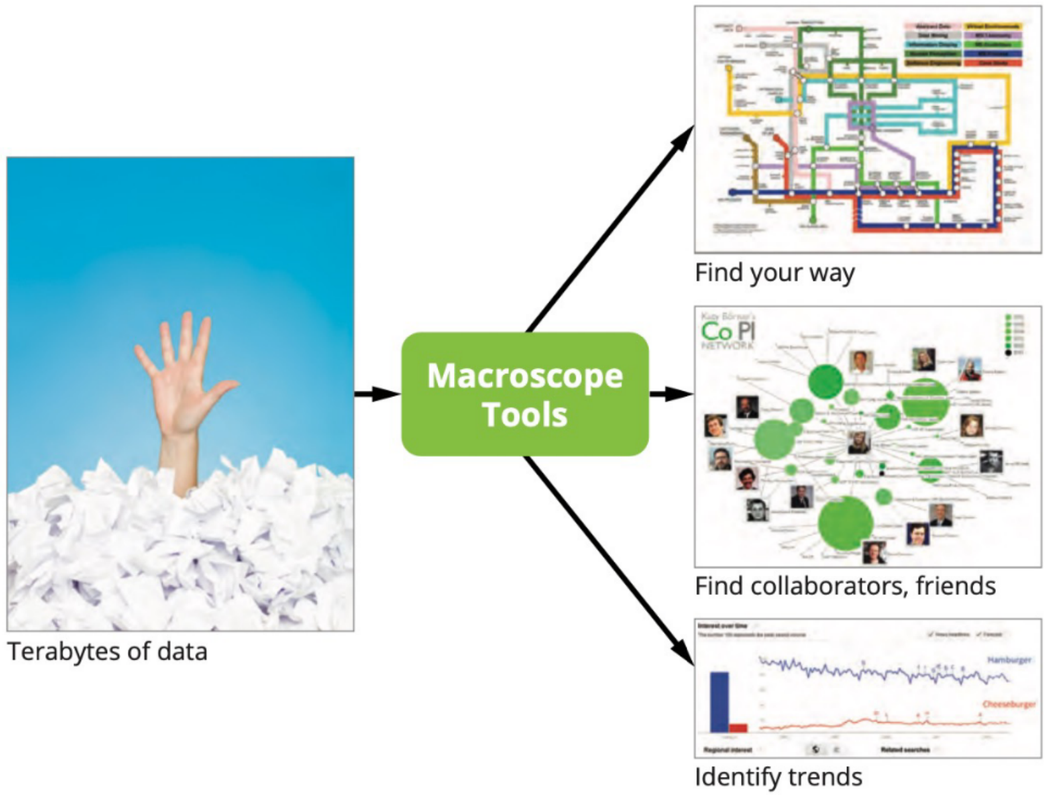
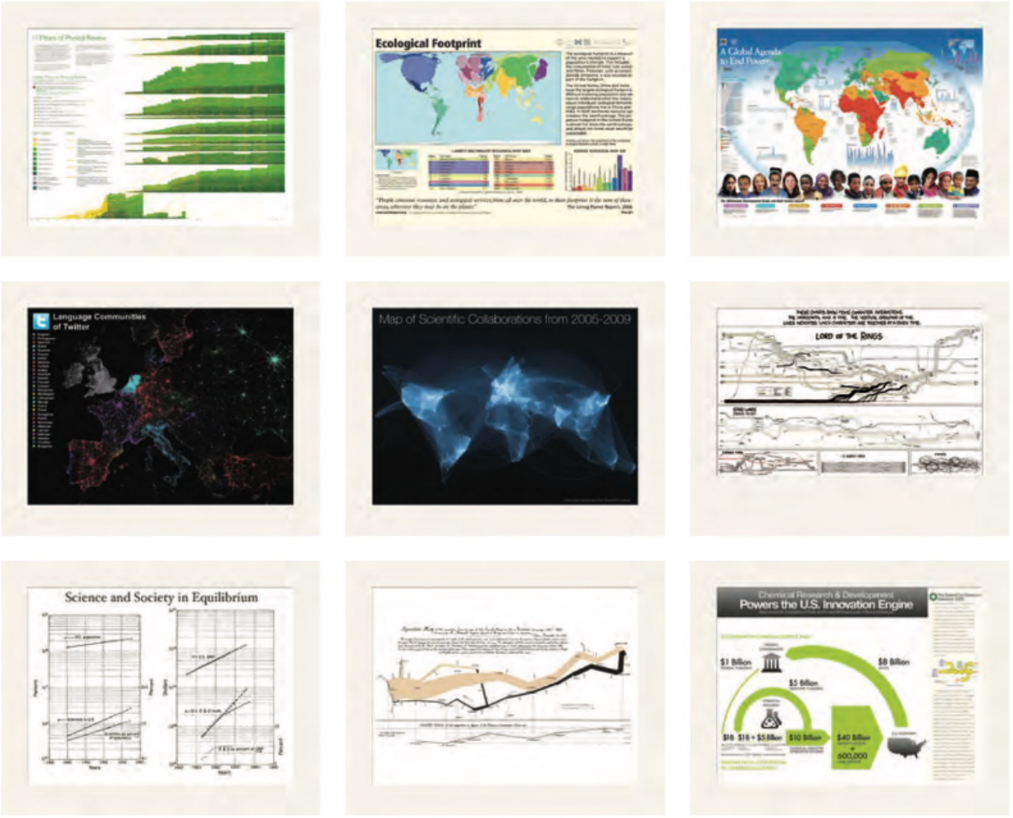
# Data Visualization in Research

