

Interactivity + Accessibility

Data Visualization



What you will learn today

The value of interactivity

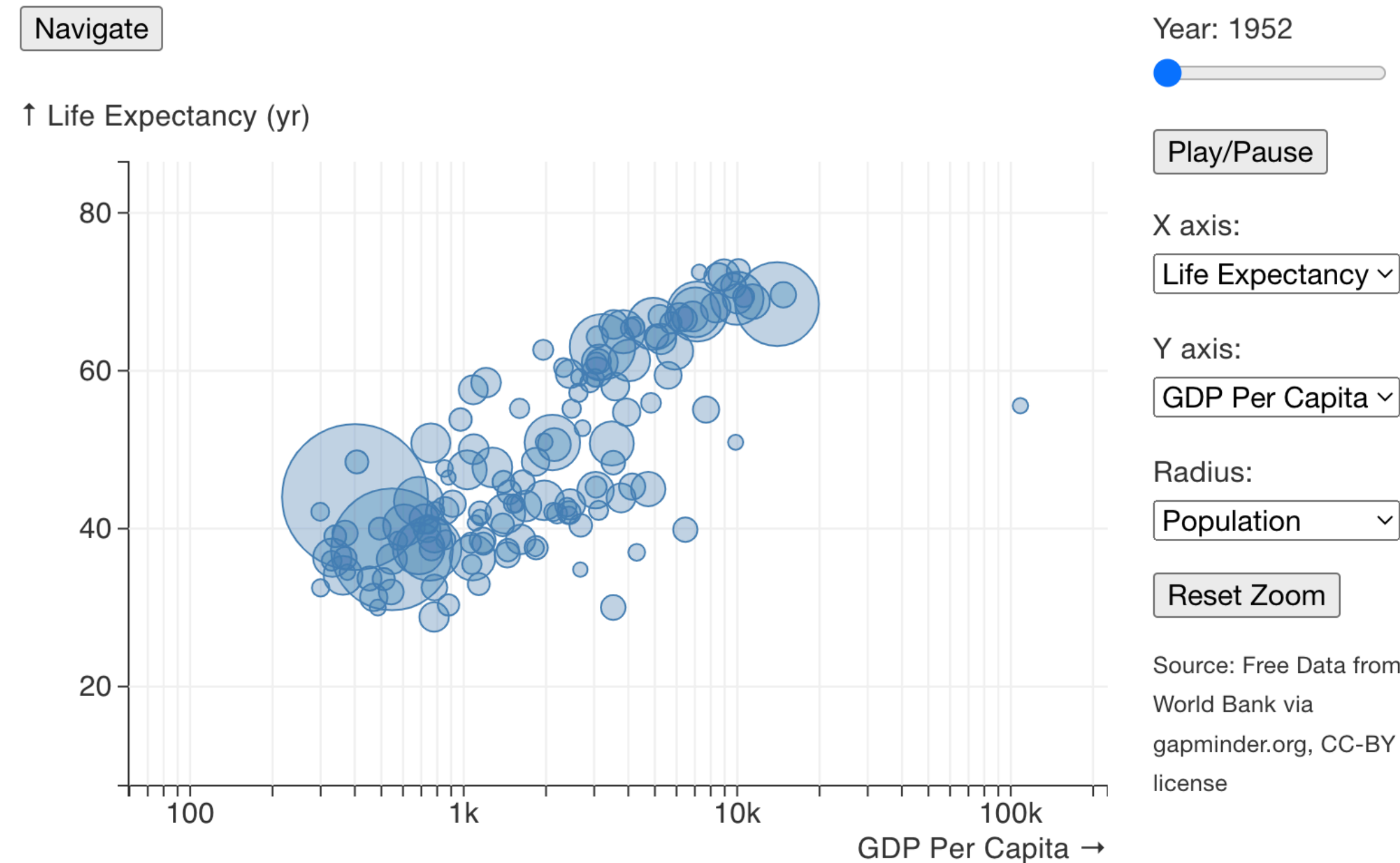
Principles of interaction design

Principles of accessible interaction design

The Value of Interactivity

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.

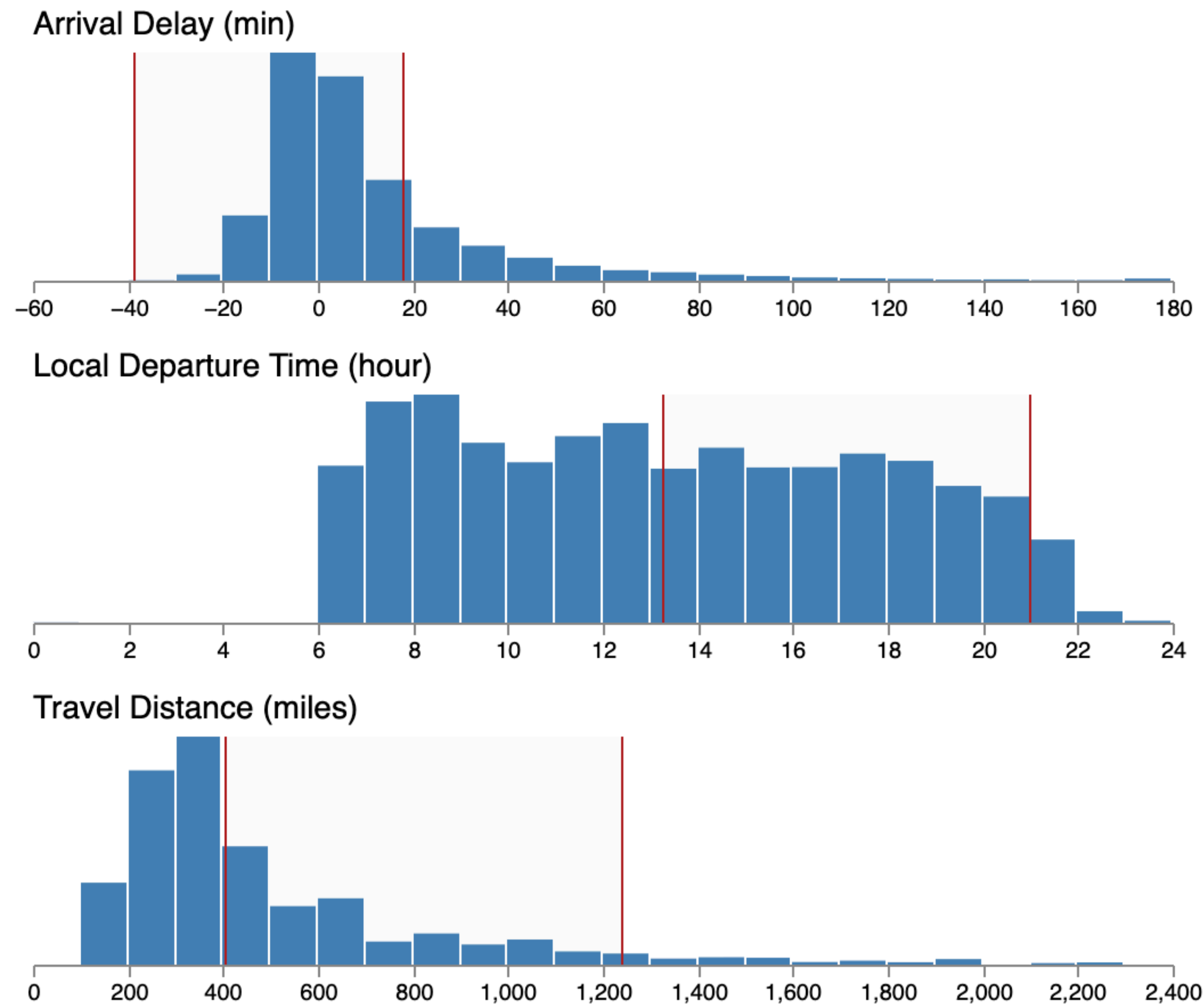


<https://dig.cmu.edu/counterpoint/2024/04/30/gapminder-accessible.html>



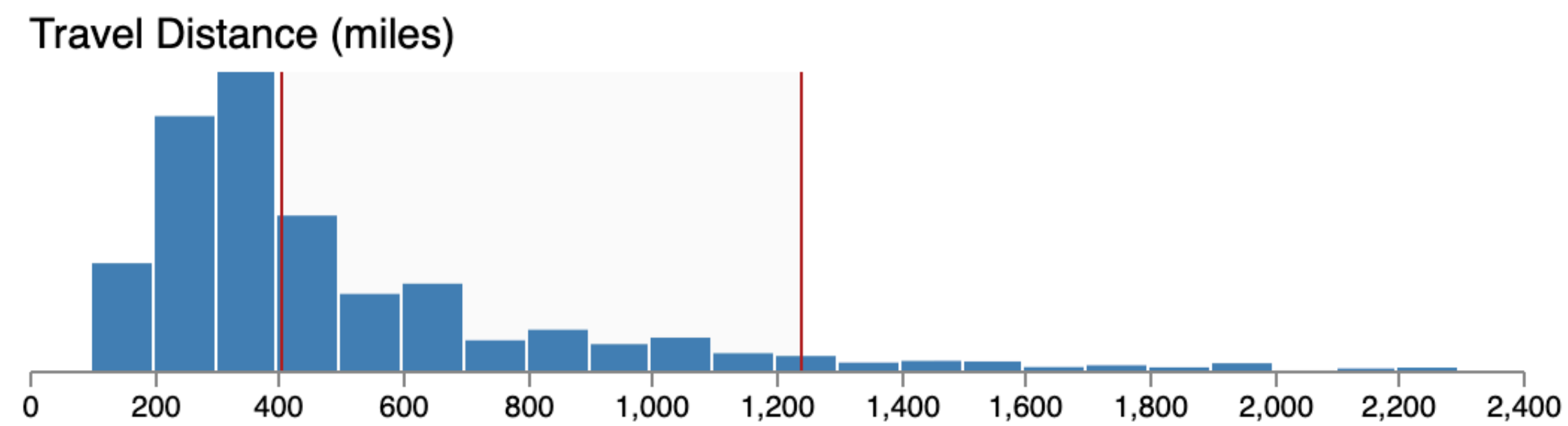
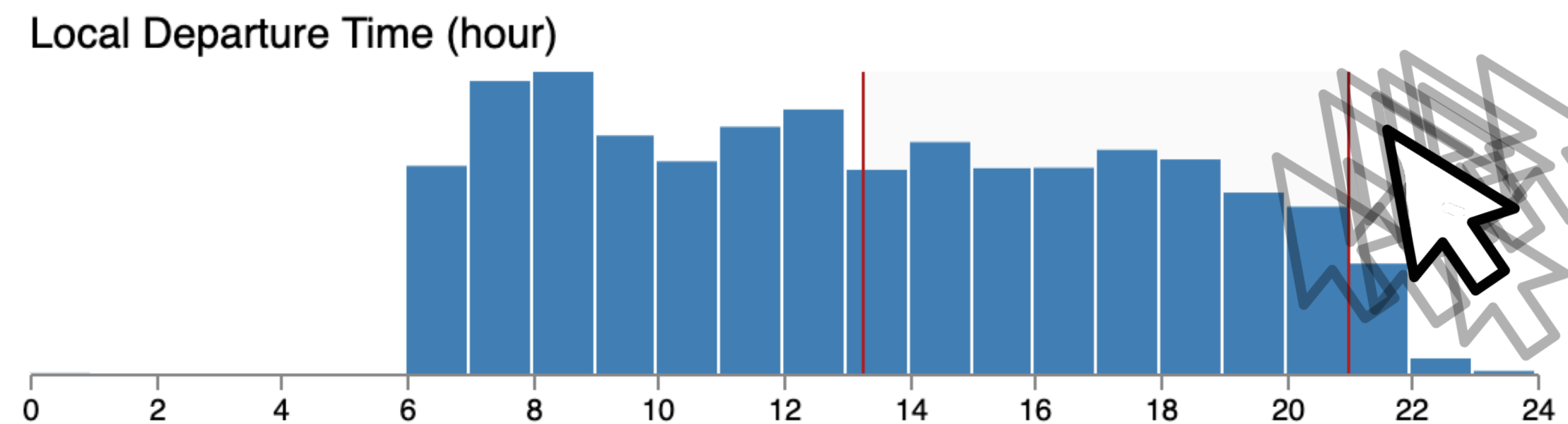
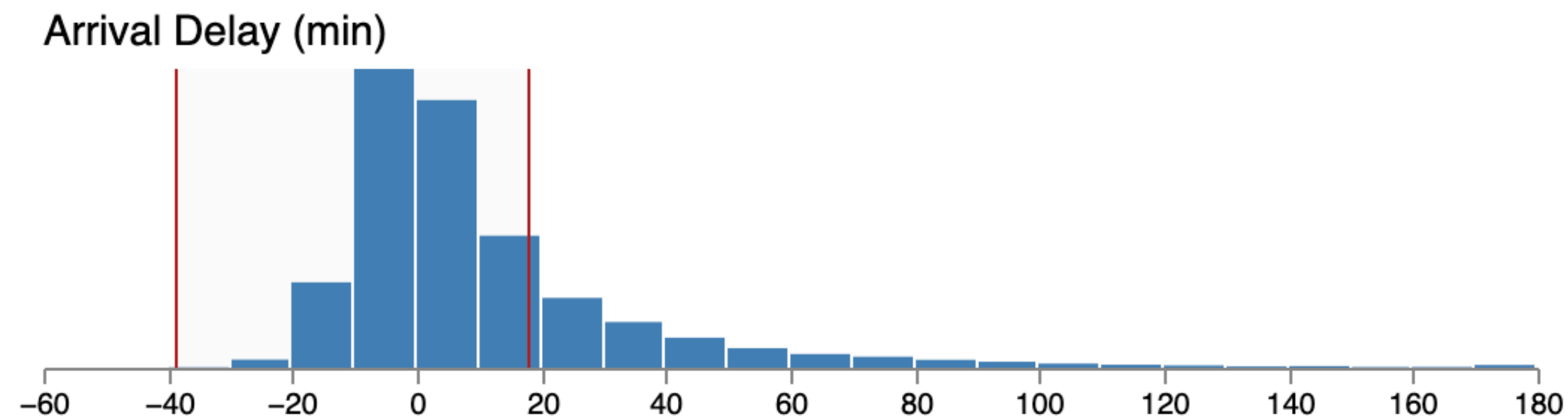
Dragicevic, P., Ramos, G., Bibliowicz, J., Nowrouzezahrai, D., Balakrishnan, R., and Singh, K. (2008). **Video Browsing by Direct Manipulation.** CHI '08.

The Value of Interactivity



<https://vega.github.io/editor/#/examples/vega/crossfilter-flights>

The Value of Interactivity



Note: Expecting users to hover on something tiny is an accessibility design failure

<https://vega.github.io/editor/#/examples/vega/crossfilter-flights>

The Value of *Accessible* (multi-modal) Interactivity

A video with sliders

Video loaded. You may now connect.

Connect Feelter

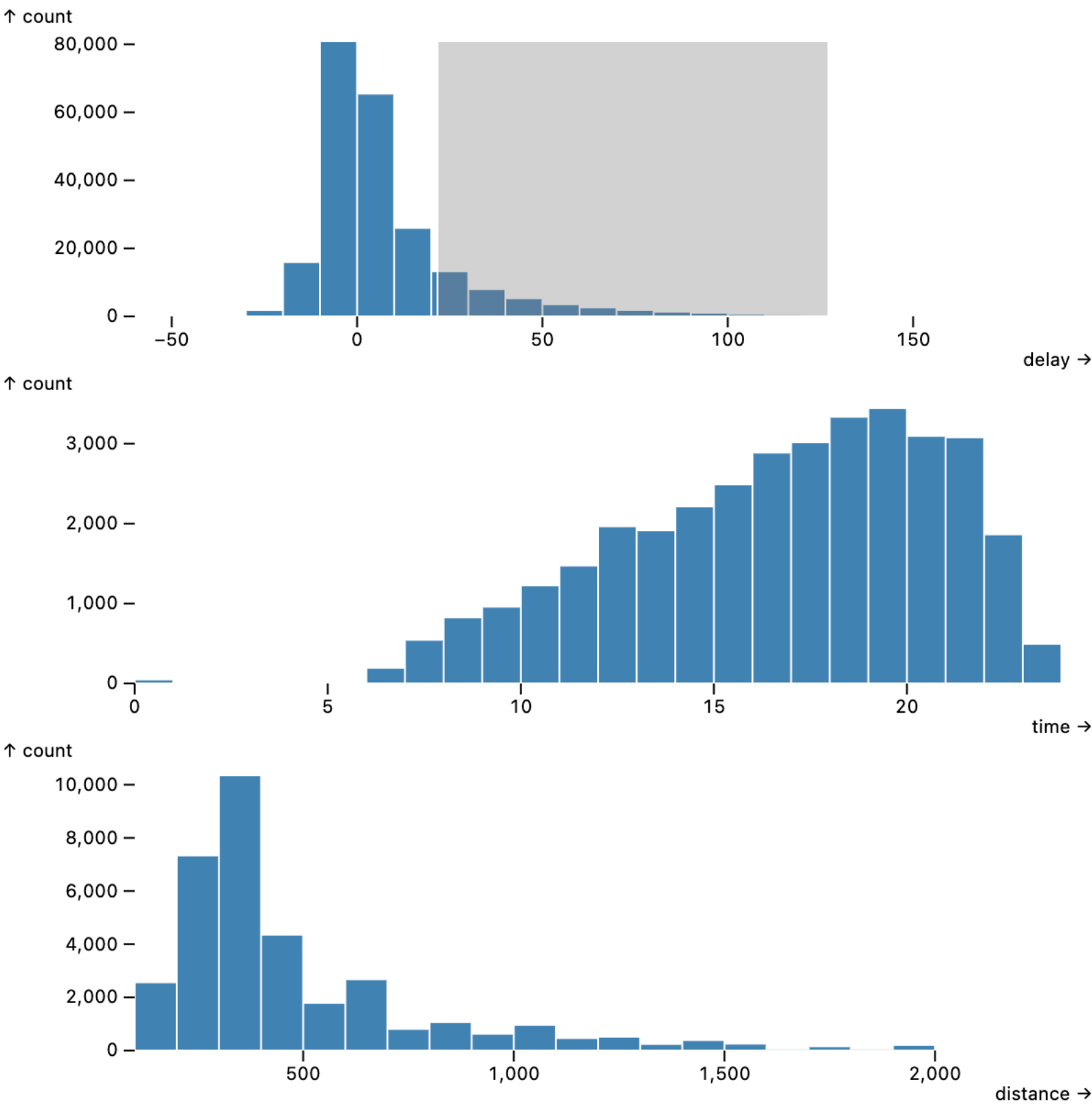
The top slider controls the volume, the bottom controls the video's progress. Moving the bottom slider will move you rapidly forward or backward through the video.

Tapping or touching the top slider will also pause or unpause the video. Note that adjusting the volume may pause or unpause the video. Simply tap the top slider again if it paused or unpaused when you didn't want it to.



[Go back to main page](#)

<https://dig.cmu.edu/cross-feelter/video.html>



<https://dig.cmu.edu/cross-feelter/slider.html>

Accessibility principle: “Operability”

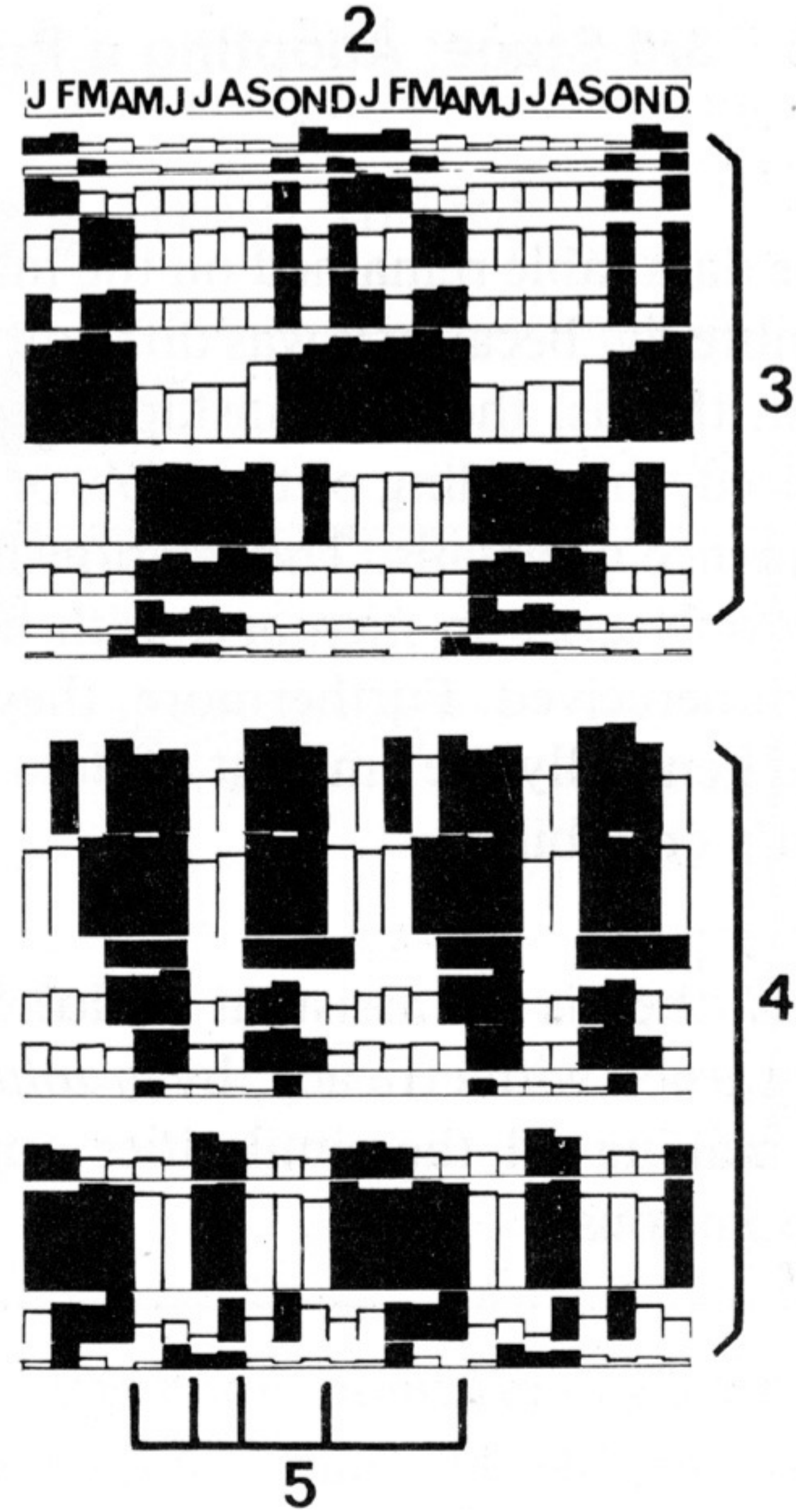
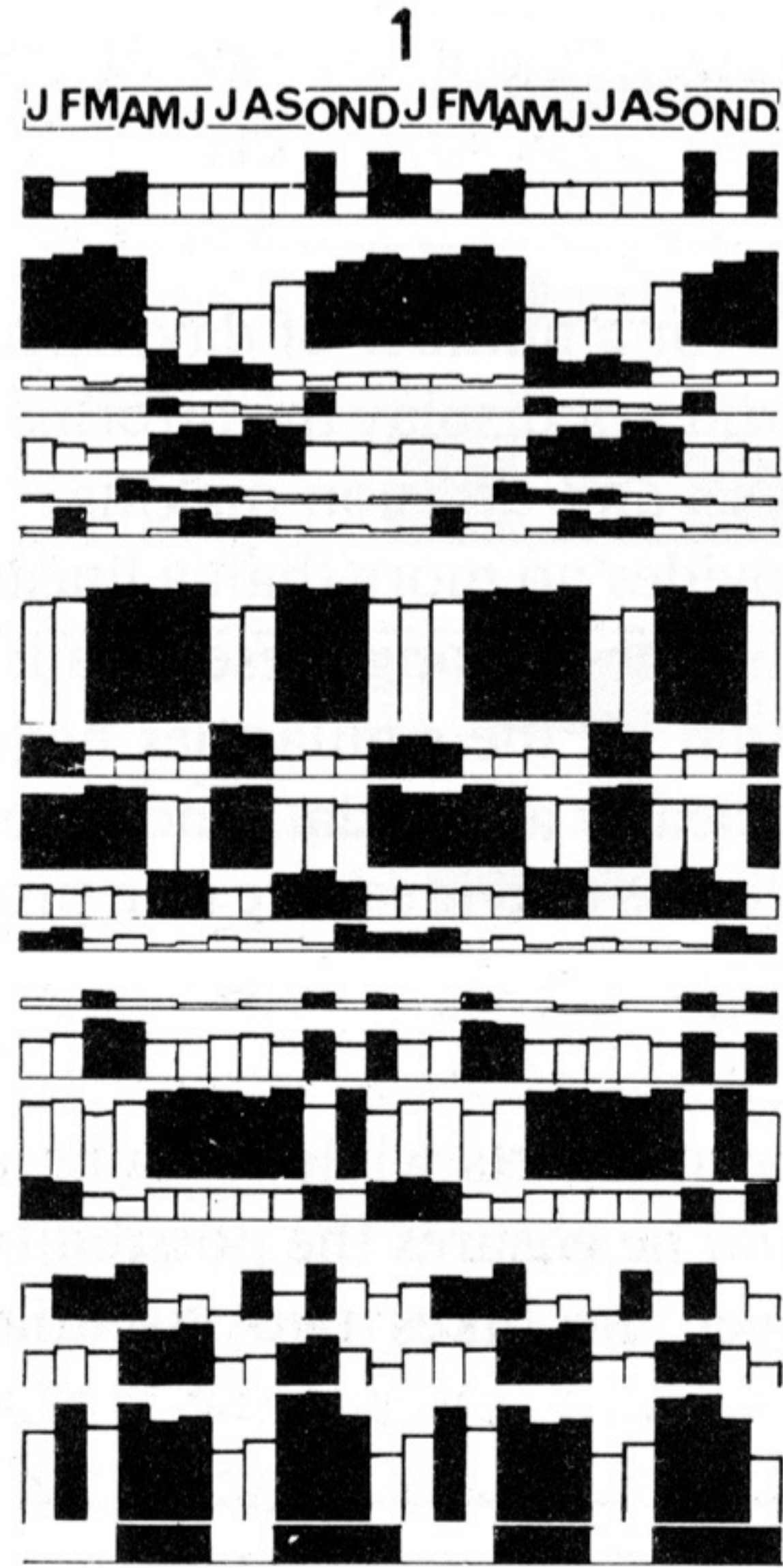
Can someone operate this in multiple ways? Is each way easy?

