Data Visualization (CSCI 627/490)

Introduction

Dr. David Koop

What is Data Visualization?

How is it different from Computer Graphics?

The purpose of computing is about insight, not numbers

— R. W. Hamming

The purpose of **visualization** is about **insight**, not pictures

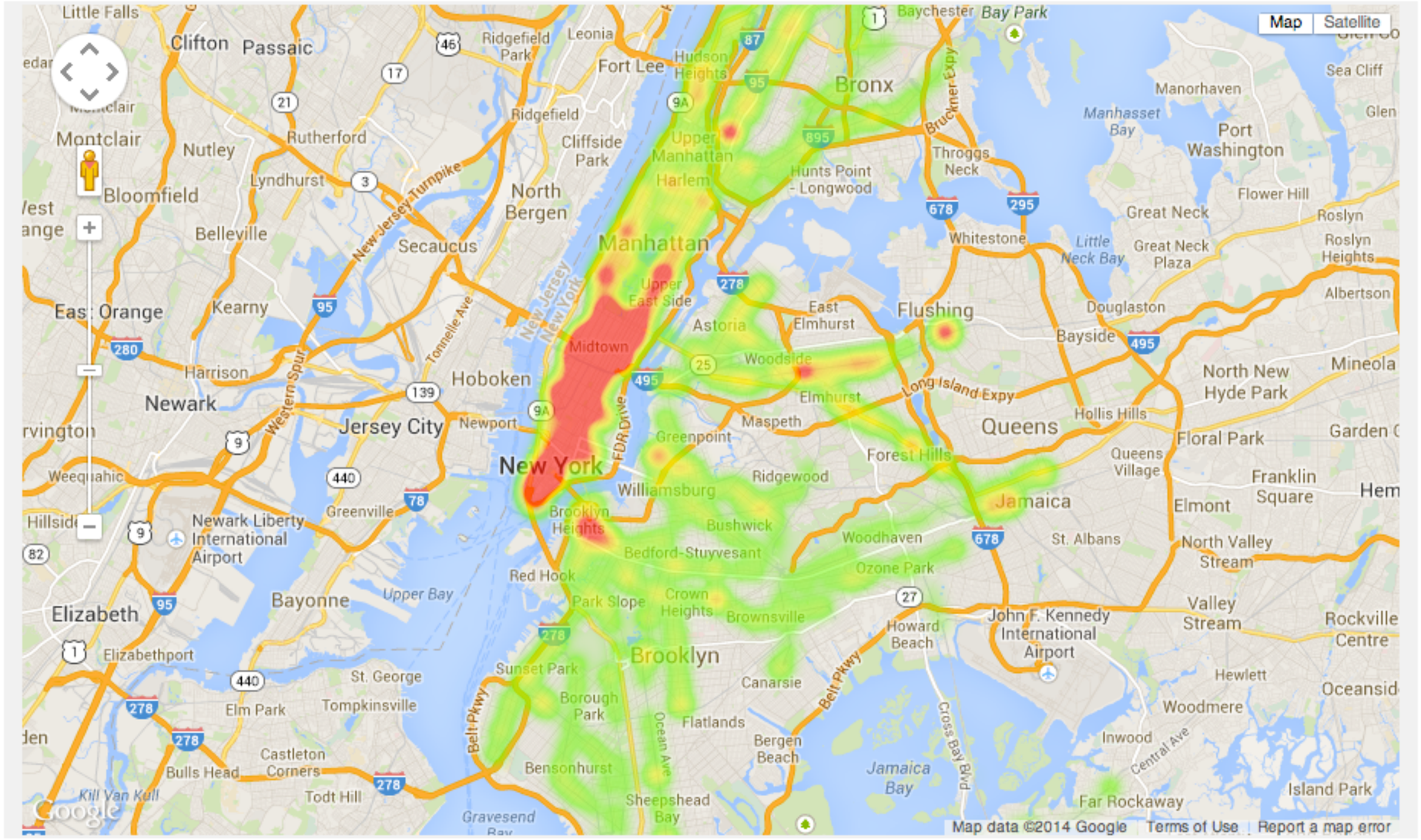
— B. Shneiderman

Why do we visualize data?
(vs. looking at tables?)

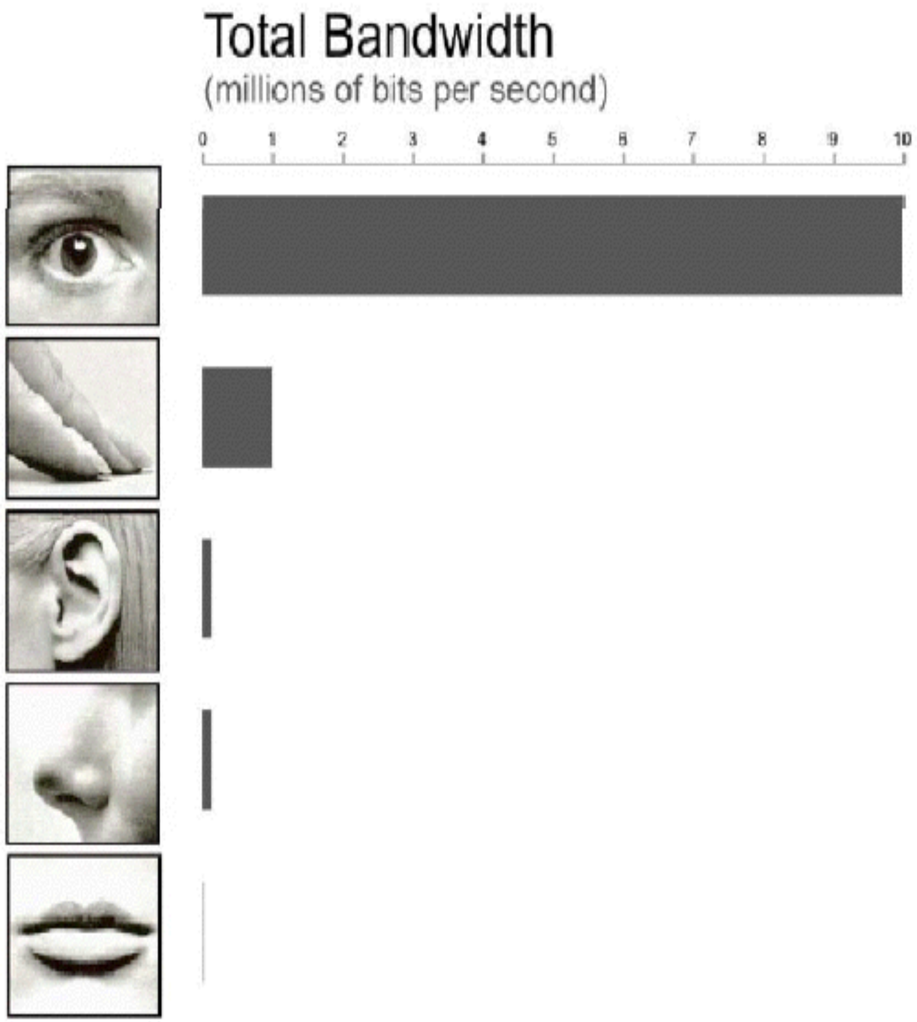
MTA Fare Data Table

	REMOTE	STATION	FF	SEN/DIS	7-D AFAS UNL	D AFAS/RMF U	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	00005031	00030645	00054376
6	R033	42ND STREET/TIMES SQUARE	00159382	00005945	00000378	00001205	00000690	00058931	00078644
7	R022	34TH STREET & 6TH AVENUE	00156008	00006276	00000487	00001543	00000712	00058910	00110466
8	R084	59TH STREET/COLUMBUS CIRCLE	00155262	00009484	00000589	00002071	00000542	00053397	00113966
9	R020	47-50 STREETS/ROCKEFELLER	00143500	00006402	00000384	00001159	00000723	00037978	00090745
10	R179	86TH STREET-LEXINGTON AVE	00142169	00010367	00000470	00001839	00000271	00050328	00125250
11	R023	34TH STREET & 6TH AVENUE	00134052	00005005	00000348	00001112	00000649	00031531	00075040
12	R029	PARK PLACE	00121614	00004311	00000287	00000931	00000792	00025404	00065362
13	R047	42ND STREET & GRAND CENTRAL	00100742	00004273	00000185	00000704	00001241	00022808	00068216
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

