Visual Encodings

CS 7250

SPRING 2020

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NORTHEASTERN UNIVERSITY

Slides and inspiration from Michelle Borkin, Krzysztof Gajos, Hanspeter Pfister, Miriah Meyer, Jonathan Schwabish, and David Sprague

BURNING QUESTIONS?

PREVIOUSLY, ON CS 7250…
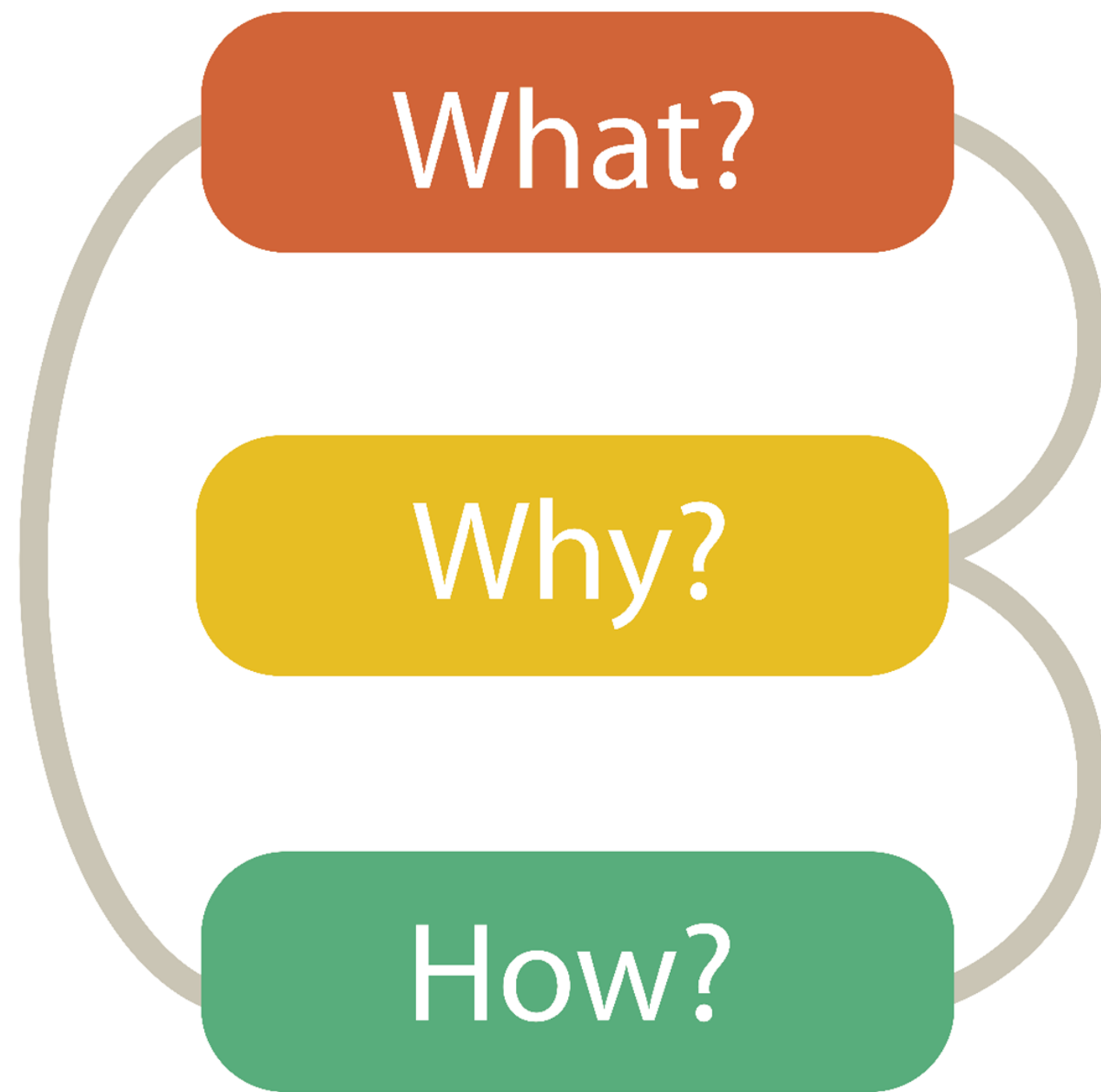
Analysis

What?   What data is shown?

Why?   Why is the user analyzing / viewing it?

How?   How is the data presented?

Analysis

What? DATA ABSTRACTION

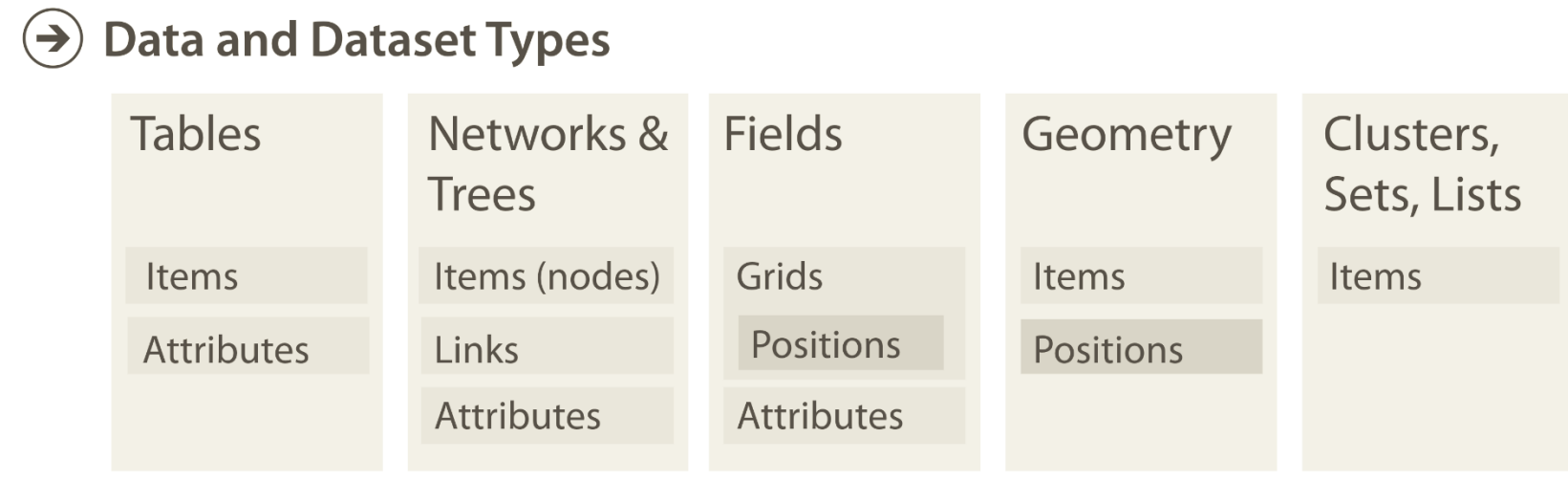**Why?** TASK ABSTRACTION

How? VISUAL ENCODING

DATA ABSTRACTION

Why abstract?

Avoids domain specific terms thus easier to apply to other cases (broadly applicable results).

