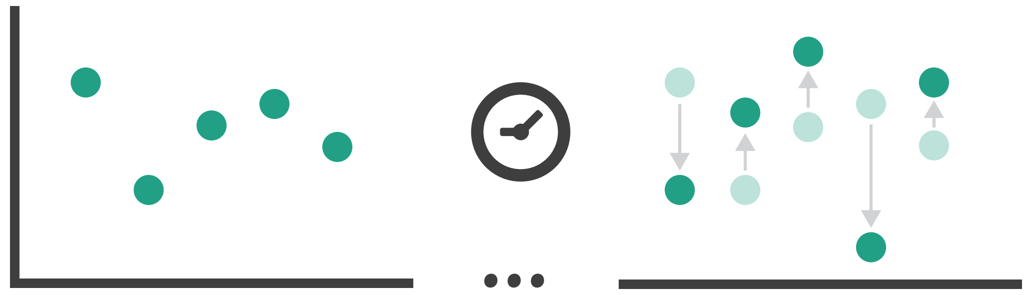
Data Visualization (CSCI 490/680)

Multiple Views & Filtering

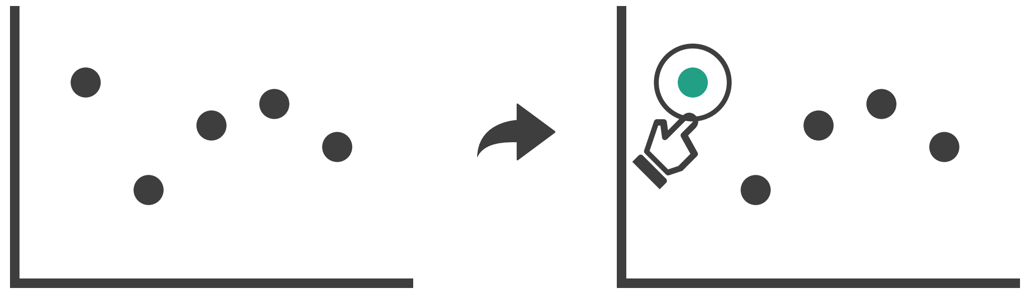
Dr. David Koop

Interaction Overview

➔ Change over Time



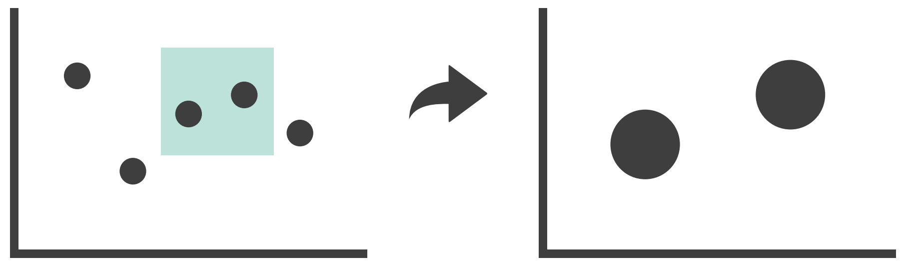
➔ Select



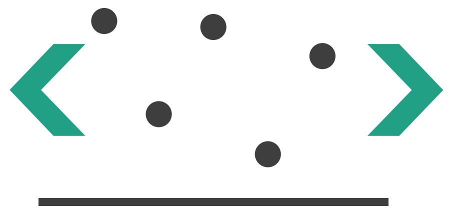
➔ Navigate

→ Item Reduction

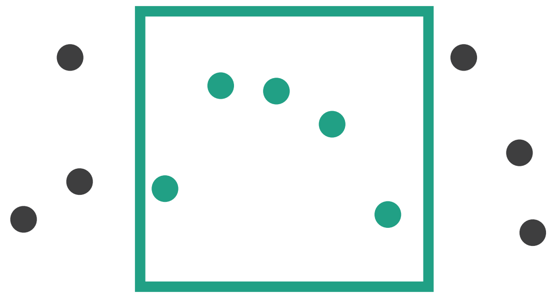
→ *Zoom*
Geometric or *Semantic*



→ *Pan/Translate*



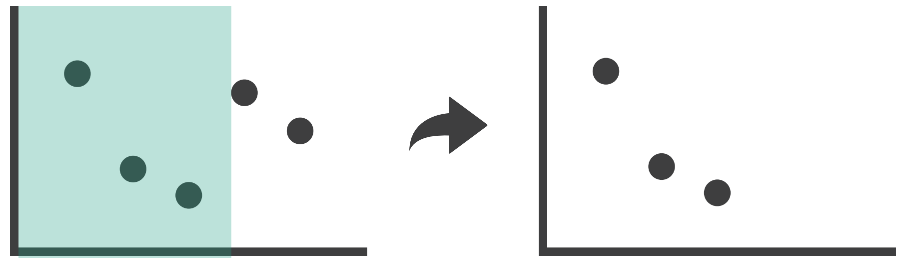
→ *Constrained*



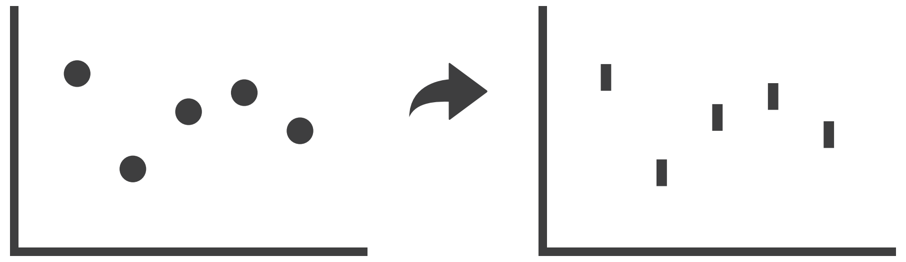
→ Attribute Reduction

→ *Slice*

→ *Cut*

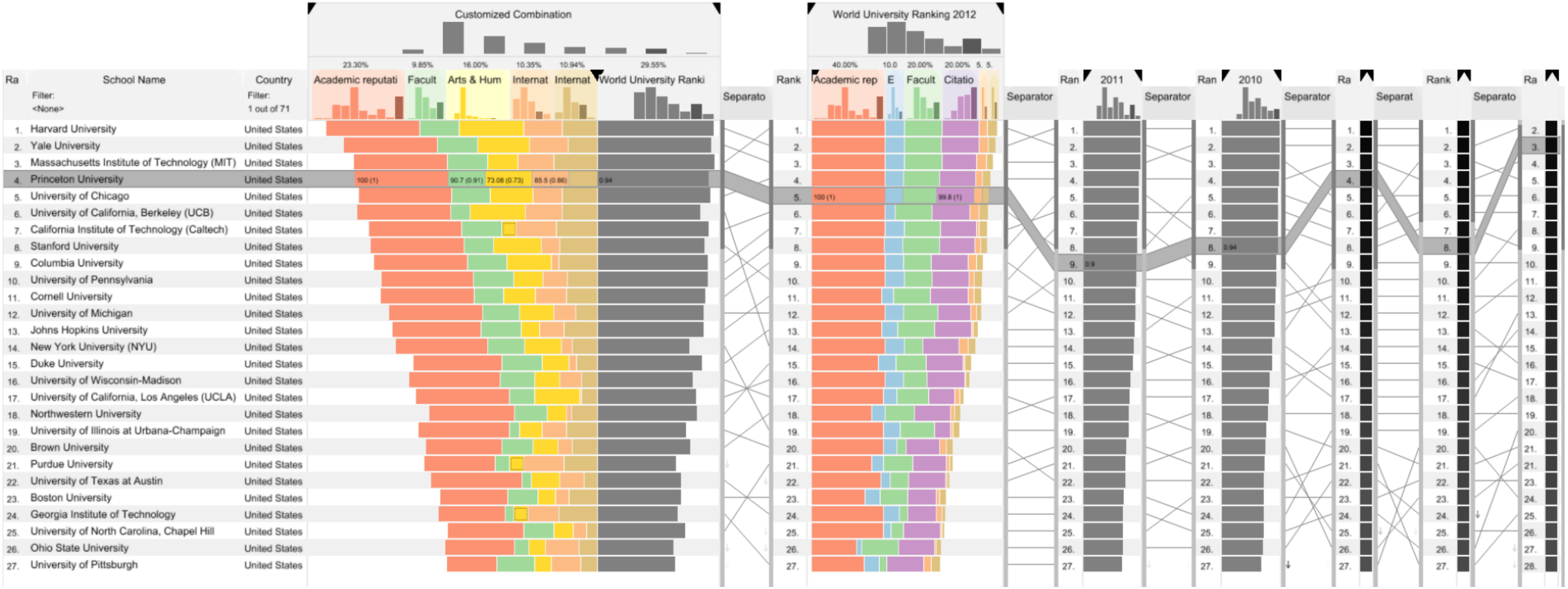


→ *Project*



[Munzner (ill. Maguire), 2014]

Sorting & Slope Graphs: LineUp



[Gratzl et al., 2013]

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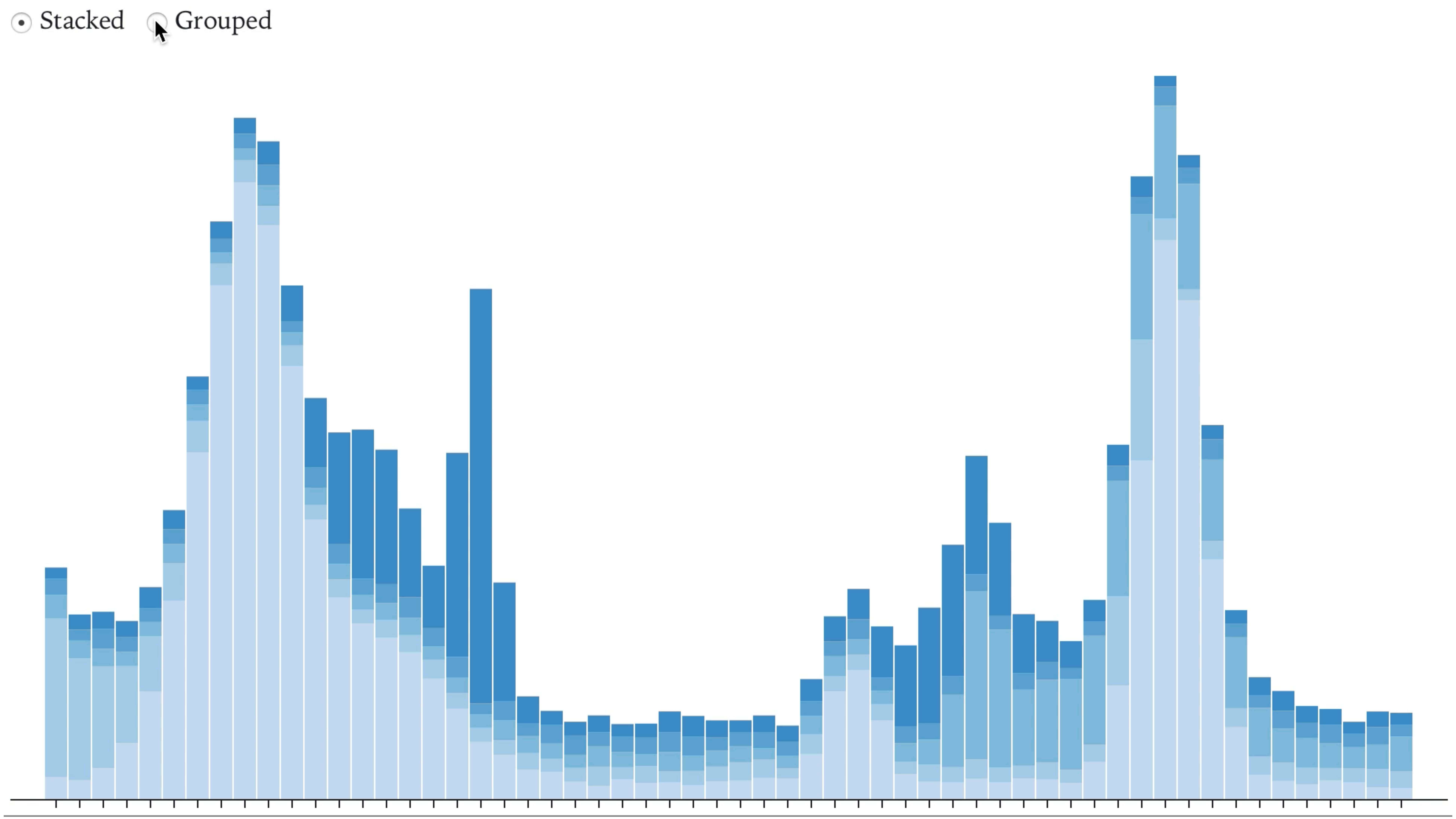
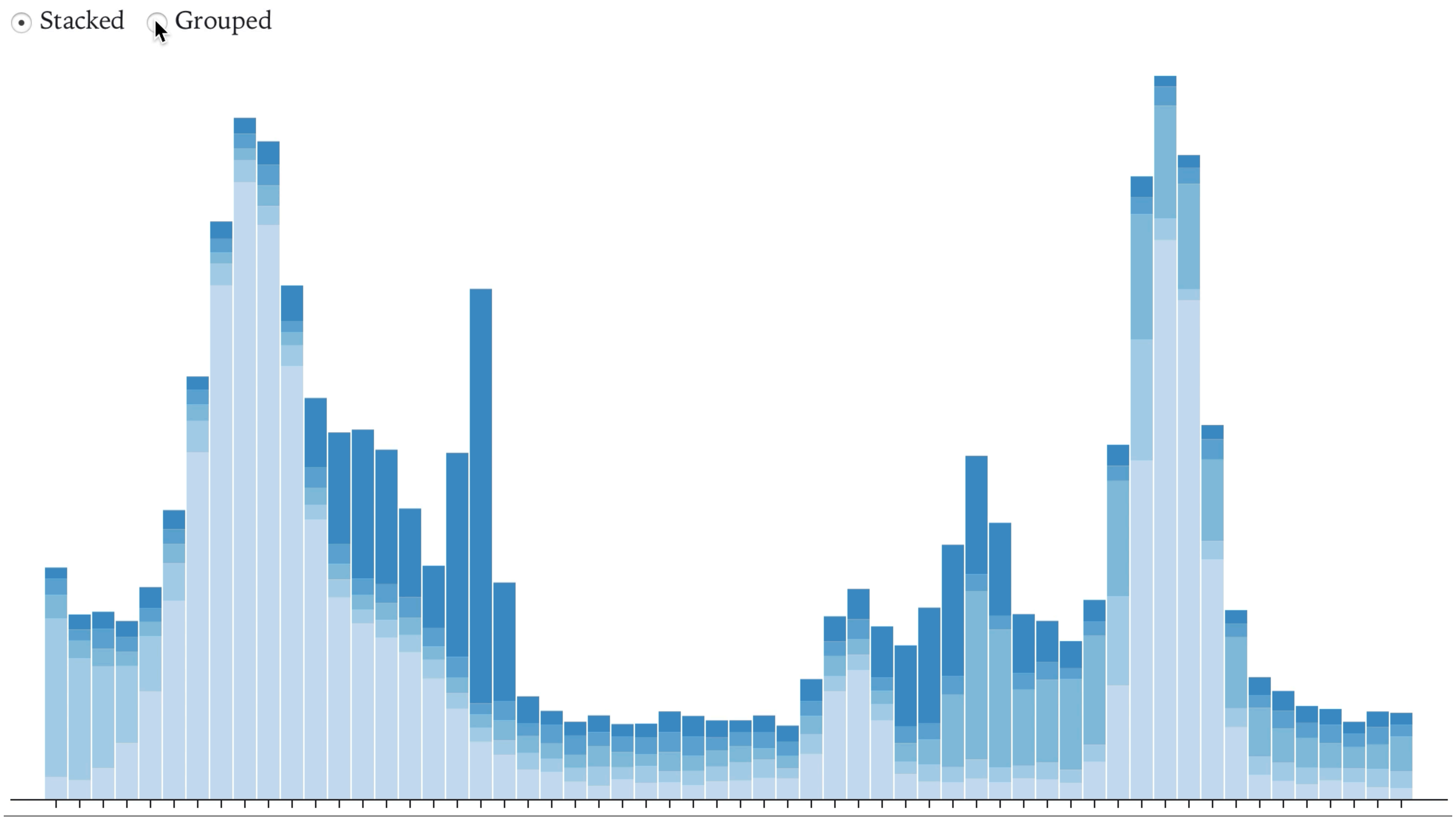
J♣	A♥	K♥
J♠	A♦	K♦

Animated Transitions



[M. Bostock]

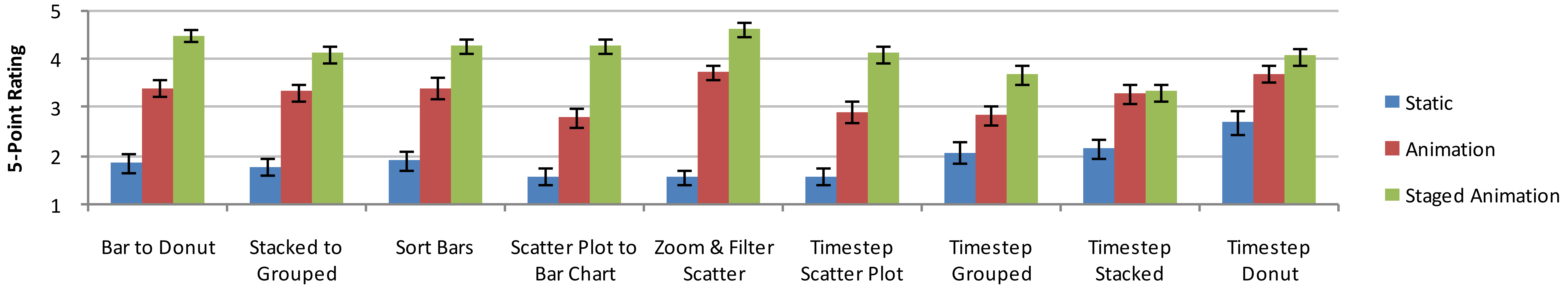
Animated Transitions



[M. Bostock]

Heer and Robertson Study

- 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

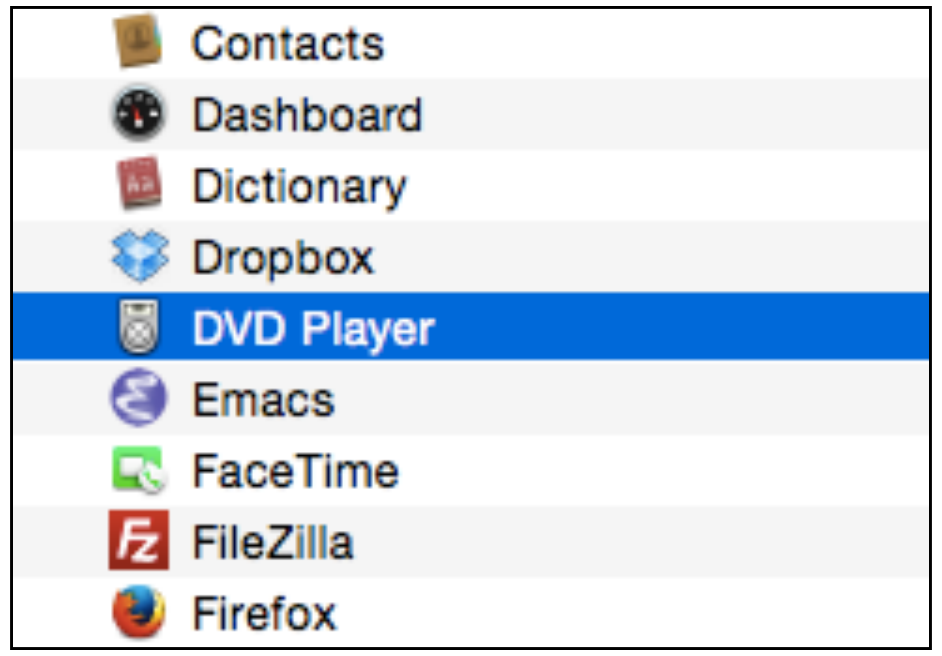
[Heer and Robertson, 2007]

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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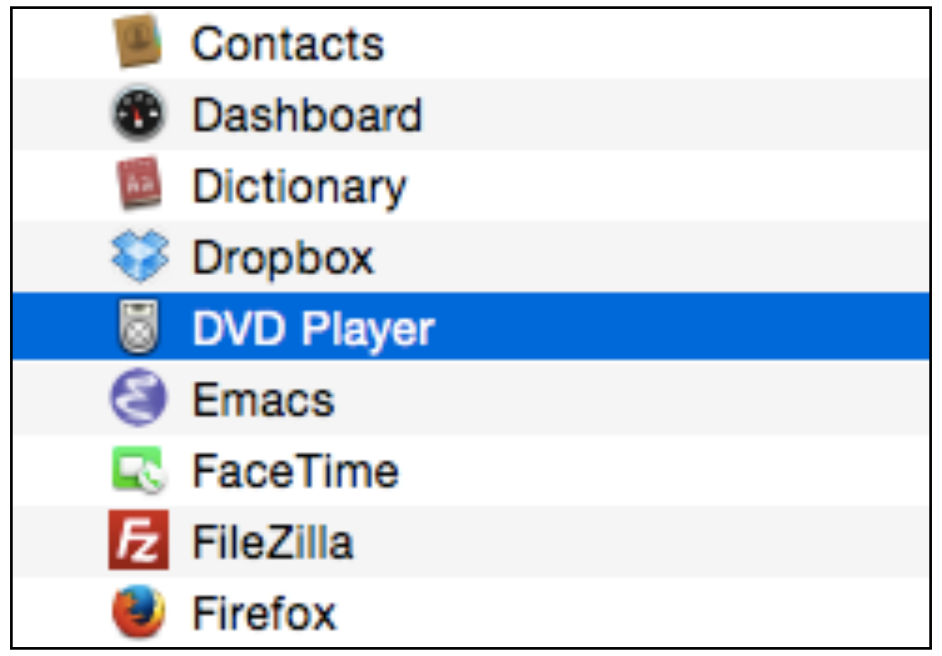
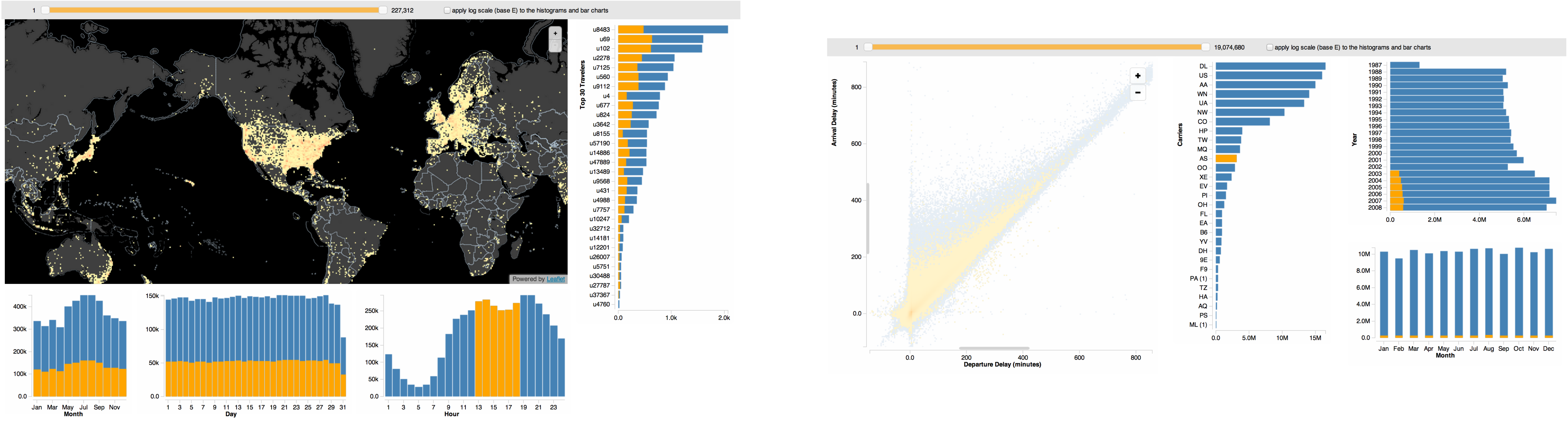


