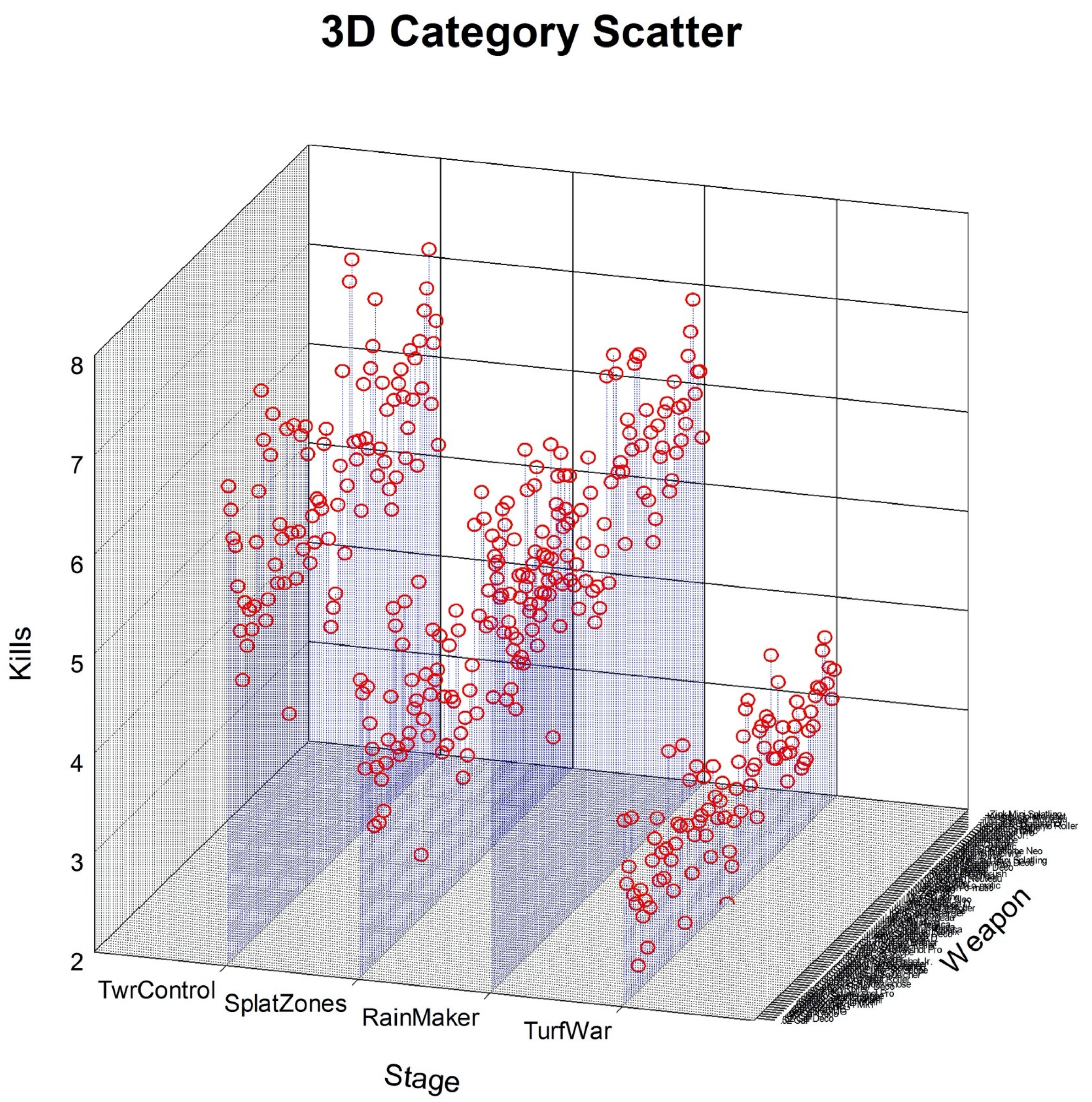
Data Visualization (CSCI 627/490)

Interaction & Multiple Views

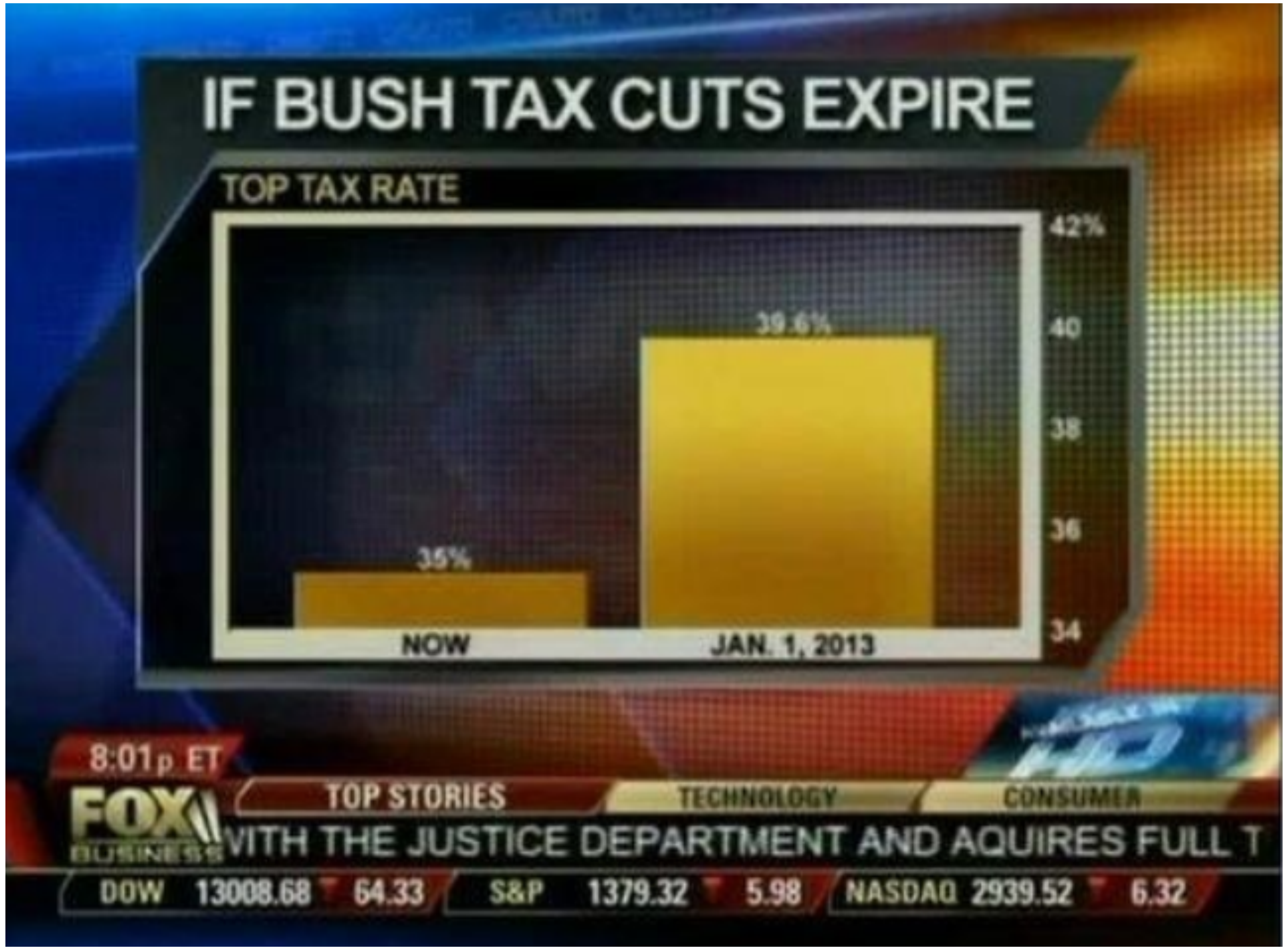
Dr. David Koop

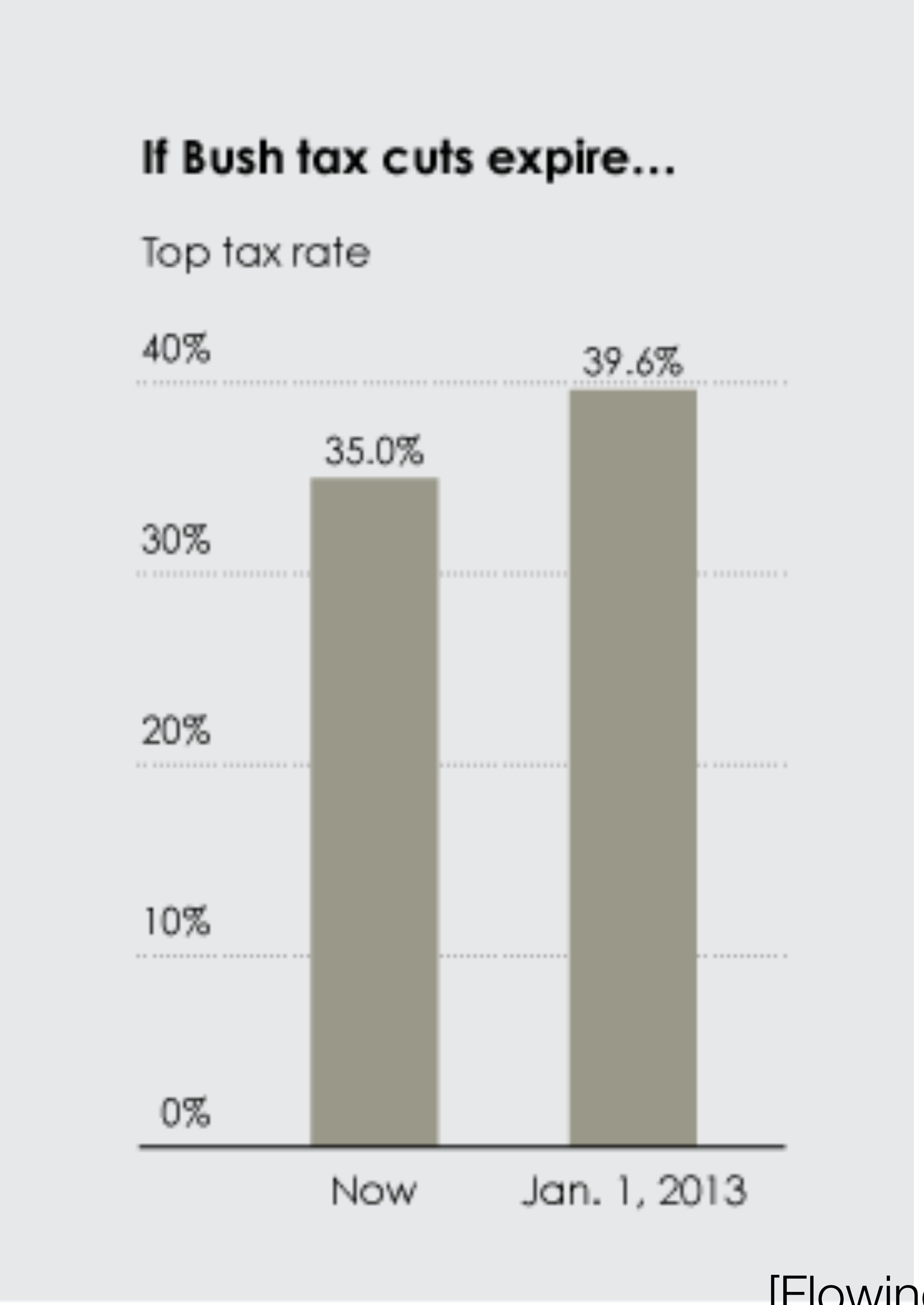
What is wrong with here and how can it be fixed?



[WTF Visualizations, 2017]

Good: Data magnitude <=> Mark magnitude

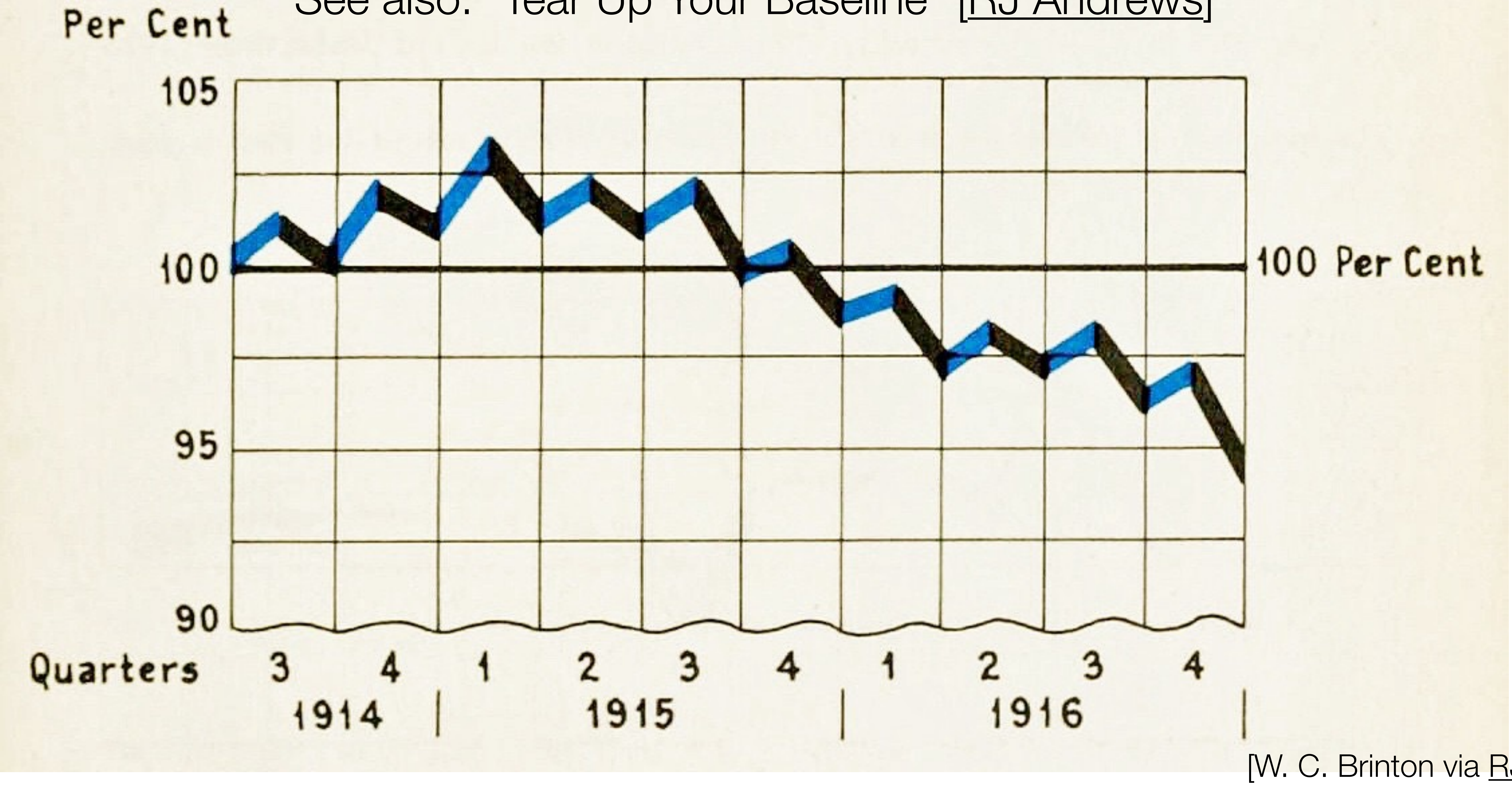




[Flowing Data, 2012]

Show when the baseline is not zero

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

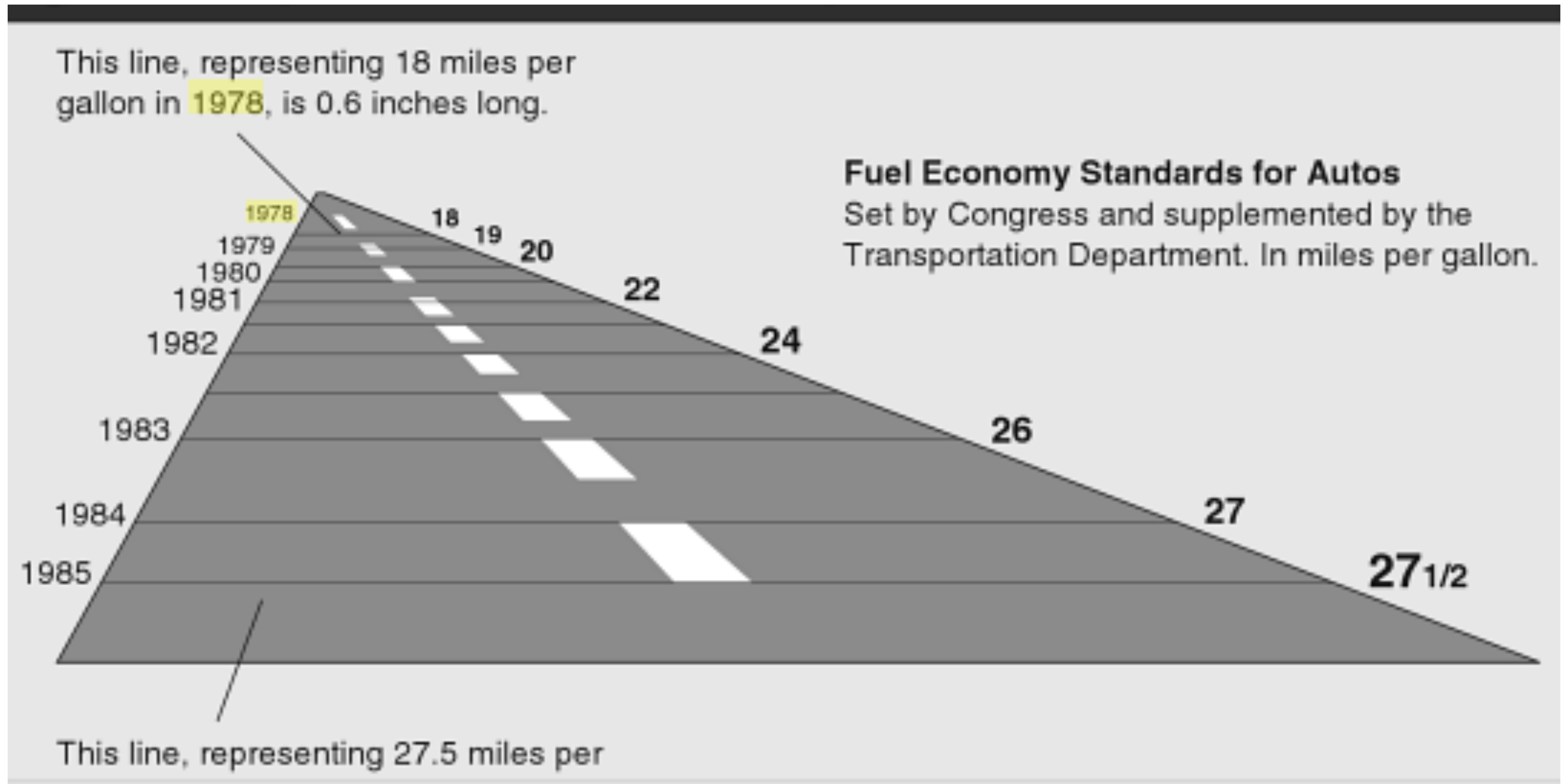


[W. C. Brinton via RJ Andrews]

Tufte's Lie Factor

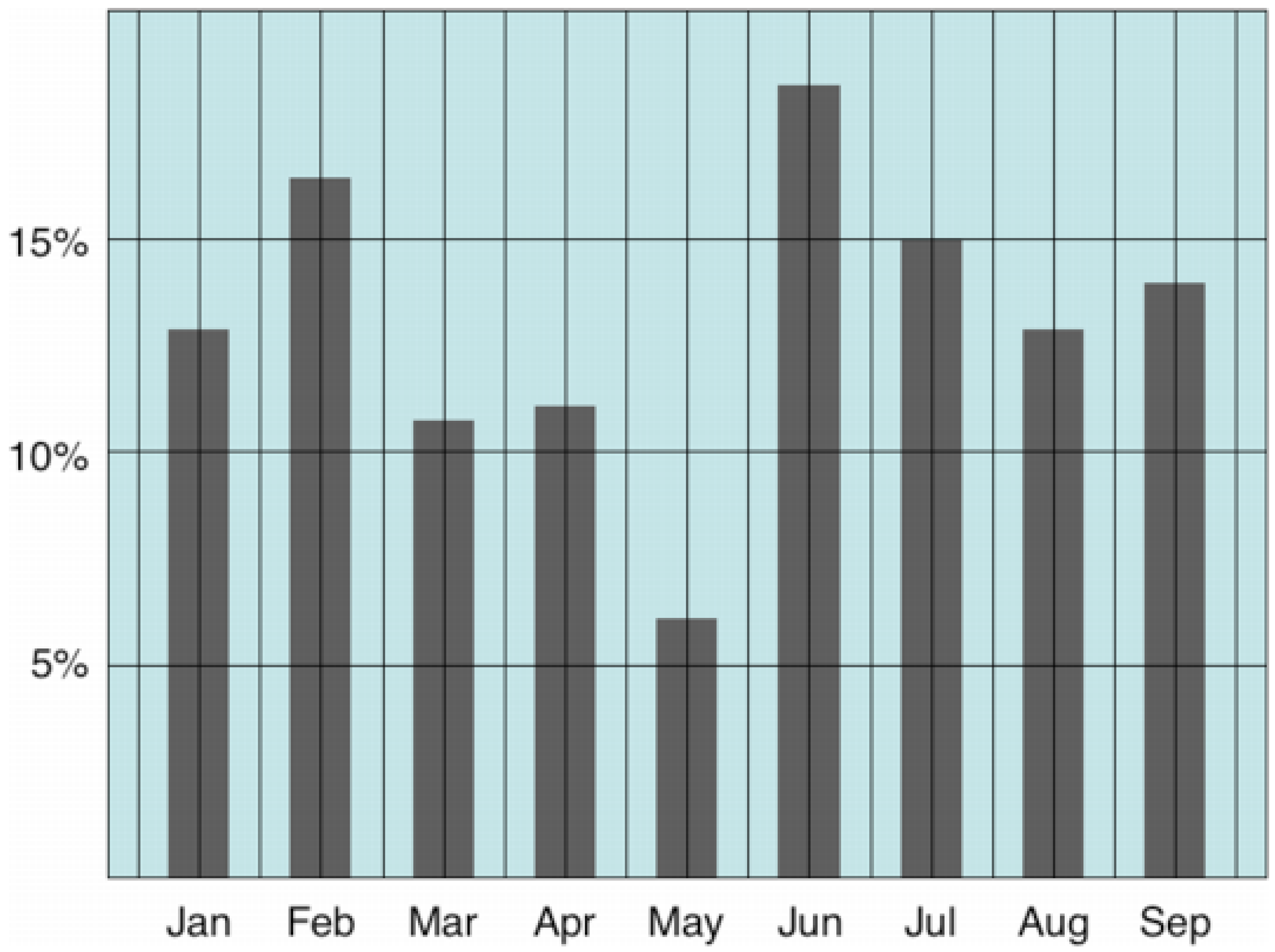
- Size of effect = (2nd value - 1st value) / (1st value)
- Lie factor = (size of effect in graphic) / (size of effect in data)
- In the graphic:

