

# Information Visualization

---

## Visualization Review

Dr. David Koop

“Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.”

— T. Munzner

# Definition

	REMOTE	STATION	FF	SEN/DIS	7-D AFAS UNL	D AFAS/RMF I	JOINT RR TKT	7-D UNL	30-D UNL
1	R011	42ND STREET & 8TH AVENUE	00228985	00008471	00000441	00001455	00000134	00033341	00071255
2	R170	14TH STREET-UNION SQUARE	00224603	00011051	00000827	00003026	00000660	00089367	00199841
3	R046	42ND STREET & GRAND CENTRAL	00207758	00007908	00000323	00001183	00003001	00040759	00096613
4	R012	34TH STREET & 8TH AVENUE	00188311	00006490	00000498	00001279	00003622	00035527	00067483
5	R293	34TH STREET - PENN STATION	00168768	00006155	00000523	00001065	000050		
6	R033	42ND STREET/TIMES SQUARE	00159382	00005945	00000378	00001205	000006		
7	R022	34TH STREET & 6TH AVENUE	00156008	00006276	00000487	00001543	000007		
8	R084	59TH STREET/COLUMBUS CIRCLE	00155262	00009484	00000589	00002071	000005		
9	R020	47-50 STREETS/ROCKEFELLER	00143500	00006402	00000384	00001159	000007		
10	R179	86TH STREET-LEXINGTON AVE	00142169	00010367	00000470	00001839	000002		
11	R023	34TH STREET & 6TH AVENUE	00134052	00005005	00000348	00001112	000006		
12	R029	PARK PLACE	00121614	00004311	00000287	00000931	000007		
13	R047	42ND STREET & GRAND CENTRAL	00100742	00004273	00000185	00000704	000012		
14	R031	34TH STREET & 7TH AVENUE	00095076	00003990	00000232	00000727	00001459	00024284	00038671
15	R017	LEXINGTON AVENUE	00094655	00004688	00000190	00000833	00000754	00020018	00055066
16	R175	8TH AVENUE-14TH STREET	00094313	00003907	00000286	00001144	00000256	00038272	00074661
17	R057	BARCLAYS CENTER	00093804	00004204	00000454	00001386	00001491	00039113	00068119
18	R138	WEST 4TH ST-WASHINGTON SQ	00093562	00004677	00000251	00000965	00000127	00031628	00074458

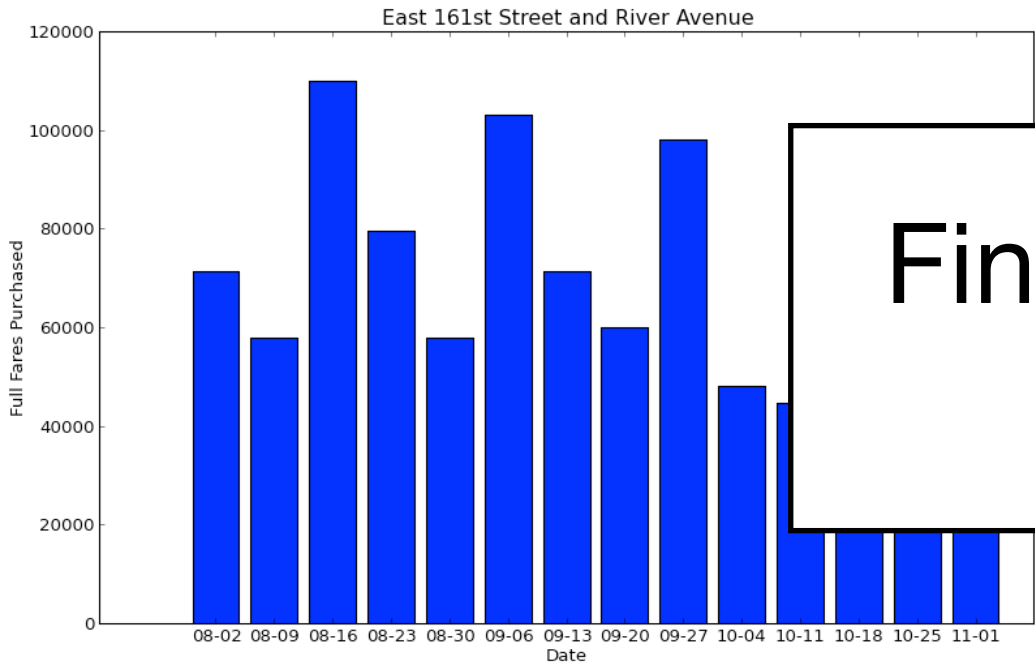
NYC Subway  
Fare Data

Definition

	REMOTE	STATION	FF	SEN/DIS	7-D AFAS UNL	D AFAS/RMF L	JOINT RR TKT	7-D UNL	30-D UNL
1	R011	42ND STREET & 8TH AVENUE	00228985	00008471	00000441	00001455	00000134	00033341	00071255
2	R170	14TH STREET-UNION SQUARE	00224603	00011051	00000827	00003026	00000660	00089367	00199841
3	R046	42ND STREET & GRAND CENTRAL	00207758	00007908	00000323	00001183	00003001	00040759	00096613
4	R012	34TH STREET & 8TH AVENUE	00188311	00006490	00000498	00001279	00003622	00035527	00067483
5	R293	34TH STREET - PENN STATION	00168768	00006155	00000523	00001065	000050		
6	R033	42ND STREET/TIMES SQUARE	00159382	00005945	00000378	00001205	000006		
7	R022	34TH STREET & 6TH AVENUE	00156008	00006276	00000487	00001543	000007		
8	R084	59TH STREET/COLUMBUS CIRCLE	00155262	00009484	00000589	00002071	000005		
9	R020	47-50 STREETS/ROCKEFELLER	00143500	00006402	00000384	00001159	000007		
10	R179	86TH STREET-LEXINGTON AVE	00142169	00010367	00000470	00001839	000002		
11	R023	34TH STREET & 6TH AVENUE	00134052	00005005	00000348	00001112	000006		
12	R029	PARK PLACE	00121614	00004311	00000287	00000931	000007		
13	R047	42ND STREET & GRAND CENTRAL	00100742	00004273	00000185	00000704	000012		
14	R031	34TH STREET & 7TH AVENUE	00095076	00003990	00000232	00000727	00001459	00024284	00038671
15	R017	LEXINGTON AVENUE	00094655	00004688	00000190	00000833	00000754	00020018	00055066
16	R175	8TH AVENUE-14TH STREET	00094313	00003907	00000286	00001144	00000256	00038272	00074661
17	R057	BARCLAYS CENTER	00093804	00004204	00000454	00001386	00001491	00039113	00068119
18	R138	WEST 4TH ST-WASHINGTON SQ	00093562	00004677	00000251	00000965	00000127	00031628	00074458

NYC Subway Fare Data

Definition



Find Interesting NYC Subway Ridership Patterns

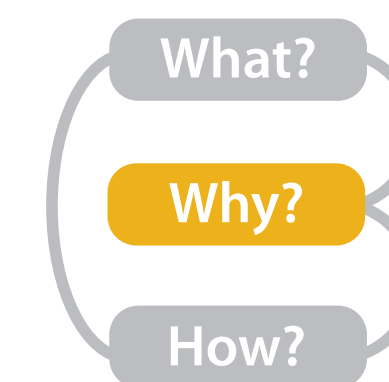
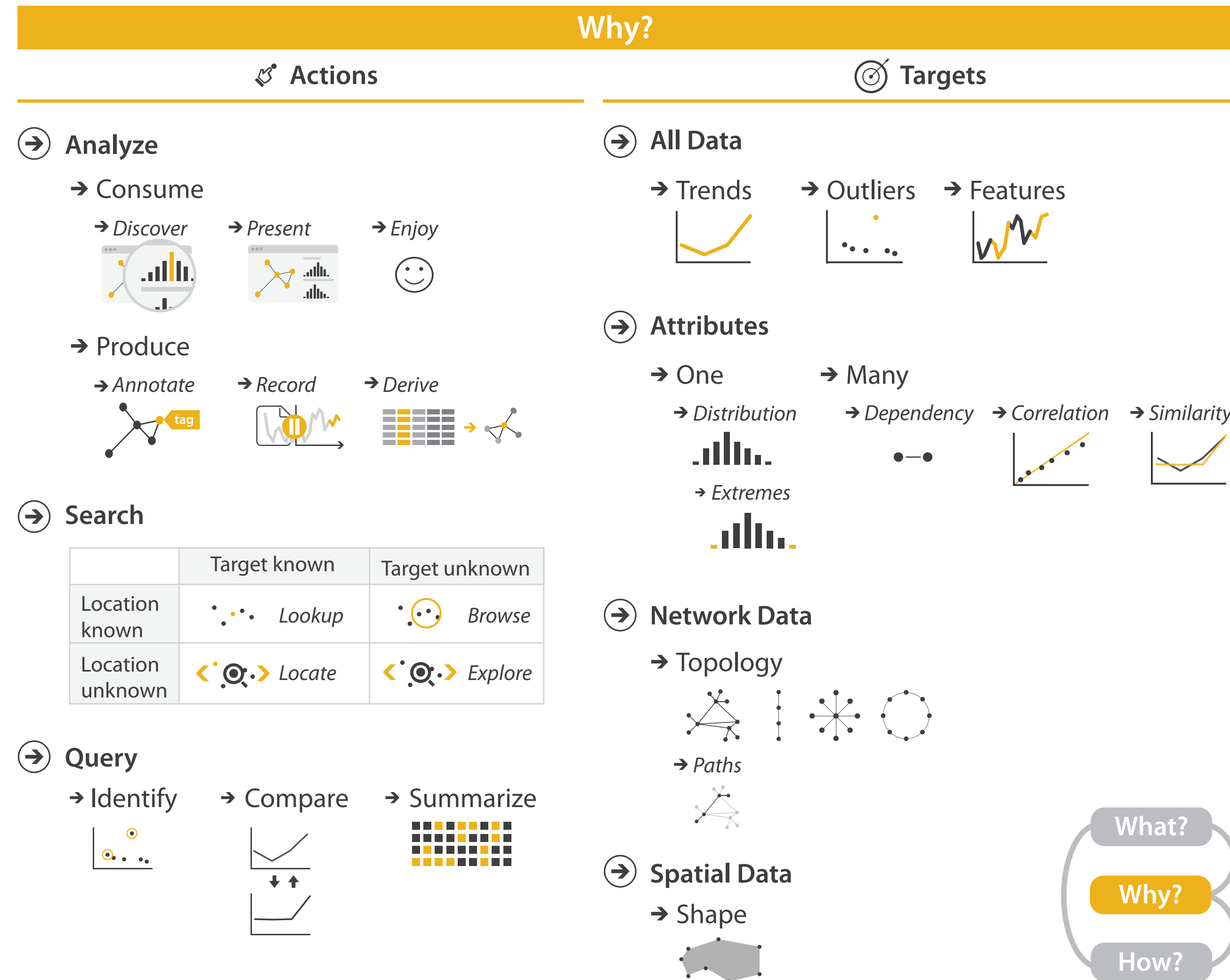
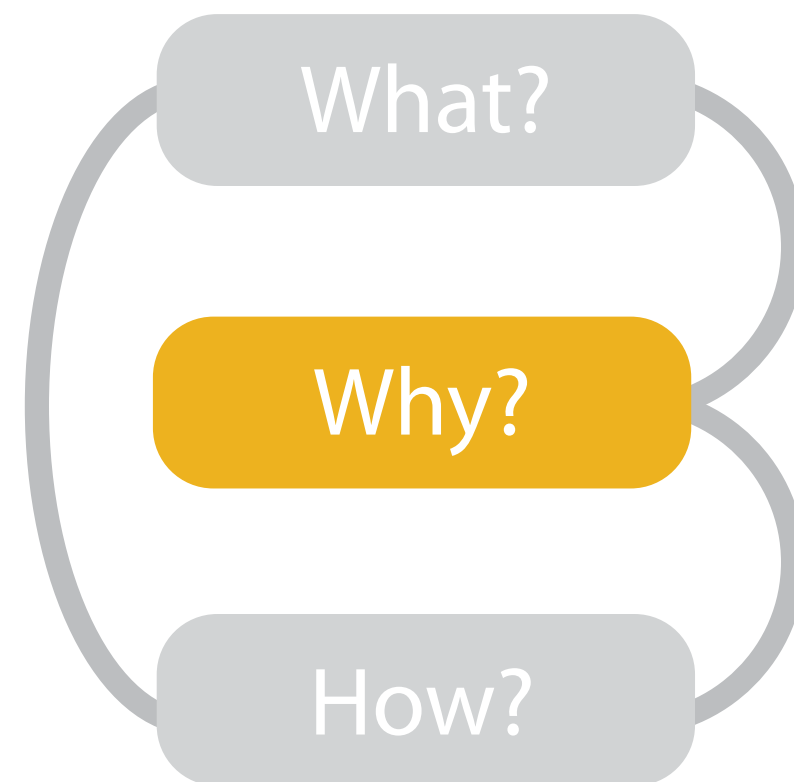


# Categorical, Ordinal, and Quantitative

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
32	7/16/07	2-High	Medium Box	0.6	7/18/07
32	7/16/07	2-High	Medium Box	0.65	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
69	6/4/05	4-Not Specified		0.6	6/6/05
70	12/18/06	5-Low		0.59	12/23/06
70	12/18/06	5-Low		0.82	12/23/06
96	4/17/05	2-High		0.55	4/19/05
97	1/29/06	3-Medium		0.38	1/30/06
129	11/19/08	5-Low		0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
166	9/12/07	2-High	Small Box	0.55	9/14/07
193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

