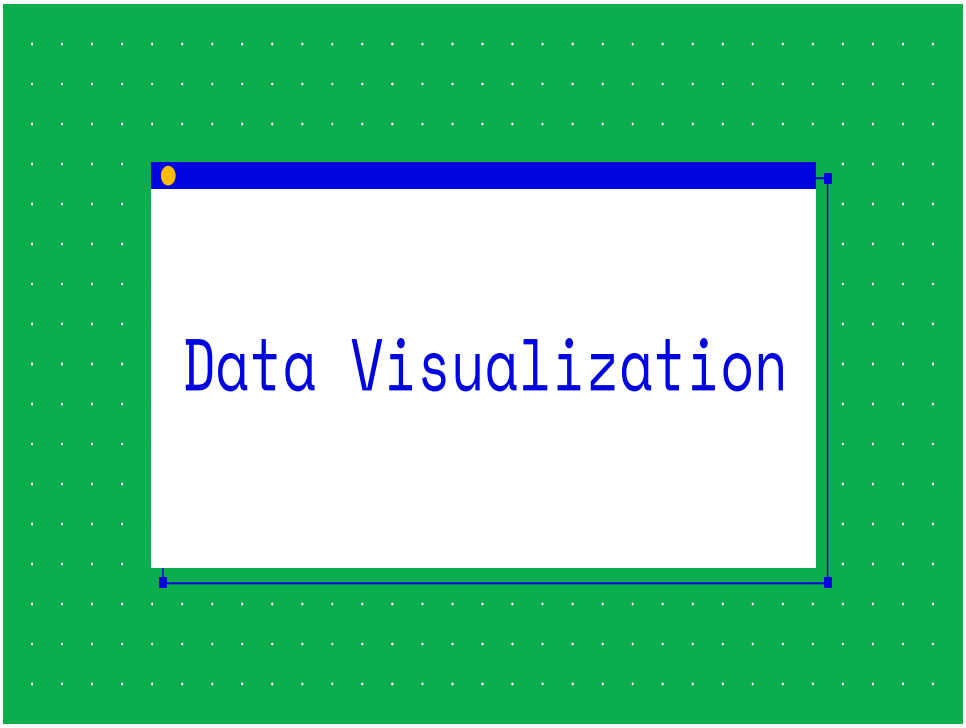

Data Visualization

Agenda:

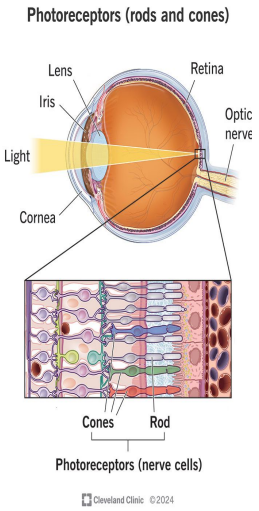
1. Color Vision Deficiency (CVD)
2. CVD-friendly Designing Tips & Accessibility
3. Visualization Example
4. Google Sheets Charts
5. Questions

Here is a quick overview of what we'll cover today.

Color Vision Deficiency (CVD)

Color Vision Deficiency (CVD)

- Persons with **CVD**:
  - colors most people see as different will look the same for them
  - results from the absence/malfunction of one or more of
    - the 3 cone photoreceptor types in the retina
- **Colorblindness** is not the most accurate term
  - instead, use **CVD**
- **CVD** doesn't mean: person can't see color



https://my.clevelandclinic.org/health/body/photoreceptors-rods-and-cones

- Deficiency is the reverse of Efficiency.
- So CVD can be translated as
  - قصور في رؤية الألوان

CVD Types

1) **Red-green CVD**
   - About **8% of men**
     - 6% of men have green-weak (deuteranomaly) & green-blind (deuteranopia)
     - 2% of men have red-weak (protanomaly) & red-blind (protanopia)
   - About **0.5% of women**

2) **Blue-yellow CVD**
   - About **5% of all CVD cases**
   - **Yellow** is RGB(255, 255, 0)
   - **Types**: blue-weak (Tritanomaly)& blue-blind (Tritanopia)

- 2% of men
  - have red-weak or mild (protanomaly)
  - OR
  - have red-blind or severe (protanopia)

- deuteranomaly/deuteranopia/
  - https://www.color-blindness.com/deuteranopia-red-green-color-blindness/
- protanomaly/protanopia/
  - https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/color-blindness/types-color-blindness
- **Protanomaly**
  - makes red look more green and less bright
- **Protanopia** and **deuteranopia** both make you unable to tell the difference between red and green at all

