

Cross-*feel*tering: Exploring a coordinated, cross-interaction prototype for blind data interaction



Frank Elavsky, PhD Student



Human-
Computer
Interaction
Institute

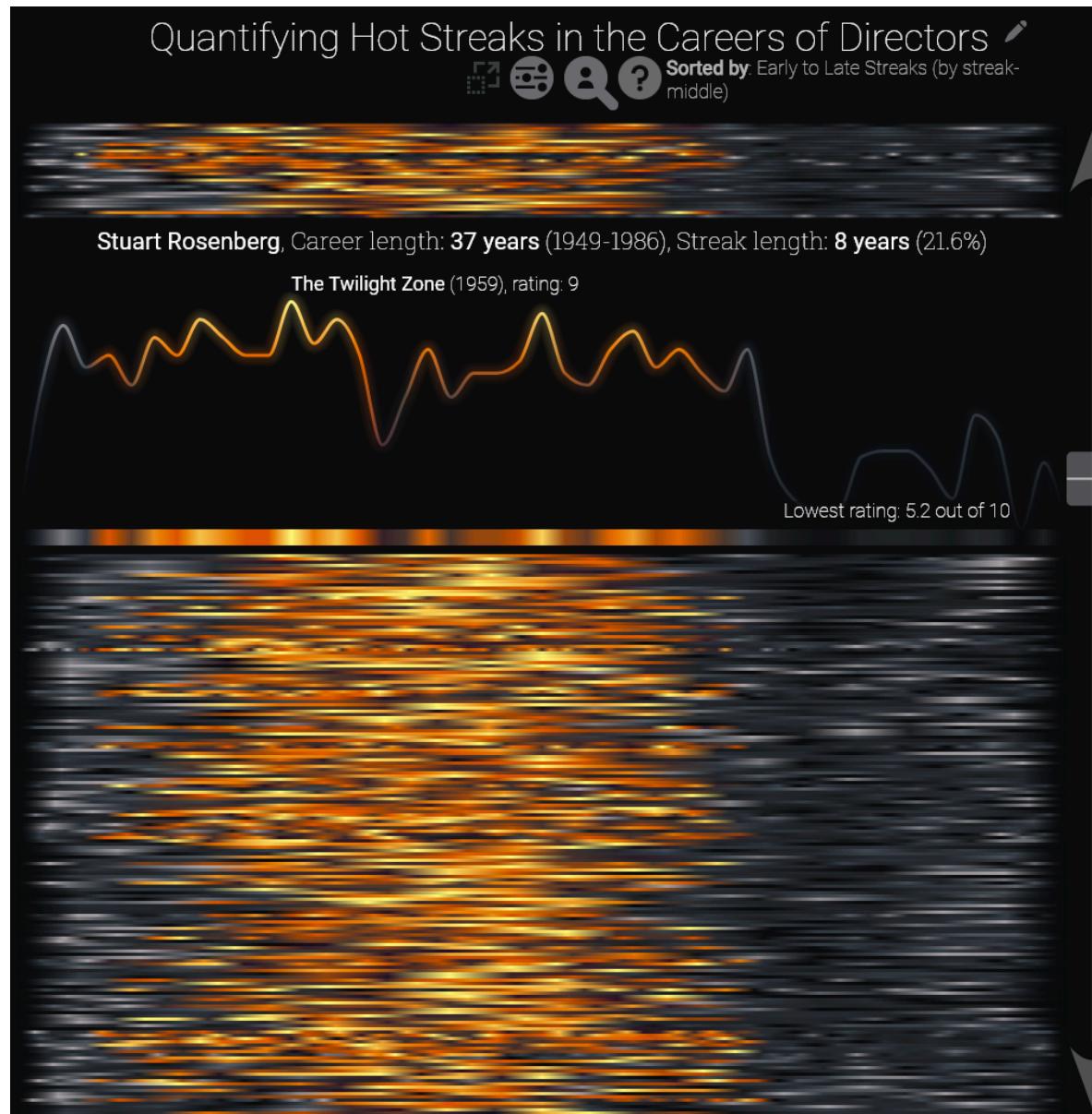


hcii.cmu.edu, axle-lab.com, dig.cmu.edu

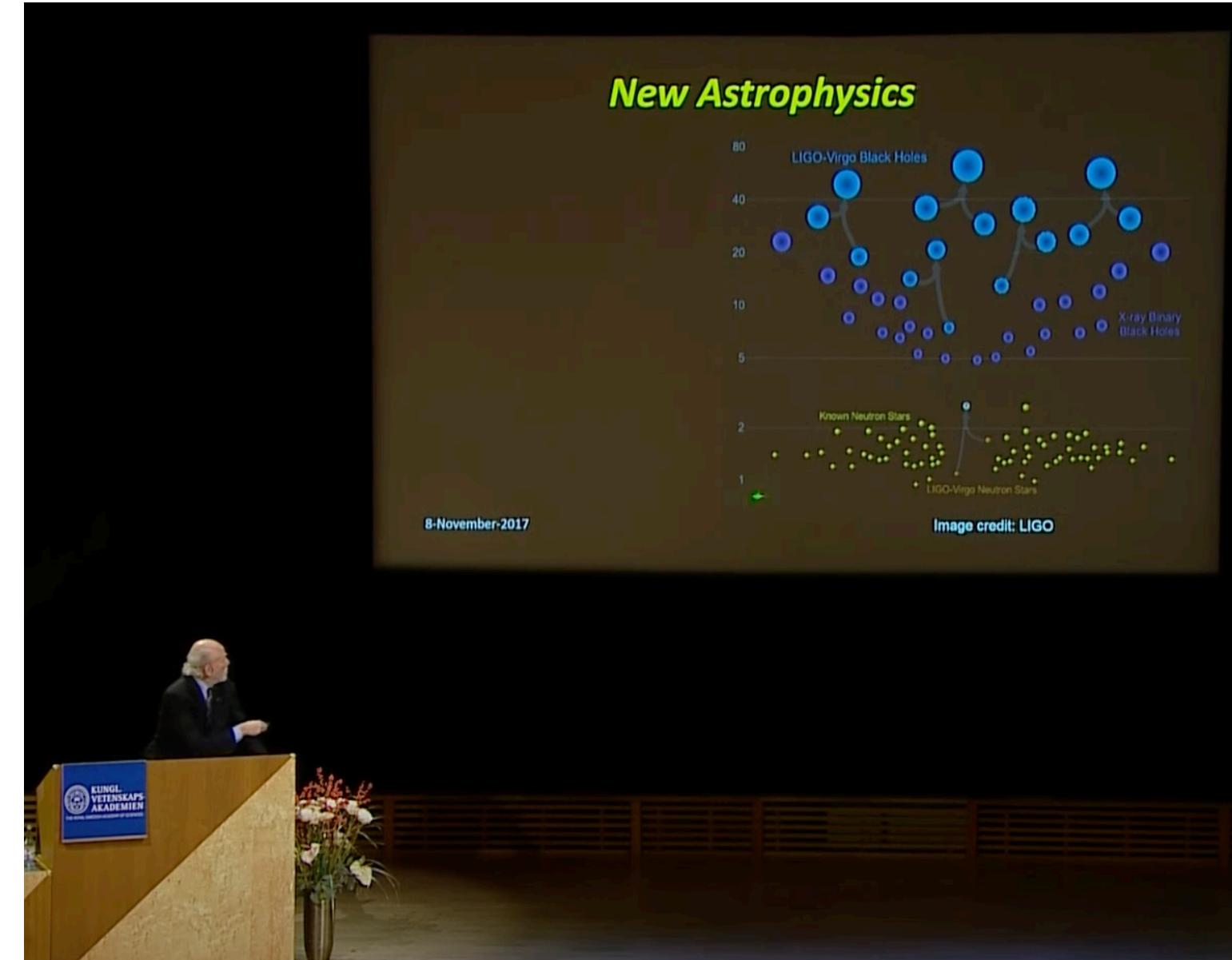
My pre-phd work in visualization

Industry and research engineering

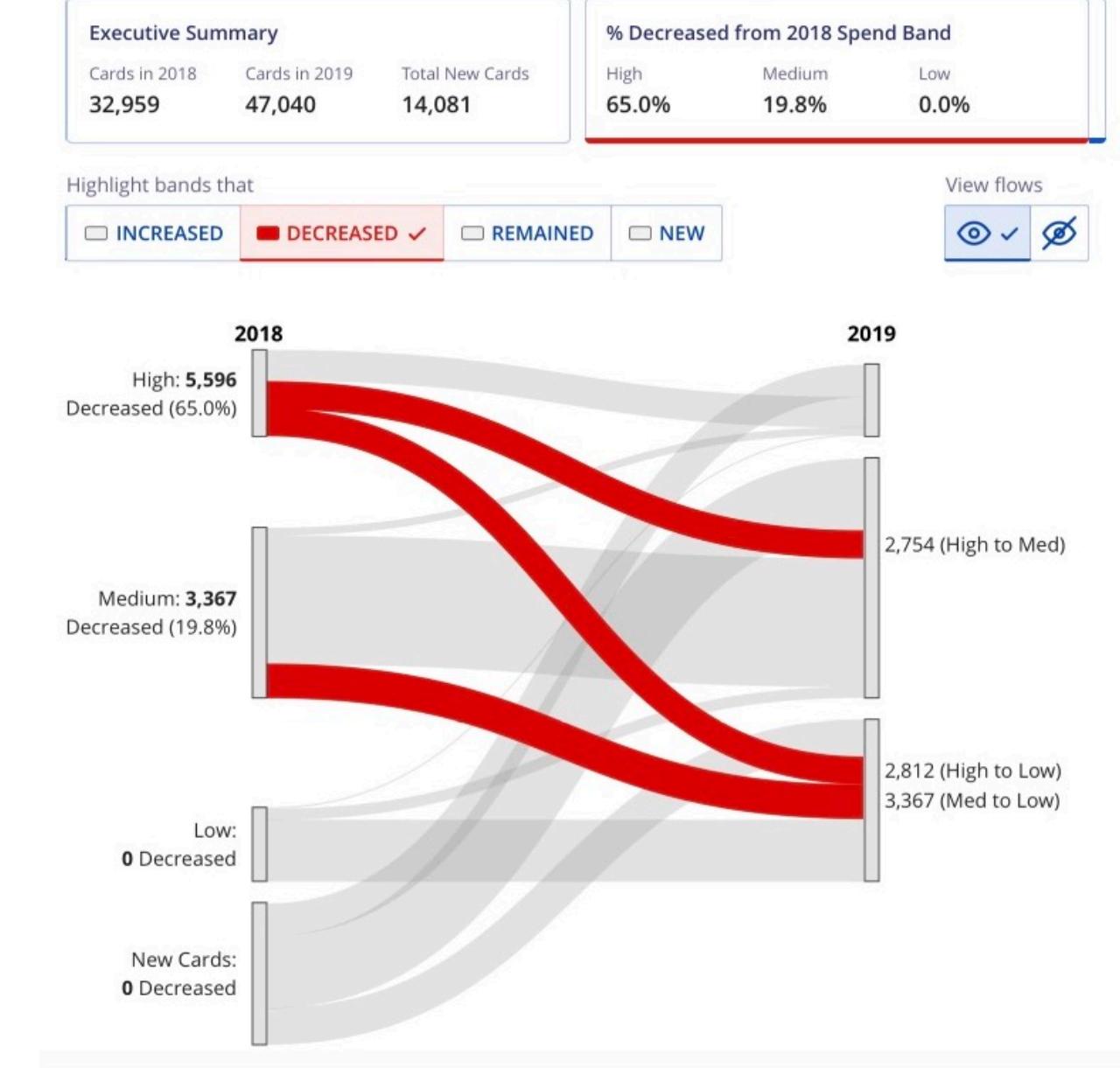
Dense model visualizations



Domain-specific visualizations



Data visualization library

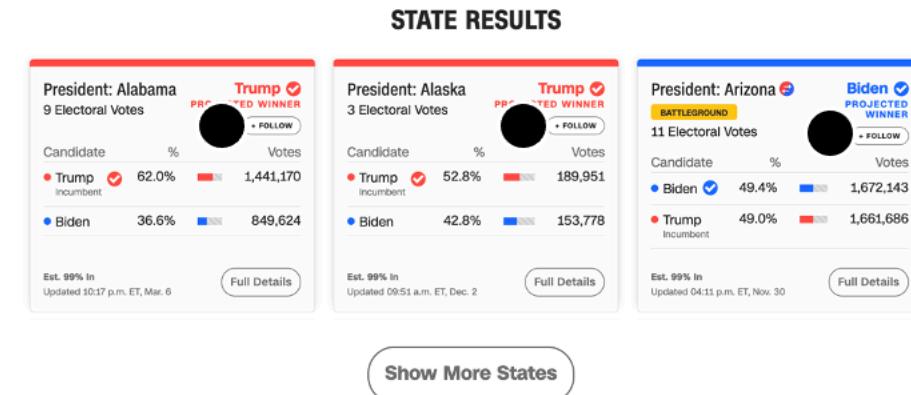
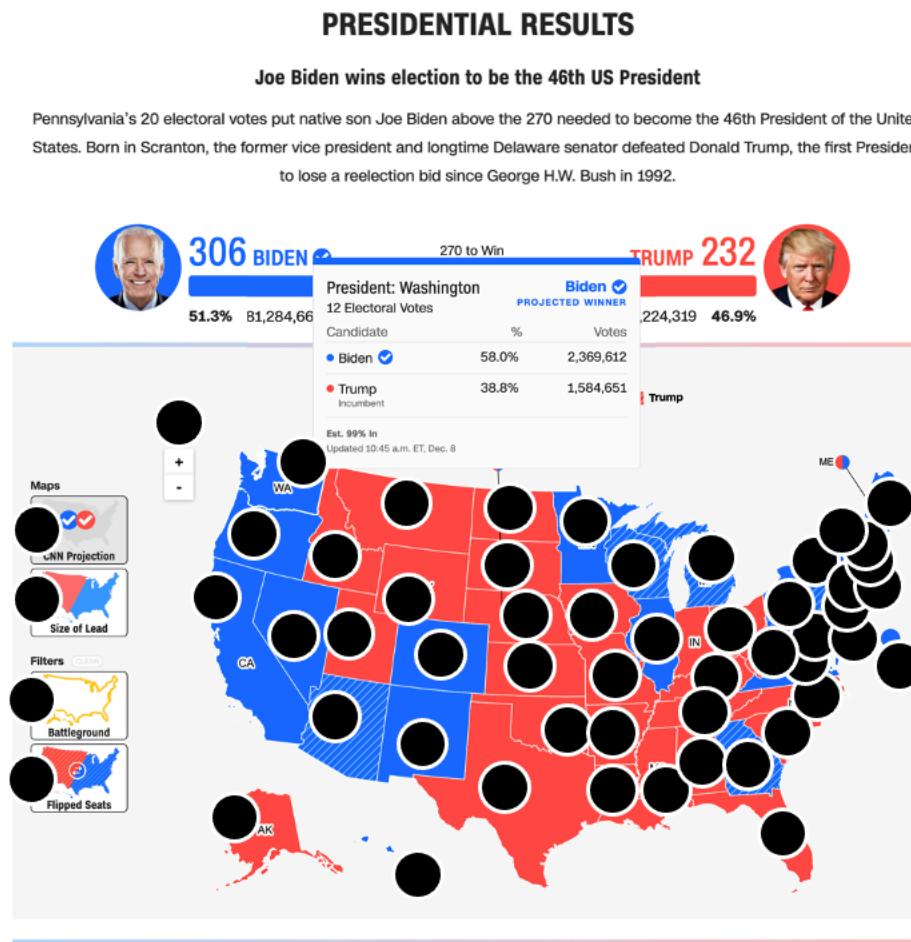


What and how of visualization accessibility

(My recent research)

Chartability:

What are accessibility barriers?



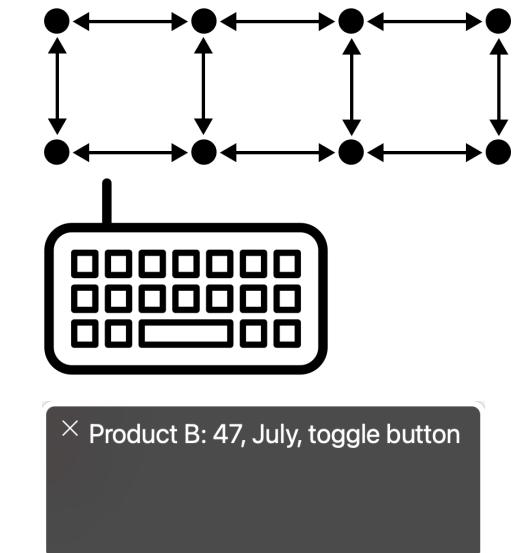
Data Navigator:

How do we build accessible visualizations?

Structure

Input

Rendering



To any visualization toolkit

What if we let users hack chart designs?

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

Estimated US Energy Consumption in 2017
Source: Lawrence Livermore National Laboratory

