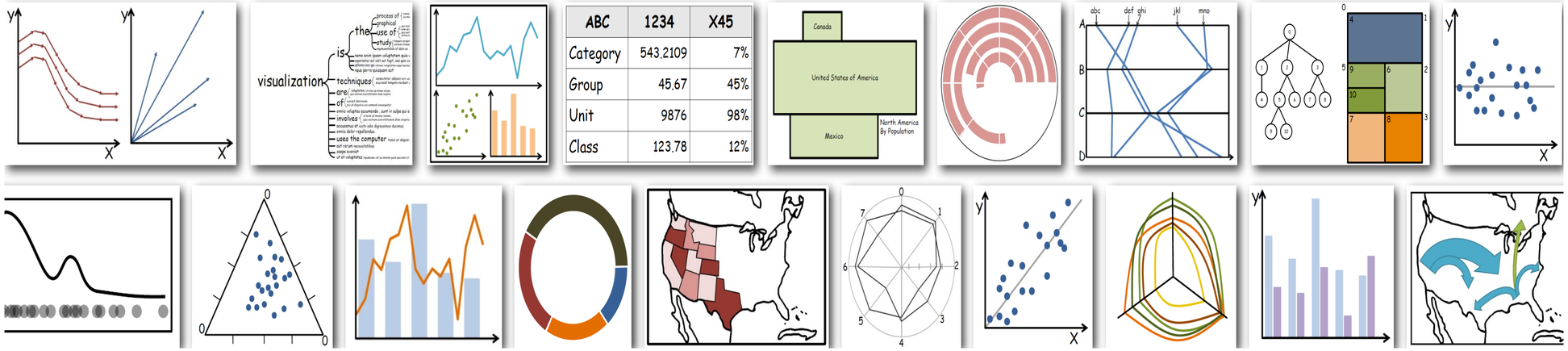


Lecture
Interaction Techniques - I

DATA ANALYSIS & VISUALIZATION

FALL 2021

Dr. Muhammad Faisal Cheema

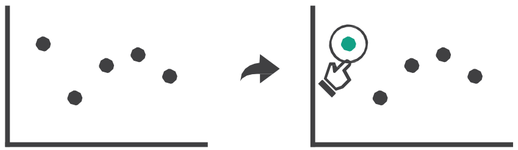
FAST NU

Guidelines for Interaction Design

Interaction Overview

Change over Time

Select

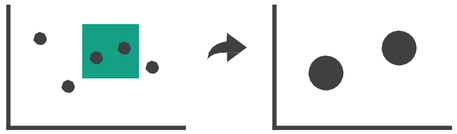


Navigate

Item Reduction

Zoom

Geometric or *Semantic*

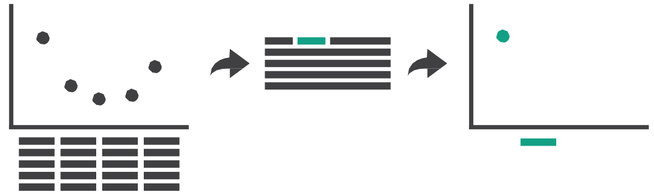


Pan/Translate

Constrained

Attribute Reduction

Slice



Cut

Project

[Munzner (ill. Maguire), 2014]

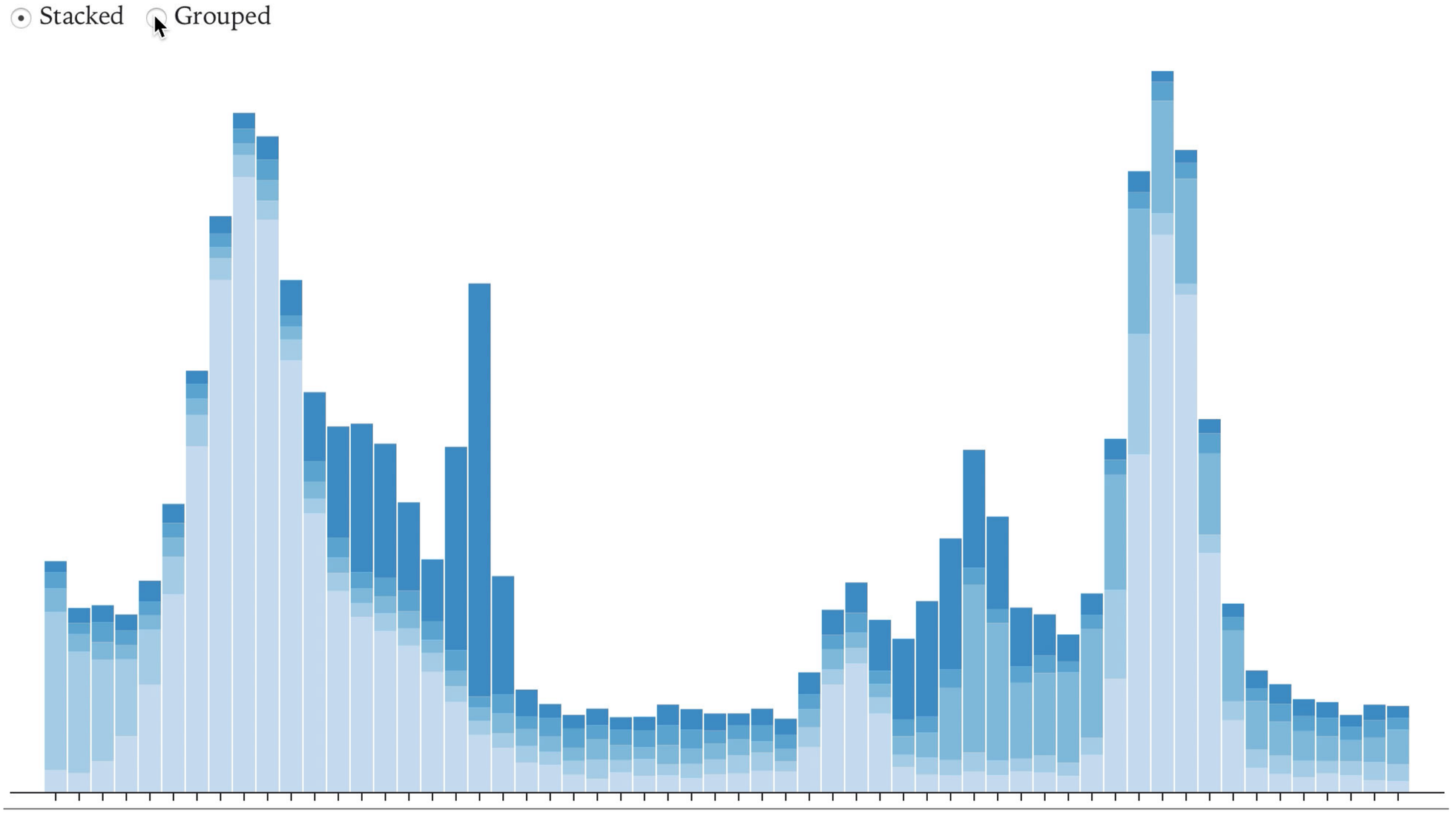
Interaction Overview

- Change over Time

Why Interaction is required?

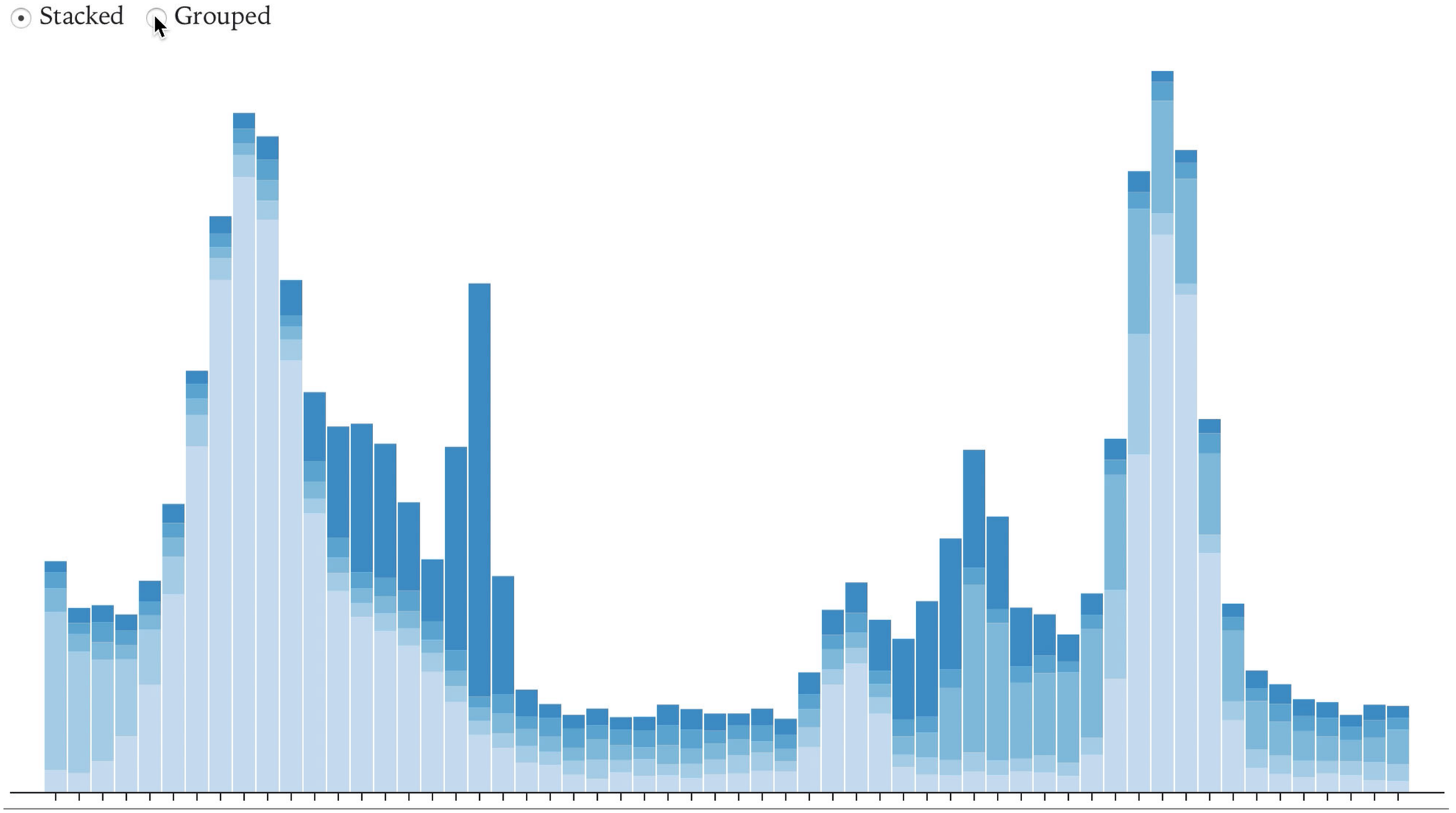
- The view changes over time
- Changes can affect almost any aspect of the visualization
  - encoding
  - arrangement
  - ordering
  - viewpoint
  - attributes being shown
  - aggregation level

