Communicating with Data – Visualization Fundamentals Pt. 1

Dr. Ab Mosca (they/them)

Slides based off slides courtesy of Jordan Crouser (https://jcrouser.github.io/)

Plan for Today

- A quick history lesson
- Mental models: how we process information
- Visualization building blocks
- Takeaways

Checking in

- Do you see posts on Moodle?
- Did you join the class Gradescope?
- Did you submit labo1 with your group?

Preparing for labs

- Our labs will be run using Tableau, a drag-and-drop visualization tool suite
- Tableau for Teaching has donated license keys (good for one year) for everyone enrolled in this course
- Instructions for downloading are on the next slide. Download before next class (Thursday 09/12)
- Need help? Ping me, or come to office hours

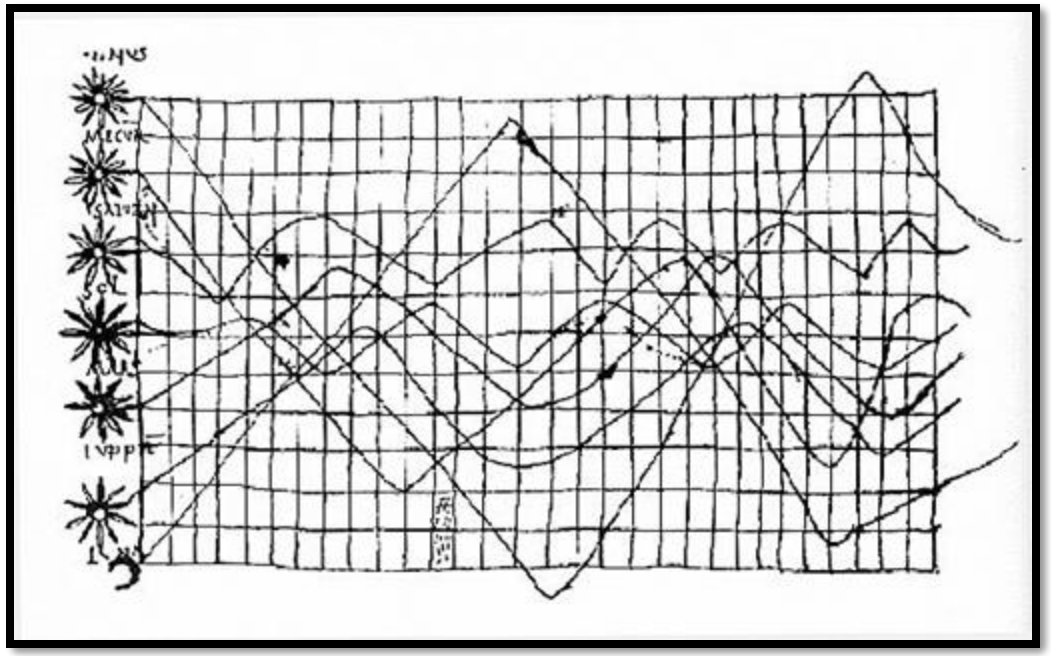
Preparing for labs

1. Download the latest version of Tableau Desktop and Tableau Prep Builder: https://www.tableau.com/tft/activation
2. Click on the link above and select "Download Tableau Desktop" and "Download Tableau Prep Builder". On the form, enter your school email address for Business E-mail and enter the name of your school for Organization.
3. Activate with your product key: TCR8-EF41-95B0-0D5E-FFAE
4. Already have a copy of Tableau Desktop installed? Update your license in the application: Help menu → Manage Product Keys

(Incomplete) History of Visualization: 15,000BC

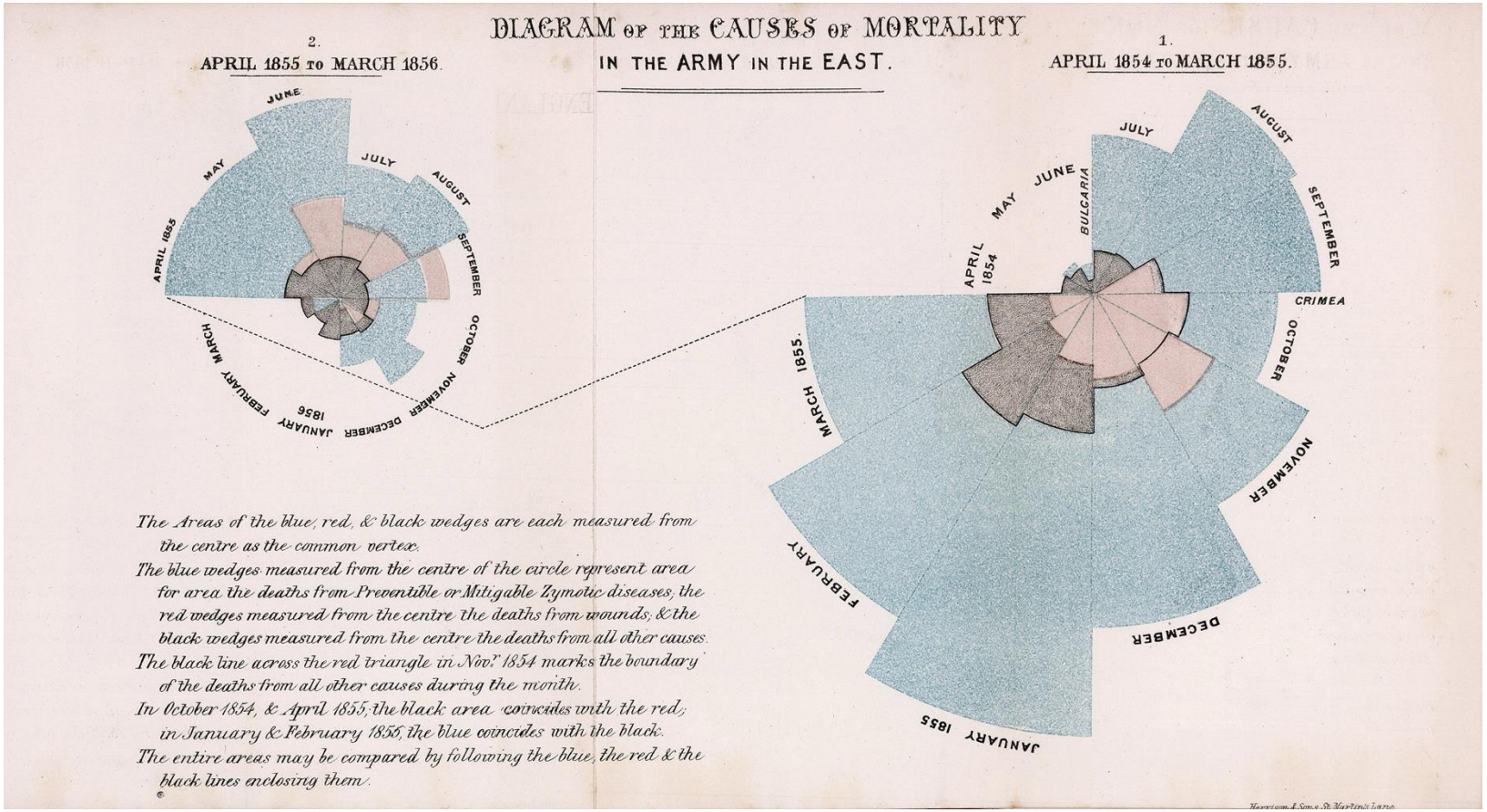
15,000 BC. Laxcaux, France

(Incomplete) History of Visualization: 900s



- Oldest known attempt to show changing values graphically
- Inclinations of the planetary orbits over time

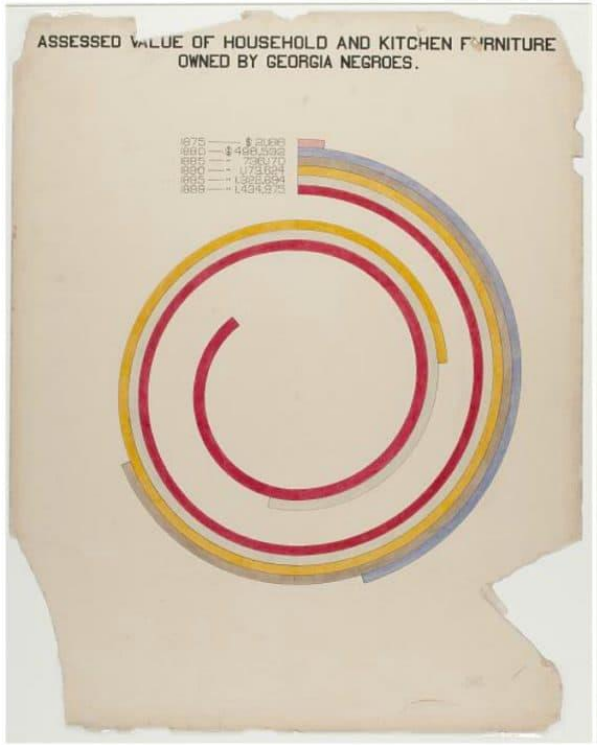
(Incomplete) History of Visualization: mid-1800s

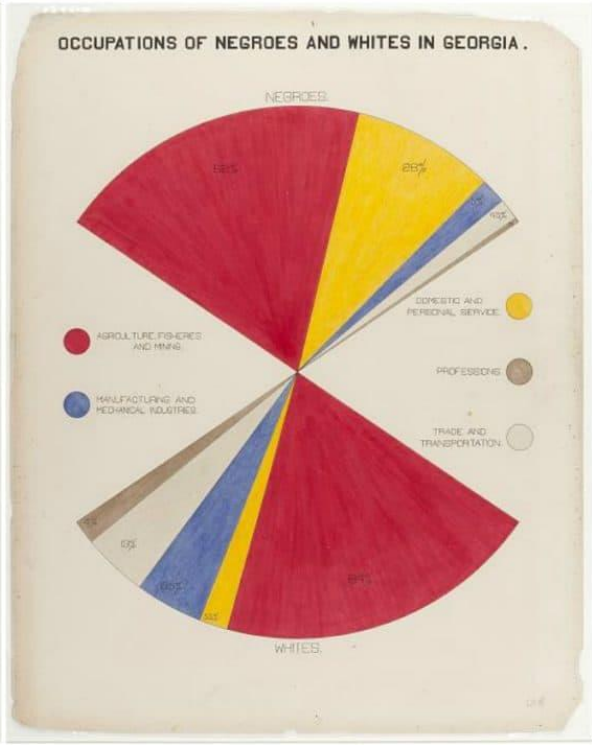


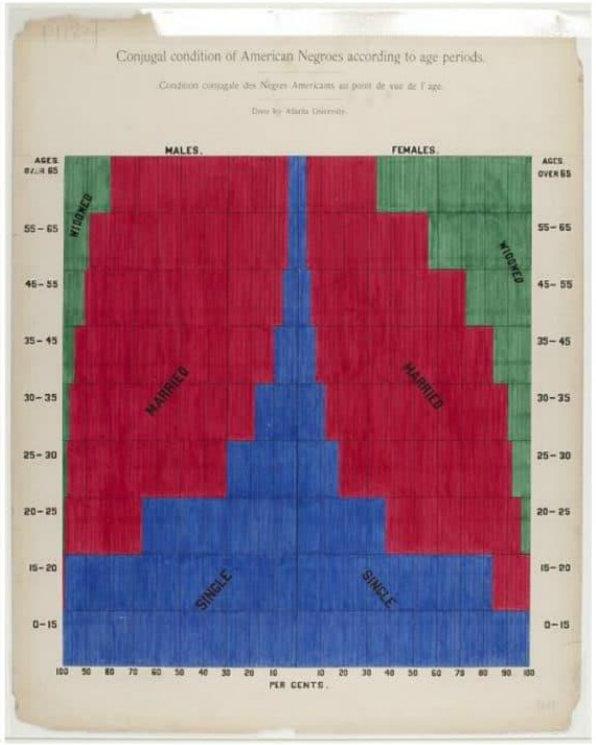
- Florence Nightingale
- Statistician, early adopter of visualization, founder of modern nursing
- Used this visualization to argue for better sanitary practices