CVD Types

3) Monochromacy

- Complete malfunction of two or all three cone photoreceptor types in the retina
- Very rare cases (1 in 33,000), and can be divided into
  - **Blue Cone Monochromacy (BCM)**
    - red and green cones do not function
    - see mostly in shades of blue and gray
  - **Rod Monochromacy (Achromatopsia)**
    - is often referred to as complete color blindness
    - see the world in shades of black, white, and gray (like an old black and white film)

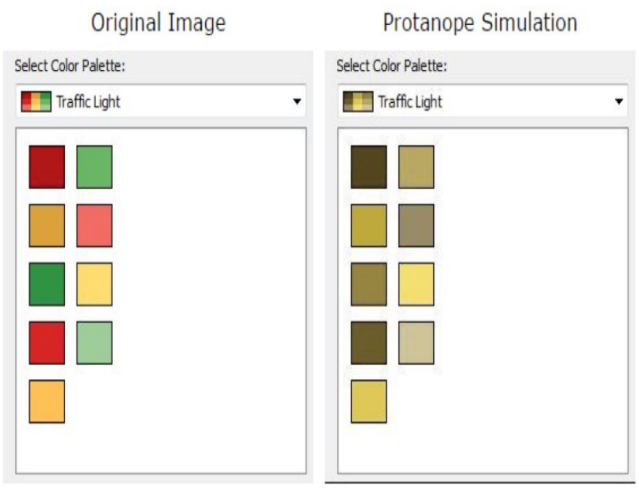
CVD Commonly Referred to as

- **green-weak** (deuteranomaly)
- **red-weak** (protanomaly)
- **red-green colorblindness**
  - green-blind (deuteranopia)
  - red-blind (protanopia)

Deuteranope Simulation

- deuteranomaly (green-weak) & deuteranopia (green-blind)

Protanope Simulation



- protanomaly (mild) & protanopia (severe)

Data-viz Rule

Don’t use red & green together


CVD-friendly
Designing Tips &
Accessibility

CVD-friendly Designing Tips

1. Red and green together can be problematic, but

2. Be aware that it's not just red and green.

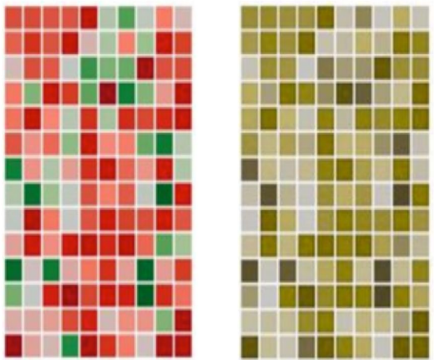
3. Use a CVD-friendly palette when appropriate.

4. If you must use red and green together, you can:
   a. leverage light vs. dark
   b. stand each color (red and green) alone
   c. offer alternate methods of distinguishing data
   d. use a checkbox (or similar GUI) to switch the color palette to a CVD-friendly palette

- **Stand each color (red and green) alone**
  - and they are labeled well, then it may not be an issue if they both appear brown

Tip 1) Red and green can be problematic but

- Although Data-viz Rule, red and green may be needed to tell
  - a good number vs. a bad number in a table
  - one line vs. another line in the same line chart
  - a good square from a bad square
- We can see how difficult this would be for one with CVD



Tip 2) More Complex Than Red vs. Green

- For someone with **strong CVD**
  - **red** & **green** & **orange** all can appear **brown**
  - Maybe more accurate to say: Don't use **red** & **green** & **brown** & **orange** together
    - In the RGB model: orange is RGB(255,165,0) & brown is RGB(150, 75, 0)

- Also, when mixing colors, they can be problematic.
  - **Example**: using **blue** & **purple** together
    - In the RGB model, **purple** is RGB(160,32,240)
    - If someone has issues with **red**, they may have issues with **purple** (appear **blue**)