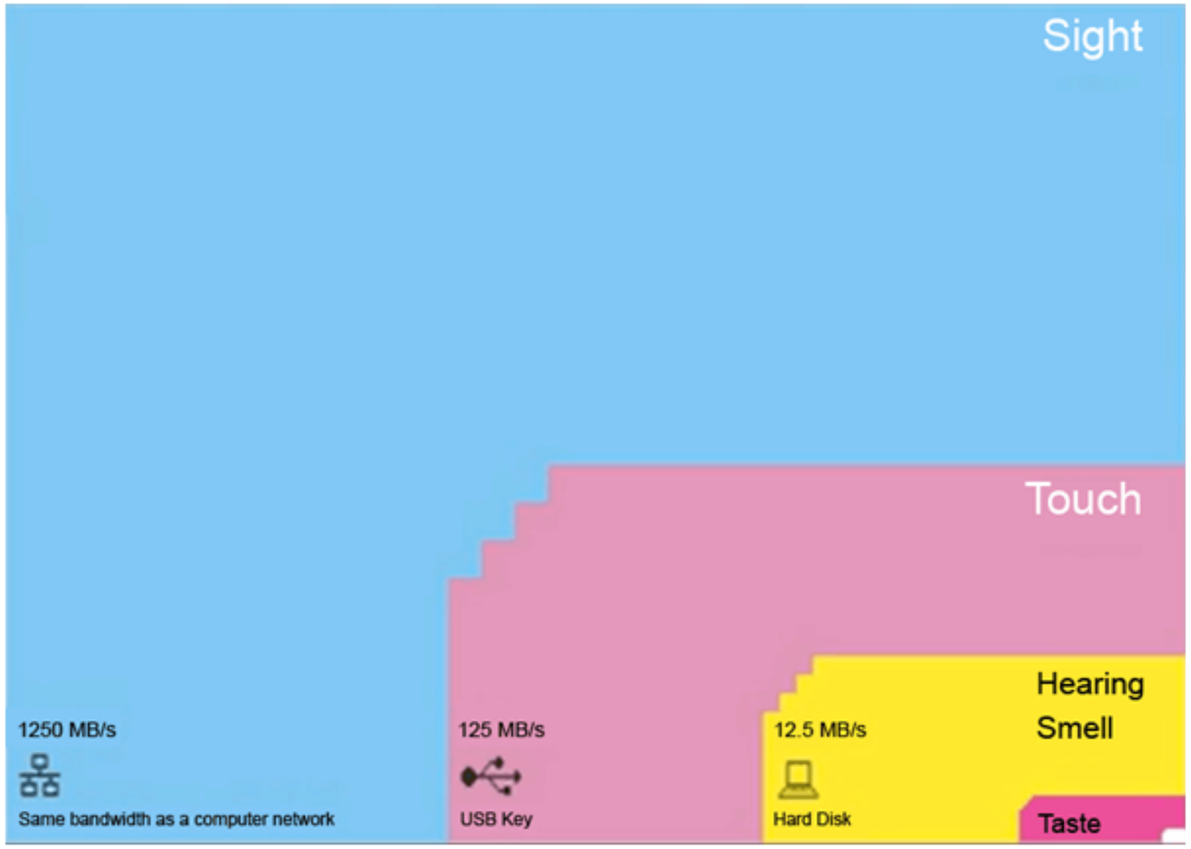
MTA Fare Data Visualization



Why do we visualize data?



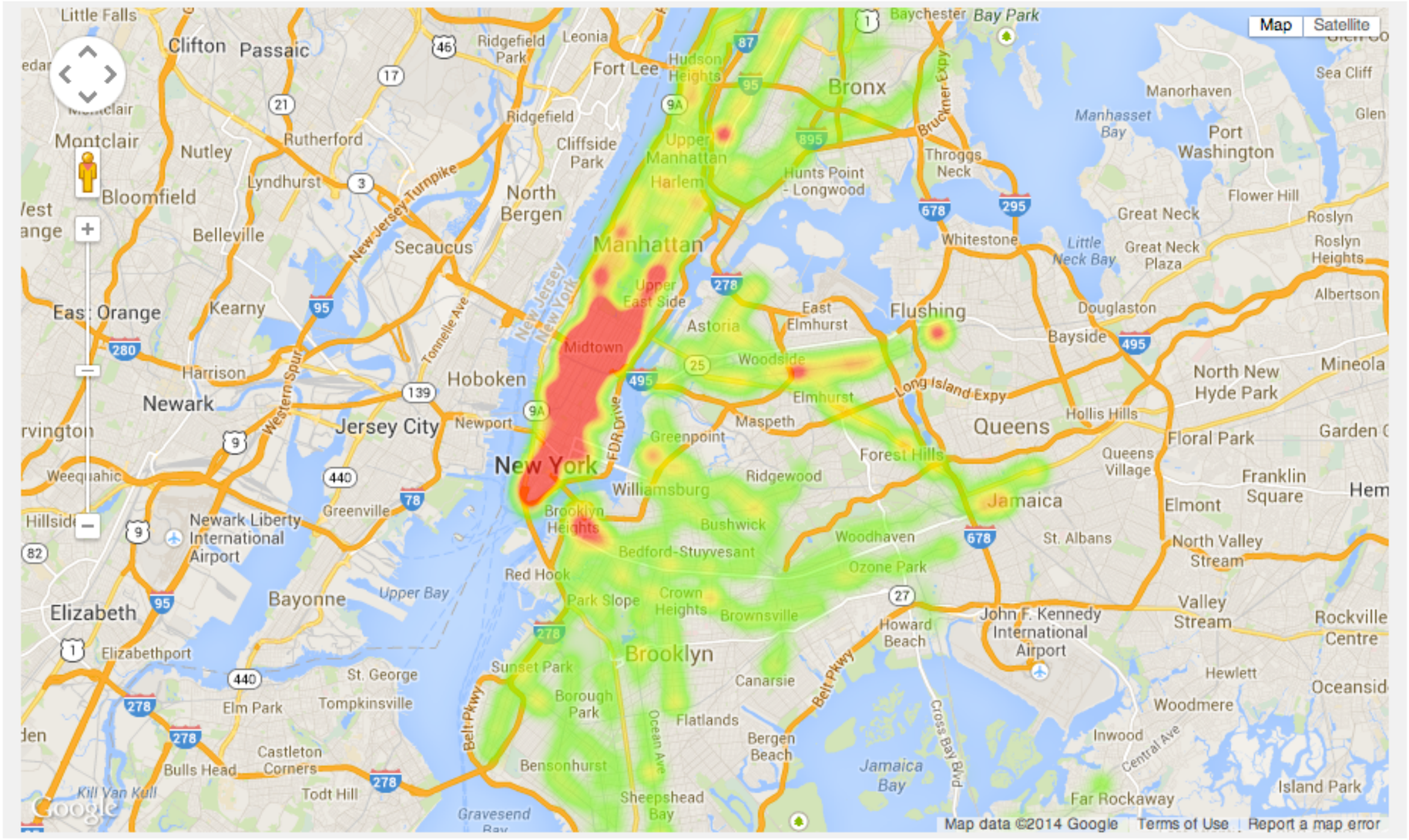
[via A. Lex]



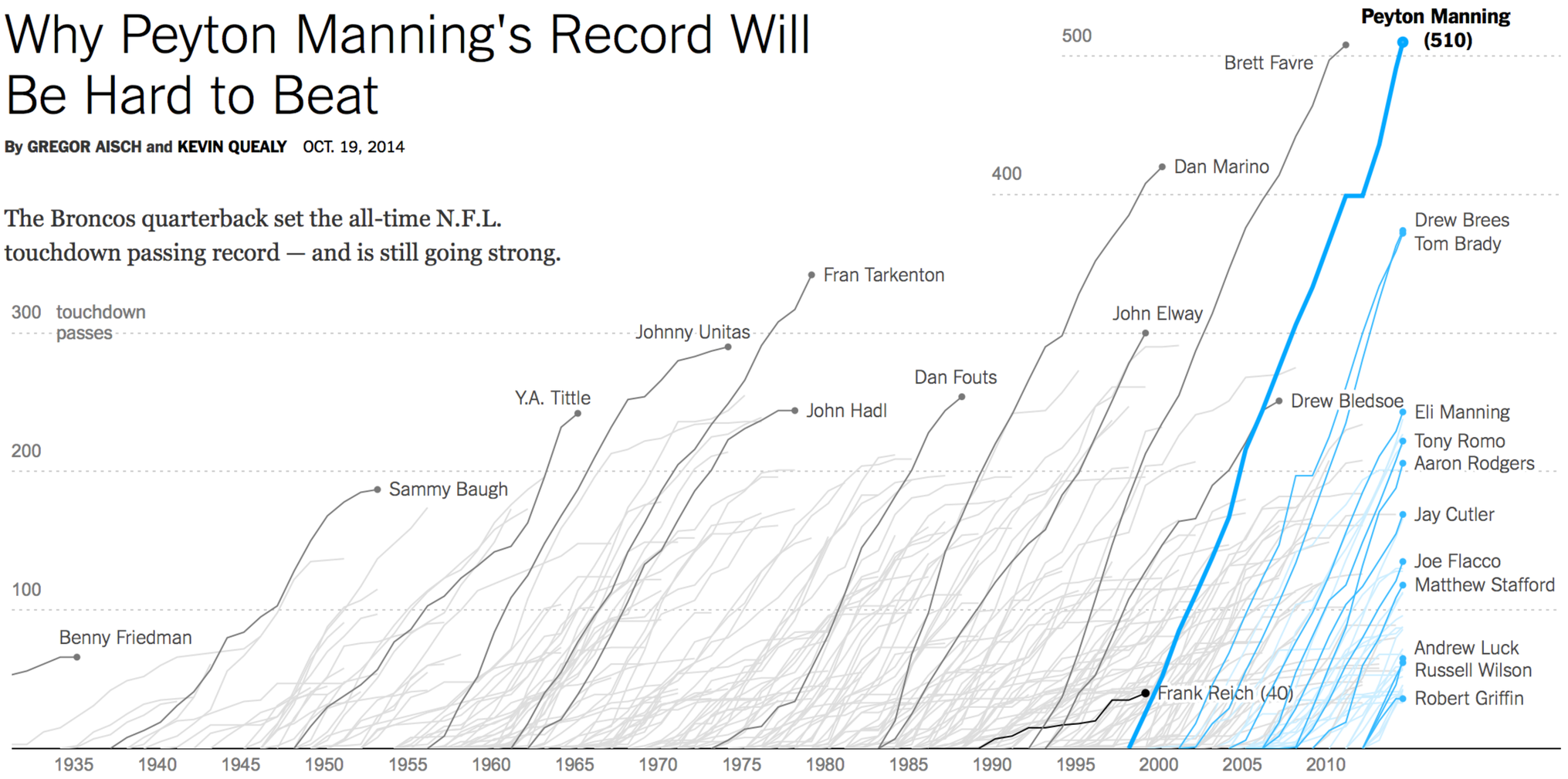
[T. Nørretranders]