https://en.wikipedia.org/wiki/Florence_Nightingale

(Incomplete) History of Visualization: mid-1800s



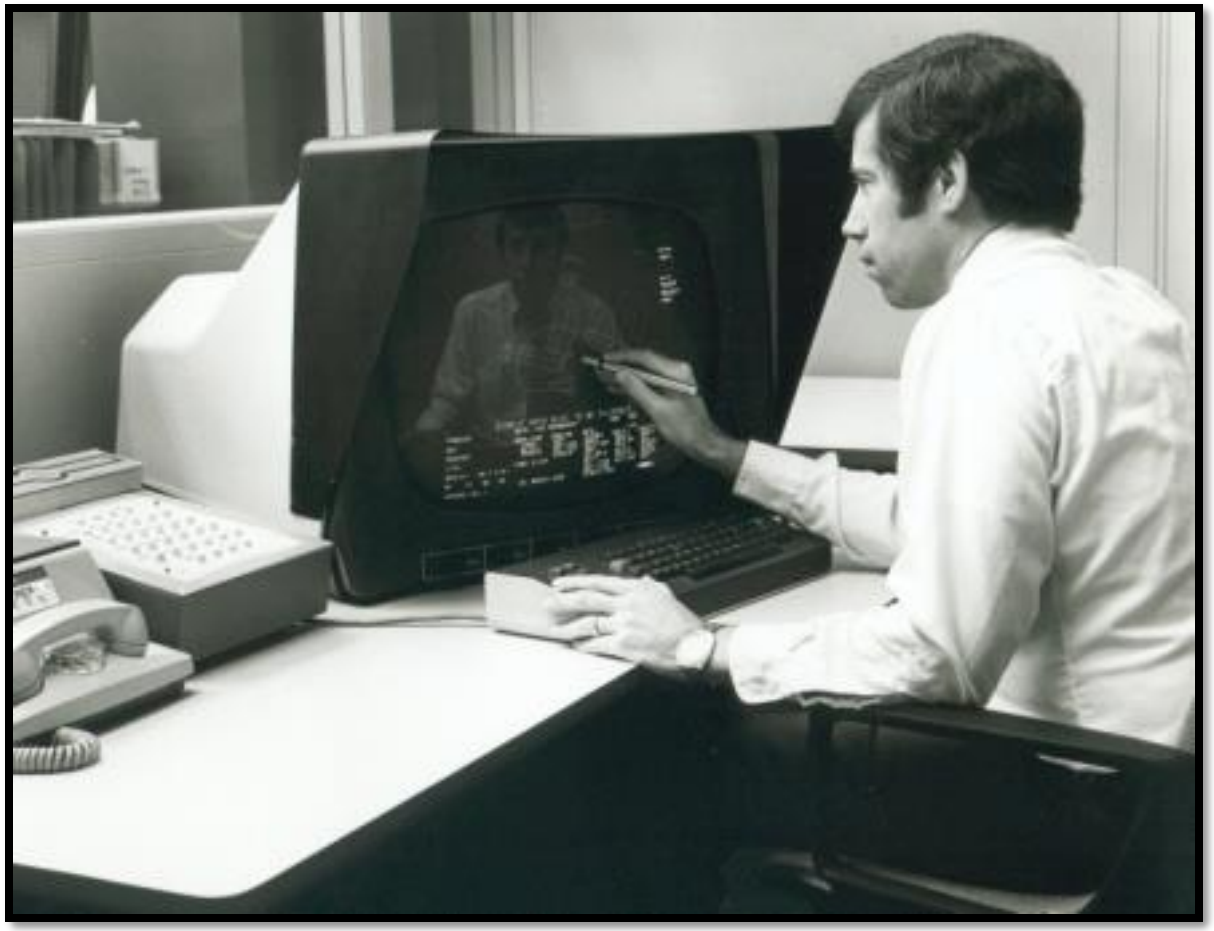




- W.E.B. Du Bois
- Sociologist
- "Data Portraits" were displayed at the Paris Exposition in 1900 to challenge norms and show how Black folks fit into American progress

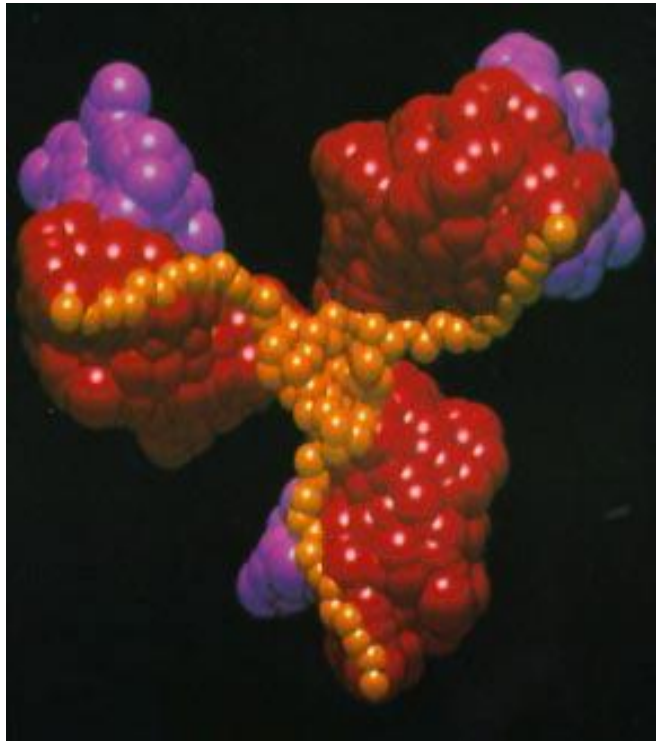
https://www.wbur.org/news/2019/02/21/web-du-bois-infographics-humanity-african-american

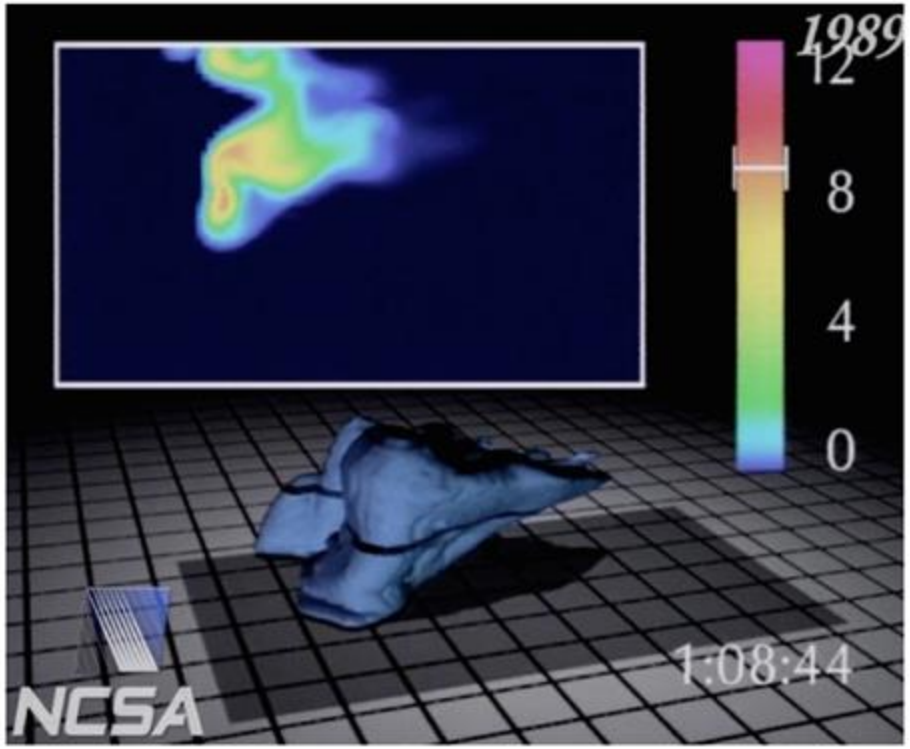
(Incomplete) History of Visualization: 1970s



- CAD/CAM, building cars, planes, chips
- Starting to think about: 3D, animation, edu, medicine

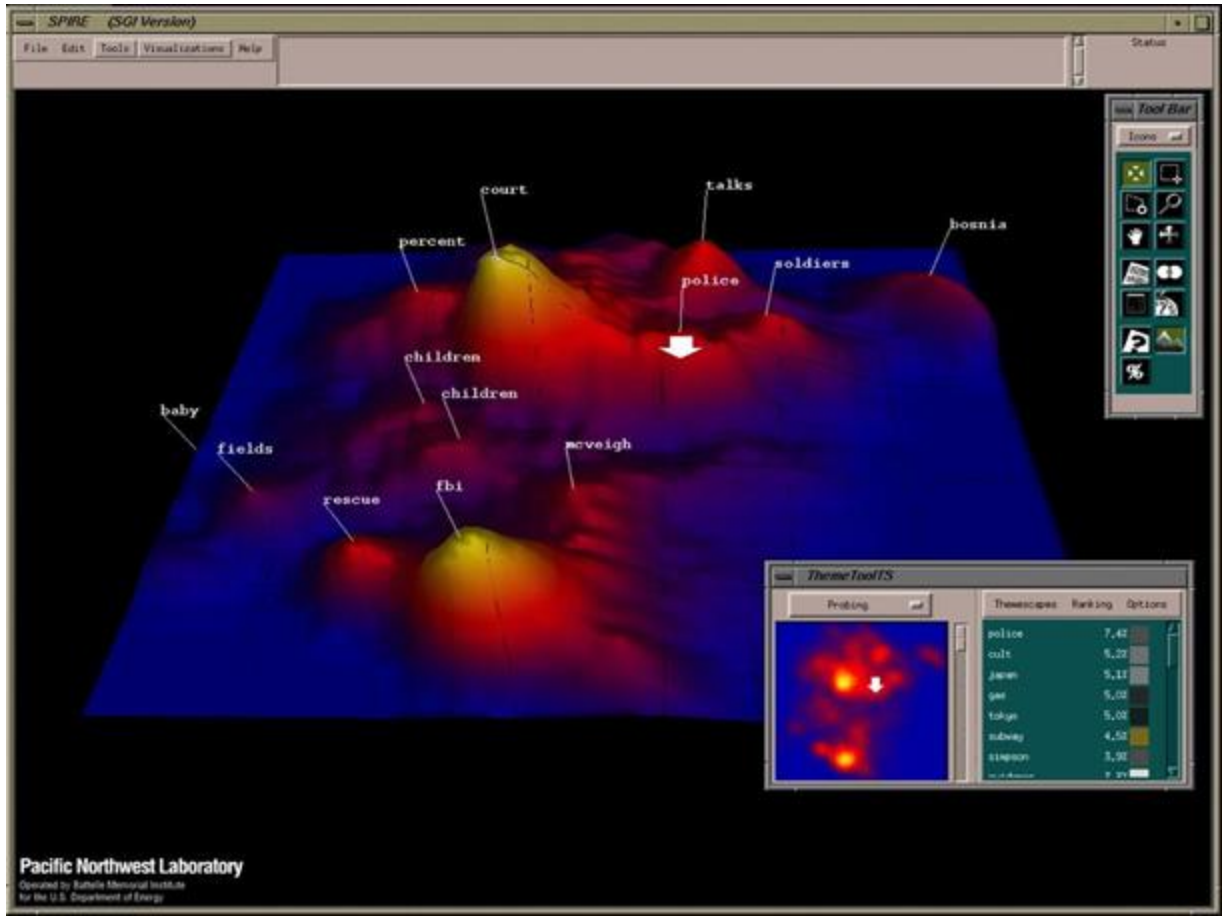
(Incomplete) History of Visualization: 1980s





- Scientific visualization, physical phenomena
- Starting to think about: photorealism, entertainment

(Incomplete) History of Visualization: 1990s

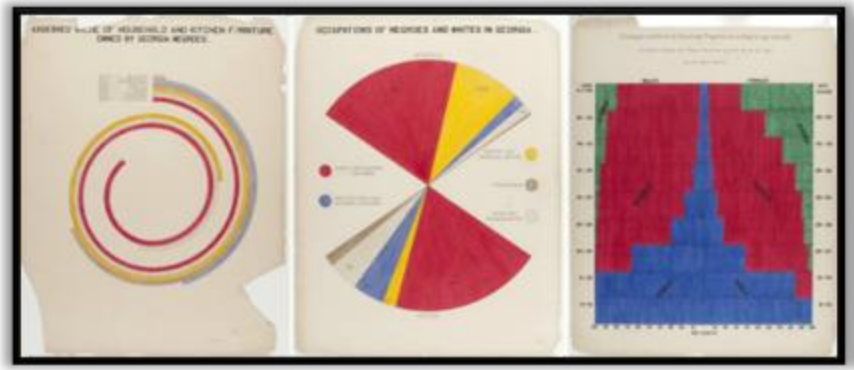


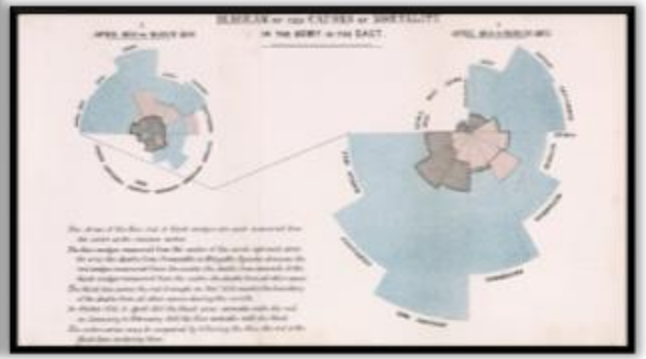
- Information visualization, storytelling
- Starting to think about: online spaces, interaction

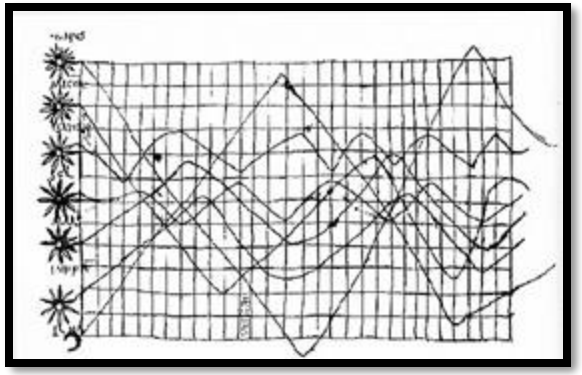
(Incomplete) History of Visualization: 2000s

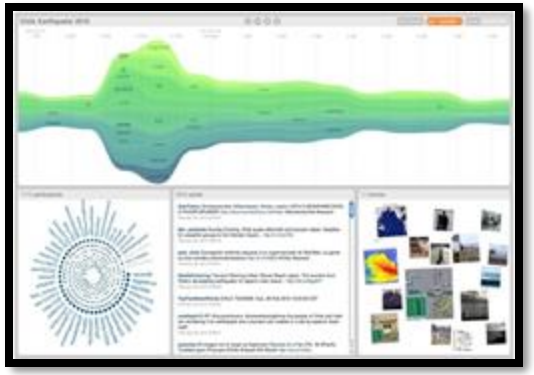
- Coordination across multiple views, interaction
- Starting to think about: sensemaking, provenance

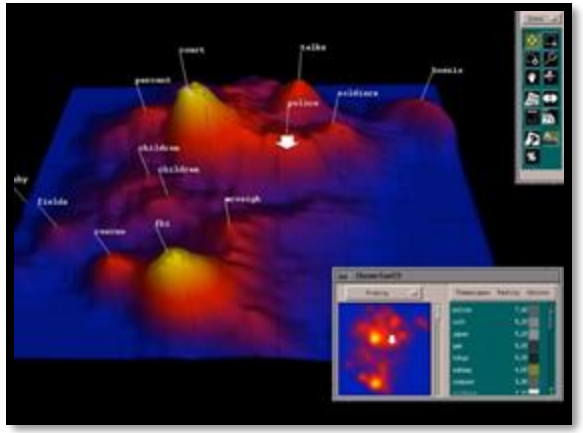
Discussion: what are they all trying to do?

