

Interaction

DSC 106: Data Visualization

Sam Lau

UC San Diego

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#3872 640



Announcements

Lab 3 (JavaScript) out, checkoffs due 1/26.

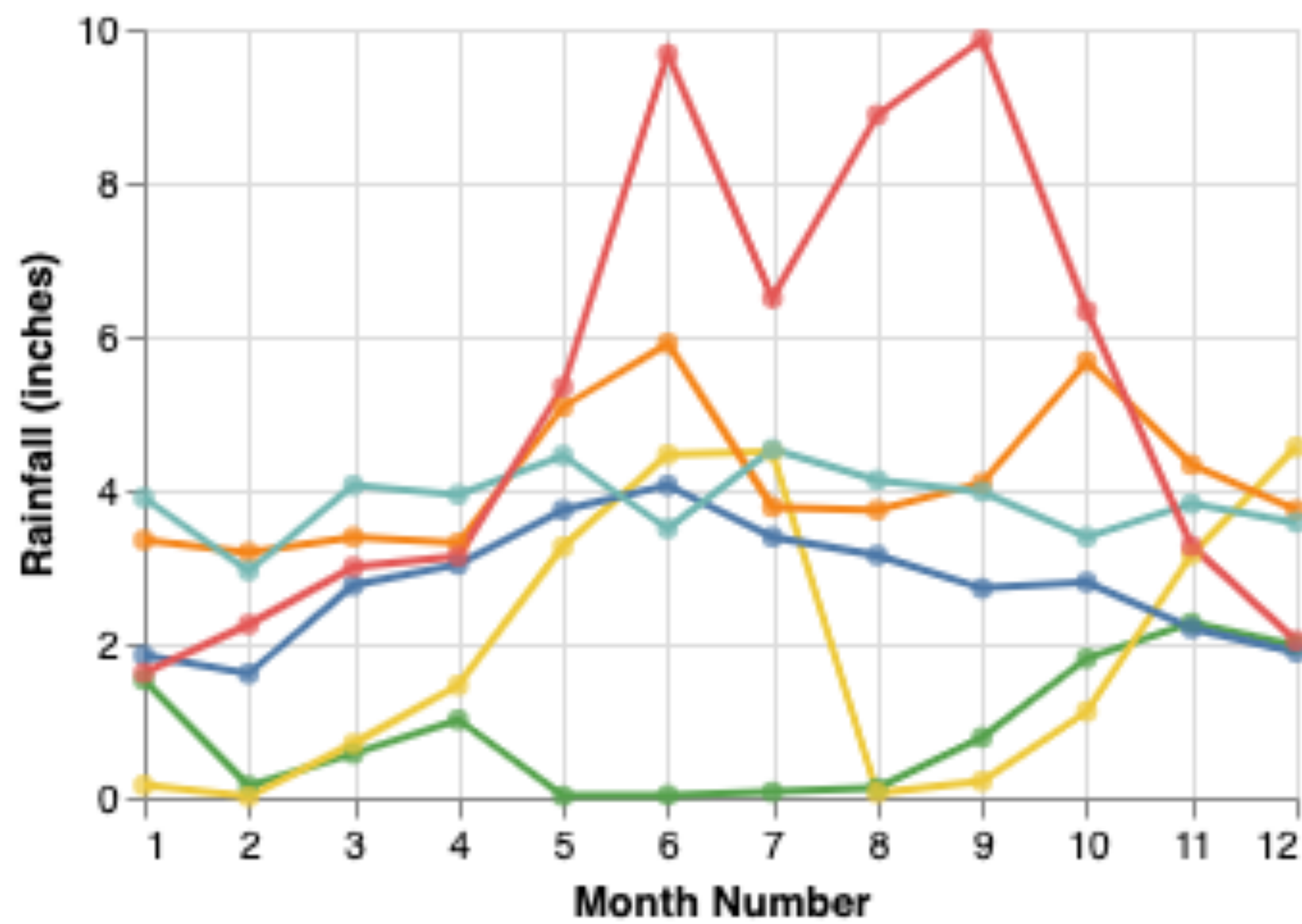
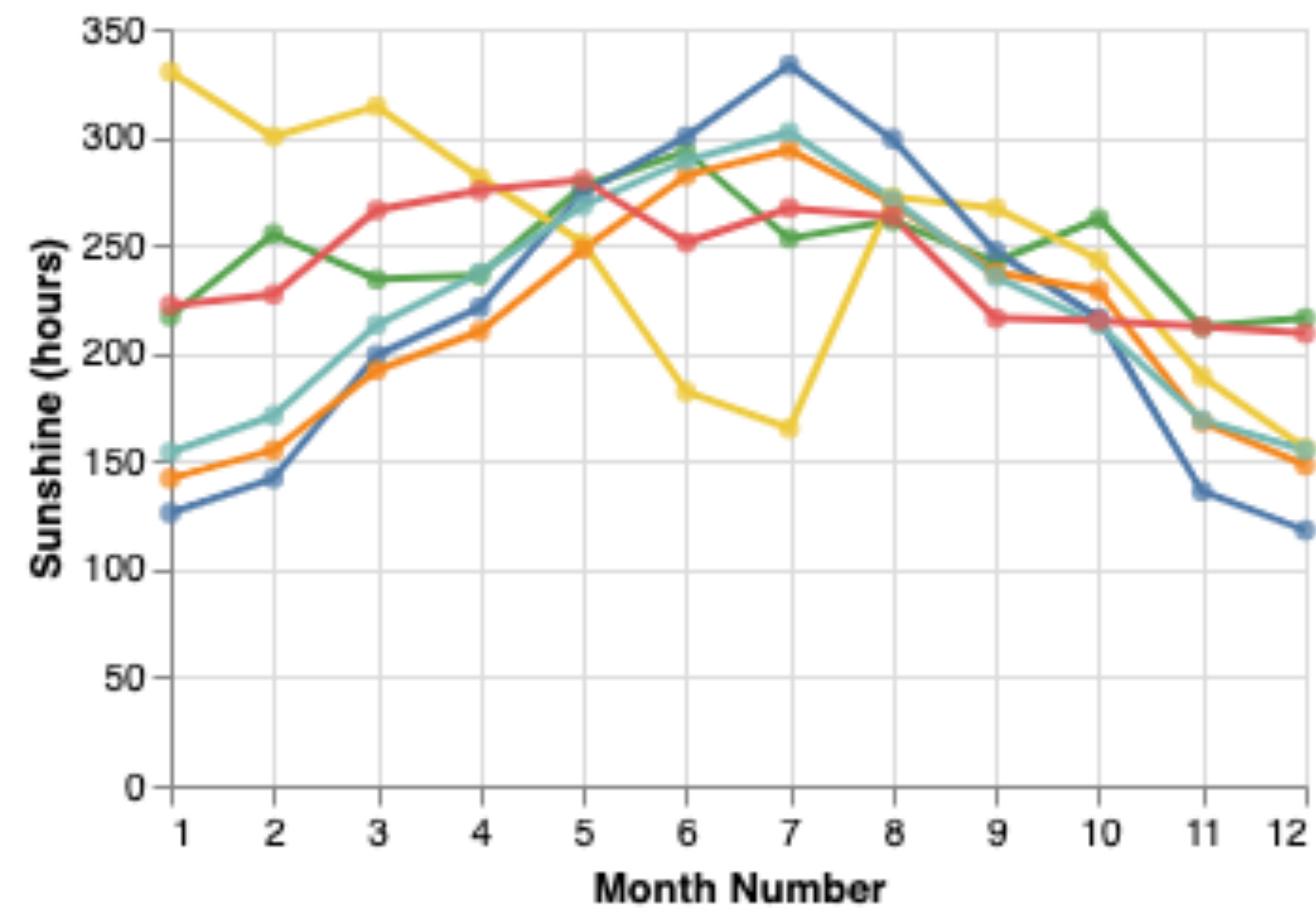
Project 2 out, due on Friday 2/2.

FAQs:

1. When will Project 1 be graded? Aiming for Friday.

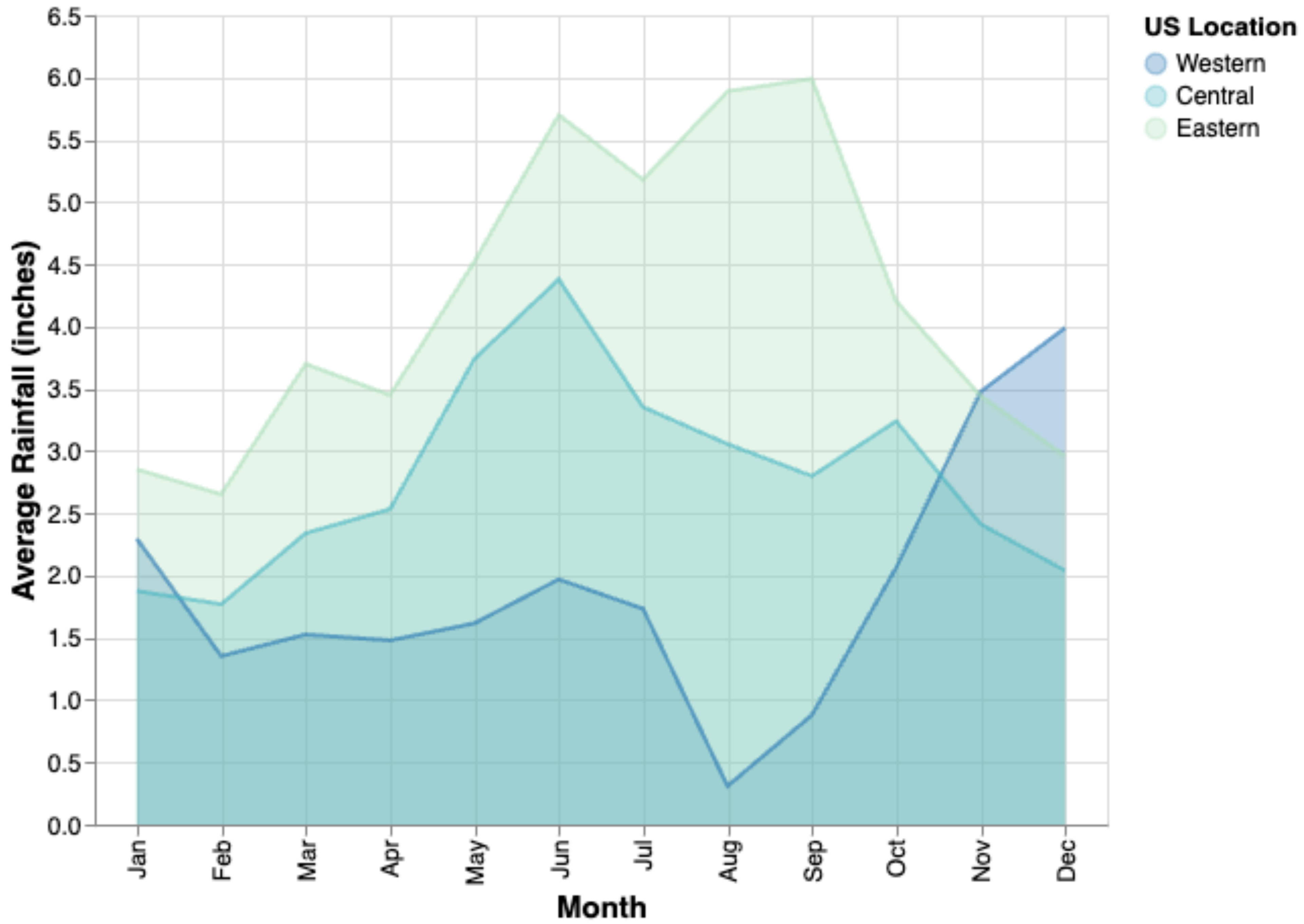
Neat A1 submissions!

Seasonal Sunshine and Rainfall Trends in Major U.S. Cities



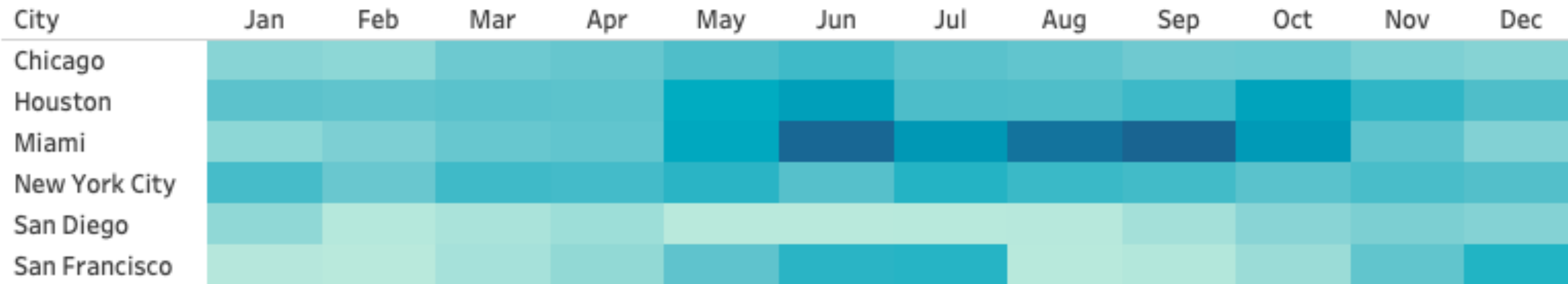
- city**
- Chicago
 - Houston
 - Miami
 - New York City
 - San Diego
 - San Francisco

Which US region (Western, Central, or Eastern) has the highest average rainfall throughout the year?



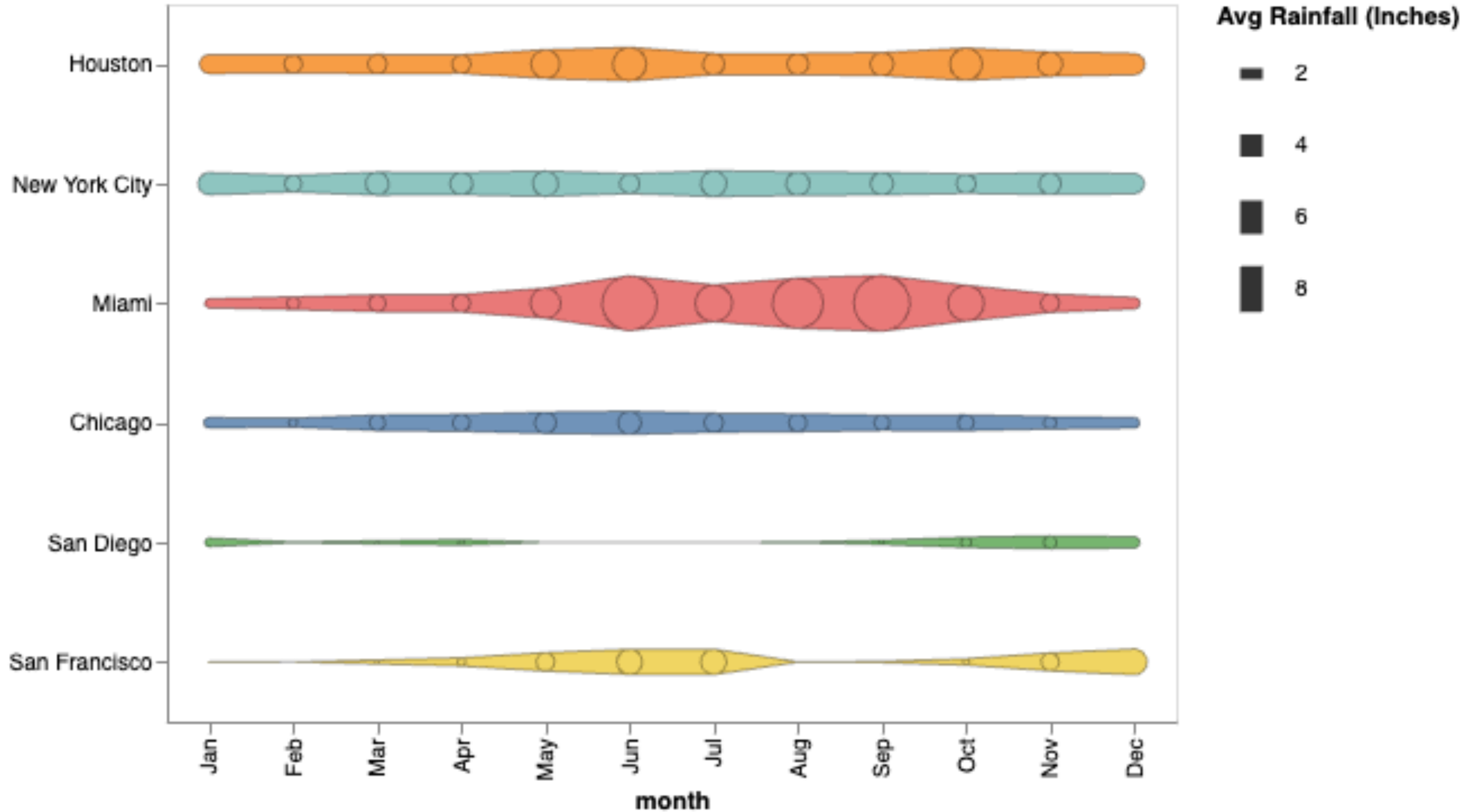
Rain Distribution Across Major U.S. Cities

Rain (inches)

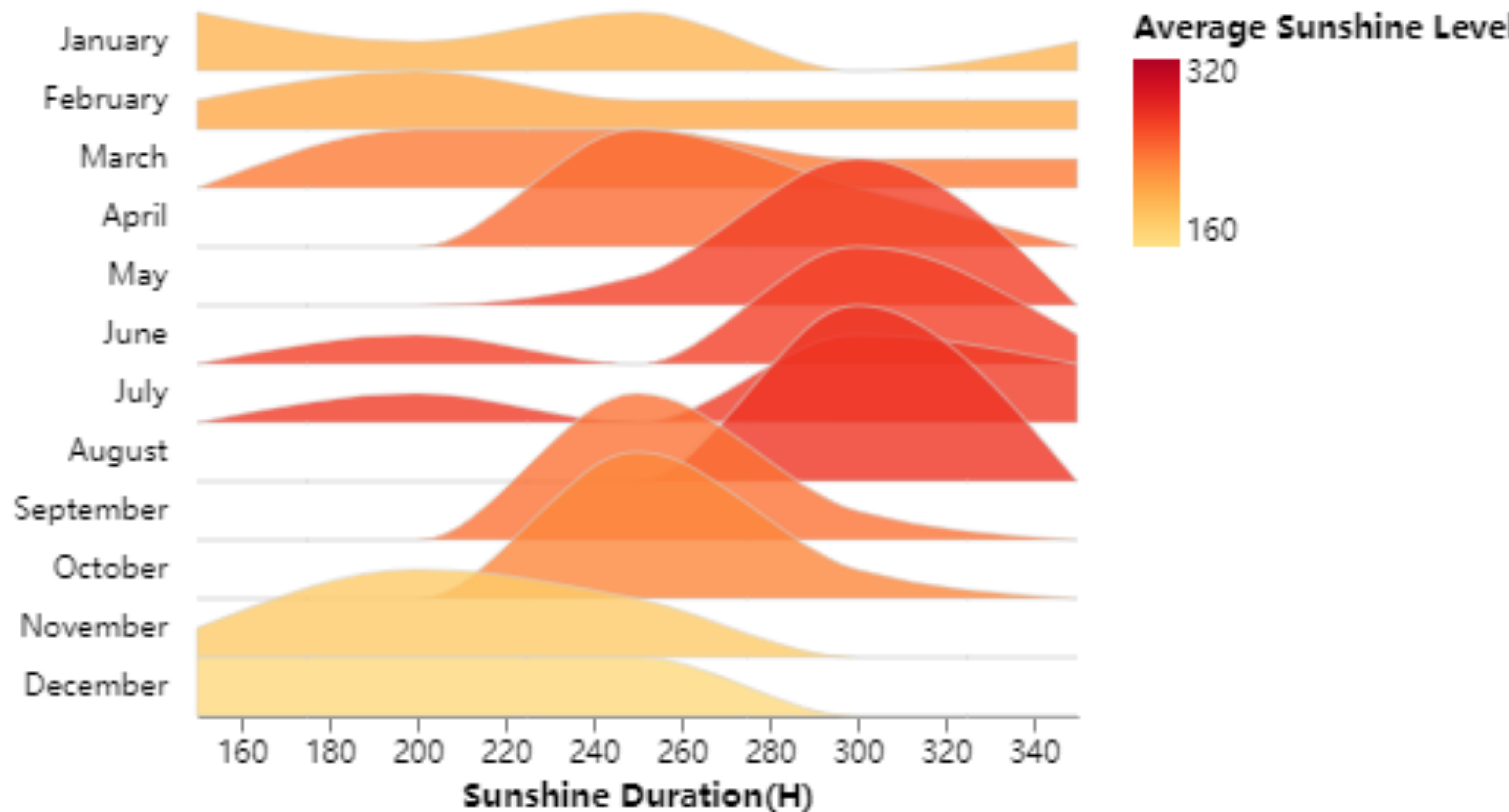


How Rainfall Differs Between Cities Through the Year

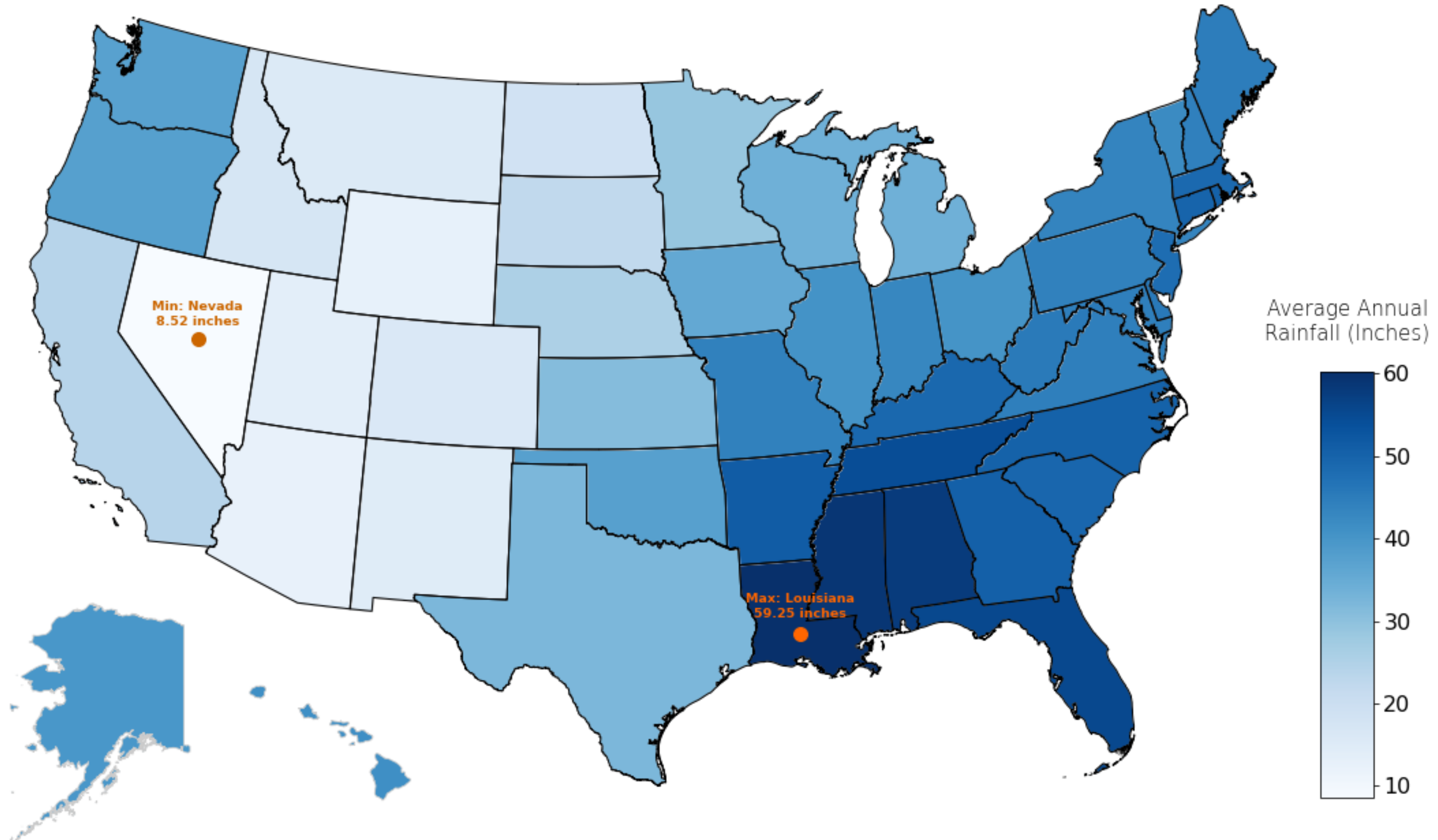
The size of the line represents the average inches of rainfall for that month



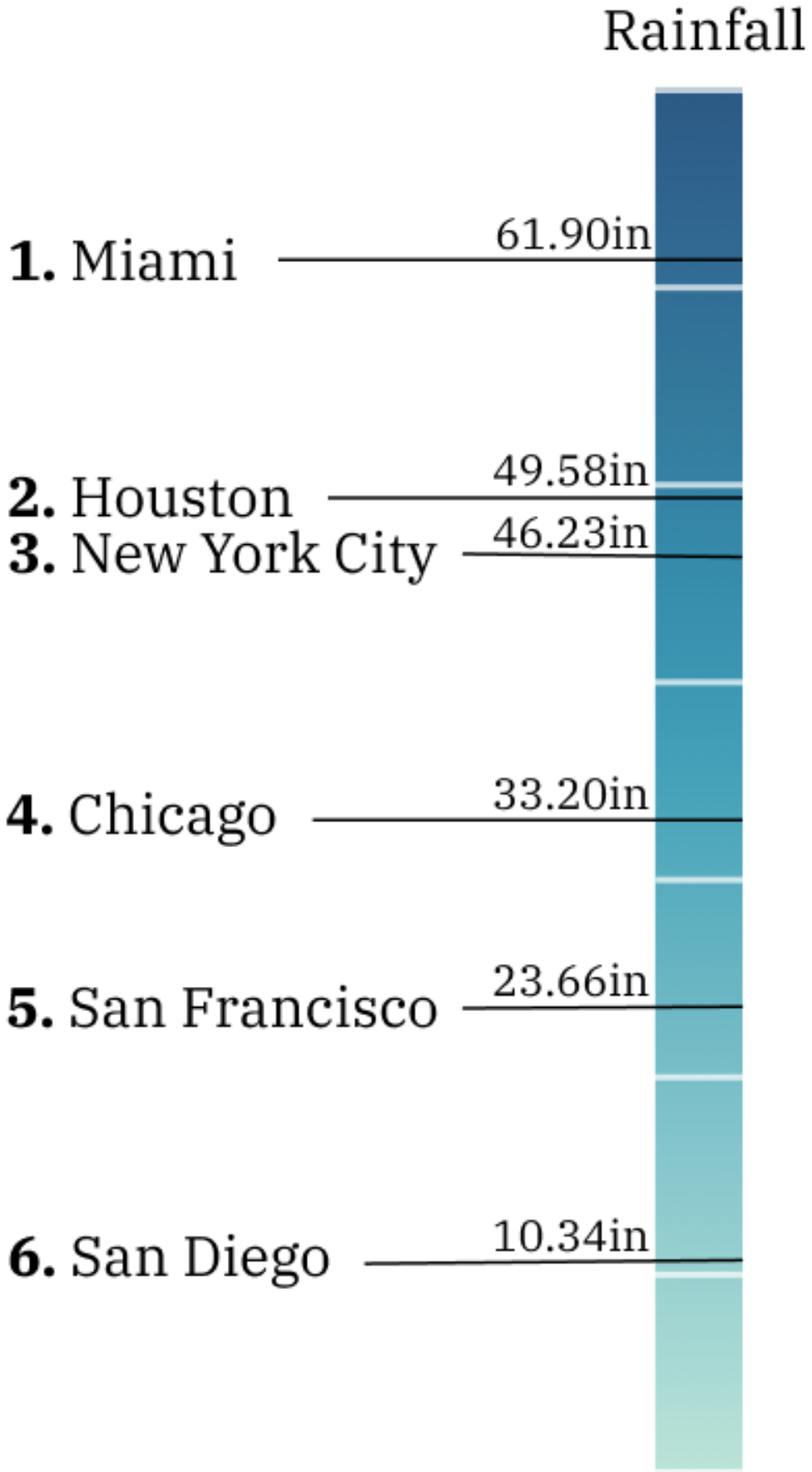
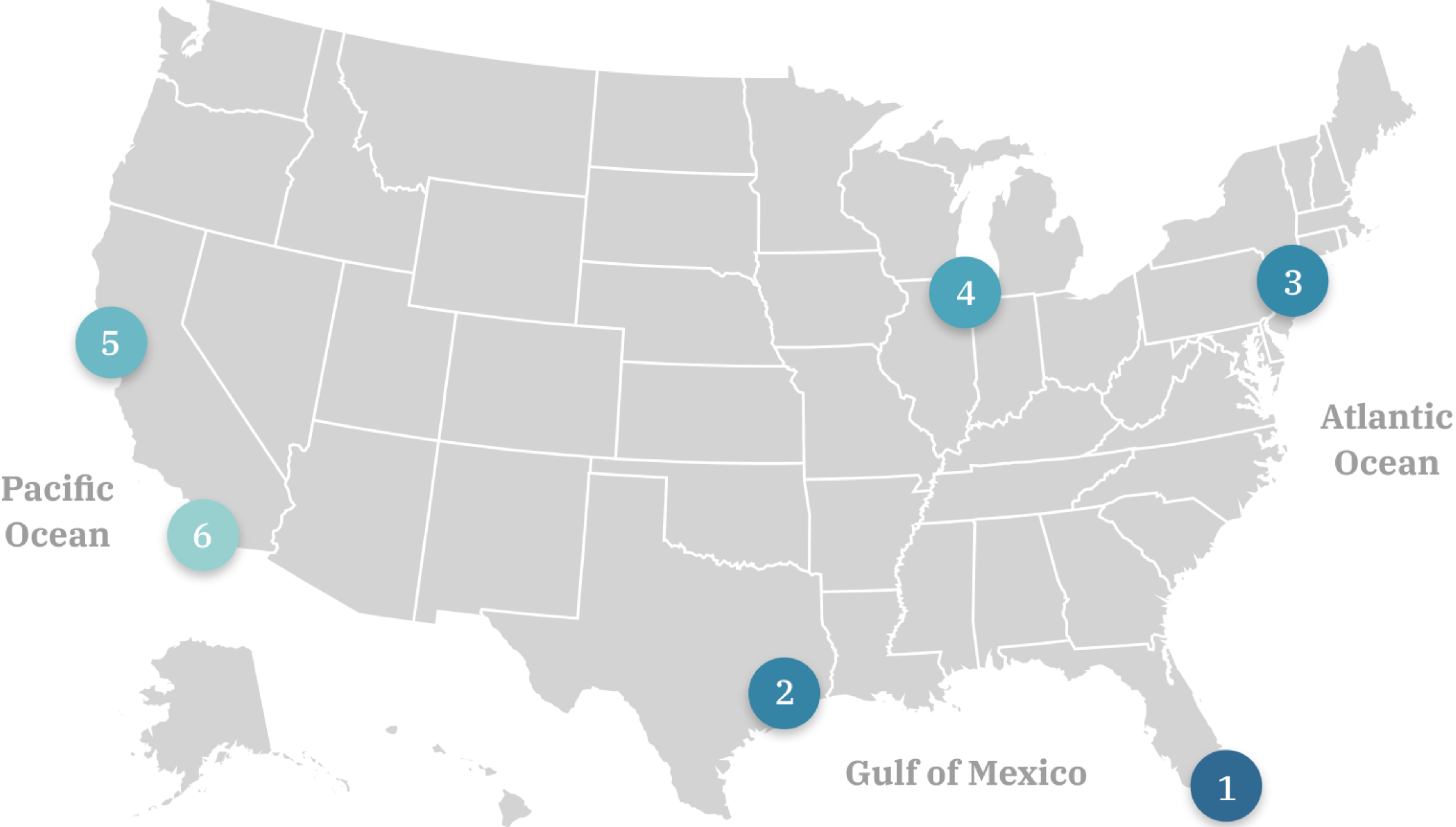
Sunshine Distribution Across Months



Which U.S. States Receive the Least and Most Rain Yearly, on Average?



