SWE 632 - Design & Development of User Interfaces

Spring 2021

George Mason University

Dr. Kevin Moran

Week 12:

Information Visualization

Administrivia

- Project Checkpoint 6 - *Due Today*
- Project Checkpoint 7 out today - *Due Next Week*
- Final Project Presentation - *Due April 28th (2 Weeks)*
- Discussion Question for Week 13 - *Posted after class*

Project Checkpoint 7

Description

In this Project Checkpoint, you will critique the visual design of your web app to identify 10 weaknesses and then create a new visual design that addresses these issues.

1. You should provide separate URLs for (1) the previous HW6 version of your web app and (2) the new, updated HW7 version of your web app.
2. Critique the HW6 version of your web app using the principles and guidelines outlined in the Week 8-12 lectures and readings, identifying 7 weaknesses of the design. For each weakness, provide a (1) representative screenshot of the issue and (2) a one paragraph explanation of how the design violates a visual design or information visualization principle or guideline. Across the 10 weaknesses you identify, you should make use of at least 7 distinct principles and/or guidelines.
3. Address the design weaknesses by creating an improved design for your web app. For each weakness, (1) provide a short paragraph describing the change you made and how it addresses the issue and (2) a representative screenshot of how the new design addresses the issue.
4. In grading your assignment, we will evaluate the (1) degree to which the identified weaknesses follow from the utilized design principles and guidelines and (2) the effectiveness with which the changes address the identified issues.

Final Project Presentations

Description

In the Final Project Presentation, your project group will give a brief **6 minute presentation** on the process you used in shaping the interaction design of your app.

- Your presentation should contain 3 sections:
  a. Briefly summarize (in a minute or less) the purpose of your app and the key use cases it supports. Include a link to the final version of your app. This might or might not take the form of a brief demo. It should be clear from your summary the primary use cases that your app supports.
  b. Briefly describe 2 of the most "interesting" (e.g., far-reaching, unexpected, surprising) revisions you made to your app over the course of the semester. For each revision, describe (1) the original design and behavior of the app (a screenshot may help), (2) the method used to identify the issue (e.g., heuristic evaluation, visual design guideline), (3) the issue, and (4) how the issue was addressed in the revised design.
  c. Reflecting on the project as a whole over the course of the semester, briefly describe 2 lessons your group learned about HCI through working on your project. Lessons learned can be anything related to user interface design, including, but not limited to, when or how to use various HCI methods, an important design consideration you discovered, or the pros and cons of a particular design tradeoff. Your goal here is to offer two interesting insights into user interface design from which others may learn.
- Your presentation should be short and be approximately 6 minutes. To ensure sufficient time for all groups to present, presentations cannot exceed 7 minutes. To help you keep track of time, you'll be notified at the 5 min, 6 min, and 7 min marks. If your presentation exceeds 7 minutes, your group will lose points, and you may be stopped. You should think carefully about how to cover each of the 3 sections within 6 minutes and should consider practicing to check the timing of your presentation.

Class Overview

1. *Overview of Information Visualization:* Illustrating Data
2. *Mapping Data to Visual Form:* Choosing the Right Expression
3. *Visualization Examples:*
    1. Time-series Data
    2. Maps
    3. Hierarchies
    4. Networks
4. *Design Considerations:* Designing for InfoVis
7. *7 Minute Break*
8. *Group Activity:* Designing an Information Visualization
9. *Tech Talk:* Flutter
10. *Tech Talk:* Appsheets

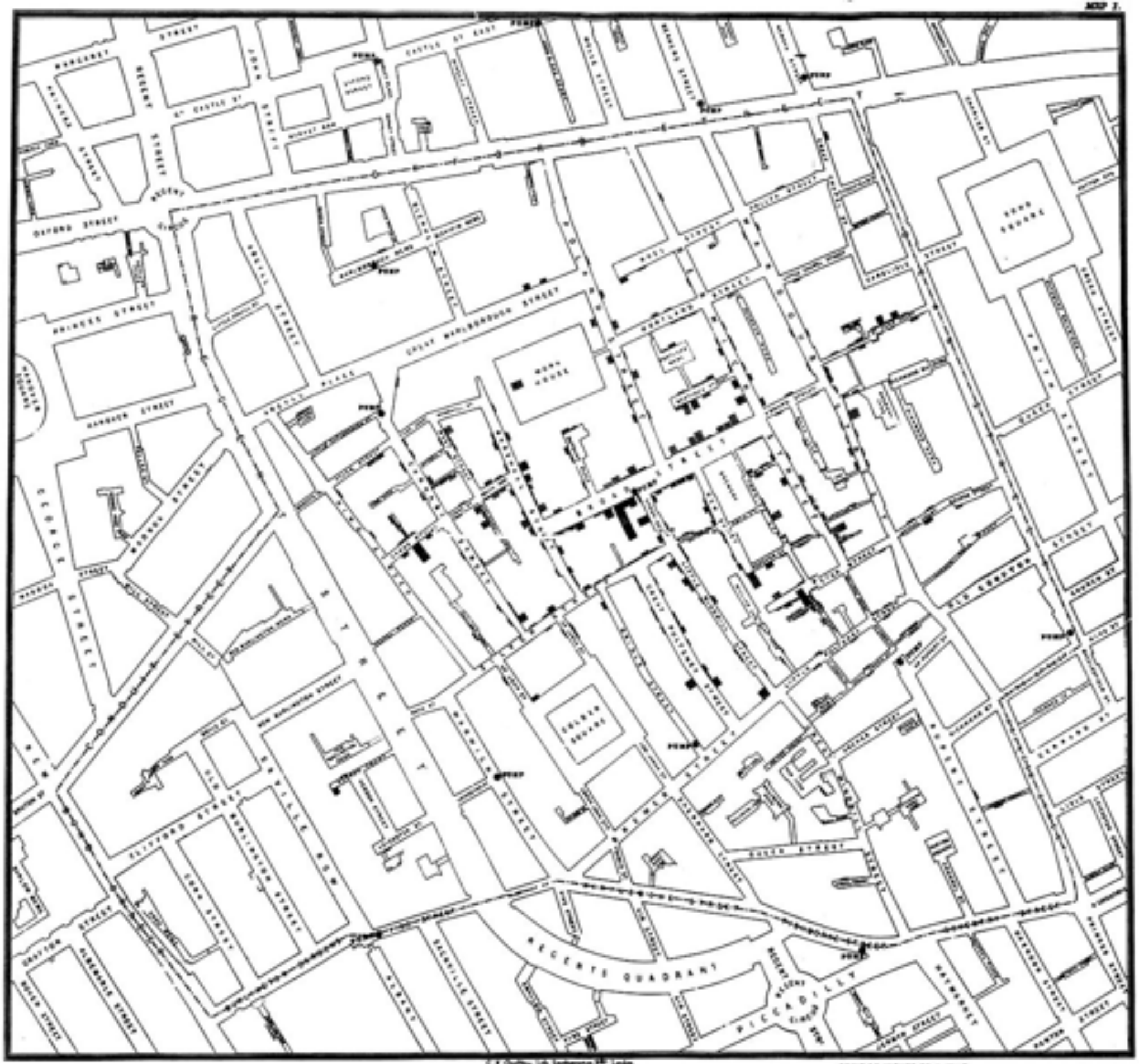
Overview of Information Visualization

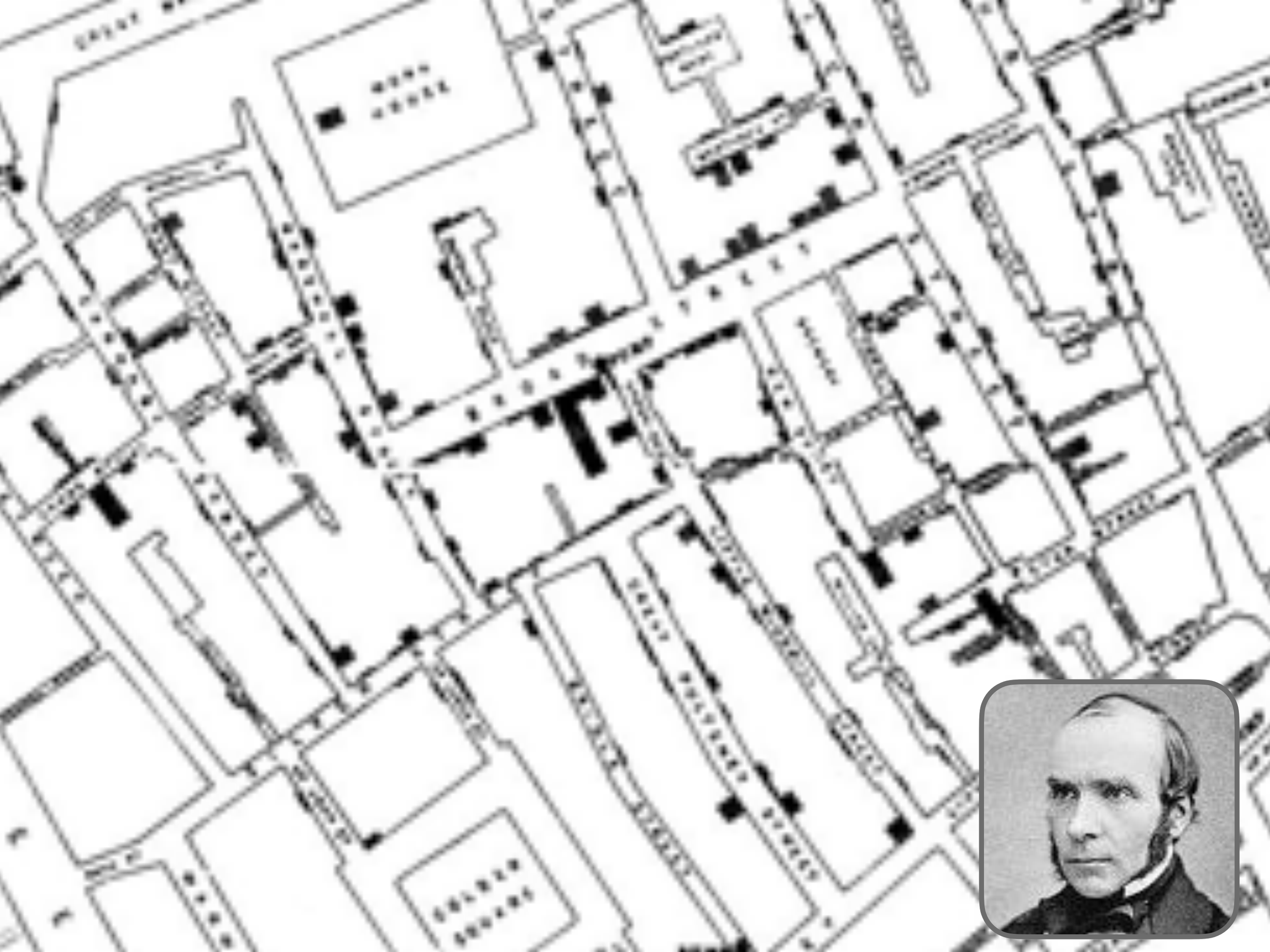
Today

- What types of information visualization are there?
  - Which one should you choose?
- What principles and guidelines inform the design of information visualizations?
- How can interactivity be used to design better information visualizations?

Cholera Epidemic in London, 1854

- >500 fatal attacks of cholera in 10 days
  - Concentrated in Broad Street area of London
  - Many died in a few hours
- Dominant theory of disease: caused by noxious odors
- Afflicted streets deserted by >75% inhabitants


OXFORD STREET
PRINCES STREET
HANOVER STREET
GREAT MARLBOROUGH STREET
REGENT STREET
PICCADILLY
ROAD 20 INCHES TO A MILE.



Investigation and Aftermath

- Based on ***visualization***, did case by case investigation
- Found that ***61 / 83*** positive identified as using well water from Broad Street pump
- Board ordered pump-handle to be removed from well
- Epidemic soon ***ended***
- Solved centuries old question of how cholera spread

Methods used by Snow

- Placed data in appropriate ***context*** for assessing cause & effect
  - Plotted on map, included well location
  - Reveals proximity as cause
- Made quantitative ***comparisons***
  - Fewer deaths closer to brewery, could investigate cause
- Considered ***alternative*** explanations & contrary cases
  - Investigated cases not close to pump, often found connection to pump
- Assessment of possible ***errors*** in numbers

Amplifying Cognition

Amplifying Cognition

- Information Visualization can amplify cognition by:

Amplifying Cognition

- Information Visualization can amplify cognition by:

  1. Increasing the memory and processing resources available to users

Amplifying Cognition

- Information Visualization can amplify cognition by:

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  2. Reducing the search for information

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- Information Visualization can amplify cognition by:

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  2. Reducing the search for information

  3. Using visual representations to enhance the detection of patterns

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  4. Enabling perceptual inference

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  5. Using perceptual attention mechanisms for monitoring

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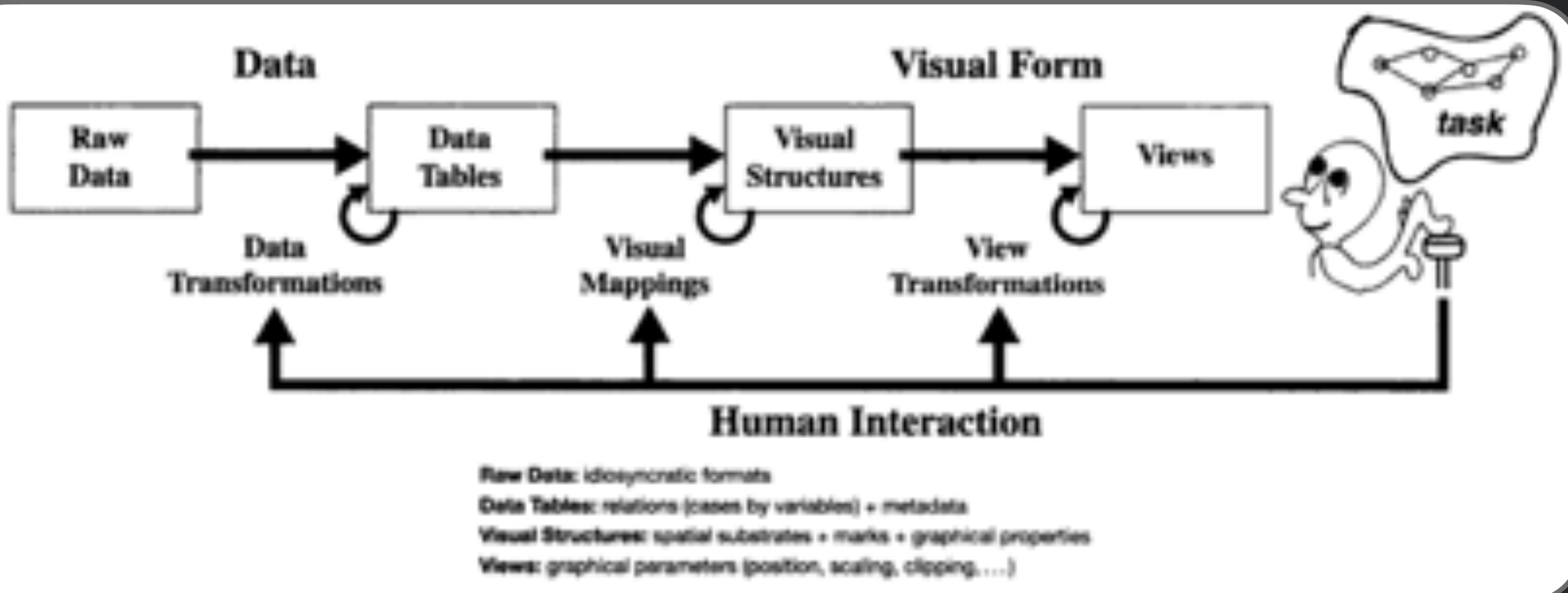
  4. Enabling perceptual inference

