Data Visualization and Accessibility

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What is Accessibility?

What is Accessibility?

- Accessibility is the practice of ensuring everyone can access our content, **including people with disabilities**.

- Accessiblity $\neq$ Availability:
  "People often talk about how their applications are accessible 24/7 over the Internet. That is not what we are talking about. That is simply availability. We are talking about accessibility for people with disabilities."
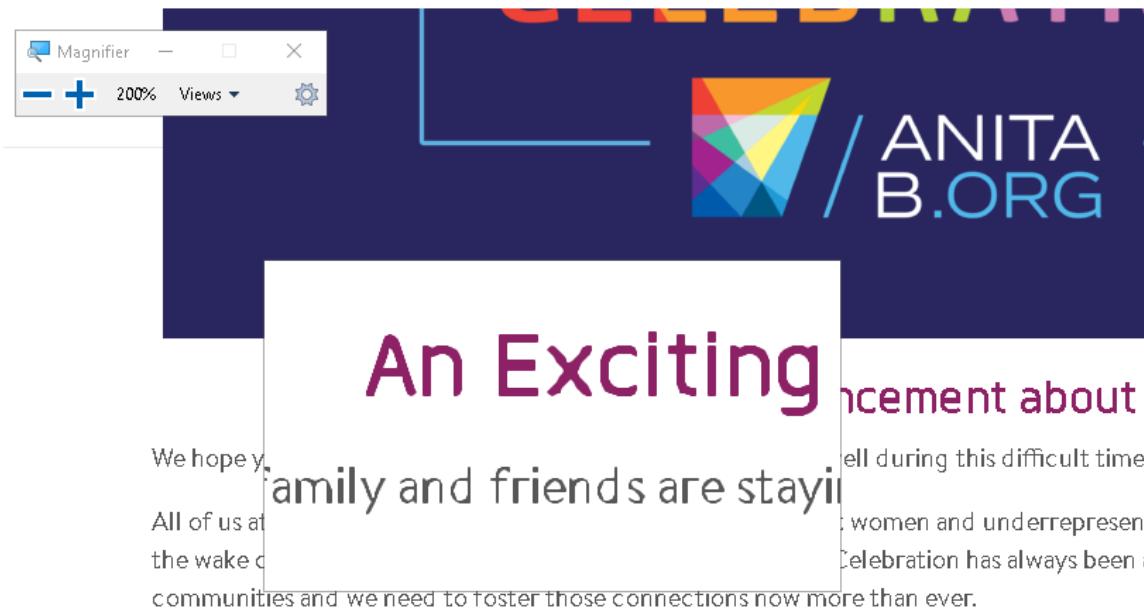
  – Derek Featherstone, Level Access

Derek Featherstone. 2015. UX Foundations: Accessibility. LinkedIn Learning.
https://www.linkedin.com/learning/ux-foundations-accessibility/

Goal: Empower people with disabilities to access online content

Computer magnifier for people with low vision

Examples of Accessibility: Assistive Technology

Goal: Empower people with disabilities to access online content

Closed captioning for people who are deaf and hard of hearing

https://blog.video.ibm.com/ai-video-technology/the-future-of-closed-captioning-with-ai/

Intersection: Data Visualization and Accessibility

Intersection: Data Visualization and Accessibility

"Data visualization is the presentation of data in a pictorial or graphical format. It enables decision makers to see analytics presented visually, so they can grasp difficult concepts or identify new patterns."
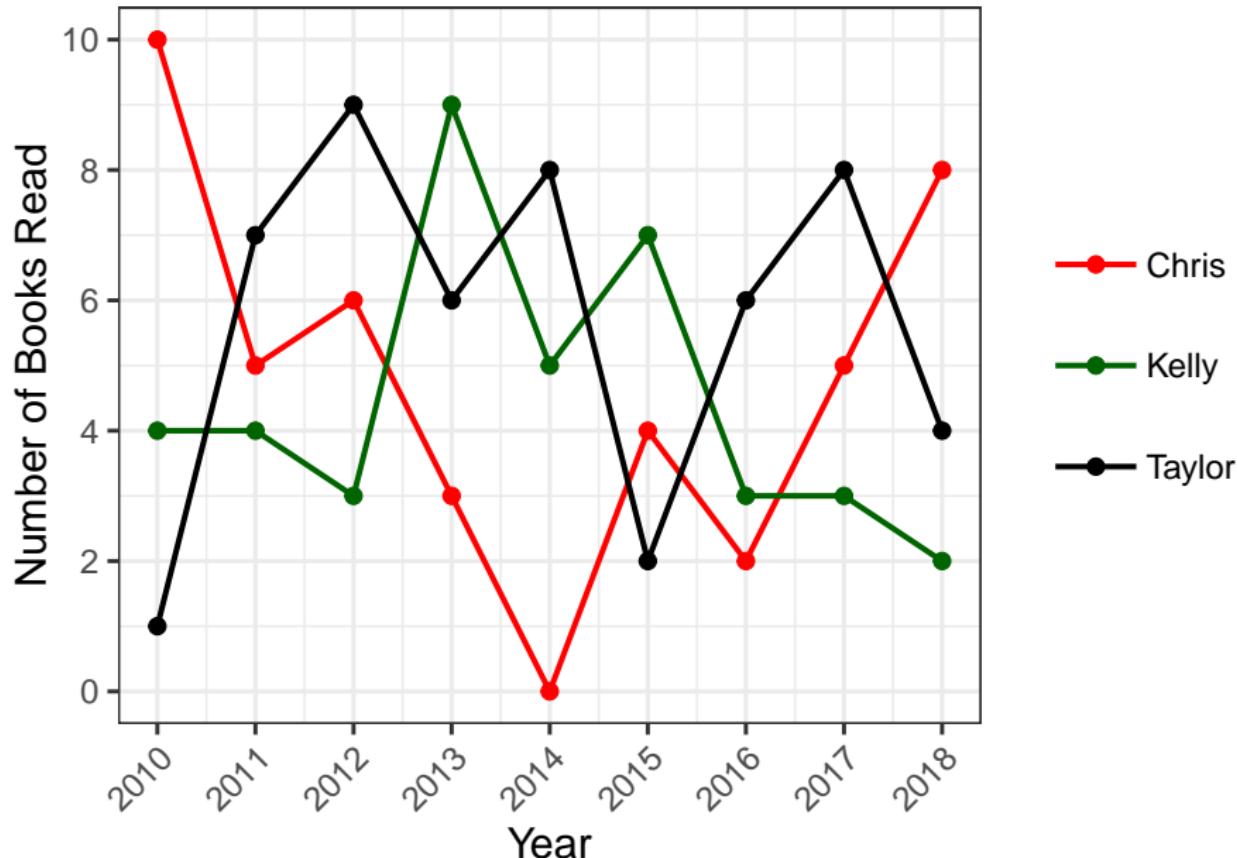
– SAS Analytics

