#### Information Visualization

#### Visualization Research

Dr. David Koop





### Visualization Tools & Tradeoffs

- Fast, turnkey approaches
- Control over all visual elements
- You can use **multiple** tools! Think about purpose
  - Exploration
  - Explanation (custom design, handle interaction)







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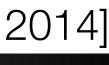
### Scatterplot Matrices and Parallel Coordinates

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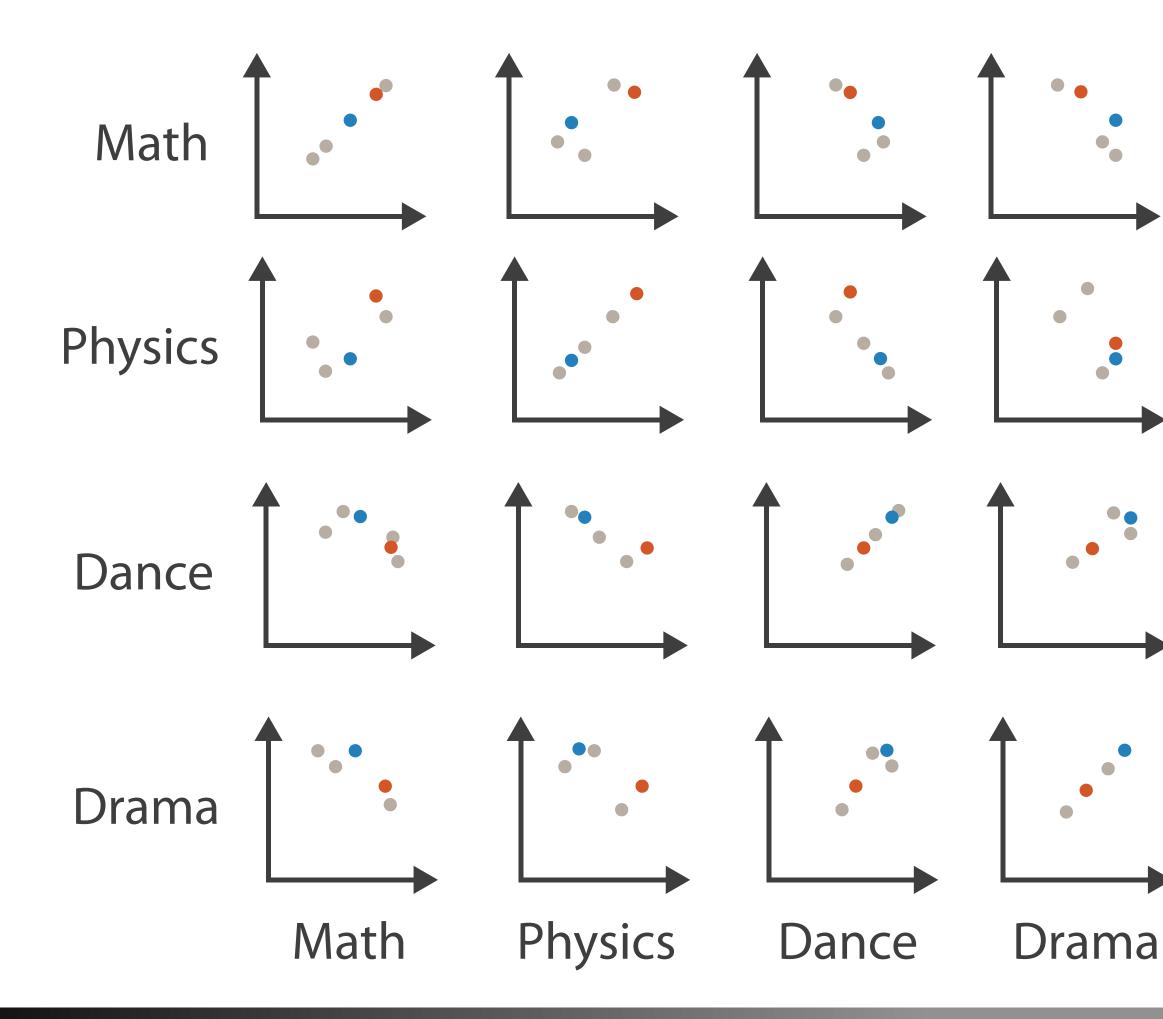






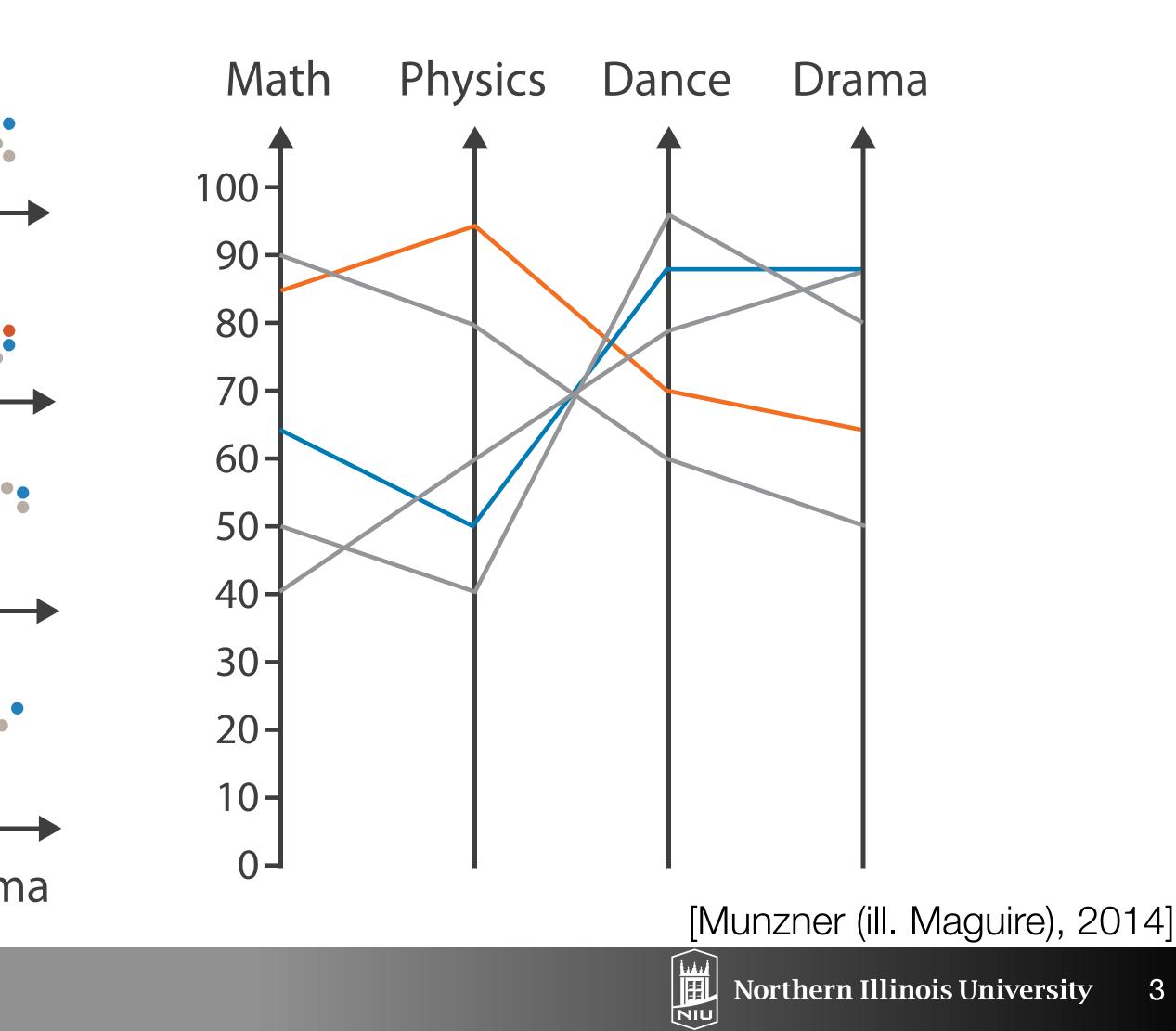
### Scatterplot Matrices and Parallel Coordinates

#### Scatterplot Matrix



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**Parallel Coordinates** 

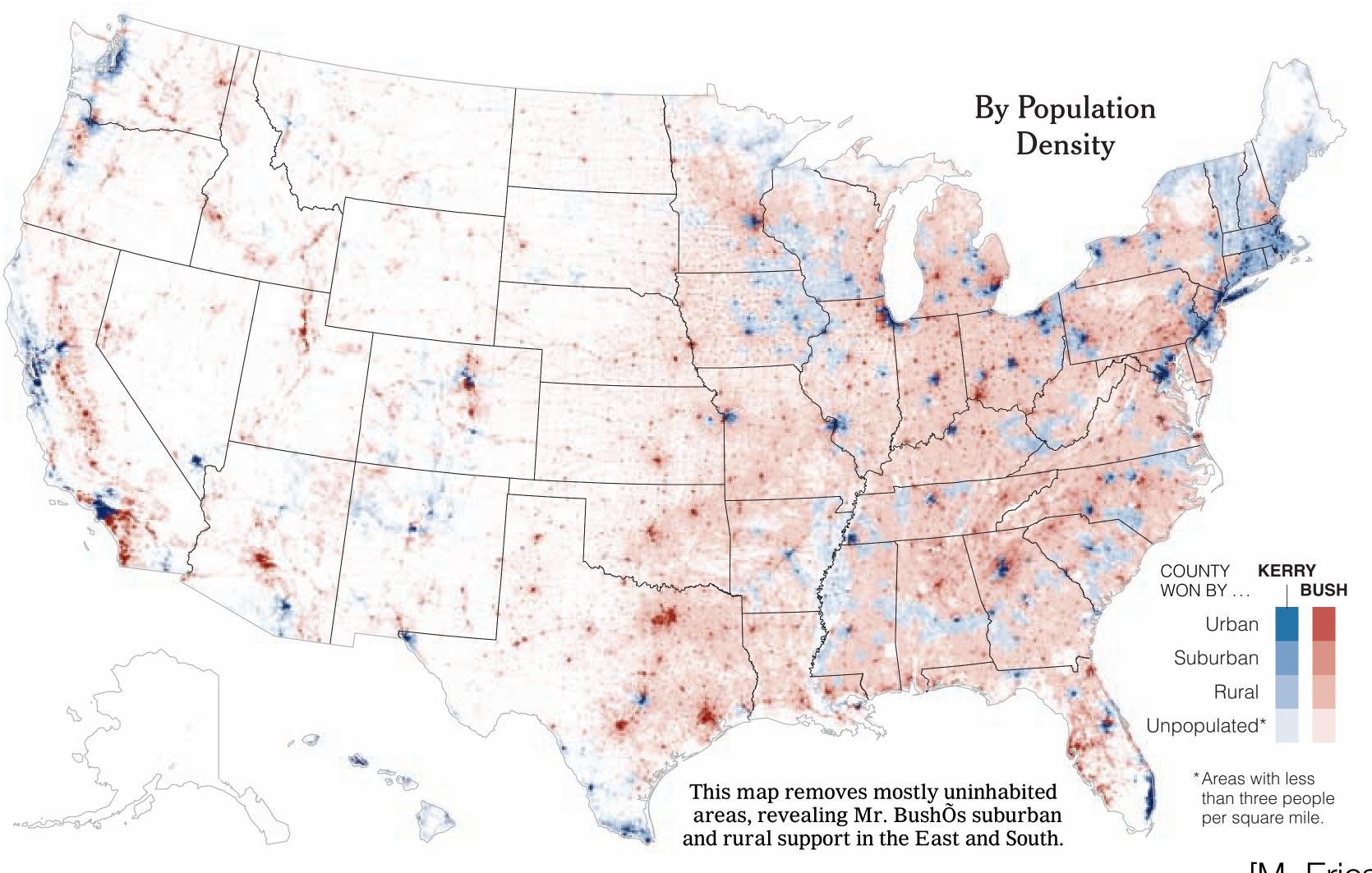








### Map with Two Variables



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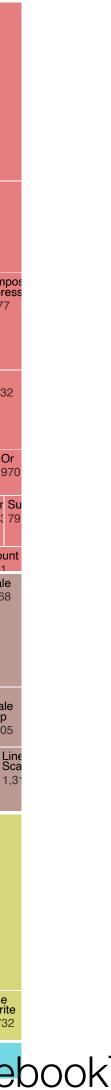
4

#### Ireemaps

- Containment marks instead of connection marks
- Encodes some attribute of the items as the **size** of the rectangles
- Not as easy to see the intermediate rectangles
- Scalability: millions of leaf nodes and links possible
- Need a layout algorithm!
  - Slice-and-Dice vs. Squarify
- Viewing Hierarchy: Cushion Treemap