The Sankey diagram illustrates the flow of energy in the United States in 2017. Energy flows from various sources (Nuclear, Wind, Natural Gas, Coal, Biomass, Petroleum) through Electricity & Heat to residential, commercial, industrial, and transportation sectors. A significant portion of energy is also rejected as waste.

Energy Sources

Monthly Energy Consumption

Source	Consumption (Quads)
Geothermal	0.21
Solar	0.77
Wind	2.35
Hydro	2.76
Biomass	4.92
Nuclear	8.42
Coal	13.96
Natural Gas	28.01
Petroleum	36.2

Total Quads

Highcharts.com

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Legend:

- Solar
- Natural Gas
- Wind
- Hydro
- Biomass
- Coal
- Petroleum
- Geothermal

Highcharts.com

[Interactive demo link](#)

4

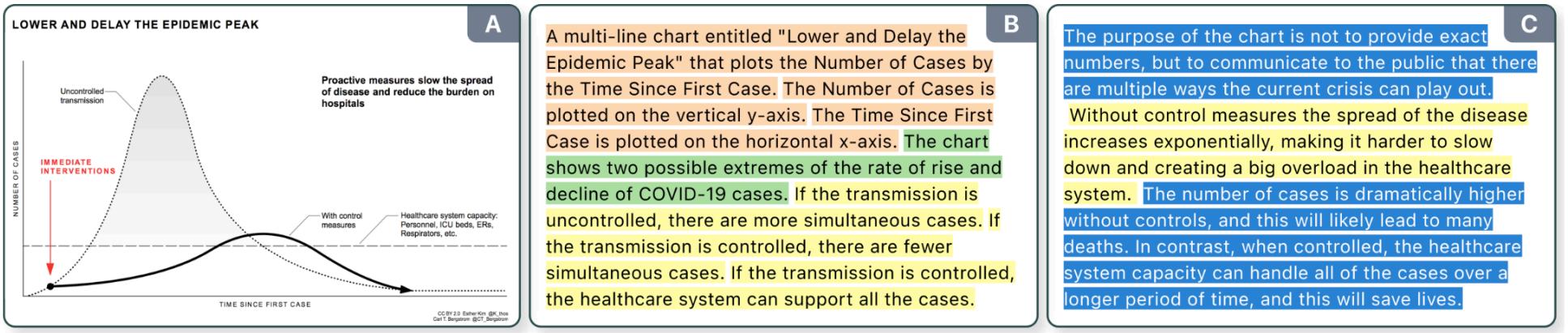
HIGHSOFT

Highcharts.com

Accessible data *representation*

Accessible data representation

Descriptions



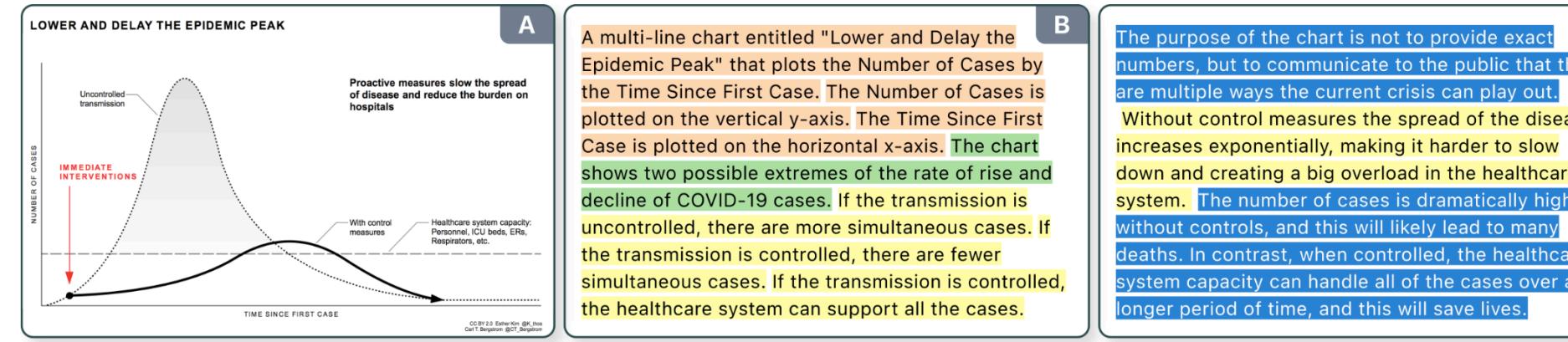
Long Description

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

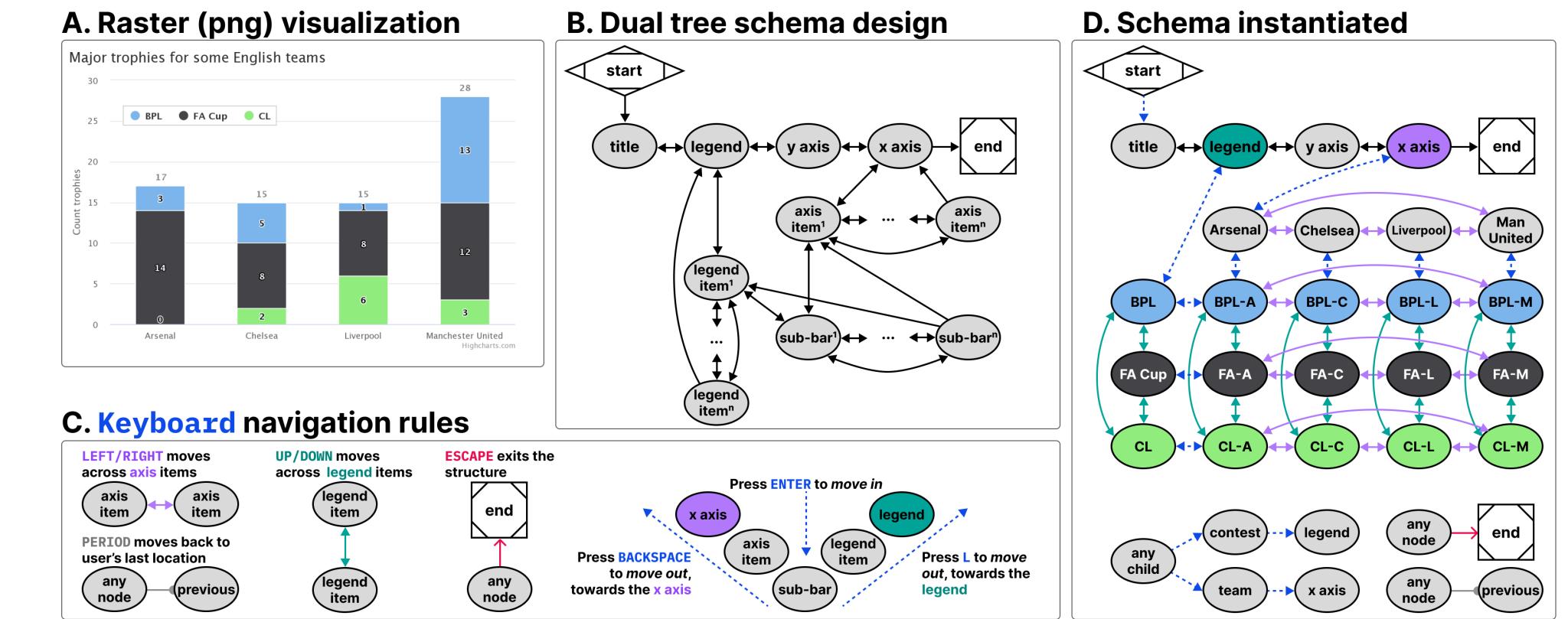


Long Description

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](#)