  5. Using perceptual attention mechanisms for monitoring

  6. Encoding Information in a manipulable medium

Mapping Data to Visual Form

Designing an Information Visualization



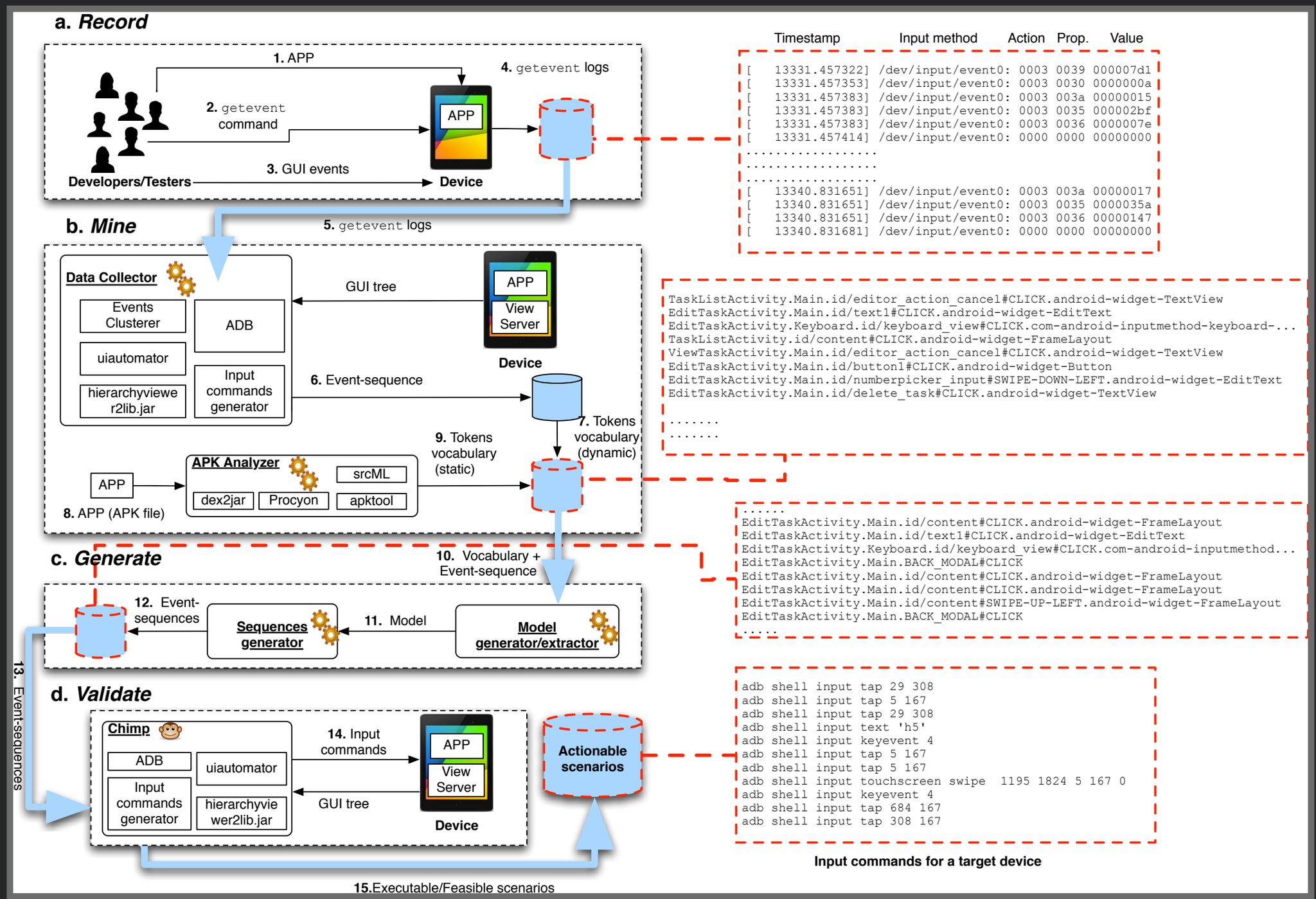
Types of Raw Data

- Nominal - unordered set ***without*** a quantitative value
  - Gender: male, female
  - Hair color: brown, black, blonde, gray, orange, ...
- Ordinal - ***ordered*** set, with no meaning assigned to differences
  - How do you feel today: very unhappy, unhappy, ok, happy, very happy
  - Undefined how much better happy is than ok
- Quantitative - ***numeric*** value
  - Height, weight, distance, ...

Data Transformations

- Classing / binning: Quantitative —> ordinal
  - Maps ranges onto ***classes*** of variables
    - Can also count # of items in each class w/ histogram
- Sorting: Nominal —> ordinal
  - Add order between items in sets
- Descriptive statistics: mean, average, median, max, min, …

Example Uses of a Data Transformation

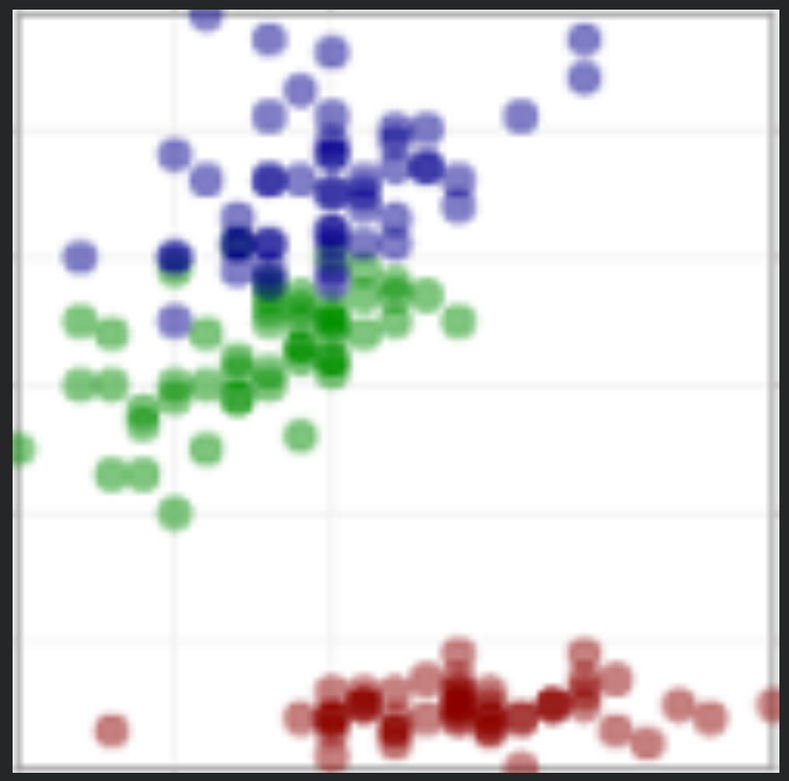


Visual Structures

- 3 components
  - spatial substrate
  - marks
  - marks’ graphical properties

Spatial Substrate

- Axes that divide space
- Types of axes - unstructured, nominal, ordinal, quantitative
- Composition - use of multiple orthogonal axes (e.g., 2D scatterplot, 3D)



Marks

- Points (0D)
- Lines (1D)
- Areas (2D)
- Volumes (3D)

Marks' Graphical Properties

- Quantitative (Q), Ordinal (O), Nominal (N)
- Filled circle - good; open circle - bad

	Spatial	Object
Extent	(Position) —|—|—|—| Size ● ● • ·	Gray Scale ■ ■ ■ □
Dif-ferential	Orientation — / | \	Color ■ ■ ■ ■ Texture ■ ▨ ▨ ■ Shape ■ ★ ● ◆

Effectiveness of Graphical Properties

- Quantitative (Q), Ordinal (O), Nominal (N)
- Filled circle - good; open circle - bad

	Spatial	Q	O	N	Object	Q	O	N
Extent	(Position)	●	●	●	Grayscale	◑	●	○
	Size	●	●	●				
Differential	Orientation	◑	◑	●	Color	◑	◑	●
					Texture	◑	◑	●
					Shape	○	○	●

Animation

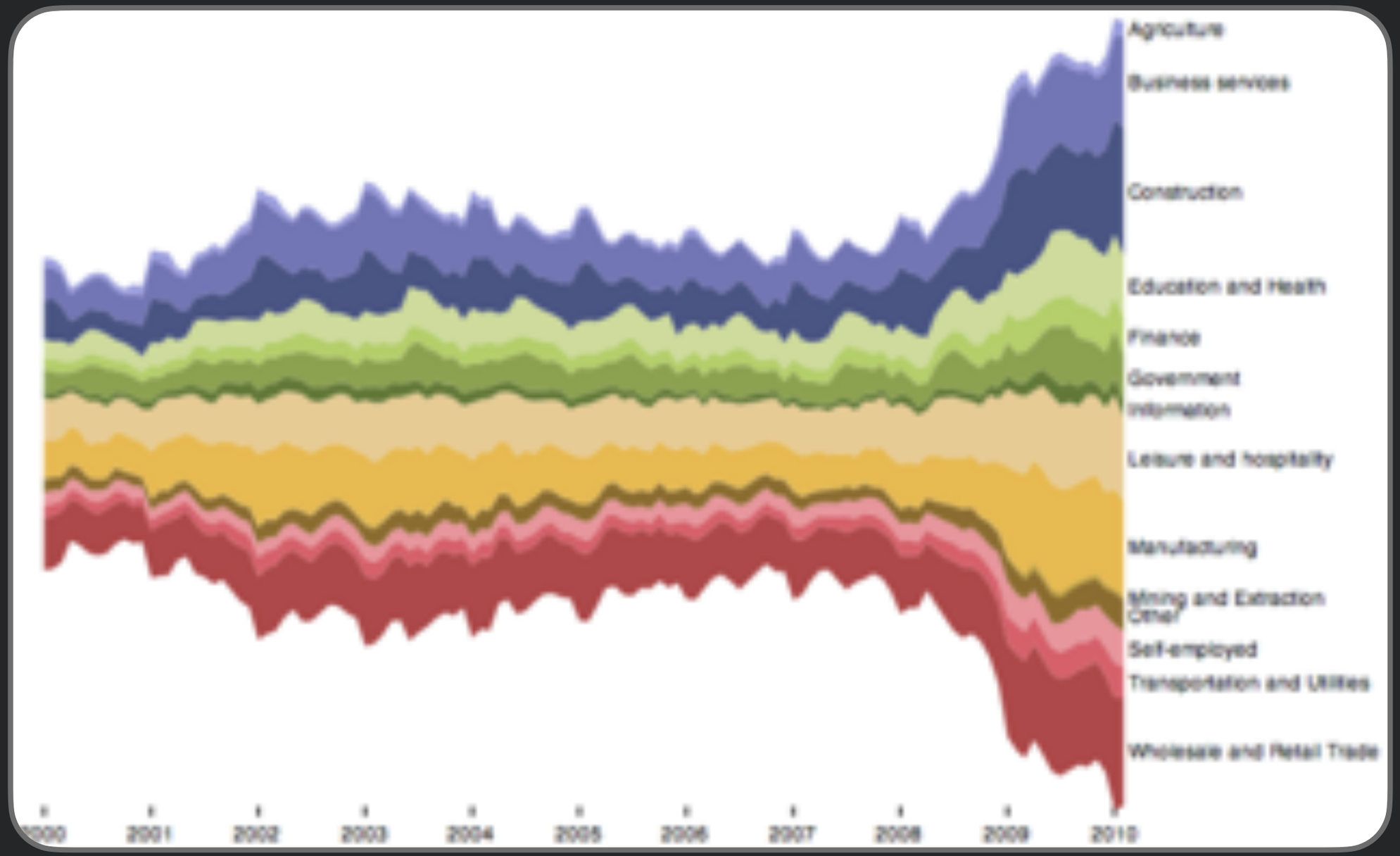
- Visualization can change over time
- Could be used to encode data as a function of time
  - But often not effective as makes direct comparisons hard
- Can be more effective to animate transition from before to after as user configures visualization