What are the purposes for visualization?

Analysis: Subway Ridership Density



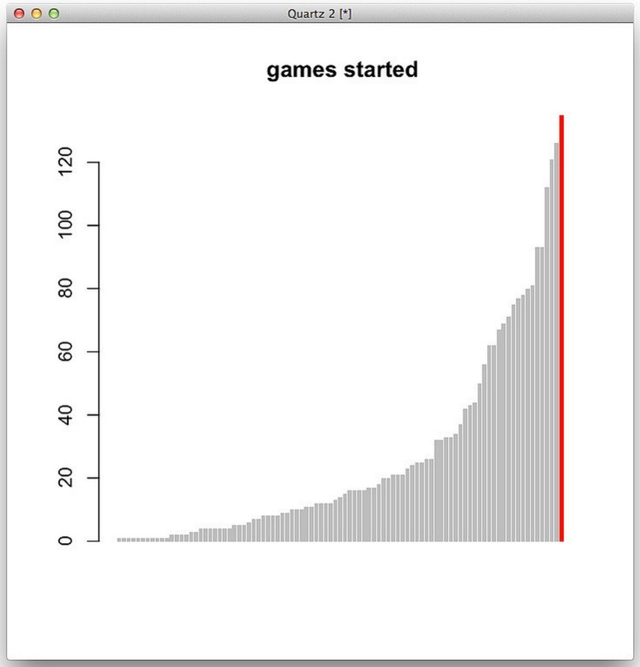
Communication: Peyton's Records

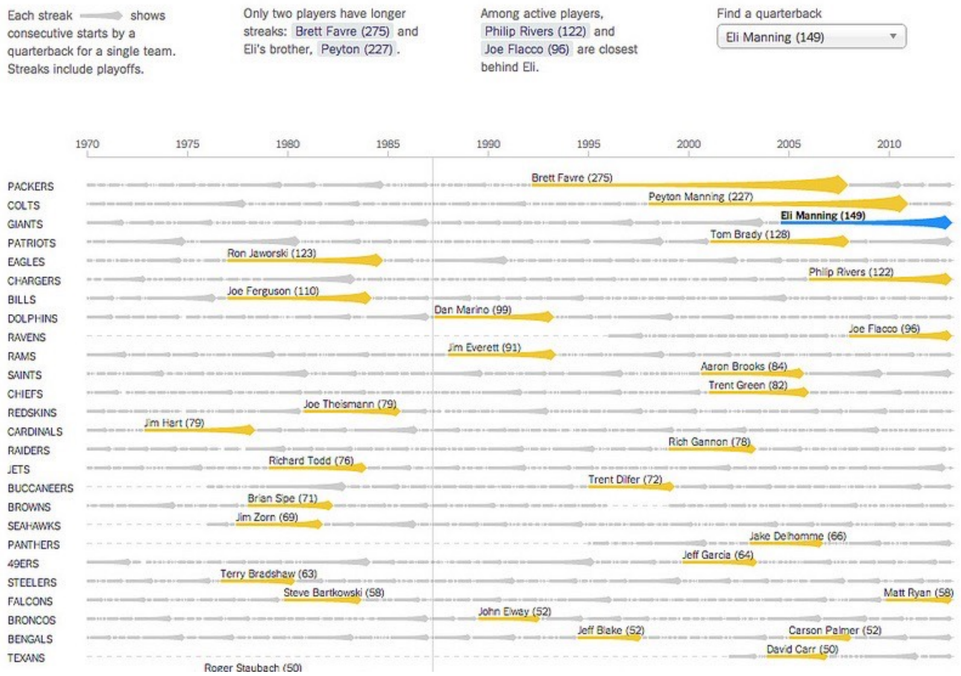


[G. Aisch and K. Quealy, NYTimes]

Exploration <-> Communication Spectrum

Consecutive Starts by a Quarterback for a Single Team





Exploration — Confirmation — Communication

Questions — **Answers/Persuasion**

[K. Quealy, 2013]

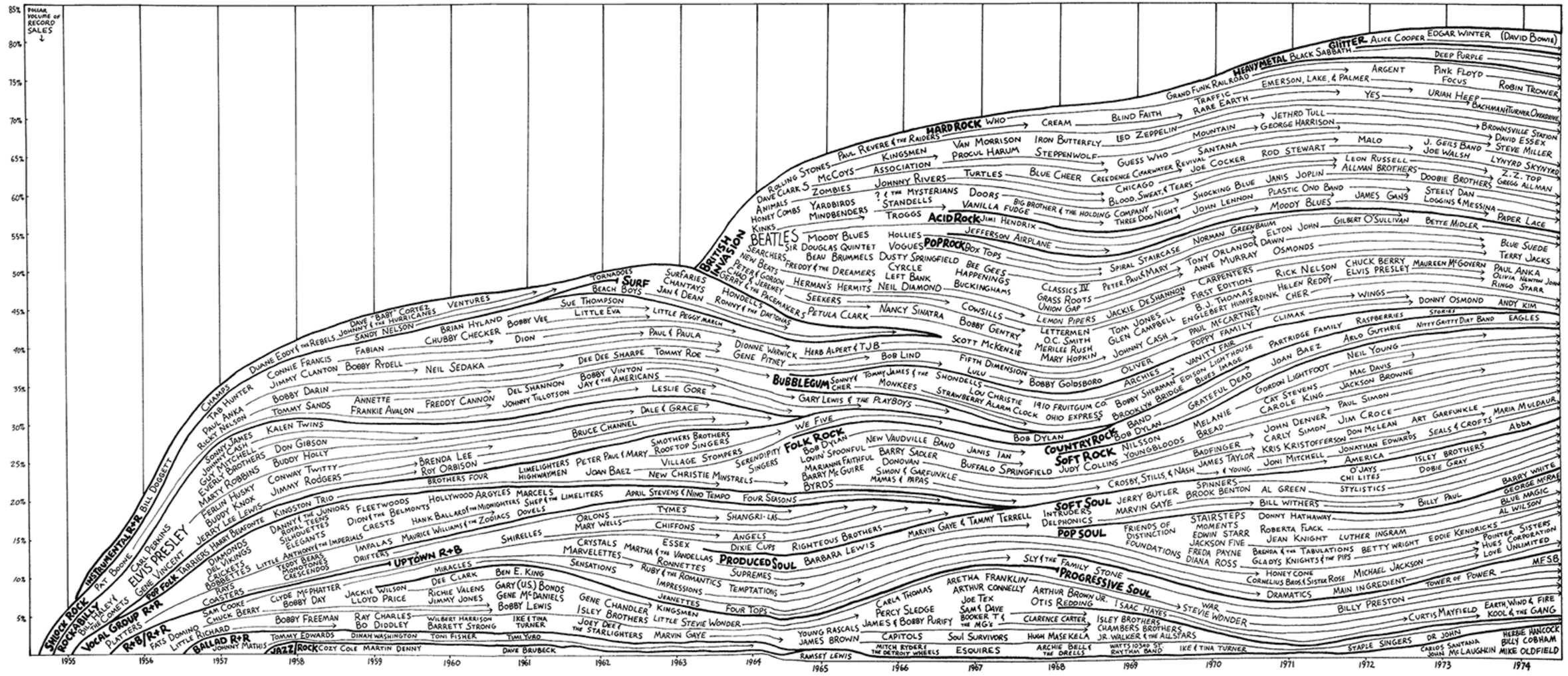
What types of data can we visualize?