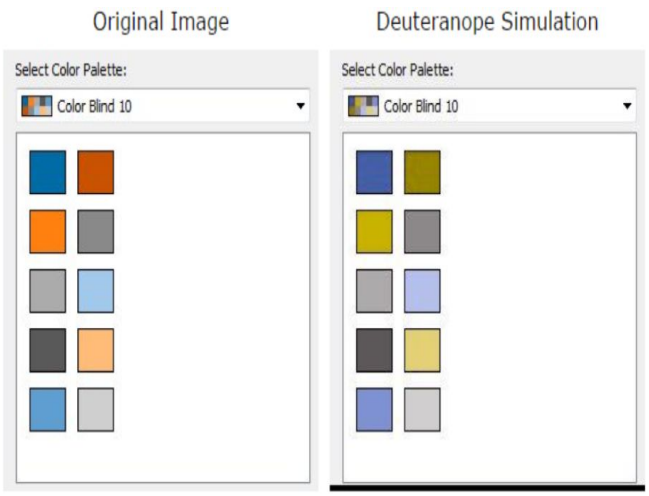
- Also, gray & pink or gray & brown can be problematic.

Tip 3) CVD-friendly Palette

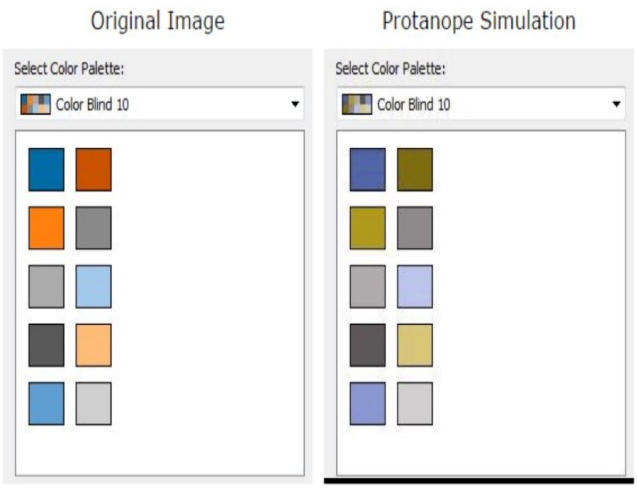
- One color combined with another color is generally fine
  - when one of them is not usually associated with CVD

- For the most common conditions of CVD
  - **blue** would generally look **blue**
  - **Examples:**
    - **blue/orange** is a common CVD-friendly palette
    - **blue/red** or **blue/brown** would also work

Tip 3) Deuteranope-friendly Palette



Tip 3) Protanope-friendly Palette



Tip 4-a) Leverage Light vs. Dark

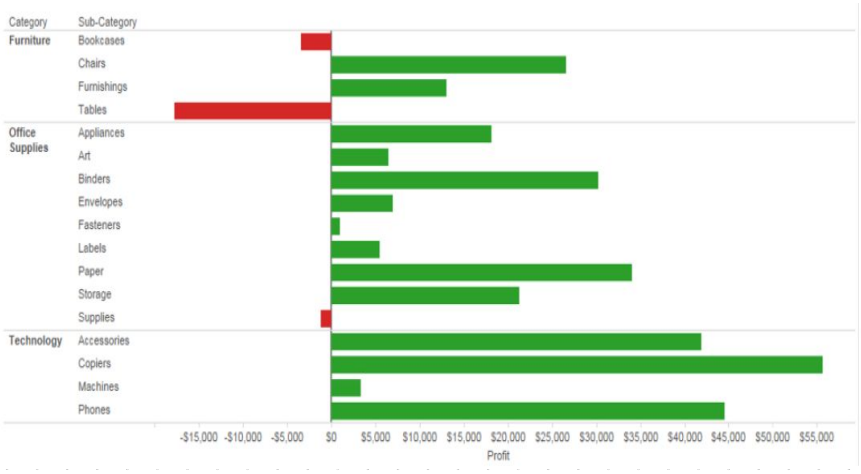
- The problem with **CVD** is **red vs. green** and not **light vs. dark**.

- Almost anyone can tell the difference between:
  - **very light color** and **very dark color**

- To use red and green together, we can use:
  - **light green**
  - **medium yellow**
  - **very dark red**

- Someone who has strong **CVD:**
  - would see as a **sequential color scheme**
  - would at least be able to distinguish based on **light vs. dark**