Interaction Latency

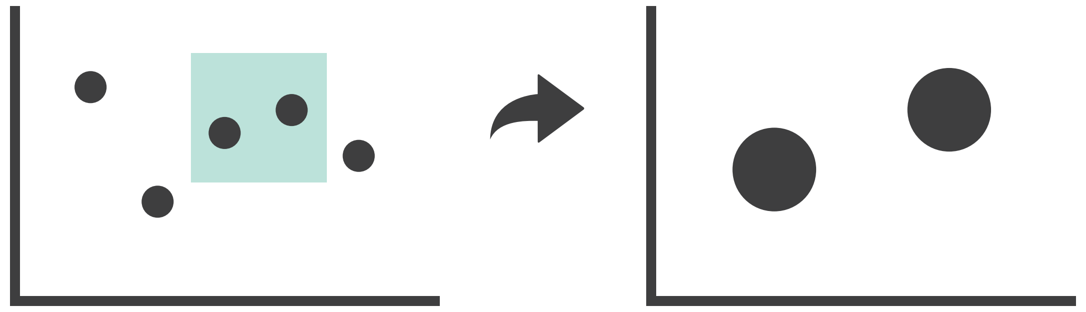
- The Effects of Interactive Latency on Exploratory Visual Analysis, Z. Liu and J. Heer, 2014
- Brush & link, select, pan, zoom



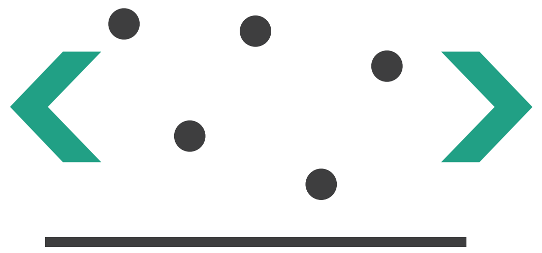
- 500ms added latency causes significant cost
  - decreases user activity and dataset coverage
  - reduces rate of observations, generalizations, and hypotheses

Navigation

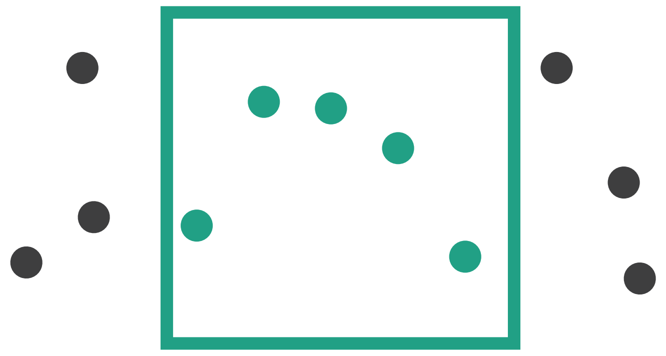
- ➔ Item Reduction
  - ➔ *Zoom*
    Geometric or *Semantic*



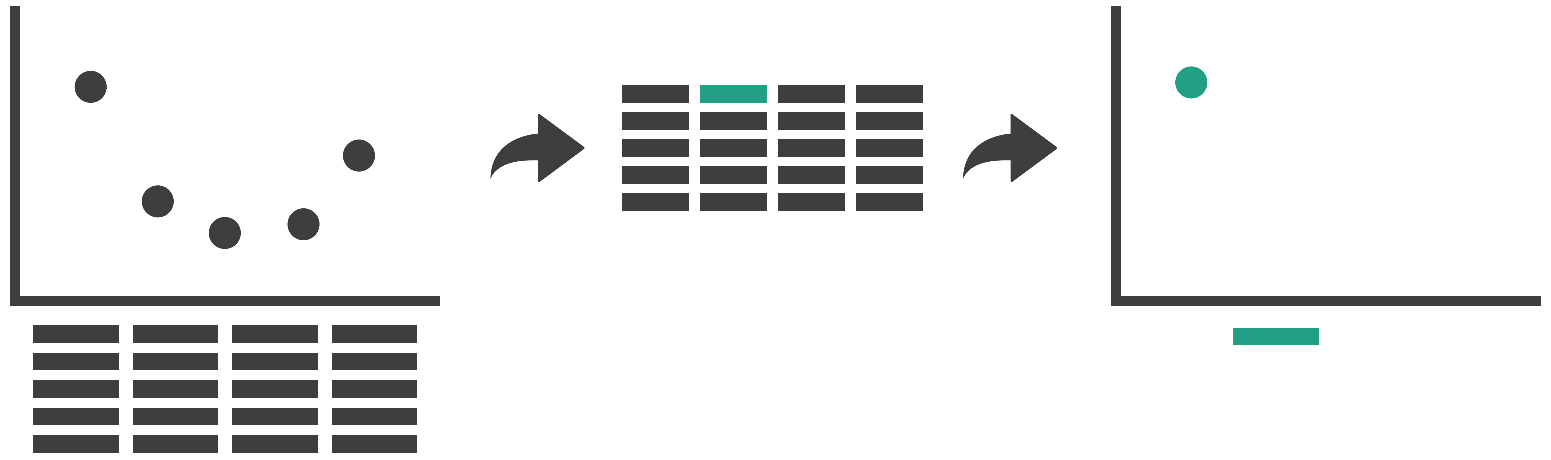
  - ➔ *Pan/Translate*



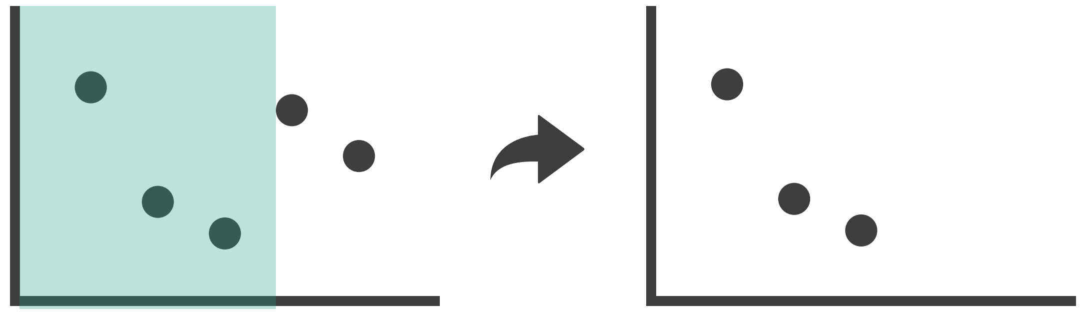
  - ➔ *Constrained*



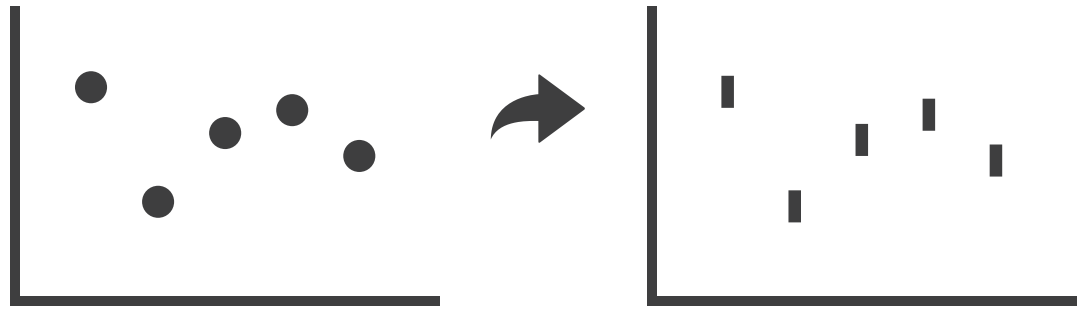
- ➔ Attribute Reduction
  - ➔ *Slice*



  - ➔ *Cut*



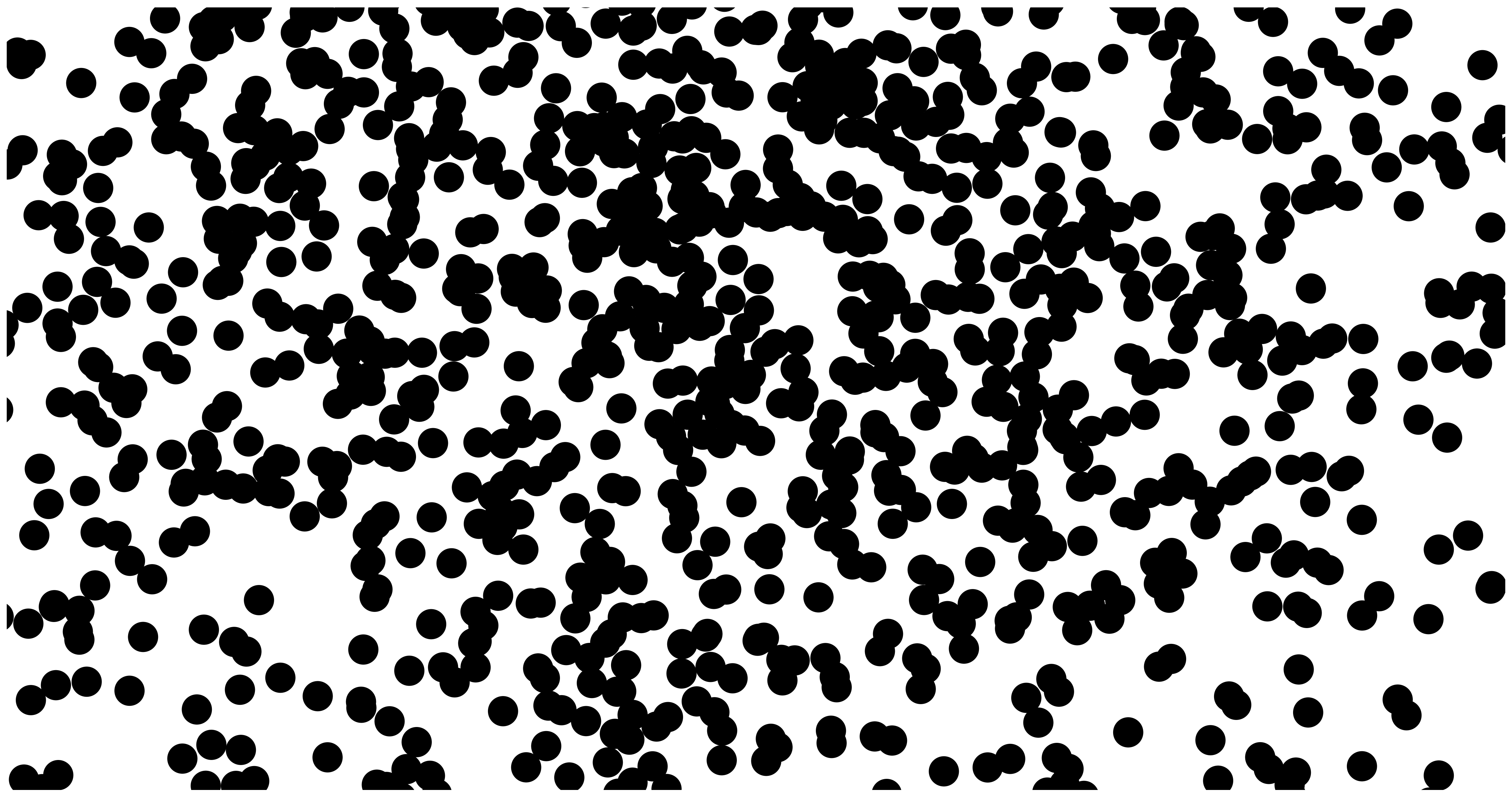
  - ➔ *Project*

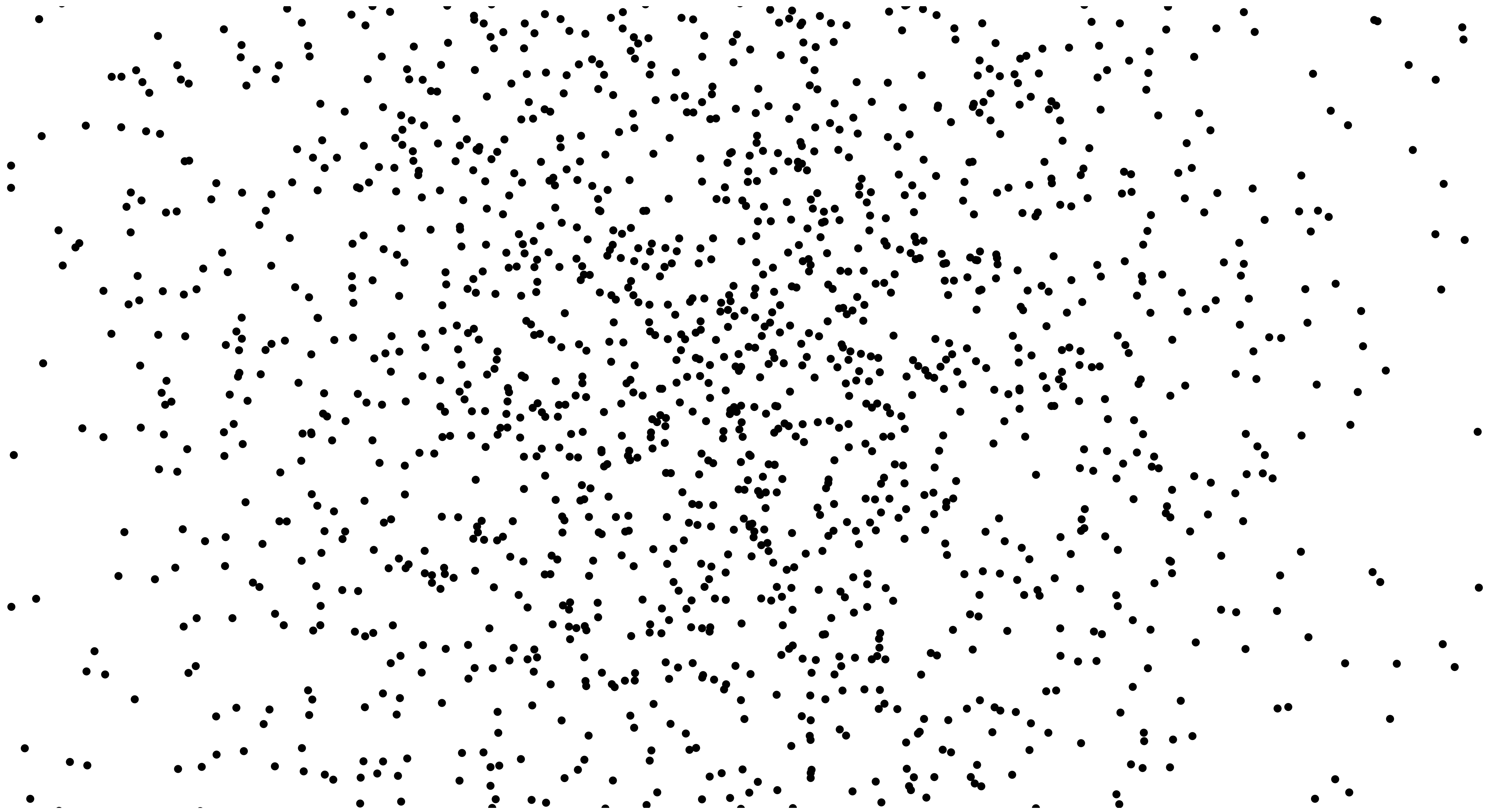


[Munzner (ill. Maguire), 2014]

Geometric vs. Semantic Zooming

- Geometric zoom: like a camera
- Semantic zoom: visual appearance of objects can change at different scales





[M. Bostock]

Project Design

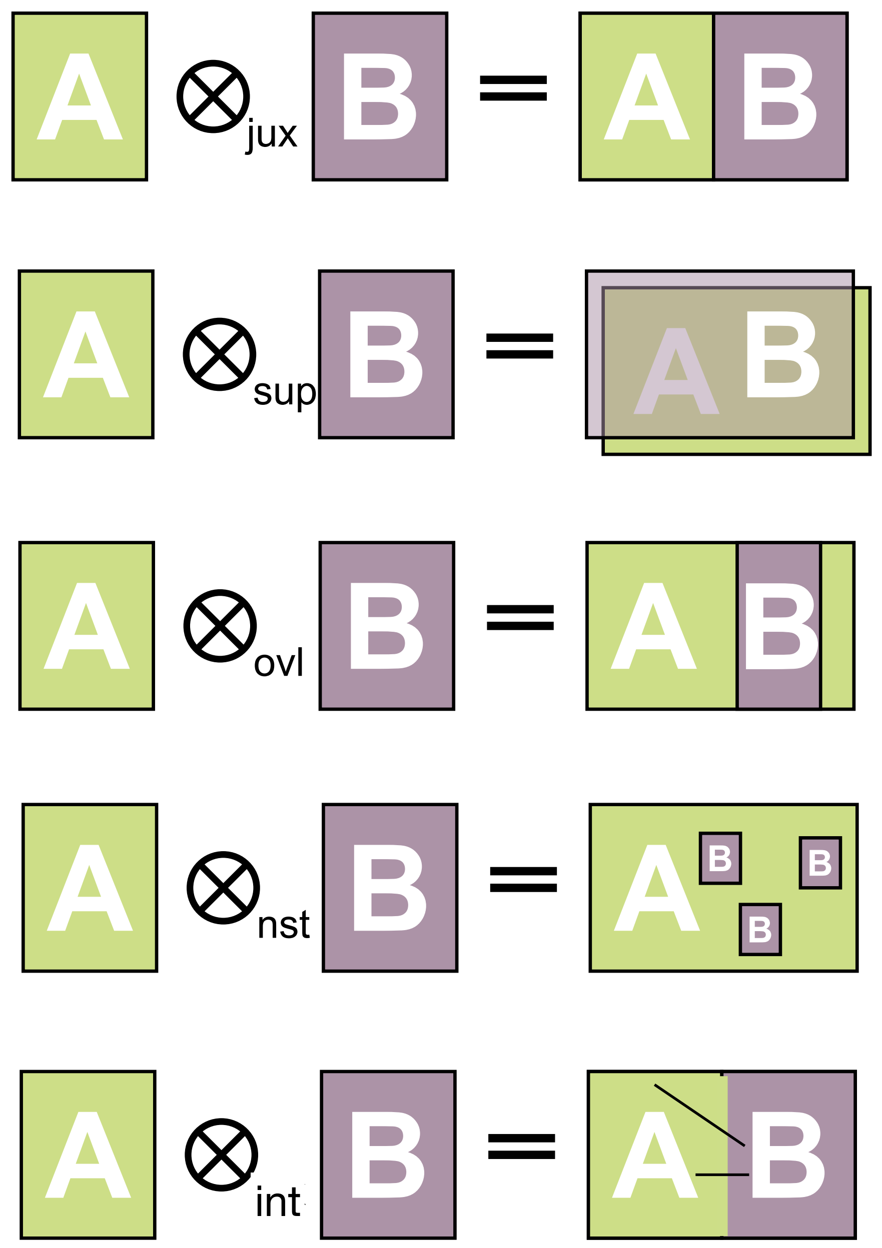
- Work on turning your visualization ideas into designs
- Turn in:
  - Three Designs Sketches
  - Progress on Implementation
- Options:
  - Try vastly different options
  - Refine an initial idea
- Due Monday, Nov. 11

Assignment 5

- Farming data with multiple views & interaction
- Add Crop Sales Information

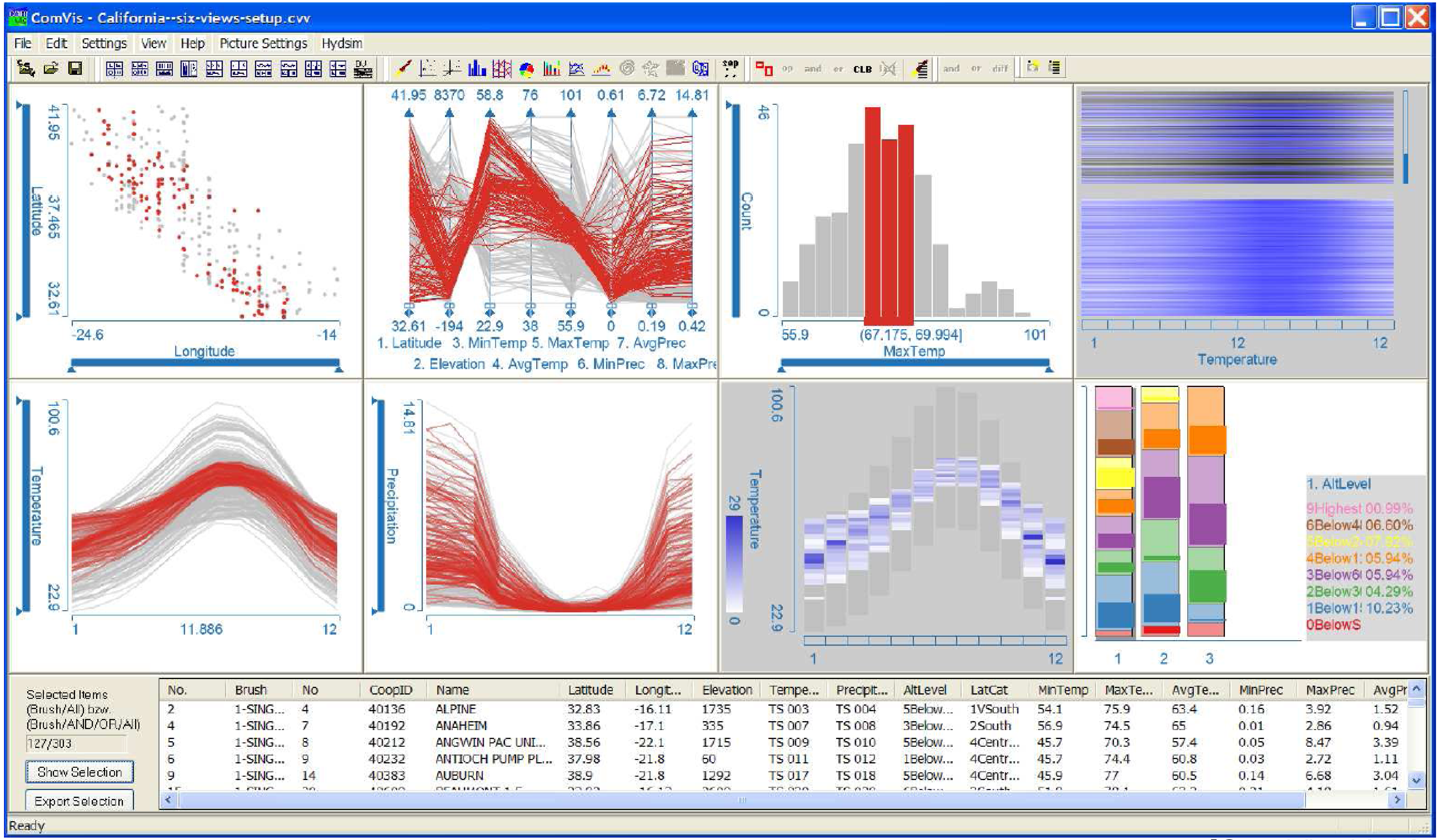
Design Space of Composite Visualization

- 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



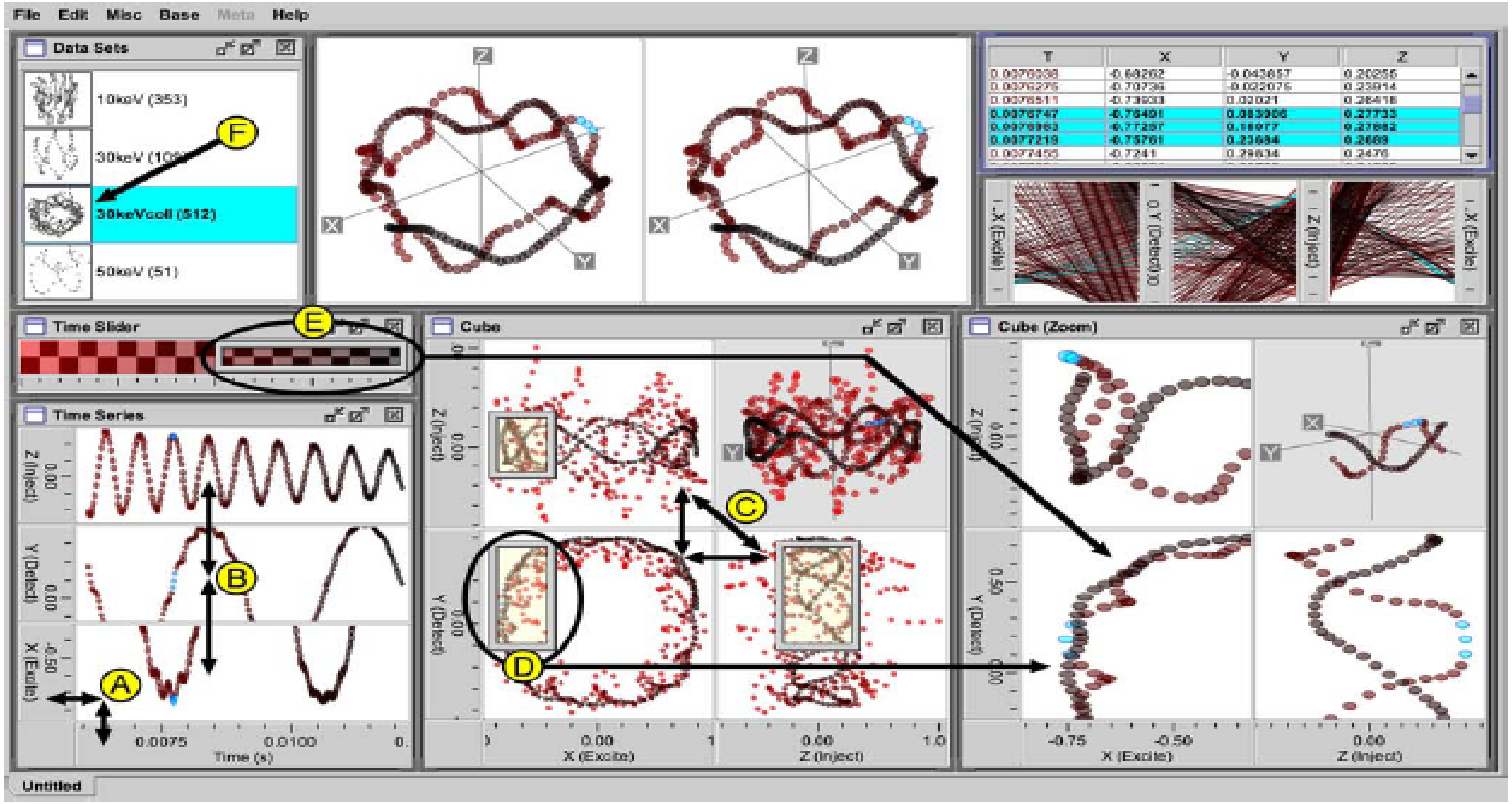
[W. Javed and N. Elmqvist, 2012]