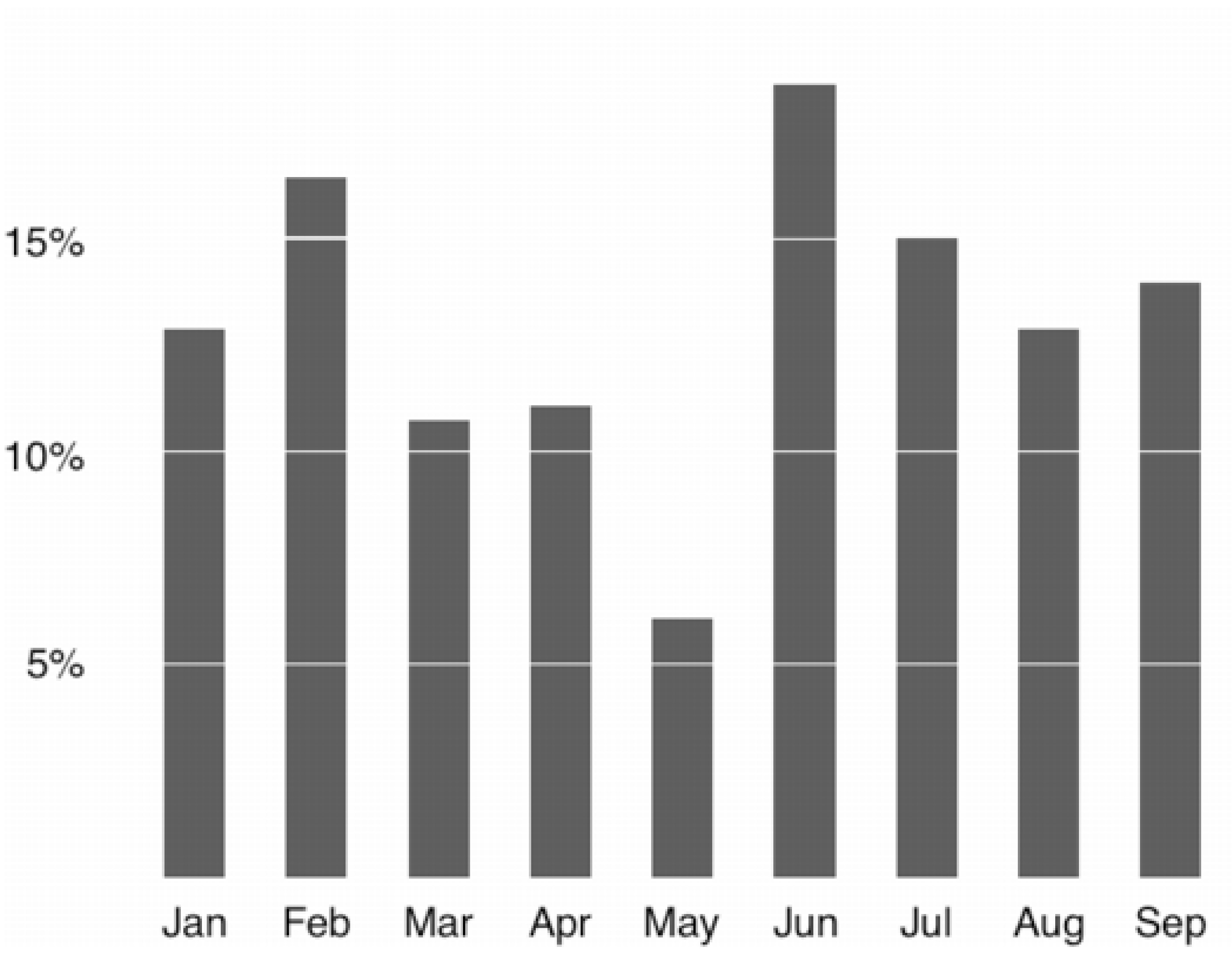
$$\text{Lie Factor} = \frac{\frac{5.3 - 0.6}{0.6}}{\frac{27.5 - 18}{18}} = 14.8$$



[InfoVis Wiki]

Avoid Chartjunk



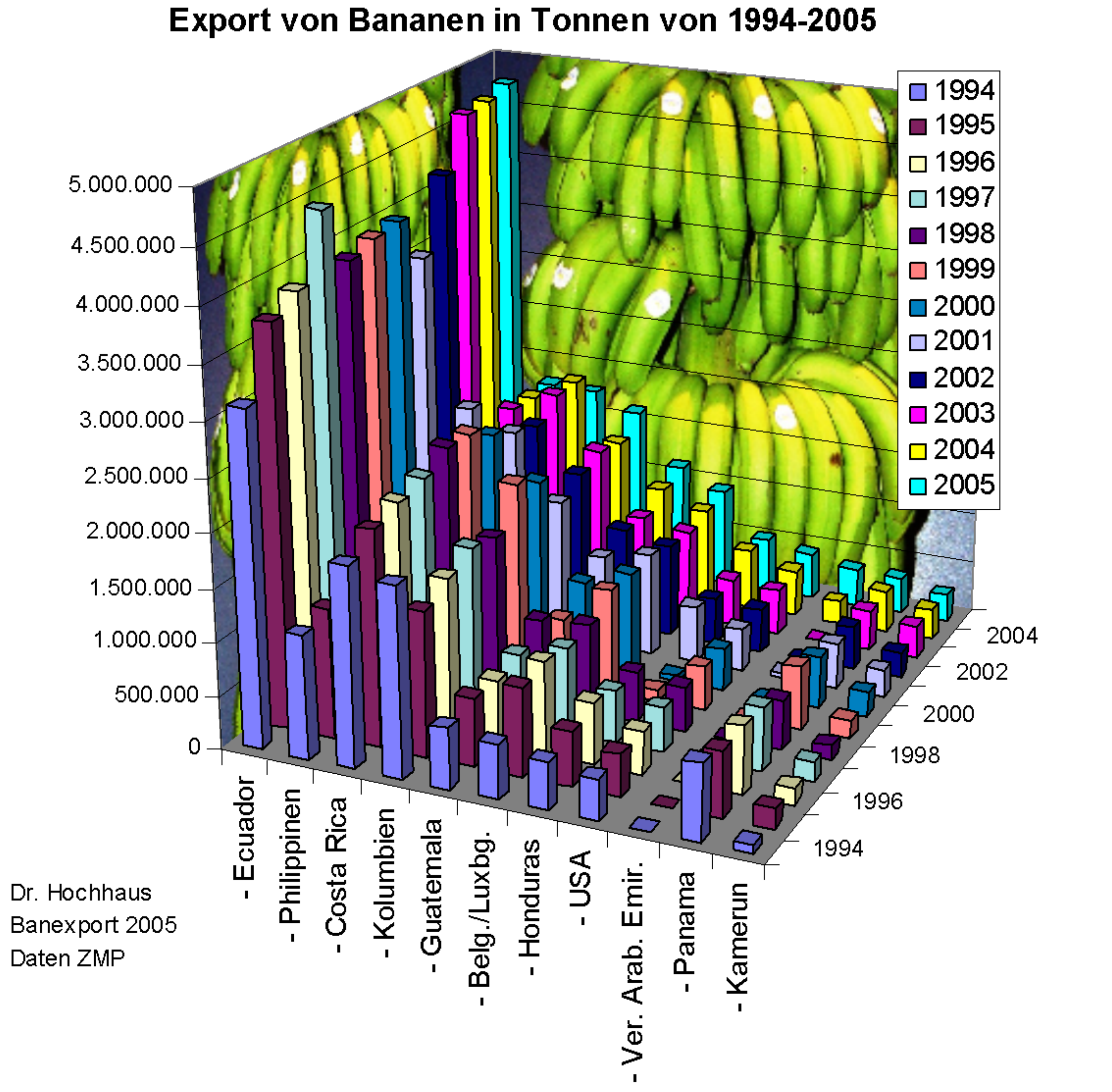


[T. Brey via A. Lex]

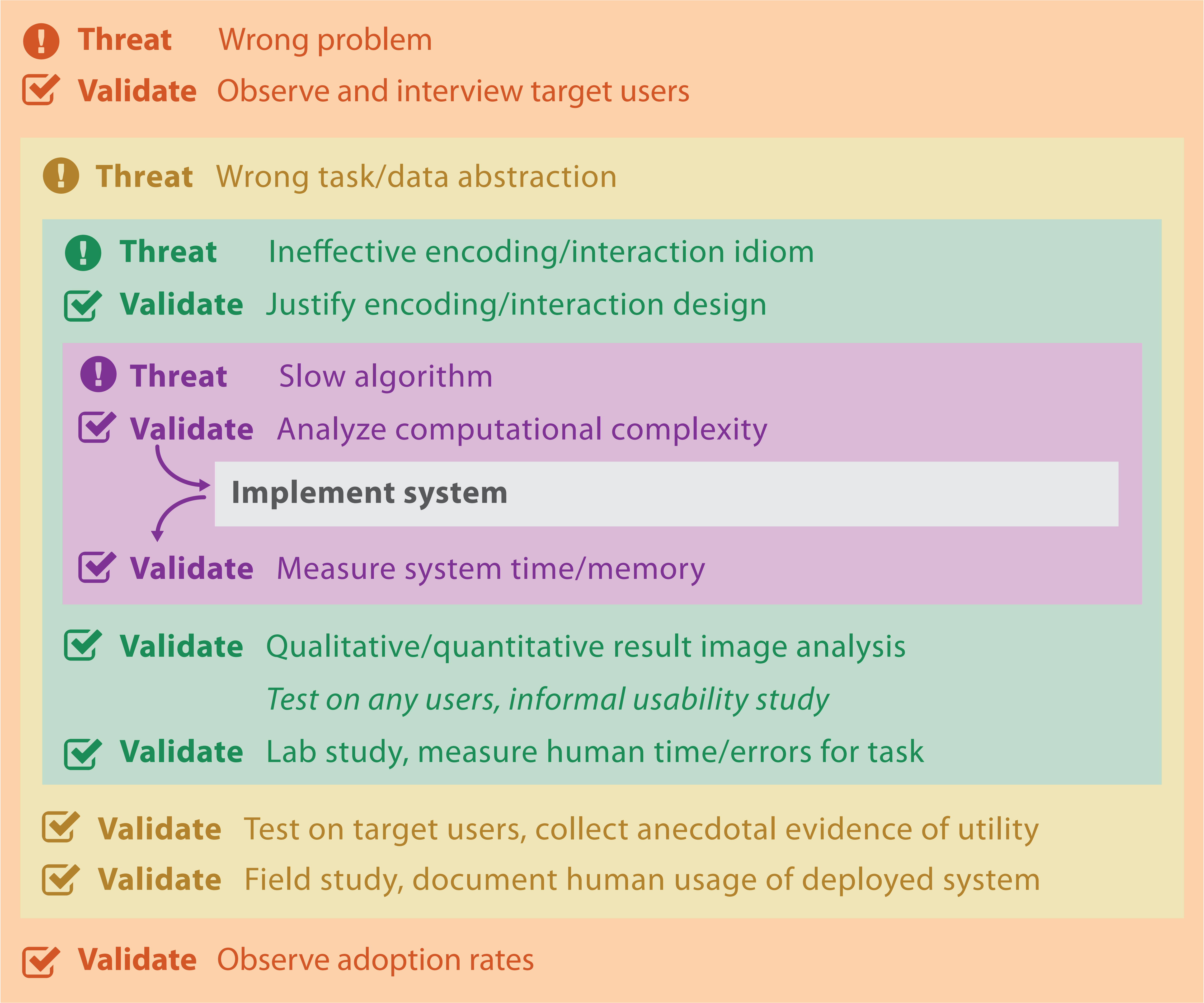
No Unjustified 3D

- Occlusion hides information
- Perspective distortion dangers
- Tilted text isn't legible

- Can **help** with shape perception

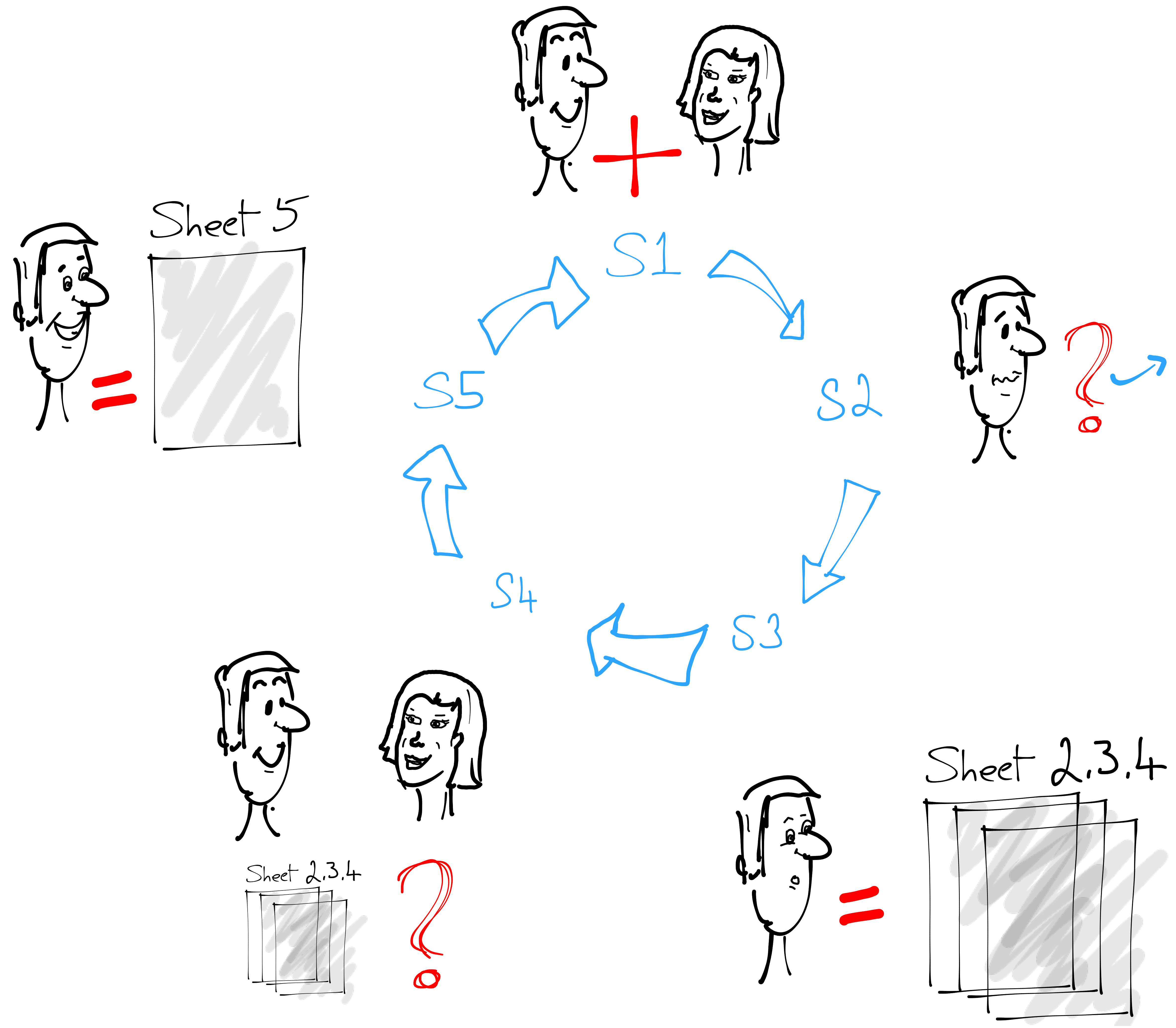


Validation at each level



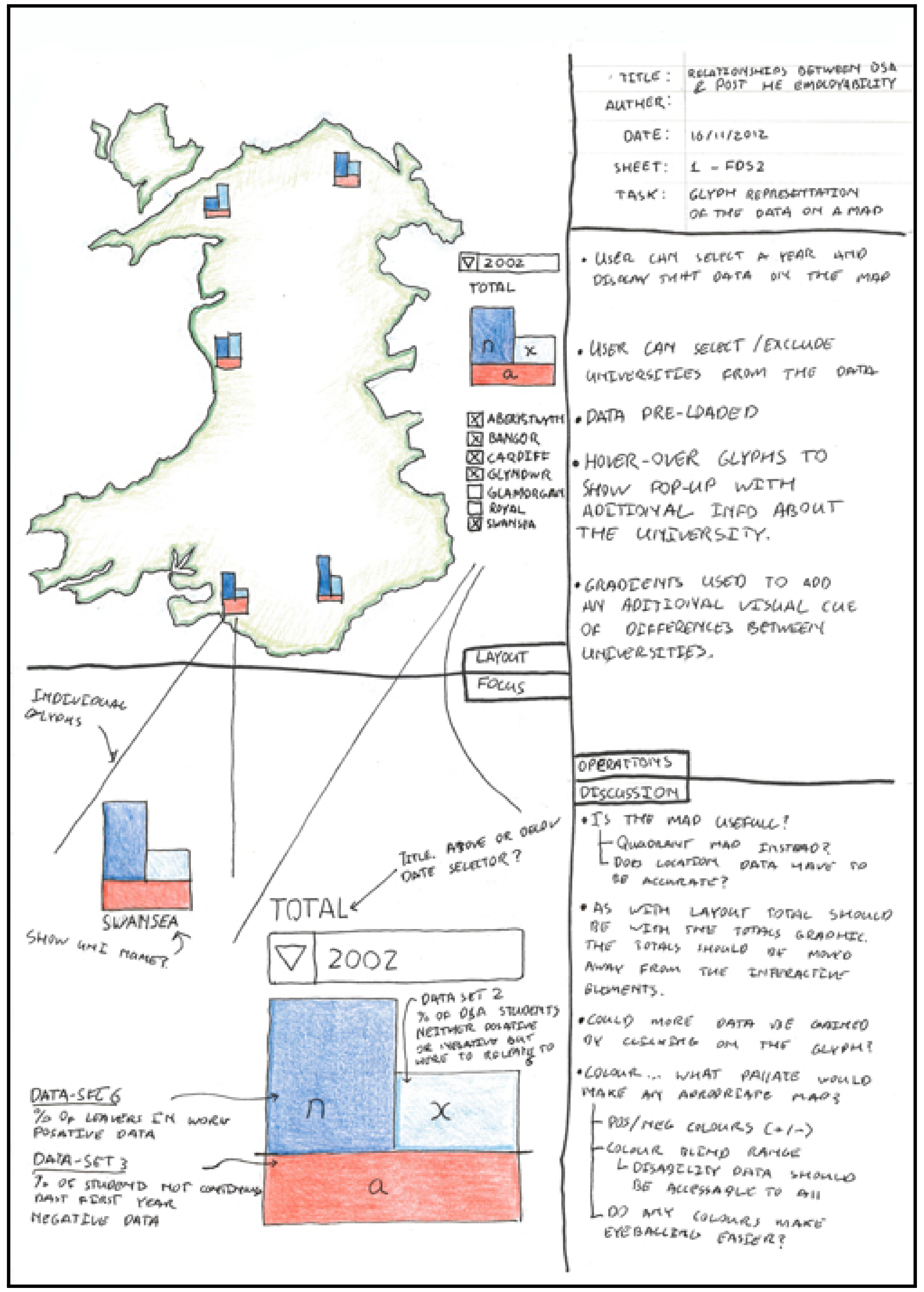
[Munzner, 2014]

