2024

frank.computer

# Accessibility and Visualization

## An introduction.

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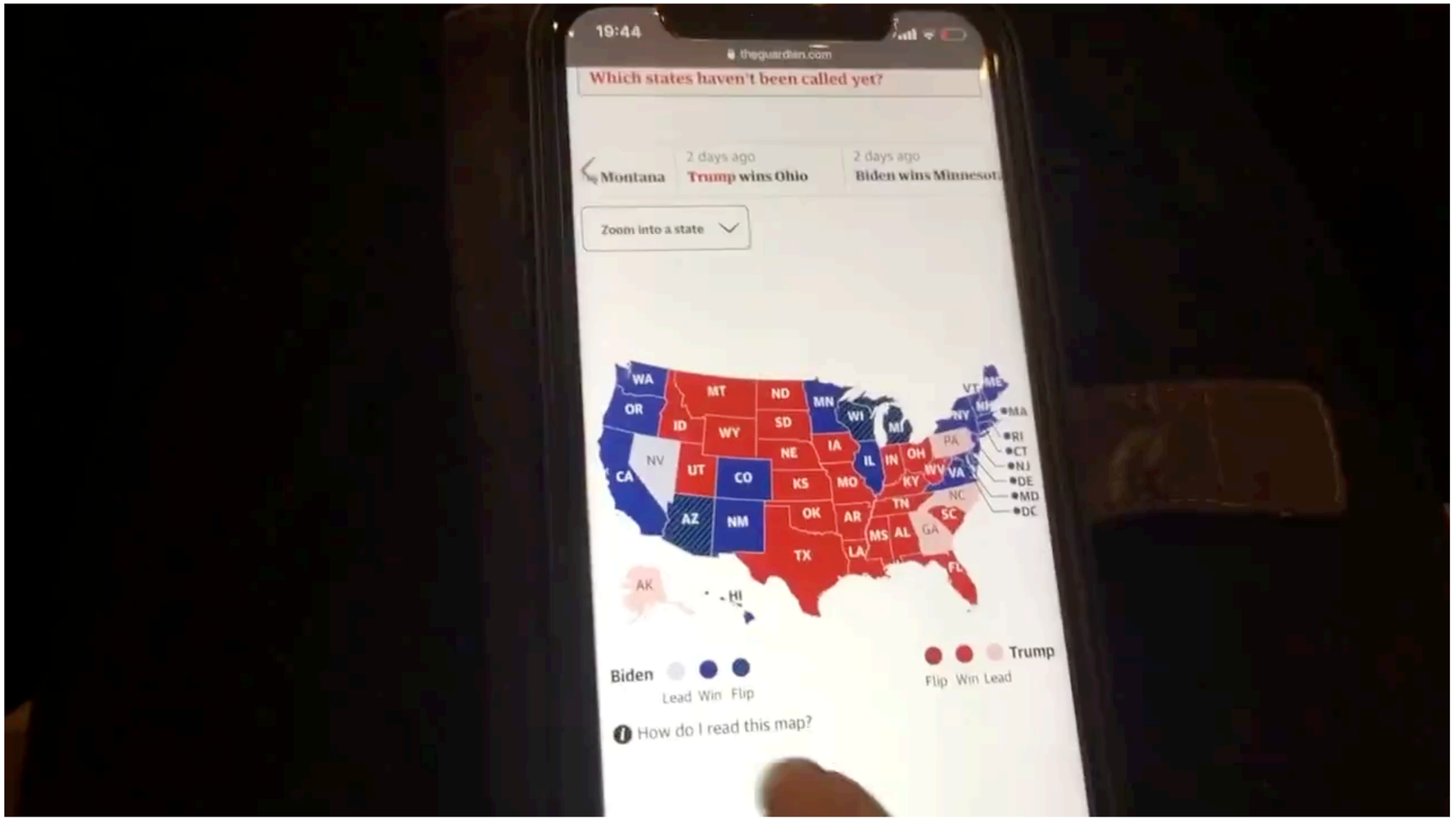
# What is an inaccessible experience like?

## Credit: Sarah Fossheim [on twitter]

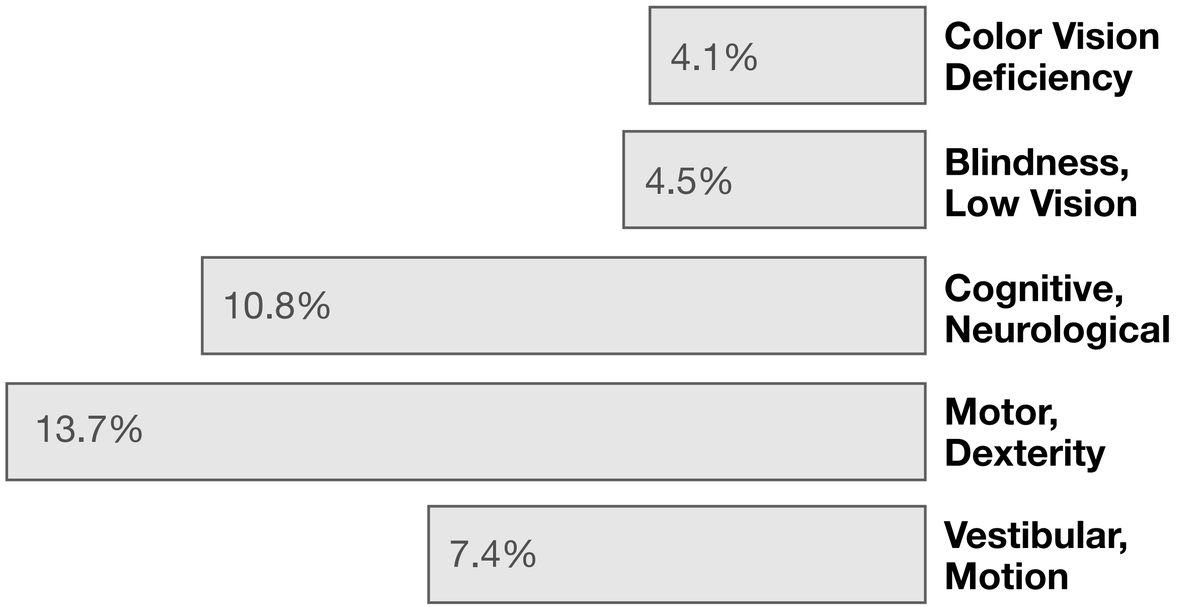


# Access is a human right

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

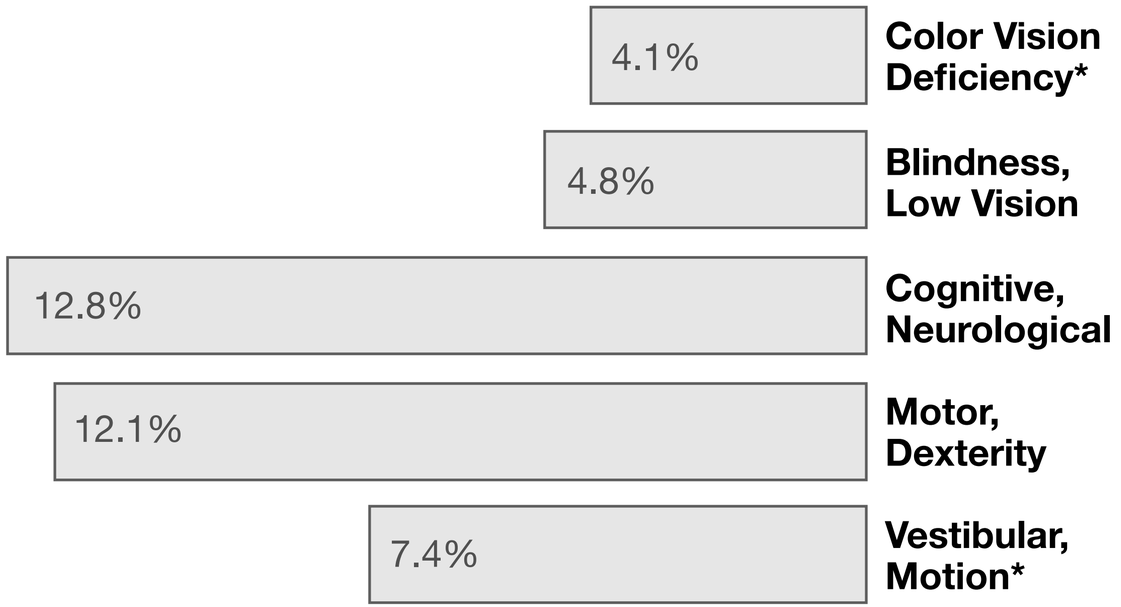
It is the morally and ethically correct thing to do.

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




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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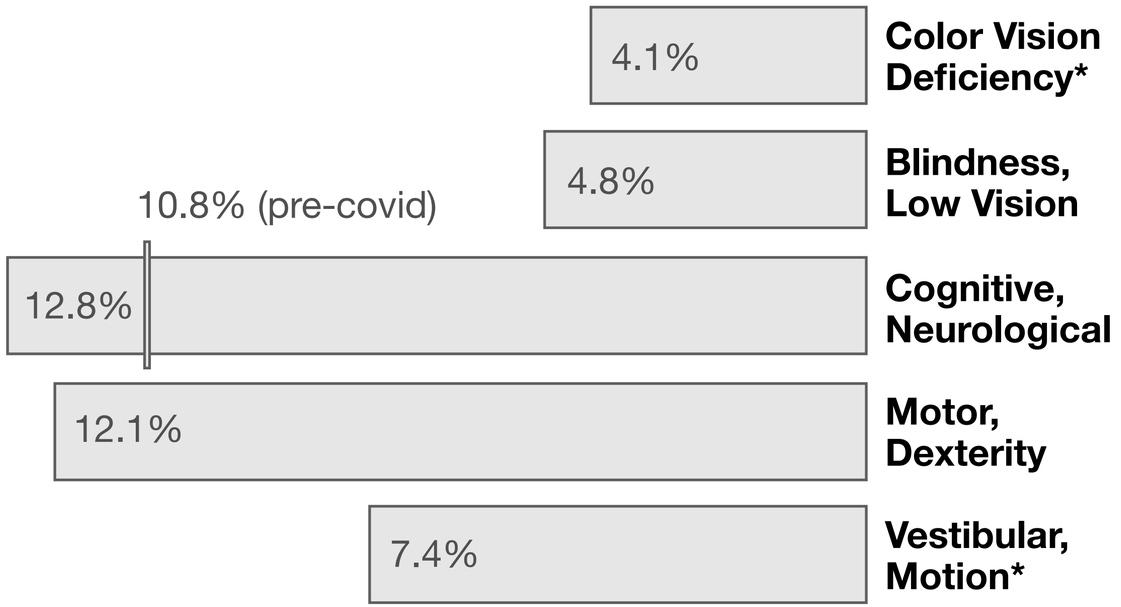
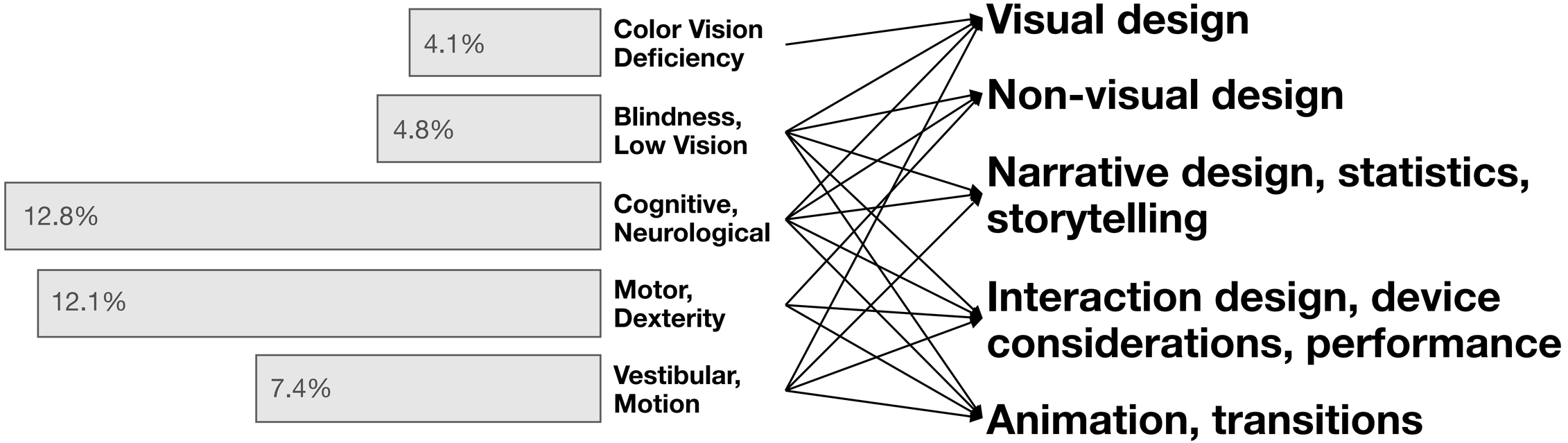


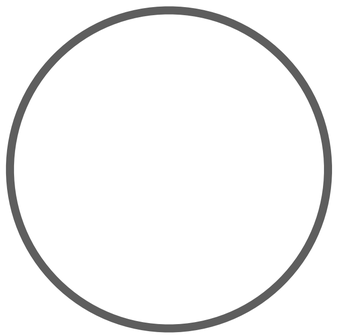

# Cognitive disability is on the rise

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

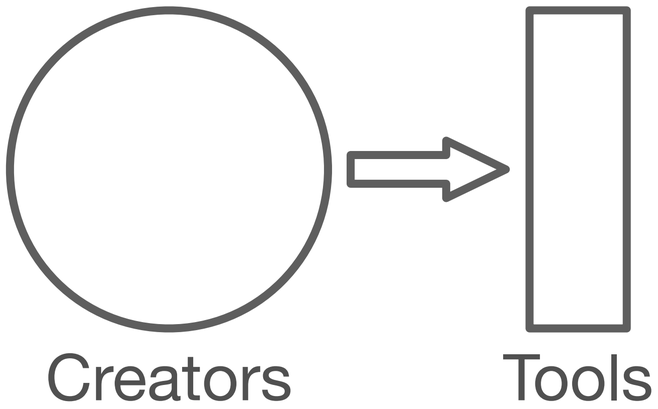
*No new data

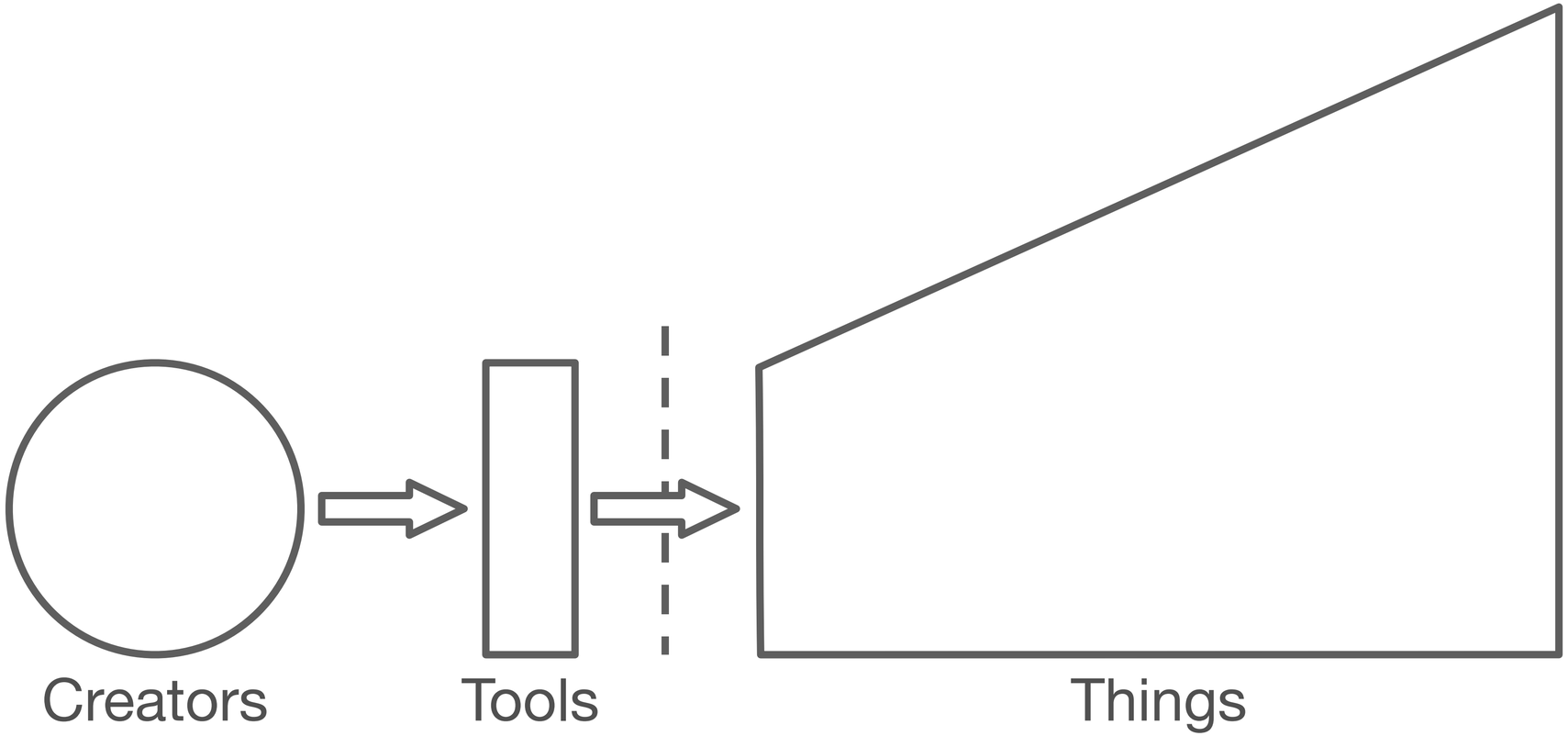
# Accessibility affects every aspect of visualization work