How Does Location Impact the Average Annual Rainfall of Major U.S. Cities?



"My Husband Hates Rain. I Love Rain and Hate My Husband. Where's the Best Place to Live in the US?"

WINTER Avg. Precipitation



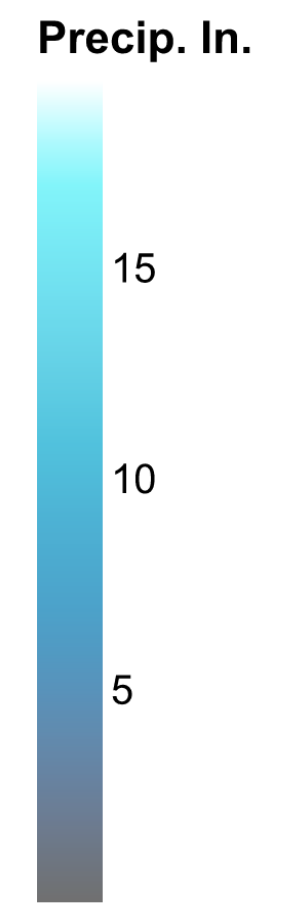
SPRING Avg. Precipitation



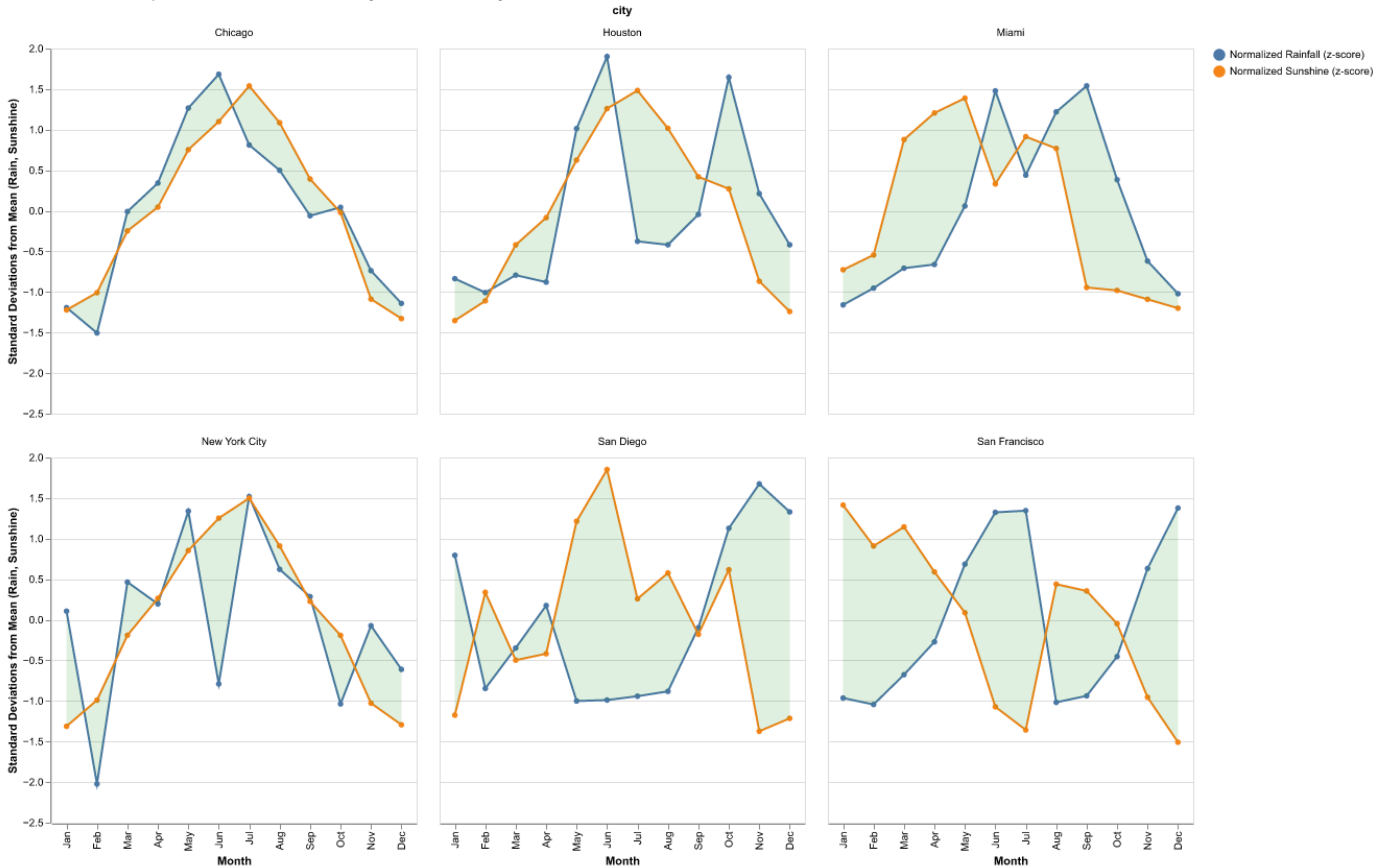
SUMMER Avg. Precipitation



FALL Avg. Precipitation



What is the relationship between sunshine and rainfall by month for each city?



US Rainfall in Major Cities By Season

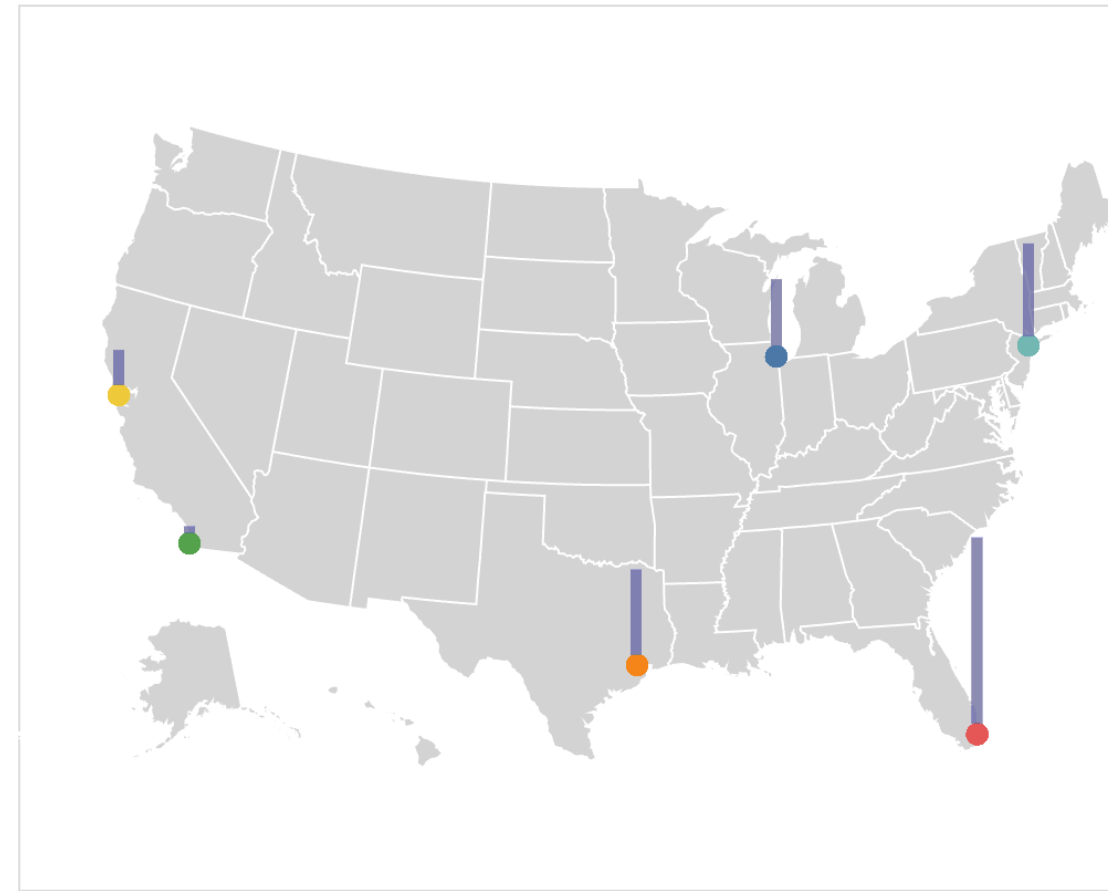
Average Winter Rainfall



Average Spring Rainfall



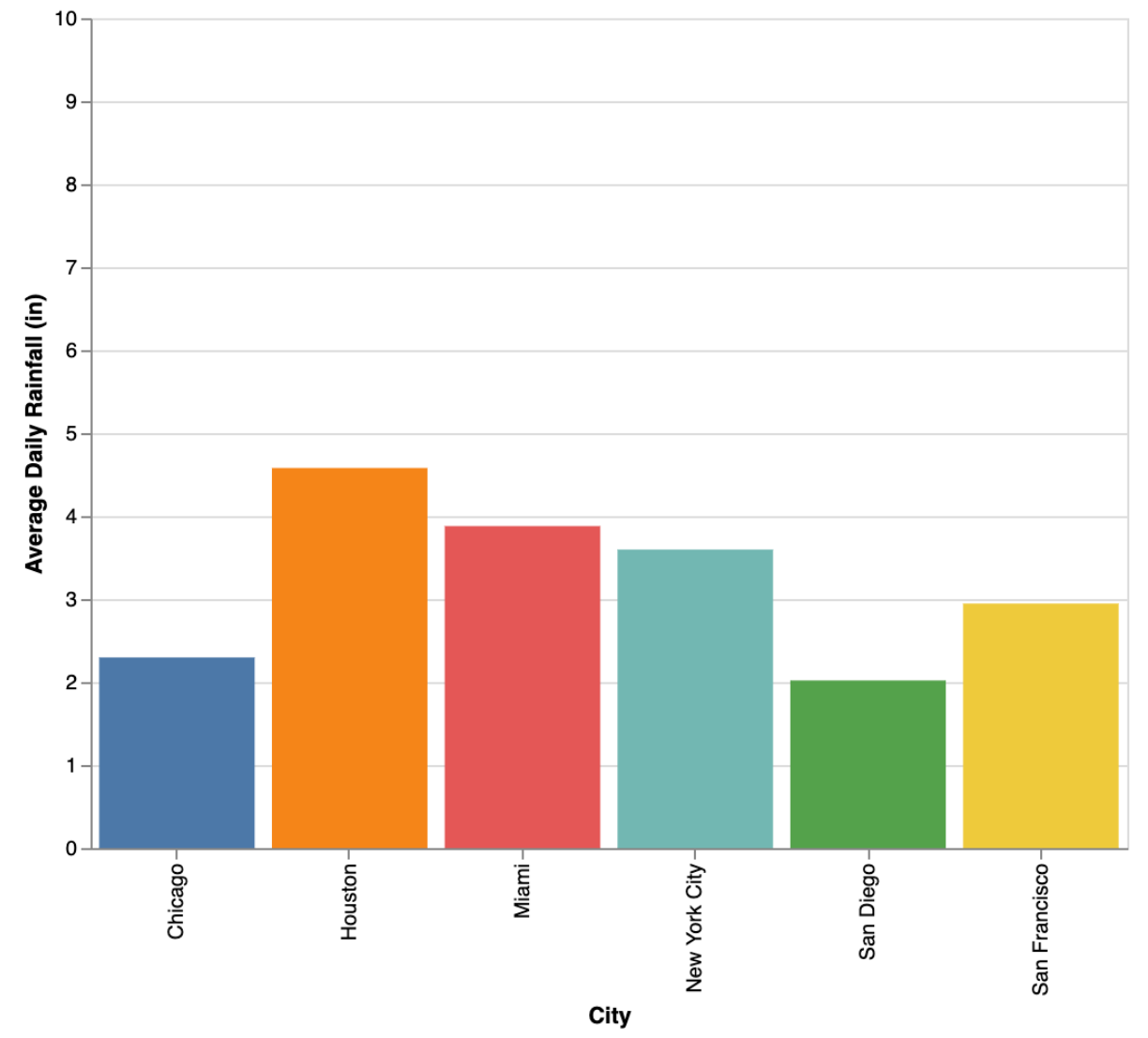
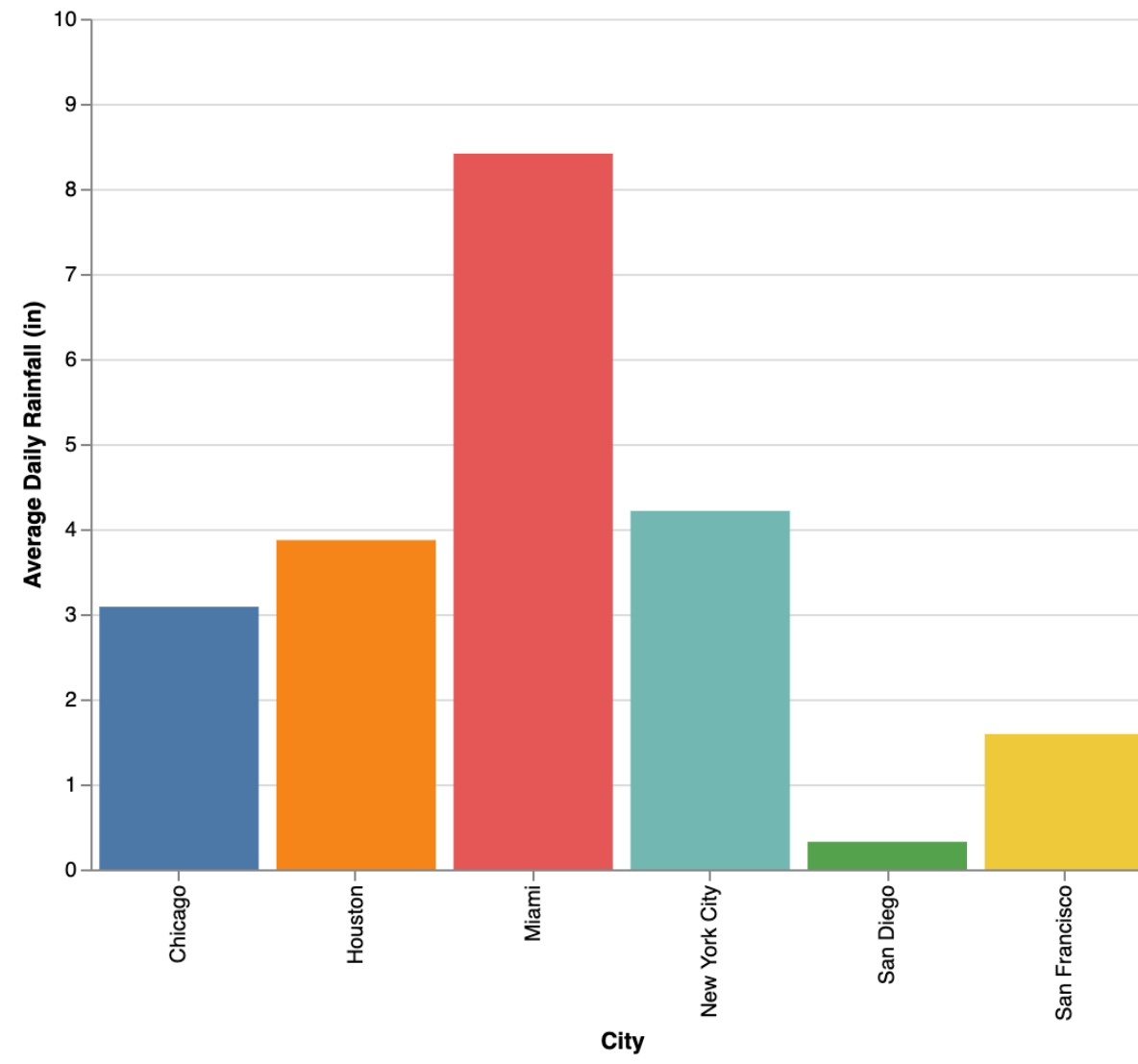
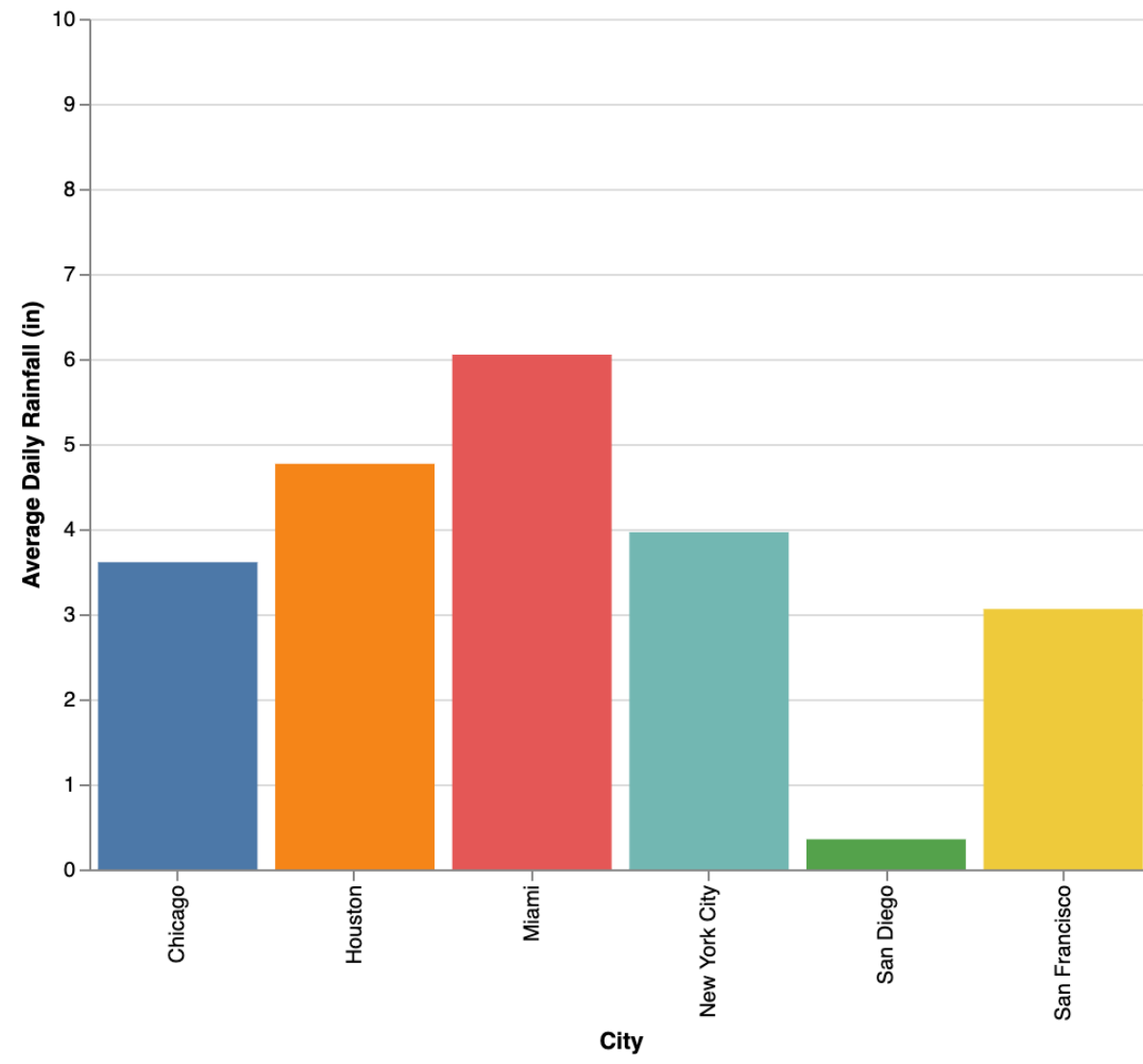
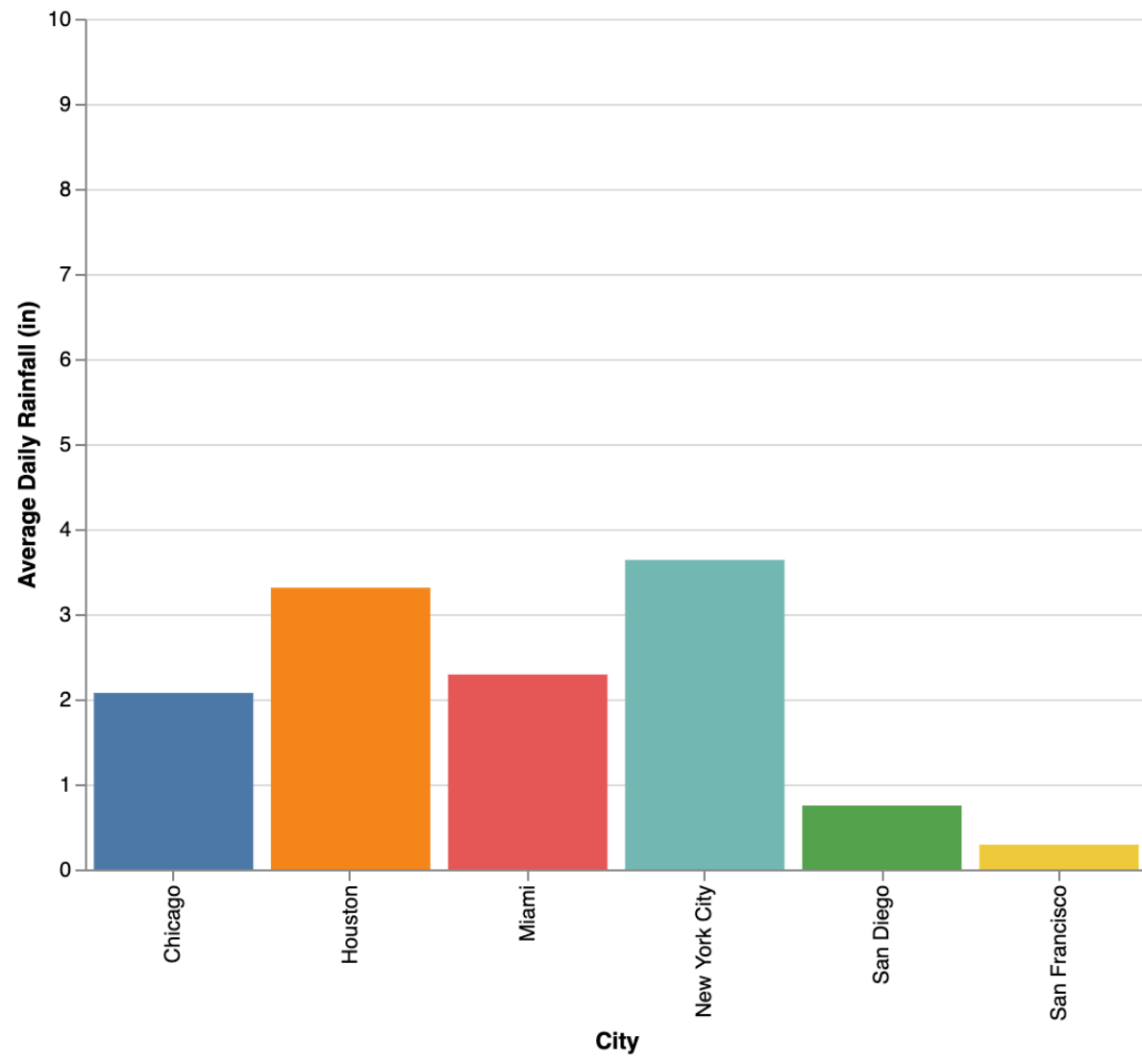
Average Summer Rainfall



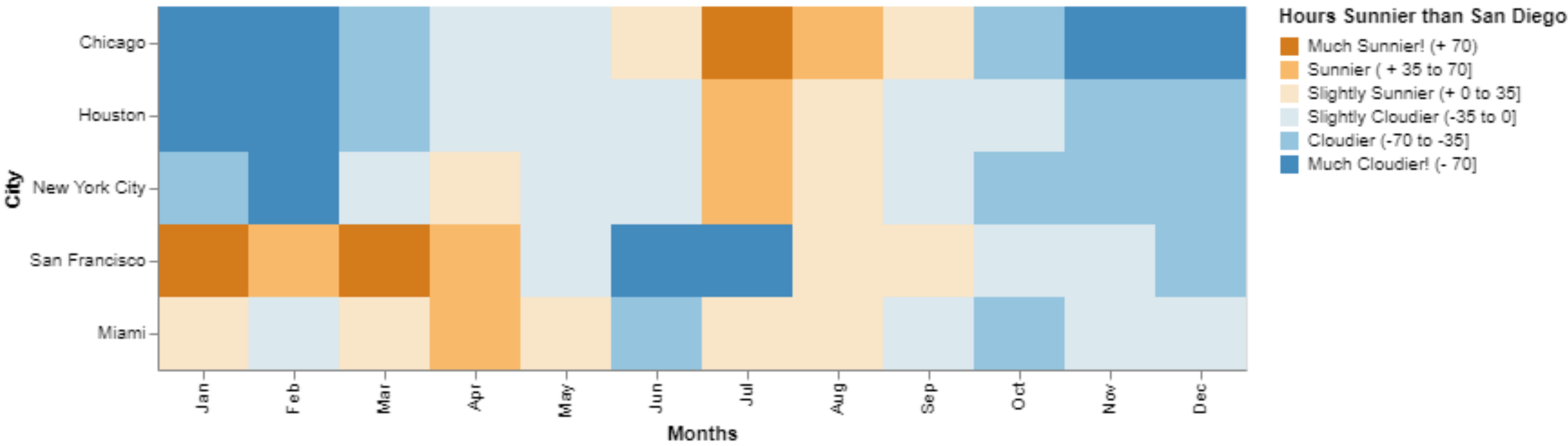
Average Fall Rainfall



- Chicago
- Houston
- Miami
- New York City
- San Diego
- San Francisco



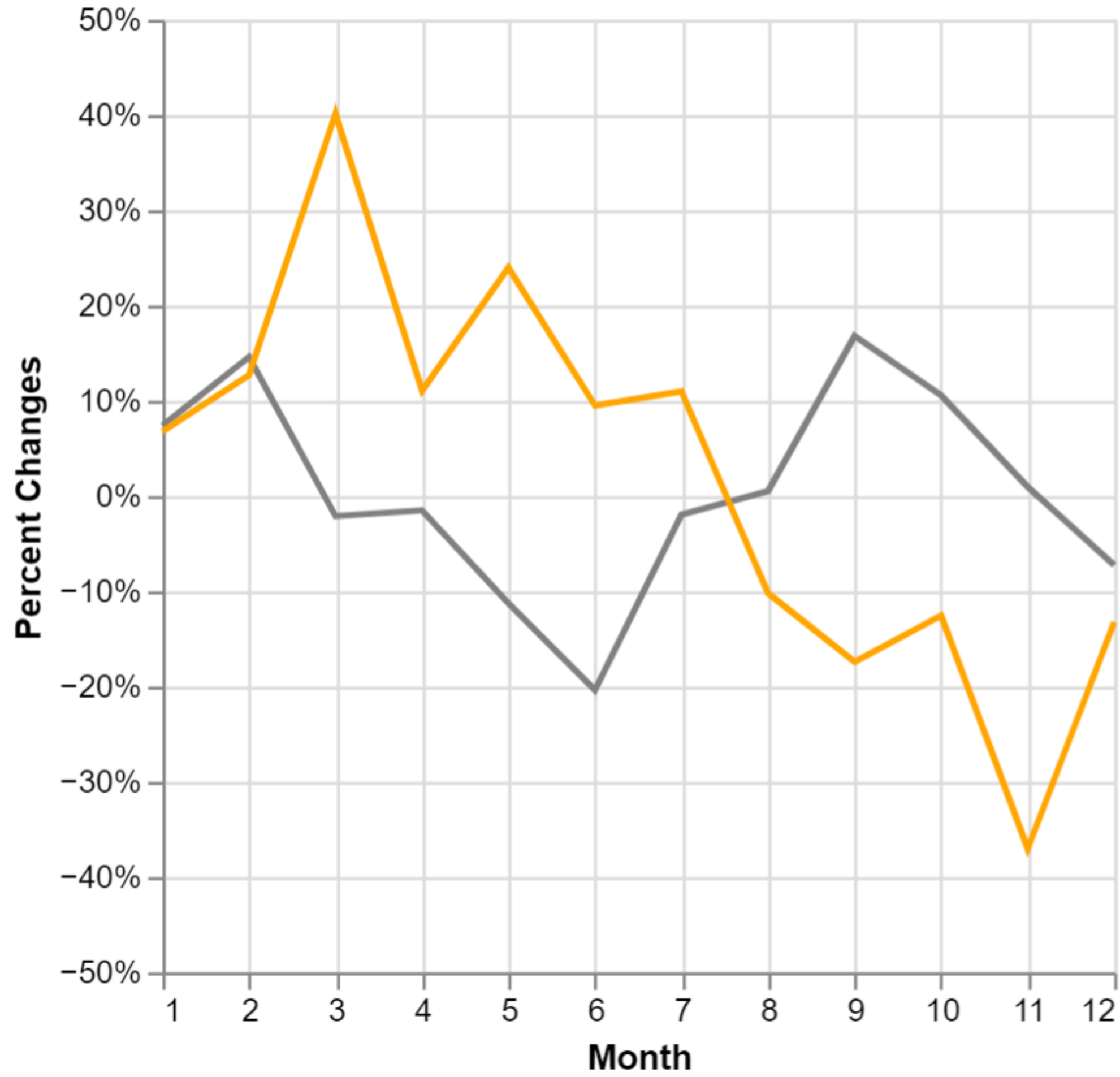
Did Your City Received More Sunlight to Sunny San Diego in the Same Month?



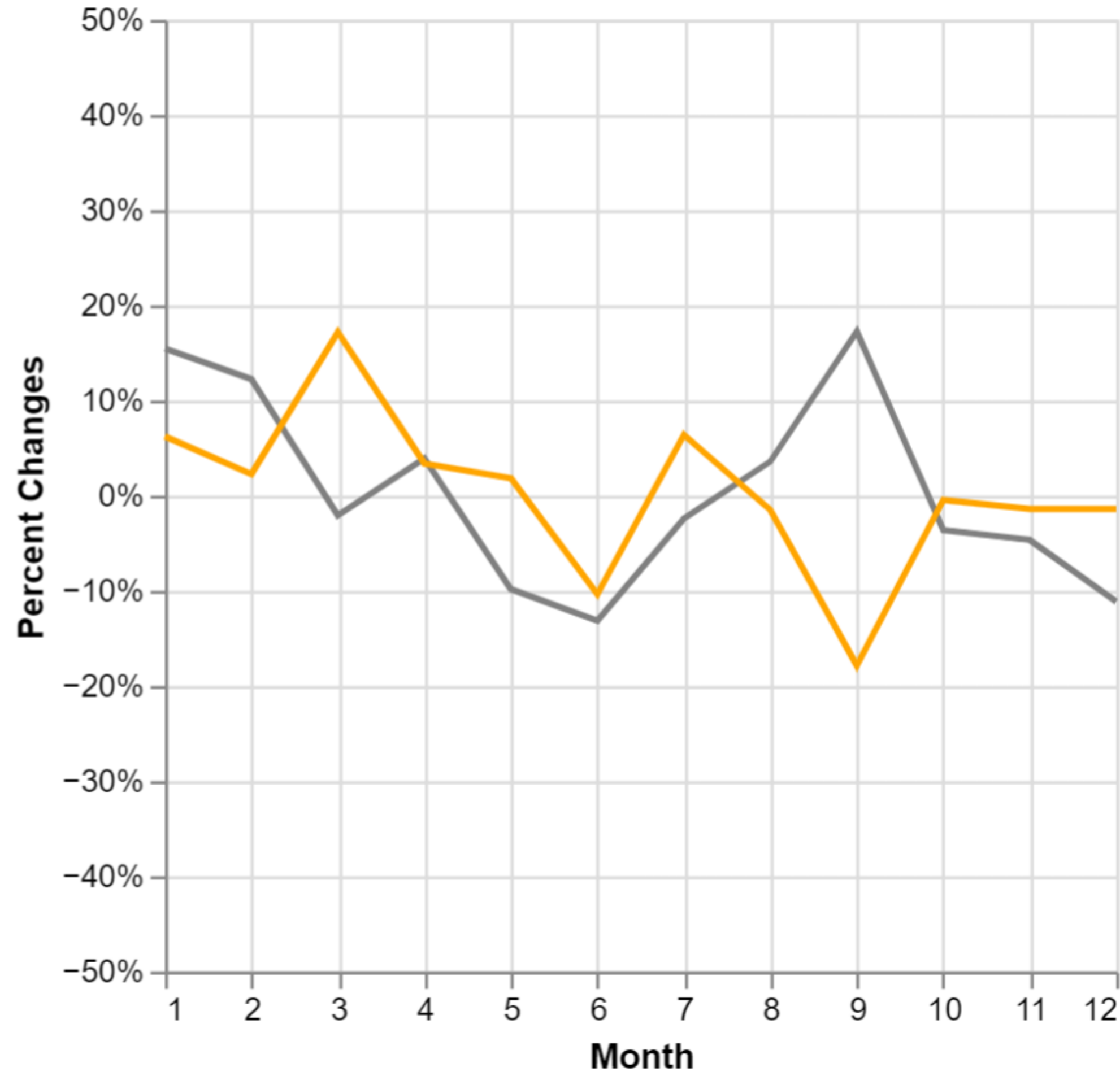
A Tale of Two Cities: How Dramatic are the Effects of Seasonal Depression?