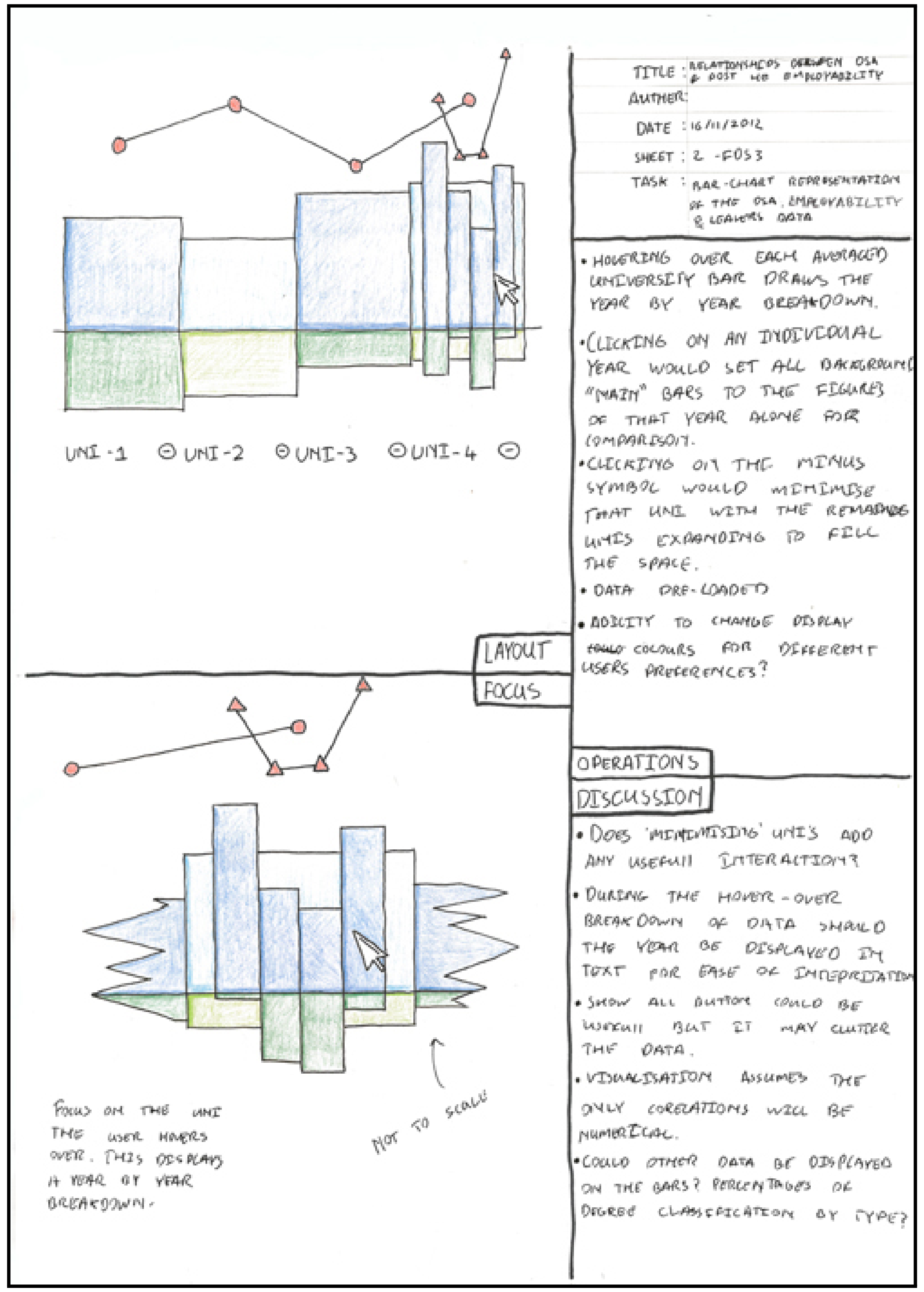
Five Design Sheet Method

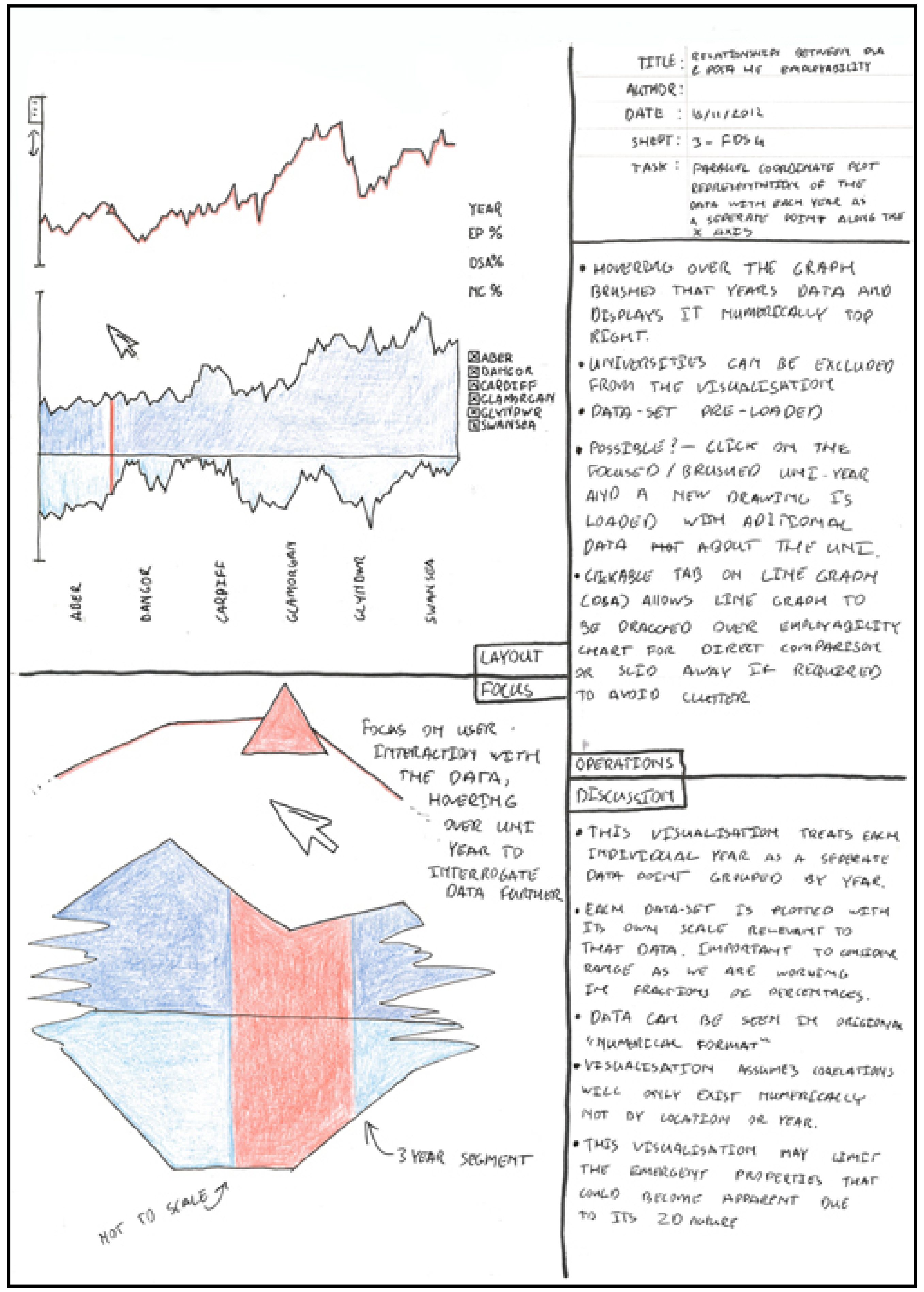


[J. Roberts et al., 2016]

Sheets 2-4







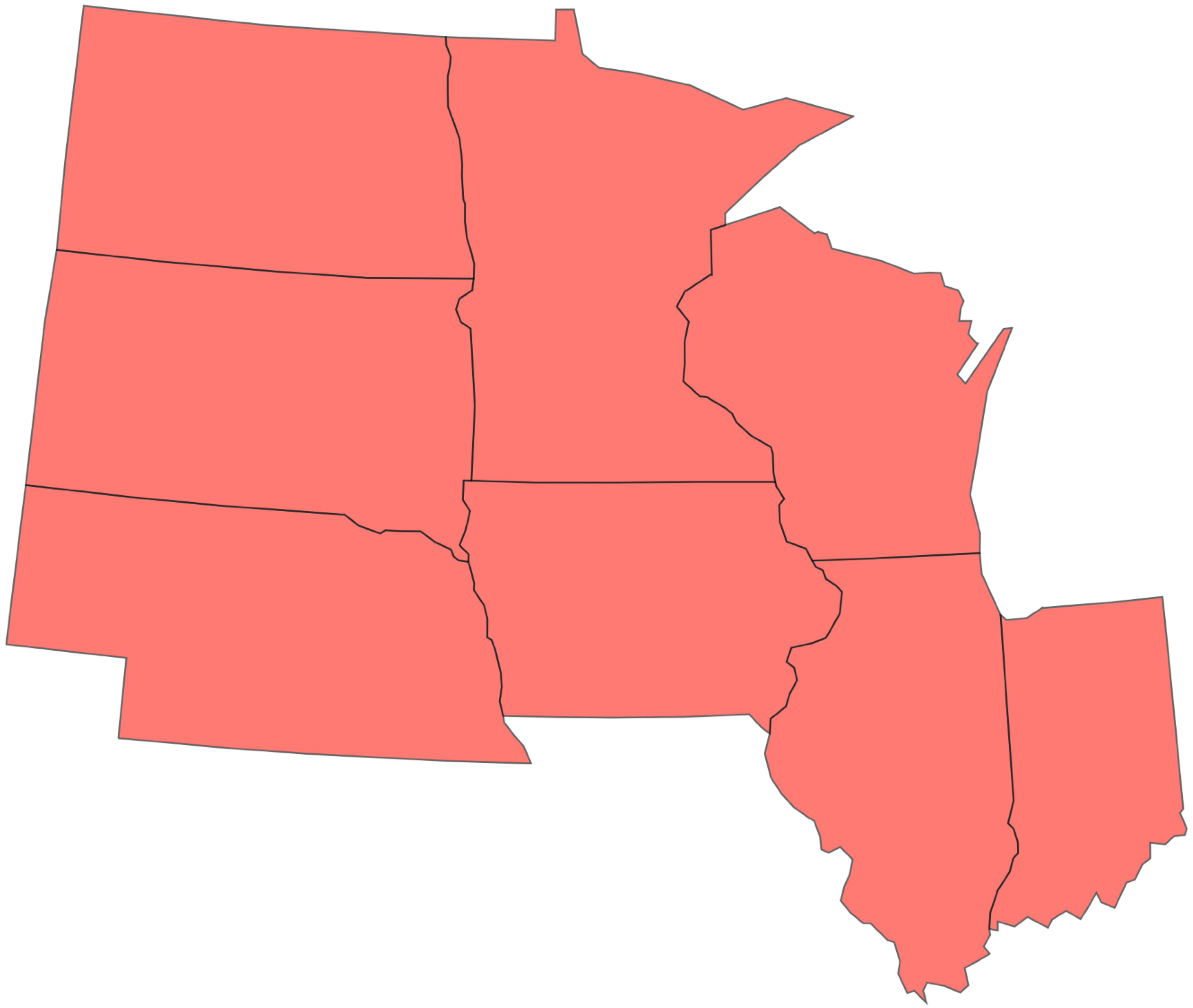
[J. Roberts et al., 2016]

Project Design

- Work on turning your visualization ideas into designs
- Turn in:
  - Three Designs Sketches
  - One Bad Design
  - Progress on Implementation
- Options:
  - Try vastly different options
  - Refine an initial idea
- Due Friday, Nov. 13

Assignment 4

- Geospatial Visualizations & Treemap
  - Choose colormaps carefully
  - Add legend
- Due Nov. 2



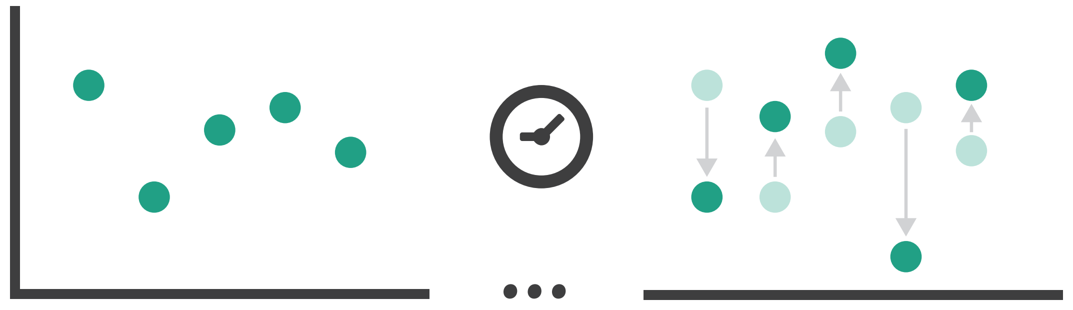
Guidelines for Interaction Design

Interaction

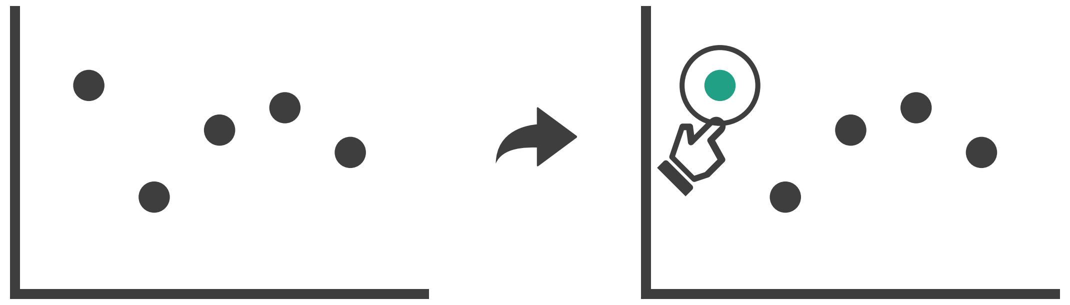
- The view changes over time
- Changes can affect almost any aspect of the visualization
  - encoding
  - arrangement
  - ordering
  - viewpoint
  - attributes being shown
  - aggregation level

Interaction Overview

➔ Change over Time



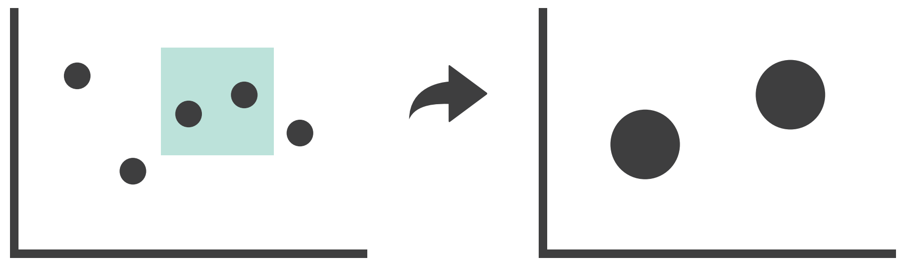
➔ Select



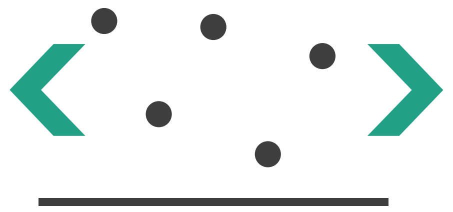
➔ Navigate

➔ Item Reduction

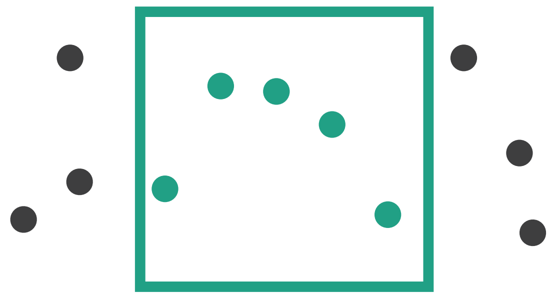
➔ *Zoom*
Geometric or *Semantic*



➔ *Pan/Translate*



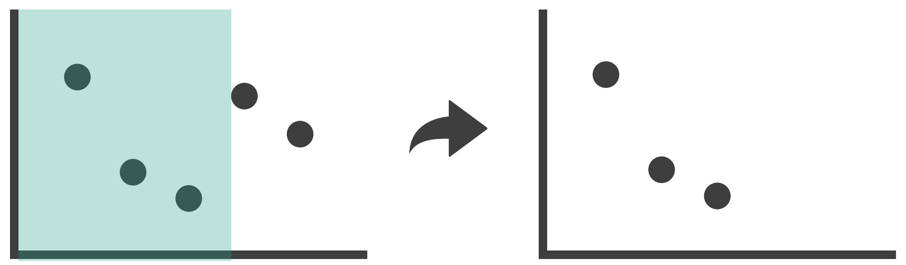
➔ *Constrained*



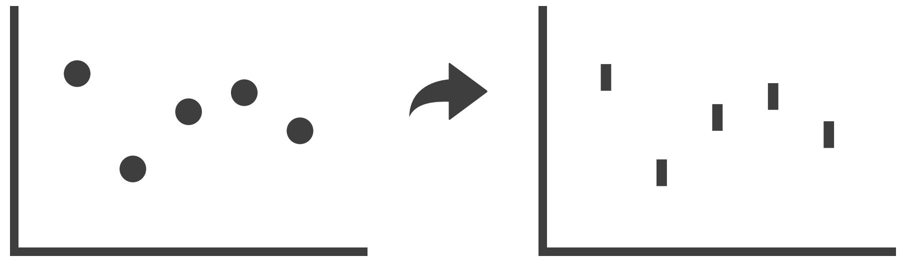
➔ Attribute Reduction

➔ *Slice*

➔ *Cut*



➔ *Project*

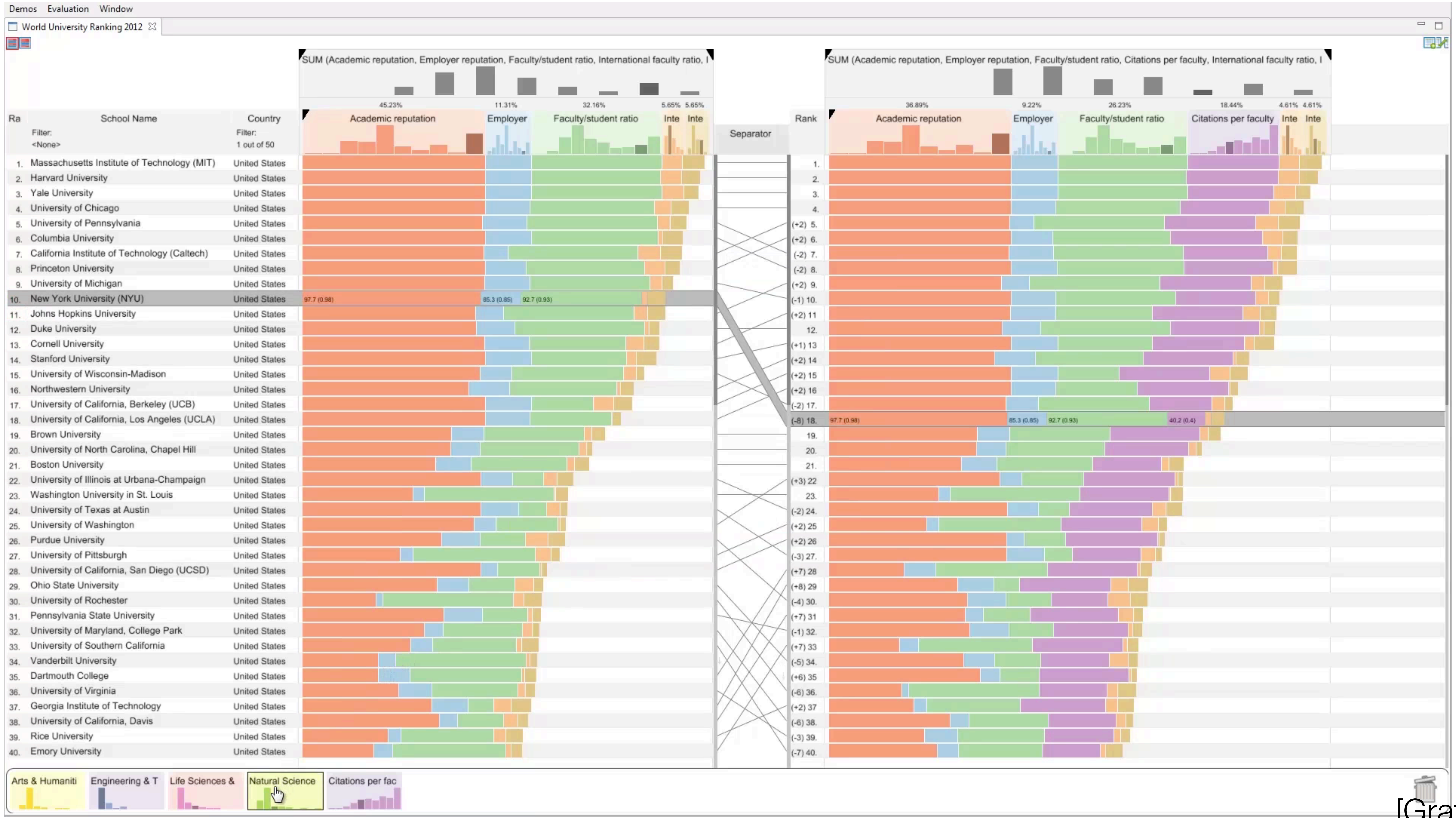


[Munzner (ill. Maguire), 2014]

