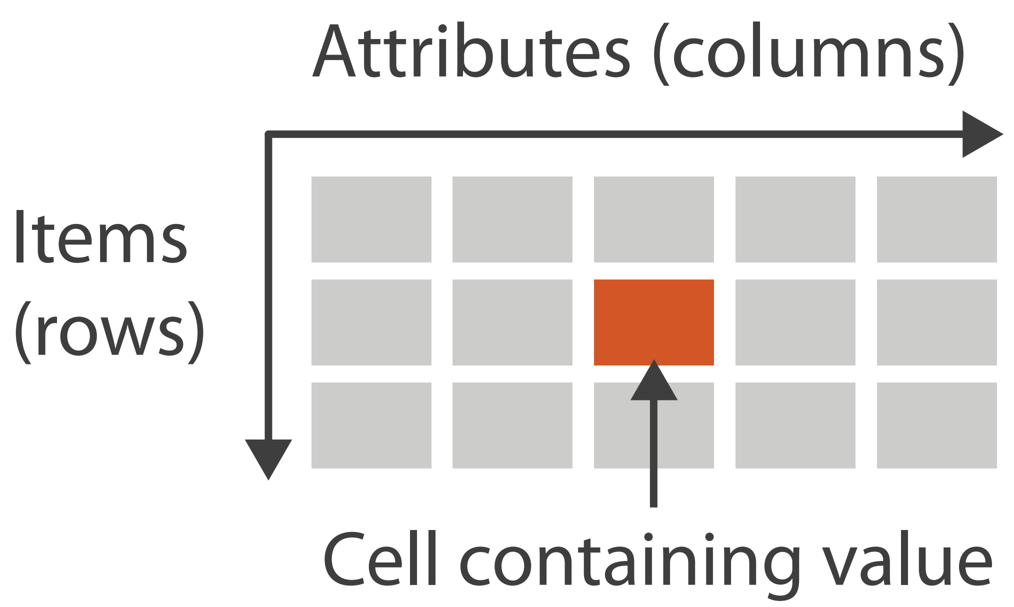
Data Visualization (CSCI 627/490)

Design & D3

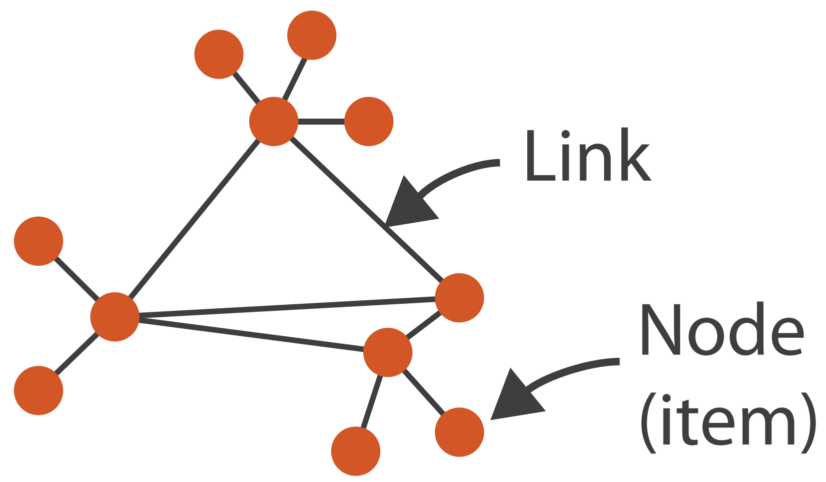
Dr. David Koop

Dataset Types

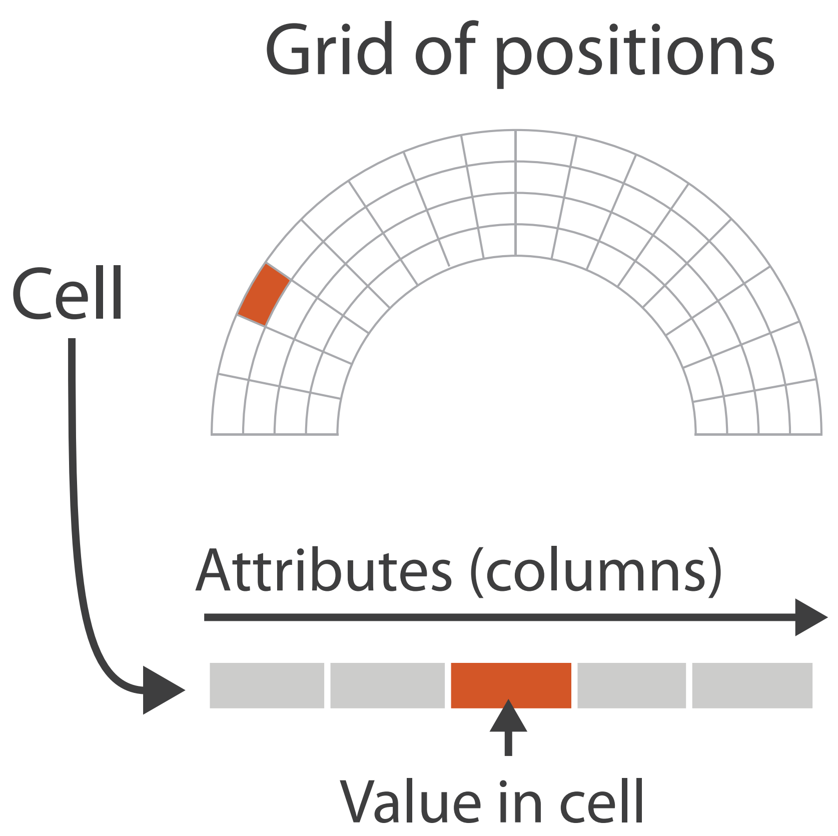
- Tables



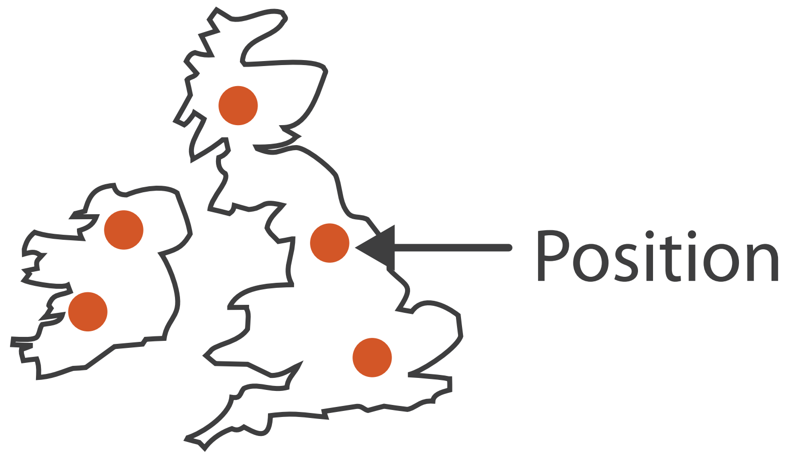
- Networks



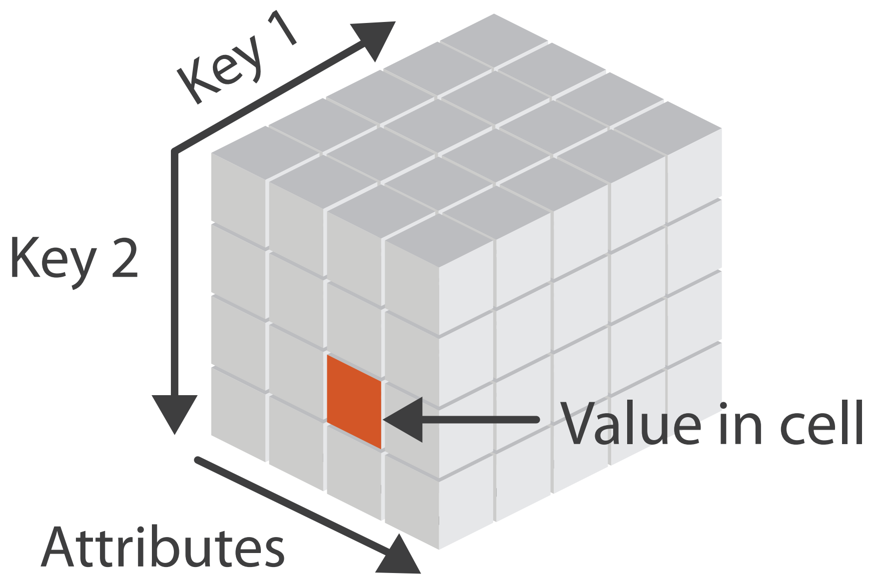
- Fields (Continuous)



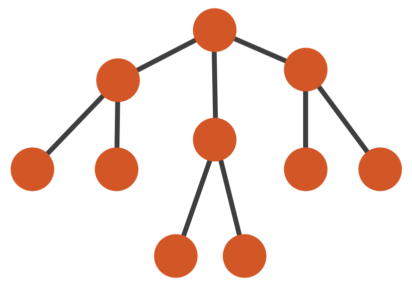
- Geometry (Spatial)



- *Multidimensional Table*



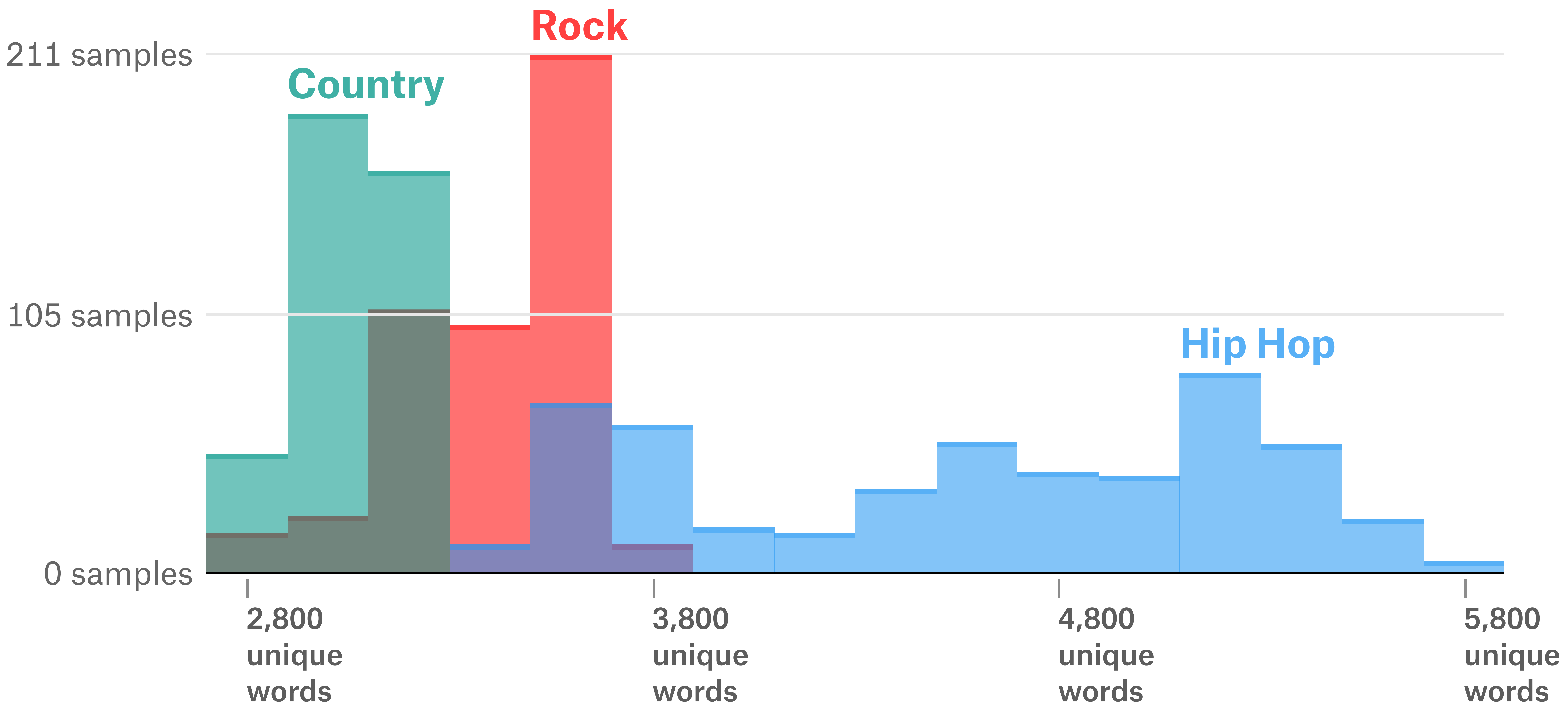
- *Trees*



[Munzner (ill. Maguire), 2014]

Sets & Lists

of Unique Words Used in 500 Random Samples of 35,000 Lyrics from Country, Rock, Hip Hop



Raw Lyrics Data via John W. Miller

[M. Daniels, 2019]

