

Looking to the future of accessible data interfaces



Frank Elavsky, PhD Student

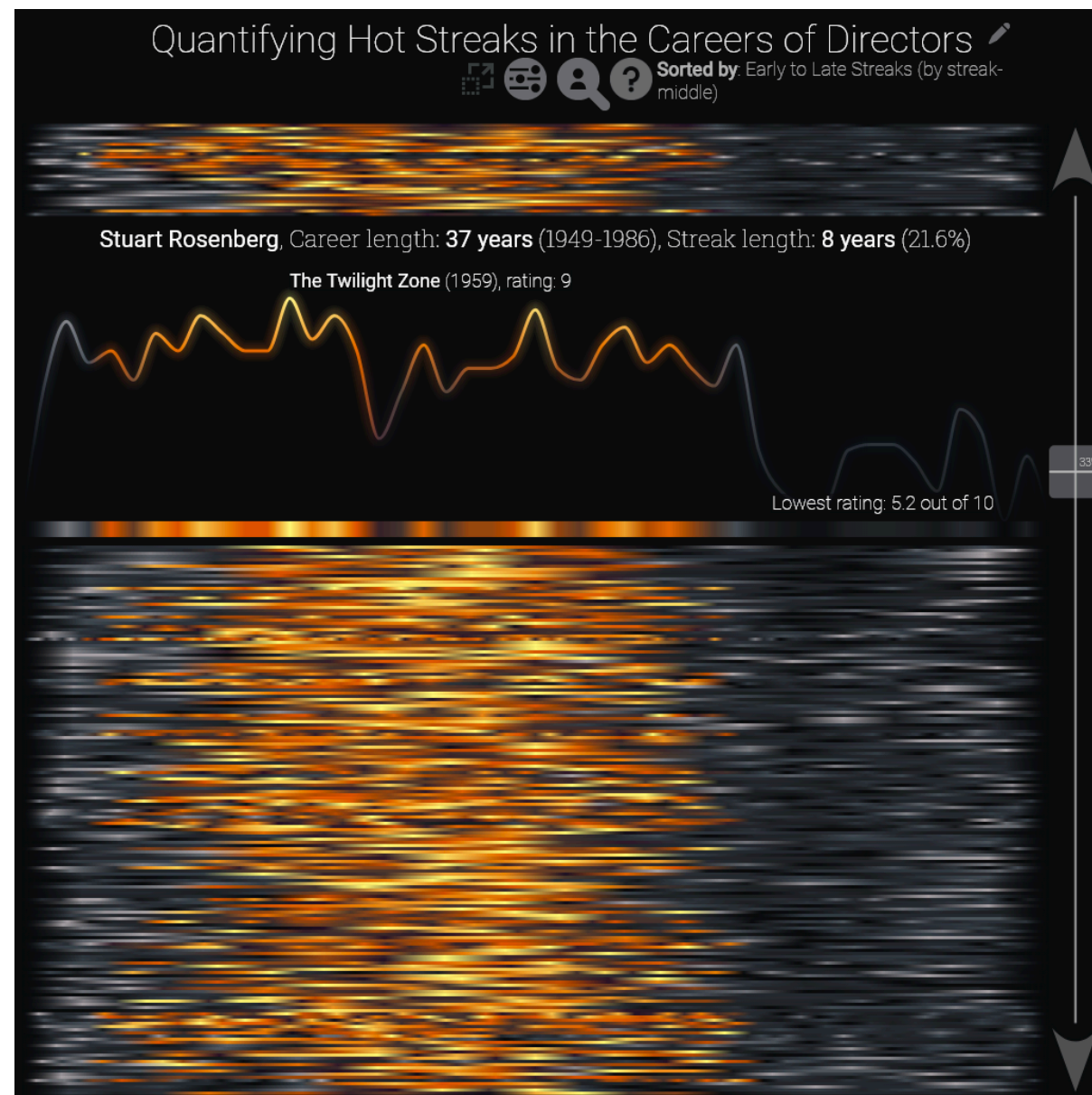


hcii.cmu.edu, axle-lab.com, dig.cmu.edu

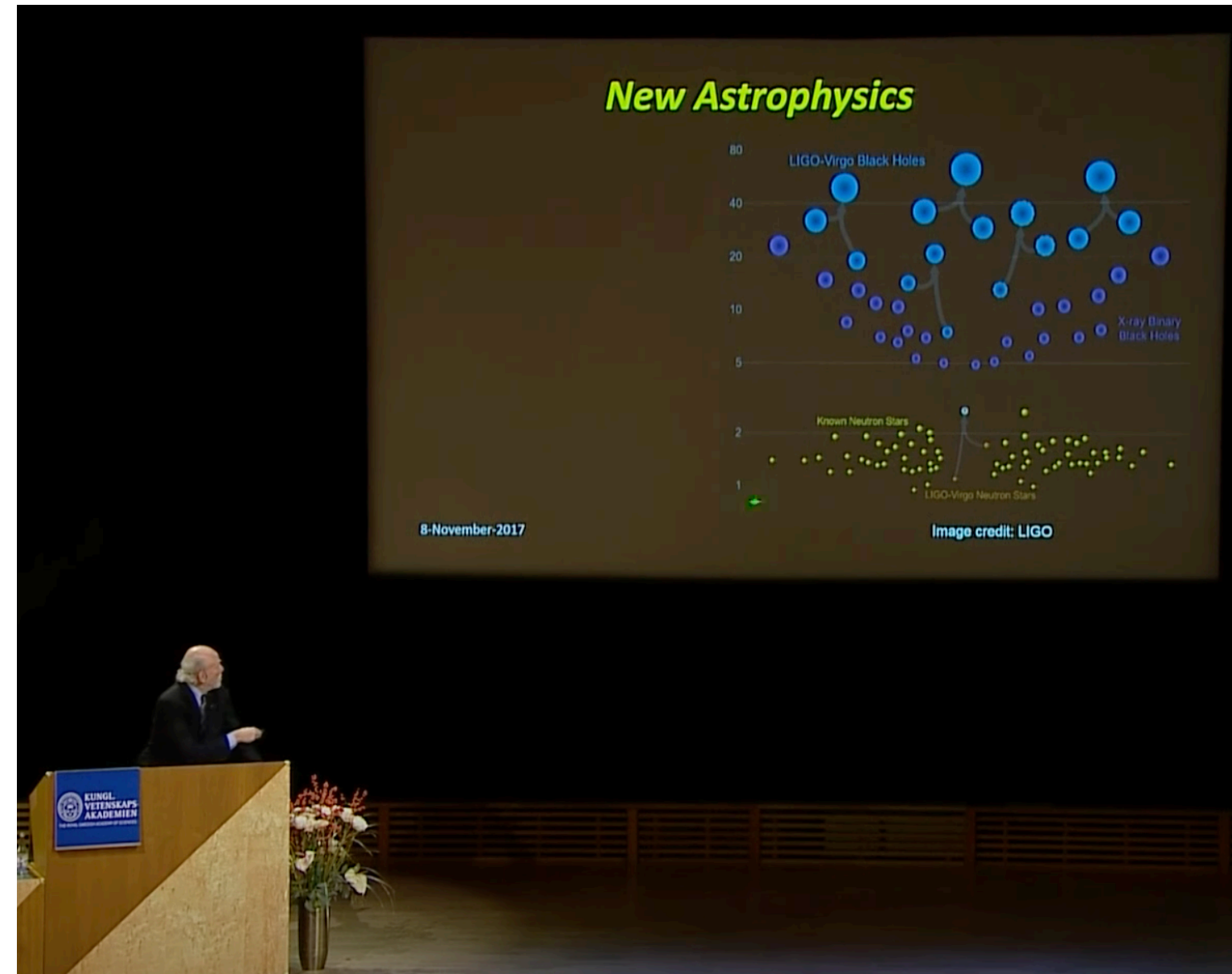
My pre-phd work in visualization

Industry and research engineering

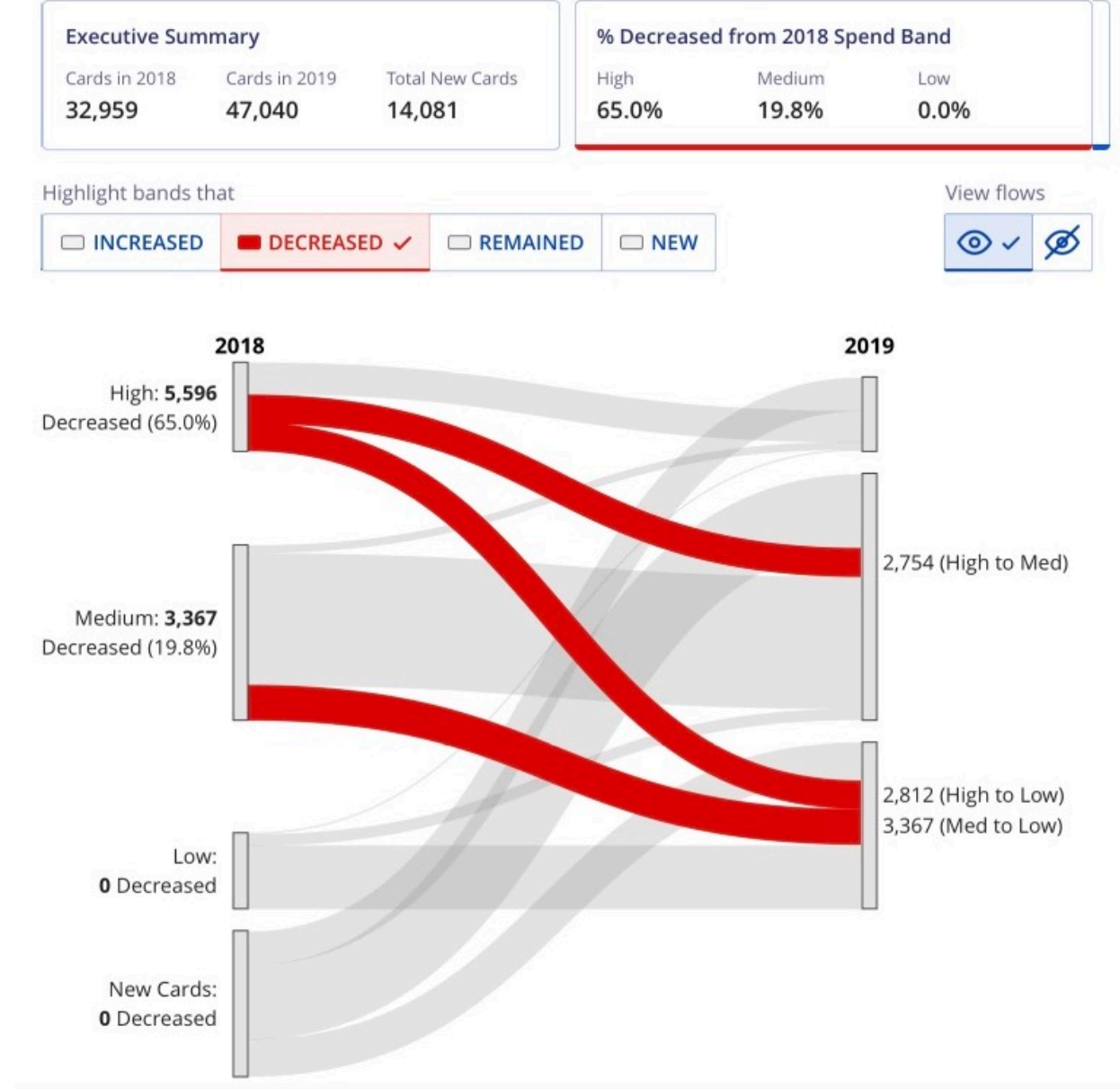
Dense model visualizations



Domain-specific visualizations



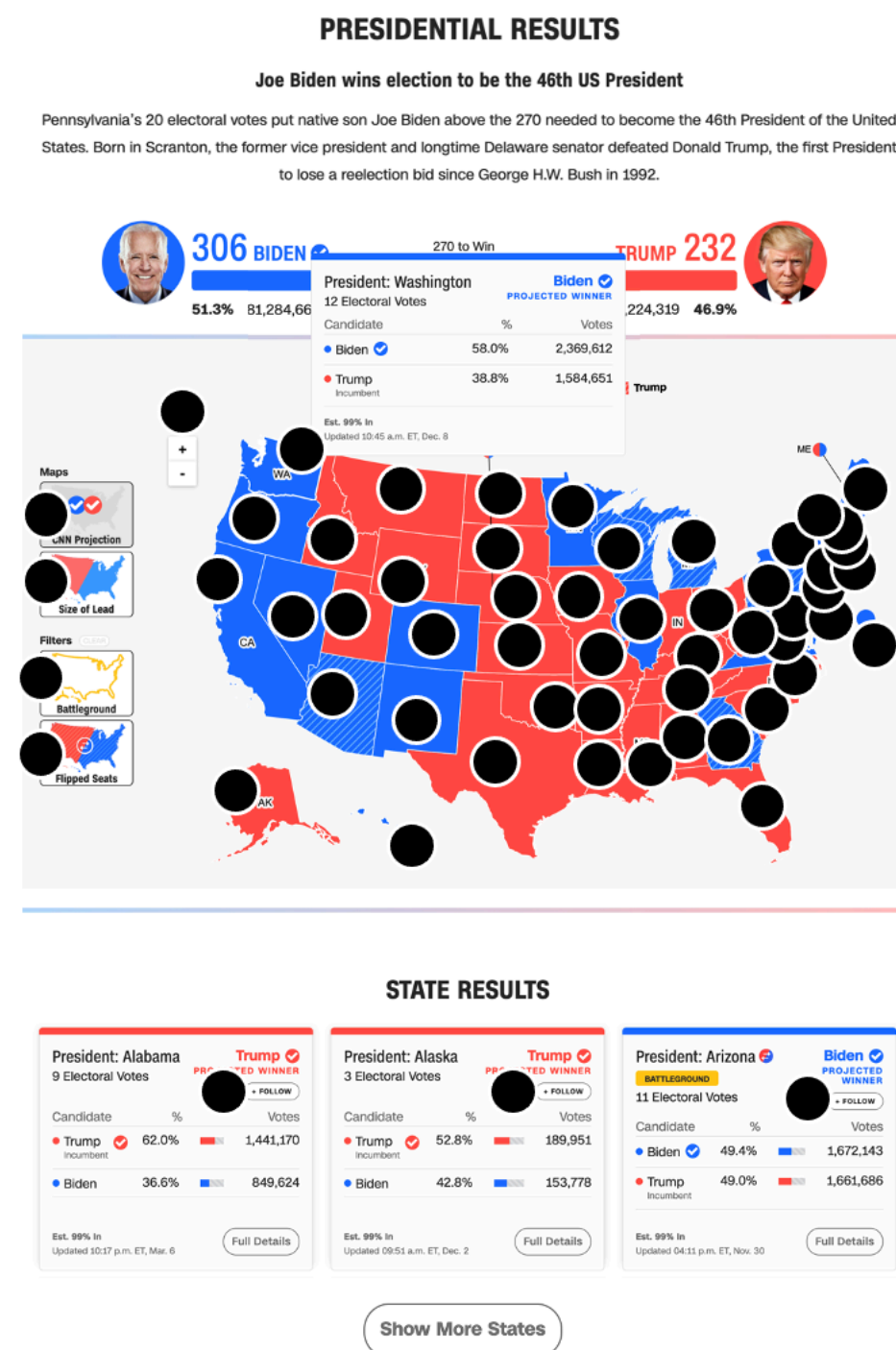
Data visualization library



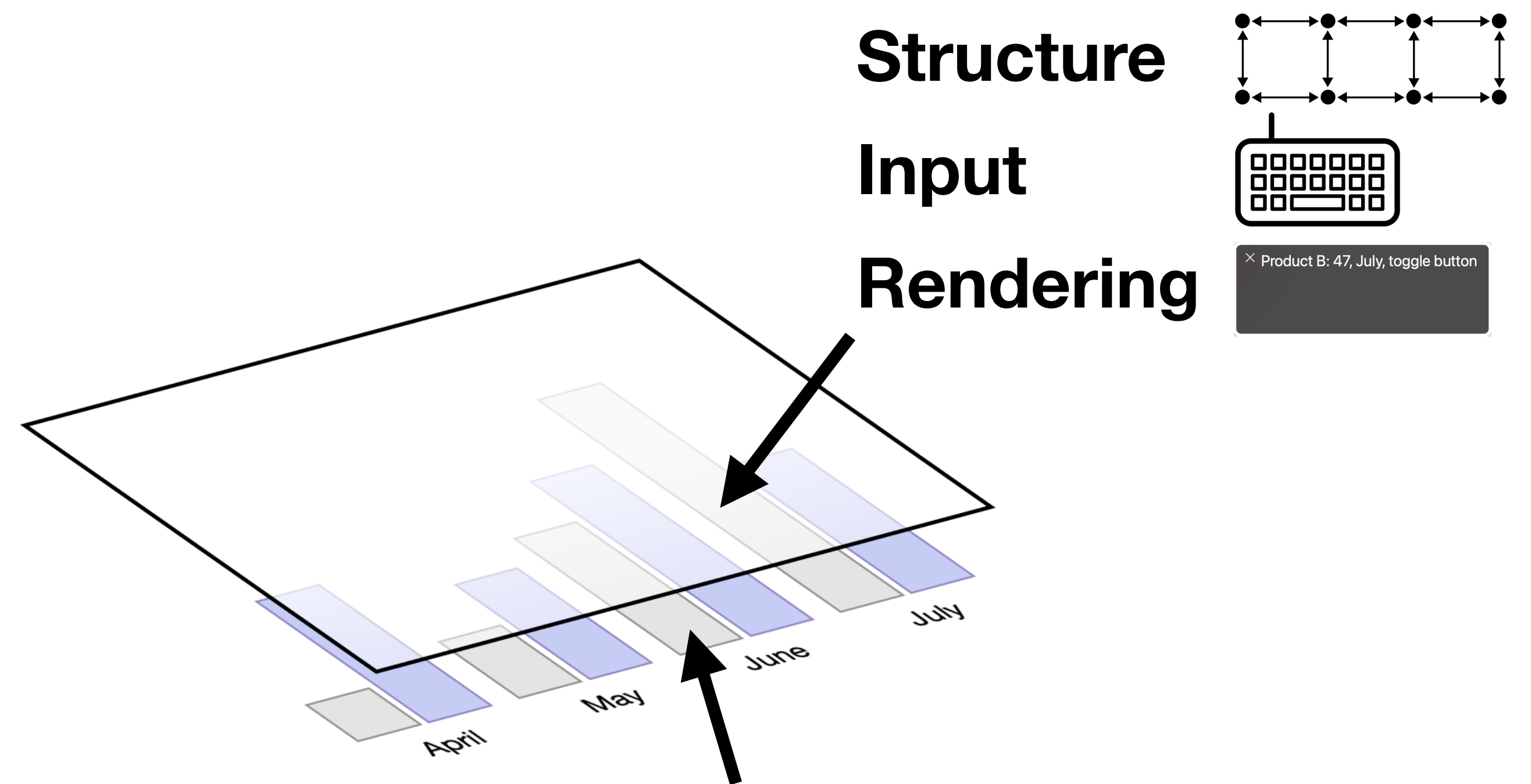
What and how of visualization accessibility

(My recent research)

Chartability:
What are accessibility barriers?



