YOW! 2025

frank.computer

From Charted to Uncharted Territory

Accessibility and Interactive Data Experiences

Frank Elavsky

Human-Computer Interaction Institute

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

Understanding perception *of* language

Set 1		Set 2		Set 3		Set 4	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

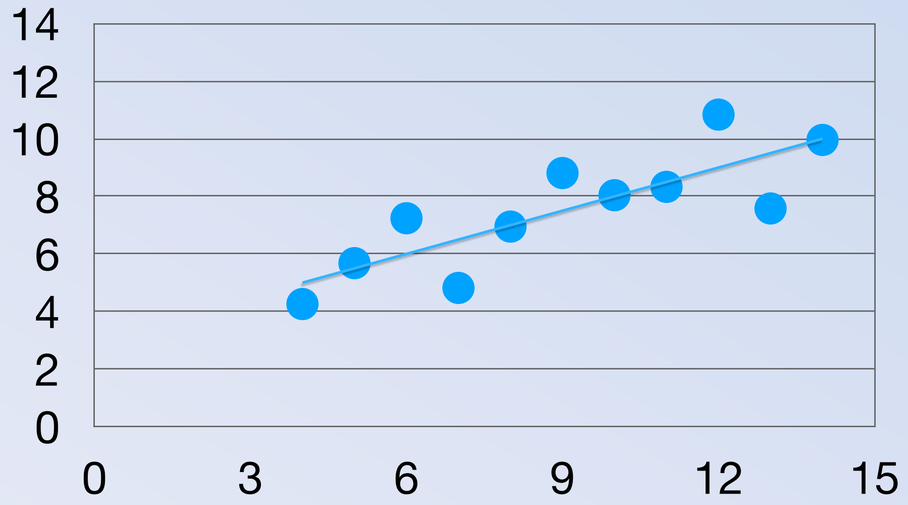
Summary Statistics **Linear Regression**

$u_X = 9.0$ $\sigma_X = 3.317$ $Y^2 = 3 + 0.5\ X$

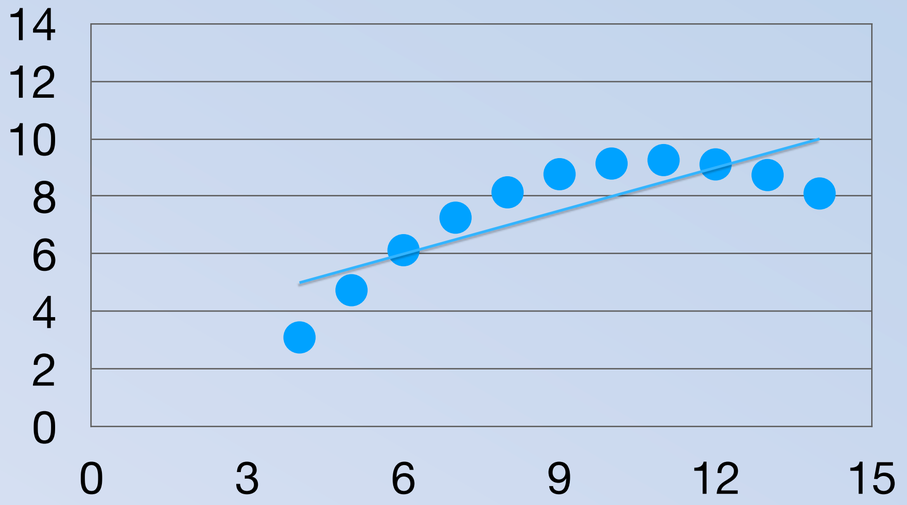
$u_Y = 7.5$ $\sigma_Y = 2.03$ $R^2 = 0.67$

[Anscombe 1973]

Set 1



Set 2



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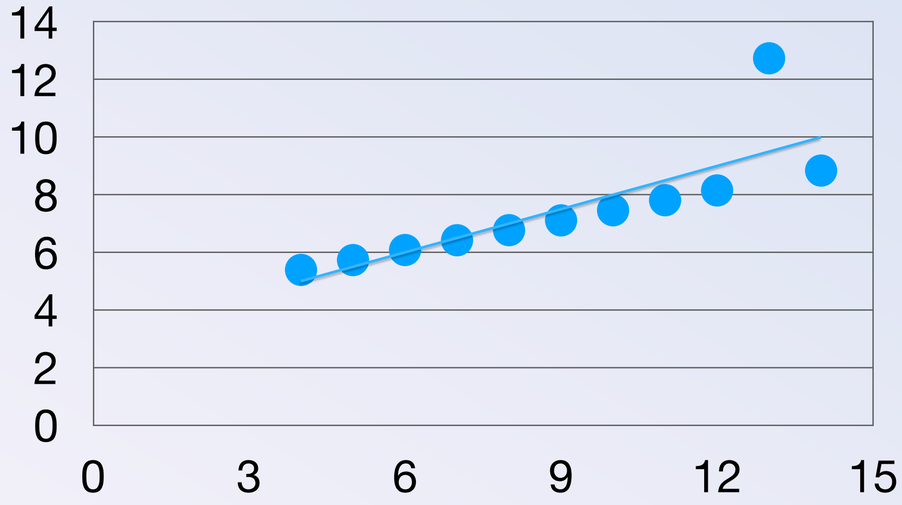

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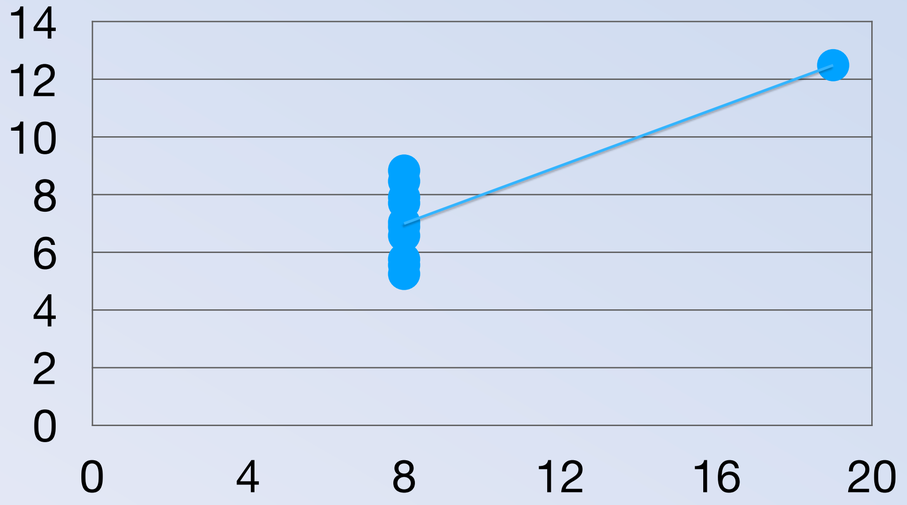
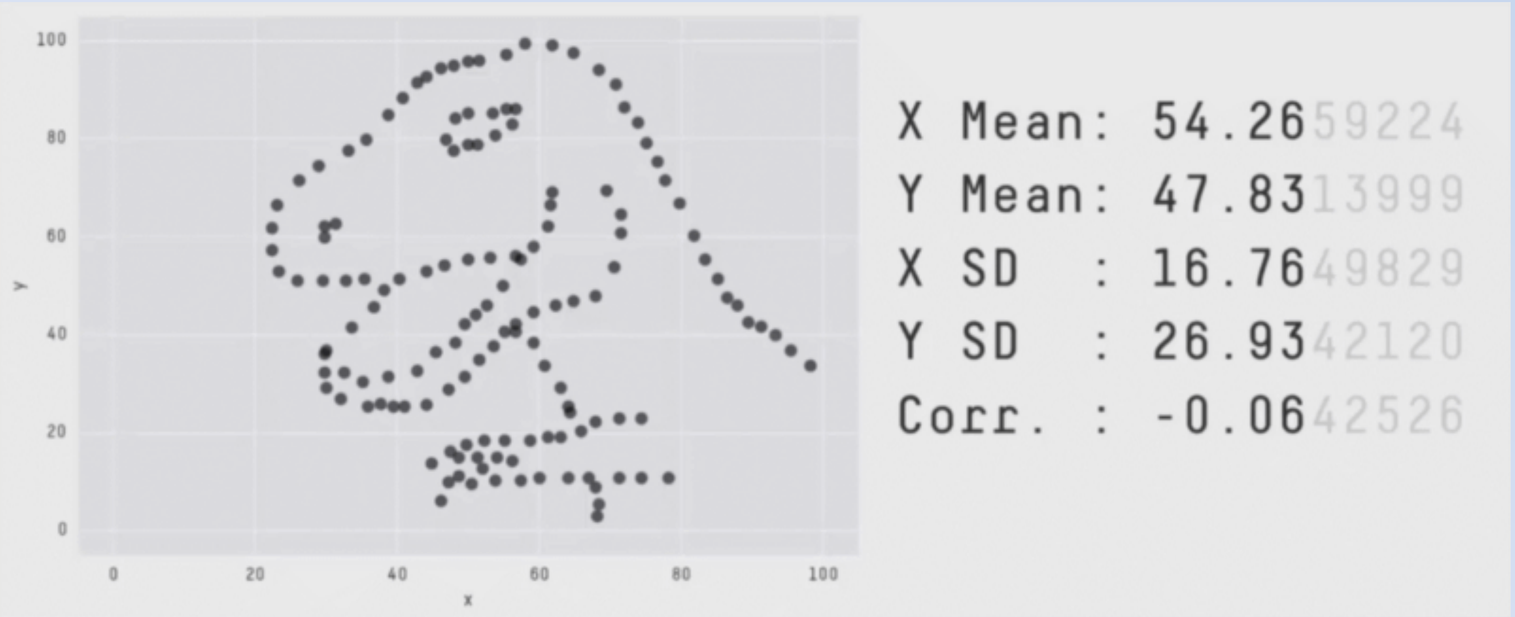




Animation inspired by Alberto Cairo's "Datasaurus Dozen" dataset

Agenda

1. **Why** (20%)
2. **What** (30%)
3. **How** (50%)

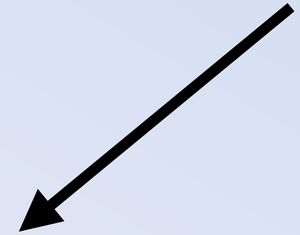
Agenda

1. **Why** (0%)
2. **What** (0%)
3. **How** (100%)

Agenda

1. **Why** (0%)
2. **What** (0%)
3. **How** (100%)

By the end of this talk,
You'll be ready for this



Agenda

1. **Why** (20%)
2. **What** (30%)

---

3. **How** (50%)

Accessibility 101

Agenda

1. **Why** (20%)

Accessibility 101

2. **What** (30%)

---

3. **How** (50%)

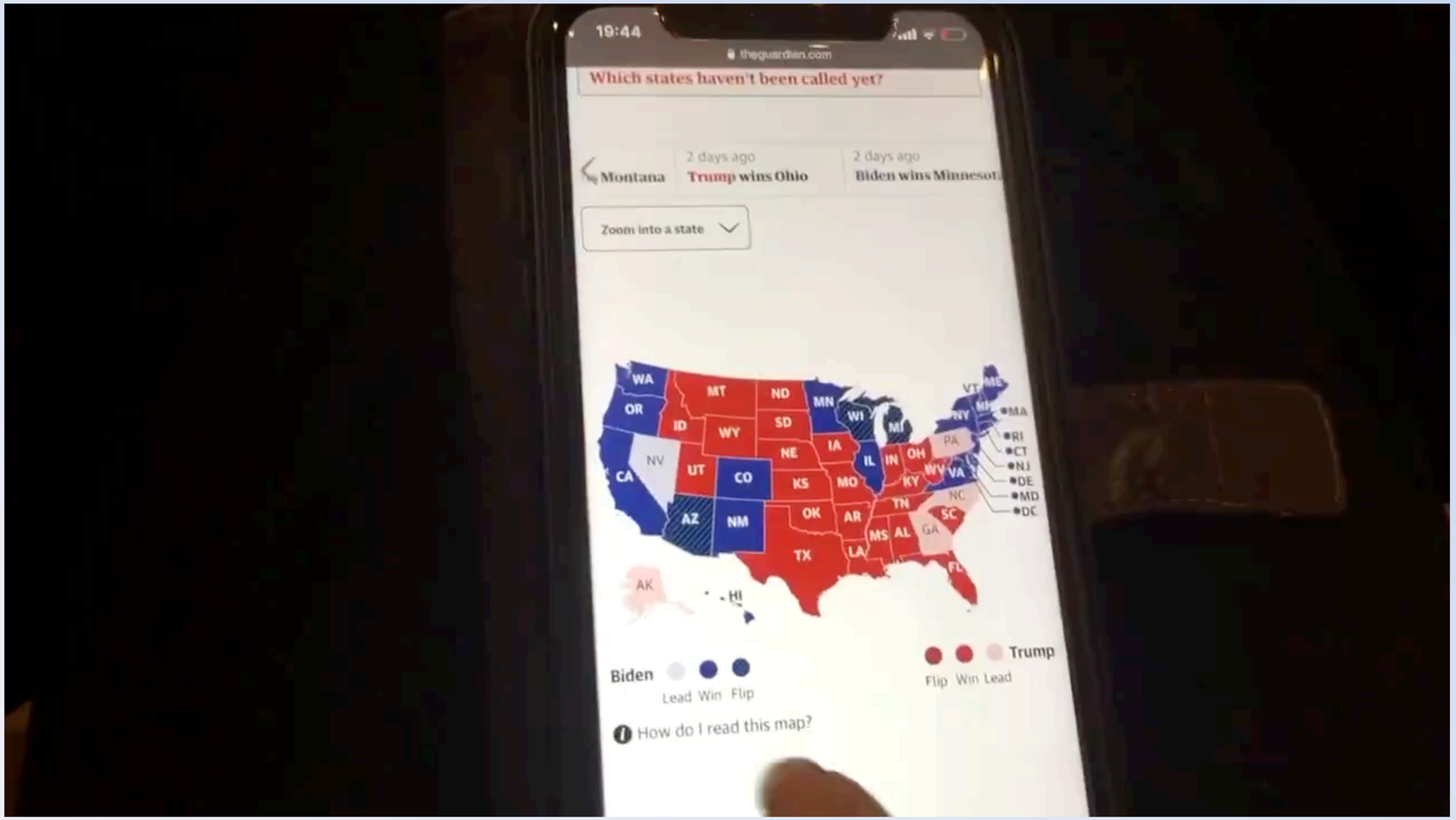
Vis+Accessibility 801

Why?

(Why do accessibility work? Why care?)

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

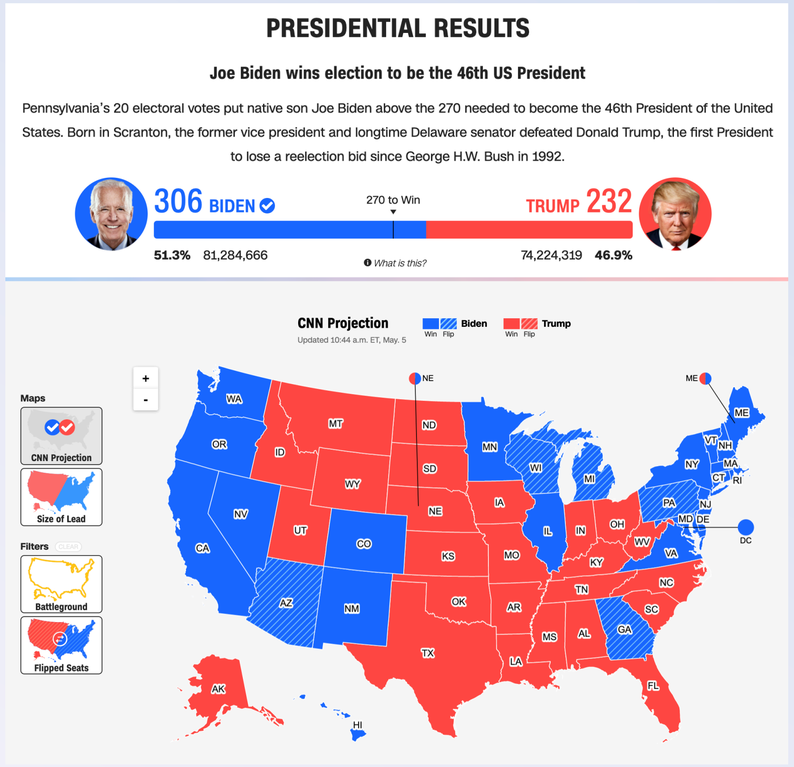
Accessibility is an internationally recognized human right.

It is the morally and ethically correct thing to do.

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

People with disabilities deserve to:

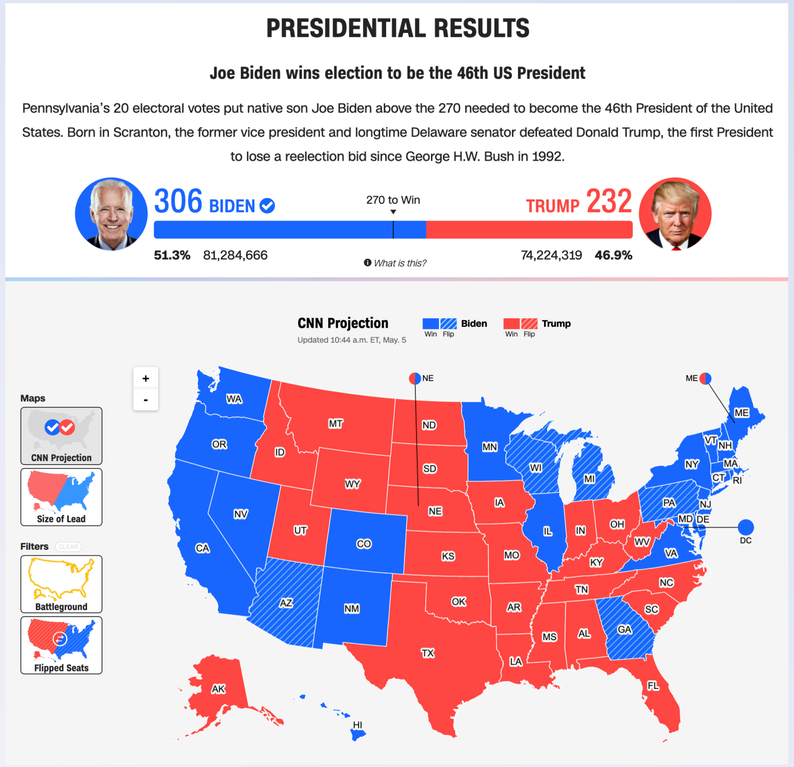
Participate in politics



Credit: CNN

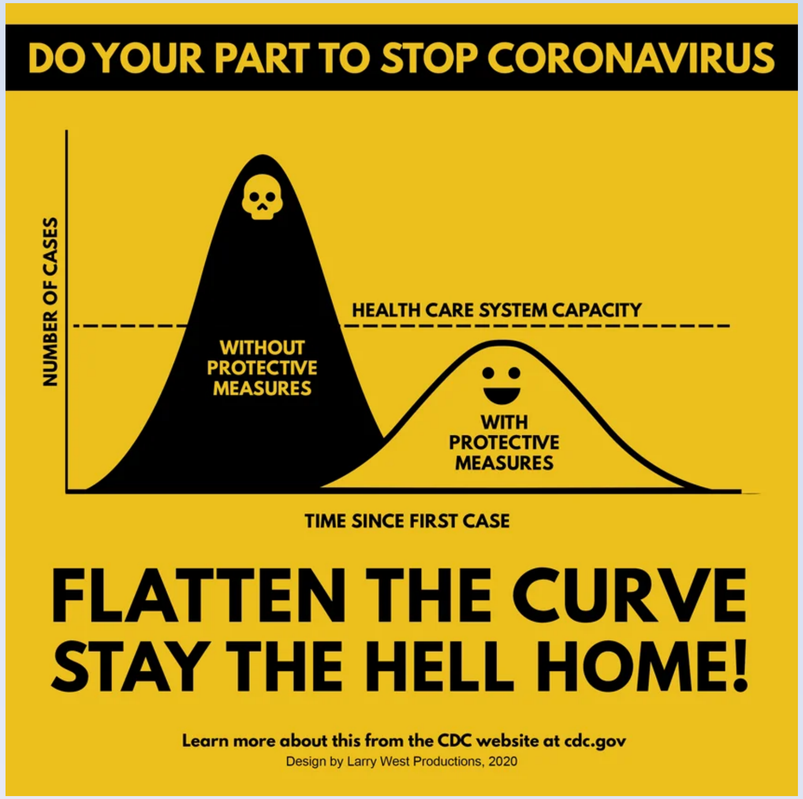
People with disabilities deserve to:

Participate in politics



Credit: CNN

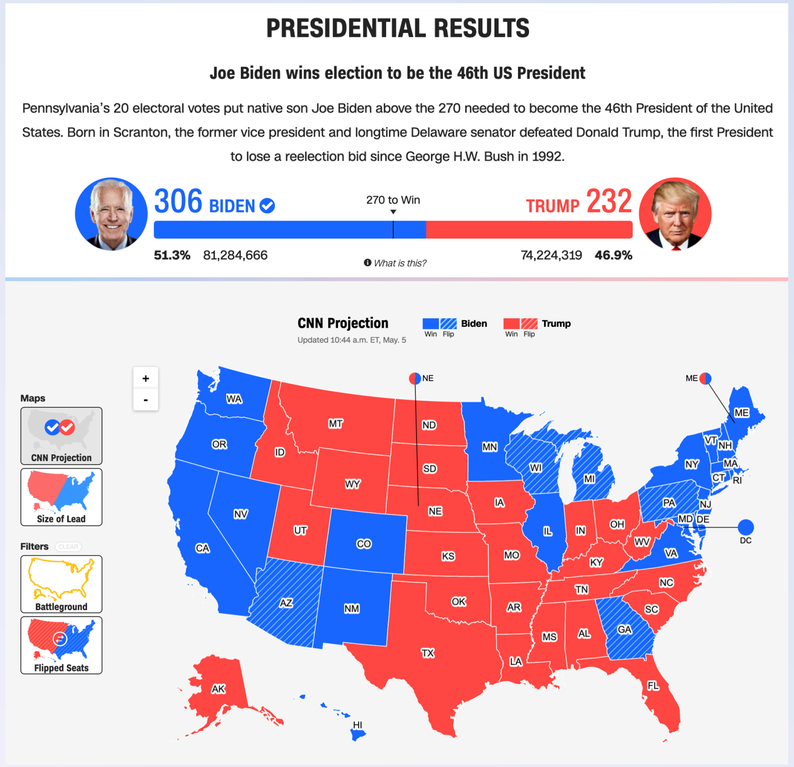
Make informed decisions



Credit: Reddit

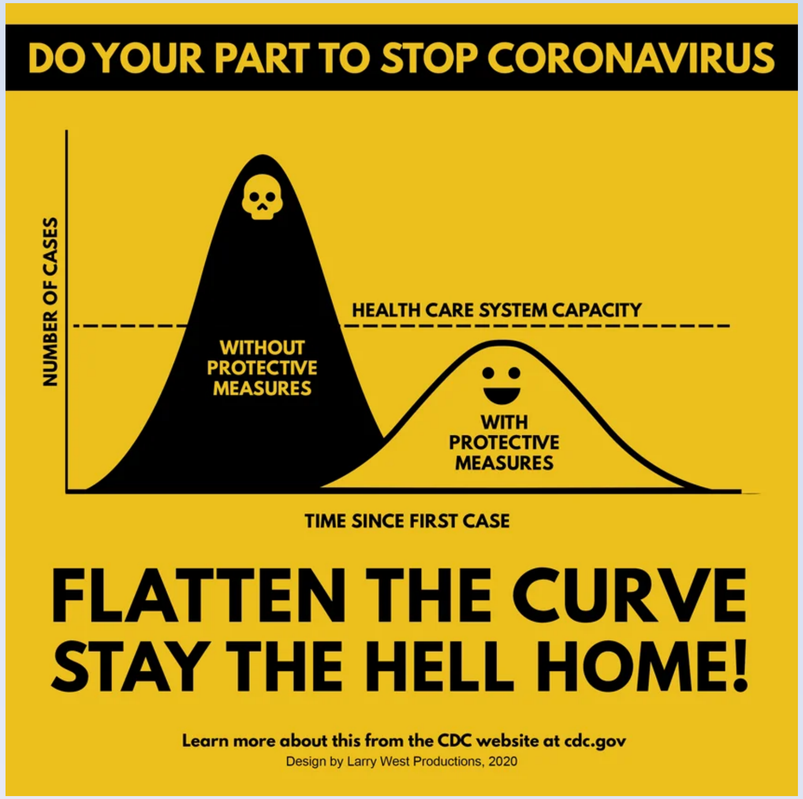
People with disabilities deserve to:

