Data Visualization (CSCI 627/490)

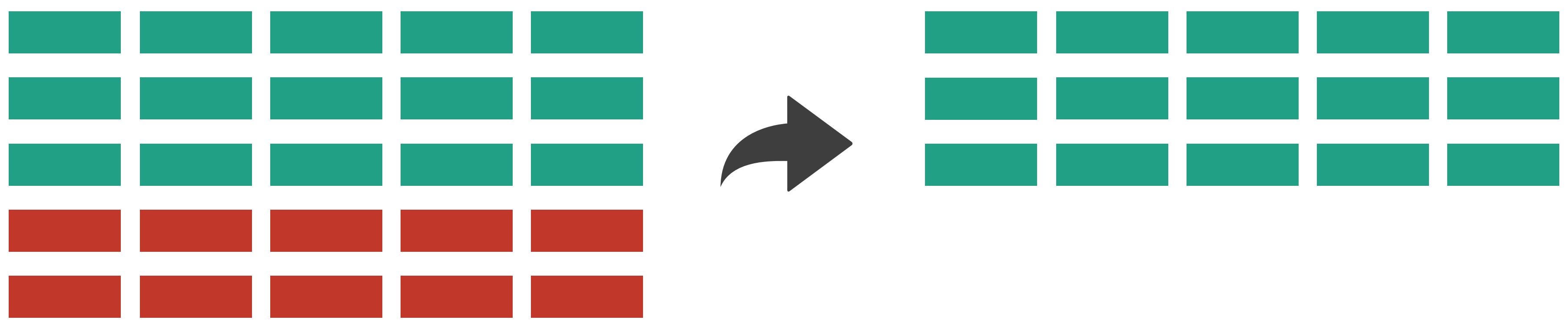
Aggregation & Focus+Context

Dr. David Koop

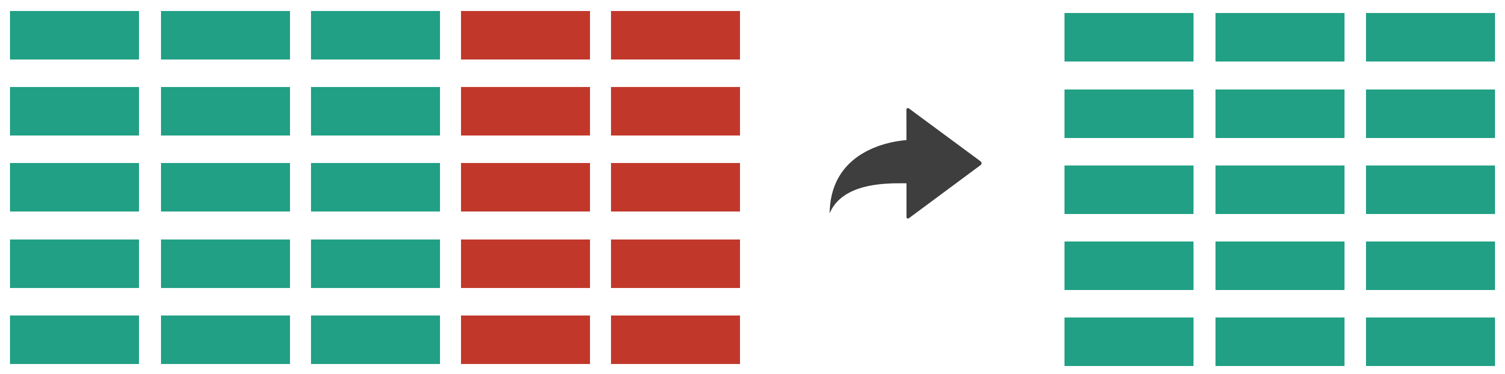
Overview: Reducing Items & Attributes

Filter

- Items

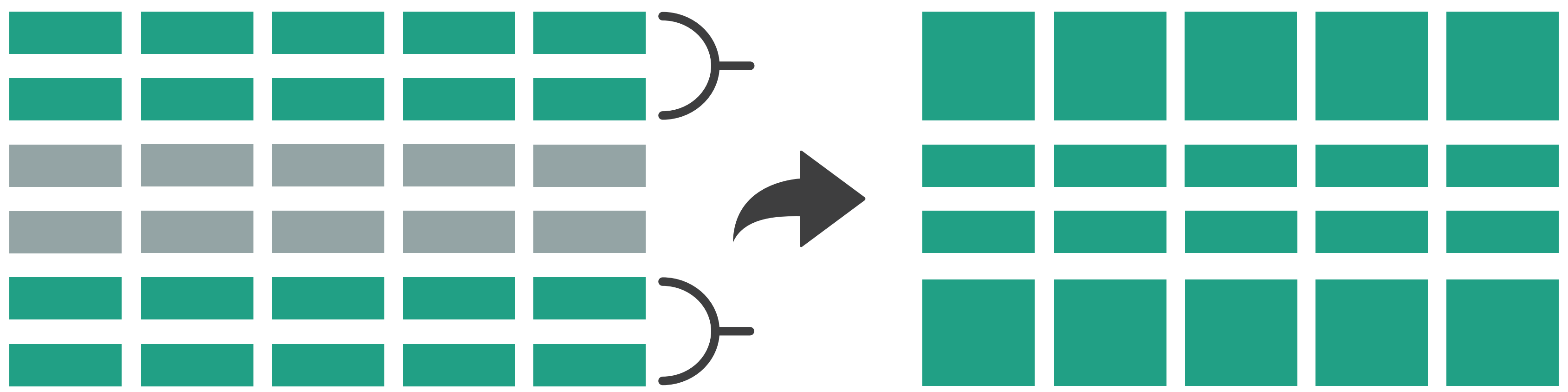


- Attributes

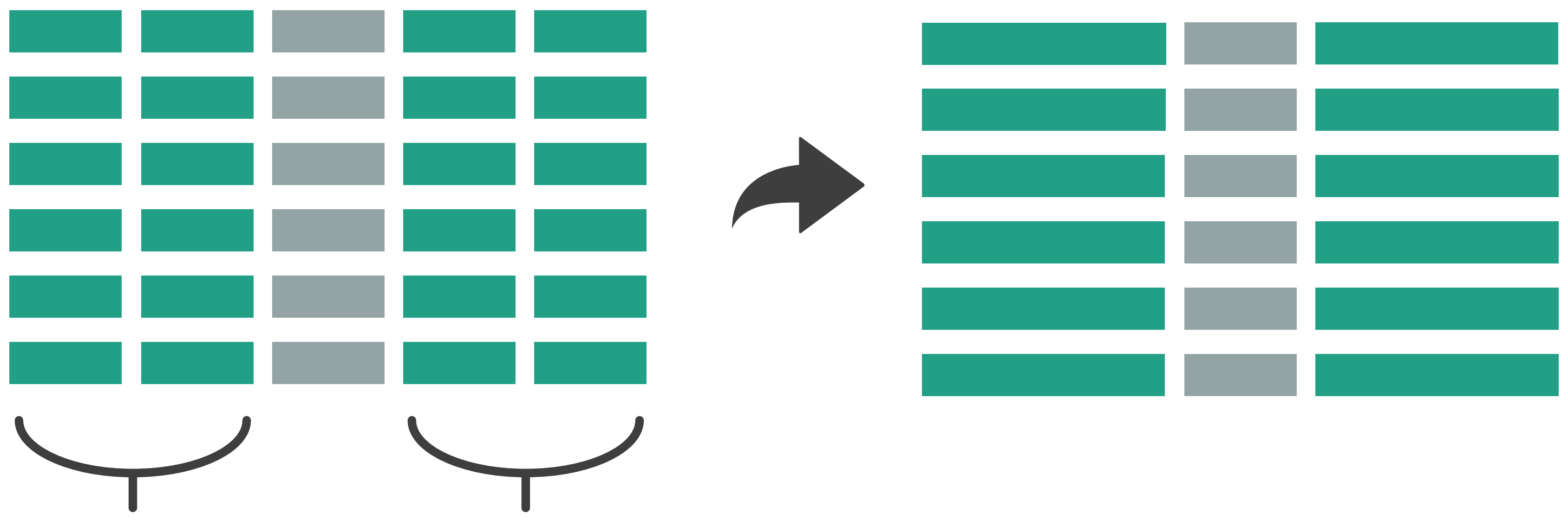


Aggregate

- Items

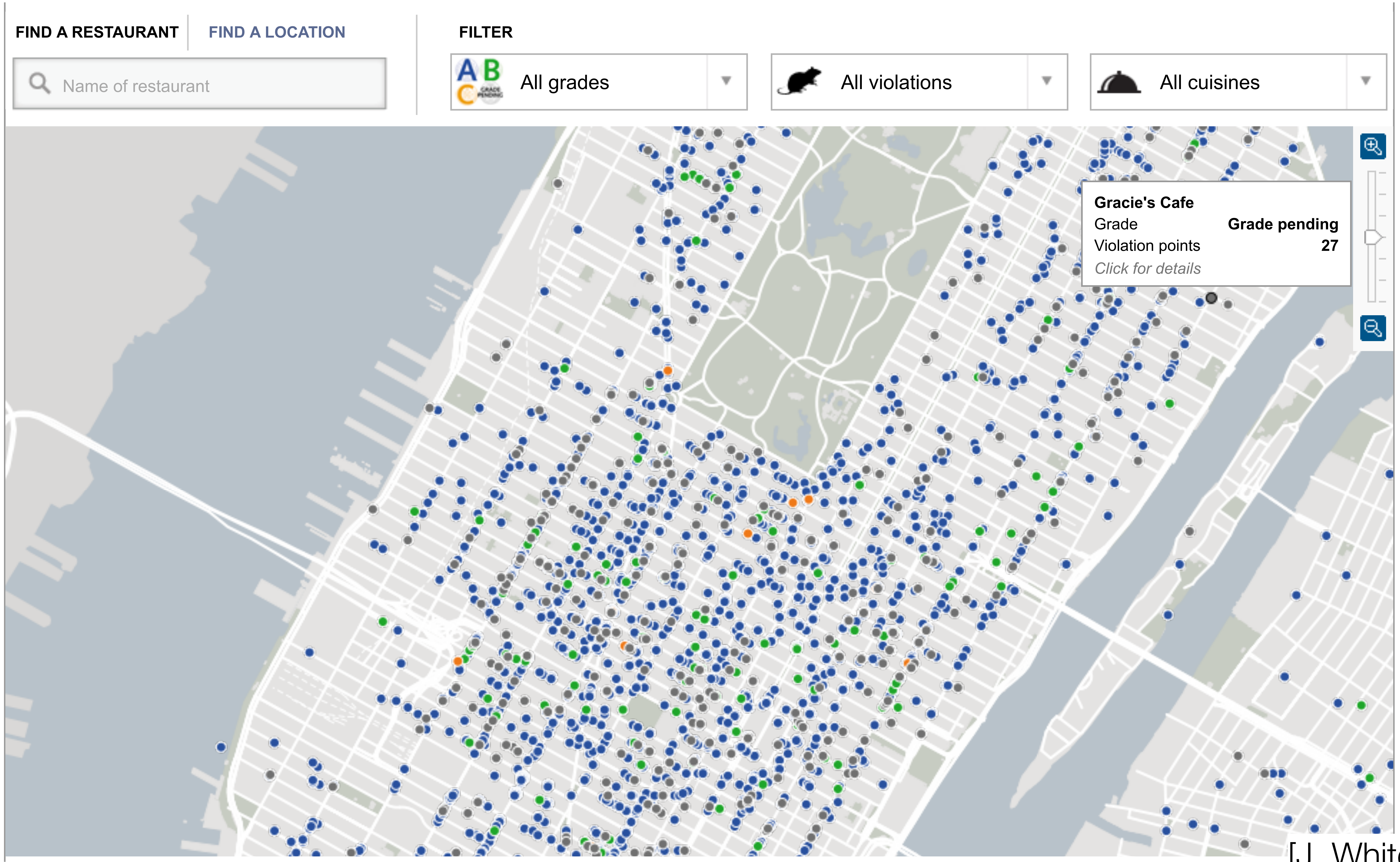


- Attributes



[Munzner (ill. Maguire), 2014]

Item Filtering on Maps

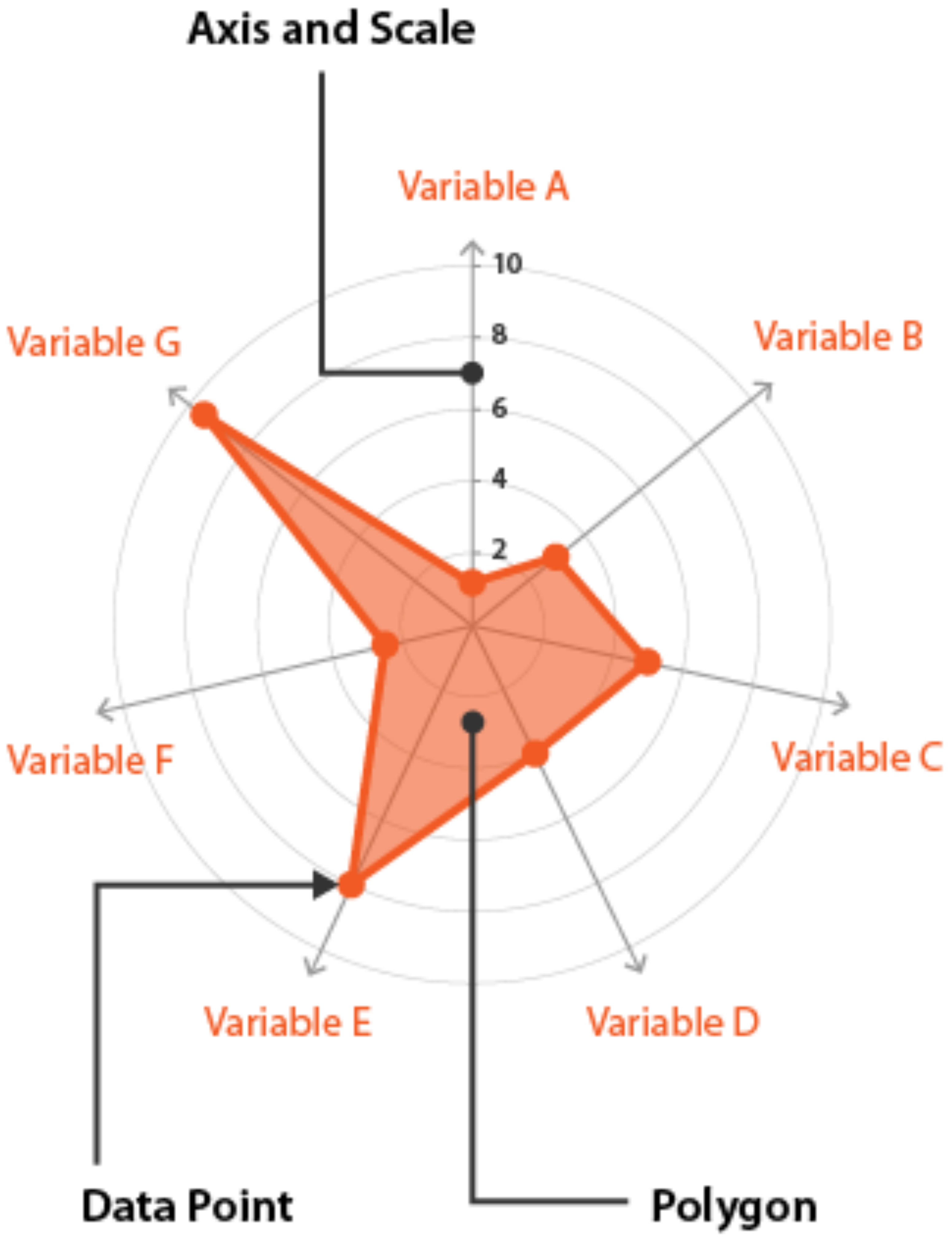


[J. White, New York Times]

Star Plots (aka Radar Charts)

[K. Schaul]