Juxtaposition



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

Juxtaposition



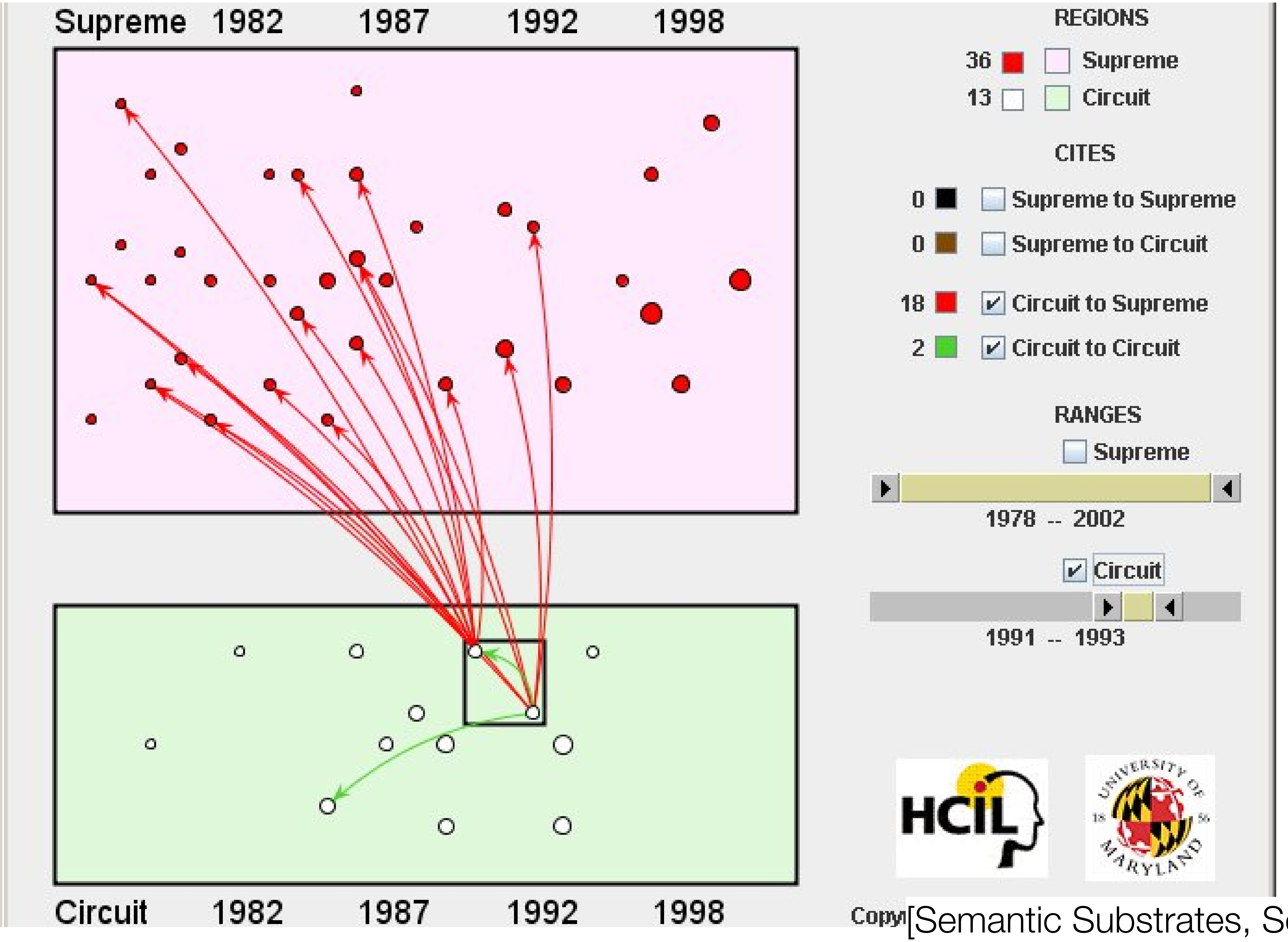
[Improvise, C. Weaver, 2004]

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.

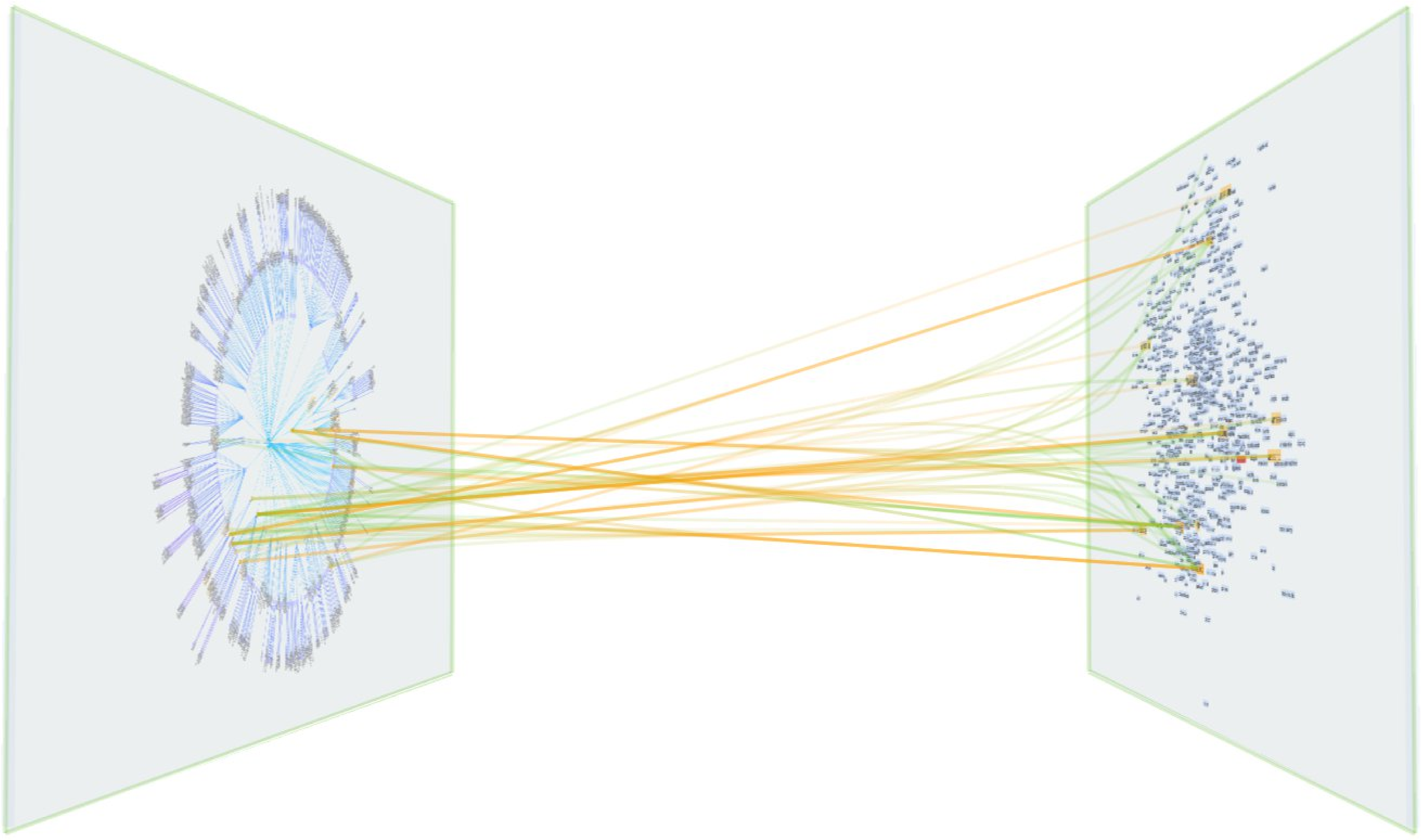
[W. Javed and N. Elmqvist, 2012]

Integration



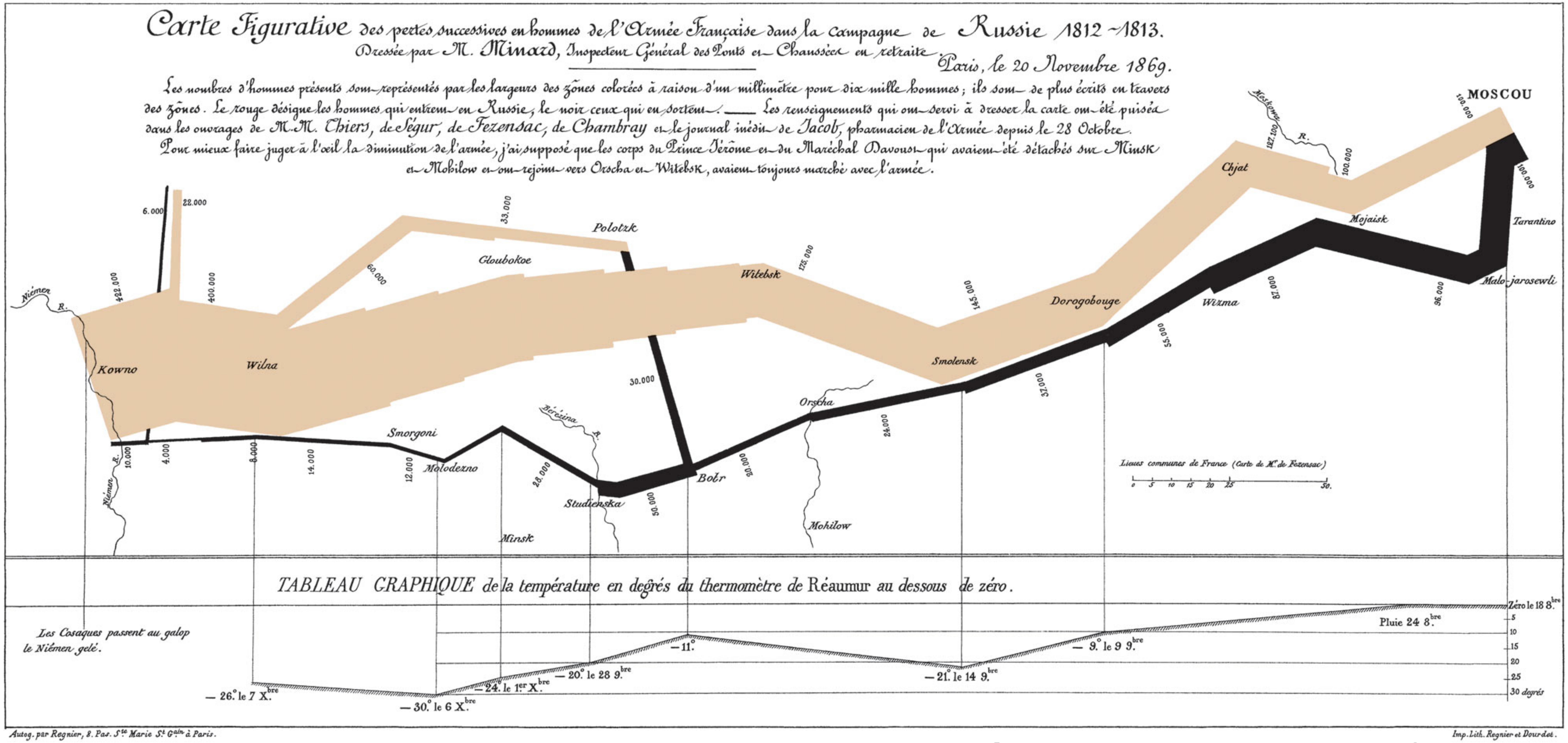
[Semantic Substrates, Schneiderin and Aris, 2006]

Integration



[VisLink, Collins and Carpendale, 2007]

Integration



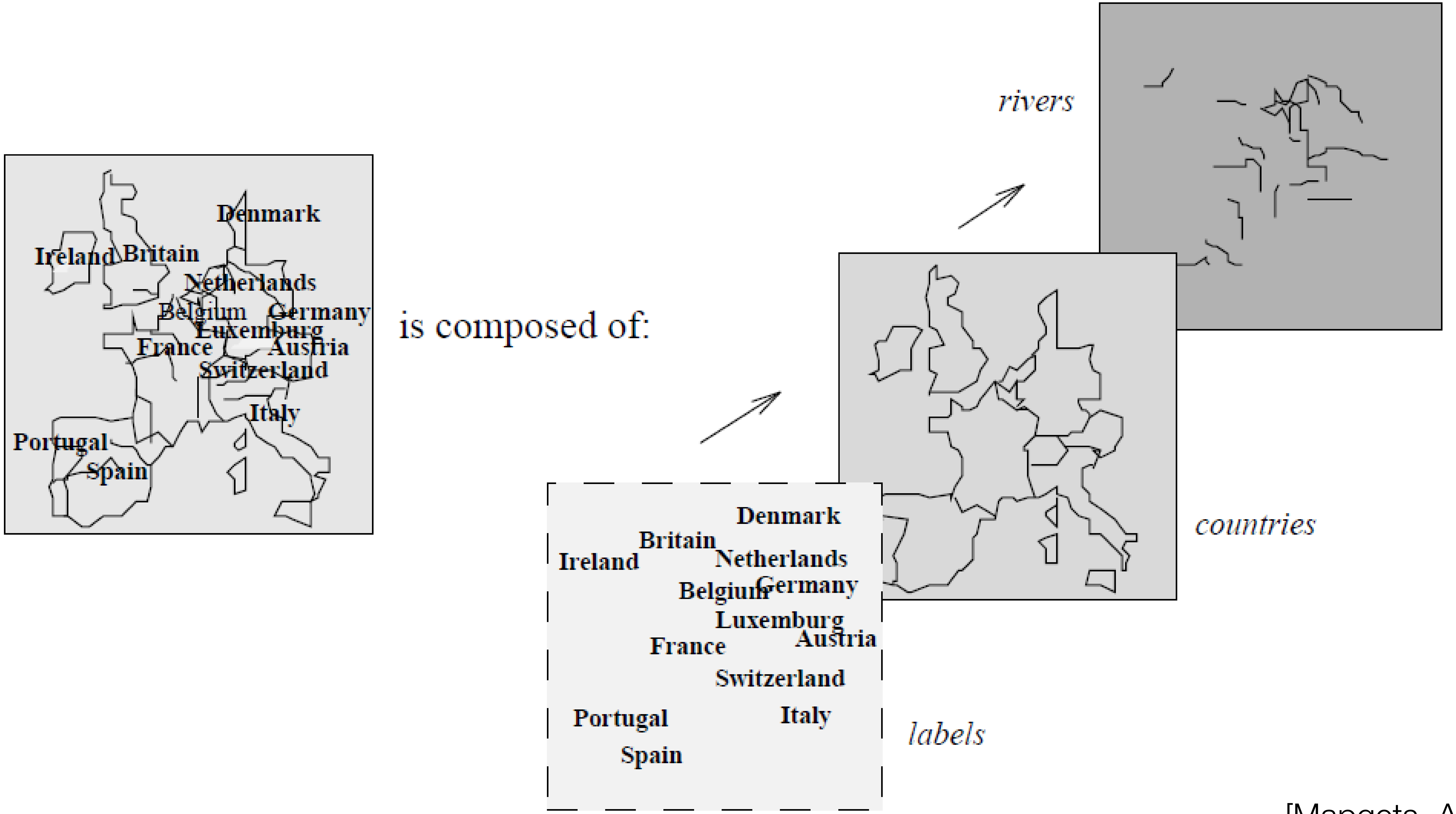
[Napoleon's March to Moscow, C. J. Minard, 1869]

Integration Guidelines

- Benefits:
  - Easy to perceive one-to-one and one-to-many relations between items in components
  - Visualizations are less independent compared to juxtaposed views, but still separate
- Drawbacks:
  - Extra visual clutter added to the overall view
  - Display space is split between the views
  - Some dependencies exist between views to allow for the visual linking
- Applications: Use for heterogeneous datasets where correlation and comparisons between views is particularly important.

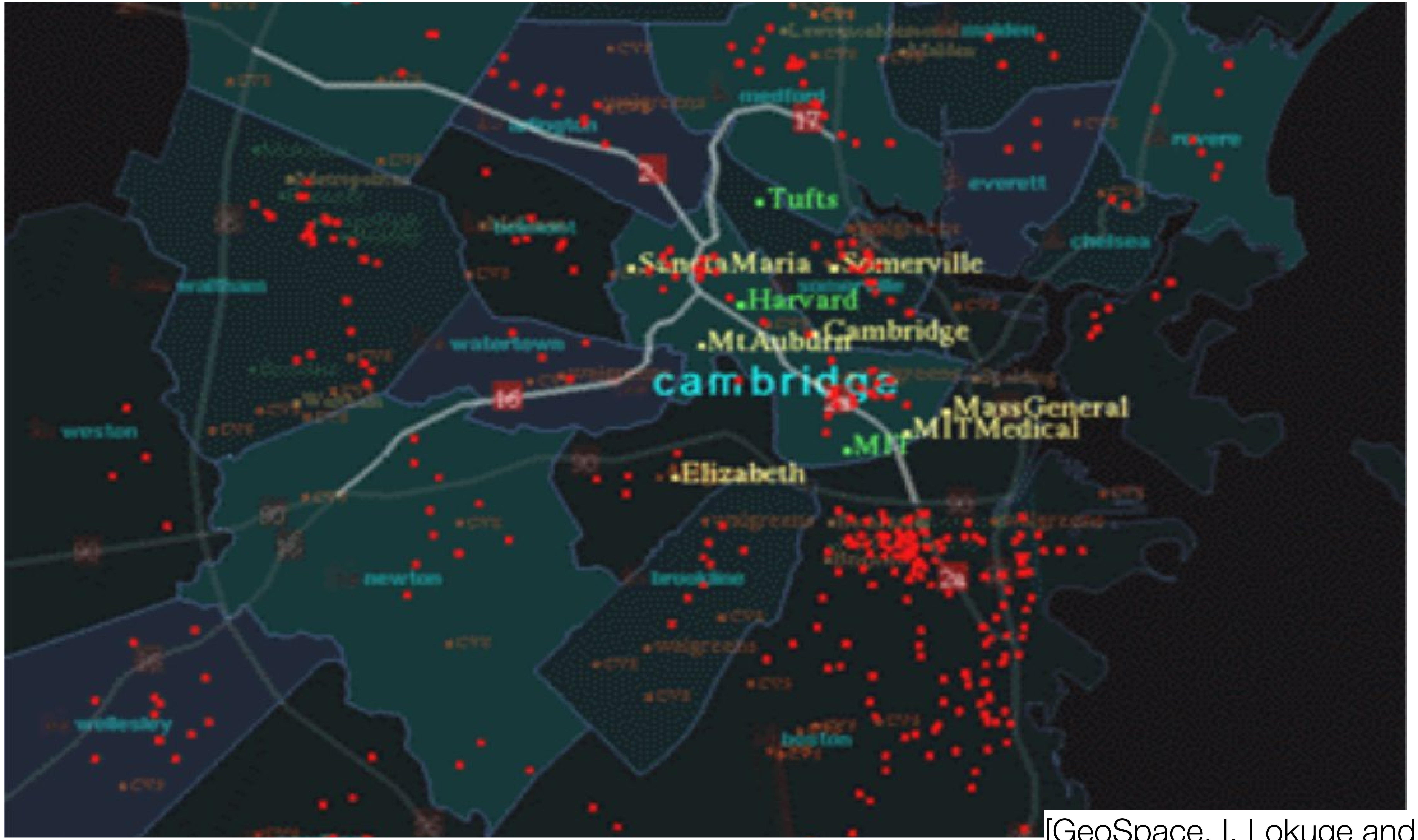
[W. Javed and N. Elmqvist, 2012]

Superimposition



[Mapgets, A. Voisard, 1995]

Superimposition



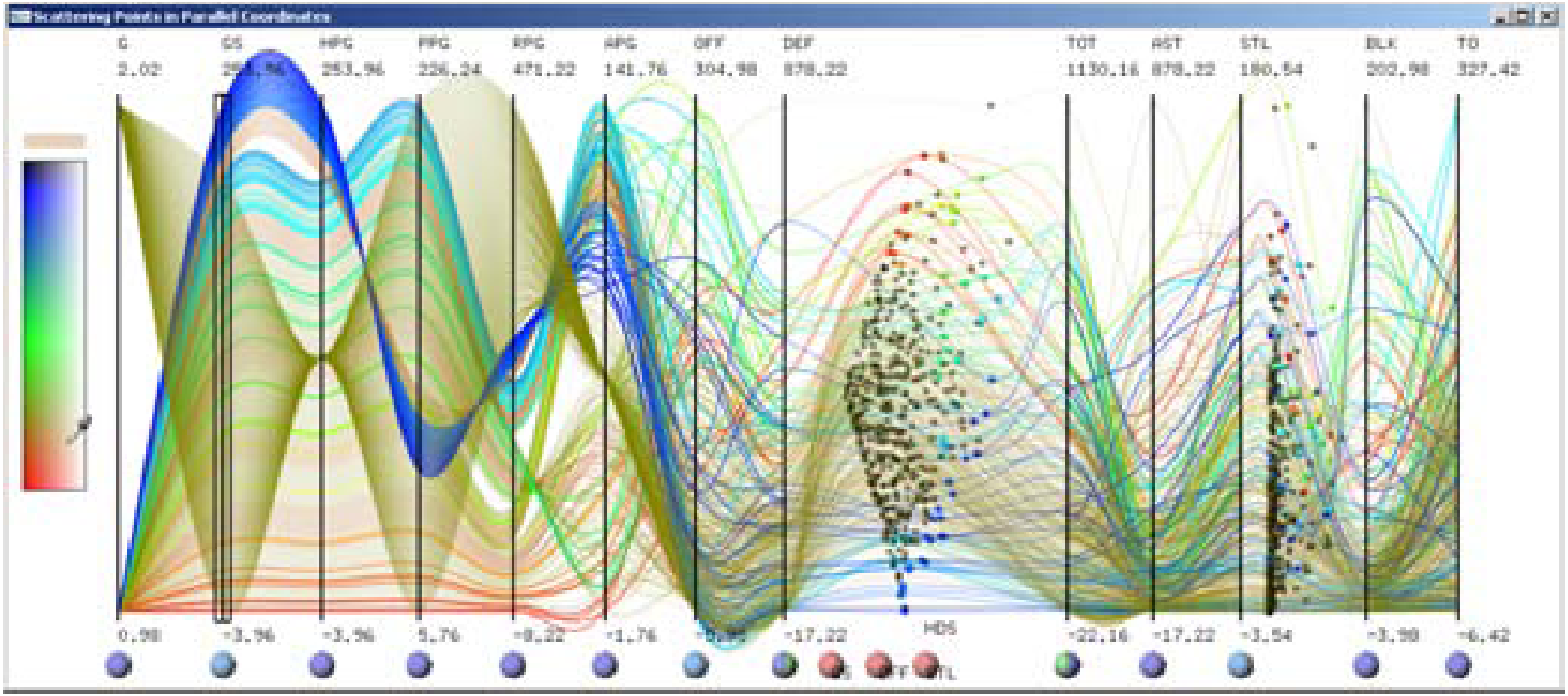
[GeoSpace, I. Lokuge and S. Ishizaki, 1995]

Superimposition Guidelines

- Benefits:
  - Allows direct comparison in the same visual space.
- Drawbacks:
  - May cause occlusion and high visual clutter.
  - The client visualization must share the same spatial mapping as the host visualization.
- Applications: In settings where comparison is common, or where the component visualization views need to be as large as possible (potentially the entire available space).

