

# SWE 632 - Design & Development of User Interfaces

---



George Mason  
University

---

Instructor:  
Dr. Kevin Moran

Teaching Assistant:  
David Gonzalez Samudio

Class will start in:  
**20:00**

# SWE 632 - Design & Development of User Interfaces

---



George Mason  
University

---

Instructor:  
Dr. Kevin Moran

Teaching Assistant:  
David Gonzalez Samudio

Class will start in:  
**20:00**

# SWE 632 - Design & Development of User Interfaces

Fall 2020



George Mason  
University

---

Dr. Kevin Moran

## *Week 13:* Information Visualization





# Administrivia

- Project Checkpoint 6 - *Due Today*
- Project Checkpoint 7 out today - *Due Next Week*
- Final Project Presentation - *Due Dec 1st (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 7 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 Visual Design and Information Visualization 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 7 weaknesses you identify, you should make use of at least 5 distinct principles and guidelines.
3. Address the visual design weaknesses by creating an improved visual 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 visual design and information visualization 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.
  - d. 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. Vue.js: Binhui, Cynthia, & Harshita

# Overview of Information Visualization





# Today

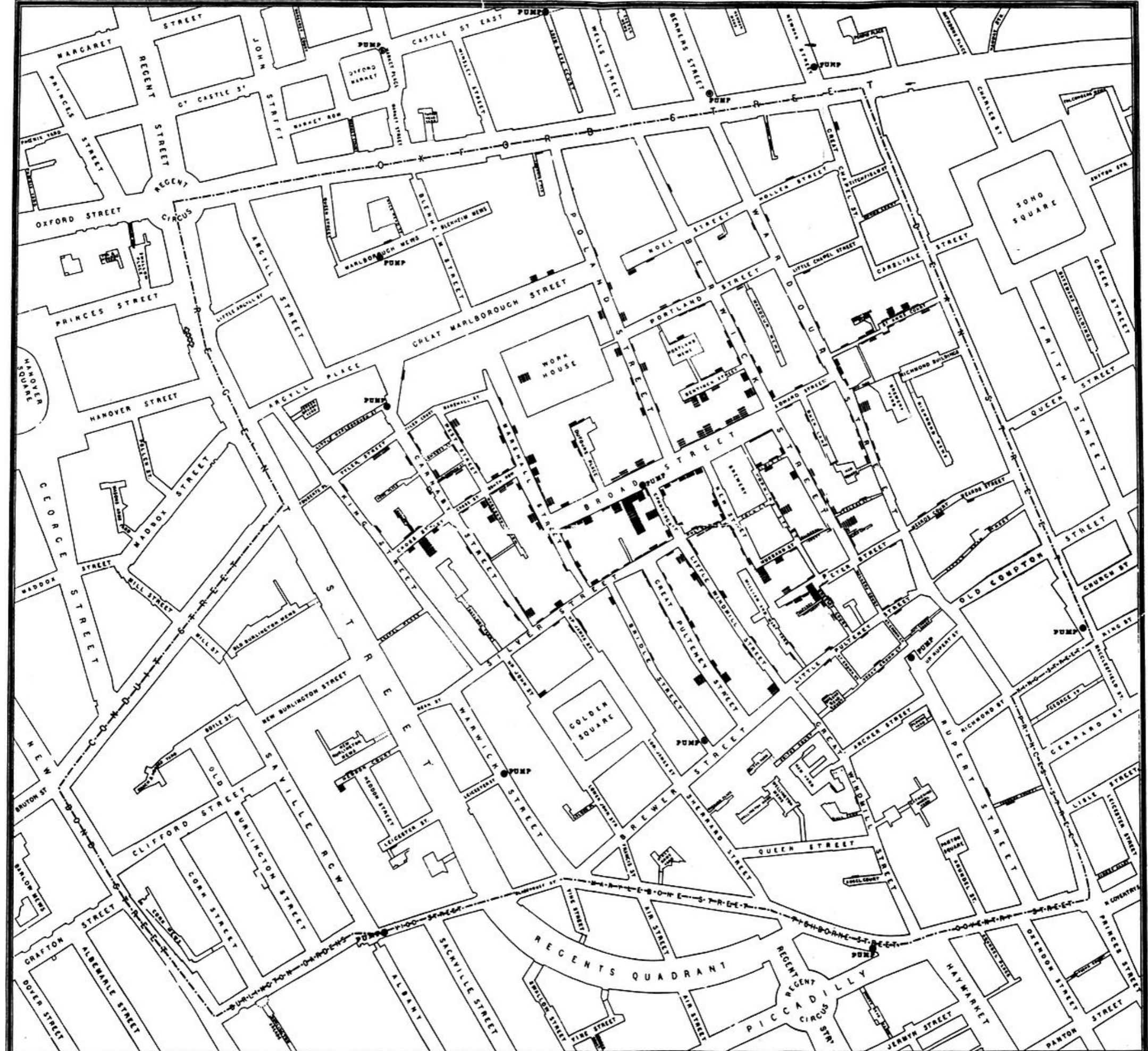


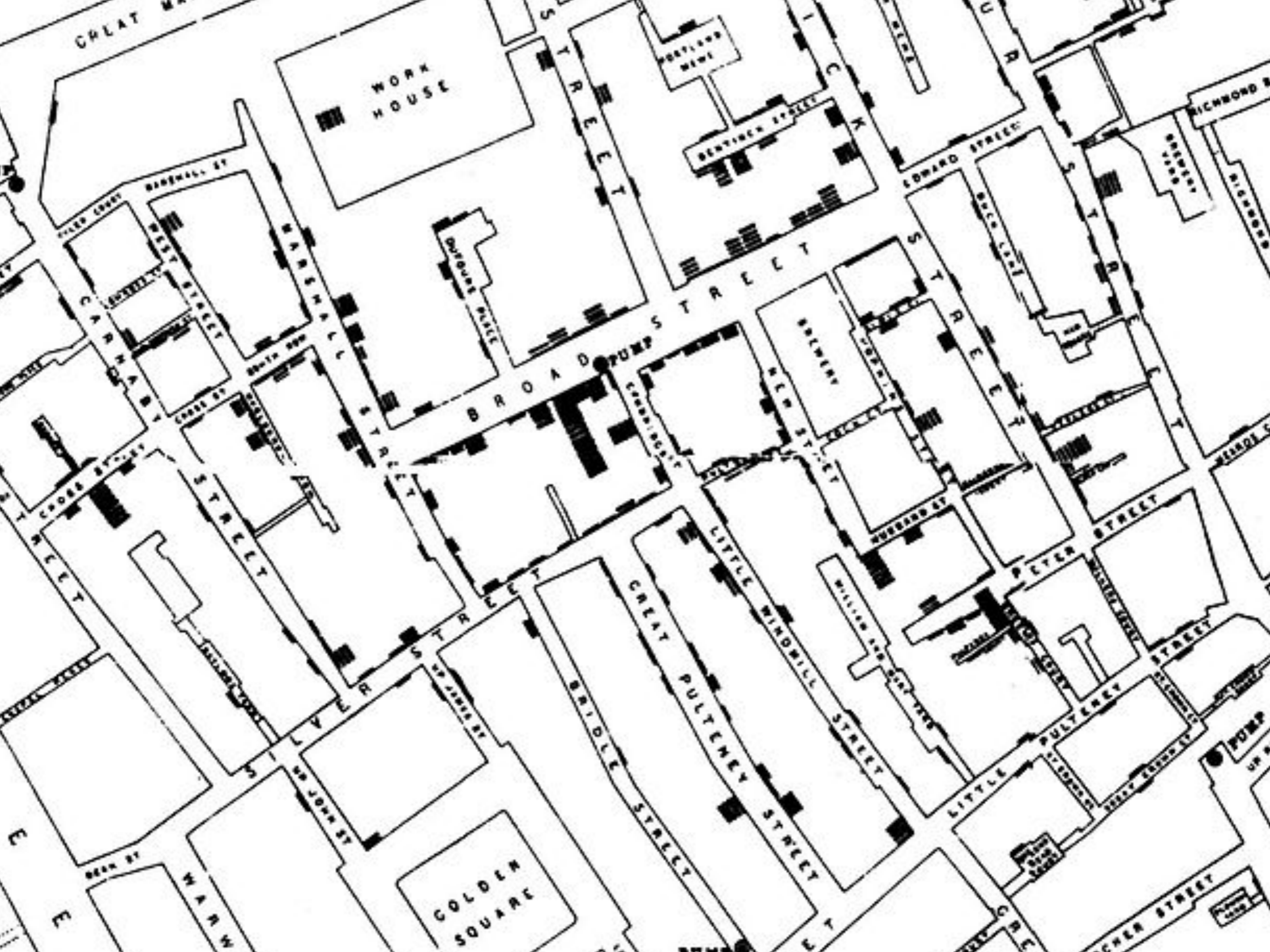
- What types of information visualization are there?
  - Which one should you choose?
- What principles and guidelines inform the design of information visualizations?
- How can interactivity be used to design better information visualizations?

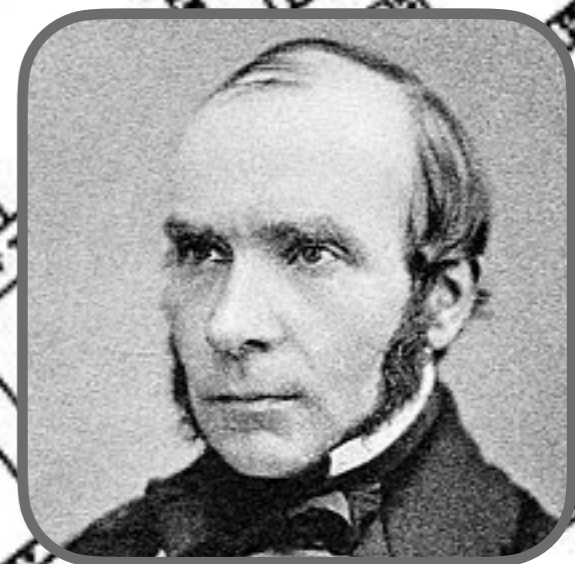
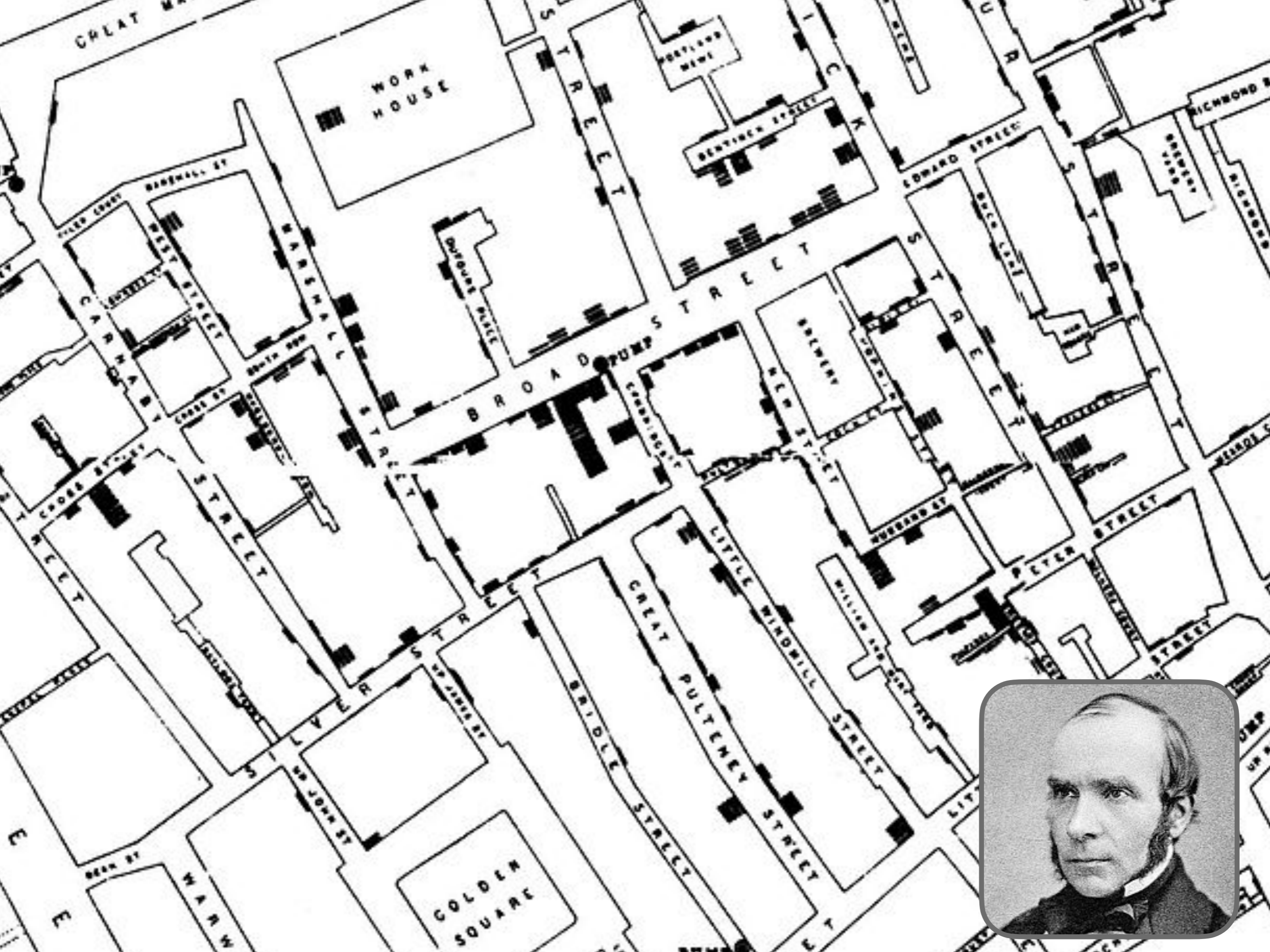


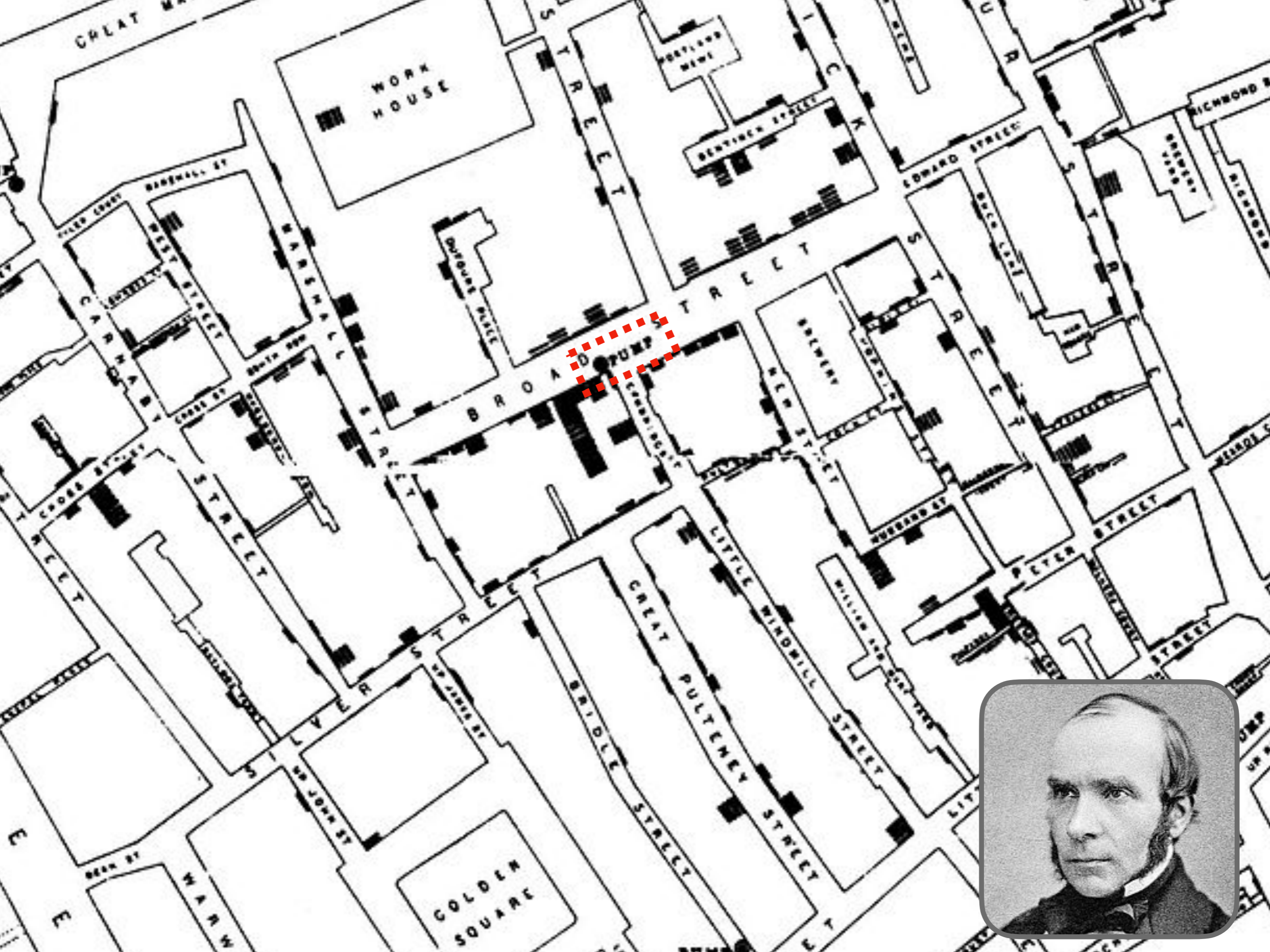
# Cholera Epidemic in London, 1854

- >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











# 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:
  1. *Increasing the memory and processing resources available to users*
  2. *Reducing the search for information*



