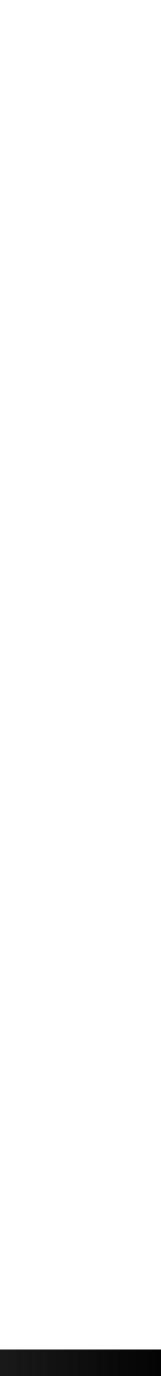
Data Visualization (CSCI 627/490)

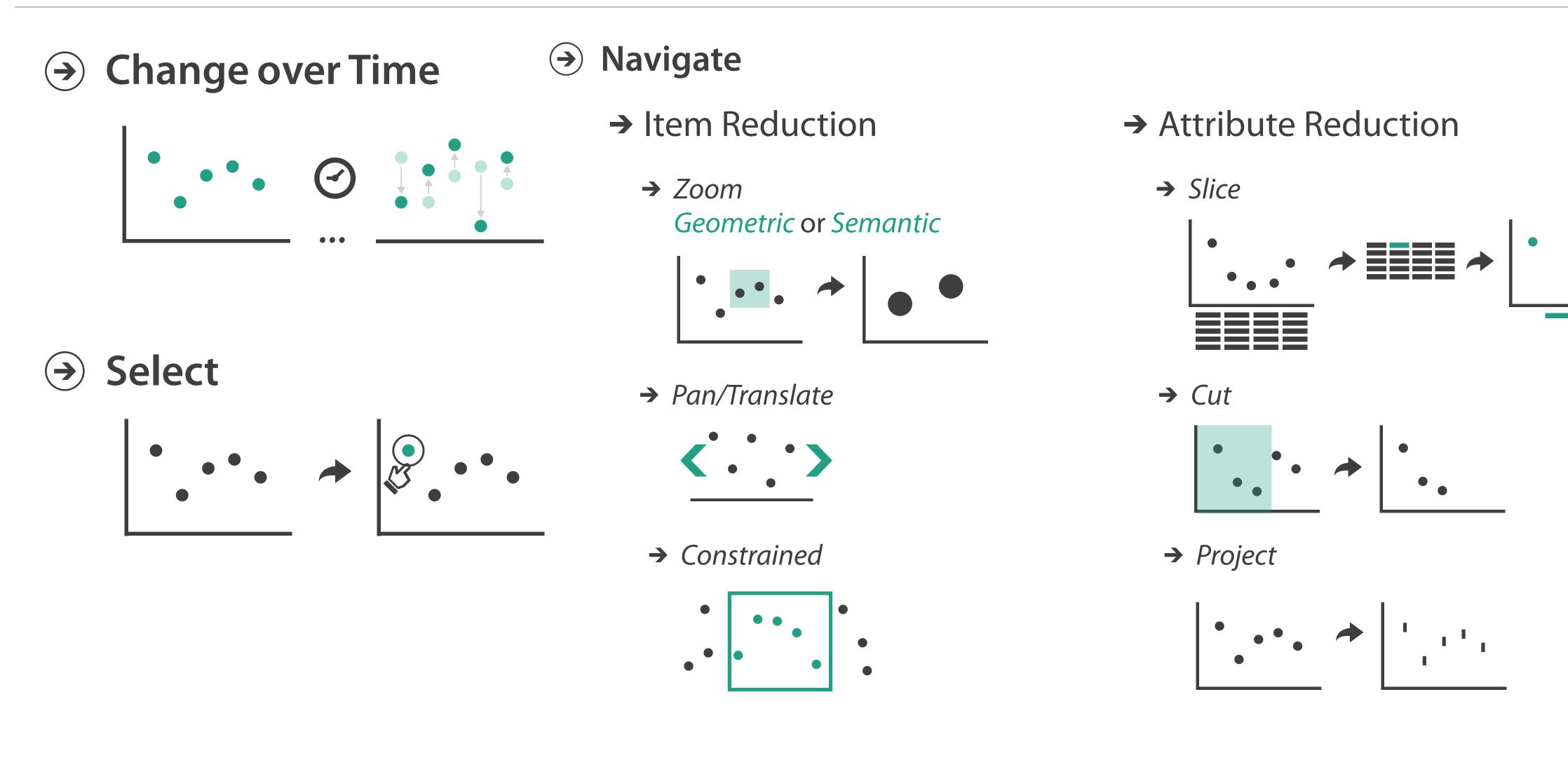
Multiple Views

Dr. David Koop





Interaction Overview



D. Koop, CSCI 627/490, Fall 2023

[Munzner (ill. Maguire), 2014]



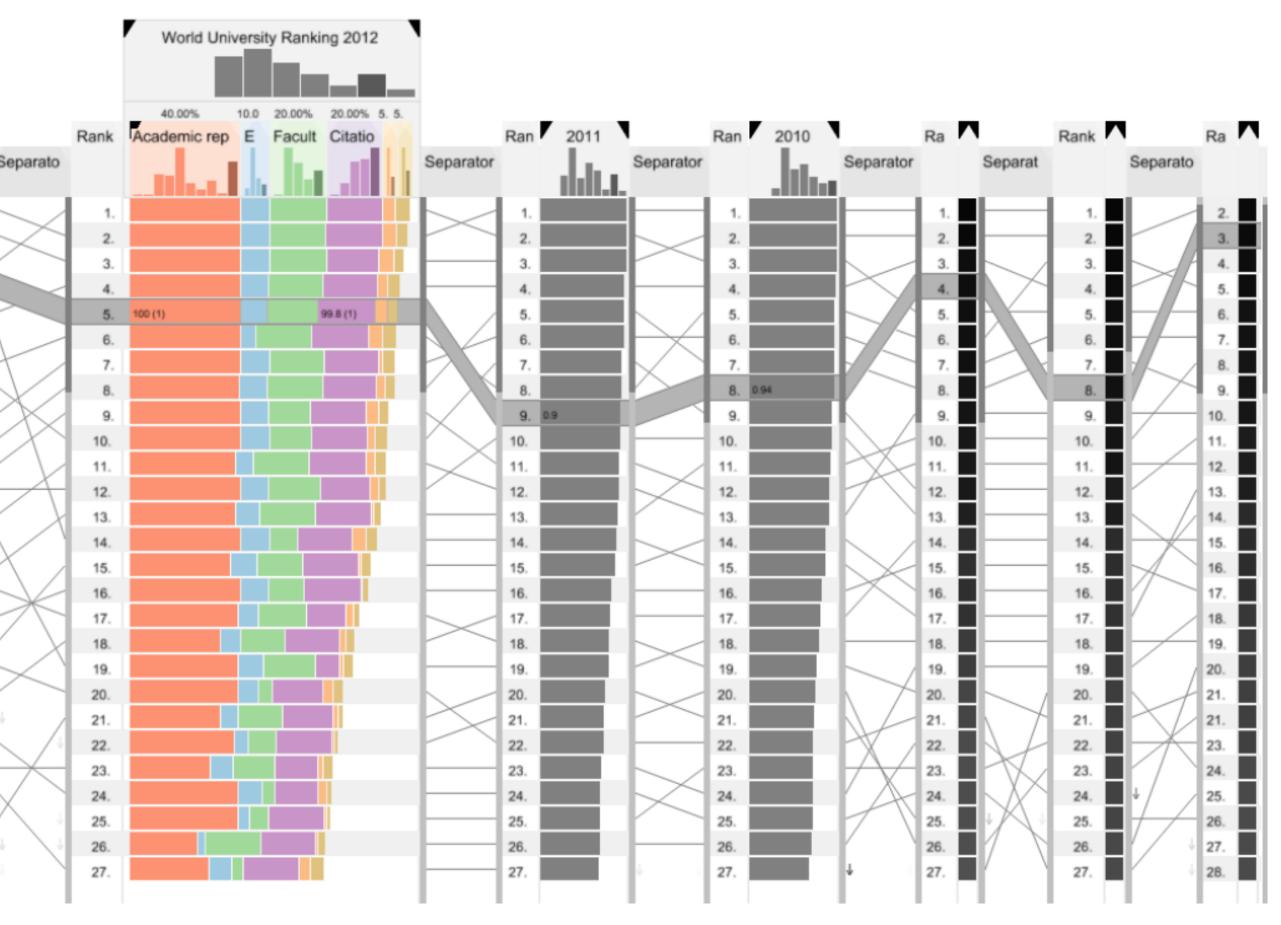


2

Sorting & Slope Graphs: LineUp

				Customized Combination								
Ra	School Name Filter: <none></none>	Country Filter: 1 out of 71	23.30% Academic reputati	9.85% Facult	16.00% Arts & Hu			29.55% World University Ranki				
1.	Harvard University	United States										
2.	Yale University	United States										
З.	Massachusetts Institute of Technology (MIT)	United States										
4.	Princeton University	United States	100 (1)		90.7 (0.91) 73	1.06 (0.73) 8	35.5 (0.86)	0.94				
5.	University of Chicago	United States										
6.	University of California, Berkeley (UCB)	United States										
7.	California Institute of Technology (Caltech)	United States										
8.	Stanford University	United States										
9.	Columbia University	United States										
10.	University of Pennsylvania	United States										
11.	Cornell University	United States										
12.	University of Michigan	United States										
13.	Johns Hopkins University	United States										
14.	New York University (NYU)	United States										
15.	Duke University	United States										
16.	University of Wisconsin-Madison	United States										
17.	University of California, Los Angeles (UCLA)	United States										
18.	Northwestern University	United States										
19.	University of Illinois at Urbana-Champaign	United States										
20.	Brown University	United States										
21.	Purdue University	United States										
22.	University of Texas at Austin	United States										
23.	Boston University	United States										
24.	Georgia Institute of Technology	United States										
25.	University of North Carolina, Chapel Hill	United States										
26.	Ohio State University	United States										
27.	University of Pittsburgh	United States										

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[Gratzl et al., 2013]

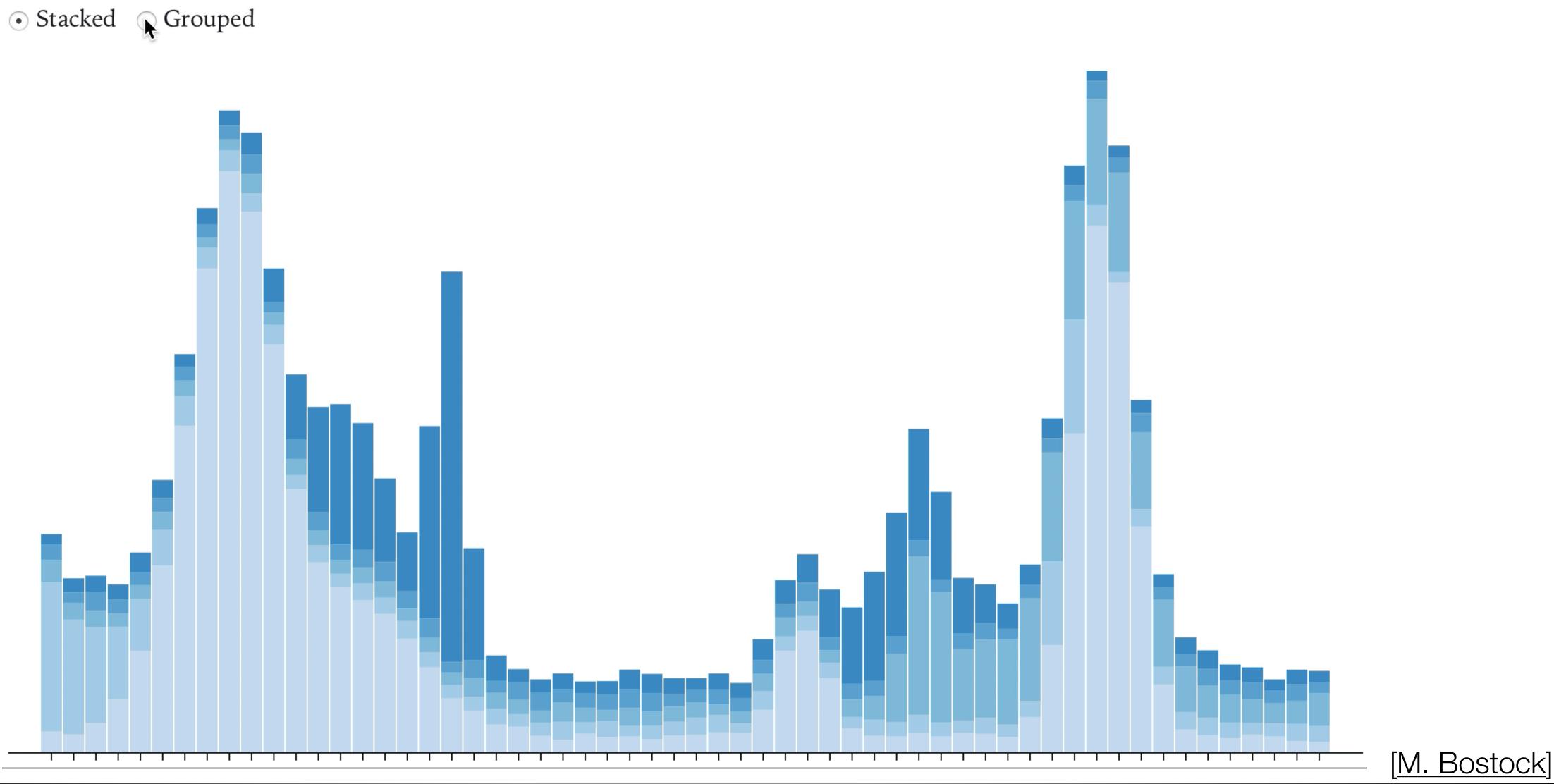








Animated Transitions

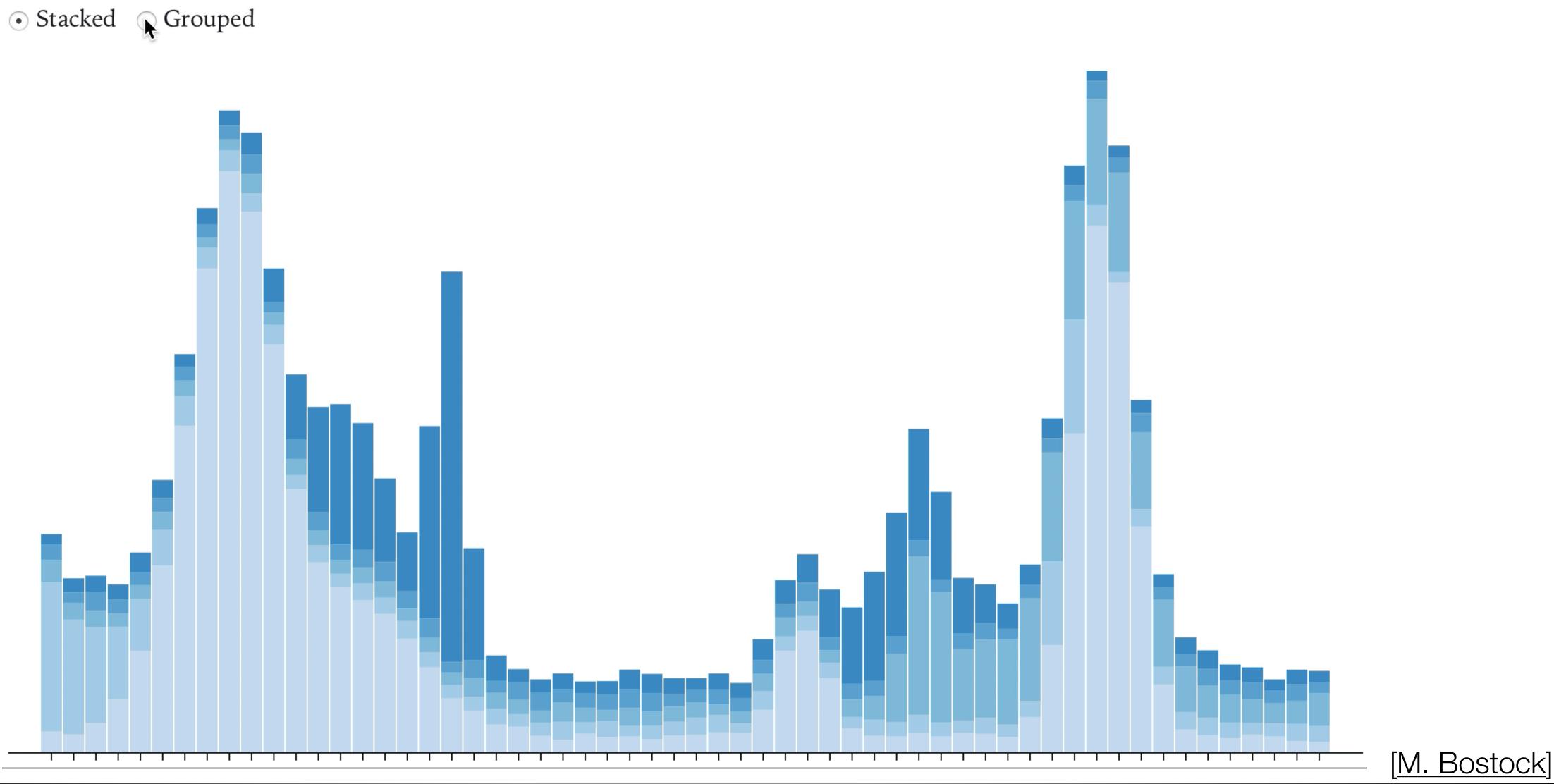








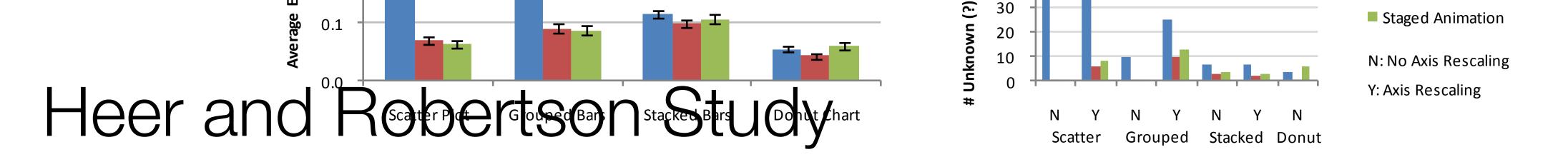
Animated Transitions



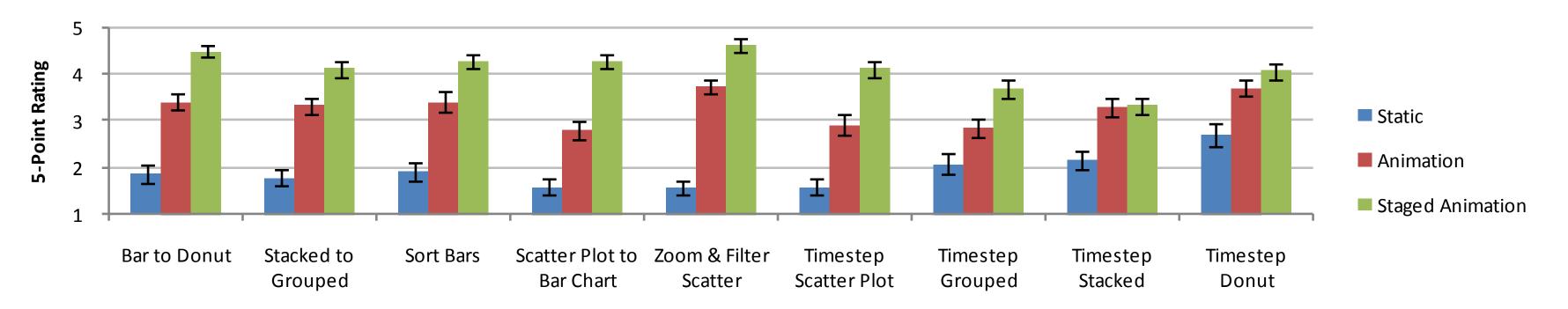








• User Preferences: Staged animation > animation > static transitions



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











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

al encoding sual popout color to be preserved

Contacts	
Dashboard	
Dictionary	
💱 Dropbox	
DVD Player	
Emacs	
FaceTime	
Fz FileZilla	
🕘 Firefox	