Data Navigator:
How do we build accessible visualizations?



To any visualization toolkit

Chartability has helped me audit and train others

978 access failures found in ~60 minutes.

Perceivable:

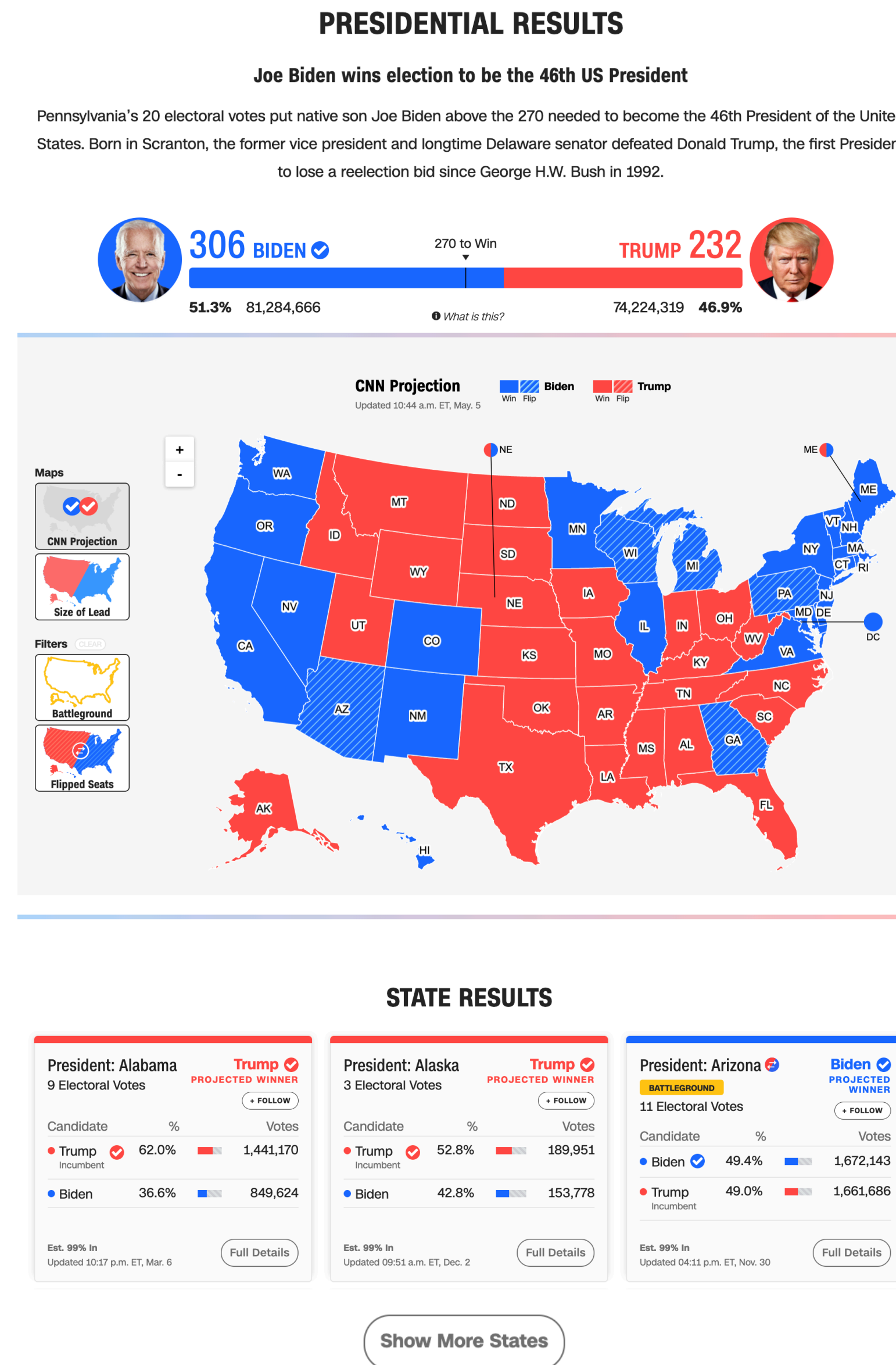
- 6 – Low contrast
- 57 - Content is only visual
- 50 - Color alone is used
- 3 - Meaningful elements can be distinguished

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

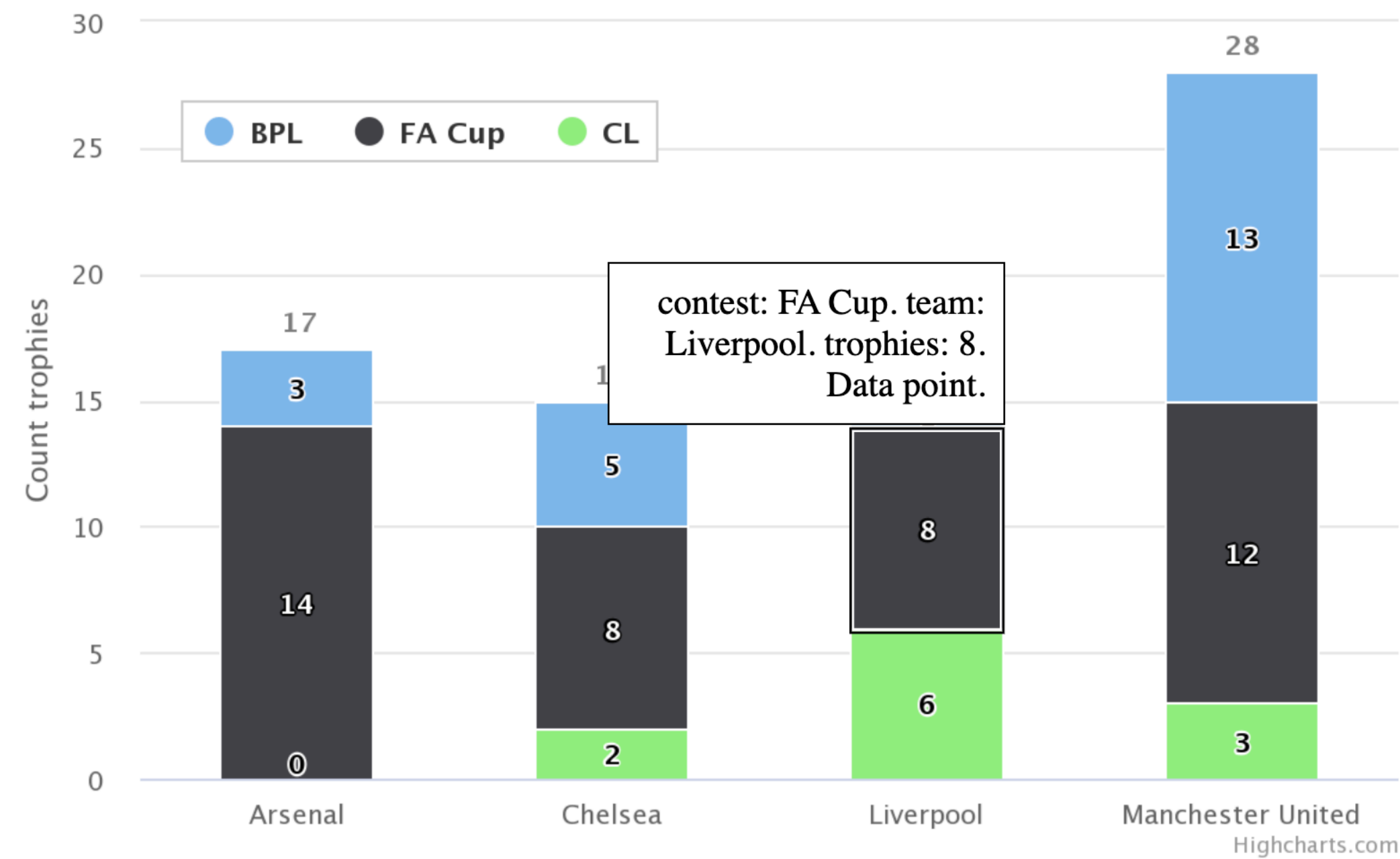
Flexible:

- 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

Data Navigator makes previously inaccessible formats more accessible

Enter navigation area

Major trophies for some English teams

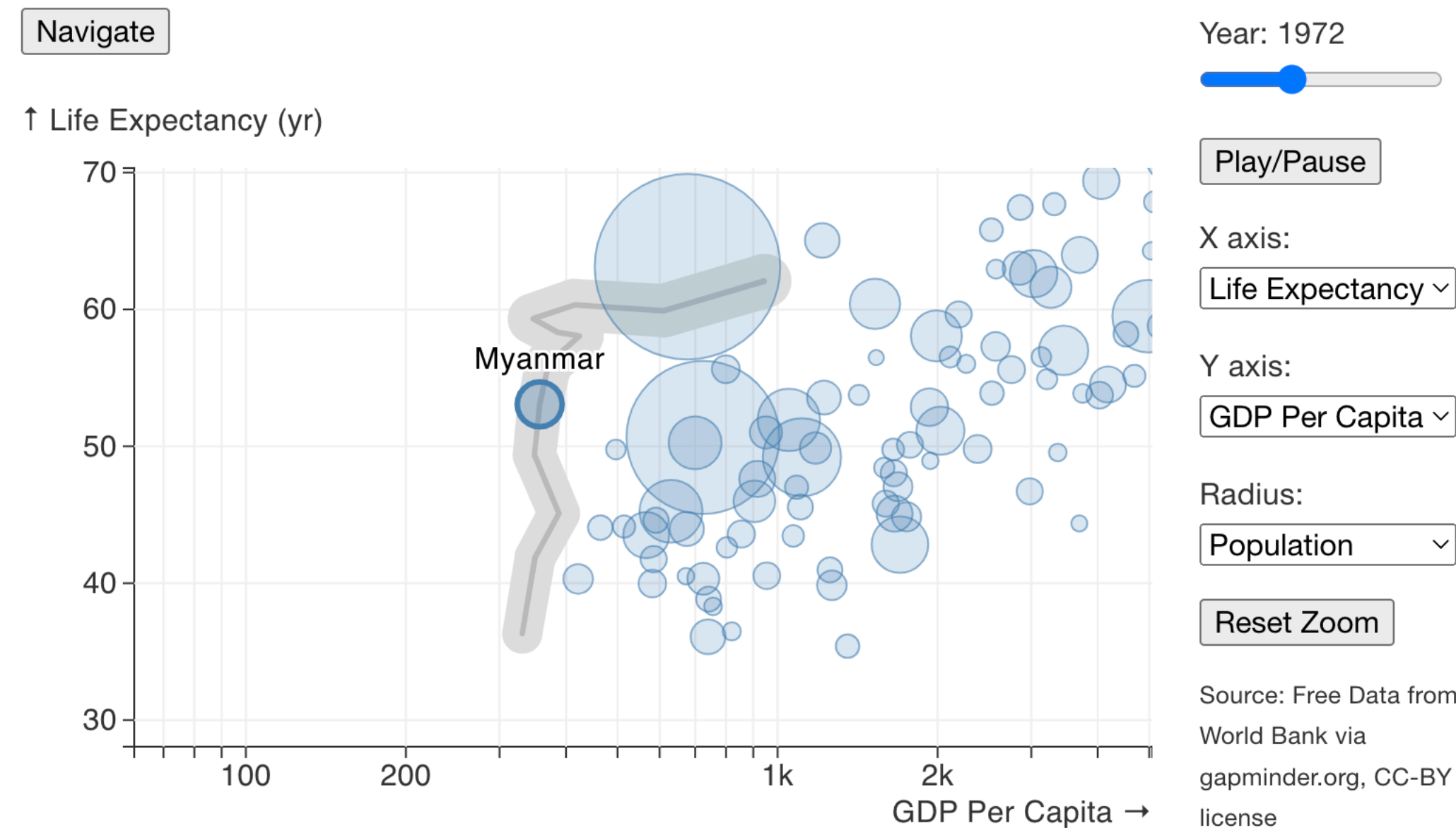


[Interactive demo link](#)

Data Navigator also opened up new collaborations

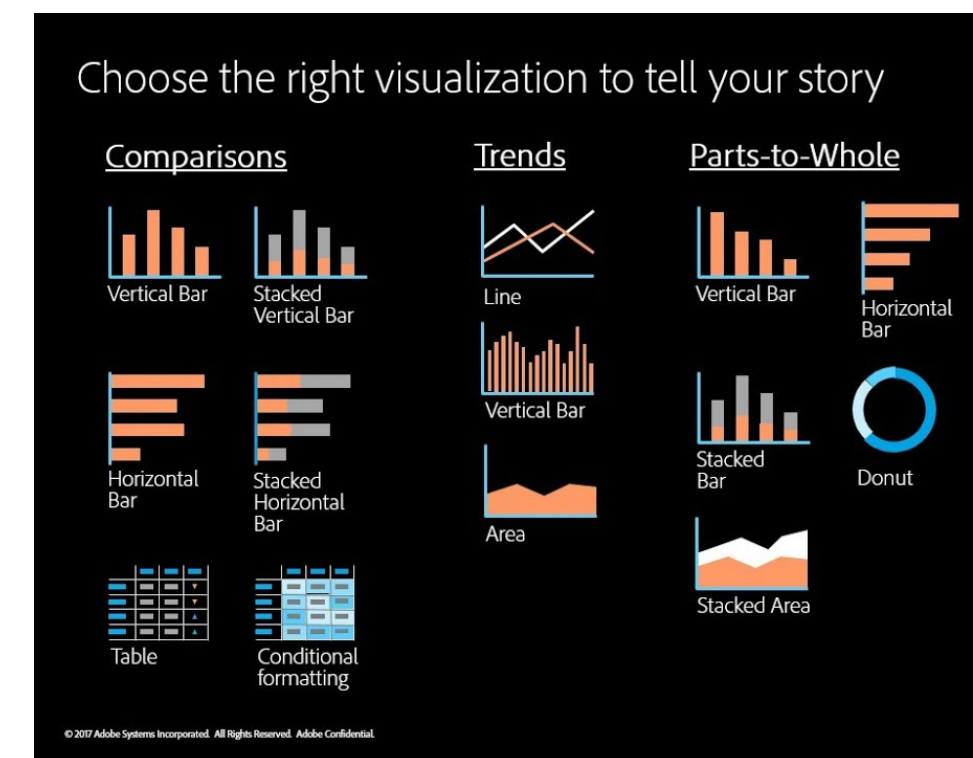
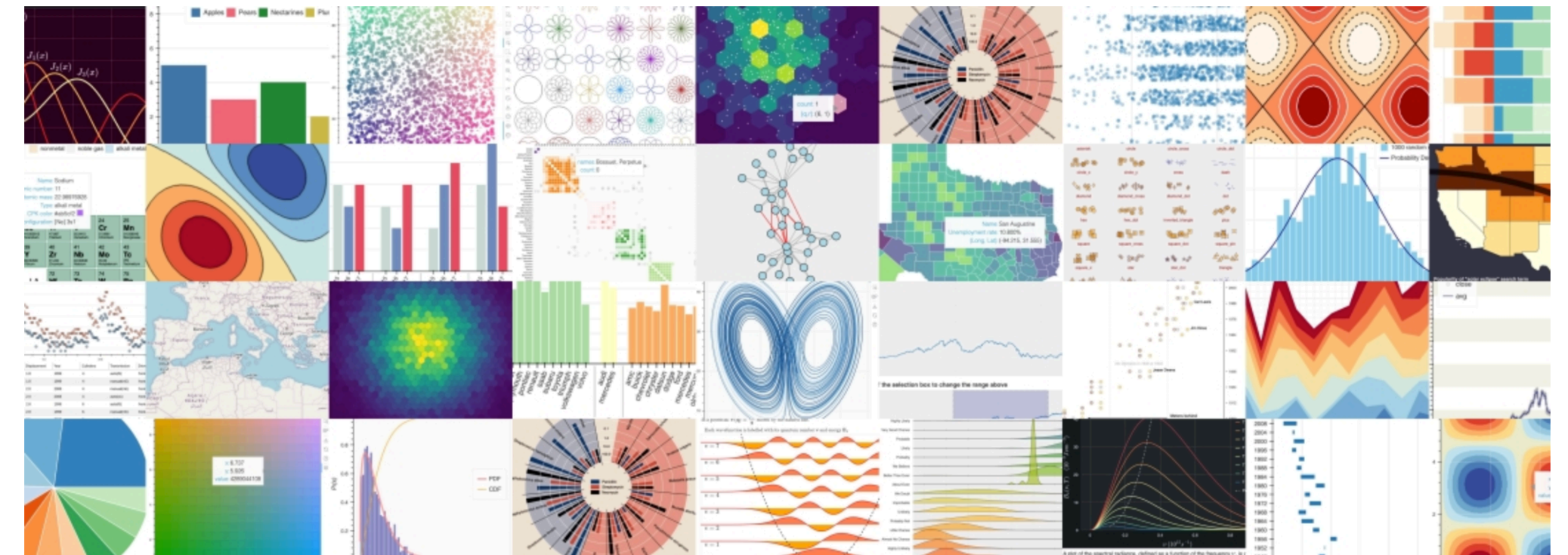
Example: Accessible Gapminder Chart

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.



