2024

Looking to the future of accessible data interfaces HIGHJOFT



Frank Elavsky, PhD Student

frank.computer



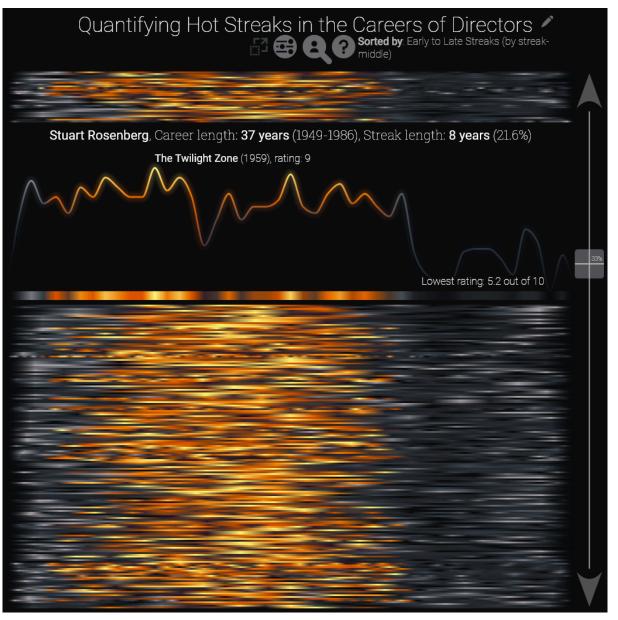
hcii.cmu.edu, axle-lab.com, dig.cmu.edu



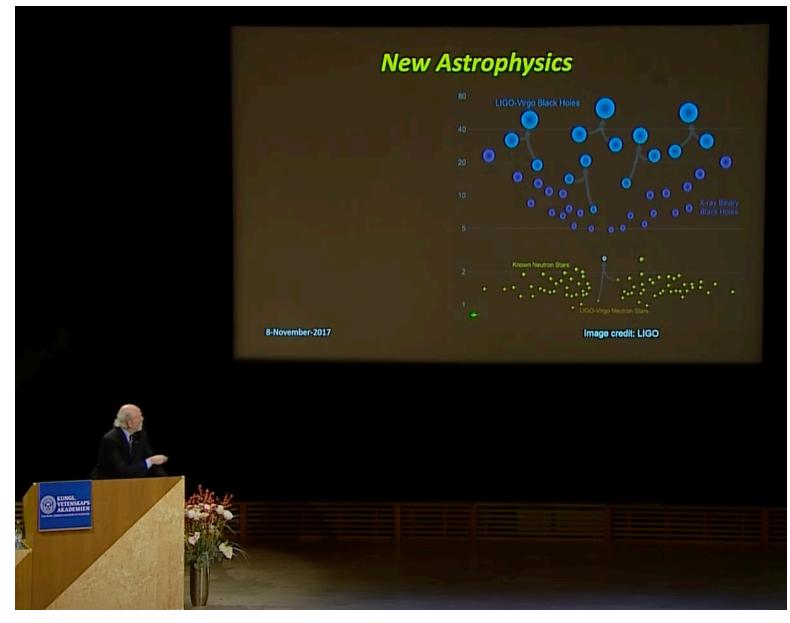


My pre-phd work in visualization Industry and research engineering

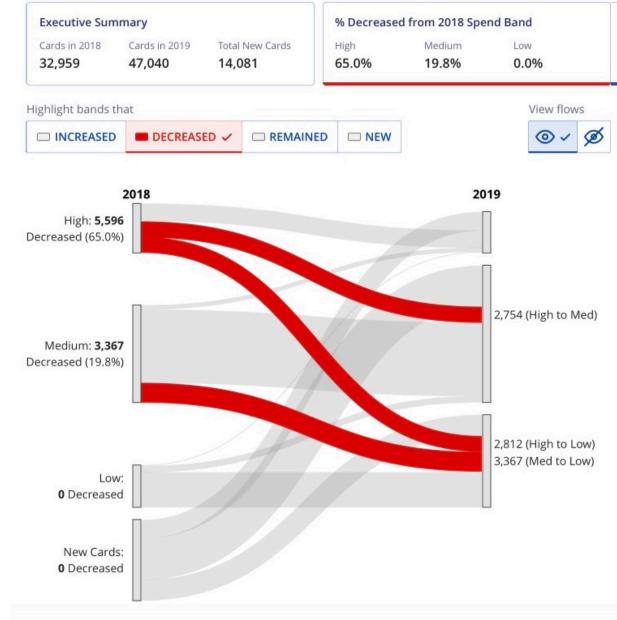
Dense model visualizations



Domain-specific visualizations



Data visualization library





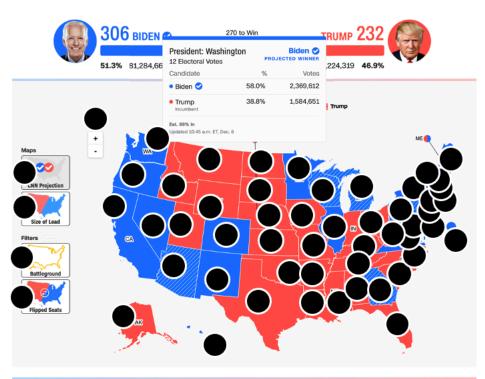
What and how of visualization accessibility (My recent research)

Chartability: **What** are accessibility barriers?

PRESIDENTIAL RESULTS

Joe Biden wins election to be the 46th US Presiden

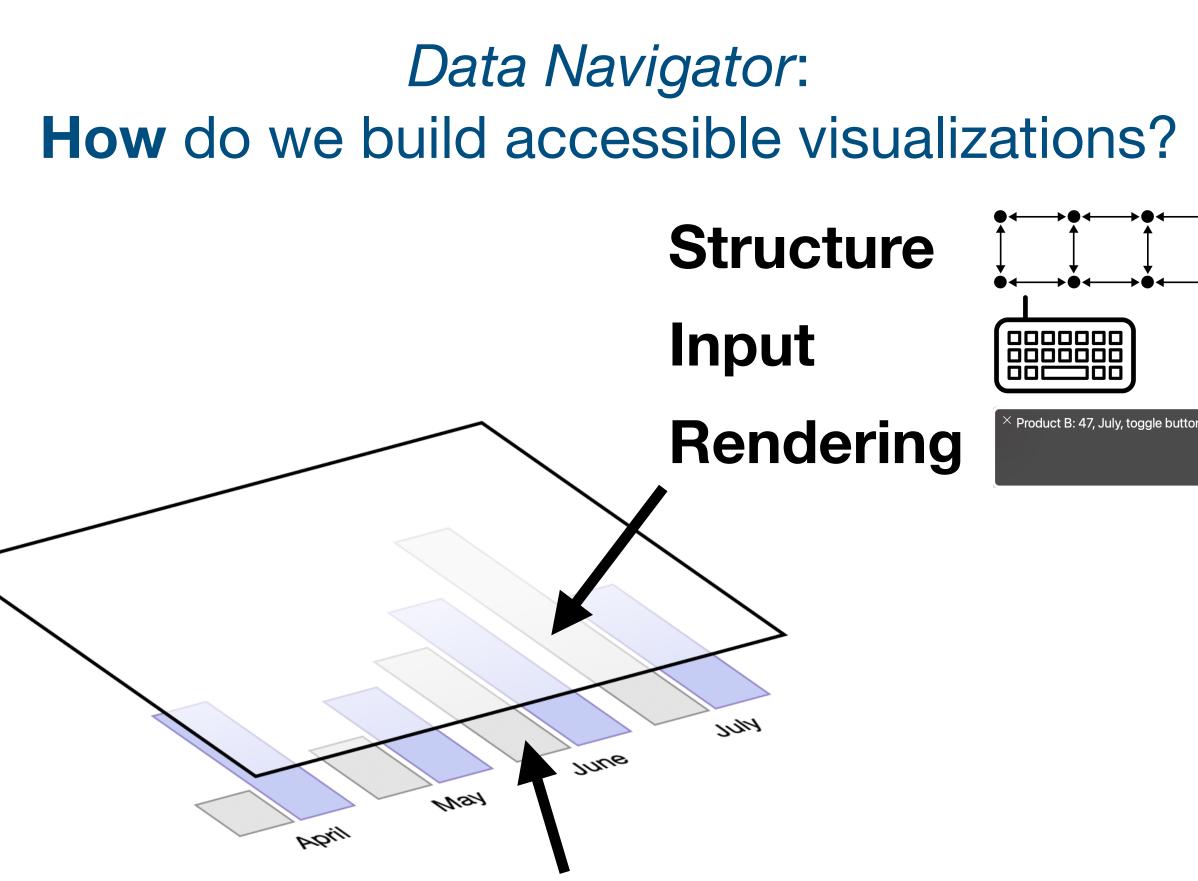
Pennsylvania's 20 electoral votes put native son Joe Biden above the 270 needed to become the 46th President of the United States. Born in Scranton, the former vice president and longtime Delaware senator defeated Donald Trump, the first President to lose a reelection bid since George H.W. Bush in 1992.



STATE RESULTS

President: Alaba 9 Electoral Votes	ma PRC	Trump S TED WINNER	President: Al 3 Electoral Vot			TUMP S ED WINNER • FOLLOW	President: / BATTLEGROUND 11 Electoral V			Biden O PROJECTED WINNER
Candidate	%	Votes	Candidate	%	-	Votes	Candidate	%	•	Votes
Trump 😏 62	.0% 💻 🛛	1,441,170	• Trump 🔗	52.8%	121	189,951	• Biden 🥝	49.4%		1,672,143
Biden 36	.6% 🔳 🕬	849,624	 Biden 	42.8%	021	153,778	Trump Incumbent	49.0%	1 00	1,661,686
Est. 99% In Jpdated 10:17 p.m. ET, M	ar. 6	Full Details	Est. 99% In Updated 09:51 a.m.	ET, Dec. 2	Fu	II Details	Est. 99% in Updated 04:11 p.r	n. ET, Nov. 30	(Full Details

Show More States



To any visualization toolkit





Chartability has helped me audit and train others **PRESIDENTIAL RESULTS** Joe Biden wins election to be the 46th US President

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

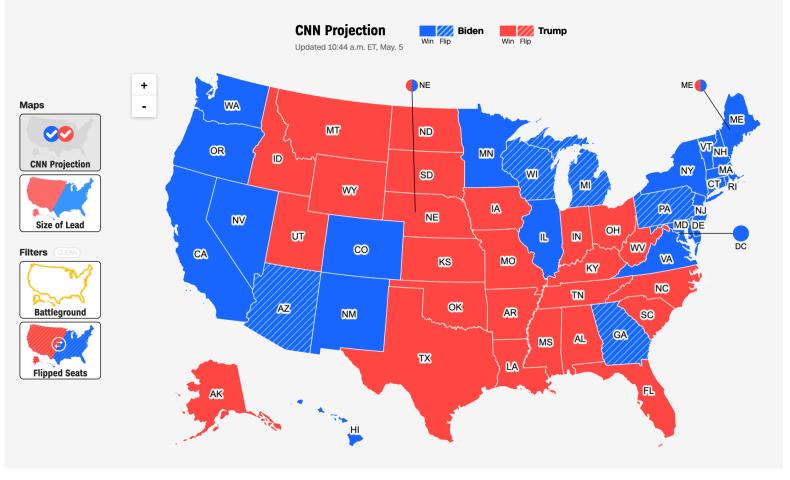
Operable:

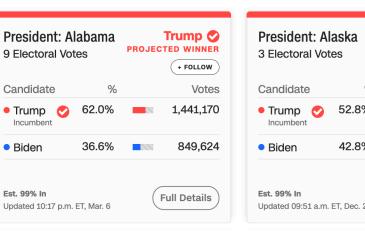
- 54 Interaction modality only has one input type
- 58 No interaction cues or instructions
- **5** Low contrast on interactive elements
- 4 Keyboard focus indicator missing
- **4** Complex actions have no alternative
- **18** Target pointer interaction is too small

Understandable:

- 4 Interactive context is not clear
- 6 Metrics or variables are undefined







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

STATE RESULTS

Trump S PROJECTED WINNER + FOLLOW	President: Arizona 🗟 BATTLEGROUND 11 Electoral Votes	Biden O PROJECTED WINNER + FOLLOW
Votes	Candidate %	Votes
189,951	• Biden 🤡 49.4%	1,672,143
153,778	• Trump 49.0% Incumbent	1,661,686
Details	Est. 99% In Updated 04:11 p.m. ET, Nov. 30	Full Details

Robust:

275 - Does not conform to standards

- 82 Semantically invalid
- 12 Fragile technology support

Compromising:

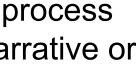
54 - Information can only be reached through single process 61 - Information cannot be navigated according to narrative or structure

Assistive:

101 - Navigation and interaction is tedious

Flexible:

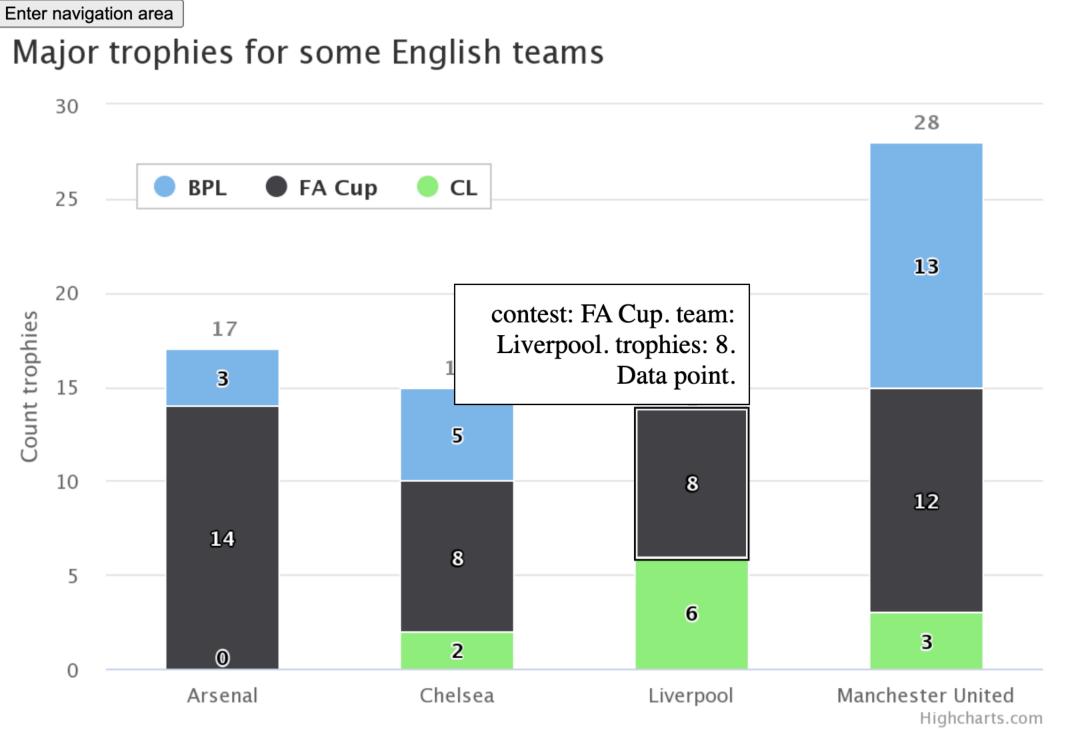
- 2 User style change not respected
- **121** User text adjustments are not respected
- 1 Scrolling experiences cannot be adjusted or opted out of
- Contrast and textures cannot be adjusted





4

Data Navigator makes previously inaccessible formats more accessible



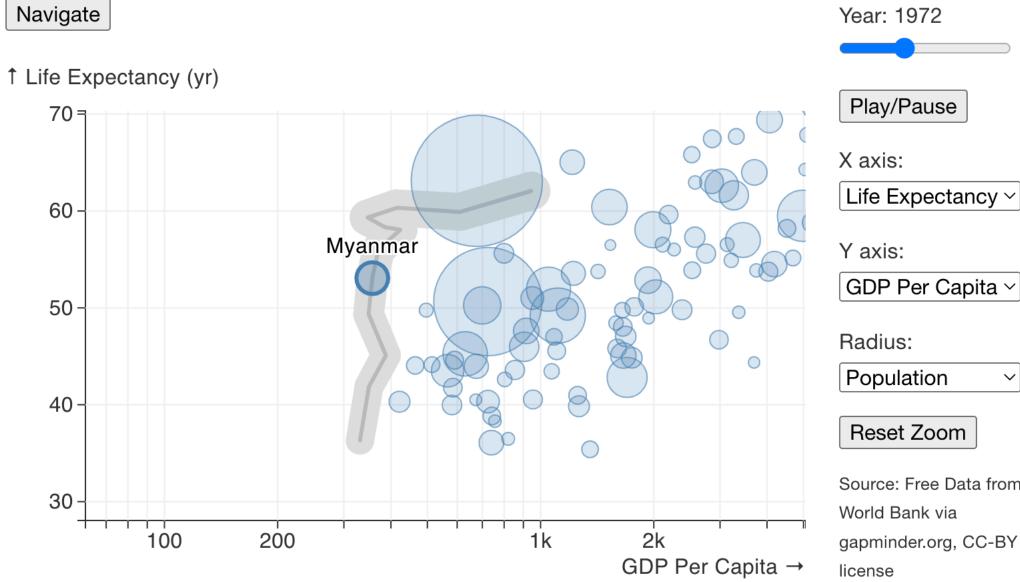
Interactive demo link

5

Data Navigator also opened up new collaborations

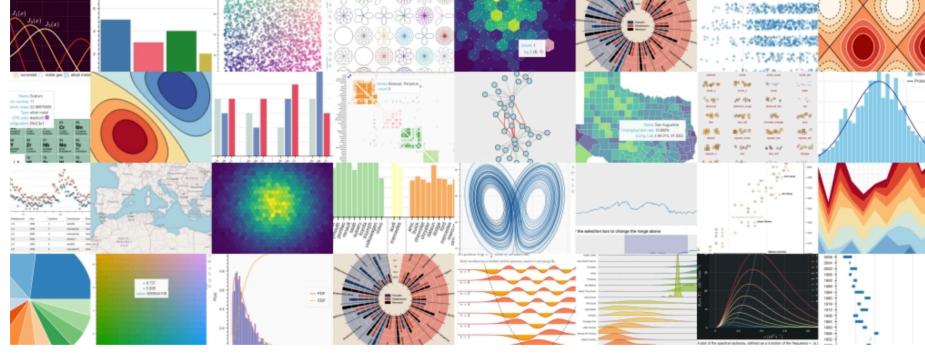
Example: Accessible Gapminder Chart

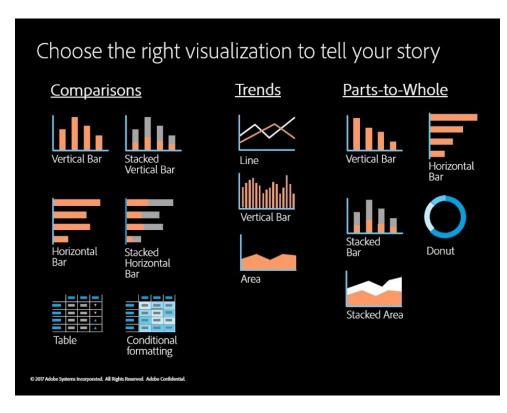
Below is a responsive, screen-reader-navigable version of the chart shown on the homepage. Press Navigate to enter keyboard navigation. Or, change your "prefers reduced motion" system setting to see fade animations instead of motion.



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.

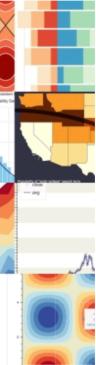
- Life Expectancy ~
- Source: Free Data from







Interactive demo link



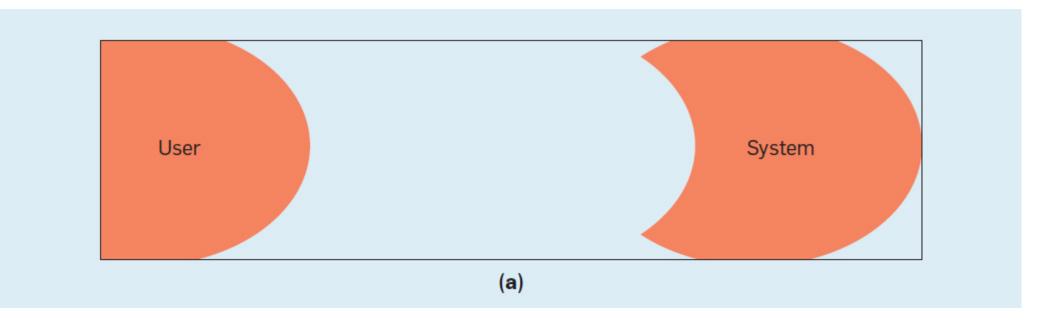




What are some "big-P" Problems in accessibility and visualization?

