

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.

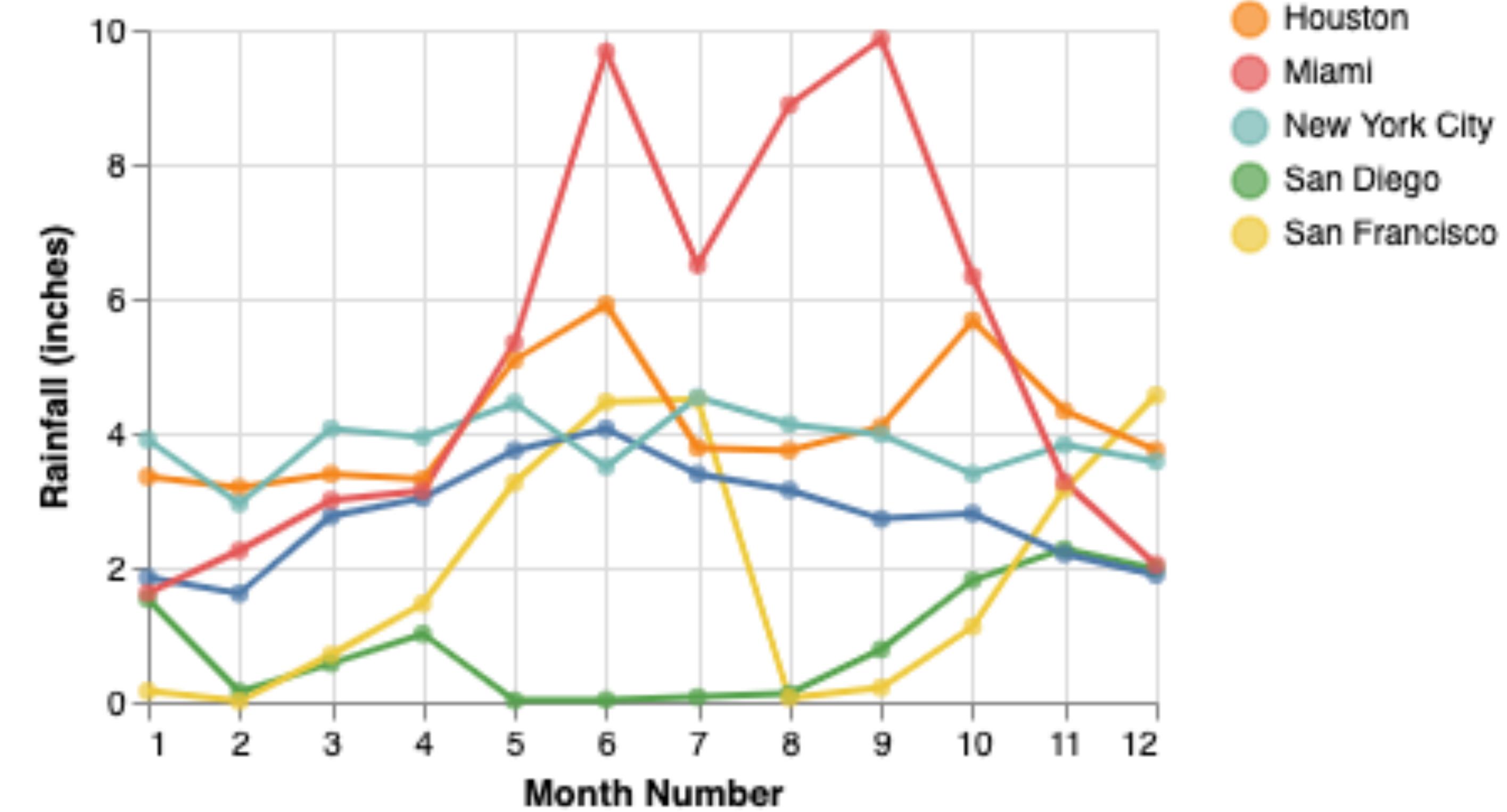
