2024

frank.computer

Looking to the future of accessible data interfaces

HIGHSOFT

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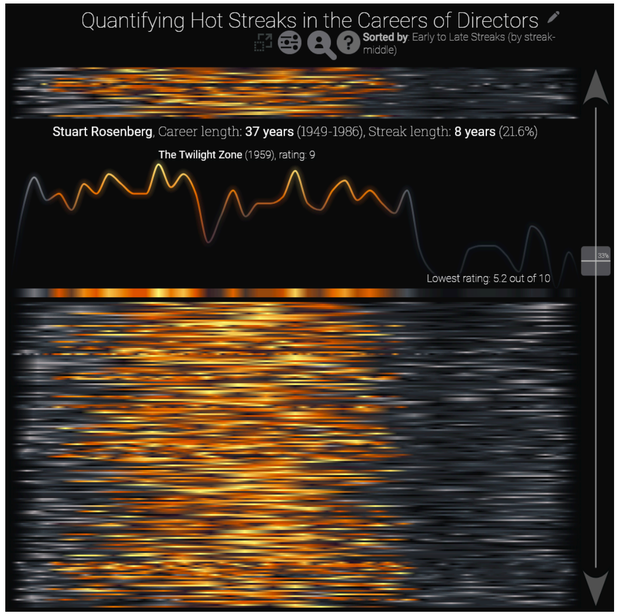
Human-Computer Interaction Institute

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

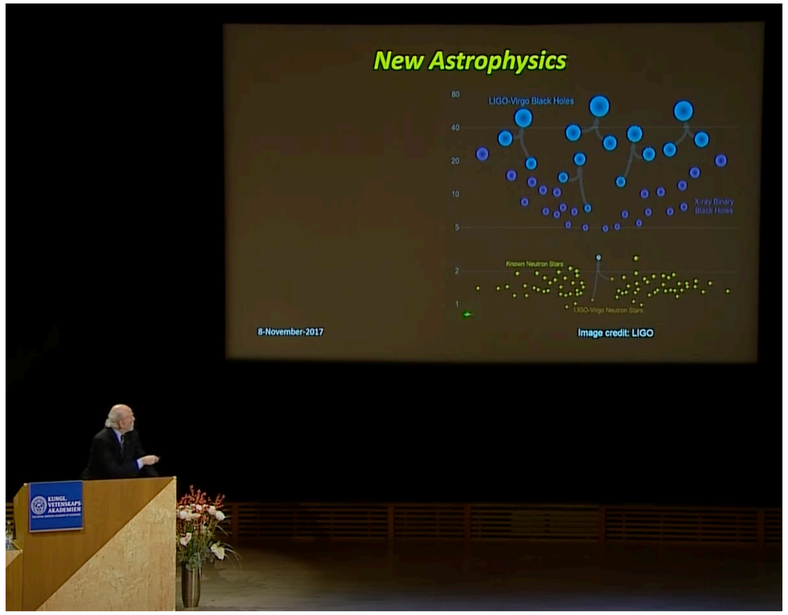
My pre-phd work in visualization

Industry and research engineering

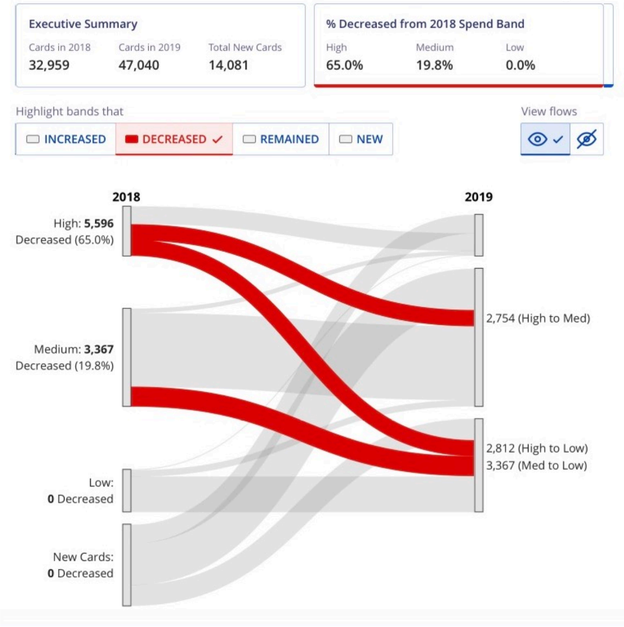
Dense model visualizations



Domain-specific visualizations



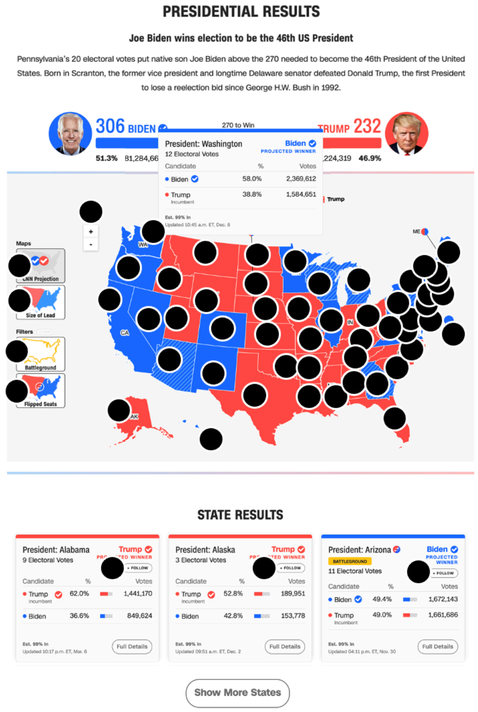
Data visualization library



What and how of visualization accessibility

(My recent research)

Chartability:
What are accessibility barriers?

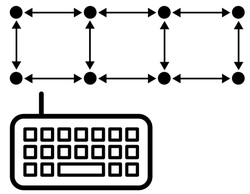


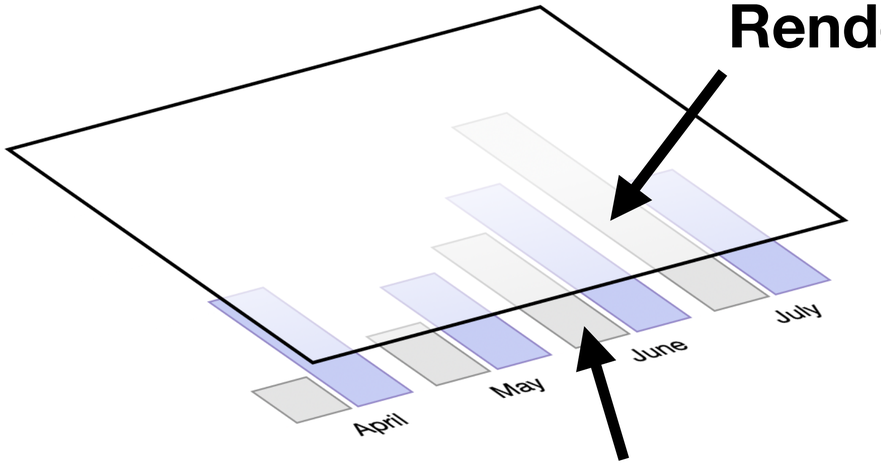
Data Navigator:
How do we build accessible visualizations?

Structure

Input

Rendering





Product B: 47, July, toggle button

To any visualization toolkit

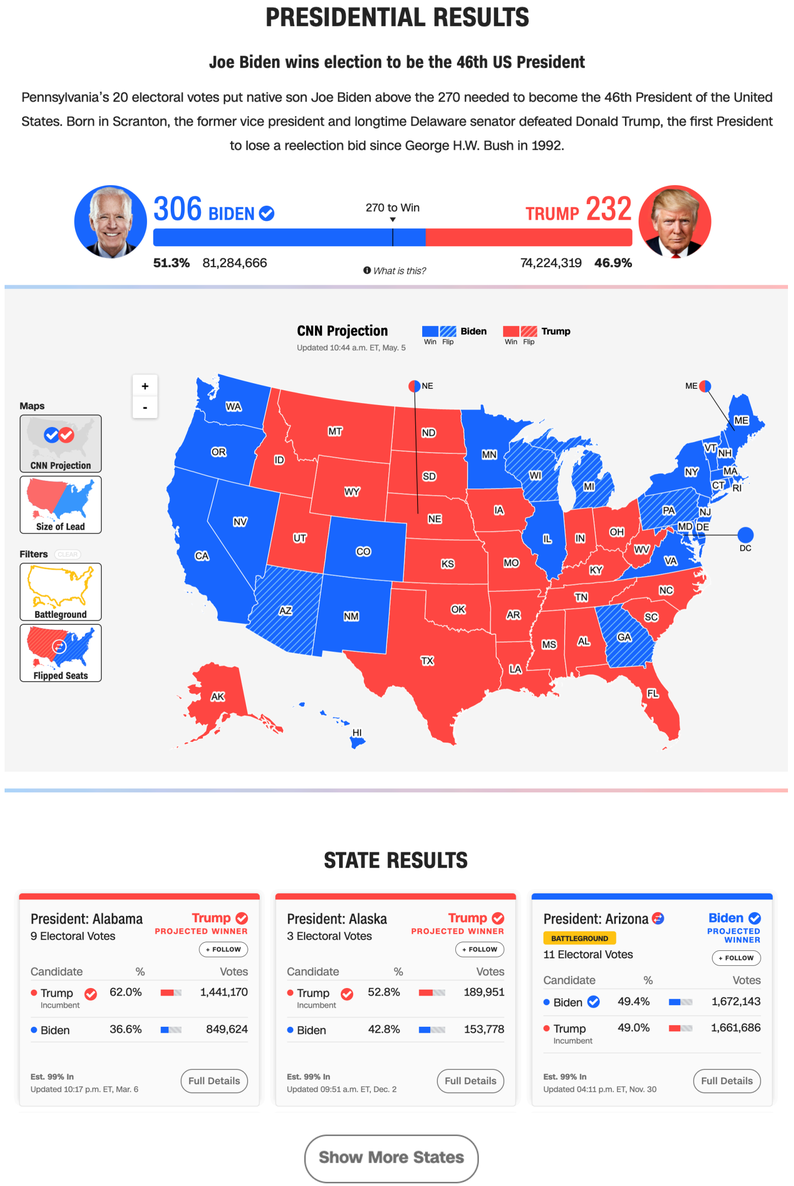
Chartability has helped me audit and train others