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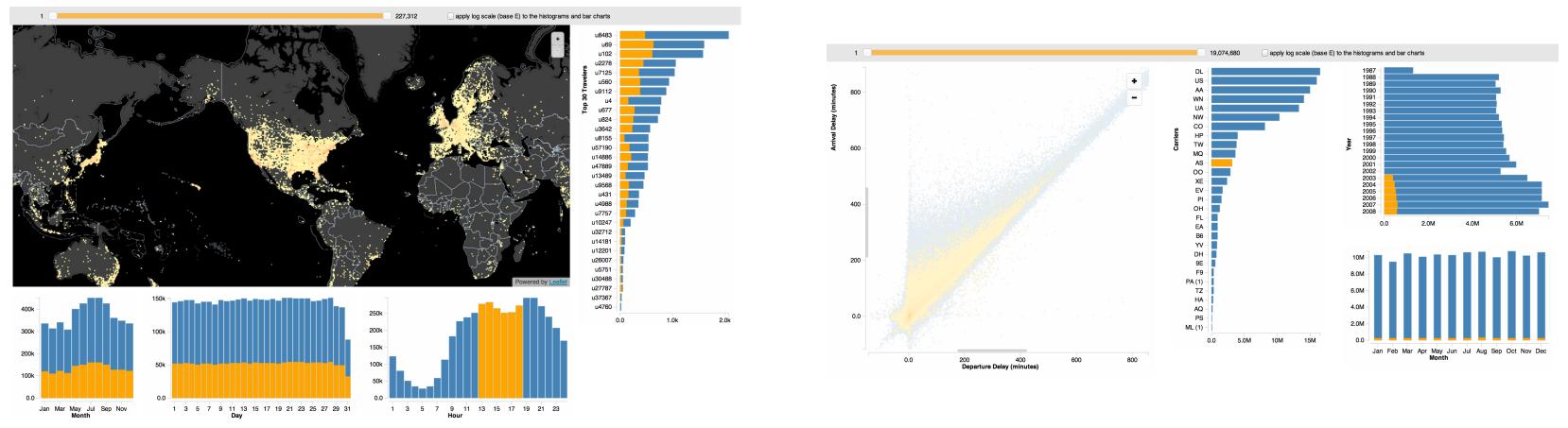
Contacts	
Dashboard	
Dictionary	
💱 Dropbox	
DVD Player	
Emacs	
FaceTime	
Fz FileZilla	
🕘 Firefox	





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

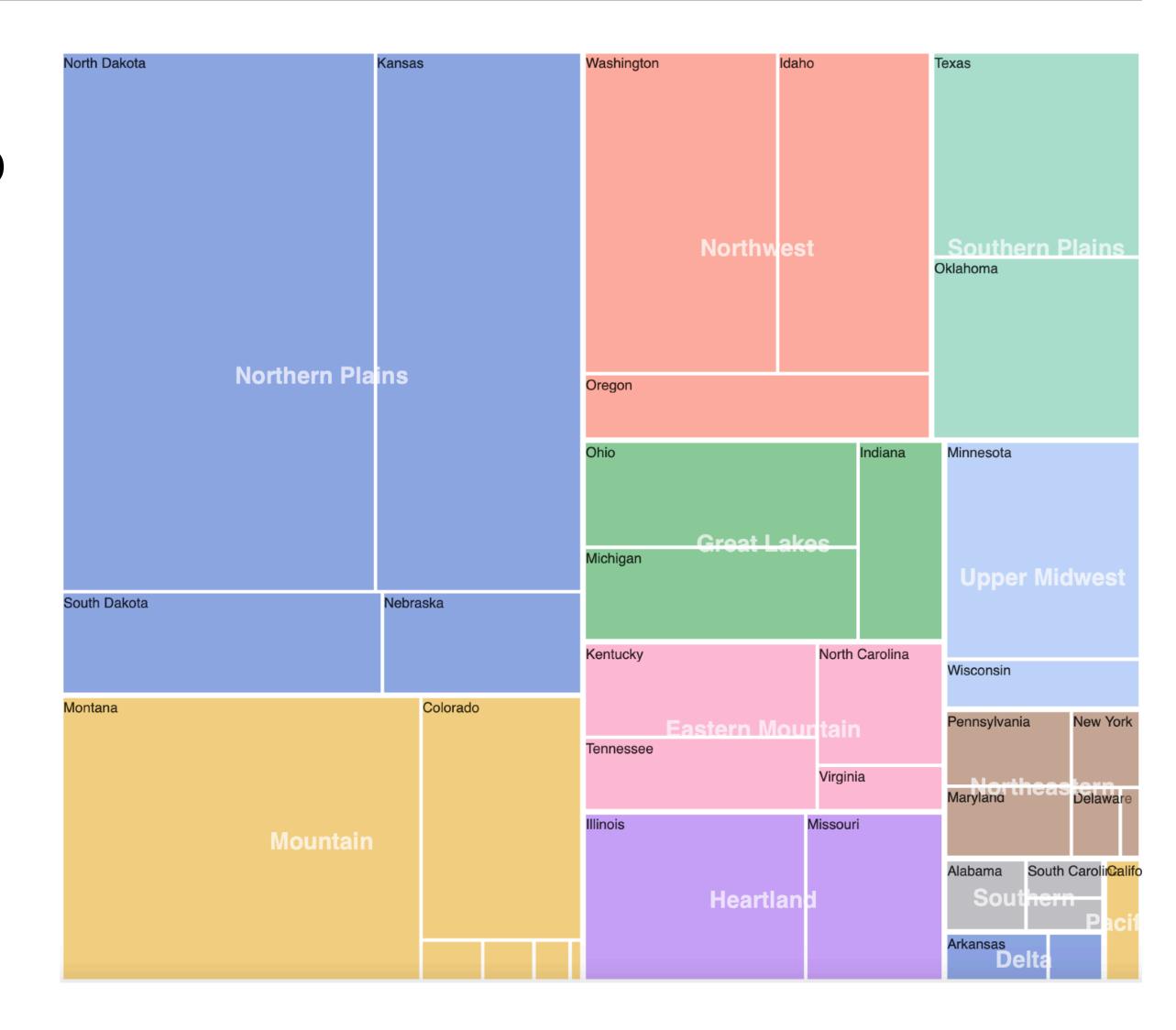






<u>Assignment 4</u>

- Crop Production in the US
- Geospatial Visualizations & Treemap
 - Choose colormaps carefully
 - Add legend
- You may use D3 or Observable Plot
 - Part 1a: D3
 - Part 3 will require some D3 for treemap layout









Project Design

- Feedback on Blackboard
- Work on turning your visualization ideas into designs
- Turn in:
 - Three Designs Sketches
 - One Bad Design
 - Be creative: <u>https://xeno.graphics/</u>
- Due Nov. 15

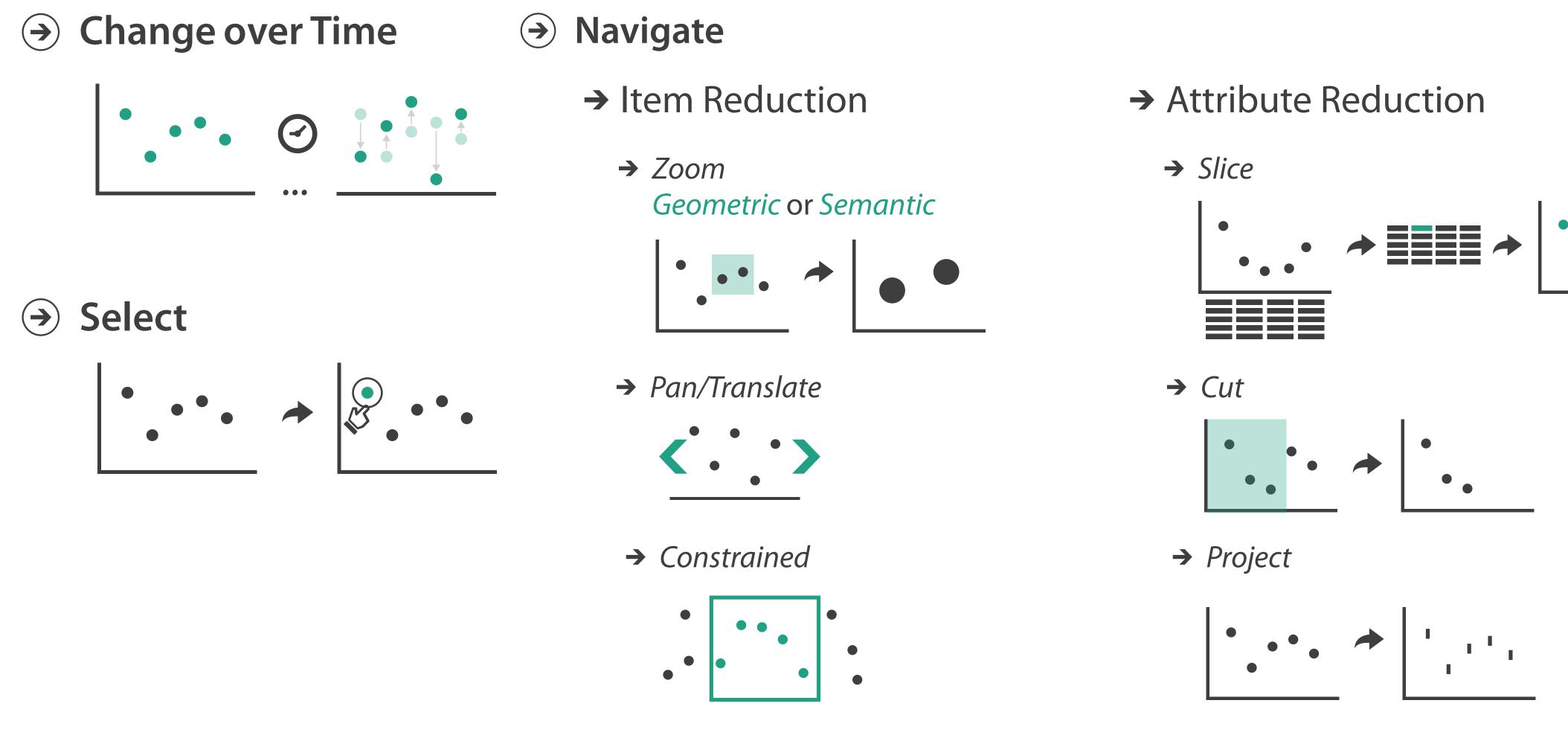
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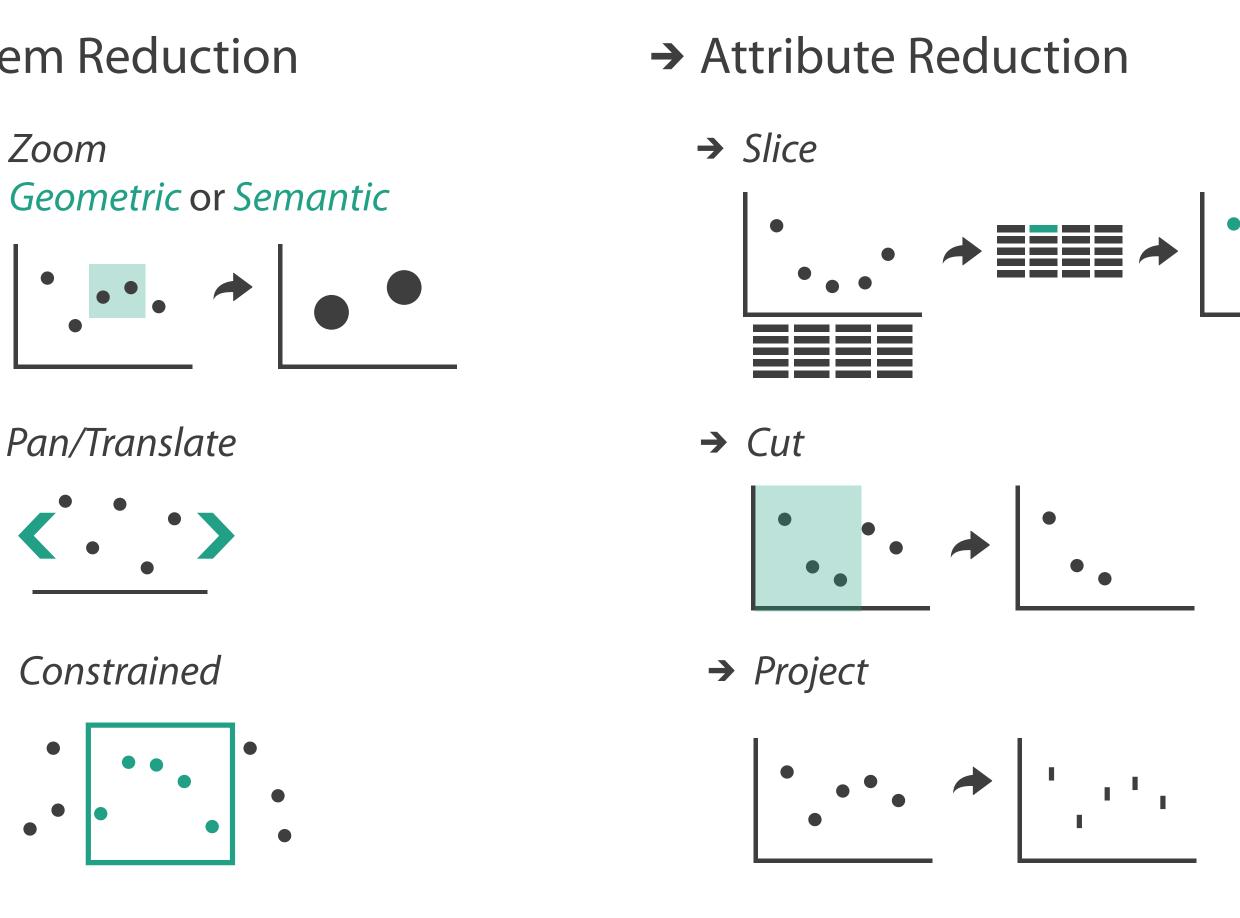
- Check data attributes, makes sure tasks are visual, rethink drop-downs





Interaction Overview





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[Munzner (ill. Maguire), 2014]





Navigation

- change
- Camera analogy: only certain features visible in a frame
 - Zooming
 - Panning (aka scrolling)
 - Translating
 - Rotating (rare in 2D, important in 3D)

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• Fix the layout of all visual elements but provide methods for the viewpoint to





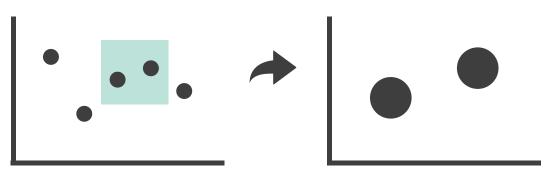


12

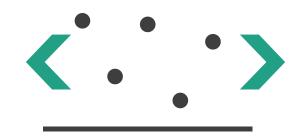
Navigation

→ Item Reduction

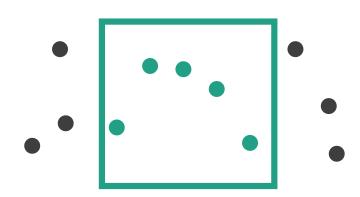




→ Pan/Translate

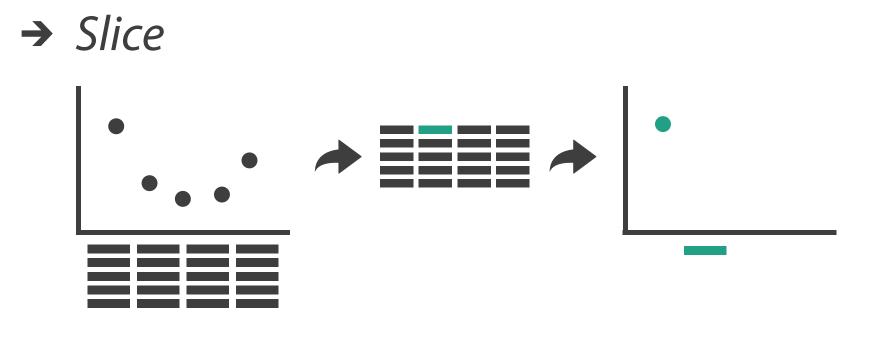


→ Constrained

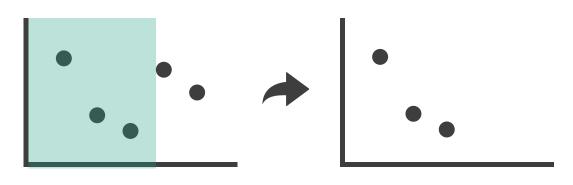


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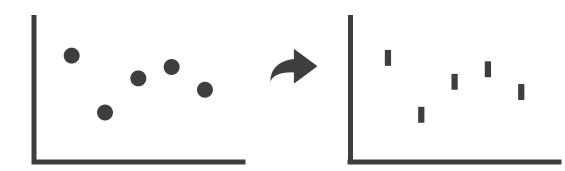
→ Attribute Reduction







→ Project



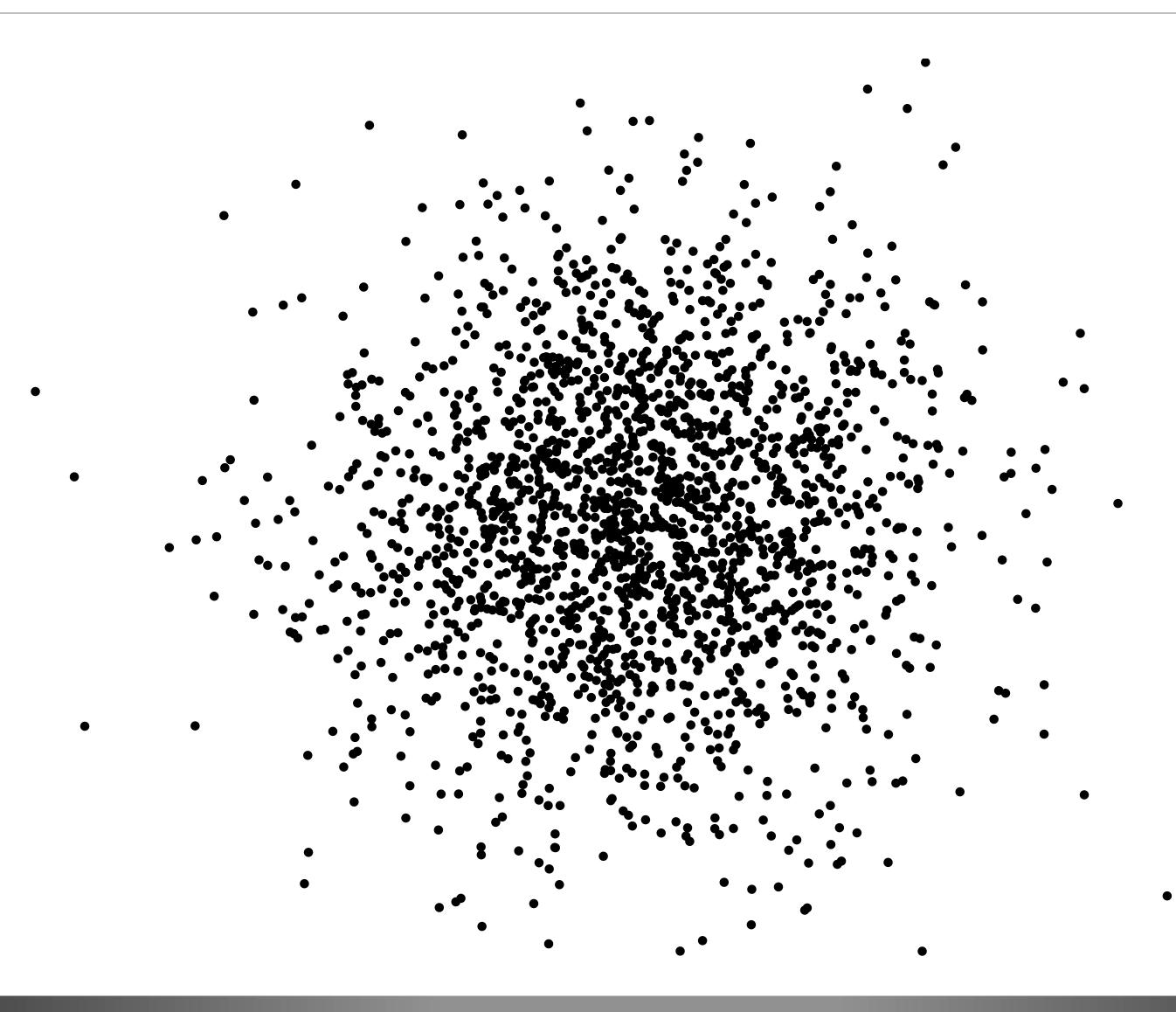
[Munzner (ill. Maguire), 2014]