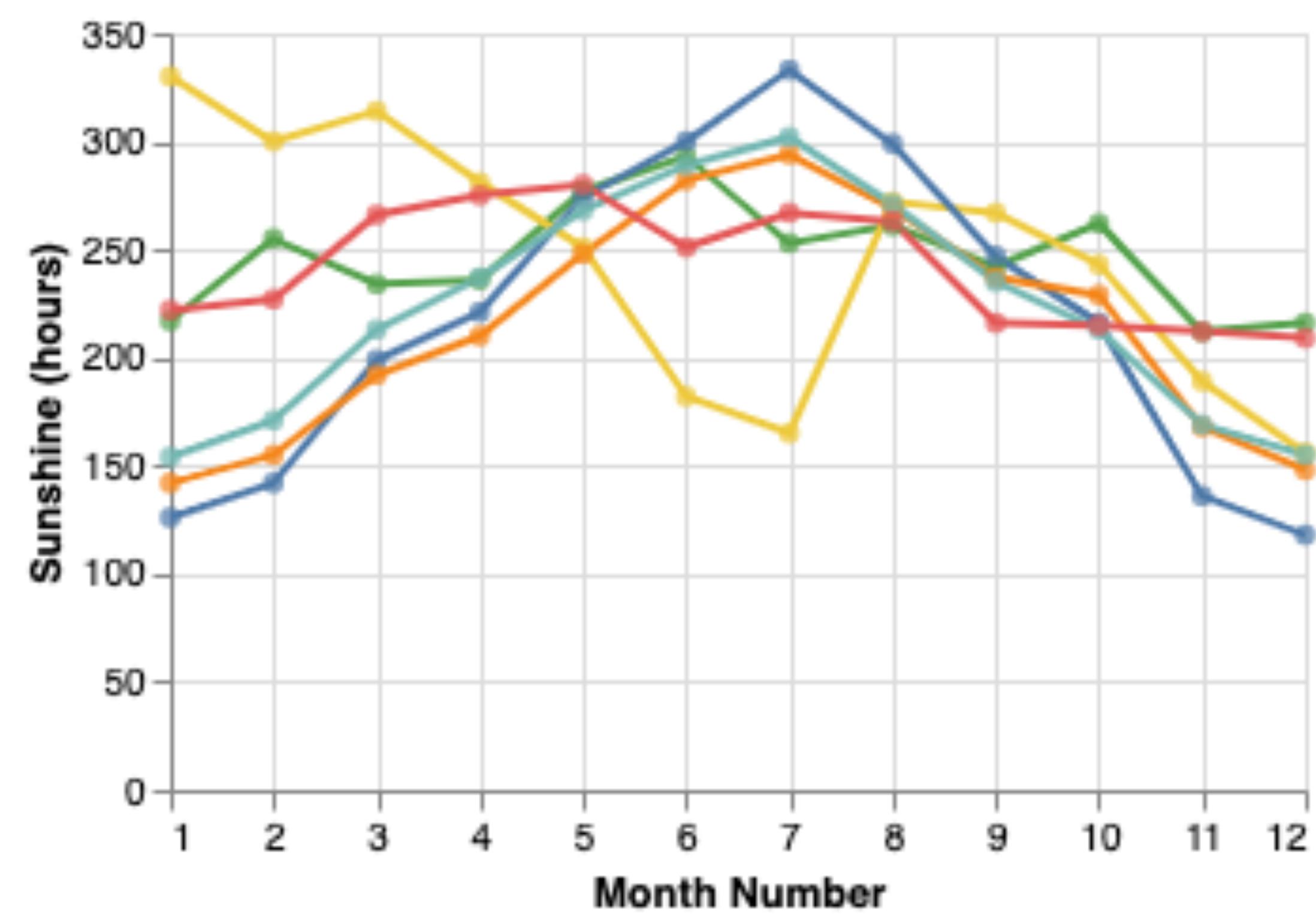
Project 2 out, due on Friday 2/2.

