

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.**
- Accessibility ≠ 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.”

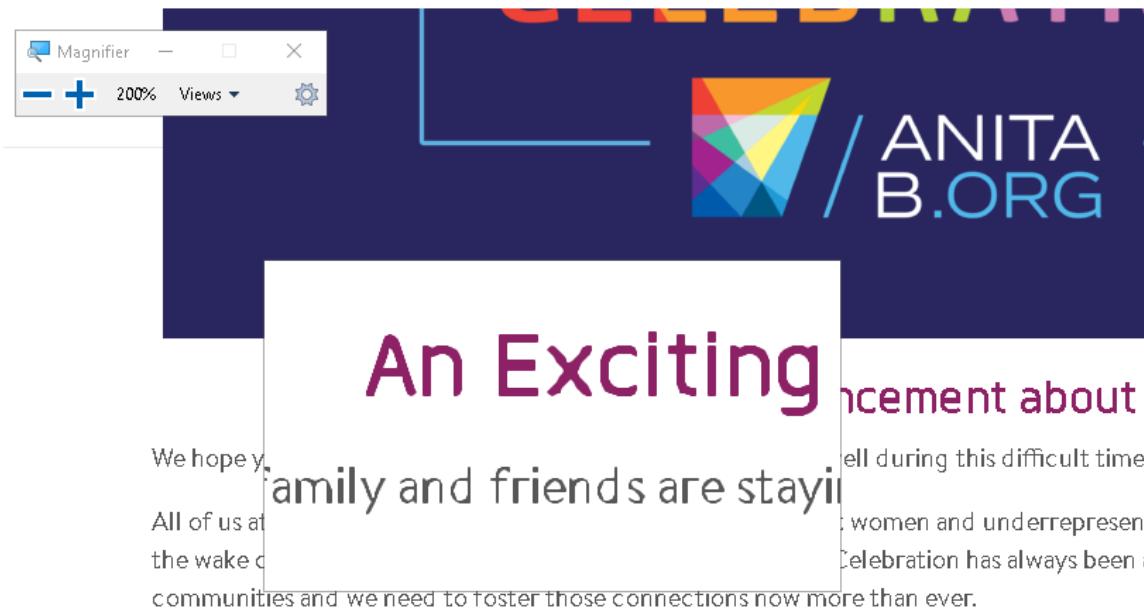
– Derek Featherstone, Level Access

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

Examples of Accessibility: Assistive Technology

Goal: Empower people with disabilities to access online content

Computer magnifier for the vision impaired



Examples of Accessibility: Assistive Technology

Goal: Empower people with disabilities to access online content

Closed captioning for the hearing impaired



<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.”