Participate in politics



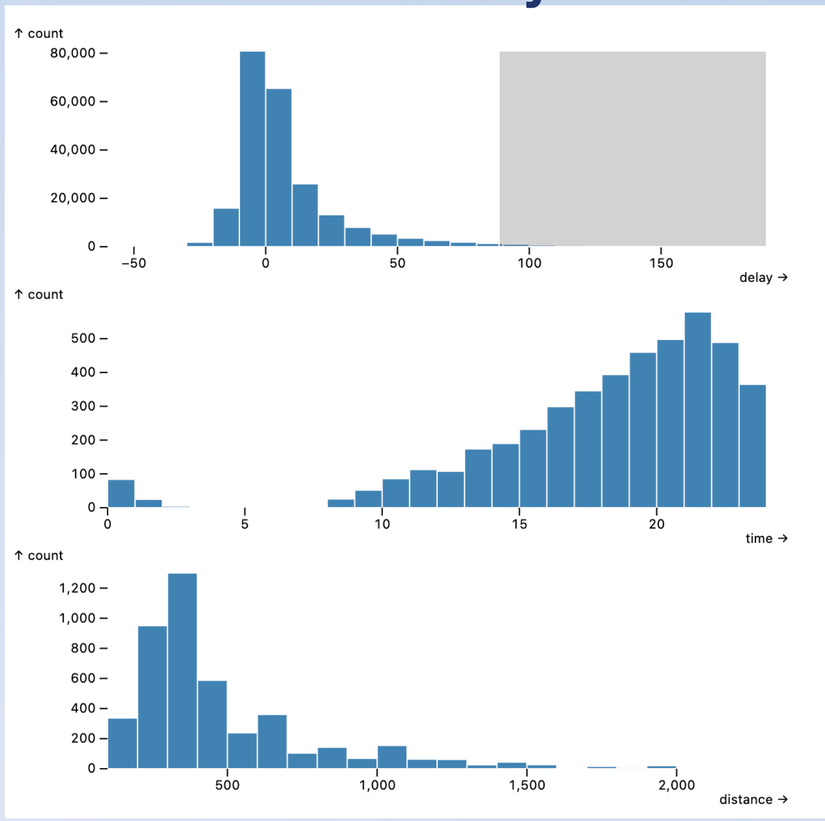
Credit: CNN

Make informed decisions

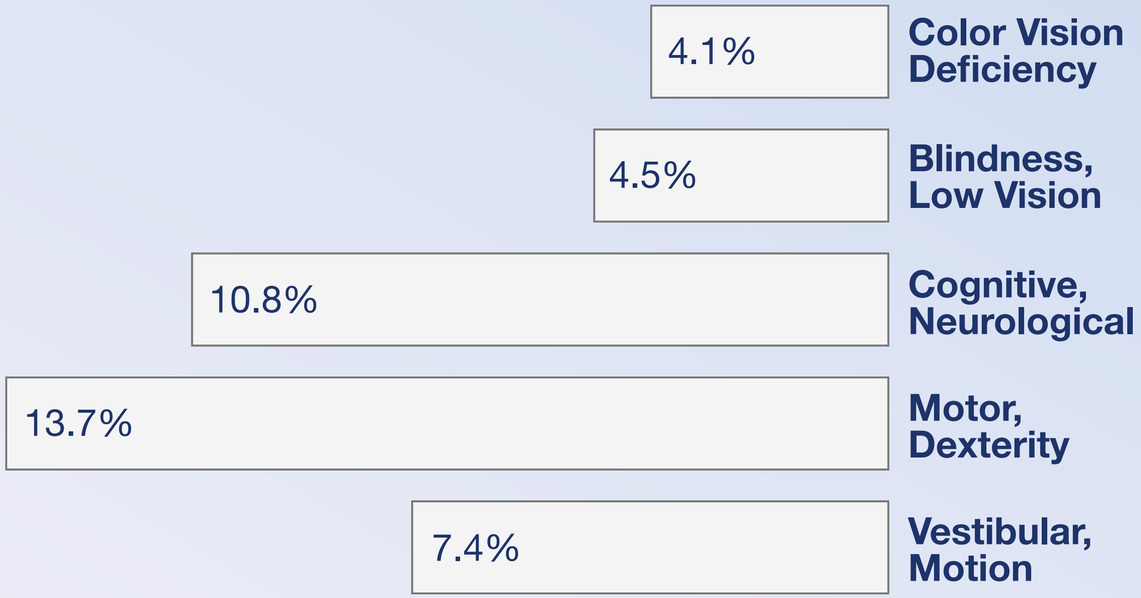


Credit: Reddit

Analyze data quickly and efficiently



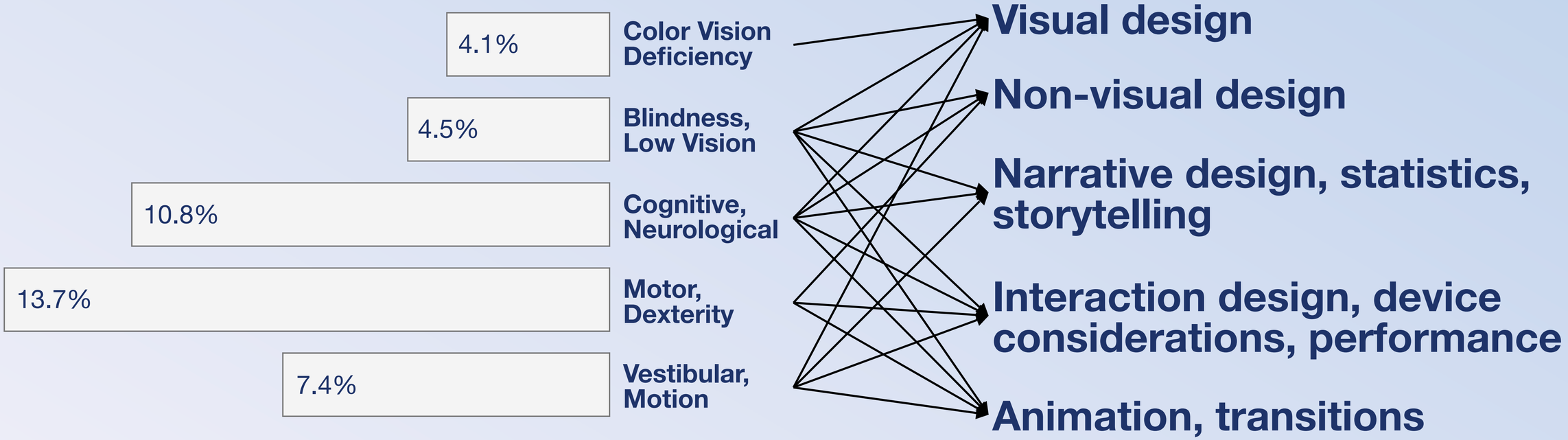
Credit: Our research

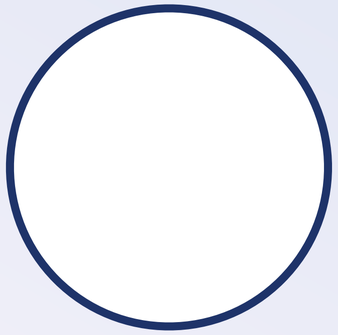


Source: Okoro et al. “Prevalence of Disabilities and Health Care Access by Disability Status and Type Among Adults”

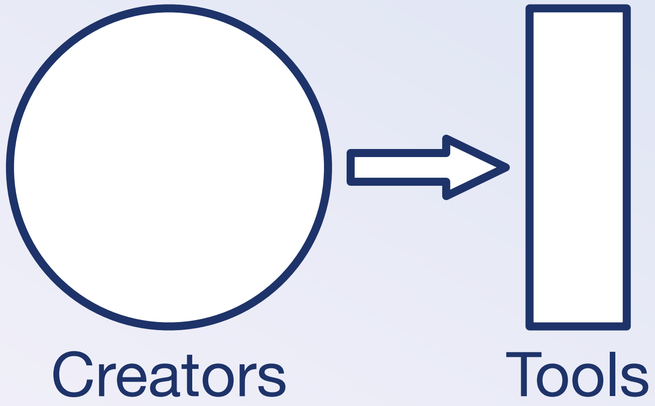
~27% of people living in the United States self-report living with a disability that affects their daily life.

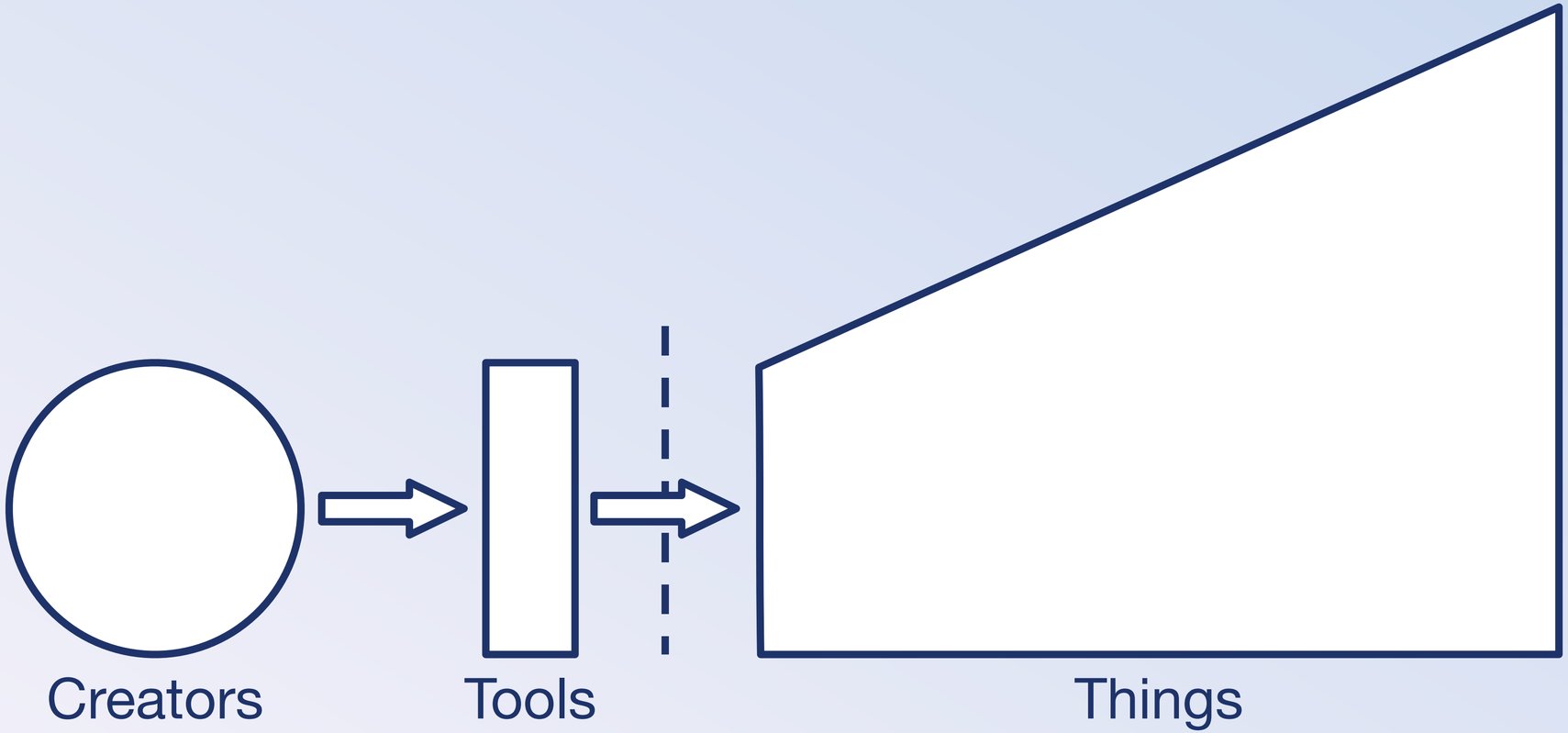
Accessibility affects every aspect of visualization work

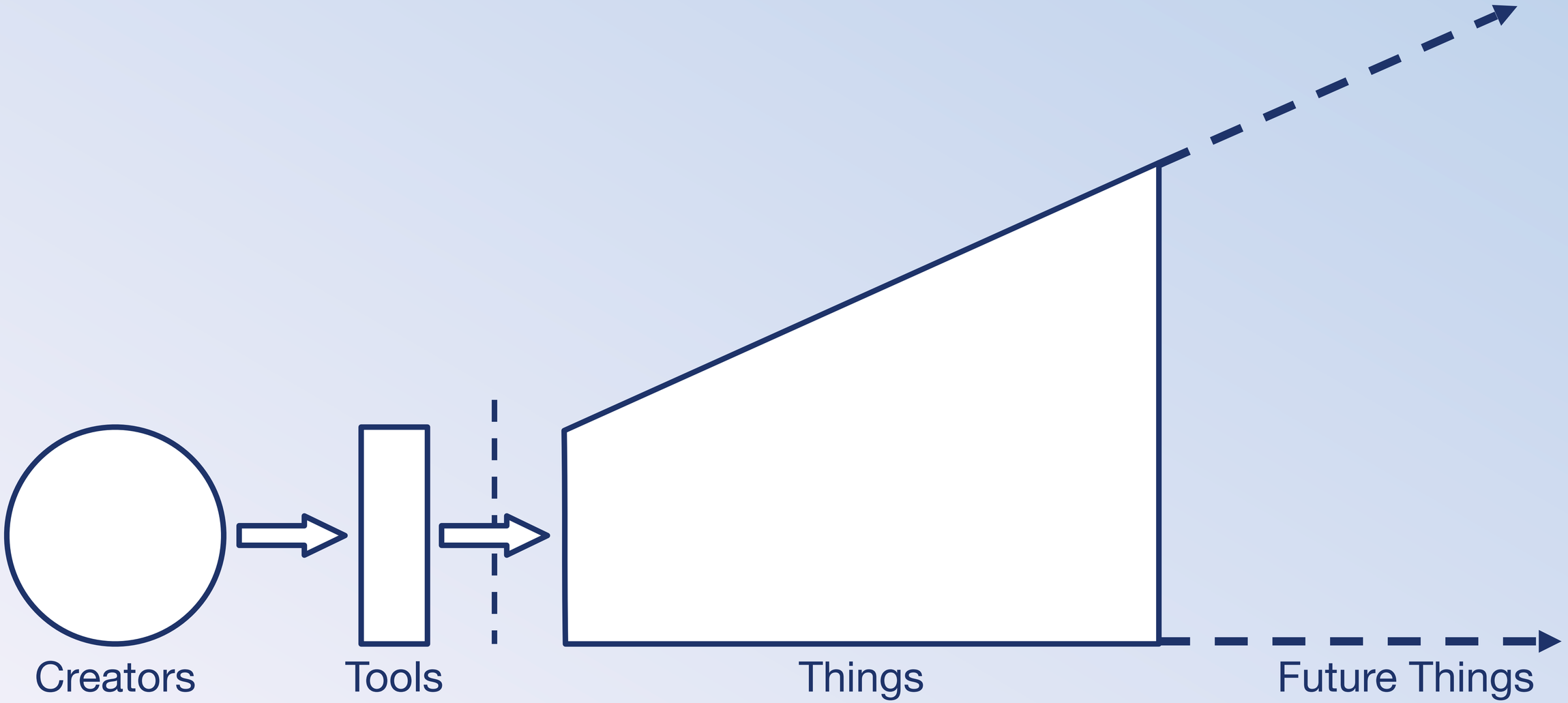




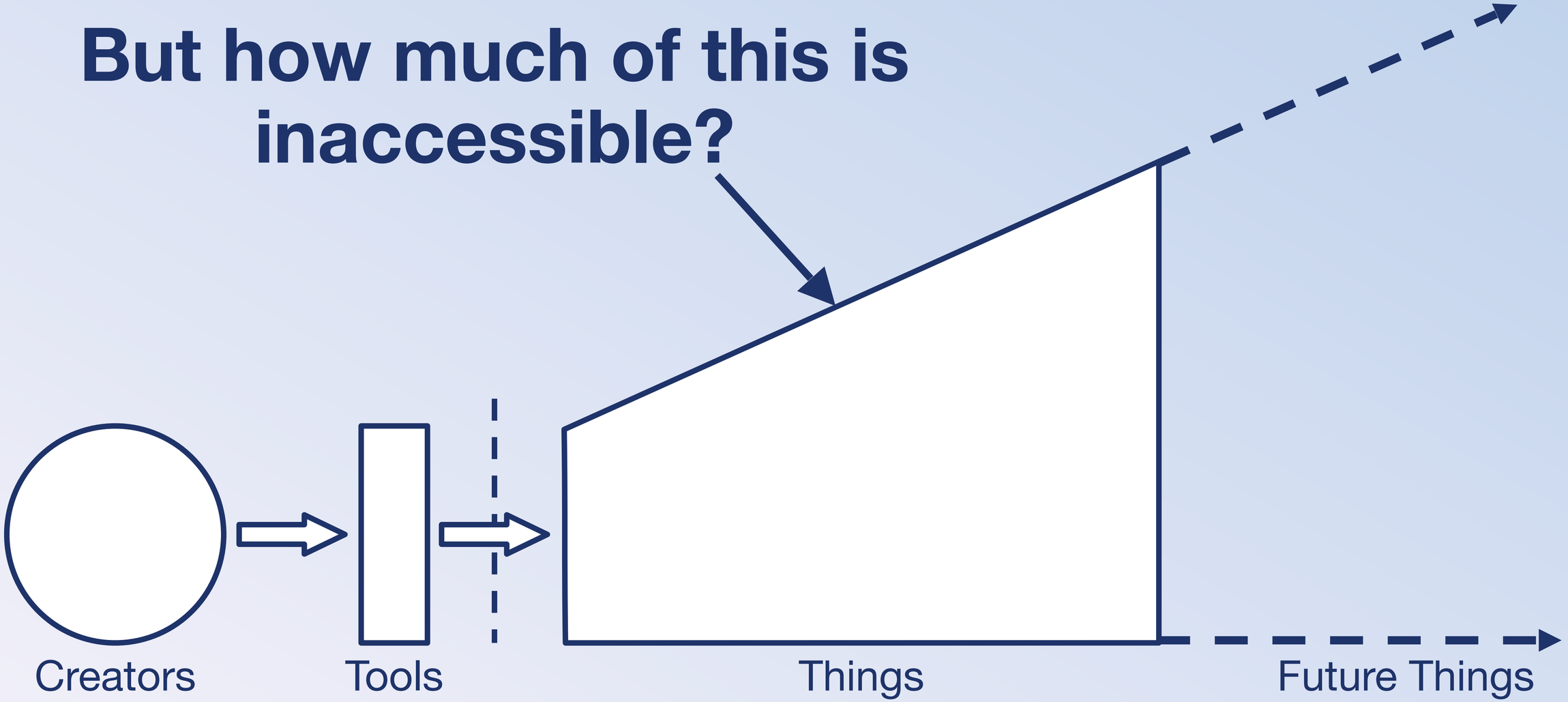
Creators


Creators
Tools


Creators
Tools
Things

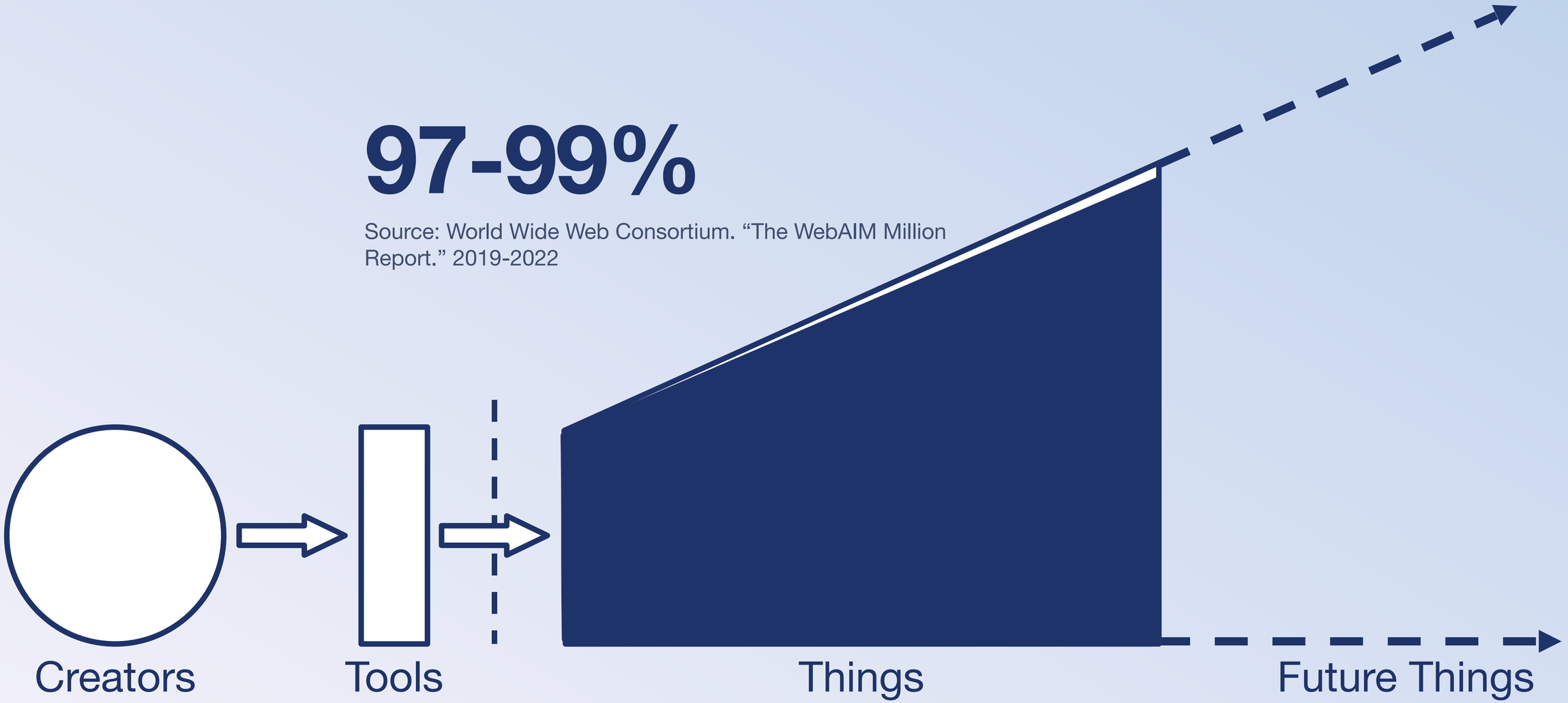

Creators
Tools
Things
Future Things

But how much of this is inaccessible?



