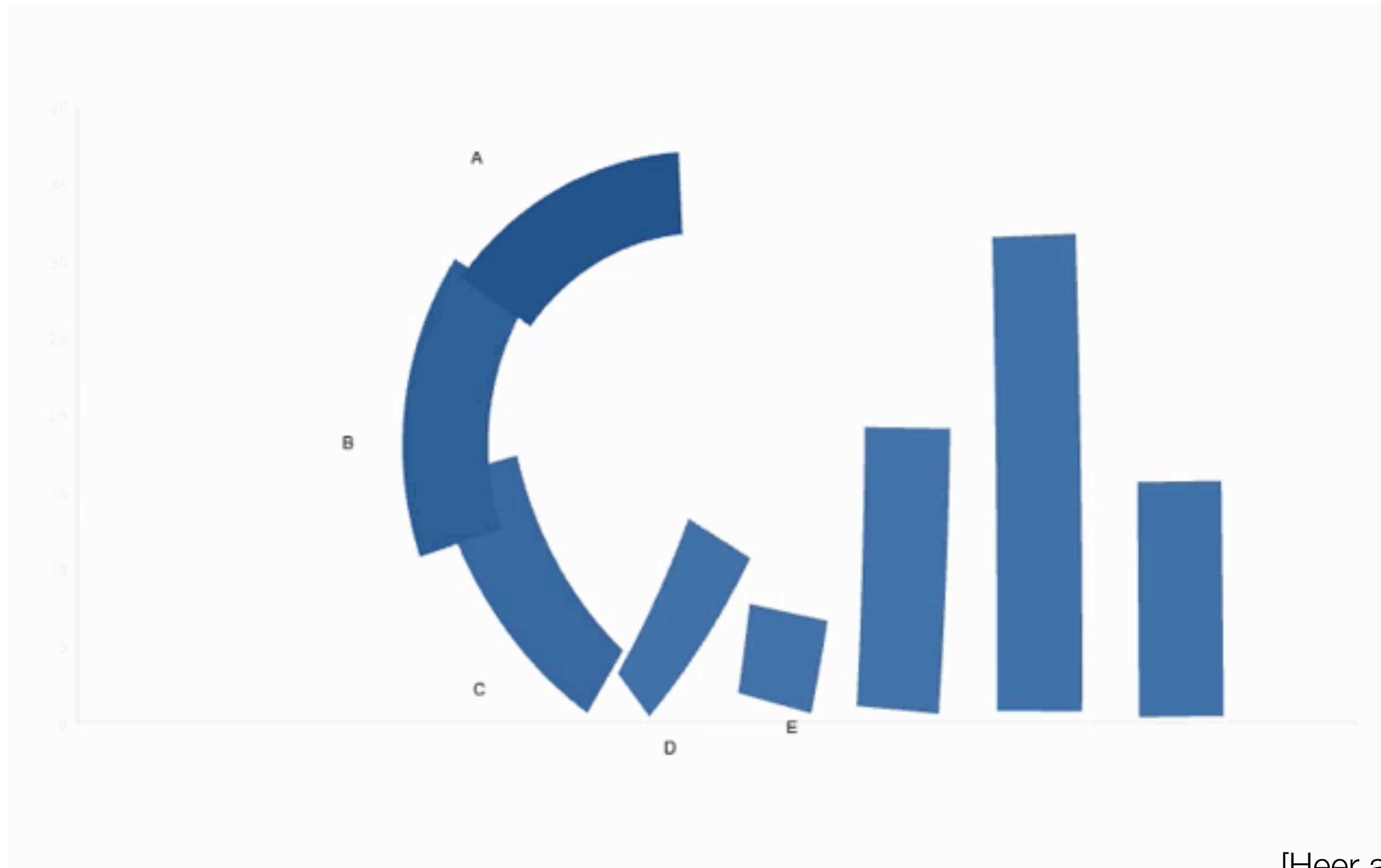
- "Jump cuts" are hard to follow
- Animations help users maintain sense of context between two states
- Empirical study showed that they work (Heer & Robertson, 2007)

Studying Animated Transitions



[Heer and Robertson, 2007]

Studying Animated Transitions



[Heer and Robertson, 2007]

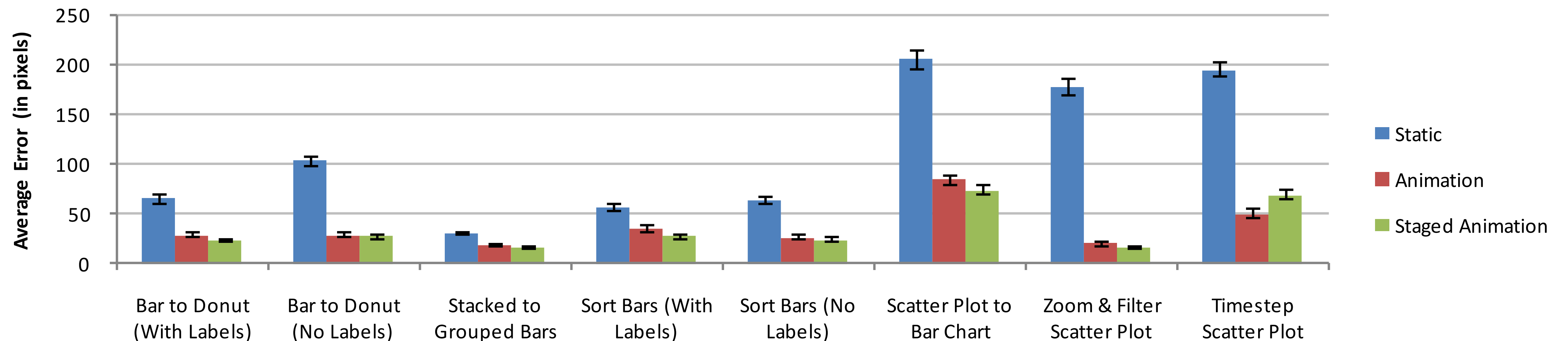
Design Considerations

- Based on Tversky et al.'s Congruence and Apprehension Principles
- Congruence (Expressiveness):
 - Use consistent semantic-syntactic mappings
 - Respect semantic correspondence
 - Avoid ambiguity
- Apprehension (Effectiveness):
 - Group similar transitions
 - Minimize occlusion
 - Maximize predictability
 - Use simple transitions
 - Use staging for complex transitions
 - Transitions as long as needed, but no longer