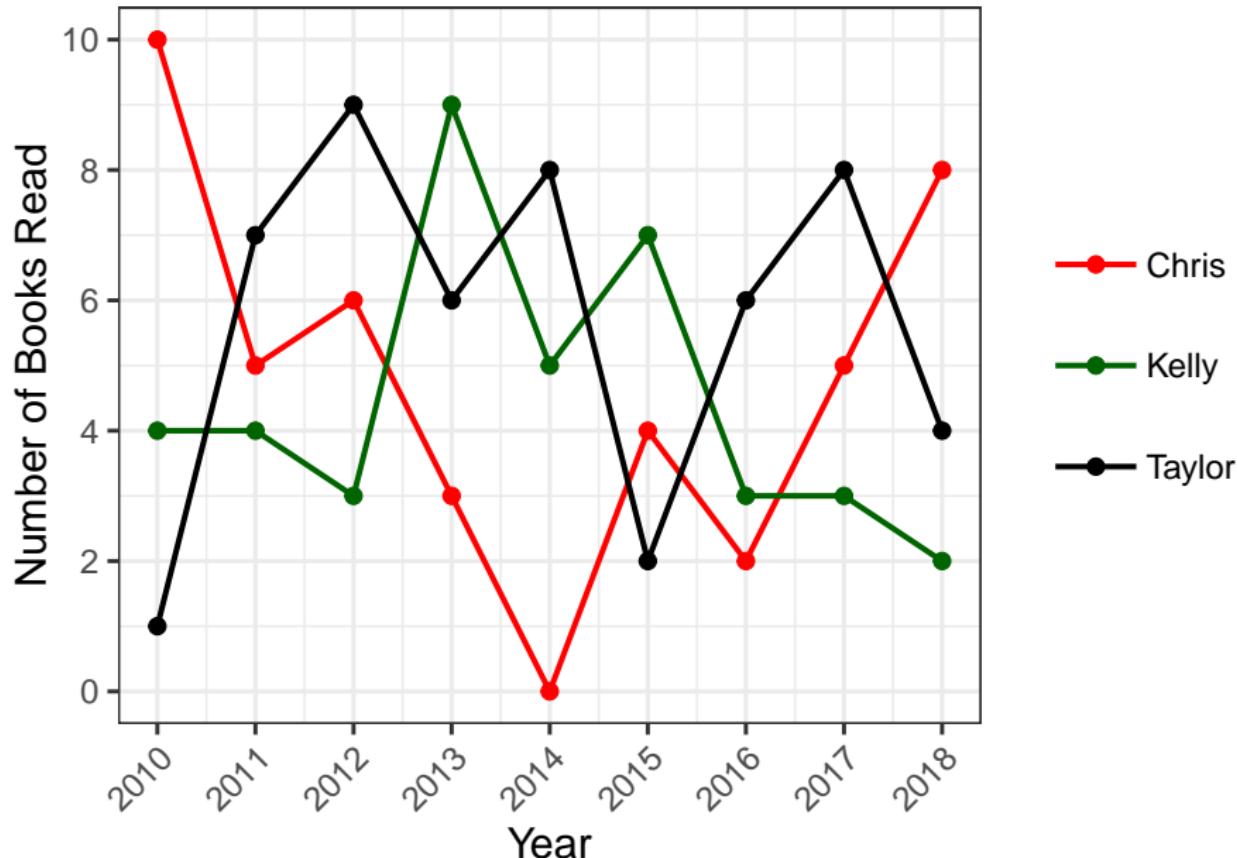
– SAS Analytics

The goal is to **convey the message to the audience.**

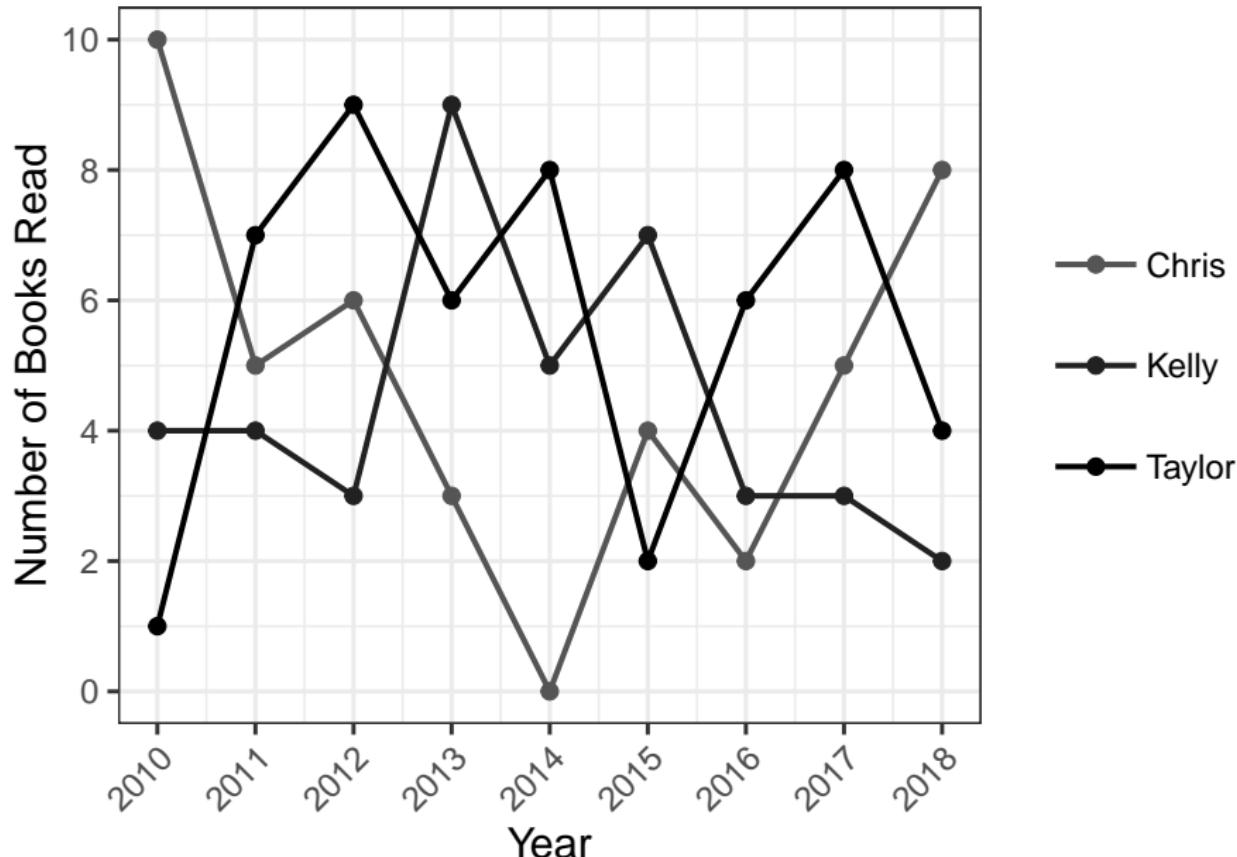
What's the point when some people cannot even read the graph?

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:

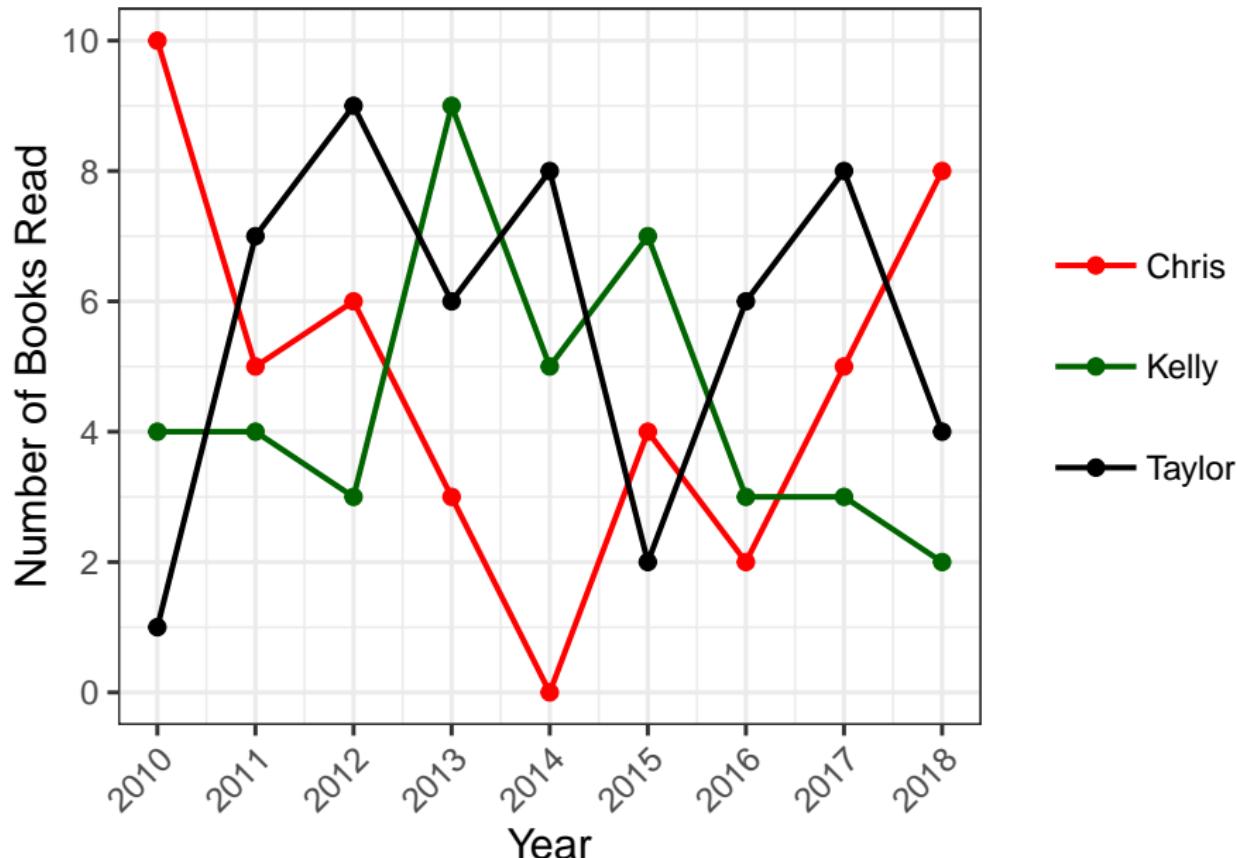
- Approximately 300 million people
- About 4.5% of the global population
- Almost the same number of the entire US population!

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?