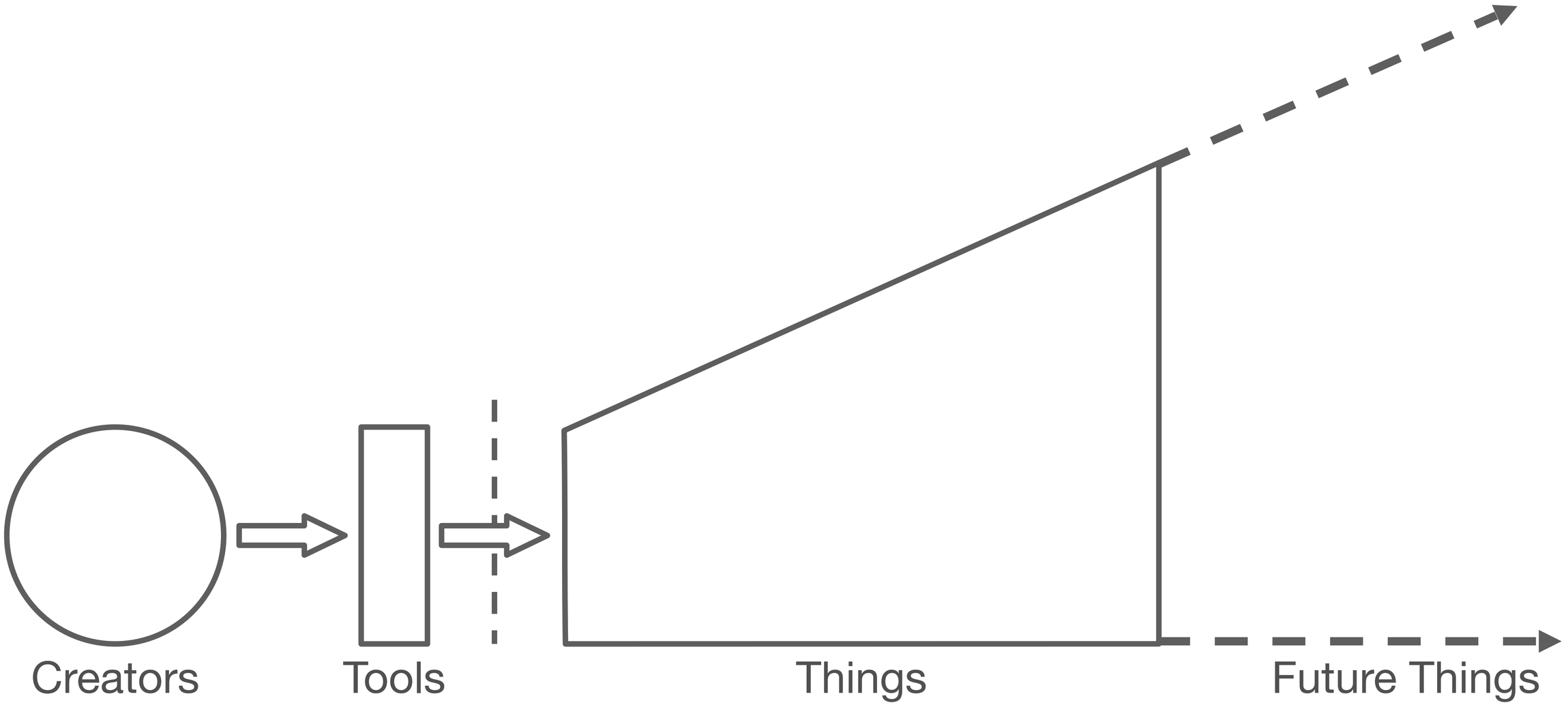




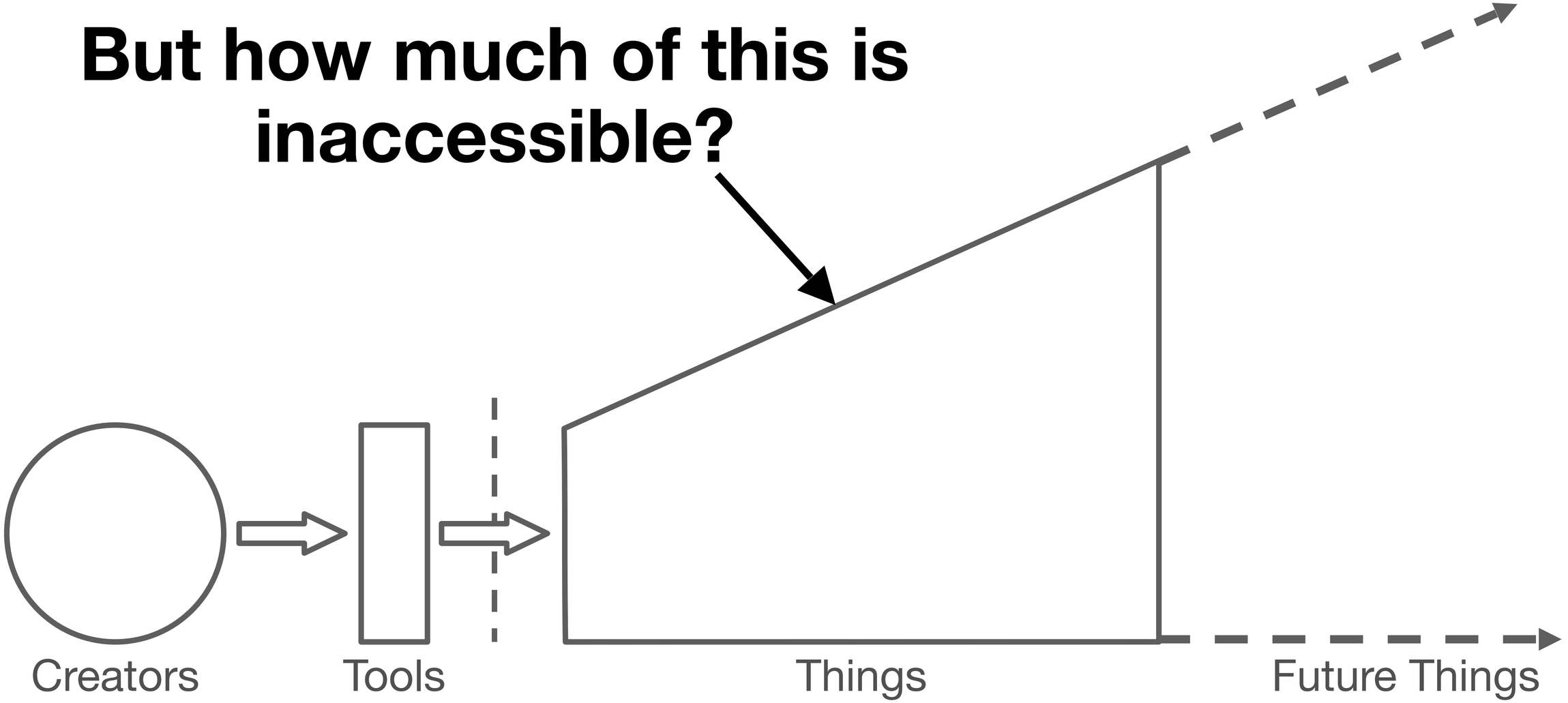
Creators


Creators
Tools


Creators
Tools
Things

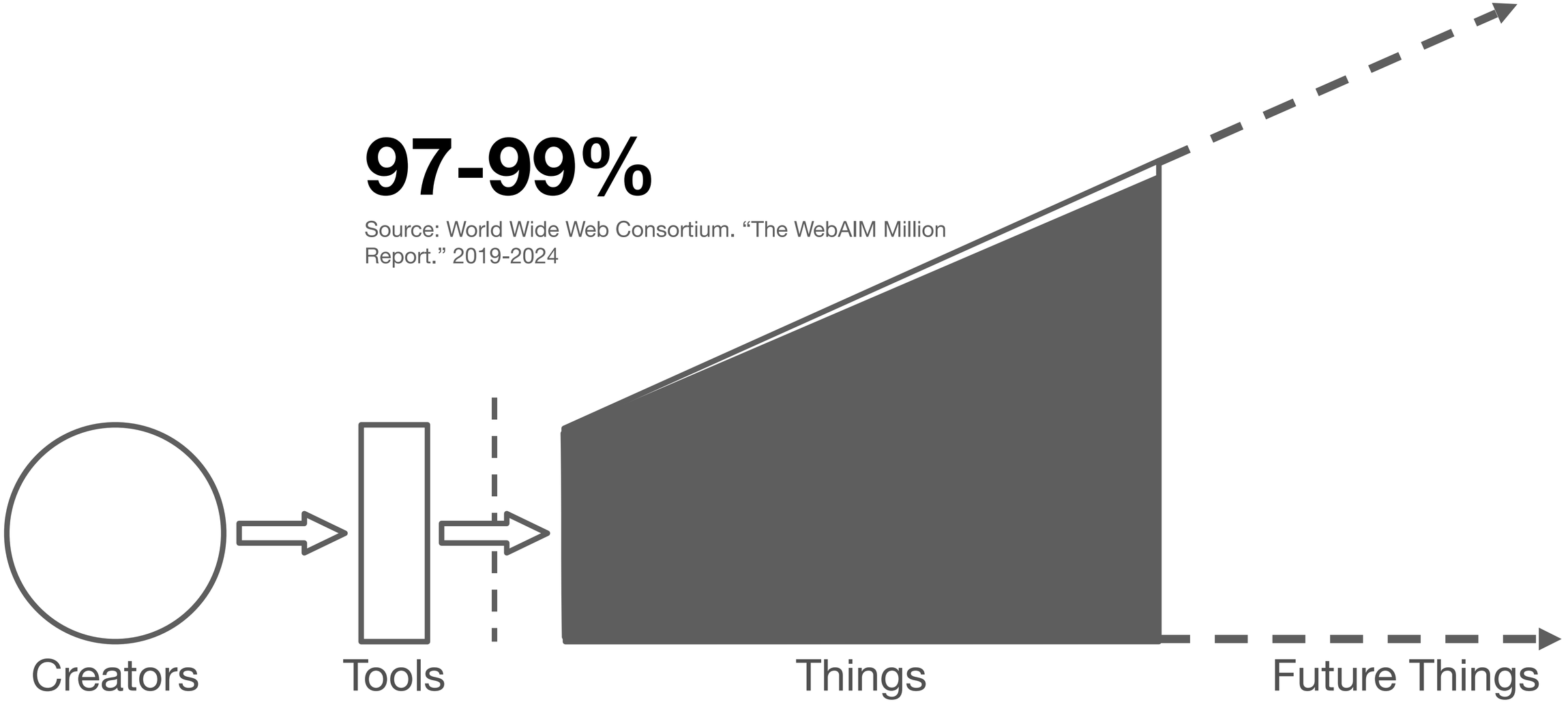

Creators
Tools
Things
Future Things

# But how much of this is inaccessible?



# 97-99%

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

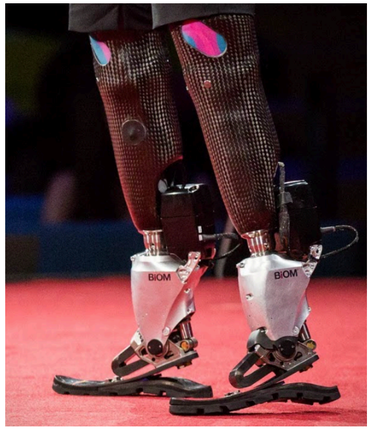


# Who is responsible for making this accessible?

# 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.



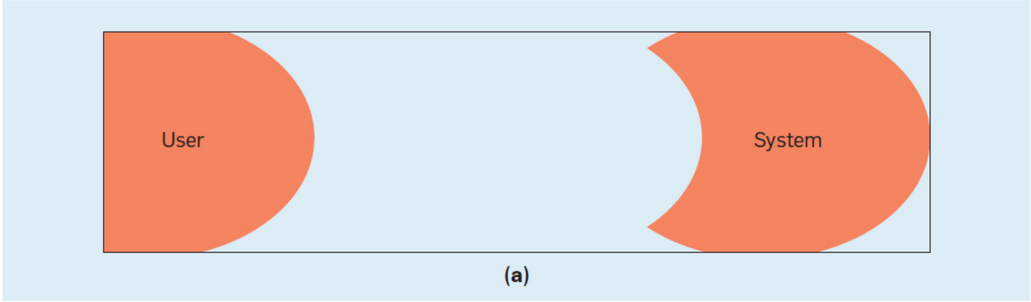

**Social framing**: The *curb* is the source/location where disability is produced (as a “barrier” to access).

# *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



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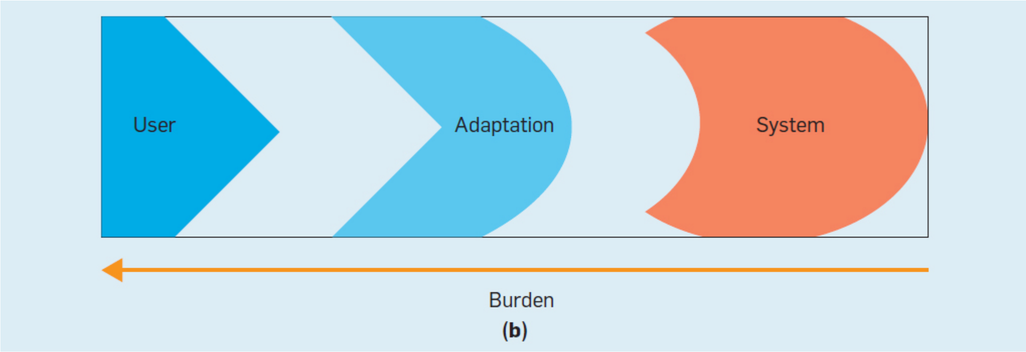

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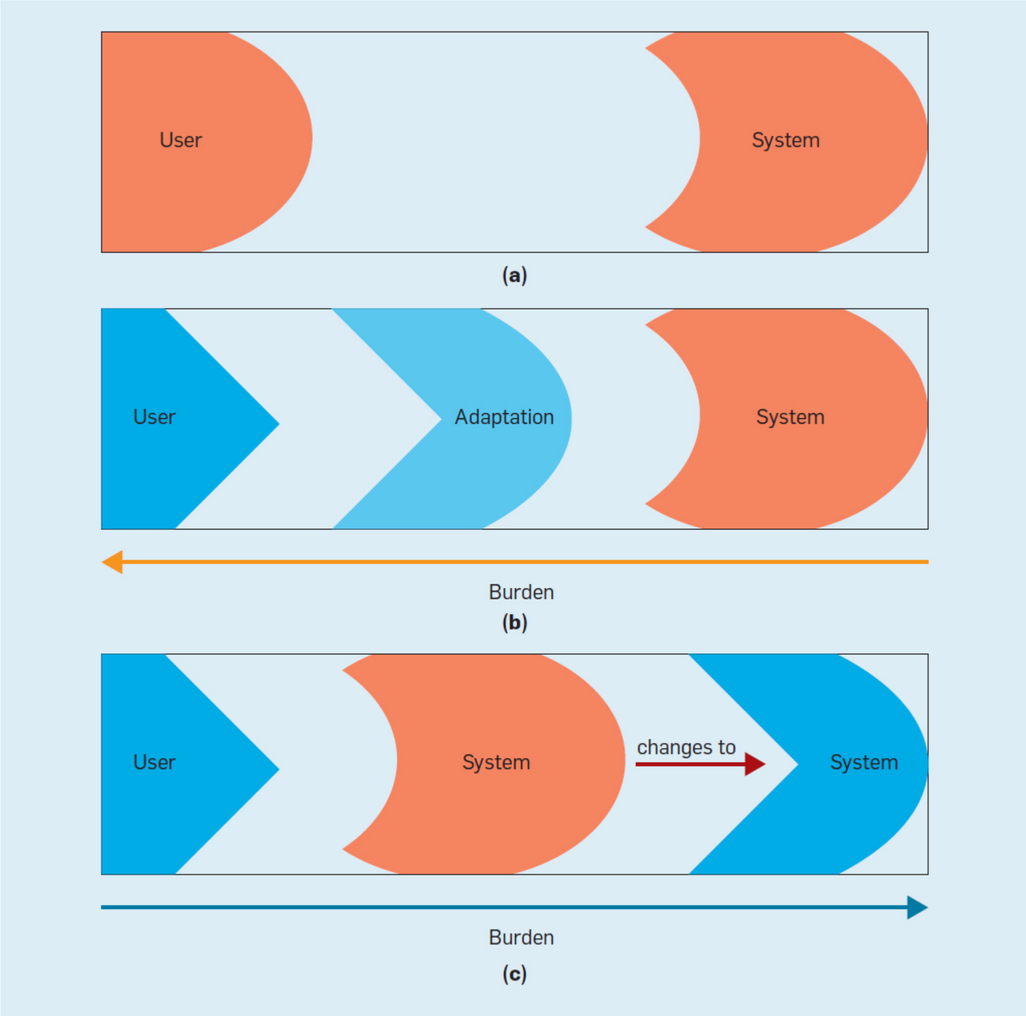


# A curb exclusively assumes the ability to step up

# A cut curb has fewer *exclusive* ability assumptions

# Concept: **Situational Impairment**

**Permanent**

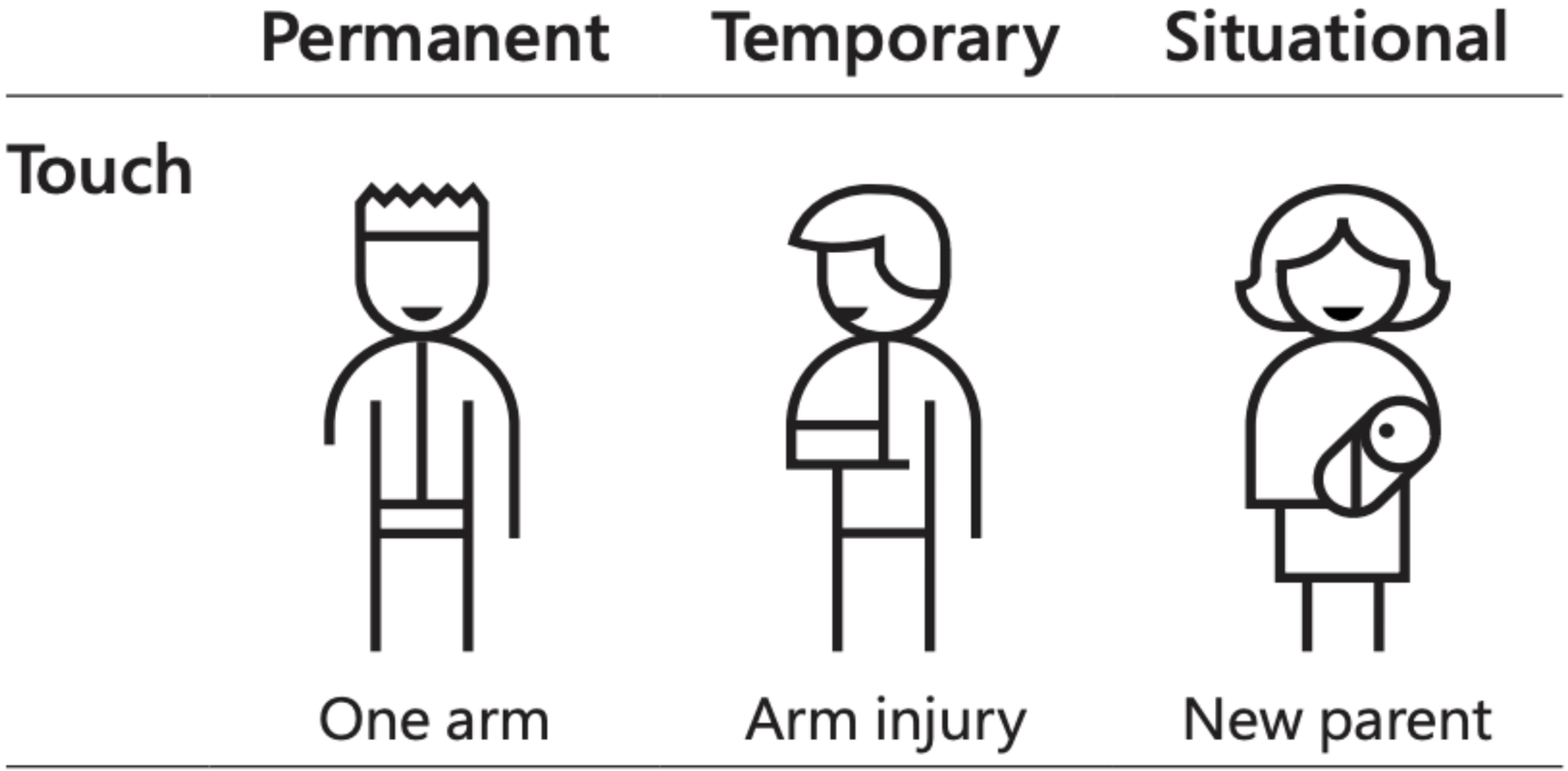
**Touch**

One arm

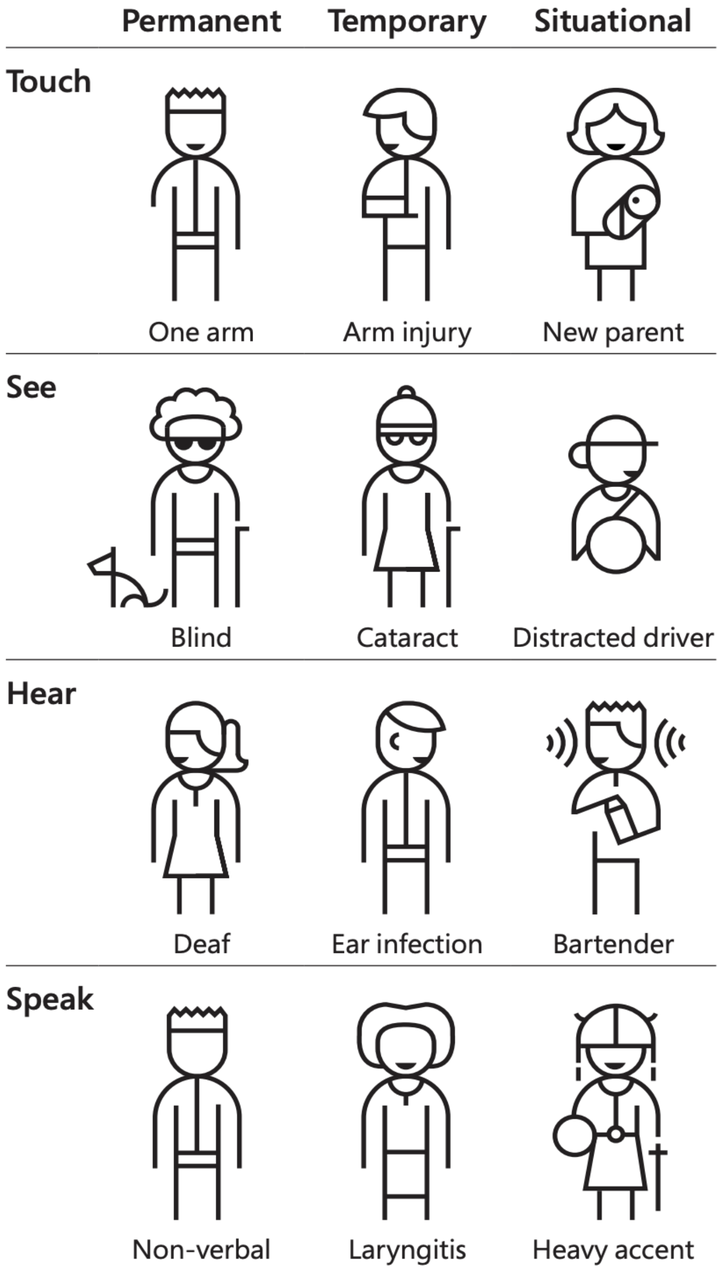
| | Permanent | Temporary |
|---|---|---|
| Touch |  |  |
| | One arm | Arm injury |

| | 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

# Turns out, a lot of barriers are *shared*!

# So 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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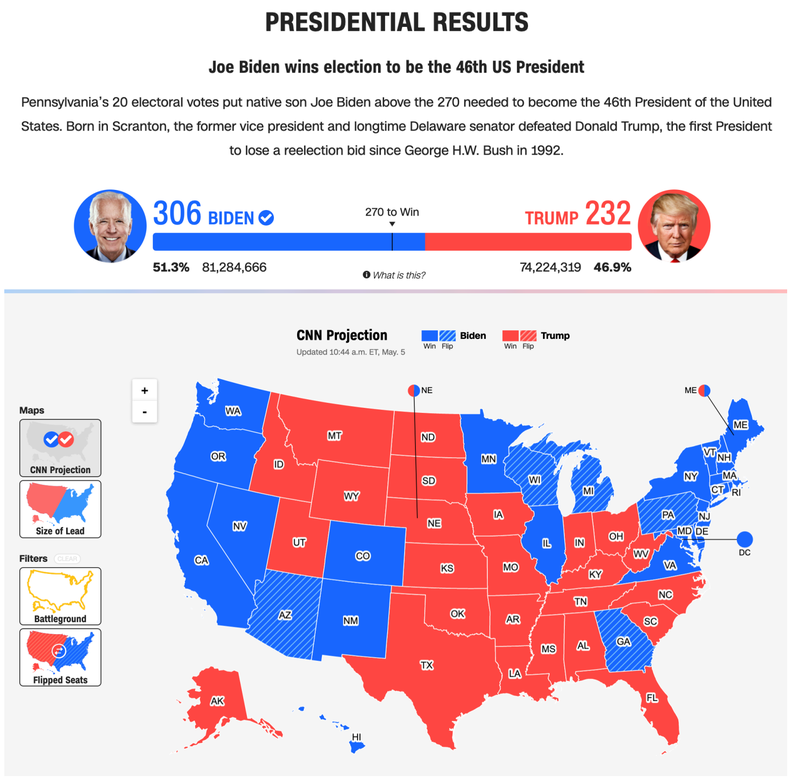


# Let's evaluate this map from CNN with Chartability.

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**

**P**erceivable
**O**perable
**U**nderstandable
**R**obust

Chartability's additions:

+
**C**ompromising
**A**
**F**

**P**erceivable
**O**perable
**U**nderstandable
**R**obust

Chartability's additions:

**+**
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**F**

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**O**perable
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**R**obust

Chartability's additions:

+
**C**ompromising
**A**ssistive
**F**lexible

# POUR+CAF

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

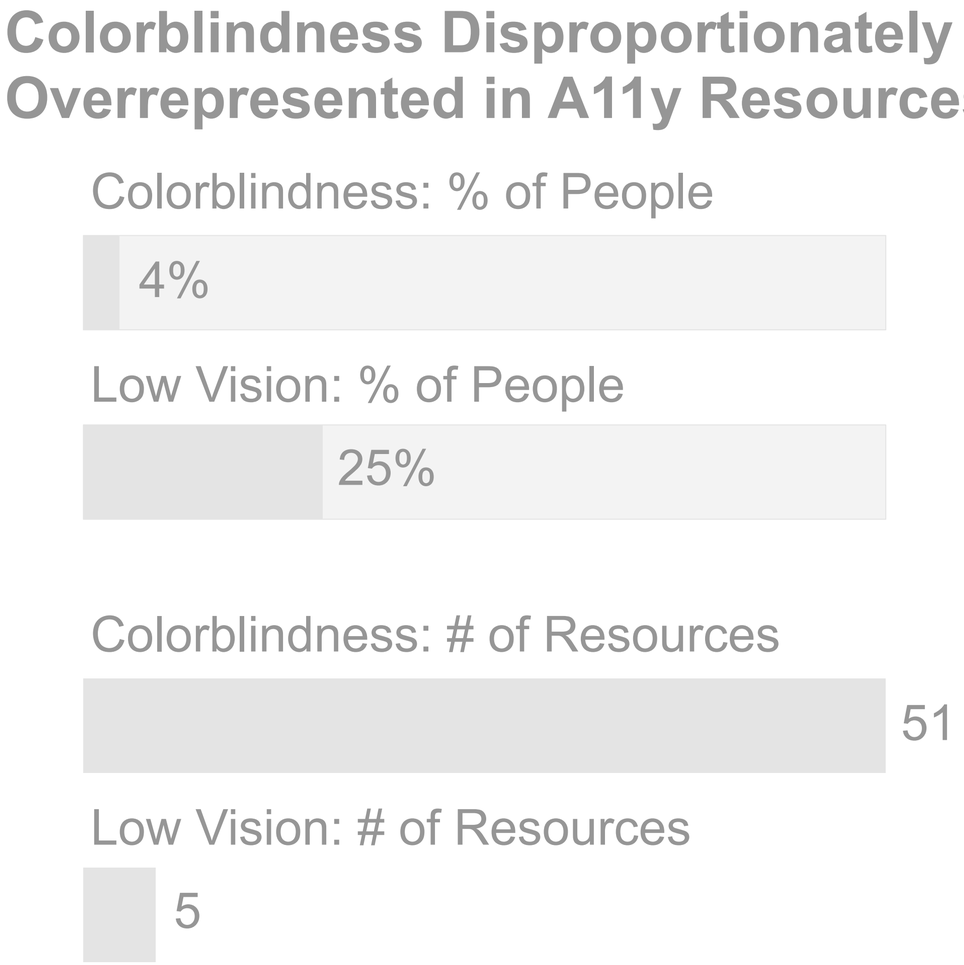
# Perceivable

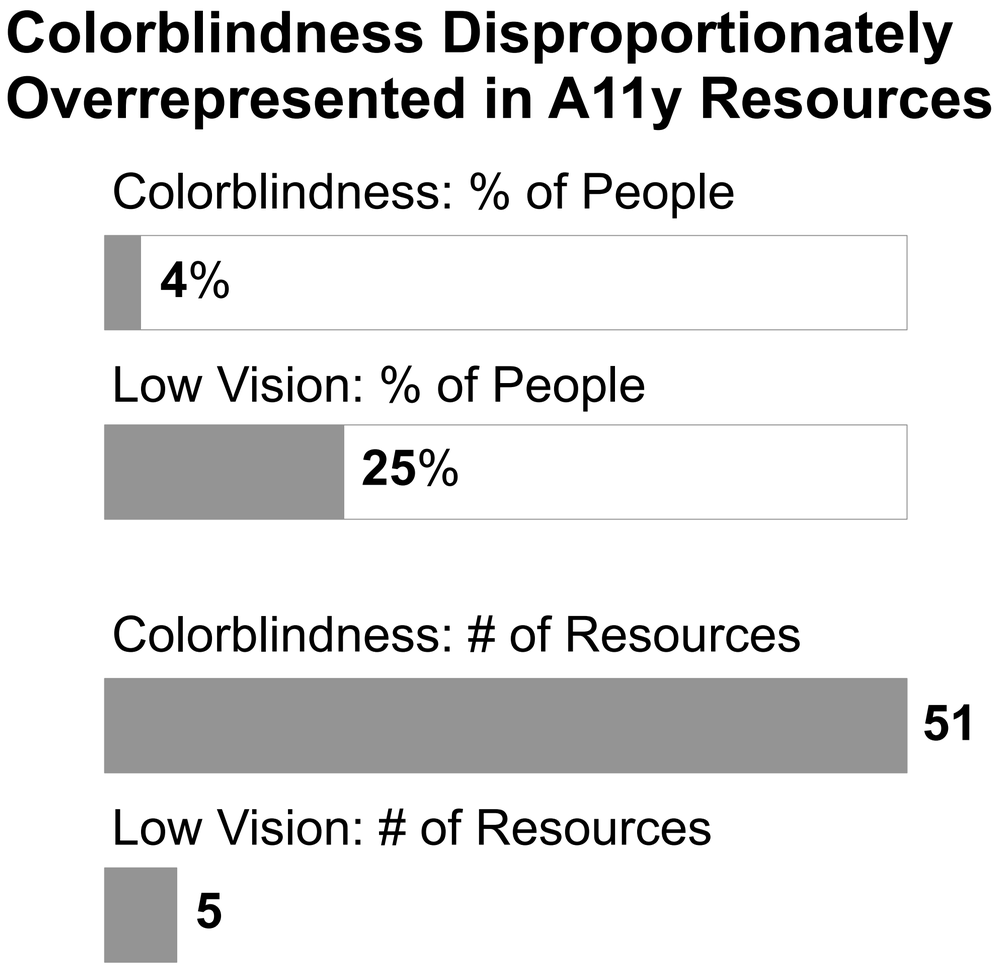
## Can someone perceive this in multiple ways? Is each way easy?