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



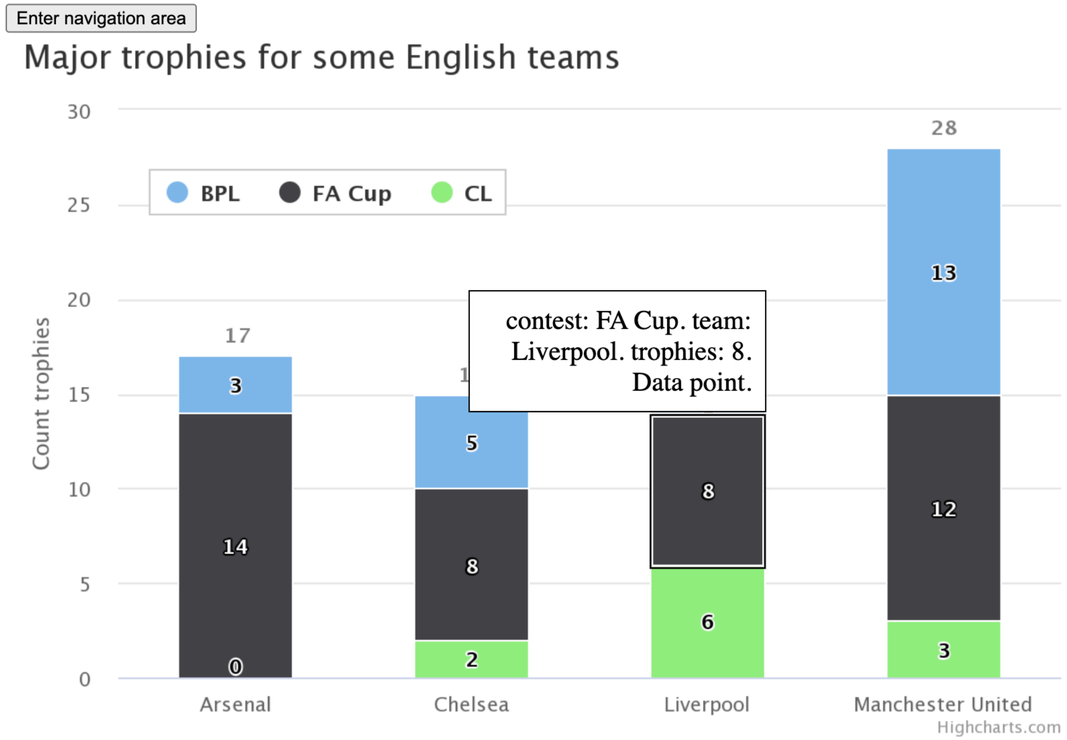
Robust:
275 - Does not conform to standards
82 - Semantically invalid
12 - Fragile technology support

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



Interactive demo link

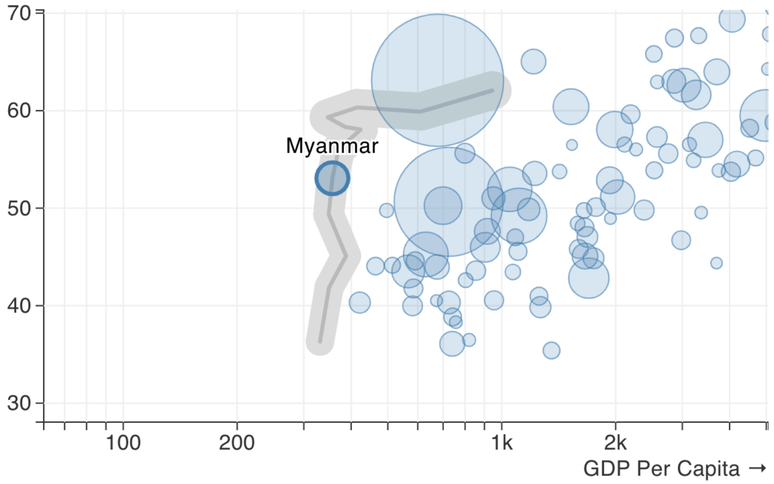
Data Navigator also opened up new collaborations

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.

Navigate

↑ Life Expectancy (yr)



Year: 1972

Play/Pause

X axis: Life Expectancy

Y axis: GDP Per Capita

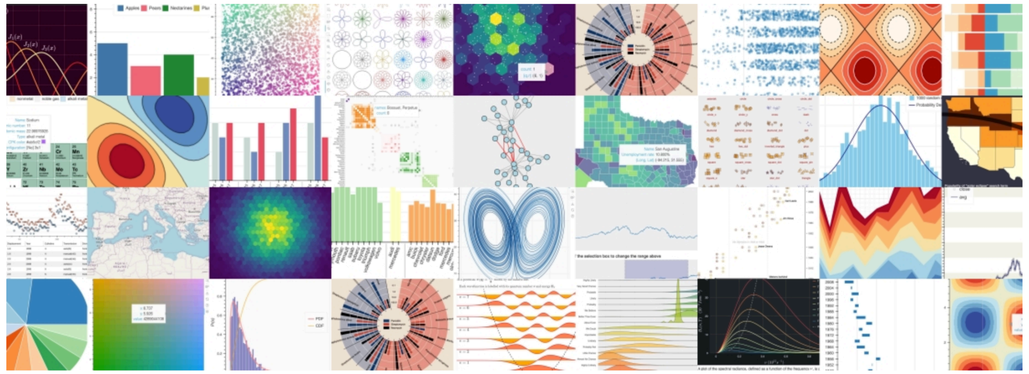
Radius: Population

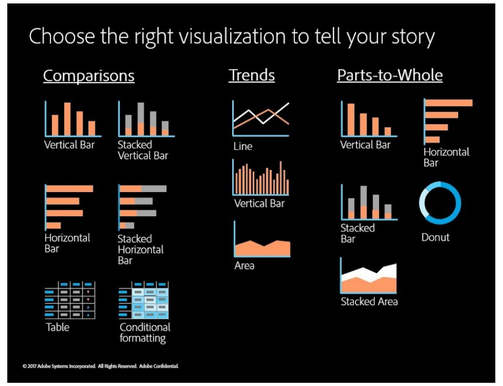
Reset Zoom

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

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



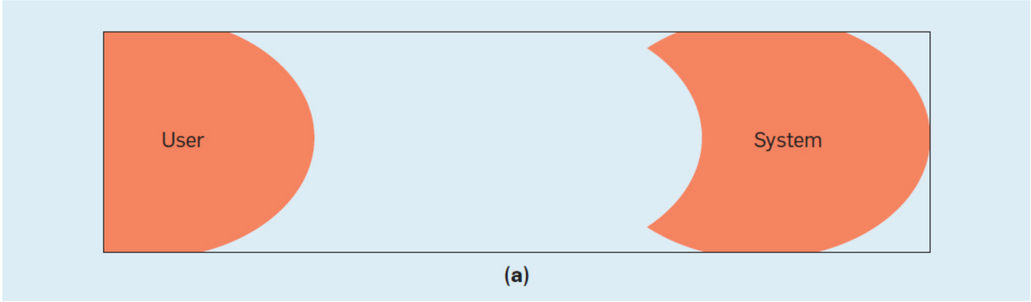


What are some “big-P” Problems in accessibility and visualization?

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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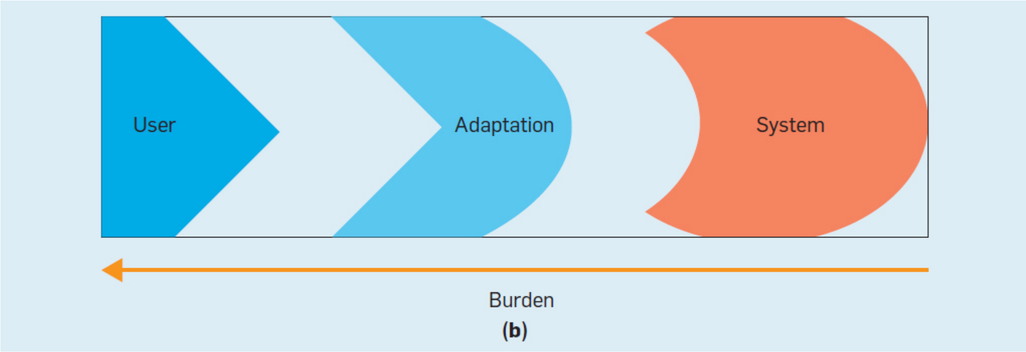

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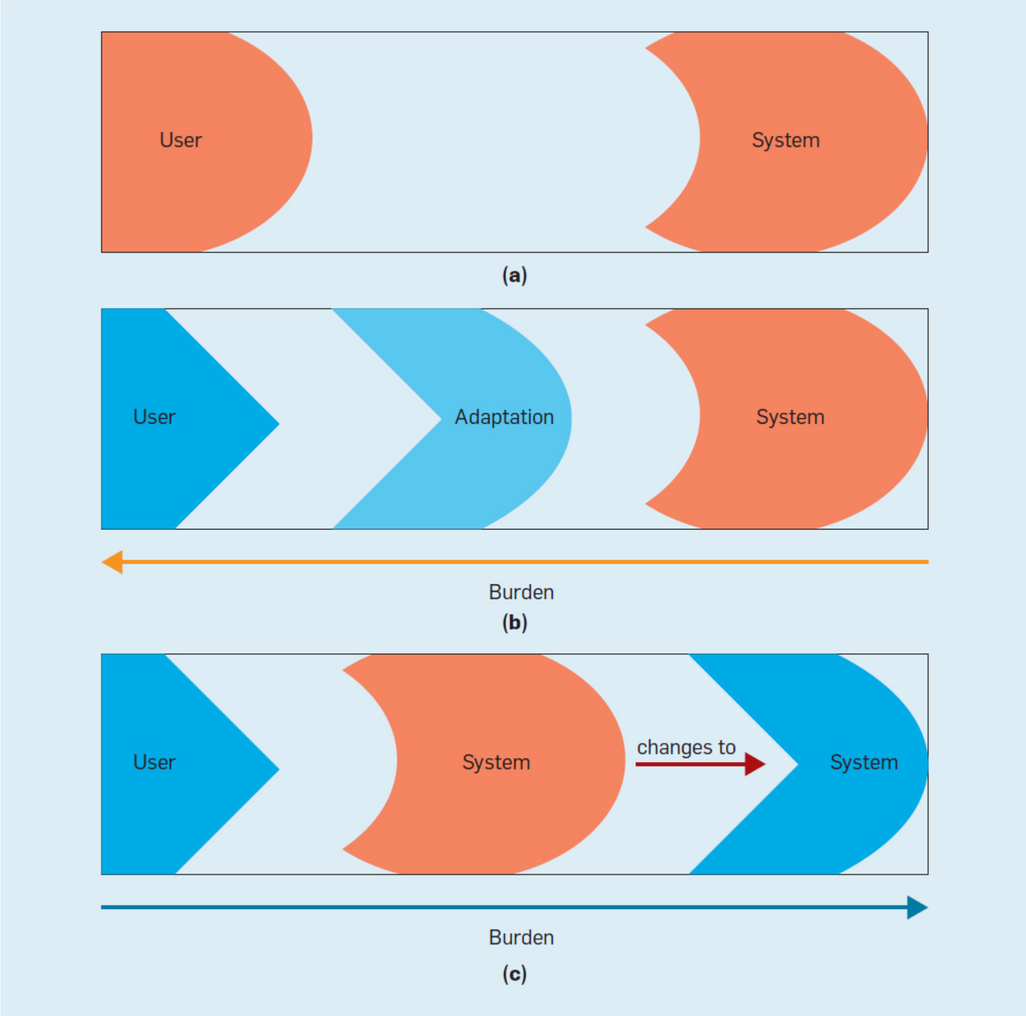
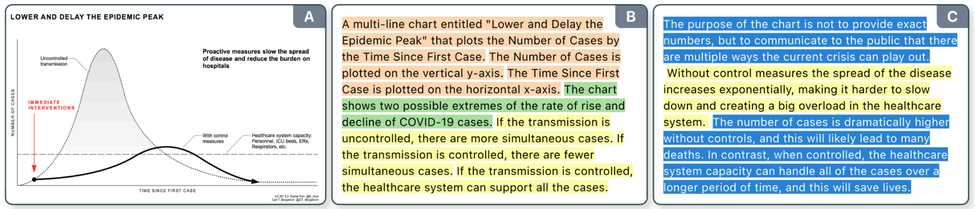