Types of Data

- Tables
- Networks (Graphs)
- Spatial Data
  - Geography
  - Physical (e.g. Scientific, Medical)
- Text
- Sets

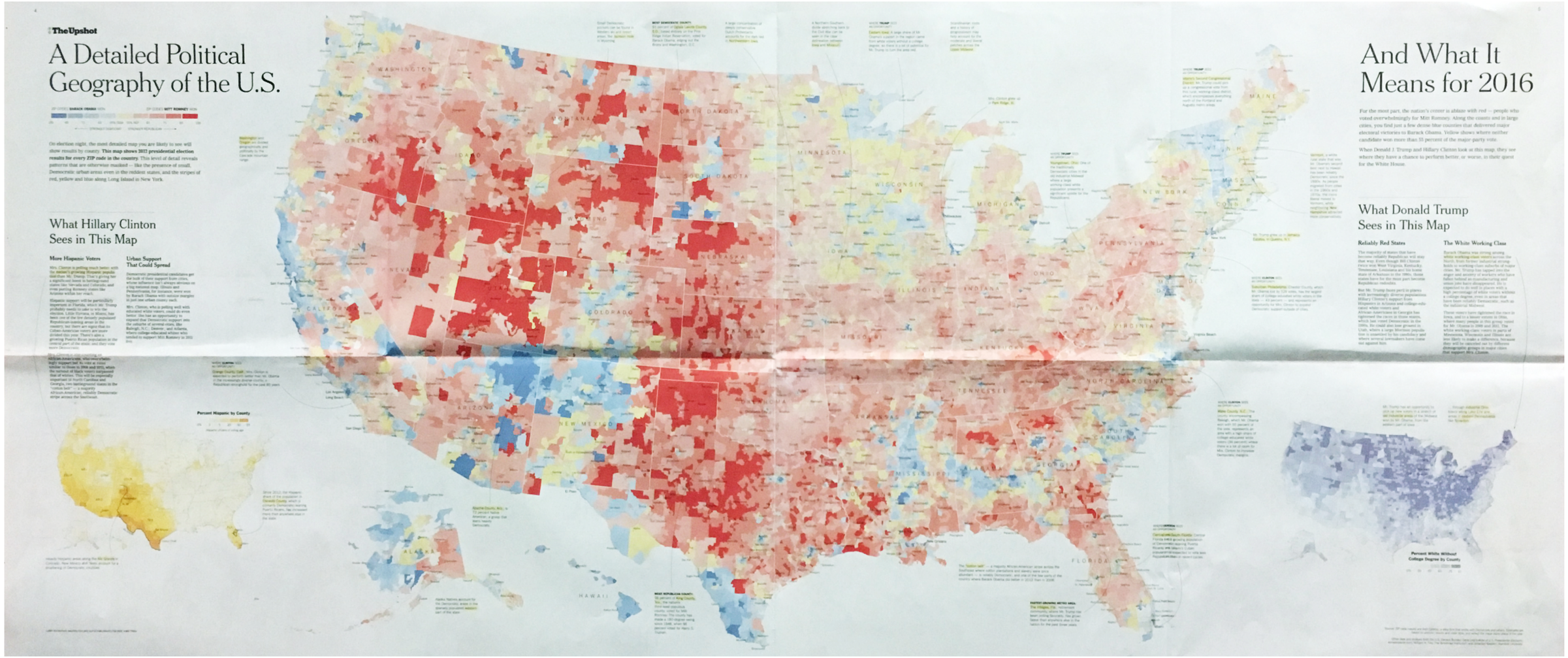
Where have you seen visualizations?

Books/Posters



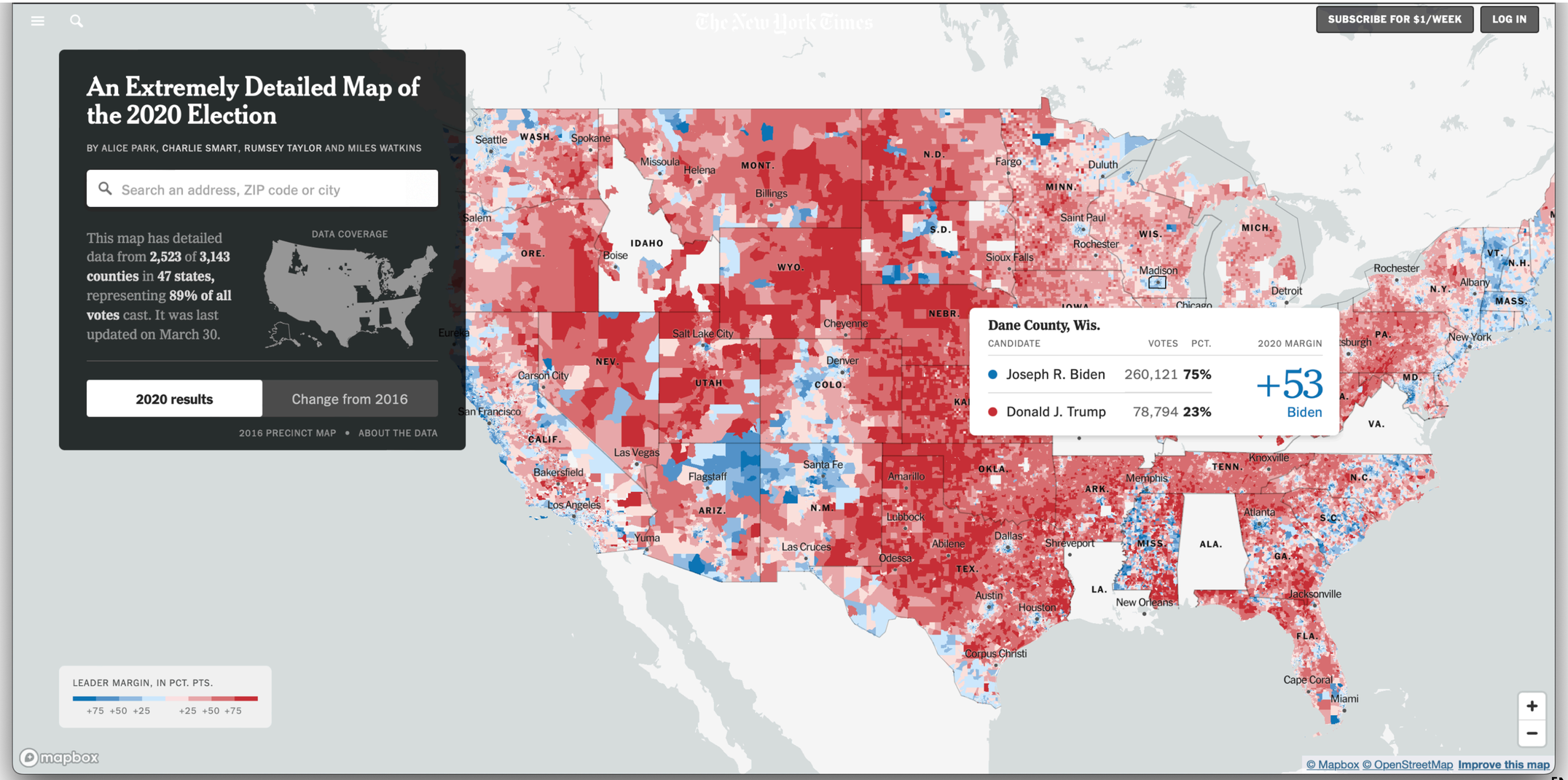
[Rock 'N' Roll is Here to Pay, R. Garofalo, 1977 (via Tufte)]

Newspapers



[NYTimes]

