2024

frank.computer

Accessibility and Visualization

Basics & beyond: a thorough introduction to an advanced topic.

Frank Elavsky

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Today's agenda

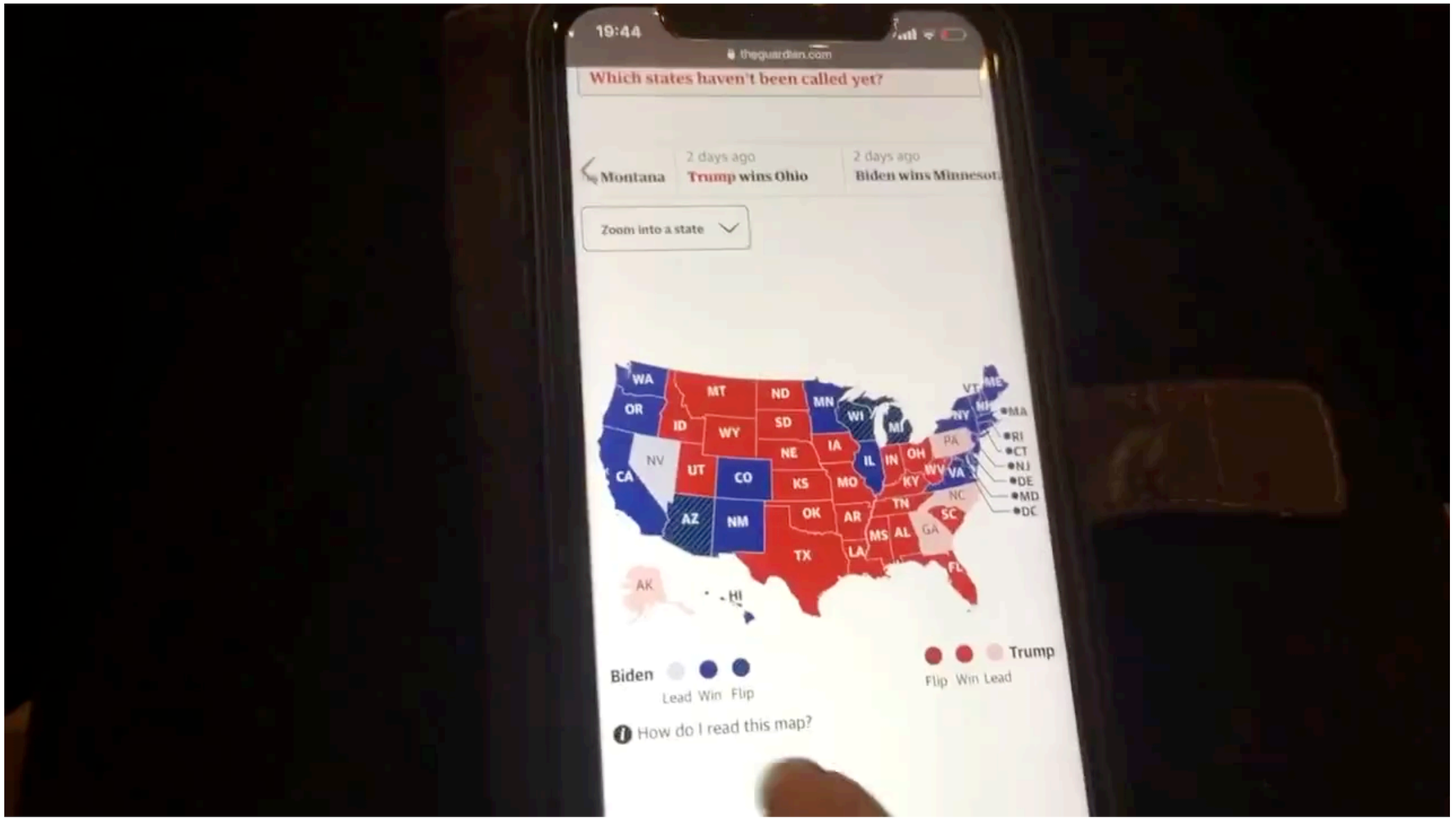
10 minute break every hour, each part also includes time for questions

- **Part 1**: *90mins*
  - Important concepts in accessibility and disability
  - Cool emerging work and sharing
- **Part 2**: *90 minutes*
  - How to catch accessibility barriers in a visualization
- **Part 3**: *90 minutes*
  - We evaluate a data visualization *in the wild* together
  - You break into groups and evaluate a data visualization
  - You share your evaluation with the larger group
- **Part 4**: *90 minutes*
  - Watch me design a visualization using digital and physical materials
  - You practice designing an accessible visualization using data (in groups)

Part 1: What is accessibility and visualization?

What is an inaccessible experience like?

Credit: Sarah Fossheim [on twitter]



So “accessibility:” What is it?

Accessibility:

1. The qualities that make an experience open or usable to all.

Accessibility:

1. The qualities that make an experience open or usable to all.
2. **The qualities that make an experience open or usable specifically for people with disabilities.**

Access is a human right

Accessibility for people with disabilities is an internationally recognized human right.

It is the morally and ethically correct thing to do.

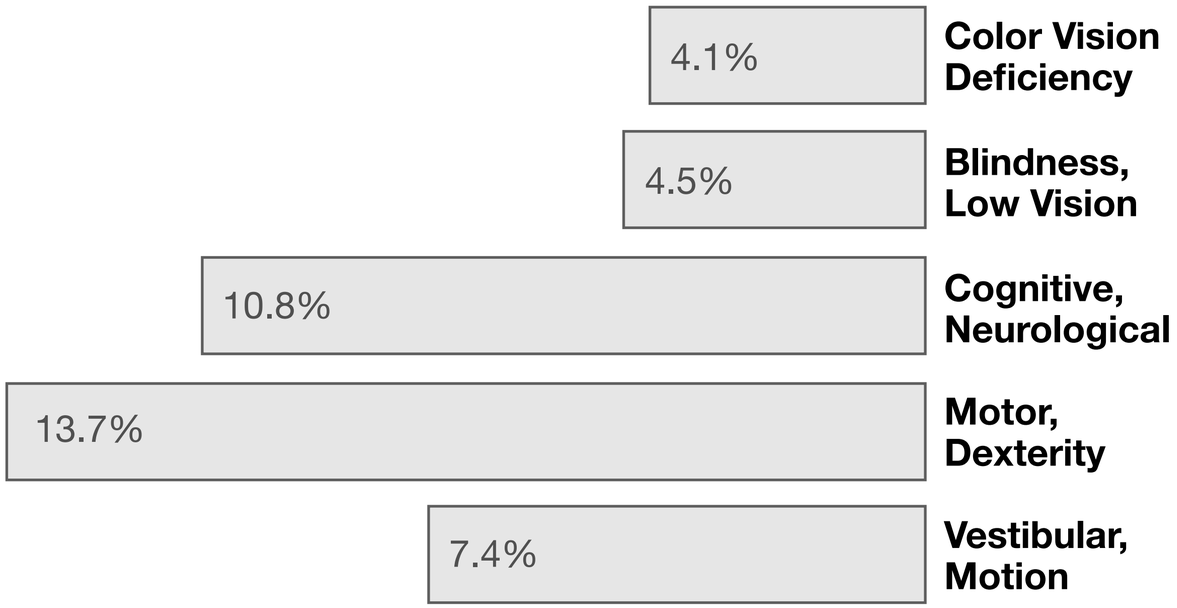
UN CRPD Article 9: Accessibility, UN CRPD Article 10: Right to Life

It is expensive to exclude accessibility

15% of time to include accessibility during a project

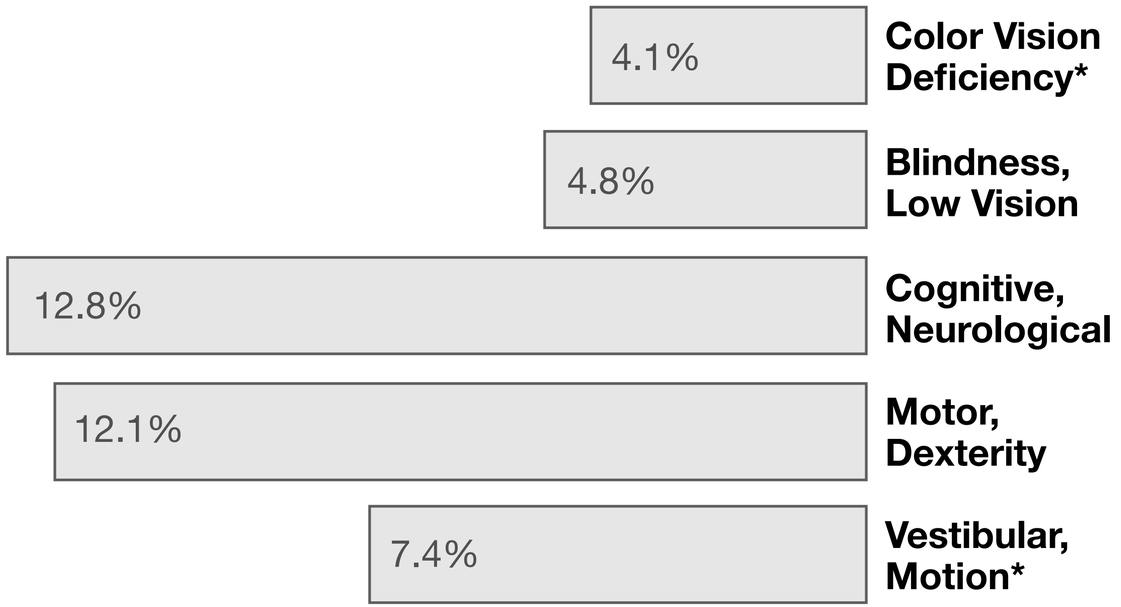
And this helps make sure ~**27**% of all people aren’t excluded

But excluding accessibility costs a project **1.5**-**10**x more time later



Source: Okoro et al. “Prevalence of Disabilities and Health Care Access by Disability Status and Type Among Adults”

~26% of people living in the United States self-report living with a disability that affects their daily life (2017)



Centers for Disease Control and Prevention. Disability and Health Data System (DHDS). 2023. Available from: http://dhds.cdc.gov
*No new data

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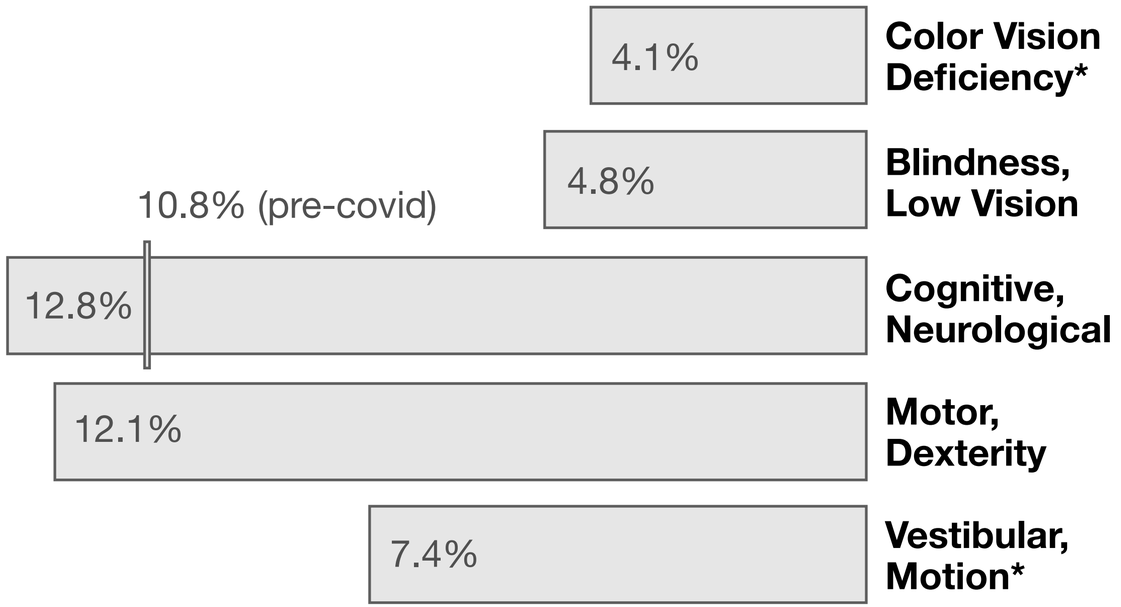
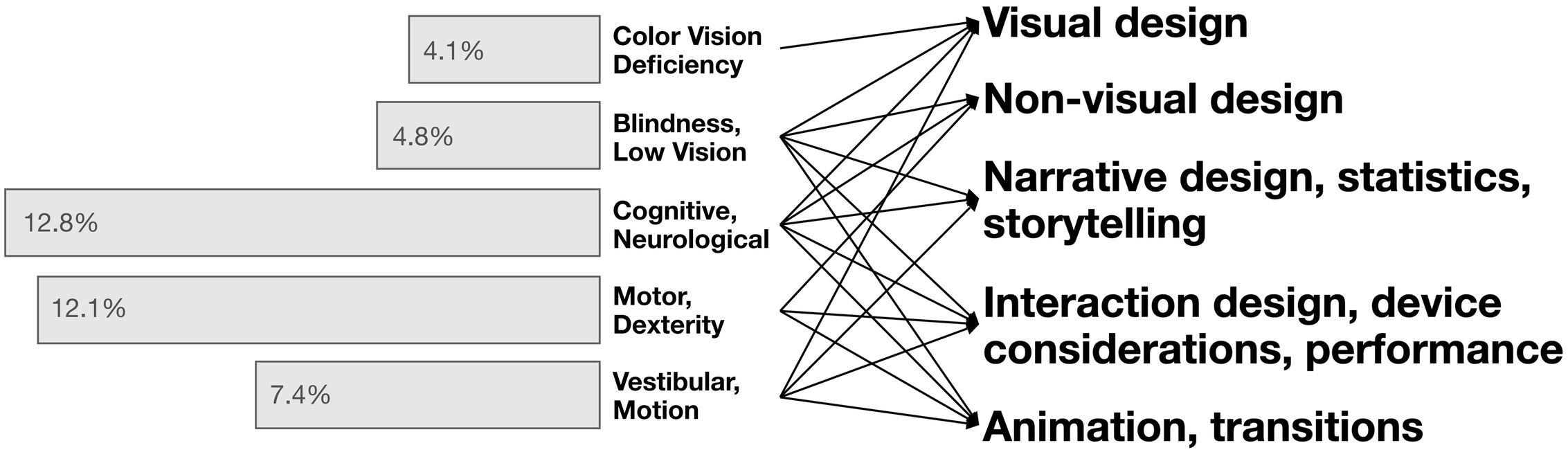


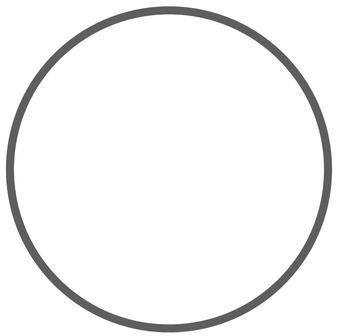
Cognitive disability is on the rise

Centers for Disease Control and Prevention. Disability and Health Data System (DHDS). 2023. Available from: http://dhds.cdc.gov

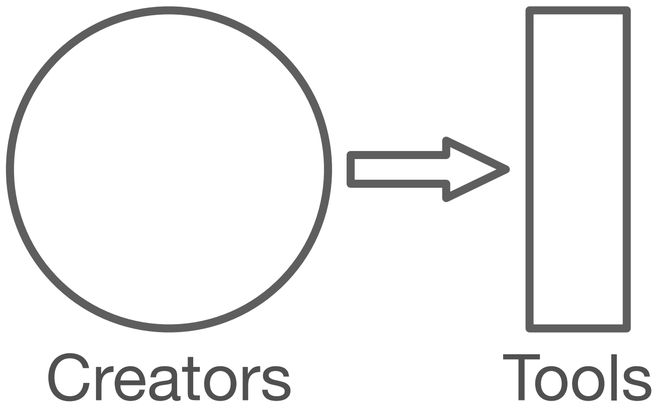
*No new data

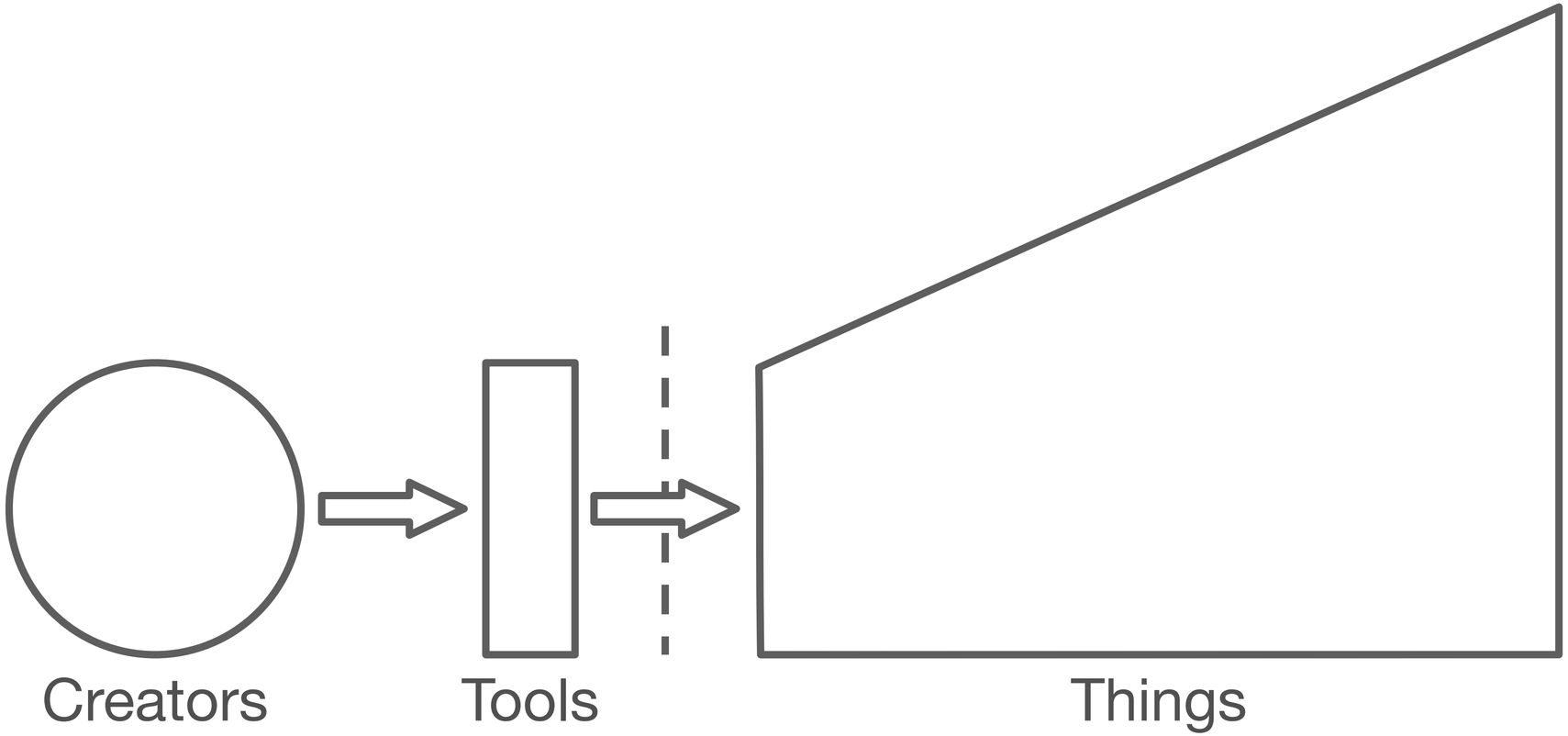
Accessibility affects every aspect of visualization work