By Subhanya Sivajothy

# What is Data Visualization?

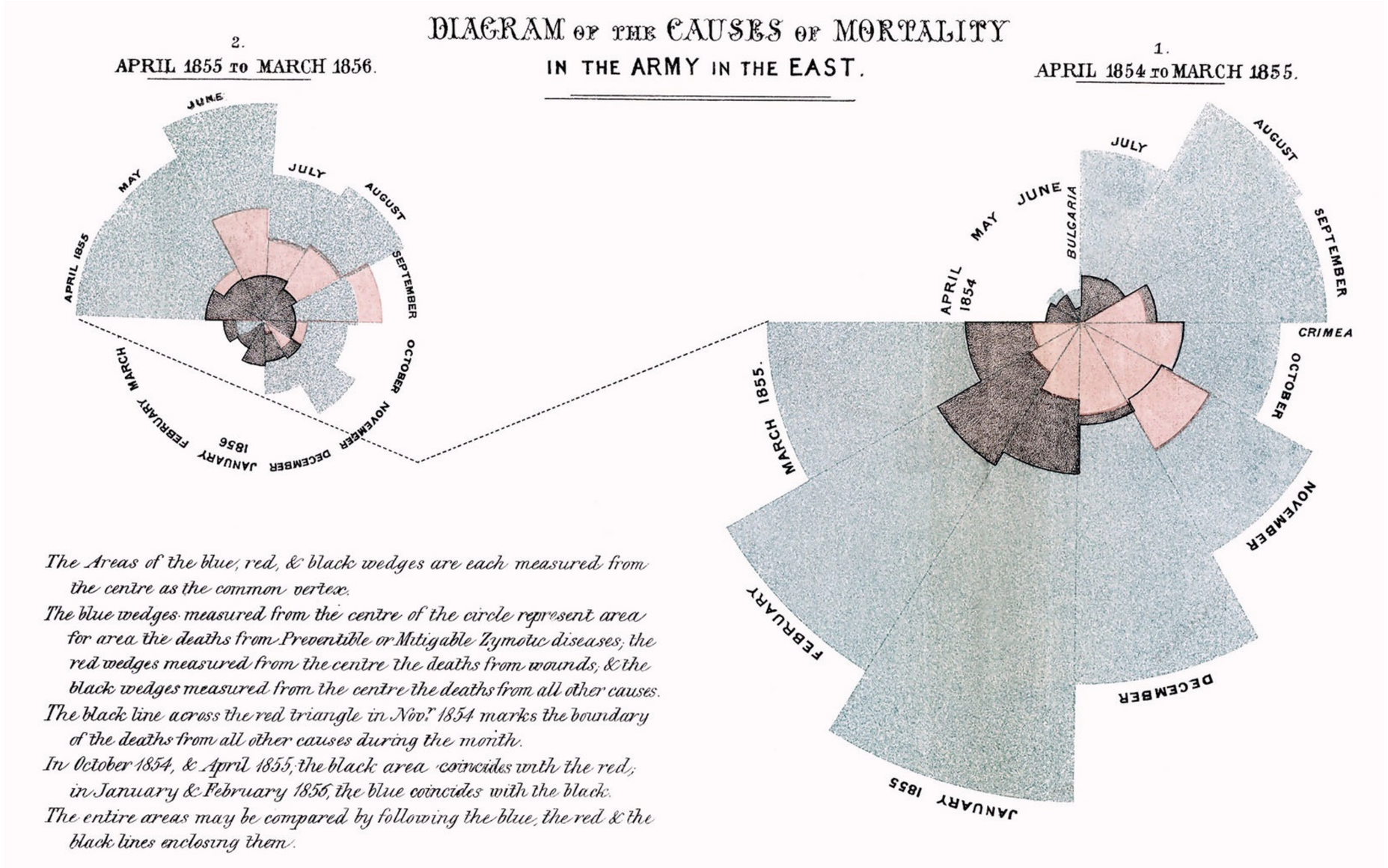


# Why Use Data Visualizations?




## It's all about you!


*Dr. John Snow's Cholera Map in 1854*

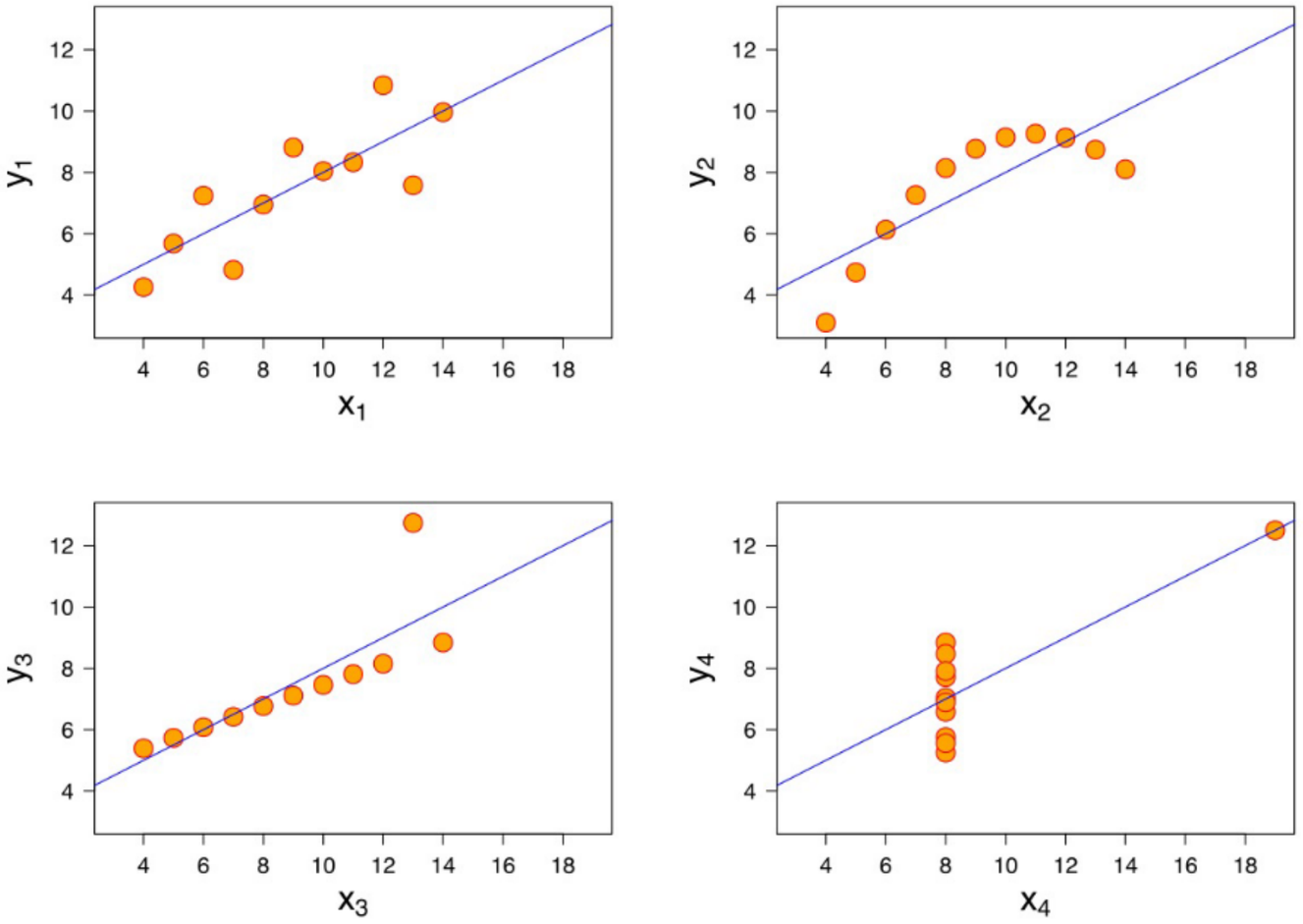



*Florence Nightingale's Rose Diagram*

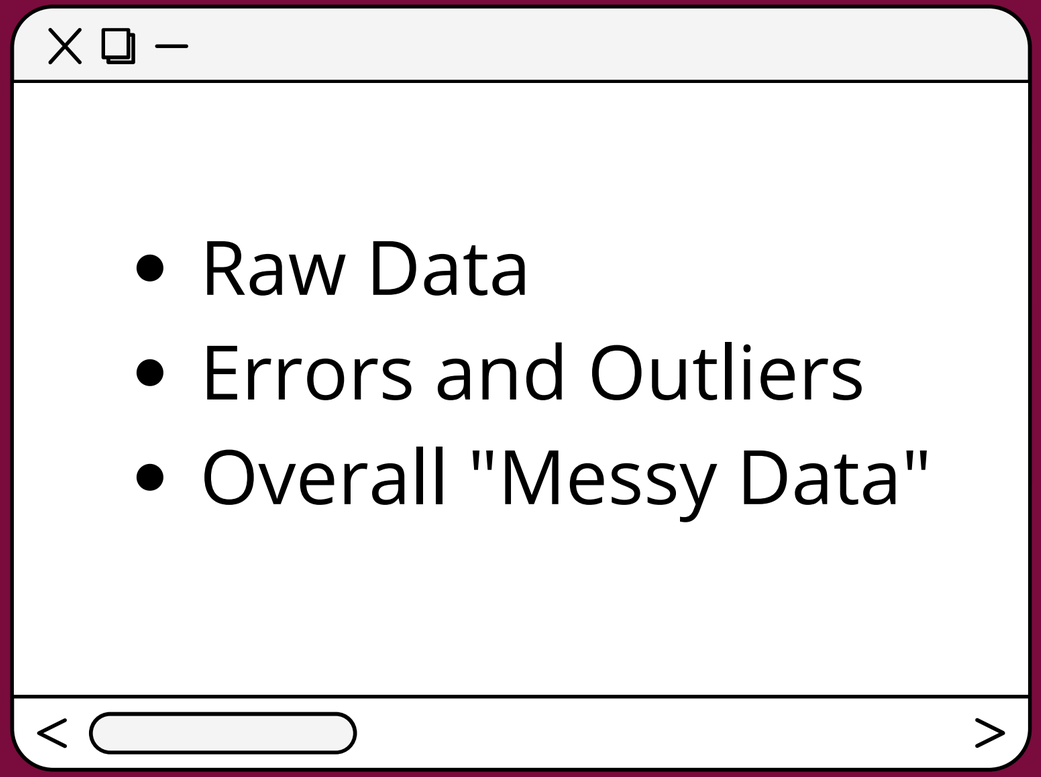
# Exploratory Data Analysis

# Anscombe's Quartet

| Anscombe's Data | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Observation | x1 | y1 | | x2 | y2 | | x3 | y3 | | x4 | y4 |
| 1 | 10 | 8.04 | | 10 | 9.14 | | 10 | 7.46 | | 8 | 6.58 |
| 2 | 8 | 6.95 | | 8 | 8.14 | | 8 | 6.77 | | 8 | 5.76 |
| 3 | 13 | 7.58 | | 13 | 8.74 | | 13 | 12.74 | | 8 | 7.71 |
| 4 | 9 | 8.81 | | 9 | 8.77 | | 9 | 7.11 | | 8 | 8.84 |
| 5 | 11 | 8.33 | | 11 | 9.26 | | 11 | 7.81 | | 8 | 8.47 |
| 6 | 14 | 9.96 | | 14 | 8.1 | | 14 | 8.84 | | 8 | 7.04 |
| 7 | 6 | 7.24 | | 6 | 6.13 | | 6 | 6.08 | | 8 | 5.25 |
| 8 | 4 | 4.26 | | 4 | 3.1 | | 4 | 5.39 | | 19 | 12.5 |
| 9 | 12 | 10.84 | | 12 | 9.13 | | 12 | 8.15 | | 8 | 5.56 |
| 10 | 7 | 4.82 | | 7 | 7.26 | | 7 | 6.42 | | 8 | 7.91 |
| 11 | 5 | 5.68 | | 5 | 4.74 | | 5 | 5.73 | | 8 | 6.89 |
| | | | | Summary Statistics | | | | | | | |
| N | 11 | 11 | | 11 | 11 | | 11 | 11 | | 11 | 11 |
| mean | 9.00 | 7.50 | | 9.00 | 7.500909 | | 9.00 | 7.50 | | 9.00 | 7.50 |
| SD | 3.16 | 1.94 | | 3.16 | 1.94 | | 3.16 | 1.94 | | 3.16 | 1.94 |
| r | 0.82 | | | 0.82 | | | 0.82 | | | 0.82 | |