Sorting

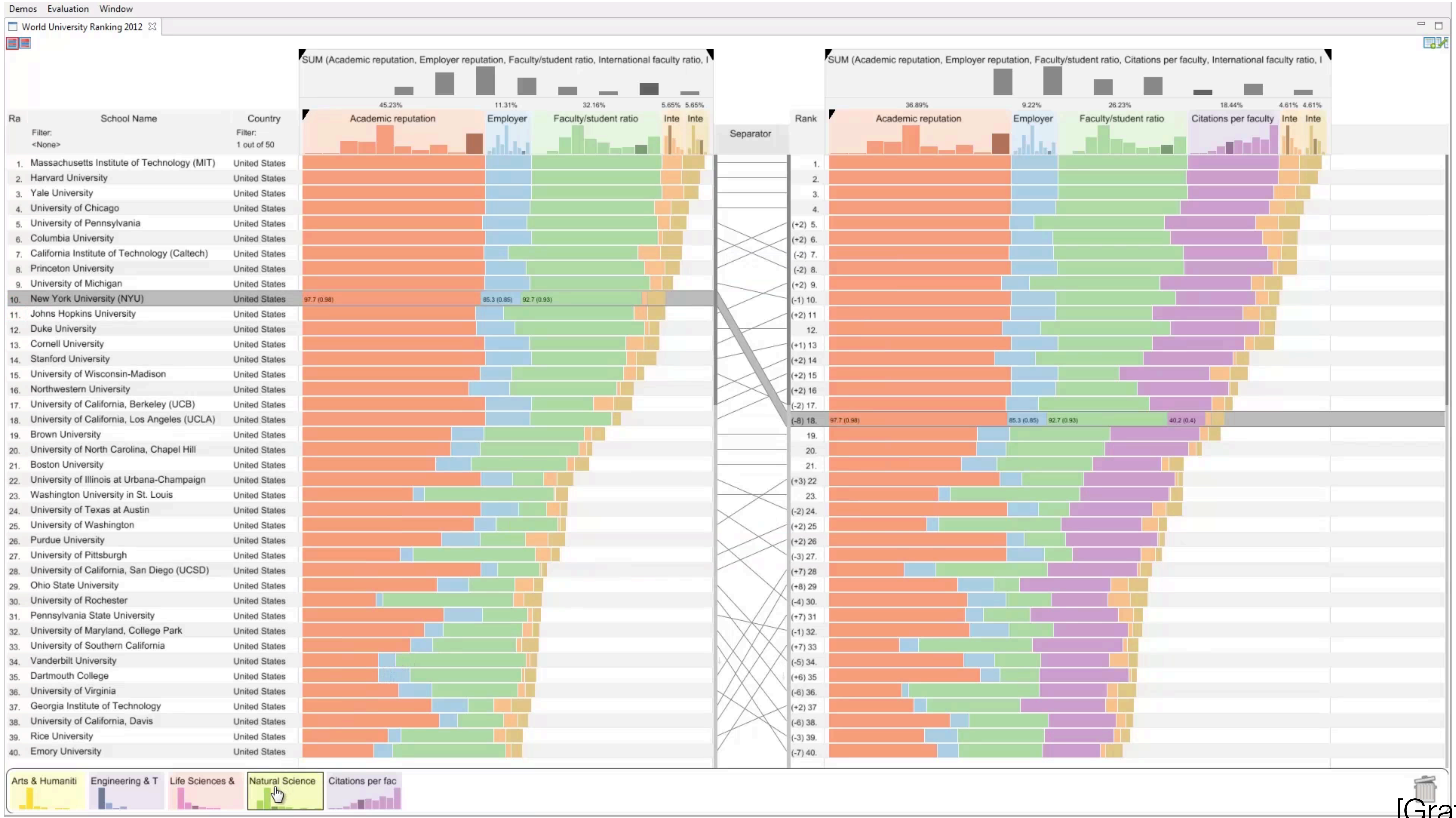
- Allow user to find patterns by reordering the data
- Do this with tabular data all the time
- Note that categorical attributes don't really need sorting
  - We can compare these attributes no matter what order
  - Instead, sort categorical attribute based on an ordered attribute

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

Q♣	A♣	Q♠
K♦	Q♣	K♣
A♥	J♣	A♦
A♦	Q♠	J♦
Q♠	J♦	Q♣
Q♥	Q♦	J♥
A♣	J♥	A♠
K♠	J♠	J♣
K♥	K♦	J♠
A♠	K♣	A♥
J♥	Q♥	K♠
Q♦	K♥	Q♥
K♣	A♠	A♣
J♦	K♠	Q♦
J♣	A♥	K♥
J♠	A♦	K♦

Animation: Jump Cut vs. Animated Transitions

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A♣	J♥	A♠
K♠	J♠	J♣
K♥	K♦	J♠
A♠	K♣	A♥
J♥	Q♥	K♠
Q♦	K♥	Q♥
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J♦	K♠	Q♦
J♣	A♥	K♥
J♠	A♦	K♦

Side-by-side views

Q♣	A♦
K♦	Q♥
A♥	Q♠
A♦	A♣
Q♠	Q♦
Q♥	J♦
A♣	K♦
K♠	Q♣
K♥	K♥
A♠	A♠
J♥	J♠
Q♦	A♥
K♣	J♣
J♦	K♠
J♣	K♣
J♠	J♥

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K♣	J♣
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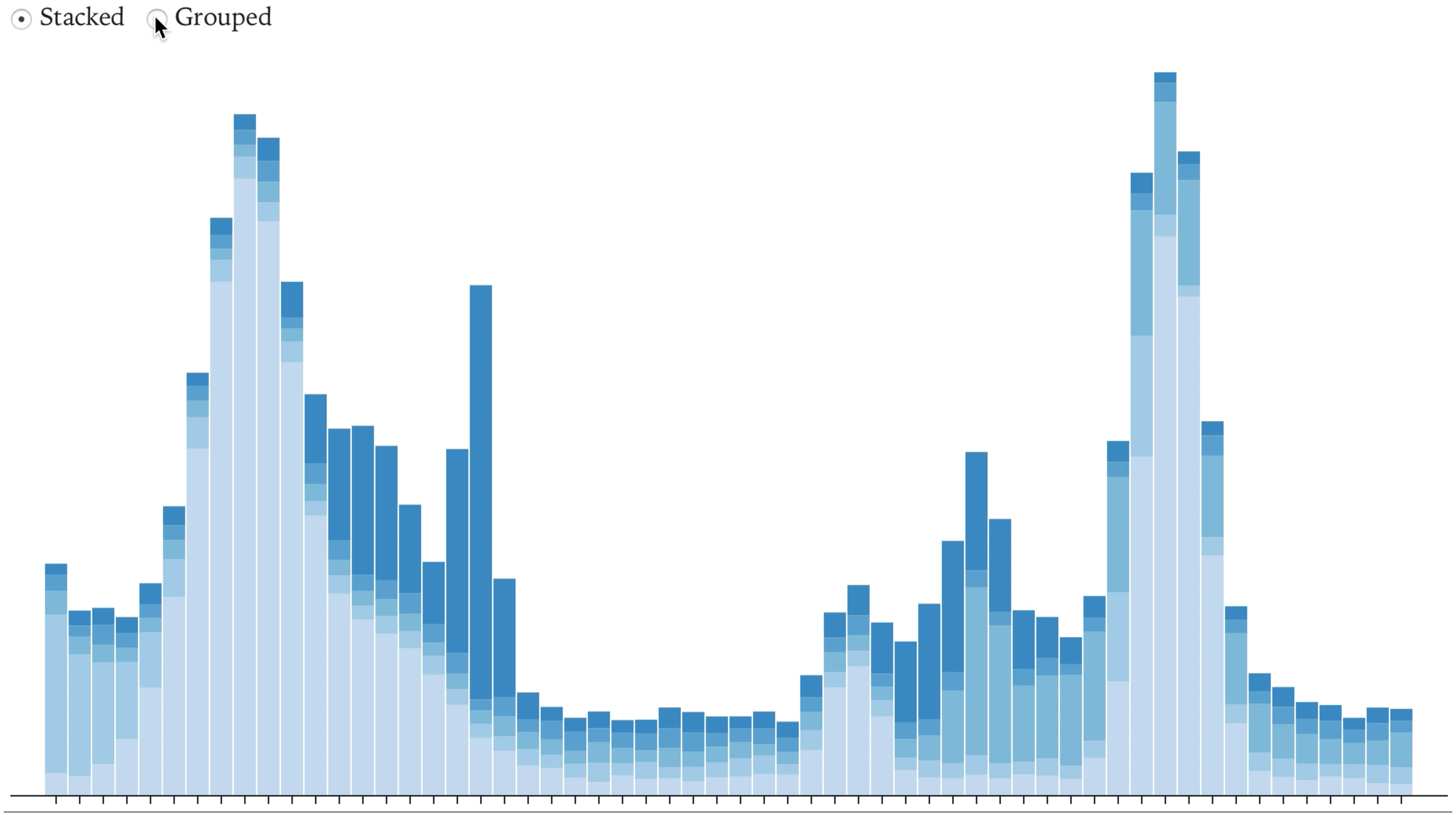
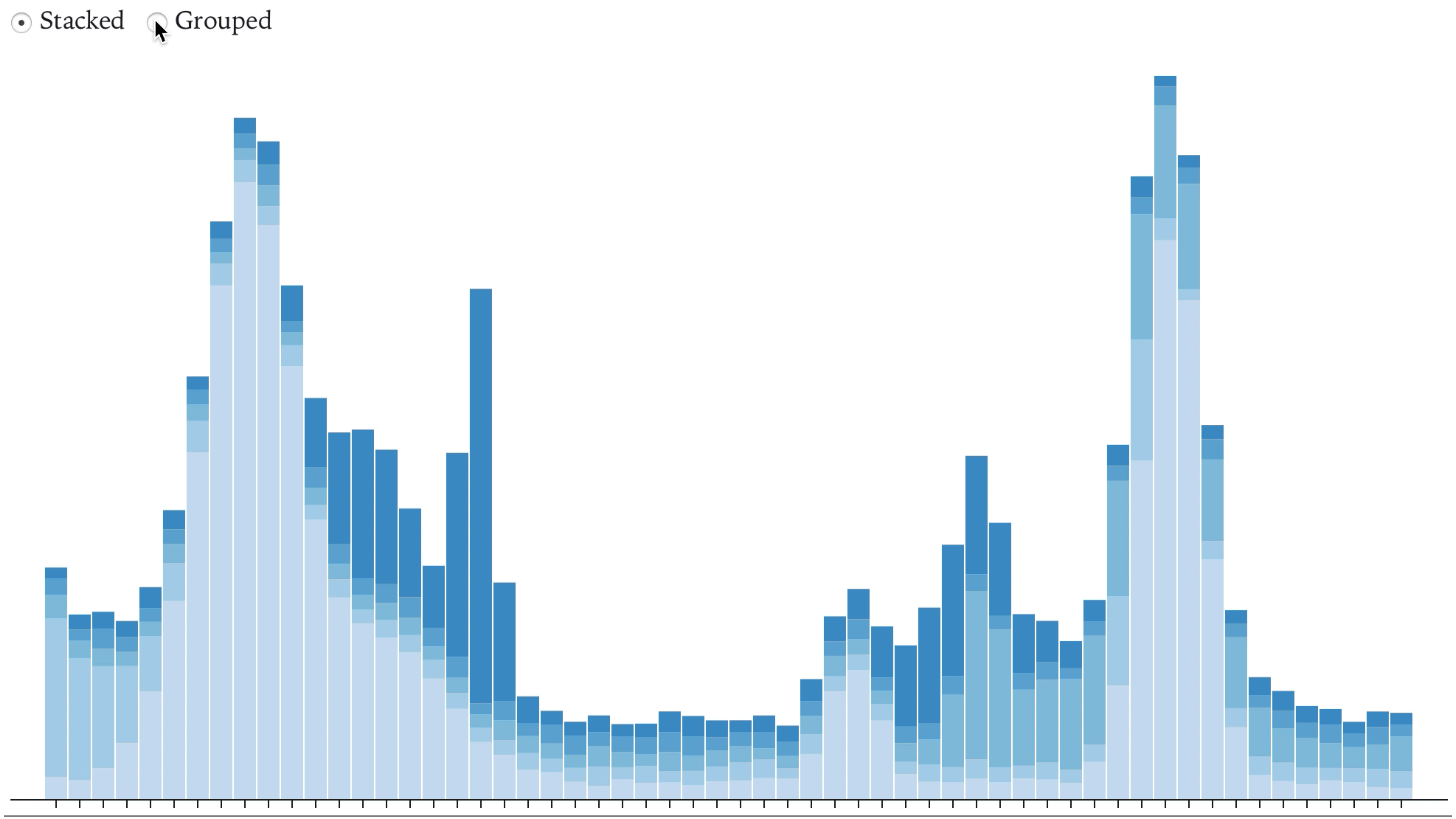
J♣	K♣
J♠	J♥

Animated Transitions



[M. Bostock]

Animated Transitions



[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]

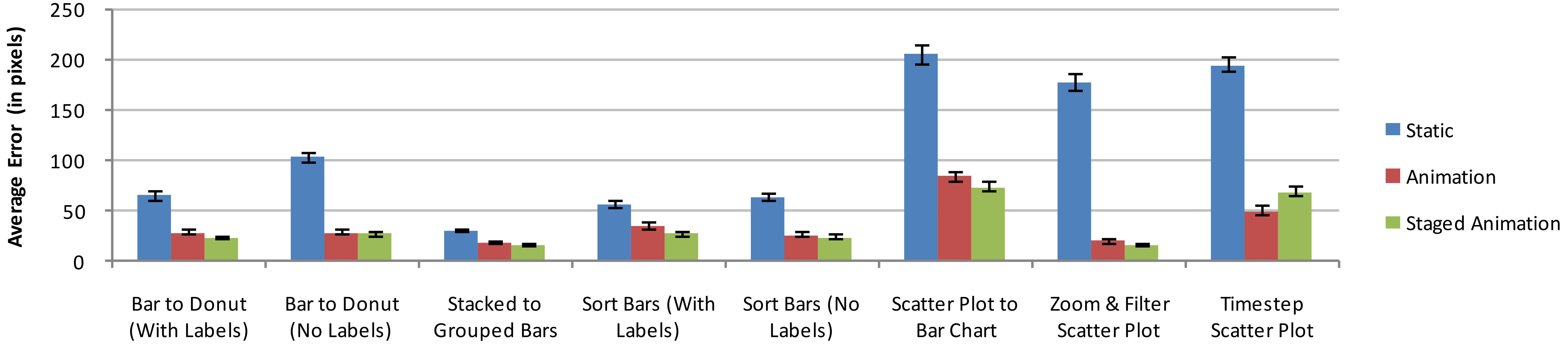
Design Considerations

- 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)

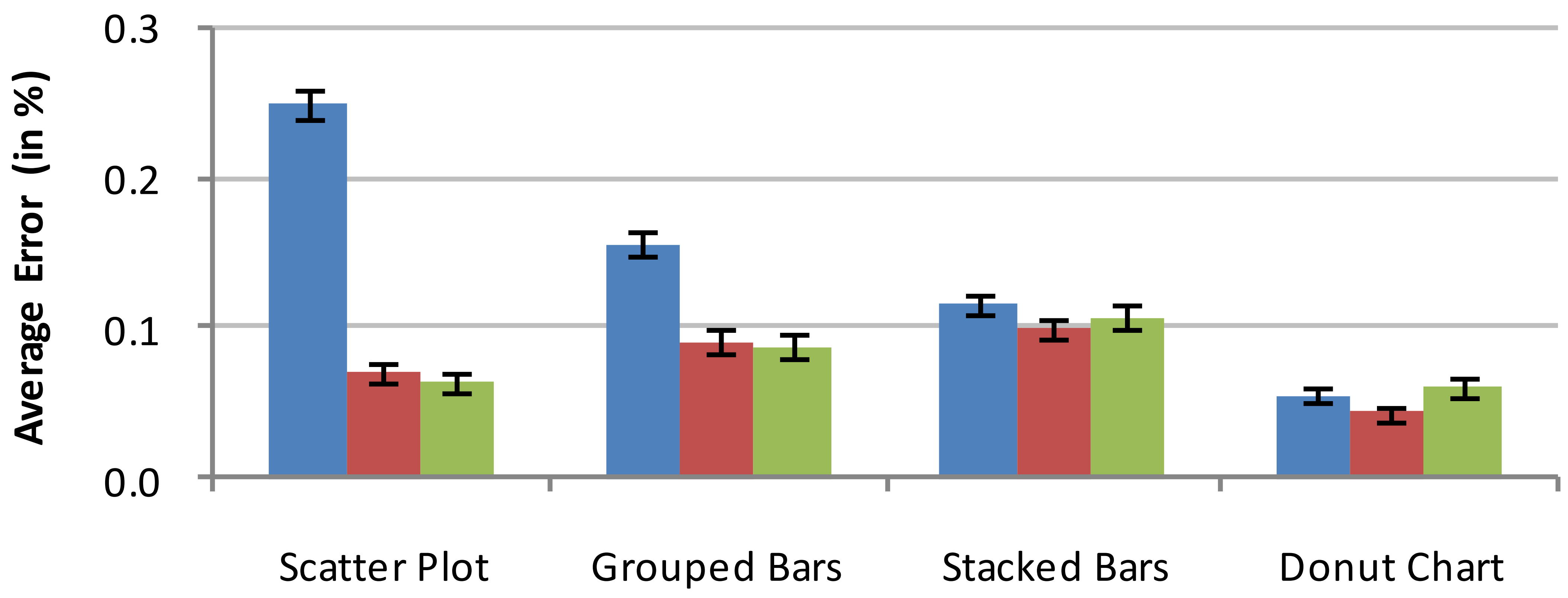
- Object Tracking: Follow objects across a transition and identify the locations of the objects in the final graphic
  - Tests: bar chart to donut chart, stacked to grouped bars, sorting a bar chart, scatter plot to bar chart, timestep in a scatterplot
  - Either a jump cut or an animated transition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

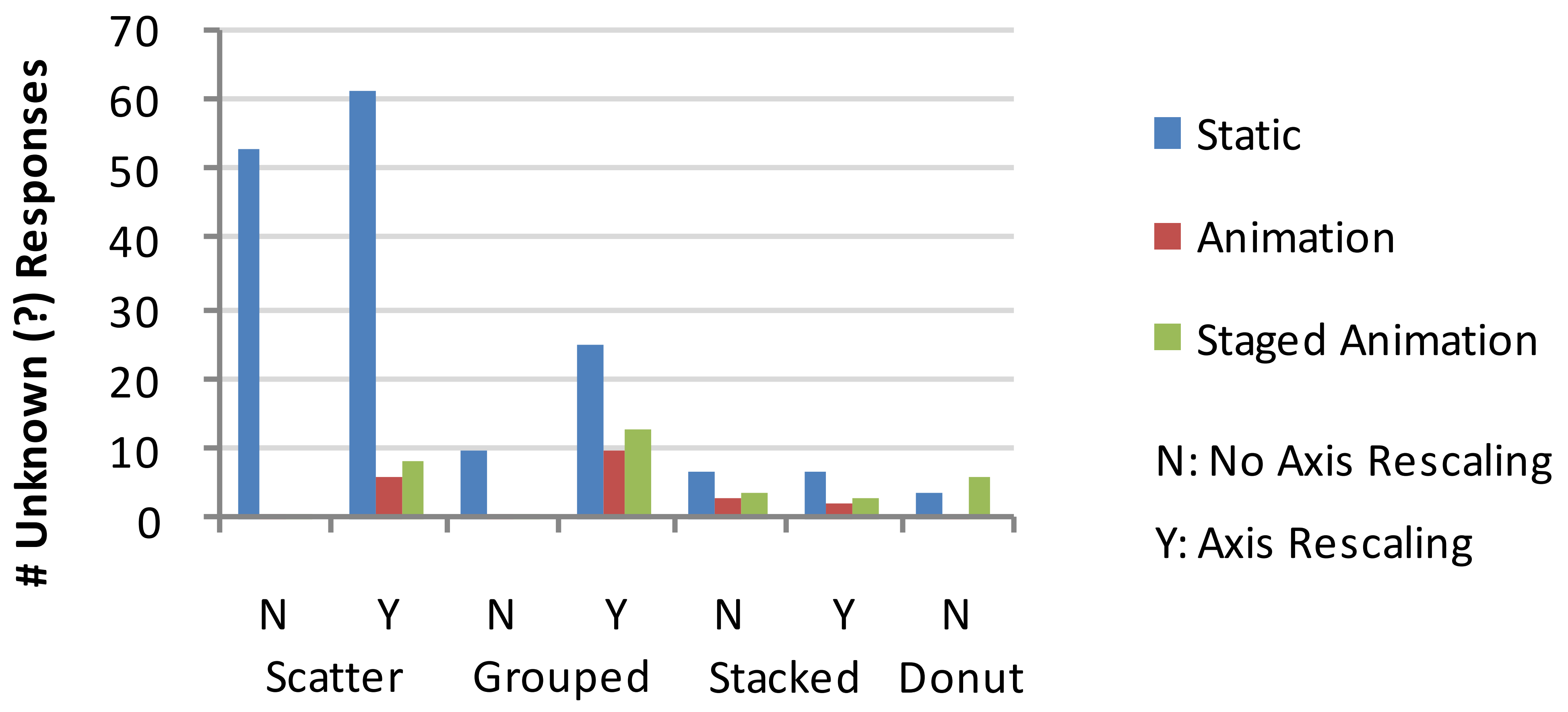


[Heer and Robertson, 2007]