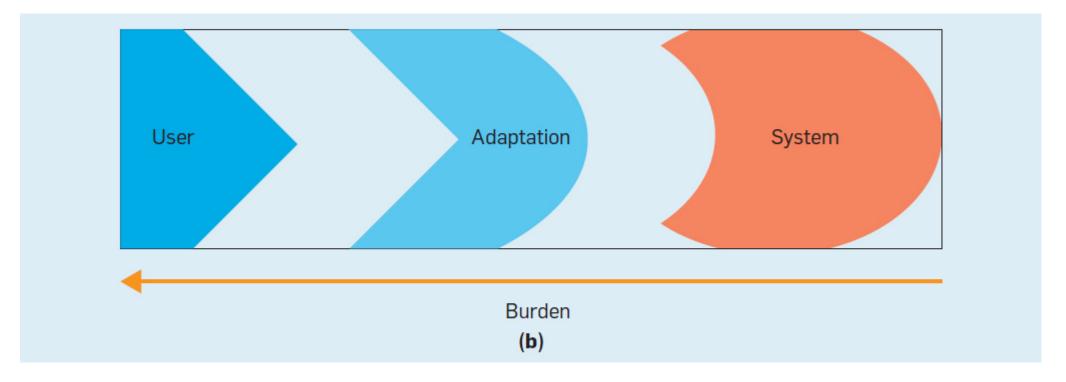
Problem 1: **Ability Assumptions** produce static systems

Ability Assumptions



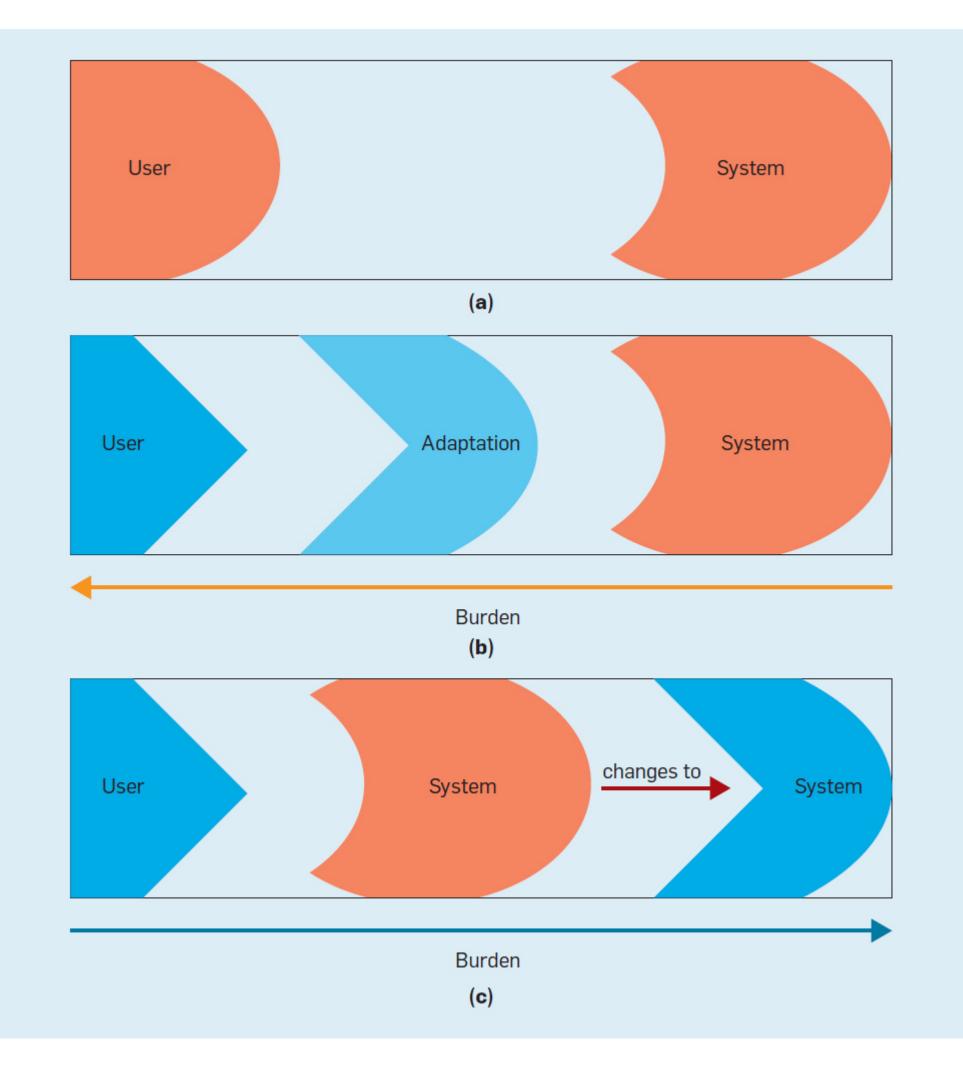
(Wobbrock et al) https://cacm.acm.org/magazines/2018/6/228034-ability-based-design/fulltext

Ability Assumptions



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

Ability Assumptions

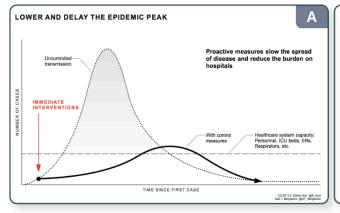


(Wobbrock et al) https://cacm.acm.org/magazines/2018/6/228034-ability-based-design/fulltext

blind people) limits what we can do

Problem 2: **Centering research** and development on screen readers (not

Descriptions



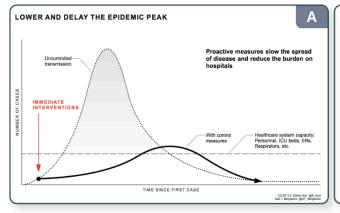
A multi-line chart entitled "Lower and Delay the Epidemic Peak" that plots the Number of Cases by the Time Since First Case. The Number of Cases is plotted on the vertical y-axis. The Time Since First Case is plotted on the horizontal x-axis. The chart shows two possible extremes of the rate of rise and decline of COVID-19 cases. If the transmission is uncontrolled, there are more simultaneous cases. If the transmission is controlled, there are fewer simultaneous cases. If the transmission is controlled, the healthcare system can support all the cases.

The purpose of the chart is not to provide exact numbers, but to communicate to the public that there are multiple ways the current crisis can play out. Without control measures the spread of the disease increases exponentially, making it harder to slow down and creating a big overload in the healthcare system. The number of cases is dramatically higher without controls, and this will likely lead to many deaths. In contrast, when controlled, the healthcare system capacity can handle all of the cases over a longer period of time, and this will save lives.

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.

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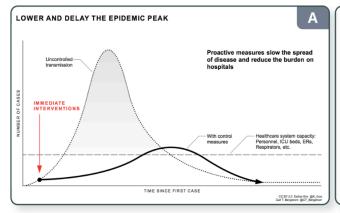
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Image source

Structure B. Dual tree schema design A. Raster (png) visualization **D. Schema instantiated** Major trophies for some English teams start 🧹 start 🖒 🔵 BPL 🛛 🖷 FA Cup 👘 CL •(legend)**∢ →**(yaxis)∢ title end title -→(x axis) axis item **C. Keyboard** navigation rules ESCAPE exits the LEFT/RIGHT move structure Press ENTER to mov axis item axis item end PERIOD moves back to any child item Press L to move out, towards the Press BACKSPACE user's last location to move out, towards the x axis any node any node legend item

Descriptions



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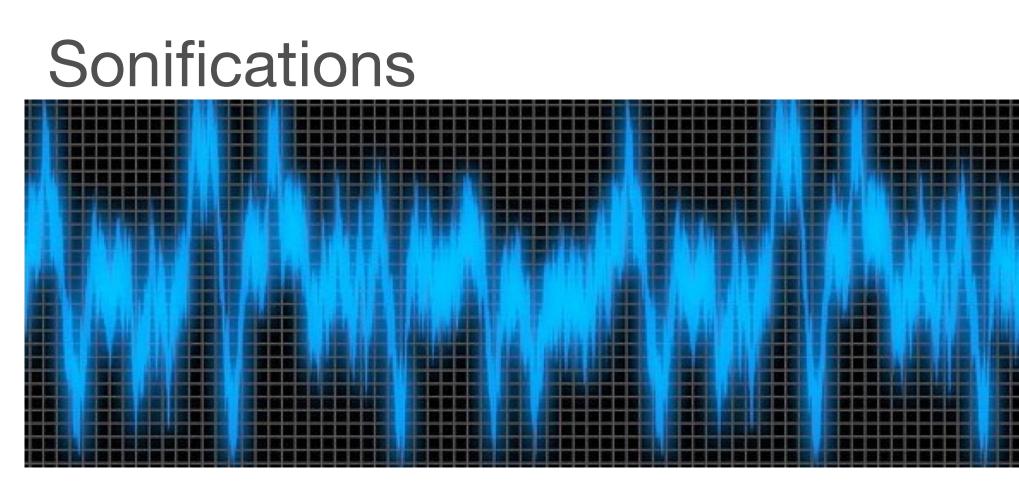
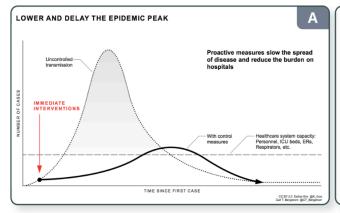


Image source

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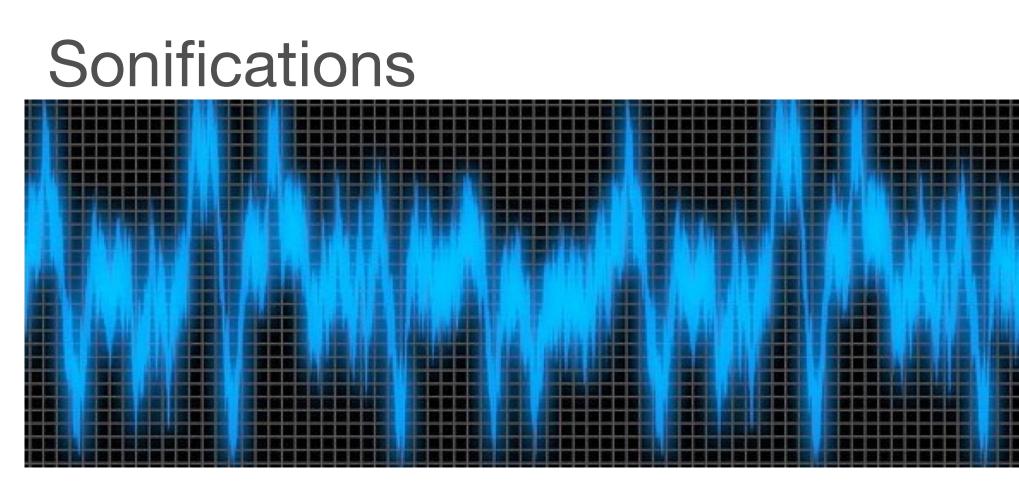
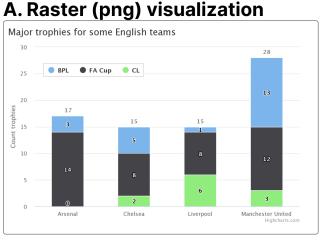