A graphic is not “drawn” once and for all; it is “constructed” and reconstructed until it reveals all the relationships constituted by the interplay of the data. The best graphic operations are those carried out by the decision-maker [themselves].

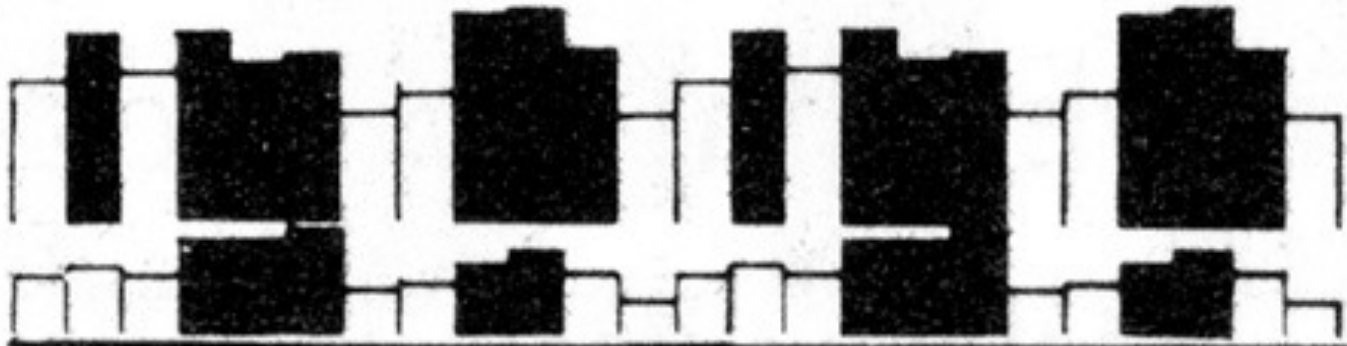
Jacques Bertin (1918 – 2010)



J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —"—— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —"—— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —"—— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —"—— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —"—— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —"—— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY ———"——
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —"—— 20-35 —"——
48	49	42	48	54	55	53	51	55	46	55	43	15	% —"—— 35-55 —"——
25	22	17	15	19	19	19	19	19	20	19	22	16	% —"—— MORE THAN 55 —"——
163	167	166	174	152	155	145	170	157	174	165	156	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.60	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	70	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS



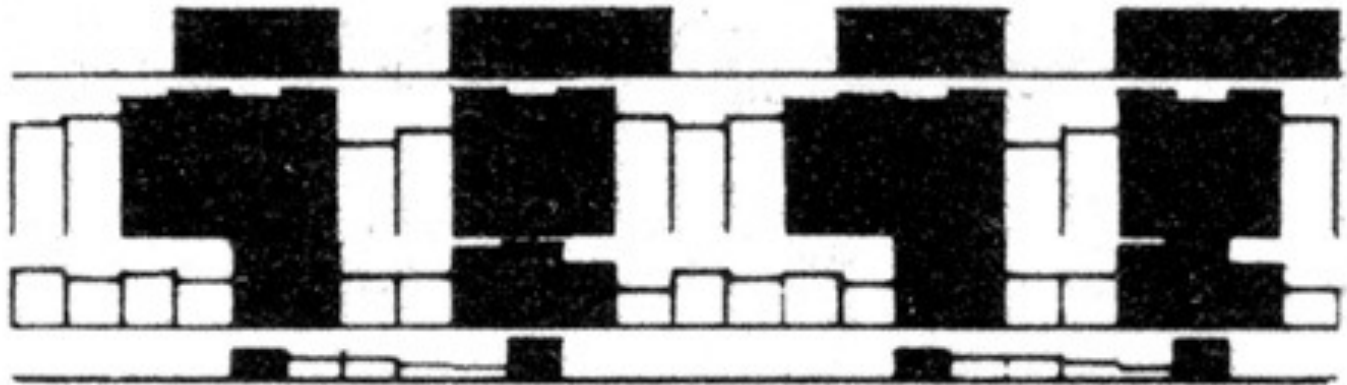
J F M A M J J A S O N D J F M A M J J A S O N D



19 % OCCUPANCY

18 LENGTH OF STAY

ACTIVE AND
SLOW PERIODS



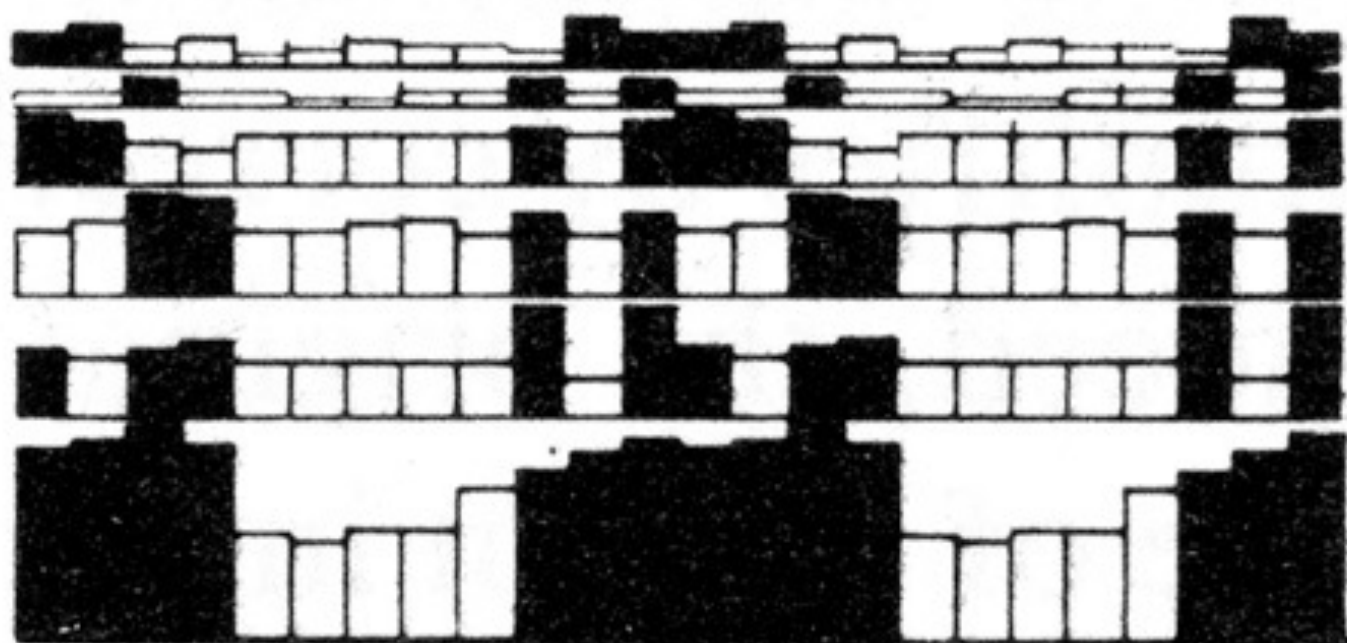
20 CONVENTIONS

8 BUSINESSMEN

11 AGENCY RESERVATIONS

4 SOUTH AMERICA

DISCOVERY FACTORS



12 AIR CREWS

13 CLIENTS UNDER 20 YEARS

16 CLIENTS MORE THAN 55 YEARS

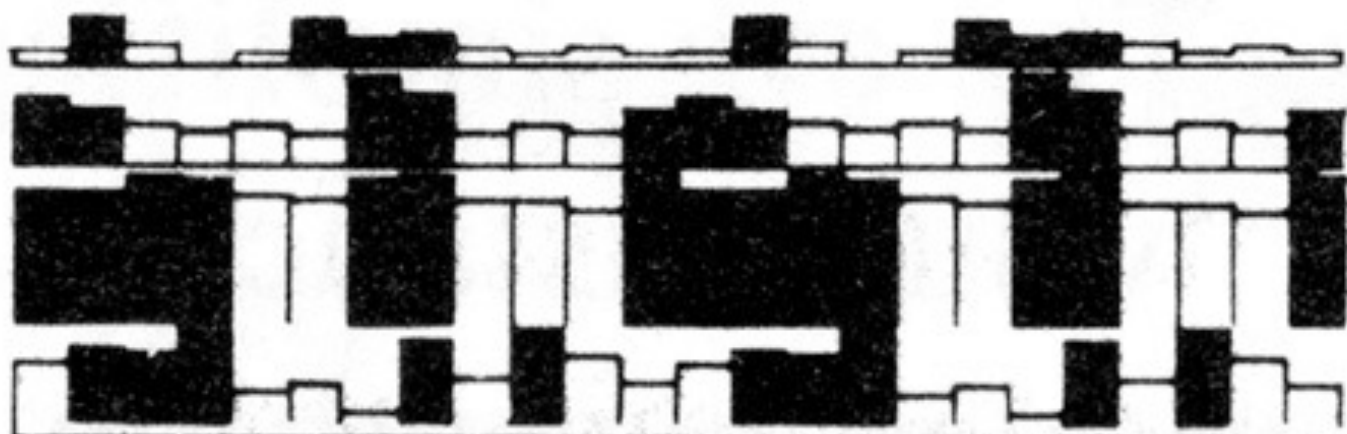
14 CLIENTS FROM 20-35 YEARS

1 FEMALE CLIENTELE

2 LOCAL CLIENTELE

RECOVERY FACTORS

WINTER



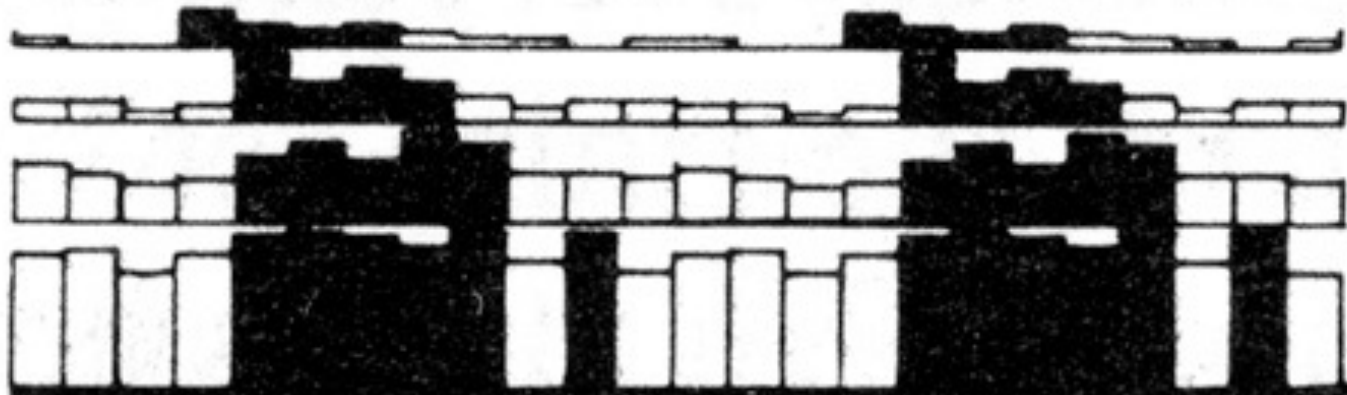
7 ASIA

9 TOURISTS

10 DIRECT RESERVATION

17 PRICE OF ROOMS

WINTER-SUMMER



6 MIDDLE EAST, AFRICA

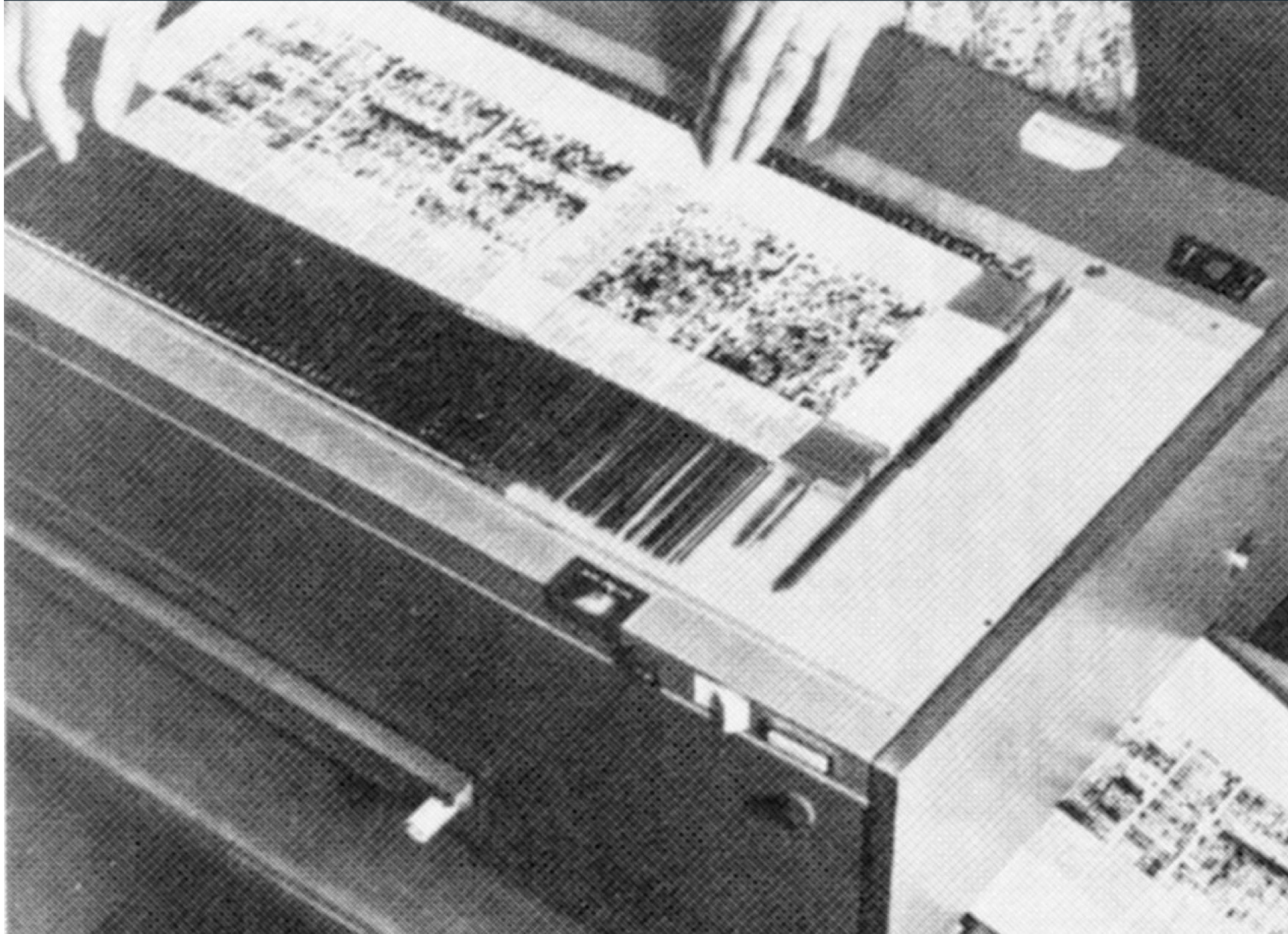
3 U. S. A.

5 EUROPE

15 CLIENTS FROM 35-55 YEARS

SUMMER

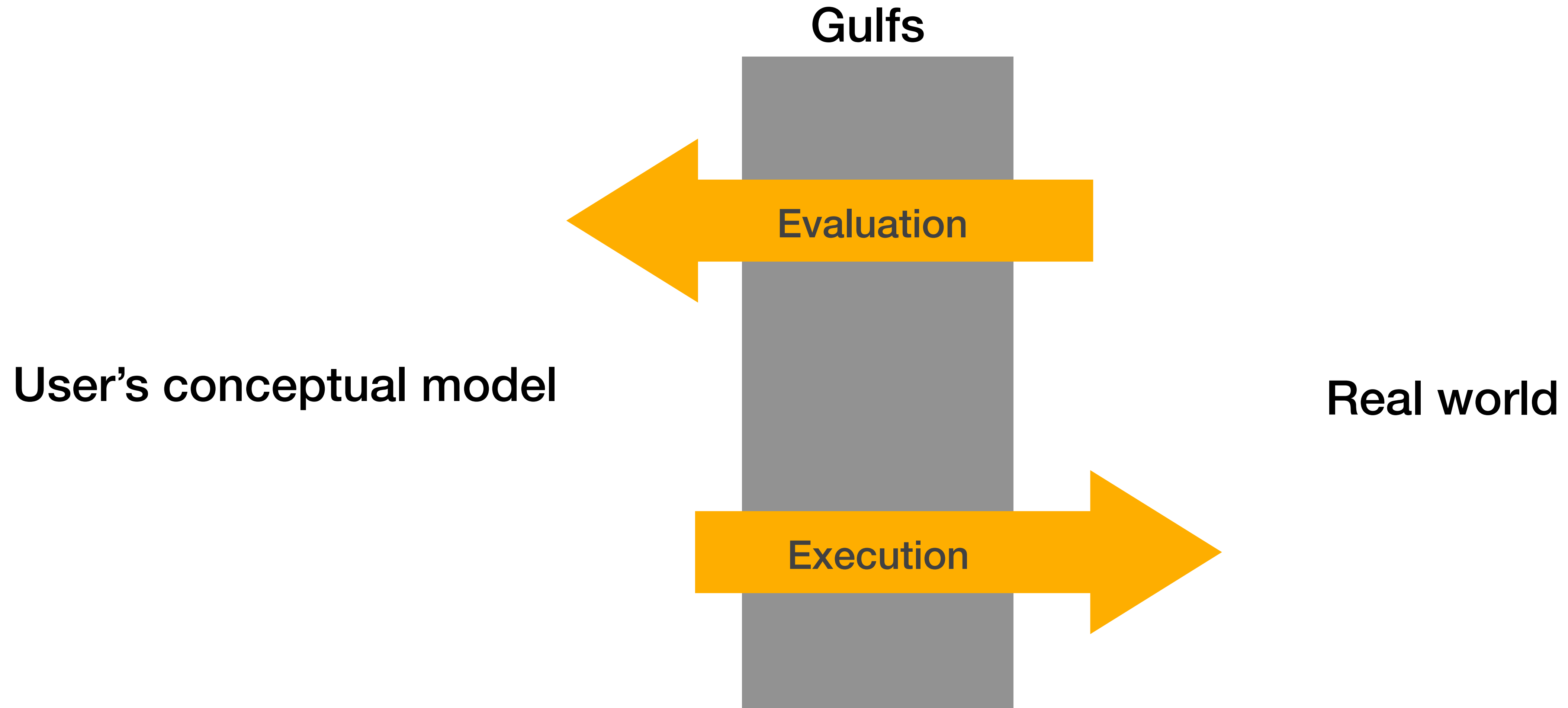






Interaction between people and machines requires mutual *intelligibility* or *shared understanding*.

Gulfs of Execution & Evaluation



[Hutchins, Hollan, and Norman, 1985]

Gulf of Evaluation

What's the state of the system?

Gulf of Execution

How do I change this system?

