

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

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	BLUE	WHITE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED

Set 1

X	Y
10	8.04
8	6.95
13	7.58
9	8.81
11	8.33
14	9.96
6	7.24
4	4.26
12	10.84
7	4.82
5	5.68

Set 2

X	Y
10	9.14
8	8.14
13	8.74
9	8.77
11	9.26
14	8.1
6	6.13
4	3.1
12	9.11
7	7.26
5	4.74

Set 3

X	Y
10	7.46
8	6.77
13	12.74
9	7.11
11	7.81
14	8.84
6	6.08
4	5.39
12	8.15
7	6.42
5	5.73

Set 4

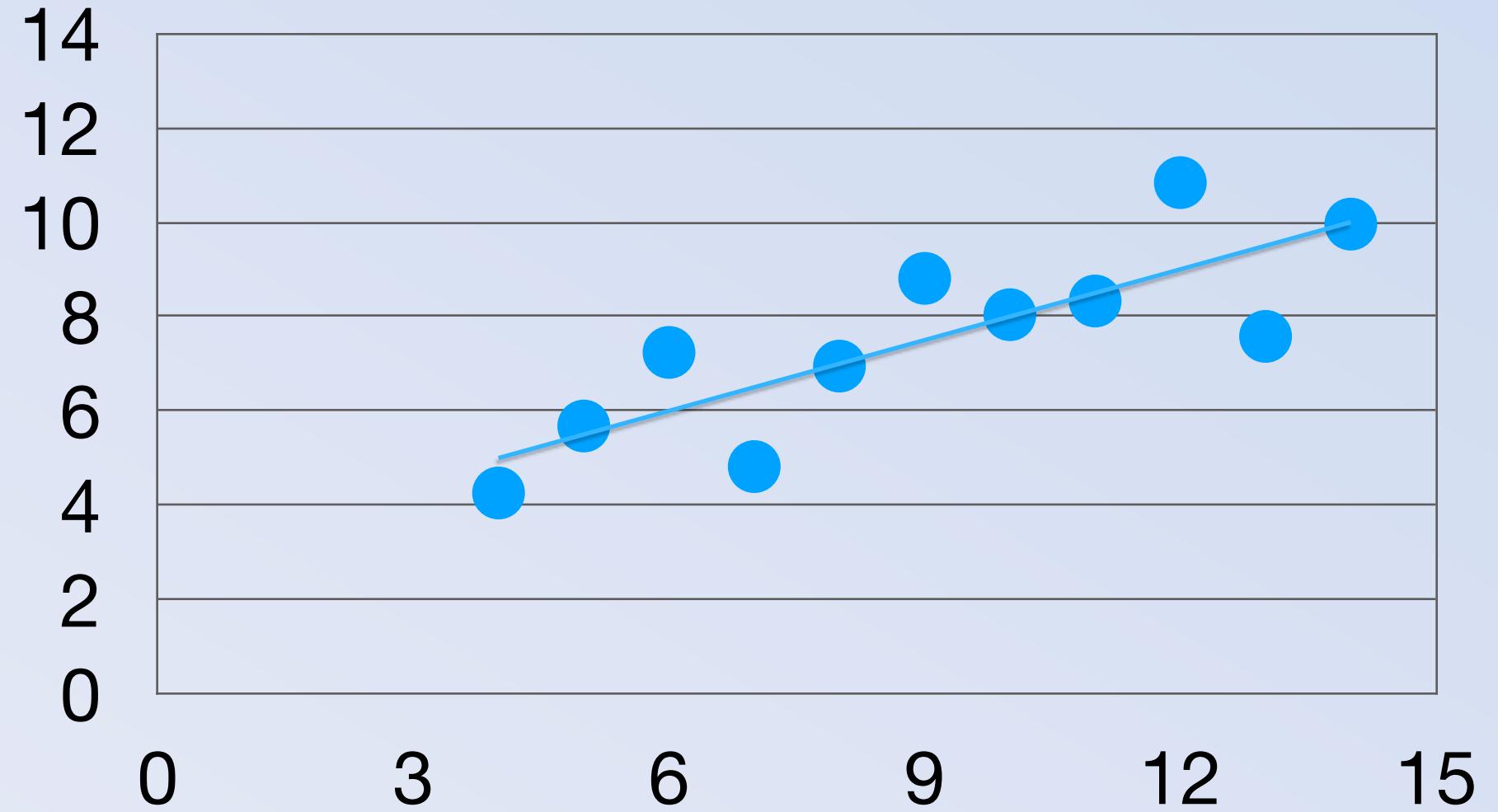
X	Y
8	6.58
8	5.76
8	7.71
8	8.84
8	8.47
8	7.04
8	5.25
19	12.5
8	5.56
8	7.91
8	6.89

Summary Statistics Linear Regression

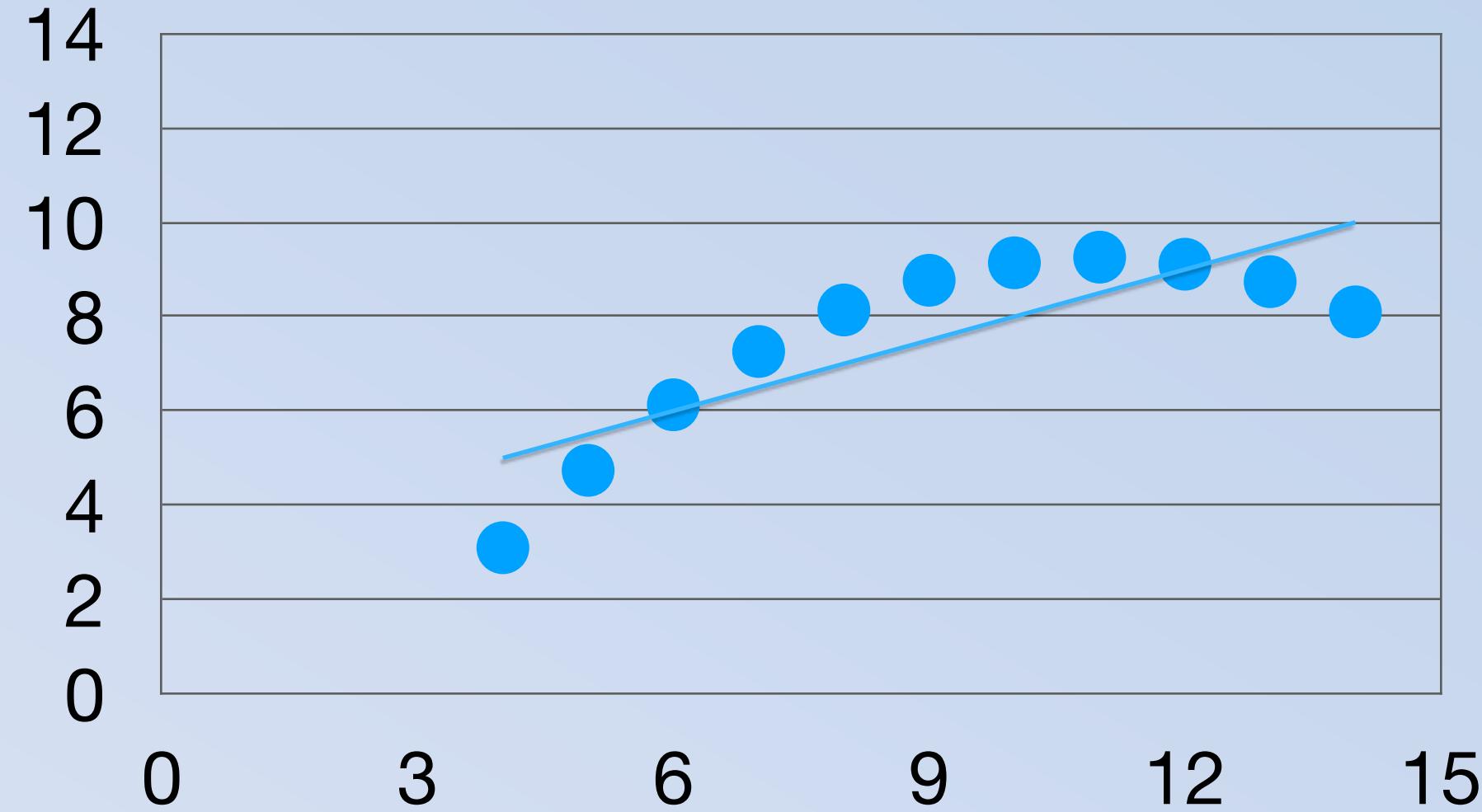
$$\begin{aligned} \bar{X} &= 9.0 & \sigma_X &= 3.317 & Y^2 &= 3 + 0.5 X \\ \bar{Y} &= 7.5 & \sigma_Y &= 2.03 & R^2 &= 0.67 \end{aligned}$$

[Anscombe 1973]

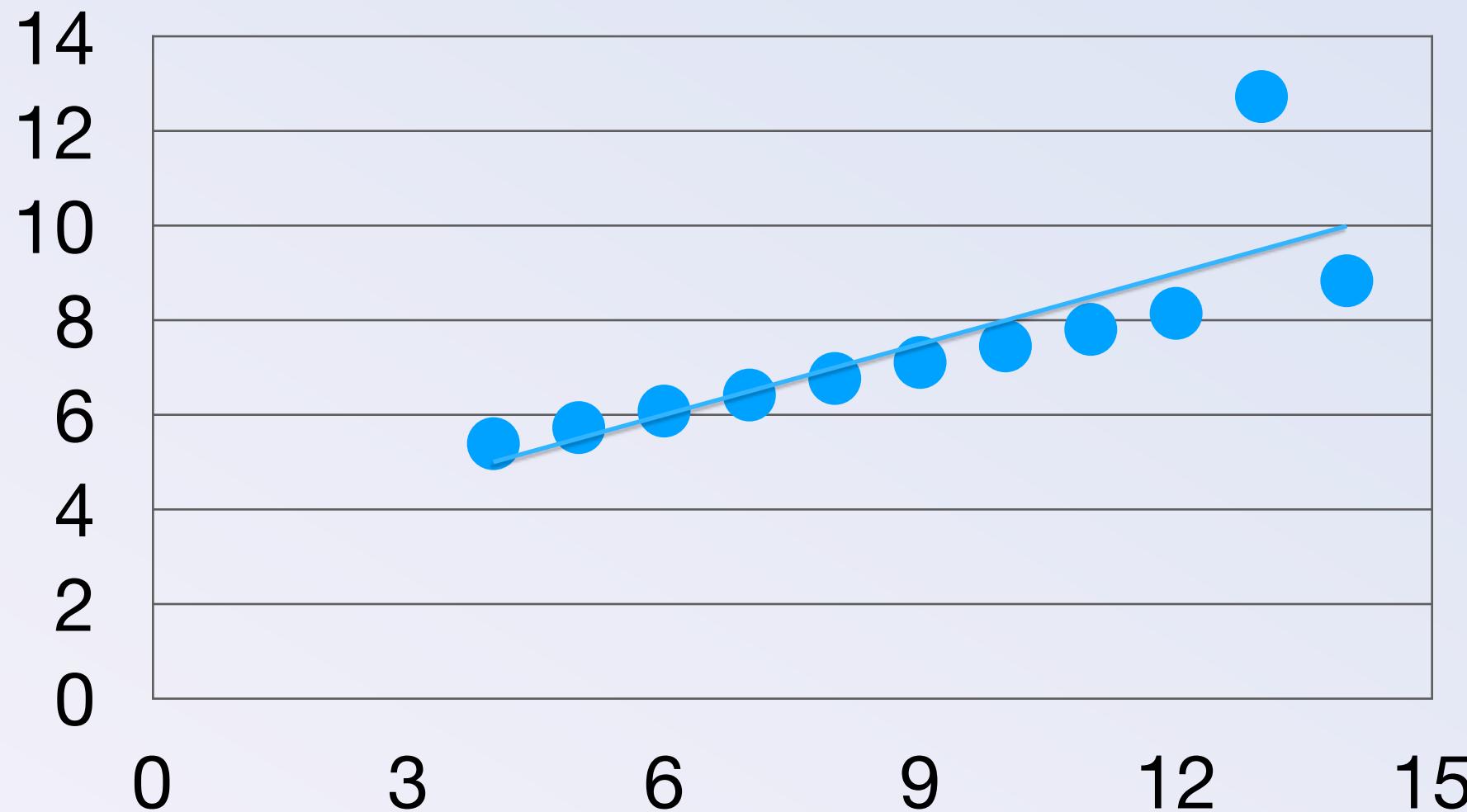
Set 1



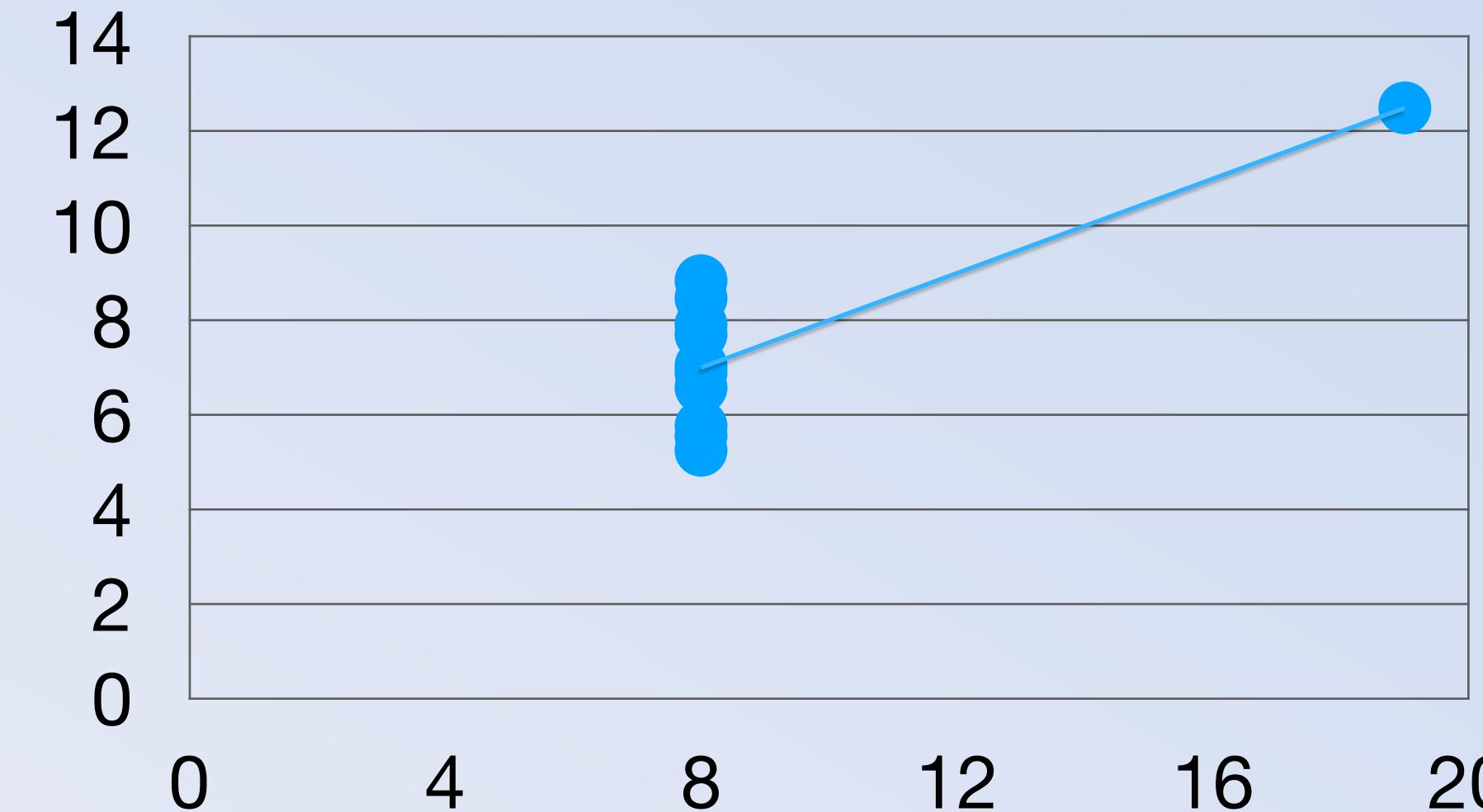
Set 2

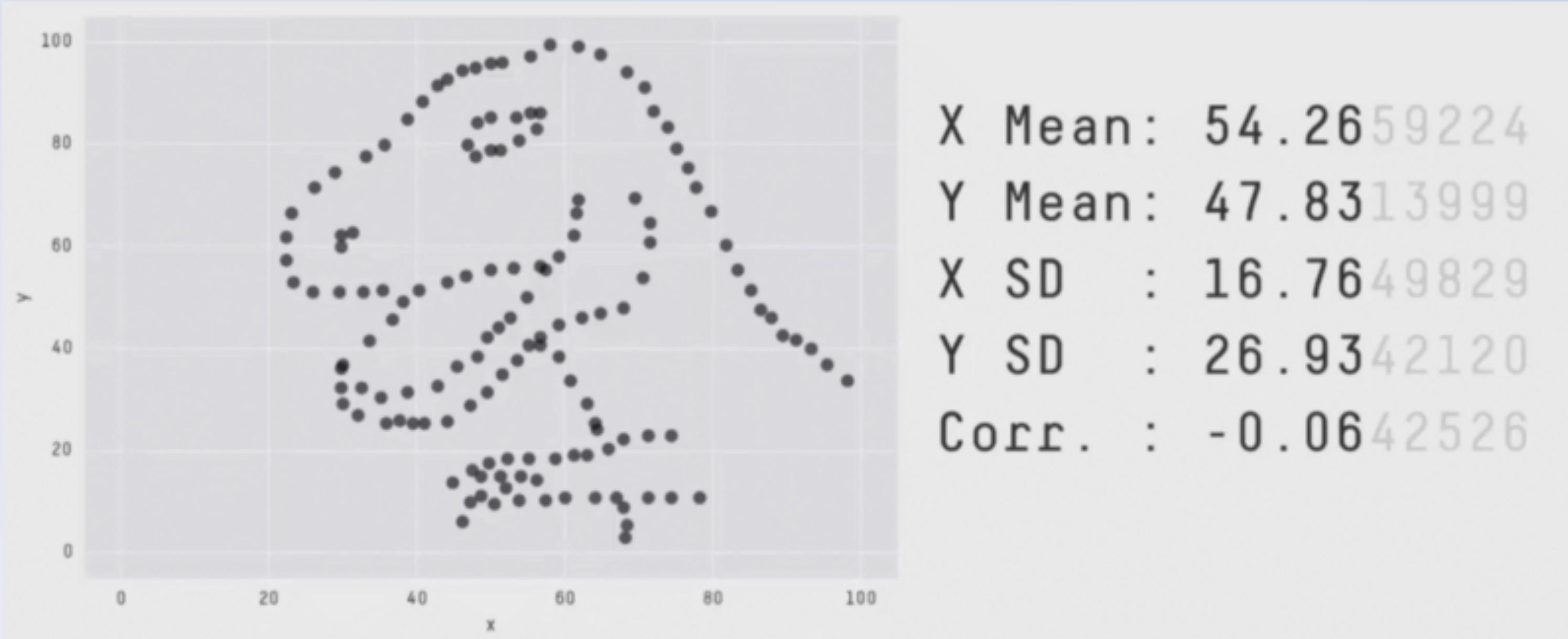


Set 3



Set 4





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%)

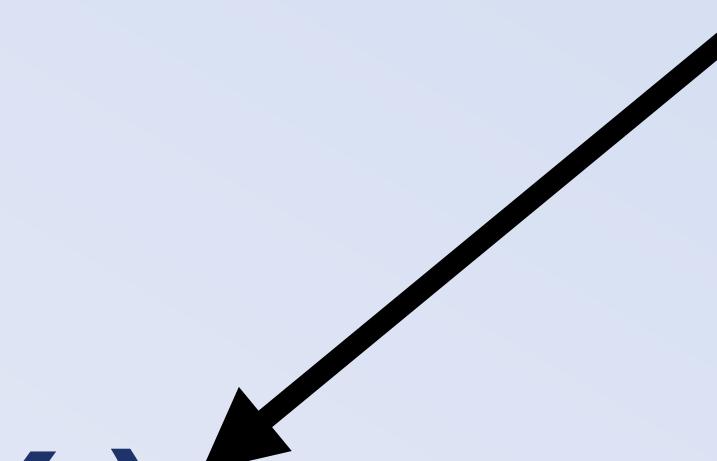
Agenda

1. Why (0%)

2. What (0%)

3. How (100%)

By the end of this talk,
You may have wanted this



Agenda

1. Why (20%)

2. What (30%)

3. How (50%)

Accessibility 101



Agenda

1. Why (20%)

2. What (30%)

3. How (50%)

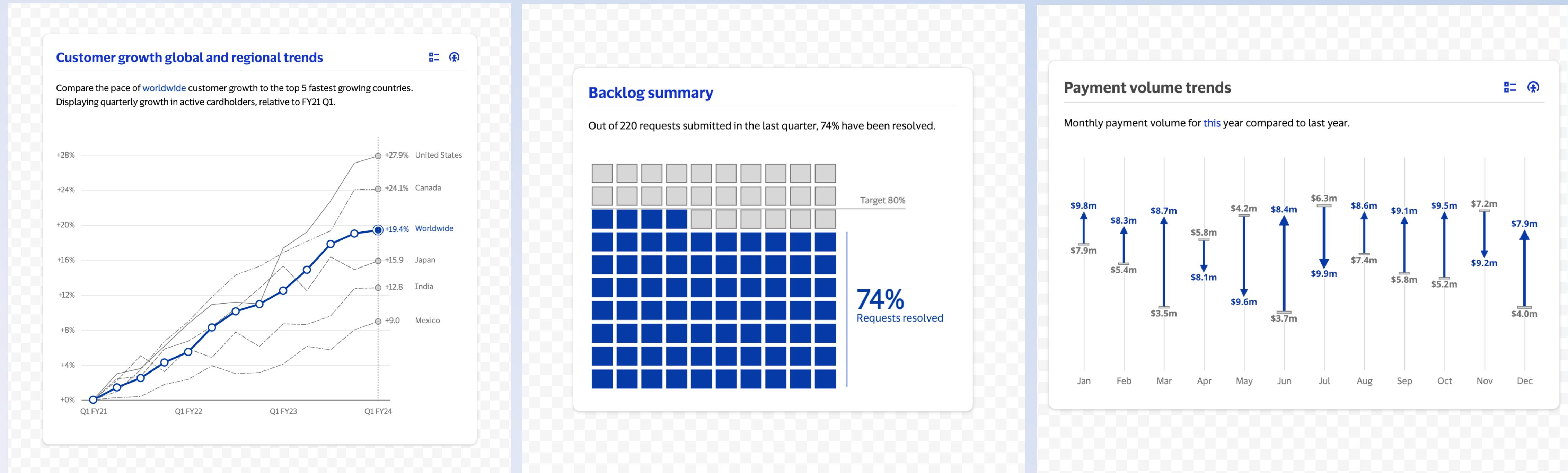
Accessibility 101



Vis+Accessibility 801



Prior work: Staff-level engineer making a visualization library



“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

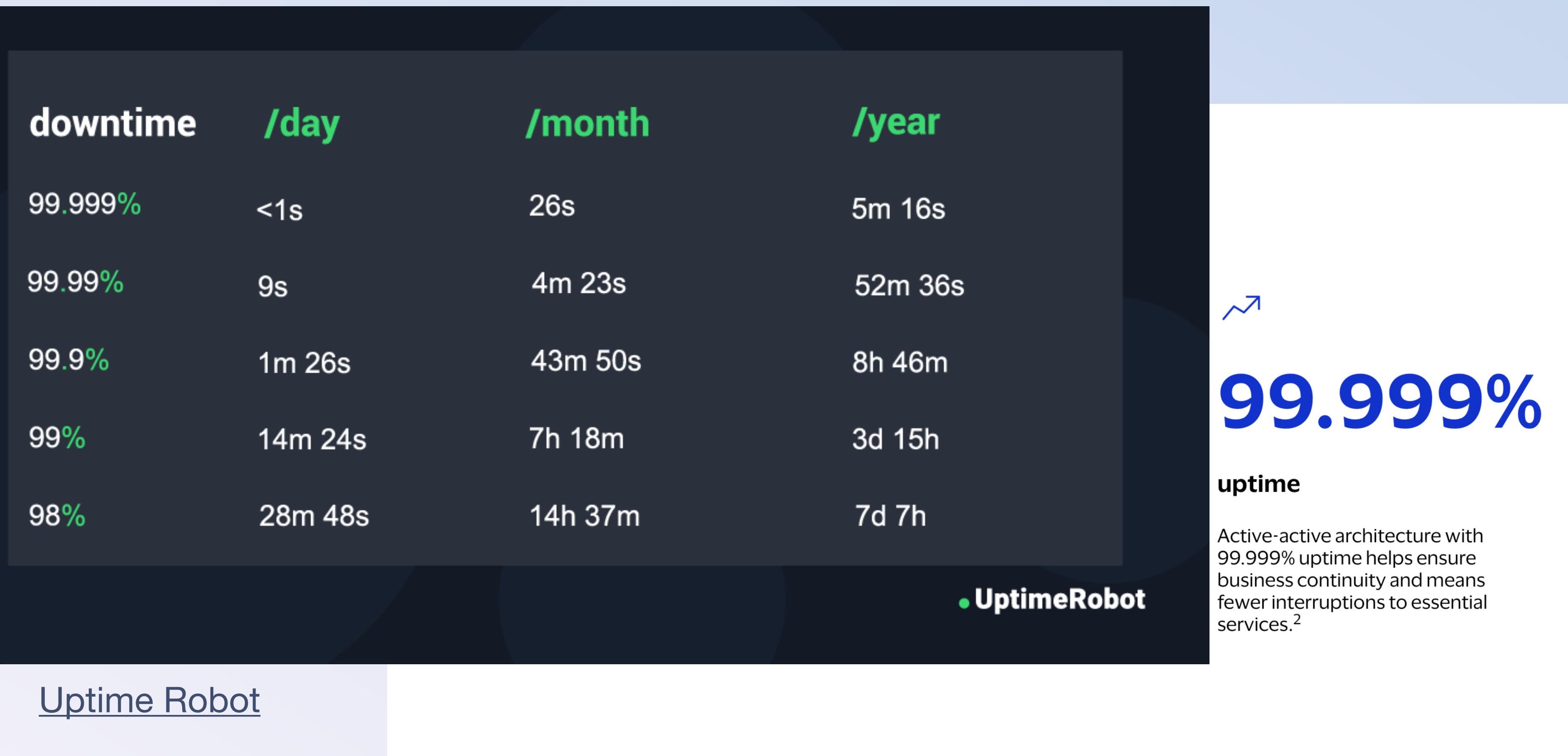
Visa's Acceptance Platform Uptime

“Five 9s” of speed and scale



Visa's Acceptance Platform Uptime

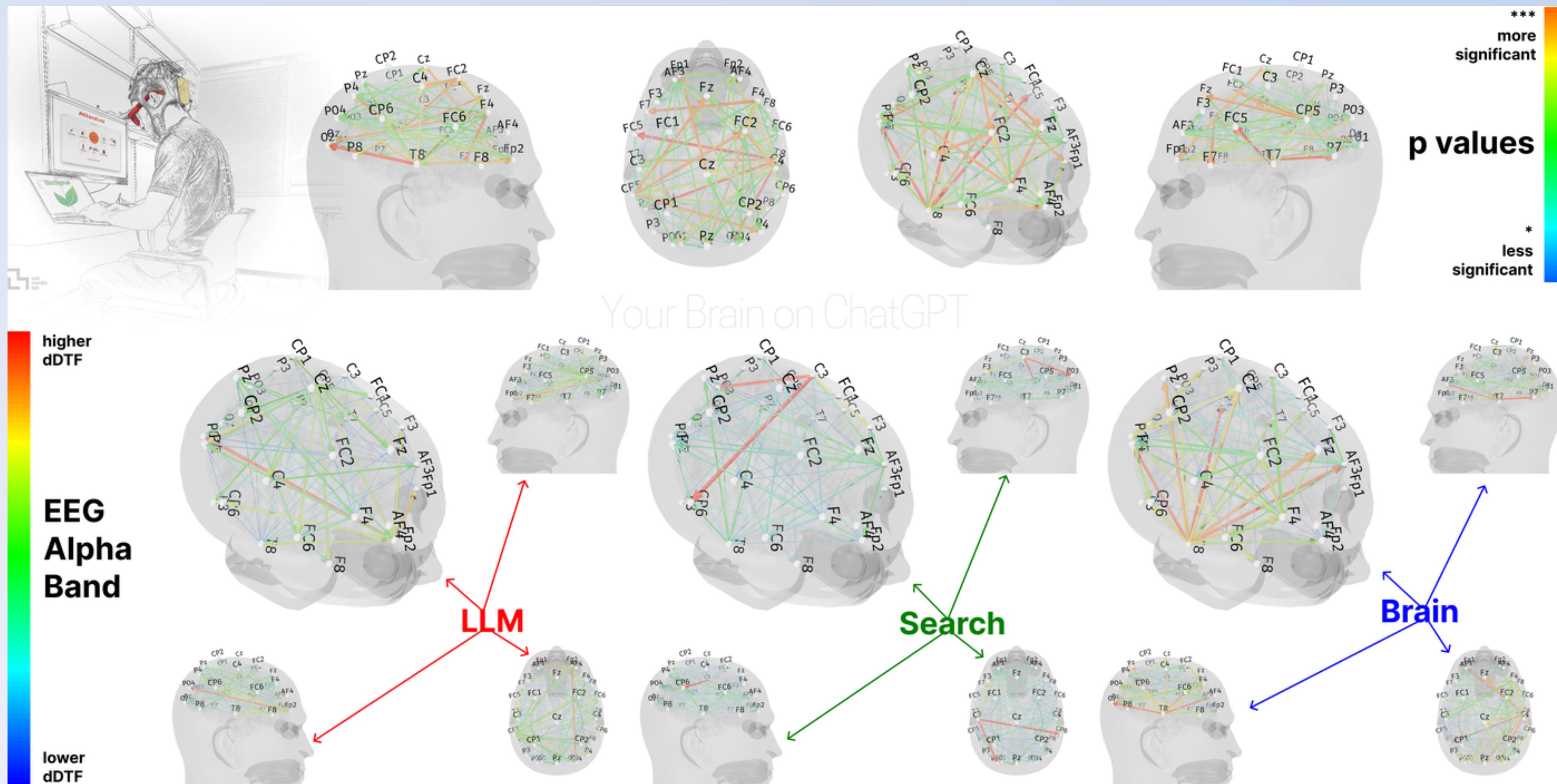
“Five 9s” of speed and scale



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"

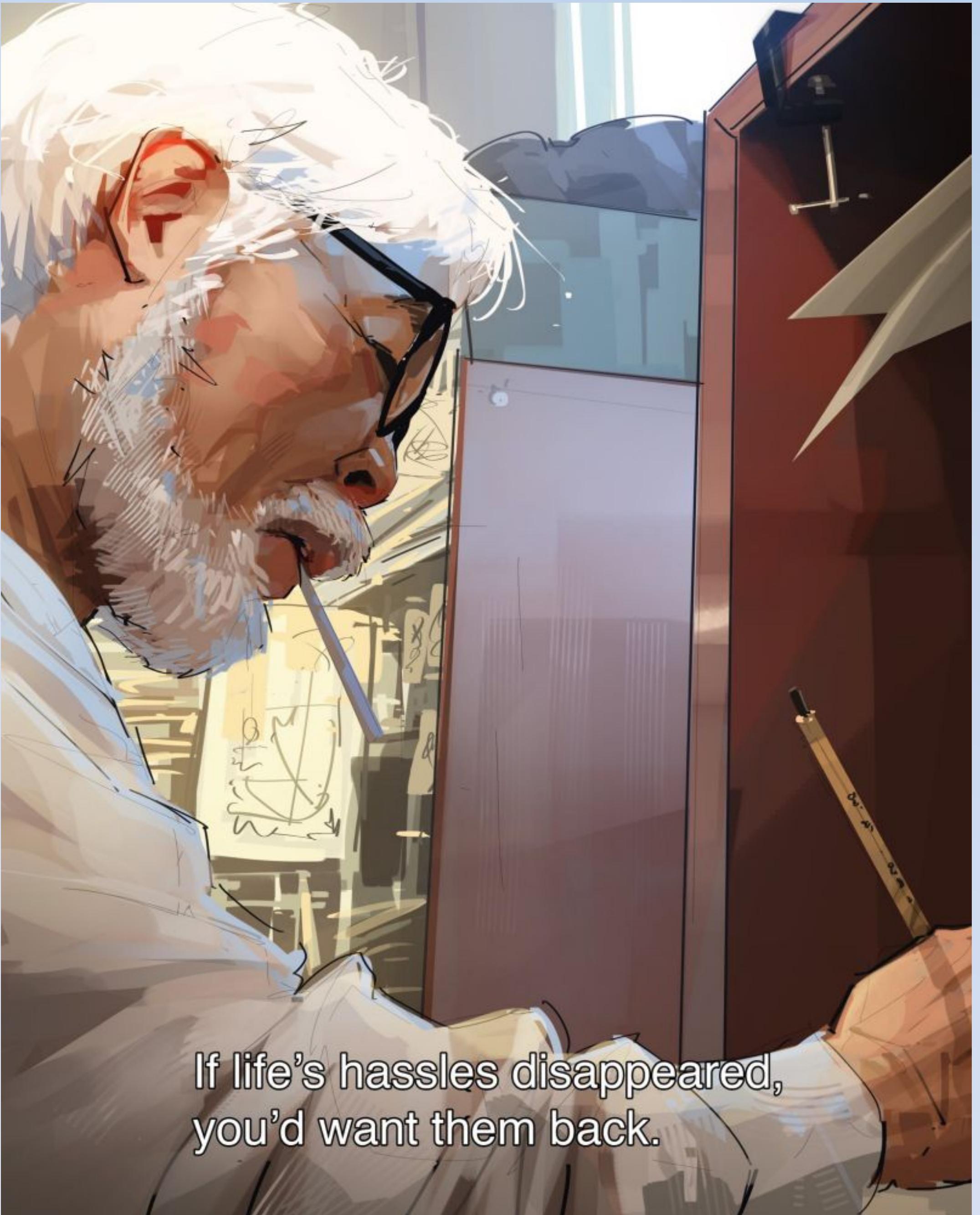
Automatic accessibility validation

▶ 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: `null`. If "null" is intended as an empty value be sure to mark the schema as `nullable()`	bar-chart.entry.js:49499
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](#)



Why?