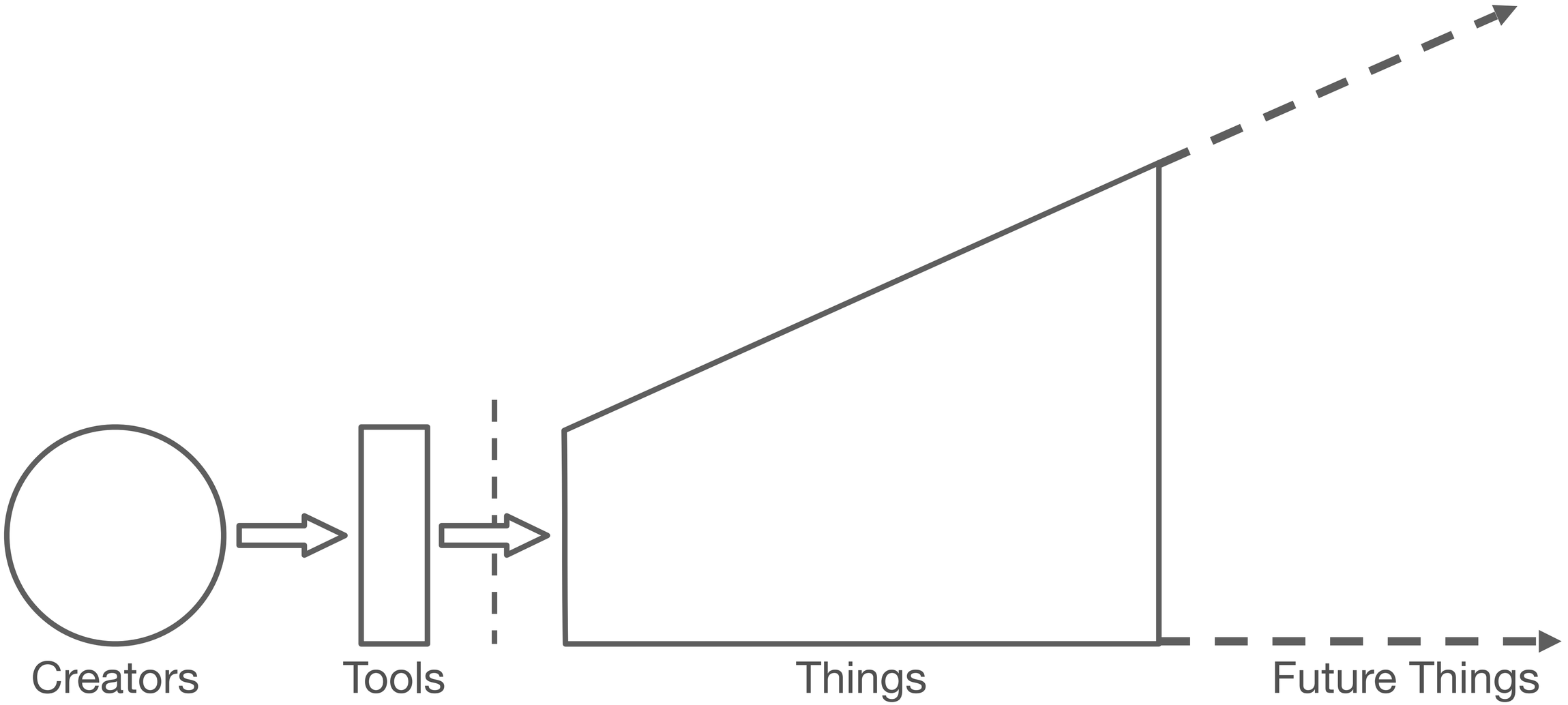




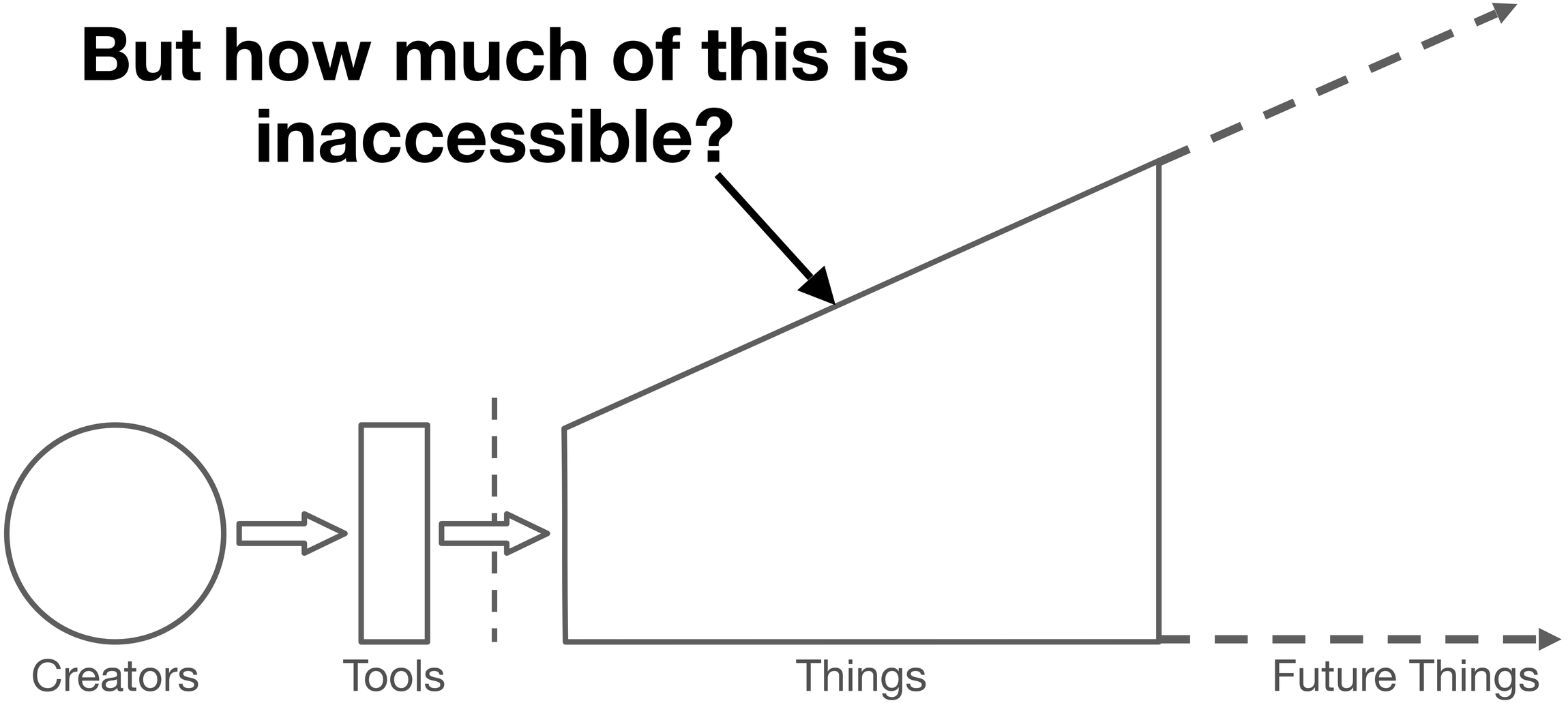
Creators


Creators
Tools


Creators
Tools
Things

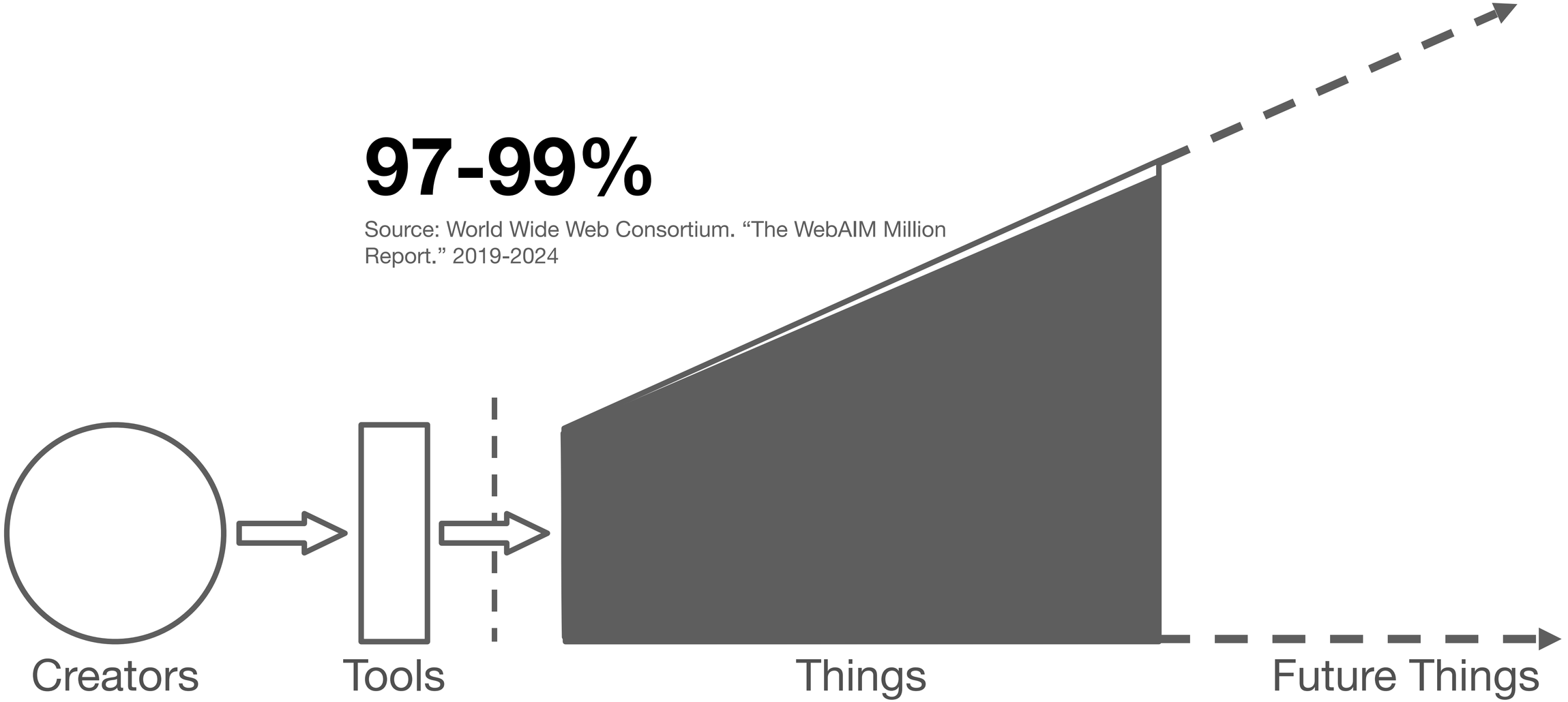

Creators
Tools
Things
Future Things

But how much of this is inaccessible?



97-99%

Source: World Wide Web Consortium. “The WebAIM Million Report.” 2019-2024



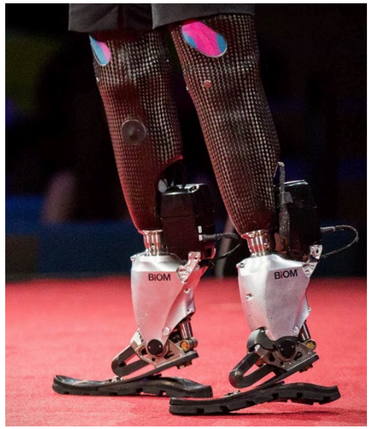
Who is responsible for making this accessible?

Concept: **The social framing of disability**

What about curbs in our cities?

Medicalizing framing: the body is the cause/location of disability (according to normative standards).

Augment or “cure” the body, the person typically bears the cost of access.



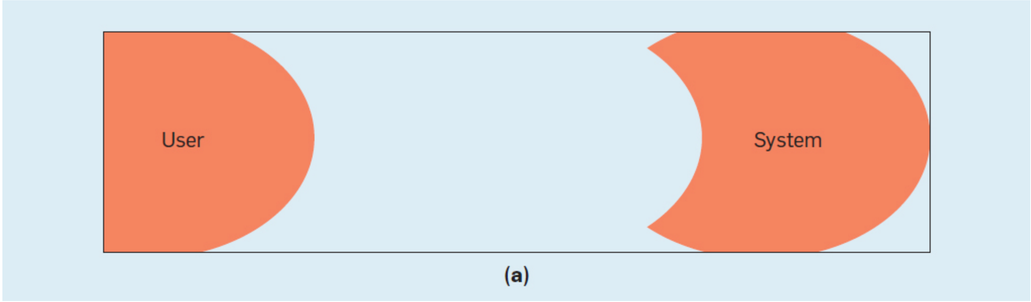
Social framing: The *curb* is the source/location where disability is produced (as a “barrier” to access).

We built barriers, so now *we* need to fix them.

Concept: **Ability Assumptions**

Ability Assumptions

(Wobbrock et al) https://cacm.acm.org/magazines/2018/6/228034-ability-based-design/fulltext



Ability Assumptions

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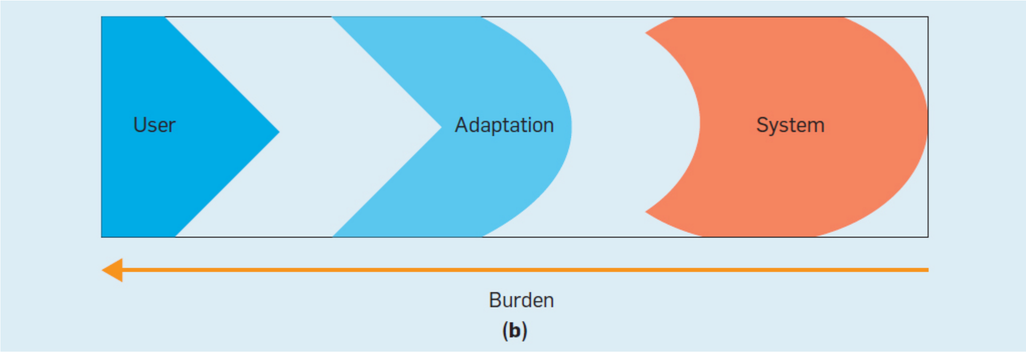

Ability Assumptions

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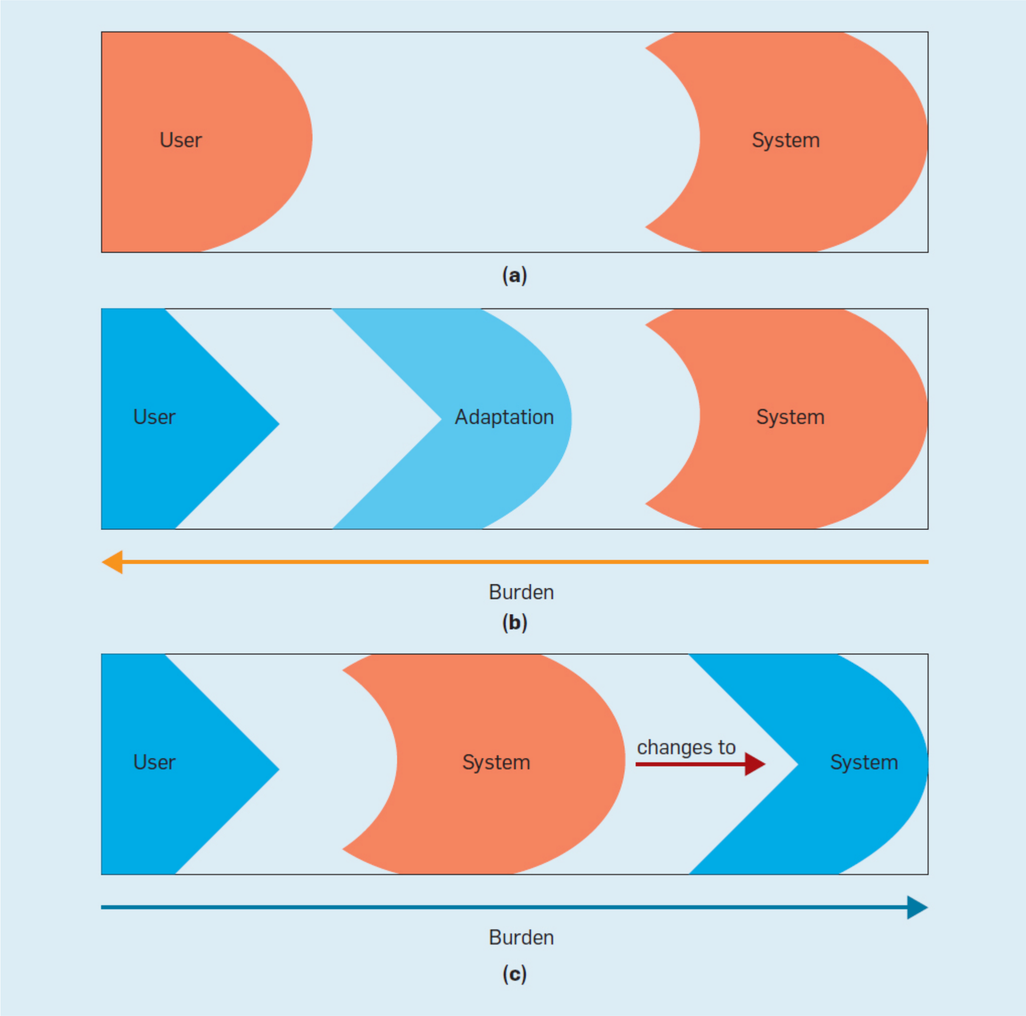


A curb exclusively assumes the ability to step up

A cut curb has fewer *exclusive* ability assumptions

Concept: **Situational Impairment**

Permanent

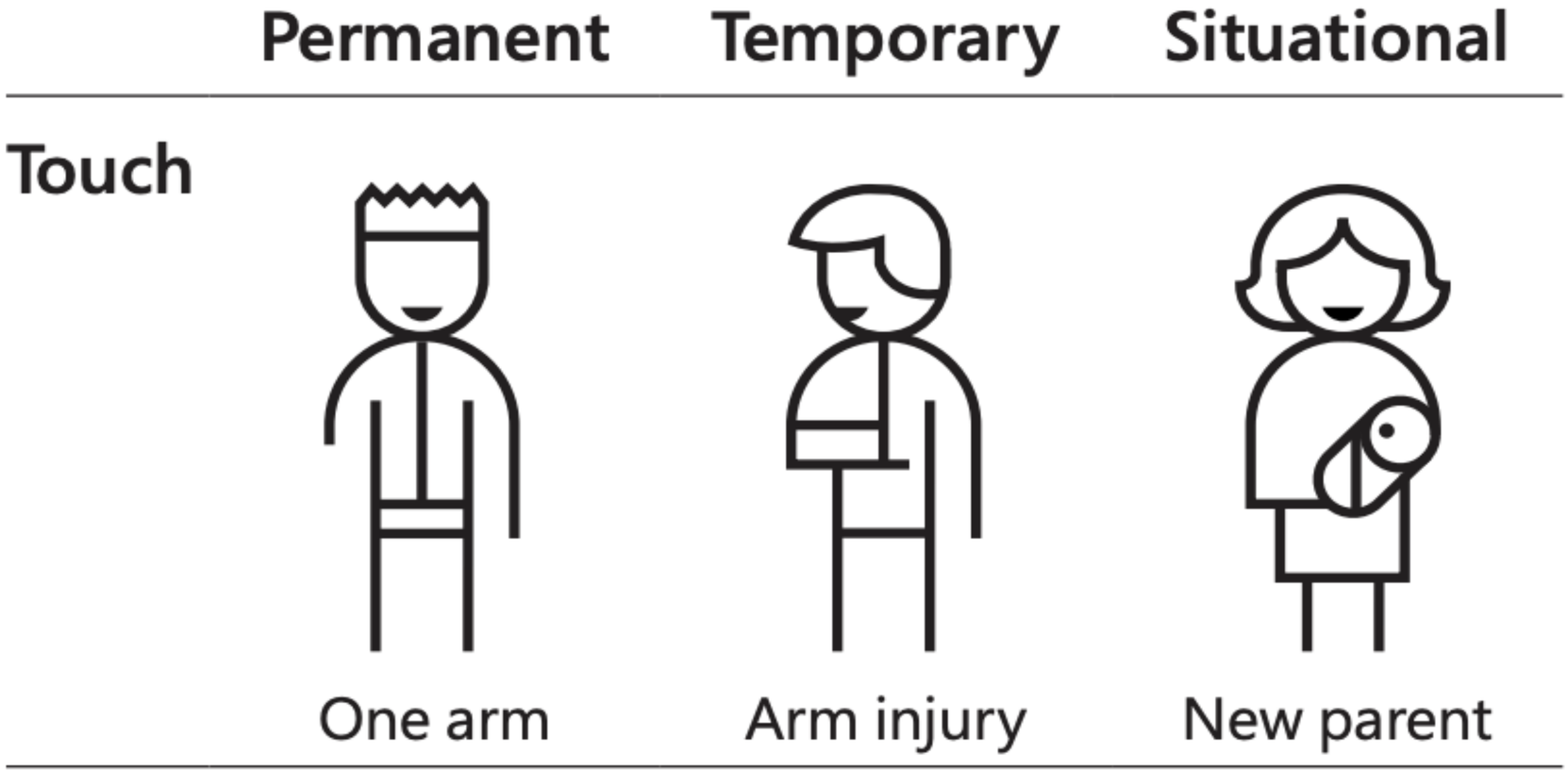
Touch

One arm

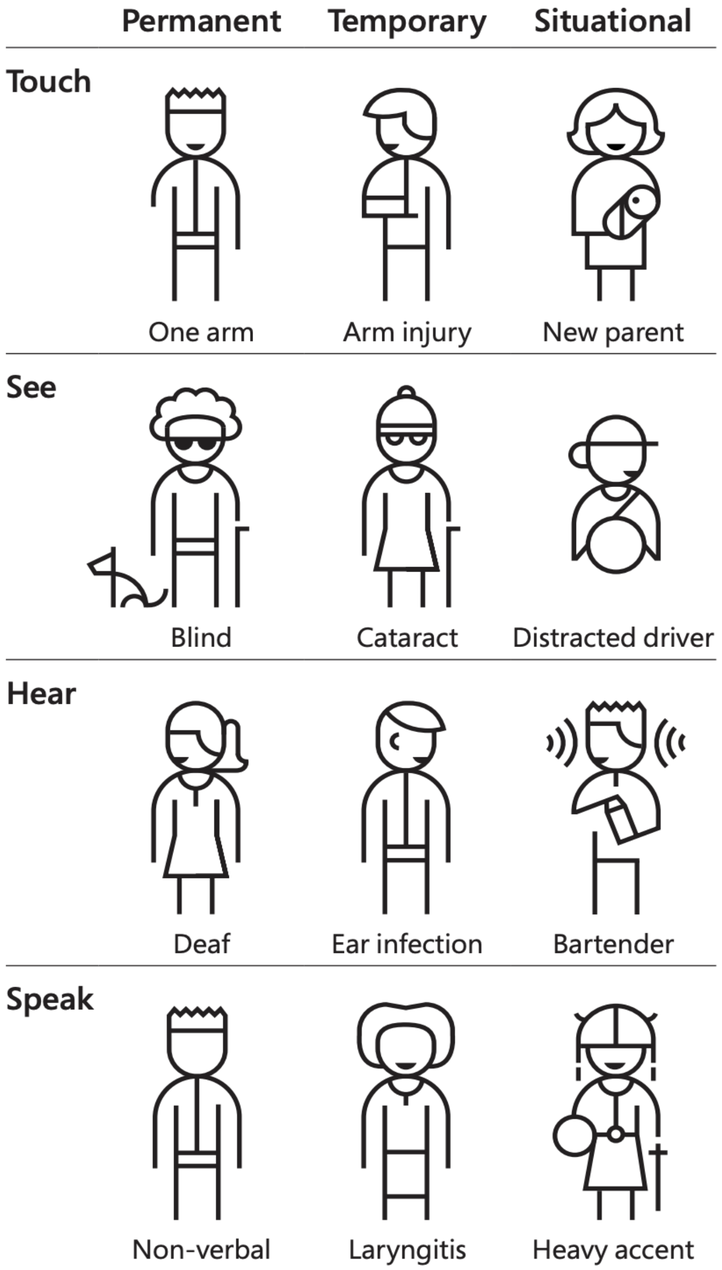
	Permanent	Temporary
Touch		
	One arm	Arm injury

	Permanent	Temporary	Situational
Touch			
	One arm	Arm injury	New parent

We all experience situational impairment in our daily lives. **Accessibility benefits everyone**!



“Design for One, Extend to All”



Microsoft’s Inclusive Design 101 Toolkit: https://download.microsoft.com/download/b/0/d/b0d4bf87-09ce-4417-8f28-d60703d672ed/inclusive_toolkit_manual_final.pdf

Discuss: Share an example where you might be impaired in some way and how accessible technology or infrastructure helps you.

Does “design for one, extend to all” have limits? Problems?

Final Concept: **Disability-Centered Design**

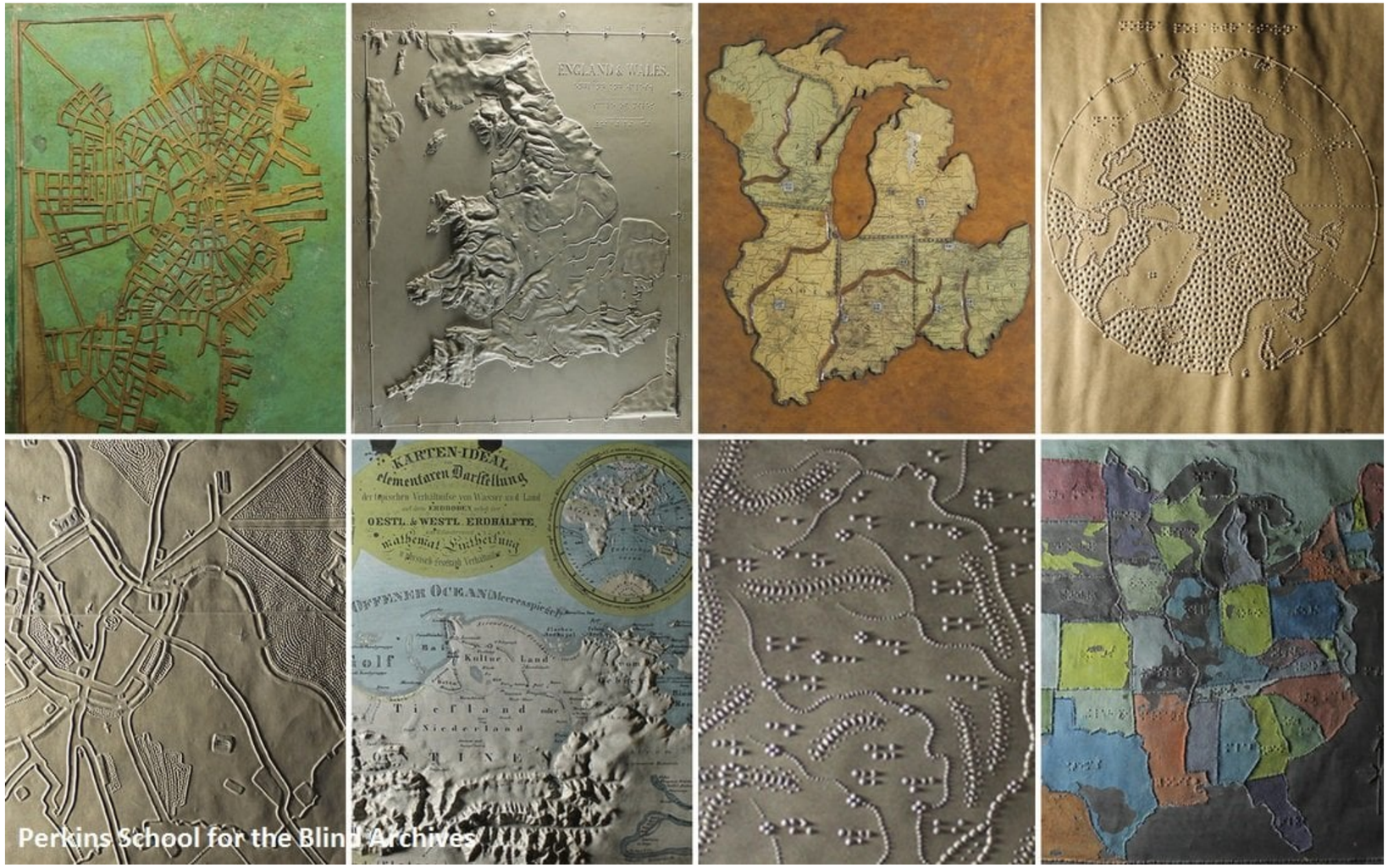
“Nothing about us without us”

And the 1977 504 sit-in.

In practice, “curb cut” work has been *prioritized*

	Permanent	Temporary	Situational
Touch	 One arm	 Arm injury	 New parent

The best work centers on people with disabilities



Perkins School for the Blind Archives, with tactile maps dating back to the early 1800s

Demo: Using a screen reader

Mac users: **VoiceOver**
Windows users: **NVDA (requires download)**

Explore: An interactive bar chart

https://frankelavsky.github.io/assessing_chart_interactivity/

Product AC is trending up, Product AB is tanking

Product AC initiated its launch with 12 clients and our internal marketing personnel cultivated 27 new acquisitions by the close of the calendar year. Product AB started with 42 clients and after a controversy in June, dropped to 4 by December.

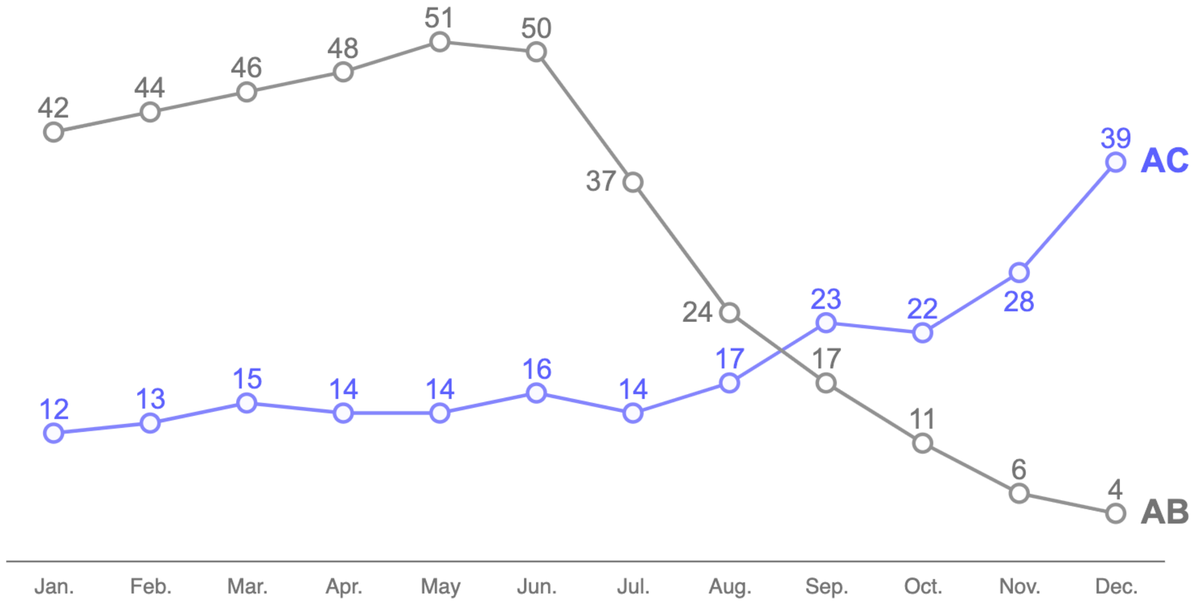


Figure 1: Last year's performance of Products AC and AB. Data is made possible by Sam Smith on the marketing data team.

The fun part of this talk: The tour!

What’s happening in the broad space of science, research, data, and accessibility right now?

The tour

Let’s look at some cool stuff:

Nasa’s James Webb Telescope captions and image descriptions

Carni Klirs’ Sonification of NYT COVID deaths

arXiv’s Accessibility Forum 2023

Tactile Maps vs 3D Printing Tactile Graphics

Embossed graphics vs Refreshable braille displays

My work

Past:

Visa Chart Components, a library of charts

Chartability, a set of guidelines

Latest:

Data Navigator!

Current:

(secret project)

Q/A time

Part 2: Learning to Catch Barriers

But how do we *catch* barriers?

Listen to people with disabilities (PWD).