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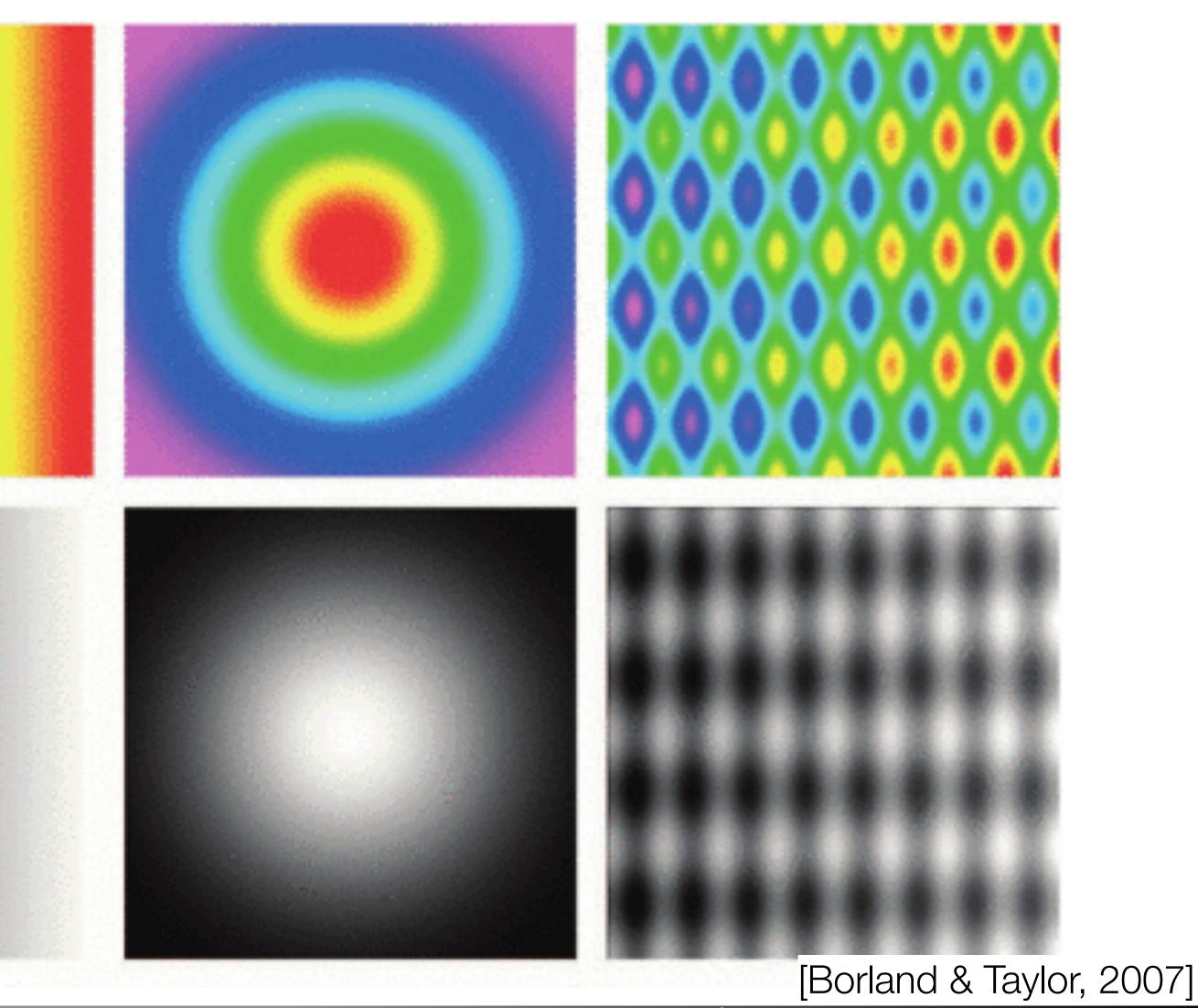






#### Avoid Rainbow Colormaps!

(a) (b)



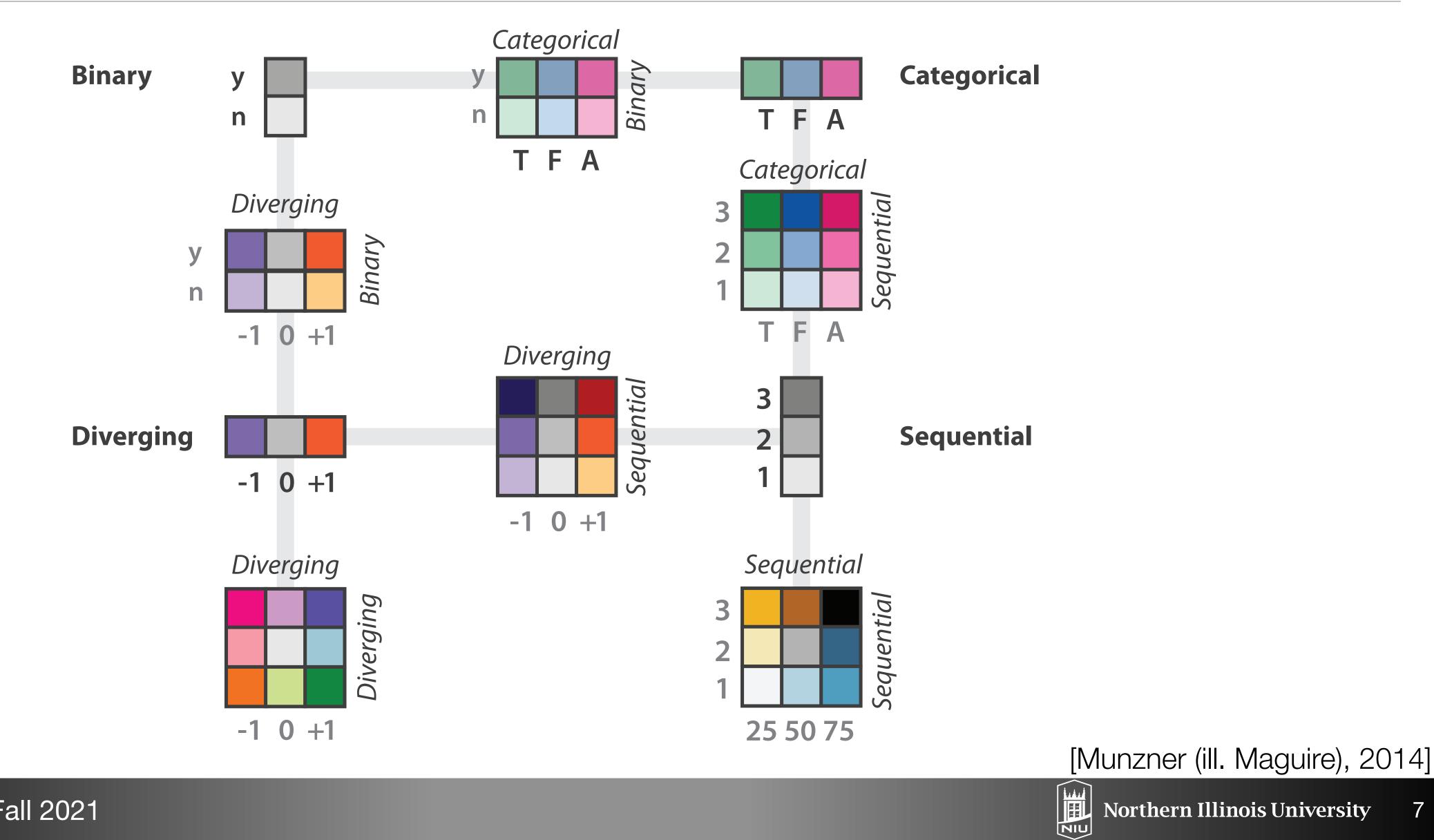




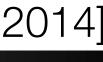




## Colormaps



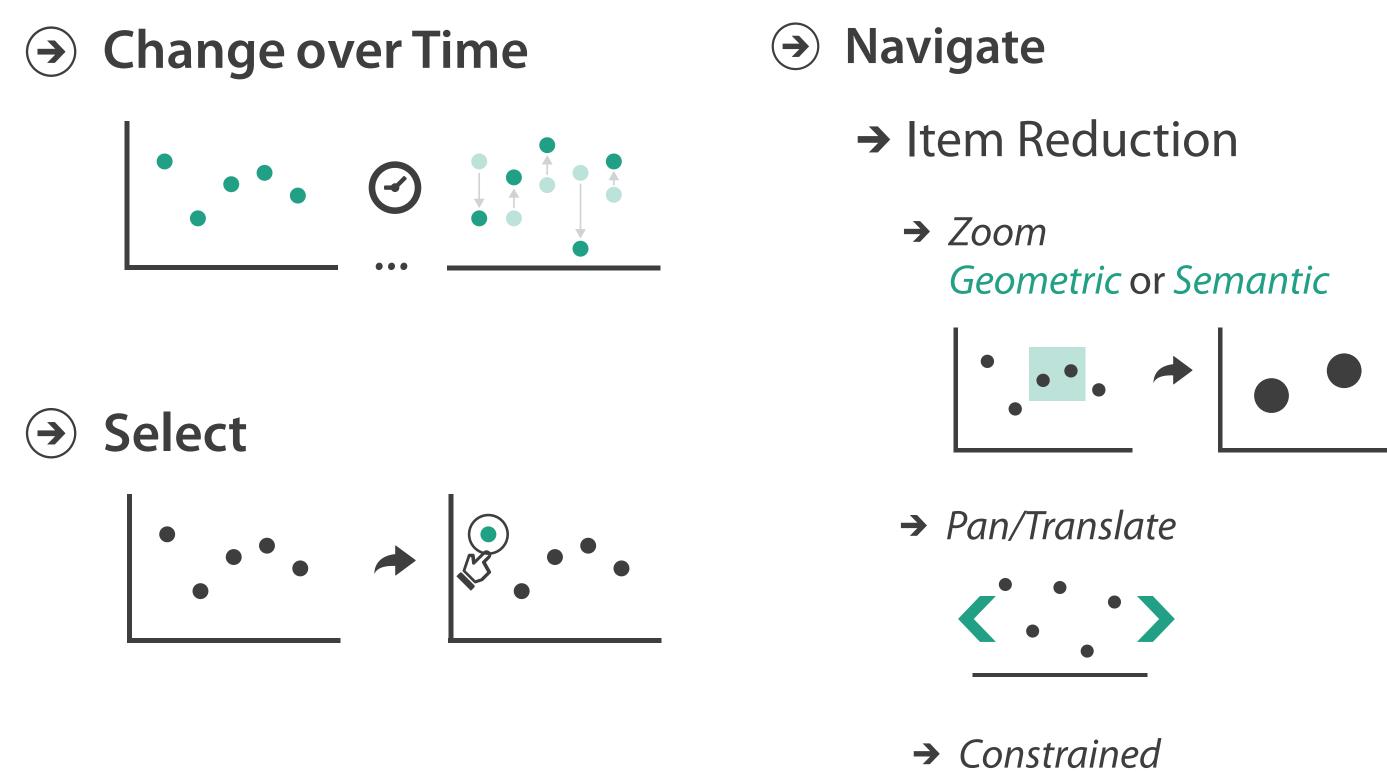
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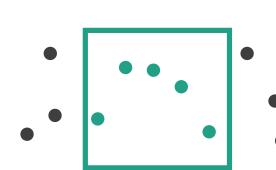


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### Interaction Overview

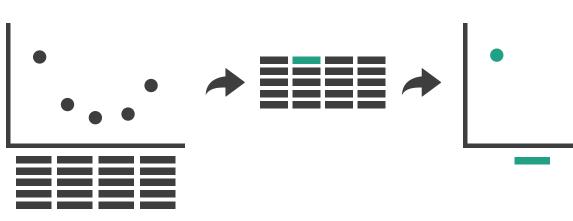




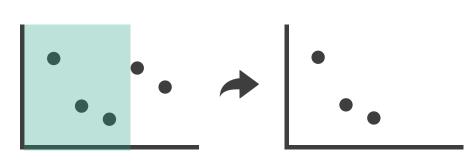
#### D. Koop, CSCI 628, Fall 2021

#### → Attribute Reduction

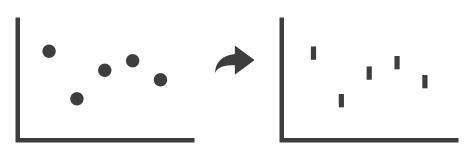
→ Slice



→ Cut



→ Project



[Munzner (ill. Maguire), 2014]