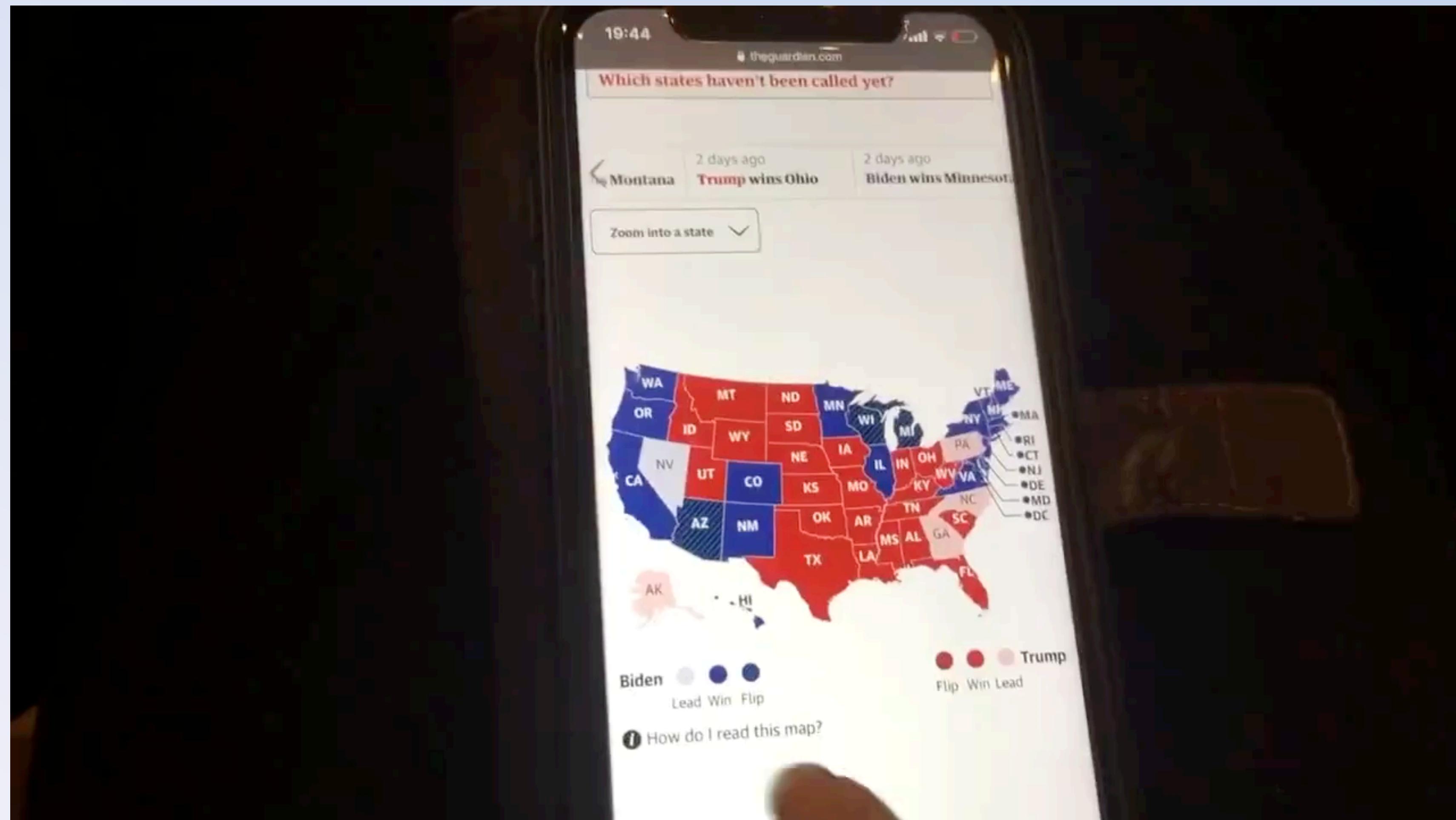
(Why do accessibility work? Why care?)

From problem solvers, to problem *understanders*

(and understanding that people's disability is not the problem:
your code, designs, and artifacts are)

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.

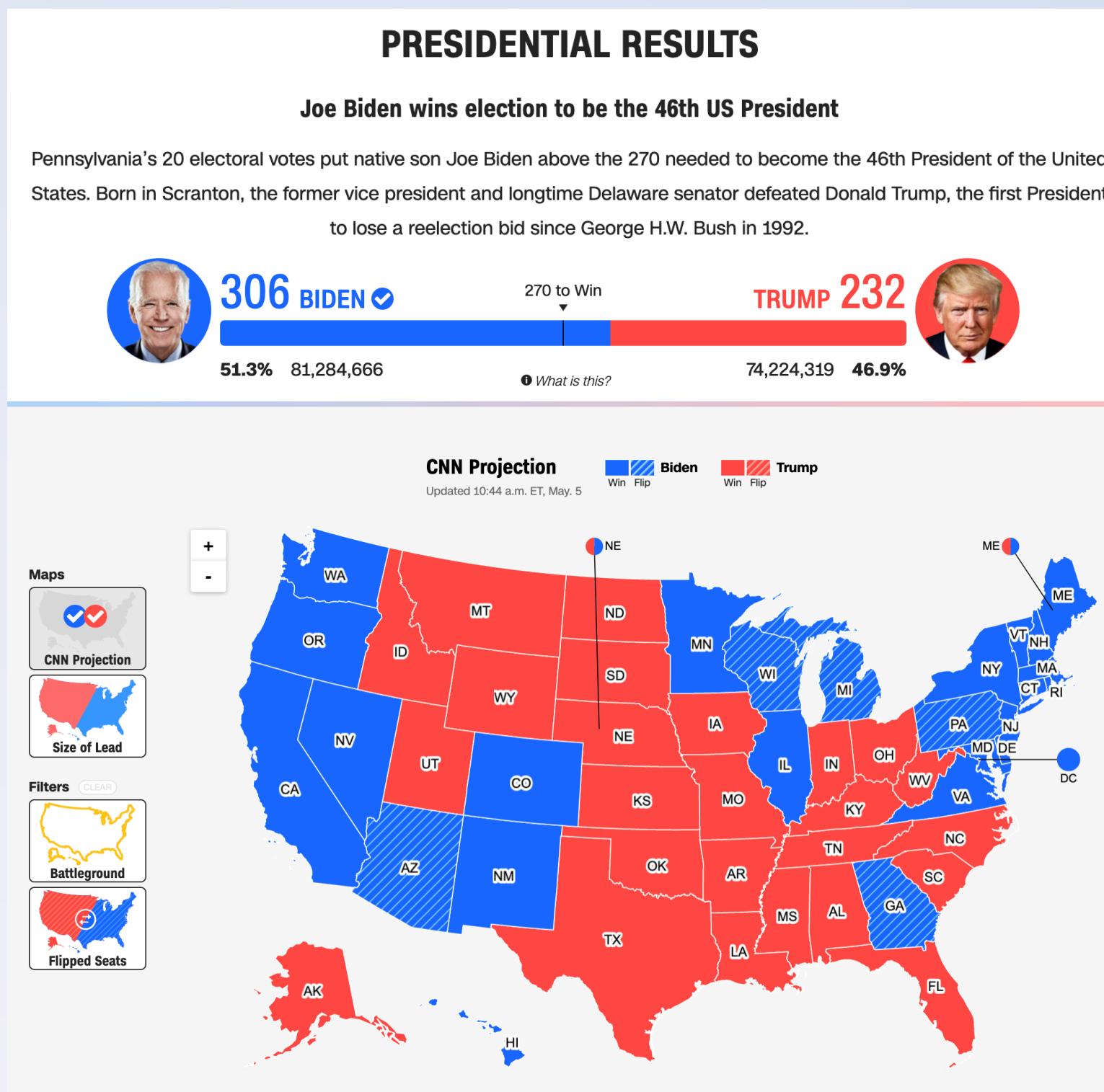
It is the morally and ethically correct thing to do.



[UN CRPD Article 9: Accessibility](#), [UN CRPD Article 10: Right to Life](#)

People with disabilities deserve to:

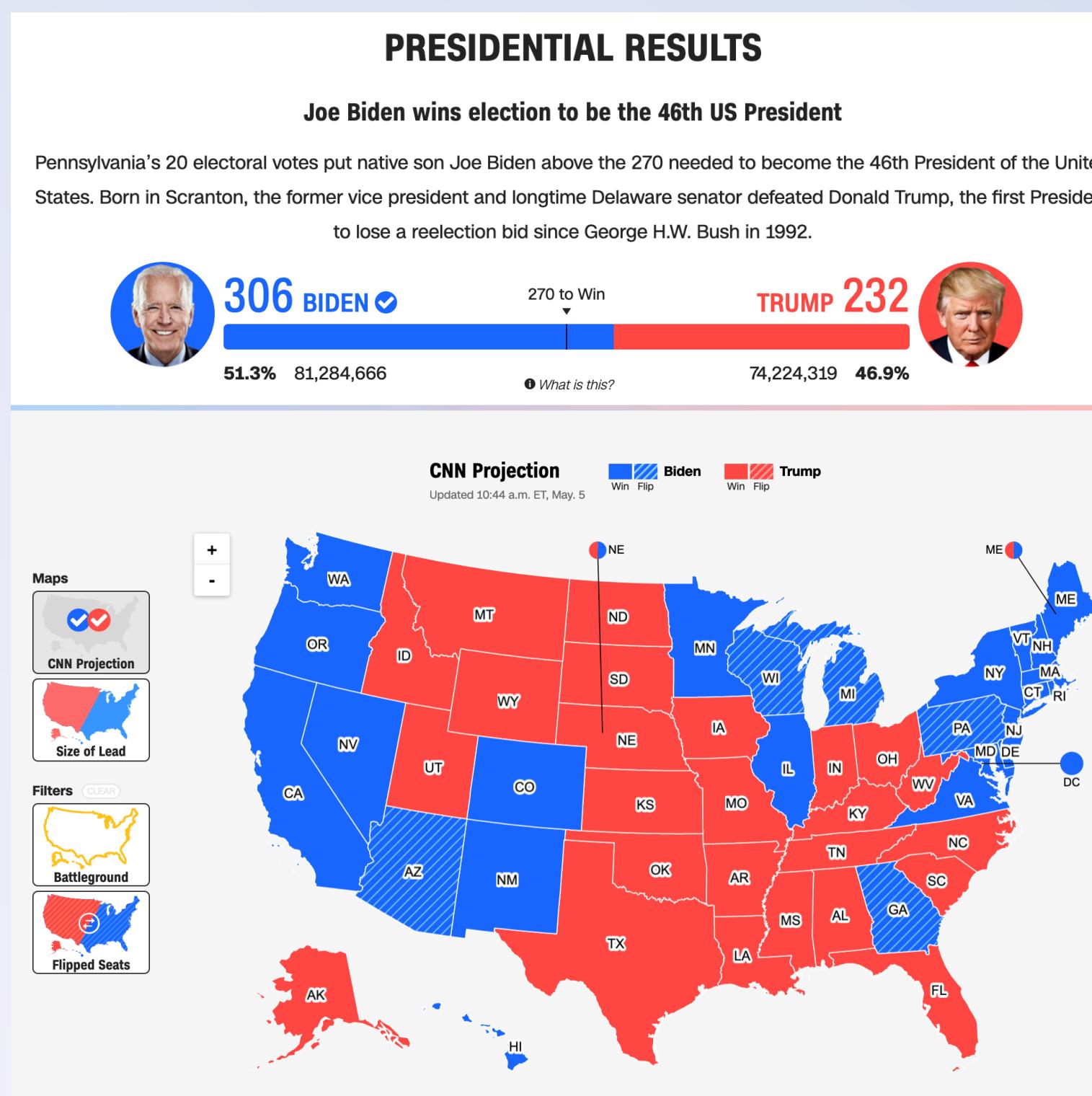
Participate in politics



Credit: [CNN](#)

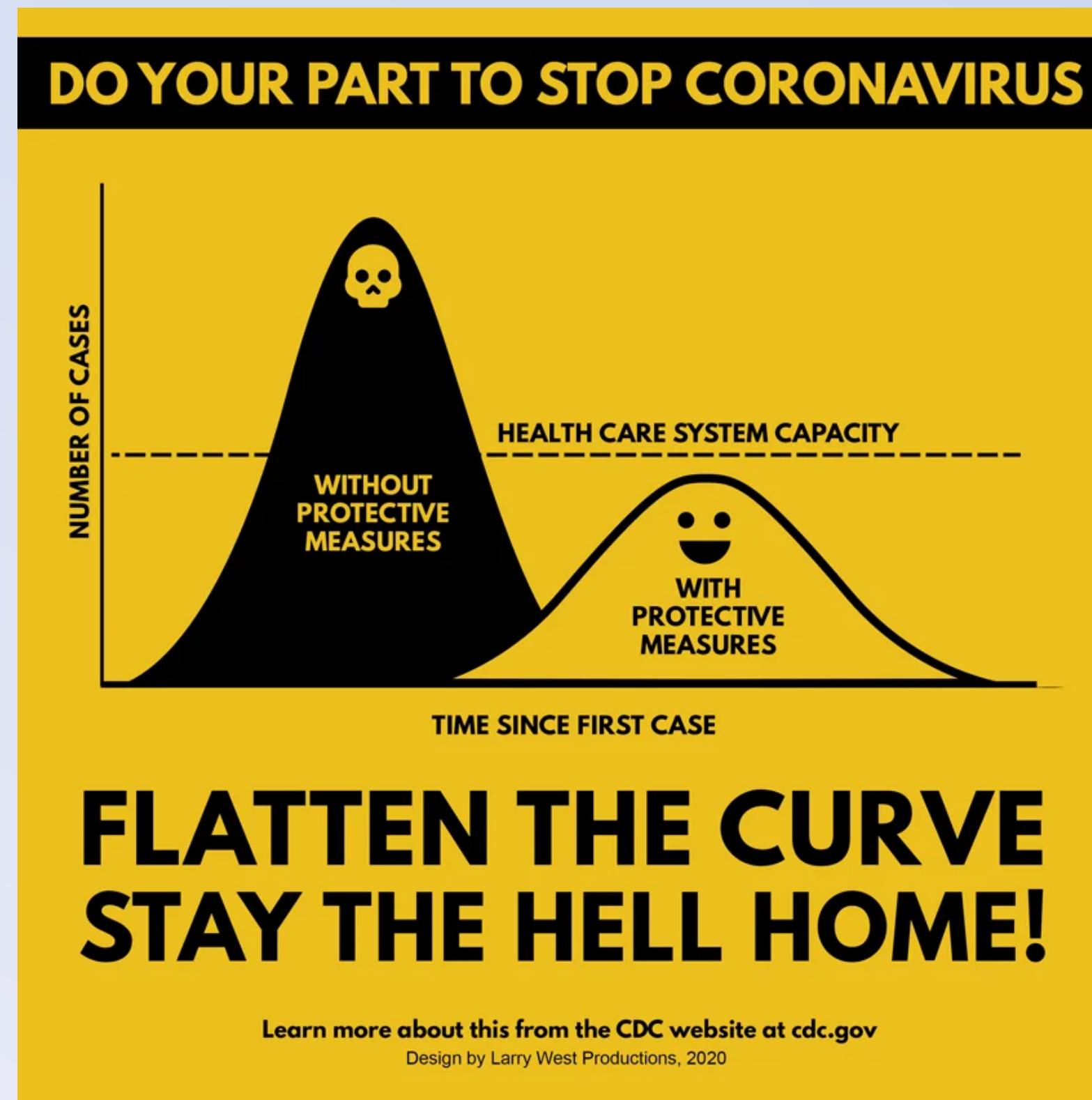
People with disabilities deserve to:

Participate in politics



Credit: [CNN](#)

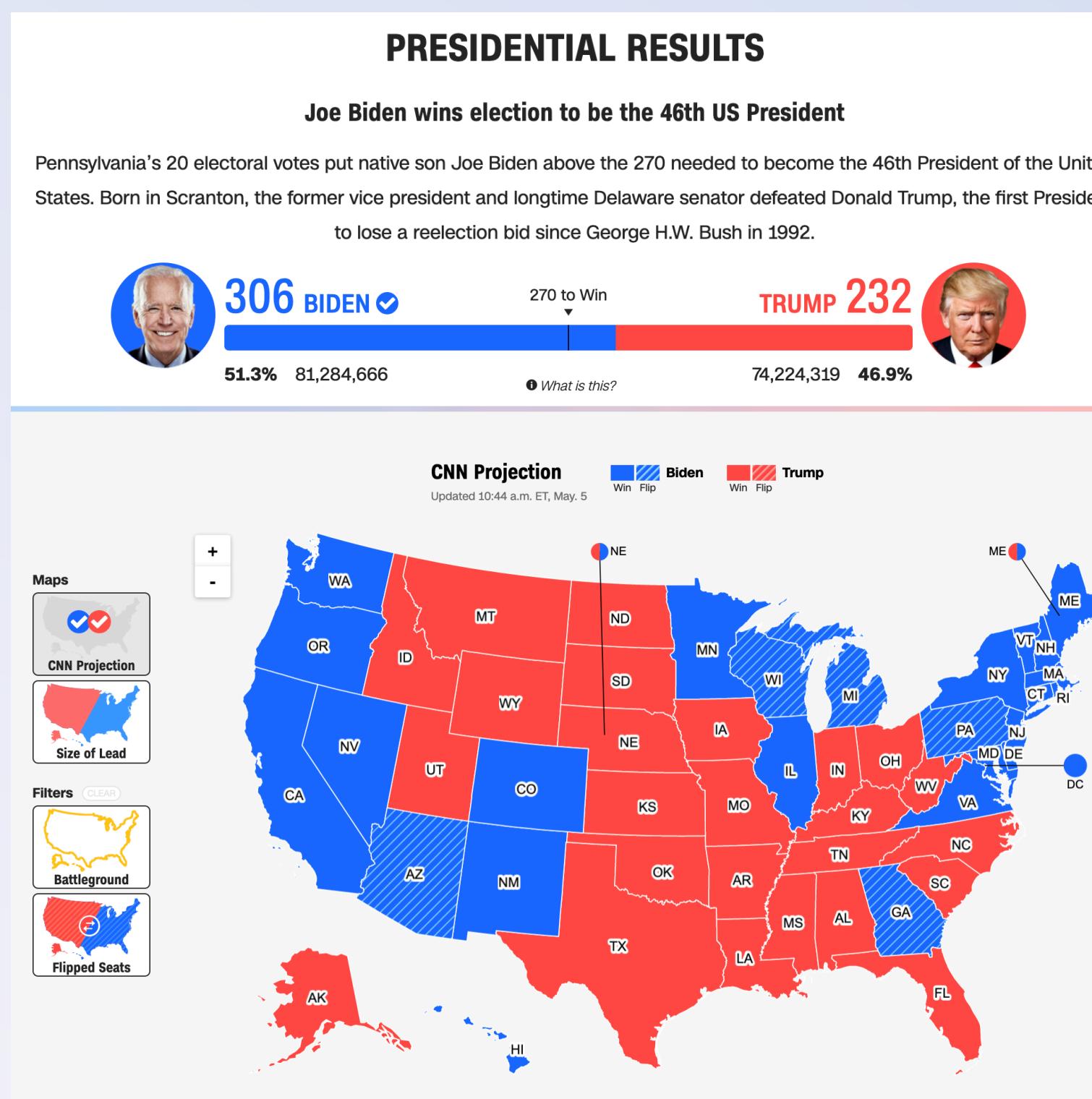
Make informed decisions



Credit: [Reddit](#)

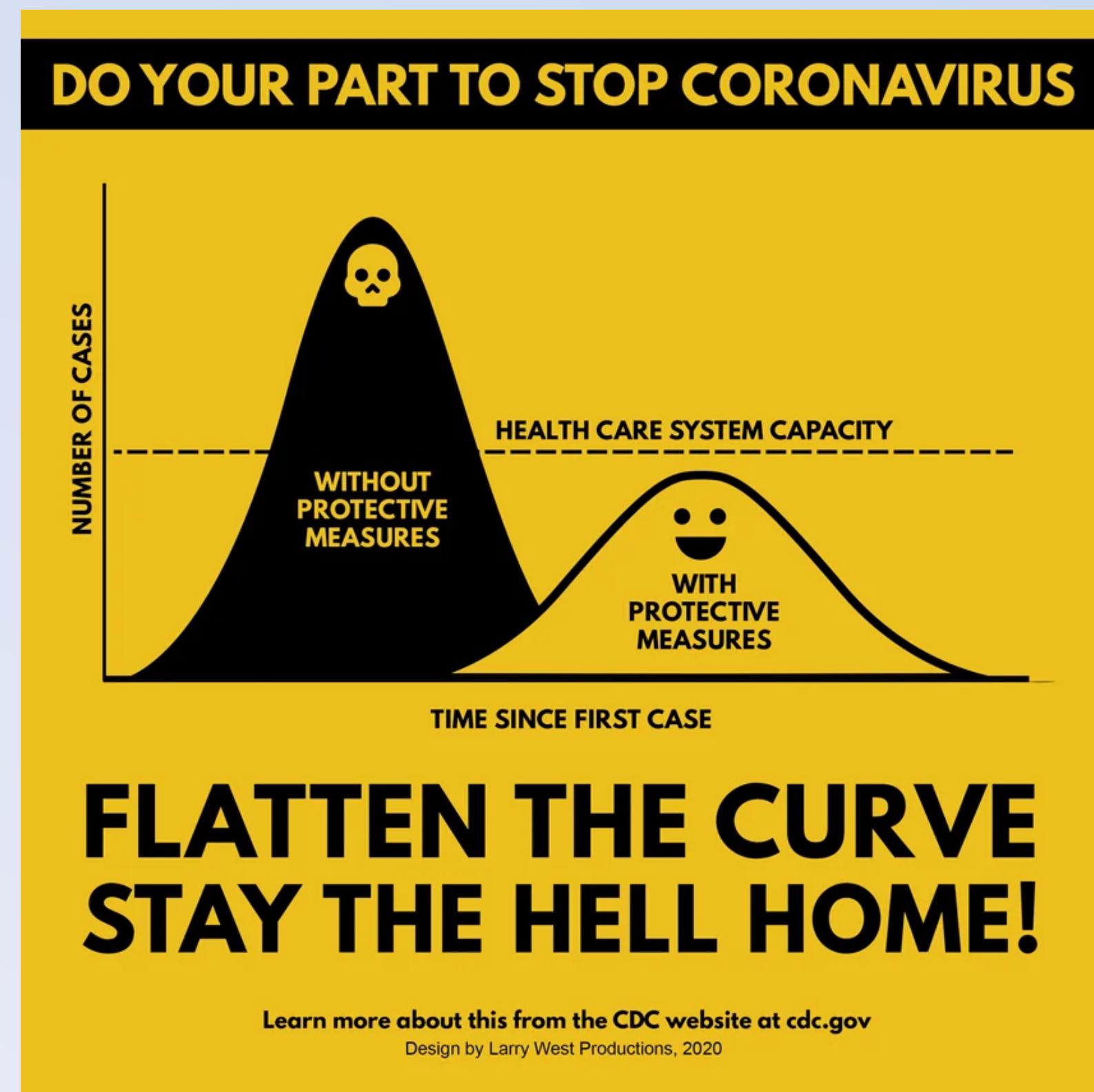
People with disabilities deserve to:

Participate in politics



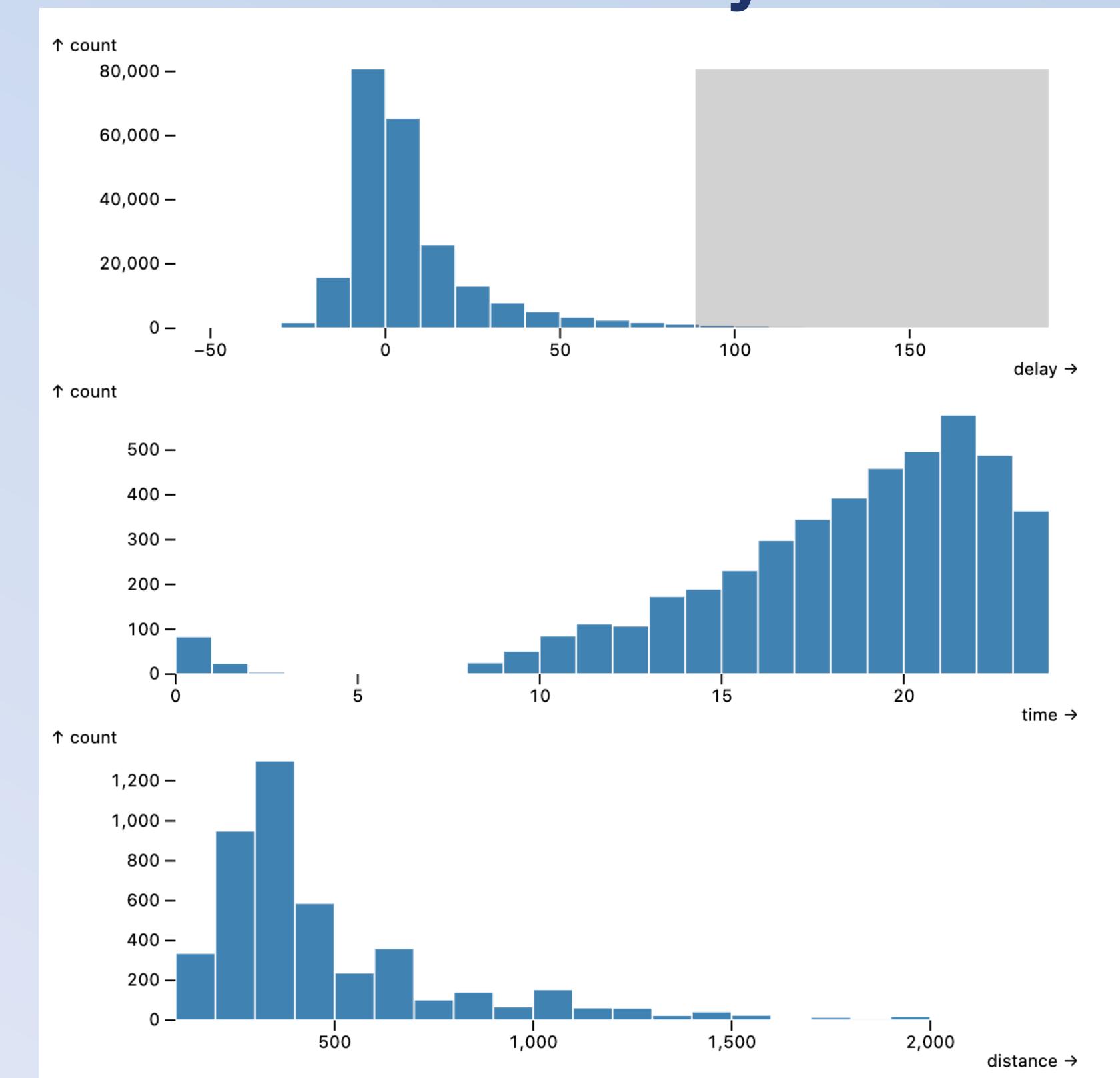
Credit: [CNN](#)

Make informed decisions



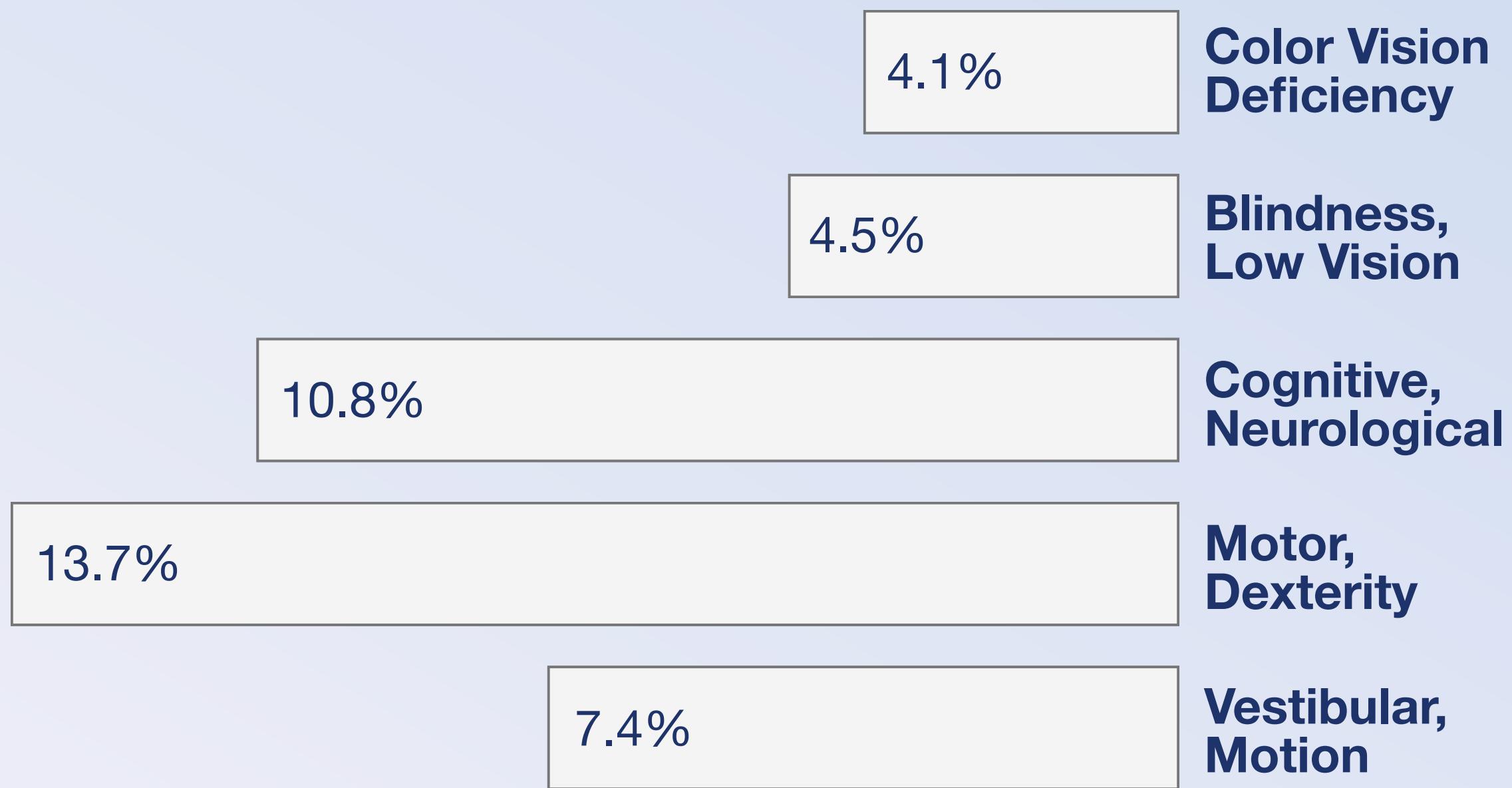
Credit: [Reddit](#)

Analyze data quickly and efficiently



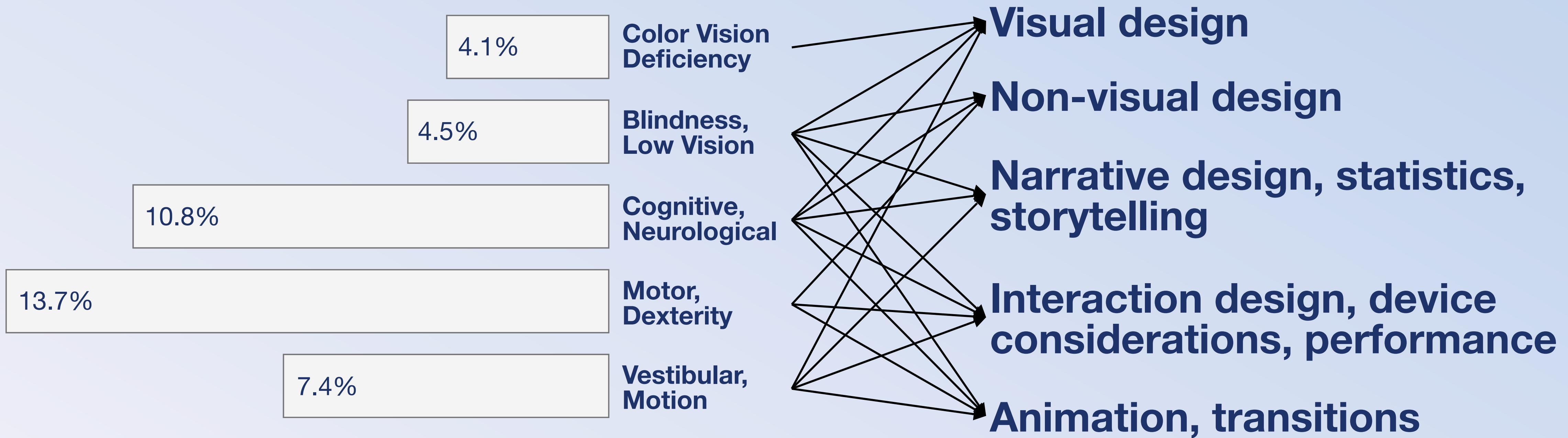
Credit: [Our research](#)

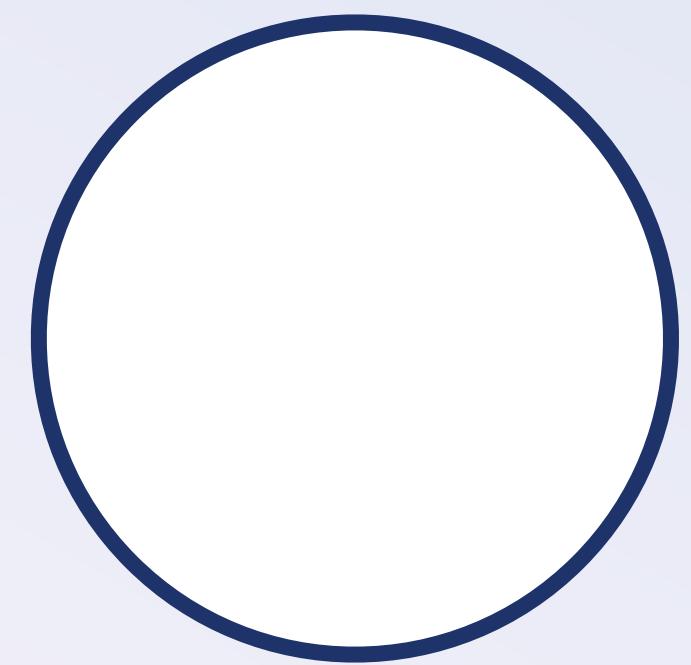
~27% of people living in the United States self-report living with a disability that affects their daily life.