Tip 4-b) Stand Each Color Alone



Tip 4-c) Alternate Distinguishing Methods

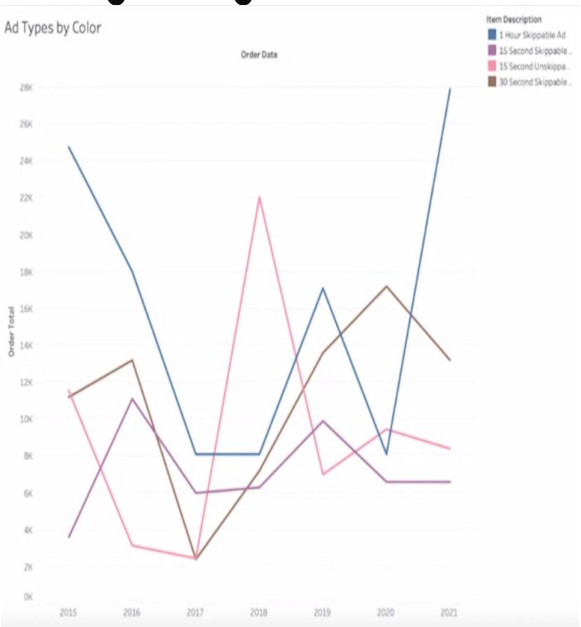
- Add indicators to allow to see that something is bad (red) vs. good (green), such as:
  - labels
  - icons
  - directional arrows
  - annotations
  - other indicators

What are graph annotations?

- highlight key data points, explain trends, or add clarity to complex information.
- come in many forms, including text labels, arrows, shapes, or even images.
- By adding them to a graph, you can make it more informative and easier to understand

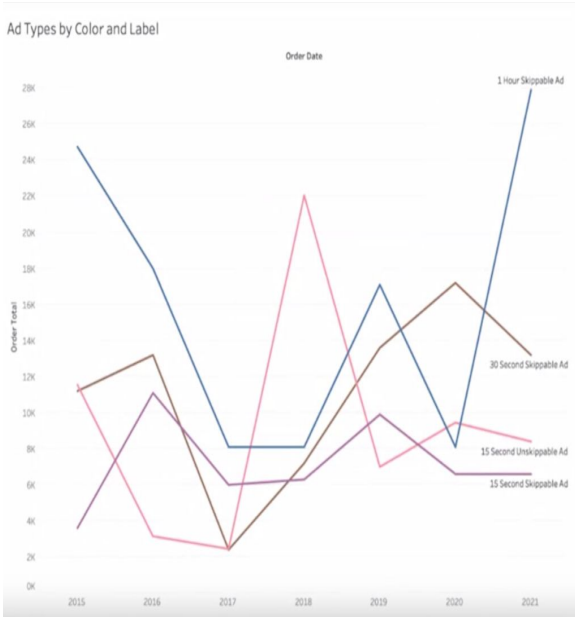
Tip 4-c) Alternate Distinguishing Methods

- The issue



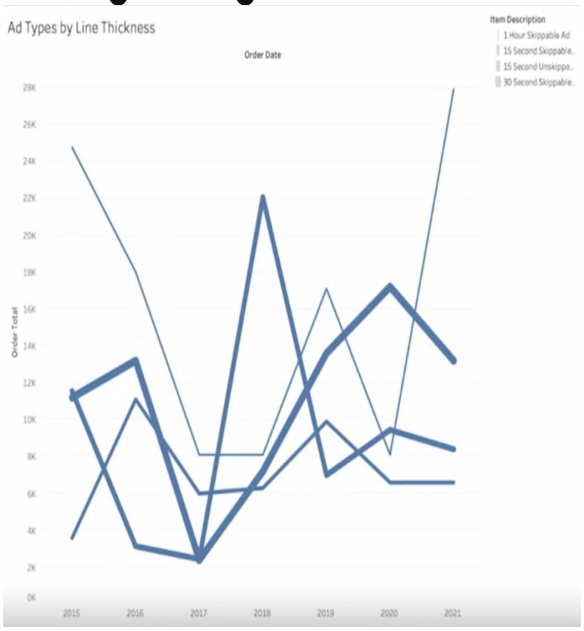
Tip 4-c) Alternate Distinguishing Methods

- Solution 1:
  - using labels
  - to provide **Accessibility**



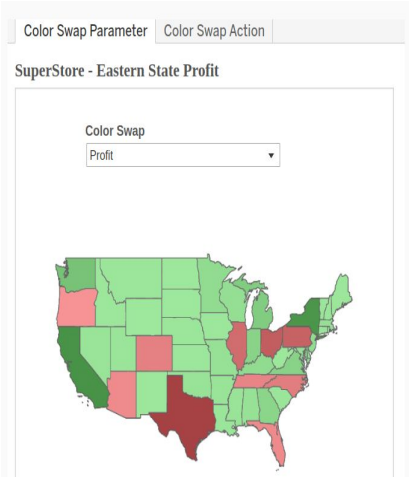
Tip 4-c) Alternate Distinguishing Methods