y1
x1
y2
x2
y3
x3
y4
x4
4
6
8
10
12
14
16
18
4
6
8
10
12

# Exploratory Data Analysis: Stage One



# Exploratory Data Analysis: Stage Two

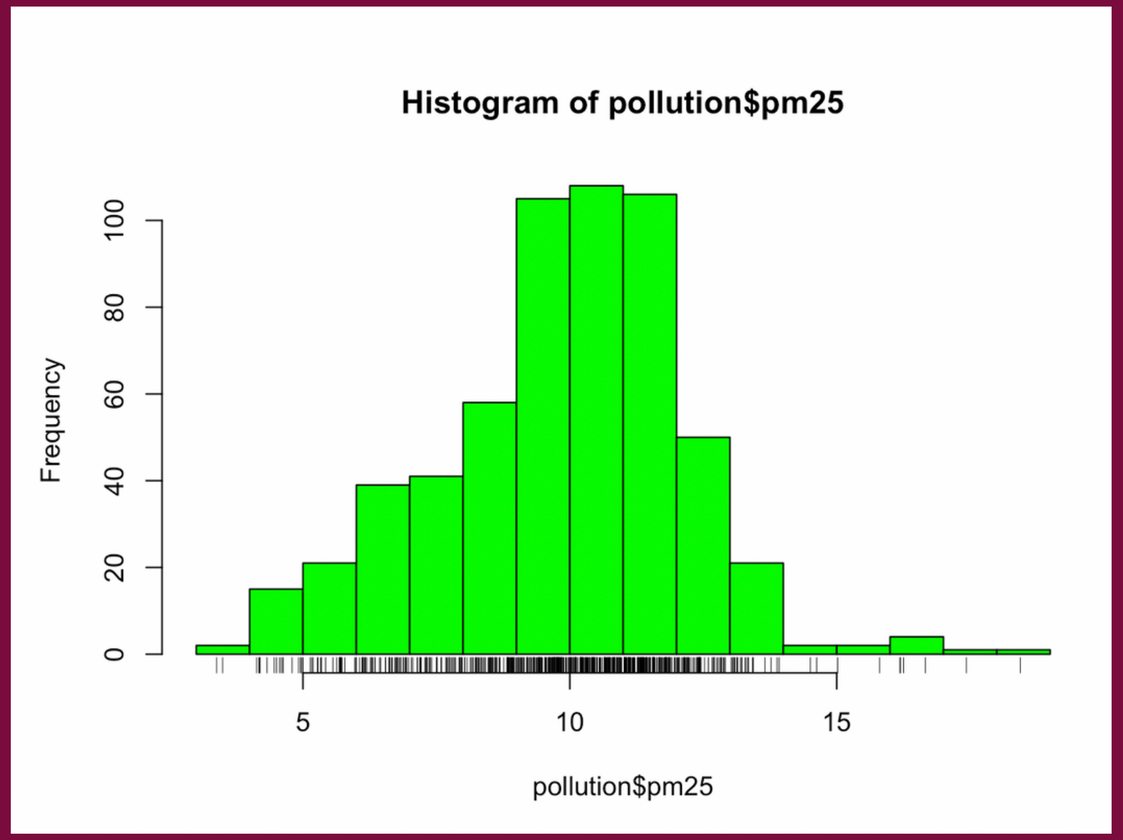
1. Generate questions about your data
2. Search for answers by visualising, transforming, and modeling your data
3. Use what you learn to refine your questions and or generate new questions
4. Repeat process until you have a graph you'd like to publish

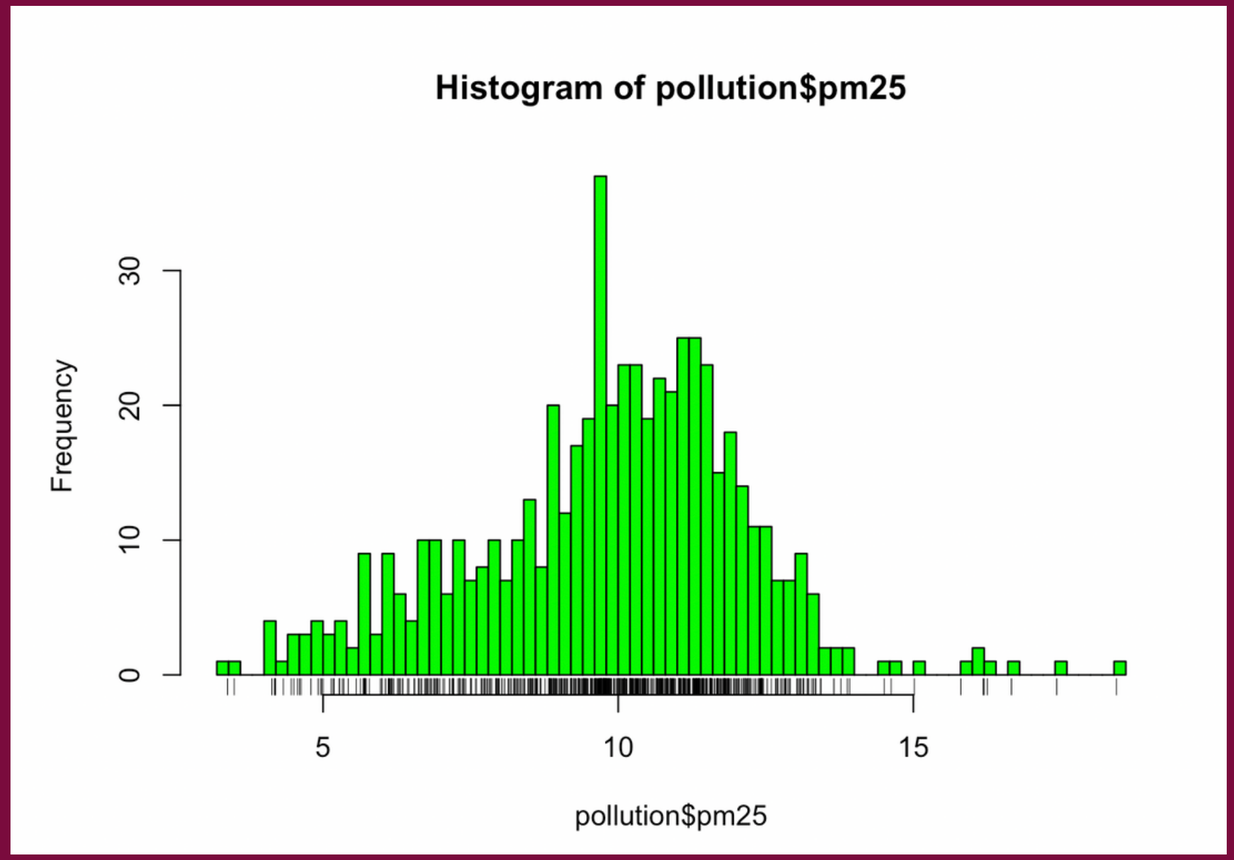
*adapted from Hadley Wickham*
*https://cfss.uchicago.edu/notes/exploratory-data-analysis/*

# Exploratory Data Analysis: Stage Two

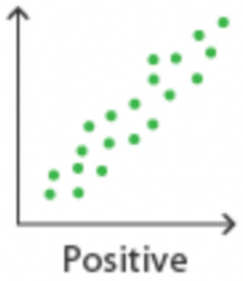
1. What type of variation occurs **within** my variables?
2. What type of covariation occurs **between** my variables?

*adapted from Hadley Wickham*
*https://cfss.uchicago.edu/notes/exploratory-data-analysis/*