Examples of Visualizations

Time-series Data

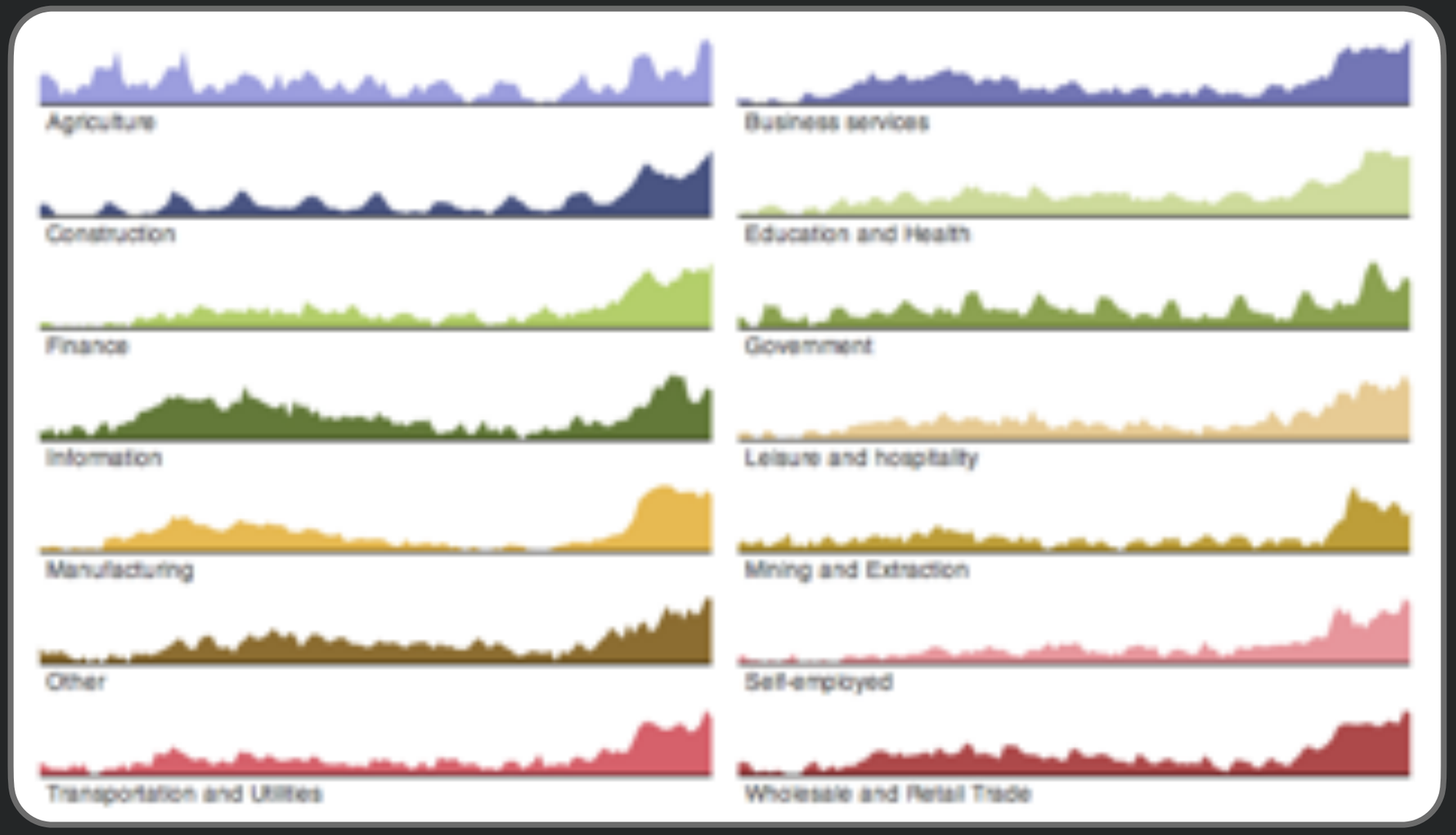
Stacked Graph

- Supports visual summation of multiple components



Small Multiples

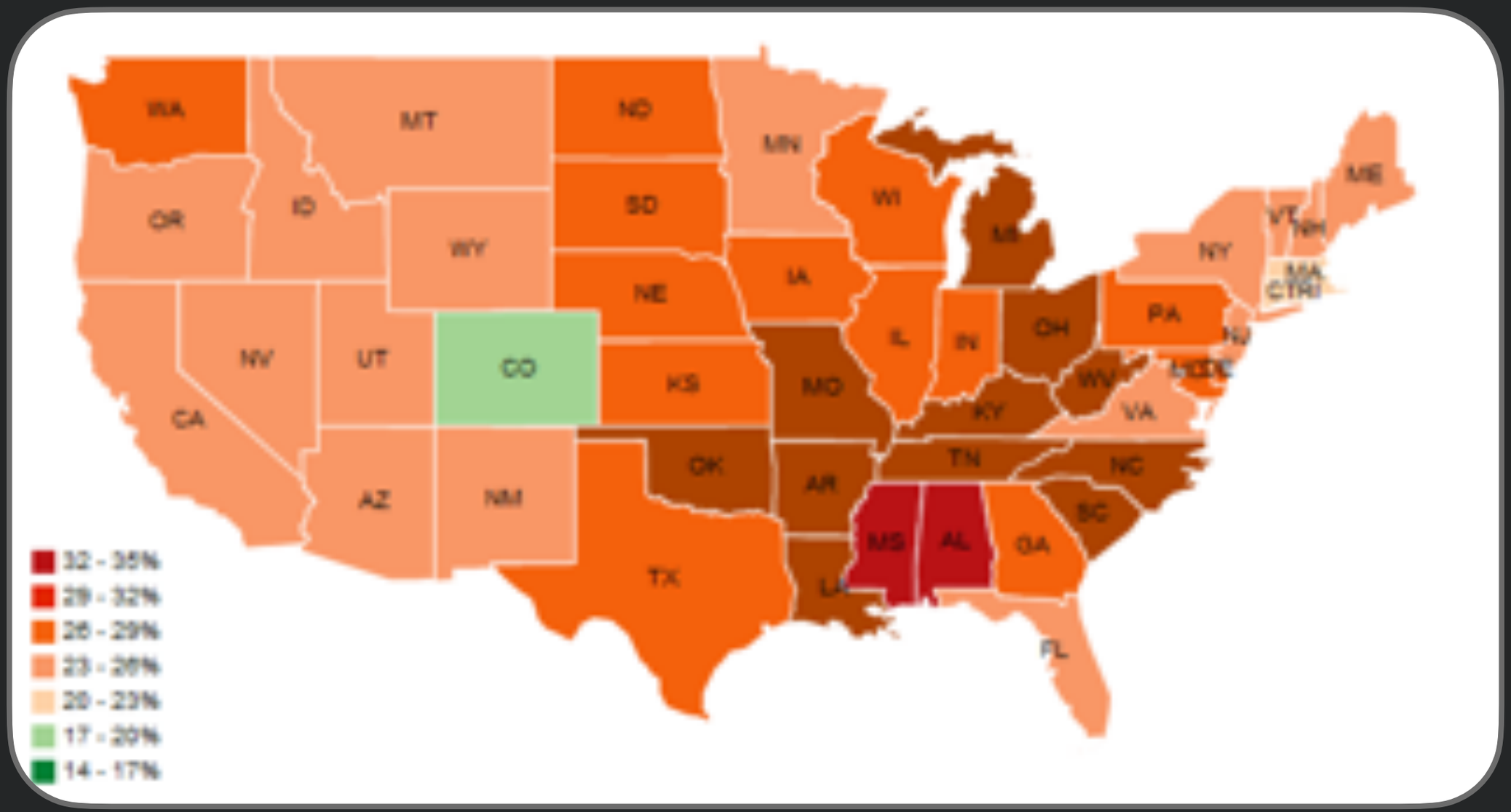
- Supports separate comparison of data series
- May have better legibility than placing all in single plot



Maps

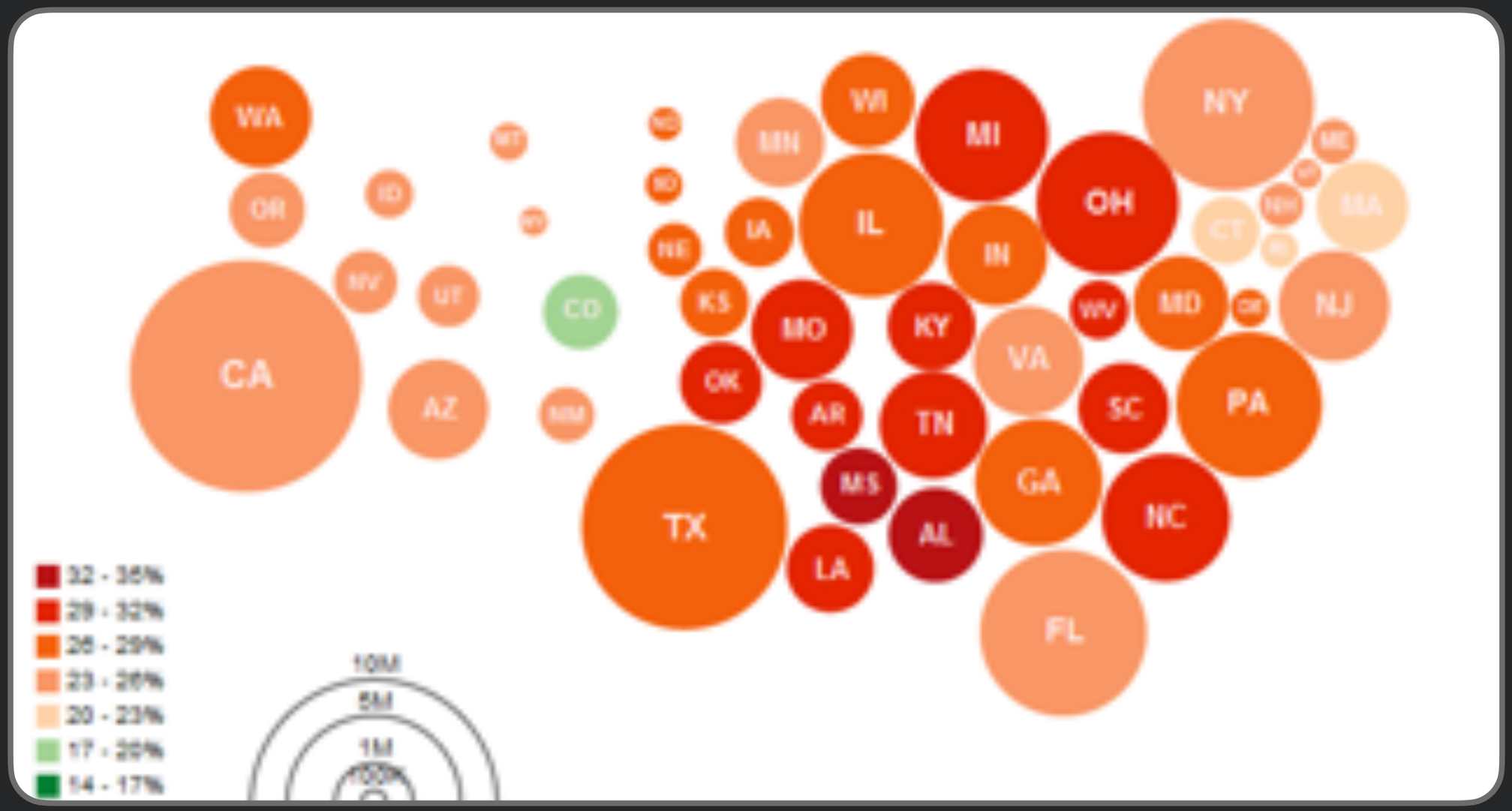
Choropleth Map

- Groups data by area, maps to color



Cartograms

- Encodes two variables w/ size & color



Cartograms

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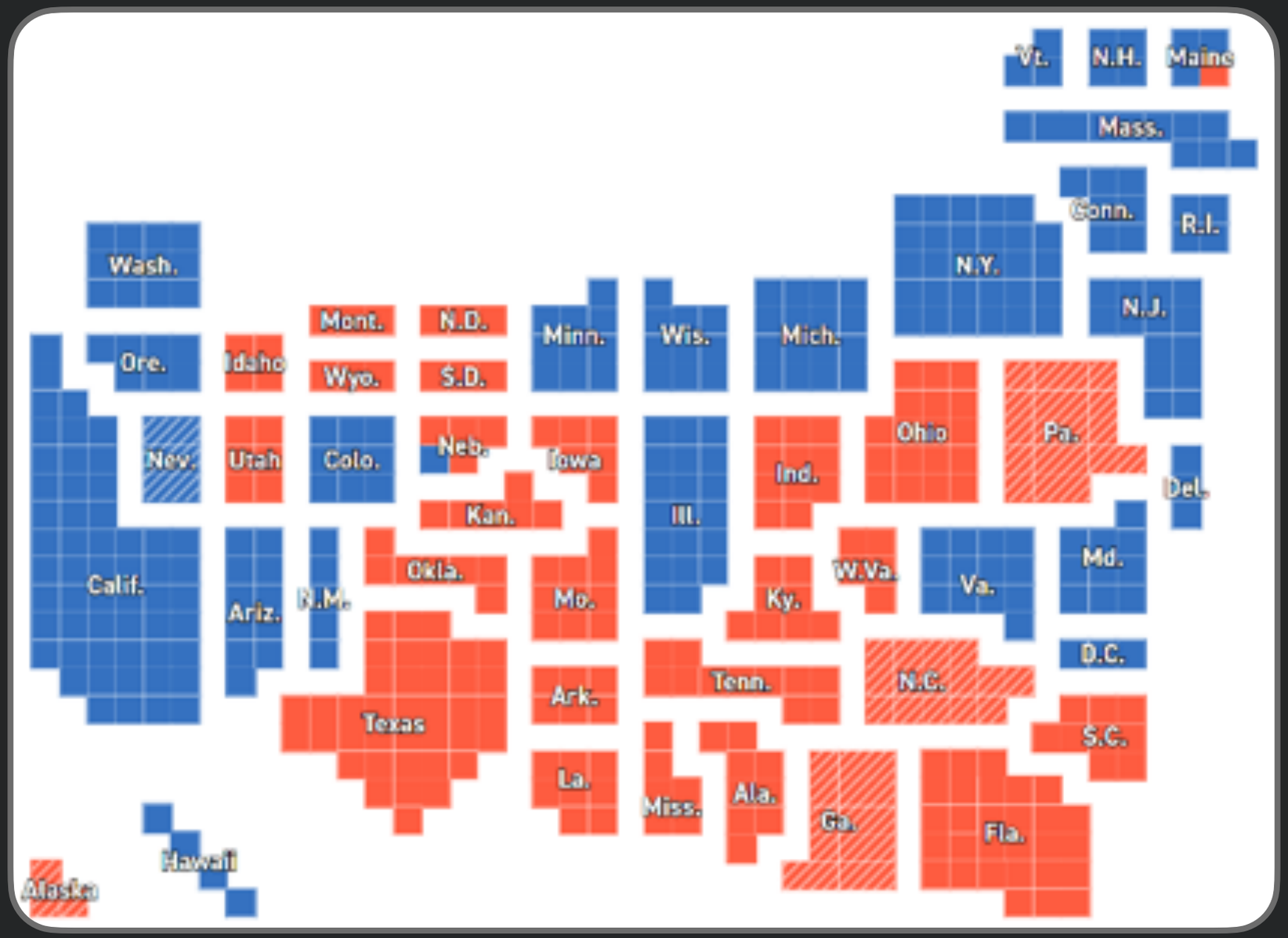
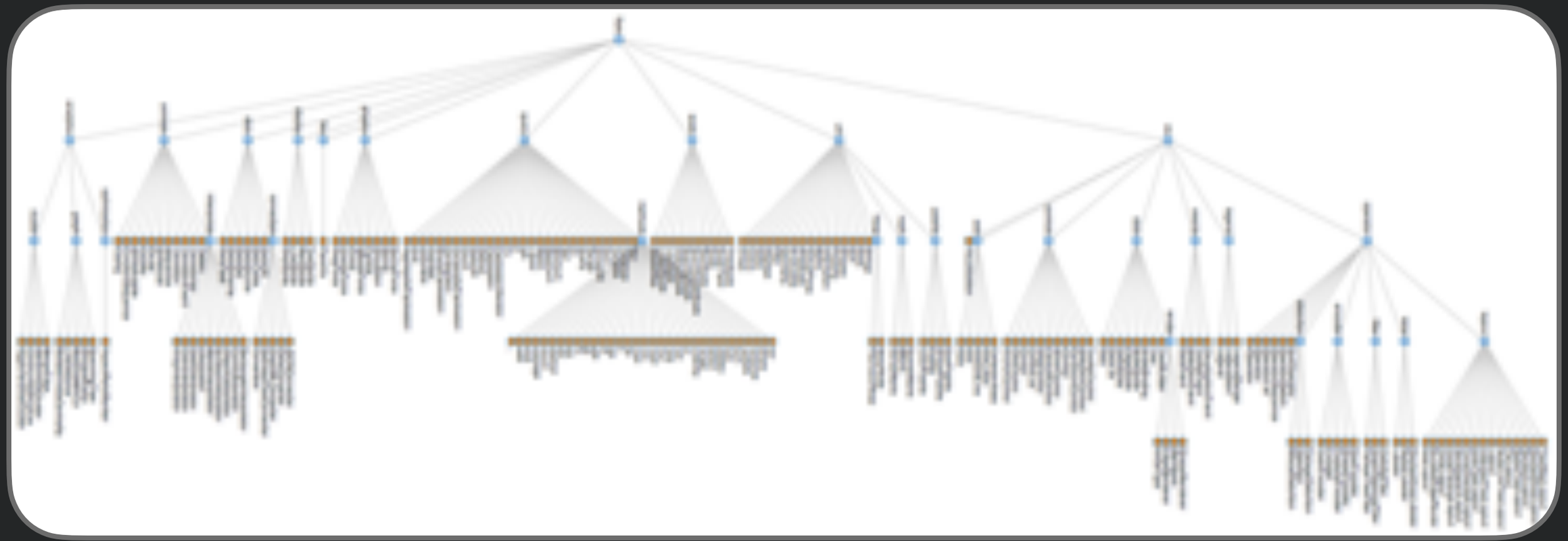