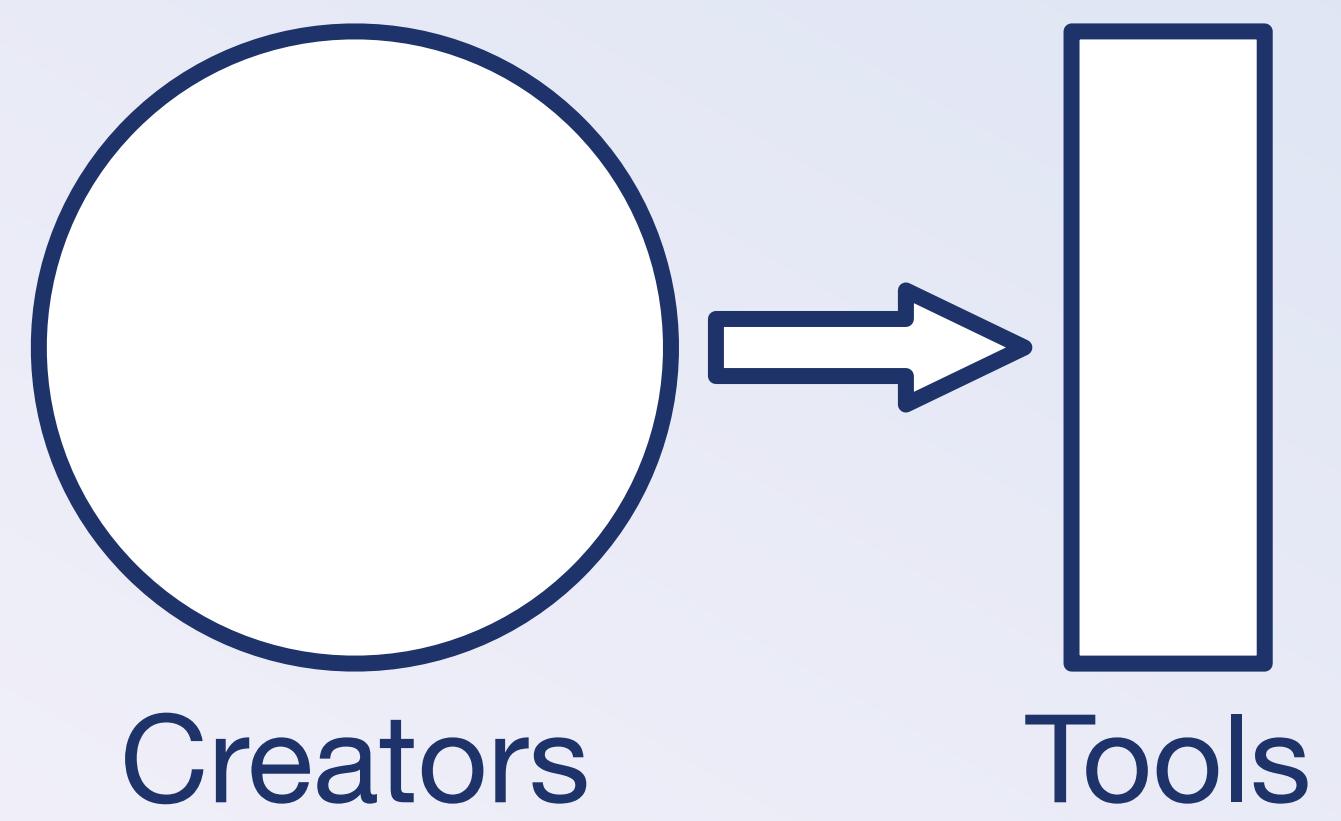
Source: Okoro et al. "Prevalence of Disabilities and Health Care Access by Disability Status and Type Among Adults"

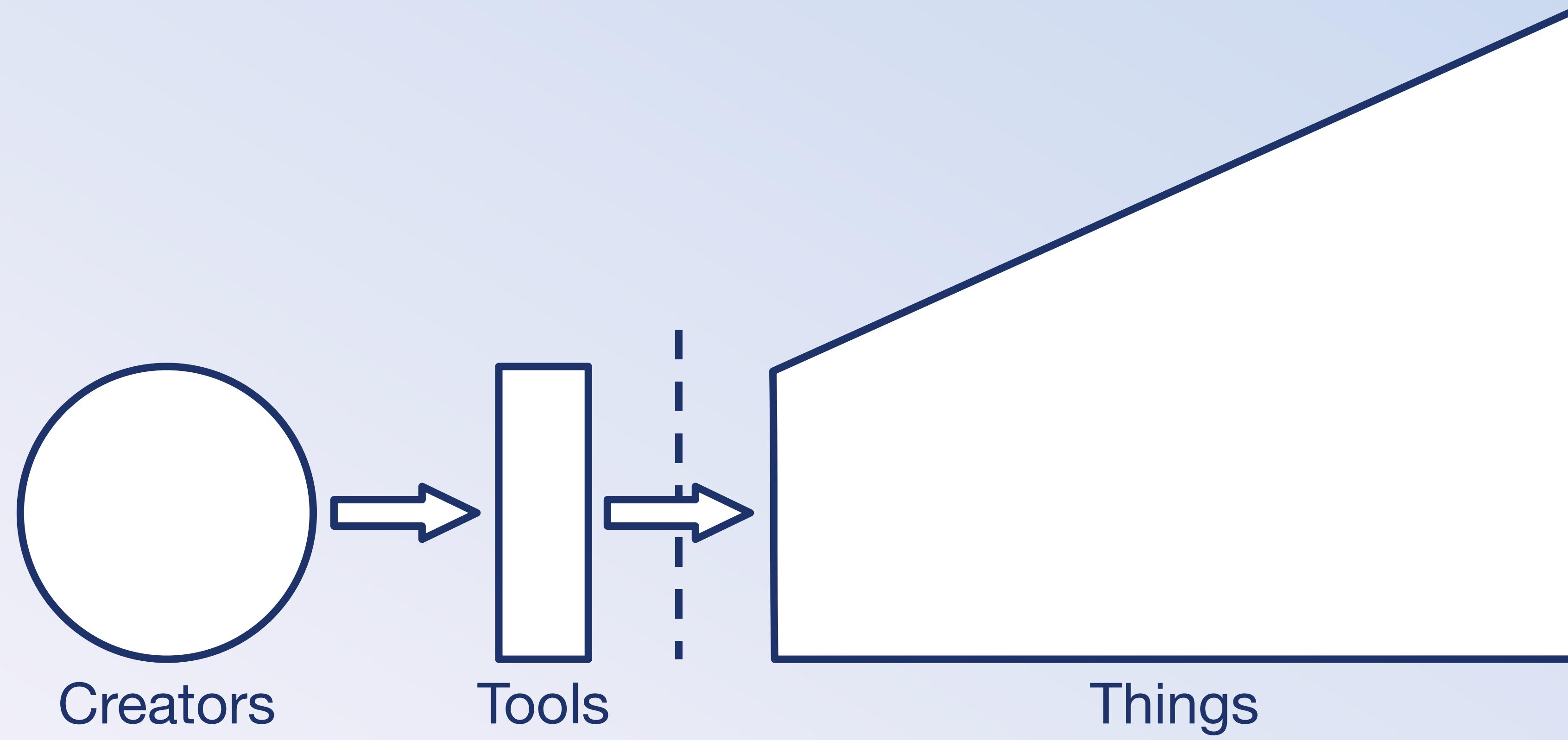
Accessibility affects every aspect of visualization work

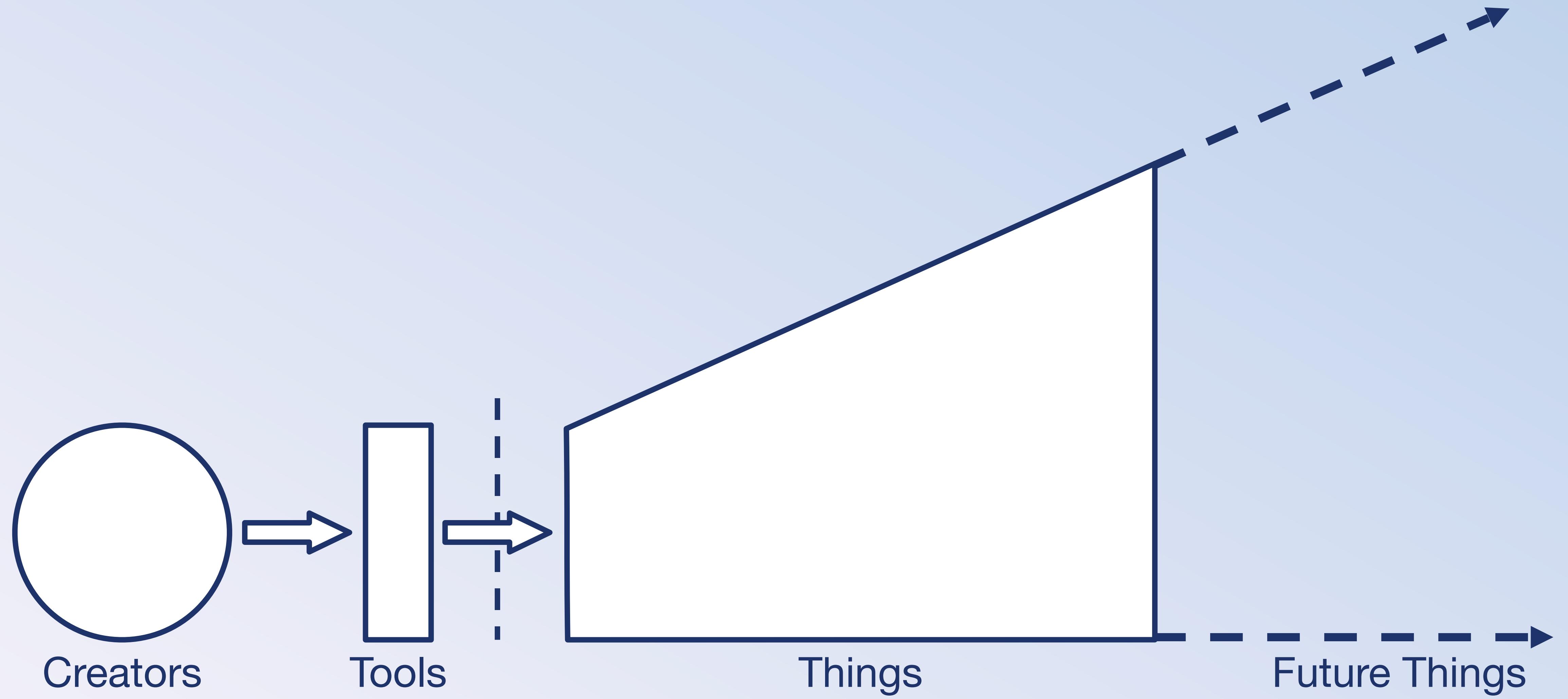




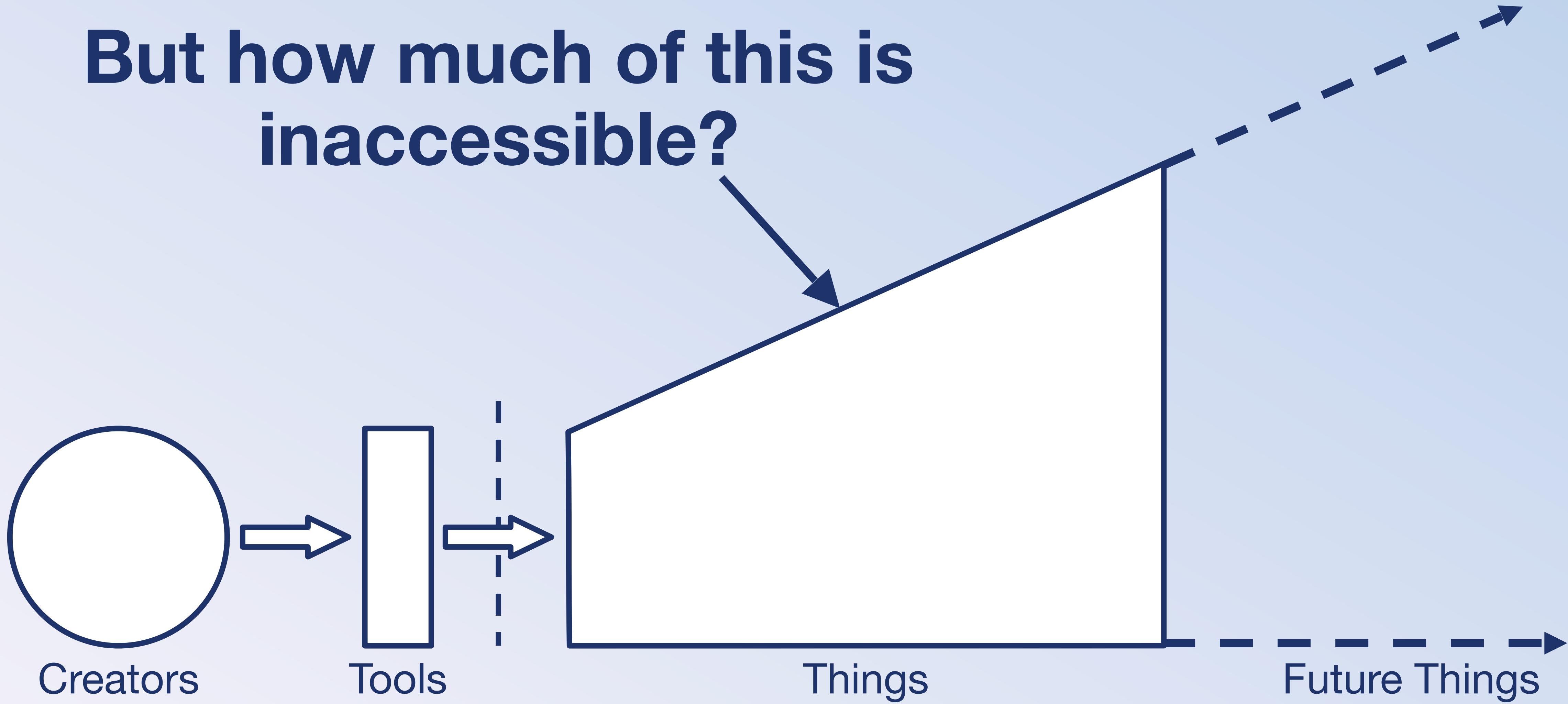
Creators

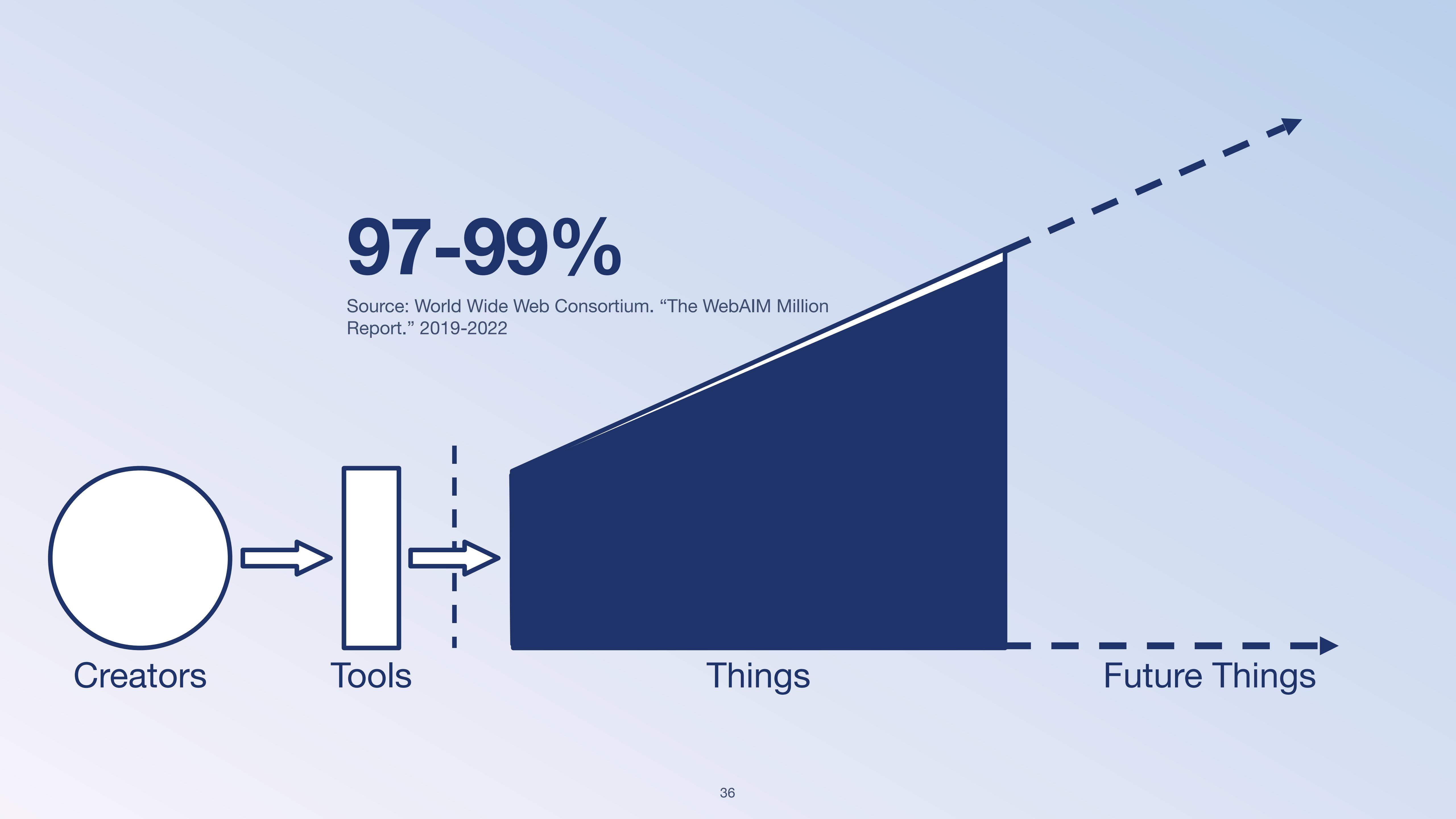






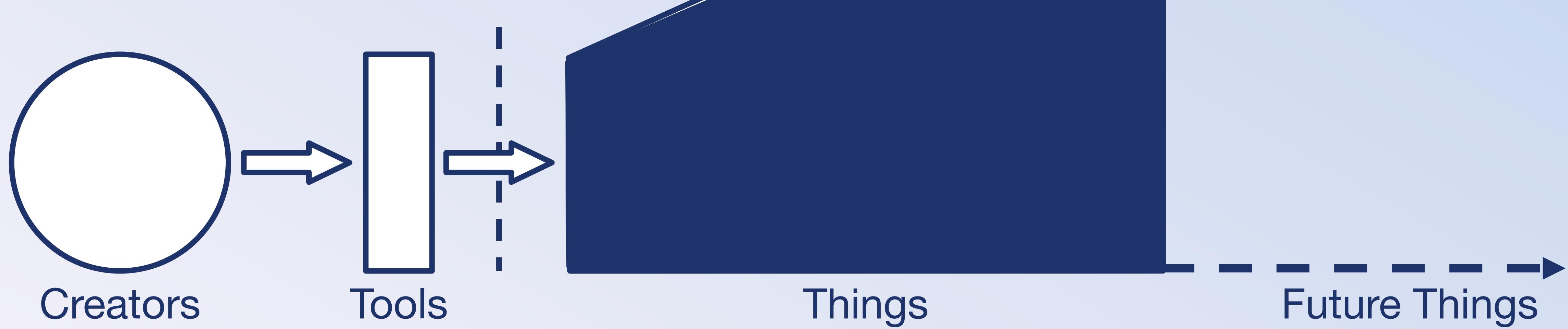
But how much of this is inaccessible?





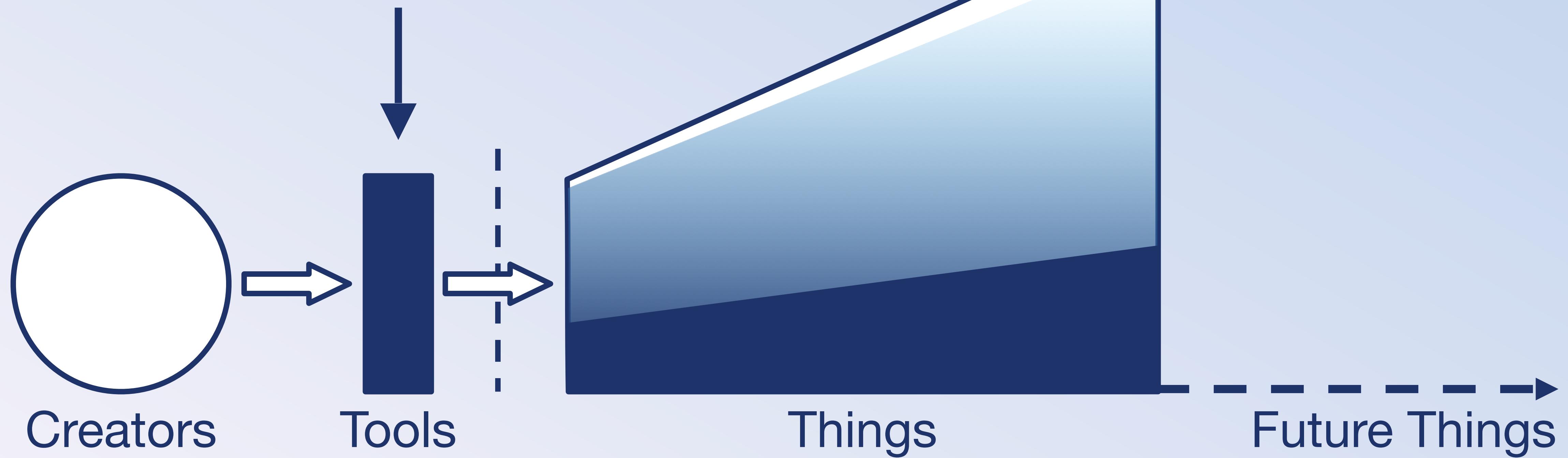
97-99%

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”



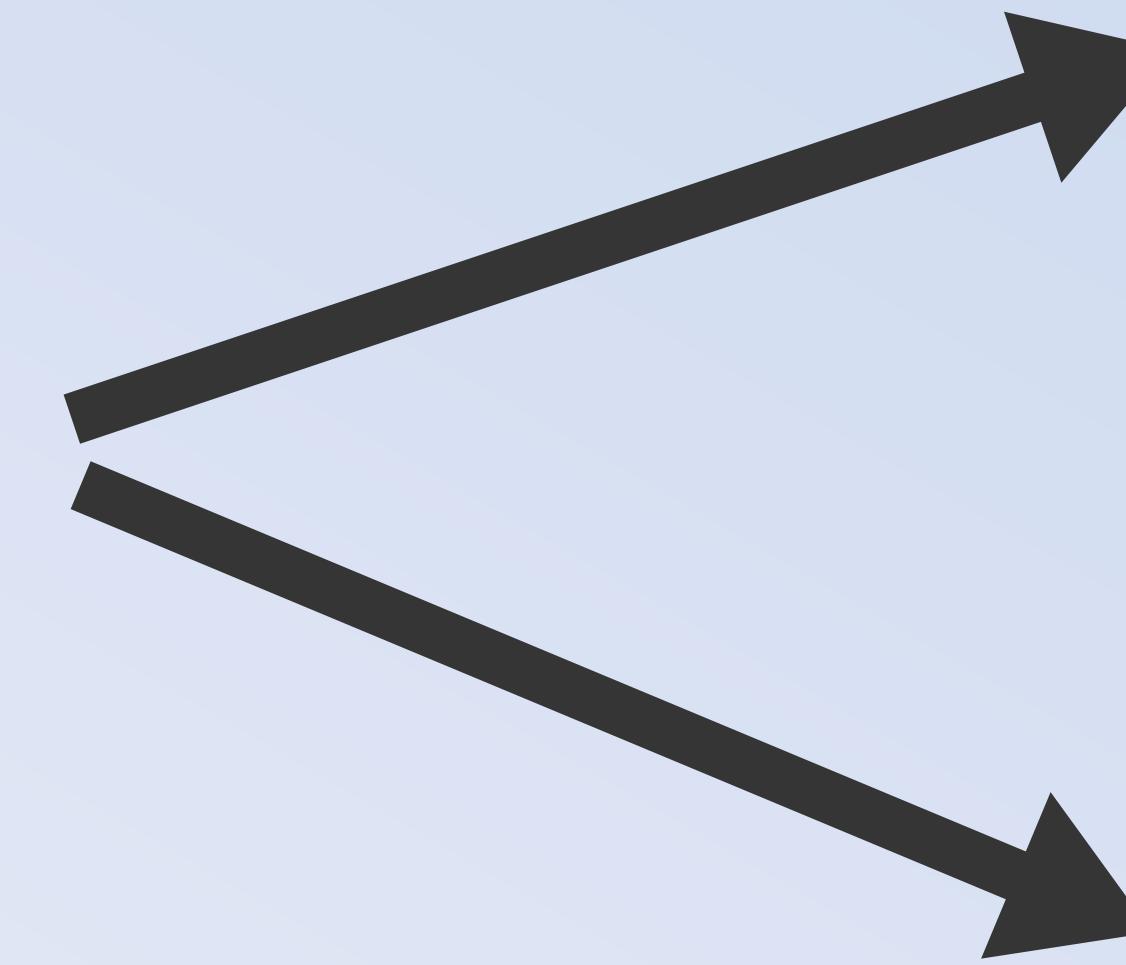
What do we do about curbs in our cities?



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



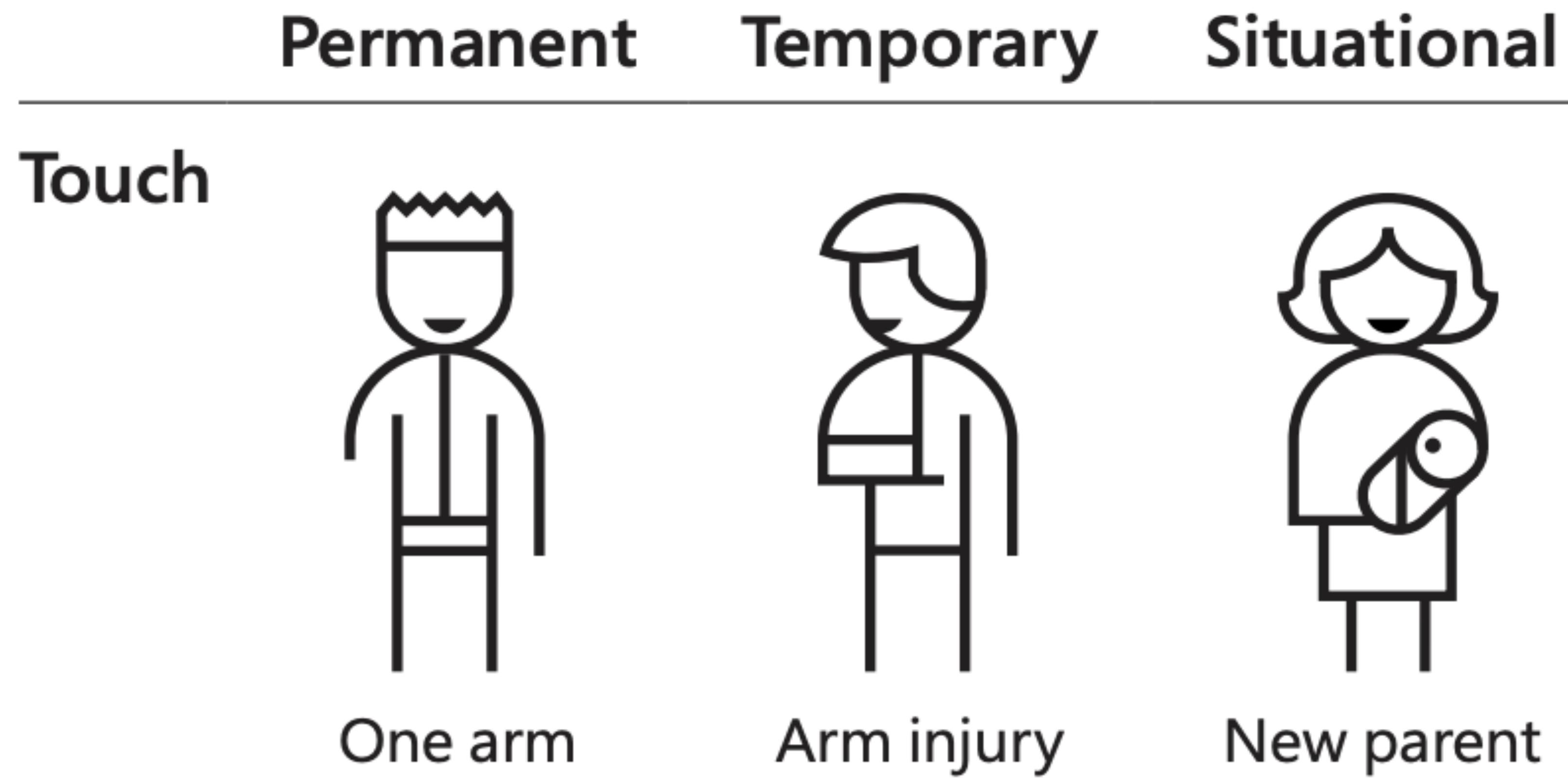
One arm



Arm injury

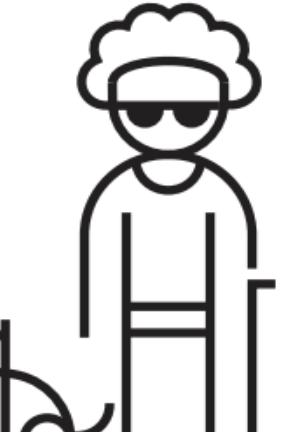
	Permanent	Temporary	Situational
Touch			
			
	One arm	Arm injury	New parent

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

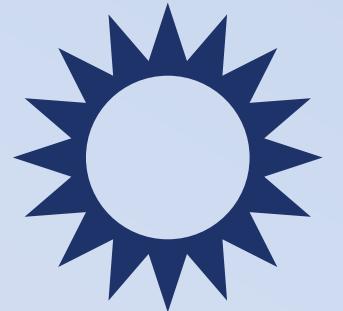


“Design for One, Extend to All”

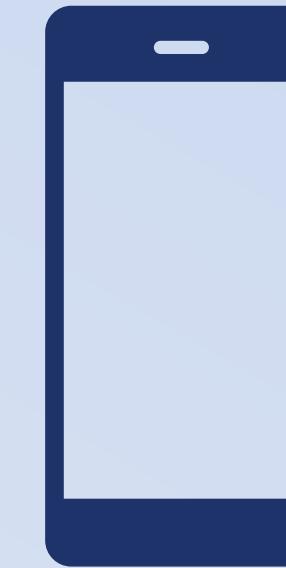
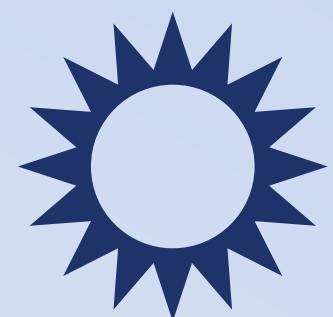
Microsoft’s Inclusive Design 101 Toolkit: https://download.microsoft.com/download/b/0/d/b0d4bf87-09ce-4417-8f28-d60703d672ed/inclusive_toolkit_manual_final.pdf

	Permanent	Temporary	Situational
Touch			
	One arm	Arm injury	New parent
See			
	Blind	Cataract	Distracted driver
Hear			
	Deaf	Ear infection	Bartender
Speak			
	Non-verbal	Laryngitis	Heavy accent

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.