There are a lot of ways to listen:

1. Actually ask them!
2. Find where they are already speaking
3. Find where they have already spoken:
    - Research
    - Blog posts
    - Accessibility standards

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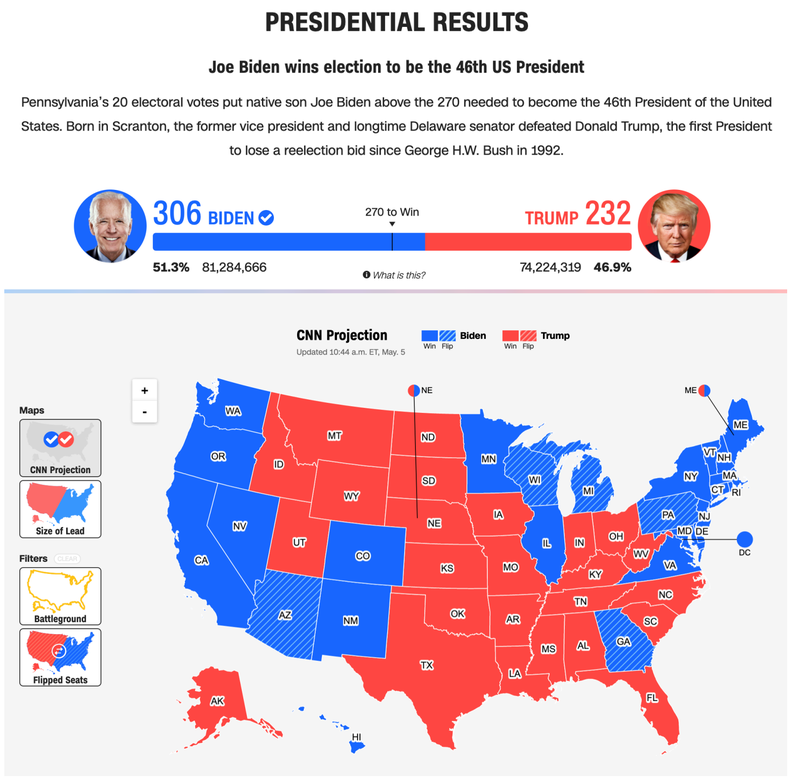
    - Blog posts
    - **Accessibility standards**



Let's evaluate this map from CNN with Chartability.

An acronym in web standards:

P

O

U

R

An acronym in web standards:

Perceivable
O
U
R

An acronym in web standards:

Perceivable
Operable
U
R

An acronym in web standards:

Perceivable
Operable
Understandable
R

The 4 pillars of accessible design:

Perceivable
Operable
Understandable
Robust

Perceivable
Operable
Understandable
Robust

Chartability's additions:

+
C
A
F

Perceivable
Operable
Understandable
Robust

Chartability's additions:

+
Compromising
A
F

Perceivable
Operable
Understandable
Robust

Chartability's additions:

+
Compromising
Assistive
F

Perceivable
Operable
Understandable
Robust

Chartability's additions:

+
Compromising
Assistive
Flexible

POUR+CAF

“I need to **pour a cup of coffee** to help me consider accessible design!”

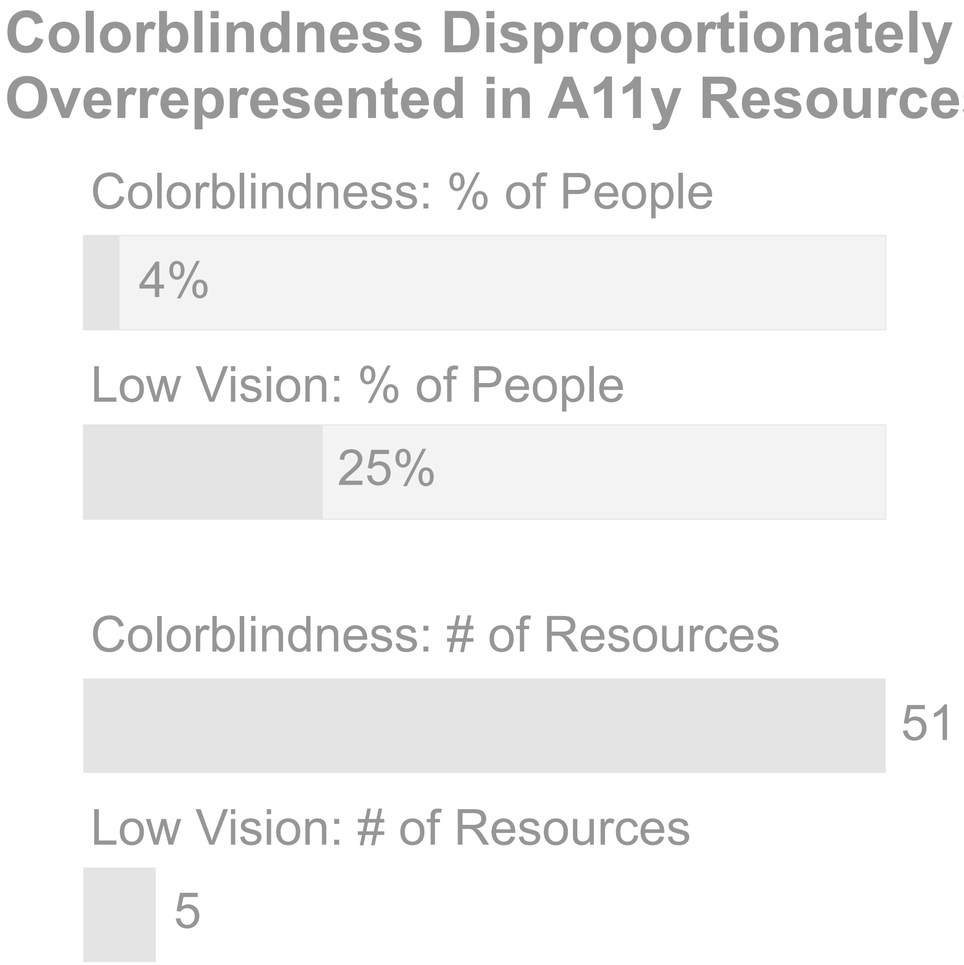
Perceivable

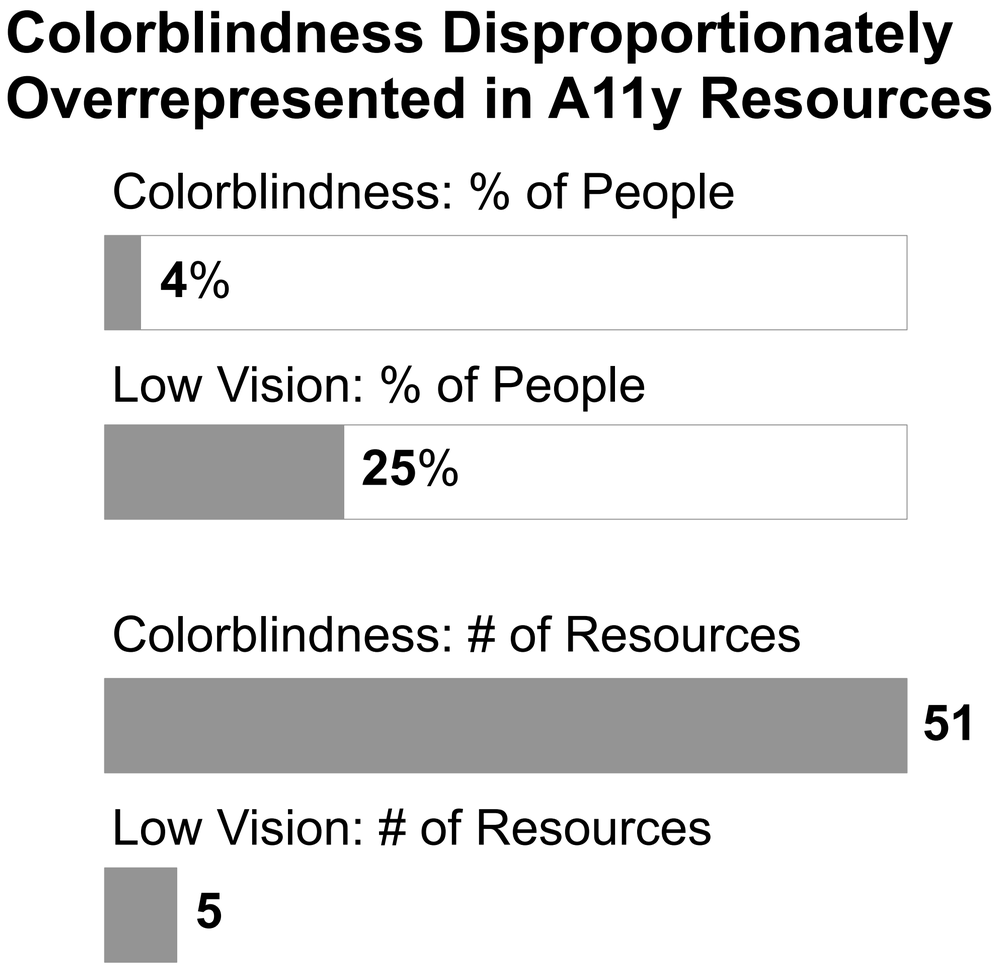
Can someone perceive this in multiple ways? Is each way easy?

Perceivable Checklist:

1. High Contrast
2. Colorblind-Safe + Redundant Encoding
3. Alt Text

Design with high contrast

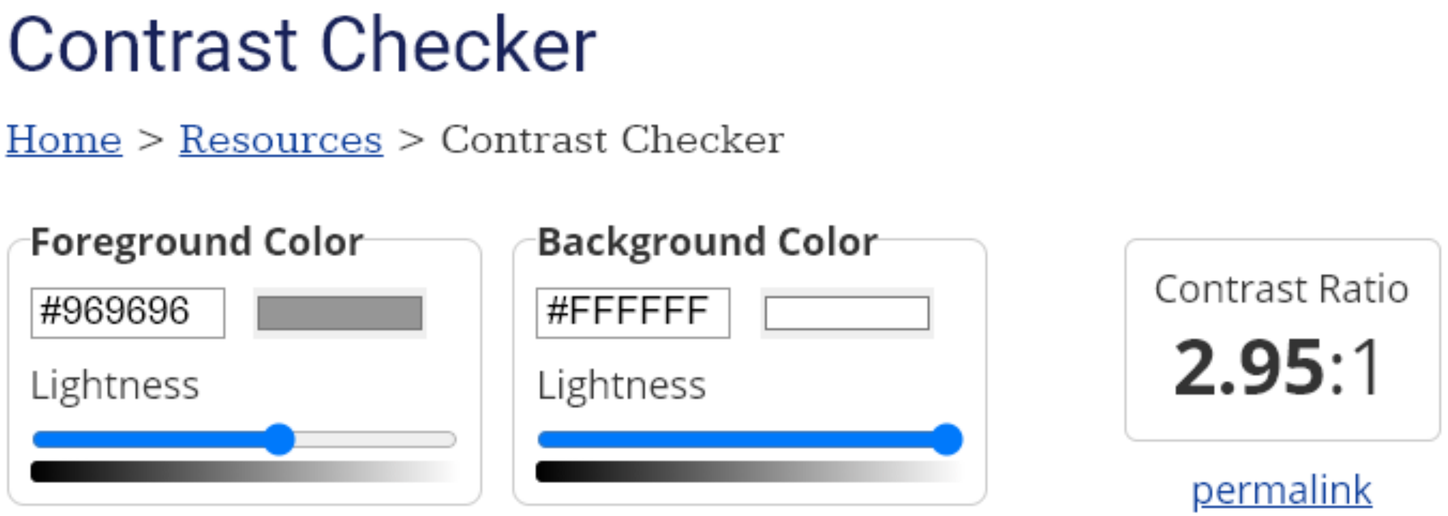




Use High Contrast Text

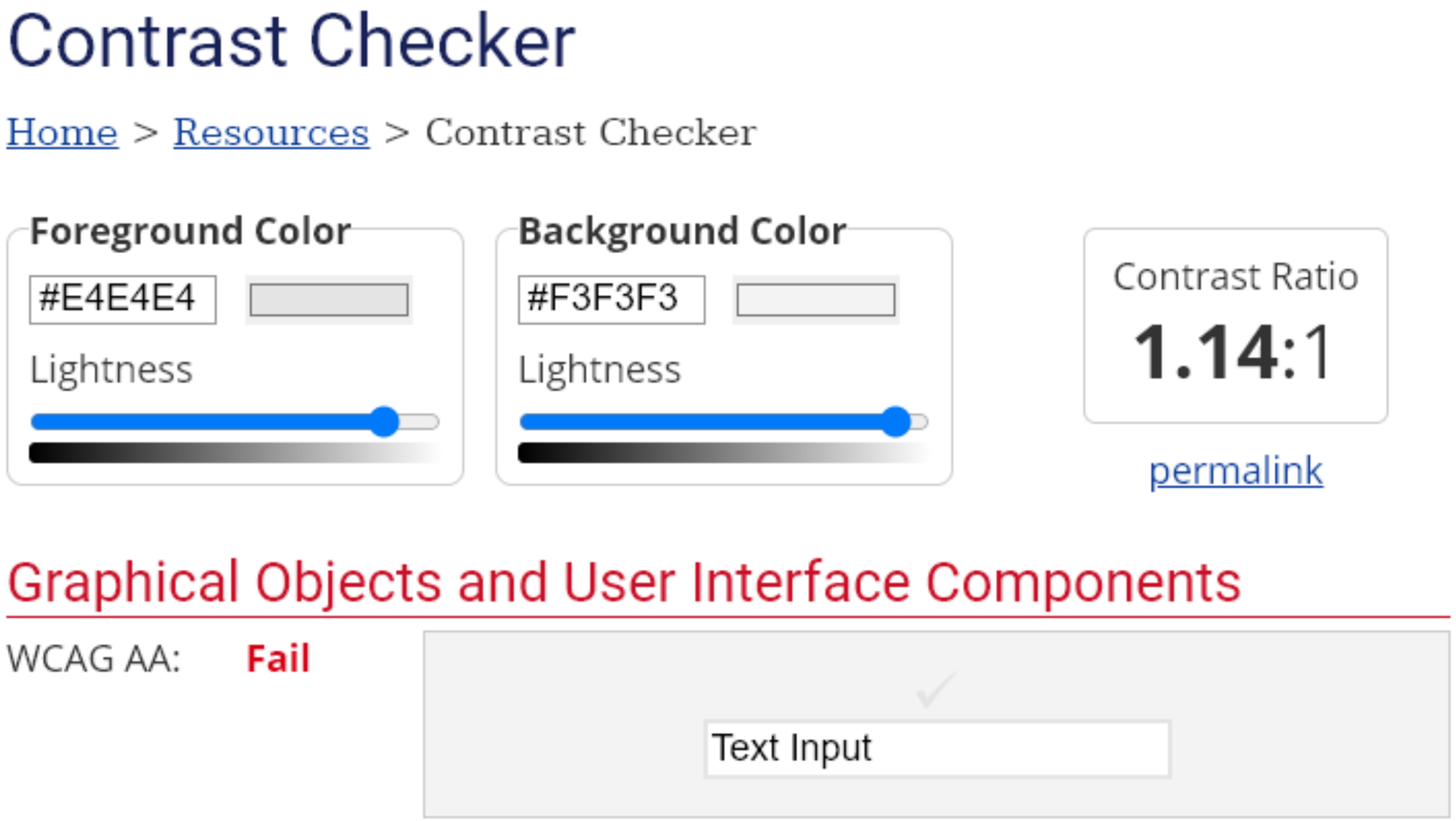
Text needs at least 4.5:1 contrast against its background.

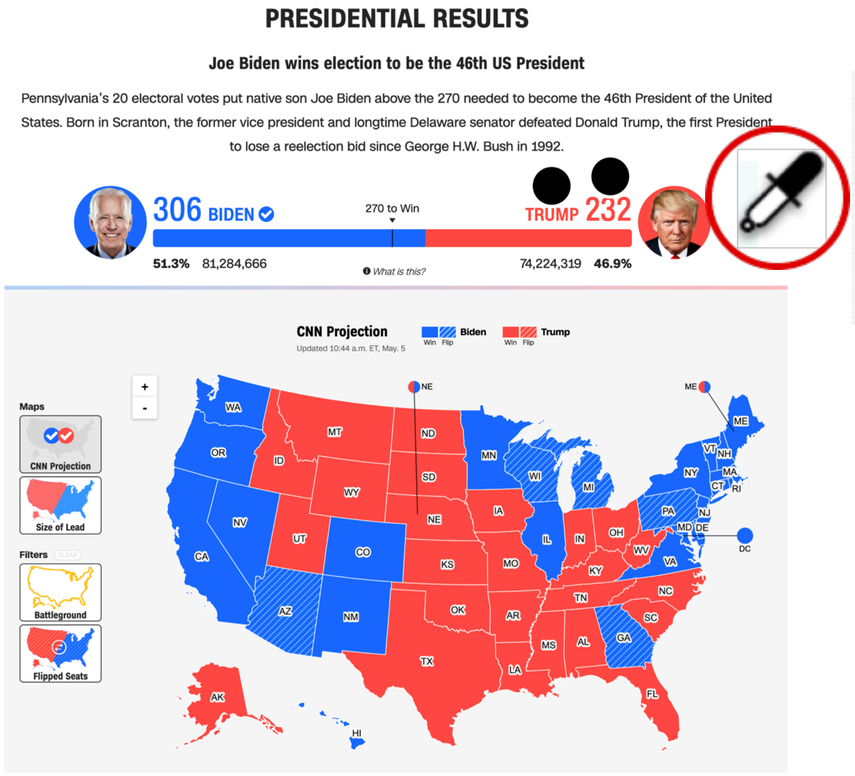
Large text (bold and 16pt or larger) can be 3:1 or higher.

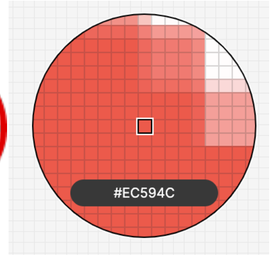


Use High Contrast Geometries

Chart elements need at least 3:1 contrast against their background.







Contrast Checker

Home > Resources > Contrast Checker

Foreground Color

#EC594C

Lightness

↔

Background Color

#FFFFFF

Lightness

Contrast Ratio

3.44:1

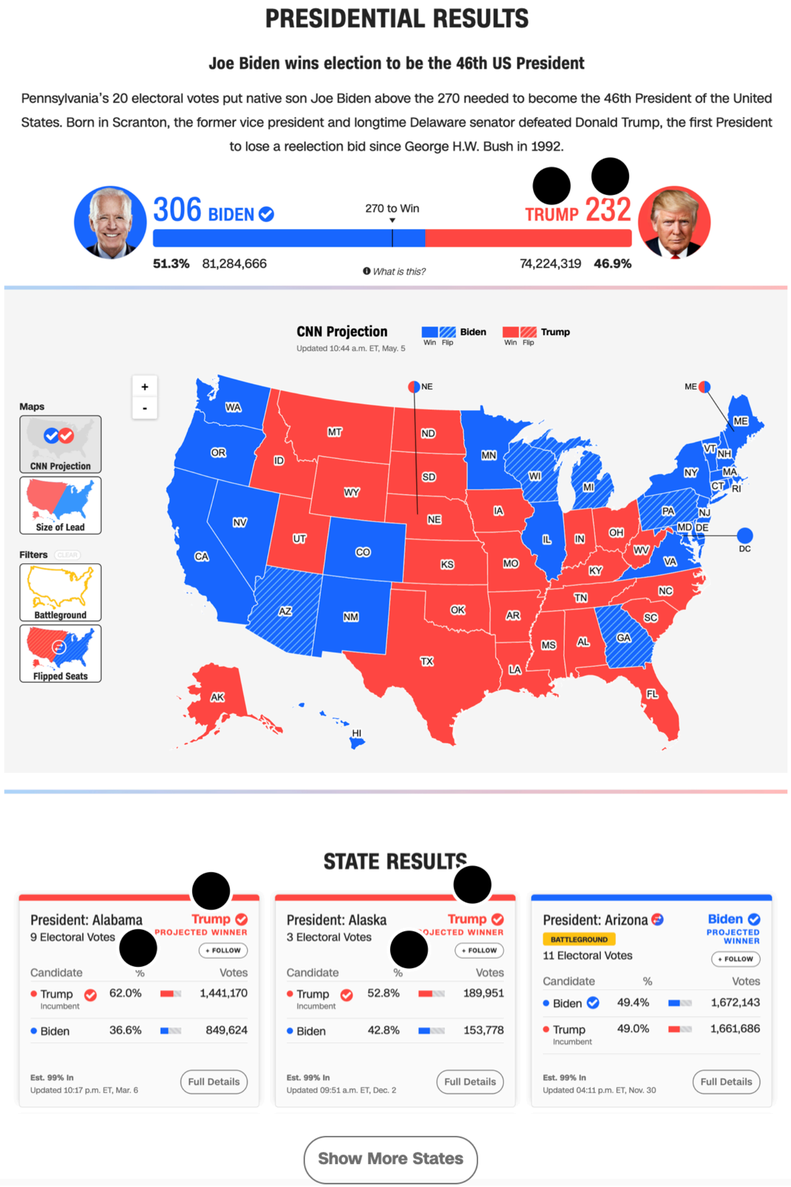
permalink

Normal Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

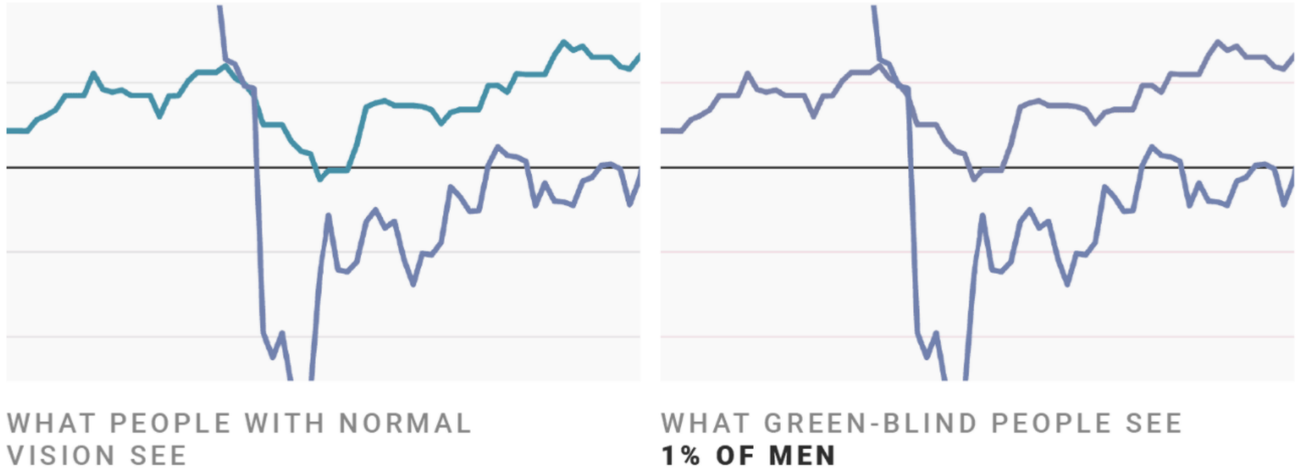
The five boxing wizards jump quickly.



6 instances of low contrast

Don’t rely on color alone!

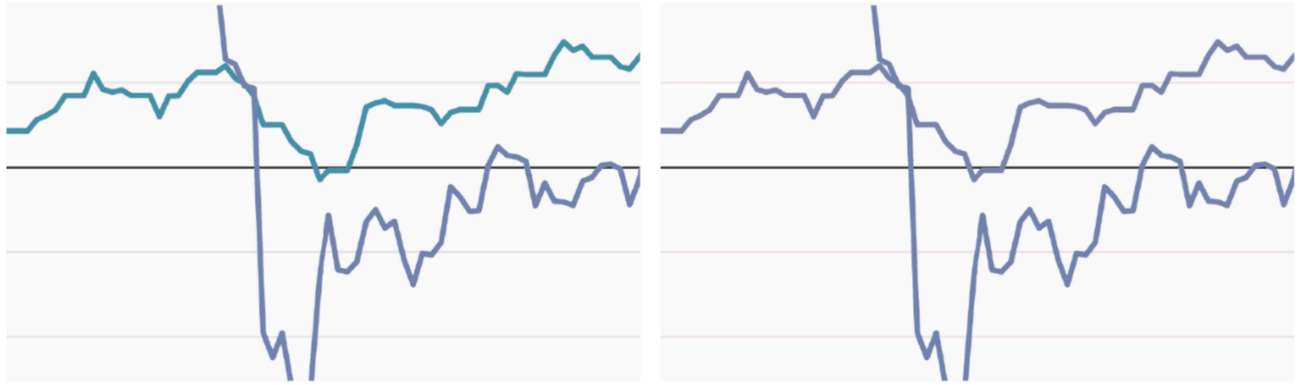
(Muth) https://blog.datawrapper.de/colorblindness-part2/



WHAT PEOPLE WITH NORMAL VISION SEE

WHAT GREEN-BLIND PEOPLE SEE
1% OF MEN

“Redundant encoding” is one strategy



WHAT PEOPLE WITH NORMAL VISION SEE

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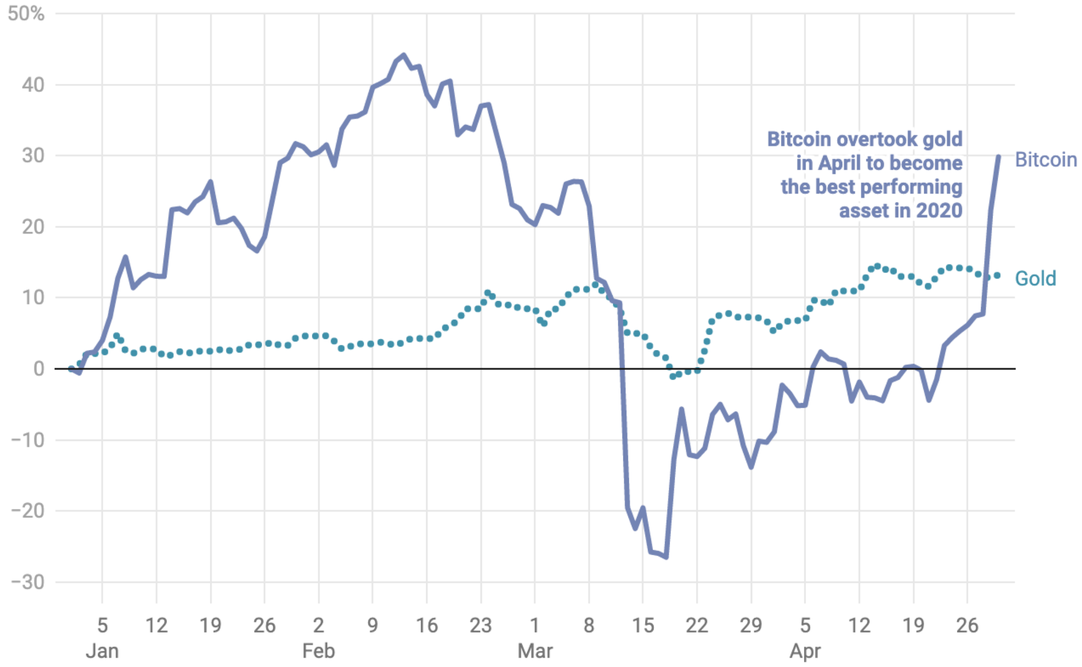
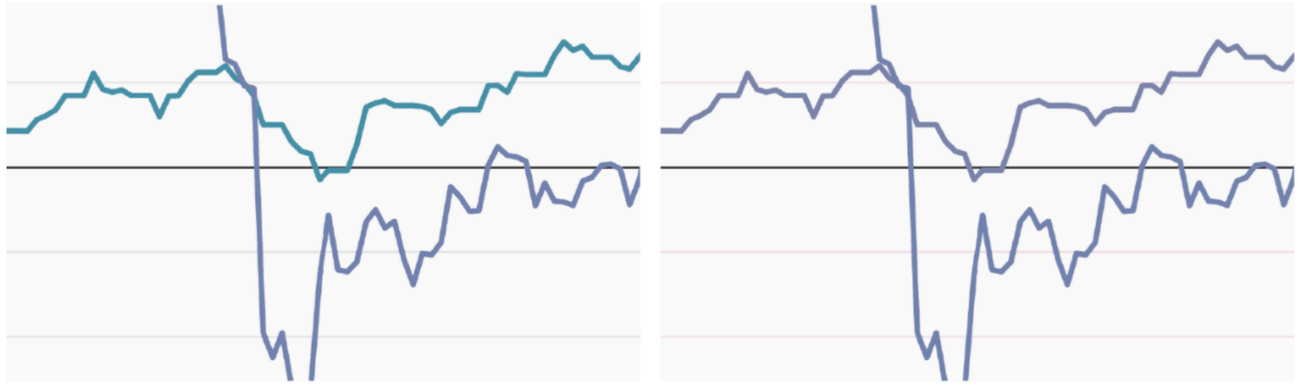
1% OF MEN



Bitcoin and gold price change (%) between January and May 2020

Chart: Based on Anthony Cuthbertson • Source: CoinMarketCap, Nasdaq, Gold Price • Get the data

A note: **“Color-vision deficiency”** and **“colorblindness”** refer to the same thing, both terms are fine to use.