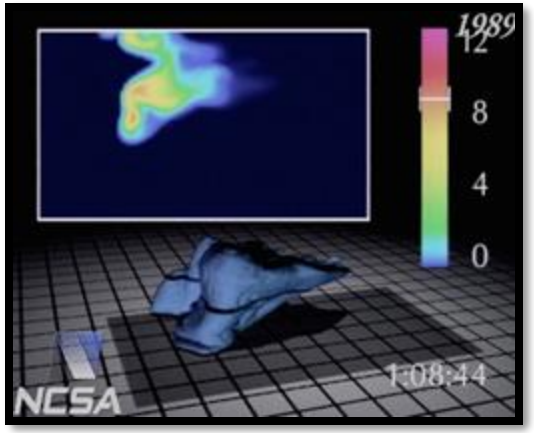




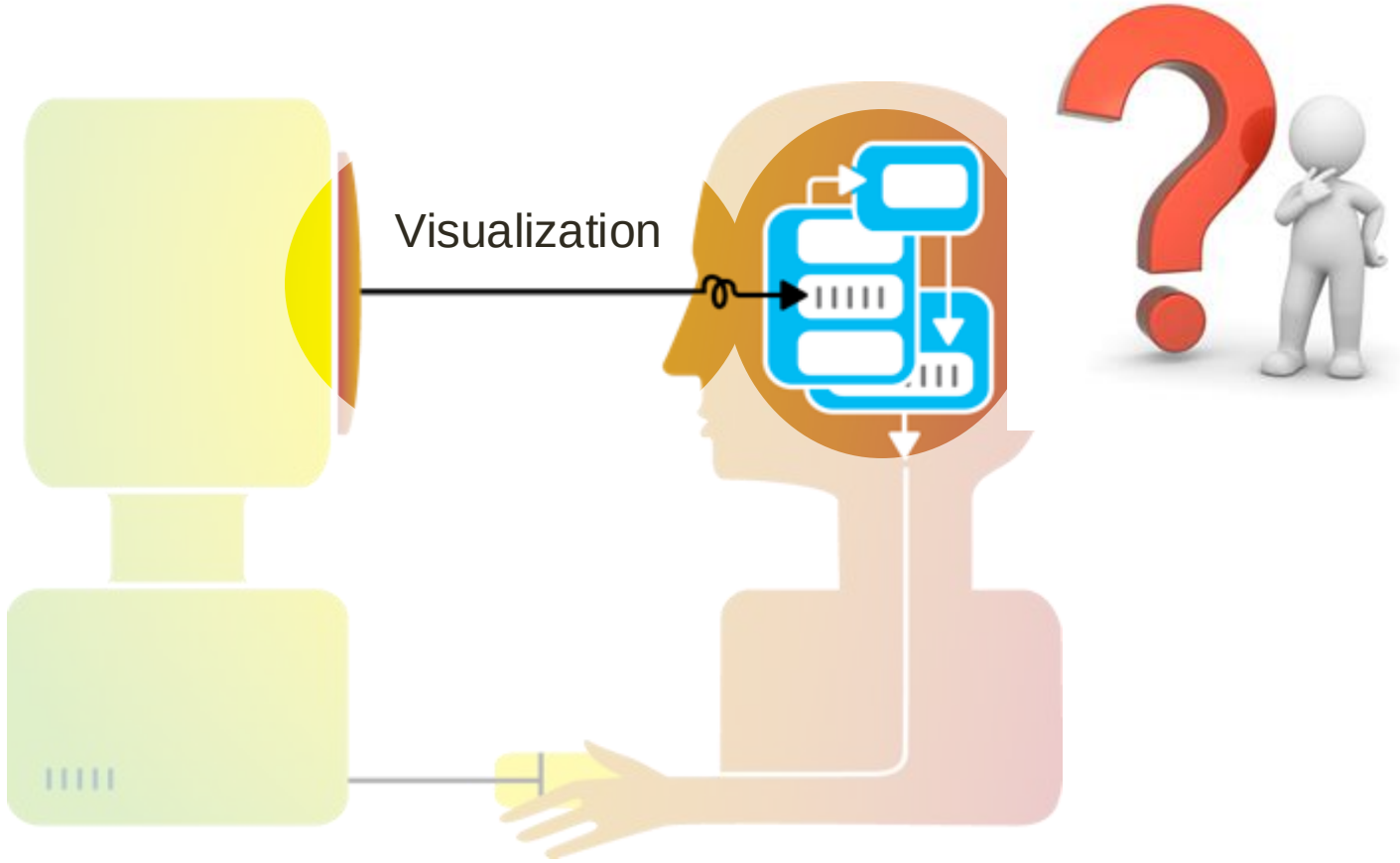




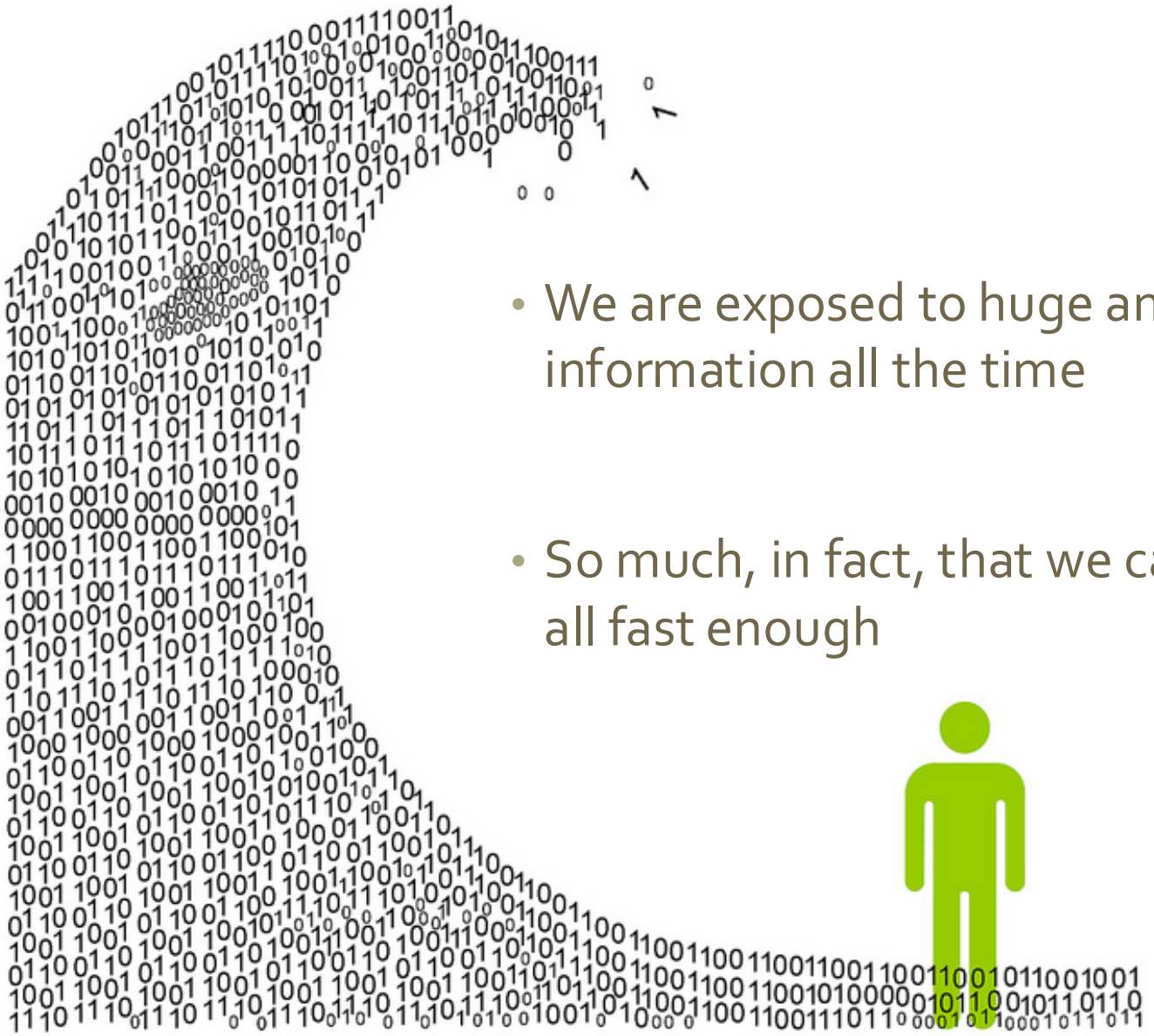




Visualization helps shape *mental models*



Information overload



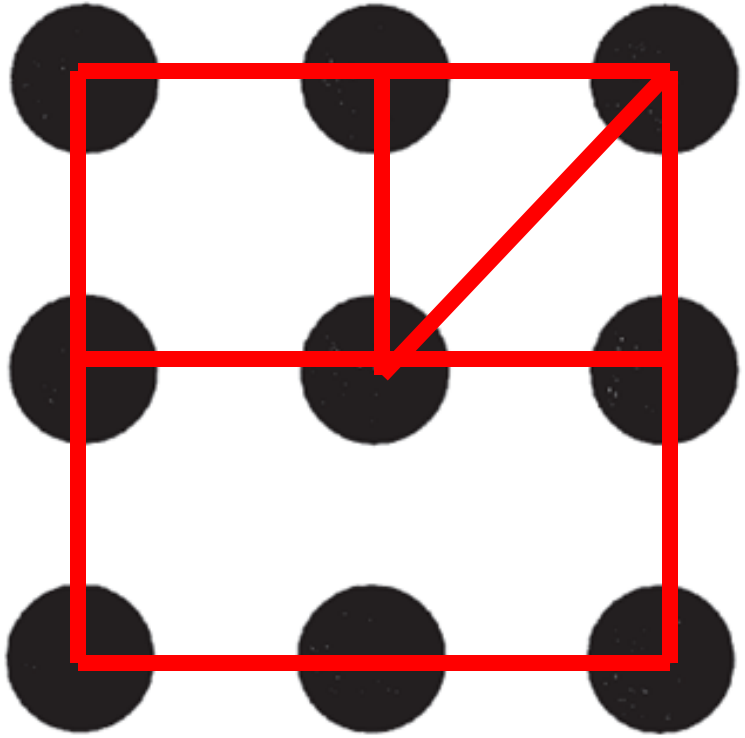
- We are exposed to huge amounts of information all the time
- So much, in fact, that we can't process it all fast enough

Mental models

To cope, we construct **mental models:** abstracted, simplified versions of the world that are more manageable