Datasets

➜ Data Types

➜ Items ➜ Attributes ➜ Links ➜ Positions ➜ Grids

➜ Data and Dataset Types

Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		

➜ Dataset Types

➜ Tables

Attributes (columns)
Items (rows)
Cell containing value

➜ Networks

Link
Node (item)

➜ Fields (Continuous)

Grid of positions
Cell
Attributes (columns)
Value in cell

➜ *Multidimensional Table*

Key 1
Key 2
Value in cell
Attributes

➜ *Trees*

➜ Geometry (Spatial)

Position
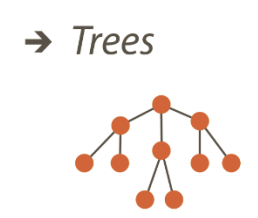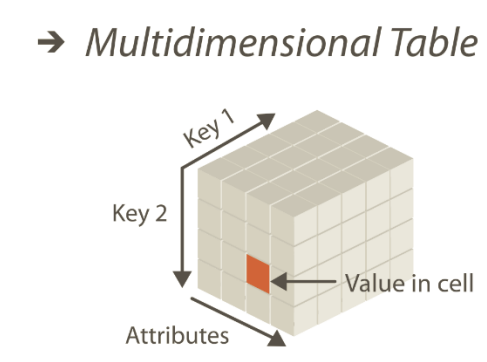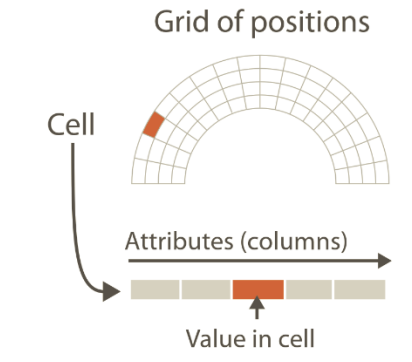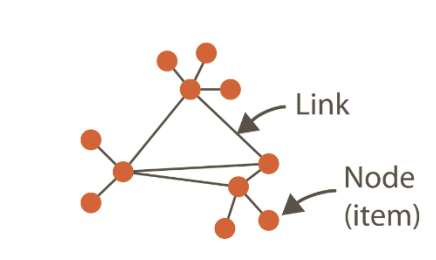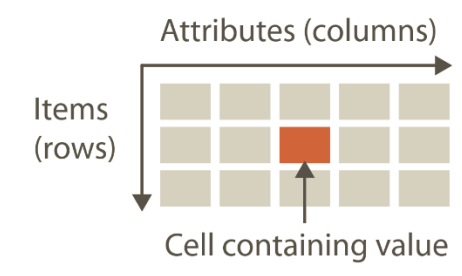
➜ Dataset Availability

➜ Static

➜ Dynamic

Attributes

➜ Attribute Types

➜ Categorical

➜ Ordered

➜ *Ordinal*

➜ *Quantitative*

➜ Ordering Direction

➜ Sequential

➜ Diverging

➜ Cyclic
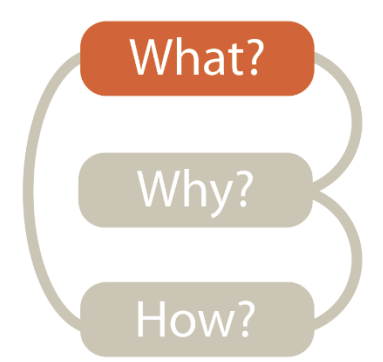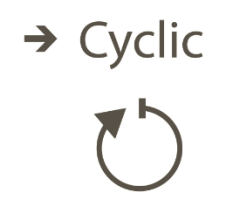
TASK ABSTRACTION

Why abstract?

Avoids domain specific terms thus easier to apply to other cases (broadly applicable results).

Actions

Analyze

Consume

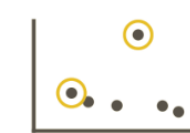Discover | Present | Enjoy

Produce

Annotate | Record | Derive

Search

	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

Query

Identify | Compare | Summarize

Targets

All Data

Trends | Outliers | Features

Attributes

One | Many

Distribution | Dependency | Correlation | Similarity

Extremes
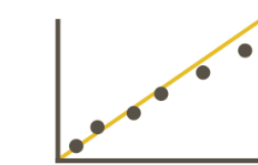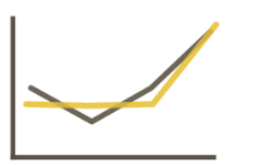
Network Data

Topology
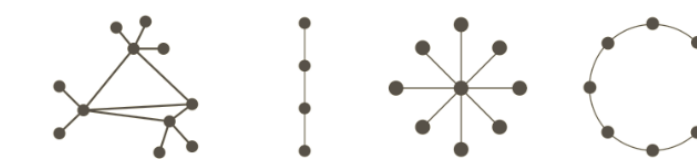
Paths

Spatial Data

Shape

What?

Why?

How?
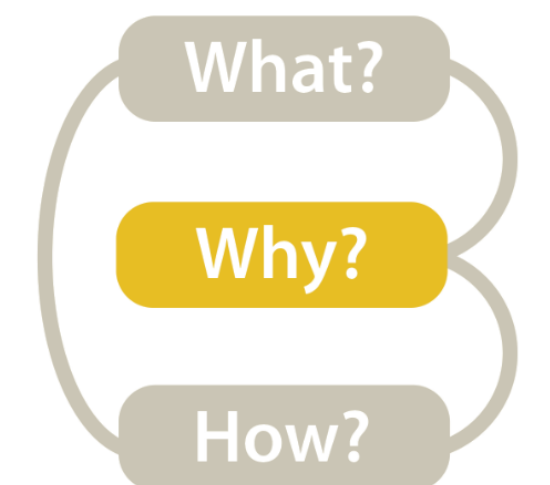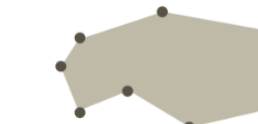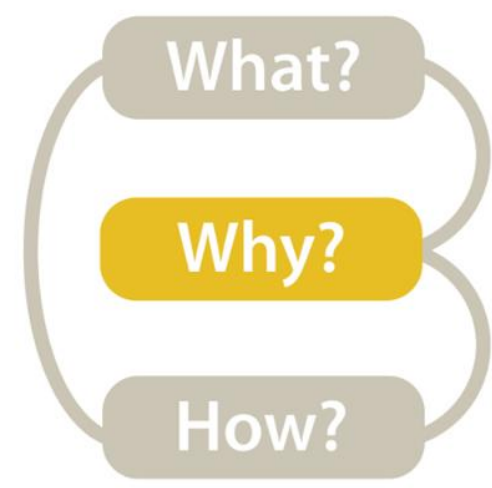
7

Task Analysis

Visualization for Public Transit Development

15m

INSTRUCTIONS:

- Break-out into groups of ~3 people.
- Pretend you are transportation engineers, e.g., for the MBTA, City of Boston.
- Discuss the "domain tasks" and classify the tasks.
- Save your notes for a later exercise!!!

Low-level

Retrieve Value	*How long is the movie Gone with the Wind?*
Filter	*What comedies have won awards?*
Compute Derived Value	*How many awards have MGM studio won in total?*
Find Extremum	*What director/film has won the most awards?*
Sort	*Rank movies by most number of awards.*
Determine Range	*What is the range of film lengths?*
Characterize Distribution	*What is the age distribution of actors?*
Find Anomalies	*Are there exceptions to the relationship between number of awards won and total movies made by an actor?*
Cluster	*Is there a cluster of typical film lengths?*
Correlate	*Is there a trend of increasing film length over the years?*

Actions

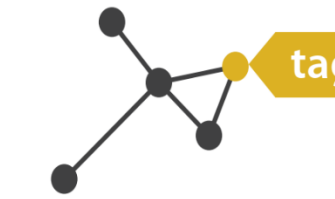### Analyze *High-level*
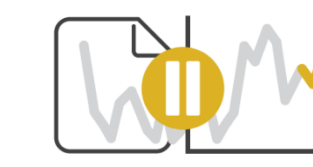
Consume
- Discover
- Present
- Enjoy

Produce
- Annotate
- Record
- Derive

Search *Mid-level*

	Target known	Target unknown
Location known	Lookup	Browse
Location unknown	Locate	Explore

Query *Low-level*

- Identify
- Compare
- Summarize

VISUAL ENCODING

Encode

Arrange

→ Express   → Separate

→ Order   → Align

→ Use

Map
from categorical and ordered attributes

→ Color

→ Hue   → Saturation   → Luminance

→ Size, Angle, Curvature, ...

→ Shape

→ Motion
Direction, Rate, Frequency, ...

Manipulate

Change

Select

Navigate

Facet

Juxtapose

Partition

Superimpose

Reduce

Filter

Aggregate

Embed

What?

Why?

How?