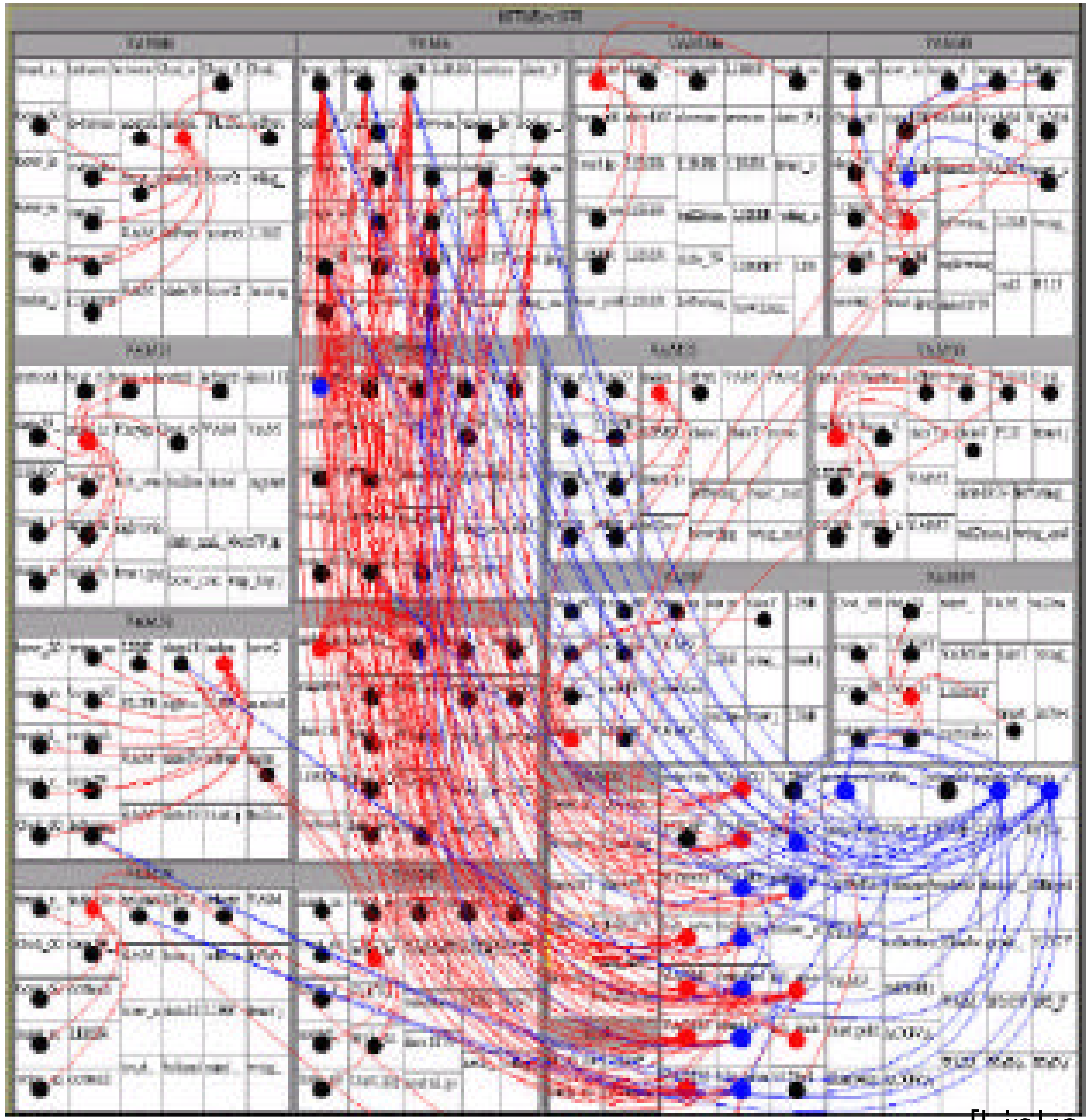
[W. Javed and N. Elmqvist, 2012]

Overloading



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

Overloading



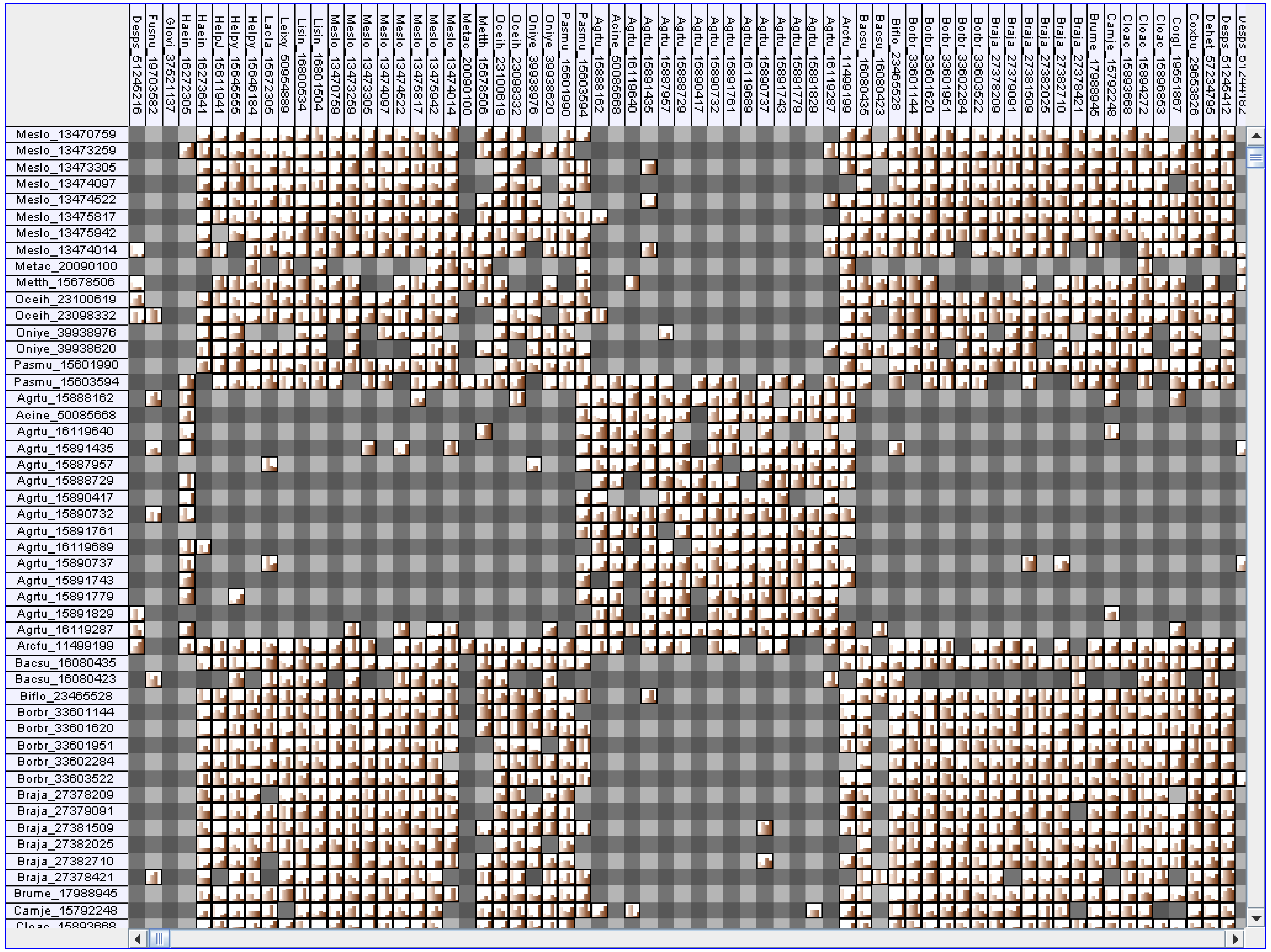
[Links on Treemaps, J.-D. Fekete et al., 2003]

Overloading Guidelines

- Benefits:
  - The client visualization does not have to share the same coordinate space as the host visualization
  - This also yield more flexibility and control over visual clutter
- Drawbacks:
  - Visual clutter is increased
  - Visual design dependencies between components are significant
- Applications: Situations where one visualization can be folded into another to yield a compact (and complex) result.

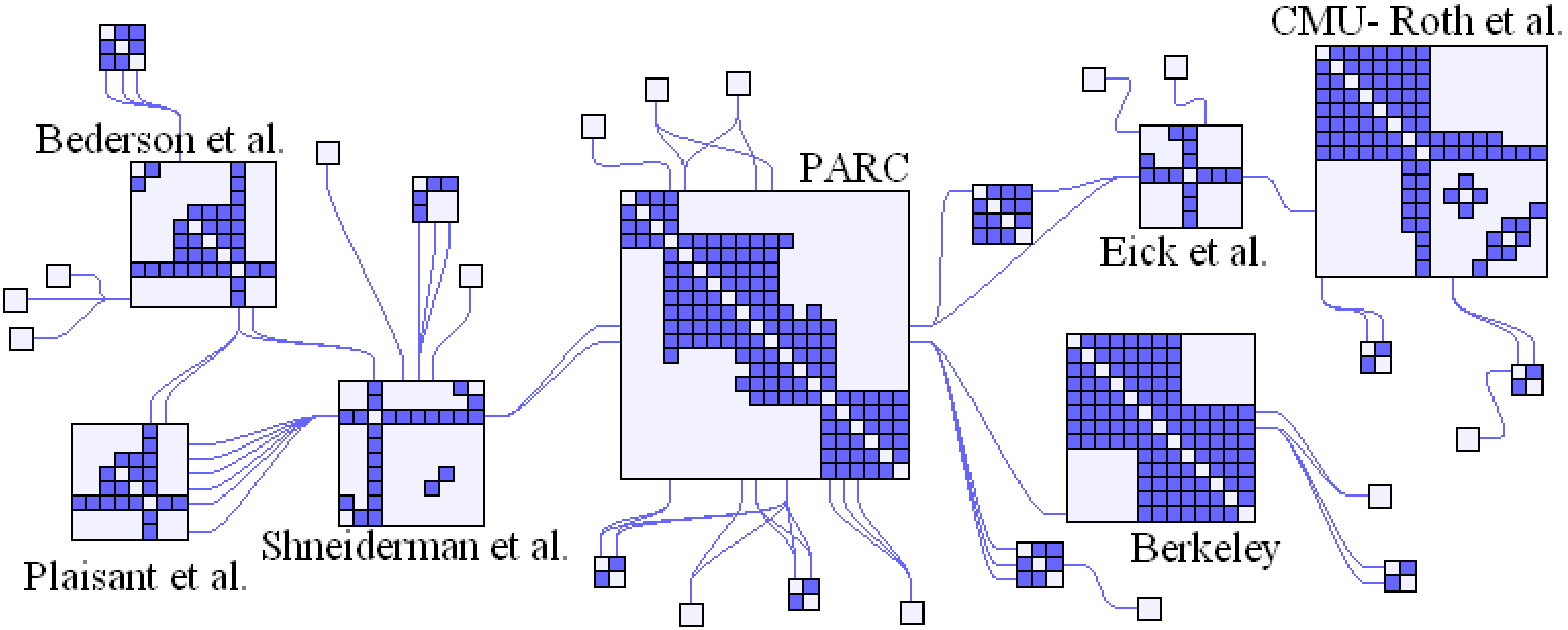
[W. Javed and N. Elmqvist, 2012]

Nesting



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

Nesting



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

Nesting Guidlines

- Benefits:
  - Very compact representation
  - Easy correlation
- Drawbacks:
  - Limited space for the client visualizations
  - Clutter is high
  - Visual design dependencies are high
- Applications: Situations that call for augmenting a particular visual representation with additional mapping

[W. Javed and N. Elmqvist, 2012]

Design Space

- Visualizations: the techniques or idioms used
- Spatial relation: relationship between visual structures in display space
- Data relation: visual relationship between items in different views
  - None: No relation
  - Item-item: One-to-one
  - Item-group: One-to-many
  - Item-dimension: Item in one view is a **scale** in another

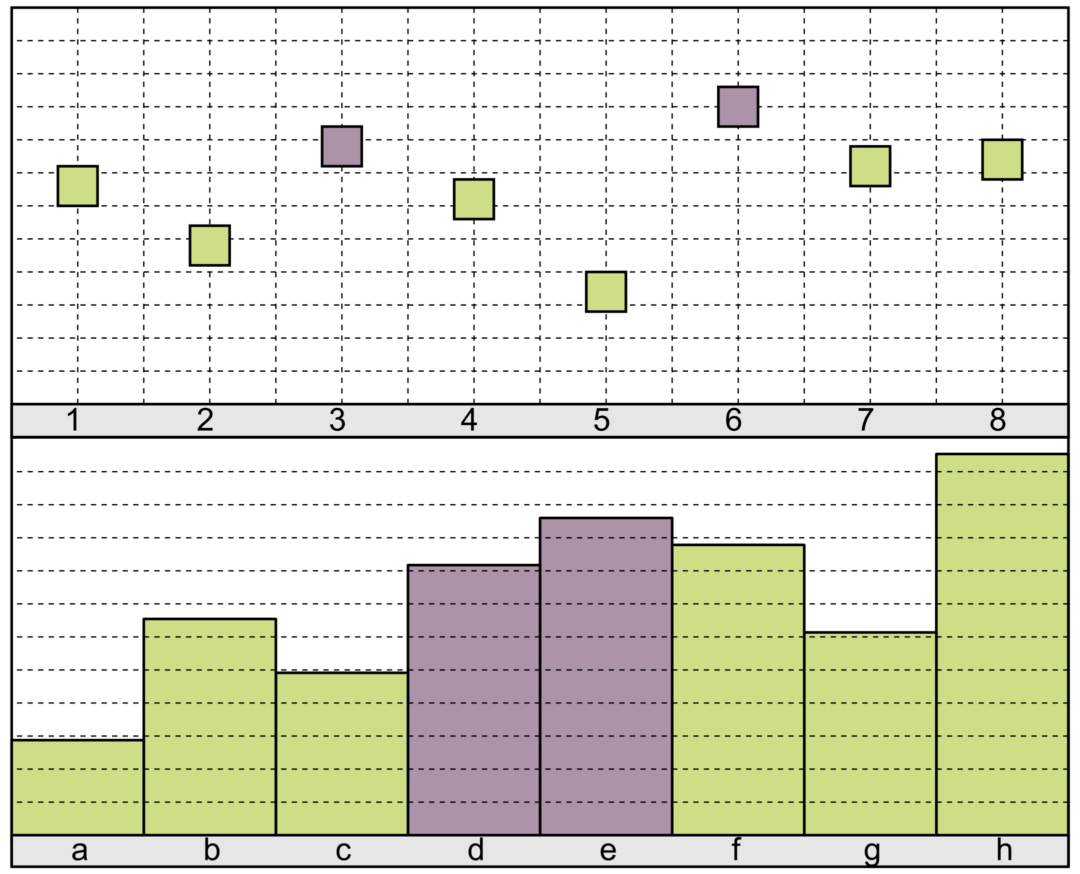
[W. Javed and N. Elmqvist, 2012]

Summary

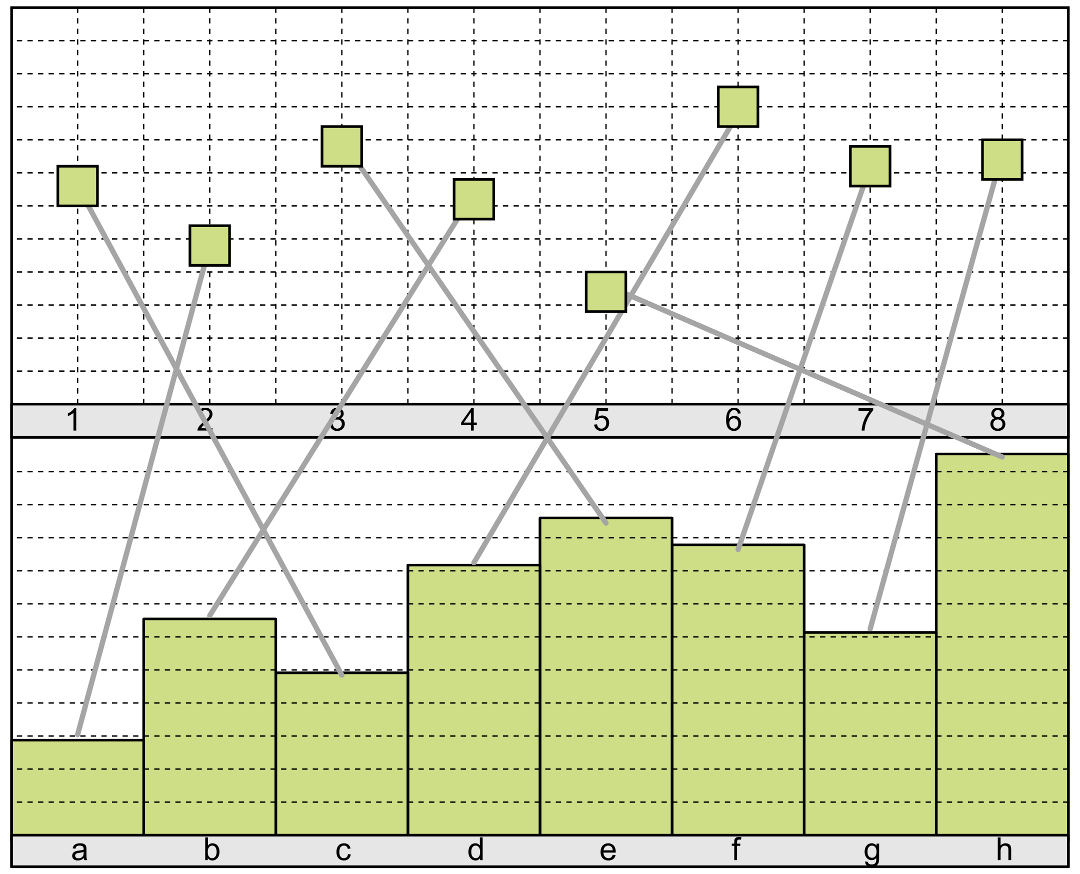
Technique	Visualization A	Visualization B	Spatial Relation	Data Relation
ComVis [24] (Figure 2)	any	any	juxtapose	none
Improvise [39] (Figure 3)	any	any	juxtapose	none
Jigsaw [36]	any	any	juxtapose	none
Snap-Together [30]	any	any	juxtapose	none
semantic substrates [34] (Figure 4)	node-link	node-link	juxtapose	item-item
VisLink [11] (Figure 5)	radial graph	node-link	juxtapose	item-item
Napoleon's March on Moscow [37]	time line view	area visualization	juxtapose	item-item
Mapgets [38] (Figure 6)	map	text	superimpose	item-item
GeoSpace [22] (Figure 7)	map	bar graph	superimpose	item-item
3D GIS [8]	map	glyphs	superimpose	item-item
Scatter Plots in Parallel Coordinates [45] (Figure 8)	parallel coordinate	scatterplot	overload	item-dimension
Graph links on treemaps [14] (Figure 9)	treemap	node-link	overload	item-item
SparkClouds [21]	tag cloud	line graph	overload	item-item
ZAME [13] (Figure 10)	matrix	glyphs	nested	item-group
NodeTrix [17] (Figure 11)	node-link	matrix	nested	item-group
TimeMatrix [44]	matrix	glyphs	nested	item-group
GPUVis [25]	Scatterplot	glyphs	nested	item-group

[W. Javed and N. Elmqvist, 2012]

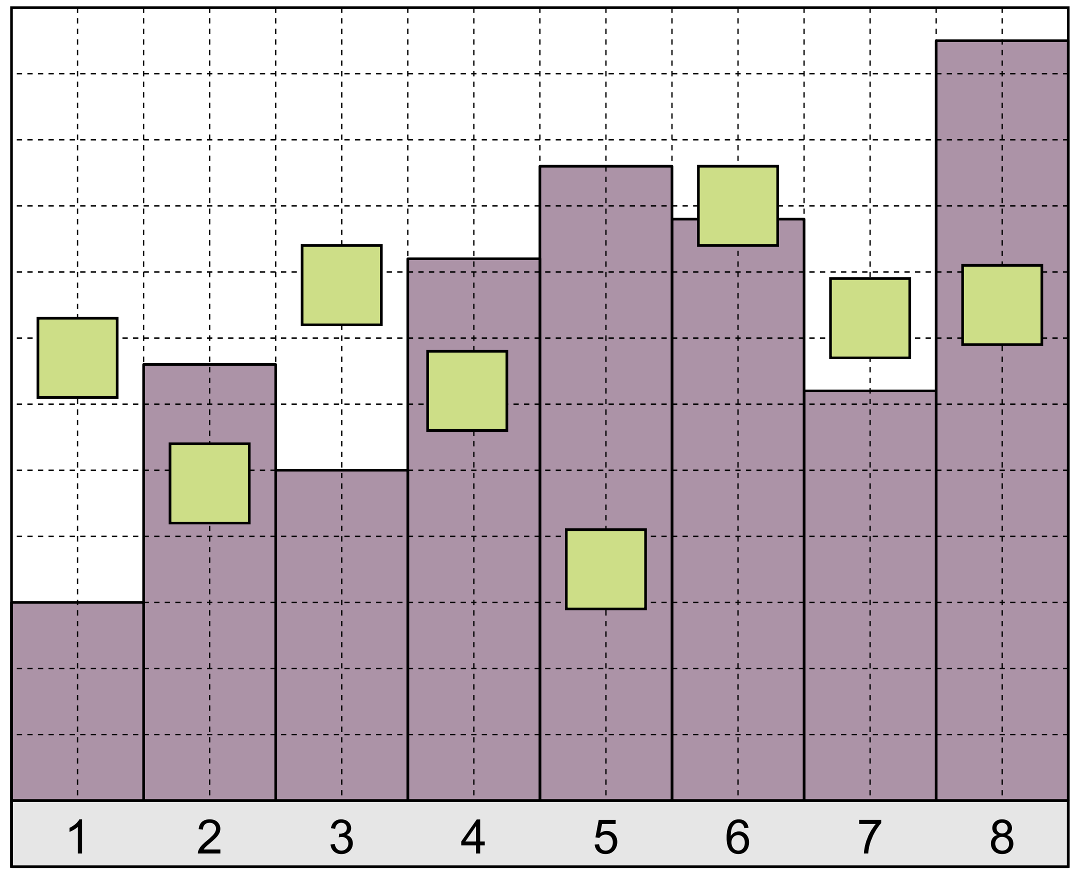
Summary (Scatterplot + Bar Chart)



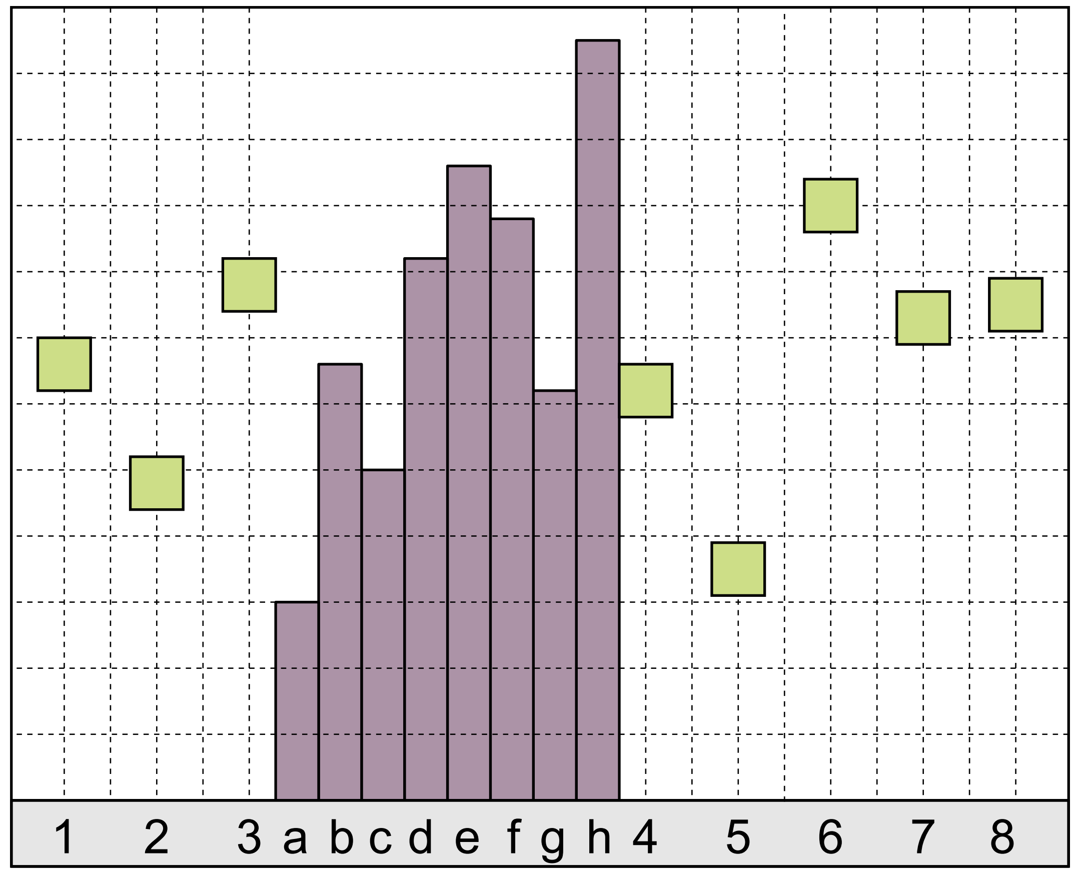
(a) Juxtaposed views.