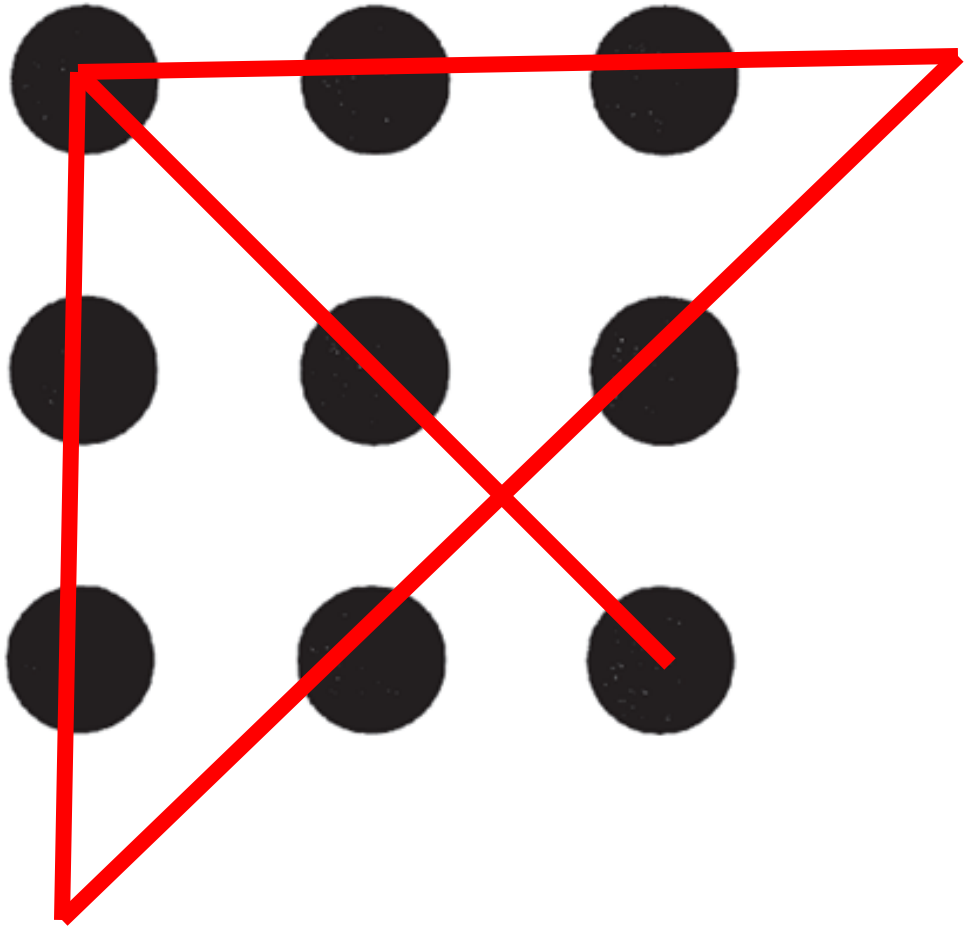
The 9-dot problem

Task 1: Connect all 9 dots using only straight lines



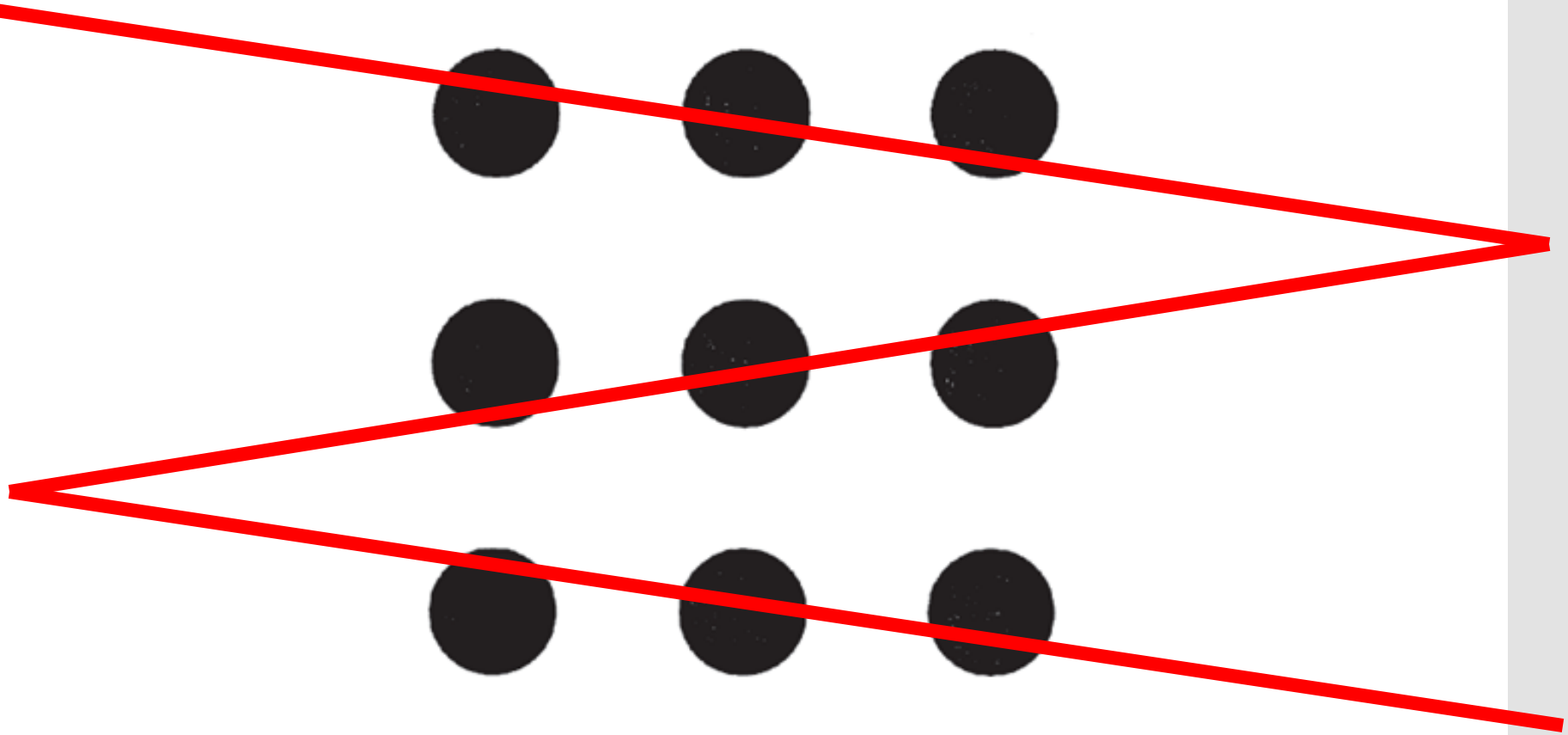
The 9-dot problem

Task 2: Connect all 9 dots using 4 straight lines



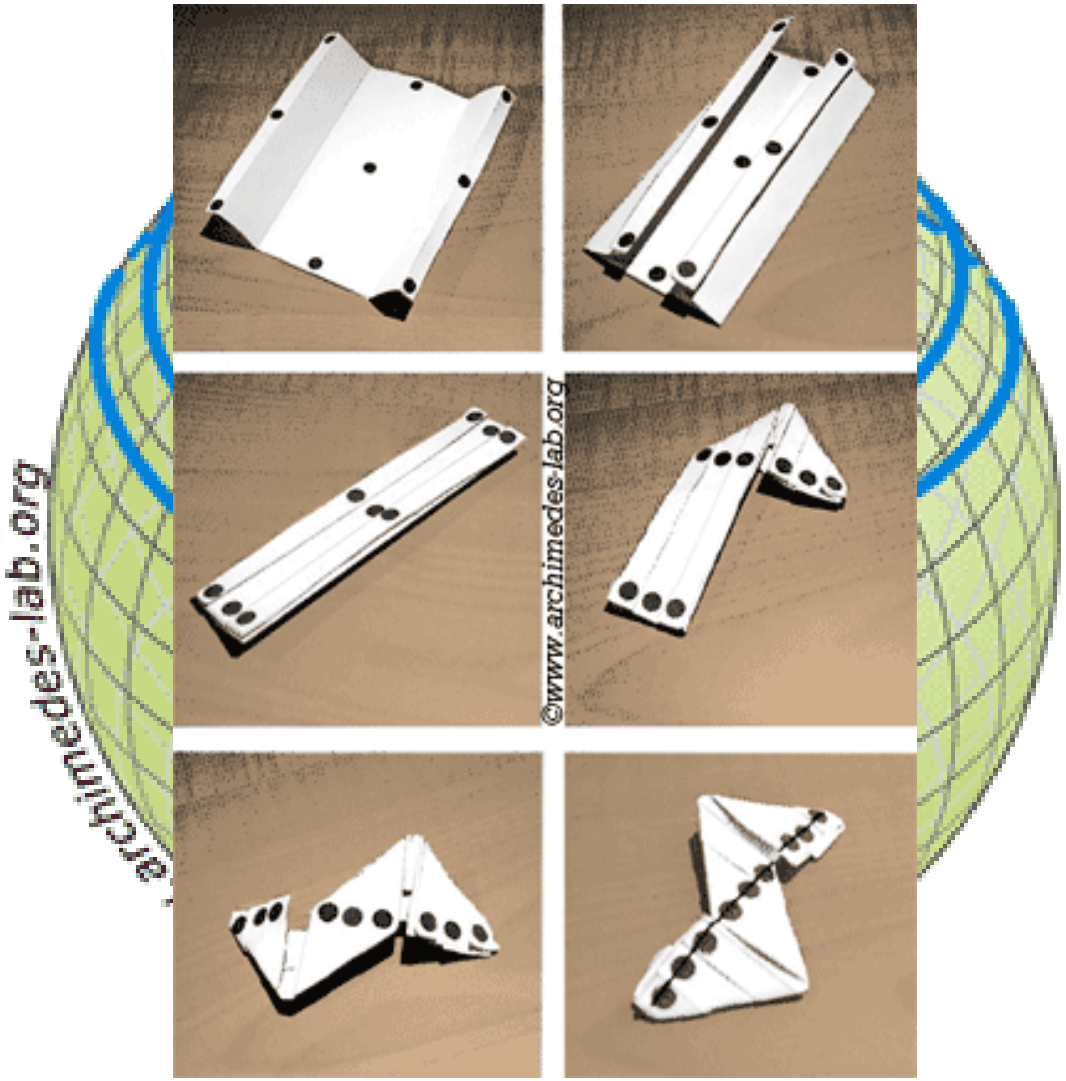
The 9-dot problem

Task 3: Connect all 9 dots using 3 straight lines



The 9-dot problem

Task 4: Connect all 9 dots using 1 straight line



Mental Models: a Sketch

Mental Models

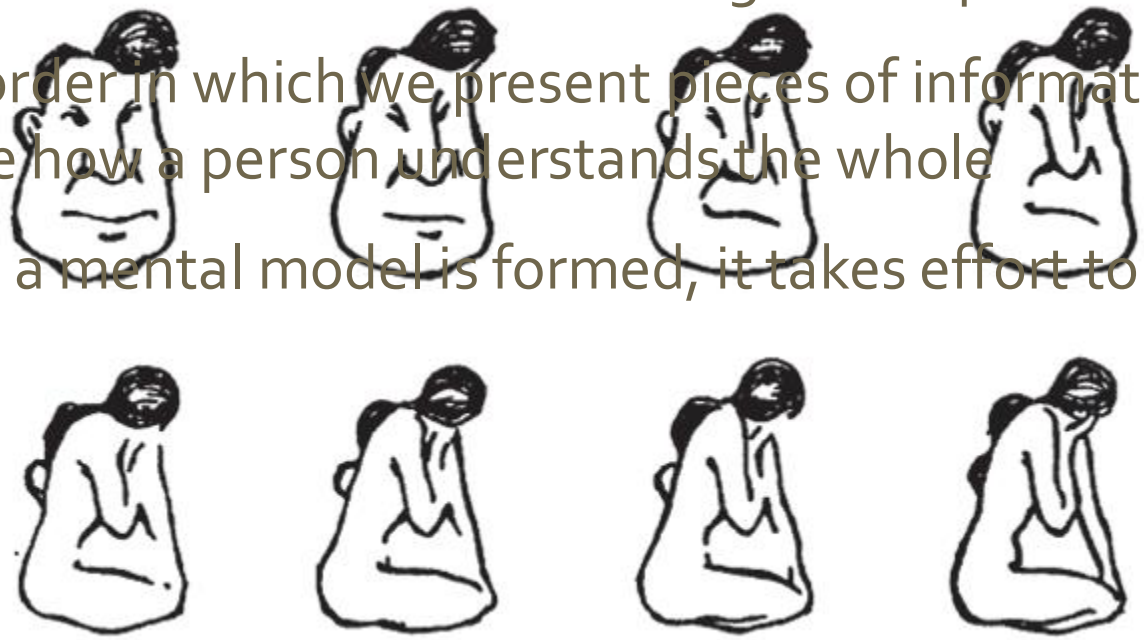
1. We tend to see what we expect to see

- Mental models are built from prior experience
- We expect new input to "fit" the existing model
- Updates are **expensive**: given input that almost fits, we'll distort information to avoid re-fitting the model
- **Expectation** is at least as strong as perception