9
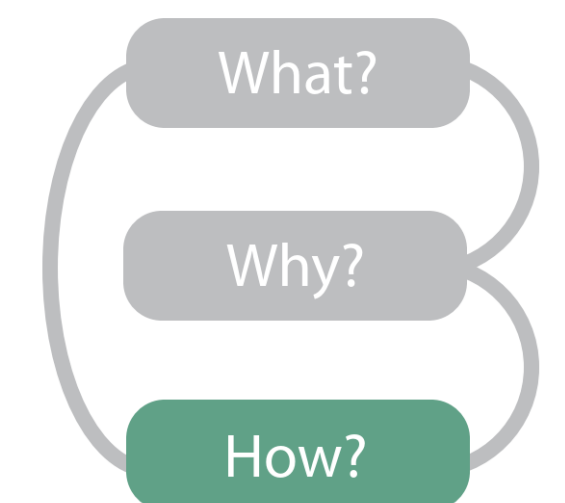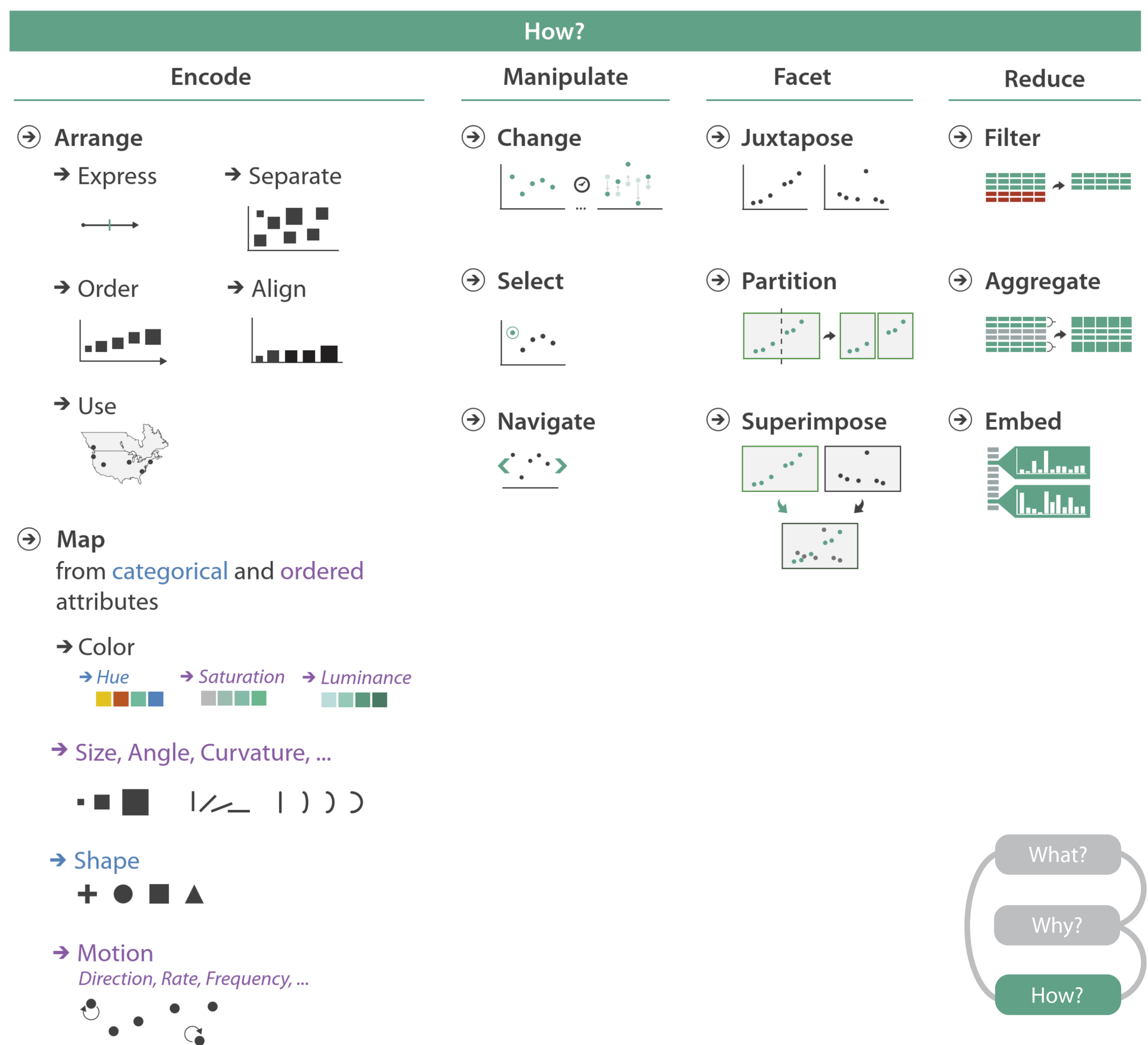
Arrange Tables

➔ **Separate, Order, Align Regions**

➔ Separate ➔ Order ➔ Align
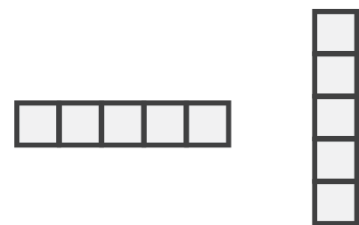
➔ *1 Key* *List* | ➔ *2 Keys* *Matrix* | ➔ *3 Keys* *Volume* | ➔ *Many Keys* *Recursive Subdivision*
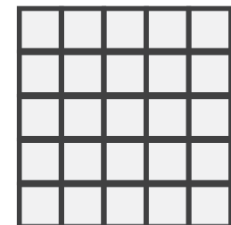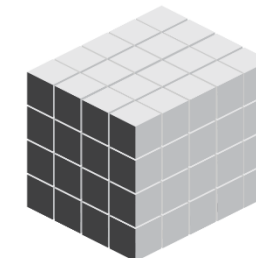
Key: an independent attribute that can be used as a unique index (Tableau Dimension)

Categorical or Ordinal

Value: a dependent attribute (i.e., cell in a table) (Tableau Measures)

Categorical Ordinal, or Quantitative

NOW, ON CS 7250...

Analysis

What? — DATA ABSTRACTION

Why? — TASK ABSTRACTION

How? — VISUAL ENCODING

GOALS FOR TODAY

- Learn (more) about visual encodings, esp. arranging tables

- Learn how to pick appropriate visual representations based on attribute type and perceptual properties