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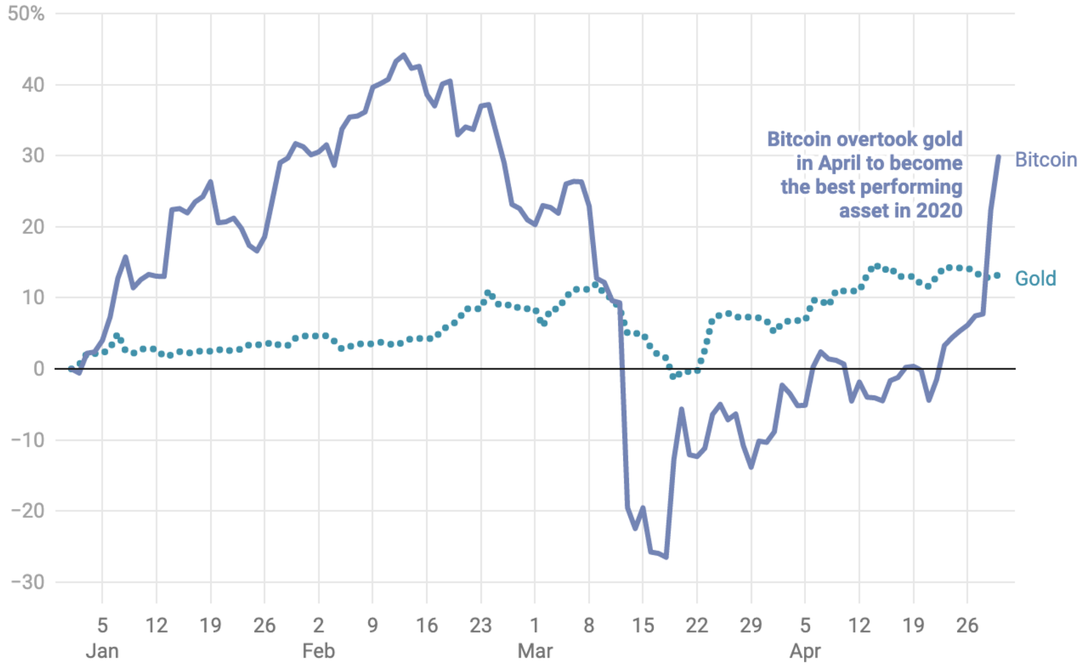
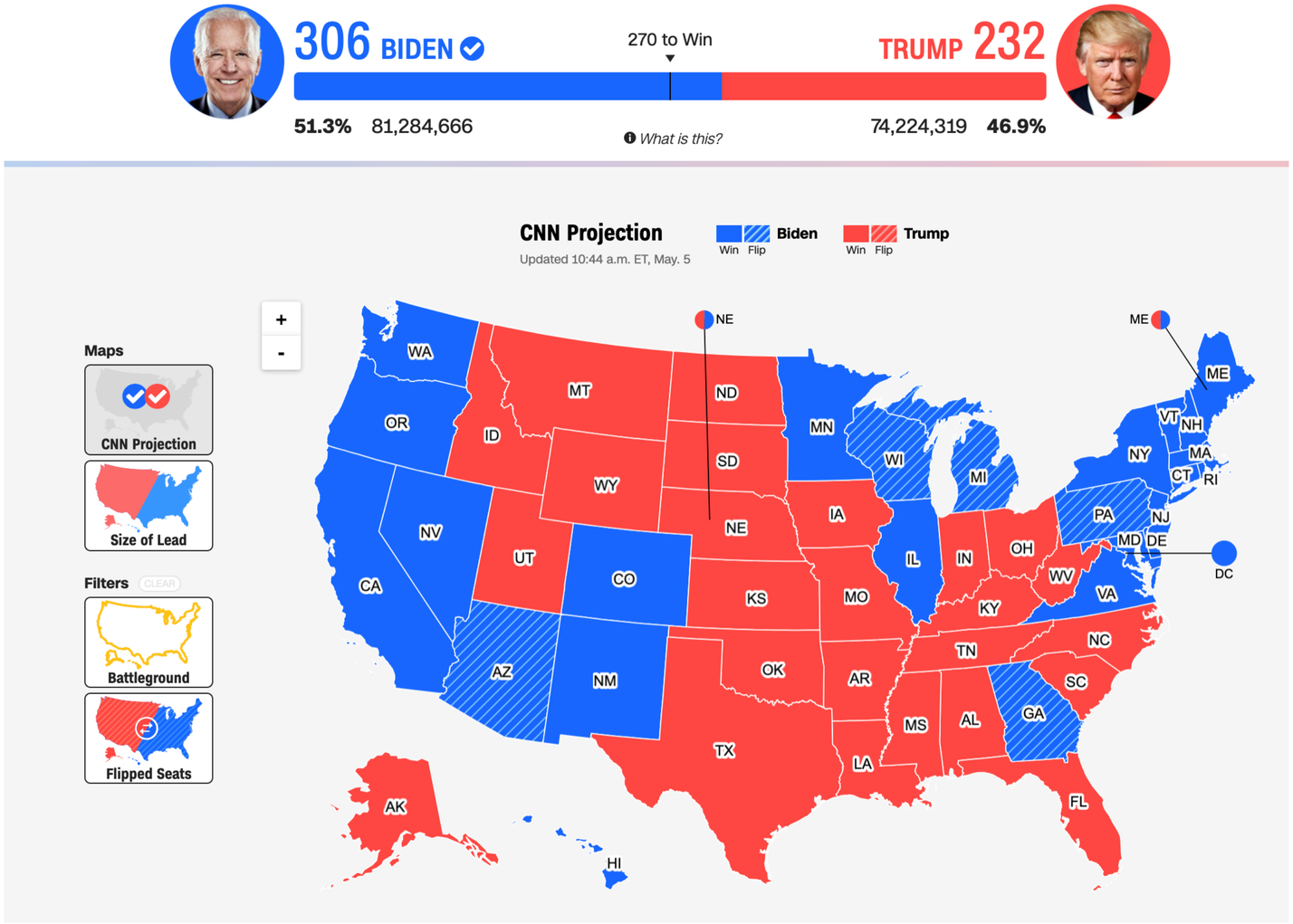


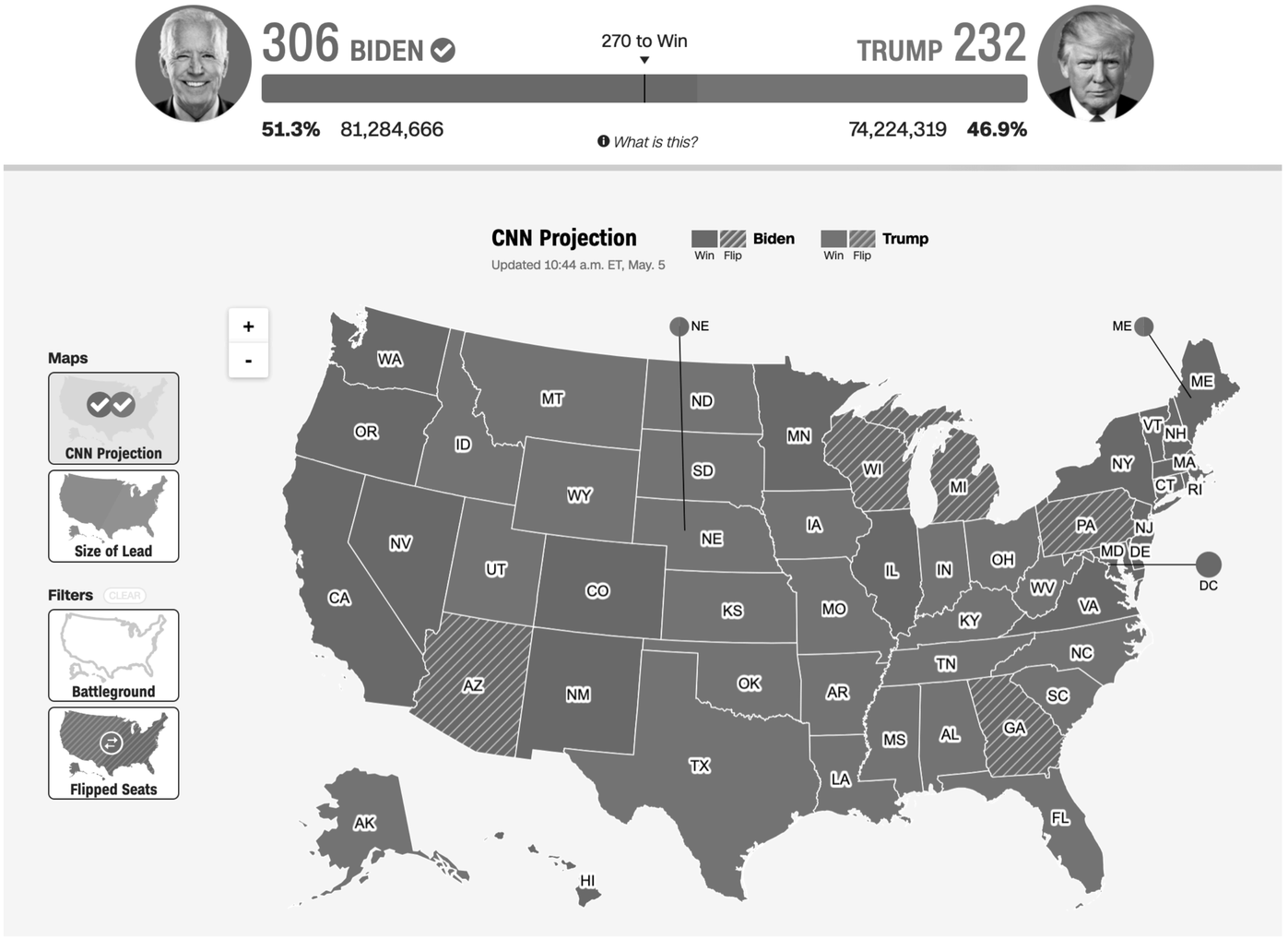
Bitcoin and gold price change (%) between January and May 2020

Chart: Based on Anthony Cuthbertson • Source: CoinMarketCap, Nasdaq, Gold Price • Get the data

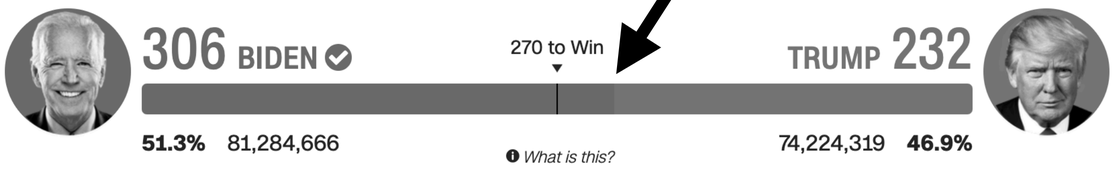
But sometimes you *can't* redundantly encode!

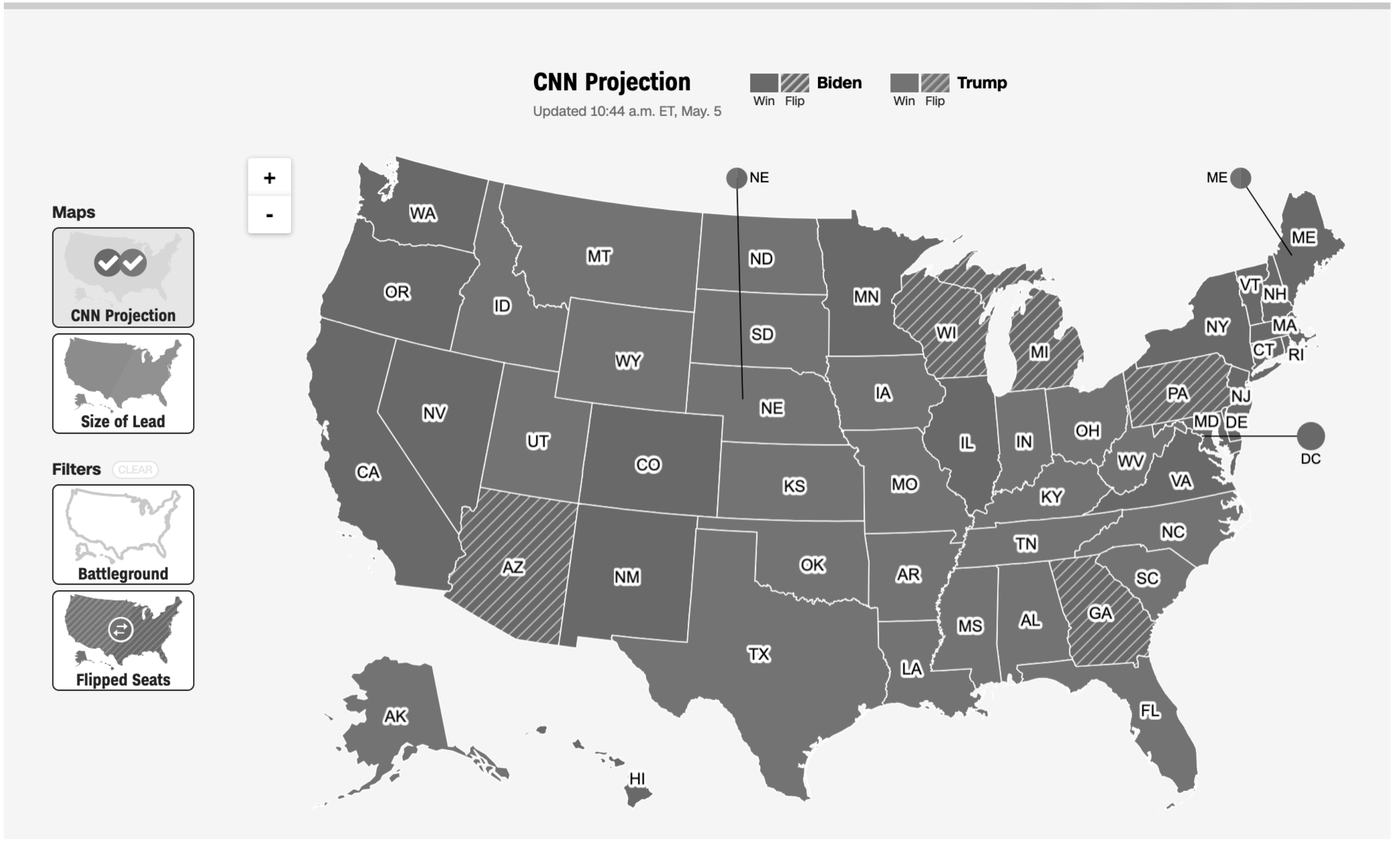


This map is trouble in greyscale

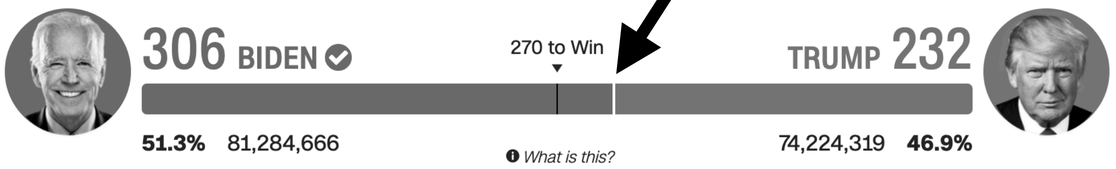


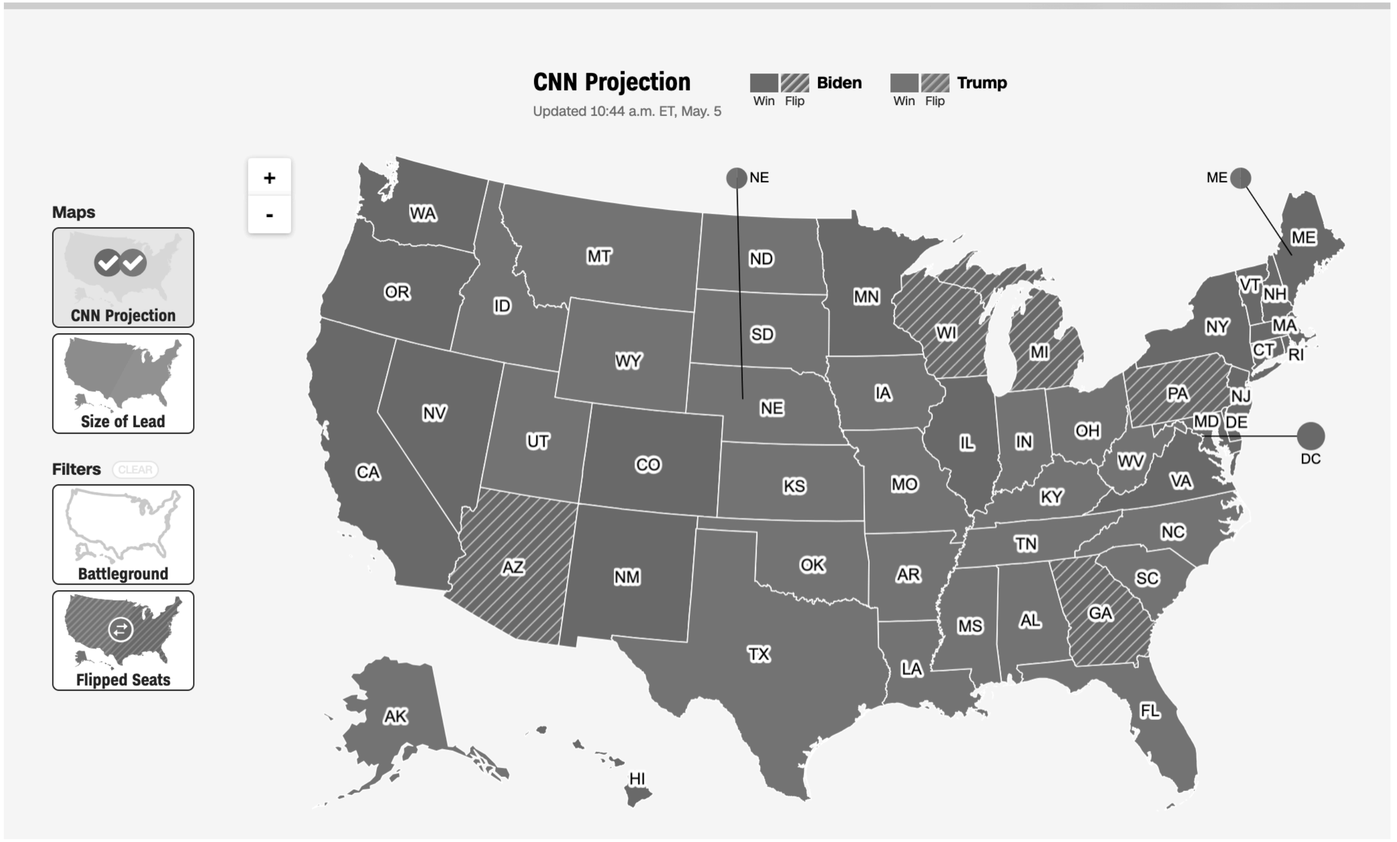
The division here matters!



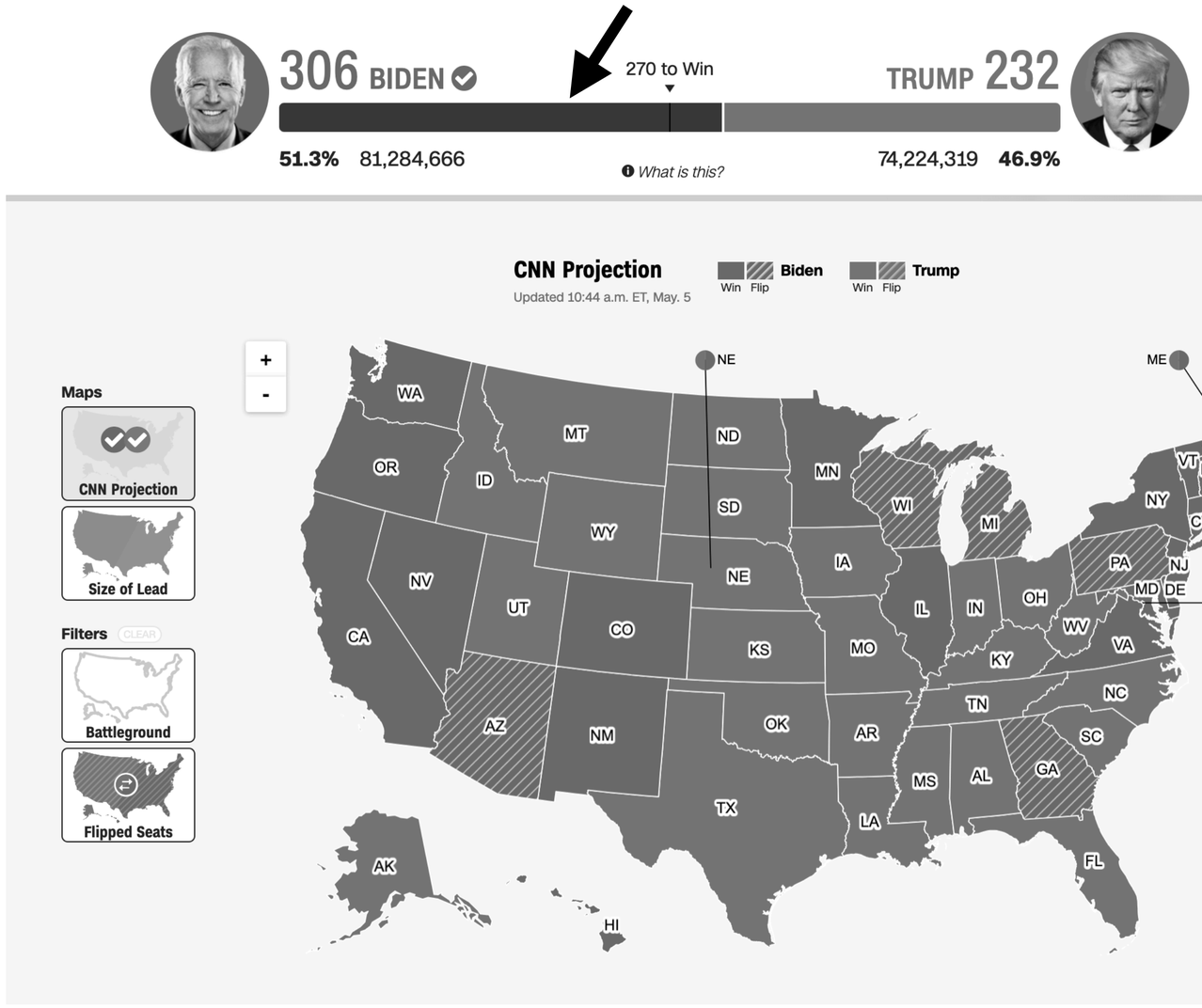


Maybe a small white divider, like the states?