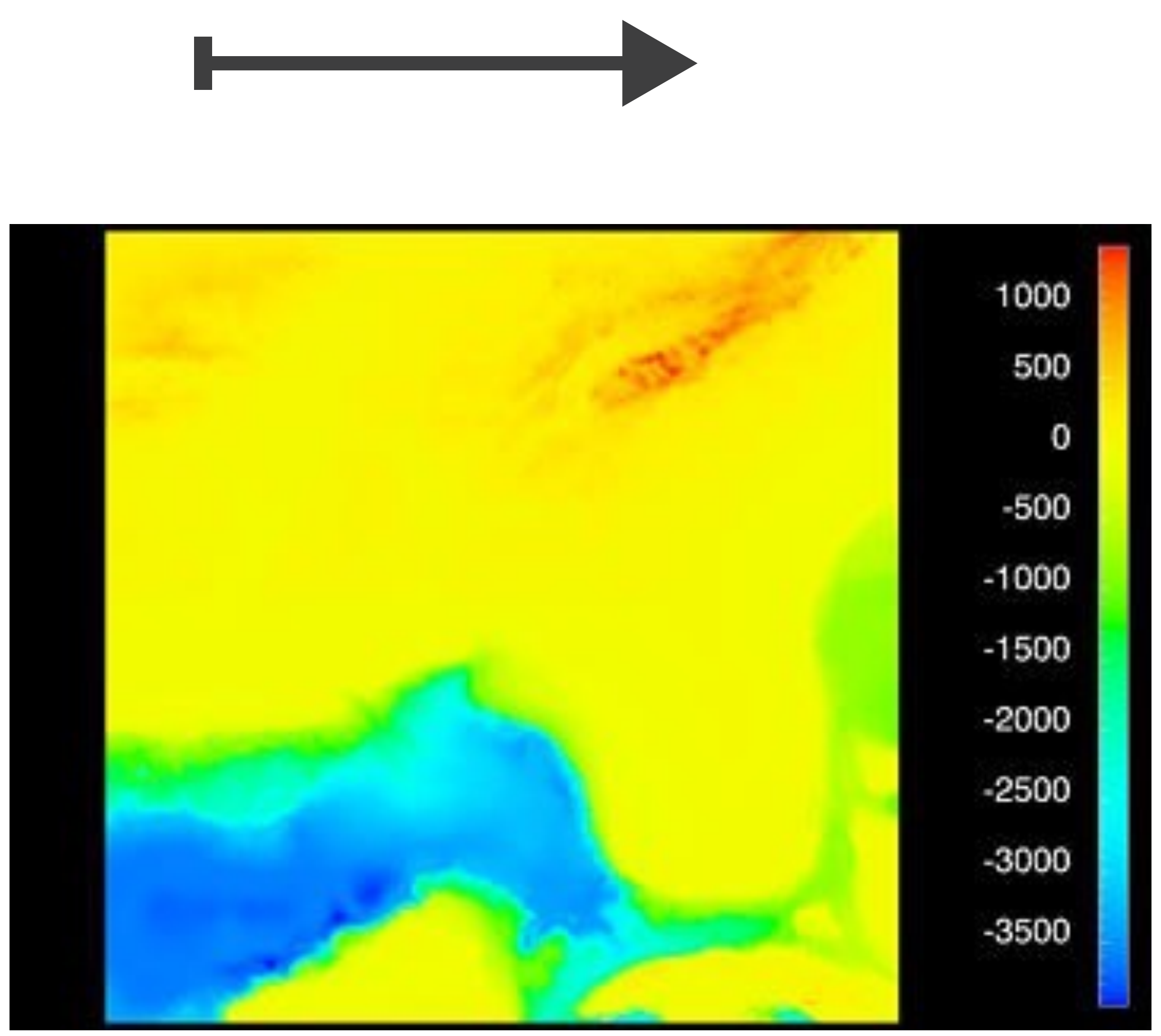
Categorial, Ordinal, and Quantitative

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 Spec[illegible]	[illegible]	0.6	6/6/05
70	12/18/06	5-Low	[illegible]	0.59	12/23/06
70	12/18/06	5-Low	[illegible]	0.82	12/23/06
96	4/17/05	2-High	[illegible]	0.55	4/19/05
97	1/29/06	3-Medium	[illegible]	0.38	1/30/06
129	11/19/08	5-Low	[illegible]	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