# Amplifying Cognition

- Information Visualization can amplify cognition by:
  1. *Increasing the memory and processing resources available to users*
  2. *Reducing the search for information*
  3. *Using visual representations to enhance the detection of patterns*



# Amplifying Cognition

- Information Visualization can amplify cognition by:
  1. *Increasing the memory and processing resources available to users*
  2. *Reducing the search for information*
  3. *Using visual representations to enhance the detection of patterns*
  4. *Enabling perceptual inference*



# Amplifying Cognition

- Information Visualization can amplify cognition by:
  1. *Increasing the memory and processing resources available to users*
  2. *Reducing the search for information*
  3. *Using visual representations to enhance the detection of patterns*
  4. *Enabling perceptual inference*
  5. *Using perceptual attention mechanisms for monitoring*



# Amplifying Cognition

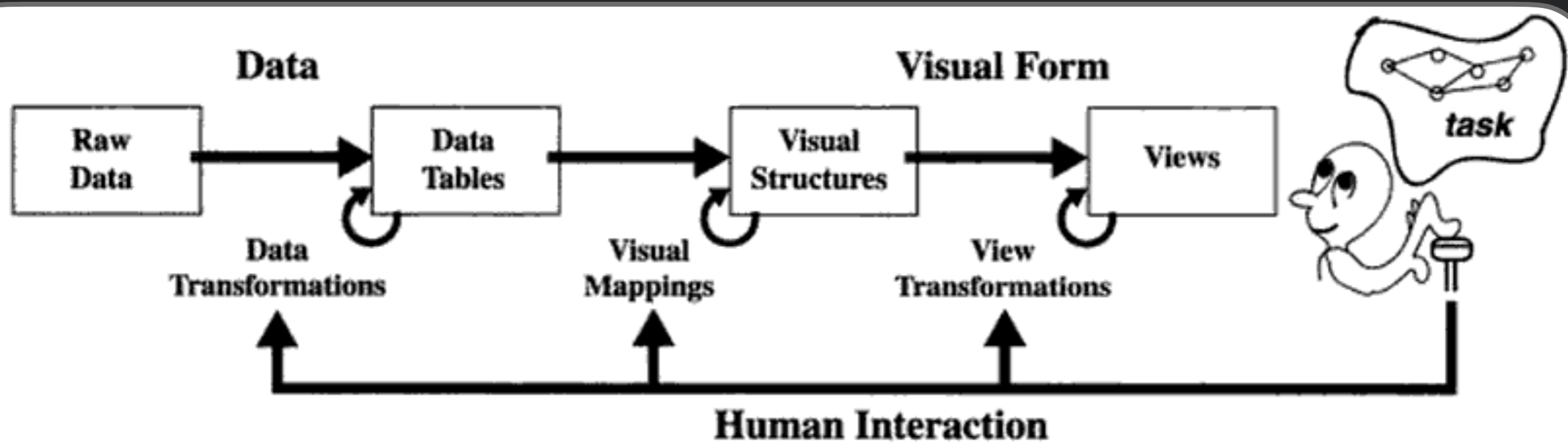
- Information Visualization can amplify cognition by:
  1. *Increasing the memory and processing resources available to users*
  2. *Reducing the search for information*
  3. *Using visual representations to enhance the detection of patterns*
  4. *Enabling perceptual inference*
  5. *Using perceptual attention mechanisms for monitoring*
  6. *Encoding Information in a manipulable medium*



# Mapping Data to Visual Form



# Designing an Information Visualization



**Raw Data:** idiosyncratic formats  
**Data Tables:** relations (cases by variables) + metadata  
**Visual Structures:** spatial substrates + marks + graphical properties  
**Views:** graphical parameters (position, scaling, clipping...)

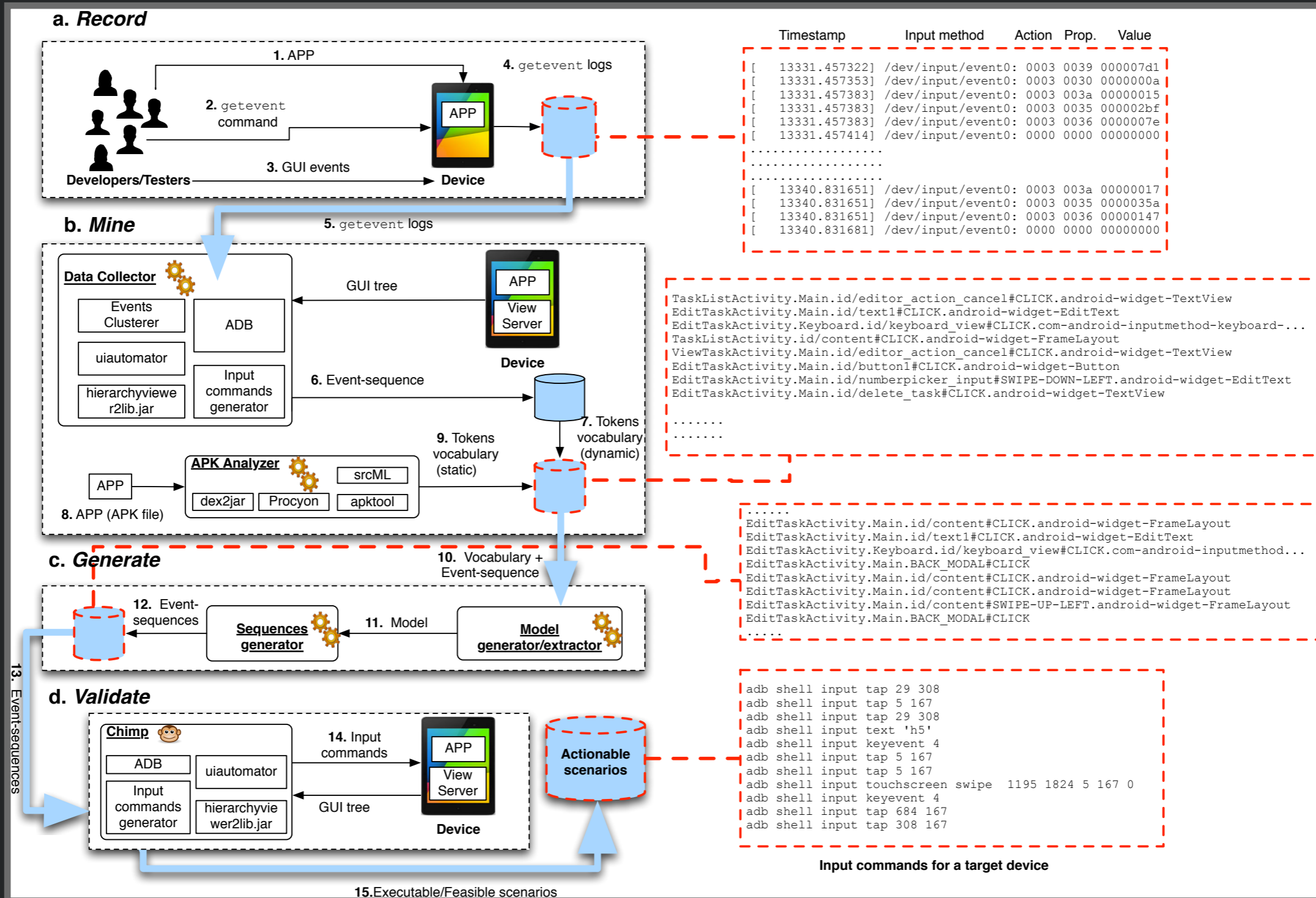
# Types of Raw Data

- 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  $\rightarrow$  ordinal
  - Maps ranges onto classes of variables
  - Can also count # of items in each class w/ histogram
- Sorting: Nominal  $\rightarrow$  ordinal
  - Add order between items in sets
- Descriptive statistics: mean, average, median, max, min, ...

# Example Uses of a Data Transformation



Timestamp	Input method	Action	Prop.	Value
[ 13331.457322]	/dev/input/event0:	0003 0039	000007d1	
[ 13331.457353]	/dev/input/event0:	0003 0030	0000000a	
[ 13331.457383]	/dev/input/event0:	0003 003a	00000015	
[ 13331.457383]	/dev/input/event0:	0003 0035	000002bf	
[ 13331.457383]	/dev/input/event0:	0003 0036	0000007e	
[ 13331.457414]	/dev/input/event0:	0000 0000	00000000	
.....				
[ 13340.831651]	/dev/input/event0:	0003 003a	00000017	
[ 13340.831651]	/dev/input/event0:	0003 0035	0000035a	
[ 13340.831651]	/dev/input/event0:	0003 0036	00000147	
[ 13340.831681]	/dev/input/event0:	0000 0000	00000000	

```
TaskListActivity.Main.id/editor_action_cancel#CLICK.android-widget-TextView
EditTaskActivity.Main.id/text1#CLICK.android-widget-EditText
EditTaskActivity.Keyboard.id/keyboard_view#CLICK.com-android-inputmethod-keyboard-...
TaskListActivity.id/content#CLICK.android-widget-FrameLayout
ViewTaskActivity.Main.id/editor_action_cancel#CLICK.android-widget-TextView
EditTaskActivity.Main.id/button1#CLICK.android-widget-Button
EditTaskActivity.Main.id/numberpicker_input#SWIPE-DOWN-LEFT.android-widget-EditText
EditTaskActivity.Main.id/delete_task#CLICK.android-widget-TextView
.....
```

```
EditTaskActivity.Main.id/content#CLICK.android-widget-FrameLayout
EditTaskActivity.Main.id/text1#CLICK.android-widget-EditText
EditTaskActivity.Keyboard.id/keyboard_view#CLICK.com-android-inputmethod-...
EditTaskActivity.Main.BACK_MODAL#CLICK
EditTaskActivity.Main.id/content#CLICK.android-widget-FrameLayout
EditTaskActivity.Main.id/content#CLICK.android-widget-FrameLayout
EditTaskActivity.Main.id/content#SWIPE-UP-LEFT.android-widget-FrameLayout
EditTaskActivity.Main.BACK_MODAL#CLICK
.....
```

```
adb shell input tap 29 308
adb shell input tap 5 167
adb shell input tap 29 308
adb shell input text 'h5'
adb shell input keyevent 4
adb shell input tap 5 167
adb shell input tap 5 167
adb shell input touchscreen swipe 1195 1824 5 167 0
adb shell input keyevent 4
adb shell input tap 684 167
adb shell input tap 308 167
```

Input commands for a target device

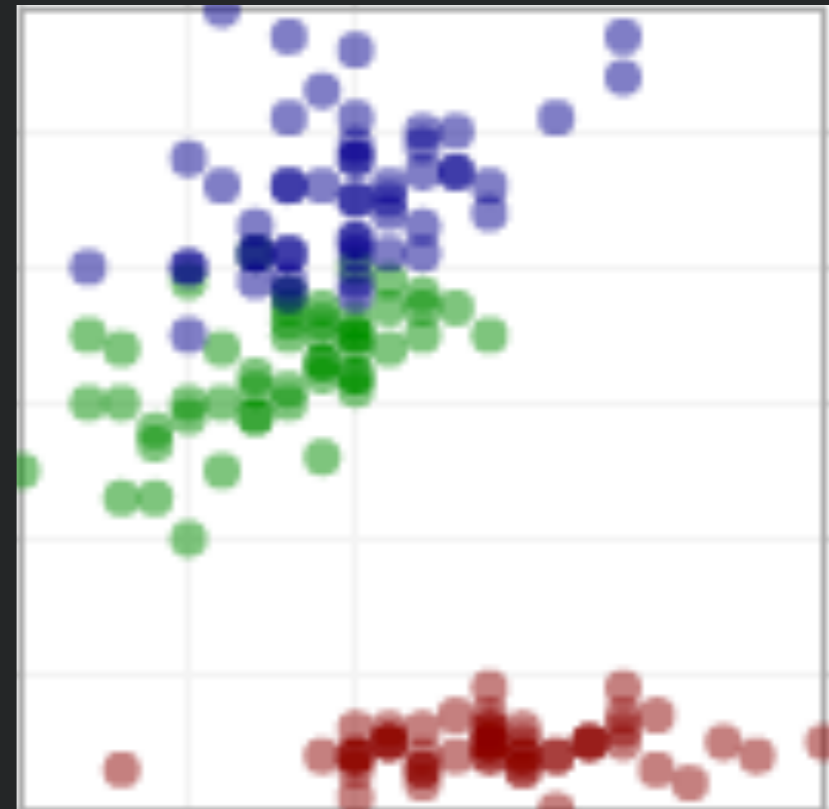


# Visual Structures

- 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)





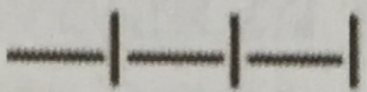
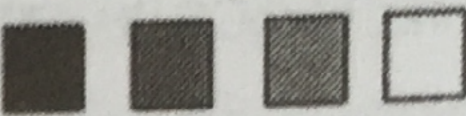
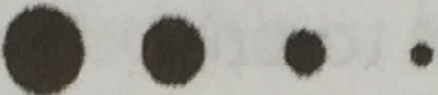
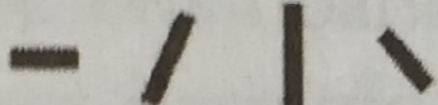


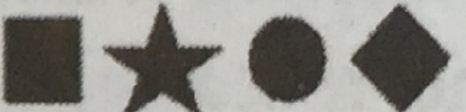
# Marks

- 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) 	Gray Scale 
	Size 	
Dif-feren-tial	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			◐	◐	●	Color	◐	◐	●
	Orientation					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