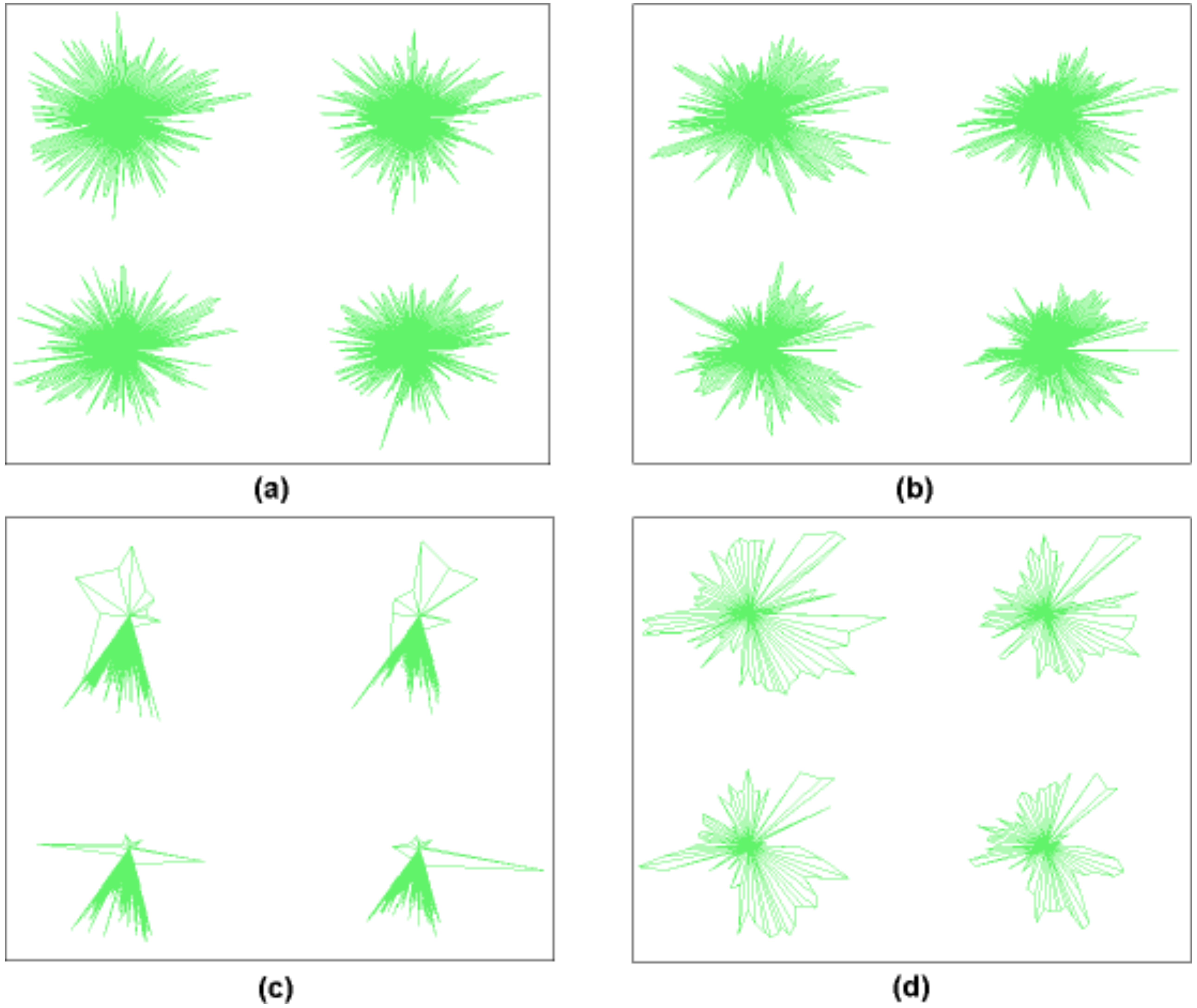
Star Plot / Radar Chart



- 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

Project Design

- Think about:
  - Data Manipulation?
  - Questions lead, not technique!
  - Be creative! (interaction too) https://xeno.graphics
- Work on turning your visualization ideas into designs
- Turn in:
  - Three Design Sketches (like sheets 2-4 from 5 Sheet Design)
  - One Bad Design Sketch (like sheets 2-4: here, justify why bad)
  - Progress on Implementation
- Due Friday

Assignment 5

- Create Multiple Views
- Filtering
- Linked Highlighting
- Aggregation

Aggregation

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

Aggregation

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

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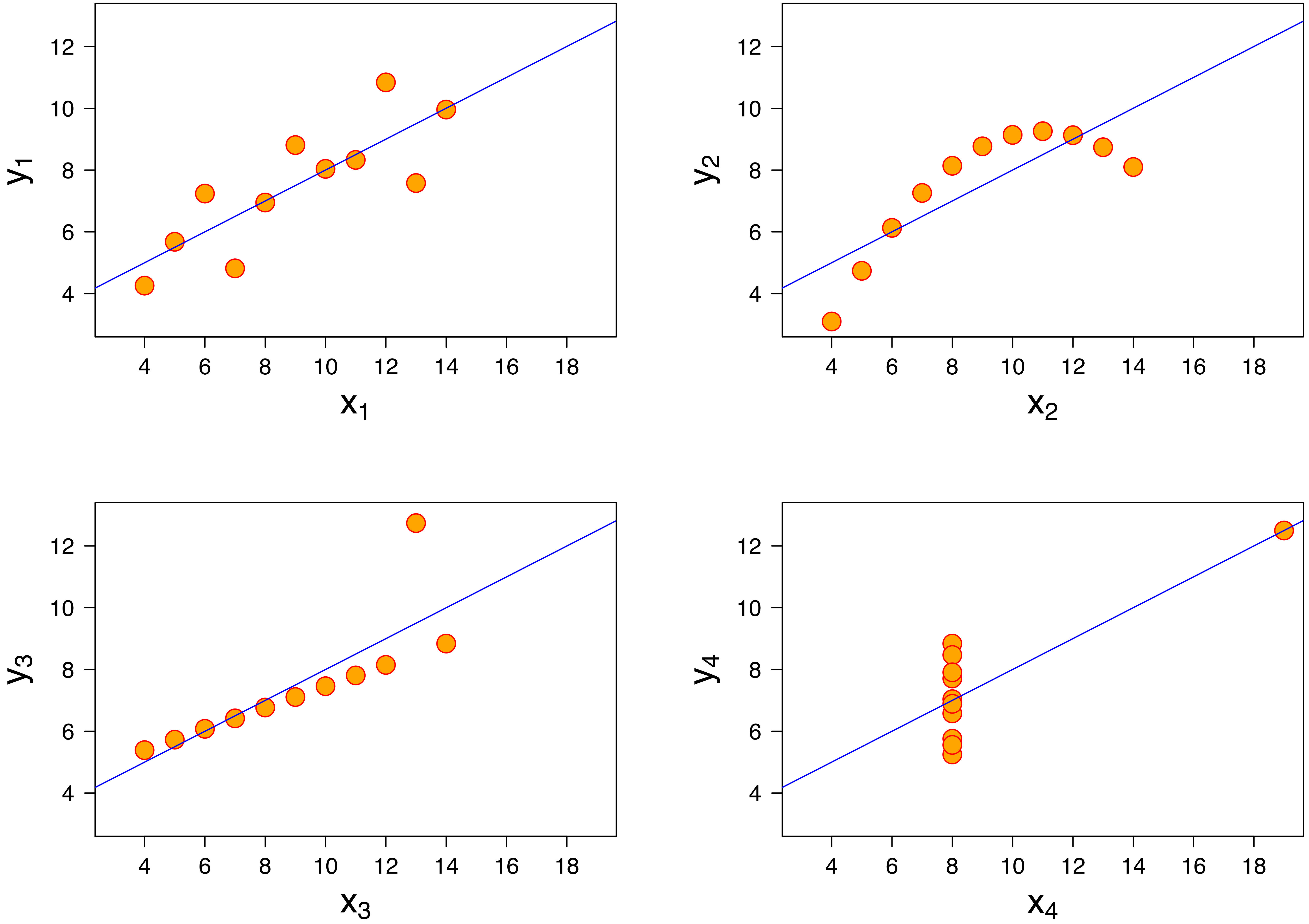
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

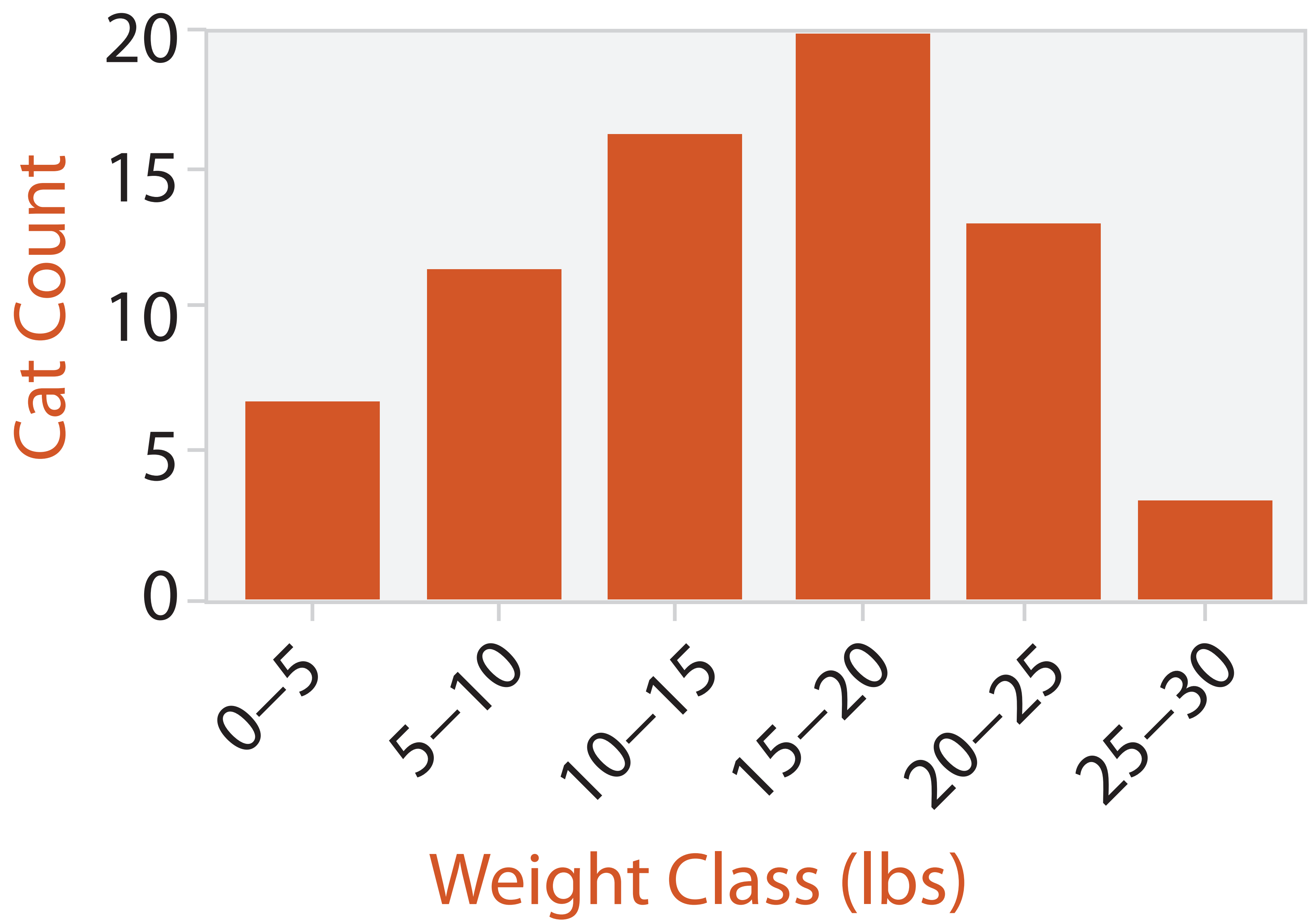
Mean of x	9
Variance of x	11
Mean of y	7.50
Variance of y	4.122
Correlation	0.816

Anscombe's Quartet



[F. J. Anscombe]

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

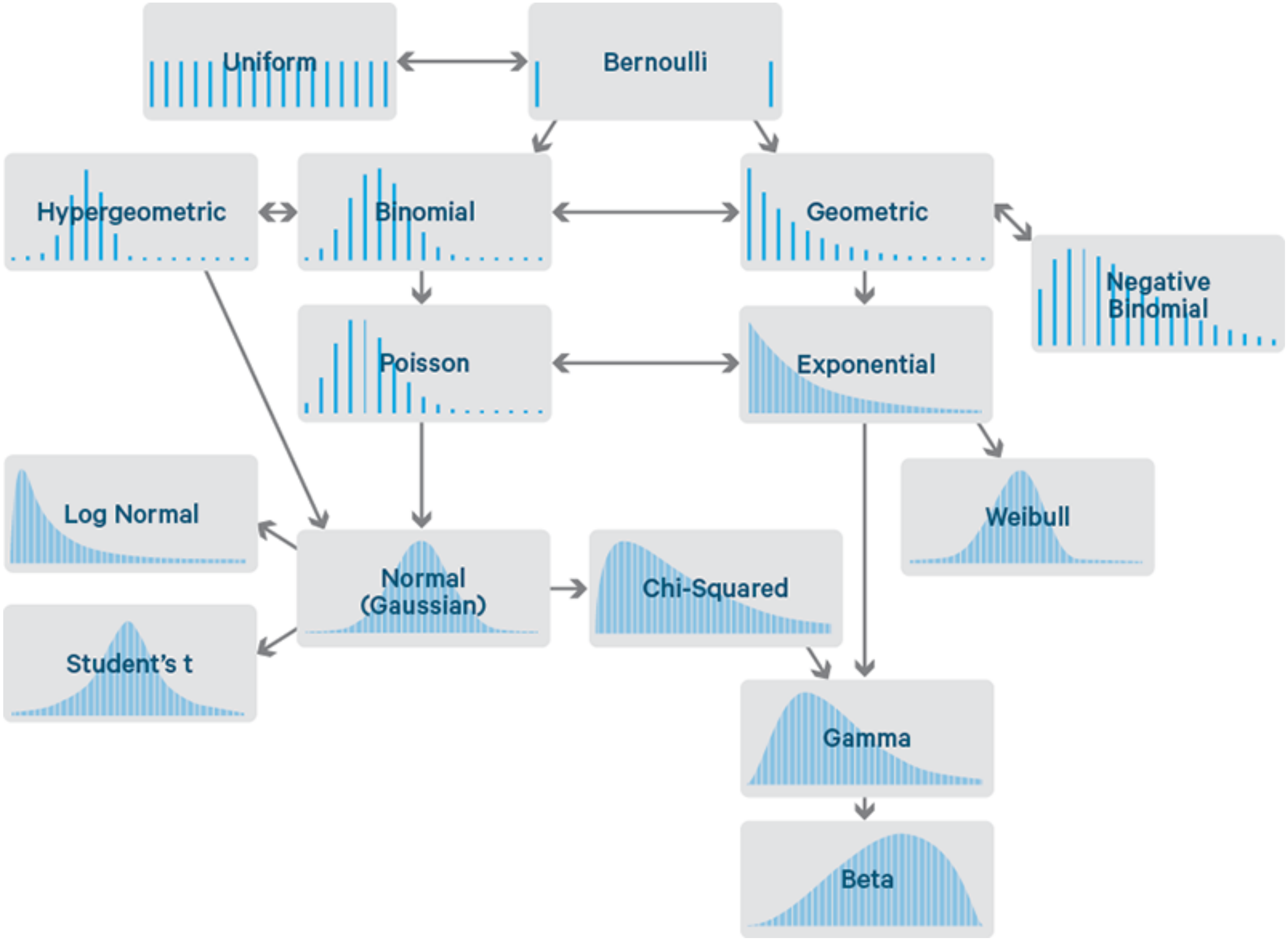
[Munzner (ill. Maguire), 2014]

Aggregation: Histograms

Observed ranks of posts by subreddit

["The reddit Front Page is Not a Meritocracy", T. W. Schneider]