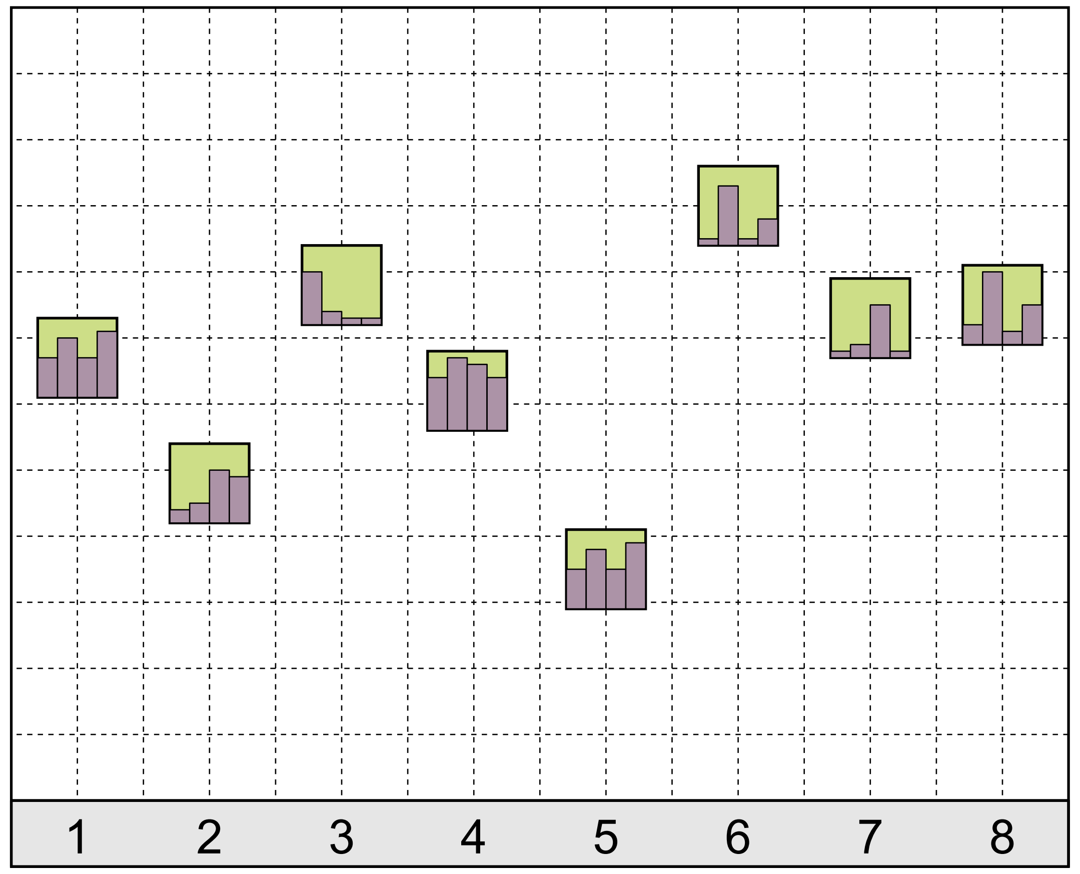
(b) Integrated views.



(c) Superimposed views.



(d) Overloaded views.



(e) Nested views.

[W. Javed and N. Elmqvist, 2012]

Multiple Views

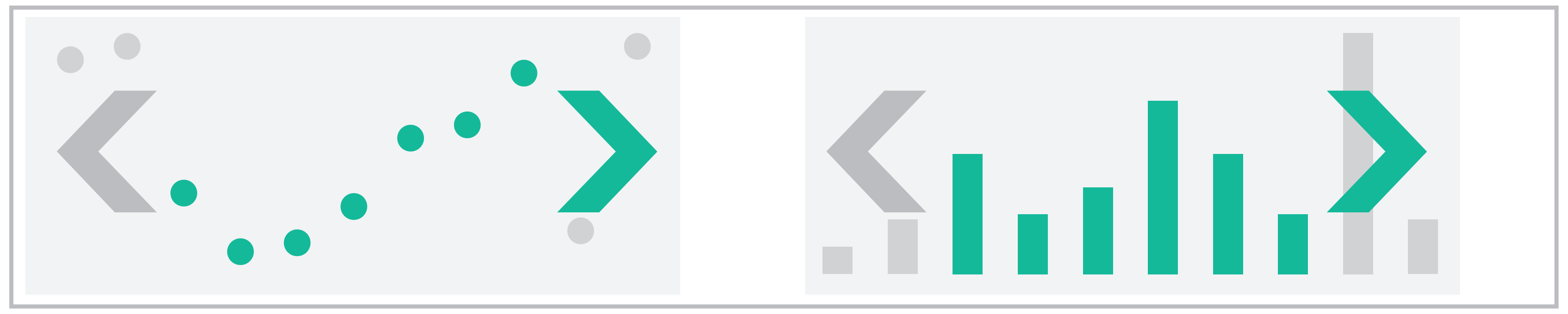
- Facet (noun and verb)
  - particular aspect or feature of something
  - to split
- Partition visualization into views/layers
  - Either juxtapose (side-by-side), superimpose (layer), nest, etc.
  - Depends on data and encoding
  - Generally, superimposing does not scale as well
  - Multiple views eats display space (either large screens or small visualizations)

Multiple Views

- Share Encoding: Same/Different
  - *Linked Highlighting*

- Share Data: All/Subset/None

- Share Navigation



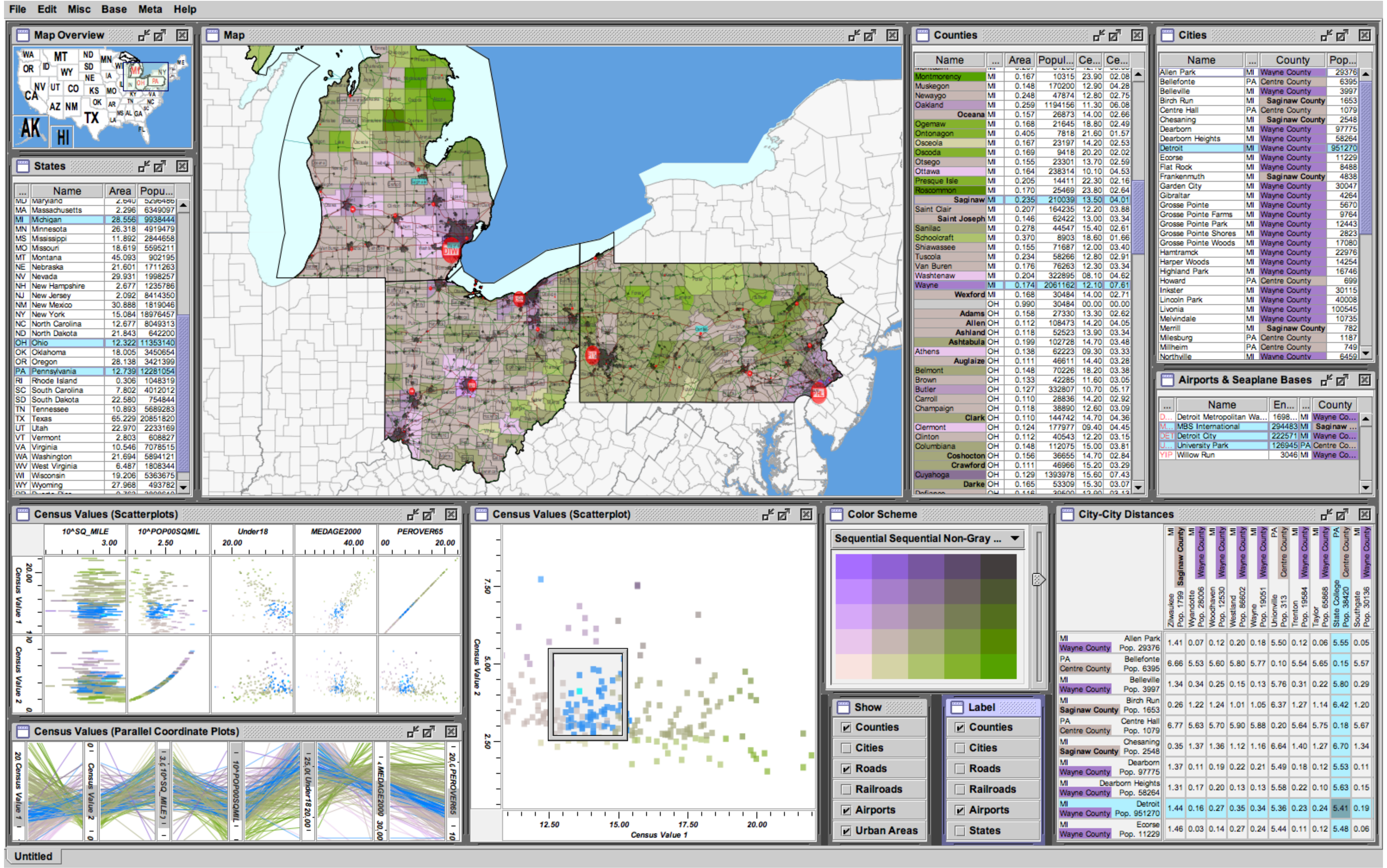
[Munzner (ill. Maguire), 2014]

Multiple Views

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

[Munzner (ill. Maguire), 2014]

Multiform



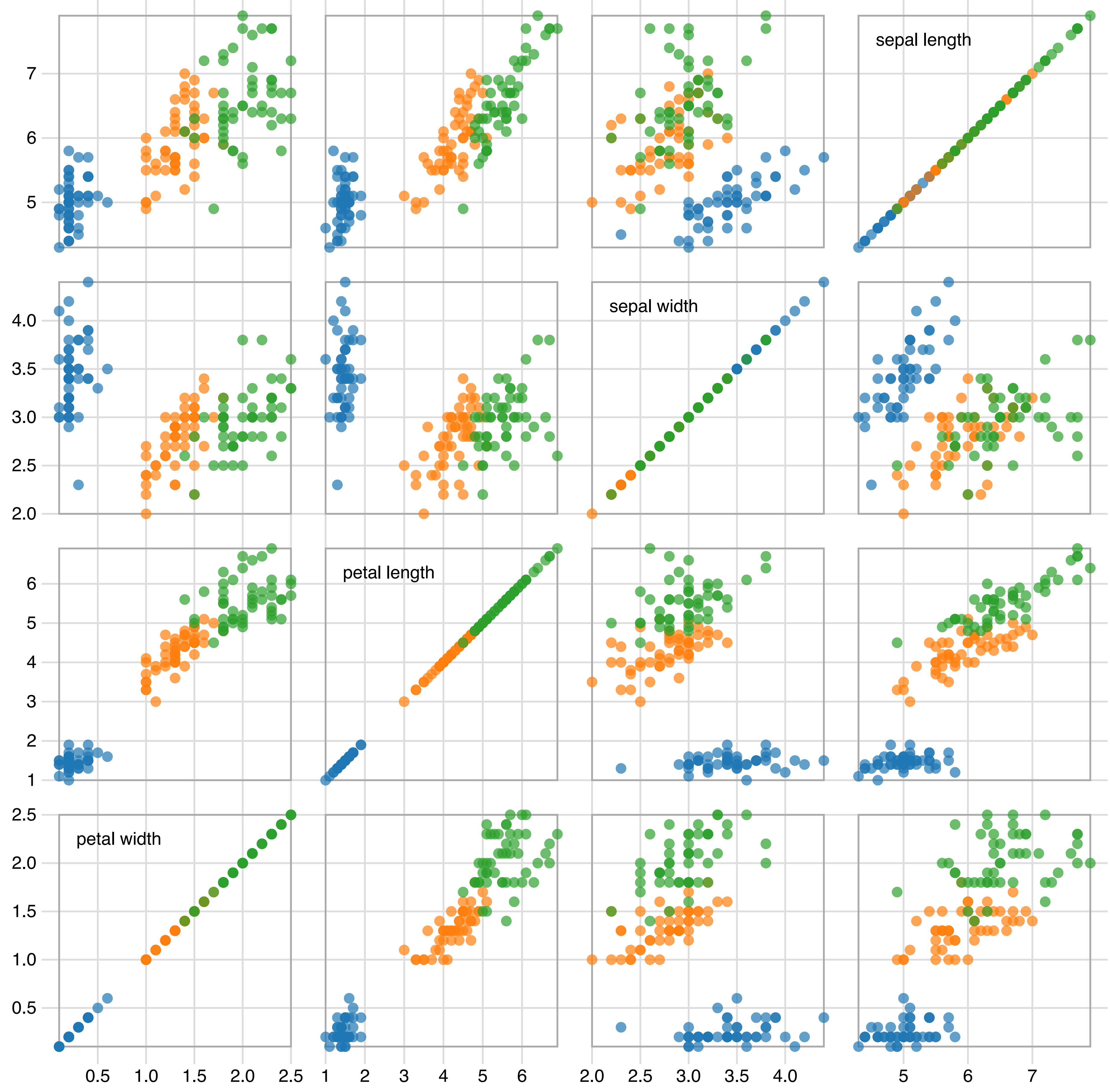
[Improvise, Weaver, 2004]

Multiform Views

- The same data visualized in different ways
- Does not need to be a totally different encoding (all choices need not be disjoint), e.g. horizontal positions could be the same
- One view becomes cluttered with too many attributes
- Consumes more screen space
- Allows greater separability between channels

Small Multiples

- Same encoding, but different data in each view (e.g. SPLOM)

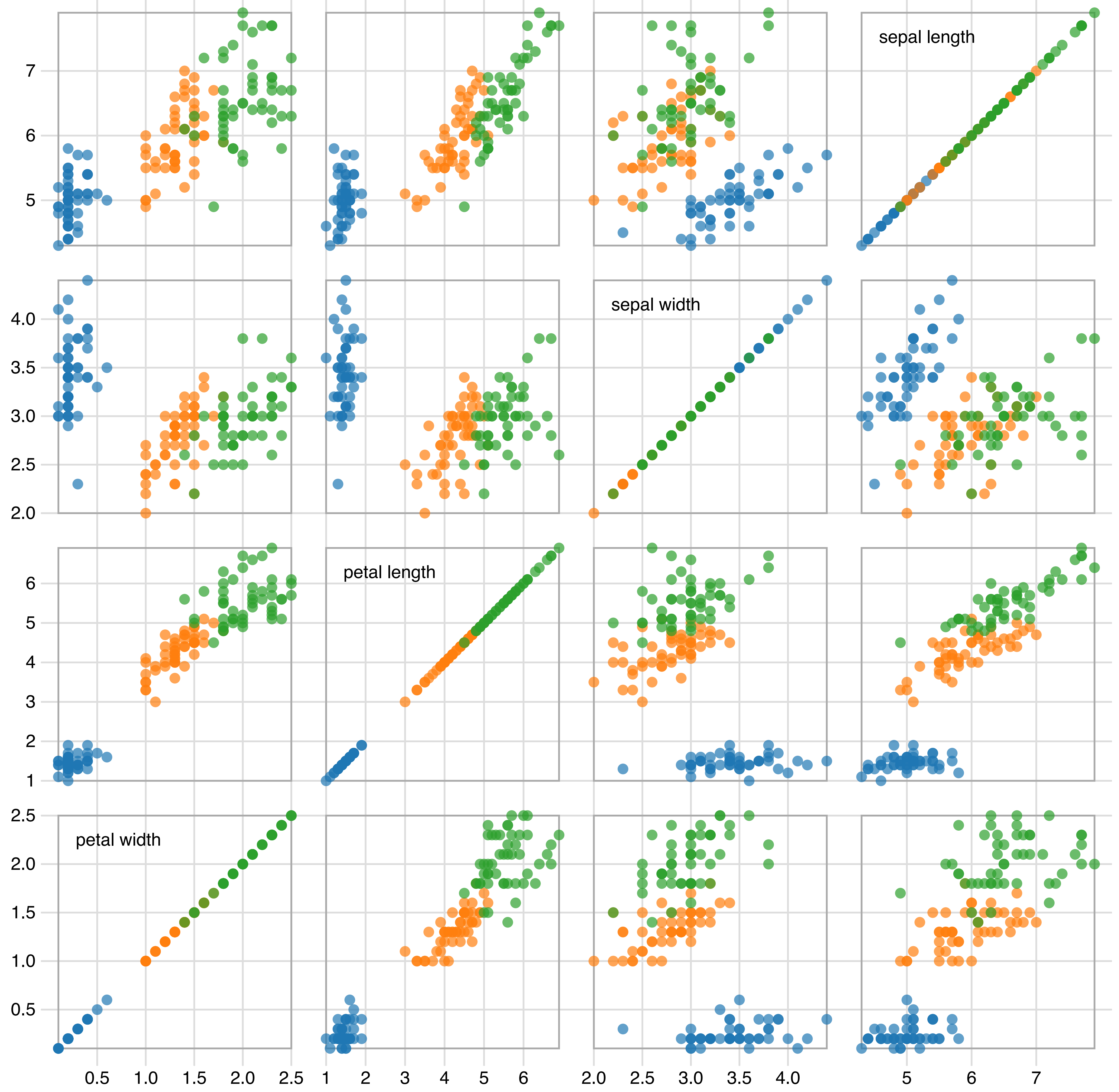


[M. Bostock]

Interaction with Multiform & Small Multiples

- Key interaction with multiform and small multiples: **brushing**
  - also called linked highlighting
- Want to understand correspondences between representation in the different views

Brushing

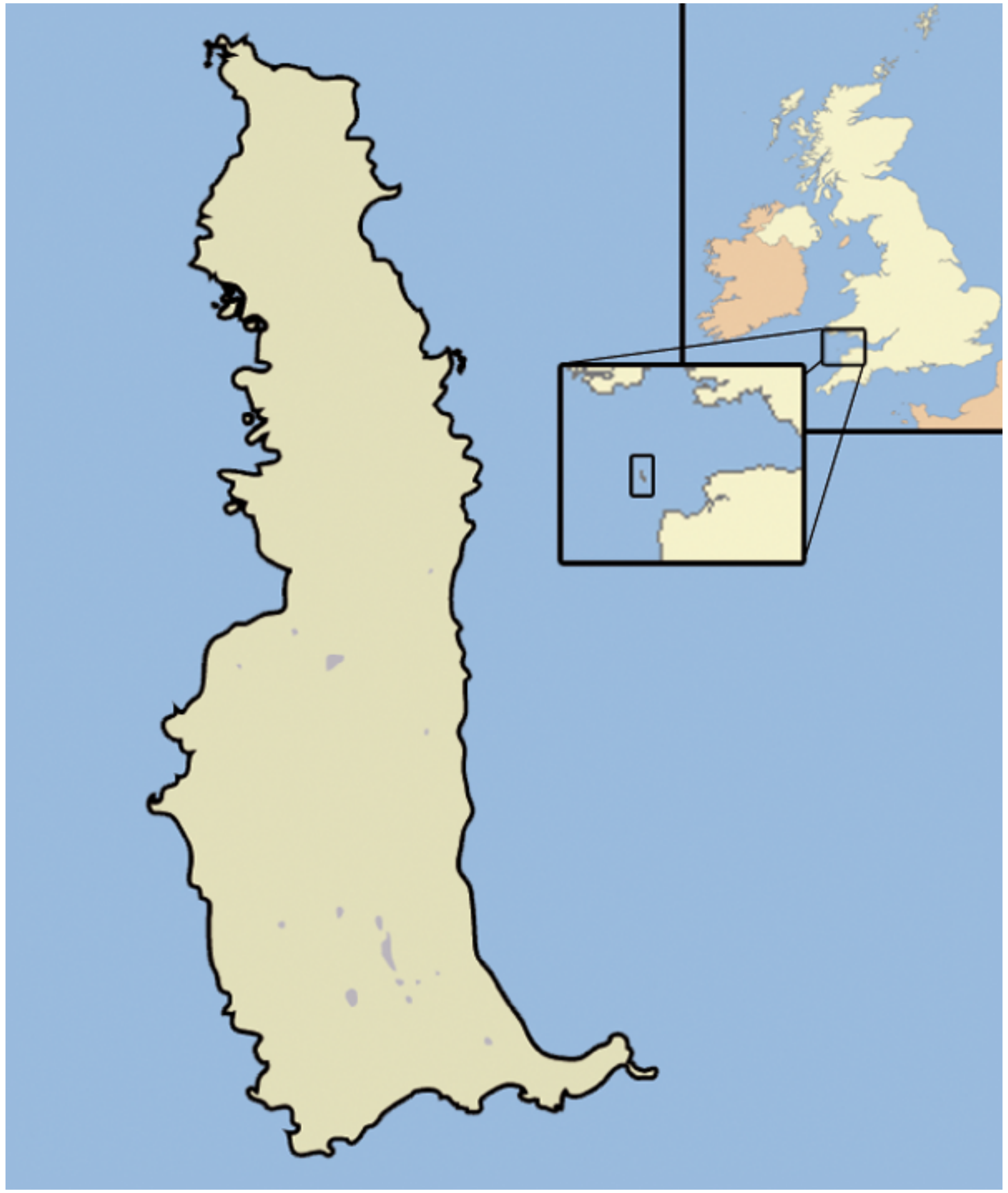


[M. Bostock]