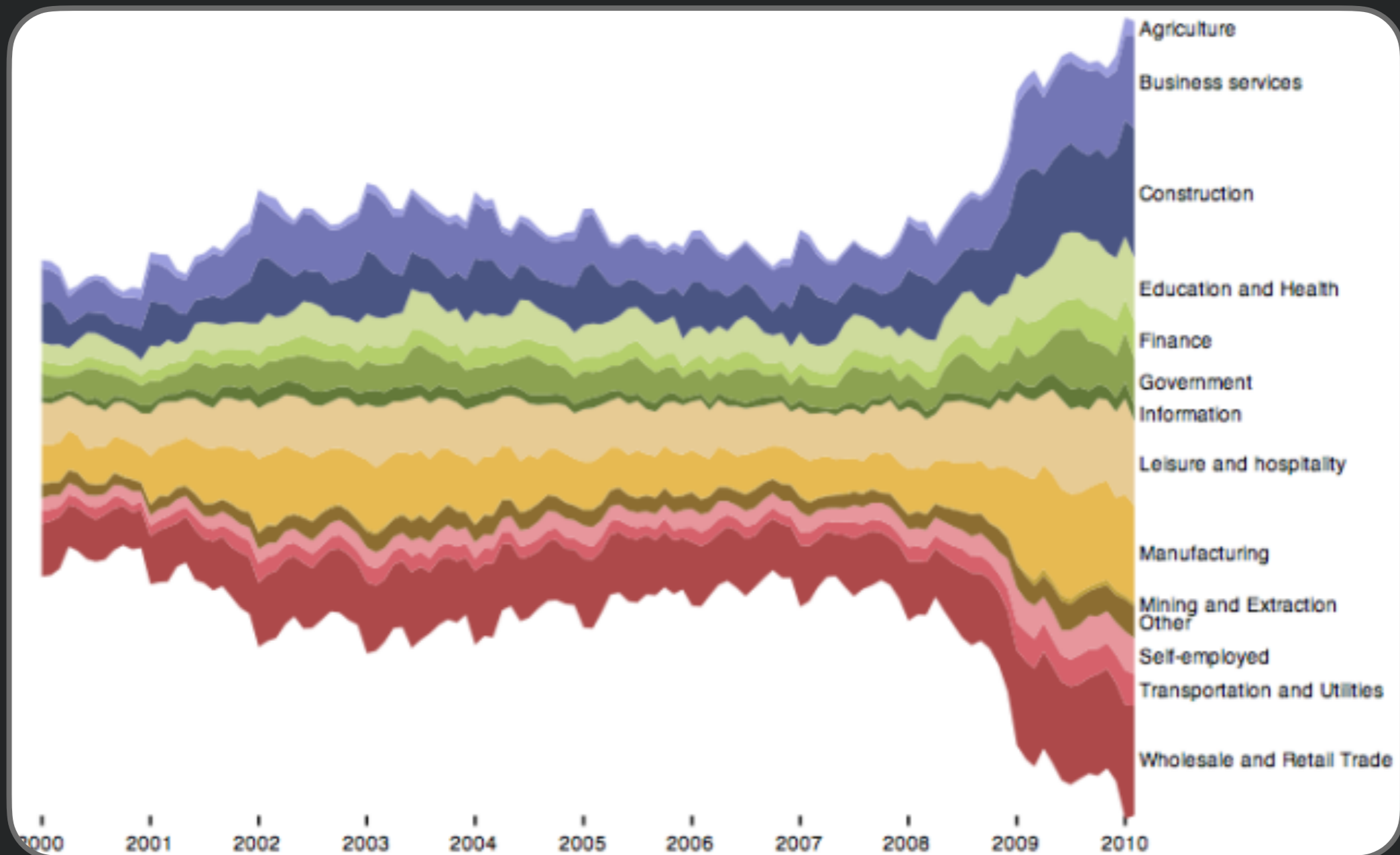


# Time-series Data



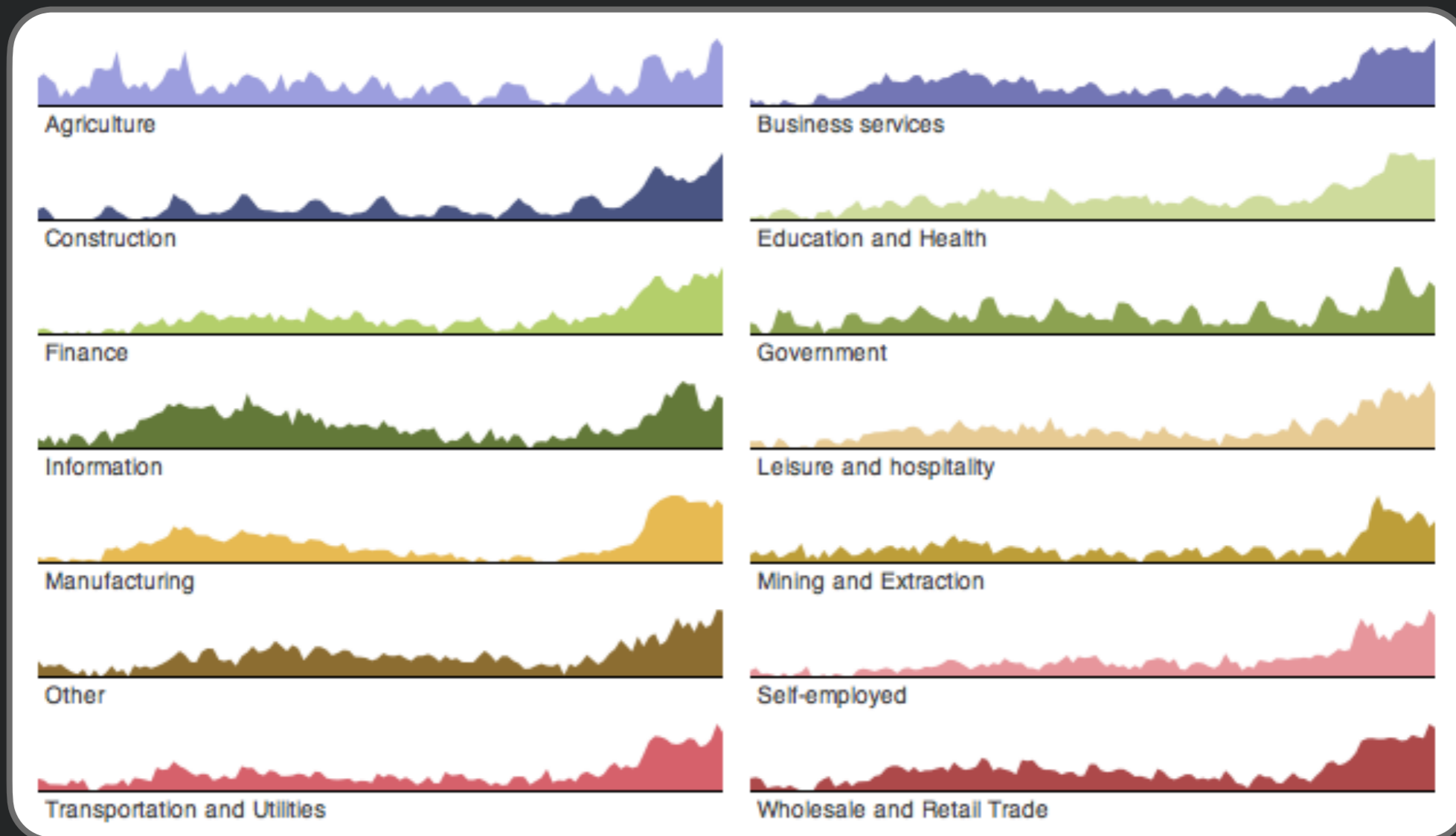
# Stacked Graph

- Supports visual summation of multiple components



# Small Multiples

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



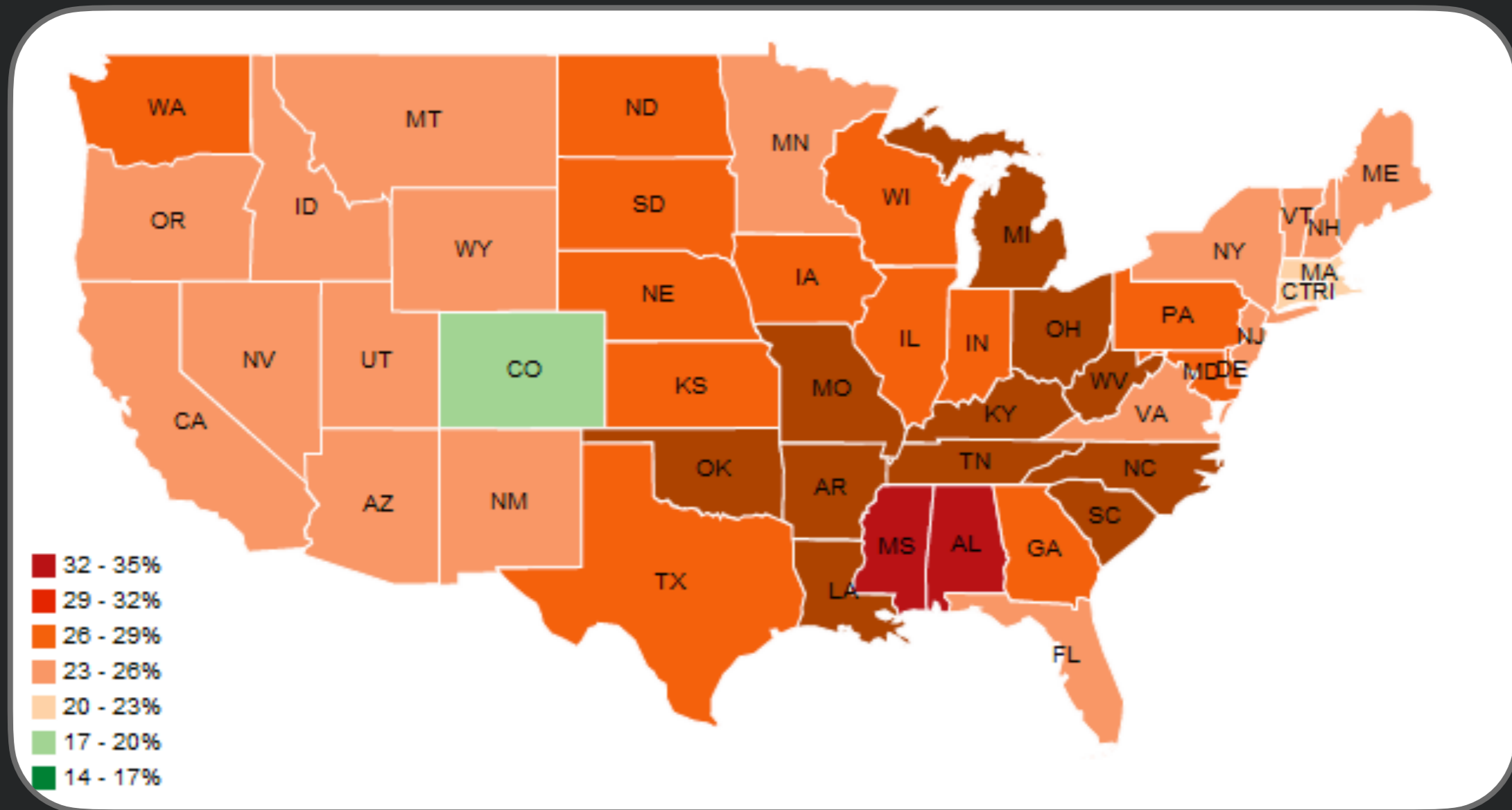
# Maps





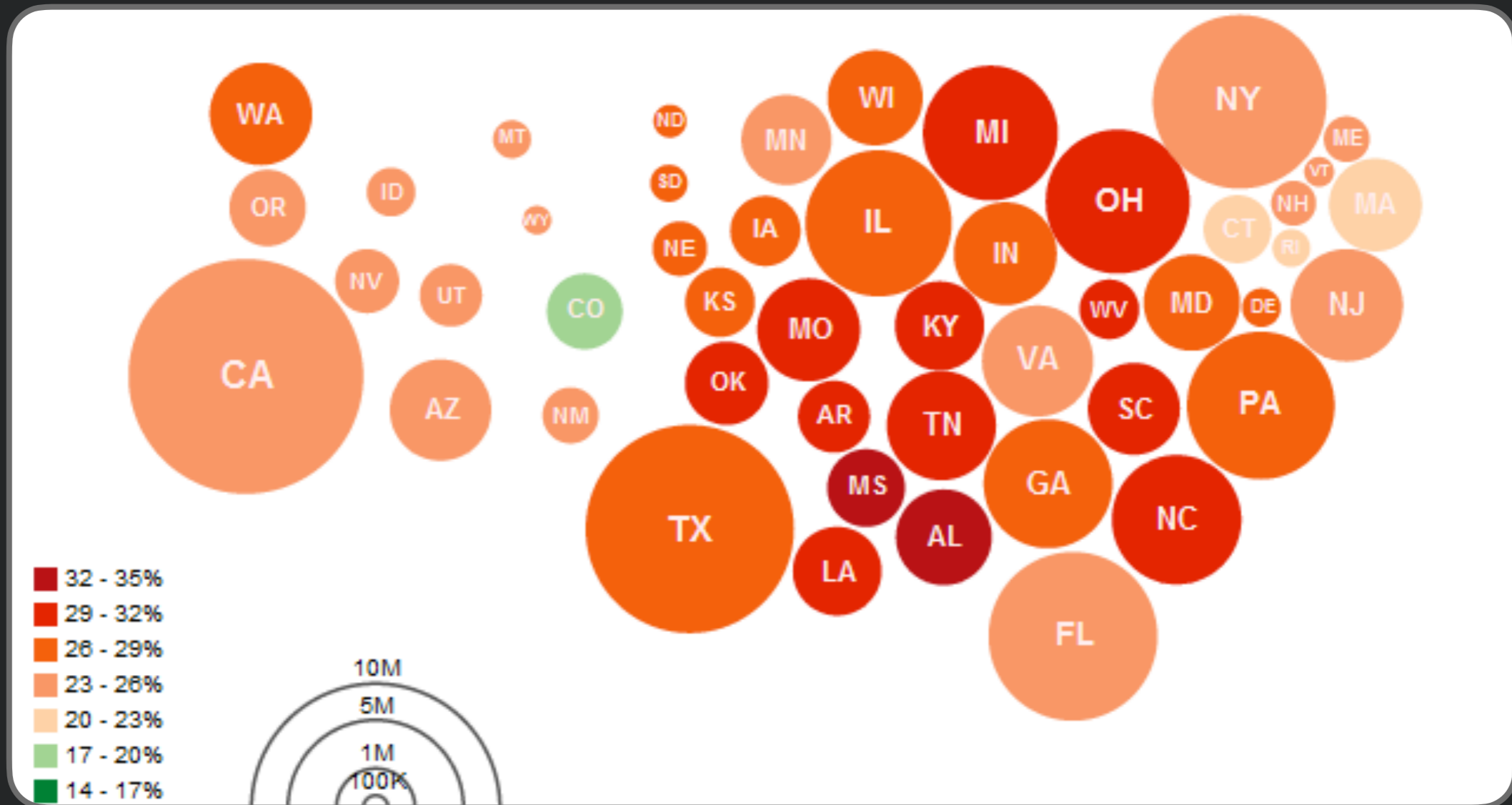
# Choropleth Map

- Groups data by area, maps to color



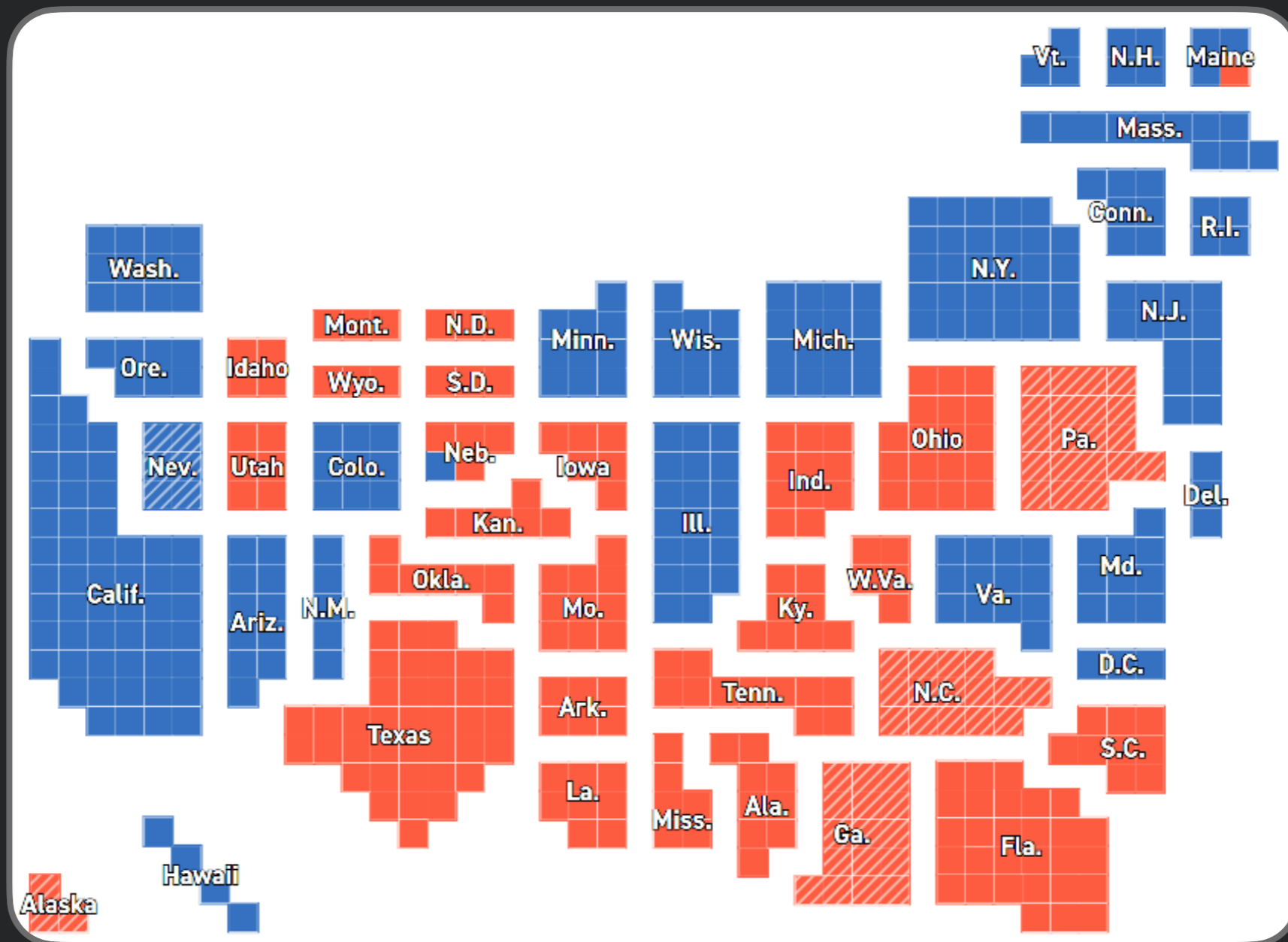