quantitative  
ordinal  
categorical

# Tasks



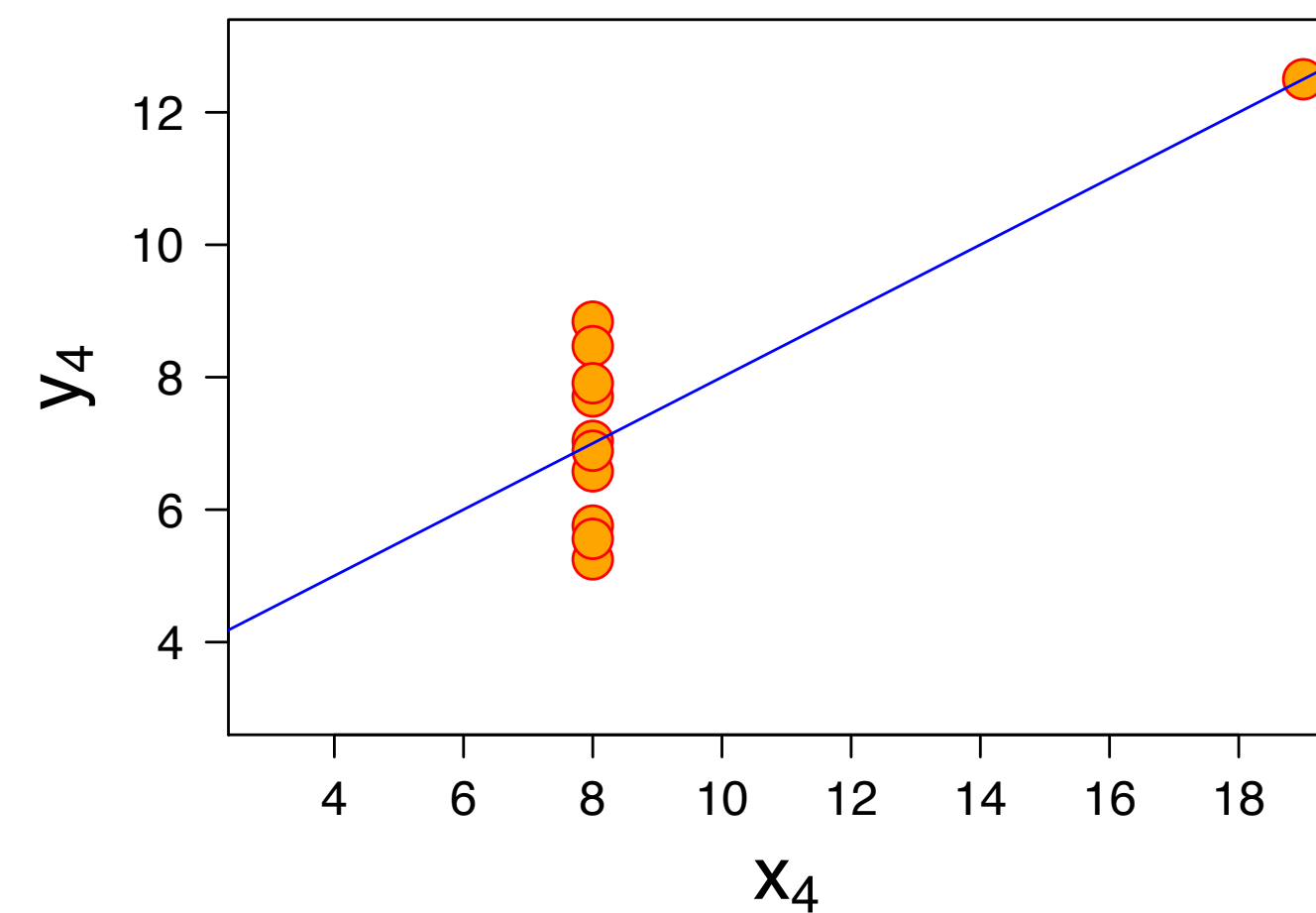
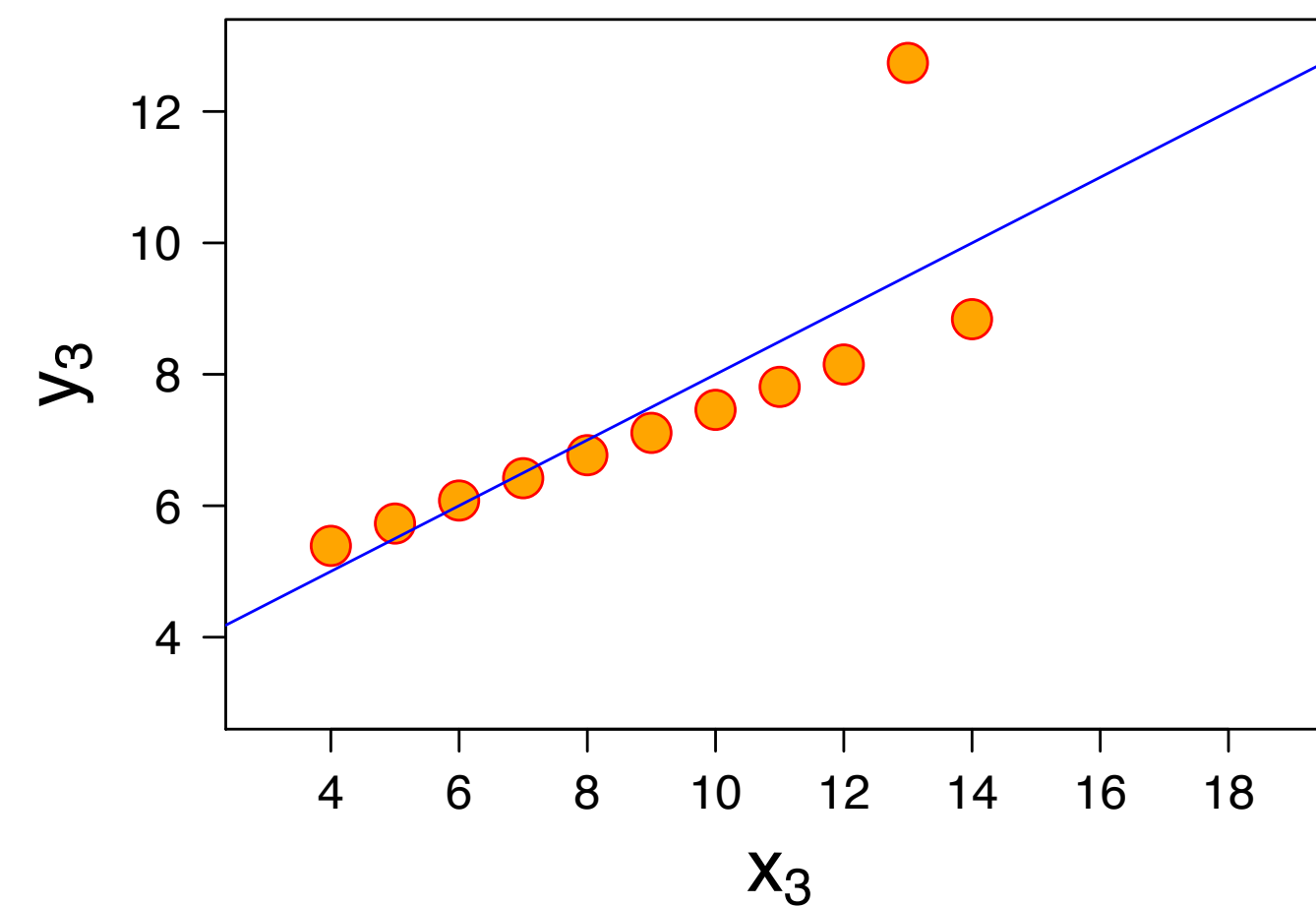
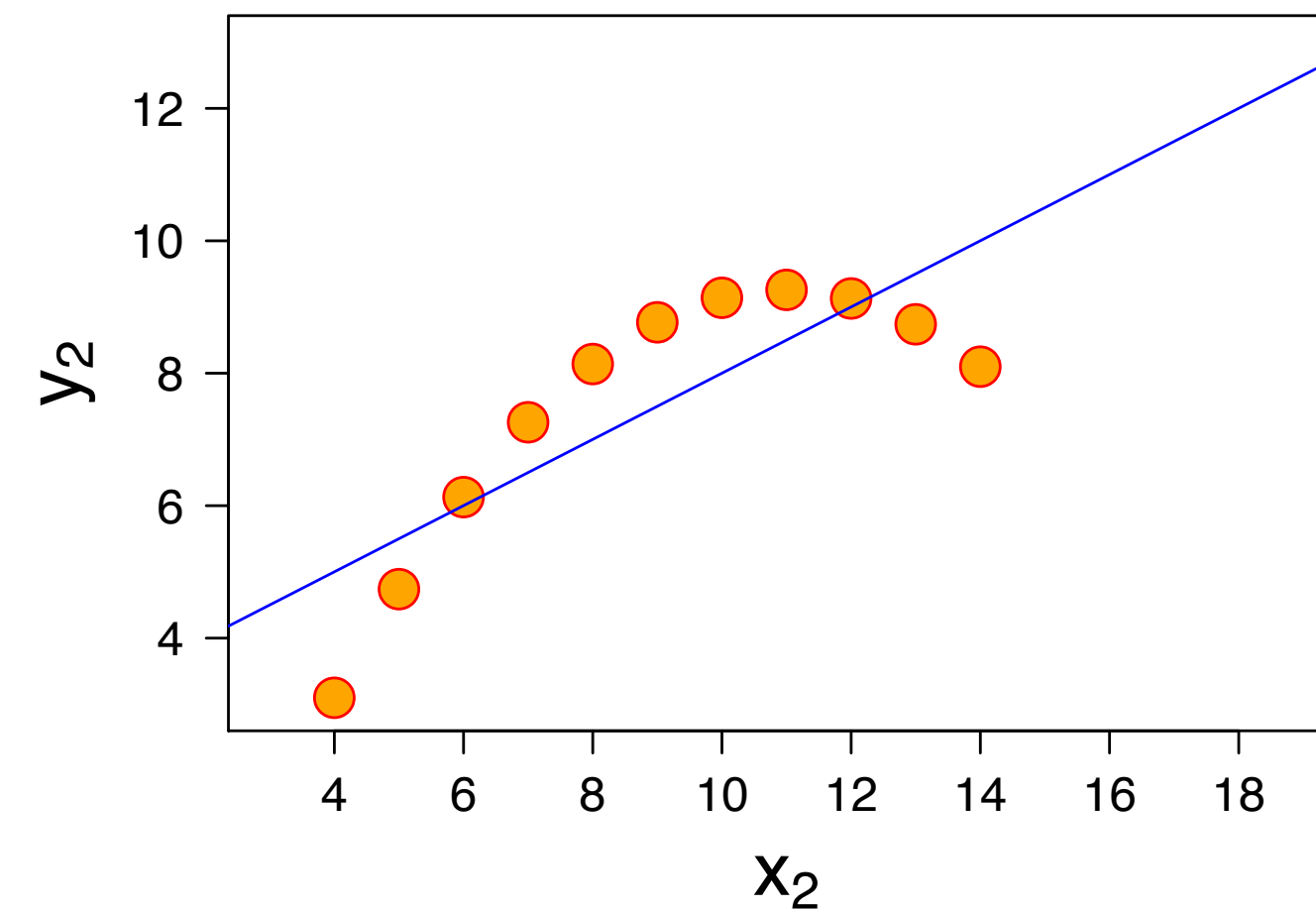
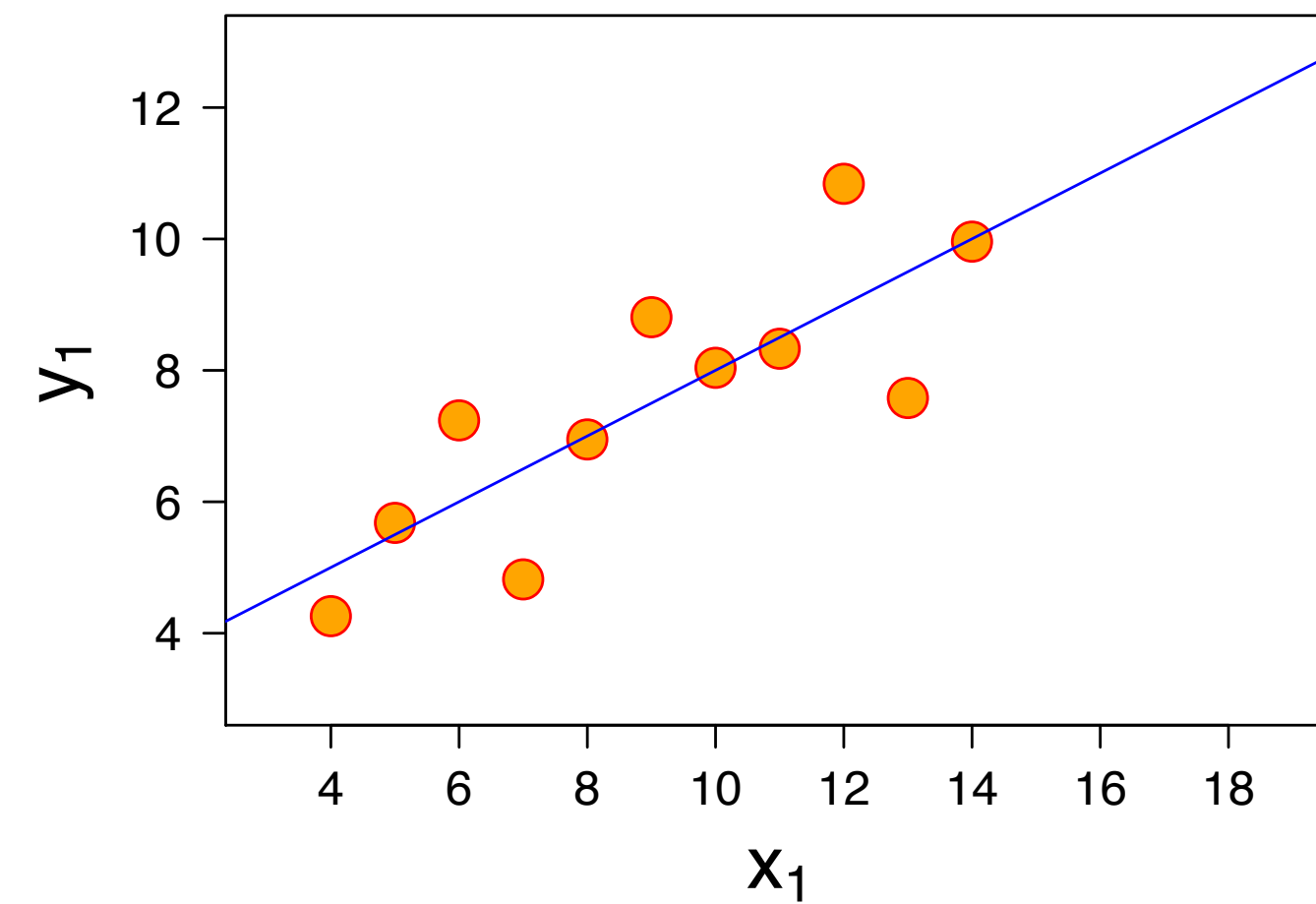
[Munzner (ill. Maguire), 2014]



# Definition

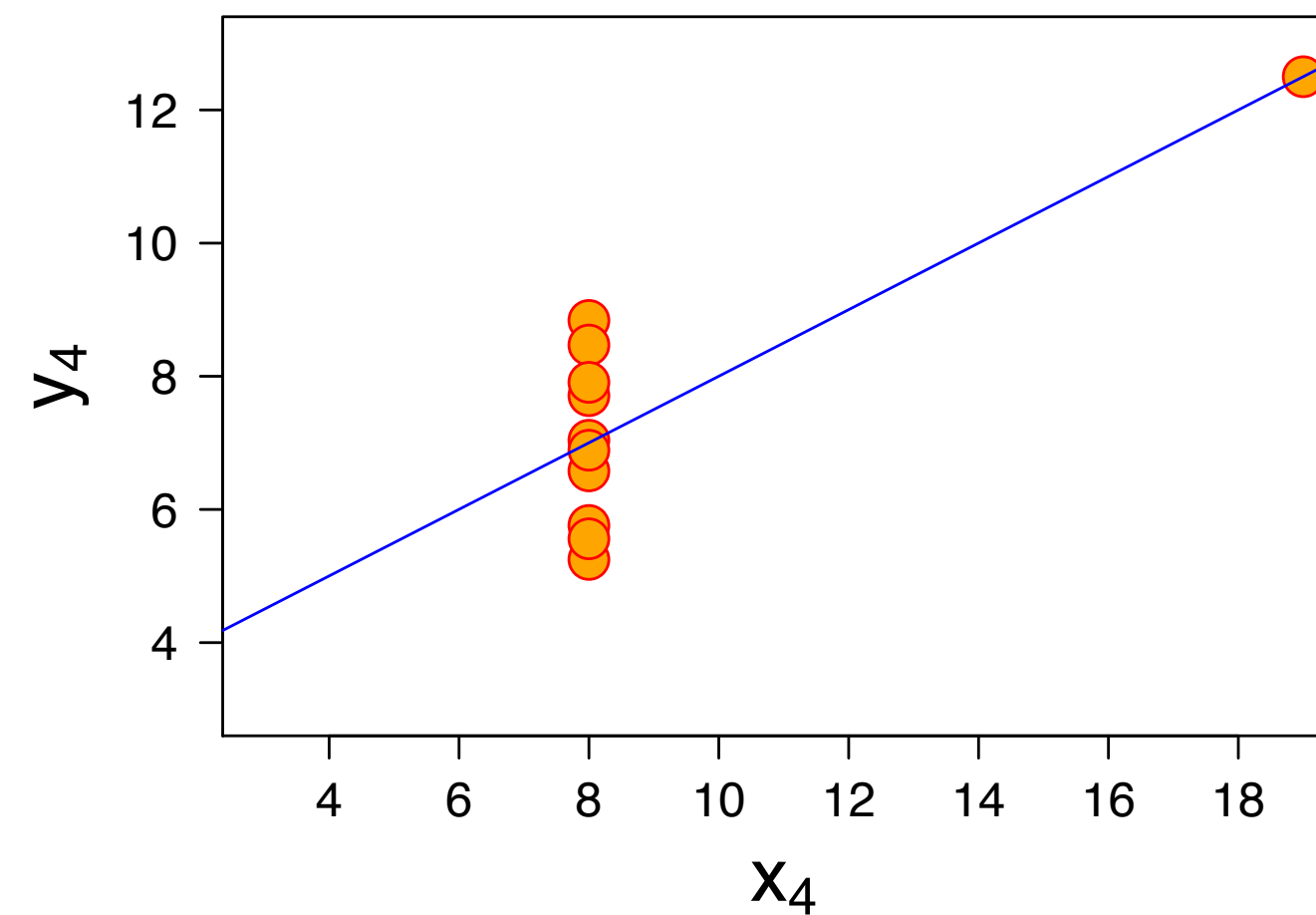
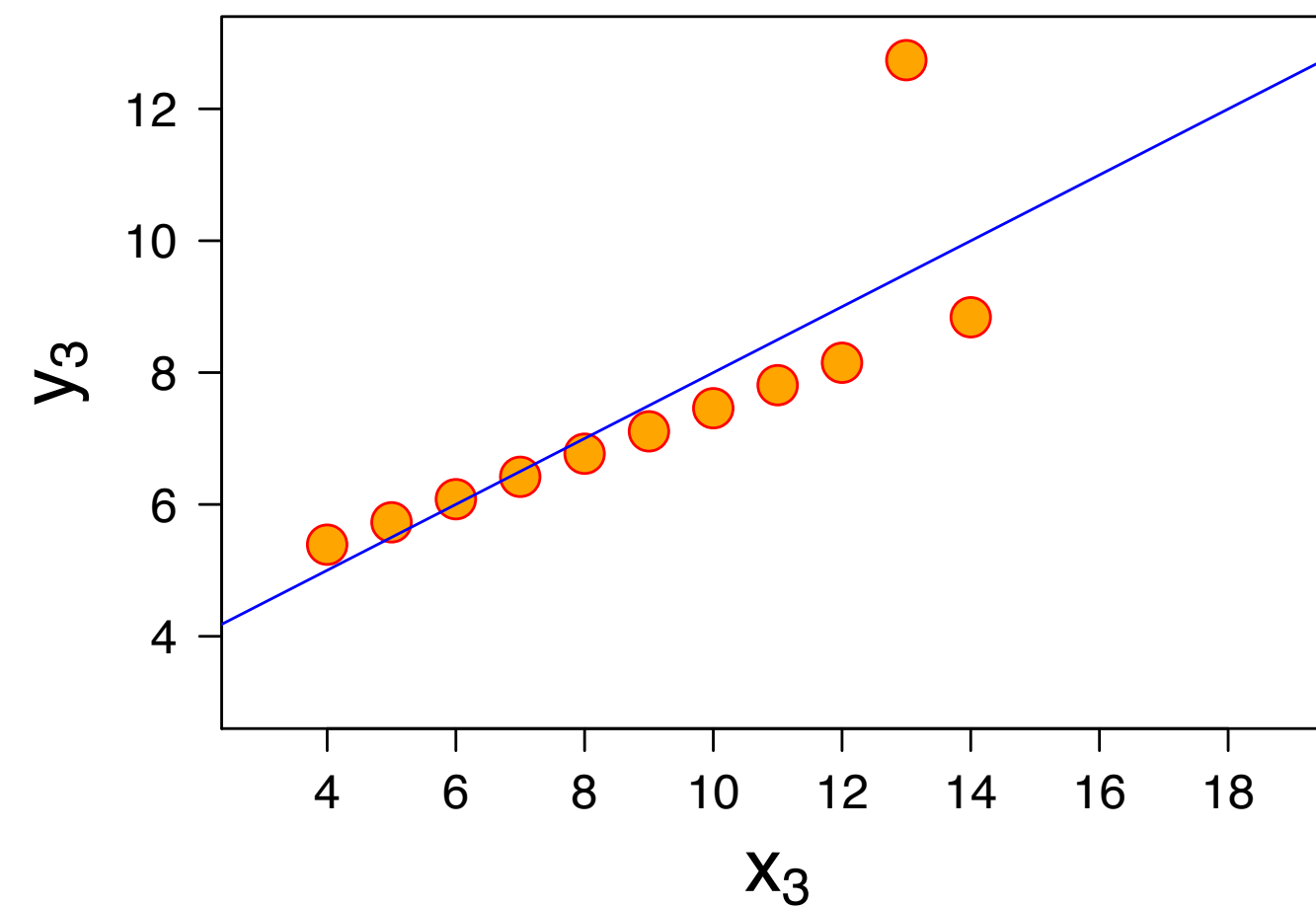
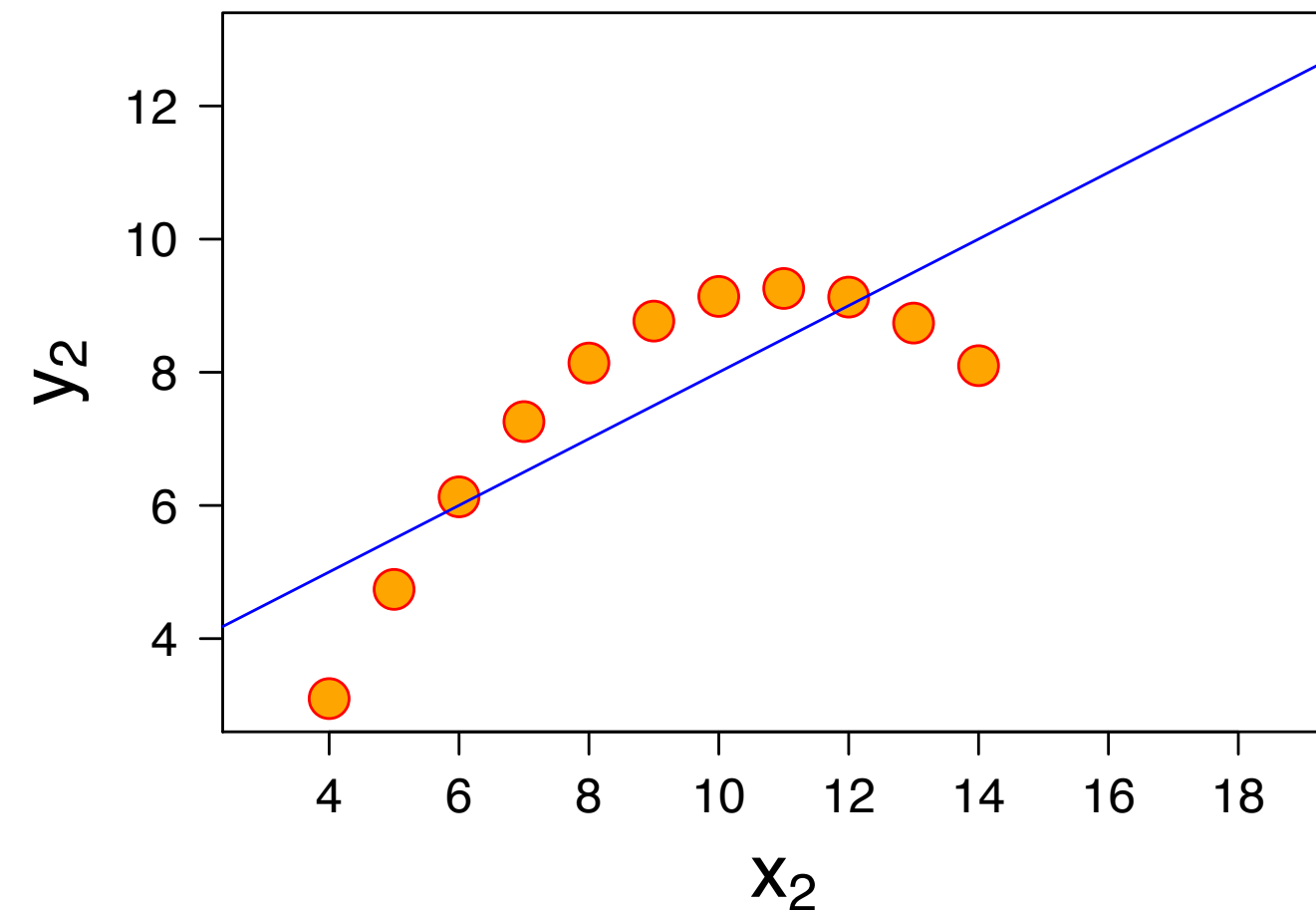
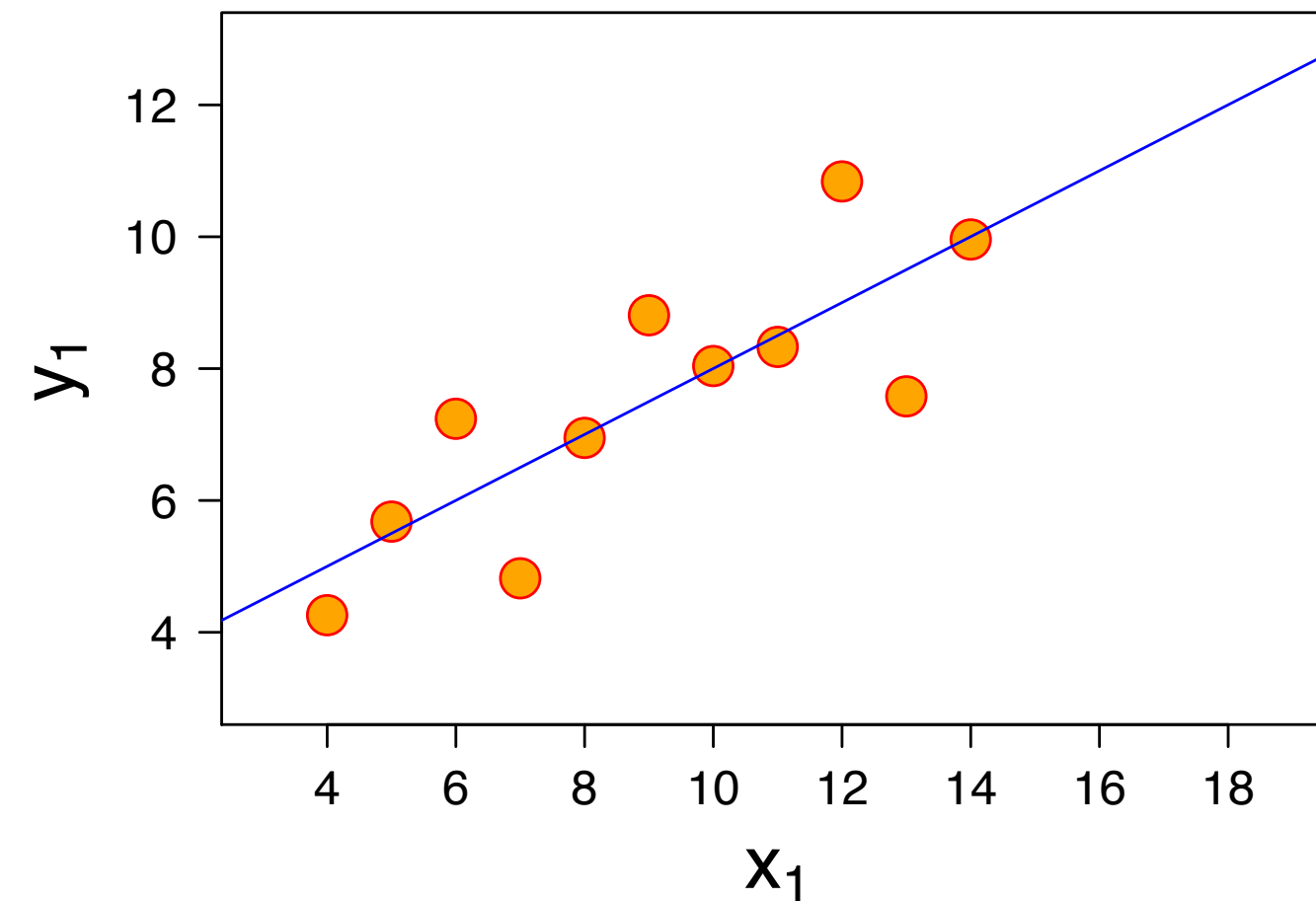