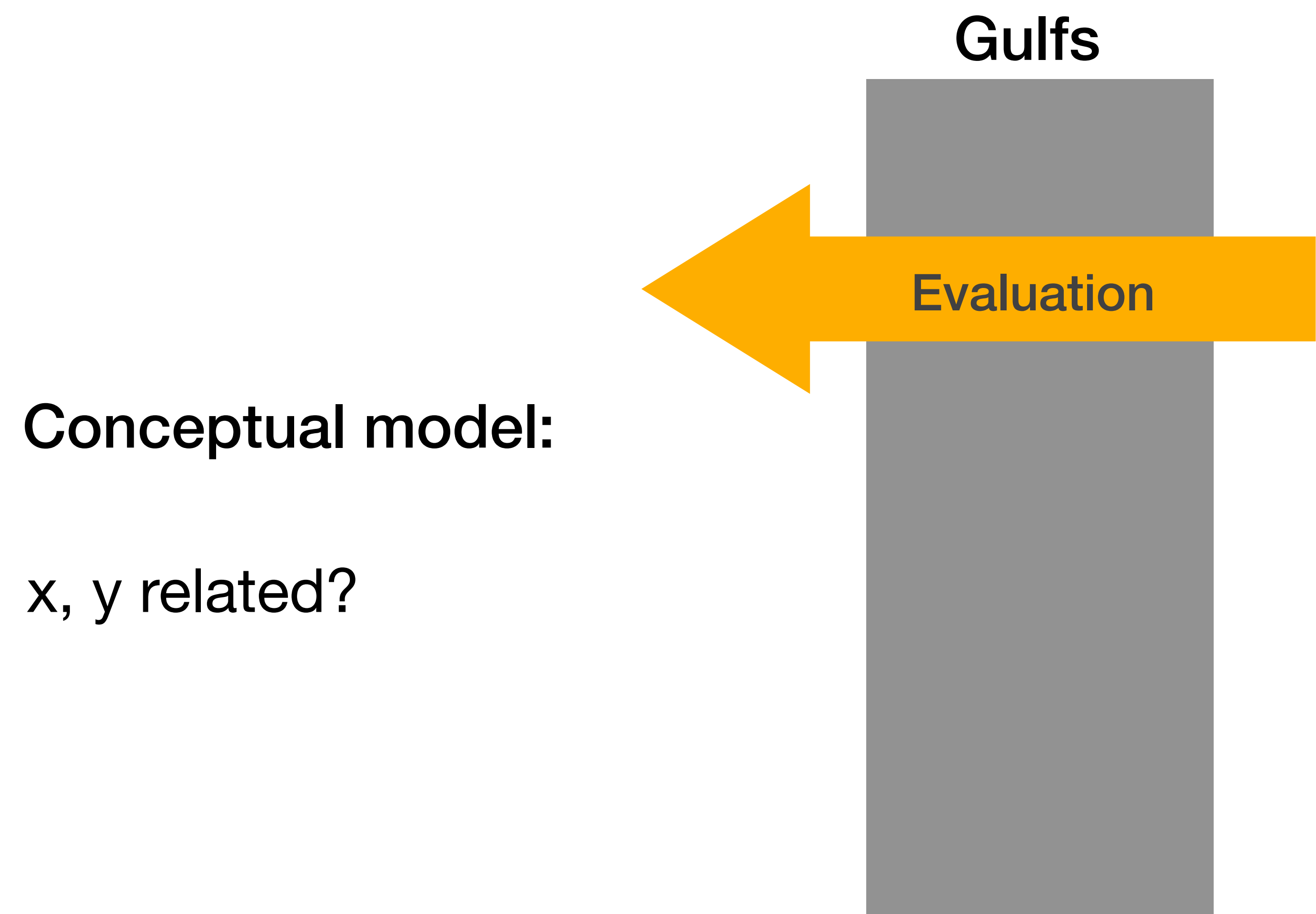
Gulf of Evaluation

The amount of effort that the person must exert to interpret the state of the system and to determine how well the expectations and intentions have been met.

Gulf of Execution

The difference between the user's intentions and the allowable actions.

Gulfs of Execution & Evaluation

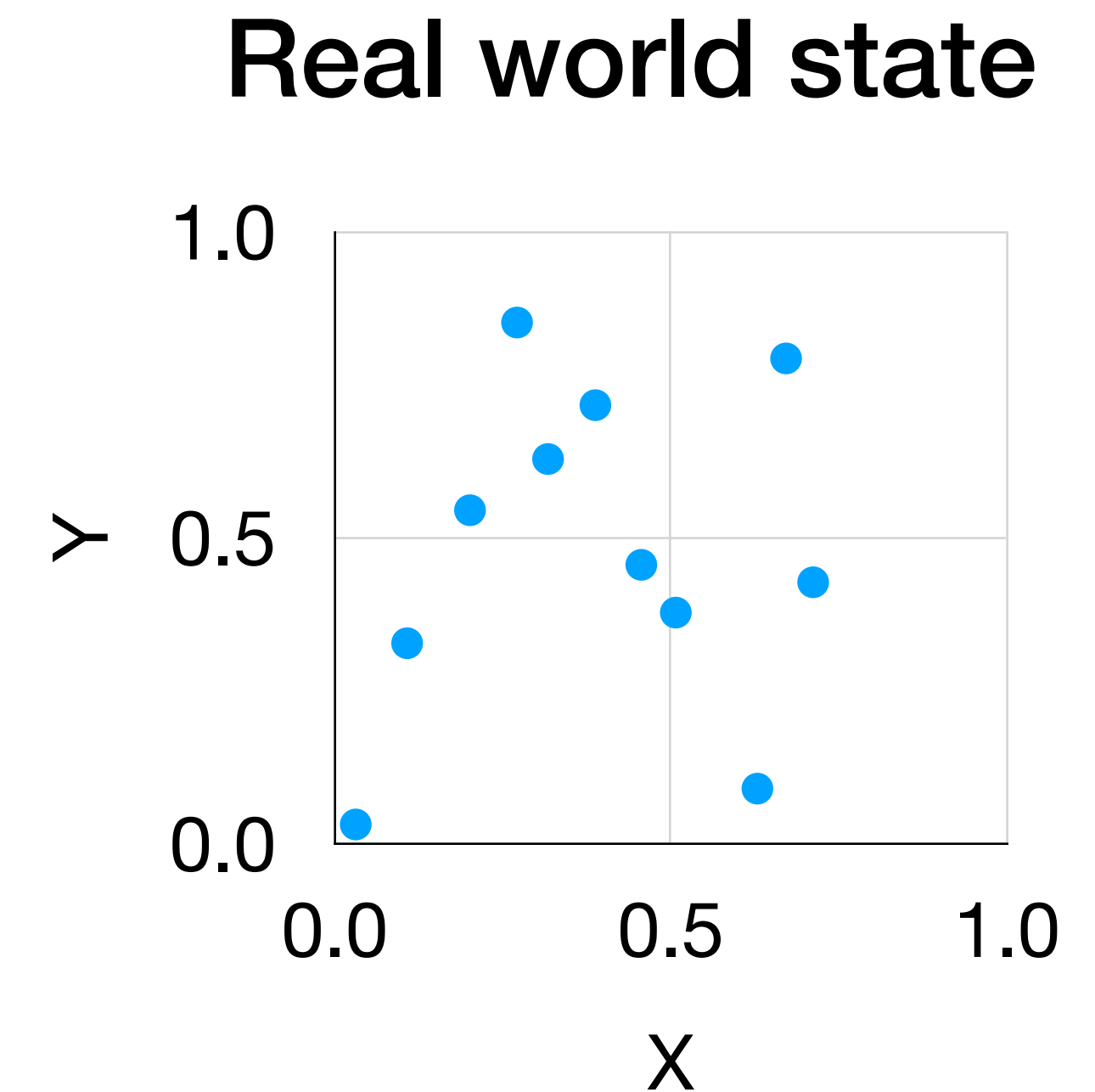
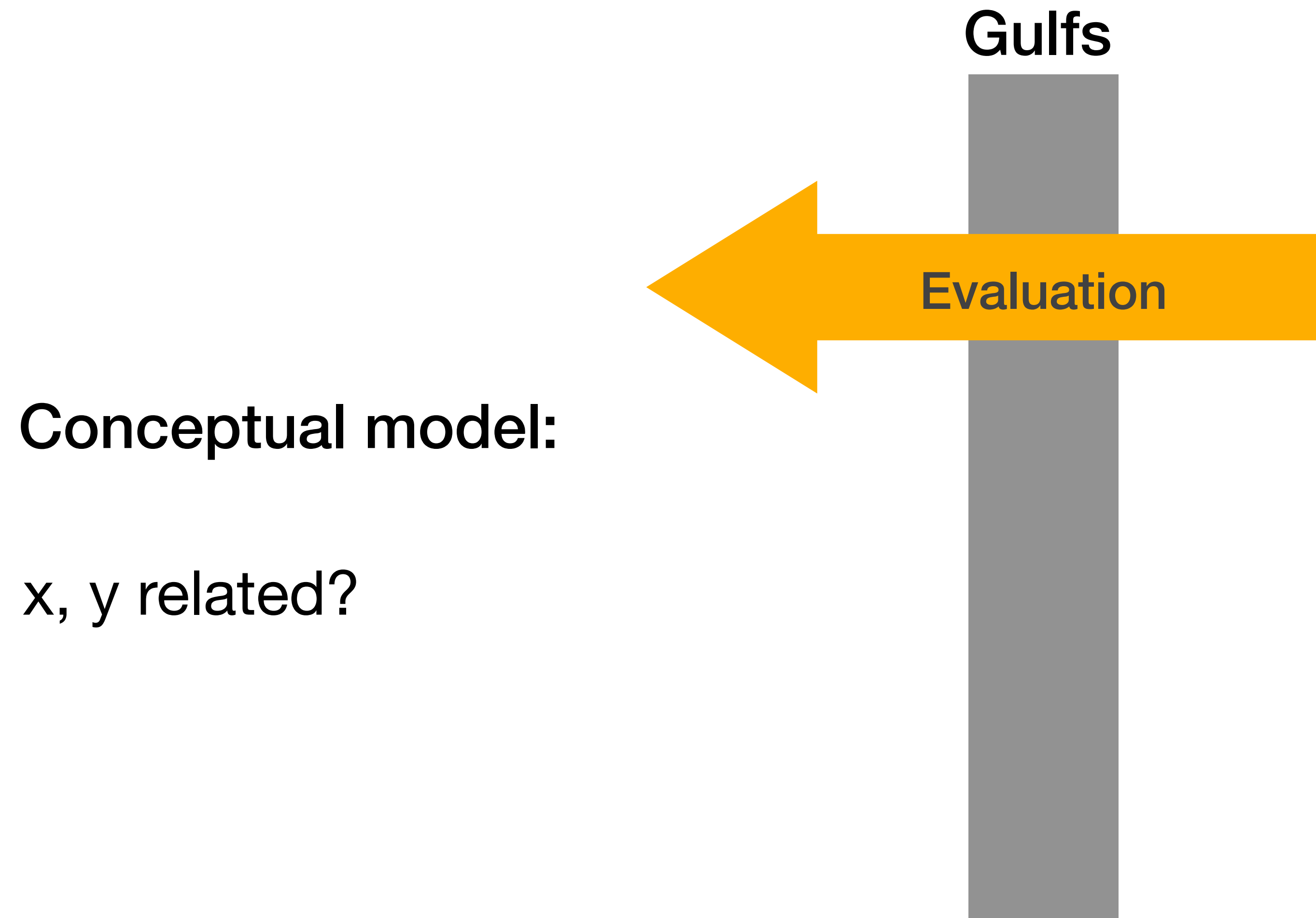


Real world state

X	Y
0.67	0.79
0.32	0.63
0.39	0.72
0.27	0.85
0.71	0.43
0.63	0.09
0.03	0.03
0.20	0.54
0.51	0.38
0.11	0.33
0.46	0.46

[Hutchins, Hollan, and Norman, 1985]

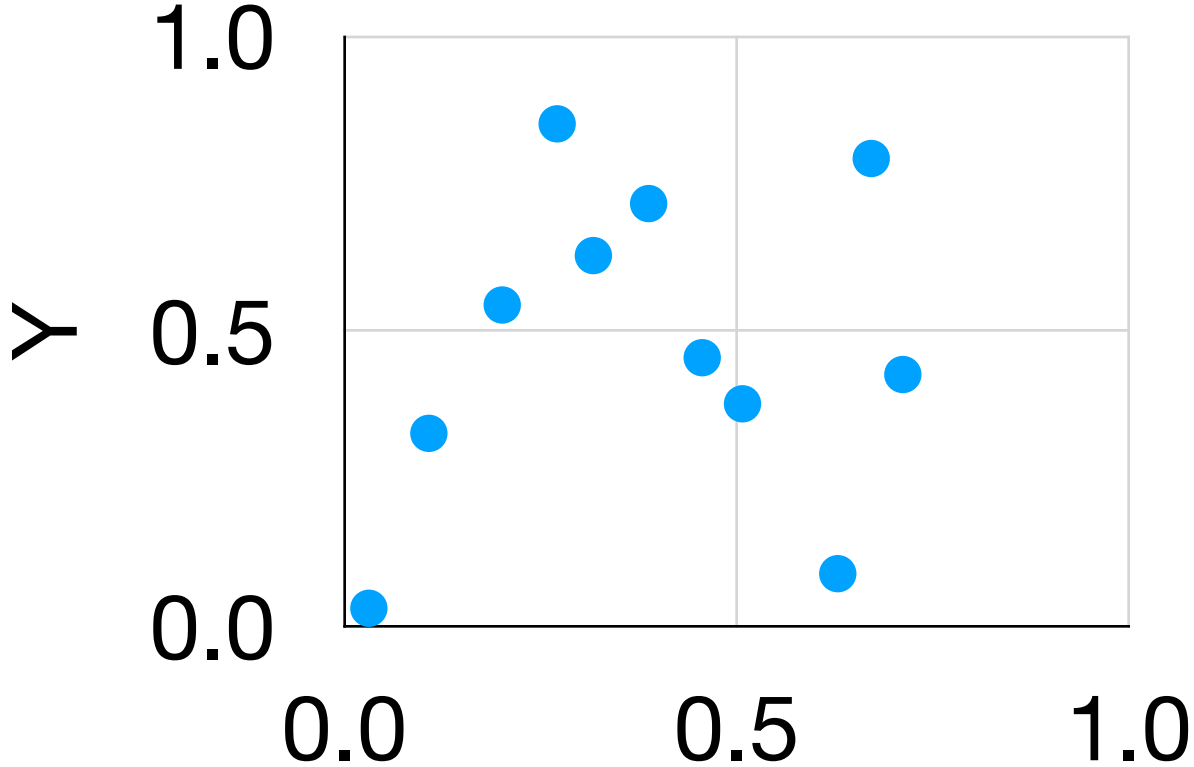
Gulfs of Execution & Evaluation



more effective visual encoding

Gulfs of Execution & Evaluation

RW target state



X



Move 90 30
Rotate 35
Pen down
...

Gulfs

Execution

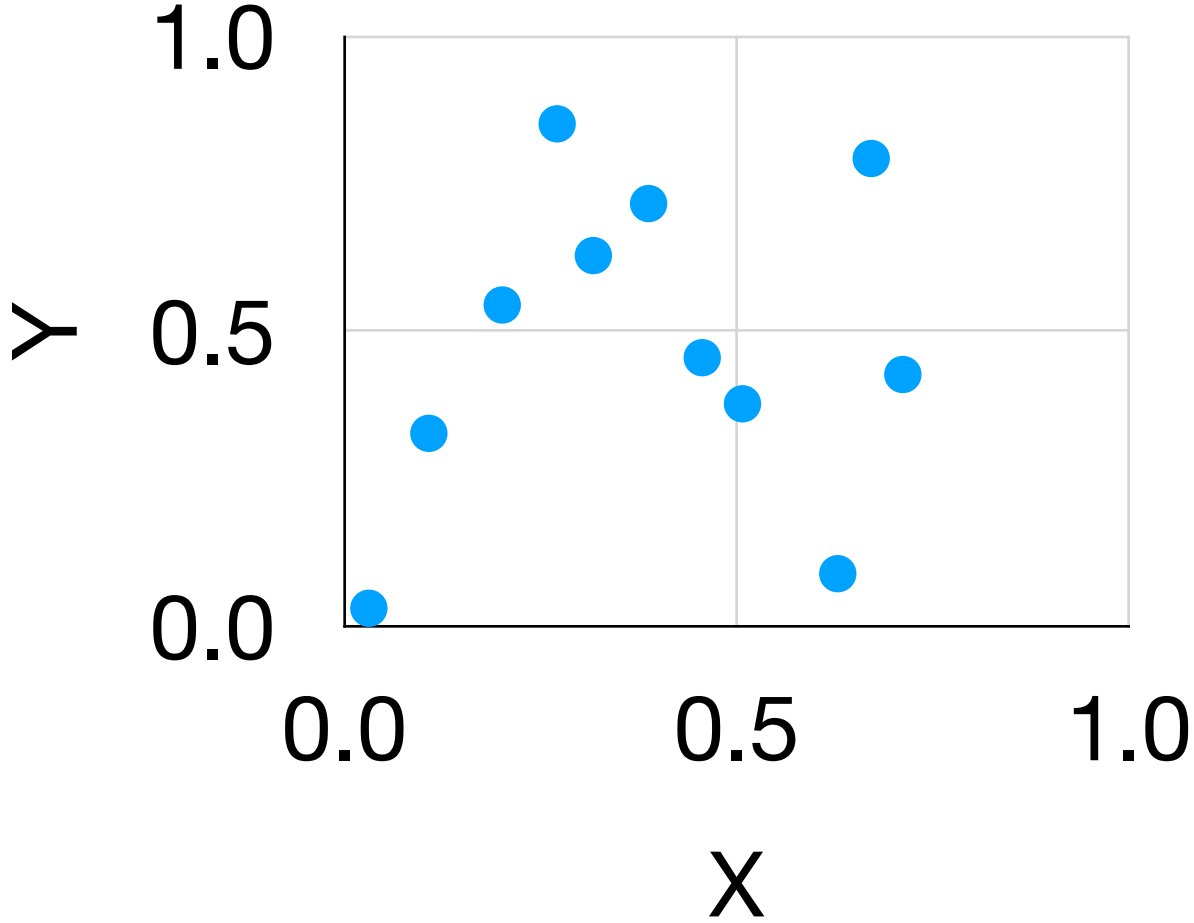
Conceptual model:



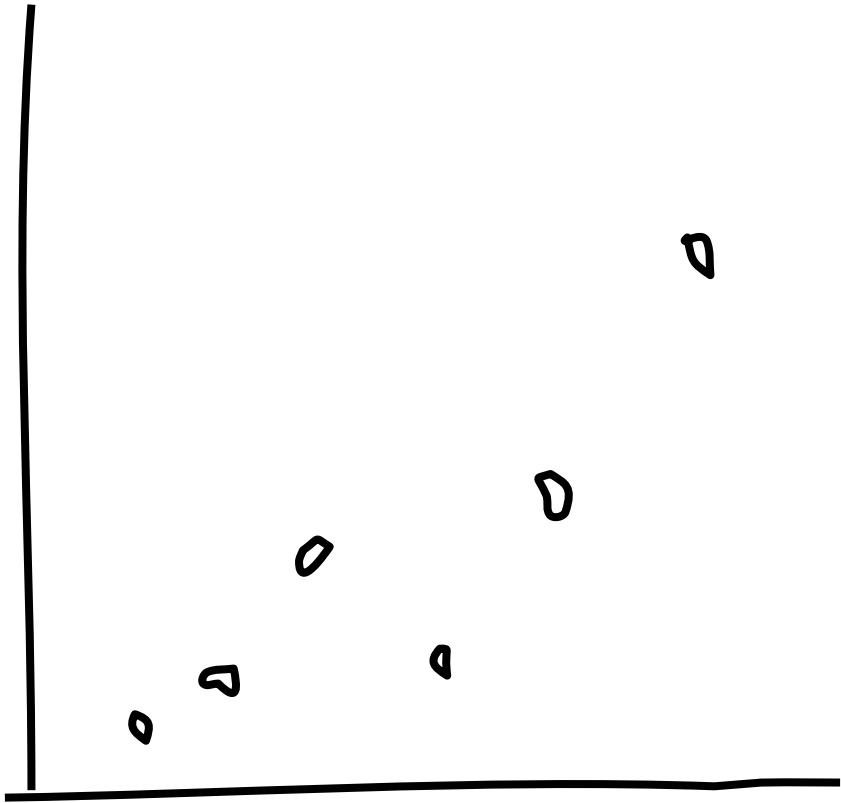
[Hutchins, Hollan, and Norman, 1985]

Gulfs of Execution & Evaluation

RW target state



Conceptual model:



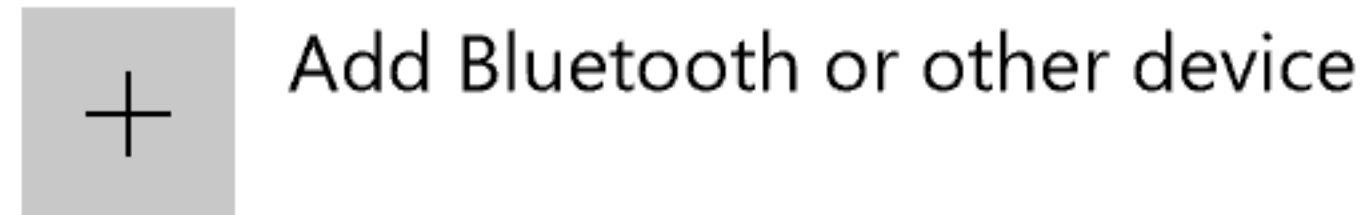
Gulfs



X	Y
0.67	0.79
0.32	0.63
0.39	0.72
0.27	0.85
0.71	0.43
0.63	0.09
...	...