# Cartograms

- Encodes two variables w/ size & color



# Cartograms

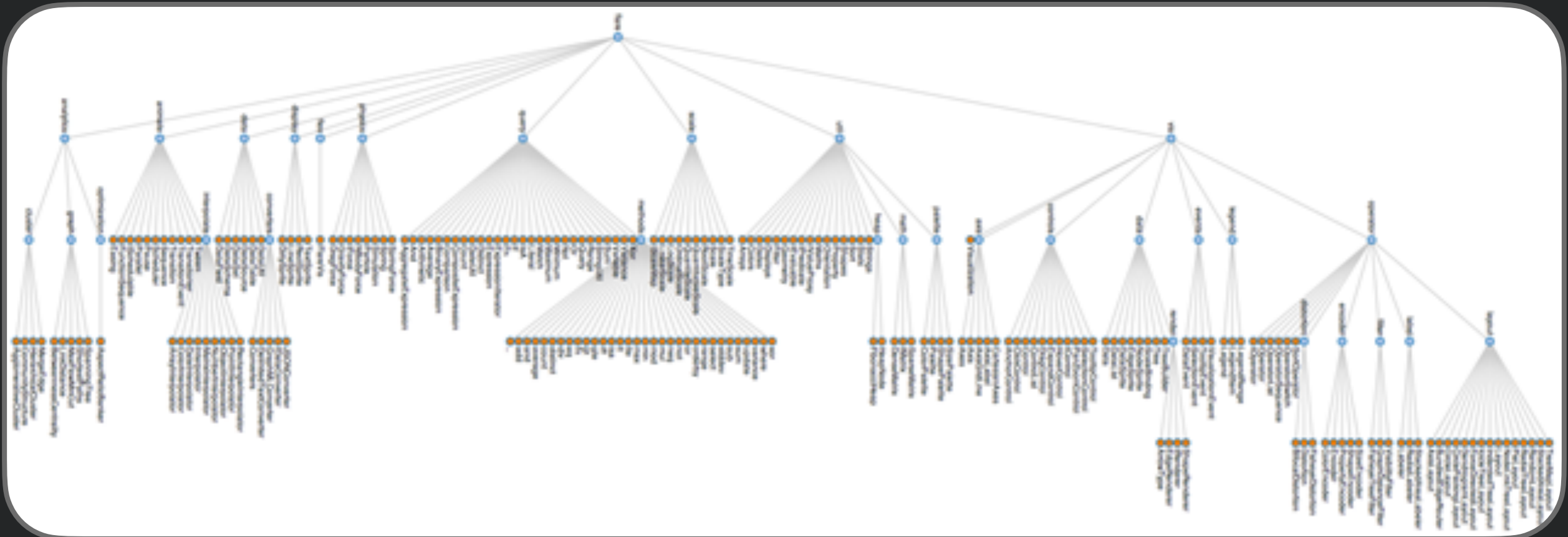
- Encodes two variables w/ size & color



# Hierarchies

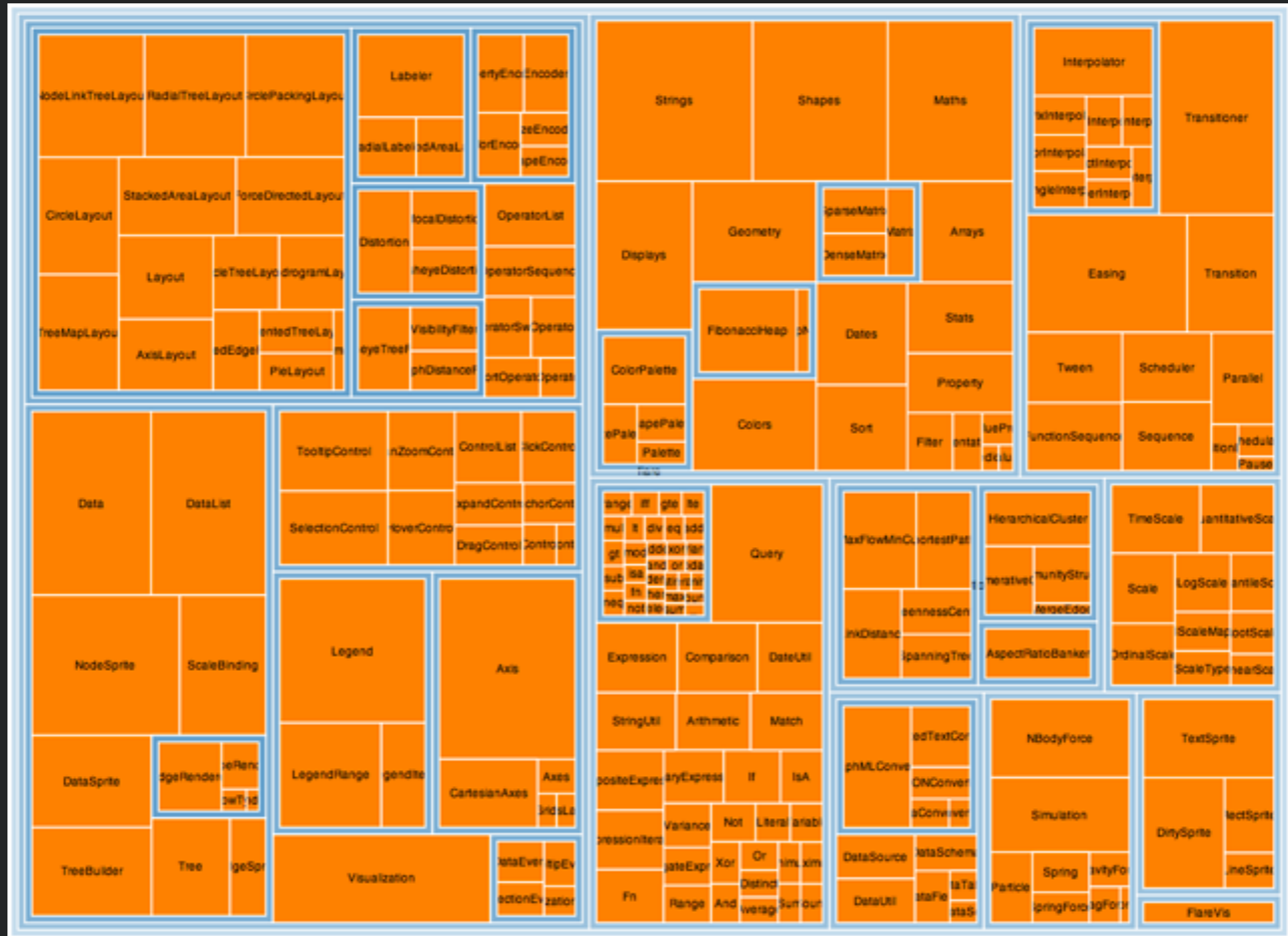


# Node Link Diagram

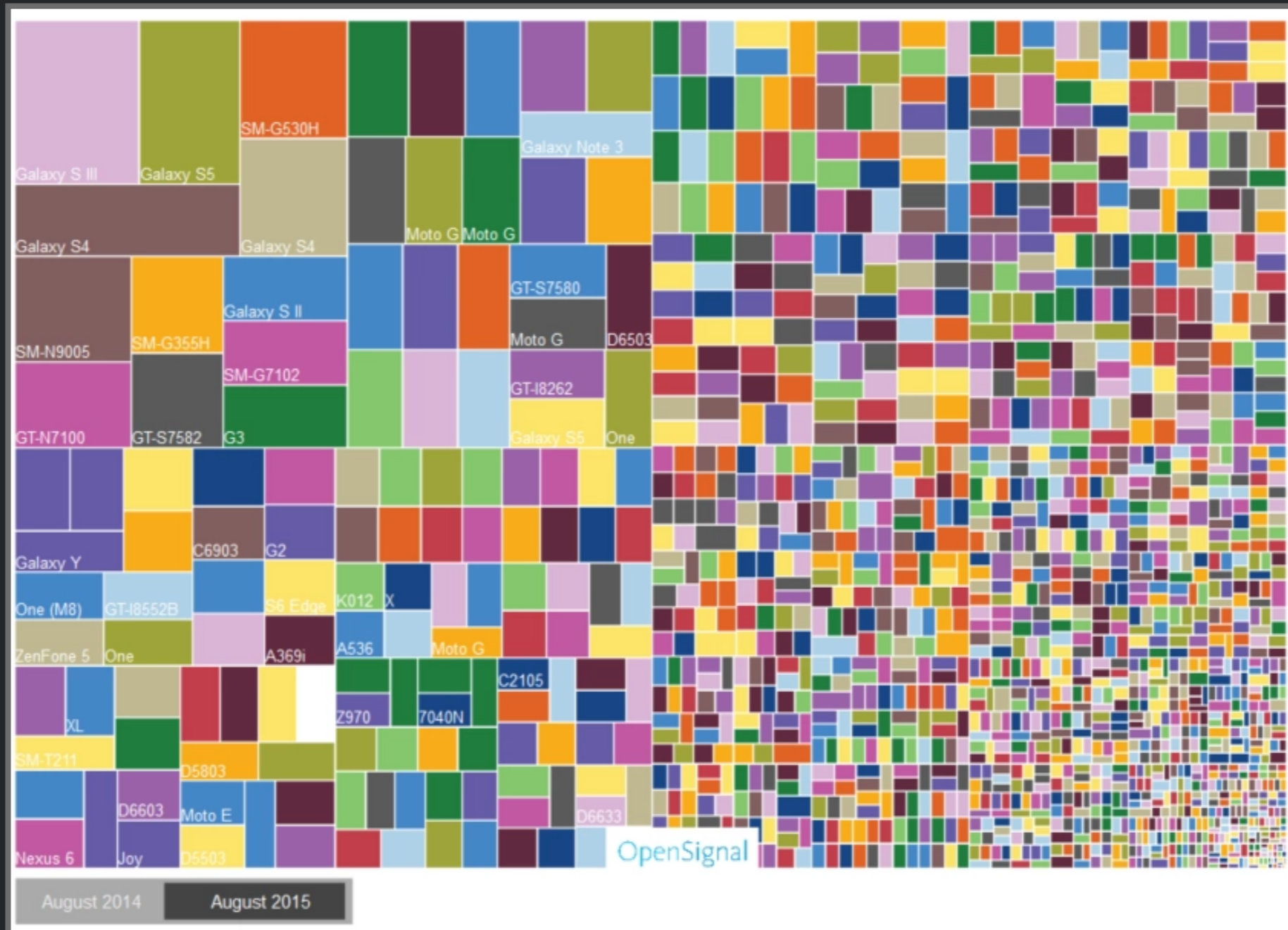




# Treemaps



# Treemaps



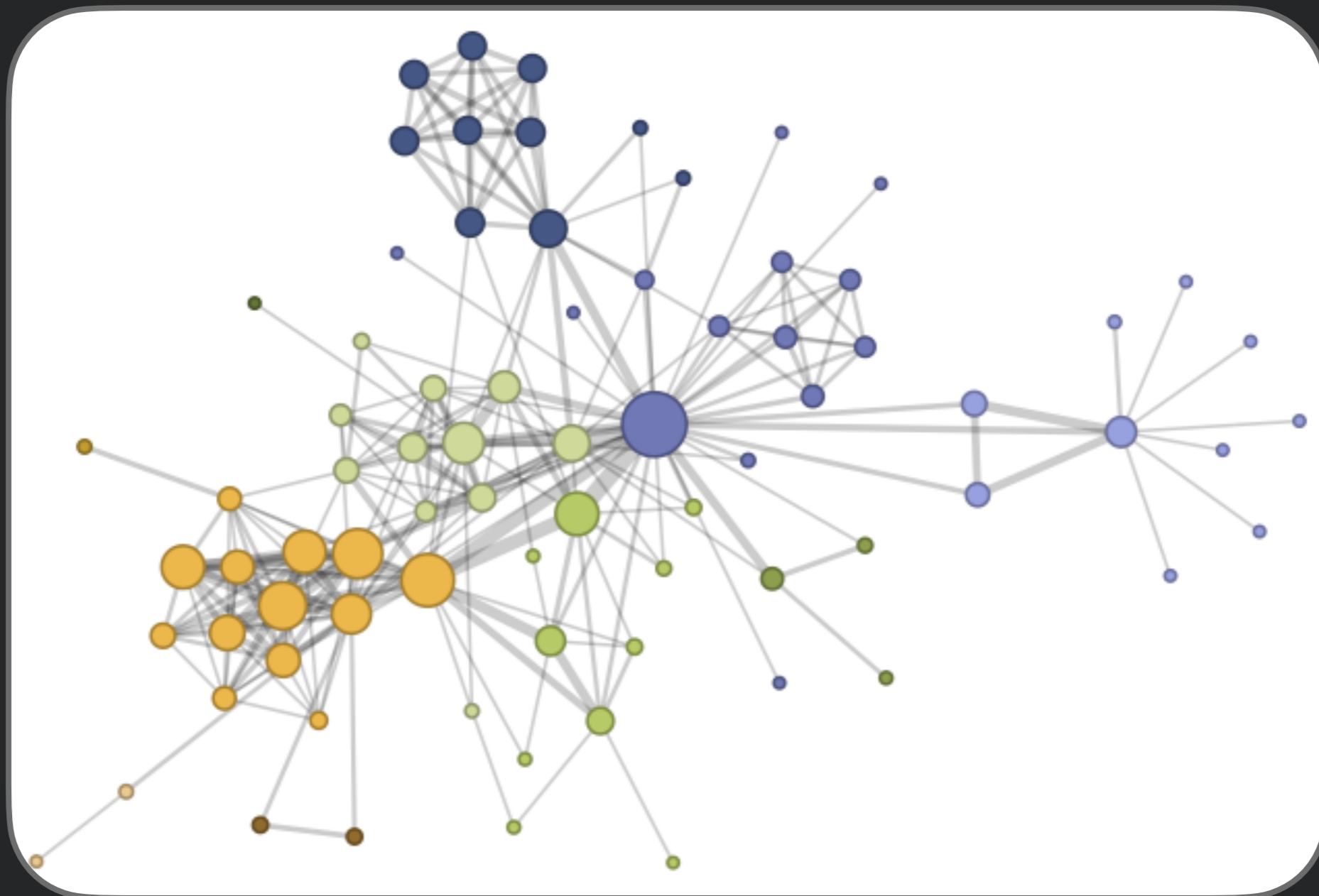


# Networks



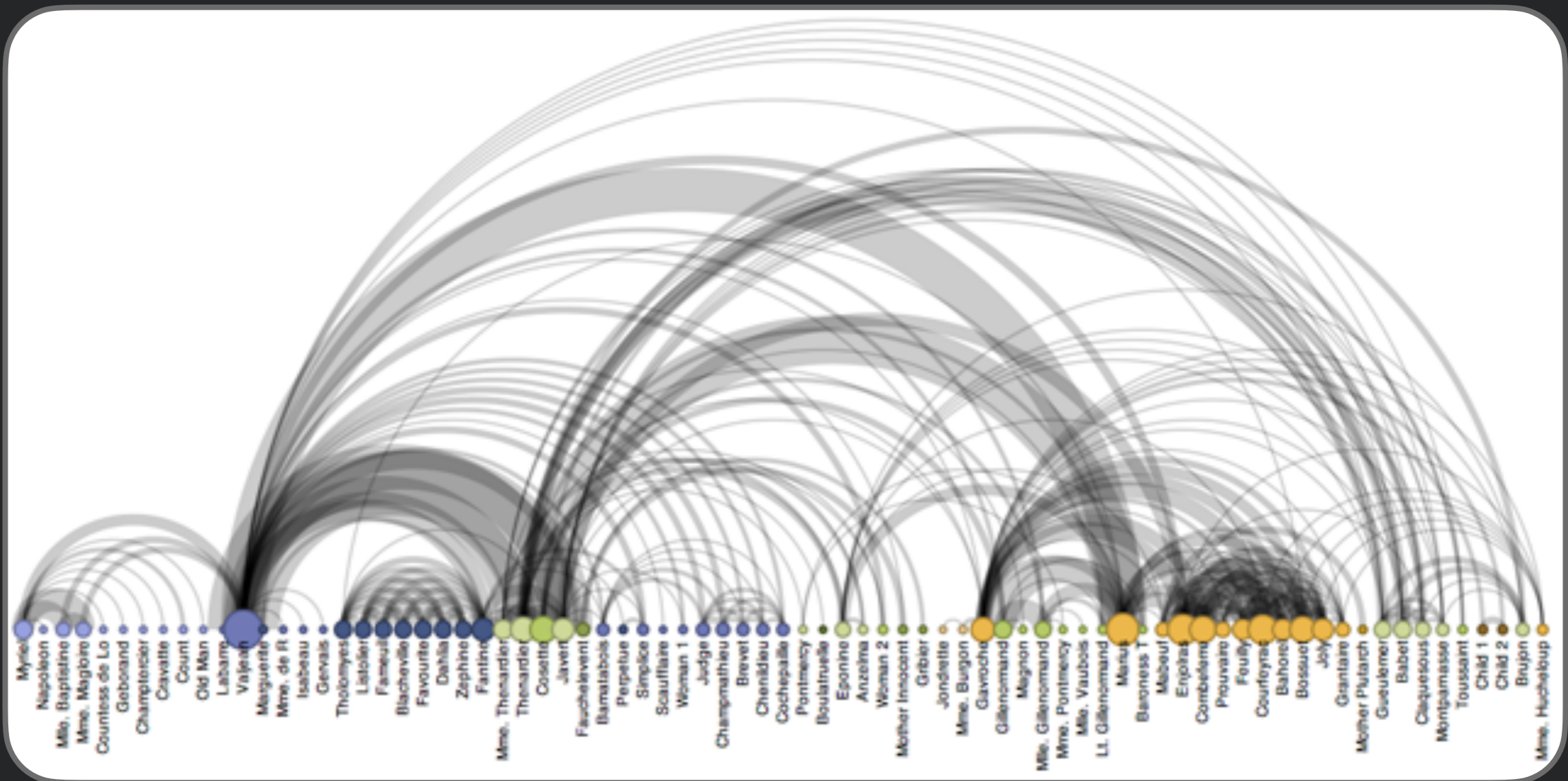
# Force-directed Layout

- Edges function as springs, find least energy configuration