The goal is to **convey the message to the audience**.
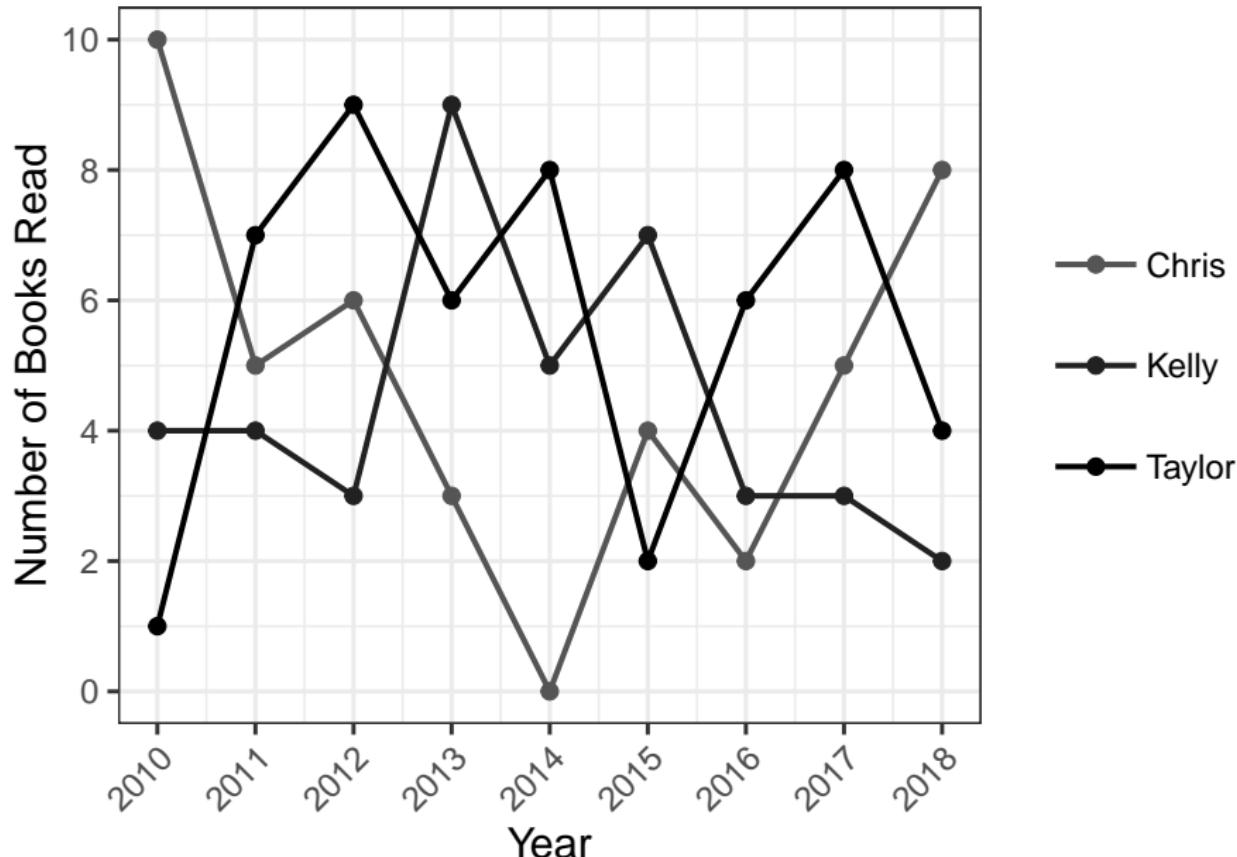
What's the point when some people cannot even read the graph?

https://www.sas.com/en_us/insights/big-data/data-visualization.html

Data visualizations also need to be accessible.

Some people cannot see colors, so they will see ...

Accessibility increases the size of audience pool

Number of people on this planet with color blindness:
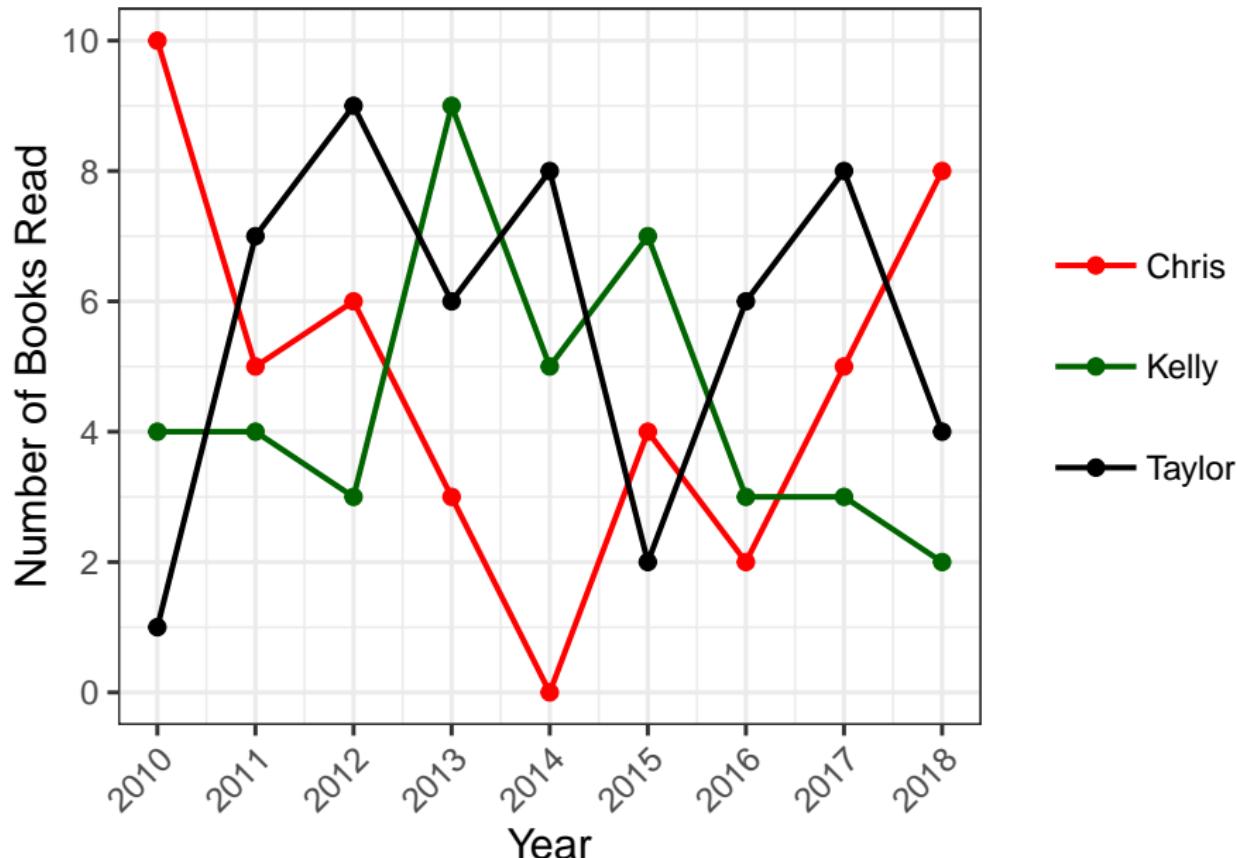
- Approximately 300 million people
- About 4.5% of the global population
- Almost the same number of the entire US population!