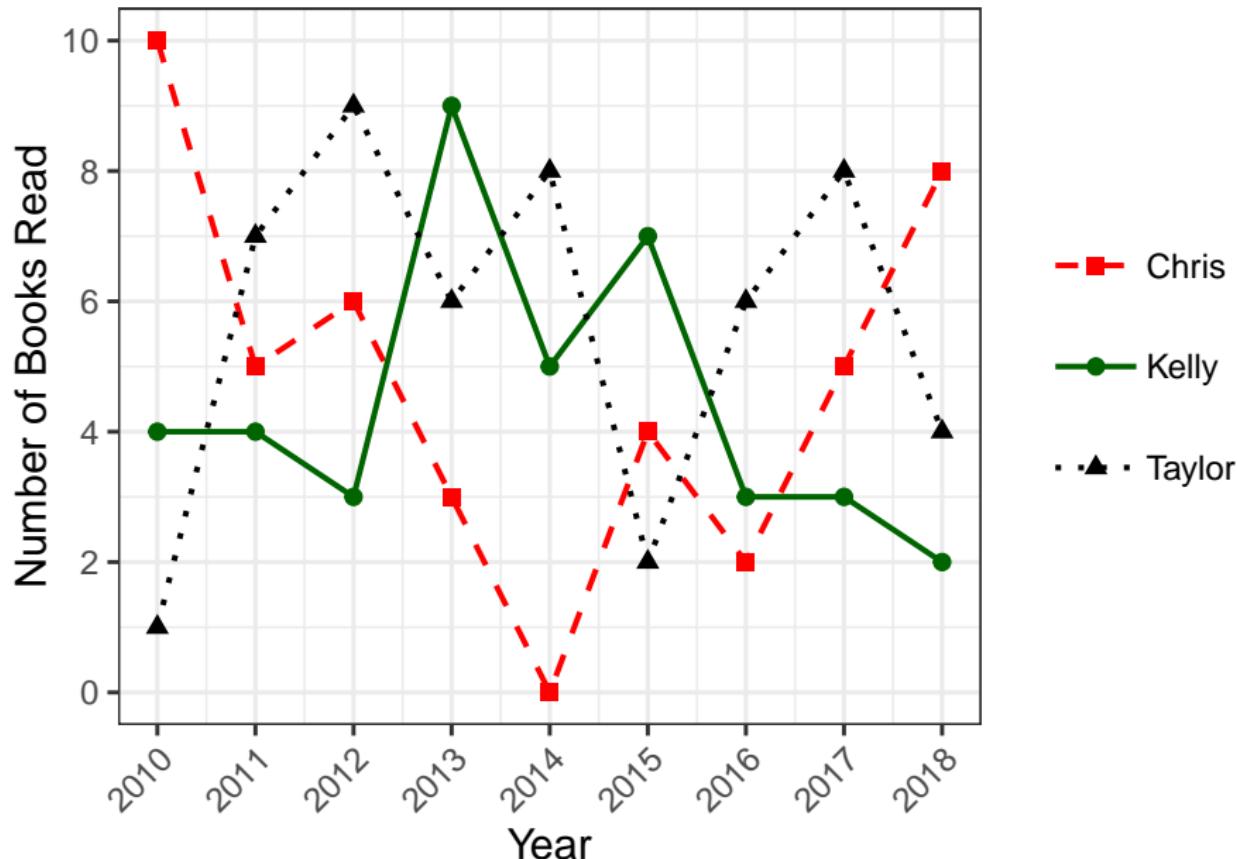


Solution: Change the point shapes and line types

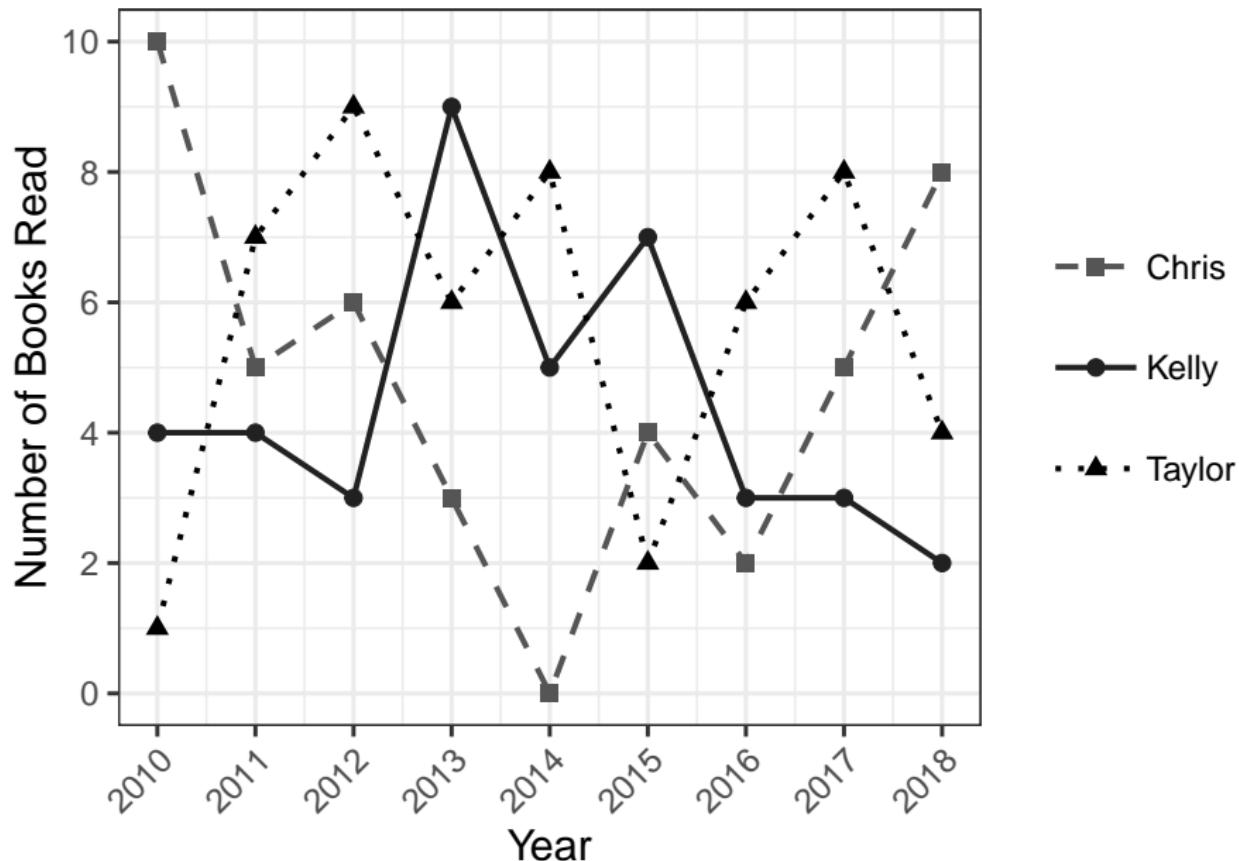
R package: ggplot2

```
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)



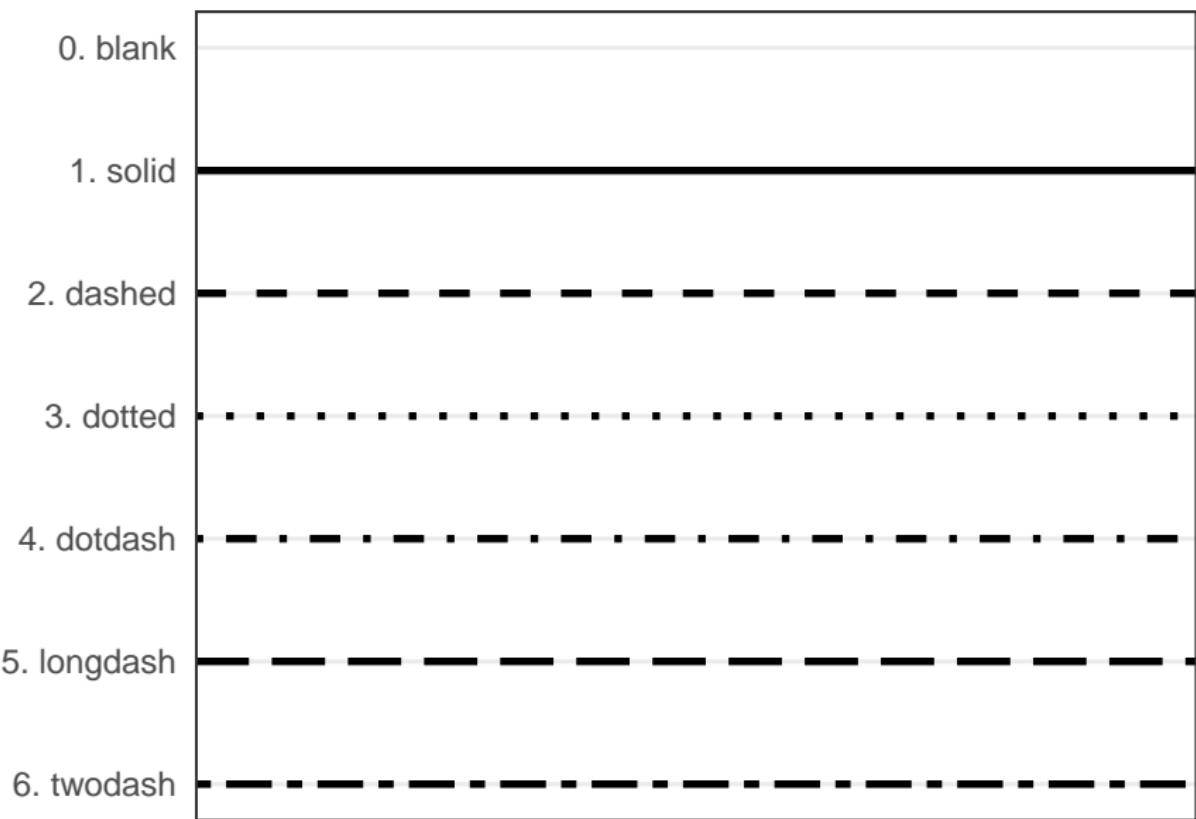
Accessible Graph (Without Color)



R Point Shapes: Options Available

0 □	1 ○	2 △	3 +	4 ×	5 ◇	6 ▽
7 ⊗	8 *	9 ◊	10 ⊕	11 ◊◊	12 田	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

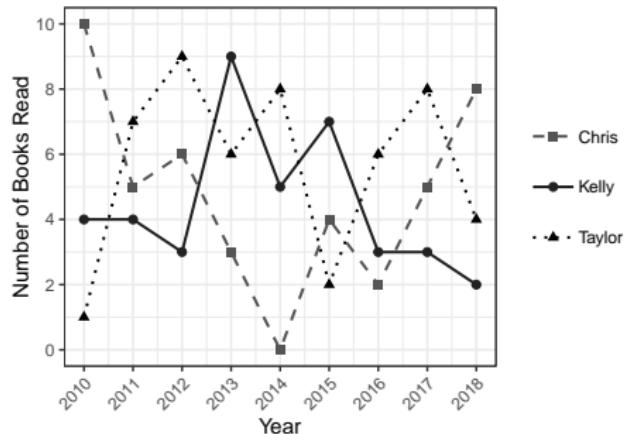
Saves costs in color printing:

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

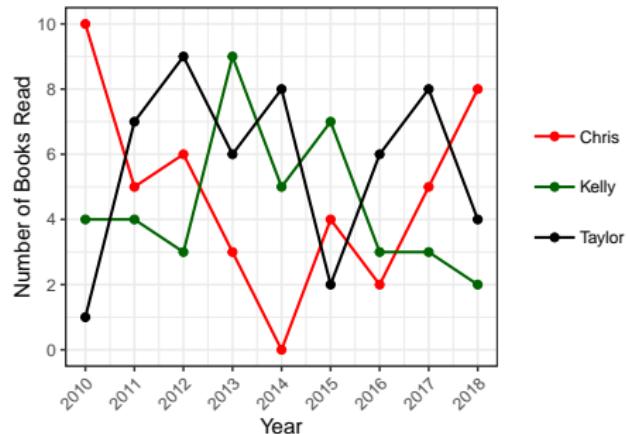