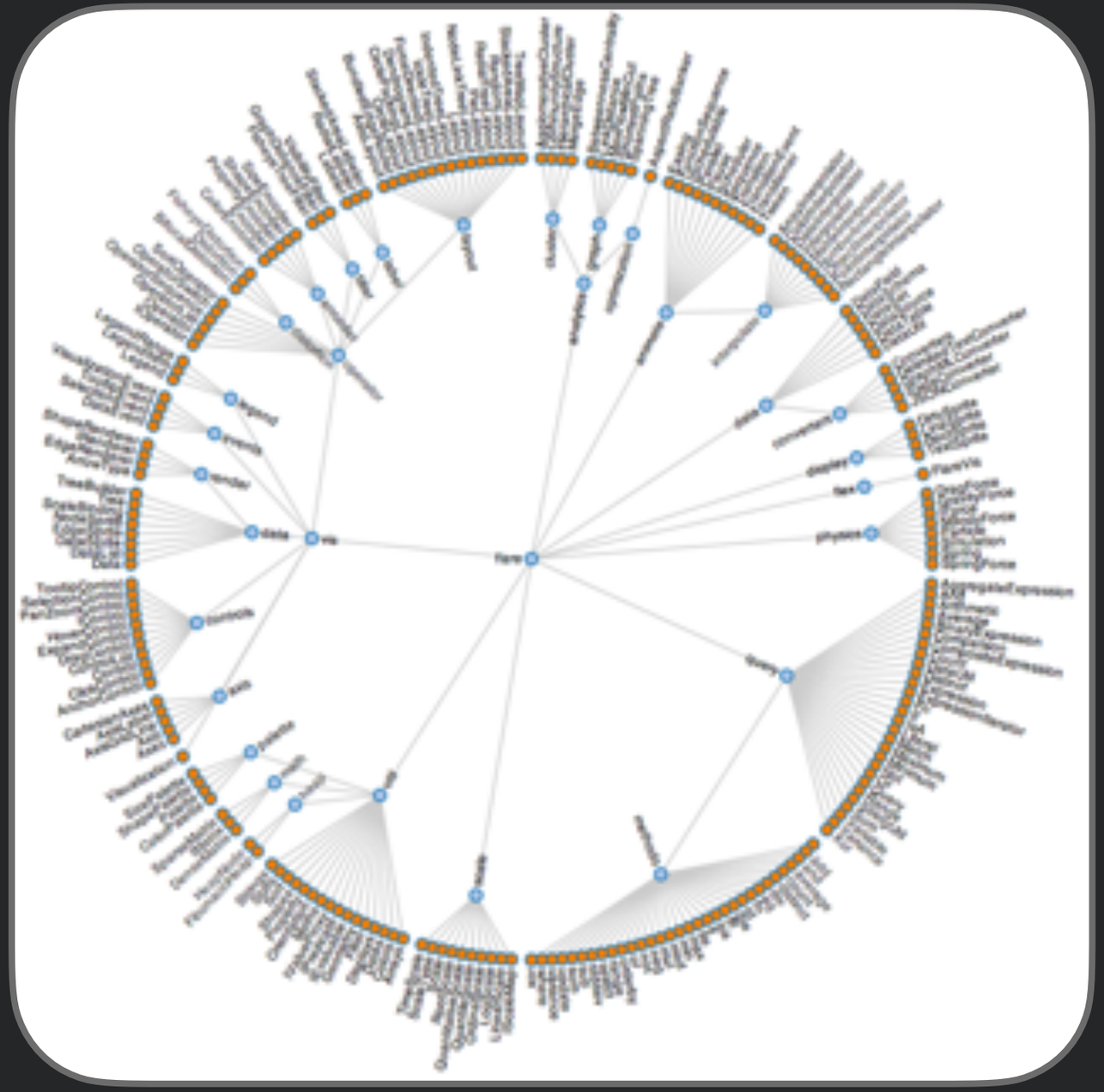
Hierarchies

Node Link Diagram



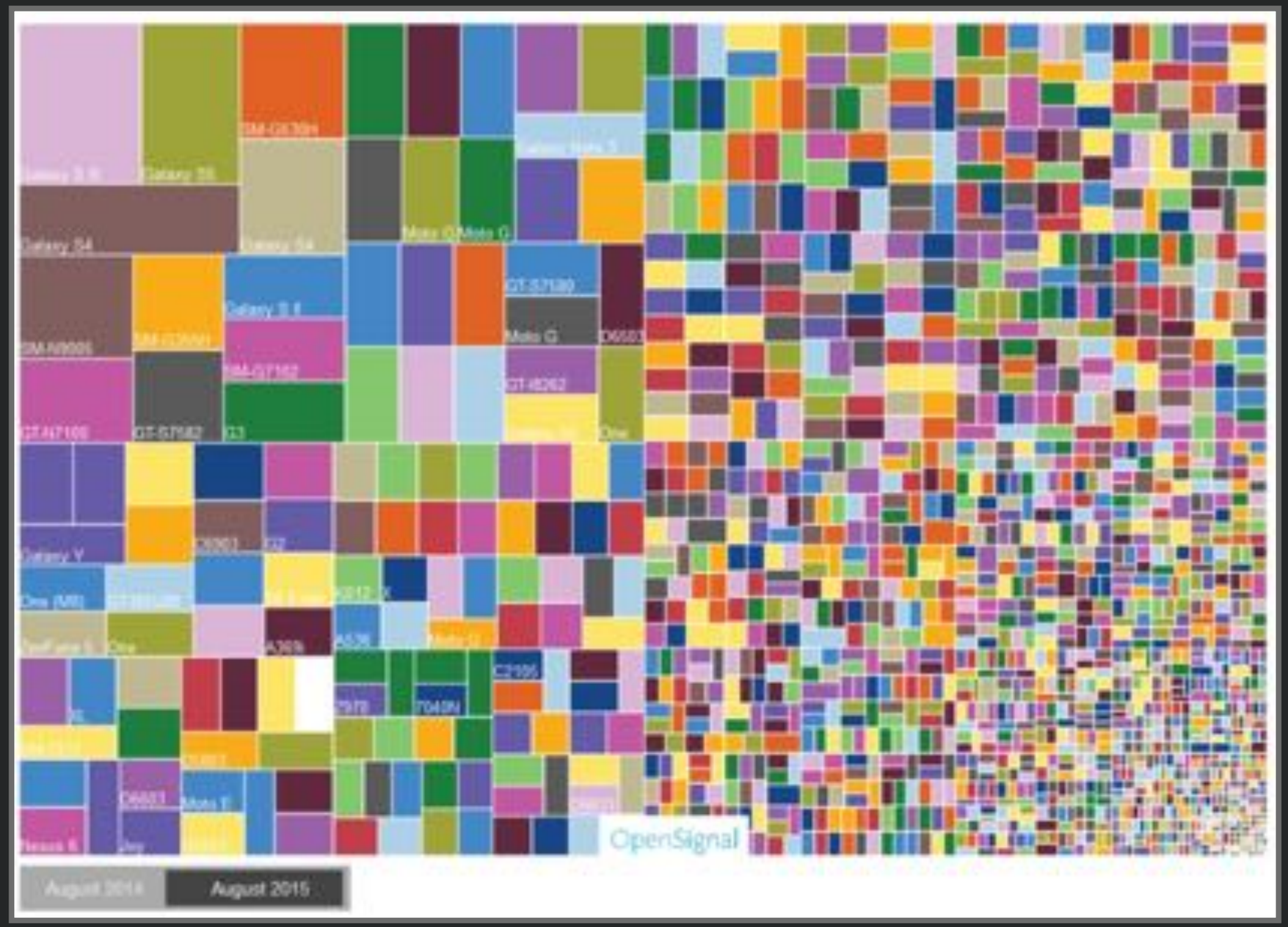
Dendrogram

- Leaf nodes of hierarchy on edges of circle



Treemaps

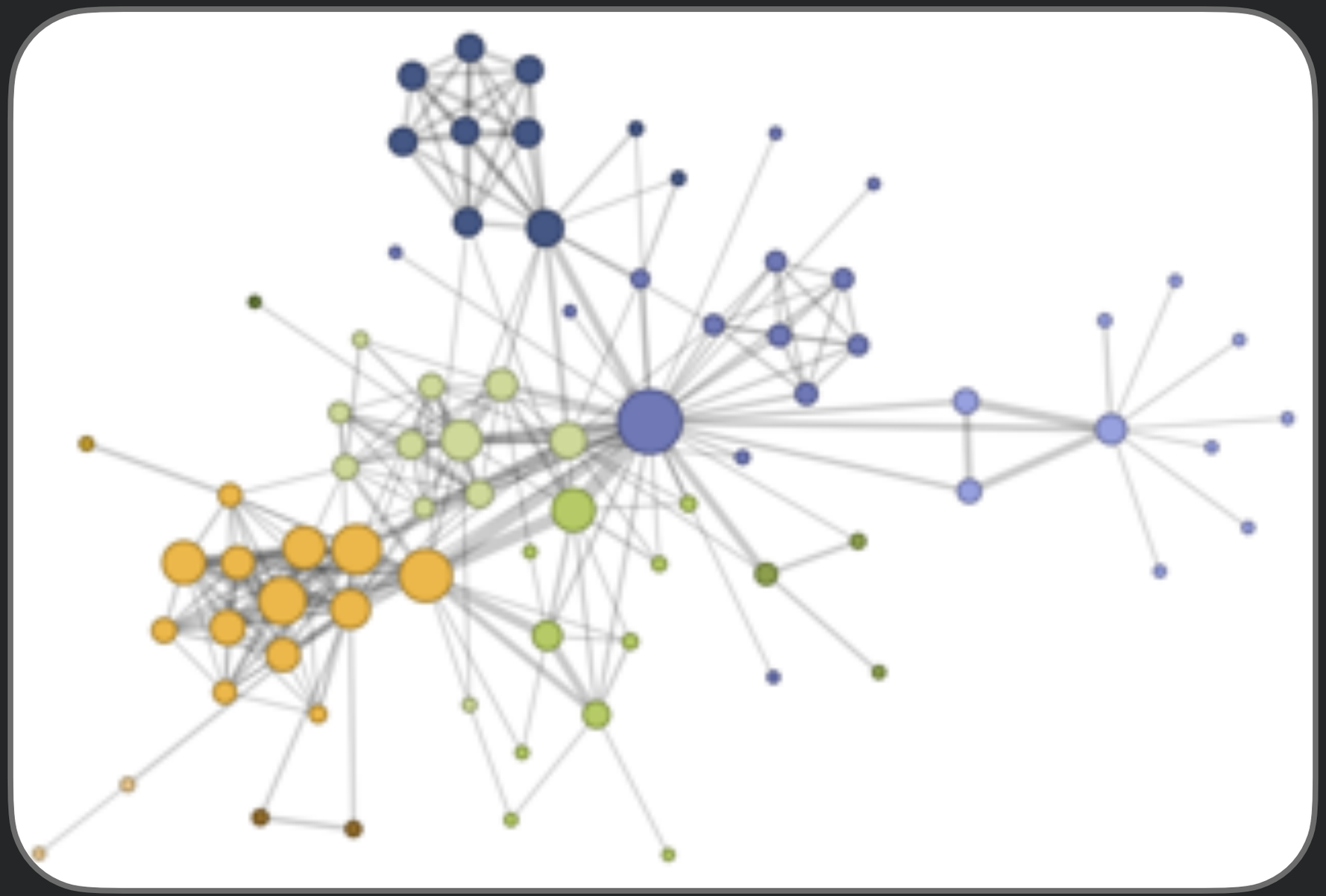
Treemaps


Galaxy S4
Galaxy S5
SM-G870A
SM-G900V
SM-G7102
GT-I9505
GT-I9082
Moto G
GT-I9300
D6503
Galaxy Y
C6903
Z2
A369
C2105
T040N
Moto Y
Nexus 6
OpenSignal
August 2014
August 2015