Problem 2: **Centering research** and development on screen readers (not blind people) limits what we can do

Accessible data *representation*

Accessible data *representation*

Descriptions



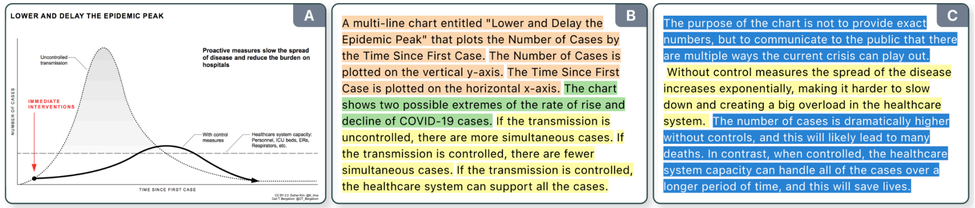
Long Description

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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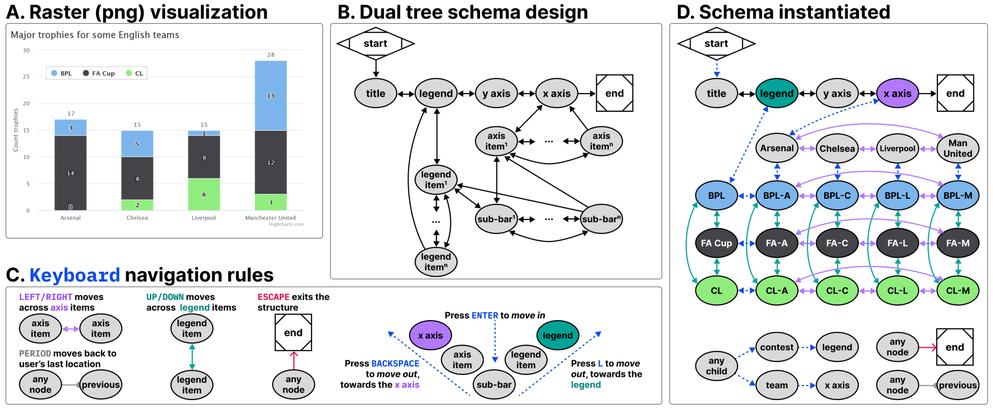

Image source

Accessible data *representation*

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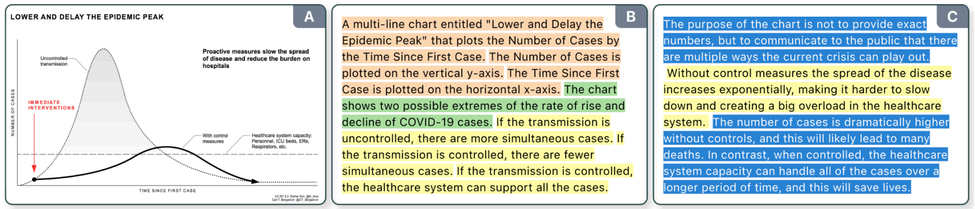

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Image source

Sonifications

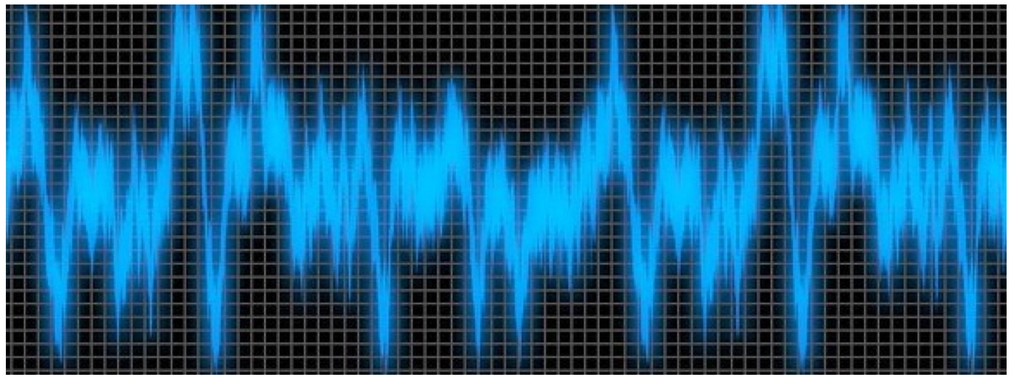

Image source

Structure

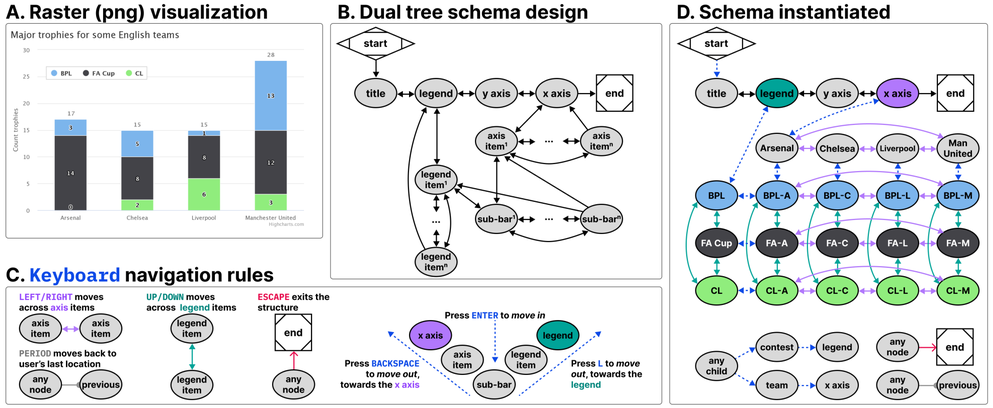

Image source

Accessible data *representation*

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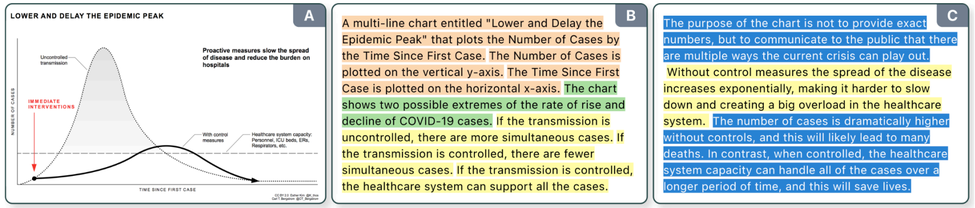

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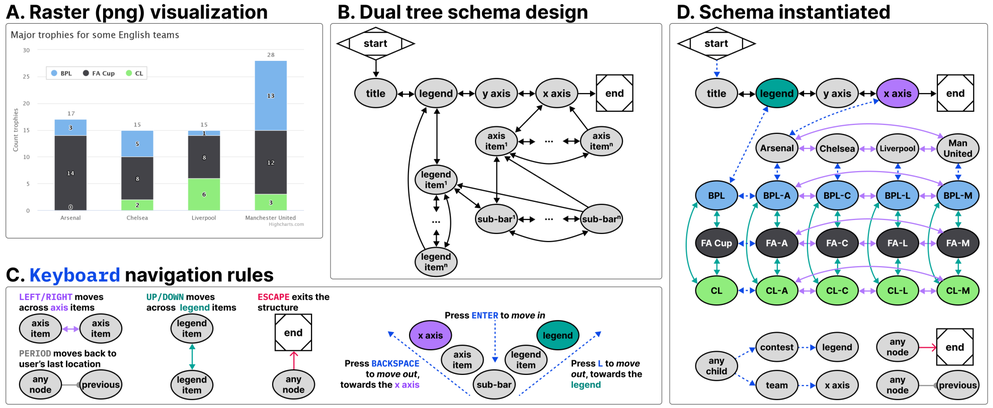


Image source

Sonifications

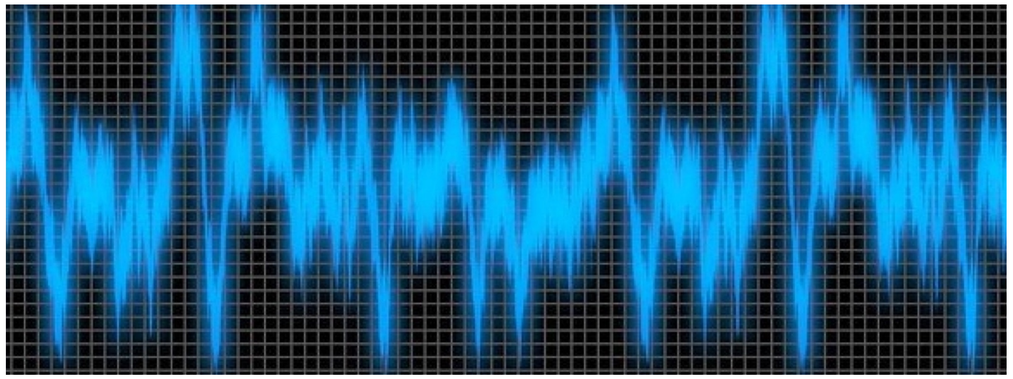
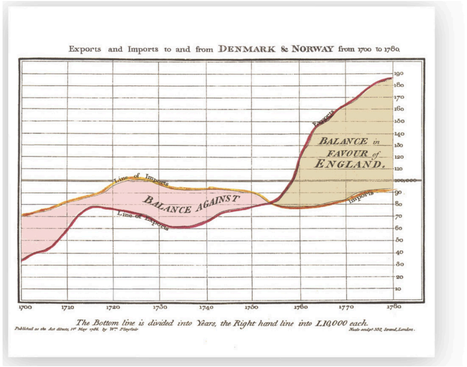