# Perceivable Checklist:

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

# Design with high contrast

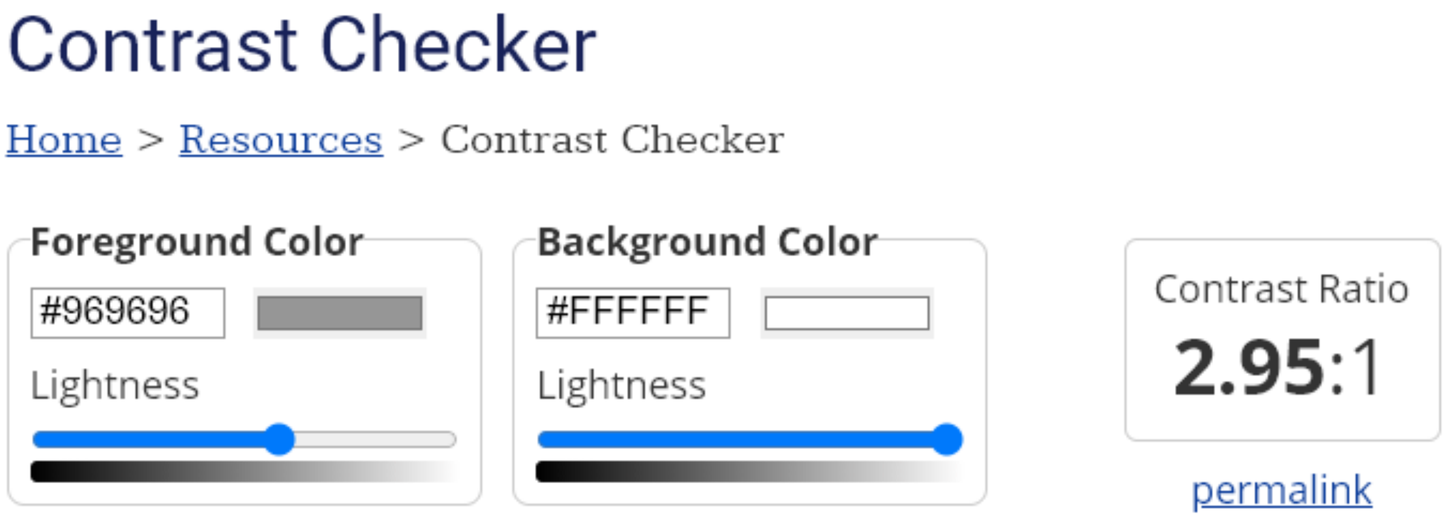


# Use High Contrast Text

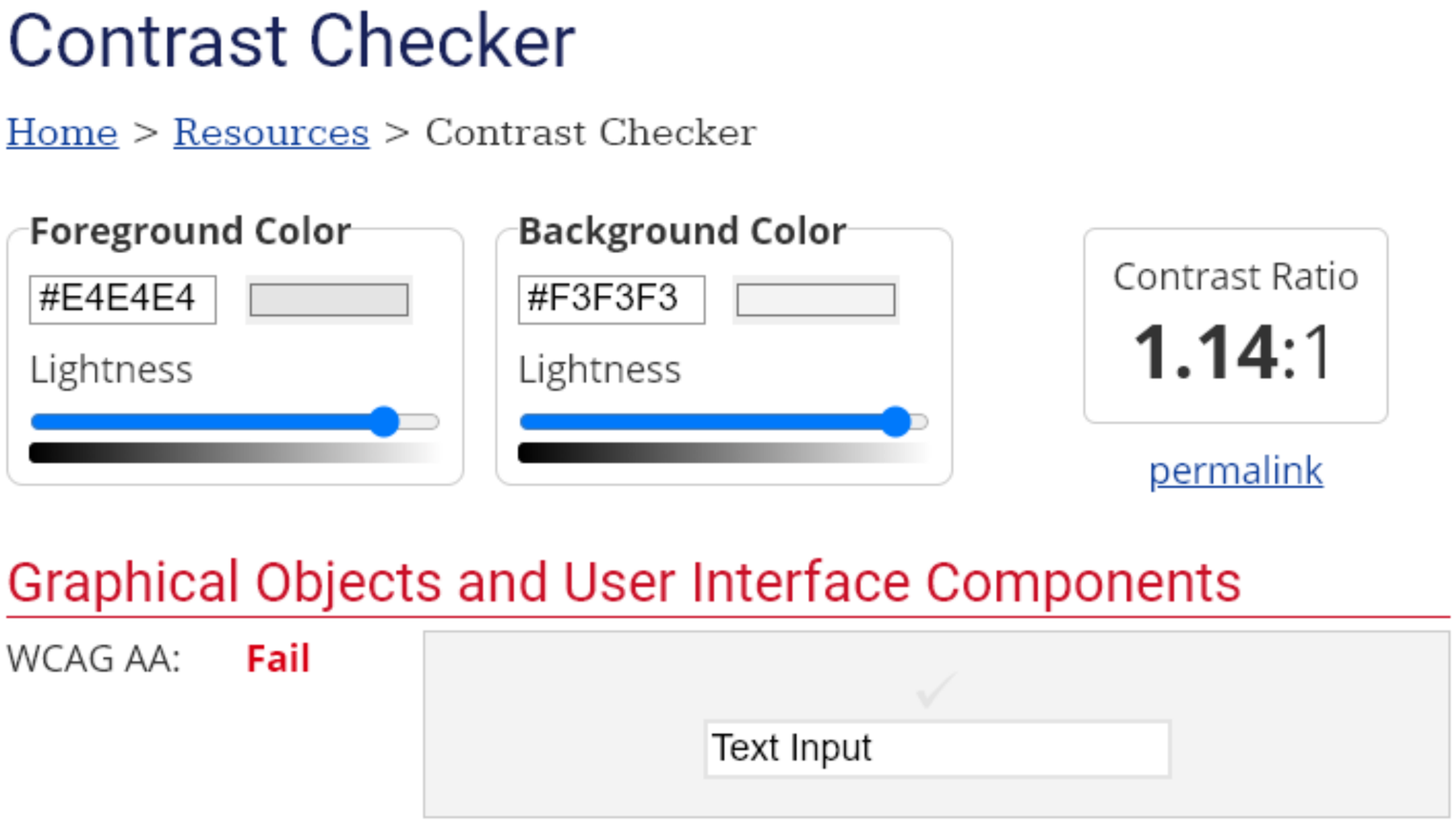
Text needs at least 4.5:1 contrast against its background.

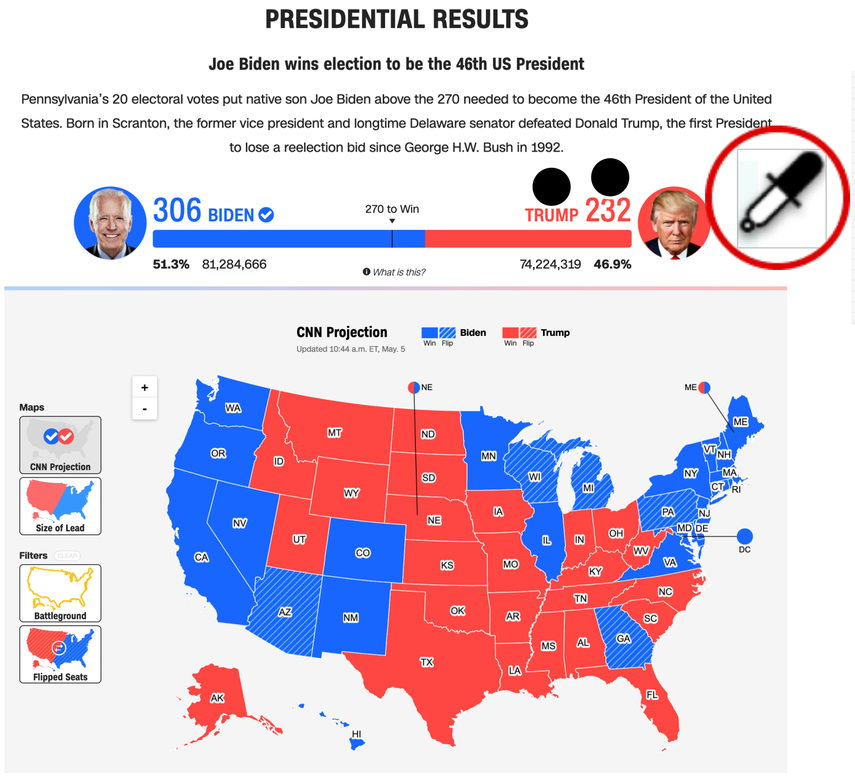
Large text (bold and 16pt or larger) can be 3:1 or higher.

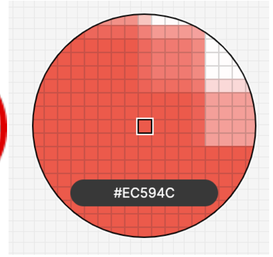


# Use High Contrast Geometries

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

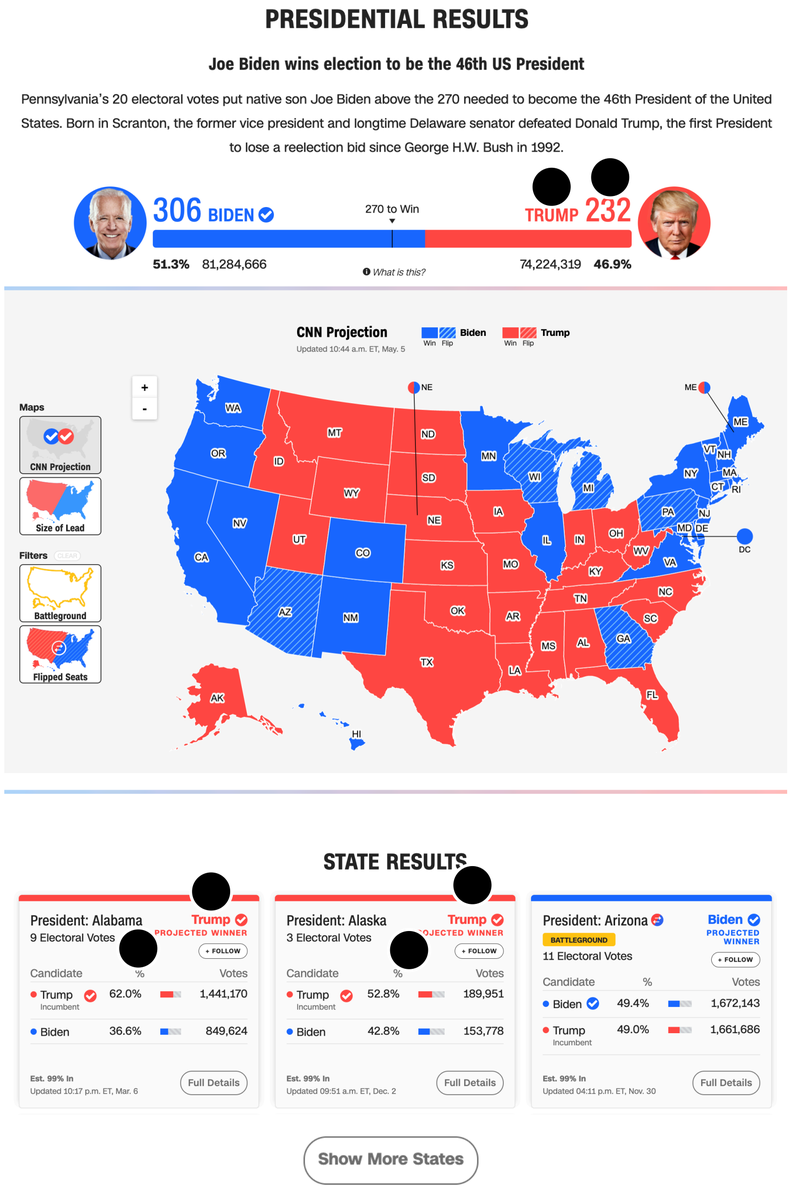
permalink

## Normal Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

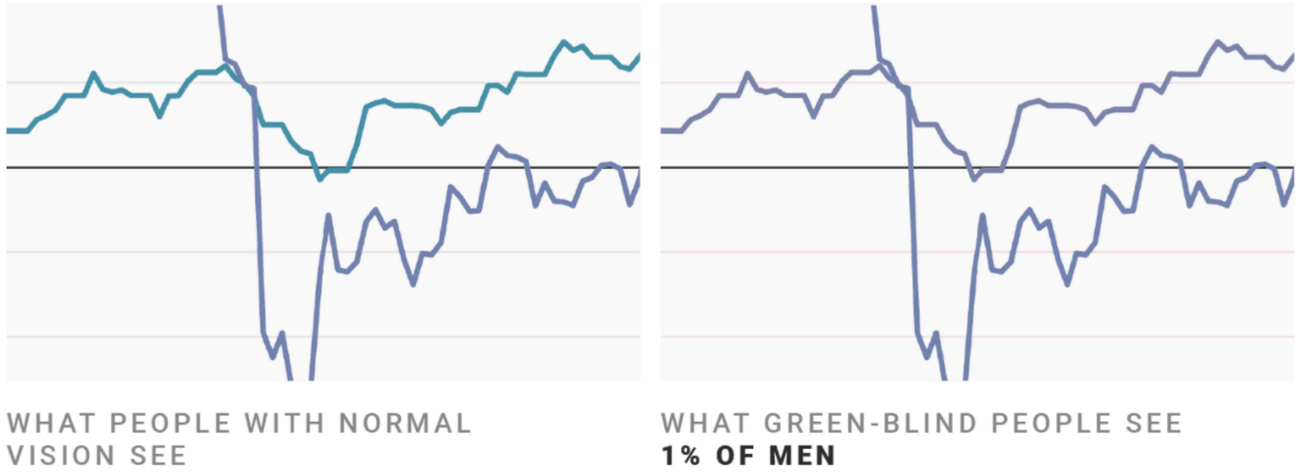
The five boxing wizards jump quickly.




# 6 instances of low contrast

# Don’t rely on color alone!

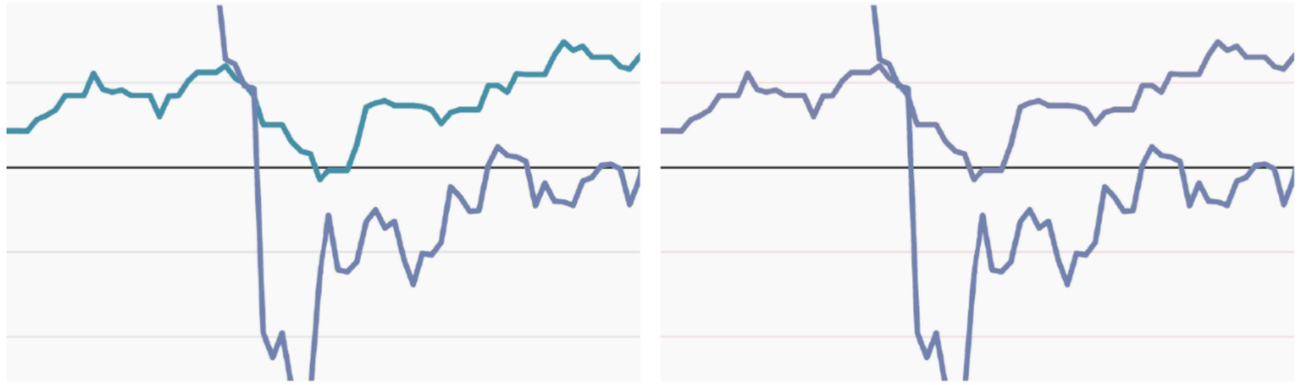
(Muth) https://blog.datawrapper.de/colorblindness-part2/



WHAT PEOPLE WITH NORMAL VISION SEE

WHAT GREEN-BLIND PEOPLE SEE
**1% OF MEN**

# “Redundant encoding” is one strategy



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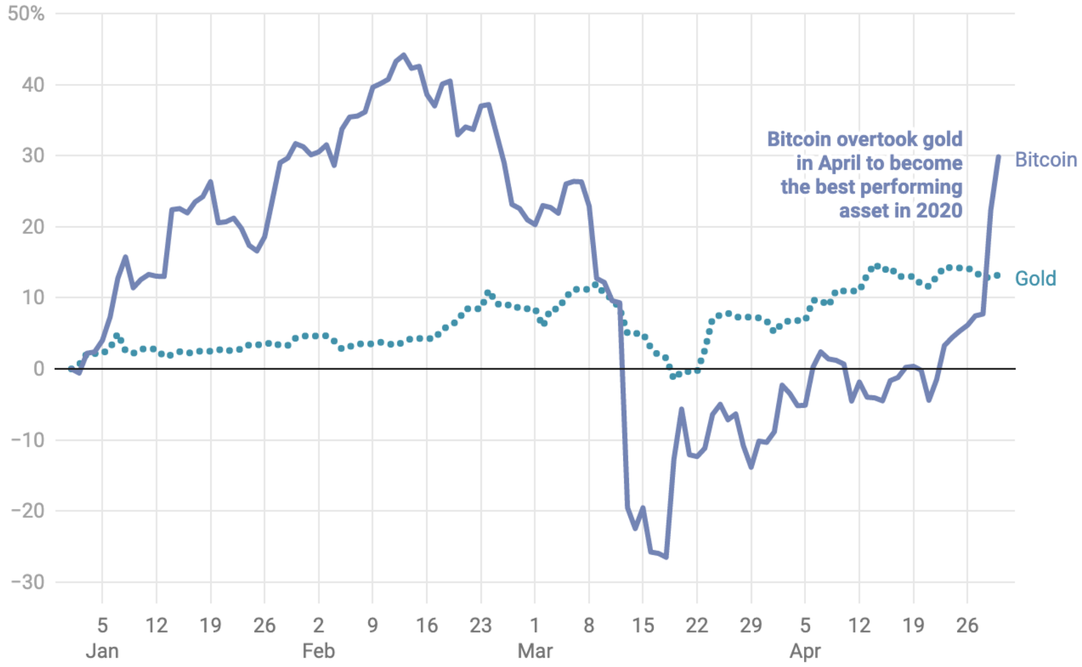
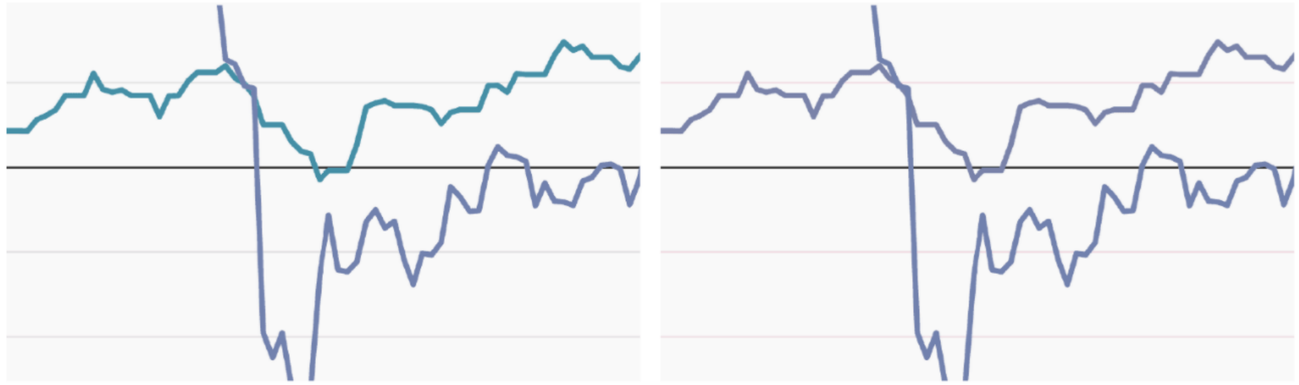