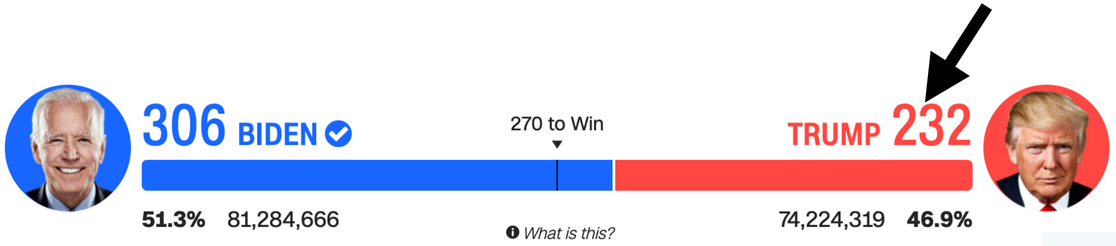


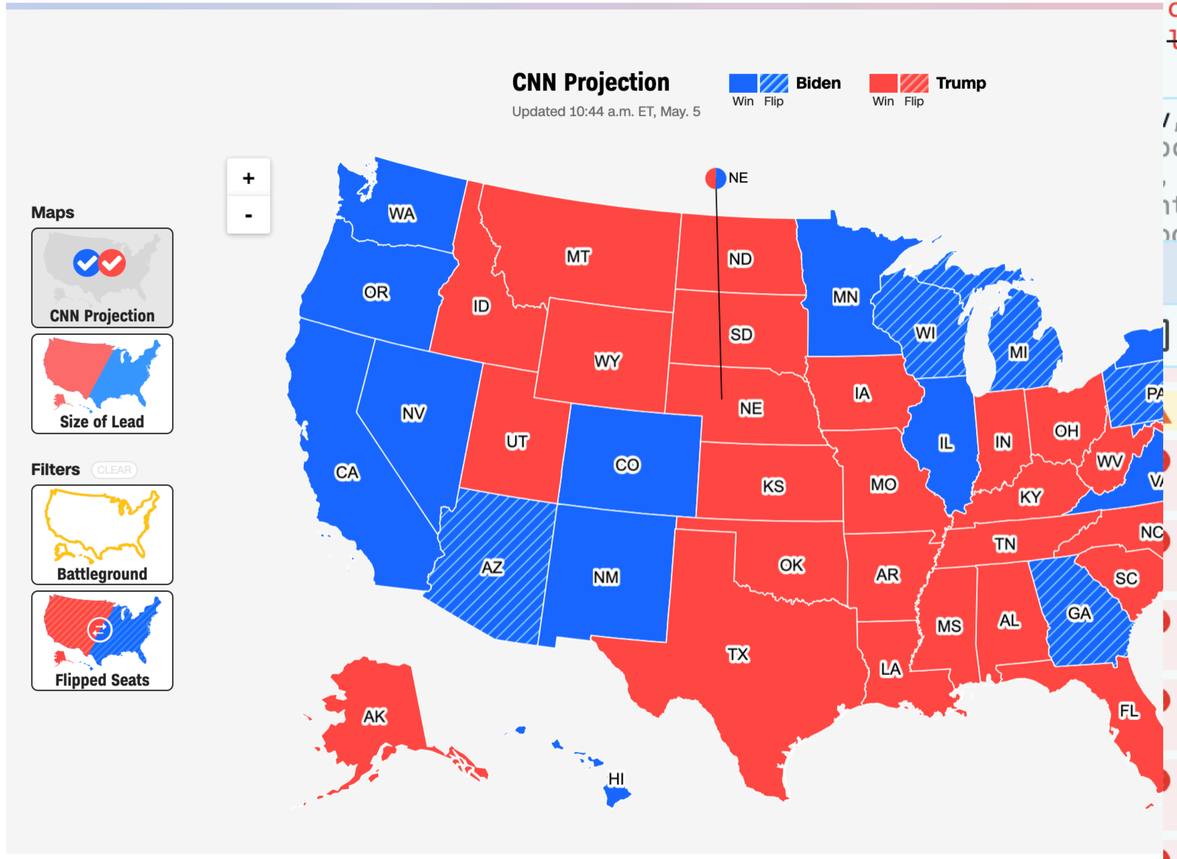


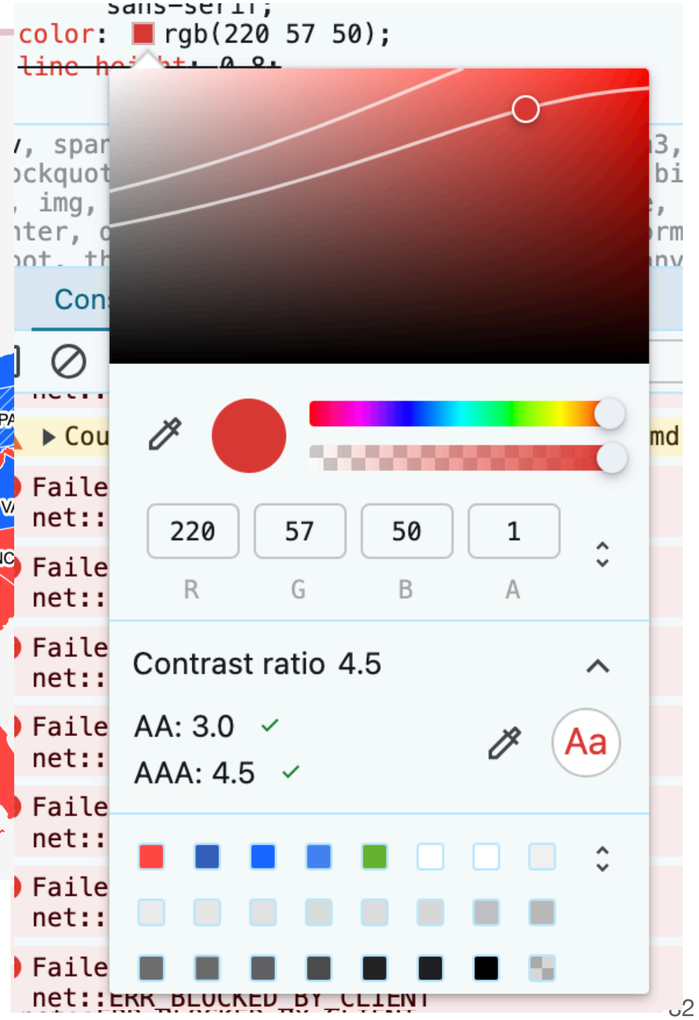
Perhaps test a darker blue too?



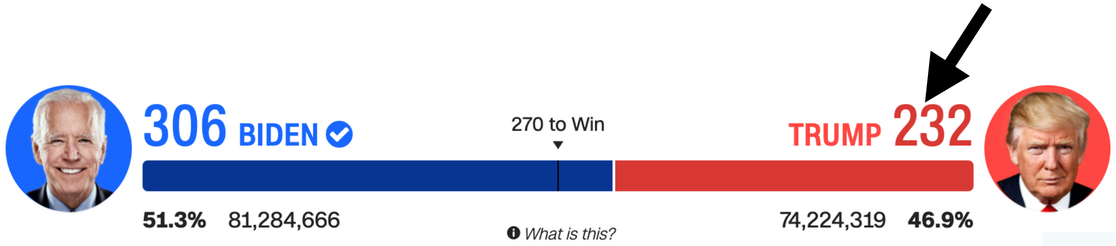
What if we fix the contrast failures at the same time?

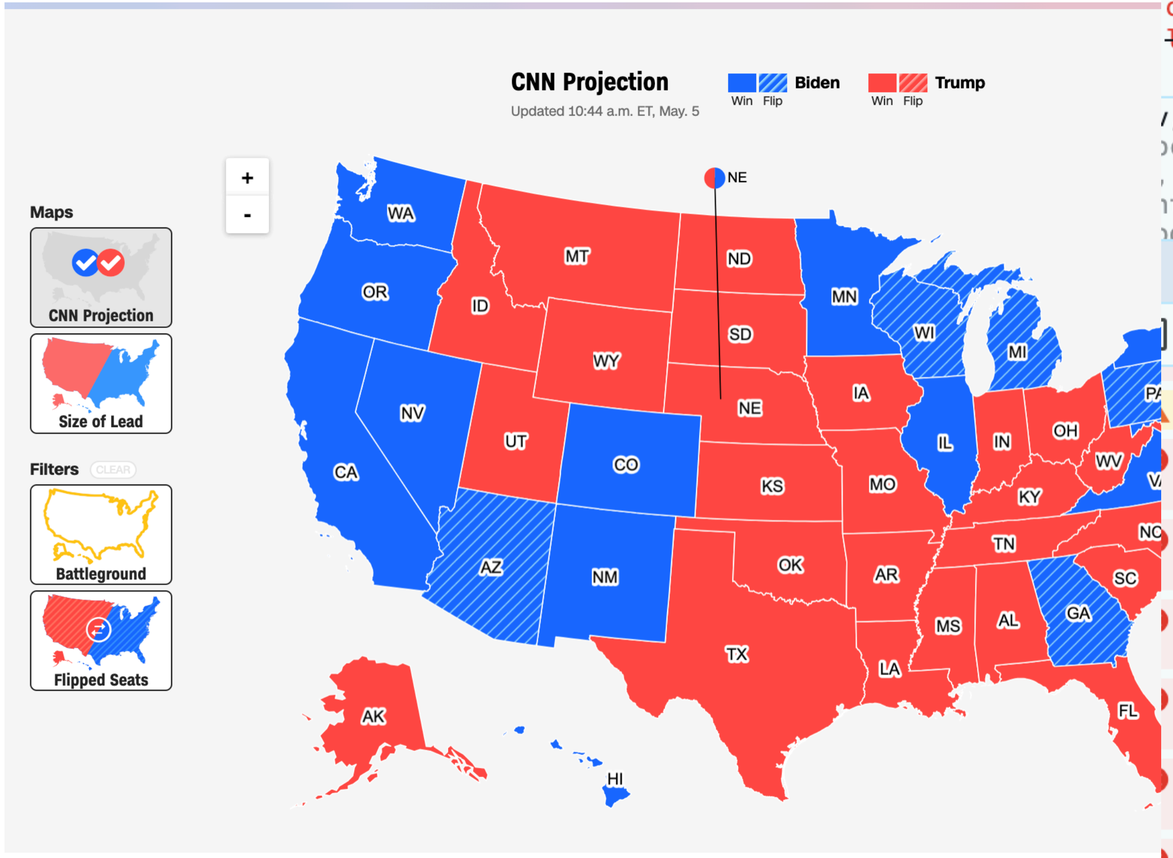


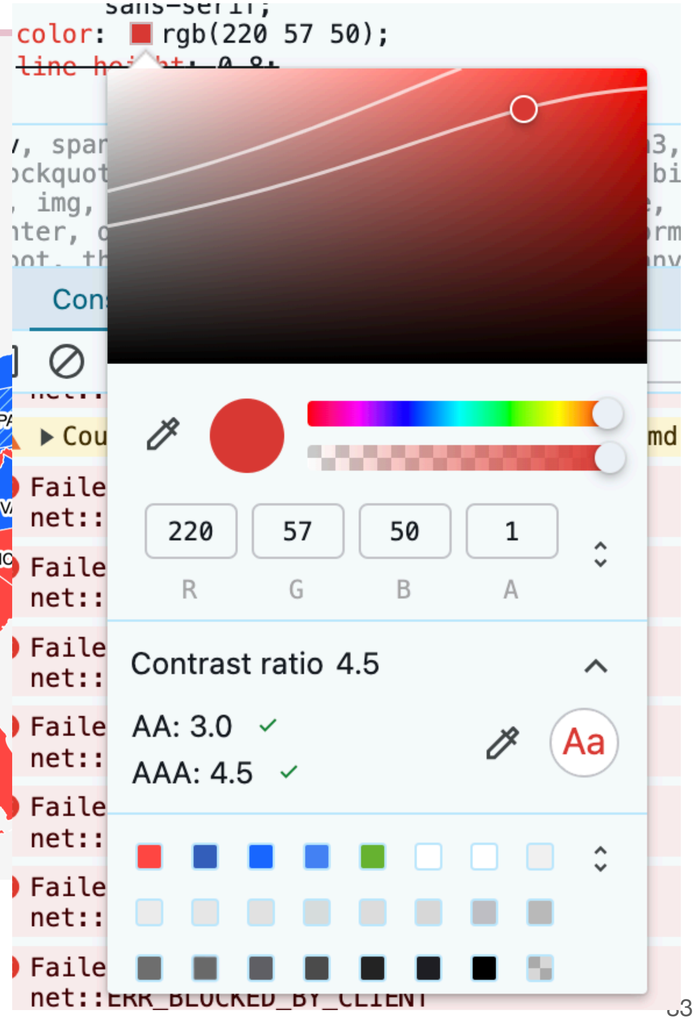




This text now passes!

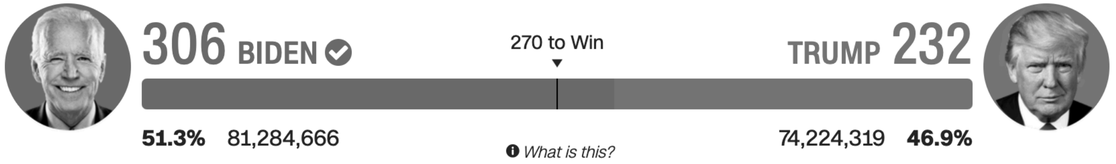


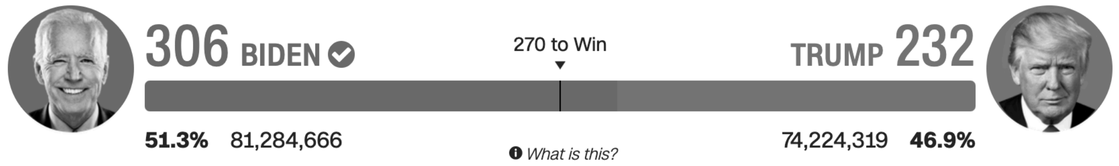




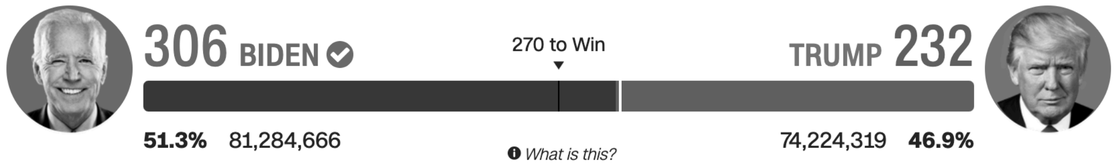
Let’s check that greyscale again…

Before

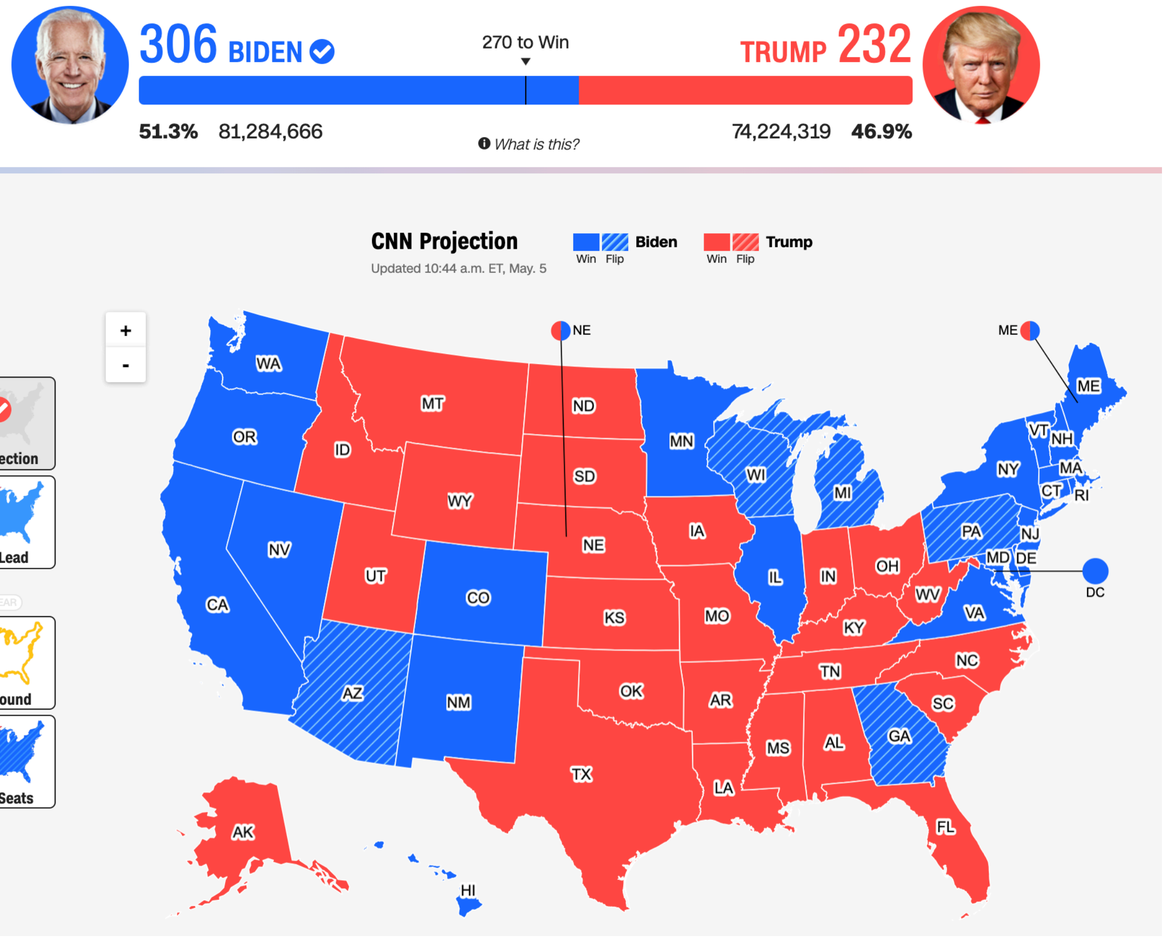

306 BIDEN
270 to Win
TRUMP 232
51.3% 81,284,666
What is this?
74,224,319 46.9%

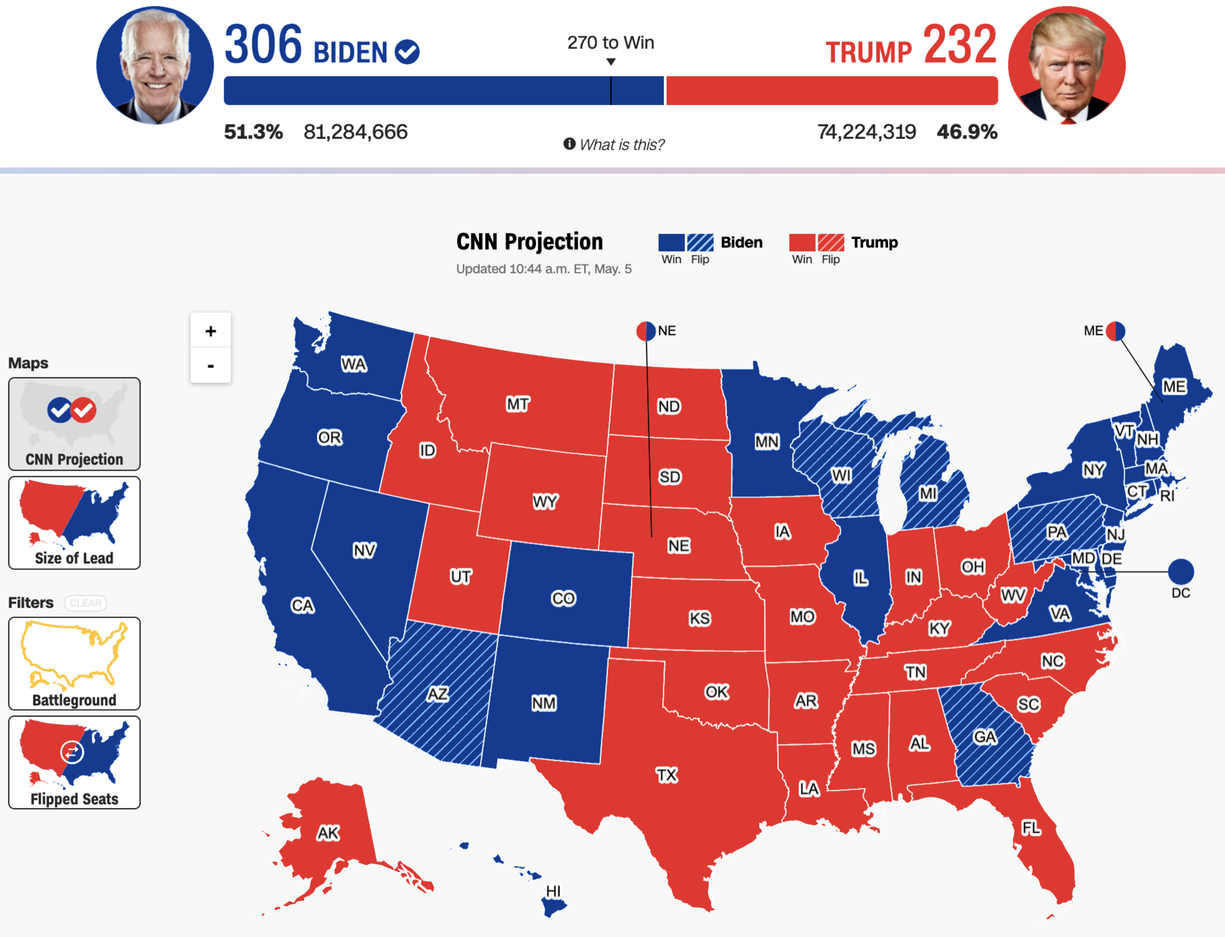

306 BIDEN
270 to Win
TRUMP 232
51.3% 81,284,666
What is this?
74,224,319 46.9%

And after!


306 BIDEN
270 to Win
TRUMP 232
51.3% 81,284,666
What is this?
74,224,319 46.9%

Sufficient contrast can help folks differentiate



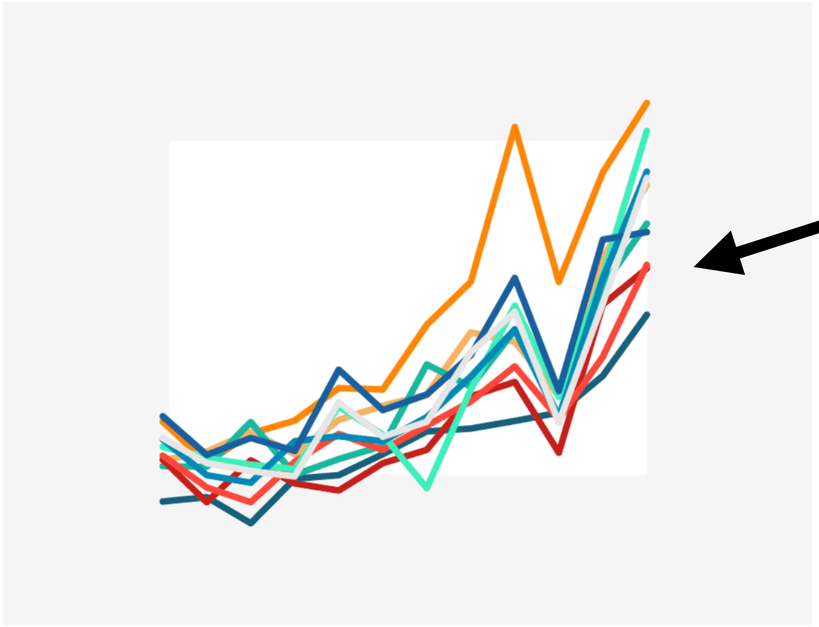


But what about more than 2 colors?

NOT IDEAL

Source: Datawrapper

But what about more than 2 colors?



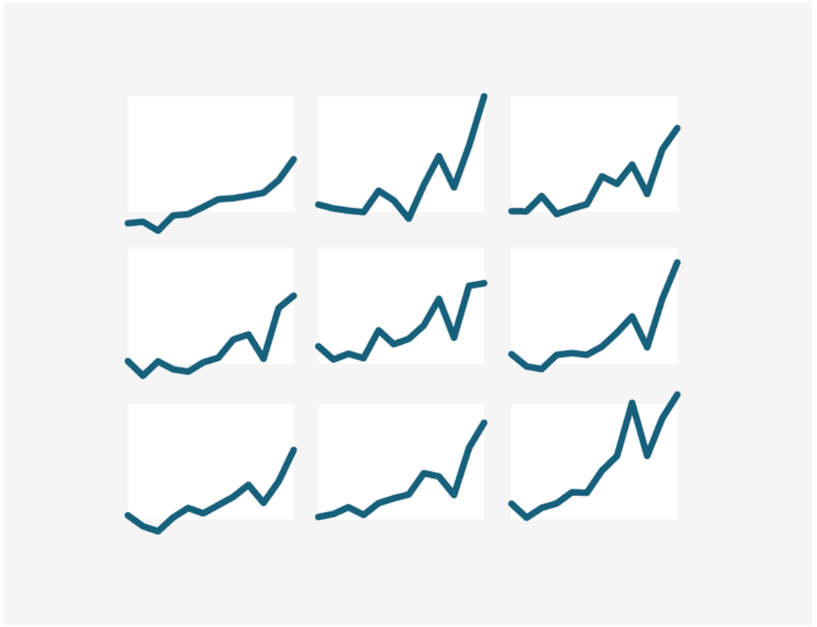
NOT IDEAL

Finding “pair” contrast gets really hard after 3+ colors…

Source: Datawrapper

Reduce your colors and redesign!

NOT IDEAL



BETTER

Source: Datawrapper

Reduce your colors and redesign!