Web


The New York Times
SUBSCRIBE FOR $1/WEEK
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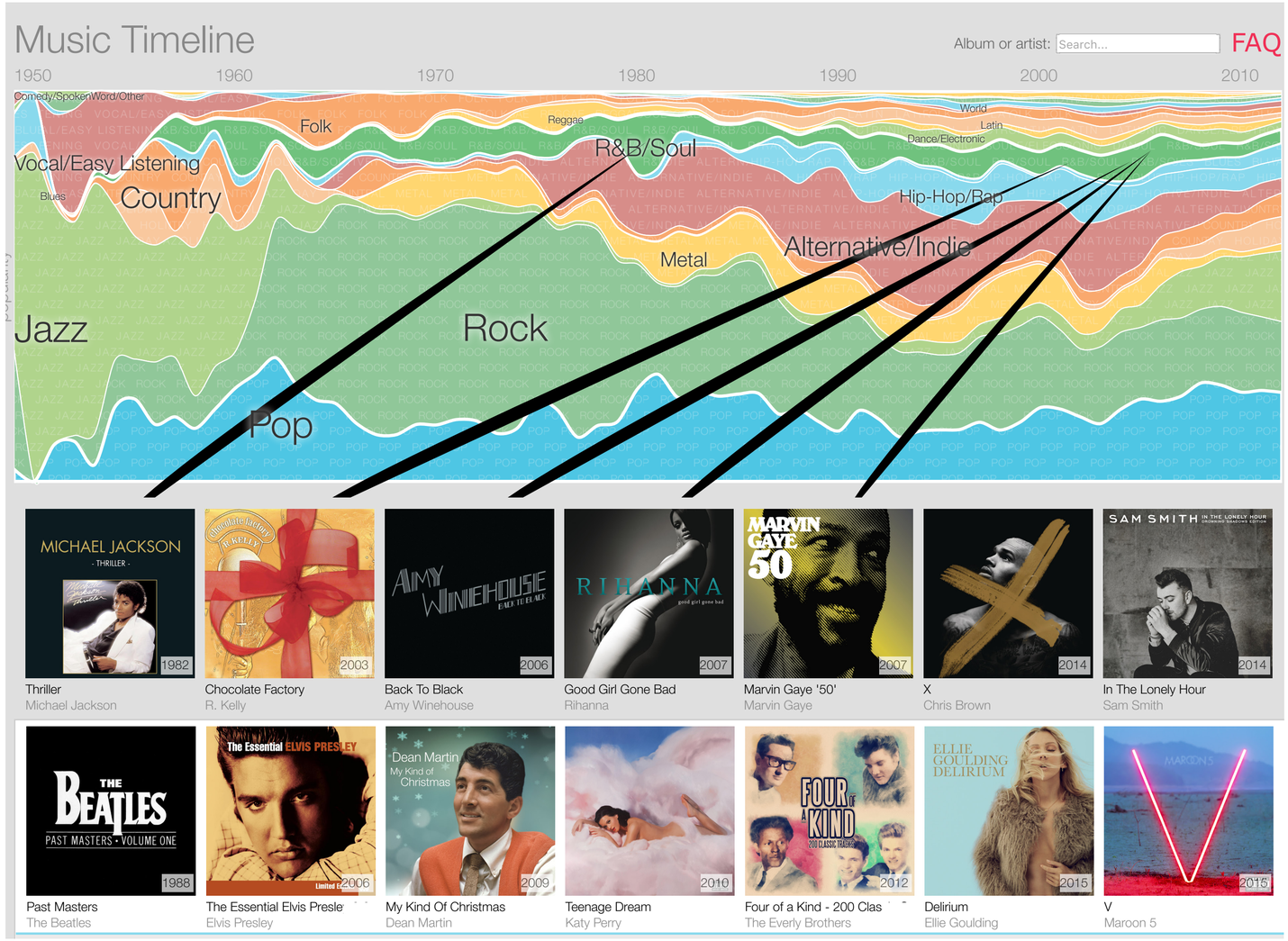
An Extremely Detailed Map of the 2020 Election
BY ALICE PARK, CHARLIE SMART, RUMSEY TAYLOR AND MILES WATKINS
Search an address, ZIP code or city
This map has detailed data from 2,523 of 3,143 counties in 47 states, representing 89% of all votes cast. It was last updated on March 30.
DATA COVERAGE
2020 results
Change from 2016
2016 PRECINCT MAP • ABOUT THE DATA
Dane County, Wis.
CANDIDATE VOTES PCT. 2020 MARGIN
Joseph R. Biden 260,121 75%
Donald J. Trump 78,794 23%
+53 Biden
LEADER MARGIN, IN PCT. PTS.
+75 +50 +25 +25 +50 +75
mapbox
© Mapbox © OpenStreetMap Improve this map

[NYTimes]

Web



[Music Timeline, Google Research (No Longer Working)]

What is the advantage of the second version?

Interaction

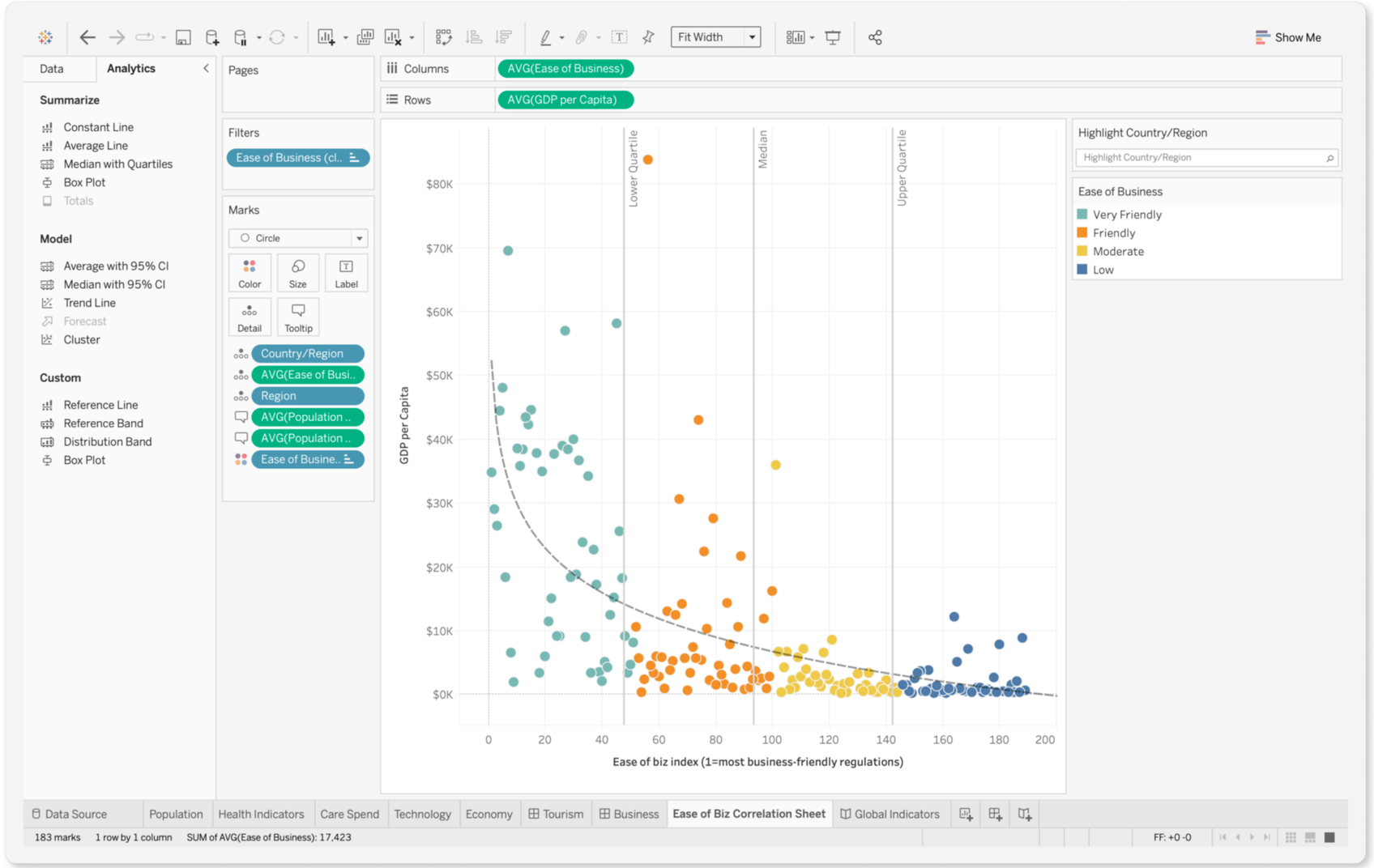
How do we create modern visualizations?

Tools

- Desktop Applications:
  - Excel (see excelcharts.com)
  - Tableau
  - …
- Grammars:
  - Vega-Lite
- Programming Frameworks
  - d3.js
  - Observable Plot, plot.ly, deck.gl
  - …

- Tradeoffs
  - Speed
  - Customization
  - Understanding
  - Dissemination

Tableau

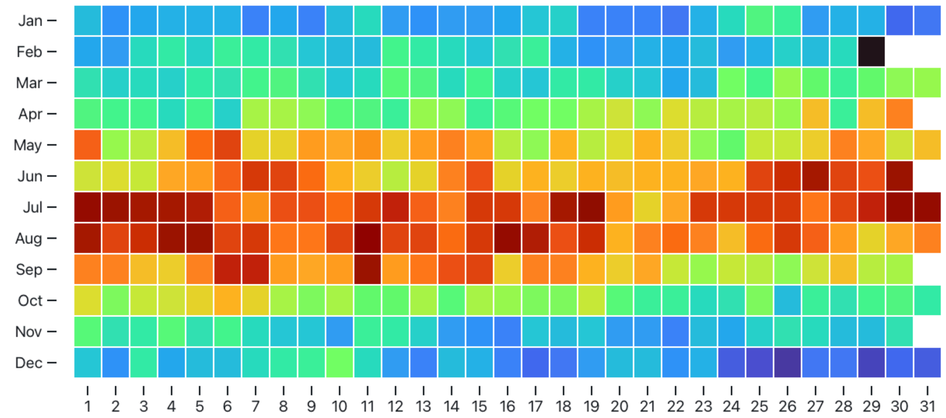


[Tableau Desktop]