Compared to a city like Miami, where sunshine hardly changes year round, Google searches for depression fluctuates much more in Chicago.

Chicago

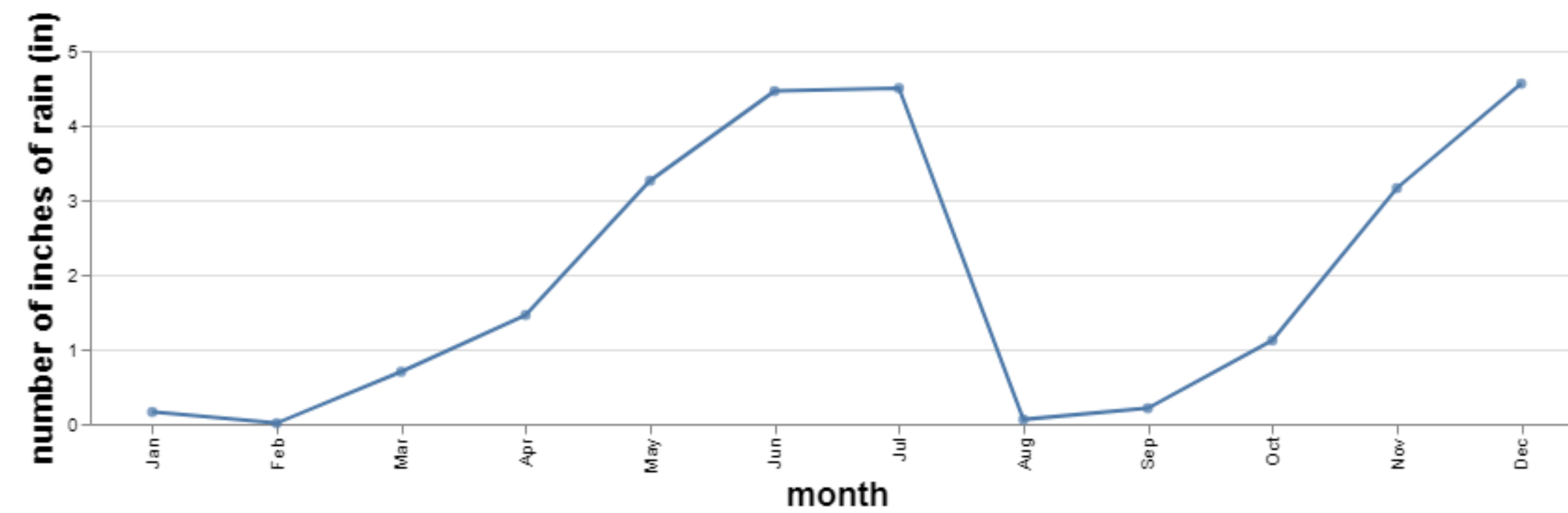
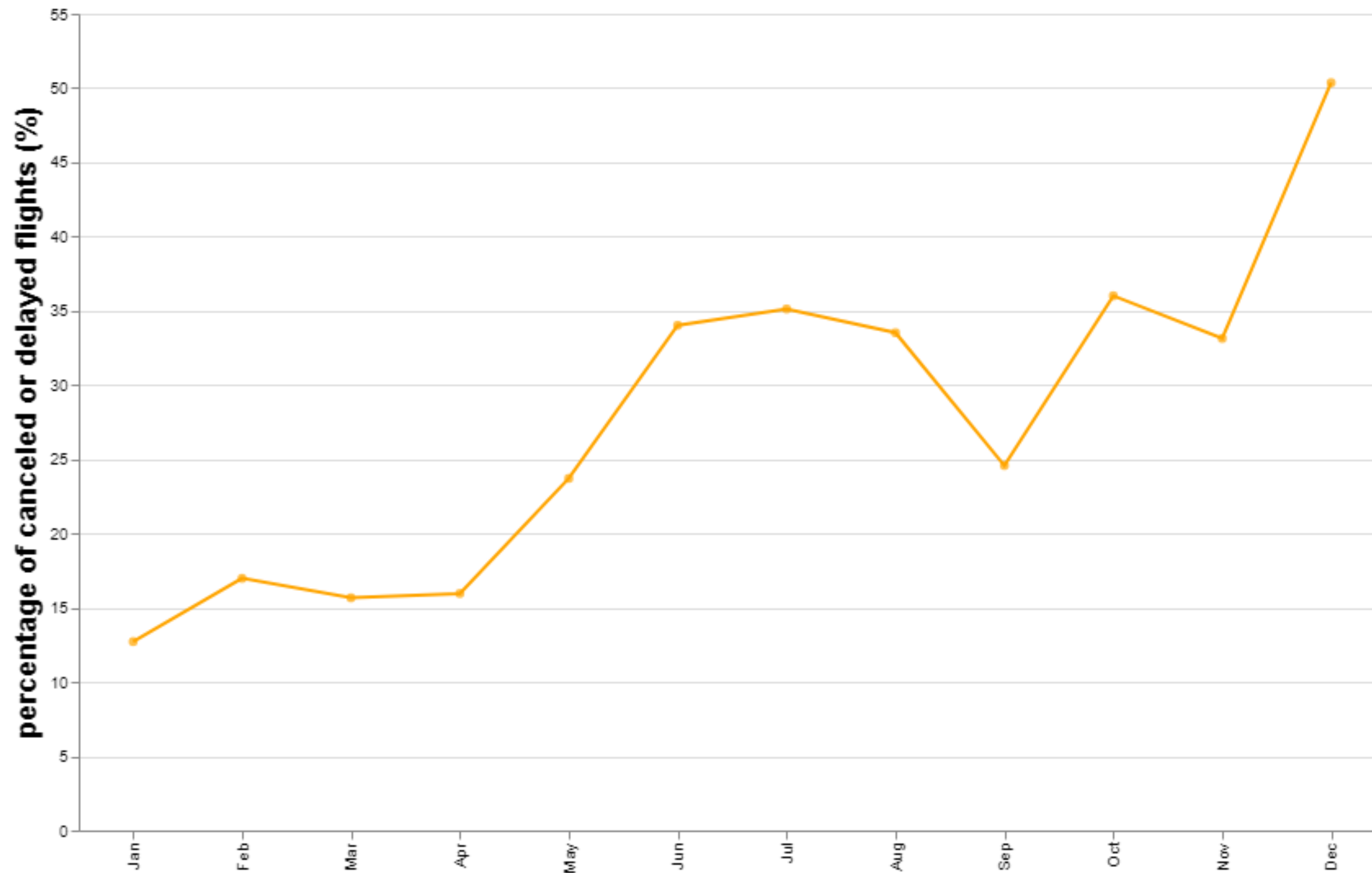


Miami



variable
— Google Searches for 'Depression'
— Hours of Sunshine

Percentage of canceled or delayed flights and inches of rain by month in San Francisco



Does San Francisco receive less sunlight in the summer than other US cities?

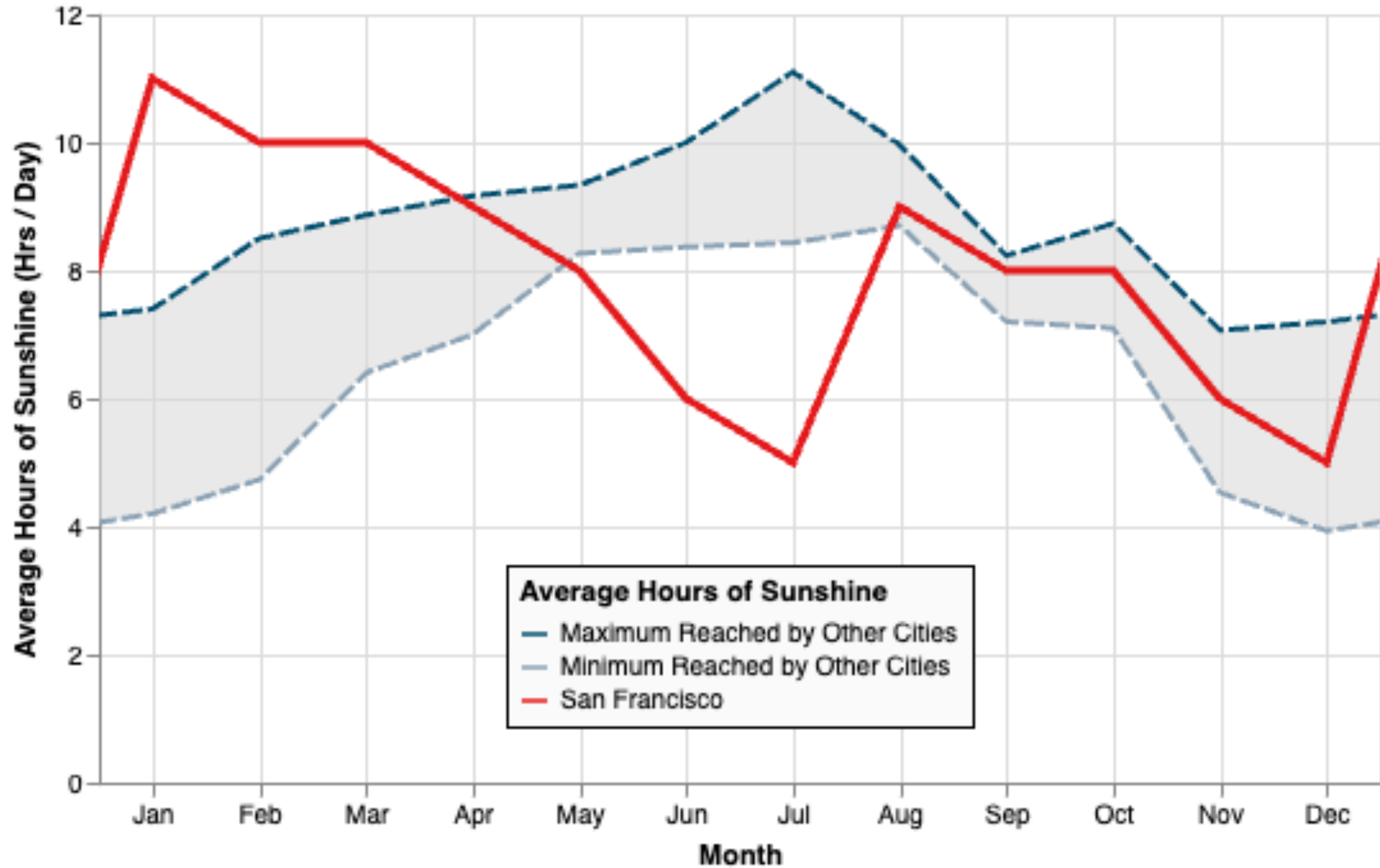
San Francisco's famous summer fog can block sunlight.



Data from usclimatedata.com, obtained through dsc106.com

How Does San Francisco's Sunshine Trend Compare to Other Major U.S. Cities?

San Francisco's Peculiar Sunshine Trend



What design decisions stood out to you?

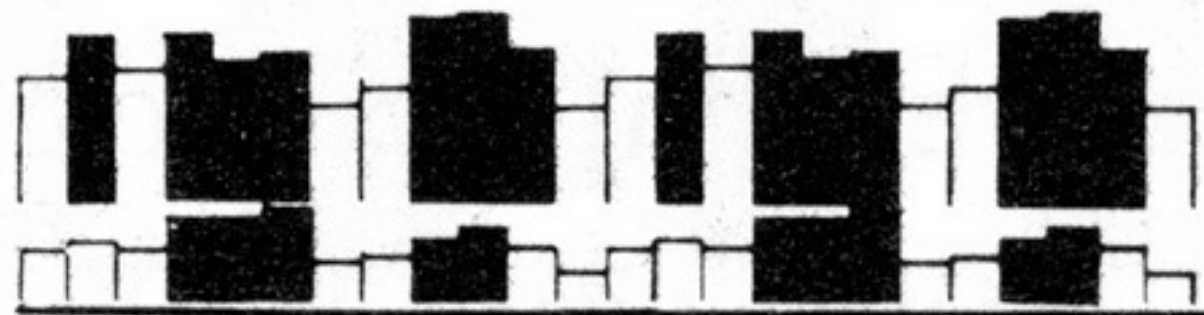
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Example: Bertin's Hotel Data

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

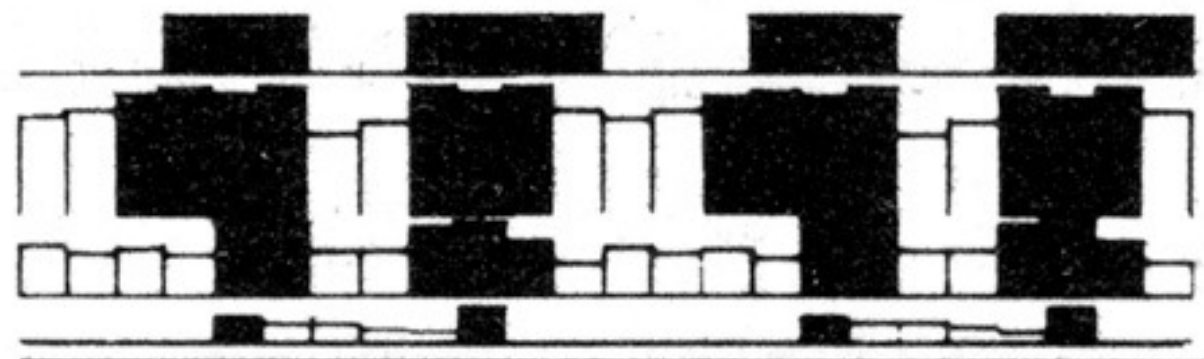
J F M A M J J A S O N D J F M A M J J A S O N D



18 % OCCUPANCY

18 LENGTH OF STAY

ACTIVE AND SLOW PERIODS



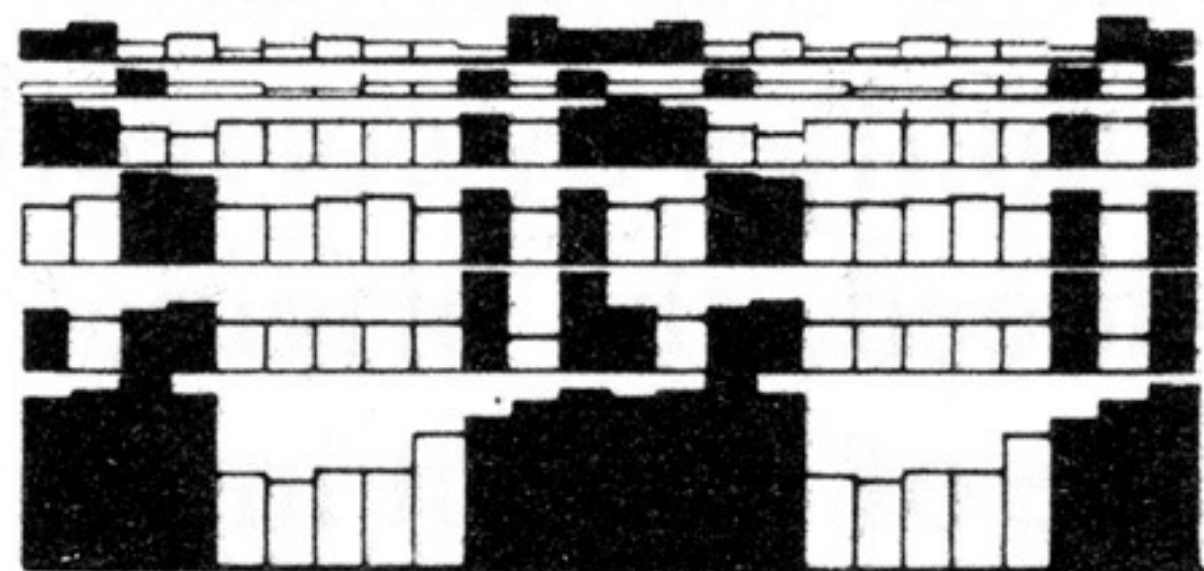
20 CONVENTIONS

8 BUSINESSMEN

11 AGENCY RESERVATIONS

4 SOUTH AMERICA

DISCOVERY FACTORS



18 AIR CREWS

18 CLIENTS UNDER 20 YEARS

18 CLIENTS MORE THAN 55 YEARS

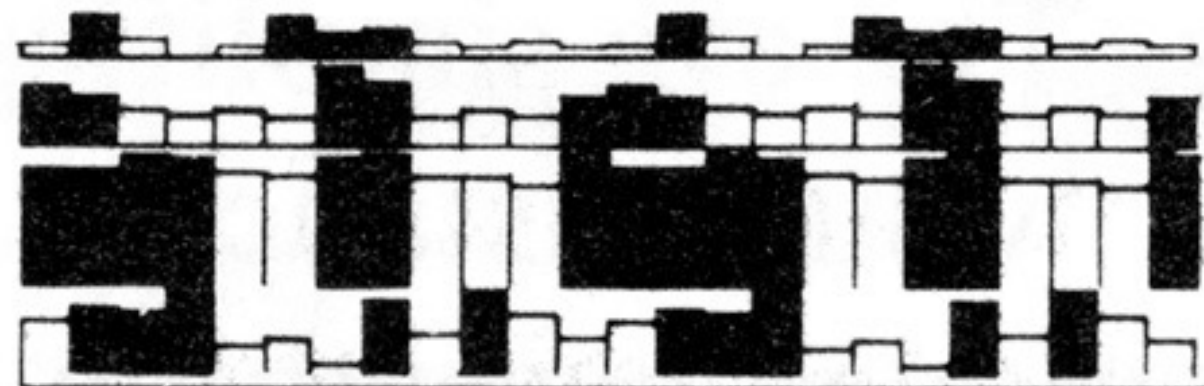
14 CLIENTS FROM 20-35 YEARS

1 FEMALE CLIENTELE

2 LOCAL CLIENTELE

RECOVERY FACTORS

WINTER



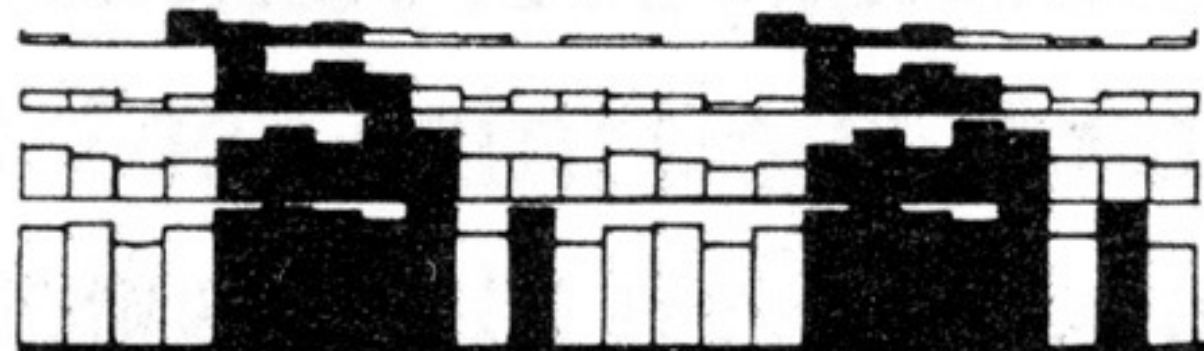
7 ASIA

9 TOURISTS

10 DIRECT RESERVATION

17 PRICE OF ROOMS

WINTER-SUMMER



6 MIDDLE EAST, AFRICA

3 U. S. A.

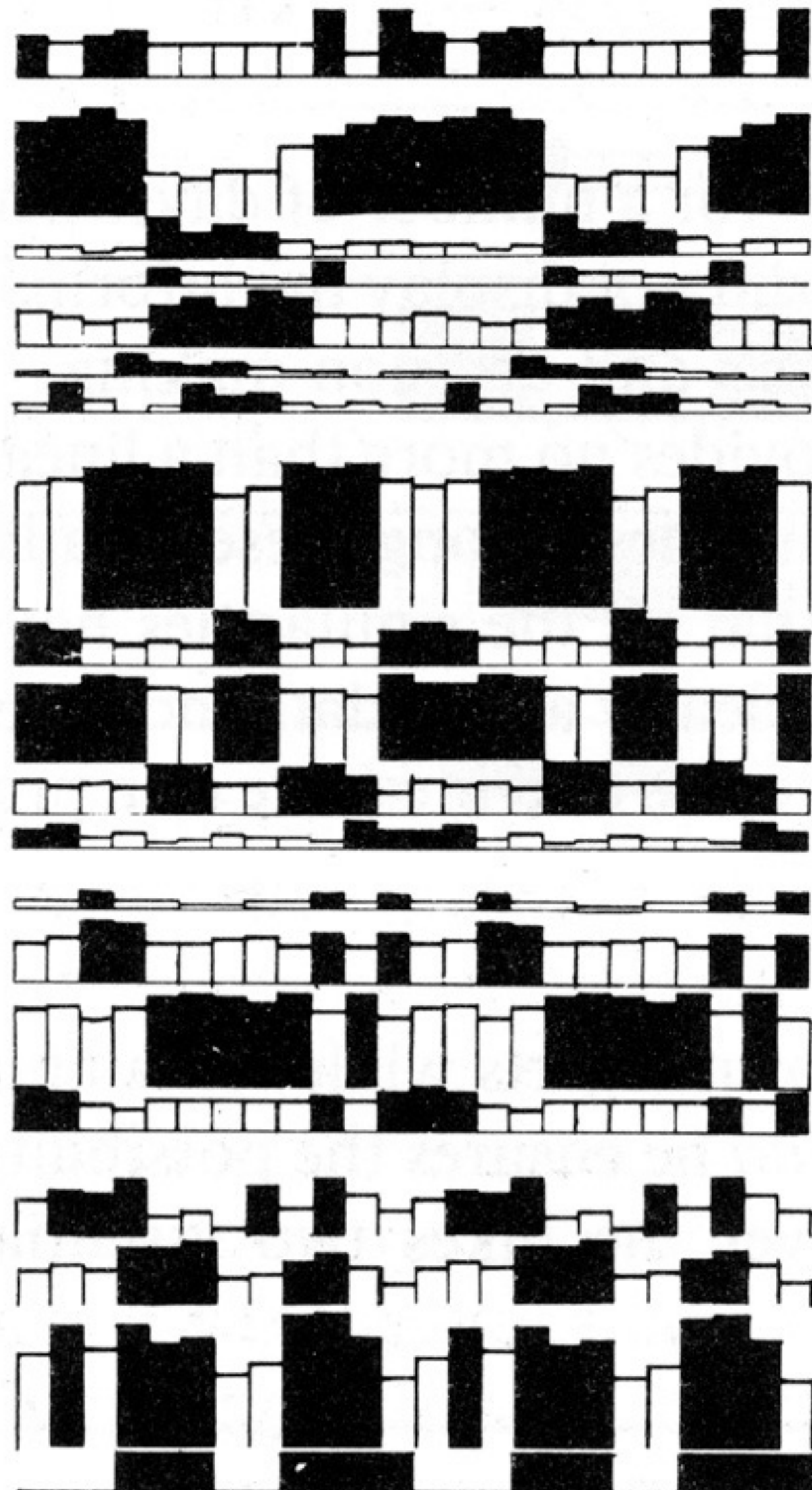
5 EUROPE

15 CLIENTS FROM 35-55 YEARS

SUMMER

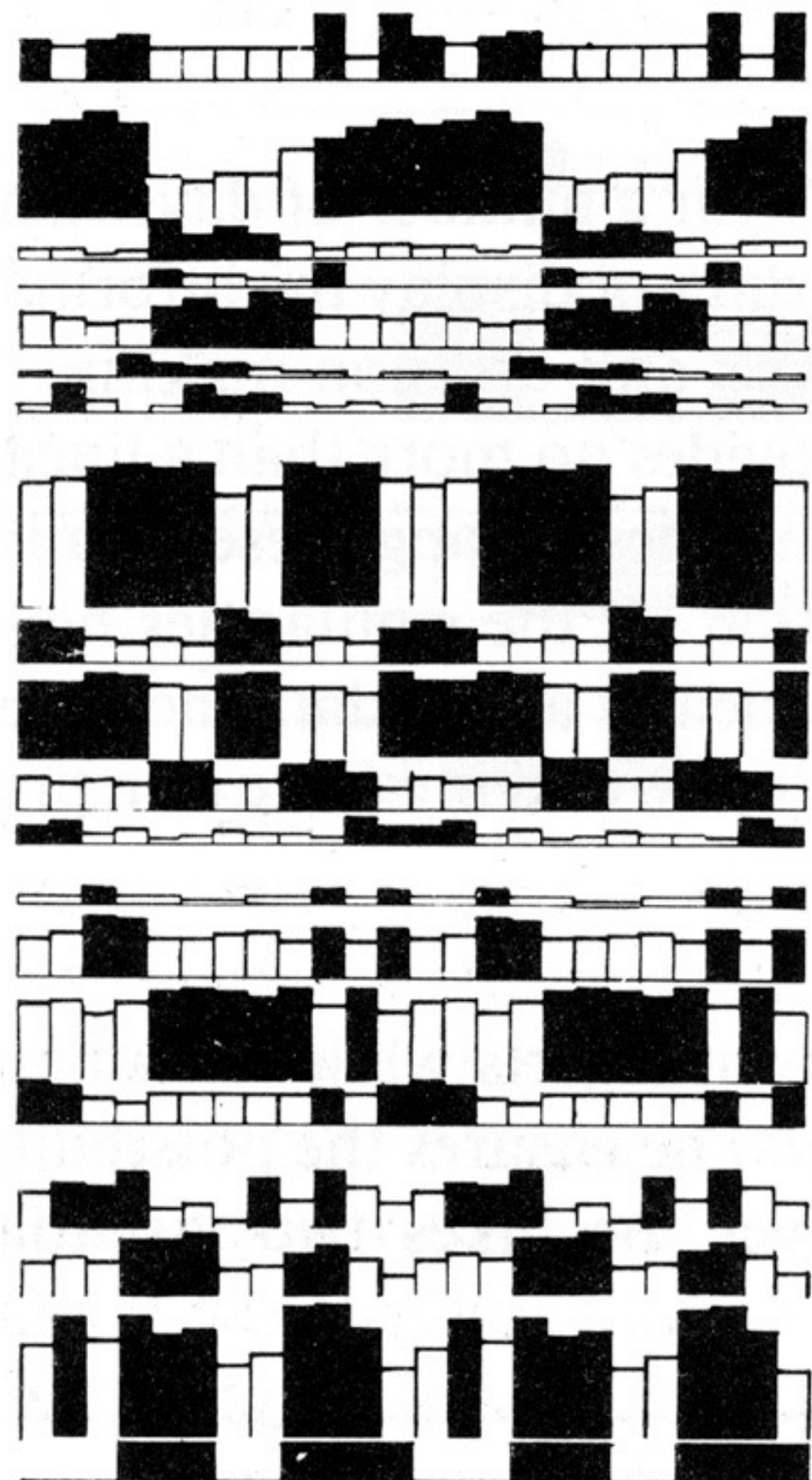
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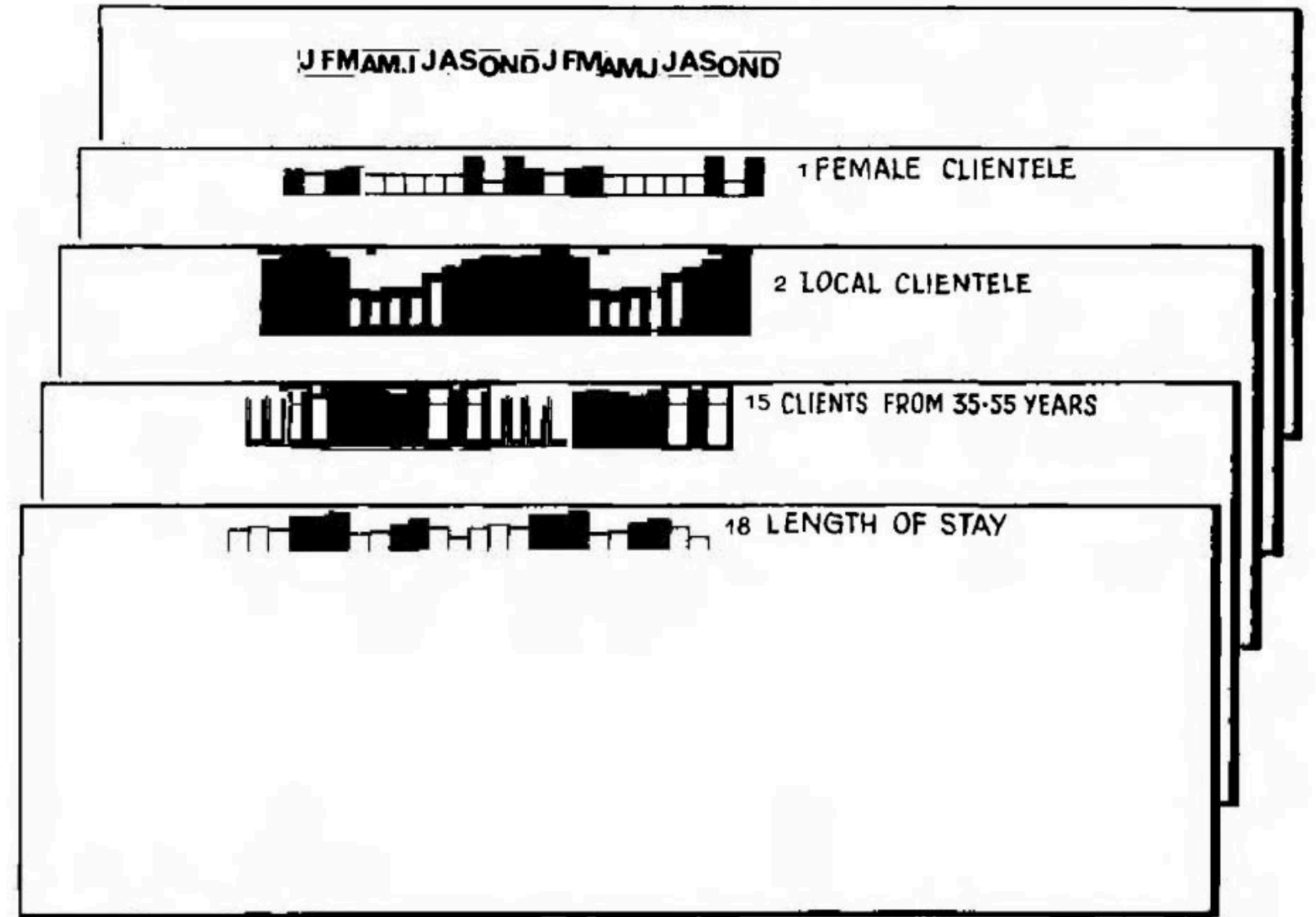
1	% CLIENTELE FEMALE
2	% —"—— LOCAL
3	% —"—— U.S.A.
4	% —"—— SOUTH AMERICA
5	% —"—— EUROPE
6	% —"—— M.EAST, AFRICA
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11	% AGENCY ———"——
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15	% —"—— 35-55 —"——
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17	PRICE OF ROOMS
18	LENGTH OF STAY
19	% OCCUPANCY
20	CONVENTIONS