Image source

A. Raster (png) visualization B. Dual tree schema design



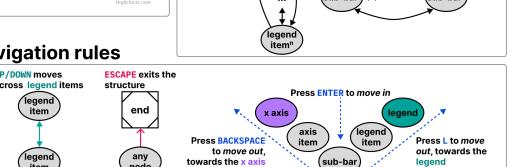
C. Keyboard navigation rules

axis item

any node axis item

PERIOD moves back to

user's last location



start

title

D. Schema instantiated

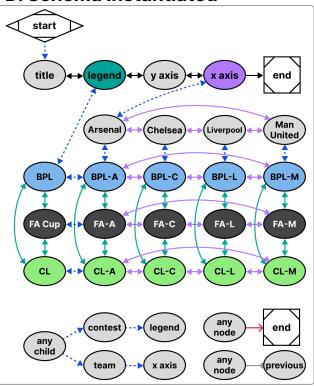
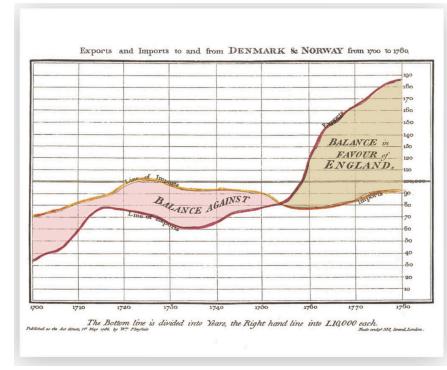
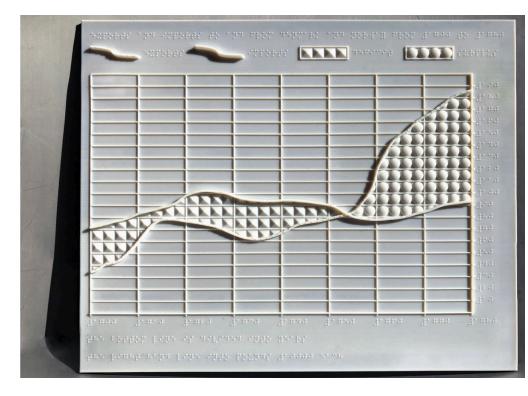


Image source

(legend) ↔ (yaxis) ↔ (xaxis)

Tactiles





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

But screen readers processes 1 input at a time



 \equiv

WikipediA

The Free Encyclopedia

(disambigu,-**---)

The cat (*Felis* species in the f domestication (and farm cat, b companionship prey like mice a

67 Nav points ~32s

sense of smell are well developed. It is a social species, but a solitar Cat communication includes vocalizations like meawing, purring, trill as well as cat body language. It can hear sounds too faint or too high as those made by small mammals. It also secretes and perceives ph

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 pets has resulted in large numbers of feral cats worldwide, contributing to the extinction of bird, mammal

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	Pood View courses , Teele
at, is the only domesticated have shown that the	Cat Temporal range: 9,500 years ago – present
monly kept as a house pet is valued by humans for it is adapted to killing small eth, and its night vision and	
r and a crepuscular predator. sing, growling, and grunting	
uency for human ears, such	
nes.	STATE IN
erate zones and throughout	
kittens. Domestic cats are	

Movement between tasks becomes cognitively expensive



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WikipediA

The Free Encyclopedia

From Wikipedia, the free encyclopedia

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Car

67 Nav point ~32s

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cat family, see Felidae. For other uses,	see Cat (disambiguation) and Cats
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at, is the only domesticated	
have shown that the	Cat
monly kept as a house pet	Temporal range: 9,500 years ago – present
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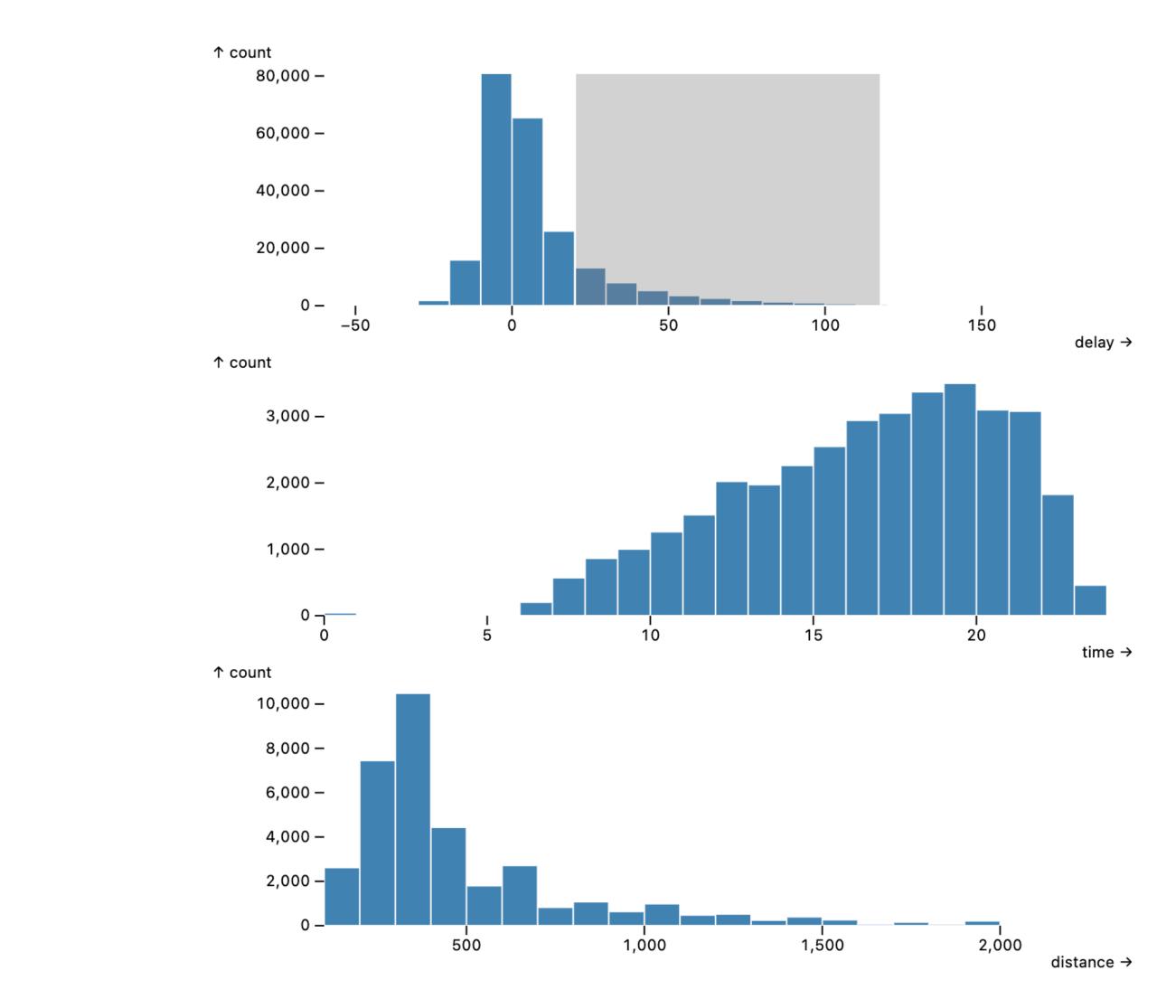
Auditory processing struggles with dual-task paradigms*

*Citation

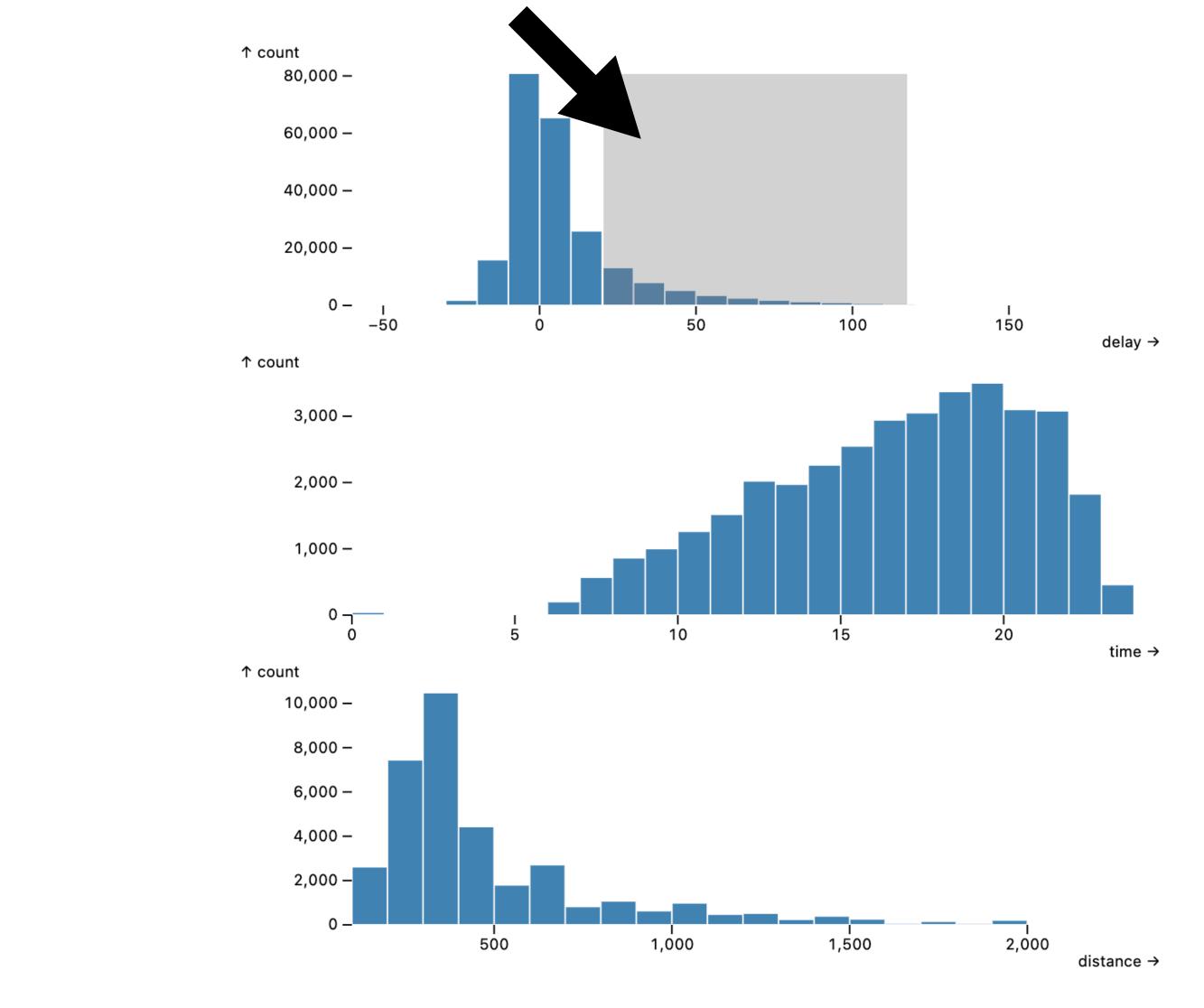
So what about cross-filtering?