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Zooming

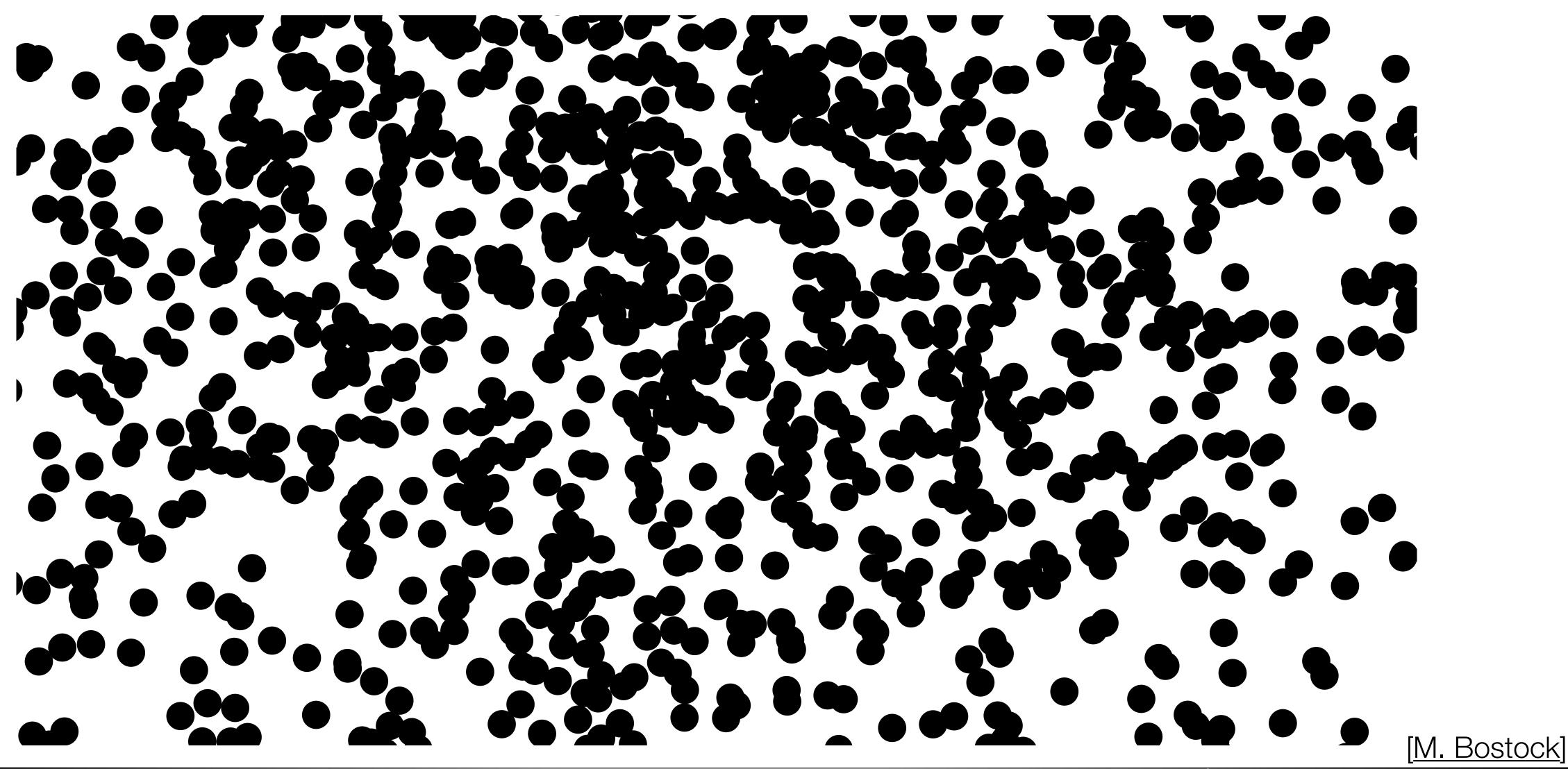








Geometric Zooming



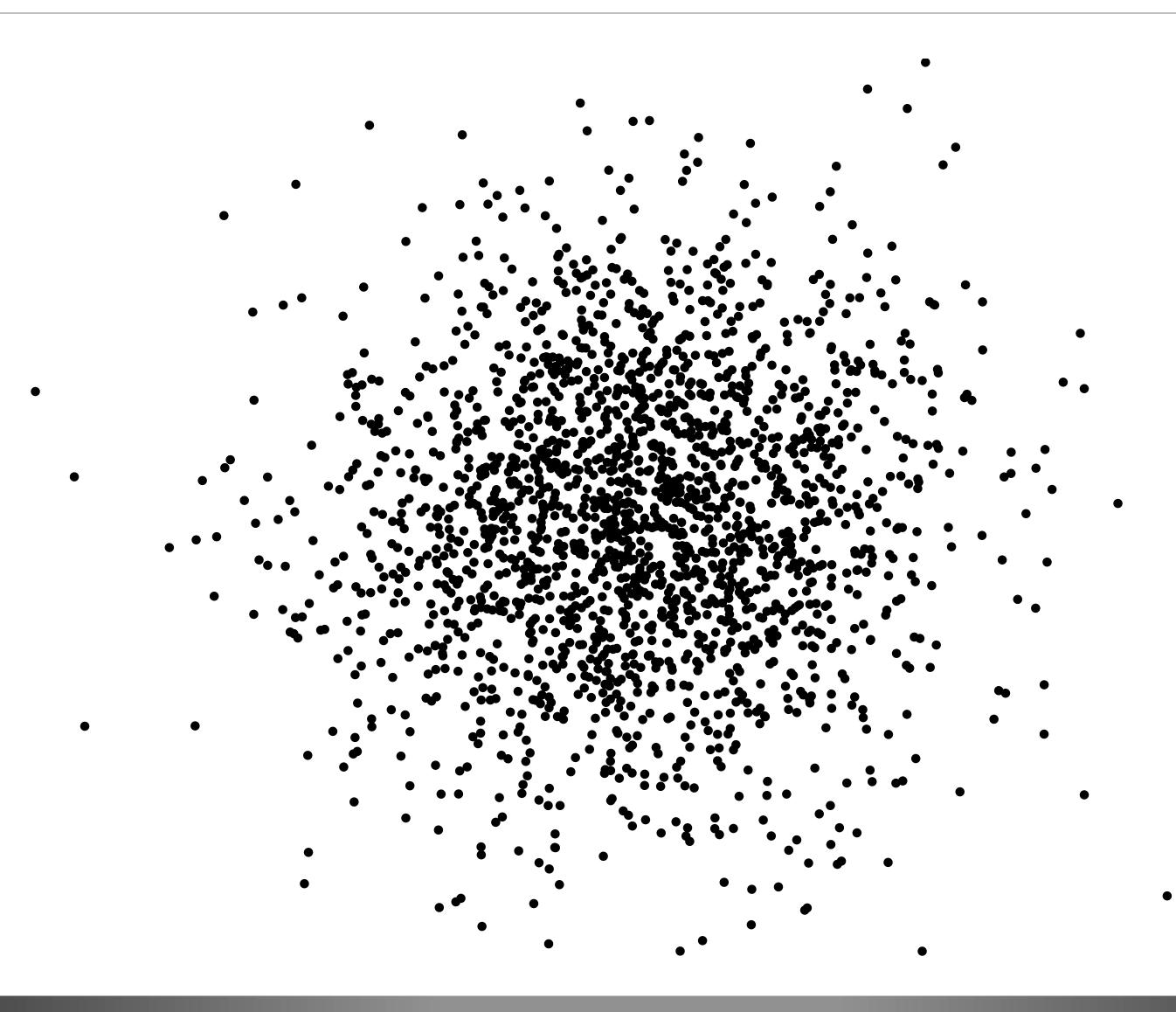








Zooming

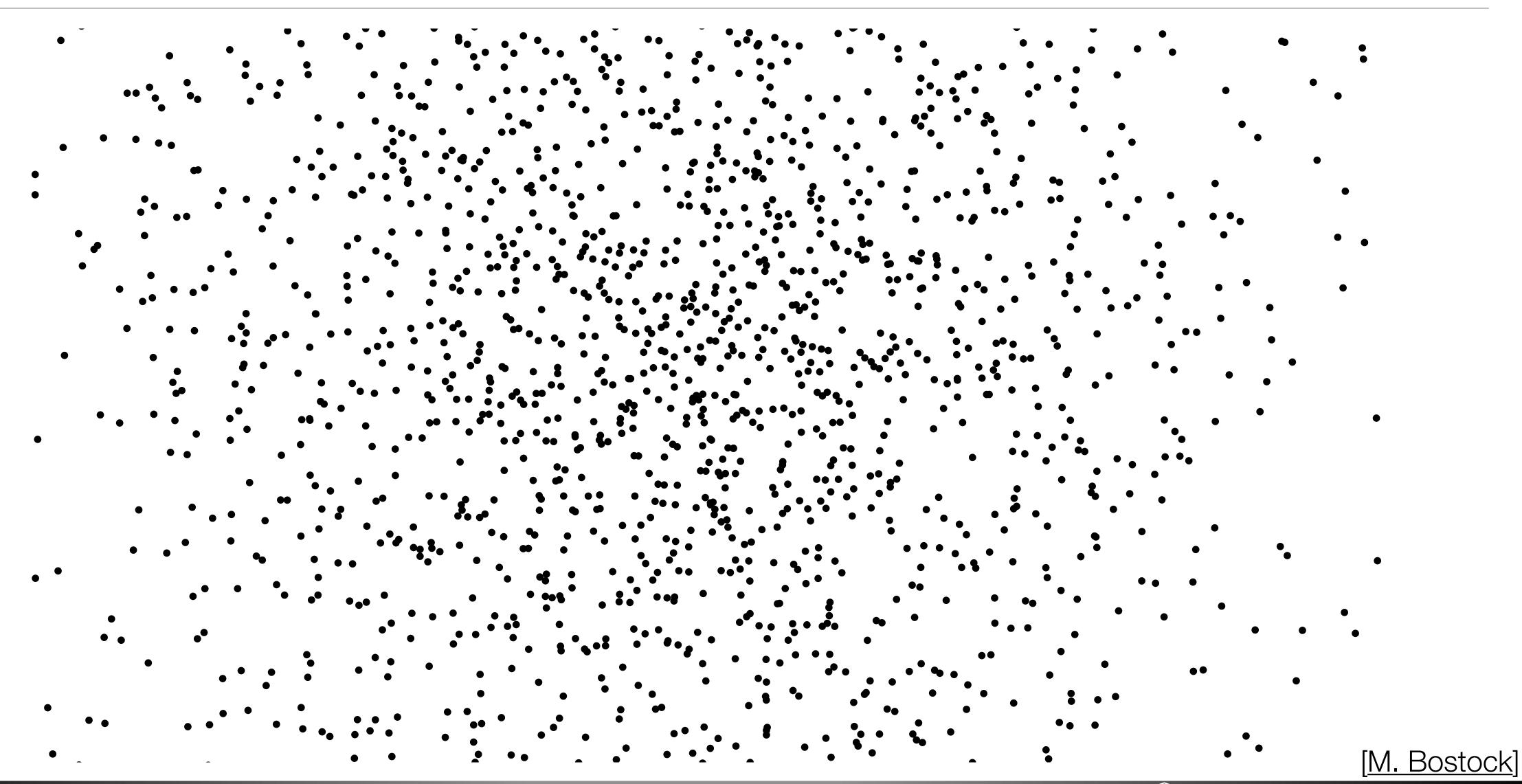








Semantic Zooming











Zooming

- Geometric Zooming: just like a camera
- scales Manua
- LiveRAC Example: (focus + context)



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• Semantic Zooming: visual appearance of objects can change at different



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Navigation Constraints

- 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
 - corresponds to a selection in another view

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• Unconstrained navigation: walking around in the world or an immersive 3D

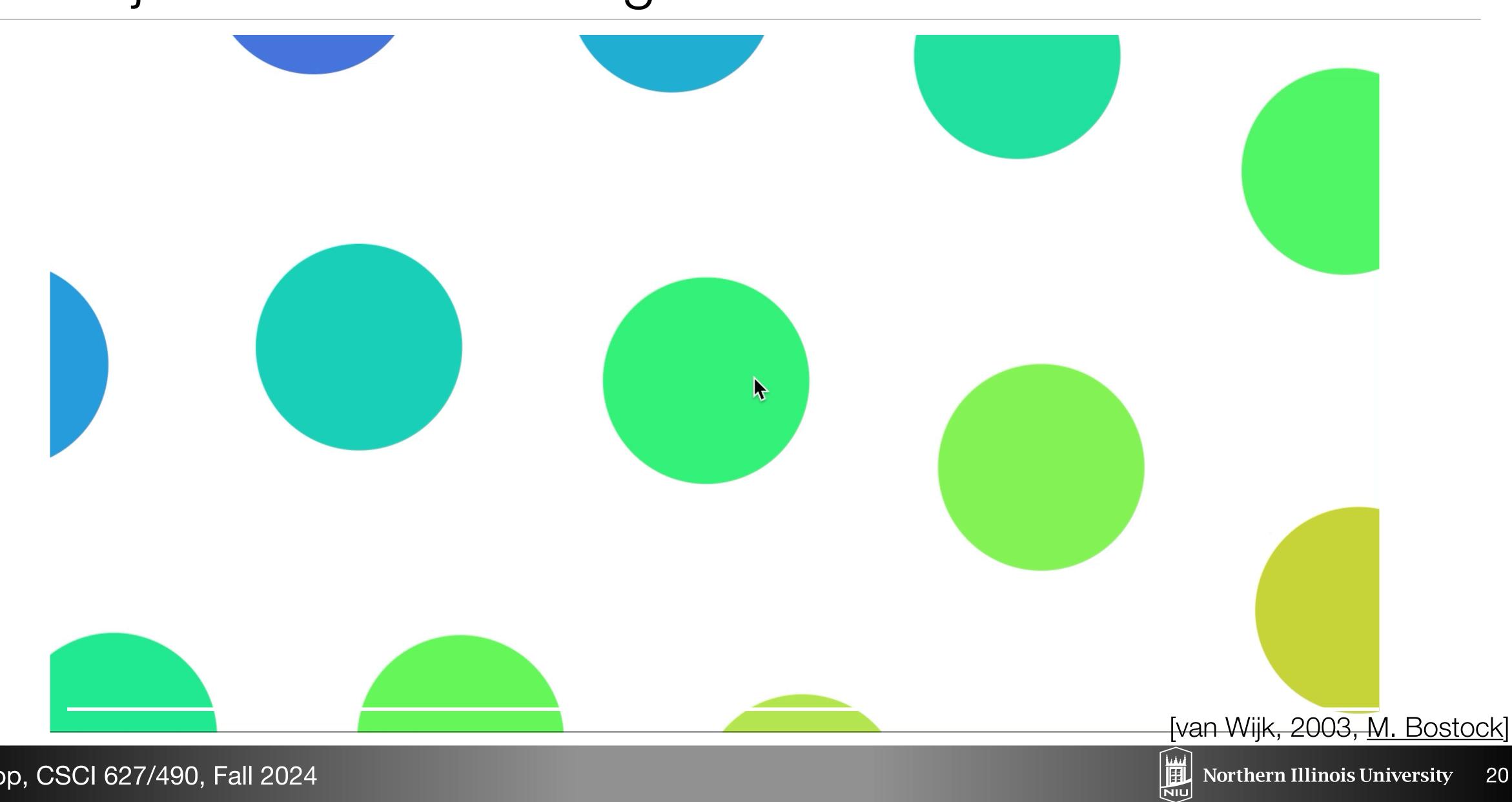
- Comes up often with multiple views: want to show an area in one view that