Mental Models

2. Mental models form quickly, & update slowly

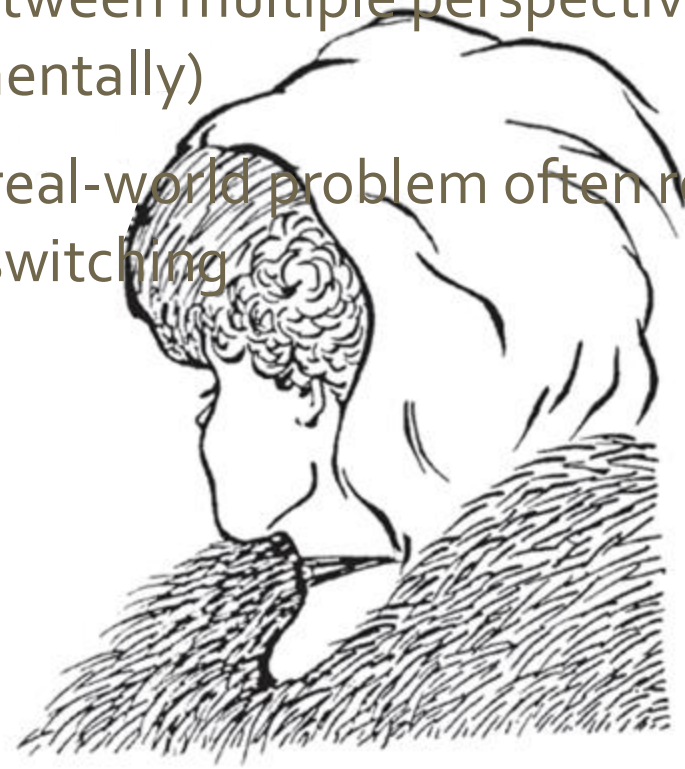
- "First impressions matter"
- Early information can have the highest impact
- The order in which we present pieces of information can shape how a person understands the whole
- Once a mental model is formed, it takes effort to alter it



Mental Models

3. New information gets incorporated into the existing model

- Integrating competing perspectives is challenging
- Switching between multiple perspectives is also difficult (visually or mentally)
- **Tricky part**: real-world problem often require such perspective switching



Mental Models

4. Initial exposure interferes with accurate perception

Blur size

128px
64px
32px
16px
8px
None

Mental Models

4. Initial exposure interferes with accurate perception

- Longer exposure to ambiguous data makes people **more confident** in their initial model
- This is true even if new data presents strong evidence that their model is **wrong**!
- Important: need to be intentional when we design, because incremental information can be **misleading**

Mental Models

The good:

- Well-tuned mental models let us process information quickly
- Frees up more processing power to synthesize information

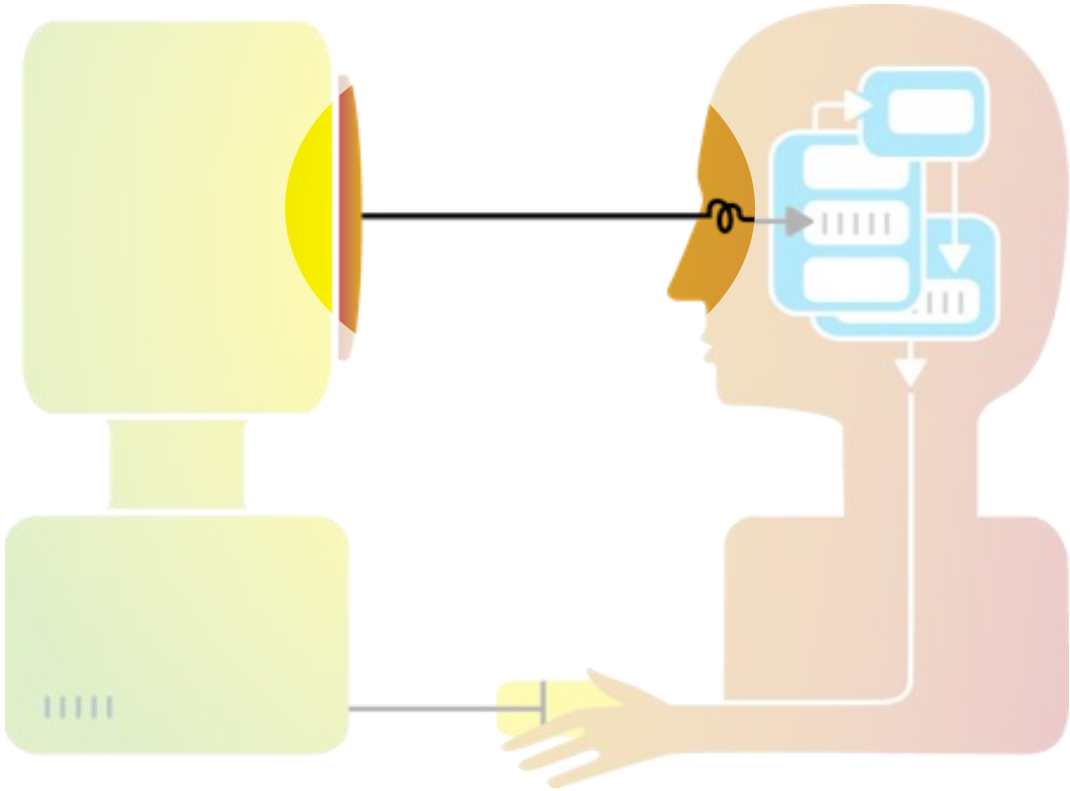
The bad:

- People (esp. experts) tend not to notice information that contradicts their mental model
- A "fresh pair of eyes" can be beneficial

The ugly:

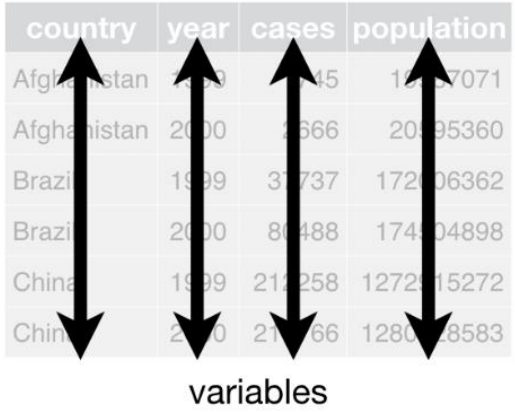
- Mental models are unavoidable: everyone has them, and they're all different
- **Key:** be aware of how mental models form, how they shape perception, and how to support (or challenge) them

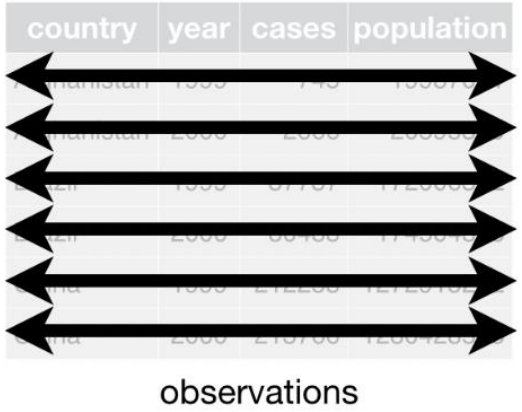
So what do we have to work with?

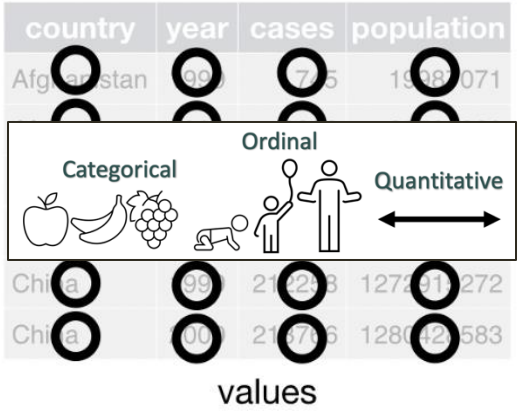


Data

- Remember…







Data → Visuals

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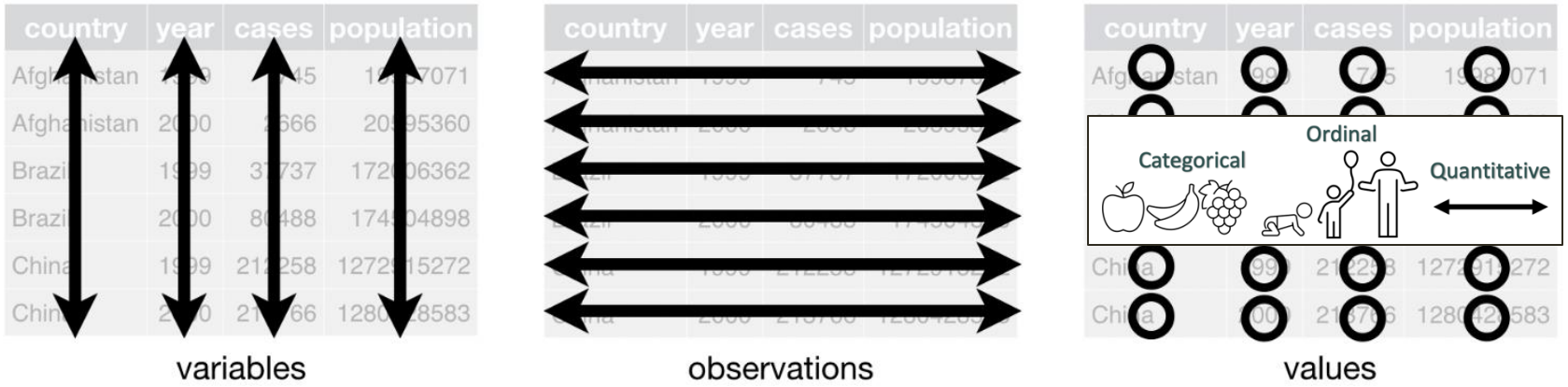
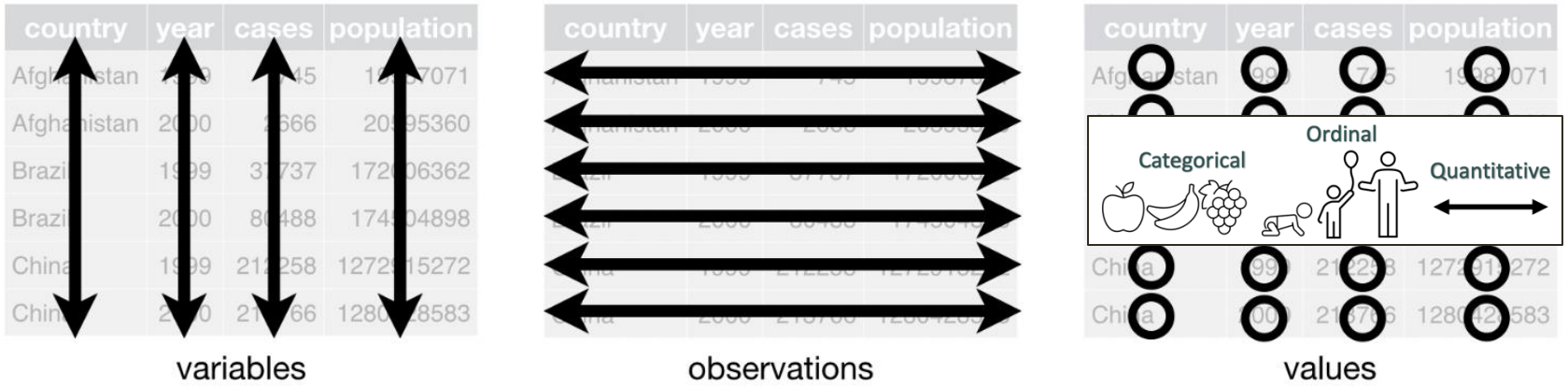


- **Big idea behind visualization**
  - Data have dimensions
  - Visualizations have dimensions, too
  - To build good visualizations, we need to **map data dimensions to visual dimensions** in a principled way

Data → Visuals

- Remember…



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Data → Visuals

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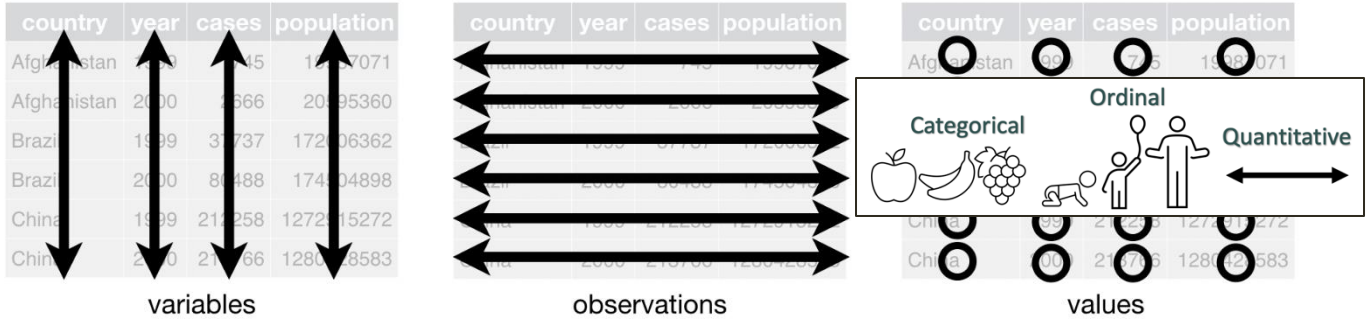
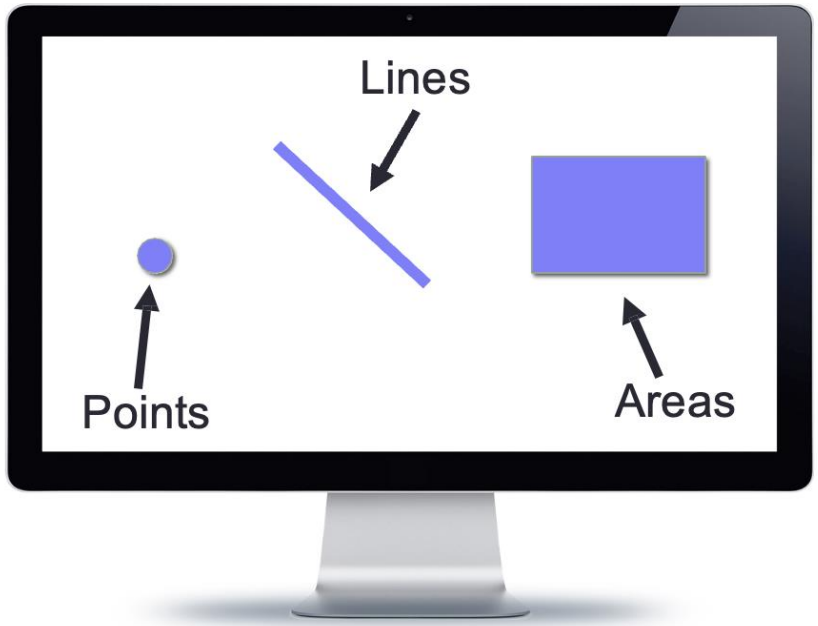