Arrange Tables - two keys

➔ *2 Keys*
   Matrix

STREAMGRAPH

Byron & Wattenberg, 2008
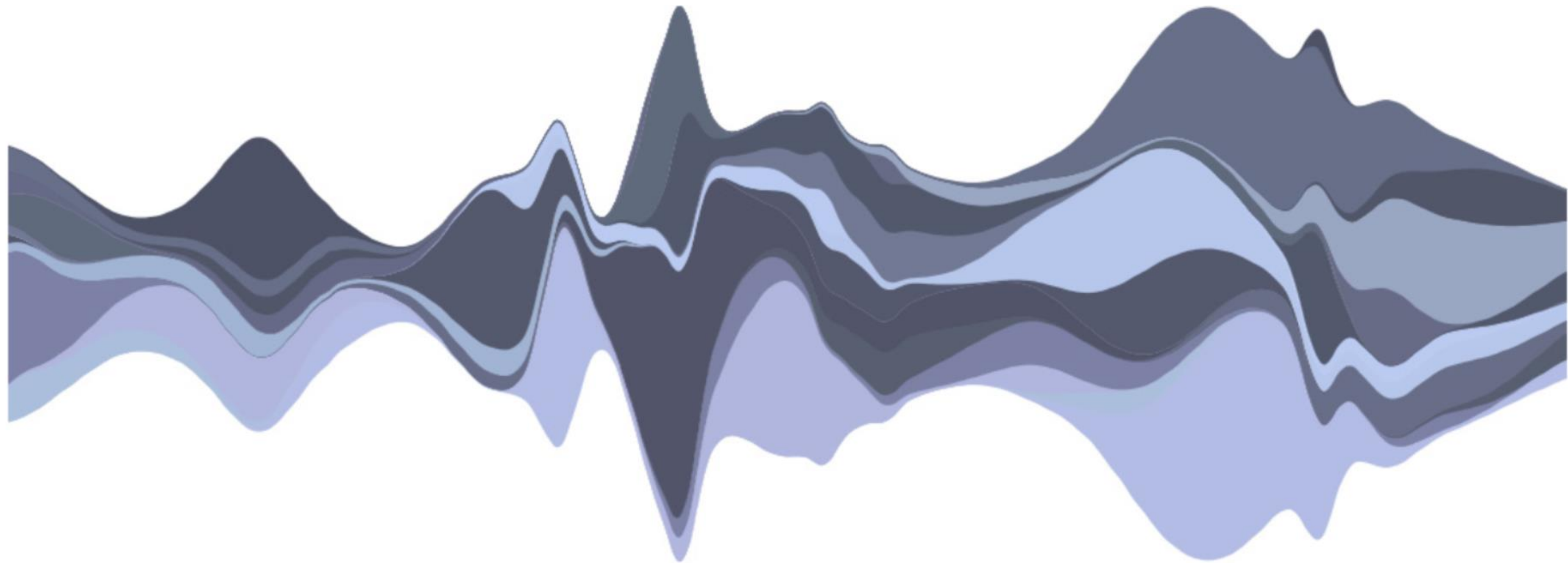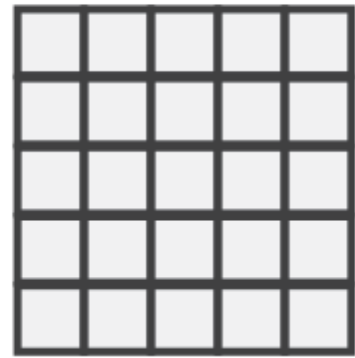
Arrange Tables - two keys
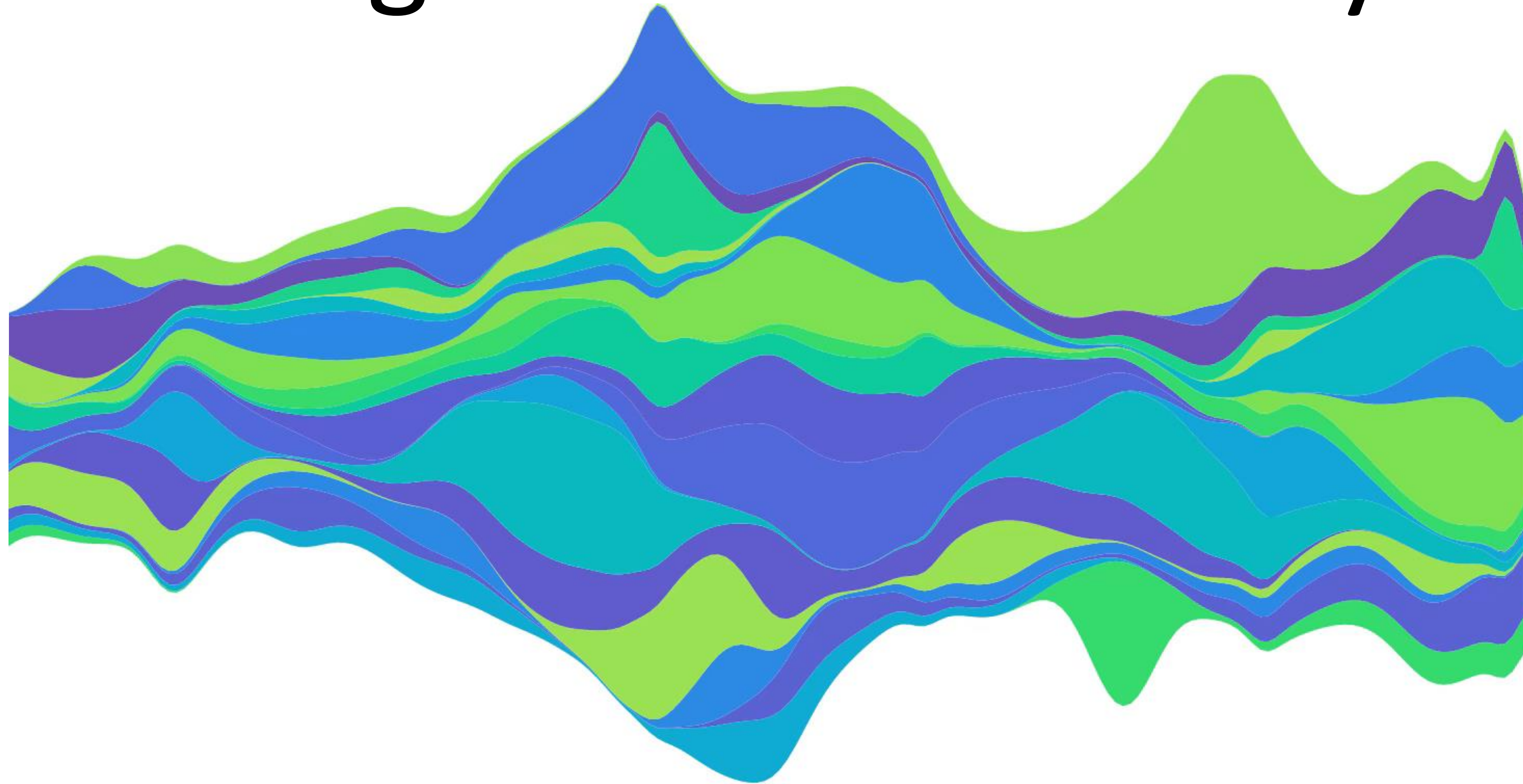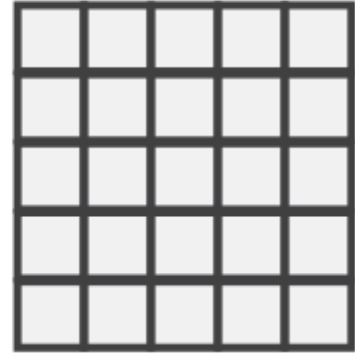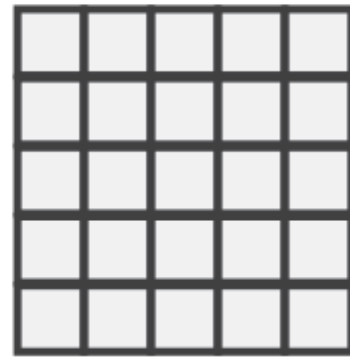
➔ *2 Keys*
Matrix