If we incorporate accessibility in data visualizations,
these people can also be included in the potential audience.

http://www.colourblindawareness.org/colour-blindness/

Example 1: Books Read per Year

How do we improve accessibility in this graph?
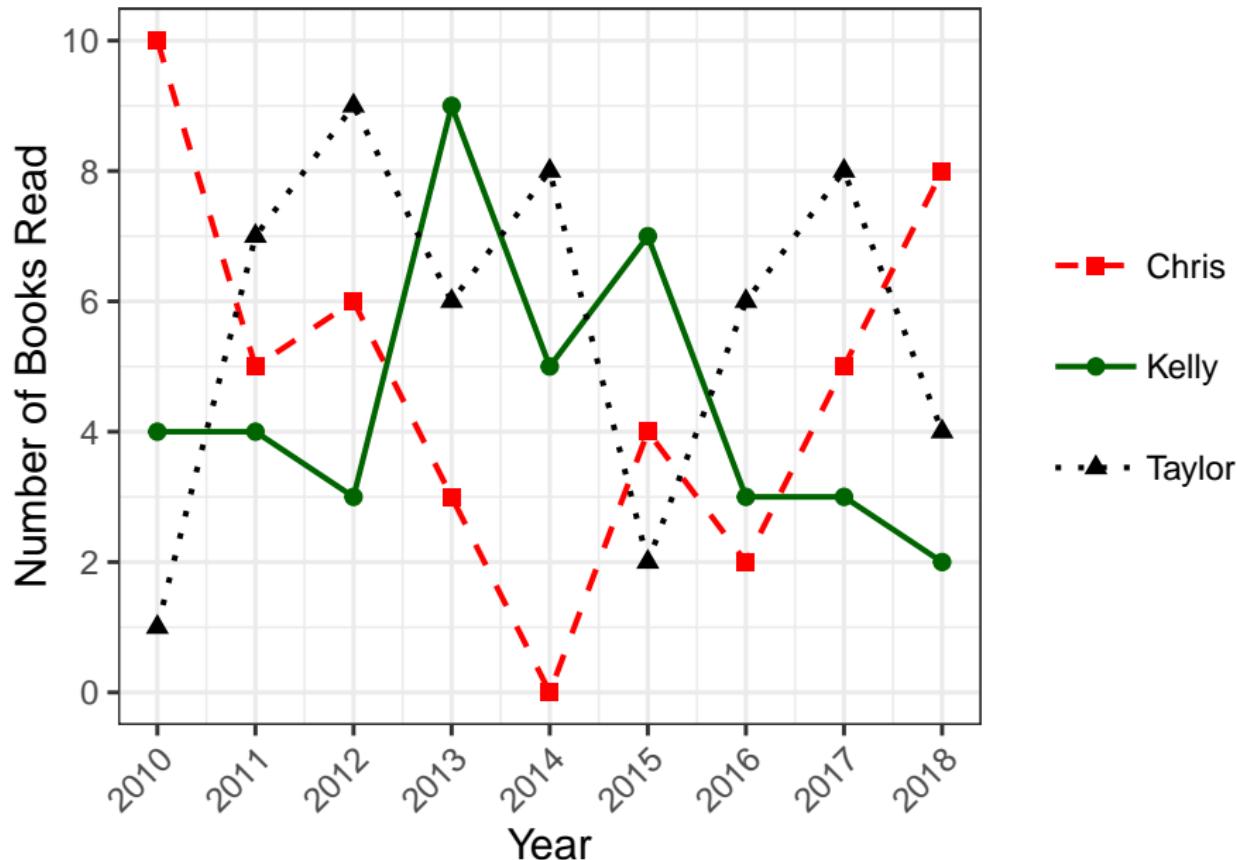
Solution: Change the point shapes and line types
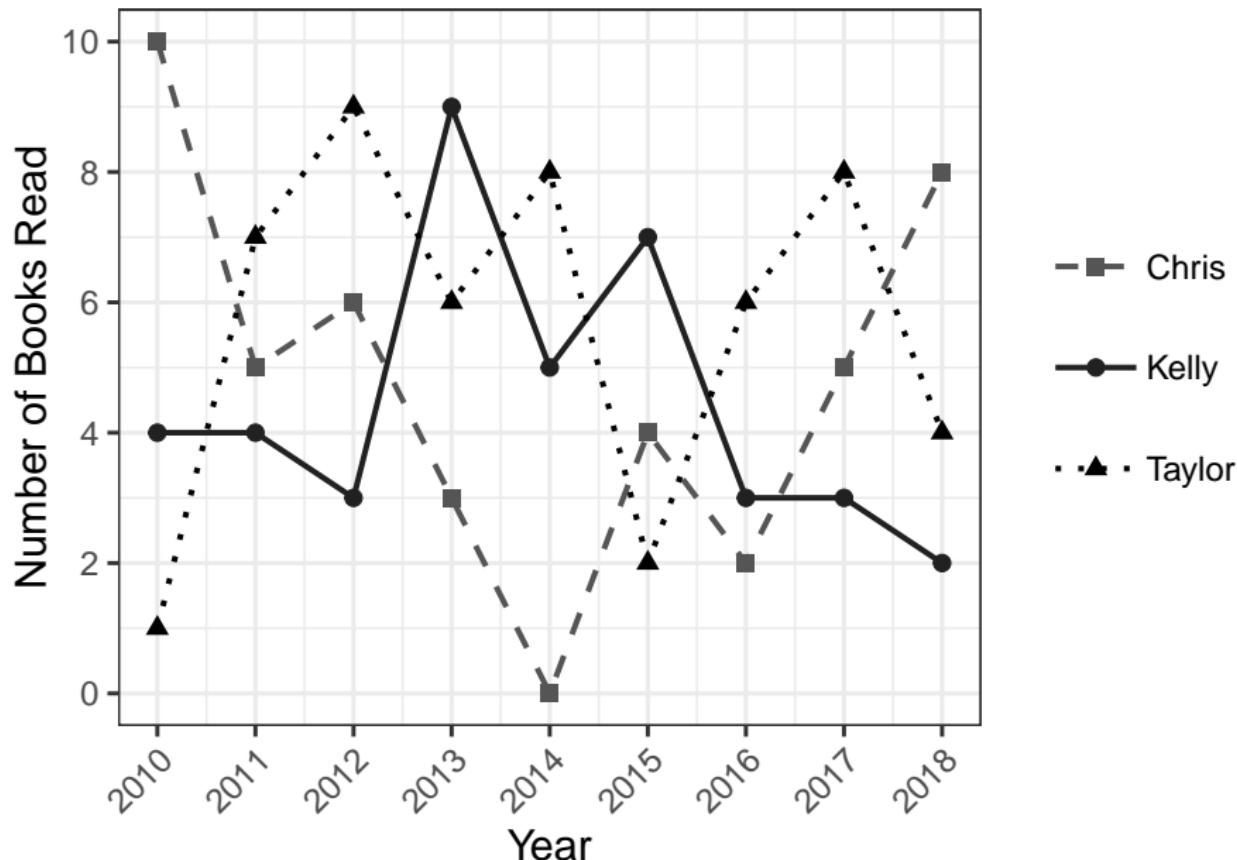
R package: ggplot2

```
scale_color_manual(values=c("red","darkgreen","black"))
scale_linetype_manual(values=c("dashed","solid","dotted"))
scale_shape_manual(values=c("square","circle","triangle"))
```