Visuals

- **Marks**
  - The "ink"



Data → Visuals

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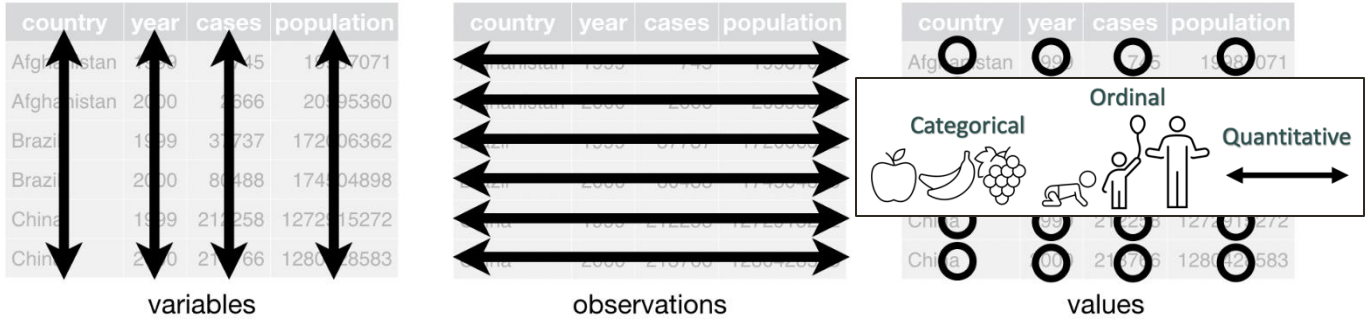

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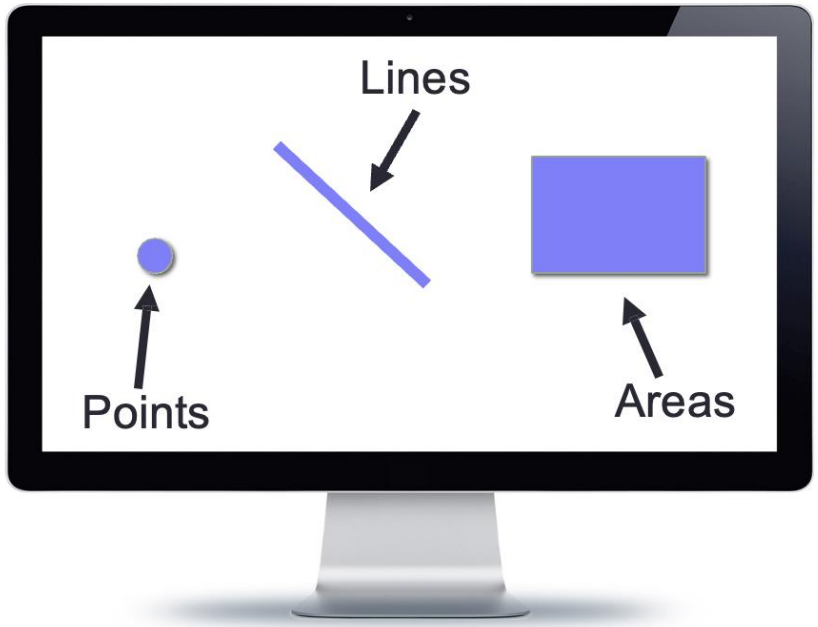
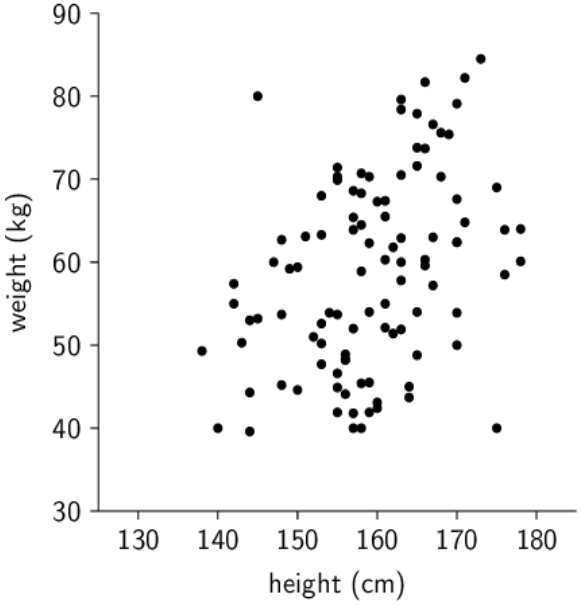


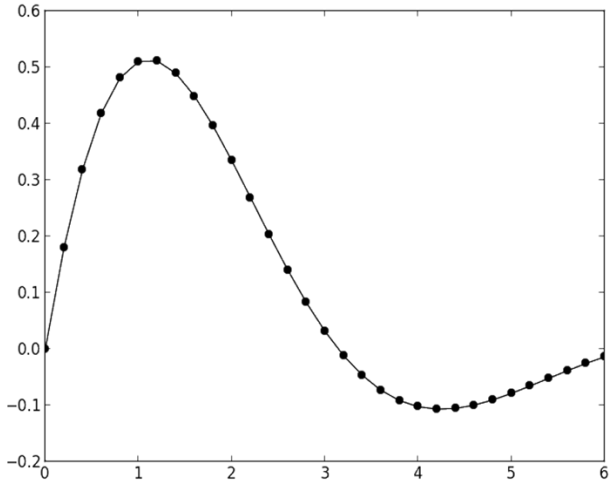
- **Channels or dimensions**
  - *How* the marks show up on the page

Visual Channels / Dimensions

Position

- Encode information using *where* mark is drawn
- Ex.

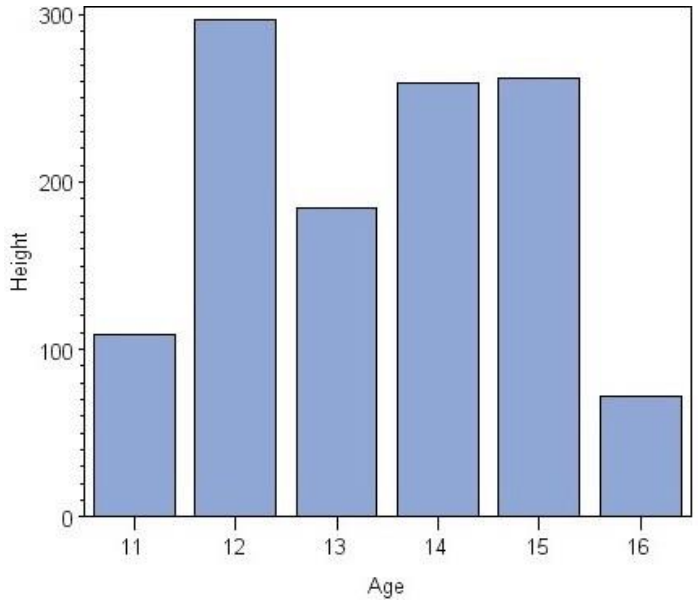


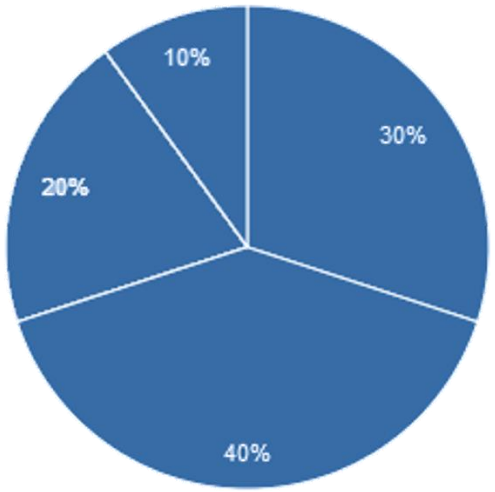


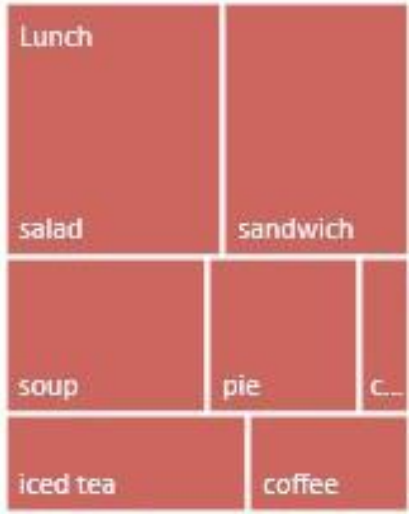
Visual Channels / Dimensions

Size

- Encode information using *how big* mark is drawn
- Ex.