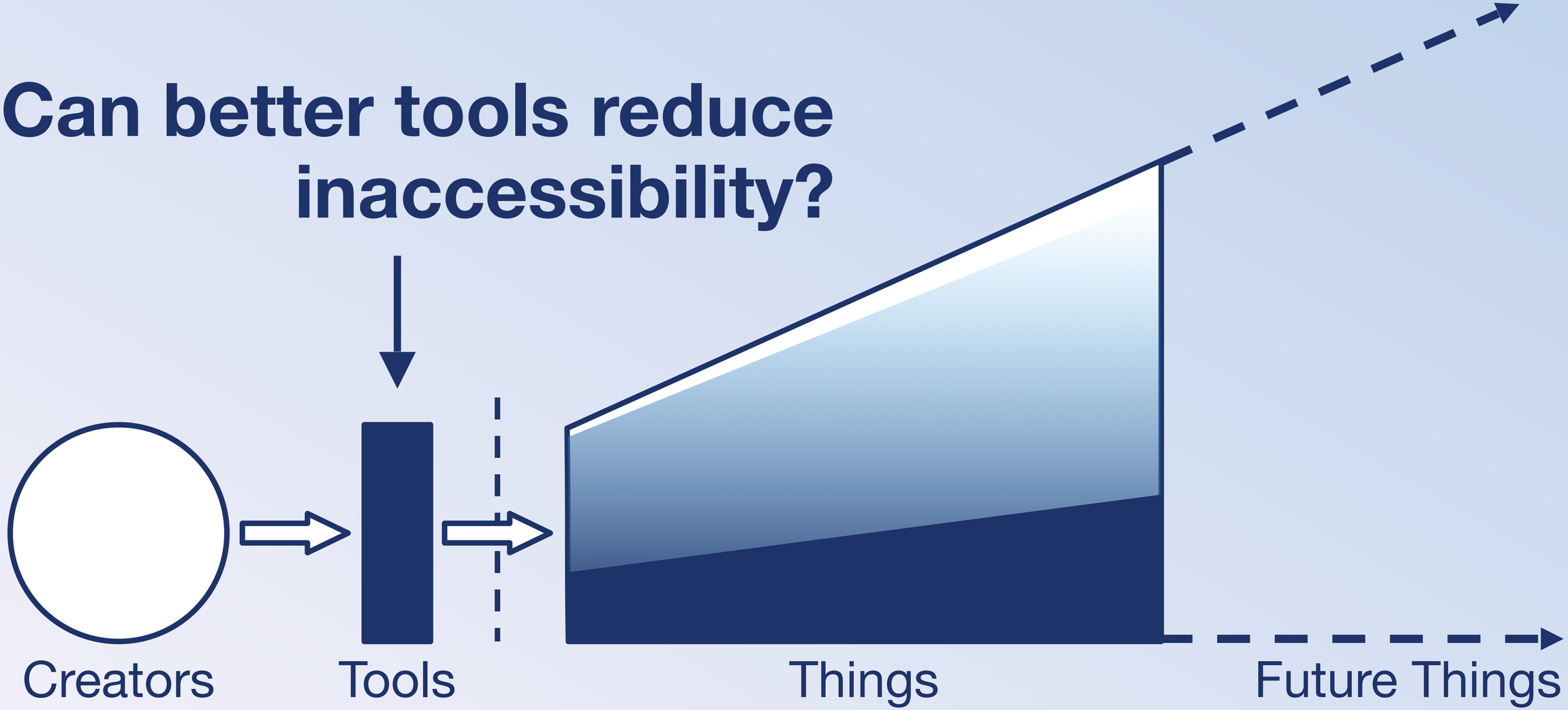
97-99%

Source: World Wide Web Consortium. “The WebAIM Million Report.” 2019-2022



The builders and the makers (*that's us*) are responsible for access.

Can better tools reduce inaccessibility?



What

(What is “disability?” What are the ways we should think about disability?)

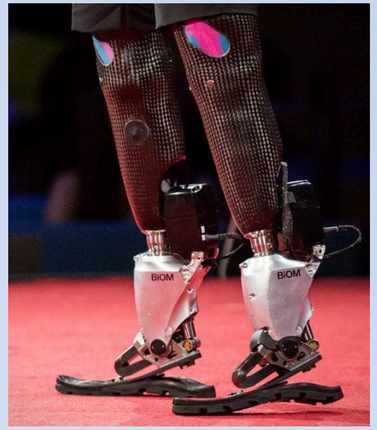
Concept(s): **social** vs **medical** models of disability

a “curb”

What do we do about curbs in our cities?

Medical model: the body is the cause of disability (according to normative standards).

Medical model: augment or “cure” the body.



Social model: The *curb* is the source of disability (a “barrier” to access).

Social model: Cut the curb and standardize.

Concept: **Situational Impairment**

Permanent

Touch

One arm

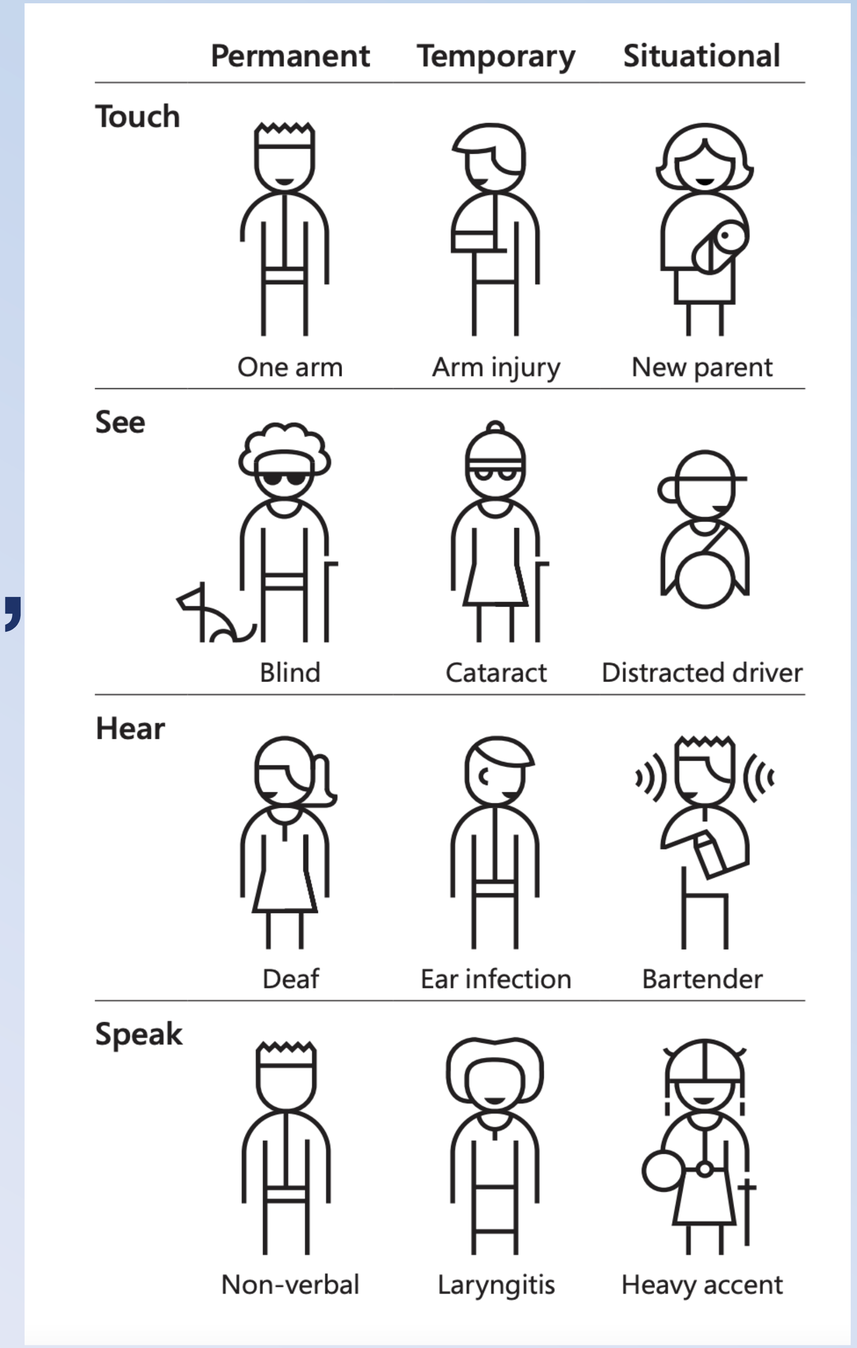
	Permanent	Temporary
Touch		
	One arm	Arm injury

	Permanent	Temporary	Situational
Touch			
	One arm	Arm injury	New parent

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

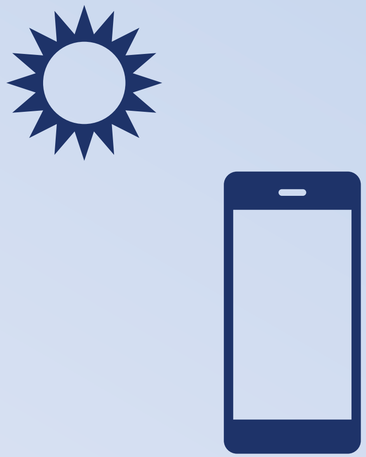
	Permanent	Temporary	Situational
Touch			
	One arm	Arm injury	New parent

“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

Consider: an example where you face a barrier in some way and how accessible technology or infrastructure helps you.



Consider: an example where you face a barrier in some way and how accessible technology or infrastructure helps you.

Consider: an example where you face a barrier 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**

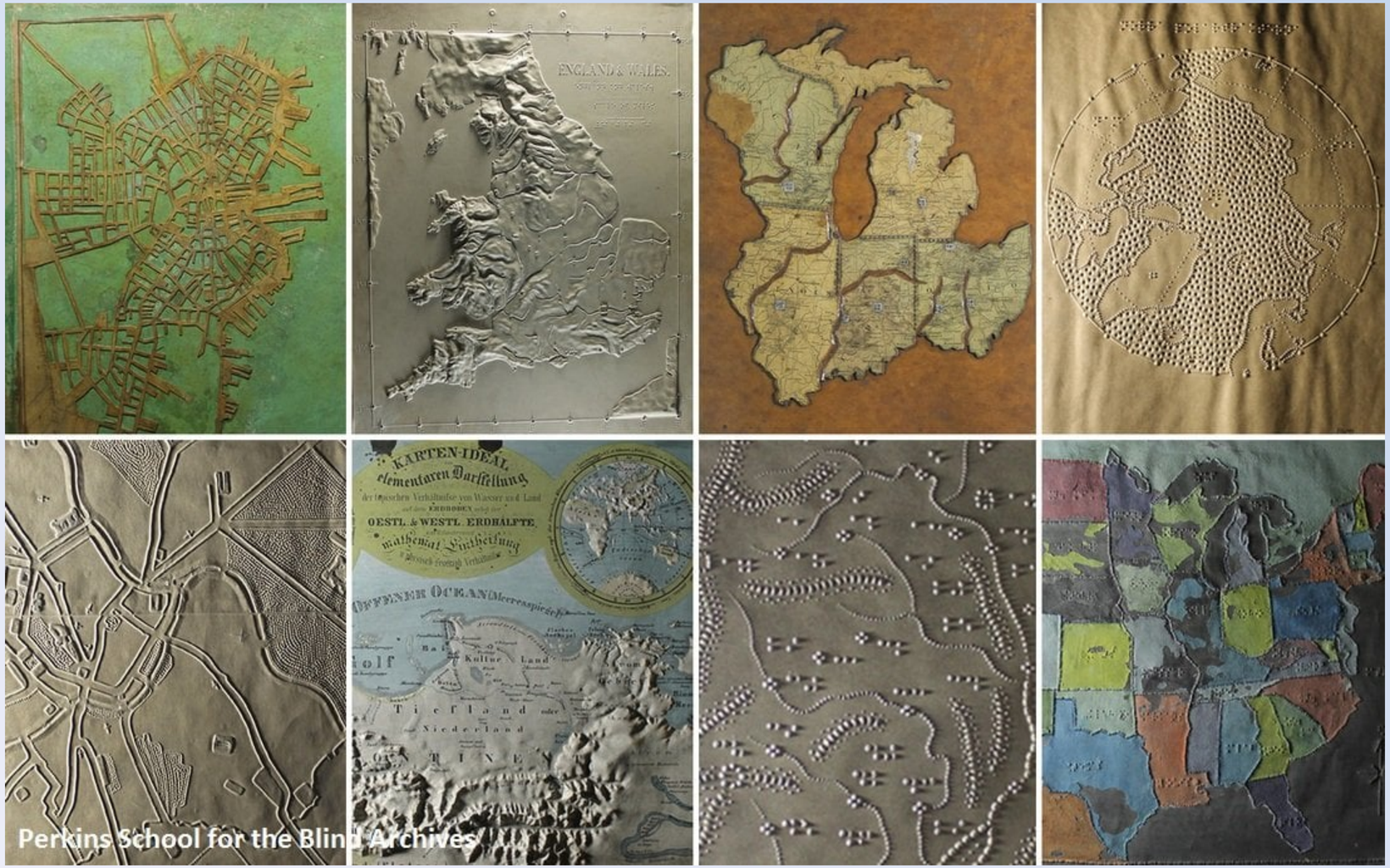
“Nothing about us without us”

And the 1977 504 sit-in.

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

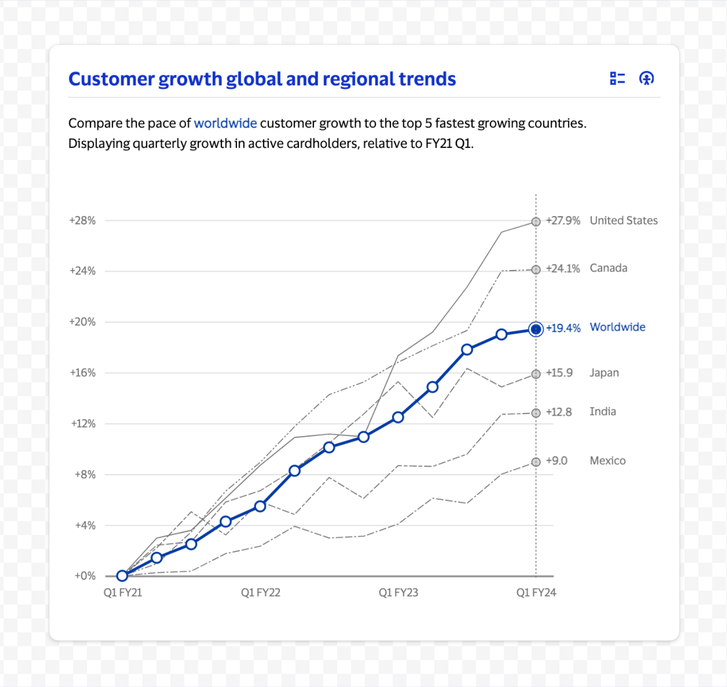
	Permanent	Temporary	Situational
Touch	 One arm	 Arm injury	 New parent

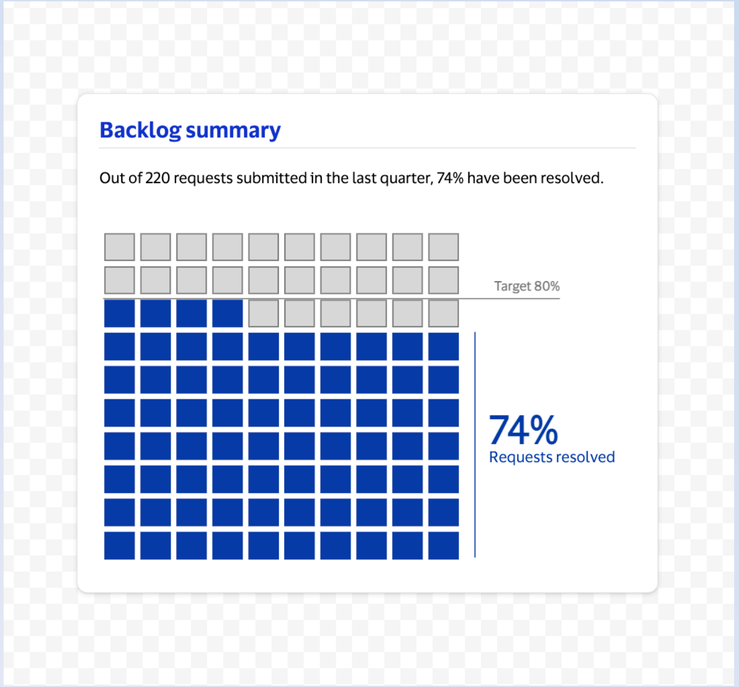
The best work *centers* on people with disabilities

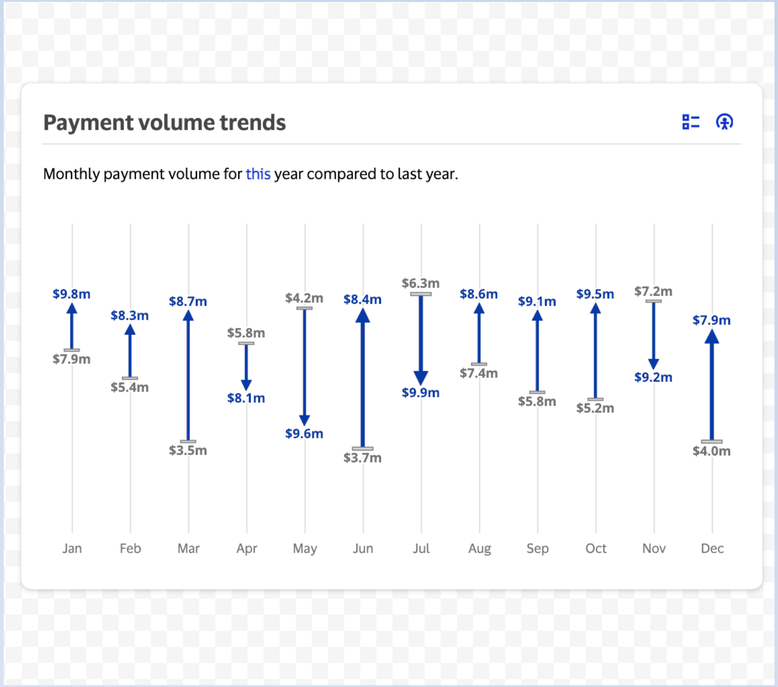


Perkins School for the Blind Archives, with tactile maps dating back to the early 1800s

Prior work: Staff-level engineer making a visualization library







Visa Chart Components, Visa Design System

“Five 9s” of speed and scale

Better for merchants

2.97%

higher approval rate

Merchants leveraging the Visa Acceptance Platform saw 2.97% higher approval rate.[1]

70bps

in lower fraud

Merchants leveraging the Visa Acceptance Platform saw 70 bps in lower fraud.[1]

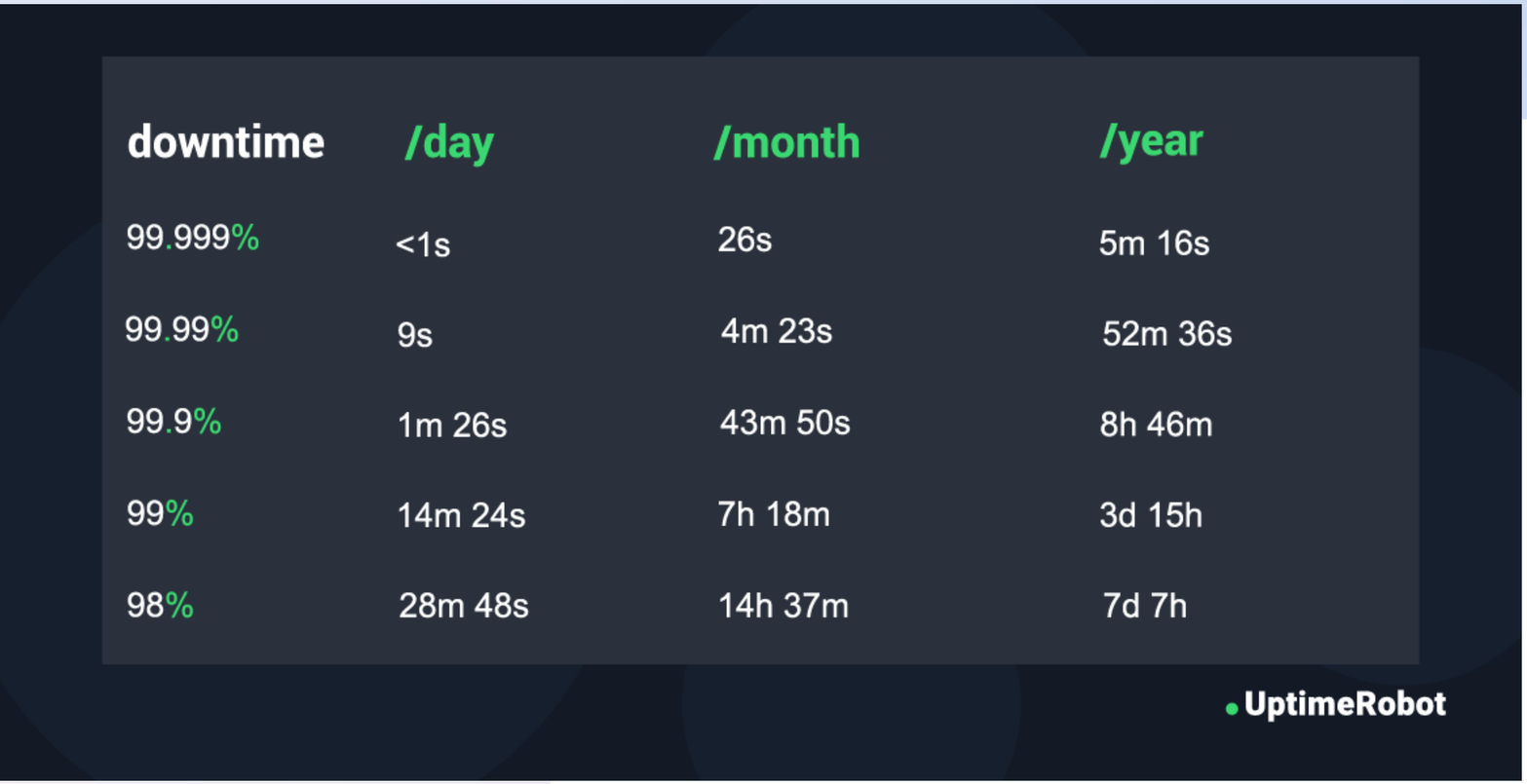
99.999%

uptime

Active-active architecture with 99.999% uptime helps ensure business continuity and means fewer interruptions to essential services.[2]

Visa’s Acceptance Platform Uptime

“Five 9s” of speed and scale



Uptime Robot

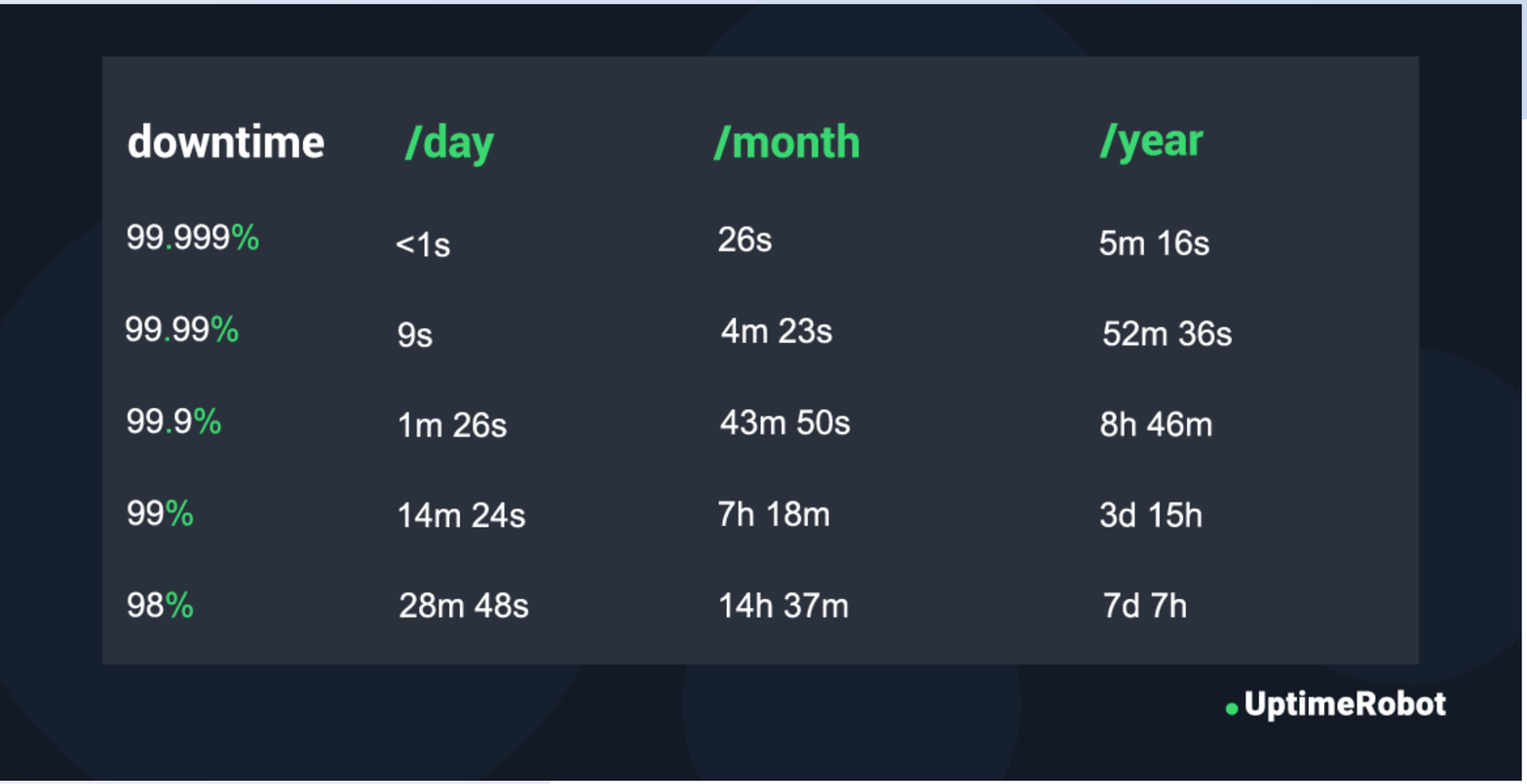
99.999%

uptime

Active-active architecture with 99.999% uptime helps ensure business continuity and means fewer interruptions to essential services.[2]