Schneiderman's Mantra

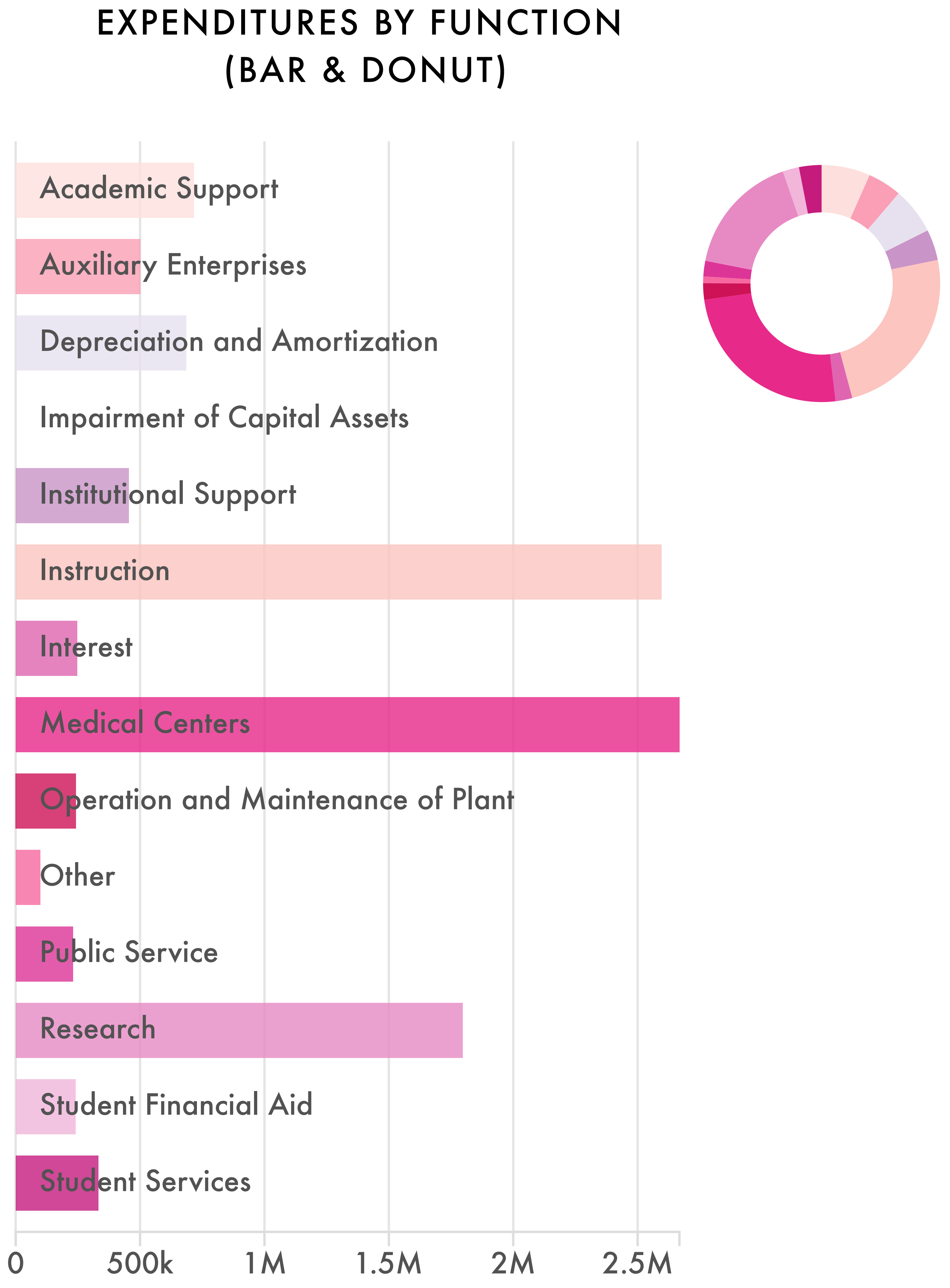
- Visual Information-Seeking Mantra [B. Schneiderman, 1996]:
  - Overview first
  - Zoom and filter (Chapter 13)
  - Details on demand
- Goal of the overview is to **summarize** all of the data
- Want specific **details** about some aspect(s) of the data, need another view/ layer
  - May be permanent: side-by-side
  - May be a popup layer: often opaque or separated
- (see textbook Ch. 6.7)

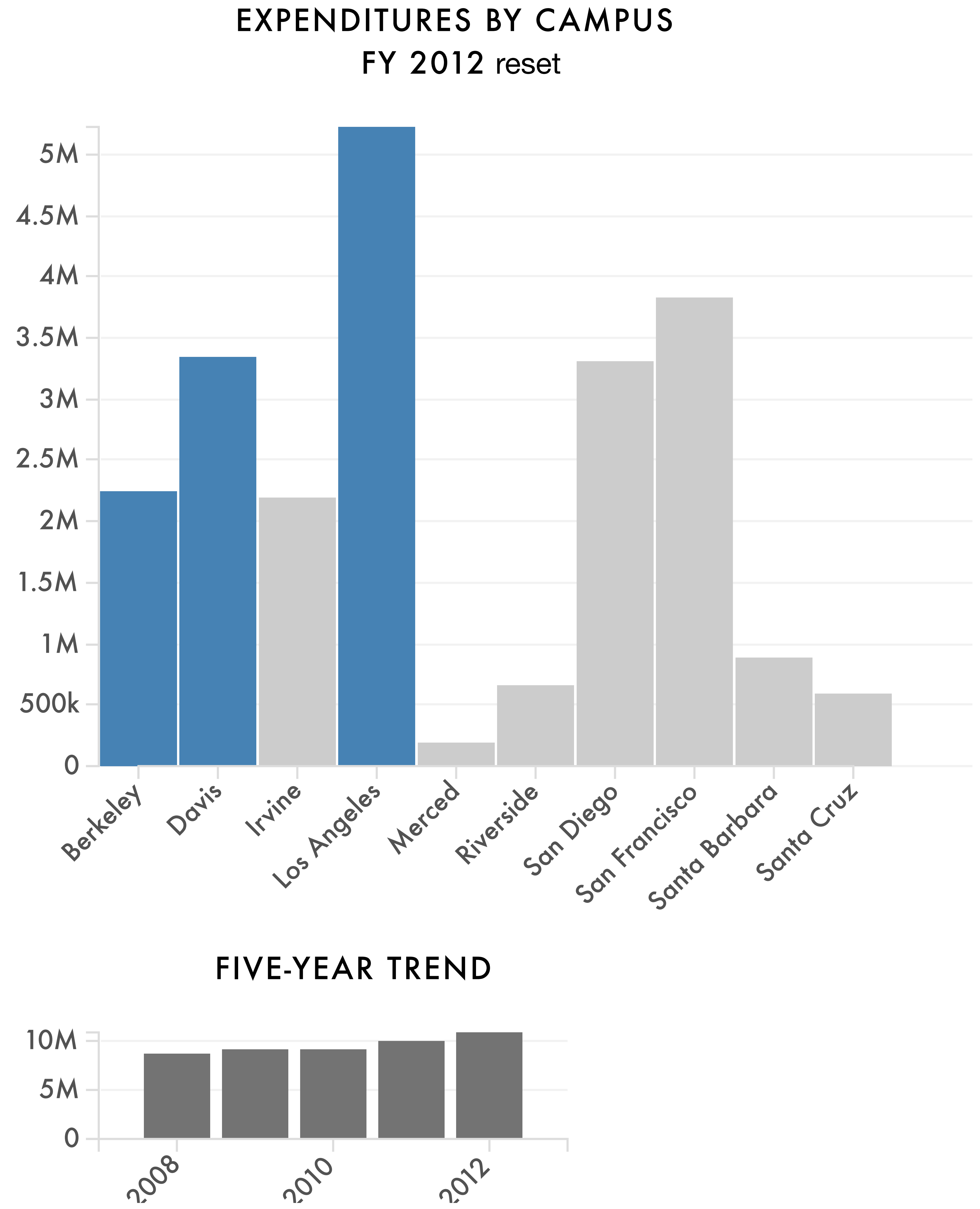
Overview-Detail View



[Wikipedia]

Overview-Detail (Different Encoding)





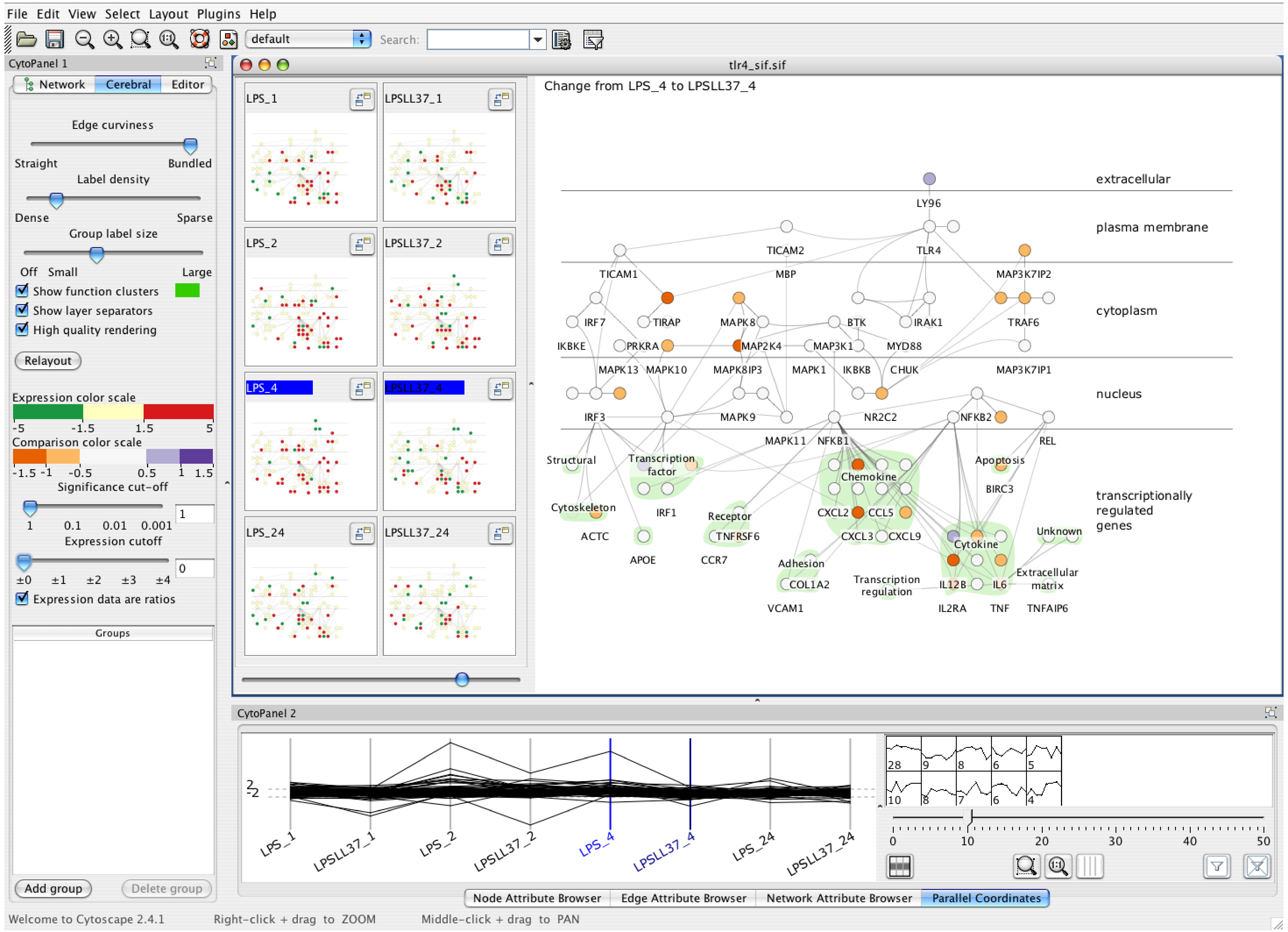
[S. Quigley]

Overview-Detail (with Zoom-Filter)

- Detail involves some subset of the full dataset
- Involves user selection or filtering of some type

- How question: includes facet
- Examples:
  - Maps: partition into two views with same encoding, overview-detail
  - UC Trends: partition into multiple views, coordinated with linked highlighting, overview+detail of expenditures

Multiform & Small Multiples (Cerebral)



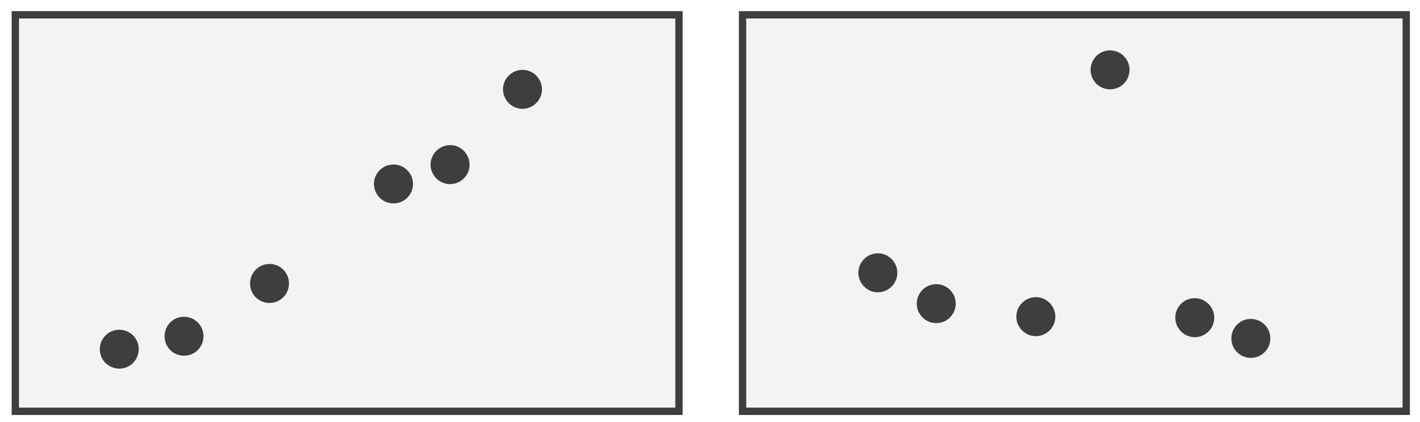
[Barsky et al., 2008]

Navigation across multiple views

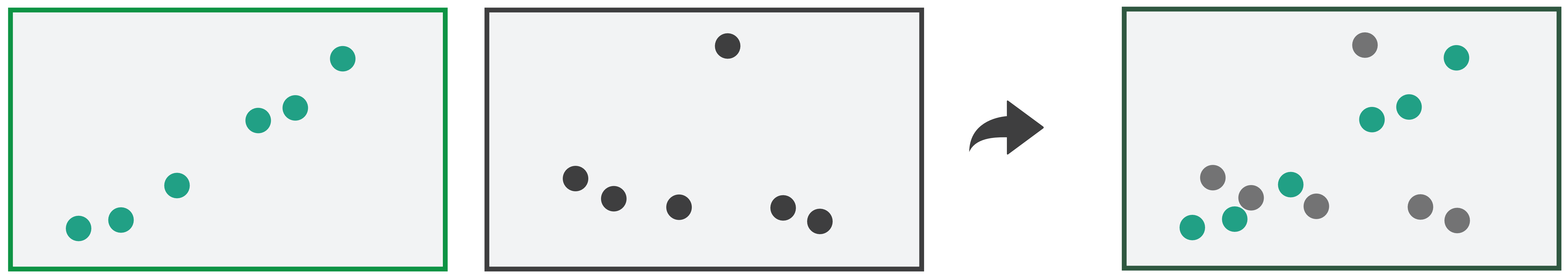
- Often navigation in one view updates navigation in another
- Example: Maps: overview shifts as you move around in detail view
- Selections in one view may trigger selections in another

Multiple Views

➔ Partition into Side-by-Side Views



➔ Superimpose Layers



[Munzner (ill. Maguire), 2014]

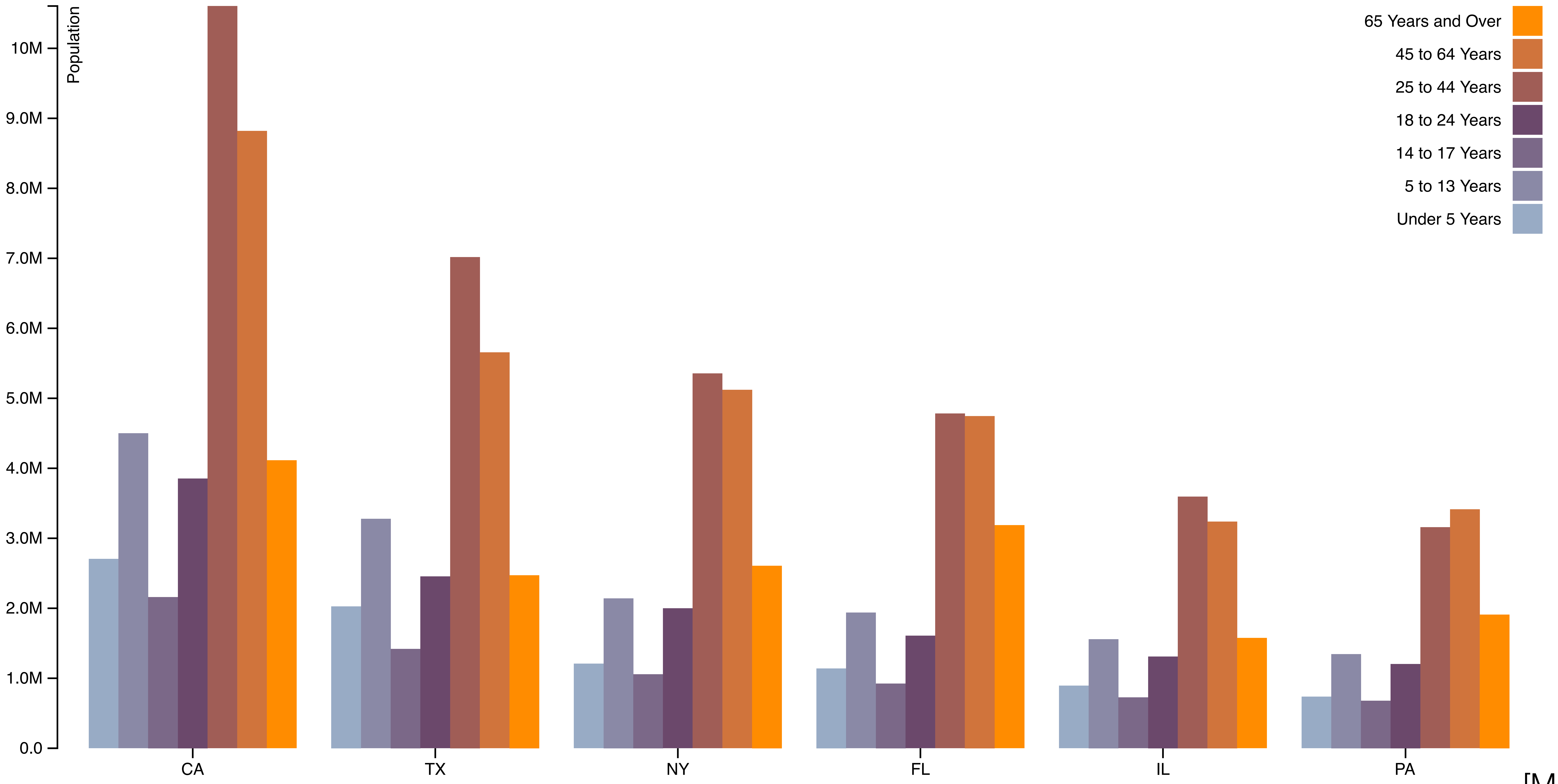
Partitioned Views

- Split dataset into groups and visualize each group
- Extremes: one item per group, one group for all items
- Can be a hierarchy
  - Order: which splits are more "related"?
  - Which attributes are used to split? usually categorical

Glyphs, Views, and Regions

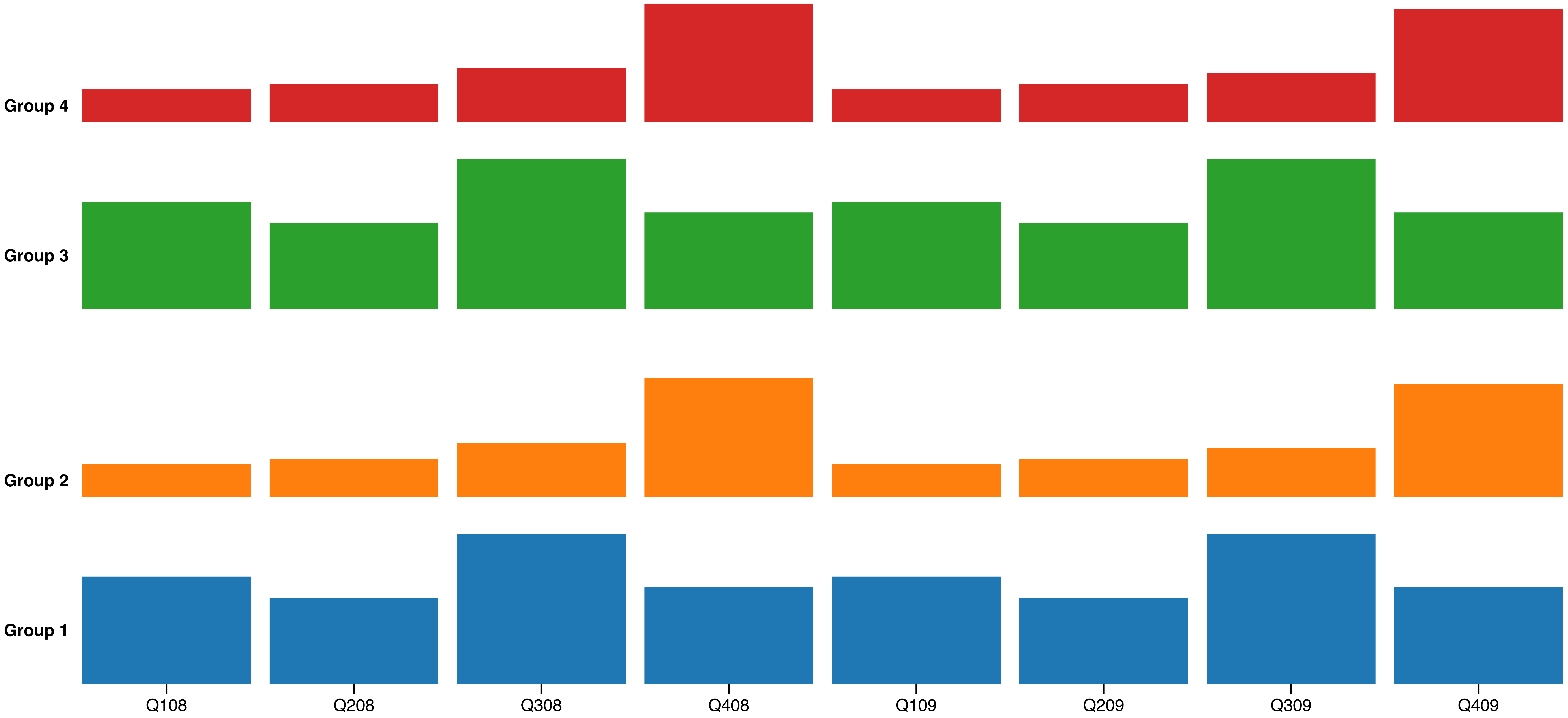
- Glyphs are composed of multiple marks
- Views are a contiguous region of space
- A region is usually associated with a group of data
- Blurry lines of distinction between them

Example: Grouped Bar Chart



[M. Bostock]