Networks

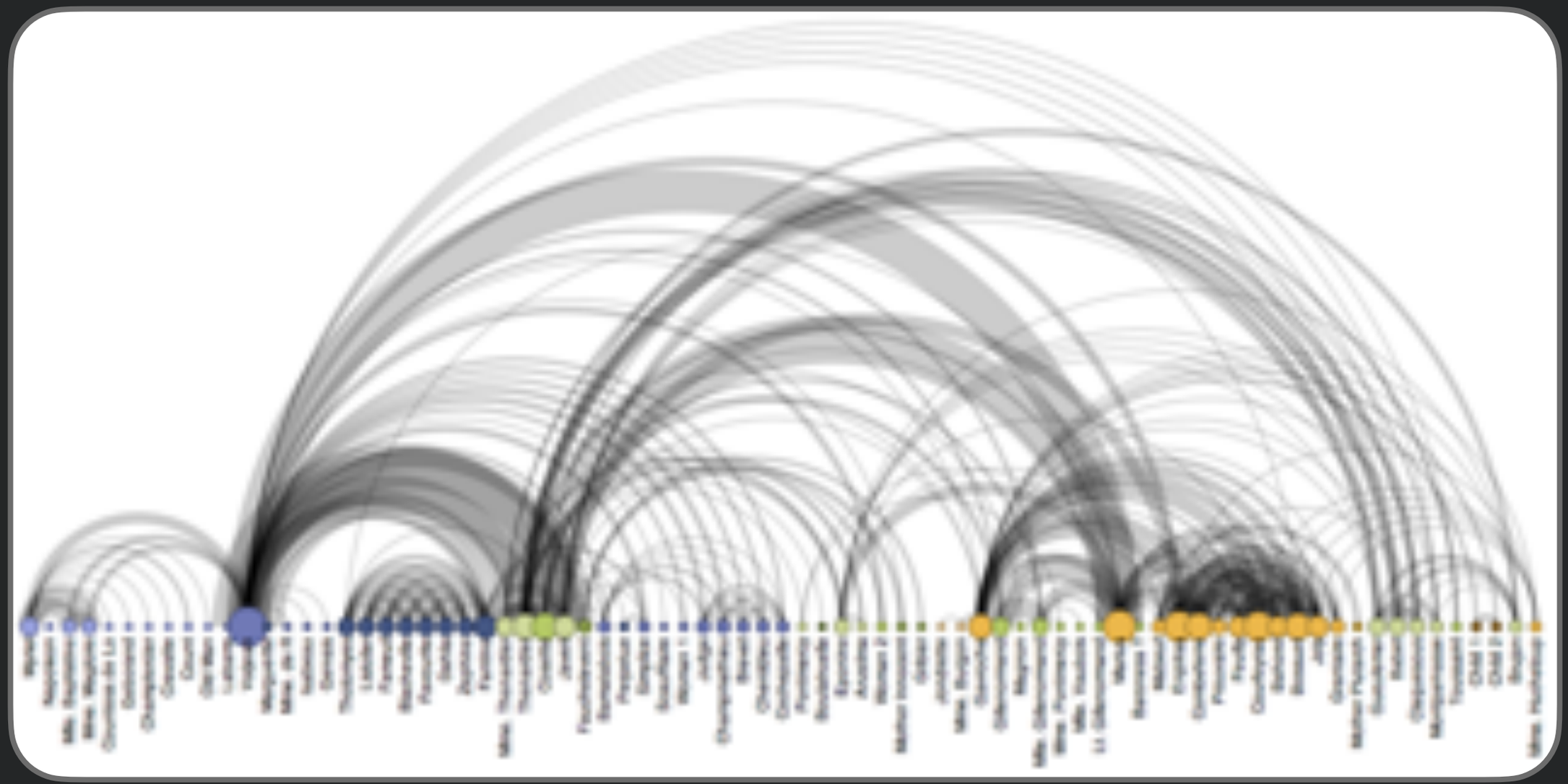
Force-directed Layout

- Edges function as springs, find least energy configuration

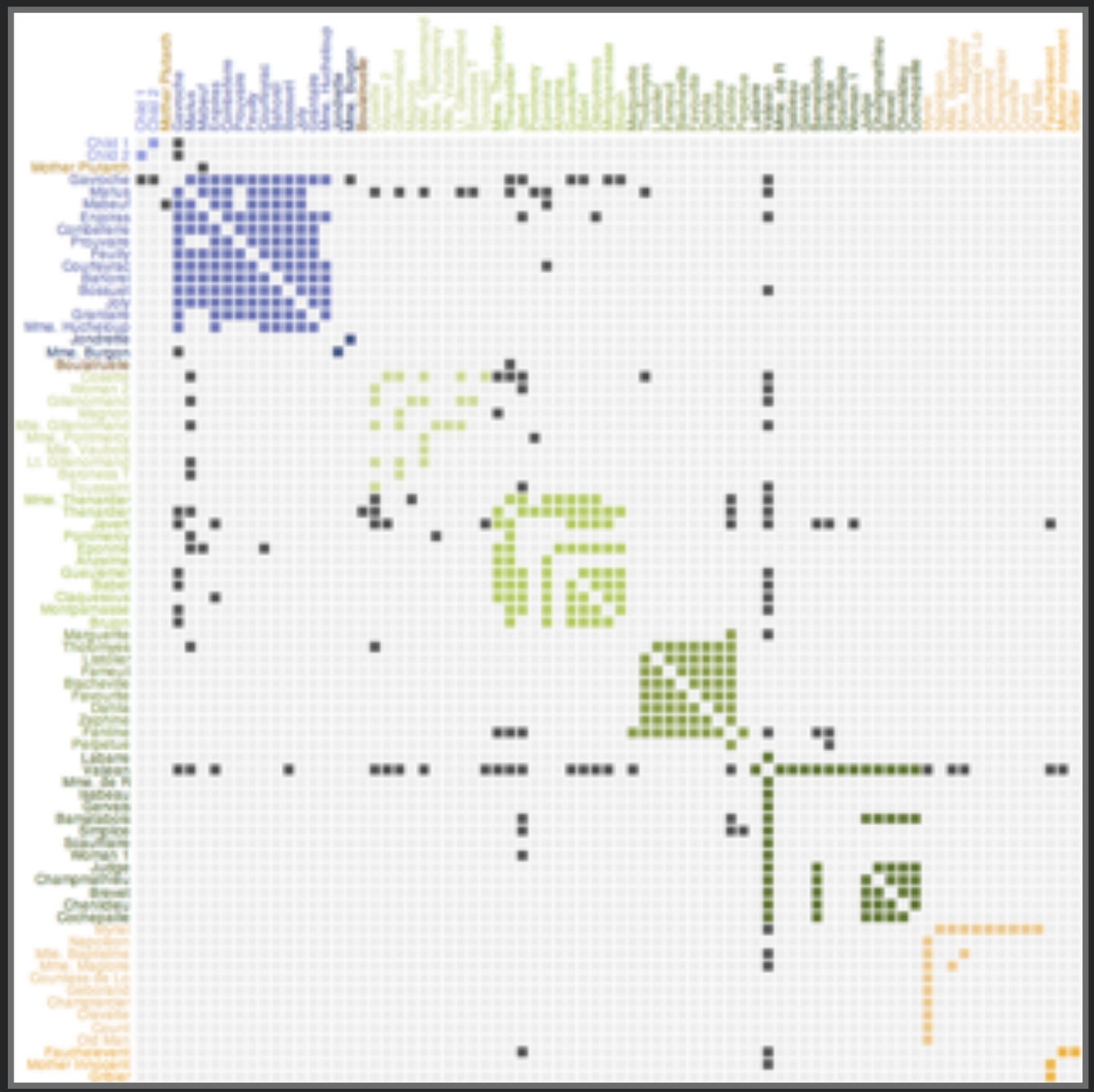


Arc Diagram

- Can support identifying cliques & bridges w/ right order



Adjacency Matrix



Design Considerations

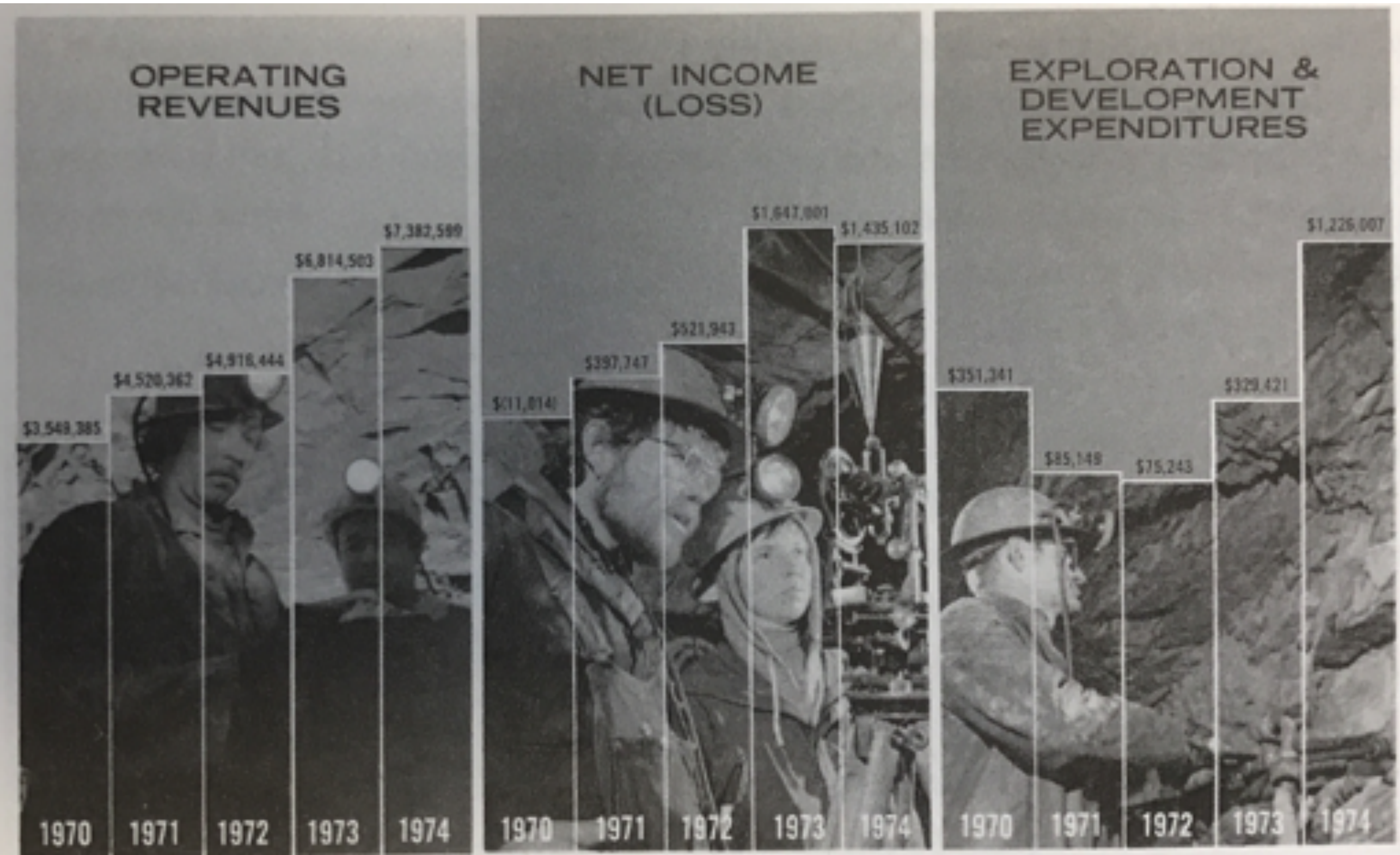
Tufte's principles of graphical excellence

- Show the ***data***
- Induce the viewer to think about the substance rather than the methodology
- Avoid distorting what the data have to say
- Present ***many*** numbers in a small space
- Make large data sets ***coherent***
- Encourage the eye to ***compare*** different pieces of data
- Reveal data at several levels of detail, from overview to fine structure
- Serve reasonable clear ***purpose***: description, exploration, tabulation, decoration

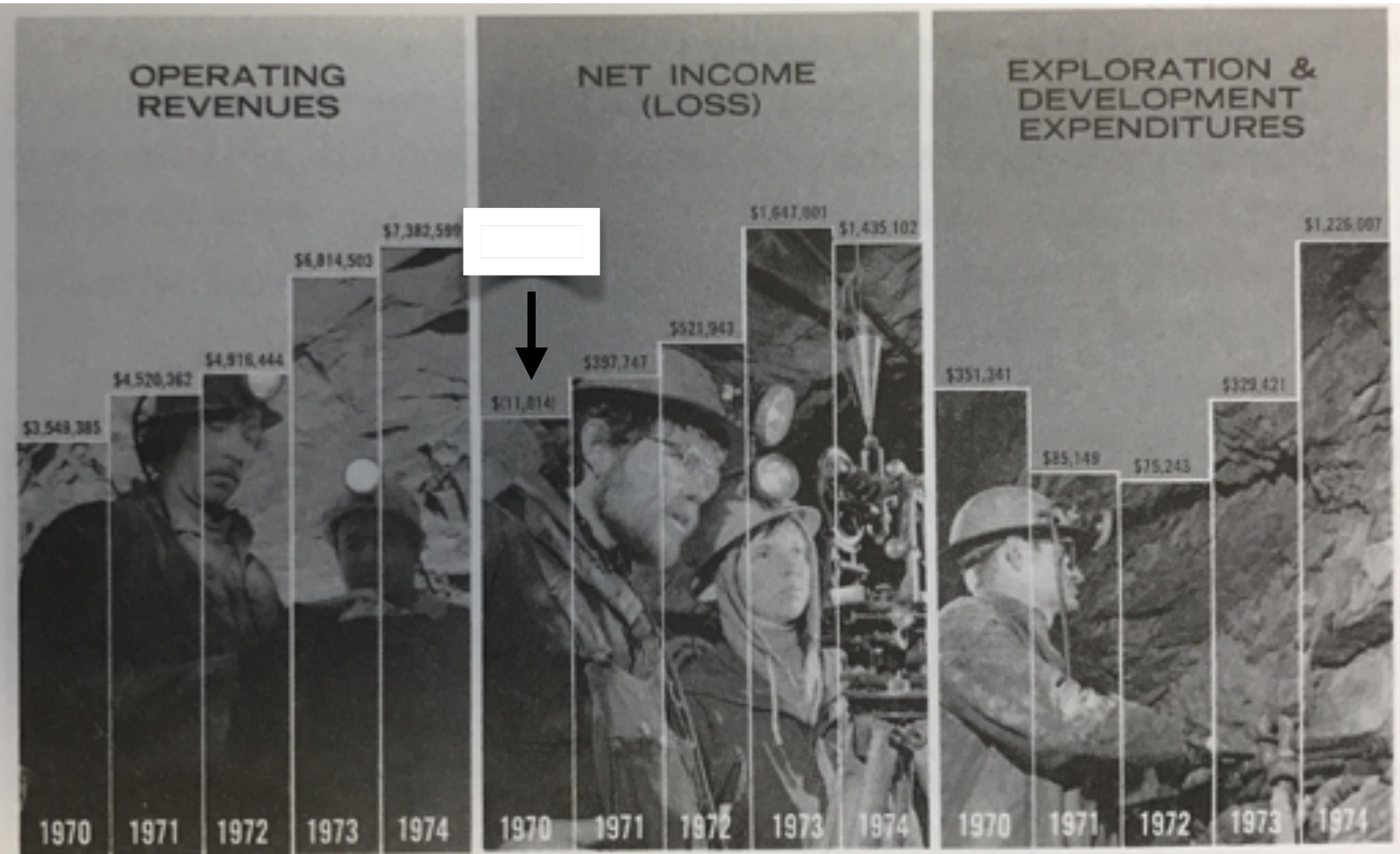
Distortions in Visualizations

- Visualizations may distort the underlying data, making it harder for reader to understand truth
- Use of ***design*** variation to try to falsely communicate ***data*** variation

Example


OPERATING REVENUES
$3,549,385
$4,520,362
$4,916,444
$6,814,503
$7,382,589
1970
1971
1972
1973
1974
NET INCOME (LOSS)
$(11,014)
$397,747
$521,943
$1,647,001
$1,435,102
1970
1971
1972
1973
1974
EXPLORATION & DEVELOPMENT EXPENDITURES
$351,341
$85,148
$75,243
$329,421
$1,226,007
1970
1971
1972
1973
1974