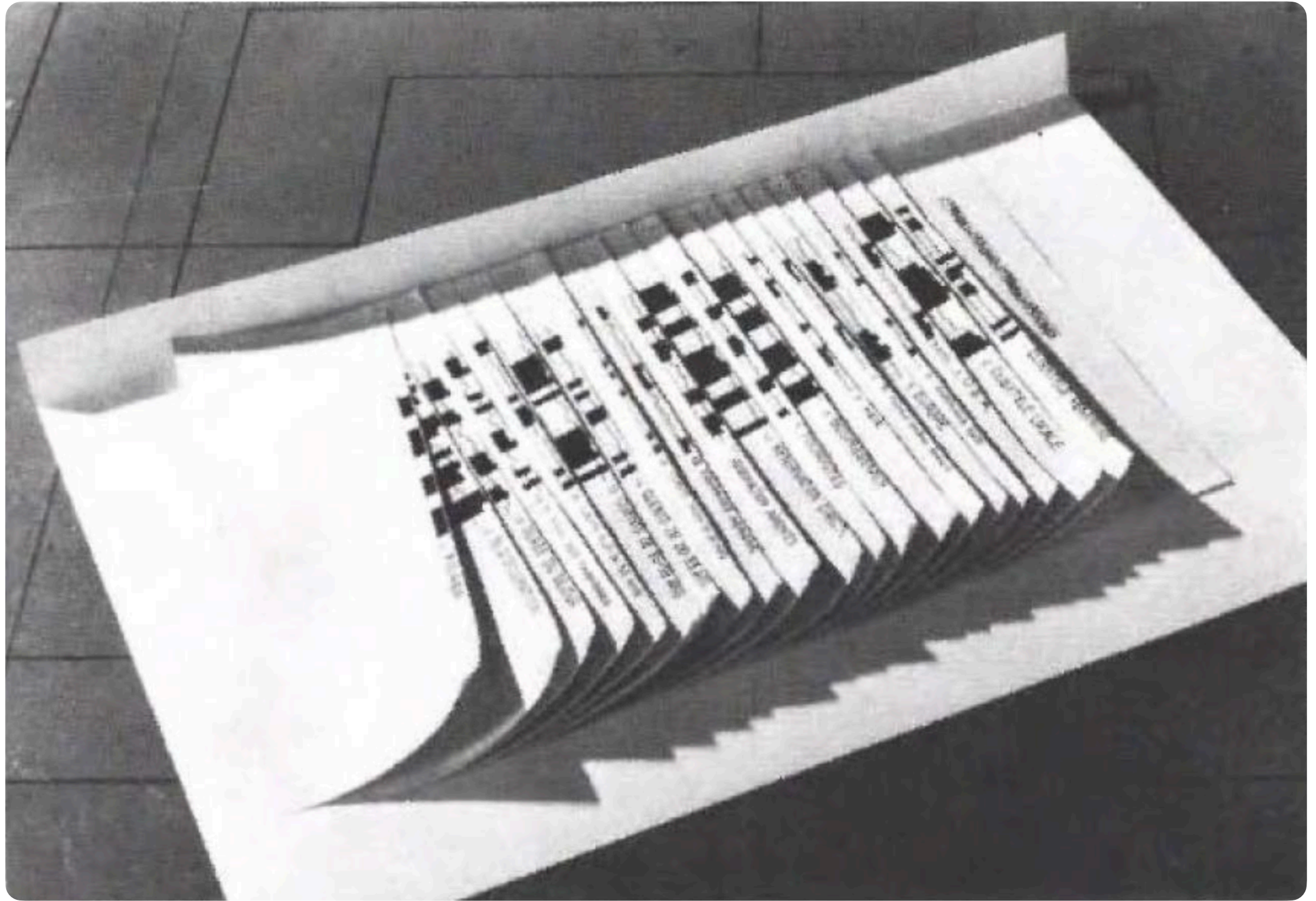
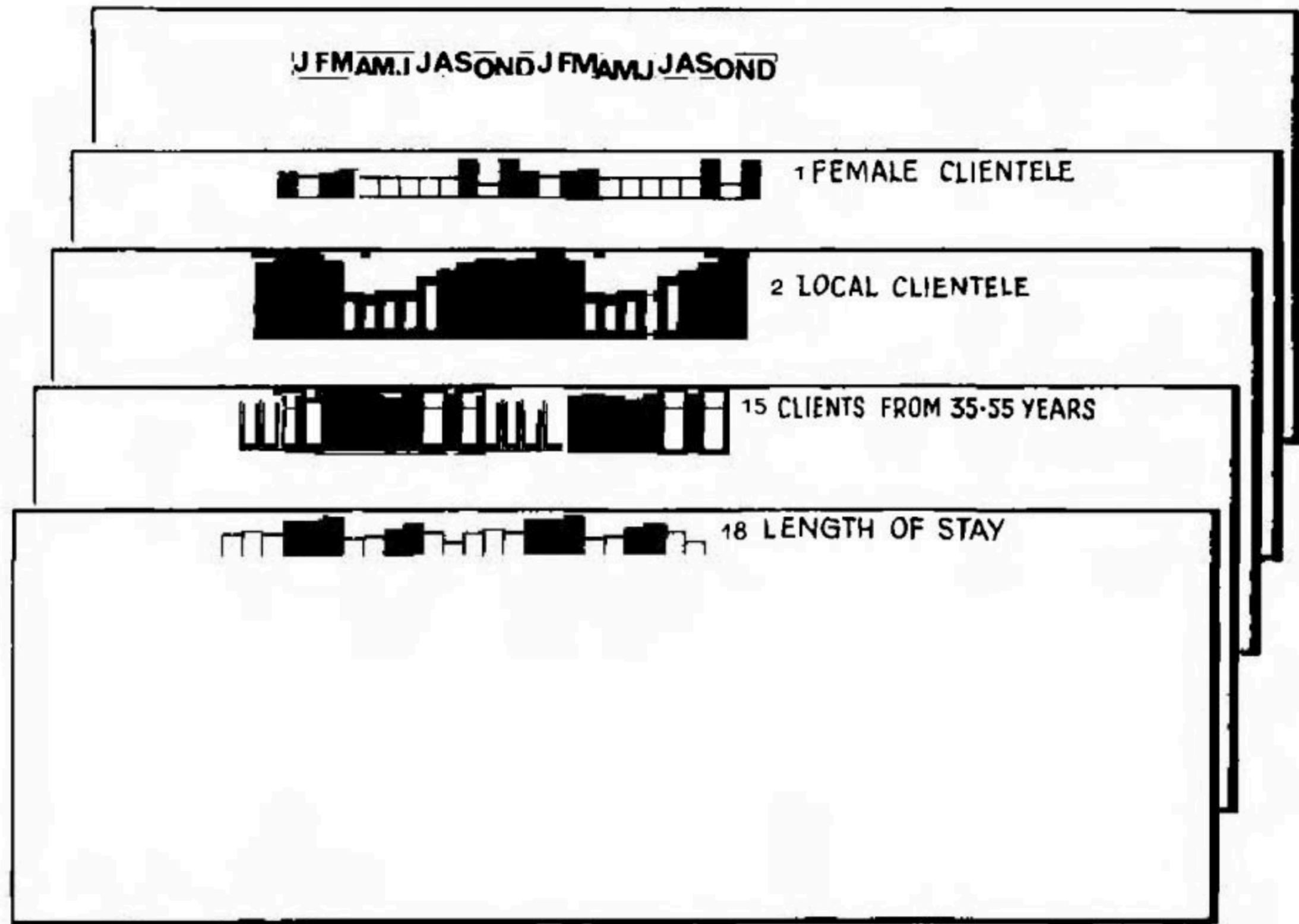
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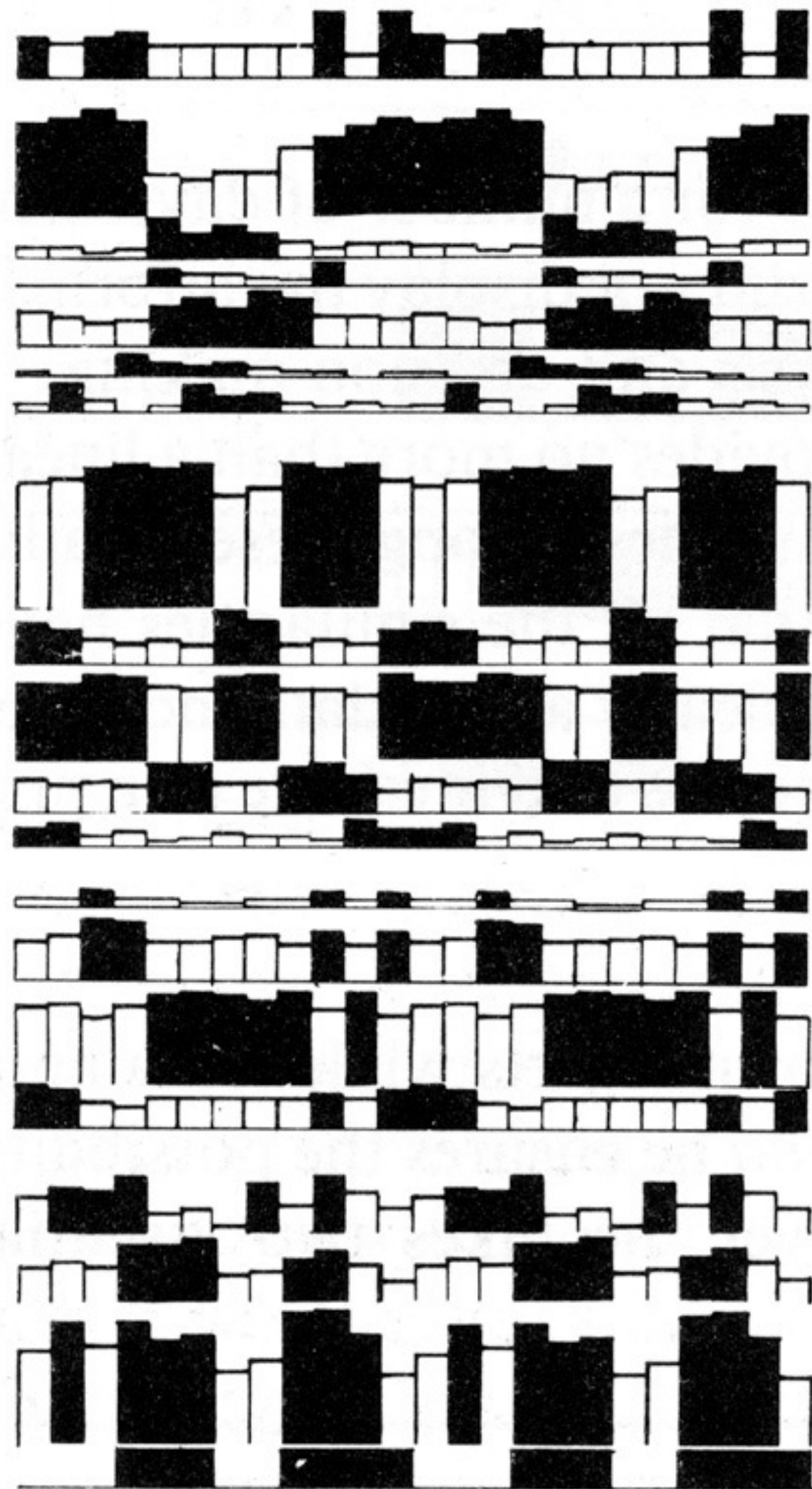
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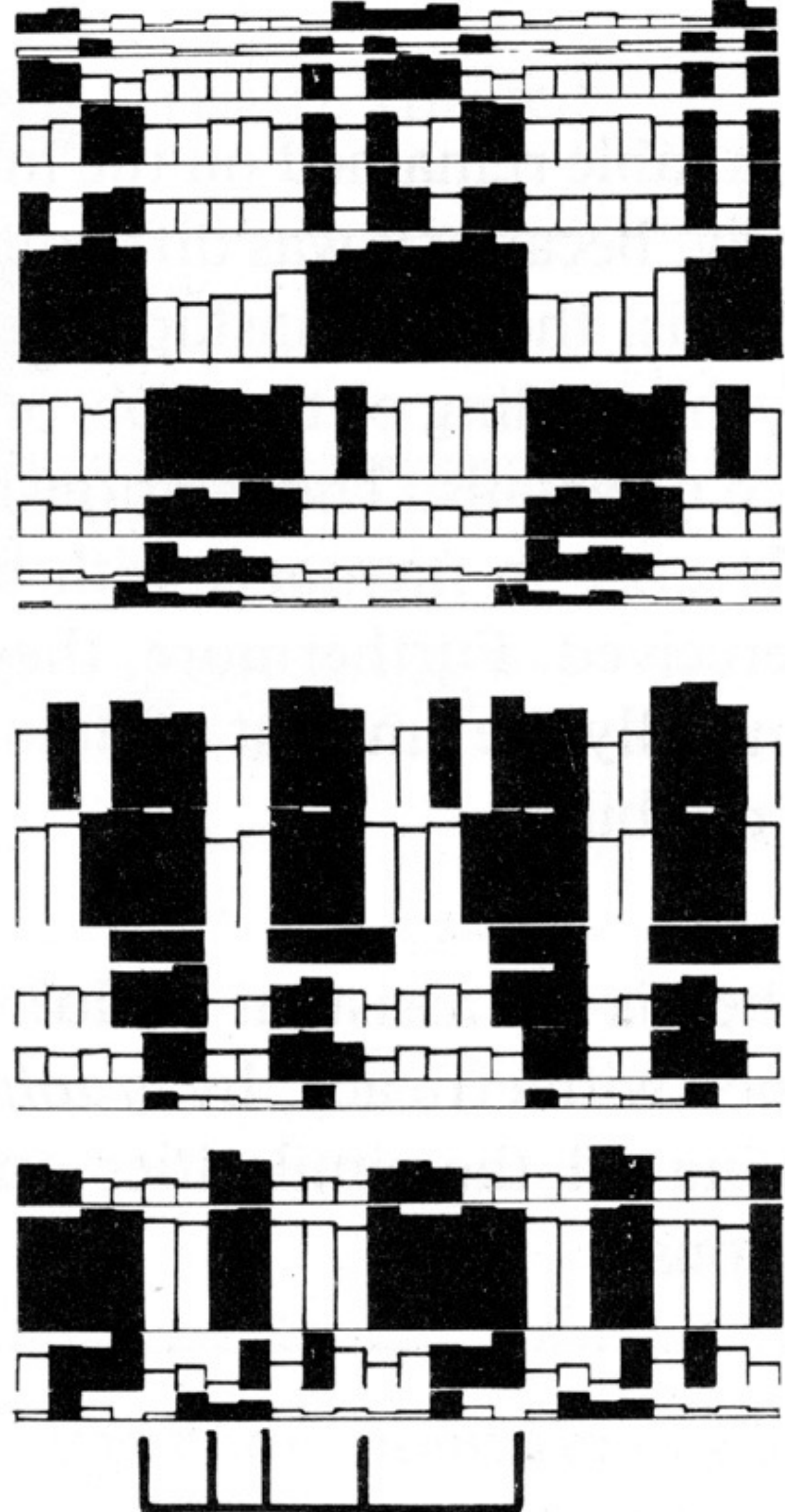
1

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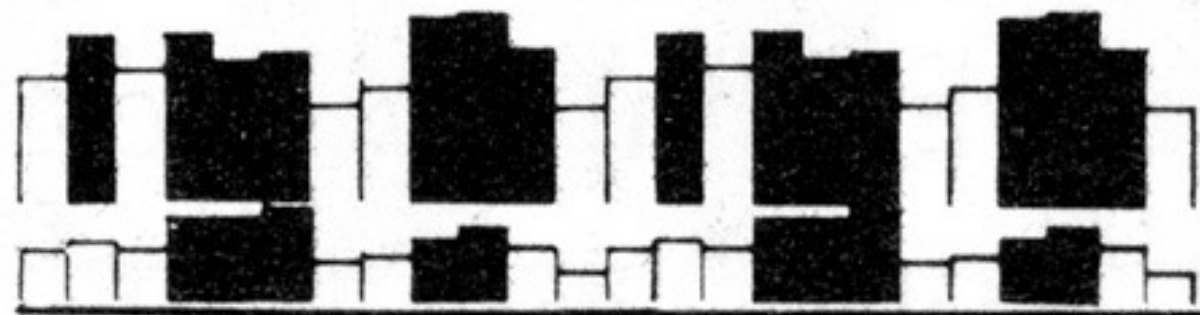


2

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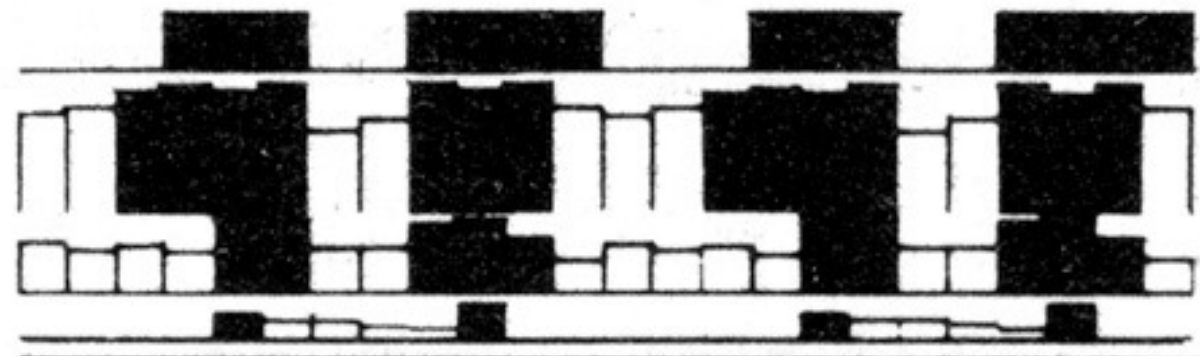
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19 % OCCUPANCY

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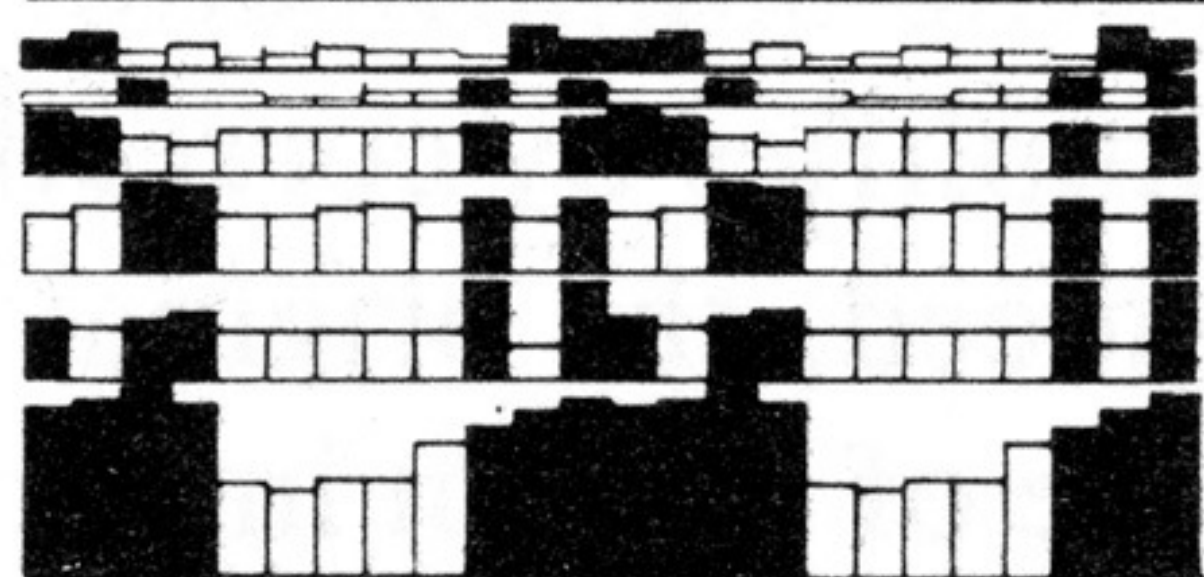
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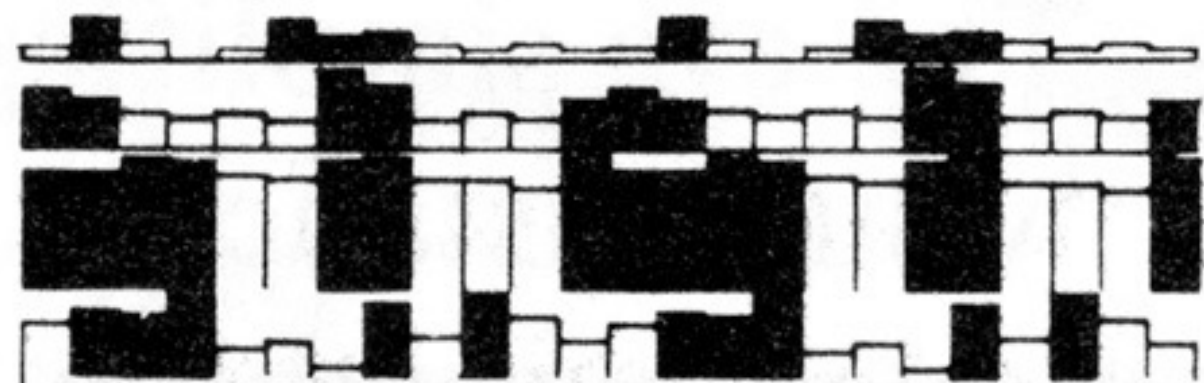
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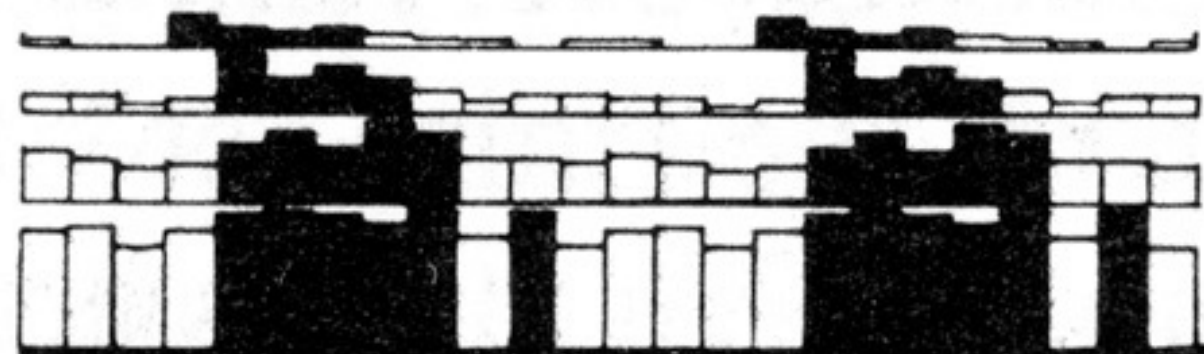
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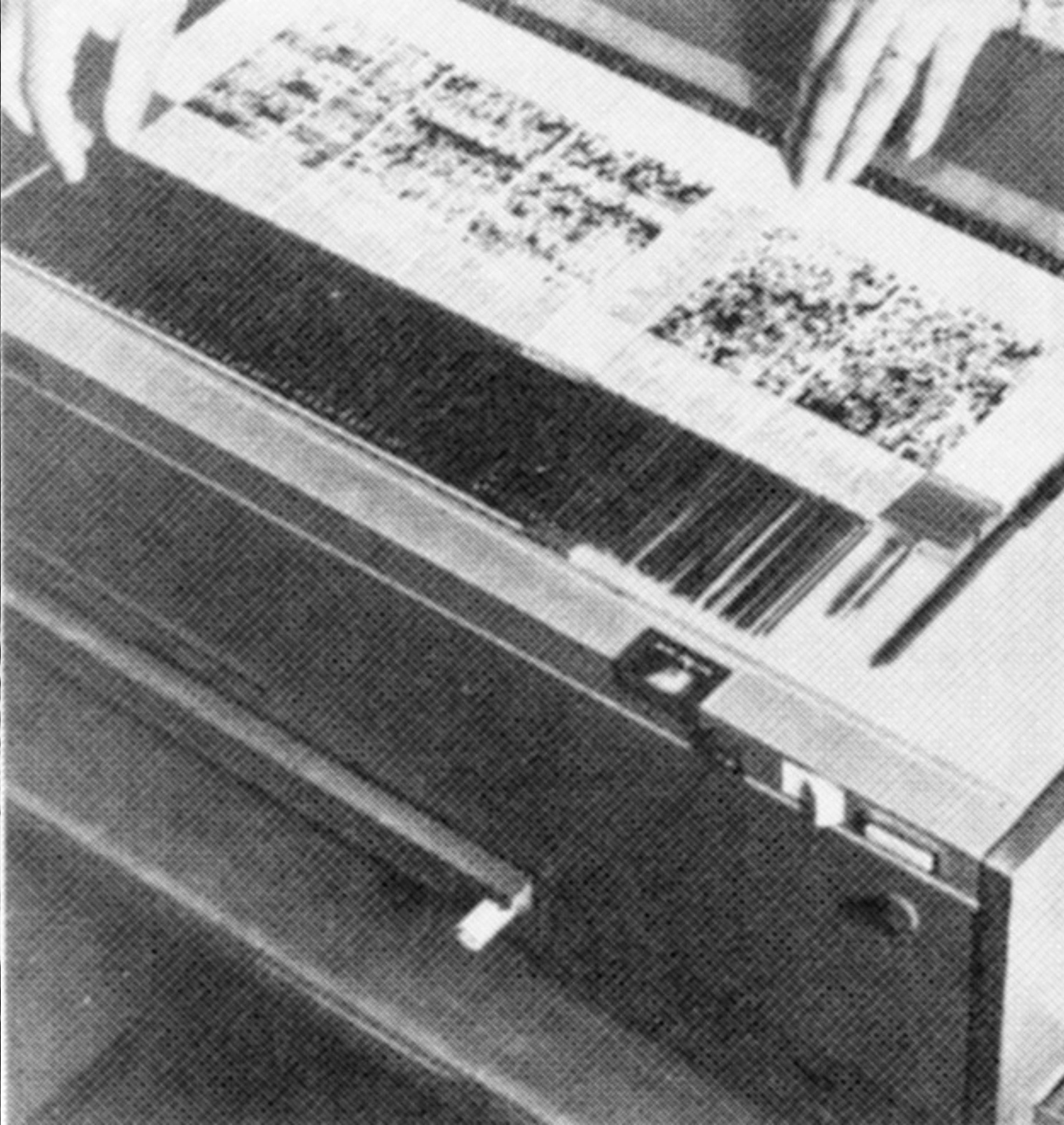
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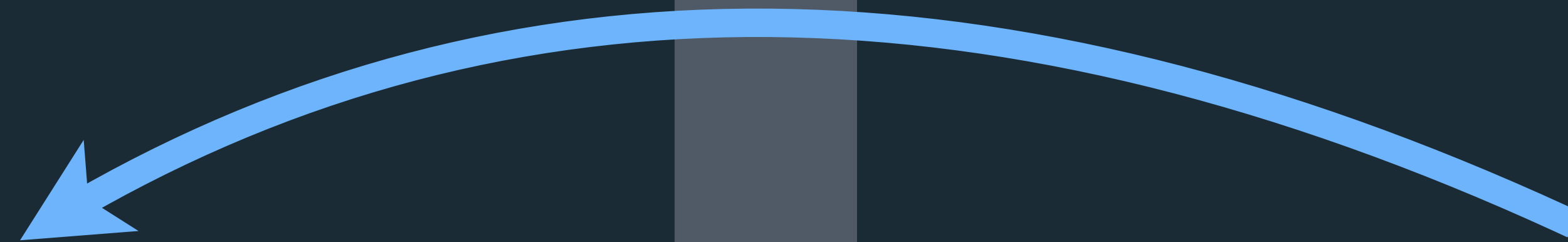


Gulf of Evaluation

The level of difficulty in interpreting the system and assessing if goals were met.



User Goals



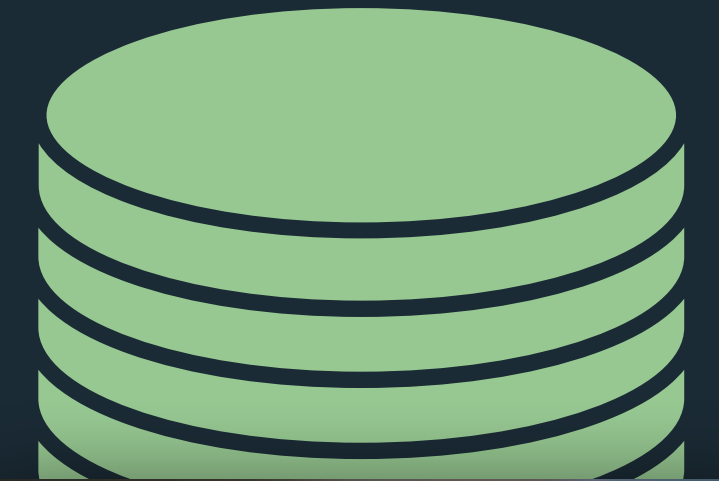
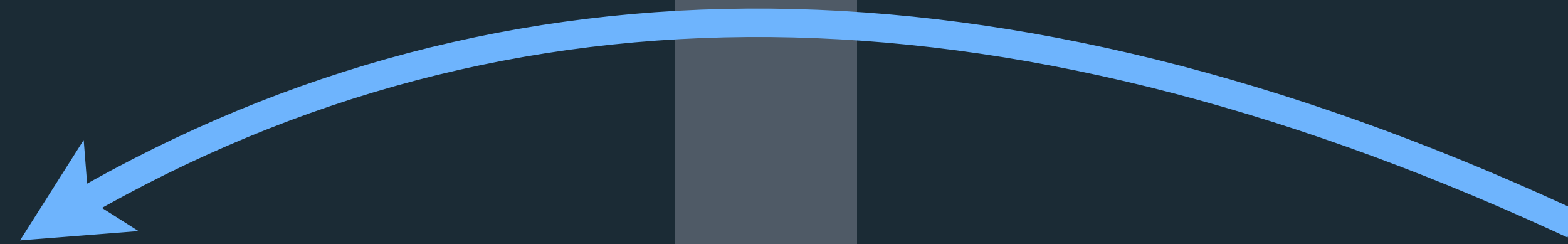
Interface

Gulf of Execution

The gap between the user's goals and their ability to achieve them using the system.

Gulf of Evaluation

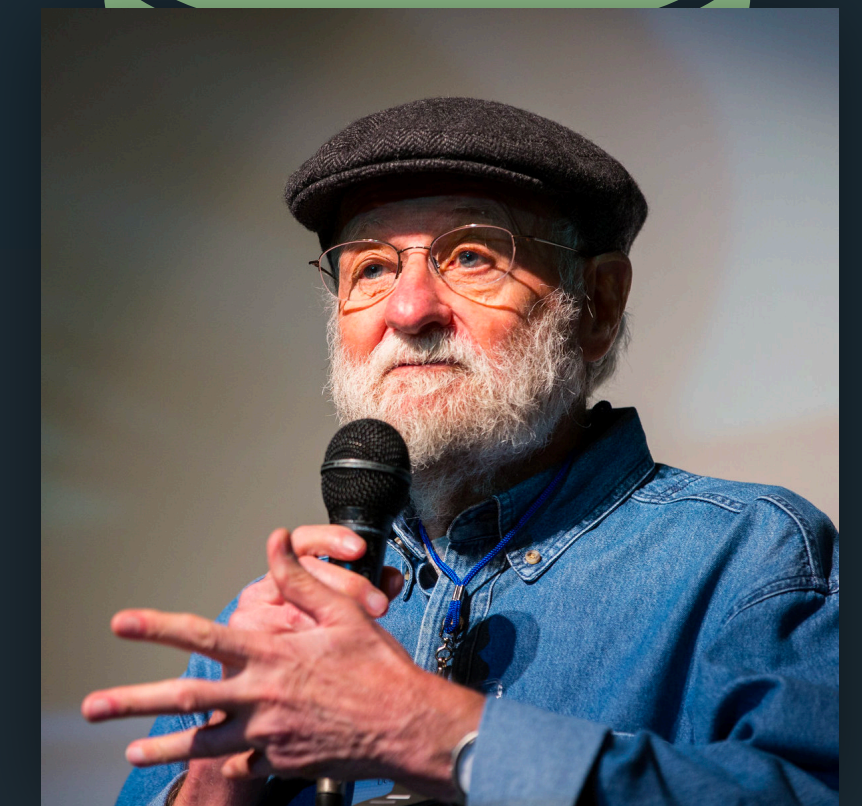
The level of difficulty in interpreting the system and assessing if goals were met.