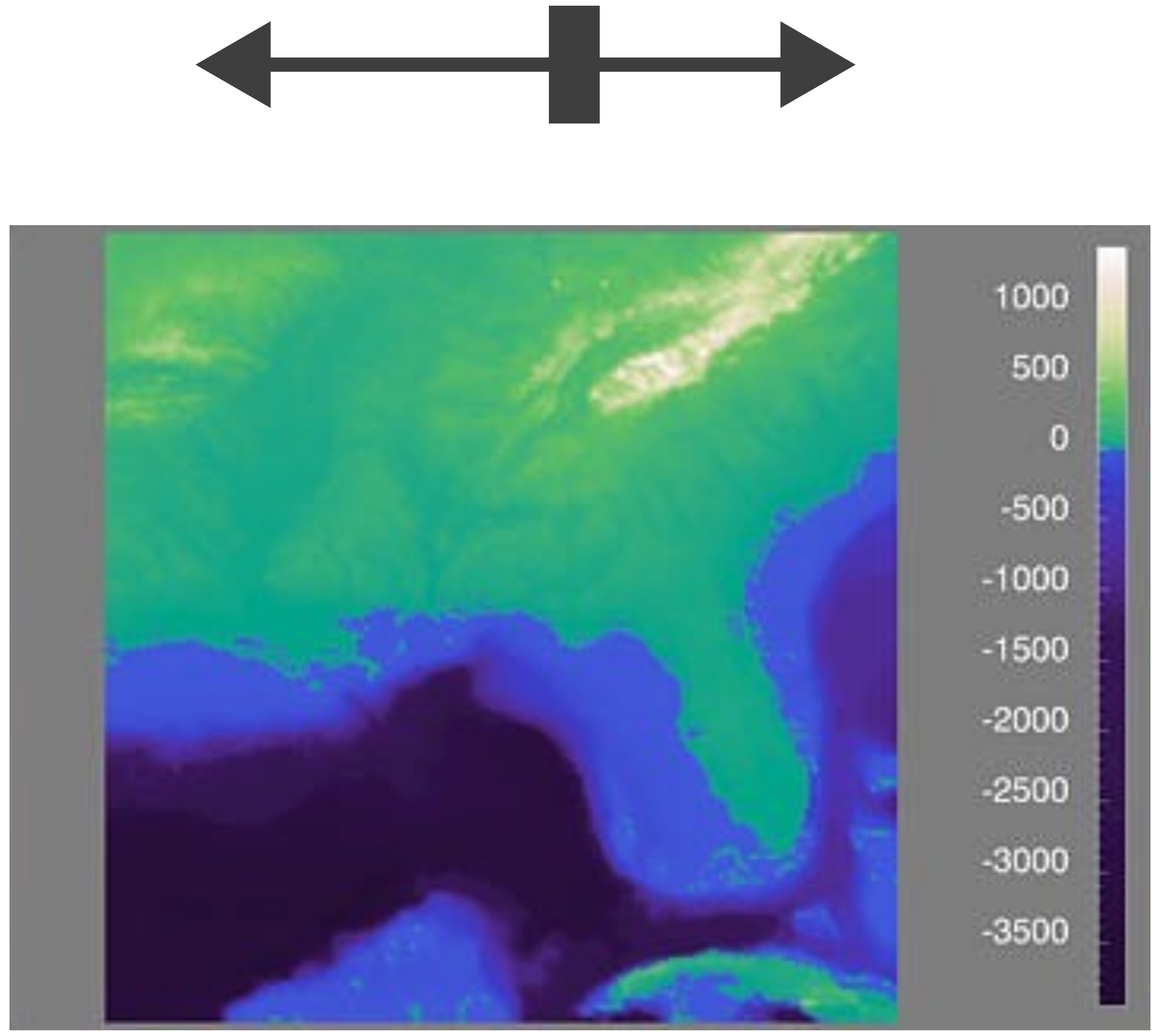
quantitative
ordinal
categorical

Ordering Direction

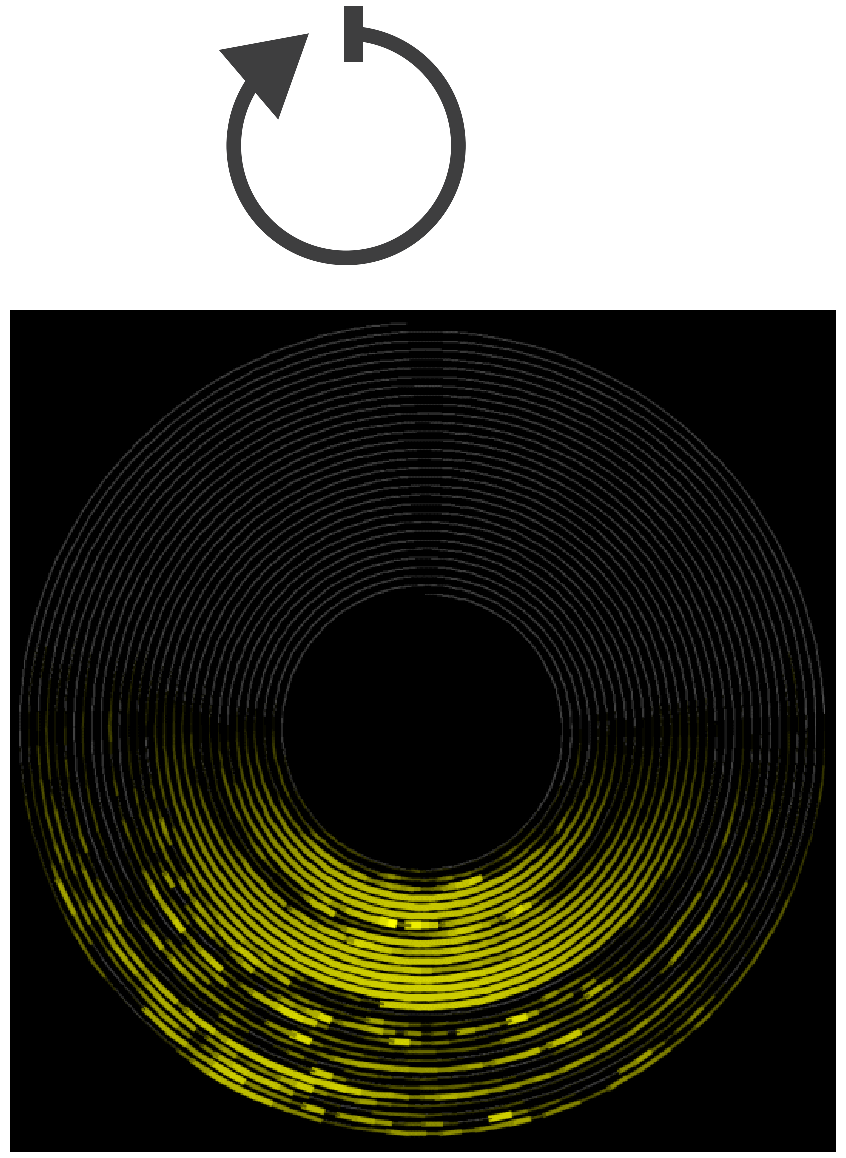
→ Sequential



→ Diverging

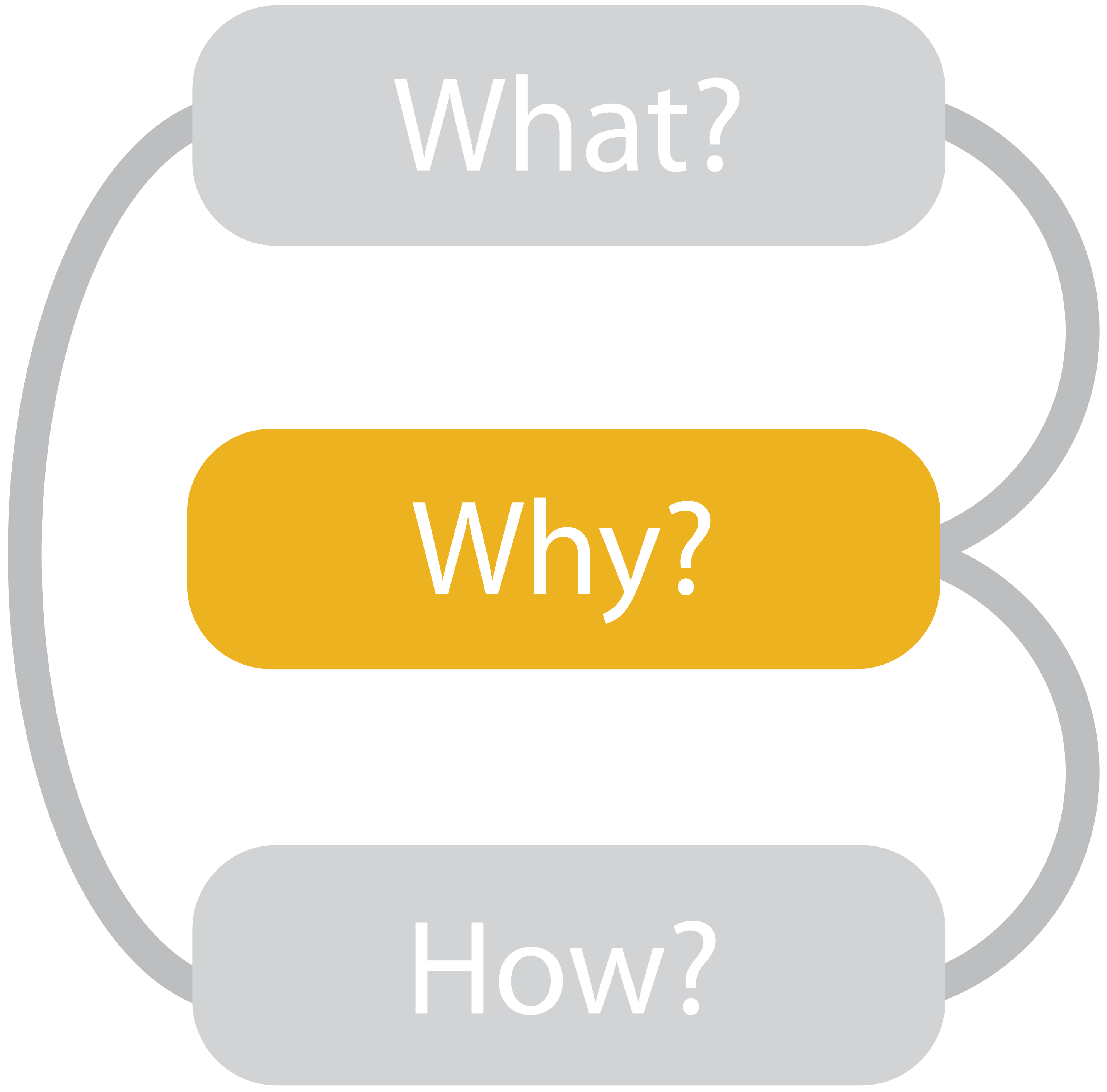


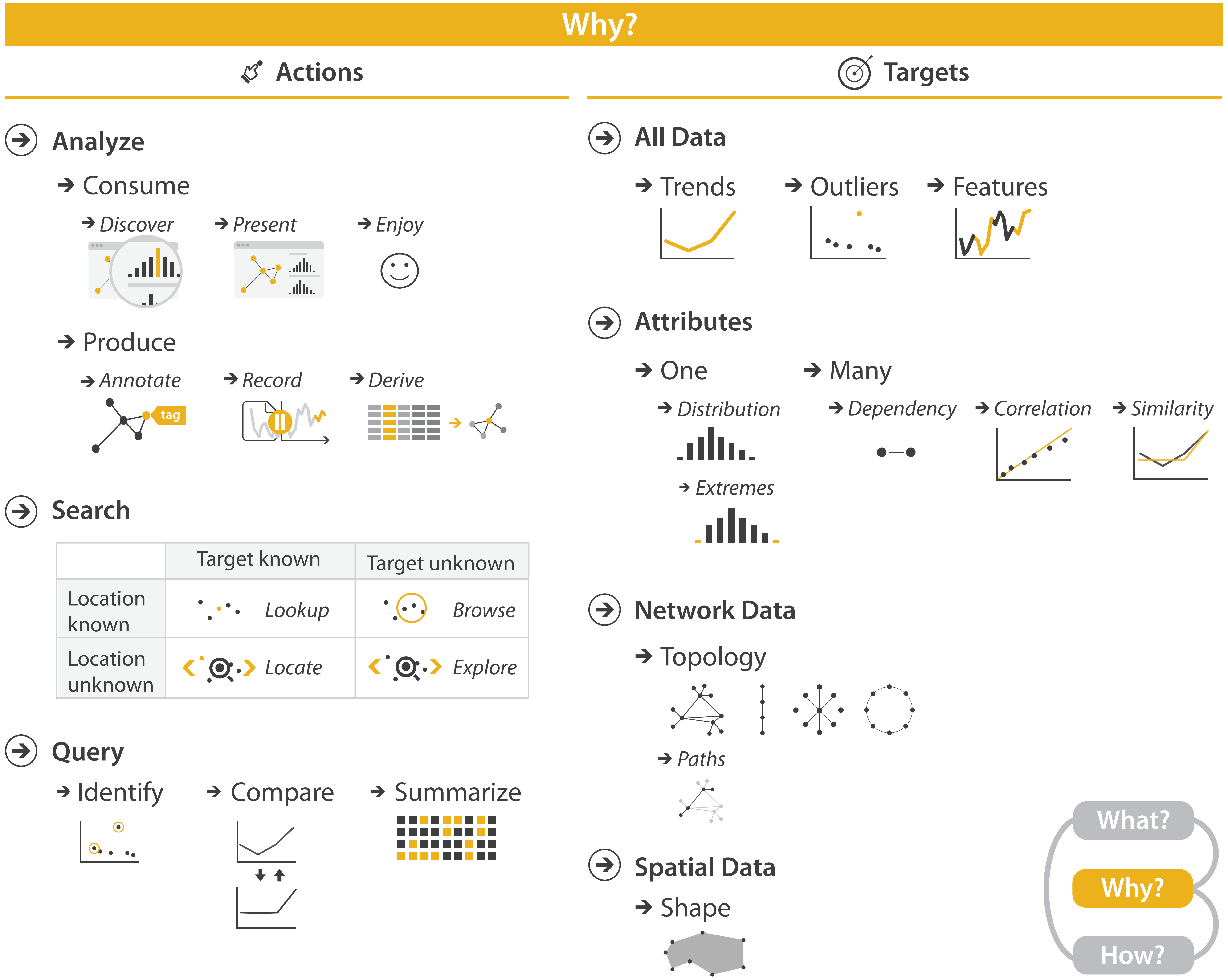
→ Cyclic



[Munzner (ill. Maguire), 2014; Rogowitz & Treinish, 1998; Weber et al., 2001]

Tasks





[Munzner (ill. Maguire), 2014]

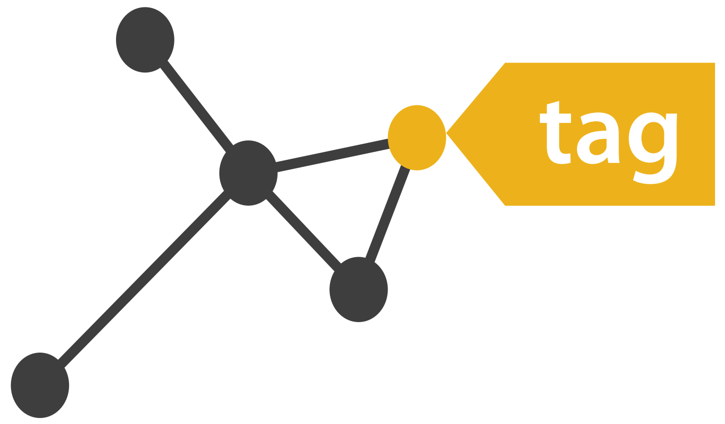
Actions: Analyze

- Consume
  - *Discover*

  - *Present*

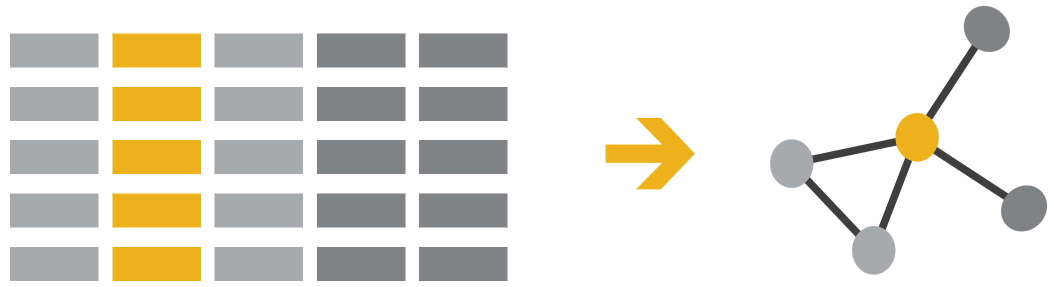
  - *Enjoy*

- Produce
  - *Annotate*



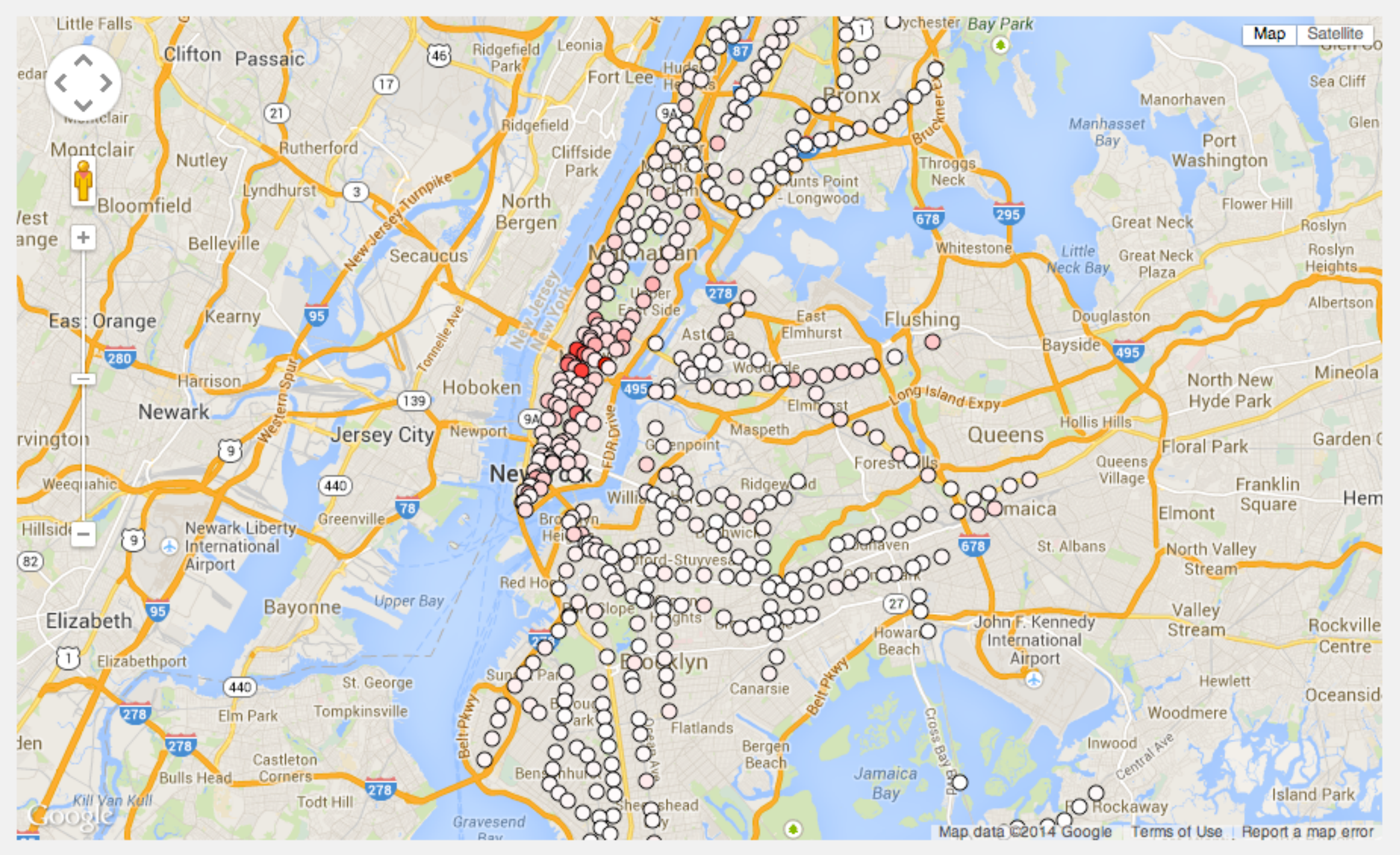
  - *Record*

  - *Derive*

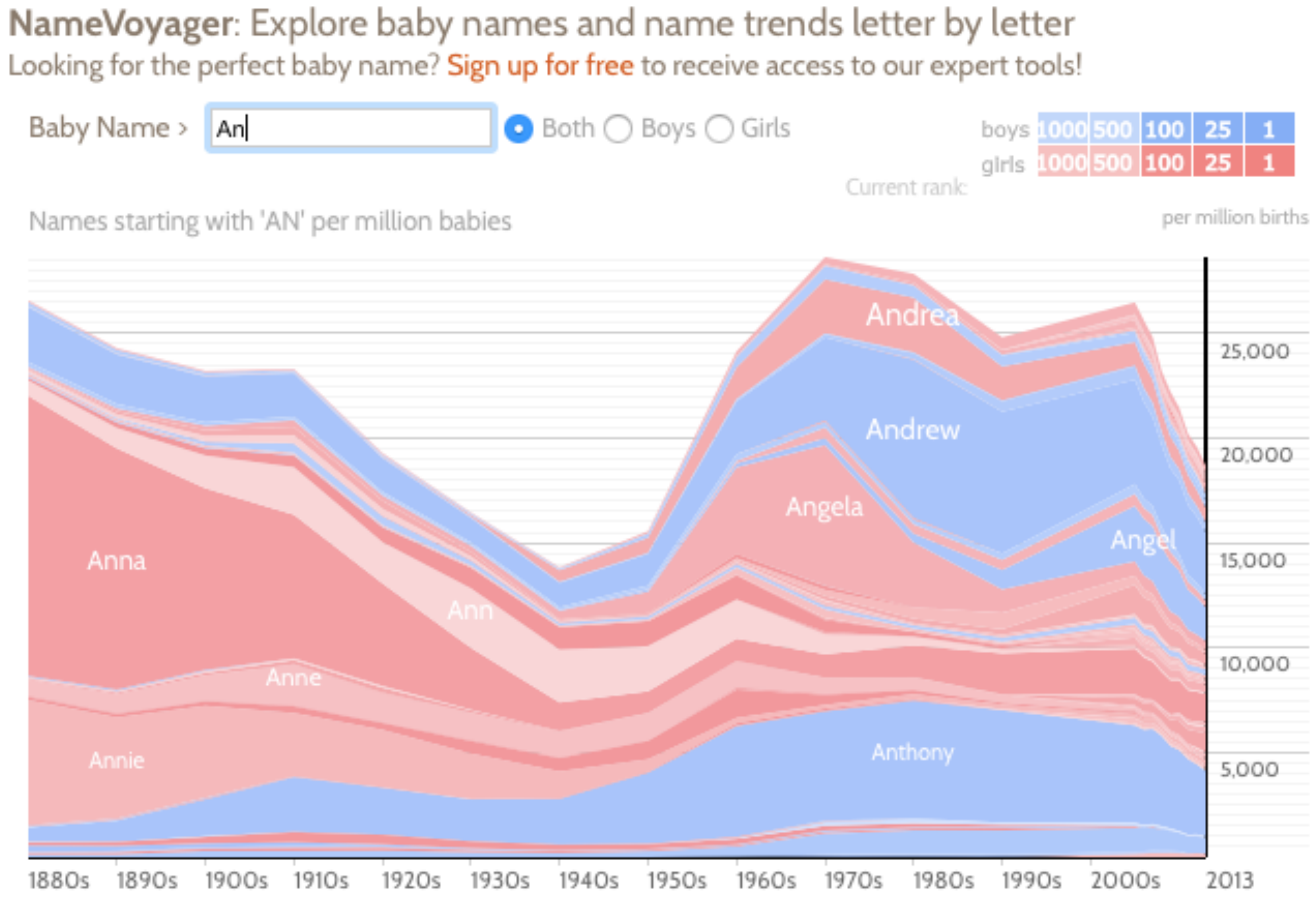


[Munzner (ill. Maguire), 2014]