Visa’s Acceptance Platform Uptime

“Five 9s” of speed and scale



downtime	/day	/month	/year
99.999%	<1s	26s	5m 16s
99.99%	9s	4m 23s	52m 36s
99.9%	1m 26s	43m 50s	8h 46m
99%	14m 24s	7h 18m	3d 15h
98%	28m 48s	14h 37m	7d 7h

UptimeRobot

Uptime Robot

99.999%

uptime

Active-active architecture with 99.999% uptime helps ensure business continuity and means fewer interruptions to essential services.[2]

233b

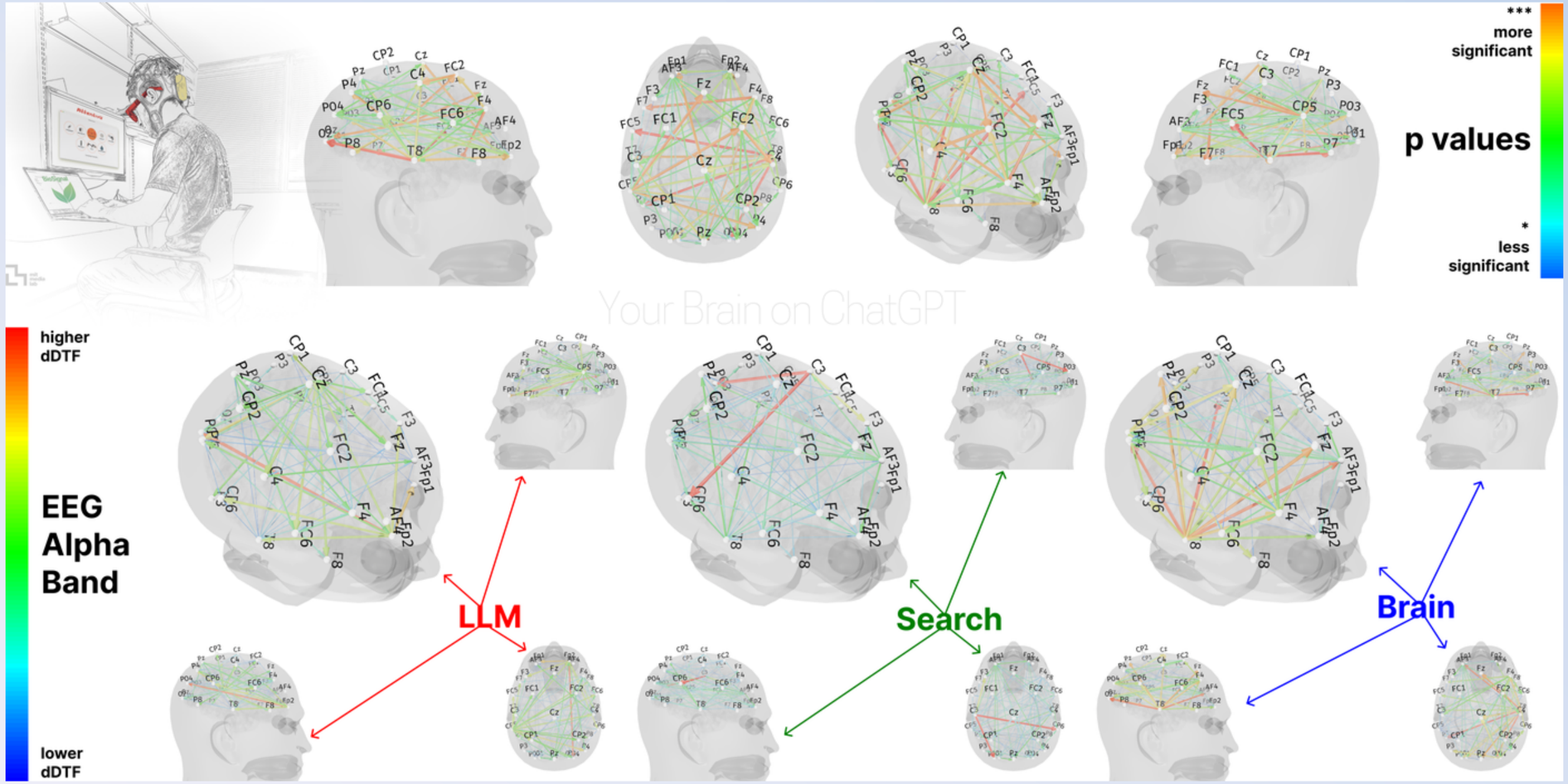
transactions/year

Visa’s 2024 Report

Visa’s Acceptance Platform Uptime

One of my big gripes with any tech focused on speed?

Automation changes our brain

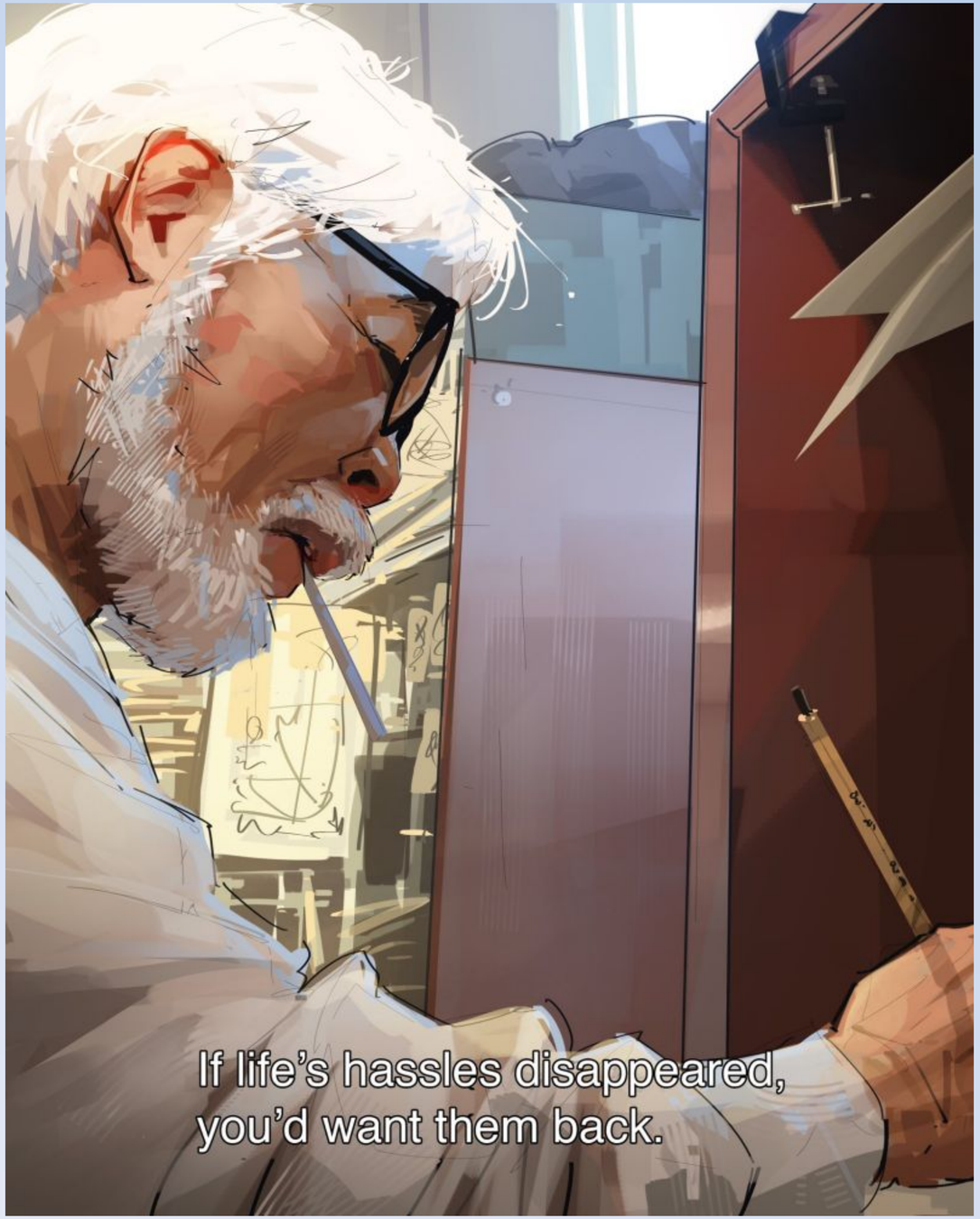


"Your Brain on ChatGPT: Accumulation of Cognitive Debt when Using an AI Assistant for Essay Writing Task"

Automatic accessibility validation

```
▸ bar-chart-1 has strong accessibility recommendations                                  bar-chart.entry.js:49478
▾ bar-chart-2 has accessibility warnings and other messages                             bar-chart.entry.js:49497
⚠ ▸ longDescription: Either accessibility.longDescription or accessibility.contextExplanation is required   bar-chart.entry.js:49499
⚠ ▸ executiveSummary: Either accessibility.purpose or accessibility.executiveSummary is required            bar-chart.entry.js:49499
⚠ ▸ elementsAreInterface: elementsAreInterface must be a `boolean` type, but the final value was:           bar-chart.entry.js:49499
  `null`.
  If "null" is intended as an empty value be sure to mark the schema as `.nullable()`
  longDescription: Either accessibility.longDescription or accessibility.contextExplanation should have minimum 40 characters and a combined length between 40 and 500 characters   bar-chart.entry.js:49481
  executiveSummary: Either accessibility.purpose or accessibility.executiveSummary should have minimum 40 characters and a combined length between 40 and 250 characters   bar-chart.entry.js:49481
  statisticalNotes: accessibility.statisticalNotes should have length between 40 and 250 characters   bar-chart.entry.js:49481
  structureNotes: accessibility.structureNotes should have length between 40 and 250 characters   bar-chart.entry.js:49481
```

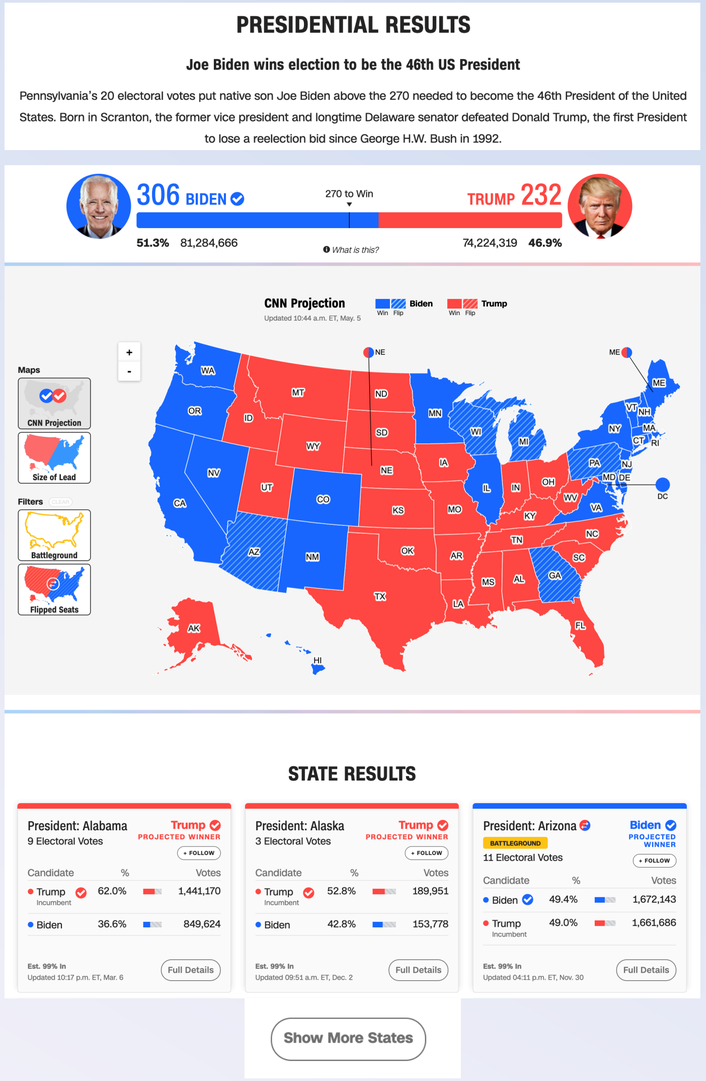
“If life’s hassles disappeared, you’d want them back”
- Hiyao Miyazaki



Art credit: Sam Yang

How

(Or, how to hassle yourself and expand your neurons for a good reason.)



How do you find and evaluate access barriers in interactive visualizations?

Chartability is a workbook of tests, tools, and principles

How do you use Chartability?

There are a lot of different ways to perform an audit, and so there are also many different ways to use Chartability. Sometimes an audit is as casual as checking your work while you do it. And other times it is a big affair that involves teams of specialists and lawyers.

Realistically, while a highly trained auditor may be able to casually evaluate an artifact in as little as 30 minutes or even hold heuristics in mind as they are doing their own creative work, those new to auditing may take anywhere between 2 and 8 hours to complete a full pass of Chartability. Professional audits, which can take weeks or months, often include multiple auditors and provide rigorous documentation and detailed recommendations for remediation, typically in the form of a report. Chartability is meant to serve both quick pass and deep dive styles of audits, so users are expected to leverage it as they see fit.

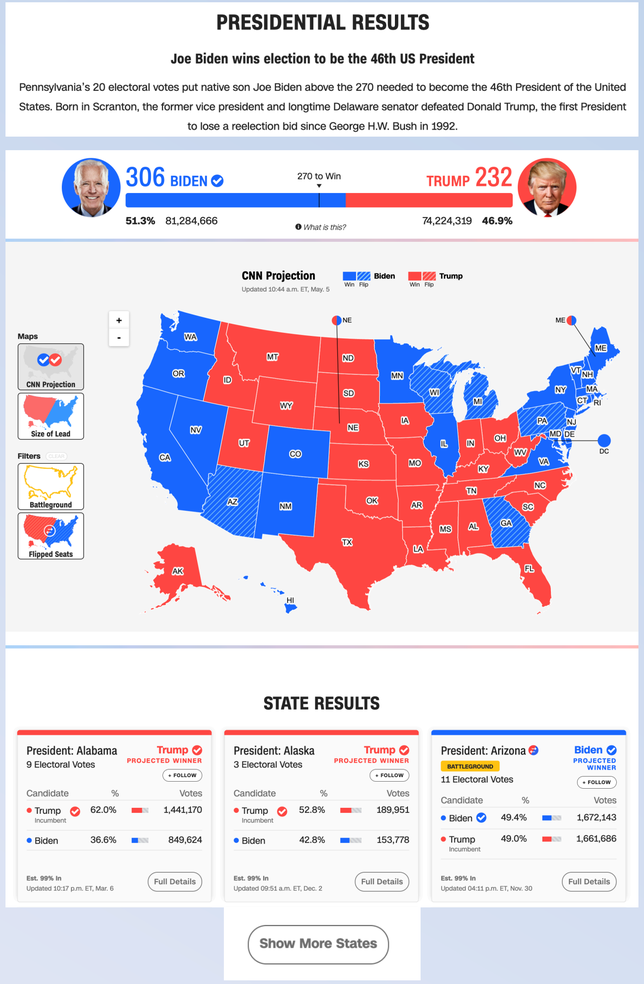
Below we give an example of what might be a fast pass audit, using Chartability, in 5 steps. This isn't super thorough, but a good way to quickly check a handful of access barriers quickly.

1. Visual Testing

Contrast Checker

Figure 1: A low contrast chart (left) compared to a higher contrast version (right). A dropper tool is extracting the fill color of the bar and then a contrast ratio has been calculated. Note that the fill color is the same on both bars, but darker borders have been added to ensure the visualization passes contrast tests.

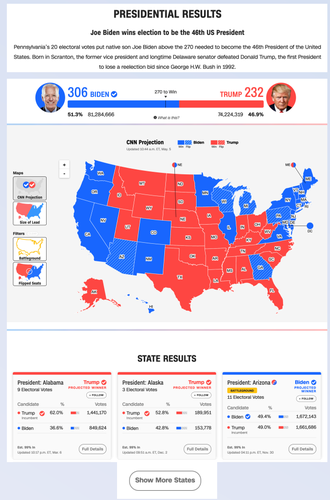
Checking for contrast is the most common critical failure across all of our audits (88% of audits failed this heuristic). In order to evaluate contrast, often a combination of automatic (code-driven) and manual tooling is performed. When manually auditing, practitioners typically use a dropper and a contrast calculator (Figure 1). Contrast is measured by finding adjacent colors that are intended to convey meaning or boundaries, and finding a ratio between them. Standards require a different minimum contrast for text (4.5:1) than geometries like marks in a chart (3:1). Most auditors find this to be one of the easiest tasks to perform, but techniques can be tricky to handle. Testing for contrast accomplishes 3 different heuristics in Chartability: ensuring text/geometries have contrast, interactive states for elements have enough contrast change, and the keyboard focus indicator is easy to distinguish.



F. Elavsky, C. Bennett, and D. Moritz, "How accessible is my visualization? Evaluating visualization accessibility with *Chartability*," Computer Graphics Forum, 2022.

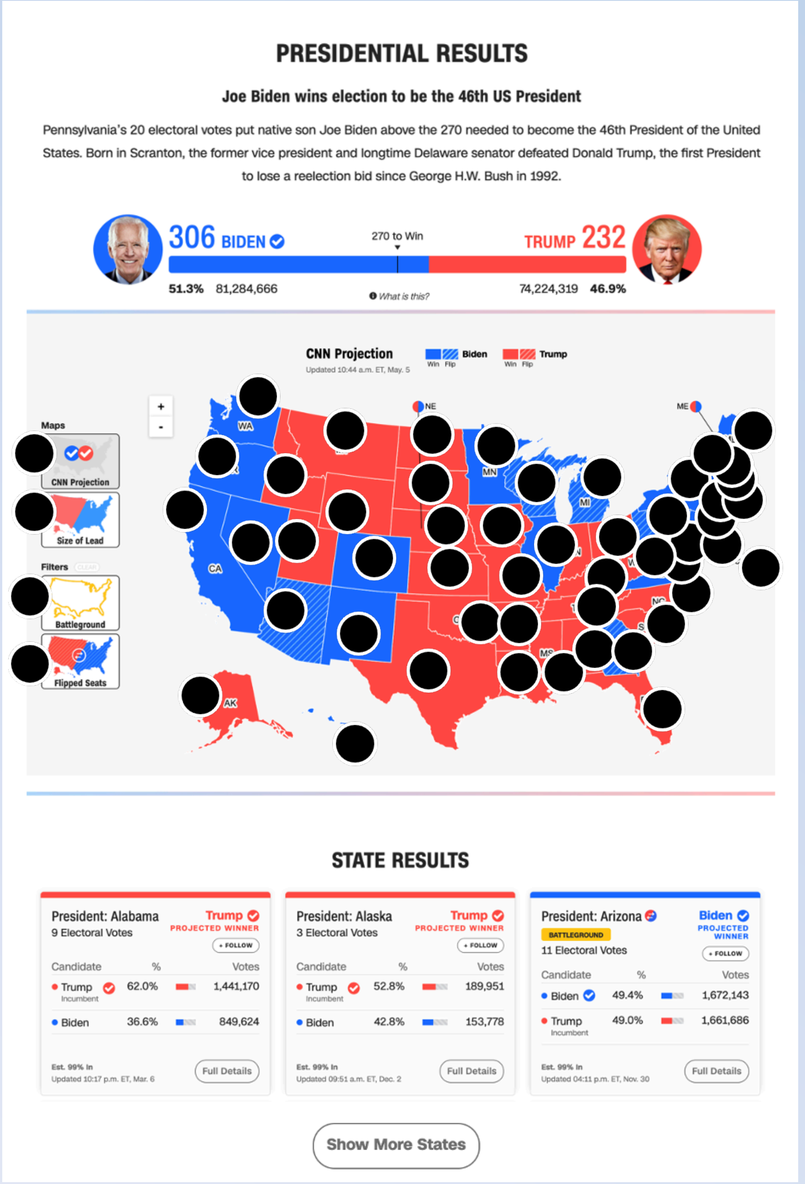
Chartability is a free, online resource

chartability.github.io/workbook



978 access barriers

Found in about an hour.