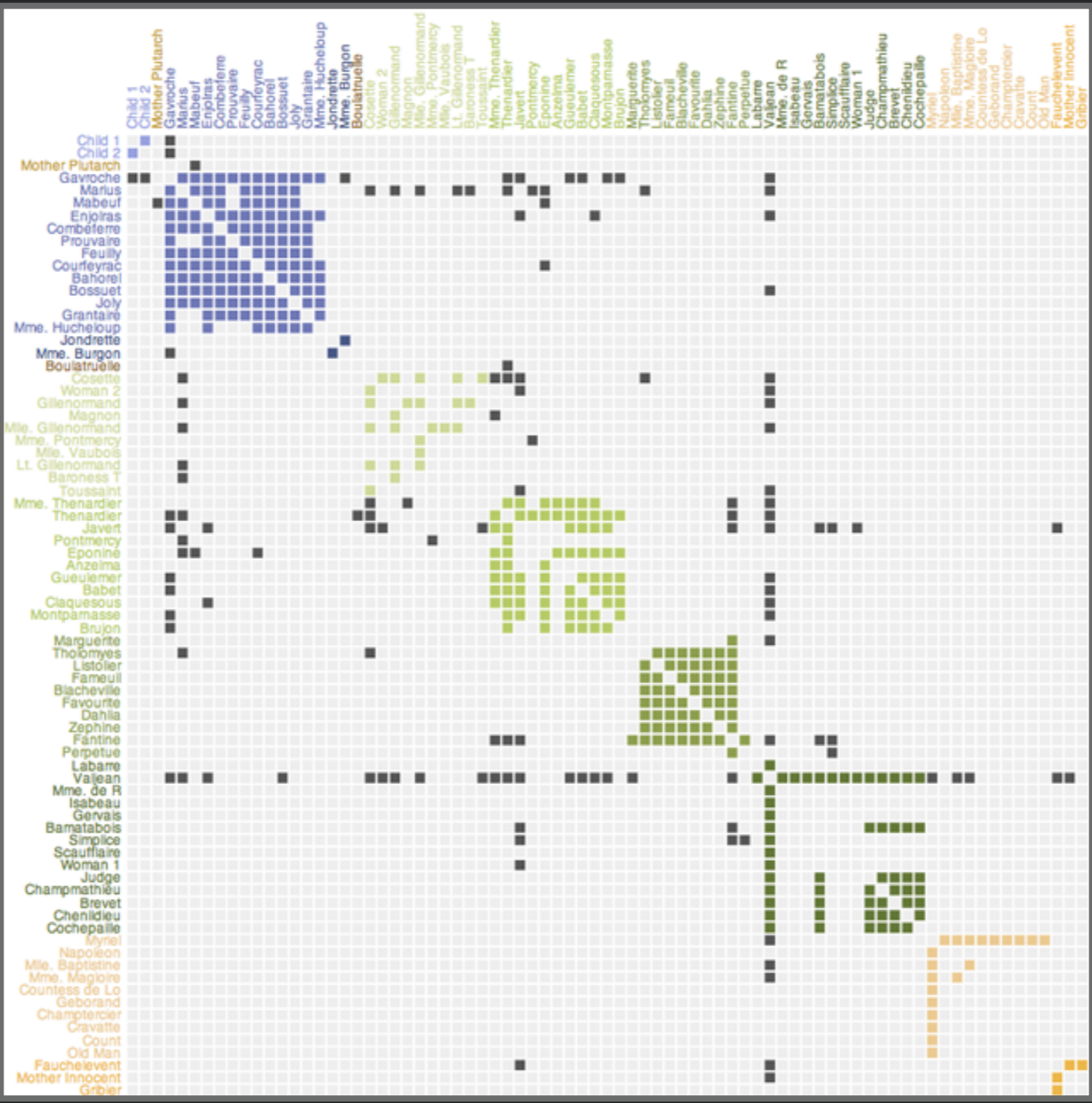
# Arc Diagram

- 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



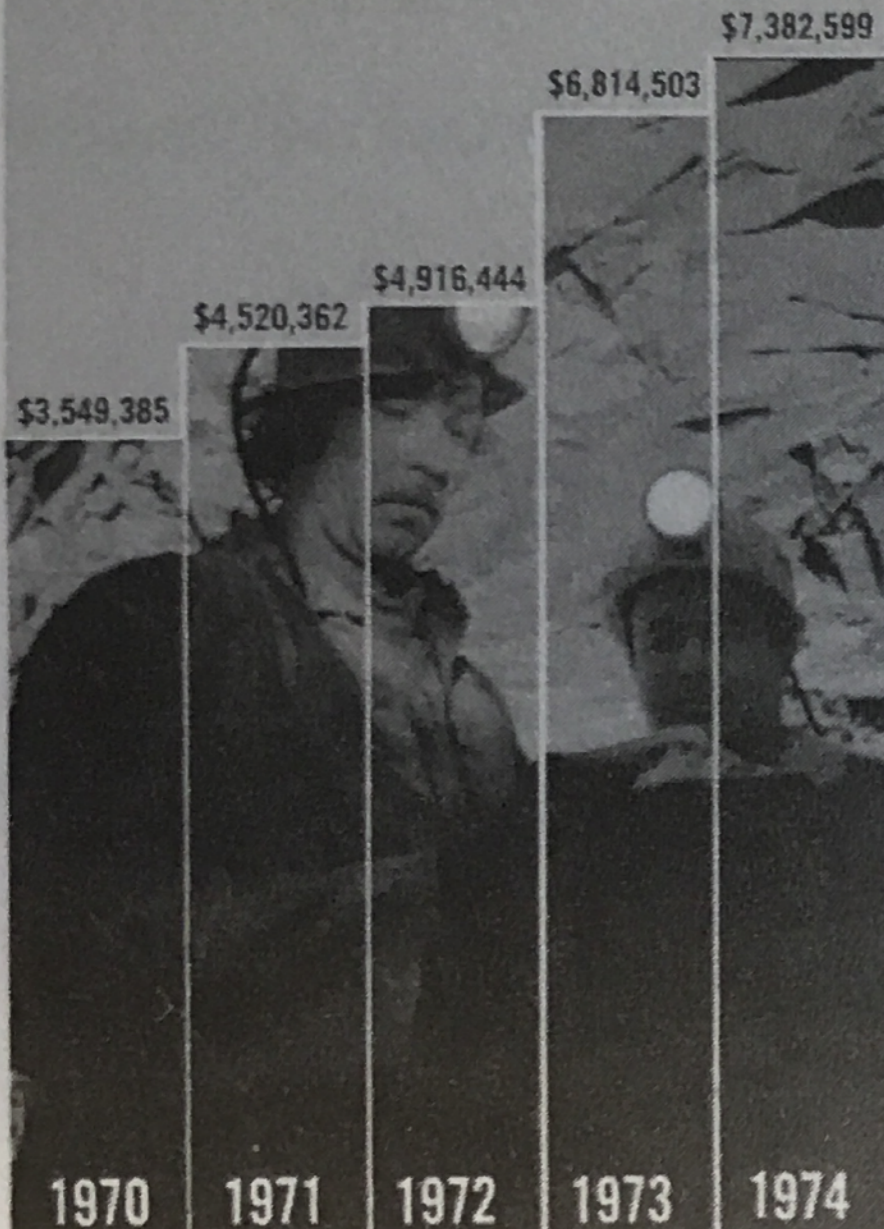
# Distortions in Visualizations

- 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

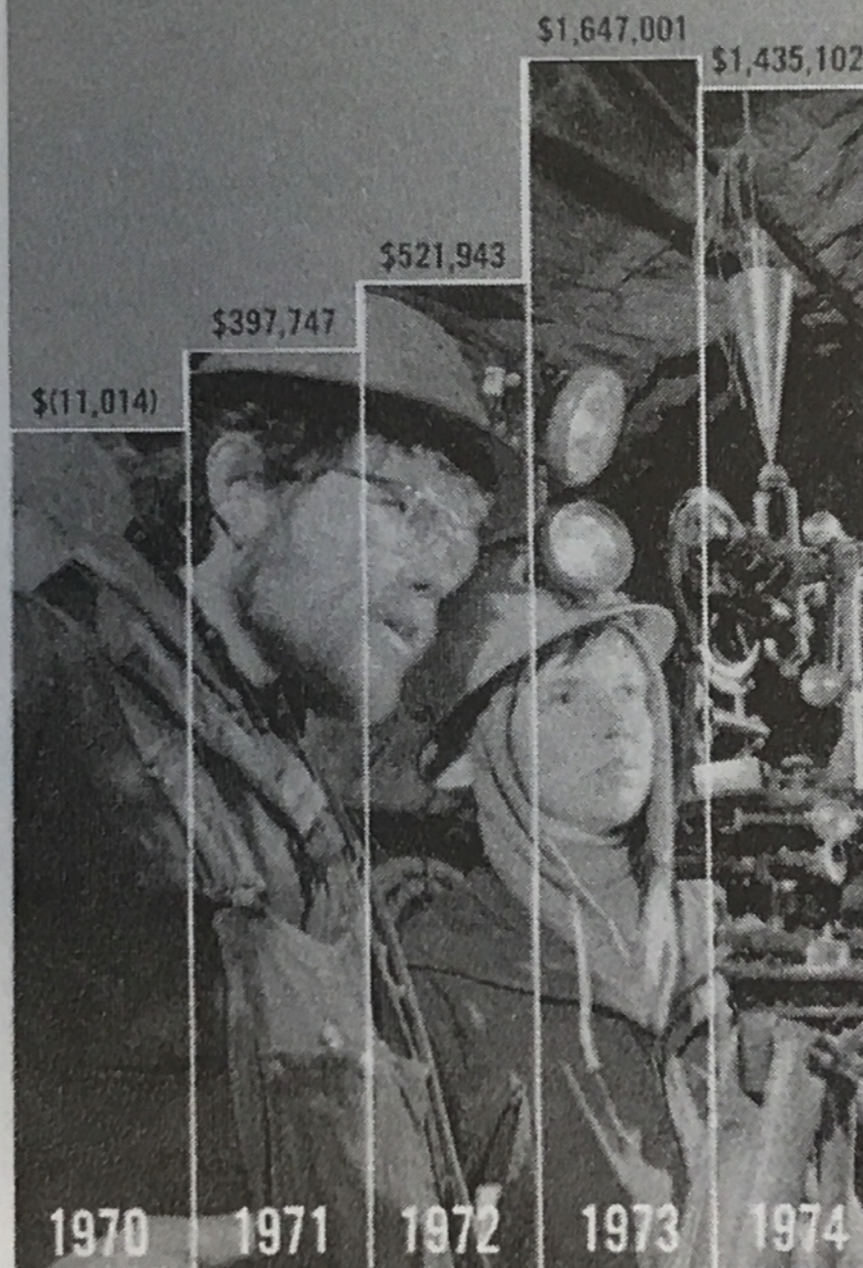
# Example



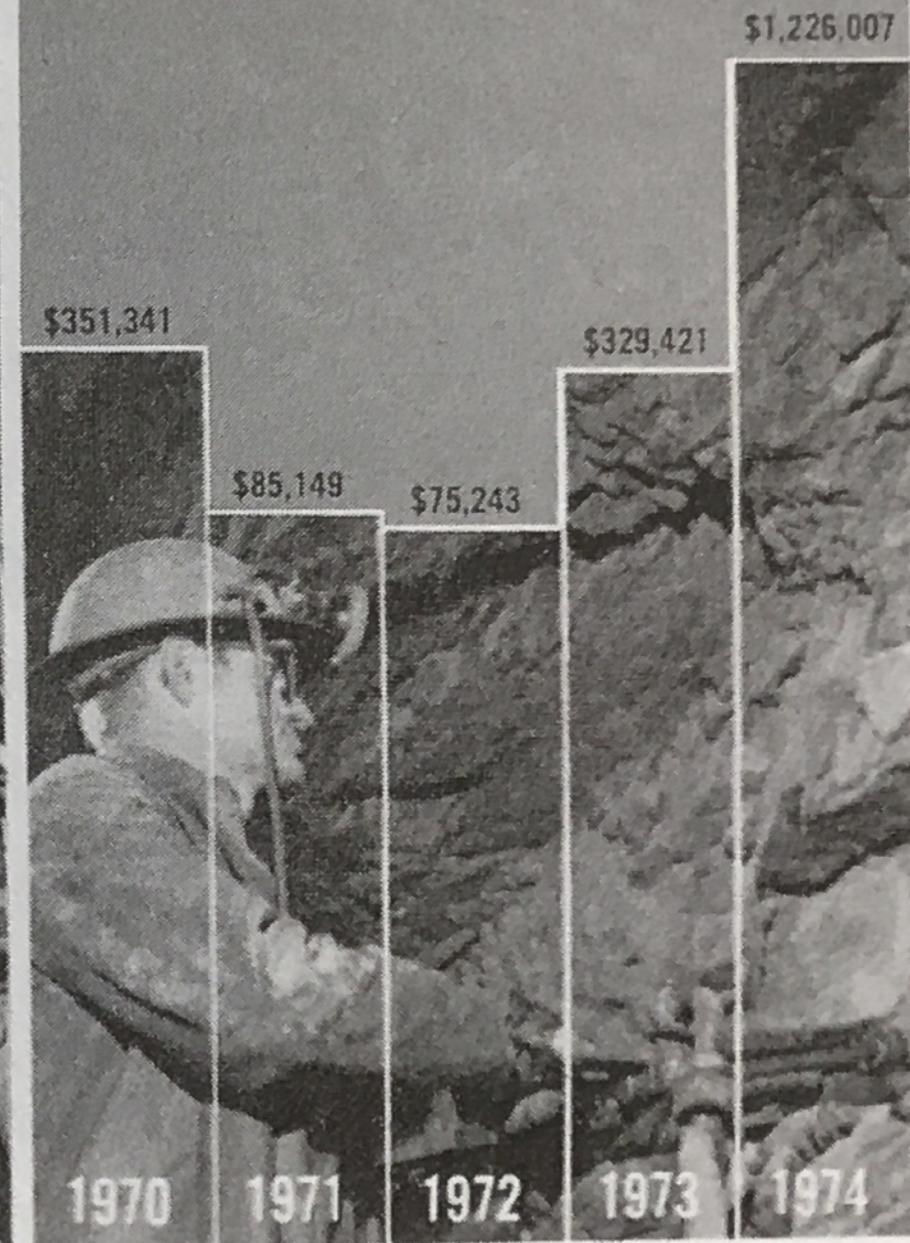
## OPERATING REVENUES



## NET INCOME (LOSS)



## EXPLORATION & DEVELOPMENT EXPENDITURES

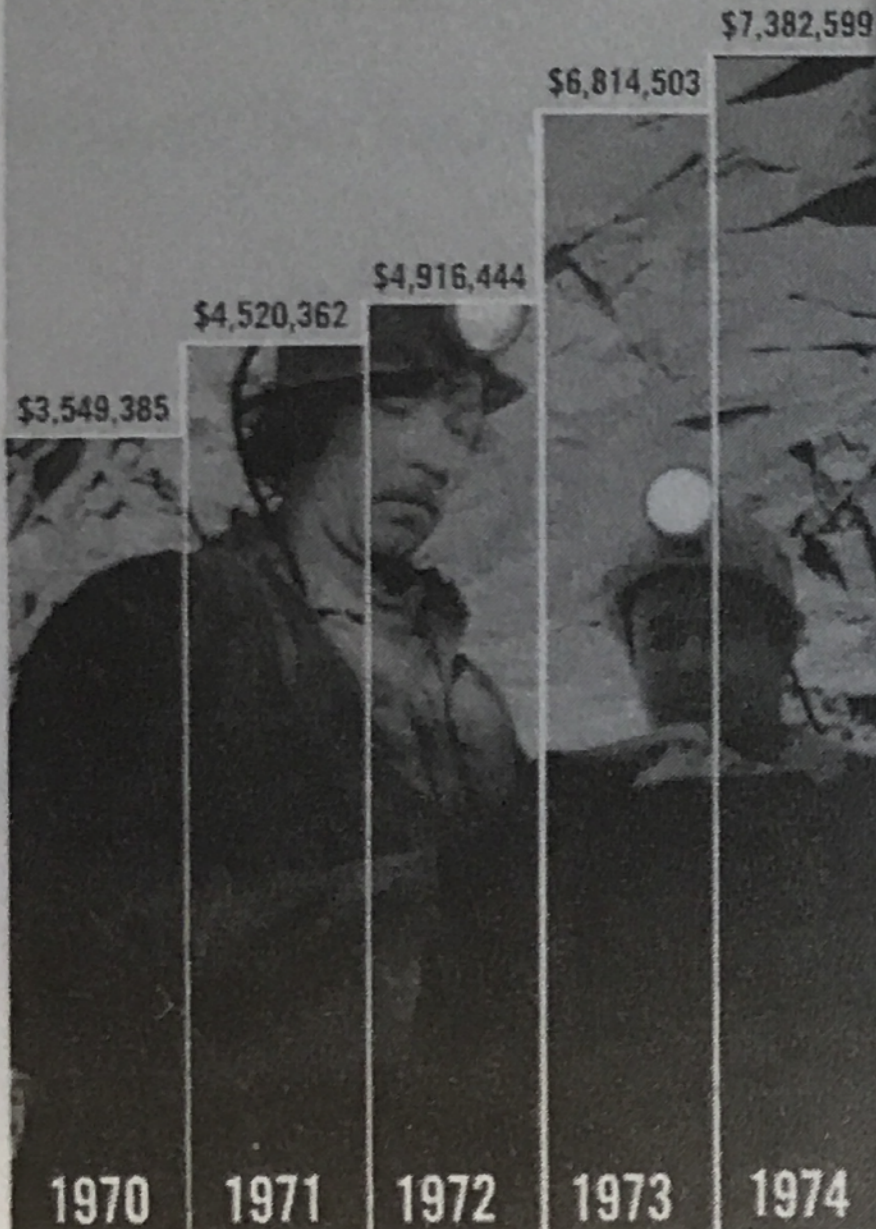