[Hutchins, Hollan, and Norman, 1985]

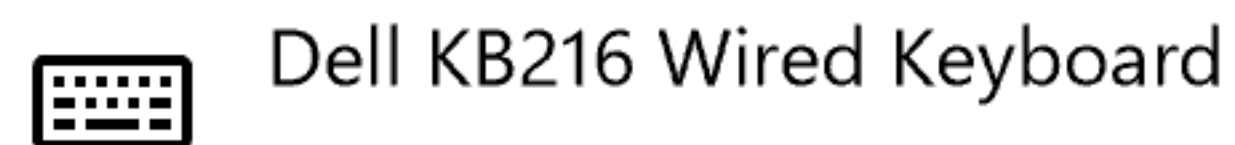
Bluetooth & other devices



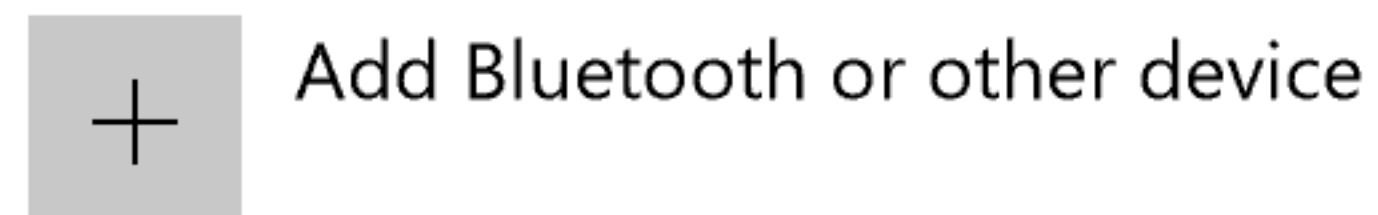
Bluetooth



Mouse, keyboard, & pen



Bluetooth & other devices

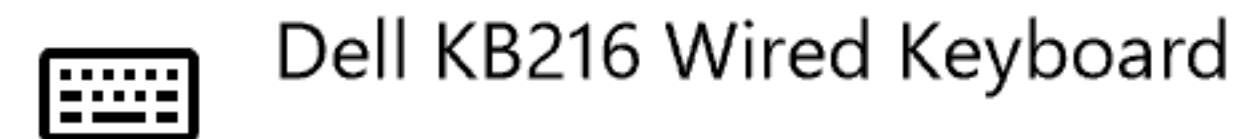


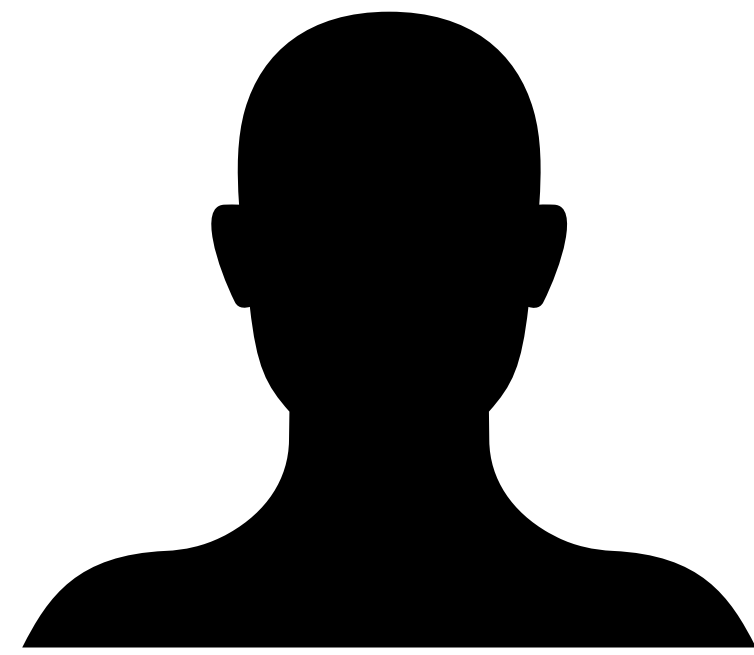
Bluetooth



Now discoverable as "DESKTOP-ISFRCAL"

Mouse, keyboard, & pen



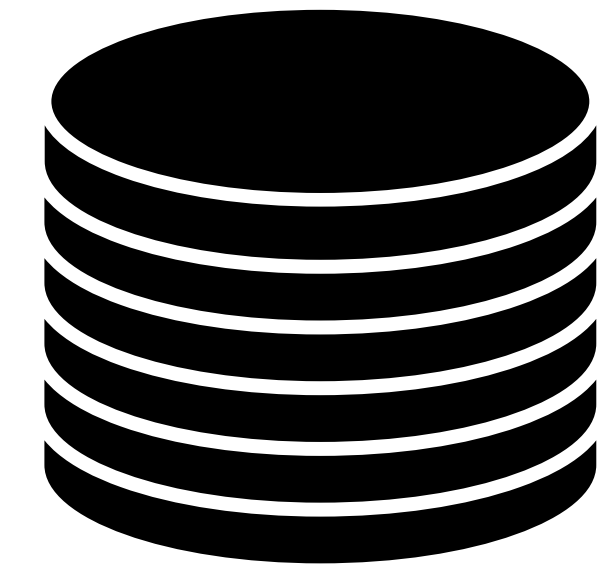


User Goals

- ✗ Results returned as a table.
- ✗ No hint on how to reformulate query.
- ✗ Slow question-answer loop.

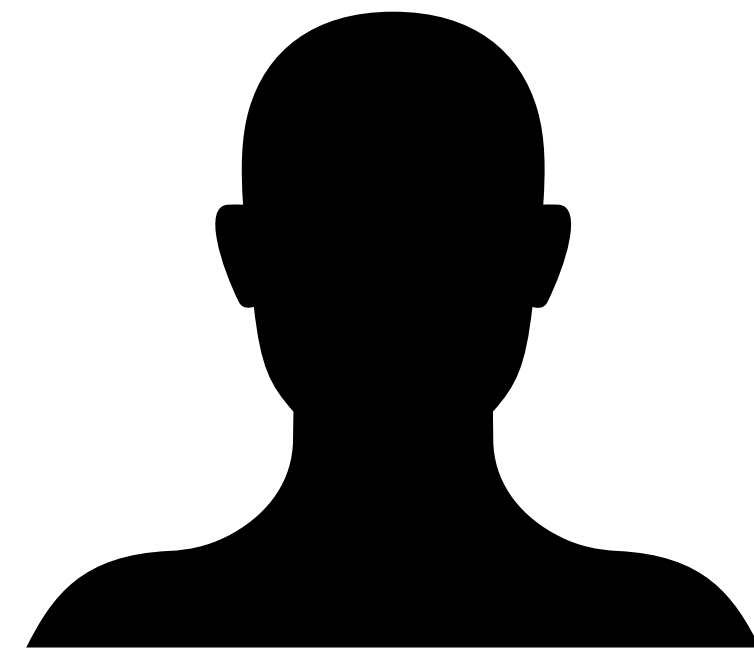


SQL



Database

- ✗ A rigid syntax designed by/for programmers.
- ✗ Difficult to do "fuzzy" matching.

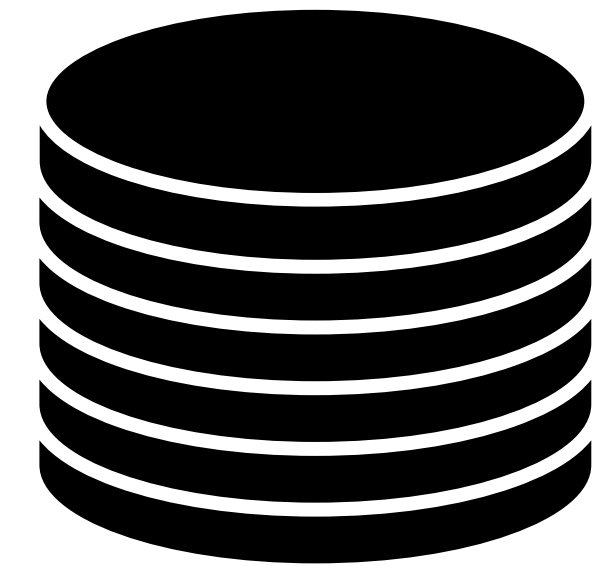


User Goals

- ✓ Visual representation of objects + actions.
- ✓ Immediate + continuous display of results.



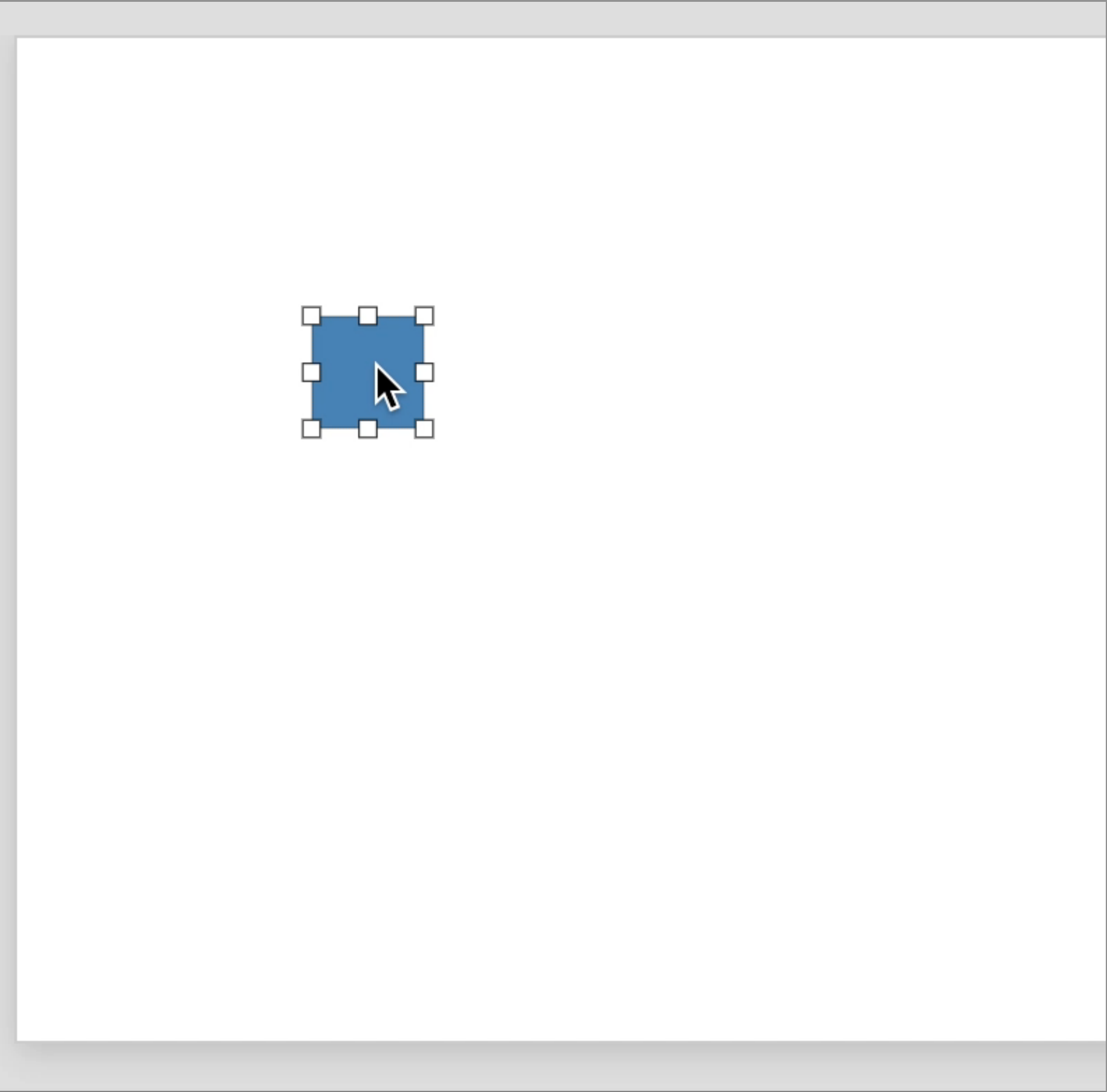
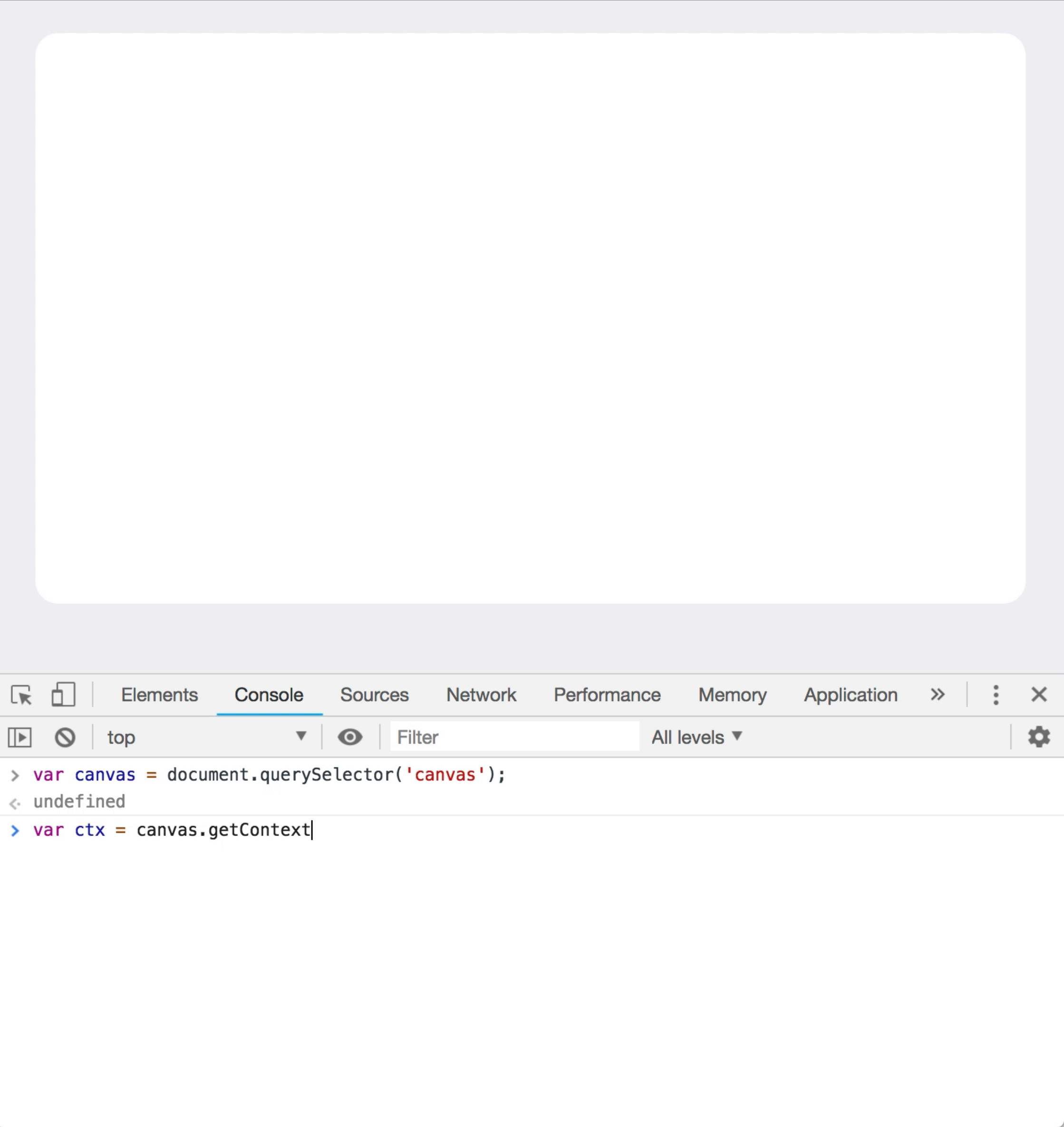
Direct Manipulation



Database



- ✓ Physical actions or labeled buttons instead of complex syntax.
- ✓ Rapid, incremental, and reversible actions.



Interaction with Visualization

Select – identify something as interesting.

Connect – show me related items.

Abstract/Elaborate – show me more or less detail.

Filter – show me something conditionally.

Reconfigure – show me a different arrangement.

Explore – show me something else.

Encode – show me a different visual representation.

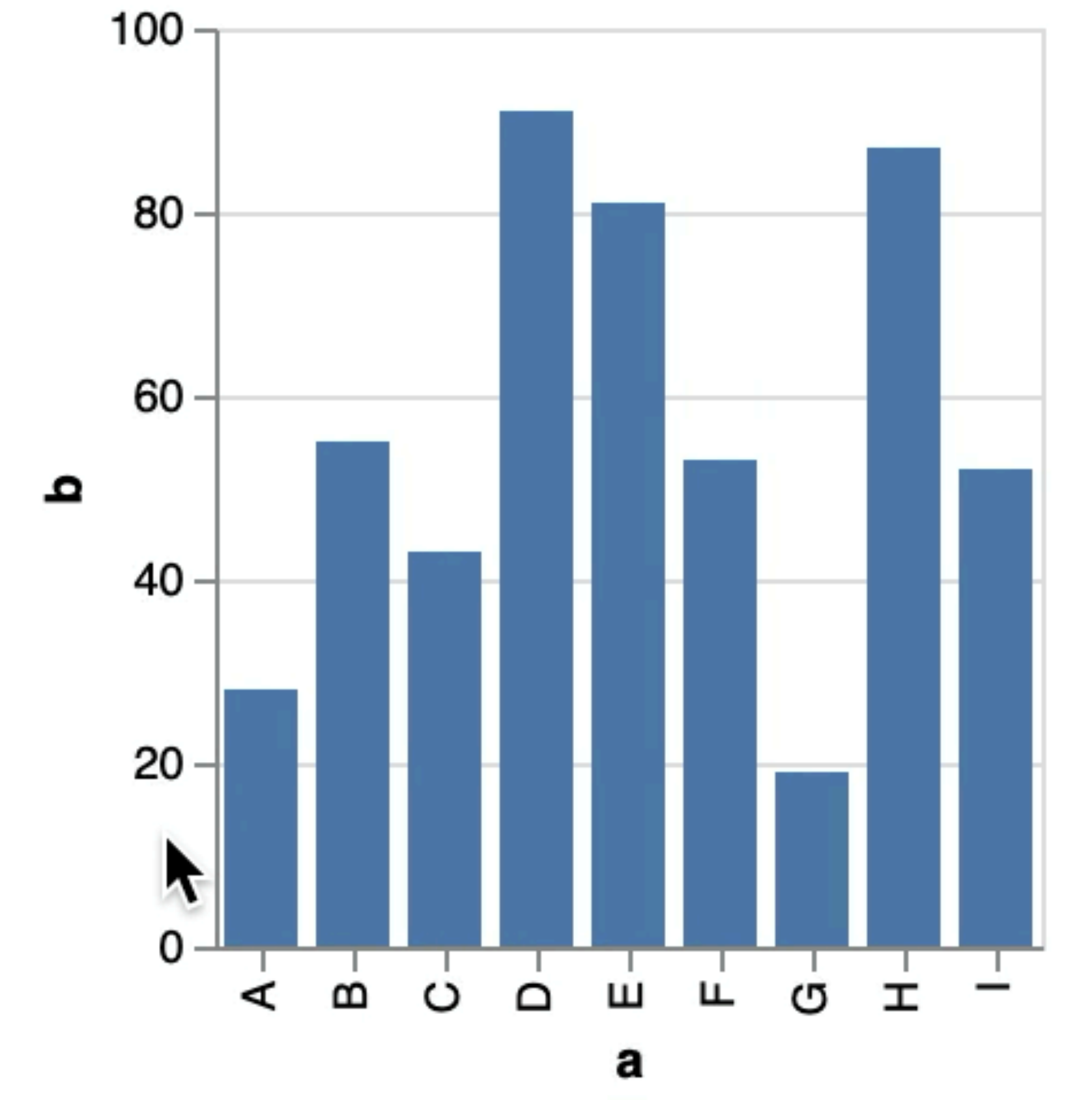
Point Selection

Identify something as interesting

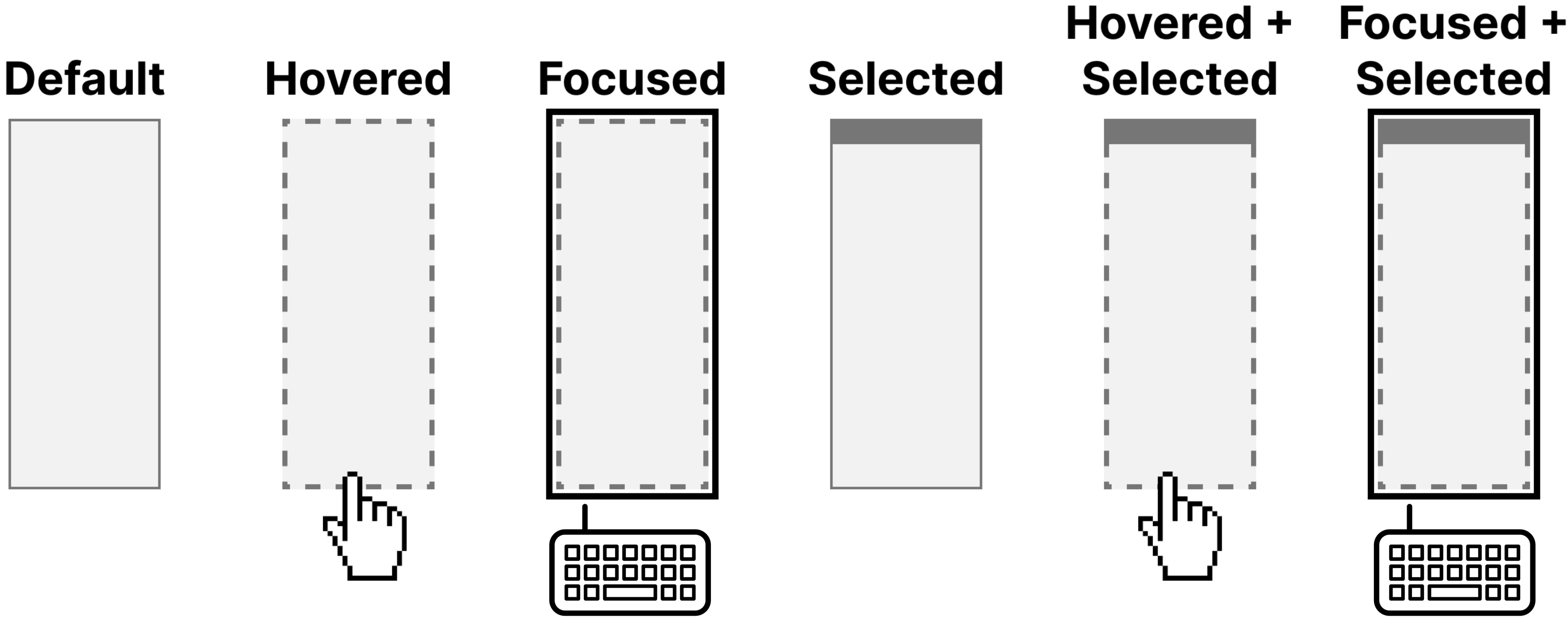
Select discrete data values.

How many points are selected? 1, 2, 3, ...

How are points selected? Mouse hover, click, tap, ...