Chartability is used in:

15+ Policy orgs and governments worldwide

World Health Organization

European Commission

USWDS

110+ Tech, news, and non-profit companies/orgs

Microsoft

GitHub

Azure

HIGHCHARTS

Adobe

jupyter

The New York Times

REUTERS

BBC

20+ Undergraduate and graduate courses

Carnegie Mellon University

Massachusetts Institute of Technology

UNIVERSITY of WASHINGTON

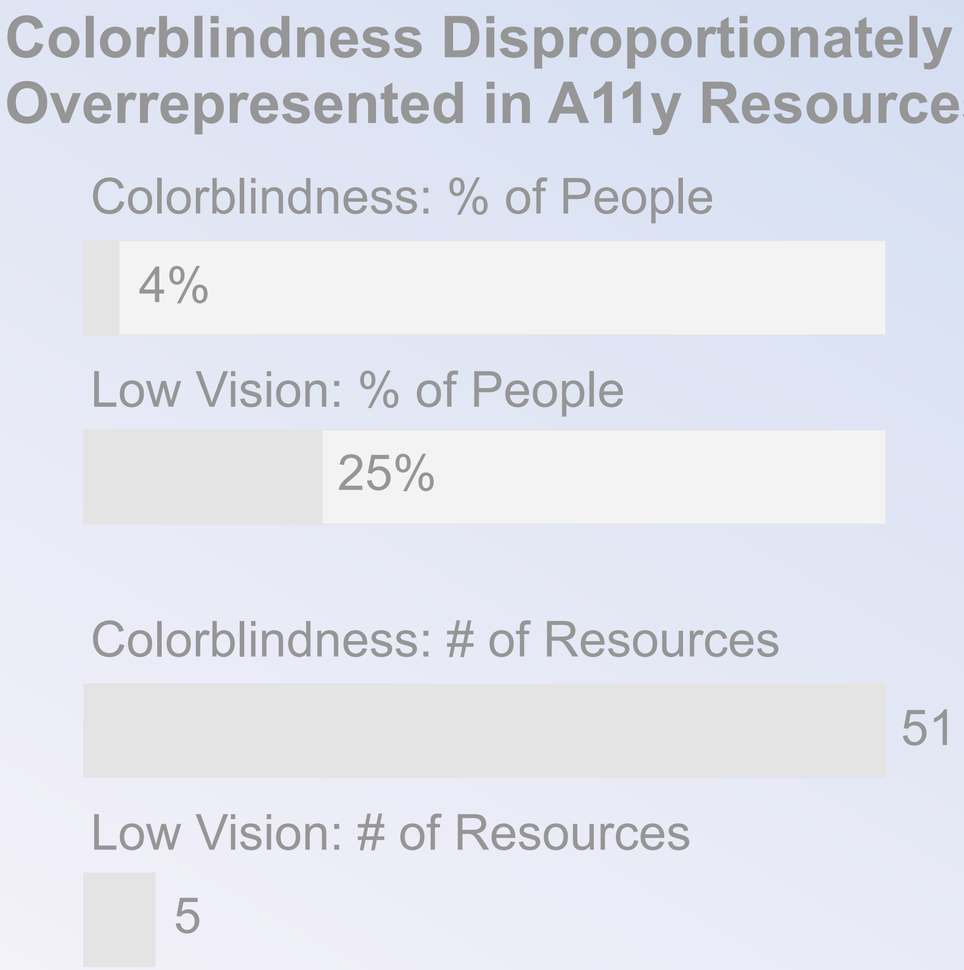
Northwestern University

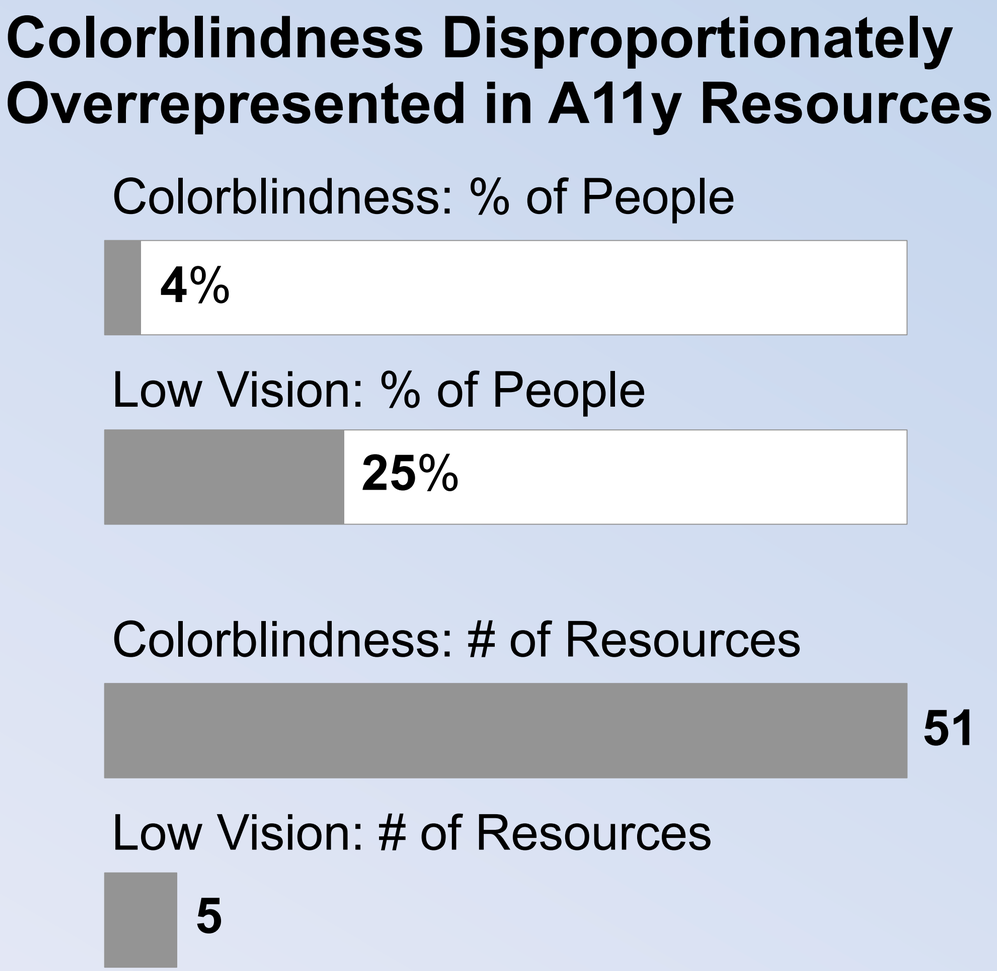
COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

Perceivable

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

Design with high contrast

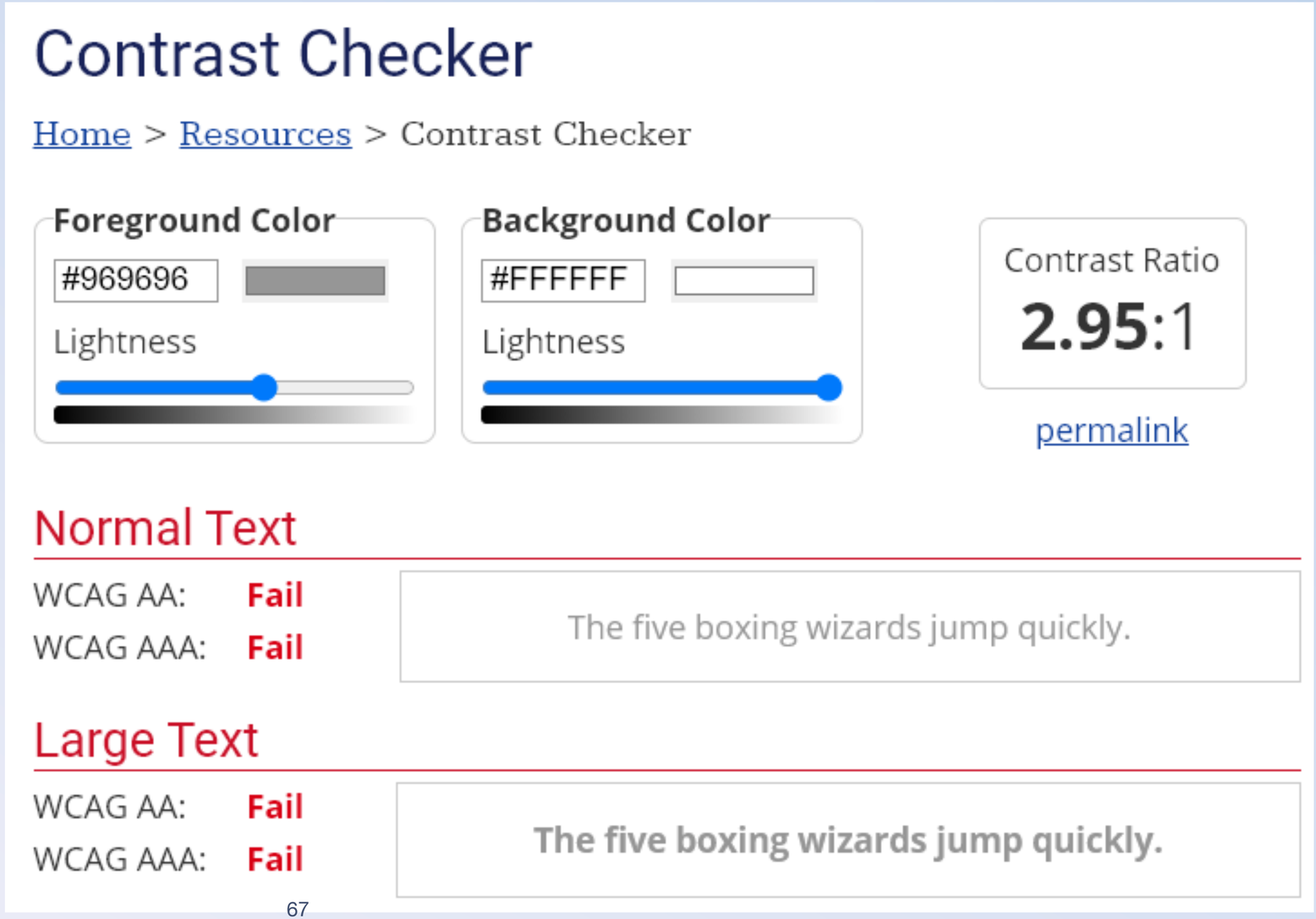


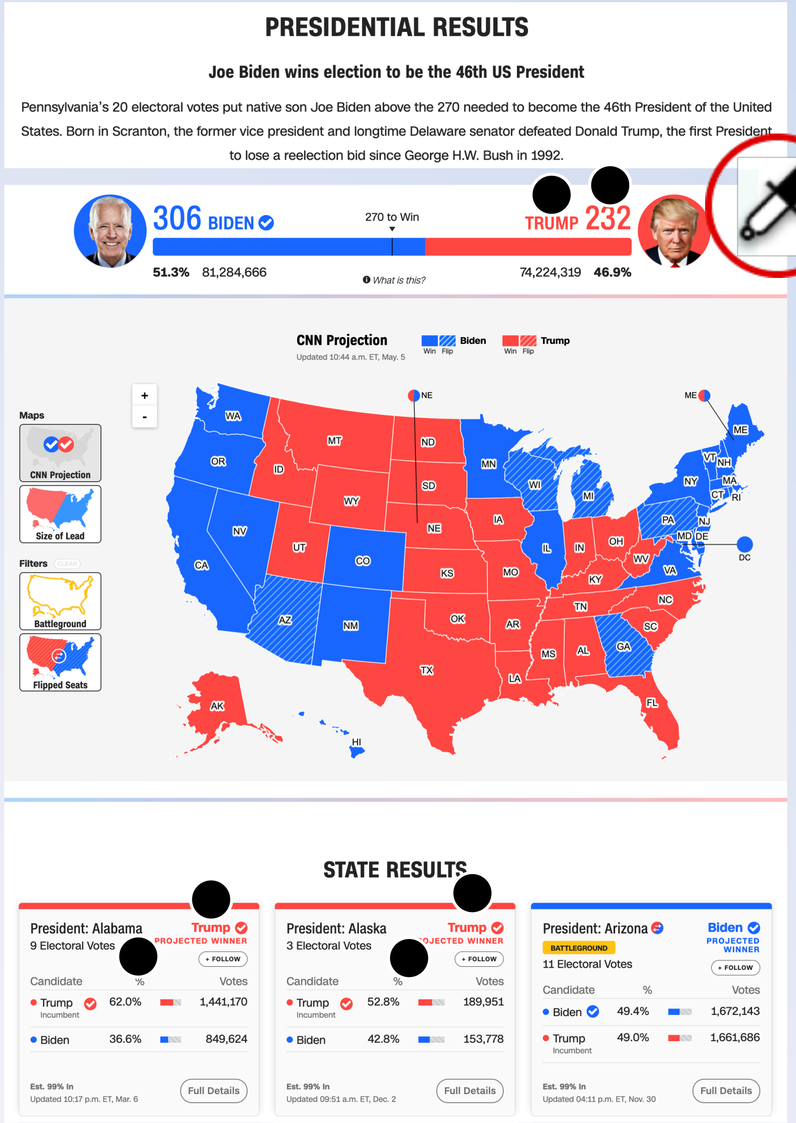


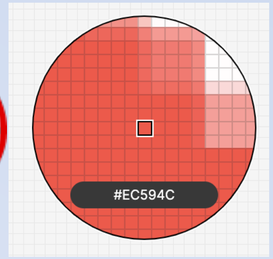
Check your contrasts

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

Large text and **geometries** must be **3:1** or higher.







Contrast Checker

Home > Resources > Contrast Checker

Foreground Color

#EC594C

Lightness

↔

Background Color

#FFFFFF

Lightness

Contrast Ratio

3.44:1

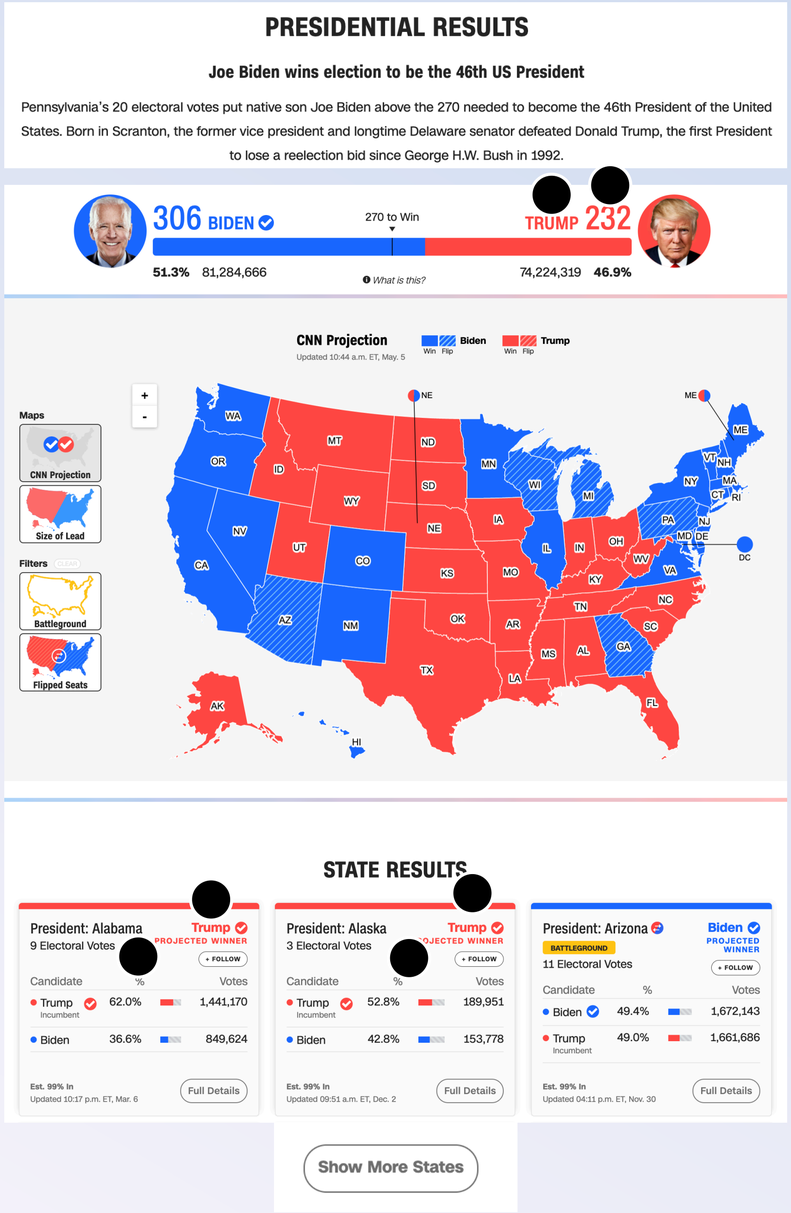
permalink

Normal Text

WCAG AA: **Fail**

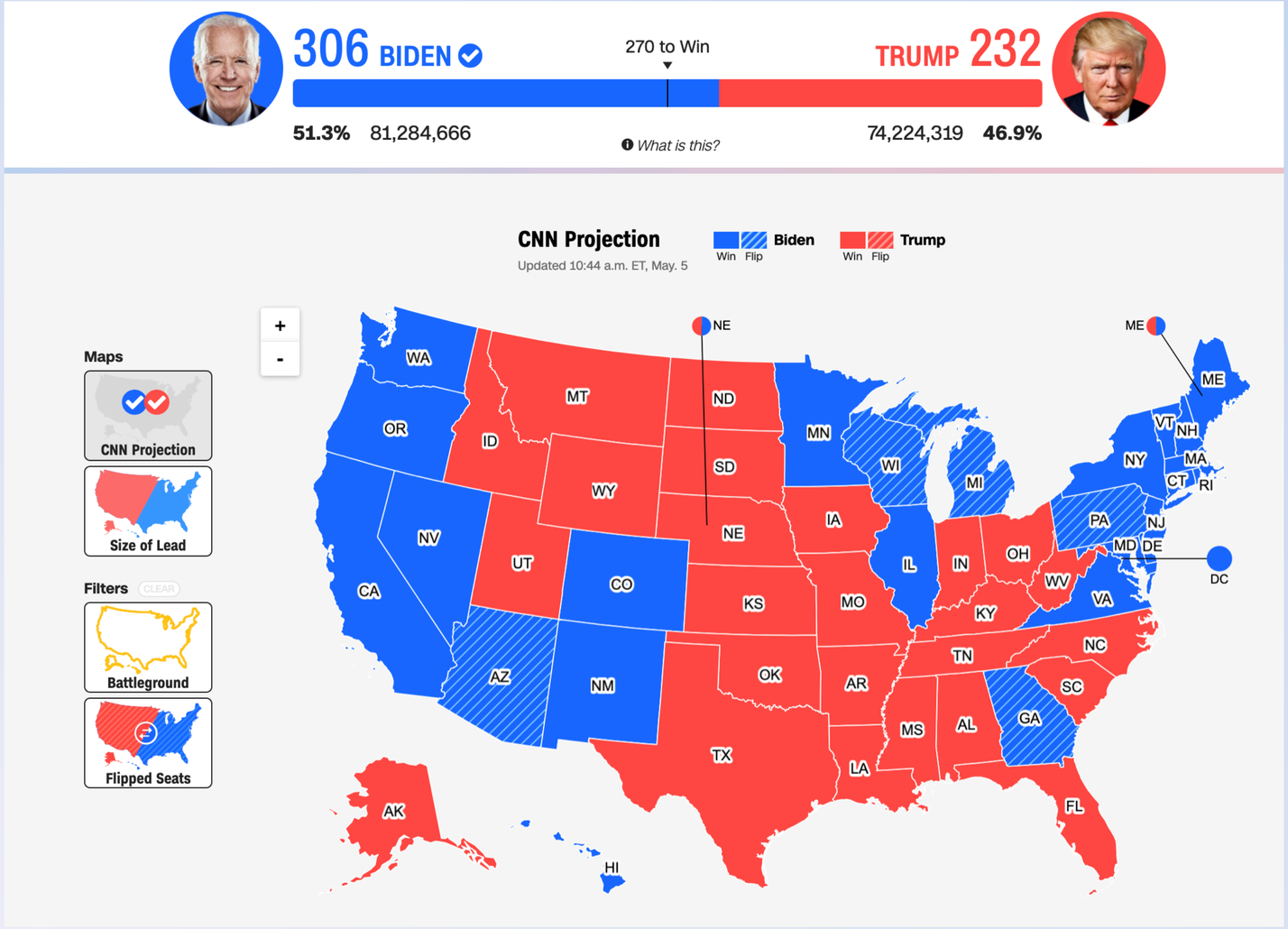
WCAG AAA: **Fail**

The five boxing wizards jump quickly.

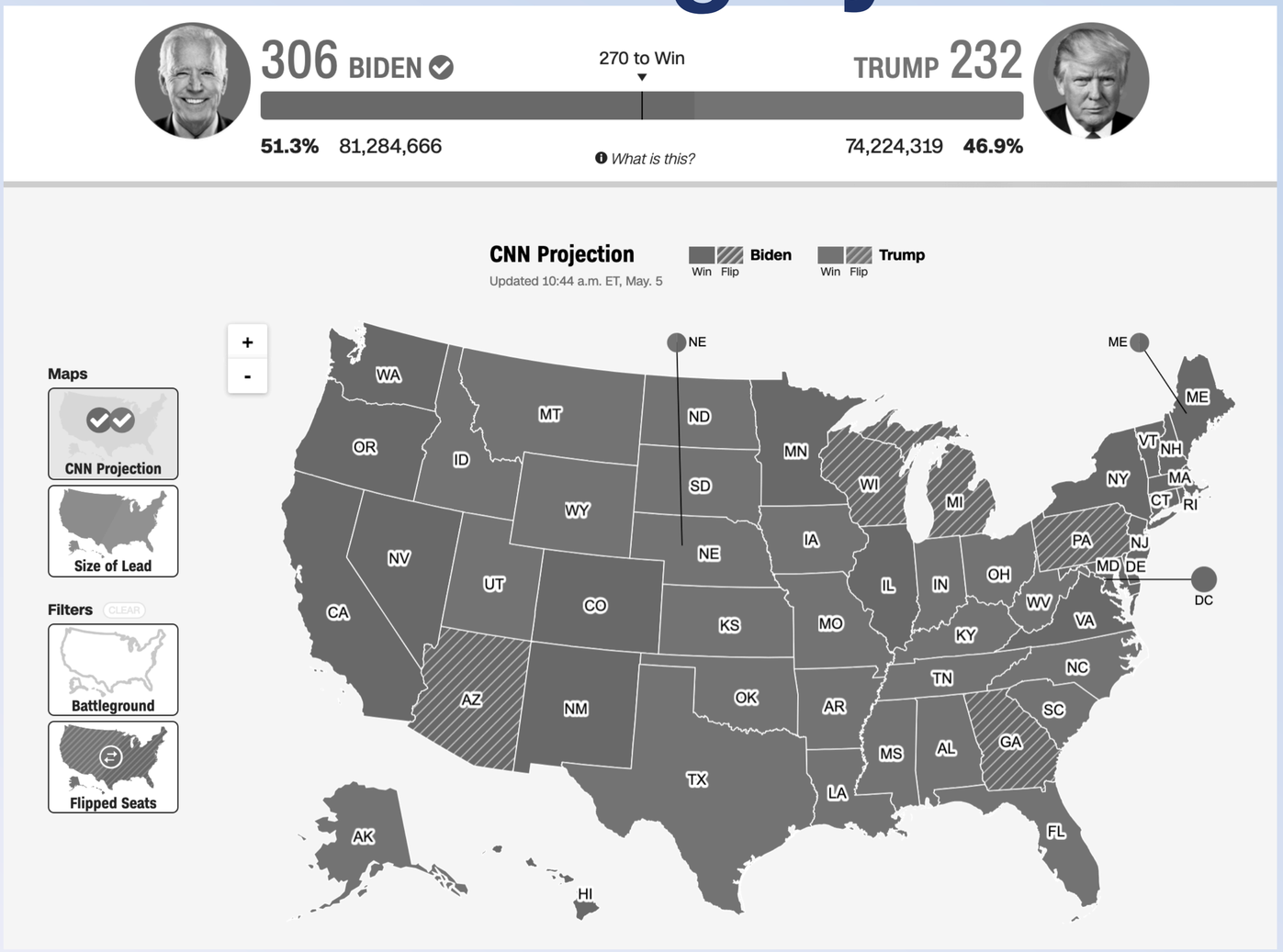


6 instances of low contrast

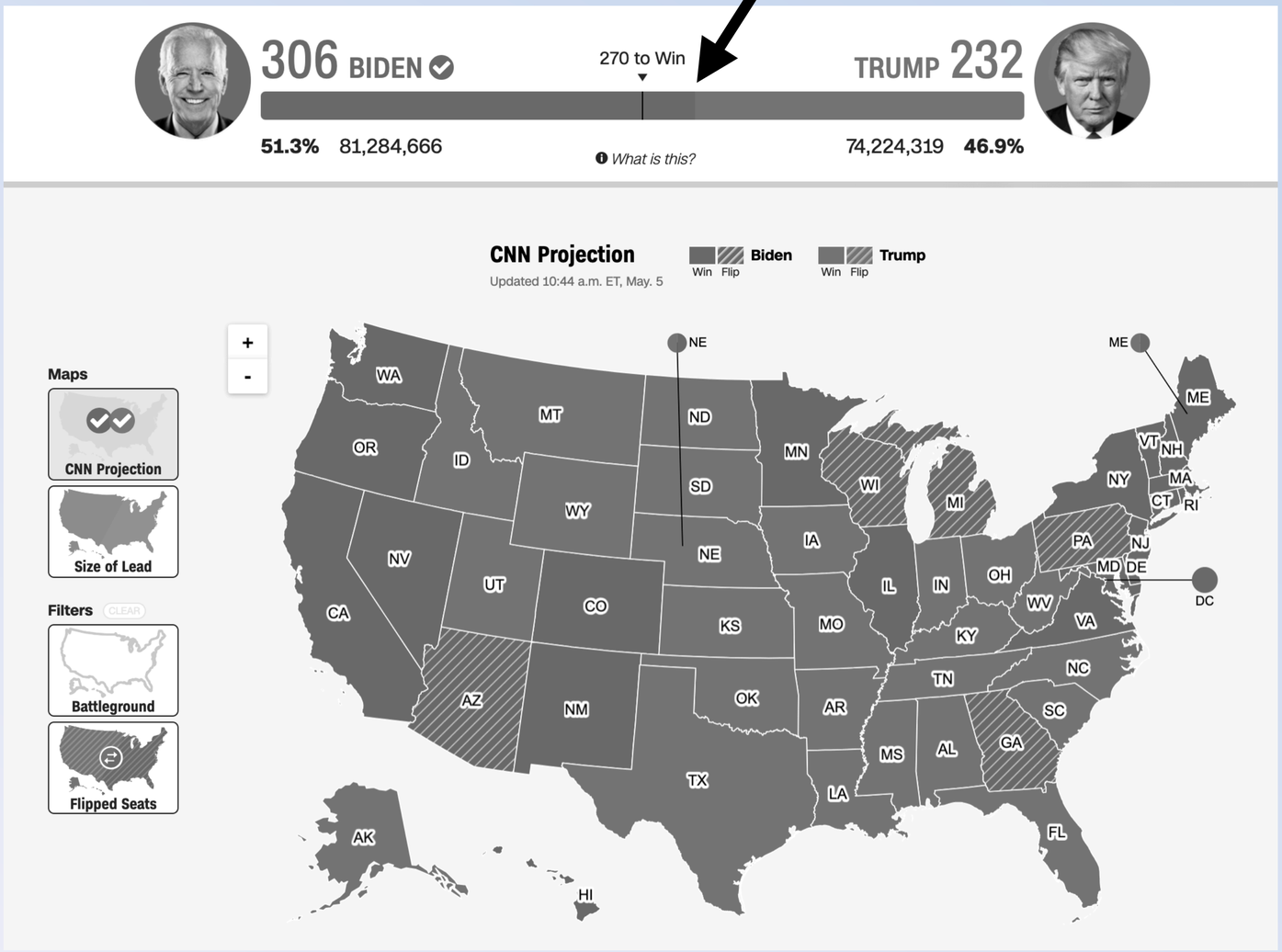
How can we fix this?