Image source

Tactiles



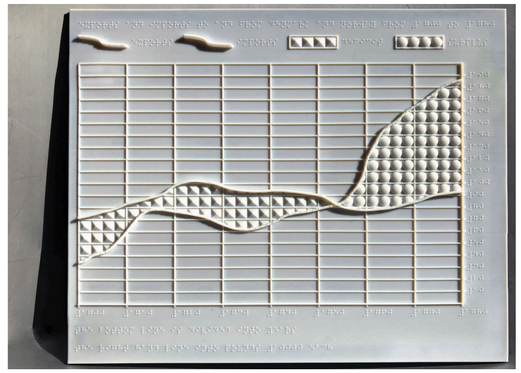
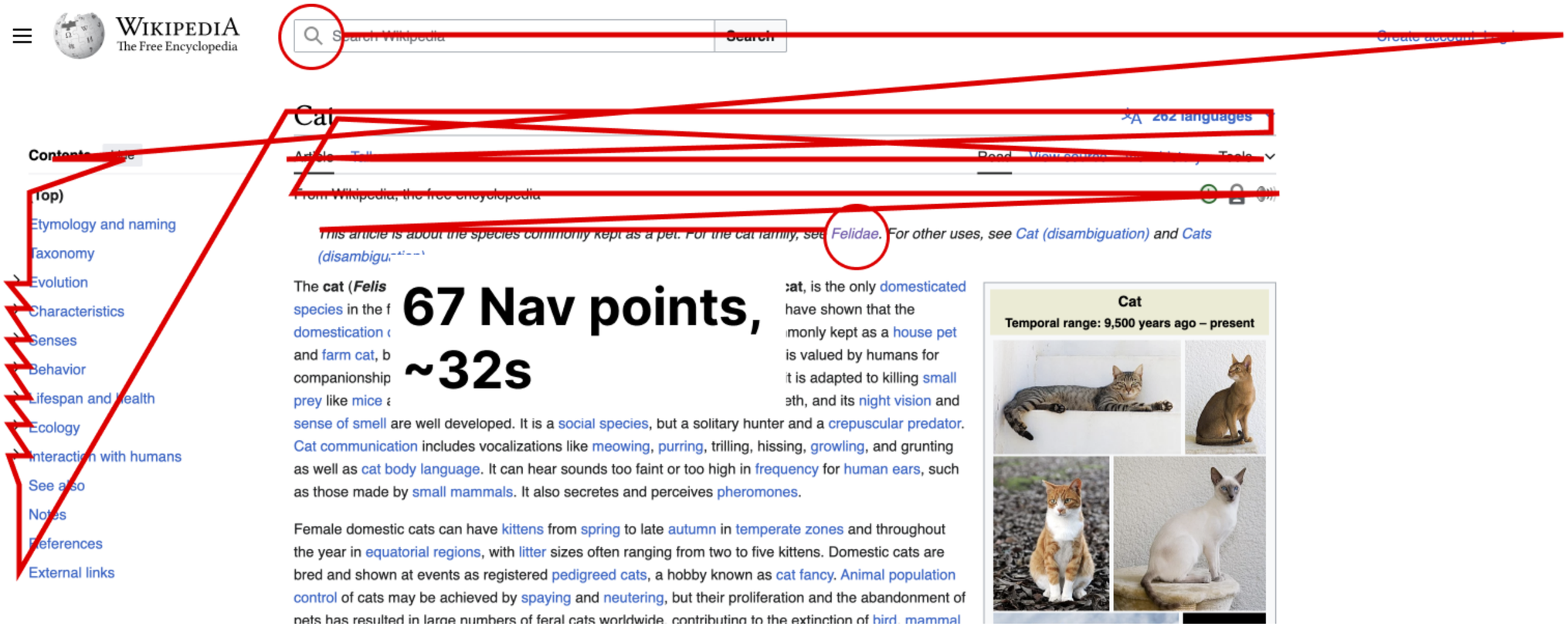


Image source

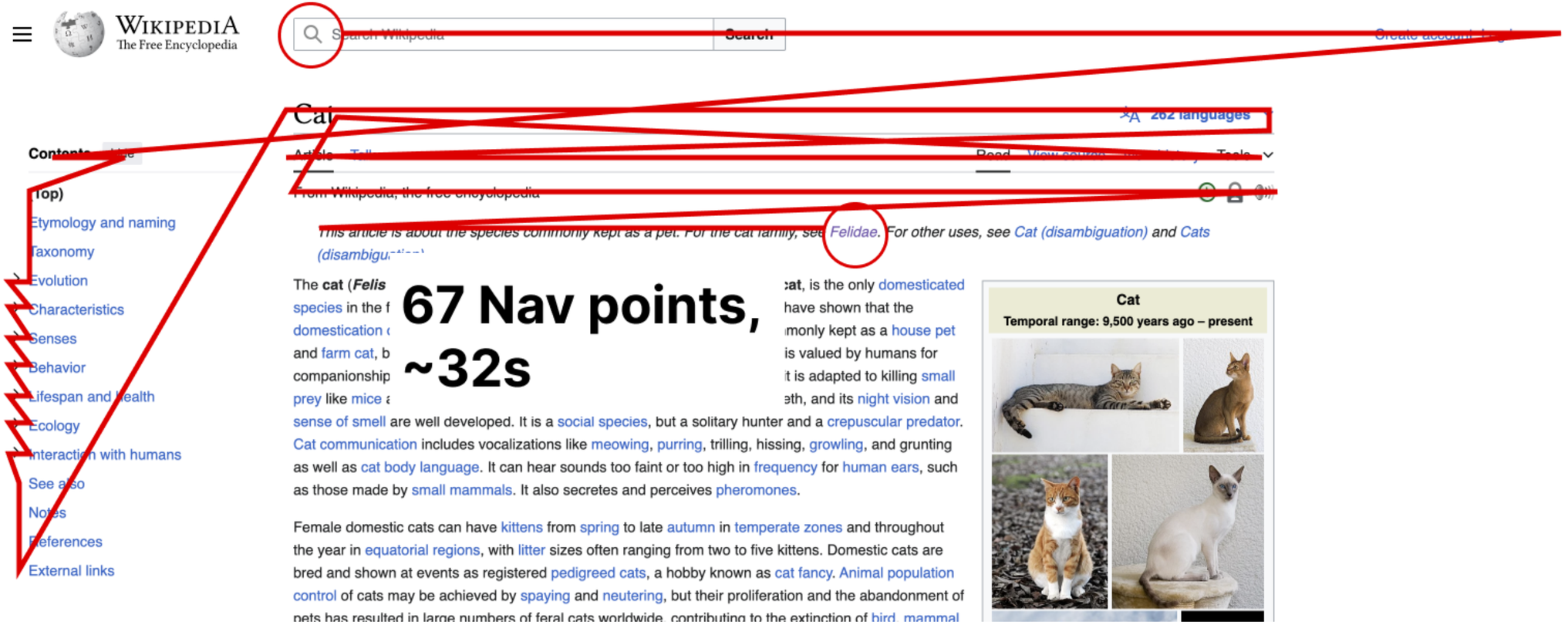
But what about *interactivity?*

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

But screen readers processes 1 input at a time



Movement between tasks becomes cognitively expensive



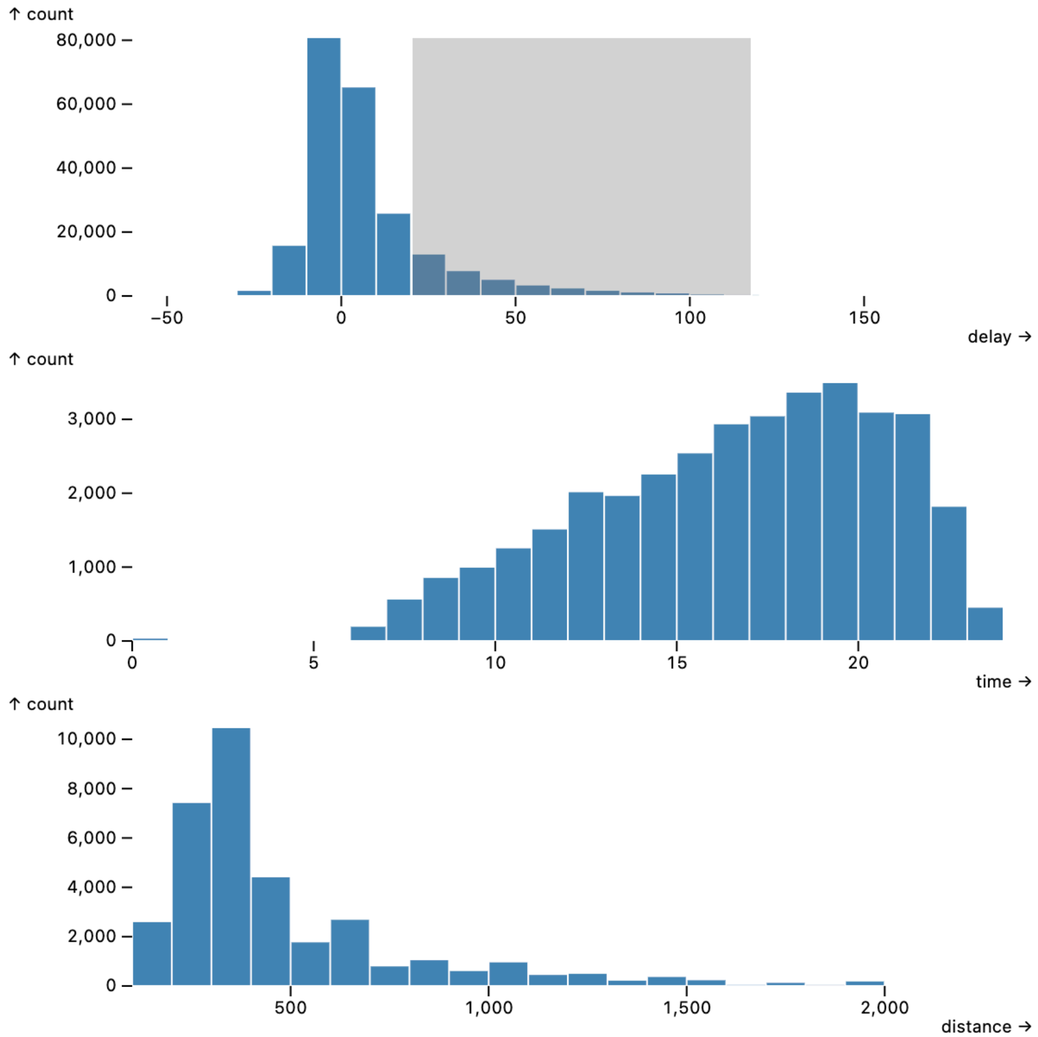
Auditory processing struggles with *dual-task* paradigms*