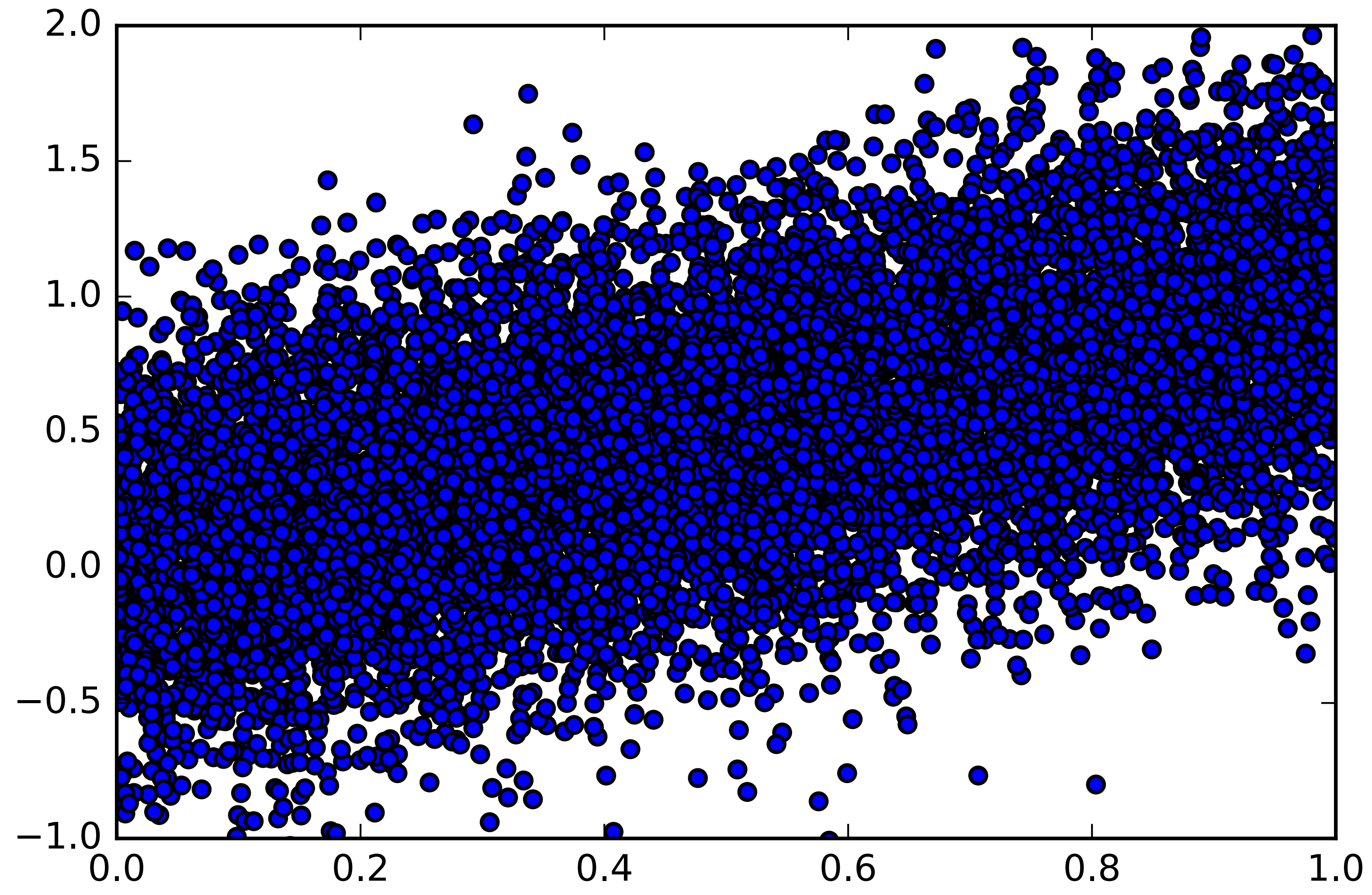
Common Distributions

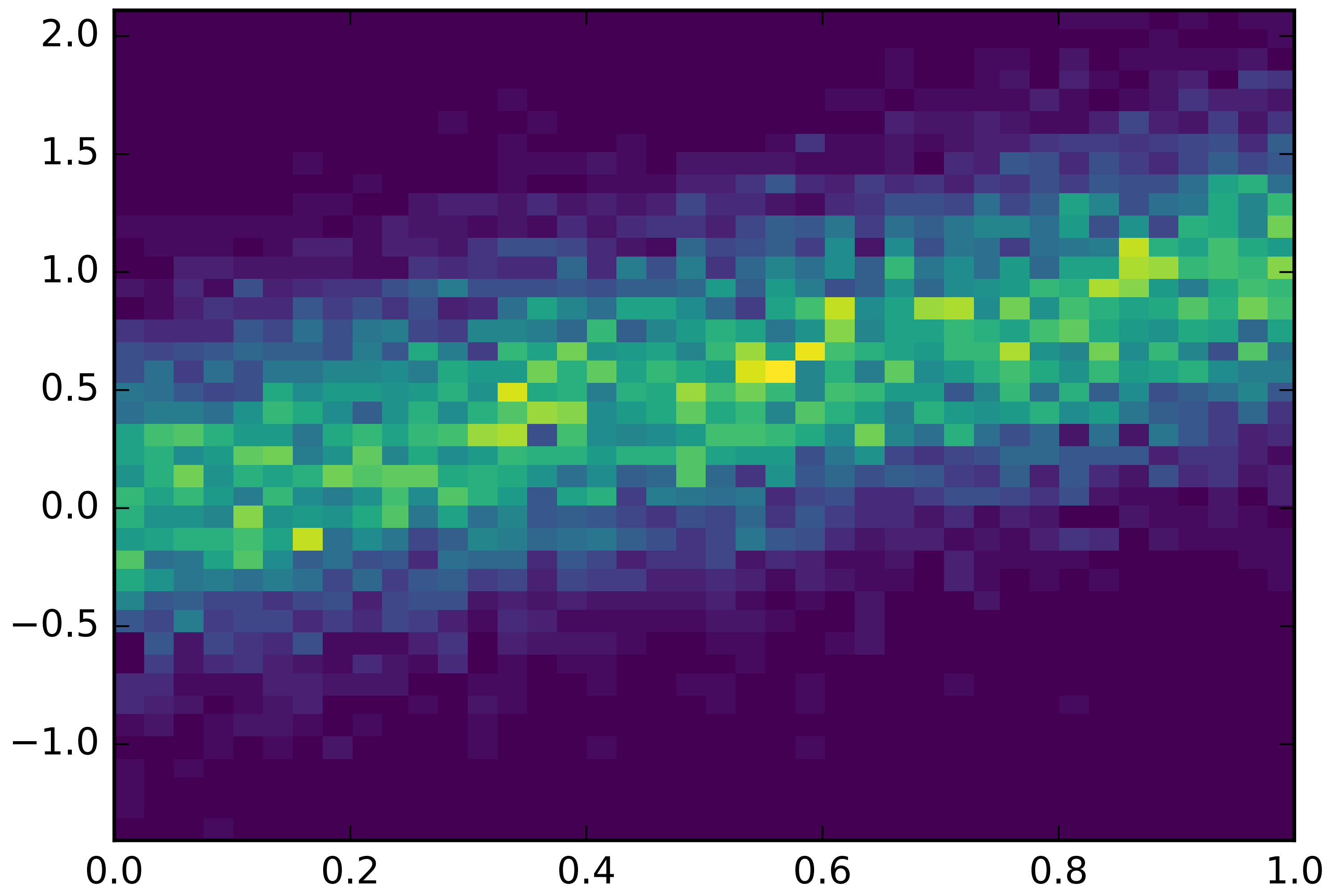


[Cloudera]

Binning Scatterplots

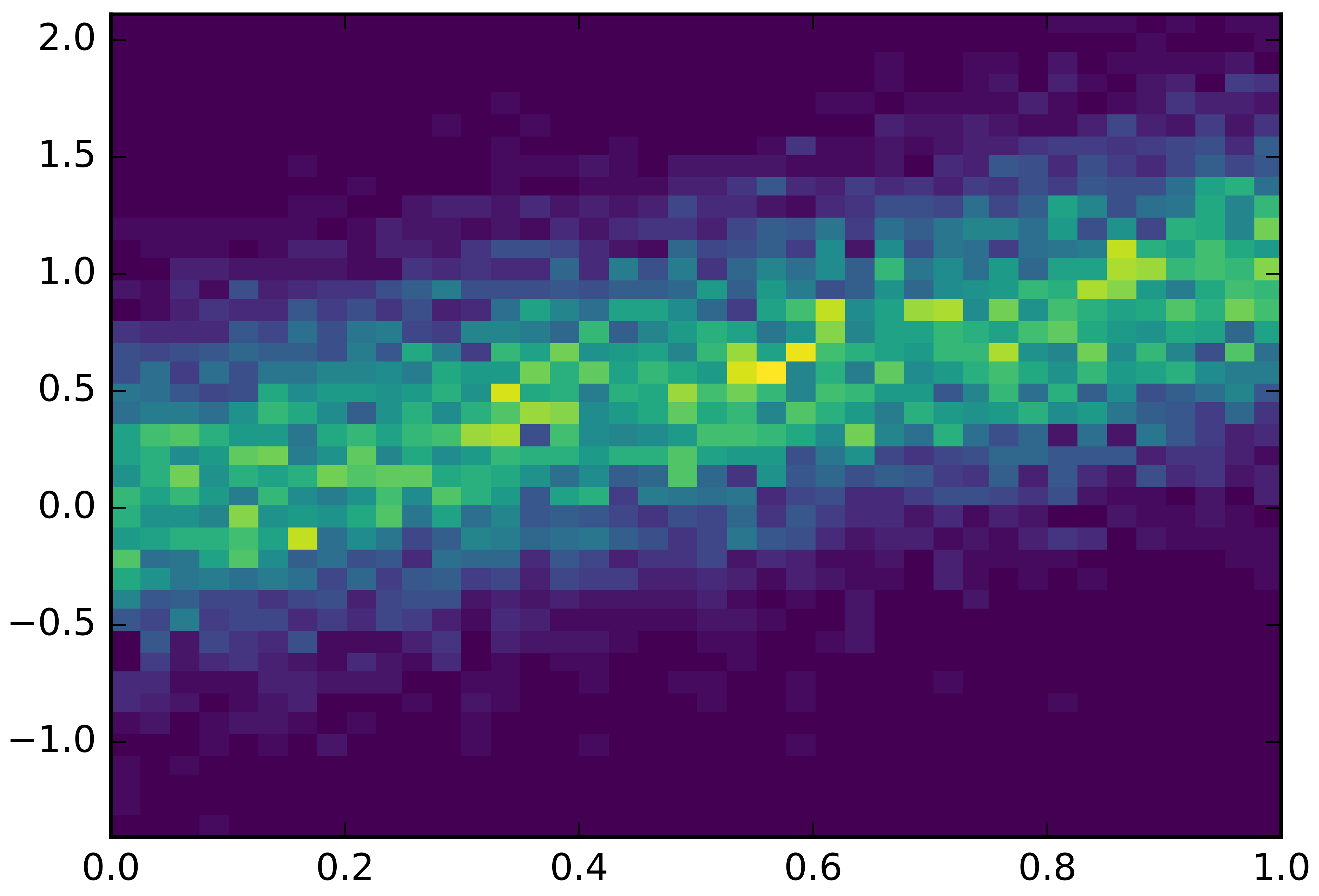
- At some point, cannot see density
- Blobs on top of blobs
- 2D Histogram is a histogram in 2D encoded using color instead of height
- Each region is aggregated

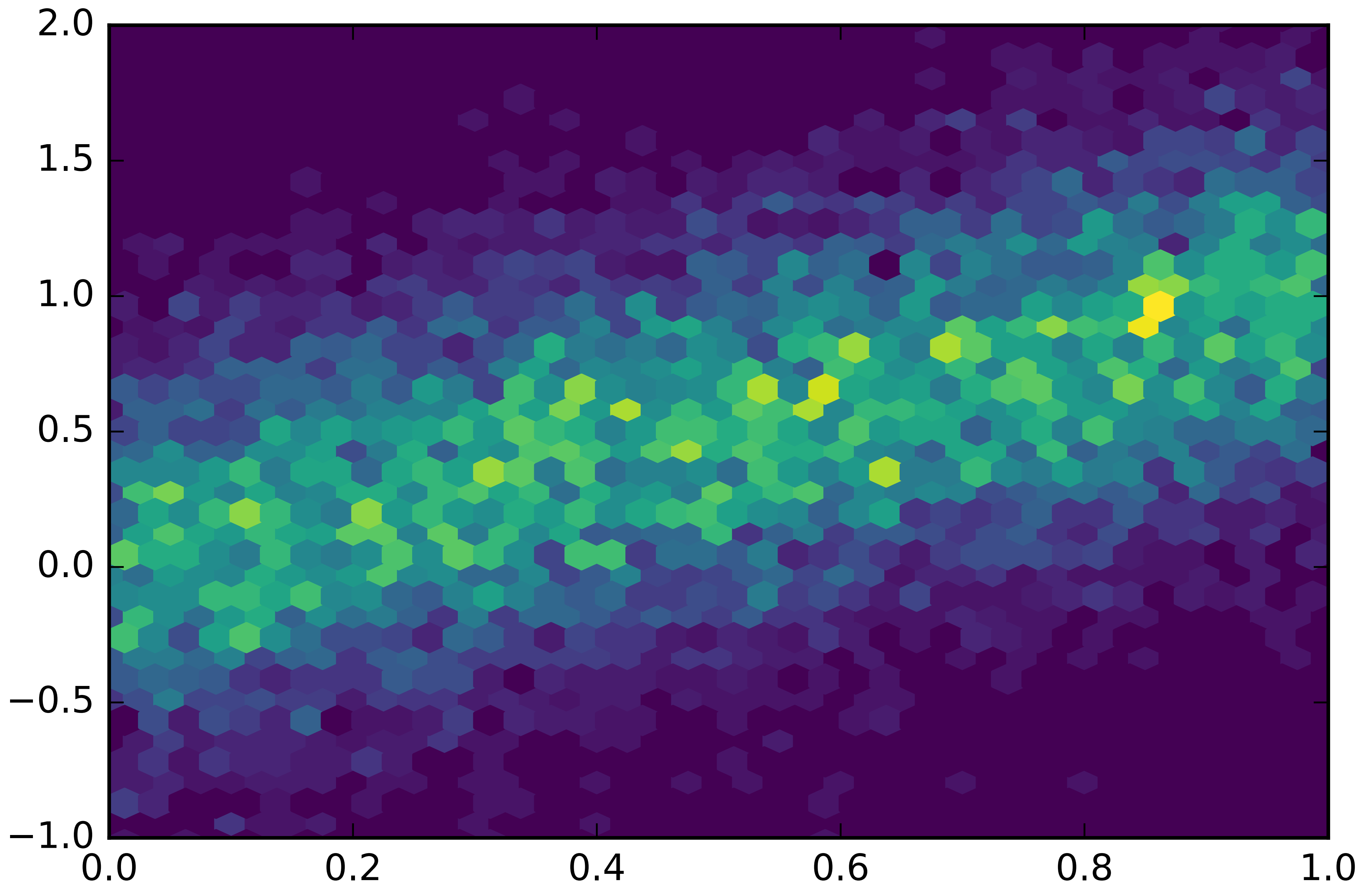




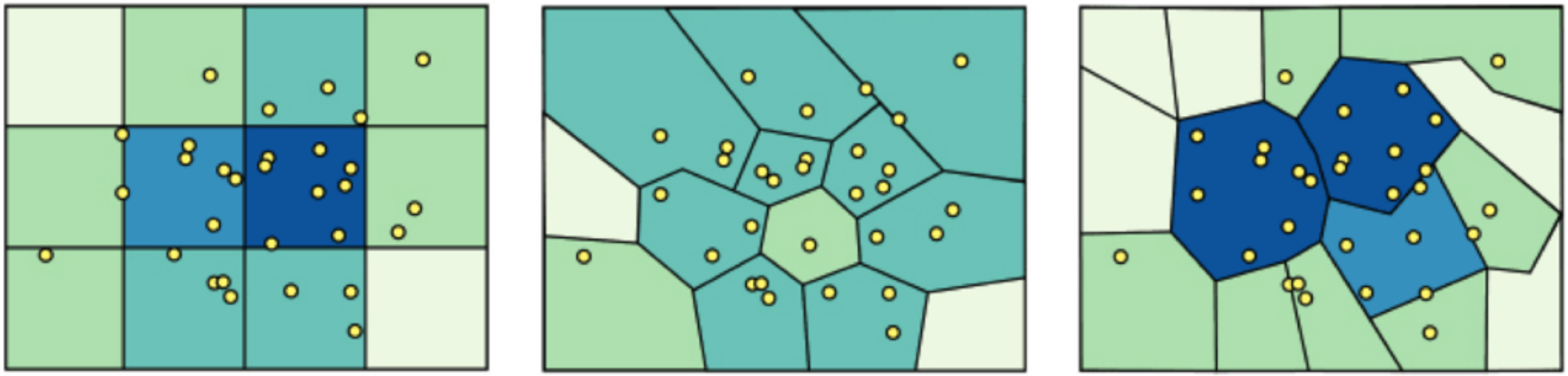
Binning

- Hexagonal bins are more circular
- Distance to the edge is not as variable
- More efficient aggregation around the center of the bin