Interactive link

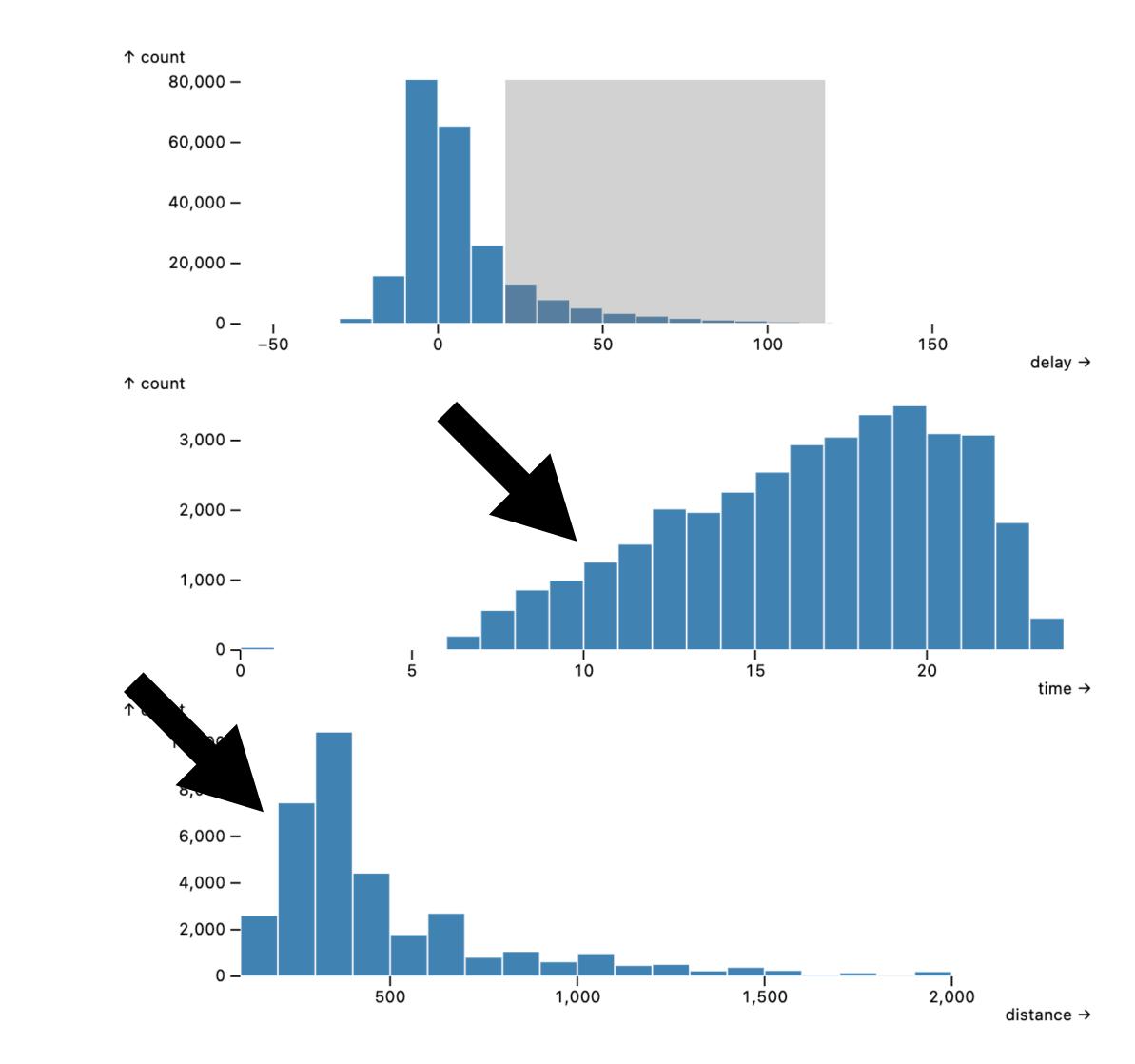
So what about cross-filtering?



Interaction in one space...



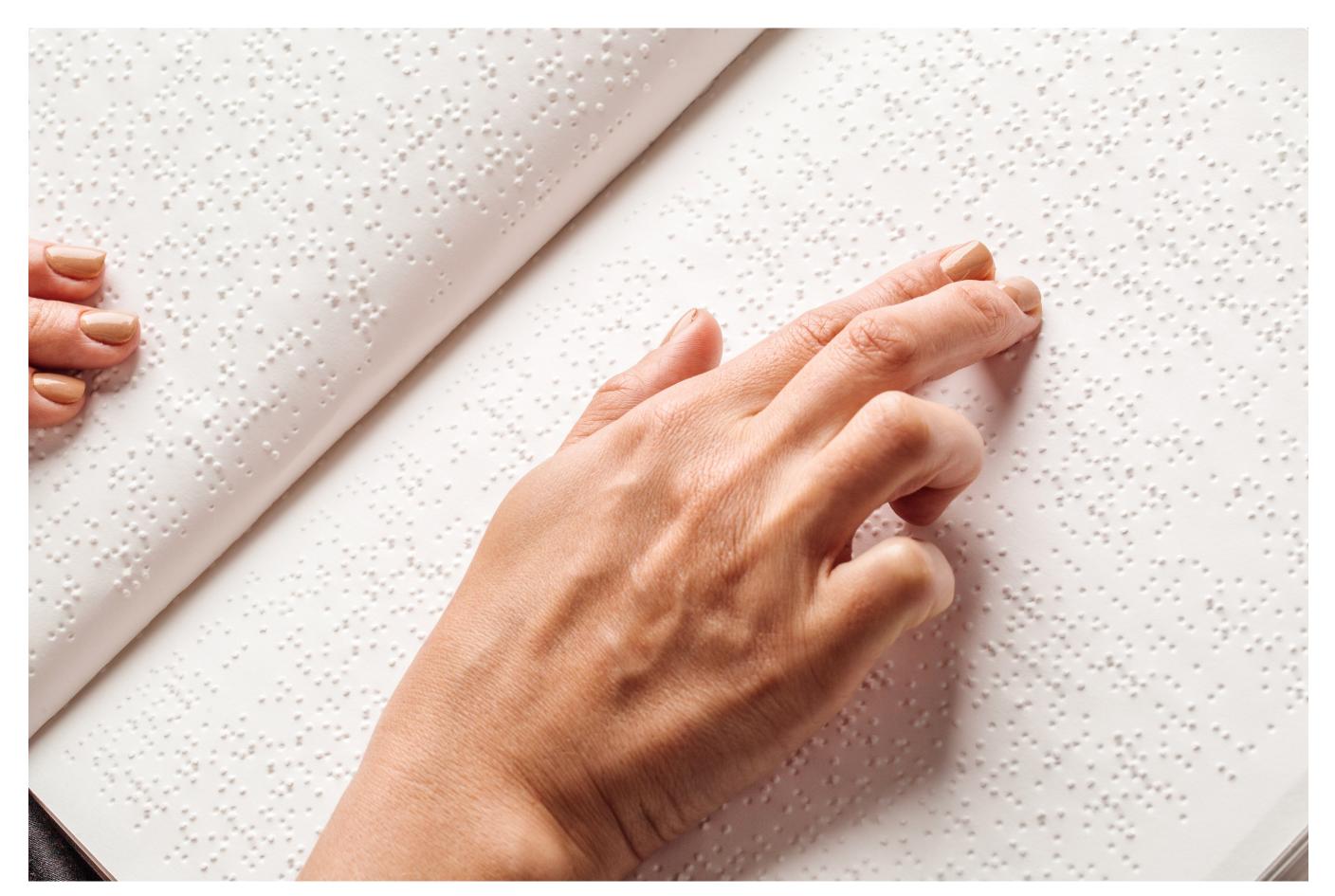
Produces simultaneous, coordinated change in another.



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

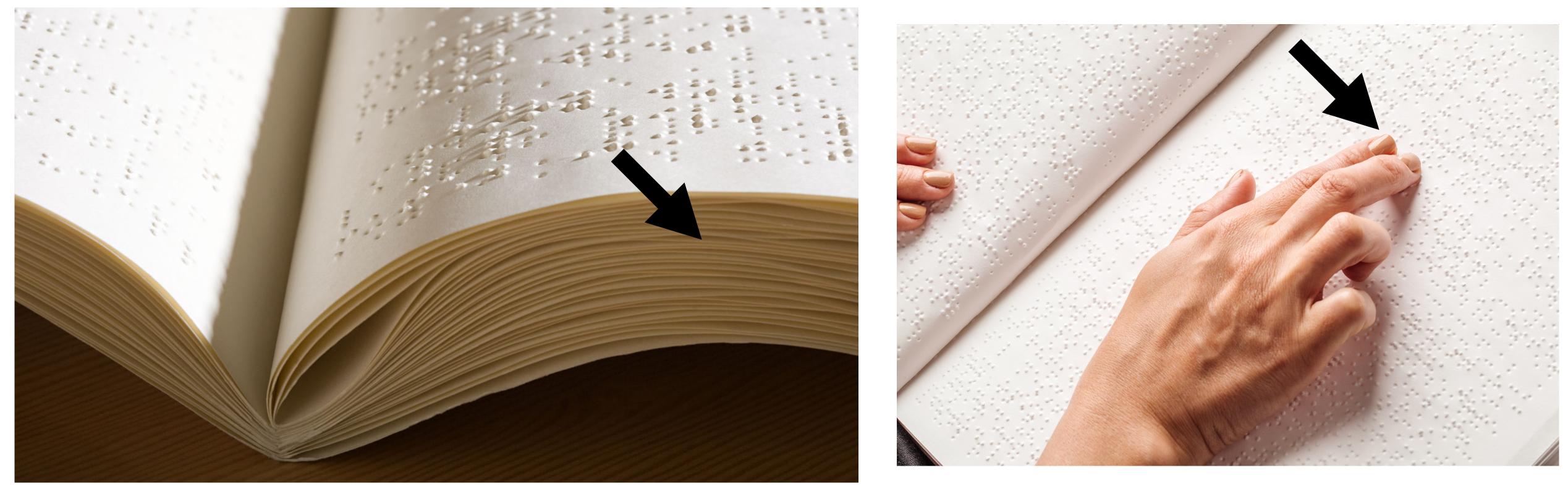
Preliminary research question: How do blind people interact with *multiple* tactile media simultaneously?

Observing: Embossed braille in a research context



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.