[Heer and Robertson, 2007]

Experiment 1 (Syntactic)

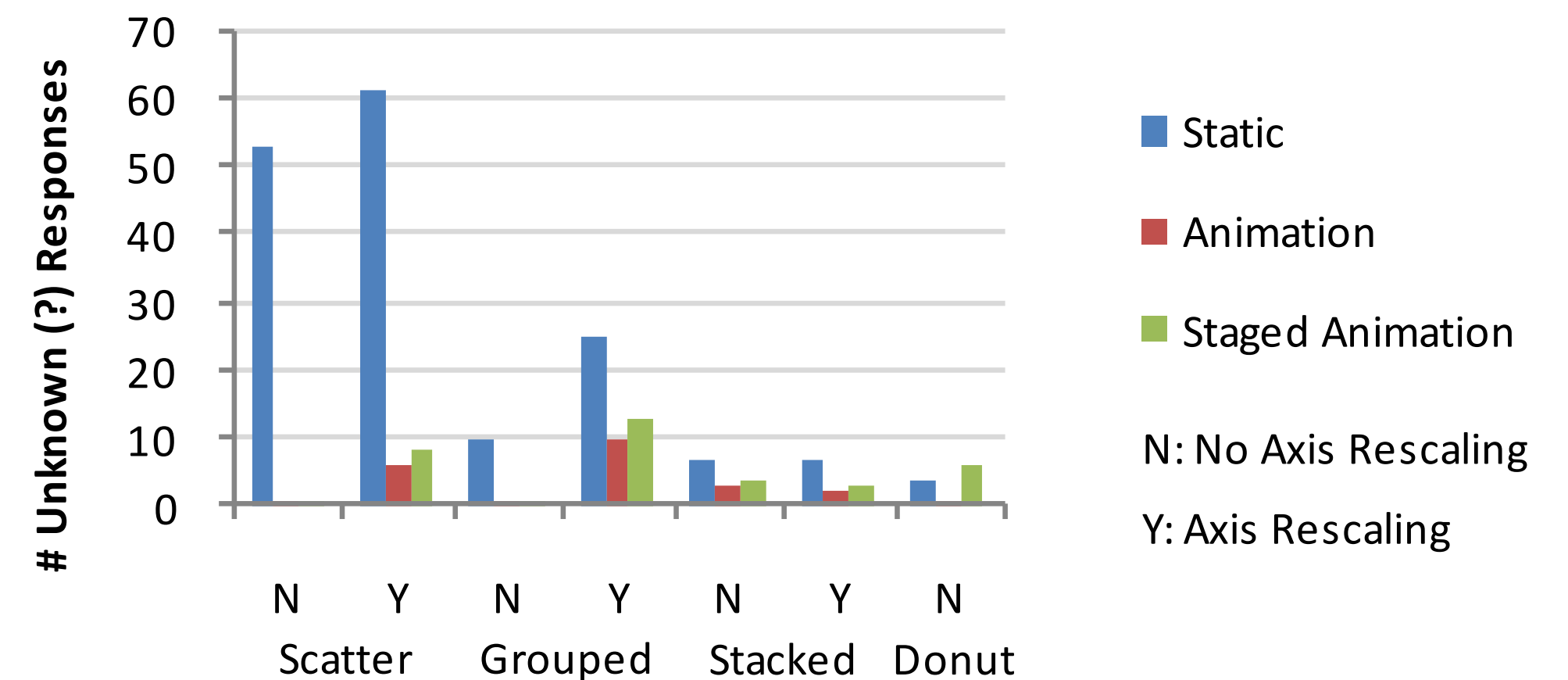
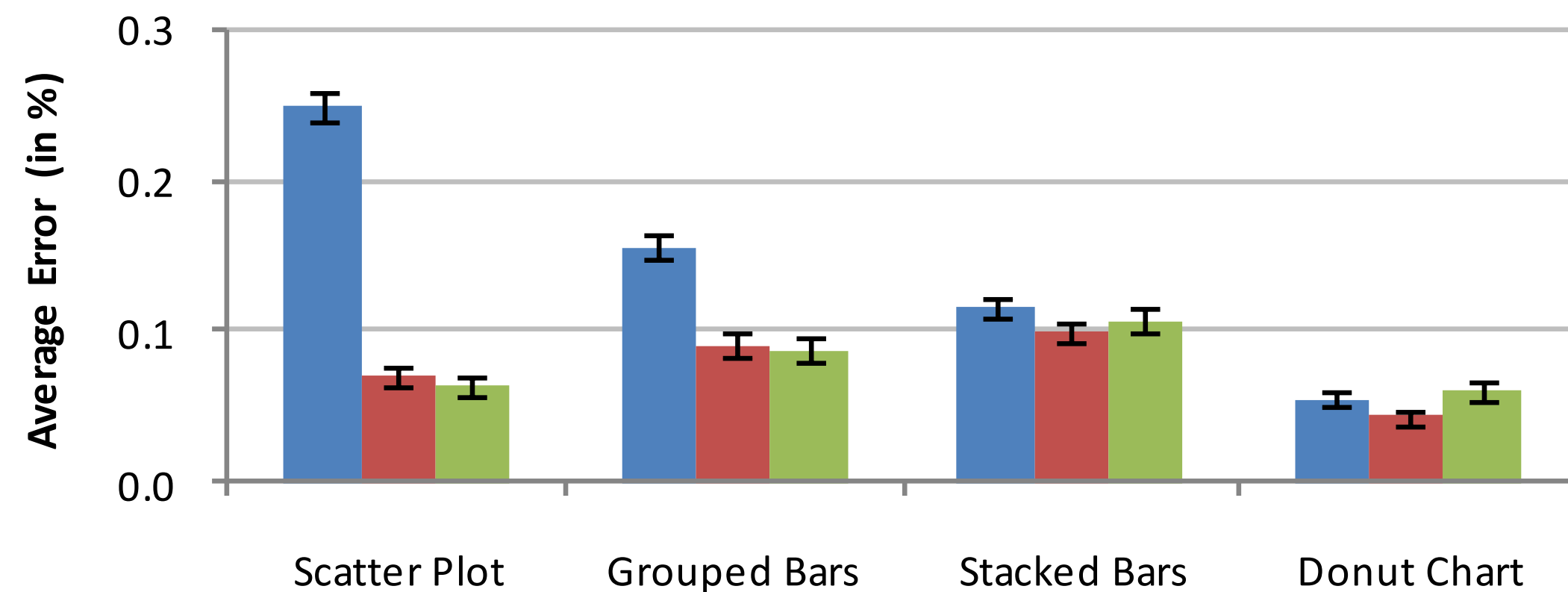
- Object Tracking: Follow objects across a transition and identify the locations of the objects in the final graphic
 - Tests: bar chart to donut chart, stacked to grouped bars, sorting a bar chart, scatter plot to bar chart, timestep in a scatterplot
 - Either a jump cut or an animated transition
 - Users pick highlighted elements after transition (measure #pixels from correct)