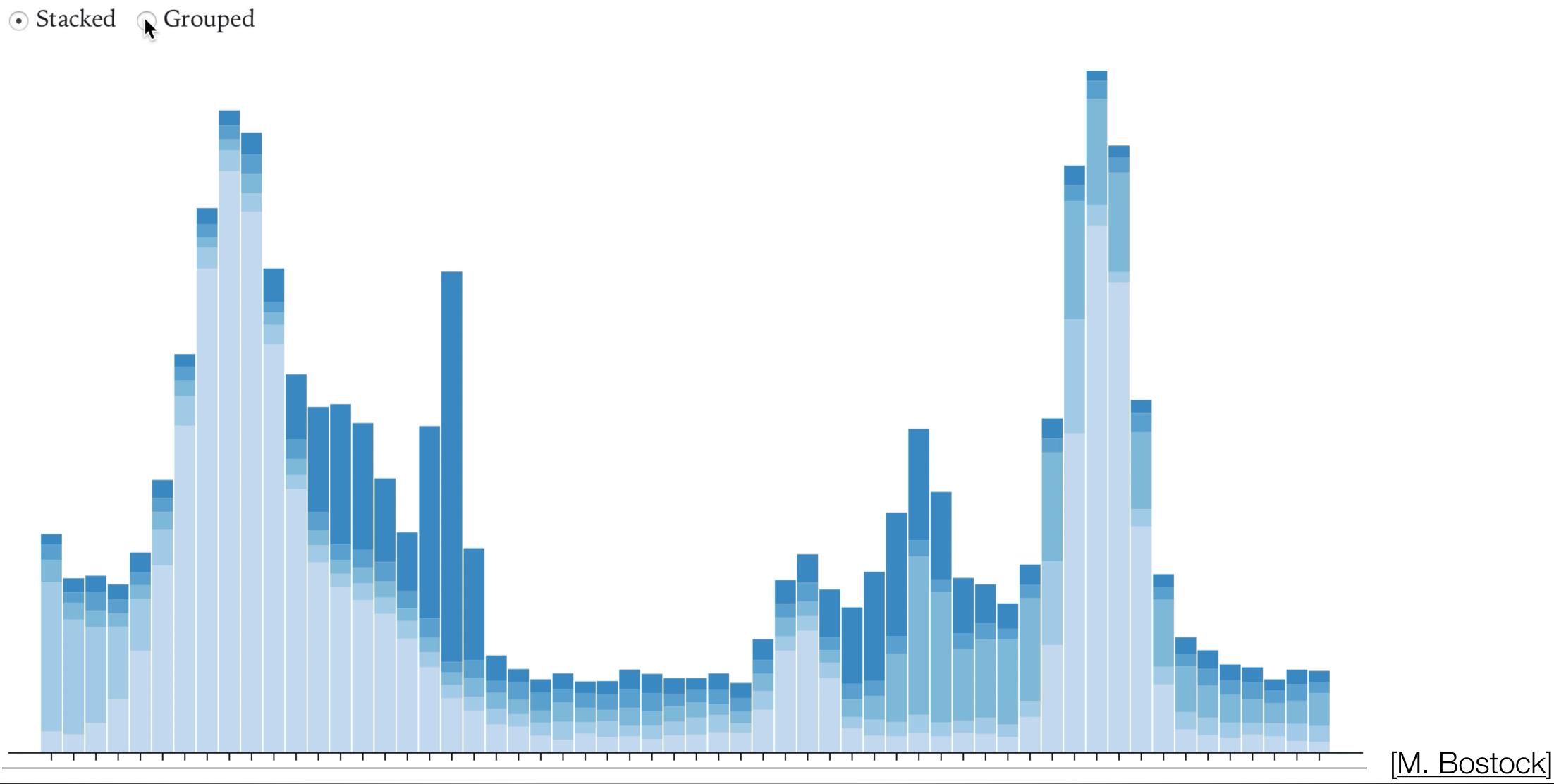


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### Animated Transitions

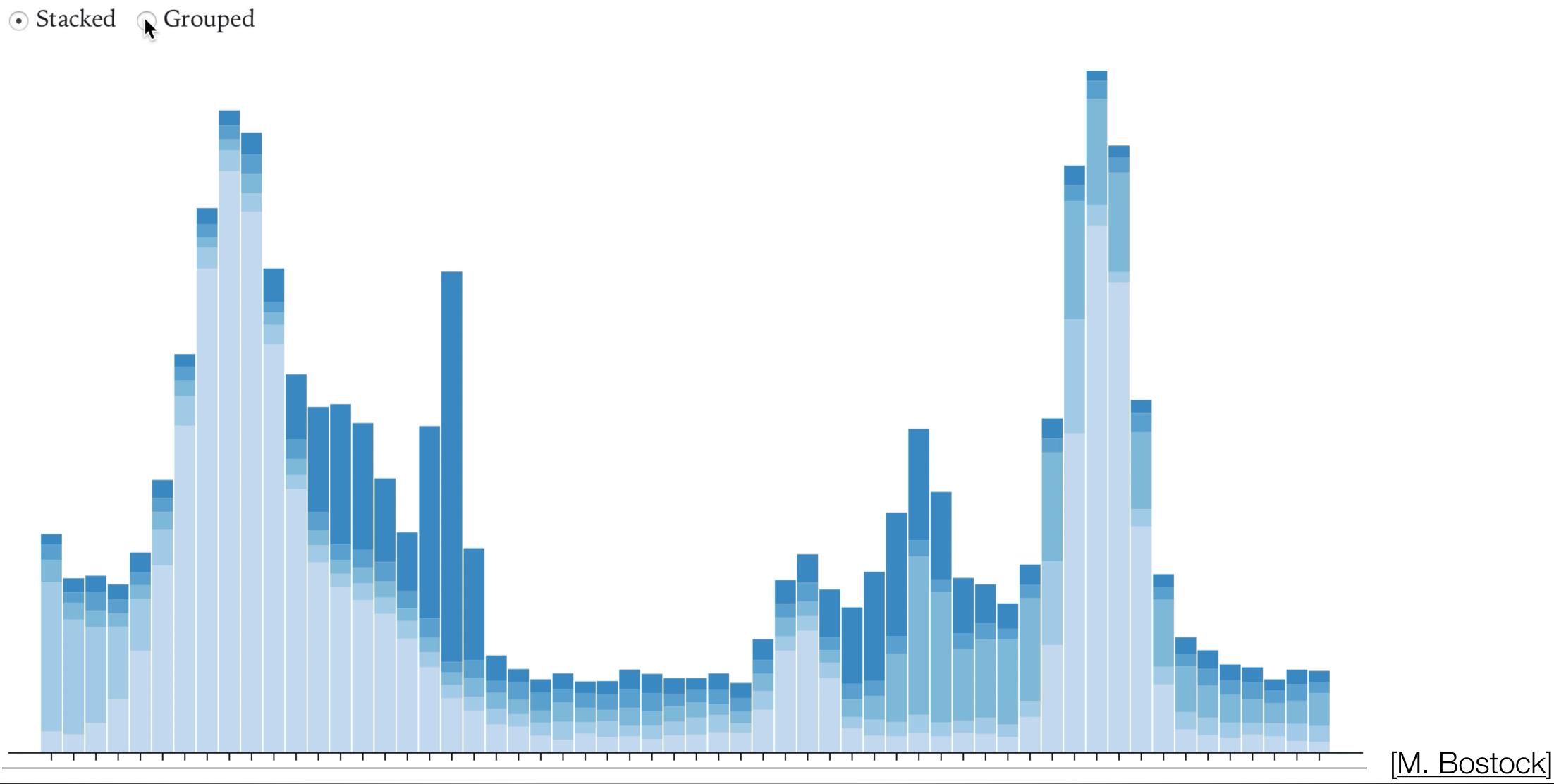








### Animated Transitions









# Multiple Views

- ➔ Juxtapose and Coordinate Multiple Side-by-Side Views
  - → Share Encoding: Same/Different
    - → Linked Highlighting



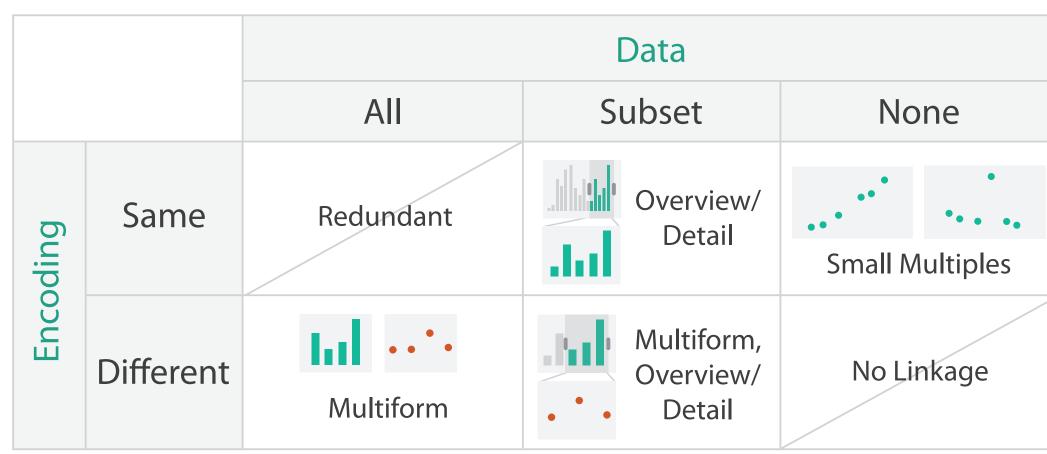
→ Share Data: All/Subset/None



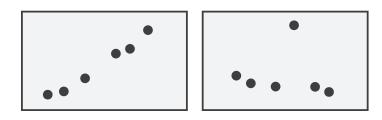
→ Share Navigation



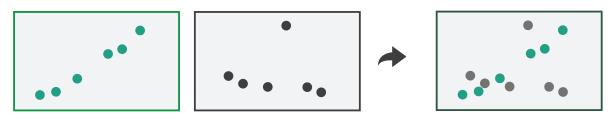
#### D. Koop, CSCI 628, Fall 2021



→ Partition into Side-by-Side Views



→ Superimpose Layers





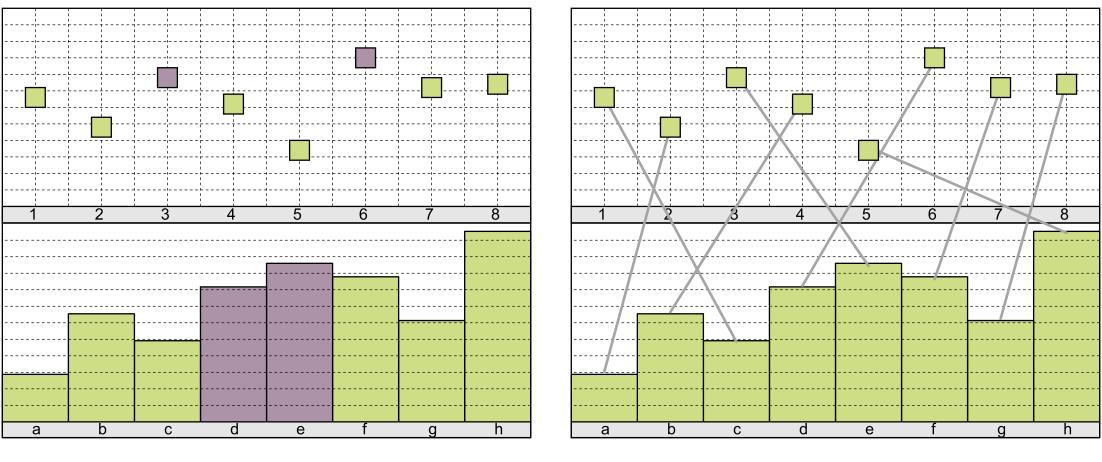


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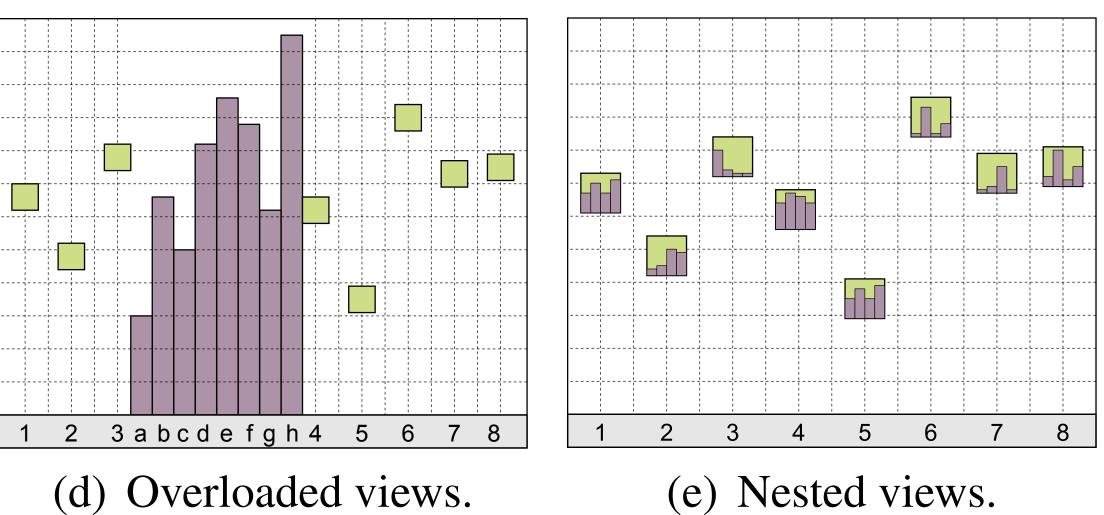


## Composite Visualization Techniques

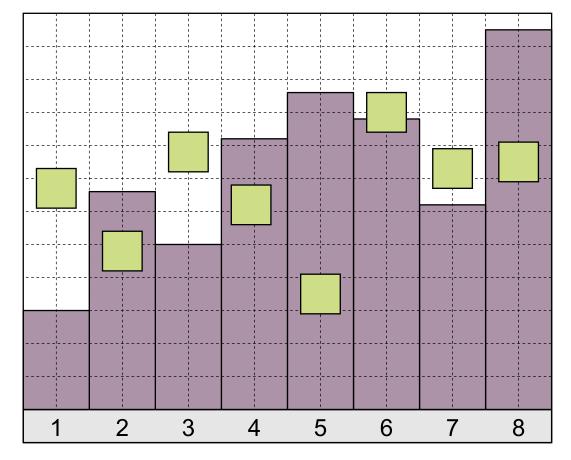


(a) Juxtaposed views.





(b) Integrated views.