Animated Transitions



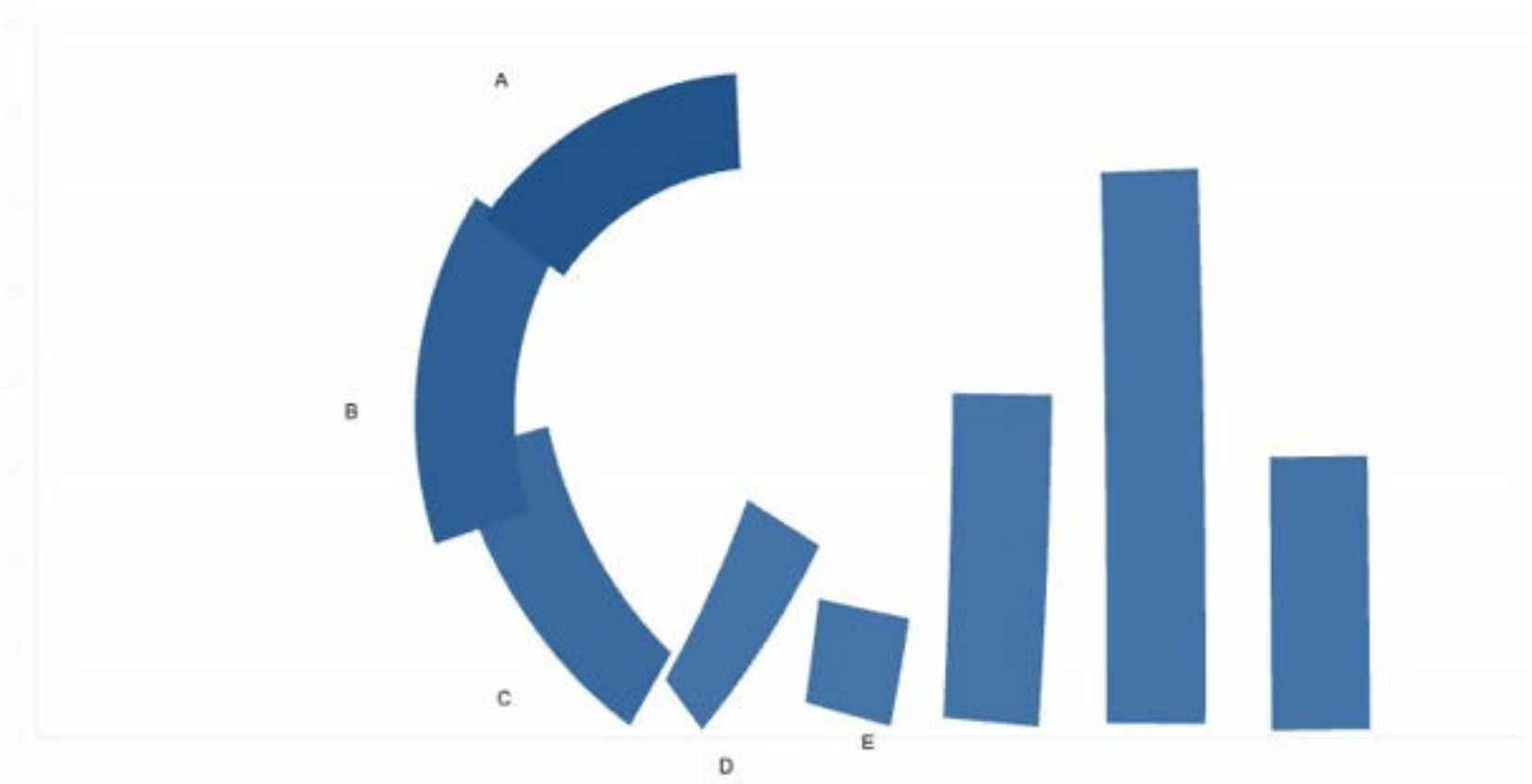
[M. Bostock]

Animated Transitions



[M. Bostock]

Studying Animated Transitions



[Heer and Robertson, 2007]

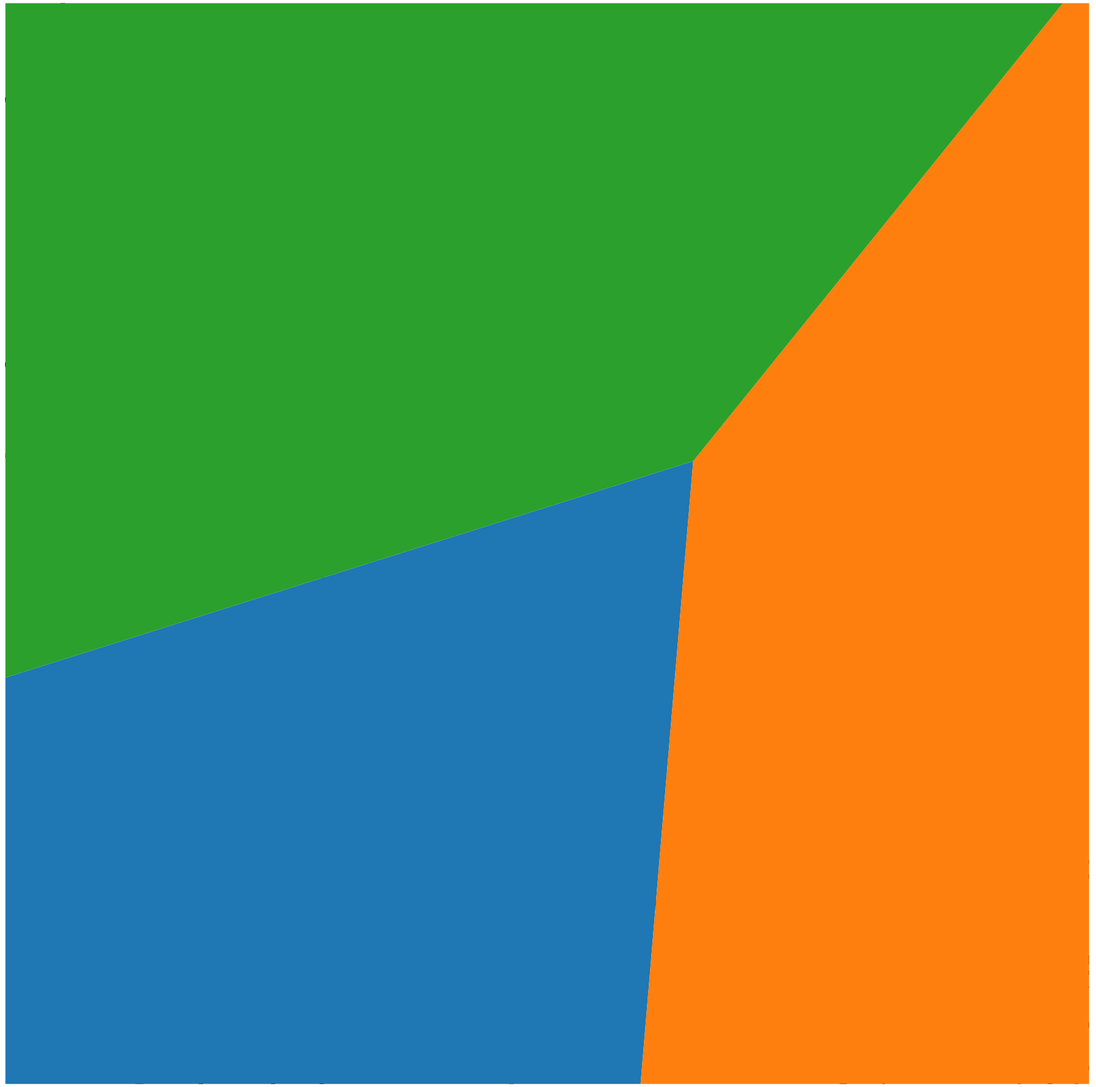
Lets view how they work

https://youtu.be/vLk7mlAtEXI

Animated Transitions

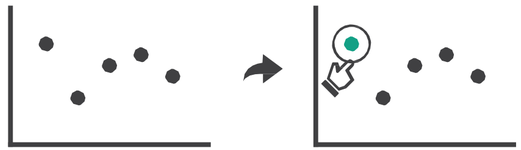
- "Jump cuts" are hard to follow
- Animations help users maintain sense of context between two states
- Empirical study showed that they work (Heer & Robertson, 2007)