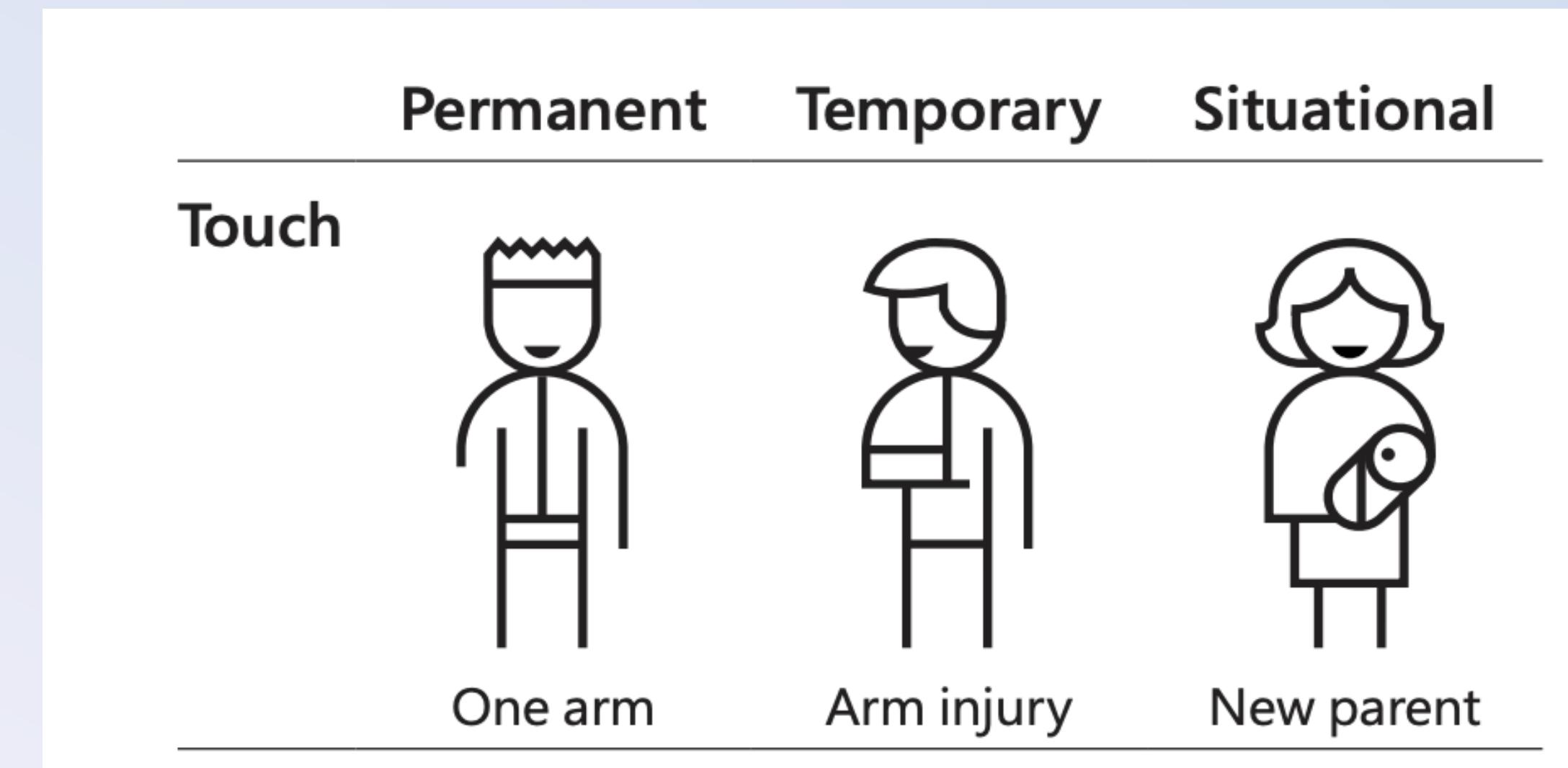
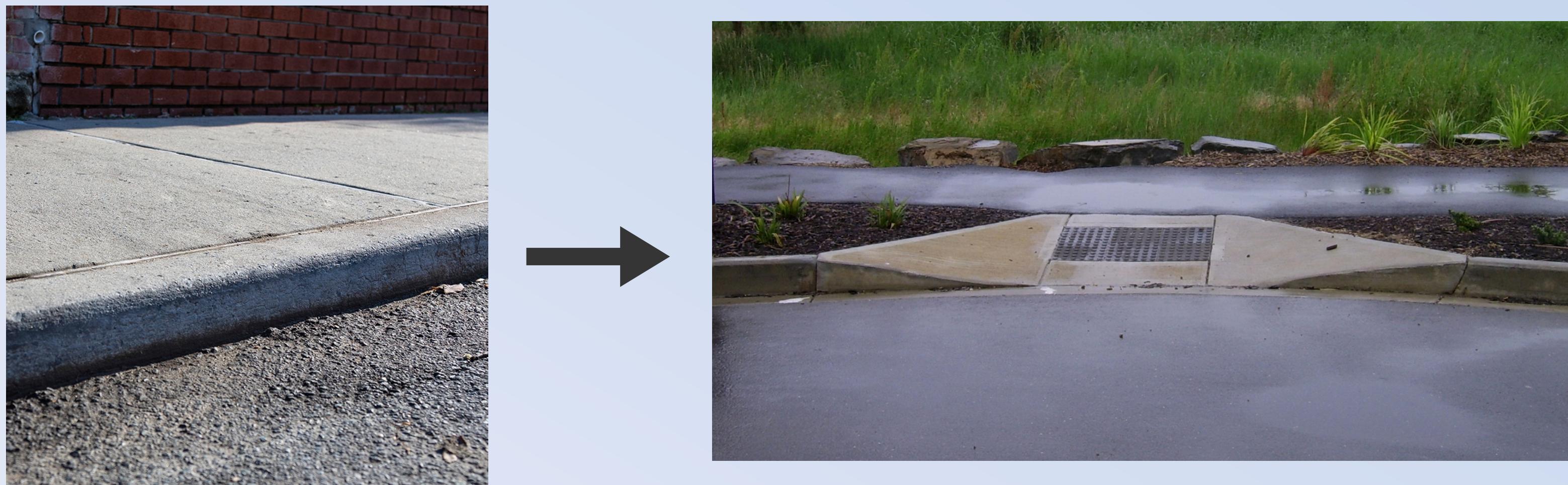
**Does “design for one, extend to all”
have limits? Problems?**

Final Concept: Disability-Centered Design

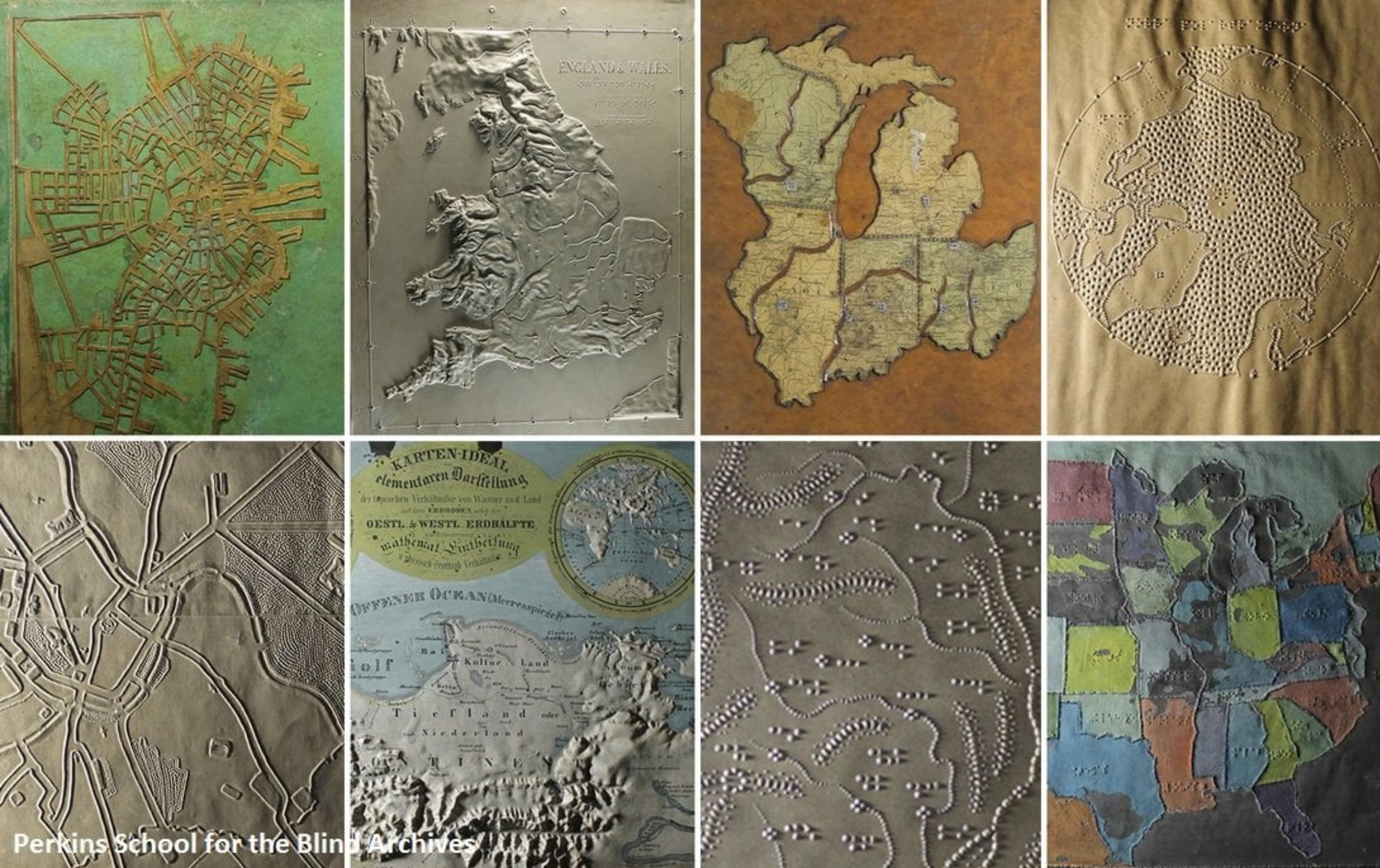
**“Nothing about us
without us”**
And the 1977 504 sit-in.



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

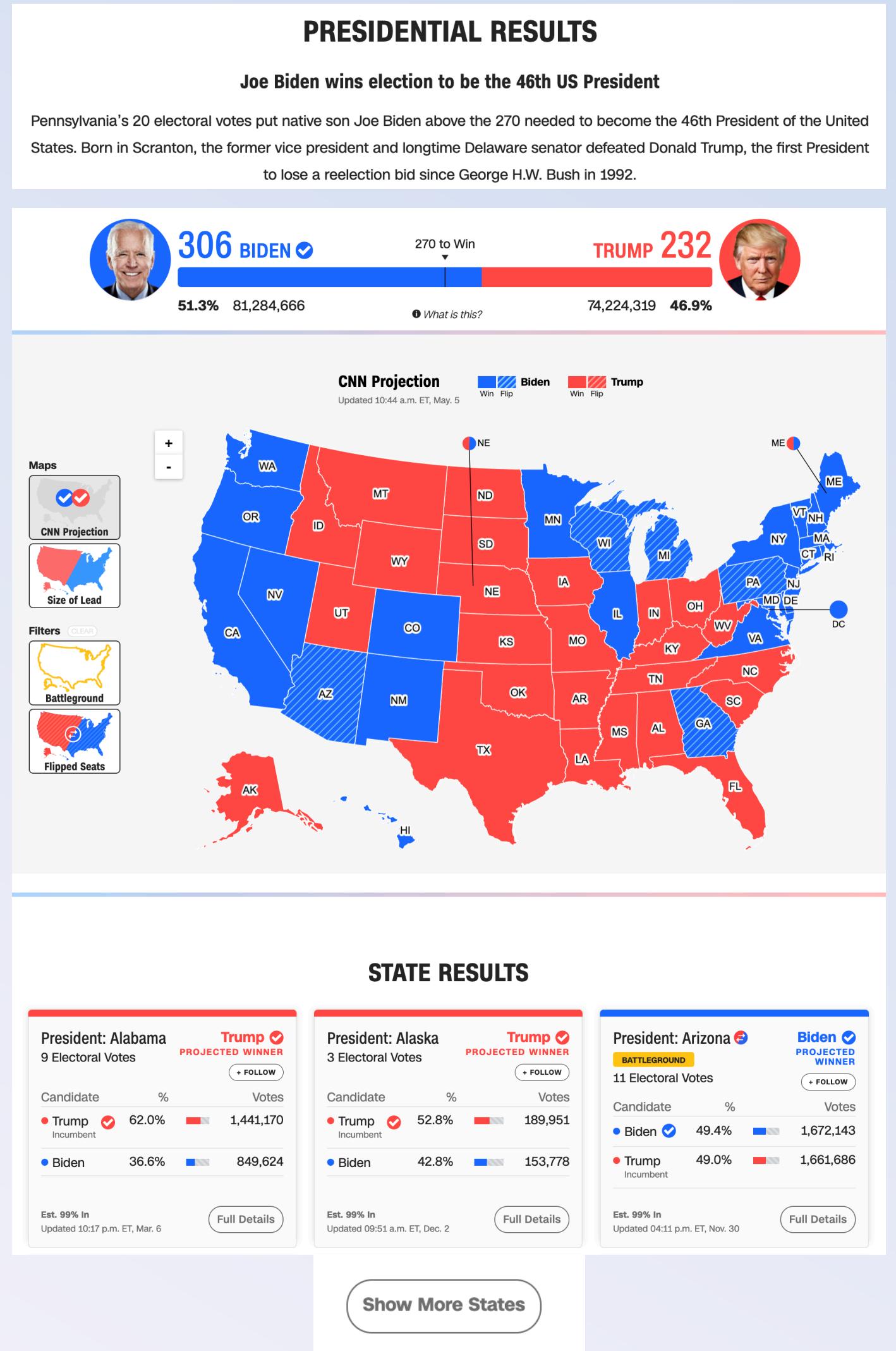


The best work centers on people with disabilities



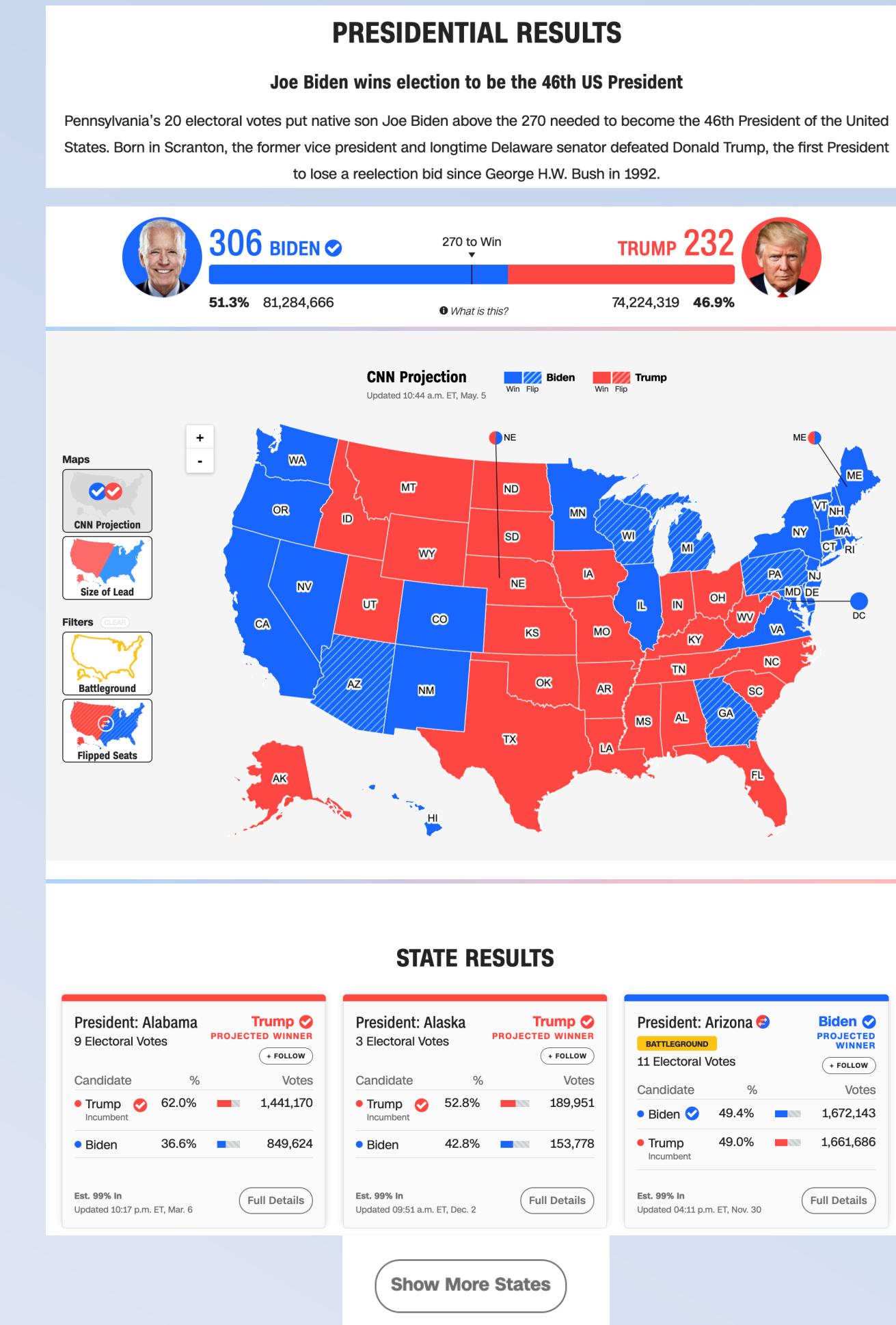
Perkins School for the Blind Archives, with tactile maps dating back to the early 1800s

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

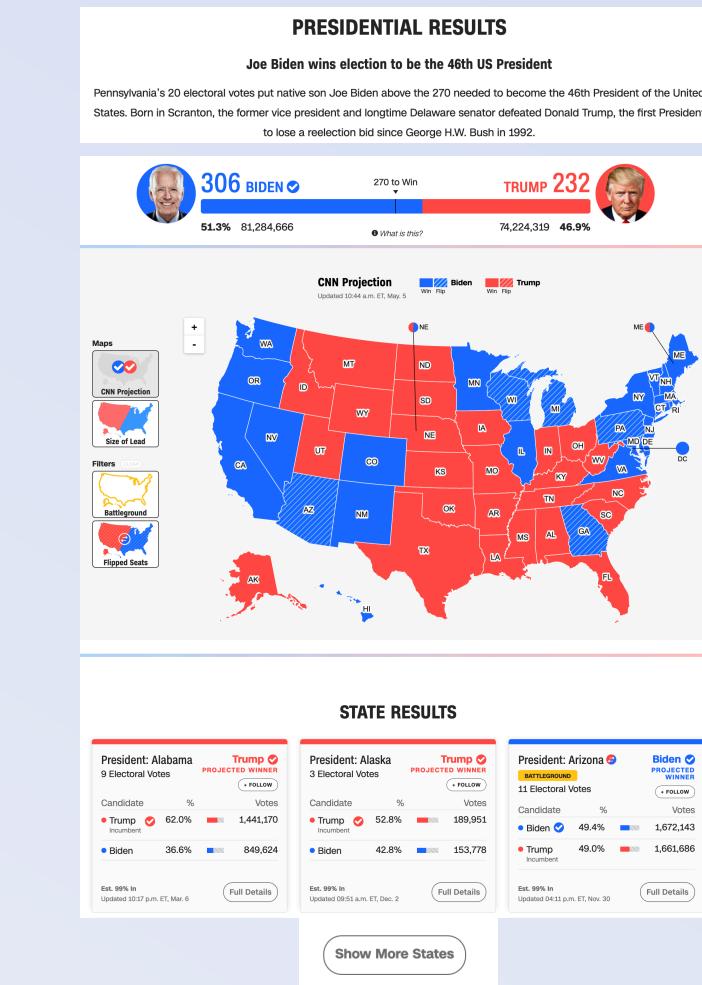
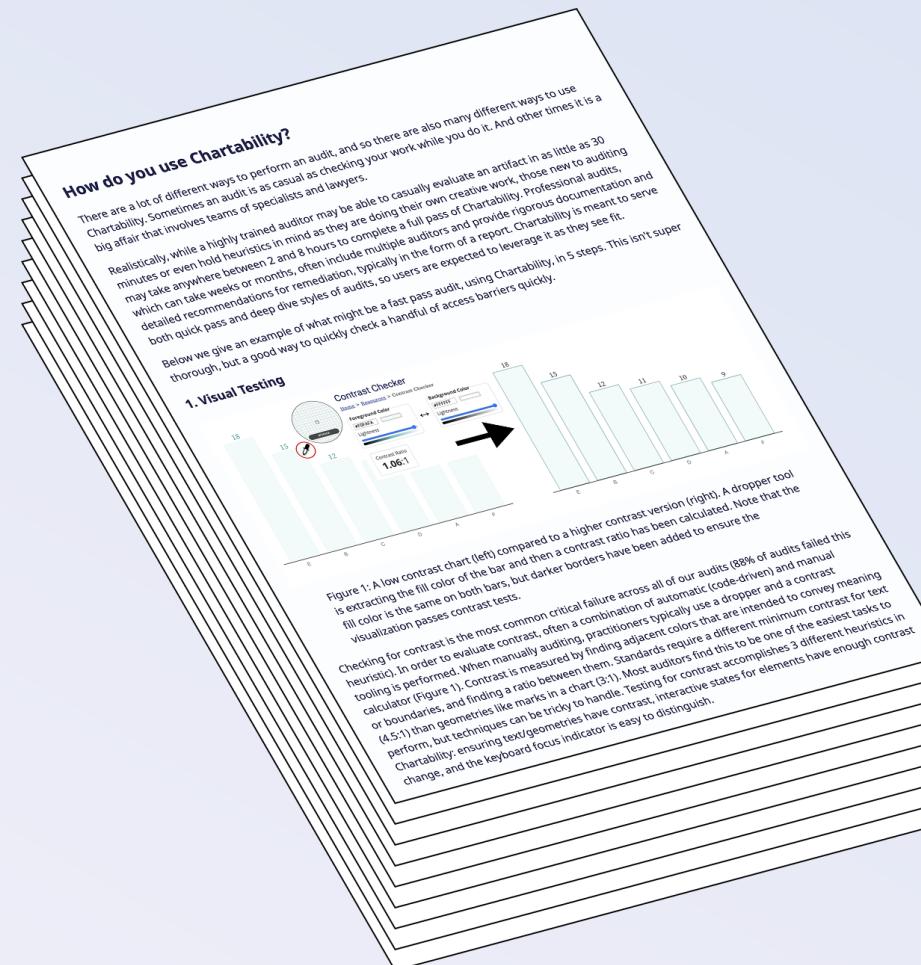


F. Elavsky, C. Bennett, and D. Moritz, “How accessible is my visualization? Evaluating visualization accessibility with Chartability,” Computer Graphics Forum, 2022.

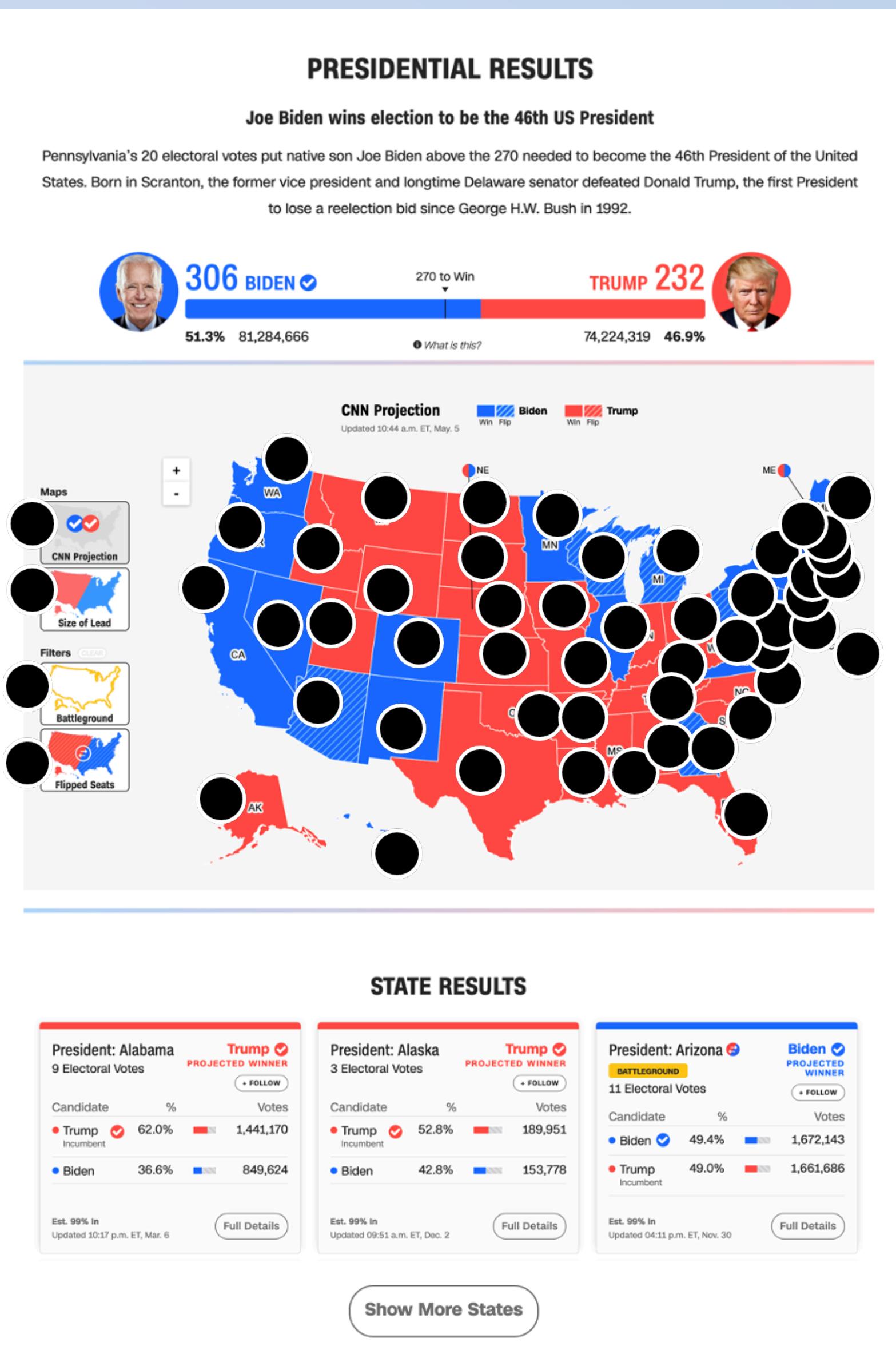
Chartability is a free, online resource

chartability.github.io/

workbook

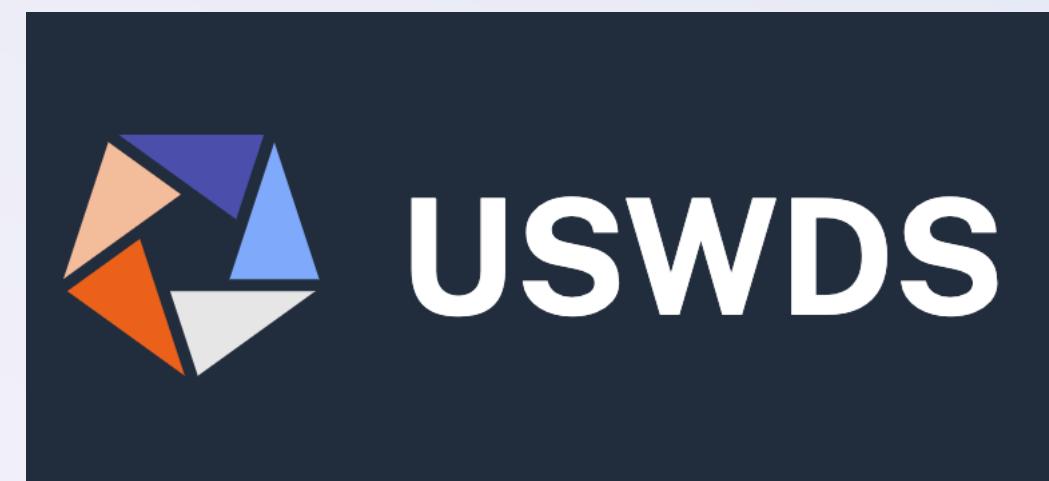


978 access barriers
Found in about an hour.