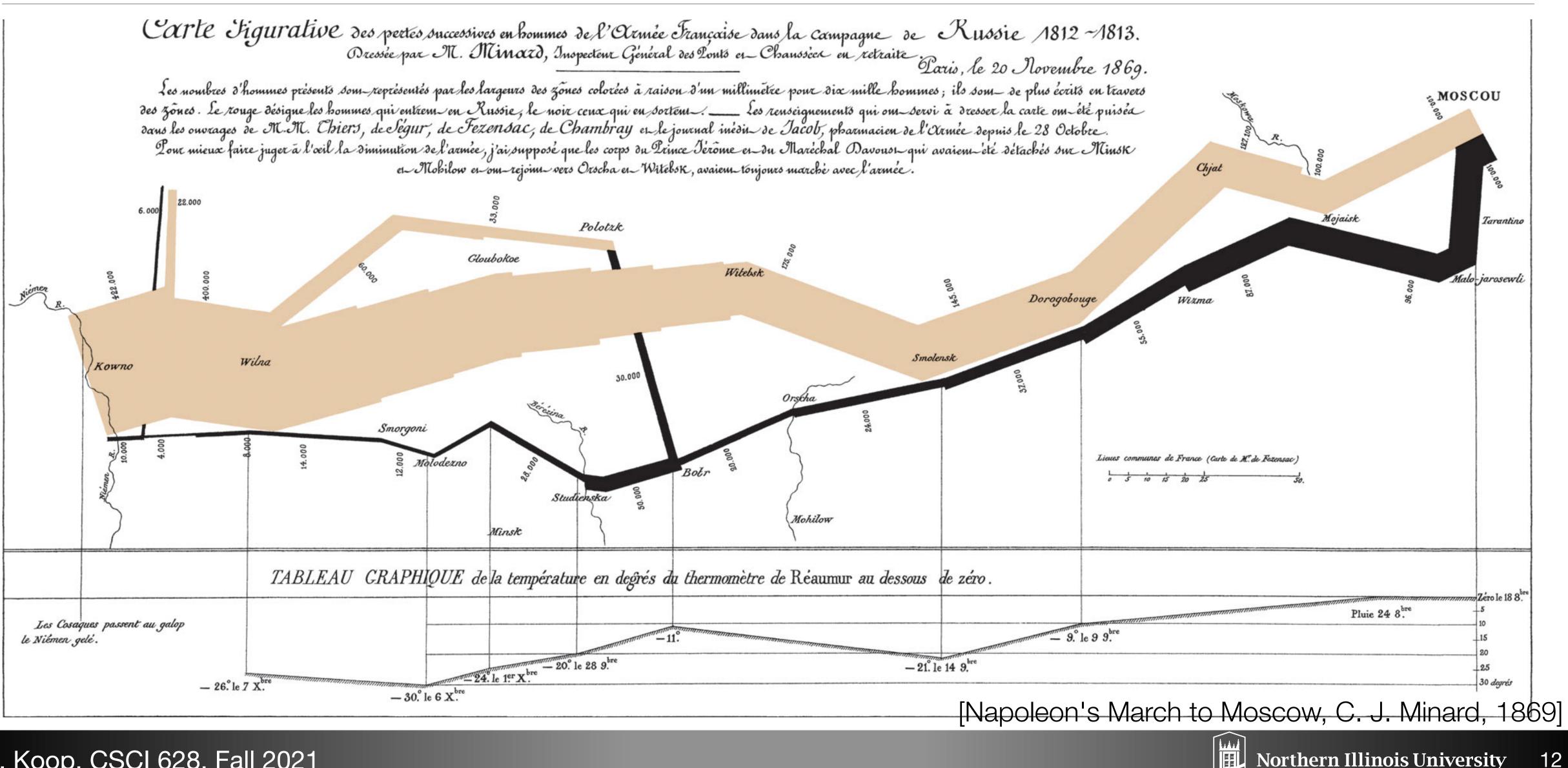
(c) Superimposed views.