K-Means (Animation)



Interaction Overview

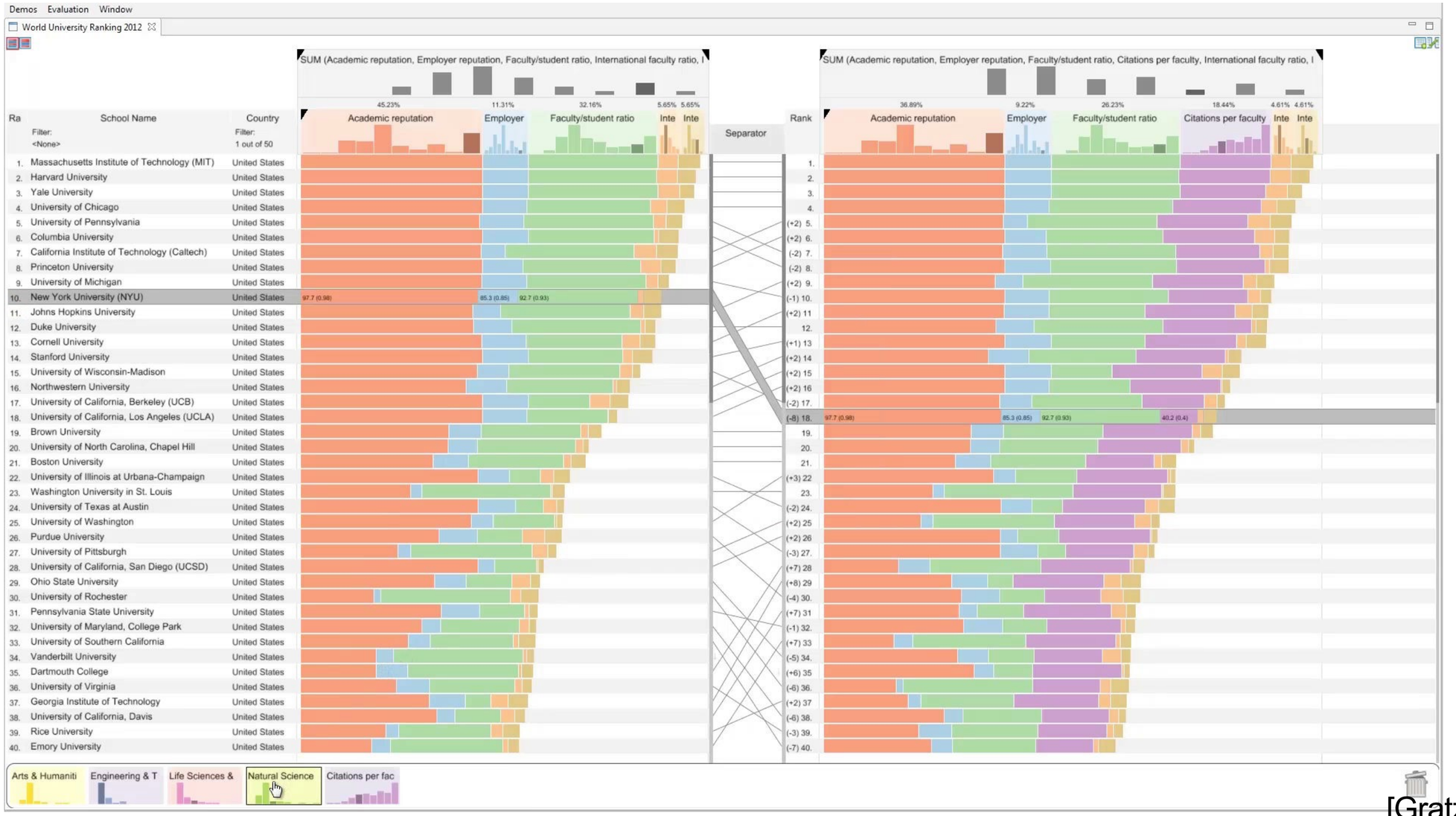
- Select



Sorting

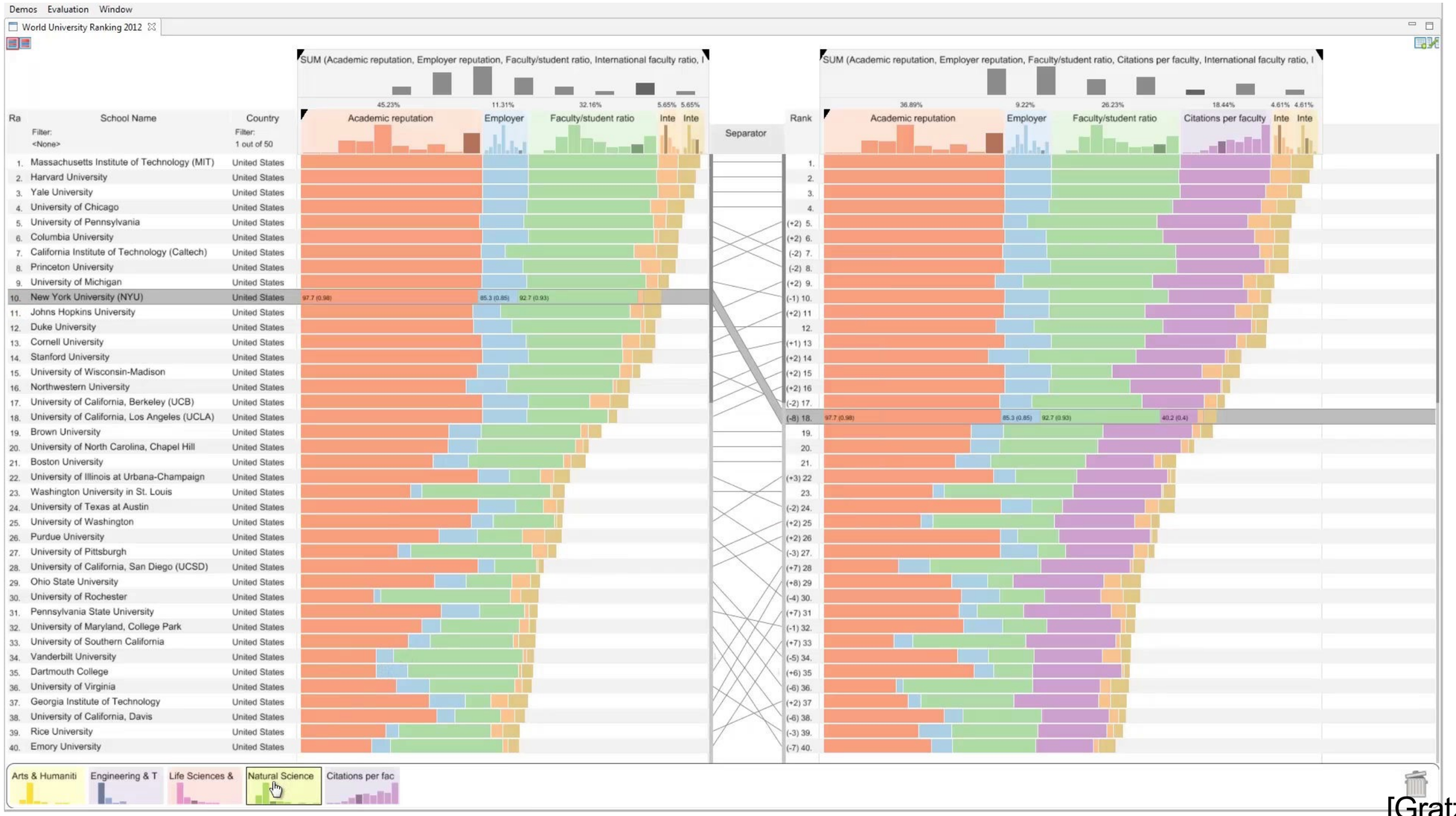
- Allow user to find patterns by reordering the data
- Do this with tabular data all the time
- Note that categorical attributes don't really need sorting
  - We can compare these attributes no matter what order
  - Instead, sort categorical attribute based on an ordered attribute

Example: LineUp



[Gratzl et al., 2013]

Example: LineUp



[Gratzl et al., 2013]