*Citation

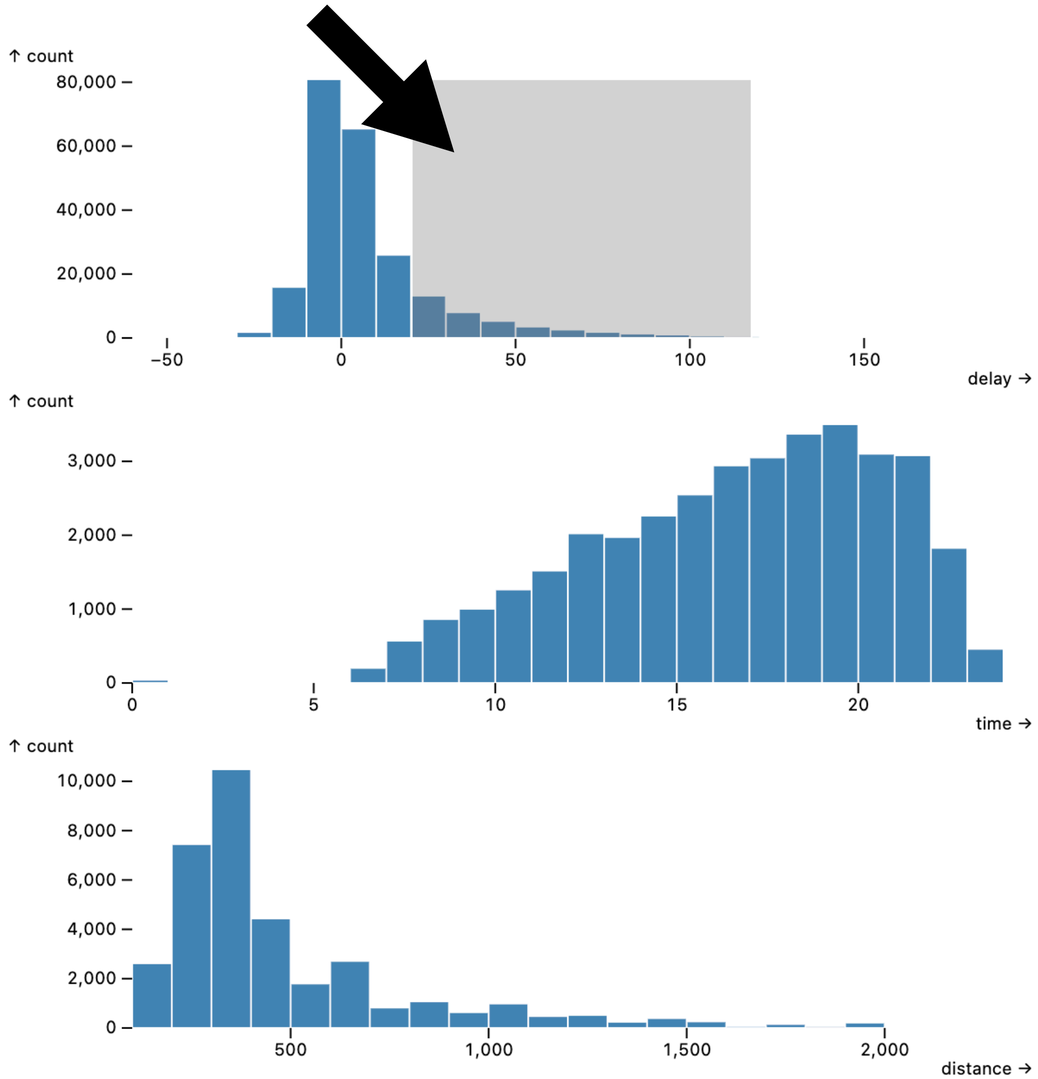
So what about cross-filtering?

Interactive link

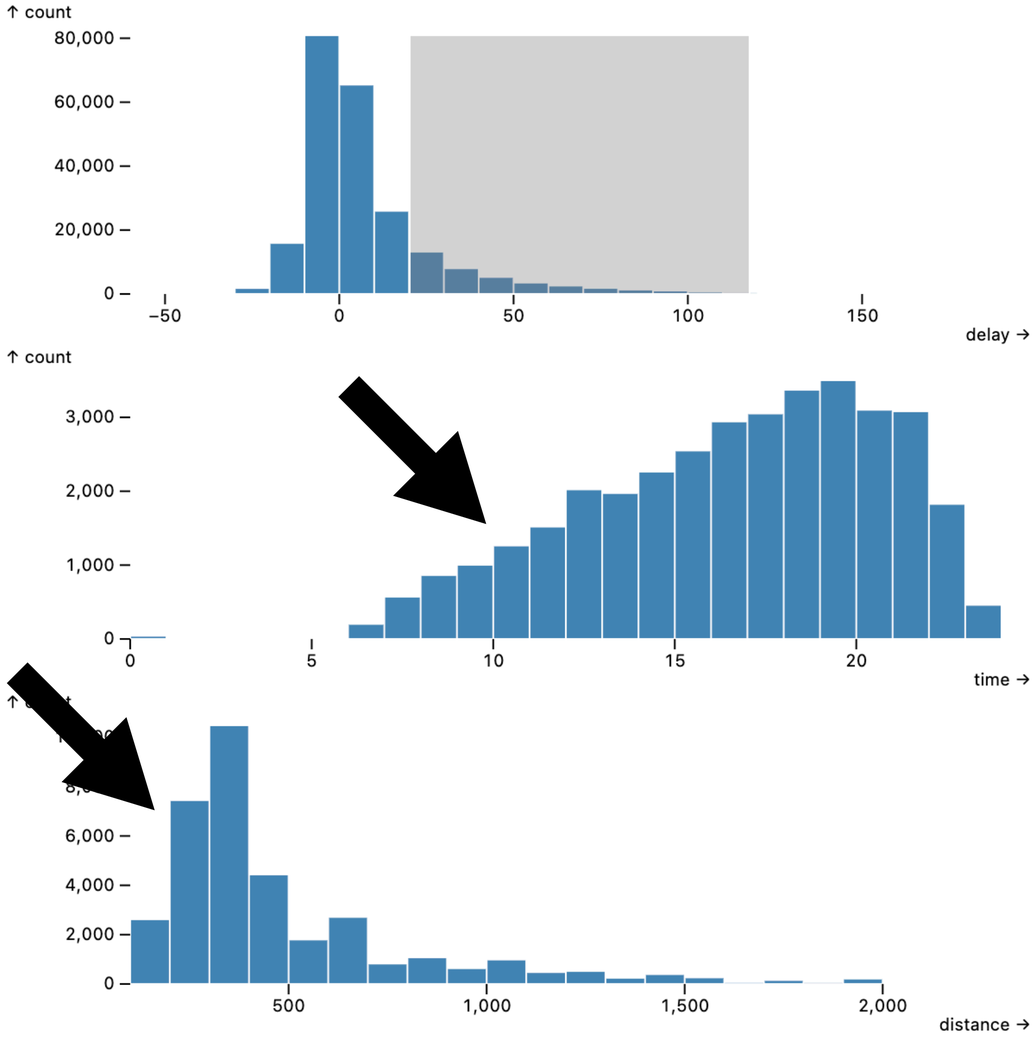
So what about cross-filtering?



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.

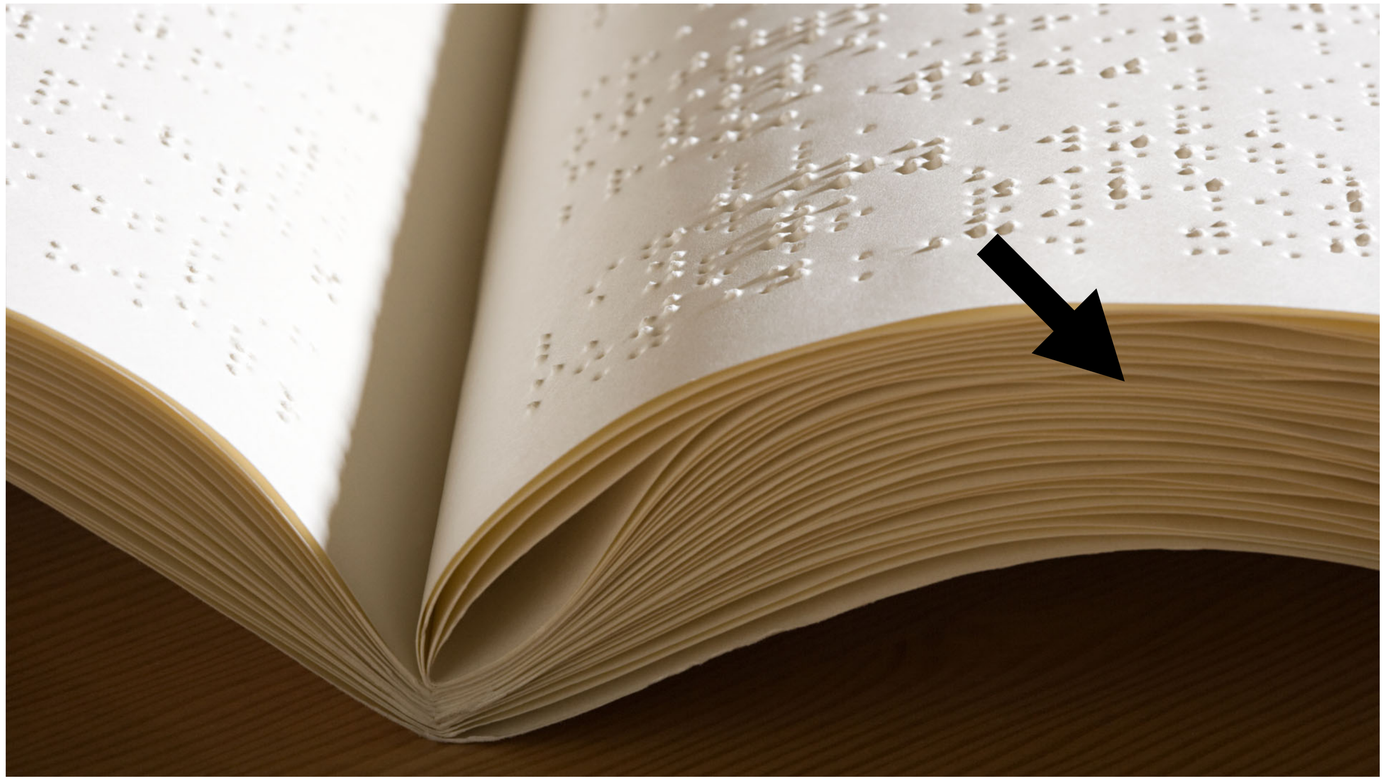
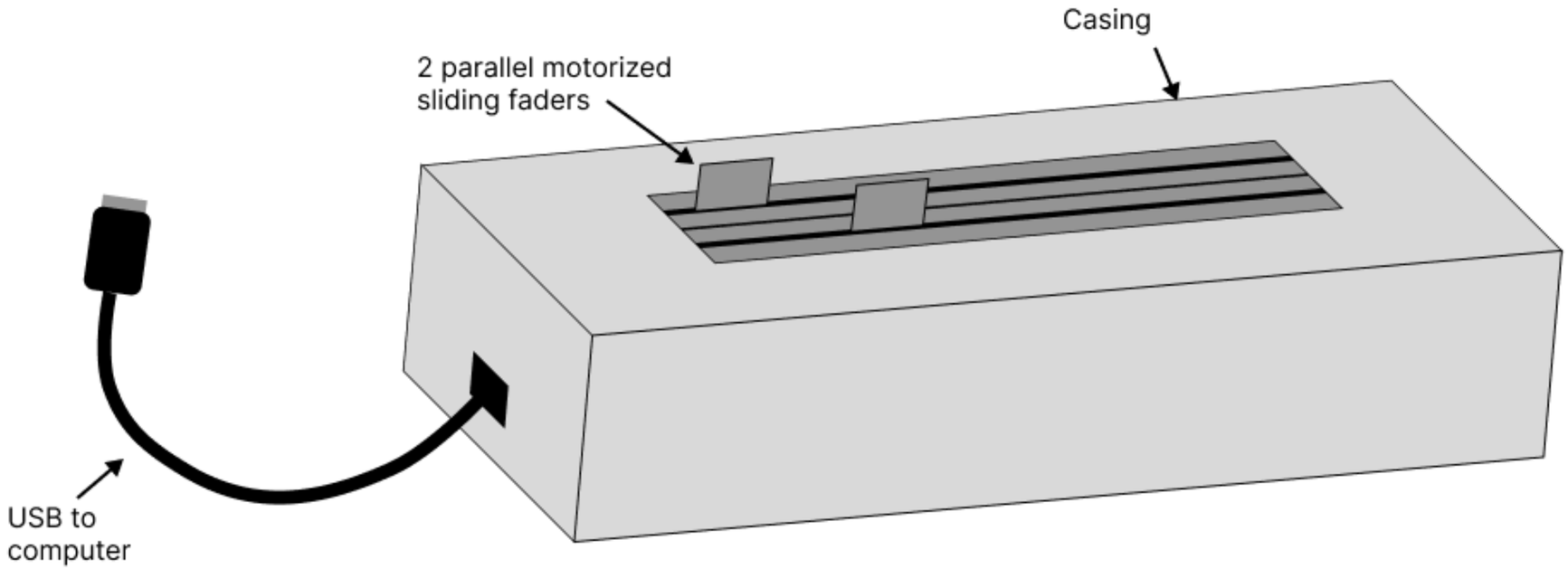