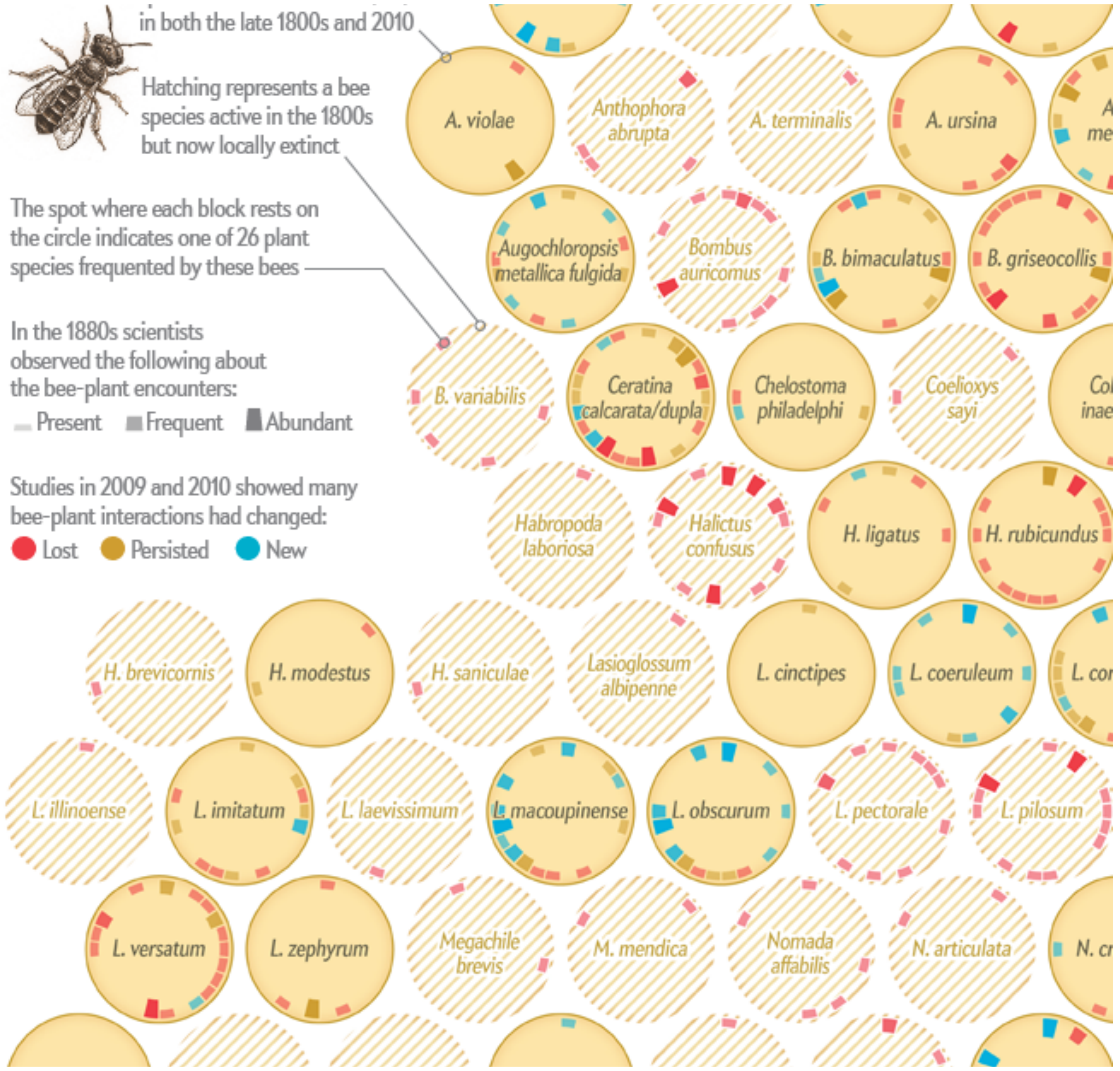
Visualization for Consumption



Discover



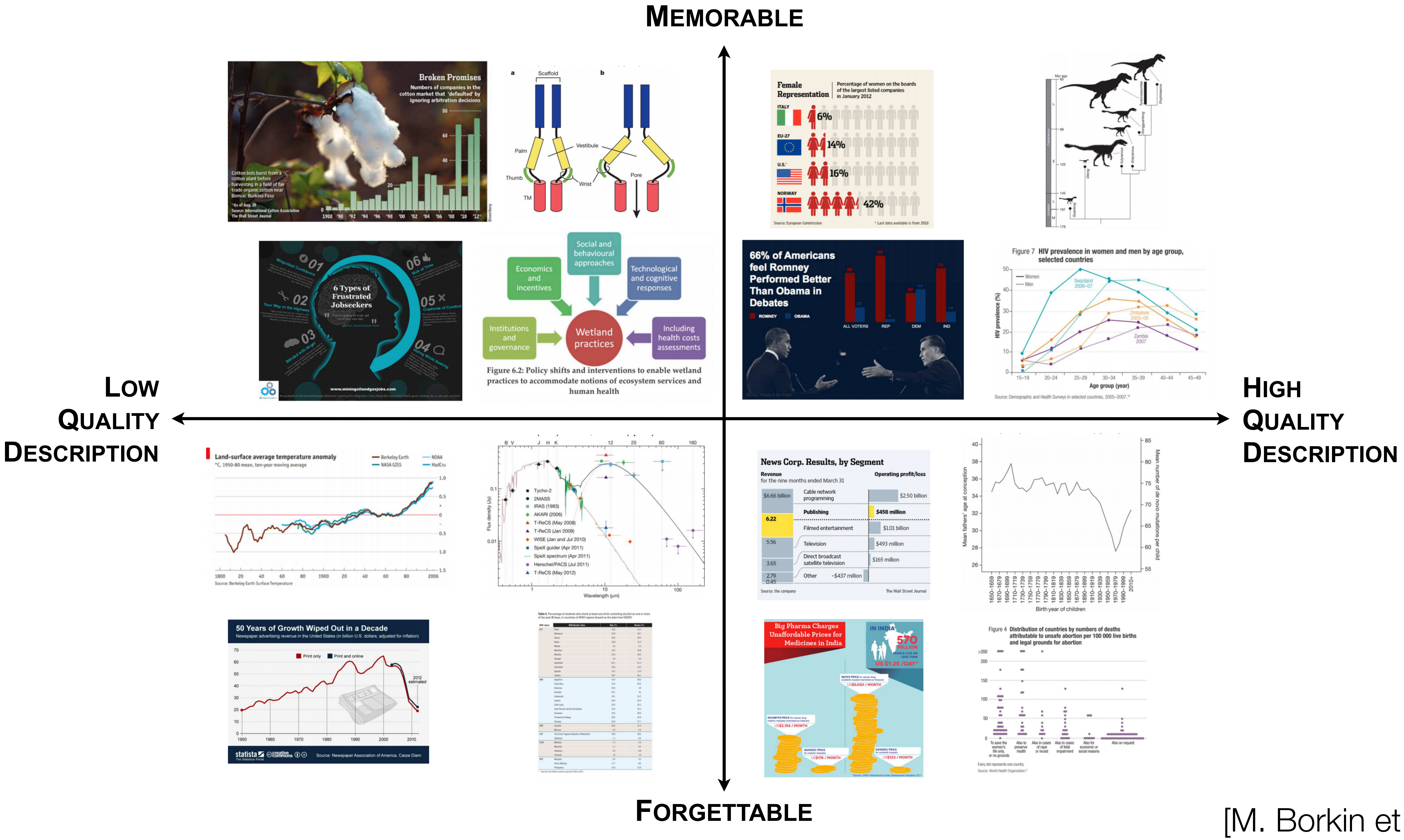
Enjoy



Present

[M. Stefaner, M. Wattenberg]

Memorability



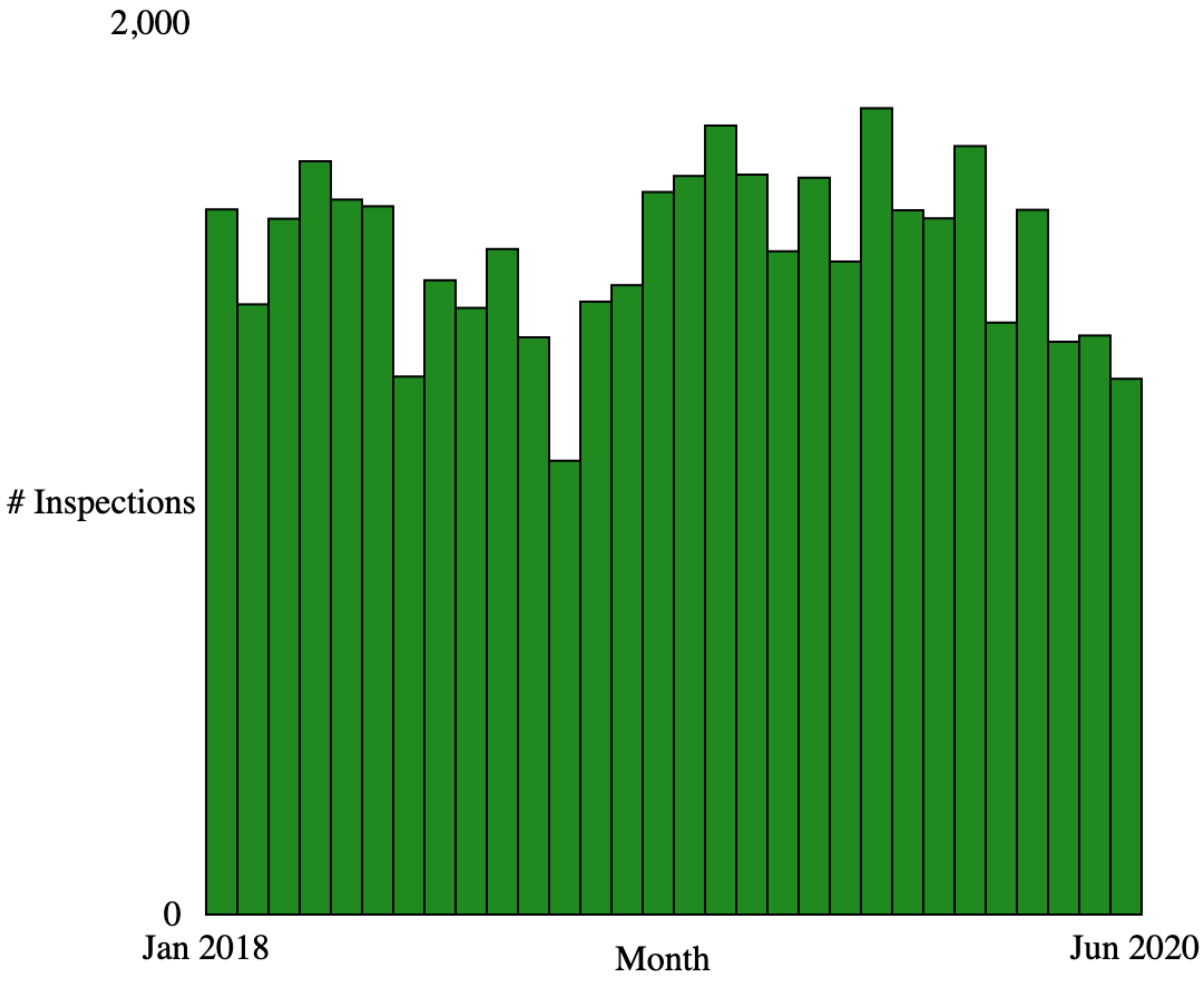
[M. Borkin et al., InfoVis 2015]

Memorability of Visualizations

- S. Few: "Visualizations don’t need to be designed for memorability – they need to be designed for comprehension. For most visualizations, the comprehension that they provide need only last until the decision that it informs is made. Usually, that is only a matter of seconds."
- B. Jones (paraphrased): People make decisions using visualizations but this isn't instantaneous like robots or algorithms; they often chew on a decision for a while
- R. Kosara: there are cases where people benefit from remembering a visualization (e.g. health-related visualization)
- Are there tradeoffs between the characteristics?

Assignment 2

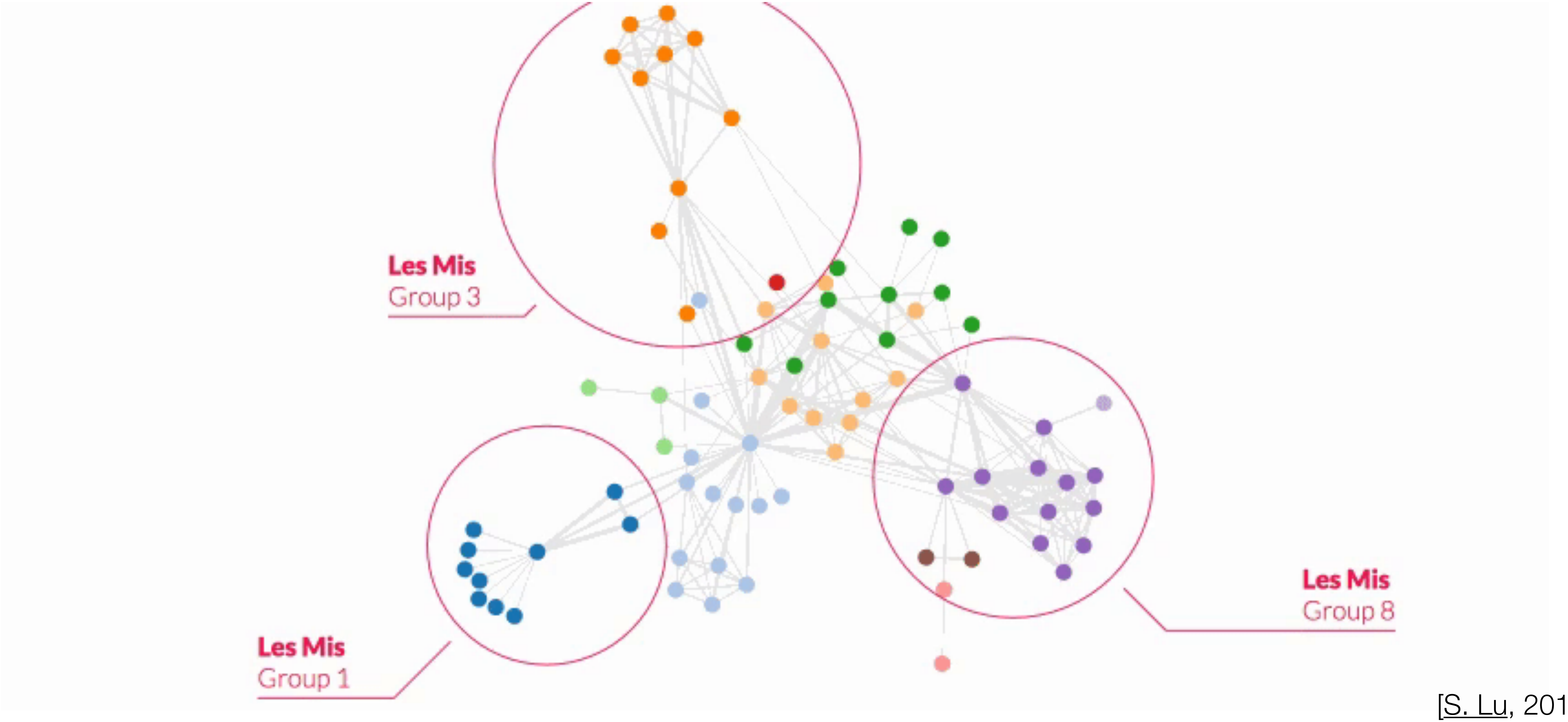
- Link
- Three parts: table, horizontal bar chart, vertical bar chart
  - data processing
  - highlighting (CSCI 627)
- Vertical chart can be tricky
- Start early!
- Questions?