FAQs:

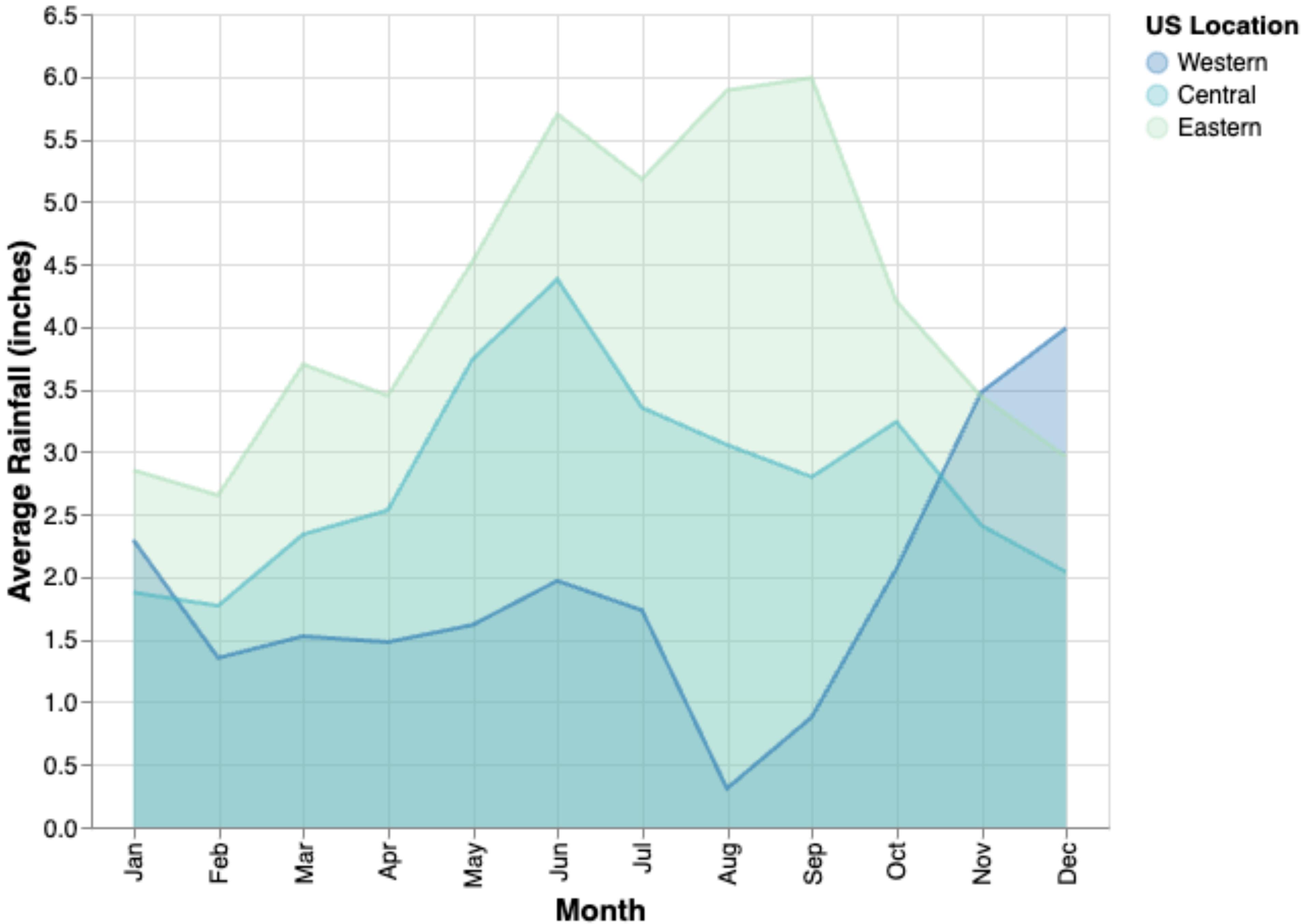
1. When will Project 1 be graded? Aiming for Friday.

Neat A1 submissions!

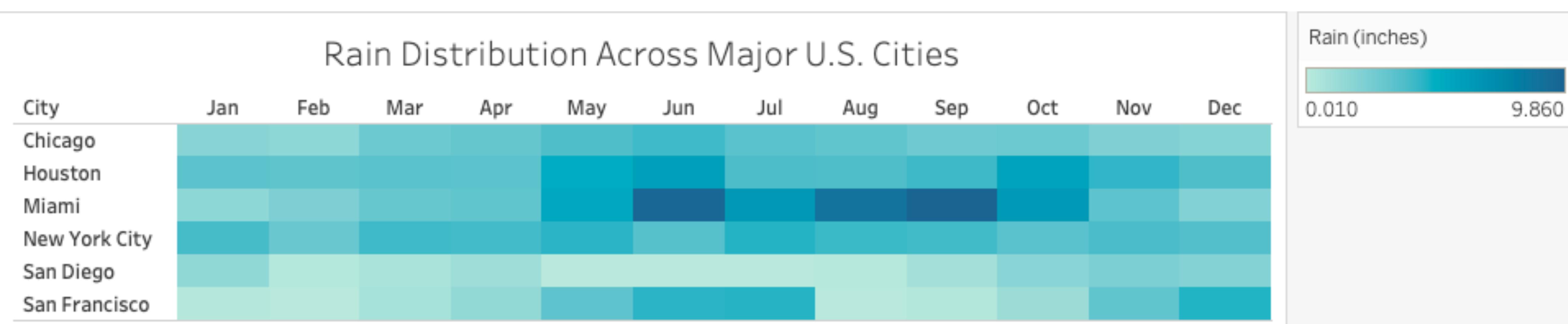
Seasonal Sunshine and Rainfall Trends in Major U.S. Cities