van Wijk Smooth Zooming

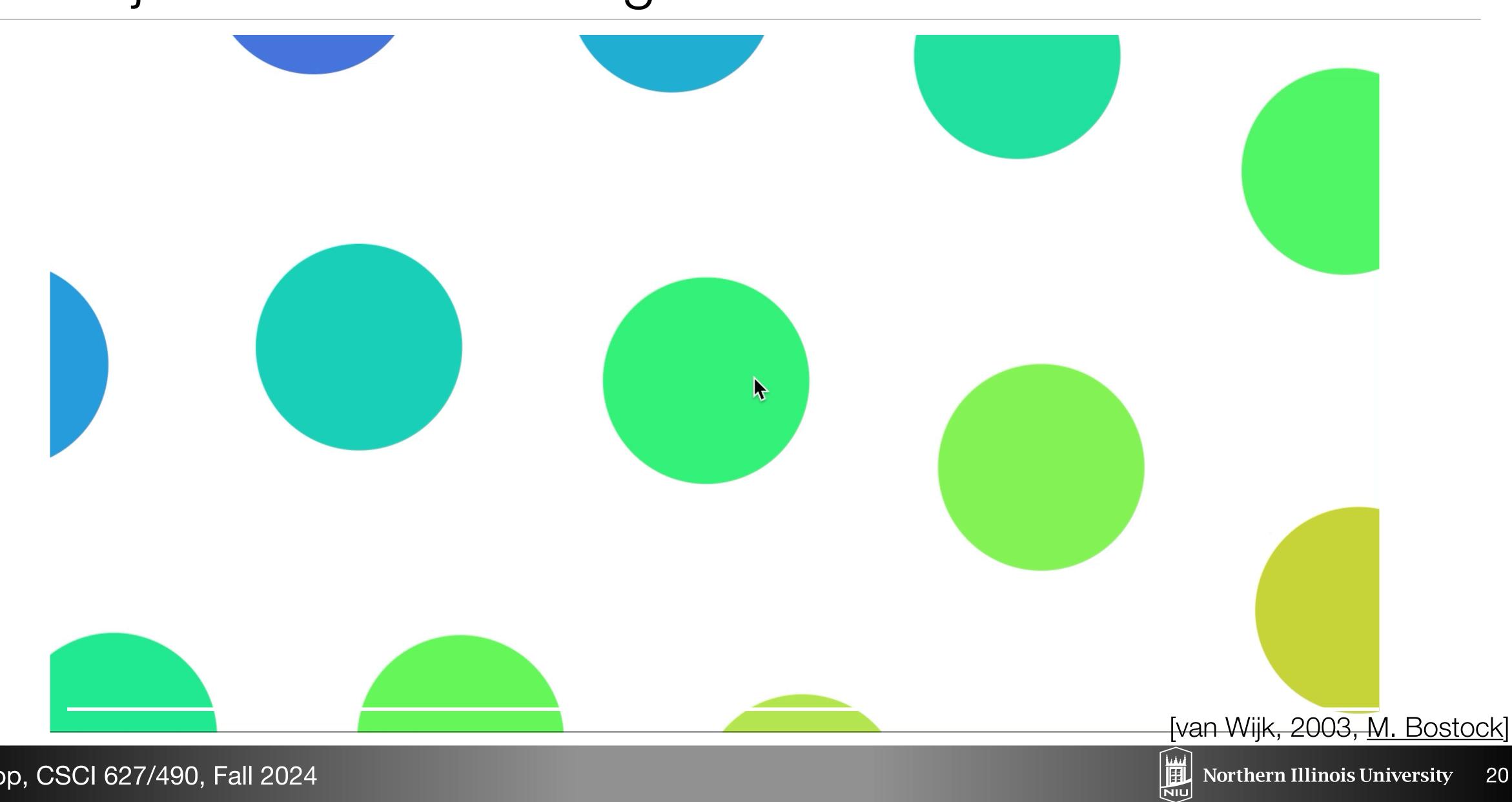








van Wijk Smooth Zooming

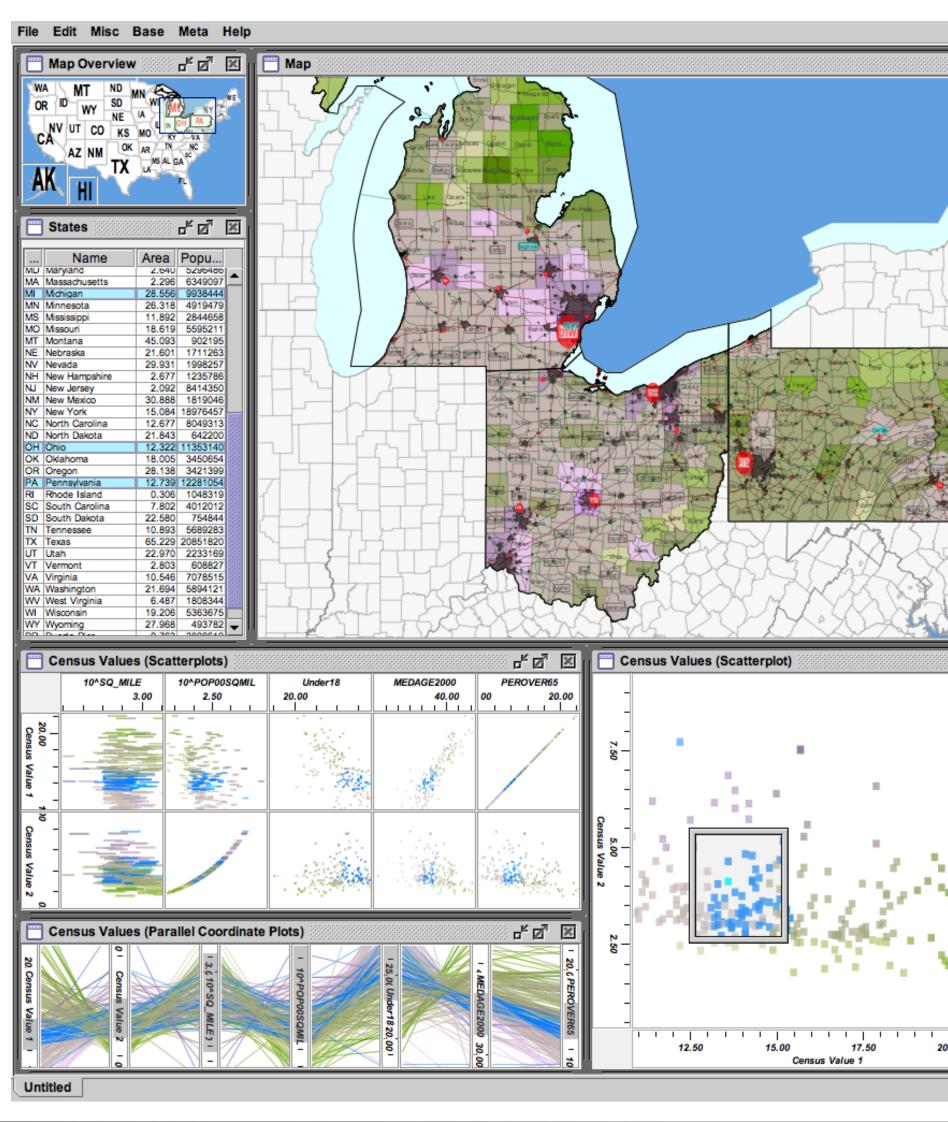








Multiple Views



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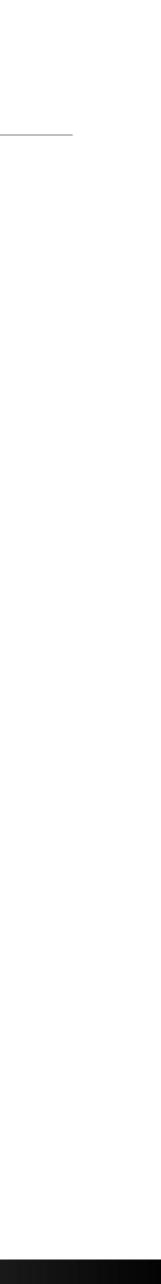




Multiple Views

- 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 \rightarrow don't need to remember





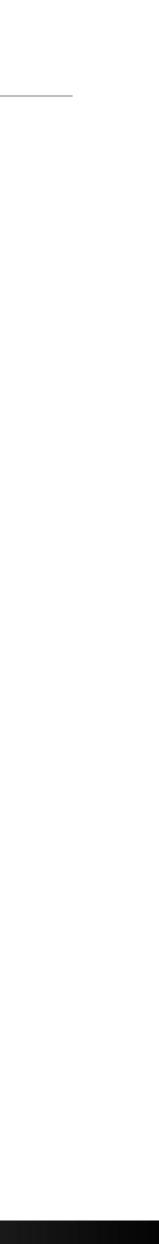




Multiple Views

- 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

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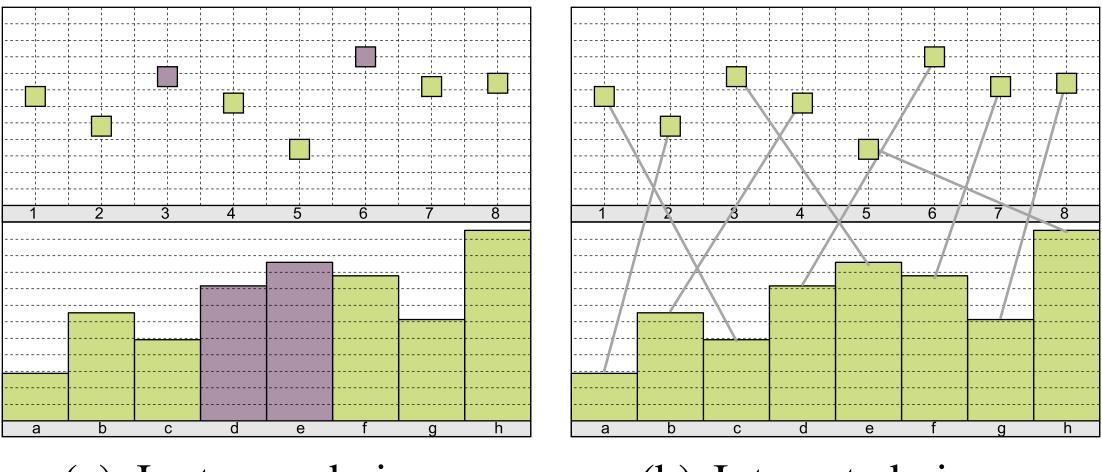
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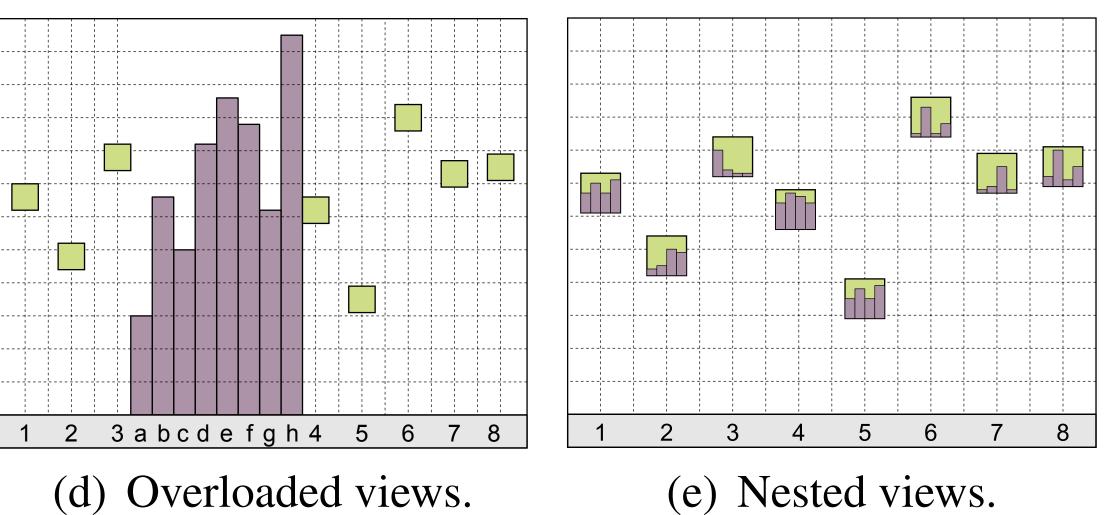


Composite Visualization Techniques

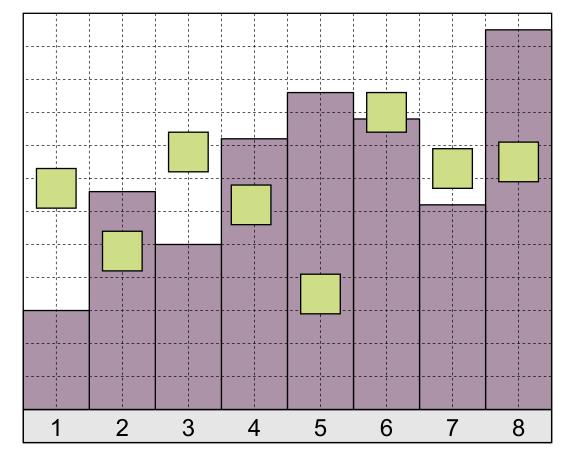


(a) Juxtaposed views.





(b) Integrated views.



(c) Superimposed views.



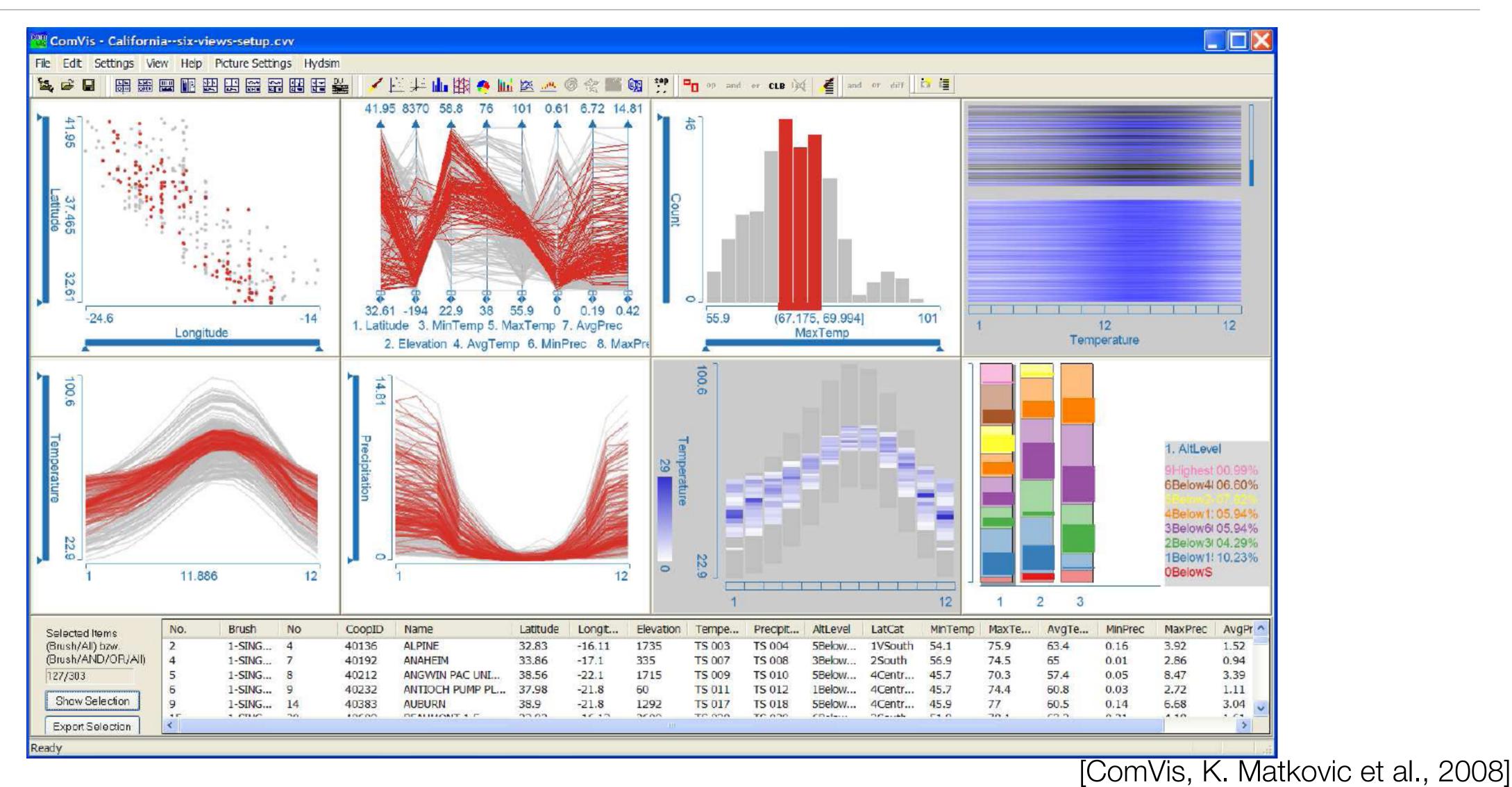








Juxtaposition



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NIU

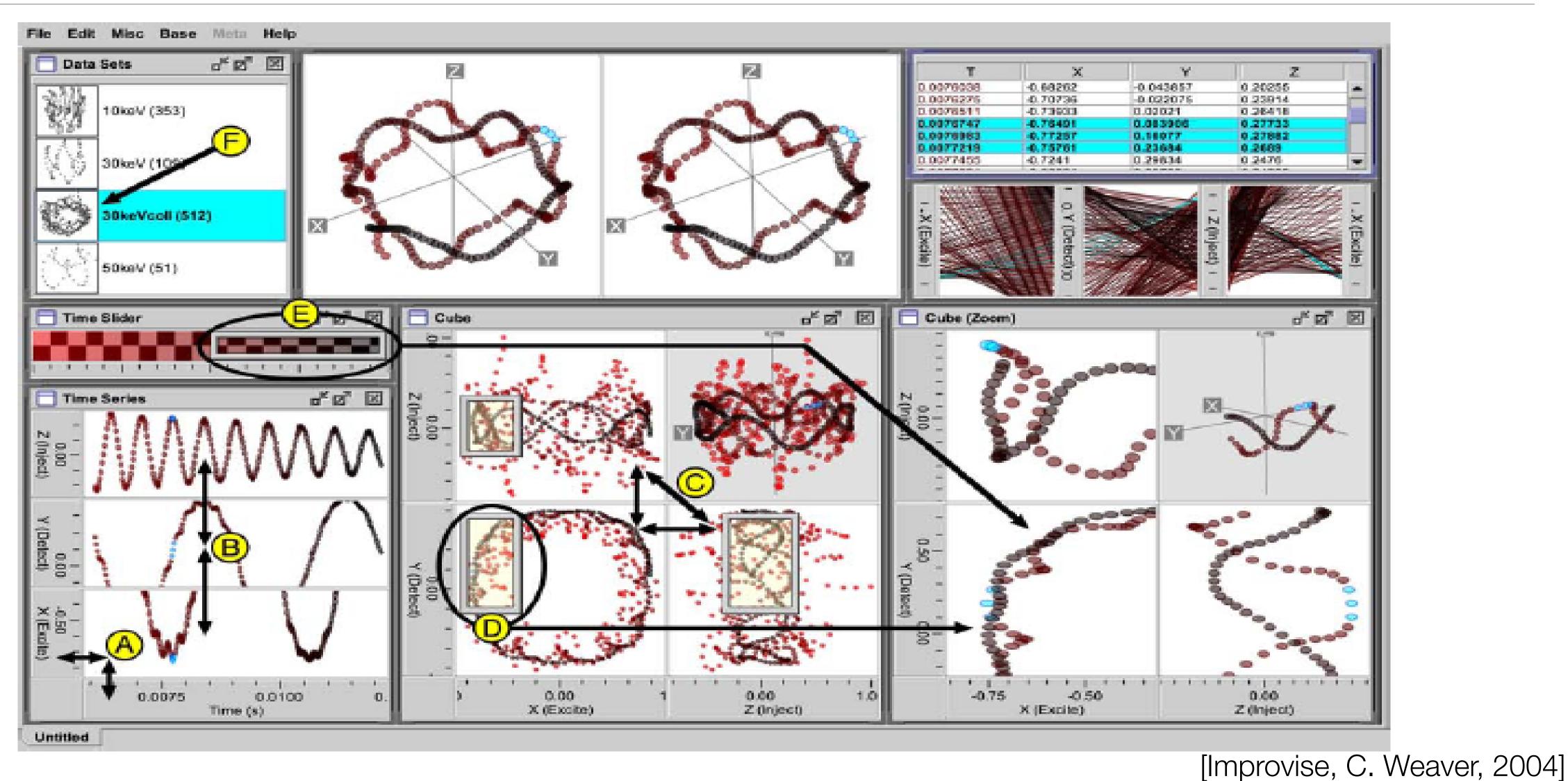
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Juxtaposition



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Juxtaposition Guidelines

- Benefits:
 - without interference
 - Easy to implement
- Drawbacks:
 - objects are selected
- combined.

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- The component visualizations are independent and can be composed

- Implicit visual linking is not always easy to see, particularly when multiple

- 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

[W. Javed and N. Elmqvist, 2012]