Observable Plot

```
seattle = ▸ Array(1461) [Object, Object, Object, Object, Object, Object, Object, Object, Object, Object, Object, Object, Object, Object, Object,
```

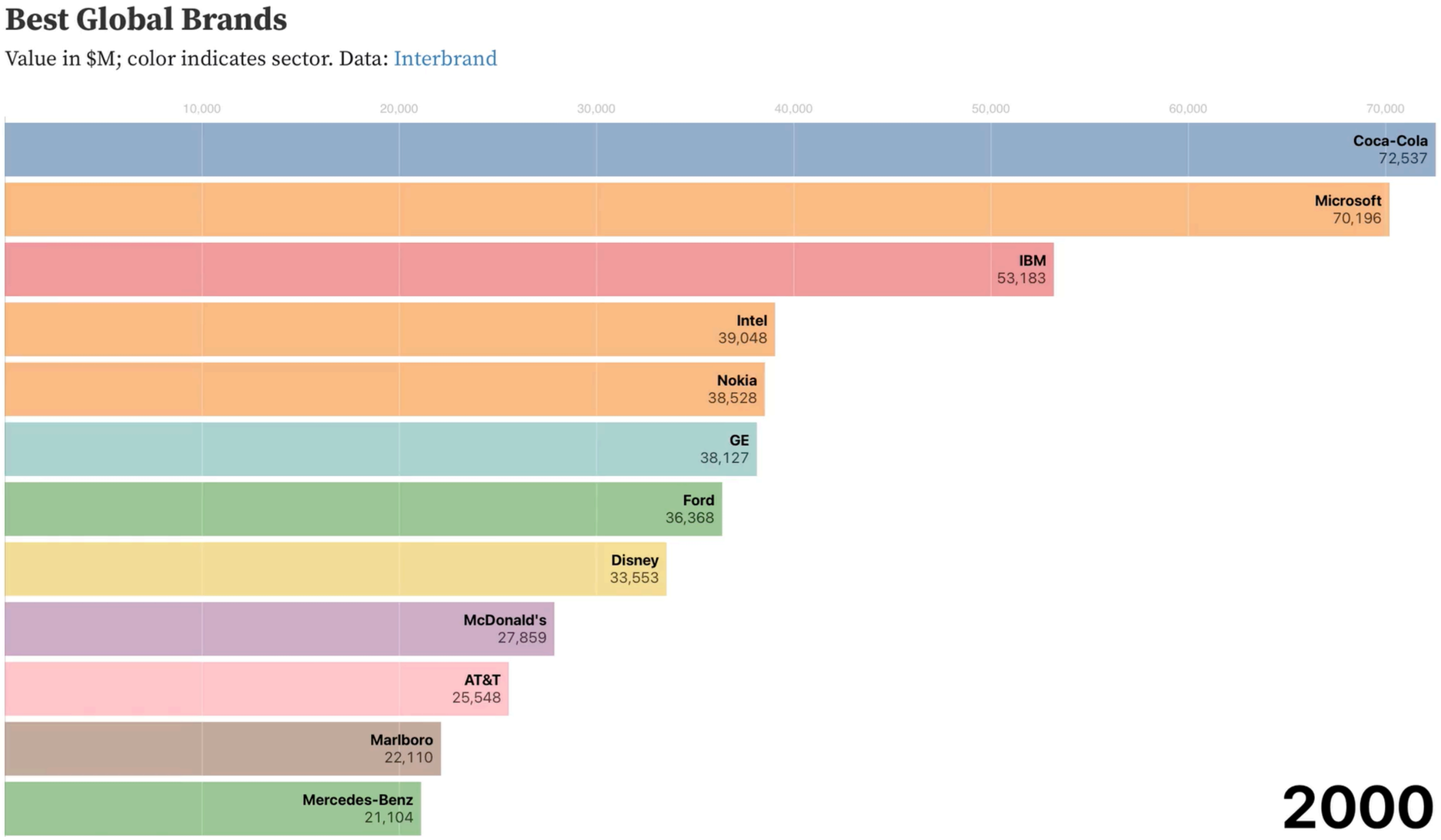
```
seattle = FileAttachment("seattle-weather.csv").csv({typed: true})
```




```
Plot.plot({
  height: 300,
  padding: 0,
  y: {
    tickFormat: Plot.formatMonth("en", "short")
  },
  marks: [
    Plot.cell(seattle, Plot.group({fill: "max"}, {
      x: d => d.date.getUTCDate(),
      y: d => d.date.getUTCMonth(),
      fill: "temp_max",
      inset: 0.5
    }))
  ]
})
```

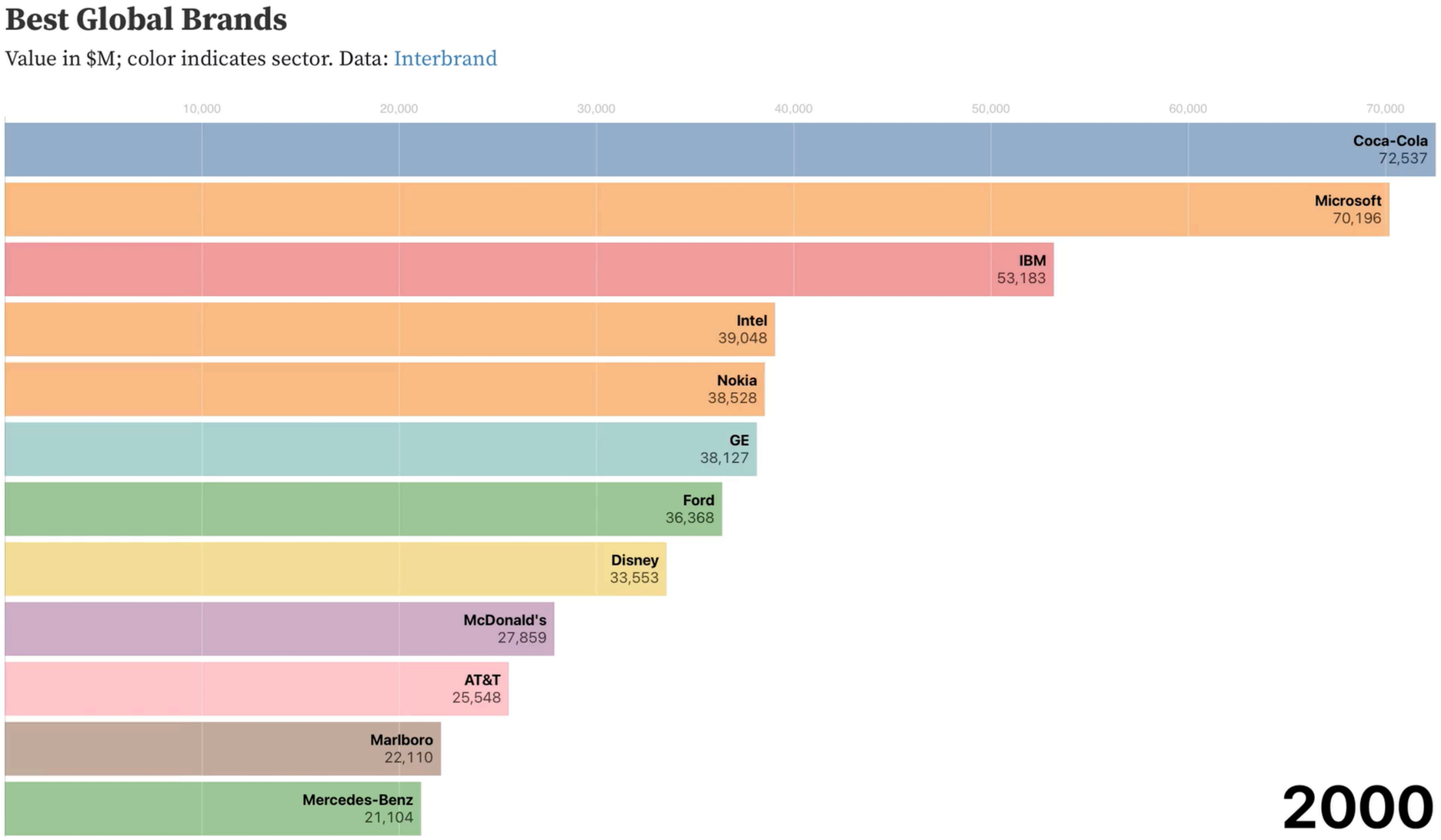
[Observable]

d3.js



[M. Bostock]