Example: Small Multiples Bar Chart

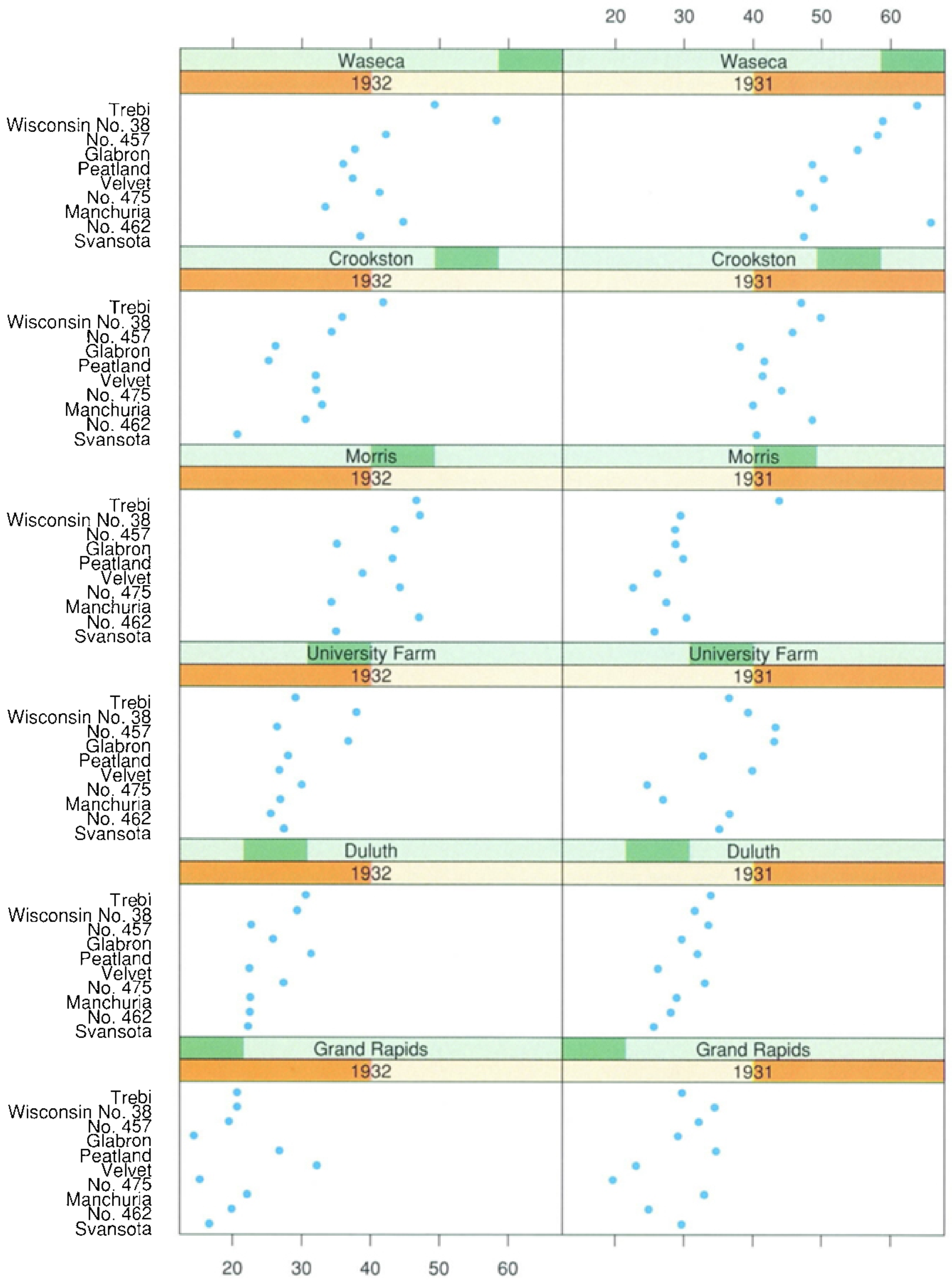


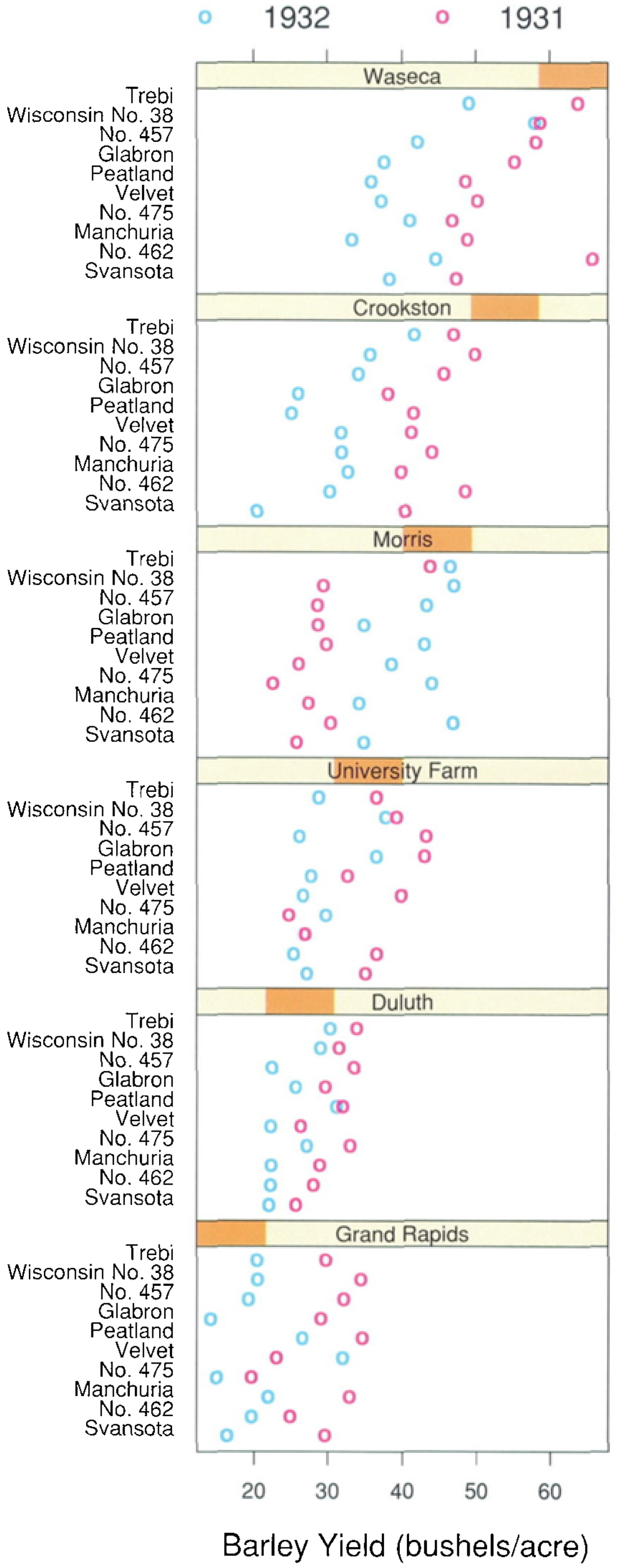
[M. Bostock]

Matrix Alignment & Recursive Subdivision

- Matrix Alignment:
  - regions are placed in a matrix alignment
  - splits go to rows and columns
  - main-effects ordering: use summary statistic to determine order of categorical attribute
- Recursive subdivision:
  - Designed for exploration
  - Involves hierarchy
  - User drives the ways data is broken down in recursive manner

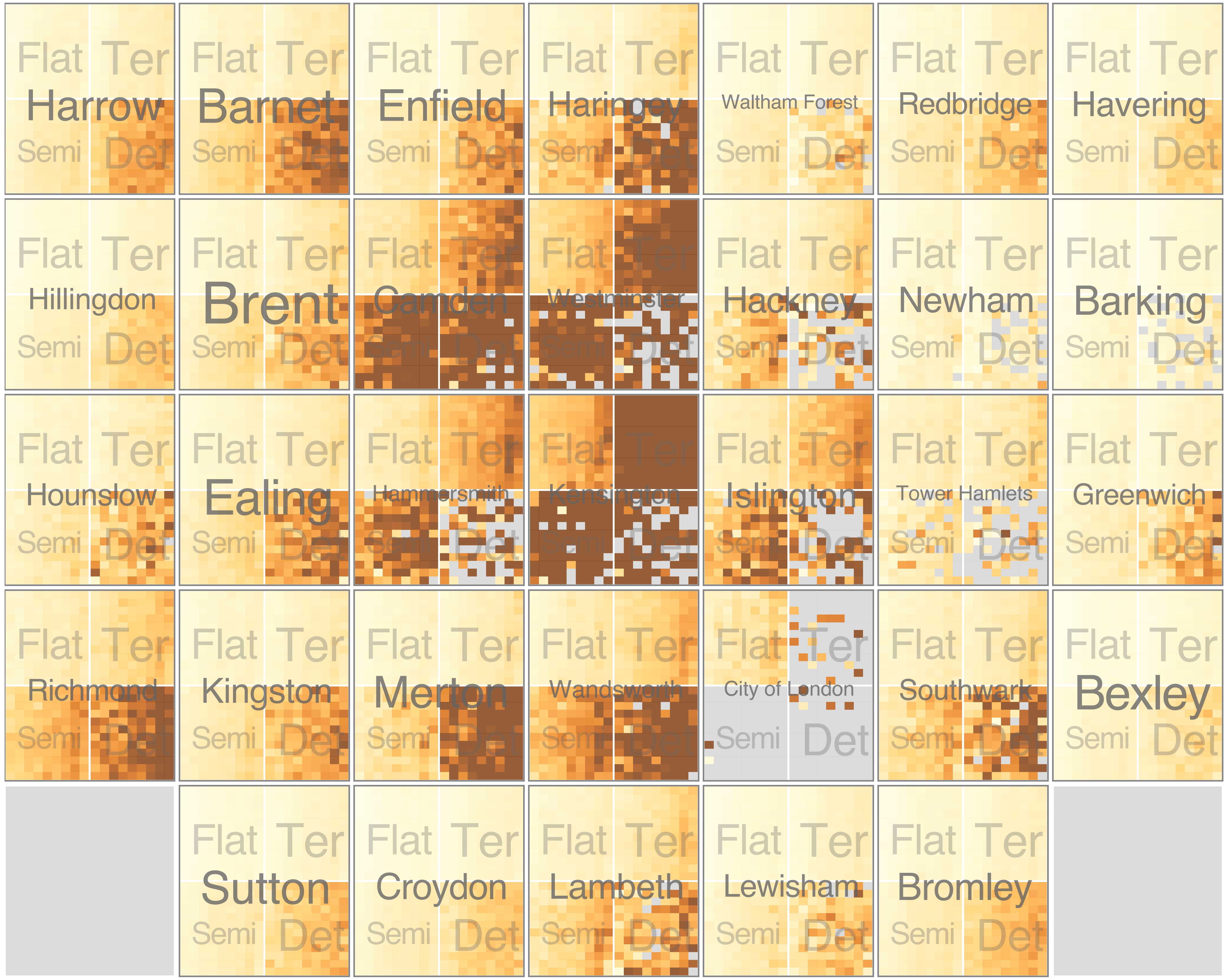
Example: Trellis Matrix Alignment





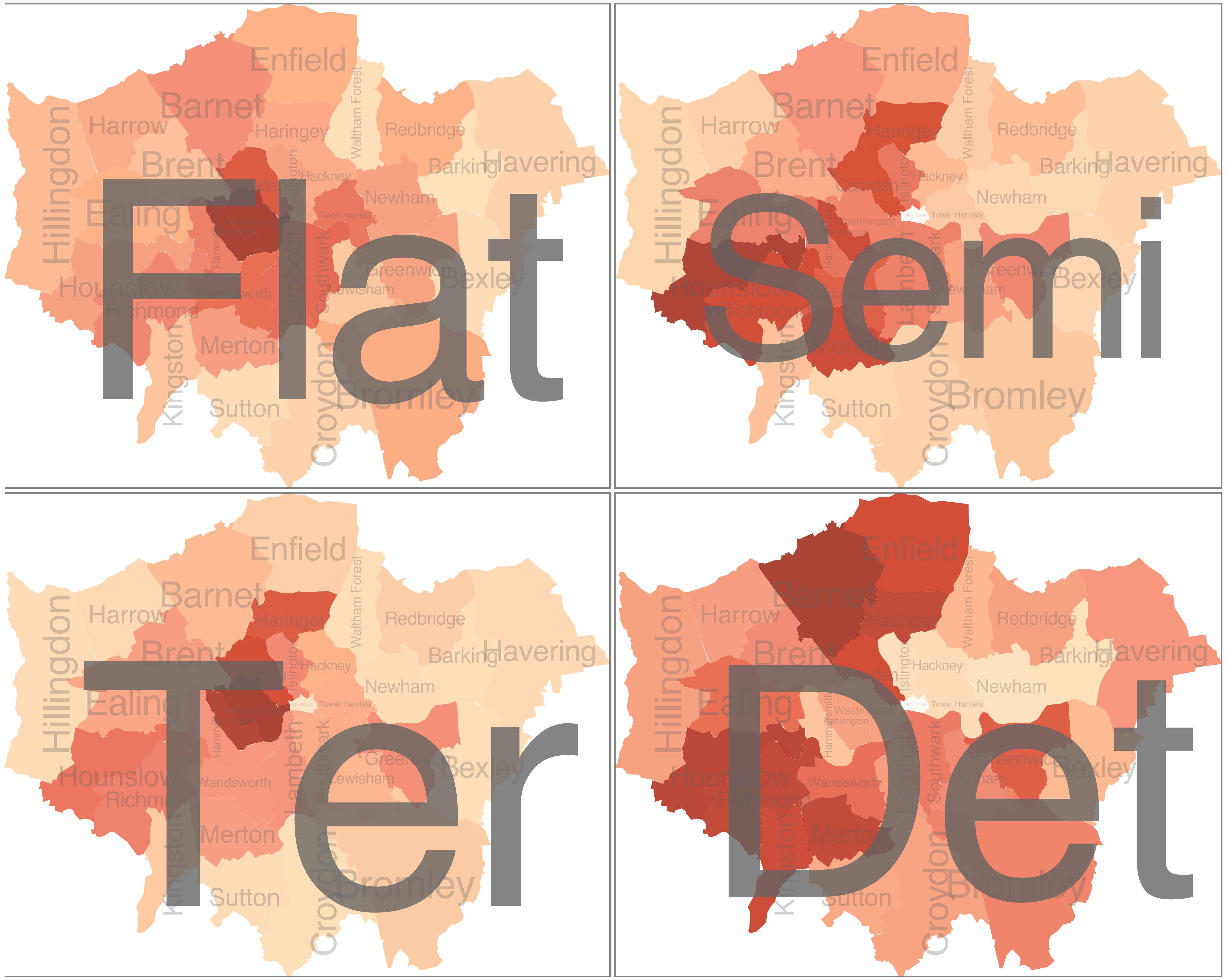
[Becker et al., 1996]

Example: HiVE System



[Slingsby et al., 2009]

Example: HiVE System



[Slingsby et al., 2009]

Reducing Complexity

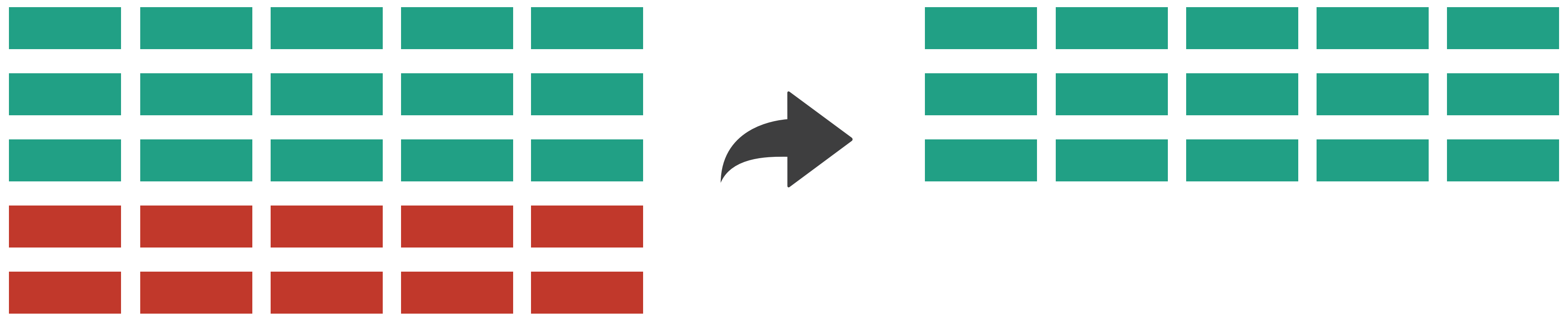
Reducing Complexity

- Too many items or attributes lead to visual clutter
- Interaction and Multiple Views can help, but often lose the ability to start understanding an entire dataset at first glance
- **Reduction** techniques show less data to reduce complexity
- Can reduce items or attributes (both are **elements**)
- **Filtering**: eliminate elements from the current view
  - "out of sight, out of mind"
- **Aggregation**: replace elements with a new element that represents the replaced elements
  - summarization is often challenging to design
- Another method is **focus+context**: show details in the context of an overview

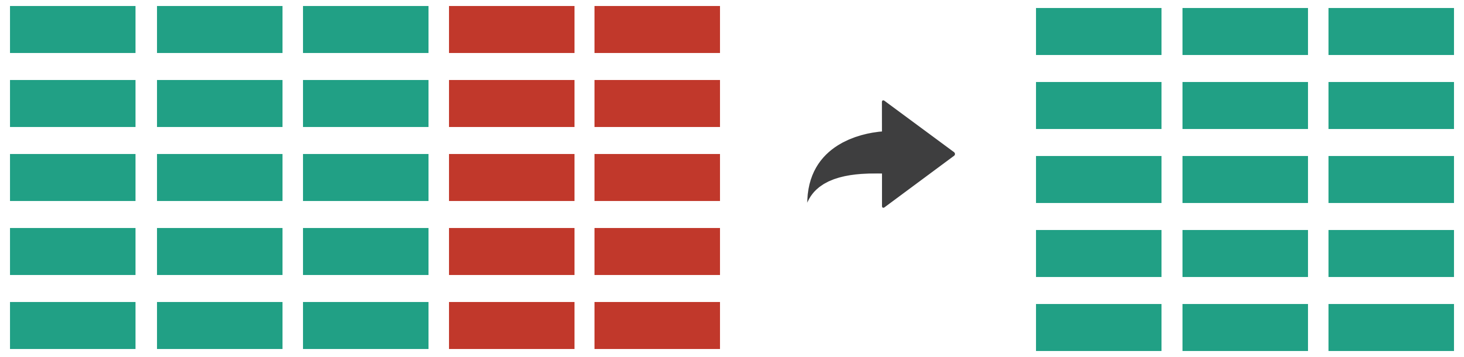
Overview: Reducing Items & Attributes

➔ Filter

→ Items

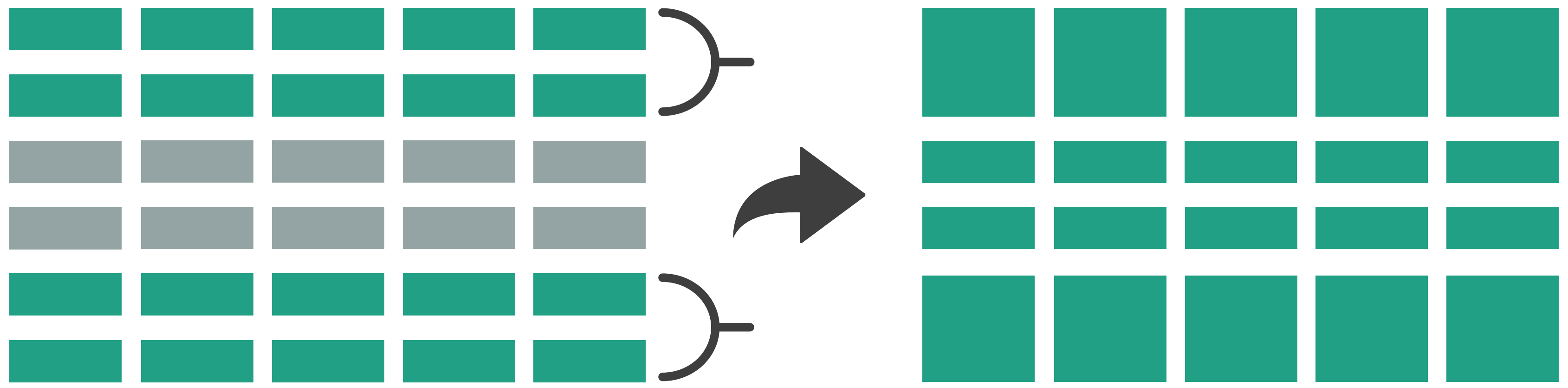


→ Attributes

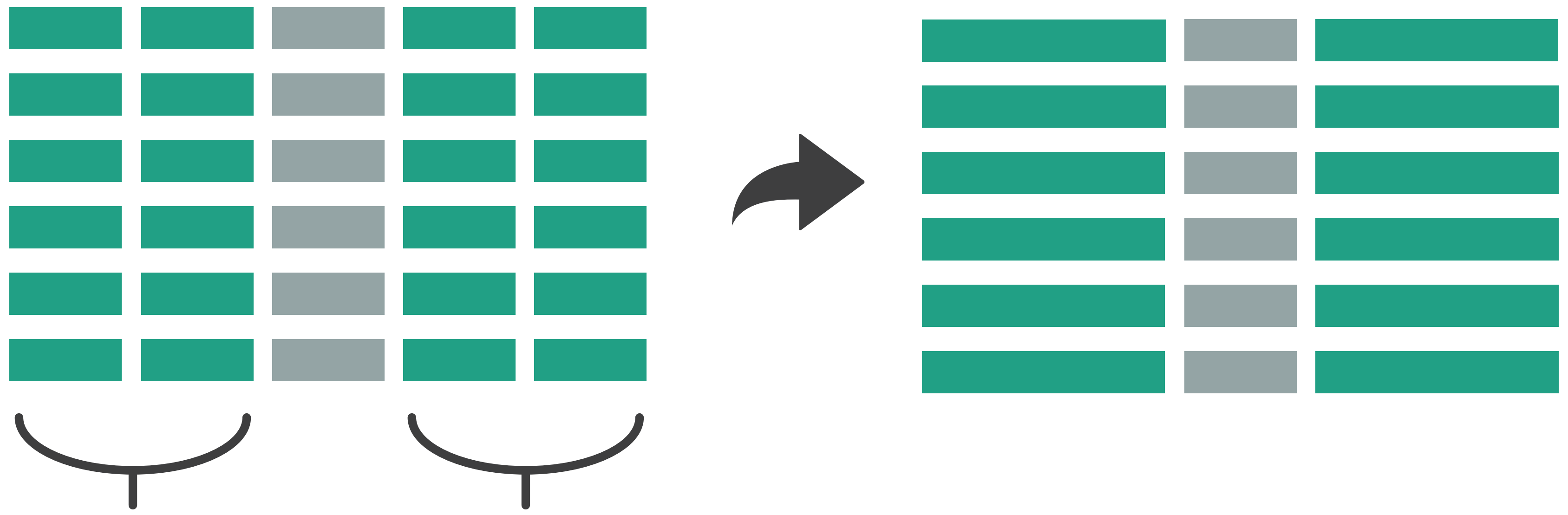


➔ Aggregate

→ Items



→ Attributes



[Munzner (ill. Maguire), 2014]