STREAMGRAPH

Bostock, 2018
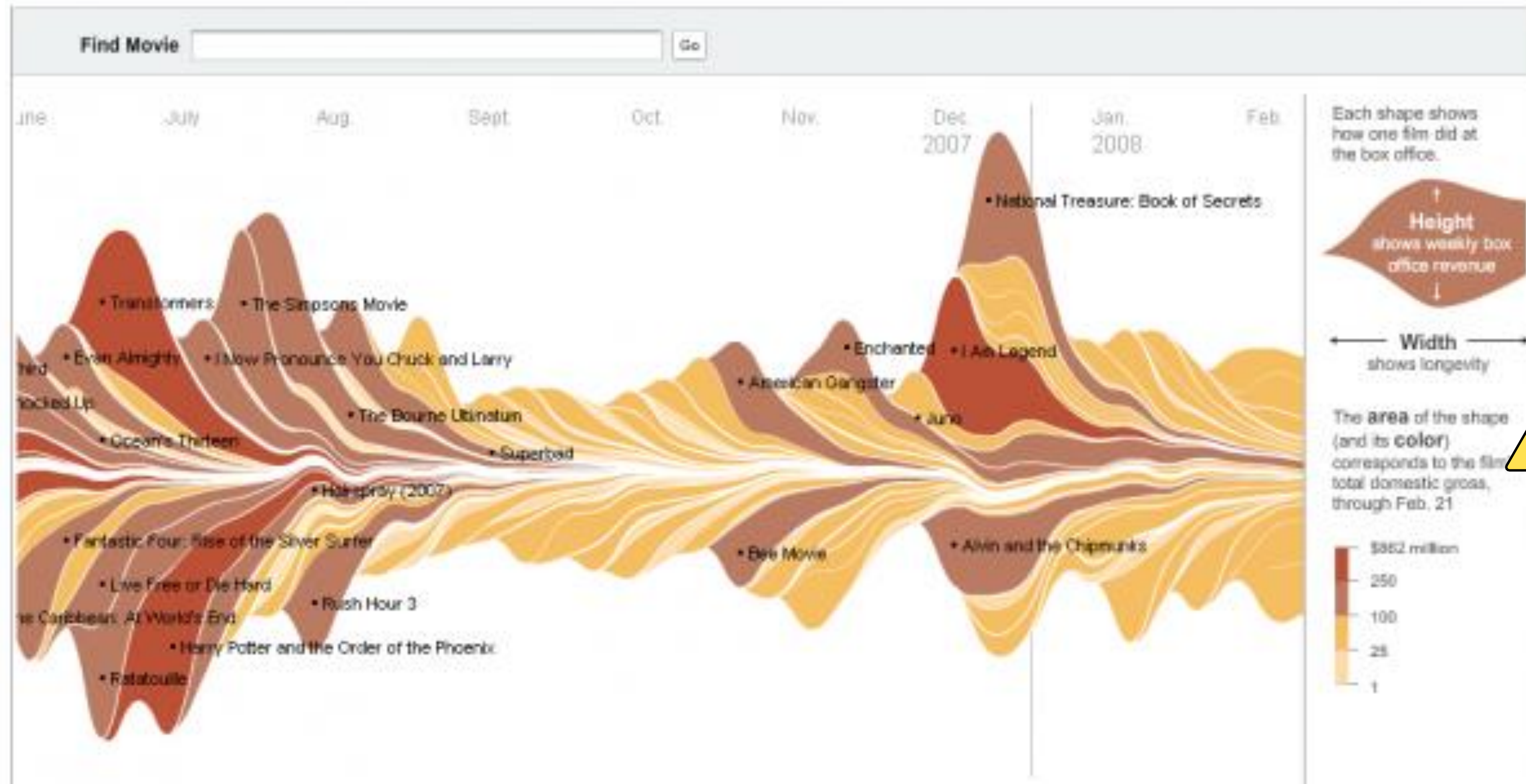
Arrange Tables - two keys

→ *2 Keys*

Matrix

Arrange Tables - two keys

→ *2 Keys*
Matrix

Shrek the Third

Pirates of the Caribbean: At World's End

Best actress · · · · ·
La Vie En Rose

Knocked Up

Ocean's Thirteen

Fantastic Four: Rise of the Silver Surfer

Evan Almighty · 1408

Live Free or Die Hard

Transformers

Ratatouille

Harry Potter and the Order of the Phoenix

I Now Pronounce You Chuck & Larry

Hairspray

The Simpsons Movie

The Bourne Ultimatum

Each shape shows how one film did at the box office.

Height shows weekly box office revenue

Width shows longevity

The **area** of the shape (and its **color**) corresponds to the film's total domestic gross, through Feb. 21

$862 million
250
100
25
1

Byron & Wattenberg, 2008

Arrange Tables - two keys

→ *2 Keys*
Matrix

Rio2016

A Visual History of Which Countries Have Dominated the Summer Olympics

By GREGOR AISCH and LARRY BUCHANAN   UPDATED August 22, 2016
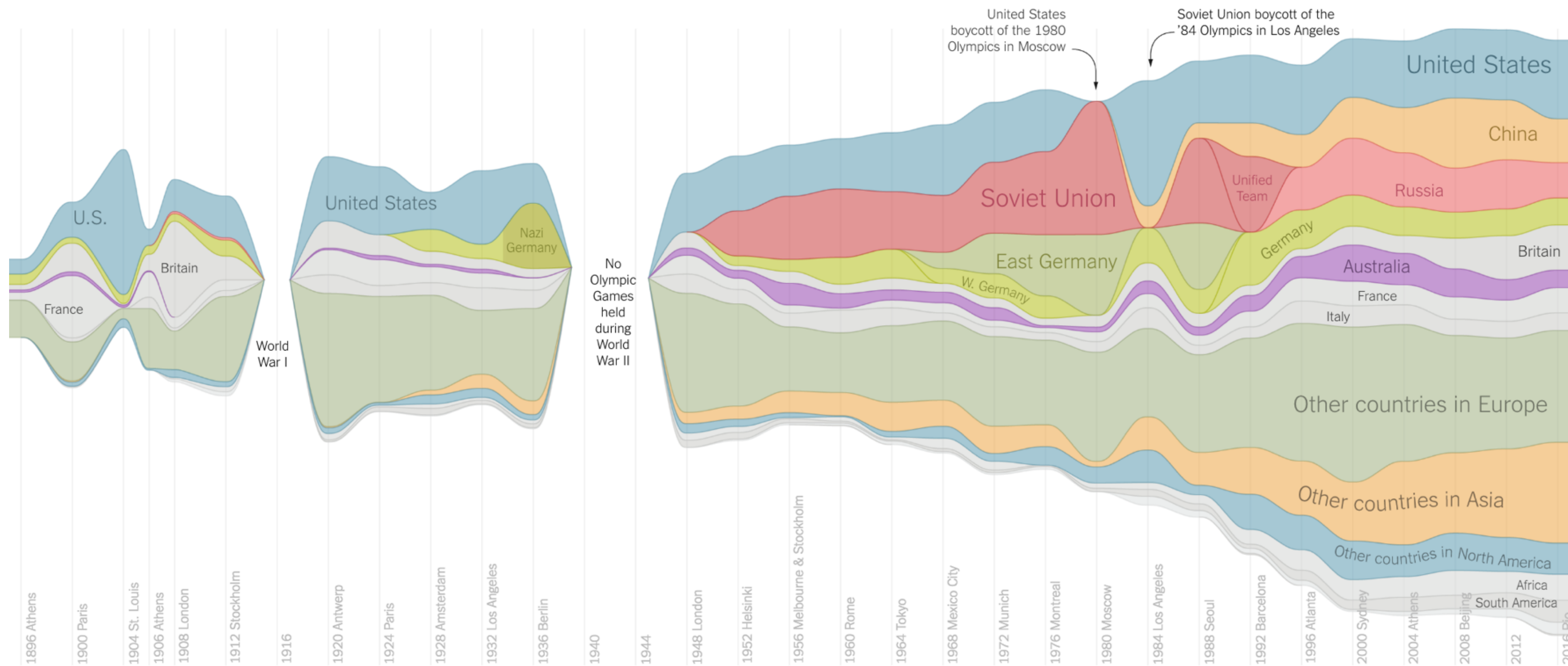
Just 10 countries — the United States, Australia and eight

Arrange Tables - Axes

Table

Math	Physics	Dance	Drama
85	95	70	65
90	80	60	50
65	50	90	90
50	40	95	80
40	60	80	90