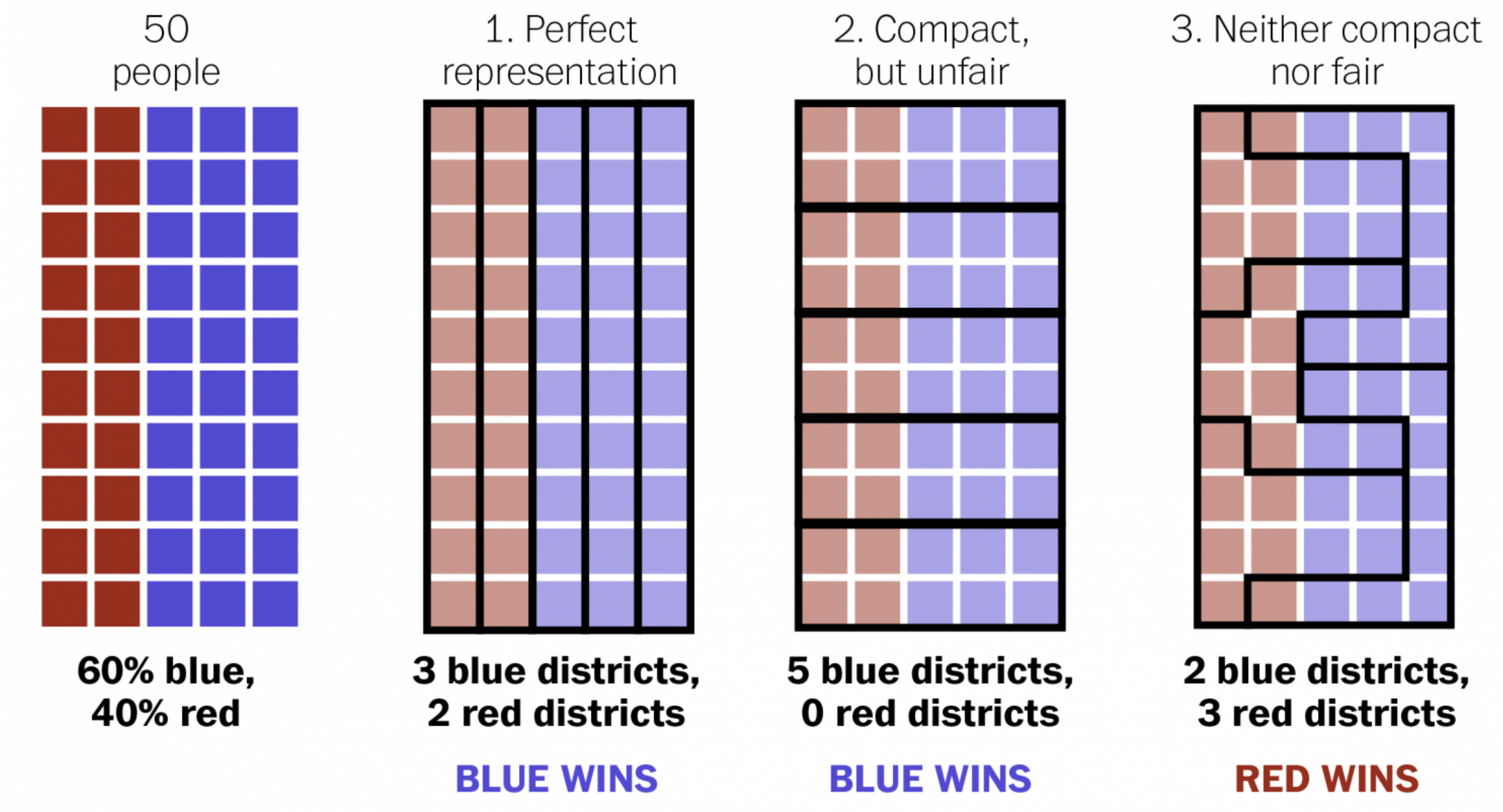
Spatial Aggregation

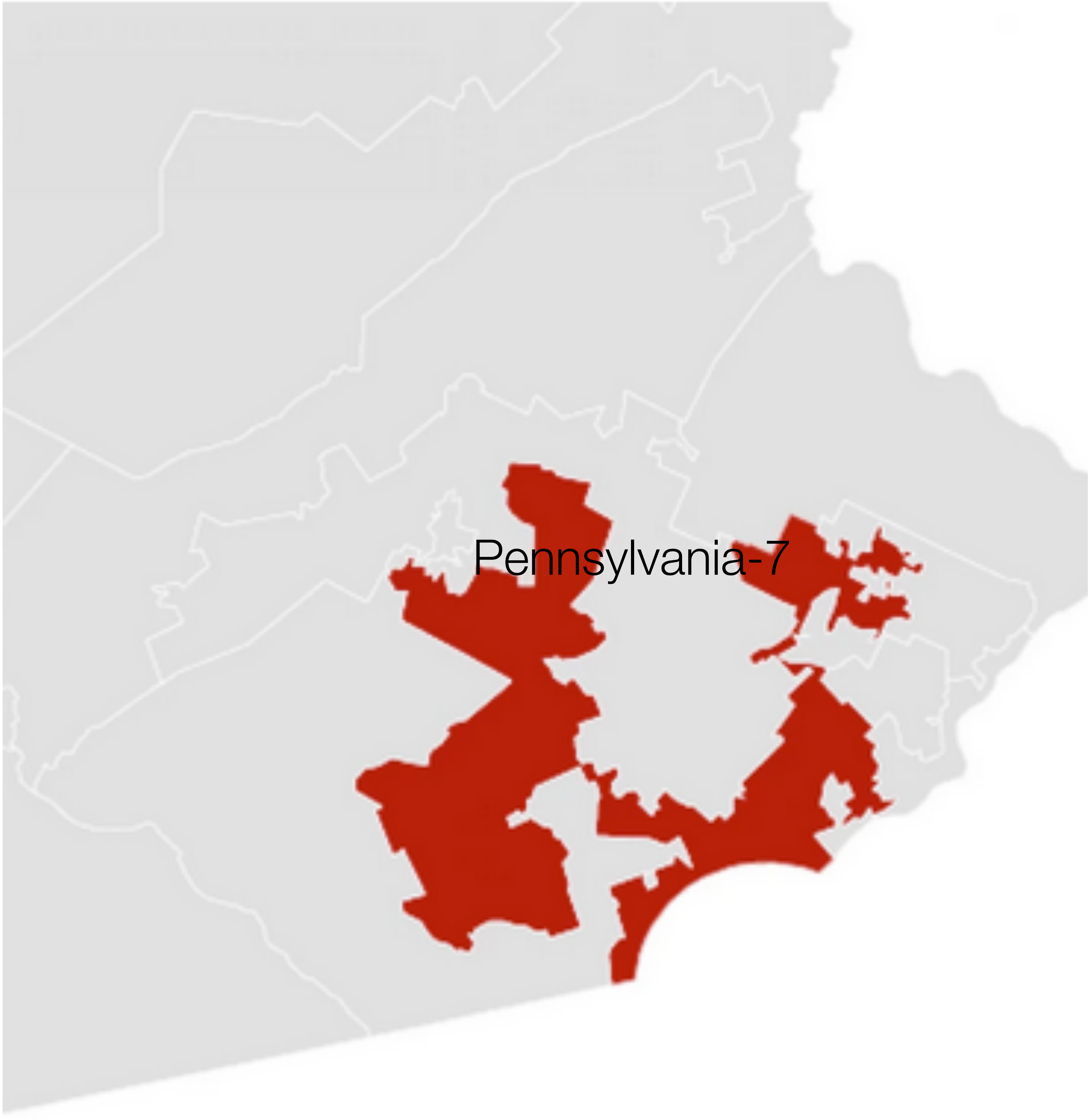


[Penn State, GEOG 486]

Modifiable Areal Unit Problem

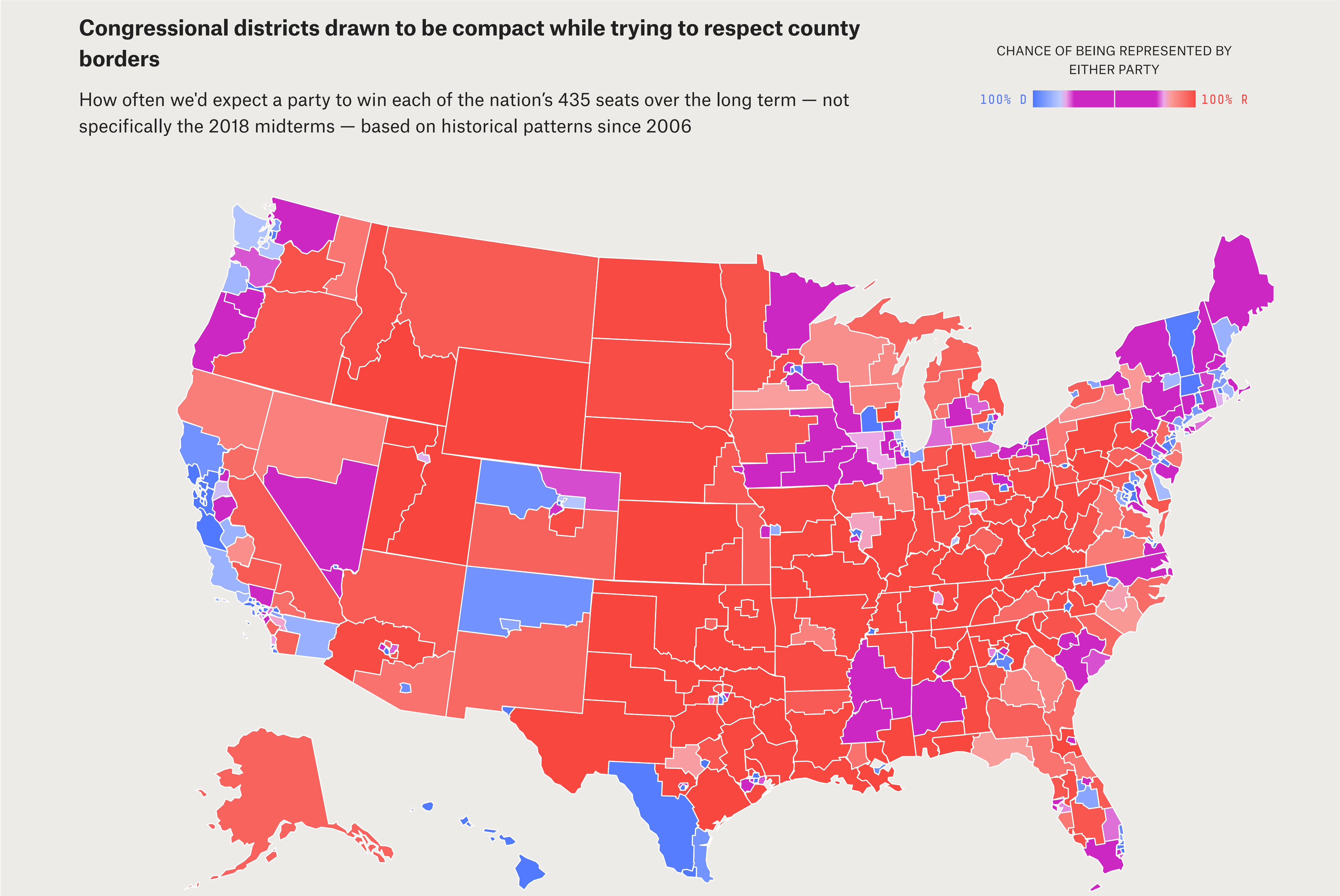
- How you draw boundaries impacts the type of aggregation you get
- Similar to bins in histograms
- Gerrymandering





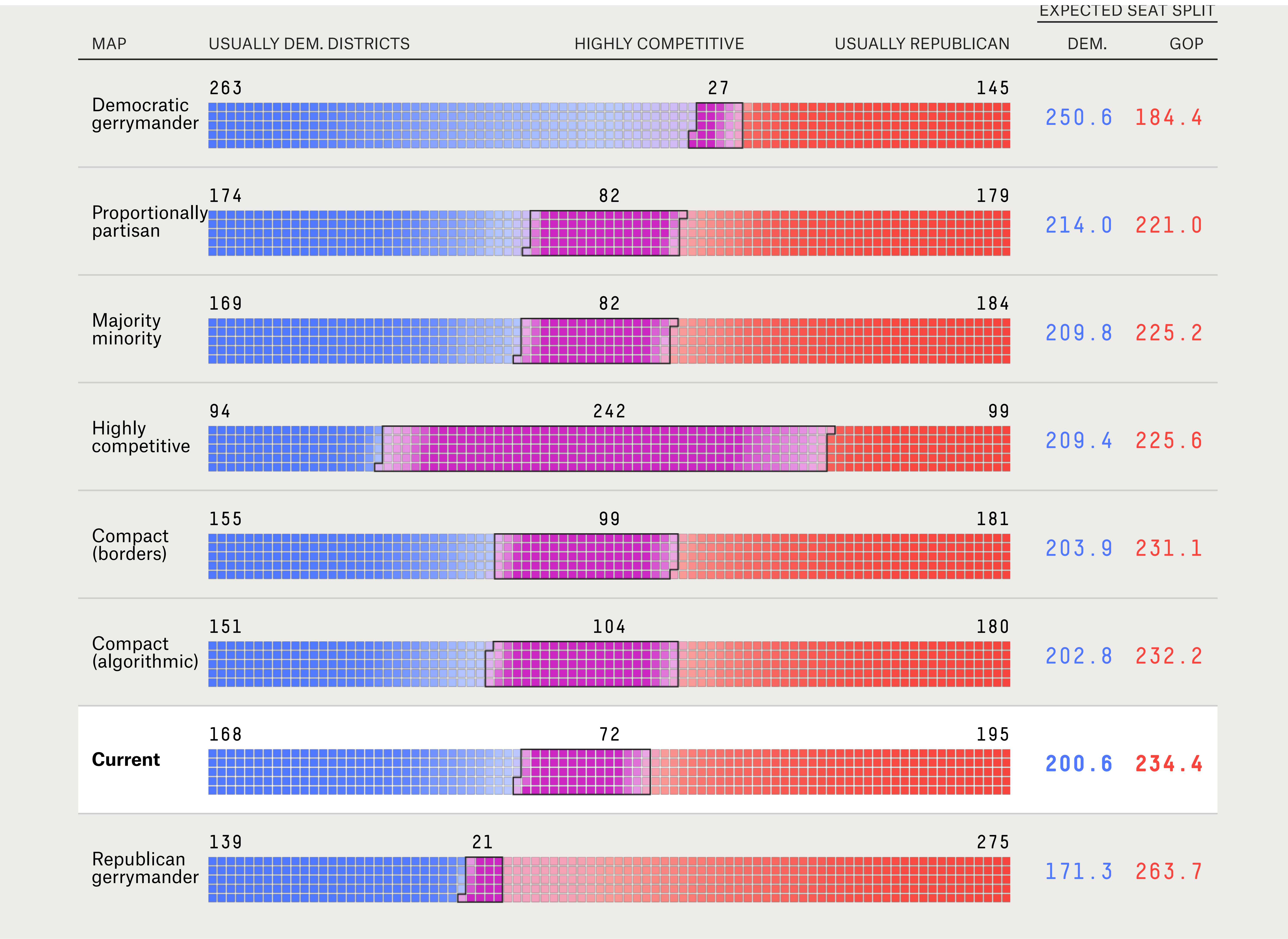
[Wonkblog, Washington Post, Adapted from S. Nass]

Drawing Different Maps: Compactness



[A. Bycoffe et al., 538]

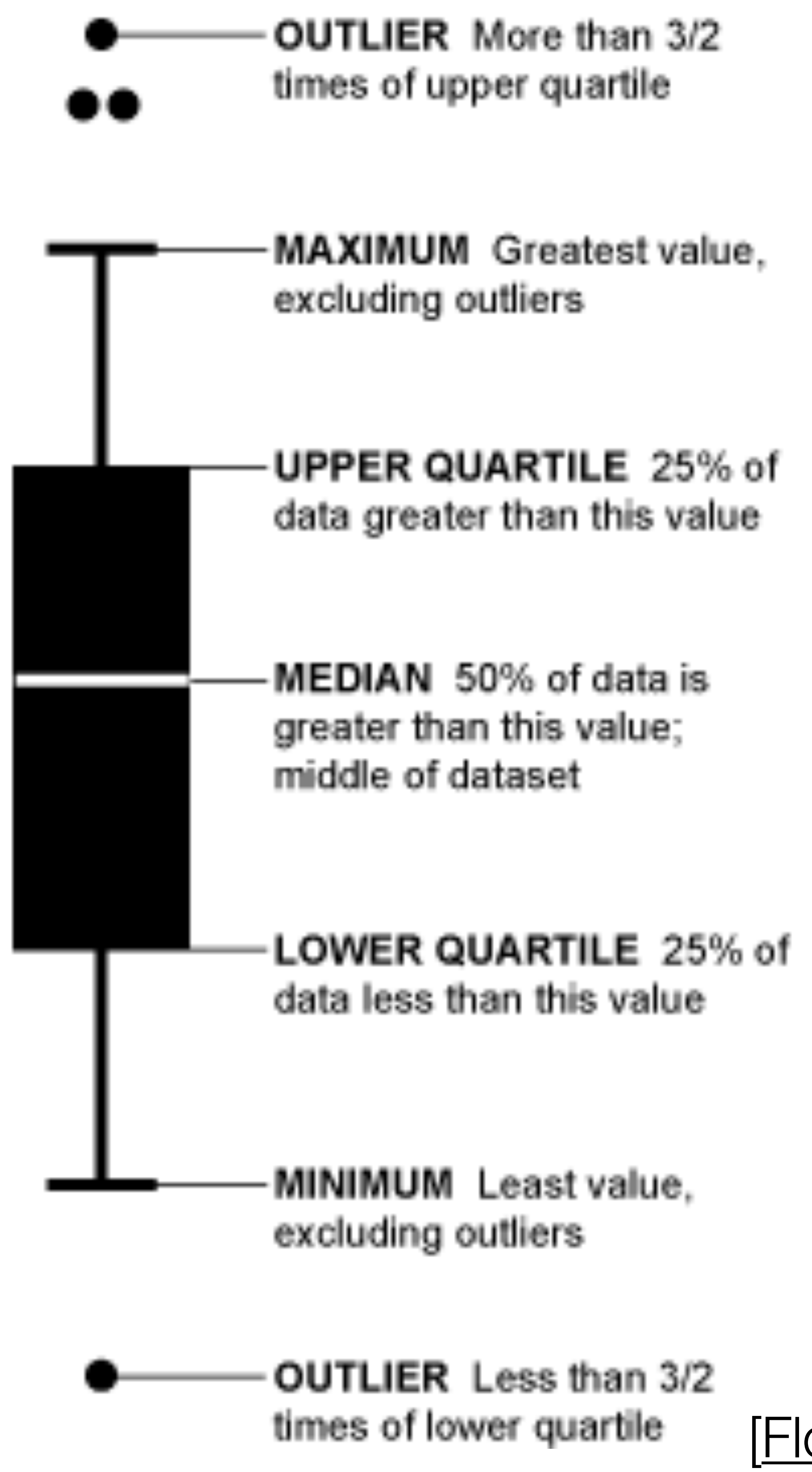
Drawing Different Maps



[A. Bycoffe et al., 538]