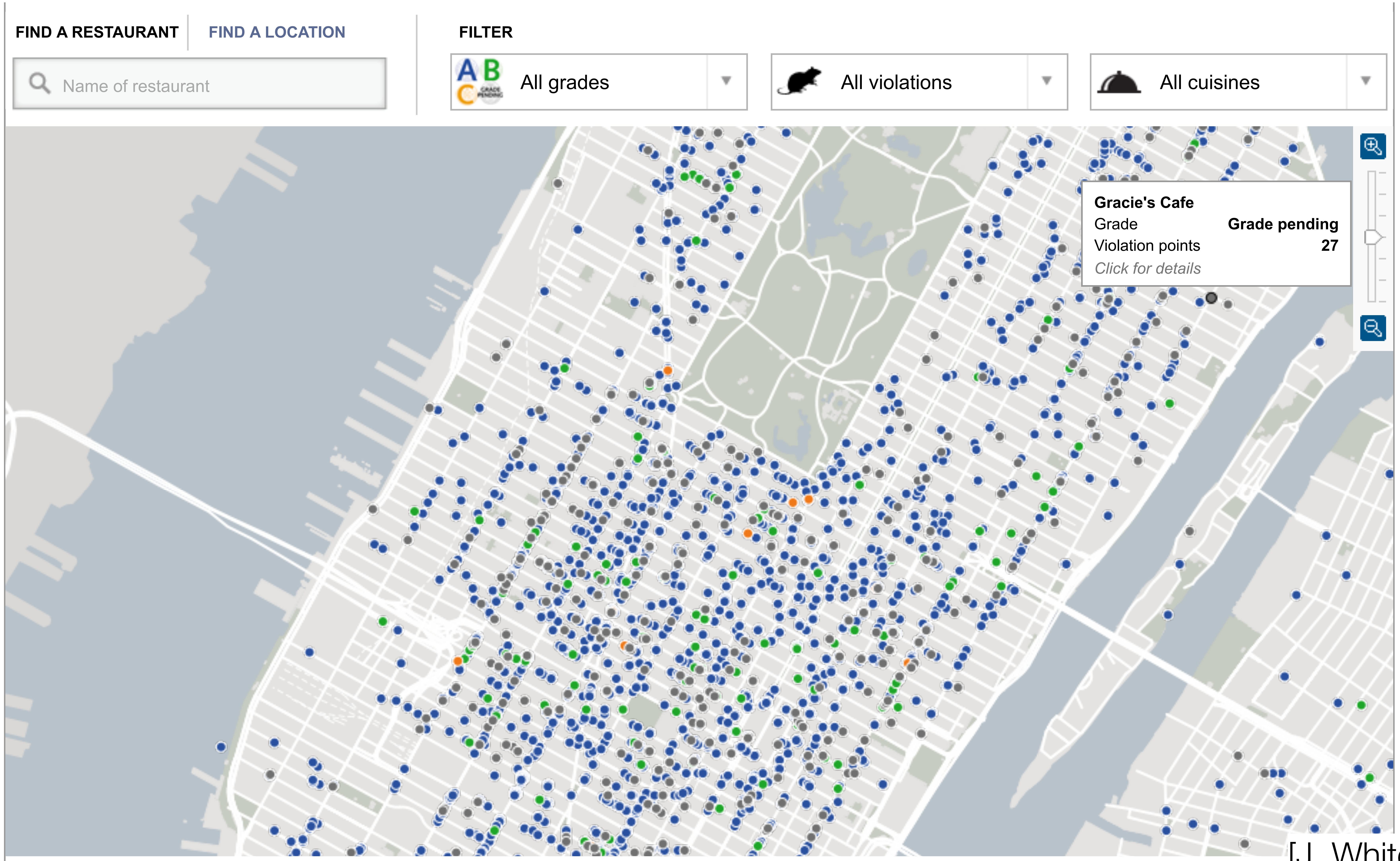
Filtering

- Just don't show certain elements
- Item filtering: most common, eliminate marks for filtered items
- Attribute filtering:
  - attributes often mapped to different channels
  - if mapped to same channel, allows many attributes (e.g. parallel coordinates, star plots), can filter
- How to specify which elements?
  - Pre-defined rules
  - User selection

Filter vs. Query

- Queries start with an empty set of items and **add** items
- Filters start with all items and **remove** items

Example: NYC Health Dept. Restaurant Ratings

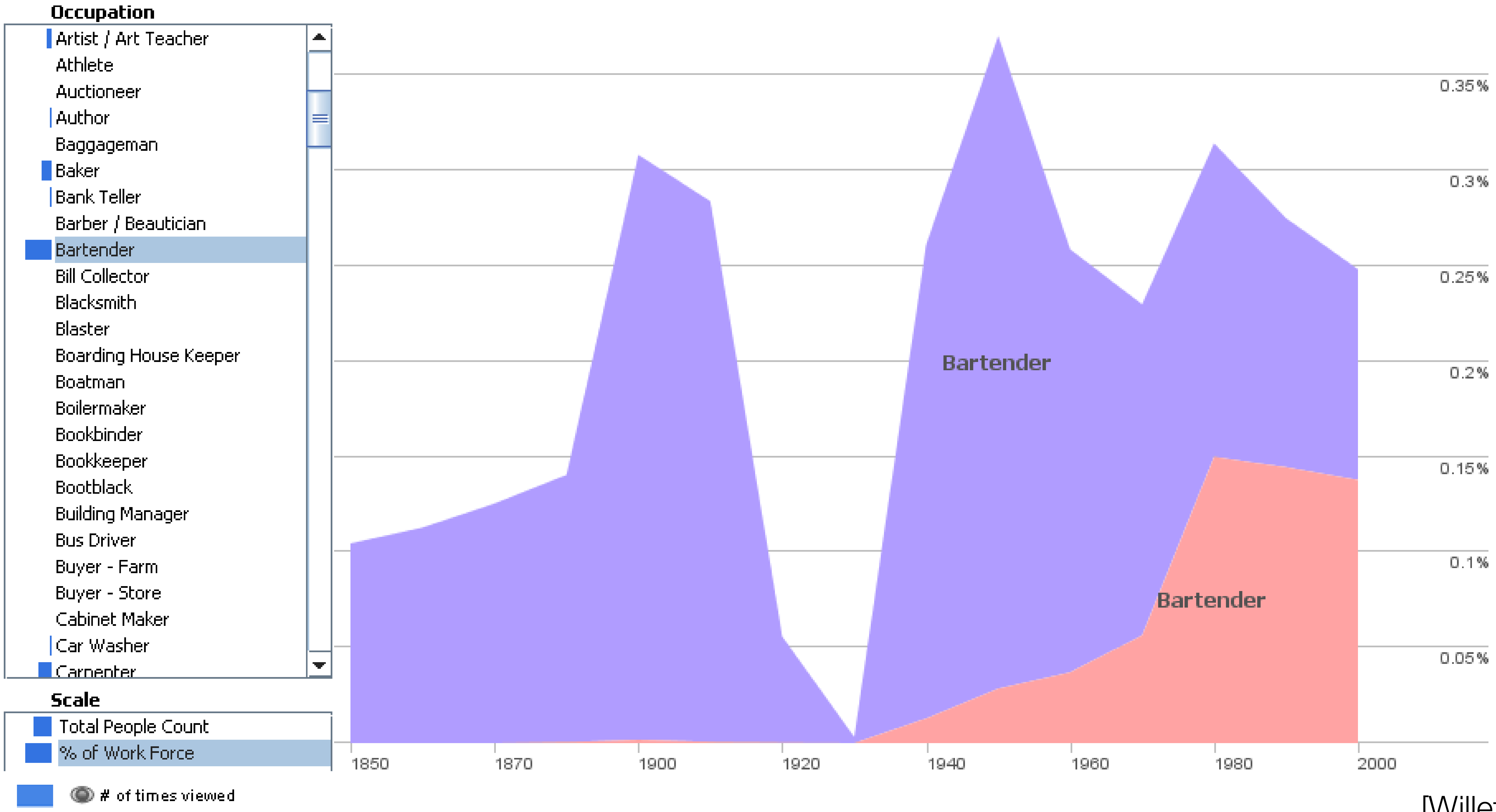


[J. White, New York Times]

Dynamic Filters

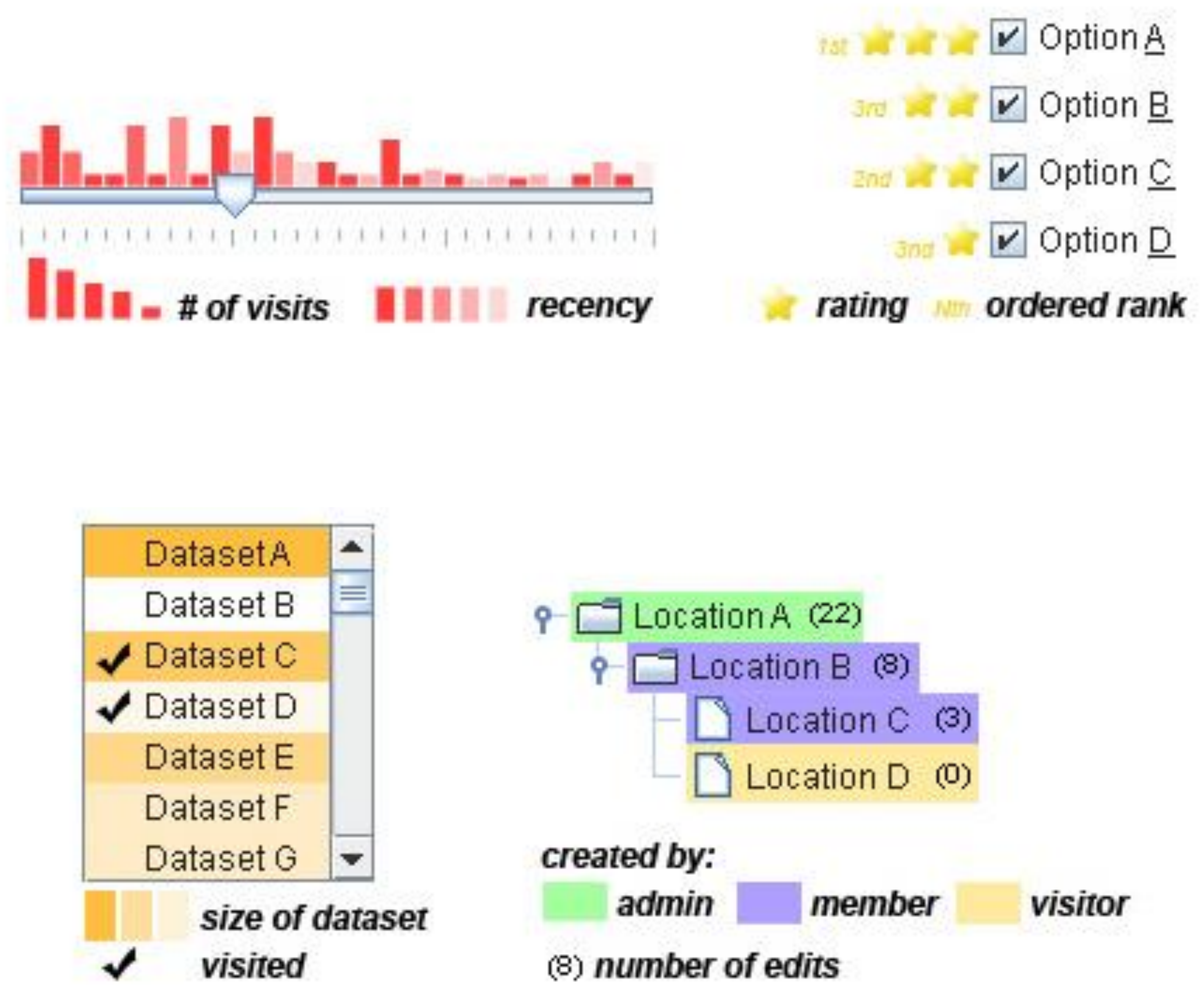
- Interaction need not be with the visualization itself
- Users interact with **widgets** that control which items are shown
  - Sliders, Combo boxes, Text Fields
- Often tied to attribute values
- Examples:
  - All restaurants with an "A" Grade
  - All pizza places
  - All pizza places with an "A" Grade

Scented Widgets



[Willett et al., 2007]

Scented Widgets



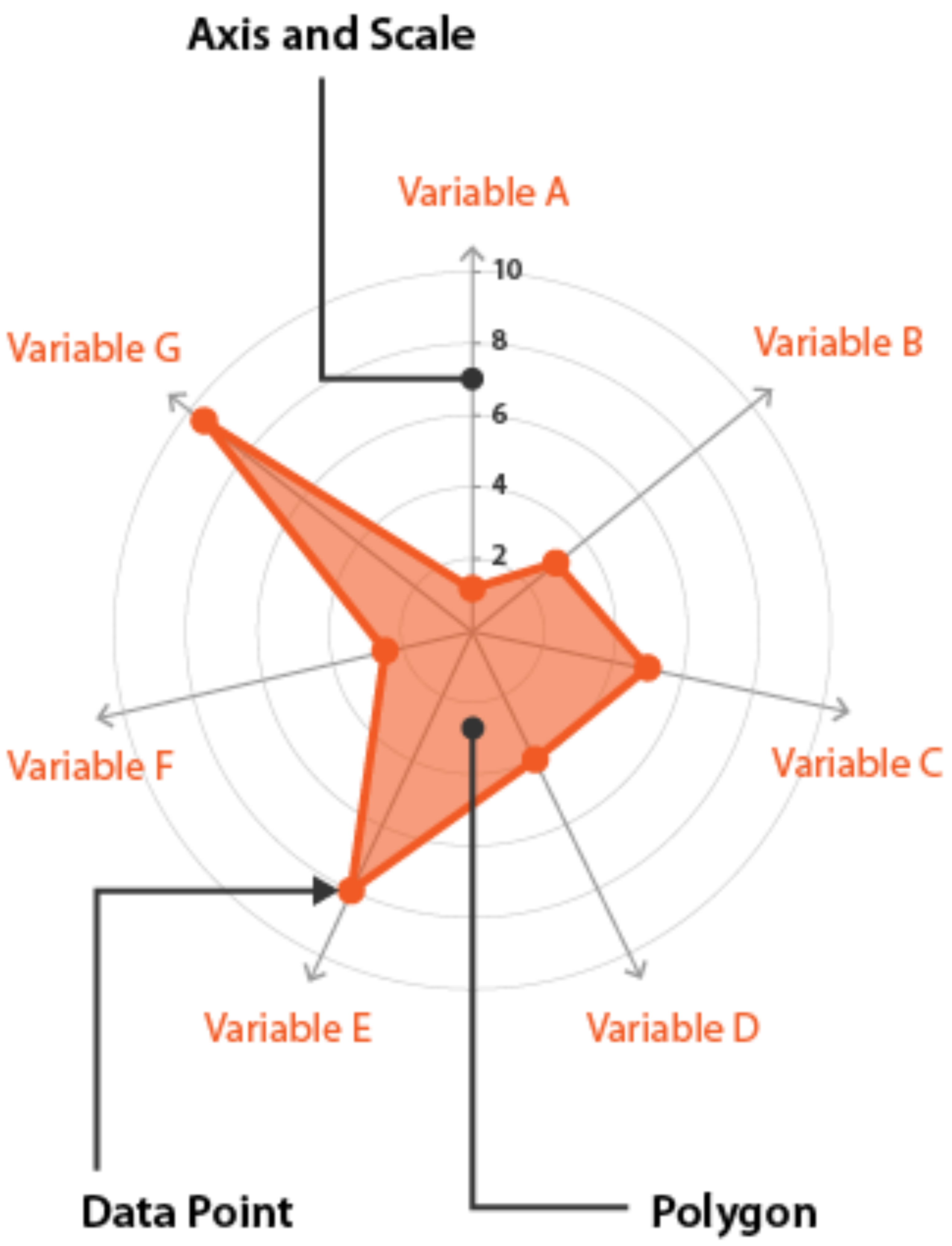
Name	Description	Example
Hue	Varies the hue of the widget (or of a visualization embedded in it)	Option A Option B
Saturation	Varies the saturation of the widget (or of a visualization embedded in it)	Option A Option B
Opacity	Varies the saturation of the widget (or of a visualization embedded in it)	Option A Option B
Text	Inserts one or more small text figures into the widget	(2) Option A (10) Option B
Icon	Inserts one or more small icons into the widget.	Option A Option B
Bar Chart	Inserts one or more small bar chart visualizations into the widget	Option A Option B
Line Chart	Inserts one or more small line chart visualizations into the widget	Option A Option B

[Willett et al., 2007]

Star Plots (aka Radar Charts)

[K. Schaul]

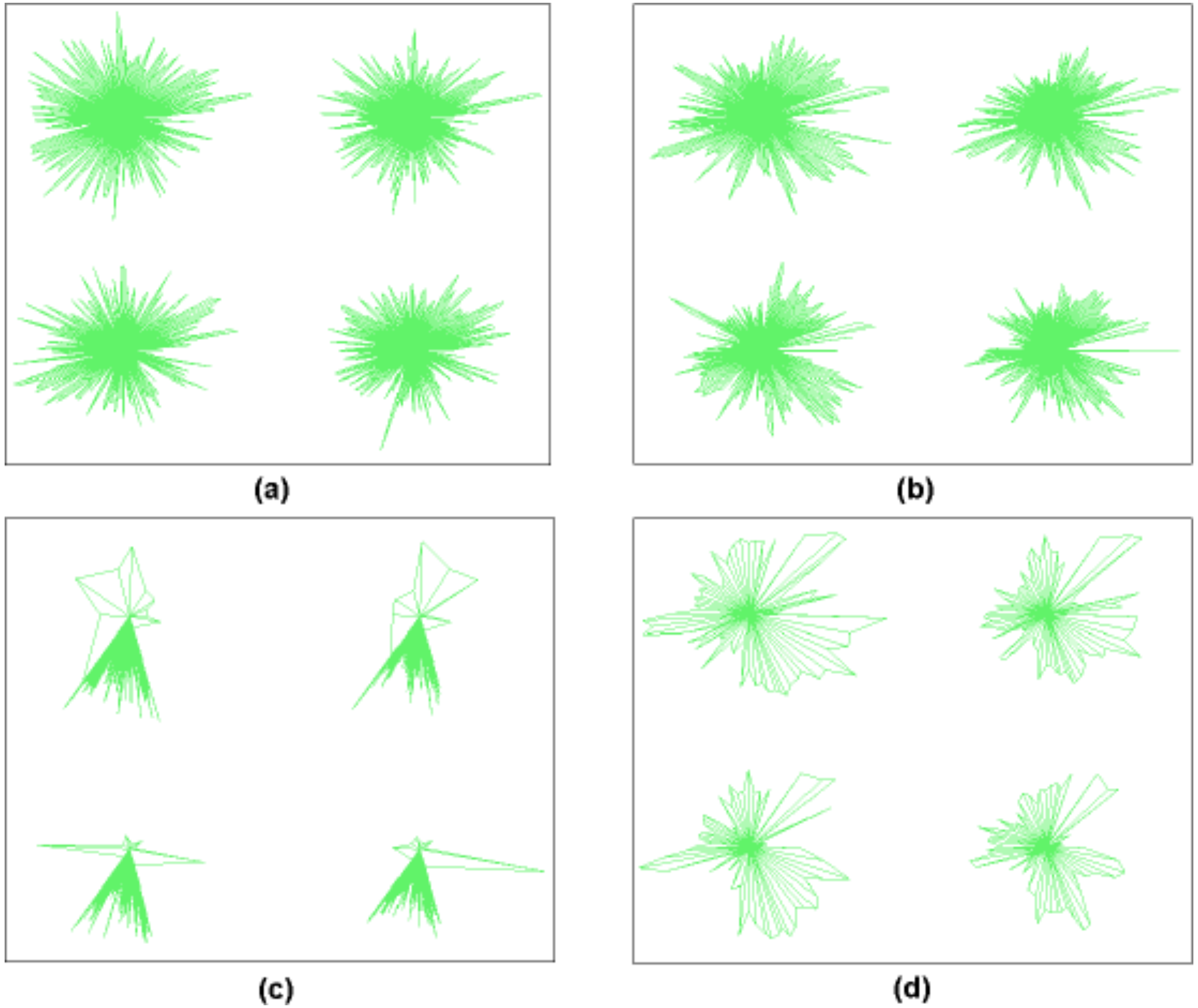
Star Plot / Radar Chart



- Use:
  - Compare variables
  - Similarities/differences of items
  - Locate outliers
- Considerations:
  - Order of axes
  - Too many axes cause problems

[S. Ribecca]

Attribute Filtering on Star Plots



[Yang et al., 2003]

Attribute Filtering

- How to choose which attributes should be filtered?
  - User selection?
  - Statistics: similarity measures, attributes with low variance are not as interesting when comparing items

- Can be combined with item filtering

Aggregation

- Usually involves **derived** attributes
- Examples: mean, median, mode, min, max, count, sum
- Remember expressiveness principle: still want to avoid implying trends or similarities based on aggregation

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

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13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
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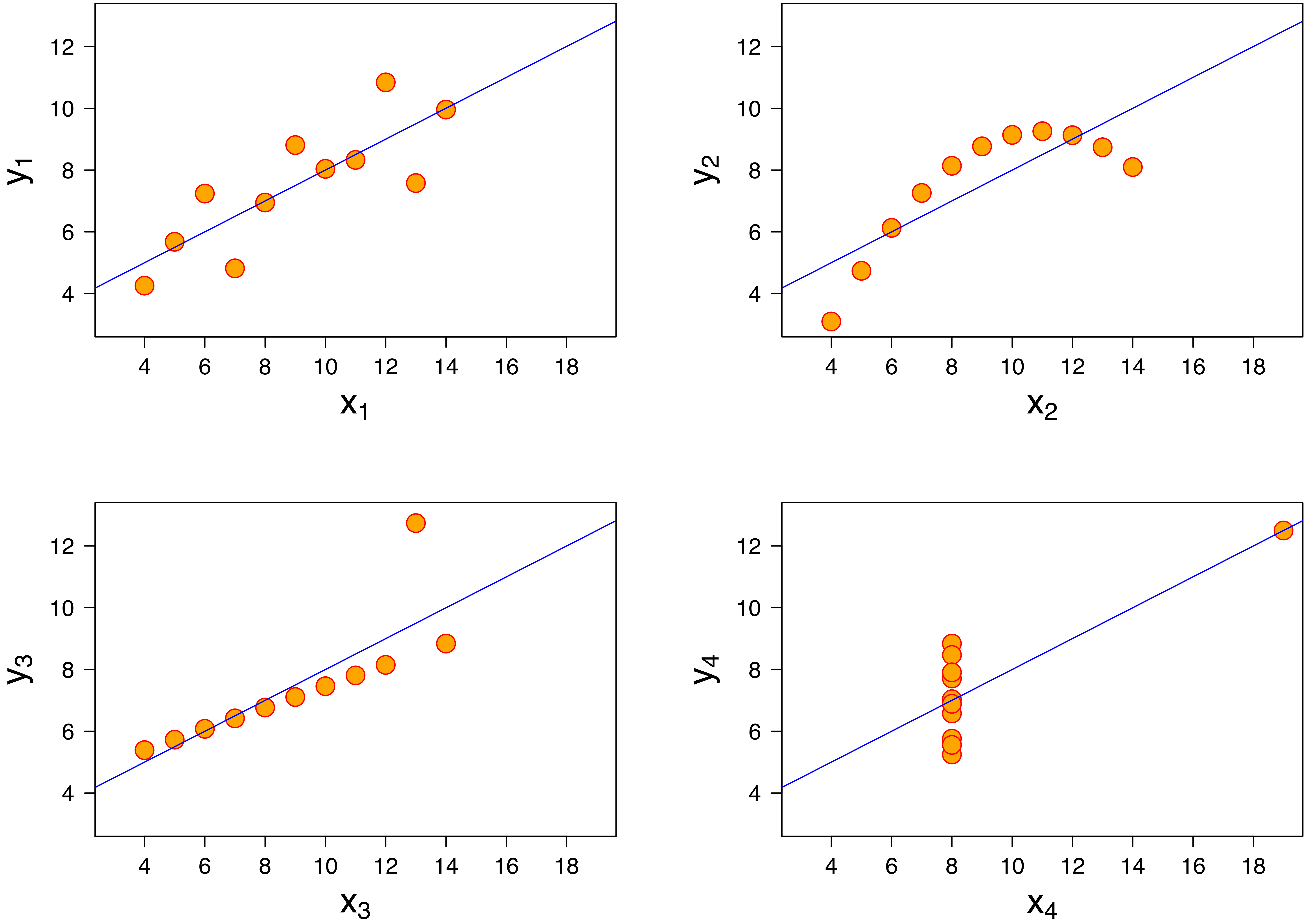
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Mean of x	9
Variance of x	11
Mean of y	7.50
Variance of y	4.122
Correlation	0.816

Anscombe's Quartet



[F. J. Anscombe]