*Bitcoin and gold price change (%) between January and May 2020*

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

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



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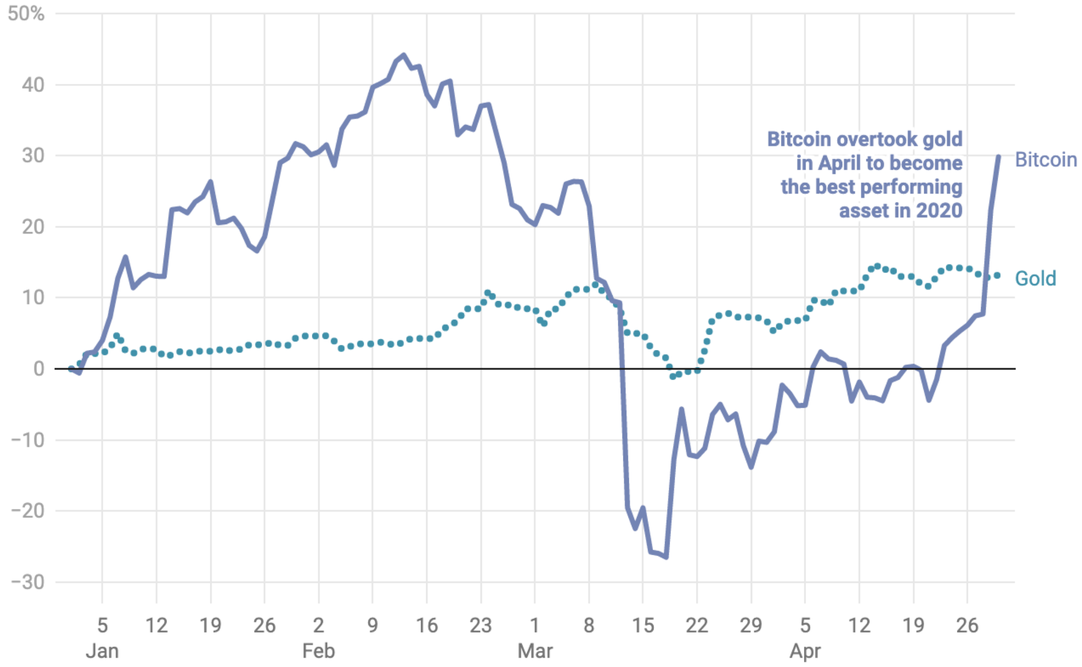


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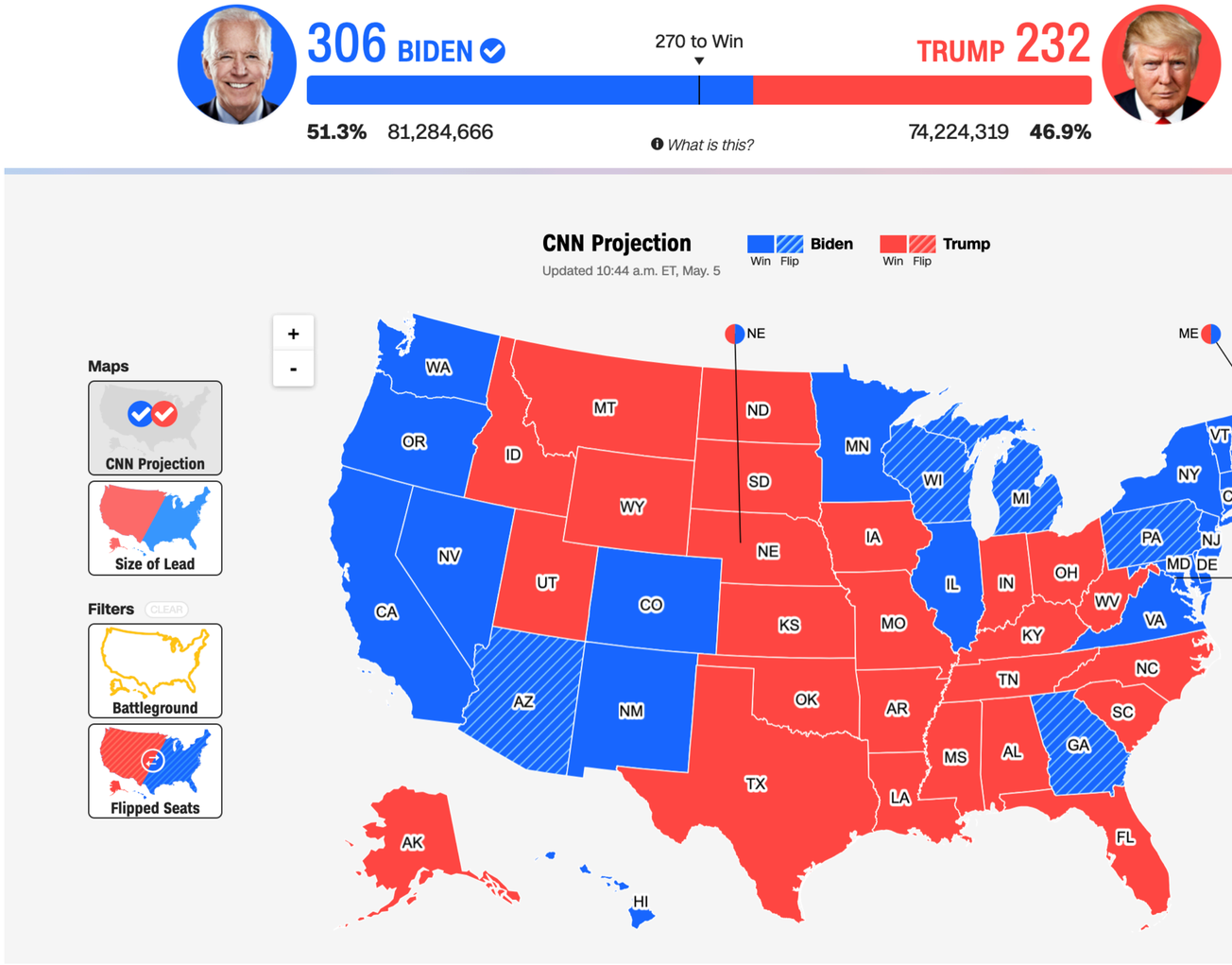
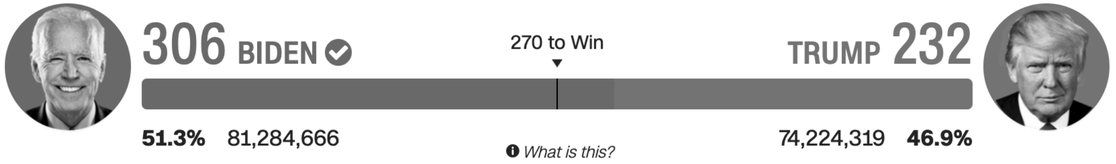
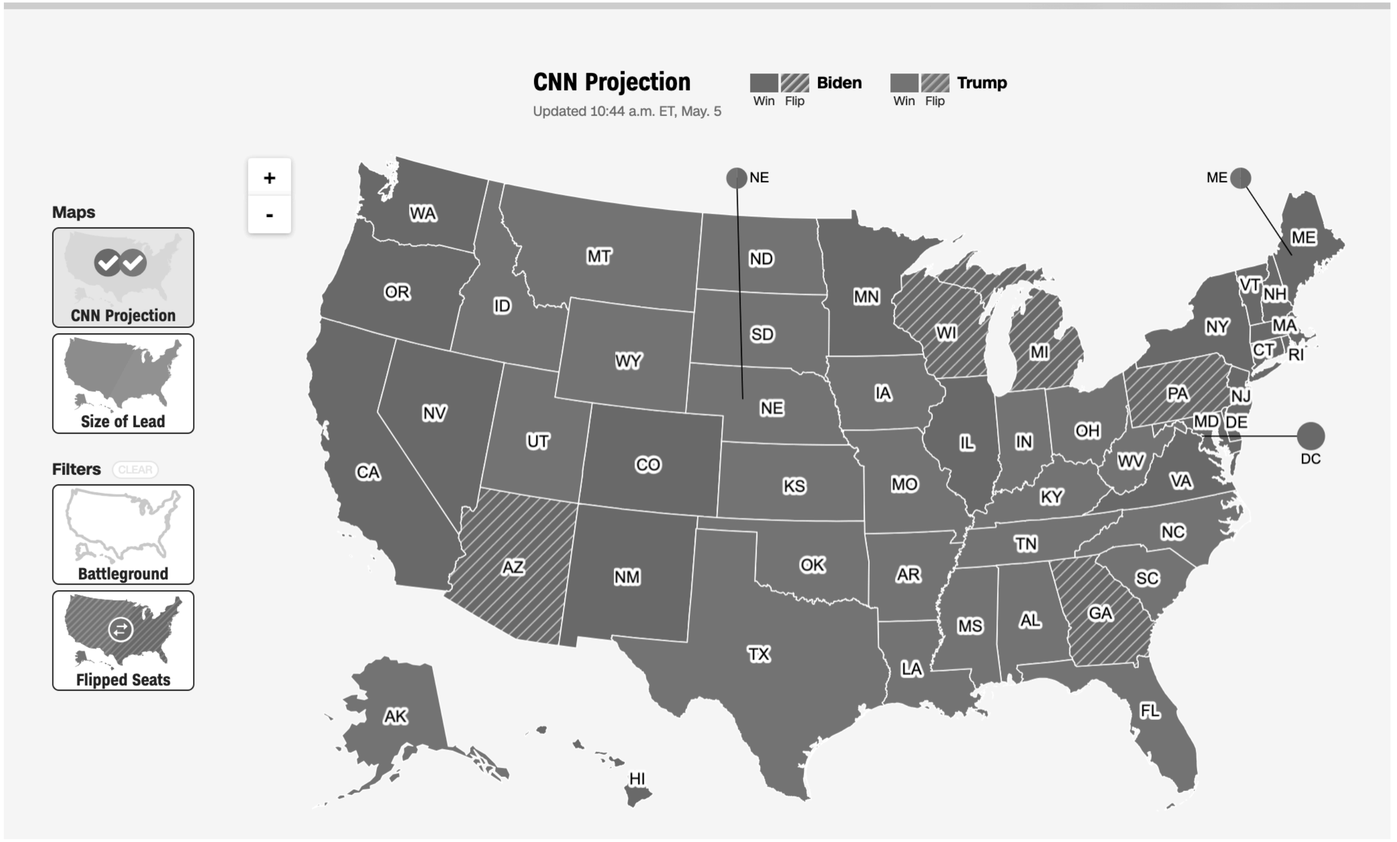
# But sometimes you *can't* redundantly encode!

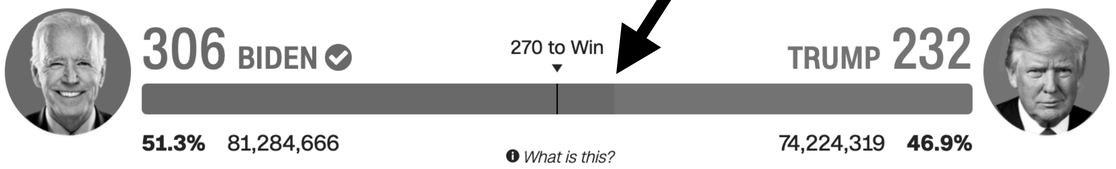


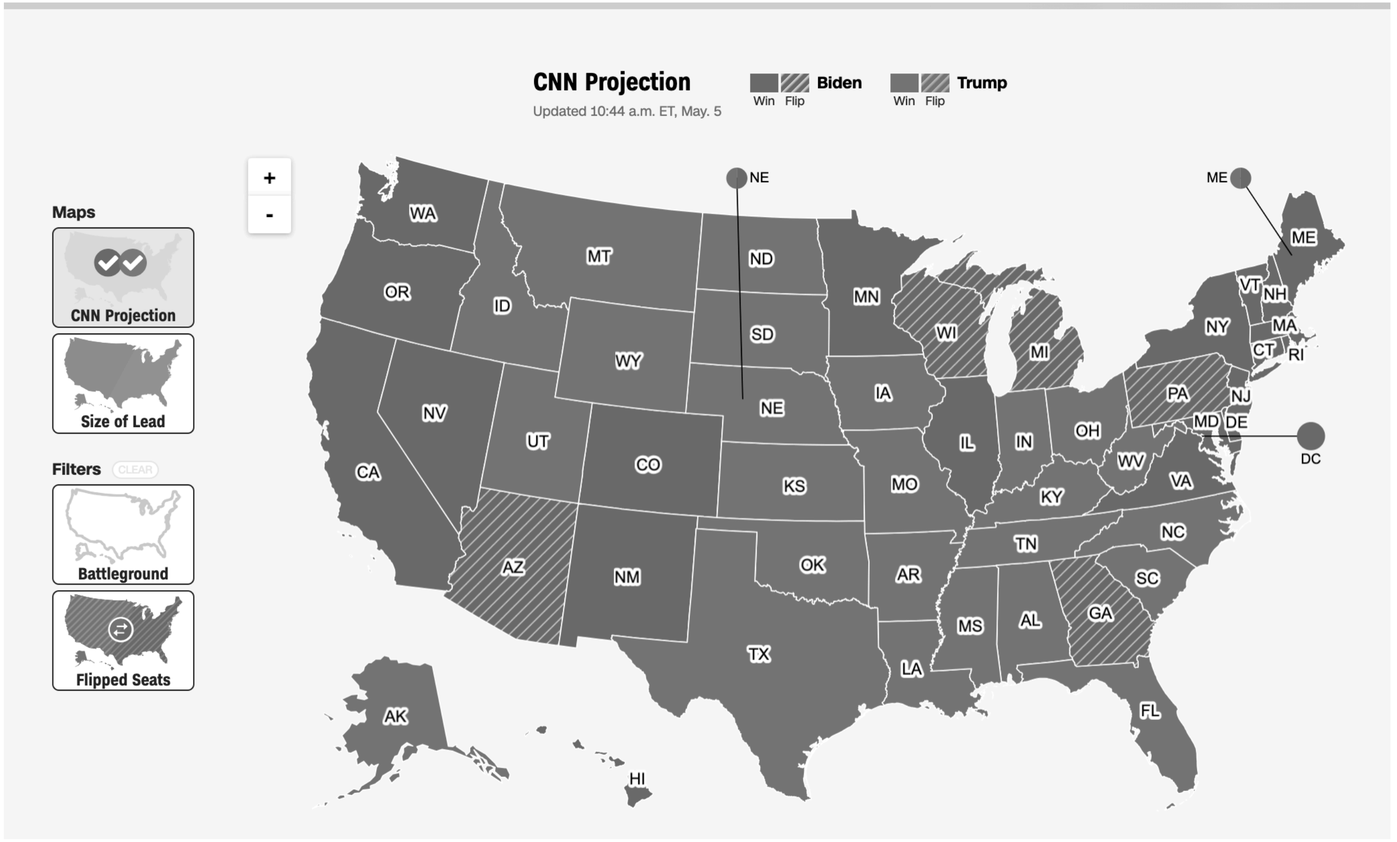
# This map is trouble in greyscale



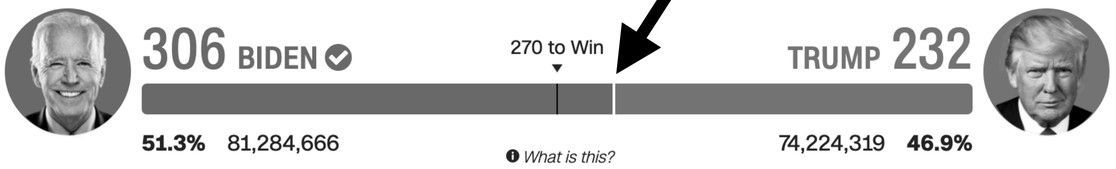



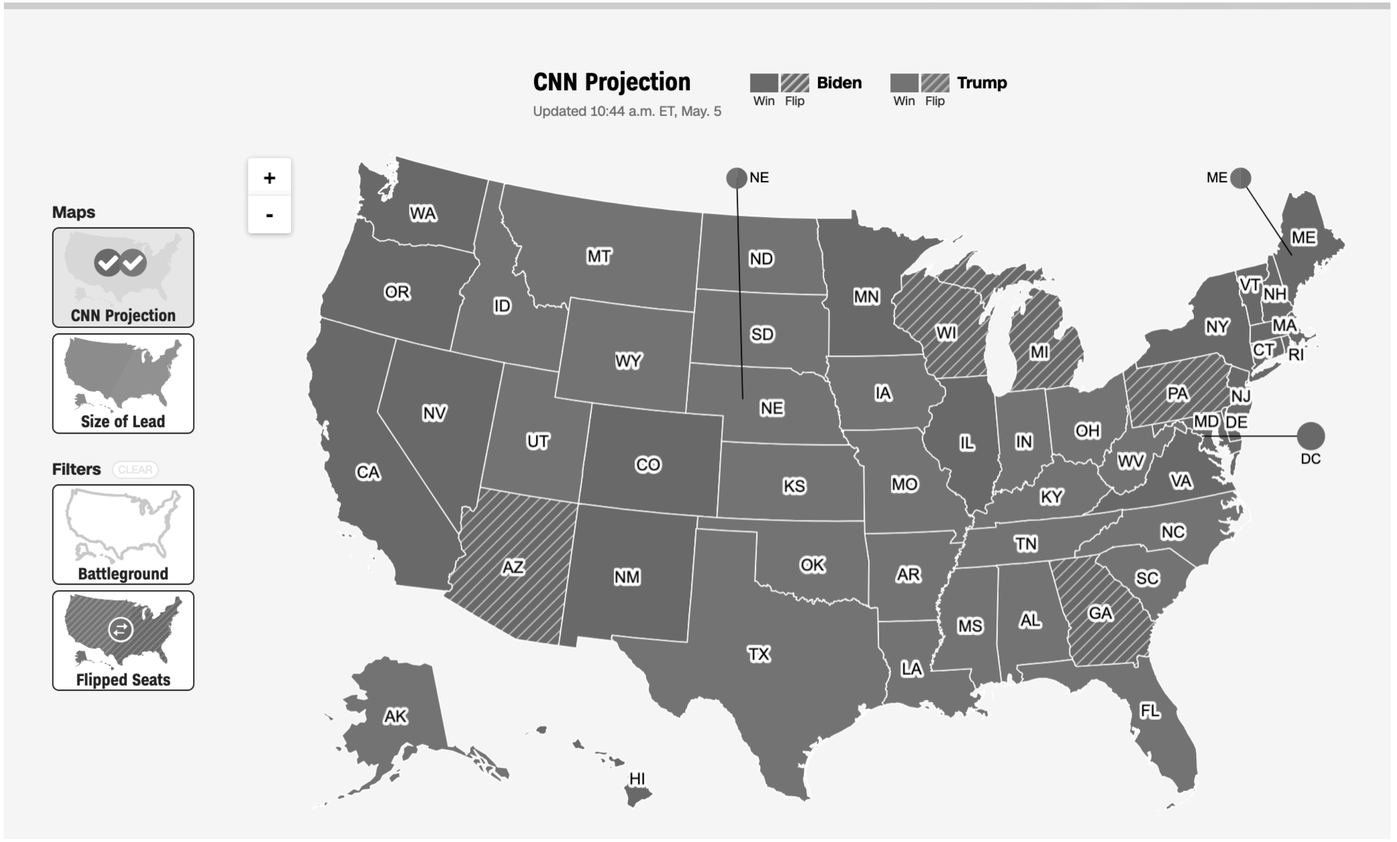
# The division here matters!