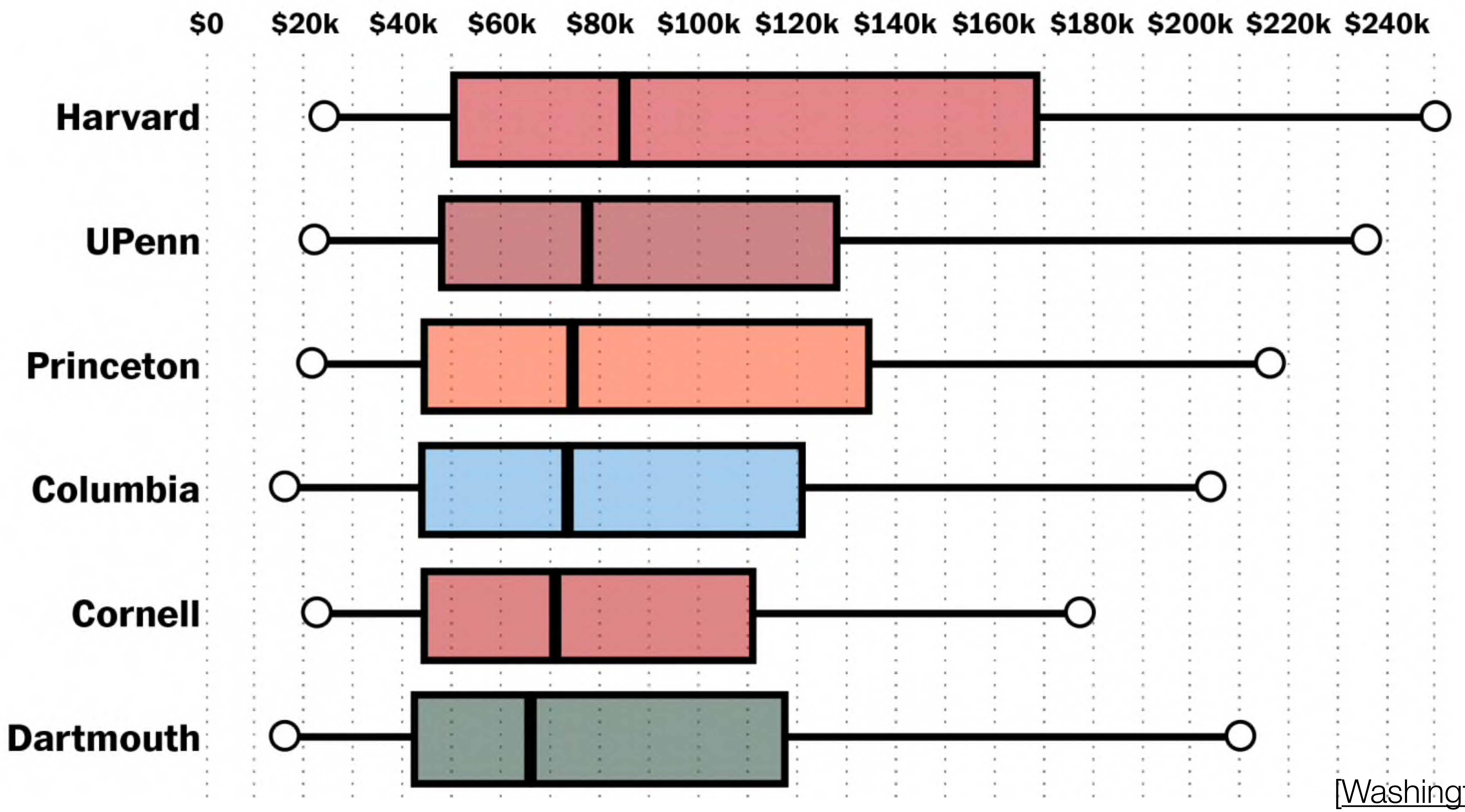
Boxplots

- Show **distribution**
- Single value (e.g. mean, max, min, quartiles) doesn't convey everything
- Created by John Tukey
- Show **spread** and **skew** of data
- Best for **unimodal** data
- Variations like vase plot for multimodal data
- Aggregation here involves many different marks



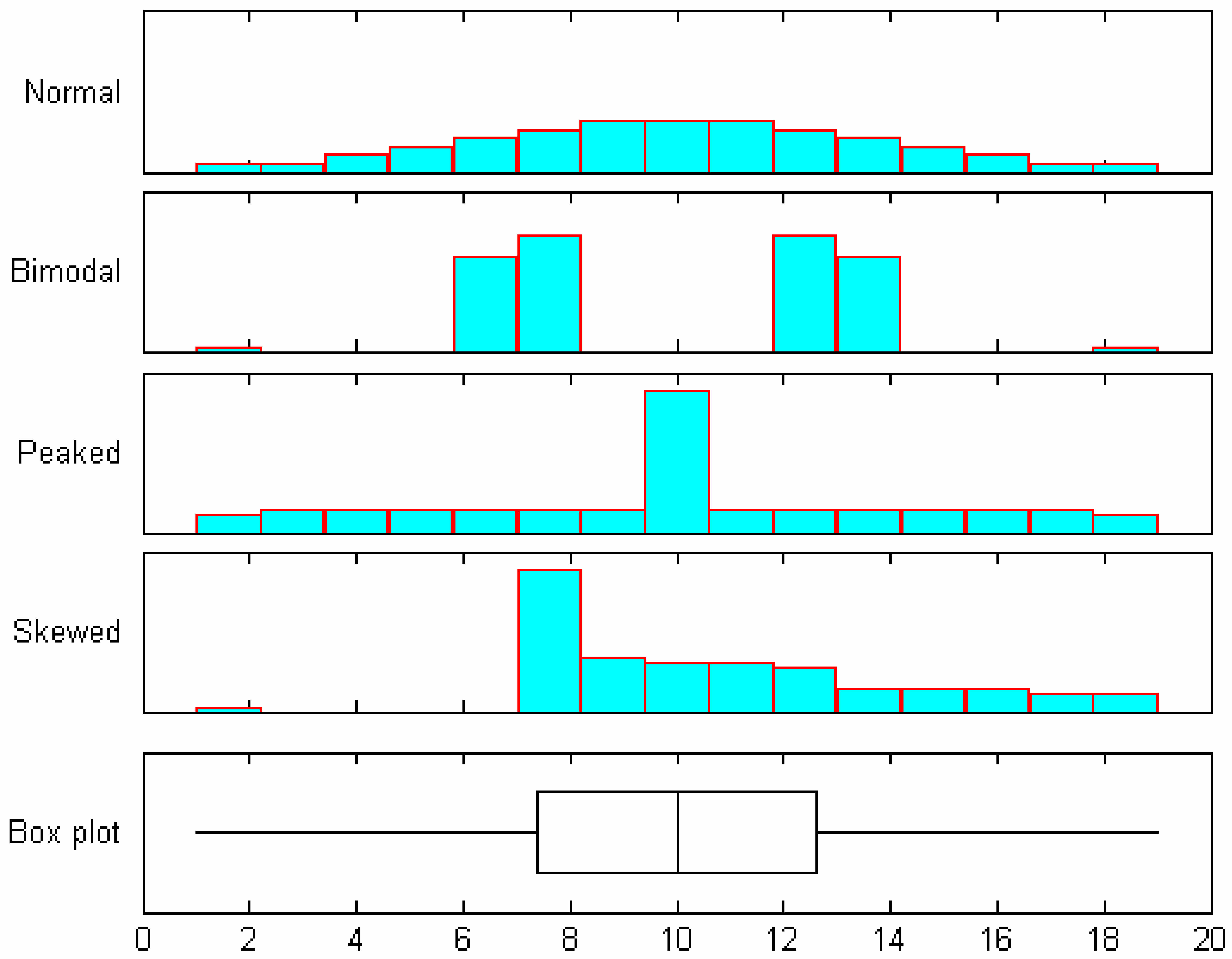
[Flowing Data]

Aggregation: Boxplots



[Washington Post, 2015]

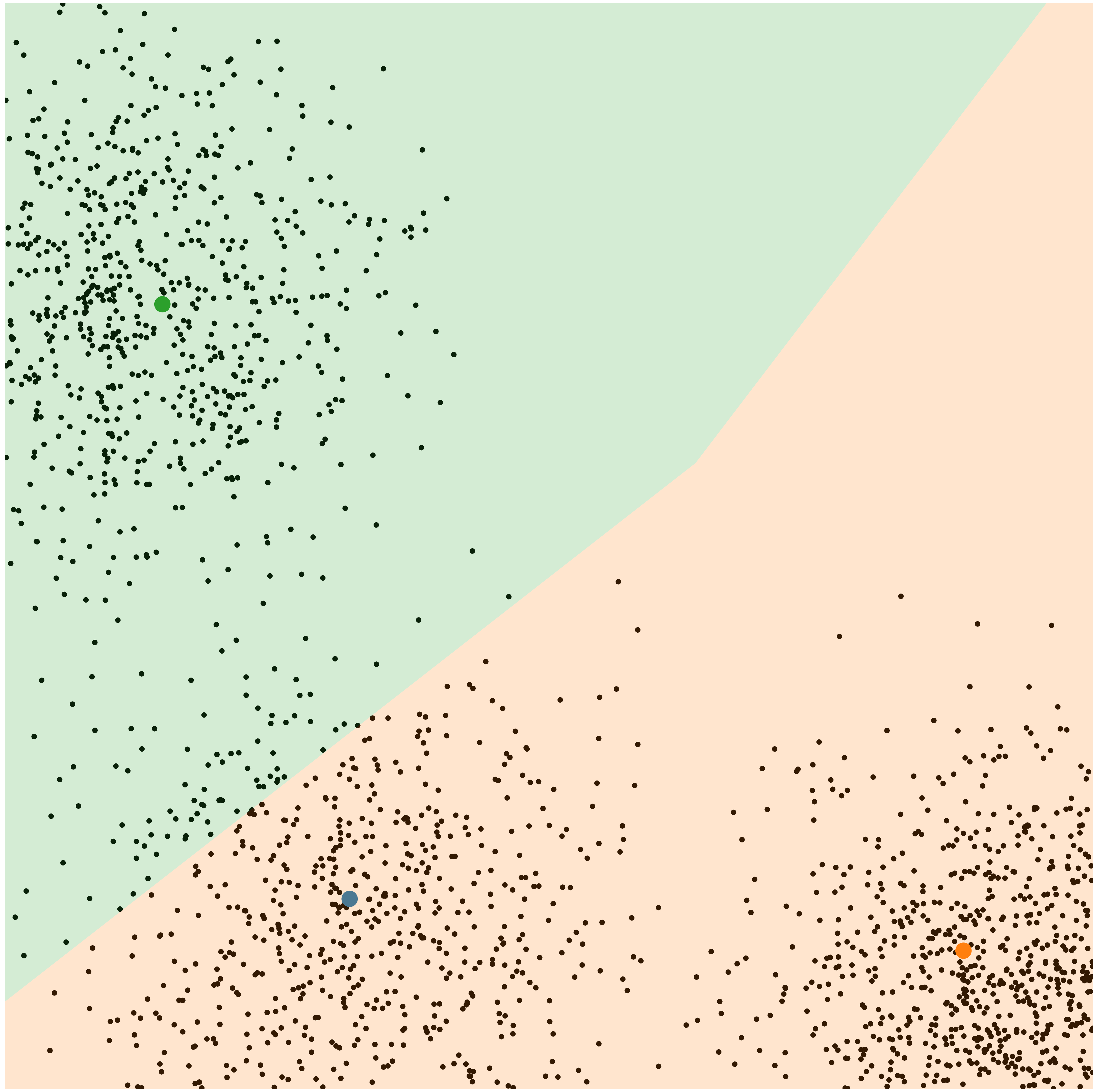
Four Distributions, Same Boxplot…



[C. Choonpradub and D. McNeil, 2005]

Attribute Aggregation

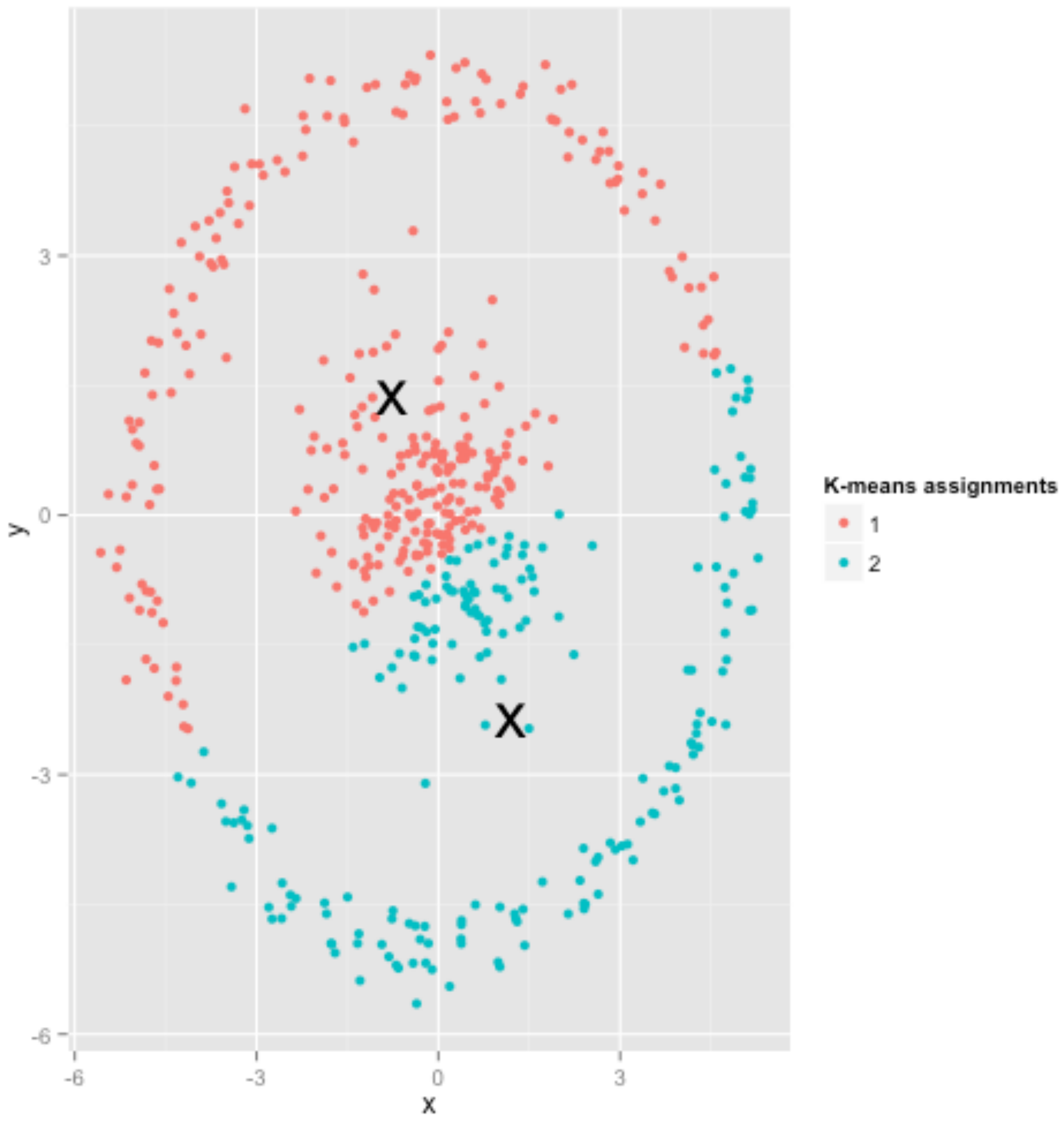
K-Means



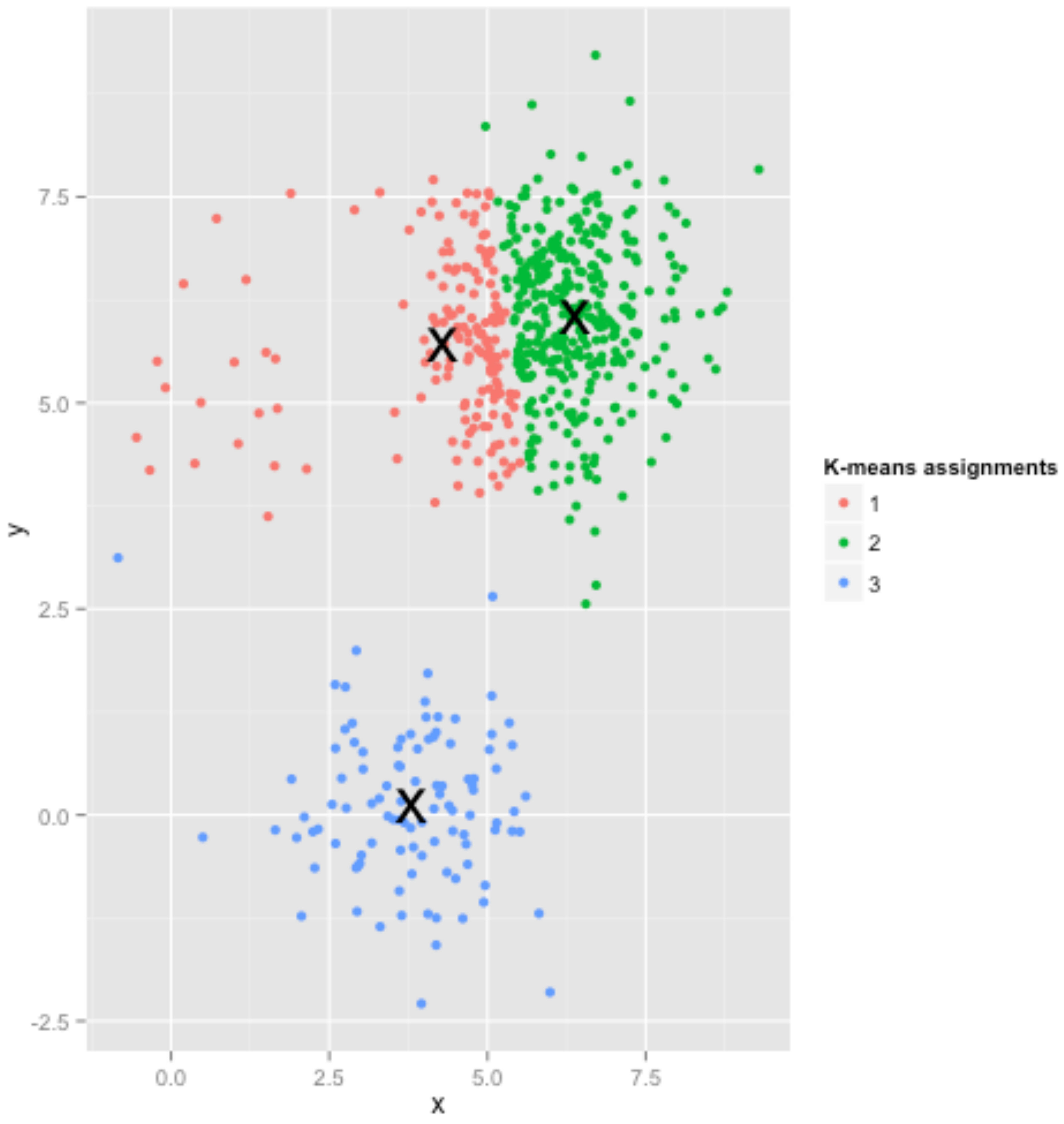
Run

[C. Polis, 2014]