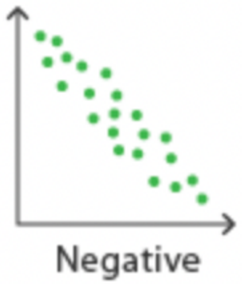


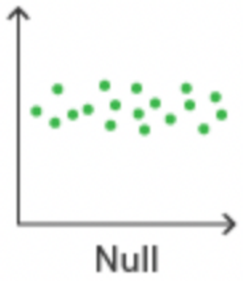

*https://bookdown.org/rdpeng/exdata/exploratory-graphs.html*



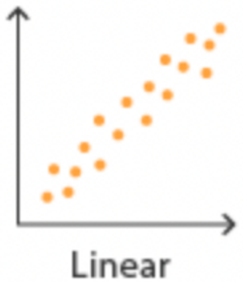
Positive



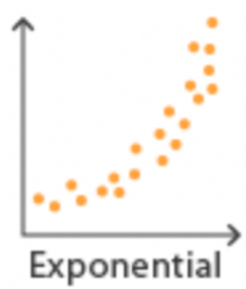
Negative



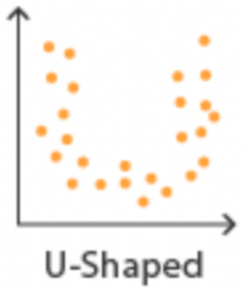
Null



Linear

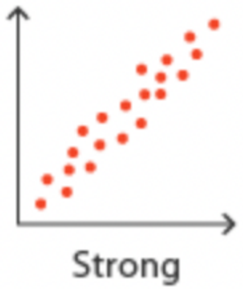


Exponential

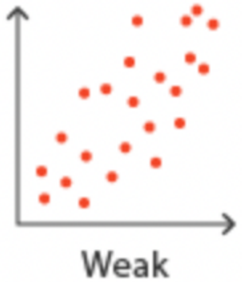


U-Shaped

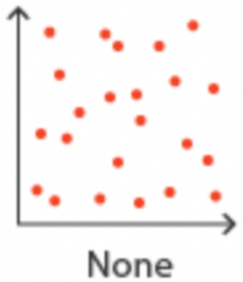
**Correlation Strength:**



Strong

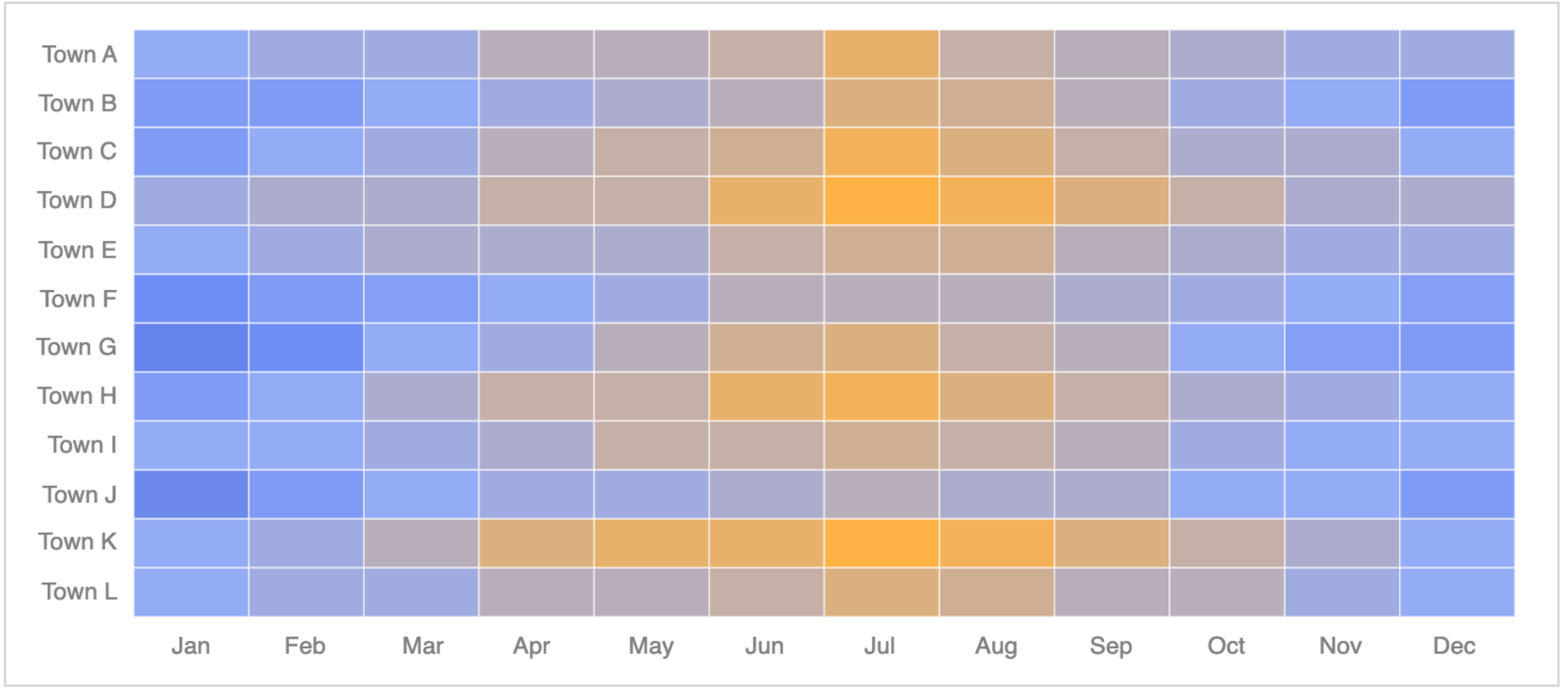


Weak



None

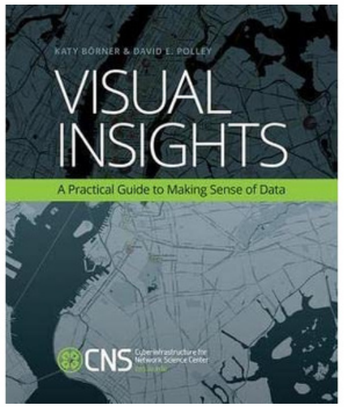
# Heatmap (Matrix)



# Data Visualization for Communication

# Workflow

1. Identify Audience and Purpose
2. Analysis: Explore and Prepare Data
3. Visualization Idioms
4. Select Visualization Elements
5. Share for Interpretation and Critique

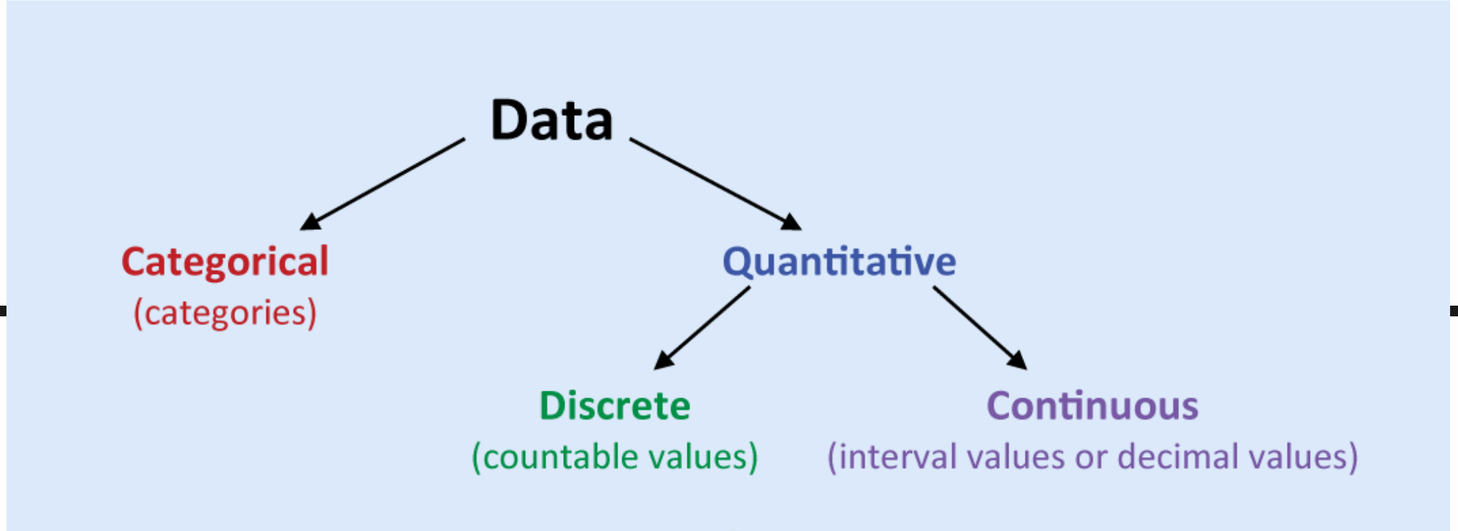



Katy Börner, David E. Polley + Kelly Schulz

# 1. Identify Audience and Purpose

| | |
|---|---|
| 01 | **Who is your audience for your visualization?** |
| 02 | **What level of familiarity do they have with your topic?** |
| 03 | **What is the purpose of your visualization?** |
| 04 | **Is it to communicate a finding, or is it exploratory for your own analysis?** |
| 05 | **What is the story that I'm trying to tell?** |

# 2. Analysis: Explore and Prepare Data




## Categorical

Categorical variables contain a finite number of categories or distinct groups. Categorical data might not have a logical order. Qualitative data is often categorical.

## Continuous

Continuous variables are numeric variables that have an infinite number of values between any two values. A continuous variable can be numeric or date/time. Continuous data is always quantitative.

## Discrete

Discrete variables are numeric variables that have a countable number of values between any two values. A discrete variable is always numeric.