Scatterplot Matrix
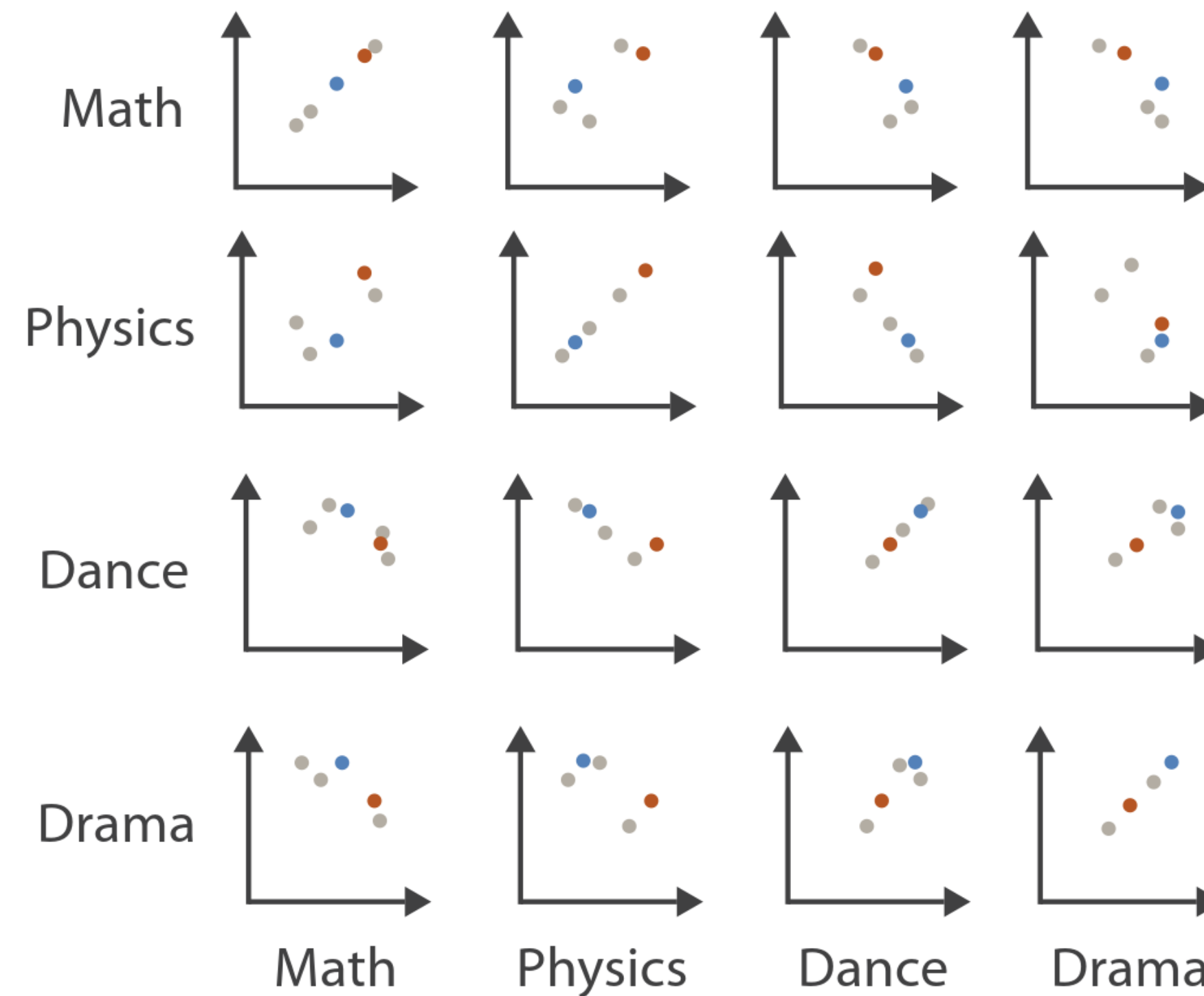
Parallel Coordinates
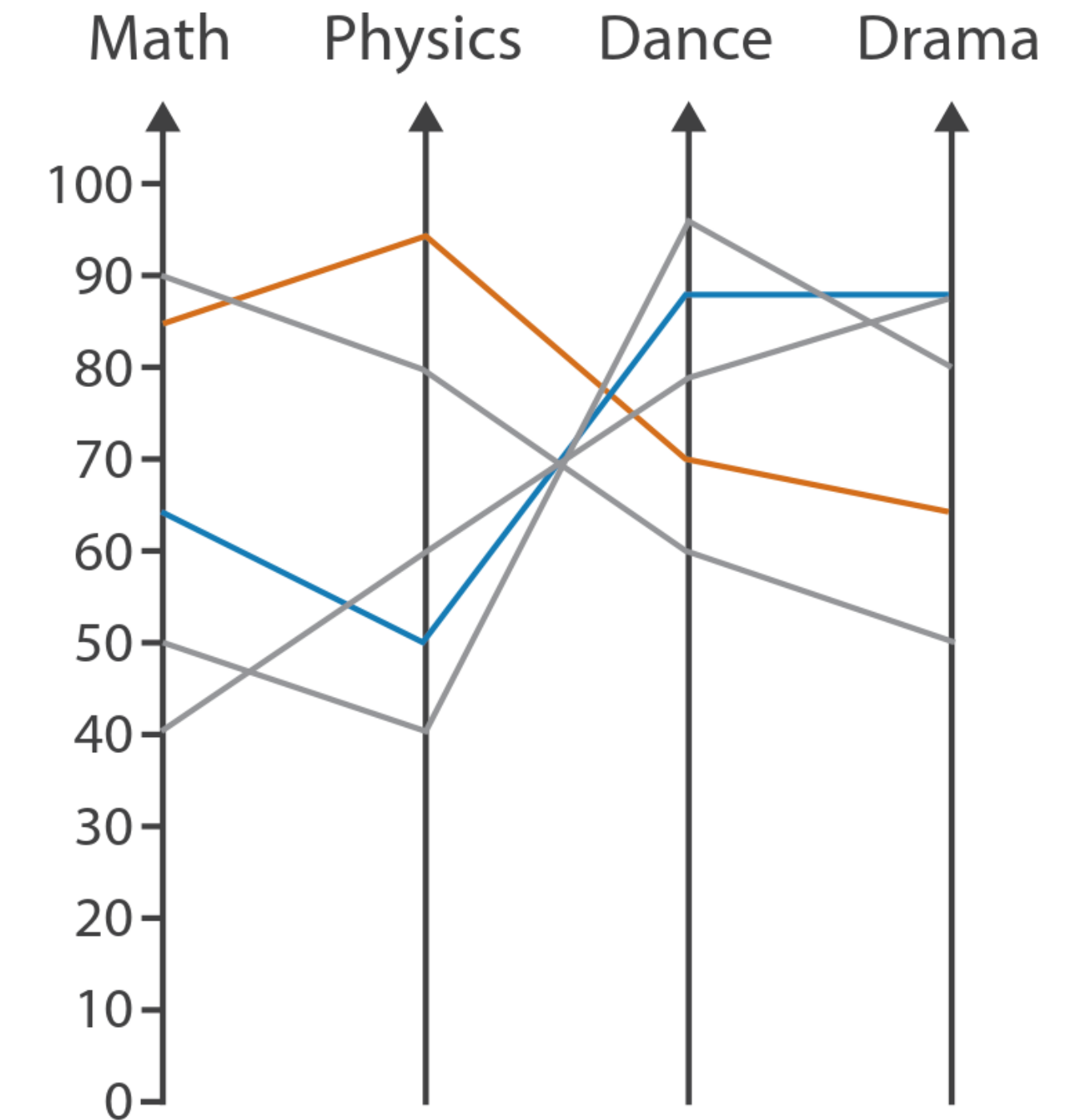
Arrange Tables - Axes