Edwin Hutchins



Jim Hollan



Don Norman

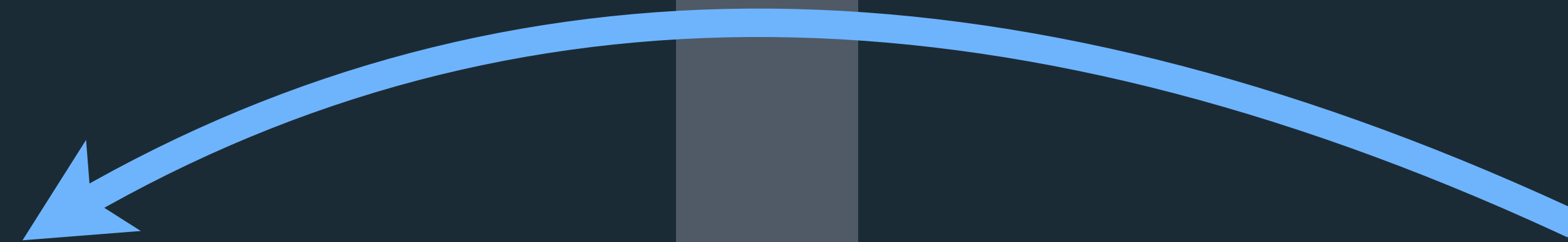
Gulf of Evaluation
The gap between goals and their ability to achieve the system.

Gulf of Evaluation

The level of difficulty in interpreting the system and assessing if goals were met.



User Goals



Interface

Gulf of Execution

The gap between the user's goals and their ability to achieve them using the system.

day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

```
pd.read_csv('stocks.csv')
```

day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45

```
df[df['price'] > 900]
```

Filter



day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
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```

```
df.sort_values('price',  
ascending=False)
```

Filter

Sort

day	stock	price
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day	symbol	price
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10/4	AMZN	965.45
10/3	MSFT	74.26
10/4	MSFT	74.69

symbol	avg(price)
AMZN	961.275
MSFT	74.475

```
df[df['price'] > 900]
```

```
df.sort_values('price', ascending=False)
```

```
df.groupby('symbol').mean()
```

Filter

Sort

"Small Multiples" + Aggregation

day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

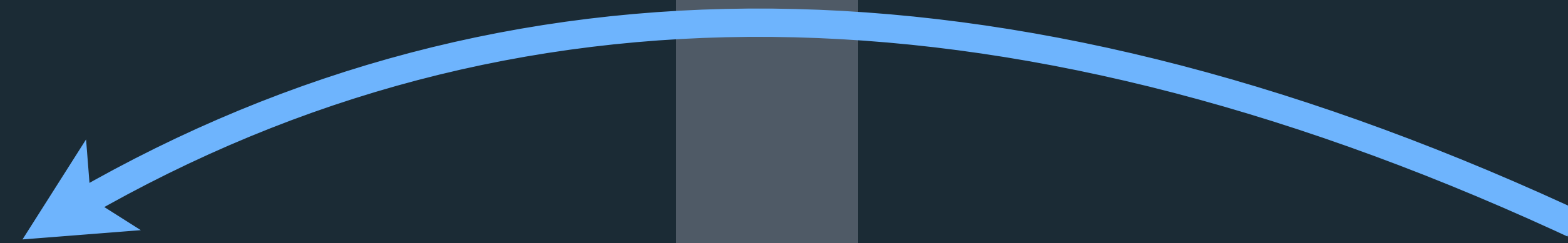
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```

Gulf of Evaluation

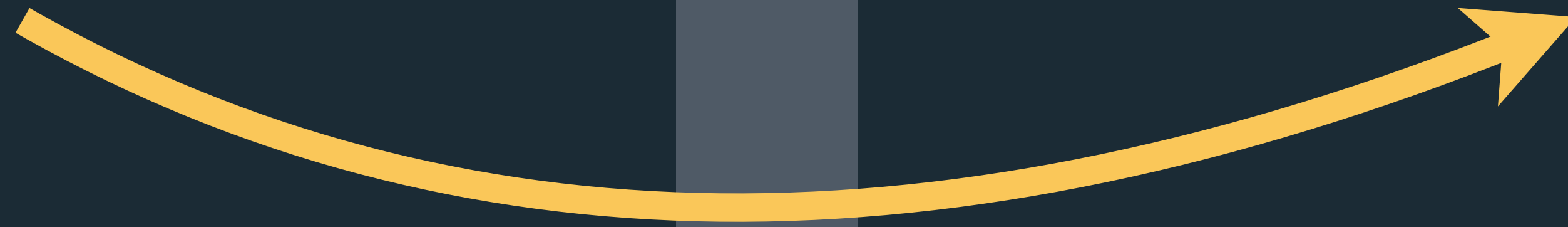
The level of difficulty in interpreting the system and assessing if goals were met.



User Goals



Interface



Gulf of Execution

The gap between the user's goals and their ability to achieve them using the system.

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

Gulf of Evaluation

Python



User Goals

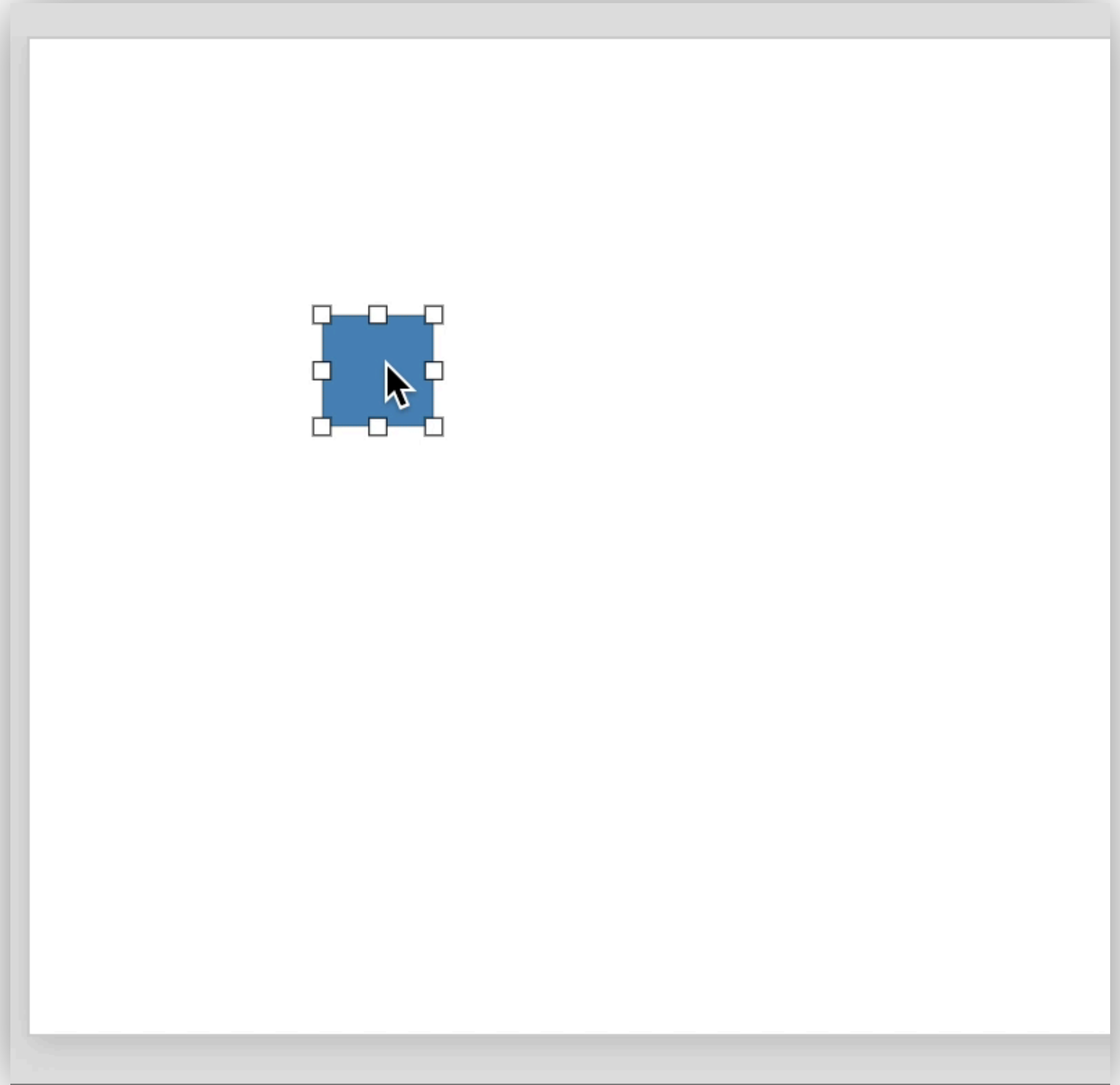


Interface

Gulf of Execution

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

The screenshot shows a web browser's developer console. The main area above the console is empty. The console toolbar includes tabs for Elements, Console, Sources, Network, Performance, Memory, and Application. The Console tab is active, showing a JavaScript error: `> var canvas = document.querySelector('canvas');` followed by `< undefined`. The current line of code is `> var ctx = canvas.getContext|`.



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

Gulf of Evaluation



User Goals

Direct Manipulation



Interface

Gulf of Execution

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

Interaction in Visualization

Select identify something as interesting.

Connect show me something conditionally.

Abstract/Elaborate show me related items.

Filter show me more or less detail.

Reconfigure show me a different arrangement.

Explore show me something else.

Encode show me a different visual representation.

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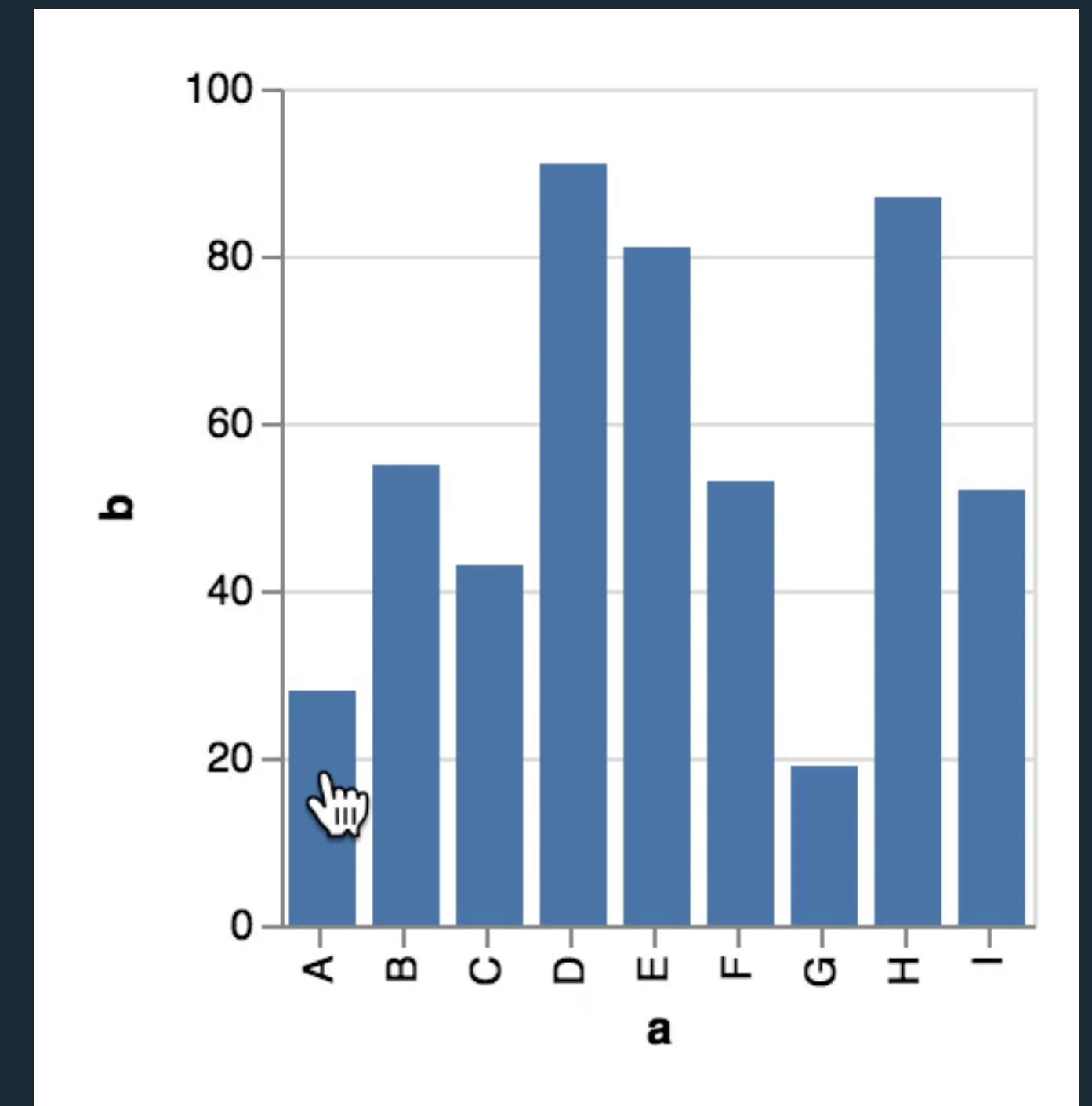
Point Selection

Select discrete data values.

Point Selection

Select discrete data values.

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

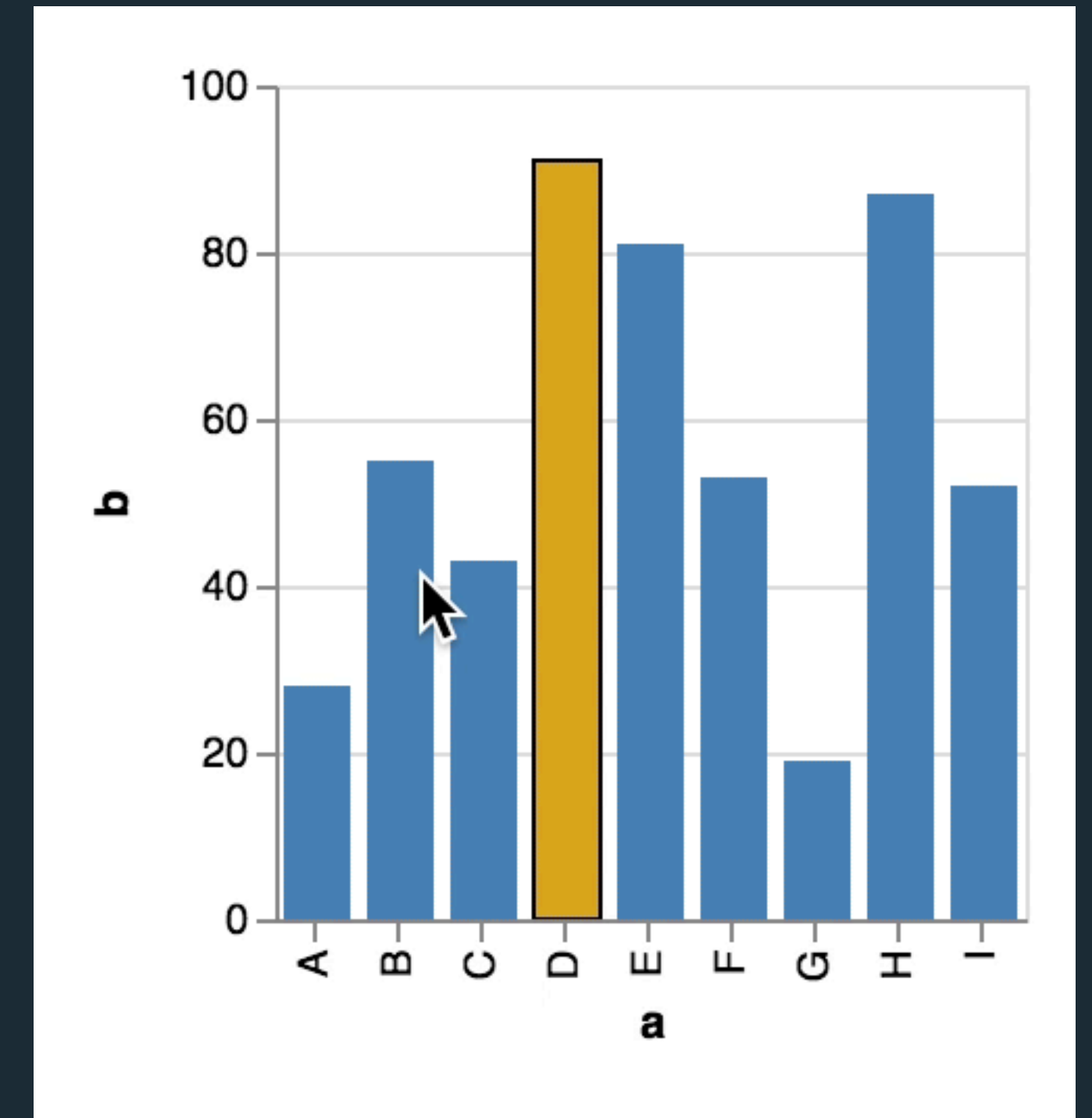


Point Selection

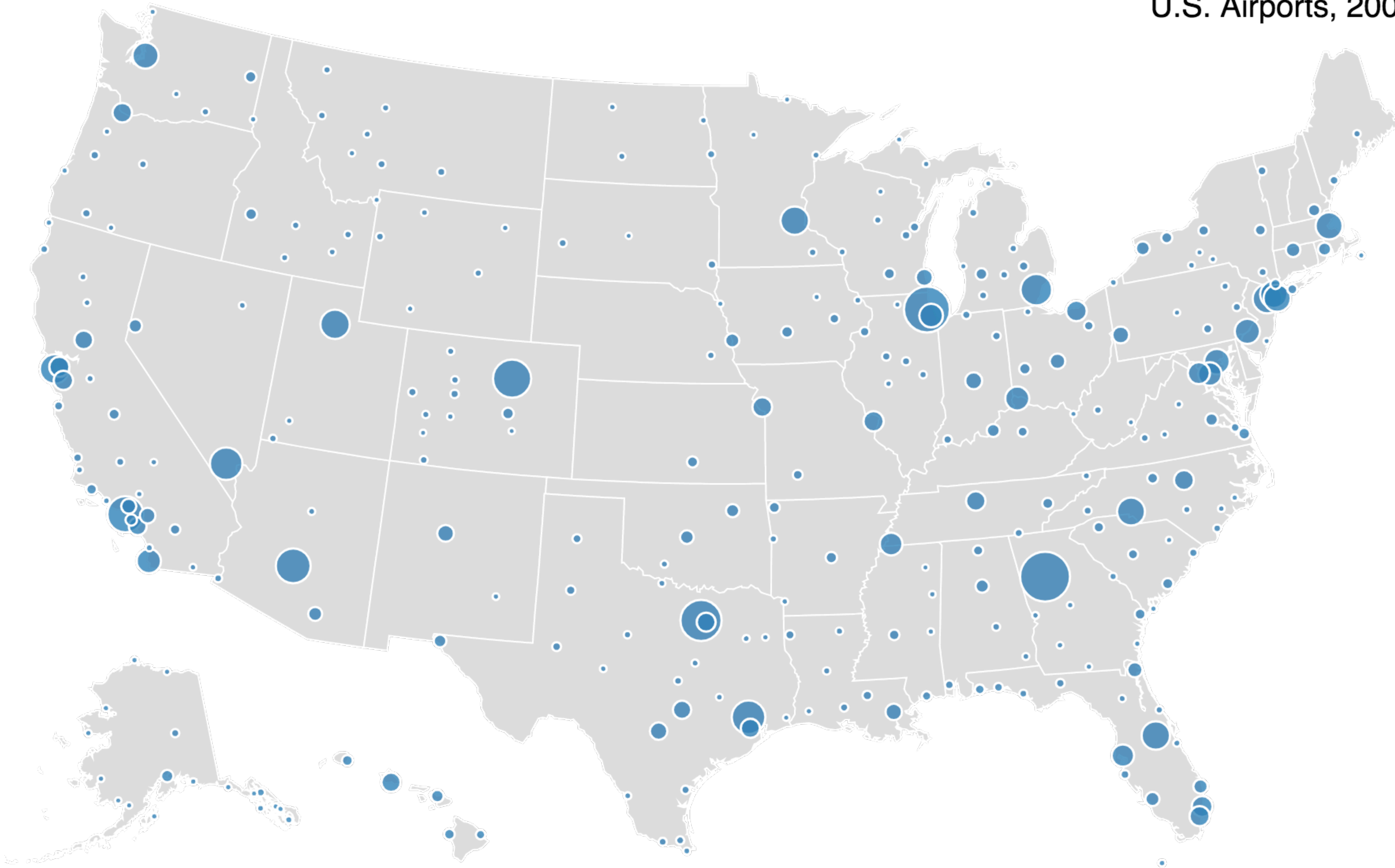
Select discrete data values.

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

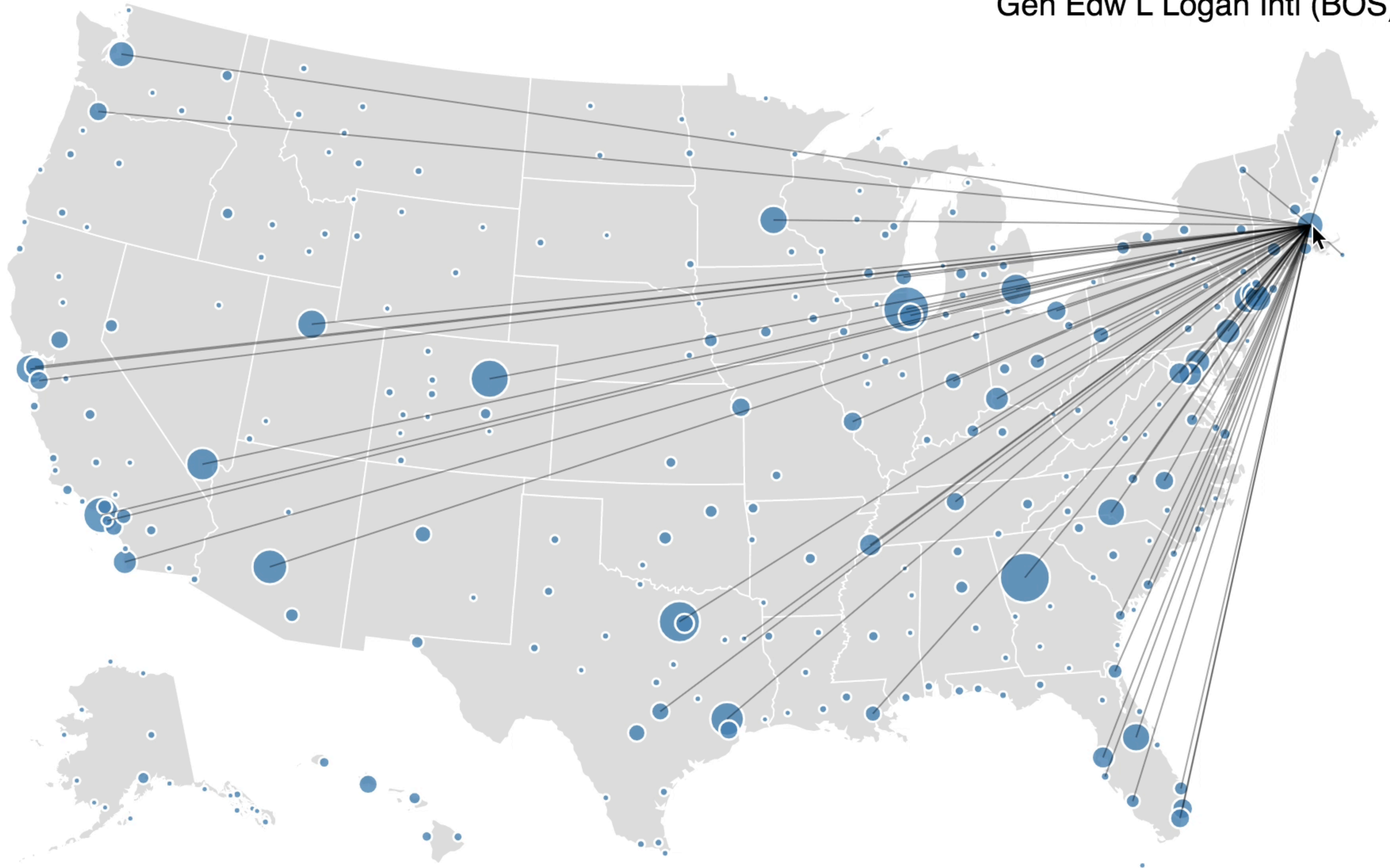
How are points selected? Mouse hover, click, tap, ...



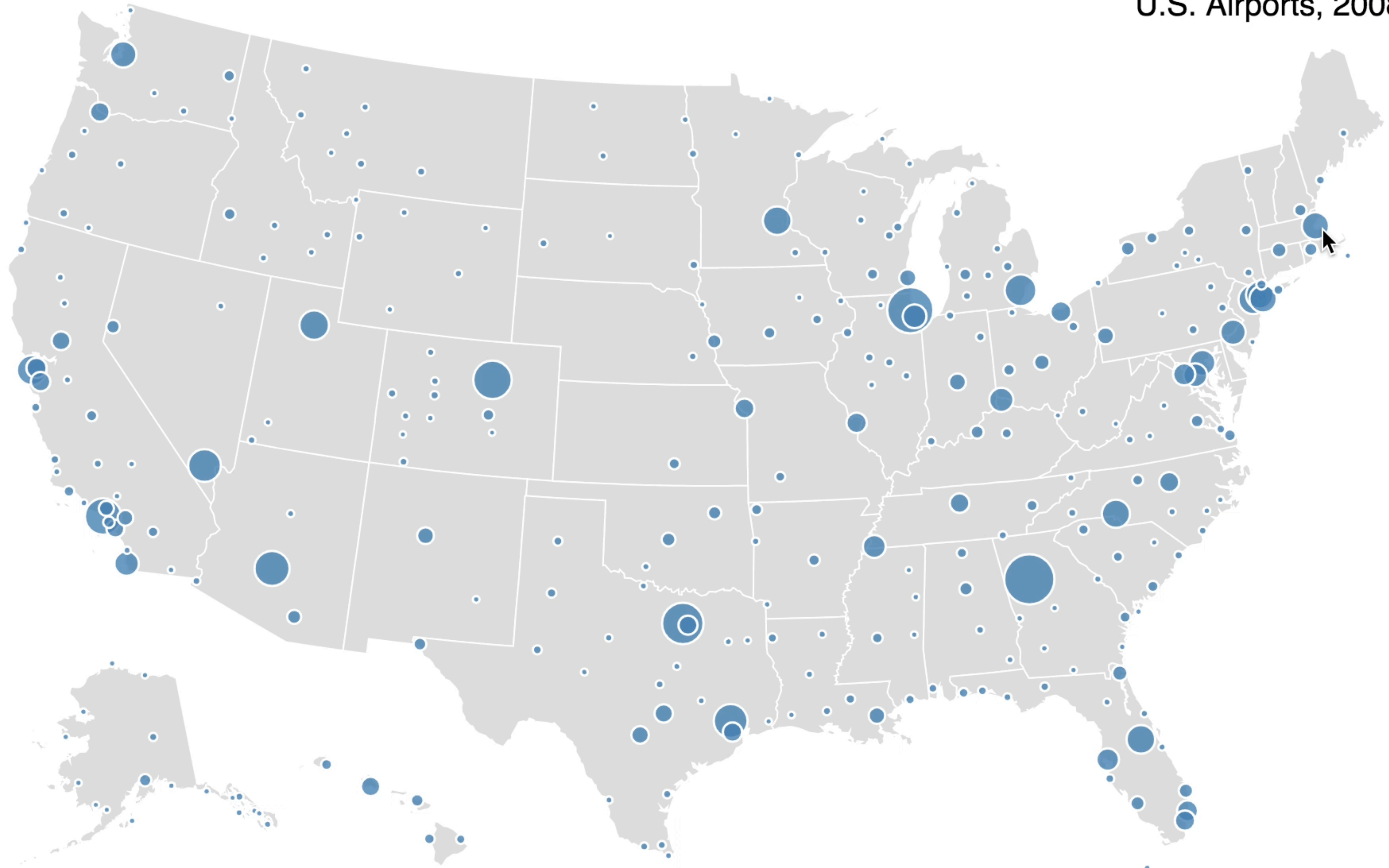
U.S. Airports, 2008



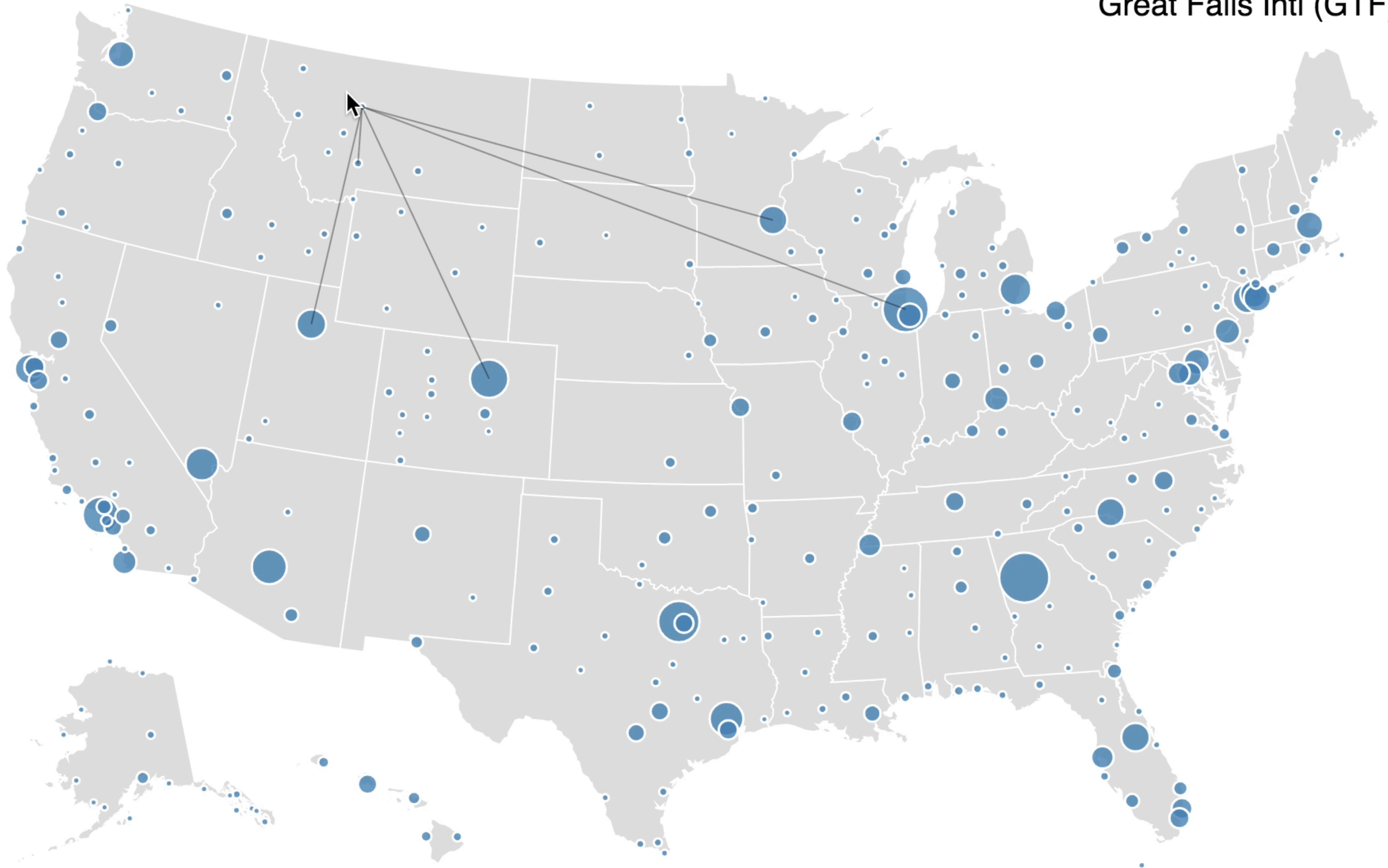
Gen Edw L Logan Intl (BOS)