Chartability is used in:

15+ Policy orgs and governments worldwide



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



20+ Undergraduate and graduate courses

Carnegie Mellon University



UNIVERSITY *of* WASHINGTON



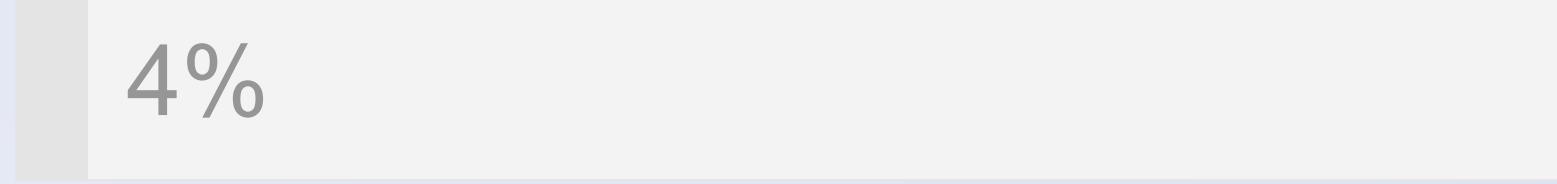
Perceivable

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

Design with high contrast

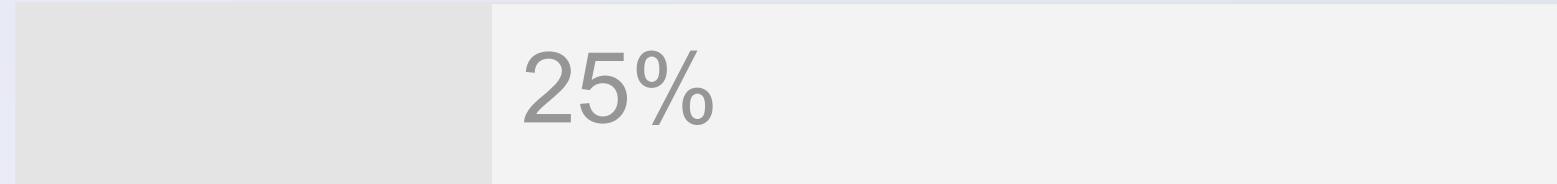
Colorblindness Disproportionately Overrepresented in A11y Resources

Colorblindness: % of People



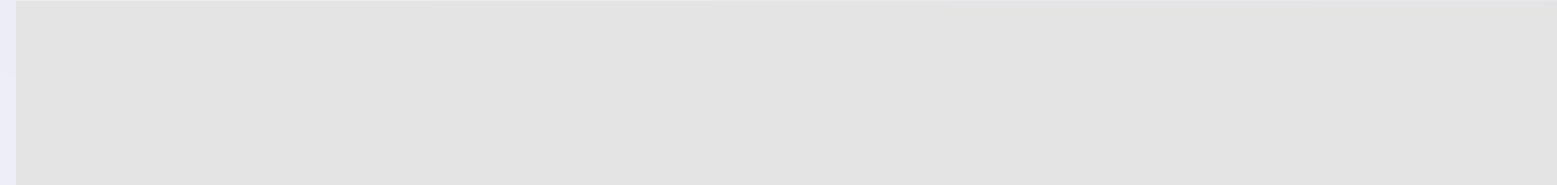
4%

Low Vision: % of People



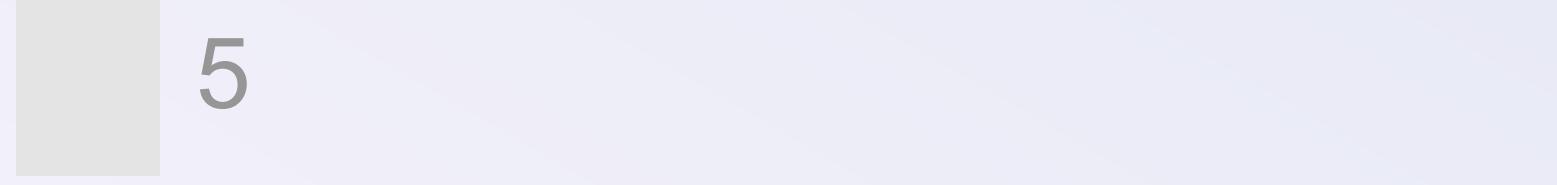
25%

Colorblindness: # of Resources



51

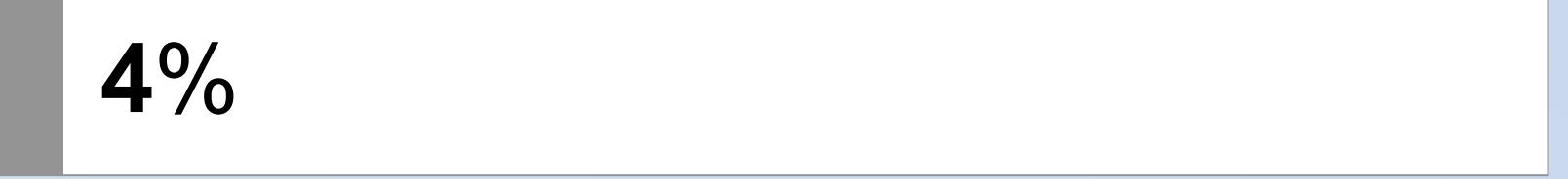
Low Vision: # of Resources



5

Colorblindness Disproportionately Overrepresented in A11y Resources

Colorblindness: % of People



4%

Low Vision: % of People



25%

Colorblindness: # of Resources



51

Low Vision: # of Resources



5

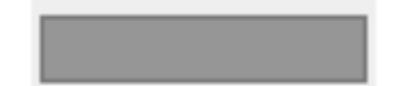
Check your contrasts

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
#969696 

Lightness 

Background Color
#FFFFFF 

Lightness 

Contrast Ratio
2.95:1

[permalink](#)

Normal Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

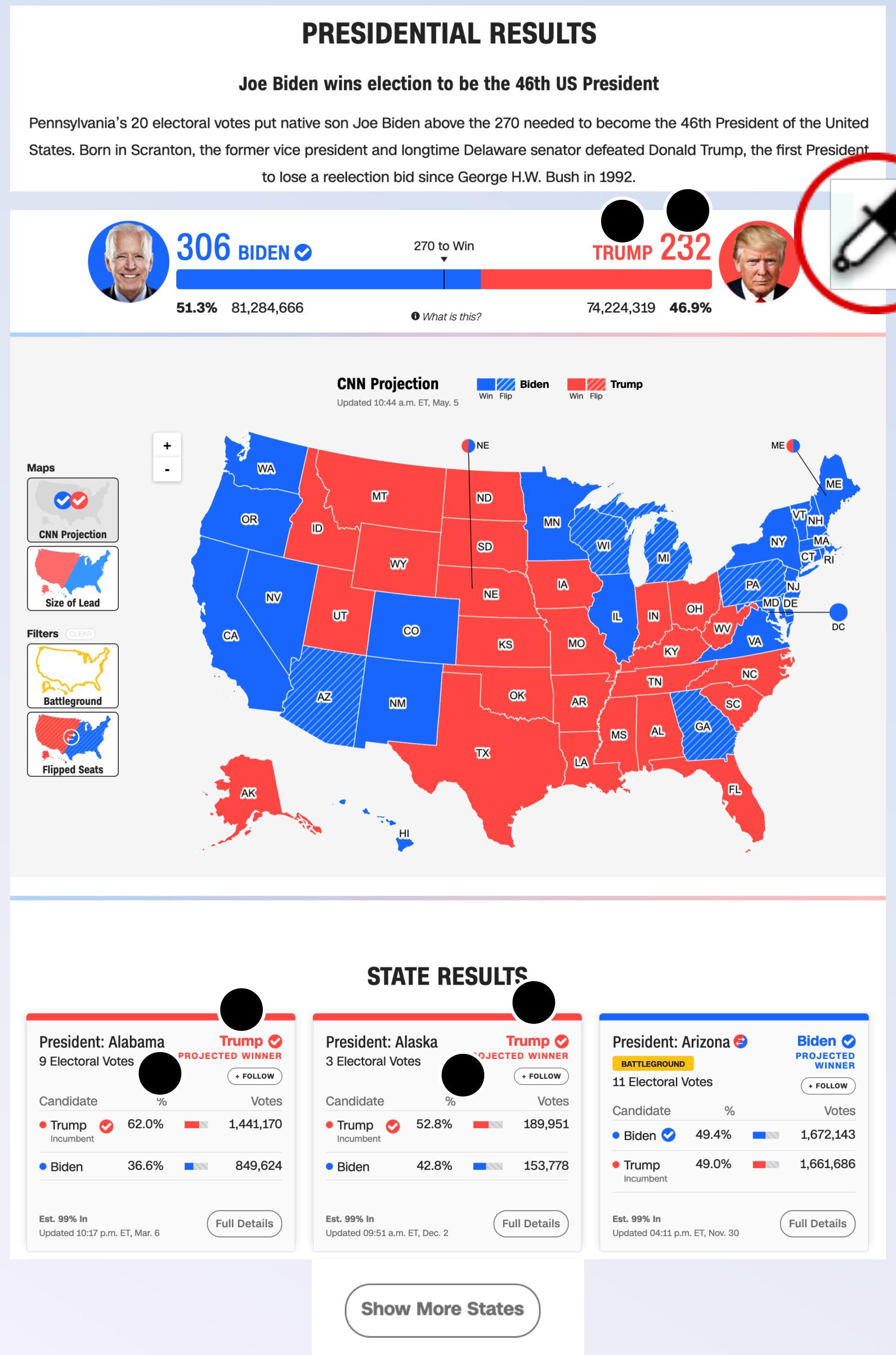
The five boxing wizards jump quickly.

Large Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

The five boxing wizards jump quickly.



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**

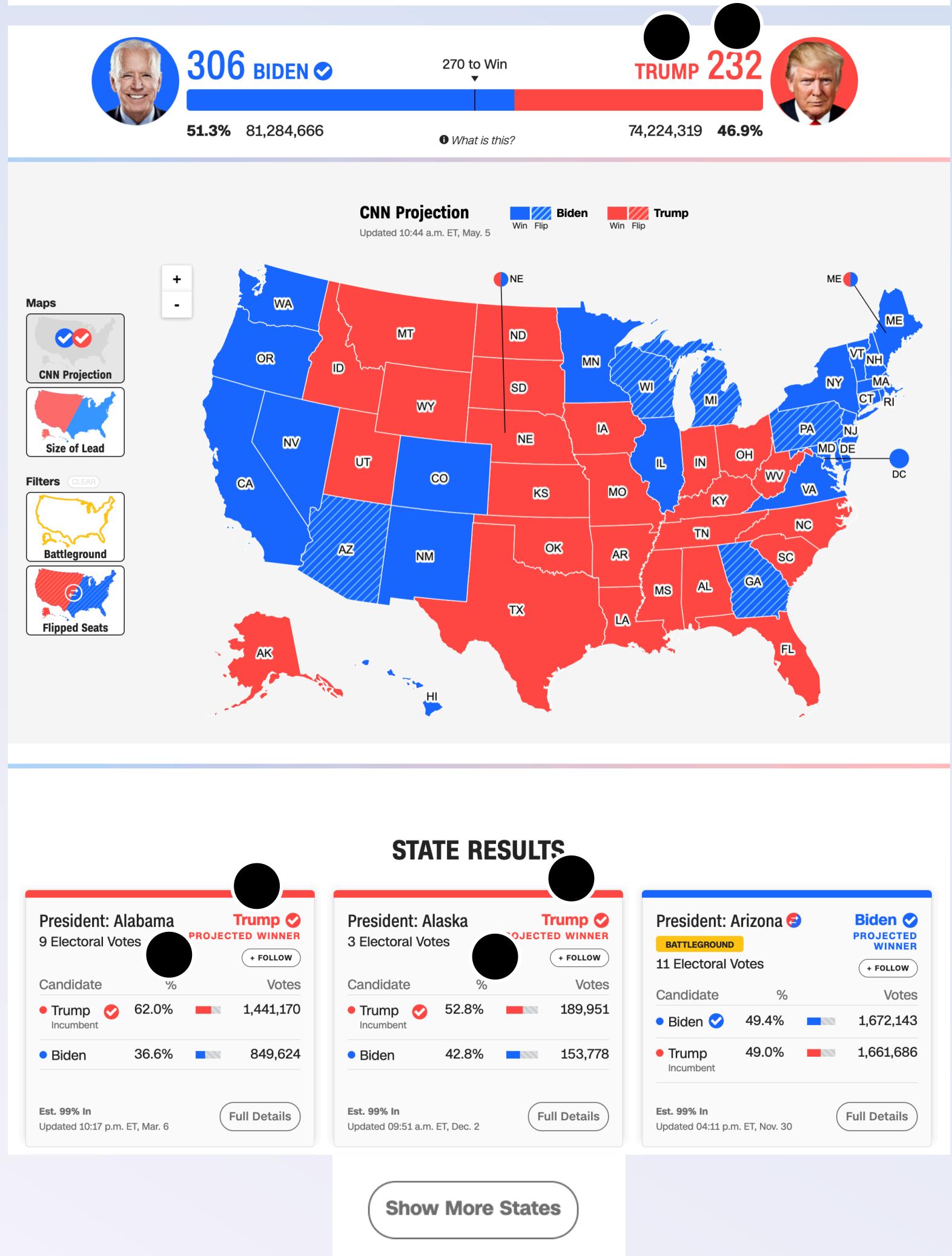
WCAG AAA: **Fail**

The five boxing wizards jump quickly.

PRESIDENTIAL RESULTS

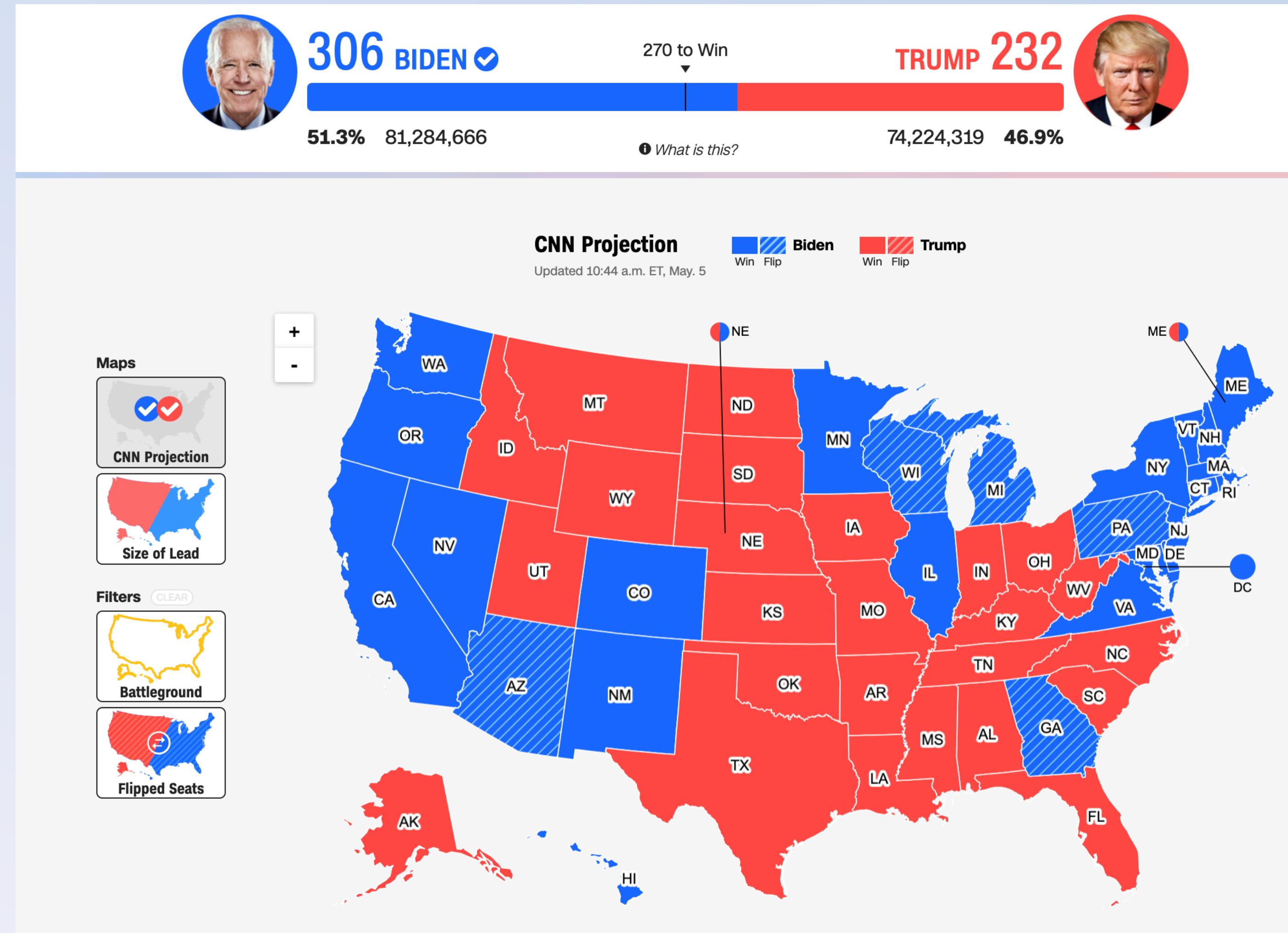
Joe Biden wins election to be the 46th US President

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.

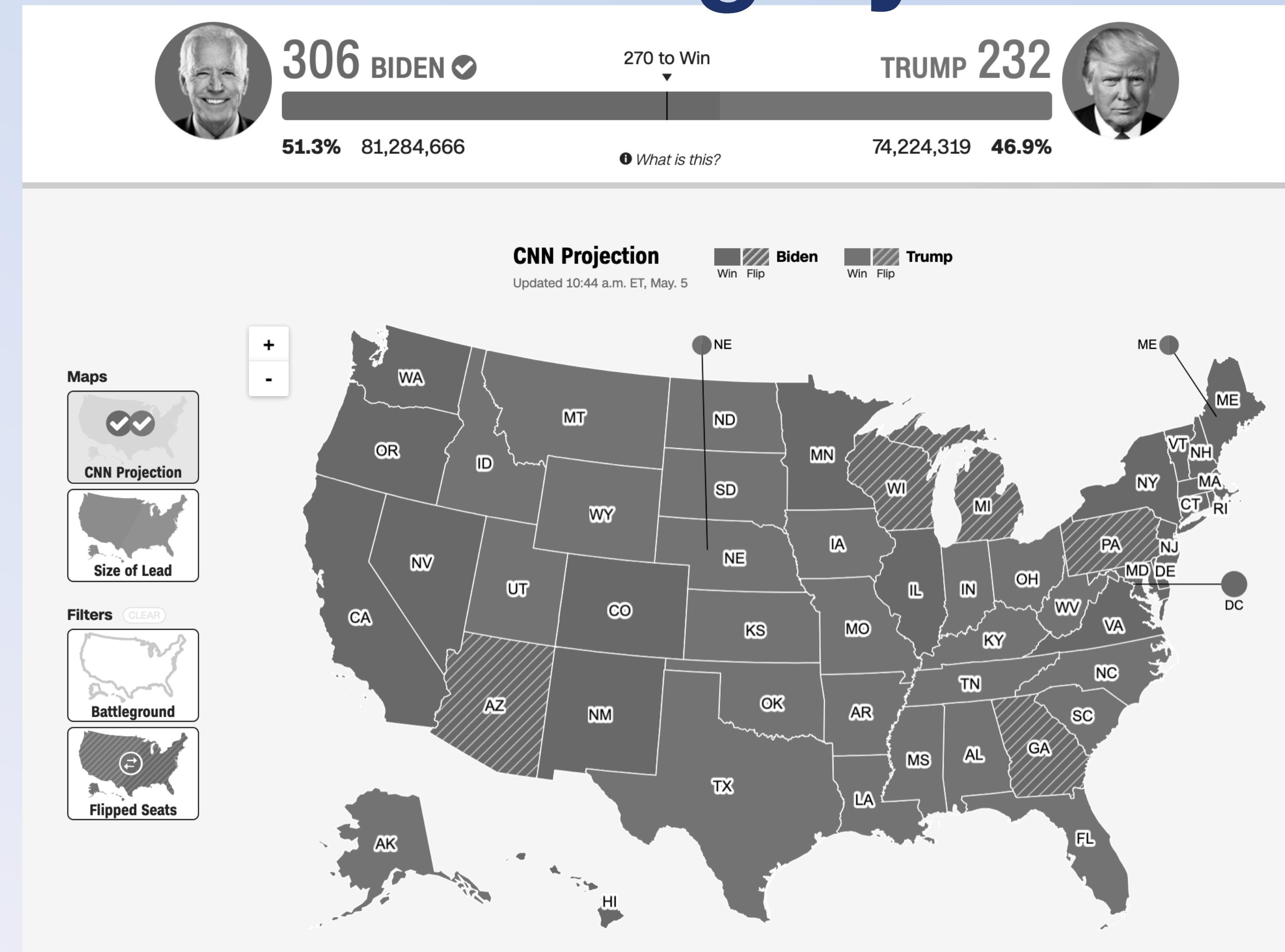


6 instances of low contrast

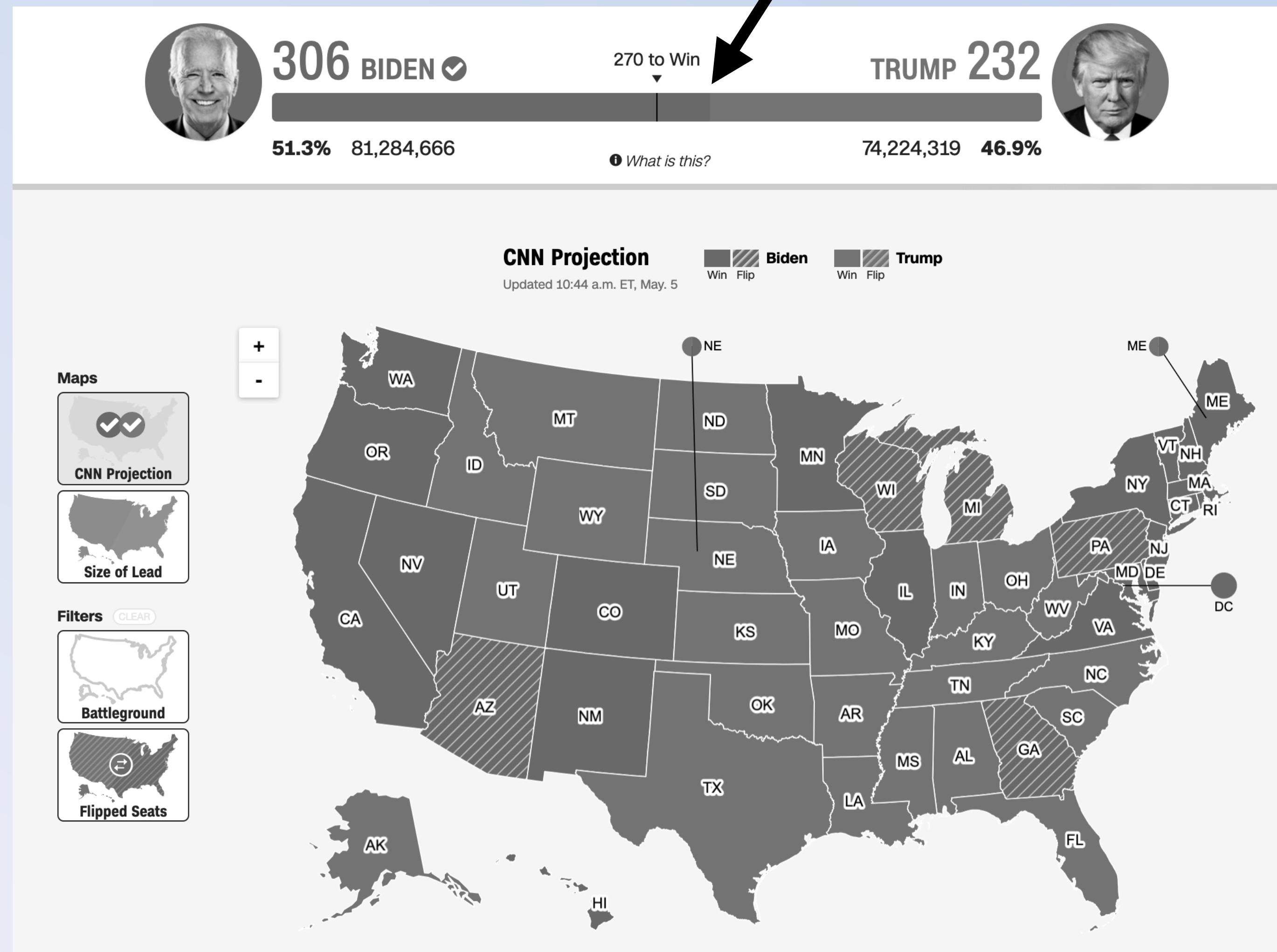
How can we fix this?



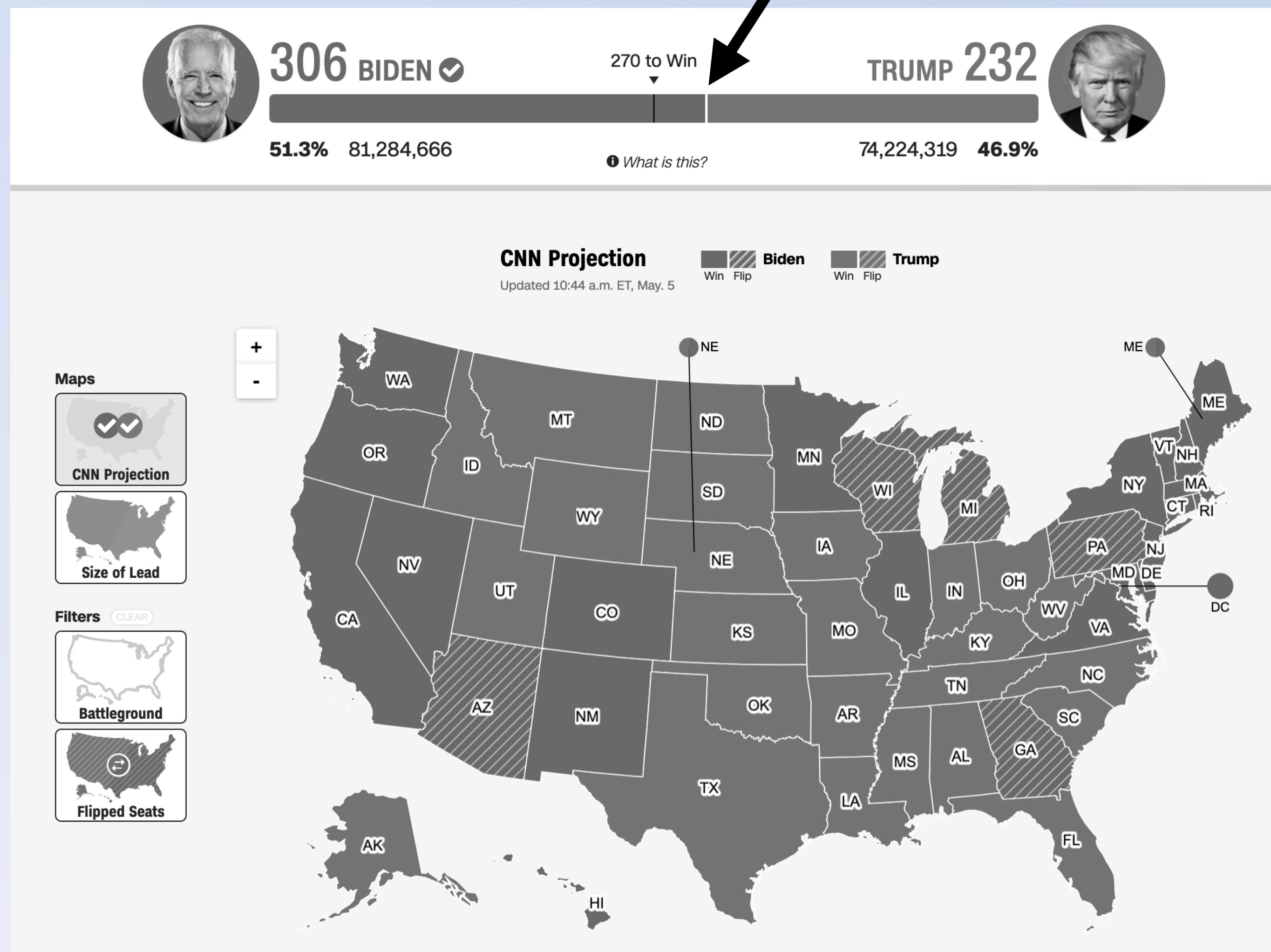
This map is trouble in greyscale



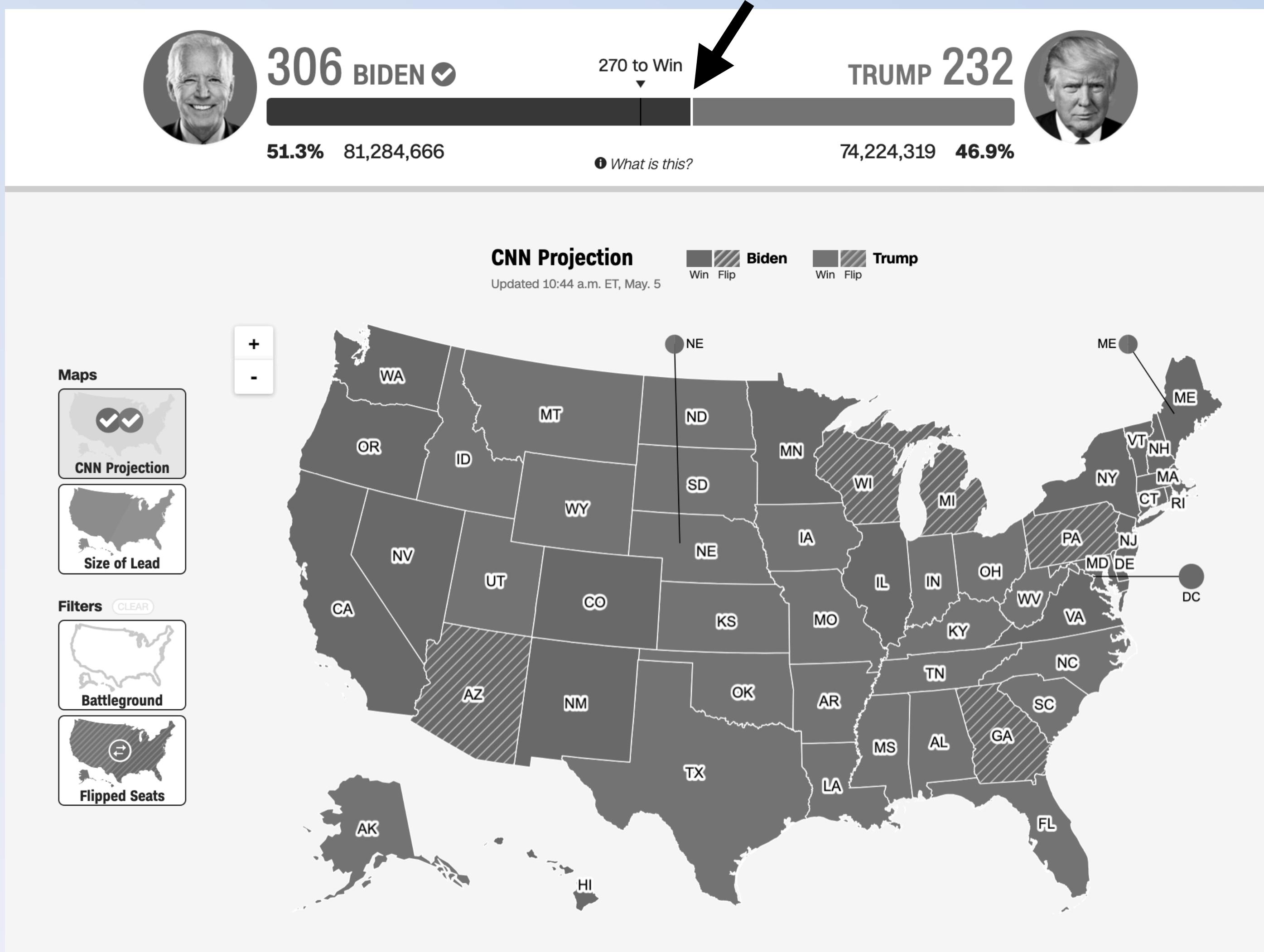
The division here matters!



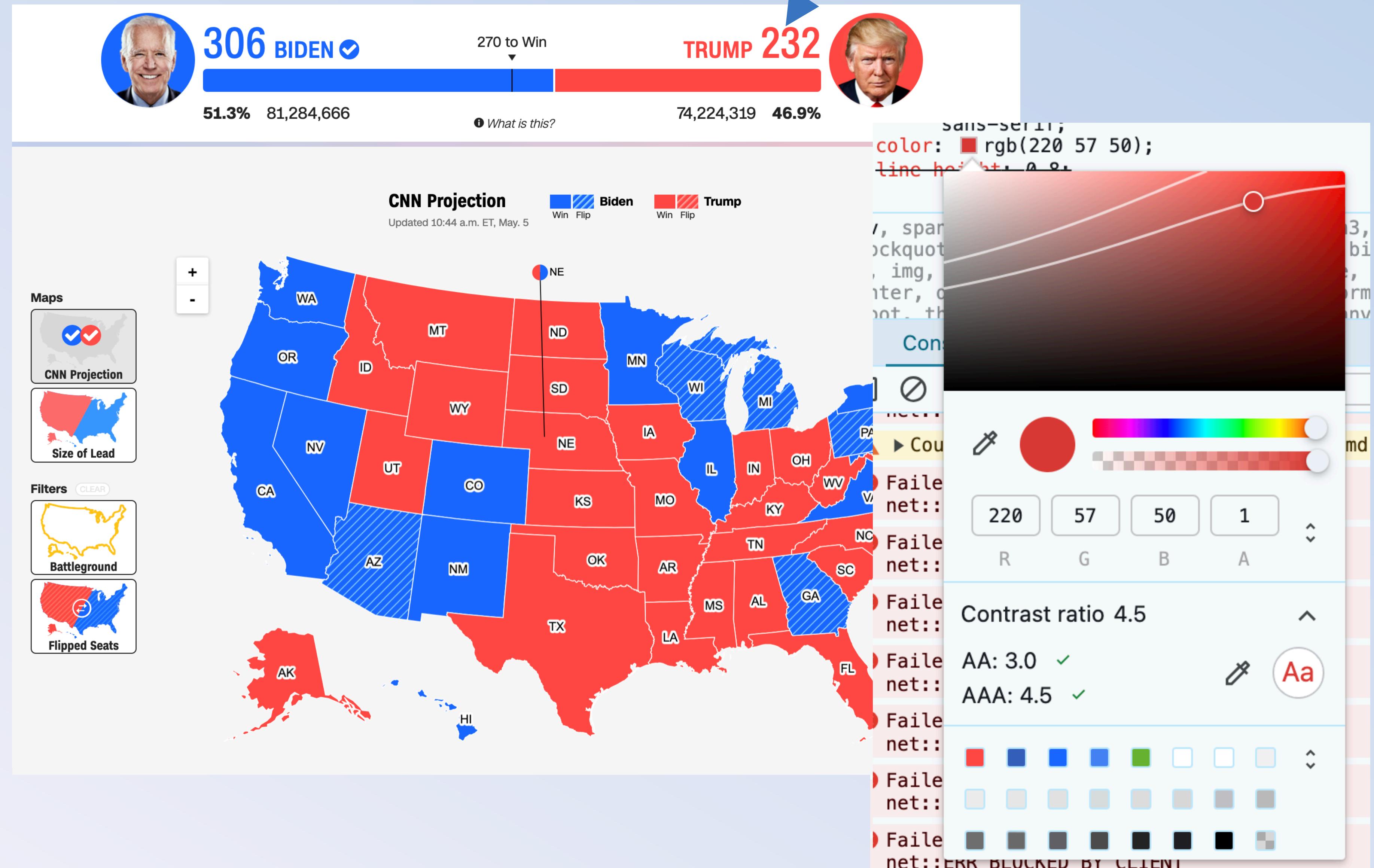
Maybe a small white divider, like the states?