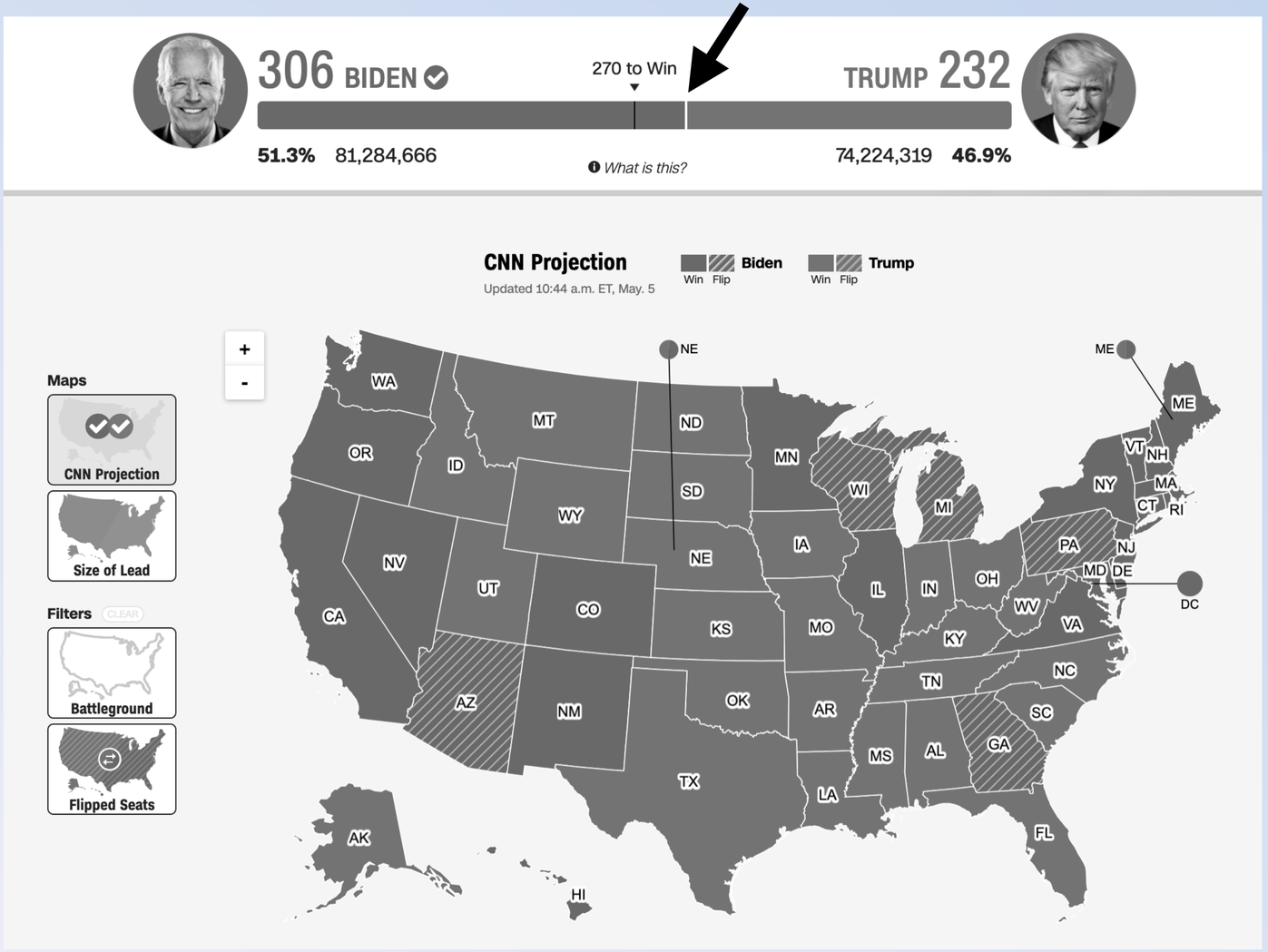
This map is trouble in greyscale



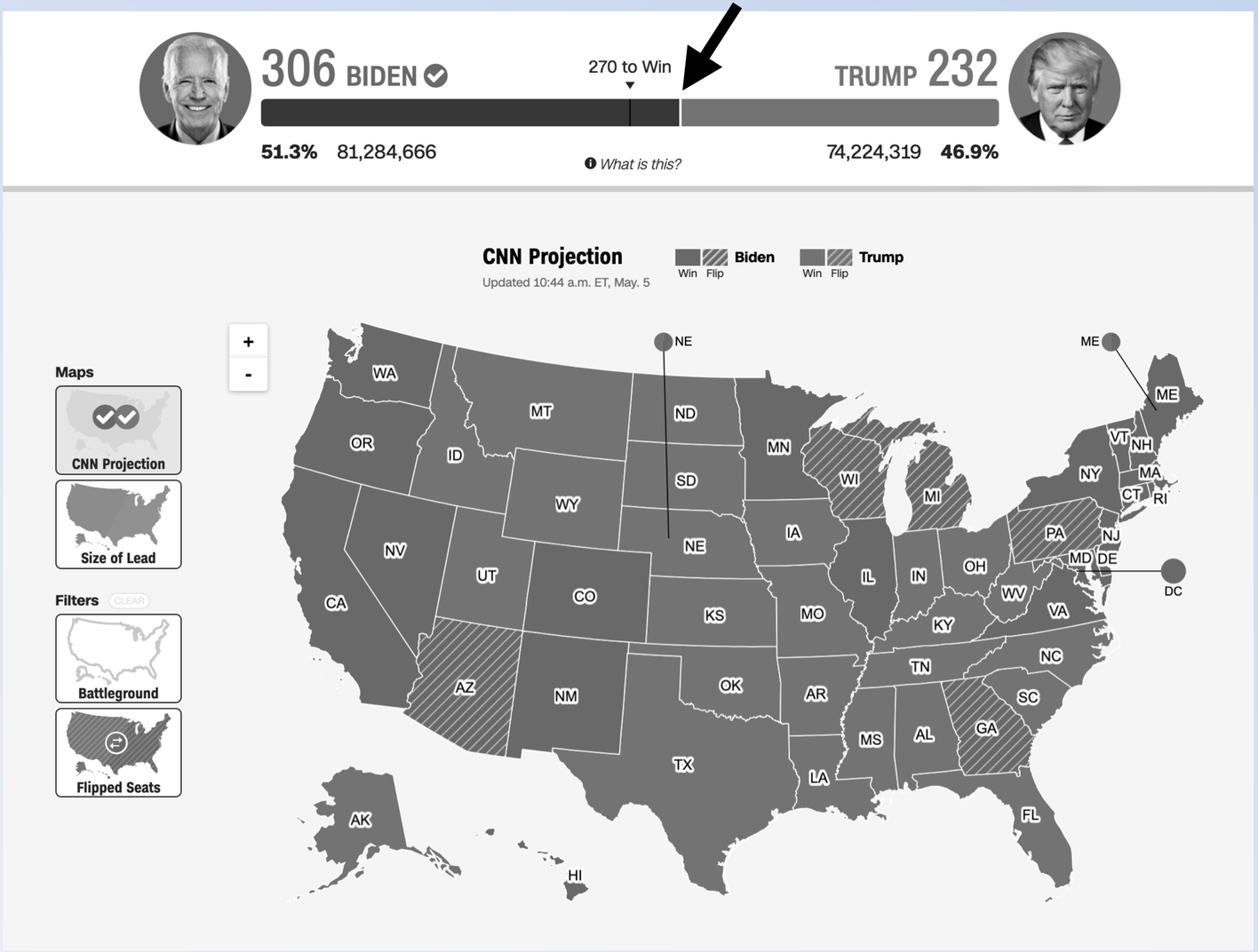
The division here matters!



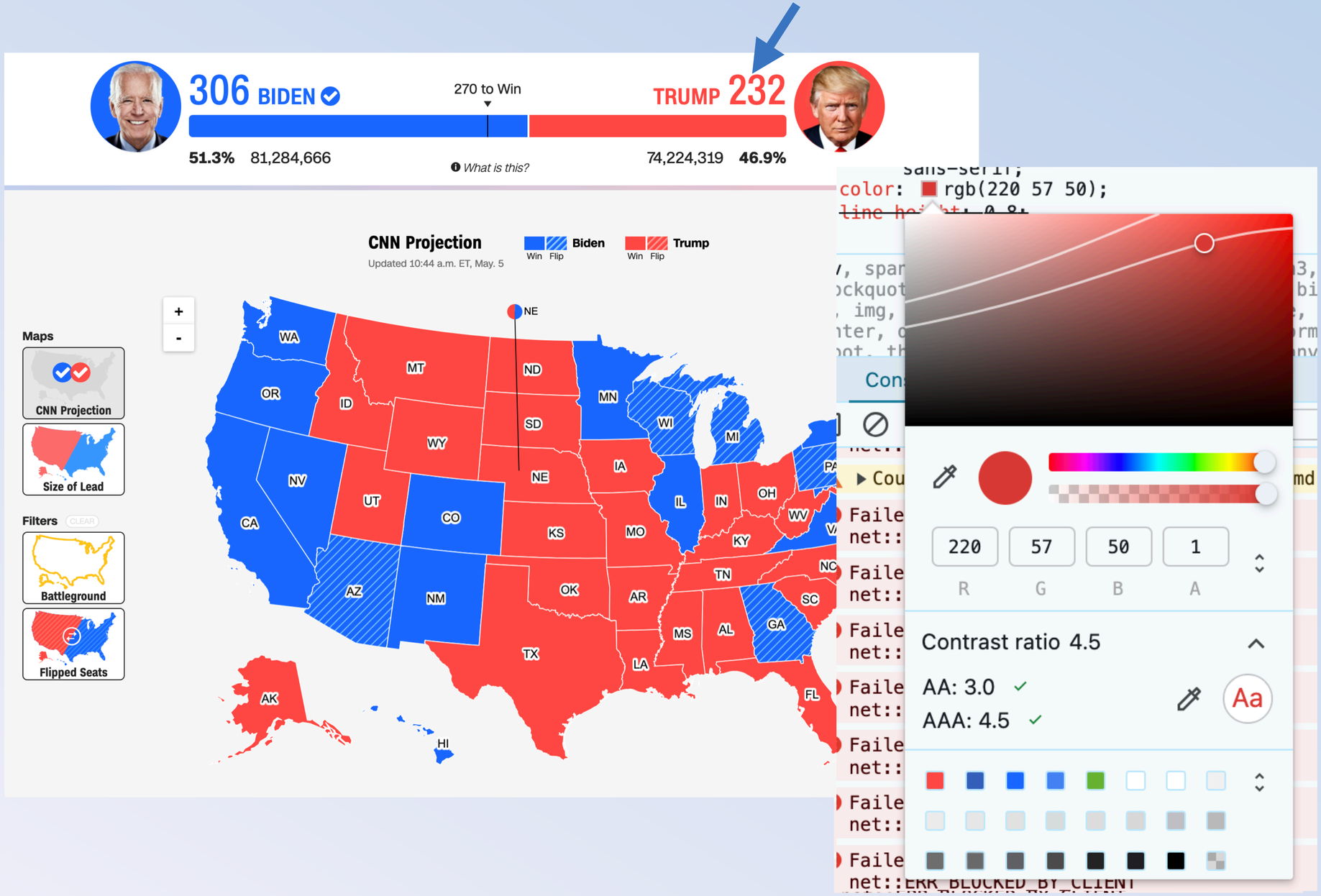
Maybe a small white divider, like the states?



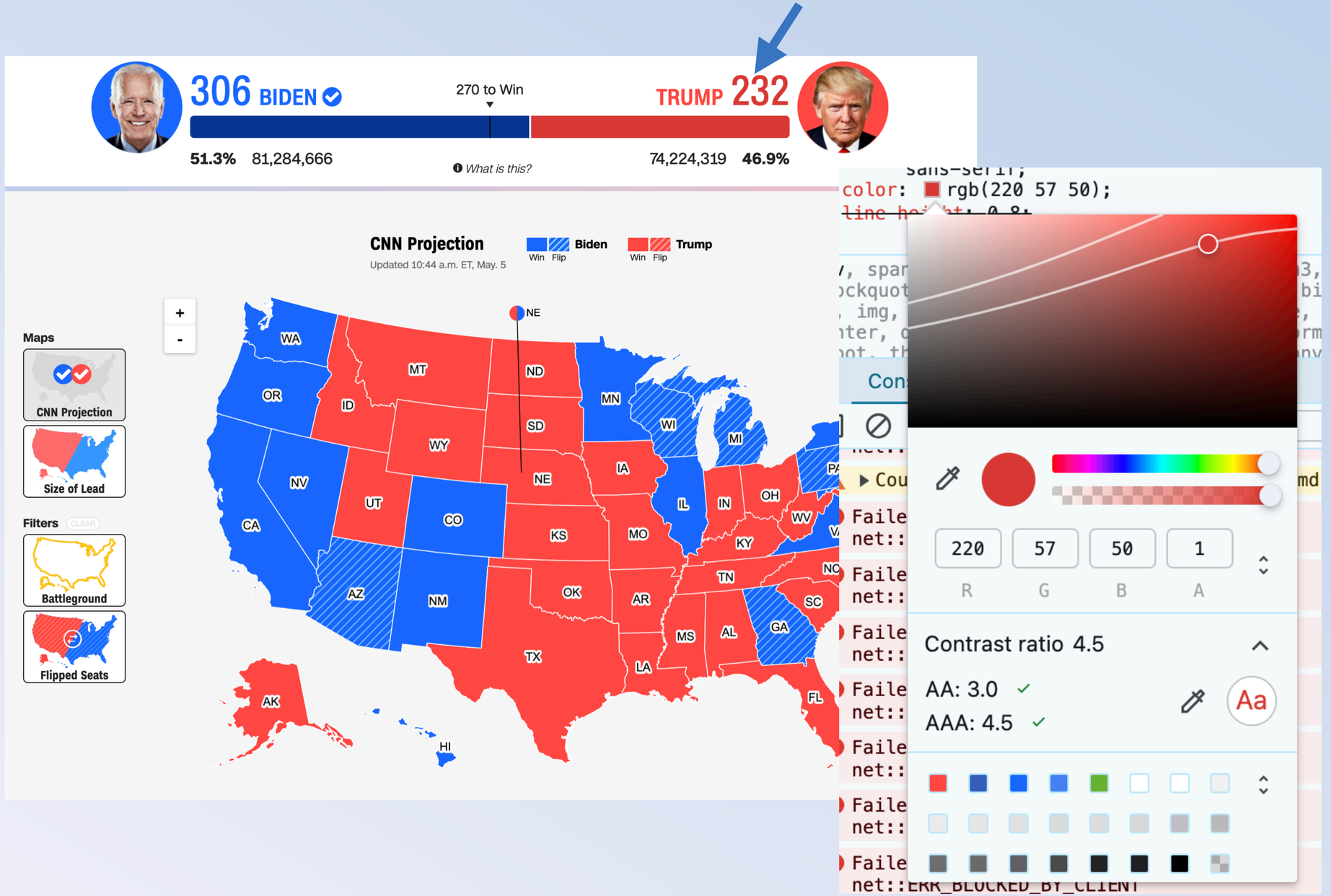
Perhaps test a darker blue too?



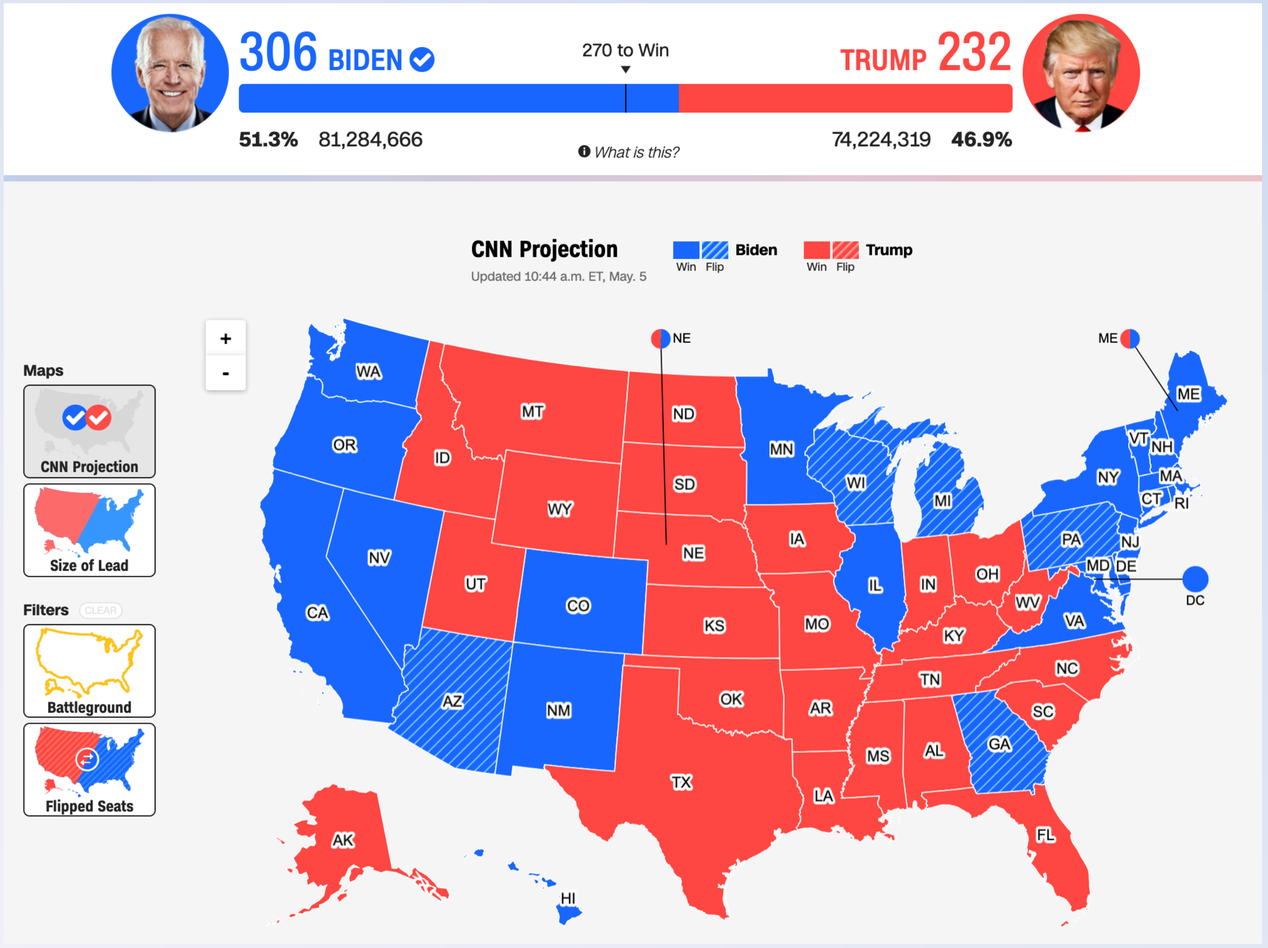
What if we fix the contrast failures at the same time?

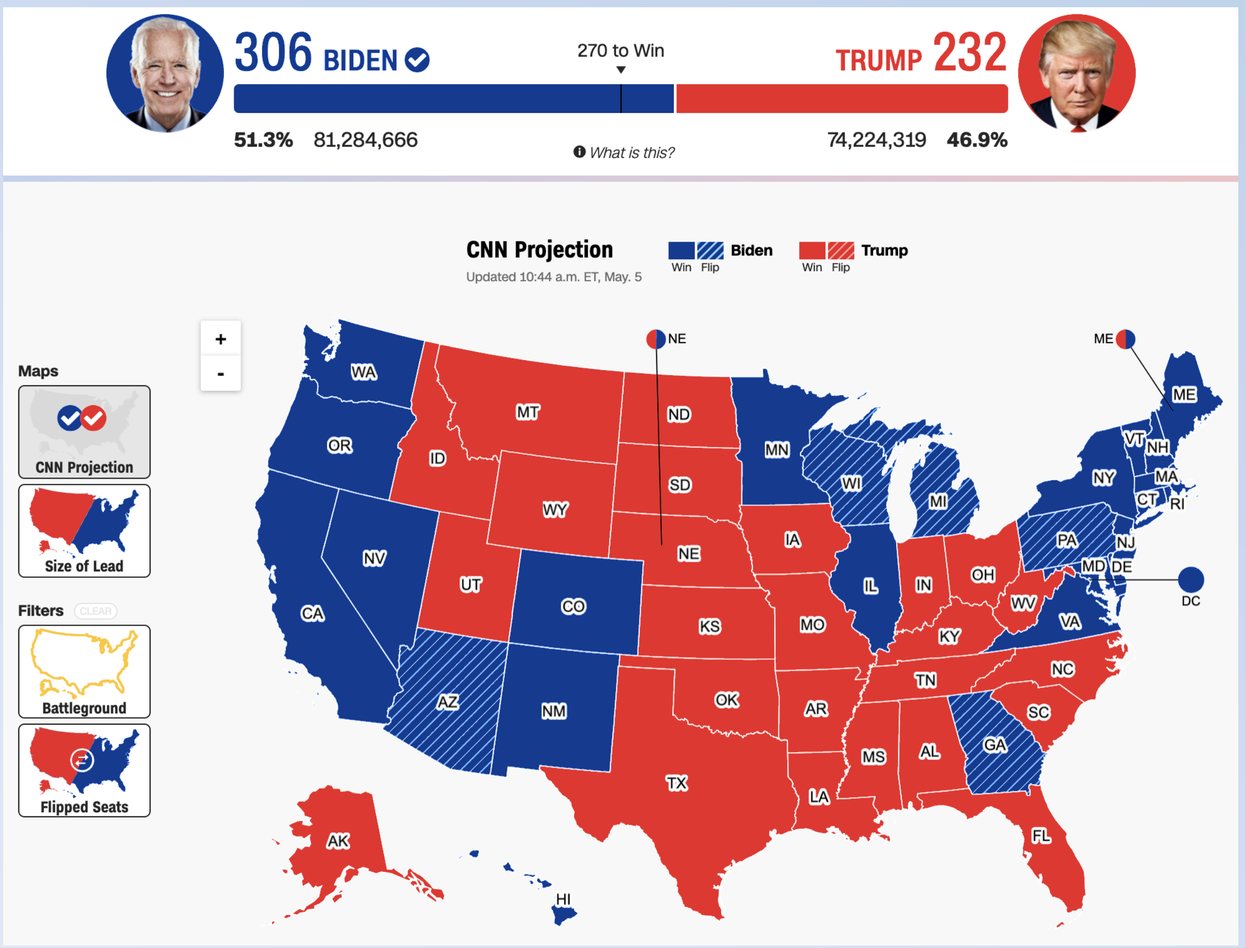


This text now passes!