# Why Visual?



[F. J. Anscombe]

# Why Visual?



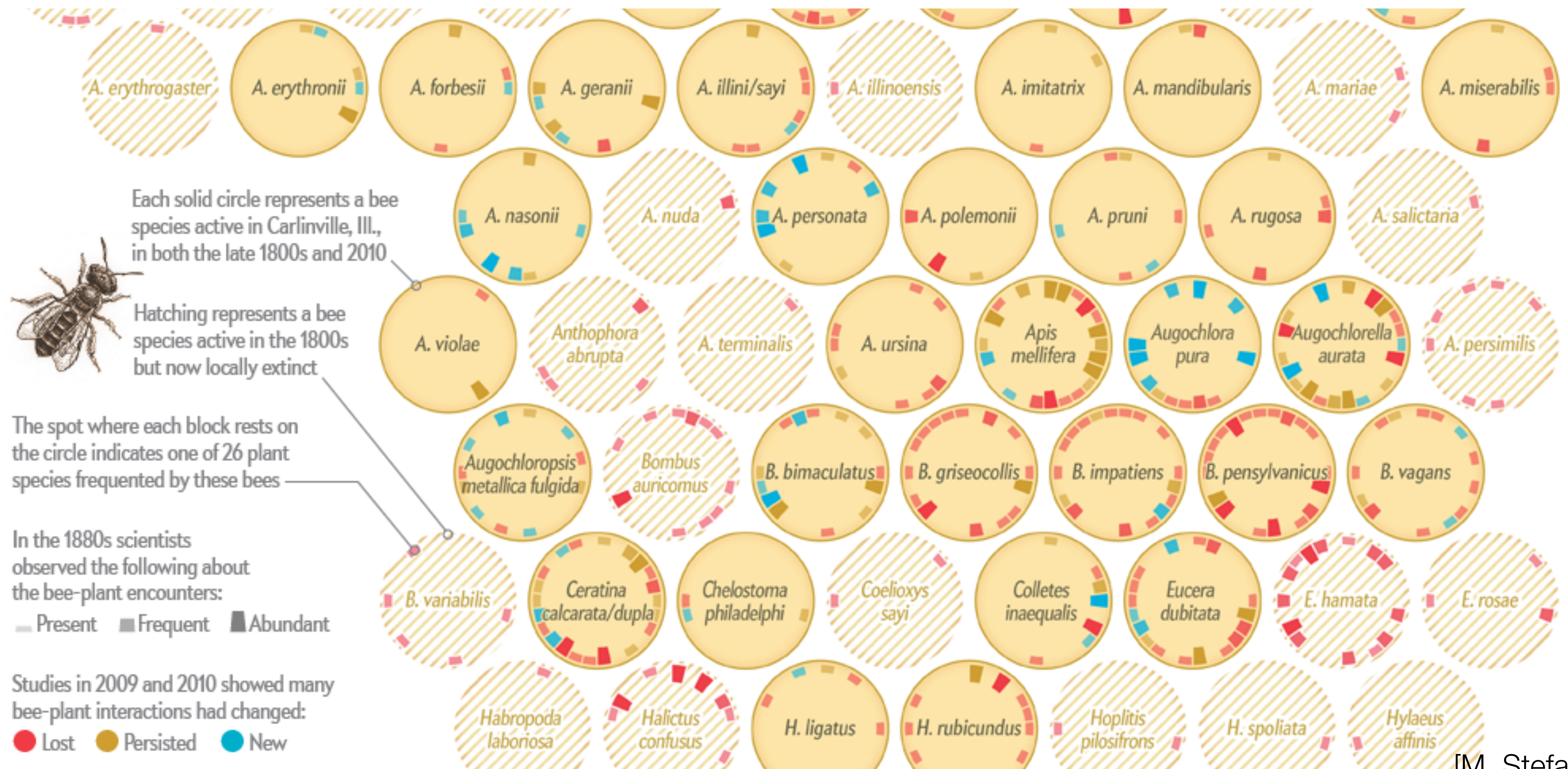
Mean of x	9
Variance of x	11
Mean of y	7.50
Variance of y	4.122
Correlation	0.816

[F. J. Anscombe]

# Definition



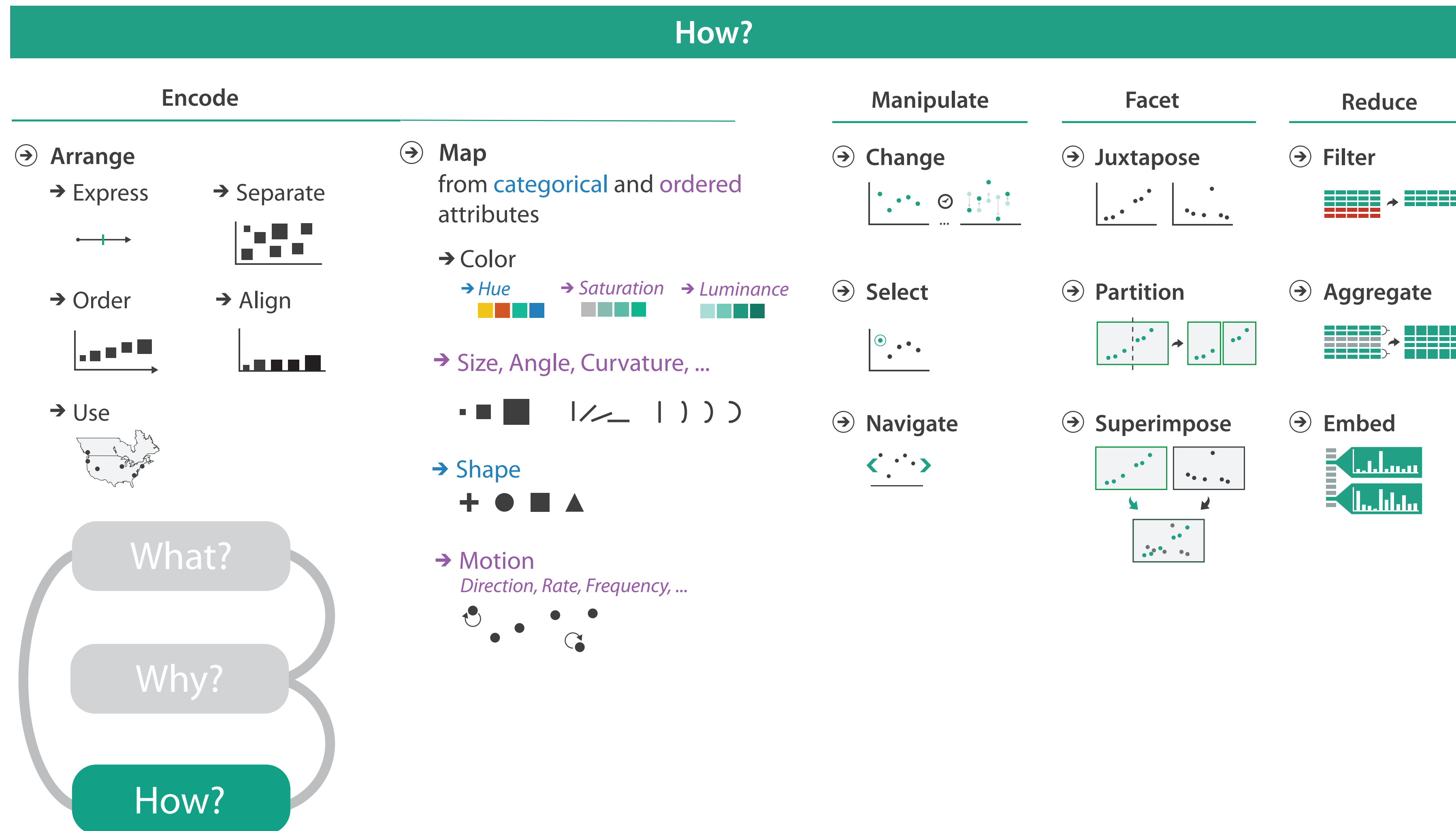
# Design Example



[M. Stefaner, 2013]



# How do we do visualization?



[Munzner (ill. Maguire), 2014]

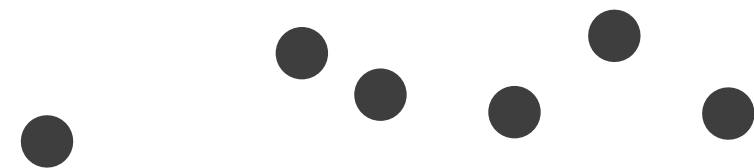


# Visual Encoding

---

- How do we encode data visually?
  - **Marks** are the basic graphical elements in a visualization
  - **Channels** are ways to control the appearance of the marks
- Marks classified by dimensionality:

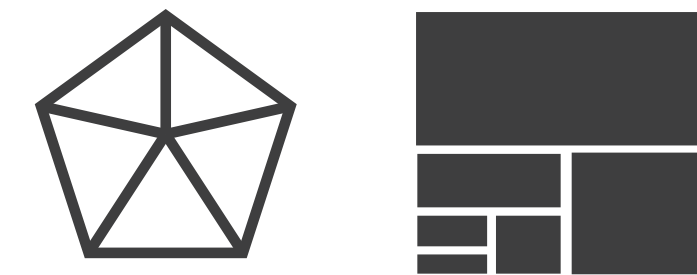
➞ **Points**



➞ **Lines**



➞ **Areas**



- Also can have surfaces, volumes
- Think of marks as a mathematical definition, or if familiar with tools like Adobe

# Visual Channels

## ➔ Position

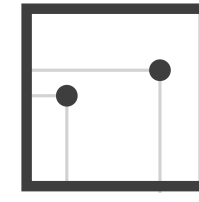
➔ Horizontal



➔ Vertical



➔ Both



## ➔ Color



## ➔ Shape



## ➔ Tilt

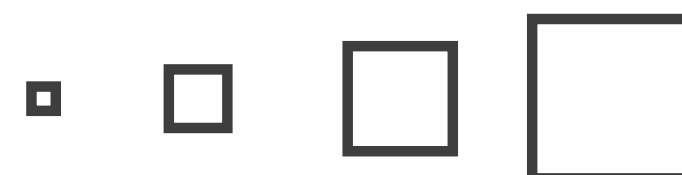


## ➔ Size

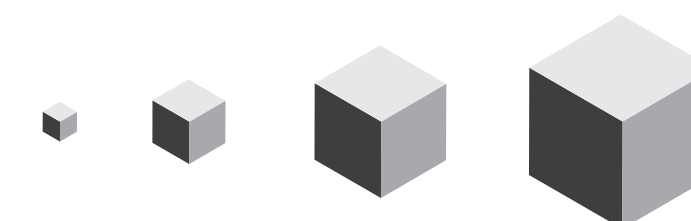
➔ Length



➔ Area



➔ Volume



[Munzner (ill. Maguire), 2014]

# Channels by Effectiveness

Channels: Expressiveness Types and Effectiveness Ranks

## ➔ **Magnitude** Channels: **Ordered** Attributes

Position on common scale 

Position on unaligned scale 

Length (1D size) 

Tilt/angle 

Area (2D size) 

Depth (3D position) 

Color luminance 

Color saturation 

Curvature 

Volume (3D size) 

Same

Same

Same

Most

Effectiveness

Least

## ➔ **Identity** Channels: **Categorical** Attributes

Spatial region 

Color hue 

Motion 

Shape 

[Munzner (ill. Maguire), 2014]

# Topic Survey

---

- Thanks for completing
- Will be finalizing the topics soon and releasing another survey to rank topics/  
dates to present