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

Highlighting

- Selection is the user action
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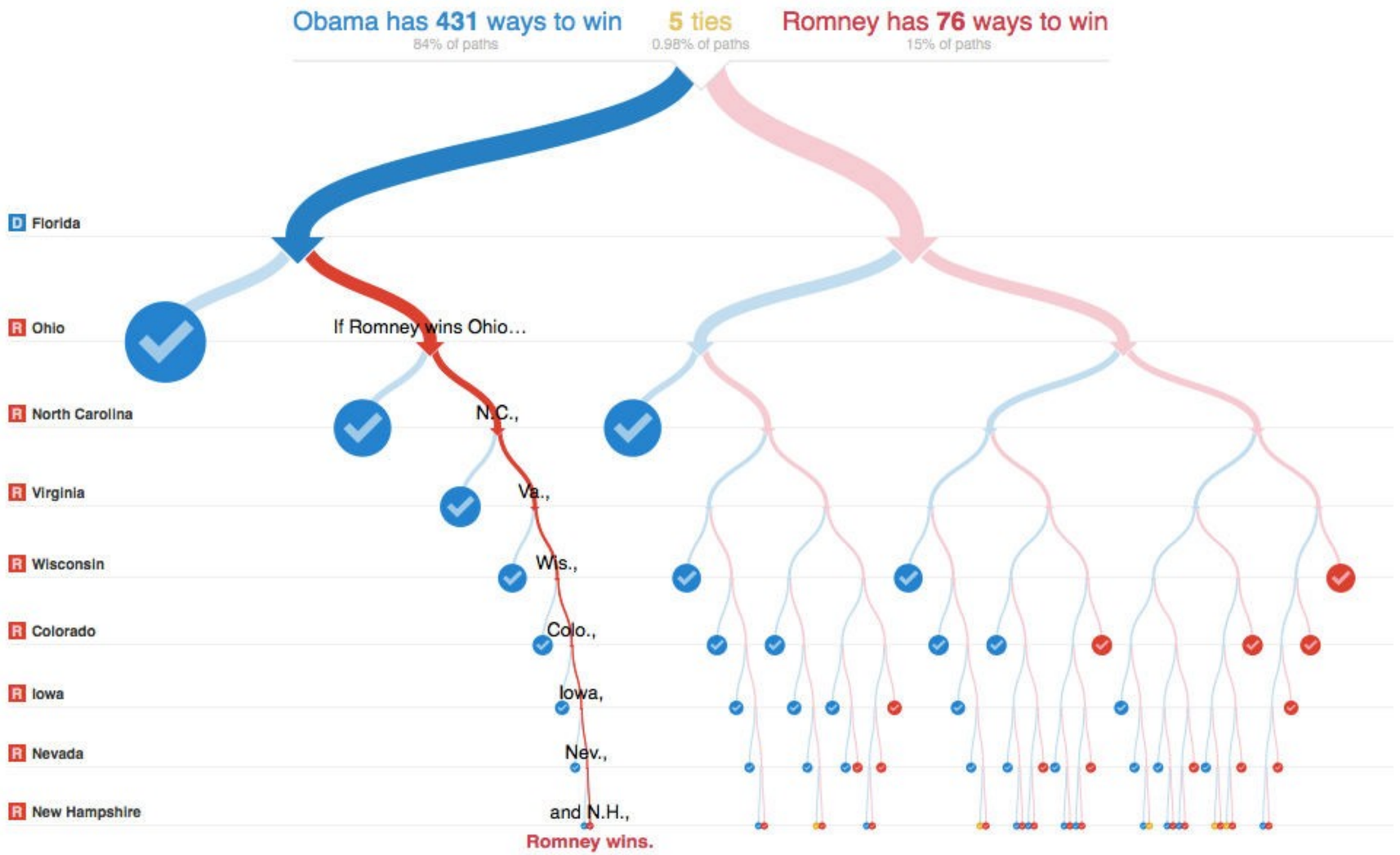
Highlighting

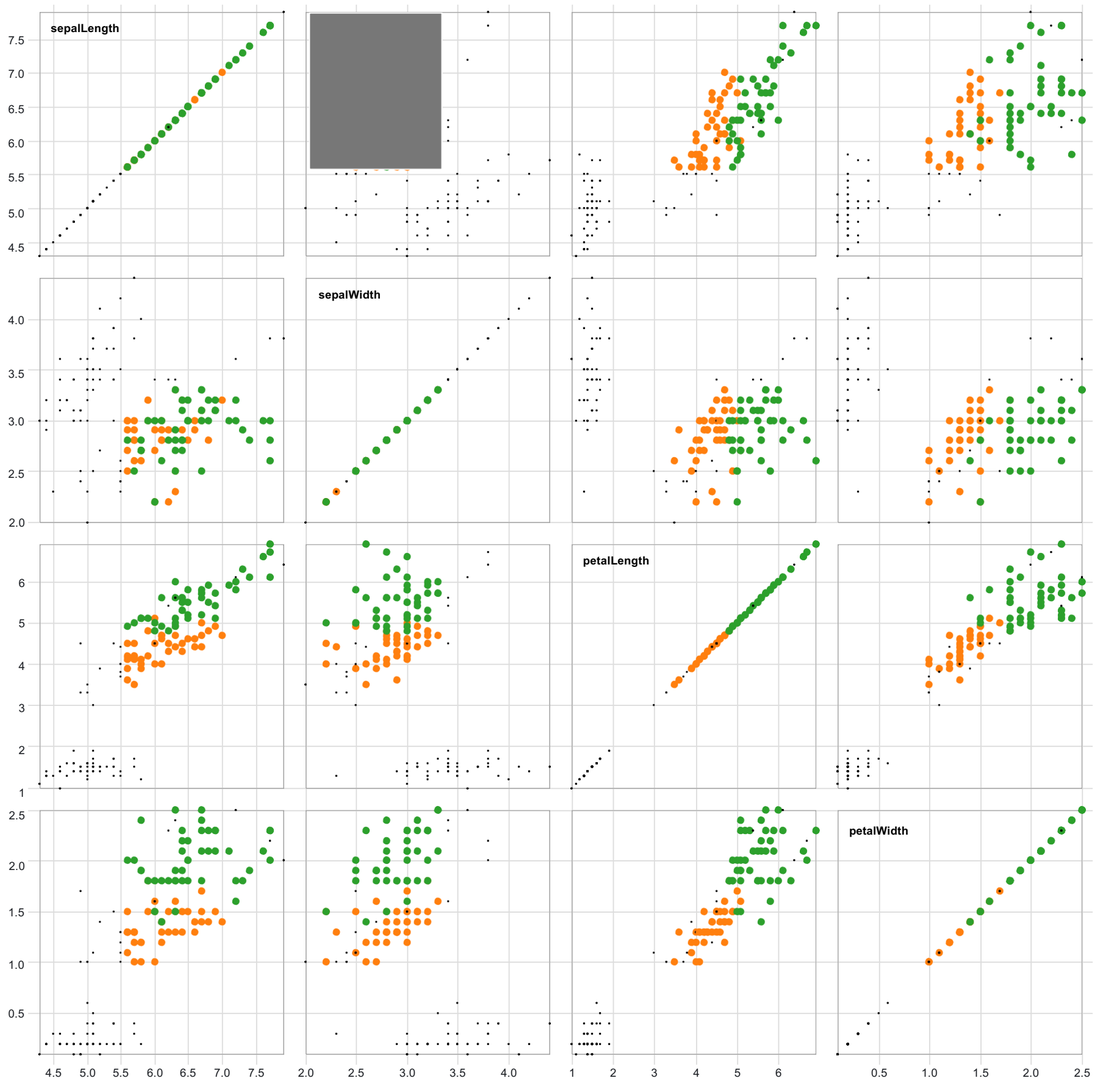


[NYTimes]

Selection Outcomes

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

Brushing



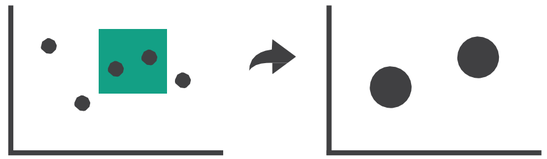
[M. Bostock]

Responsiveness Required

- Delays are perceived by users
- Visual feedback
  - Show the user they did something (highlighting, etc)
  - Interaction should happen quick!
- Latency: mouse click versus mouse hover
- Popup versus detail displays

Navigation

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

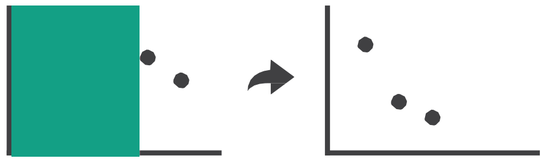


  - *Pan/Translate*

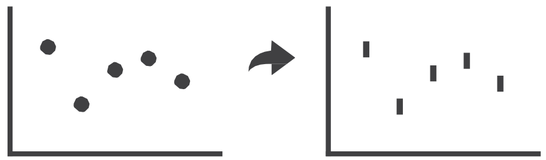
  - *Constrained*

- Attribute Reduction
  - *Slice*

  - *Cut*



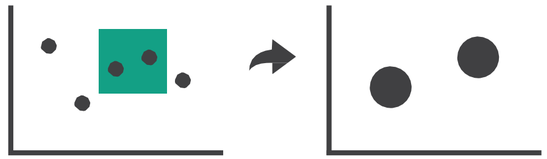
  - *Project*



[Munzner (ill. Maguire), 2014]