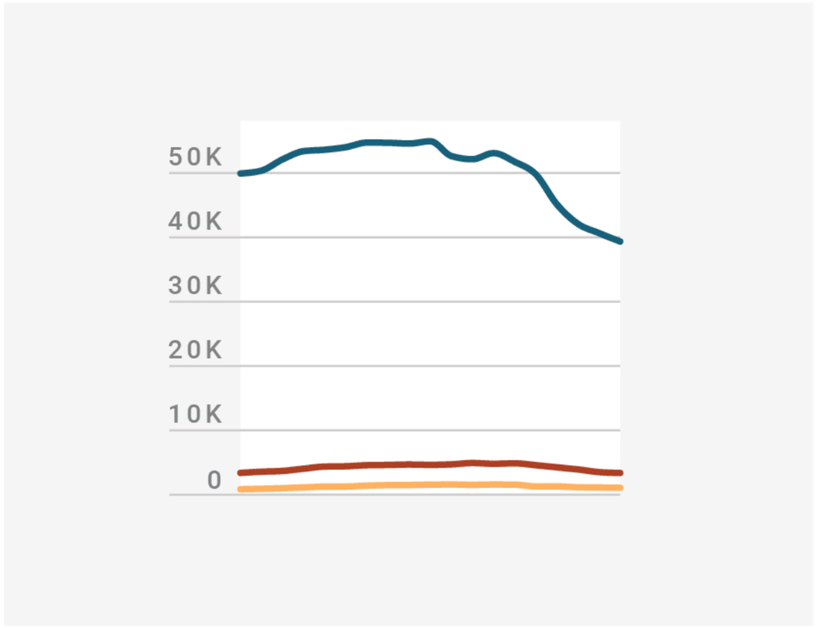
Using “small multiples” is an easy, powerful technique

NOT IDEAL

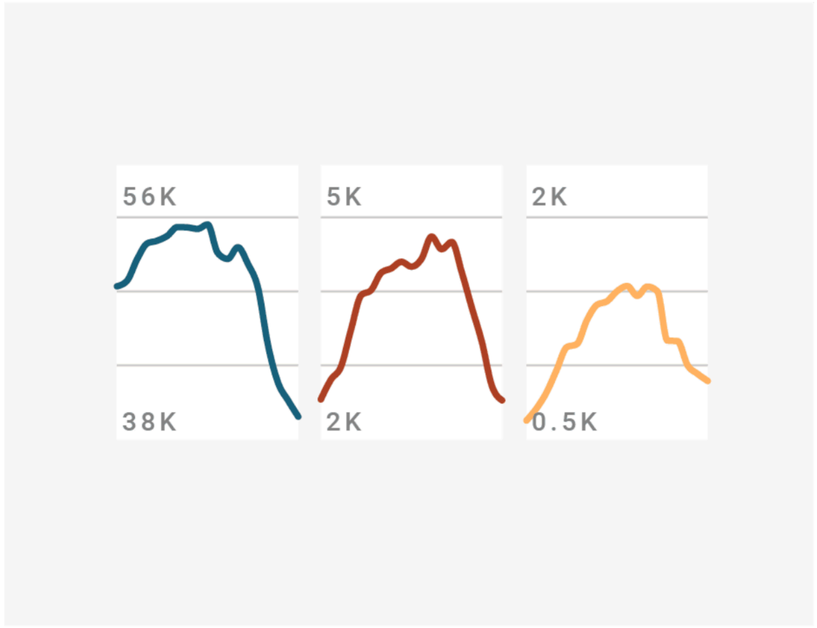
BETTER

Source: Datawrapper

Or simply separate your colors, if they matter



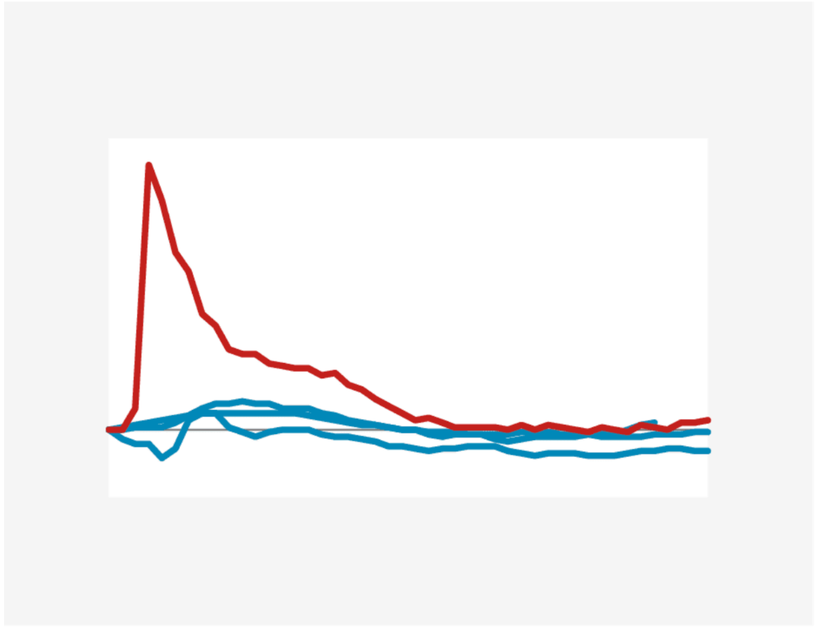
GOOD



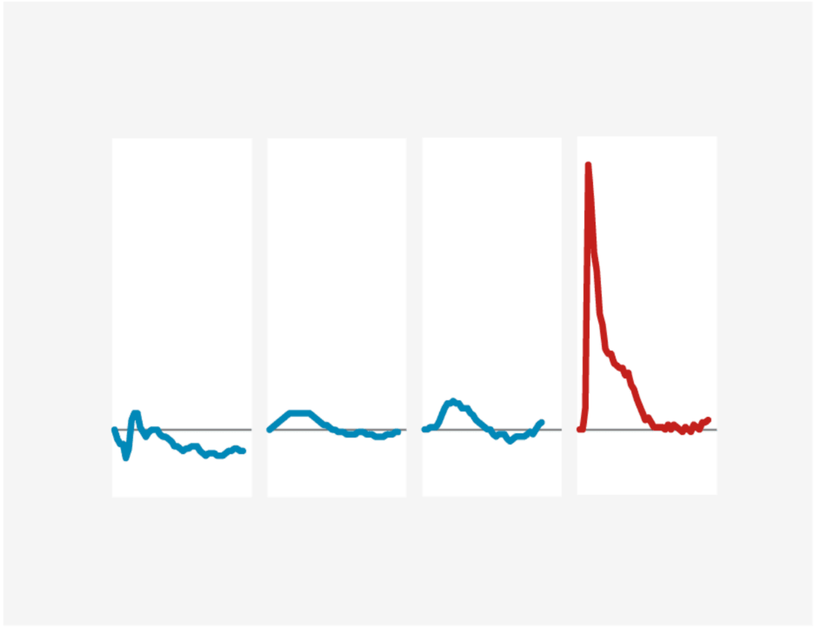
ALSO GOOD

Source: Datawrapper

My favorite use of color is to pick just one for *emphasis*



GOOD



BETTER

Source: Datawrapper

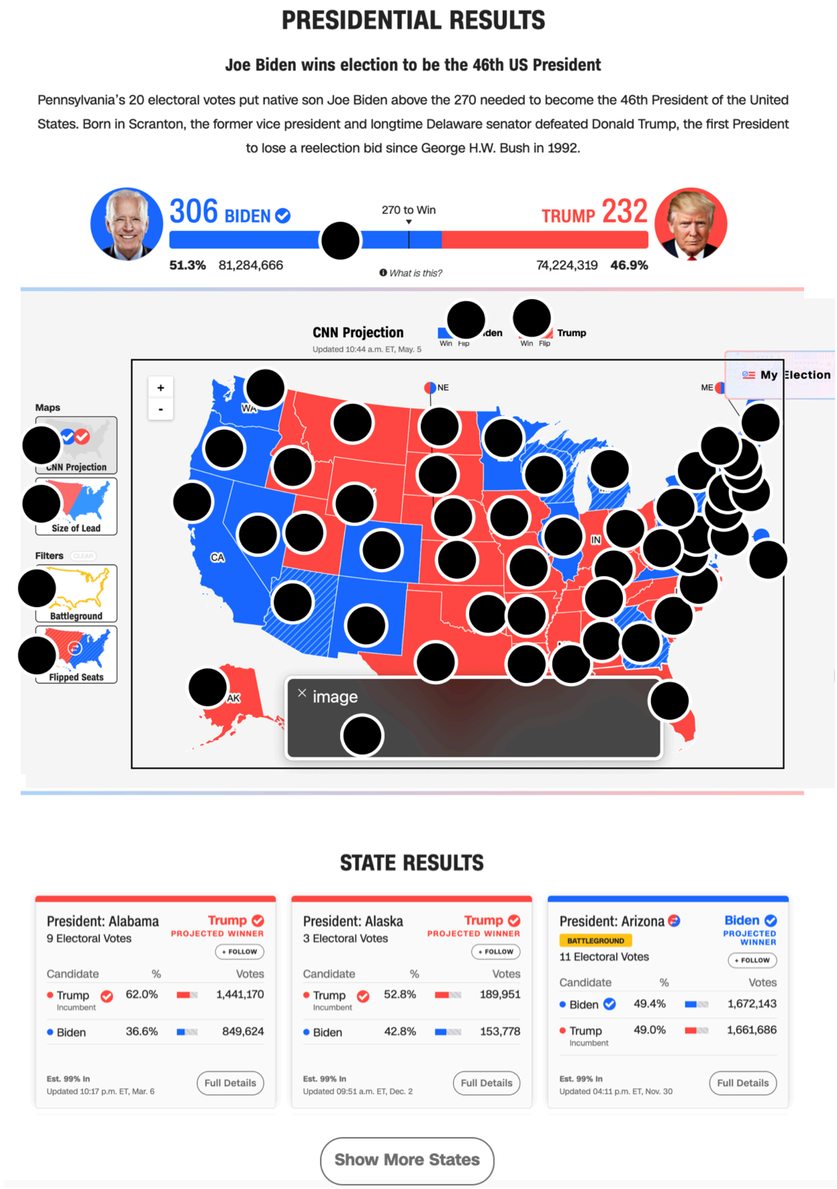
Add alt text

There is great research on alt text, but the most important thing to know is that you should add it to every image you post online (including twitter), in a document, or presentation.

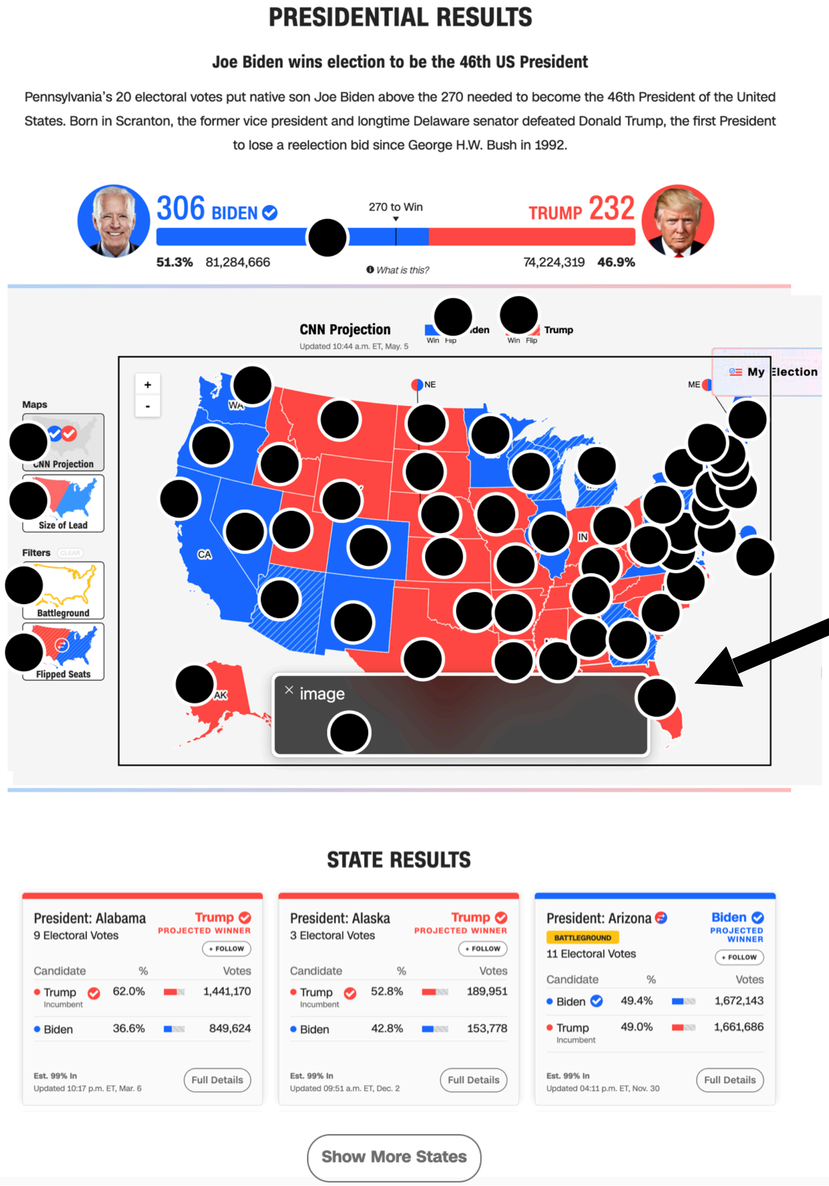
Guidance: https://medium.com/nightingale/writing-alt-text-for-data-visualization-2a218ef43f81

alt= “**Chart type** of **type of data** where **reason for including chart**”

Include a **link to data source** somewhere in the text



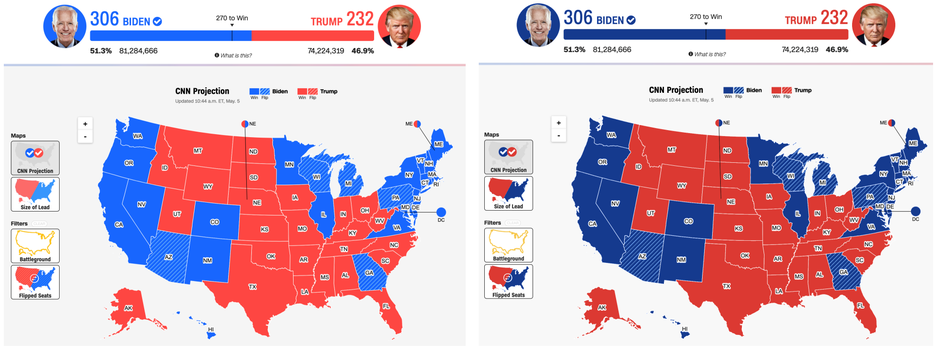
57 instances of “Content is only visual”



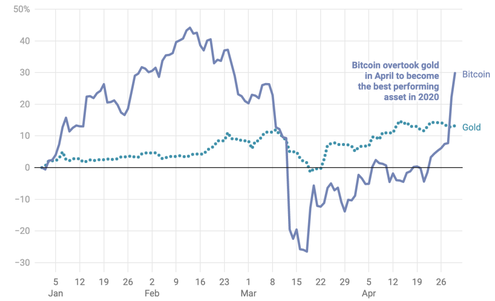
Each state should announce to screen readers what state it is and who won it, not "image!"

Recap: Perceivability

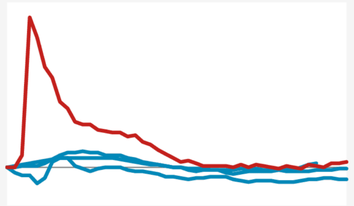
Use high contrast

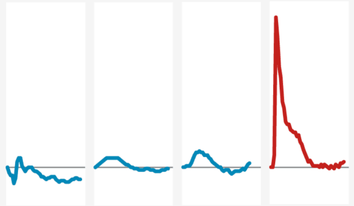


Use redundant encoding



Reduce colors and crowding





Add alt text

alt= “**Chart type** of **type of data** where **reason for including chart**”

Include a **link to data source** somewhere in the text

Perceivable Evaluation Toolkit:

1. Contrast Checker
2. Safe color design
   a. CVD Checker
   b. Redundant encoding design ideas
   c. Small multiples design ideas
3. Alt Text

Operable

Can someone operate this in multiple ways? Is each way easy?

Operable Checklist:

1. Mouse
2. Keyboard-only
3. Screen Reader

Many assistive input technologies “navigate”

A person in a wheelchair operating an old computer using a desk-mounted sip and puff device called the POSSUM.

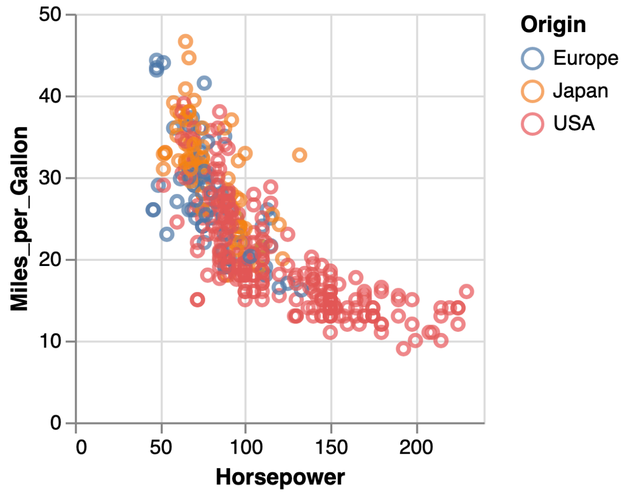
Image credit: Wikipedia, Public Domain, 1960. Photographer: Possum Ltd.

Why “keyboard-only?”

Some things work for screen readers but not for keyboard-only users!

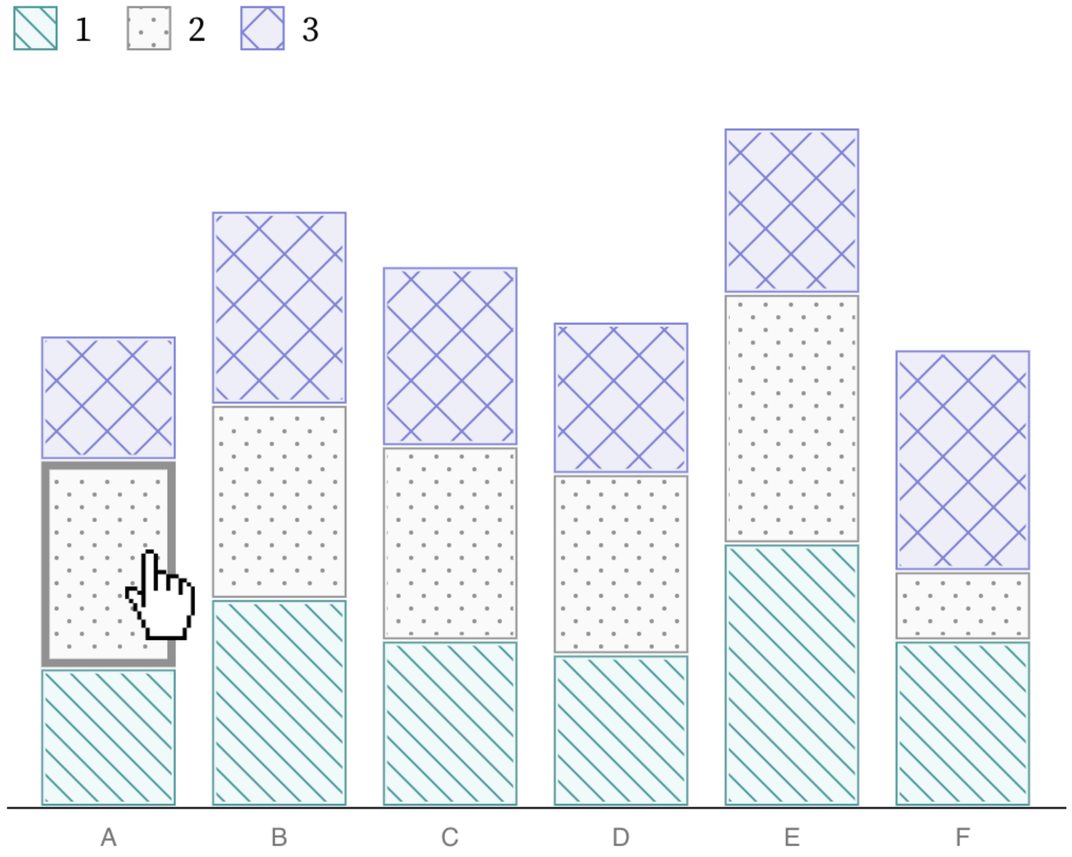
Scatterplot with External Links and Tooltips

A scatterplot showing horsepower and miles per gallons that opens a Google search for the car that you click on.



https://vega.github.io/vega-lite/examples/point_href.html

Ensure Keyboard Access (if interactive)



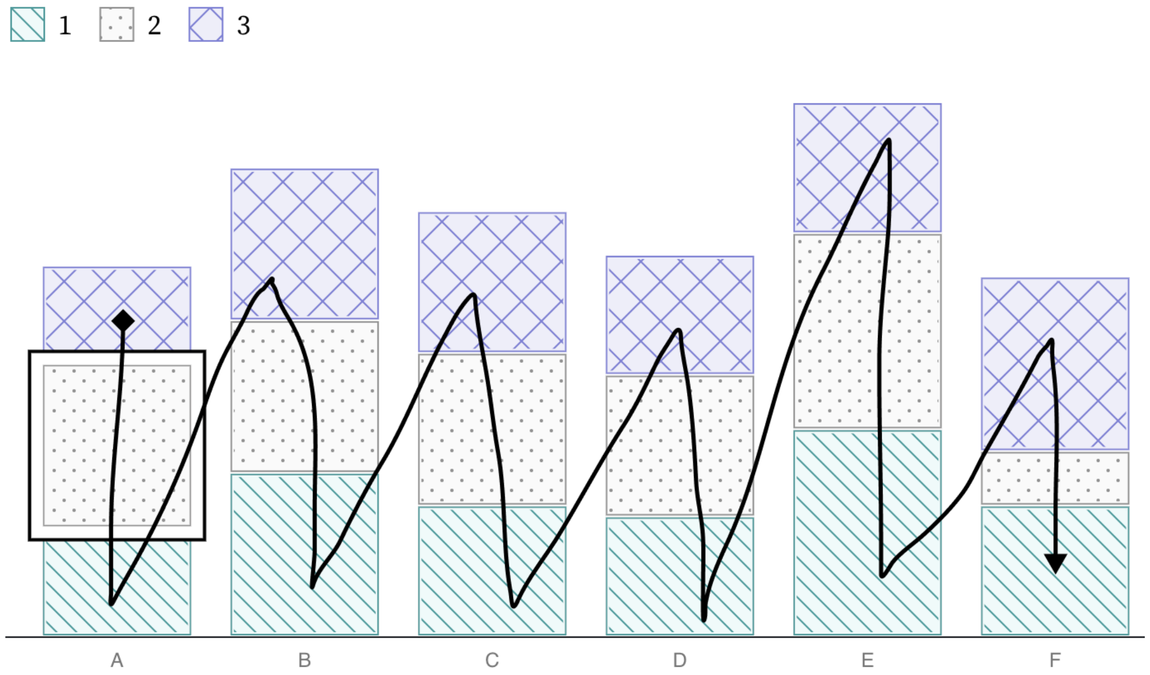
> **Status**: **Category 2** of **Building A** has been selected.

Products In Building A that belong to Category 2*

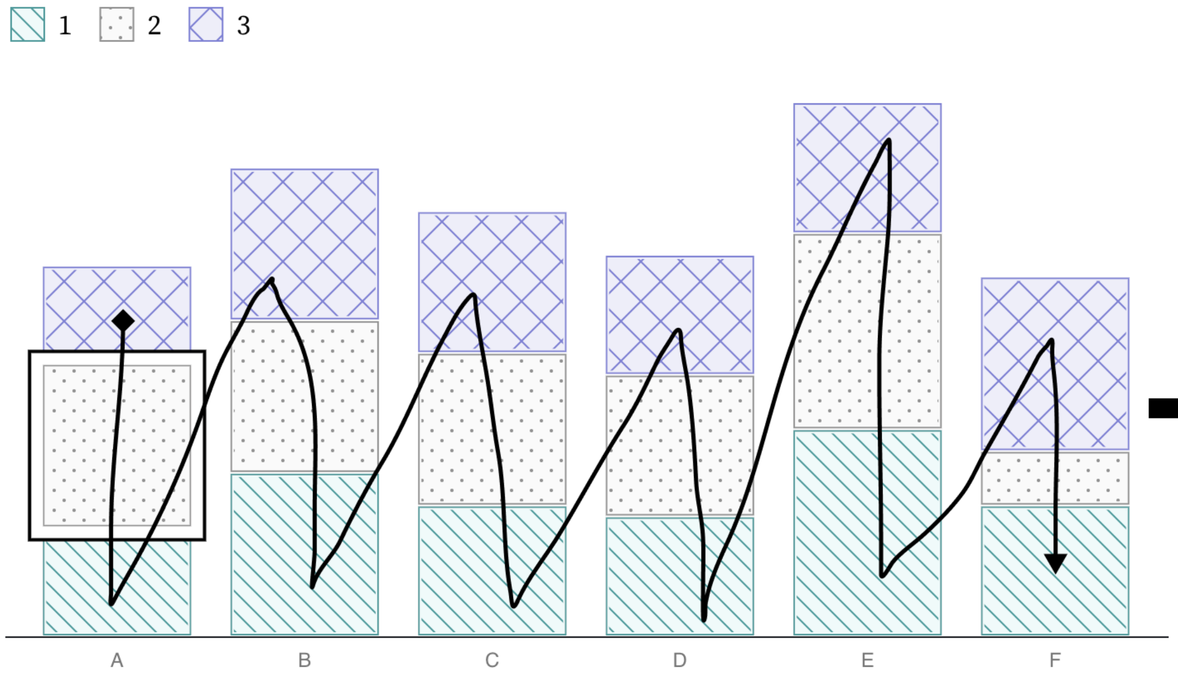
Product Name	Count in Stock
Product A	147
Product C	88
Product M	69

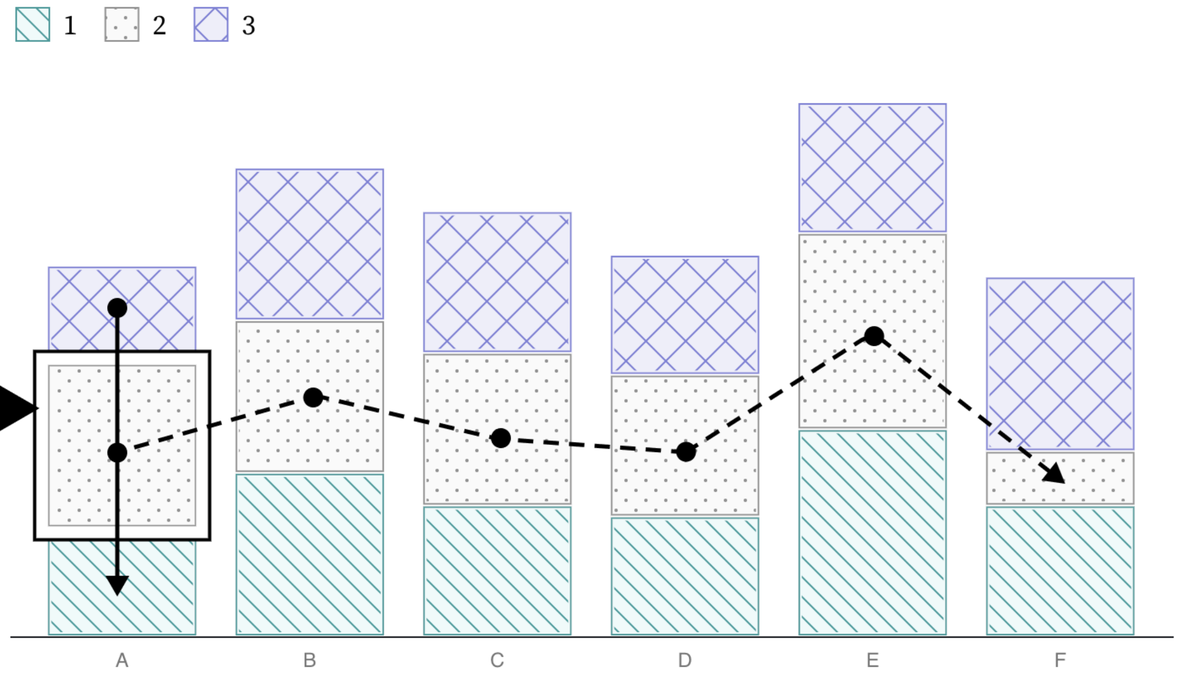
**This table has been populated by the selection in the preceding chart.*