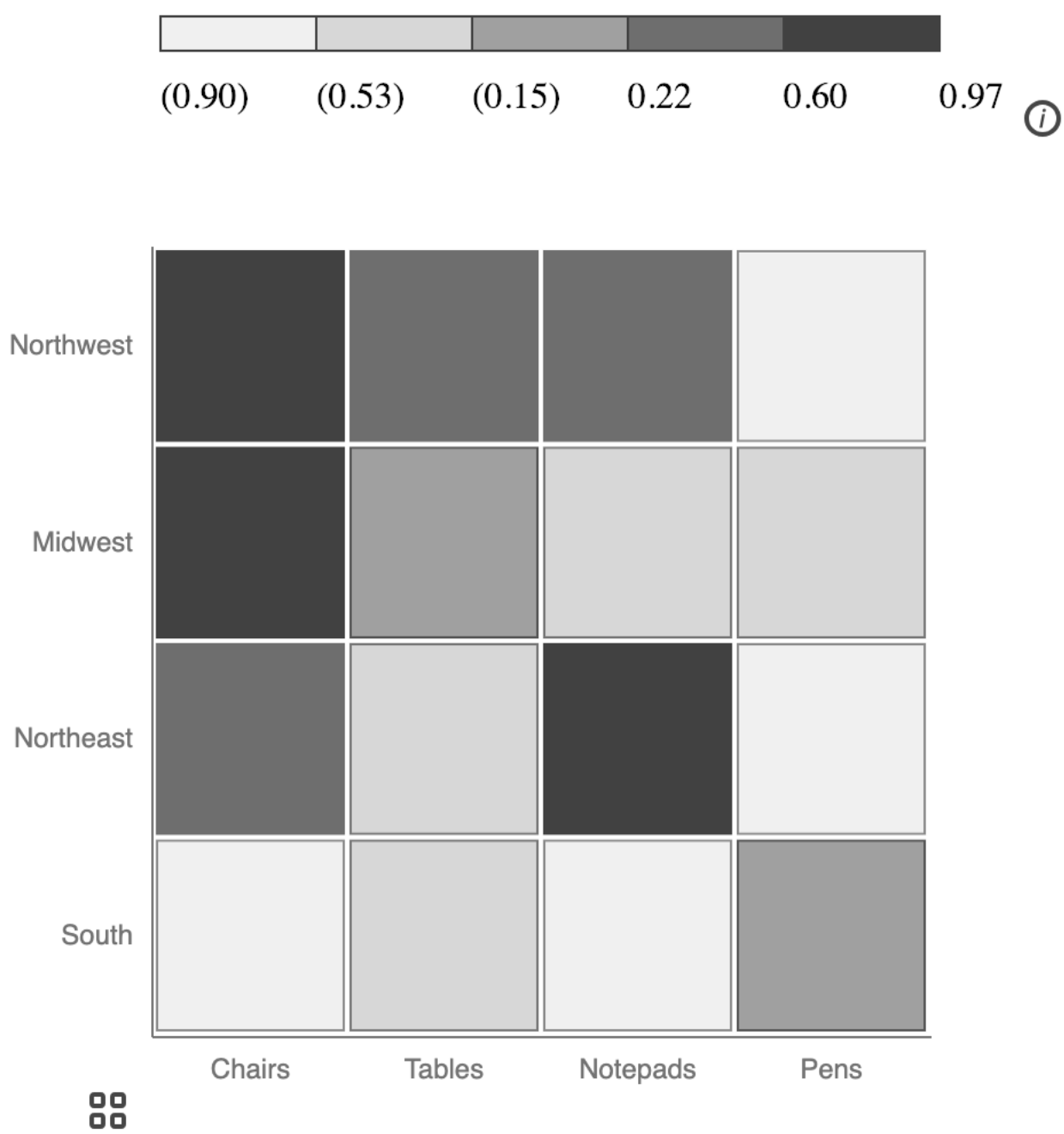
Accessible strategies showing the state of interaction



Show system state (visually *and* non-visually)

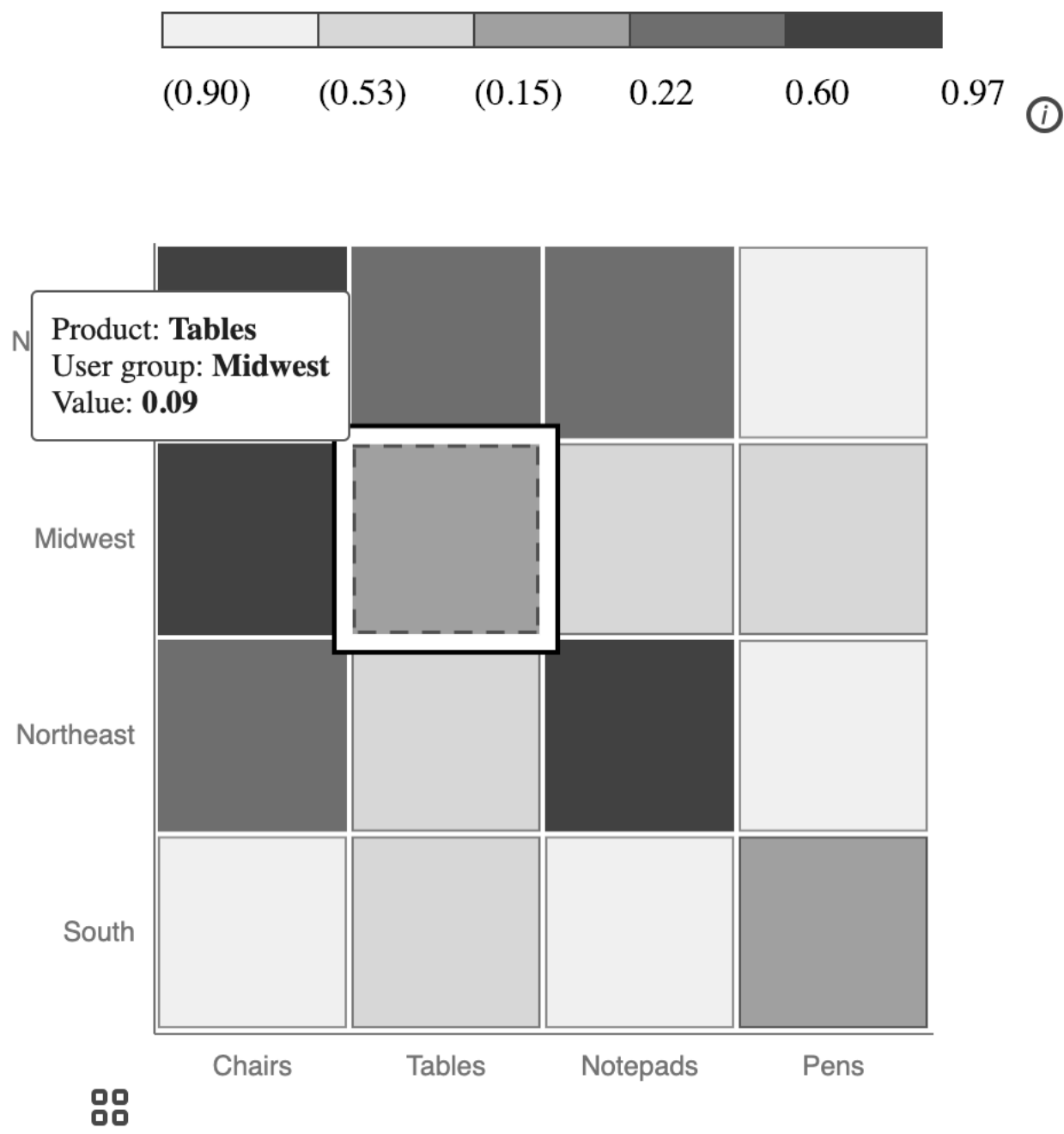
Comparing how user groups correlate to approval rates of product types

A high correlation value (close to 1) indicates that these users have a high approval rate of that product. A low correlation value (close to -1) indicates a negative approval rate of those products.

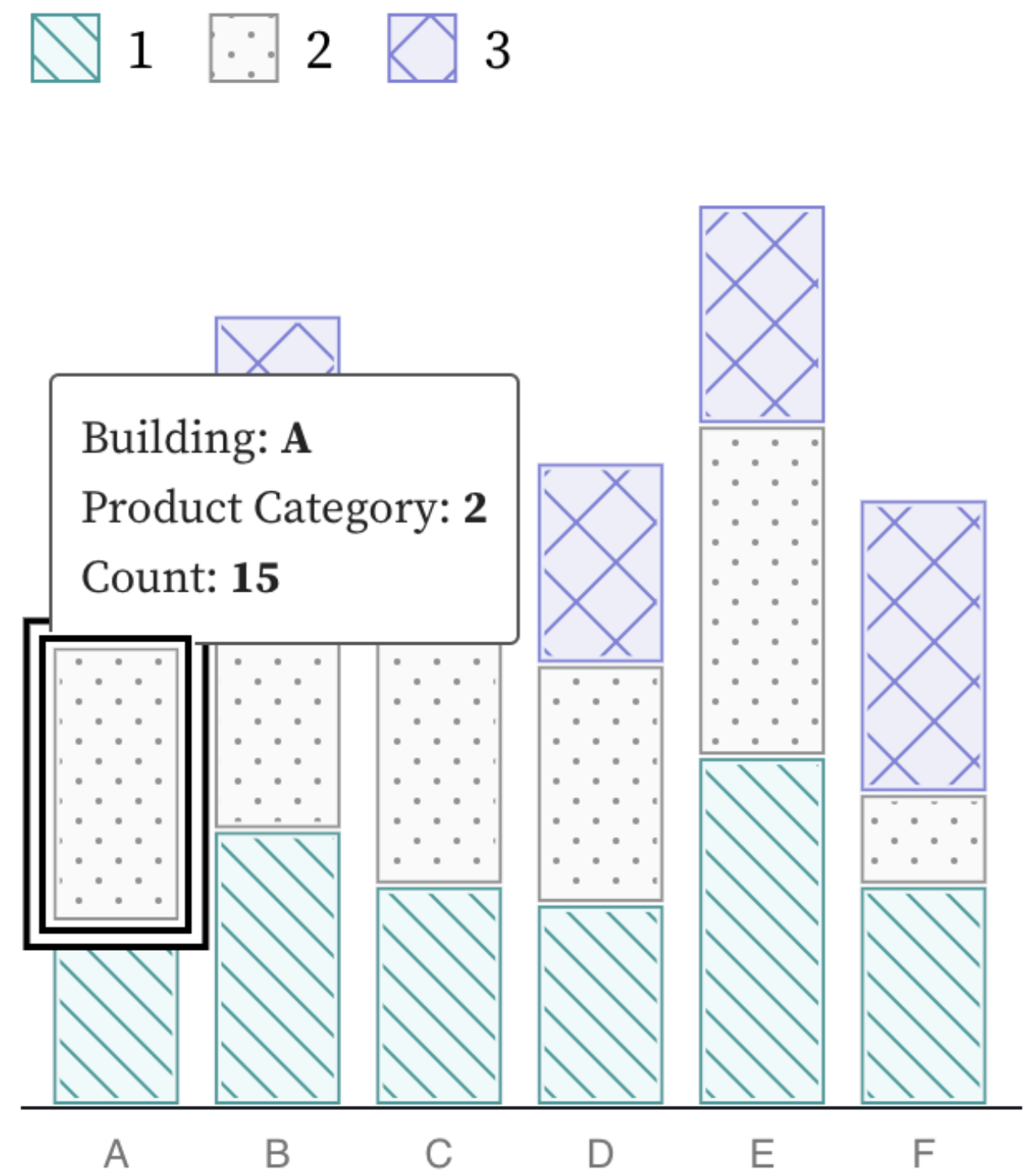


Comparing how user groups correlate to approval rates of product types

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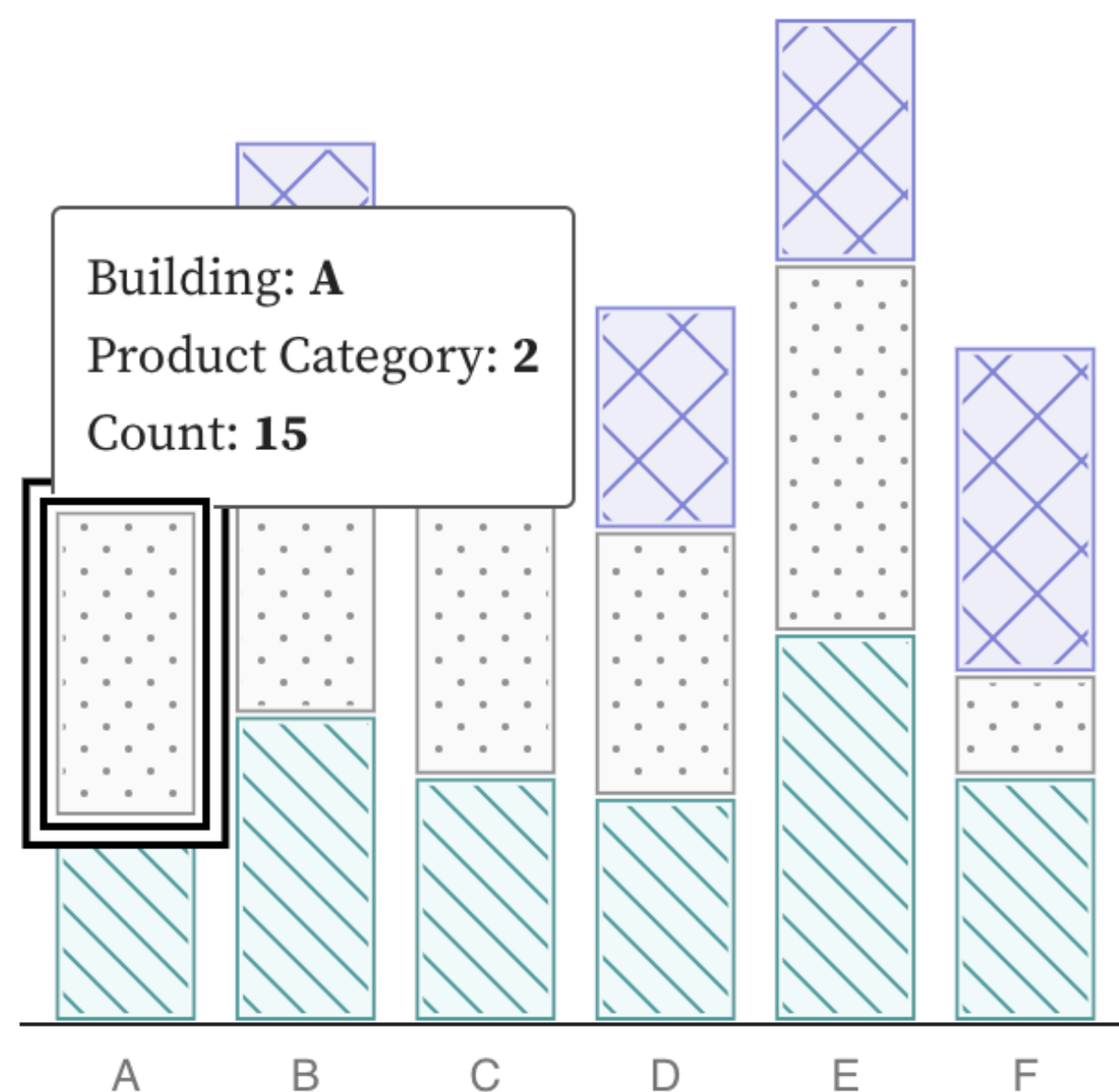
Alt text should communicate operability



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

Semantics matter

1 2 3

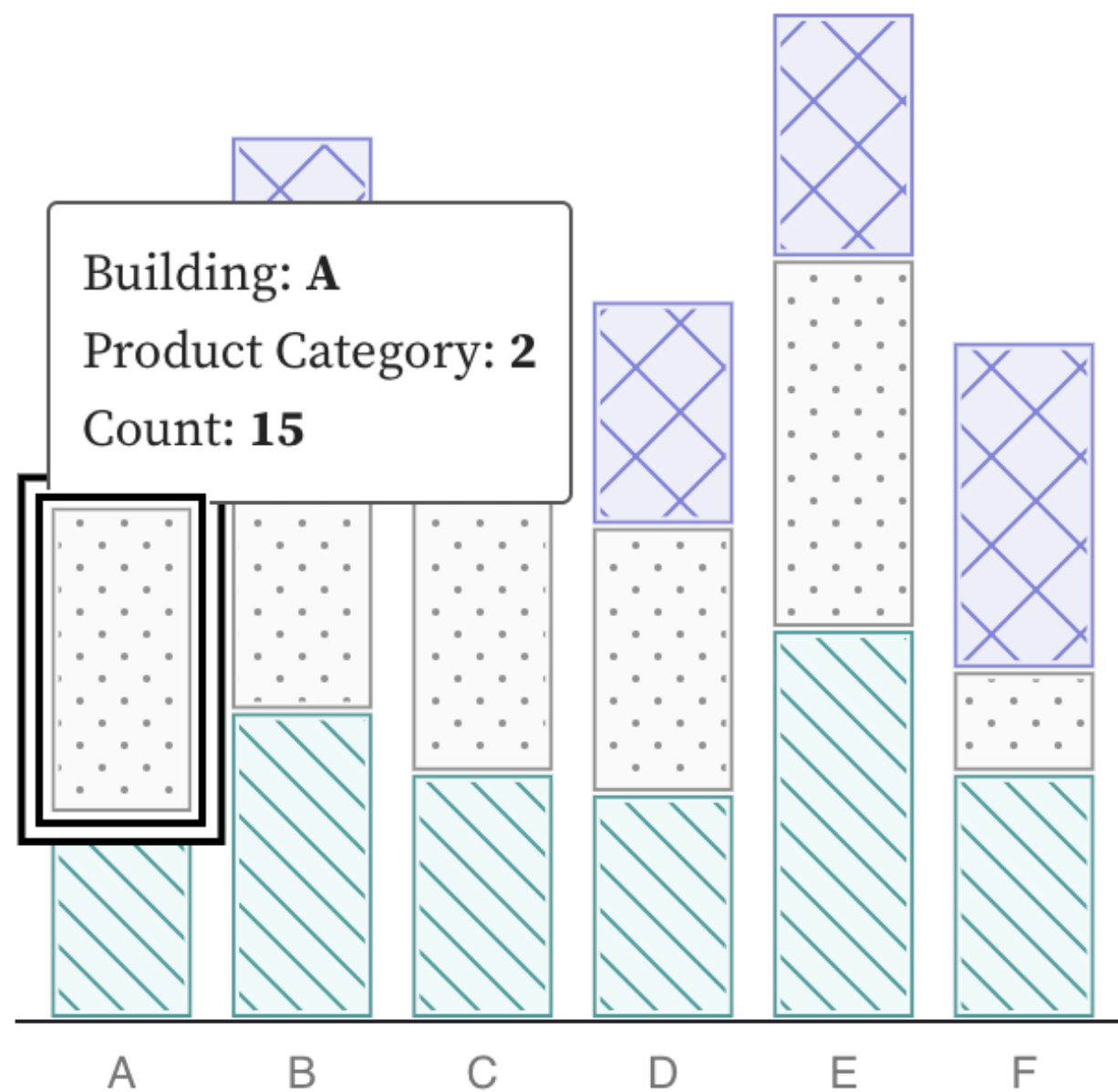


× Building A. Product Category 2.
Count 15. Bar 2 of 3. Image.

“Image” doesn’t signal
interactivity!

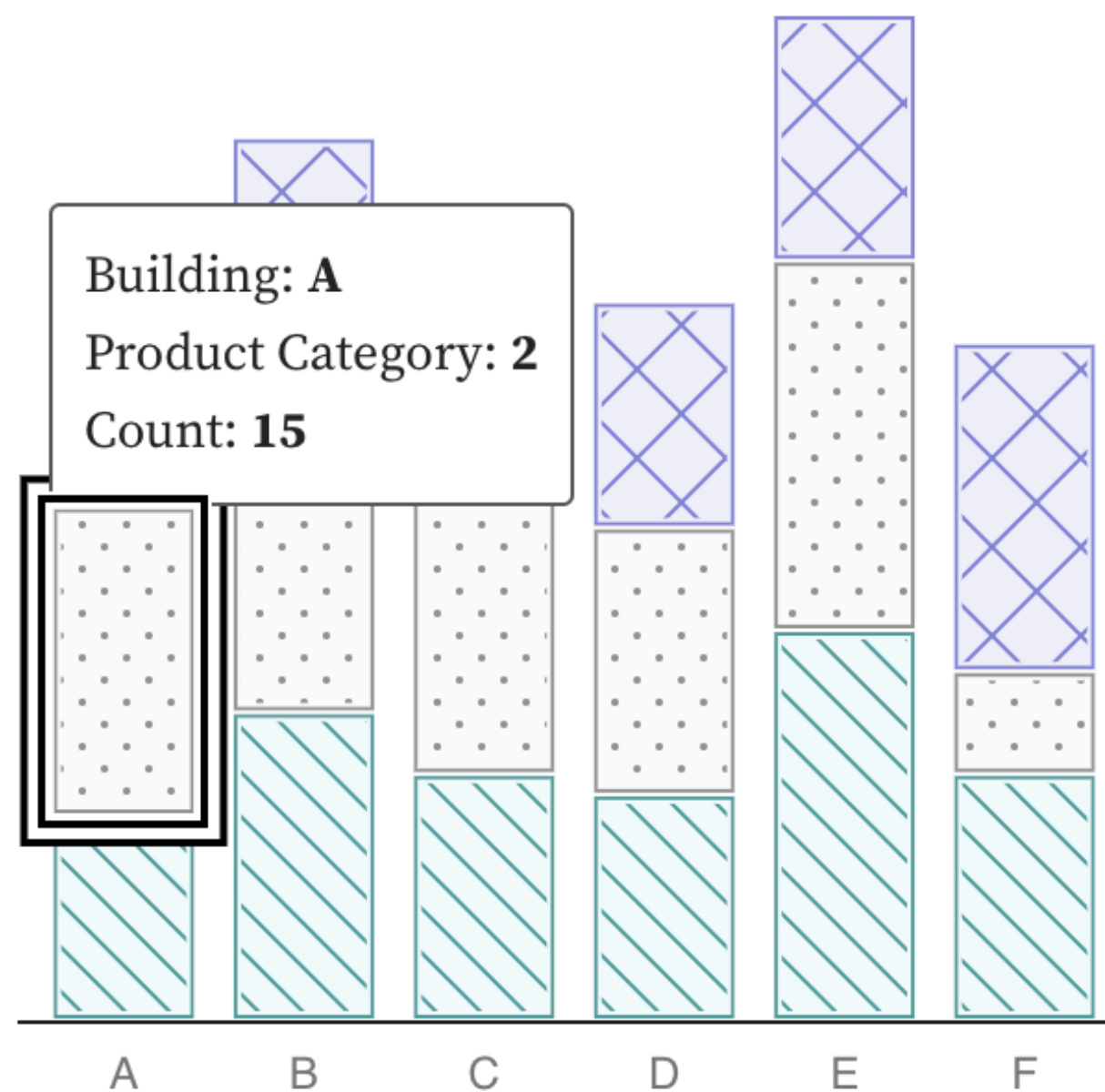
“Aria” states and roles are standardized

1 2 3



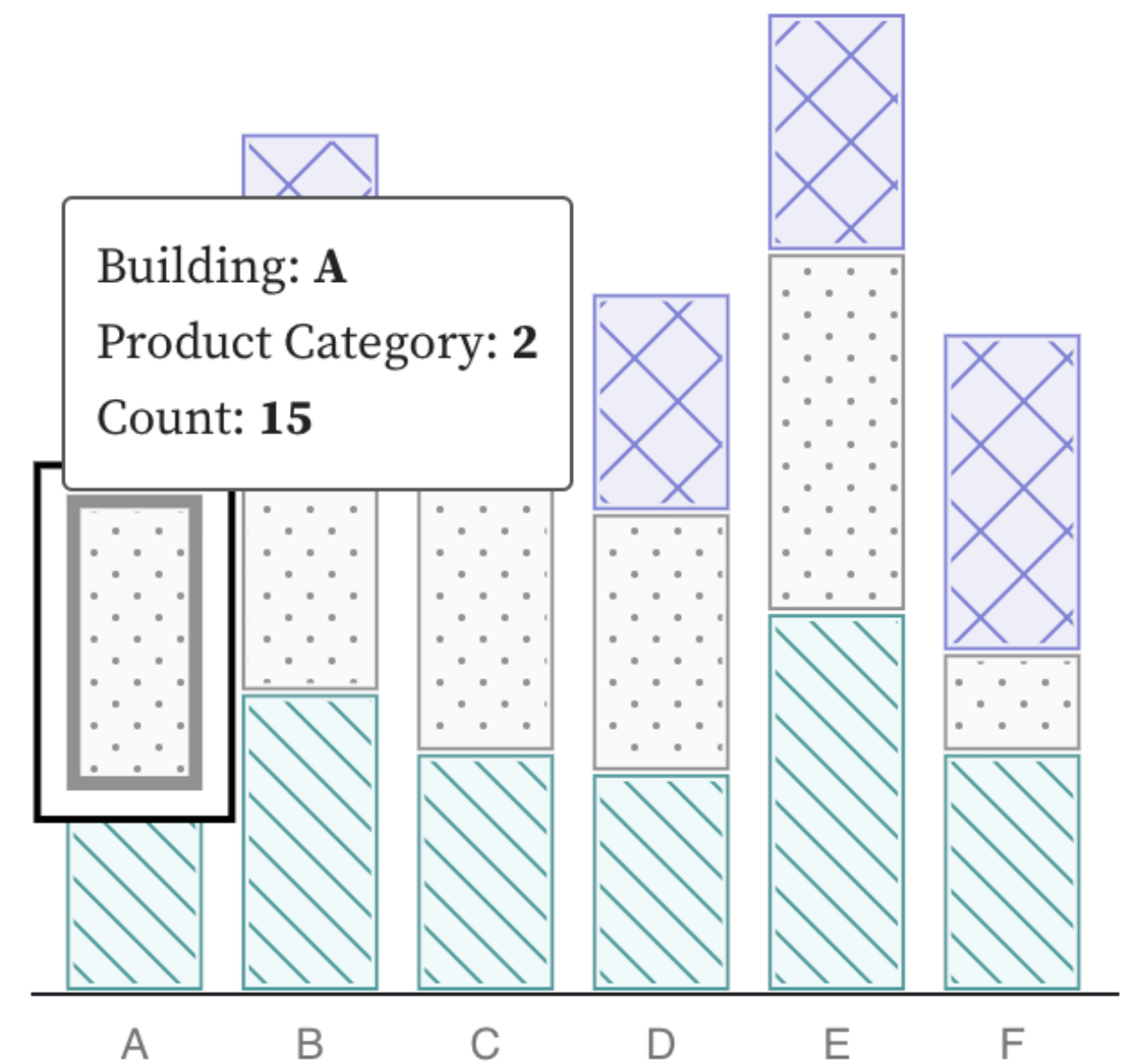
× Building A. Product Category 2.
Count 15. Bar 2 of 3. Image.