# Next Unit

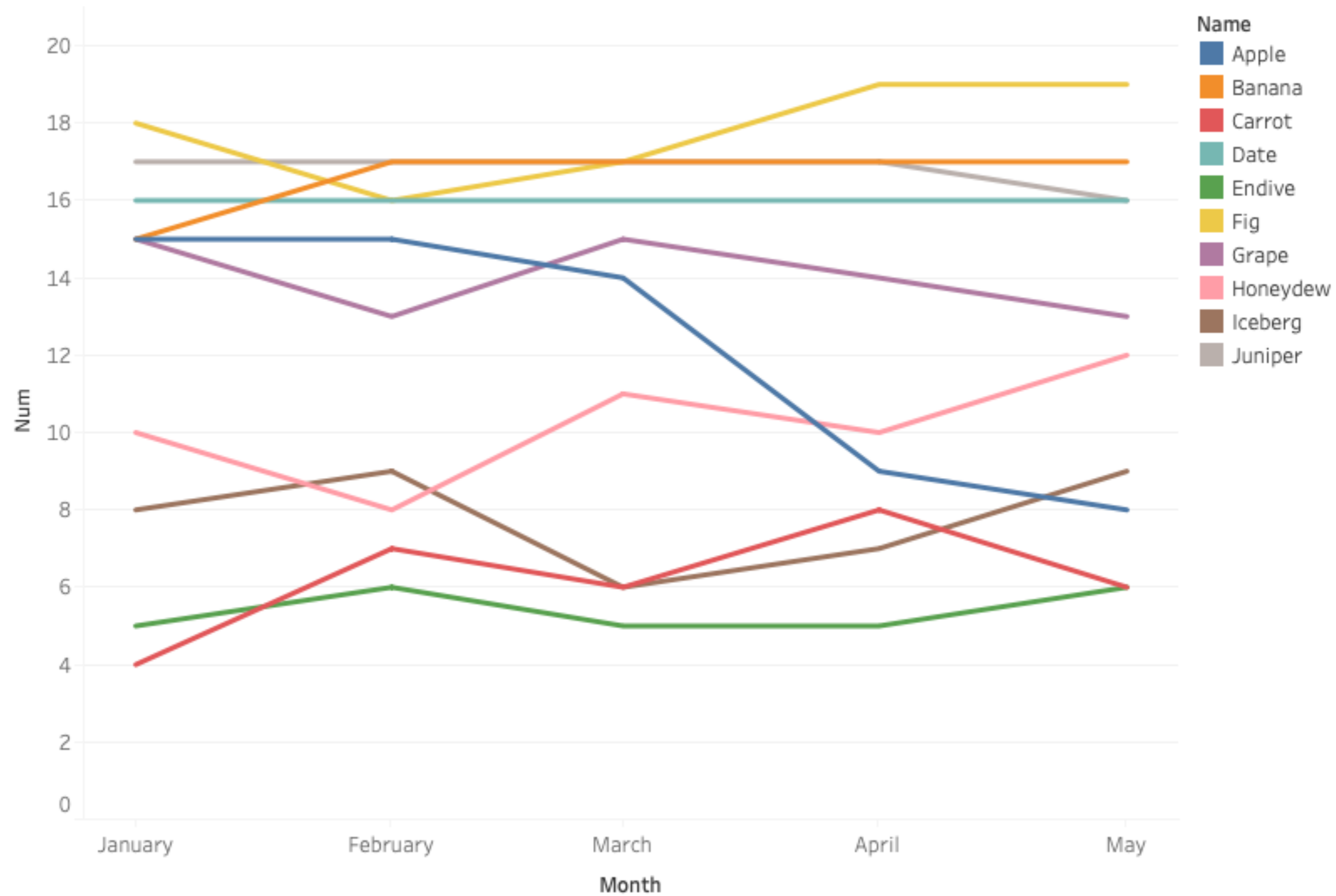
---

- Reading & Writing for InfoVis
- Critiquing InfoVis
- ...but also in general

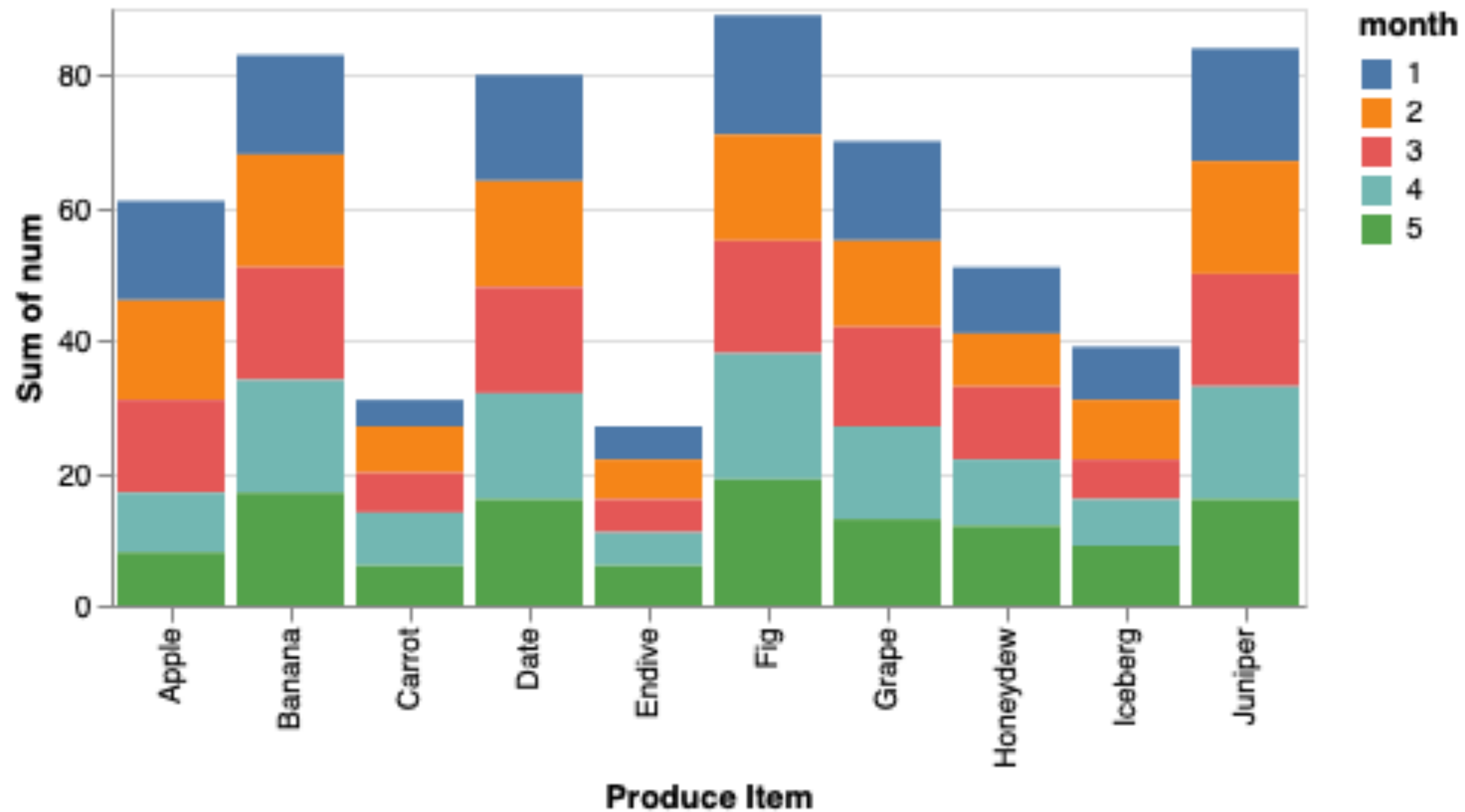


# Tools

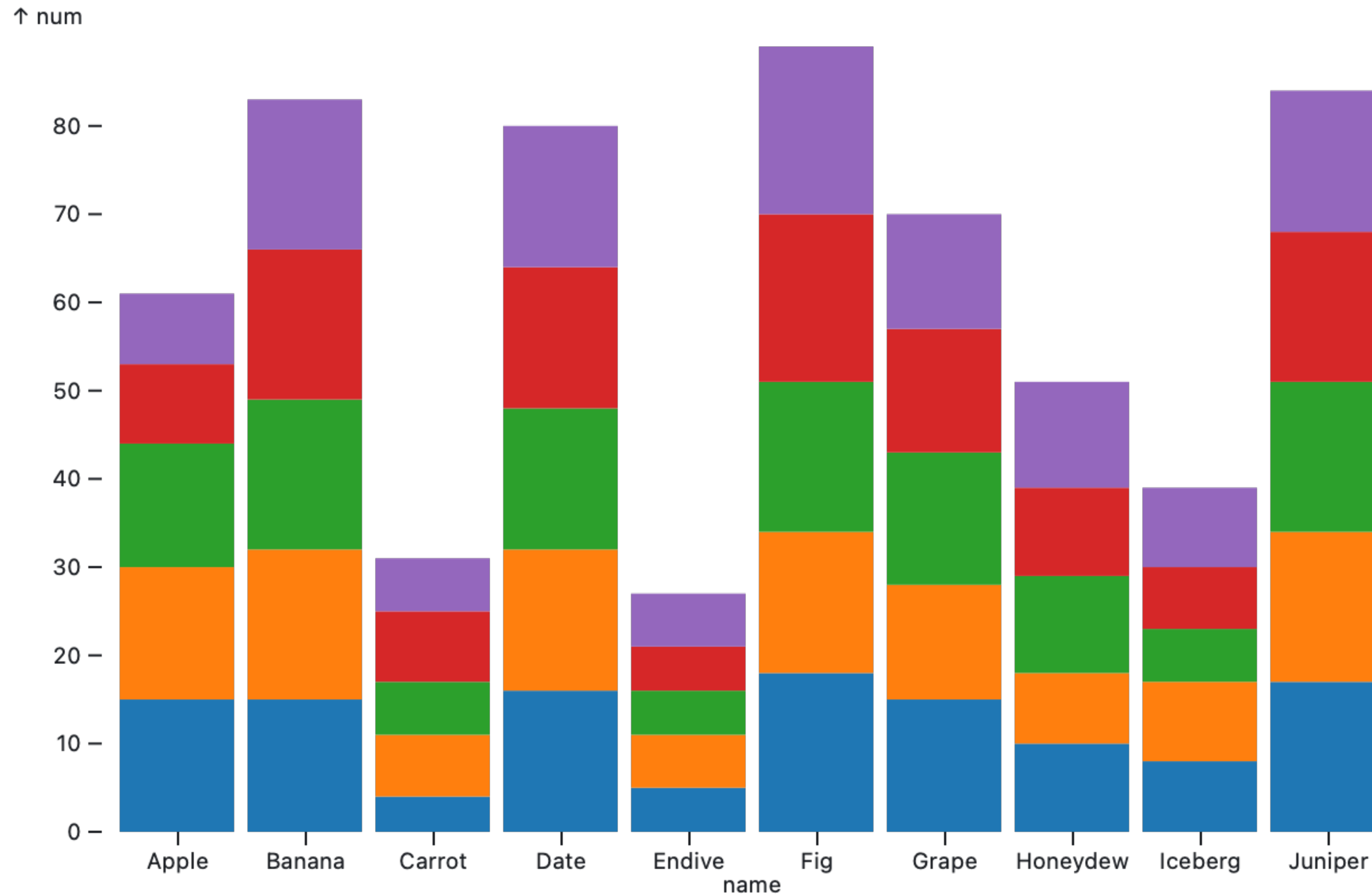
# Tableau



# Vega-Lite



# Observable Plot



# d3

---

- <http://d3js.org/>
- Supports data as a core piece of Web elements
  - **Correspondence** between data and DOM elements
  - Dealing with changing data (joins, enter/update/exit)
  - Data drives the marks and channels
- Selections (similar to CSS) that allow greater manipulation
- Integrated layout algorithms, axes calculations, etc.
- Focus on interaction support
  - Straightforward support for transitions
  - Event handling support for user-initiated changes