K-Means Issues



Shape



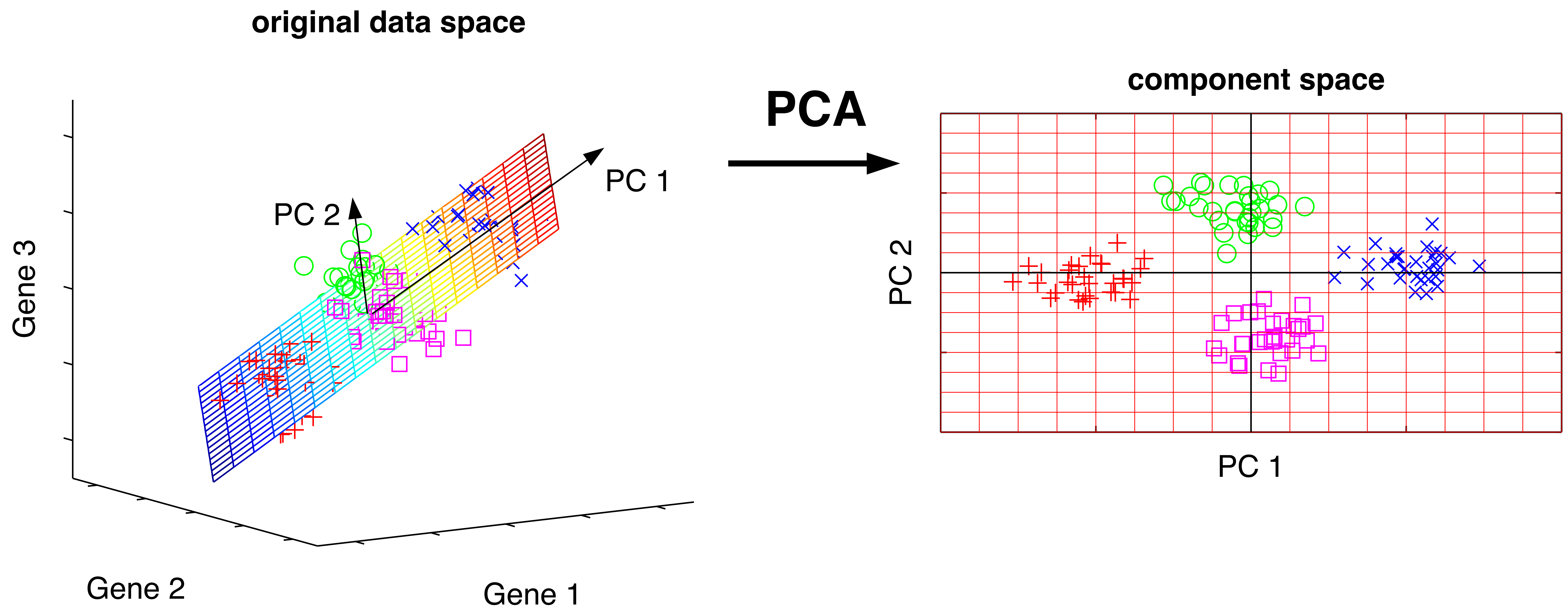
Number of Clusters

[D. Robinson, 2015]

Dimensionality Reduction

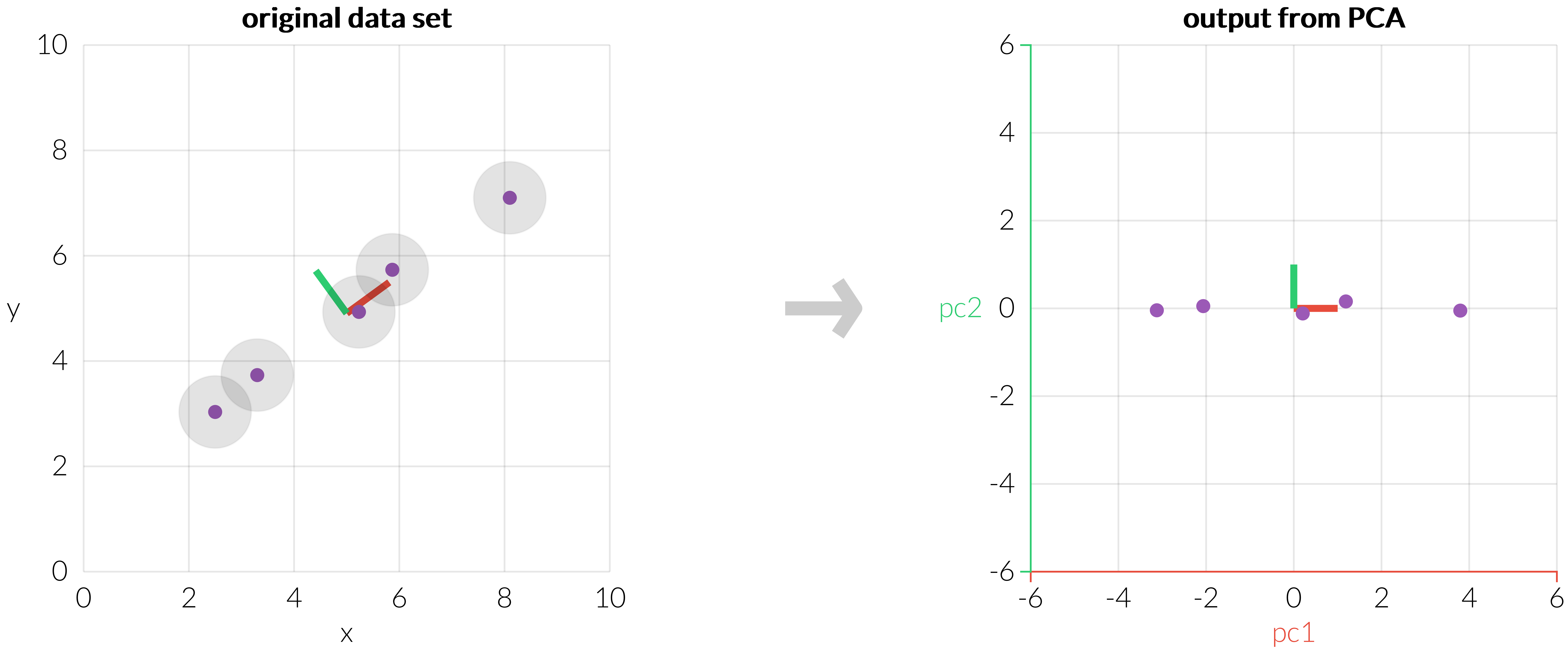
- Attribute Aggregation: Use fewer attributes (dimensions) to represent items
- Combine attributes in a way that is more instructive than examining each individual attribute
- Example: Understanding the language in a collection of books
  - Count the occurrence of each non-common word in each book
  - Huge set of features (attributes), want to represent each with an aggregate feature (e.g. high use of "cowboy", lower use of "city") that allows clustering (e.g. "western")
  - Don't want to have to manually determine such rules
- Techniques: Principle Component Analysis, Multidimensional Scaling family of techniques

Principle Component Analysis (PCA)



[M. Scholz, CC-BY-SA 2.0]

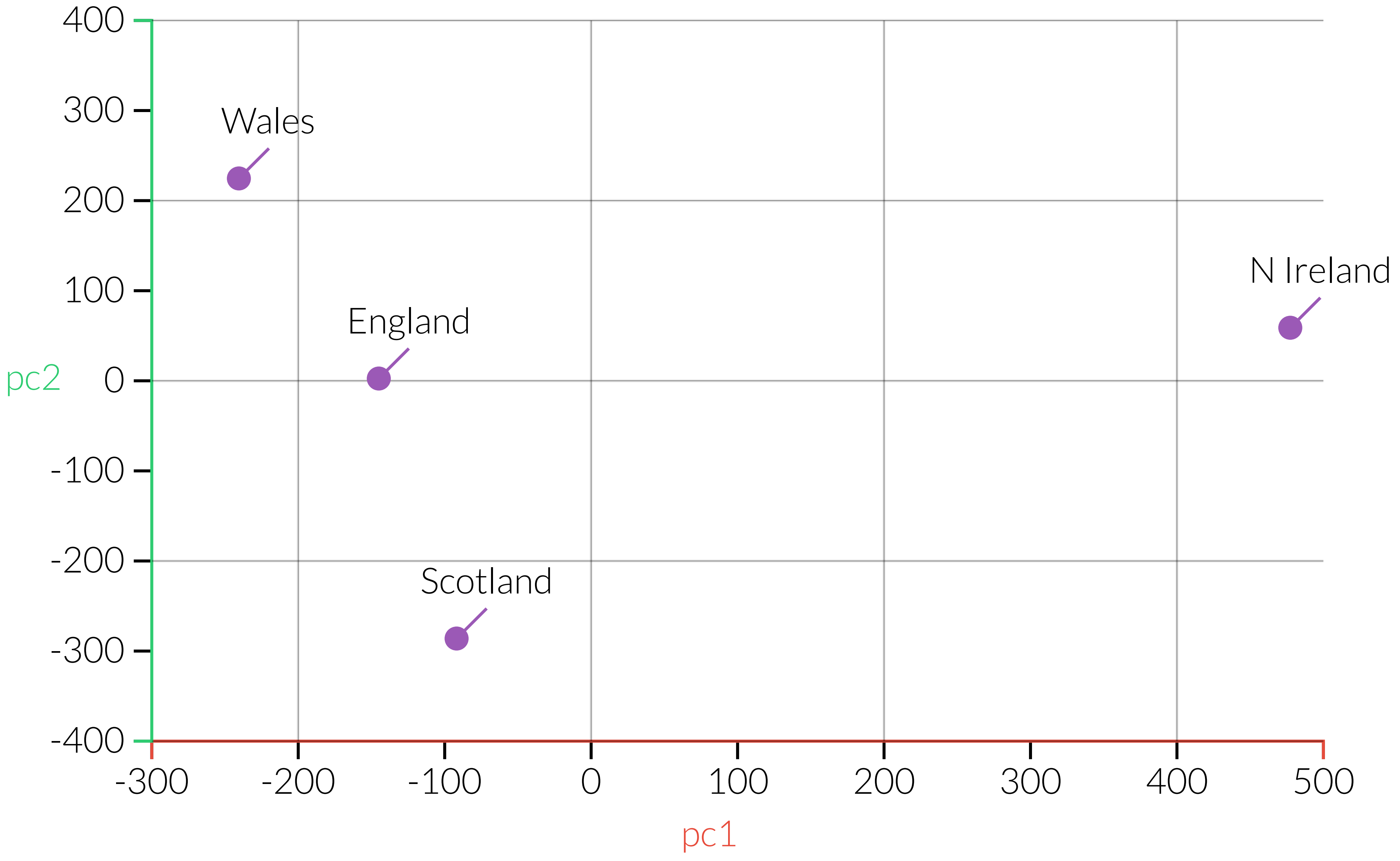
PCA



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

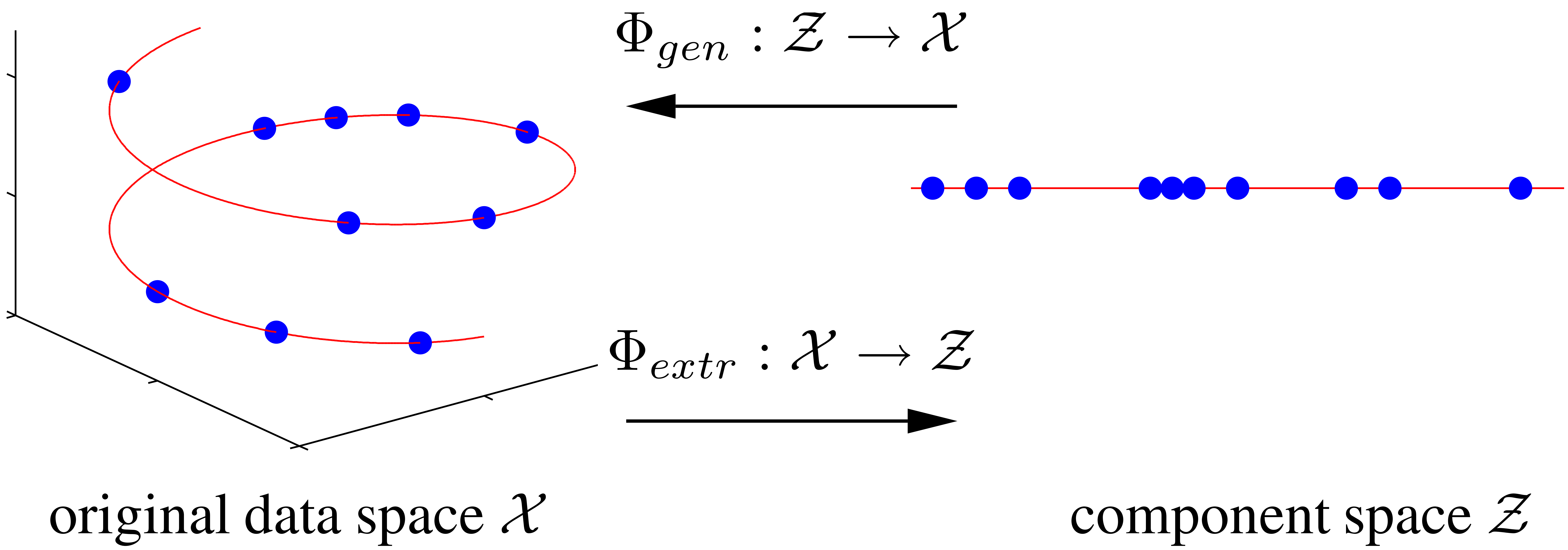
17 dimensions to 2

	England	N Ireland	Scotland	Wales
Alcoholic drinks	375	135	458	475
Beverages	57	47	53	73
Carcase meat	245	267	242	227
Cereals	1472	1494	1462	1582
Cheese	105	66	103	103
Confectionery	54	41	62	64
Fats and oils	193	209	184	235
Fish	147	93	122	160
Fresh fruit	1102	674	957	1137
Fresh potatoes	720	1033	566	874
Fresh Veg	253	143	171	265
Other meat	685	586	750	803
Other Veg	488	355	418	570
Processed potatoes	198	187	220	203
Processed Veg	360	334	337	365
Soft drinks	1374	1506	1572	1256
Sugars	156	139	147	175

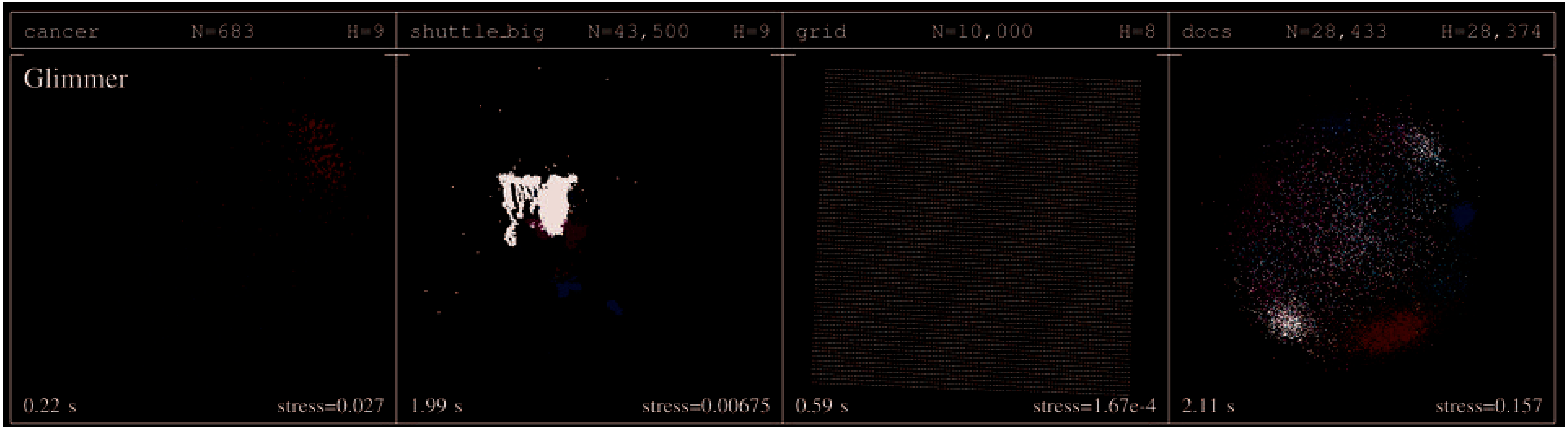


[Principle Component Analysis Explained, Explained Visually, V. Powell & L. Lehe, 2015]