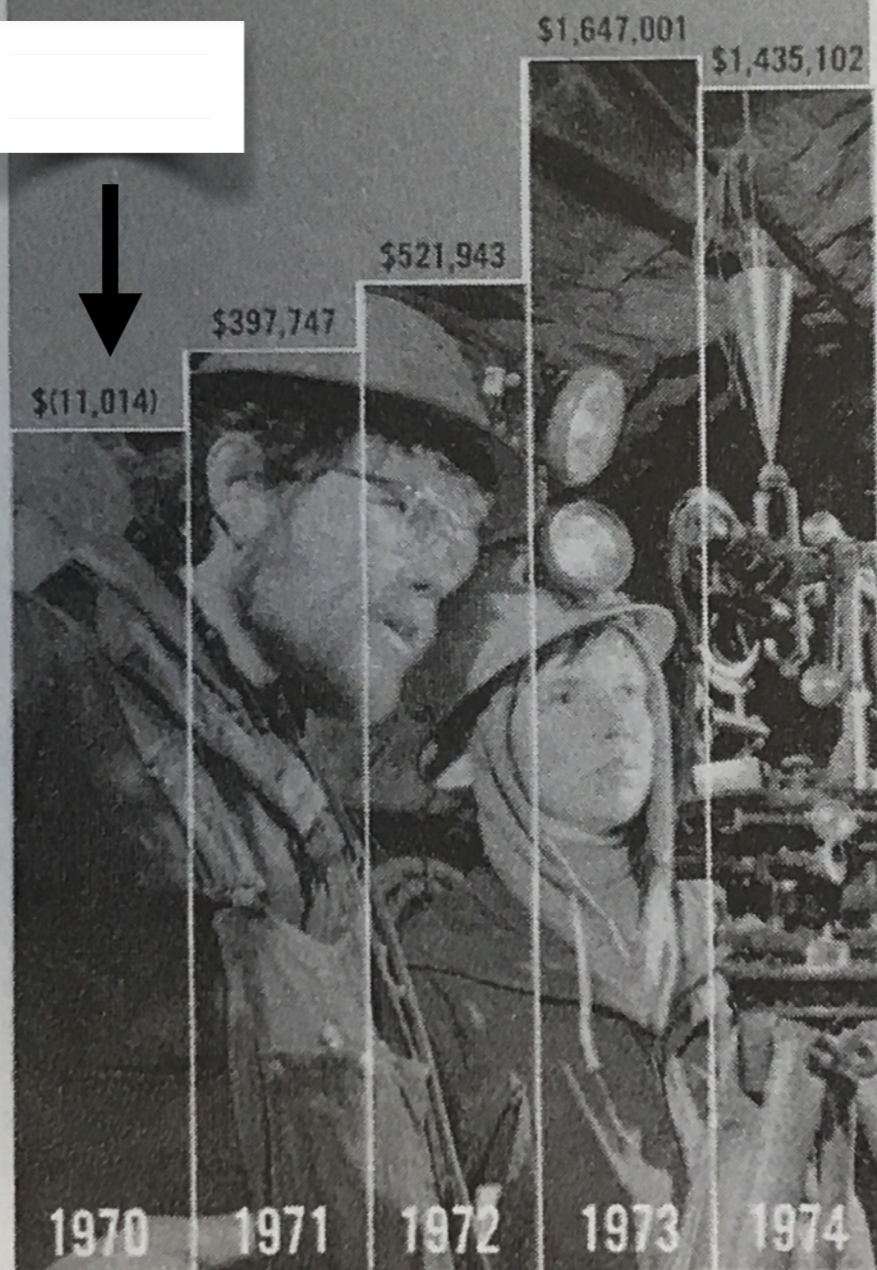
# Example



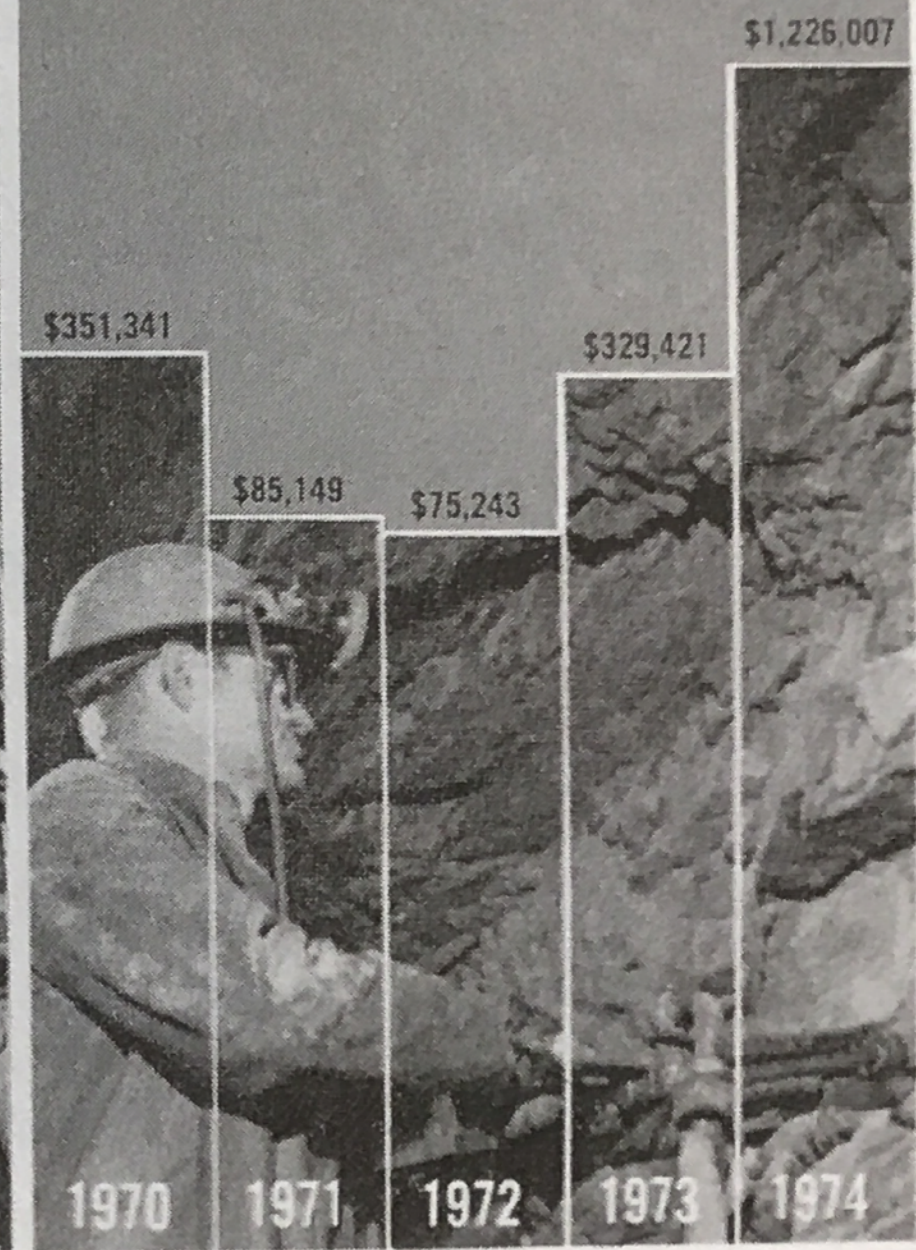
## OPERATING REVENUES



## NET INCOME (LOSS)



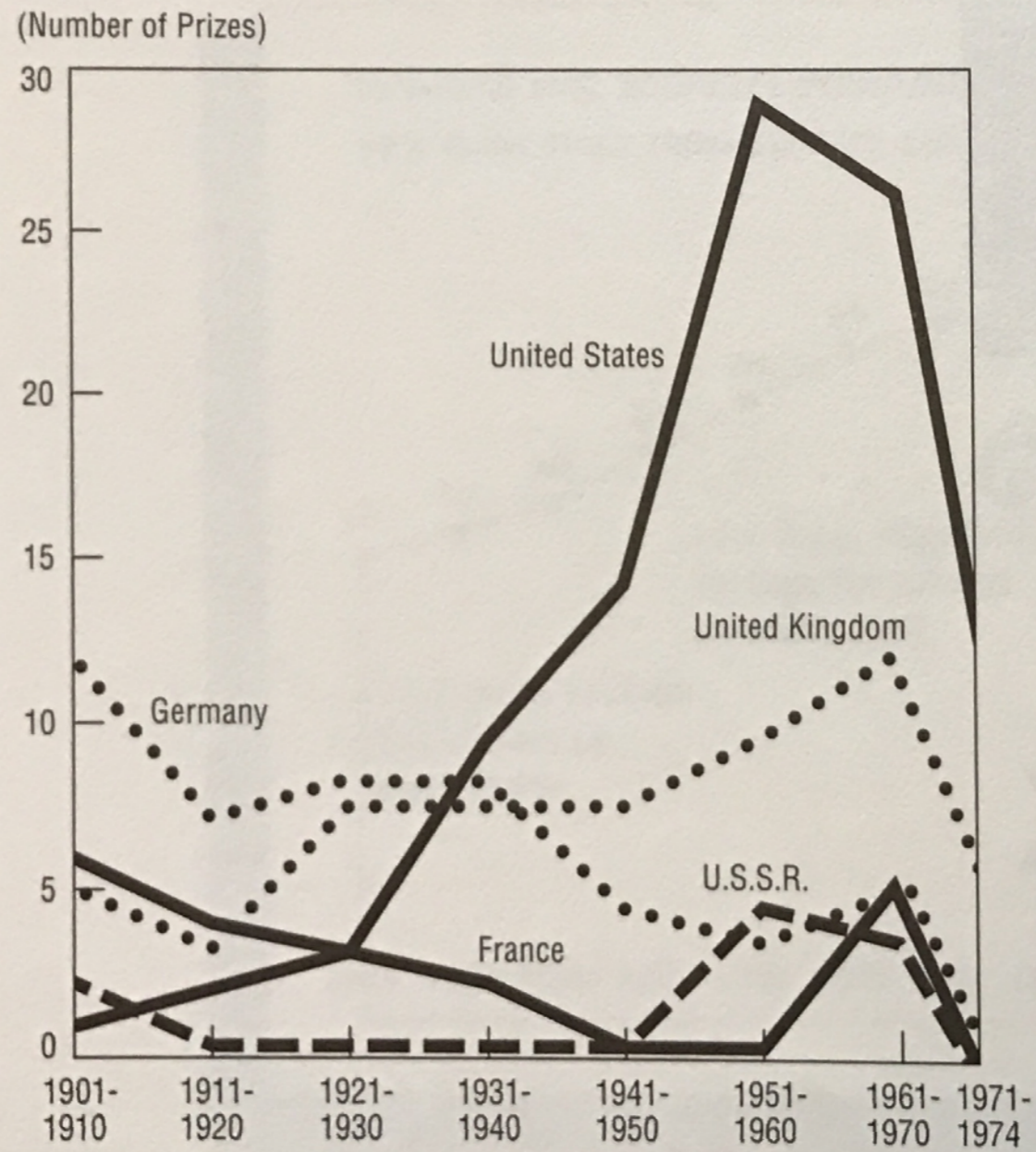
## EXPLORATION & DEVELOPMENT EXPENDITURES



# Example



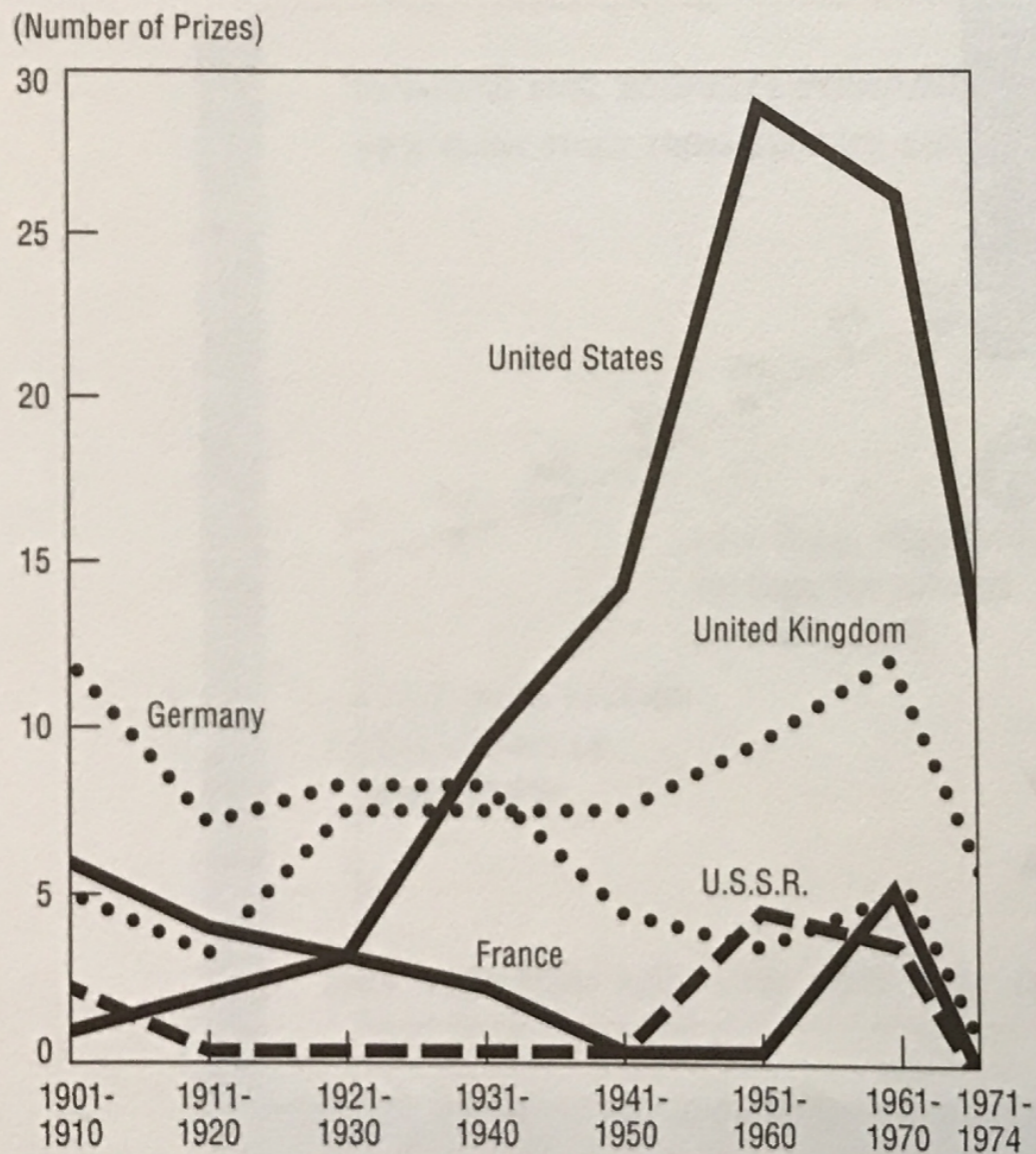
**Nobel Prizes Awarded in Science,  
for Selected Countries, 1901-1974**



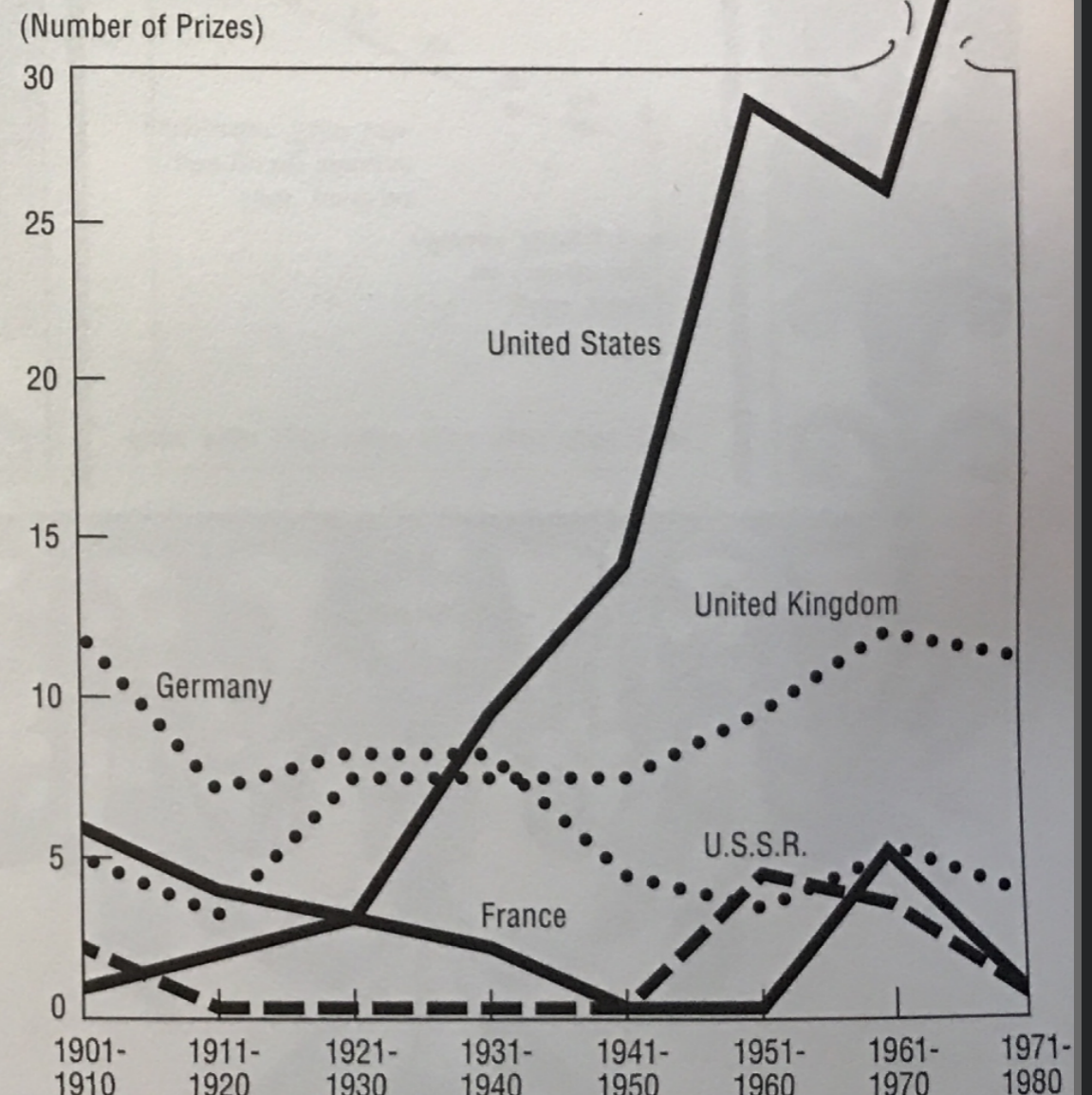
# Example (corrected)