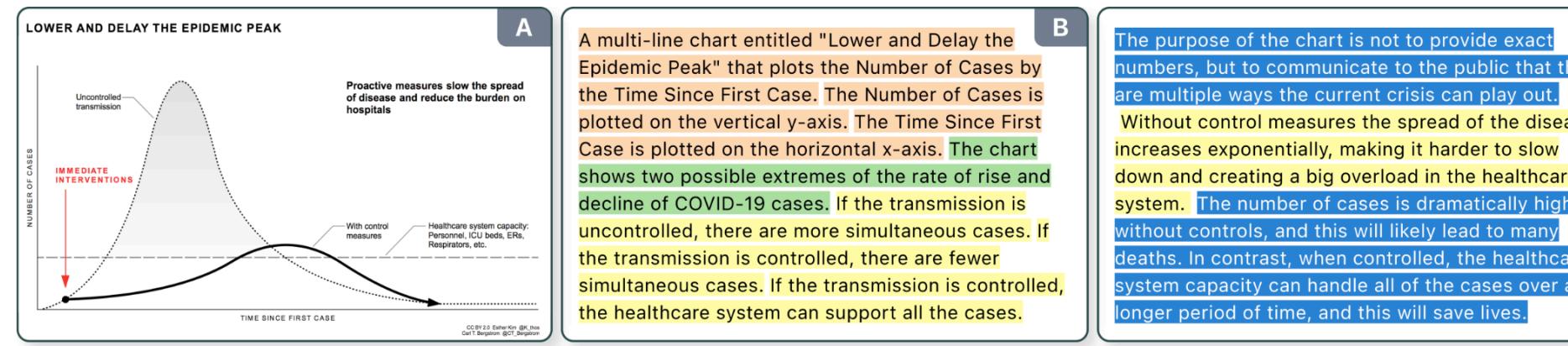
Structure



[Image source](#)

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

Structure

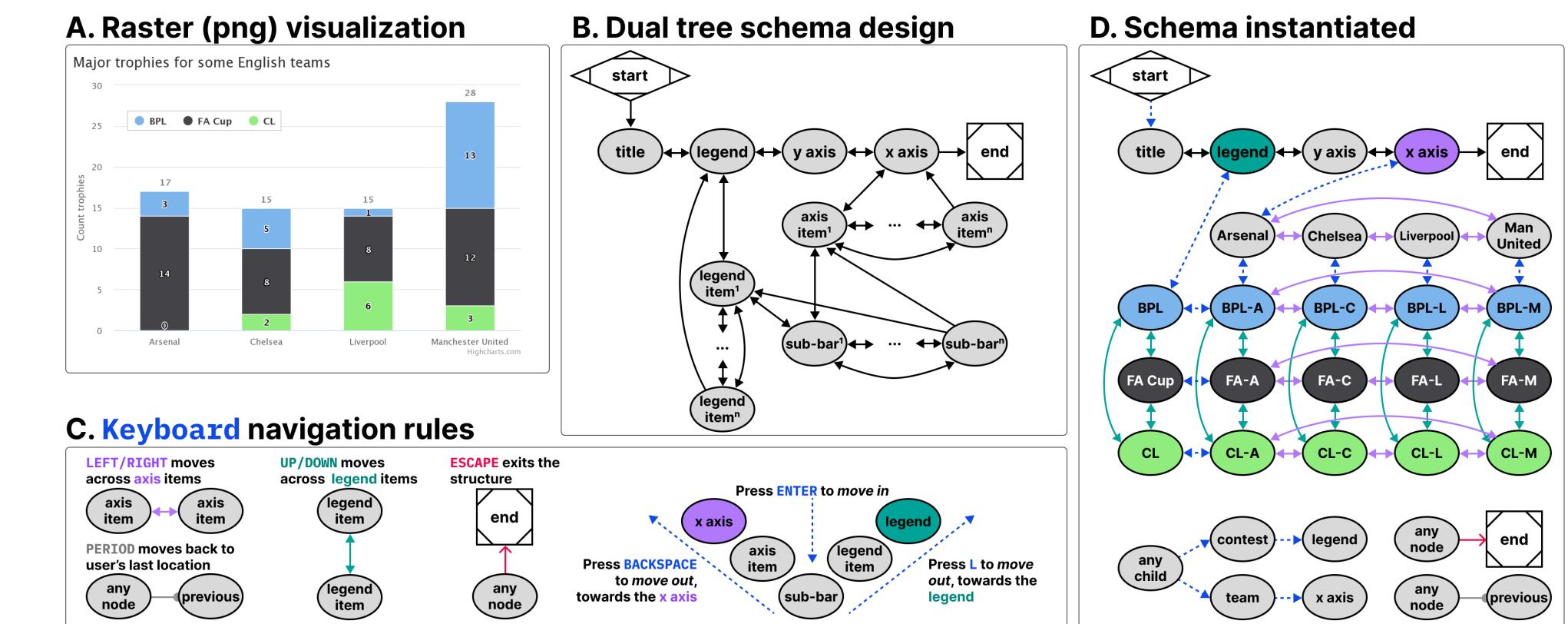


Image source

Sonifications

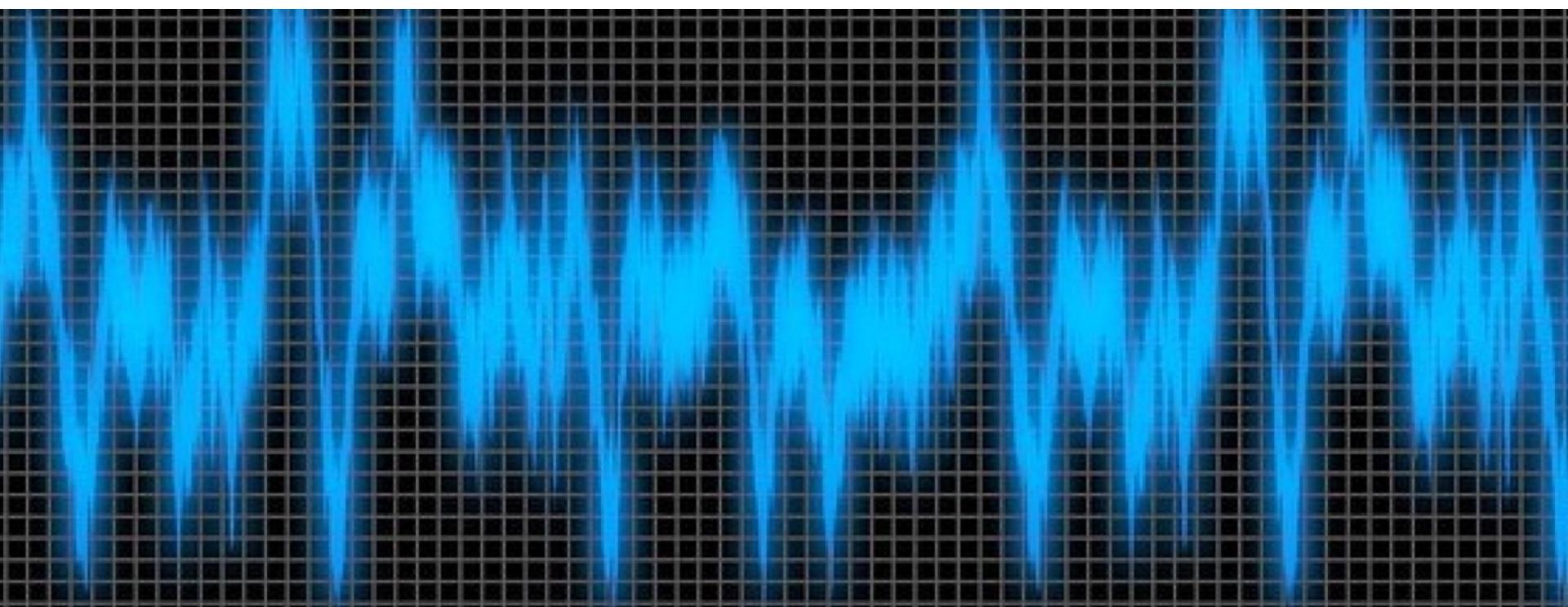
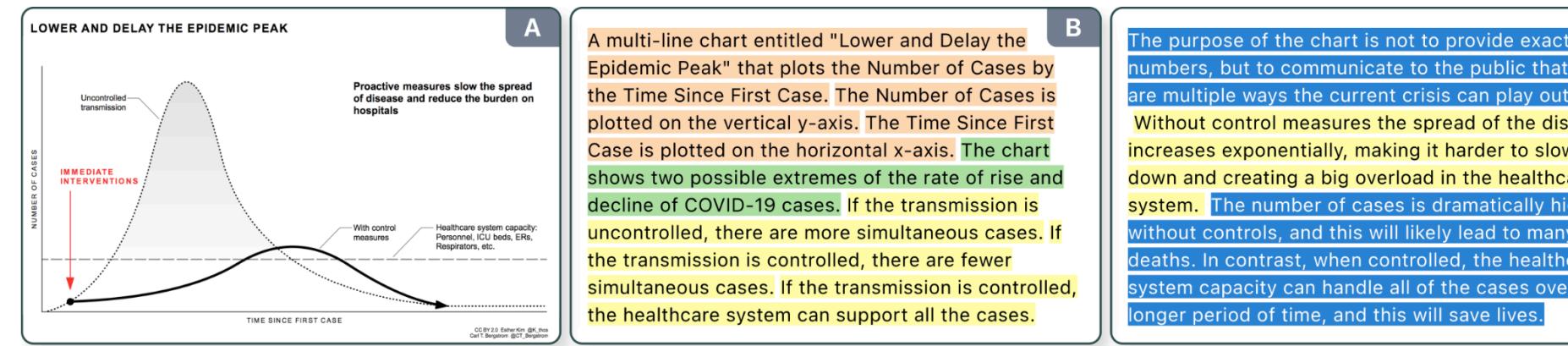


Image source

Accessible data representation

Descriptions

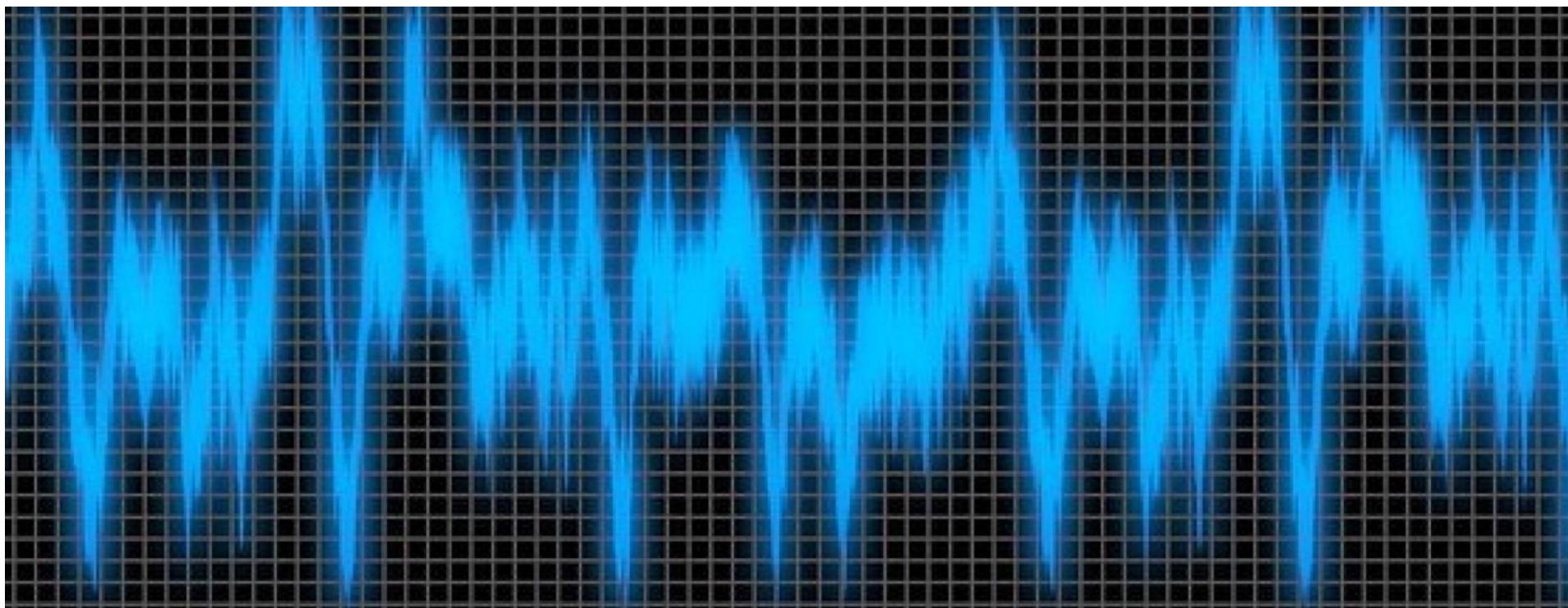


Long Description

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.