Navigation

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



  - *Pan/Translate*

  - *Constrained*

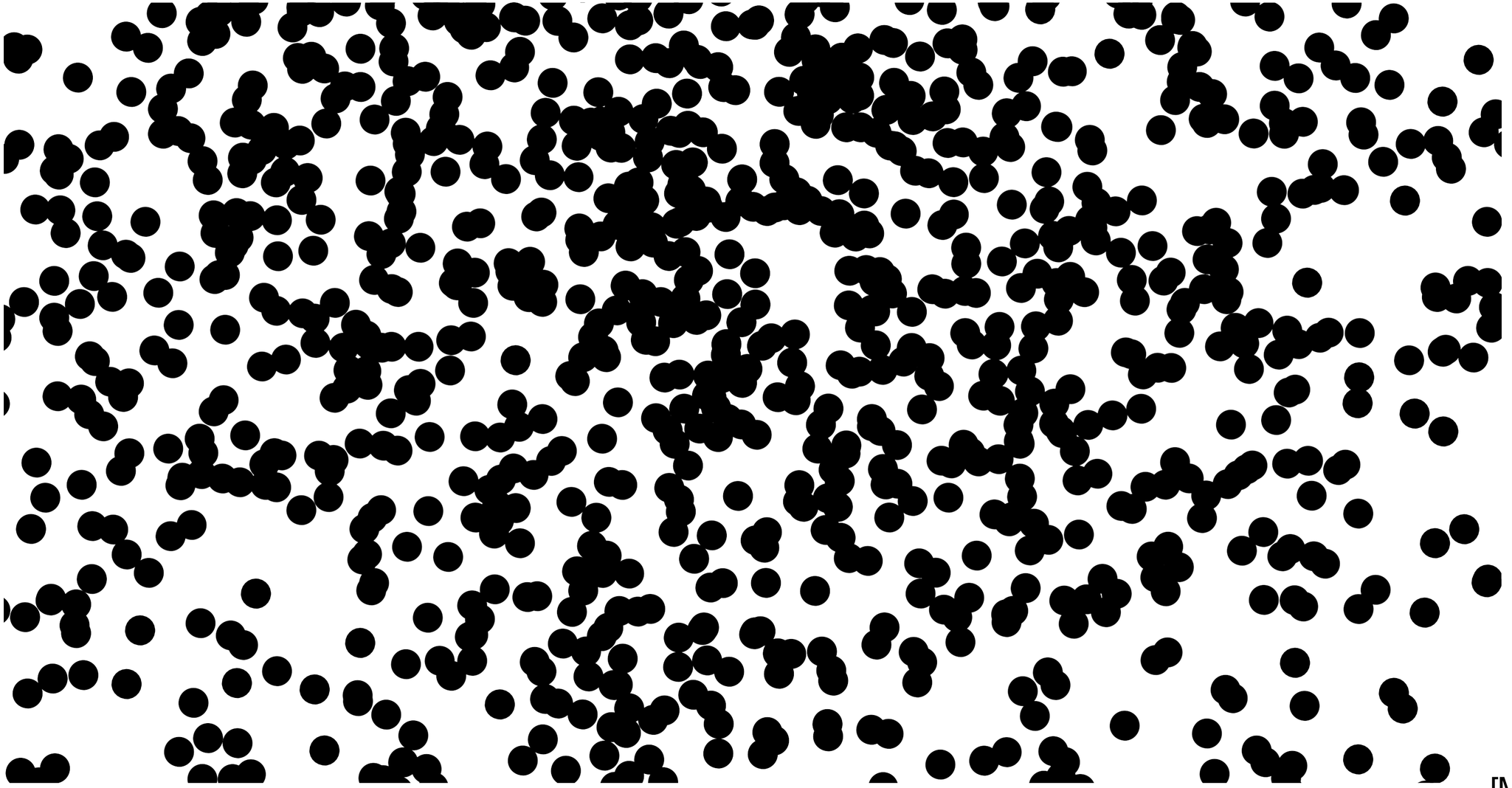
Navigation

- Fix the layout of all visual elements but provide methods for the viewpoint to change
- Camera analogy: only certain features visible in a frame
  - Zooming
  - Panning (aka scrolling)
  - Translating
  - Rotating (rare in 2D, important in 3D)

Zooming

[M. Bostock]

Geometric Zooming

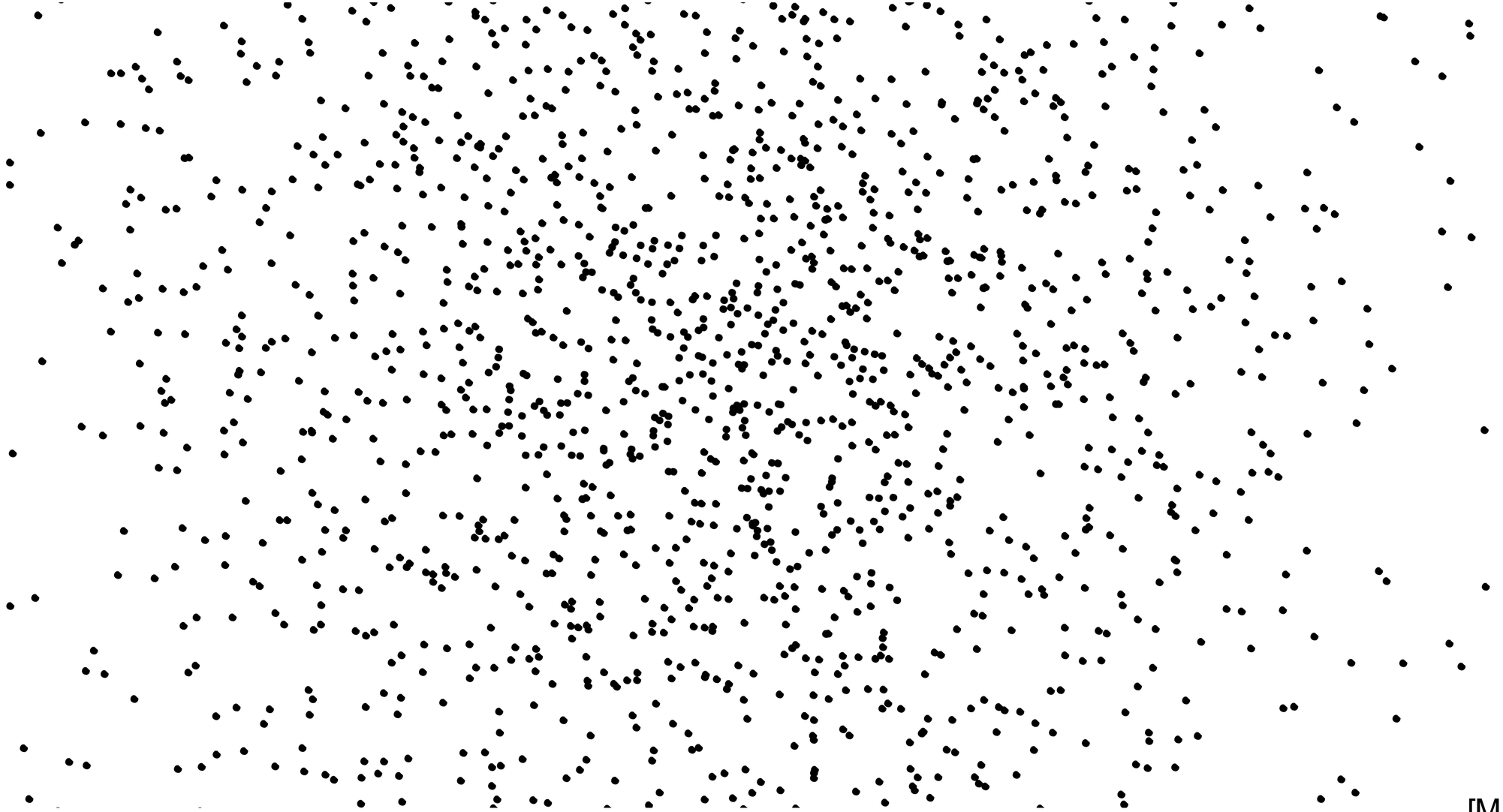


[M. Bostock]

Zooming

[M. Bostock]

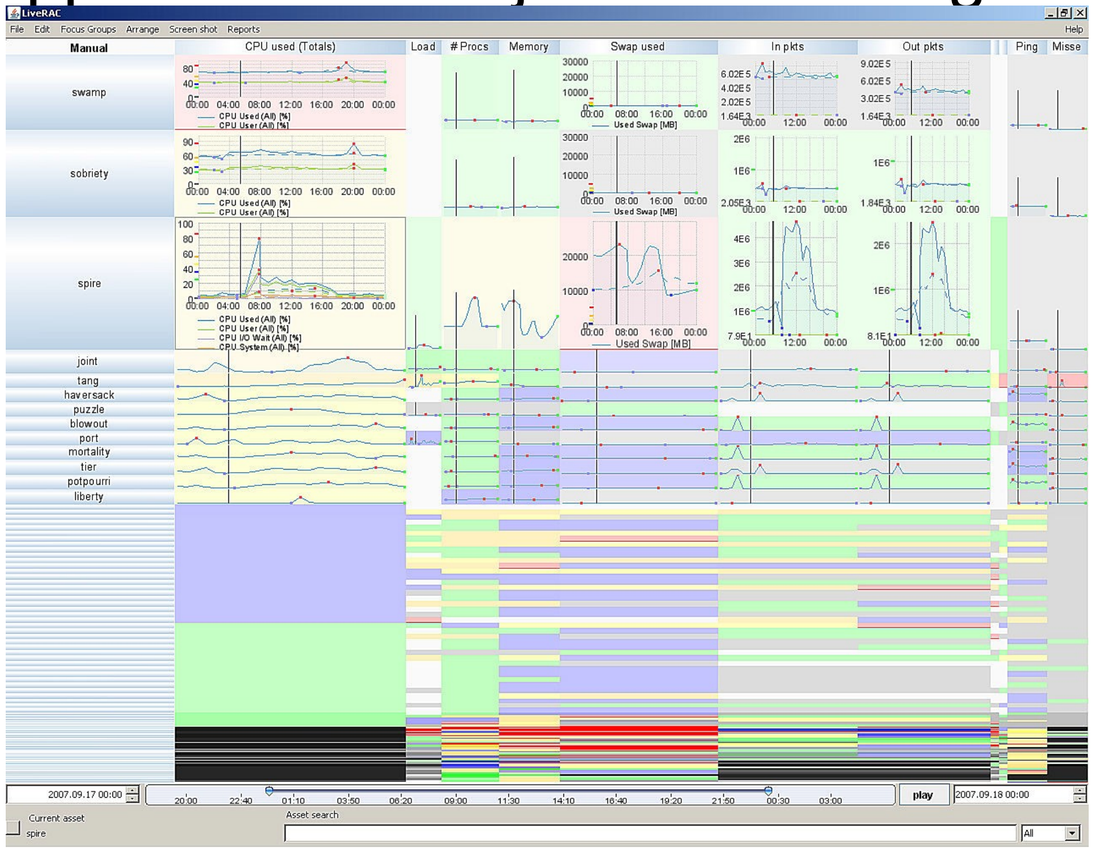
Semantic Zooming



[M. Bostock]