Example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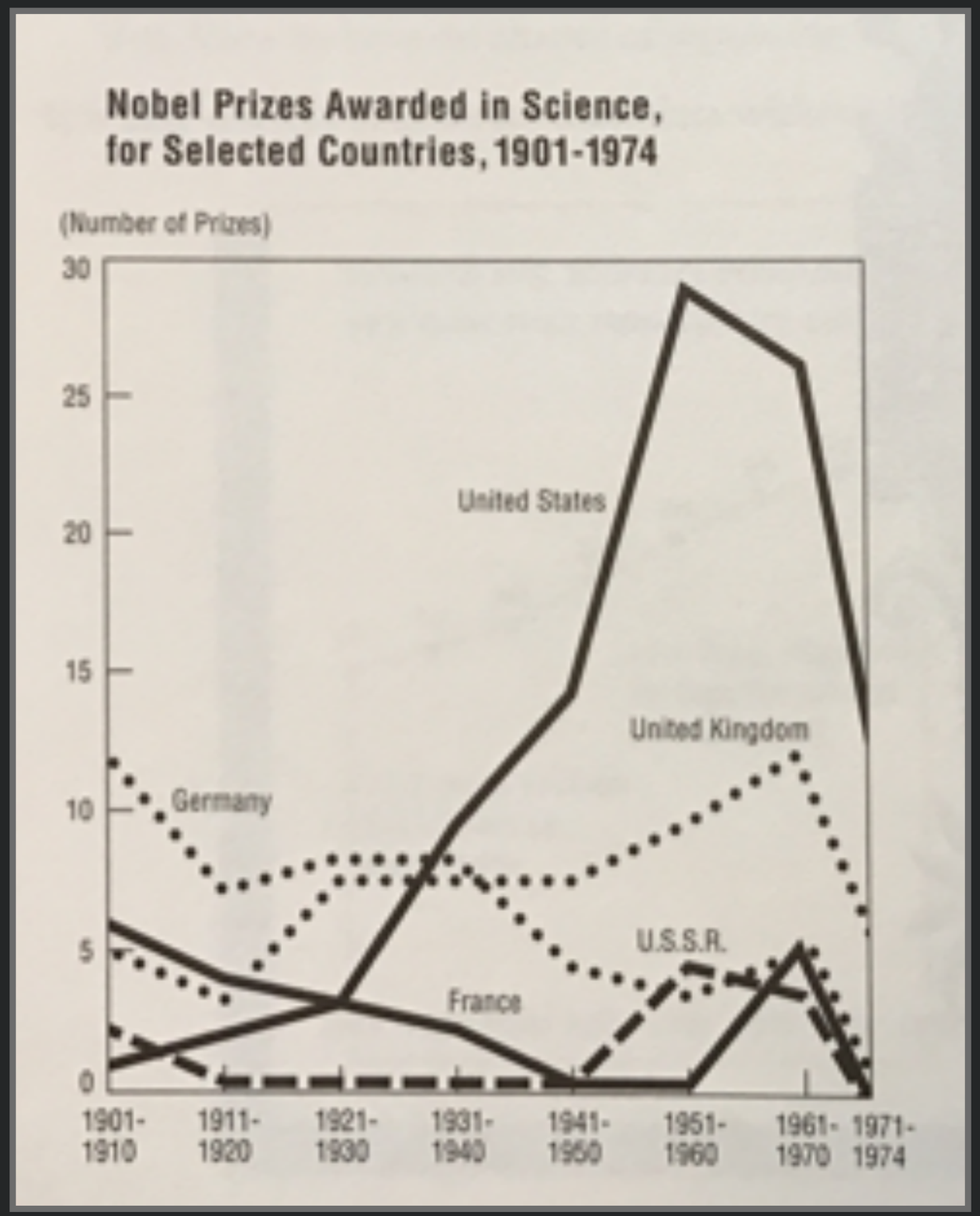
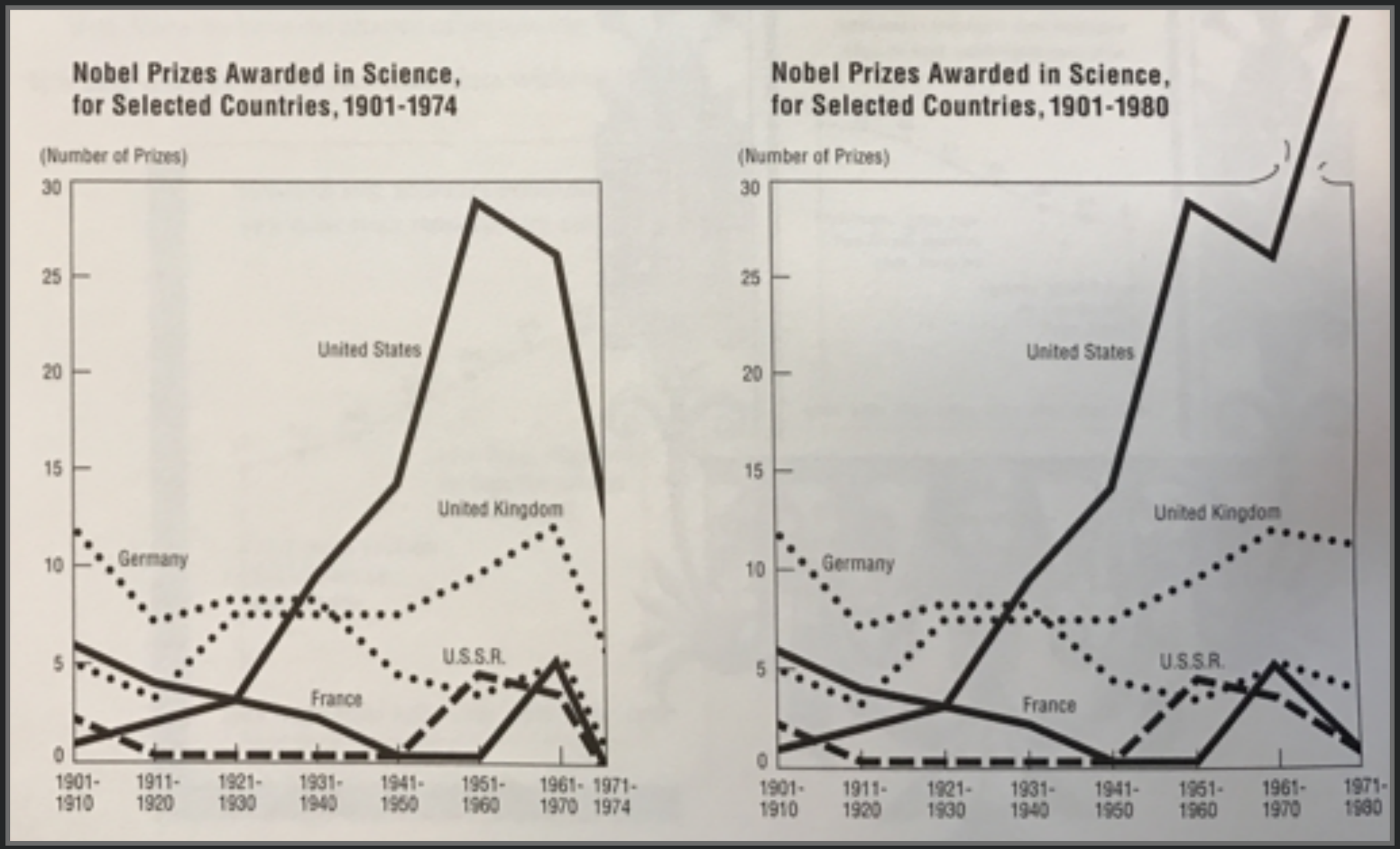
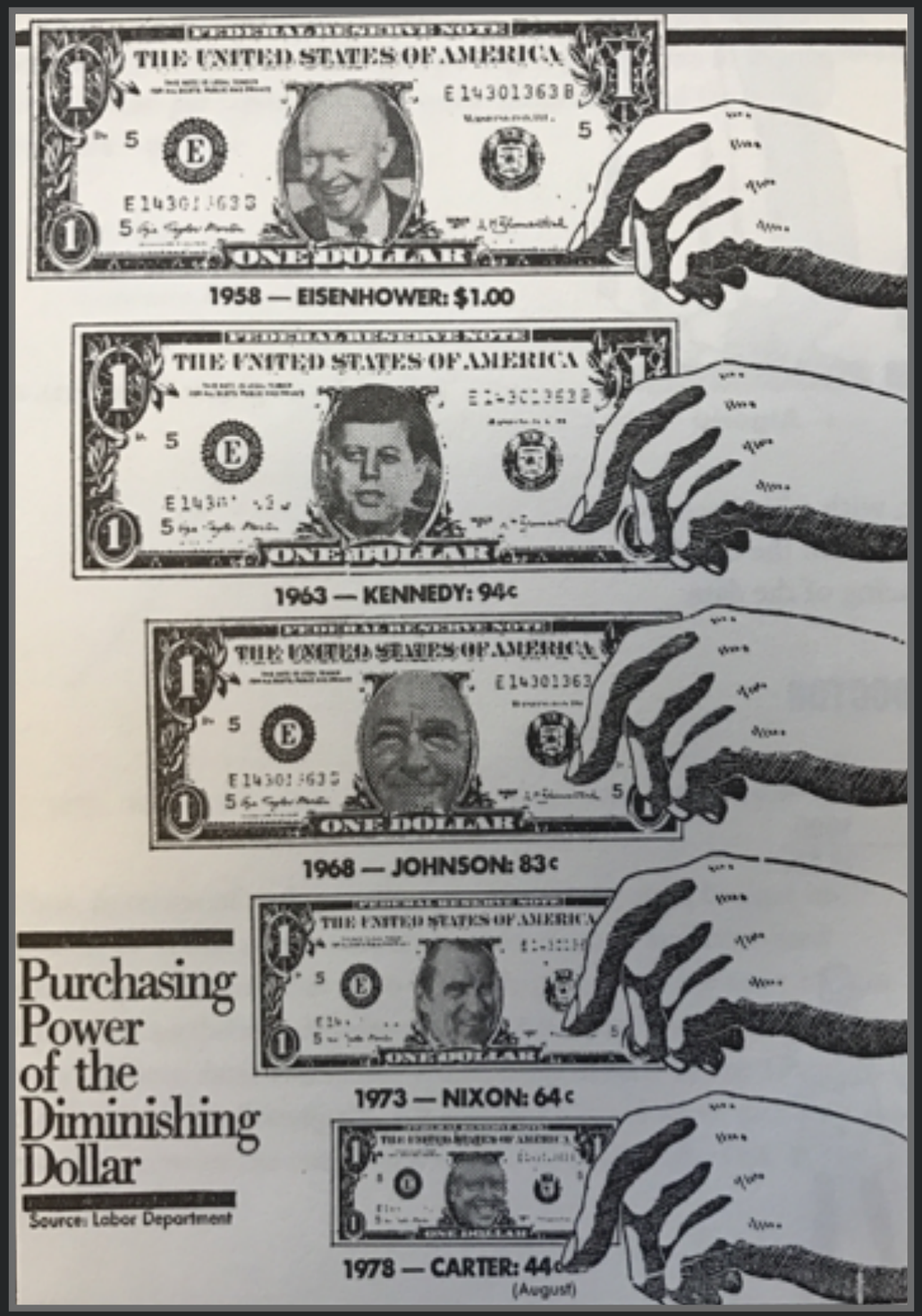
Example


Nobel Prizes Awarded in Science,
for Selected Countries, 1901-1974
(Number of Prizes)
30
25
20
15
10
5
0
United States
United Kingdom
Germany
U.S.S.R.
France
1901-1910
1911-1920
1921-1930
1931-1940
1941-1950
1951-1960
1961-1970
1971-1974

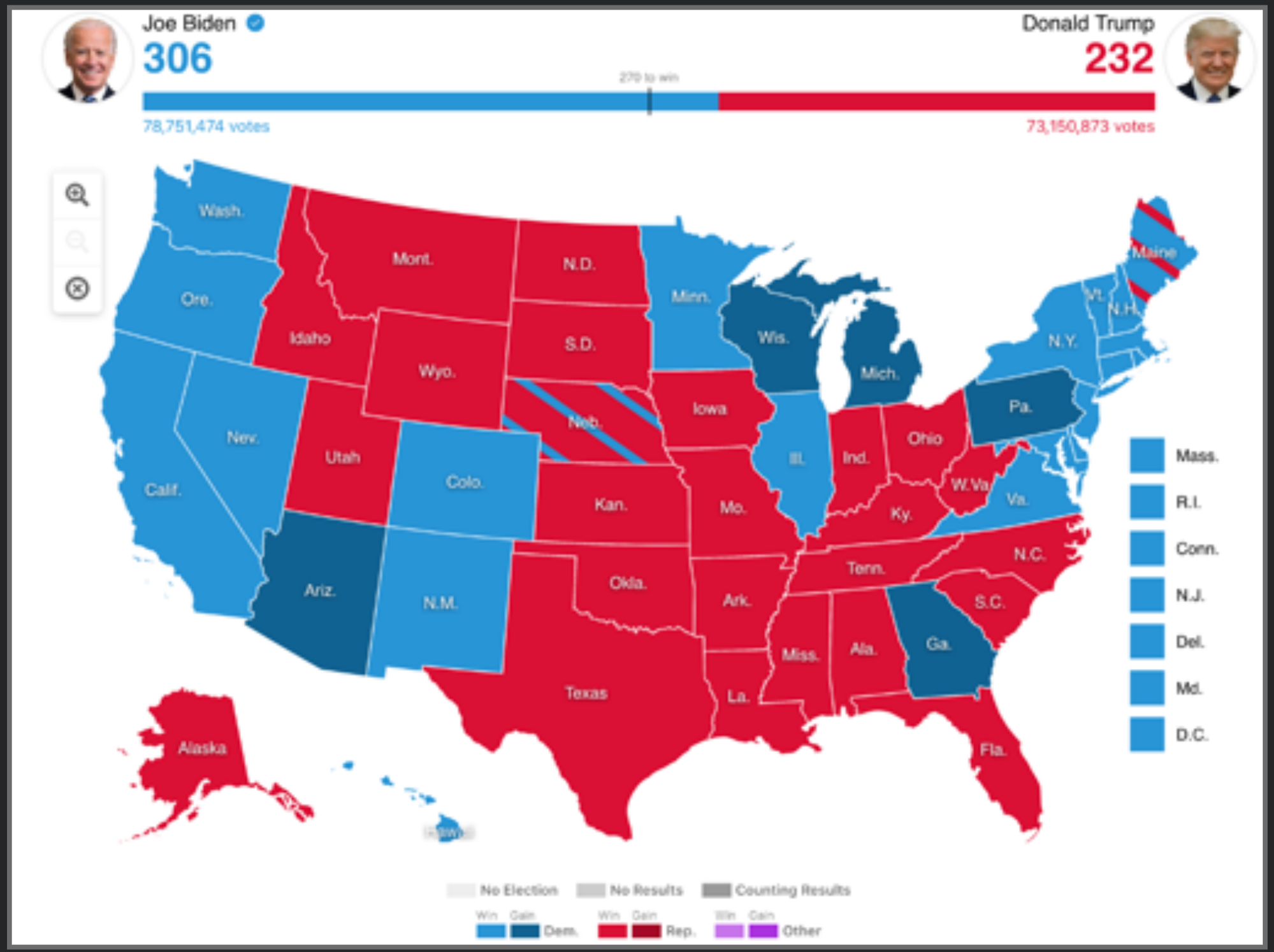
Example (corrected)