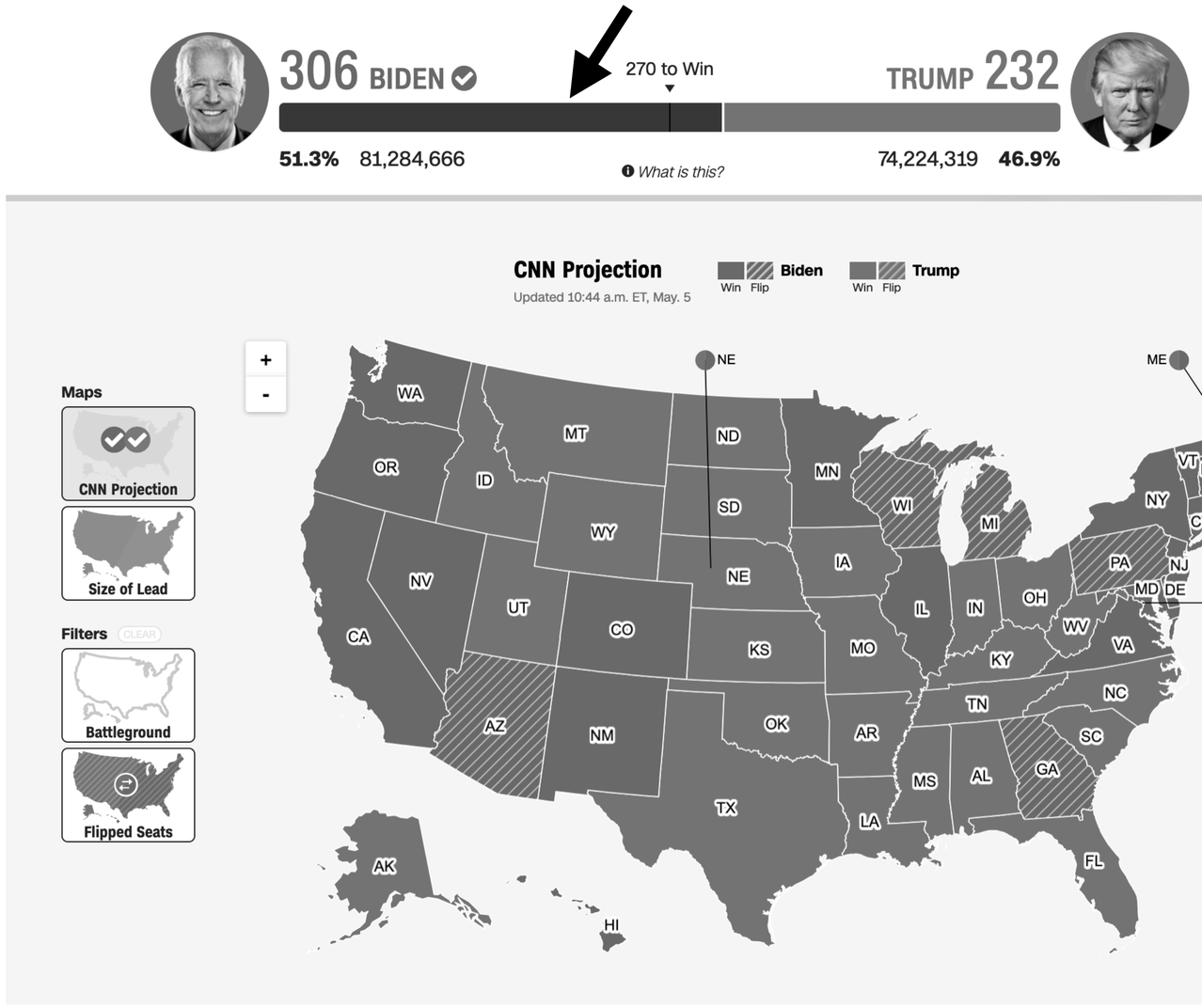



# Maybe a small white divider, like the states?

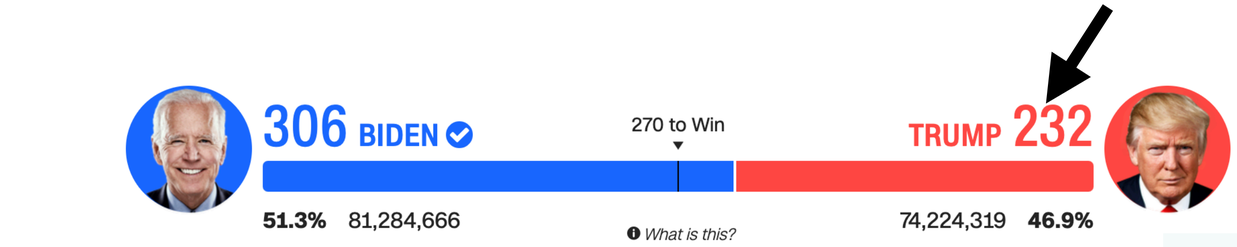


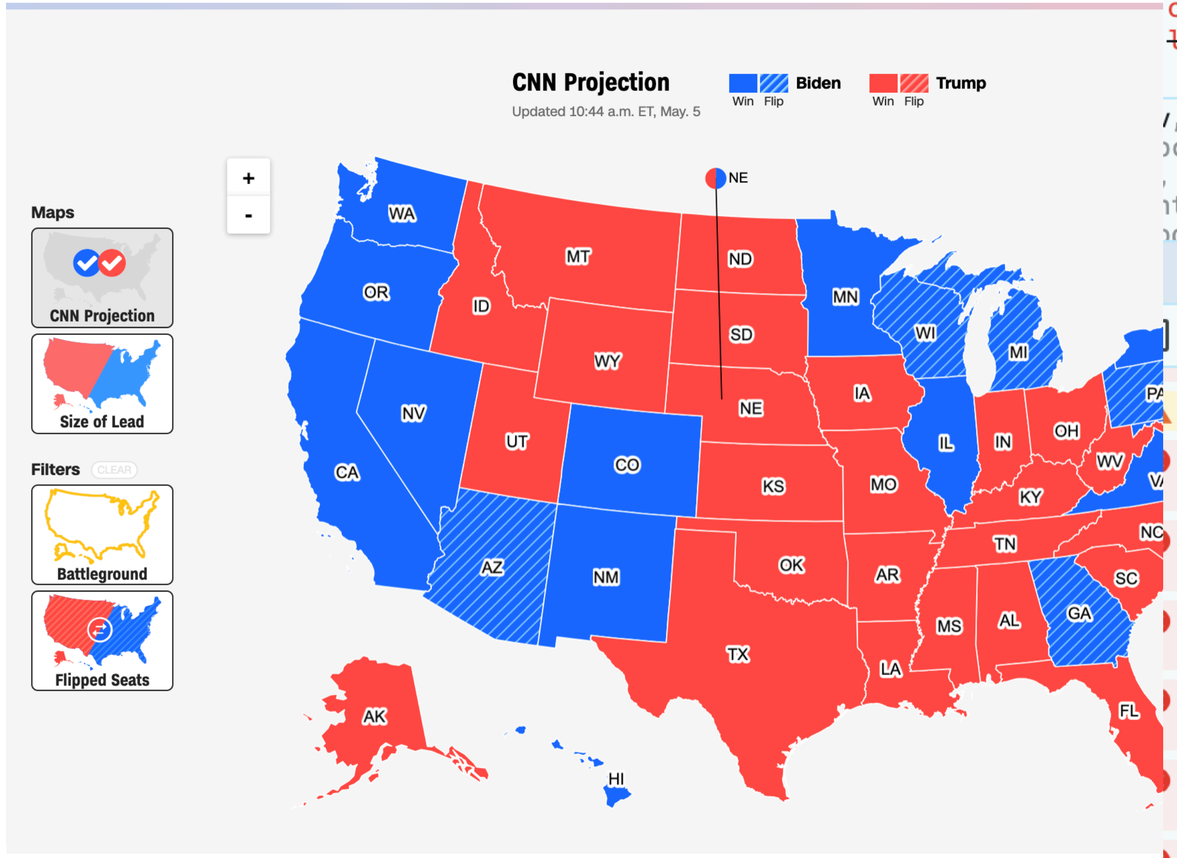



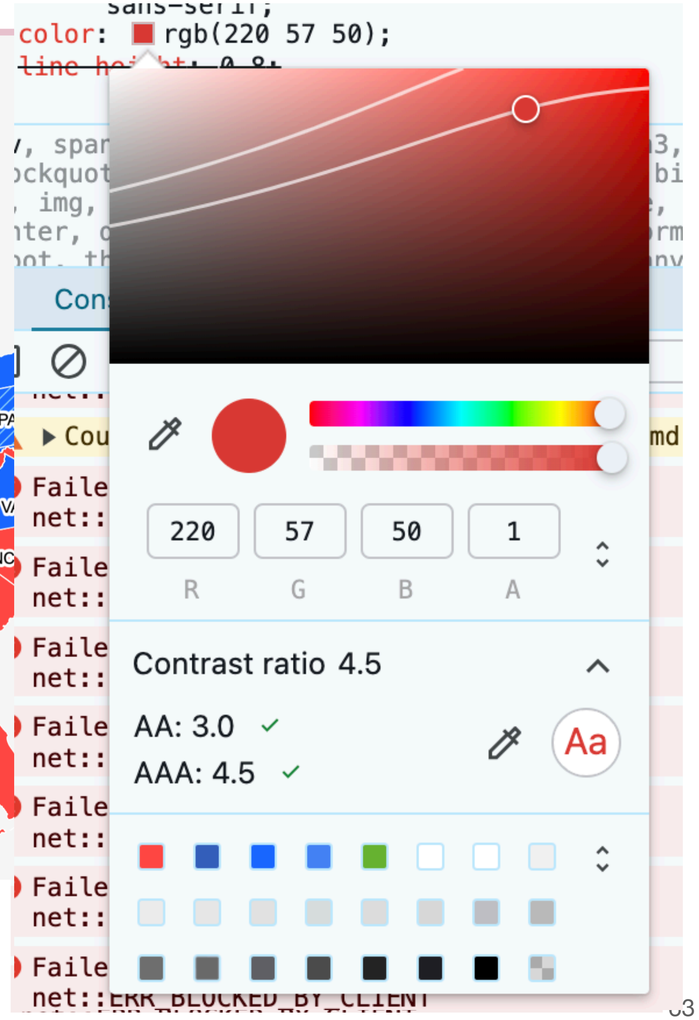
# Perhaps test a darker blue too?



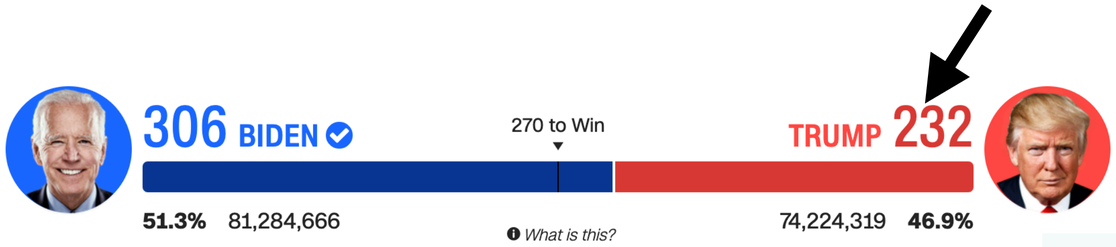
# What if we fix the contrast failures at the same time?

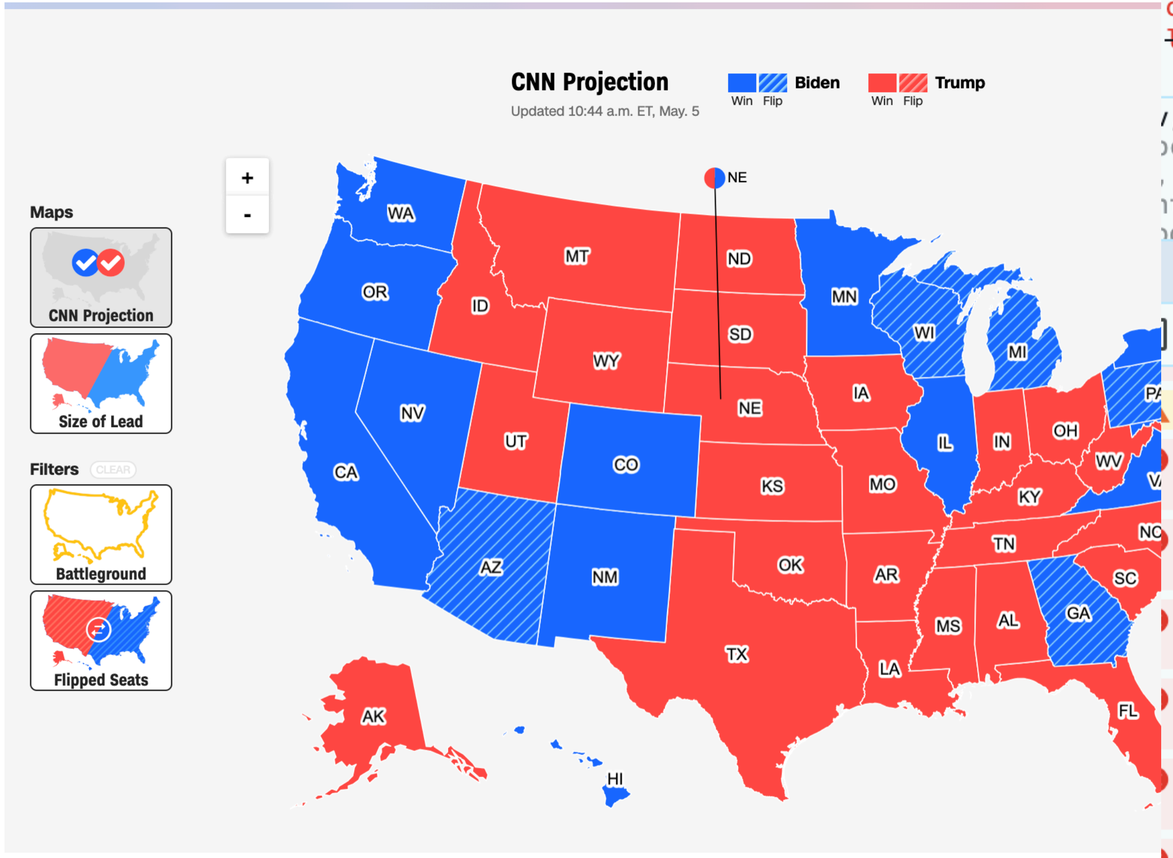


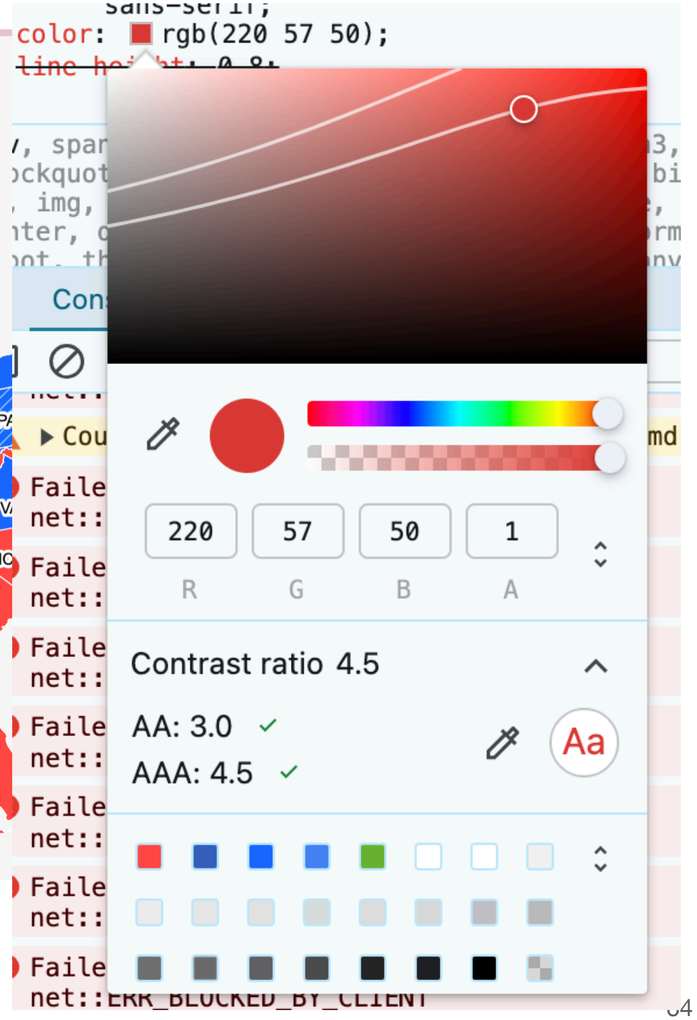



# This text now passes!

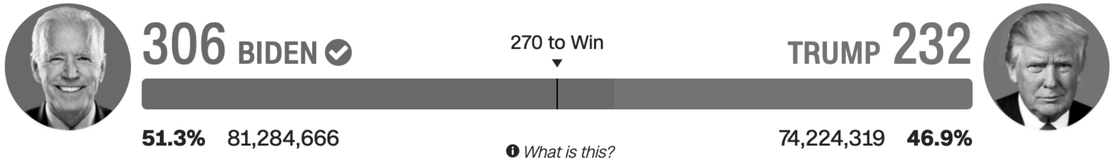


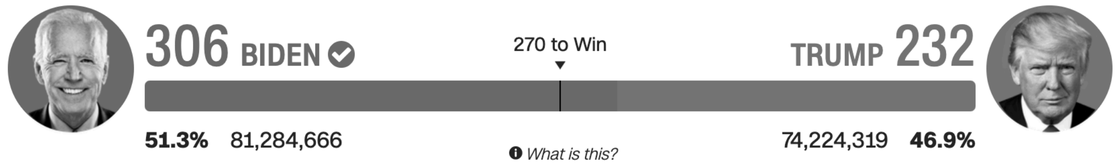



# Let’s check that greyscale again…

# 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
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What is this?
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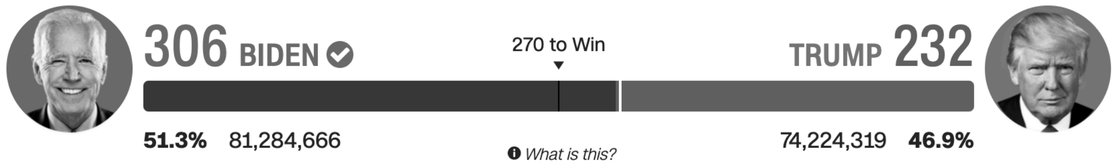
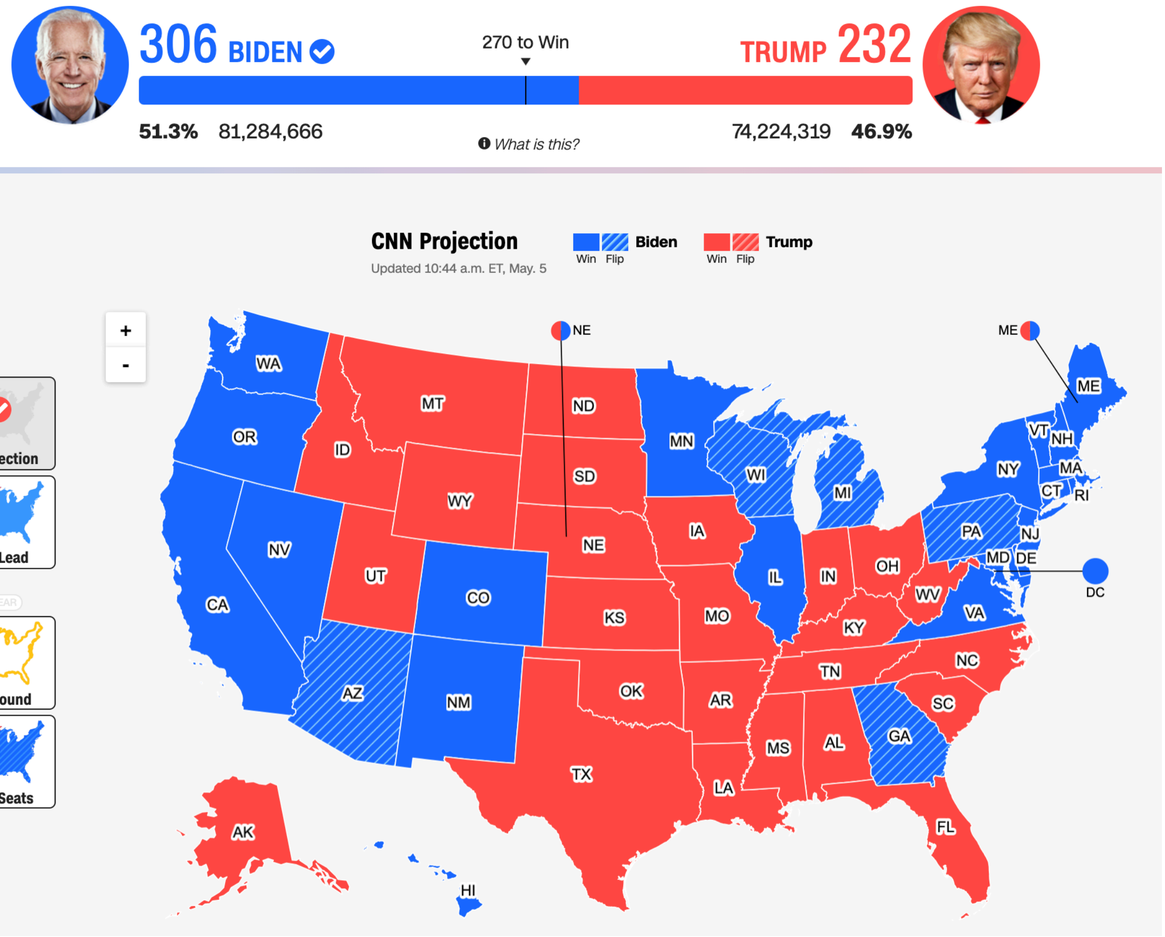
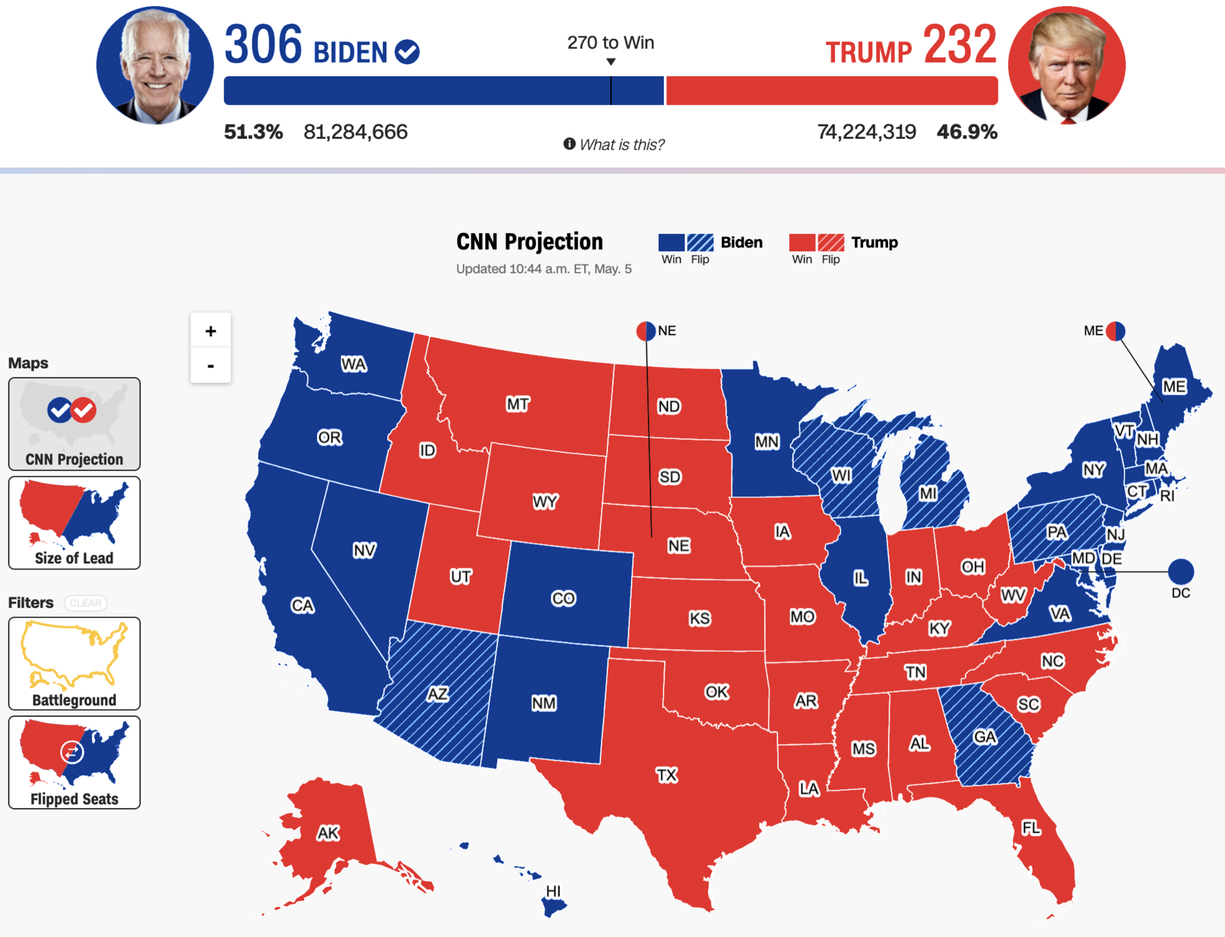
## And after!