1 2 3



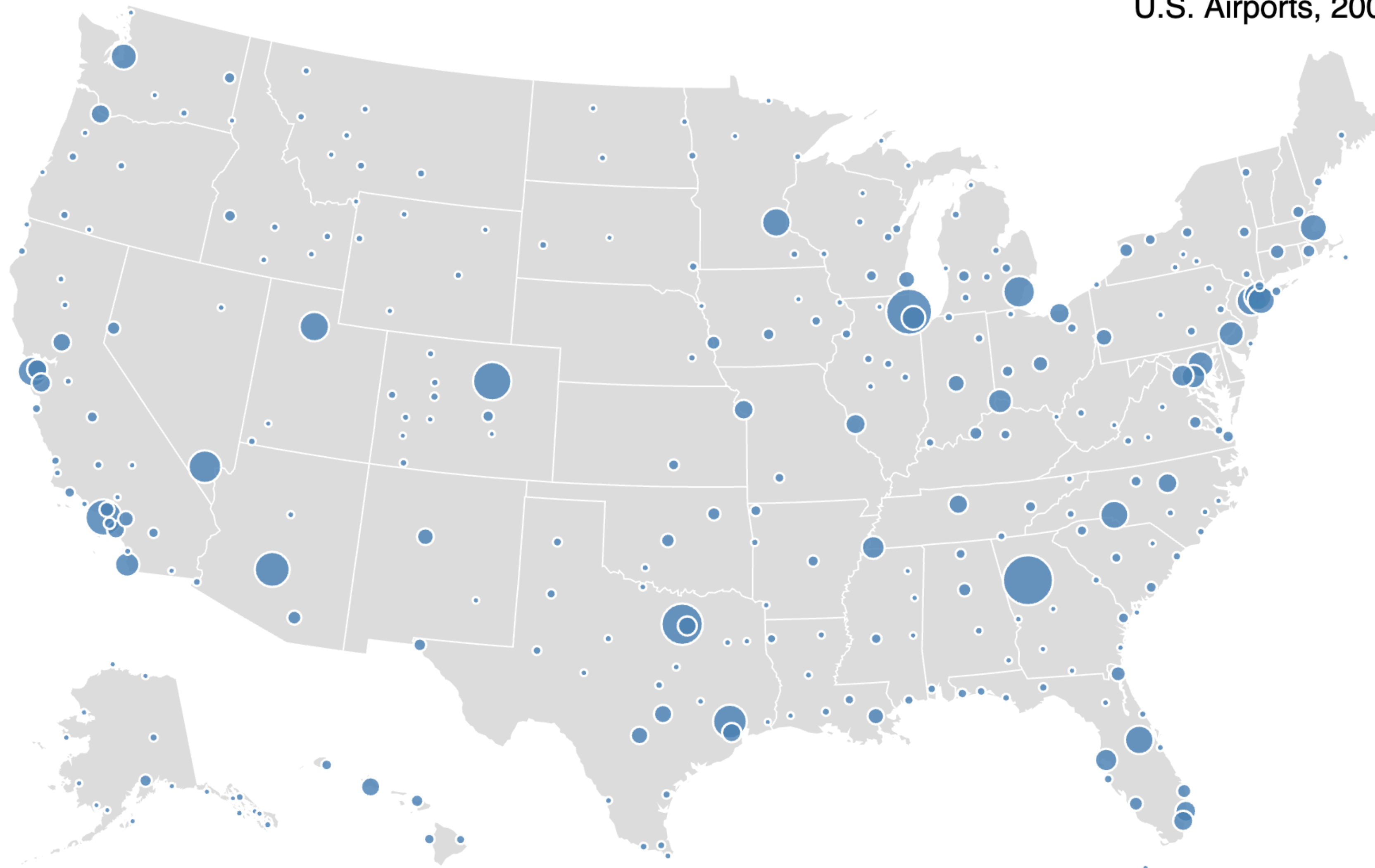
× Building A. Product Category
2. Count 15. Bar 2 of 3., toggle
button

1 2 3



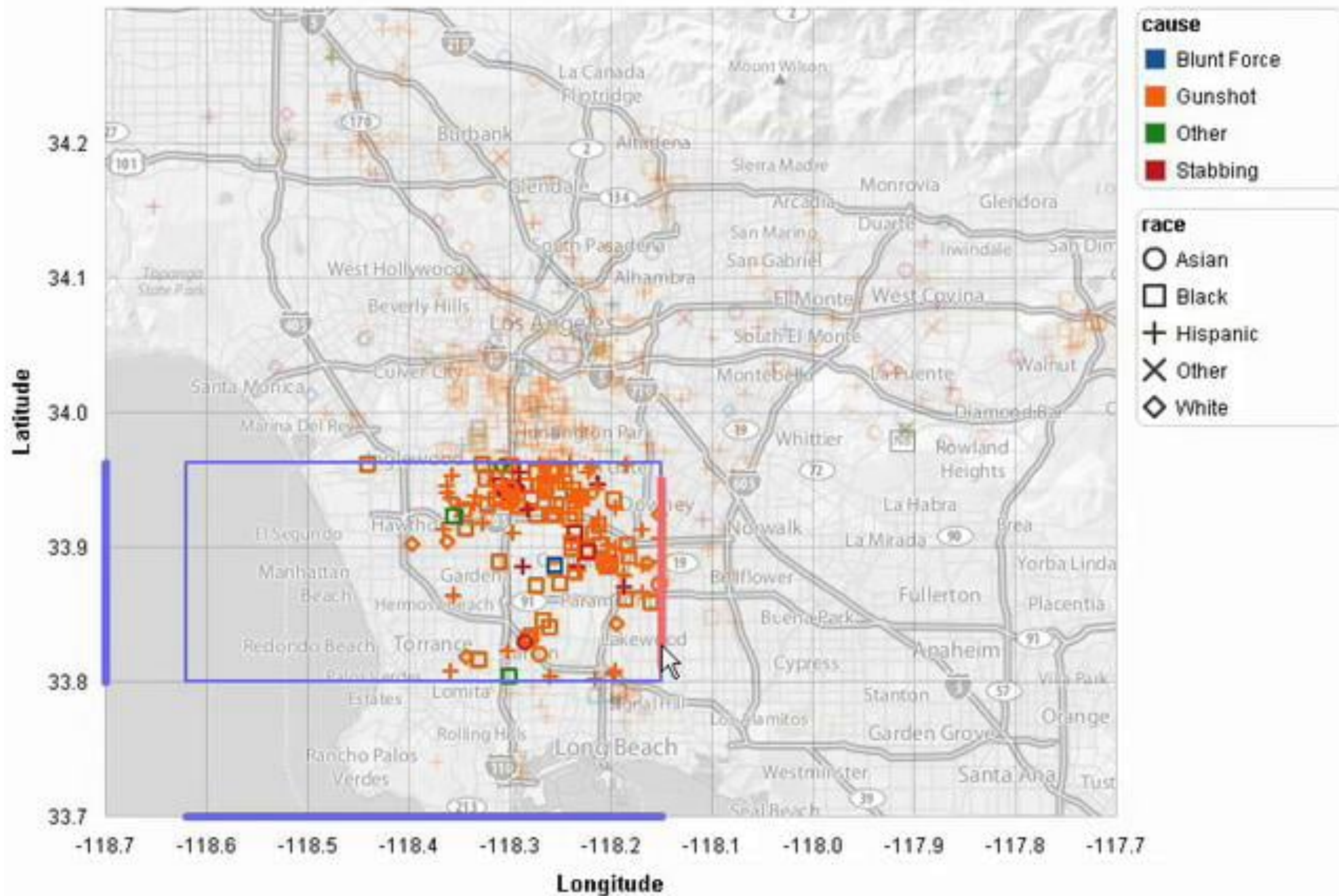
× selected, Building A. Product
Category 2. Count 15. Bar 2 of
3., toggle button

U.S. Airports, 2008



<https://vega.github.io/vega/examples/airport-connections/>

Homicide Victims in Los Angeles County, 2007 (Source: LA Times)



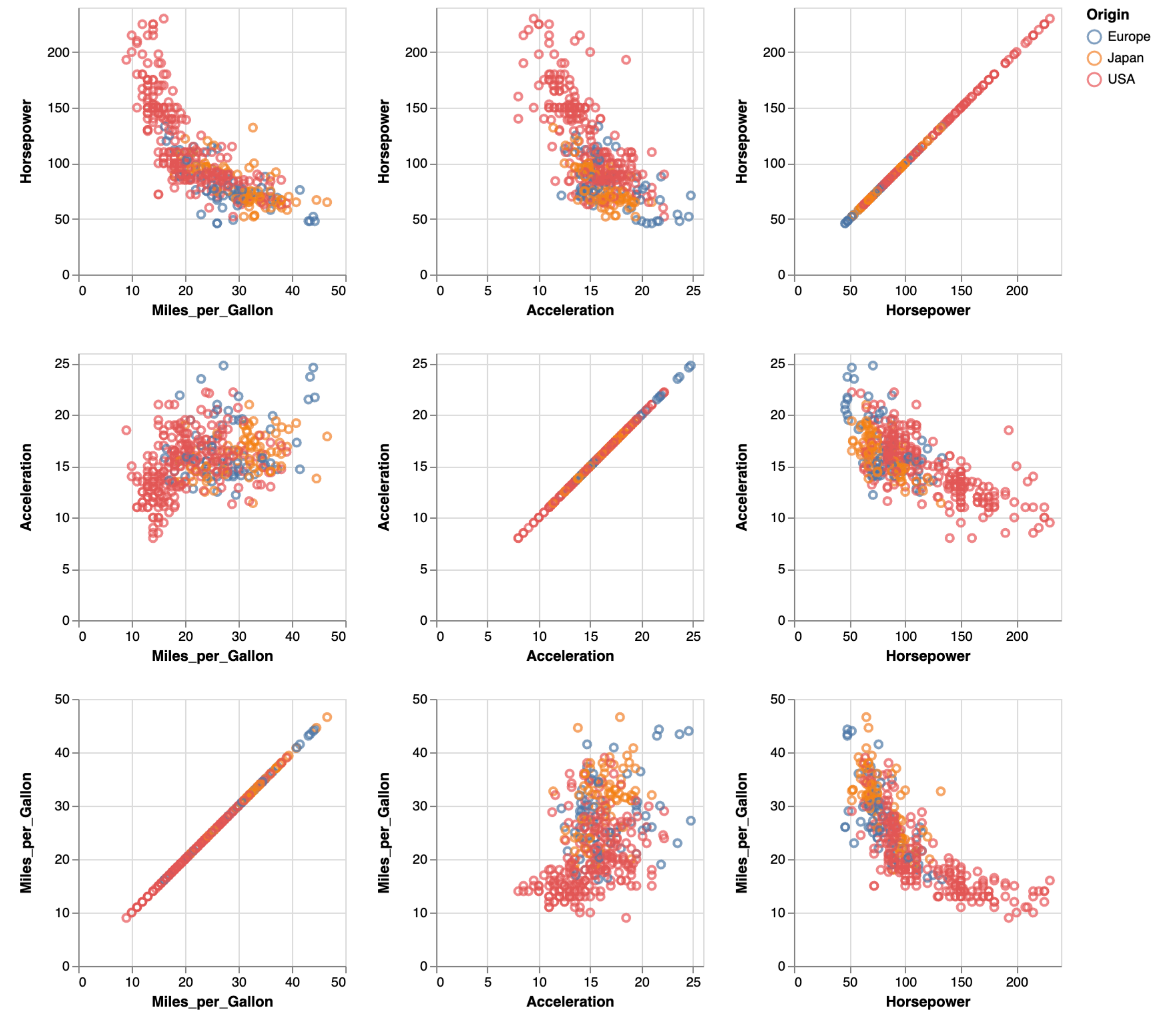
Heer et al., Generalized Selection via Interactive Query Relaxation

Connect

show me related items

Brushing & linking:
selection is called a "brush", and
the selected data is shown
("linked") in other views.

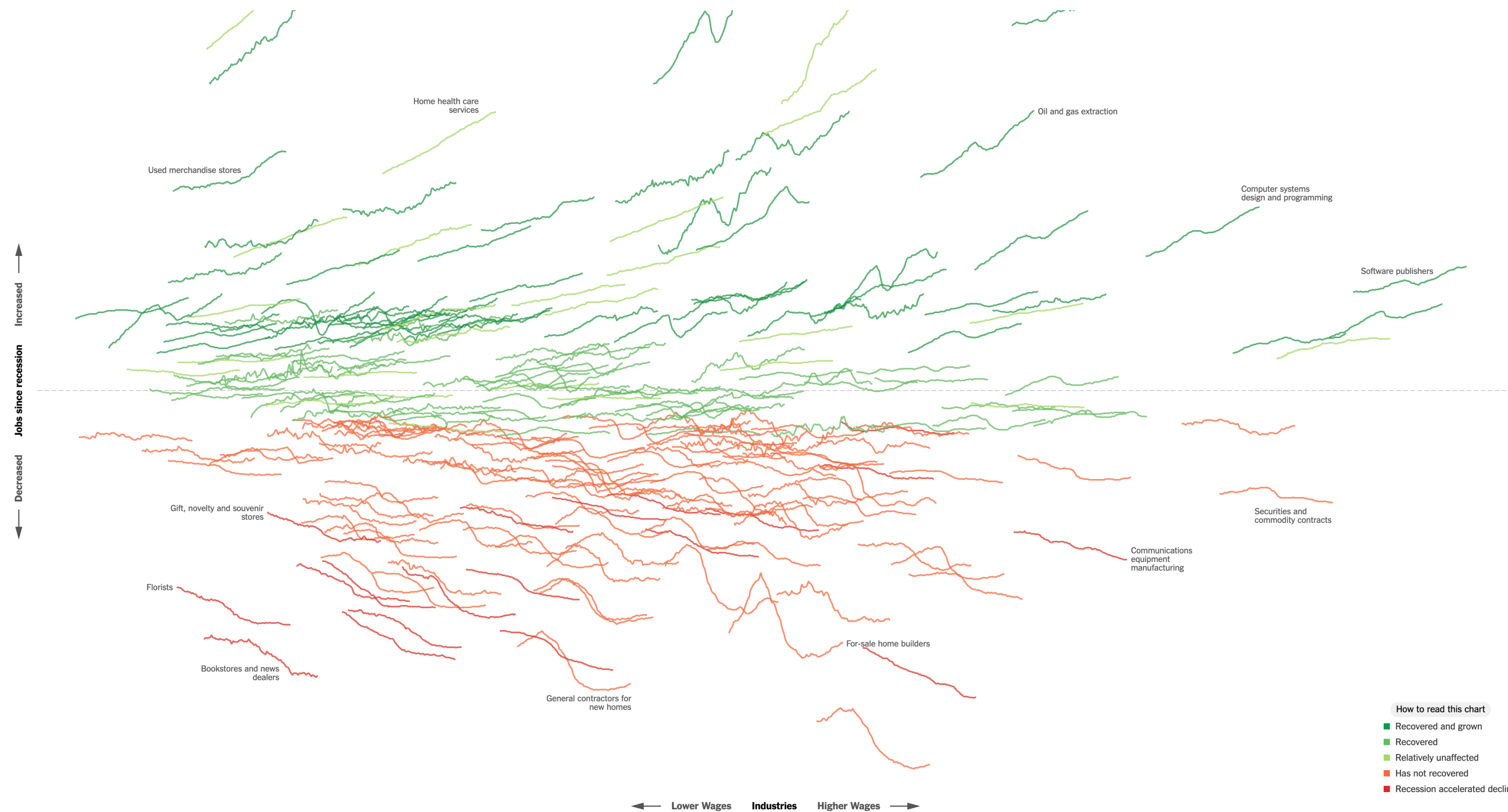
Link by *tuple* (i.e., explicitly identify
and match the same data values
across every view).



https://vega.github.io/vega-lite/examples/interactive_splom.html

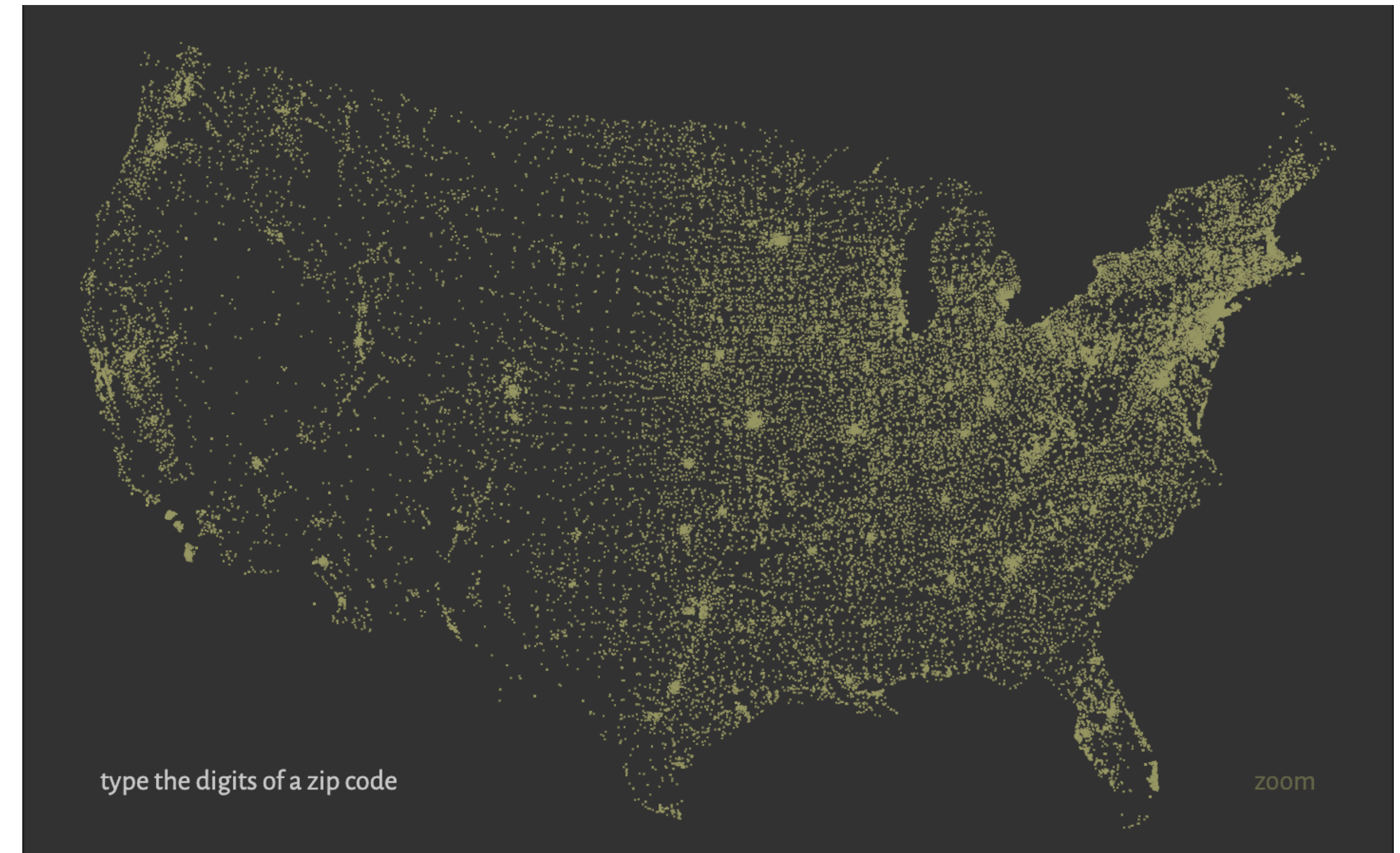
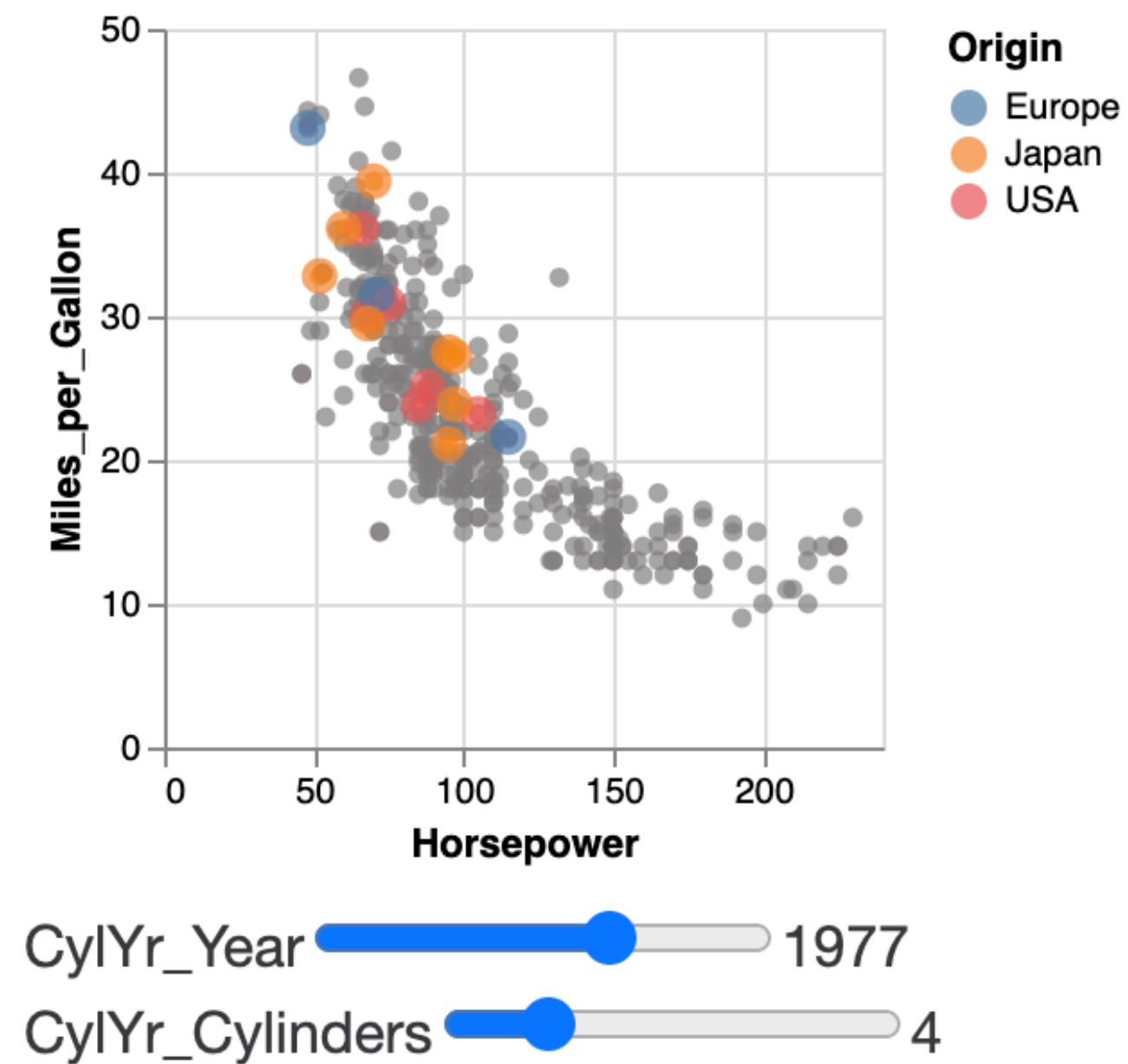
Abstract/Elaborate