Non-linear Dimensionality Reduction

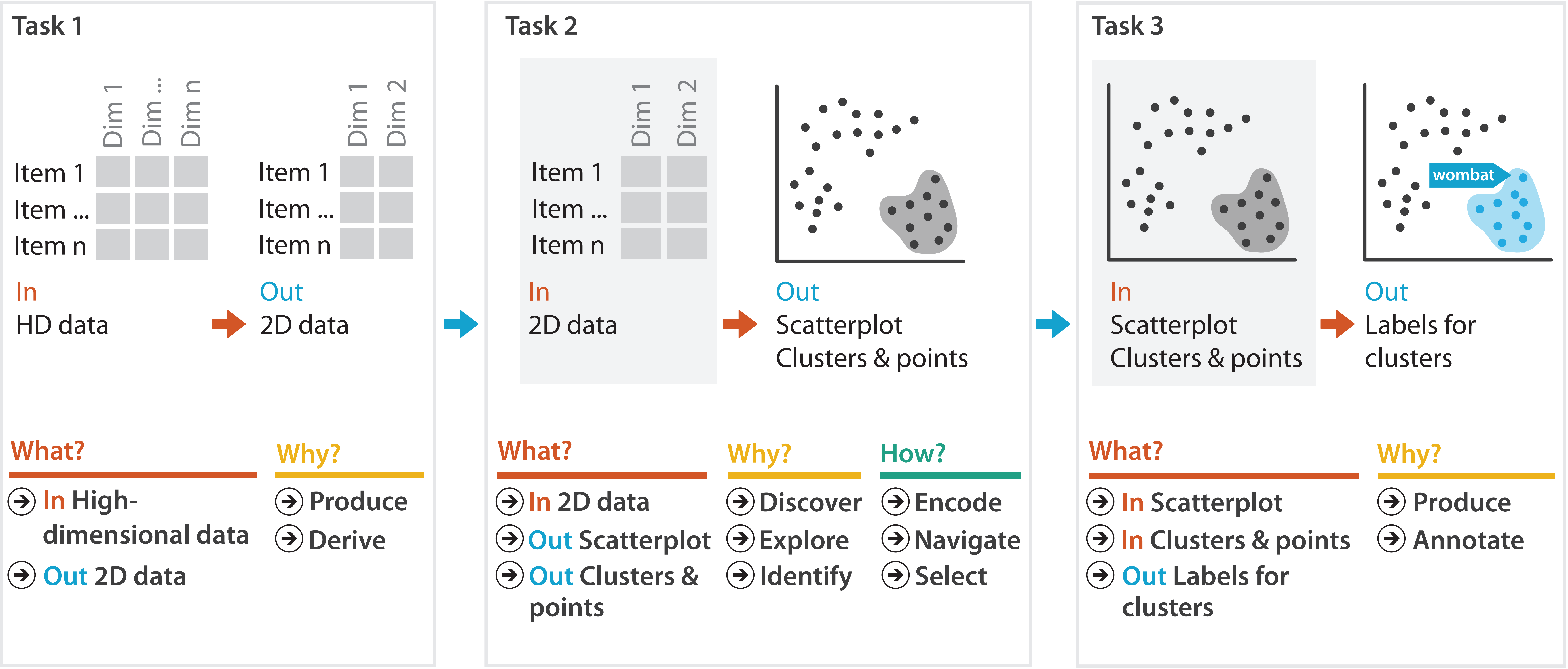


Dimensionality Reduction in Visualization



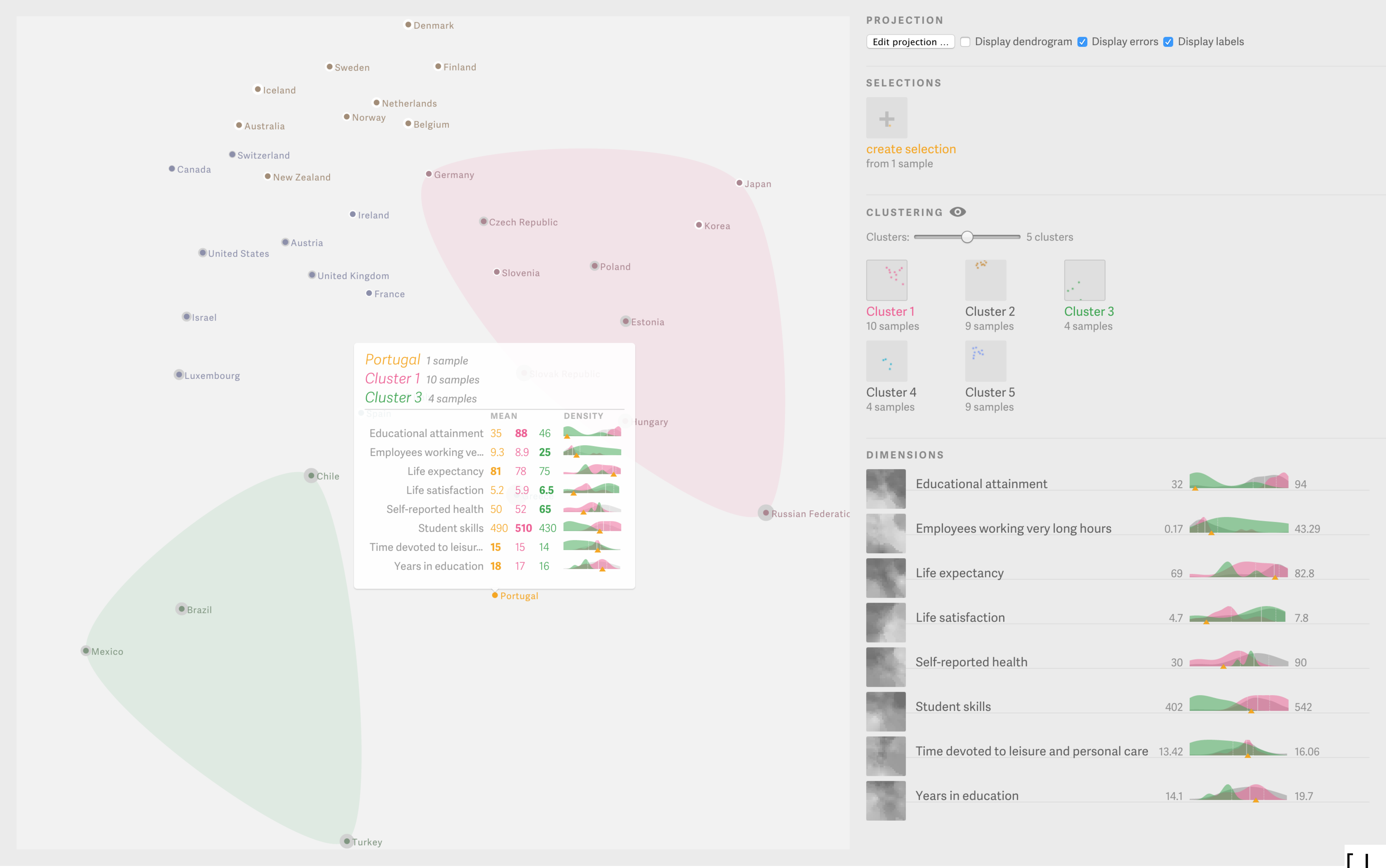
[Glimmer, Ingram et al., 2009]

Tasks in Understanding High-Dim. Data



[Munzner (ill. Maguire), 2014]

Probing Projections



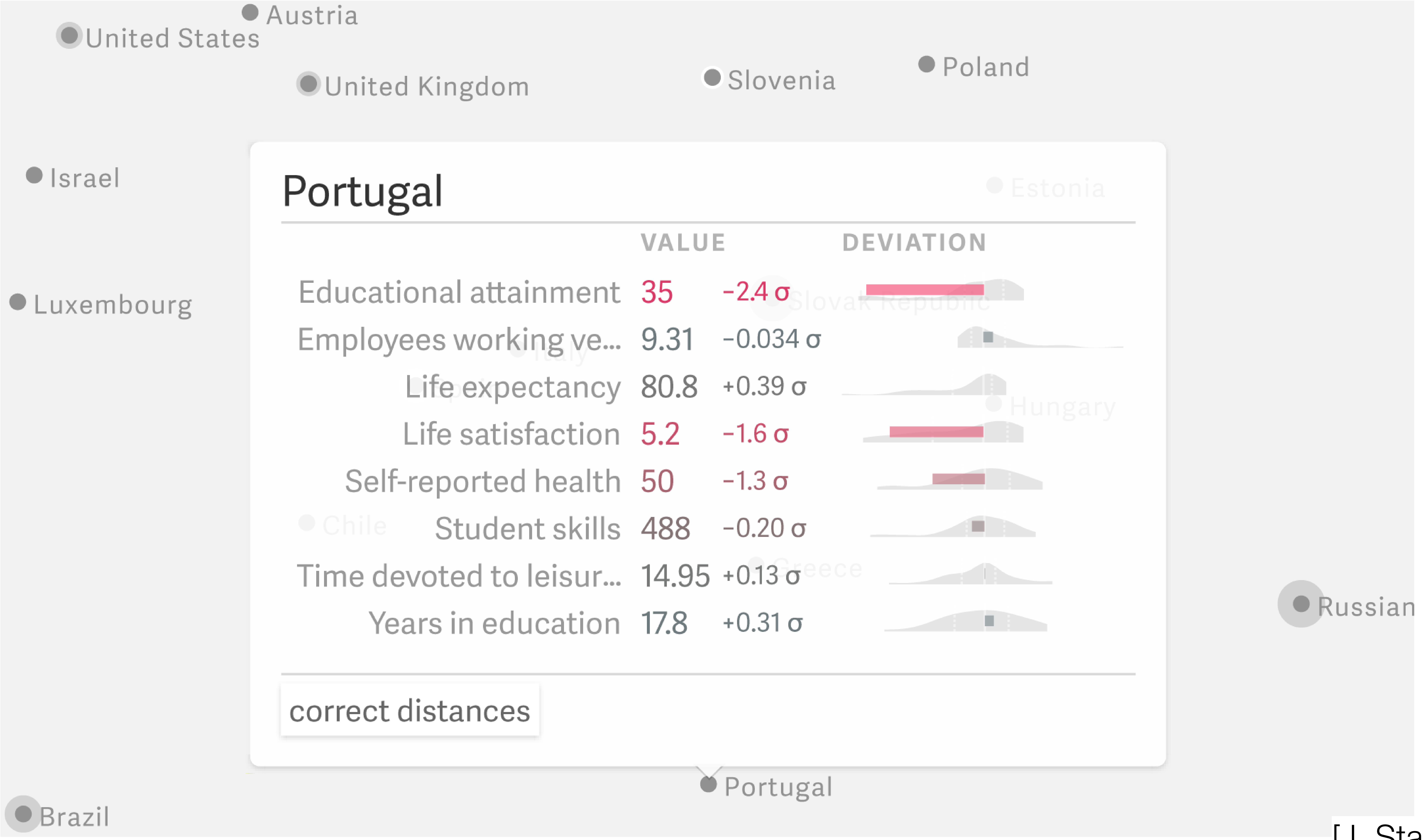
[J. Stahnke et al., 2015]

Probing Projection Goals

- Examining the Projection
- Exploring the Data
- Design Goals:
  - Show and correct approximation errors
  - Allow for multi-level comparisons
  - Spatial orientation
  - Consistent design
- Allow **grouping** of samples
  - Selections
  - Classes
  - Clusters

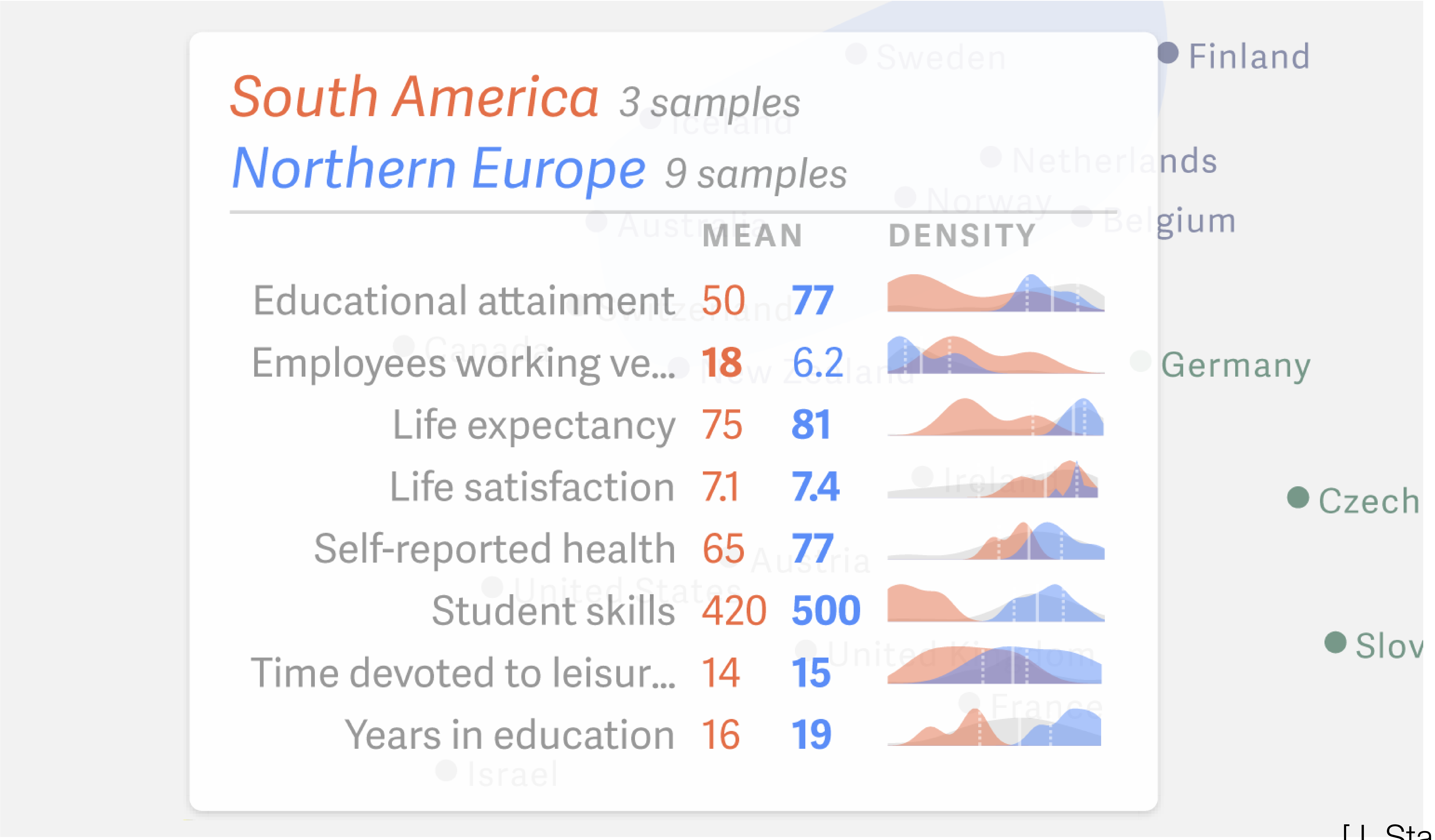
[J. Stahnke et al., 2015]

Tooltips with statistics



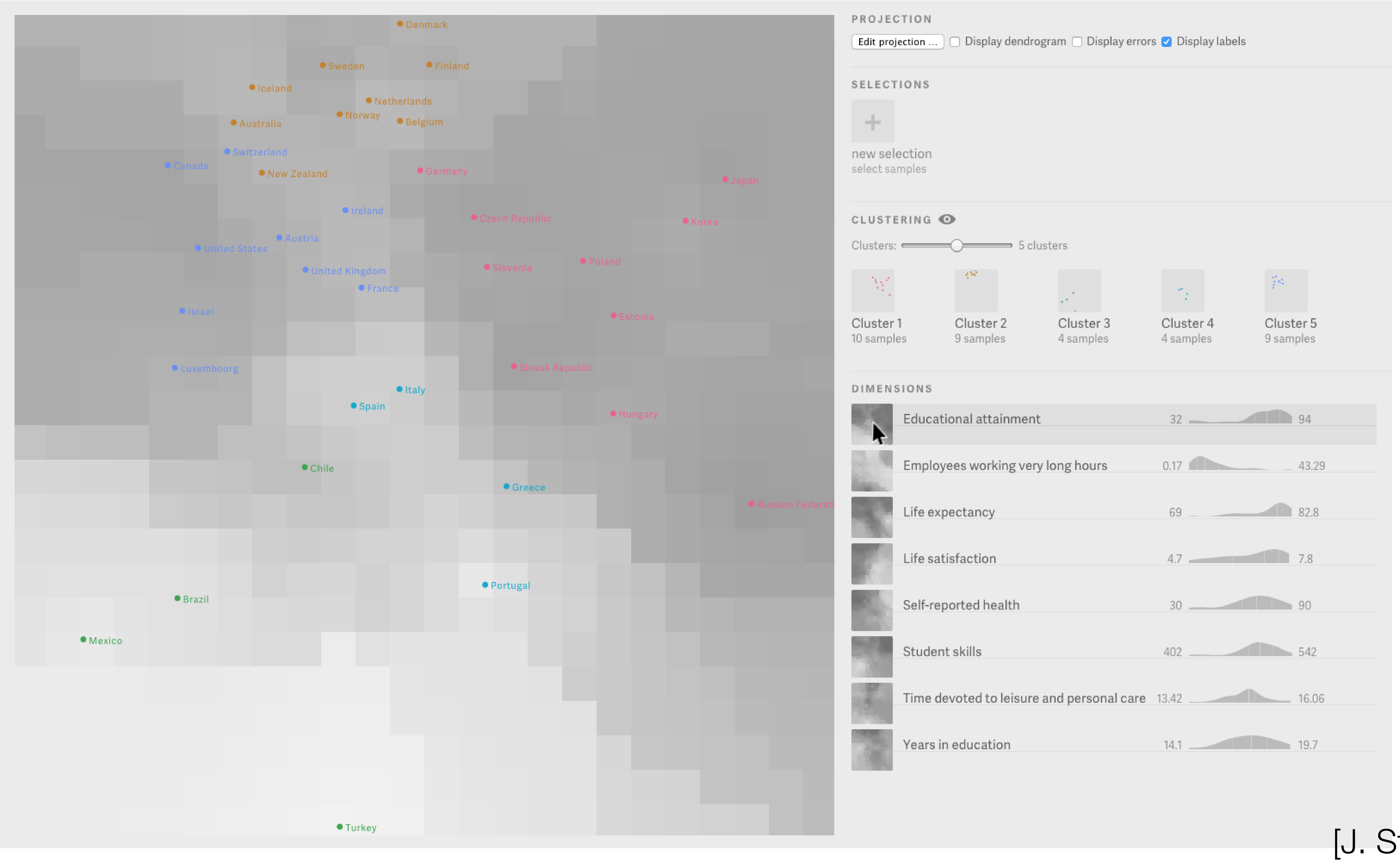
[J. Stahnke et al., 2015]