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



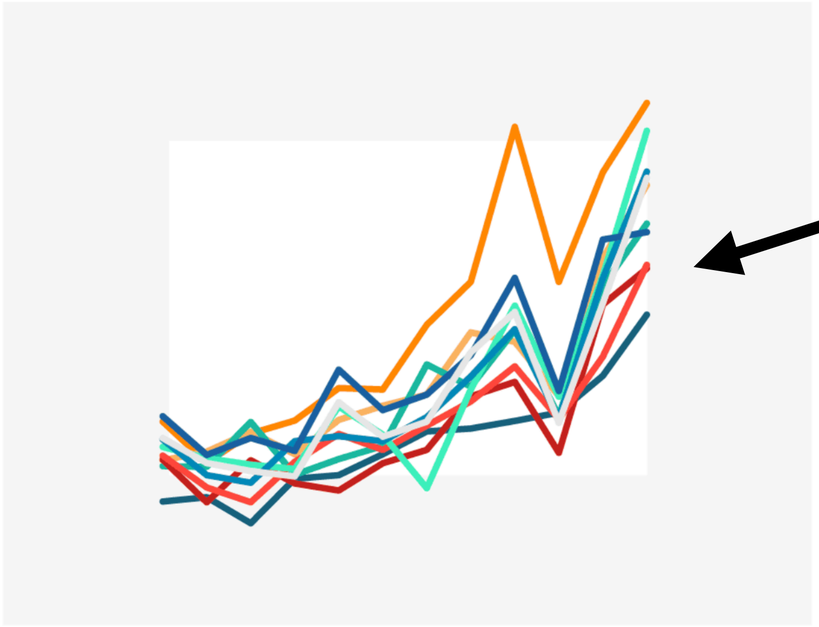



# But what about more than 2 colors?

NOT IDEAL

Source: Datawrapper

# But what about more than 2 colors?



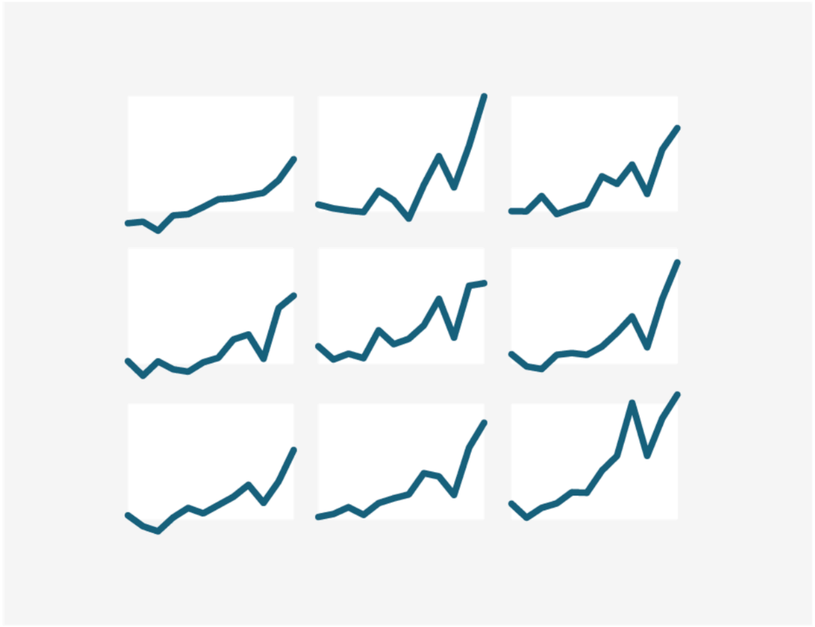
NOT IDEAL

**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!

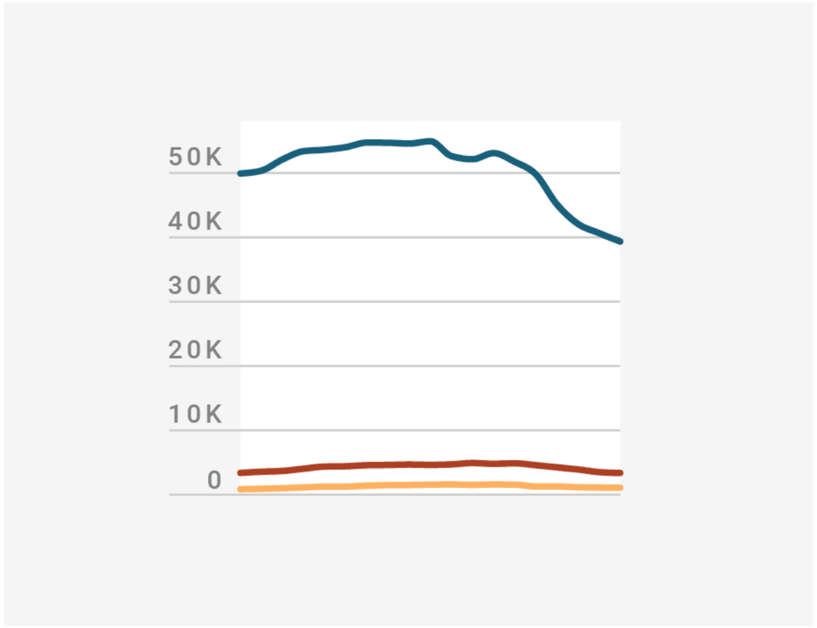
**Using “small multiples” is an easy, powerful technique**

NOT IDEAL

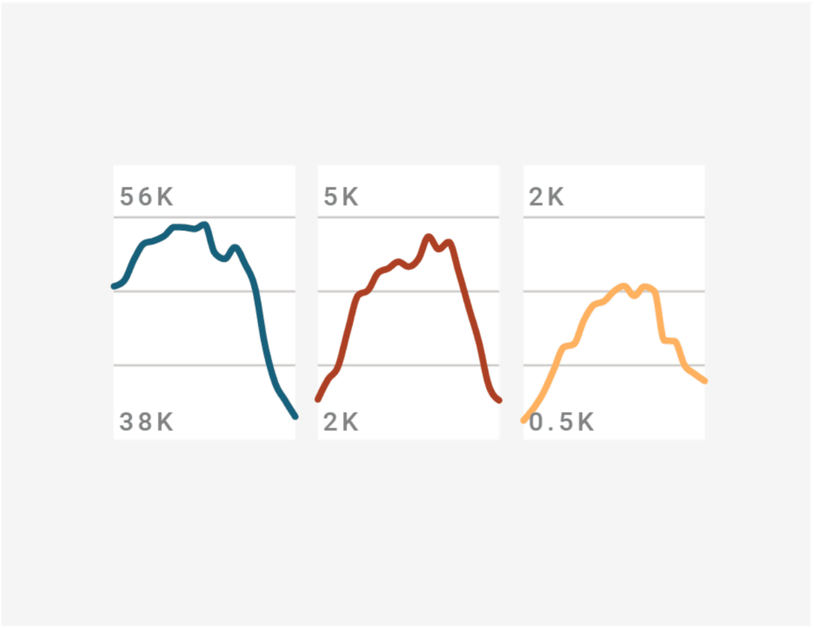
BETTER

Source: Datawrapper

# Or simply separate your colors, if they matter



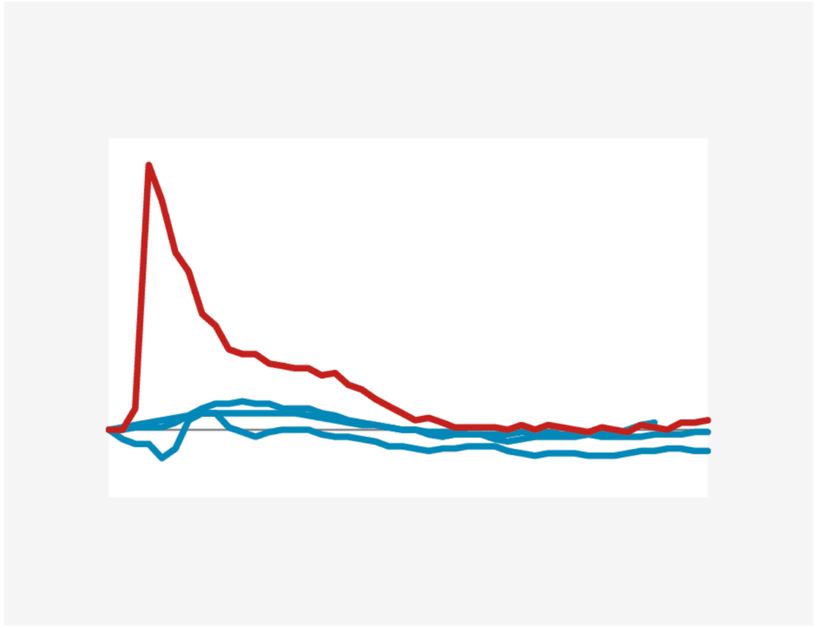

GOOD



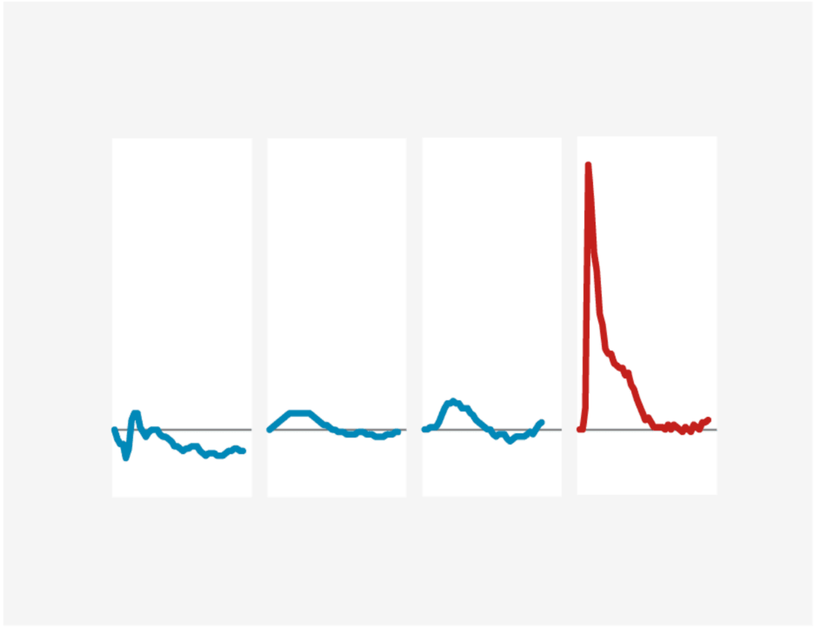

ALSO GOOD

Source: Datawrapper

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



GOOD



BETTER

Source: Datawrapper

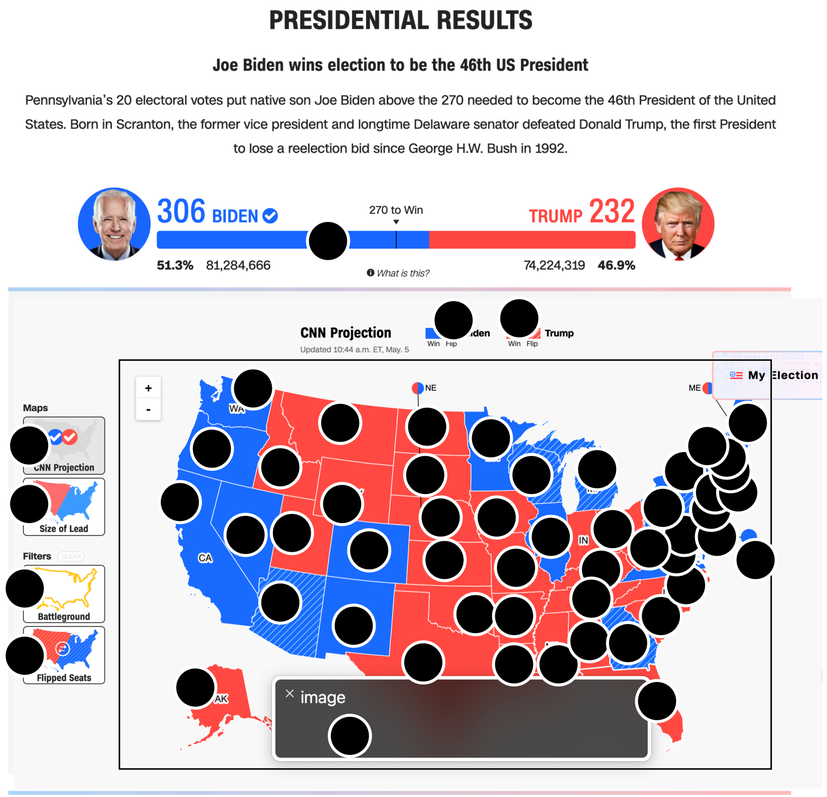
# Add alt text

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

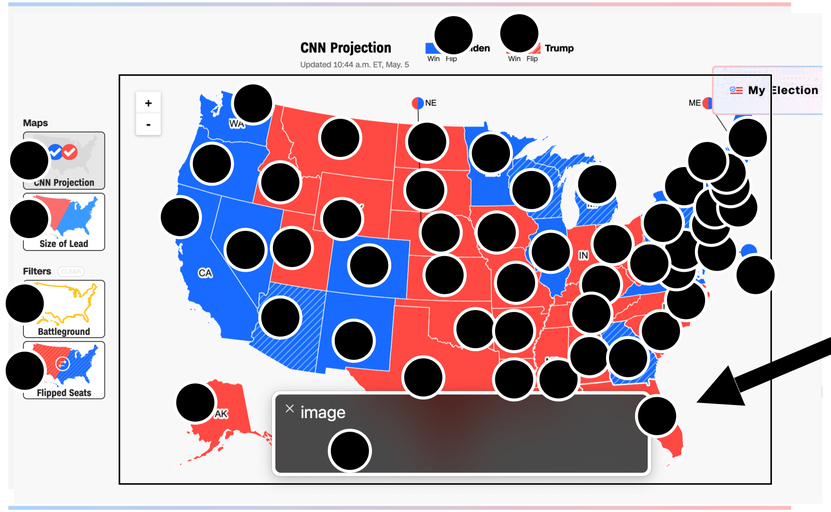



# 57 instances of “Content is only visual”

## PRESIDENTIAL RESULTS

**Joe Biden wins election to be the 46th US President**

Pennsylvania's 20 electoral votes put native son Joe Biden above the 270 needed to become the 46th President of the United States. Born in Scranton, the former vice president and longtime Delaware senator defeated Donald Trump, the first President to lose a reelection bid since George H.W. Bush in 1992.


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

## STATE RESULTS

| President: Alabama | Trump PROJECTED WINNER |
|---|---|
| 9 Electoral Votes | + FOLLOW |

| Candidate | % | Votes |
|---|---|---|
| Trump Incumbent | 62.0% | 1,441,170 |
| Biden | 36.6% | 849,624 |

Est. 99% In
Updated 10:17 p.m. ET, Mar. 6
Full Details

| President: Alaska | Trump PROJECTED WINNER |
|---|---|
| 3 Electoral Votes | + FOLLOW |

| Candidate | % | Votes |
|---|---|---|
| Trump Incumbent | 52.8% | 189,951 |
| Biden | 42.8% | 153,778 |

Est. 99% In
Updated 09:51 a.m. ET, Dec. 2
Full Details

| President: Arizona | Biden PROJECTED WINNER |
|---|---|
| BATTLEGROUND | + FOLLOW |
| 11 Electoral Votes | |

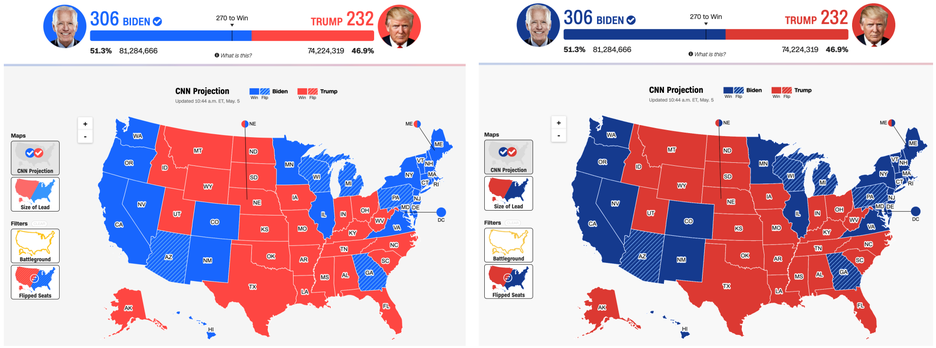
| Candidate | % | Votes |
|---|---|---|
| Biden | 49.4% | 1,672,143 |
| Trump Incumbent | 49.0% | 1,661,686 |

Est. 99% In
Updated 04:11 p.m. ET, Nov. 30
Full Details

Show More States

# Recap: Perceivability

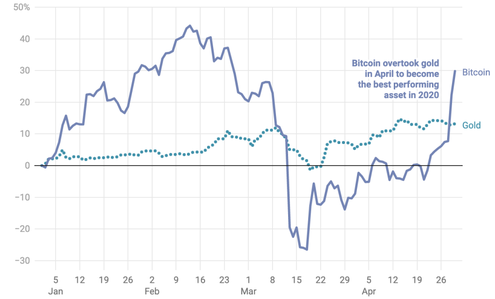
## Use high contrast



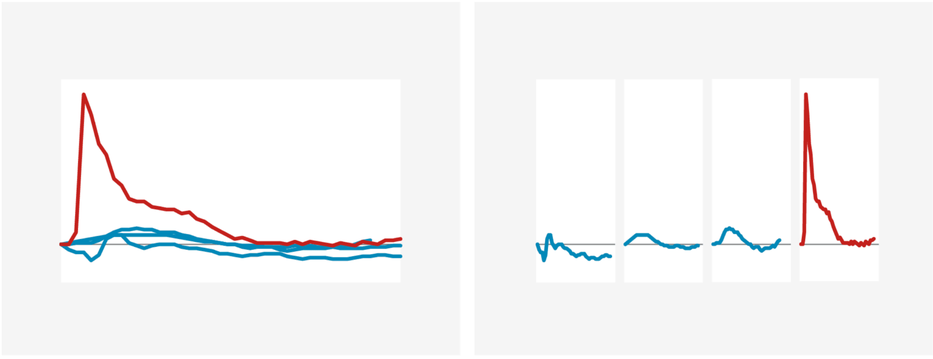




## Use redundant encoding




## 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.

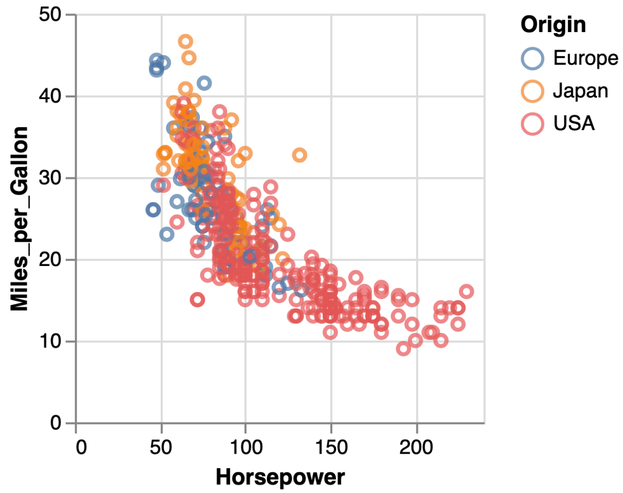
Image credit: Wikipedia, Public Domain, 1960. Photographer: Possum Ltd.

# Why “keyboard-only?”

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

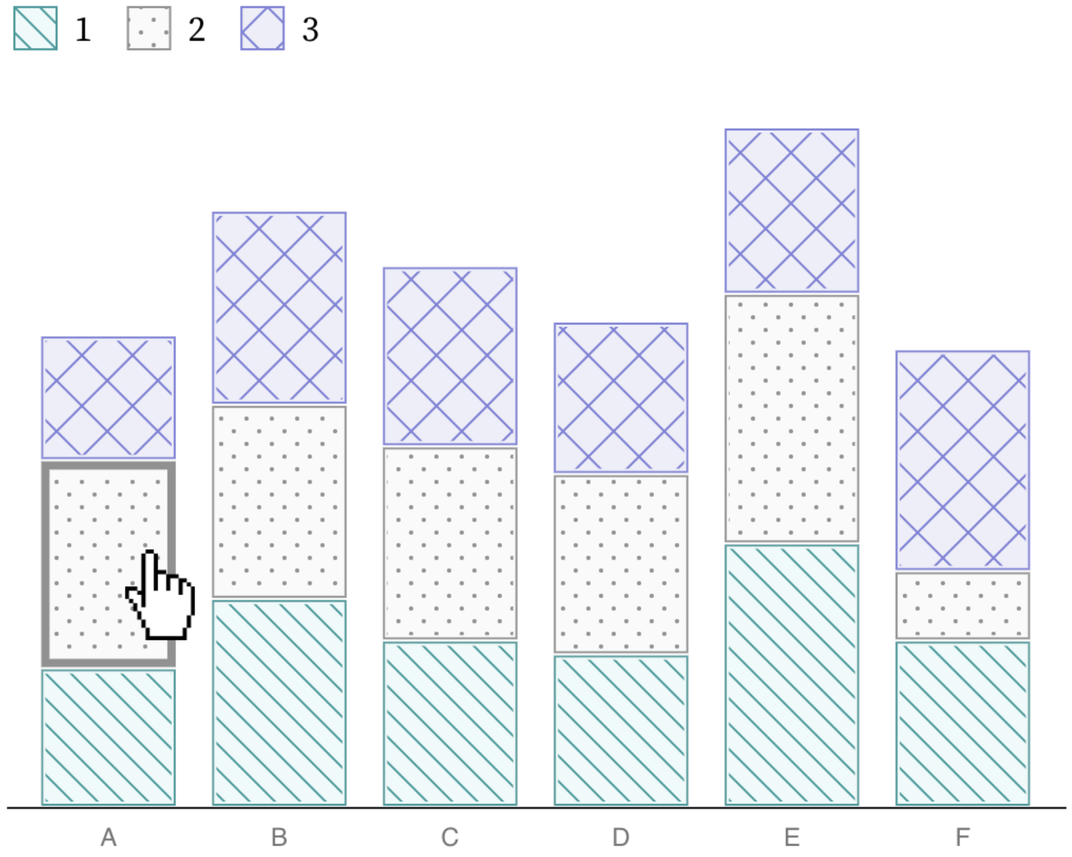
## Scatterplot with External Links and Tooltips

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)



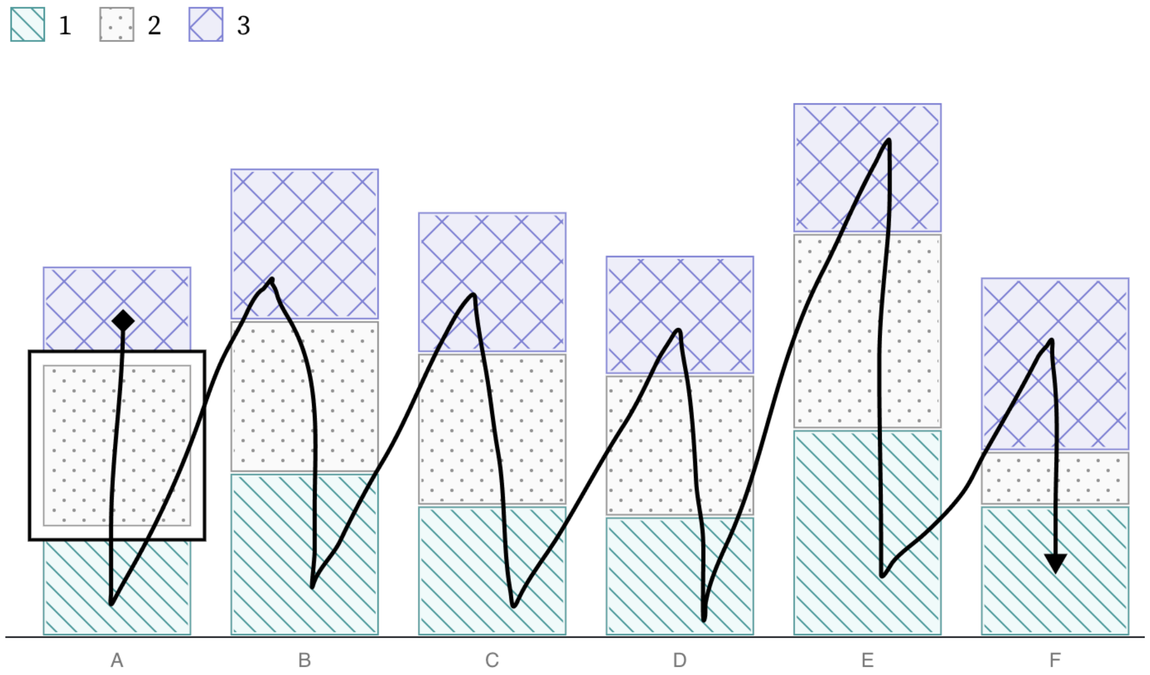

> **Status**: **Category 2** of **Building A** has been selected.