➔ **Axis Orientation**
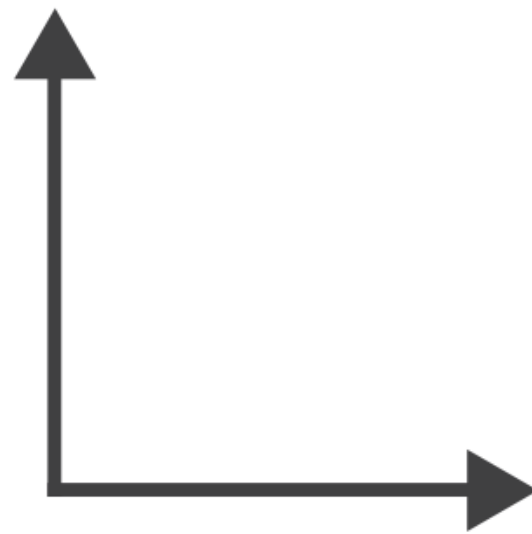
➔ Rectilinear   ➔ Parallel   ➔ Radial
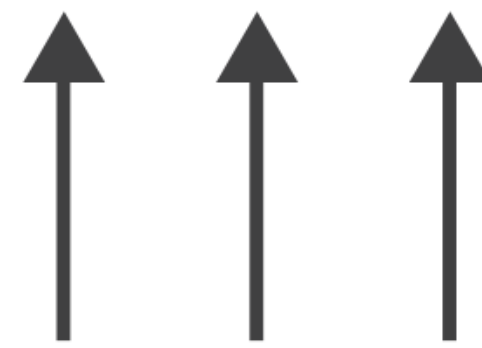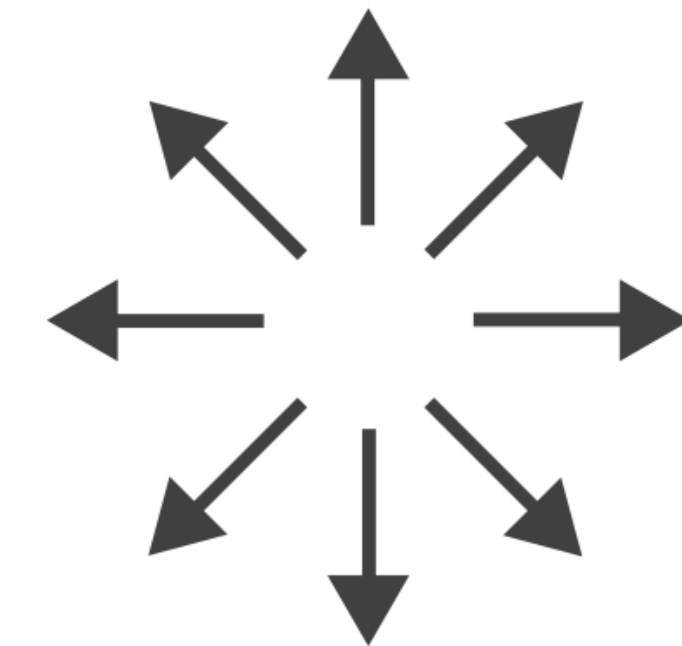
Arrange Tables
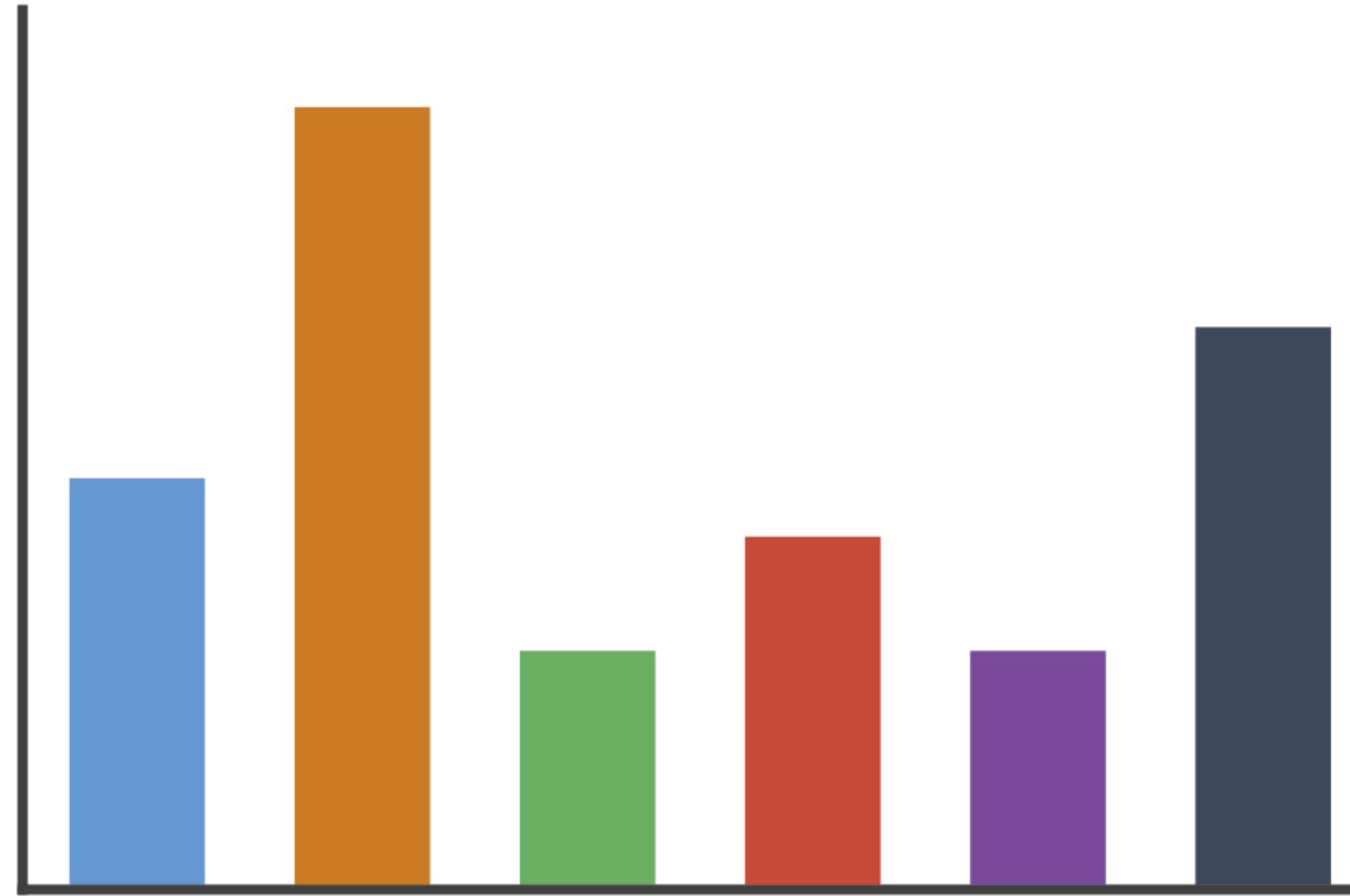
→ Rectilinear
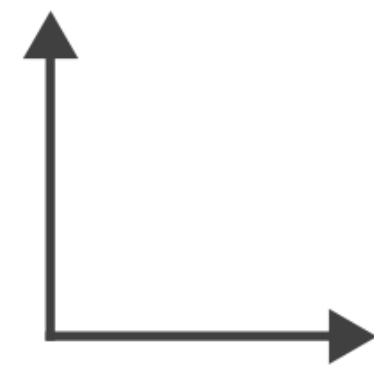
→ Radial
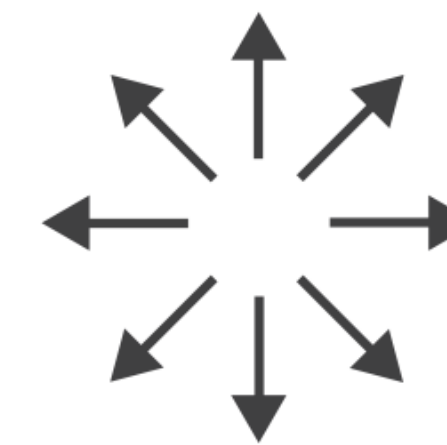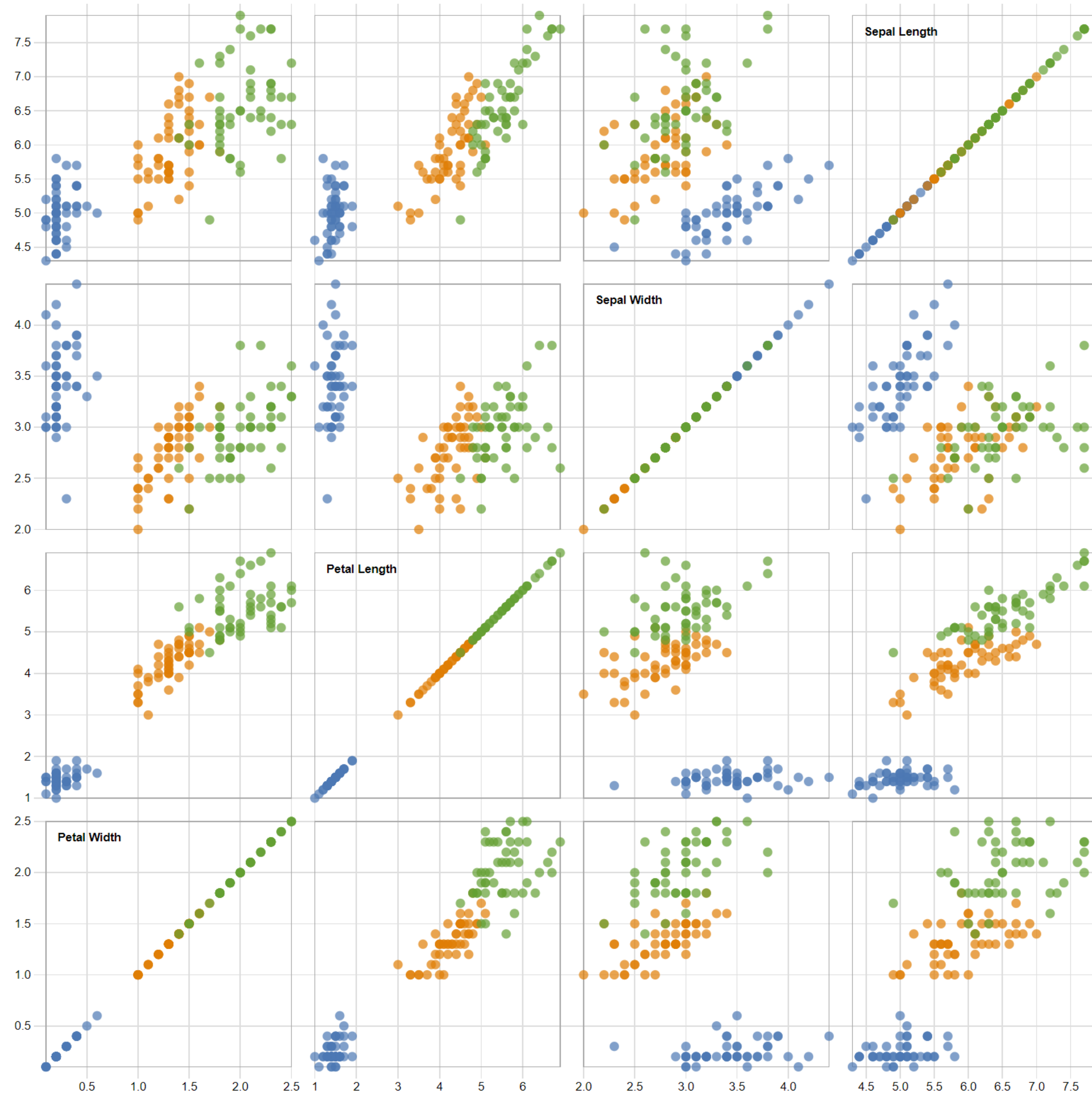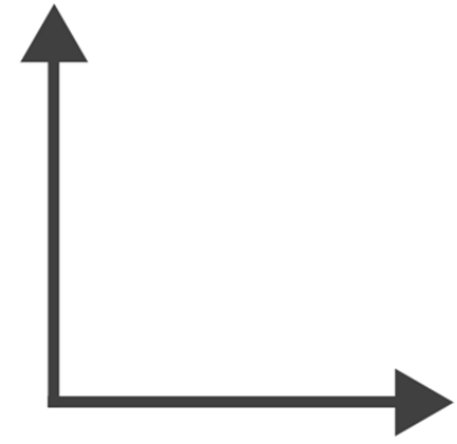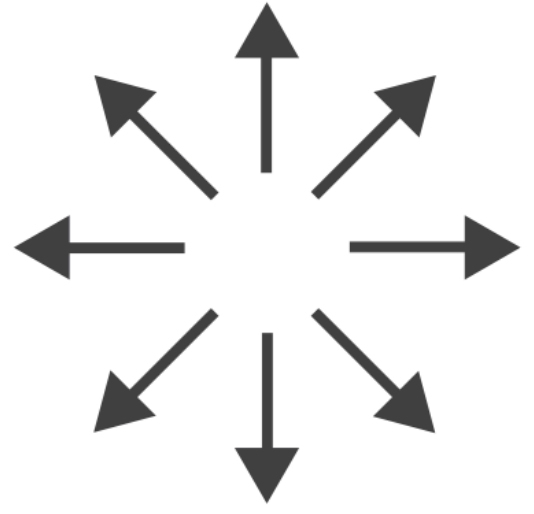
→ Rectilinear