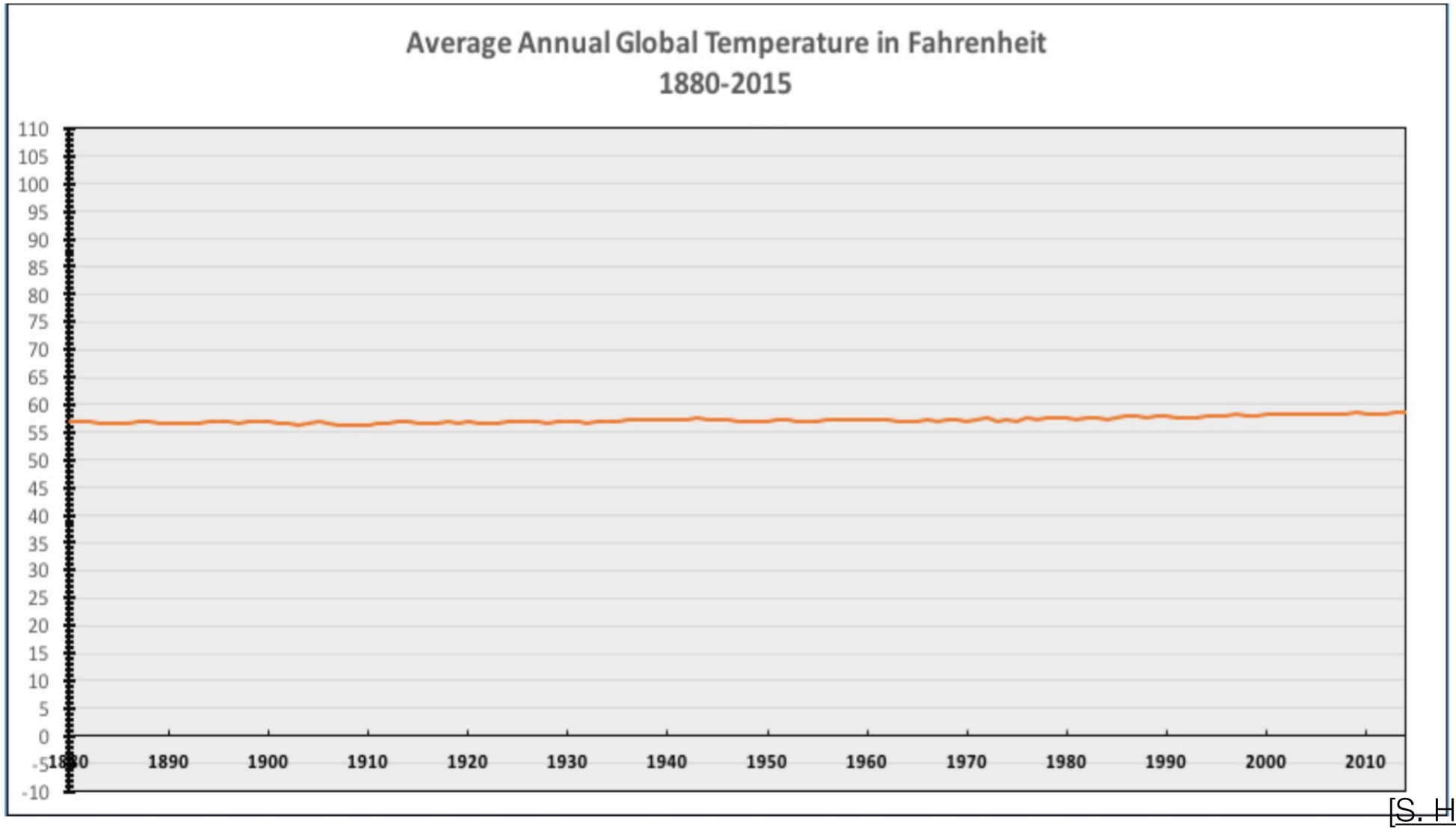
d3.js



[M. Bostock]

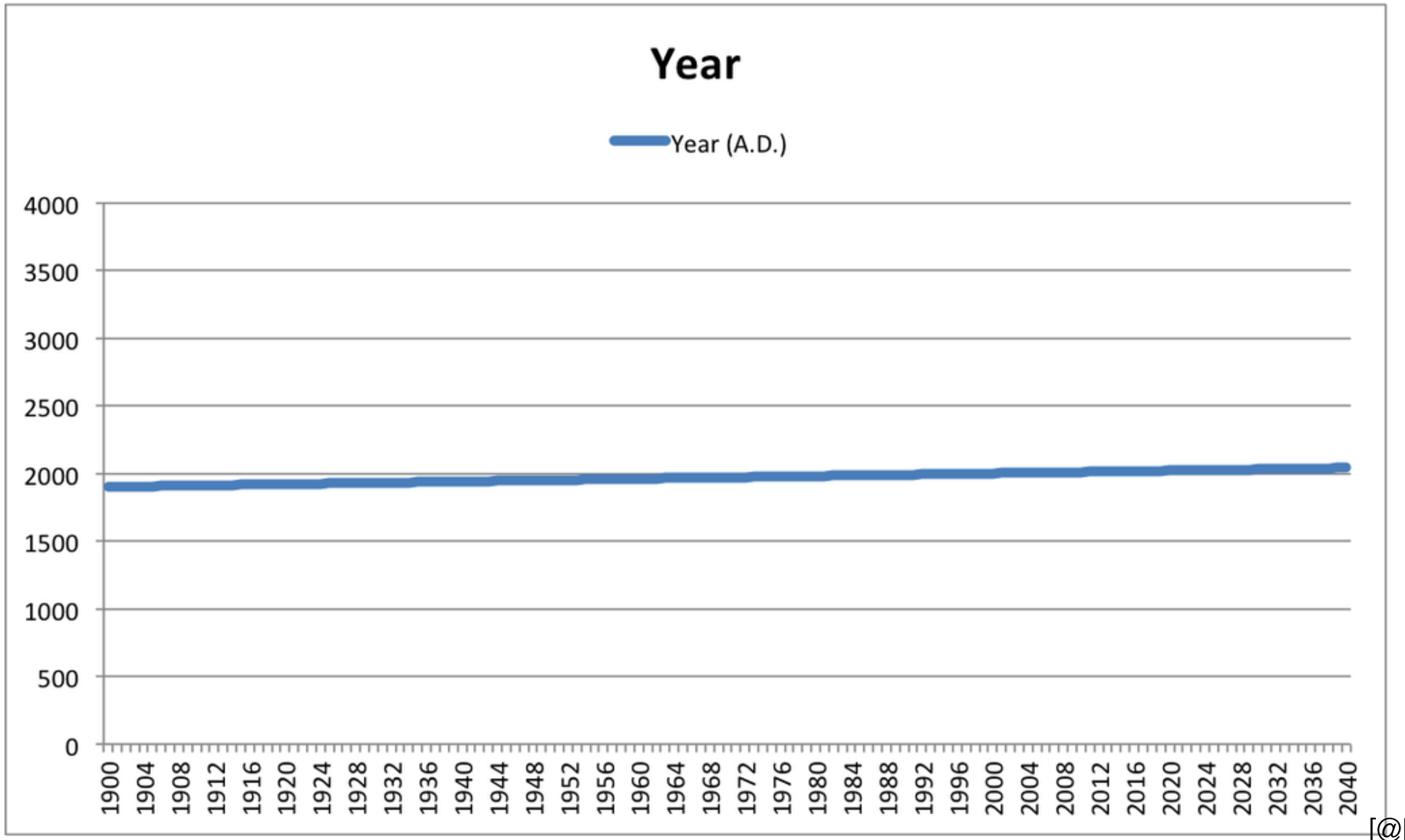
Why do we care about the design of visualizations?