Visualization for Production

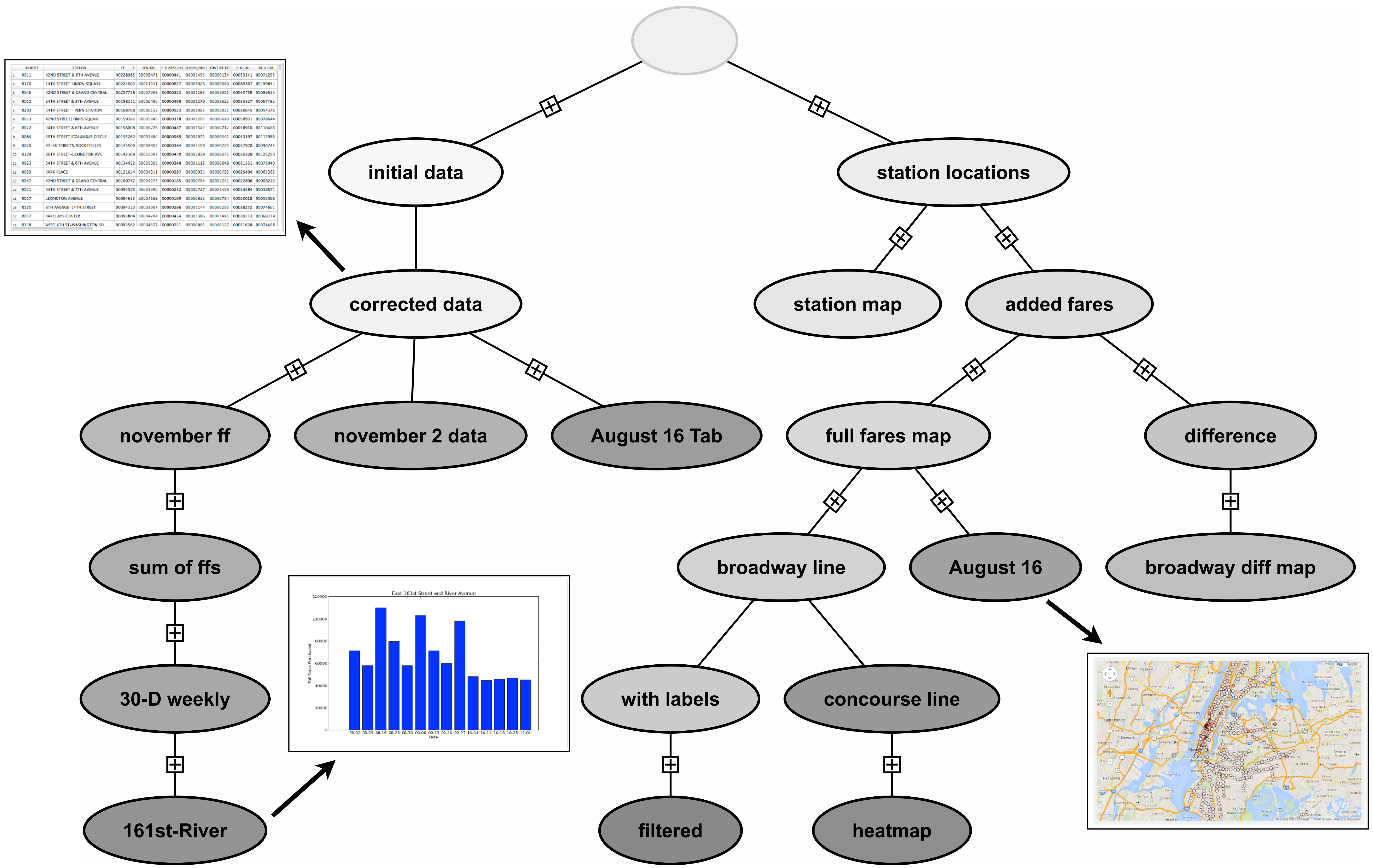
- Generate new material
- Annotate
- Record
- Derive (Transform)

Annotation: Circle Annotations

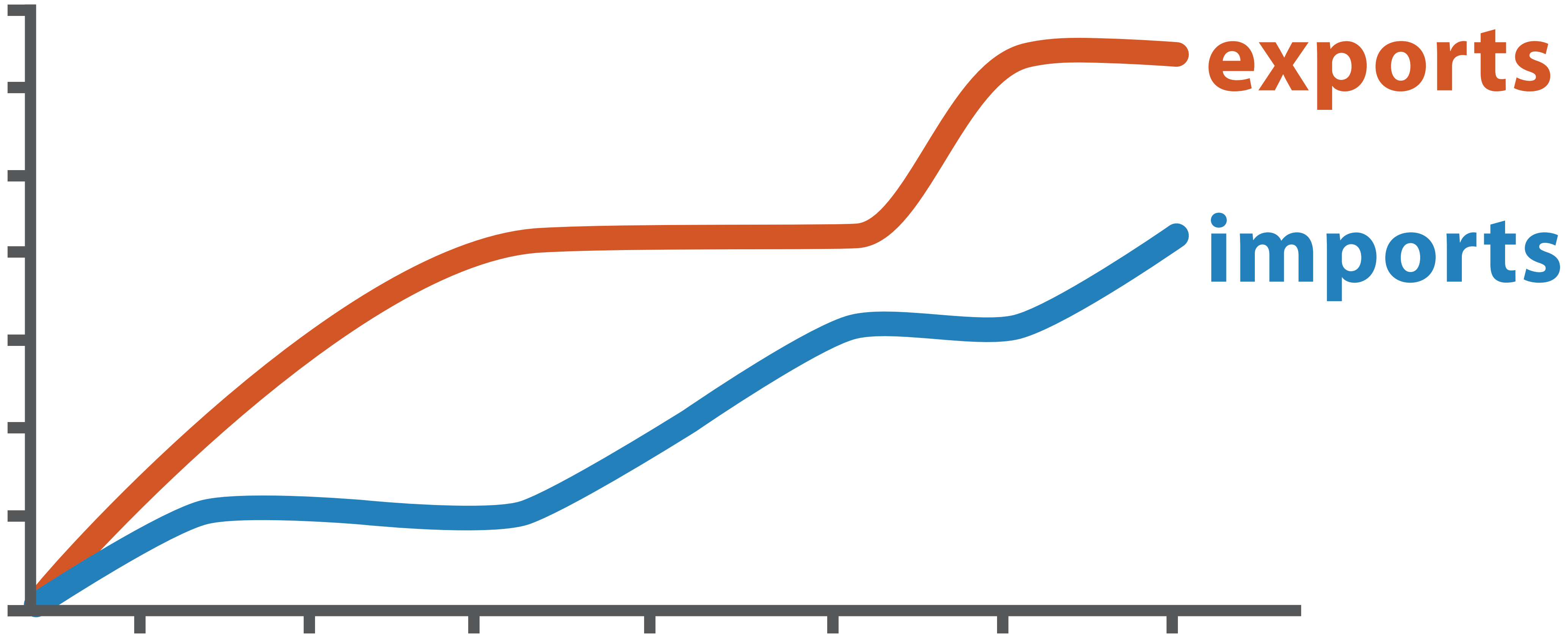


[S. Lu, 2017]

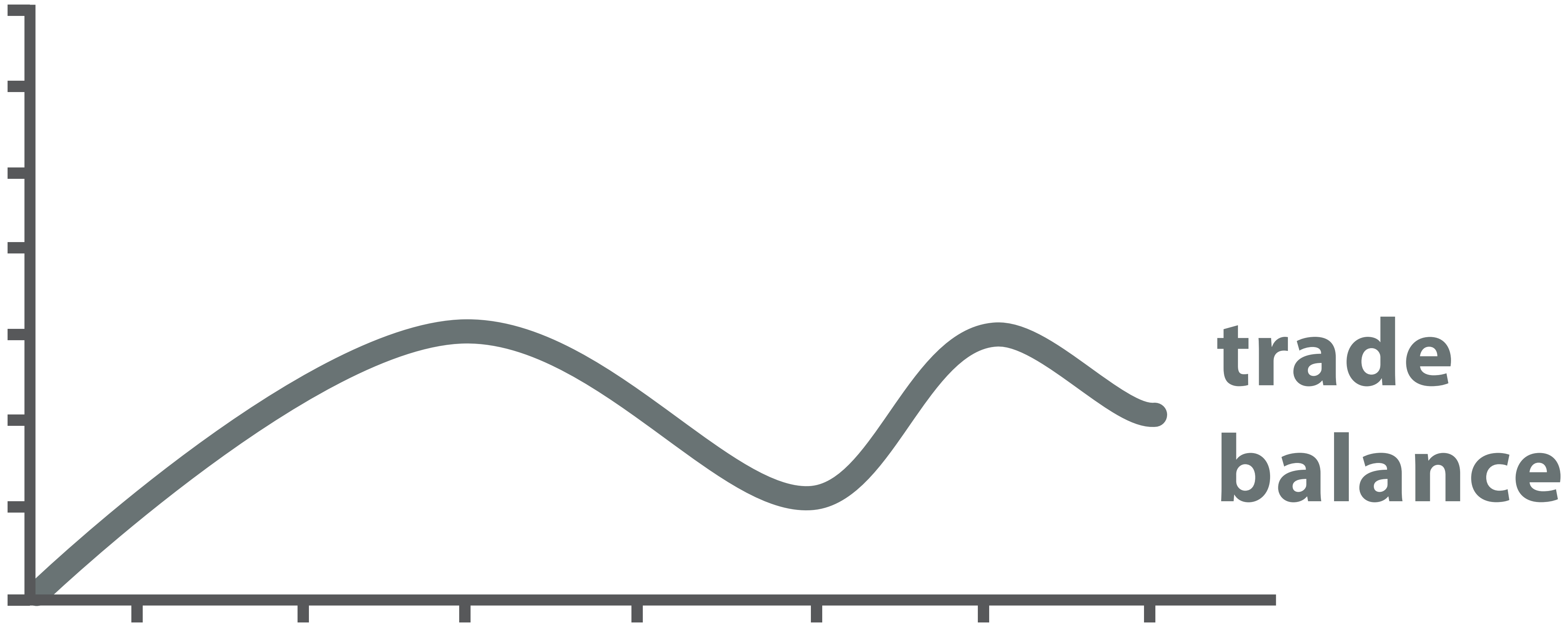
Record: Provenance of MTA Data Exploration



Derived Data



Original Data



trade balance = exports − imports

Derived Data

[Munzner (ill. Maguire), 2014]

Visualization for Production

- Generate new material
- Annotate:
  - Add more to a visualization
  - Usually associated with text, but can be graphical
- Record:
  - Persist visualizations for historical record
  - Provenance (graphical histories): how did I get here?
- Derive (Transform):
  - Create new data
  - Create derived attributes (e.g. mathematical operations, aggregation)

Actions: Search

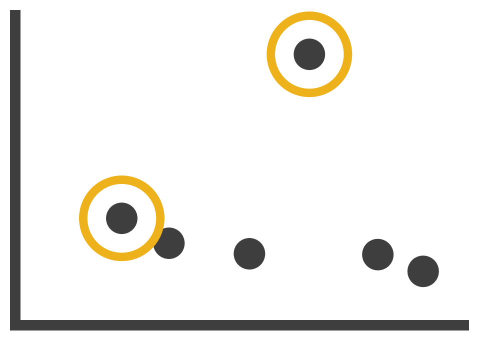
- What does a user know?
  - Lookup: check bearings
  - Locate: find on a map
  - Browse: what's nearby
  - Explore: where to go
    - Patterns