Accessible Graph (Color)
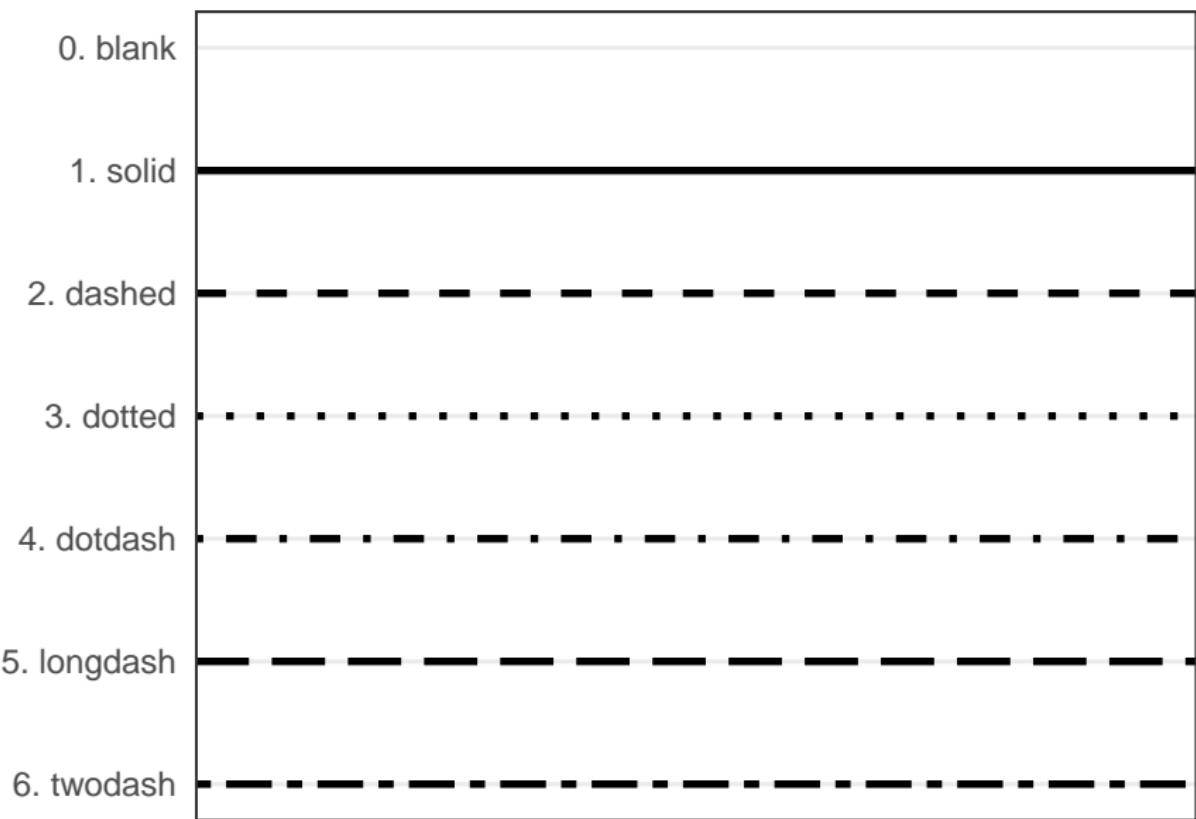
Accessible Graph (Without Color)

R Point Shapes: Options Available

0	1	2	3	4	5	6
□	○	△	+	×	◇	▽

7	8	9	10	11	12	13
⊠	✳	⬖	⊕	⧓	⊞	⊗

14	15	16	17	18	19	20
◹	■	●	▲	◆	●	•

21	22	23	24	25		
●	■	◆	▲	▼		

R Line Types: Options Available

Benefits of Accessible Data Visualizations

Accessibility is good business practice because it ...

Improves graph readability for:

- People with color blindness
- People who print the graph in black and white
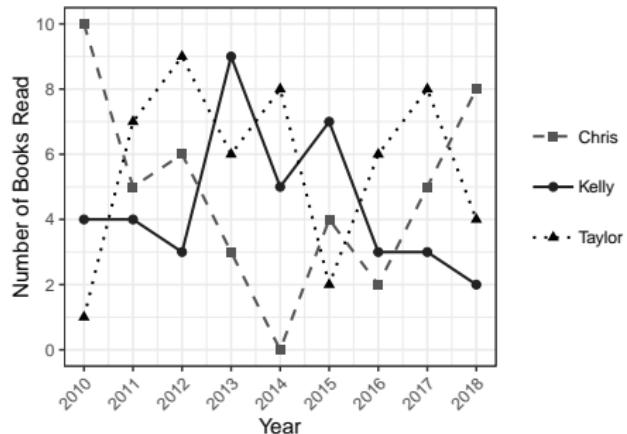
Saves costs in color printing:

- Journal of the American Statistical Association (JASA) charges **$400 for a color figure** if it needs to be printed in color.

https://www.tandfonline.com/action/authorSubmission?show=instructions&journalCode=uasa20&#pubCharge
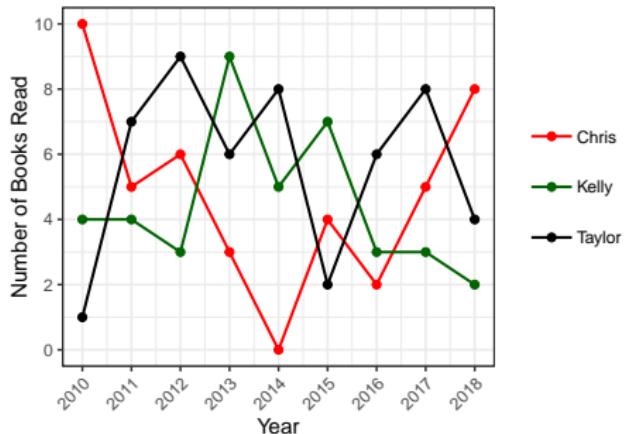
Benefits of Accessible Data Visualizations

Accessible graph

Inaccessible graph: Extra charge!

Takeaways: Color Usage in Data Visualizations

- We can use color, but we should not solely rely on color.
  Each trend needs to be distinguishable in the absence of color.