[Heer and Robertson, 2007]

Experiment 2 (Semantic)

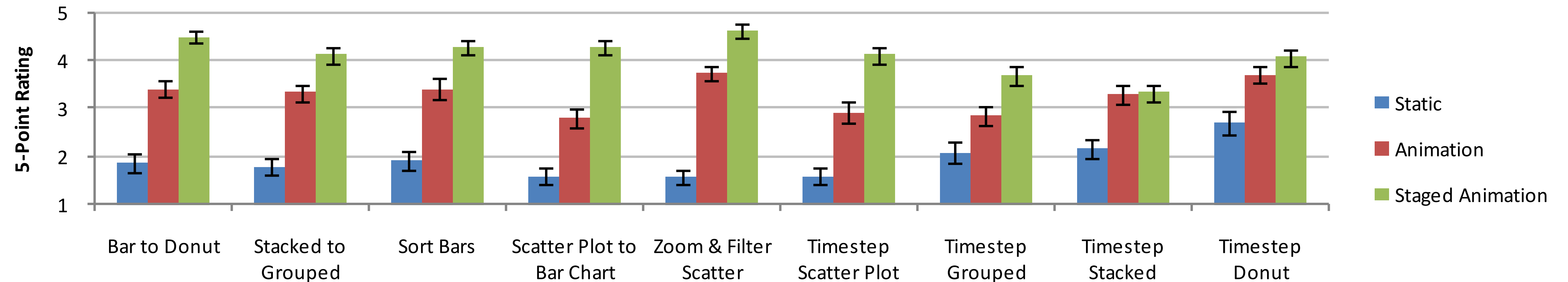
- Estimating Changing Values: Follow a single target across transition and estimate the percentage change in value
 - Tests: axis rescaling + timestep animations
 - In stacked bars, each stack level updates separately, donut charts are multi-stage
 - Users asked to enter an estimate of change (increments of 20% from -90% to 90% or click "?" for no idea)



[Heer and Robertson, 2007]

Results/Conclusions

- User Preferences: Staged animation > animation > static transitions



- Animation improves graphical perception
- Staging is better (do axis rescaling before value changes)
- Avoid axis rescaling when possible

[Heer and Robertson, 2007]

Change Blindness

- <https://www.youtube.com/watch?v=uO8wpm9HSB0>



Change Blindness

- <https://www.youtube.com/watch?v=uO8wpm9HSB0>



Selection

- Selection is often used to initiate other changes
- User needs to select something to drive the next change
- What can be a selection target?
 - Items, links, attributes, (views)
- How?
 - mouse click, mouse hover, touch
 - keyboard modifiers, right/left mouse click, force
- Selection modes:
 - Single, multiple
 - Contiguous?

Highlighting

- Selection is the user action
- Feedback is important!
- How? Change selected item's visual encoding
 - Change color: want to achieve visual popout
 - Add outline mark: allows original color to be preserved
 - Change size (line width)
 - Add motion: marching ants