Lewis & Ruth Sherman Centre for Digital Scholarship
scds.ca

McMaster University Library

## 2. Analysis: Explore and Prepare Data

# Common Tasks

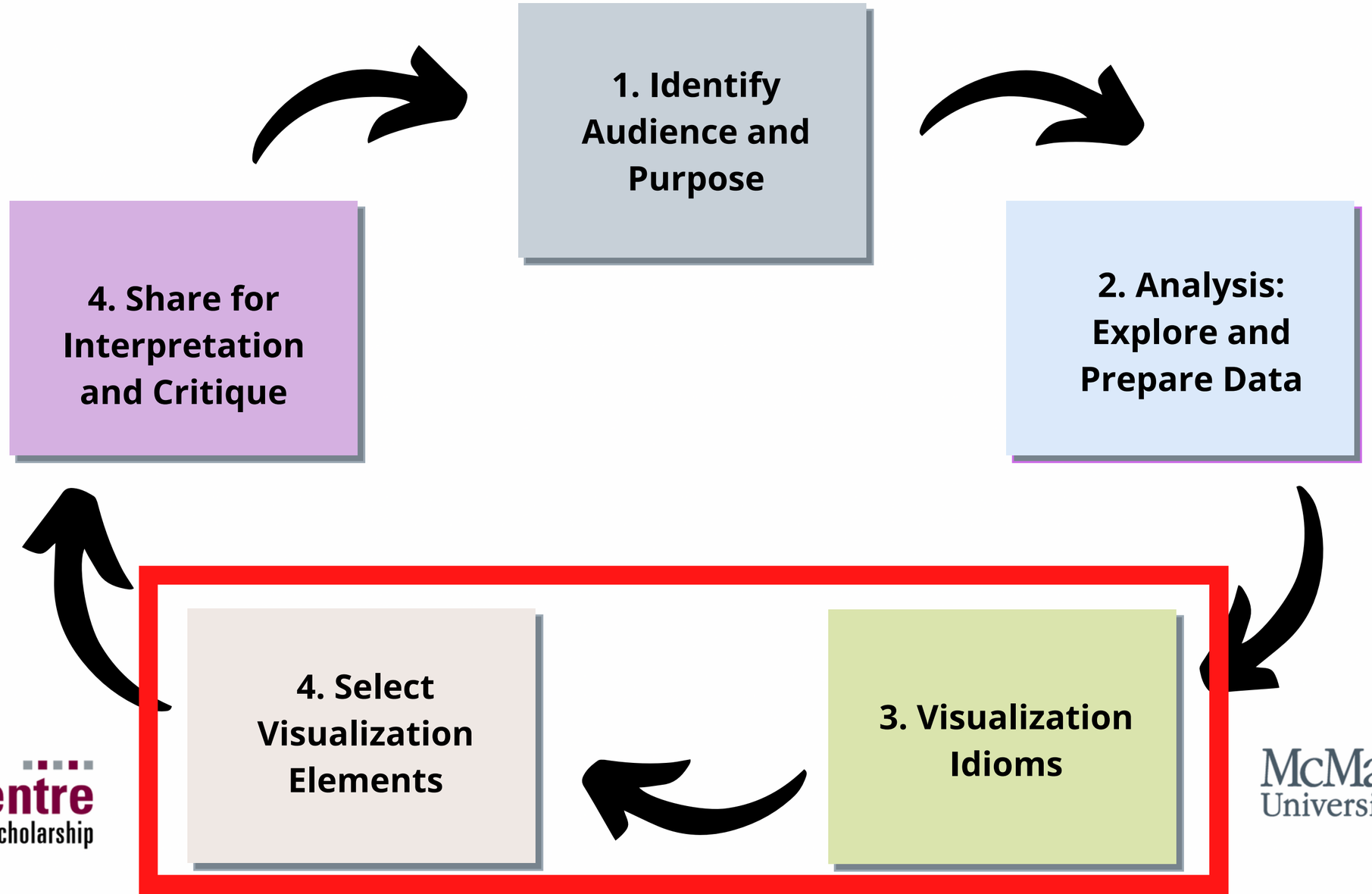
formatting values

anomalies and missing data

standardizing values and
remove pre-aggregated data

readable headings

# Workflow


1. Identify Audience and Purpose
2. Analysis: Explore and Prepare Data
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4. Select Visualization Elements
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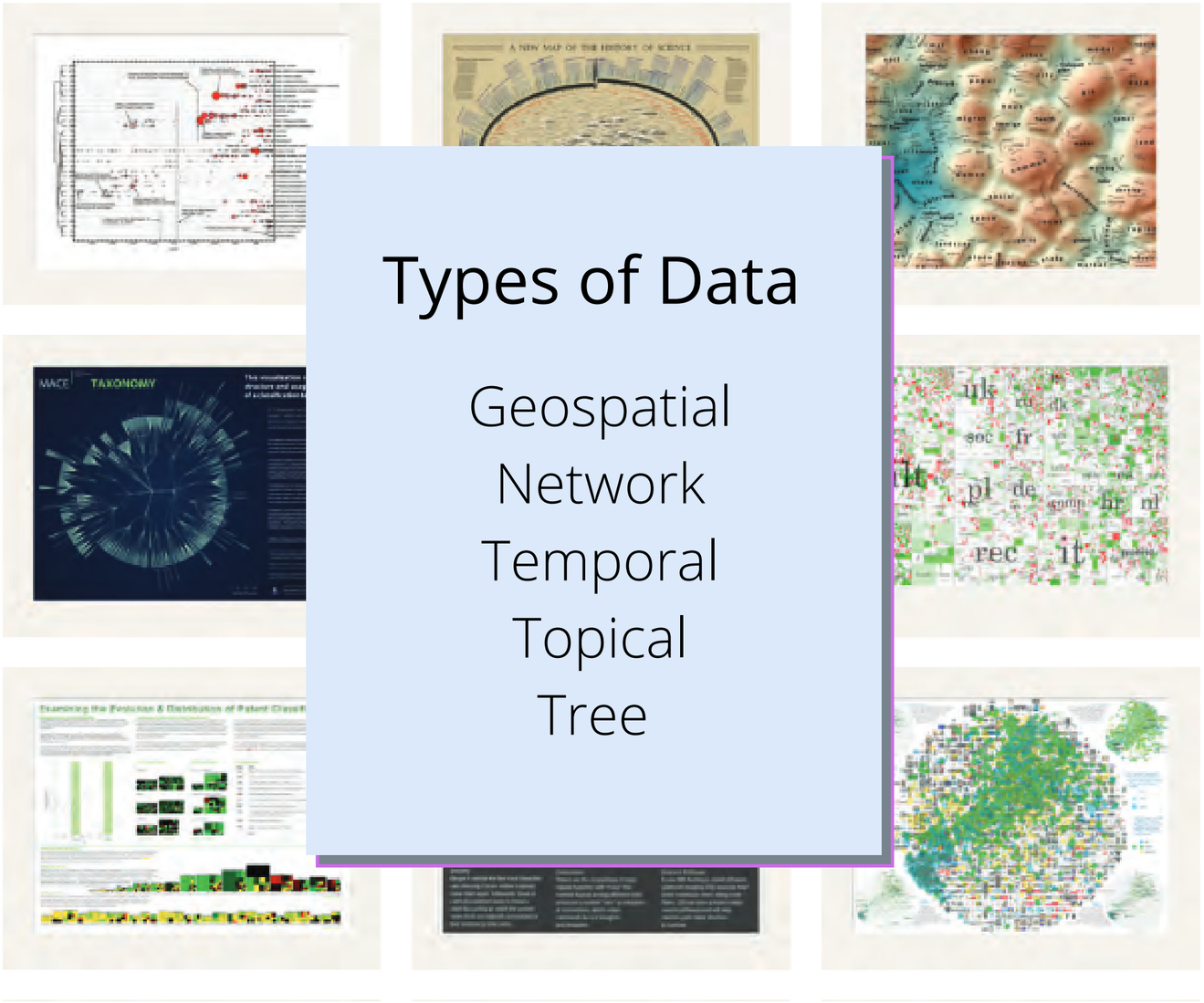
# 3. Visualization Idioms




## Types of Data

Geospatial
Network
Temporal
Topical
Tree

# Choosing Idioms

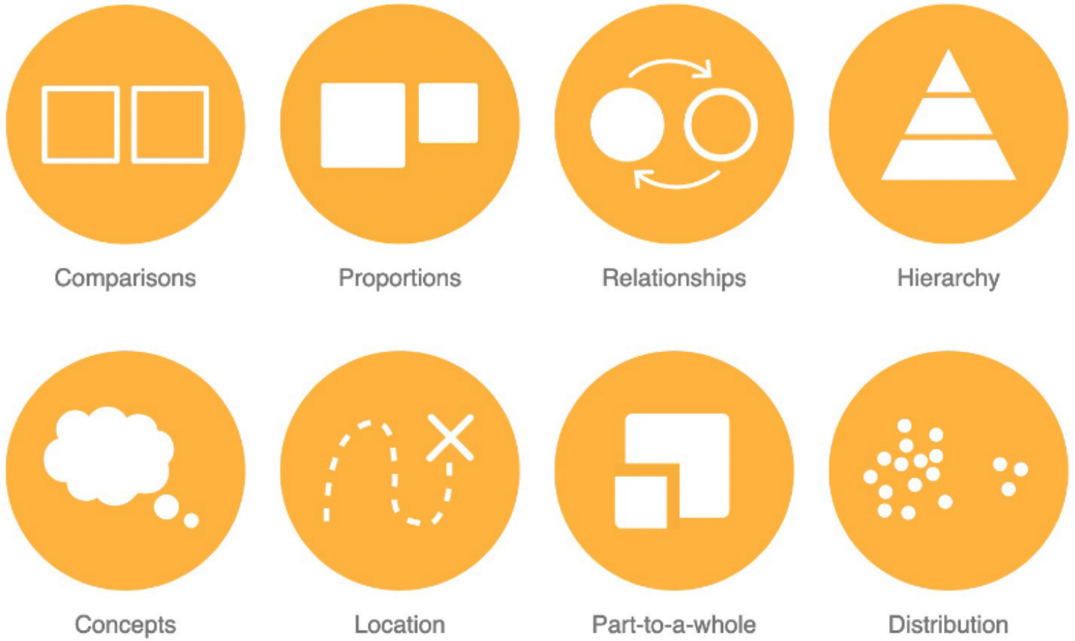
| | | |
|---|---|---|
| 01 | **Geospatial** | **Bubble Map, Choropleth Map** |
| 02 | **Temporal** | **Timeline, Line Graph, Area Chart, Histogram, Bubble Chart** |
| 03 | **Network** | **Arc Diagram, Chord Diagram, Network Diagram** |
| 04 | **Topical** | **Wordclouds, Bar Graph, Tree Maps** |
| 05 | **Tree** | **Sunburst diagram, Tree Map, Flowchart** |

# 3. Visualization Idioms

## The Data Visualisation Catalogue

### What do you want to show?

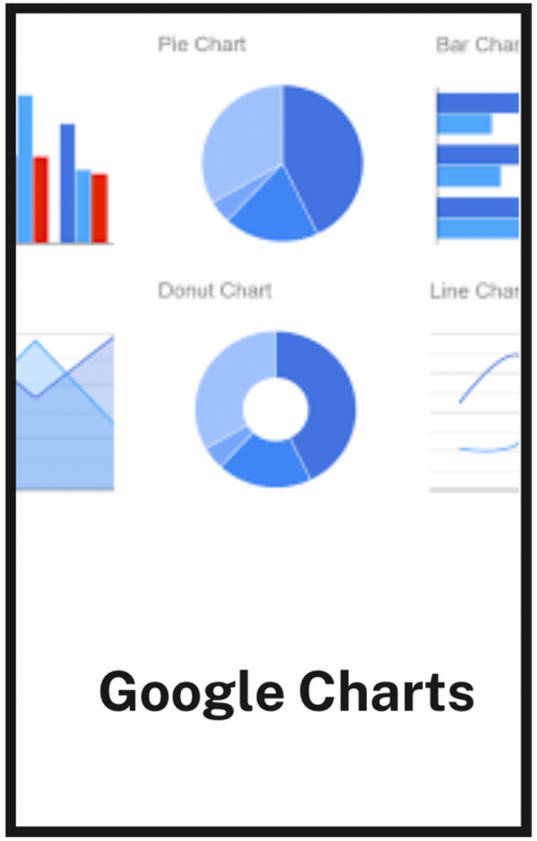
Here you can find a list of charts categorised by their data visualization functions or by what you want a chart to communicate to an audience. While the allocation of each chart into specific functions isn't a perfect system, it still works as a useful guide for selecting chart based on your analysis or communication needs.