<https://www.tandfonline.com/action/authorSubmission?show=instructions&journalCode=uasa20&#pubCharge>

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

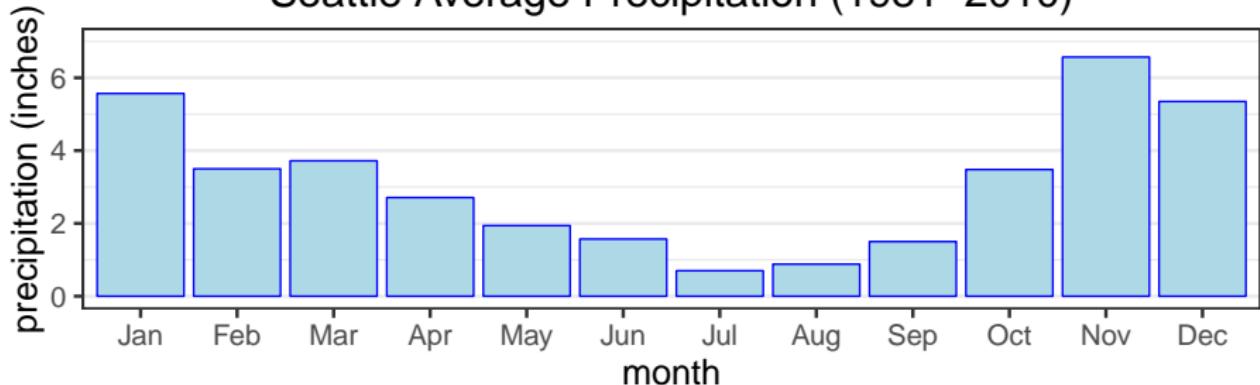
- In the summer, Phoenix gets thunderstorms ⇒ high precipitation.
- “Severe thunderstorms can produce heavy rain, flash flooding, dangerous winds, hail, dust storms and lightning.”
 - Arizona Emergency Information Network



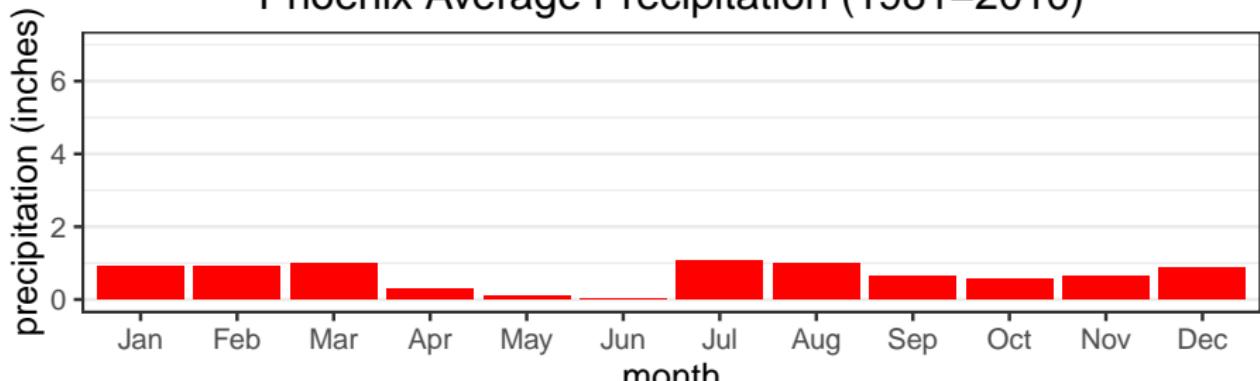
<https://ein.az.gov/hazards/thunderstorms>

Precipitation: Seattle vs Phoenix (Data from Wikipedia)

Seattle Average Precipitation (1981–2010)

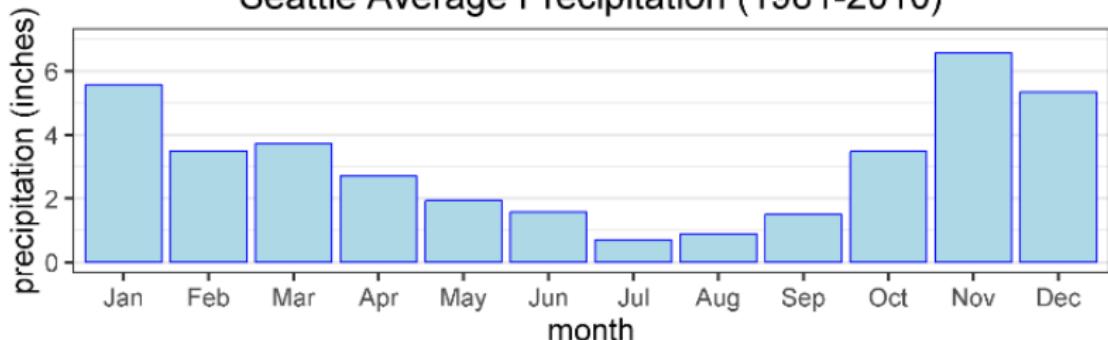