**Products In Building A that belong to Category 2***

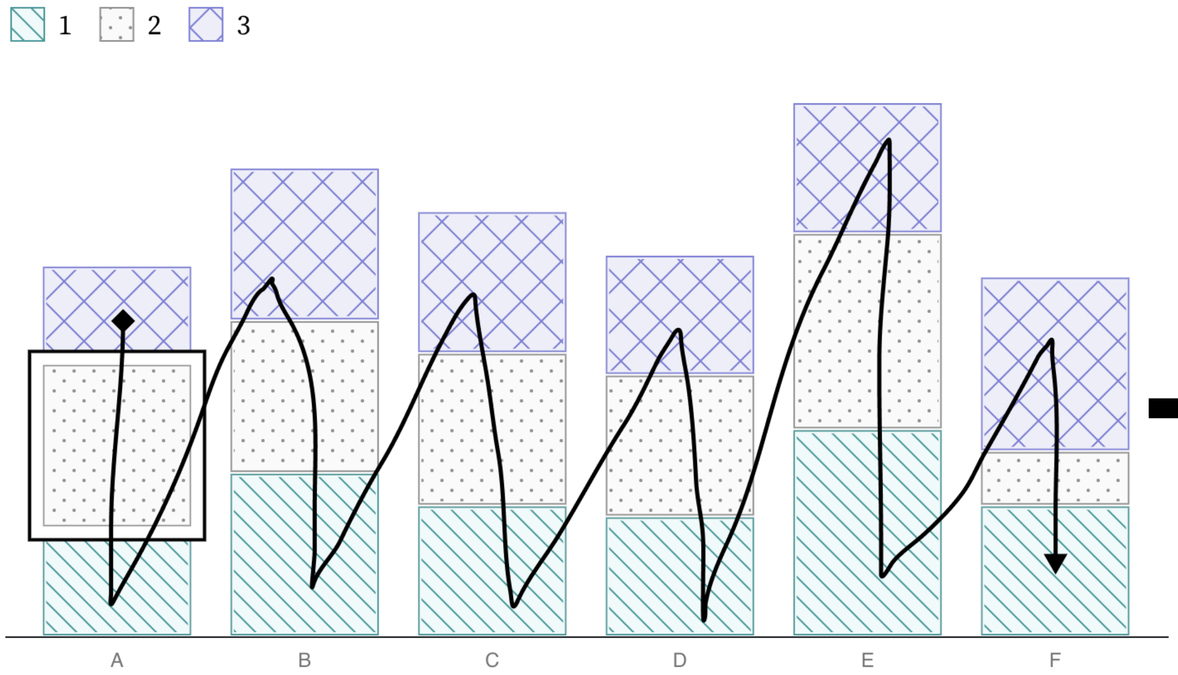
| Product Name | Count in Stock |
|---|---|
| Product A | 147 |
| Product C | 88 |
| Product M | 69 |

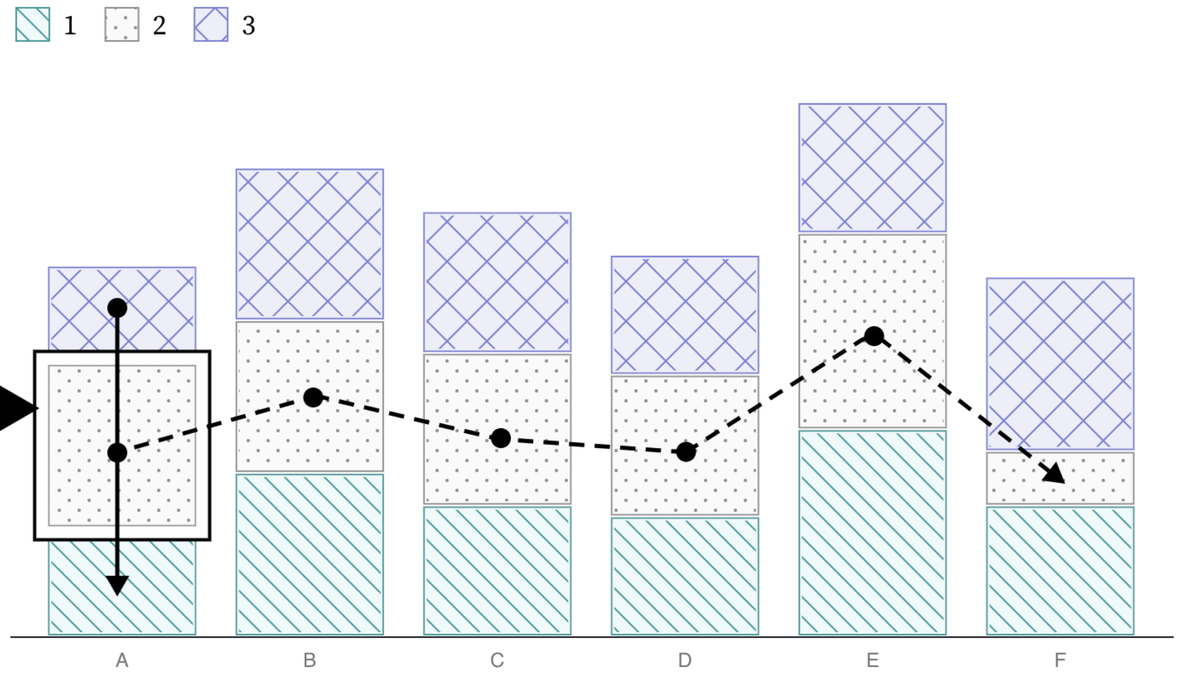
**This table has been populated by the selection in the preceding chart.*

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

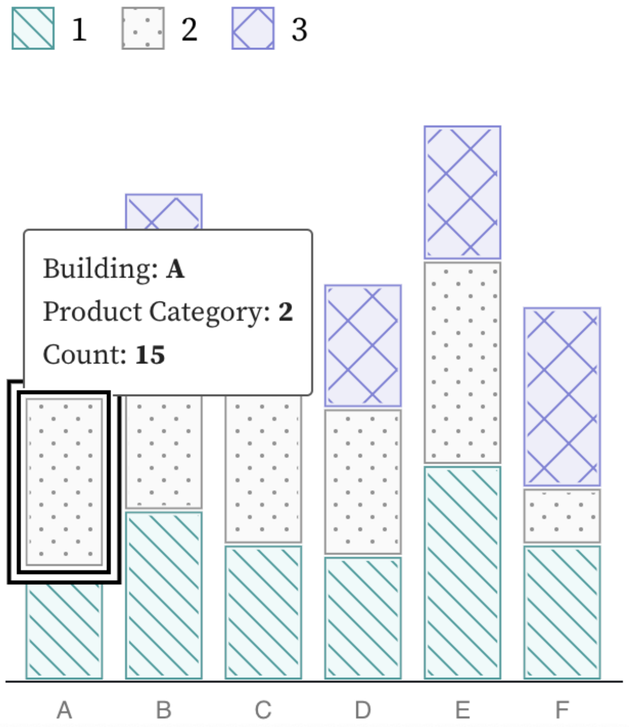


# Consider more flexible movement when data *exploration* matters



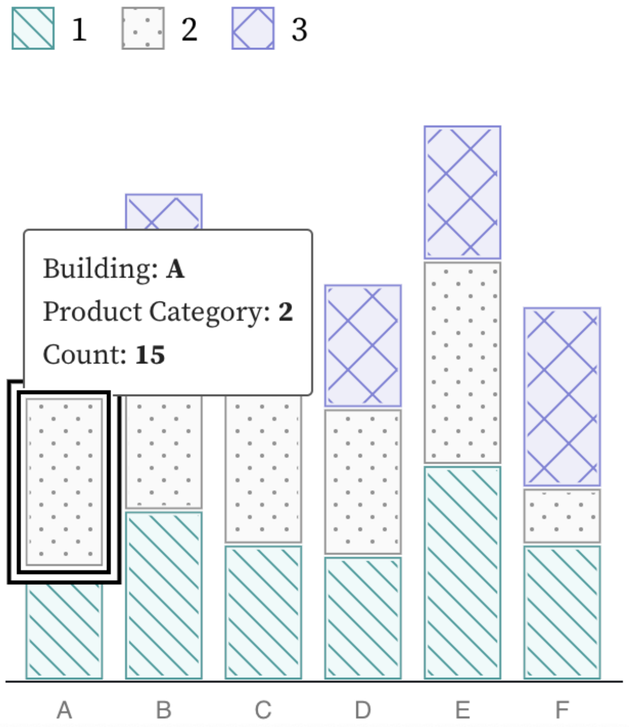



# Alt text should communicate operability




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

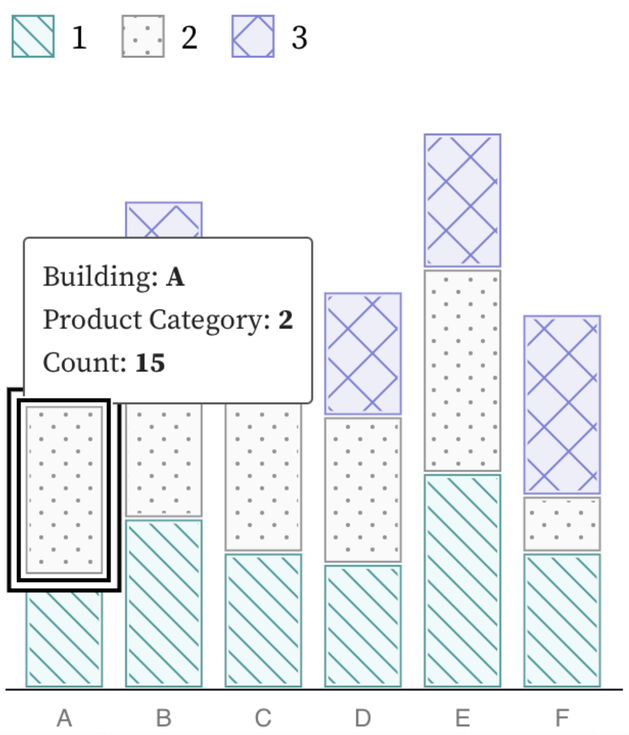
# Semantics matter



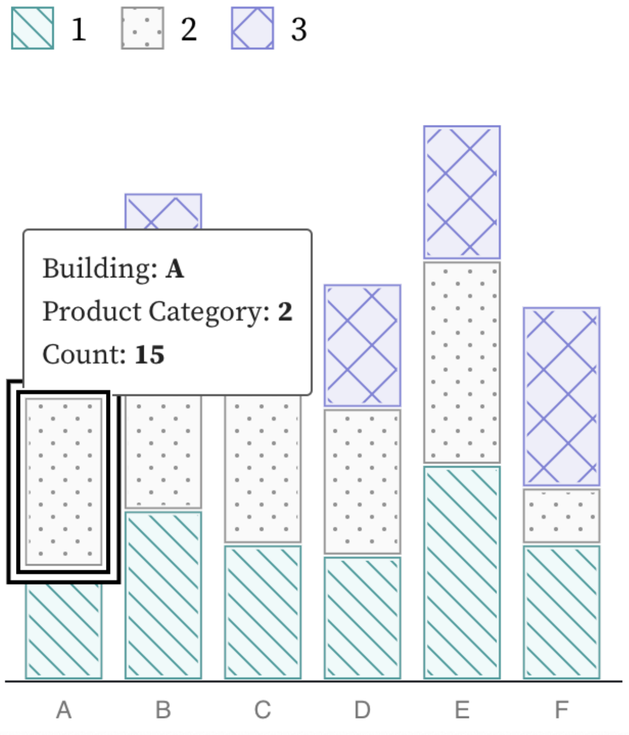

Building A. Product Category 2. Count 15. Bar 2 of 3. Image.

**“Image” doesn’t signal interactivity!**

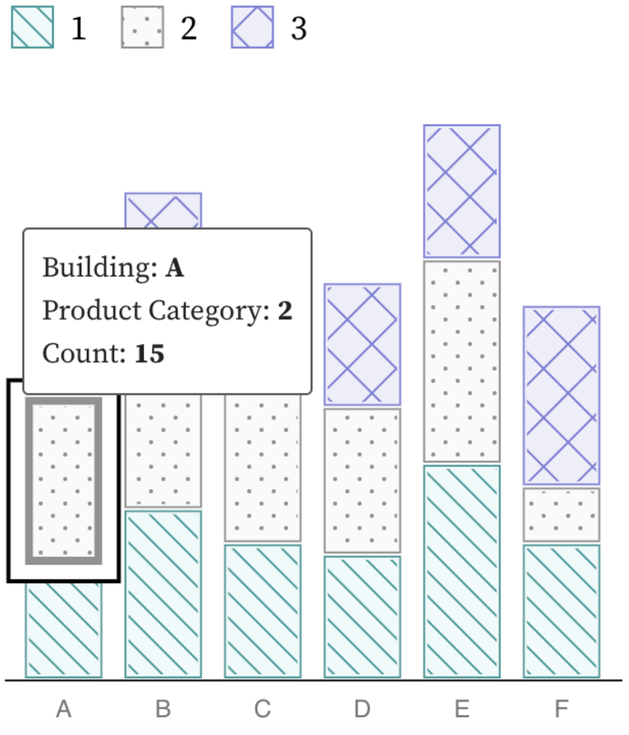
# “Aria” states and roles are standardized