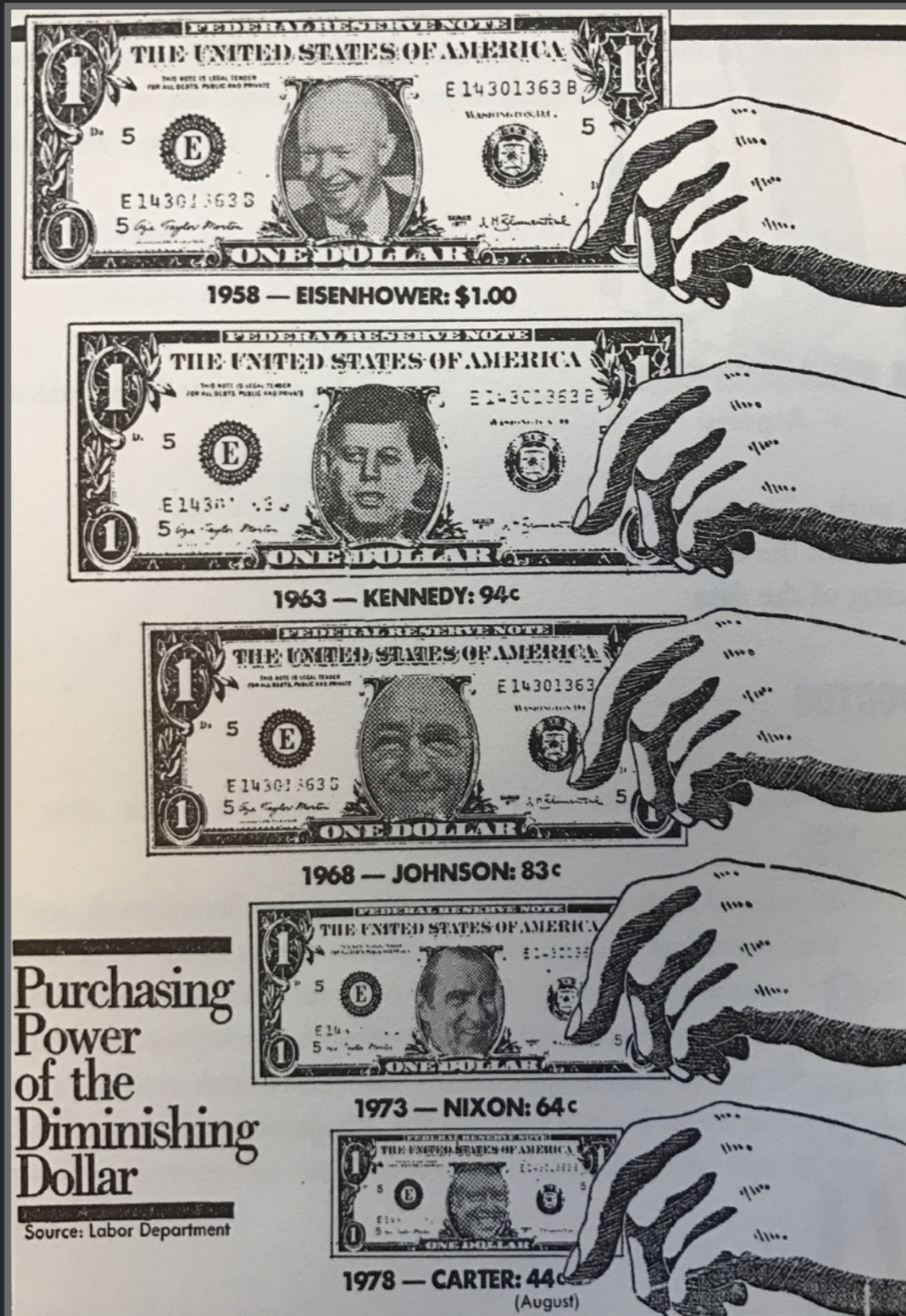
### Nobel Prizes Awarded in Science, for Selected Countries, 1901-1974



### Nobel Prizes Awarded in Science, for Selected Countries, 1901-1980

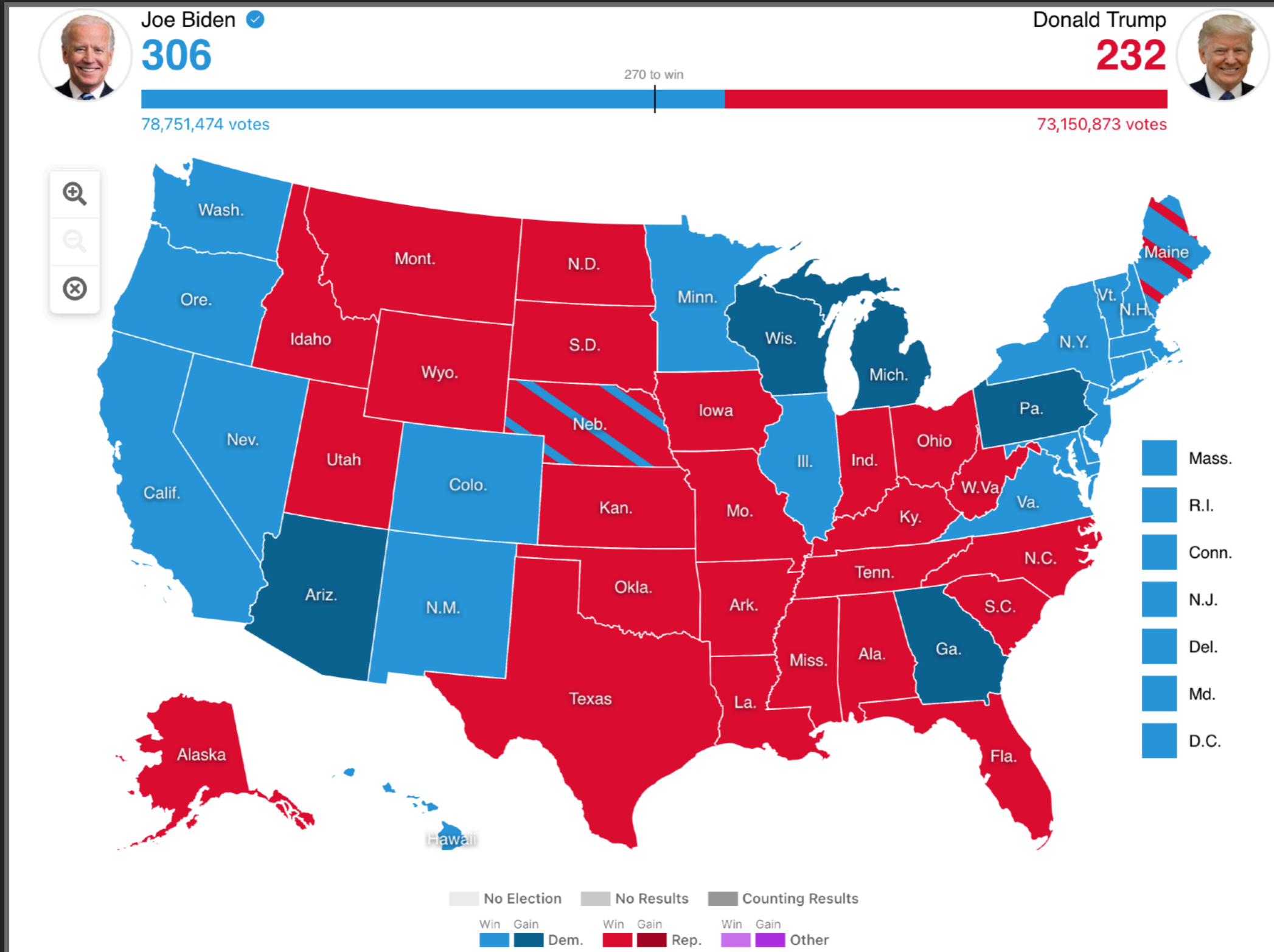


# Example





# Traditional Electoral Map



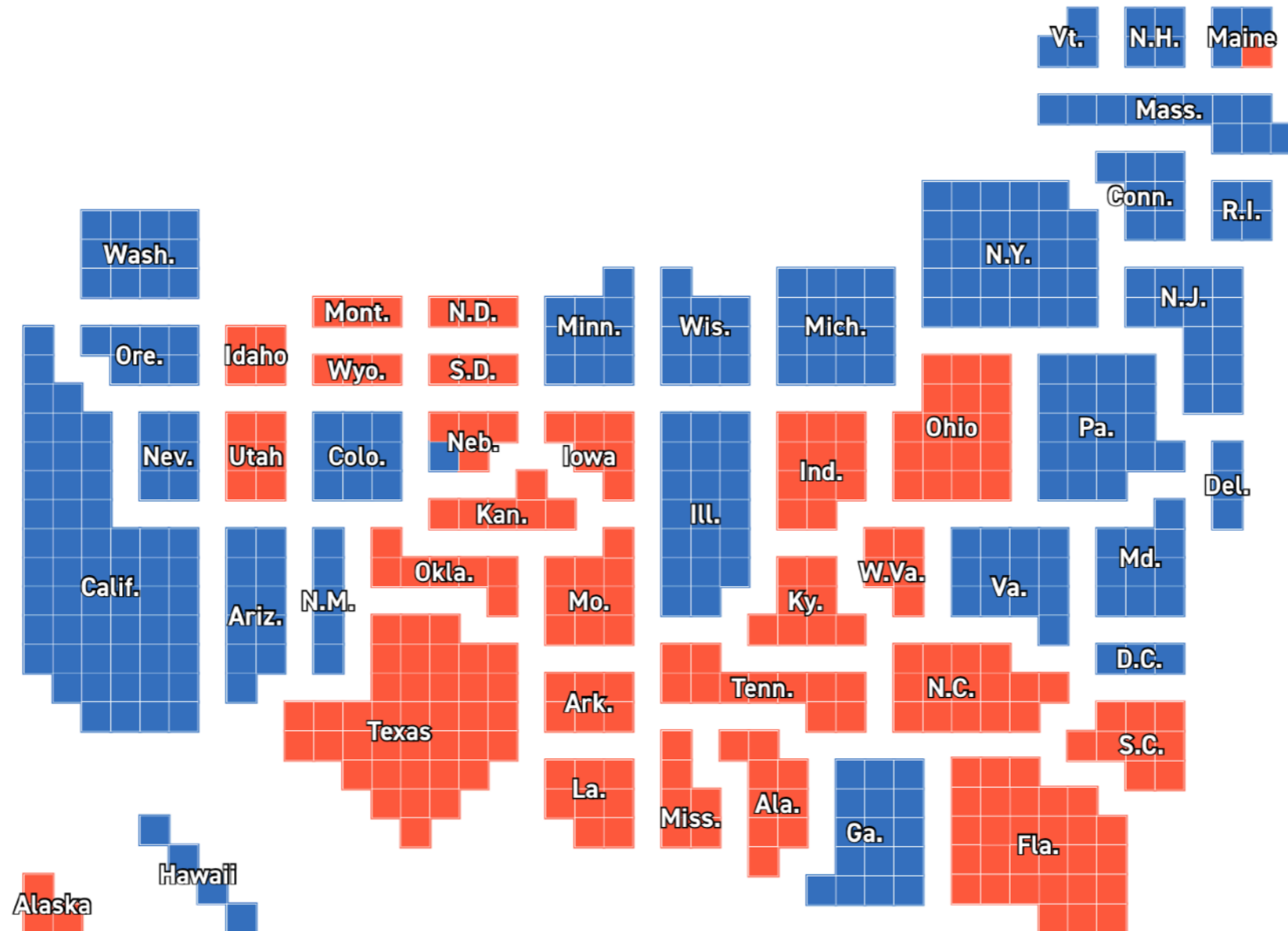


# Weighted Electoral Map

✓ 306 BIDEN

270 to win

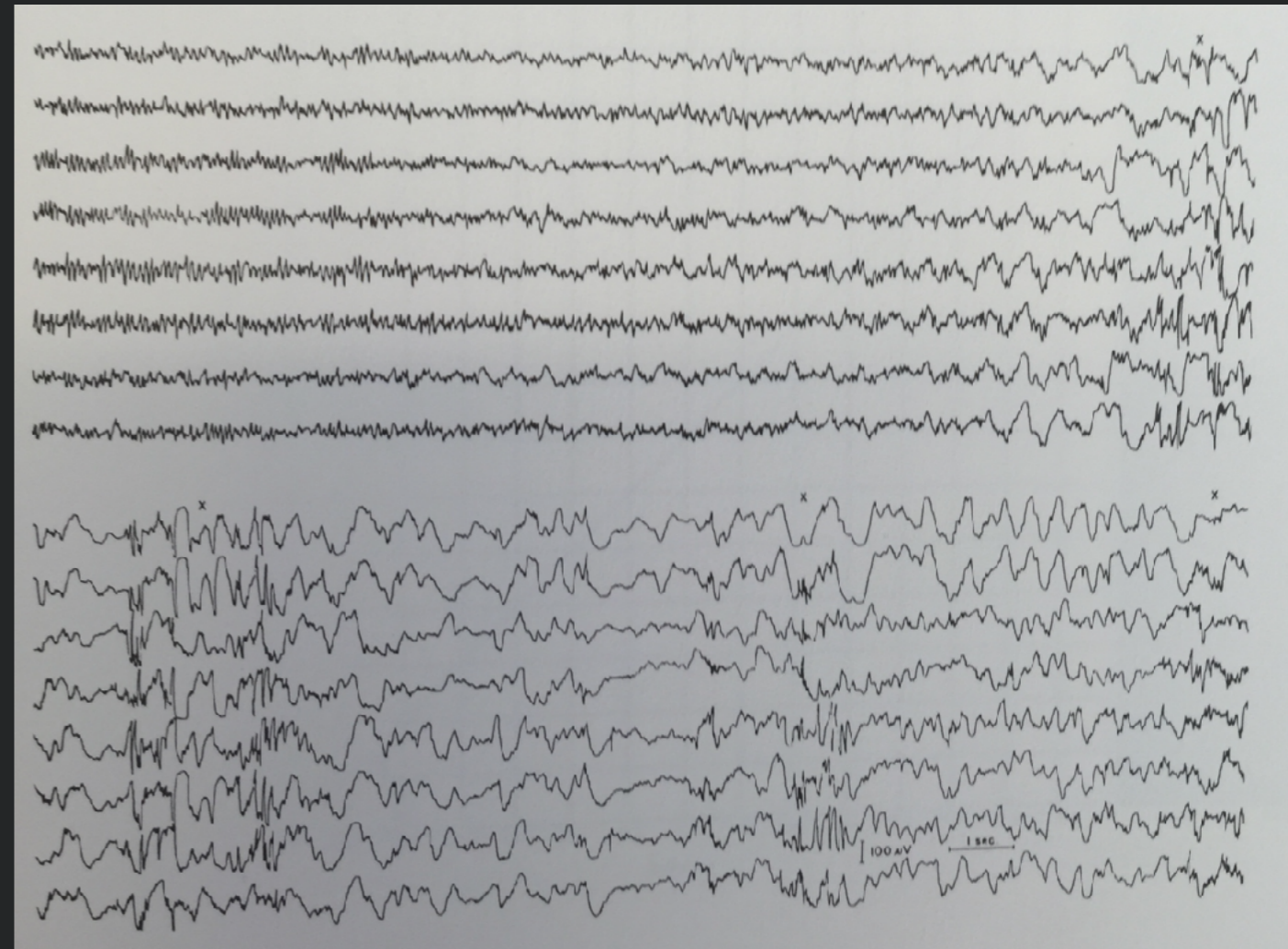
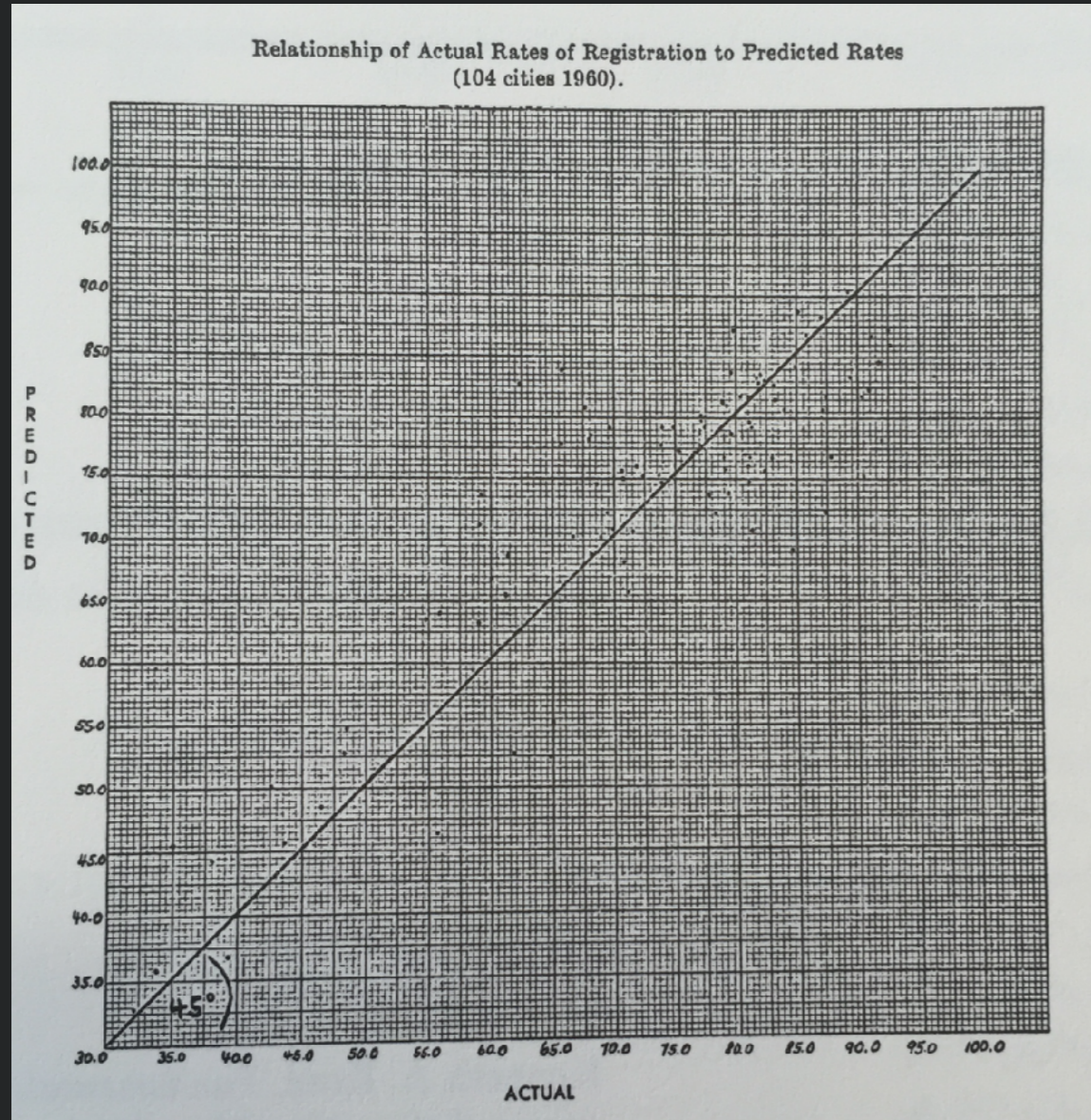
TRUMP 232