Zooming

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



[McLachlan et al., 2008]

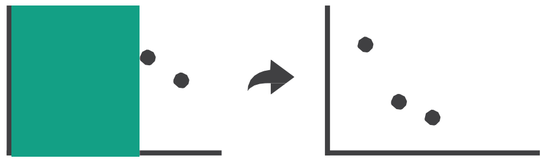
Navigation Constraints

- Unconstrained navigation: walking around in the world or an immersive 3D environment
  - Fairly standard in computer games to go where you want
  - Constrained by walls, objects (collision detection)
- Constrained navigation:
  - 3D: camera must be right-side up
  - Limit pan/zoom to certain areas
  - Comes up often with multiple views: want to show an area in one view that corresponds to a selection in another view

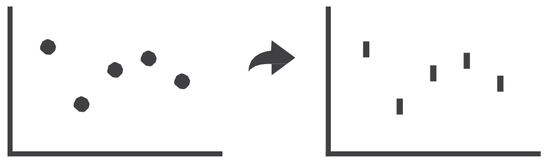
Navigation

- Attribute Reduction
  - *Slice*

  - *Cut*



  - *Project*

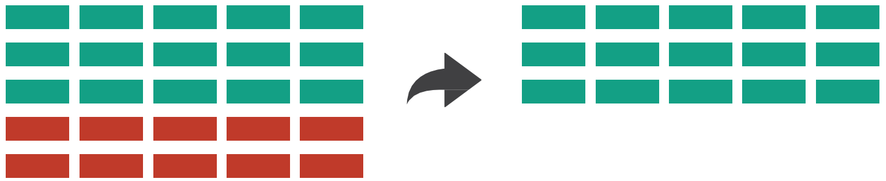


[Munzner (ill. Maguire), 2014]

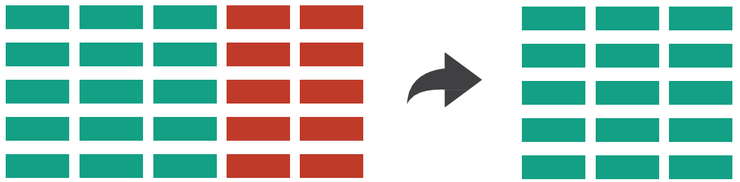
Overview: Reducing Items & Attributes

Filter

- Items

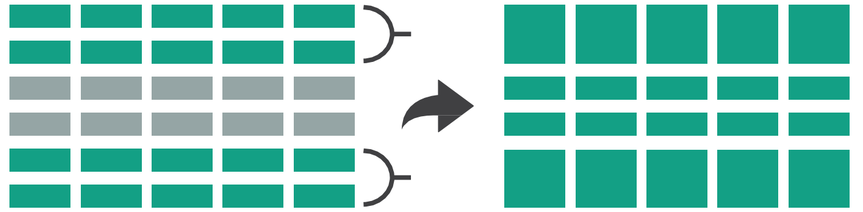


- Attributes

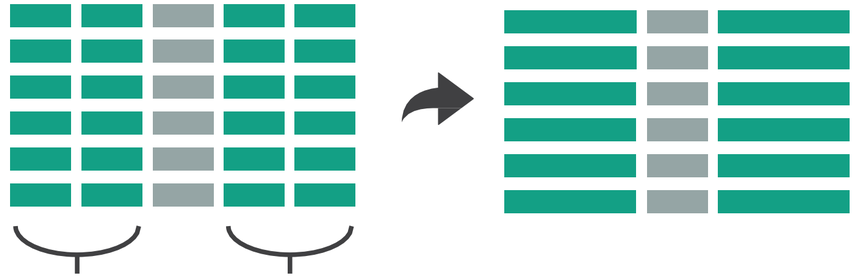


Aggregate

- Items



- Attributes



[Munzner (ill. Maguire), 2014]