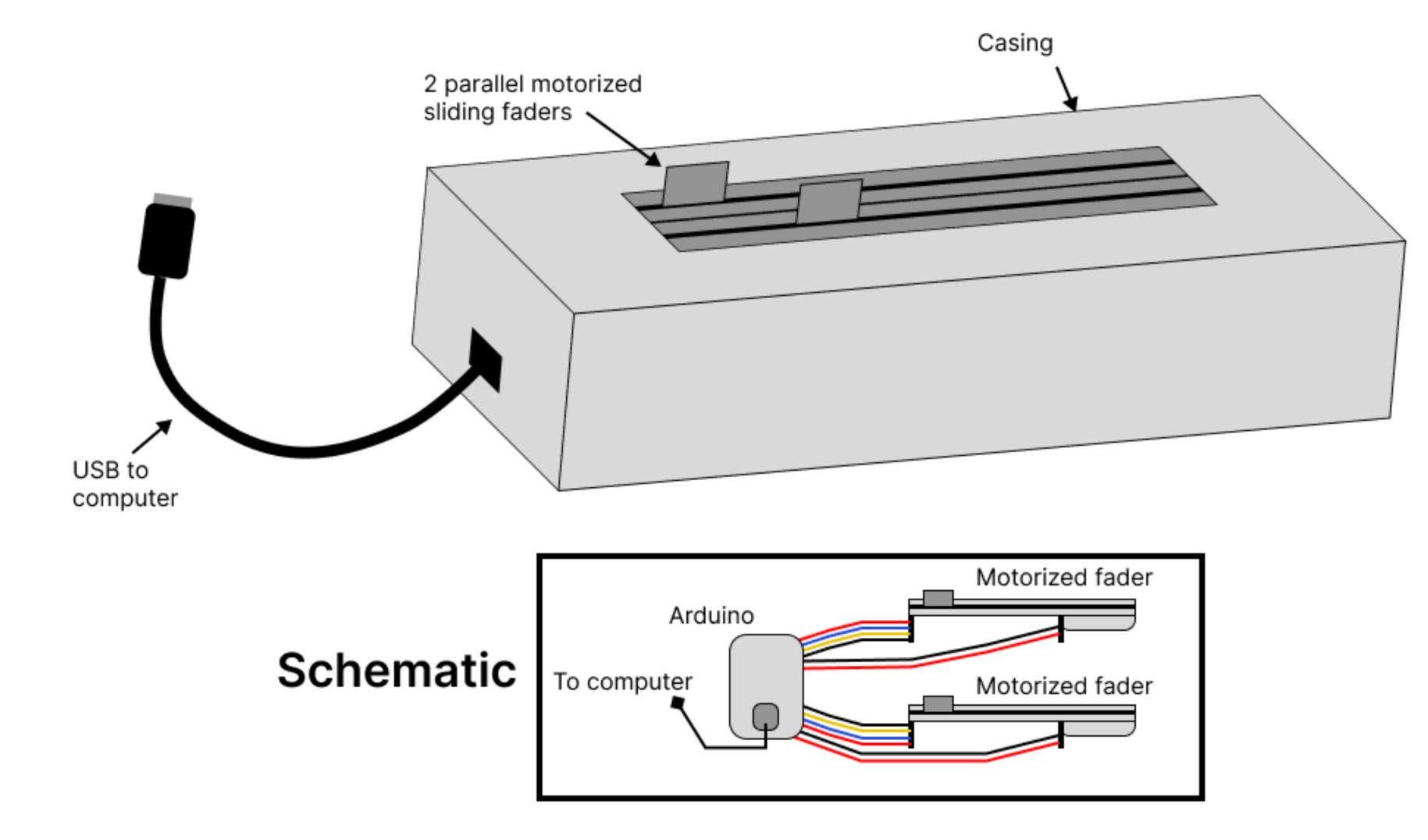
Observation 2: Coordinating perception and comparison