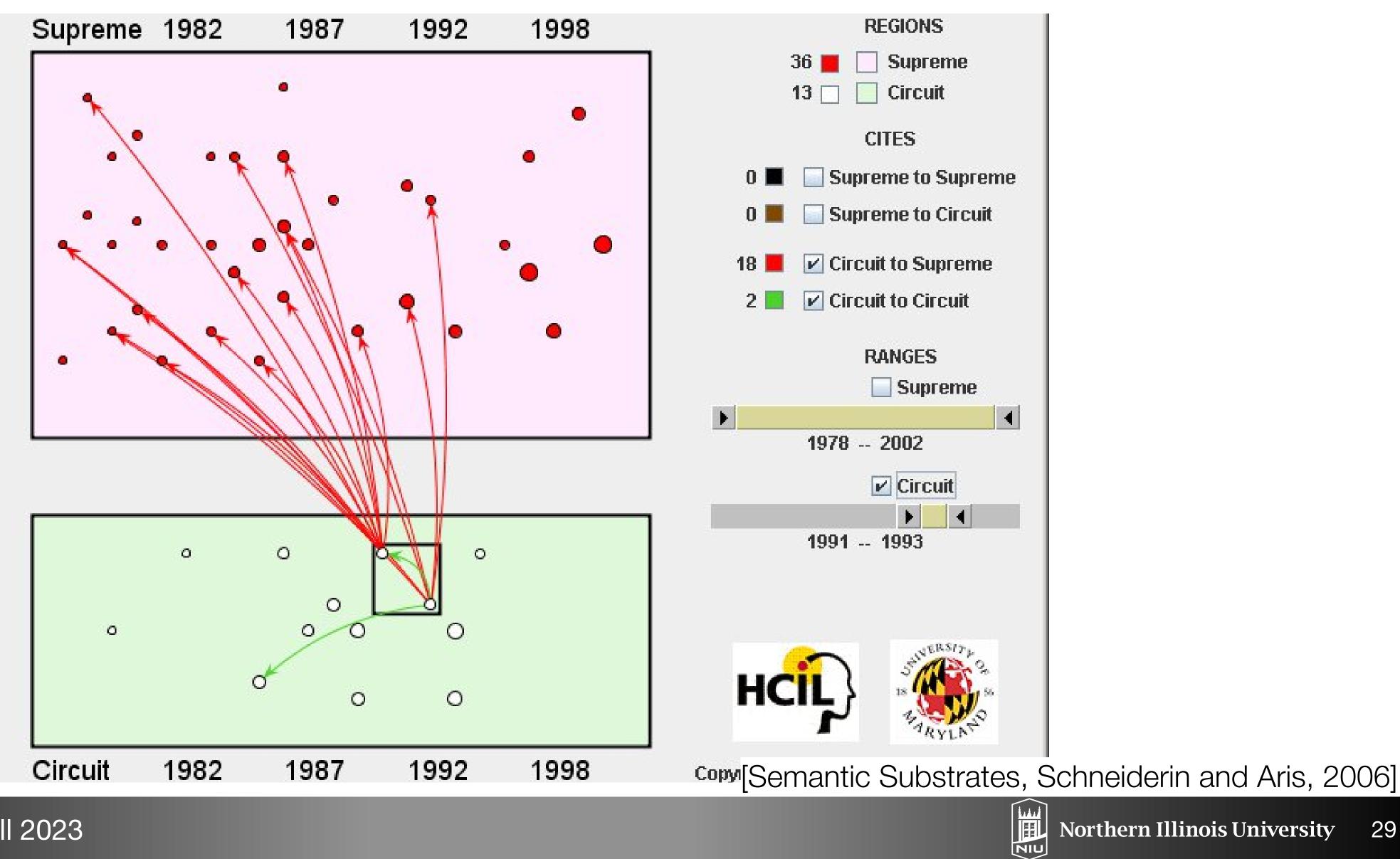








Integration



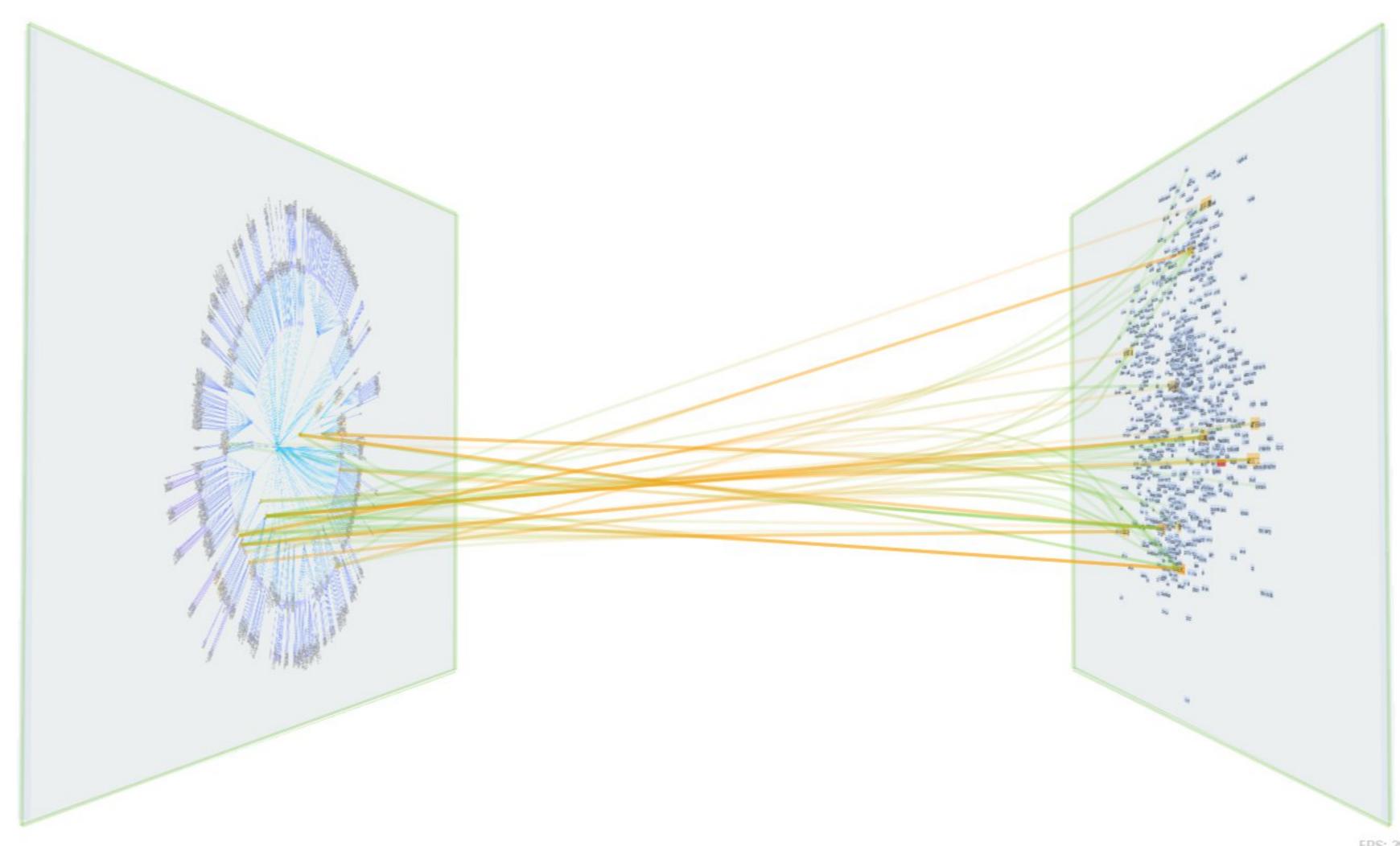








Integration



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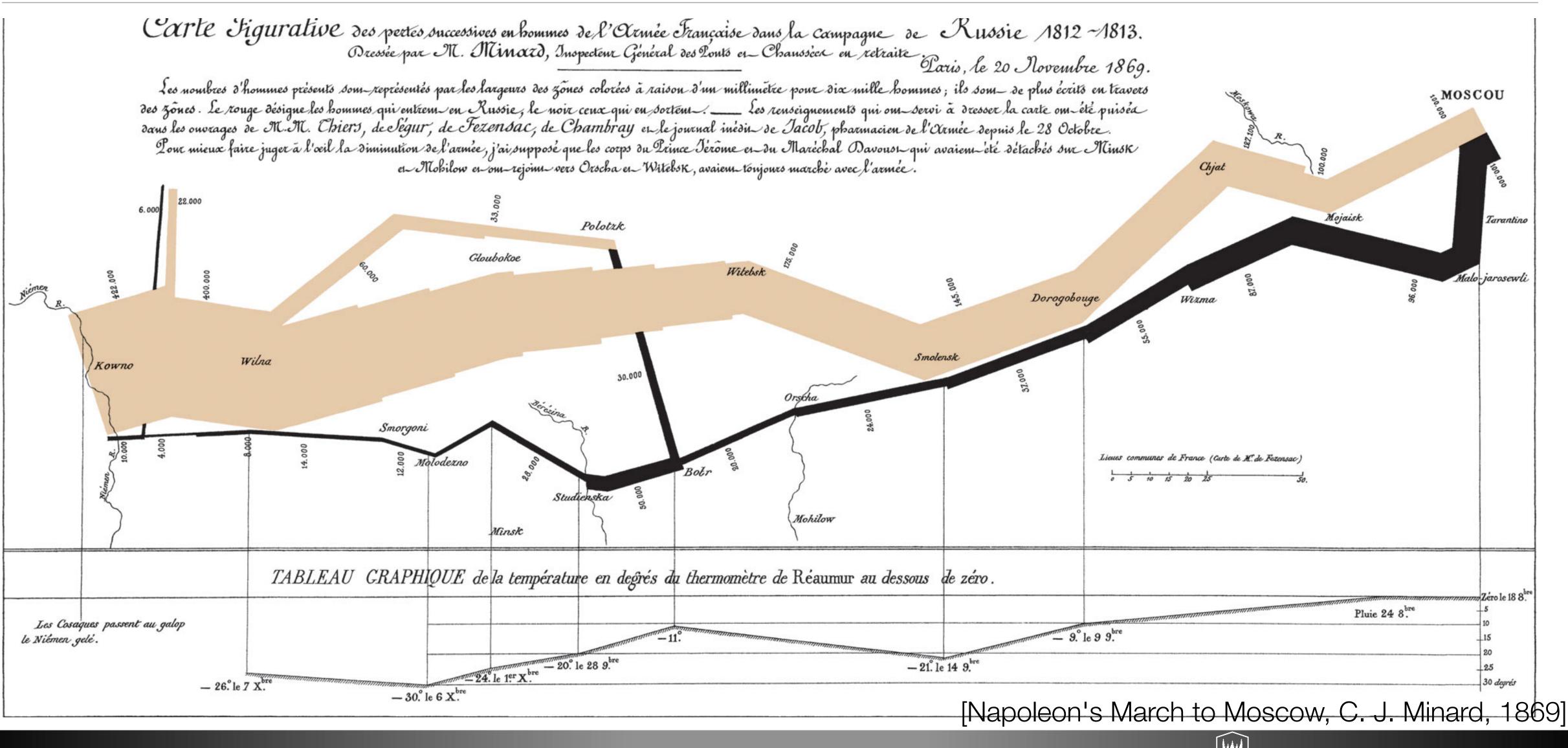
[VisLink, Collins and Carpendale, 2007]







Integration



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Integration Guidelines

- Benefits:
 - components
 - 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]

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- Easy to perceive one-to-one and one-to-many relations between items in

- Visualizations are less independent compared to juxtaposed views, but still



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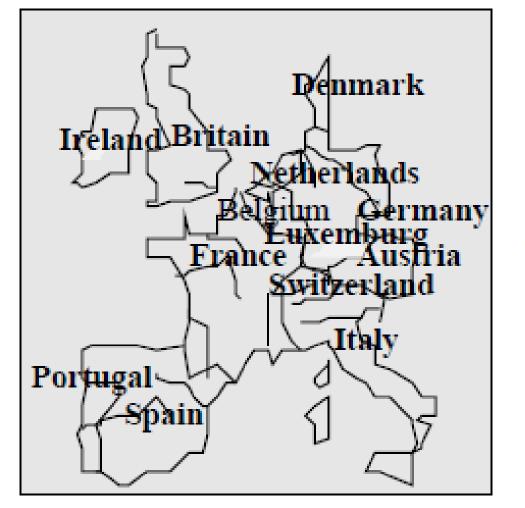








Superimposition

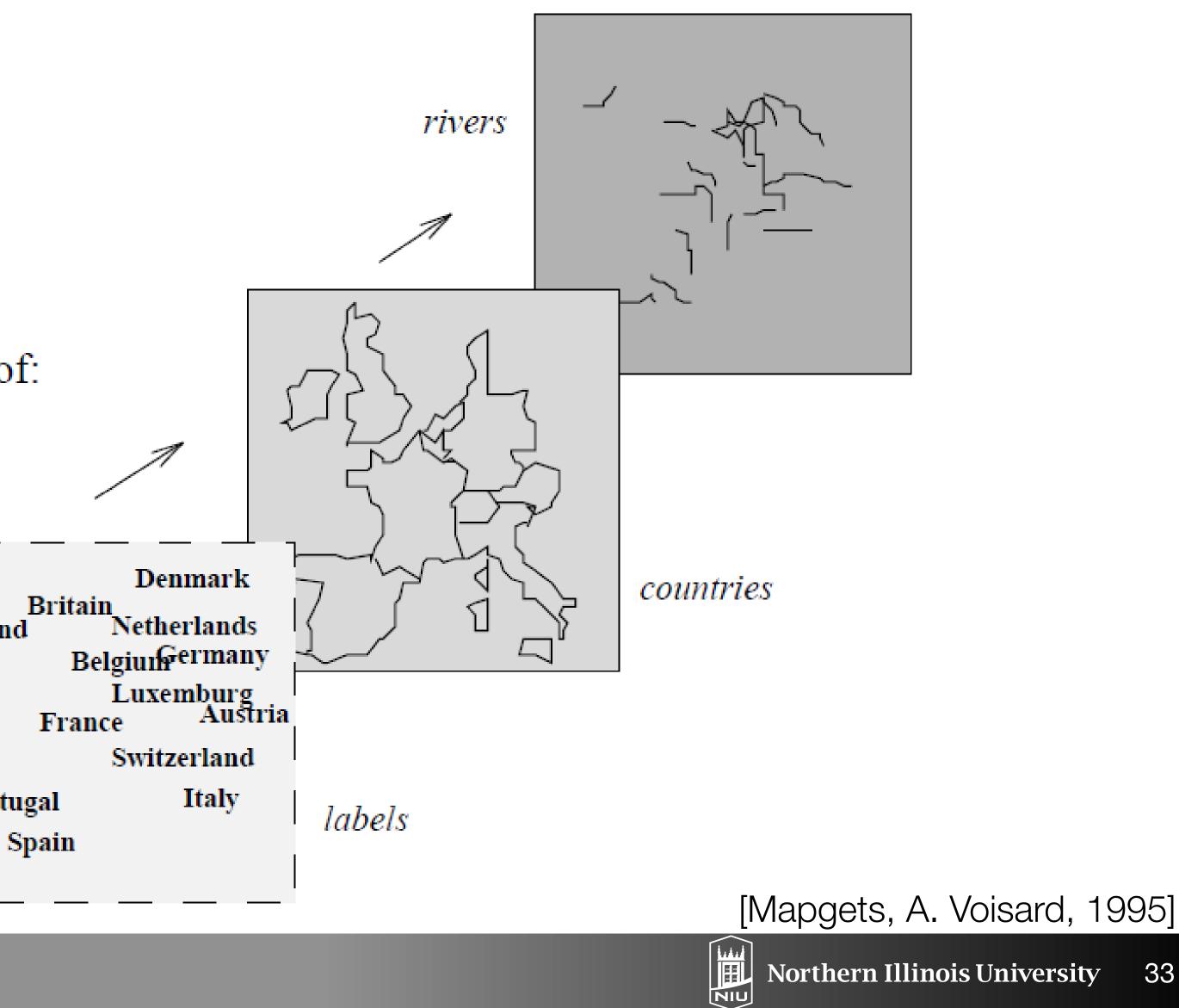


is composed of:

Ireland

Portugal

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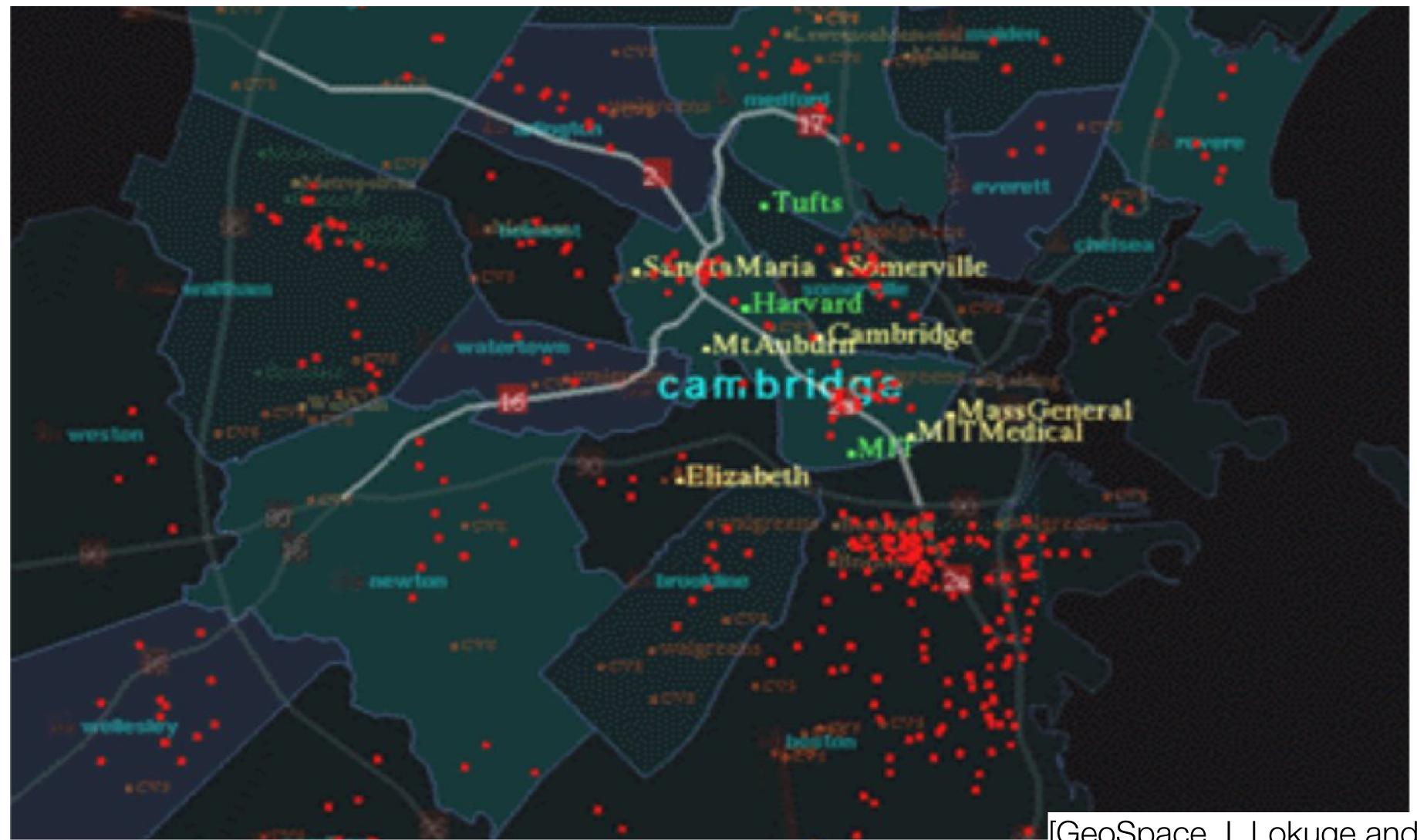








Superimposition



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[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).

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[W. Javed and N. Elmqvist, 2012]

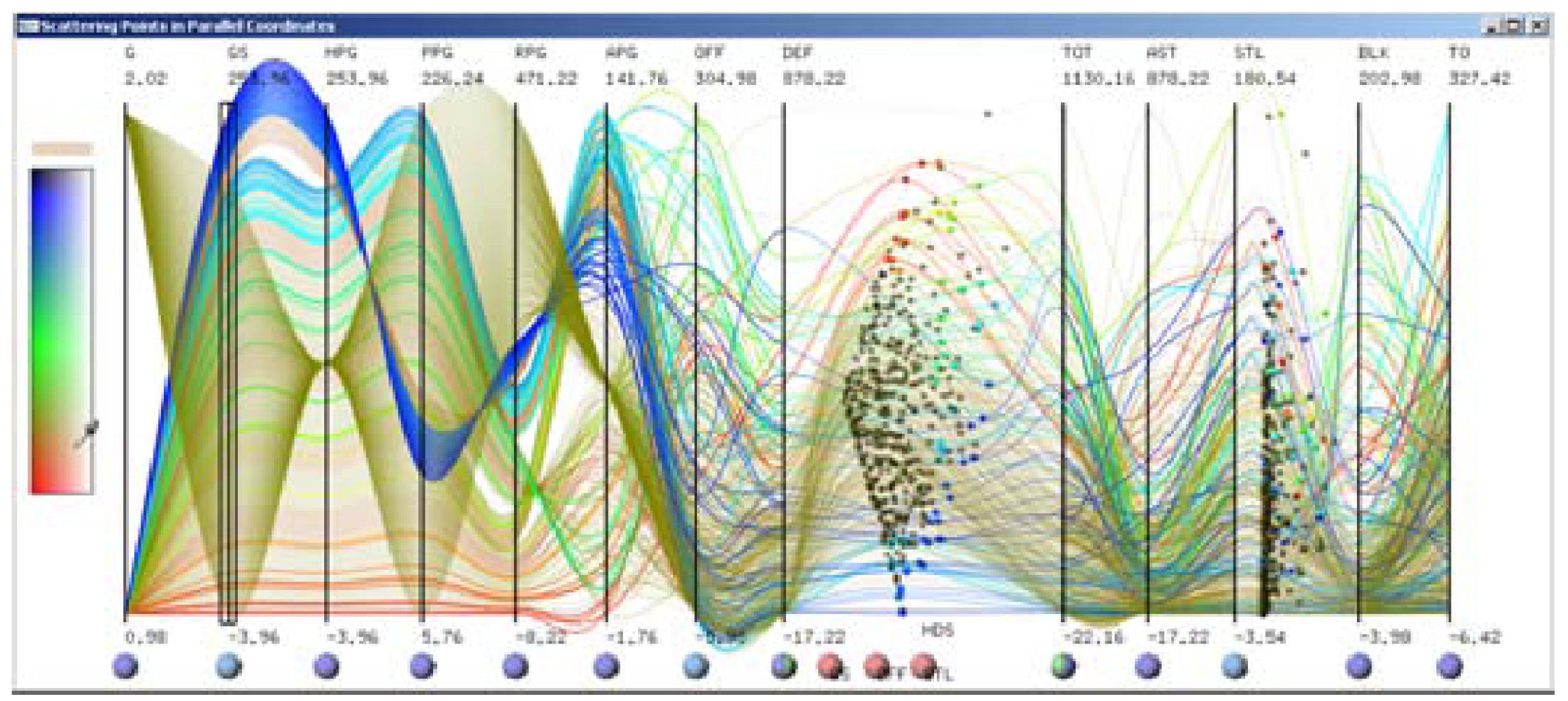




35



Overloading





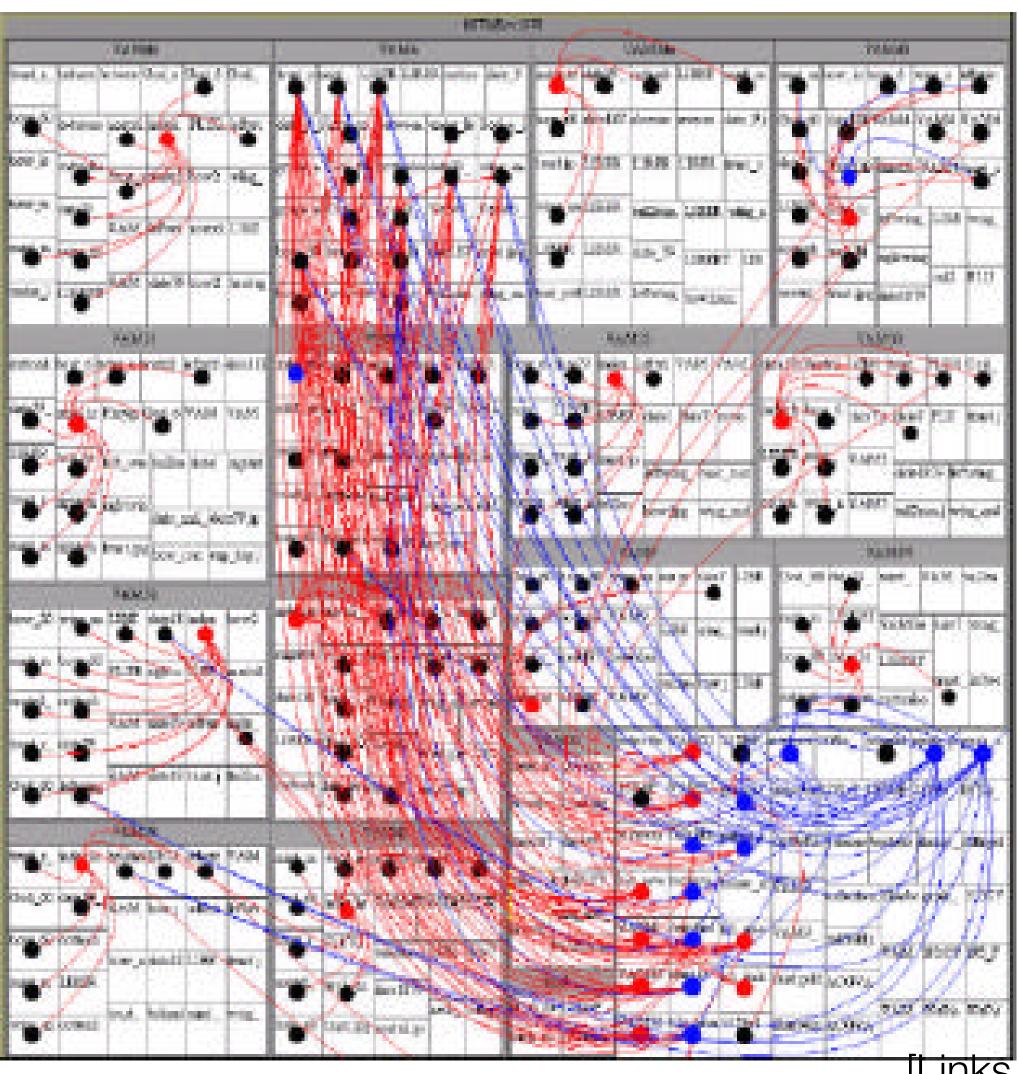








Overloading



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









Overloading Guidelines

- Benefits:
 - 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
- yield a compact (and complex) result.