How does someone move around? By default, it is as elements are rendered:

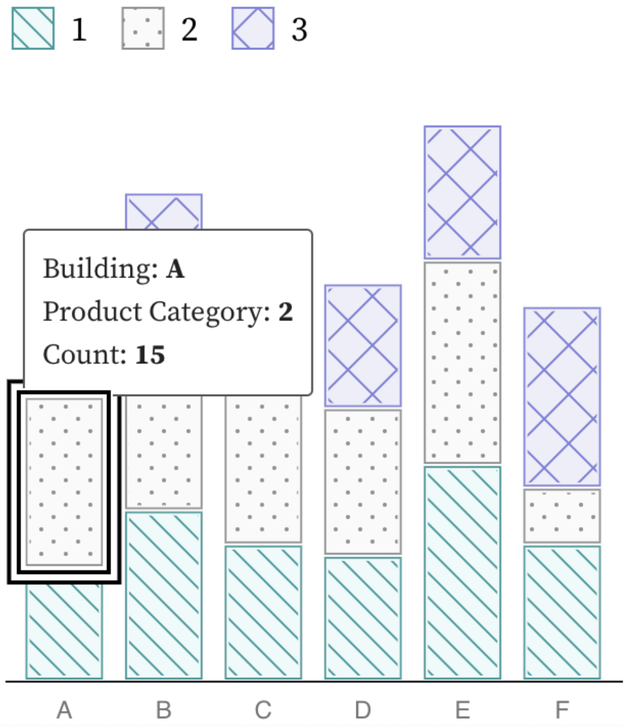


Consider more flexible movement when data *exploration* matters



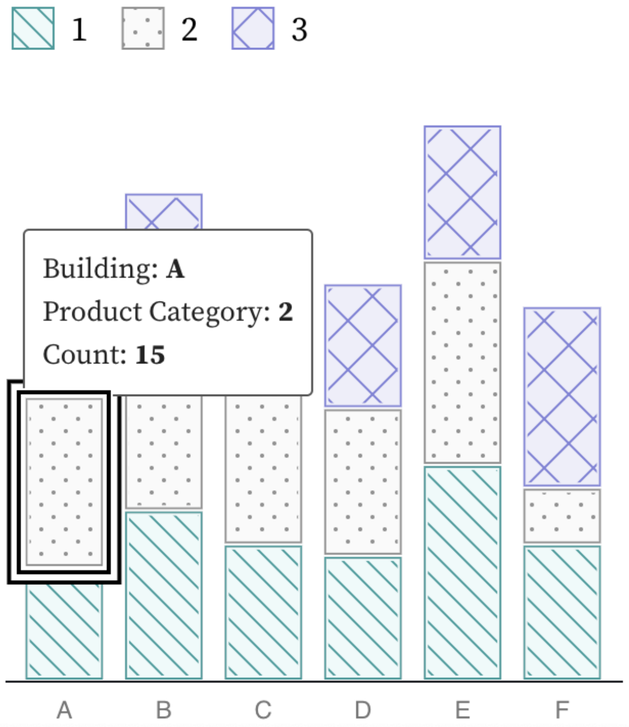


Alt text should communicate operability



Building A. Product Category 2. Count 15. Bar 2 of 3. Image.

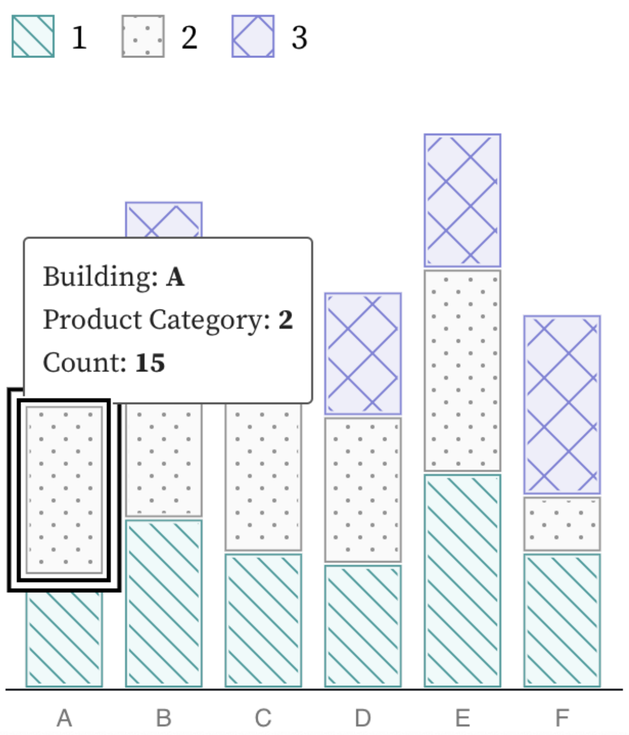
Semantics matter



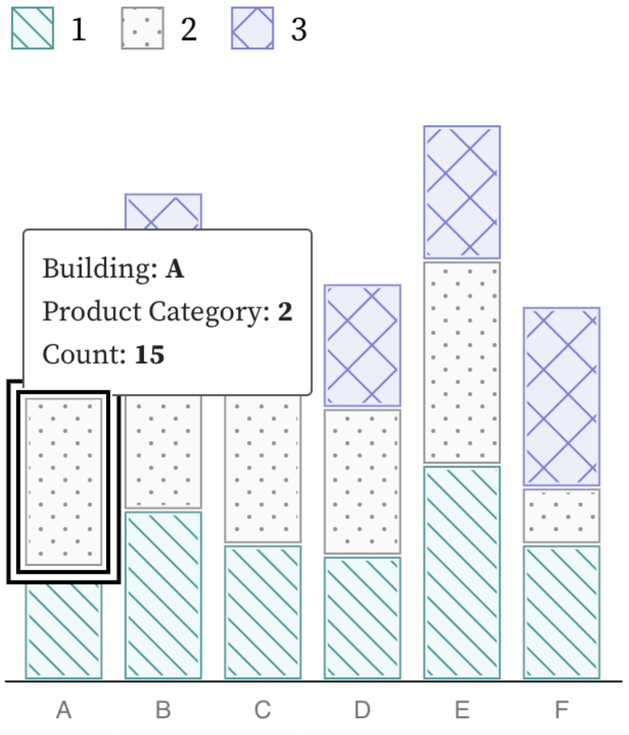
Building A. Product Category 2. Count 15. Bar 2 of 3. Image.

“Image” doesn’t signal interactivity!

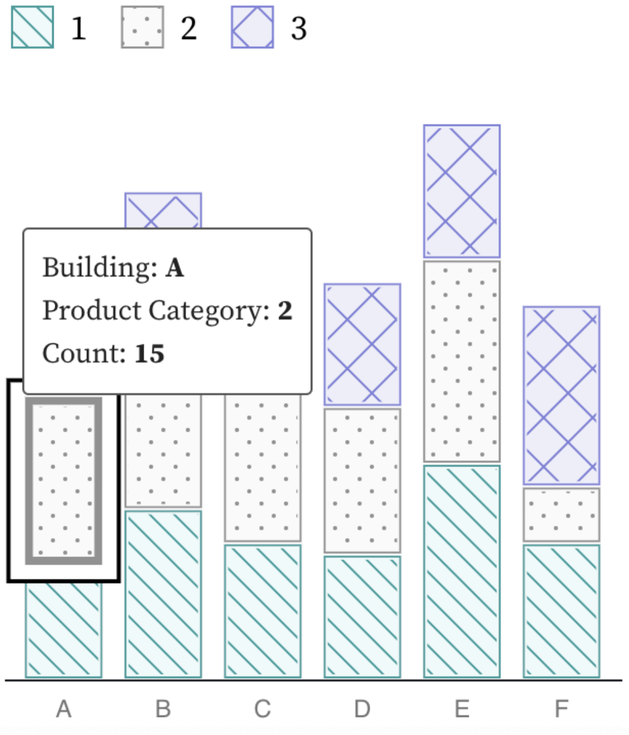
“Aria” states and roles are standardized



× Building A. Product Category 2. Count 15. Bar 2 of 3. Image.



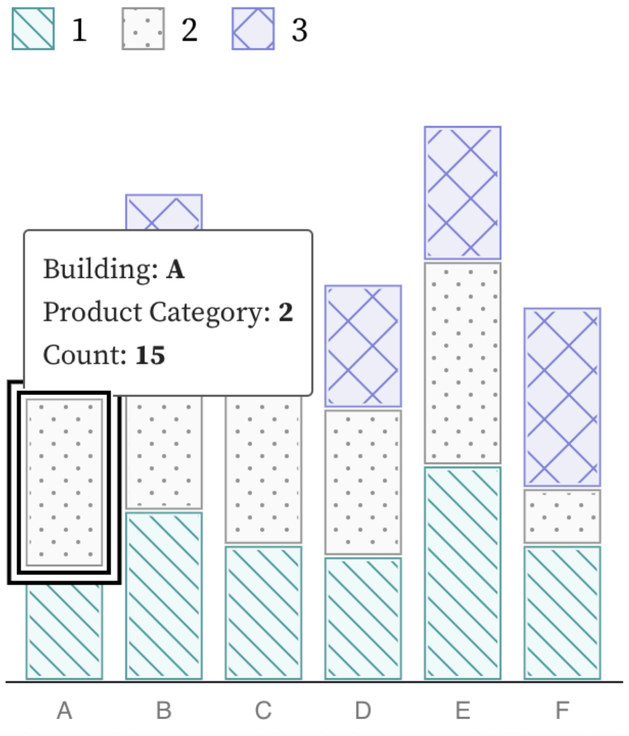
× Building A. Product Category 2. Count 15. Bar 2 of 3., toggle button



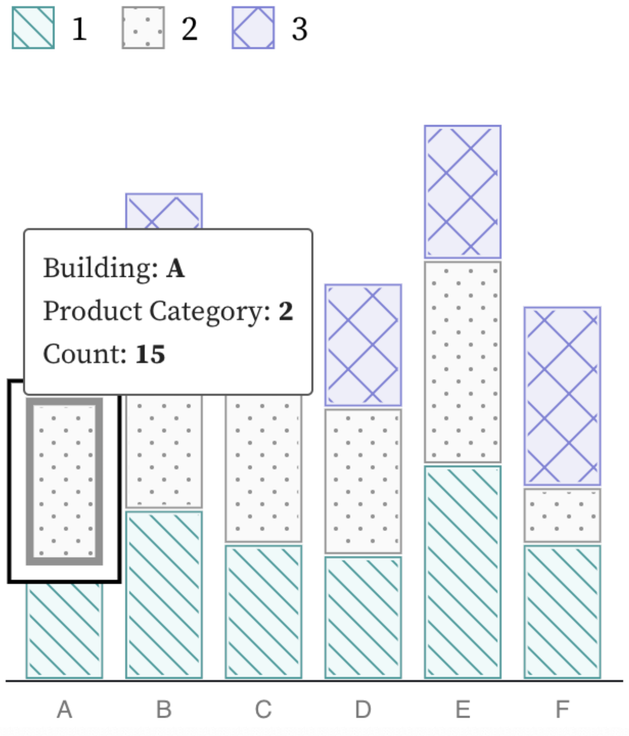
× selected, Building A. Product Category 2. Count 15. Bar 2 of 3., toggle button

Communicating operability should be visual too

Hovered/focused



Selected

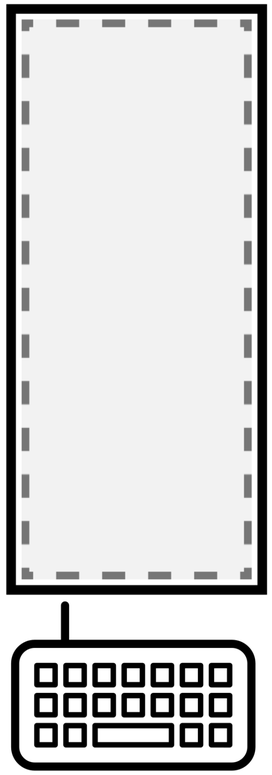


Design your own interaction styling

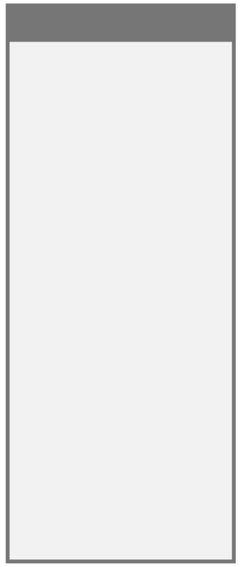
Default

Hovered

Focused

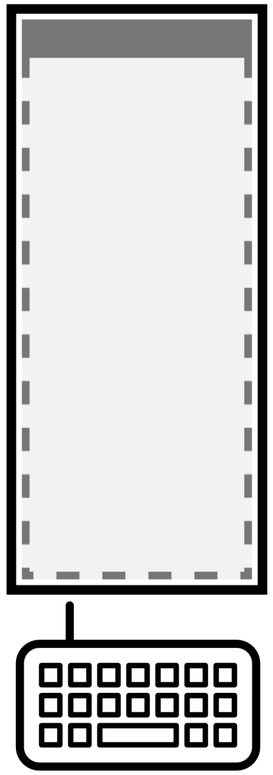


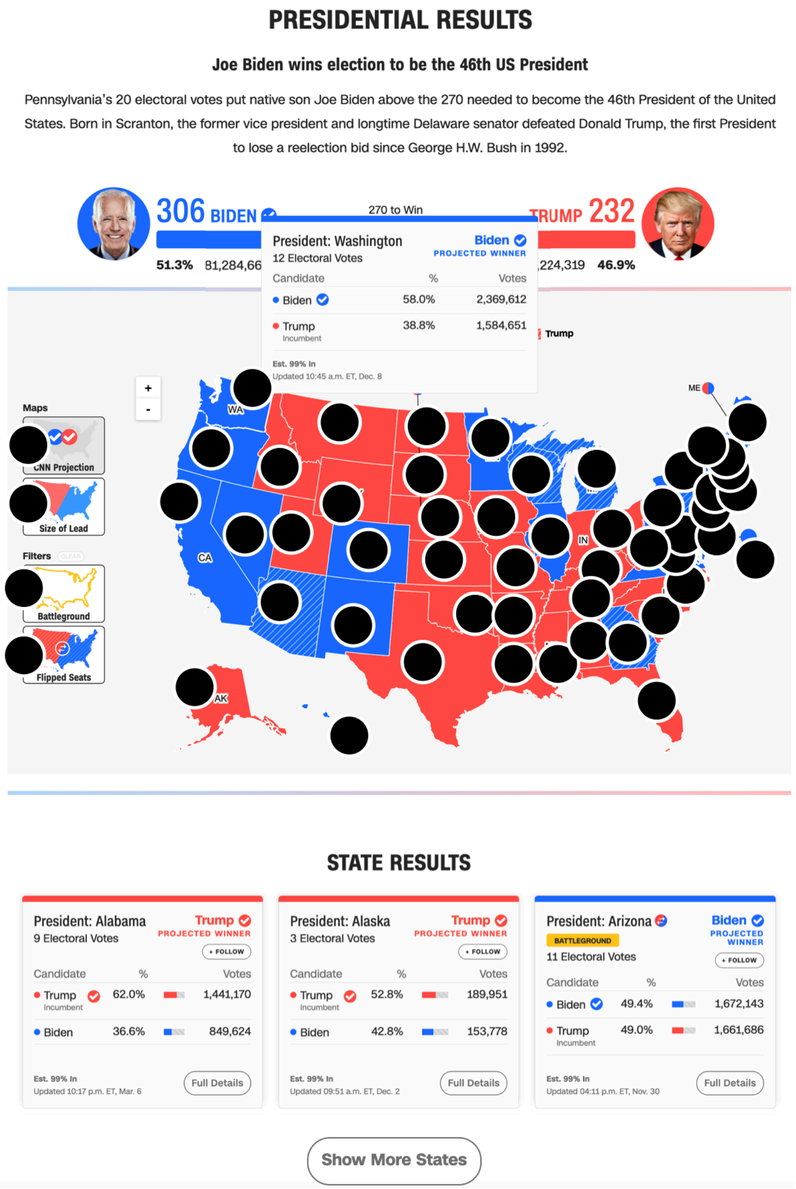
Selected



Hovered + Selected

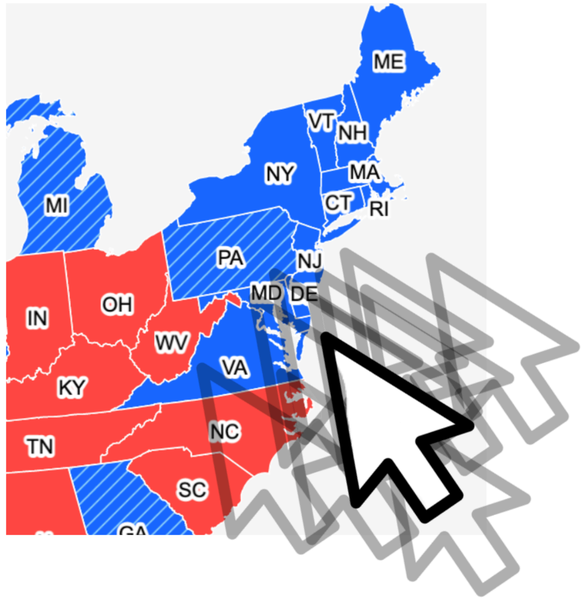
Focused + Selected

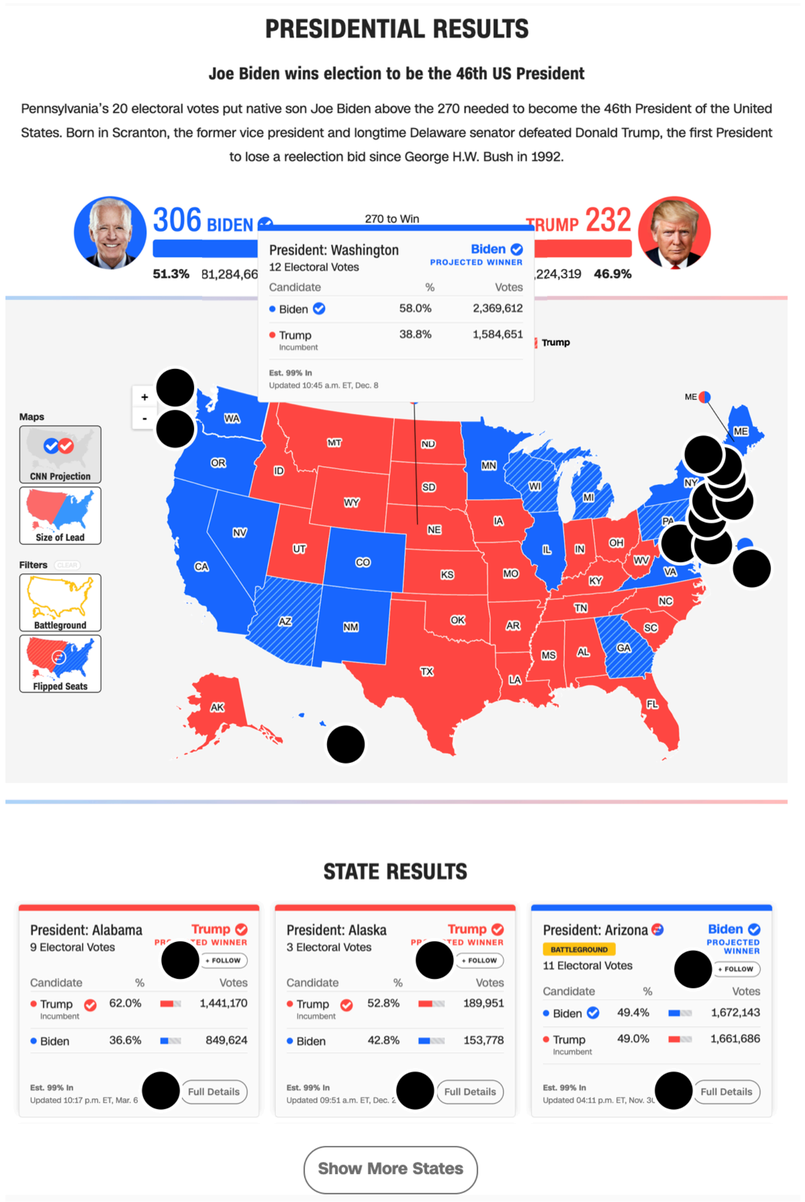




54 instances of “only one input type”

Expecting users to hover on something tiny is an accessibility design failure

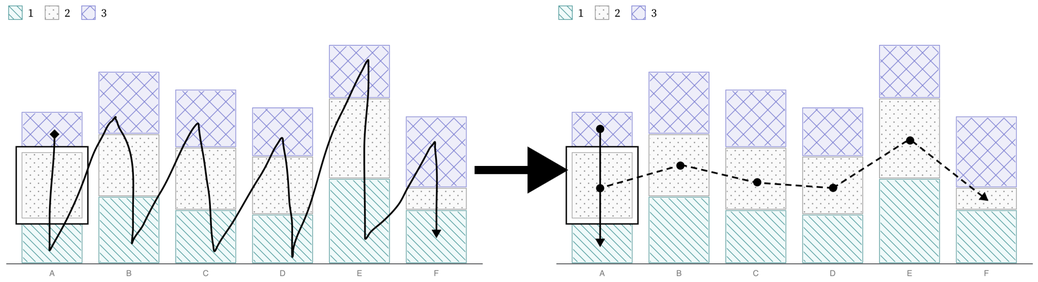




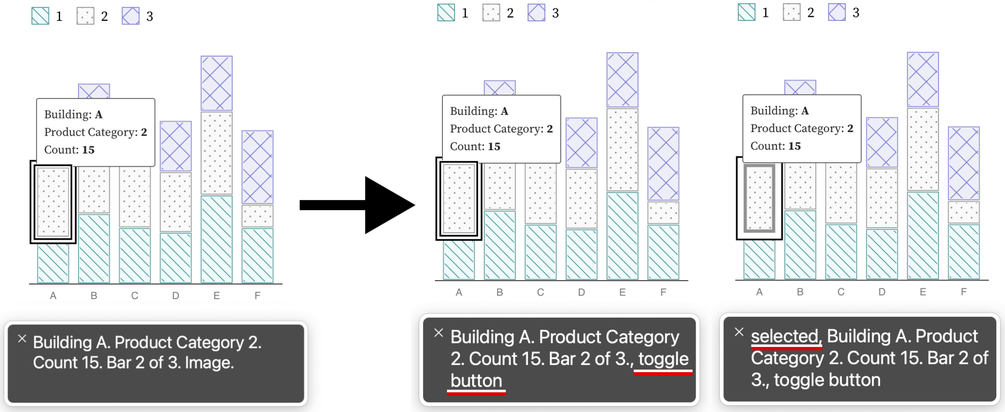
18 instances of “target pointer size is too small”

Recap: Operability

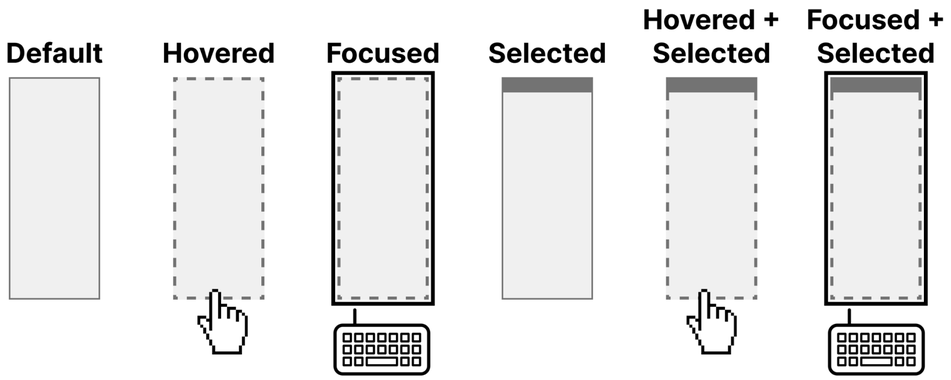
Consider how someone navigates



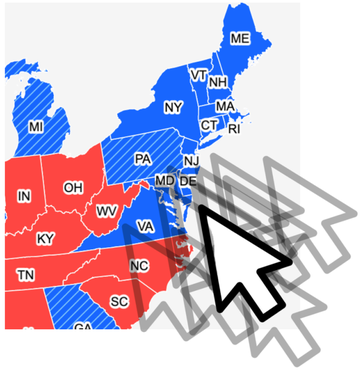
Describe the functionality of elements



Communicate interaction state visually



Improve the size of interaction areas



Operable Evaluation Toolkit:

1. **Use your mouse**: can it do something meaningful? (tooltip, click event, etc) If so:
   a. Test using a **keyboard-only**: can you navigate *and* use keyboard activation (spacebar/enter) on the visualization?
   b. Test using a **screen reader**: Can you use a screen reader to navigate and use keyboard activation on the visualization?
2. **Check sizes:** can a mouse *easily* interact with this?