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

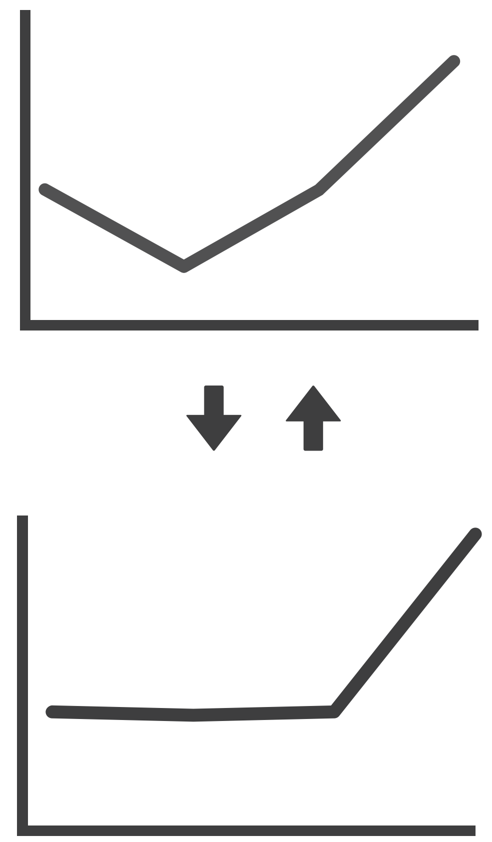
[Munzner (ill. Maguire), 2014]

Query

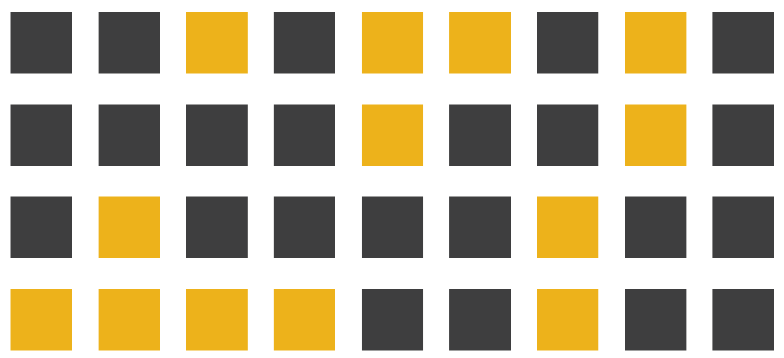
→ Identify



→ Compare



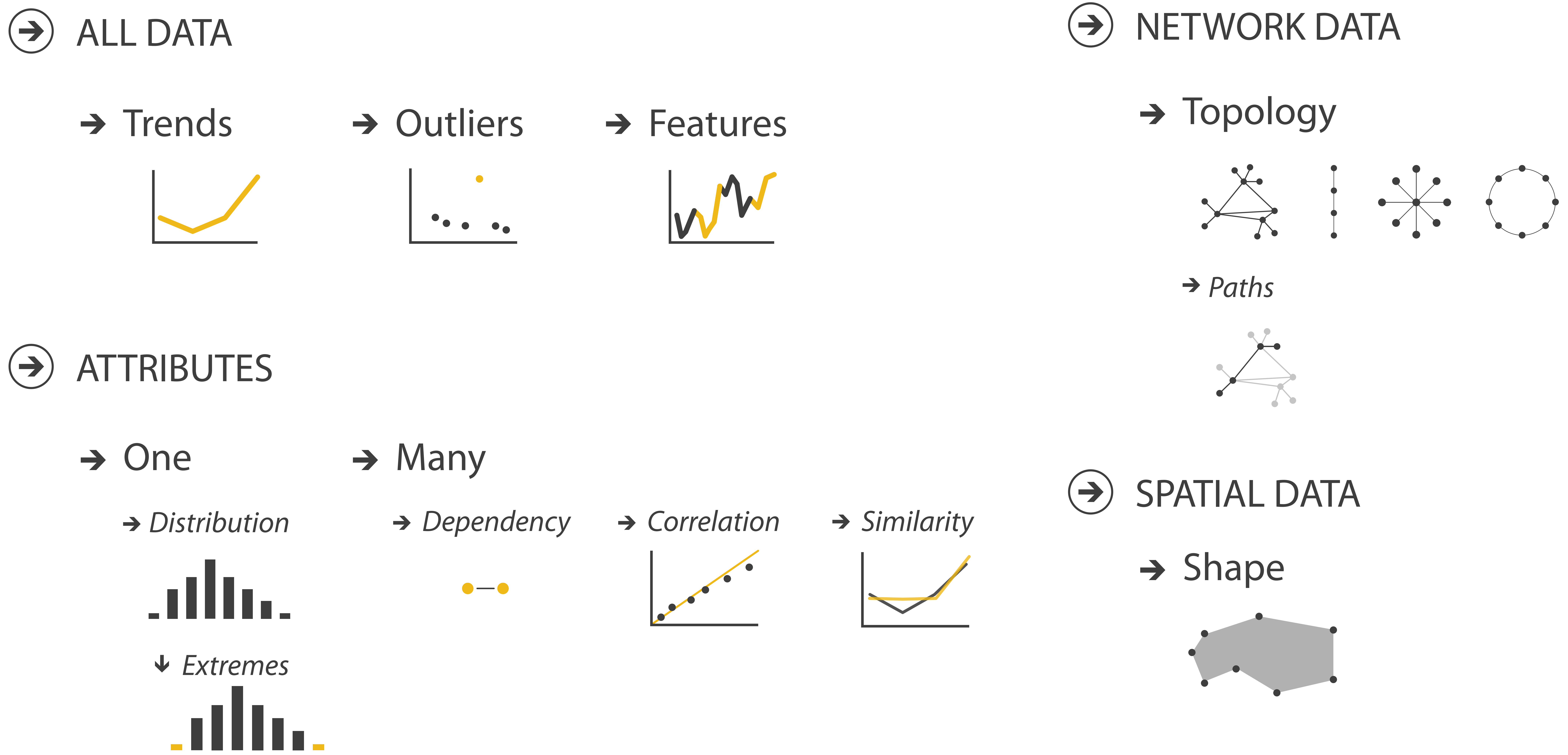
→ Summarize



- Number of targets: One, Some (Often 2), or All
- Identify: characteristics or references
- Compare: similarities and differences
- Summarize: overview of everything

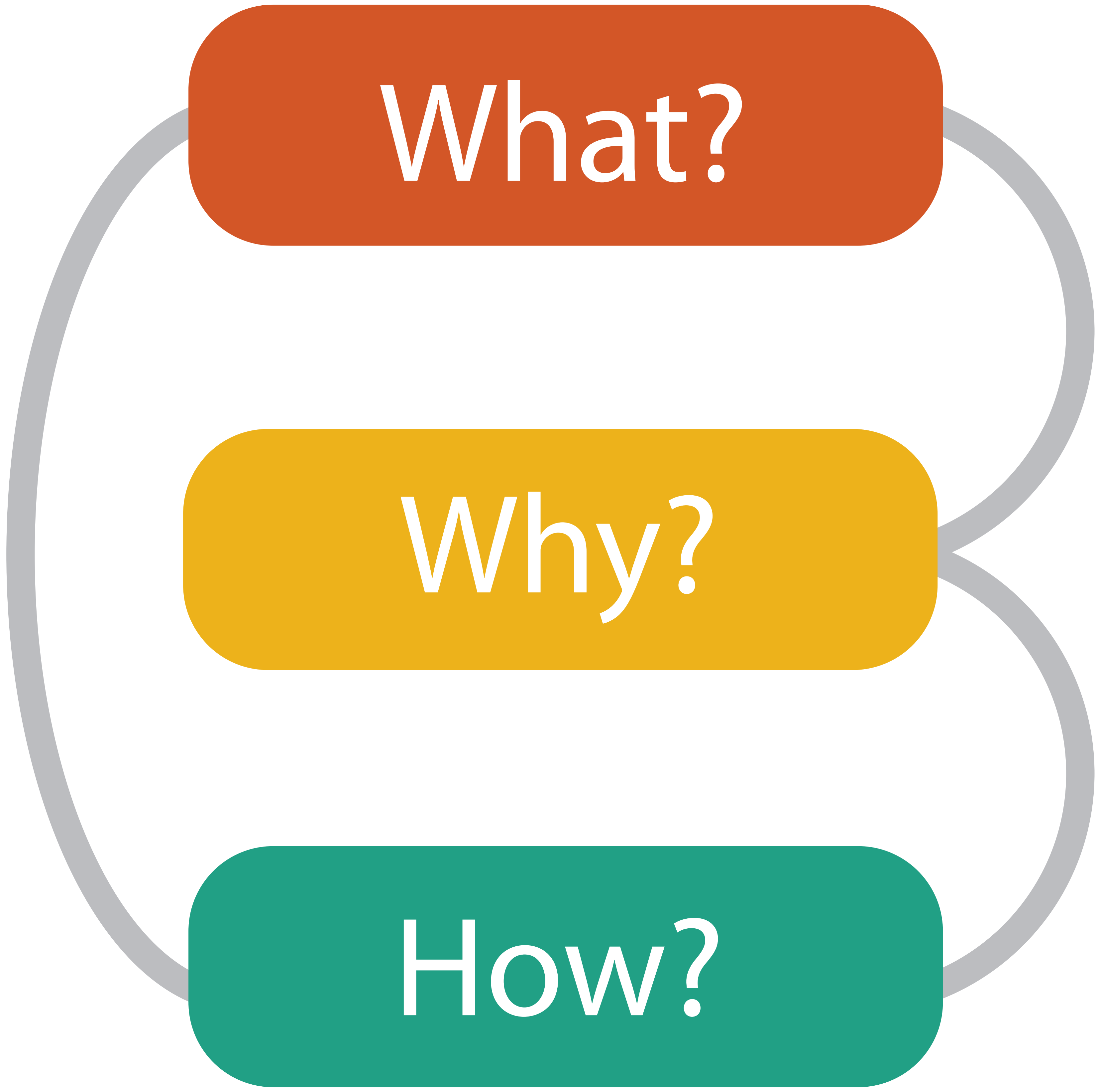
[Munzner (ill. Maguire), 2014]

Targets



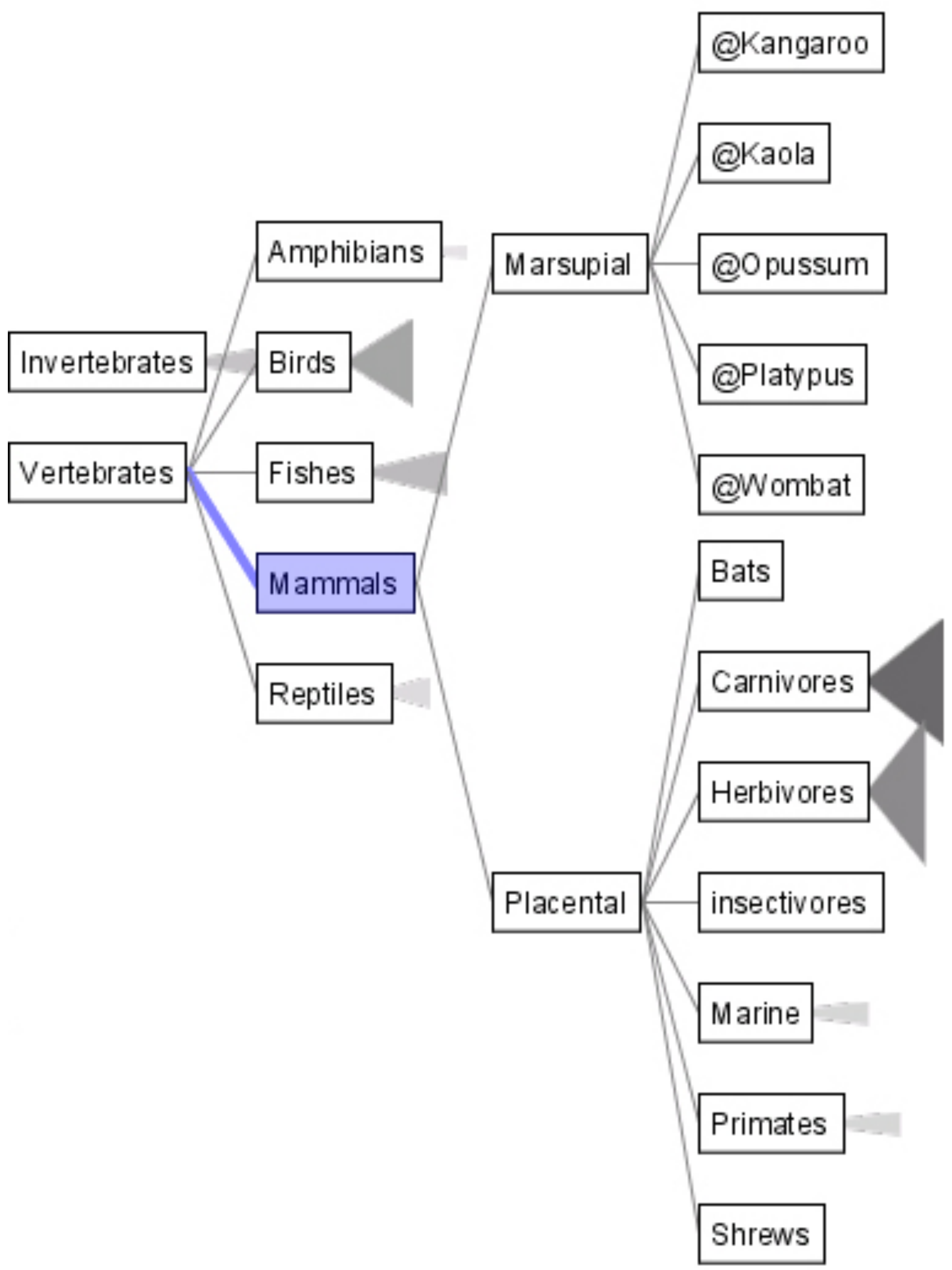
[Munzner (ill. Maguire), 2014]