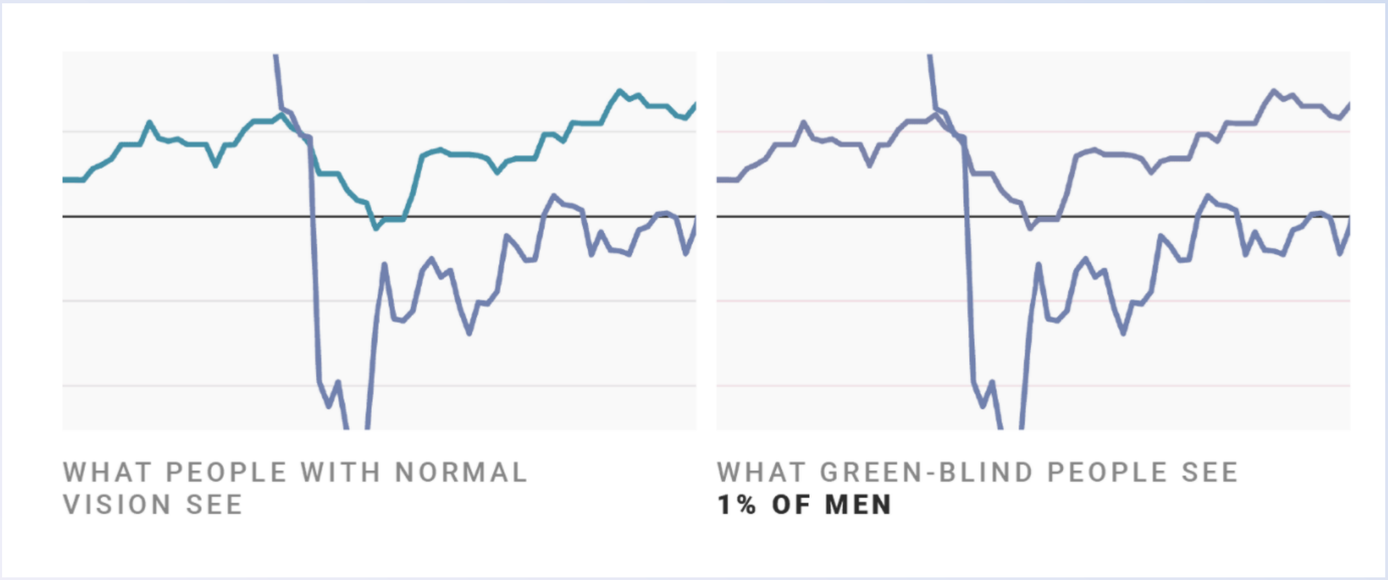


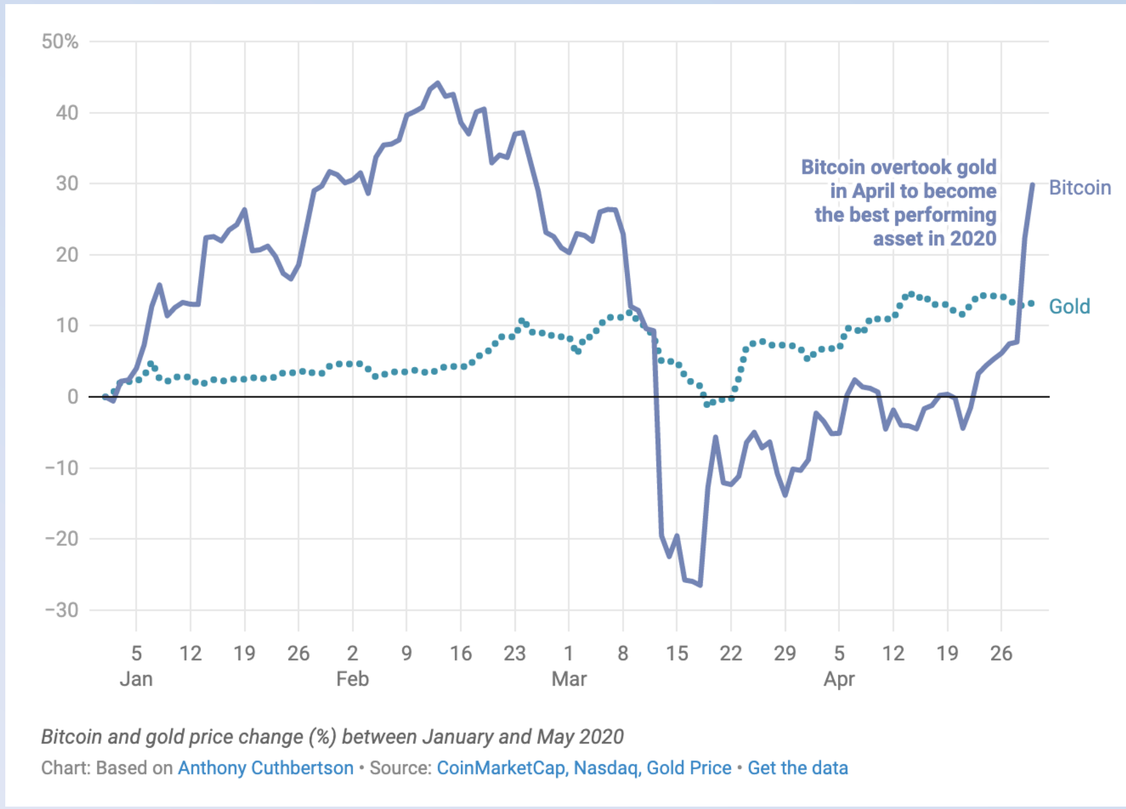
Sufficient contrast can help folks differentiate





Don’t rely on color alone!





Data Wrapper’s color guide

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

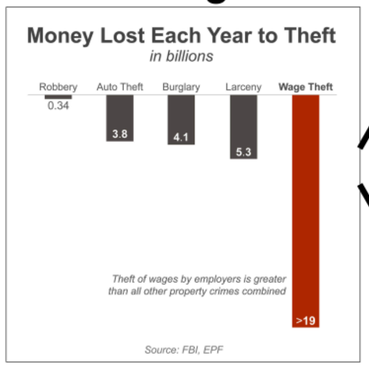
Beware of un-monitored LLMs/MMMs

Playing telephone with generative models: "verification disability," "compelled reliance," and accessibility in data visualization

Frank Elavsky*
Carnegie Mellon University

Cindy Xiong Bearfield†
Georgia Tech

Source Image



chatGPT to chatGPT

Claude to Claude

Beware of un-monitored LLMs/MMMs

Pick the better prompt:

“Describe this image”

“Write alt text for this for someone who is blind”

“Describe this image and do not make mistakes”

Playing telephone with generative models: “verification disability,” “compelled reliance,” and accessibility in data visualization

Frank Elavsky*
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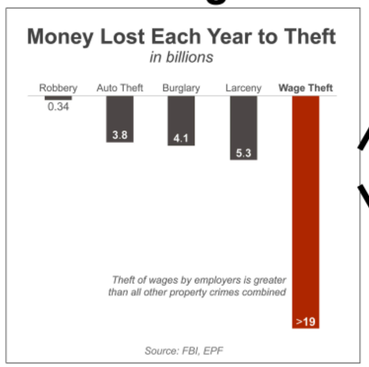
Source Image



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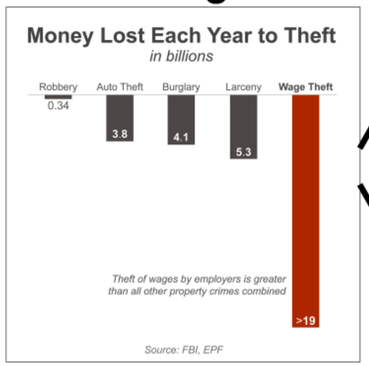

chatGPT to chatGPT

Claude to Claude

Beware of un-monitored LLMs/MMMs

Pick the better prompt:

And check the output!

“Describe this image”

“Write alt text for this for someone who is blind”

“Describe this image and do not make mistakes”

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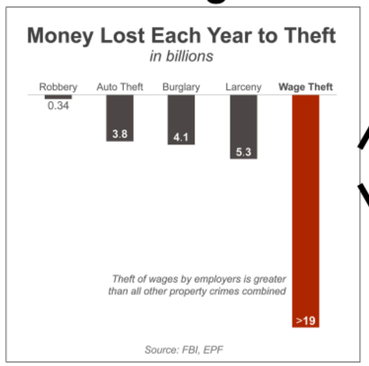
Source Image



chatGPT to chatGPT

Claude to Claude

Operable

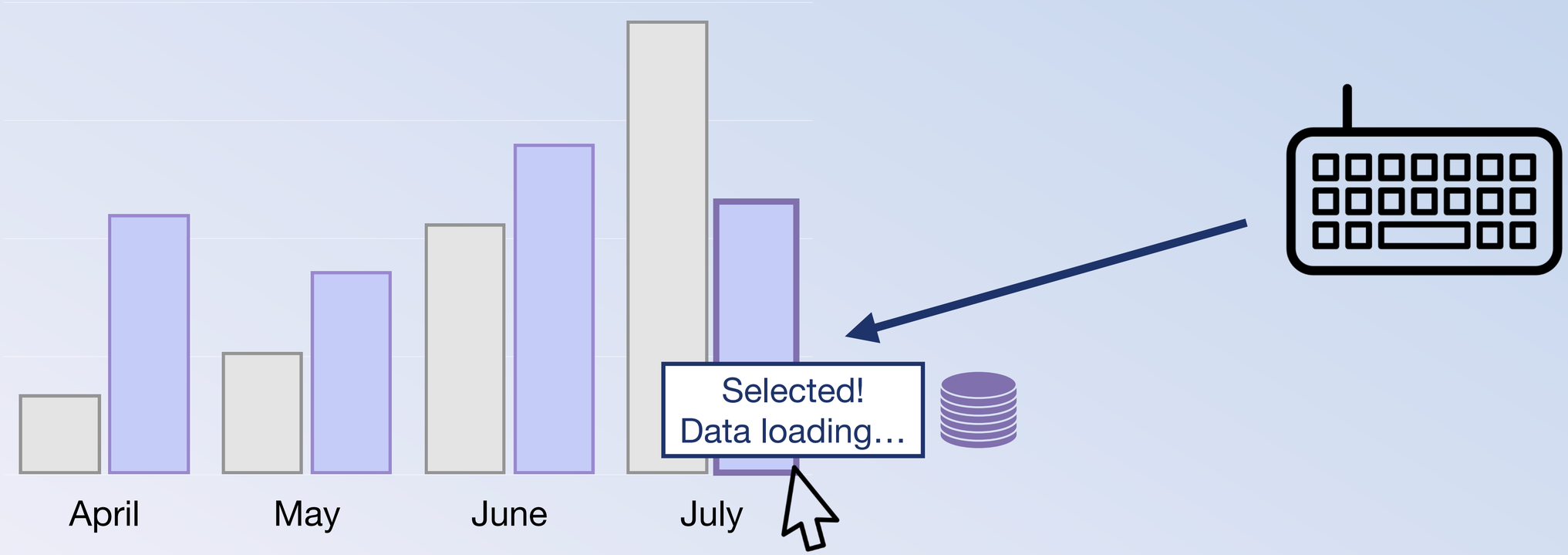
Can someone operate this in multiple ways? Is each way easy?

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.

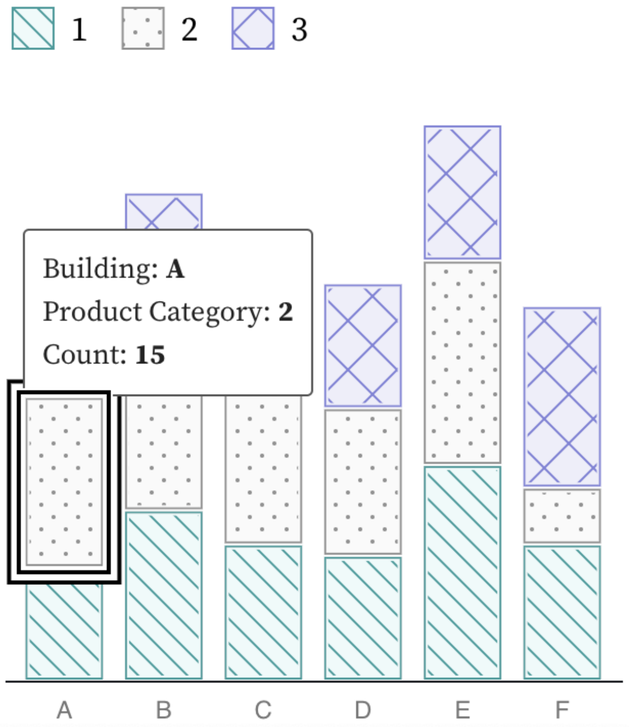
A keyboard should be able to do everything a mouse can



WAI. “Understanding success criterion 2.1.1: keyboard.” *WCAG standard*, W3C, 2017.

Alt text should communicate operability

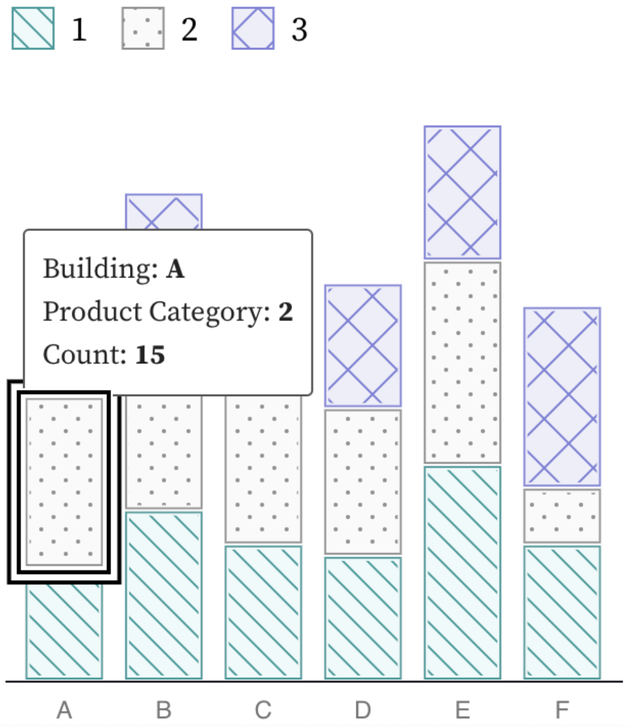
Source: Visa Chart Components, Frank Elavsky (2017-2019)



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

Semantics matter

Source: Visa Chart Components, Frank Elavsky (2017-2019)

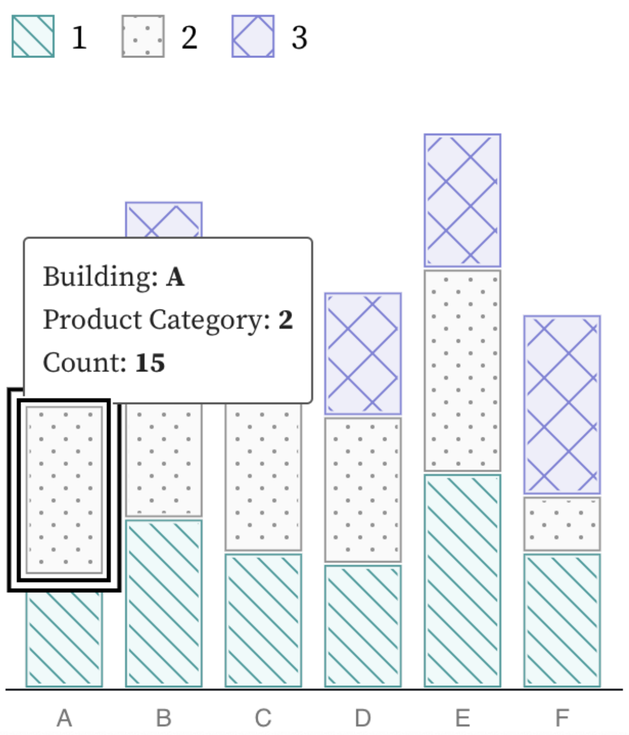


Building A. Product Category 2. Count 15. Bar 2 of 3. Image.

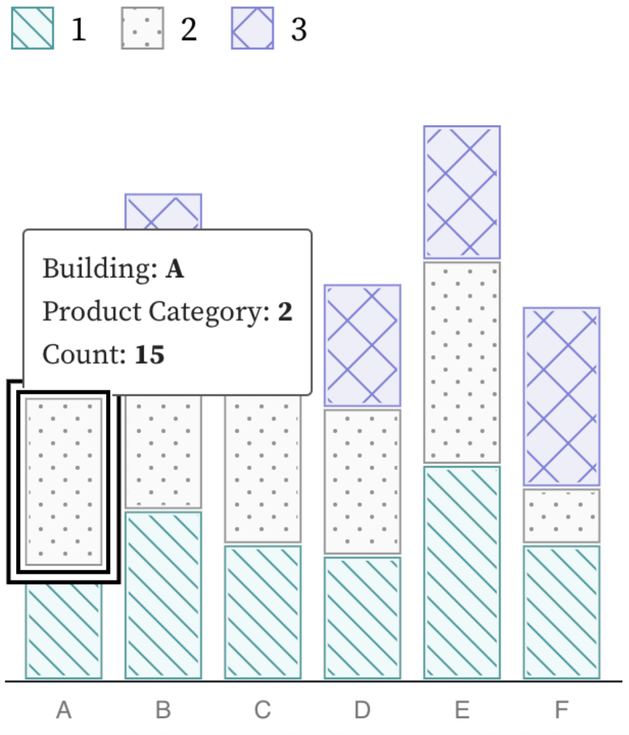
“Image” doesn’t signal interactivity!

ARIA semantics are standardized

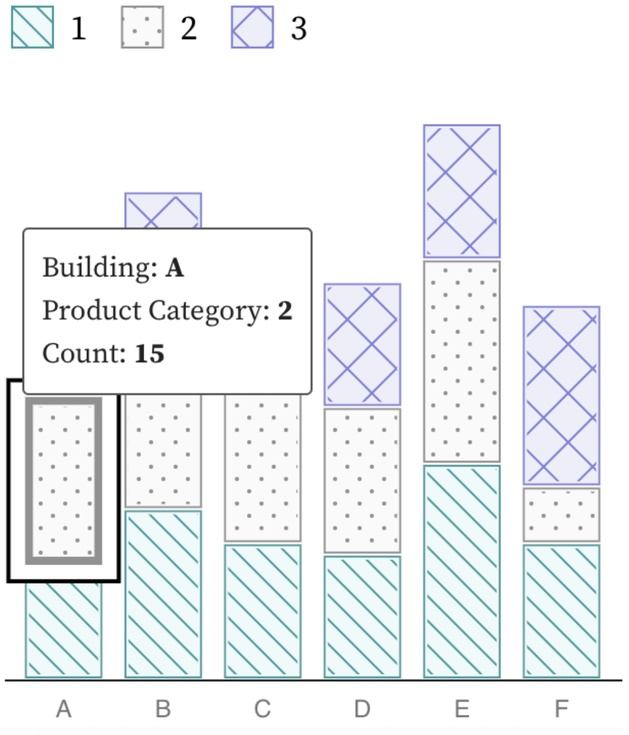
Source: Visa Chart Components, Frank Elavsky (2017-2019)



× 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

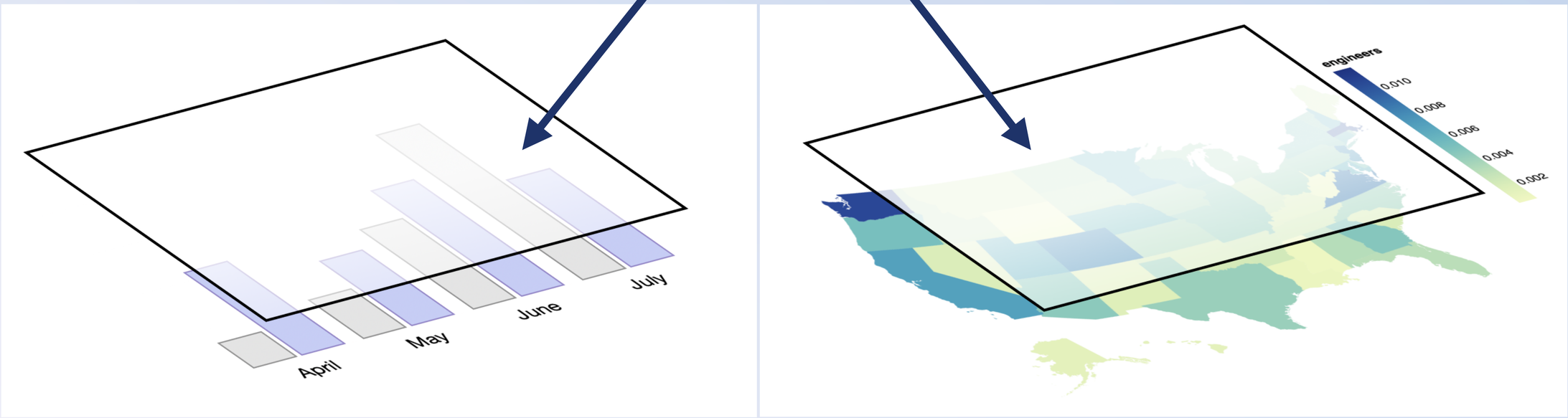


× selected, Building A. Product Category 2. Count 15. Bar 2 of 3., toggle button

Data Navigator

Frank Elavsky et al (2023)

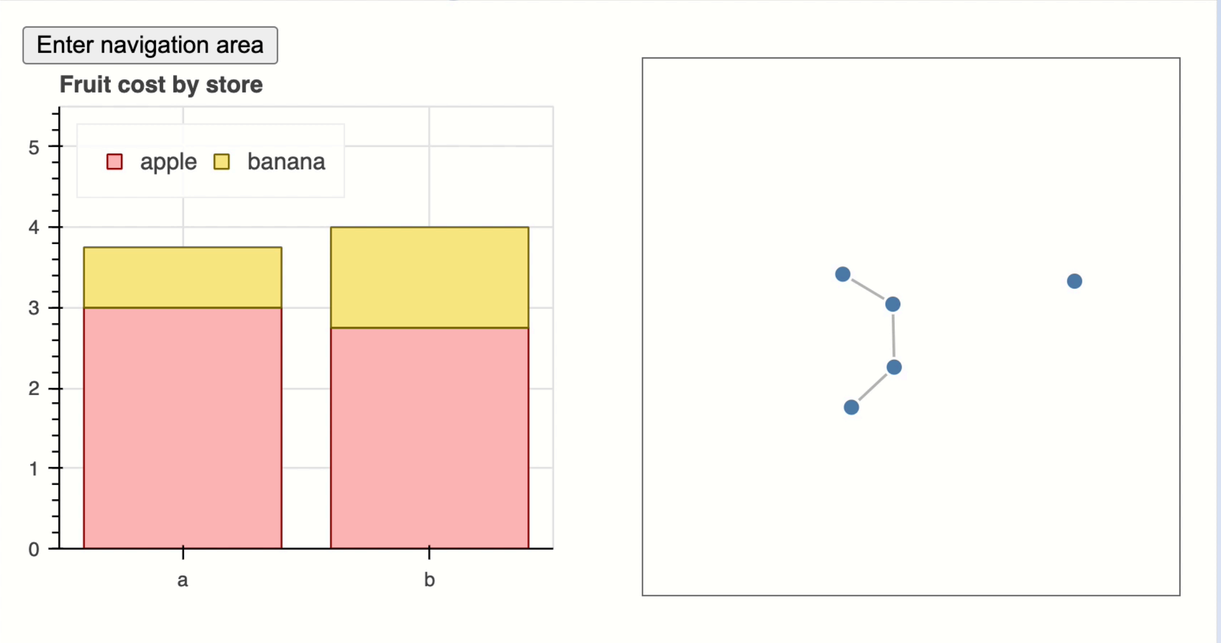
An interactive layer that interfaces between data structures and assistive technologies



Data Navigator

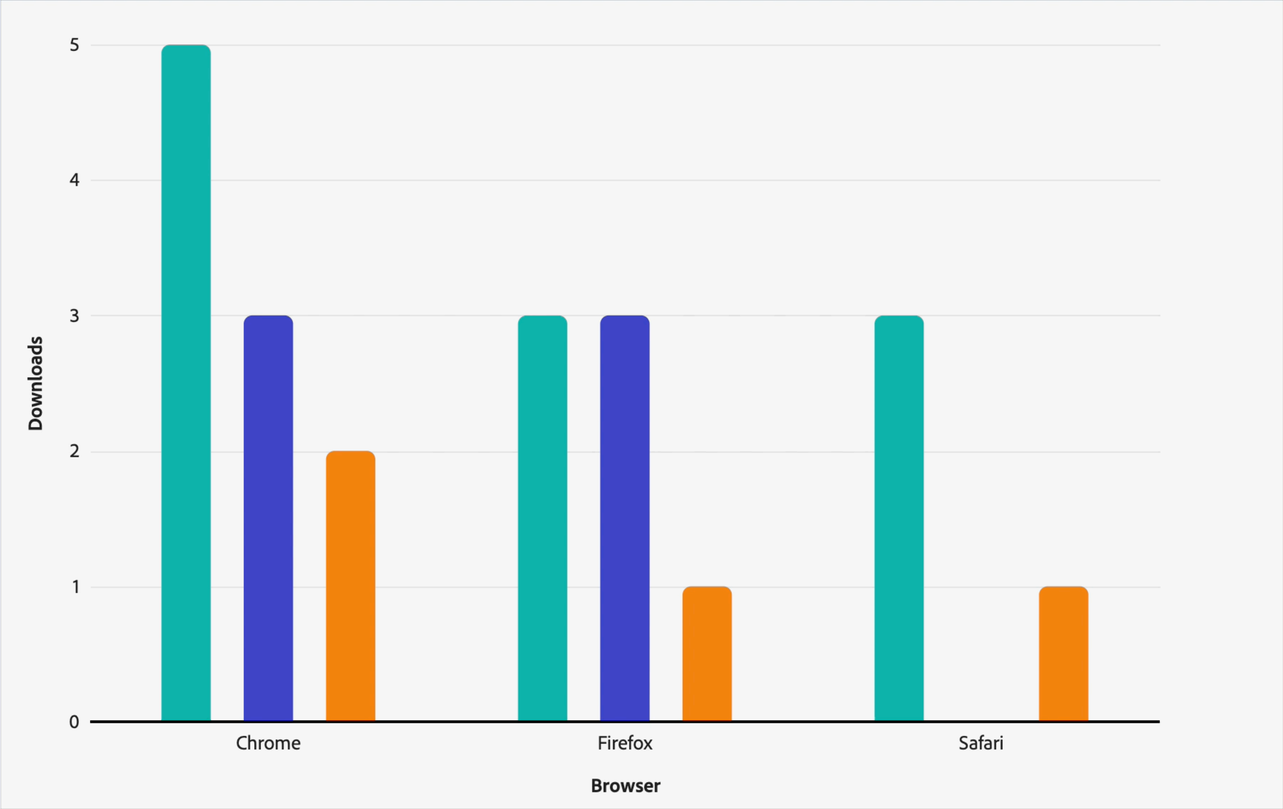
Data Navigator: Empowering practitioners

Bokeh, a Python visualization library



Data Navigator: Empowering practitioners

React Spectrum Charts, Adobe’s visualization design system



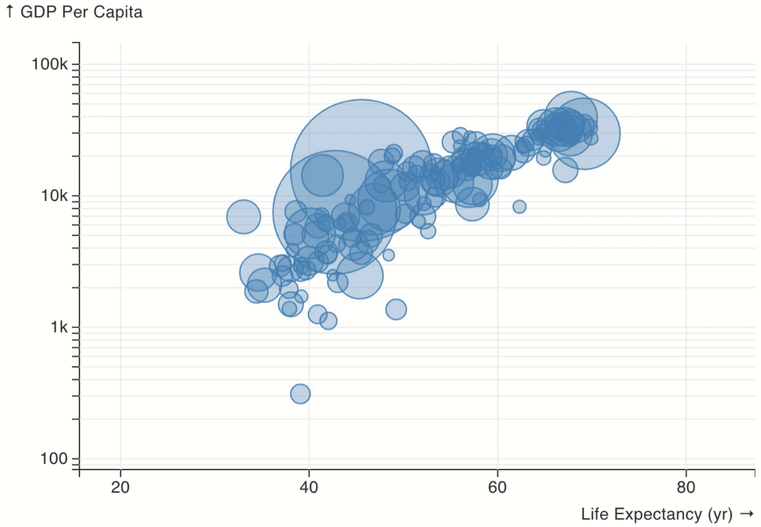
Counterpoint: navigating animations

Sivaraman's *Counterpoint* (2024)

Example: Accessible Gapminder Chart

Below is a responsive, screen-reader-navigable version of the chart shown on the homepage. Press Navigate to enter keyboard navigation. Or, change your "prefers reduced motion" system setting to see fade animations instead of motion.