Myanmar 1972: GDP Per Capita is 357, Life Expectancy (yr) is 53.1, Population is 28,500,000. In 5 years, GDP Per Capita increases by 3.9% and Life Expectancy (yr) increases by 5.6%. left/right arrow to change country, up/down arrow to change year, space to summarize trend, backspace to return.

[Interactive demo link](#)

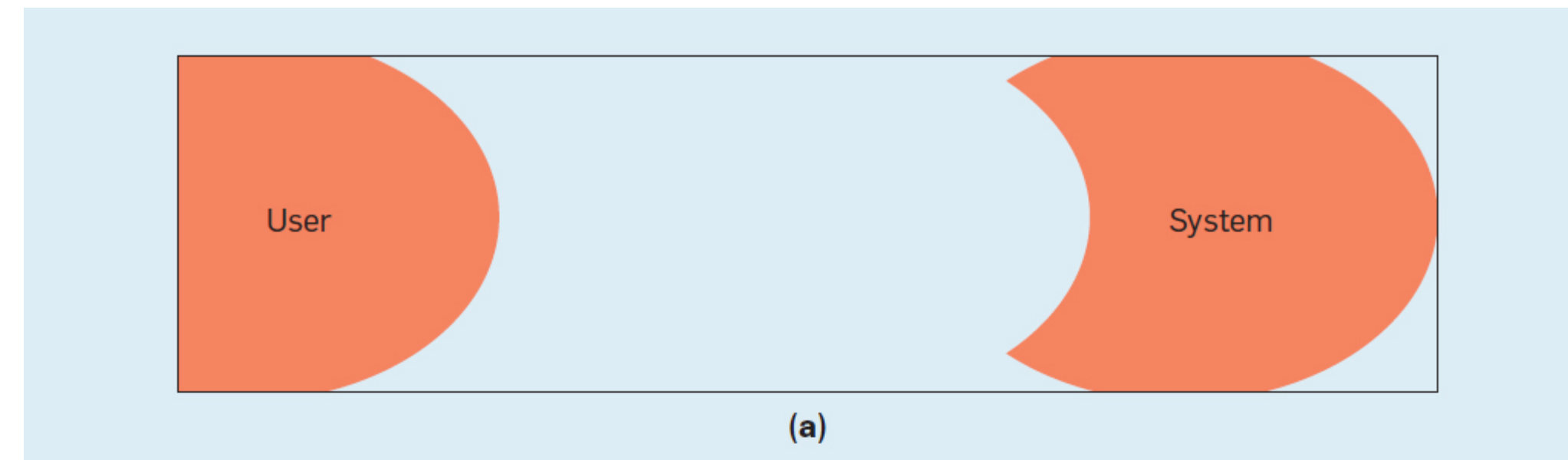


What are some “big-P” Problems in accessibility and visualization?

Problem 1: **Ability Assumptions** produce static systems

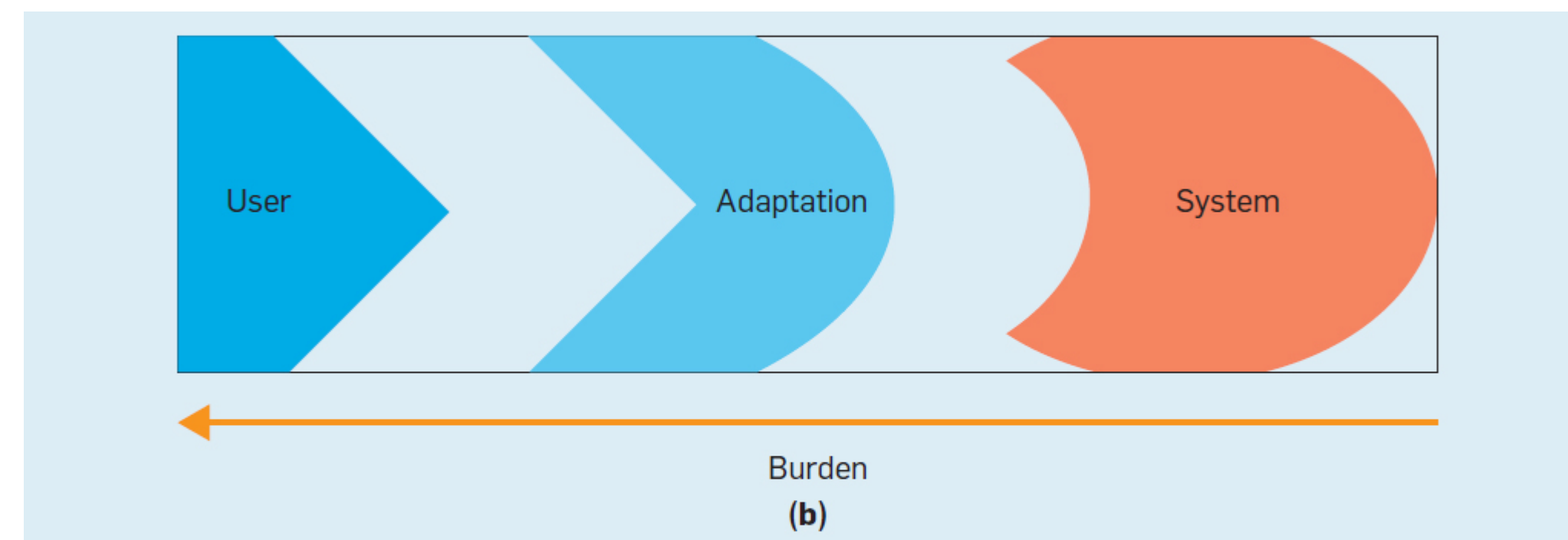
Ability Assumptions

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



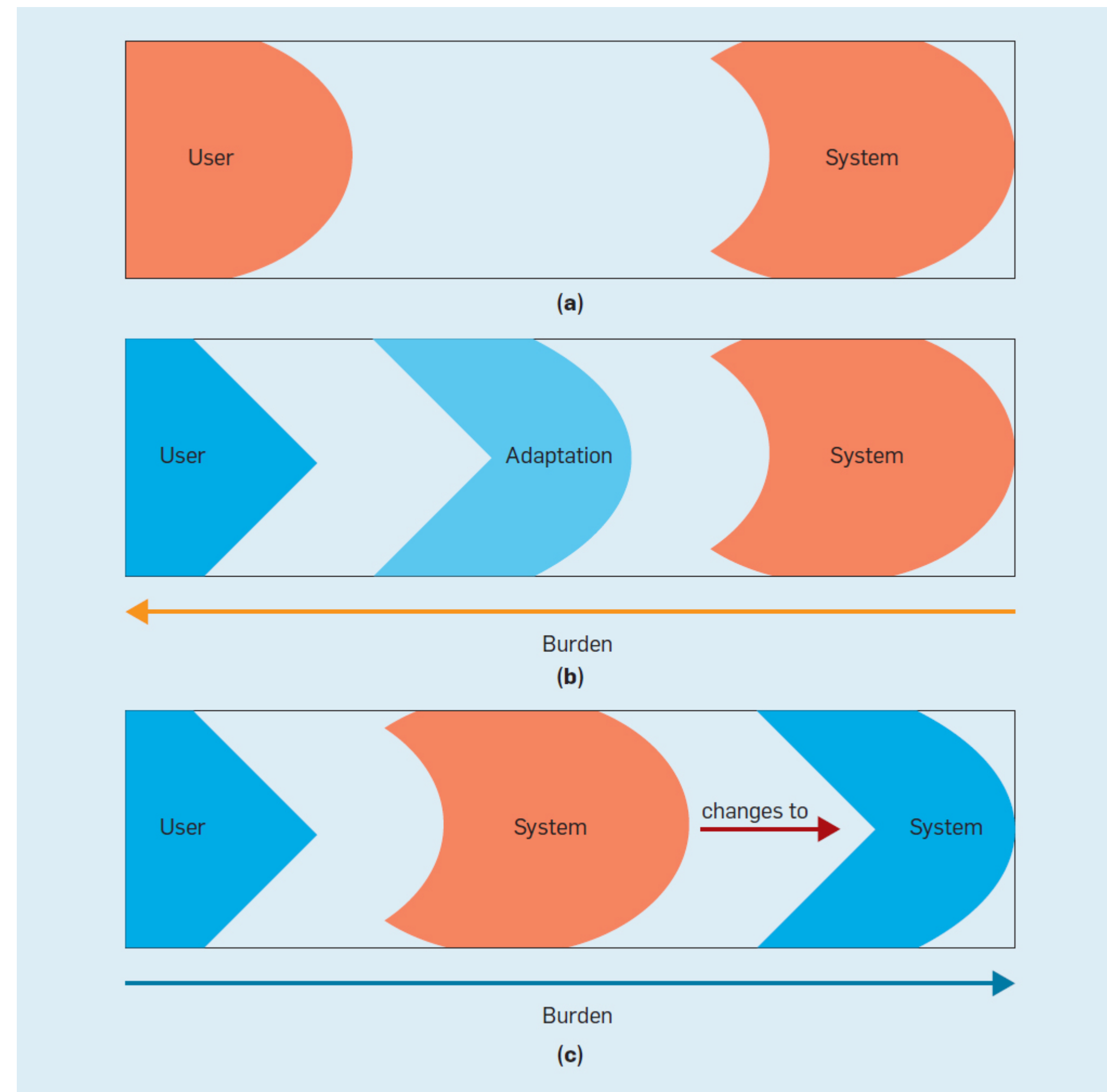
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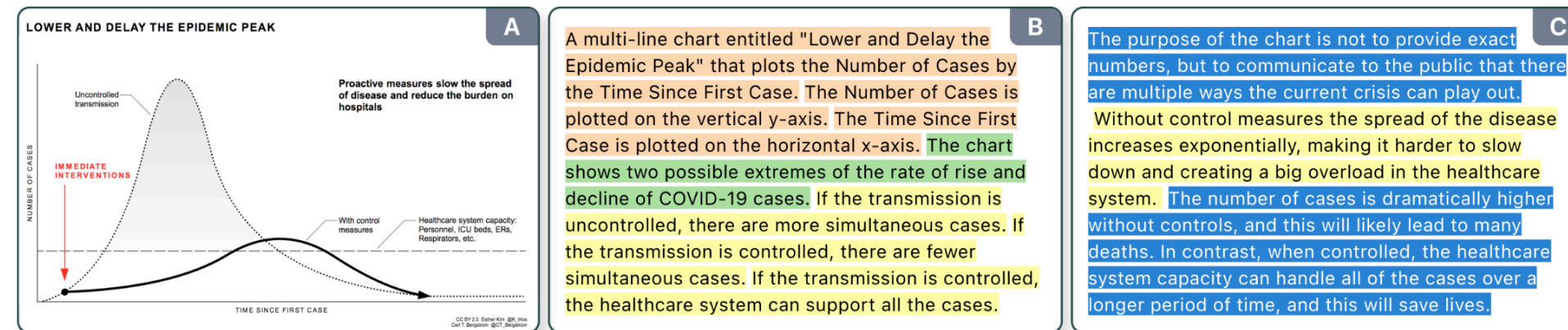


Problem 2: Centering research and development on screen readers (not blind people) limits what we can do

Accessible data *representation*

Accessible data *representation*

Descriptions



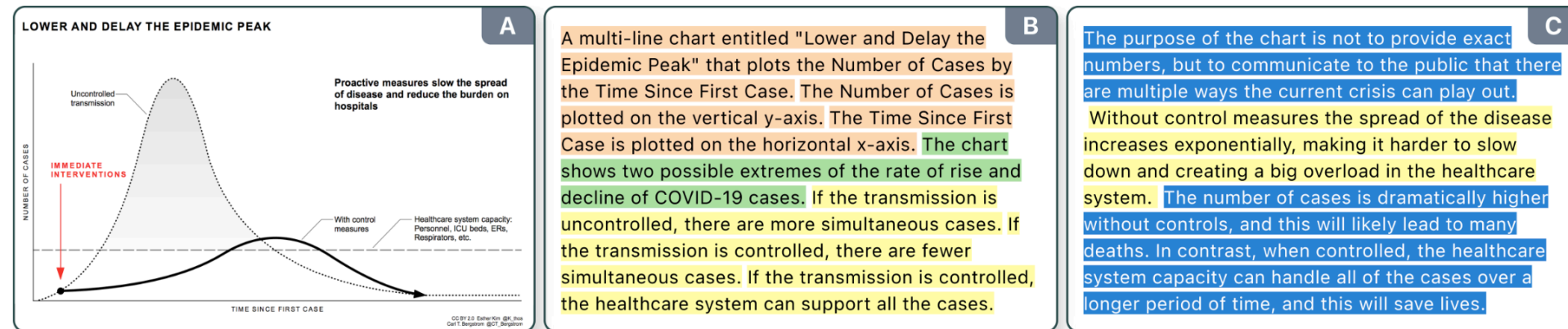
Long Description

Visualizations like "Flatten the Curve" (A) efficiently communicate critical public health information, while simultaneously excluding people with disabilities [11, 28]. To promote accessible visualization via natural language descriptions (B, C), we introduce a four-level model of semantic content. Our model categorizes and color codes sentences according to the semantic content they convey.

Image source

Accessible data *representation*

Descriptions

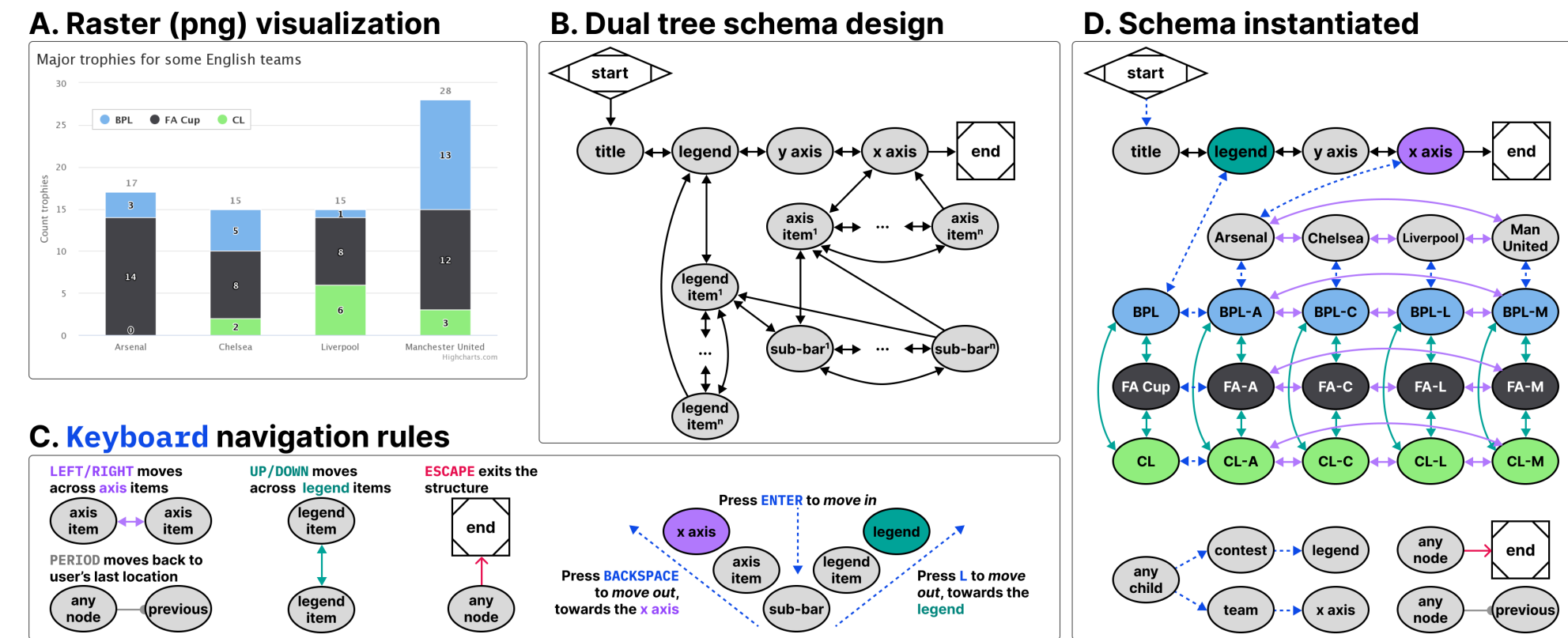


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[Image source](#)

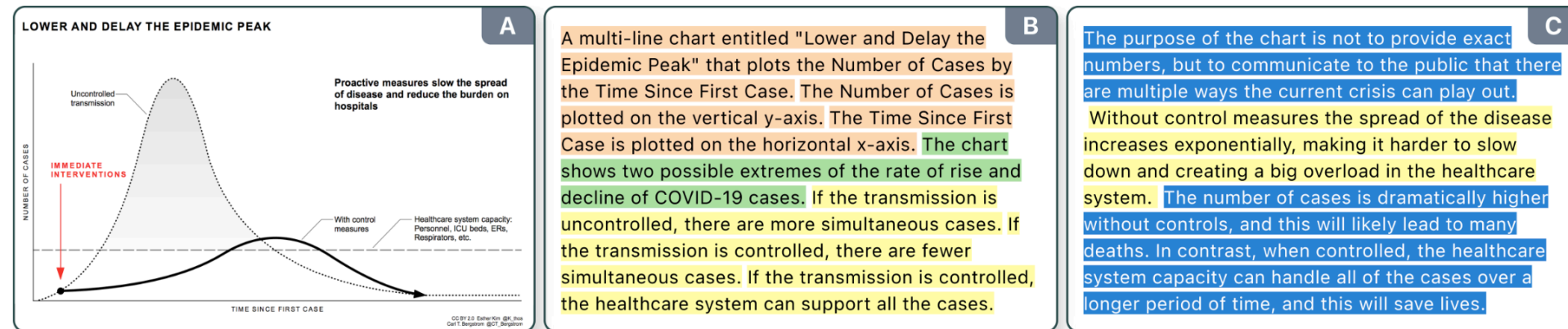
Structure



[Image source](#)