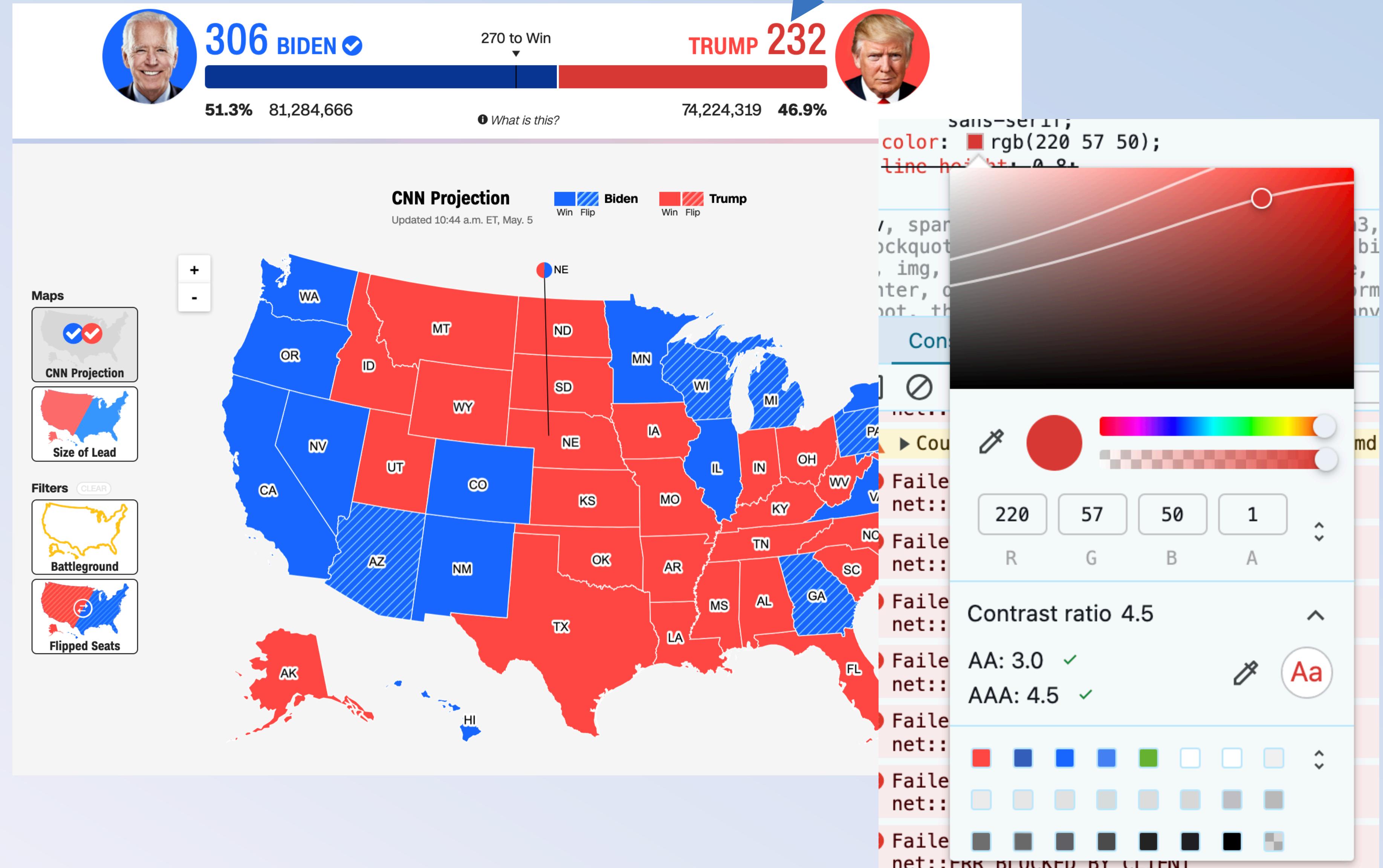
Perhaps test a darker blue too?



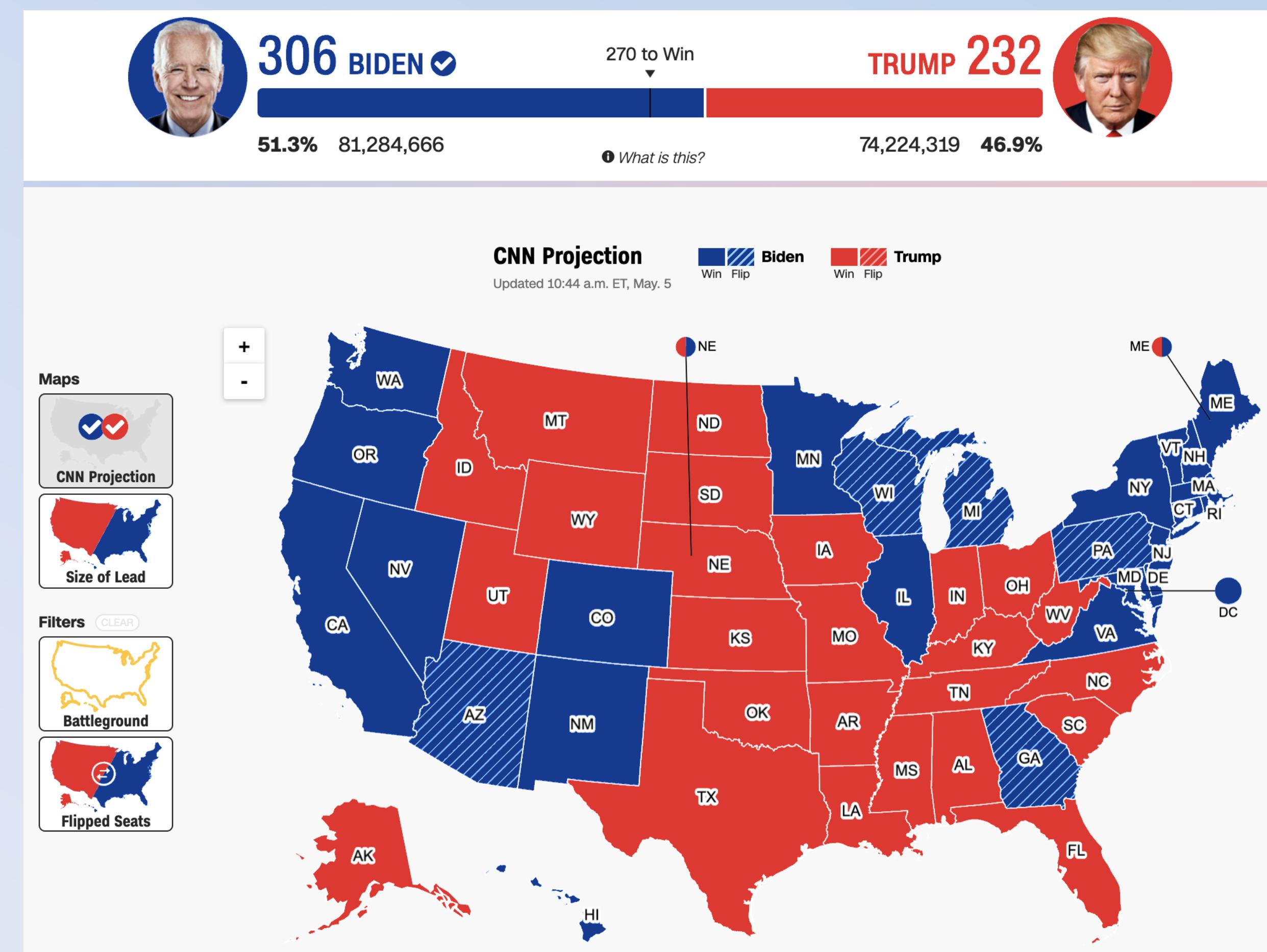
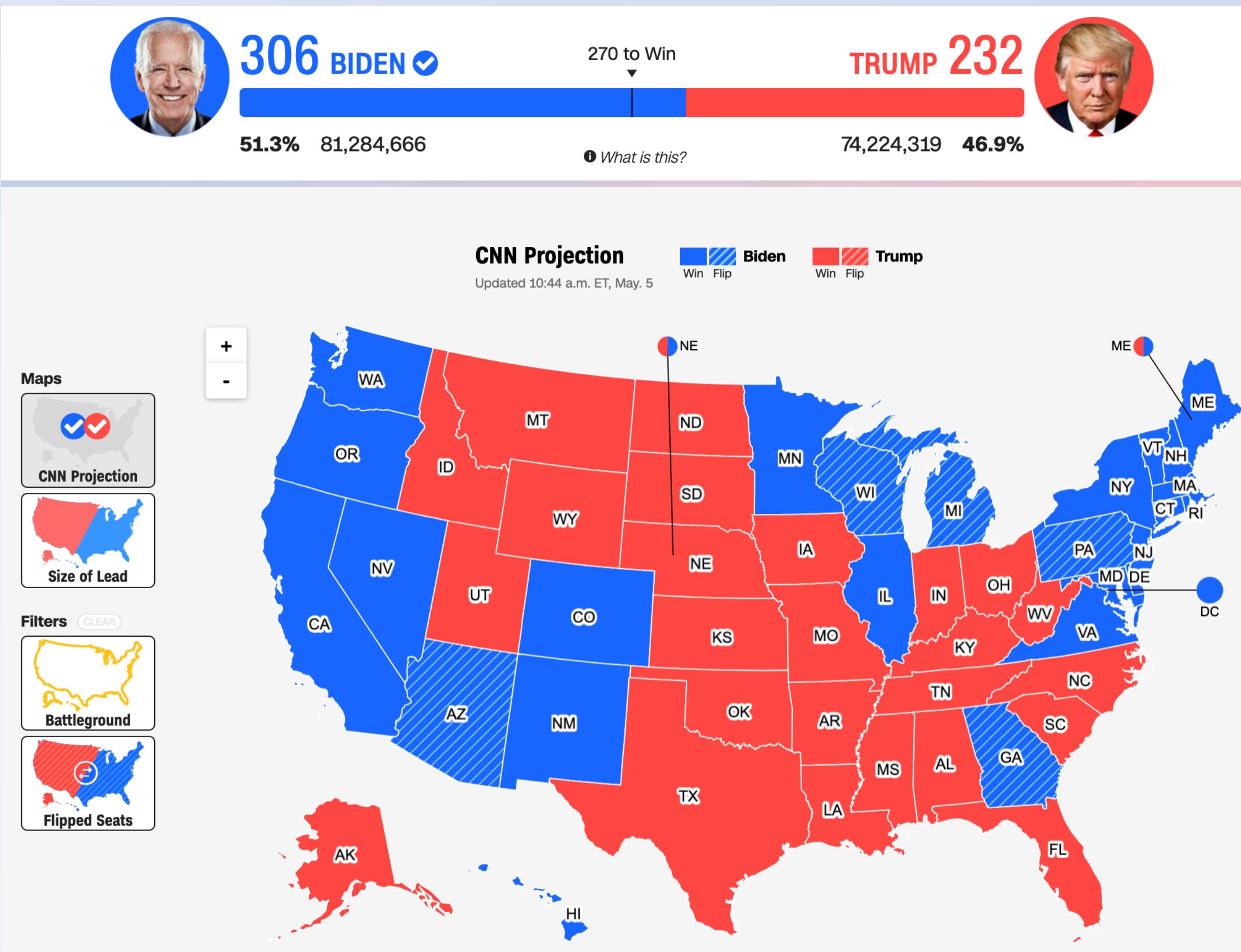
What if we fix the contrast failures at the same time?



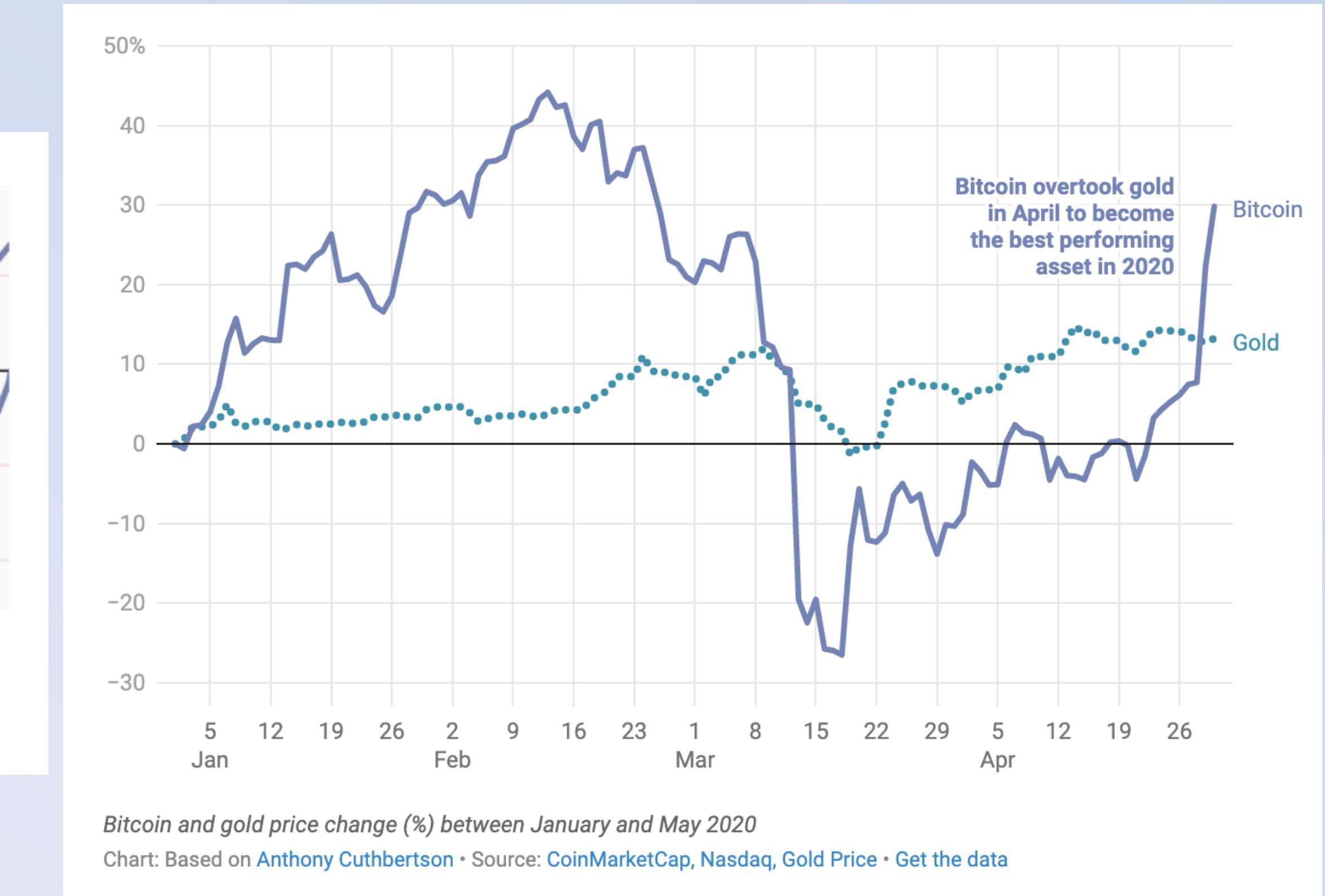
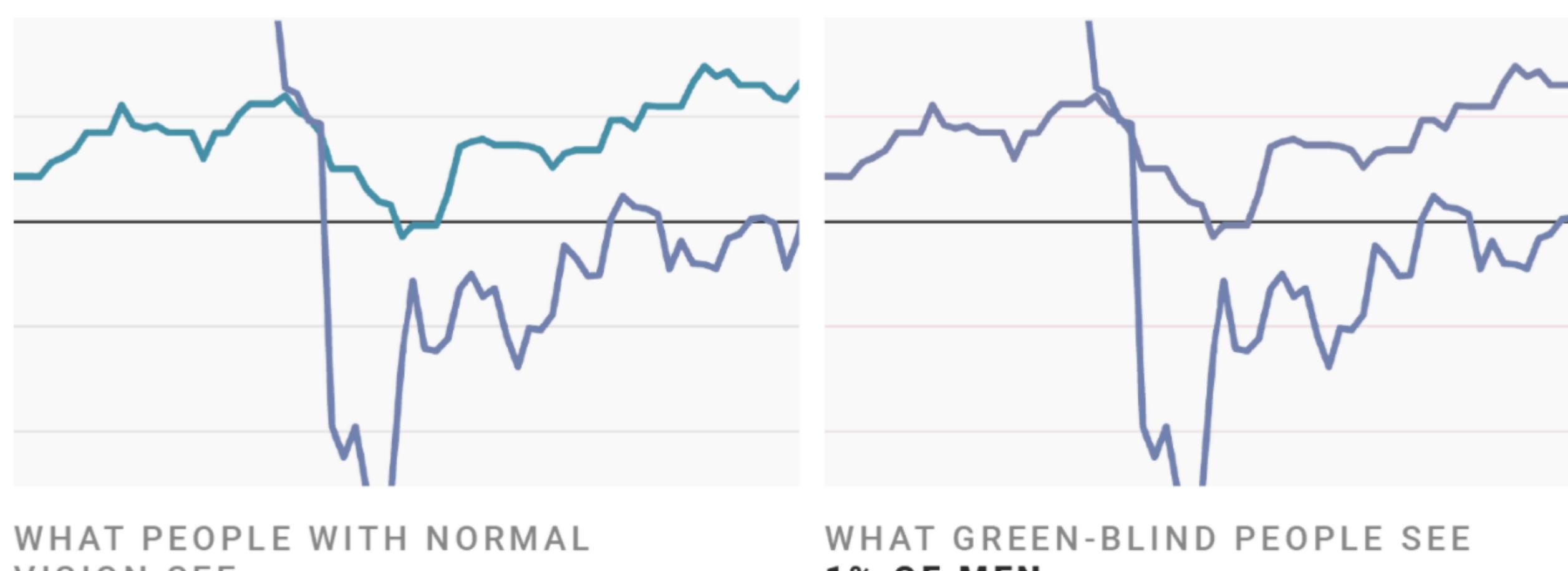
This text now passes!



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**"

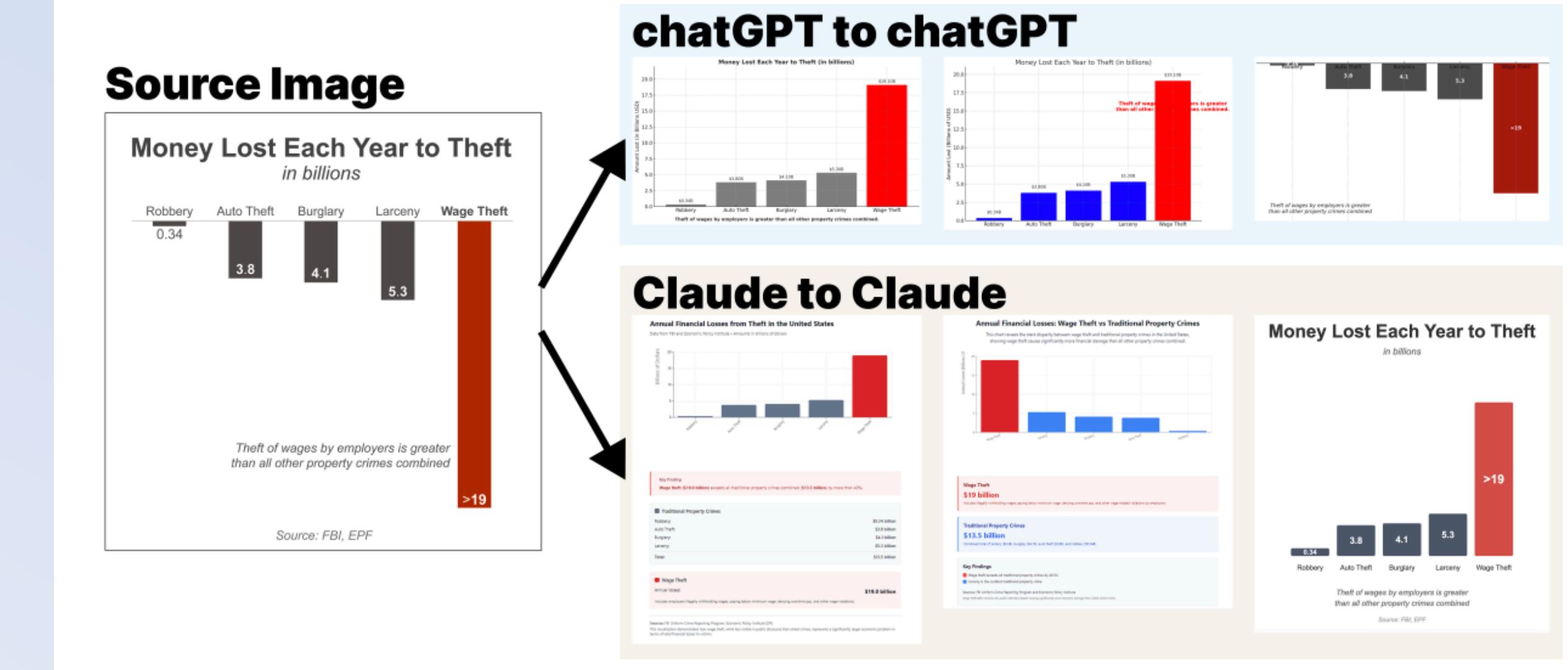
Include a **link to data source**
somewhere in the text

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



Beware of un-monitored LLMs/MMMs

Pick the better prompt:

“Describe this image”

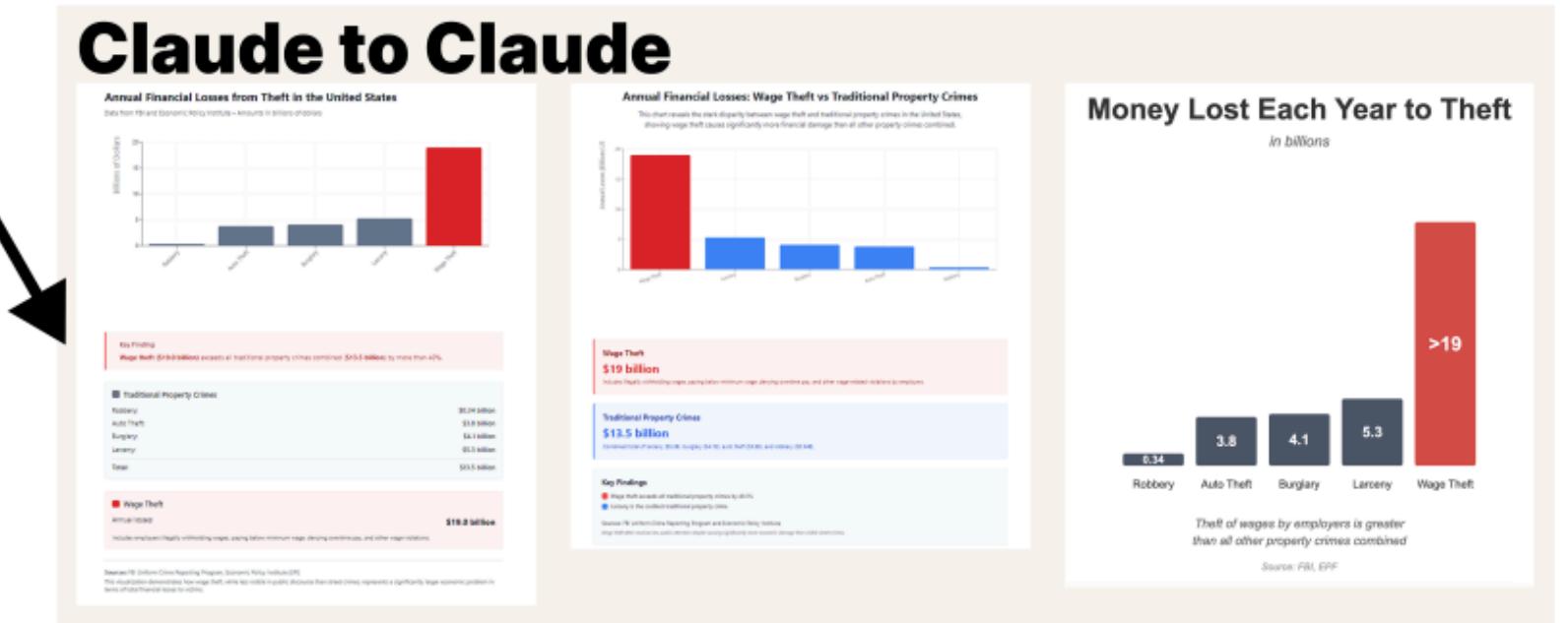
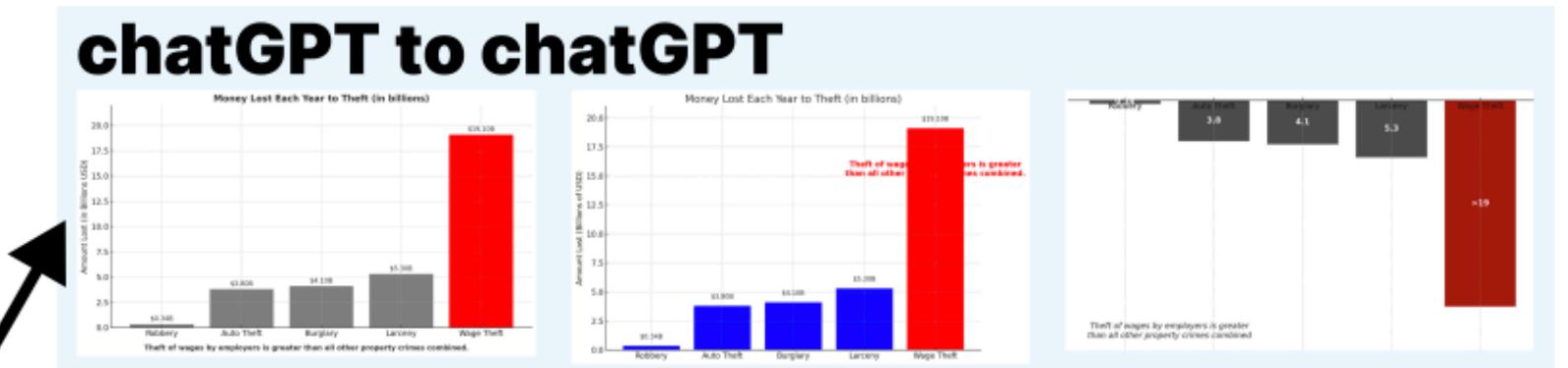
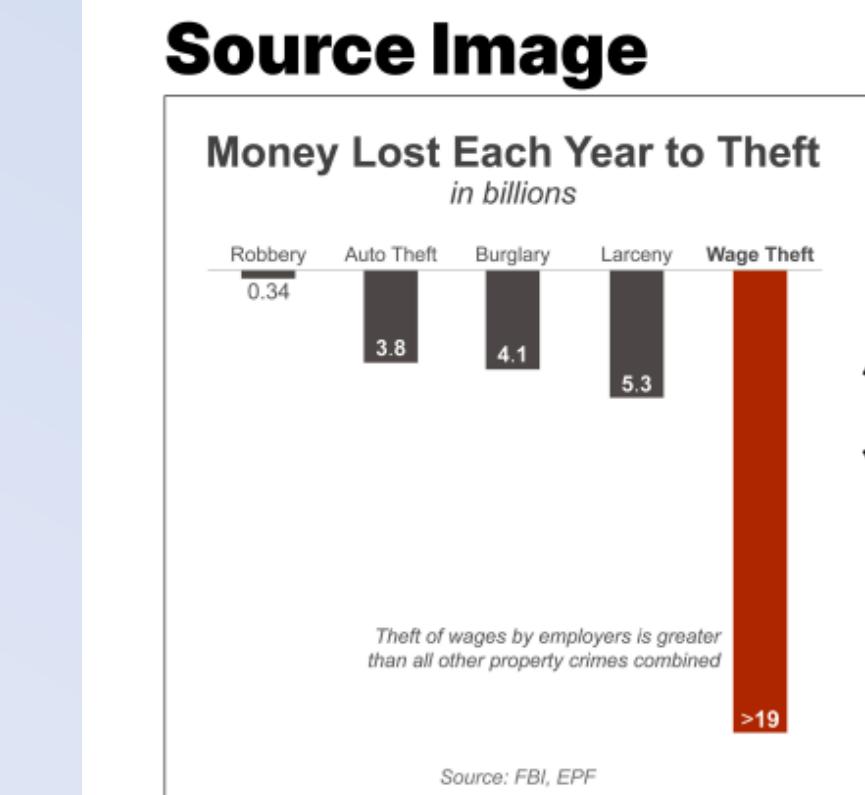
“Write alt text for this for someone who is blind”

“Describe this image and do not make mistakes”

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Pick the better prompt:

“Describe this image”

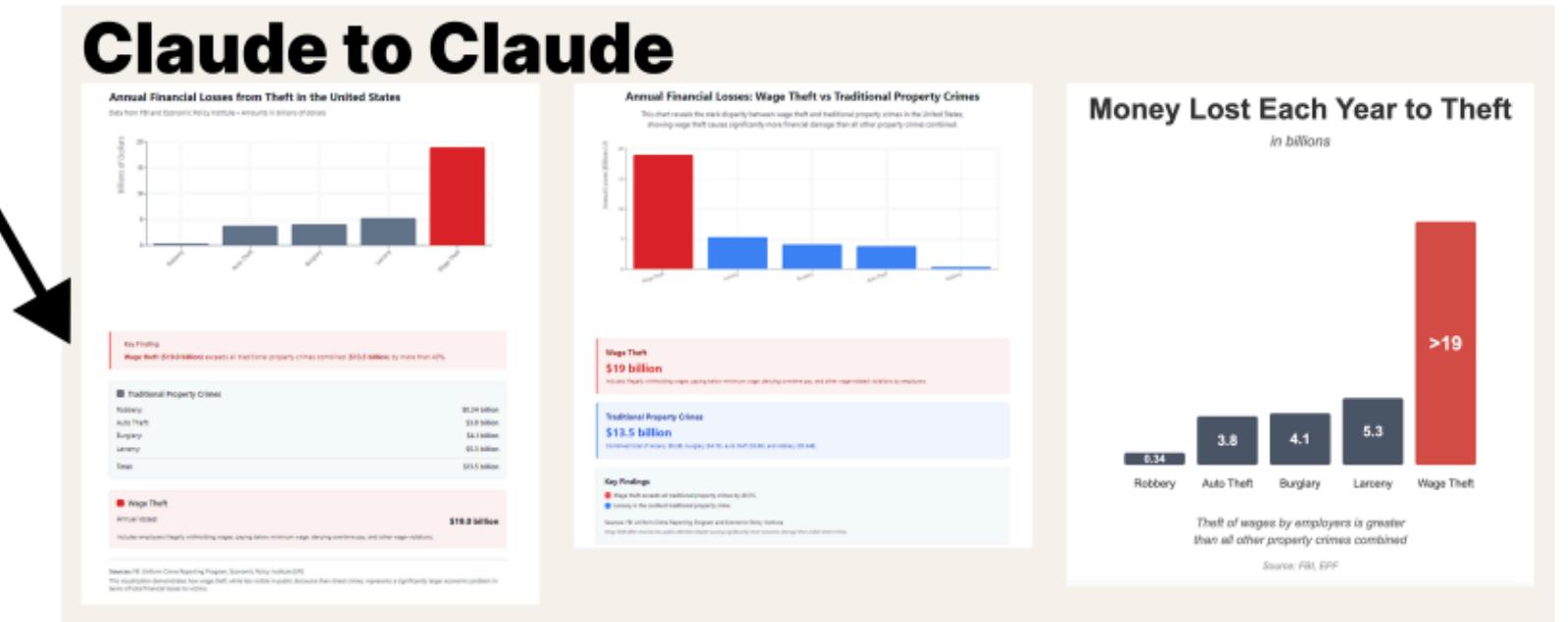
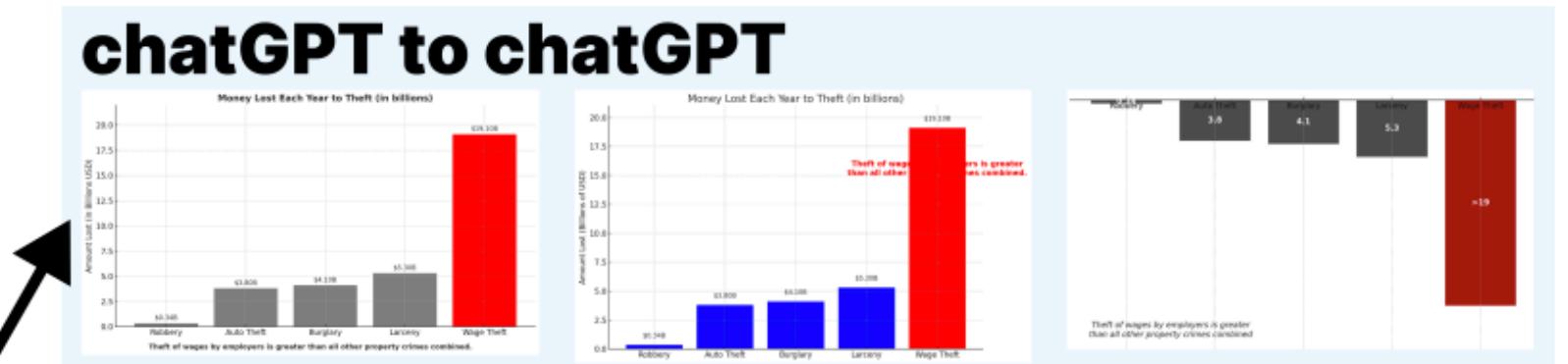
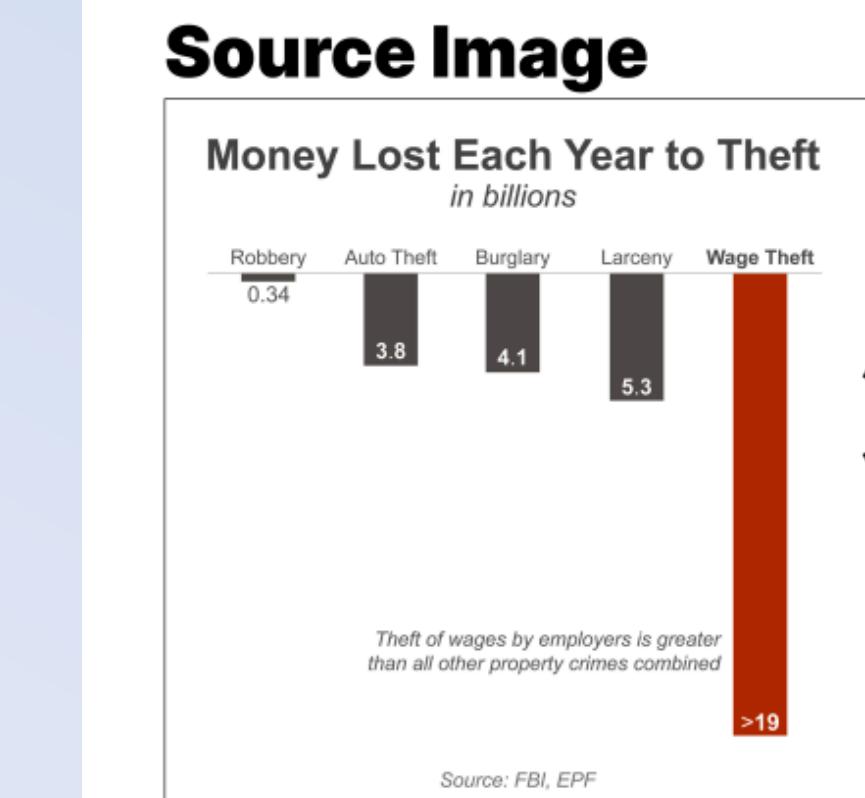
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Beware of un-monitored LLMs/MMMs

Pick the better prompt:

And check the output!