# 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)

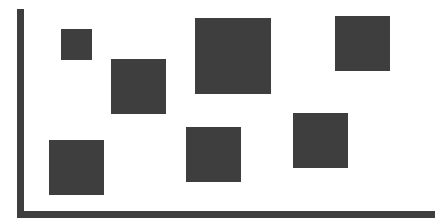
# Arrange Tables

## ➔ Express Values

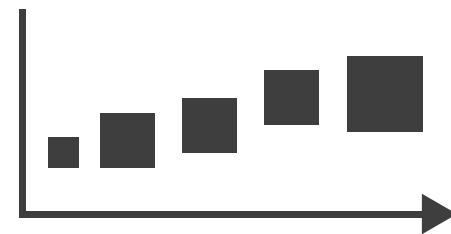


## ➔ Separate, Order, Align Regions

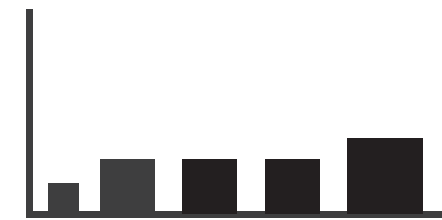
➔ Separate



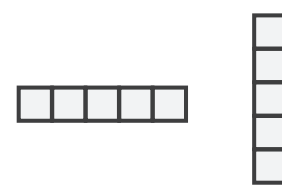
➔ Order



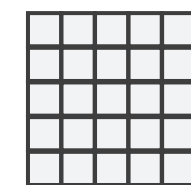
➔ Align



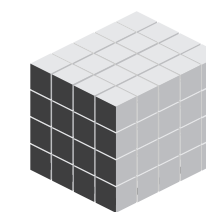
➔ 1 Key  
*List*



➔ 2 Keys  
*Matrix*



➔ 3 Keys  
*Volume*

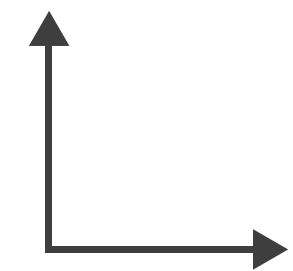


➔ Many Keys  
*Recursive Subdivision*



## ➔ Axis Orientation

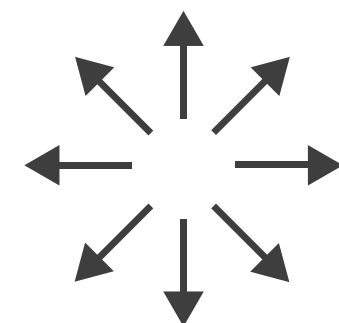
➔ Rectilinear



➔ Parallel

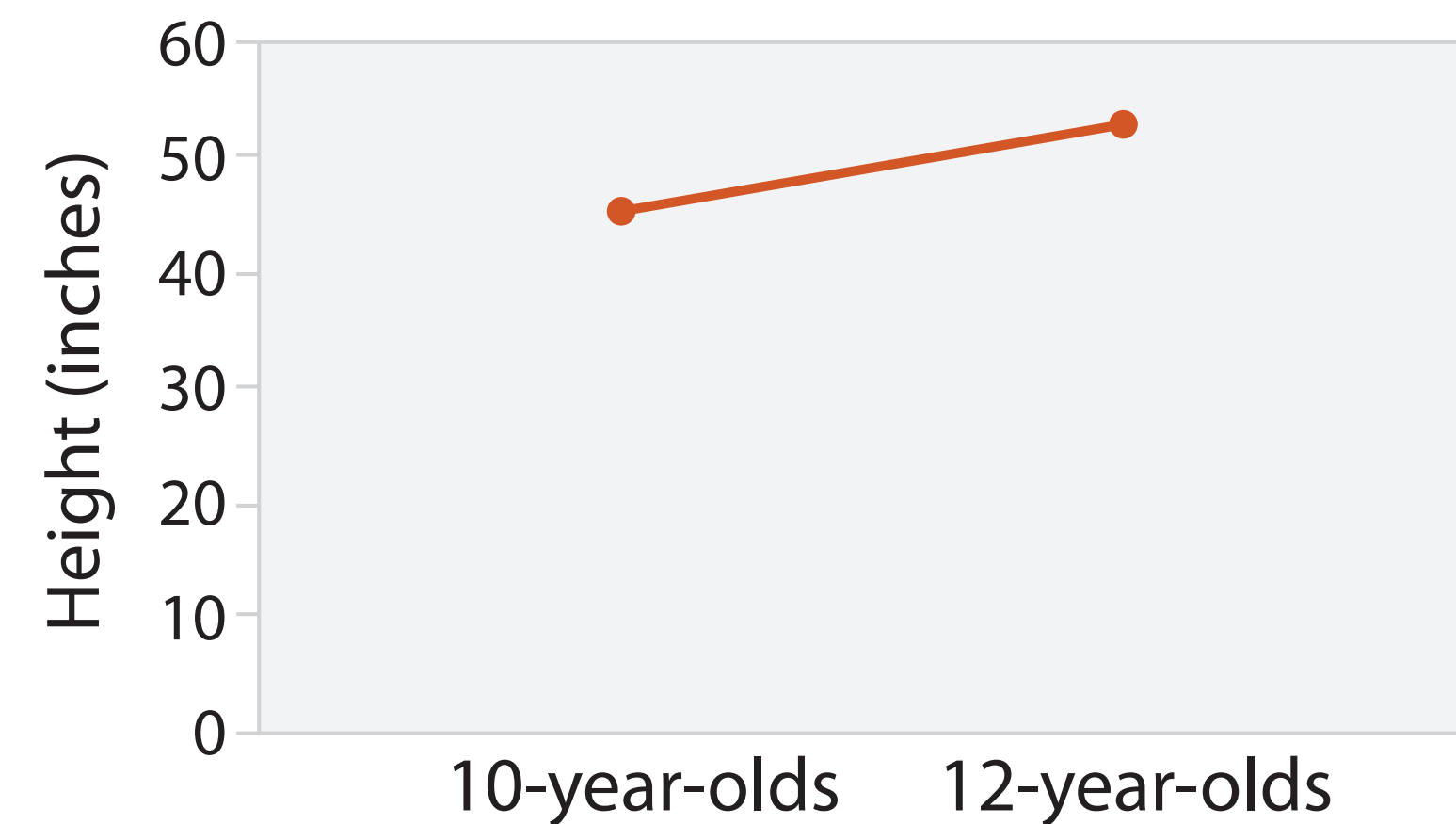
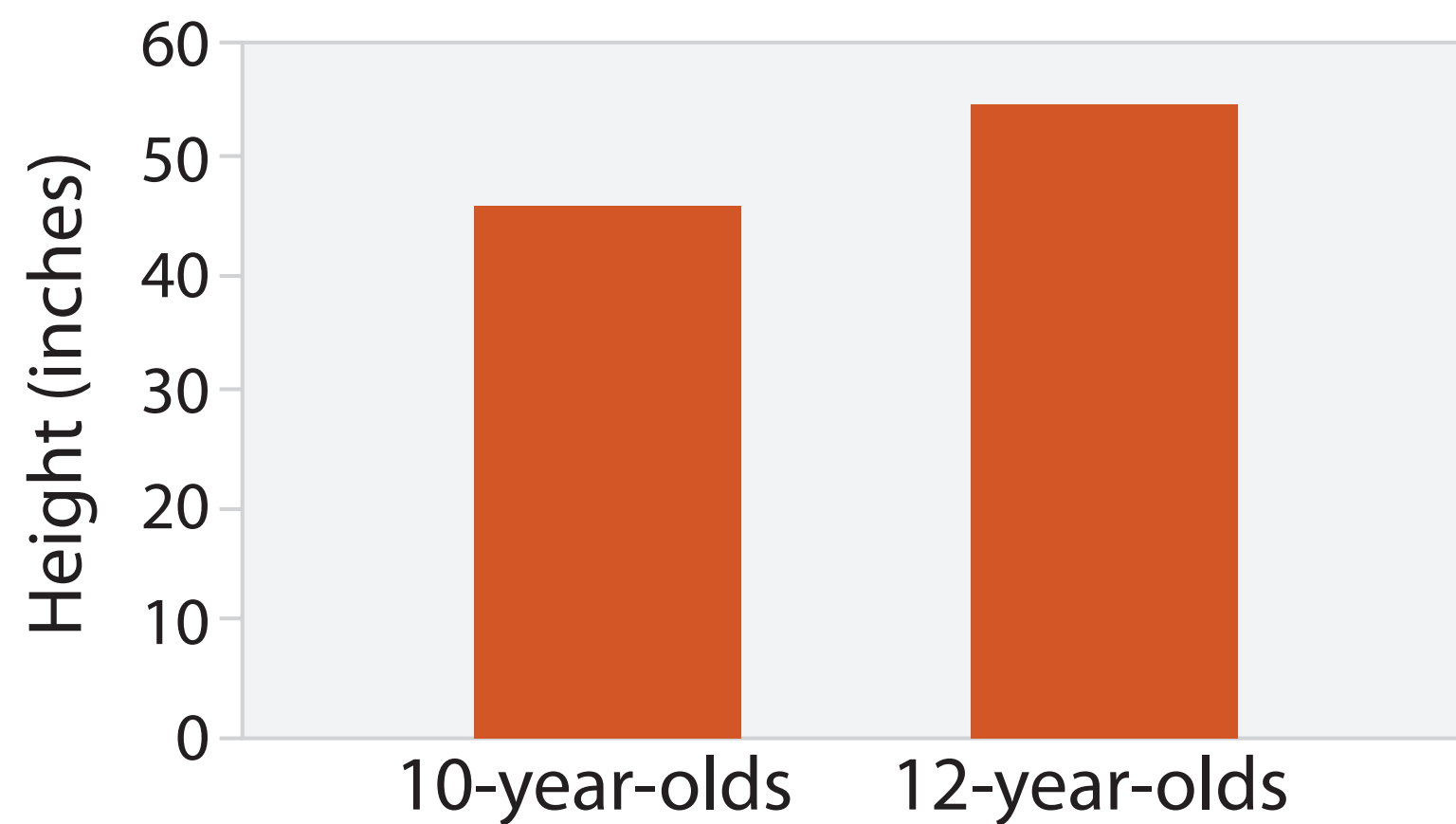
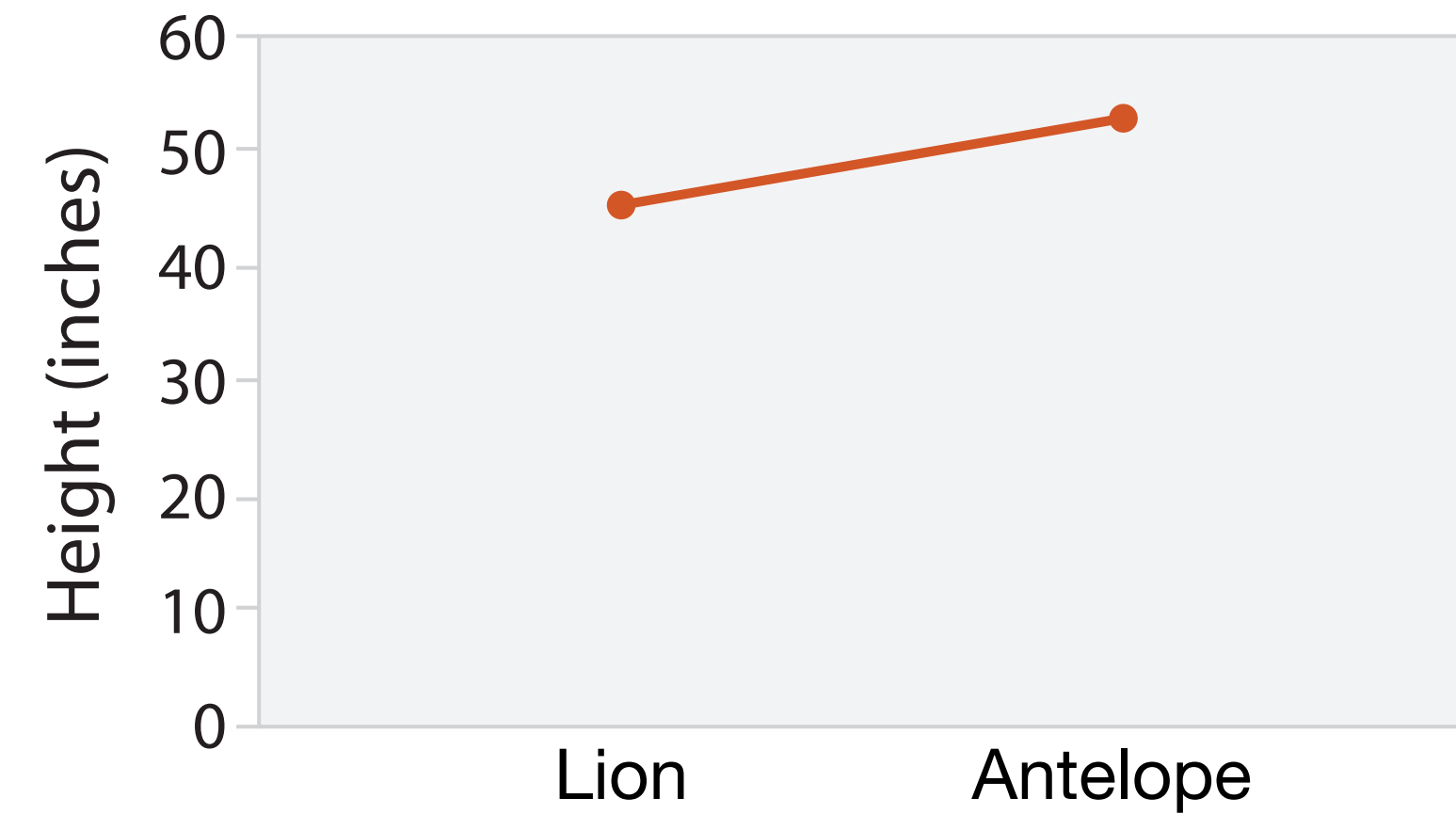
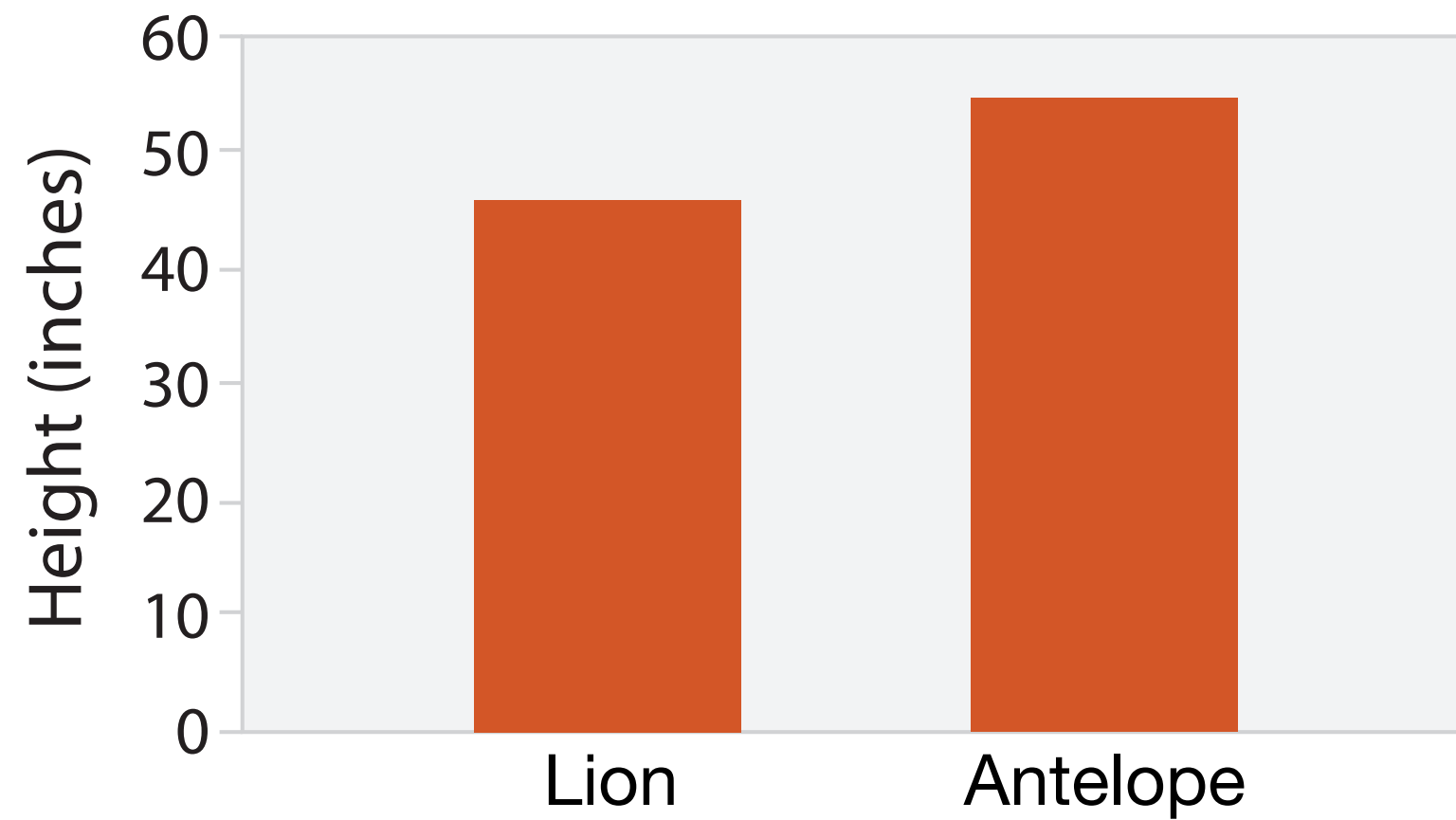


➔ Radial



[Munzner (ill. Maguire), 2014]

# Proper Use of Line and Bar Charts



[Adapted from Zacks and Tversky, 1999, Munzner (ill. Maguire), 2014]

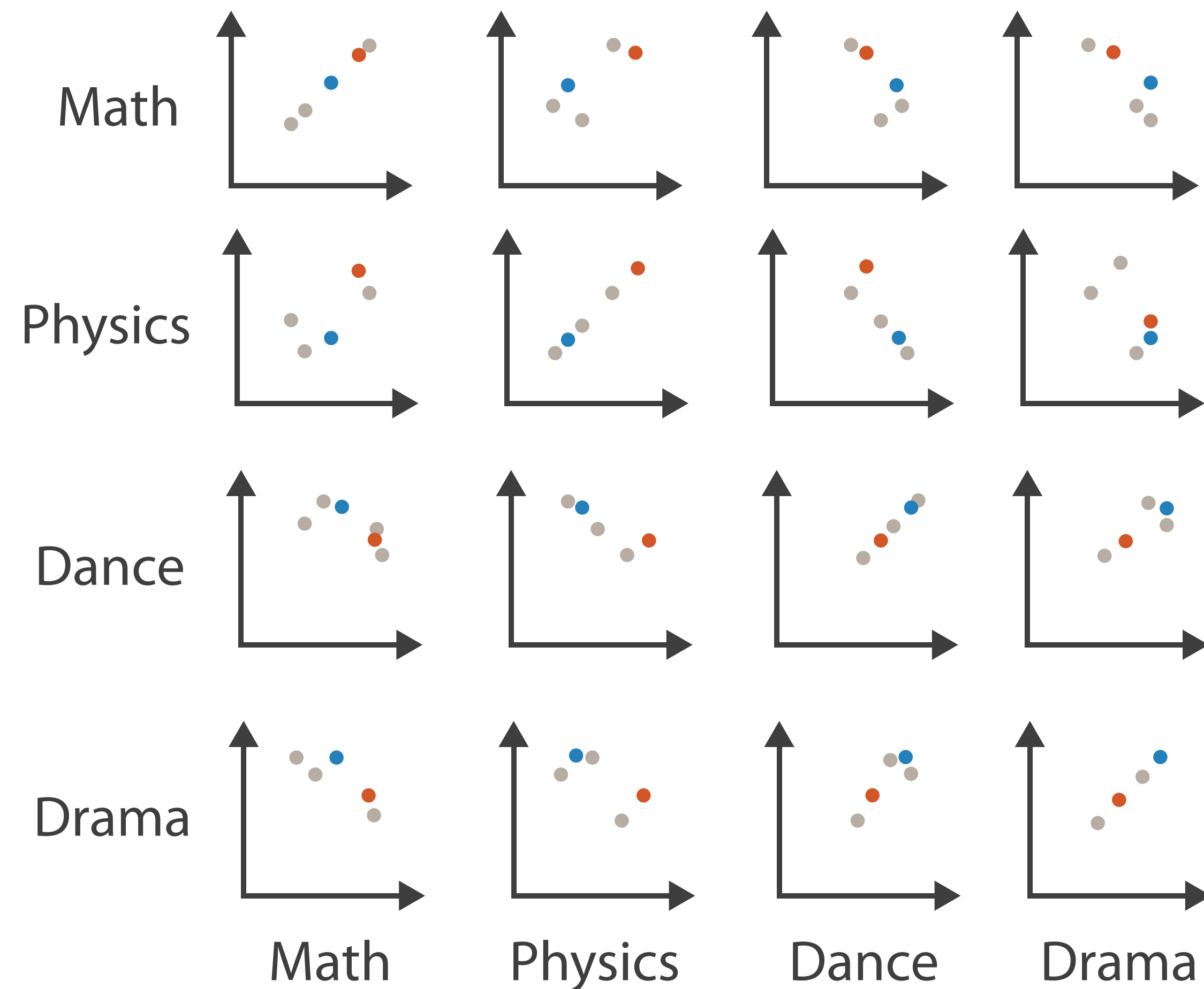
# Scatterplot Matrices and Parallel Coordinates

---

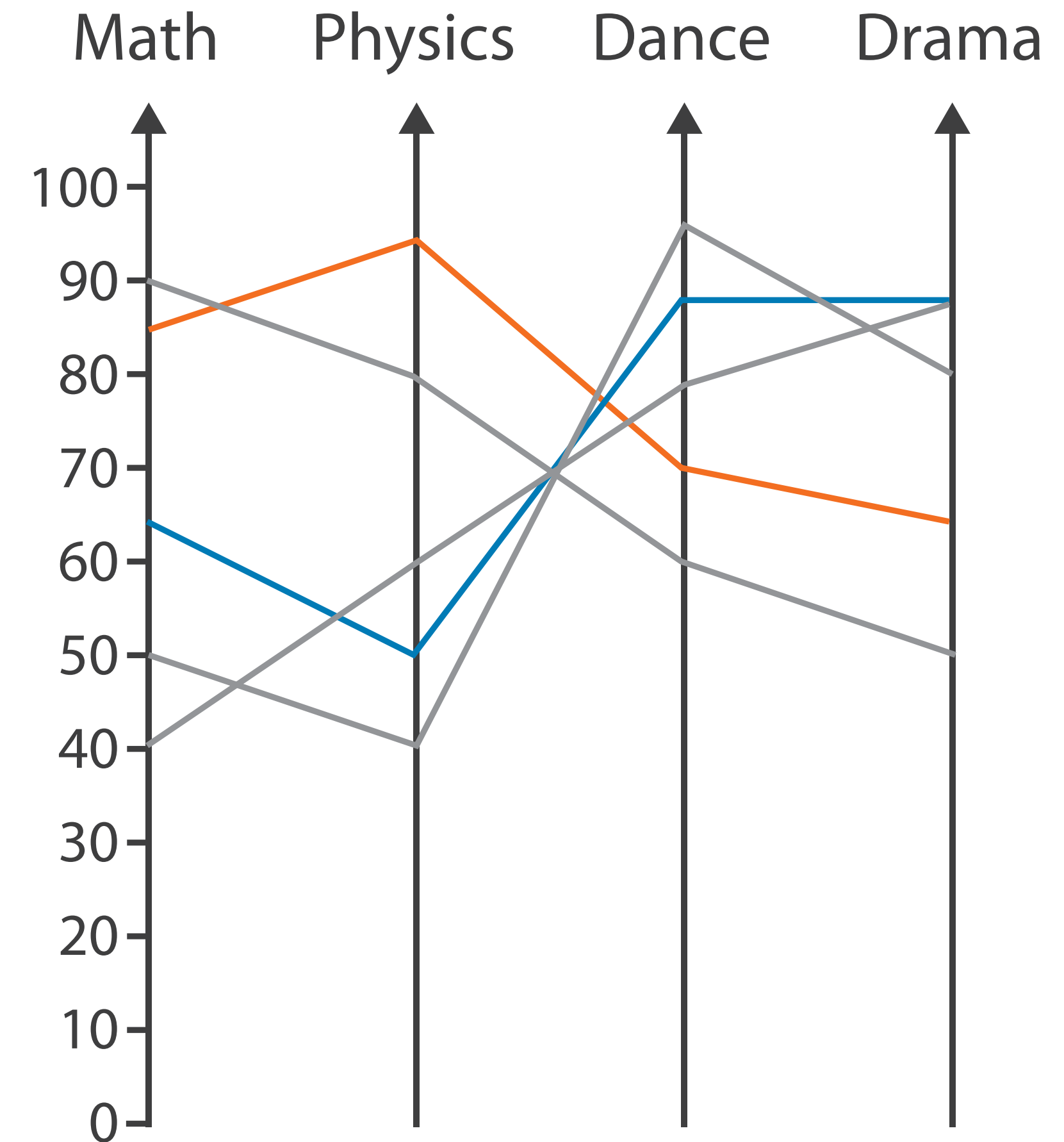
[Munzner (ill. Maguire), 2014]