# Tools for Data Visualization

MS Excel

Tableau




Google Charts

D3.js

**4. Select Visual Elements**

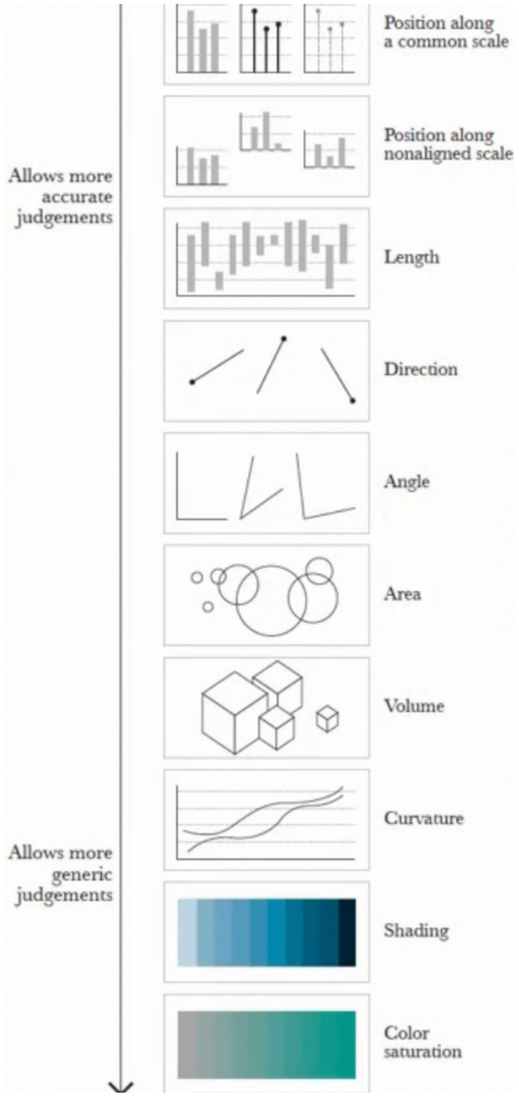
## Marks

- basic graphical element in an image
i.e the points, bars, lines, areas

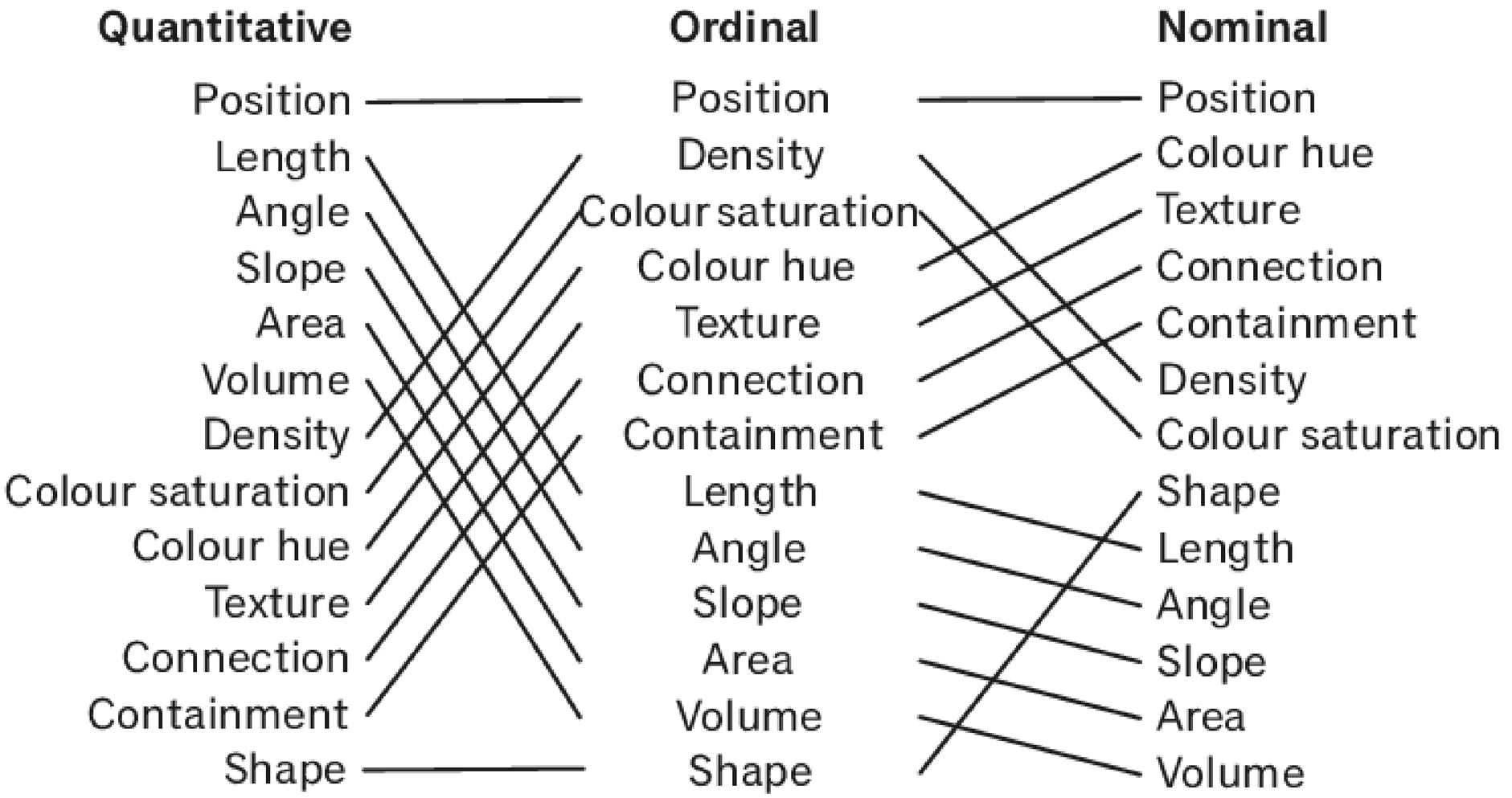
## Channels

- The attributes of a mark.
i.e position, shape, size, or color.

# 4. Select Visual Elements




Perception of graphical elements (Cleveland & McGill, 1984, P532)



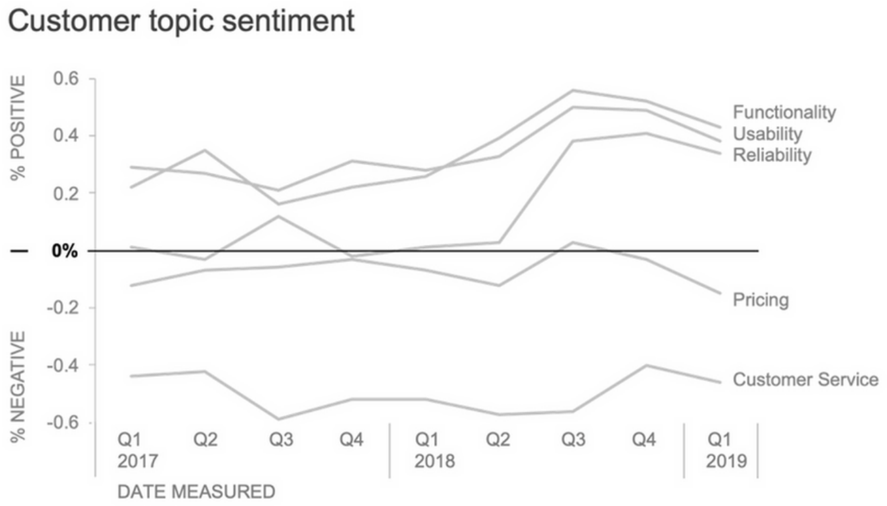

*The Mackinlay ranking of perceptual task*

## 5. Share for Interpretation and Receive Feedback

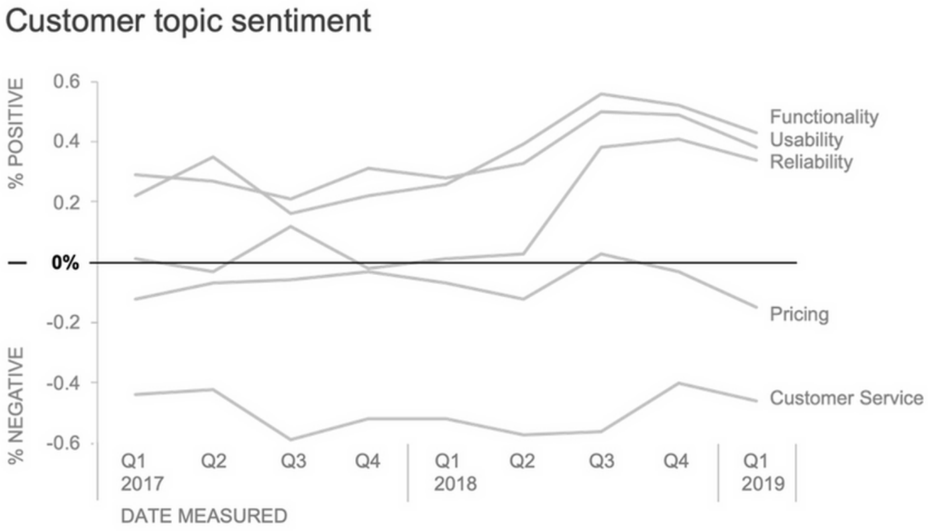
| | |
|---|---|
| 01 | **Would a user be able to understand the basics in 15 seconds?** |
| 02 | **Is this visualization honest about what isn't represented?** |
| 03 | **Have I properly attributed the work?** |