Bostock, Rivière' 2019

→ Radial

→ Radial
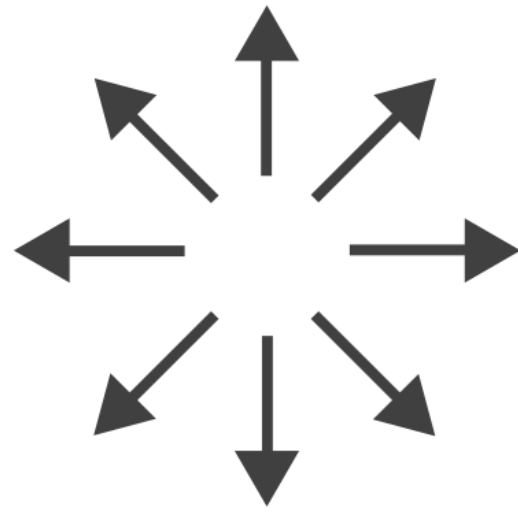
DIAGRAM OF THE CAUSES OF MORTALITY IN THE ARMY IN THE EAST.

FLORENCE NIGHTINGALE (C. 1858)

→ Parallel

cylinders   displacement (cc)   power (hp)   weight (lb)   0-60 mph (s)   year

Note: Higher is worse

Davies, 2019

25
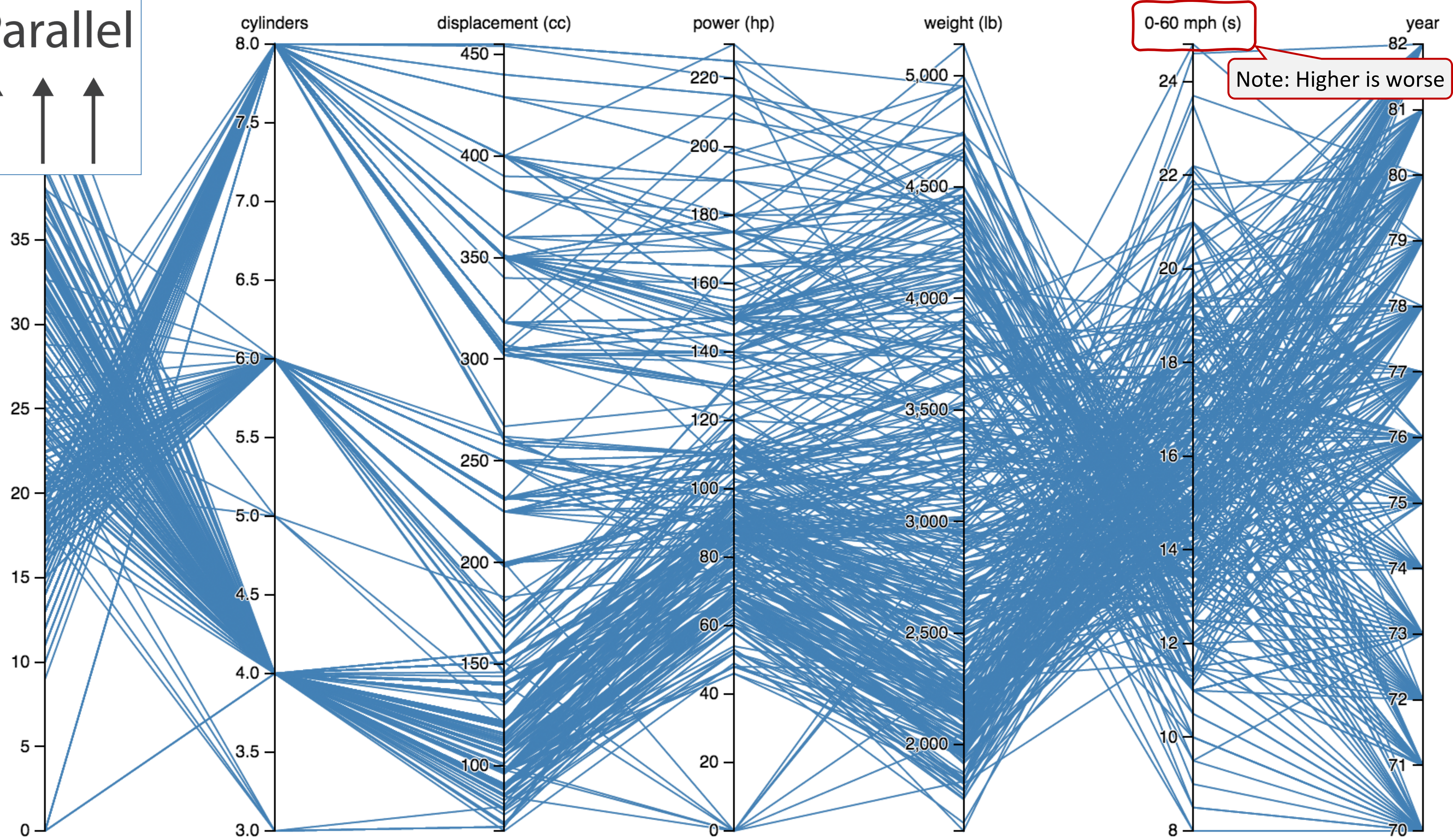
Arrange Tables – Many Keys (Tree)

→ *Many Keys*
Recursive Subdivision

finviz, 2020

In-Class Exercise: Design From Task Analysis

In-Class Design

Task Analysis→Visualization for Public Transit Development

38 min

INSTRUCTIONS:

- [In-Class Design — Task Analysis→Visualization for Public Transit Development on Canvas](#)

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)

Most

Effectiveness

Least

Same

Same

→ **Identity Channels: Categorical Attributes**

Spatial region

Color hue

Motion

Shape