Phoenix Average Precipitation (1981–2010)

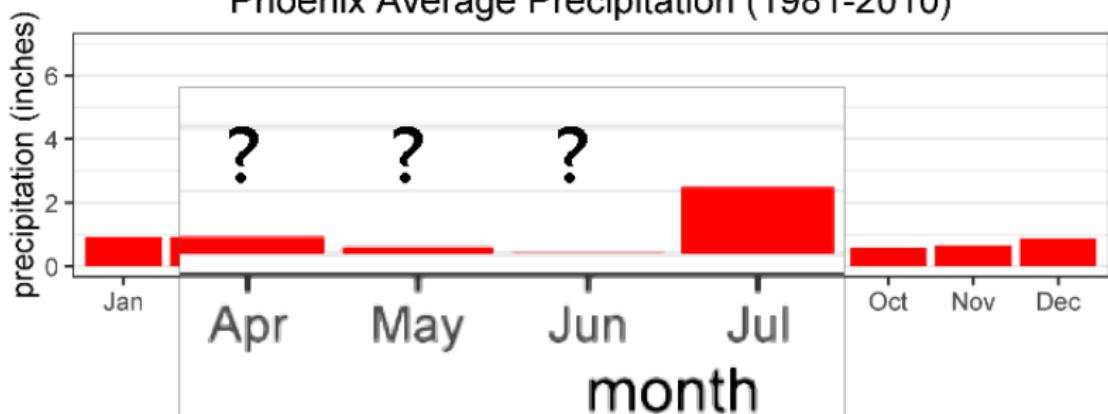


Concern: Missing data for Phoenix?

Seattle Average Precipitation (1981-2010)



Phoenix Average Precipitation (1981-2010)



Add labels to address missing data concerns

R package: ggplot2

- **Create the labels:**

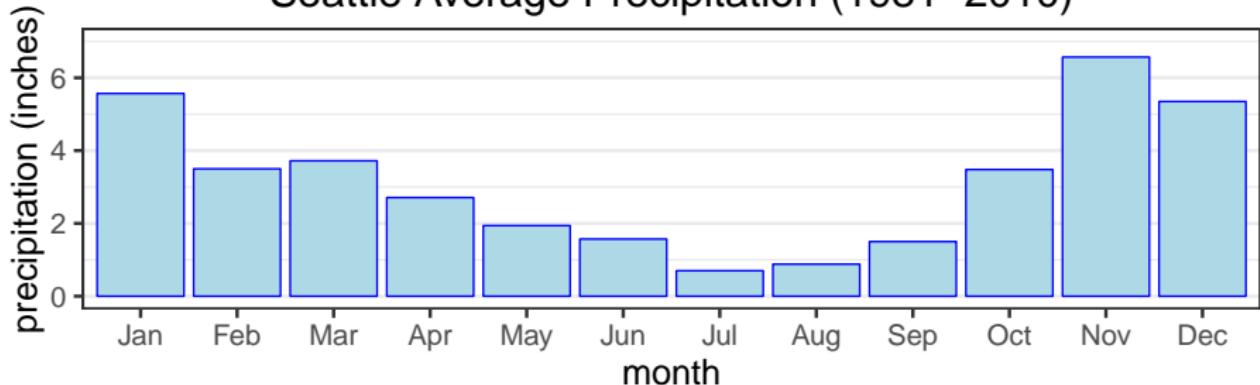
```
phoenix$rain_label =  
c("", "", "", phoenix$rain_inches[4:6], "", "", "", "", "", "")  
phoenix$rain_unit =  
c("", "", "", "inches", "inches", "inches", "", "", "", "", "", "")
```

- **Add the labels to ggplot:**

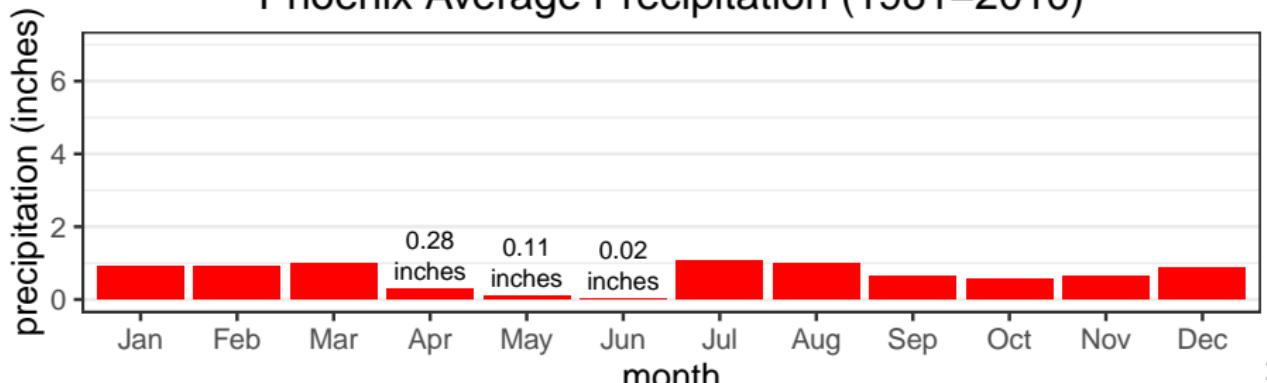
```
geom_text(aes(label=rain_label),  