- Accessibility benefits not only people with disabilities,
  but also improves the overall user experience.

Geri Coady. 2017. Color Accessibility Workflows. A Book Apart.
https://abookapart.com/products/color-accessibility-workflows

Example 2: Comparison of Precipitation

Climate: Seattle vs Phoenix

- Seattle: Oceanic climate

- Phoenix: Hot desert climate

Phoenix: High Precipitation in July and August
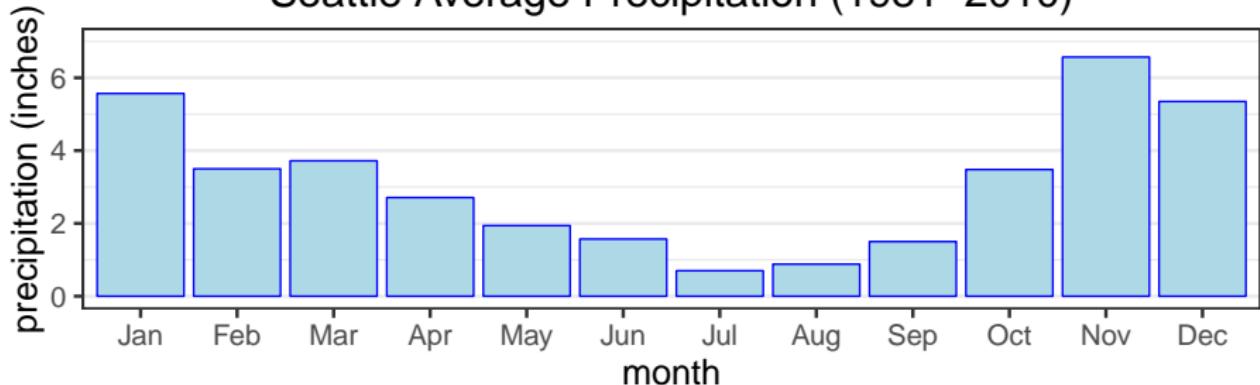
- In the summer, Phoenix gets thunderstorms $\Rightarrow$ high precipitation.

- "Severe thunderstorms can produce heavy rain, flash flooding, dangerous winds, hail, dust storms and lightning."

  – Arizona Emergency Information Network

https://ein.az.gov/hazards/thunderstorms
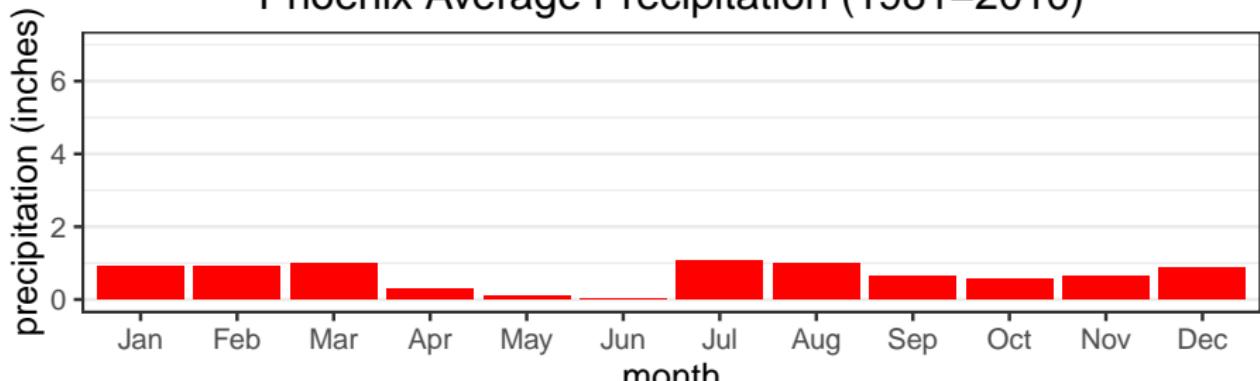
Precipitation: Seattle vs Phoenix (Data from Wikipedia)

Seattle Average Precipitation (1981–2010)
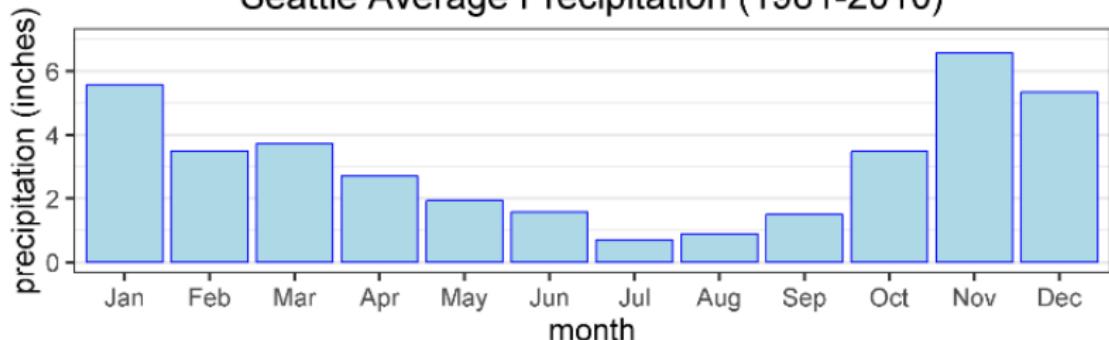
Phoenix Average Precipitation (1981–2010)
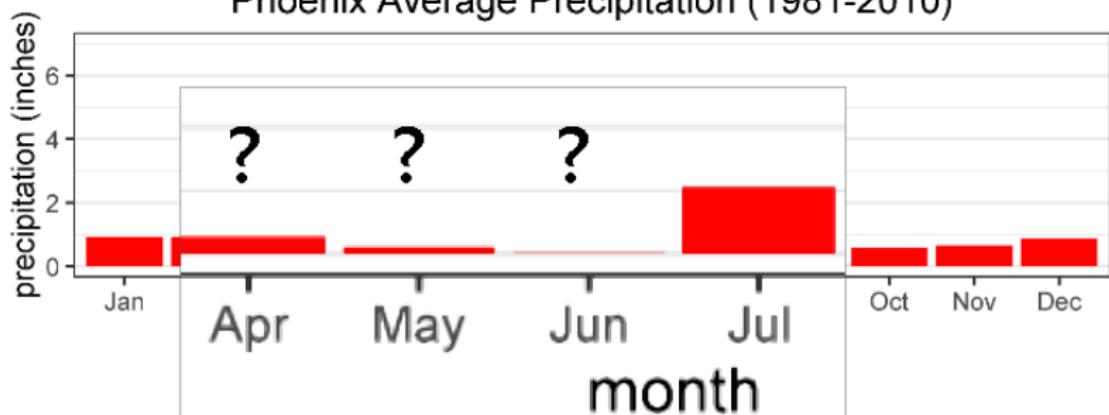
Concern: Missing data for Phoenix?