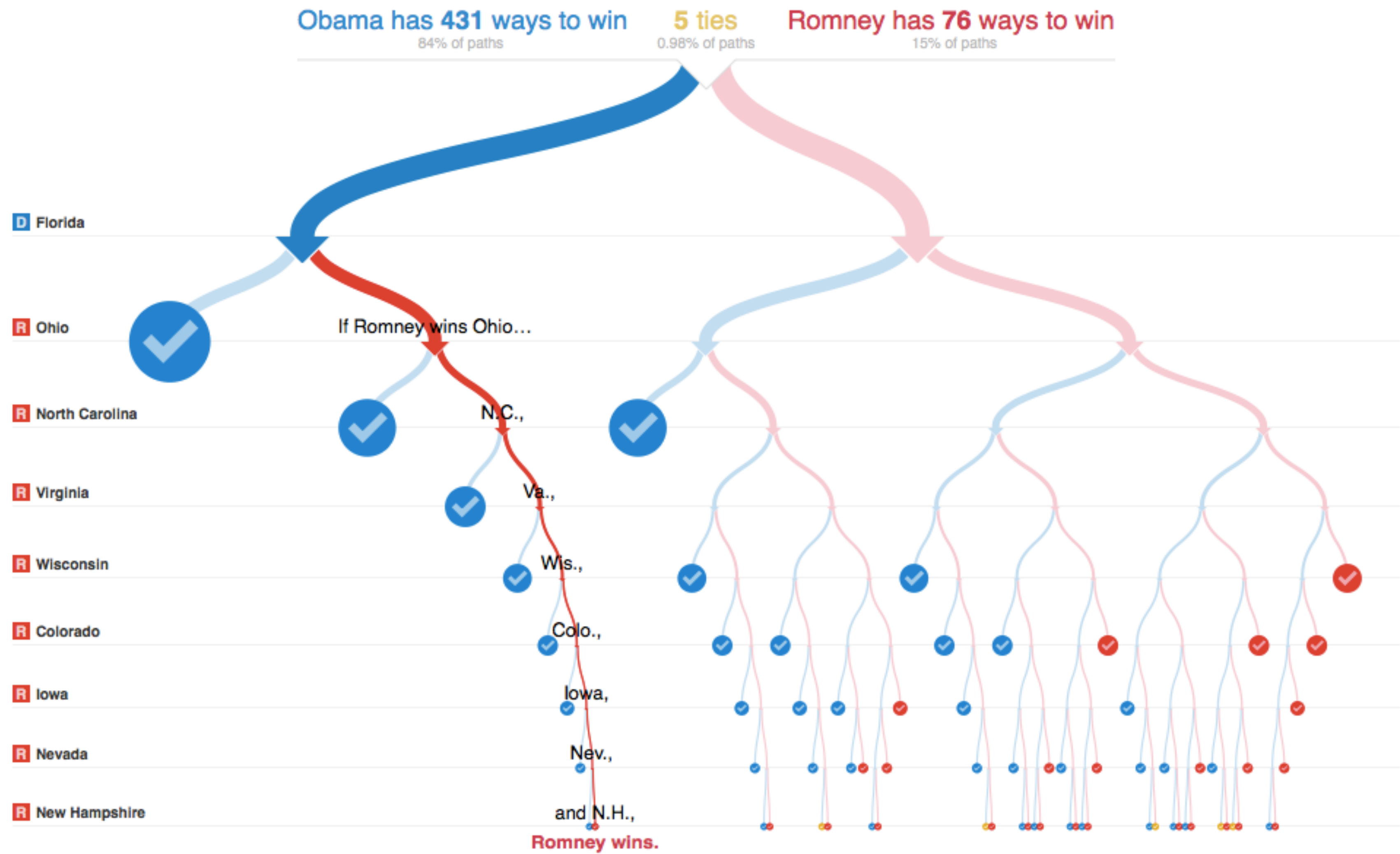


Highlighting

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Highlighting



[NYTimes]

Selection Outcomes

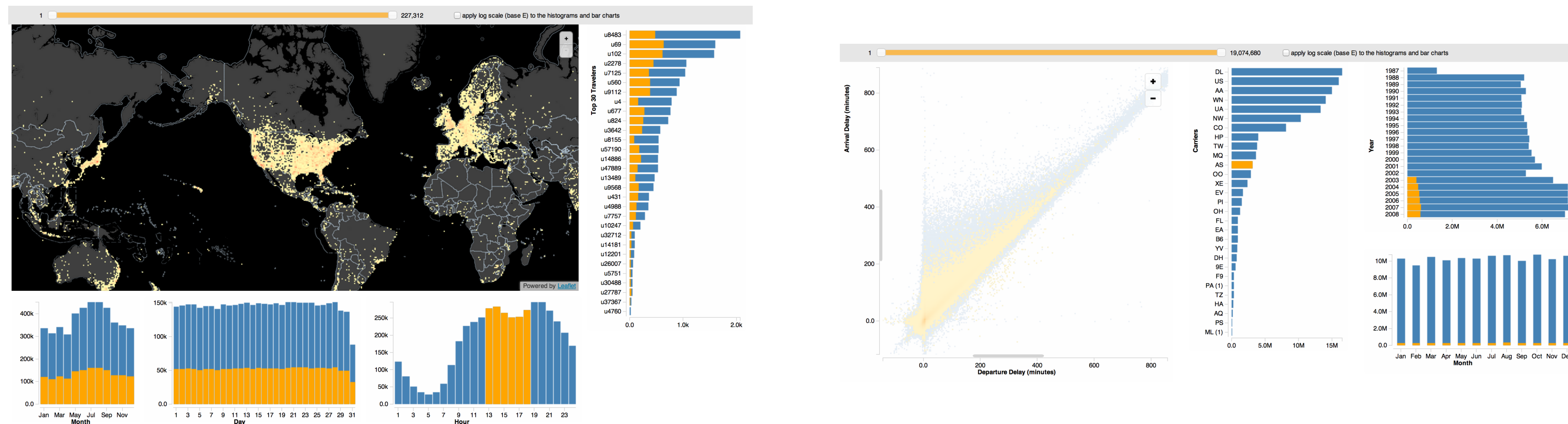
- Selection is usually a part of an action sequence
- Can filter, aggregate, reorder selected items

Responsiveness Required

- Delays are perceived by users
- Visual feedback
 - Show the user they did something (highlighting, etc)
 - Interaction should happen quick!
- Latency: mouse click versus mouse hover
- Popup versus detail displays

Interaction Latency

- The Effects of Interactive Latency on Exploratory Visual Analysis, Z. Liu and J. Heer, 2014
- Brush & link, select, pan, zoom



- 500ms added latency causes significant cost
 - decreases user activity and dataset coverage
 - reduces rate of observations, generalizations, and hypotheses

Navigation

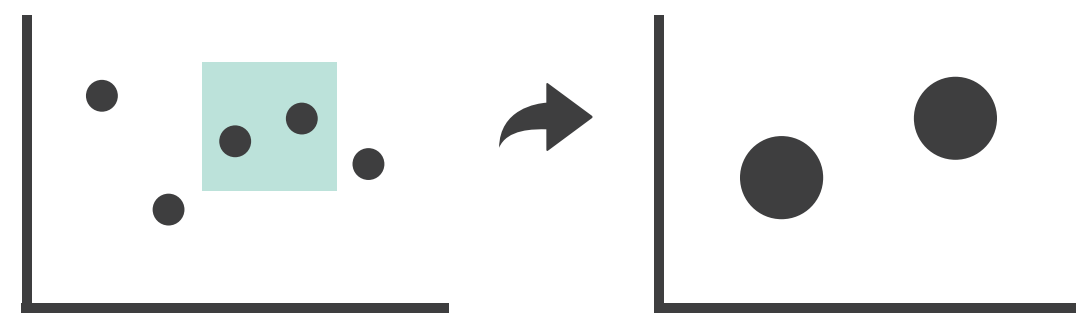
- Fix the layout of all visual elements but provide methods for the viewpoint to change
- Camera analogy: only certain features visible in a frame
 - Zooming
 - Panning (aka scrolling)
 - Translating
 - Rotating (rare in 2D, important in 3D)