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- The client visualization does not have to share the same coordinate space

Applications: Situations where one visualization can be folded into another to

[W. Javed and N. Elmqvist, 2012]





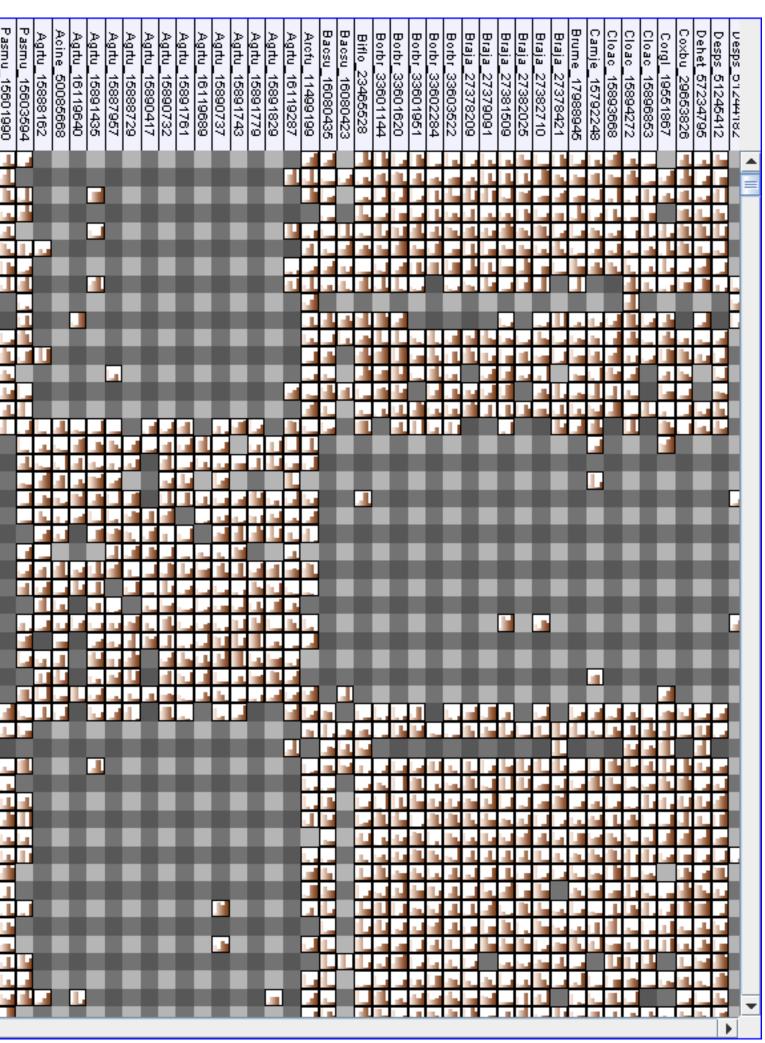
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Nesting

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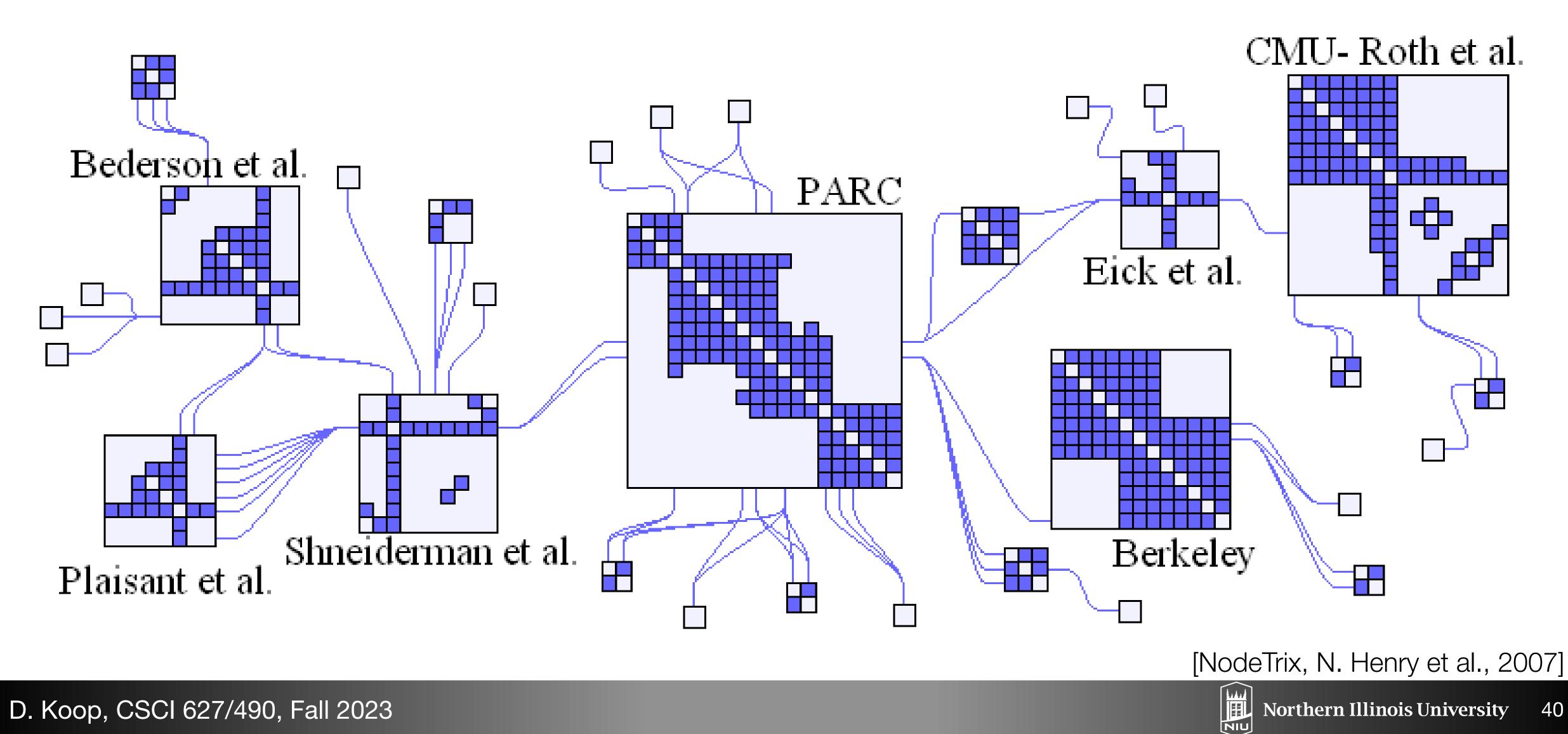








Nesting



Nesting Guidelines

- 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

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[W. Javed and N. Elmqvist, 2012]



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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

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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

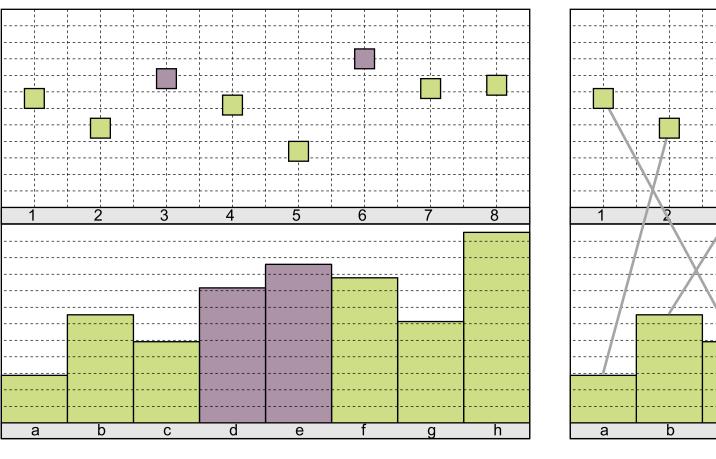
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[W. Javed and N. Elmqvist, 2012]



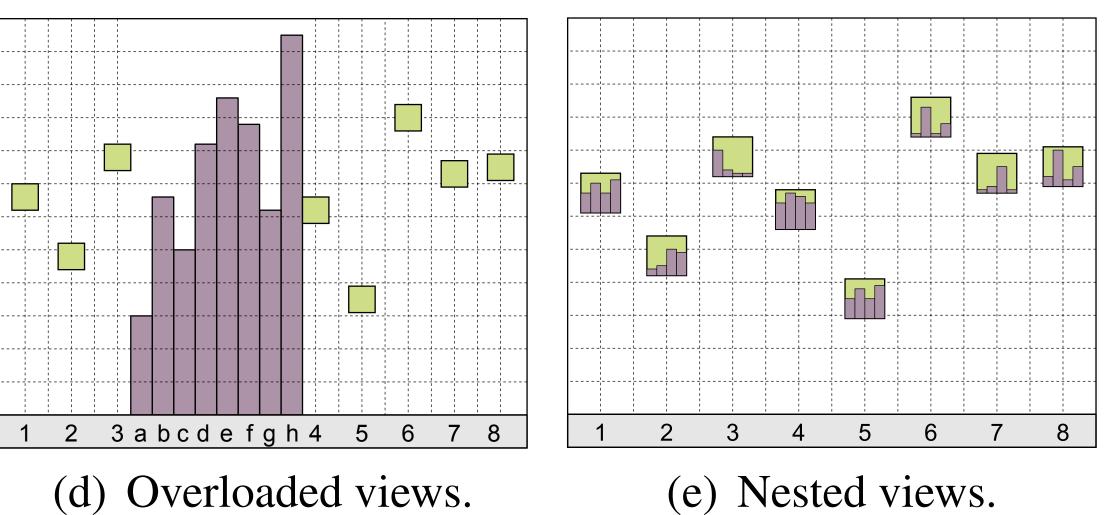


Summary (Scatterplot + Bar Chart)

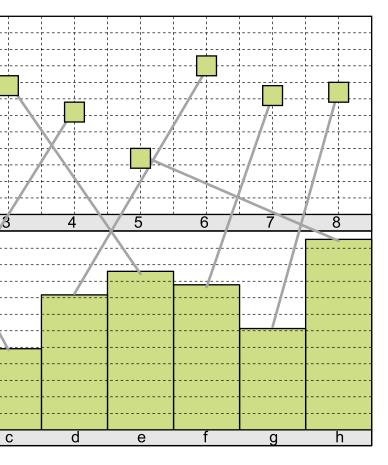


(a) Juxtaposed views.

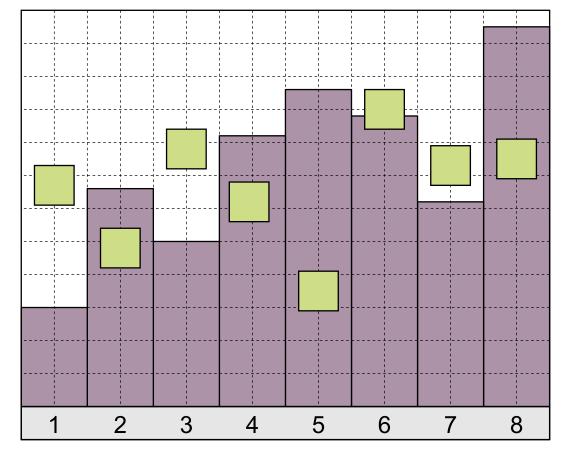




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(b) Integrated views.



(c) Superimposed views.







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- 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)





→ Share Encoding: Same/Different

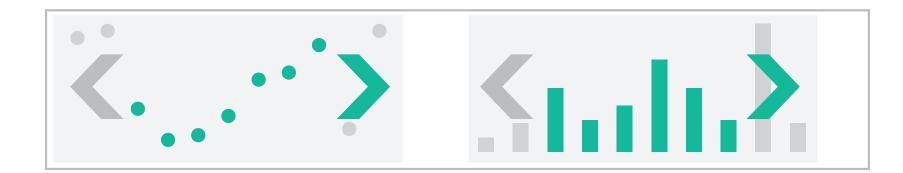
→ Linked Highlighting



→ Share Data: All/Subset/None



Share Navigation



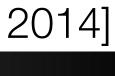
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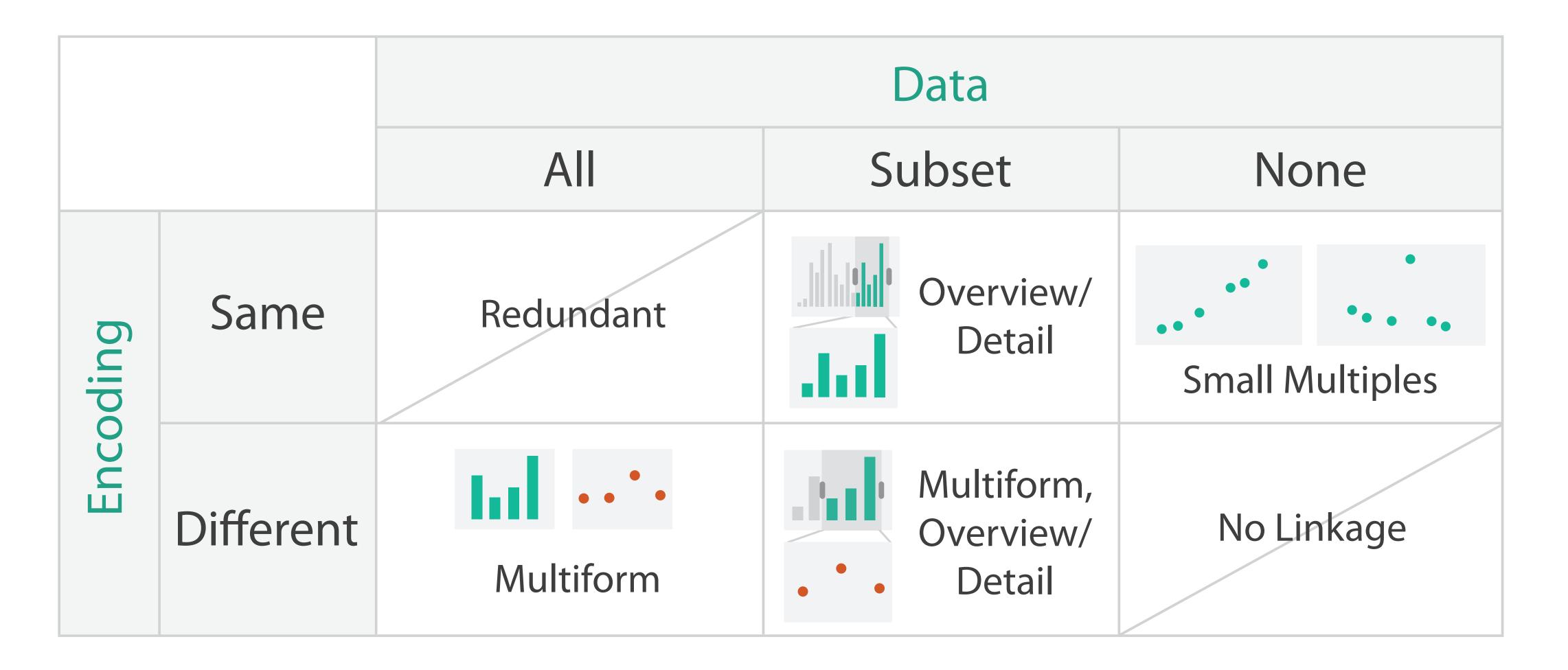




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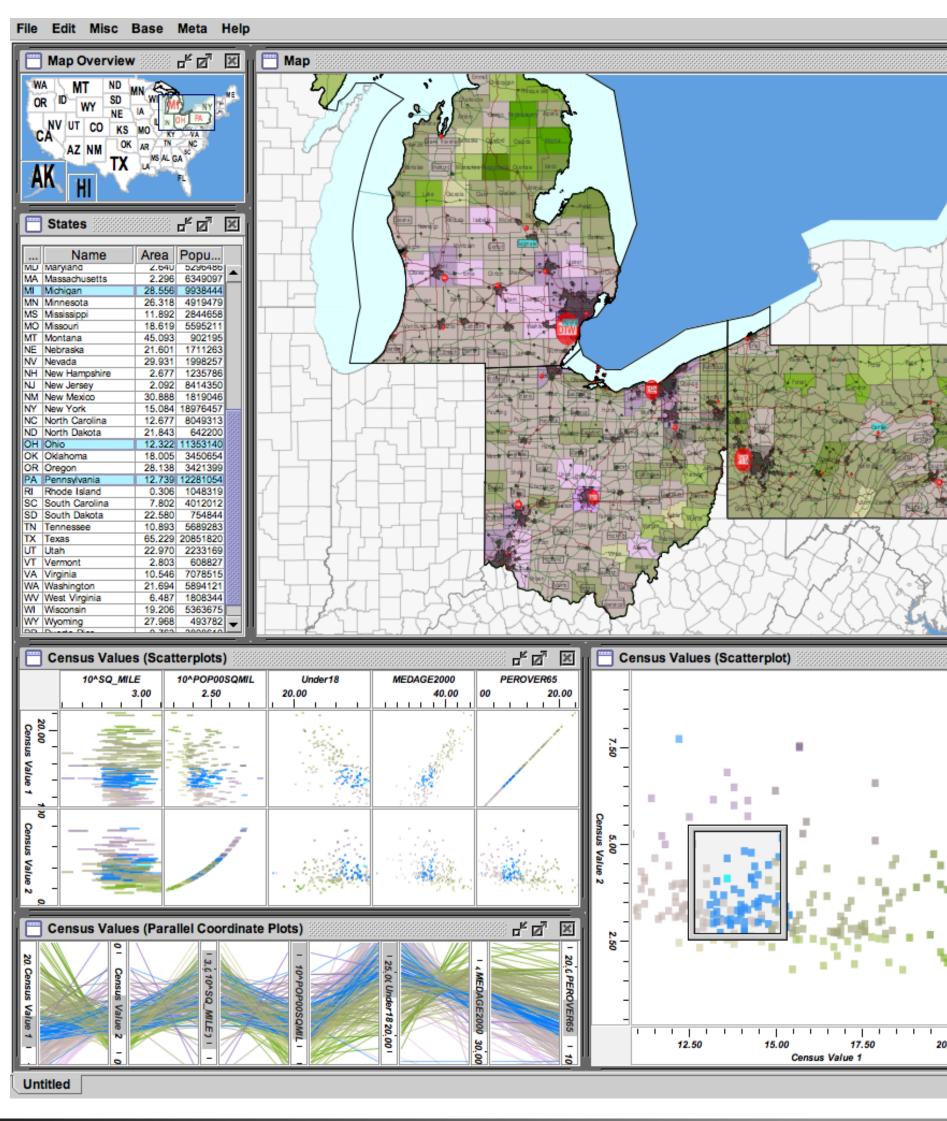
[Munzner (ill. Maguire), 2014]