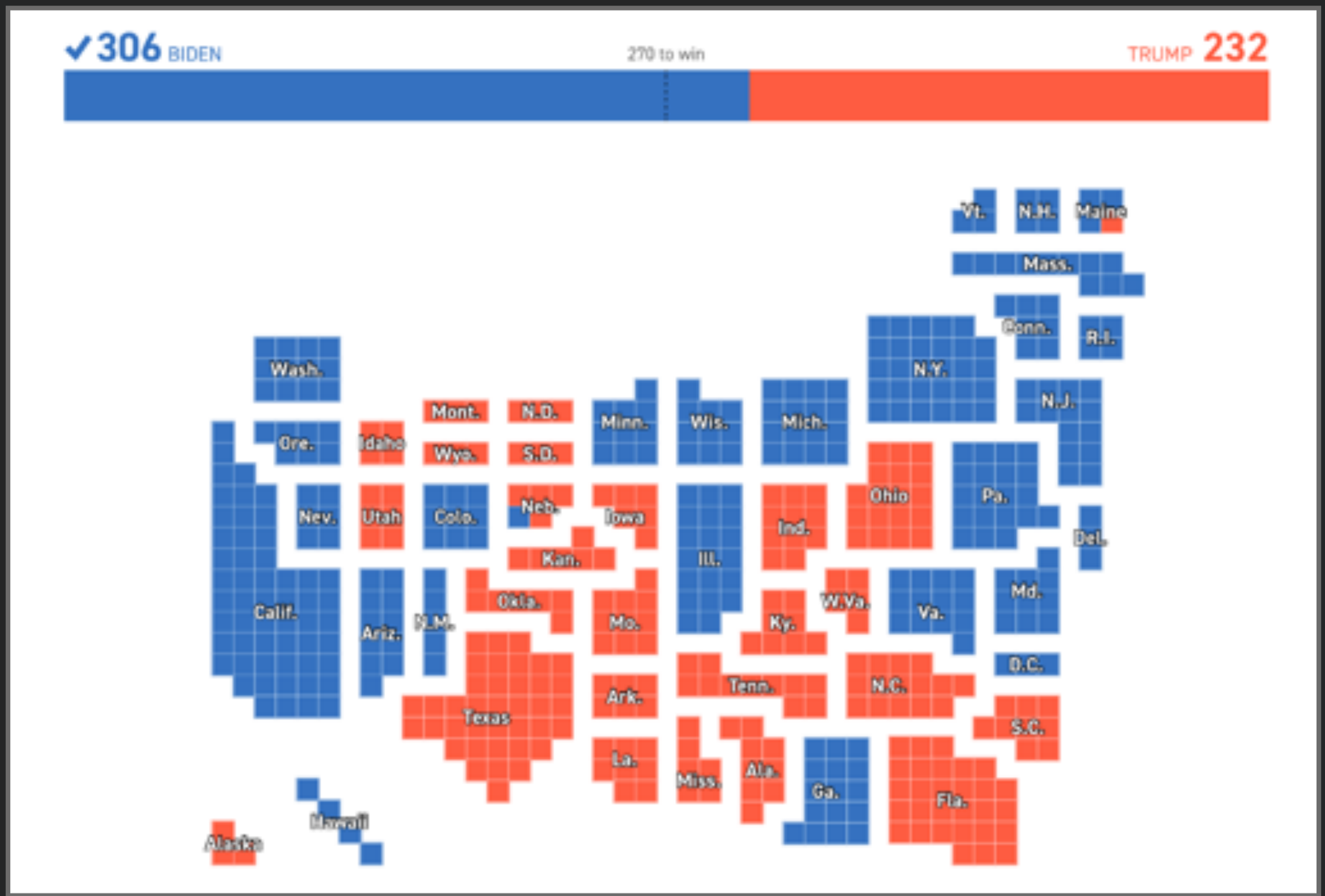
Example


THE UNITED STATES OF AMERICA
ONE DOLLAR
1958 — EISENHOWER: $1.00
1963 — KENNEDY: 94¢
1968 — JOHNSON: 83¢
1973 — NIXON: 64¢
1978 — CARTER: 44¢
(August)
Purchasing Power of the Diminishing Dollar
Source: Labor Department

Traditional Electoral Map



Weighted Electoral Map



Data-ink

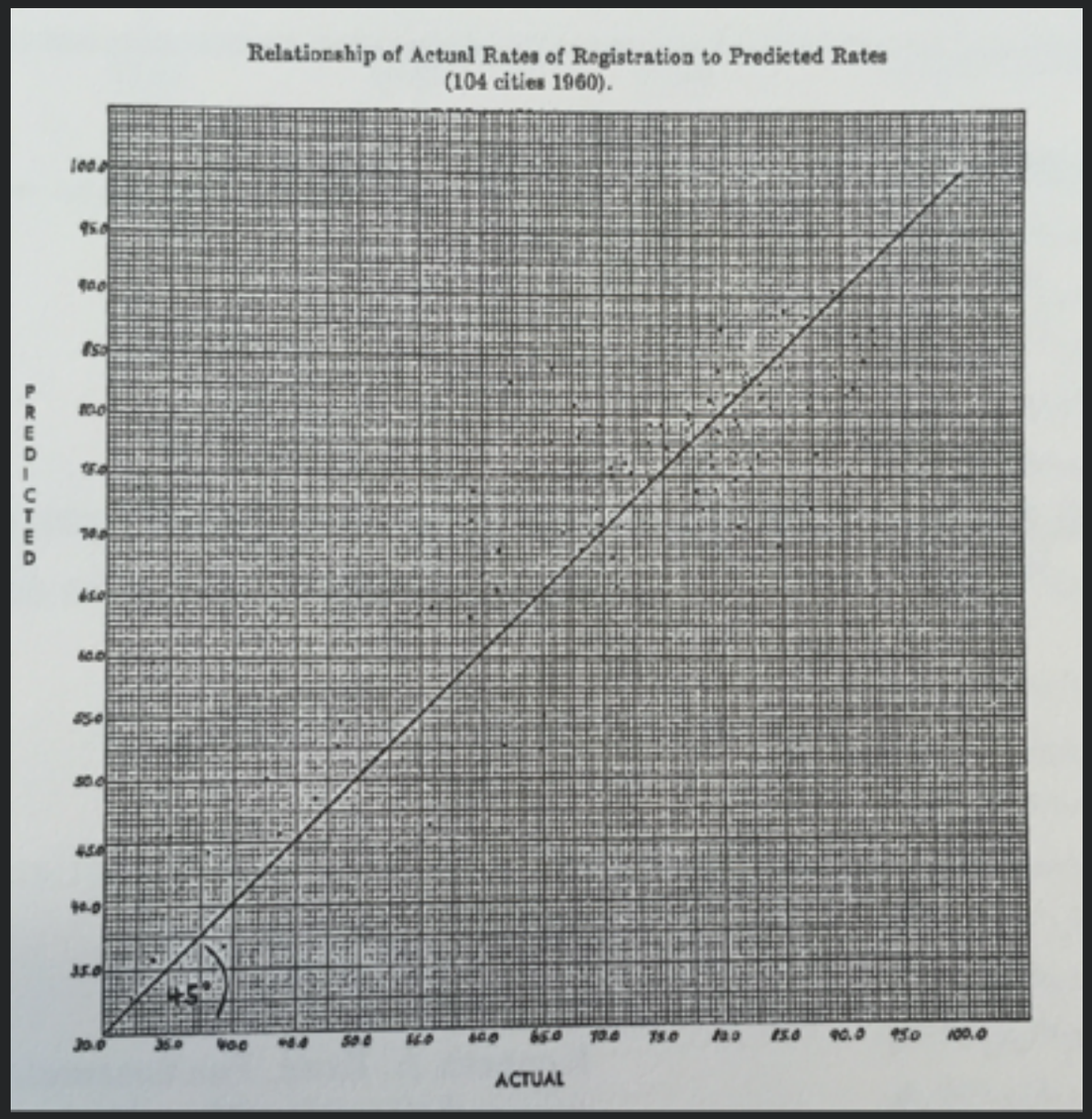
- Data-ink - non-redundant ink encoding data information

$$\text{Data-ink ratio} = \frac{\text{Data-ink}}{\text{Total ink used to print the graphic}}$$

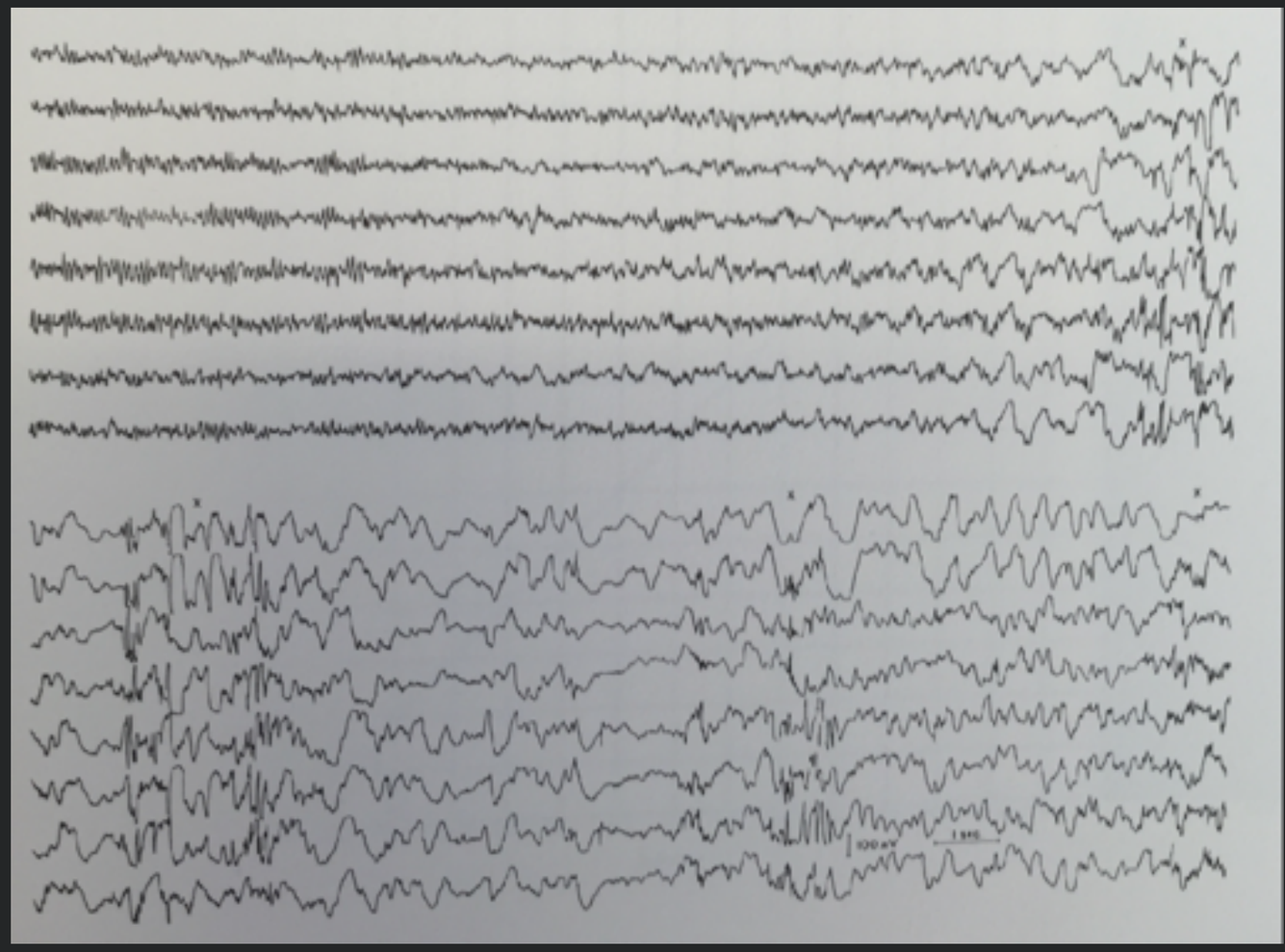
= proportion of a graphic's ink devoted to the non-redundant display of data-information