Navigation

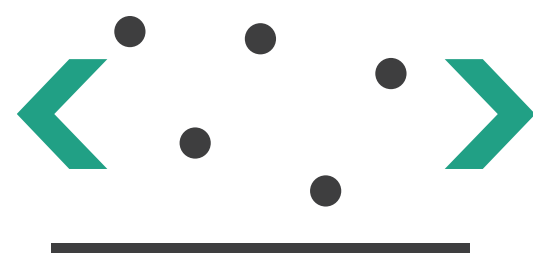
→ Item Reduction

→ Zoom

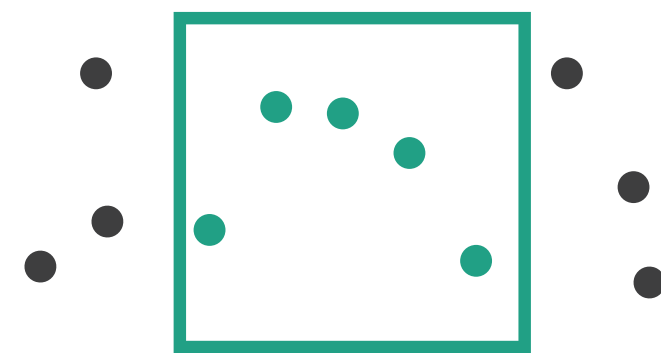
Geometric or *Semantic*



→ Pan/Translate

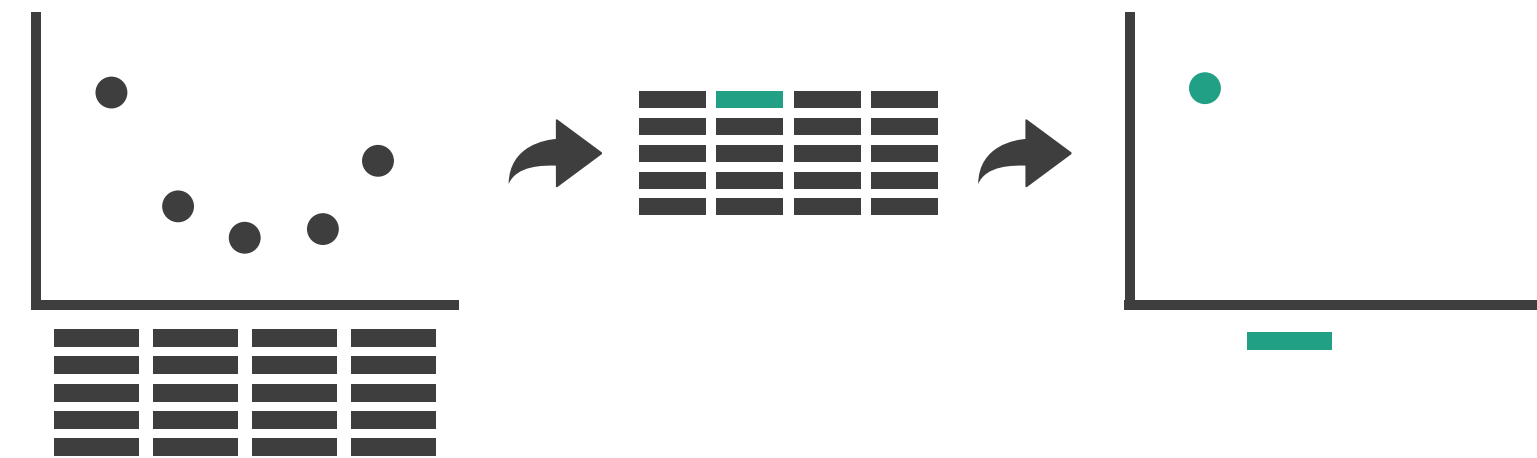


→ Constrained

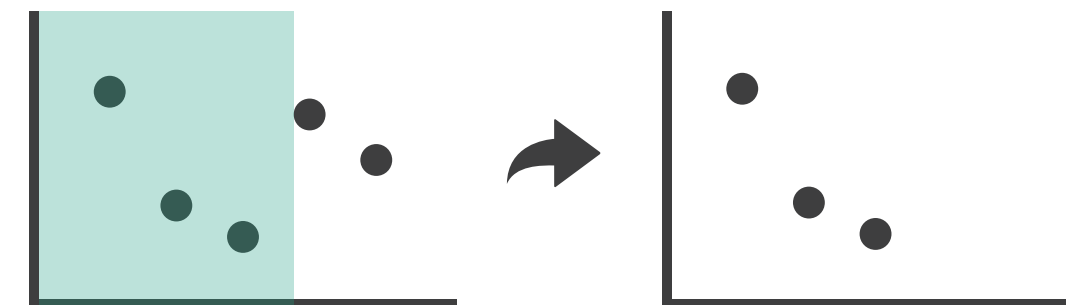