show me more or less detail



Filter

show me something conditionally

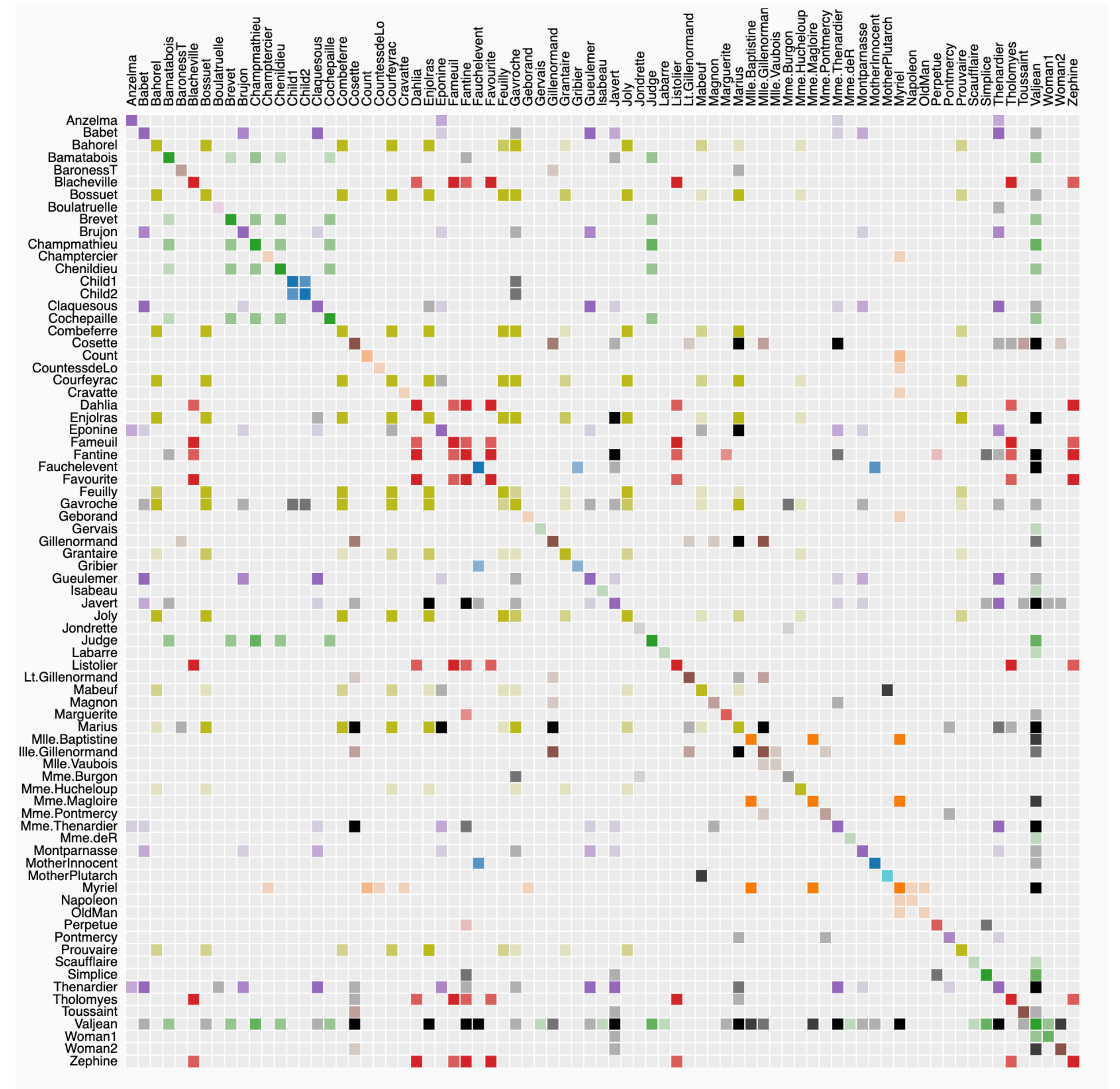


https://vega.github.io/vega-lite/examples/interactive_query_widgets.html

<https://benfry.com/zipdecode/>

Reconfigure

show me a different arrangement

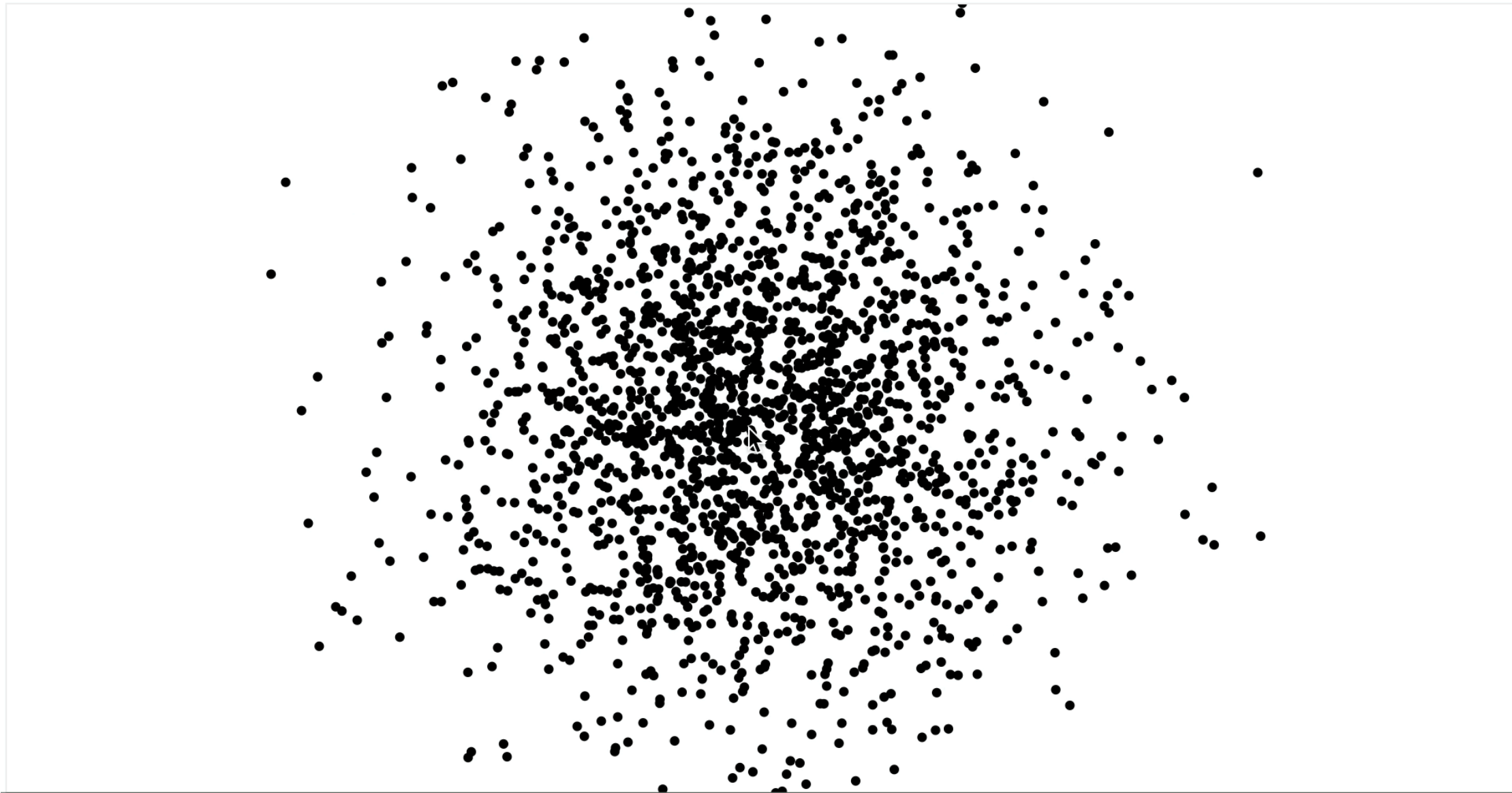


<https://bost.ocks.org/mike/miserables/>

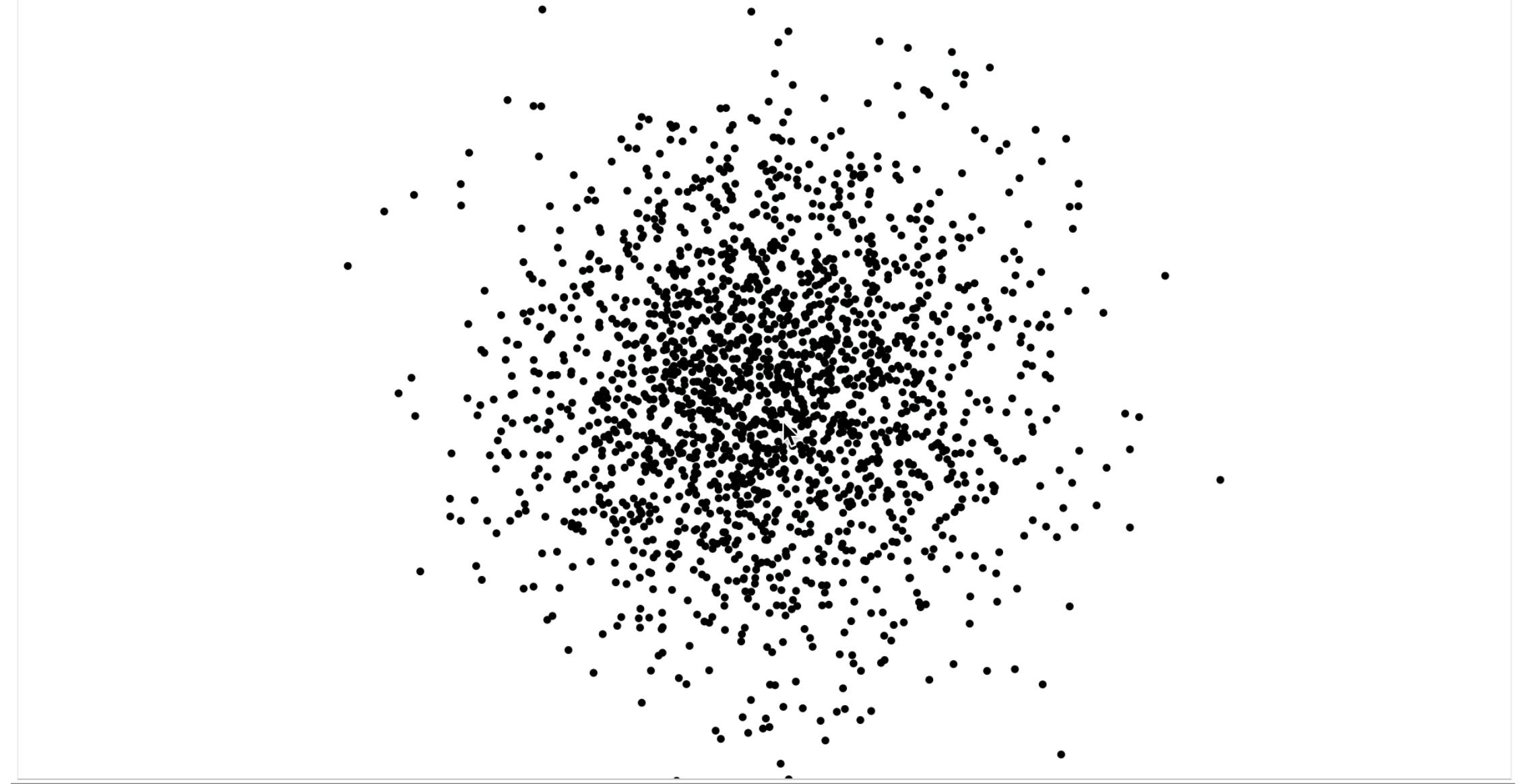
Explore

show me something else

Geometric Zoom

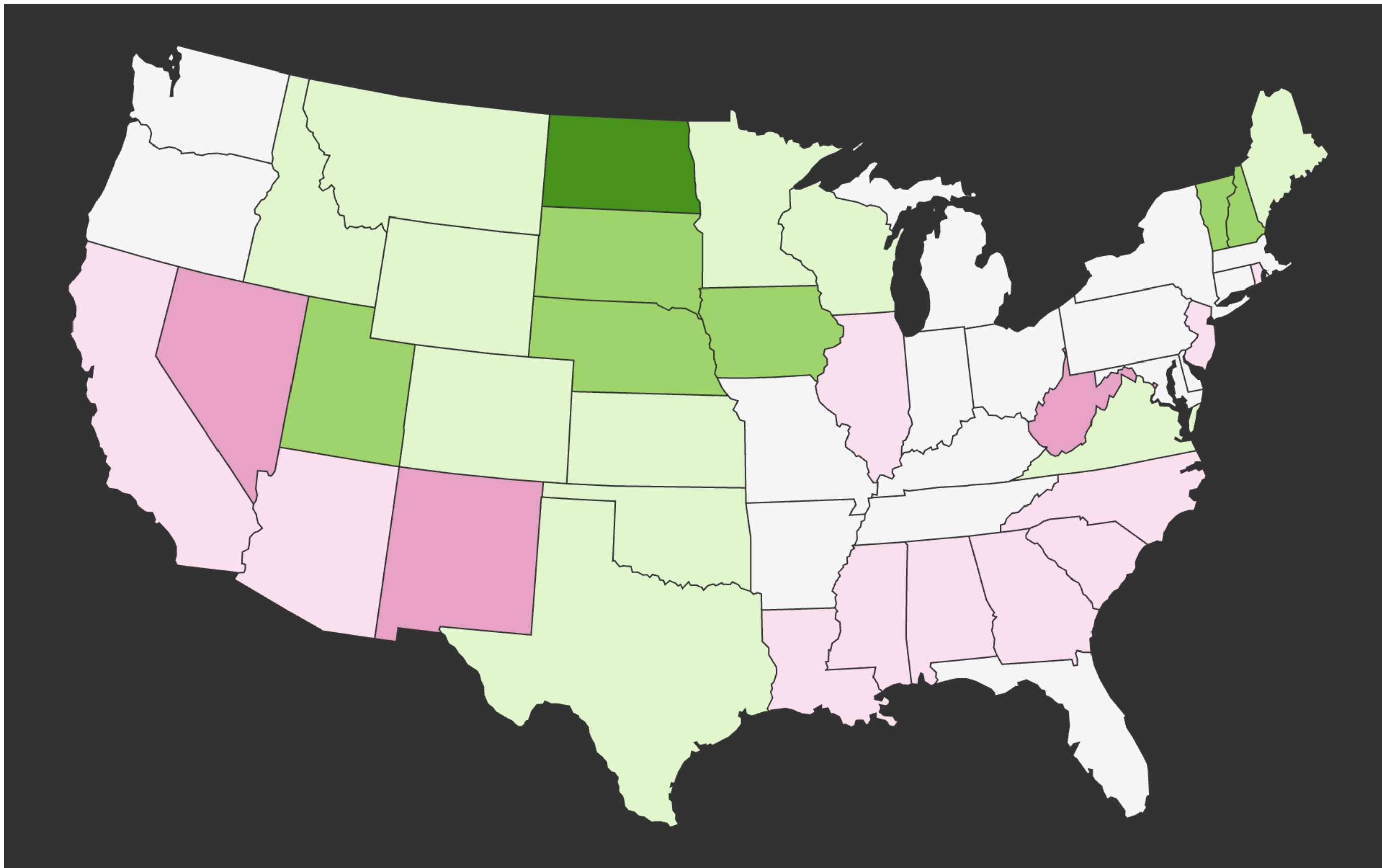


Semantic Zoom



Explore

show me something else

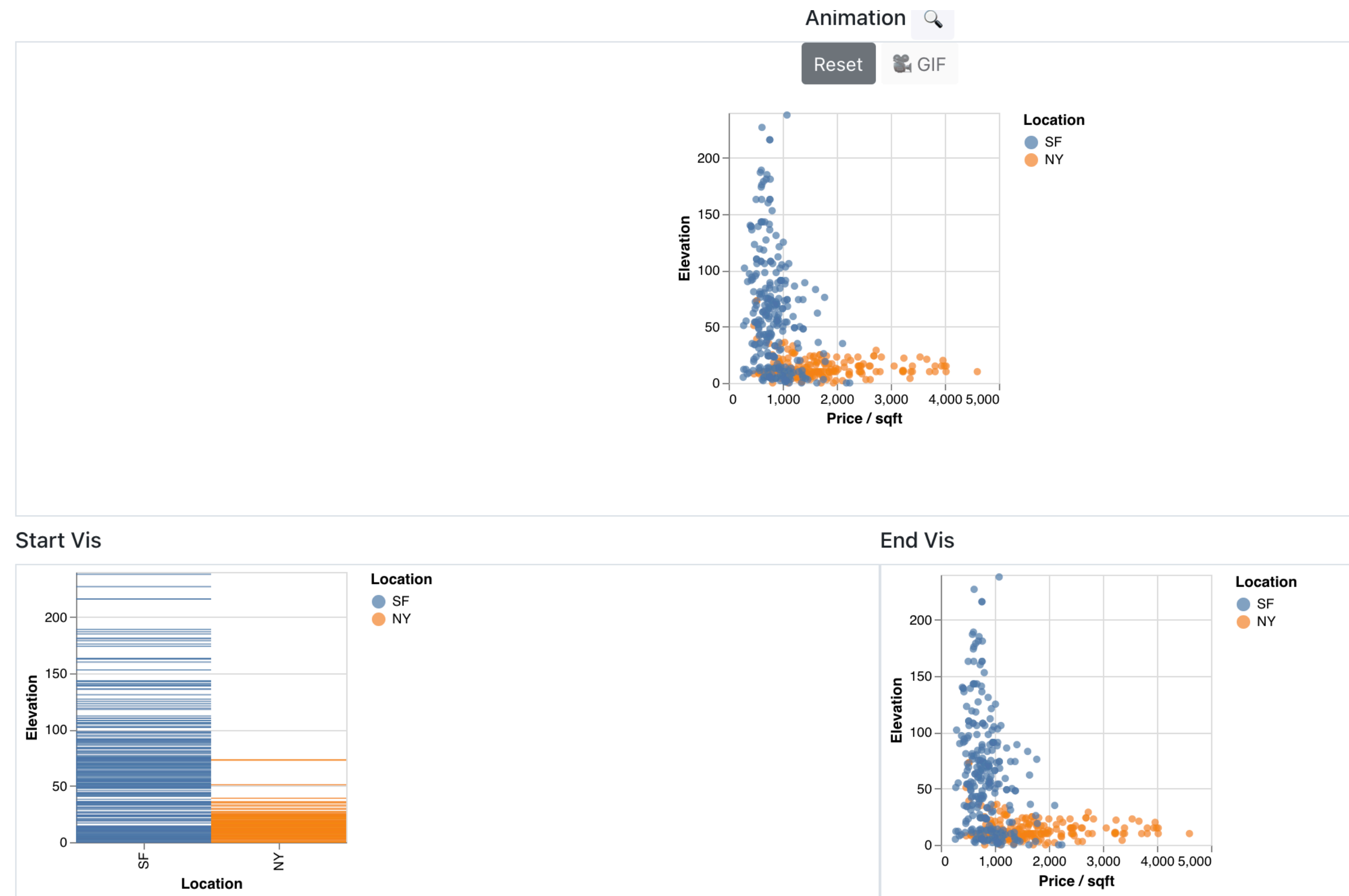


<https://bl.ocks.org/cmgiven/d39ec773c4f063a463137748097ff52f>

Encode

show me a different visual representation

<https://uwdata.github.io/gemini-editor/>
→ dot plot to scatter plot



What are common ways you
could enable interaction of a
data table?