- Solution 2:
  - using Lines Thickness
  - to provide **Accessibility**



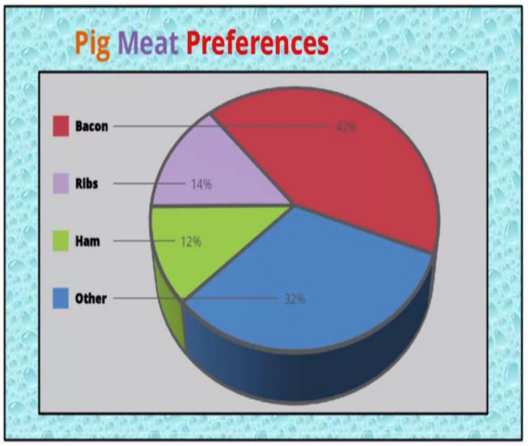
Tip 4-d) Use a UI element to Switch Color Palette

- Use a checkbox (or similar GUI) to switch the color palette to **CVD-friendly Palette**

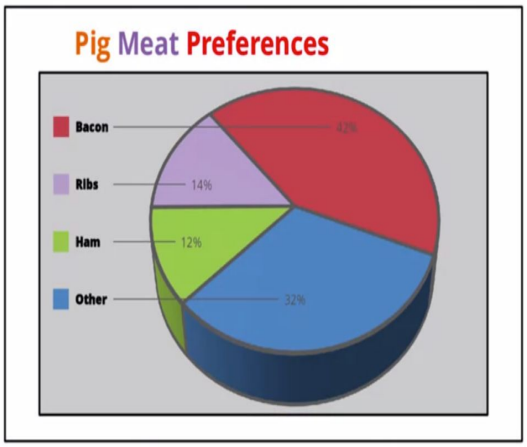


Visualization Example

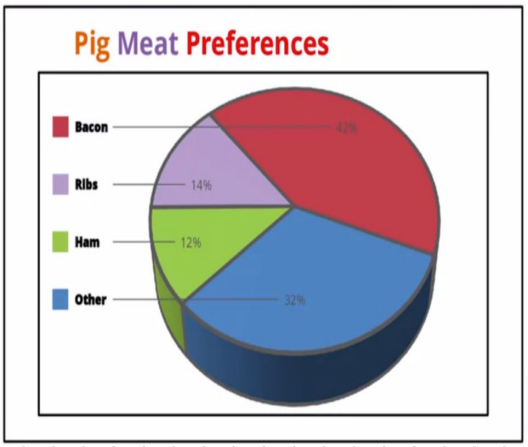
Visualization Example (1/12)



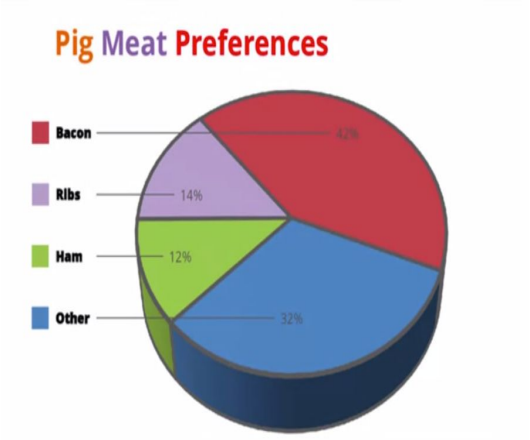
Visualization Example (2/12)



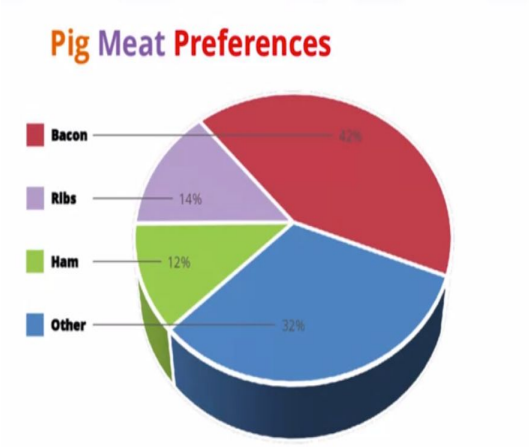
Visualization Example (3/12)