→ Attribute Reduction

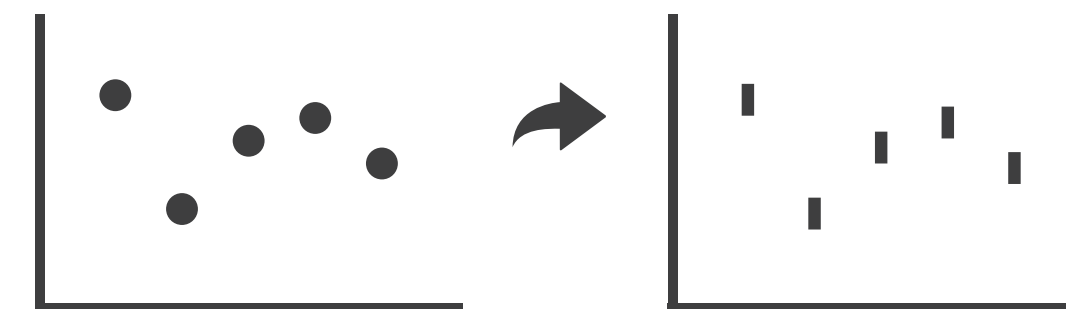
→ Slice



→ Cut



→ Project



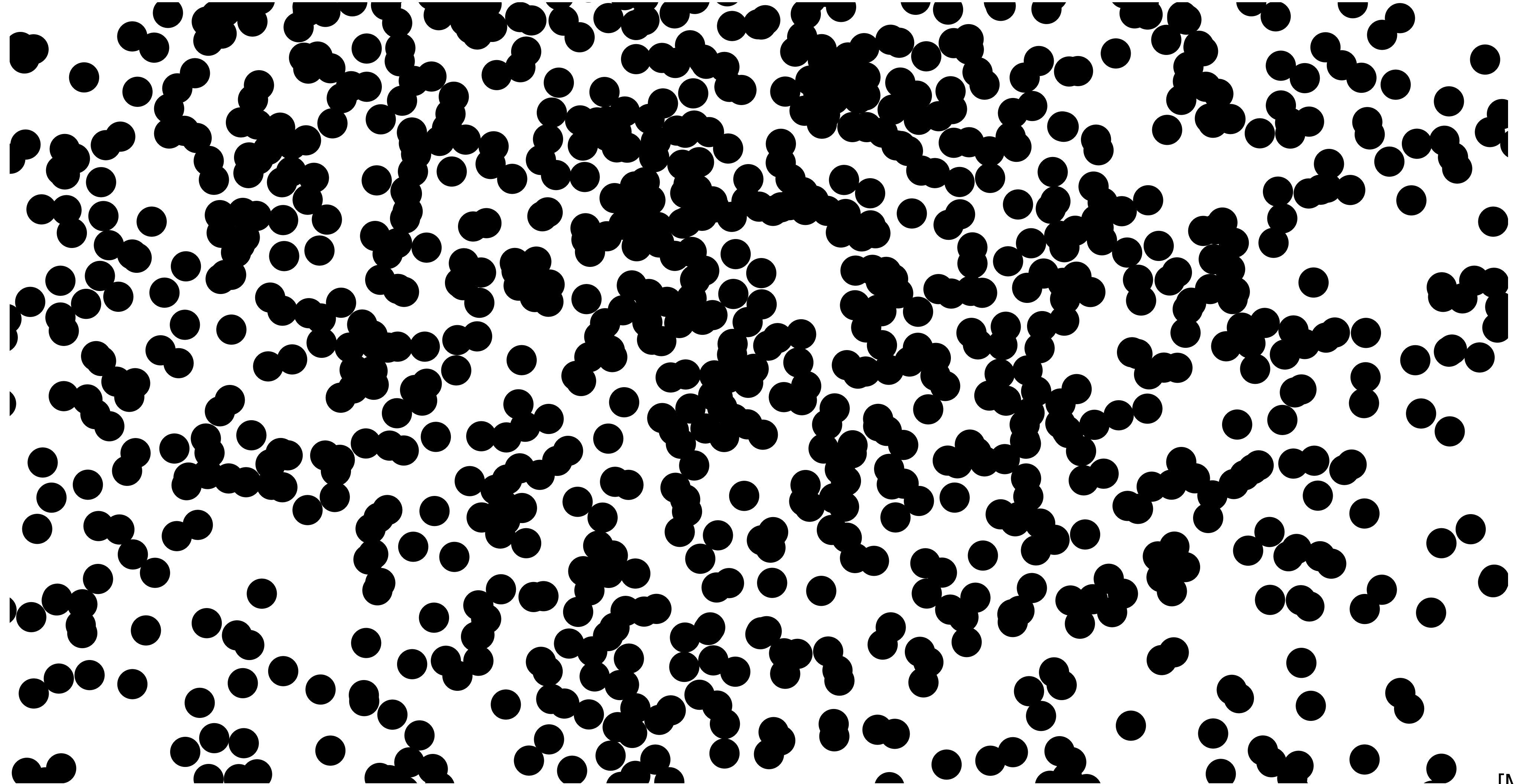
[Munzner (ill. Maguire), 2014]

Zooming



[M. Bostock]

Geometric Zooming



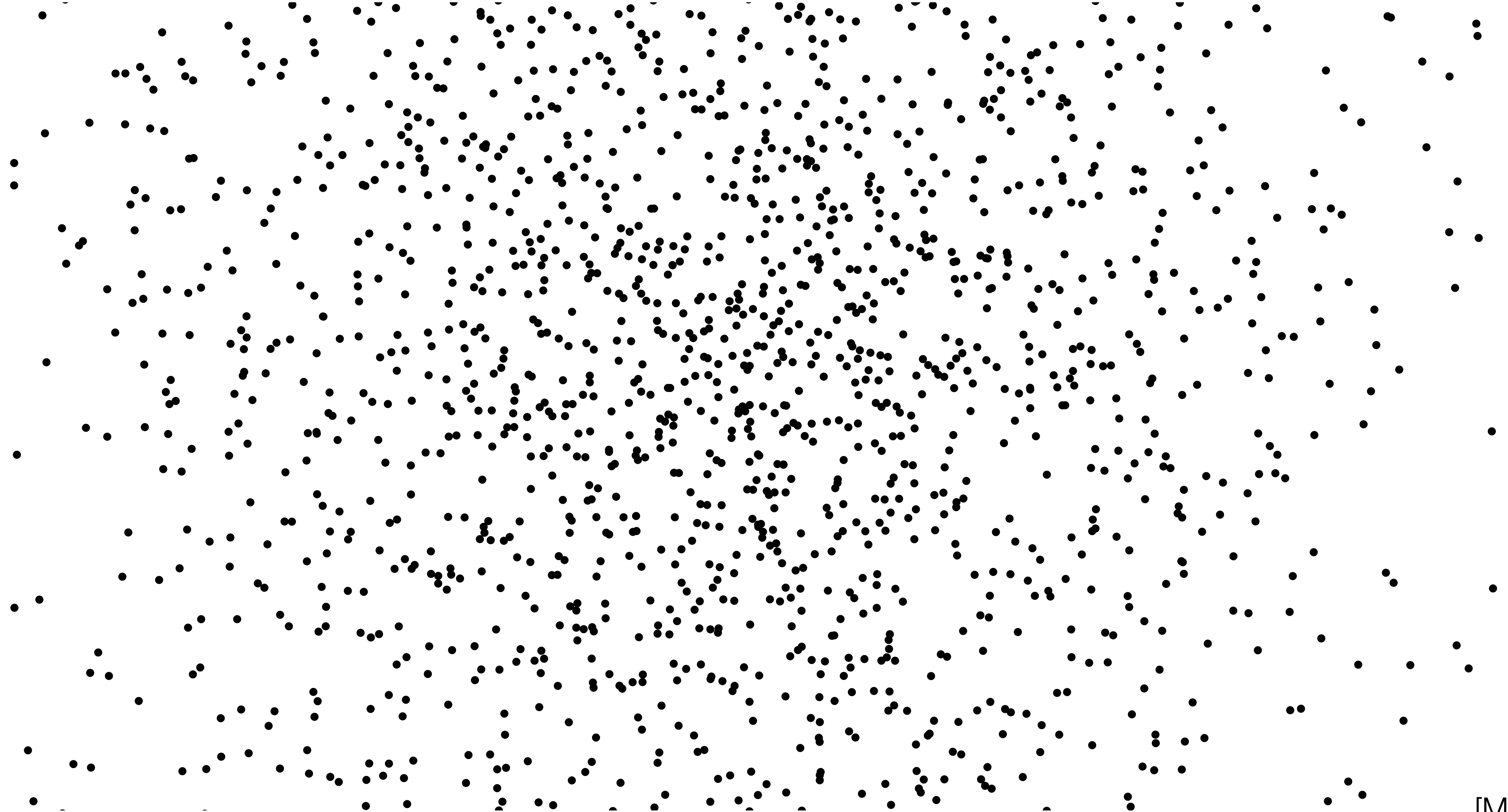
[M. Bostock]