Image source

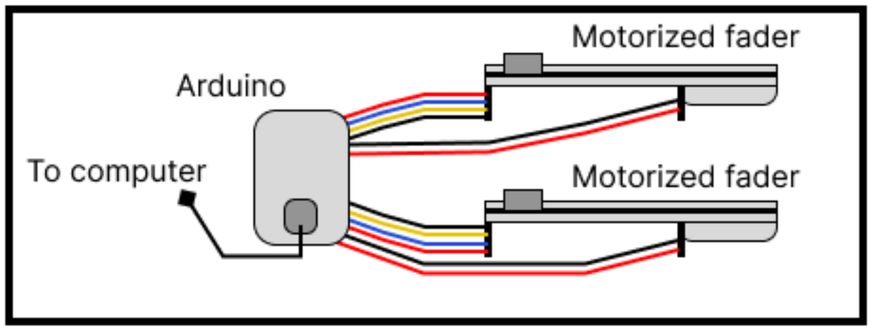
Observation 2: Coordinating perception and comparison

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

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



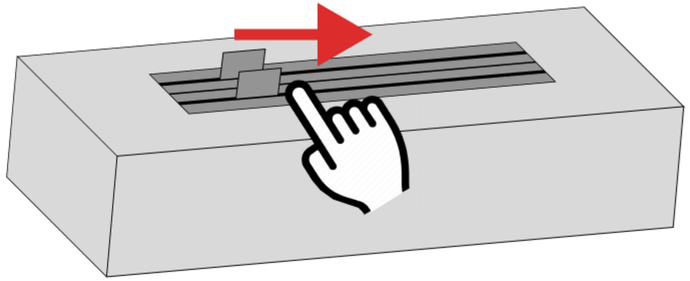
Schematic



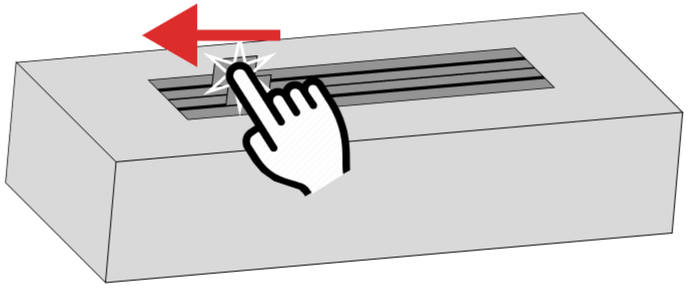
One slider can work with video

1. Video plays with progress slider moving

2. Slider follows, can be felt



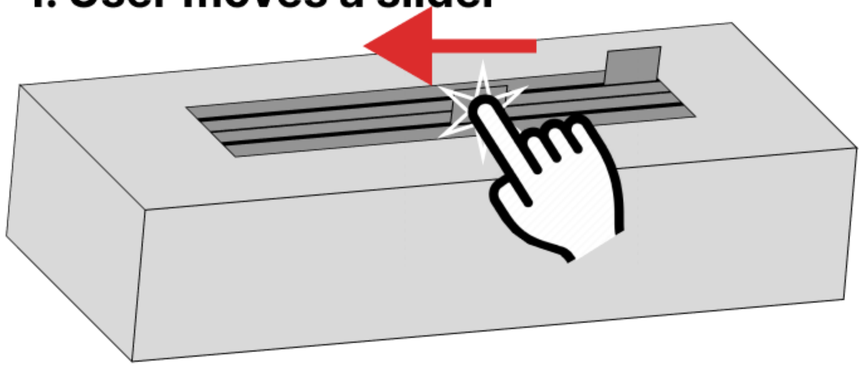
3. User can move slider



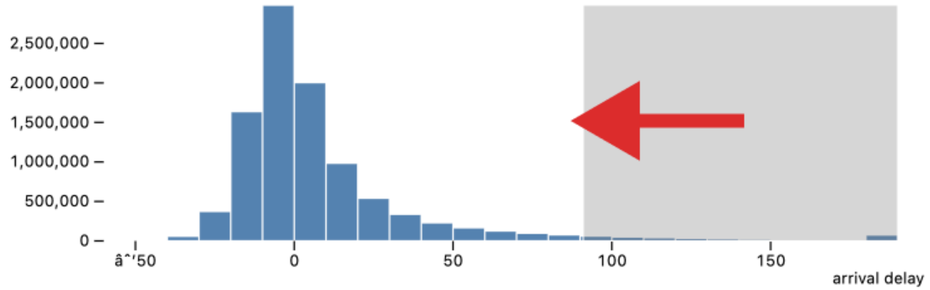
4. Video slider will move with slider change

While 2 sliders works for cross-filtering

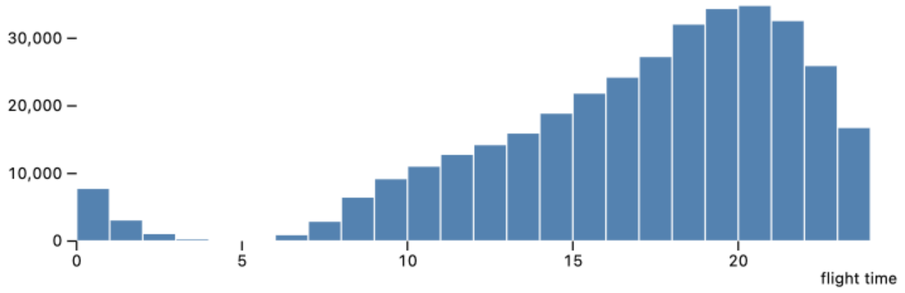
1. User moves a slider



2. Corresponding filter edge moves with

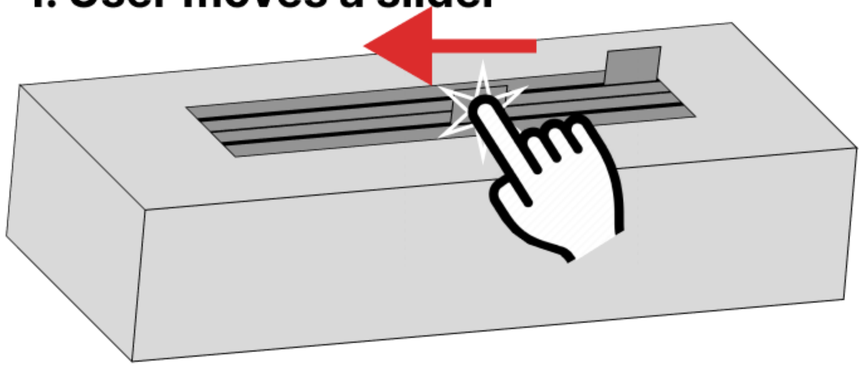


3. Secondary visualization updates



A tactile display can render the input *or* output chart

1. User moves a slider



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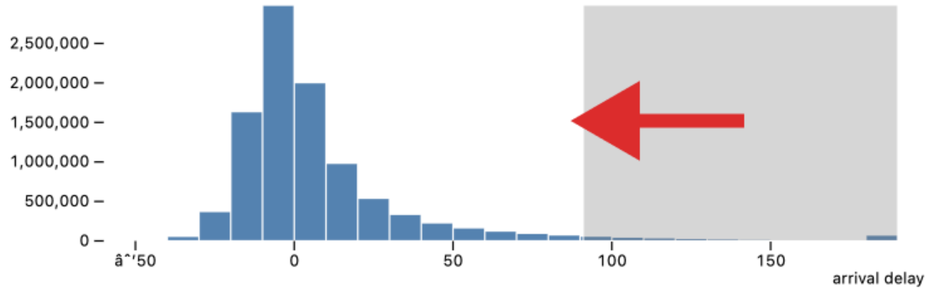