Multiform

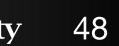


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Multiform Views

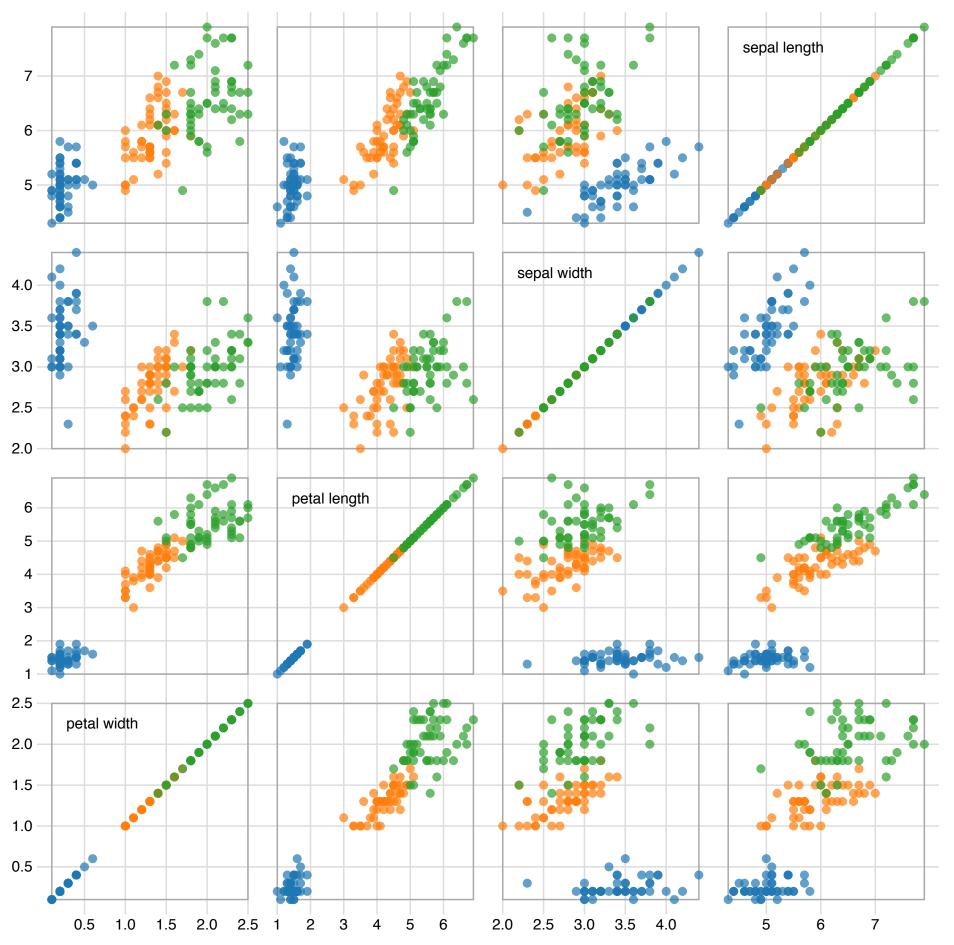
- The same data visualized in different ways
- Does not need to be a totally different encoding (all choices need not be disjoint), e.g. horizontal positions could be the same
- One view becomes cluttered with too many attributes
- Consumes more screen space
- Allows greater separability between channels





Small Multiples

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











Interaction with Multiform & Small Multiples

- Key interaction with multiform and small multiples: **brushing**
 - also called linked highlighting
- views

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• Want to understand correspondences between representation in the different

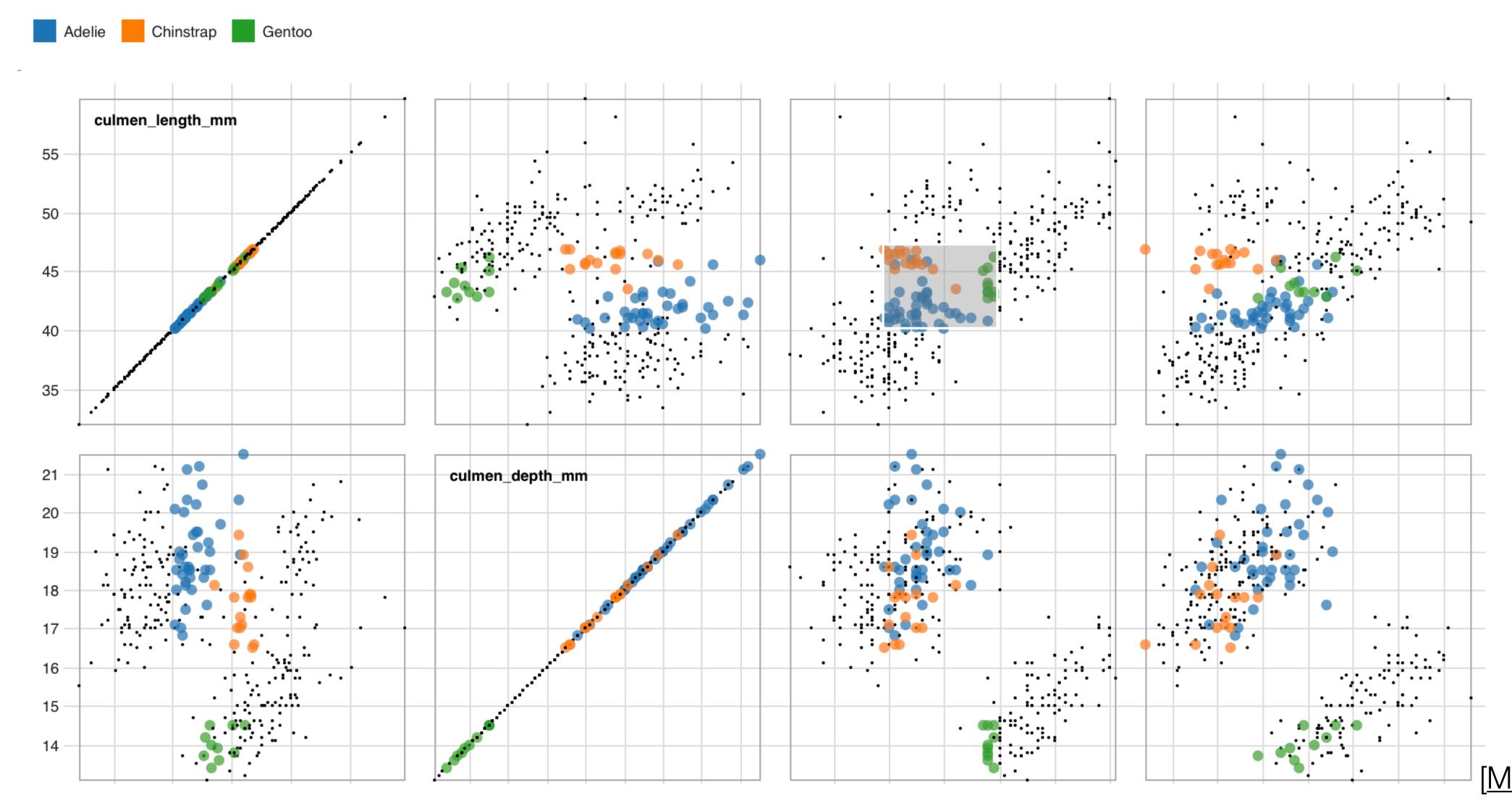








Brushing











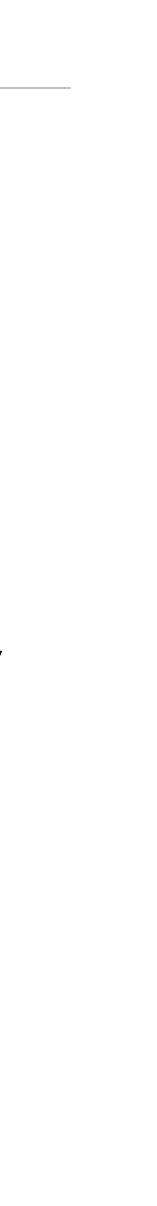
Schneiderman's Mantra

- 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
- layer
 - May be permanent: side-by-side
 - May be a popup layer: often opaque or separated
- (see textbook Ch. 6.7)

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• Want specific **details** about some aspect(s) of the data, need another view/

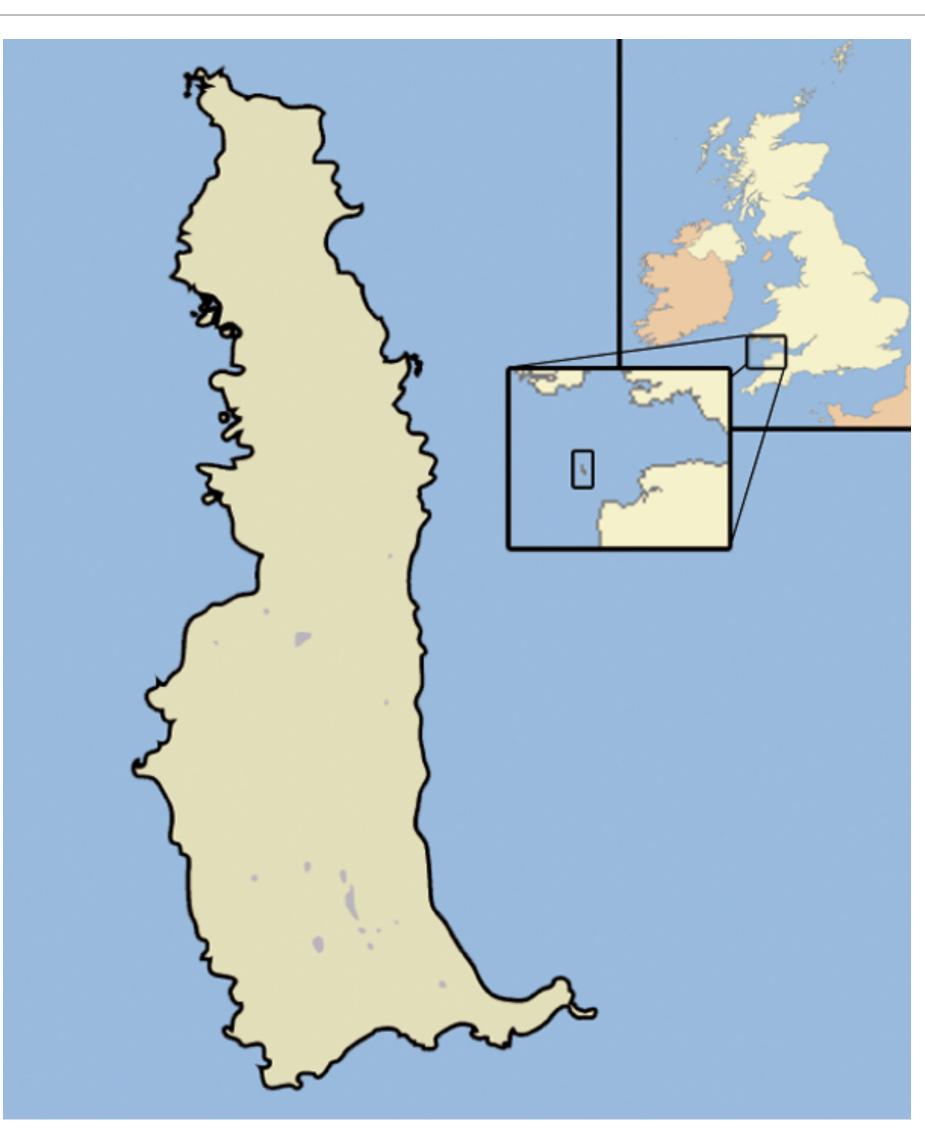








Overview-Detail View





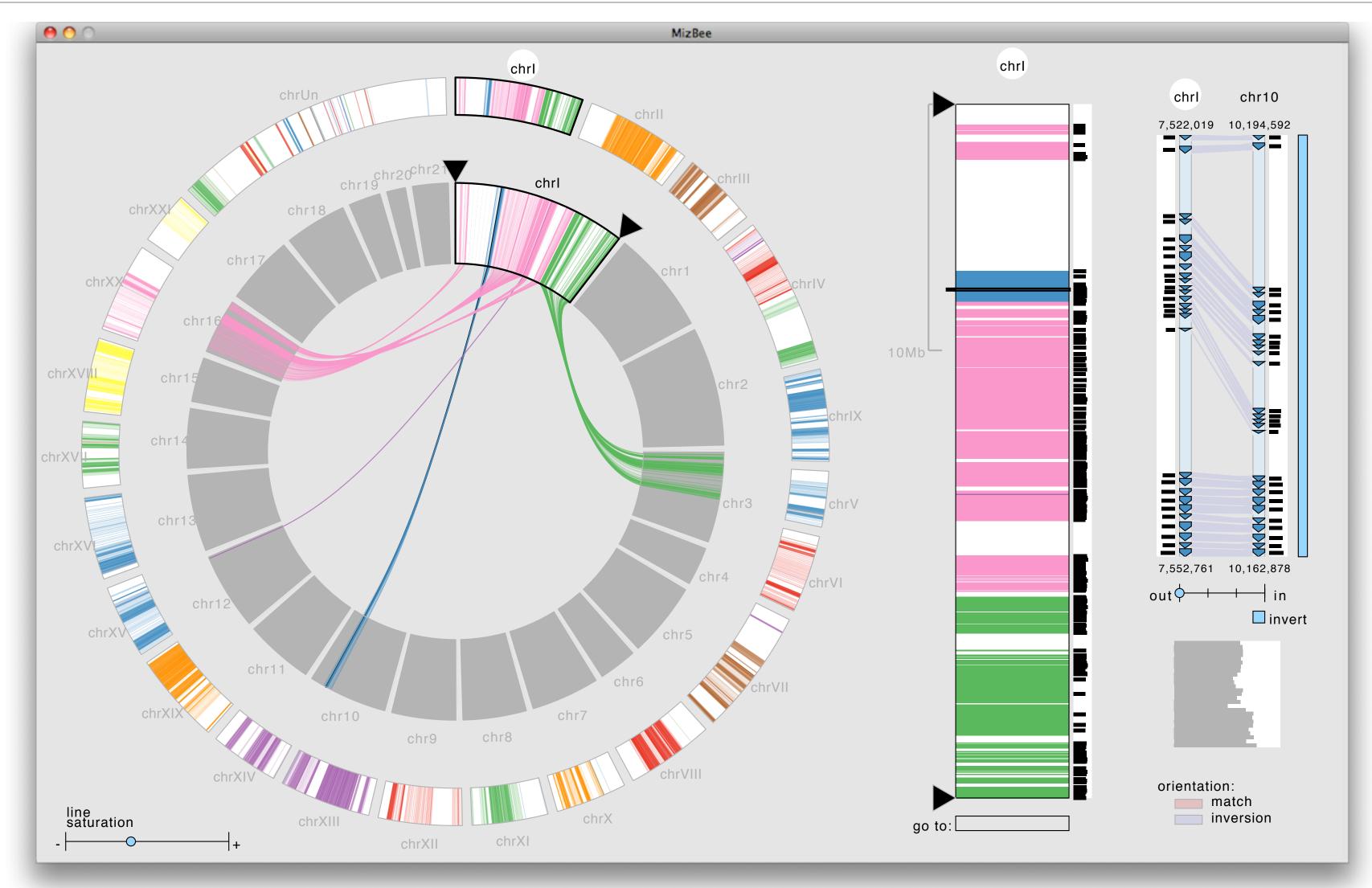








Overview-Detail (Different Encoding)











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
 - overview+detail of expenditures

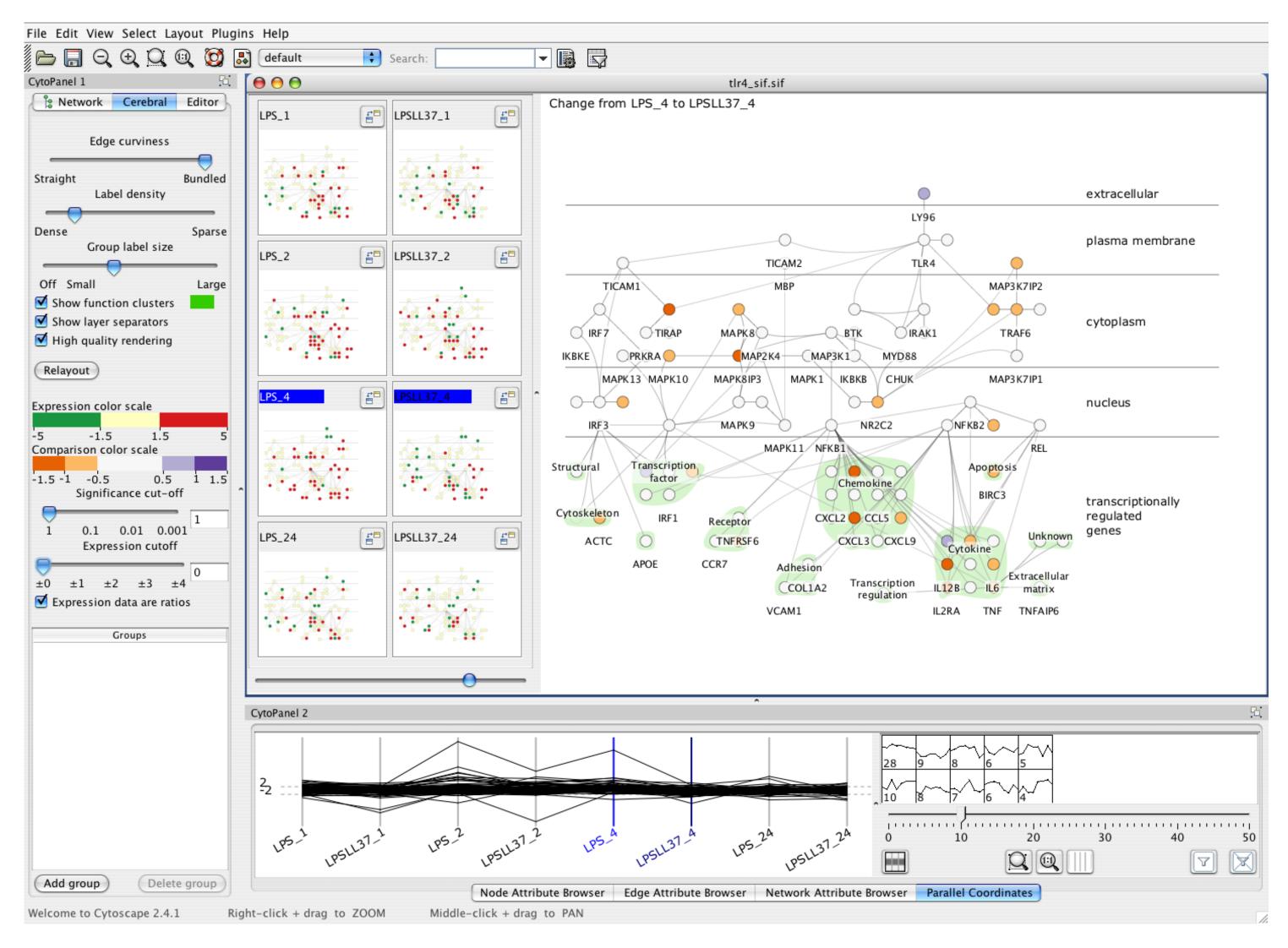
- UC Trends: partition into multiple views, coordinated with linked highlighting,







Multiform & Small Multiples (Cerebral)