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



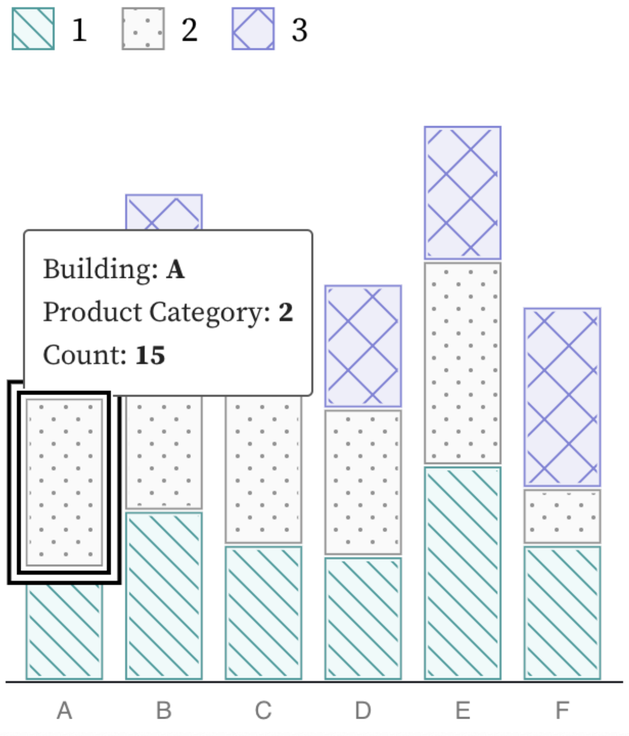

× Building A. Product Category 2. Count 15. Bar 2 of 3., toggle button



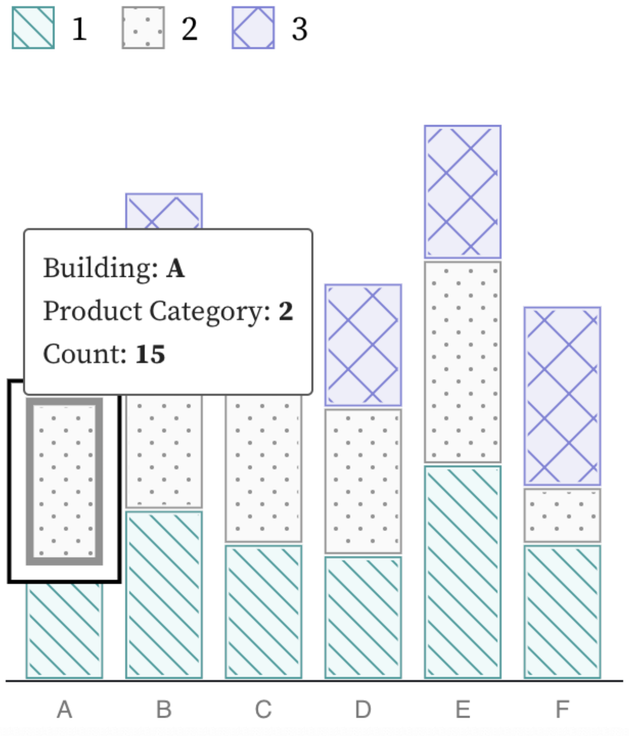

× selected, Building A. Product Category 2. Count 15. Bar 2 of 3., toggle button

# Communicating operability should be visual too

## Hovered/focused




## Selected

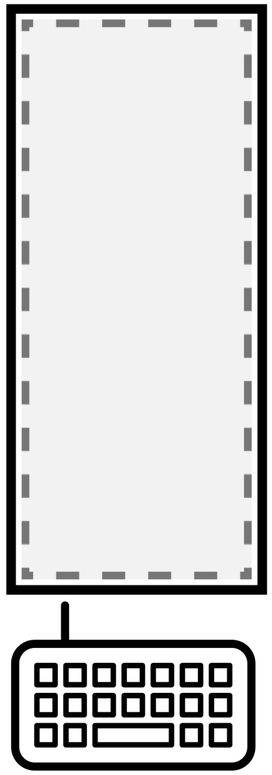


# Design your own interaction styling

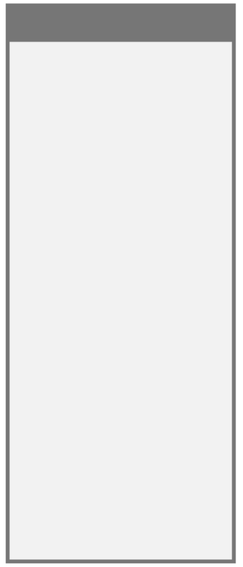
Default

Hovered

Focused

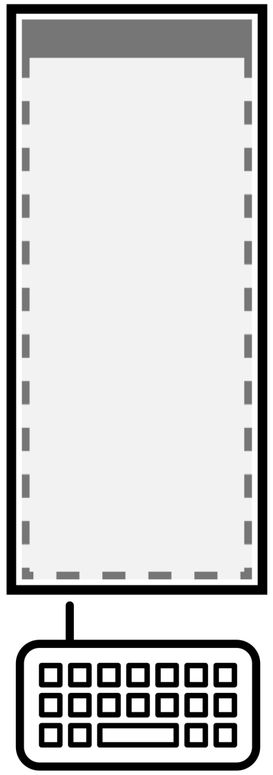


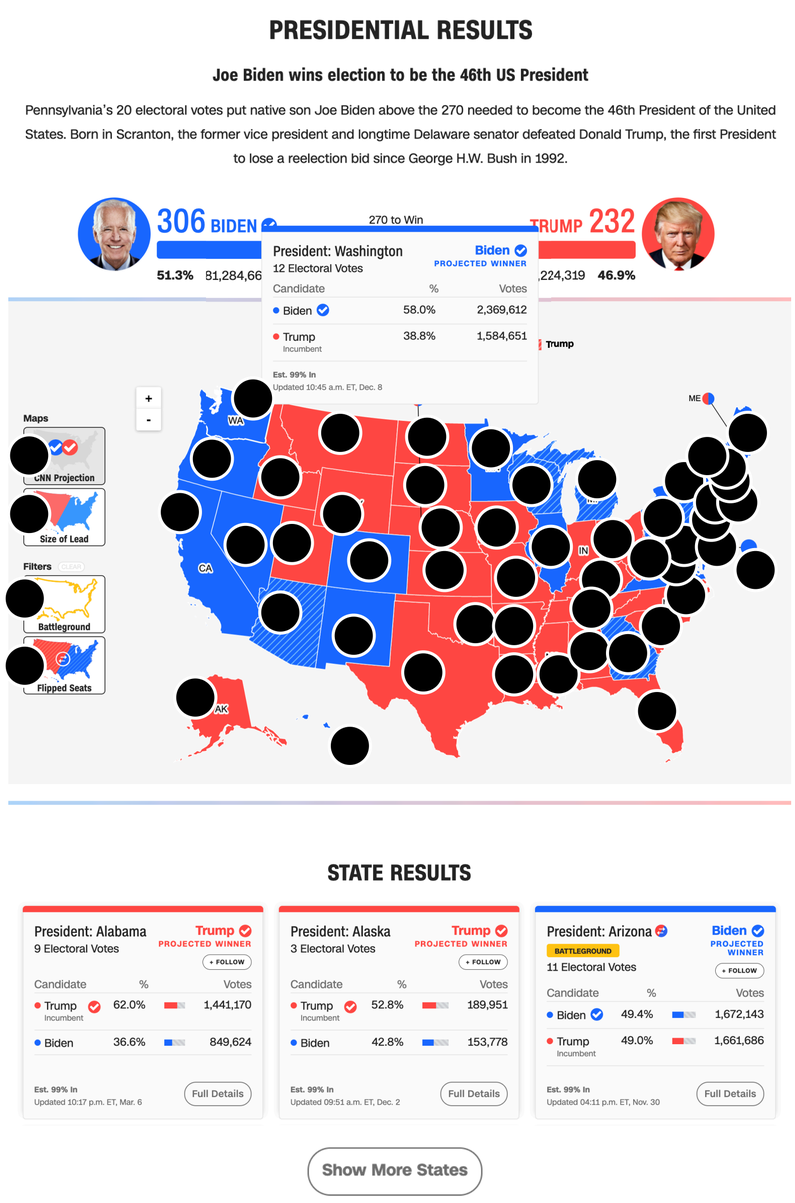
Selected



Hovered + Selected

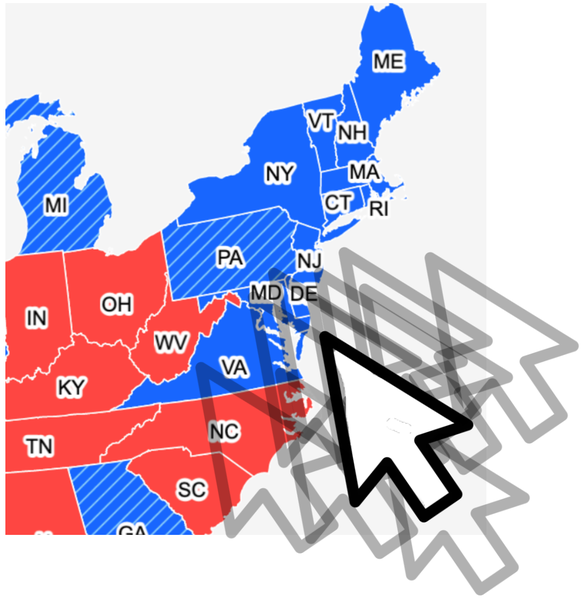
Focused + Selected

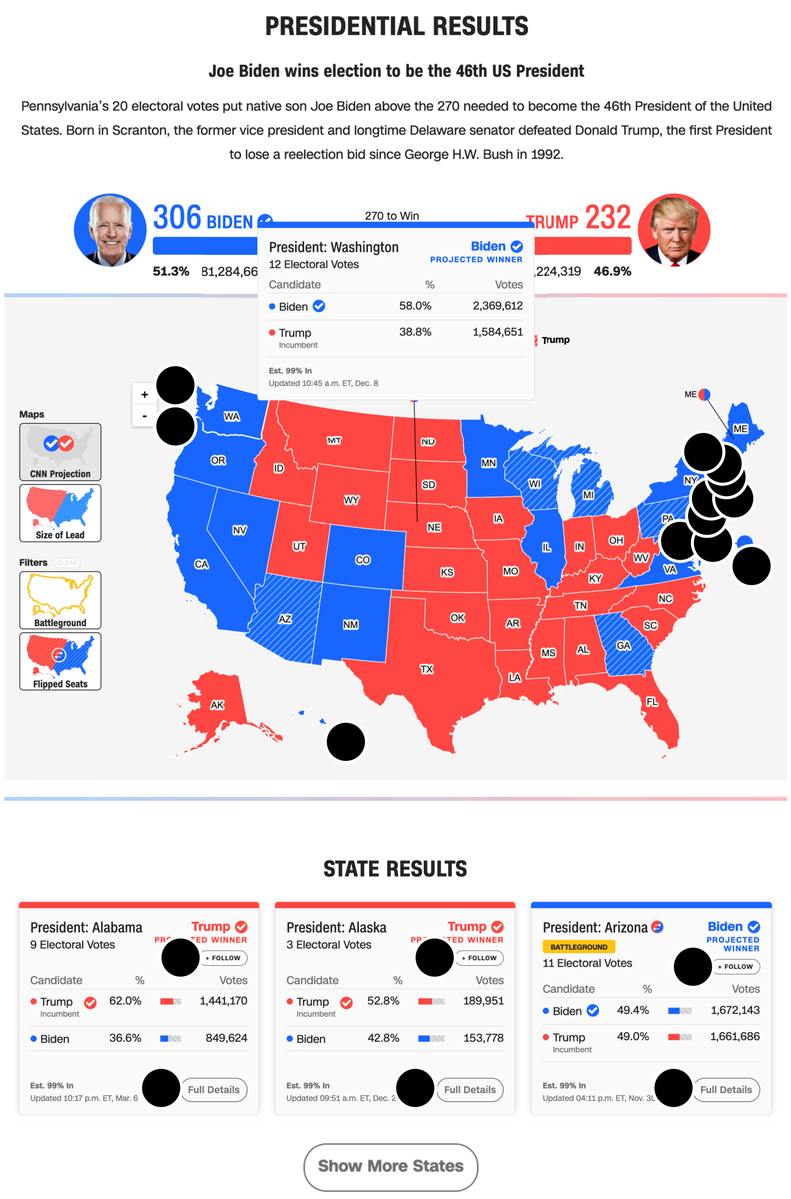





# 54 instances of “only one input type”

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

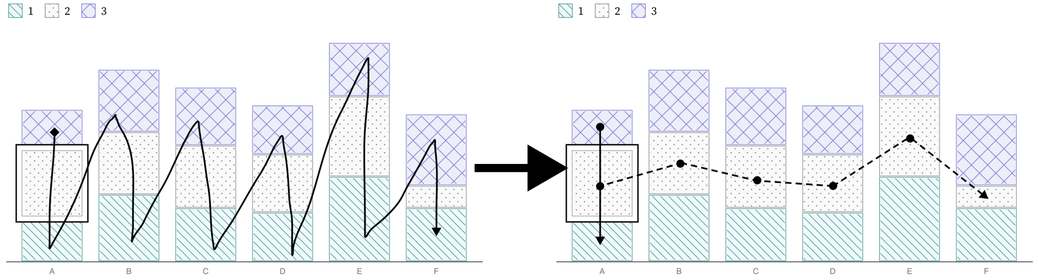




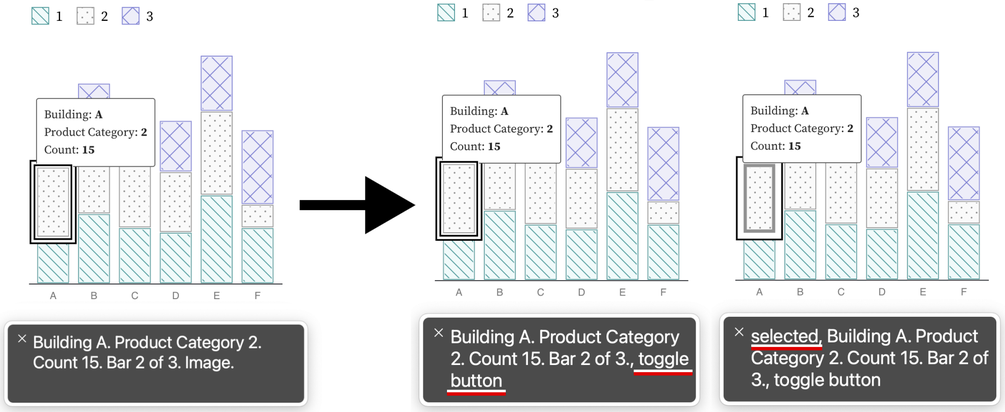

# 18 instances of “target pointer size is too small”

# Recap: Operability

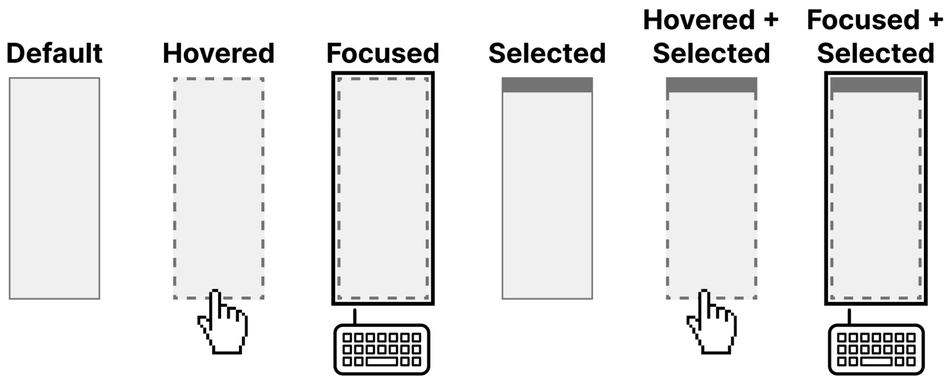
## Consider how someone navigates



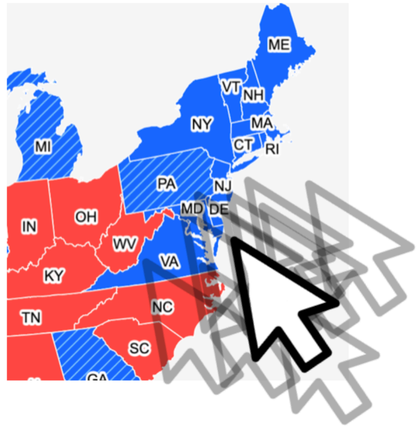

## Describe the functionality of elements




## 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?

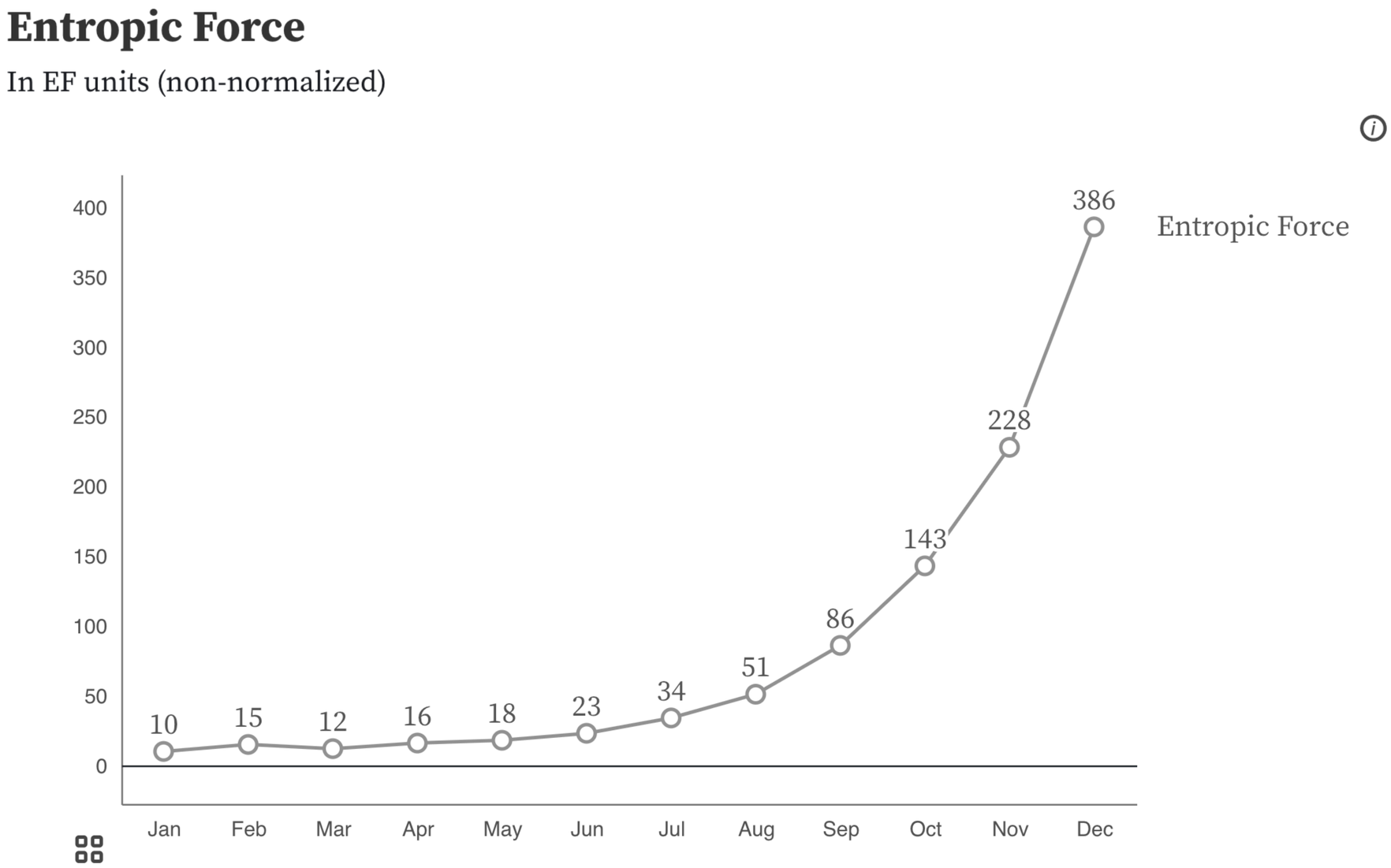
# Understandable

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

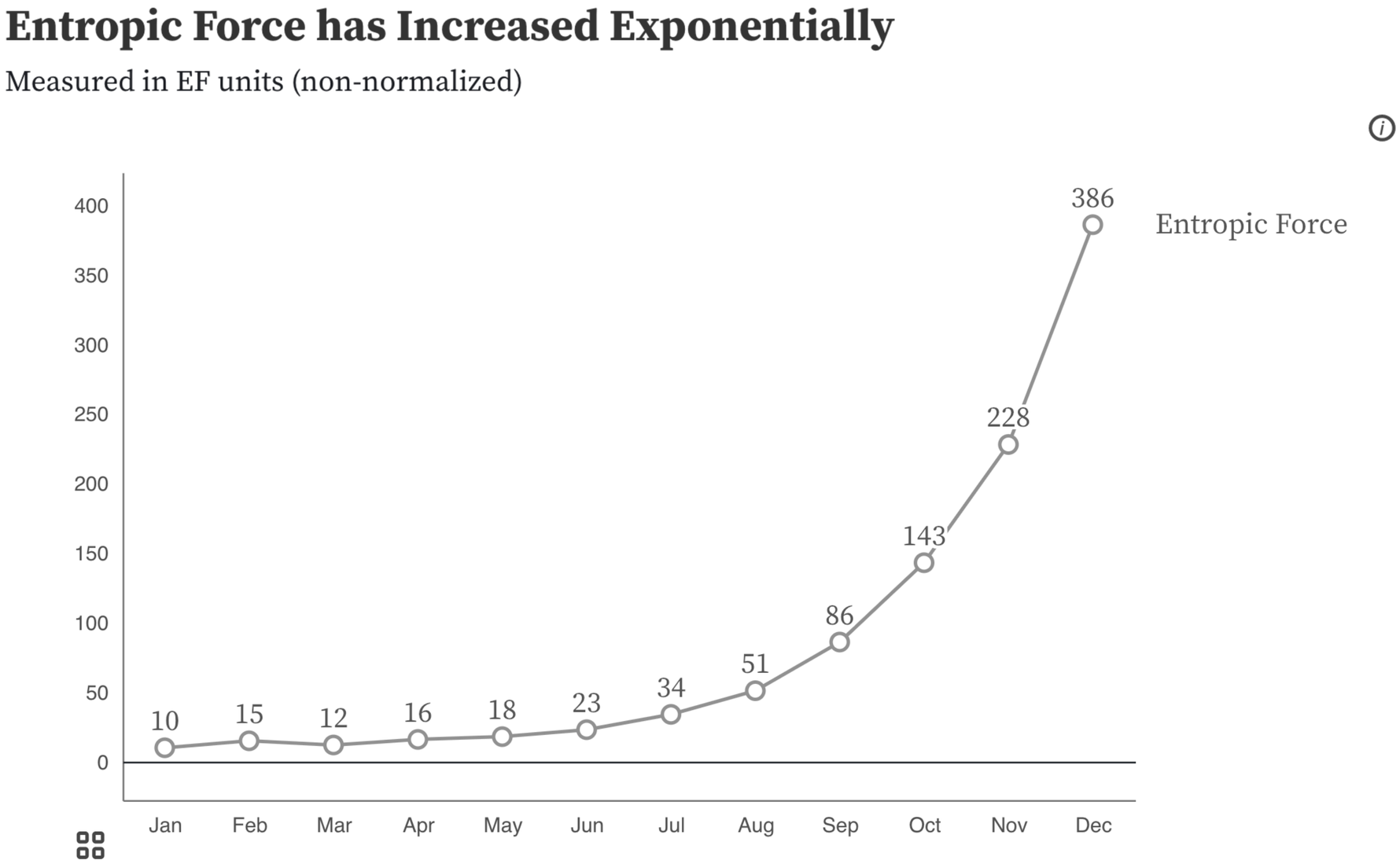
# Understandable Checklist:

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

# Non-descriptive titles are inaccessible



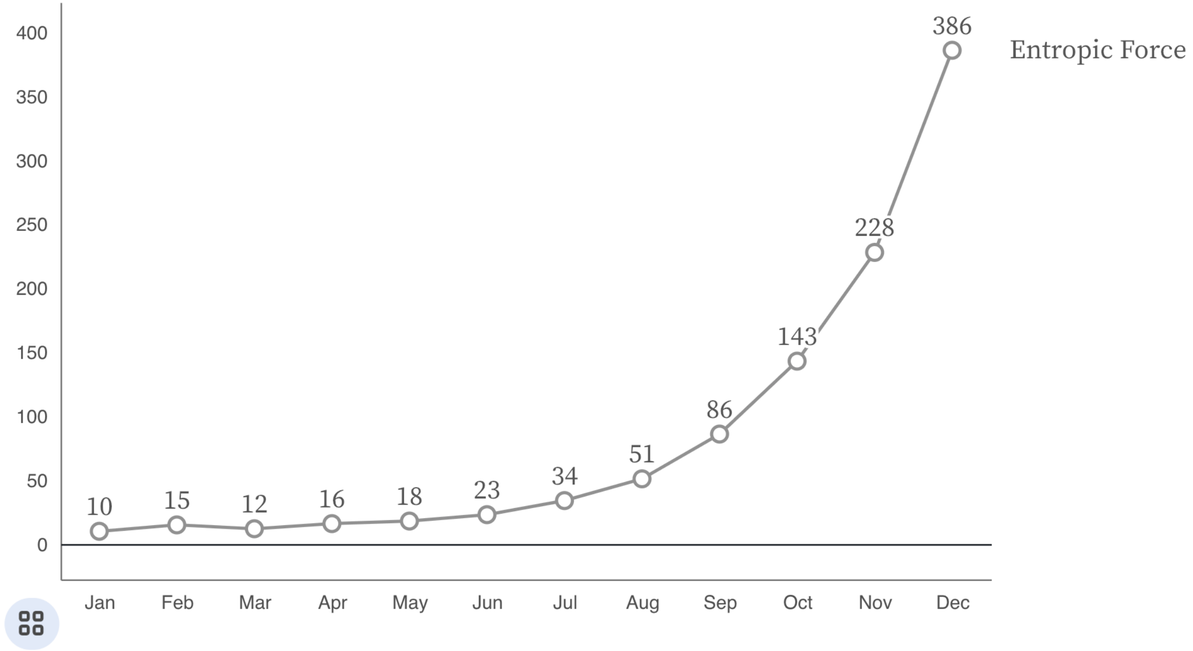
# Descriptive titles have summaries/takeaways

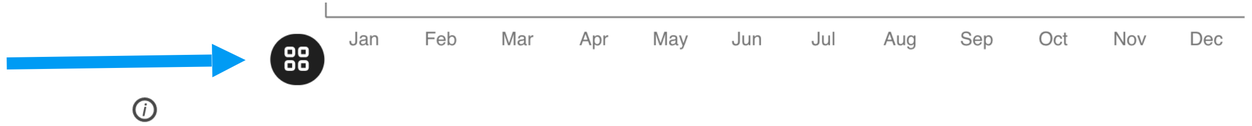


# All charts should have data available!

## 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.

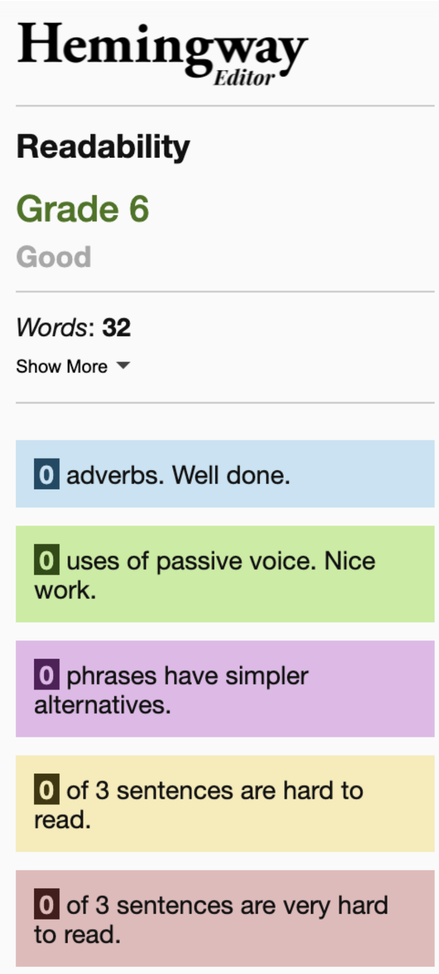
**2** of 3 sentences are very hard to read.

# 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)

→

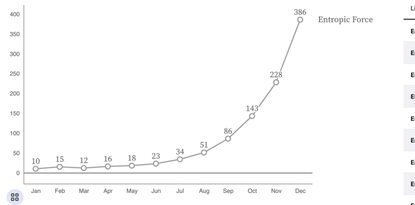
**Entropic Force has Increased Exponentially**

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.

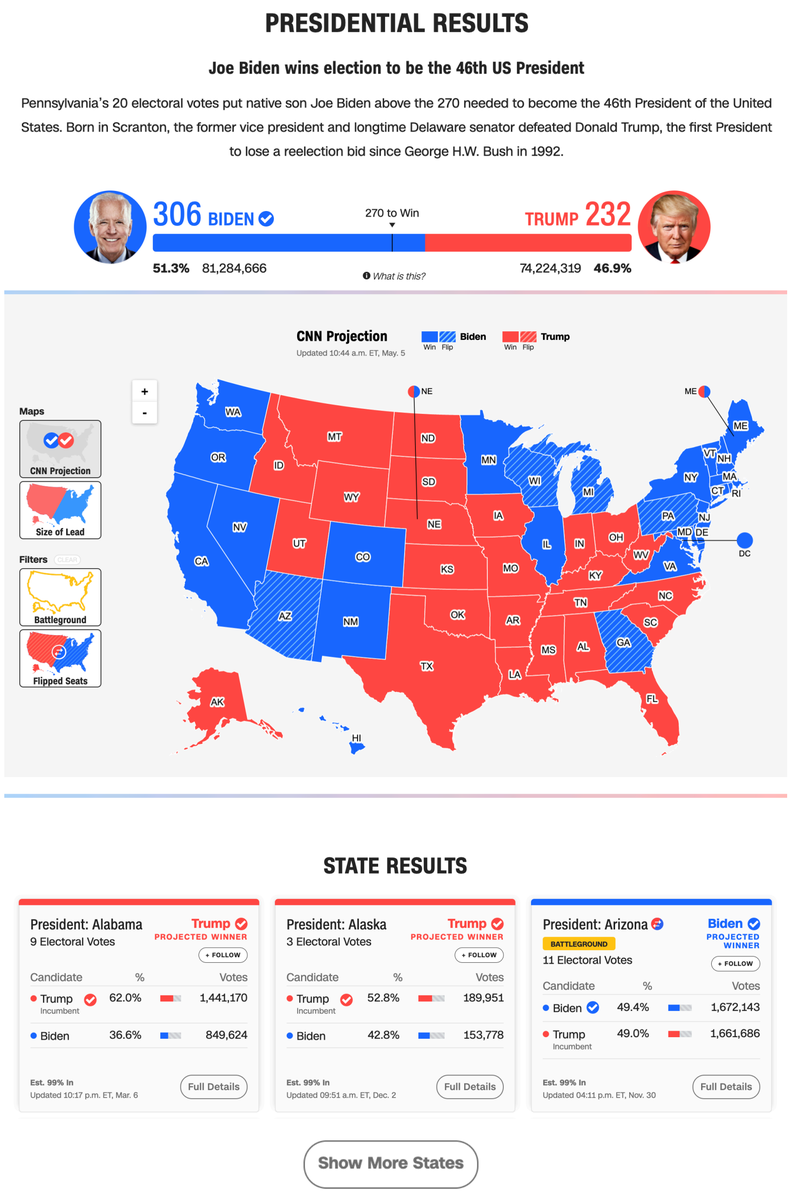
0 phrases have simpler alternatives.

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:**

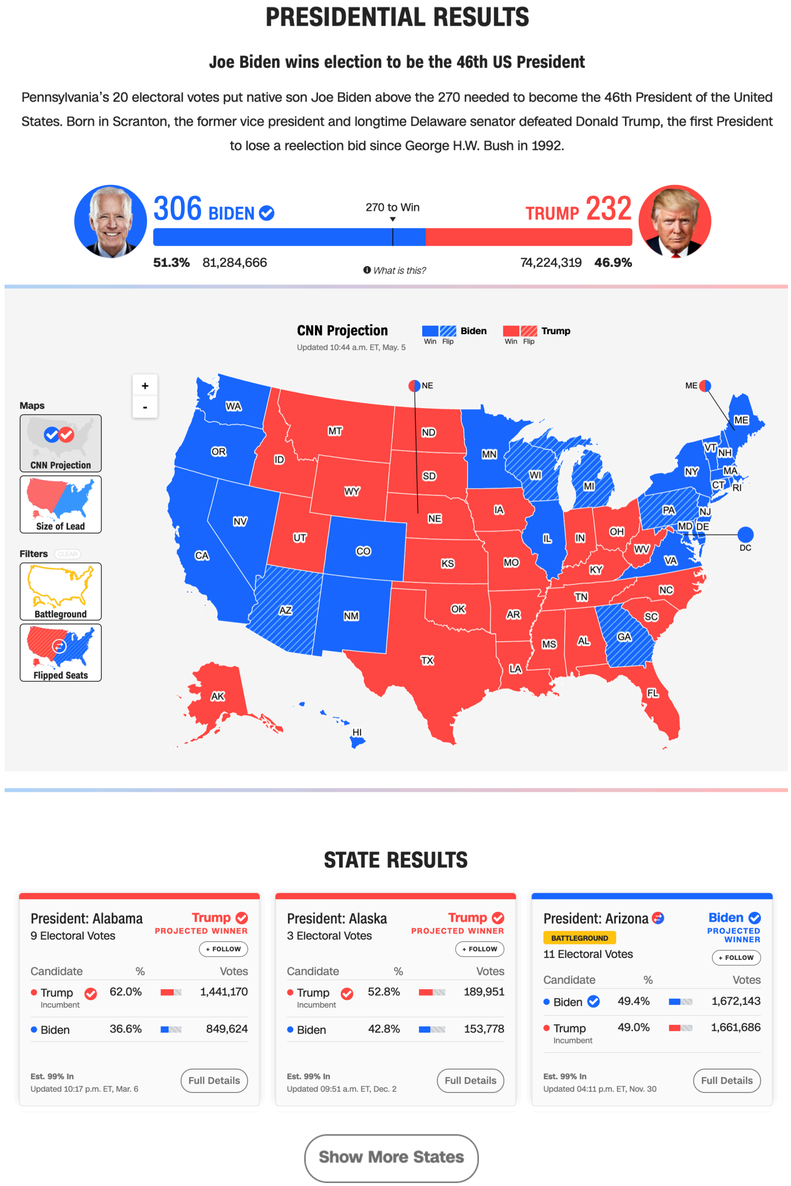
Robust,
Compromising,
Assistive,
and Flexible

# 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

# My work

Past:

Visa Chart Components, a library of charts

Chartability, a set of guidelines

Latest:

Data Navigator!

Current:

*(secret project)*

2024

frank.computer

★Slides here

# Accessibility and Visualization

## An introduction.

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