Navigate



Year: 1992

Play/Pause

X axis:
Life Expectancy

Y axis:
GDP Per Capita

Radius:
Population

Reset Zoom

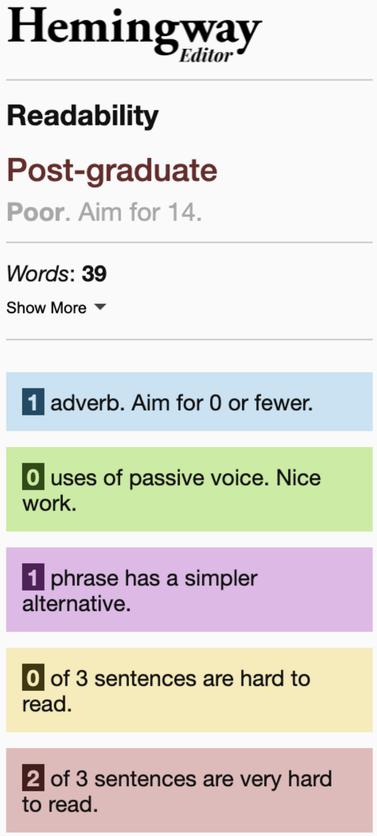
Source: Free Data from World Bank via gapminder.org, CC-BY license

Understandable

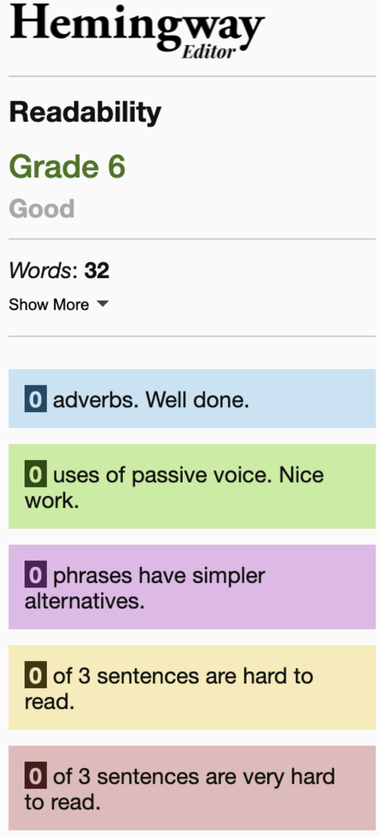
Can someone understand this in multiple ways? Is each way easy?

Keep summaries as non-technical as possible

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.

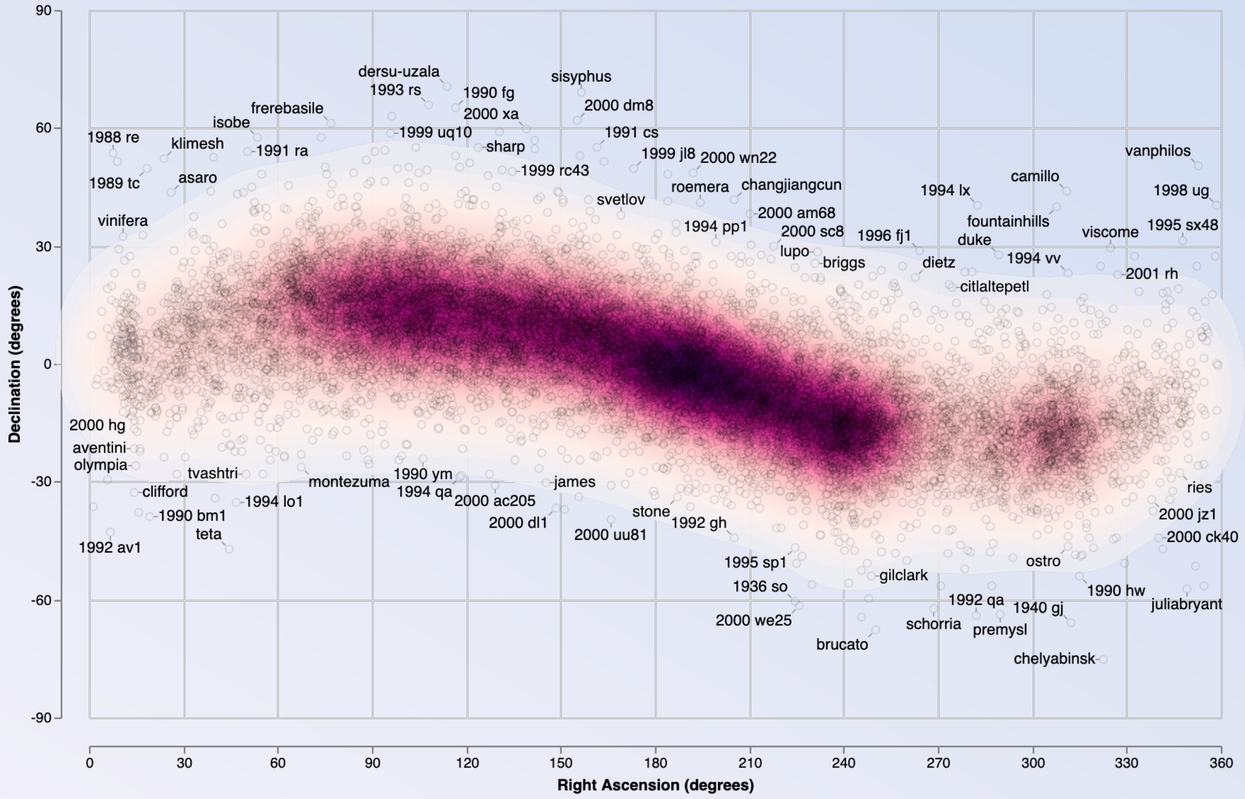


Measured in EF units (non-normalized). These units are helpful for catching bad data loss when we remove our data at random. We are producing too much entropic force in our latest models.



Label collision detection

Source: Moritz et el, Vega-label (2018-2020)



Label collision detection

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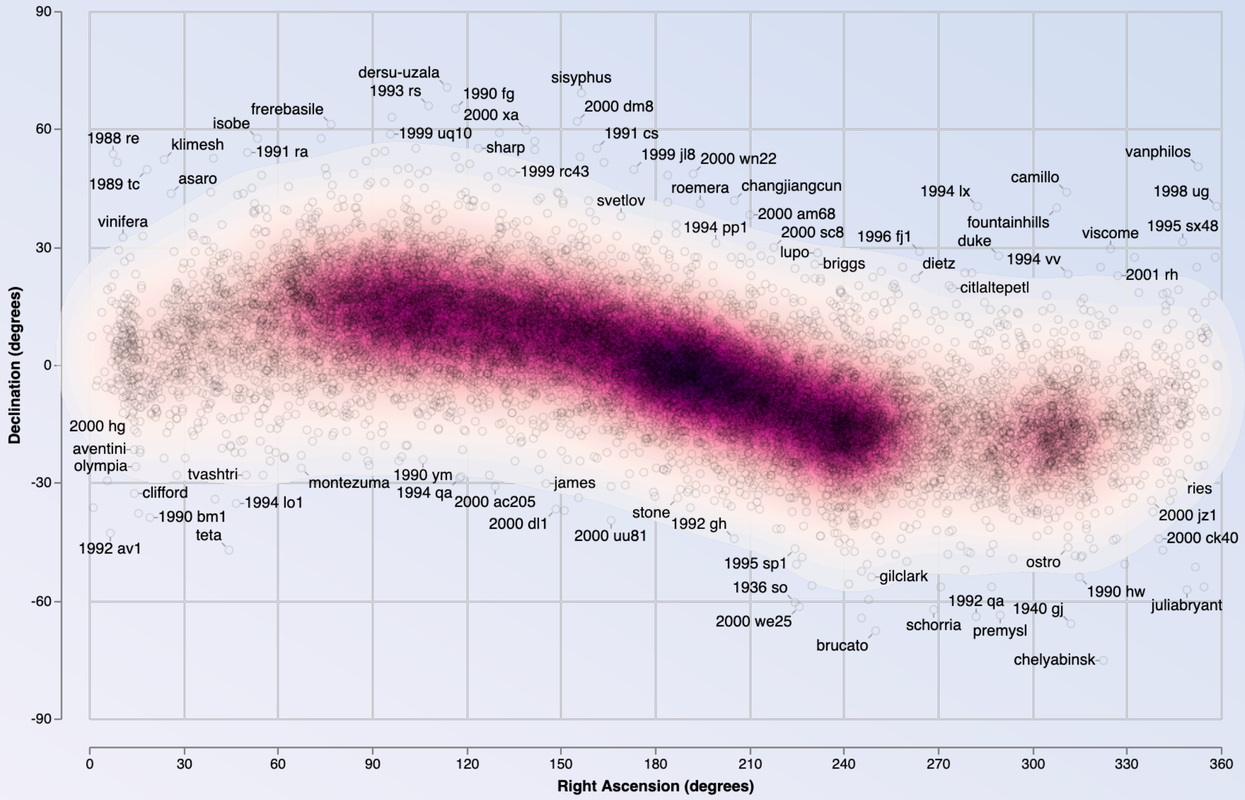

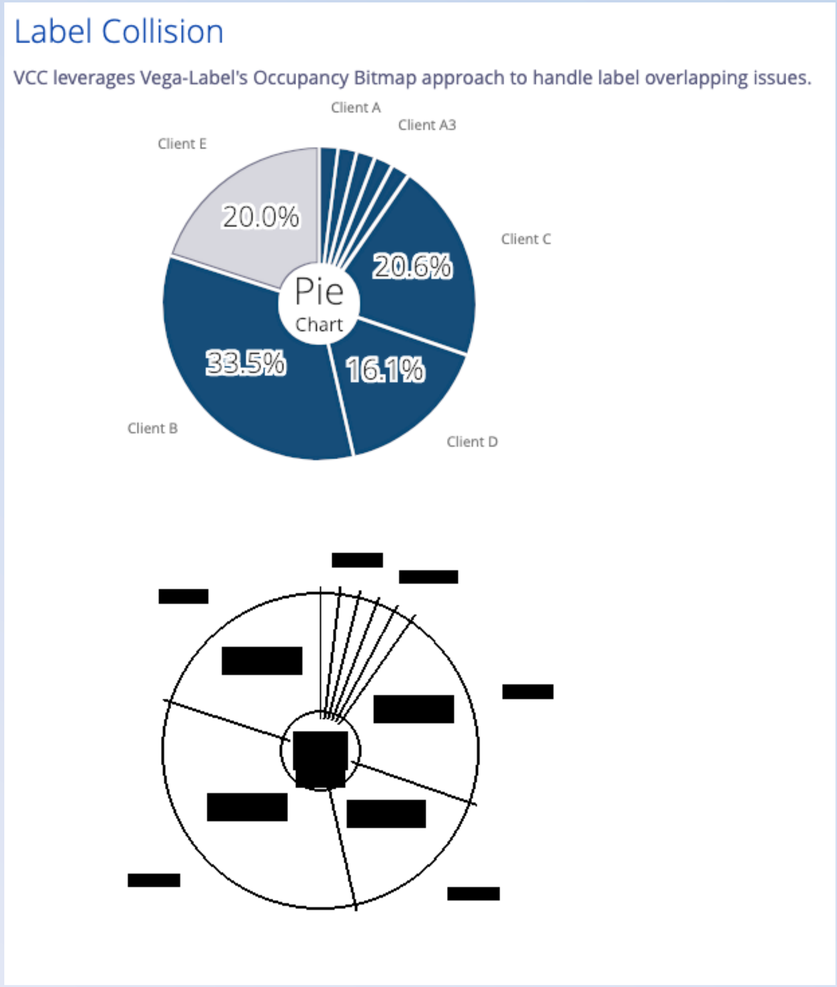

Label collision detection

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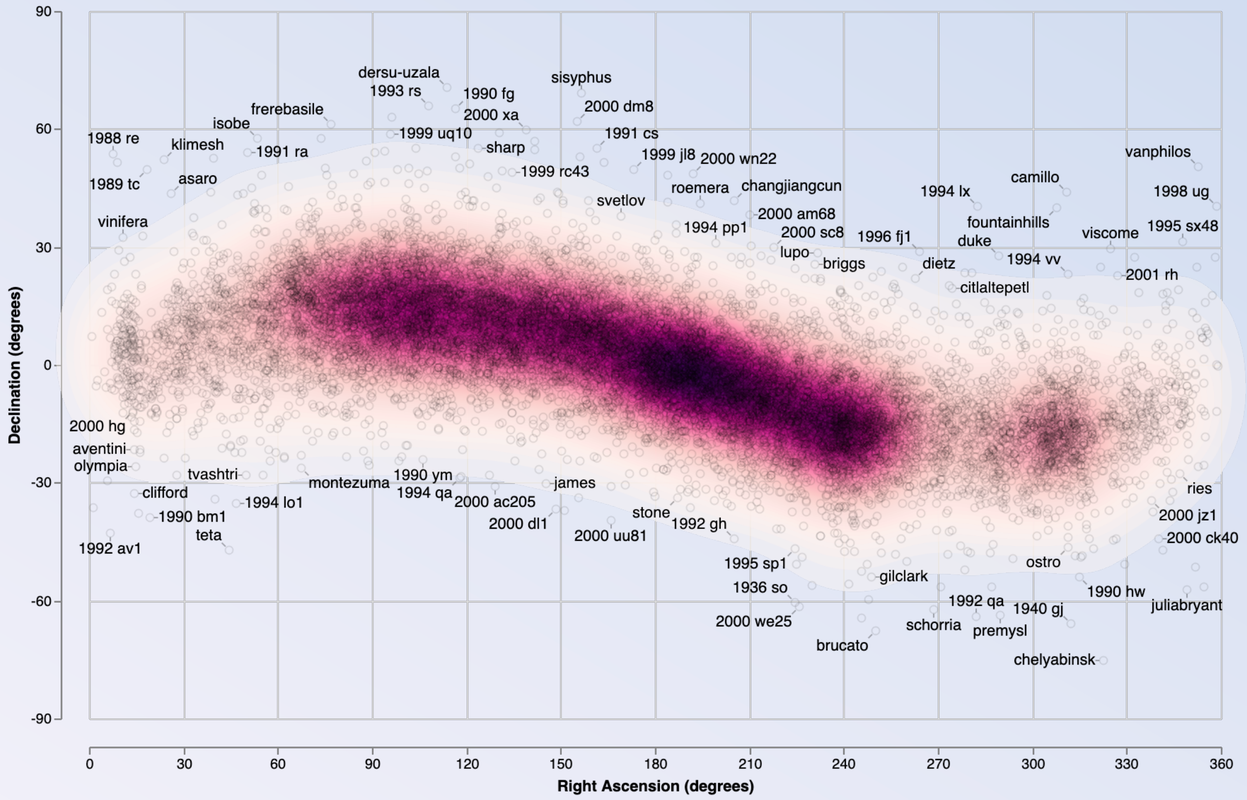
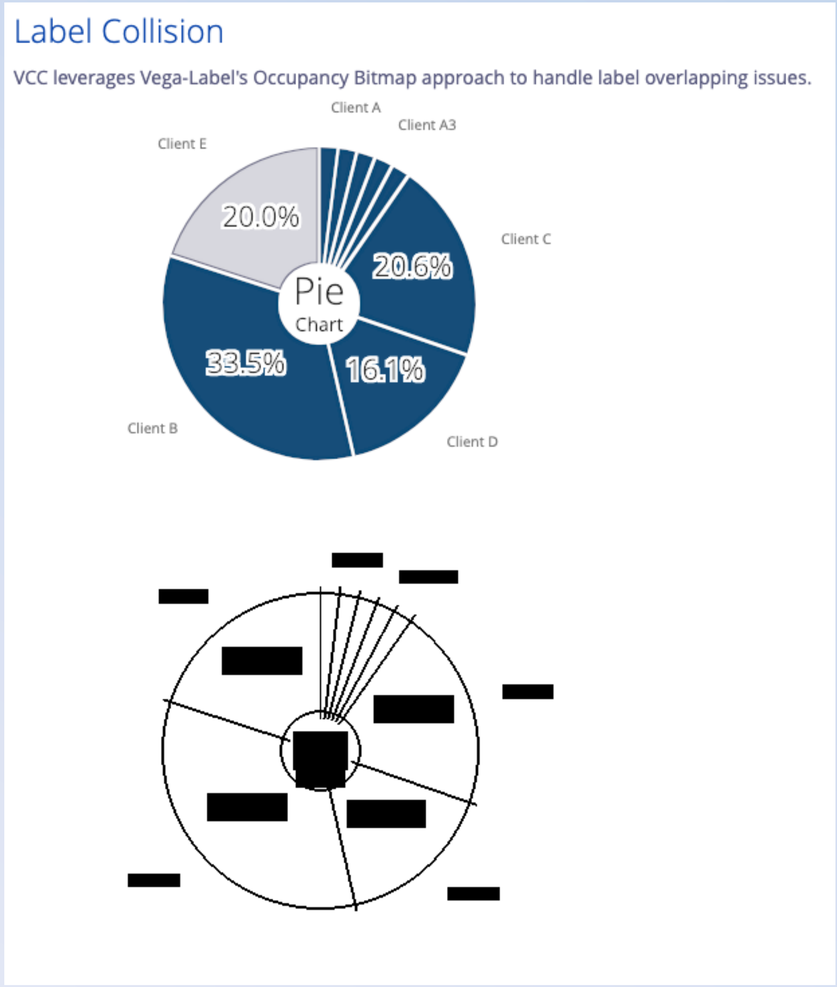
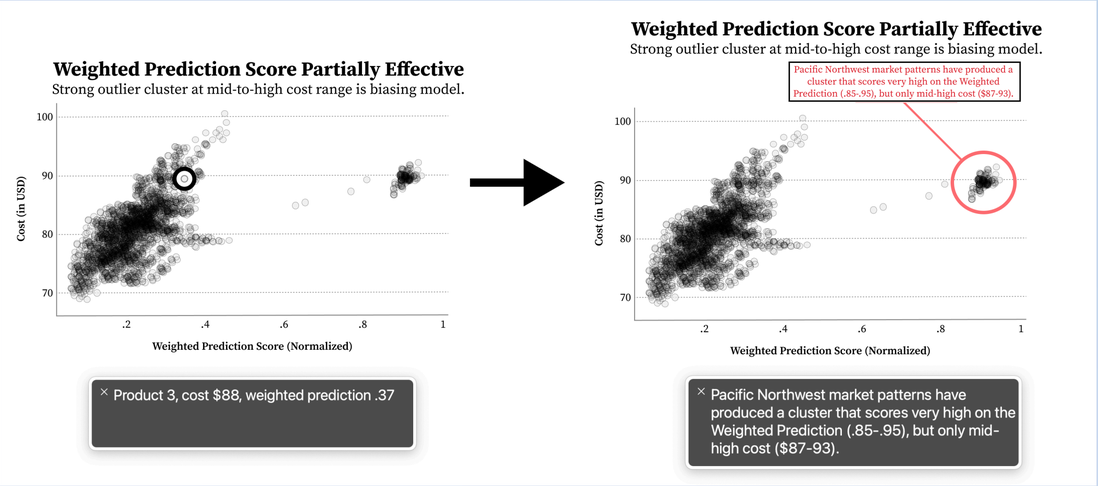
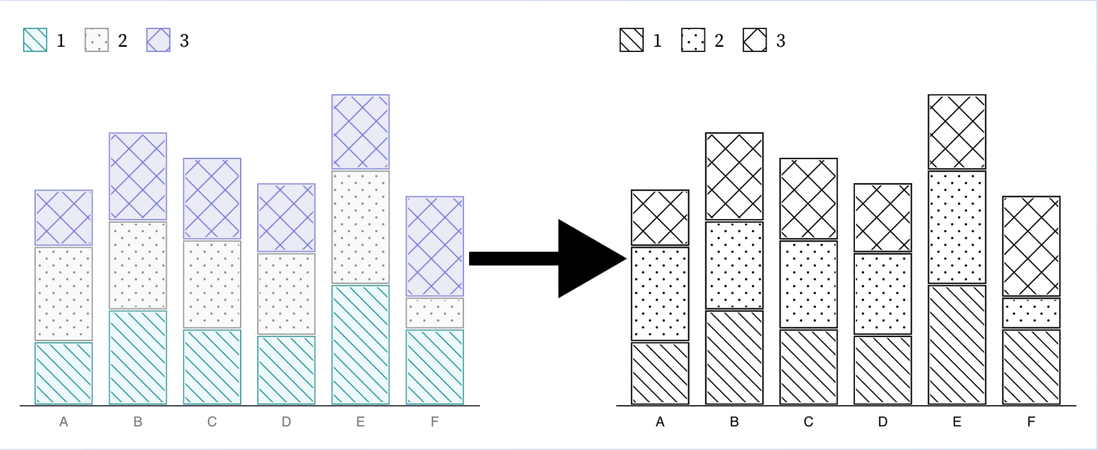




Check out Chartability for more

- **Perceivable**
- **Operable**
- **Understandable**
- Robust
- Compromising
- Assistive
- Flexible





Chartability

YOW! 2025

frank.computer

★Slides here

From Charted to Uncharted Territory

Accessibility and Interactive Data Experiences

Frank Elavsky

Human-Computer Interaction Institute

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