Zooming



[M. Bostock]

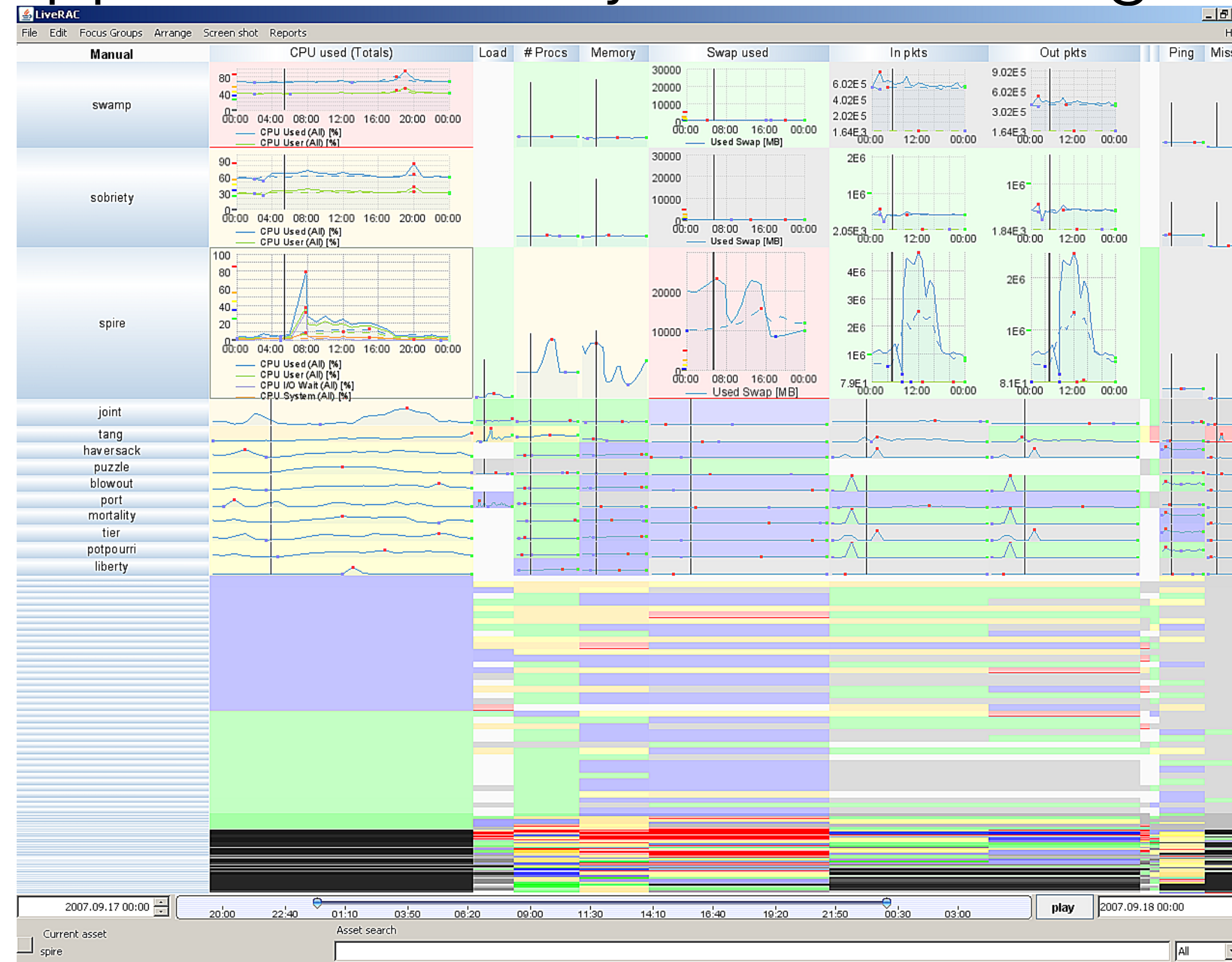
Semantic Zooming



[M. Bostock]

Zooming

- Geometric Zooming: just like a camera
- Semantic Zooming: visual appearance of objects can change at different scales
- LiveRAC Example: (focus + context)