Accessible data representation

Descriptions

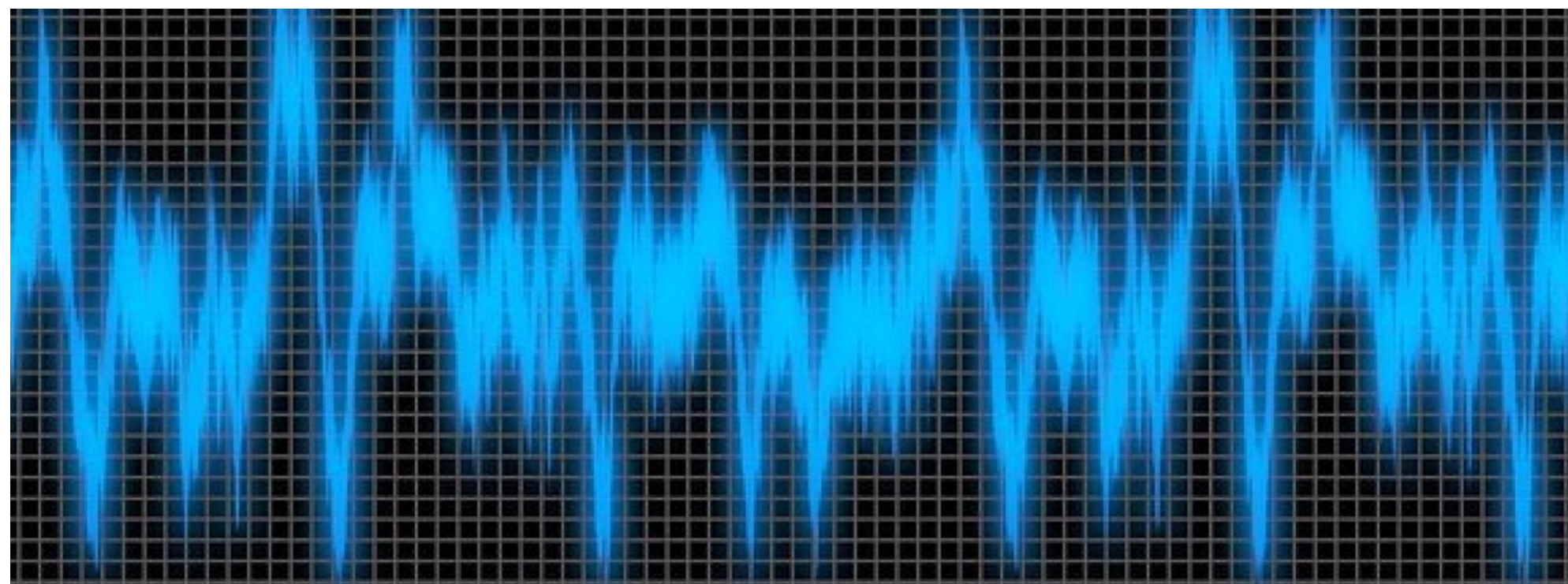


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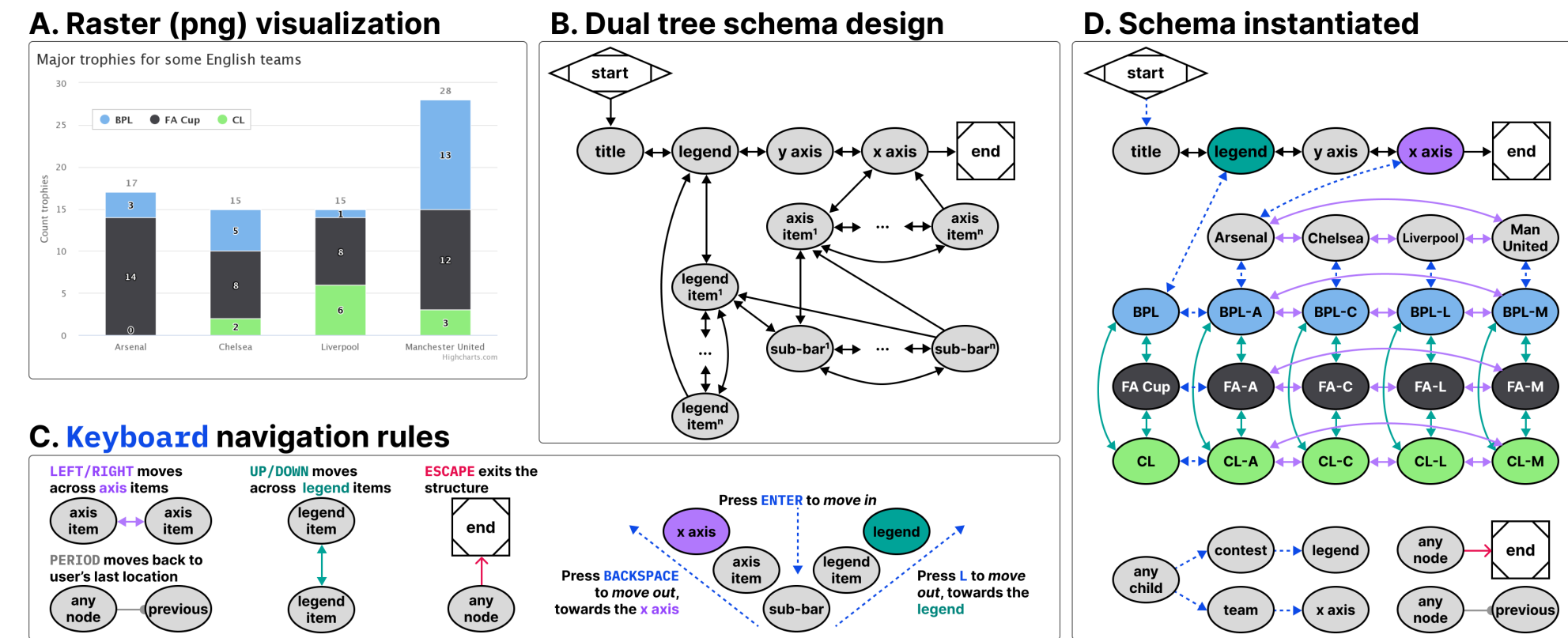
[Image source](#)

Sonifications



[Image source](#)

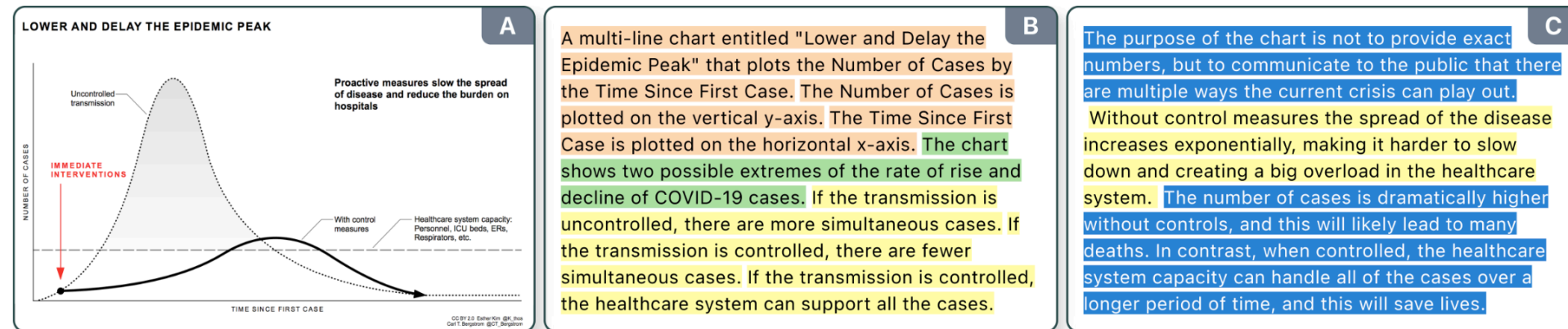
Structure



[Image source](#)

Accessible data representation

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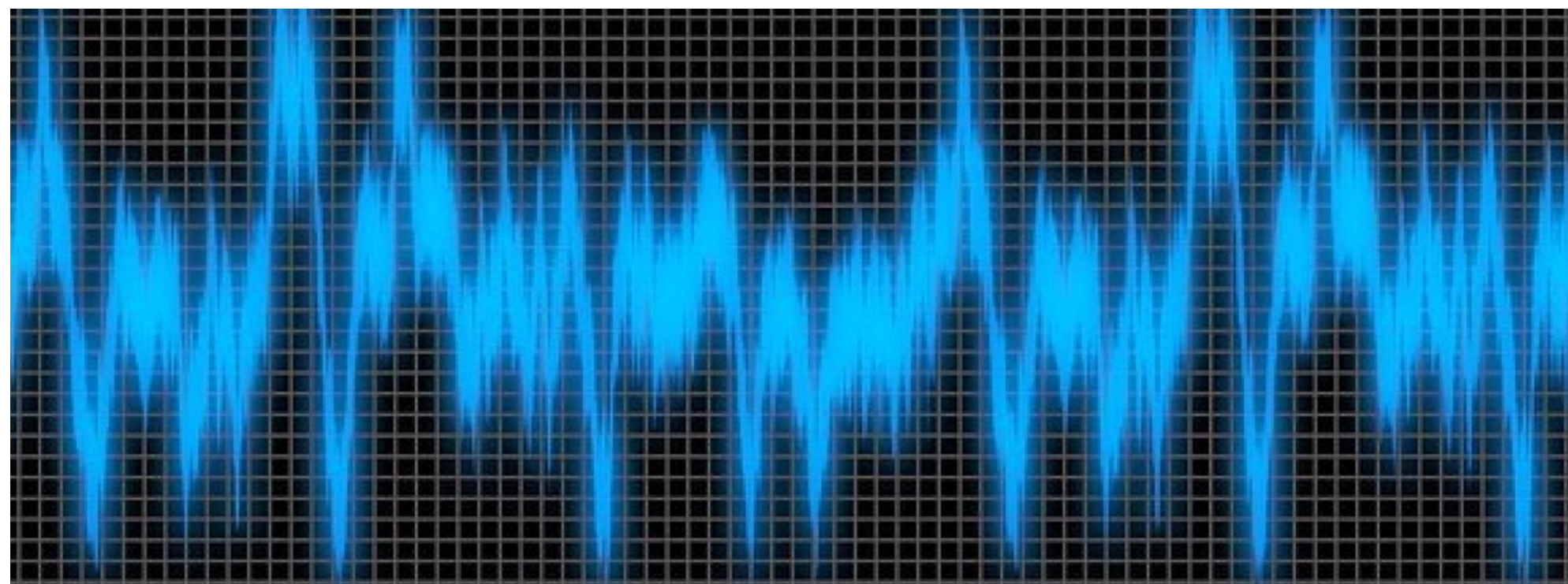


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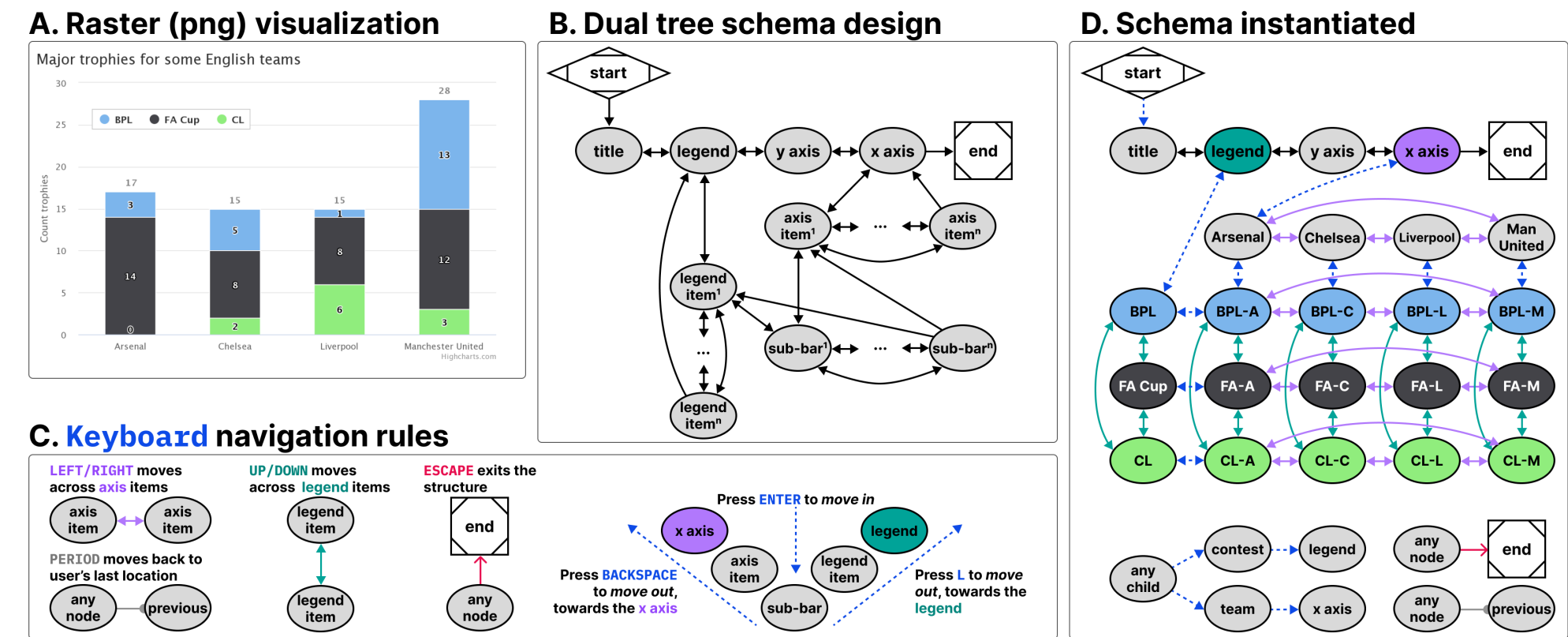
[Image source](#)

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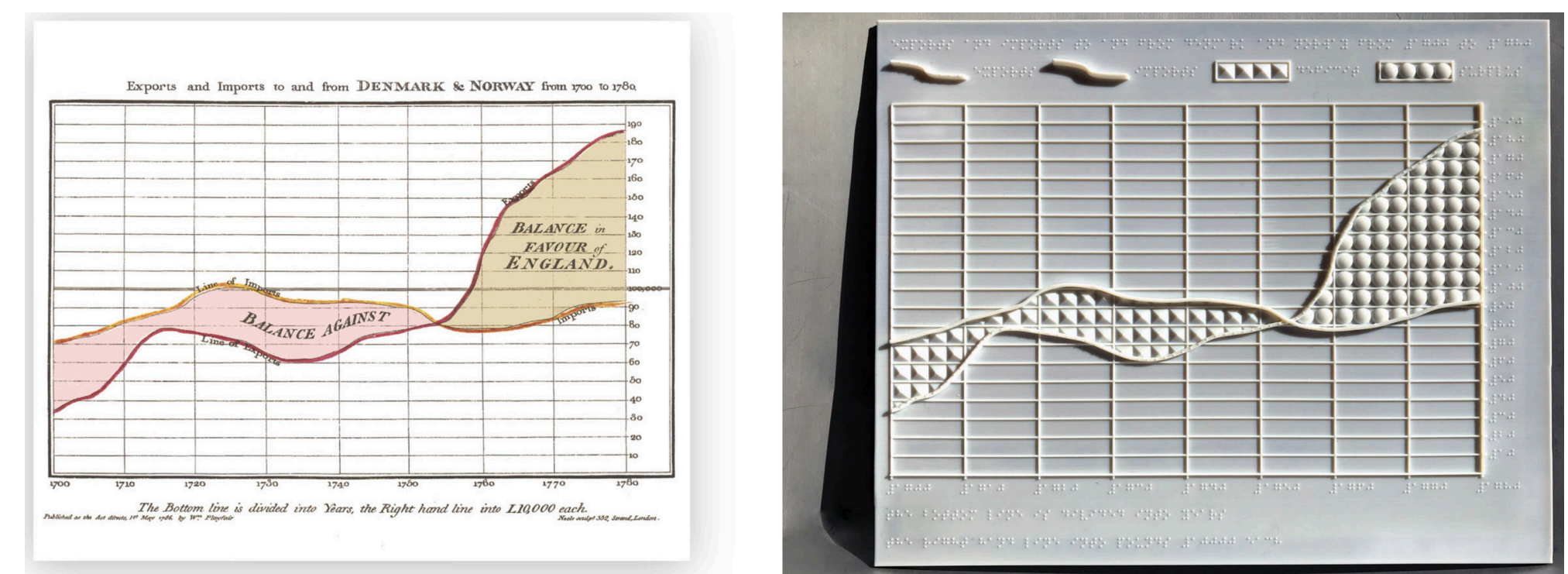
[Image source](#)

Structure



[Image source](#)

Tactiles



[Image source](#)

But what about *interactivity*?

Output has been our focus, primarily. But what about *input*?

But screen readers processes 1 input at a time

WIKIPEDIA The Free Encyclopedia

Search Wikipedia Search

Create account Log in

Cat

262 languages

Article Talk Read View source View history Tools

From Wikipedia, the free encyclopedia

This article is about the species commonly kept as a pet. For the cat family, see [Felidae](#). For other uses, see [Cat \(disambiguation\)](#) and [Cats \(disambiguation\)](#).

The **cat** (*Felis catus*) is the only domesticated species in the family Felidae. It is commonly kept as a house pet and farm cat, but also as a companion animal and a pest control agent. The cat is valued by humans for its adaptability to killing small prey like mice and its night vision and sense of smell are well developed. It is a social species, but a solitary hunter and a crepuscular predator. Cat communication includes vocalizations like meowing, purring, trilling, hissing, growling, and grunting as well as cat body language. It can hear sounds too faint or too high in frequency for human ears, such as those made by small mammals. It also secretes and perceives pheromones.

Female domestic cats can have kittens from spring to late autumn in temperate zones and throughout the year in equatorial regions, with litter sizes often ranging from two to five kittens. Domestic cats are bred and shown at events as registered pedigreed cats, a hobby known as cat fancy. Animal population control of cats may be achieved by spaying and neutering, but their proliferation and the abandonment of cats has resulted in large numbers of feral cats worldwide, contributing to the extinction of bird and mammal species.