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

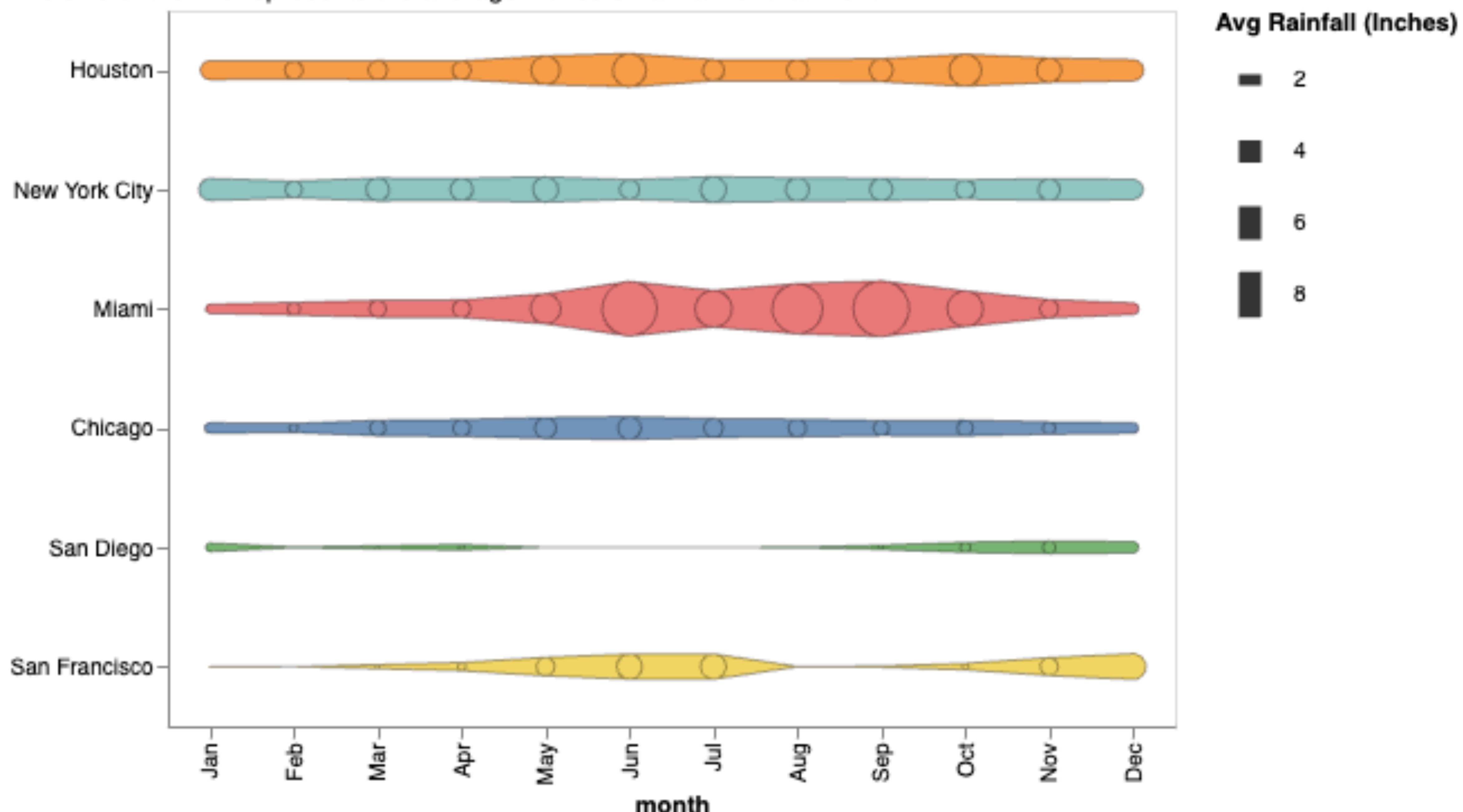


Rain Distribution