Comparing Two Groups



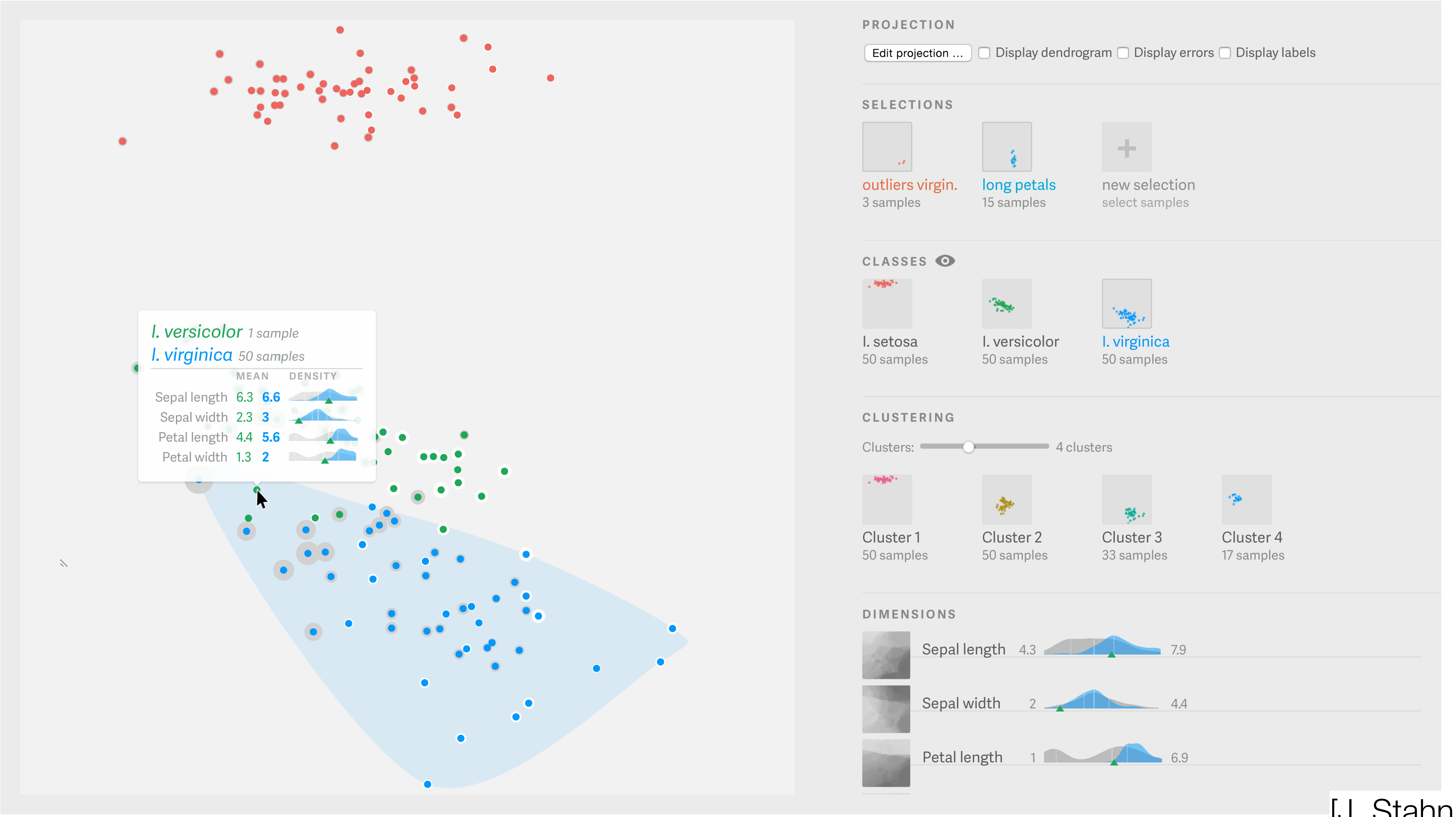
[J. Stahnke et al., 2015]

Heatmap from Dimension Hover



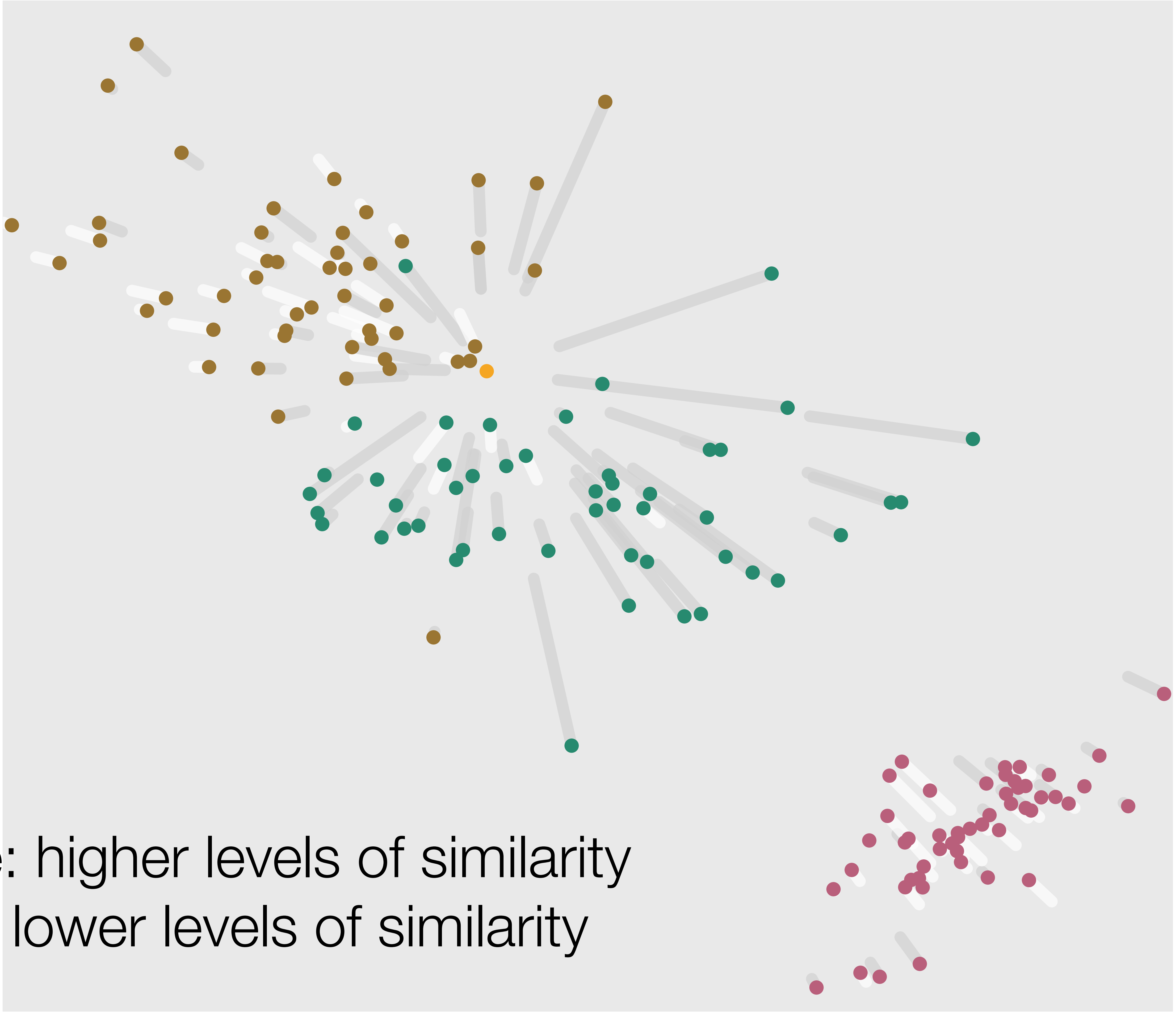
[J. Stahnke et al., 2015]

Showing Error via Sample-centric Halos



[J. Stahnke et al., 2015]

Showing Projection Errors



White: higher levels of similarity
Gray: lower levels of similarity

[J. Stahnke et al., 2015]

User Study & Results

- Types of Questions:
  - How would you try to characterize the type X?
  - In what way are X and Y different in their properties?
  - Are the projections of X and Y correct or do they deviate? How do you interpret this?
  - Can you discover which parts of the cluster combinations are A, B, and C?
- Discussion:
  - Learnability: need more effective mechanisms for grasping the concepts behind dimensionality reduction
  - Manipulation: What happens with results?
  - Large data: What about text corpora?

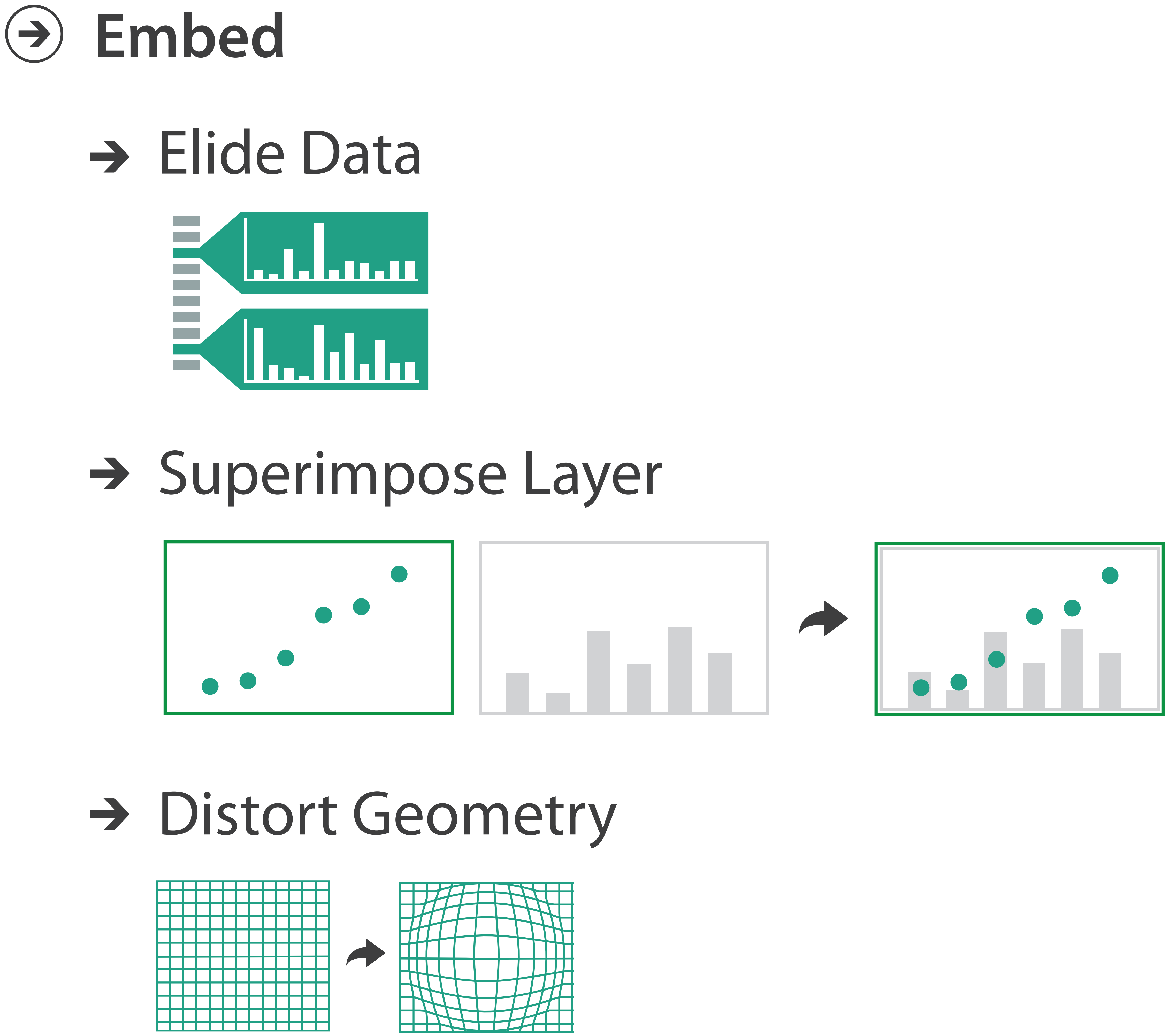
[J. Stahnke et al., 2015]

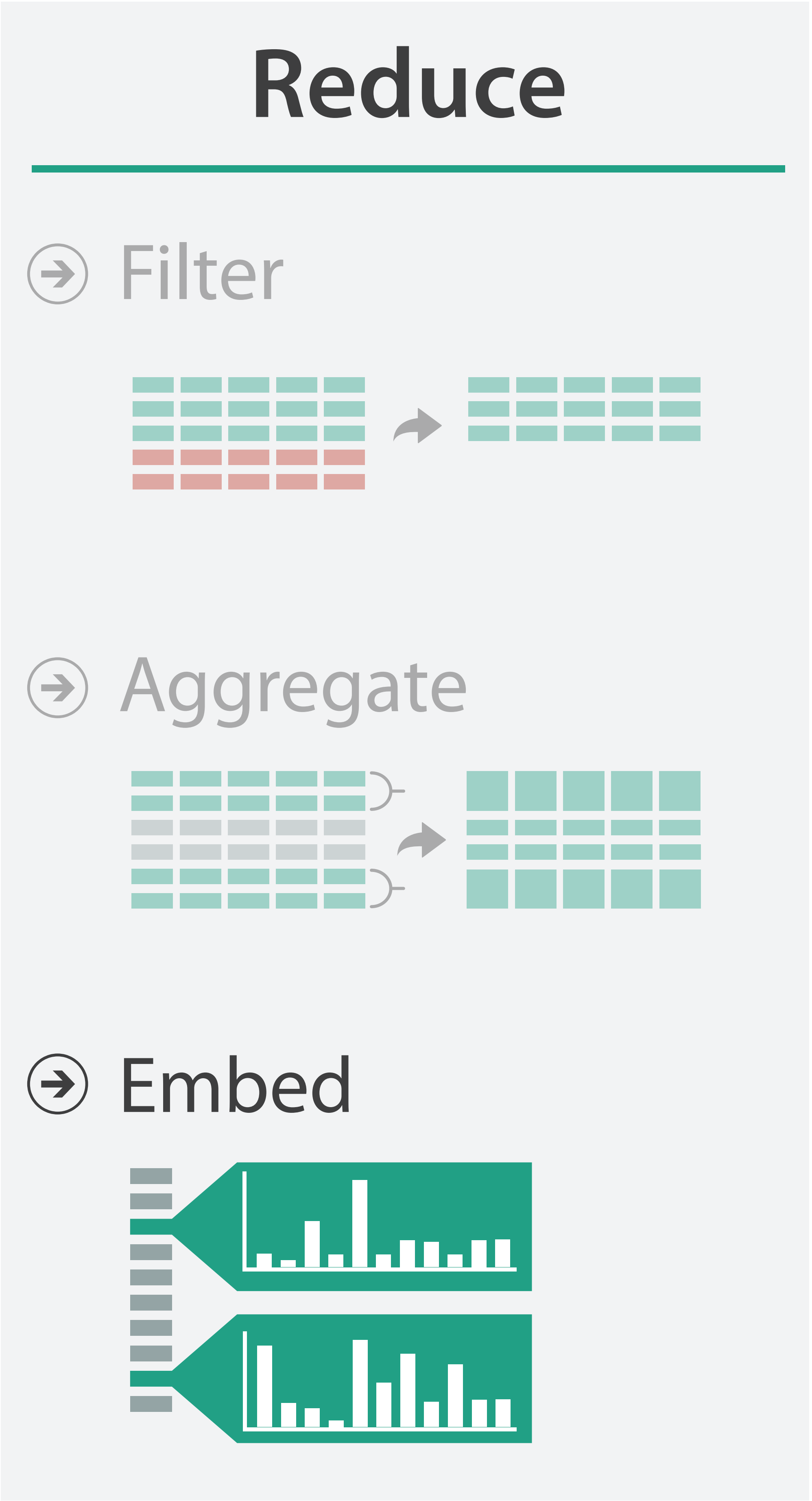
Focus+Context

Focus+Context

- Show everything at once but compress regions that are not the current focus
  - User shouldn't lose sight of the overall picture
  - May involve some aggregation in non-focused regions
  - "Nonliteral navigation" like semantic zooming
- Elision
- Superimposition: more directly tied than with layers
- Distortion

Focus+Context Overview





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