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



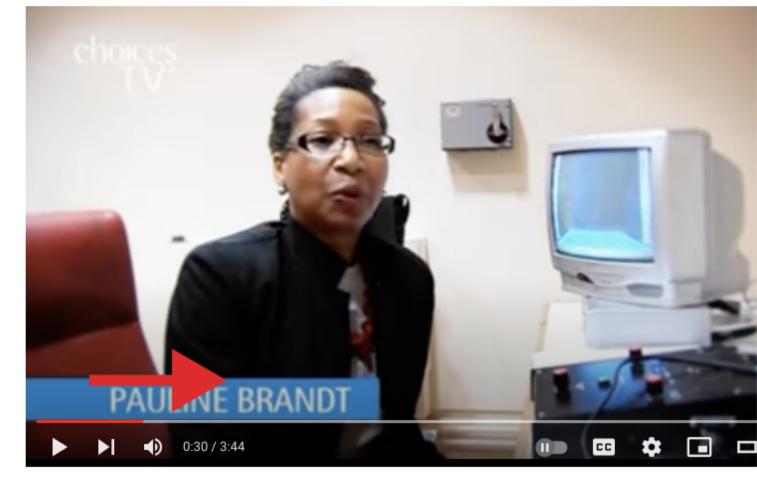


Prototype 2: the cross-feelter, 2 motorized faders

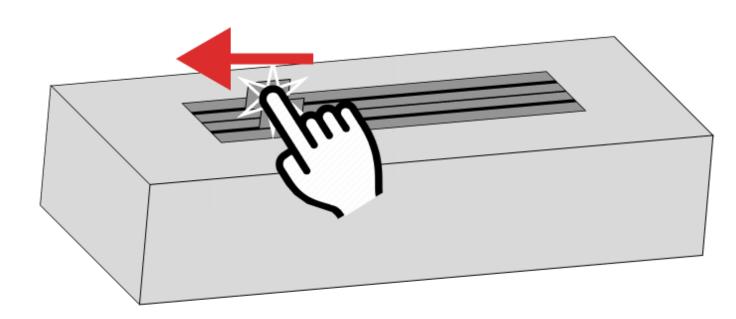


One slider can work with video

1. Video plays with progress slider moving

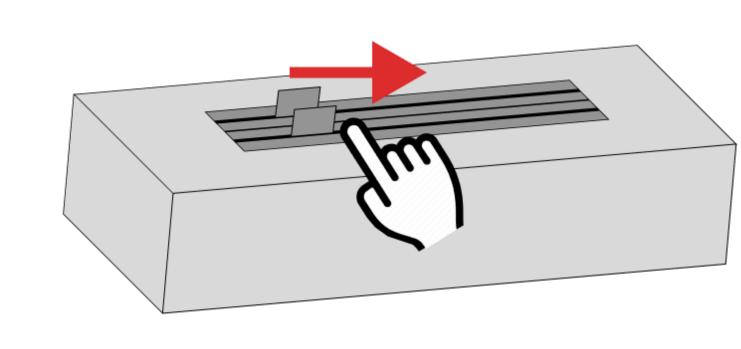


3. User can move slider

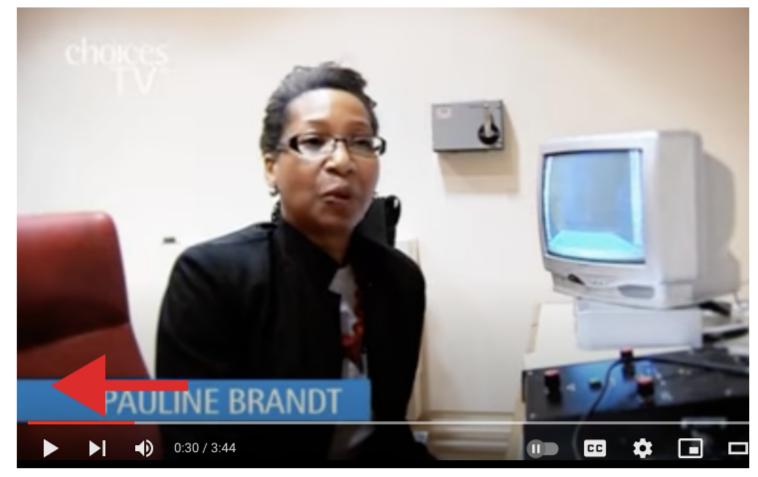




2. Slider follows, can be felt

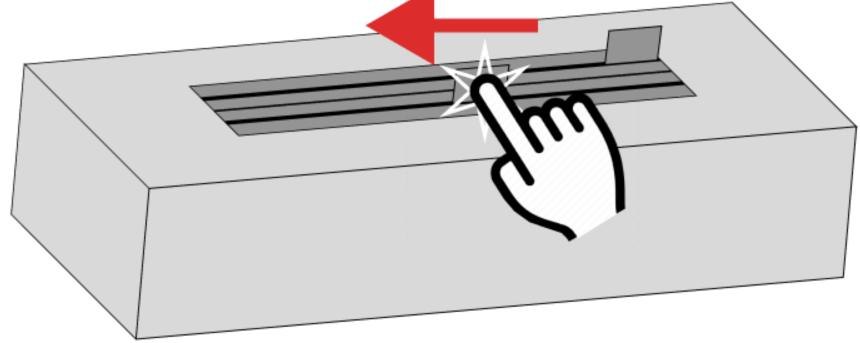


4. Video slider will move with slider change

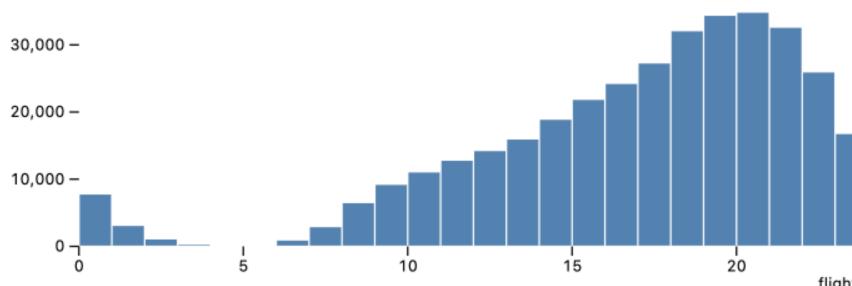


While 2 sliders works for cross-filtering

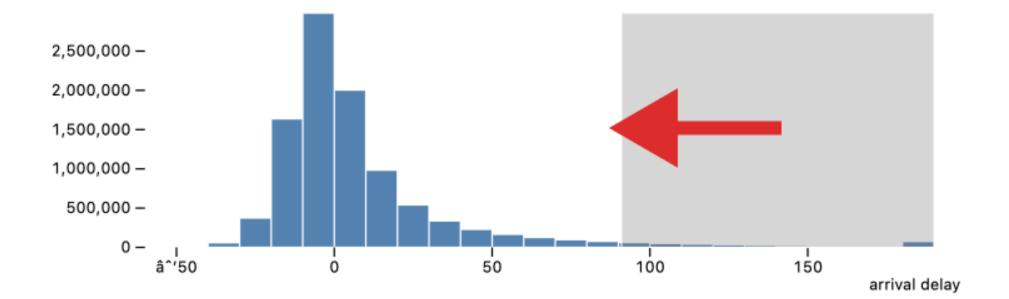
1. User moves a slider



3. Secondary visualization updates



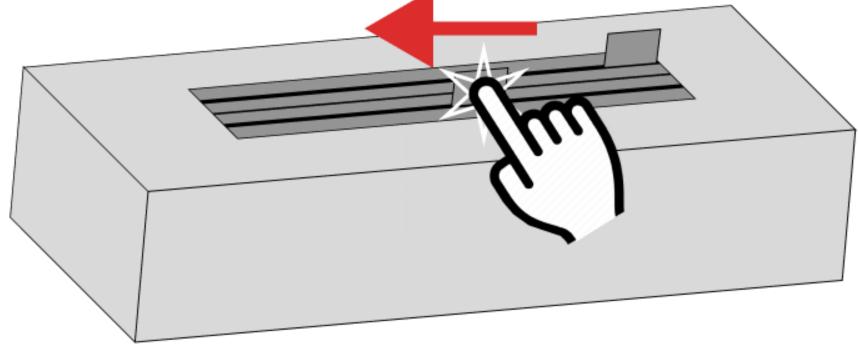
2. Corresponding filter edge moves with



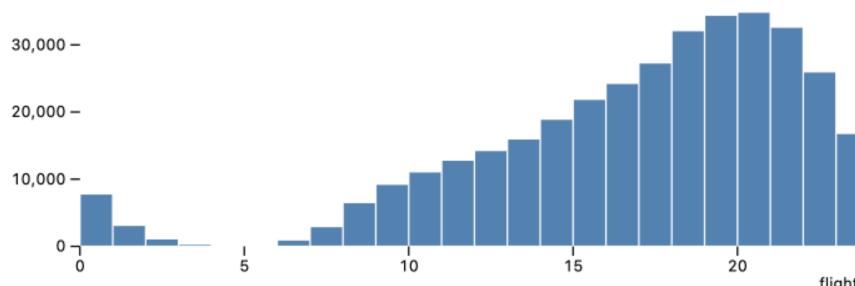
flight time

A tactile display can render the input or output chart

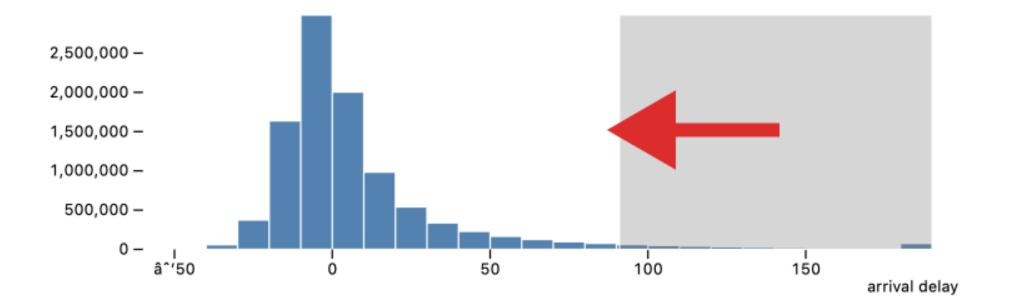
1. User moves a slider



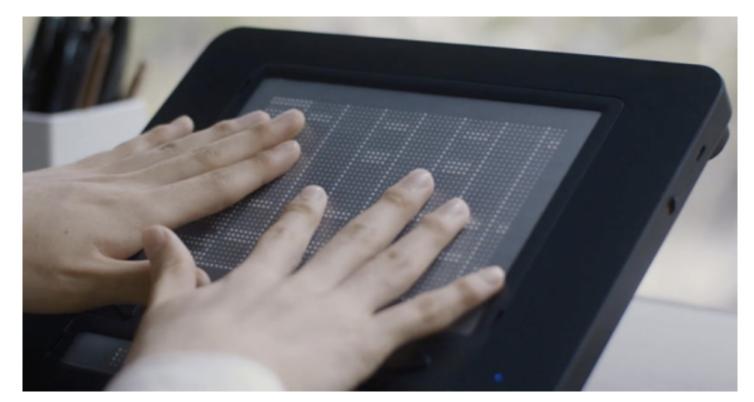
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2. Corresponding filter edge moves with



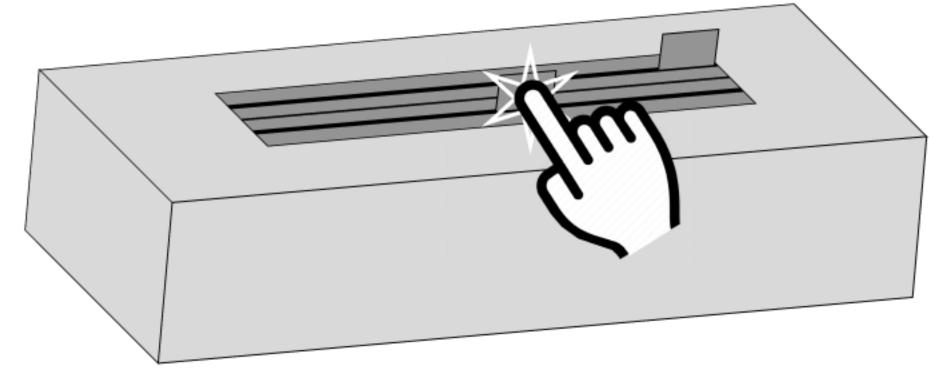
4. Tactile display renders

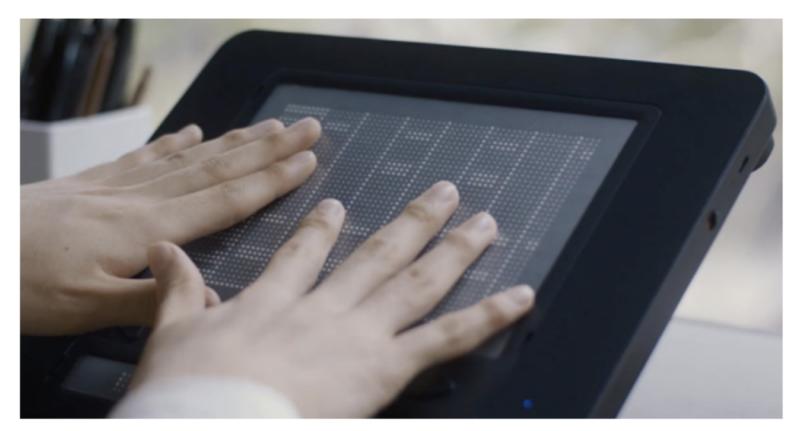


flight time

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

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



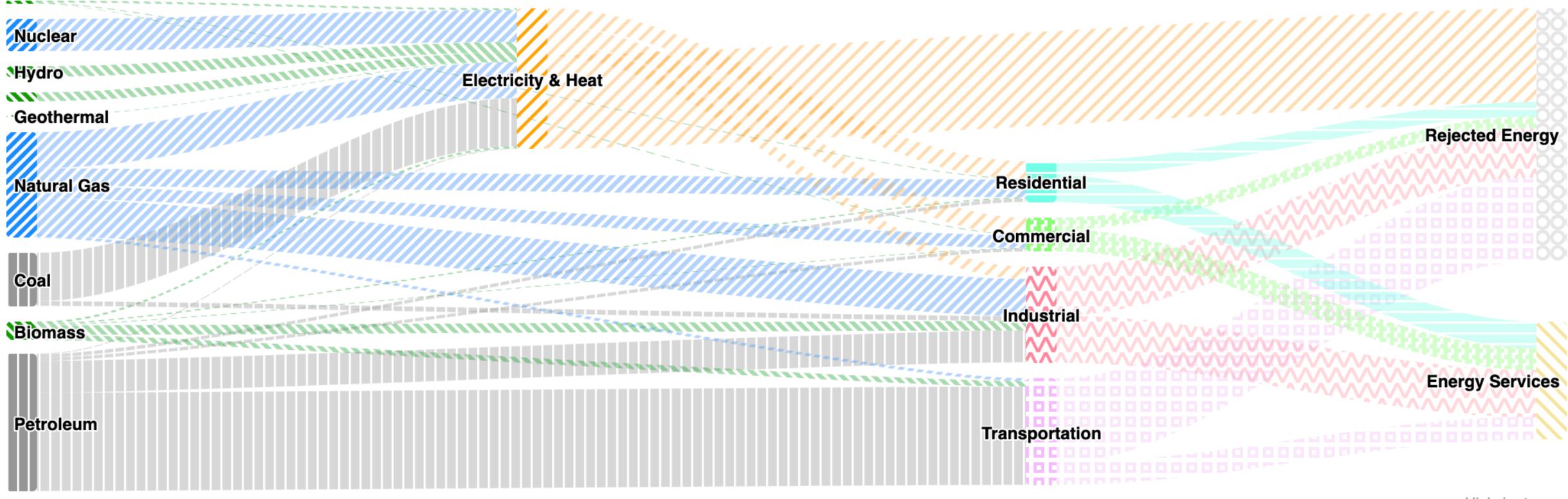


Problem 3: **Access Friction** is when accessibility for someone produces a barrier for others

What about this is accessible? Why?

Estimated US Energy Consumption in 2017

Source: Lawrence Livermore National Laboratory



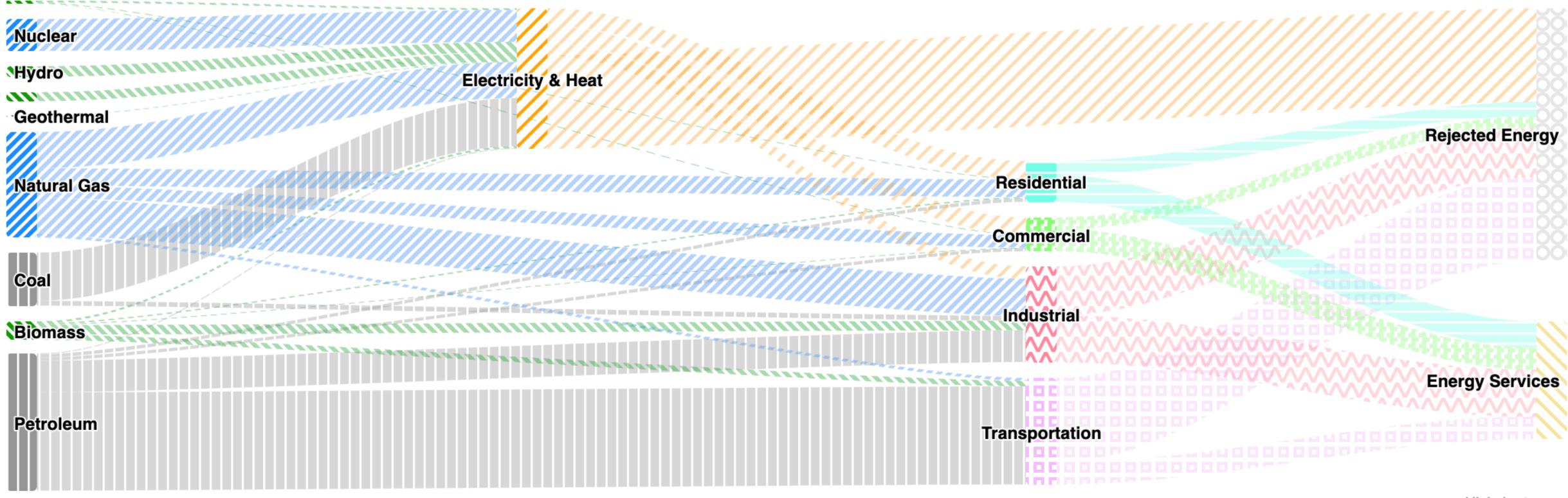
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

Highcharts.com

What about this might be a barrier? Why?