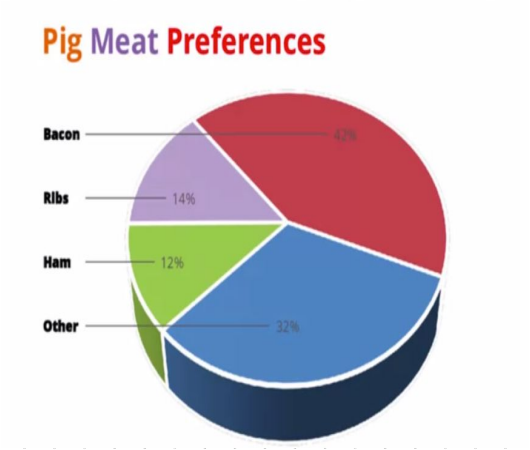
Visualization Example (4/12)



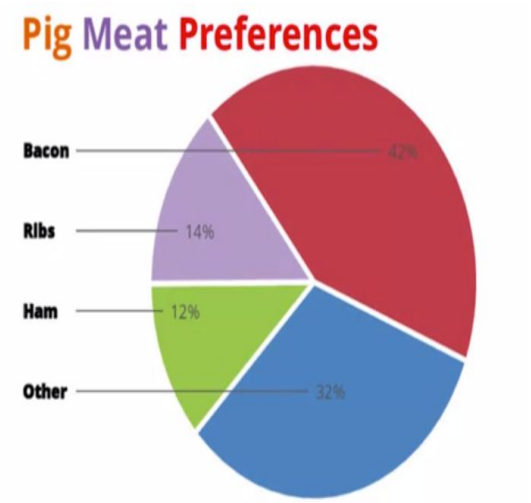
Visualization Example (5/12)



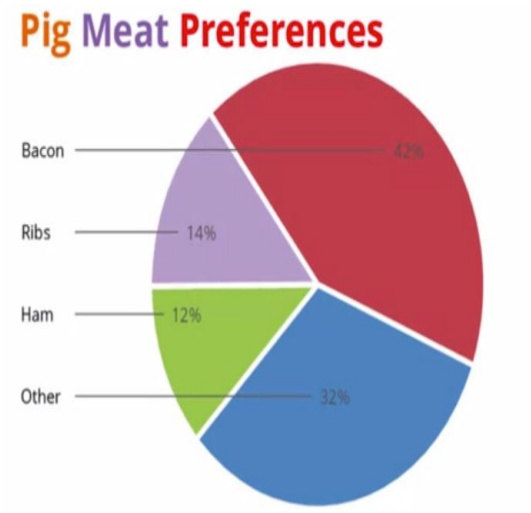
Visualization Example (6/12)



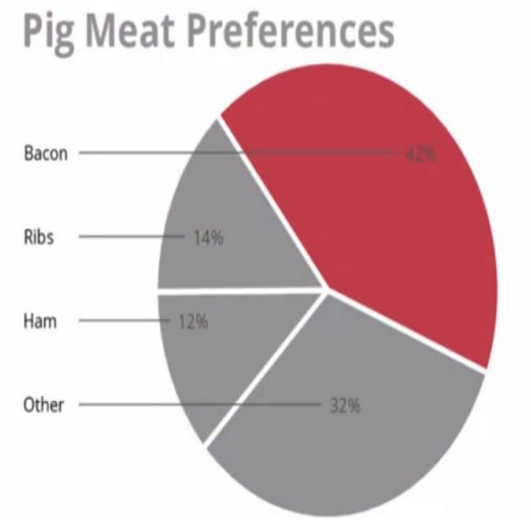
Visualization Example (7/12)



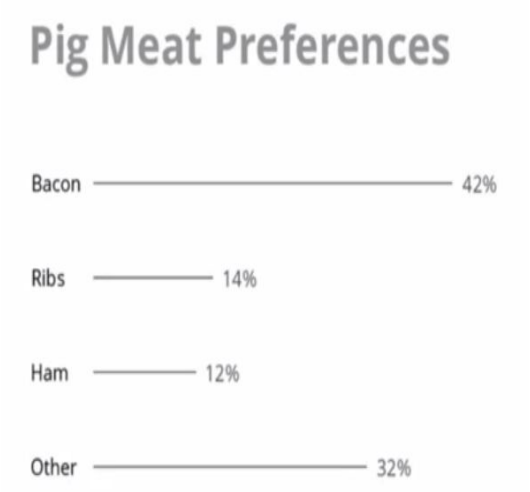
Visualization Example (8/12)