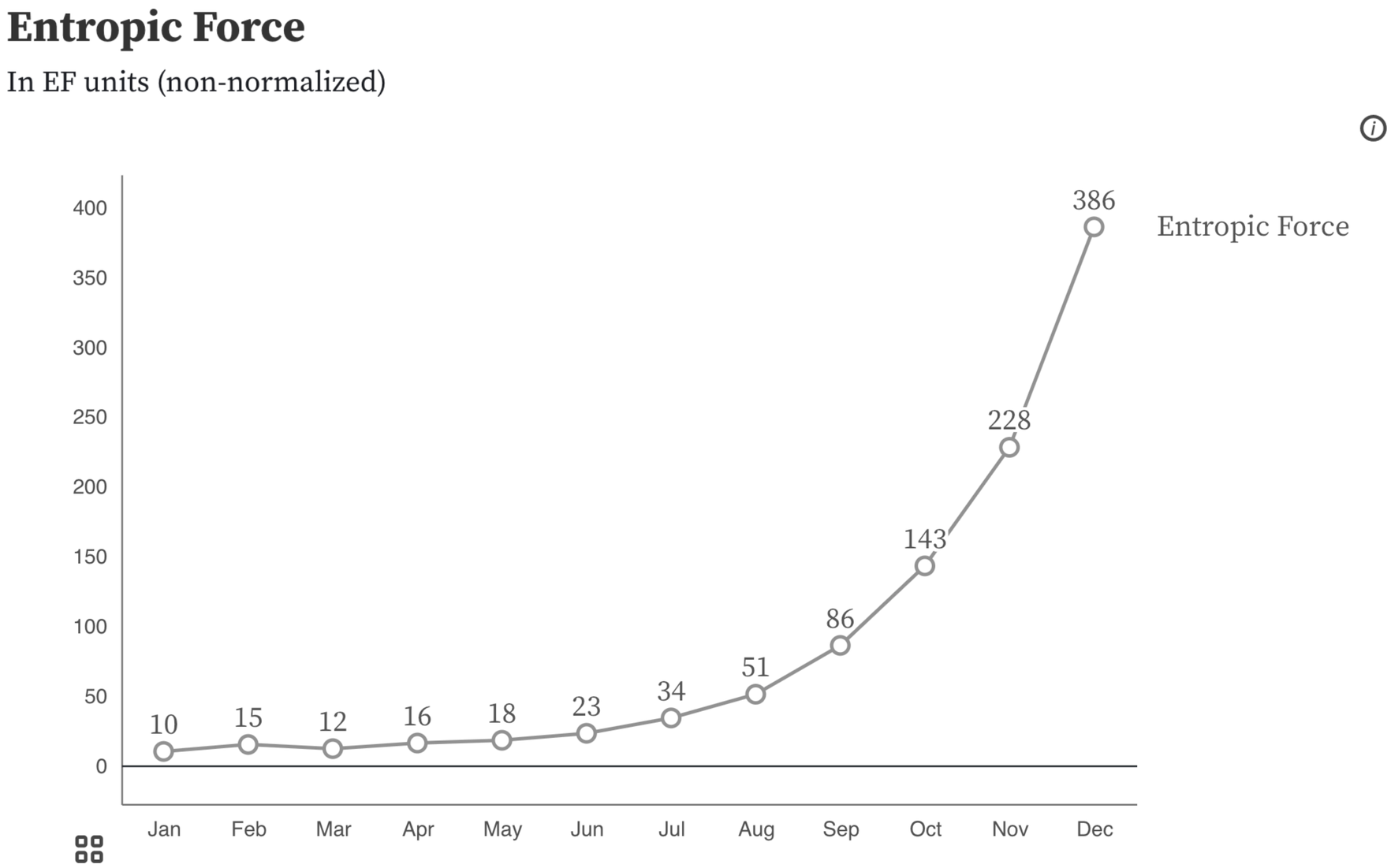
Understandable

Can someone understand this in multiple ways? Is each way easy?

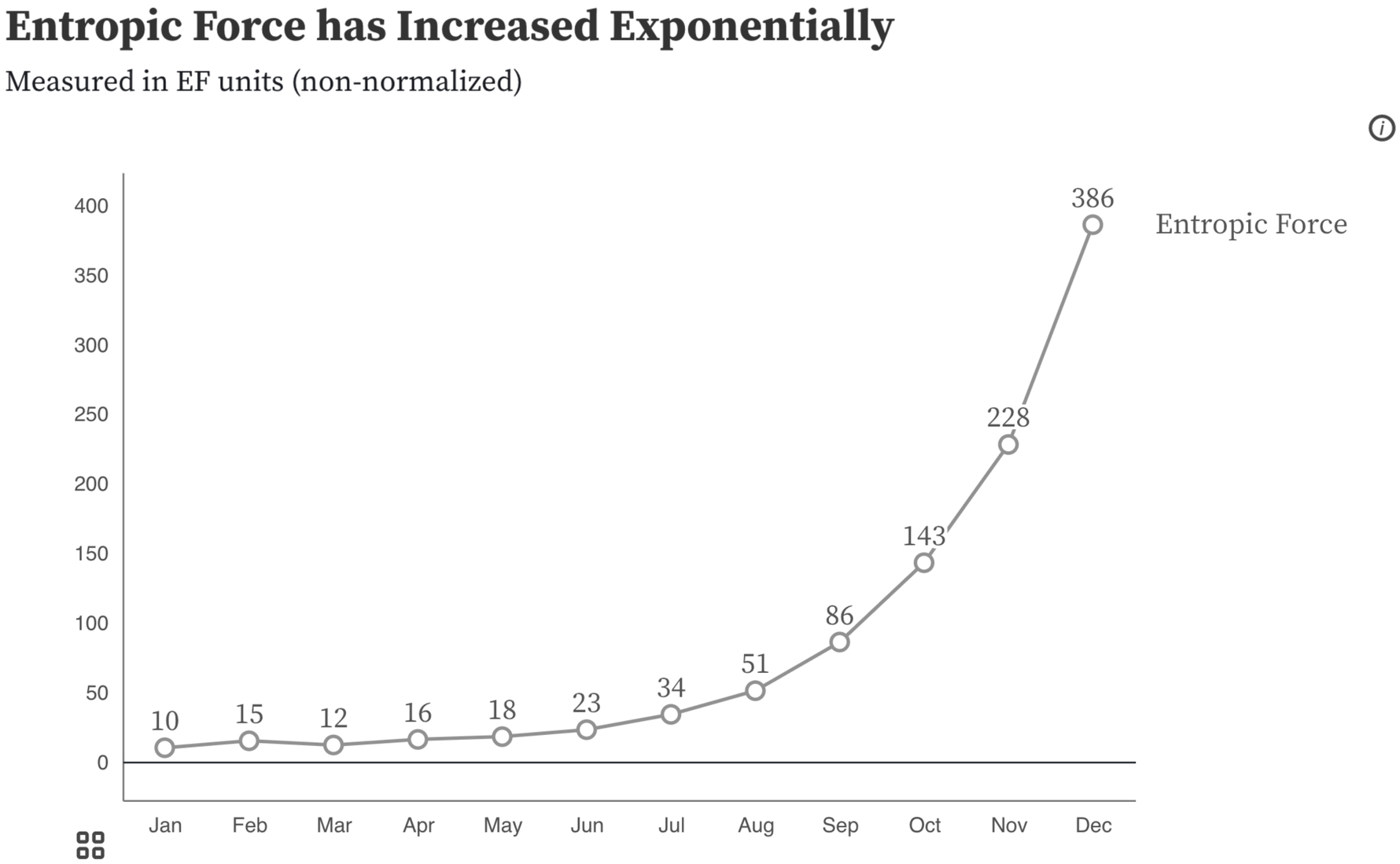
Understandable Checklist:

1. Descriptive title, summary, or caption
2. Data table or data download
3. Reading level

Non-descriptive titles are inaccessible



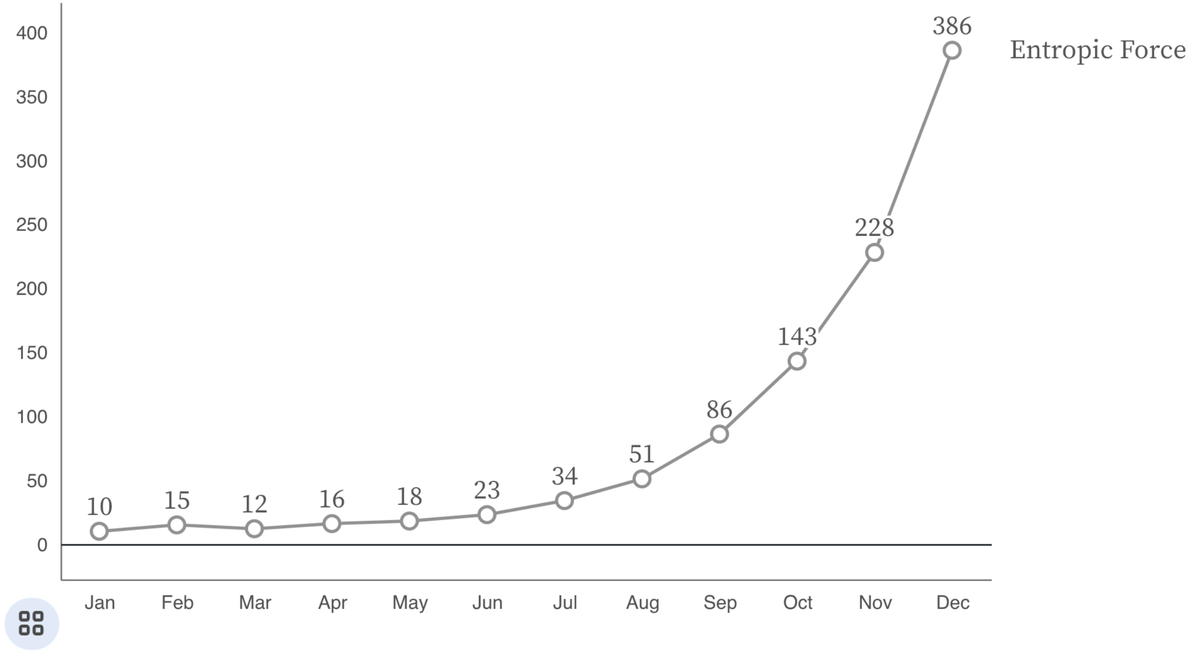
Descriptive titles have summaries/takeaways

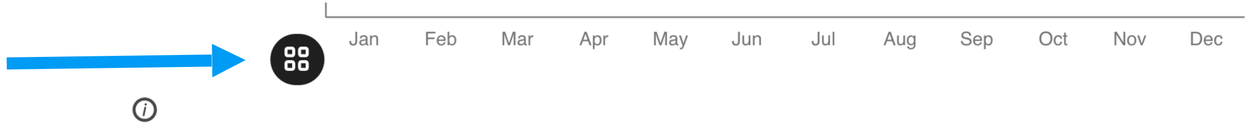


All charts should have data available!

Entropic Force has Increased Exponentially

Measured in EF units (non-normalized)





Line	Date	Value	Note
Entropic Force	Jan	10	Lowest Value
Entropic Force	Feb	15	
Entropic Force	Mar	12	
Entropic Force	Apr	16	
Entropic Force	May	18	
Entropic Force	Jun	23	
Entropic Force	Jul	34	
Entropic Force	Aug	51	
Entropic Force	Sep	86	
Entropic Force	Oct	143	
Entropic Force	Nov	228	
Entropic Force	Dec	386	Highest Value

Technical language is often overkill

Measured in EF units (non-normalized). EF units are valuable for catching egregious over-simulation in models that use randomized data decimation techniques. This particular evaluation findings demonstrate that the randomization models are significantly over-producing entropy in our latest force simulations.

Hemingway Editor

Readability

Post-graduate

Poor. Aim for 14.

Words: **39**

Show More

1 adverb. Aim for 0 or fewer.

0 uses of passive voice. Nice work.

1 phrase has a simpler alternative.

0 of 3 sentences are hard to read.

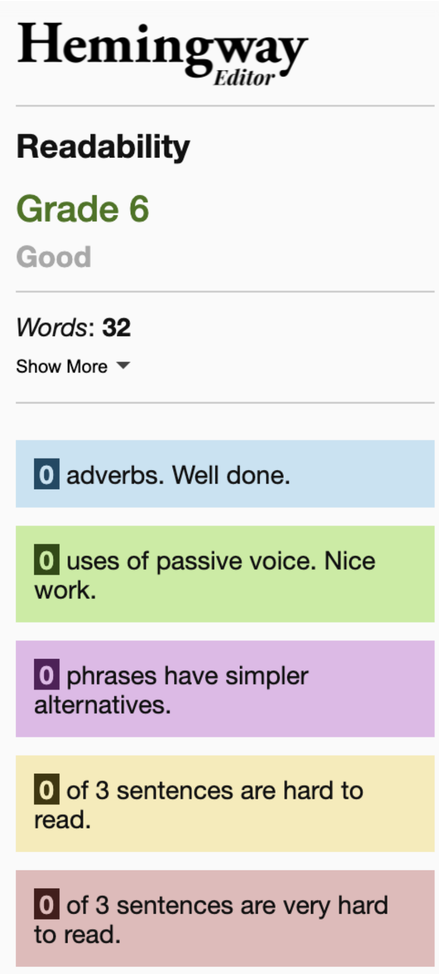
2 of 3 sentences are very hard to read.

Keep summaries as non-technical as possible

If the topic is technical, provide a “plain language” summary somewhere close by that is easy to find (either in the same location or with by providing a link).

Measured in EF units (non-normalized). EF units are valuable for catching egregious over-simulation in models that use randomized data decimation techniques. This particular evaluation findings demonstrate that the randomization models are significantly over-producing entropy in our latest force simulations.

Measured in EF units (non-normalized). These units are helpful for catching bad data loss when we remove our data at random. We are producing too much entropic force in our latest models.



Recap: Understandability

Use concise, descriptive titles

Entropic Force

In EF units (non-normalized)

→

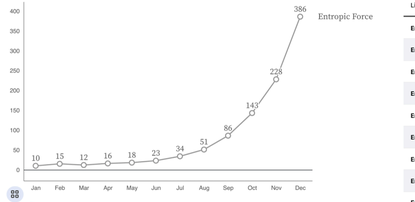
Entropic Force has Increased Exponentially

Measured in EF units (non-normalized)

Add easy-to-access data or tables

Entropic Force has Increased Exponentially

Measured in EF units (non-normalized)



Line	Date	Value	Note
Entropic Force	Jan	10	Lowest Value
Entropic Force	Feb	15	
Entropic Force	Mar	12	
Entropic Force	Apr	16	
Entropic Force	May	18	
Entropic Force	Jun	23	
Entropic Force	Jul	34	
Entropic Force	Aug	51	
Entropic Force	Sep	86	
Entropic Force	Oct	143	
Entropic Force	Nov	228	
Entropic Force	Dec	386	Highest Value

Simplify your language

Measured in EF units (non-normalized). EF units are valuable for catching egregious over-simulation in models that use randomized data decimation techniques. This particular evaluation findings demonstrate that the randomization models are significantly over-producing entropy in our latest force simulations.

Hemingway Editor

Readability

Post-graduate

Poor. Aim for 14.

Words: **39**

Show More

1 adverb. Aim for 0 or fewer.

0 uses of passive voice. Nice work.

1 phrase has a simpler alternative.

0 of 3 sentences are hard to read.

2 of 3 sentences are very hard to read.

Measured in EF units (non-normalized). These units are helpful for catching bad data loss when we remove our data at random. We are producing too much entropic force in our latest models.

Hemingway Editor

Readability

Grade 6

Good

Words: **32**

Show More

0 adverbs. Well done.

0 uses of passive voice. Nice work.

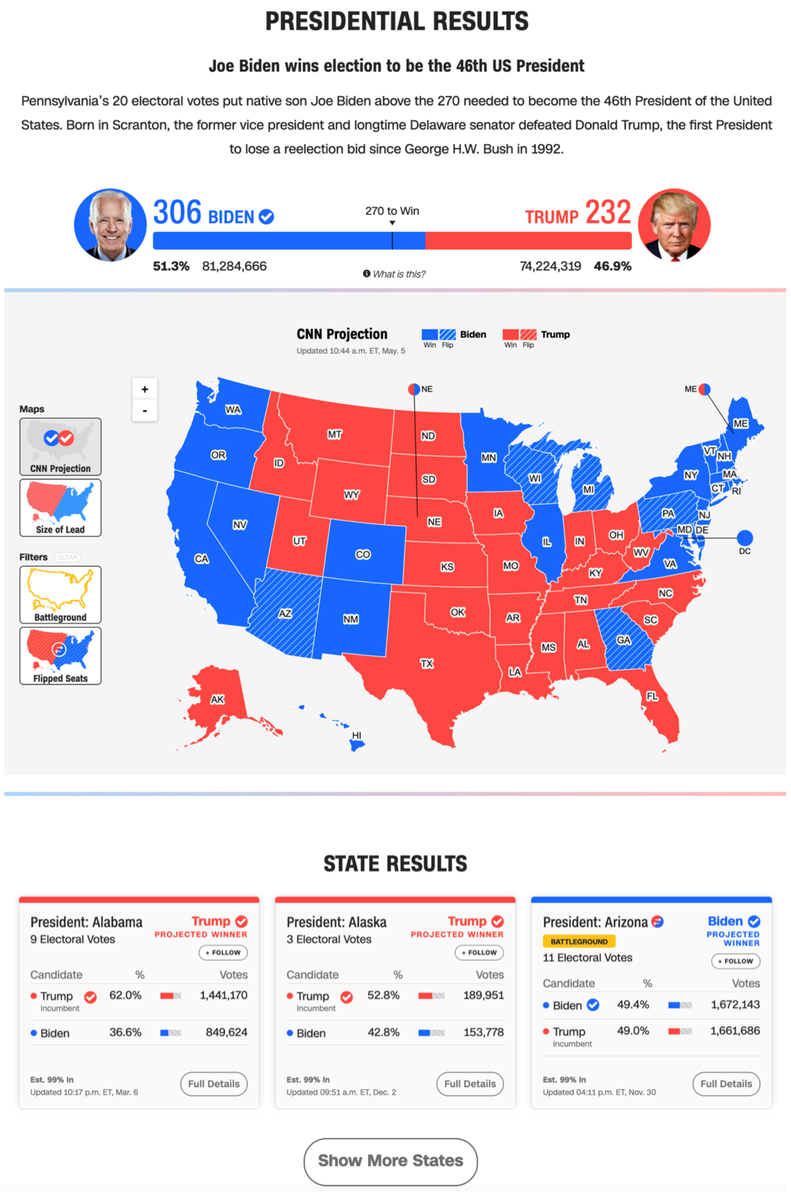
0 phrases have simpler alternatives.

0 of 3 sentences are hard to read.

0 of 3 sentences are very hard to read.

Understandable Evaluation Toolkit:

1. Is there a descriptive title, summary, or caption?
2. Is there an accessible table or downloadable data file provided?
3. Is the descriptive text supporting the visualization presented at a reading level at grade 9 or below?



Continue this for:

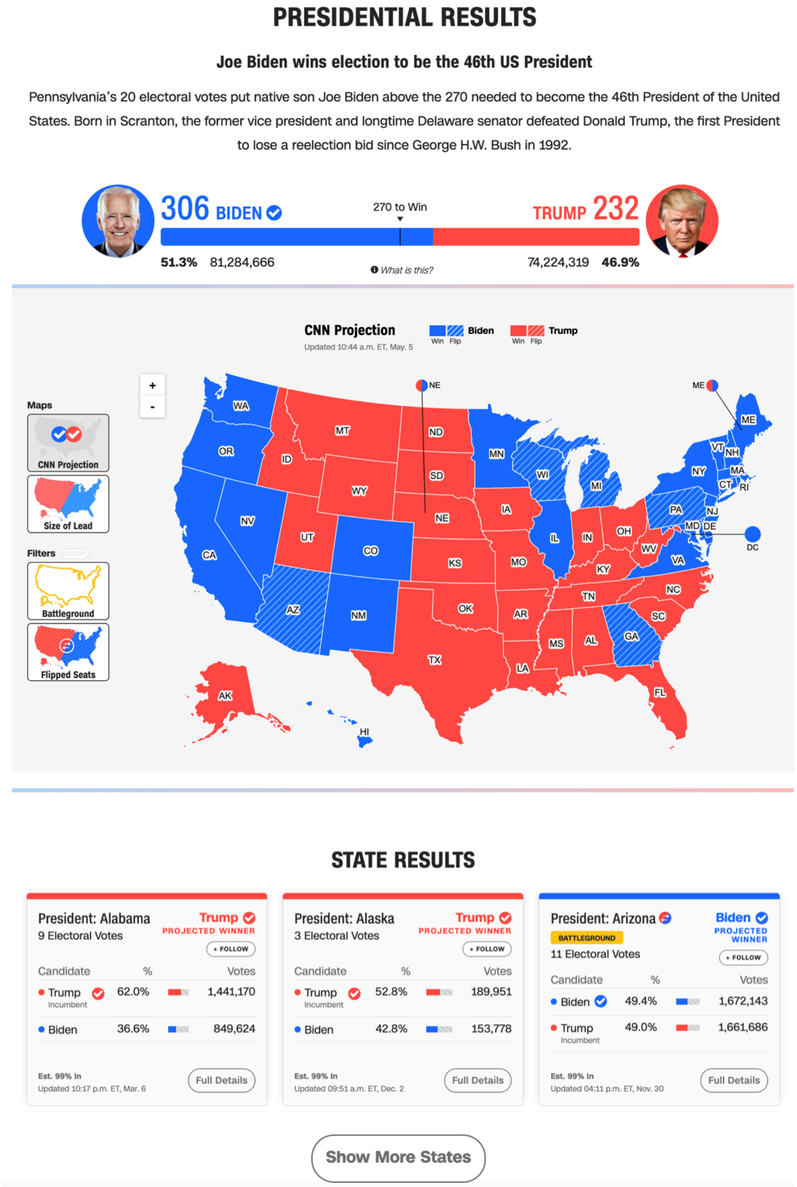
Robust,
Compromising,
Assistive,
and Flexible

978 access failures found in ~60 minutes.

Perceivable:
6 – Low contrast
57 - Content is only visual
50 - Color alone is used
3 - Meaningful elements can be distinguished

Operable:
54 - Interaction modality only has one input type
58 - No interaction cues or instructions
5 - Low contrast on interactive elements
4 - Keyboard focus indicator missing
4 - Complex actions have no alternative
18 - Target pointer interaction is too small

Understandable:
4 - Interactive context is not clear
6 - Metrics or variables are undefined



Robust:
275 - Does not conform to standards
82 - Semantically invalid
12 - Fragile technology support

Compromising:
54 - Information can only be reached through single process
61 - Information cannot be navigated according to narrative or structure

Assistive:
101 - Navigation and interaction is tedious

Flexible:
2 - User style change not respected
121 - User text adjustments are not respected
1 - Scrolling experiences cannot be adjusted or opted out of
Contrast and textures cannot be adjusted

Q/A time

Part 3: Practice Catching Barriers

Collaboratively catch barriers in the wild! (divide into groups of 3-6)

Does anyone have a visualization they have encountered lately (or made themselves) that they would like to evaluate together as a group?

Criteria:

- The visualization isn’t static (it is interactive, has dynamic data, animations, or a combination of the 3)
- It is publicly available (not behind a paywall)

Instructions: (60m)

Divide the labor and/or “pair” on tasks

1. Find and document barriers
    A. Perceivable
    B. Operable
    C. Understandable
2. Make notes/suggestions for fixing or re-designing

Sharing time (each group share!) (20m)

Q/A time

Part 4: Practice Designing Accessible Visualizations

Let’s collaboratively re-design! (30m)

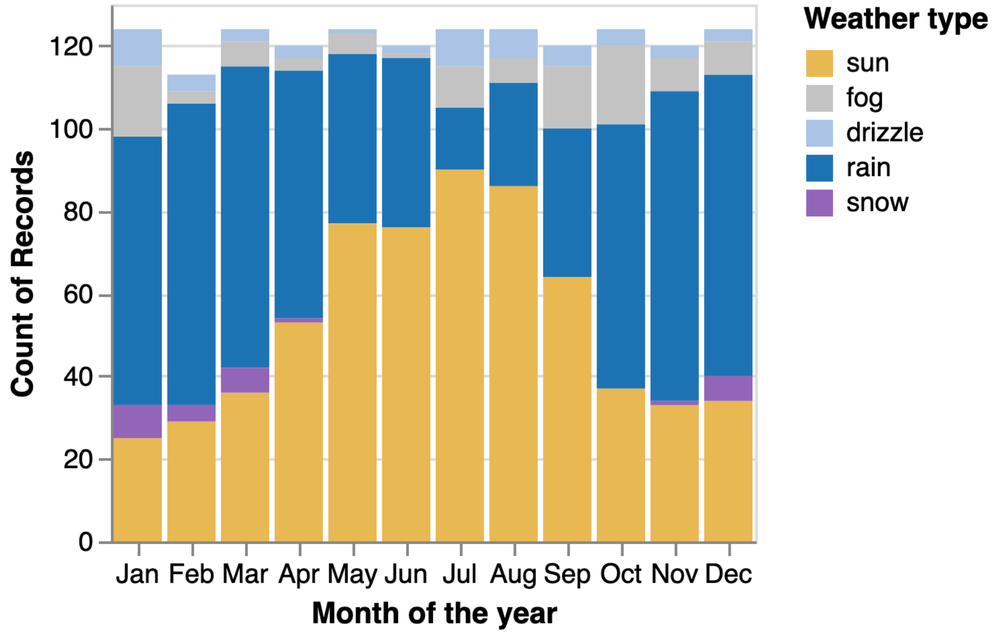
Examine our data (Excel)

Sketch some ideas (Paper)

Hone in on a story, task, or message

Make a visual! (Figma)

Data can be downloaded here:



From accessible *visualization* to accessible *representations*

Tactile data representation (30m)

Group up! (3-4 per group)

Pick some materials

Co-craft tactile representations:

1. Inspect your data
2. Discuss a story/message
3. “Sketch” designs for it with physical materials!

Browse and discuss! (10 & 10m)

Half the room: Investigate what others did. Ask them why they made the decisions they made. Ask them what story they wanted to tell.

After 10 minutes, swap!

Q/A time (bonus demo?)

2024

frank.computer

★Slides here

Accessibility and Visualization

Basics & beyond: a thorough introduction to an advanced topic.

Frank Elavsky

Human-Computer Interaction Institute

hcii.cmu.edu, axle-lab.com, dig.cmu.edu