Estimated US Energy Consumption in 2017

Source: Lawrence Livermore National Laboratory



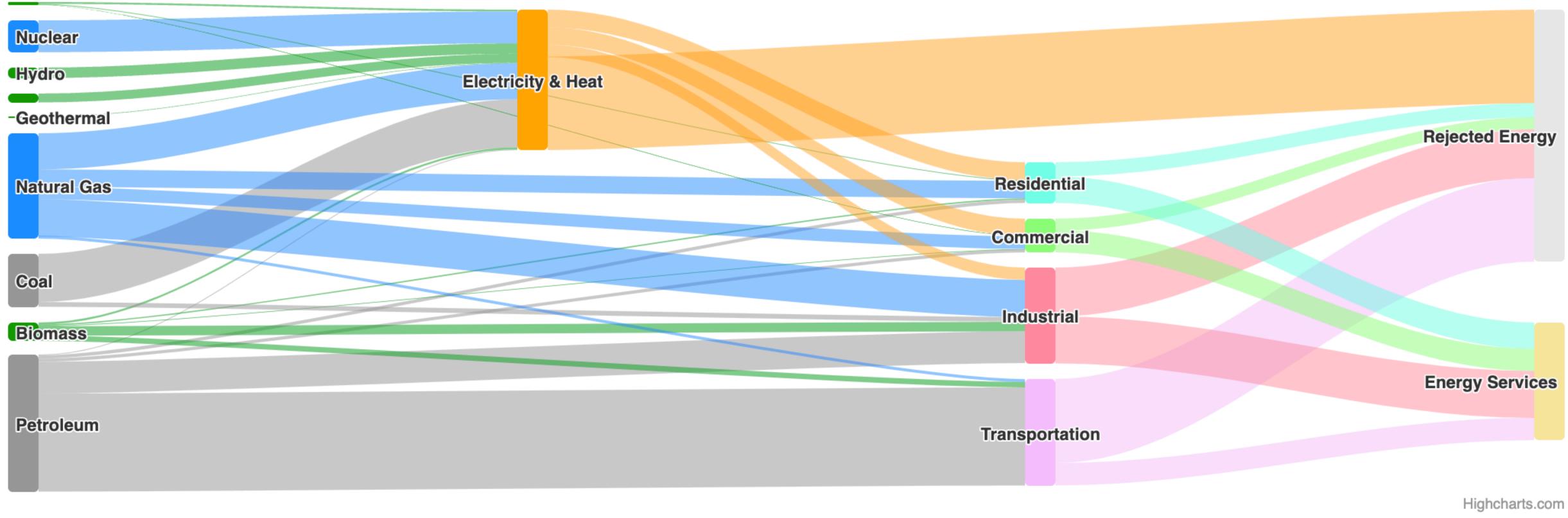
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Highcharts.com

What about this now might be a barrier?

Estimated US Energy Consumption in 2017

Source: Lawrence Livermore National Laboratory

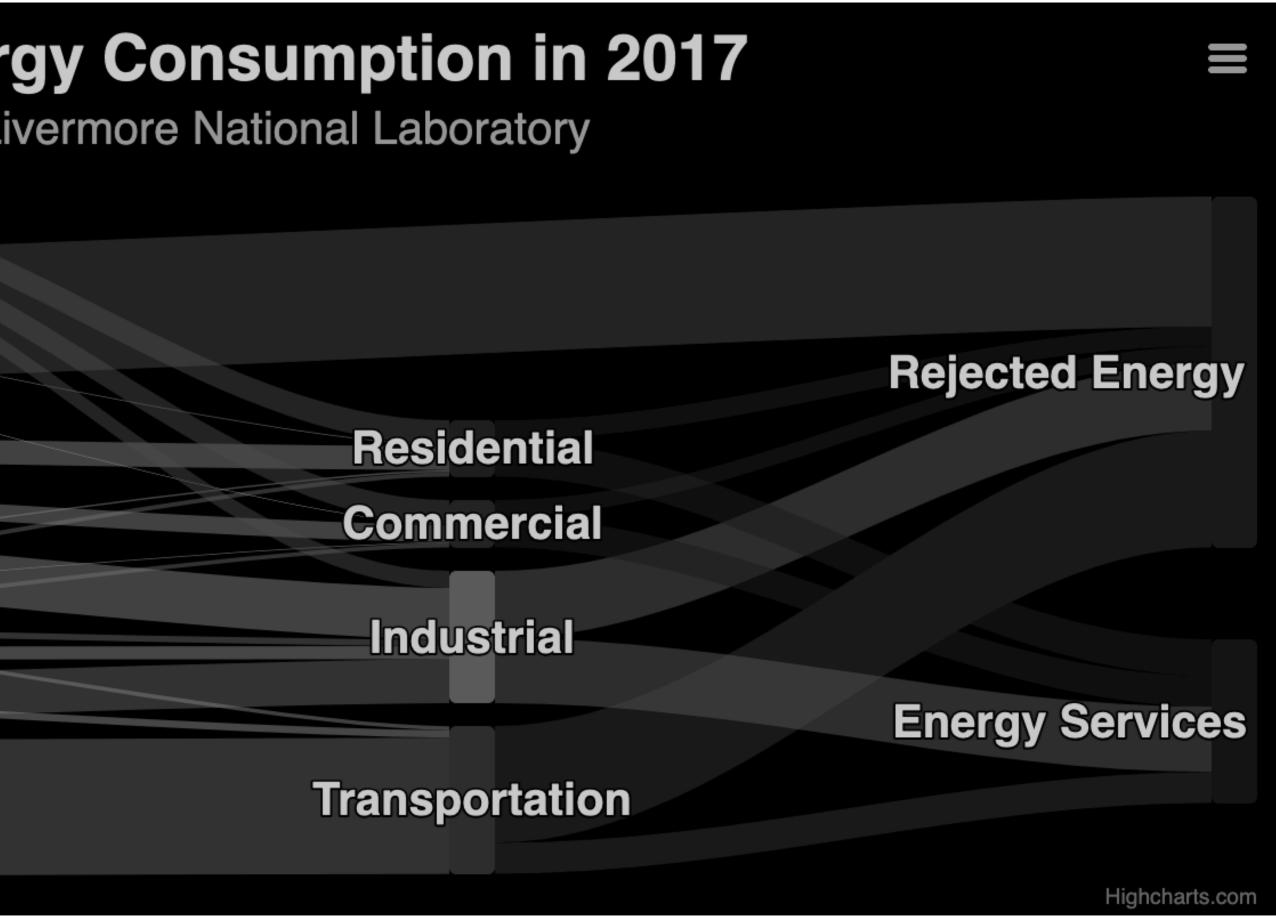


Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

So some folks use tools to hack what they want

	Estimated US Ener Source: Lawrence Li
Nuclear -Wind	Electricity & Heat
Natural Gas	
Coal	
Petroleum	

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

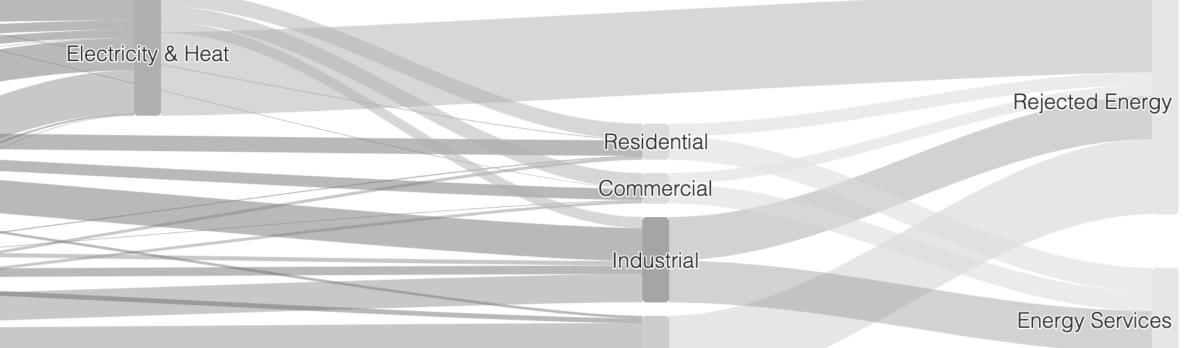


What if we let users hack the design?

Preferences	
Hide unavailable options 🗸	Nuclear
▼ Comprehension	Nuclear
default moderate robust	Wind
$\bigcirc \qquad \bigcirc \qquad \bigcirc$	
Alt text appearance	Natural Gas
default show high level show all	
$\bigcirc \qquad \bigcirc \qquad \bigcirc$	Coal
Description verbosity	Biomass
default disable minimal verbose	
\bigcirc \bigcirc \bigcirc \bigcirc	Petroleum
▼ Text	
default minimalist moderate maximalist	
$\bigcirc \bigcirc \bigcirc \bigcirc \bigcirc$	Energy Sources
▼ Font Size	Geothermal 0.21
default small medium large	Solar 0.77
\bigcirc \bigcirc \bigcirc \bigcirc	Wind 2.35
Title	Hydro 2.76
	ium+ large Biomass 4.92
\bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc	Nuclear 8.42
Subtitle	Coal 13
default small small+ medium medi	ium+ large Natural Gas
$\bigcirc \bigcirc $	Petroleum
Series Labels	0 5 10 15
default small small+ medium med	ium+ large
$\bigcirc \bigcirc $	

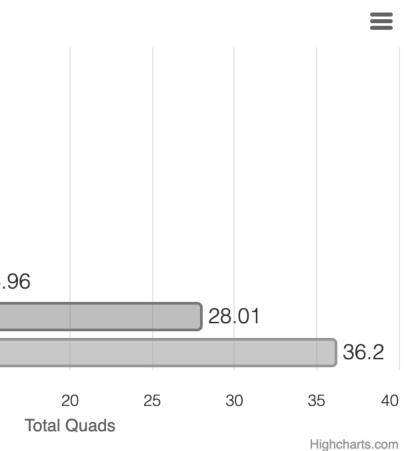
Estimated US Energy Consumption in 2017

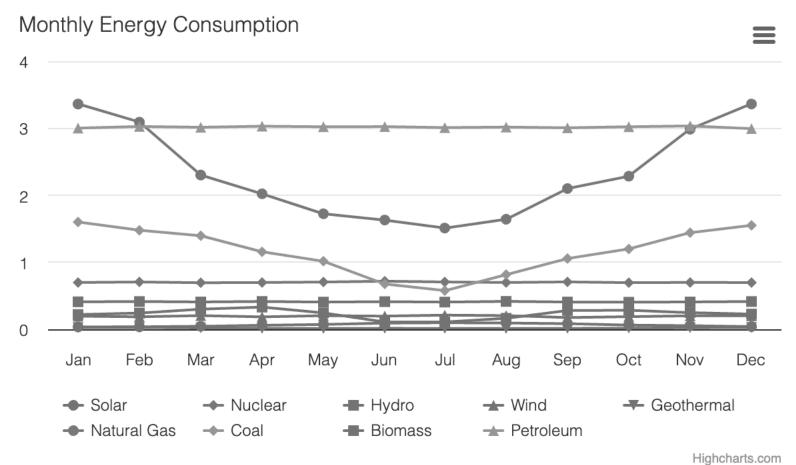
Source: Lawrence Livermore National Laboratory





Highcharts.com





Interactive demo link

2024

Looking to the future of accessible data interfaces HIGHJOFT



Frank Elavsky, PhD Student







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