# Scatterplot Matrices and Parallel Coordinates

## Scatterplot Matrix



## Parallel Coordinates

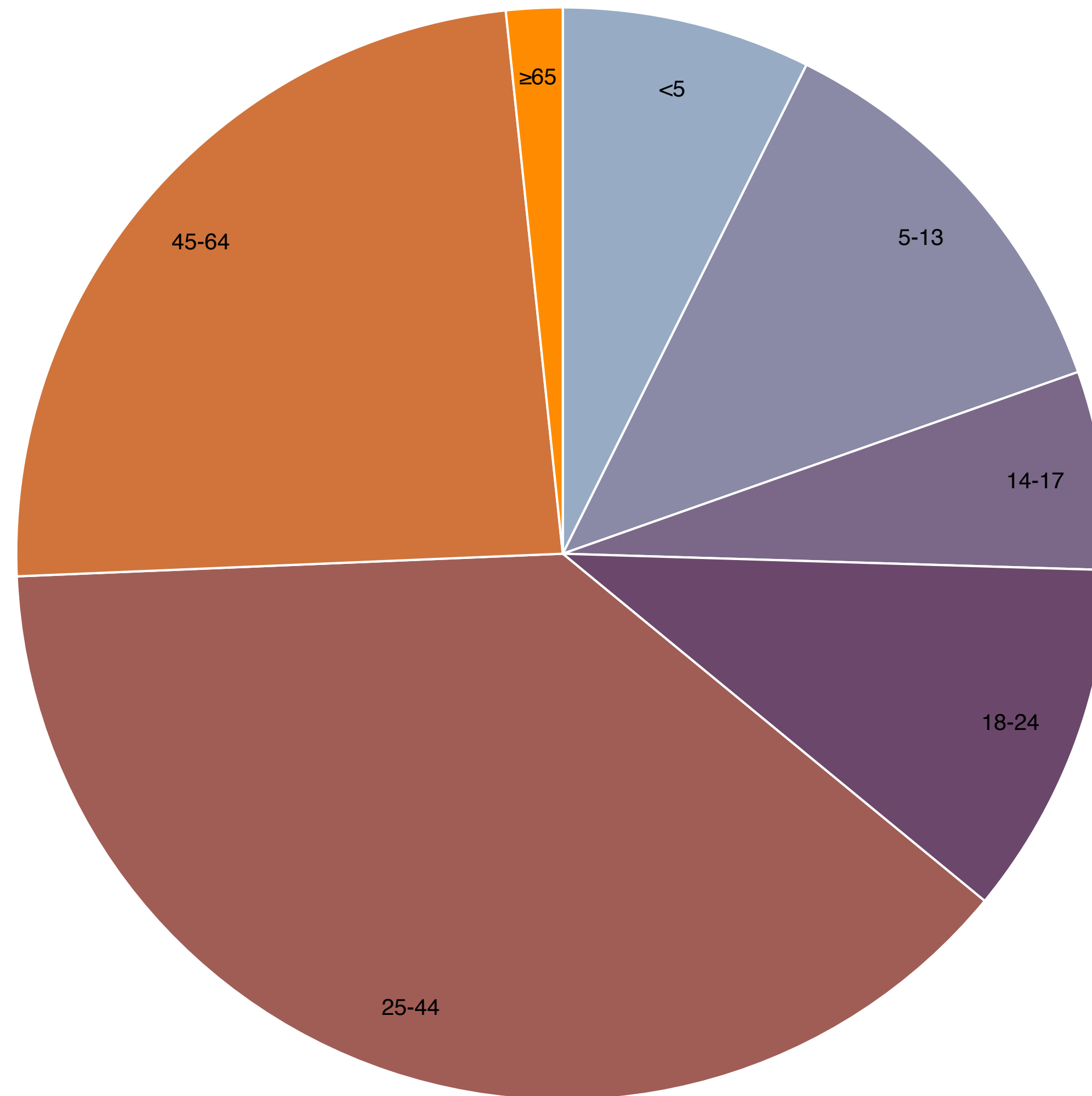


[Munzner (ill. Maguire), 2014]



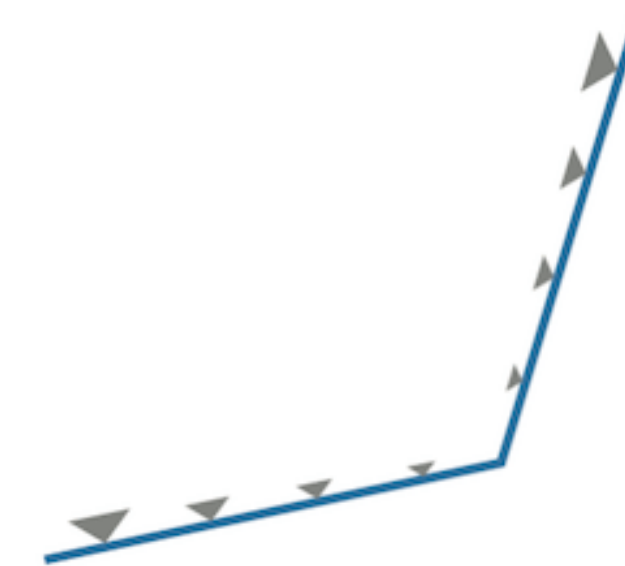
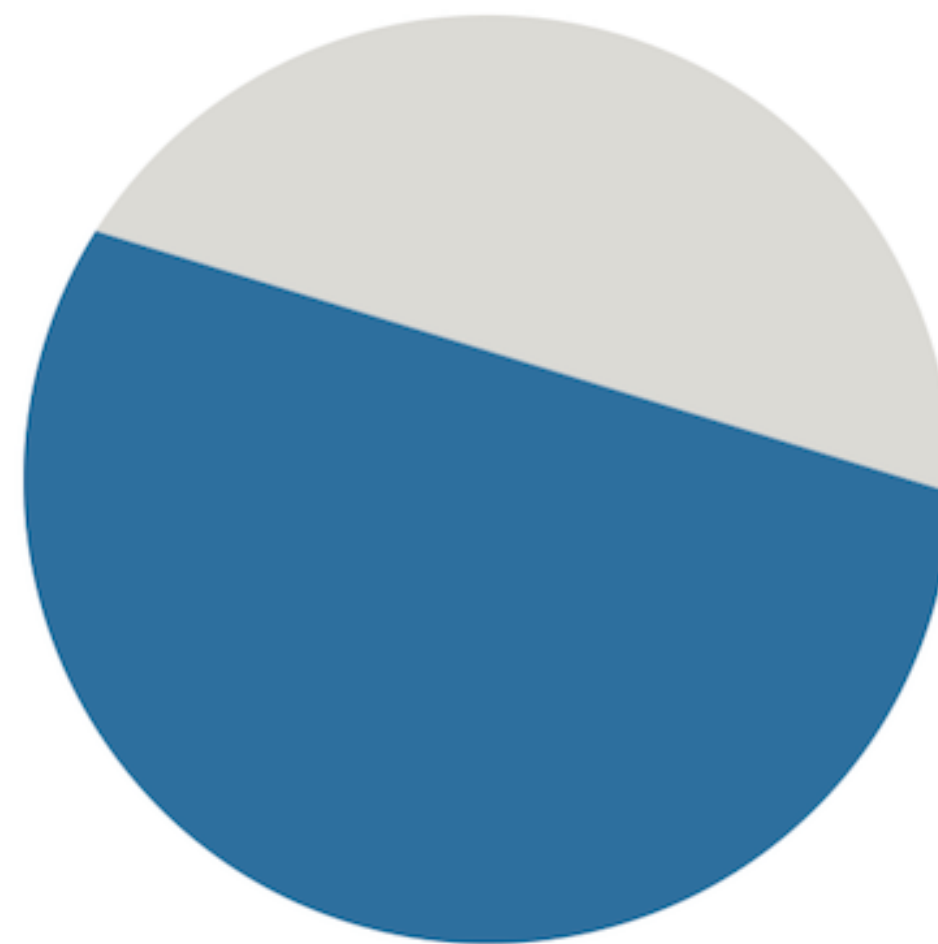
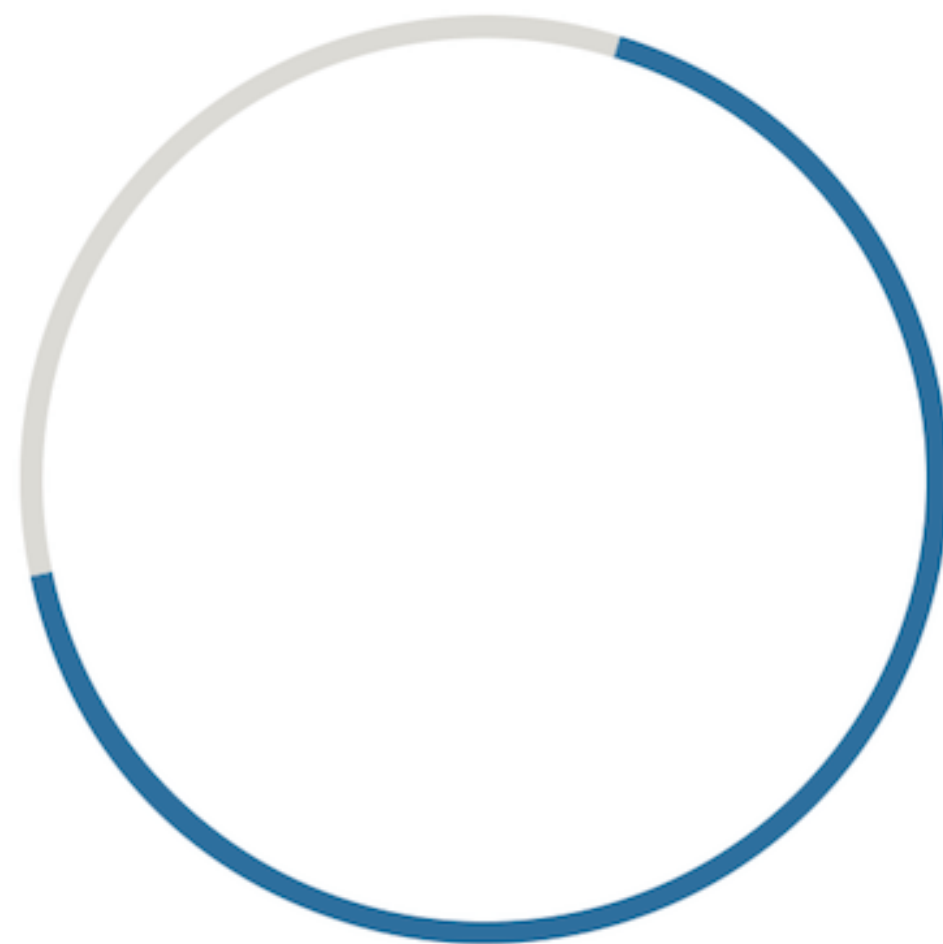
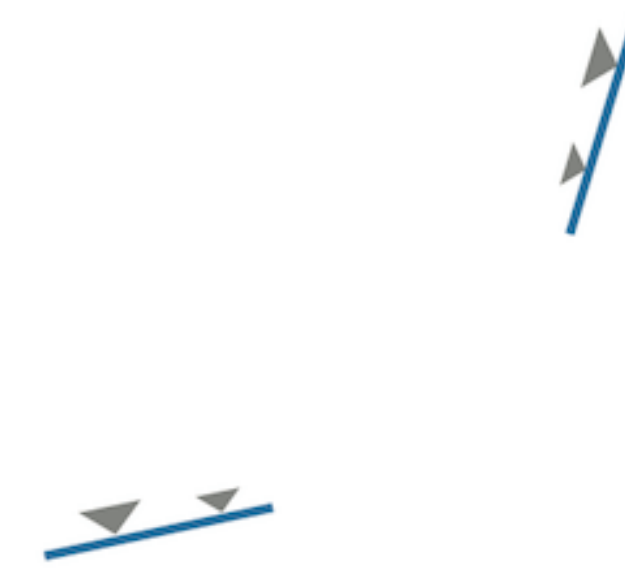
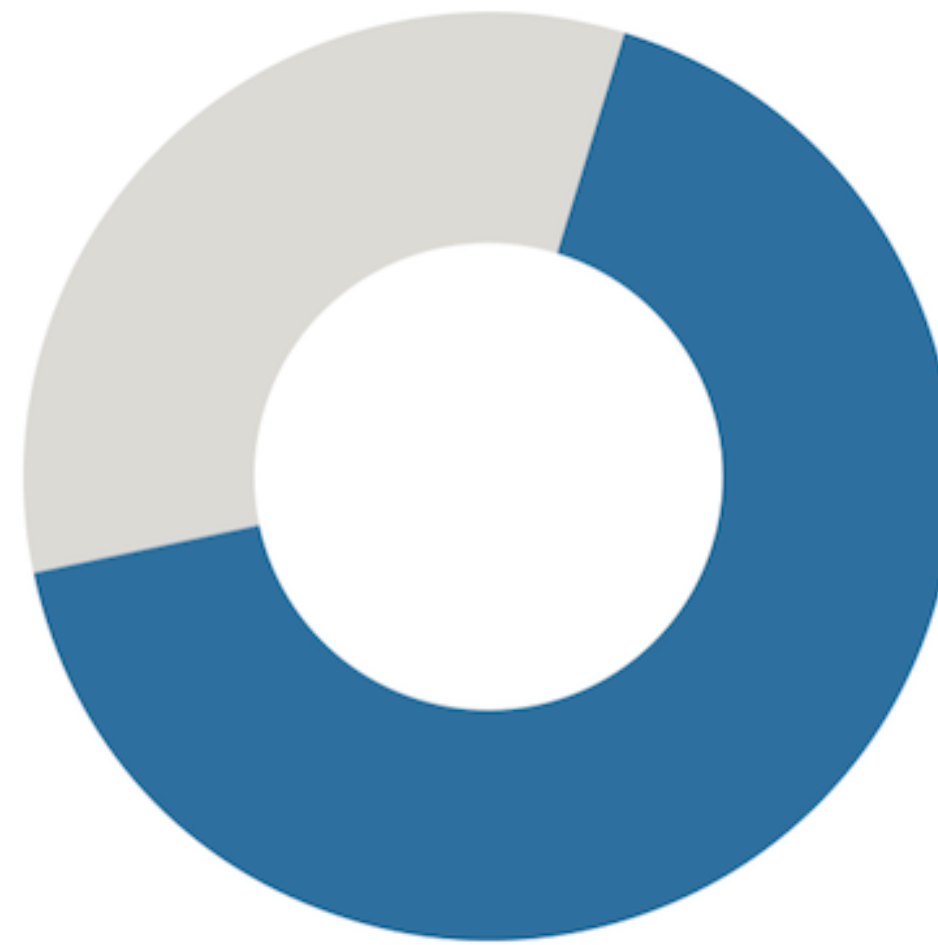
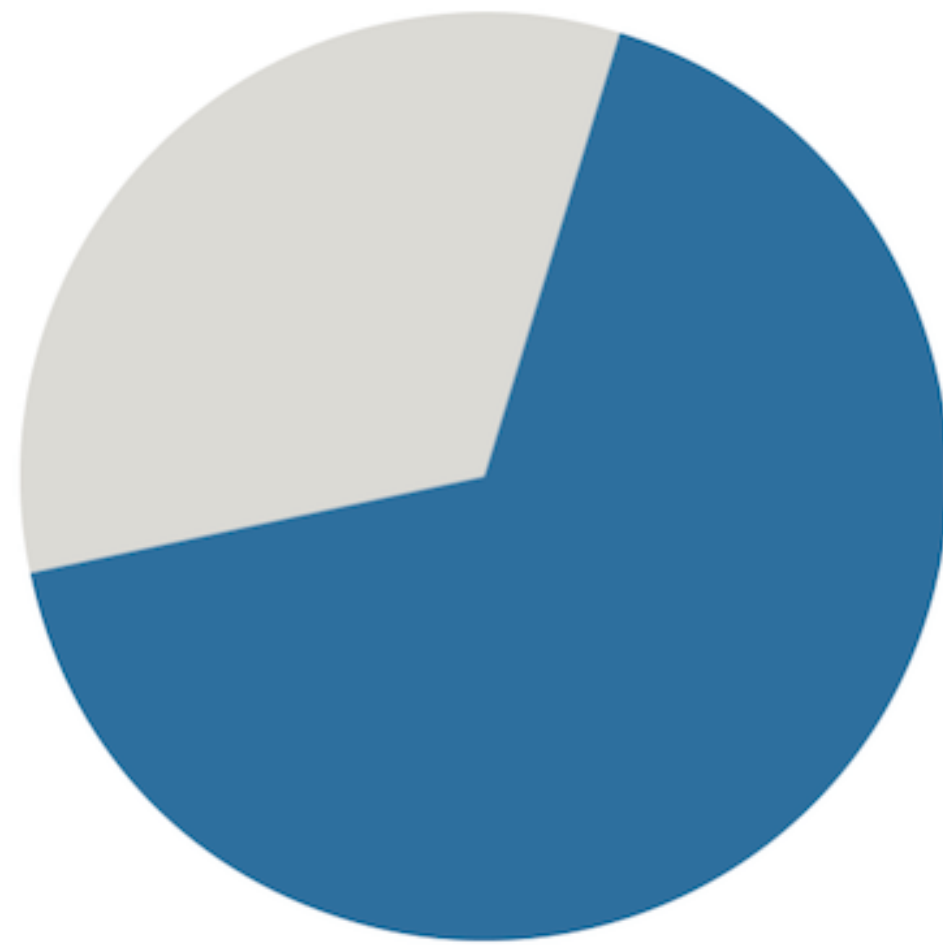
# Pie Chart

---



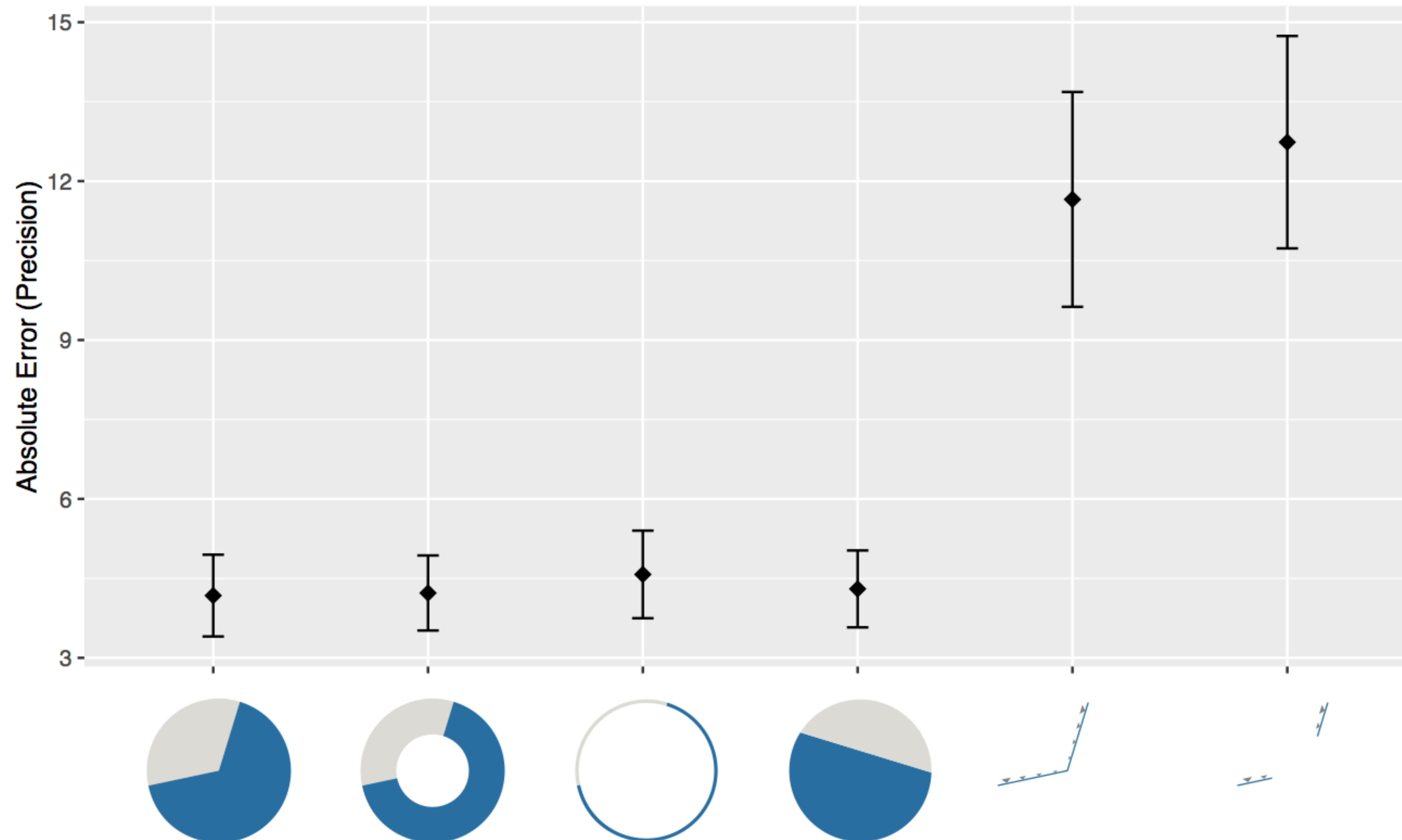
[Pie Chart, Bostock, 2017]