# Ethics & Accessibility in Visualization, and Critical Design Practices

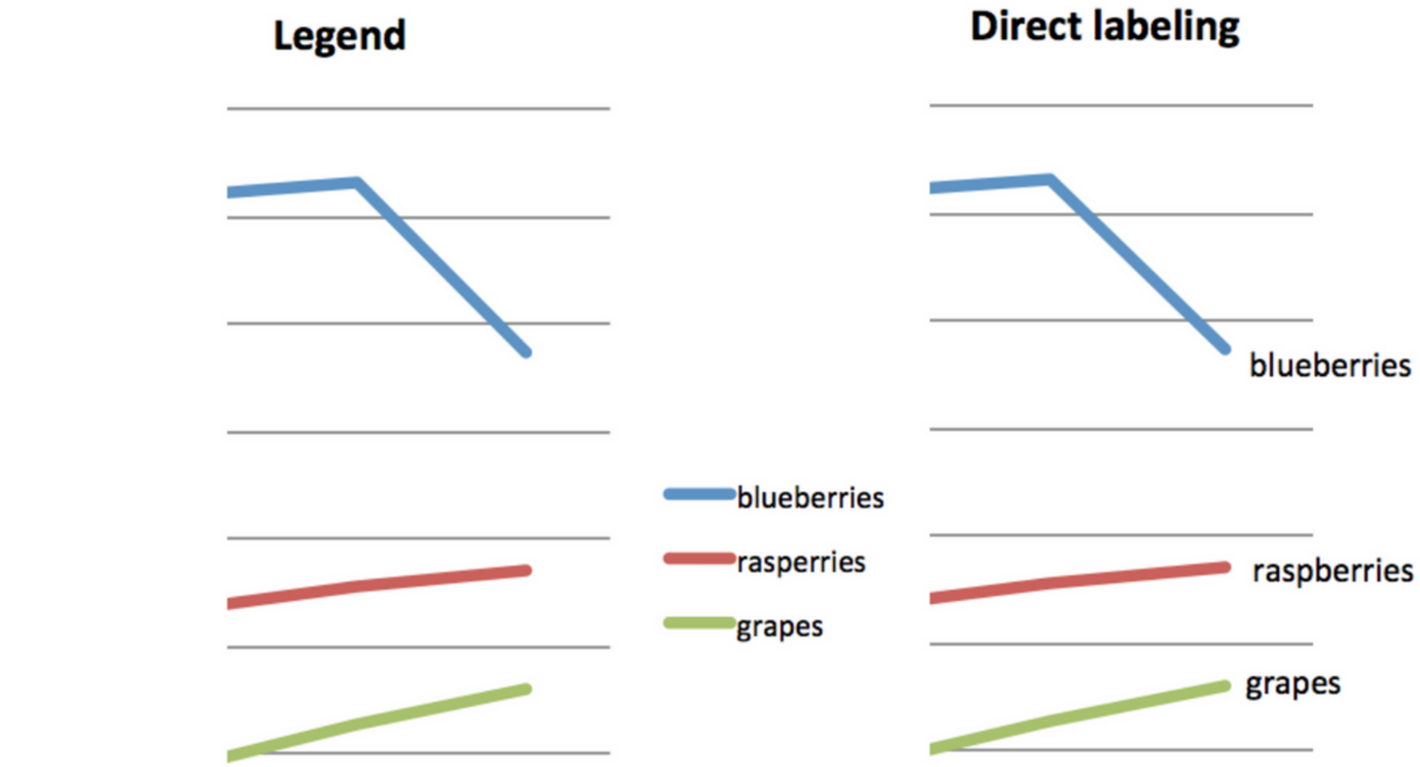
# Action needed to address **recent decline**




# Success: efforts to increase **reliability** worked!




*https://www.storytellingwithdata.com/blog/2018/6/26/accessible-data-viz-is-better-data-viz*




An example graph using legend vs. direct labeling

*https://www.storytellingwithdata.com/blog/2018/6/26/accessible-data-viz-is-better-data-viz*

# Check type and colour contrast

**Small Non-Bold Text (less than 18pt, or approximately 1.5em rendered) for FFFFFF**

| Color Code | Sample Text | Sample Text (inverted) | Pass or Fail | Ratio (pass>=4.5) |
|---|---|---|---|---|
| 0072CE | Lorem ipsum | Lorem ipsum | PASS | 4.89 |
| 4497DC | Lorem ipsum | Lorem ipsum | FAIL | 3.13 |

*https://www.storytellingwithdata.com/blog/2018/6/26/accessible-data-viz-is-better-data-viz*

Example of the for the color palette contrast evaluation tool WCAG standards

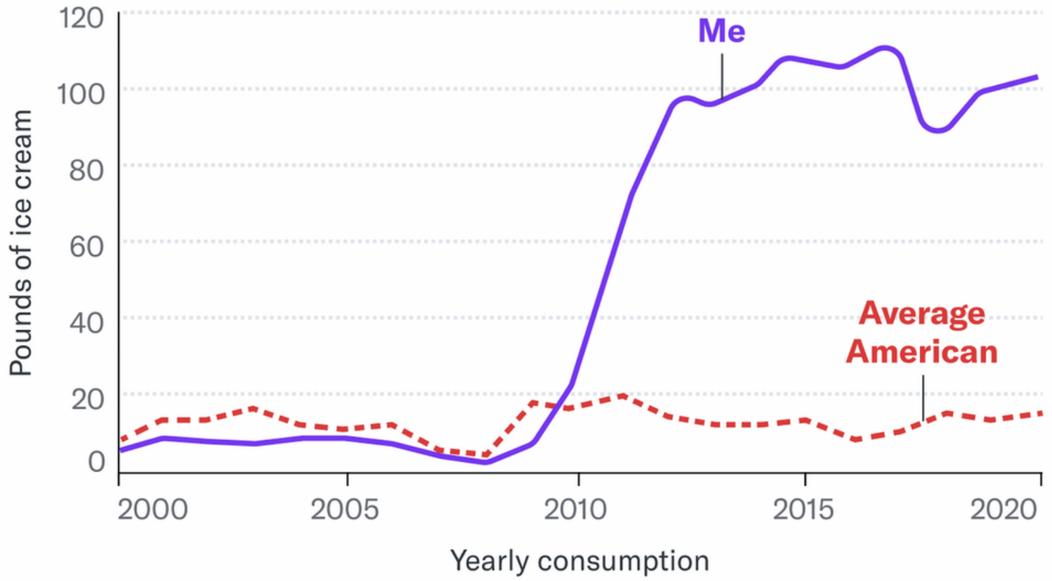
# Adding Alt Text

```
<img src="pancakes.png" alt="Stack of blueberry pancakes with powdered sugar">
```

*source: https://www.storytellingwithdata.com/blog/2018/6/26/accessible-data-viz-is-better-data-viz*