“Describe this image”

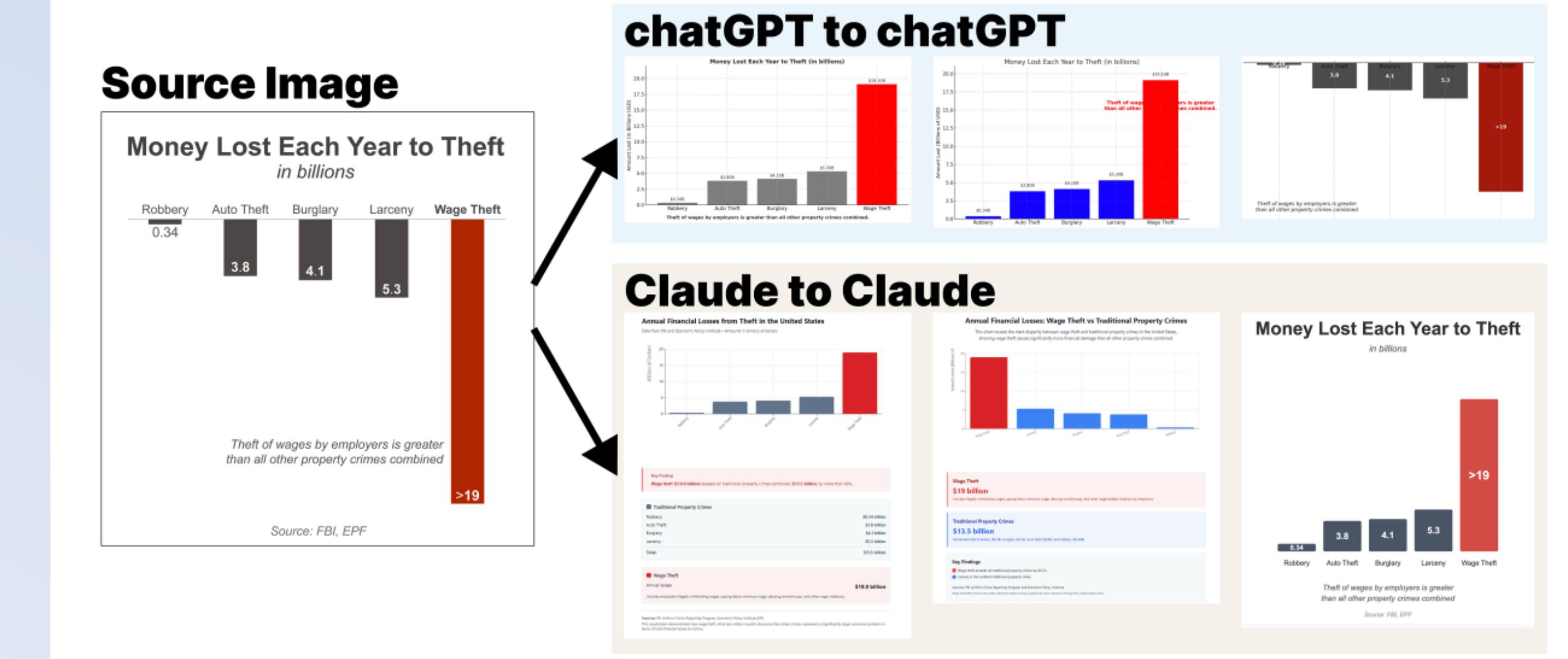
“Write alt text for this for someone who is blind”

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Operable

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

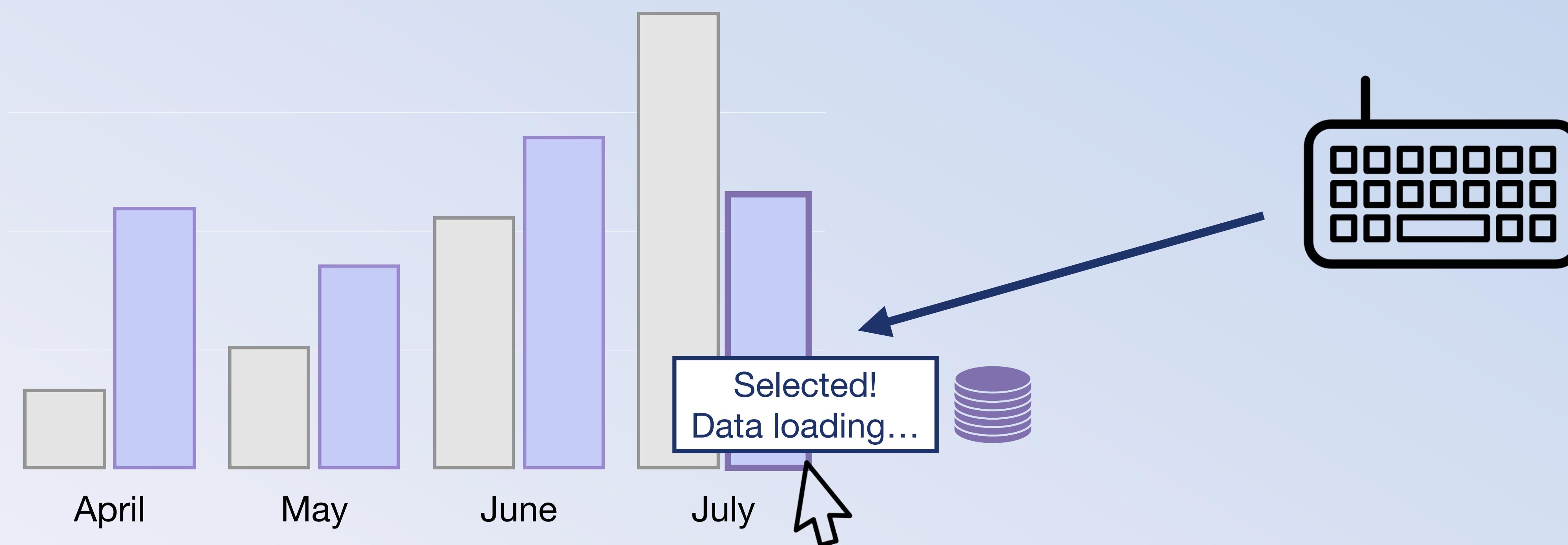
Many assistive input technologies “navigate”



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.

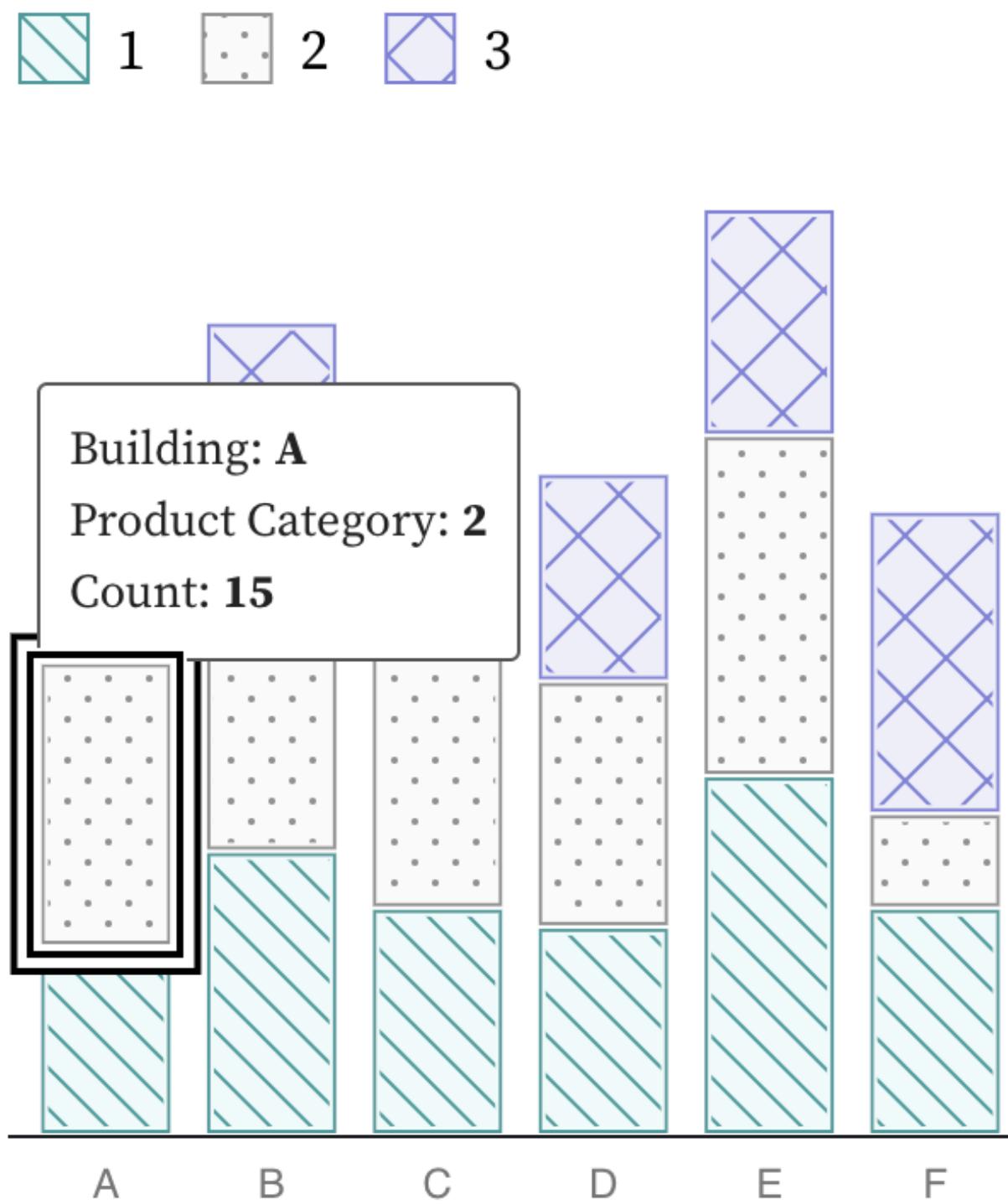
A keyboard should be able to do everything a mouse can



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

Alt text should communicate operability

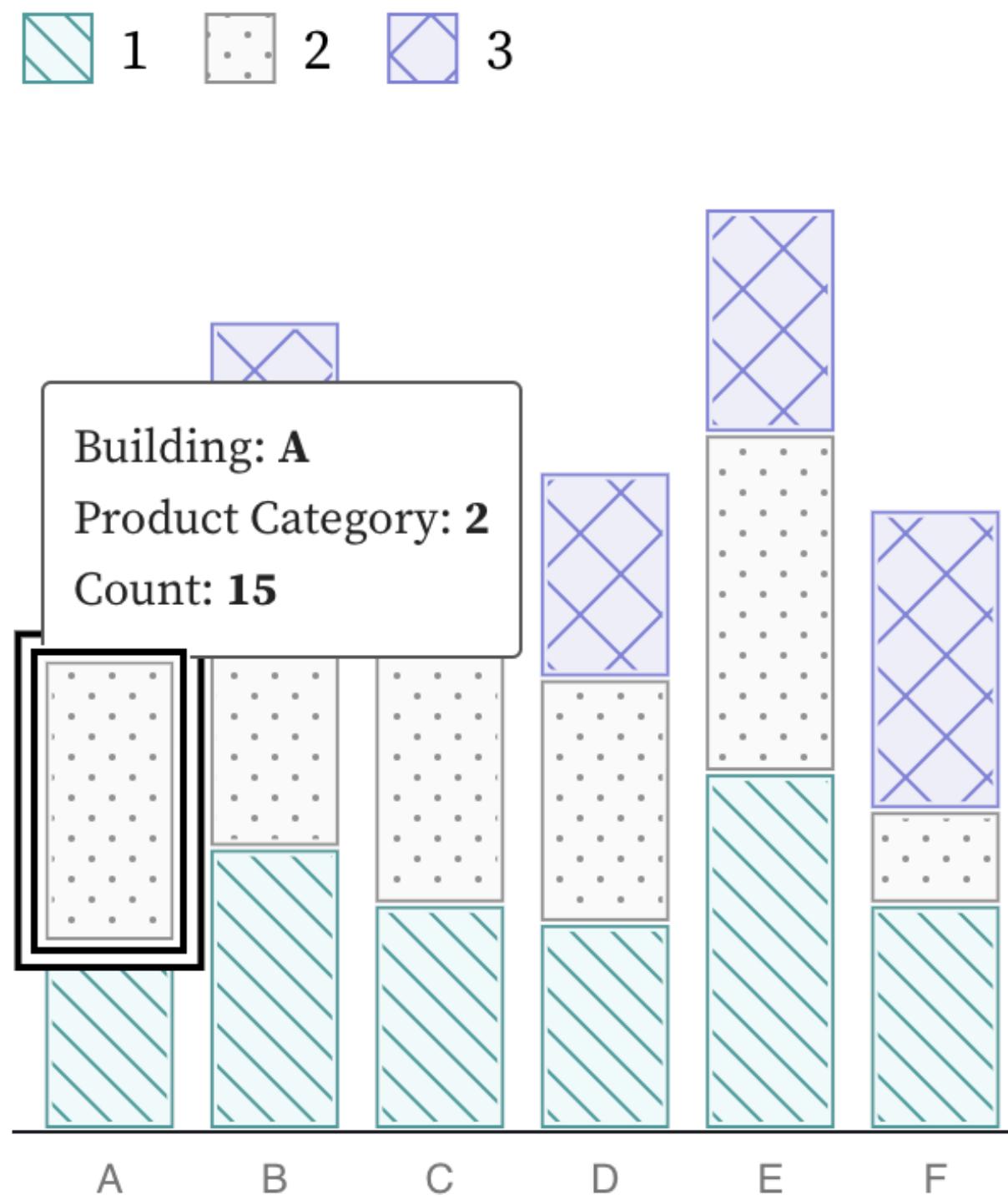
Source: Visa Chart Components, Frank Elavsky (2017-2019)



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

Semantics matter

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



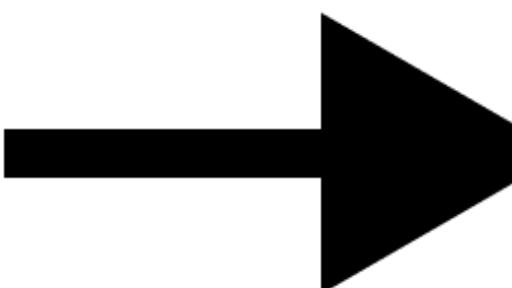
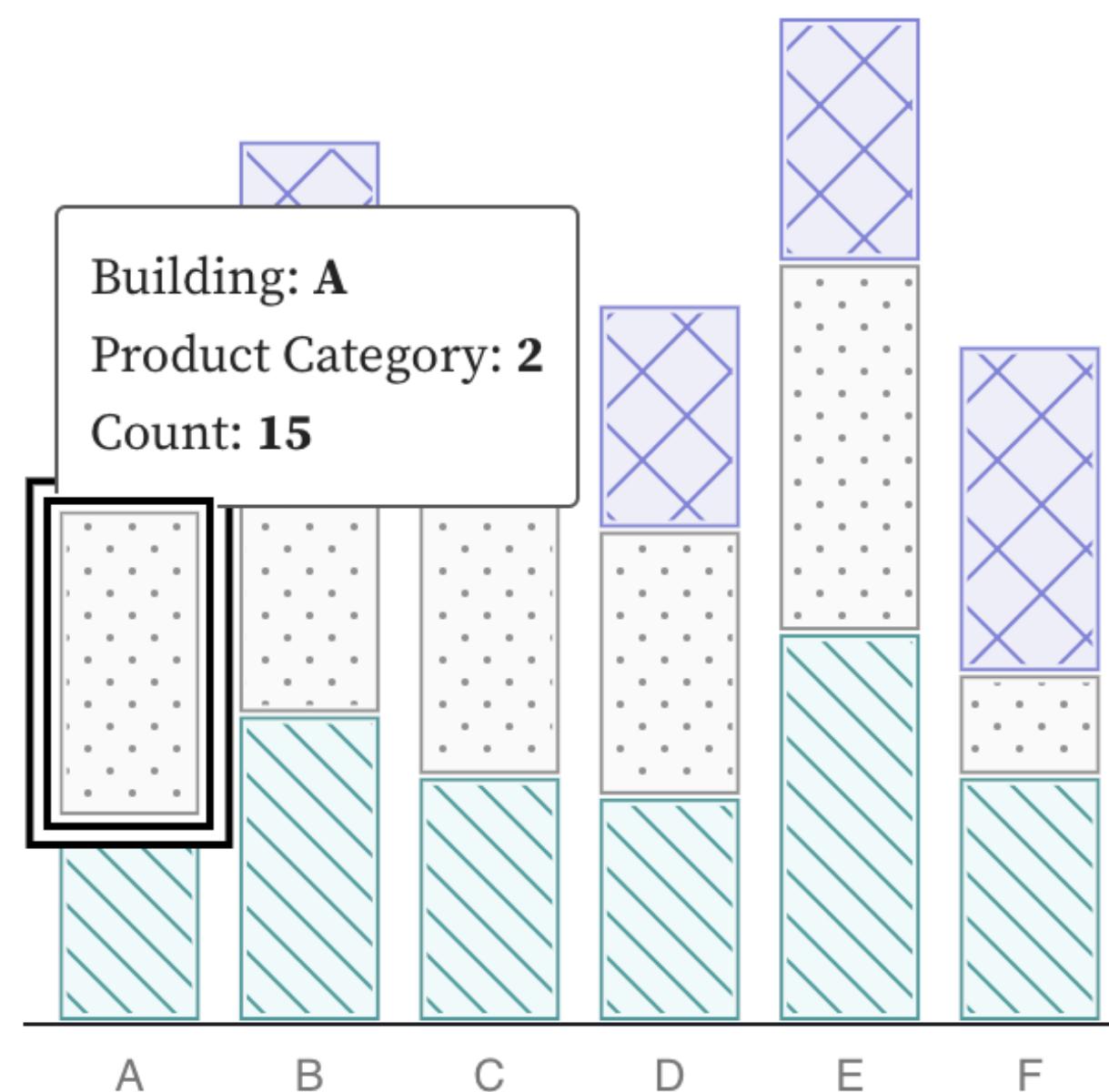
× Building A. Product Category 2.
Count 15. Bar 2 of 3. Image.

“Image” doesn’t signal interactivity!

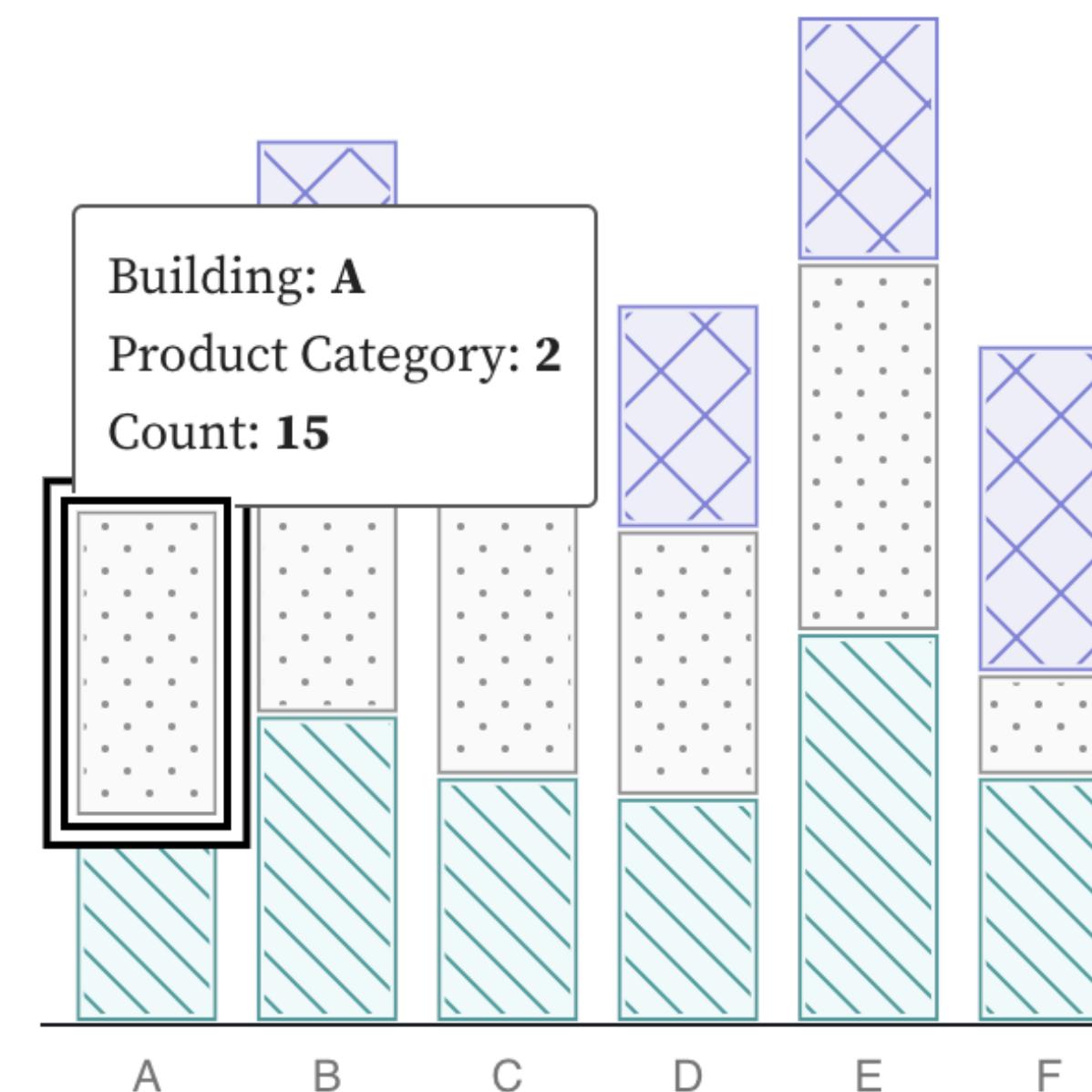
ARIA semantics are standardized

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

1 2 3



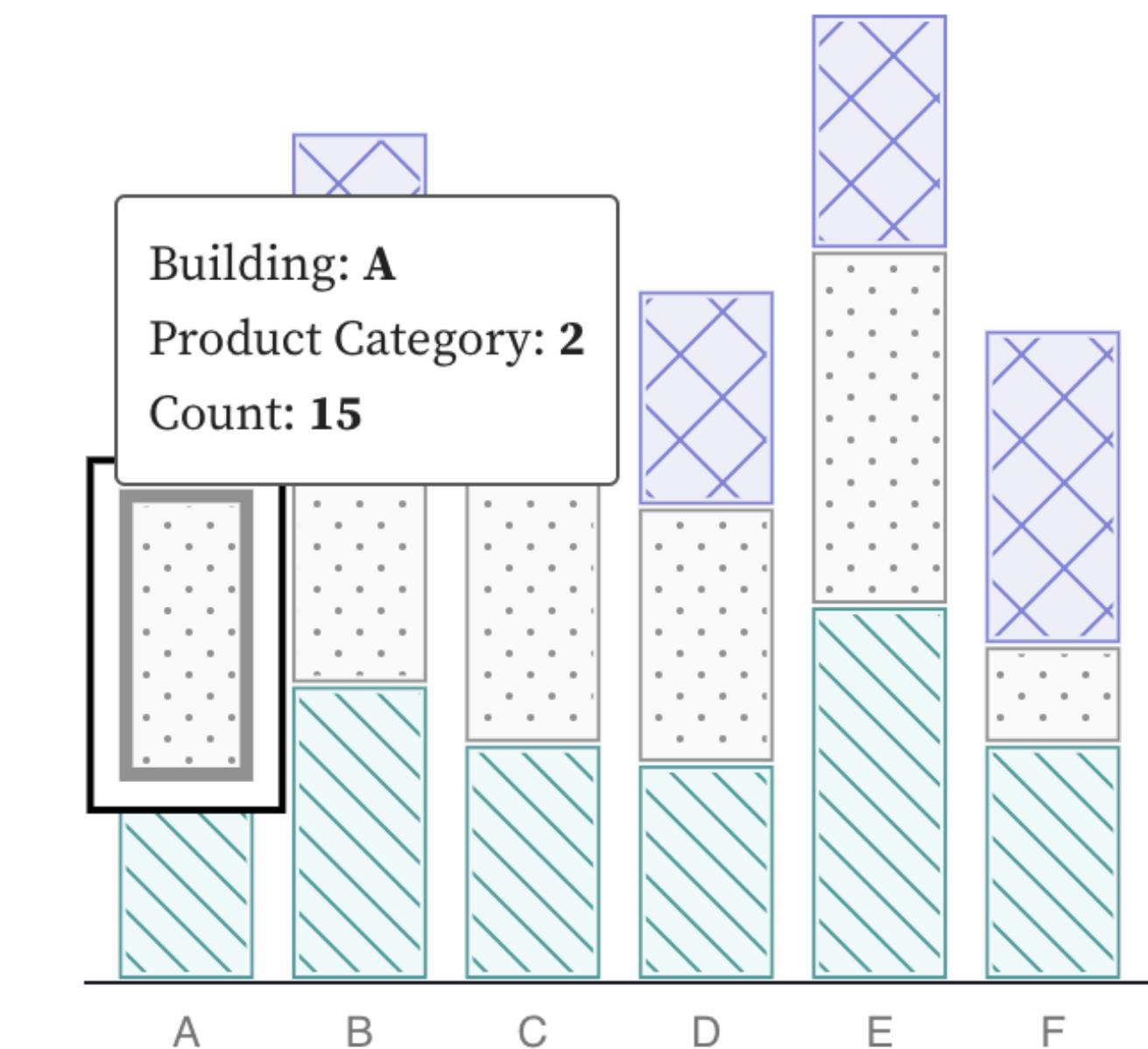
1 2 3



× 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

1 2 3

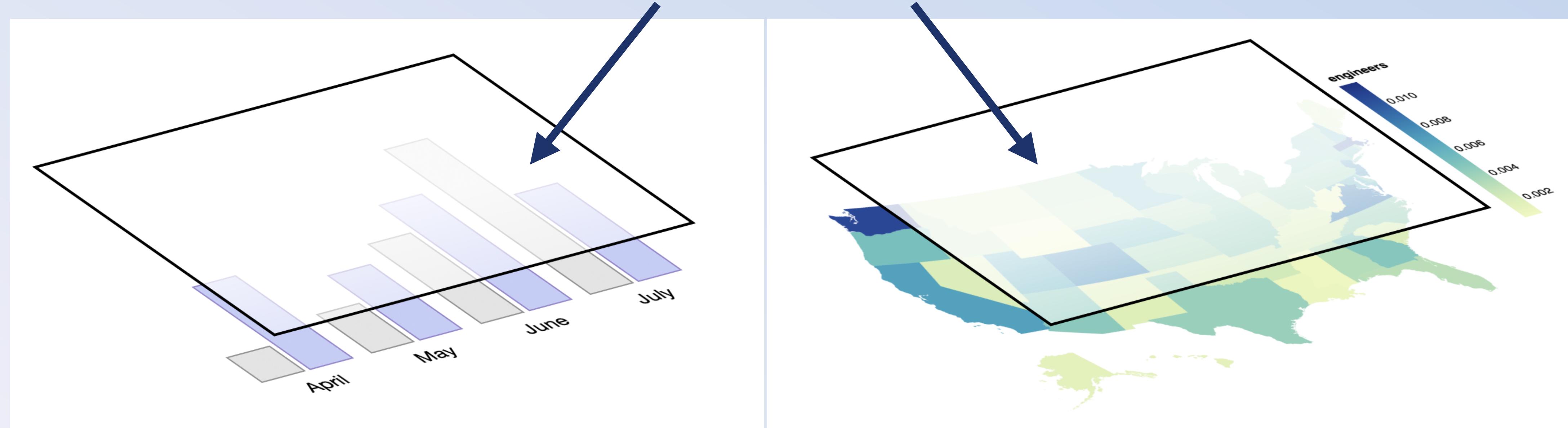


× selected, Building A. Product
Category 2. Count 15. Bar 2 of
3., toggle button

Data Navigator

Frank Elavsky et al (2023)

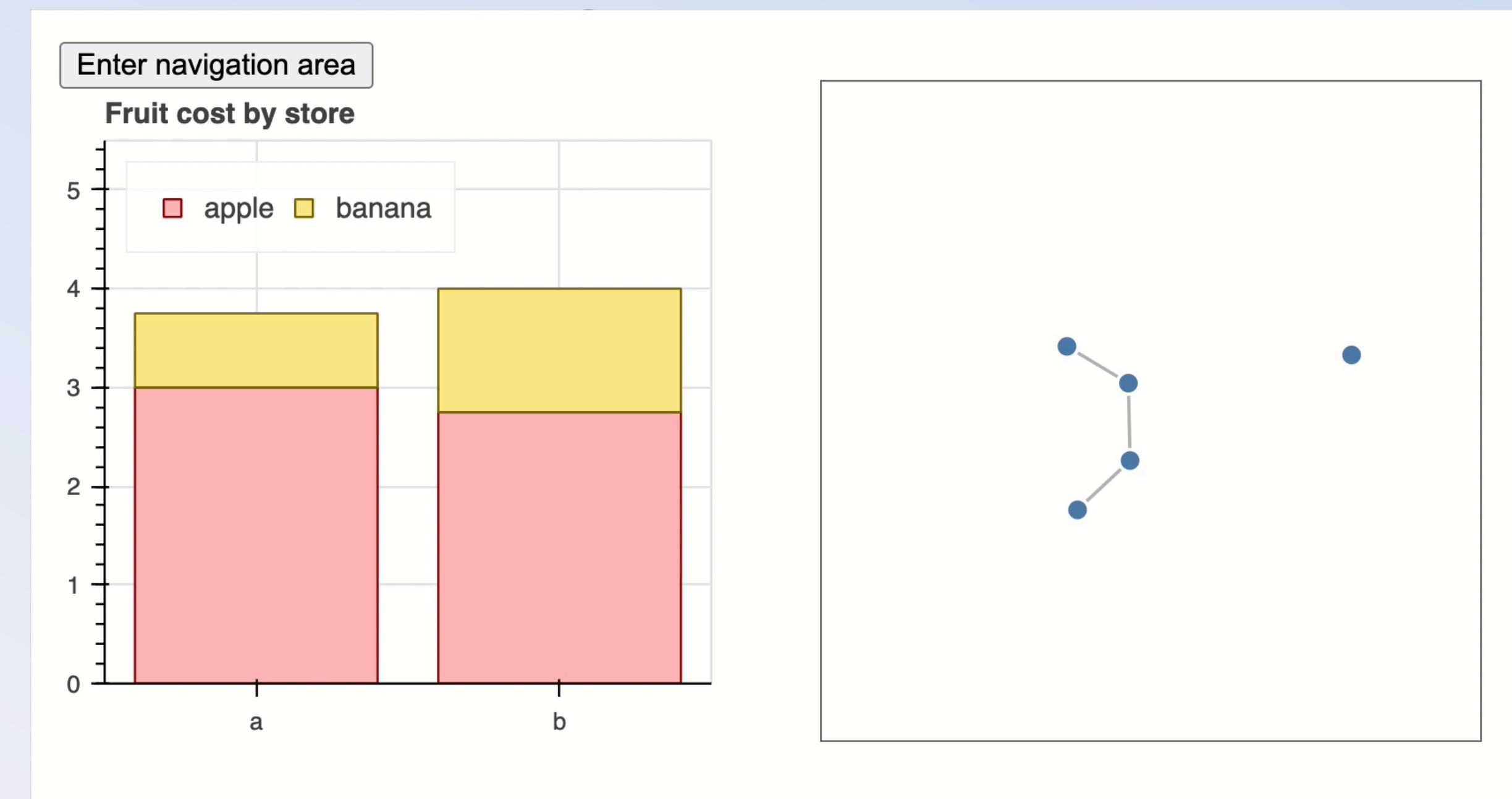
An interactive layer that interfaces between data structures and assistive technologies