Design: Focus on only the y-axis



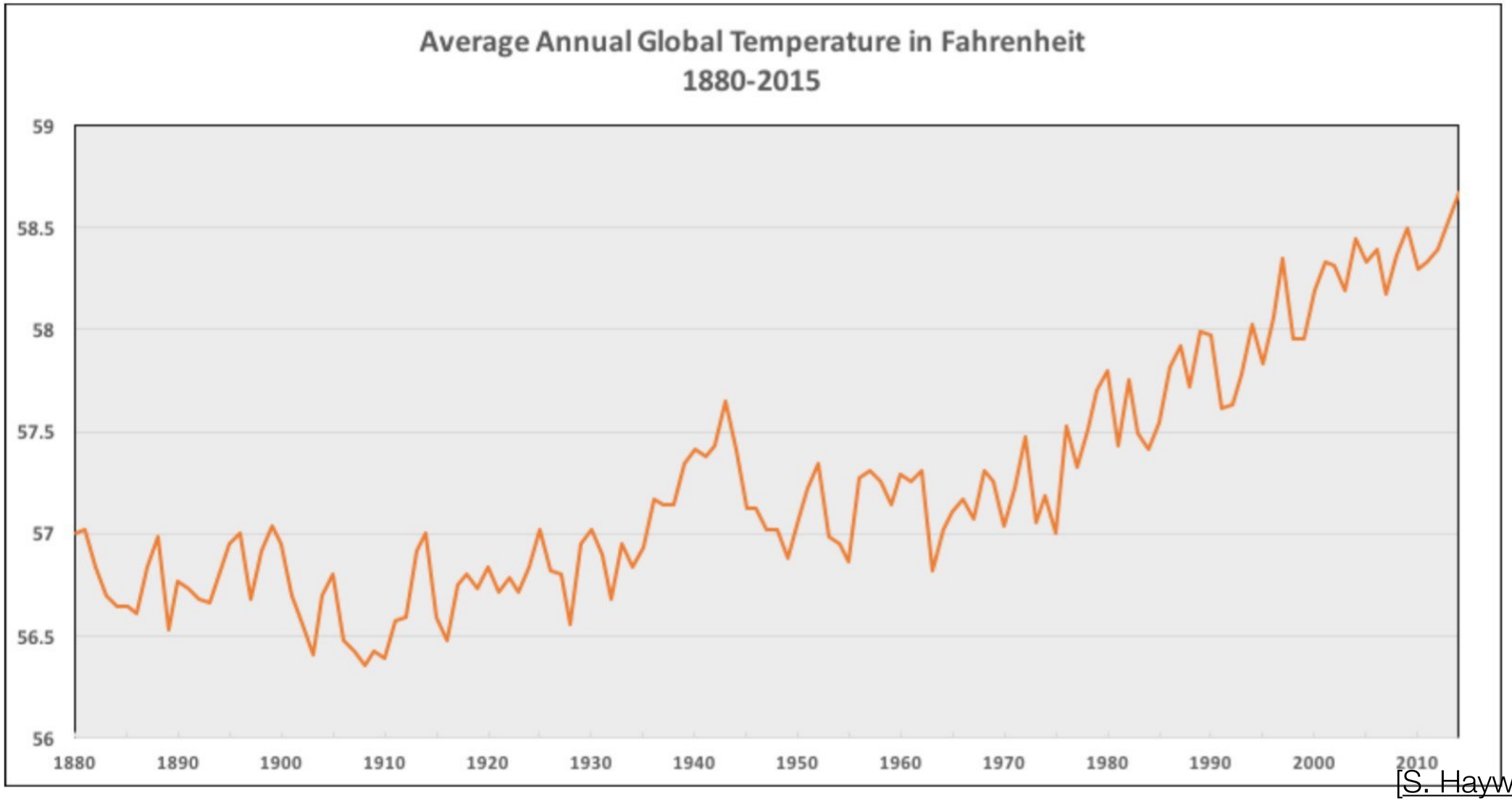
[S. Hayward, 2015]

Design: Year on the y-axis



[@bizweekgraphics]

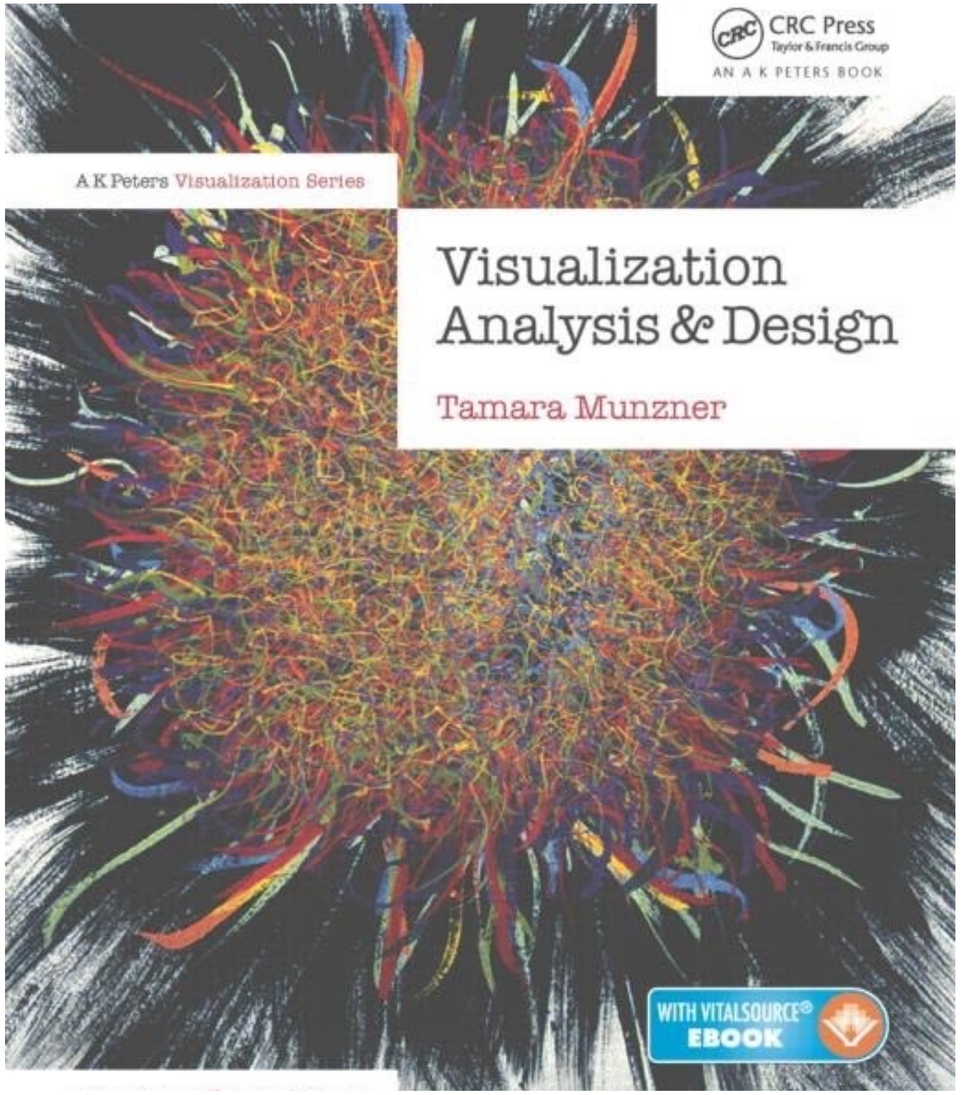
Design: Different y-axis



[S. Hayward, 2015]

Administrivia

- Course Web Site
- Syllabus
  - Plagiarism
  - Accommodations
- Textbook:
  - Required: Munzner (VAD)
- Assignments
- Exams: Midterm (Oct. 14) and Final (Dec. 9)



Administrivia

- Undergraduate (CSCI 490) and Graduate (CSCI 627)
  - Graduate: Extra reading, exam questions, project emphasis
- Research Topics:
  - Also investigate some topics in depth
  - Research papers as assigned reading (CSCI 627)
- Project: Create an interactive visualization (or vis research)
  - Design
  - Data analysis
  - Insight
  - **Presentations**: Last week of class

Exams, Quizzes, and Missed Classes

- All quizzes and exams are **in-person**, **closed-book**, and **closed-notes**
- **No makeup** quizzes or exams will be given*
- You are responsible for all material presented in class and assigned readings. If you miss a lecture, be sure to obtain class notes from a classmate before the next class meeting

Office Hours & Communication

- Office hours will be held **in person**
- Scheduled office hours are open to all students
  - M: 1:45-3pm, W: 10:45am-12pm, or by appointment
- You **do not** need an appointment to stop in during scheduled office hours
- If you need an appointment outside of those times, please email me with **details** about what you wish to discuss
- Many questions can be answered via email. **Please consider writing an email before scheduling a meeting.**
- **Do not send me screenshots of code!** (send code or Observable links)

Do not cheat!

Do not plagiarize

- It is **Academic Misconduct**
- Do your own work, do not copy anyone else's work, text, sentences, …
  - Anyone = another student, an internet source, book, blog, …
- Never quote text unless there is a specific need.
  - Usually, only famous quotes or very specific definitions
  - "I think there is a world market for maybe five computers."
    —Thomas Watson (1874-1956), Chairman of IBM, 1943)
- **Cite** sources that back up your claims or reflect the origin of an idea
  - Vertex cover is an NP-Complete problem [1]. …
    [1] Garey, M. R., and Johnson, D. S., "Computers and intractability: a guide to NP-completeness." 1979.

Do not cheat

- Cheating on assignments, projects, and exams is not allowed
- You will receive a **zero** for any assignment/exam/etc. where cheating has occurred
- You will **fail** the course if you cheat more than once
- Misconduct is reported through the university's system
- You **may** discuss problems and approaches with other students
- You **may not** copy or transcribe code from another source (includes generative AI)

Do ask questions!

Do ask questions

- If you are stuck on a specific issue with an assignment:
  - Do consult books, online documentation, tutorials
  - Do discuss that specific issue with a classmate
  - Do email me with **specific** questions
- If you are asked about a question:
  - Do not share your code
  - If the questioner is trying to cheat, walk away
  - If you see an obvious mistake, kindly point it out
  - Suggest a specific function or library that may be useful

Questions?