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

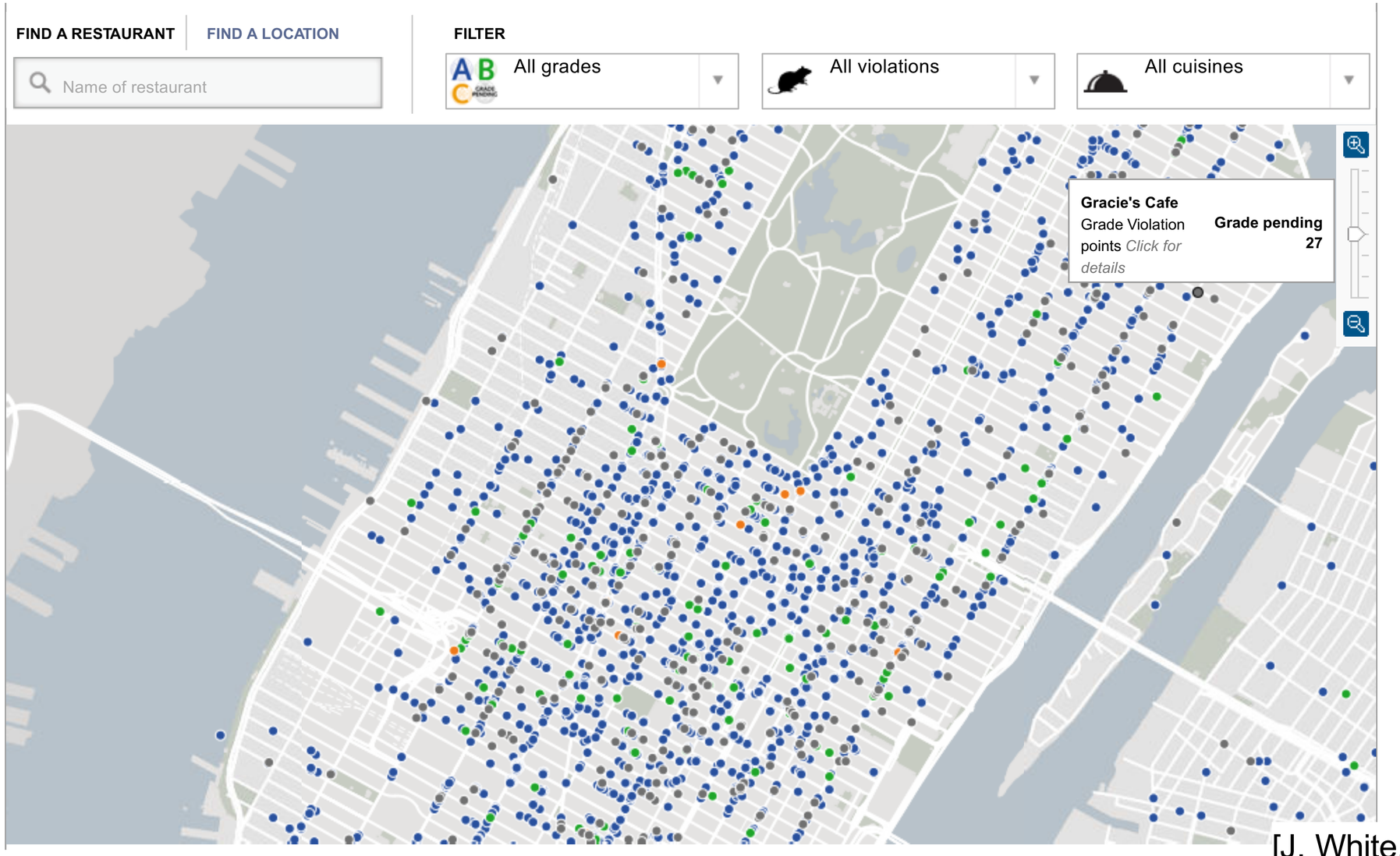
Filtering

- 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

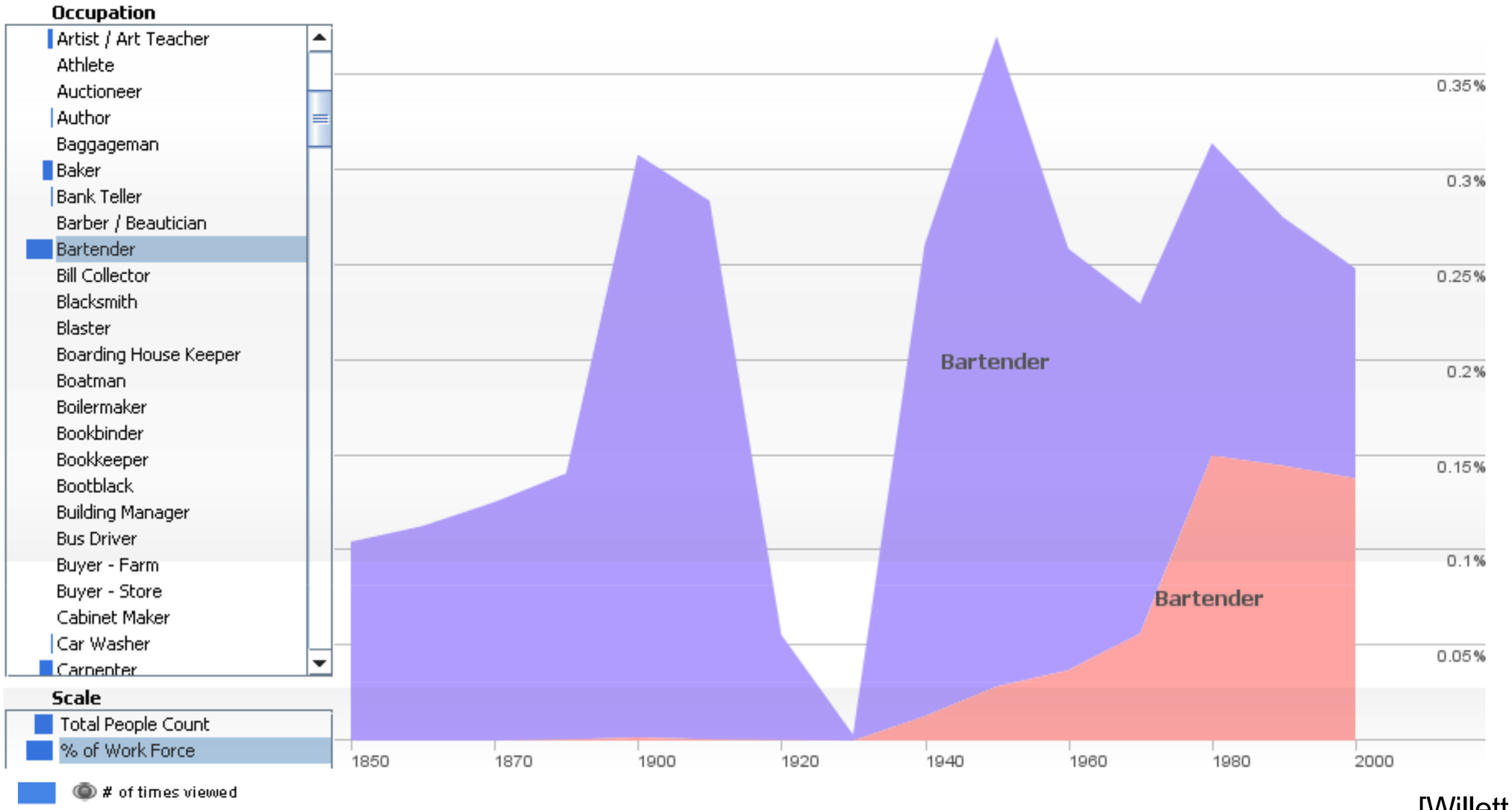


[J. White, New York Times]

Dynamic Filters

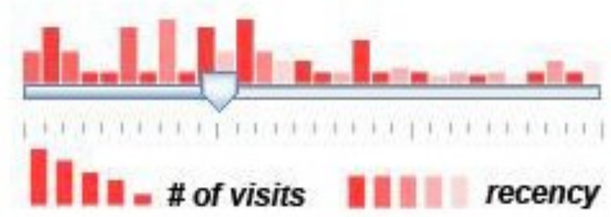
- Interaction need not be with the visualization itself
- Users interact with widgets that control which items are shown
  - Sliders, Combo boxes, Text Fields
- Often tied to attribute values
- Examples:
  - All restaurants with an "A" Grade
  - All pizza places
  - All pizza places with an "A" Grade

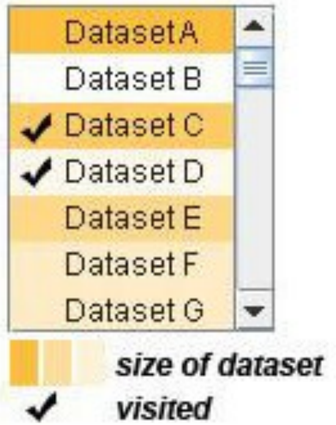
Scented Widgets

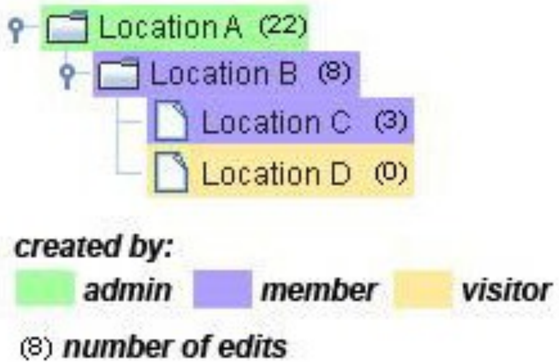


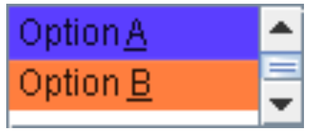
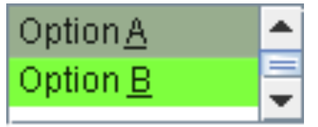
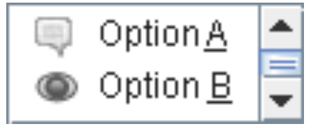
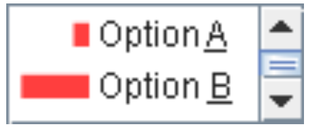
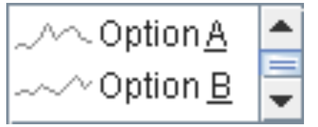
[Willett et al., 2007]

Scented Widgets







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

[Willett et al., 2007]

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

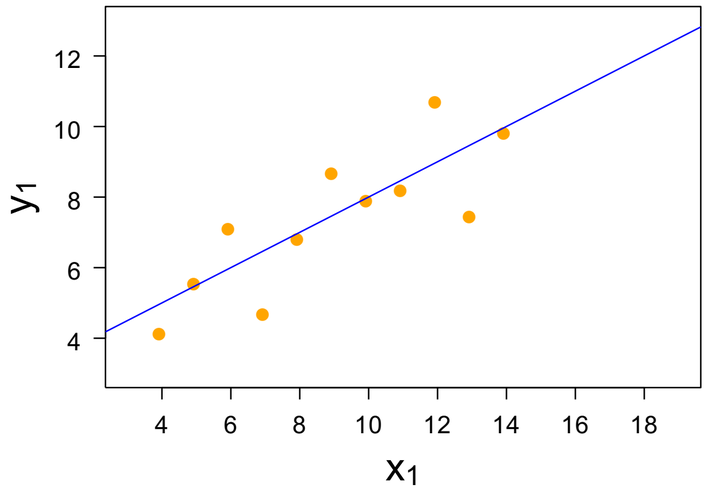
Aggregation

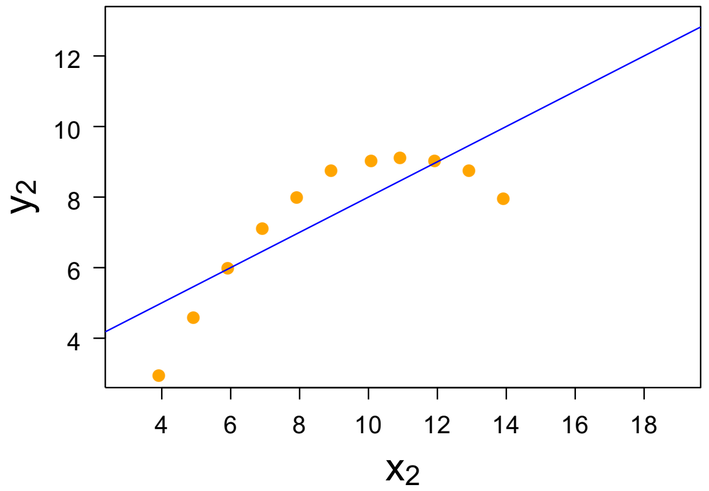
- Usually involves derived attributes
- Examples: mean, median, mode, min, max, count, sum
- Remember expressiveness principle: still want to avoid implying trends or similarities based on aggregation

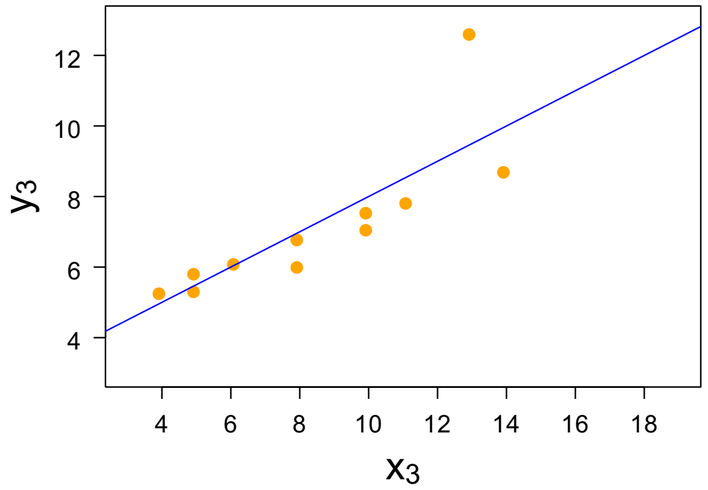
Mean of x	9
Variance of x	11
Mean of y	7.50
Variance of y	4.122
Correlation	0.816

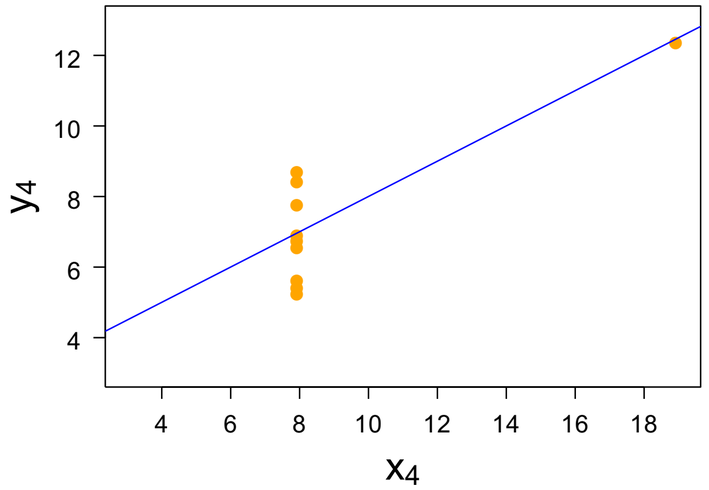
I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	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: Anscombe's Quartet (Summary statistics)