Seattle Average Precipitation (1981-2010)

Phoenix Average Precipitation (1981-2010)

Add labels to address missing data concerns

R package: ggplot2
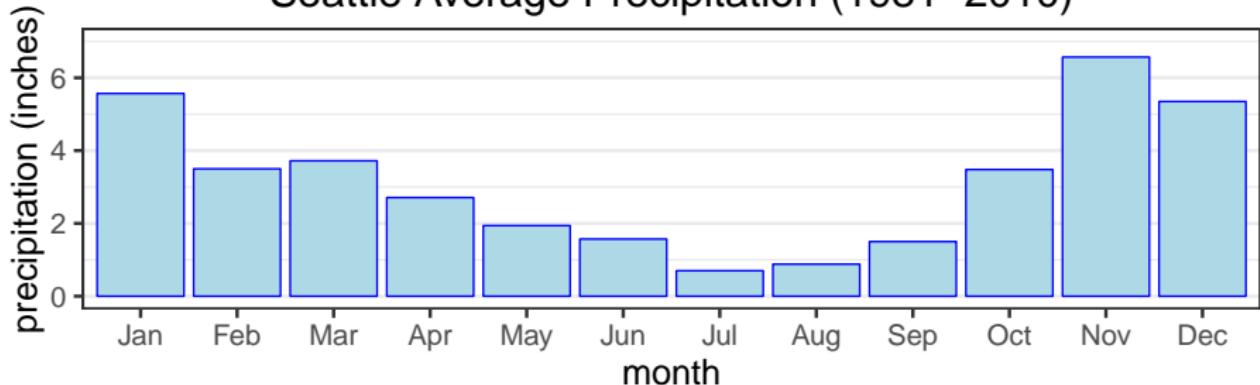
- **Create the labels:**
  ```
  phoenix$rain_label =
  c("","","",phoenix$rain_inches[4:6],"","","","","","")
  phoenix$rain_unit =
  c("","","","inches","inches","inches","","","","","","")
  ```

- **Add the labels to ggplot:**
  ```
  geom_text(aes(label=rain_label),
  position=position_dodge(width=0.9),size=6,vjust=-2.25)
  geom_text(aes(label=rain_unit),
  position=position_dodge(width=0.9),size=6,vjust=-0.5)
  ```
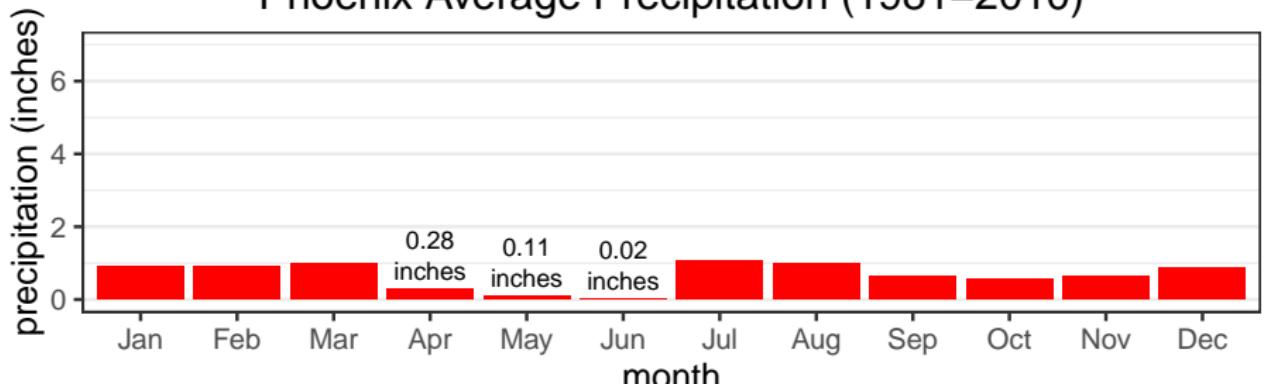
Add labels to address missing data concerns
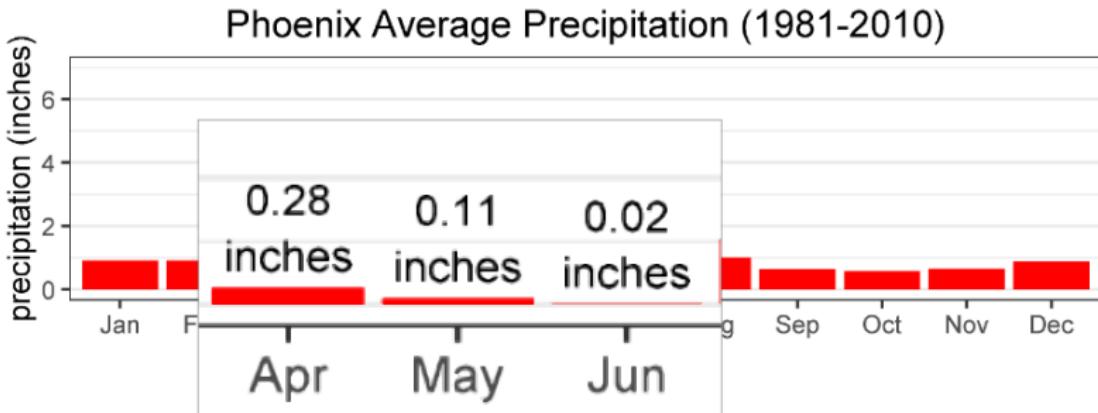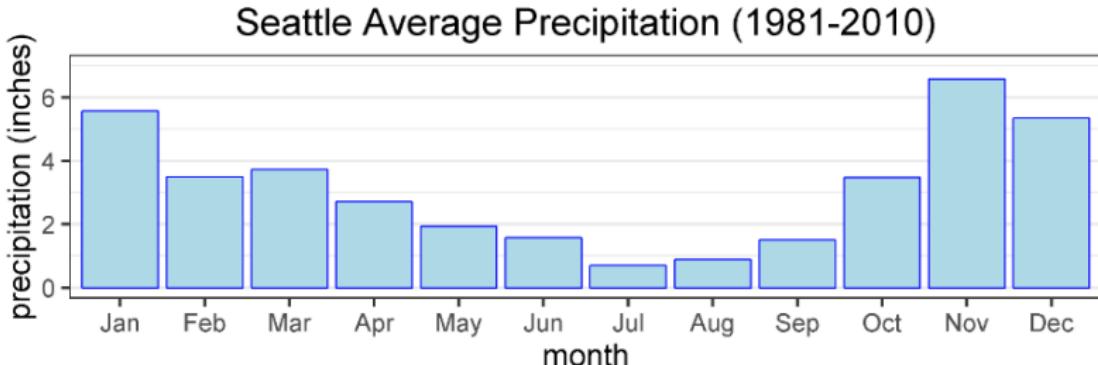
Seattle Average Precipitation (1981–2010)

Phoenix Average Precipitation (1981–2010)

Labels indicate existence of data

Seattle Average Precipitation (1981-2010)

Phoenix Average Precipitation (1981-2010)

0.28 inches   0.11 inches   0.02 inches

Apr   May   Jun

Increase the audience pool to global community

- Accessibility is to ensure that **everyone** can access our content.