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

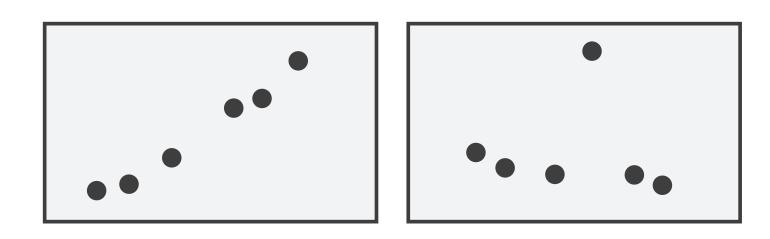




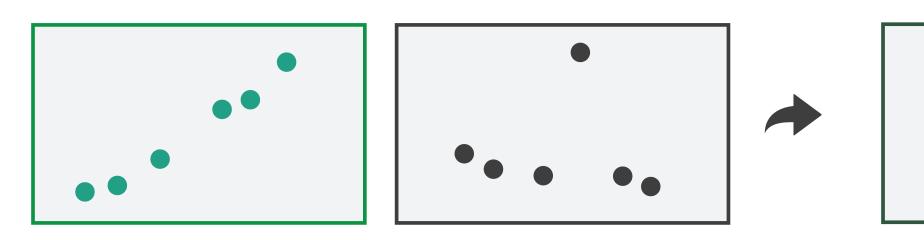




Partition into Side-by-Side Views



Superimpose Layers



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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

ize each group group for all items







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

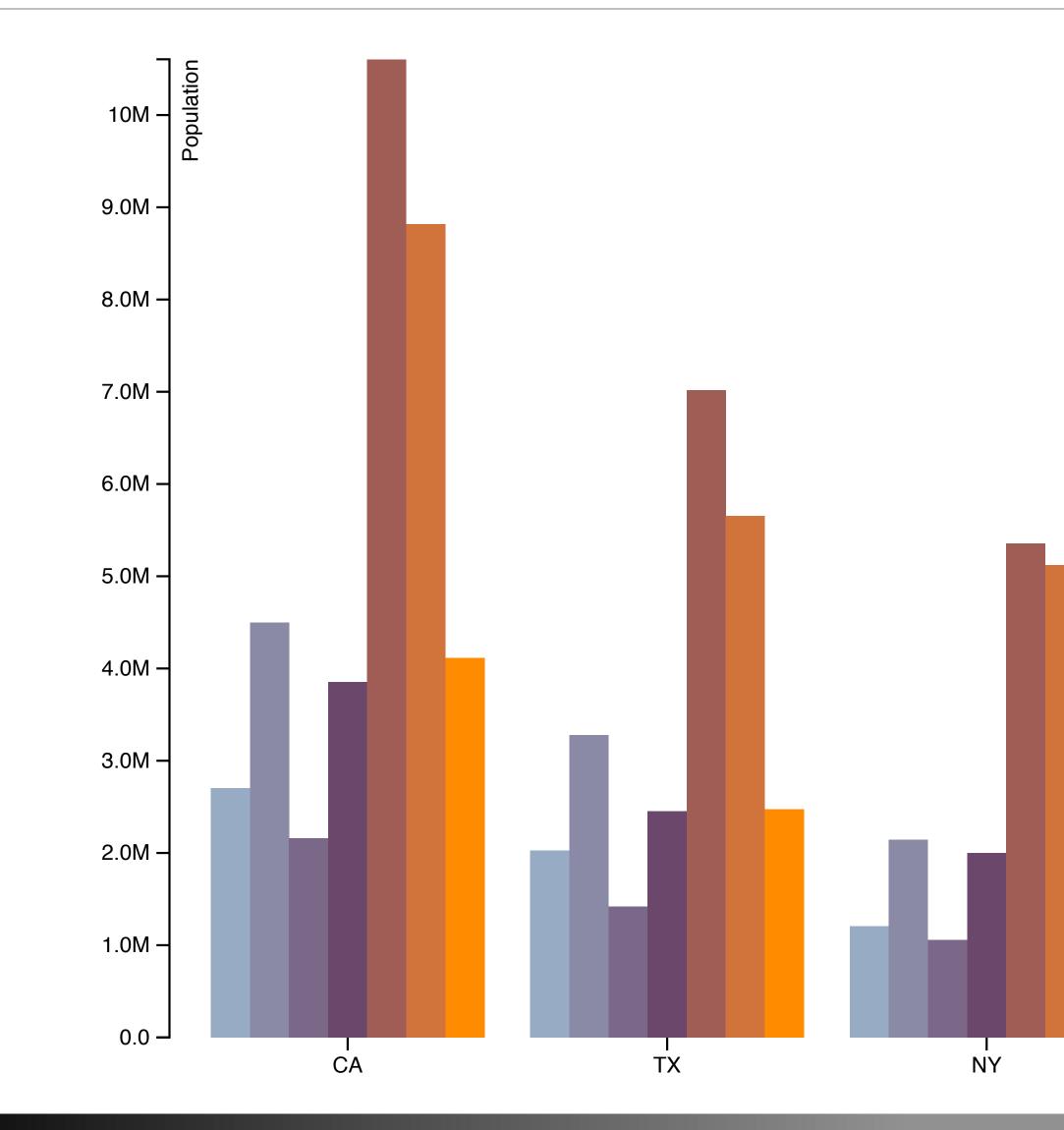






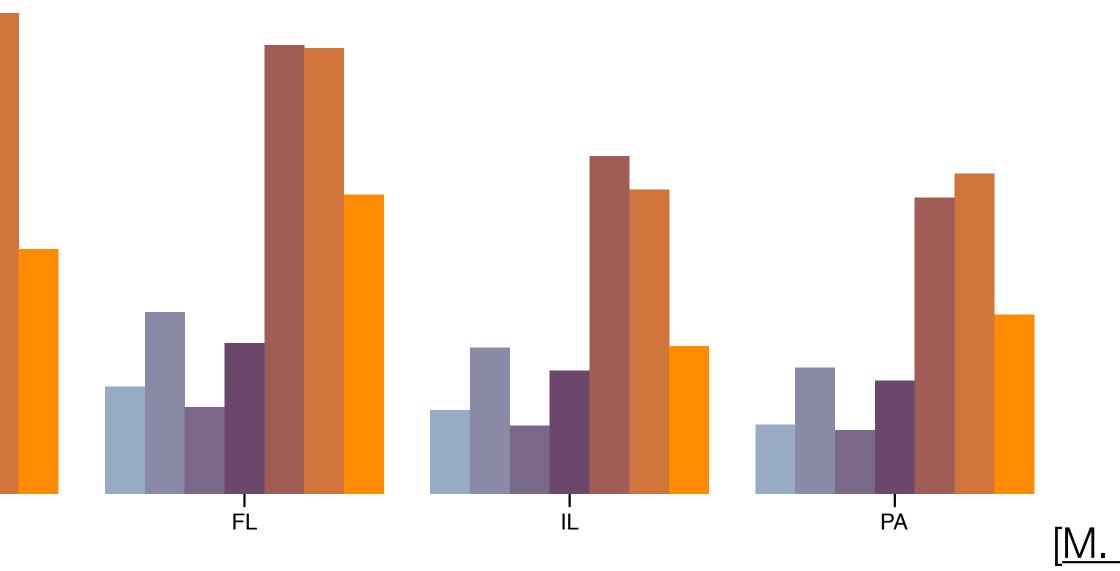


Example: Grouped Bar Chart



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65 Years and Over 45 to 64 Years 25 to 44 Years 18 to 24 Years 14 to 17 Years 5 to 13 Years Under 5 Years

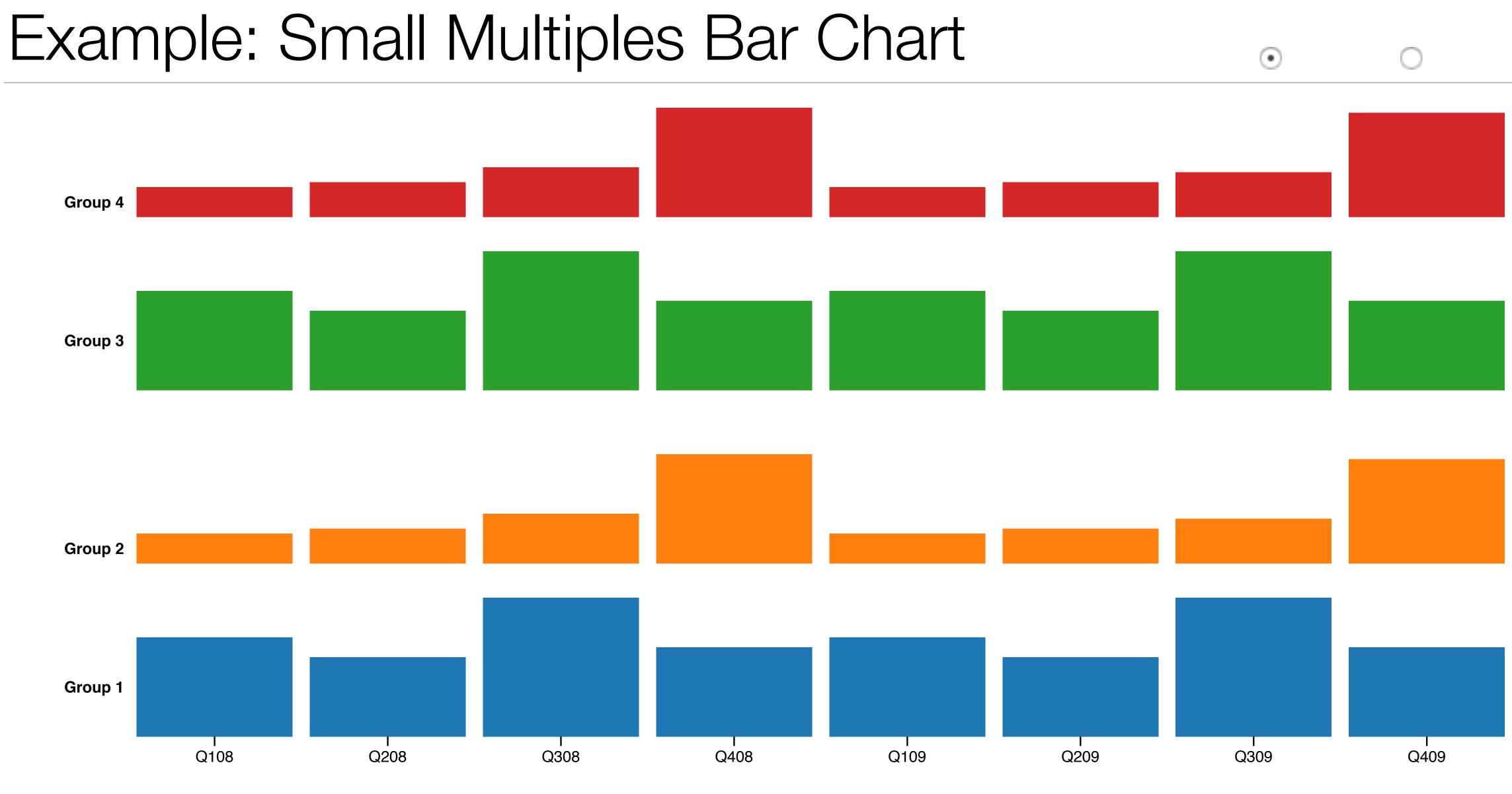




















Matrix Alignment & Recursive Subdivision

- 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

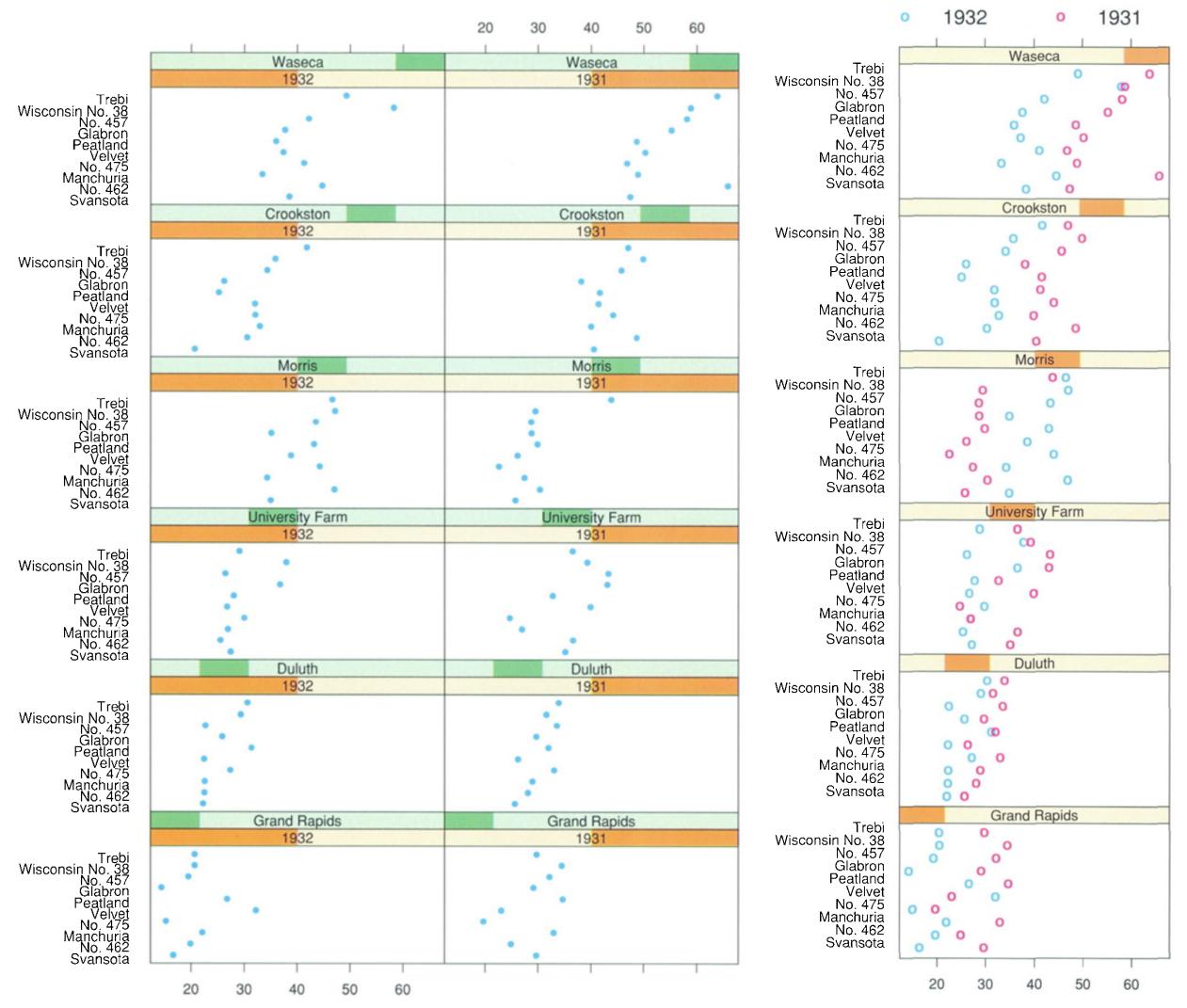








Example: Trellis Matrix Alignment



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Barley Yield (bushels/acre)



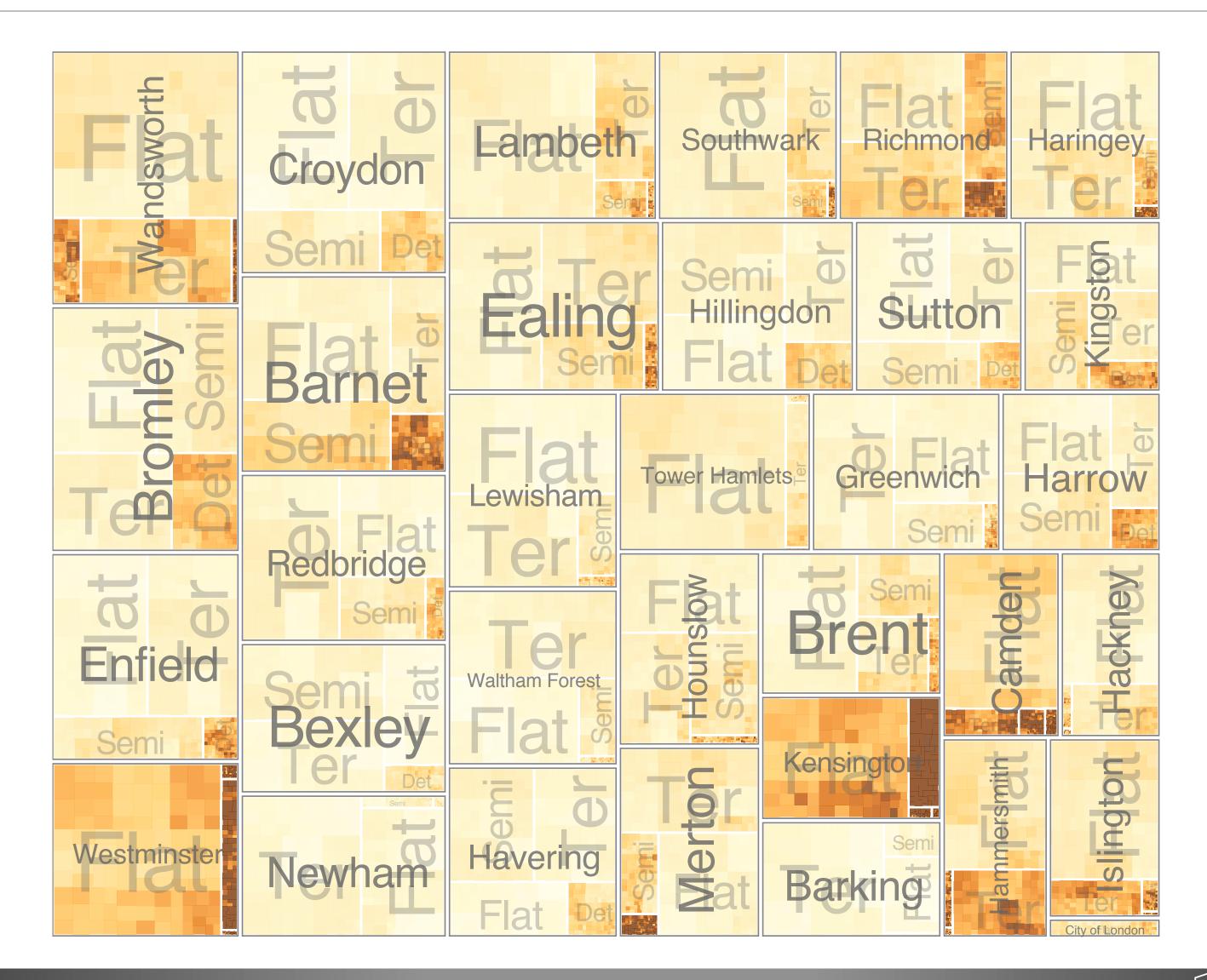


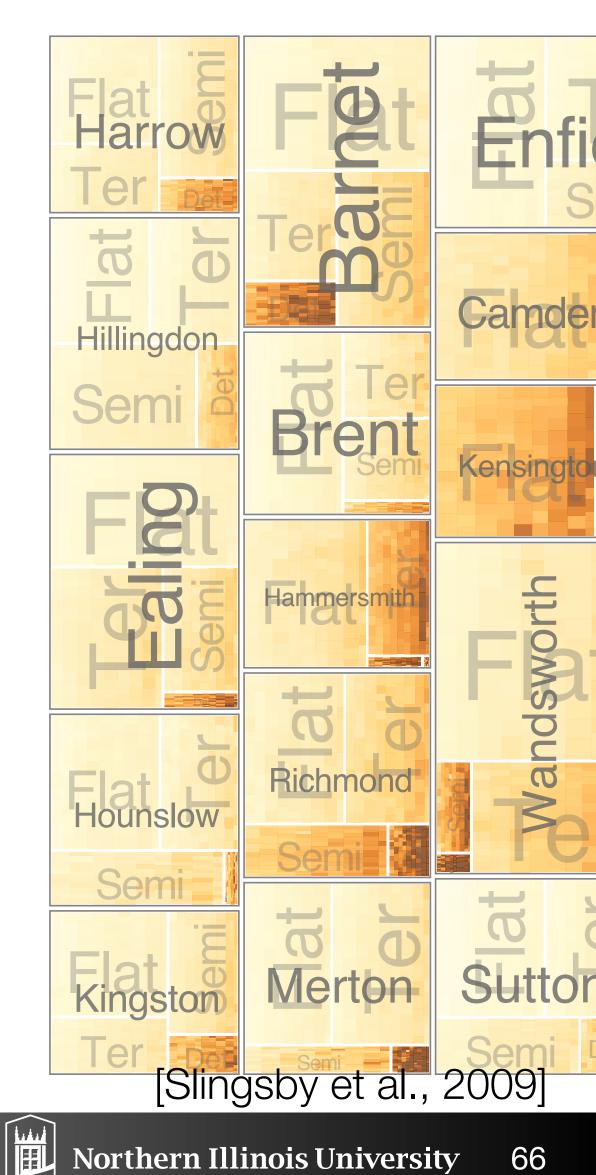






Recursive Subdivision





Example: HiVE System



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[Slingsby et al., 2009]

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