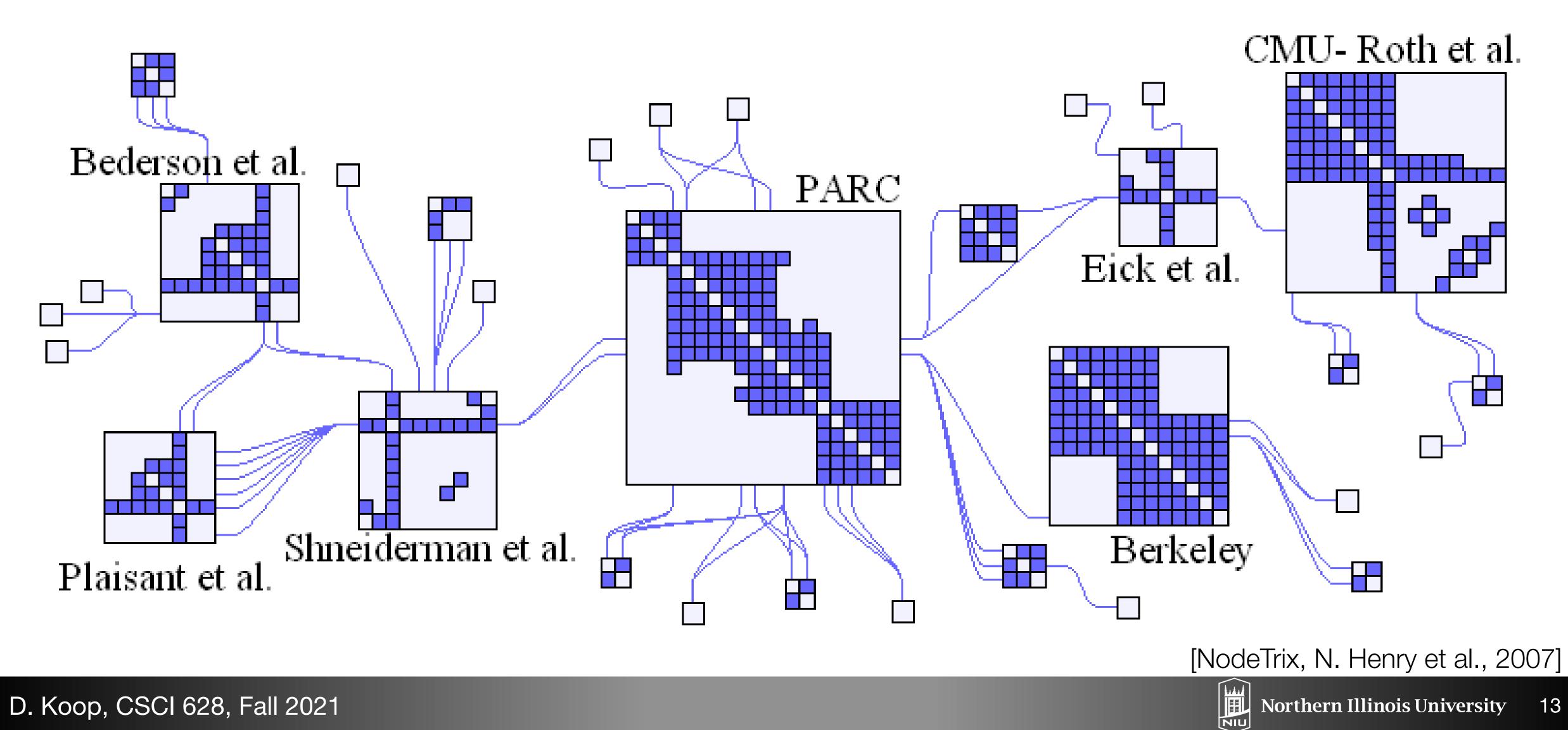


### Integration

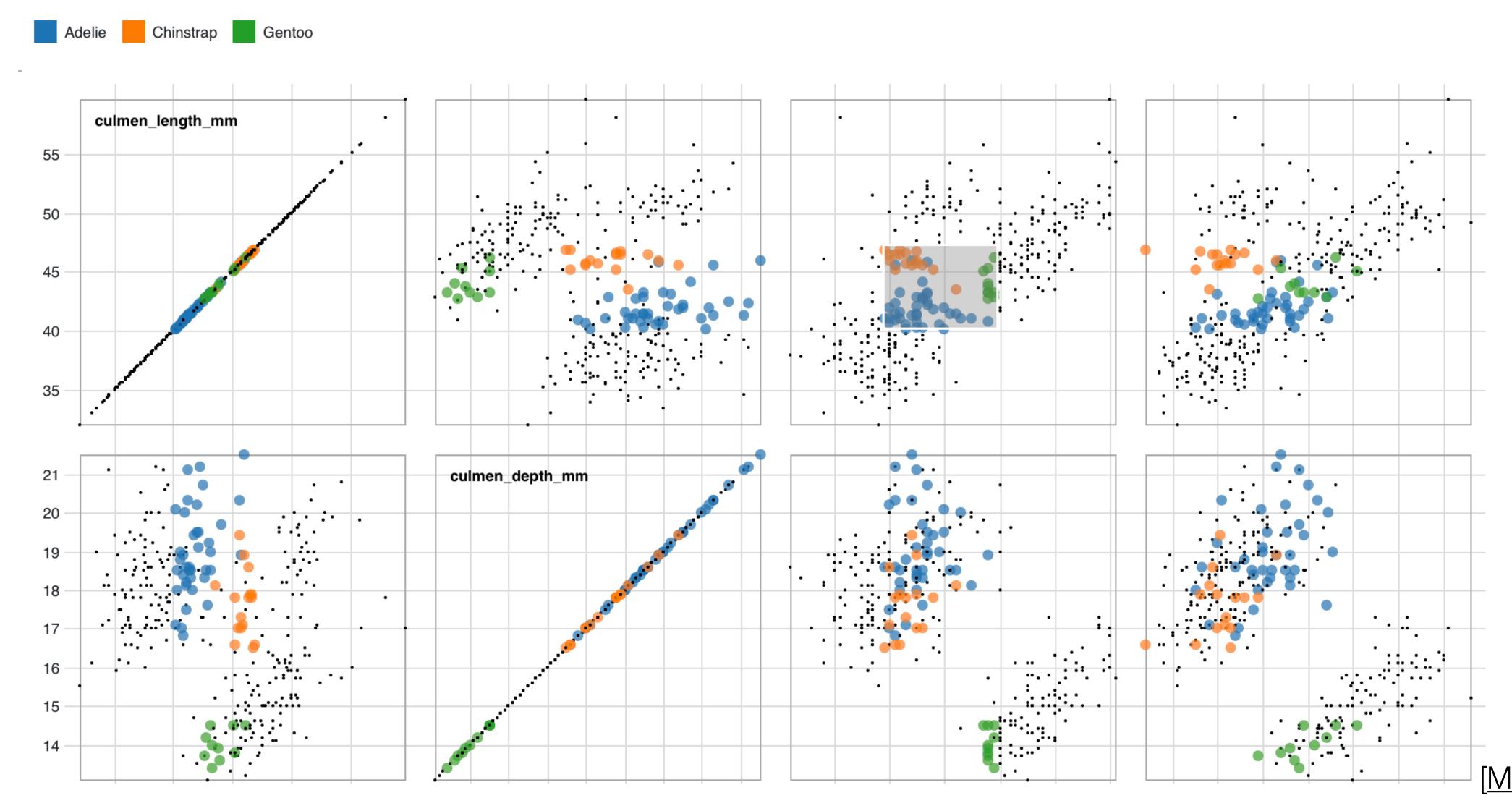




## Nesting



# Brushing



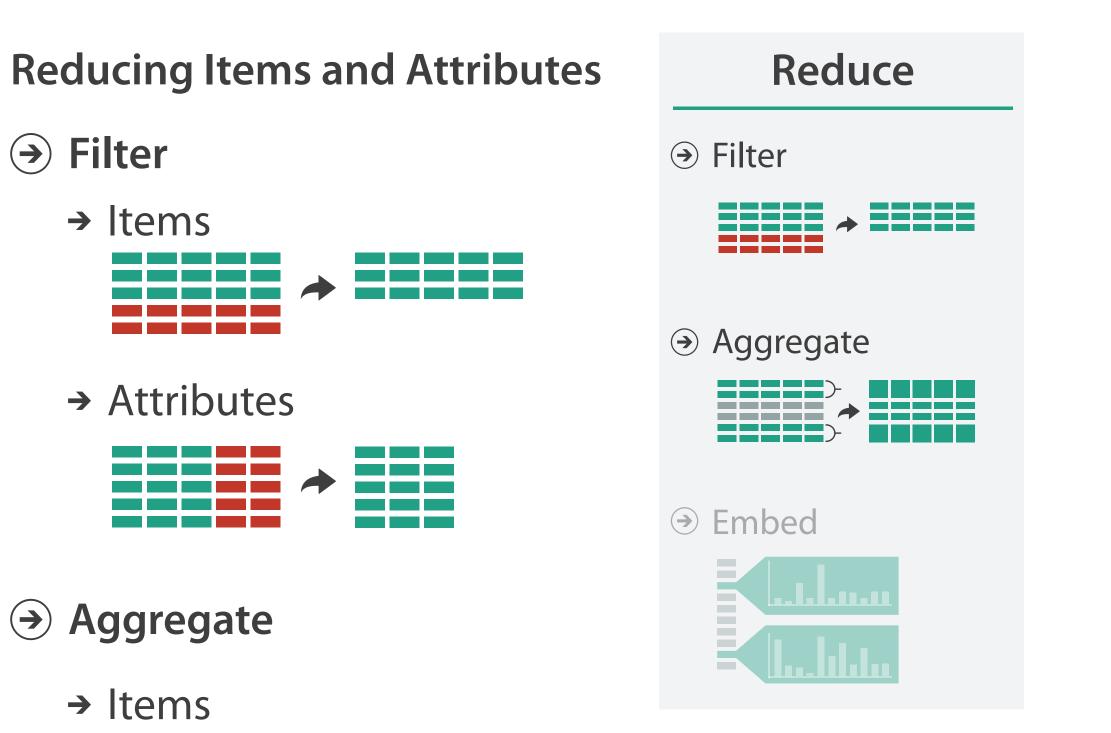


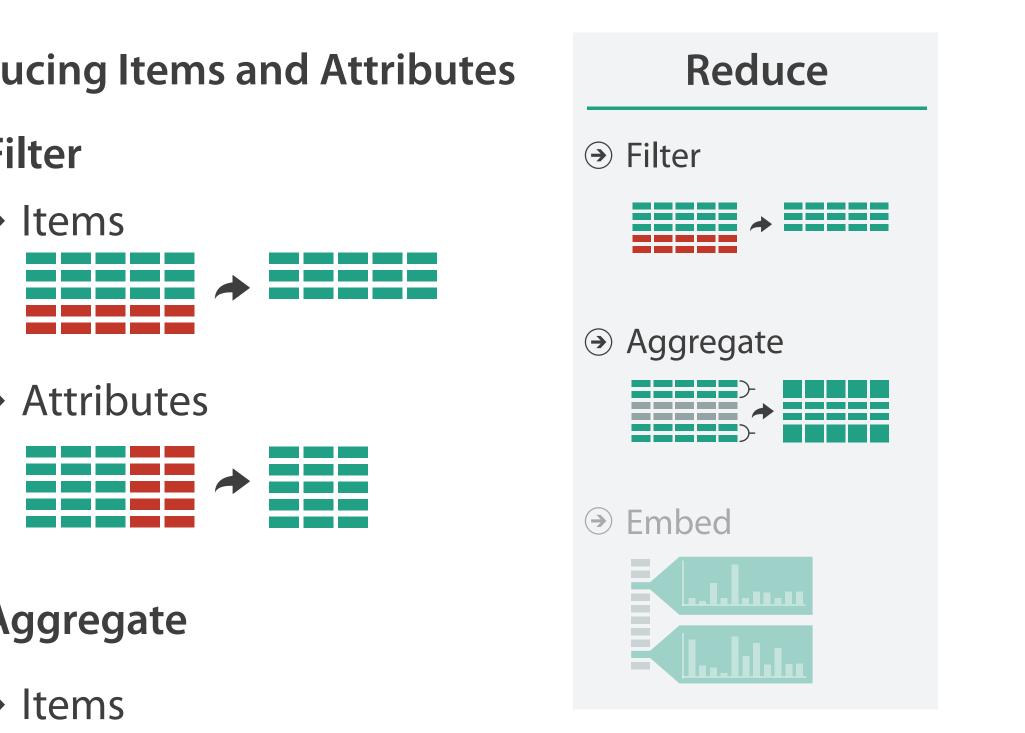




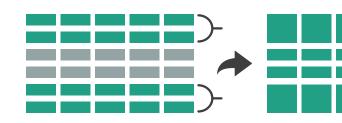
# Filtering and Aggregation

#### → Filter

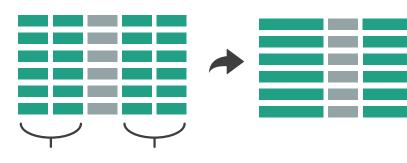




→ Aggregate

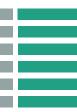


→ Attributes



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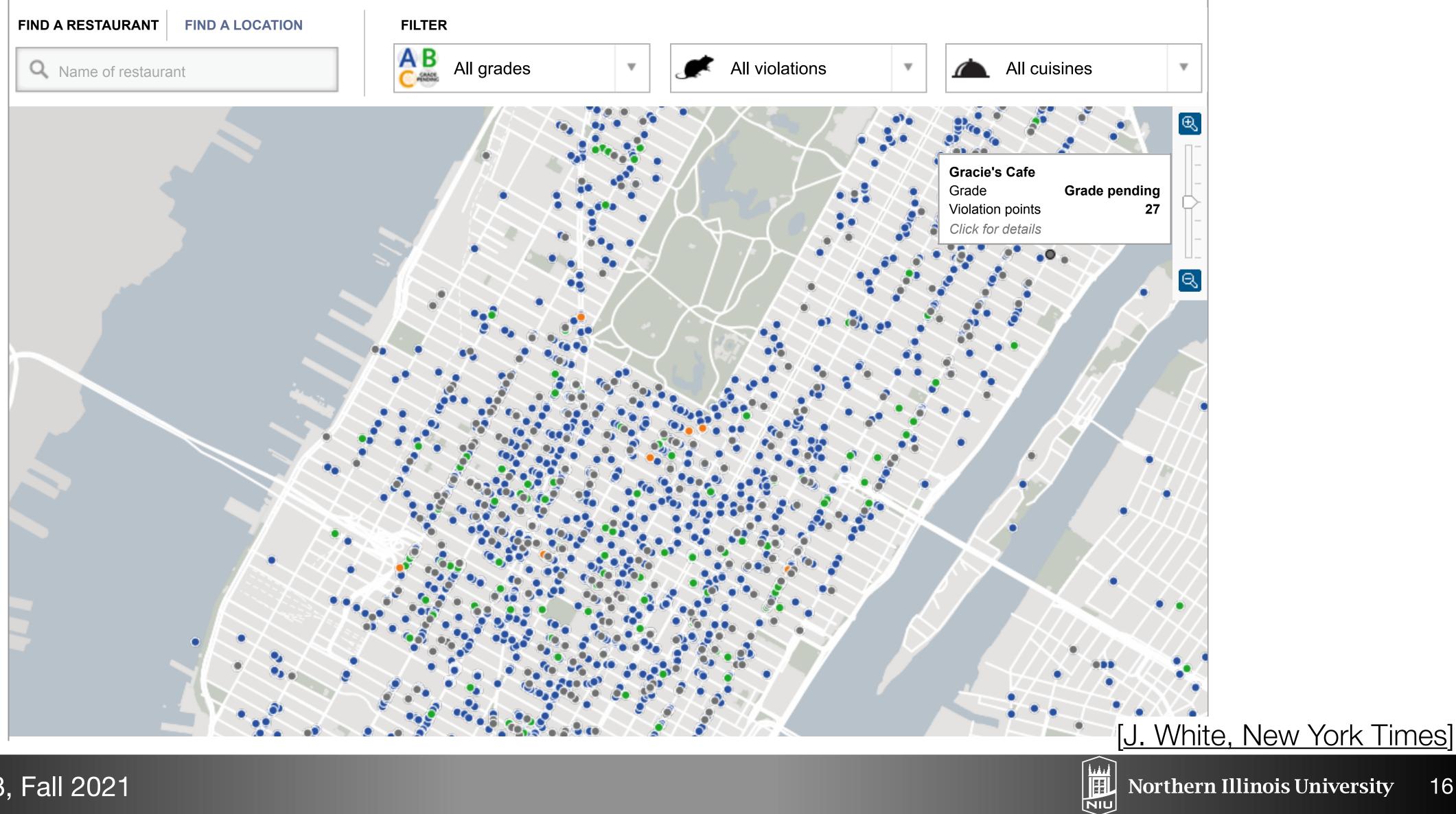




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## Filtering using Widgets



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### Aggregation: Histograms

- Very similar to bar charts

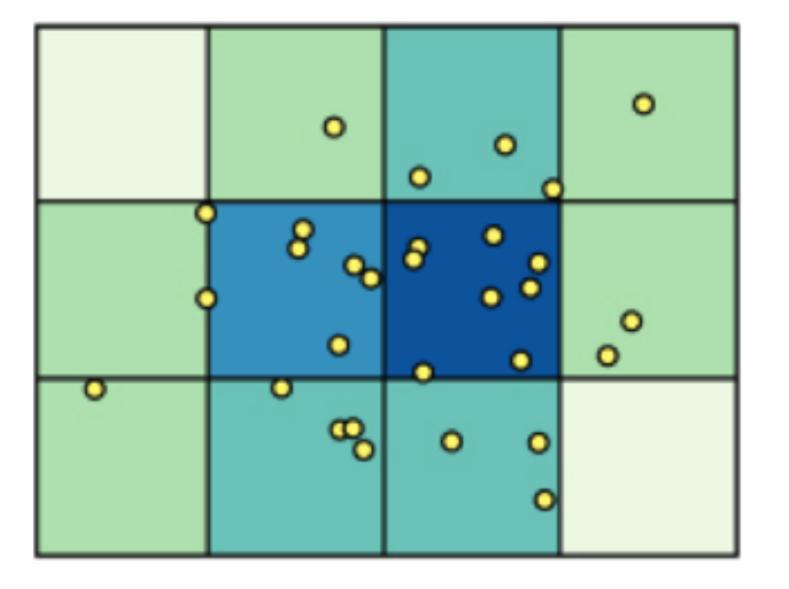
- Often shown without space between (continuity)
- Choice of number of bins
  - Important!
  - Viewers may infer different trends based on the layout

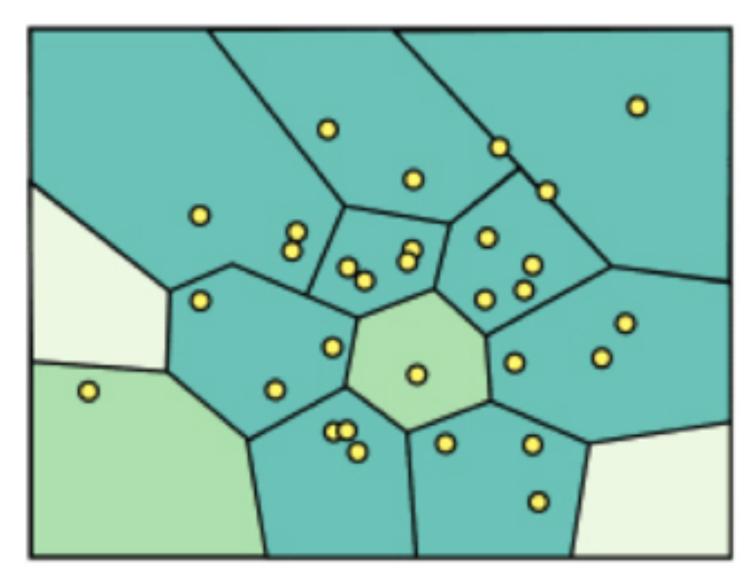




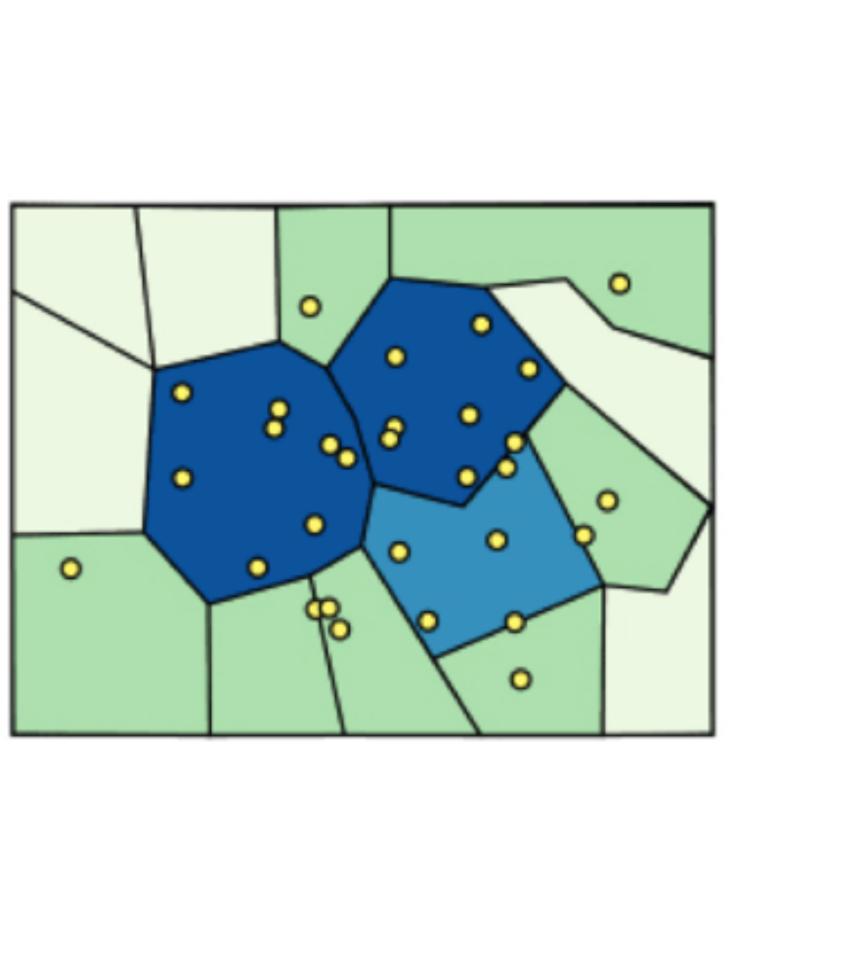


## Spatial Aggregation





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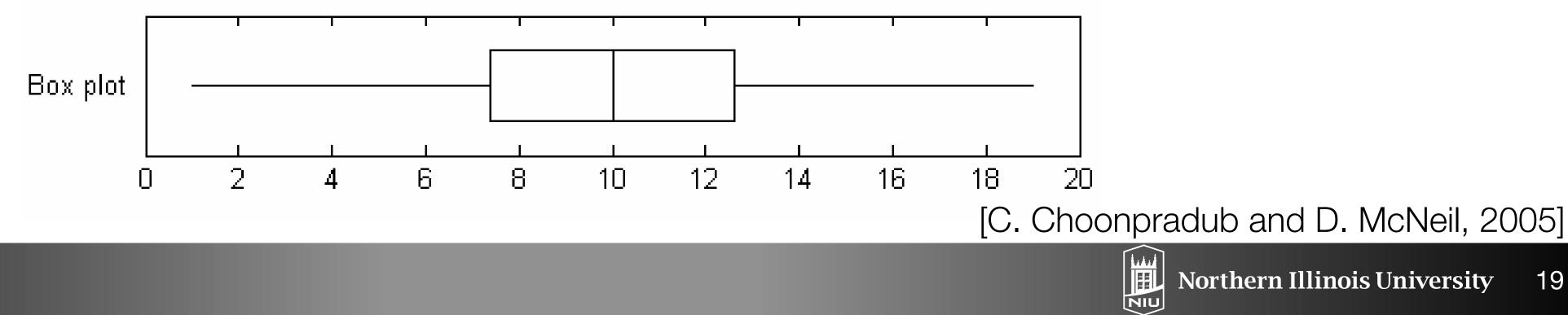