67 Nav points, ~32s

Cat
Temporal range: 9,500 years ago – present

Movement between tasks becomes cognitively expensive

The image shows a screenshot of the Wikipedia article for "Cat". Red lines and circles highlight various navigation elements: the search bar, the article title, the language selection menu, the article text, and the table of contents on the left. A large red arrow points from the search bar to the article title, and another points from the language menu to the article title. A red circle highlights the word "Felidae" in the disambiguation text. A large red arrow points from the table of contents to the article text.

67 Nav points, ~32s

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Cat
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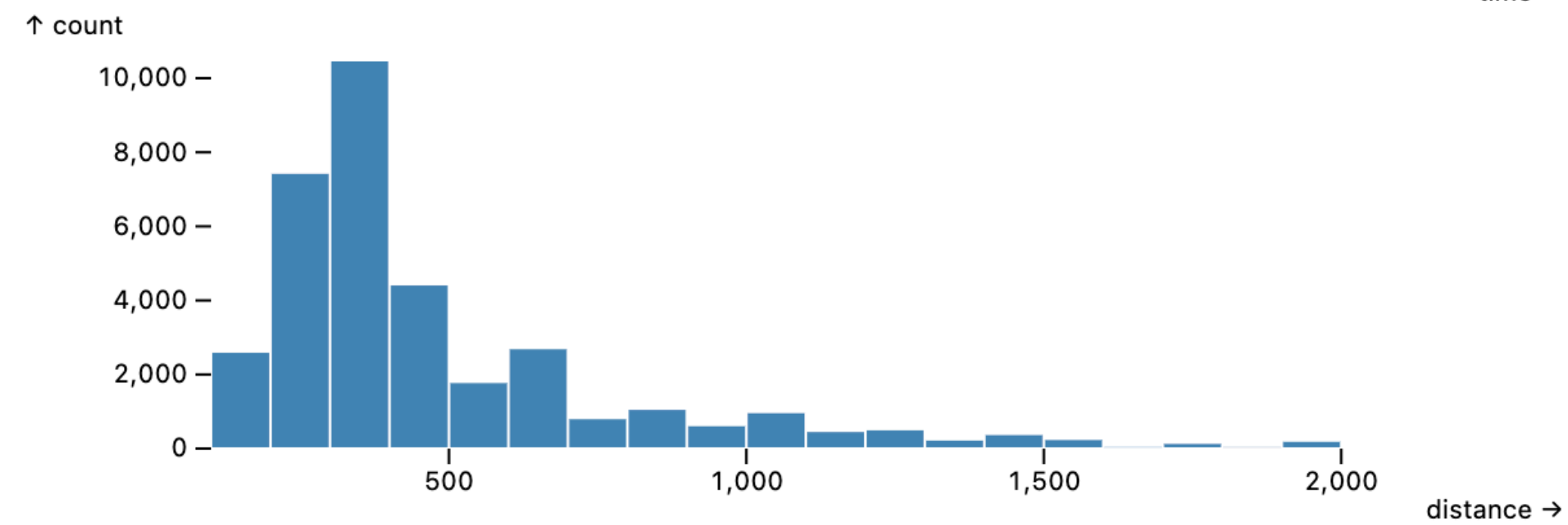
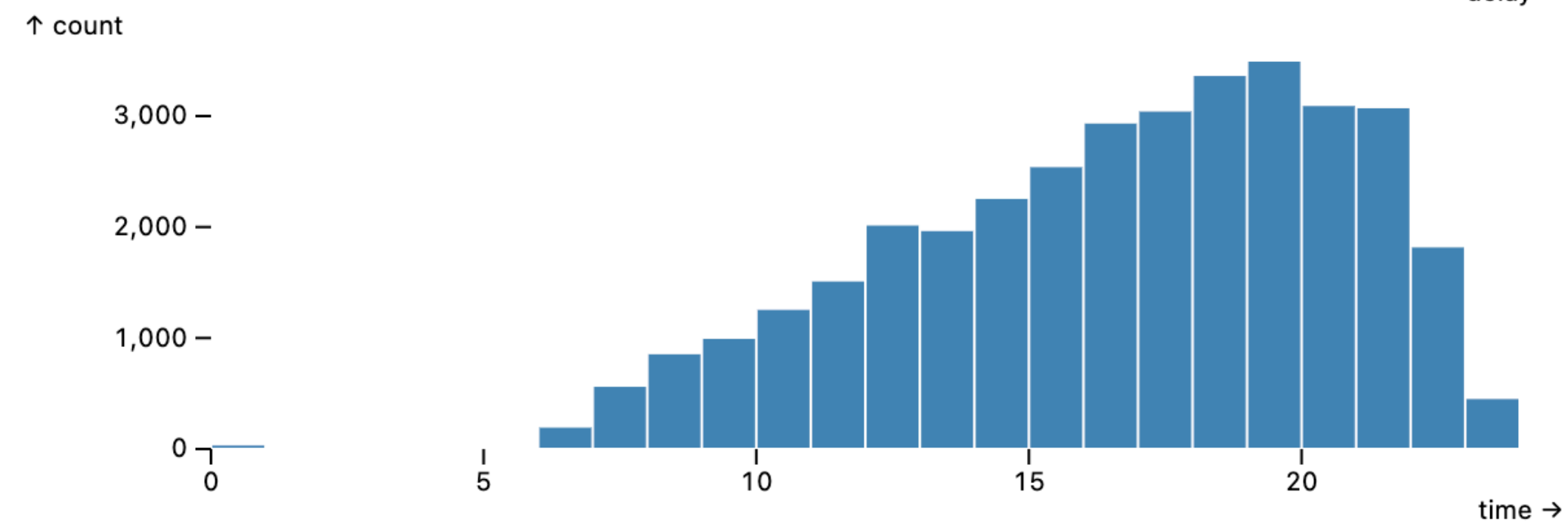
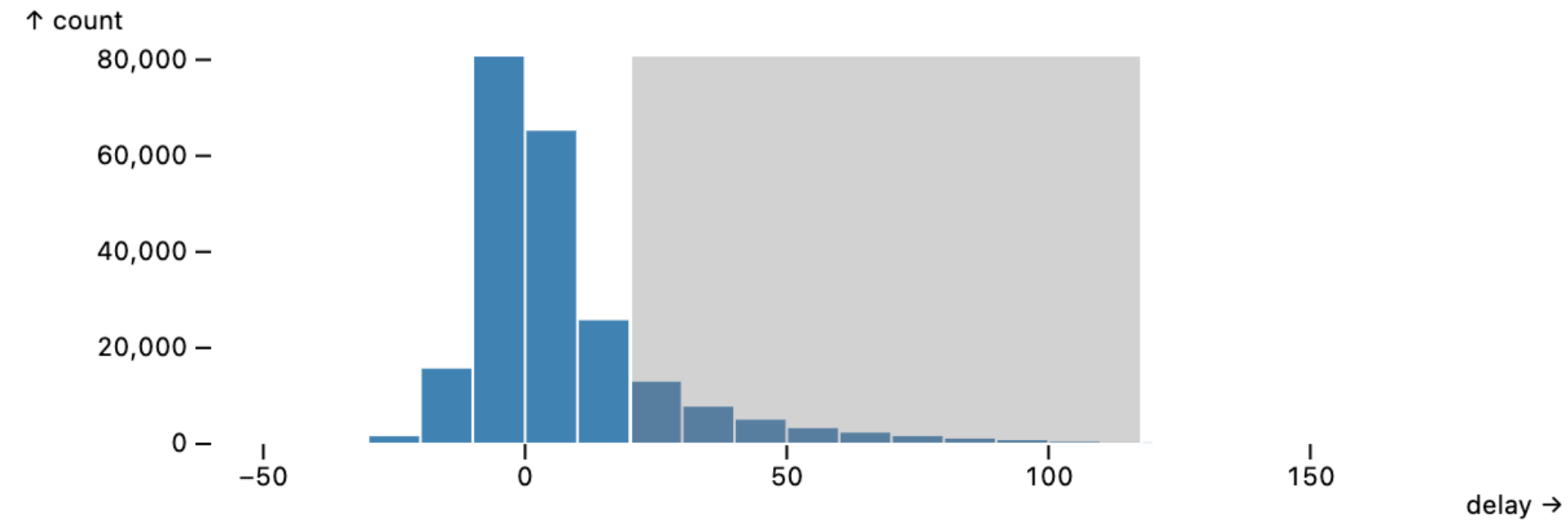
Auditory processing struggles with *dual-task* paradigms*

*Citation

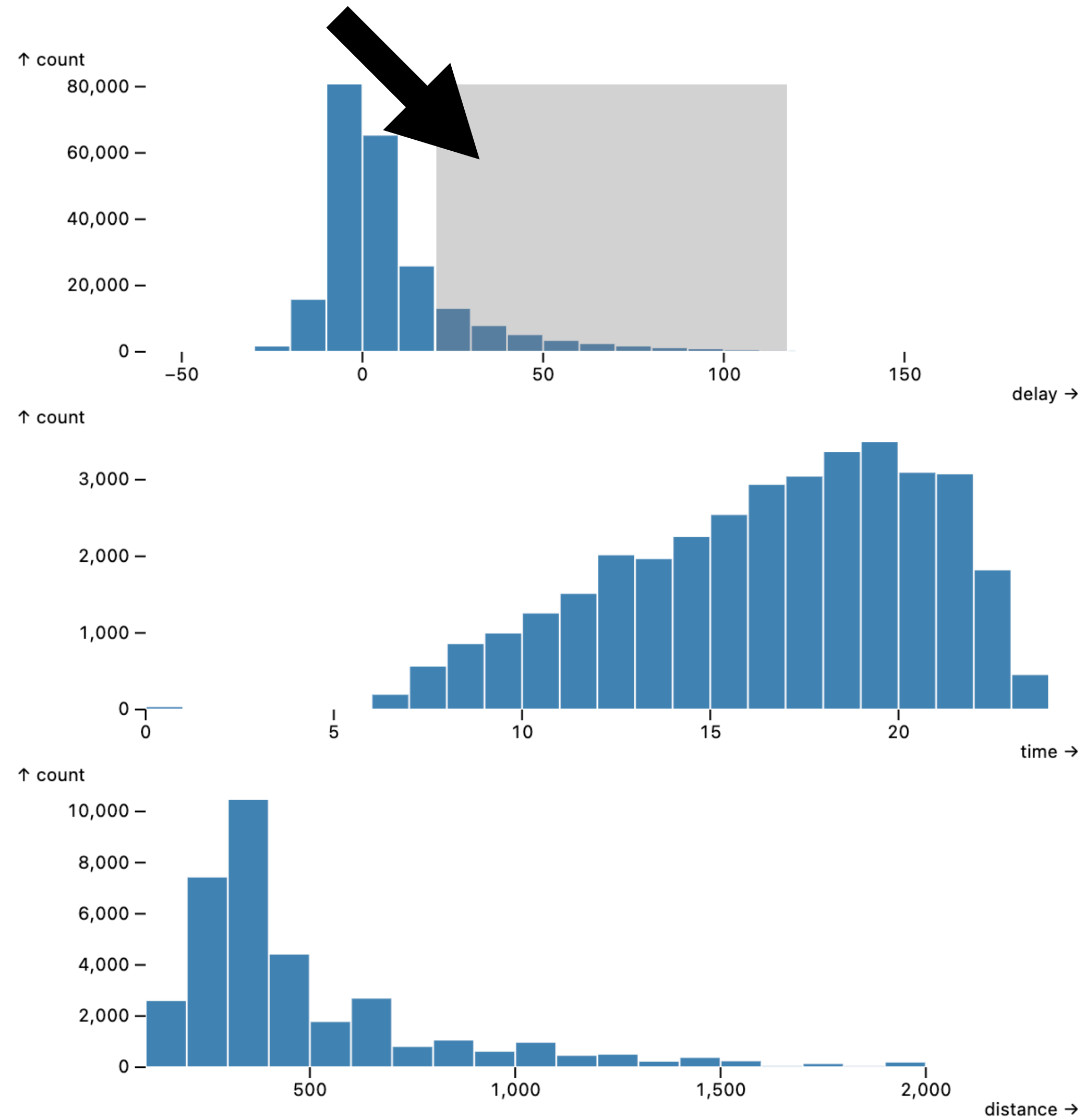
So what about cross-filtering?

[Interactive link](#)

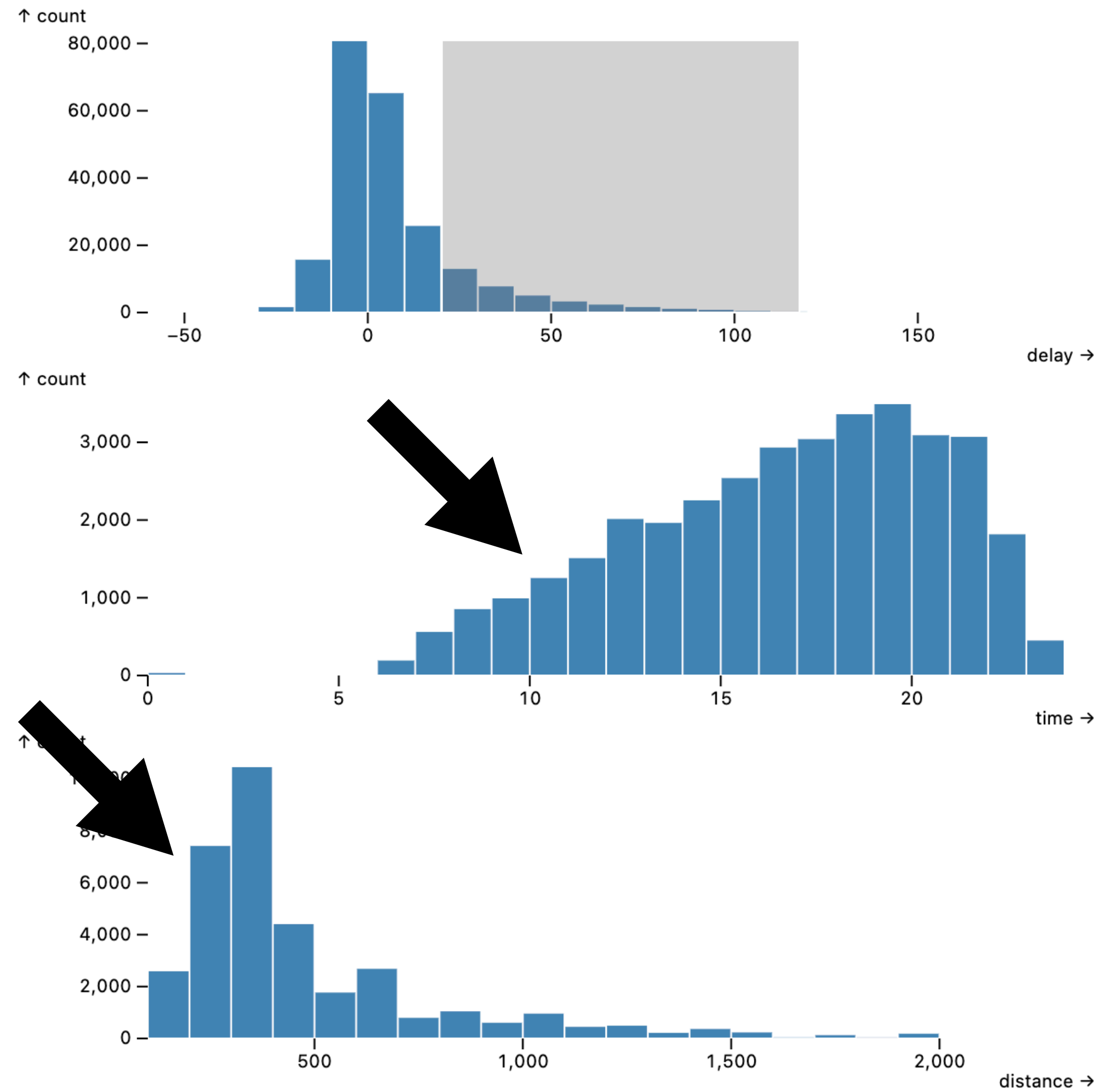
So what about cross-filtering?



Interaction in one space...



Produces simultaneous, coordinated change in another.



For blind users, descriptions, structural navigation, and sonifications will likely *not* solve this challenge.

Preliminary research question:

How do blind people interact with *multiple* tactile media simultaneously?