U.S. Airports, 2008



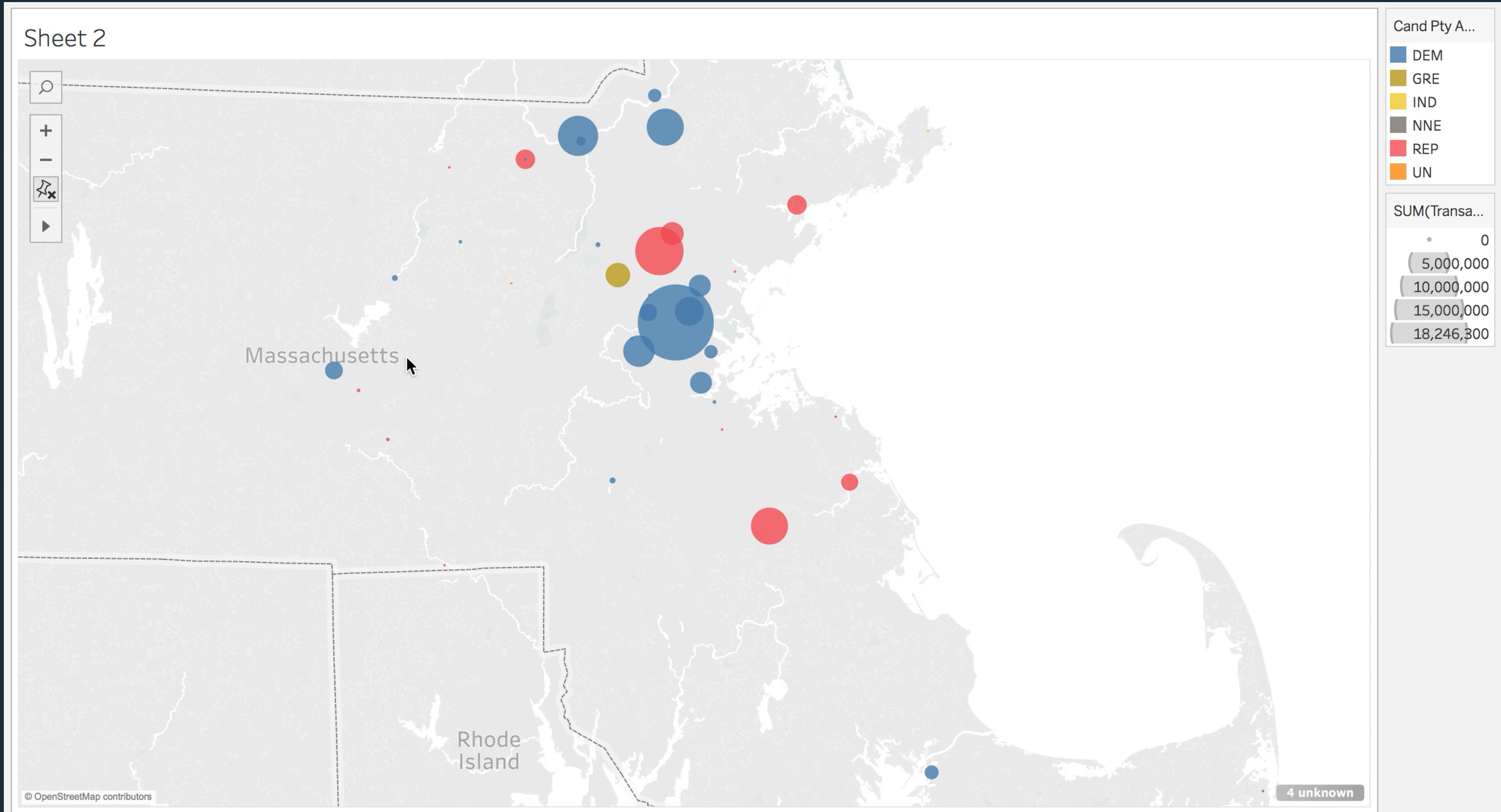
Great Falls Intl (GTF)



Region Selection

Extensional Selections: enumerate all points

Intentional Selections: describes common properties



Generalized Selection via Interactive Query Relaxation

Jeffrey Heer | Maneesh Agrawala | Wesley Willett
University of California, Berkeley

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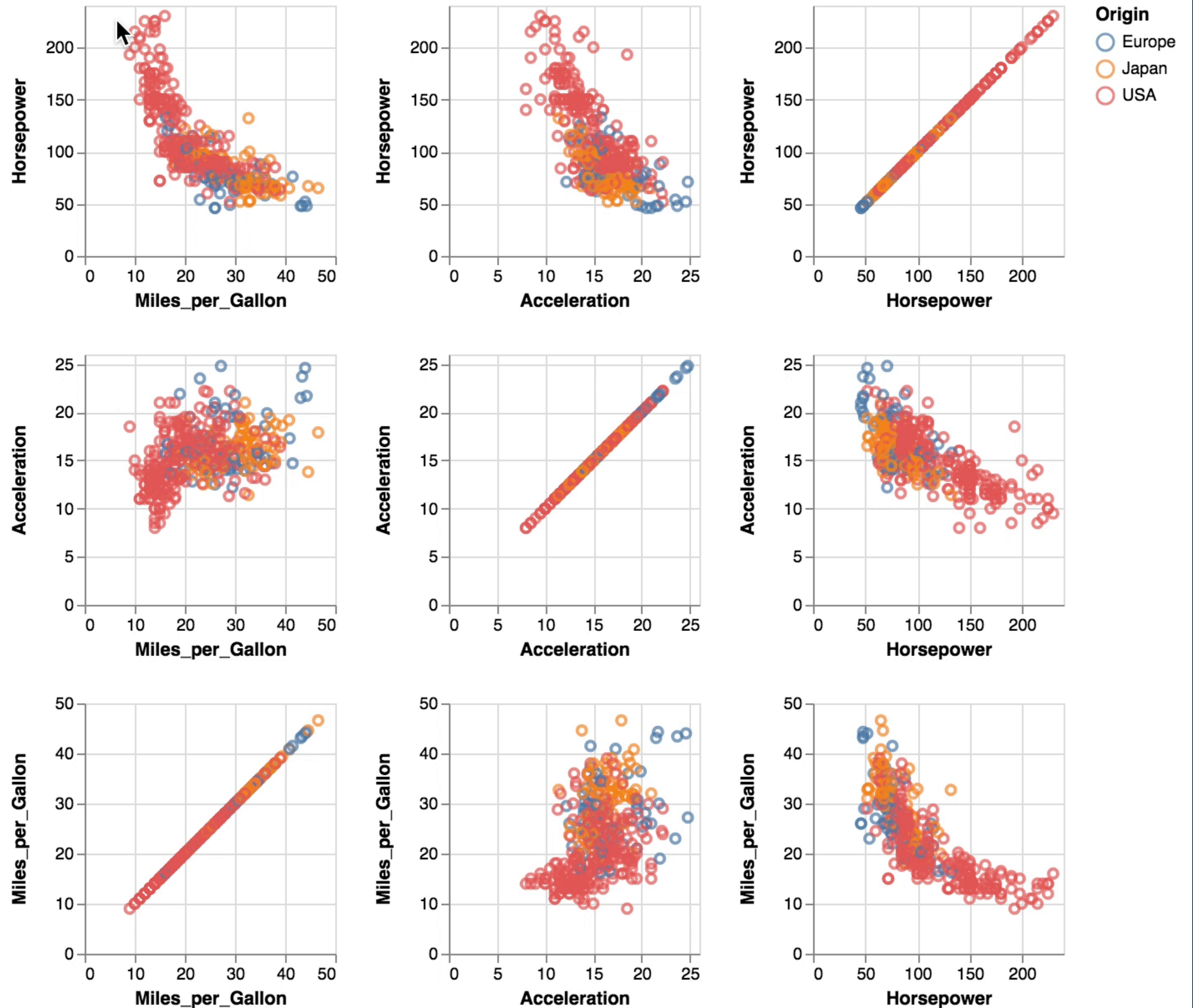
Explore show me something else.

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Connect

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

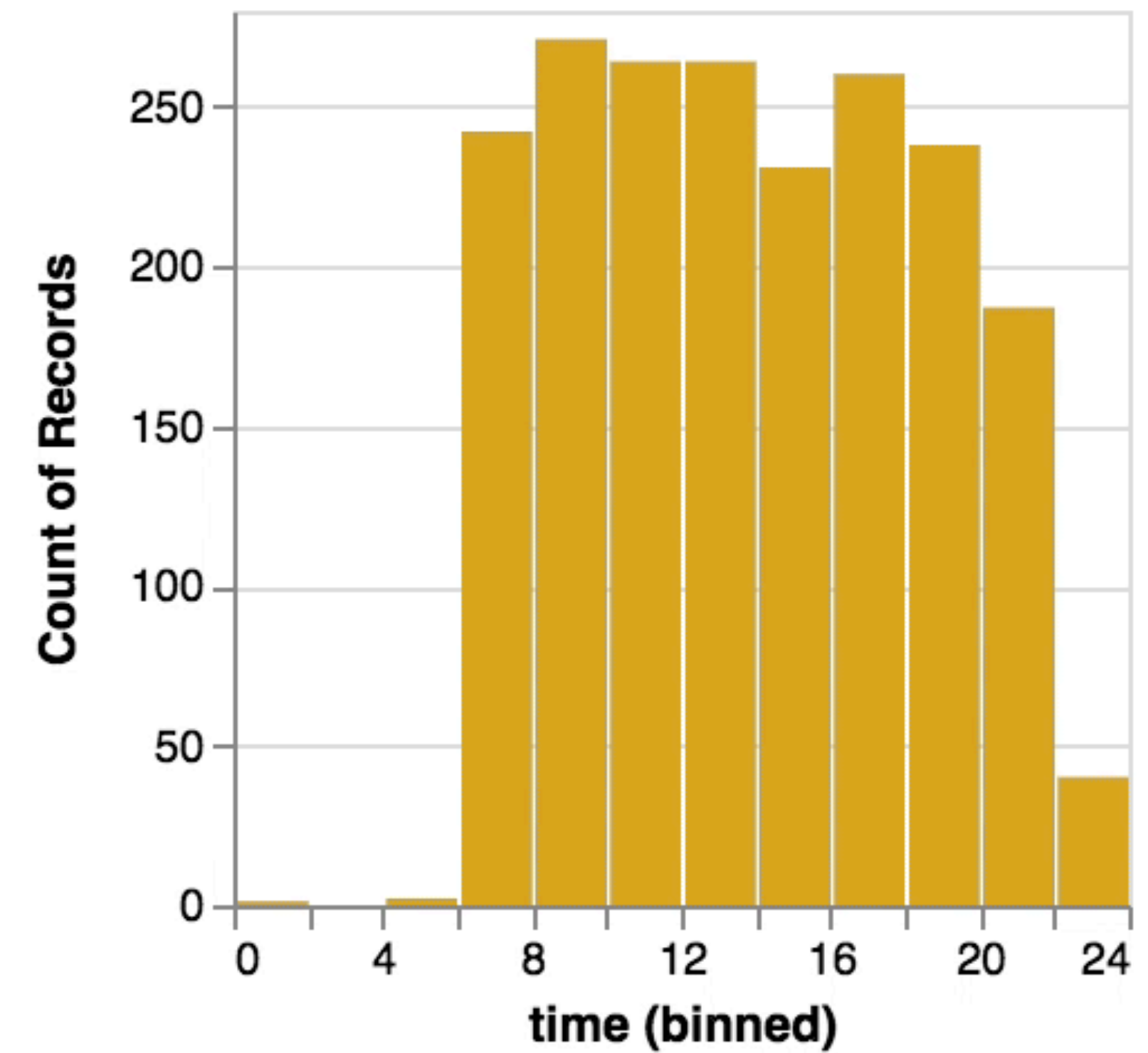
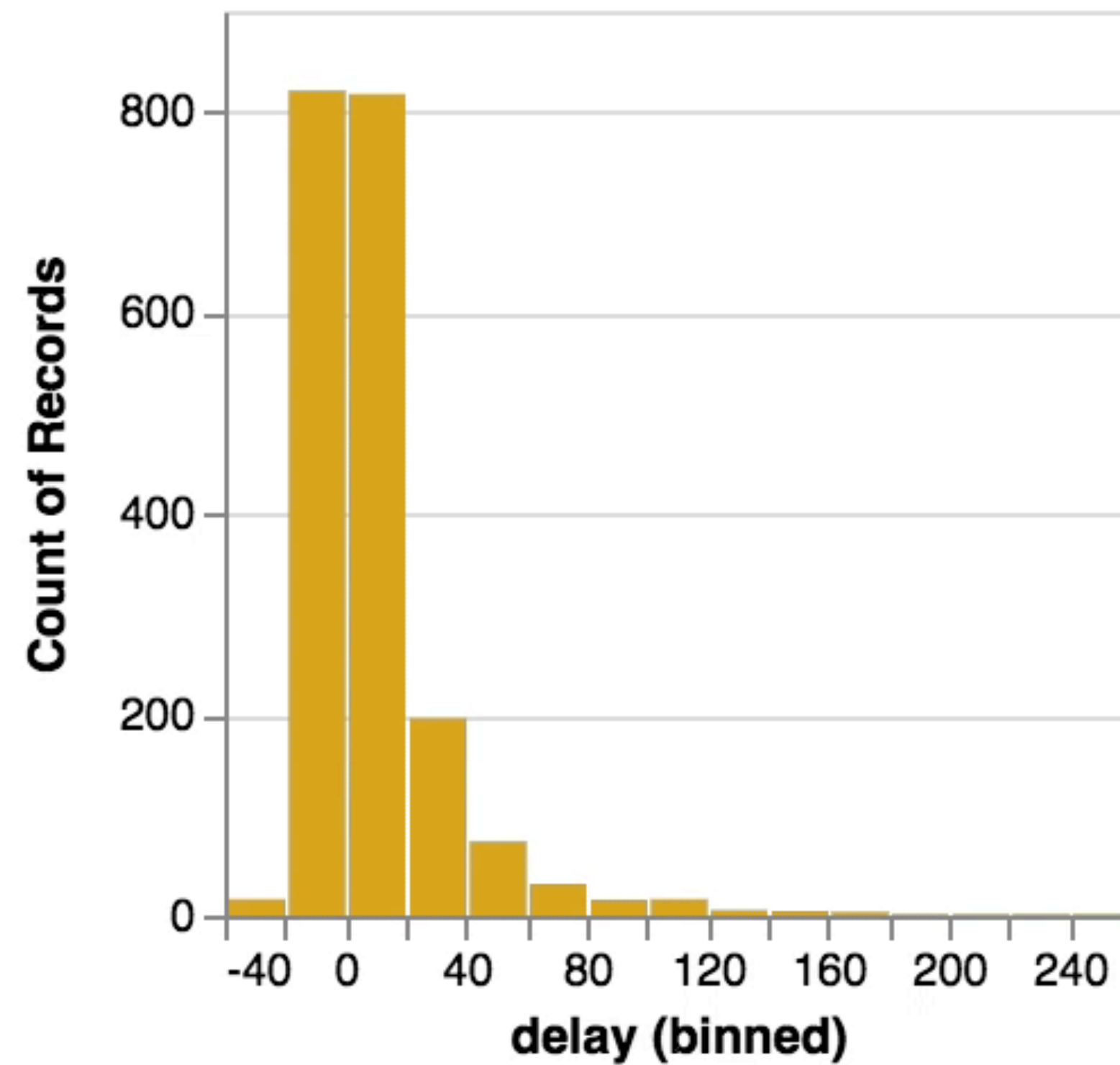
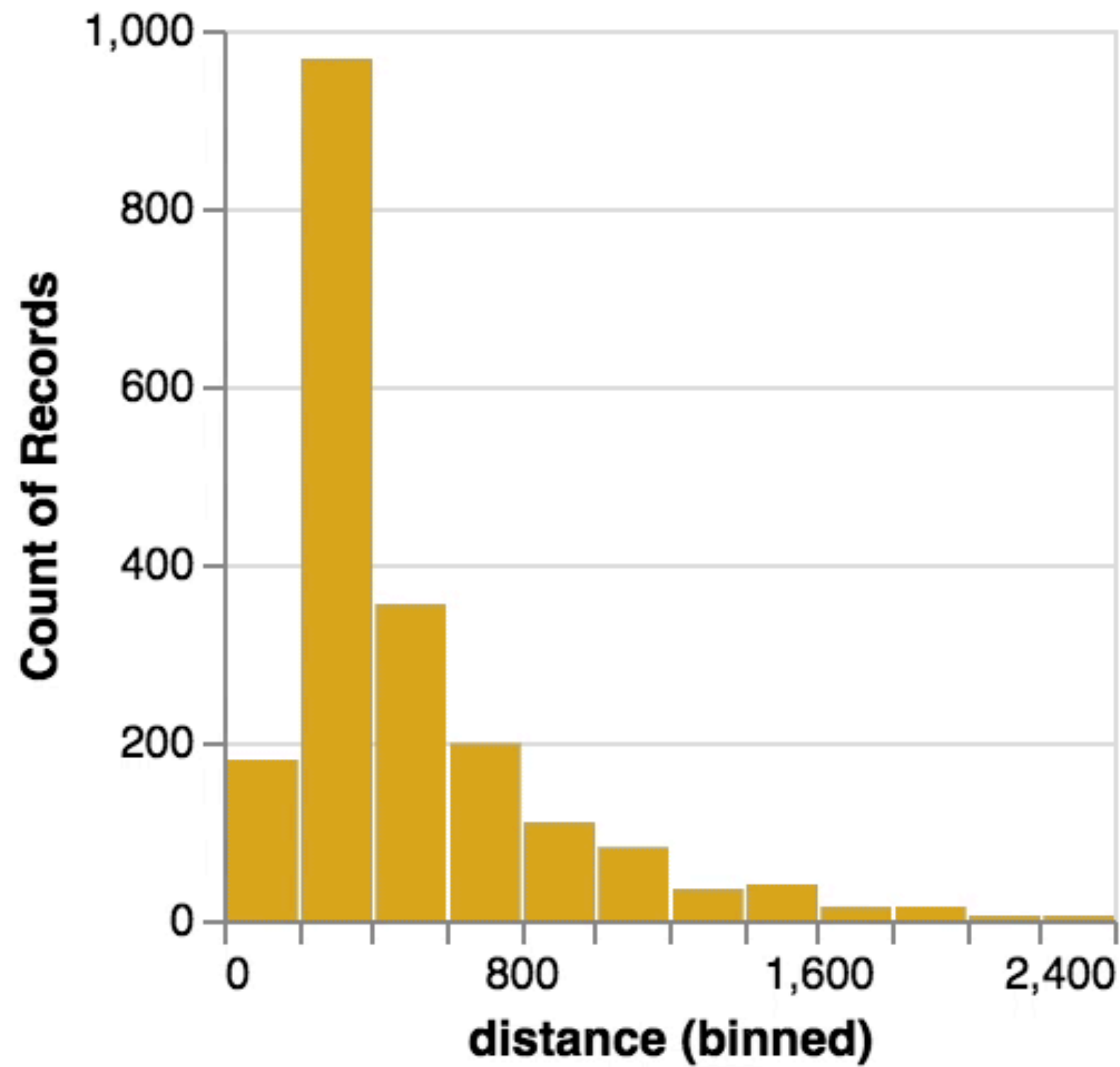
Link by *tuple* (i.e., explicitly identify and match the same data values across every view).



Connect

Link by *query* (i.e., matching range or values of fields).

Type of linking operation is not dependent on selection type (i.e., point and region selections can both be used to link by either tuple or query).





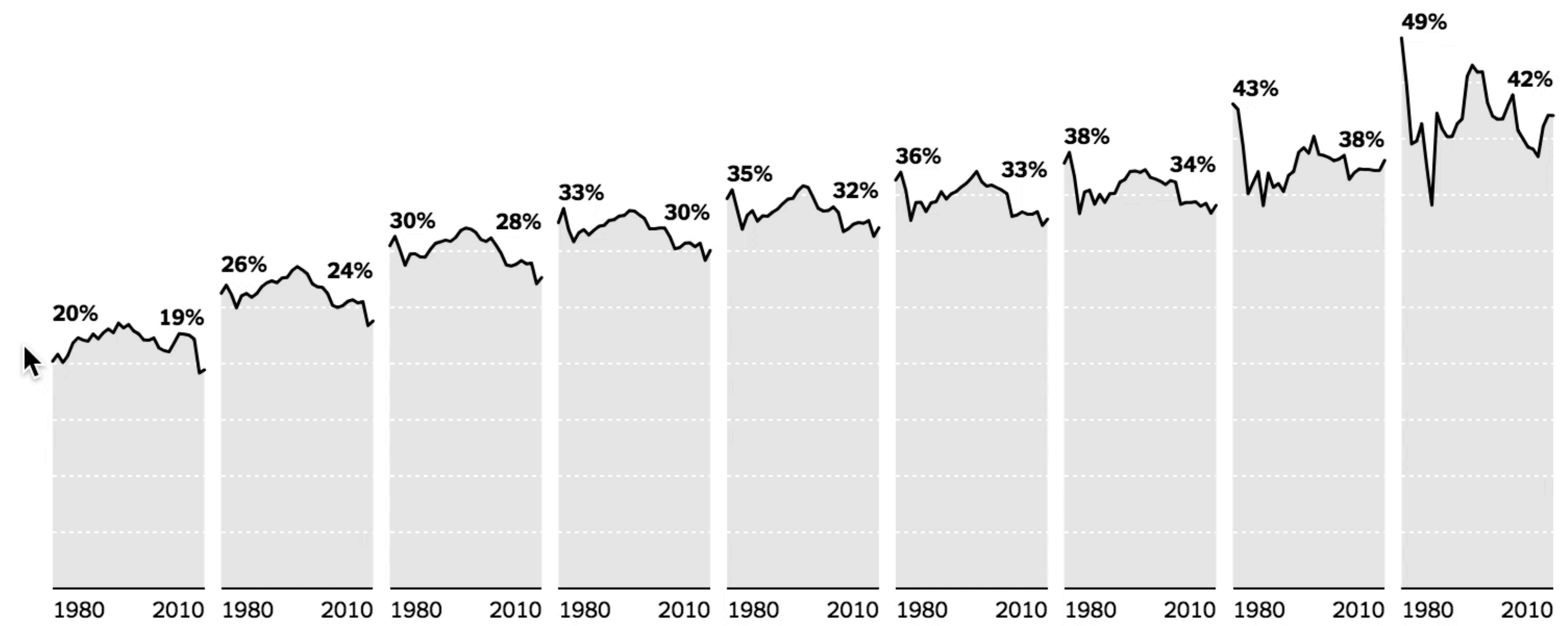
How the Tax Burden Has Changed

Most Americans paid less in taxes in 2010 than people with the same inflation-adjusted incomes paid in 1980, because of cuts in federal income taxes. At lower income levels, however, much of the savings was offset by increases in federal payroll taxes, state sales taxes and local property taxes. About half of households making less than \$25,000 saved nothing at all. [About the Data »](#) | [Related Article »](#)

- \$0-25k
- \$25-50k
- \$50-75k
- \$75-100k
- \$100-125k
- \$125-150k
- \$150-200k
- \$200-350k
- \$350k+

Tax rates have fallen for most Americans, especially high earners.

Share of yearly income paid in federal, state and local taxes, by income bracket.



Mike Bostock, Matthew Ericson and Robert Gebeloff. The New York Times, November 2011.

Interaction in Visualization

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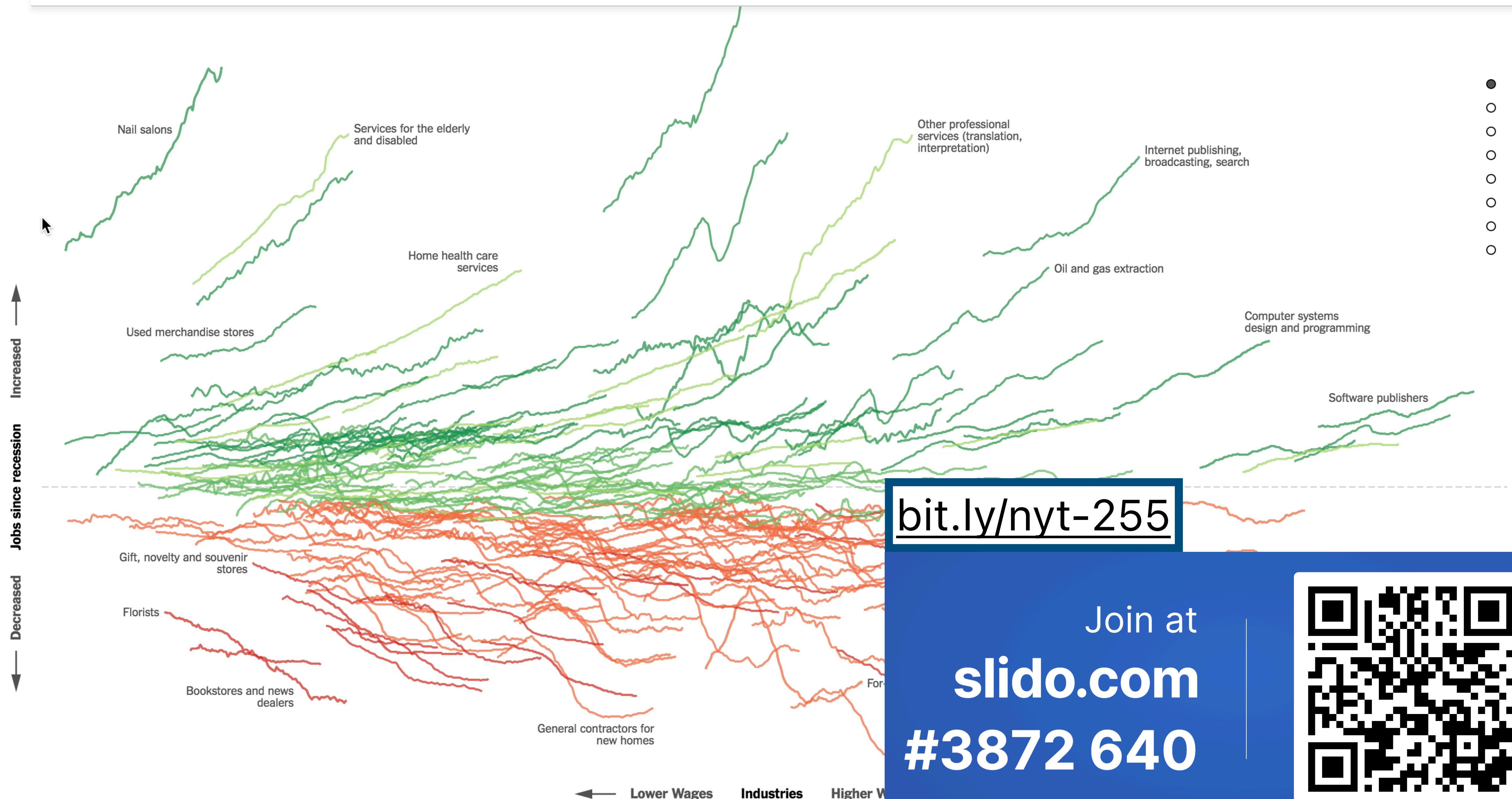
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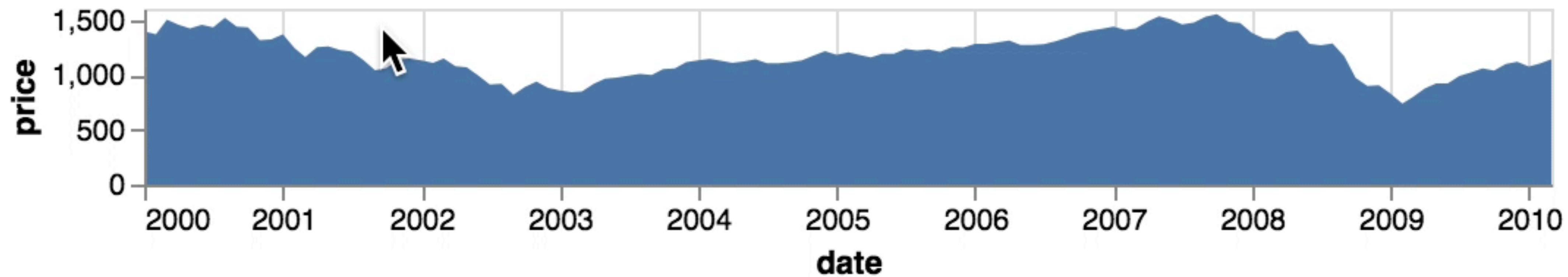
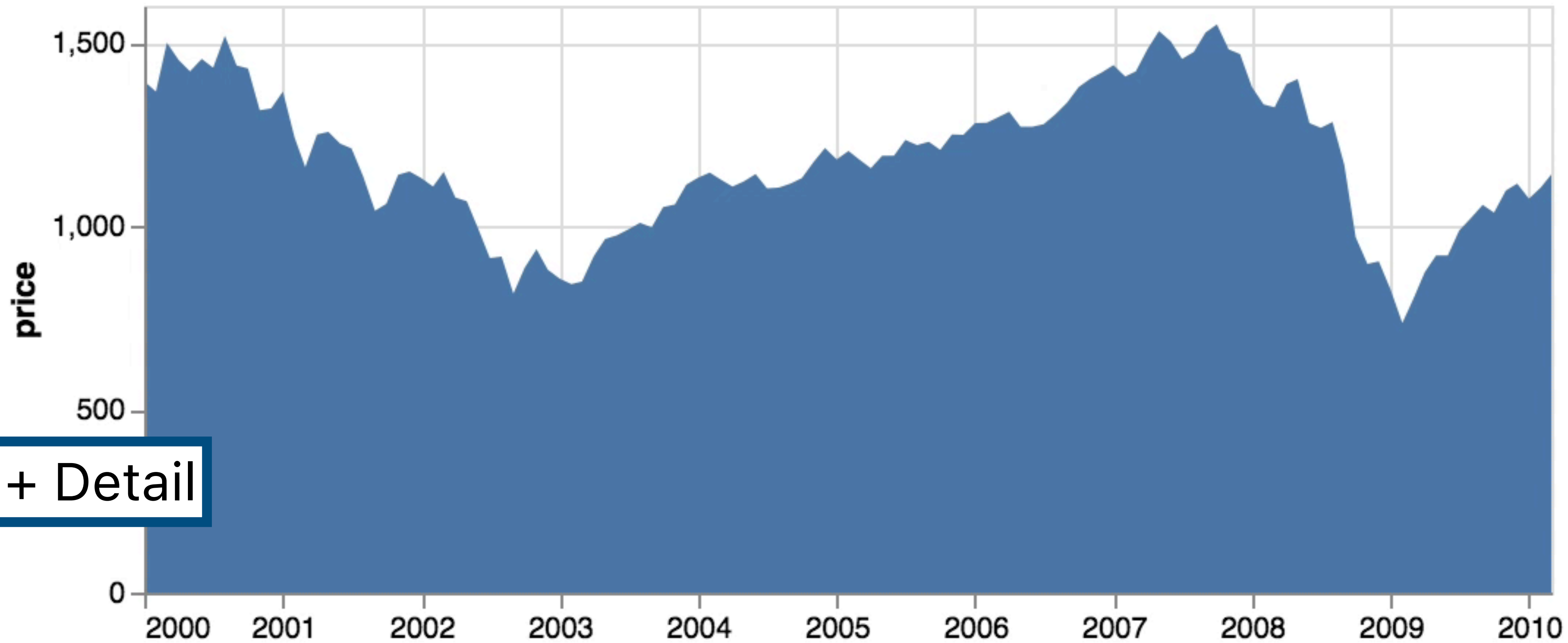