[Penn State, GEOG 486]



- 8

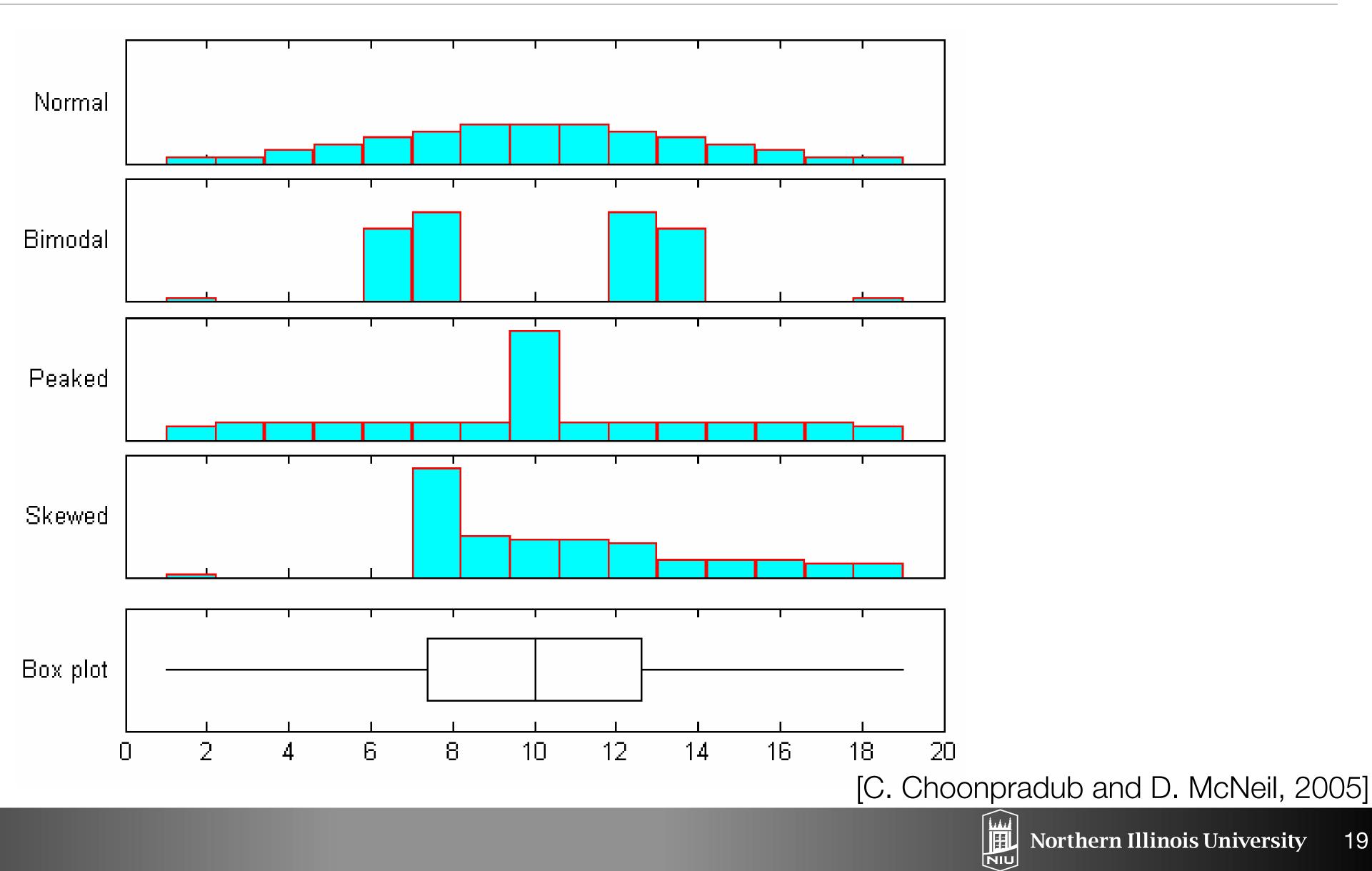
### Aggregation: Boxplot







# Aggregation: Boxplot







# Dimensionality Reduction: PCA

Alcoholic drinks Beverages Carcase meat Cereals Cheese Confectionery Fats and oils Fish Fresh fruit Fresh potatoes Fresh Veg Other meat Other Veg Processed potatoes Processed Veg Soft drinks Sugars

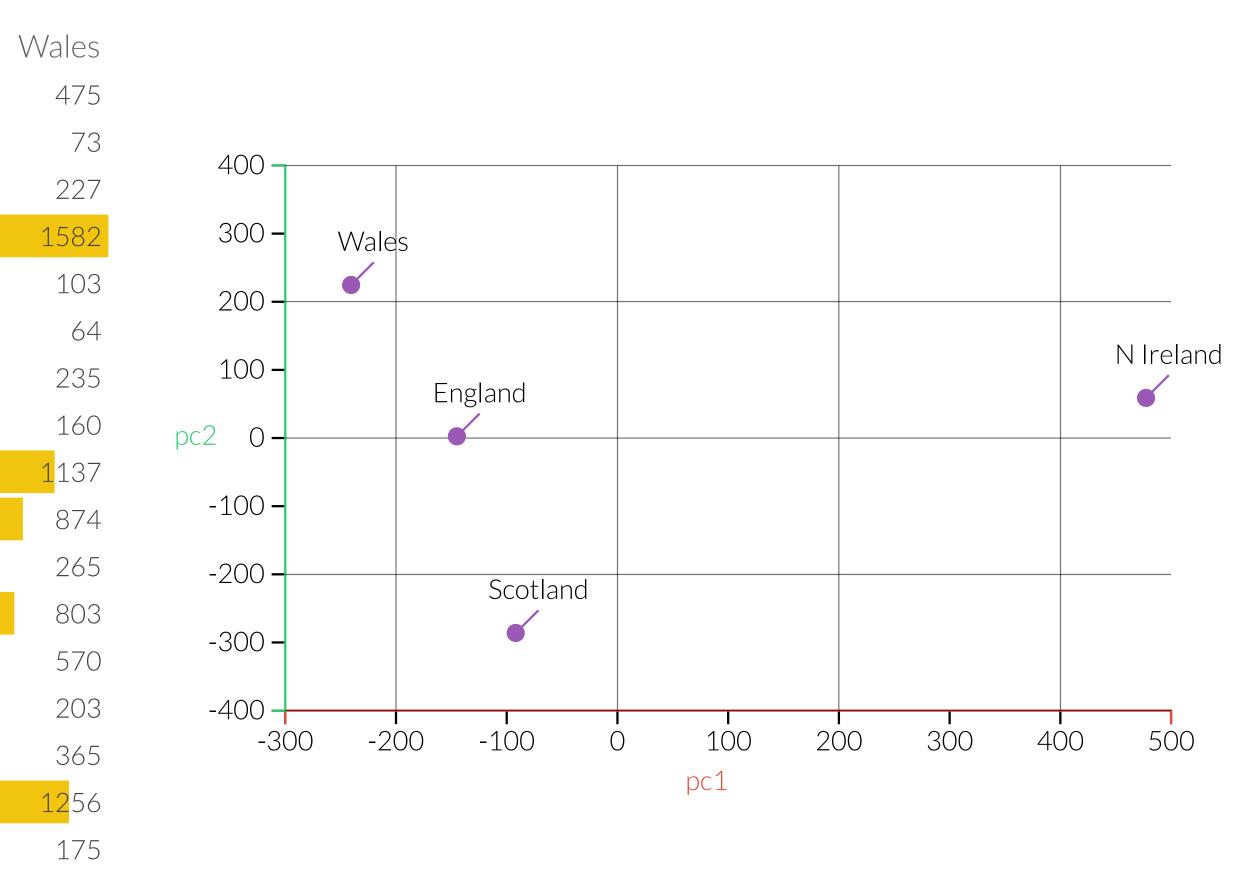
England	N Ireland	Scotland	
375	135	458	
57	47	53	
245	267	242	
1472	1494	1462	
105	66	103	
54	41	62	
193	209	184	
147	93	122	
<mark>1</mark> 102	674	957	
720	1033	566	
253	143	171	
685	586	750	
488	355	418	
198	187	220	
360	334	337	
1374	1506	1572	
156	139	147	

Wales

England

Scotland

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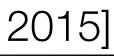


[Principle Component Analysis Explained, Explained Visually, V. Powell & L. Lehe, 2015]





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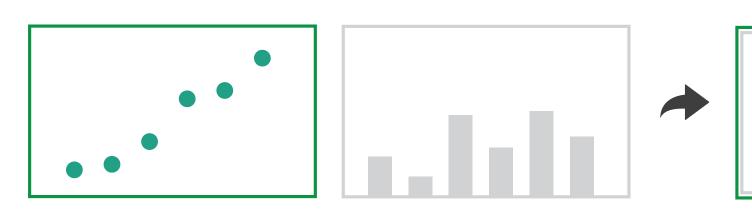
#### Focus+Context



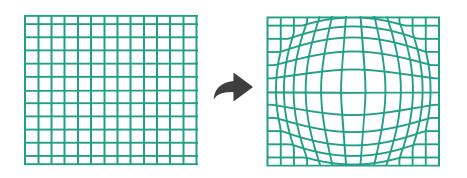
→ Elide Data



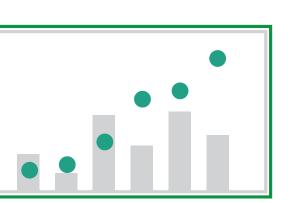
→ Superimpose Layer

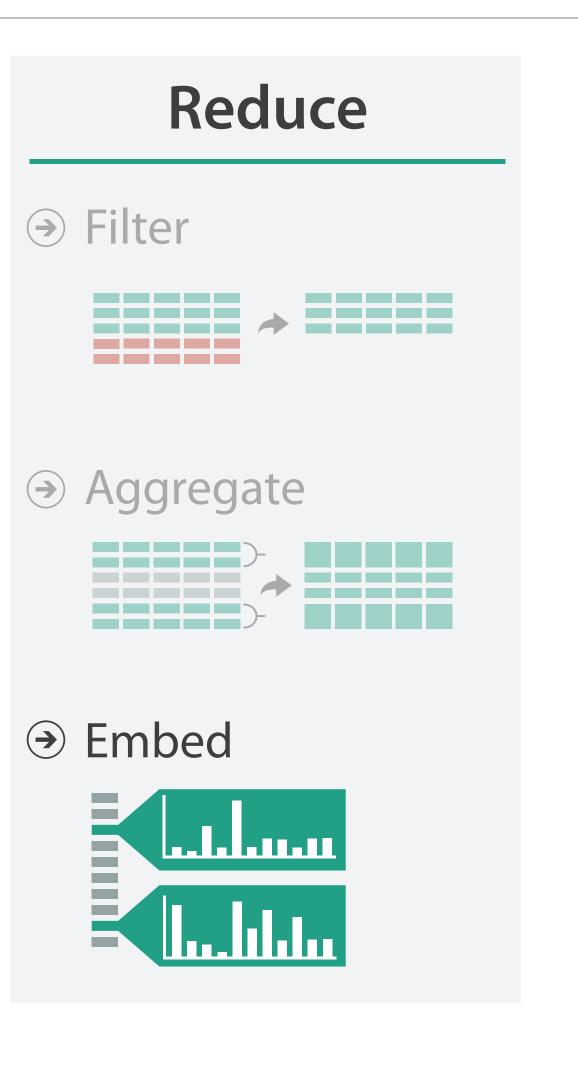


→ Distort Geometry



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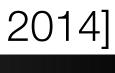




[Munzner (ill. Maguire), 2014]