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)

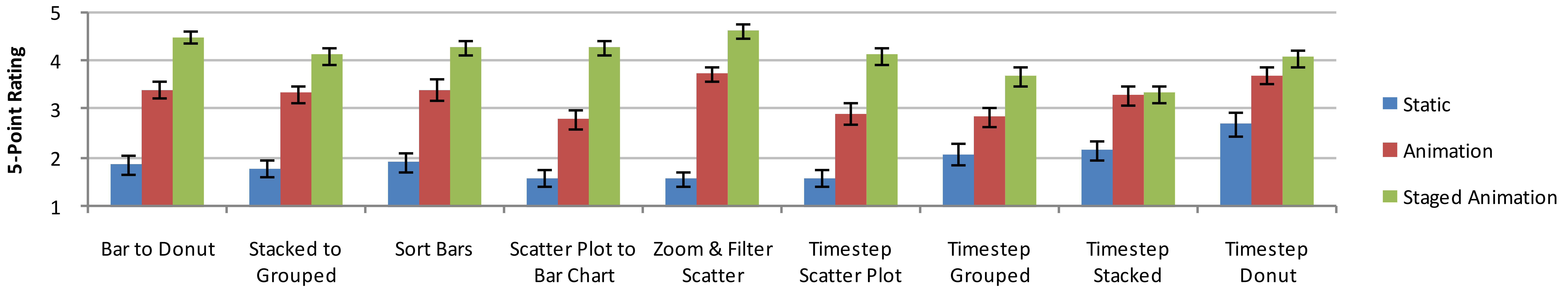




[Heer and Robertson, 2007]

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

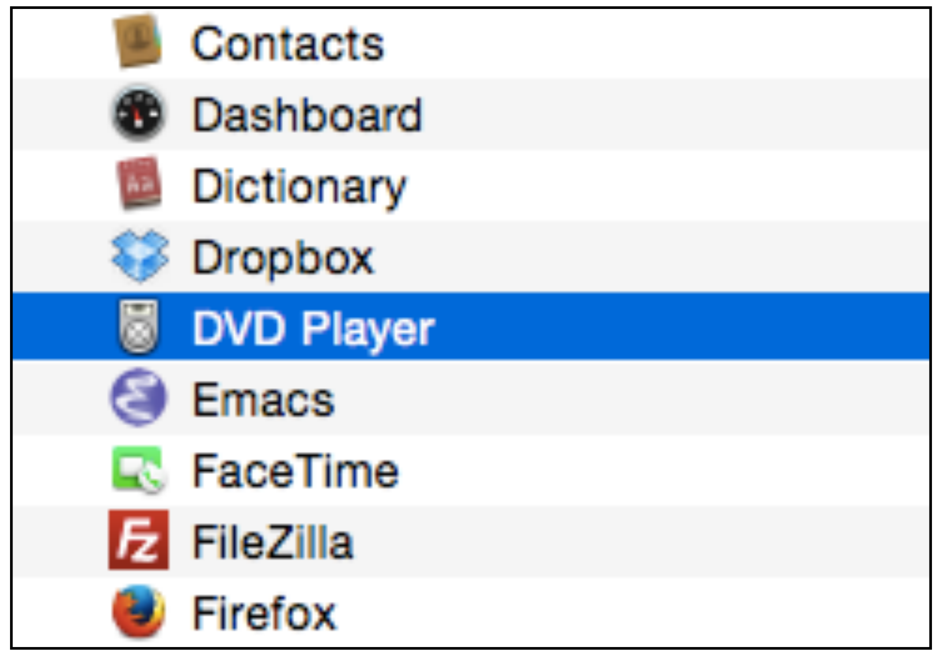
- https://www.youtube.com/watch?v=uO8wpm9HSB0

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



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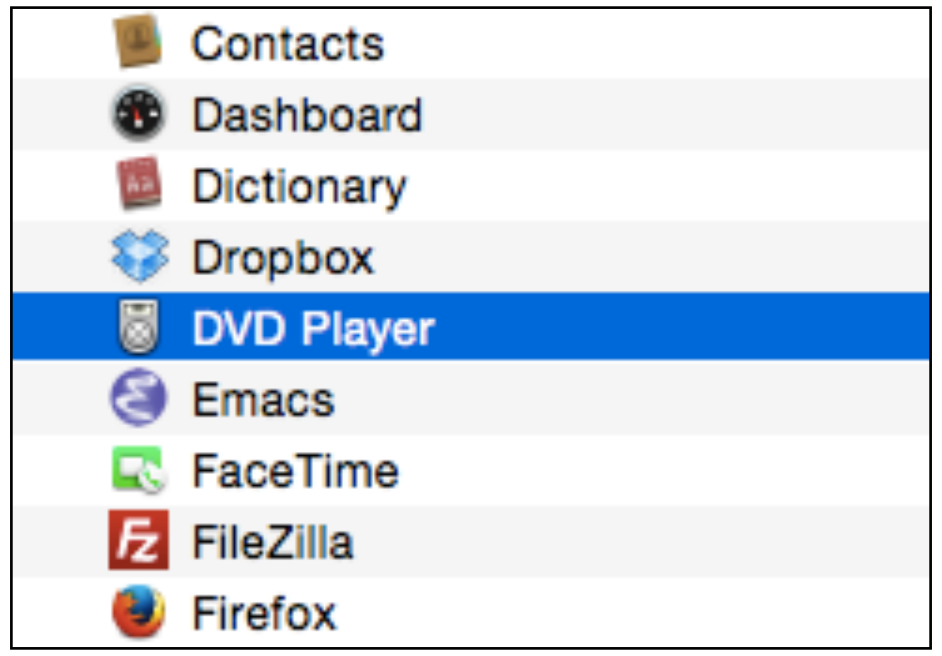
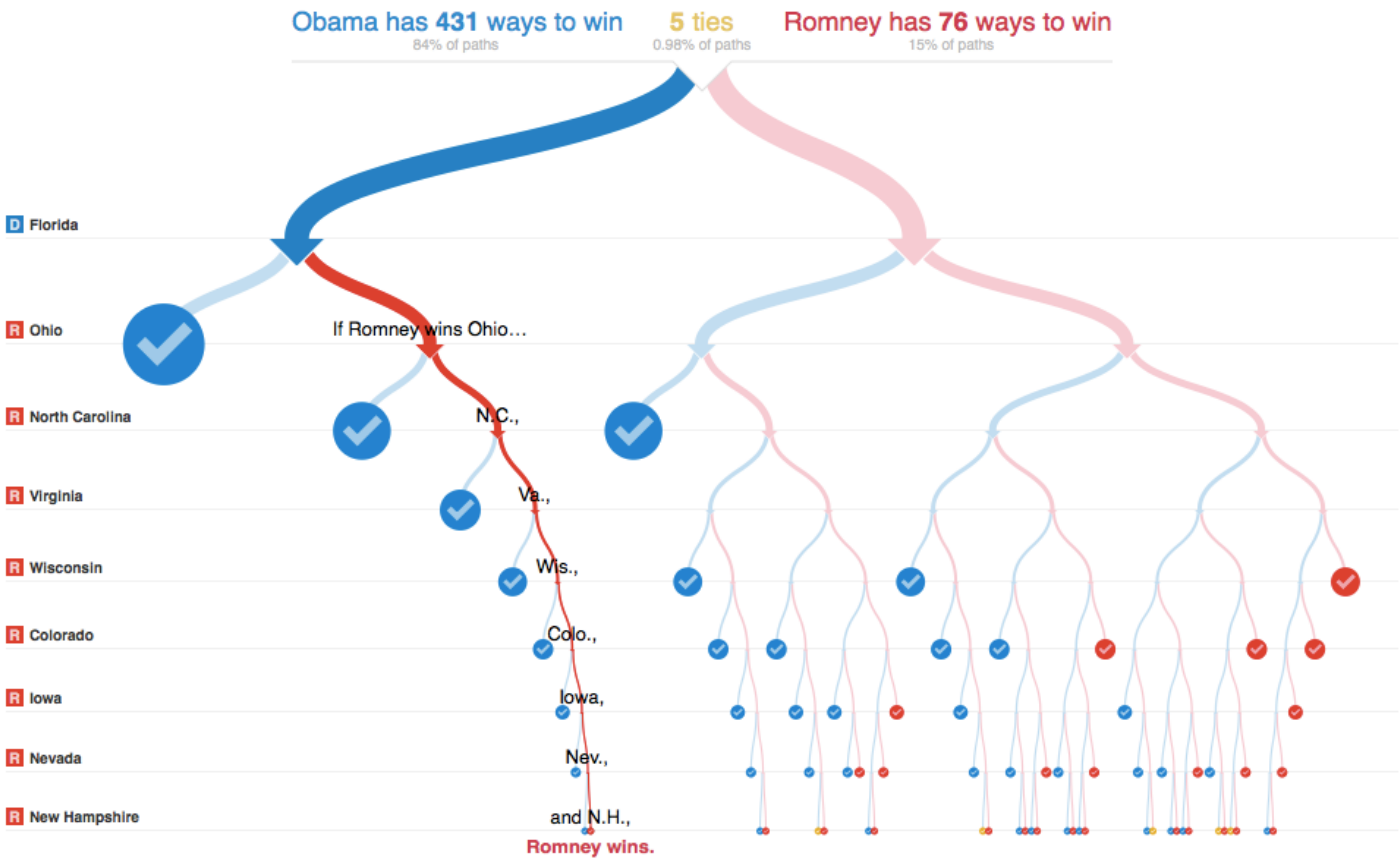


Highlighting



[NYTimes]

Selection Outcomes

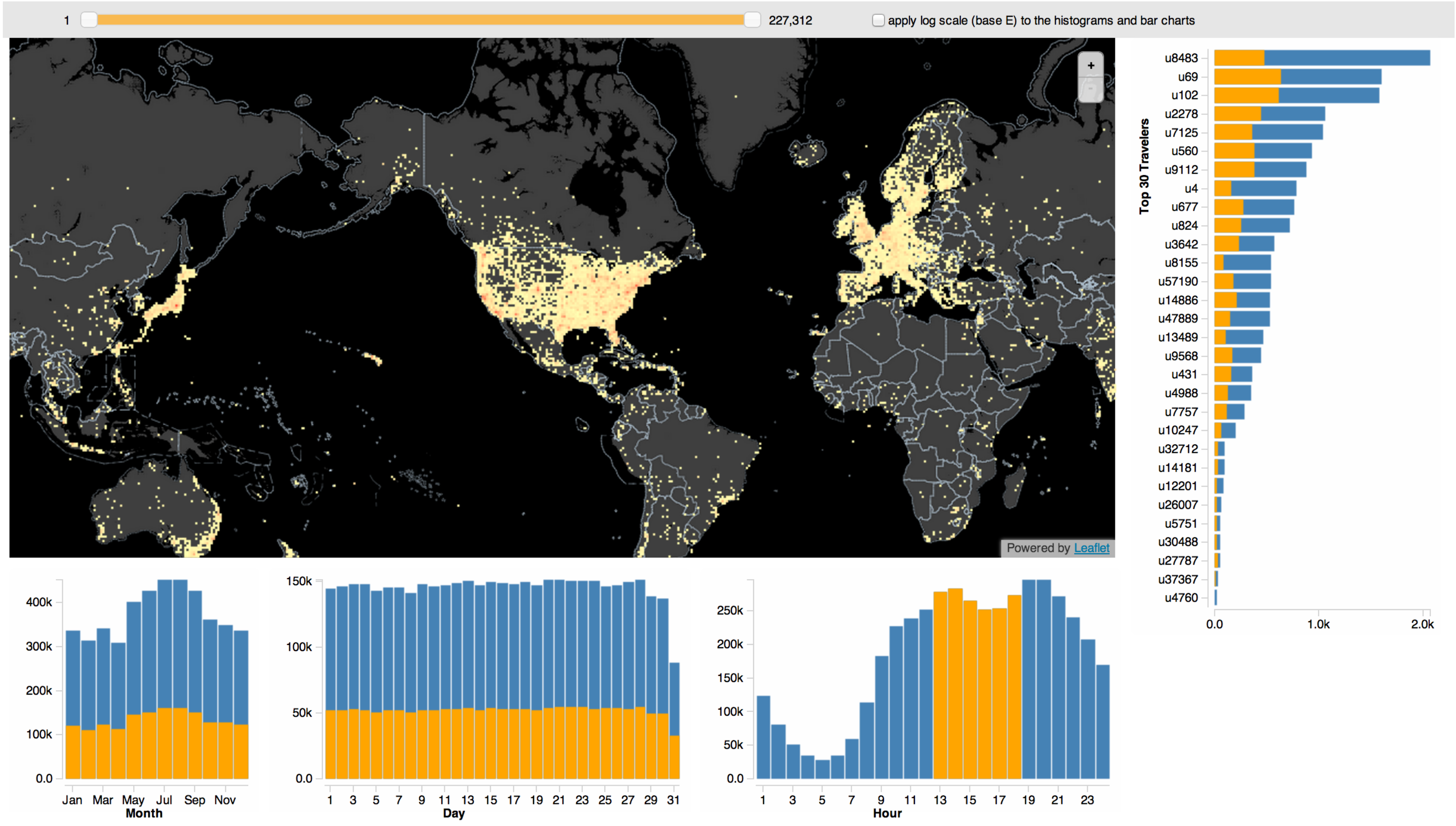
- Selection is usually a part of an action sequence
- Can filter, aggregate, reorder selected items

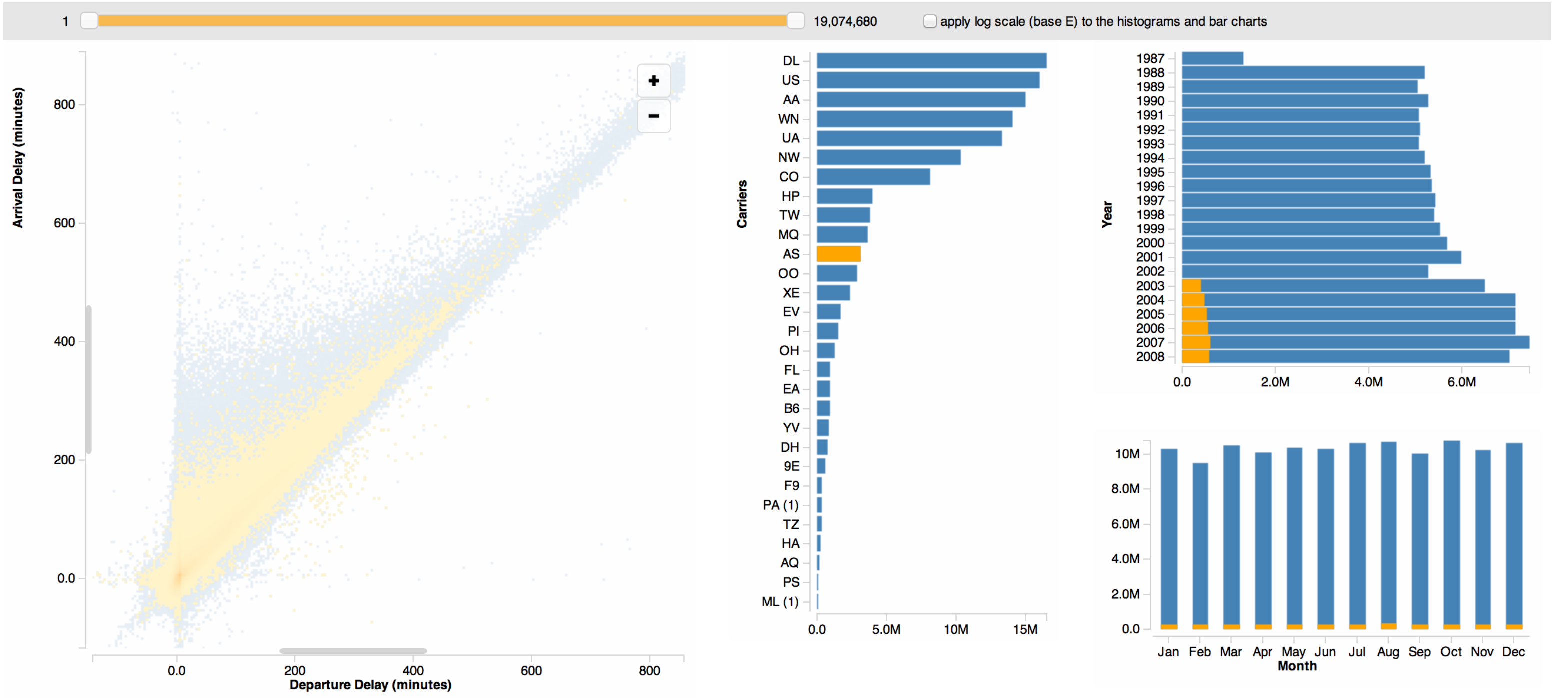
Responsiveness Required

- 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

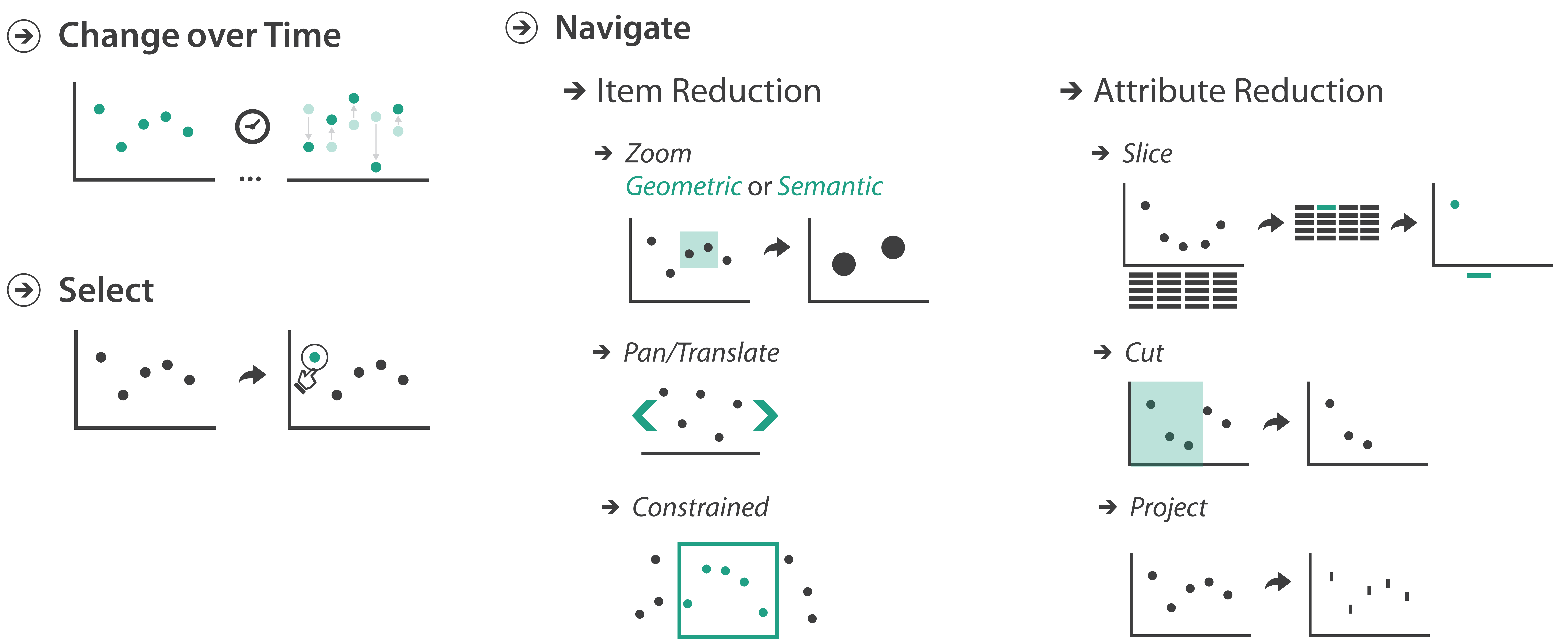
- The Effects of Interactive Latency on Exploratory Visual Analysis, Z. Liu and J. Heer, 2014
- Brush & link, select, pan, zoom





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

Interaction Overview



[Munzner (ill. Maguire), 2014]

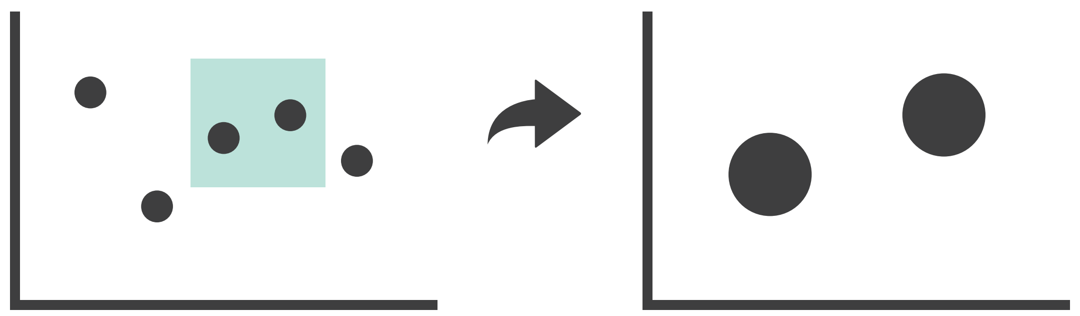
Navigation

- 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)