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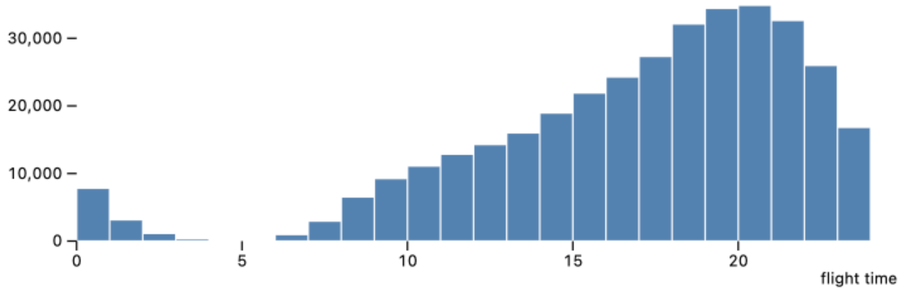
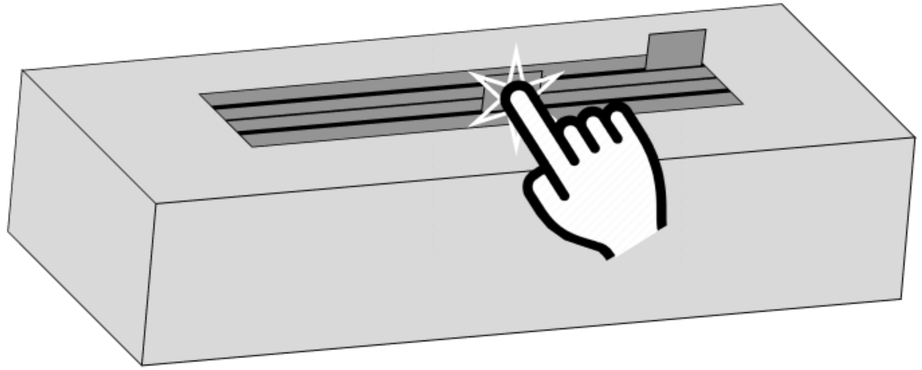


4. Tactile display renders

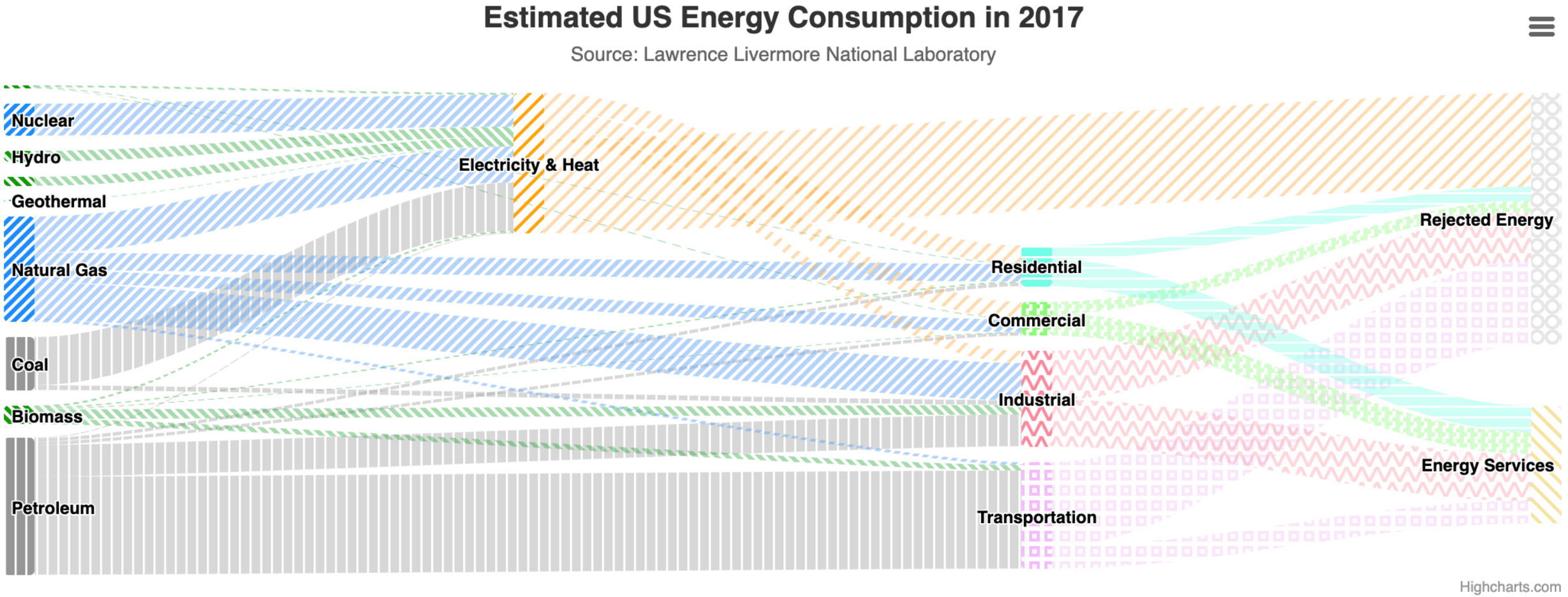
Cross-coordination! A tactile, dual-task paradigm.

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



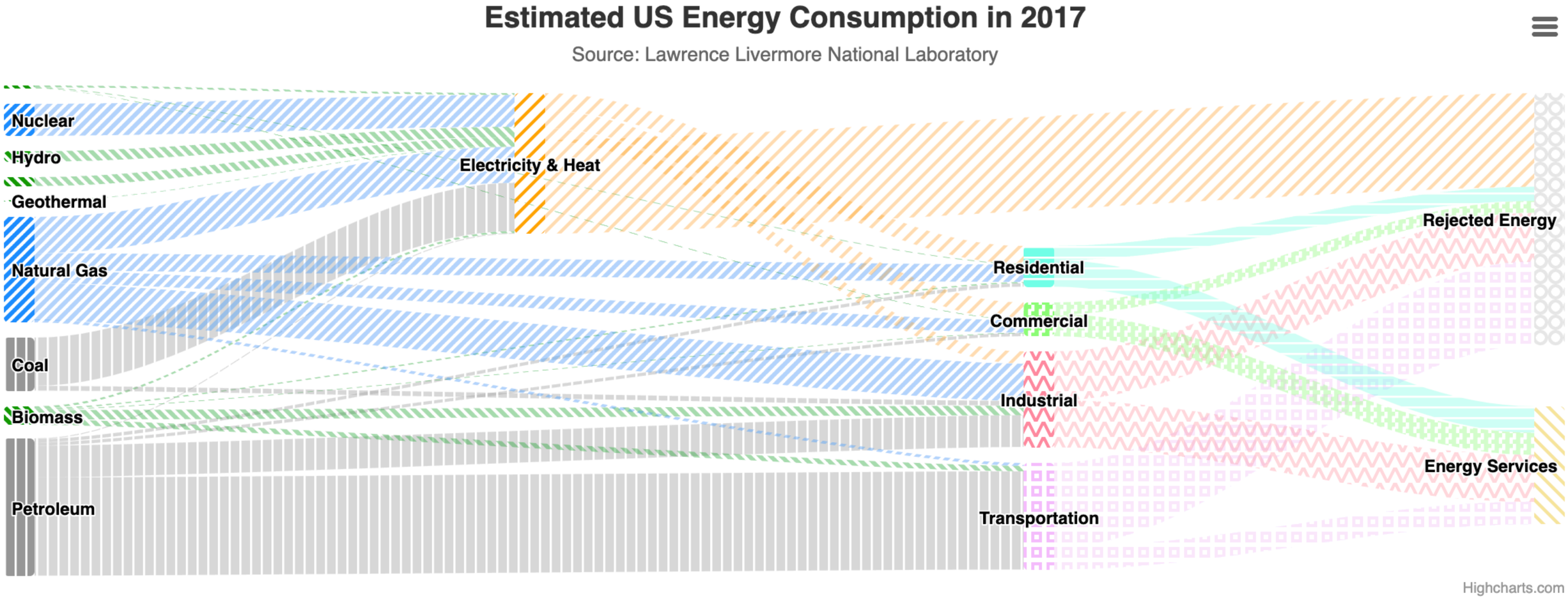
Problem 3: **Access Friction** is when accessibility for someone produces a barrier for others

What about this is accessible? Why?



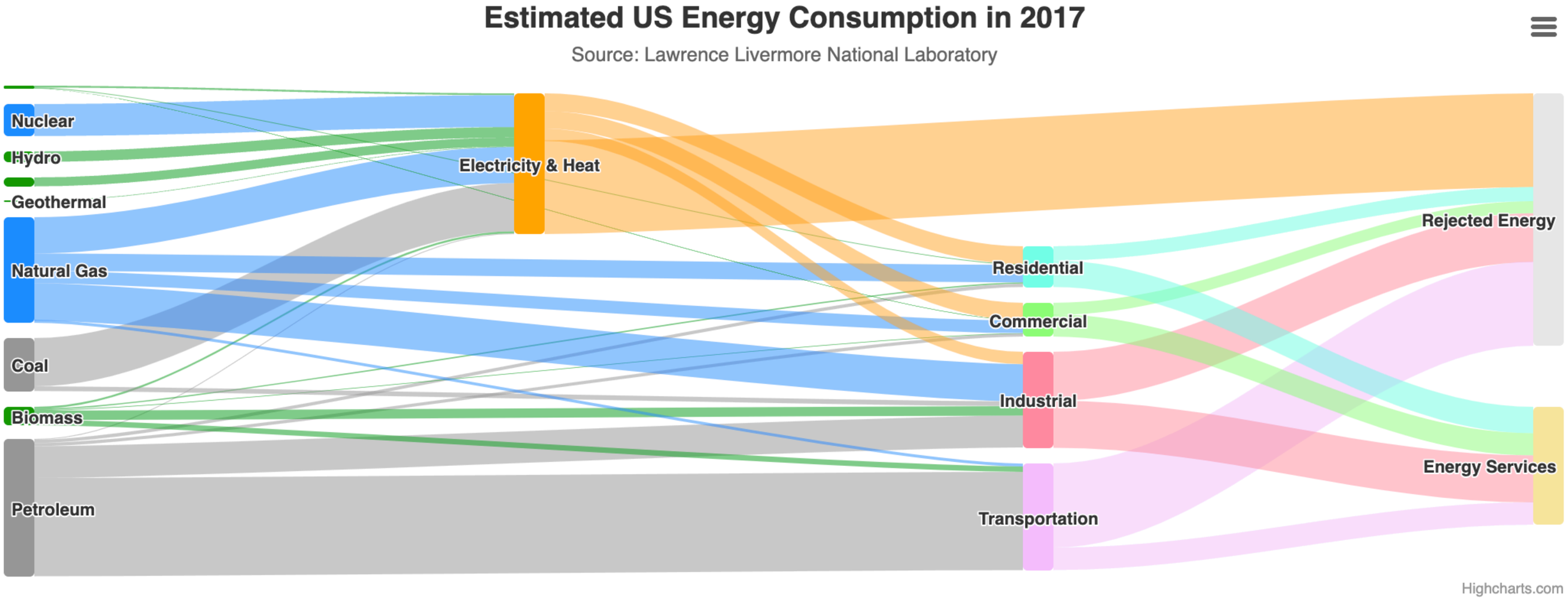
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

What about this might be a barrier? Why?