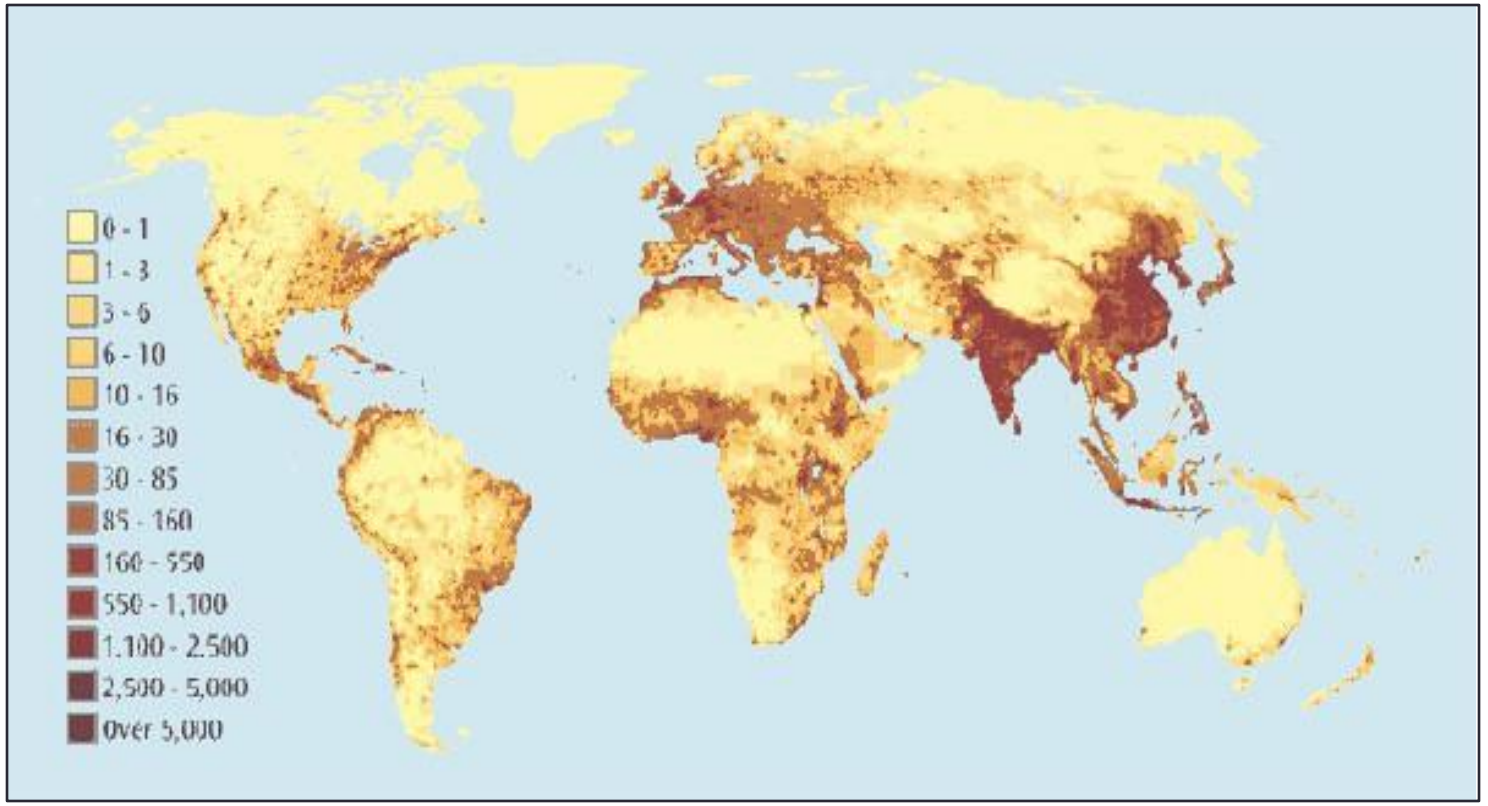




Visual Channels / Dimensions

Value

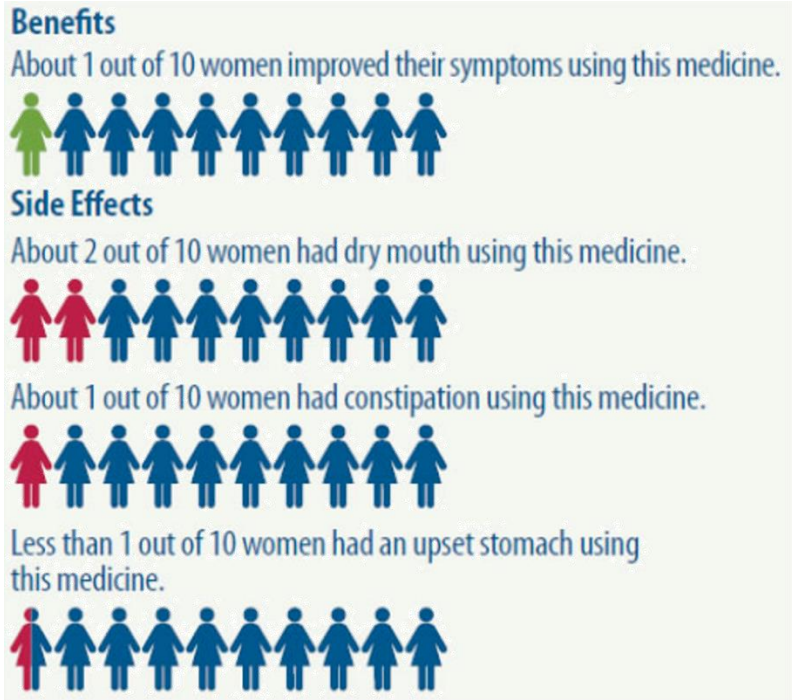
- Encode information using *how dark* mark is drawn
- Ex.

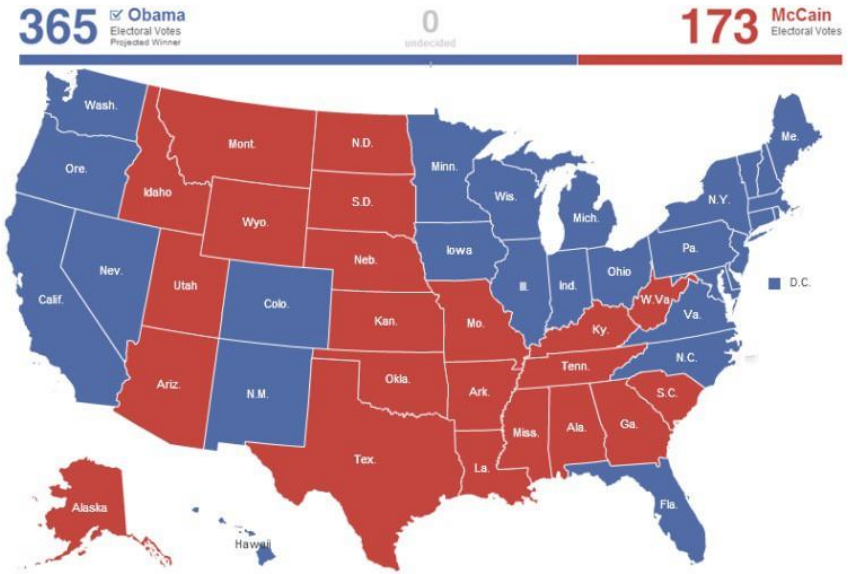


Visual Channels / Dimensions

Color

- Encode information using *hue* of mark
- Ex.

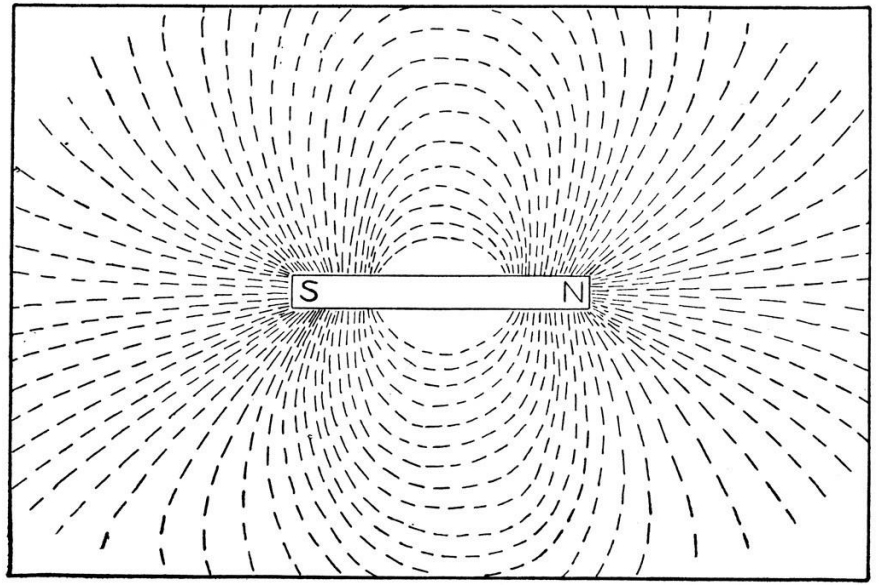




Visual Channels / Dimensions

Orientation

- Encode information using how mark is *rotated*
- Ex.



Visual Channels / Dimensions

Shape

- Encode information using how mark is *shaped*
- Ex.

Data → Visuals

- Remember… **Big idea behind visualization**
  - Map data dimensions to visual dimensions in a principled way

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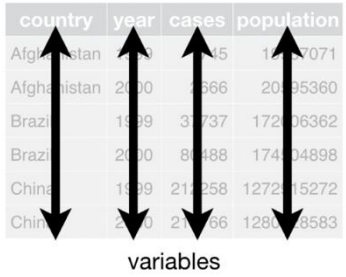
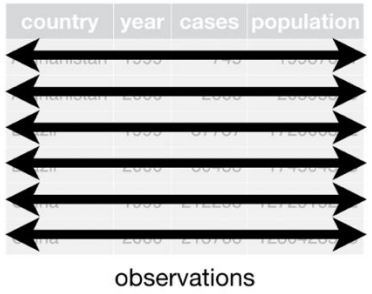
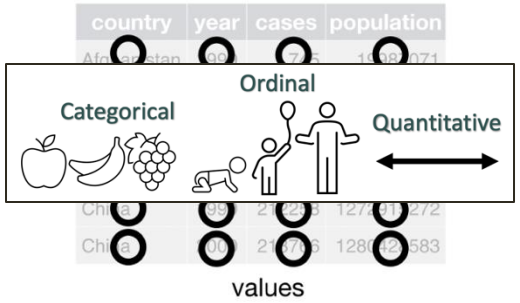
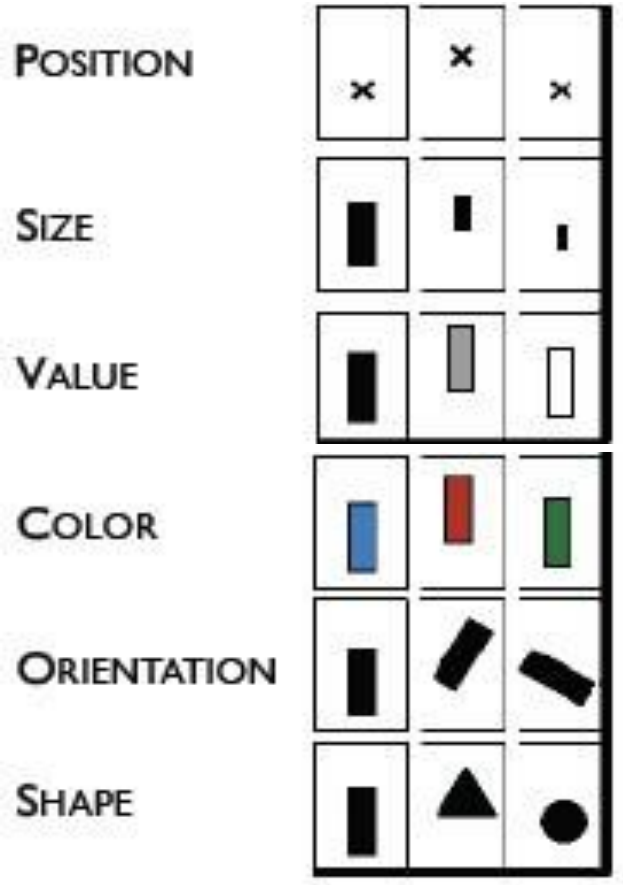


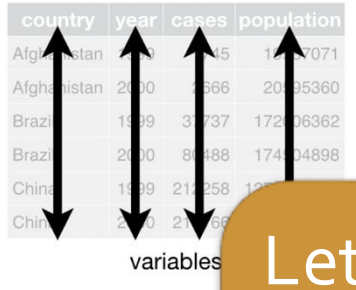


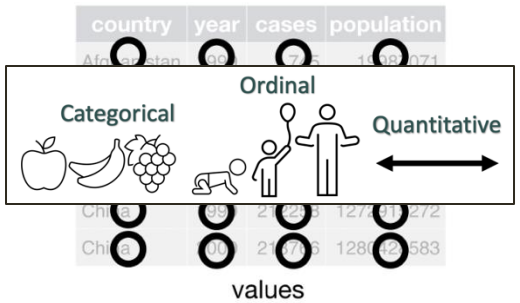




Data → Visuals

- Remember… **Big idea behind visualization**
  - Map data dimensions to visual dimensions in a principled way





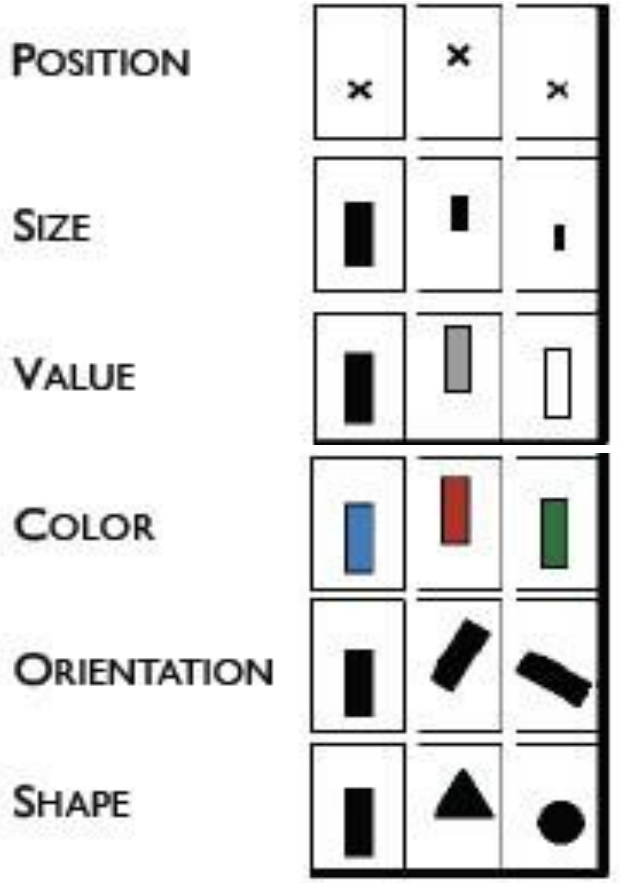
Let's experiment. Pair up with 2 other people for the next activity and find a spot on the board.

Work with your group to represent each observation in this dataset as a point (mark) styled using the visual channel you were assigned.

Be prepared to share with the class.

Data → Visuals

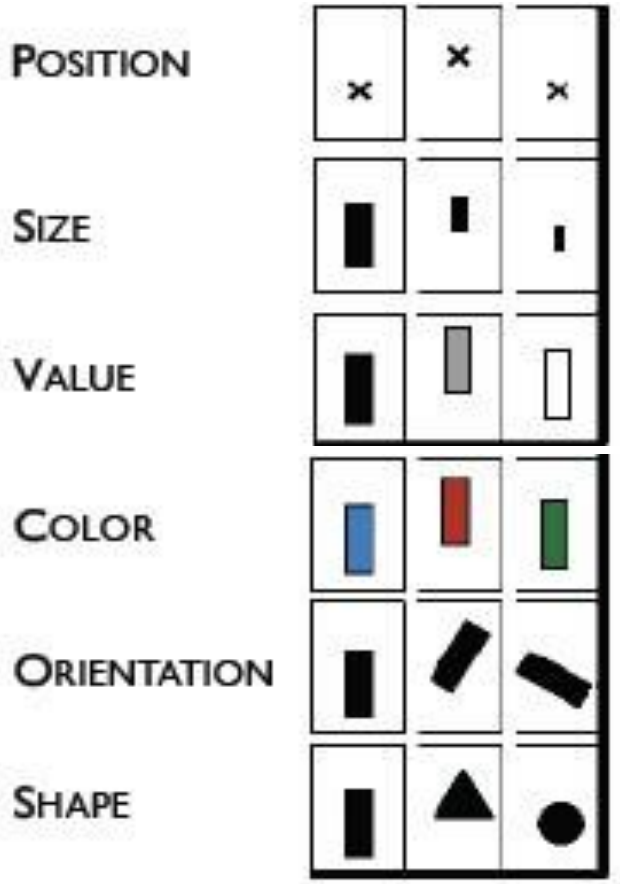
Name
blueberry
asparagus
pumpkin



Data → Visuals

What type of variable is Name?