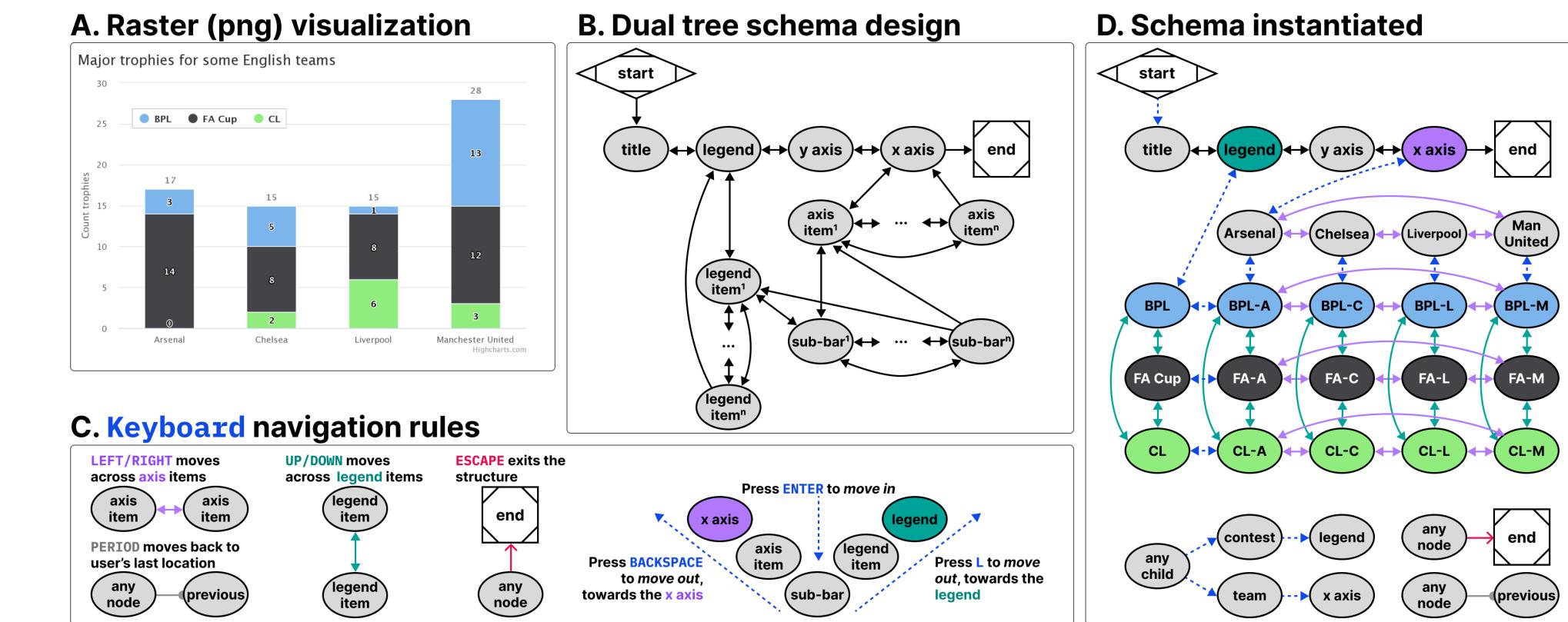
[Image source](#)

Sonifications



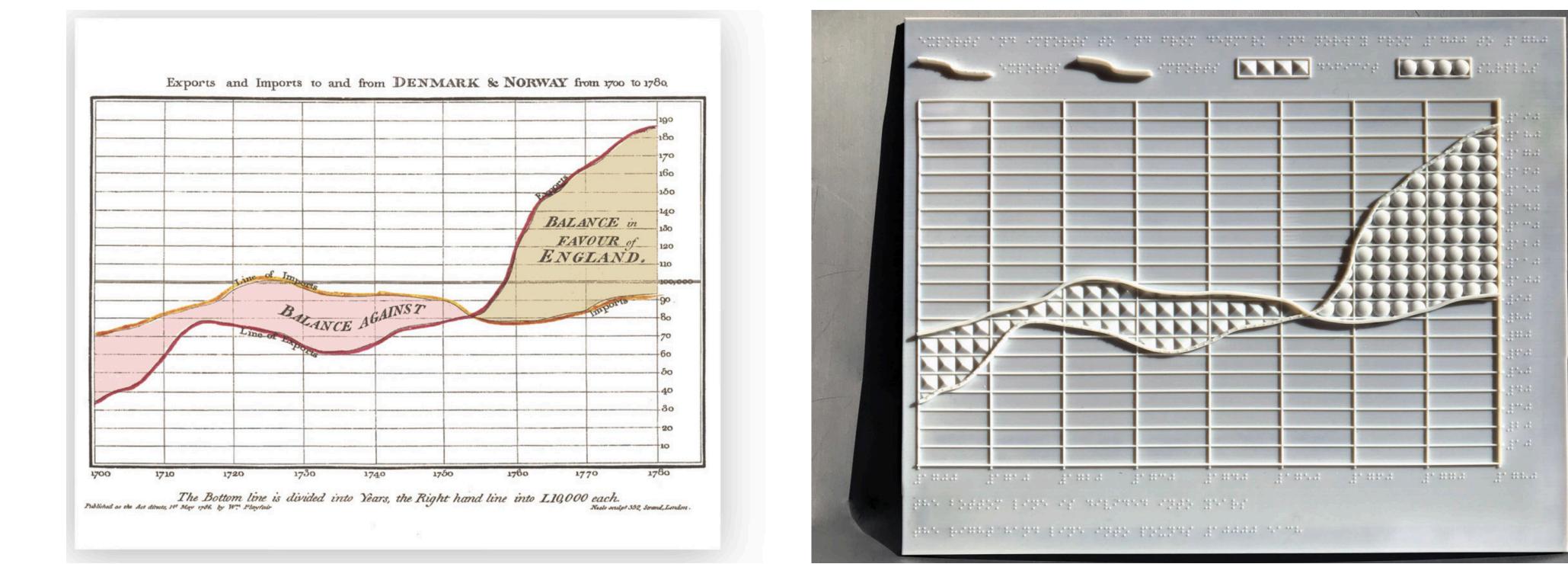
[Image source](#)

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

The screenshot shows the Wikipedia article for 'Cat'. A red box highlights the search bar and the 'Search' button. Another red box highlights the main title 'Cat'. A third red box highlights the sidebar menu on the left. A fourth red box highlights the 'Cat' link in the disambiguation section. A fifth red box highlights the image gallery on the right.

67 Nav points, ~32s

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 \(disambiguation\)](#).

Cat is the only domesticated species in the feline family that has been [domesticated](#) by humans. It is commonly kept as a house pet and is valued by humans for its companionship and ability to kill small pests, such as mice and birds, and its night vision and acute sense of smell. 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 pedigree 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](#) and [mammal](#) species.

Movement between tasks becomes cognitively expensive

The screenshot shows a Wikipedia article page for 'Cat'. A red circle highlights the search bar at the top. Another red circle highlights the 'Cat' link in the main title. Red lines connect various sections of the sidebar to the main content area, including 'Etymology and naming', 'Taxonomy', 'Evolution', 'Characteristics', 'Senses', 'Behavior', 'Lifespan and health', 'Ecology', 'Interaction with humans', 'See also', 'Notes', 'References', and 'External links'. A third red circle highlights the 'Felidae' link in the disambiguation section. A large red box highlights the main text area, which contains the following text:

**67 Nav points,
~32s**

Cat, is the only domesticated species in the feline family that has been kept by humans as a house pet. It is valued by humans for its adaptability, agility, 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 pedigree 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

Cat
Temporal range: 9,500 years ago – present

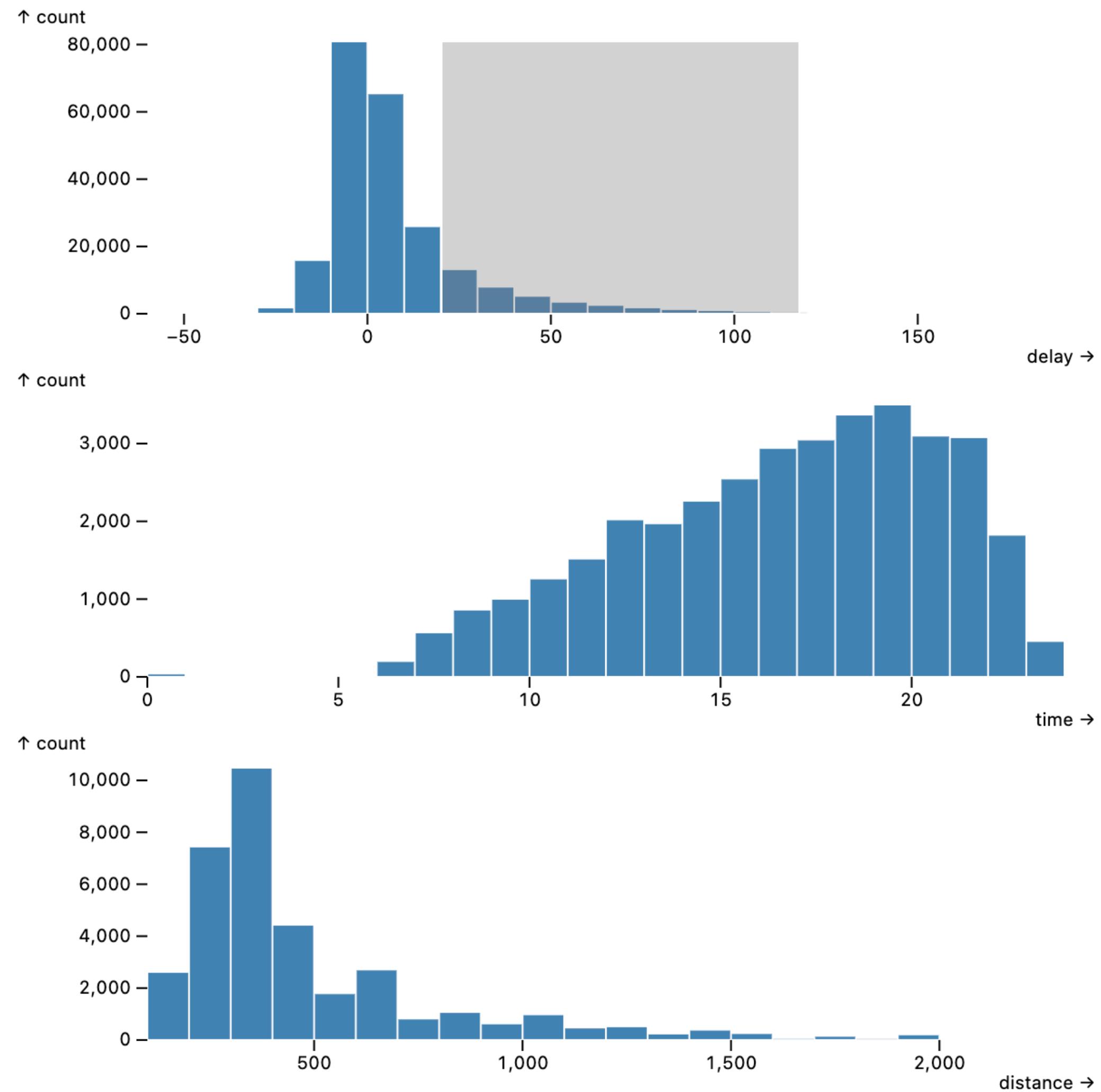
Auditory processing struggles with *dual-task* paradigms*