- Most places outside the United States use the **metric system**.
  e.g. meters, kilograms, Celsius temperature scale

- We also need to consider international people's needs as well.

Solution: Add a secondary y-axis for mm (millimeter)
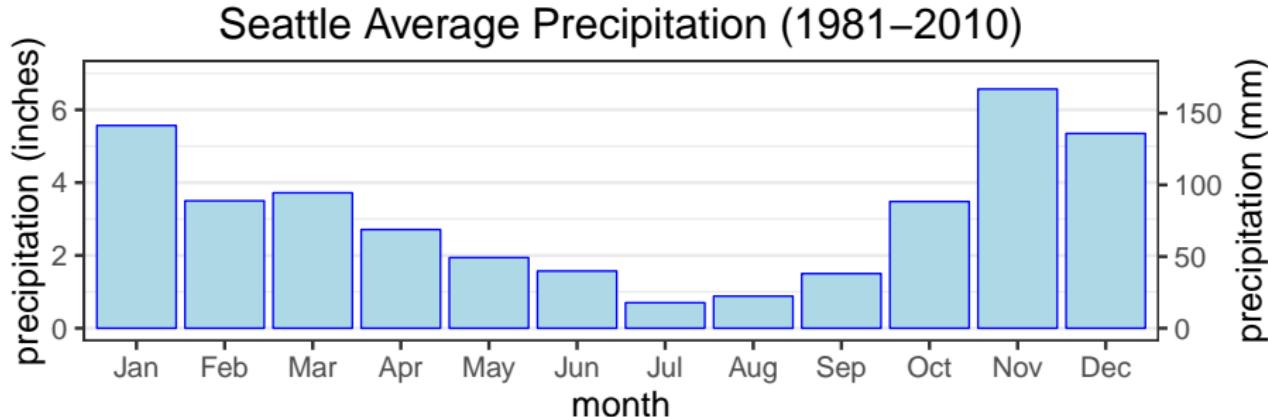
R package: ggplot2

Add the secondary y-axis for the other unit
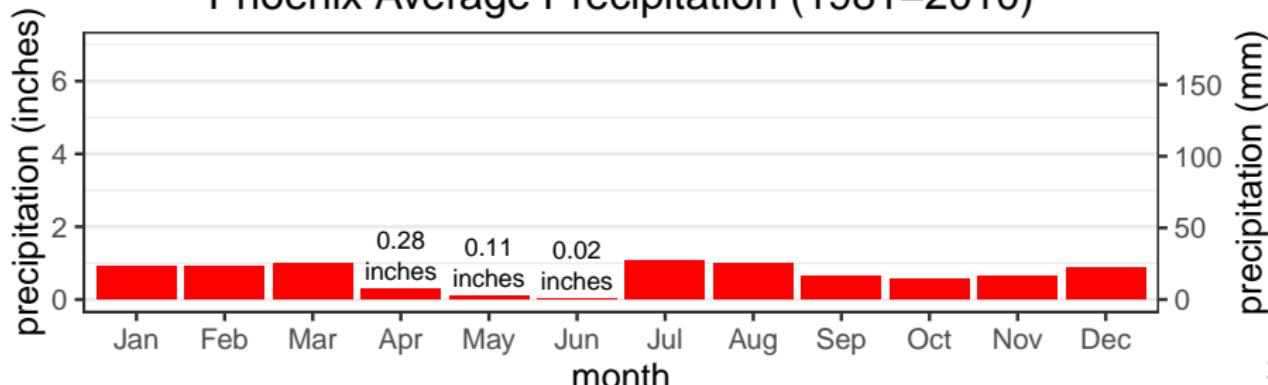
1 inch = 2.54 cm = 25.4 mm (millimeter)

```
scale_y_continuous(sec.axis =
sec_axis(~.*25.4,name="precipitation (mm)"))
```
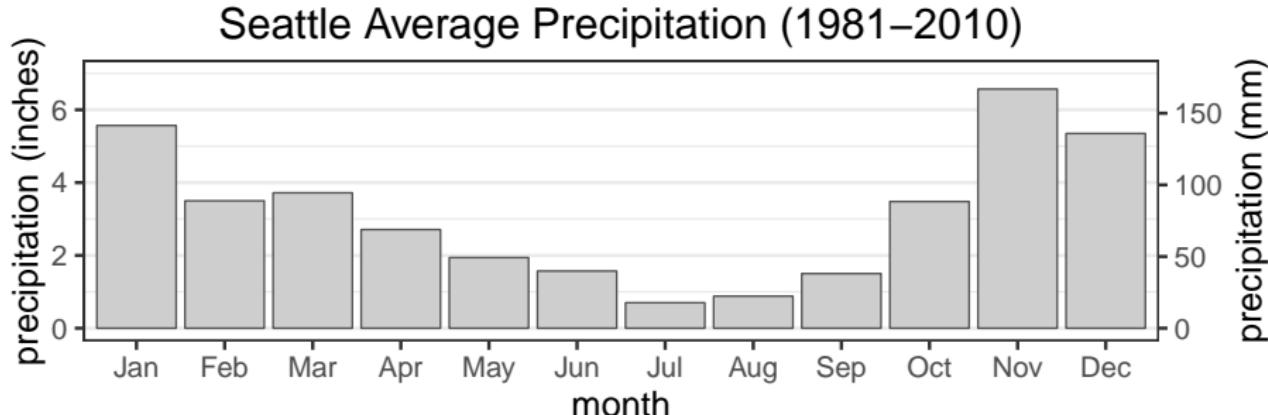
Seattle Average Precipitation (1981–2010)
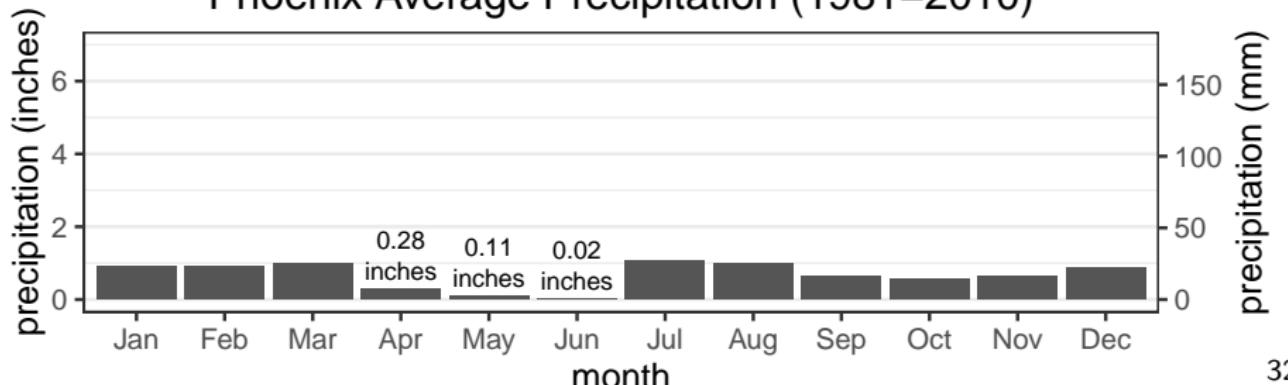
Phoenix Average Precipitation (1981–2010)

Precipitation: Seattle vs Phoenix (Without Color)

Seattle Average Precipitation (1981–2010)

Phoenix Average Precipitation (1981–2010)

Precipitation: Seattle vs Phoenix

Phoenix Precipitation
April: 0.28 inches
May: 0.11 inches
June: 0.02 inches

Precipitation: Seattle vs Phoenix

Phoenix Precipitation
April: 0.28 inches
May: 0.11 inches
June: 0.02 inches

Seattle (left)
Phoenix (right)

Takeaways

- Accessibility is to include **everyone**.