Name
blueberry
asparagus
pumpkin

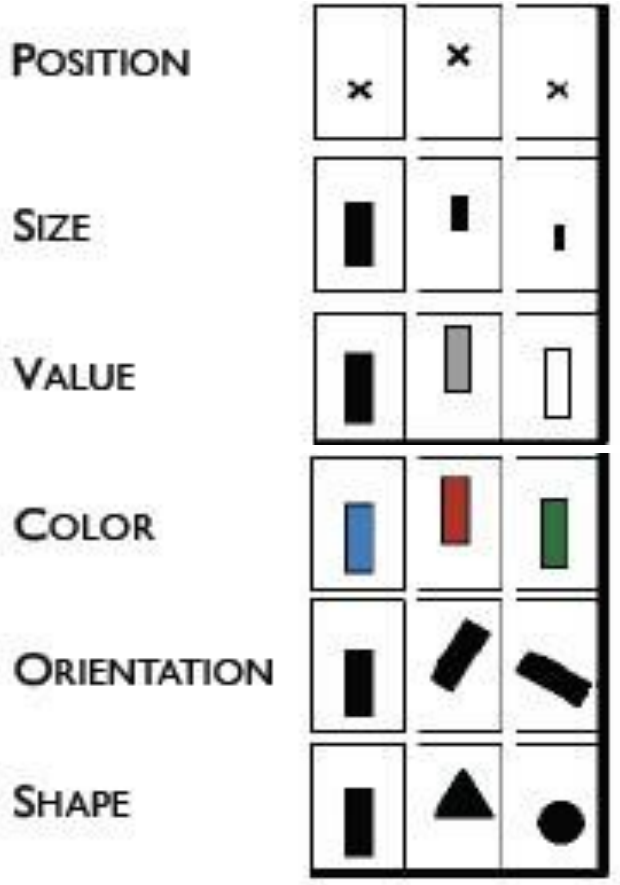


Work with your group to represent each observation in this dataset as a point (mark) styled using the visual channel you were assigned.

Be prepared to share with the class.

Data → Visuals

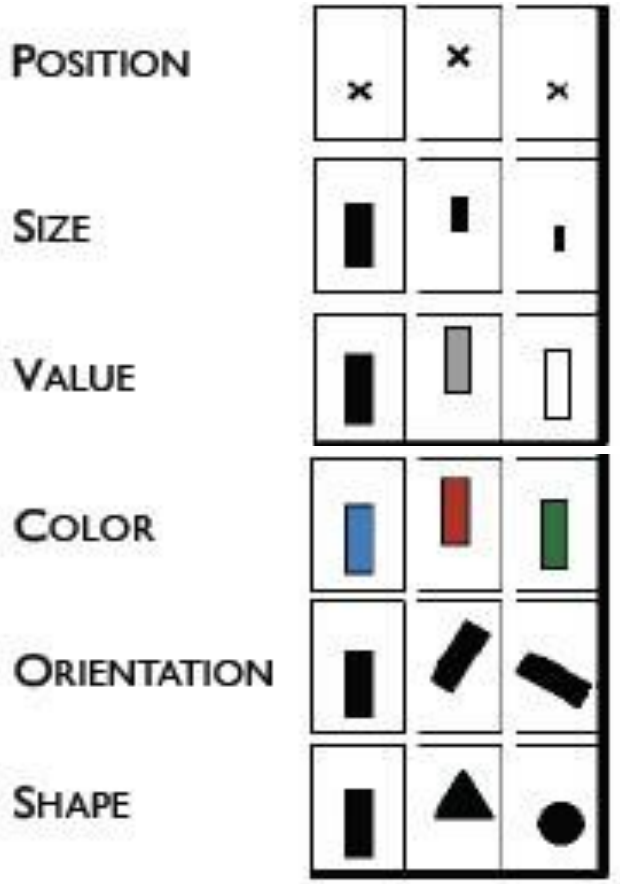
Season
summer
spring
fall



Data → Visuals

What type of variable is Season?

Season
summer
spring
fall

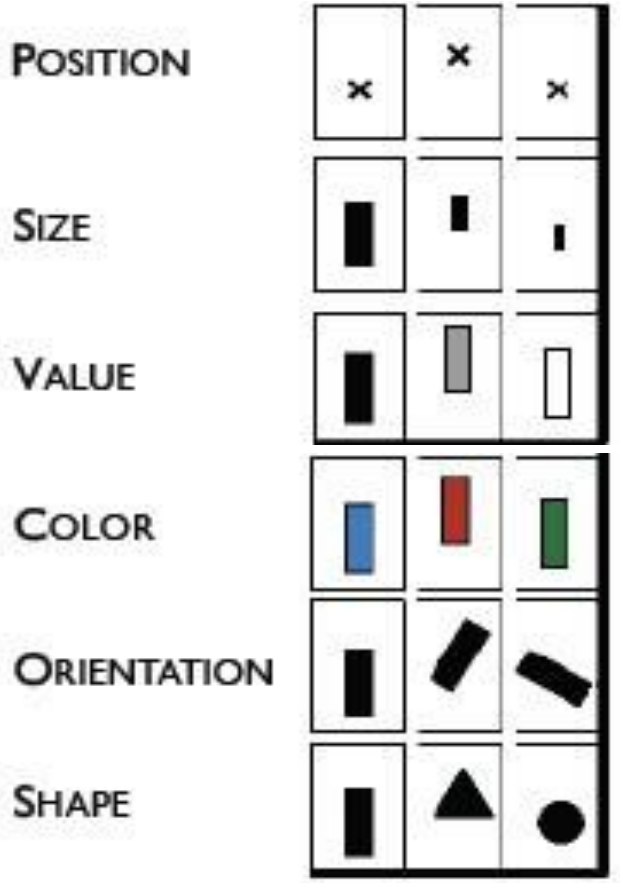


Work with your group to represent each observation in this dataset as a point (mark) styled using the visual channel you were assigned.

Be prepared to share with the class.

Data → Visuals

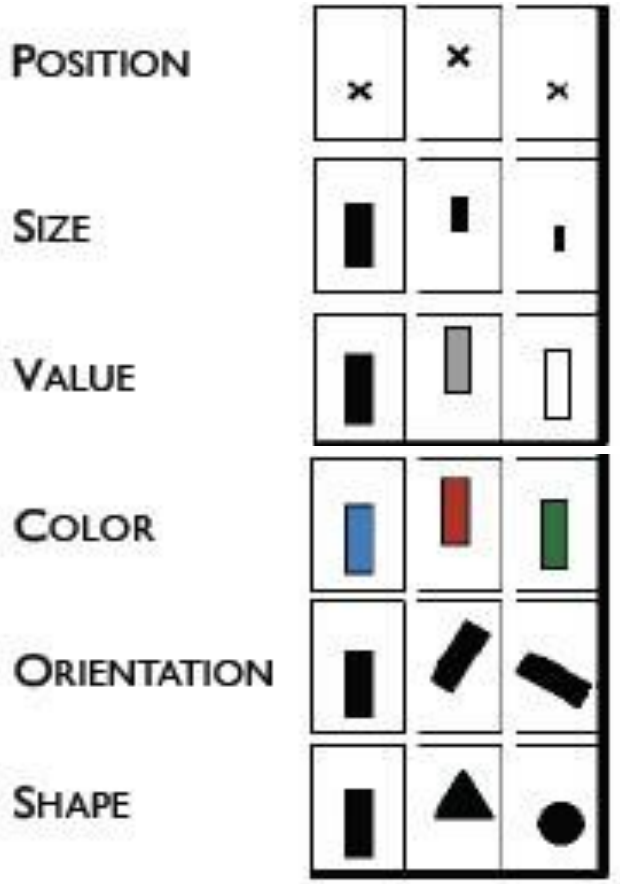
Price (per lb)
6.45
4.99
0.24



Data → Visuals

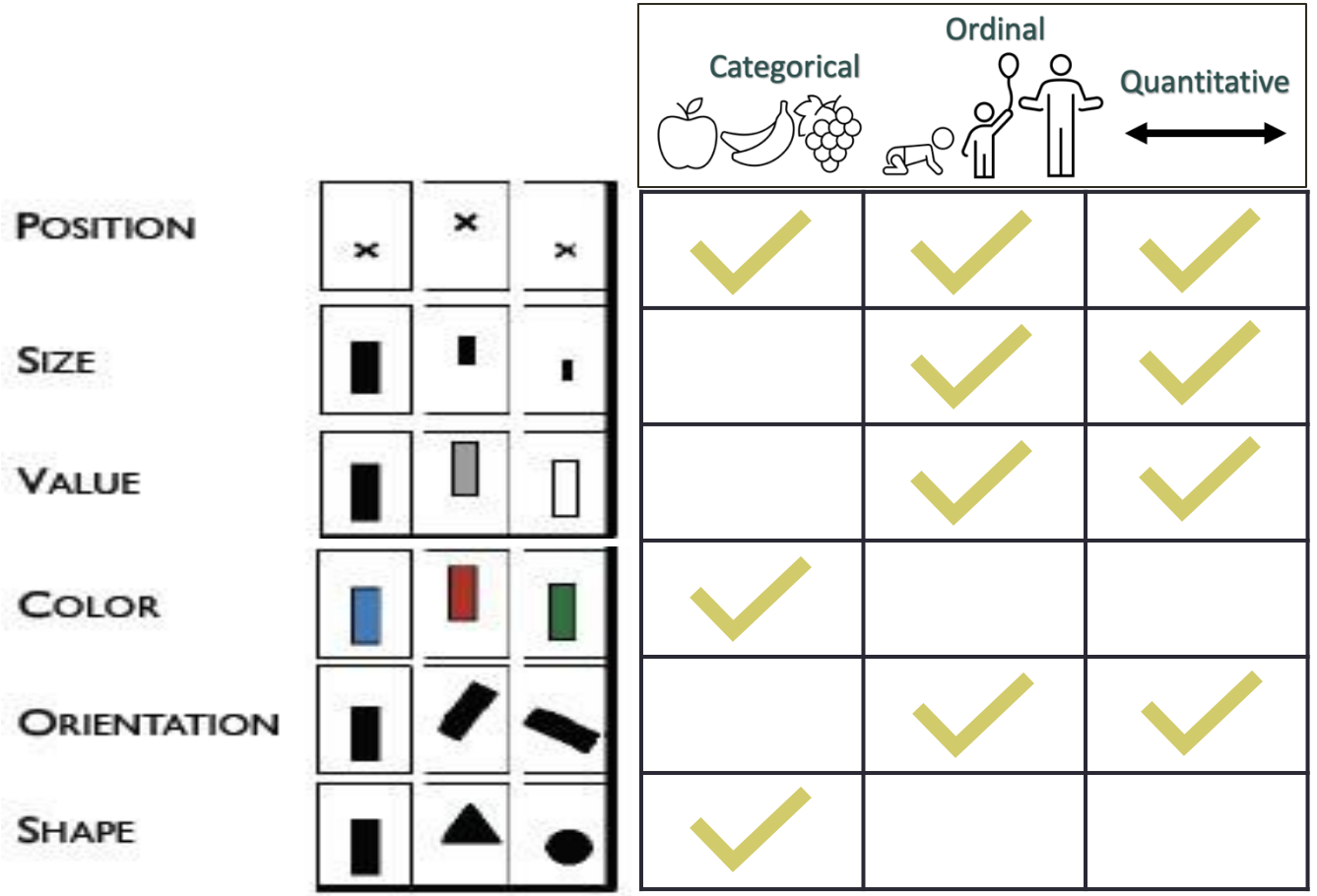
What type of variable is Price?

Price (per lb)
6.45
4.99
0.24



Data → Visuals

- Remember… **Big idea behind visualization**
  - Map data dimensions to visual dimensions in a principled way
  - Not all visual dimensions can represent all data types



Jacques Bertin, *Semiologie Graphique* (Semiology of Graphics), 1967.

Try it out!

- Work with 2 other people. Be prepared to share your work with the class.
- Find a data visualization you think is interesting
  - Some ideas: New sites, government sites, Tableau, massvis.mit.edu
  - Write down what you chose on the board so we don't get repeats!
- Identify the following:
  - What is the data that's being visualized?
  - Where did the data come from?
  - What marks and channels are used in the visualization?
  - What data dimensions do the marks and channels represent?
  - What do you learn from looking at the visualization?
  - What additional questions do you have?