*Citation

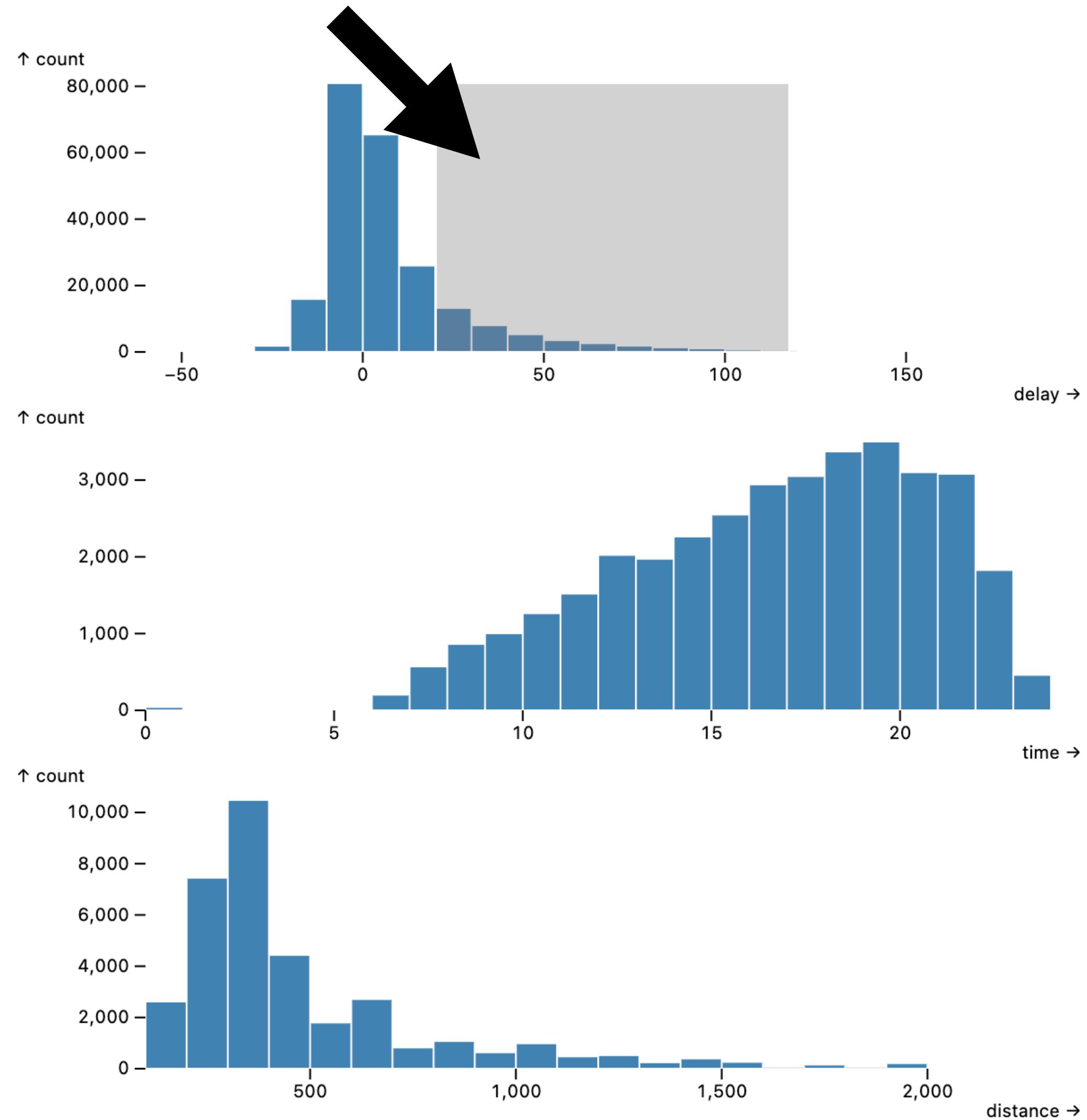
So what about cross-filtering?

[Interactive link](#)

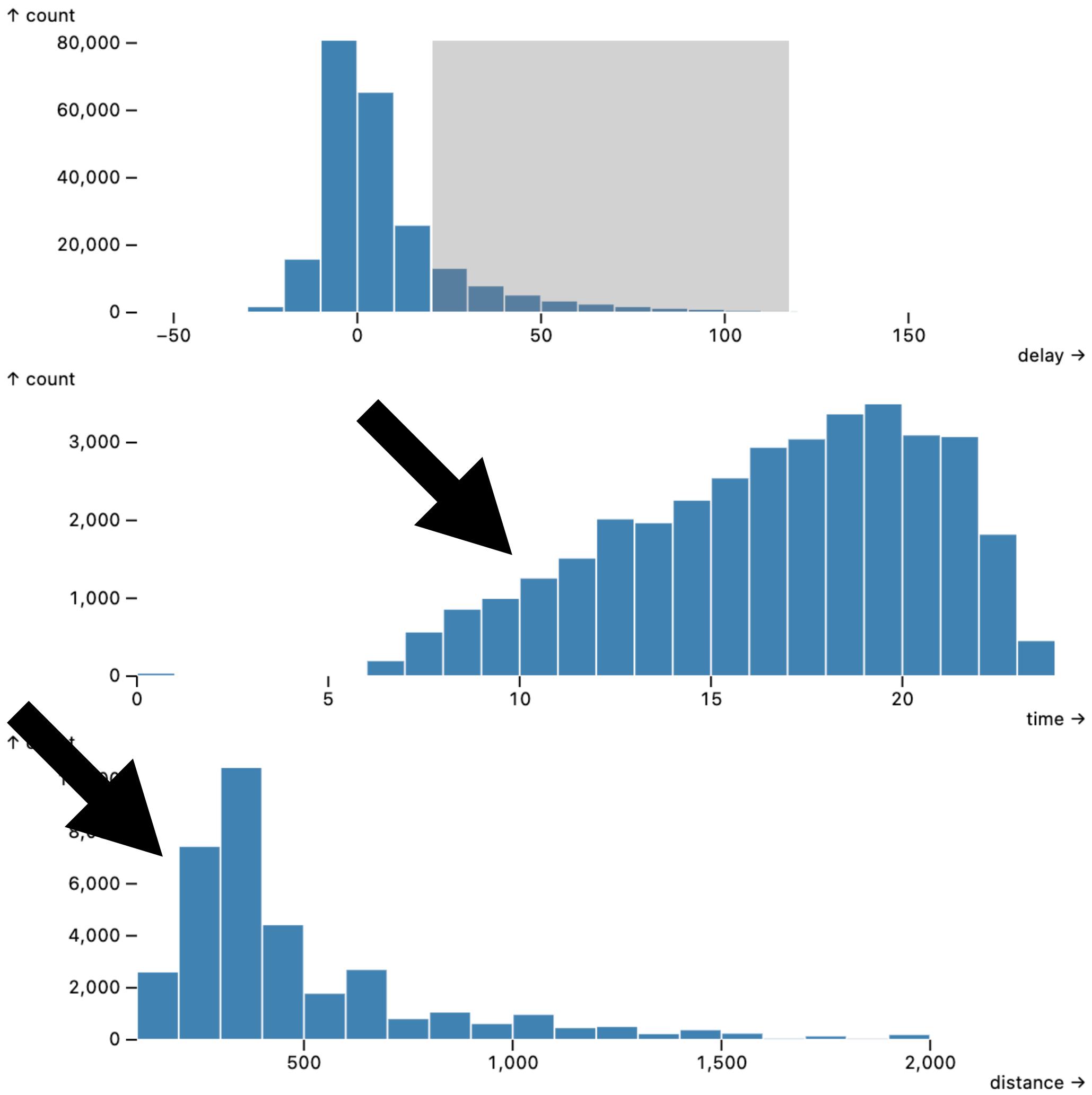
So what about cross-filtering?



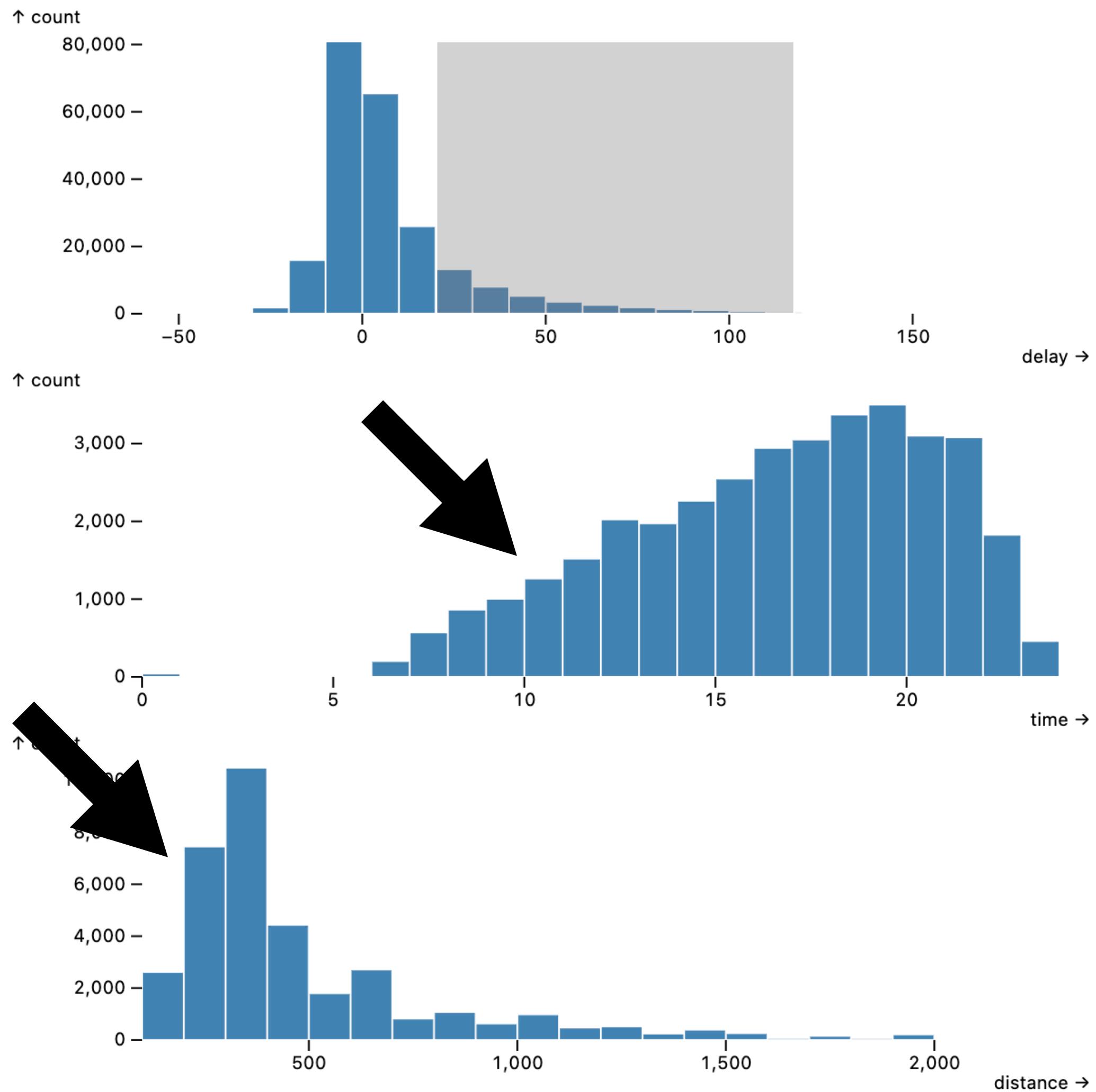
Interaction in one space...



Produces simultaneous, coordinated change in another.



How can we enable coordinated cross-interaction?



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?