Data Navigator

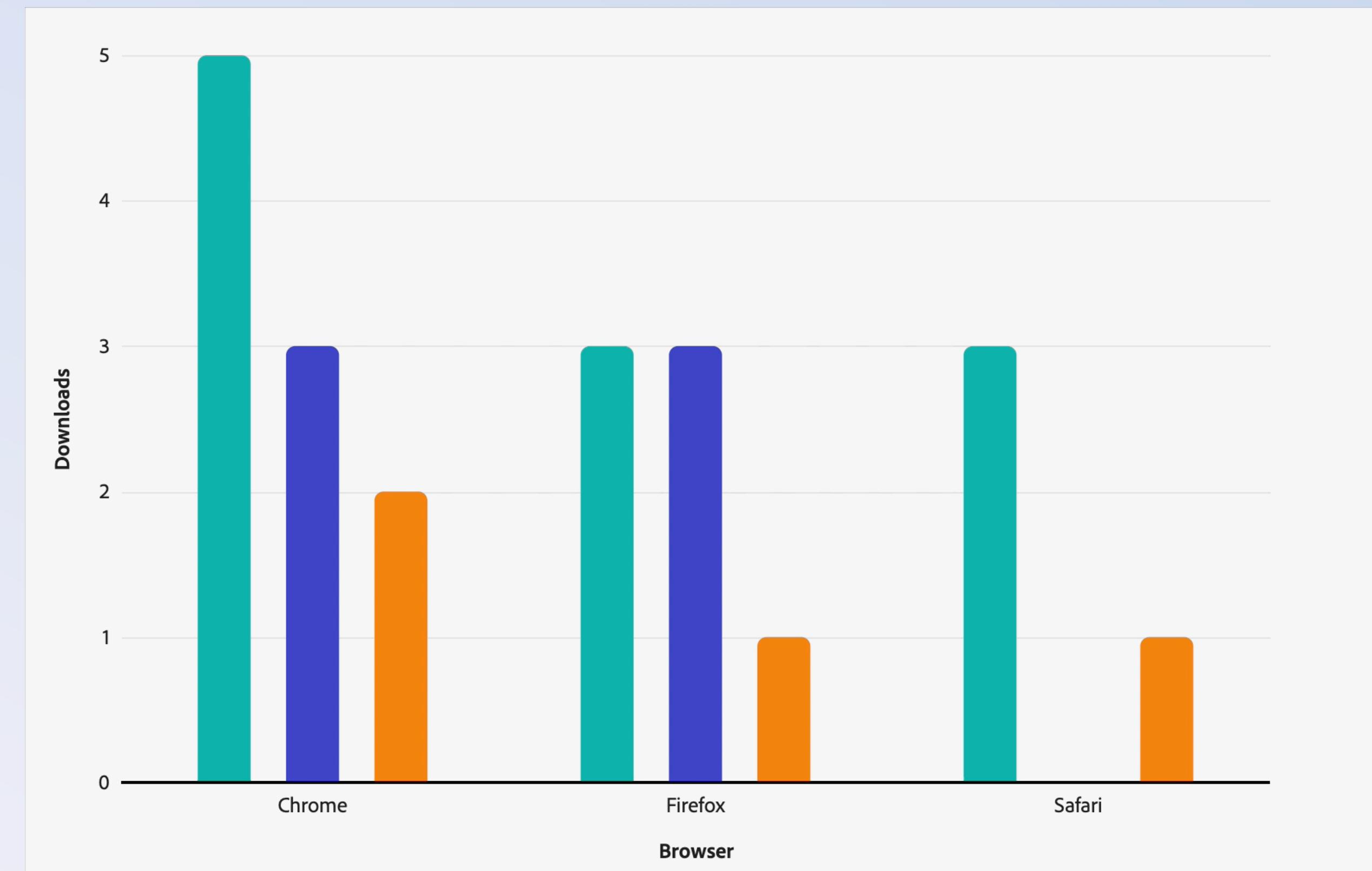
Data Navigator: Empowering practitioners

Bokeh, a Python visualization library



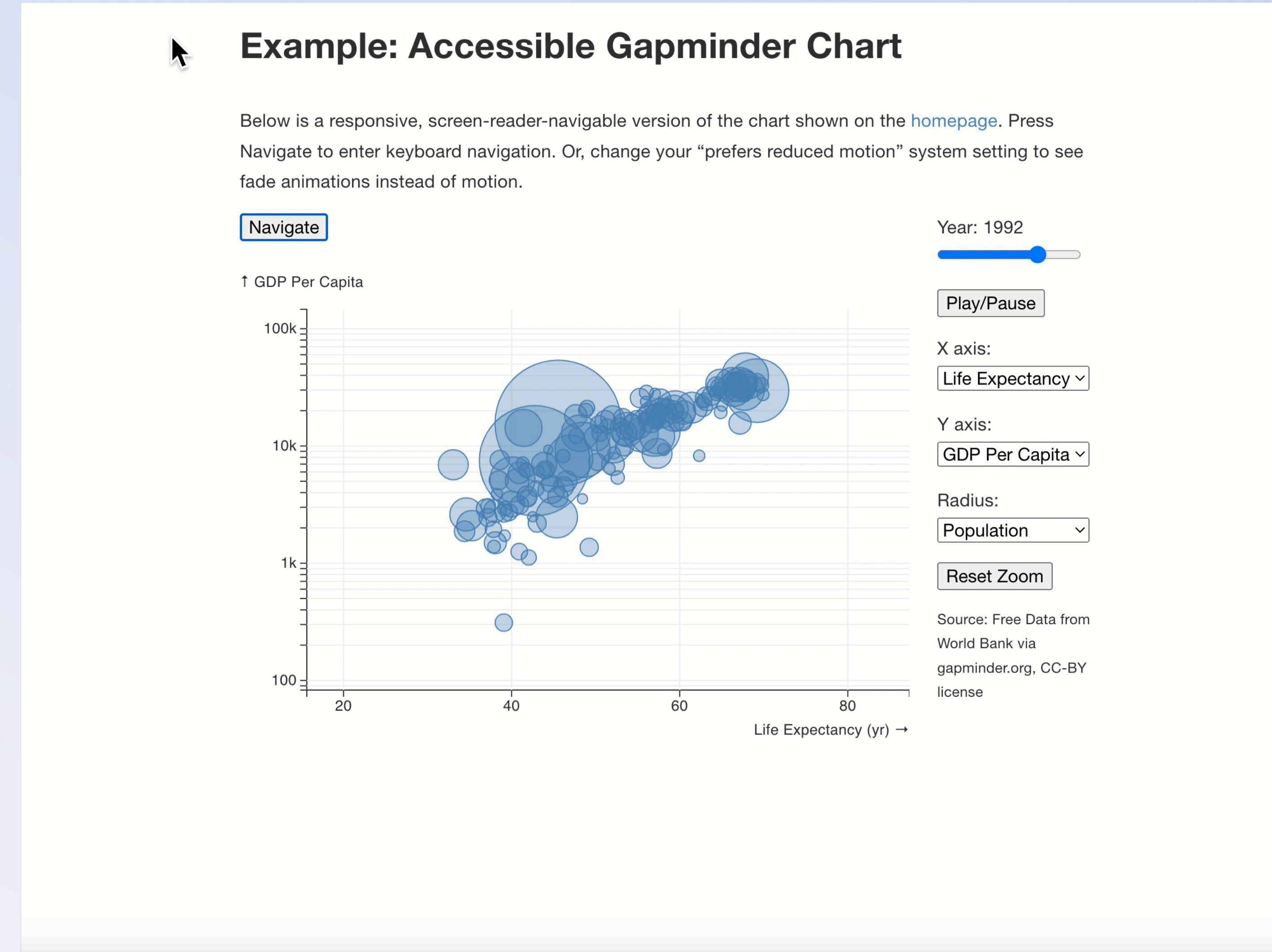
Data Navigator: Empowering practitioners

React Spectrum Charts, Adobe's visualization design system



Counterpoint: navigating animations

Sivaraman's Counterpoint (2024)



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 oversimulation in models that use randomized data decimation techniques. This particular evaluation findings demonstrate that the randomization models are significantly overproducing 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.

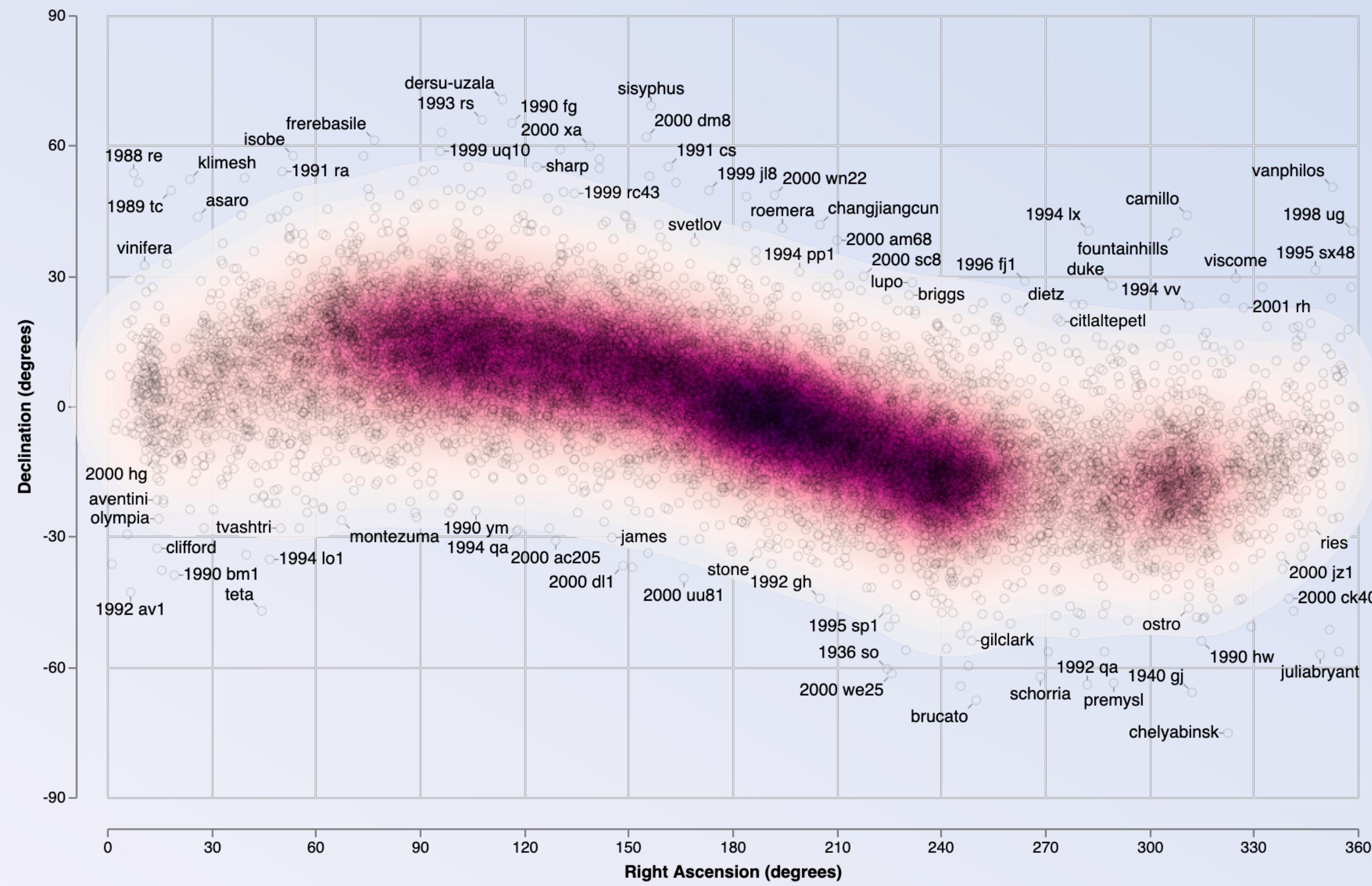
0 phrases have simpler alternatives.

0 of 3 sentences are hard to read.

0 of 3 sentences are very hard to read.

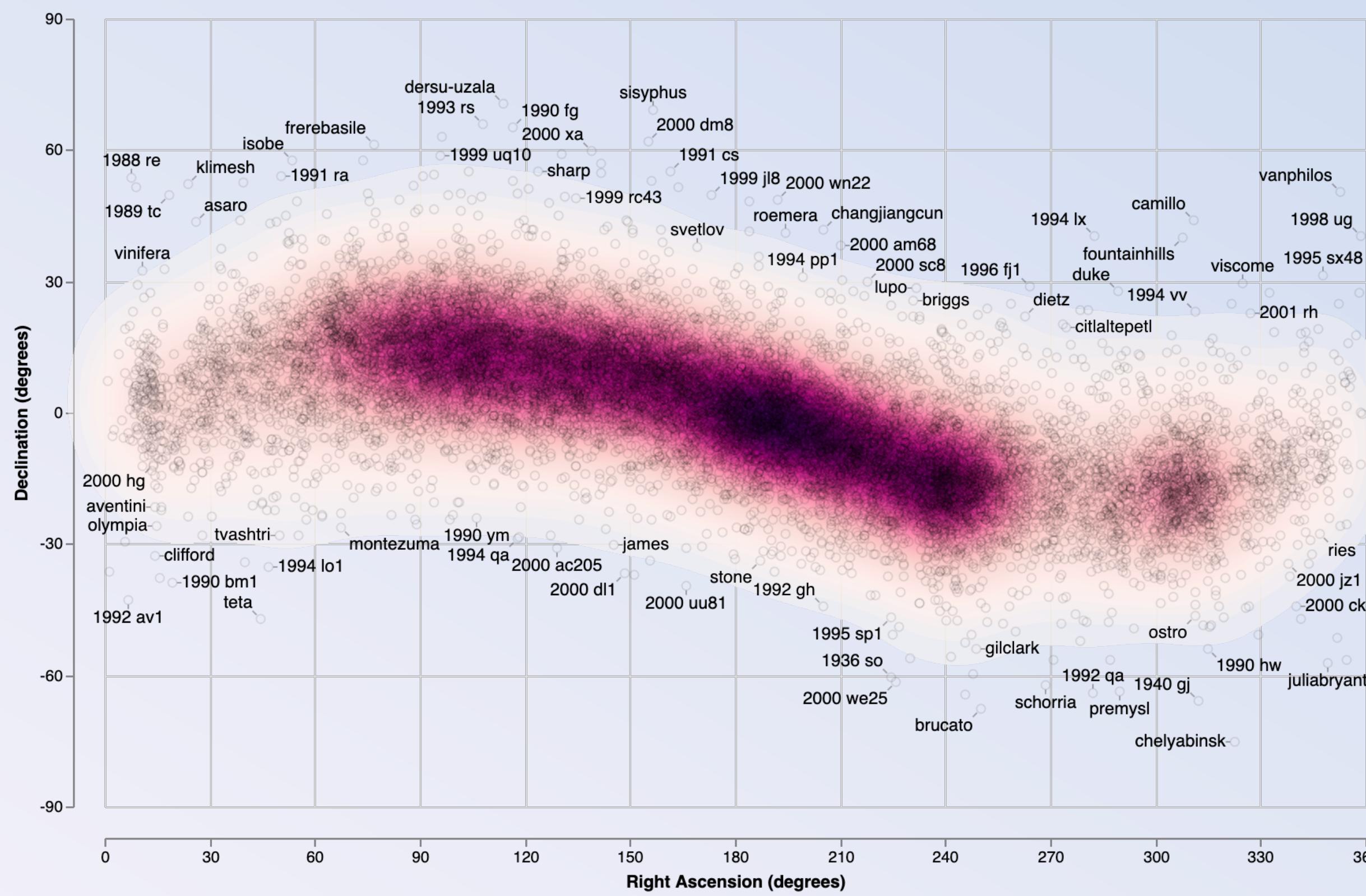
Label collision detection

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



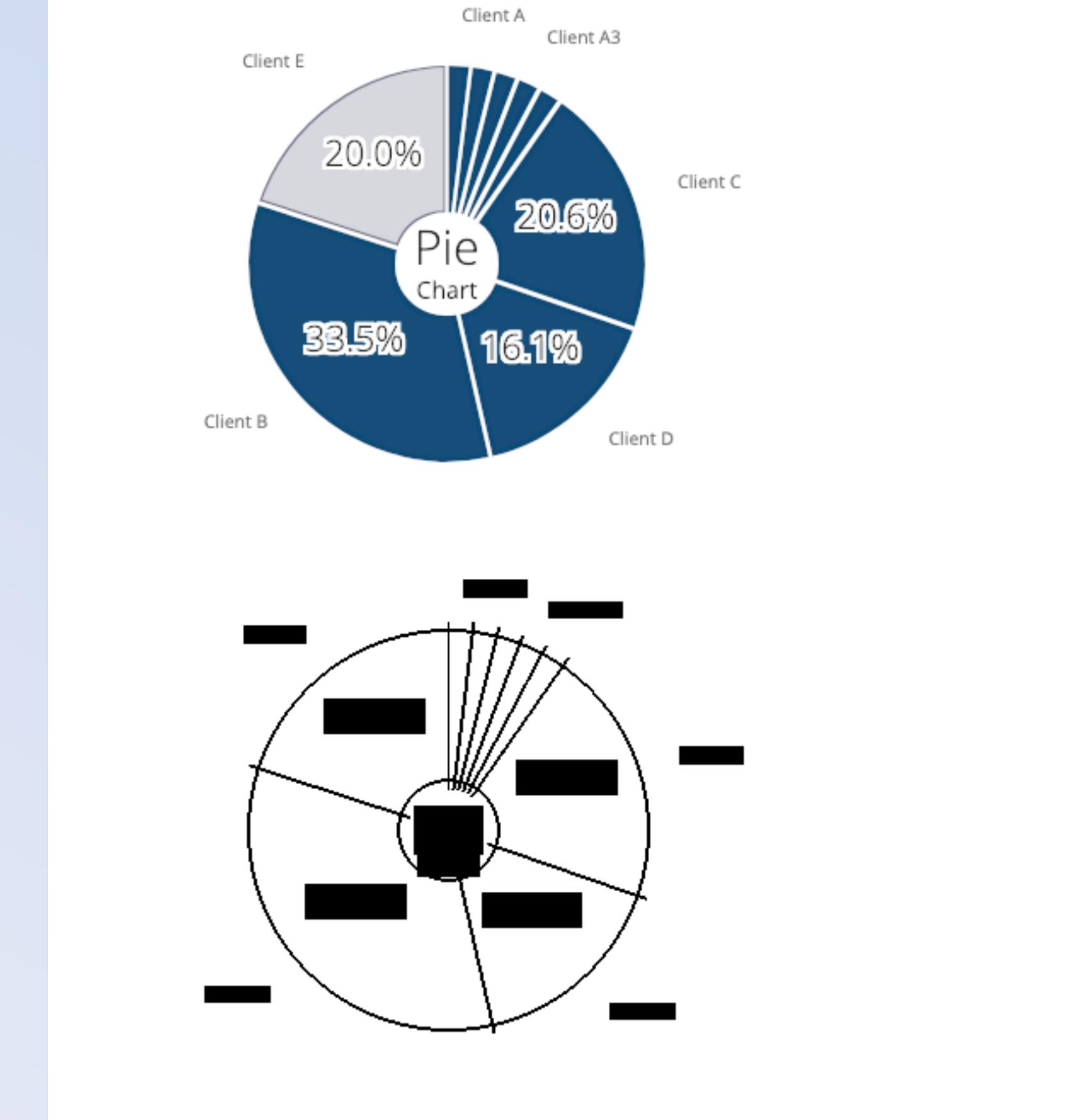
Label collision detection

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



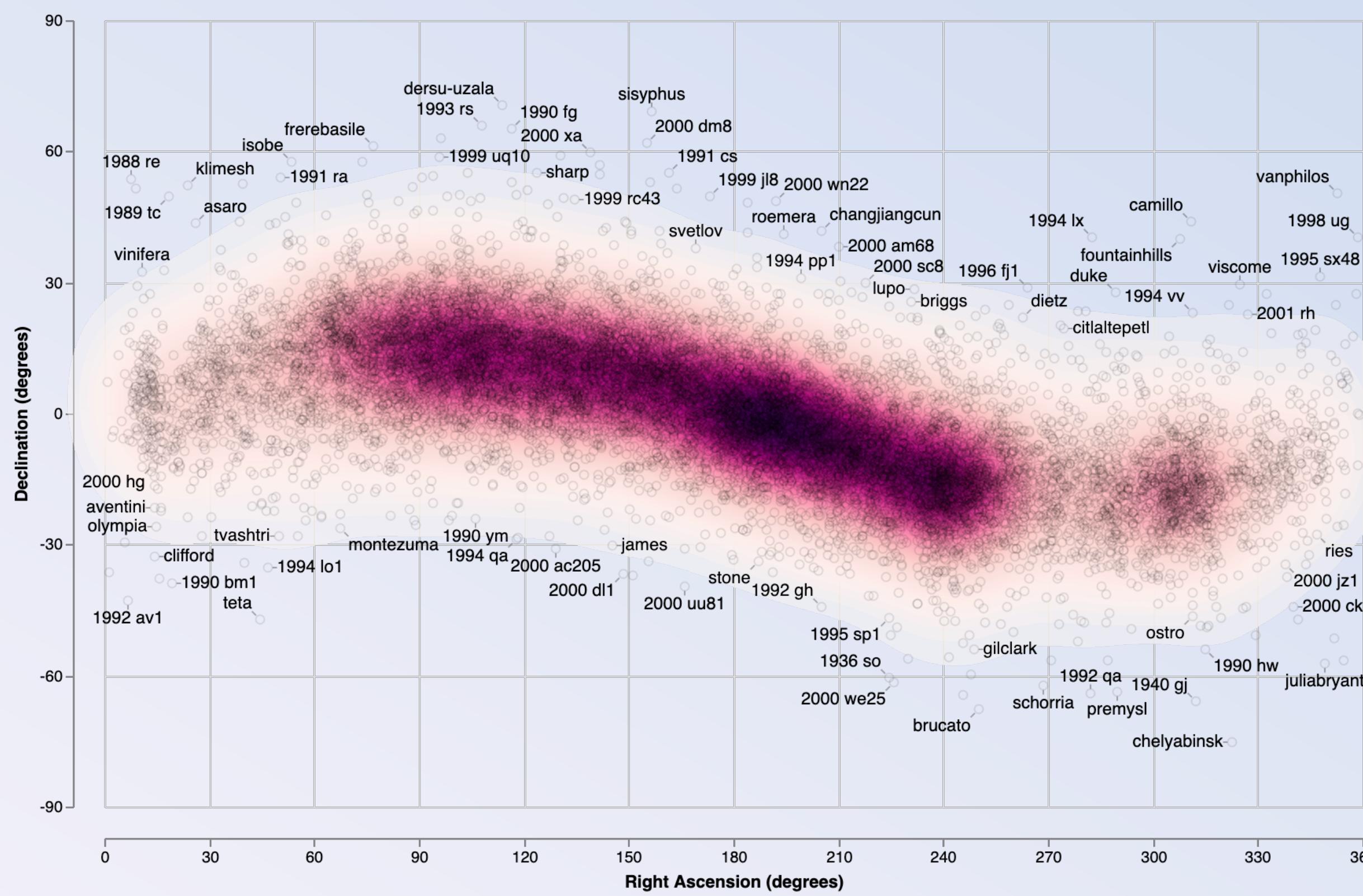
Label Collision

VCC leverages Vega-Label's Occupancy Bitmap approach to handle label overlapping issues.



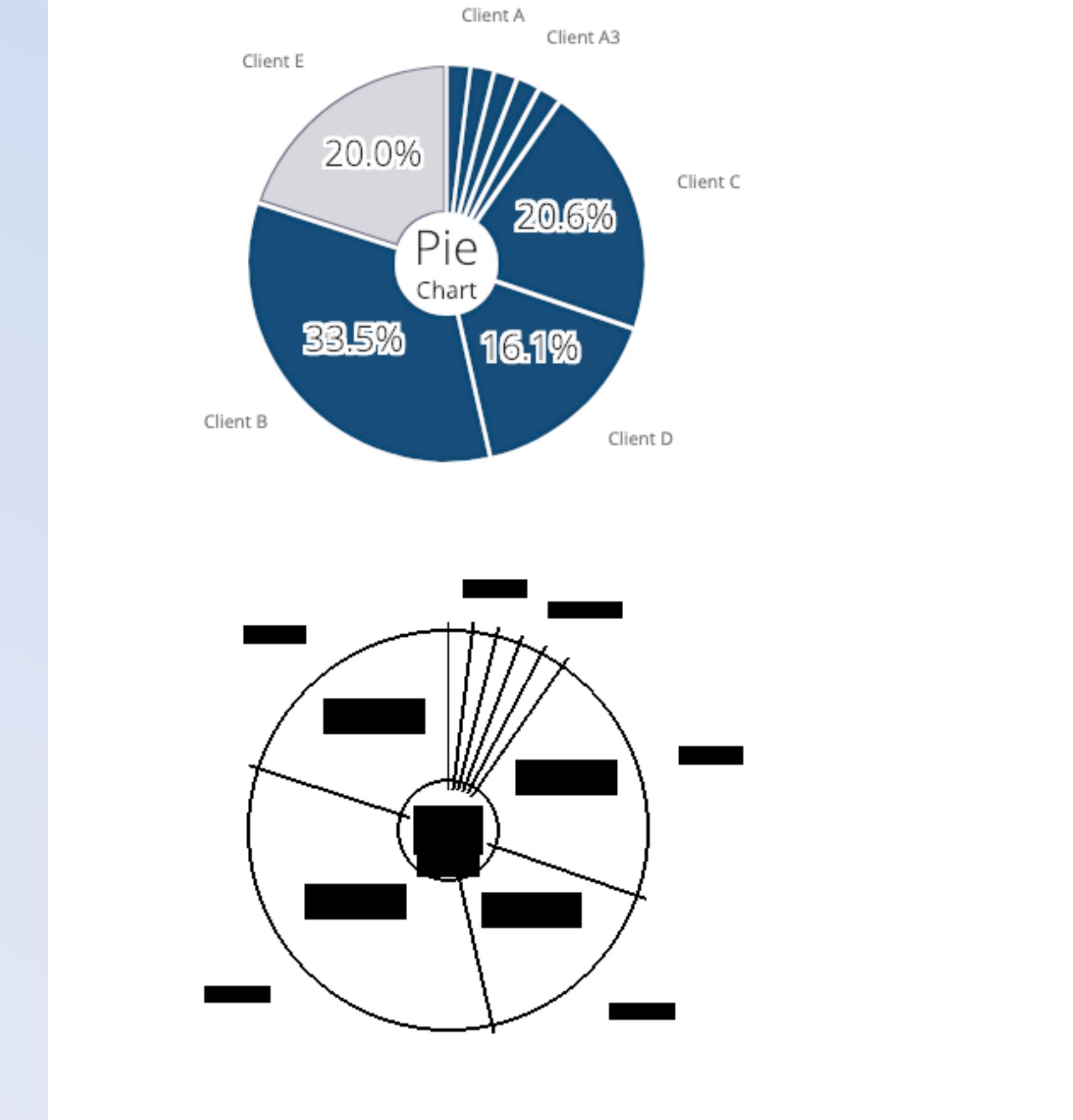
Label collision detection

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



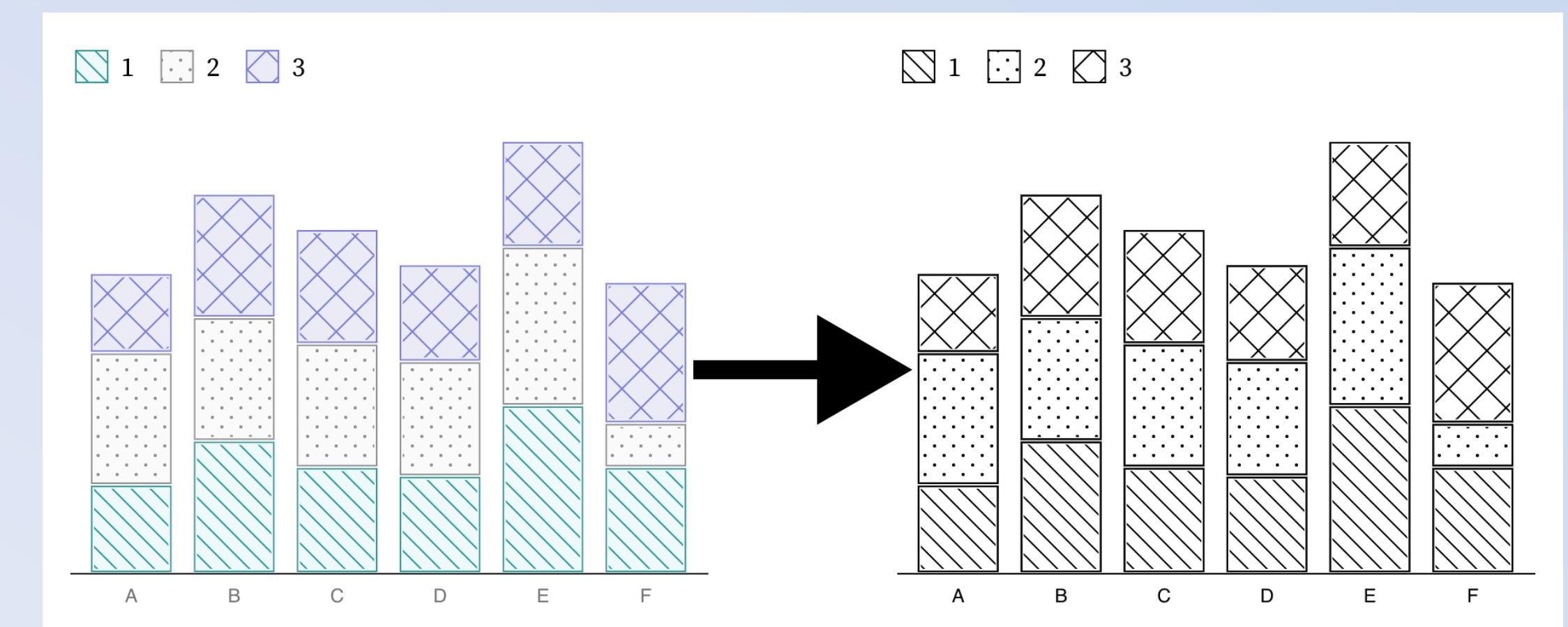
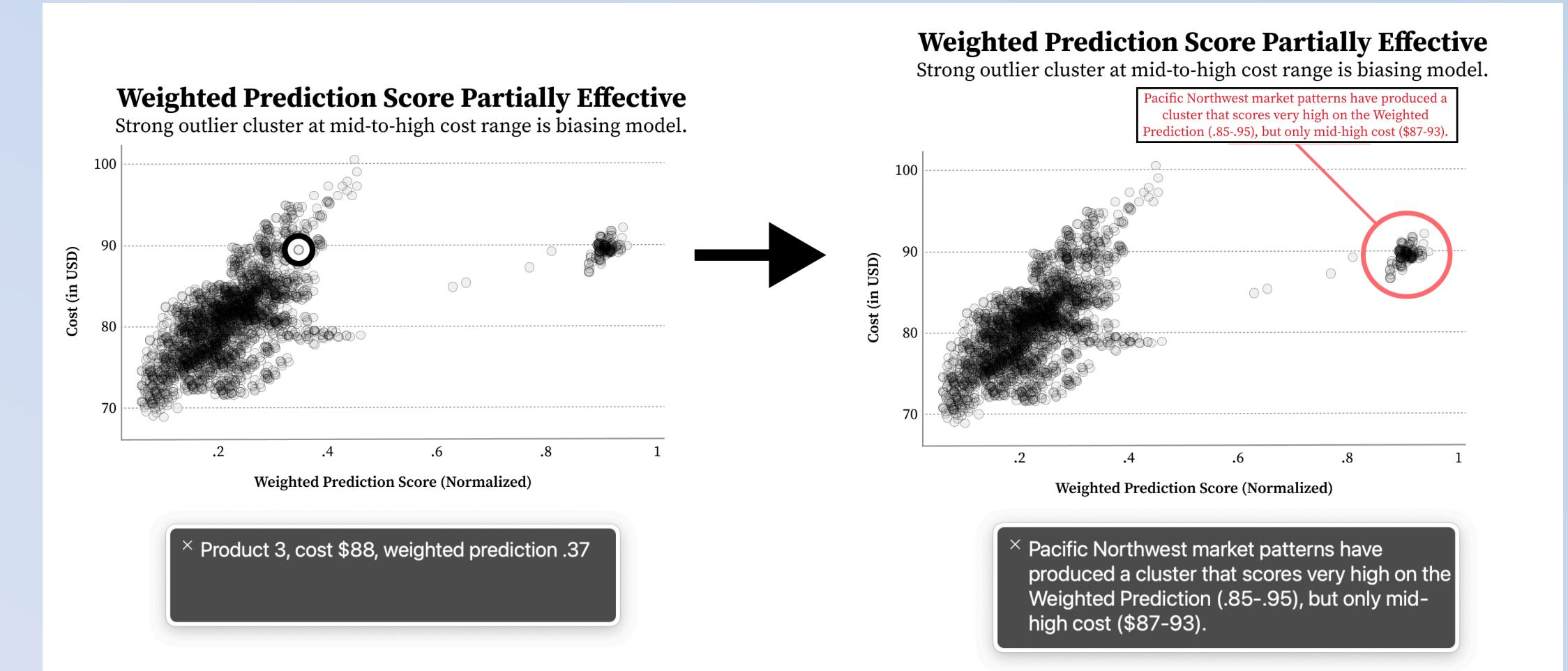
Label Collision

VCC leverages Vega-Label's Occupancy Bitmap approach to handle label overlapping issues.



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