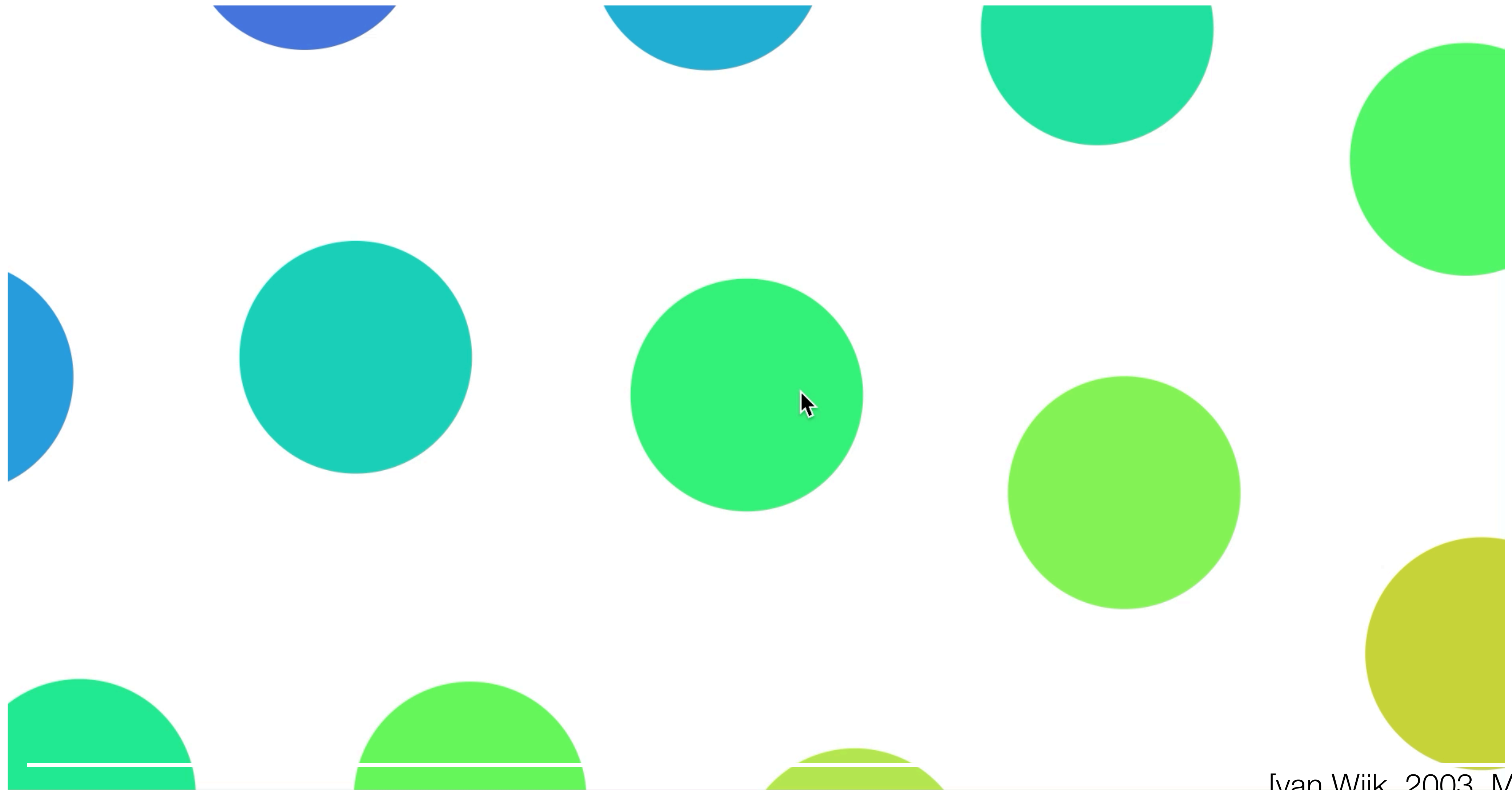


[McLachlan et al., 2008]

Navigation Constraints

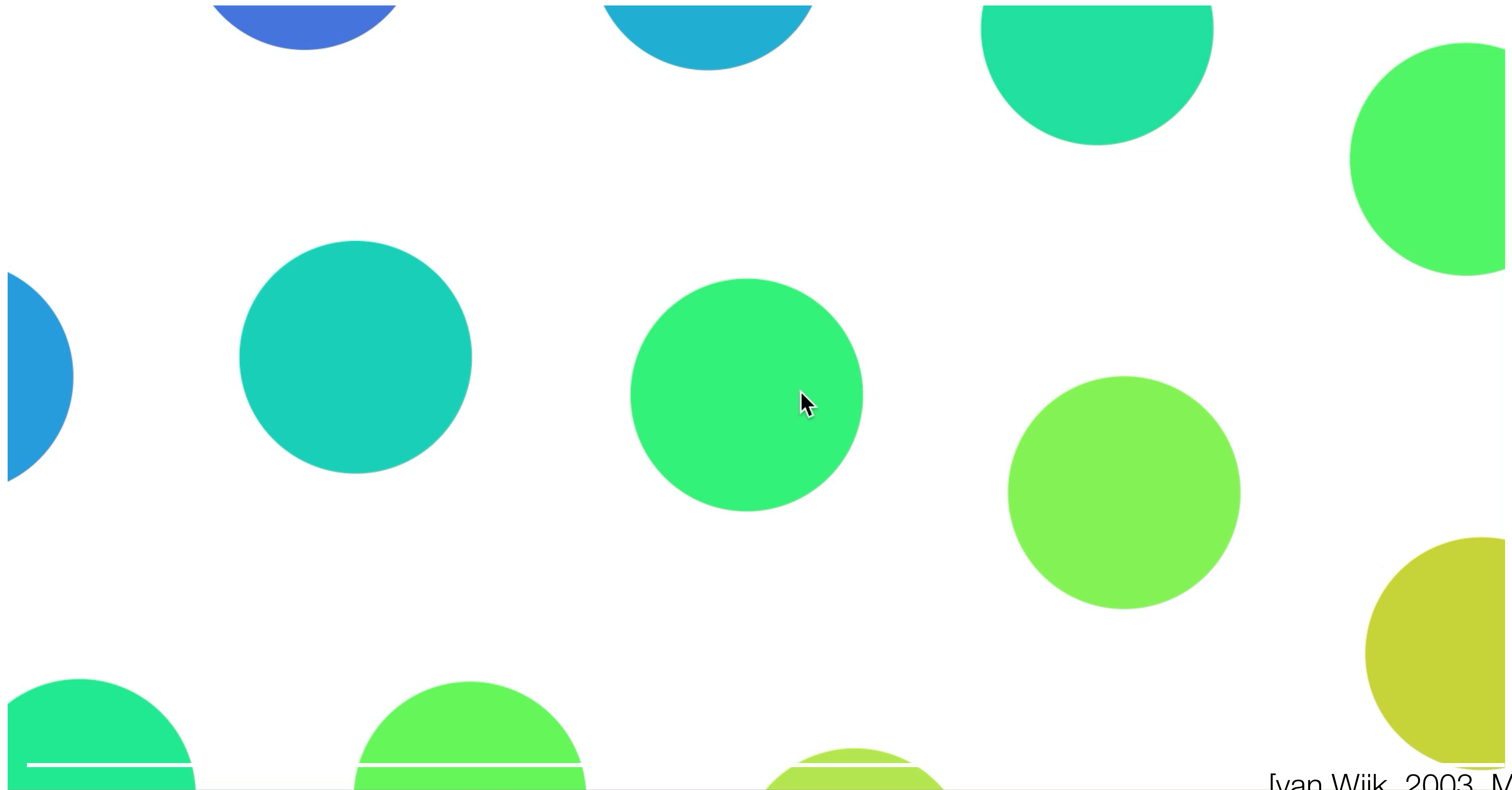
- **Unconstrained** navigation: walking around in the world or an immersive 3D environment
 - Fairly standard in computer games to go where you want
 - Constrained by walls, objects (collision detection)
- Constrained navigation:
 - 3D: camera must be right-side up
 - Limit pan/zoom to certain areas
 - Comes up often with **multiple views**: want to show an area in one view that corresponds to a selection in another view

van Wijk Smooth Zooming



[van Wijk, 2003, M. Bostock]

van Wijk Smooth Zooming



[van Wijk, 2003, M. Bostock]