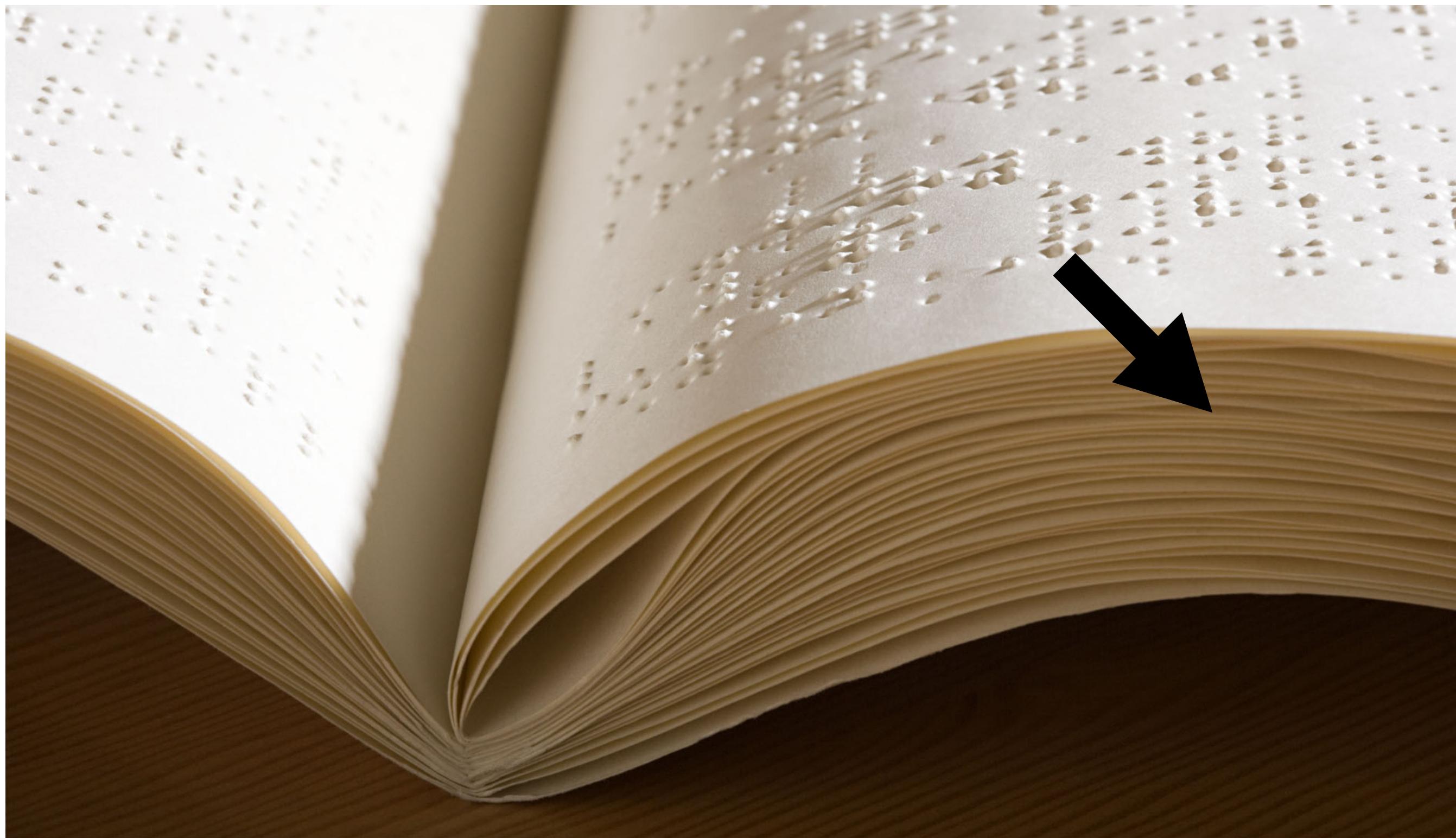
Observing: Embossed braille in a research context



[Image source](#)

Observation 1: Spatial memory storage

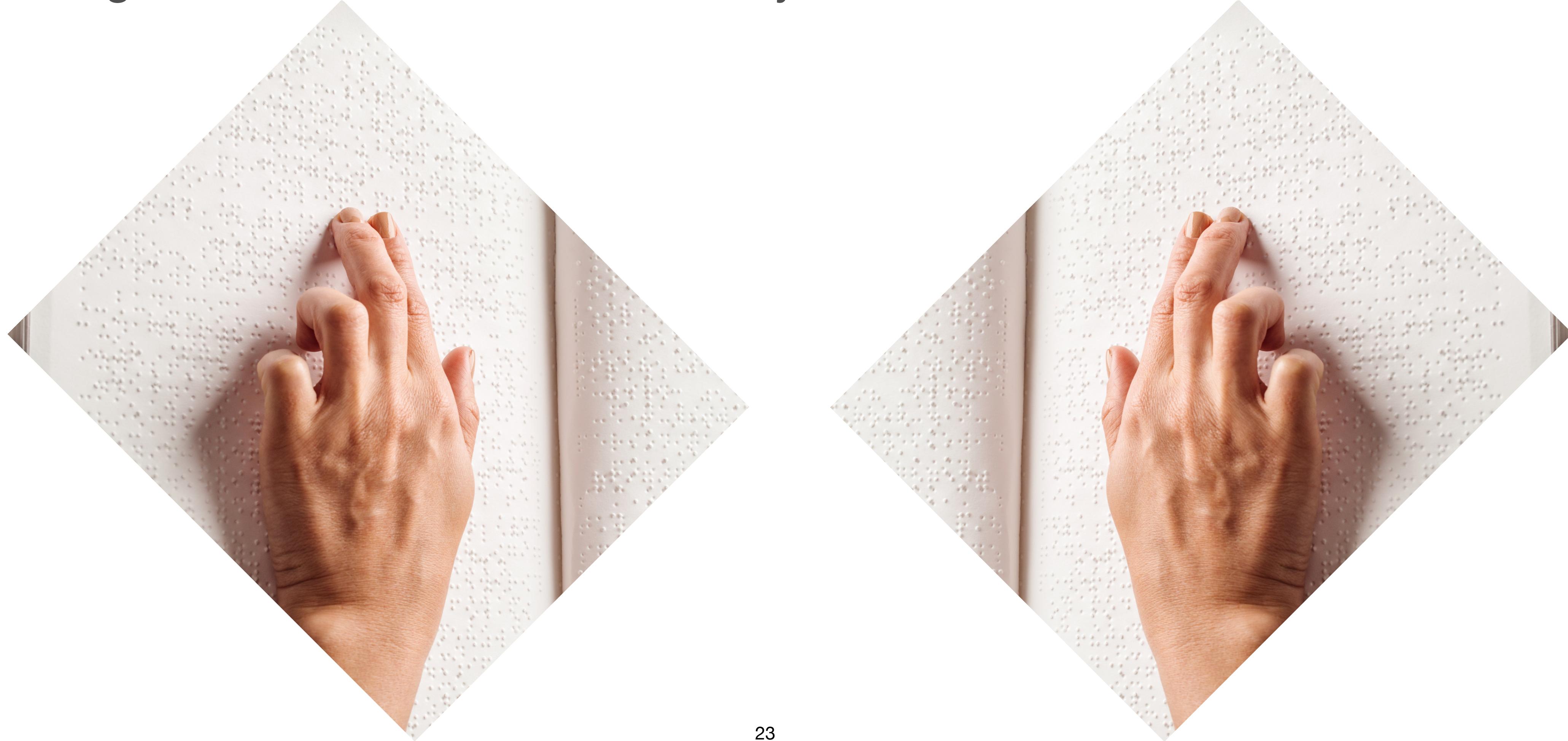
My friend didn't remember the details of a math equation exactly, but he knew *where* that equation was located in his stack of braille pages and *where* on the page the equation was.



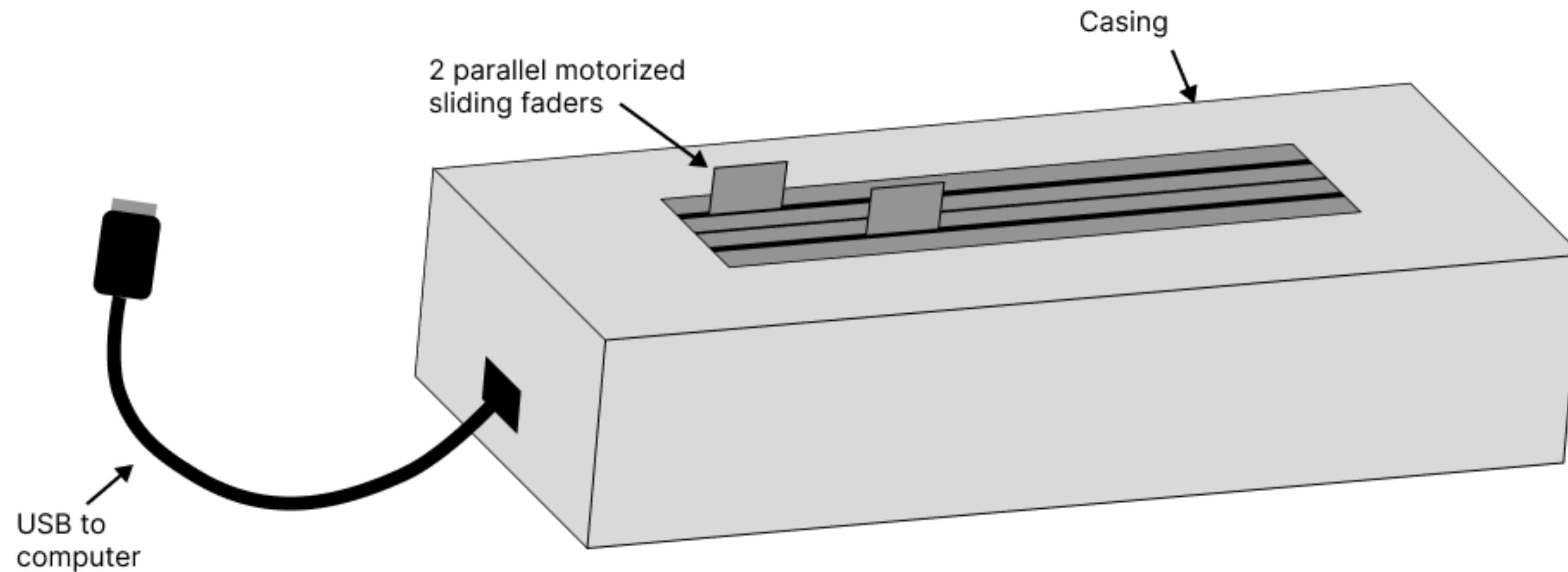
[Image source](#)

Observation 2: Coordinating perception and comparison

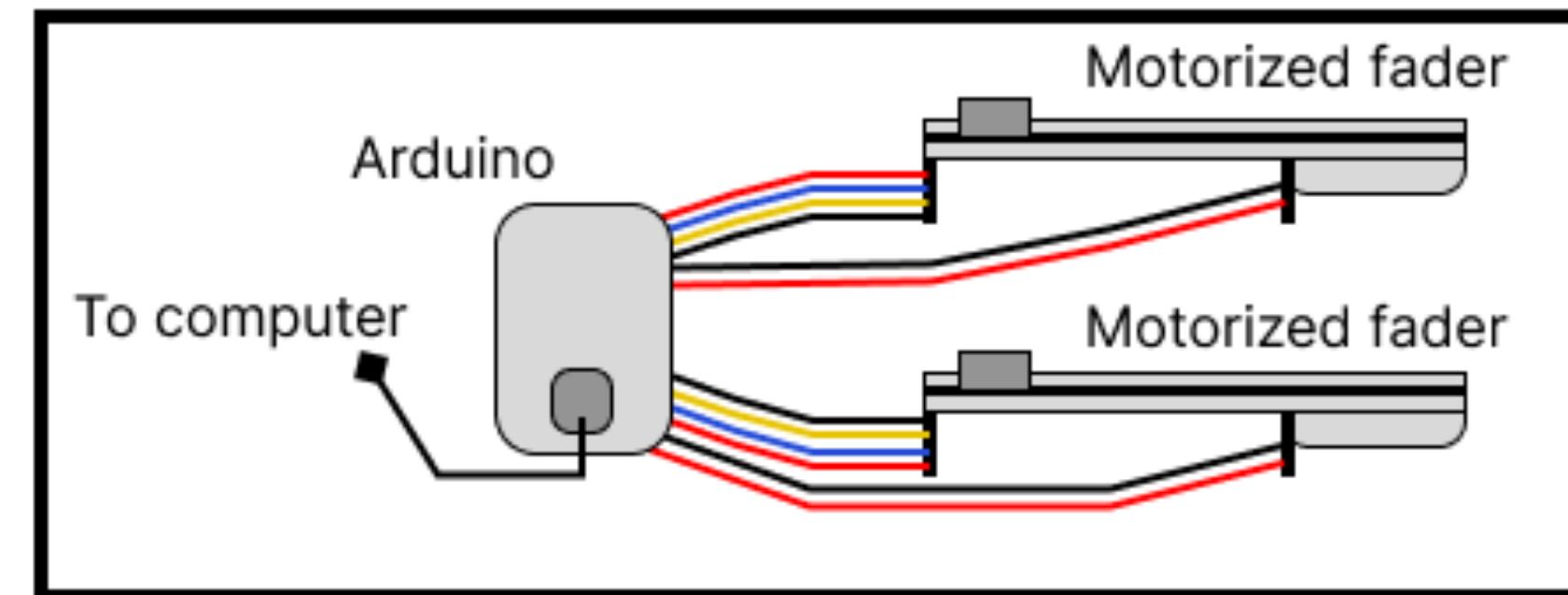
He then compared 2 equations at once. The details of each weren't important. He was *feeling* for differences simultaneously.