position=position_dodge(width=0.9), size=6, vjust=-2.25)  
geom_text(aes(label=rain_unit),  
position=position_dodge(width=0.9), size=6, vjust=-0.5)
```

Add labels to address missing data concerns

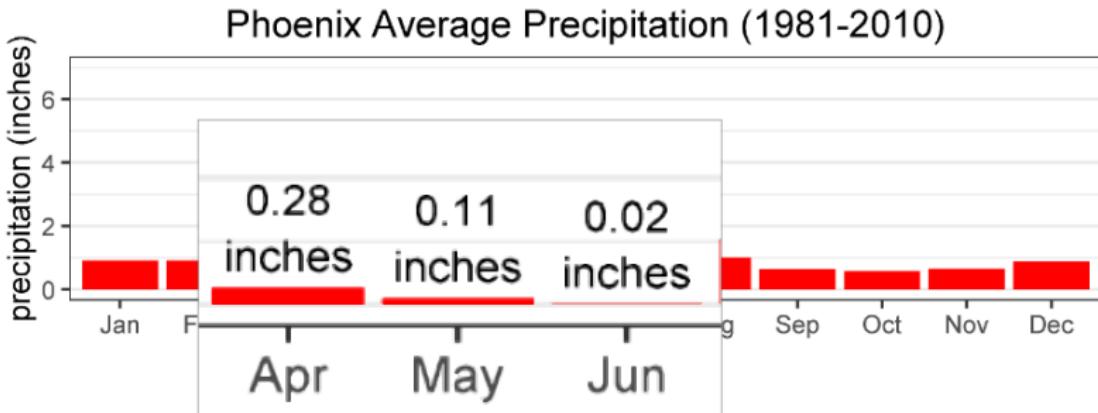
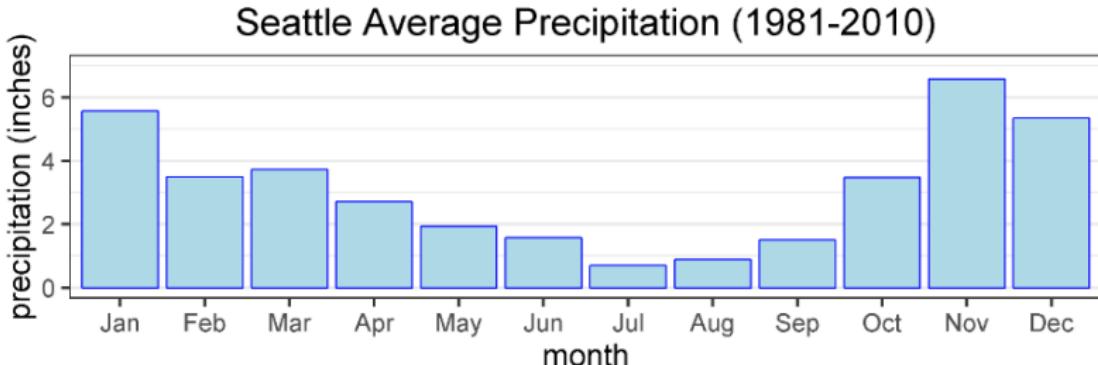
Seattle Average Precipitation (1981–2010)



Phoenix Average Precipitation (1981–2010)



Labels indicate existence of data



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)

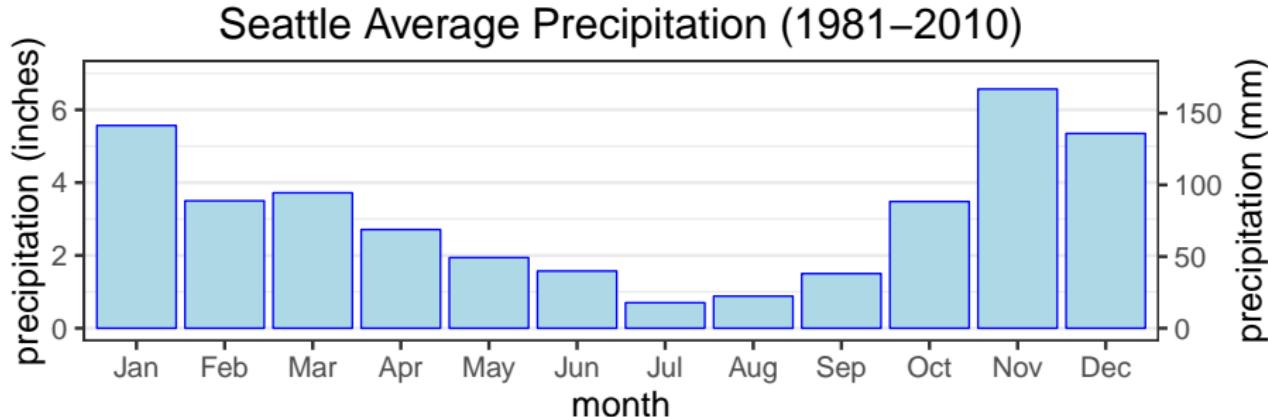
R package: ggplot2

Add the secondary y-axis for the other unit

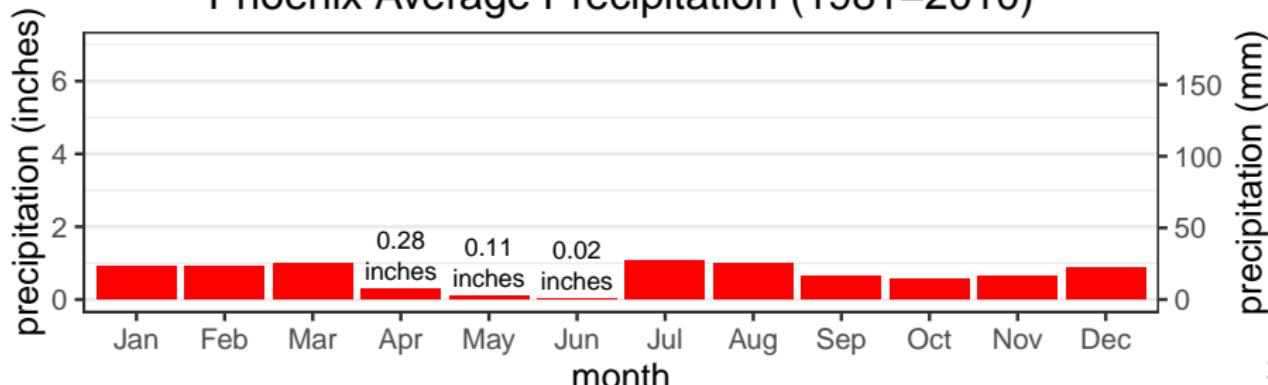
1 inch = 2.54 cm = 25.4 mm (millimeter)