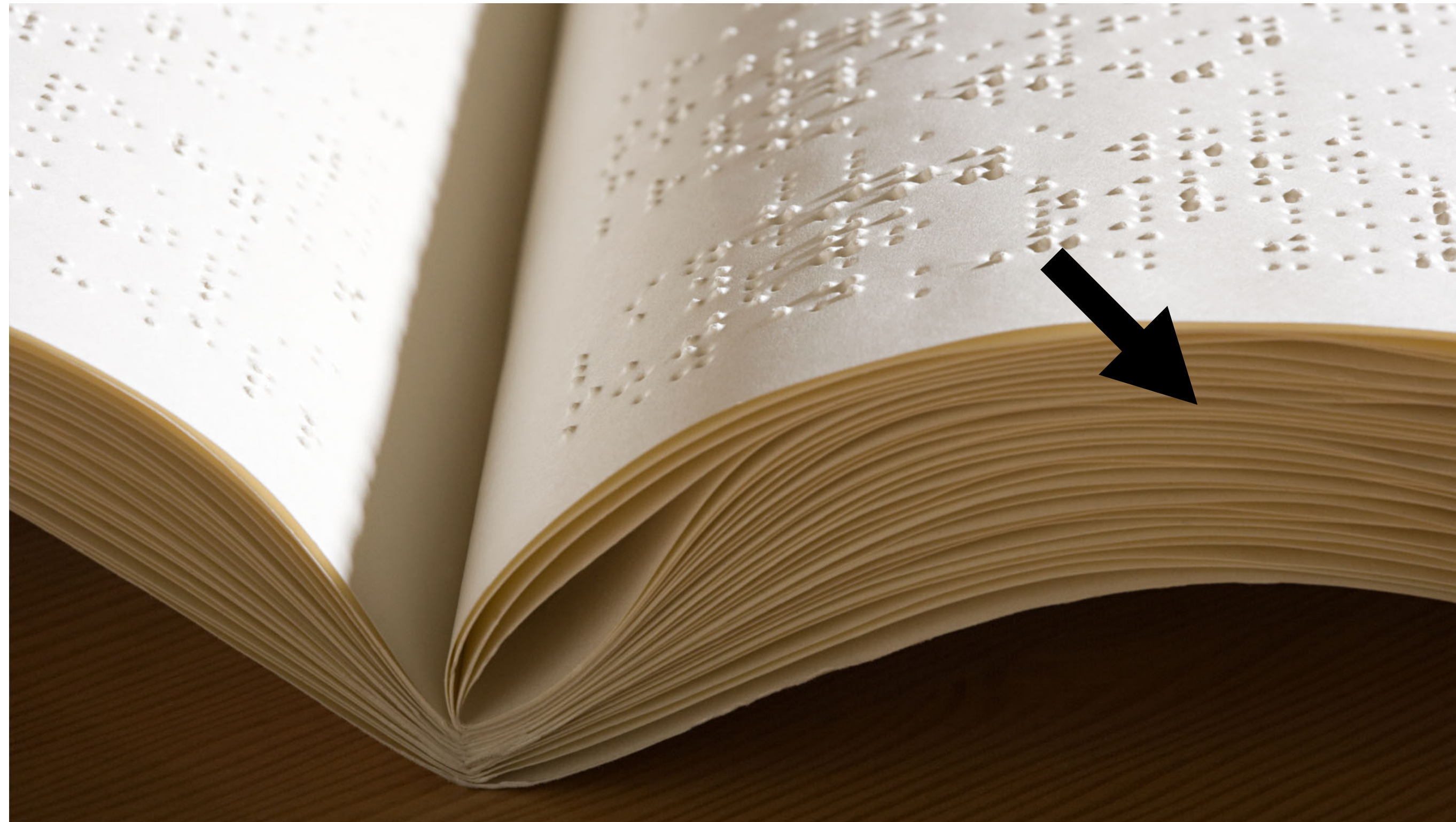
Observing: Embossed braille in a research context



[Image source](#)

Observation 1: Spatial memory storage

My friend didn't remember the details of a math equation exactly, but he knew *where* that equation was located in his stack of braille pages and *where* on the page the equation was.



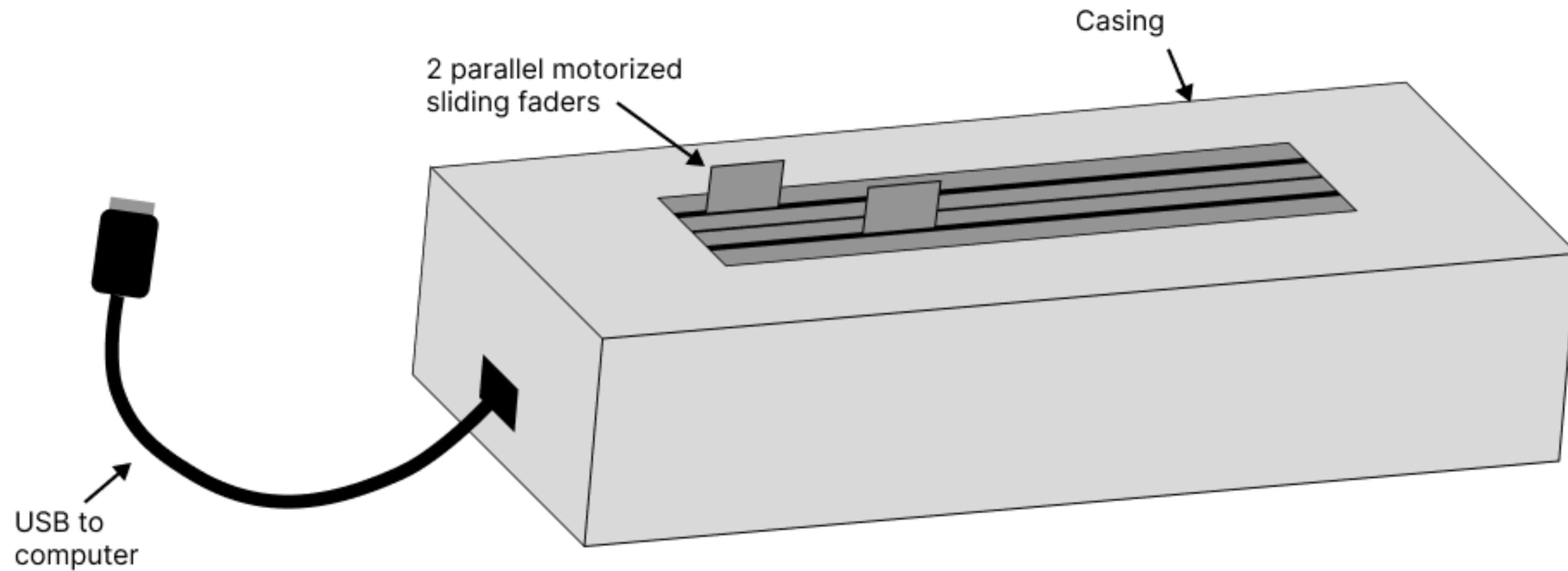
[Image source](#)

Observation 2: Coordinating perception and comparison

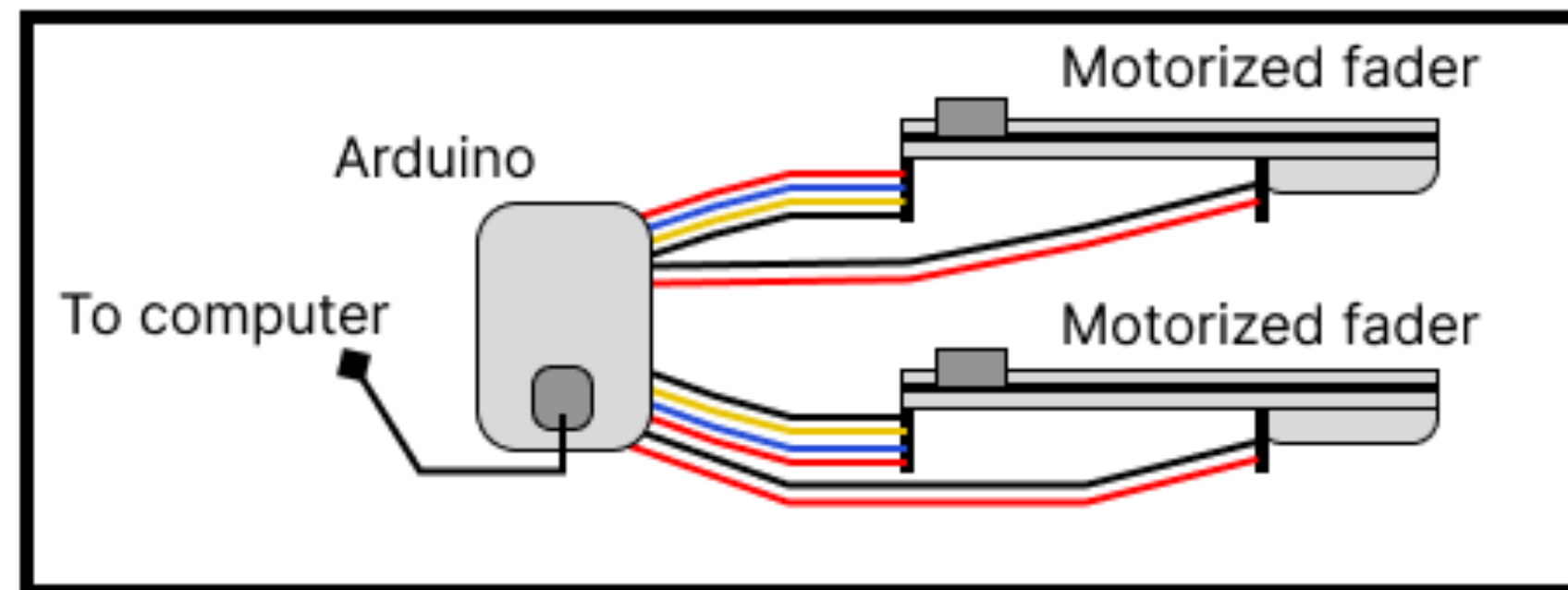
He then compared 2 equations at once. The details of each weren't important. He was *feeling* for differences simultaneously.



Prototype 2: the *cross-feeler*, 2 motorized faders



Schematic

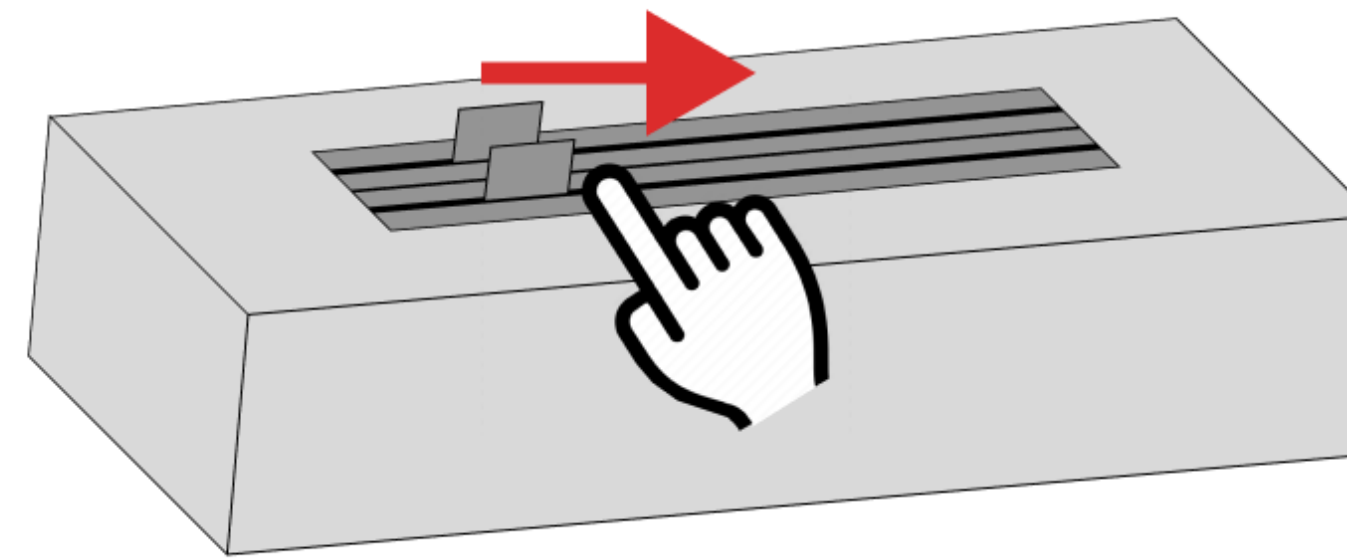


One slider can work with video

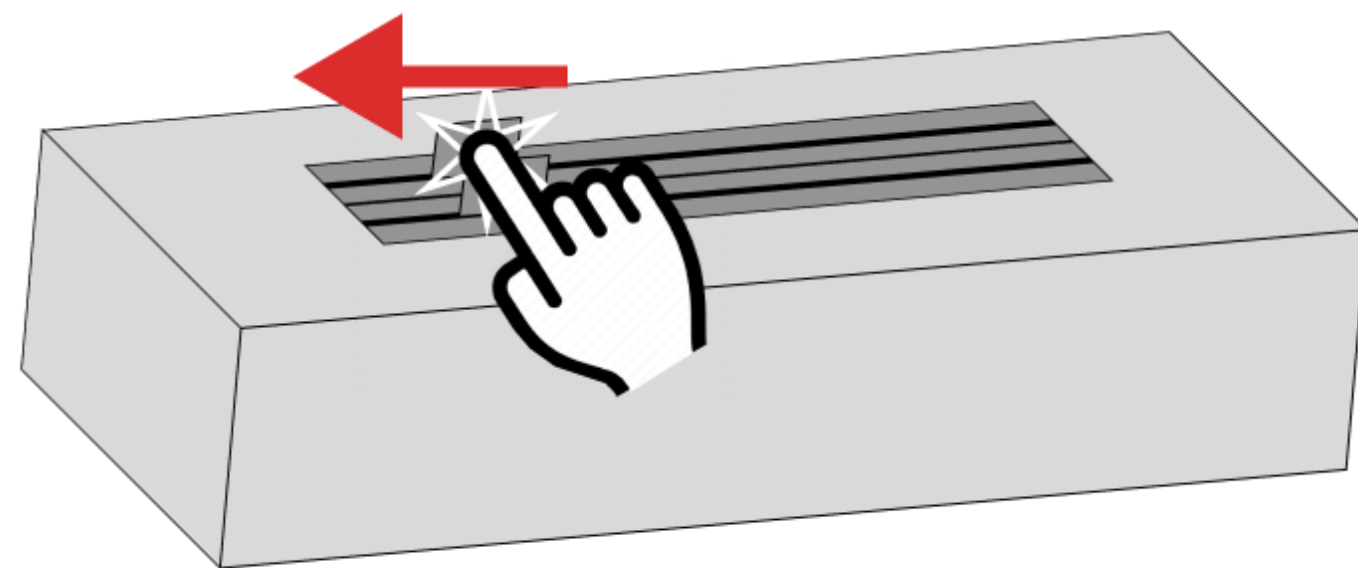
1. Video plays with progress slider moving