= 1.0 – proportion of a graphic that can be erased

Examples of Data-ink Ratio



~0

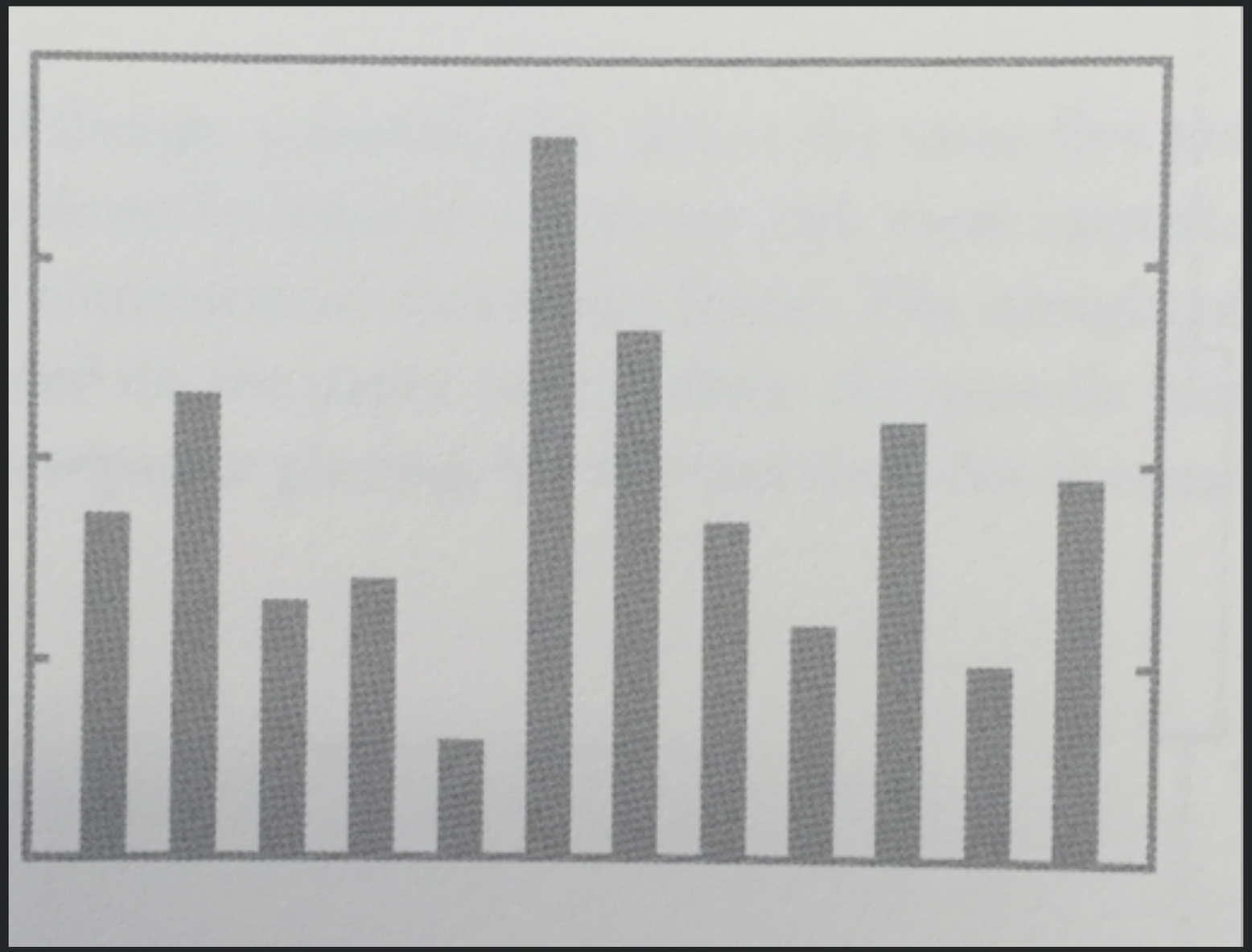


1.0

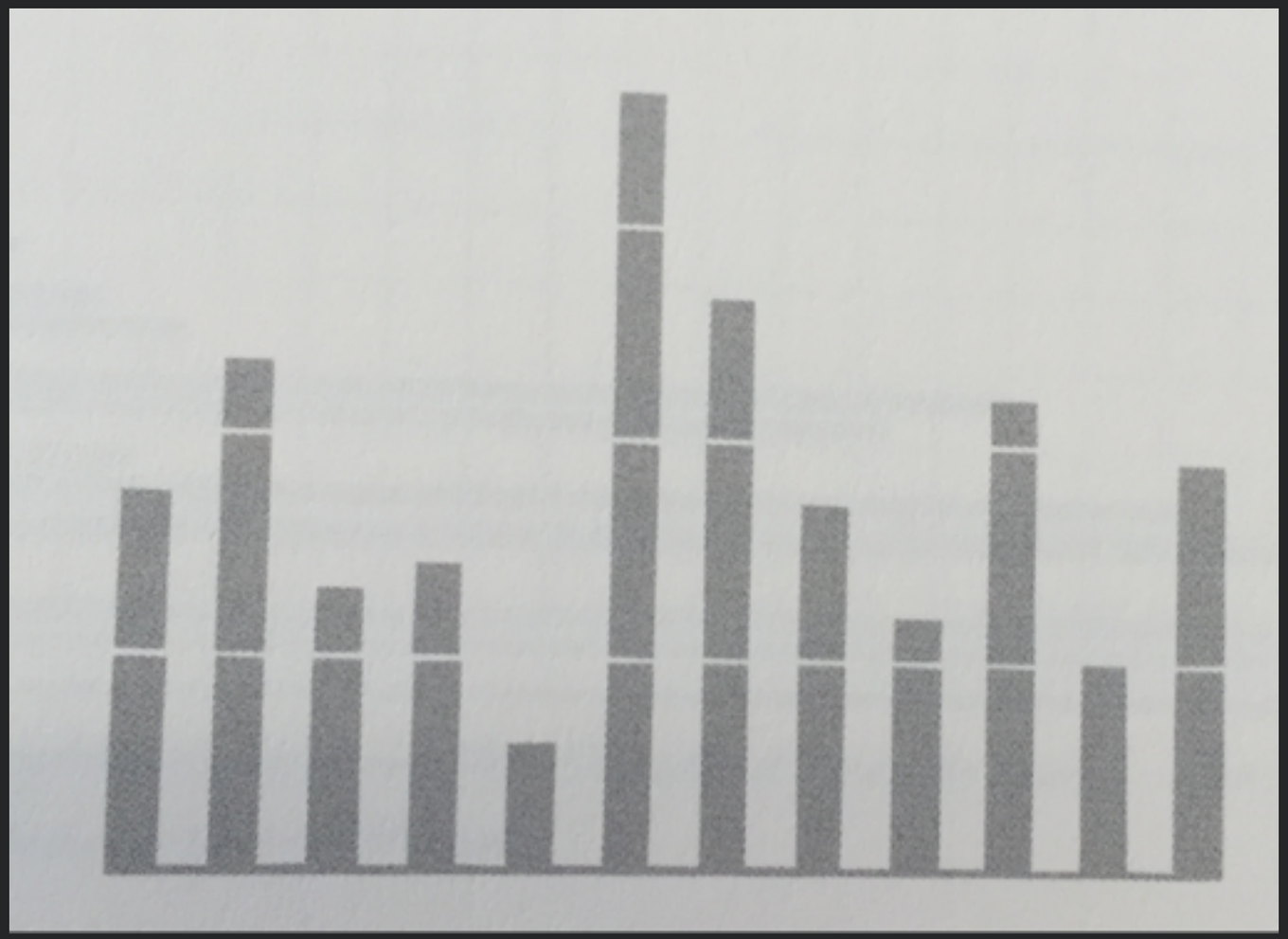
Design Principles for Data-ink

- (a.k.a. aesthetics & minimalism / elegance & simplicity)
- ***Above all else show the data***
  - Erase non-data-ink, within reason
    - Often not valuable and distracting
    - Redundancy not usually useful

Example



Example (revised)



Interacting with Visualizations

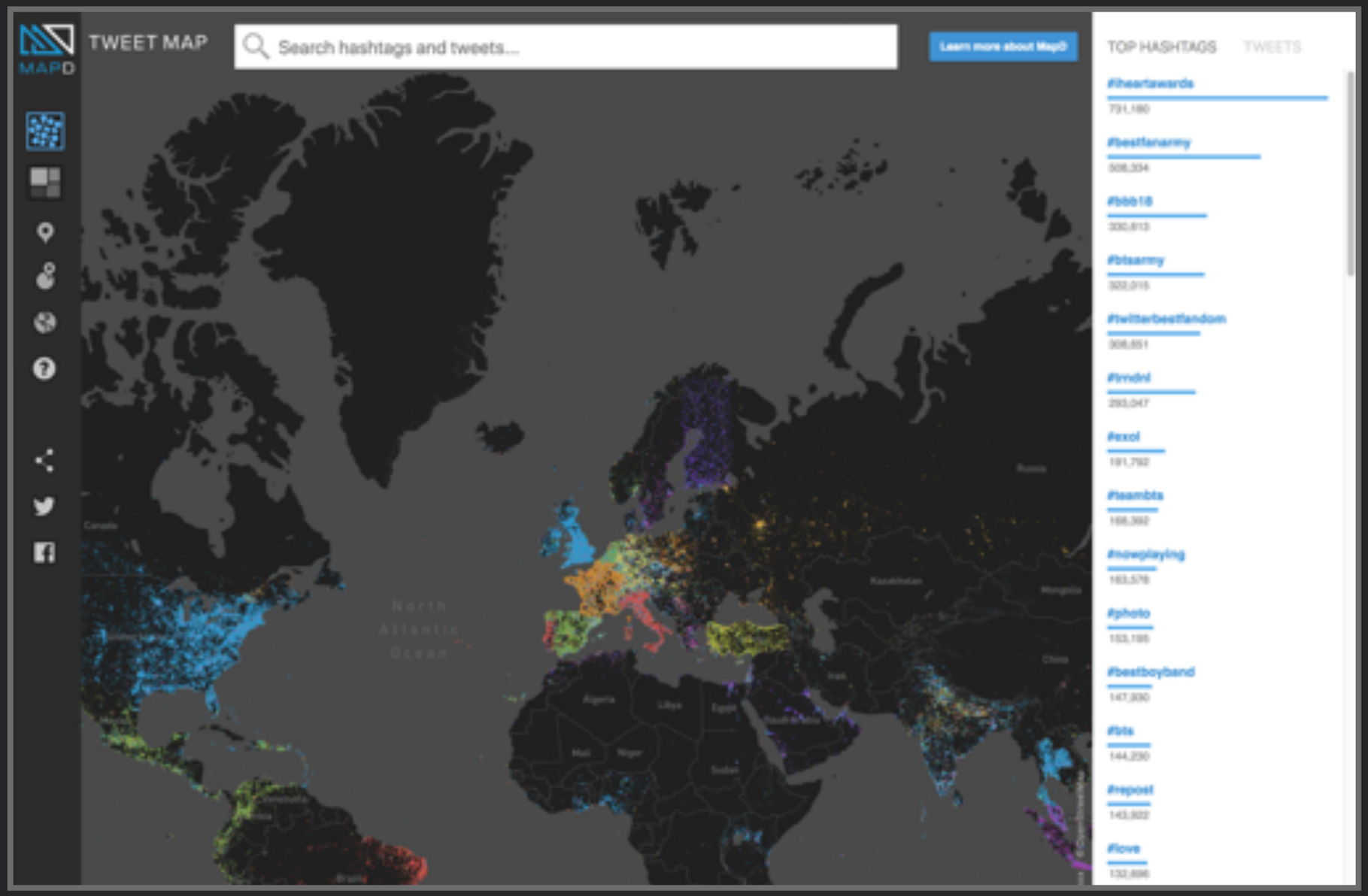
Interactive Visualizations

- Users often use iterative process of making ***sense*** of the data
  - Answers lead to new questions
- Interactivity helps user constantly change display of information to answer new questions
- Should offer visualization that offers best view of data moment to ***moment*** as desired view ***changes***

Information Visualization Tasks

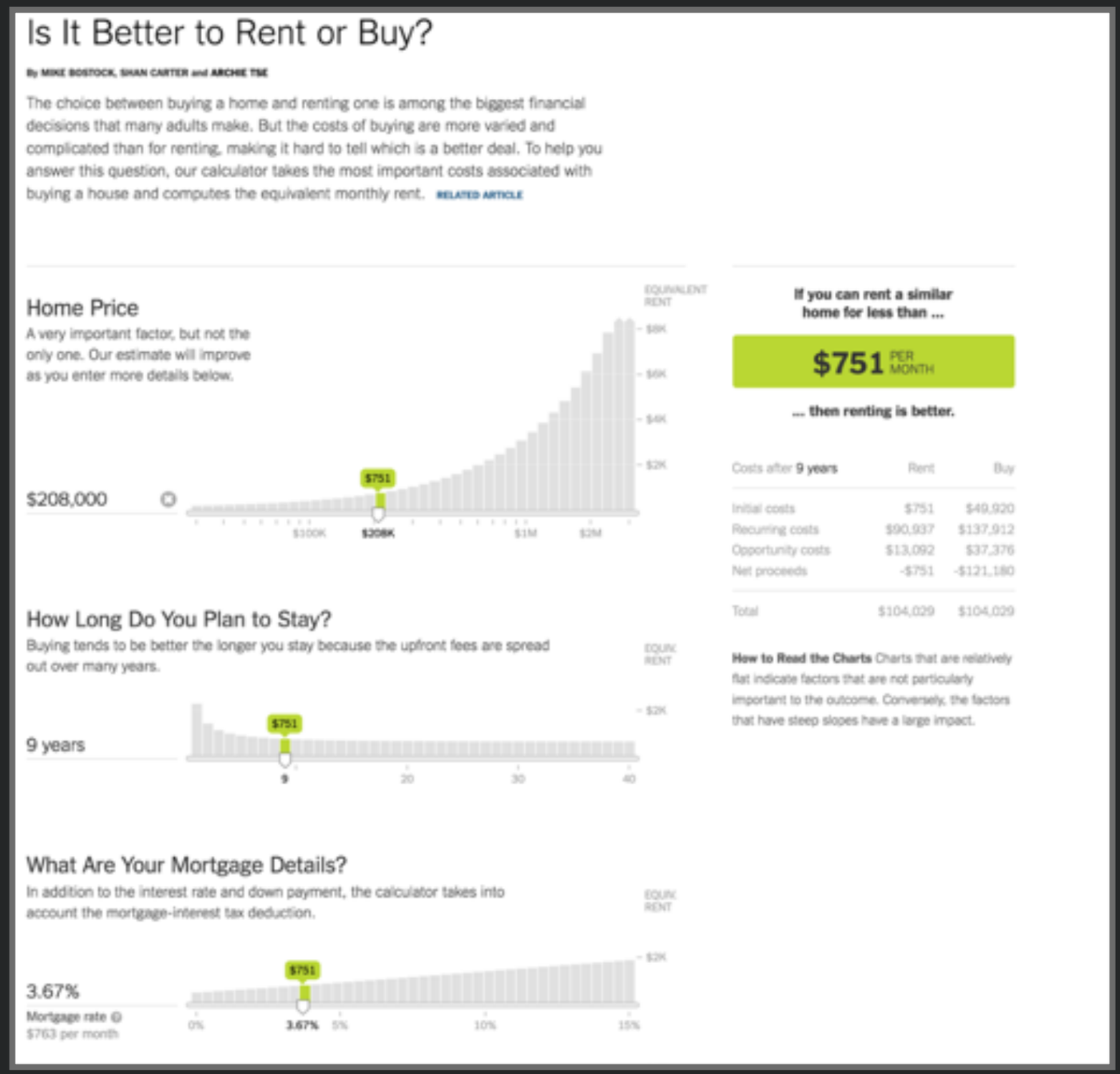
- ***Overview:*** gain an overview of entire collection
- ***Zoom:*** zoom in on items of interest
- ***Filter:*** filter out uninteresting items
- ***Details on Demand:*** select an item or group and get details
- ***Relate:*** view relationships between items
- ***History:*** support undo, replay, progressive refinement
- ***Extract:*** allow extraction of sub-collections through queries

Global Tweet Map



https://www.mapd.com/demos/tweetmap/

Renting vs. Buying Utility



Is It Better to Rent or Buy?

By MIKE BOSTOCK, SHAN CARTER and ARCHIE TSE

The choice between buying a home and renting one is among the biggest financial decisions that many adults make. But the costs of buying are more varied and complicated than for renting, making it hard to tell which is a better deal. To help you answer this question, our calculator takes the most important costs associated with buying a house and computes the equivalent monthly rent. RELATED ARTICLE

Home Price

A very important factor, but not the only one. Our estimate will improve as you enter more details below.

$208,000

EQUIVALENT RENT

$8K $6K $4K $2K

$751

$100K $208K $1M $2M

If you can rent a similar home for less than ...

$751 PER MONTH

... then renting is better.

Costs after 9 years	Rent	Buy
Initial costs	$751	$49,920
Recurring costs	$90,937	$137,912
Opportunity costs	$13,092	$37,376
Net proceeds	-$751	-$121,180
Total	$104,029	$104,029

How to Read the Charts Charts that are relatively flat indicate factors that are not particularly important to the outcome. Conversely, the factors that have steep slopes have a large impact.

How Long Do You Plan to Stay?

Buying tends to be better the longer you stay because the upfront fees are spread out over many years.

9 years

EQUIV RENT

$2K

$751

9 20 30 40

What Are Your Mortgage Details?

In addition to the interest rate and down payment, the calculator takes into account the mortgage-interest tax deduction.

3.67%

Mortgage rate
$763 per month

EQUIV RENT

$2K

$751

0% 3.67% 5% 10% 15%

https://www.nytimes.com/interactive/2014/upshot/buy-rent-calculator.html?_r=0

7 Minute Break

In-Class Activity

Design an Information Visualization

- In Breakout Rooms
  - Select a set of data to visualize and two or more representative questions to answer using this data
- Design an ***interactive*** information visualization
  - Create sketches showing the design of the information visualization
  - Should have multiple views of data, interactions to configure and move between views

Acknowledgements

- Slides adapted from Dr. Thomas Latoza's SWE 632 course