## My yearly ice cream consumption has bested the national average since 2010*

*While the spirit rings true, this statistic is entirely made up



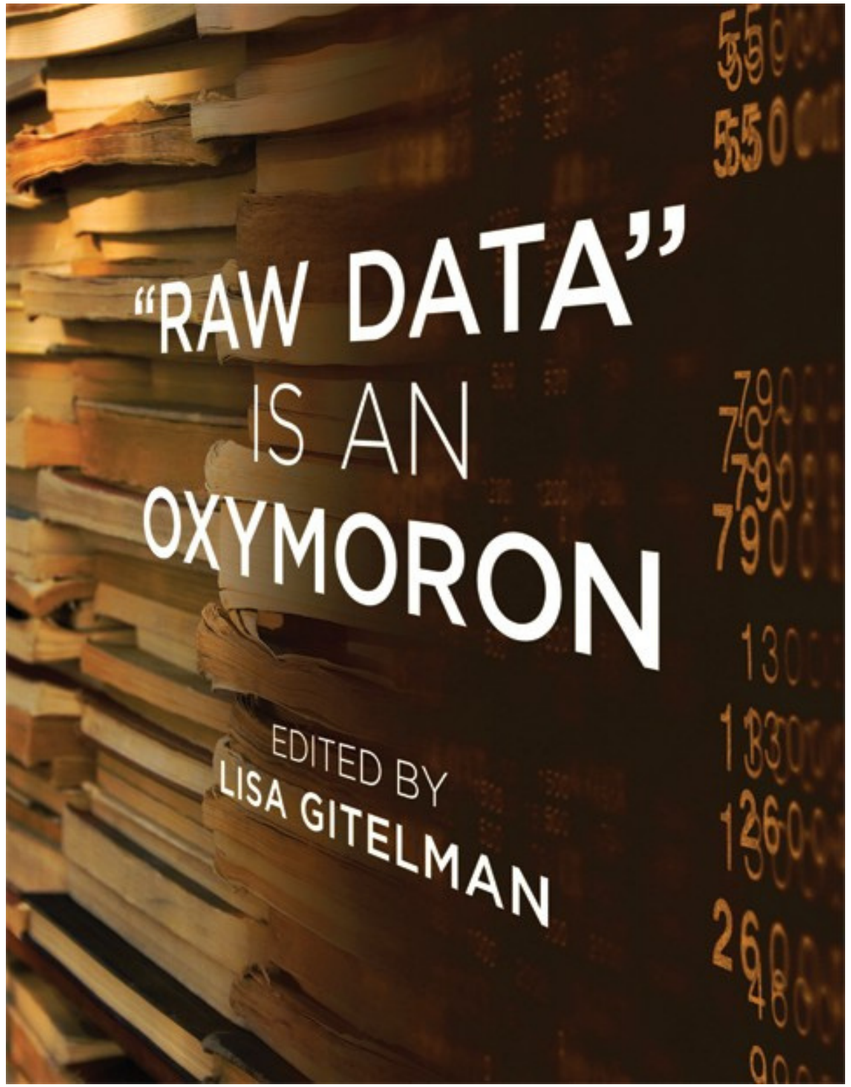

SUMMARY OF RESULTS

Since 2010, I've consumed an average of **100 lbs** of ice cream per year.
The average American has consumed only **12.7 lbs**.
This is nearly **8x** more ice cream. Oh no.

*https://www.betterment.com/design/accessible-data-visualization*

**"The world does not spontaneously quantify, curate, or data-mine itself. Rather, the process of observing the world and quantifying it is a political act, and deserves ethical consideration"**

**- Michael Correll**




*Michael Correll. 2018. "Ethical Dimensions of Visualization Research." https://arxiv.org/pdf/1811.07271.pdf*

# Make the Invisible Visible

**Visualize Hidden Labour**

**Visualize Hidden Uncertainty**

**Visualize Hidden Impacts**

**… Managing Complexity?**

*Michael Correll. 2018. "Ethical Dimensions of Visualization Research." https://arxiv.org/pdf/1811.07271.pdf*

# Collect Data With Empathy

**Encourage 'Small Data'**

**Anthropomorphize Data**

**Anonymity By Design (and Right to Due Process)**

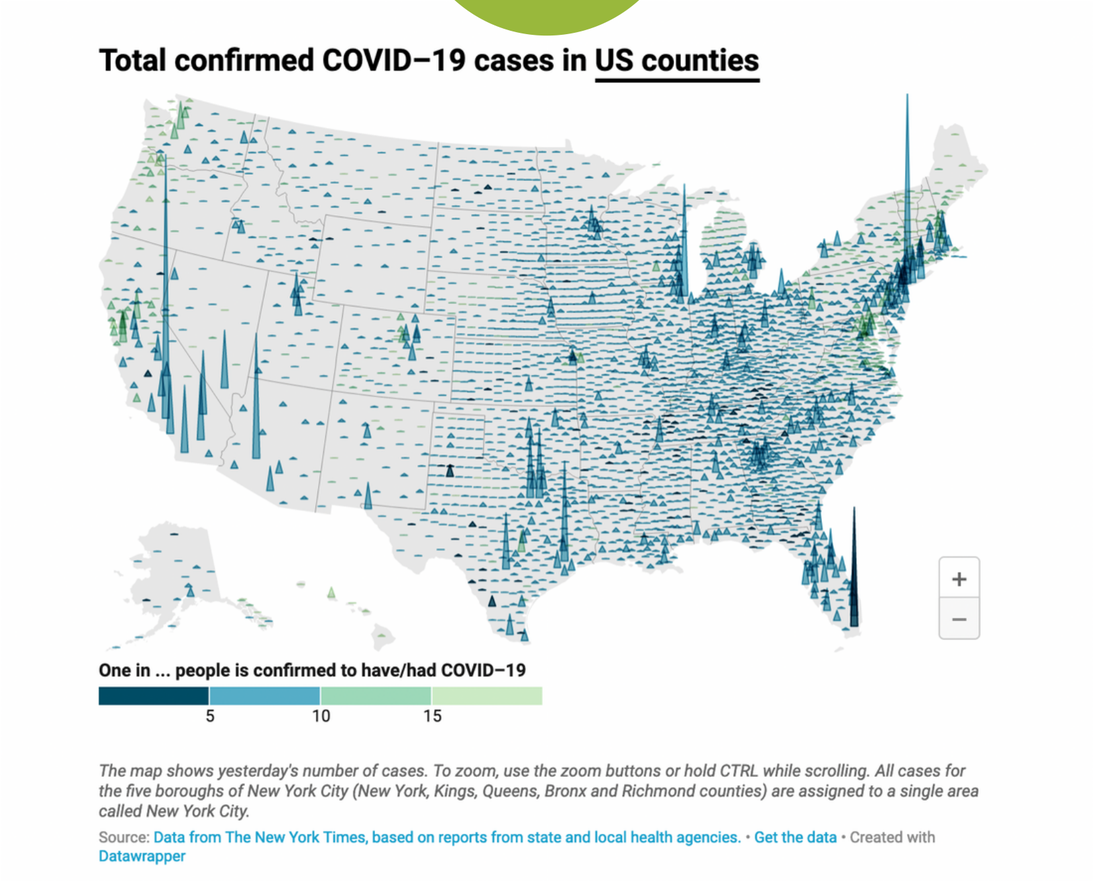
**... Including Context?**

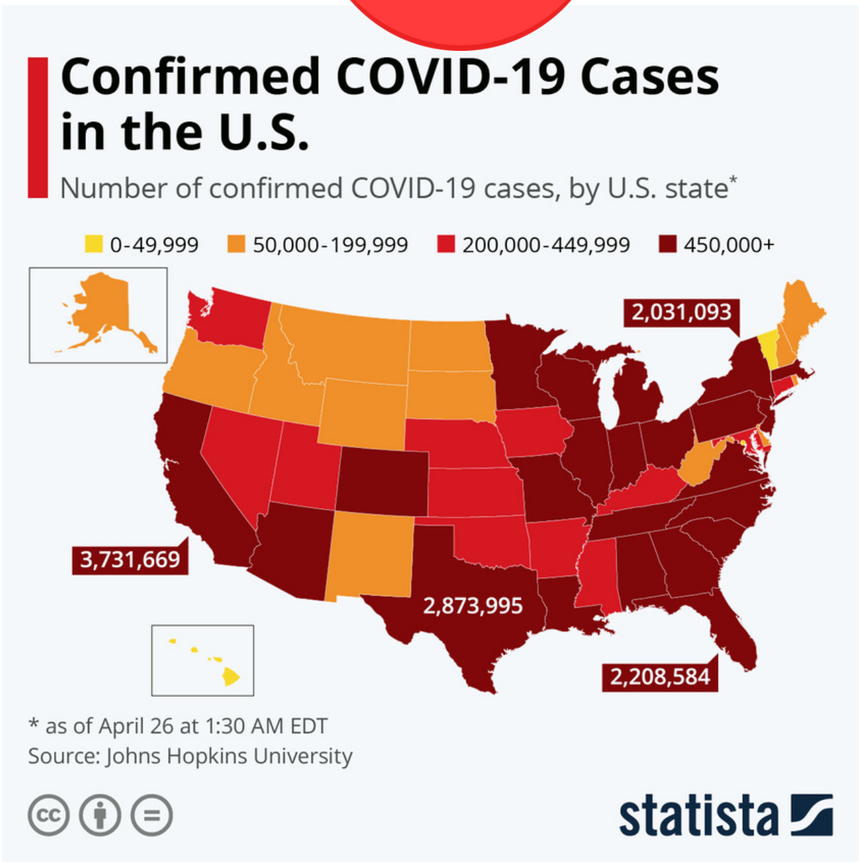
*Michael Correll. 2018. "Ethical Dimensions of Visualization Research." https://arxiv.org/pdf/1811.07271.pdf*

# Logistcal Considerations

- Are you disclosing the limits of your data in a way that is clear? For example, what all influences how cases are reported?
- If you're visualizing information that is time-sensitive such as cases, are you willing to commit to daily updates and for how long?
- Are you disclosing all sources?
- How does storage affect updating and relationships?
- What inaccuracies exist?
- What transformations are you making in storage?
- What does NULL mean?
- What decisions have you made in storage? (ex: how locations are classified?)

***https://www.tableaufit.com/the-ethics-of-visualizing-during-a-pandemic/***




*source: https://blog.datawrapper.de/coronaviruscharts/*

# Visualization Considerations

- How does the visualization limit what you can understand? (ex: A line chart shows trend, but not potential geographic patterns)
- What expertise is required to follow it? (ex: log scales)
- Who have you considered as your audience?
- Who have you (intentionally or unintentionally) ignored?
- What is your motivation for doing this?
- What values are you espousing in your visualization? Do they support or conflict with other values?
- Do you create overt alarm? Most people are already stressed.
- Does it overly abstract and calm too much? Some people aren’t taking this seriously enough.

***https://www.tableaufit.com/the-ethics-of-visualizing-during-a-pandemic/***

# Visualization Provenance

- Documenting what steps were involved in creating the visualization
- Helps you with tracing errors and reproducing steps
- Allows others to evaluating the quality of the data and the validity of the visualization output