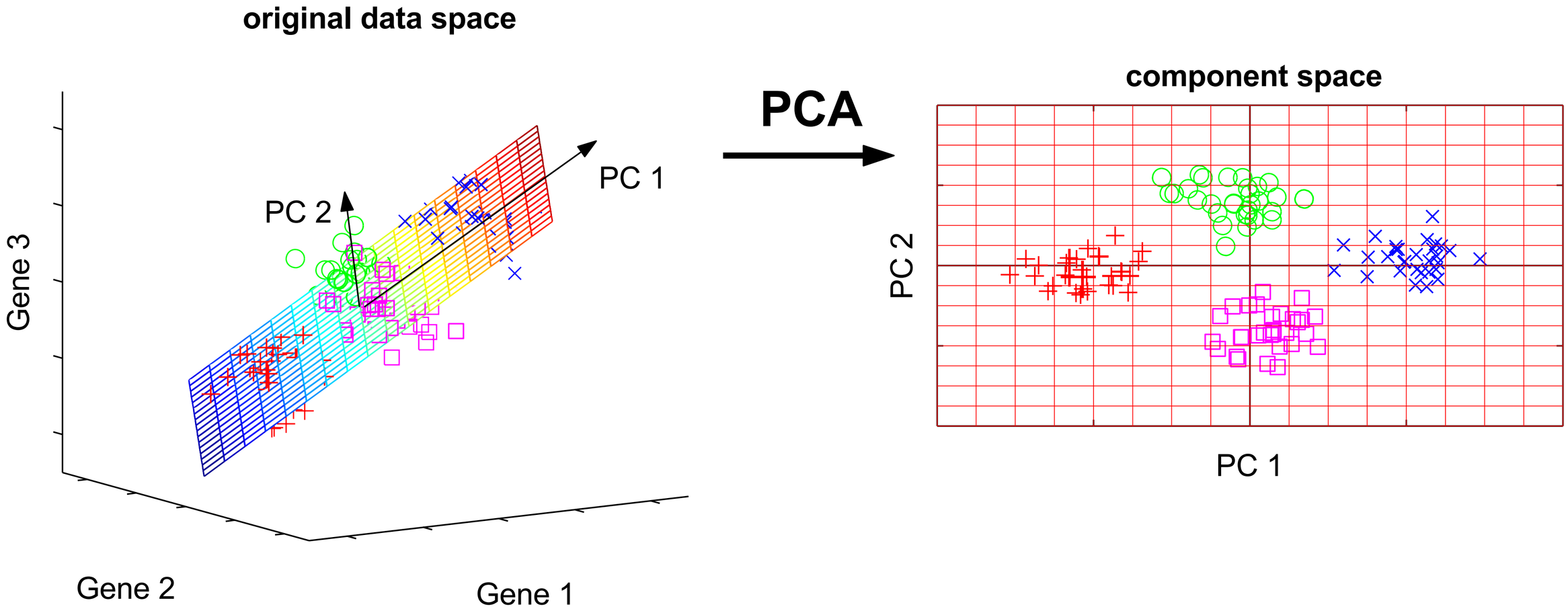






[F. J. Anscombe]

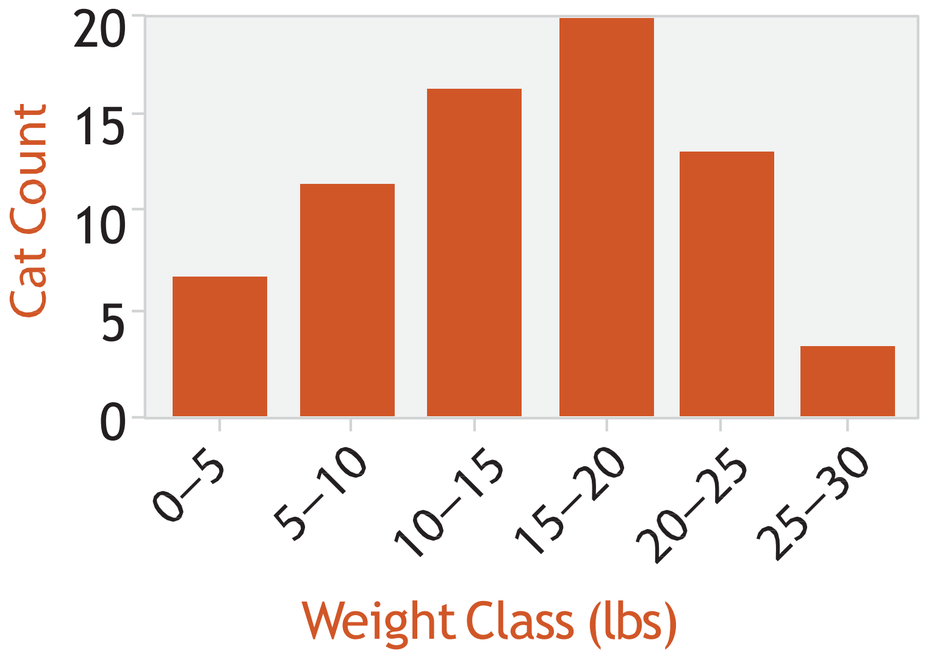
Aggregation (in terms of projection)
Principle Component Analysis (PCA)



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

Aggregation: Histograms

- Very similar to bar charts
- Often shown without space between (continuity)
- Choice of number of bins



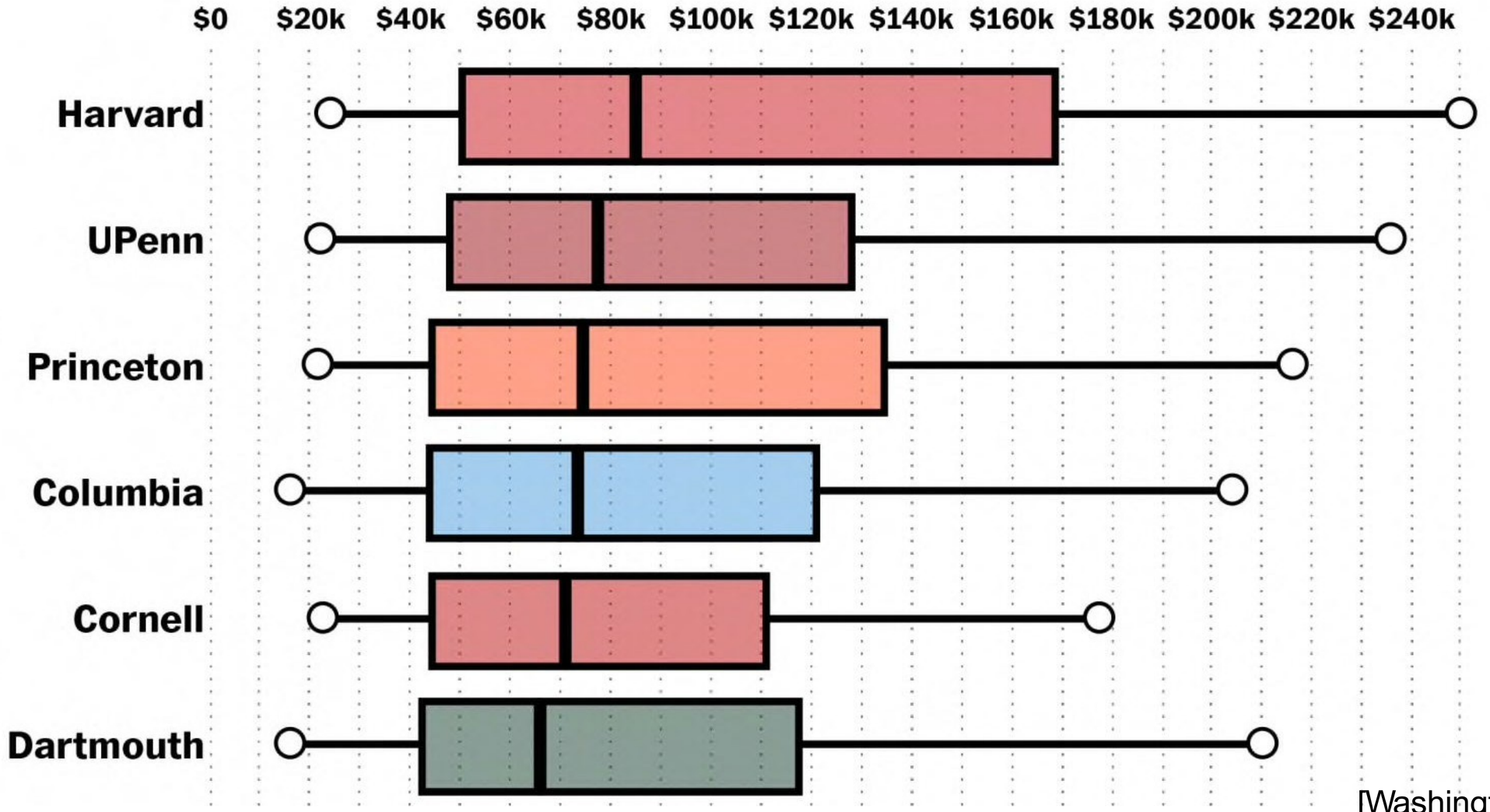
- Important!
- Viewers may infer different trends based on the layout

[Munzner (ill. Maguire), 2014]

Spatial Aggregation

[Penn State, GEOG 486]

Aggregation: Boxplots



[Washington Post, 2015]