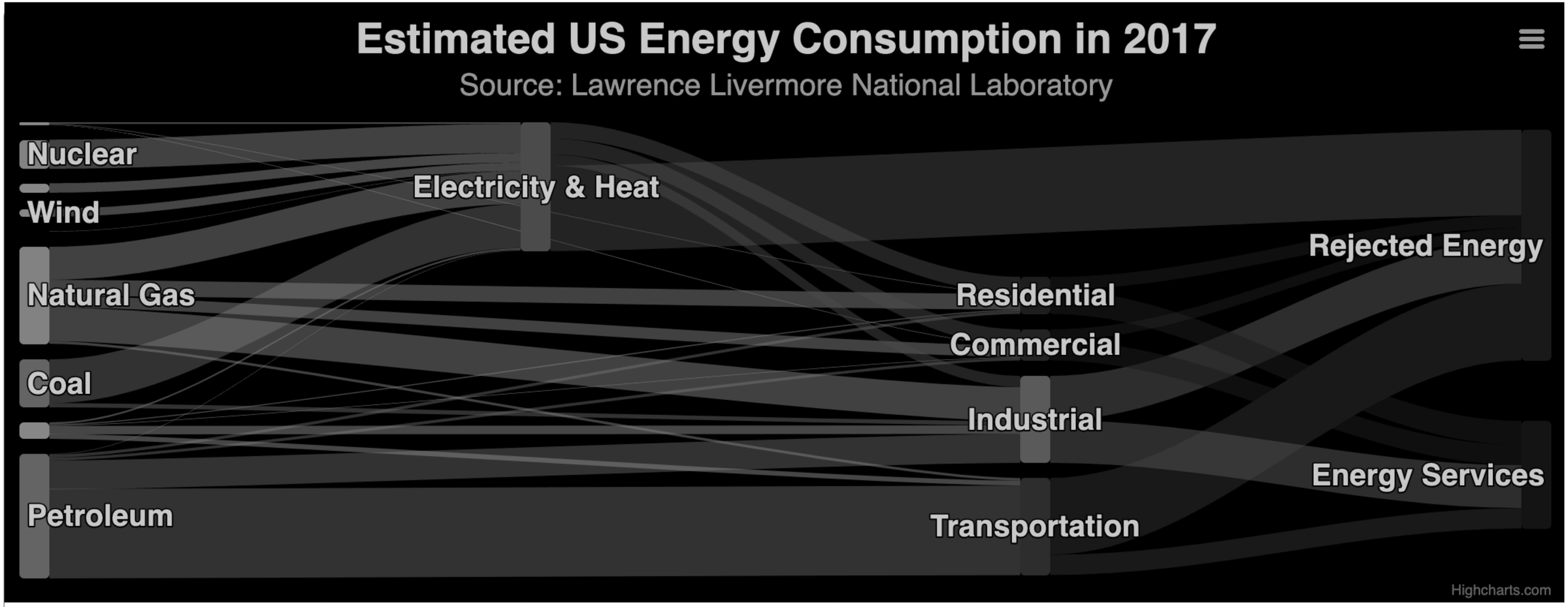
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

What about this now might be a barrier?



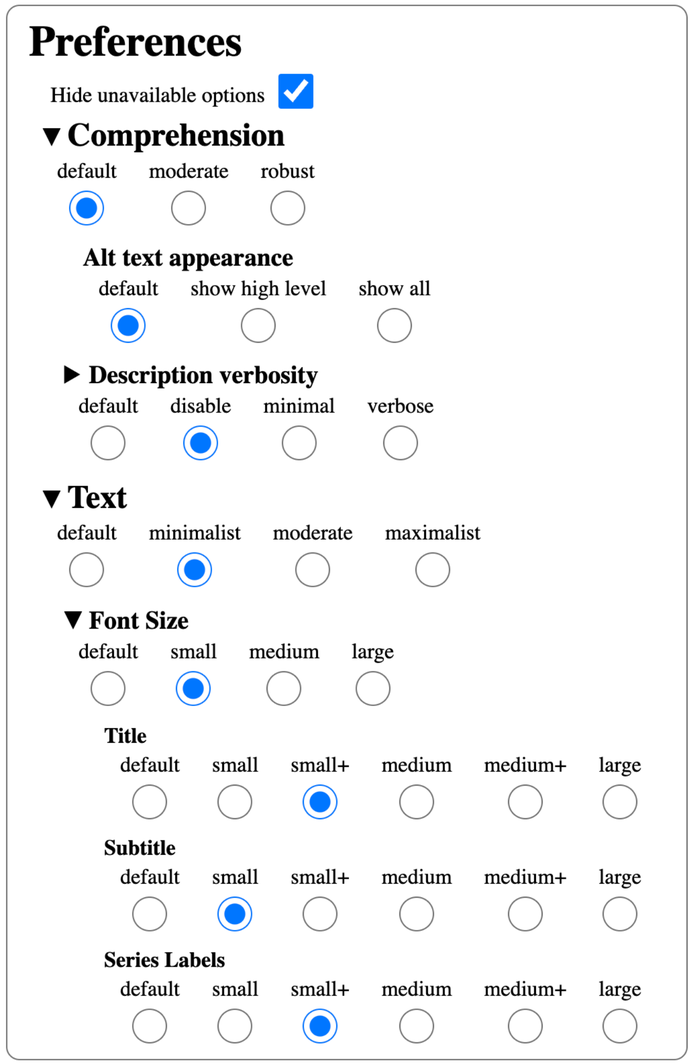
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

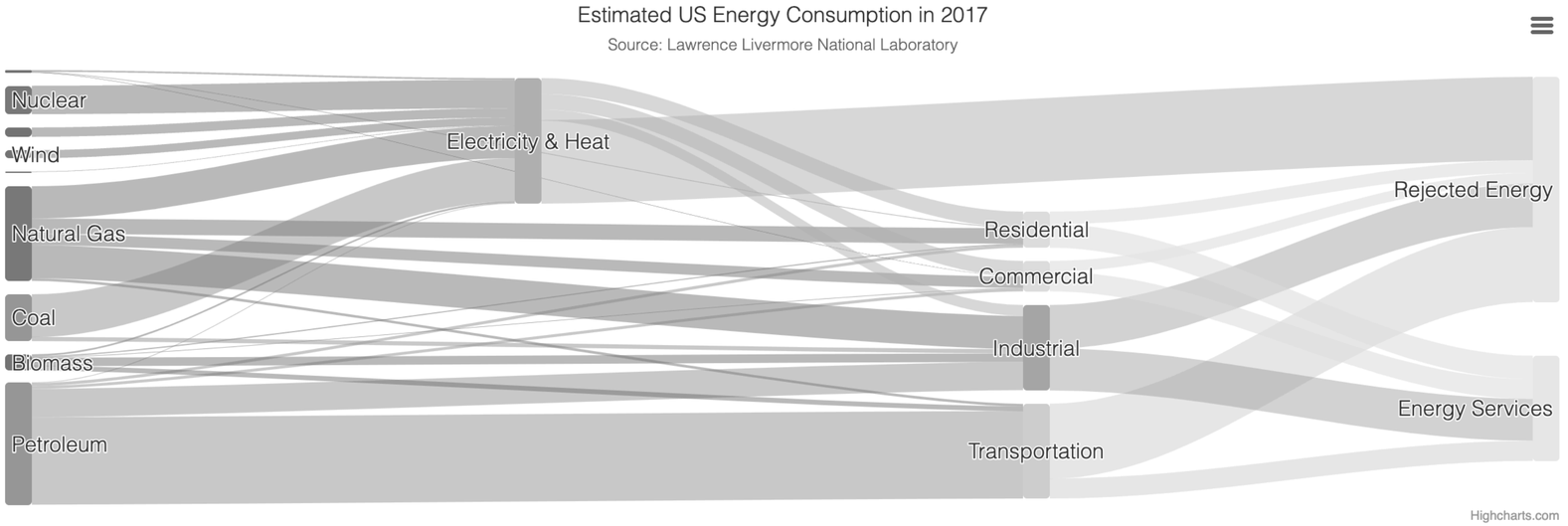
So some folks use tools to hack what they want

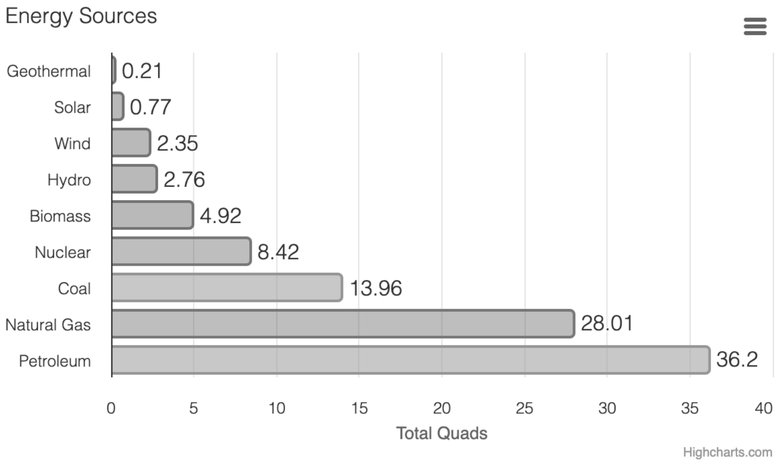


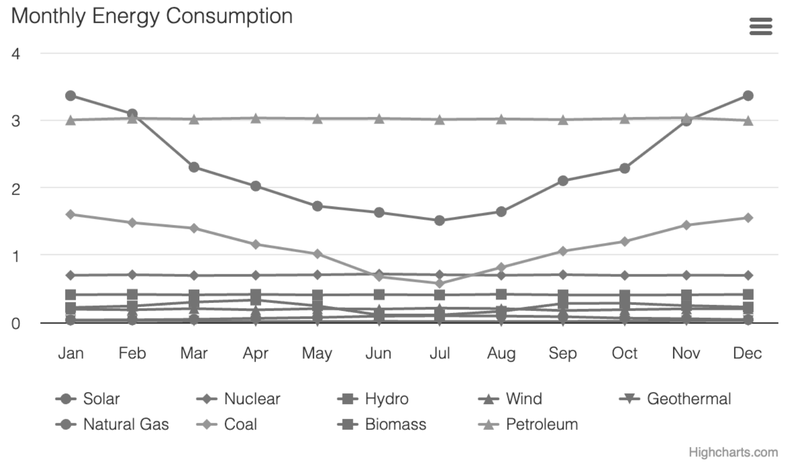
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

What if we *let* users hack the design?









Interactive demo link

2024

★Slides here → frank.computer

Looking to the future of accessible data interfaces

HIGHSOFT

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