# Judging Pie Charts: Arcs, Angles, or Areas?



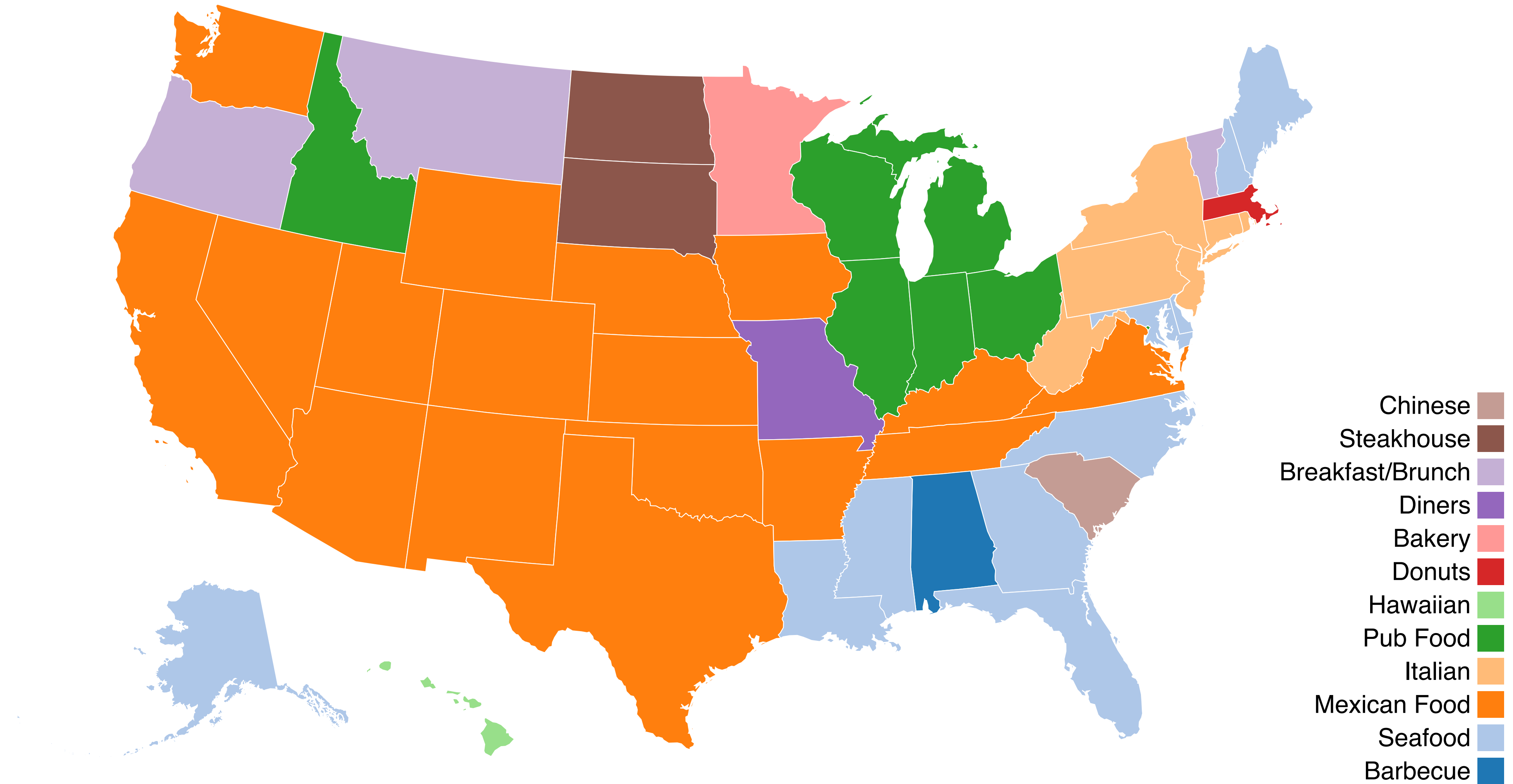
[R. Kosara and D. Skau, 2016]

# How do we judge pie charts?

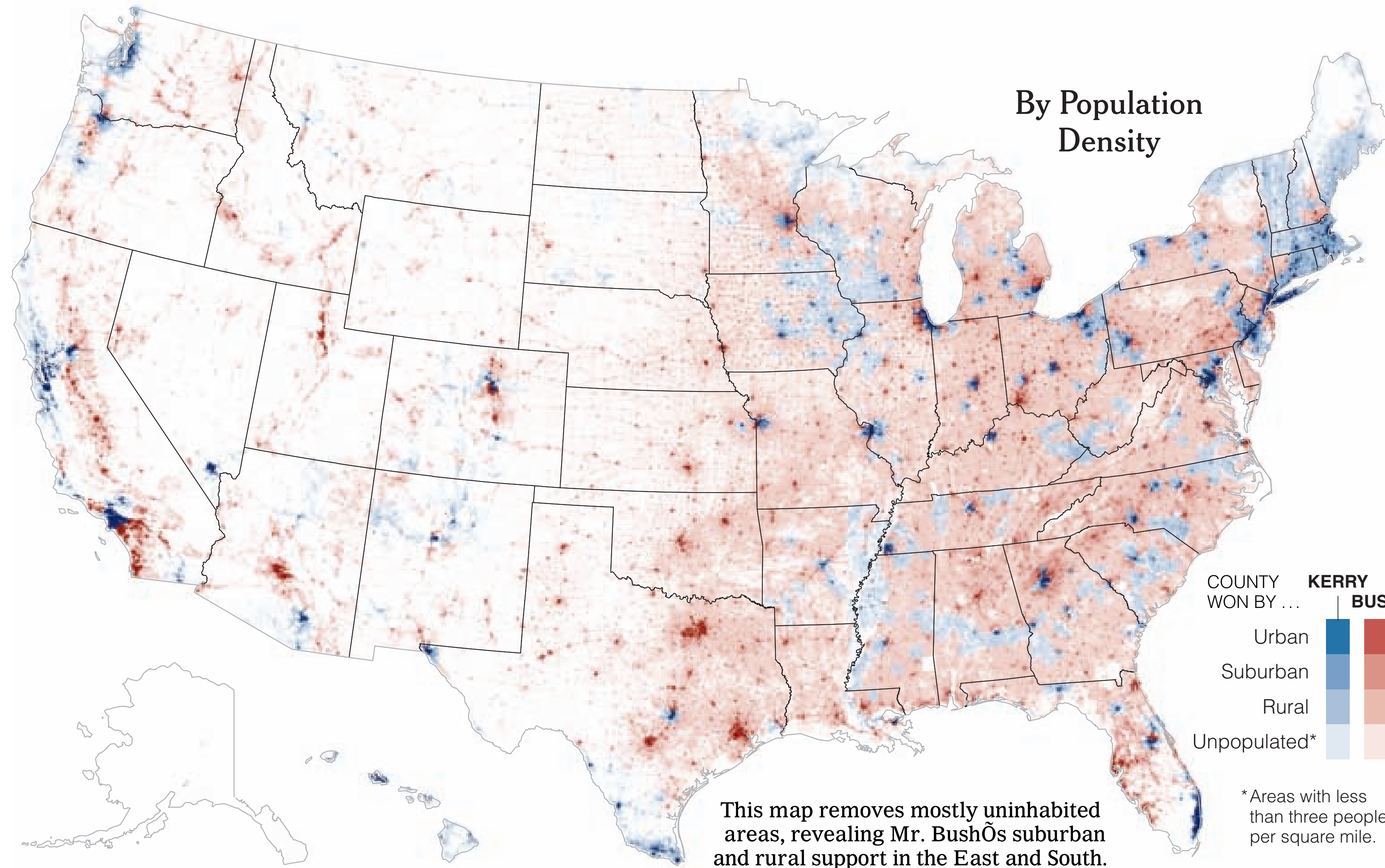


[R. Kosara and D. Skau, 2016]

# Categorical Map



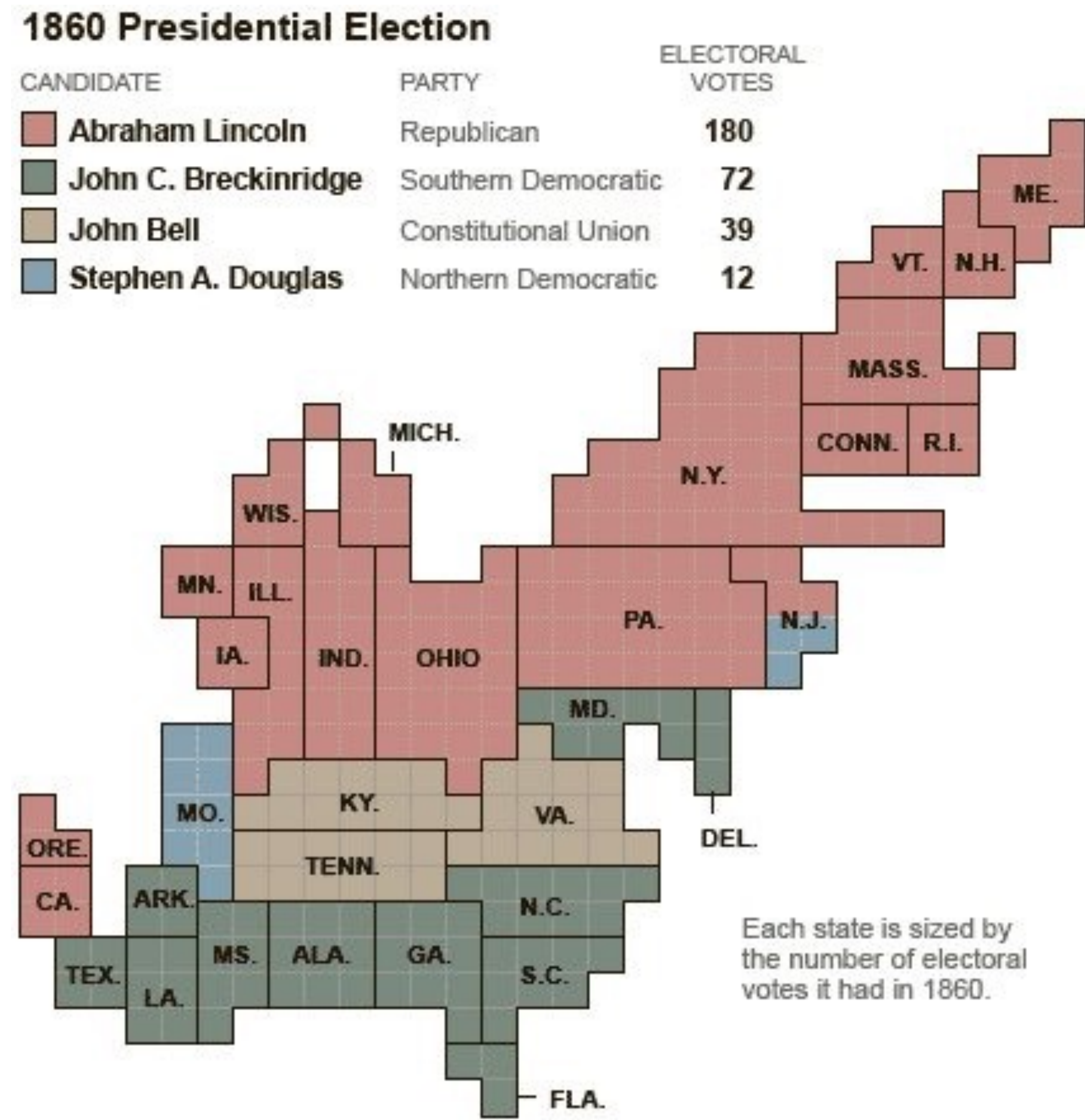
# Map with Two Variables



[M. Ericson, New York Times]



# Rectangular Cartogram



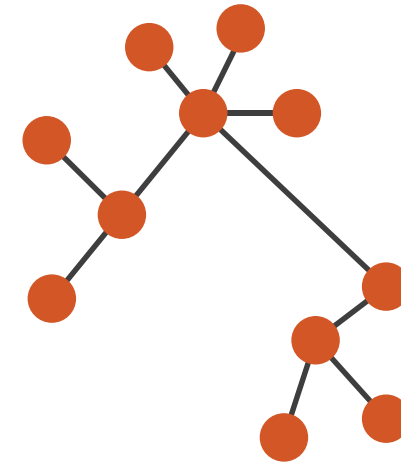
[New York Times]



# Arrange Networks and Trees

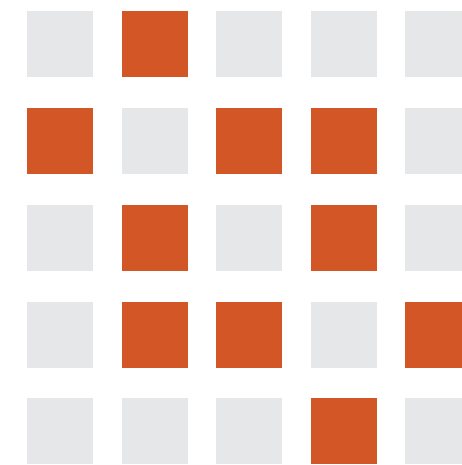
## ➔ Node–Link Diagrams Connection Marks

✓ NETWORKS ✓ TREES



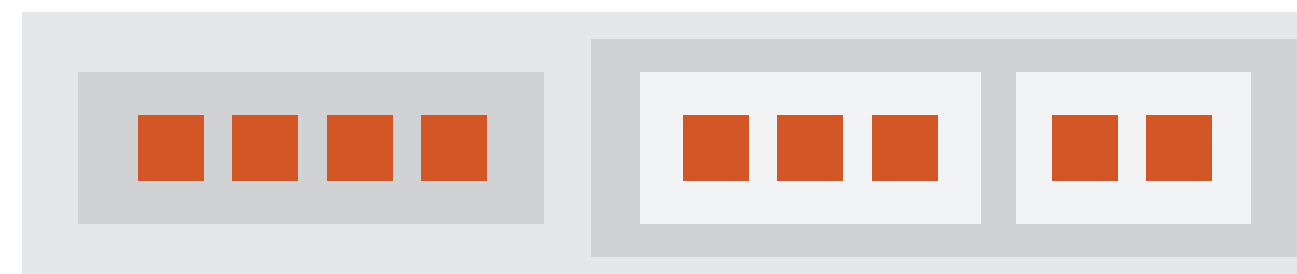
## ➔ Adjacency Matrix Derived Table

✓ NETWORKS ✓ TREES



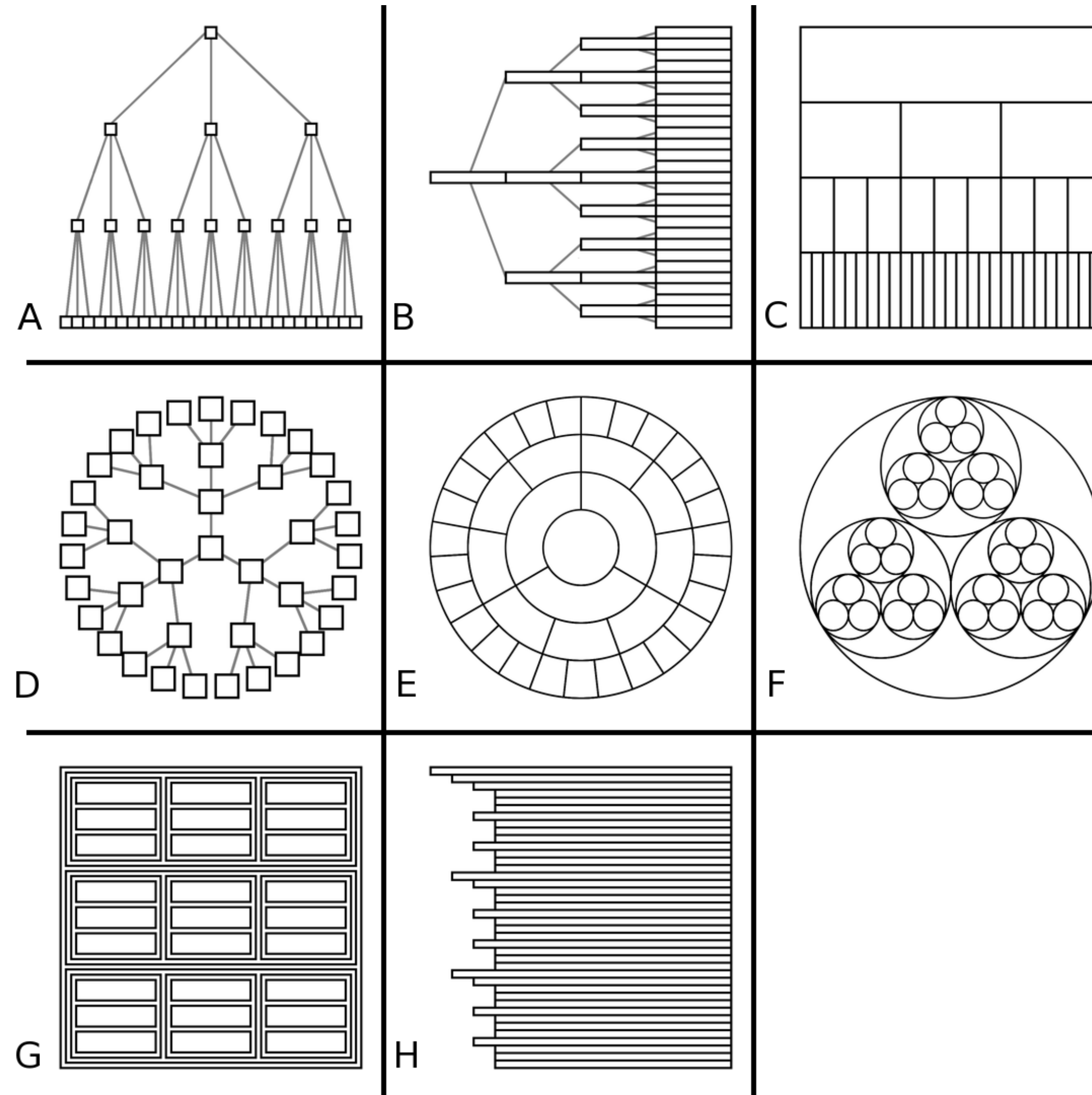
## ➔ Enclosure Containment Marks

✗ NETWORKS ✓ TREES



[Munzner (ill. Maguire), 2014]