Roadmap

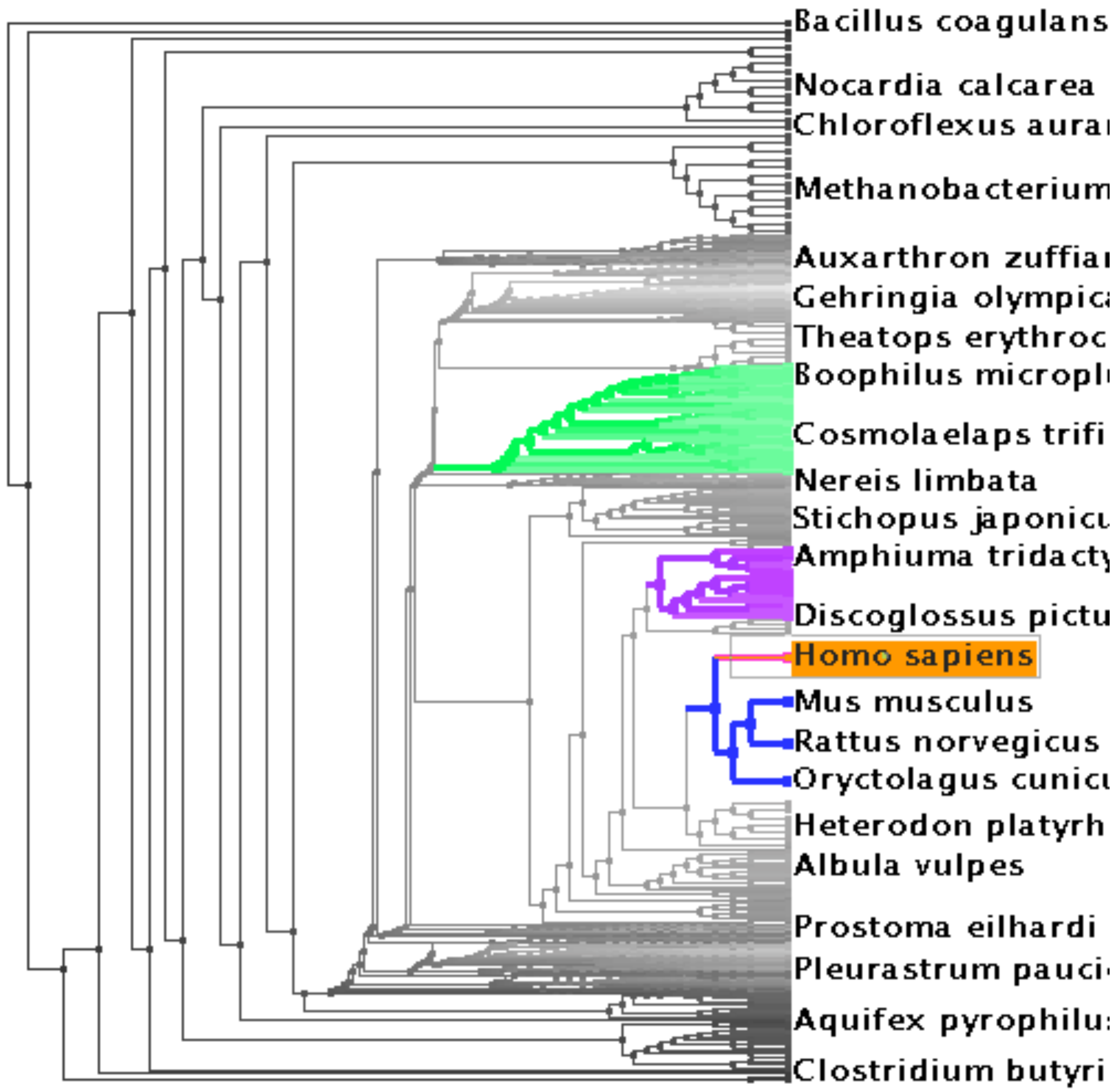


- What? → Data
  - Types
  - Semantics
- Why? → Tasks
  - Actions
  - Targets
- How → Vis Idioms/Techniques
  - Data Representation
  - Visual Encoding
  - Interaction Encoding

Analysis Example: Different "Idioms"



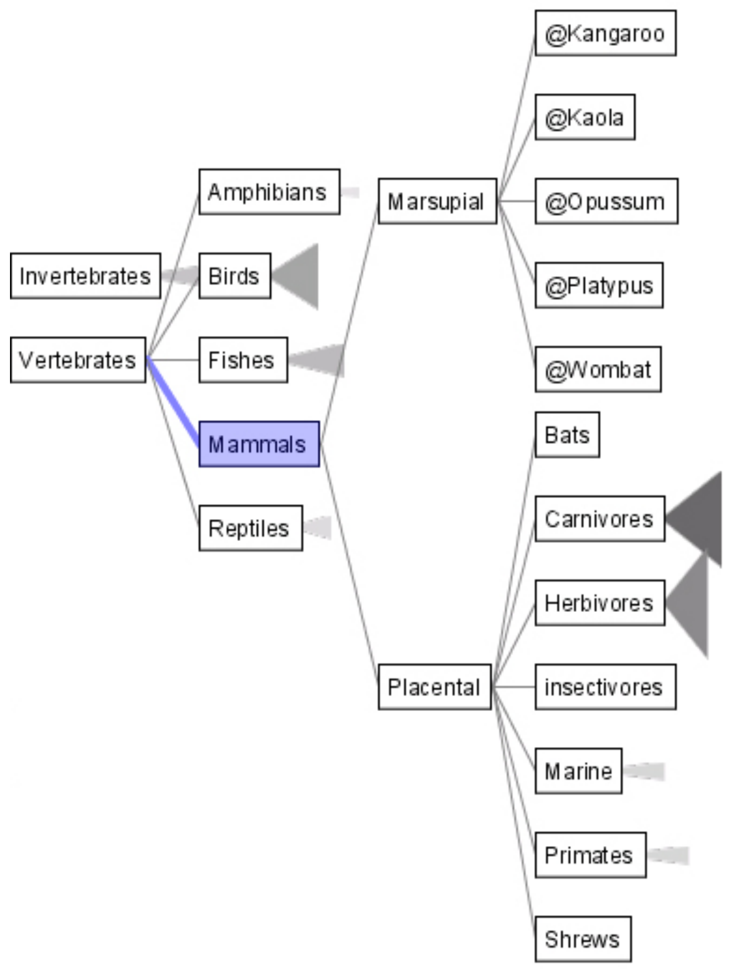
[SpaceTree, Grosjean et al.]



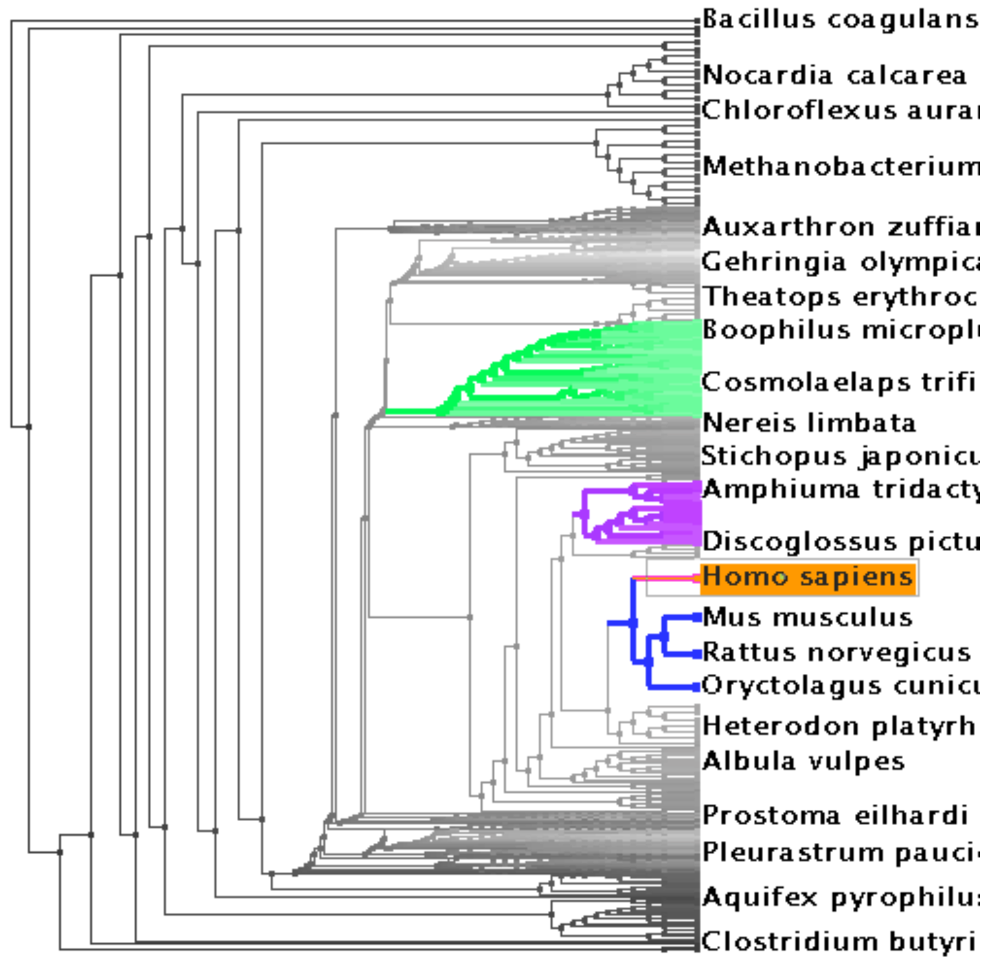
[TreeJuxtaposer, Munzner et al.]

"Idiom" Comparison

SpaceTree

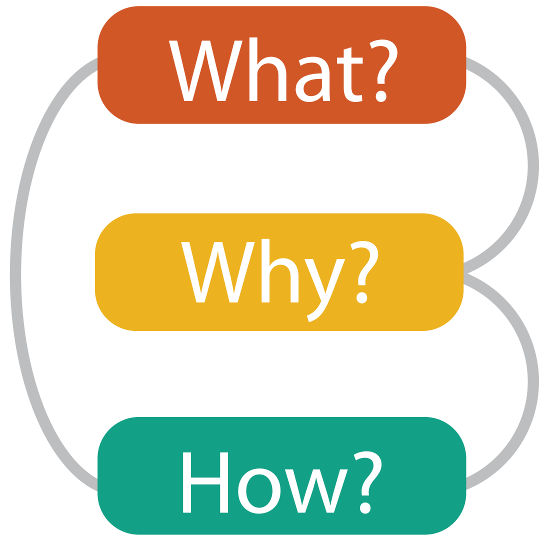


TreeJuxtaposer



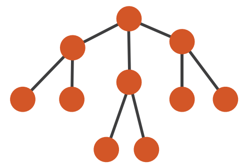
[SpaceTree: Supporting Exploration in Large Node Link Tree, Design Evolution and Empirical Evaluation. Grosjean, Plaisant, and Bederson. Proc. InfoVis 2002, p 57–64.]

[TreeJuxtaposer: Scalable Tree Comparison Using Focus+Context With Guaranteed Visibility. ACM Trans. on Graphics (Proc. SIGGRAPH) 22:453– 462, 2003.]



What?

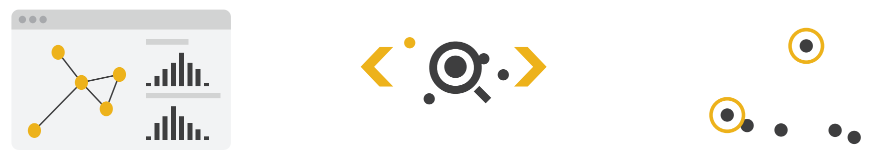
➔ **Tree**



Why?

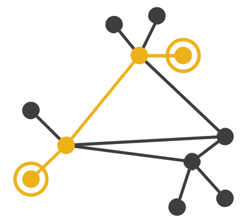
➔ **Actions**

➔ Present ➔ Locate ➔ Identify



➔ **Targets**

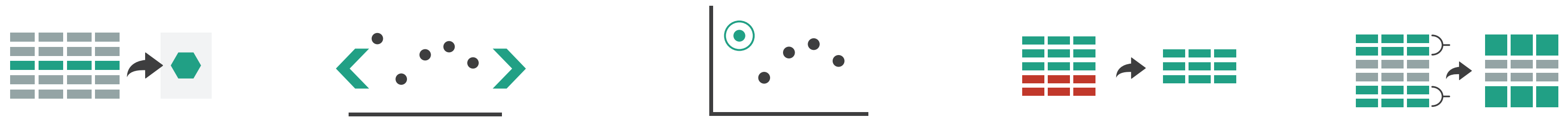
➔ Path between two nodes



How?