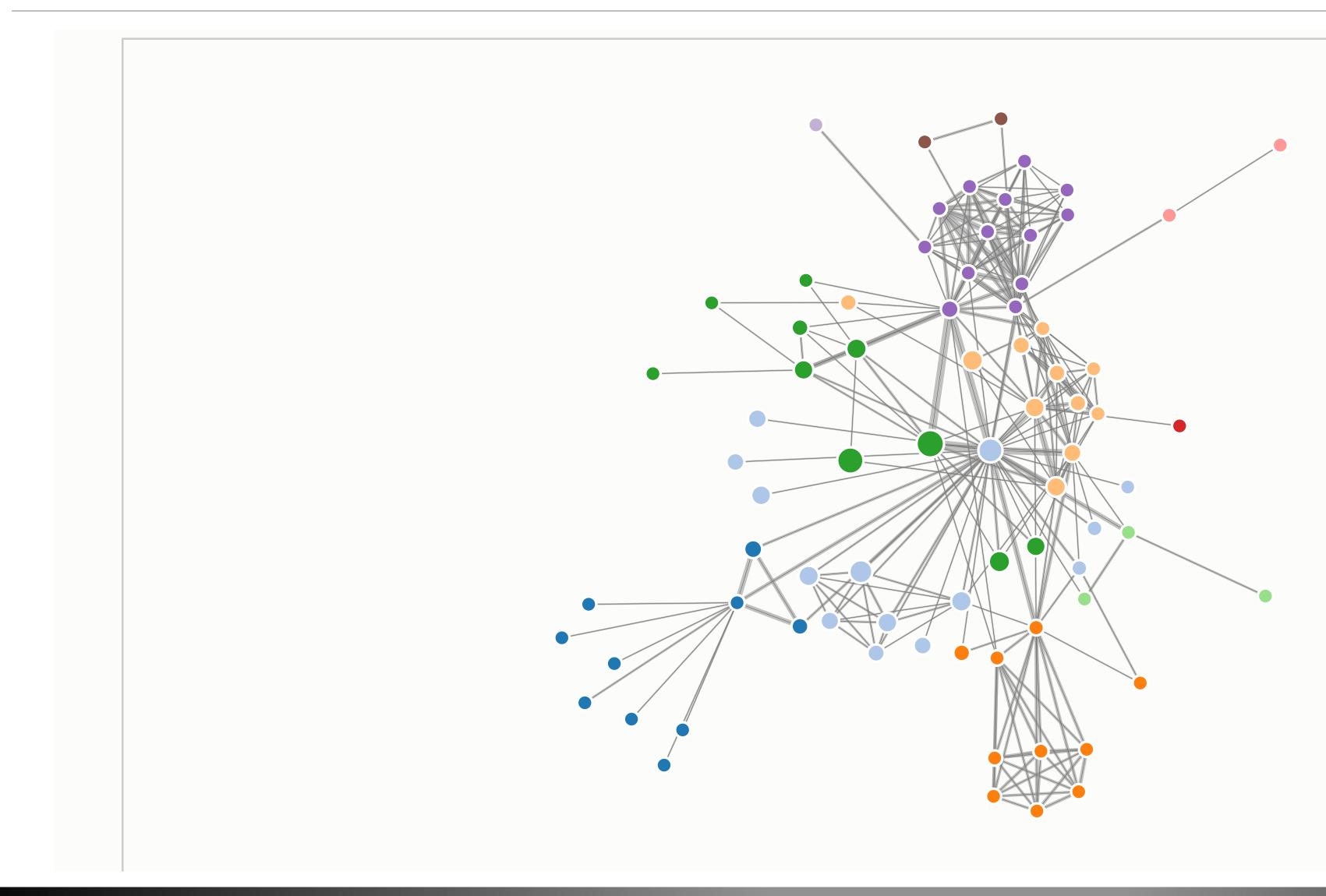


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### Fisheye Distortion



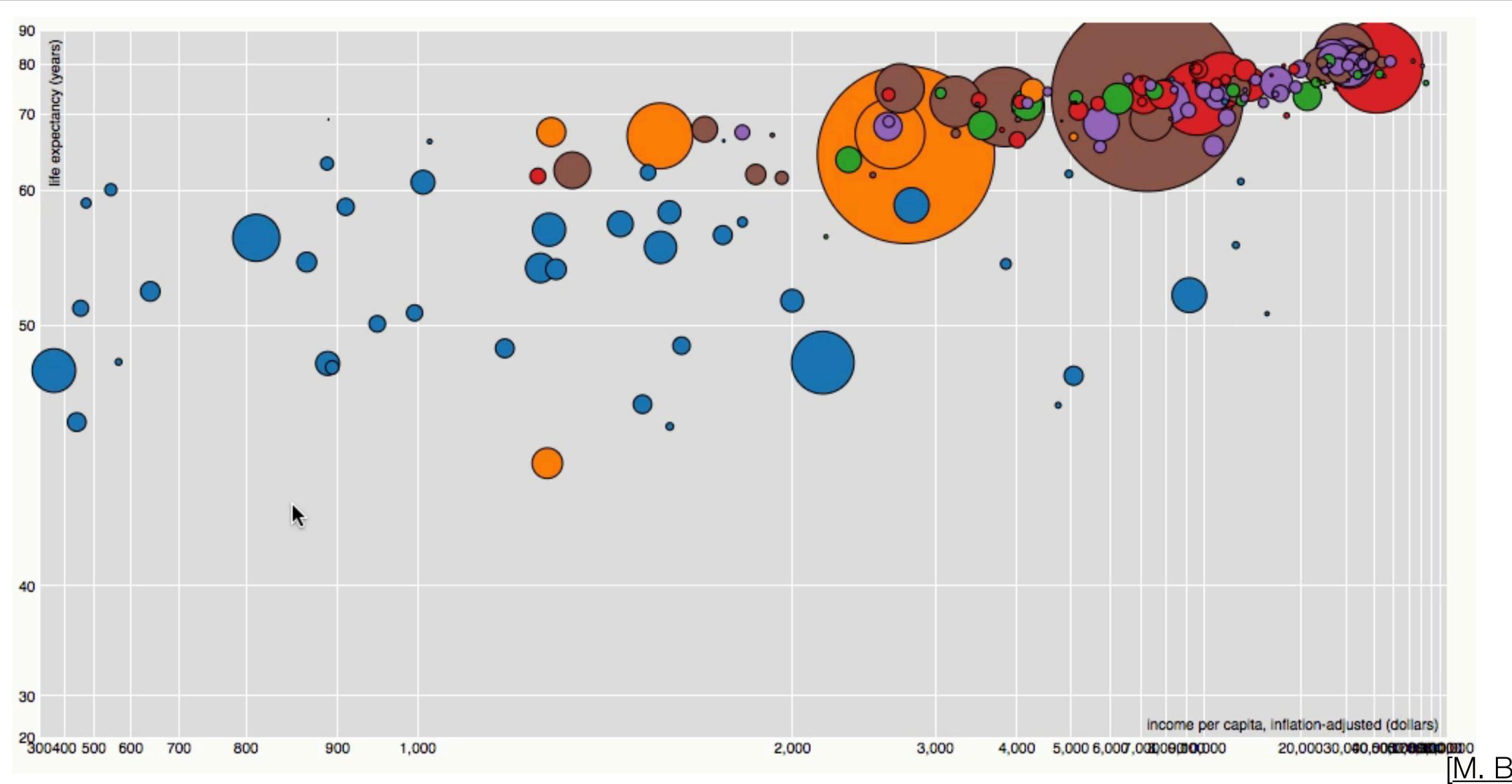








#### Cartesian Distortion



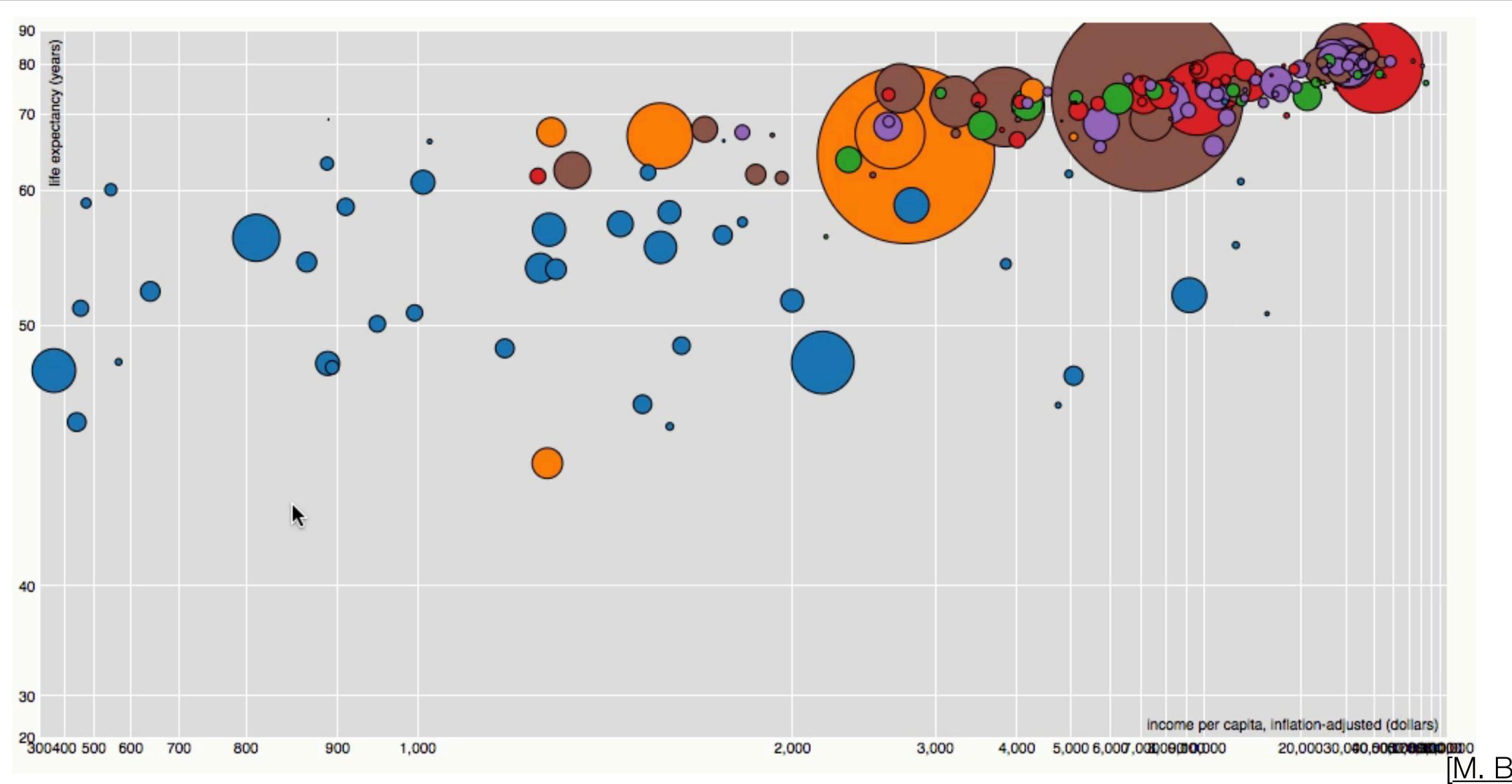








#### Cartesian Distortion











# The purpose of visualization is about **insight**, not pictures

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# – B. Shneiderman



v 2



### Visualization Research









### Visualization Research

- that improve the capabilities of users."
- in development of new tools."
- Evaluation Methods:
  - Quantitative and Qualitative
  - Validate hypotheses, refine theories.

#### D. Koop, CSCI 628, Fall 2021

• General Goals: "New visual displays, control panels, features, and workflows

• Perceptual and Cognitive Theories: help accomplish goals, guide design, aid













### Areas of Visualization Research

- Tools that make it easier to create visualizations
- New encodings
- Knowledge from controlled studies of visualization effectiveness Visualization-based communication
- Studies of visualization use in the world
- Formal theories of visualization
- Applications (Schneiderman)









### Tools that make it easier to create visualizations

- Tableau, Spotfire, D3 were all proposed and developed by visualization researchers
- Not just create visualizations, but effective visualizations
- Current Trends:
  - Web-based frameworks
  - Declarative, more concise specification (Vega-Lite)



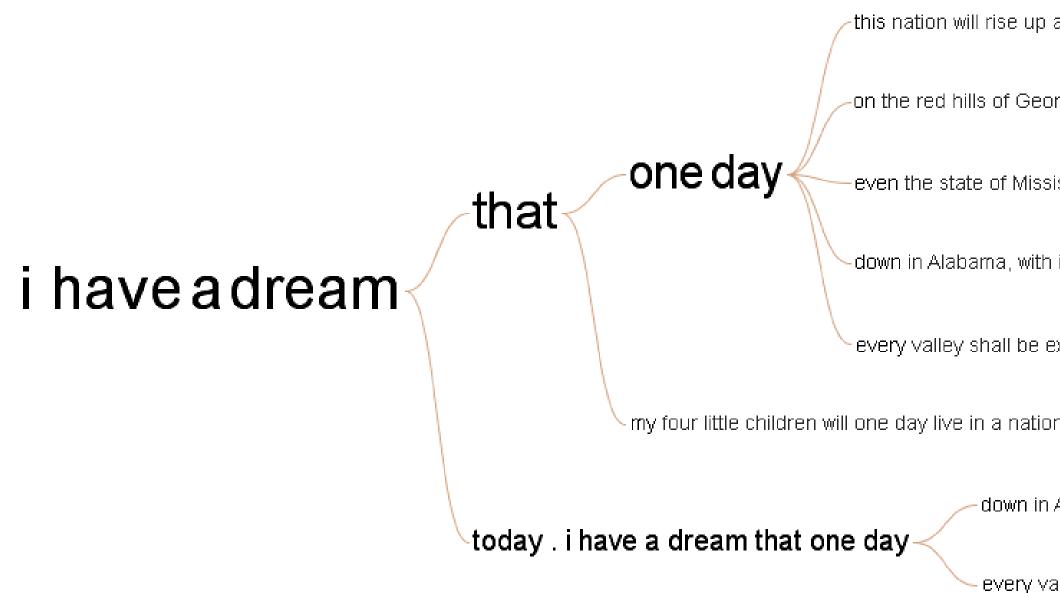






### New Encodings

- Determine what cannot currently be done
- Think about how new designs can show new, interesting patterns