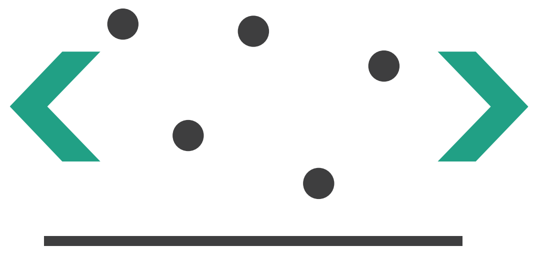
Navigation

➔ Item Reduction

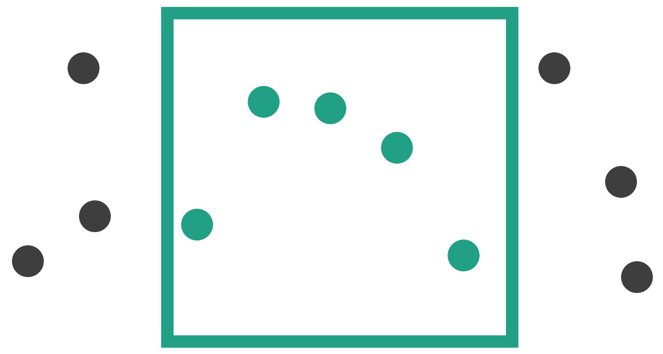
➔ *Zoom*
Geometric or *Semantic*



➔ *Pan/Translate*

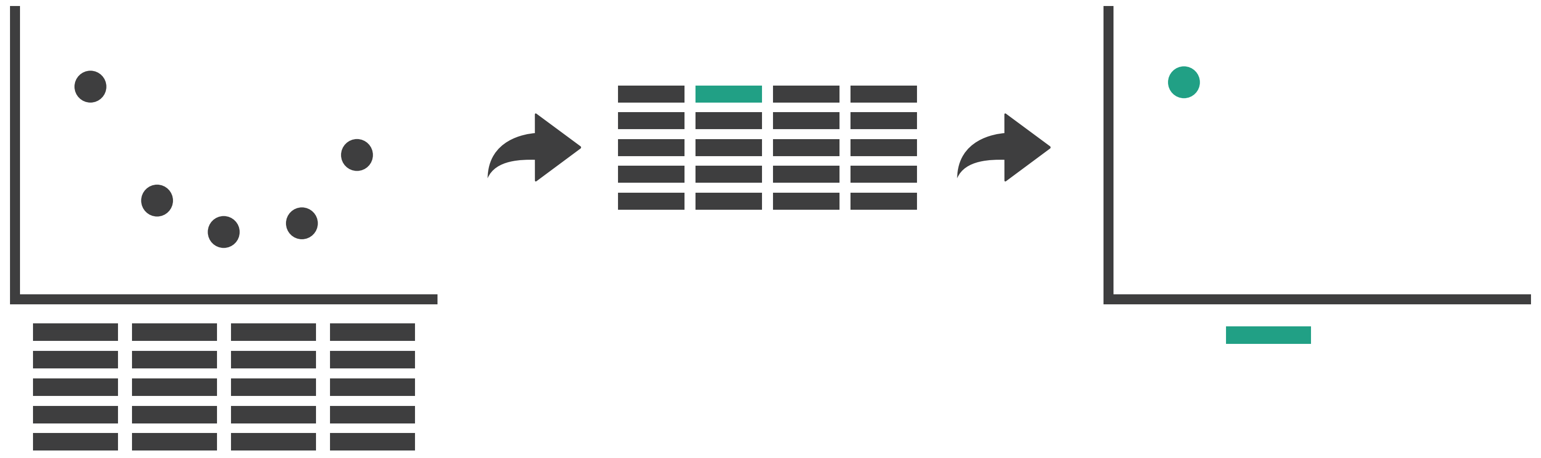


➔ *Constrained*

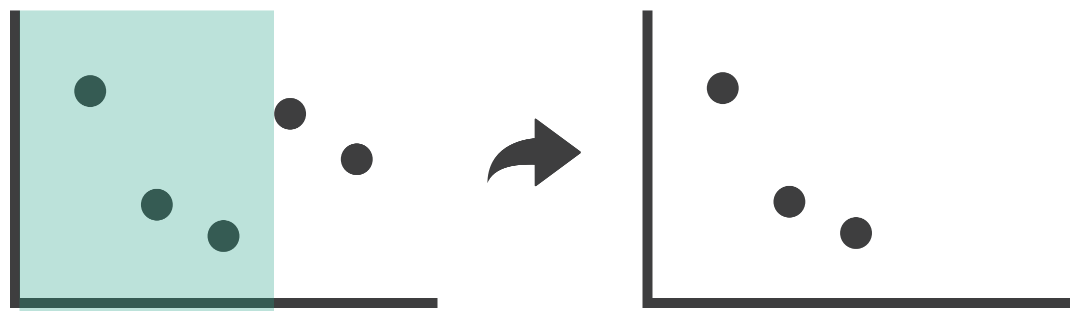


➔ Attribute Reduction

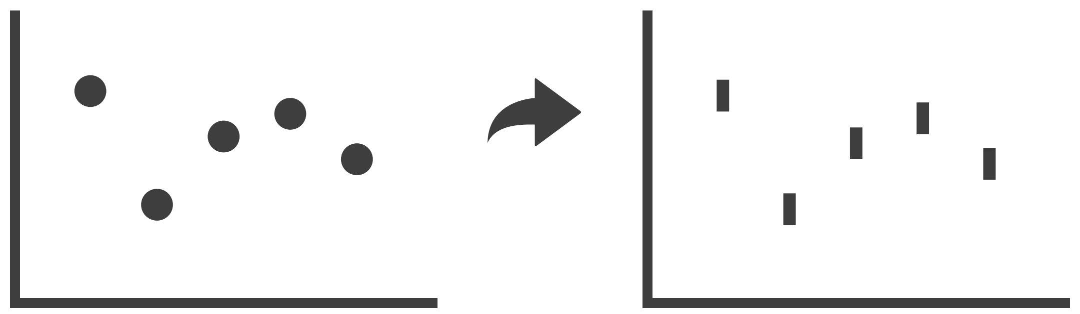
➔ *Slice*



➔ *Cut*



➔ *Project*

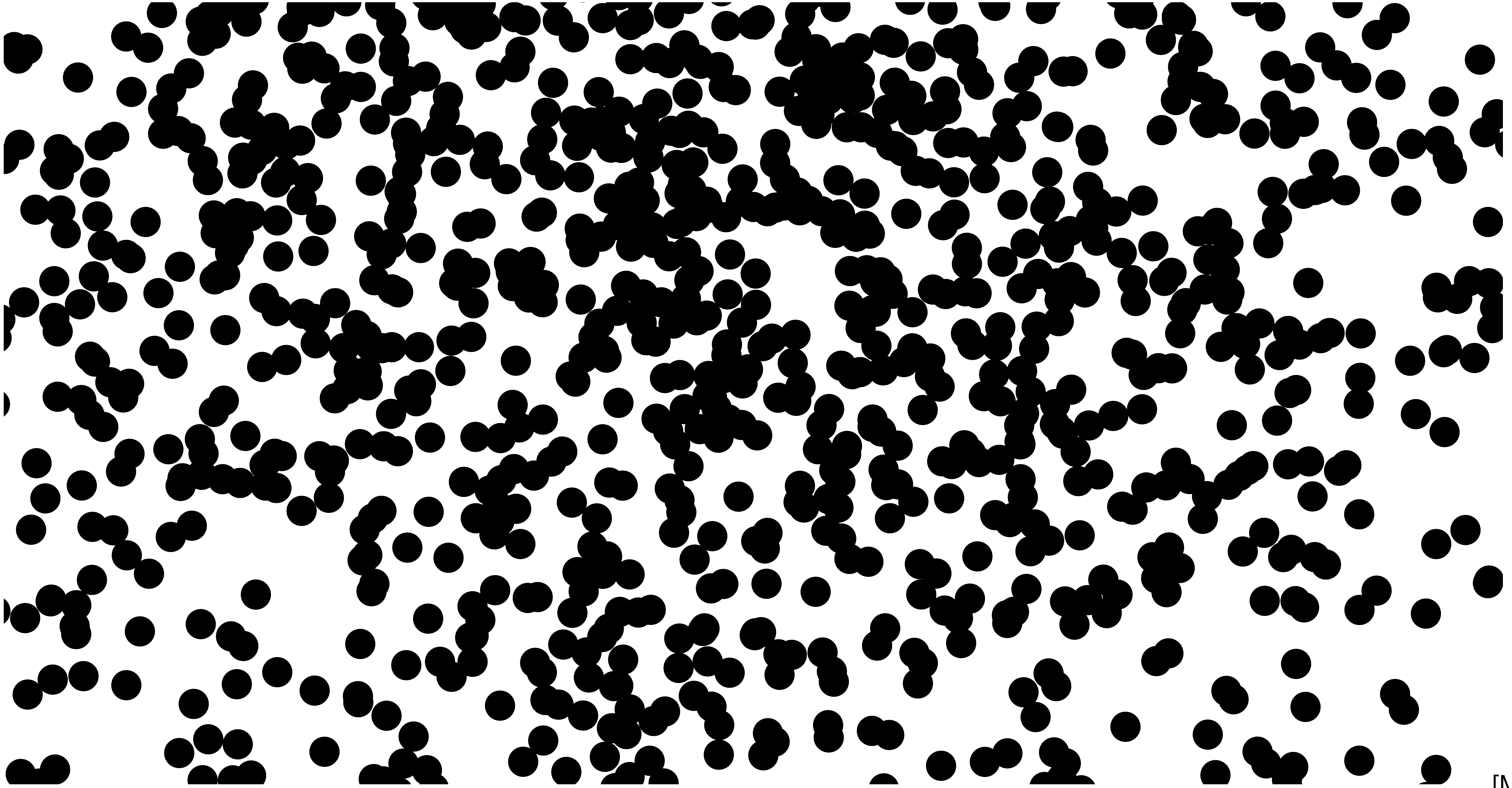


[Munzner (ill. Maguire), 2014]

Zooming

[M. Bostock]

Geometric Zooming

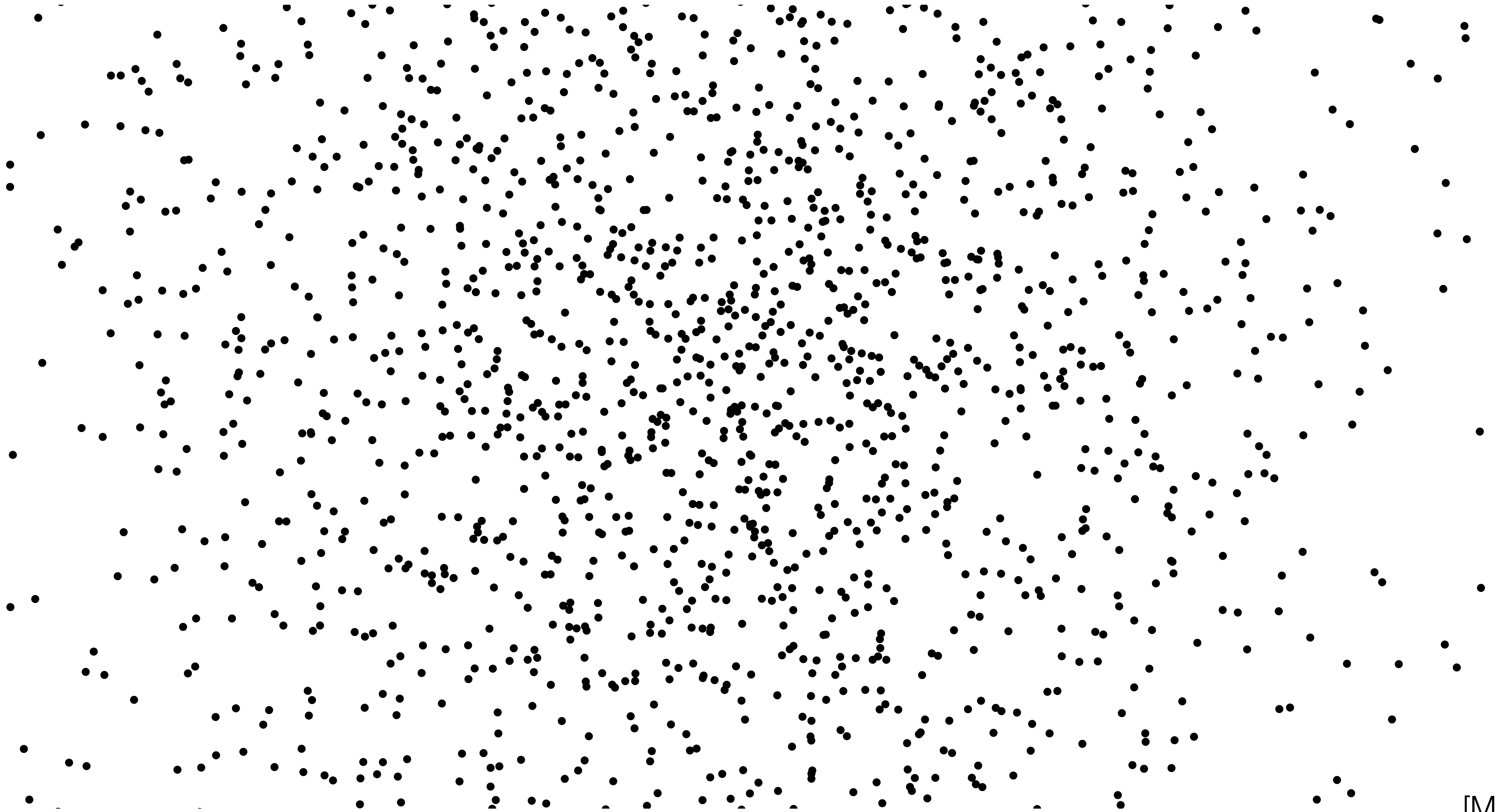


[M. Bostock]

Zooming

[M. Bostock]

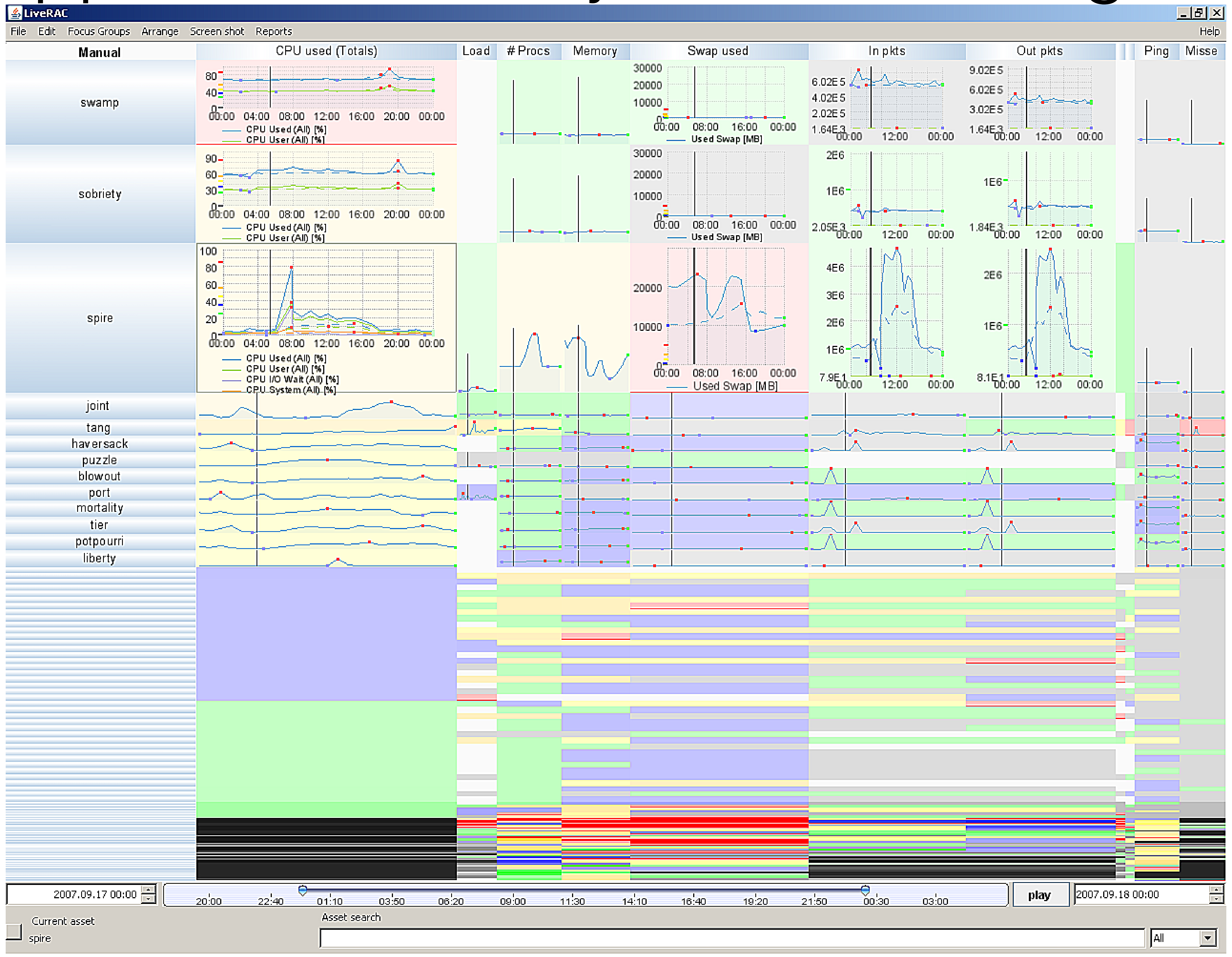
Semantic Zooming



[M. Bostock]

Zooming

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

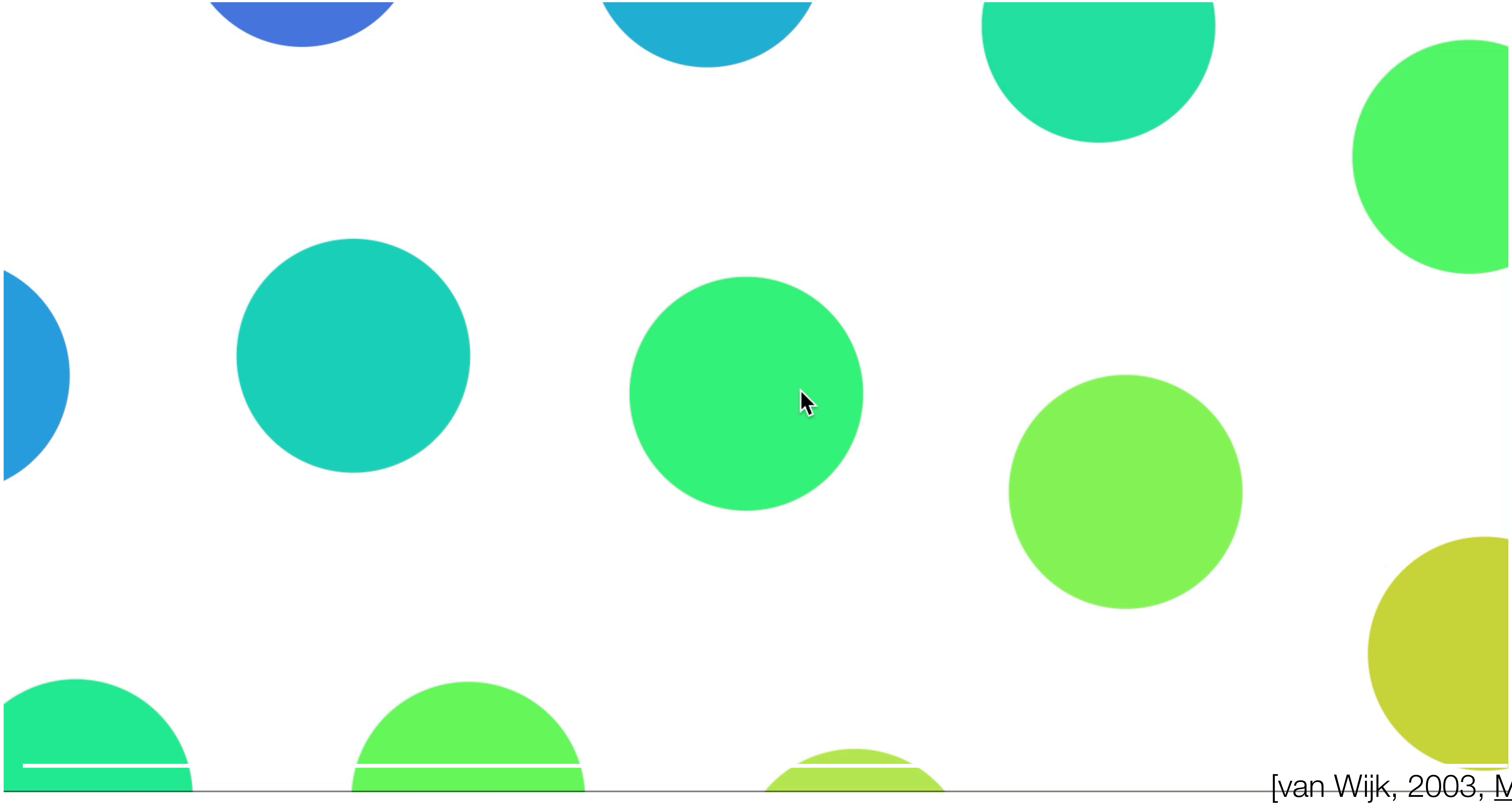


[McLachlan et al., 2008]