2. Slider follows, can be felt



3. User can move slider

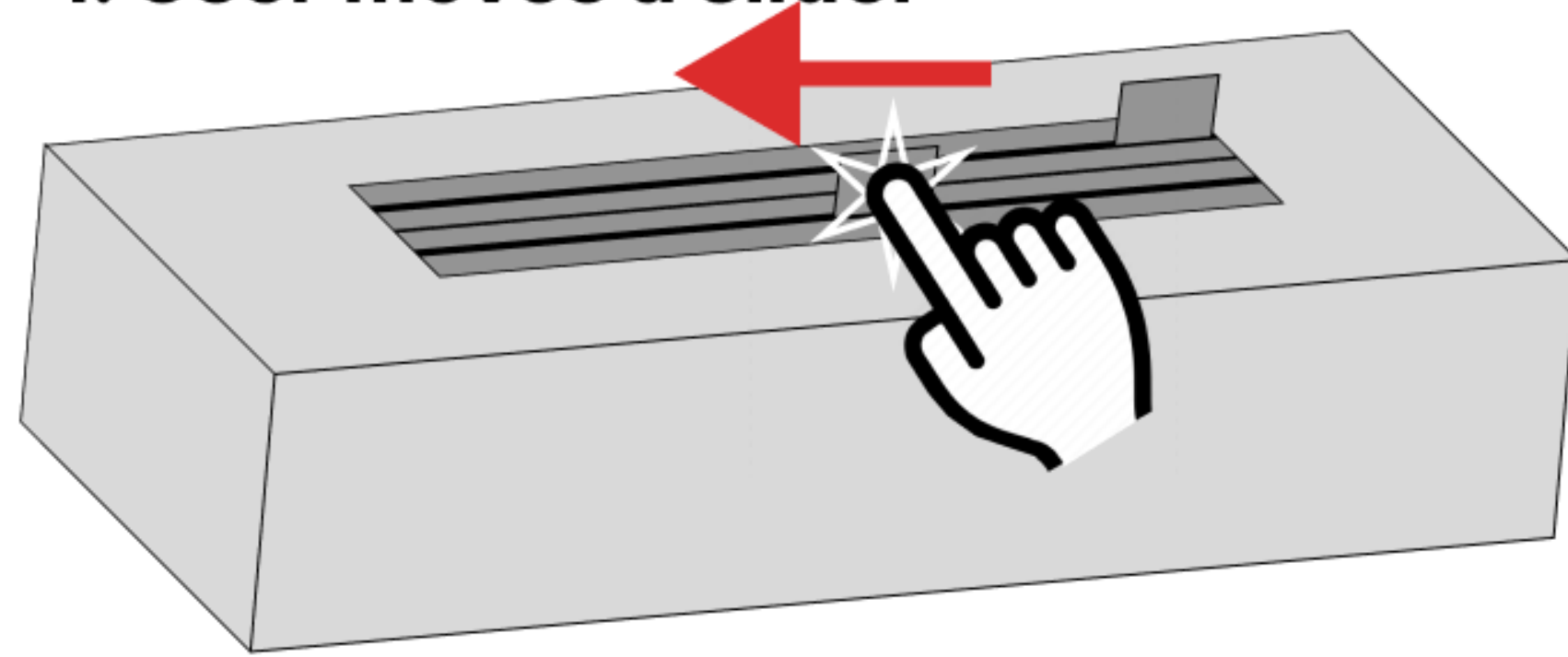


4. Video slider will move with slider change

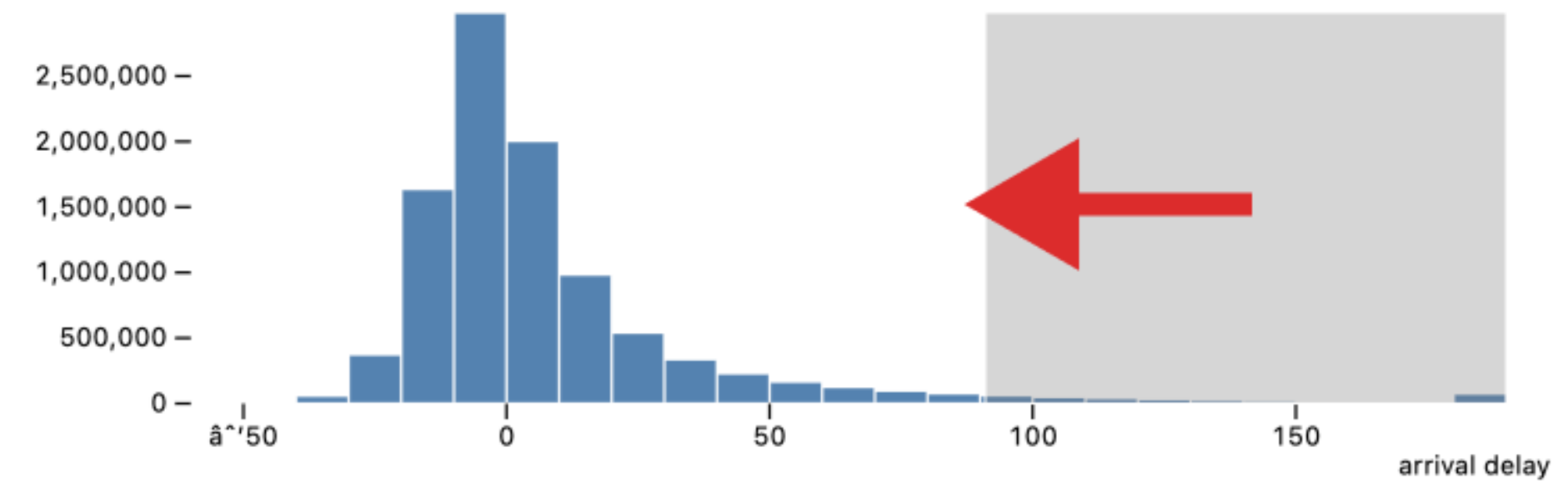


While 2 sliders works for cross-filtering

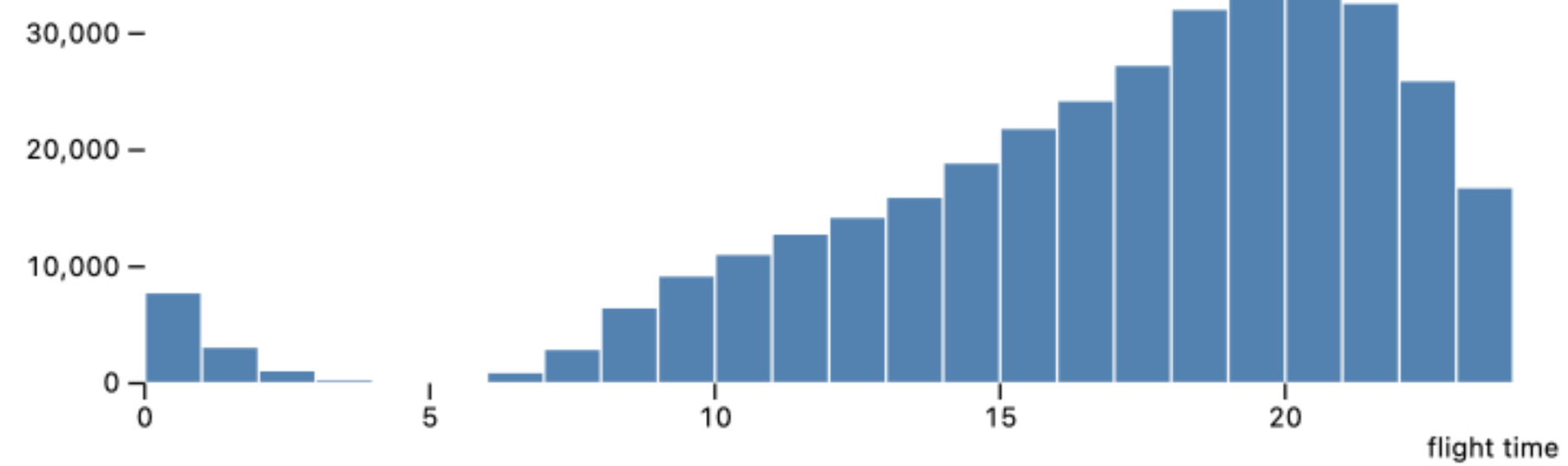
1. User moves a slider



2. Corresponding filter edge moves with

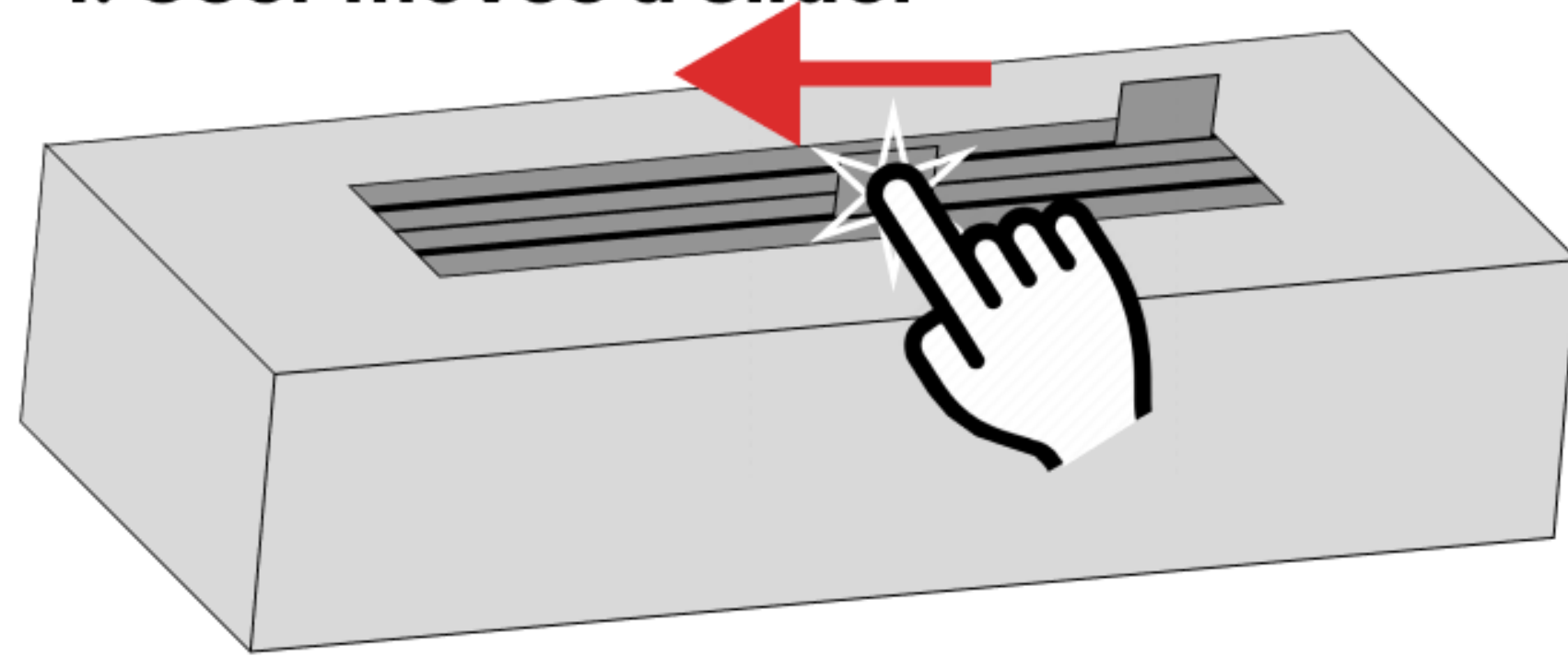


3. Secondary visualization updates

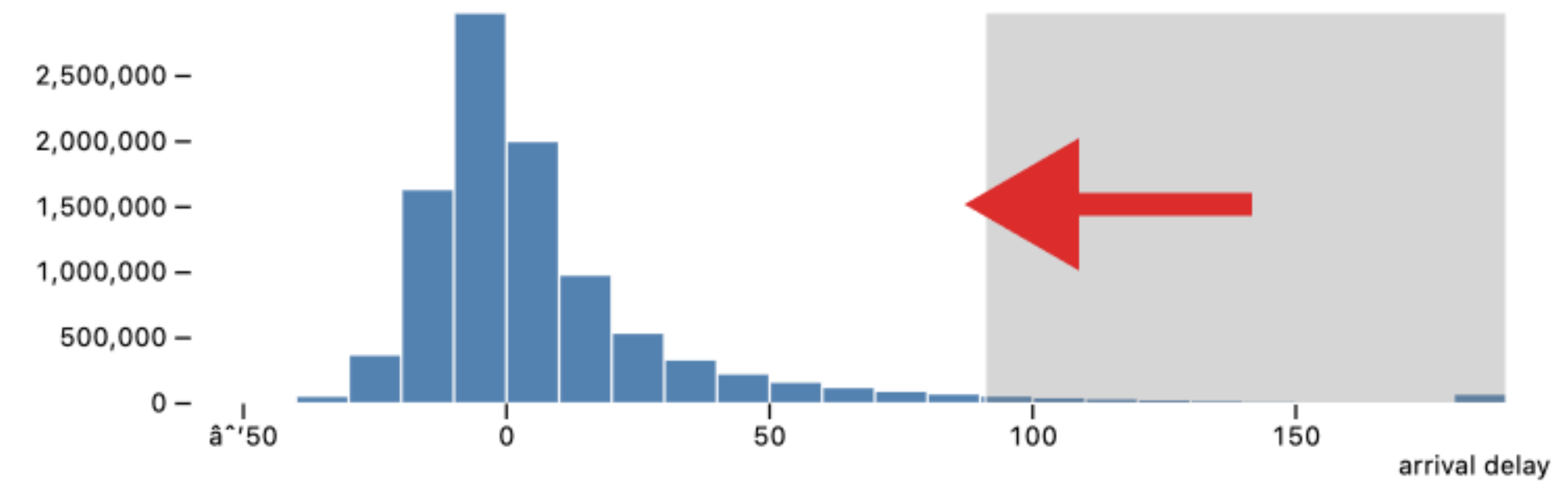


A tactile display can render the input or output chart

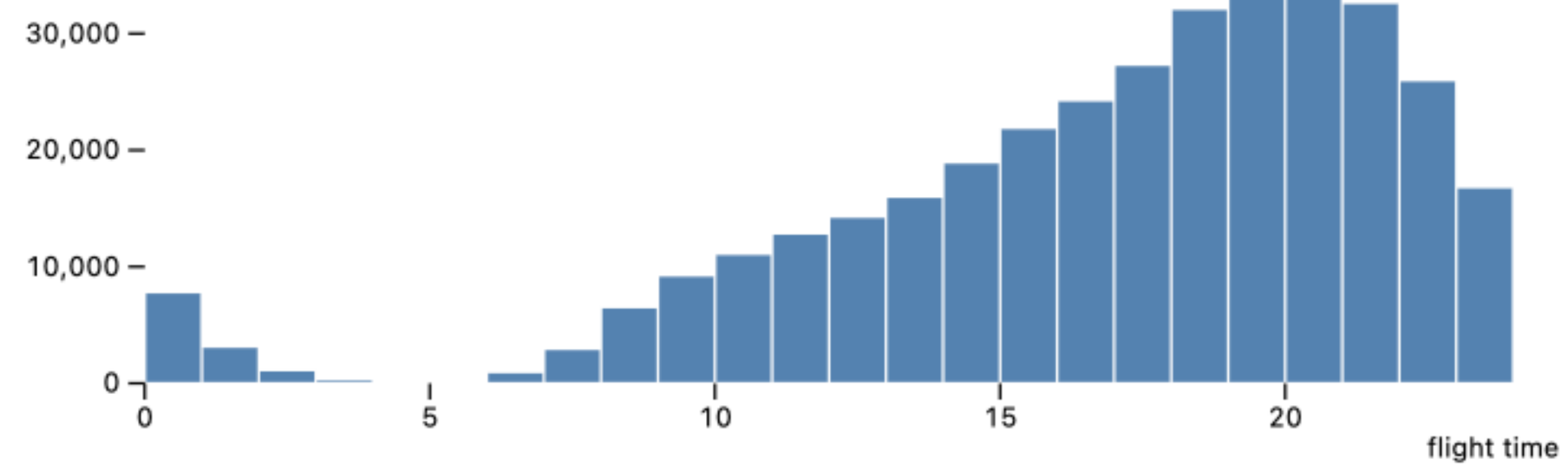
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2. Corresponding filter edge moves with



3. Secondary visualization updates

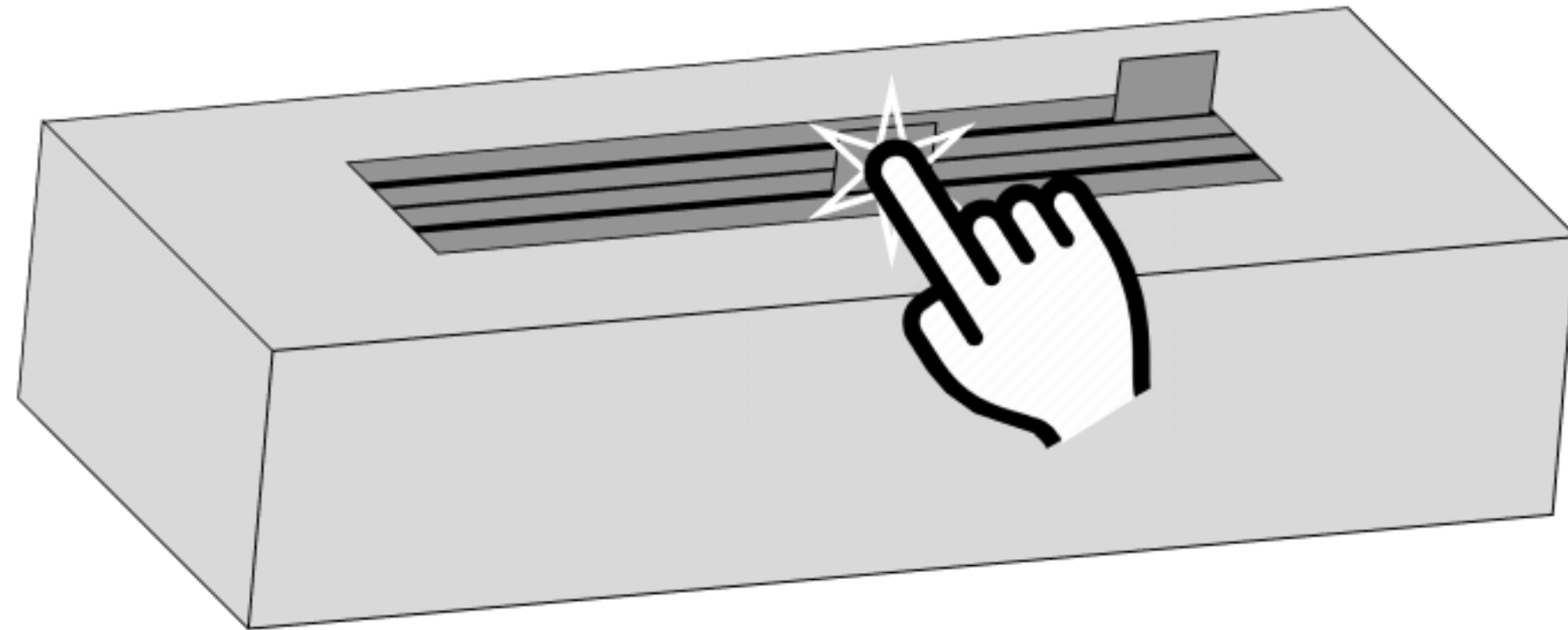


4. Tactile display renders



Cross-coordination! A tactile, dual-task paradigm.

User can interact with a space separate from their current focus!

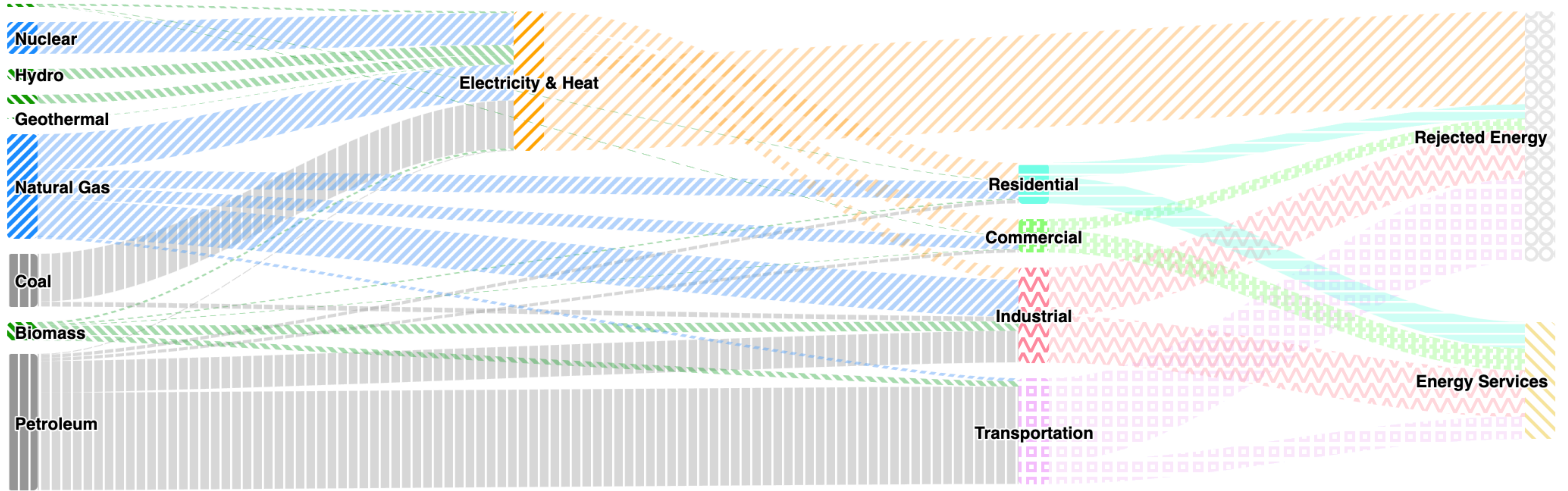


Problem 3: Access Friction is when accessibility for someone produces a barrier for others

What about this is accessible? Why?