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

$$\begin{aligned} \text{Data-ink ratio} &= \frac{\text{Data-ink}}{\text{Total ink used to print the graphic}} \\ &= \text{proportion of a graphic's ink devoted to the non-redundant display of data-information} \\ &= 1.0 - \text{proportion of a graphic that can be erased} \end{aligned}$$

# Examples of Data-ink Ratio



~0

1.0

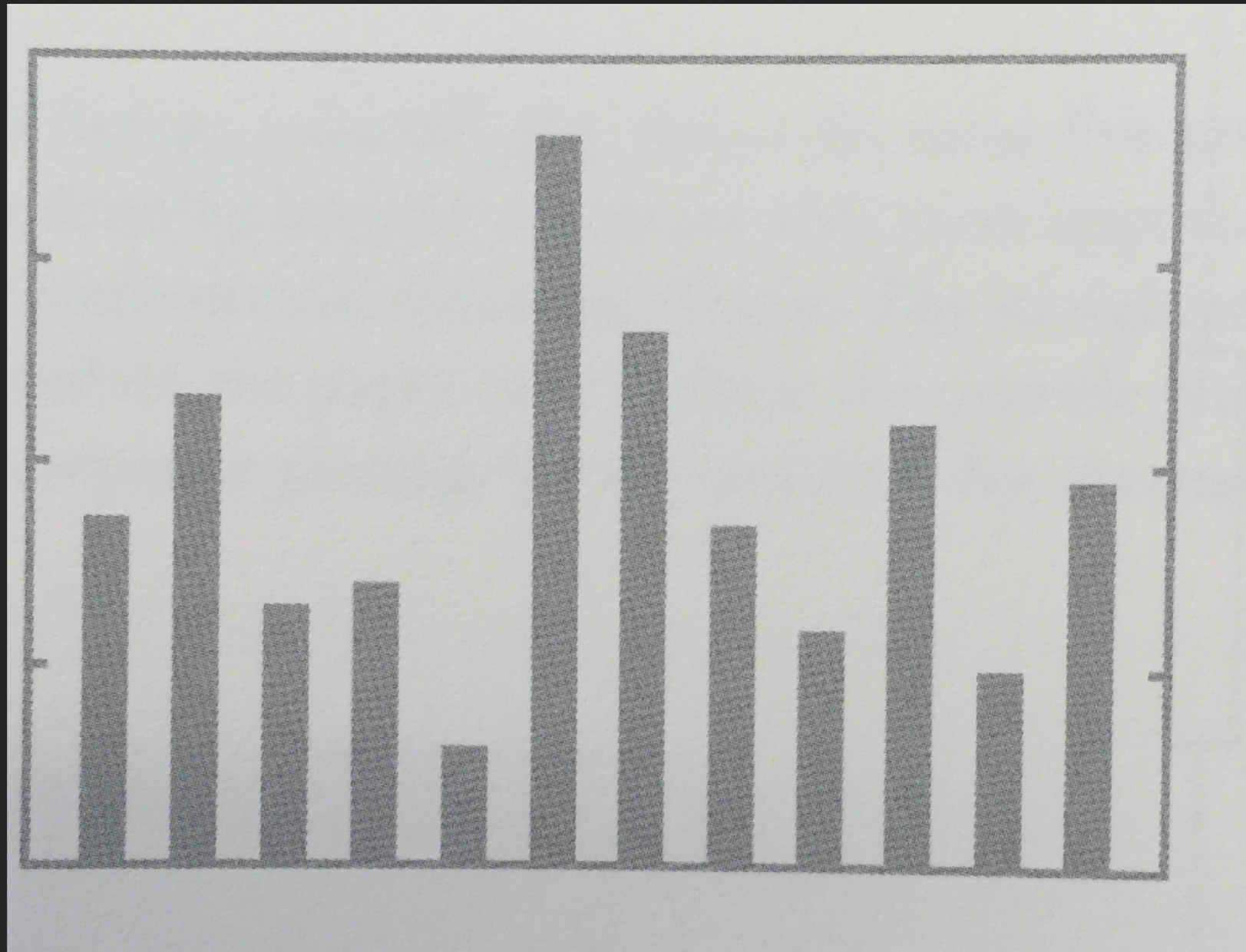




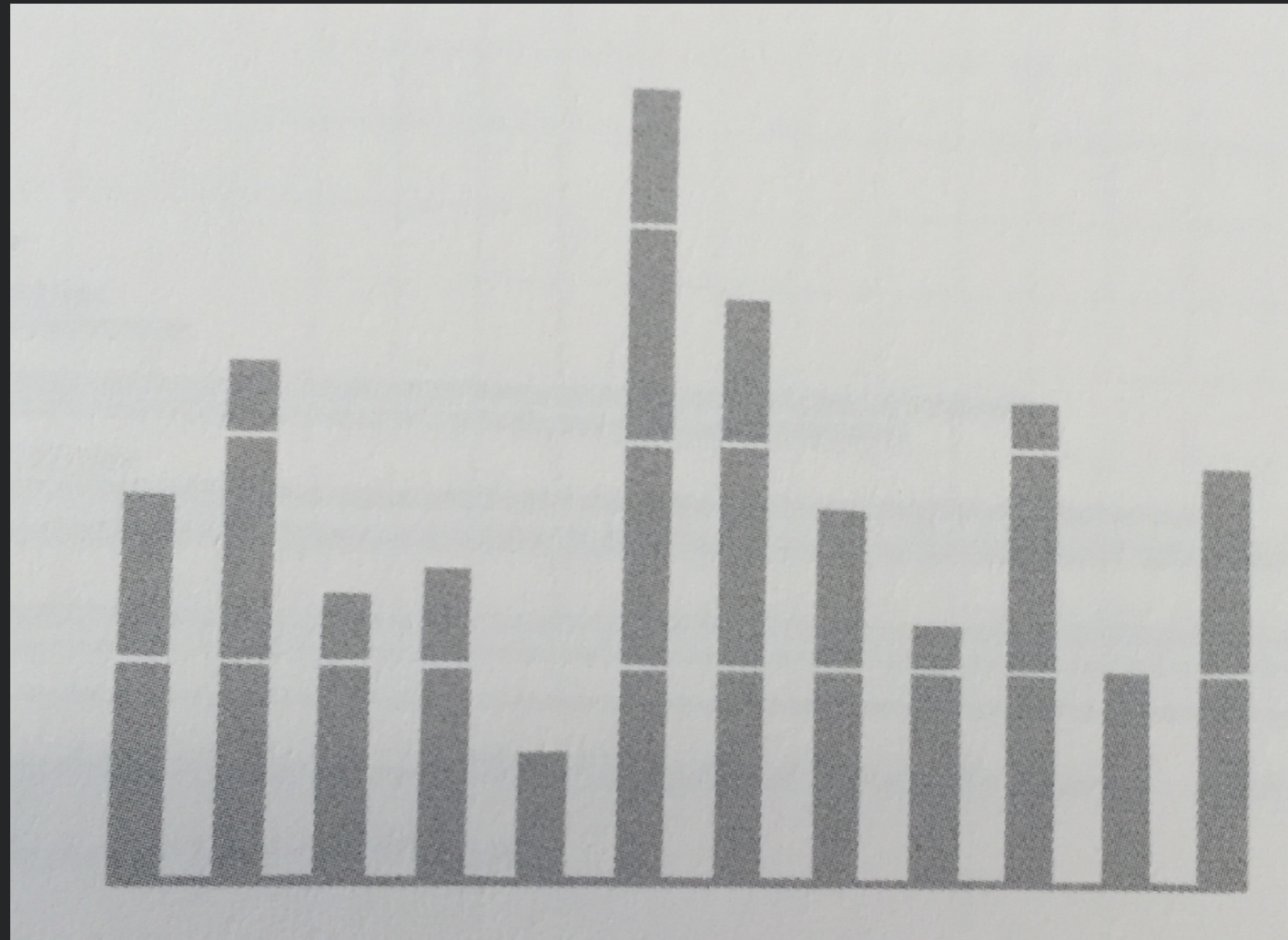
# Design Principles for Data-ink

- (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

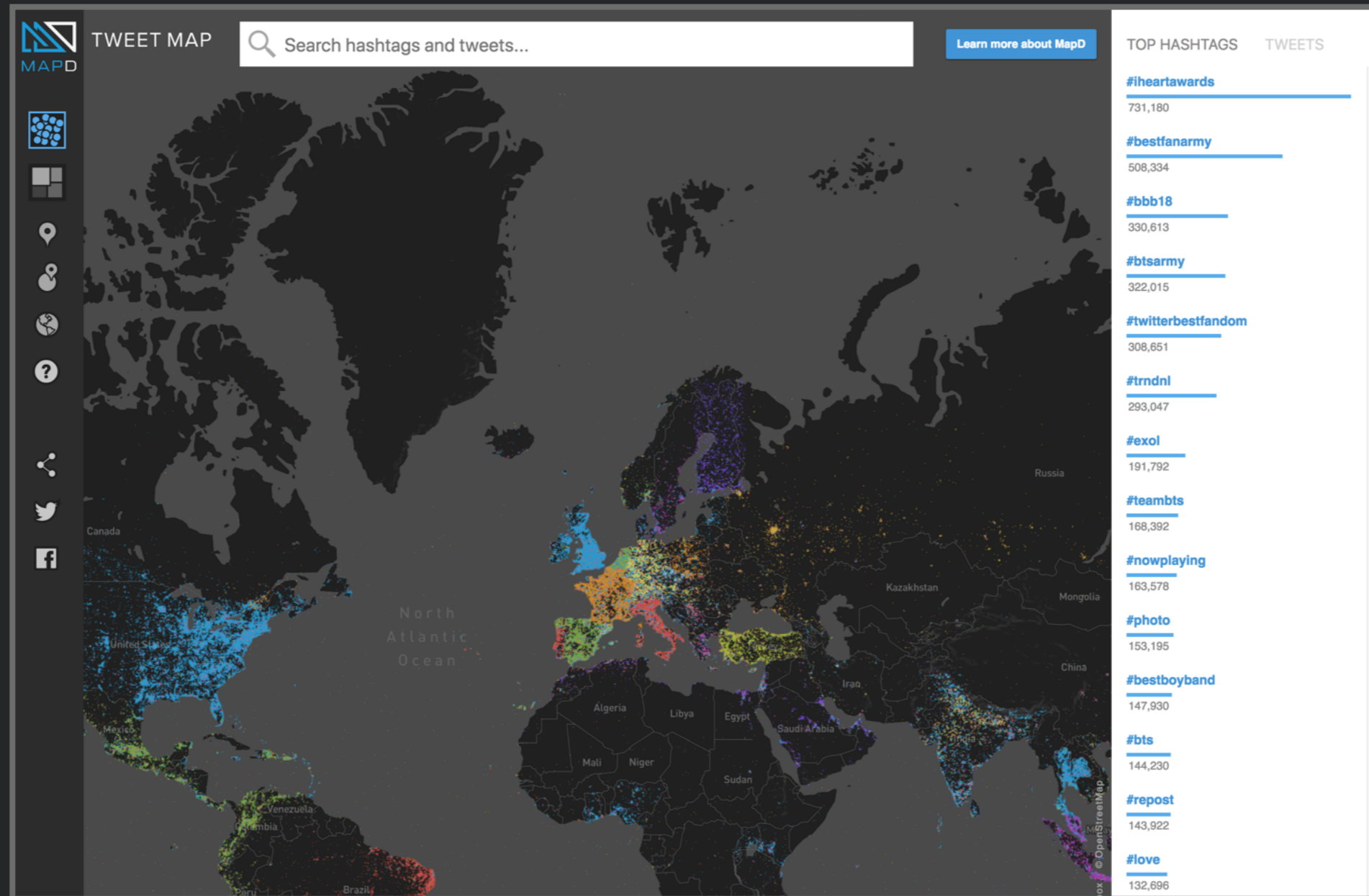
- Users often use iterative process of making sense of the data
  - Answers lead to new questions
- Interactivity helps user constantly change display of information to answer new questions
- Should offer visualization that offers best view of data moment to moment as desired view changes



# 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

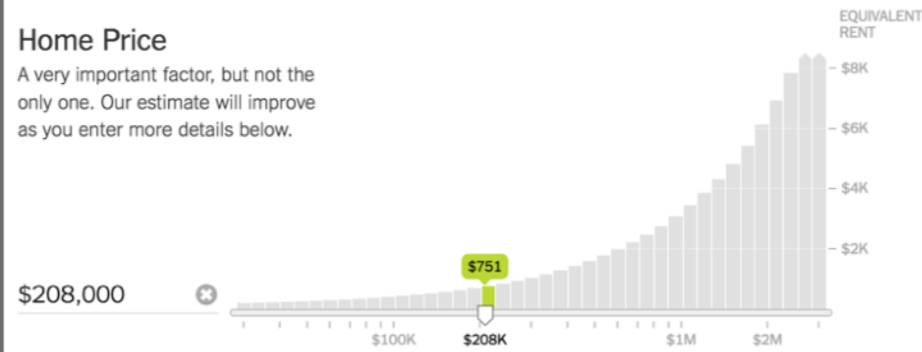
## Is It Better to Rent or Buy?

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.



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
<b>Total</b>	<b>\$104,029</b>	<b>\$104,029</b>

### How Long Do You Plan to Stay?

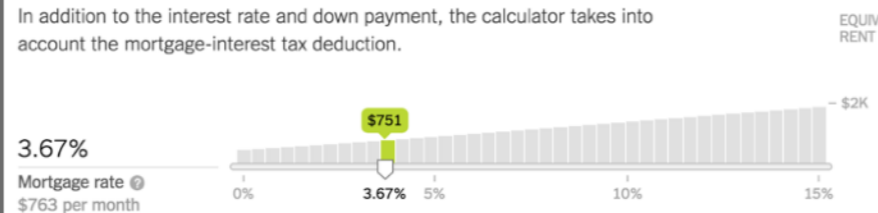
Buying tends to be better the longer you stay because the upfront fees are spread out over many years.



**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.

### What Are Your Mortgage Details?

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





# 7 Minute Break



# SWE 632 - Design & Development of User Interfaces

---



George Mason  
University

---

Instructor:

Dr. Kevin Moran

Teaching Assistant:

David Gonzalez Samudio

Class will start in:

07:00

In the Chat, paste a link  
to an *information*

# SWE 632 - Design & Development of User Interfaces

---



George Mason  
University

---

Instructor:

Dr. Kevin Moran

Teaching Assistant:

David Gonzalez Samudio

Class will start in:

07:00

In the Chat, paste a link  
to an *information*

# 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