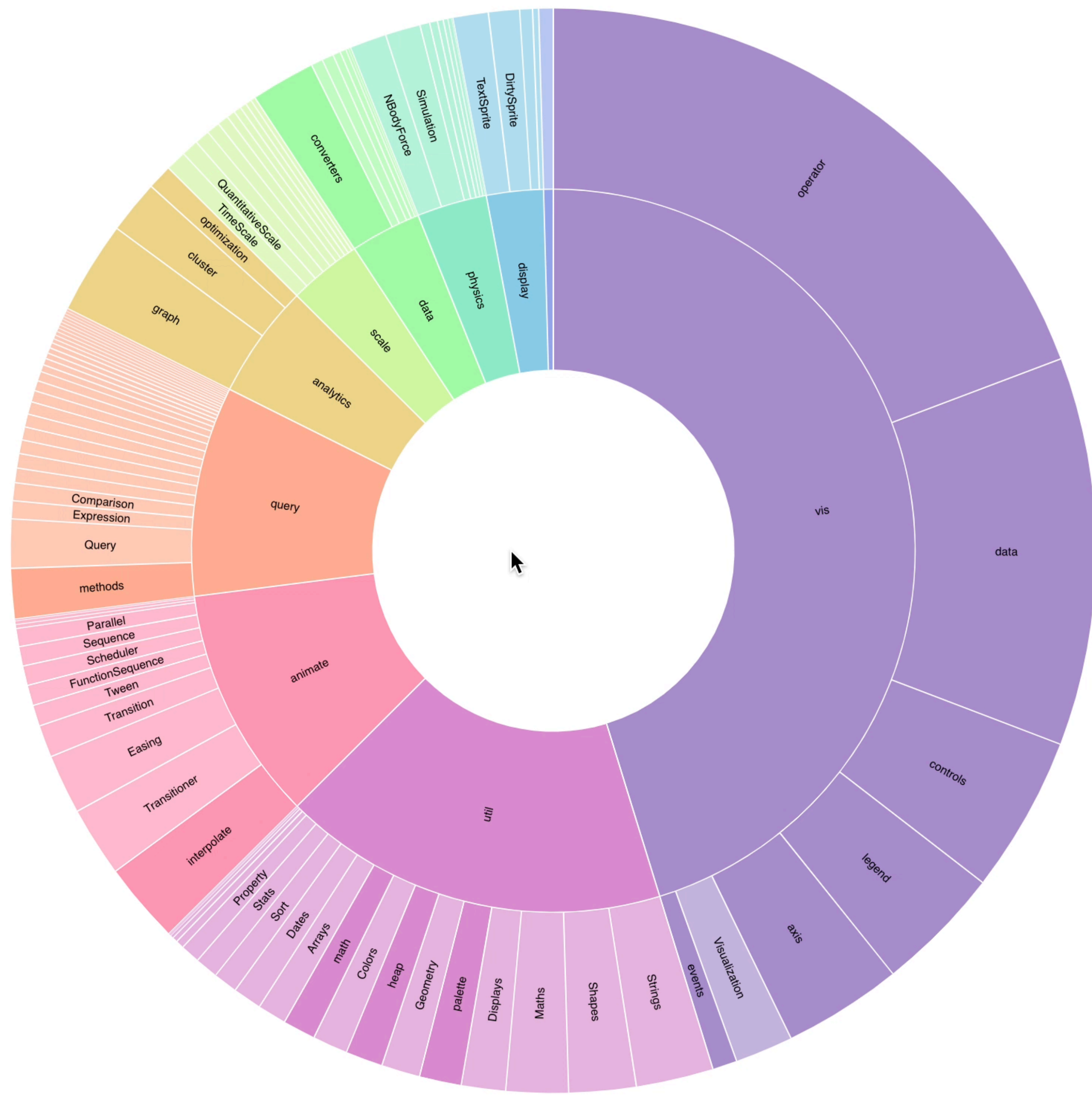
bit.ly/nyt-255

Join at
slido.com
#3872 640



Overview + Detail





Interaction in Visualization

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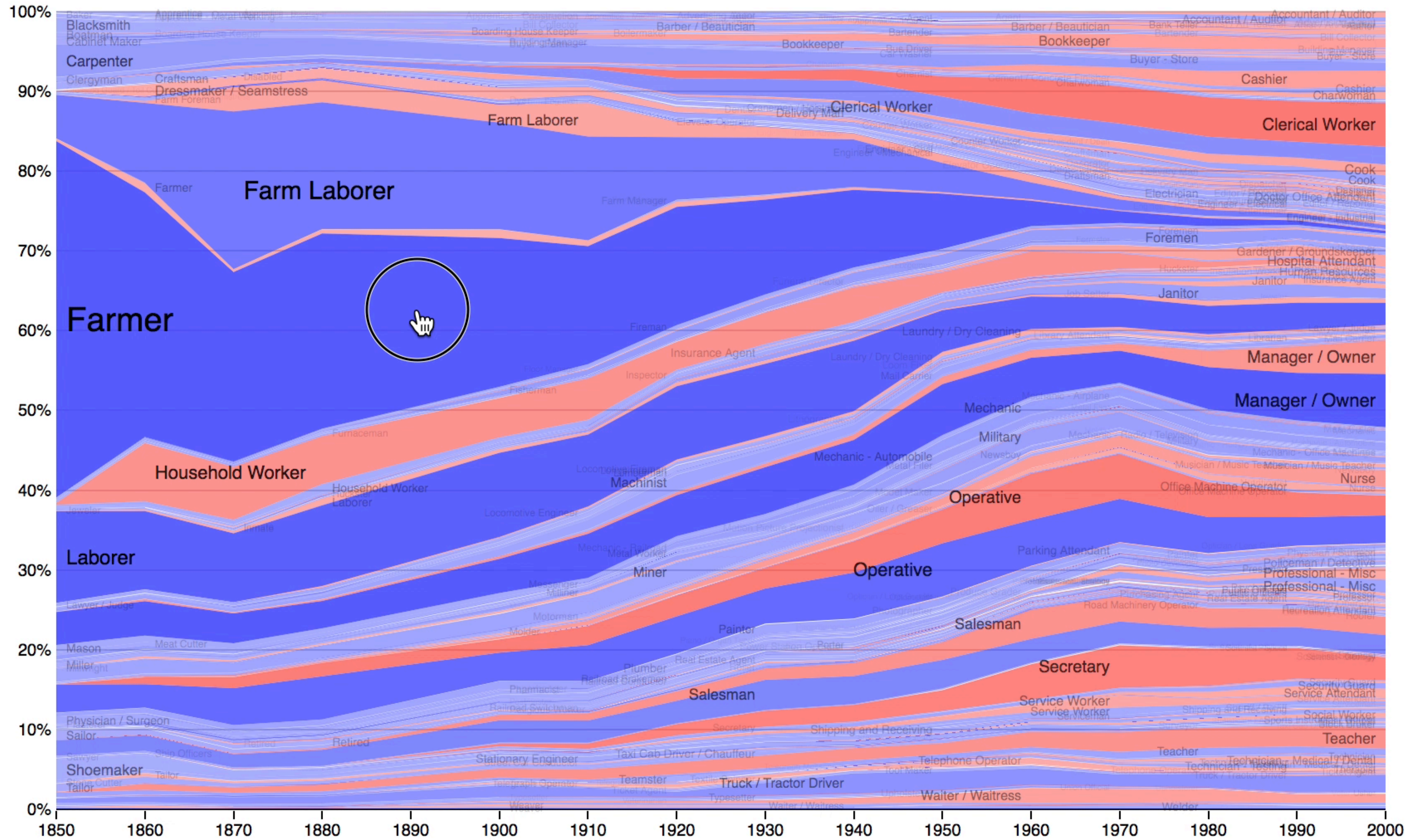
Reconfigure show me a different arrangement.

Explore show me something else.

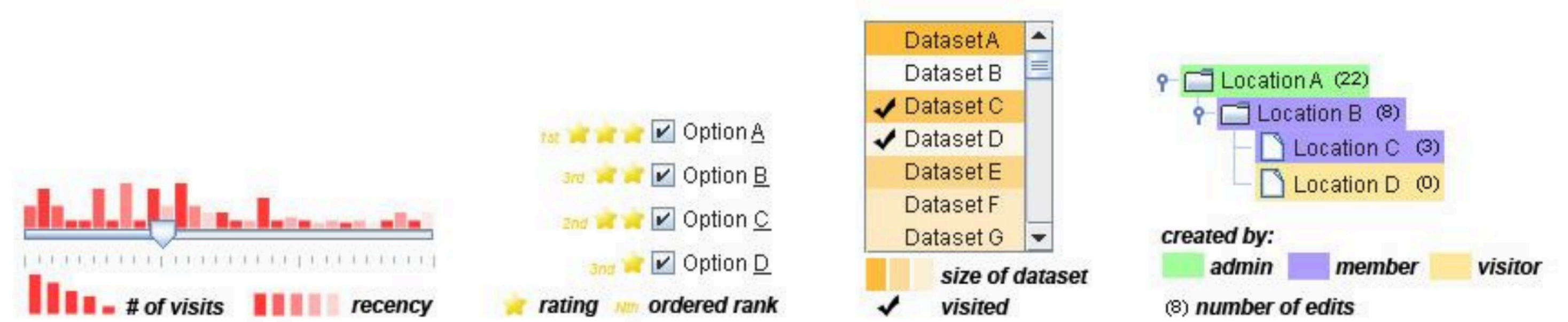
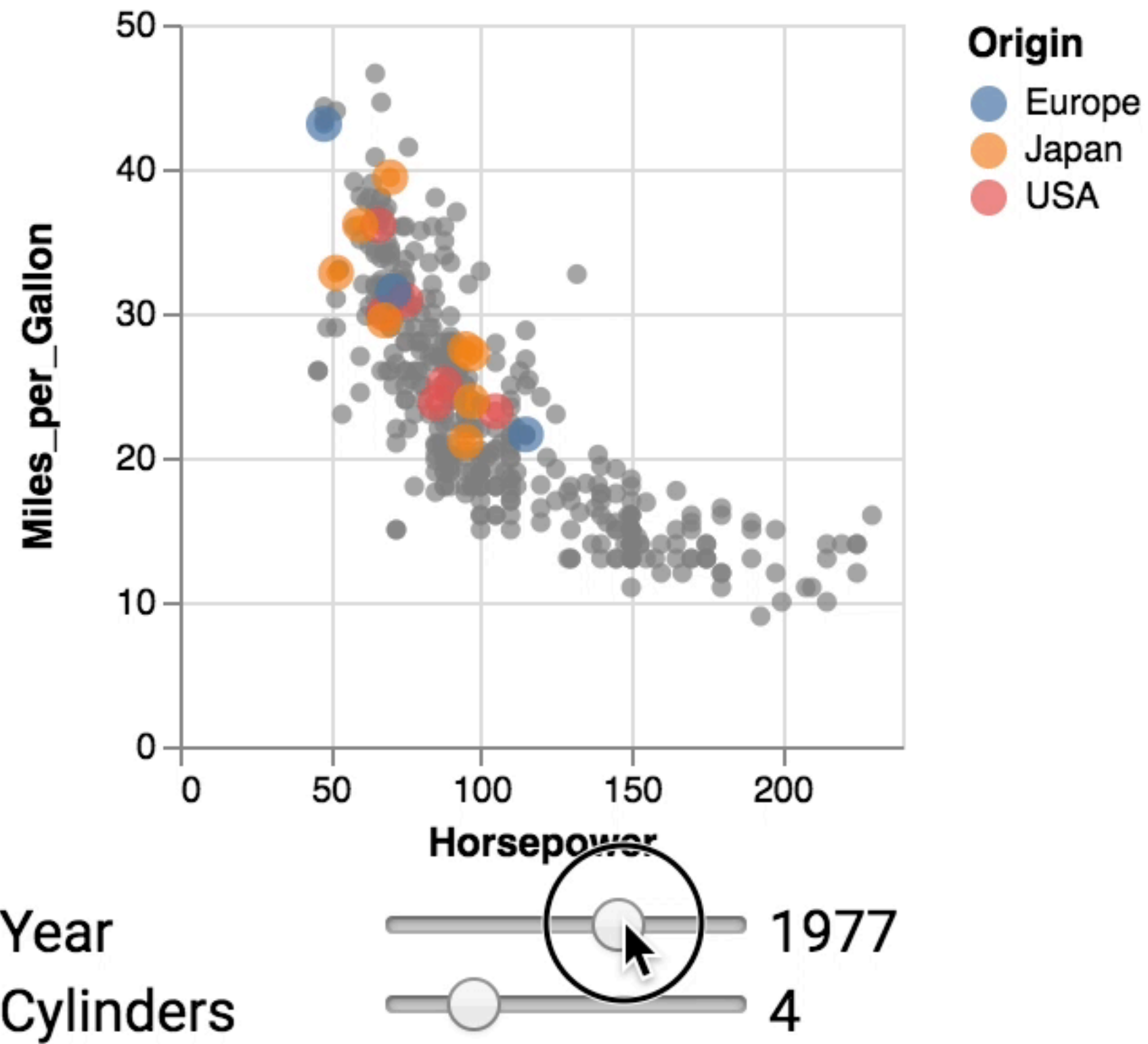
Encode show me a different visual representation.

Job Voyager

Gender: Men Women Any



search: |

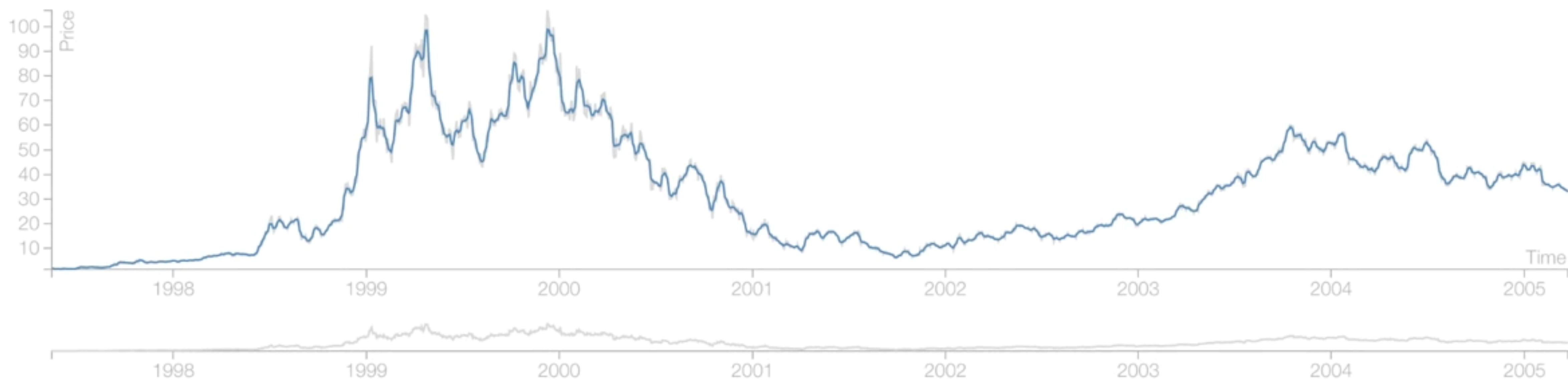


Willet, Heer, and Agrawala. Scented Widgets. *InfoVis*, 2007.

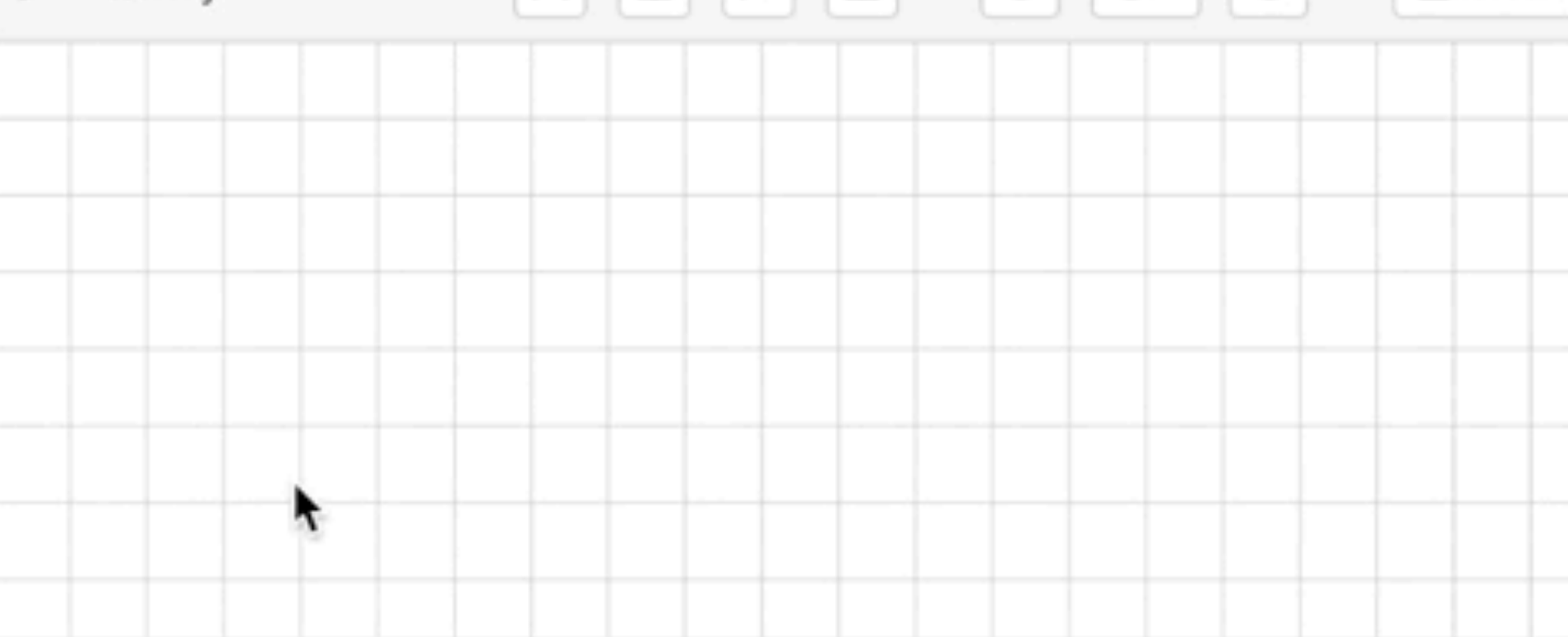
Dataset

Stock Prices: AMZN ▾

Smooth iteration:



Query



Predefined queries ▲

History ▲

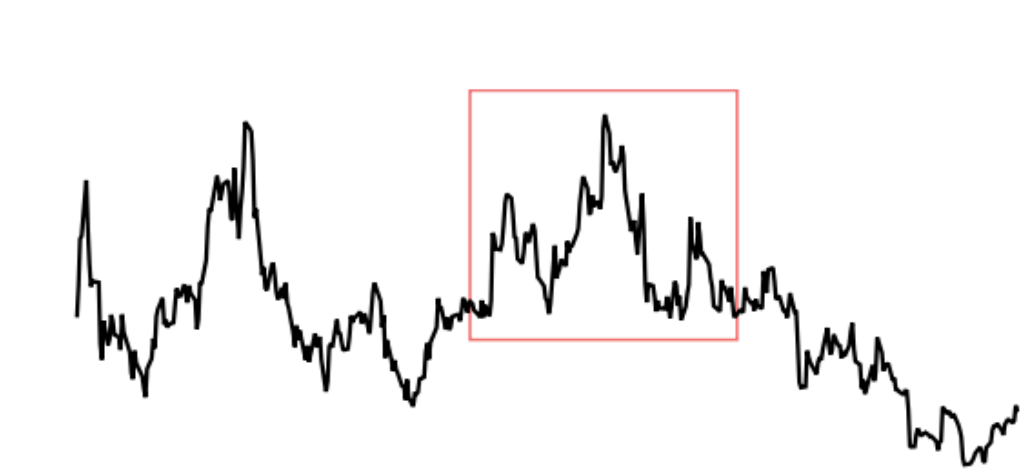
Results

Clear Feedback 🗑

Distance ↓📏 Smooth iteration Time span

Distance	Smooth iteration	Time span
----------	------------------	-----------

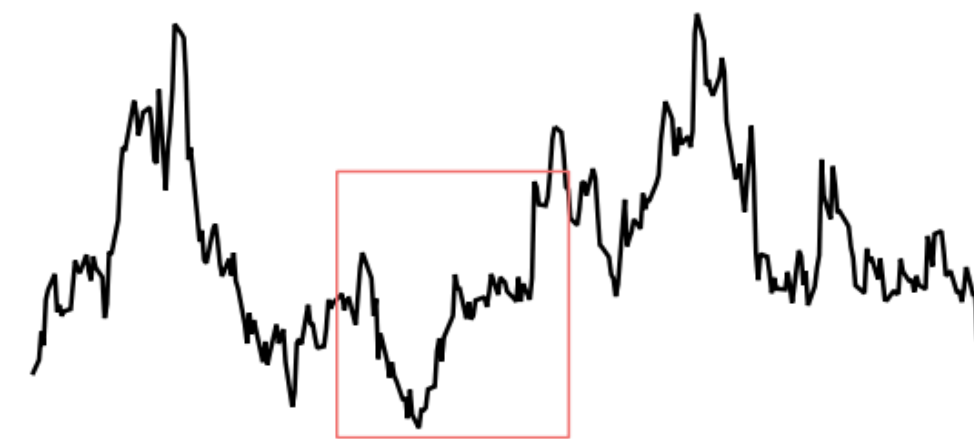
[Mannino and Abouzied. Qetch. CHI, 2018]



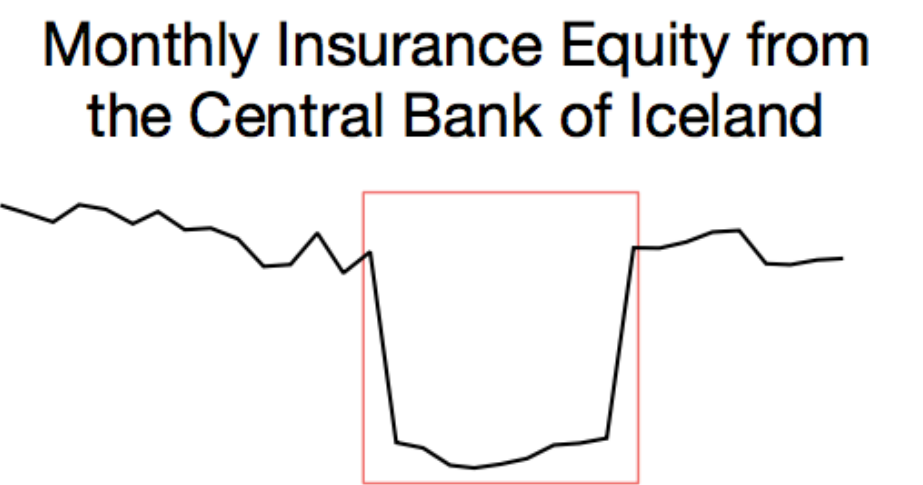
(a) Head-and-shoulders in Amazon stock prices, 150 days 10/99 to 3/00



(b) Inverted head-and-shoulders in Alaska Air Group stock prices, 108 days 08/98 to 12/98

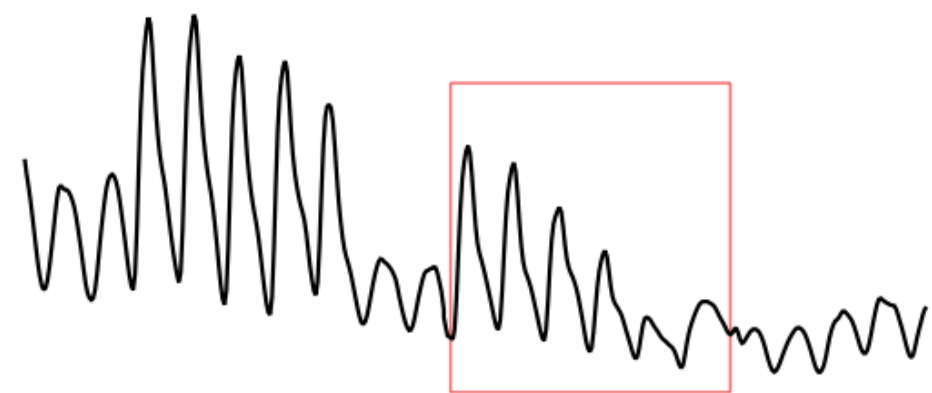


(c) Cup-with-handle in Amazon stock prices, 95 days 7/99 to 11/99

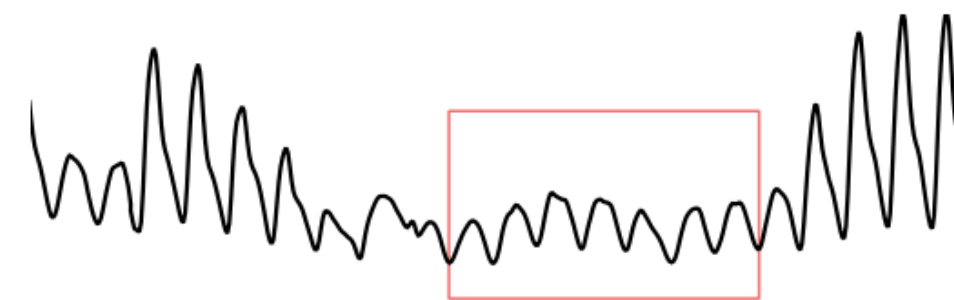


(d) Rounded-bottom, 304 days from 11/08 to 9/09

Hourly bit traffic in the UK academic network backbone 11/19/04 to 01/27/05

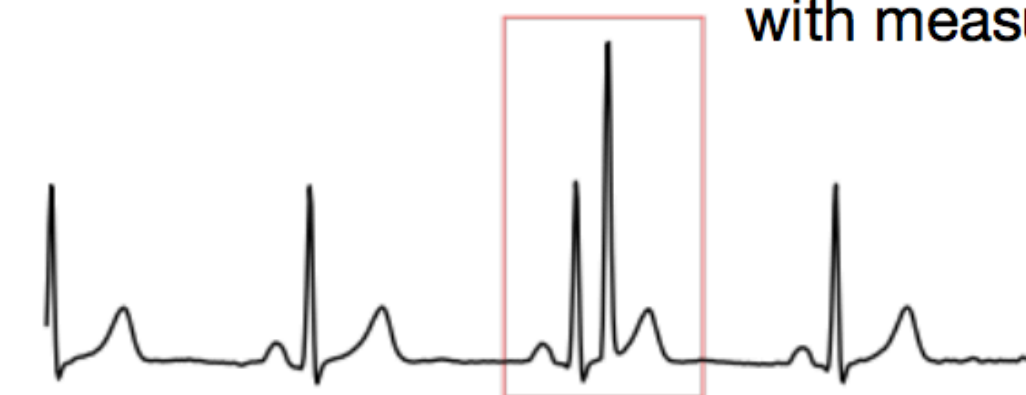


(e) Falling peaks: a six day decrease in traffic before 12/25/04 (Christmas)



(f) Seven peaks: Low traffic from 12/26/04 to 1/3/05 (Christmas to New Year's Eve)

Electrocardiograms (ECGs) from MIT-BH ST Changes, 10s data sets with measurements every 3-5ms

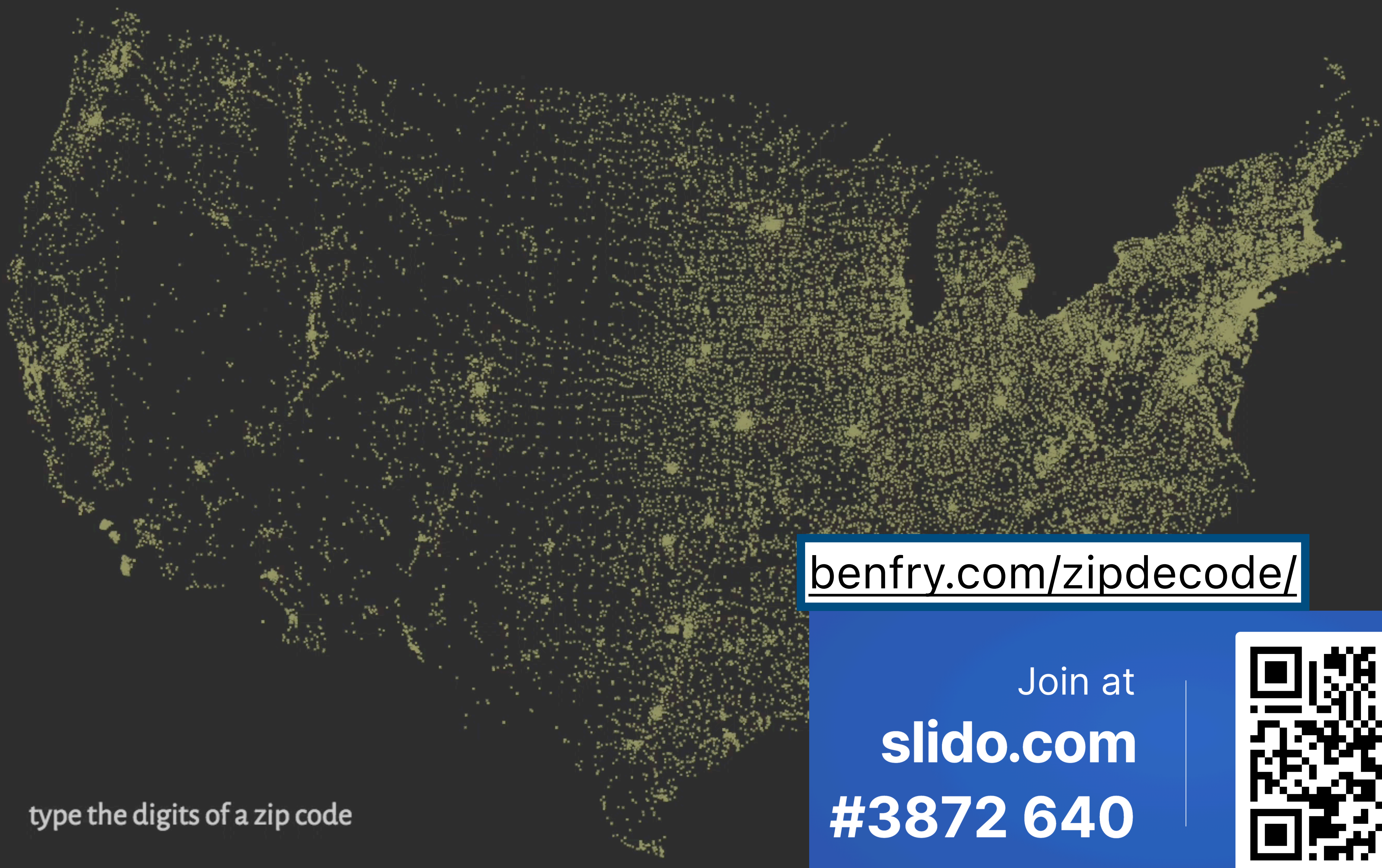


(g) Sharp rise: An ECG anomaly lasting 650ms in record 302



(h) Sharp dip: An ECG anomaly lasting 525ms in record 301

[Mannino and Abouzied. Qetch. CHI, 2018]



type the digits of a zip code

benfry.com/zipdecode/

Join at
slido.com
#3872 640



Interaction in Visualization

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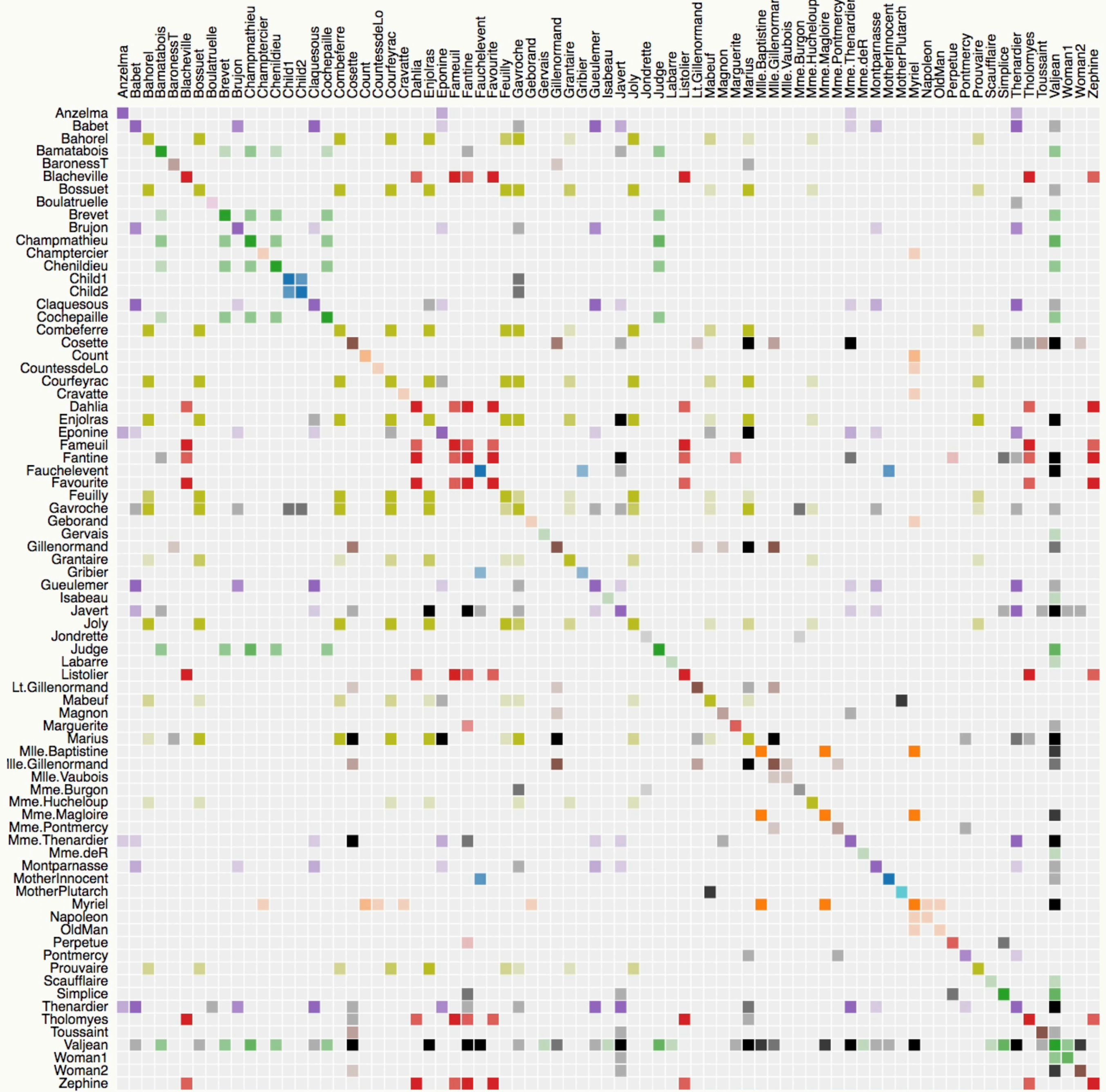
Reconfigure show me a different arrangement.