#### D. Koop, CSCI 628, Fall 2021

this nation will rise up and live out the true meaning of its creed: "We hold these truths to be self-evident,

-on the red hills of Georgia the sons of former slaves and the sons of former slave owners will be able to sit down together at

-even the state of Mississippi, a state sweltering with the heat of injustice, sweltering with the heat of oppression, will be transformed into

-down in Alabama, with its vicious racists, with its governor having his lips dripping with the words of interposition and nullification - one day.

every valley shall be exalted, and every hill and mountain shall be made low, the rough places will be made plain, and the

-my four little children will one day live in a nation where they will not be judged by the color of their skin but by the

down in Alabama, with its vicious racists, with its governor having his lips dripping with the words of interposition and nullification - one day.

every valley shall be exalted, and every hill and mountain shall be made low, the rough places will be made plain, and the

#### [[J. Hullman, 2018], Image: [Wattenberg & Viegas, 2007]









### Knowledge from studies of visualization effectiveness

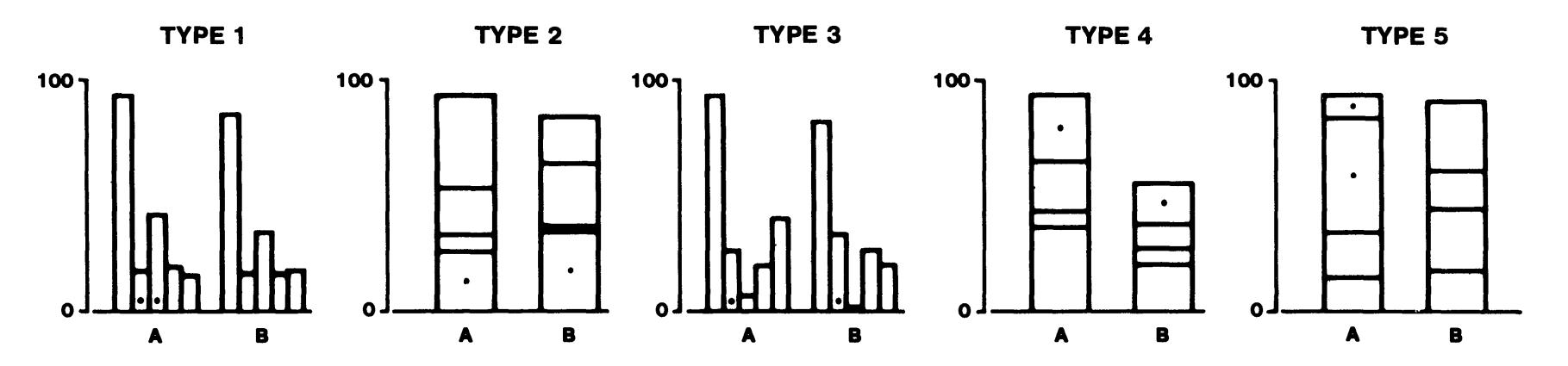


Figure 4. Graphs from position–length experiment.

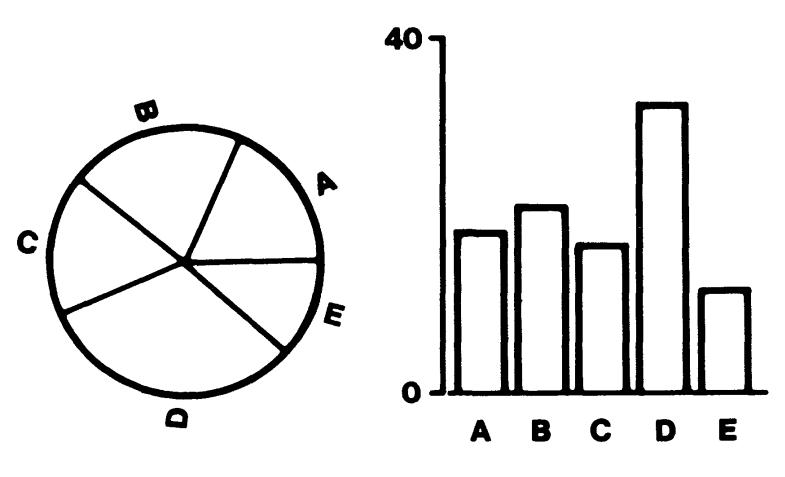


Figure 3. Graphs from position-angle experiment.



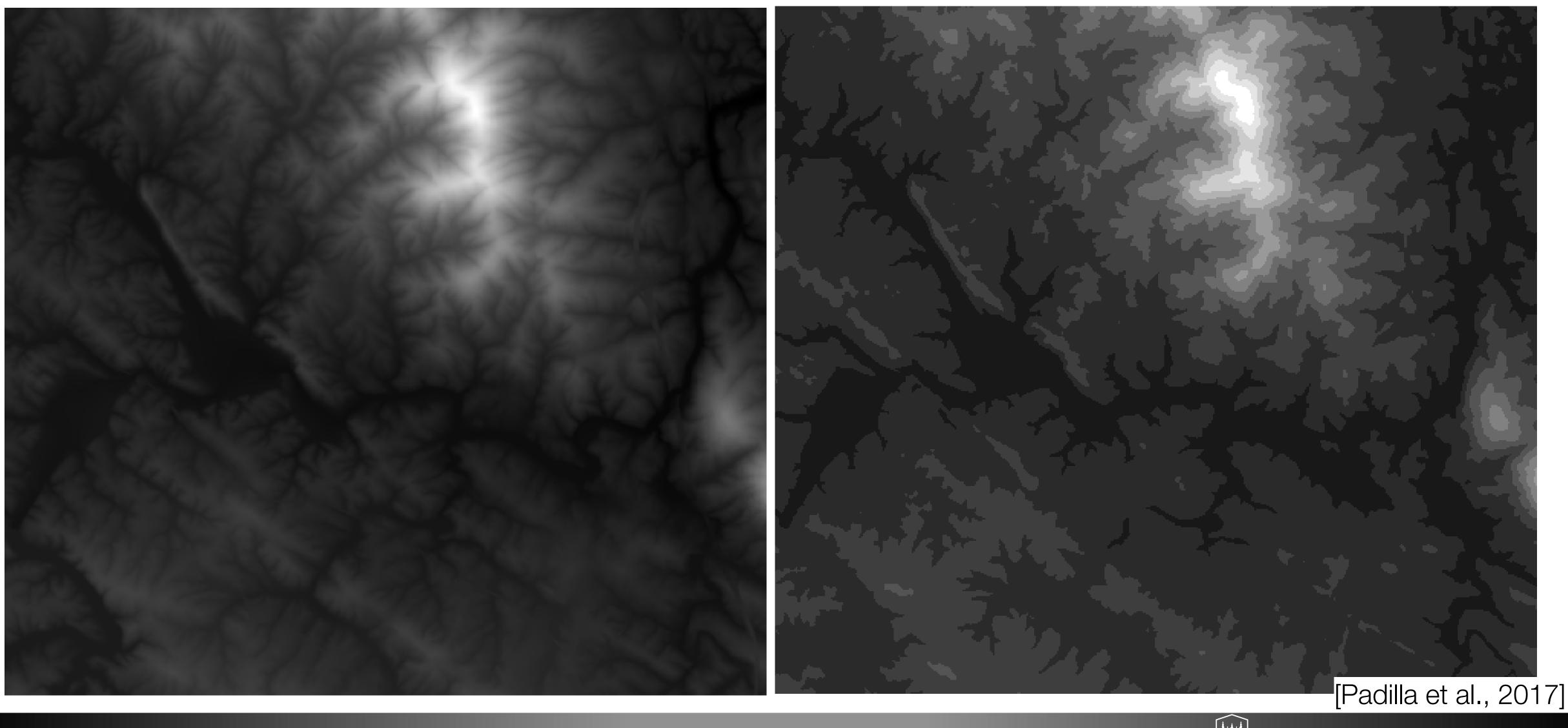








### Knowledge from studies of visualization effectiveness







# Knowledge from studies of visualization effectiveness

- Controlled experiments often focus on visual building blocks
- - Different encodings
  - Framings
  - User predispositions or prior beliefs
- Holistic studies of new visualization techniques

• Need not only very controlled, focused experiments. Can be impacted by









# Supporting Visual Analytics

- Exploratory Data Analysis
- Sensemaking & Meaning-making
- Interpretability of Machine Learning Models







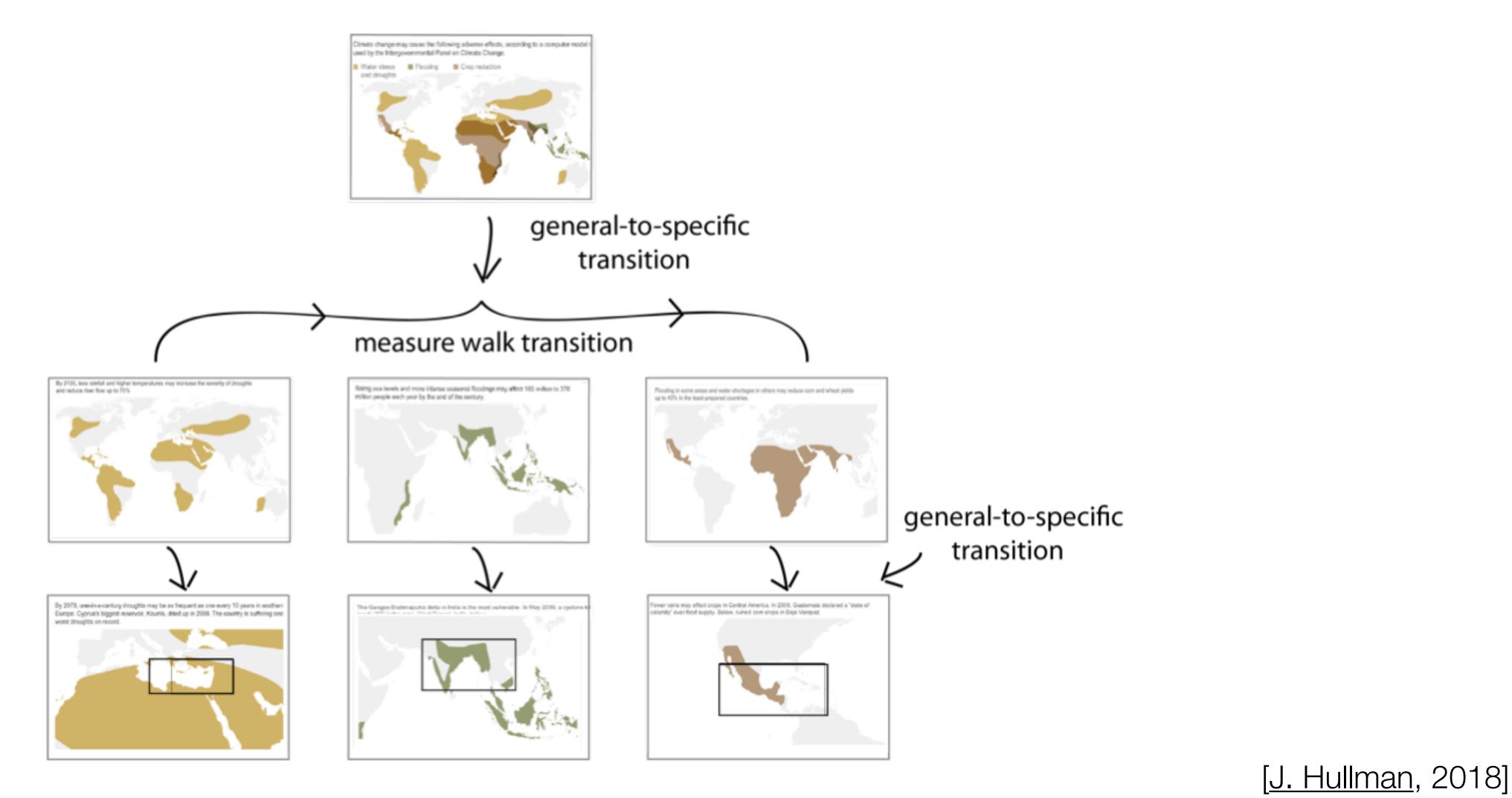








## Visualization-based Communication











## Design Studies

- Studies of visualization in the world
- Often involve collaboration with domain specialists
- as well

# Specific problems in that domain that can provide lessons for other domains











### Formal Theories of Visualization

- Grammar of Graphics
- Discrete/Continuous Taxonomy
- Algebraic Visualization











# What should Visualization Research be about?

- their prior experiences and perceptual and cognitive abilities to draw conclusions about phenomena in the real world" — J. Hullman
- Perception and cognition
- Not only that Vis A is better than Vis B, but why

• "[V] isualization is a method for contextualizing data, enabling people to apply













### Visualization Research Boundaries?

- Interactive illustration
- Satellite imagery
- Sketching and analogical reasoning
- Understanding aesthetics independent of analytical utility
- Tables
- Uncertainty Vis: Worse than Nothing?









# Grand Challenges

- Amplifying human cognition in the exploration of data.
  - Data science
  - Explainable artificial intelligence
- Information visualization is vital to successful outcomes for both topics. • Improve storytelling capacity for the general public
- Engage users to explore on their own
- Support researchers in understanding causality
- Shift from rationalism, which assumes that algorithms are the answer, to empiricism, which assumes that continuous exploration, persistent questioning, and vigorous dialog will promote a deeper understanding of our world.









# Shneiderman's Advice to a Ph.D. Student

tools."

 "Start by working on a real problem — one that you have or that you get from someone else. Working on real problems leads to better theories and better