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



Schematic

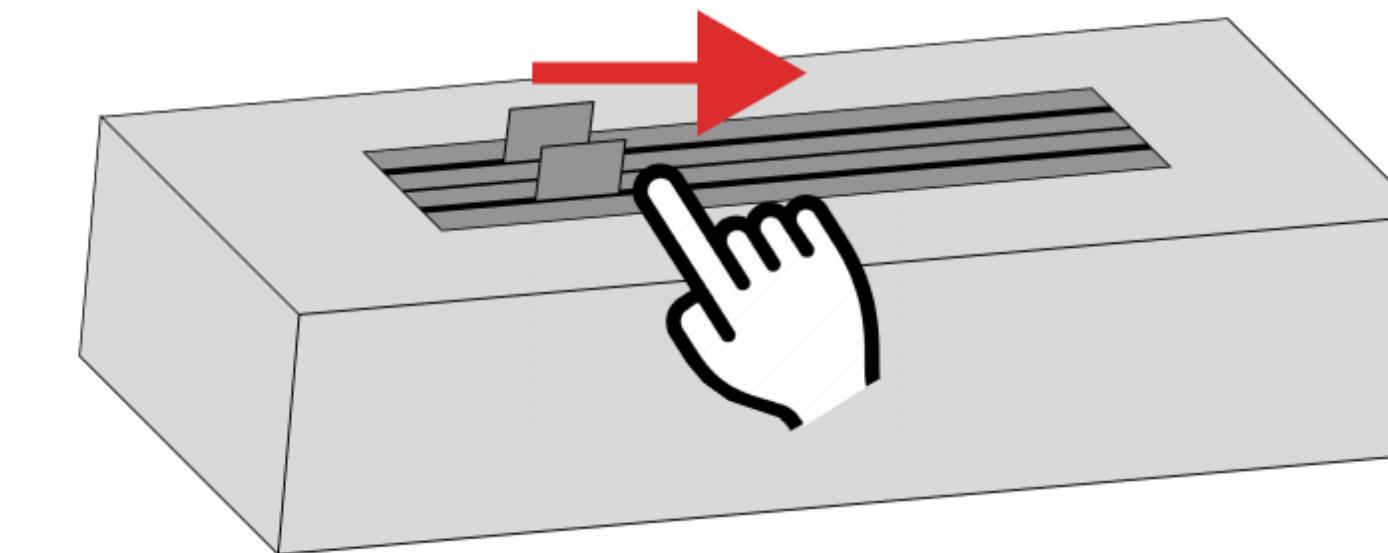


One slider can work with video

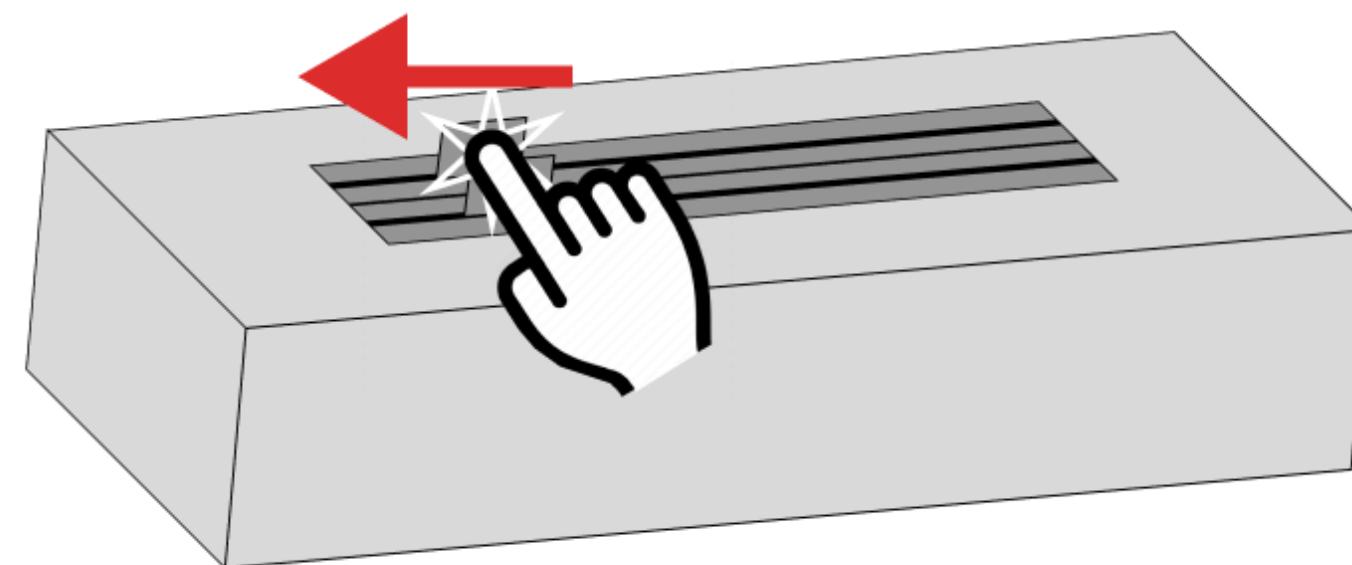
1. Video plays with progress slider moving