- People access online content in different ways.
  e.g. large print, metric units

- "Know the audience" also includes understanding their needs.

- Larger audience pool means greater potential for impact!

Non-Visual Access of Graphs

Insight Without Sight: Non-Visual Access to Data Visualization

Author: Ed Summers (Director of Accessibility, SAS)

- Blind software engineer
- 20+ years of experience in software development
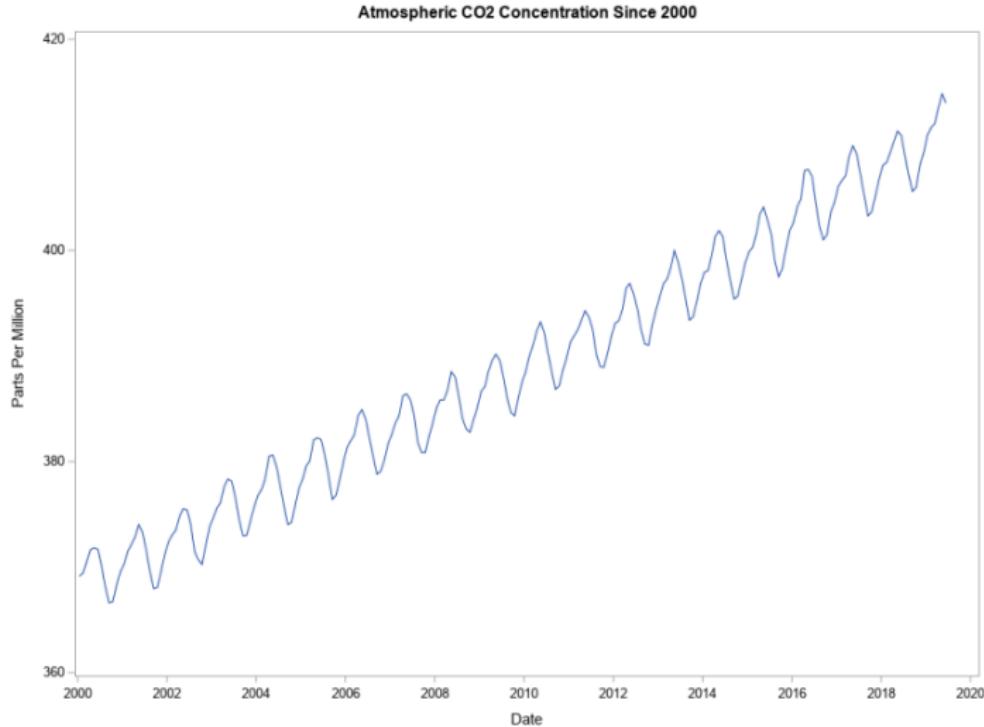
SAS Accessibility: "We democratize data."

SAS Graphics Accelerator (browser extension) uses **sound** in addition to sight, so people who are blind or with extremely low vision can also access data visualizations.

https://tinyurl.com/ghc19-braille-maps
https://www.sas.com/en_us/company-information/accessibility.html

Atmospheric CO2 Concentration Since 2000

C.D. Keeling, S.C. Piper, R.B. Bacastow, M. Wahlen, T.P. Whorf, M. Heimann, and H.A. Meijer, Exchanges of atmospheric CO2 and 13CO2 with the terrestrial biosphere and oceans from 1978 to 2000. I. Global aspects, SIO Reference Series, No. 01-06, Scripps Institution of Oceanography, San Diego, 88 pages, 2001.

Message needs to be conveyed in the absence of color.

Geographic Map (Touchable)

Conclusion

Conclusion

- **Accessibility**: Everyone should be able to read the graph, including people with and without disabilities.

- Principles are technology agnostic; they apply to most data visualization software.

- Key point: **Awareness** of the accessibility issue! Writing code is not that difficult.

Quantified Benefits of Accessibility

Accessibility is good for business:

- 78% of consumers are willing to purchase from a business which ensures access at their physical locations for people with disabilities.

<div align="right">– World Economic Forum</div>

- 54% of consumers with disabilities would shop more often at stores that have made efforts to be accessible and welcome people with disabilities.
- 71% of people with disabilities would leave a website when they find it difficult to use, due to accessibility barriers.

<div align="right">– Retail Insider</div>

https://www.weforum.org/agenda/2019/04/what-companies-gain-including-persons-disabilities-inclusion/

https://www.retail-insider.com/retail-insider/2018/2/essential-accessibility

Mindset in Creating Data Visualizations

- As people working with data, **we** are accountable for the accessibility features of the visualization.
- It is the **creator**'s responsibility to make the graph readable.

- Remember, accessibility benefits not only people with disabilities, but also improves the overall user experience.

"Data visualizations should be accessible.
If not, we are not doing it right."

– Christine Chai (chrchai@microsoft.com)

Slides on GitHub: https://tinyurl.com/sdss-2020-chai

Acknowledgments

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- Stephanie Picioccio (Microsoft Senior Software Engineer)

- Donna LaLonde (Caucus for Women in Statistics - Mentoring Program)

Resources

Accessibility in Data Visualization

- Accessibility at SAS: We democratize data.
  https://www.sas.com/en_us/company-information/accessibility.html

- Ed Summers. 2019. Insight Without Sight: Non-Visual Access to Data Visualization. Grace Hopper Celebration.
  https://tinyurl.com/ghc19-braille-maps

Accessibility in General

- Derek Featherstone. 2015. UX Foundations: Accessibility. LinkedIn Learning.
  https://www.linkedin.com/learning/ux-foundations-accessibility

- Derek Featherstone. 2018. Accessibility for Web Design. LinkedIn Learning.
  https://www.linkedin.com/learning/accessibility-for-web-design

- Geri Coady. 2017. Color Accessibility Workflows. A Book Apart.
  https://abookapart.com/products/color-accessibility-workflows

- MSFTenable: Microsoft Accessibility at a Glance.
  http://youtube.com/MSFTenable