Select

to apply a group action (delete, format,...)

Export to CSVNewDelete

Search

	ID	Product			In stock	Customer	
		name	price	Coupon		name	order
☐	0	Item name 0	2100	no	yes	Customer 0	0
☐	1	Item name 1	2101	yes	no	Customer 1	1
☒	2	Item name 2	2102	no	no	Customer 2	2
☐	3	Item name 3	2103	no	no	Customer 3	3
☐	4	Item name 4	1500	no	no	Customer 4	4
☐	5	Item name 5	2105	no	no	Customer 5	5
☐	6	Item name 6	2106	no	no	Customer 6	6
☒	7	Item name 7	2107	yes	yes	Customer 7	7
☐	8	Item name 8	2108	no	no	Customer 8	8
☐	9	Item name 9	2109	yes	no	Customer 9	9

10

12345>

SpamEmpty Spam

Journal of Biosciences and M...

Feb 18

Welcome to Submit Articles to Special...

Journal of Biosciences and Medicines (JBM)
Impact Factor: 0.87; h5-index: 17;

World Journal of Veterinary S...

Feb 16

Followup: Dear Dr. Hendrik Strobel - I...

Dear Dr. Hendrik Strobel, Greetings from
Vanessa..! Based on your research expertise,

Dreside

Feb 15

Sale DAY! New Brand KN95 Executive...

Same Day Free Shipping via USPS. Also we
offer samples

Nutrition and Nutraceuticals...

Feb 15

Follow-up/ Response Awaited- Nutriti...

Dear Researcher, Greetings. We would like to
know your interest to deliver Oral or Poster

Venture Summit

Feb 11

Venture Summit Only One Week To Ap...

Showcase your company to active
investors...submission deadline extended to

Secret Boston

Feb 10

Boston Pops In Love

Streaming LIVE from Symphony Hall! Brand
Name Boston Pops in Love Streaming

Forensic Science Today

Feb 10

mail to hendrik@strobel.com

Dear Strobel H, Hope you are doing well. We
need one article for successful release of

3
Emails Selected

Clear Selection

<http://allenfang.github.io/react-bootstrap-table/>

Reconfigure sorting

Sr. No.	Book Title ▼	Author ▼ ▲	Price ▼ ▲
1	Angels and Demons	Shivam	890
2	Harry Porter	Anuj	650
3	Hobbit	Aman	700
4	Lord of the rings	Sameer	1000
5	The little prince	Jatin	870

<https://www.webcodeexpert.com/2016/07/angularjs-how-to-sort-data-in-table.html>

Filter

“Facetting”

Faceted Search

cczarski

Search...

Go

Neighborhood: Bayview

Room Type: Entire home/apt

Private room

Price: <50

Clear All

Neighborhood

Bayview (9)

Bernal Heights (4)

Downtown/Civic Center (10)

Excelsior (21)

Financial District (1)

Show More

Room Type

Private room (9)

Shared room (1)

Price

<50 (9)

50 - 120 (111)

Rental Name	Host ID	Host Name	Neighborhood	Room Type	Price	Minimum Nights	Number of Reviews	Last Review
Quiet Private Room in Artsy Shared Home/Urban Farm	35151167	Jen	Bayview	Private room	36	2	96	28-JUL-2019
Home Away From Home Too! Room #1	17572711	James	Bayview	Private room	44	1	29	18-JUL-2019
Home Away From Home Too! Room #2	17572711	James	Bayview	Private room	44	1	23	19-JUL-2019
Home Away From Home Too! Room #3	17572711	James	Bayview	Private room	44			
Home Away From Home Too! Room #4	17572711	James	Bayview	Private room	44			
VERY LIMITED DEAL: Cheap Clean & Central (SF City)	58389796	Arjun	Bayview	Private room	49			
THE BEST DEAL: Cheap Clean & Convenient (SF City)	58389796	Arjun	Bayview	Private room	39			
Large Bedroom Comfortable Home - Full Bed	28502179	Tammy	Bayview	Private room	42			
Large Sunny Bedroom - Queen Bed	28502179	Tammy	Bayview	Private room	48			

Alzheimer

Find it!

GoPubMed Hot Topics Advanced Clipboard Help

top five & more

1 Alzheimer Disease

2 Dementia

3 Proteins

4 Humans

5 Neurons

more ...

Biological Sciences

Technology, Industry, Agriculture

Techniques and Equipment

Diseases

biological_process

Organisms

molecular_function

Natural Sciences

Anatomy

Health Care

Psychiatry and Psychology

Chemicals and Drugs

Proteins

Peptides

Pharmaceutical Preparation

Amyloid

Oxides

Enzymes

Cholinesterase Inhibitors

Amyloid beta-Protein

Butorphanol

Apolipoproteins E

cellular_component

hierarchy of content

Psychiatry and Psychology [104]

Diseases [916]

Biological Sciences [848]

Techniques and Equipment [743]

Chemicals and Drugs [680]

Health Care [607]

Natural Sciences [625]

50 articles for query "Alzheimer" relating to "Amyloid beta-Protein"

go to page: 1 2 3

Previous | Next

Show statistics for term Amyloid beta-Protein

description:

A 4-kDa protein, 39-43 amino acids long, expressed by a gene located on chromosome 21. It is the major protein subunit of the vascular and plaque amyloid filaments in individuals with Alzheimer's disease and in aged individuals with trisomy 21 (DOWN SYNDROME). The protein is found predominantly in the nervous system, but there have been reports of its presence in non-neural tissues.

synonyms:

"Amyloid AD-AP" "ABP (Alzheimer's)" "Alzheimer beta-Protein" "Amyloid Protein A4" "beta Amyloid Protein" "Alzheimer beta Protein" "Amyloid AD-AP" "Amyloid beta Protein" "beta-Amyloid Protein" "Amyloid Fibril Protein (Alzheimer's)"

Show statistics for these 50 articles

Export to: RDF Xref BibTex Endnote PlainText

43: Reduction of sortilin-1 in Alzheimer hippocampus and in cytokine-stressed human brain cells.

PMID: 17589324

Zhao Y et al. Neuroreport, 18 (11): 1187-1191, 2007

Sortilin 1 (SORL1) is a transmembrane sorting receptor that regulates the intracellular trafficking of beta-amyloid precursor protein (betaAPP).

149: [Inhibition of neuronal death by promoting degradation of intracellular amyloid beta-protein]

PMID: 17515111

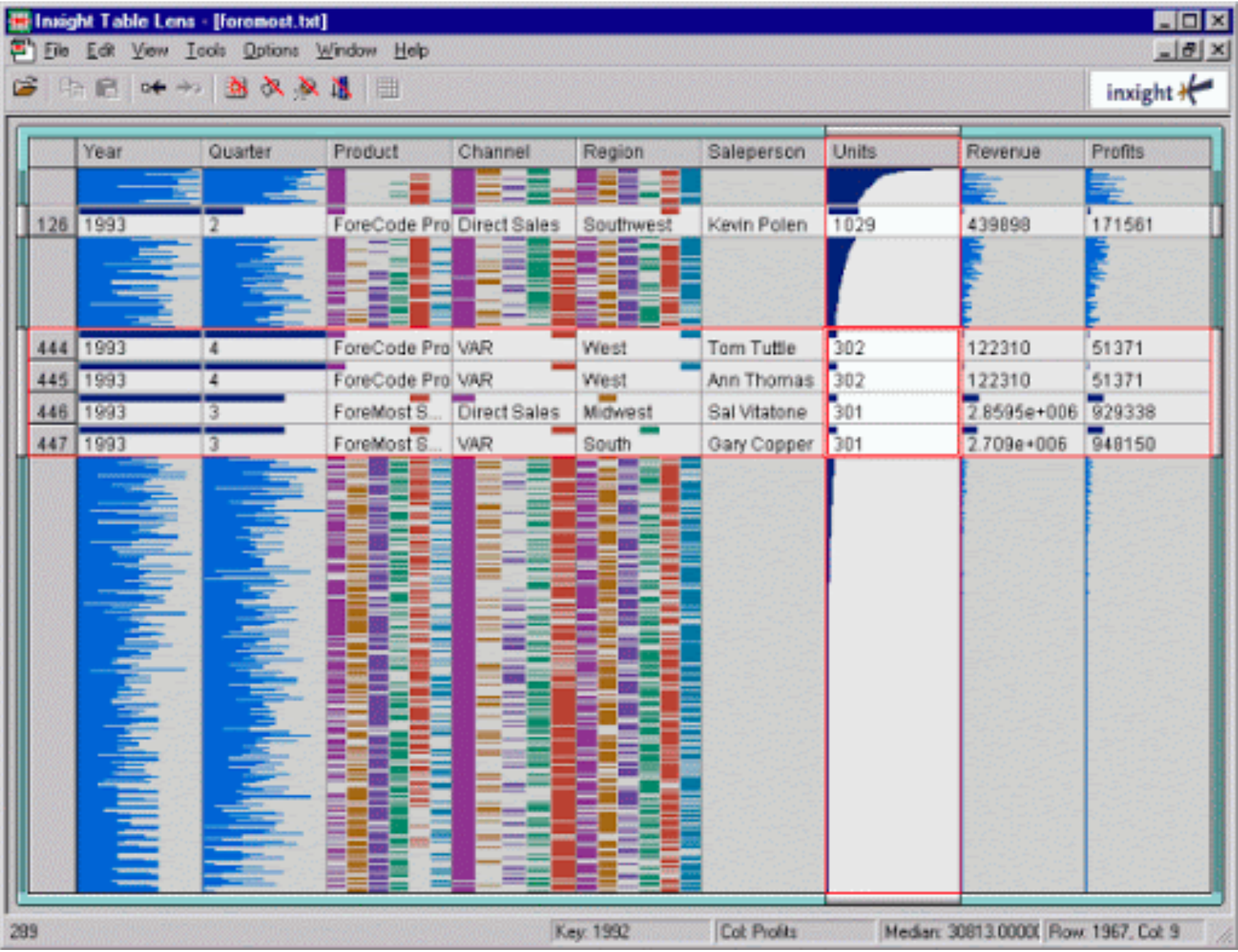
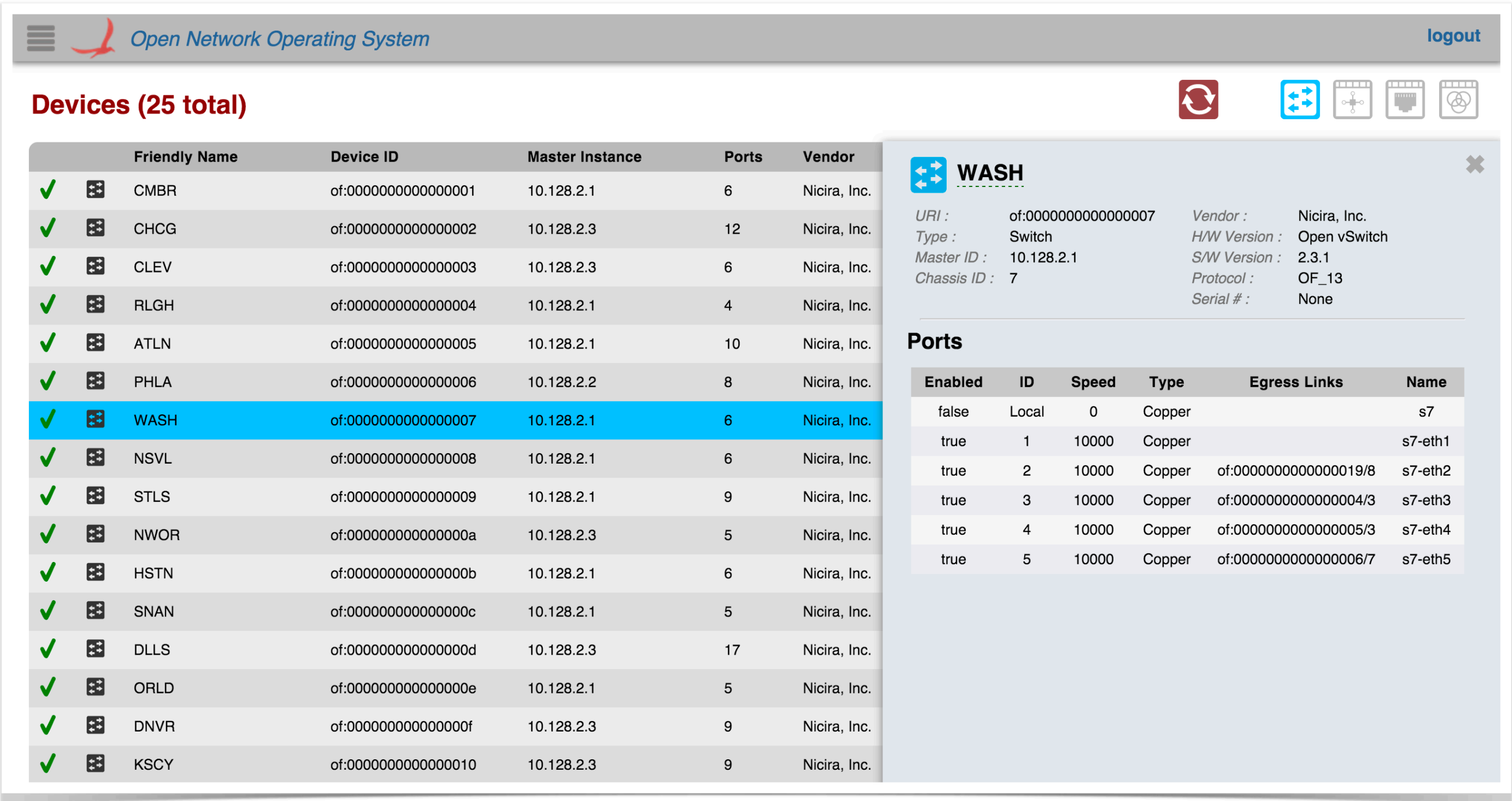
Ohnishi Y et al. Nihon Shinkei Seigaku Yakurigaku Zasshi, 27 (2): 57-62, 2007

Inhibition of aggregation of amyloid p-protein (AP) and promotion of extracellular AM removal are known

keyword filter + Facetting

Abstract/Elaborate

Interactive Detail View & Table Lens



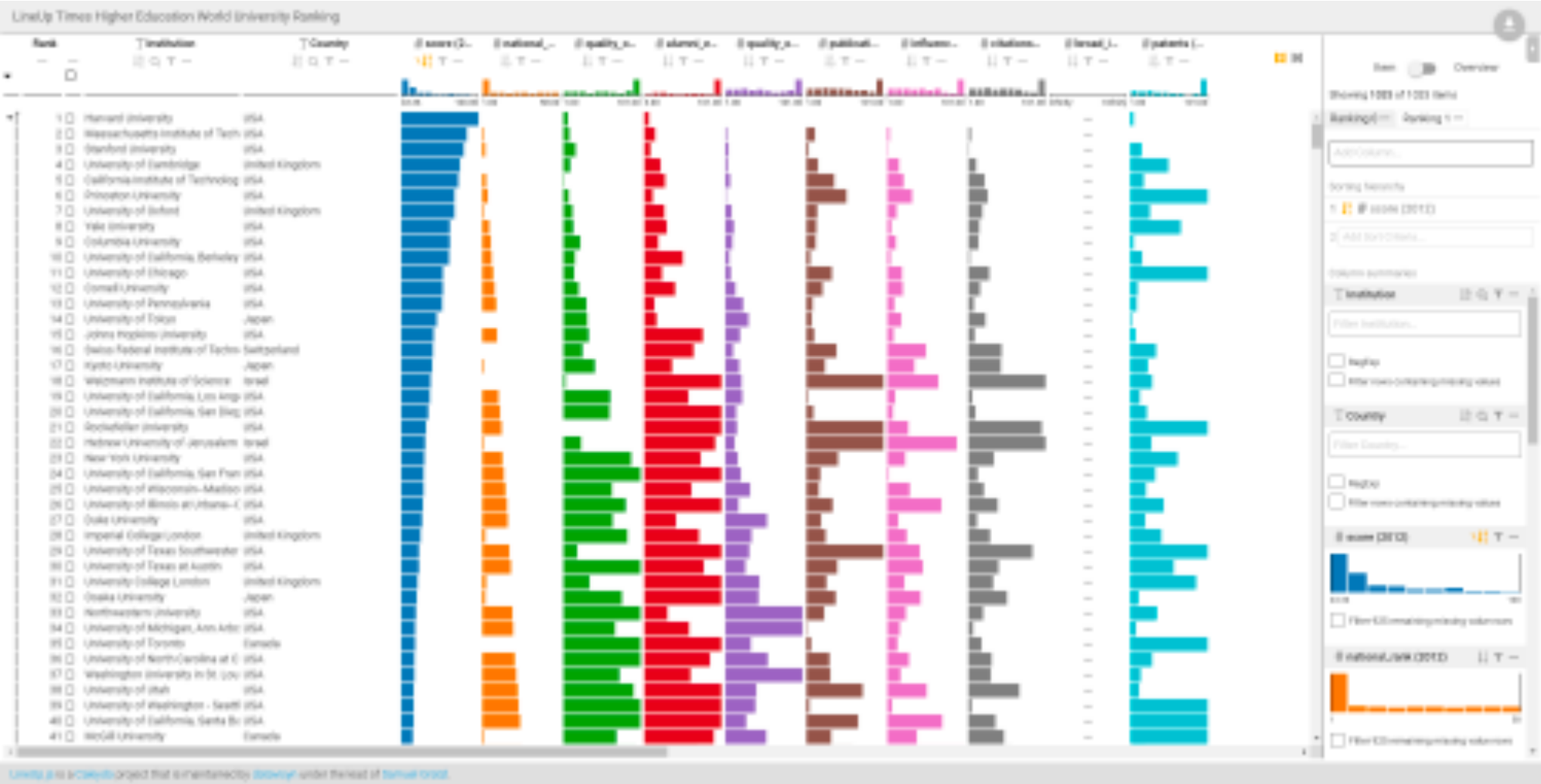
<https://wiki.onosproject.org/display/ONOS/GUI+Tabular+View>

Rao, Ramana, and Stuart K. Card. "The table lens: merging graphical and symbolic representations in an interactive focus+ context visualization for tabular information." *CHI 1994*.

Encode

Conditional Formatting & LineUp

# Tickers	7d	1mo	3mo	1yr	1mo (2y stack)	3mo (2y stack)	1yr (2y stack)
12	-2.4%	-4.8%	-5.8%	-5.9%	-4.8%	-5.8%	-5.9%
7	-16.4%	-8.7%	-10.6%	-6.9%	-8.7%	-10.6%	-6.9%
8	-0.8%	-5.4%	-3.7%	-4.2%	-5.4%	-3.7%	-4.2%
13	2.5%	0.7%	2.4%	2.1%	0.7%	2.4%	2.1%
7	-10.0%	-4.1%	-3.9%	-7.0%	-4.1%	-3.9%	-7.0%
13	-4.3%	-6.3%	-5.6%	-5.9%	-6.3%	-5.6%	-5.9%
6	-4.8%	-7.1%	-5.6%	-1.9%	-7.1%	-5.6%	-1.9%
14	-8.3%	-5.7%	-6.7%	-4.0%	-5.7%	-6.7%	-4.0%
2	9.4%	12.4%	11.0%	11.4%	12.4%	11.0%	11.4%
4	8.6%	10.4%	8.7%	8.8%	10.4%	8.7%	8.8%



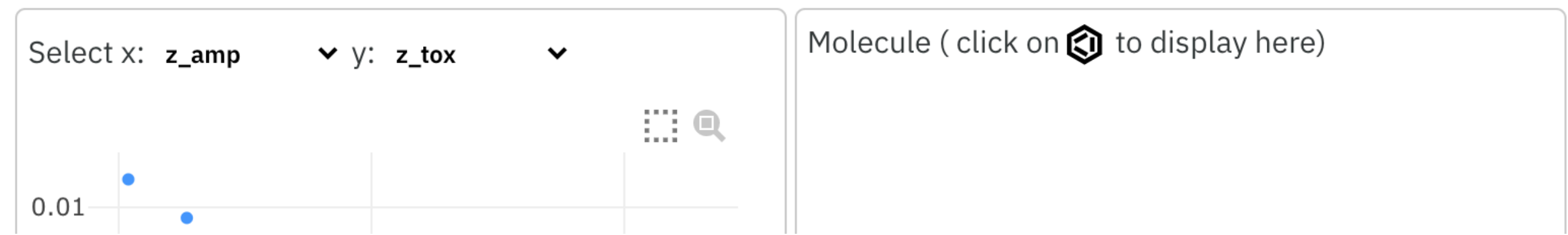
<https://stackoverflow.com/questions/28075699/coloring-cells-in-pandas>

<https://lineup.js.org/app/>

They can mix well

Interpolated Samples - using linear interpolation

interpol index	peptide	mol	Aro	Chrg	evo_end	evo_start	HMom	Inst	MolW	z_amp	z_tox
	YVSVPLH		0.1429	0	-4.655	27.75	0.1165	36.09	813.9	0.8408	0.01037
	YVSVPLH		0.1429	0	-4.655	27.75	0.1165	36.09	813.9	0.8454	0.009851
	YVSVPLH		0.1429	0	-4.655	27.75	0.1165	36.09	813.9	0.8499	0.009356
	YVSVPLPH		0.125	0	-0.449	22.38	0.09246	56.9	911.1	0.8543	0.008885
	YVSPVTP H		0.125	0	0.449	9.948	0.1454	77.14	899	0.8586	0.008437
	YLV PVT LHH		0.1111	0	1.308	7.752	0.08646	42.26	1078	0.8628	0.008012
	YL PVTPHH		0.1111	0	3.925	3.876	0.07213	63.66	1060	0.8669	0.007608
	FLPPTVFPH		0.2222	0	14.83	-1.938	0.04968	73.09	1054	0.8709	0.007225
	FLP KTFFPH		0.2	1	22.13	-2.37	0.105	59.86	1224	0.8748	0.00686
	FLPTKTFTPH		0.2	1	29.37	-4.267	0.07208	40.6	1188	0.8786	0.006514
	FLPTKTFTFPH		0.2727	1	36.28	-4.655	0.06431	66.55	1336	0.8823	0.006185
	FLPTKTFTFPH		0.2727	1	36.28	-4.655	0.06431	66.55	1336	0.8858	0.005873



<https://peptide-walk.mybluemix.net/>

Interaction with Visualization

Select – identify something as interesting.

Connect – show me related items.

Abstract/Elaborate – show me more or less detail.

Filter – show me something conditionally.

Reconfigure – show me a different arrangement.

Explore – show me something else.

Encode – show me a different visual representation.

What you will learn today

The value of interactivity

Principles of interaction design

Principles of accessible interaction design