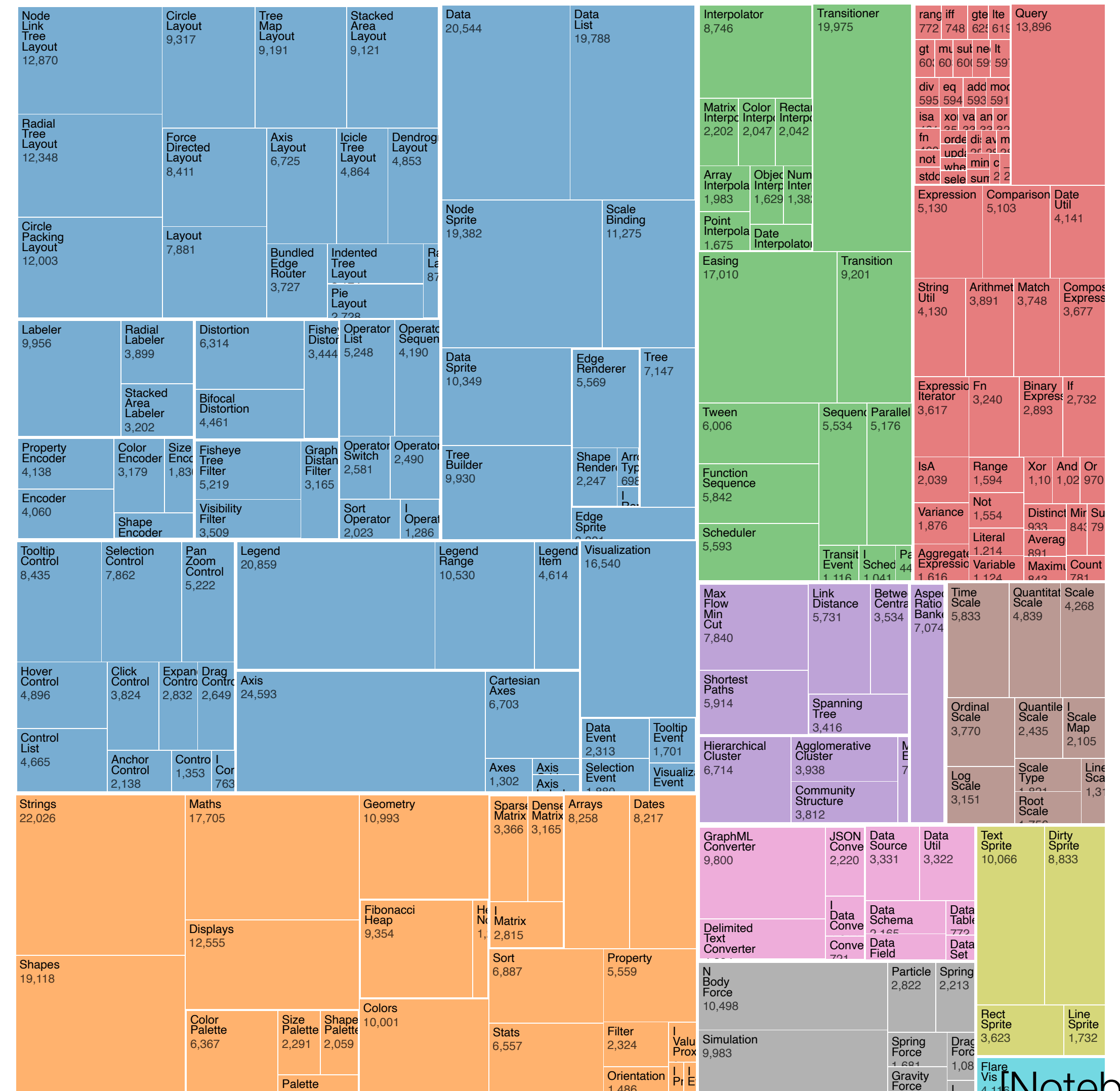
# Tree Visualizations



[McGuffin and Robert, 2010]

# Treemaps

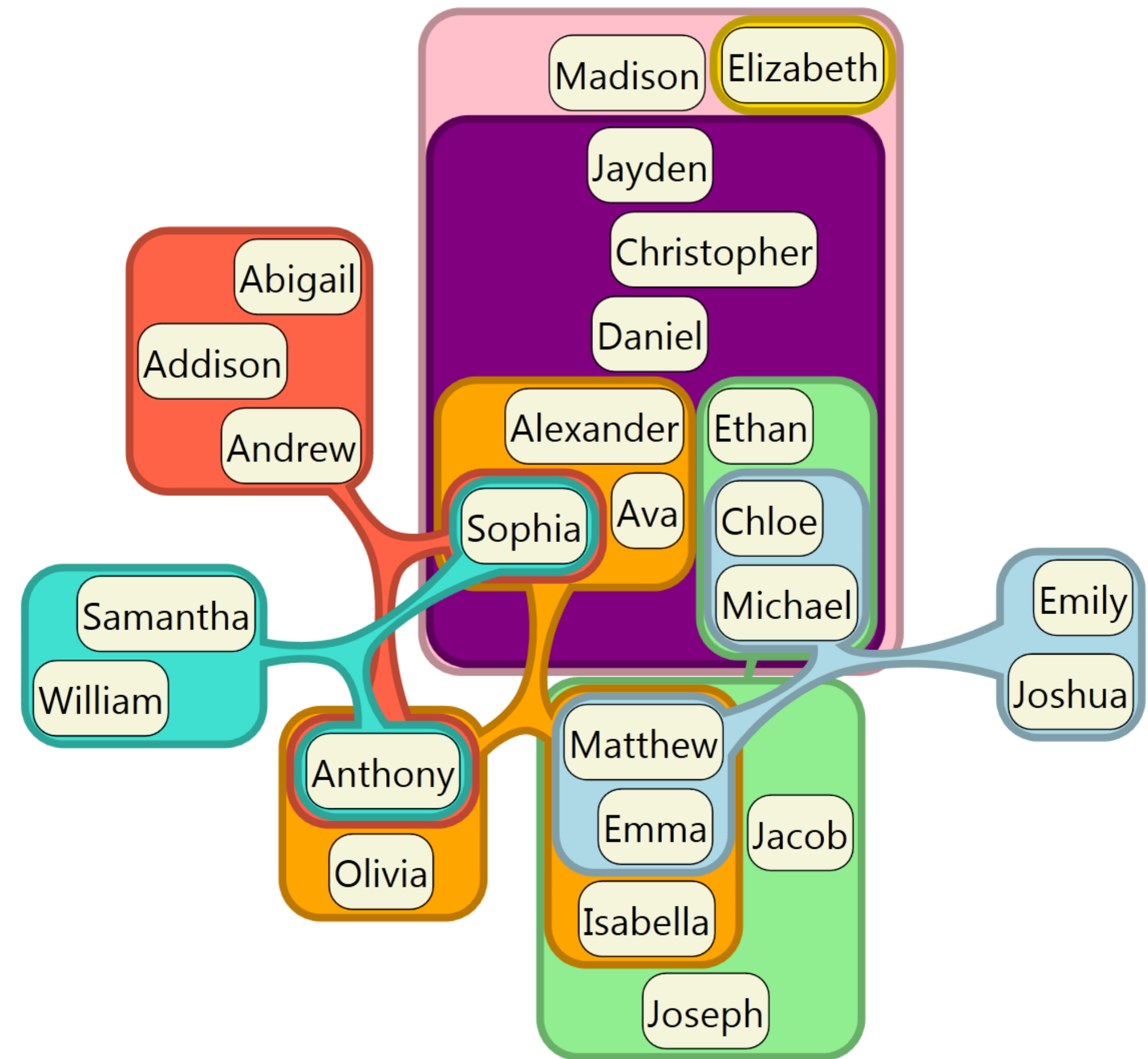
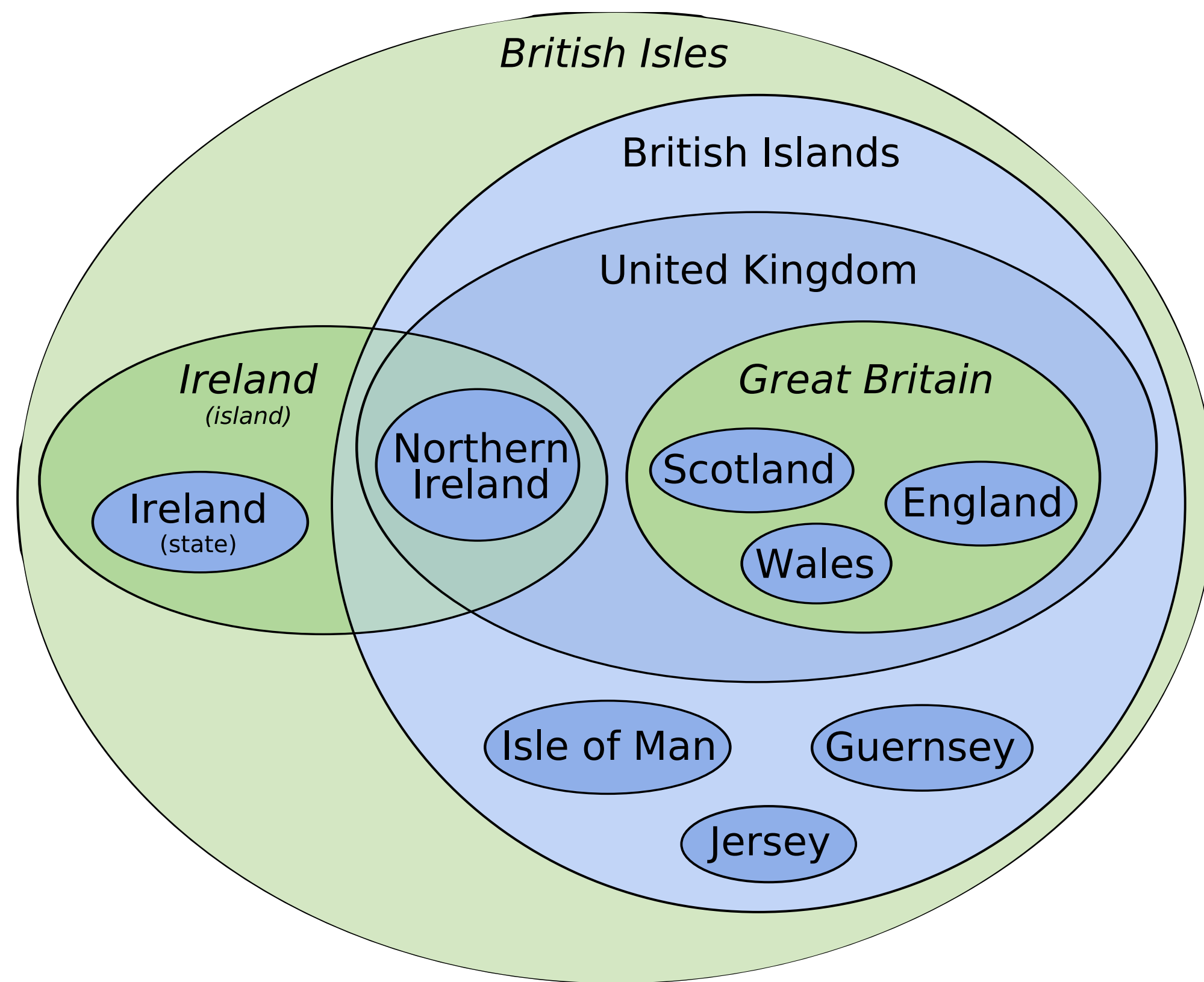
- Containment marks instead of connection marks
- Encodes some attribute of the items as the **size** of the rectangles
- Not as easy to see the intermediate rectangles
- Scalability: millions of leaf nodes and links possible
- Need a layout algorithm!
  - Slice-and-Dice vs. Squarify
  - Viewing Hierarchy: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



# [Notebook]

# Set Visualizations

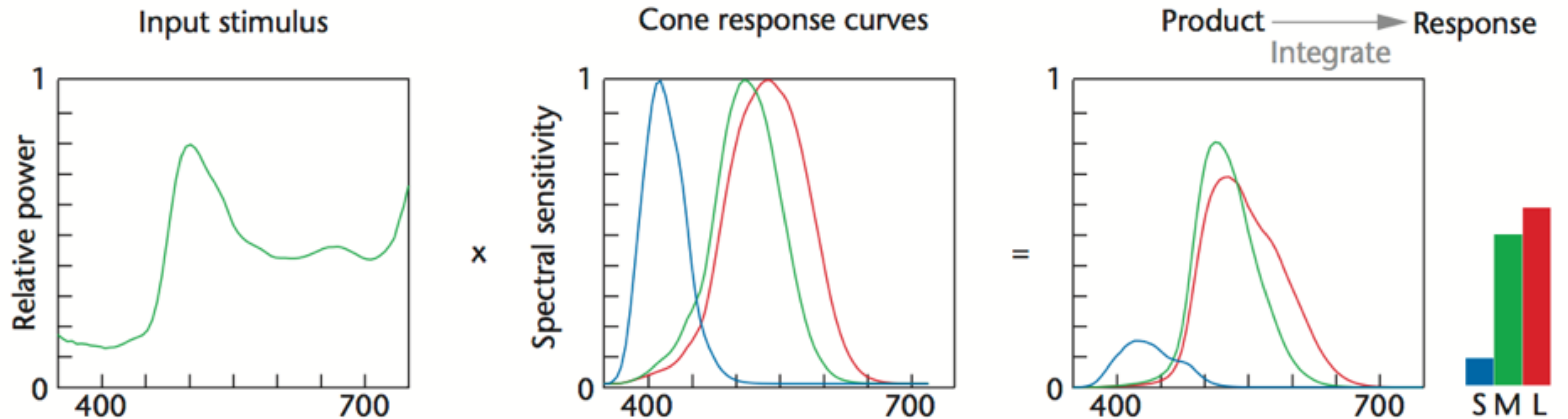
- How to show the intersection of sets?



[Wikipedia]



# Human Color Perception

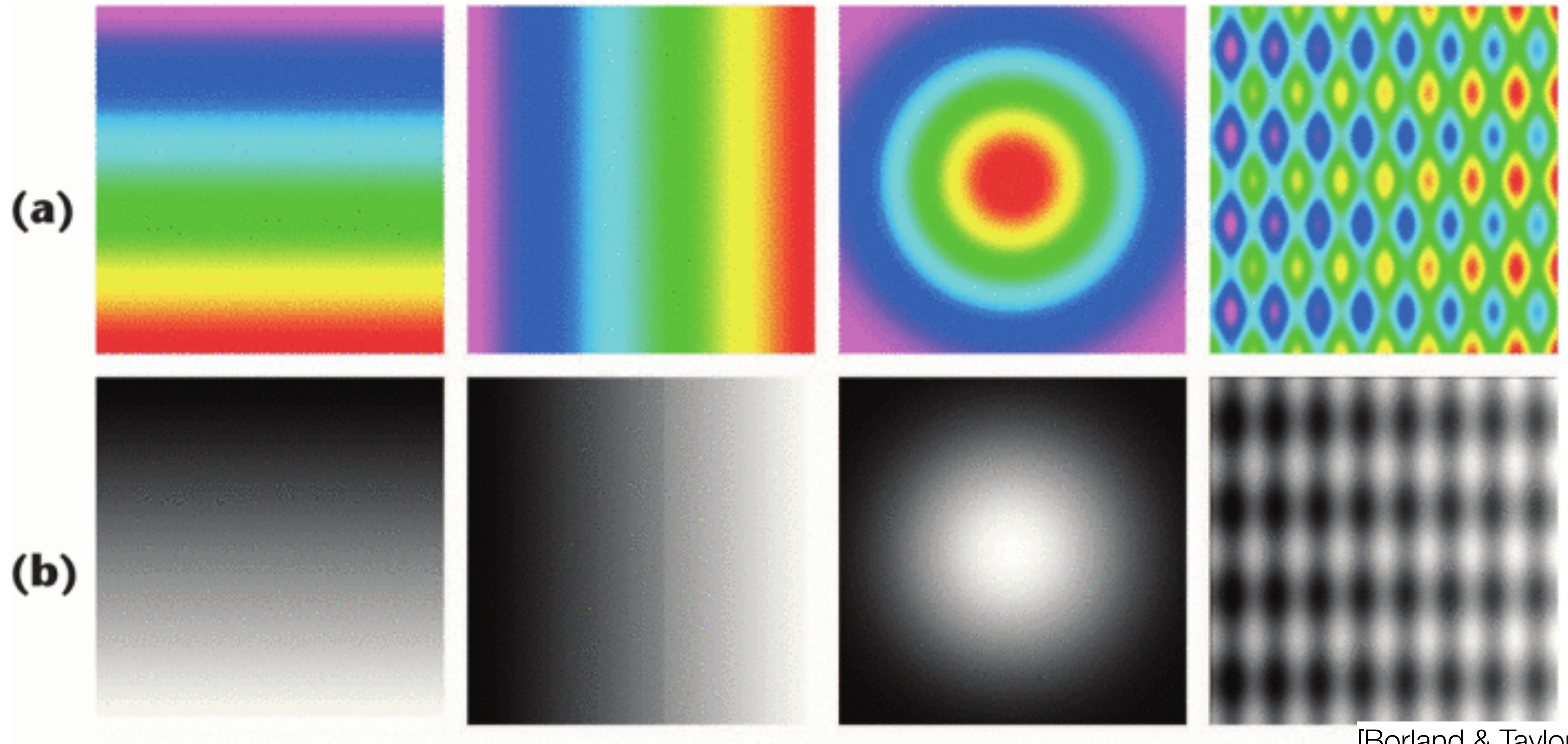


Metamerism: same three responses == same color

[via M. Meyer]



# Avoid Rainbow Colormaps!



[Borland & Taylor, 2007]