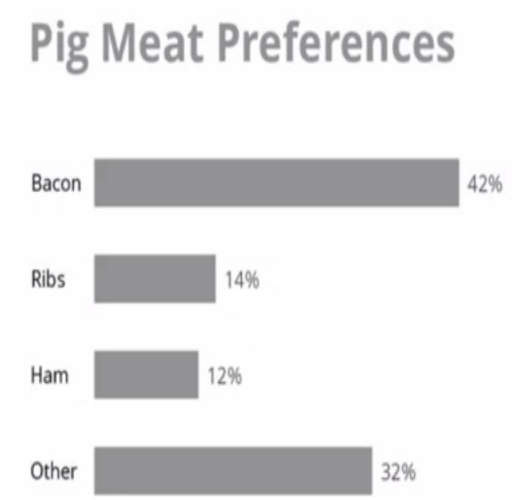
Visualization Example (9/12)



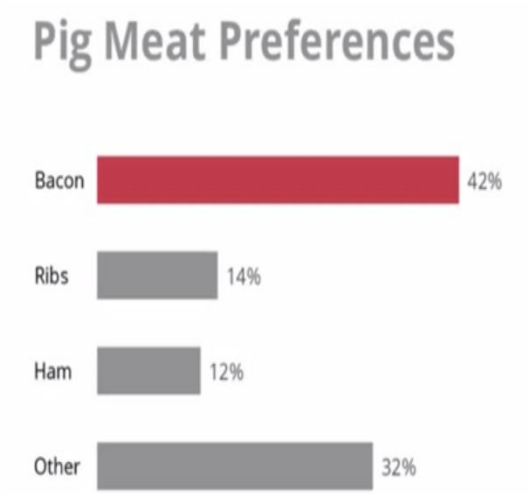
Visualization Example (10/12)



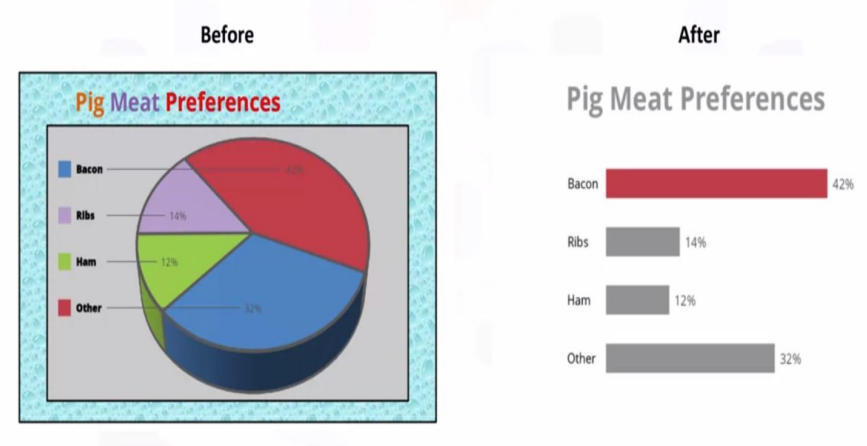
Visualization Example (11/12)



Visualization Example (12/12)