Navigation Constraints

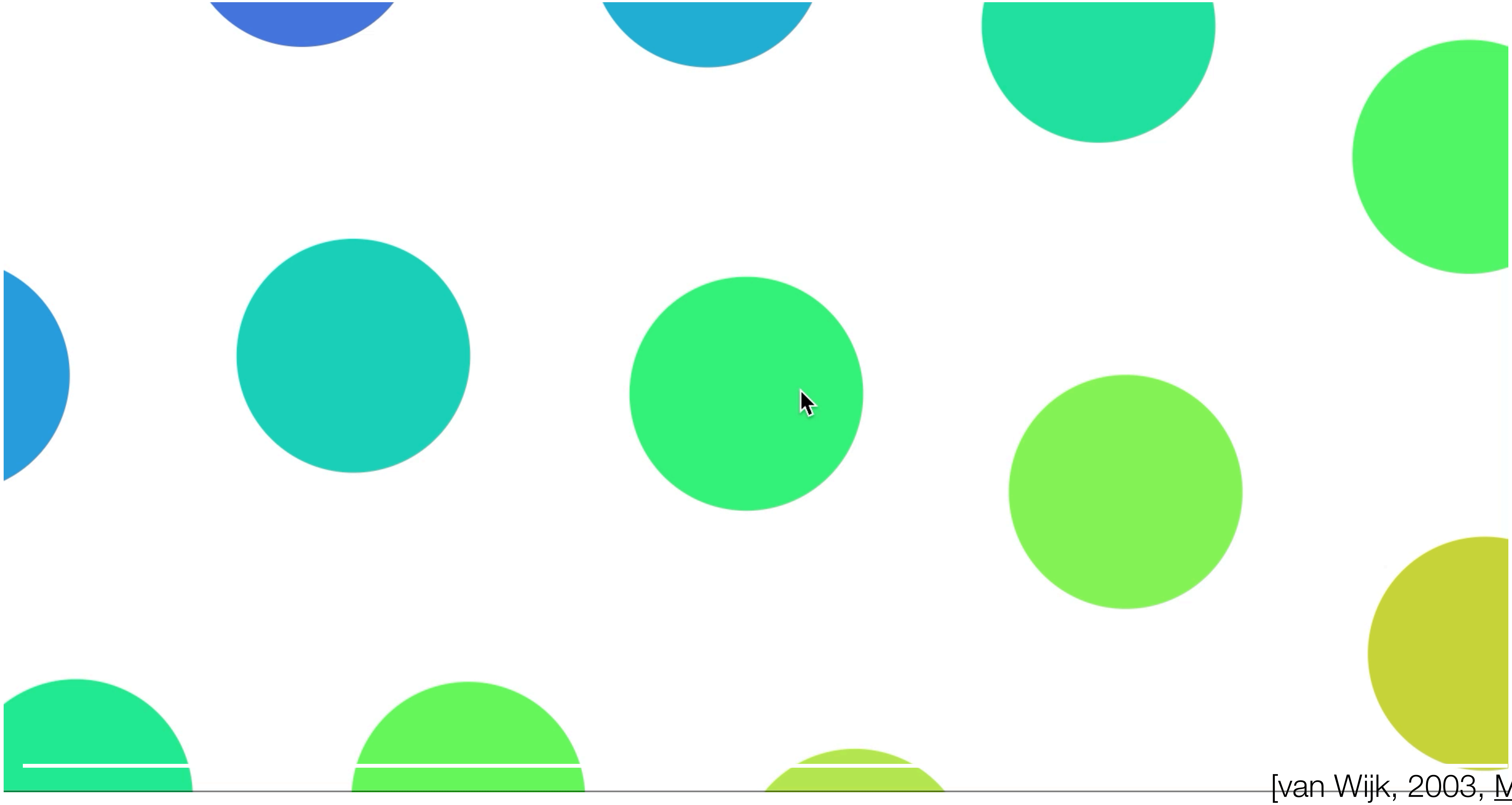
- **Unconstrained** navigation: walking around in the world or an immersive 3D environment
  - Fairly standard in computer games to go where you want
  - Constrained by walls, objects (collision detection)
- Constrained navigation:
  - 3D: camera must be right-side up
  - Limit pan/zoom to certain areas
  - 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



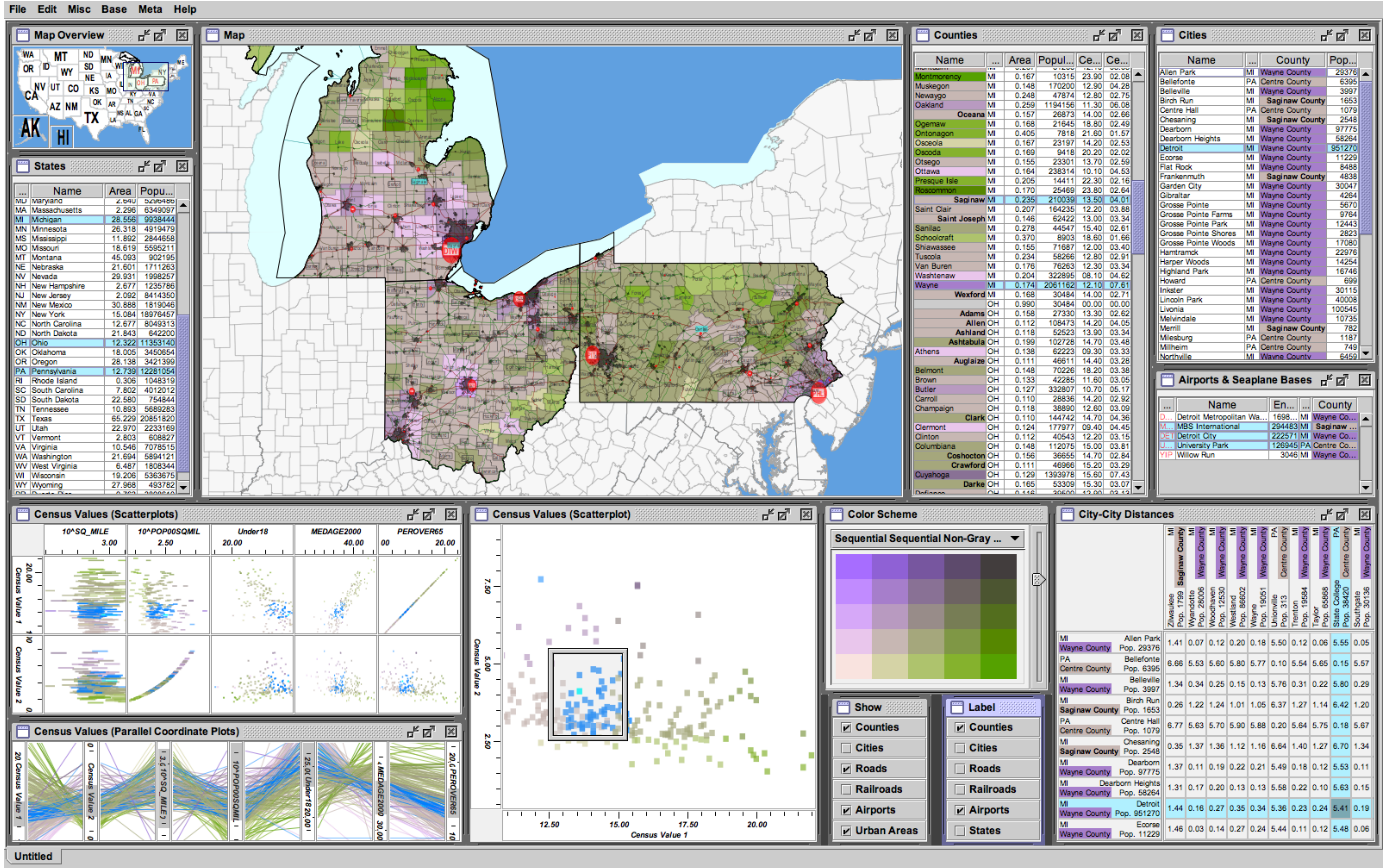
[van Wijk, 2003, M. Bostock]

van Wijk Smooth Zooming



[van Wijk, 2003, M. Bostock]

Multiple Views



[Improvise, Weaver, 2004]

Multiple Views

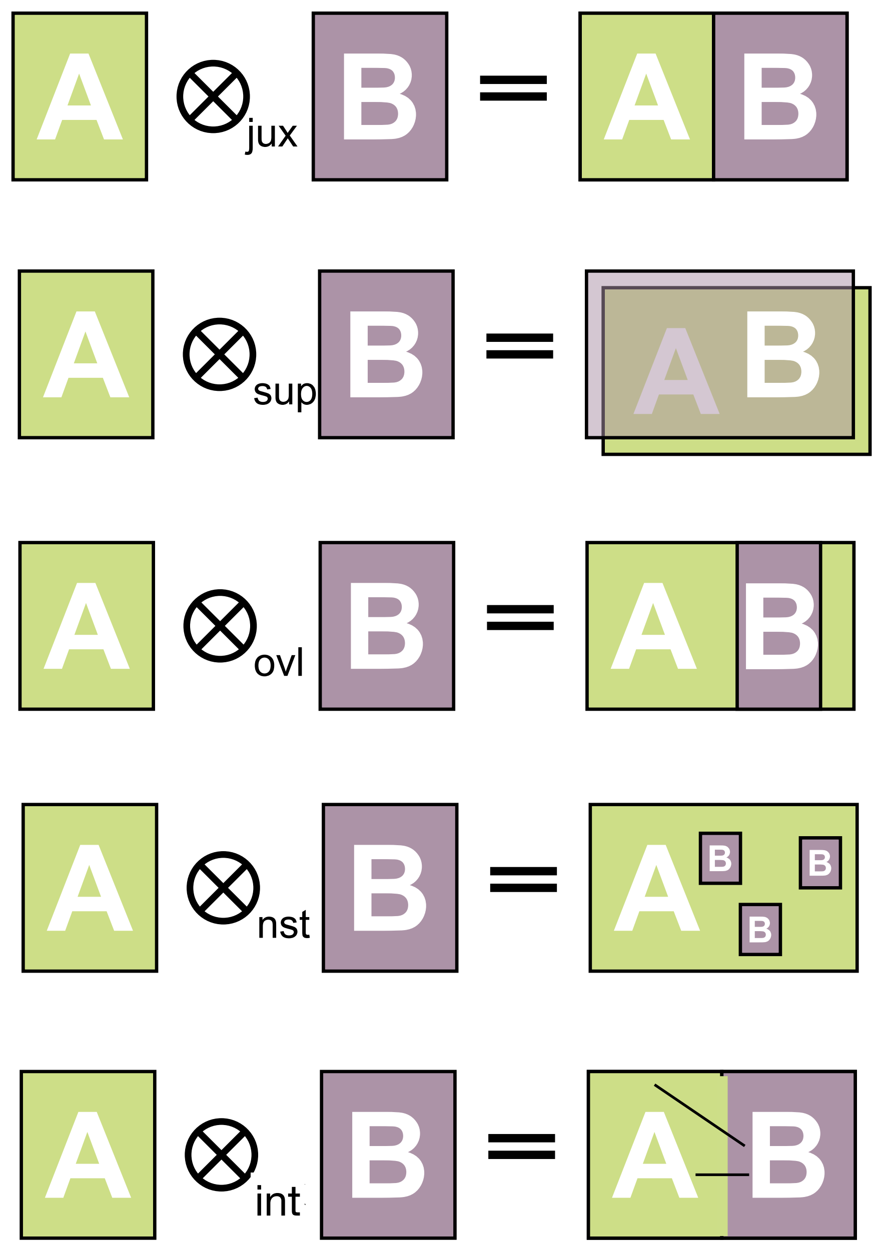
- Why have just one visualization?
- Sometimes data is best examined in more than one view
  - Clutter/visual overload
  - Different attributes (cannot show all attributes in one view)
  - Different scales (task requires overview or detail)
  - Different encodings (no single encoding is optimal for all tasks)
- Eyes Beat Memory (Ch. 6)
  - Aiding working memory:
    side-by-side/layers > animated > jump cuts
  - Showing all visual elements at once → don't need to remember

Multiple Views

- Big questions:
  - How to partition display or layer views?
  - How to coordinate views (e.g. navigation, selection)?
  - What data is shared?

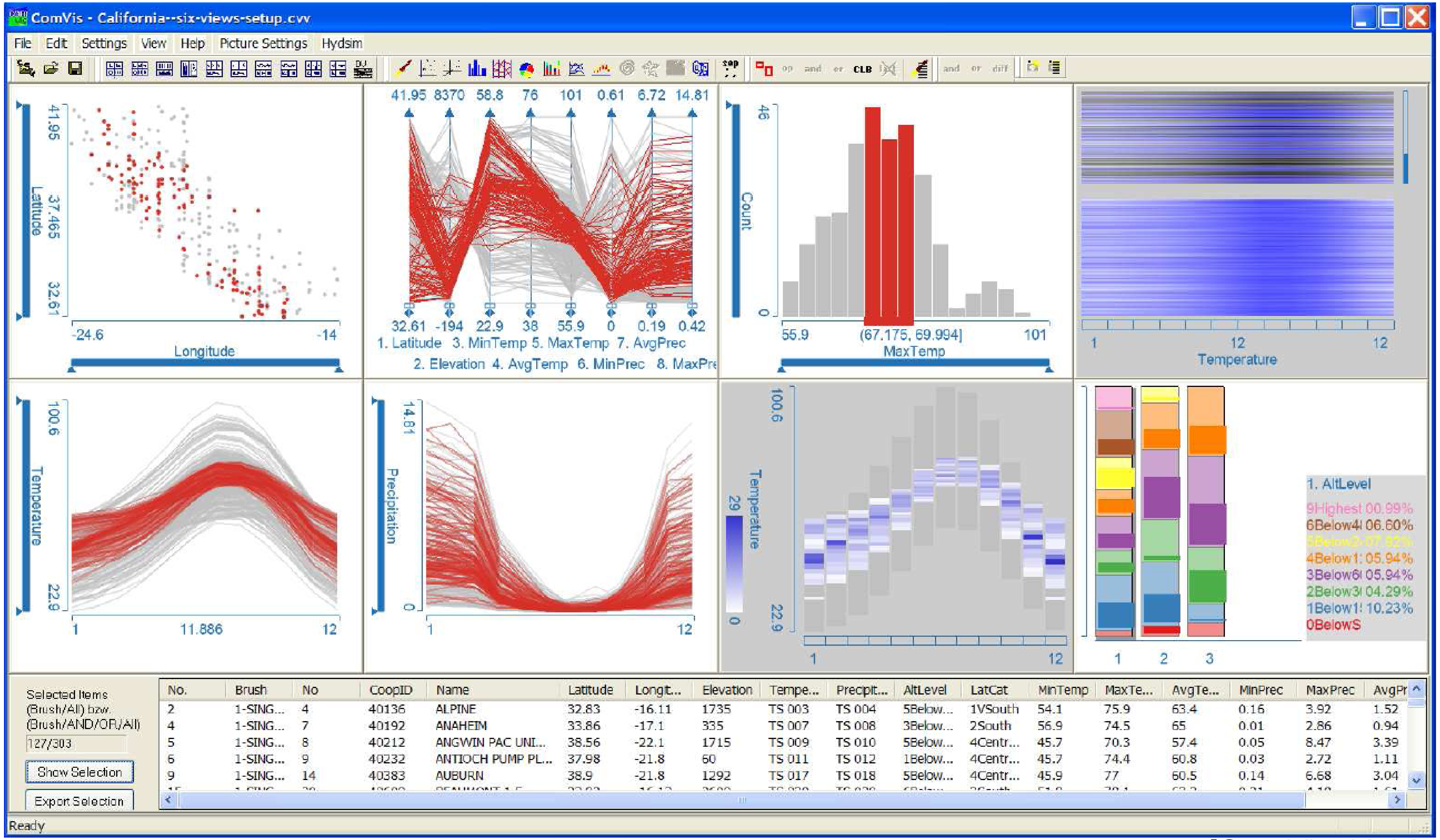
Design Space of Composite Visualization

- Composite visualization views (CVVs)
  - Includes Coordinated multiple views (CMV)
  - + More!
- Design Patterns:
  - Juxtaposition: side-by-side
  - Superimposition: layers
  - Overloading: vis meshed with another
  - Nesting: vis inside a vis (recursive vis)
  - Integration: "merge" views + links



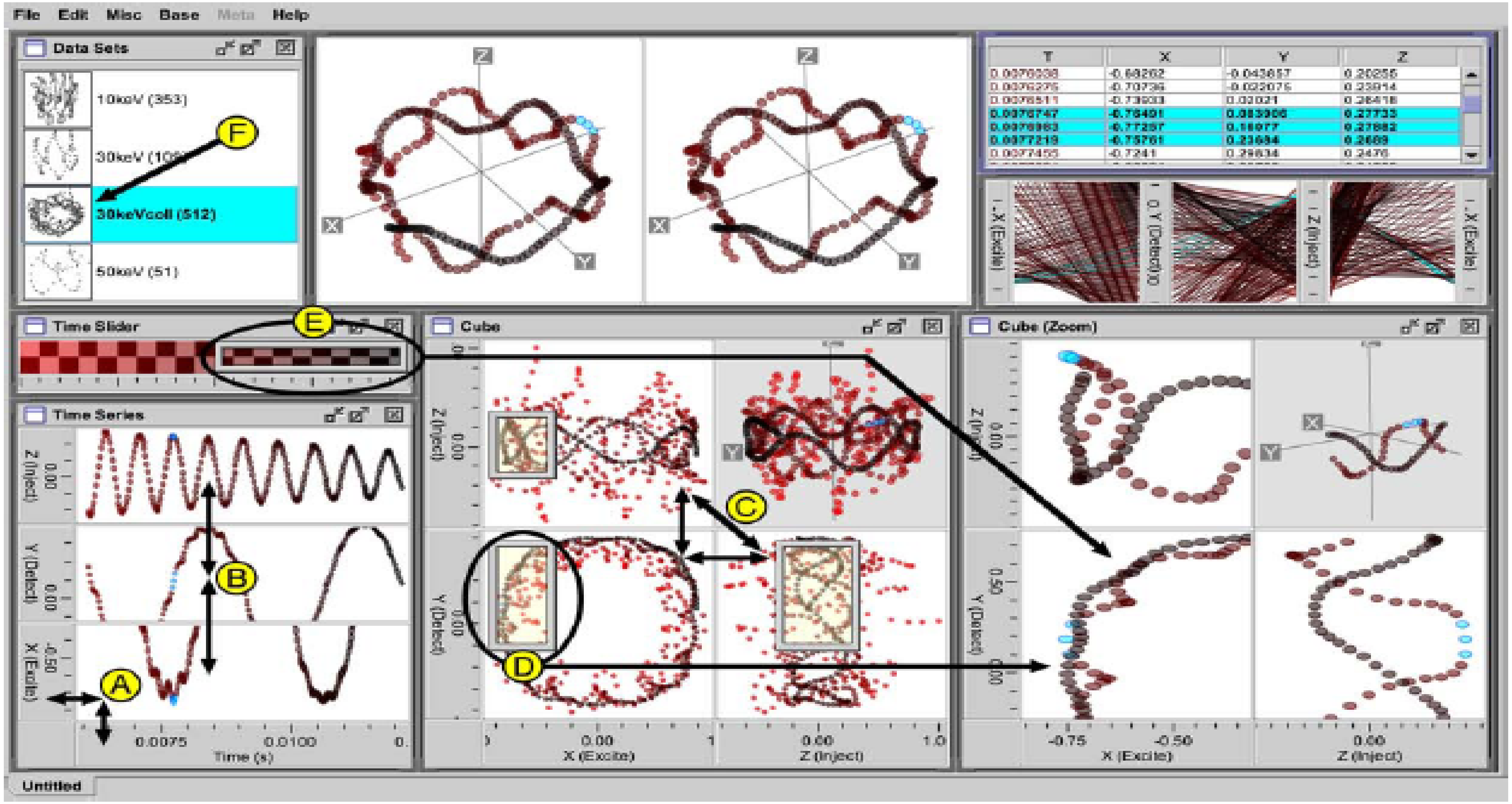
[W. Javed and N. Elmqvist, 2012]

Juxtaposition



[ComVis, K. Matkovic et al., 2008]

Juxtaposition



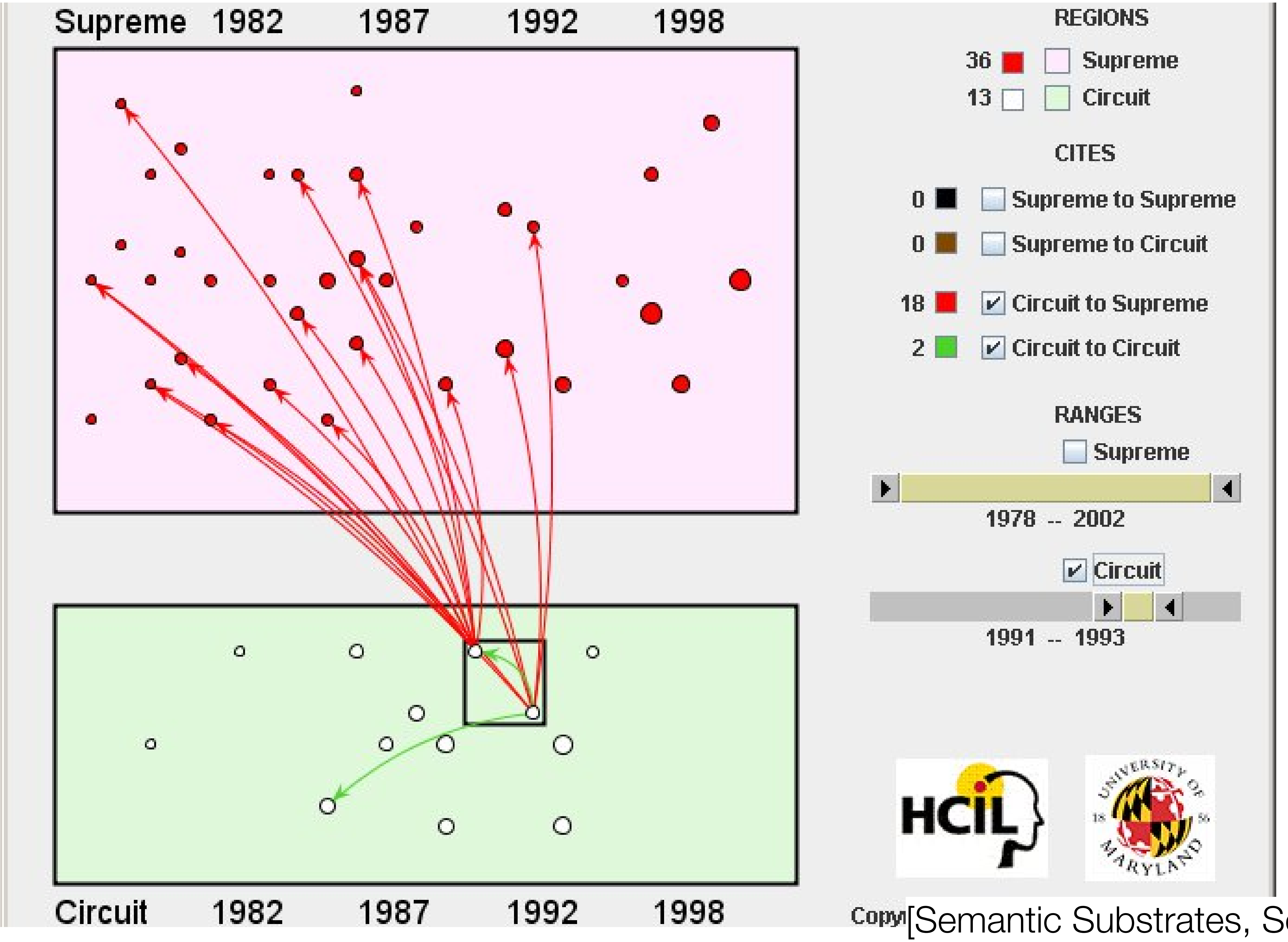
[Improvise, C. Weaver, 2004]

Juxtaposition Guidelines

- Benefits:
  - The component visualizations are independent and can be composed without interference
  - Easy to implement
- Drawbacks:
  - Implicit visual linking is not always easy to see, particularly when multiple objects are selected
  - Space is divided between the views, yielding less space for each view
- Applications: Use for heterogeneous datasets consisting of many different types of data, or for where different independent visualizations need to be combined.