```
scale_y_continuous(sec.axis =  
sec_axis(~.*25.4, name = "precipitation (mm)"))
```

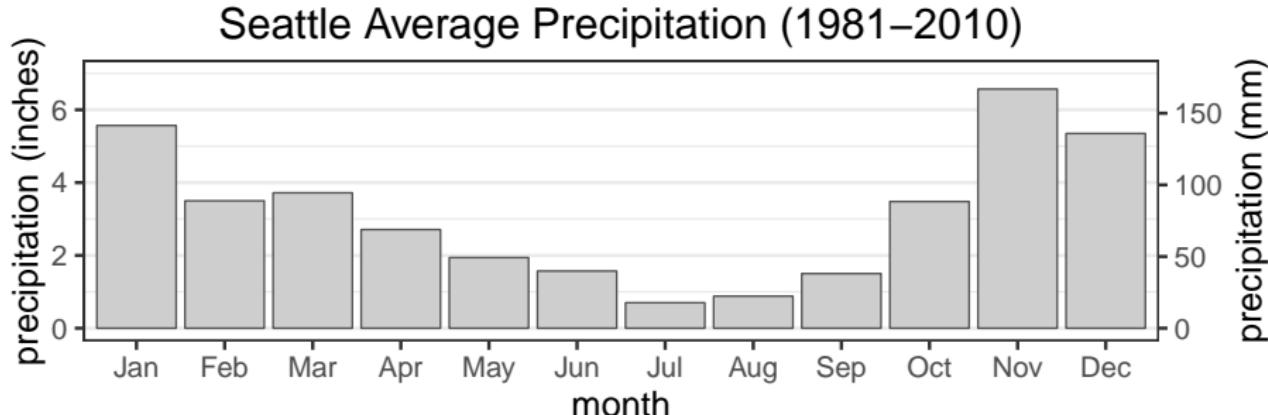
Precipitation: Seattle vs Phoenix (Accessible)



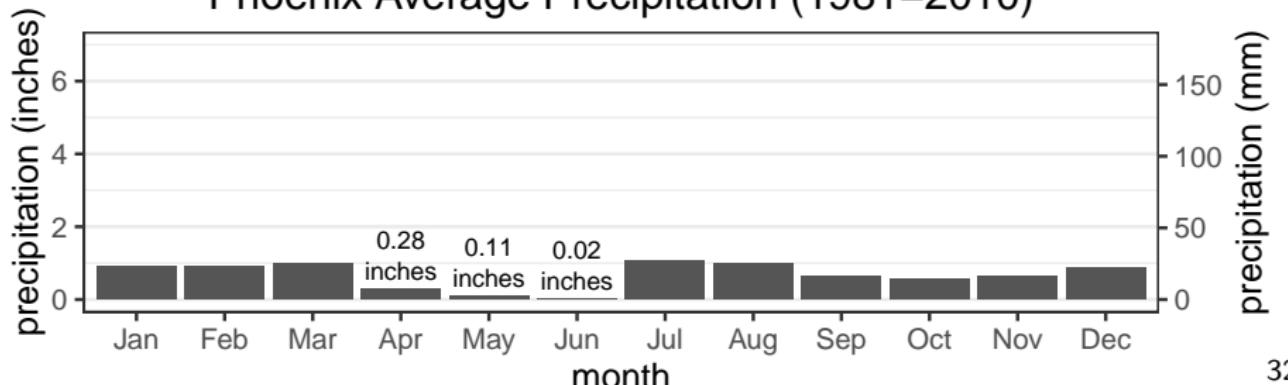
Phoenix Average Precipitation (1981–2010)



Precipitation: Seattle vs Phoenix (Without Color)

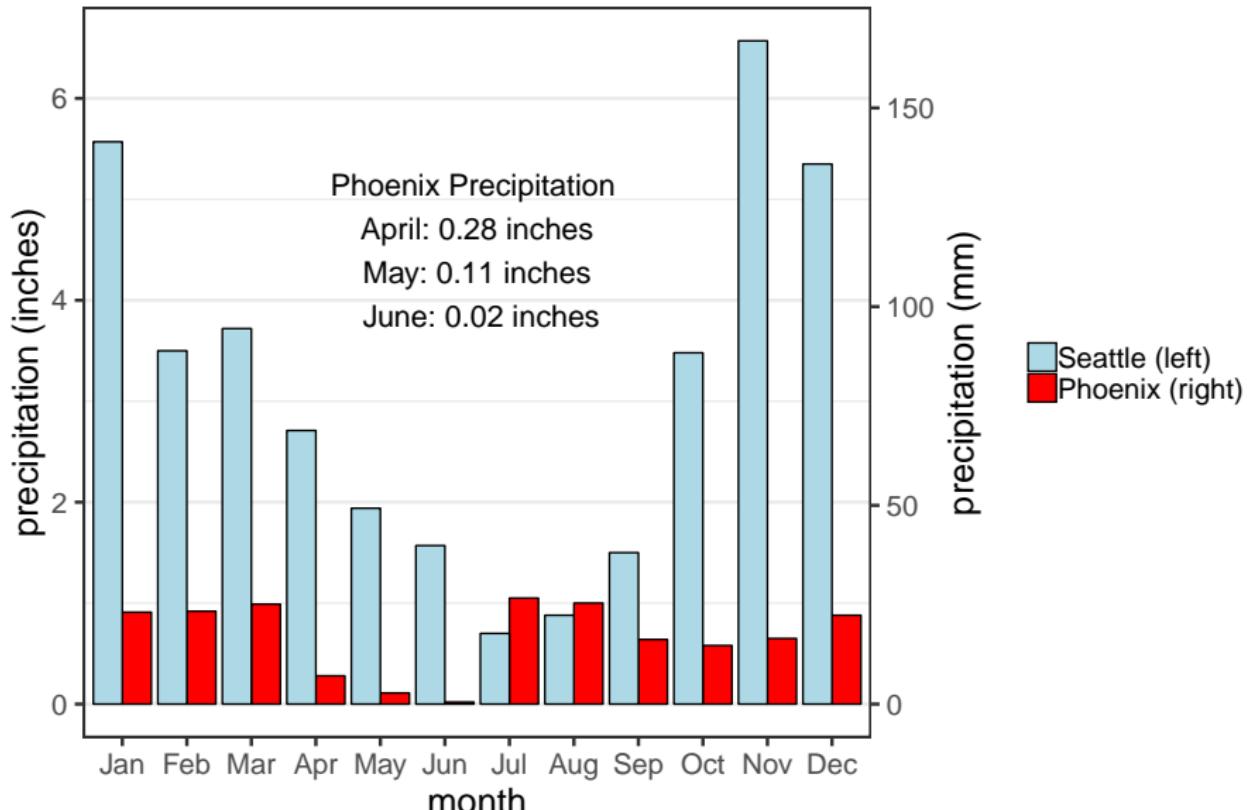


Phoenix Average Precipitation (1981–2010)



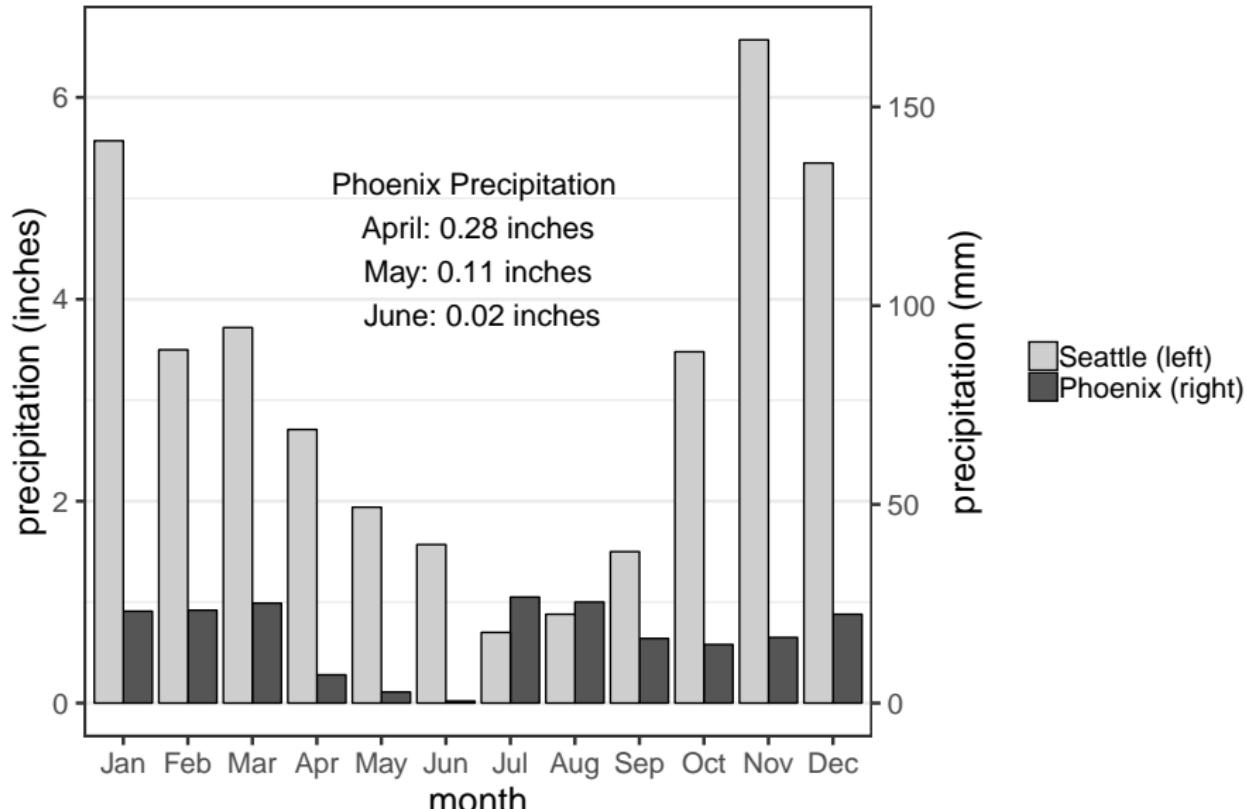
Precipitation: Seattle vs Phoenix (Accessible)

Precipitation: Seattle vs Phoenix



Precipitation: Seattle vs Phoenix (Without Color)

Precipitation: Seattle vs Phoenix



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

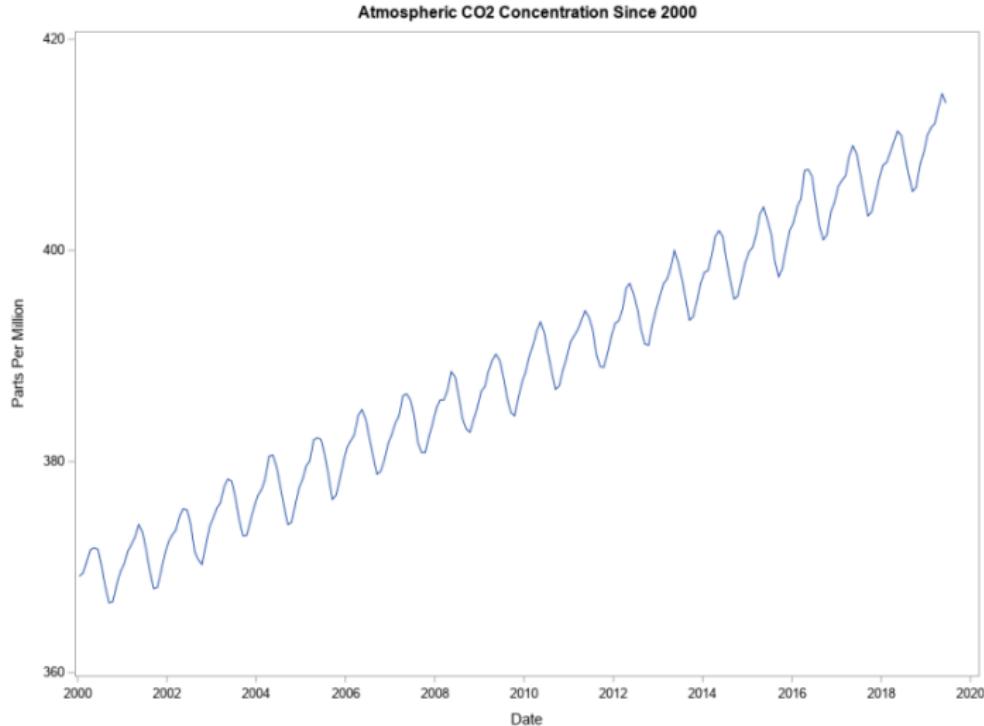
SAS Accessibility: “We democratize data.”

SAS Graphics Accelerator (browser extension) uses **sound** in addition to sight, so people with visual impairments can also access data visualizations.

<https://tinyurl.com/ghc19-braille-maps>

https://www.sas.com/en_us/company-information/accessibility.html

Original: 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.

Braille: Atmospheric CO₂ Concentration Since 2000



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.
 - World Economic Forum
- 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.
 - Retail Insider

<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.

Final Message

"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

I would like to thank the people for the discussions:

- Manish Agrawal (Microsoft Accessibility Training Program)
- 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>