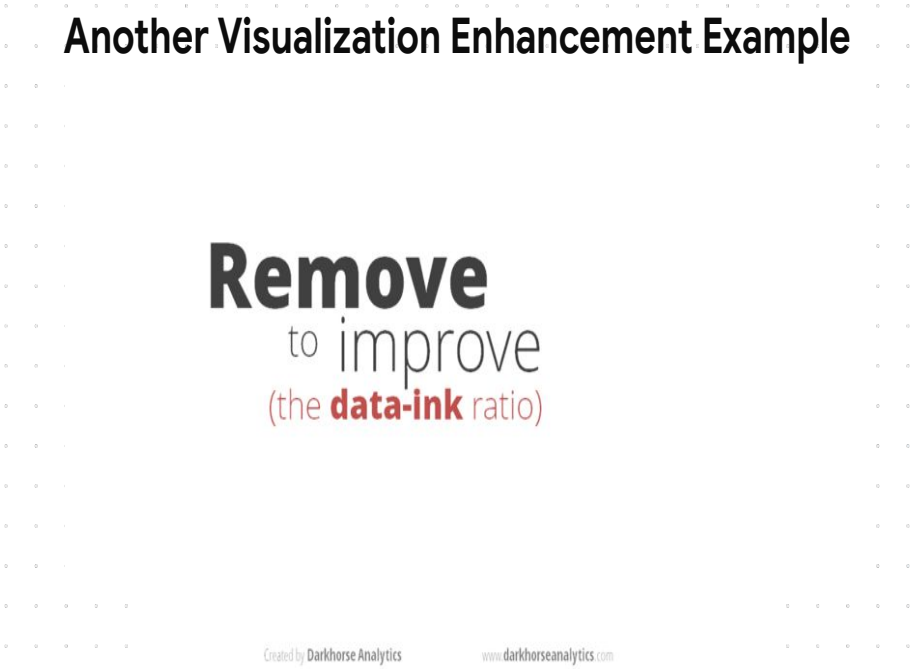


Visualization Example: Can it be enhanced more?



Can we enhance it more?

Another Visualization Enhancement Example



Data-Ink Ratio (Data-ink and Non-data-ink) from the book, “Visual Display of Quantitative Information”:

- Remove 3D
- Remove the background image
- Remove background fills
- Remove shape effects
- Remove shape outlines
- Remove bolding
- Remove (Modify) redundant labels
- Remove unnecessary gridlines
- Remove unnecessary tick marks
- Remove unnecessary axes
- Remove legends
- Label graph directly
- Avoid abbreviations
- Make graph compact

- Reveal the data at several levels of details

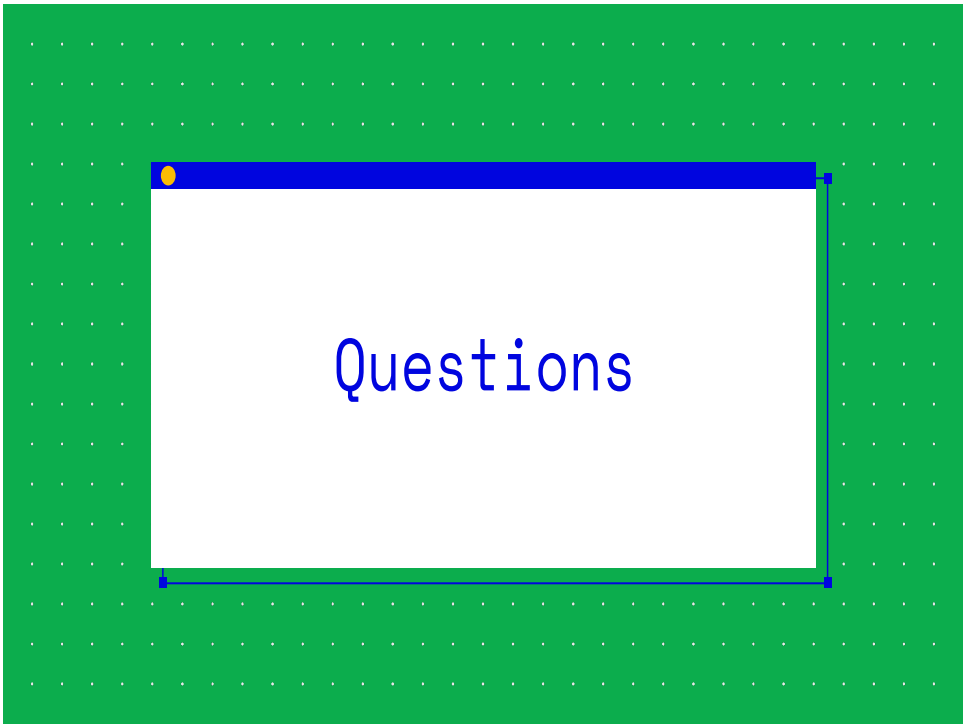
Google Sheets Charts

Check the following Google Sheets Materials on the Course GitHub Repo

1. Source Excel Files
2. Steps in PDF Files
3. Solution Links

https://support.google.com/docs/answer/3093289?sjid=13505799503151128728-EU

- In Google Sheets SPARKLINE function,
  - Colors can be written
    - using their names (e.g., "green") or
    - using their hex code (e.g., "#3D3D3D").
  - To modify the color of a line chart, change the font color of the cell.


Questions

Links

https://github.com/fcai-b/dv

References

1. https://www.tableau.com/about/blog/examining-data-viz-rules-dont-use-red-green-together
2. https://www.coursera.org/learn/foundations-data
3. https://www.tableau.com/learn/articles/data-visualization
4. https://www.coursera.org/learn/what-is-datascience