Estimated US Energy Consumption in 2017

Source: Lawrence Livermore National Laboratory



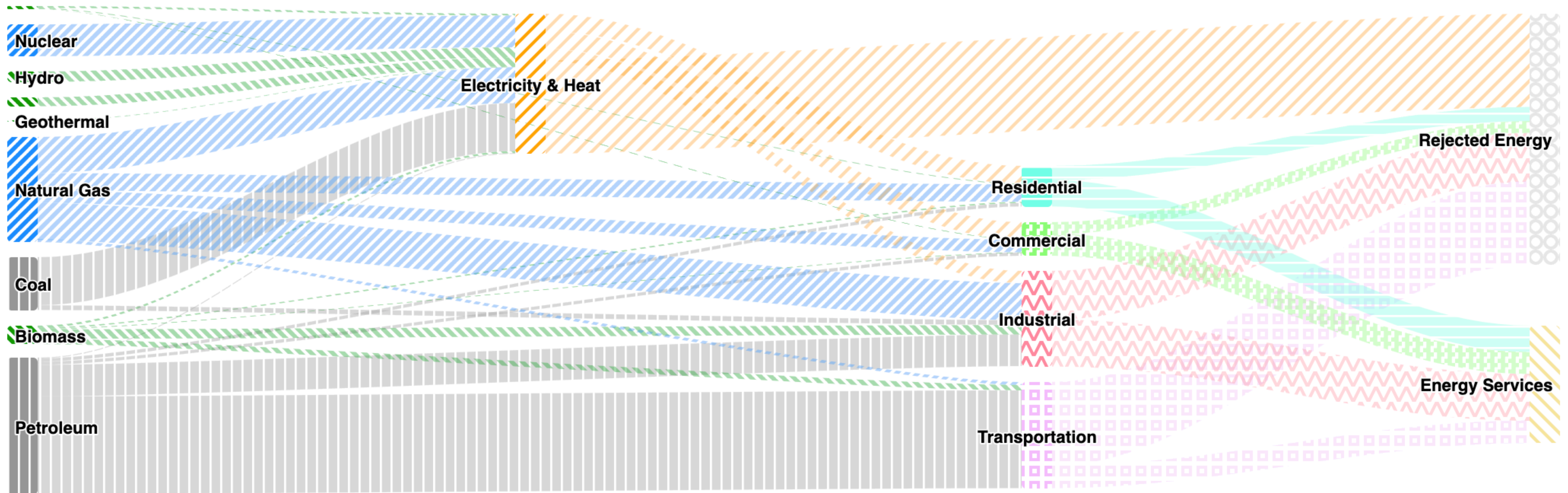
Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

What about this might be a barrier? Why?

Estimated US Energy Consumption in 2017

Source: Lawrence Livermore National Laboratory



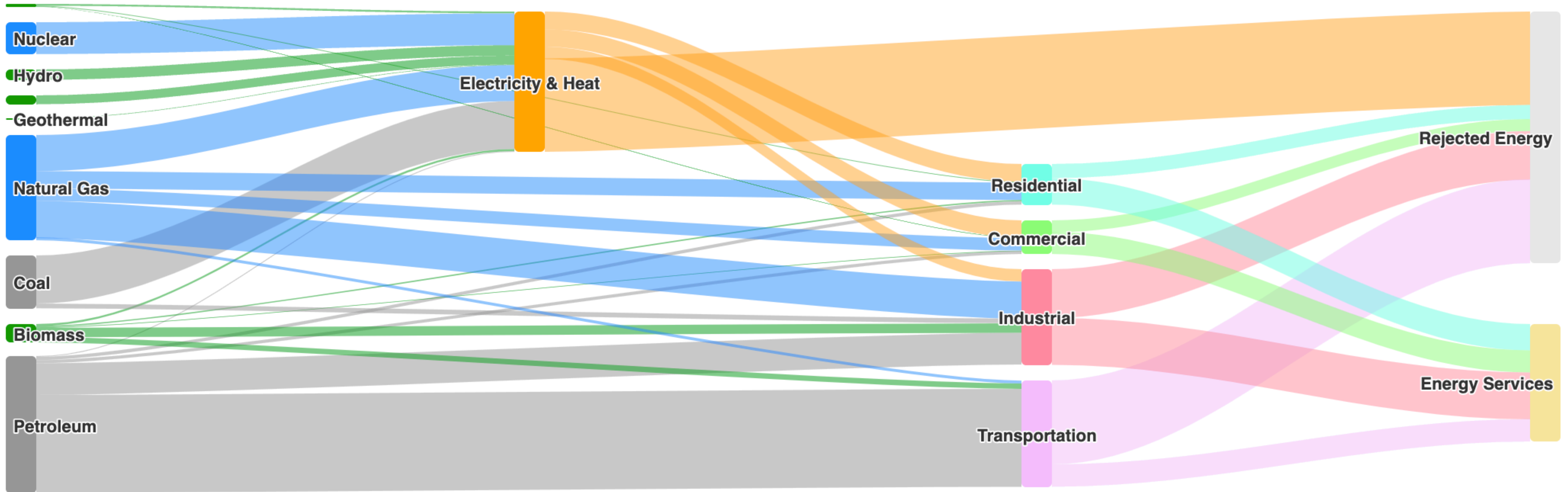
Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

What about this now might be a barrier?

Estimated US Energy Consumption in 2017

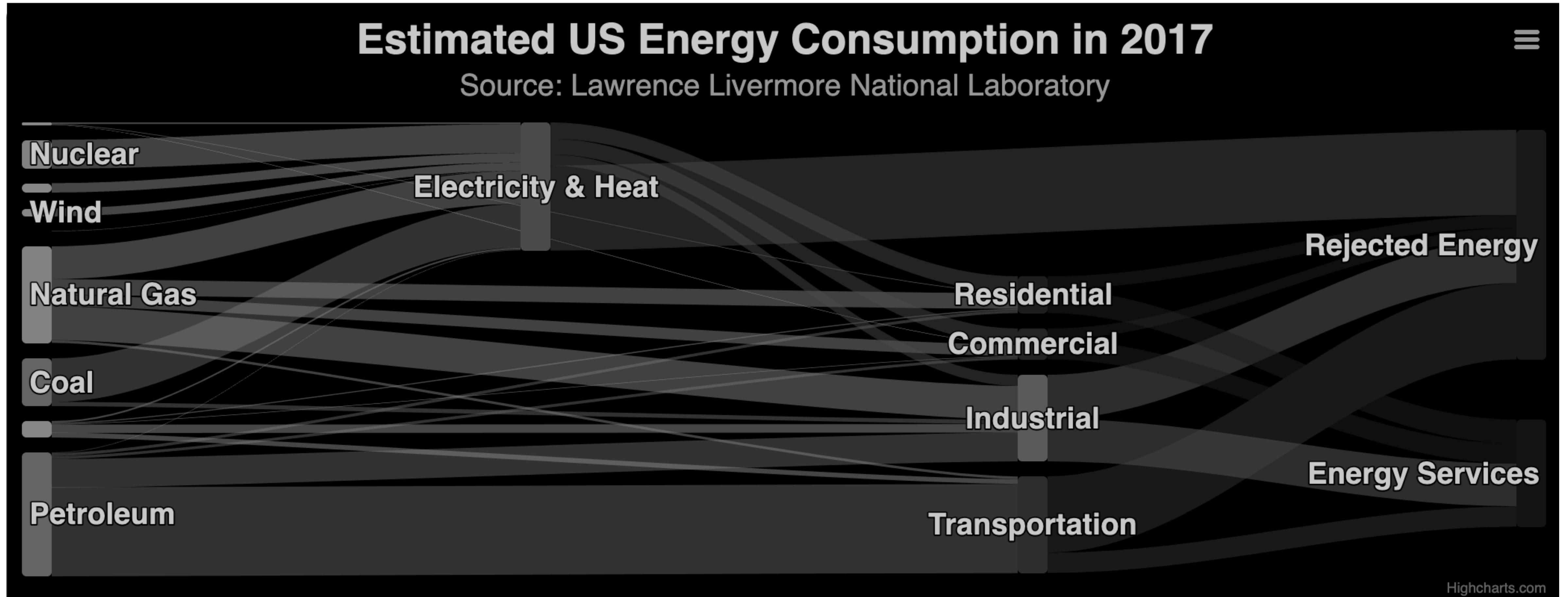
Source: Lawrence Livermore National Laboratory



Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

So some folks use tools to hack what they want



Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

What if we *let* users hack the design?

Preferences

Hide unavailable options

▼ **Comprehension**

default moderate robust

Alt text appearance

default show high level show all

► **Description verbosity**

default disable minimal verbose

▼ **Text**

default minimalist moderate maximalist

▼ **Font Size**

default small medium large

Title

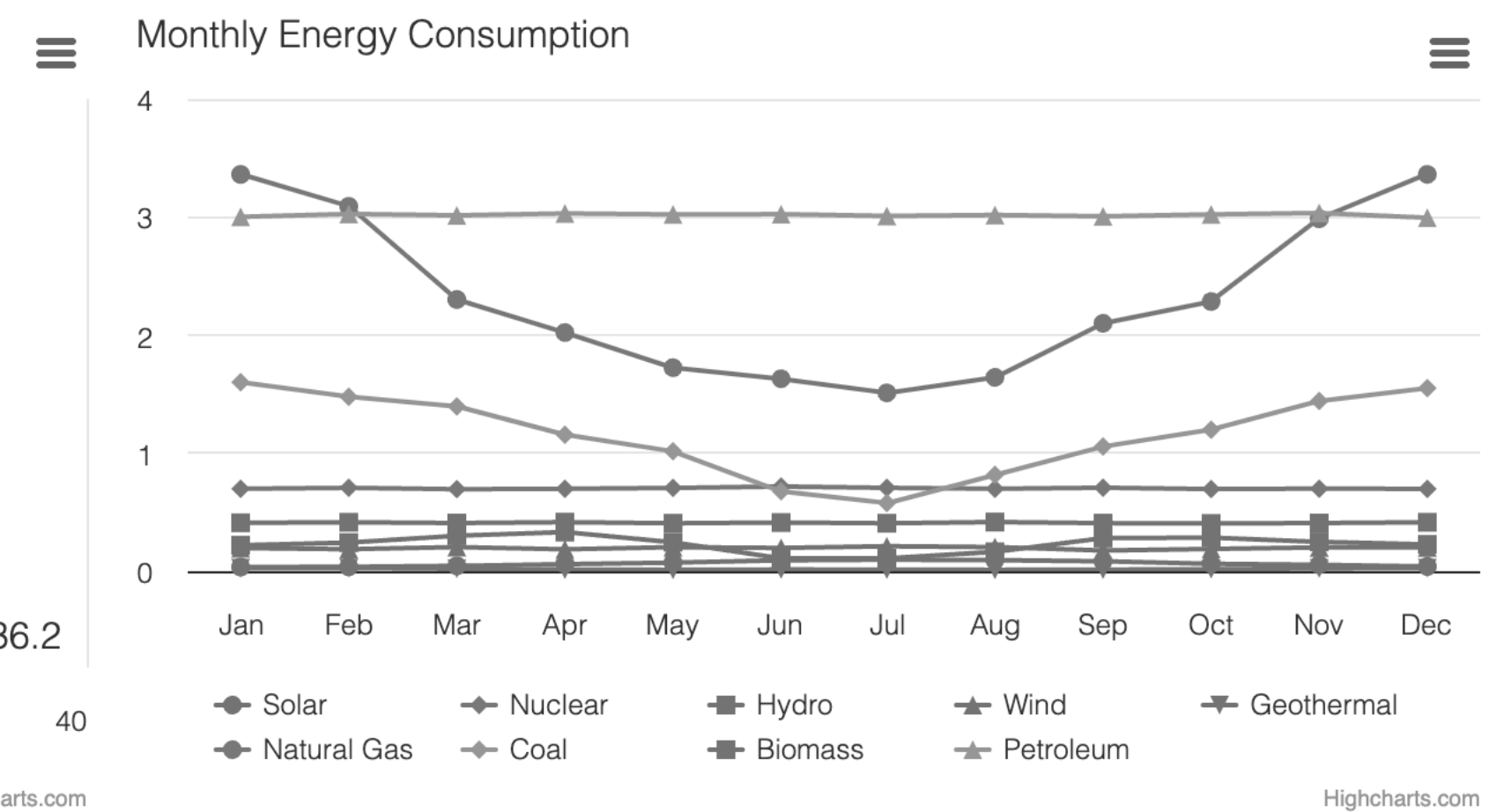
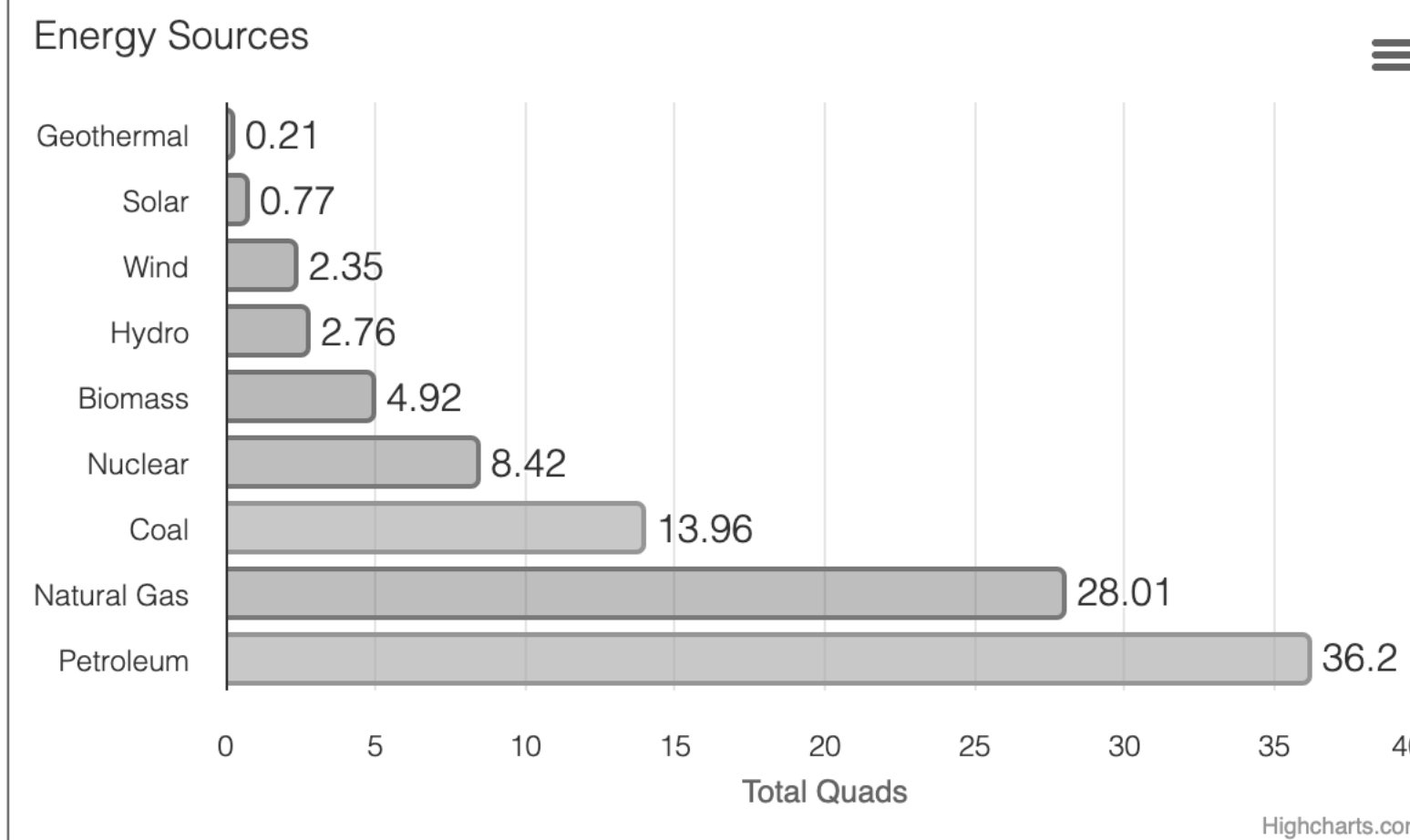
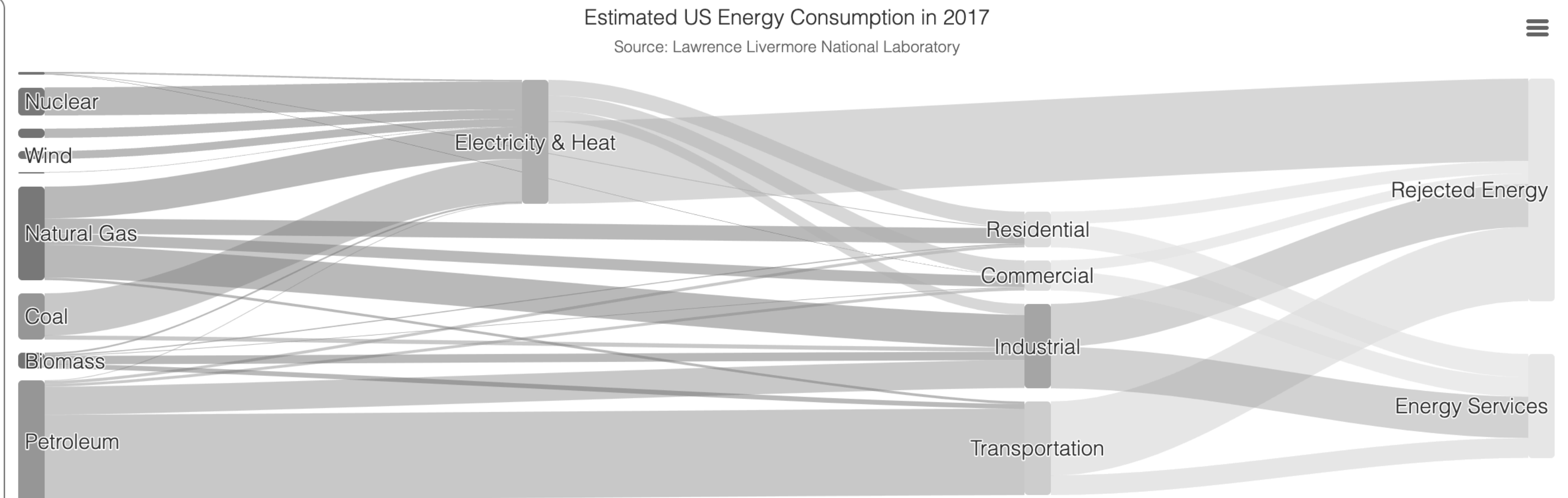
default small small+ medium medium+ large

Subtitle

default small small+ medium medium+ large

Series Labels

default small small+ medium medium+ large



[Interactive demo link](#)

2024

★ Slides here → frank.computer

Looking to the future of accessible data interfaces



Frank Elavsky, PhD Student



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