2. Slider follows, can be felt



3. User can move slider

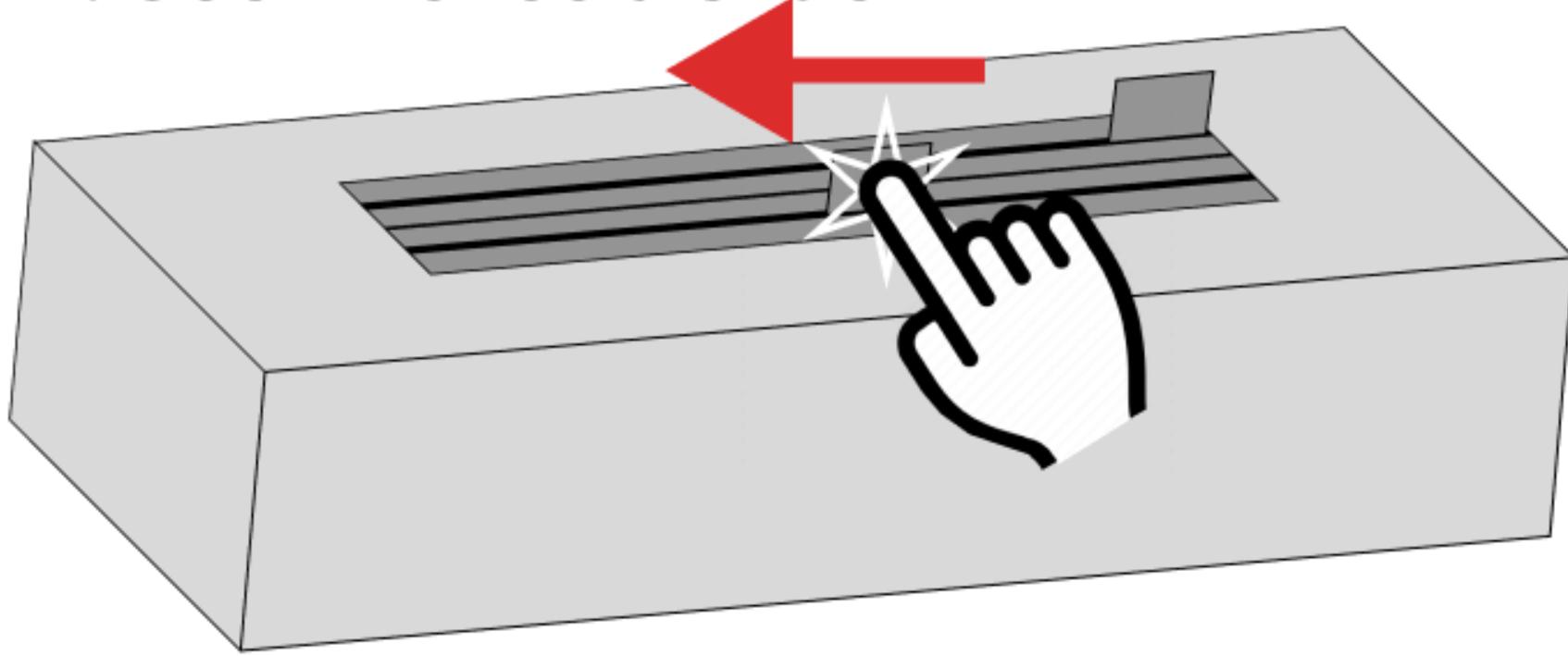


4. Video slider will move with slider change

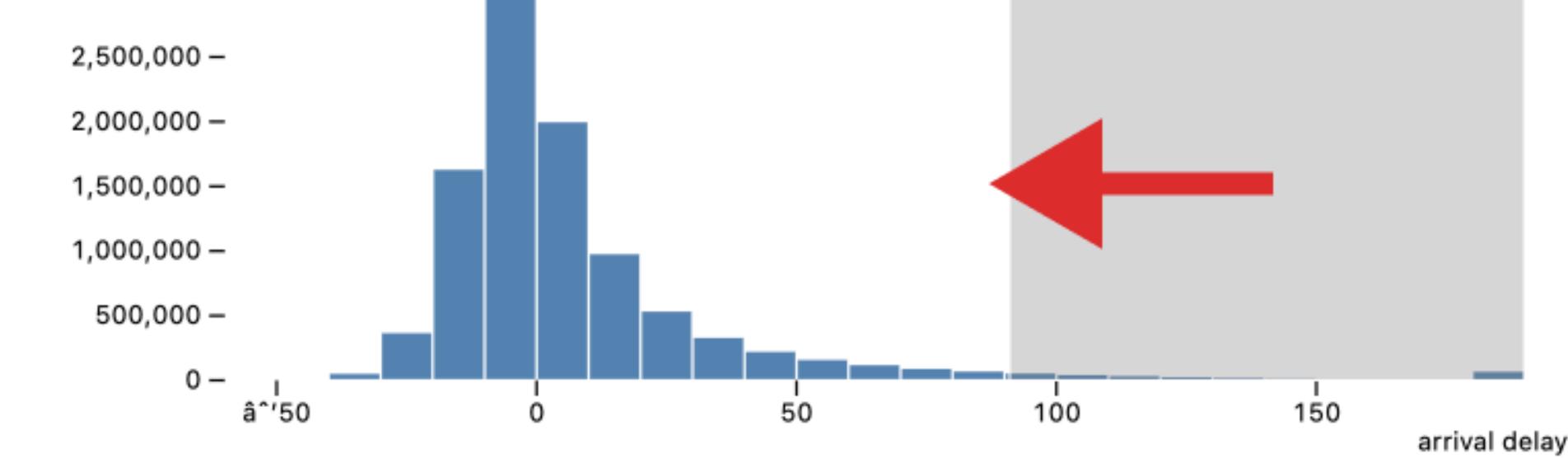


While 2 sliders works for cross-filtering

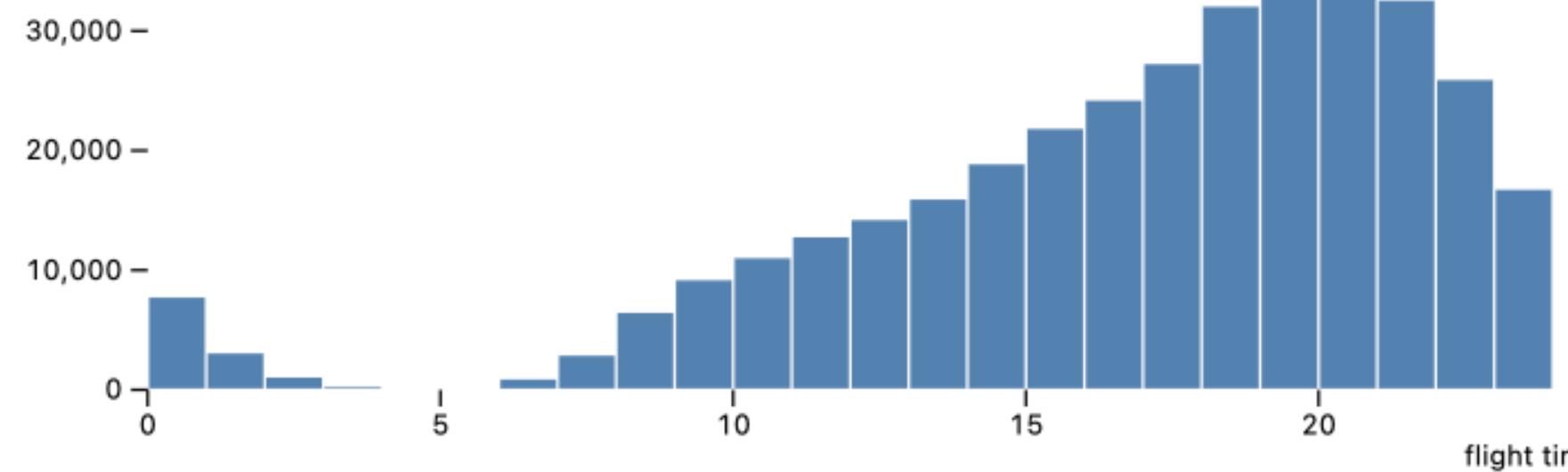
1. User moves a slider



2. Corresponding filter edge moves with

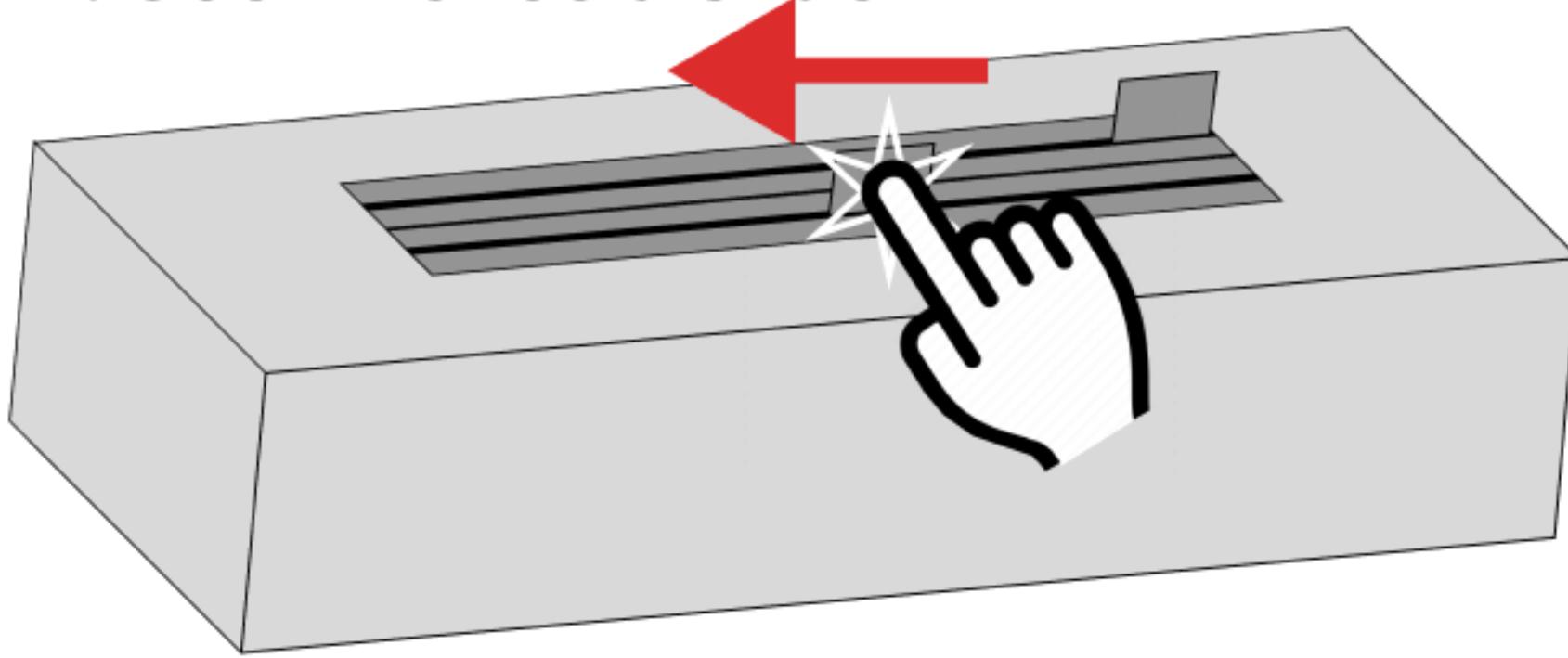


3. Secondary visualization updates

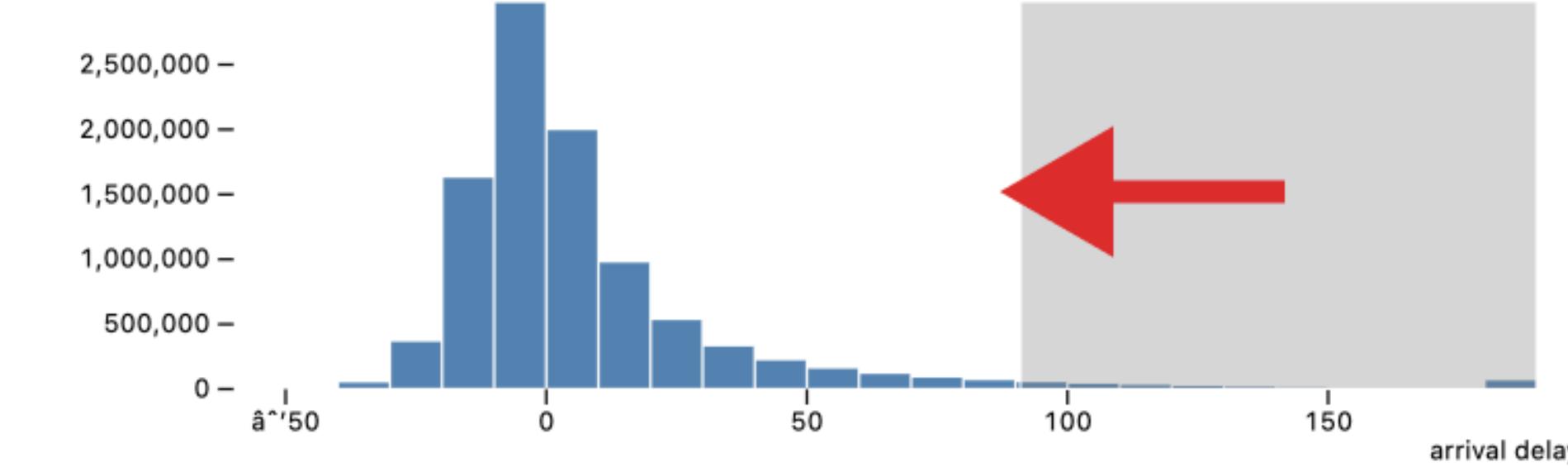


A tactile display can render the input or output chart

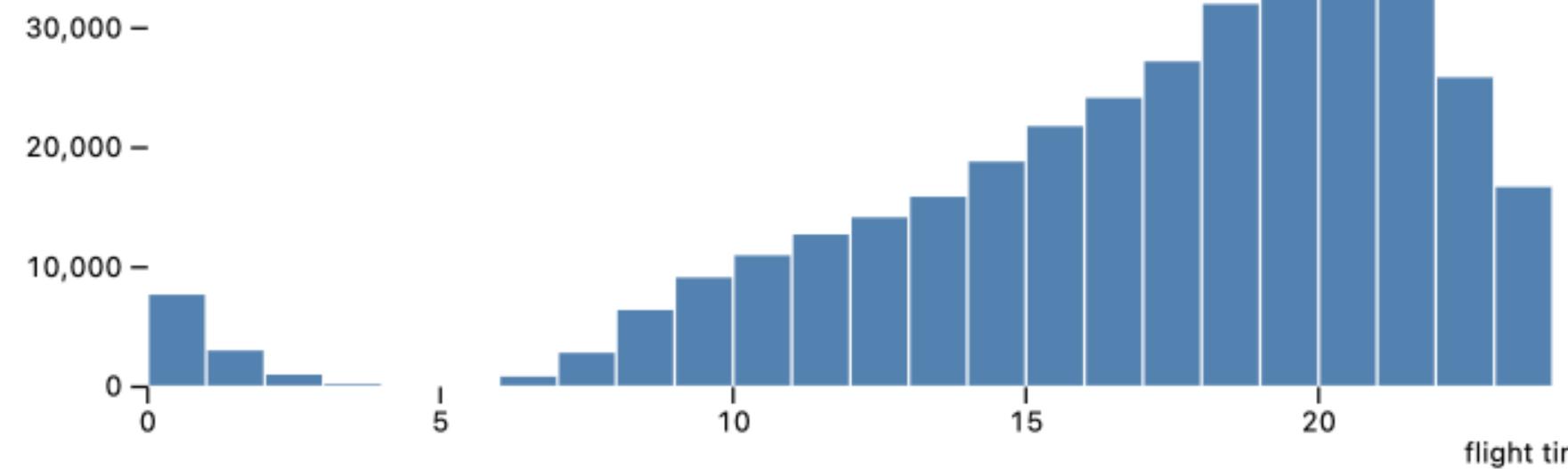
1. User moves a slider



2. Corresponding filter edge moves with



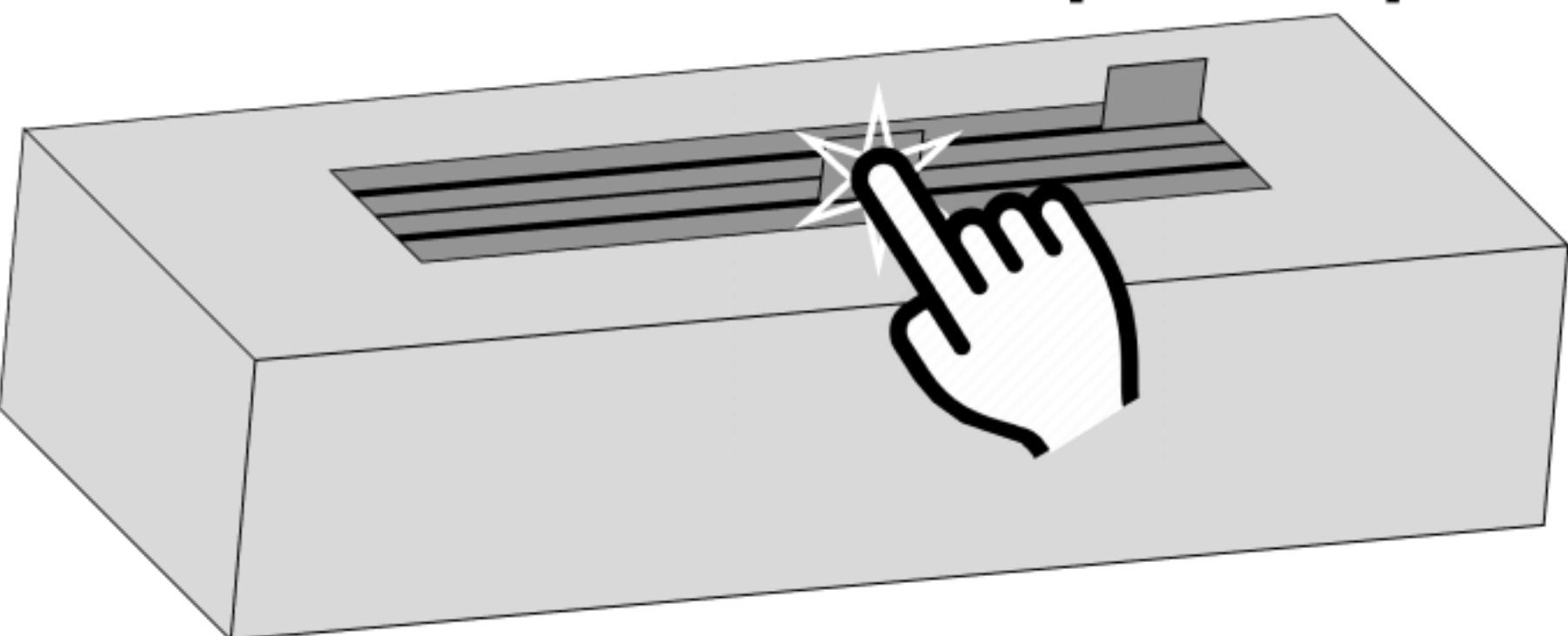
3. Secondary visualization updates



4. Tactile display renders



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



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

2025

★Slides here → frank.computer

Cross-*feelttering*: Exploring a coordinated, cross-interaction prototype for blind data interaction



Frank Elavsky, PhD Student



Human-
Computer
Interaction
Institute



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