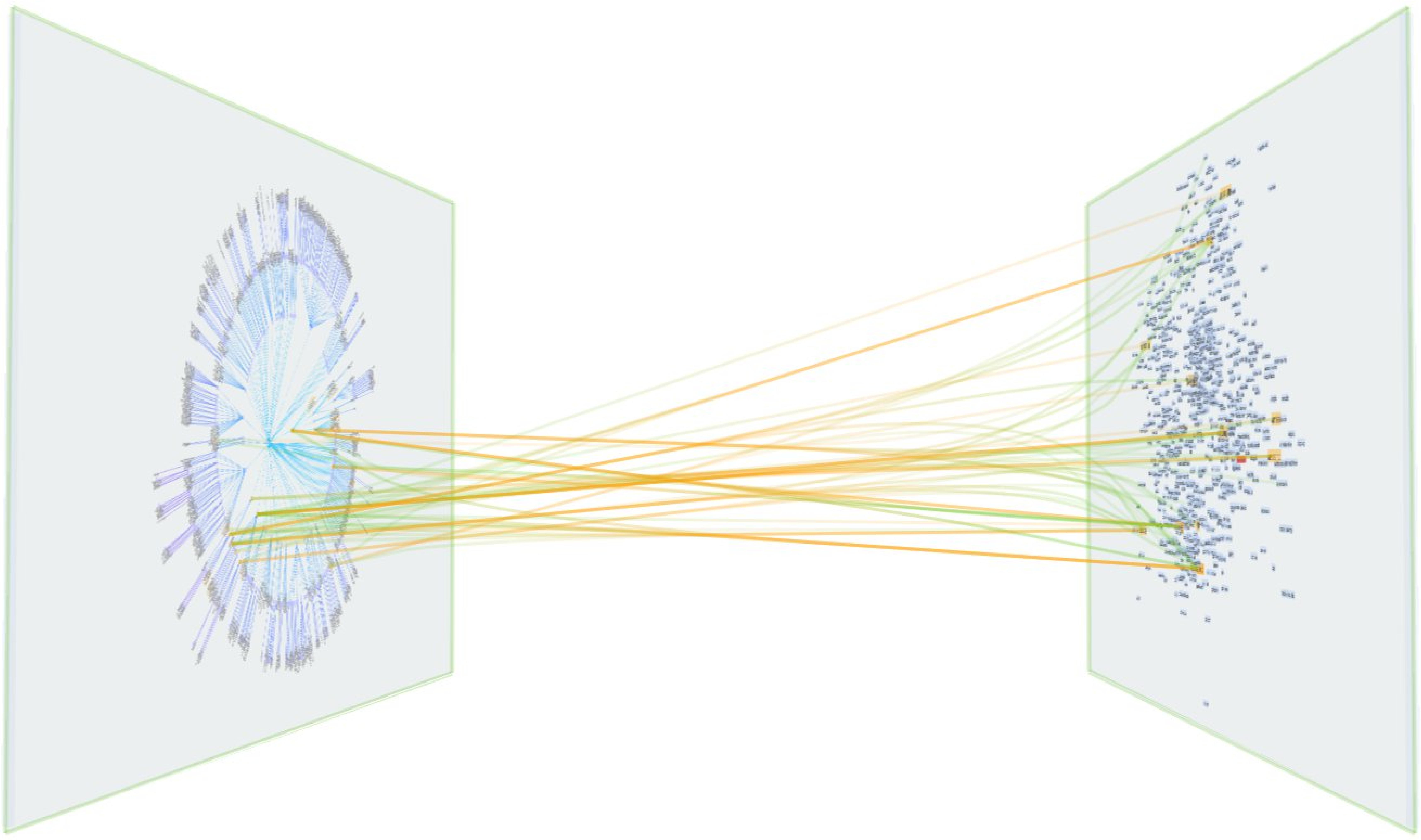
[W. Javed and N. Elmqvist, 2012]

Integration



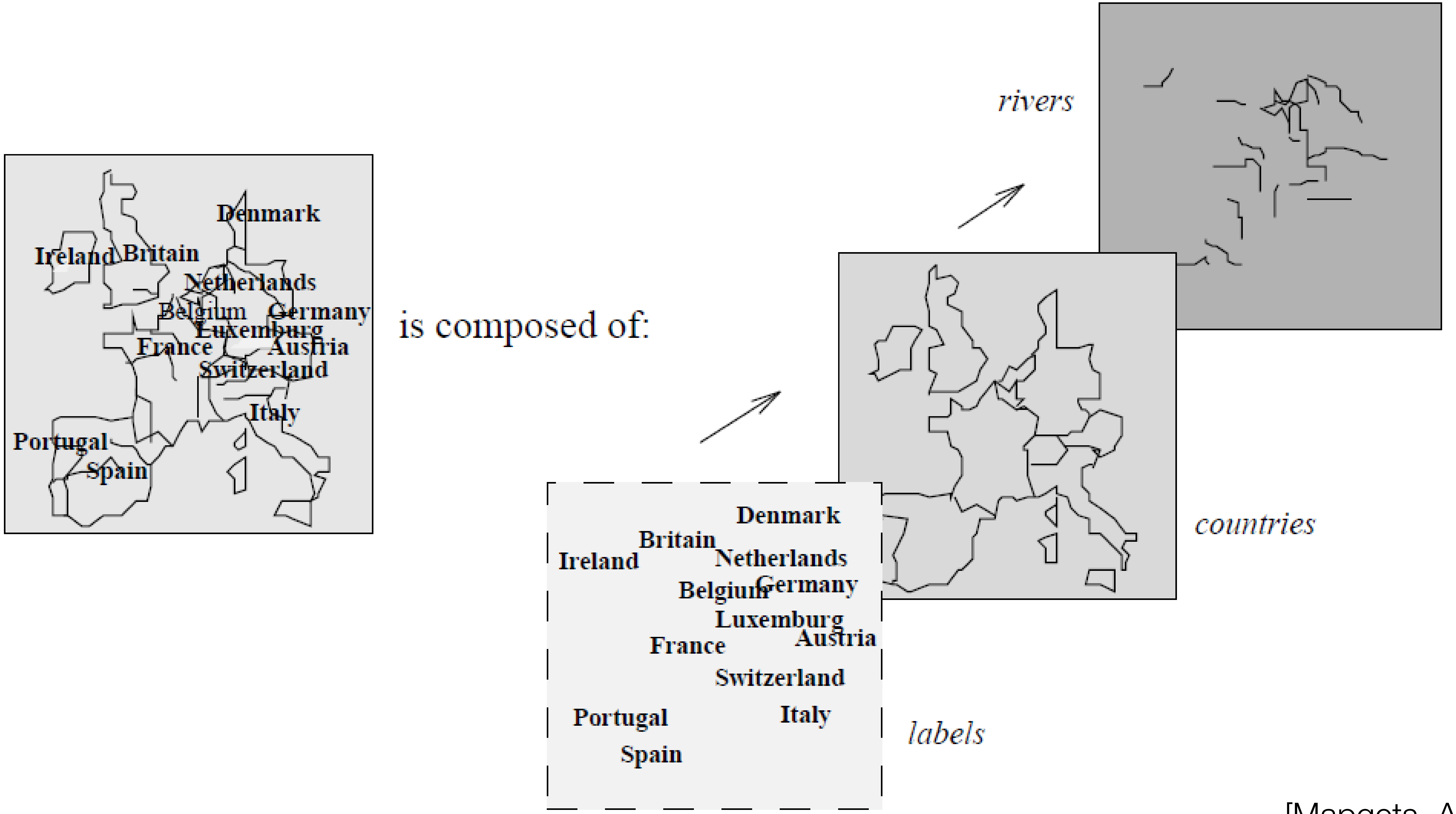
[Semantic Substrates, Schneiderin and Aris, 2006]

Integration



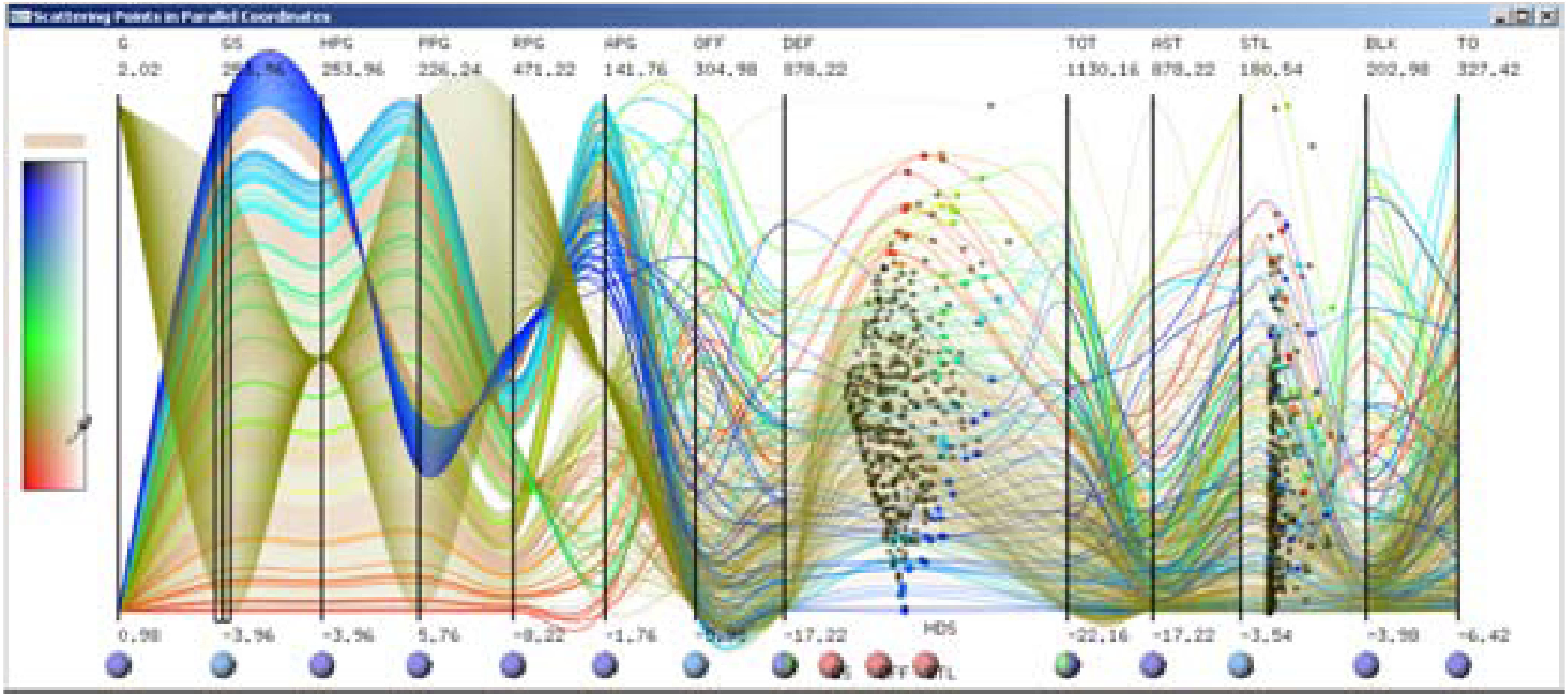
[VisLink, Collins and Carpendale, 2007]

Superimposition



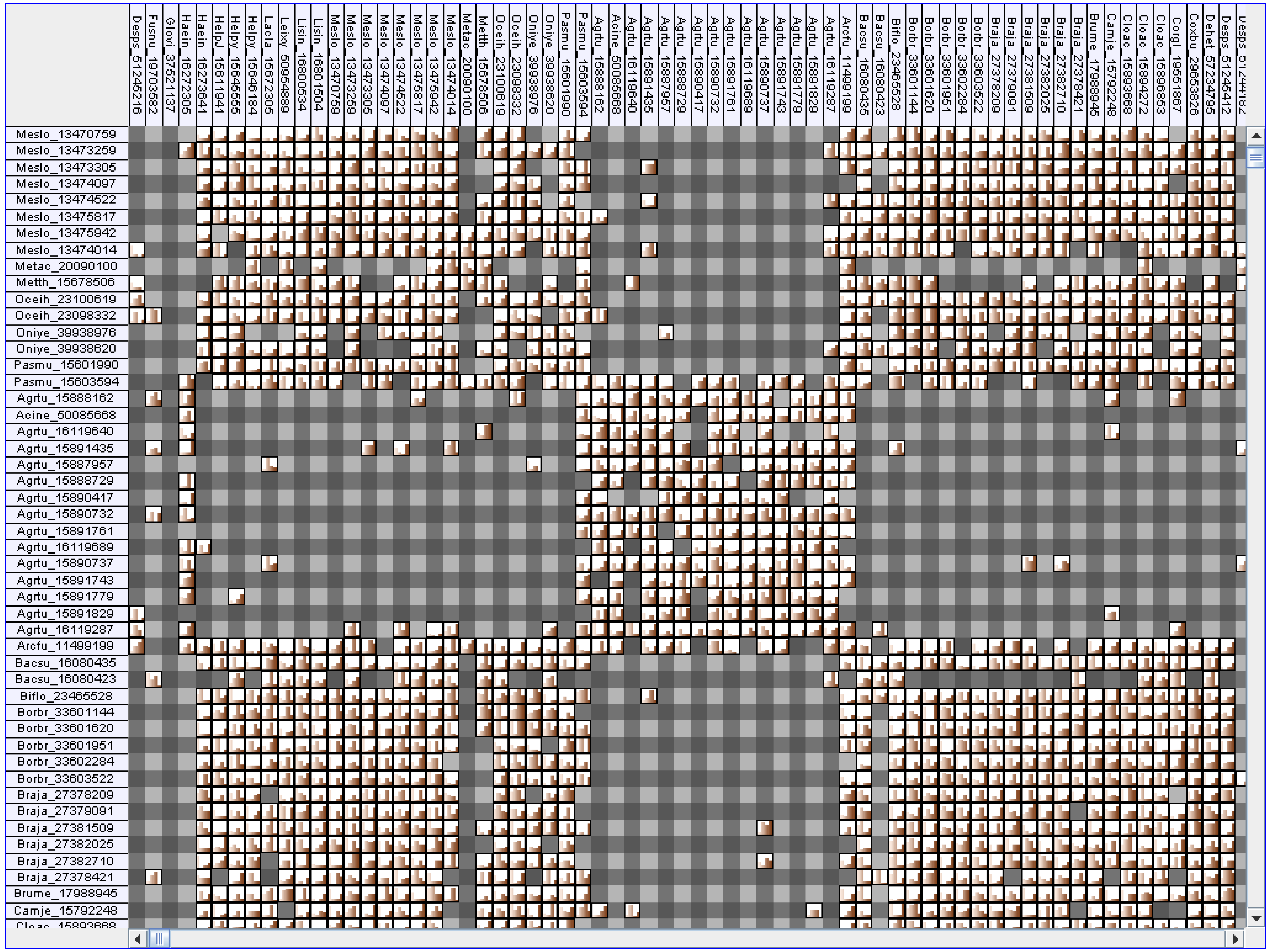
[Mapgets, A. Voisard, 1995]

Overloading



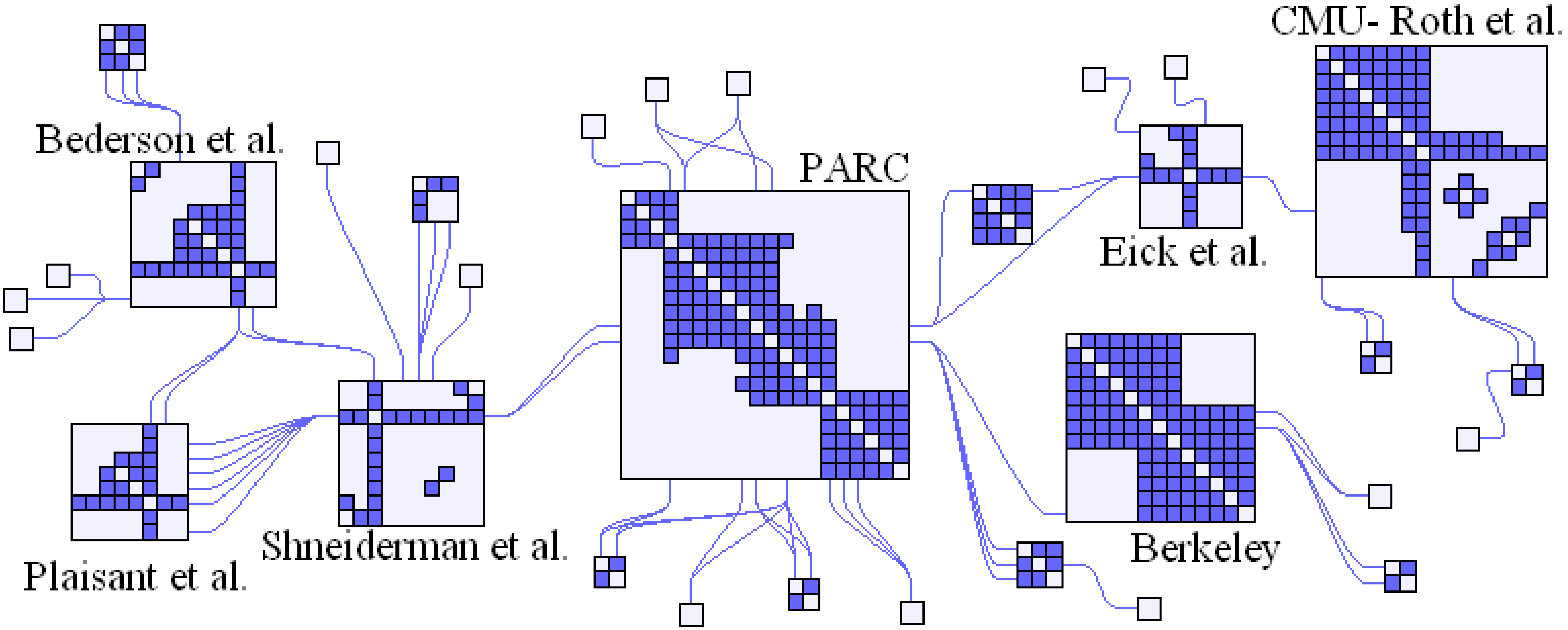
[SPCC, X. Yuan et al., 2009]

Nesting



[ZAME, N. Elmqvist et al., 2008]

Nesting



[NodeTrix, N. Henry et al., 2007]

Midterm