➔ **SpaceTree**

➔ Encode ➔ Navigate ➔ Select ➔ Filter ➔ Aggregate



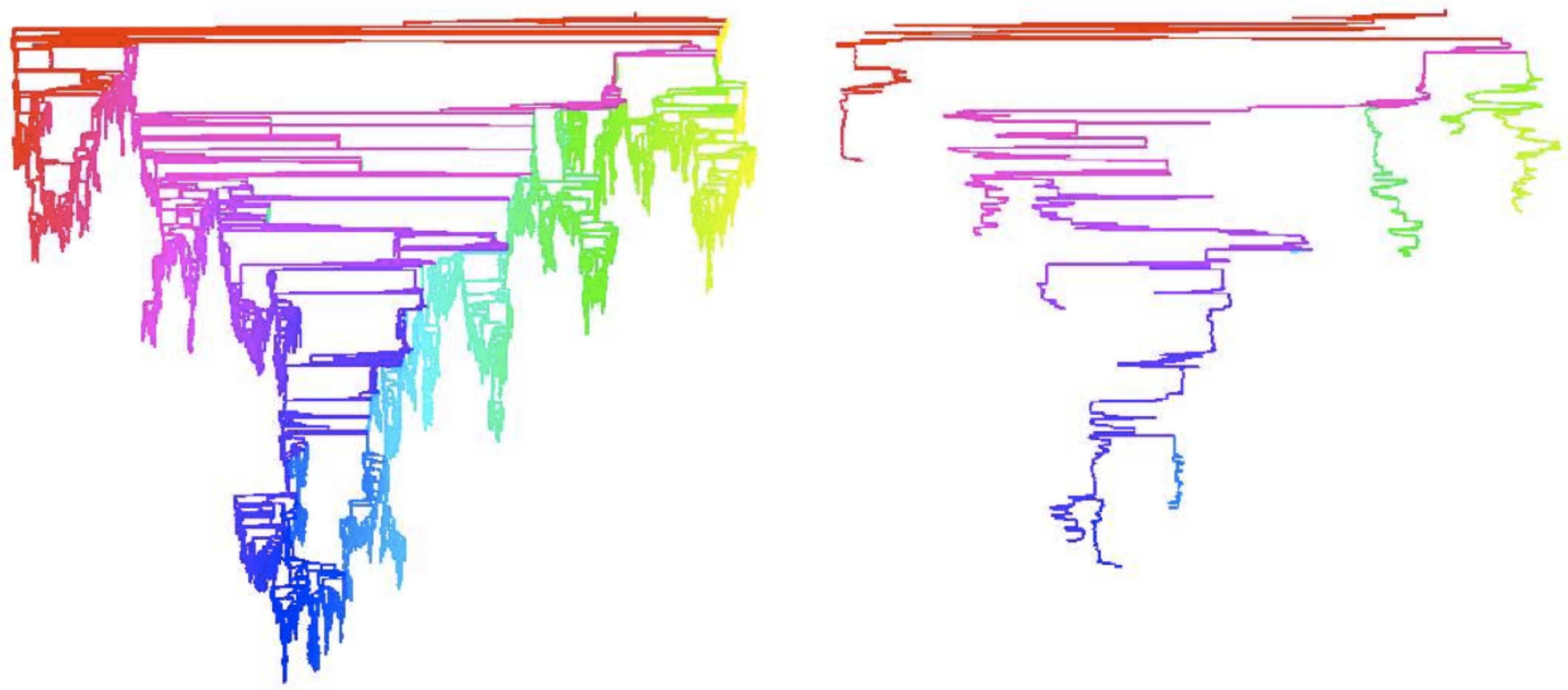
➔ **TreeJuxtaposer**

➔ Encode ➔ Navigate ➔ Select ➔ Arrange

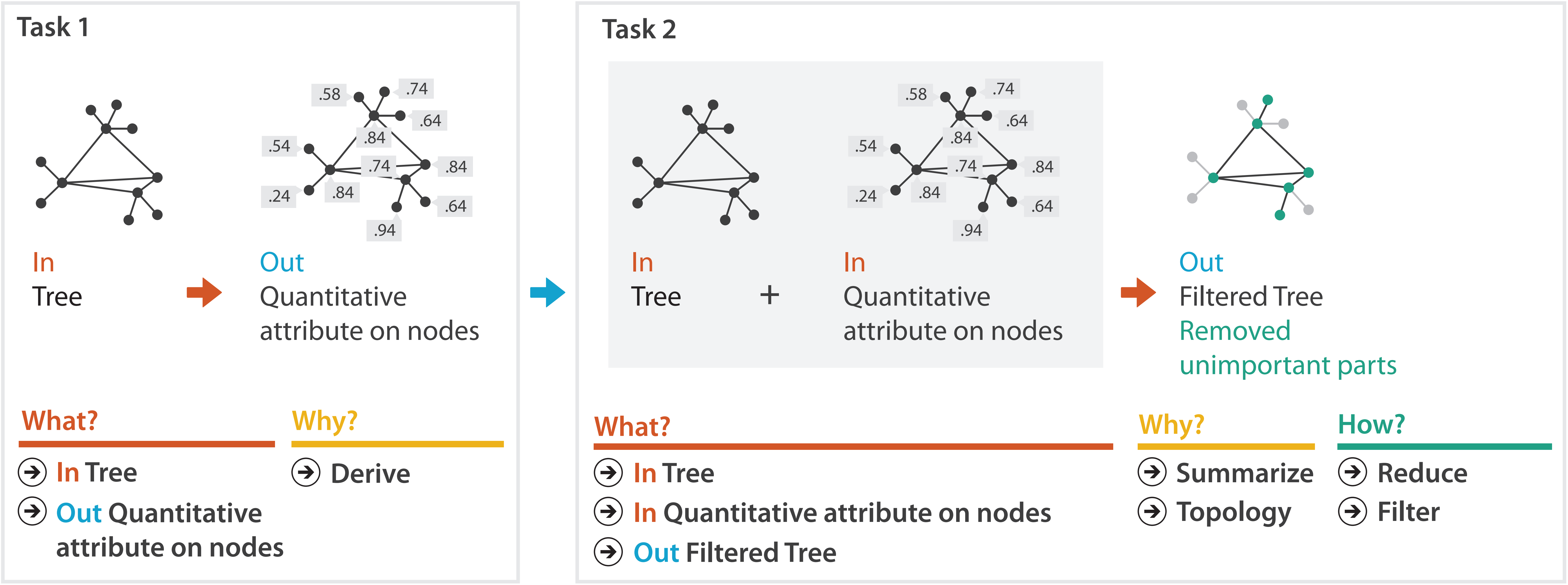
[Munzner (ill. Maguire), 2014]

Analysis Example: Derivation

- Strahler number
  - centrality metric for trees/networks
  - derived quantitative attribute
  - draw top 5K of 500K for good skeleton



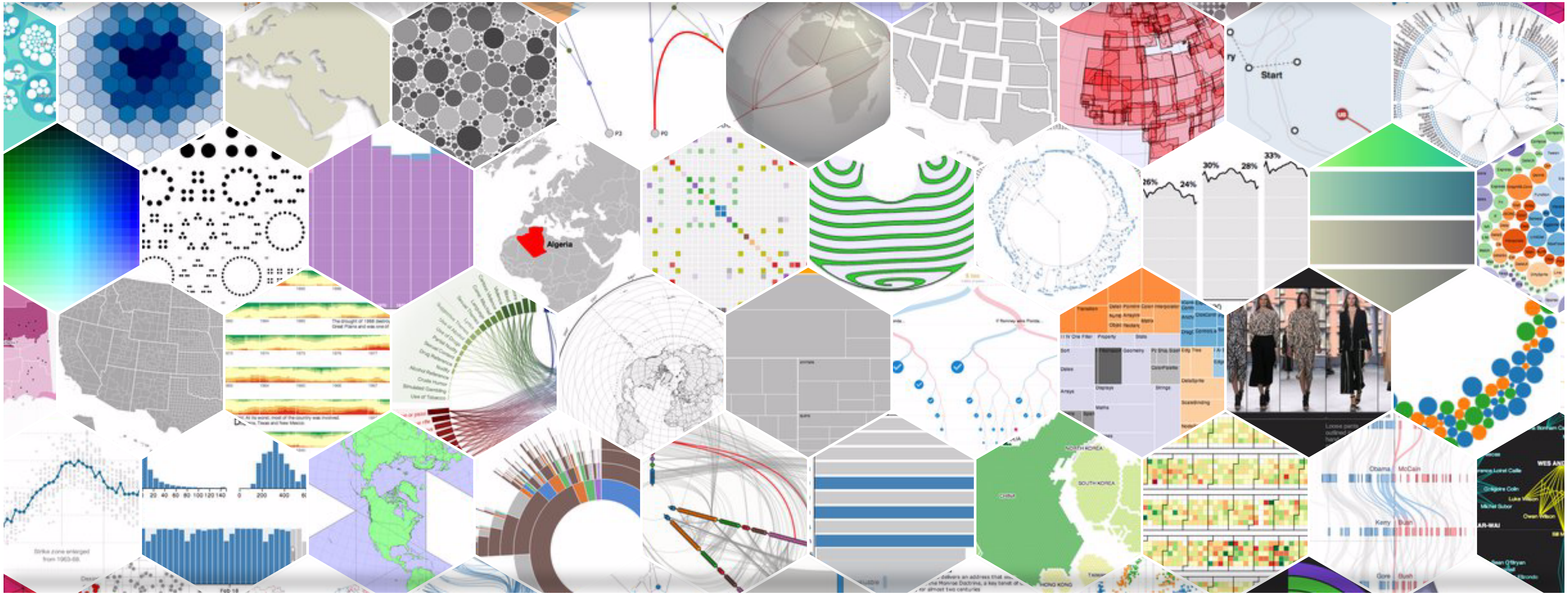
[Using Strahler numbers for real time visual exploration of huge graphs. Auber. Proc. Intl. Conf. Computer Vision and Graphics, pp. 56–69, 2002.]



[Munzner (ill. Maguire), 2014]

d3.js

Data-Driven Documents



Data-Driven Documents (D3)

- Open-Source JavaScript Library
- http://d3js.org/
- Original Authors: Mike Bostock, Vadim Ogievestky, and Jeff Heer
- Focus on Web standards, customization, and usability
- Grew from work on Protovis: more standard, more interactive
- By nature, a **low-level** library; you have control over all elements and styles
- A top project on GitHub (over 93,000 stars as of Sept. 2020)
- Lots of impressive examples
  - Bostock was a New York Times Graphics Editor
  - https://bost.ocks.org/mike/ and https://observablehq.com/@mbostock

D3 Key Features

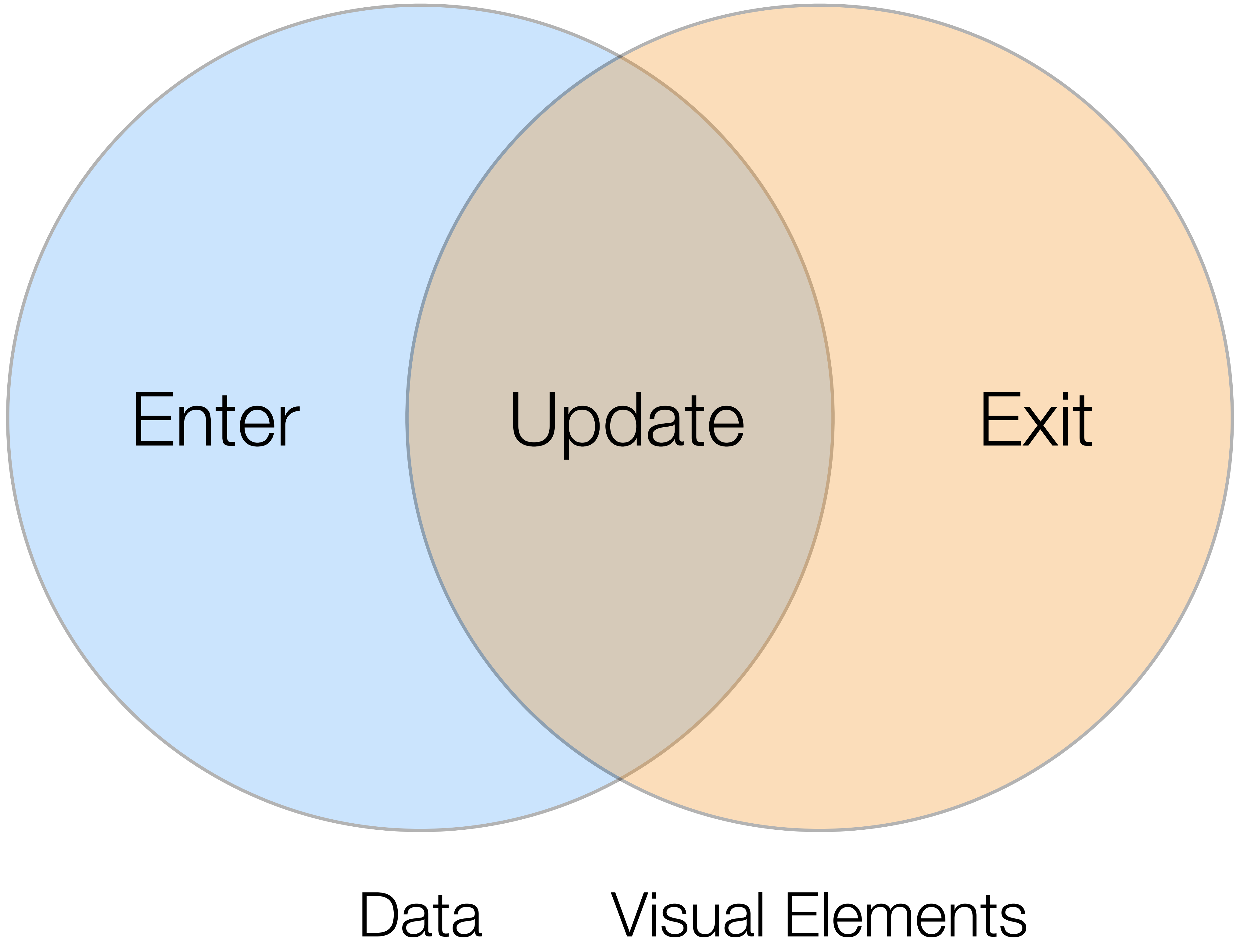
- Supports data as a core piece of Web elements
  - Loading data
  - Dealing with changing data (joins, enter/update/exit)
  - **Correspondence** between data and DOM elements
- Selections (similar to CSS) that allow greater manipulation
- Method Chaining
- Integrated layout algorithms, axes calculations, etc.
- Focus on interaction support
  - Straightforward support for transitions
  - Event handling support for user-initiated changes

D3 Introduction

- Ogievetsky has put together a nice set of interactive examples that show off the major features of D3
- http://dakoop.github.io/IntroD3/
  - (Updated from original for D3 v6)
- https://beta.observablehq.com/@dakoop/d3-intro
- Other references:
  - Murrary's book on Interactive Data Visualization for the Web
  - The D3 website: d3js.org
  - Ros's Slides on v4: https://iros.github.io/d3-v4-whats-new/

D3 Data Joins

- Two groups: data and visual elements
- Three parts of the join between them: enter, update, and exit
- enter: **`s.enter()`**, update: **`s`**, exit: **`s.exit()`**



Merge vs. Join

- Merge creates a new selection that includes the items from **both** selections
  - If you want to update all elements (including those just added via enter), use merge!
  - Useful when enter+update have similar transitions
- Join allows you to modify different parts of the selection in a single statement
  - Also will create the final selection
  - Does enter+append and exit+remove automatically
  - Pass functions to modify the enter, update, and exit parts of the selection
  - Examples: https://beta.observablehq.com/@d3/selection-join

Transitions

- Nested transitions (those that "hang off" of a parent transition) follow immediately after the parent transition