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Reconfigure

[Mike Bostock. April 2012.]



Order:

This matrix diagram visualizes character co-occurrences in Victor Hugo's *Les Misérables*.

Each colored cell represents two characters that appeared in the same chapter; darker cells indicate characters that co-occurred more frequently.

Use the drop-down menu to reorder the matrix and explore the data.

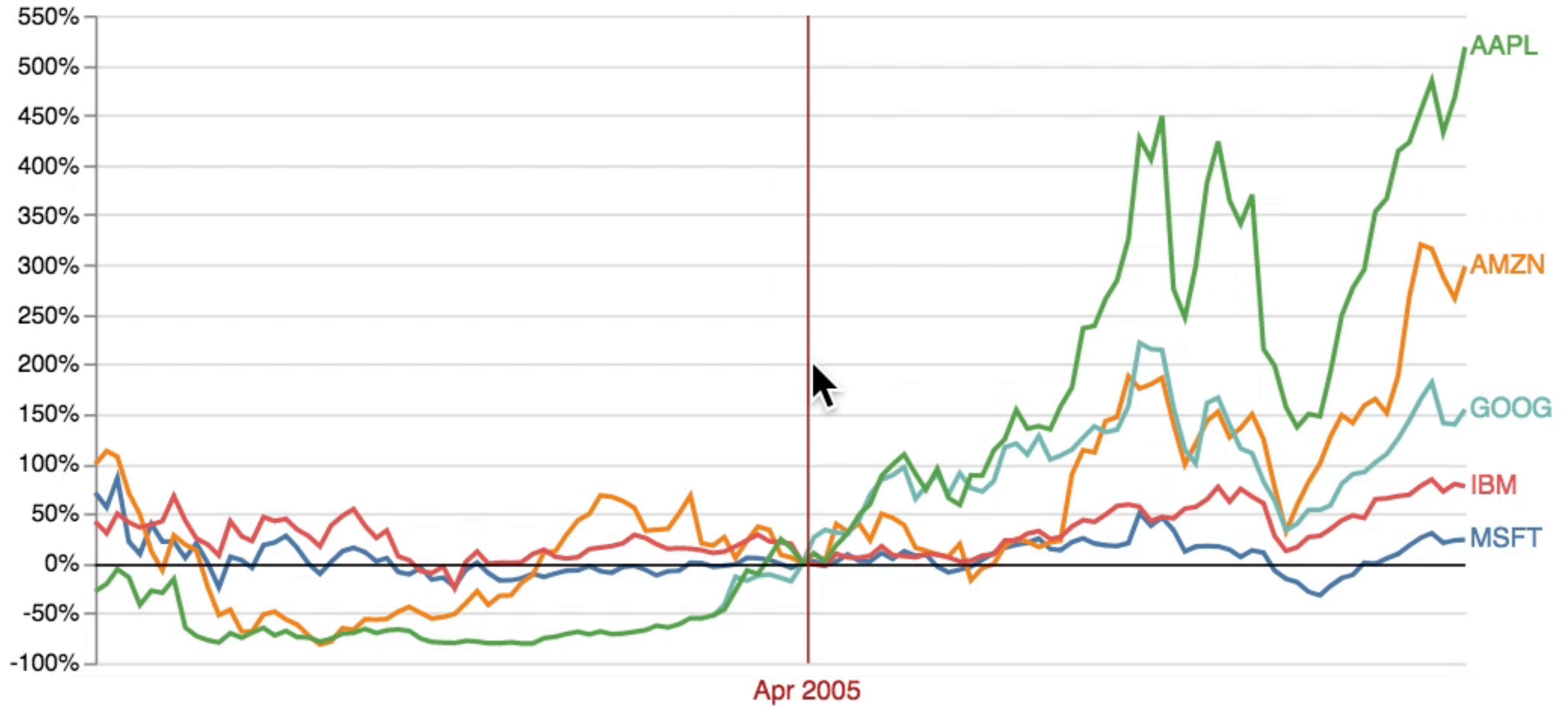
Built with [d3.js](#).

Source: [The Stanford GraphBase](#).

Reconfigure



Reconfigure



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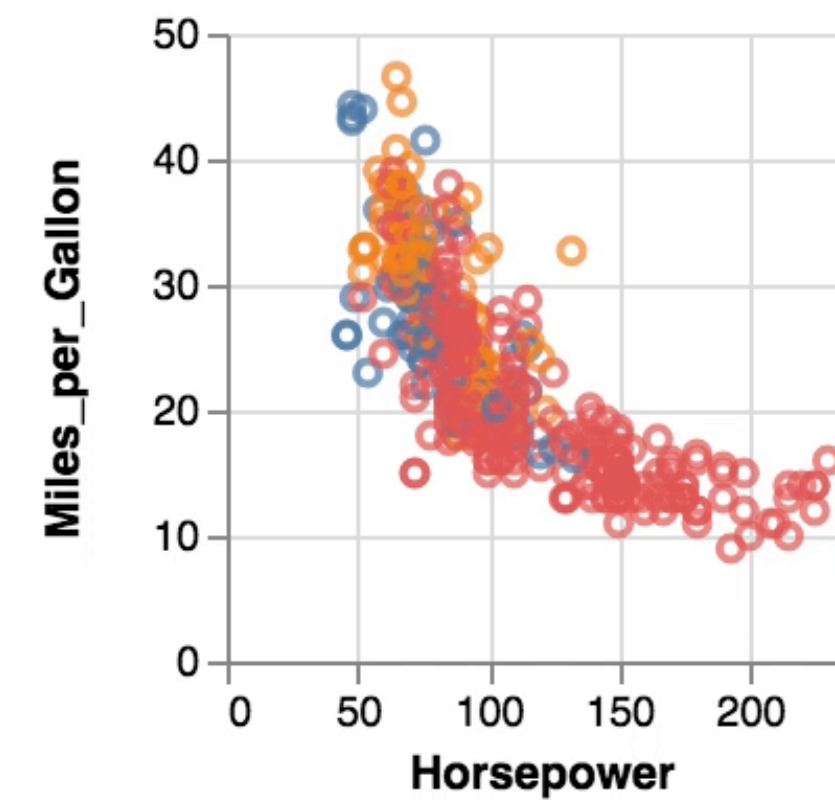
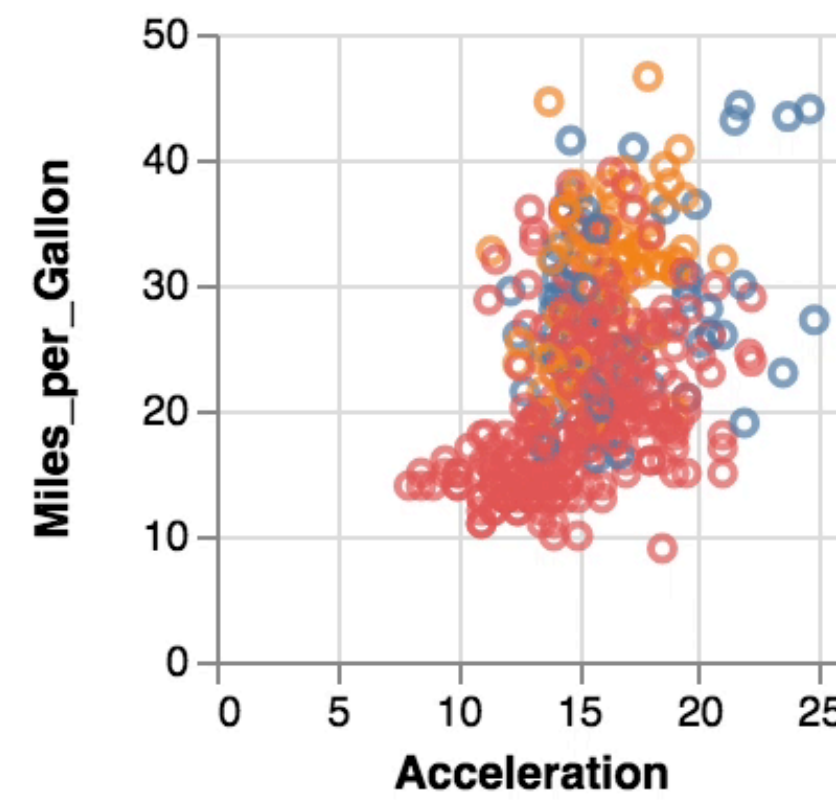
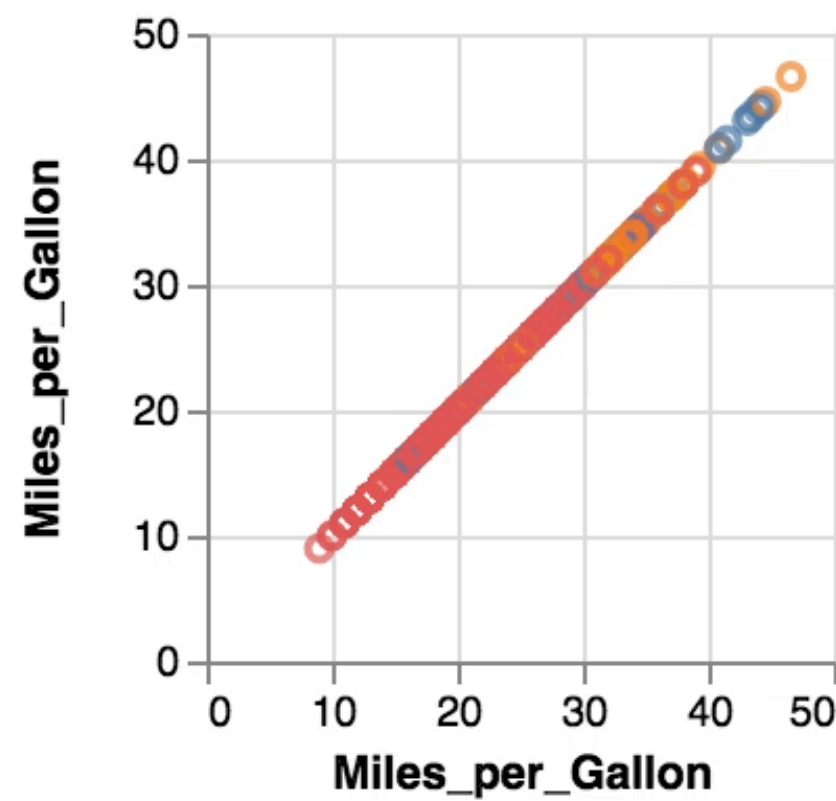
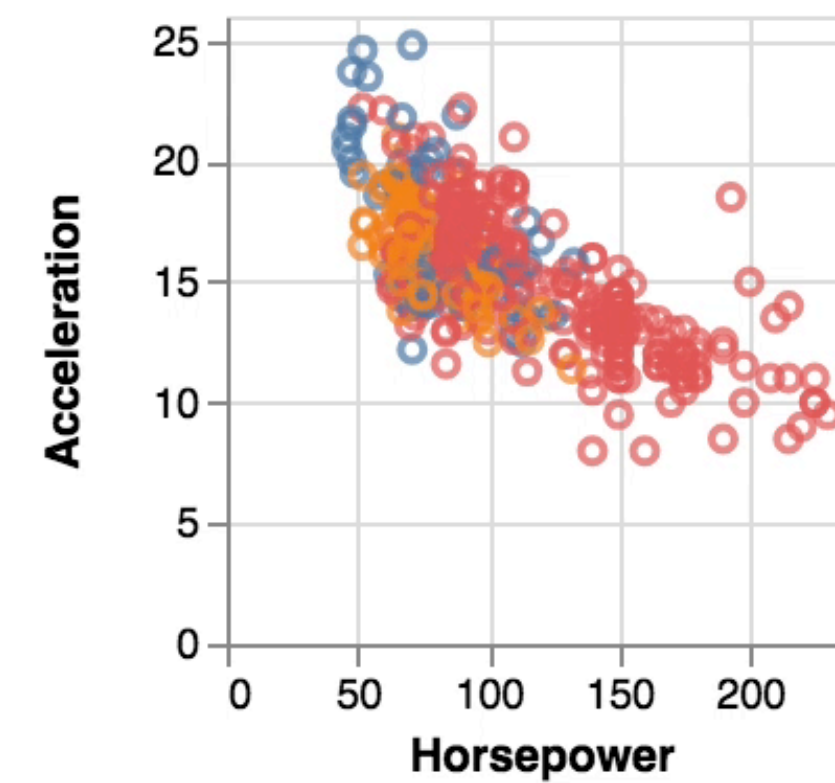
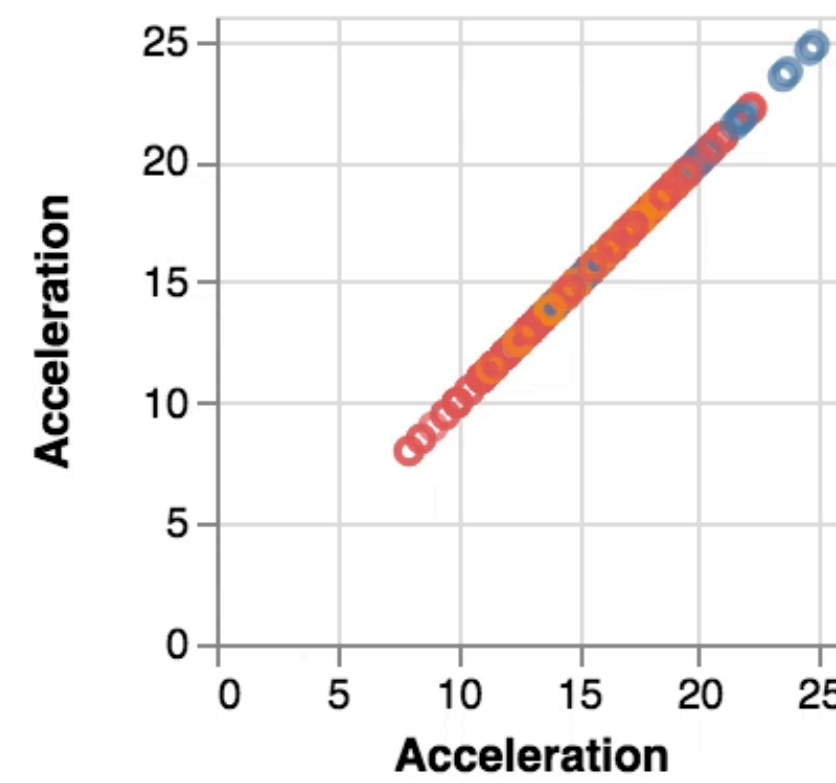
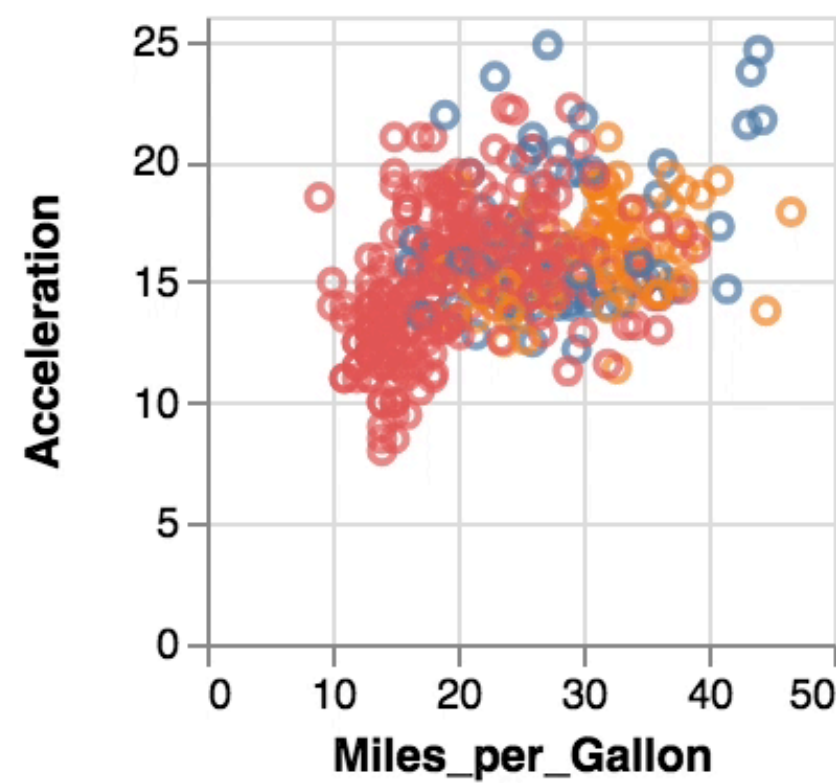
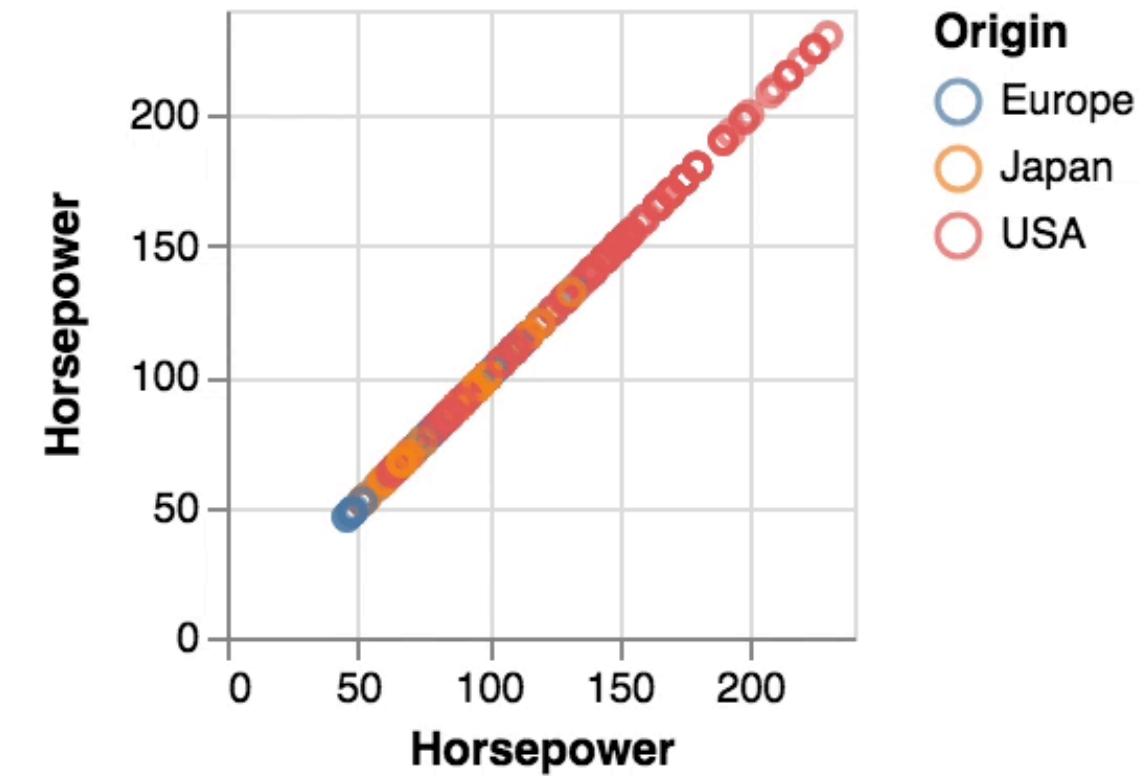
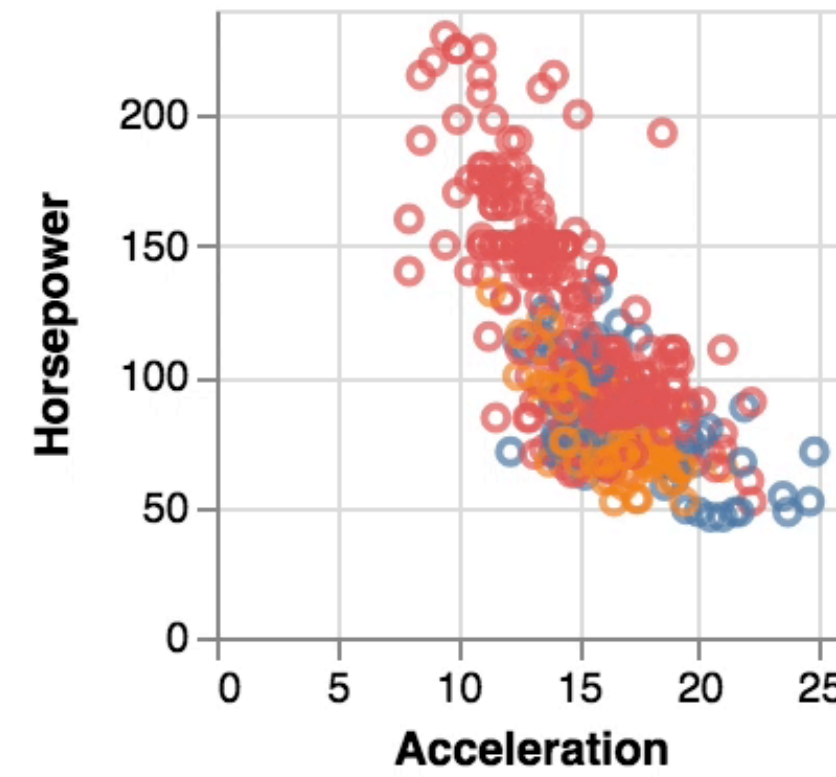
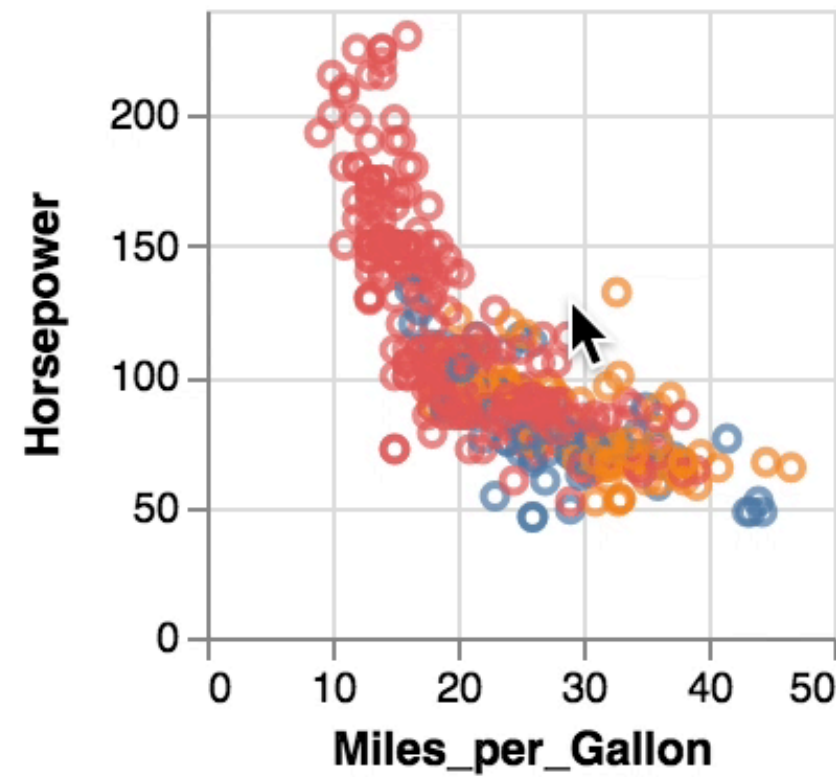
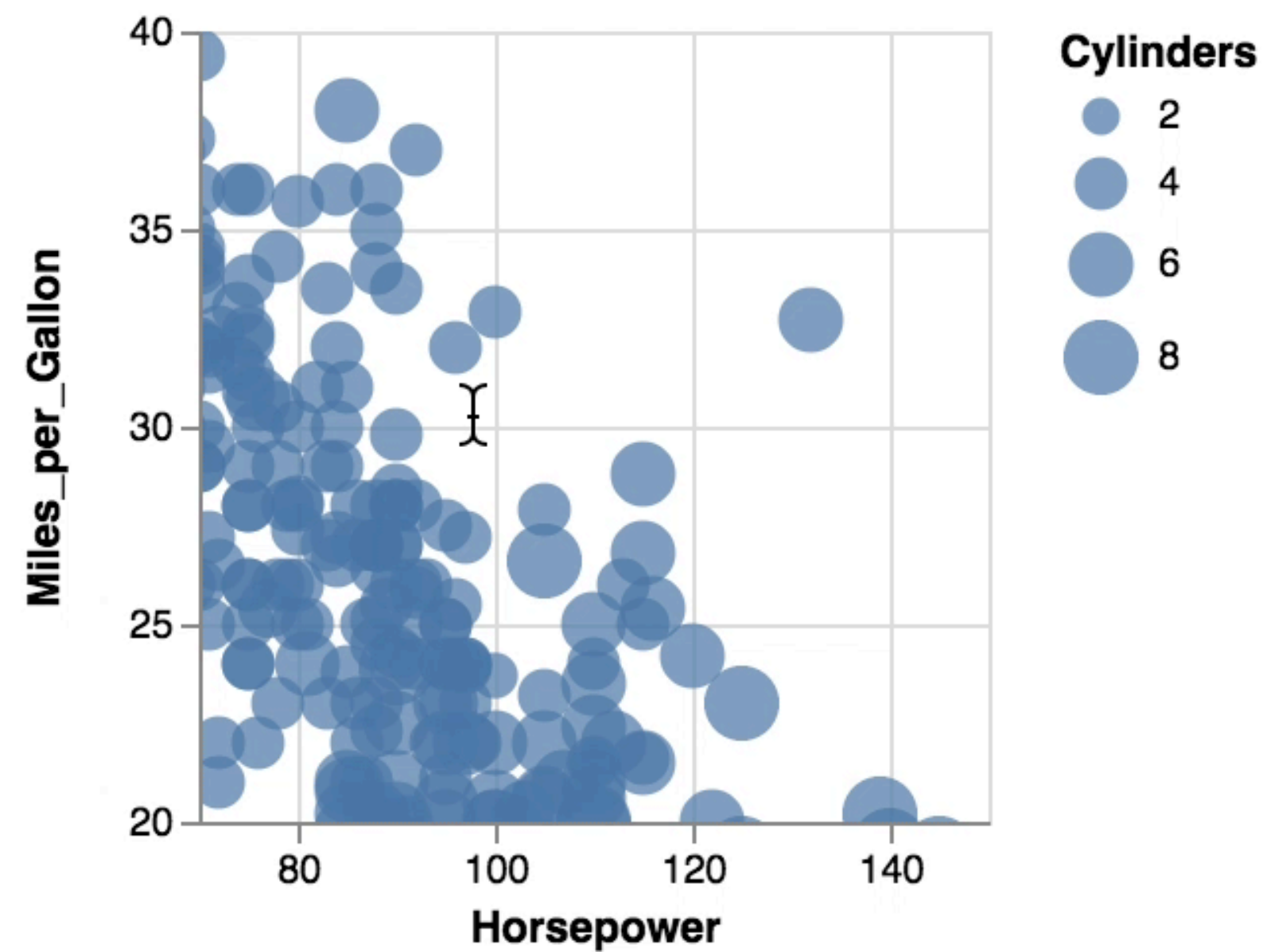
Filter show me more or less detail.

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Encode show me a different visual representation.

Explore



Explore

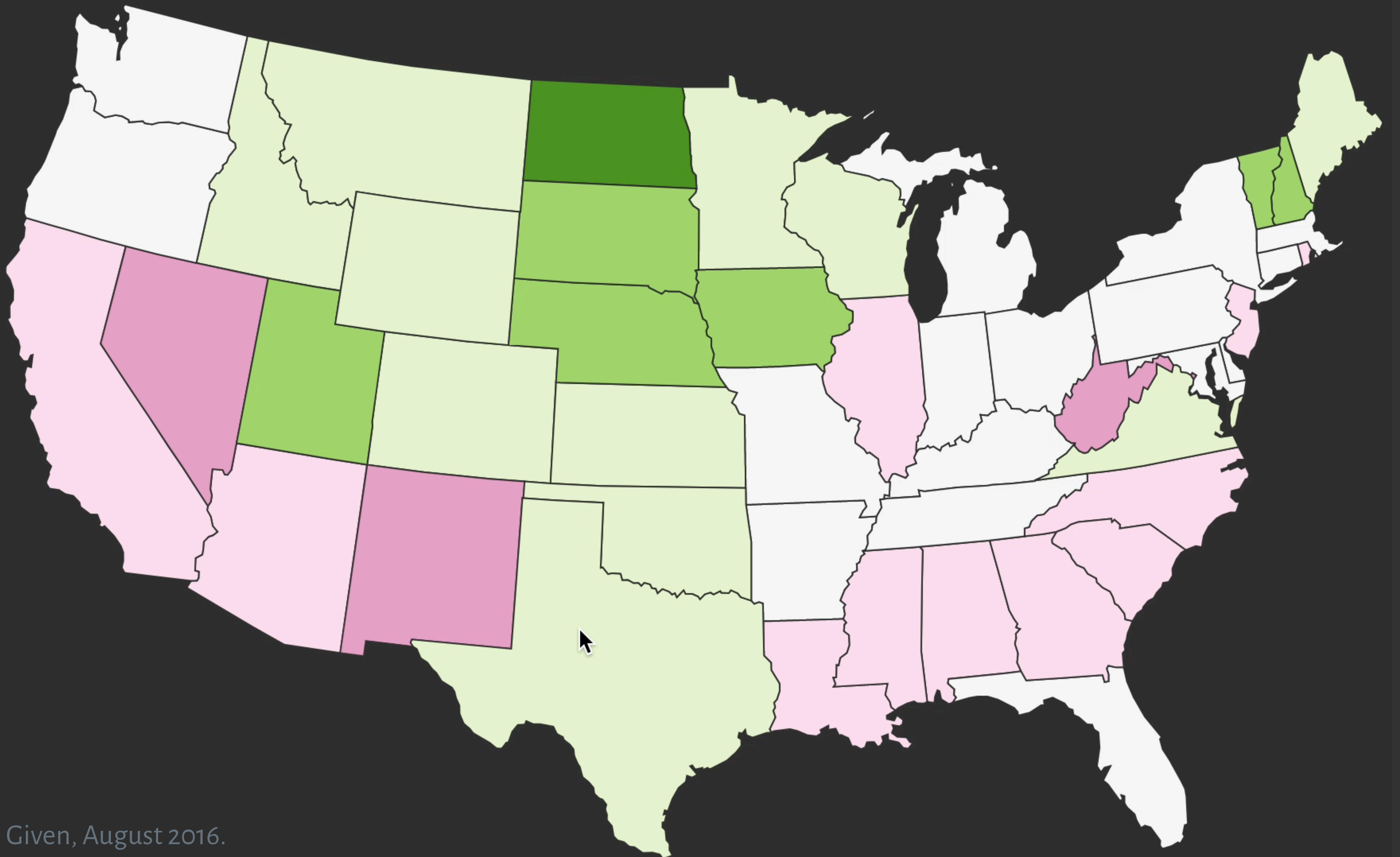
Geometric zoom: transforms the *physical view* (i.e., objects get larger as they get "closer").



Explore

Semantic zoom: transforms the *data space*
(i.e., objects stay the same size, but get further apart).





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No time, but see interactive systems like Tableau / Voyager

Encode show me a different visual representation.

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Explore show me some

Encode show me a dif

**Use interaction to help
audience see something new,
not just for visual eye candy!**