Across Major U.S. Cities

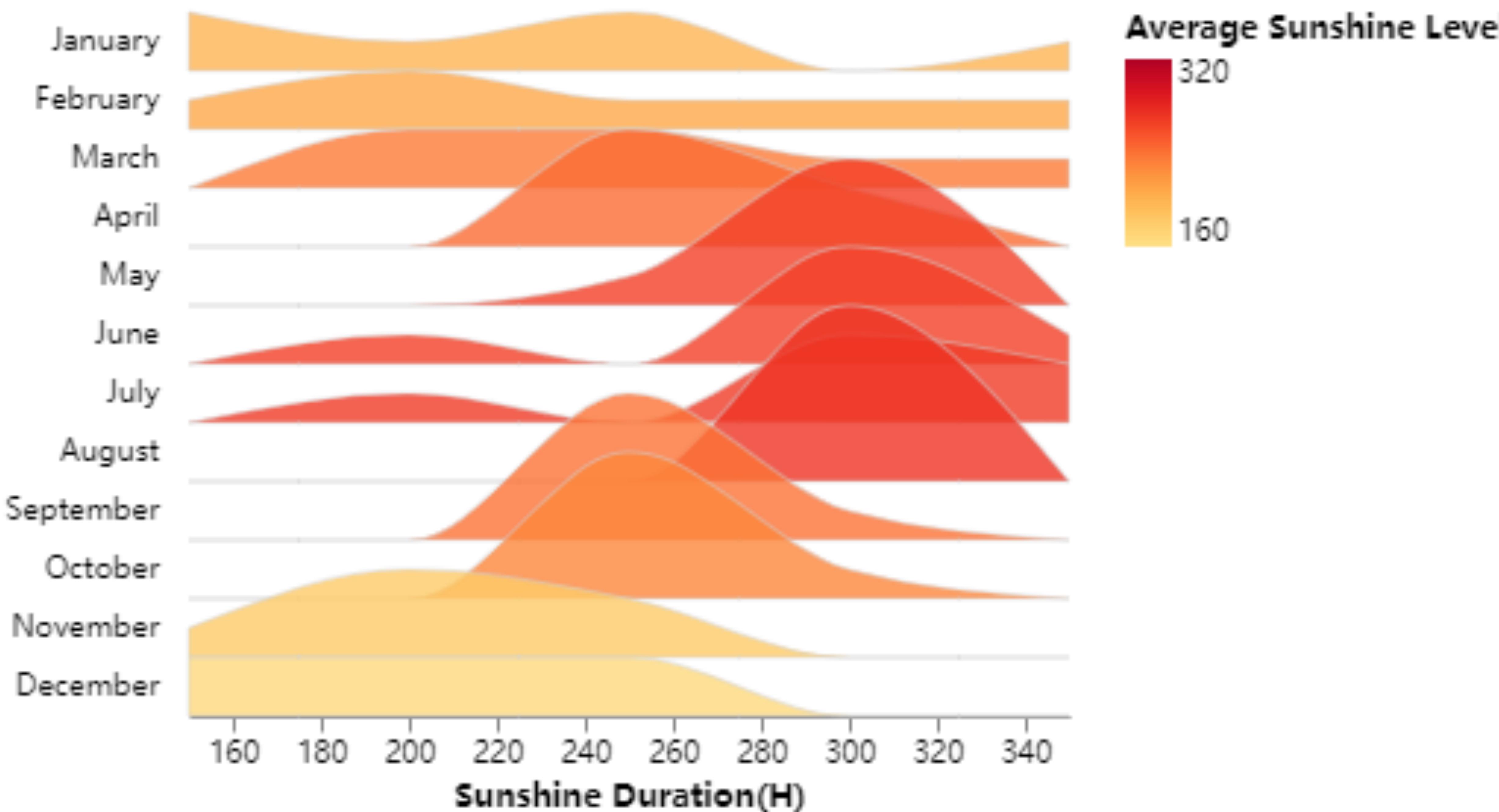


How Rainfall Differs Between Cities Through the Year

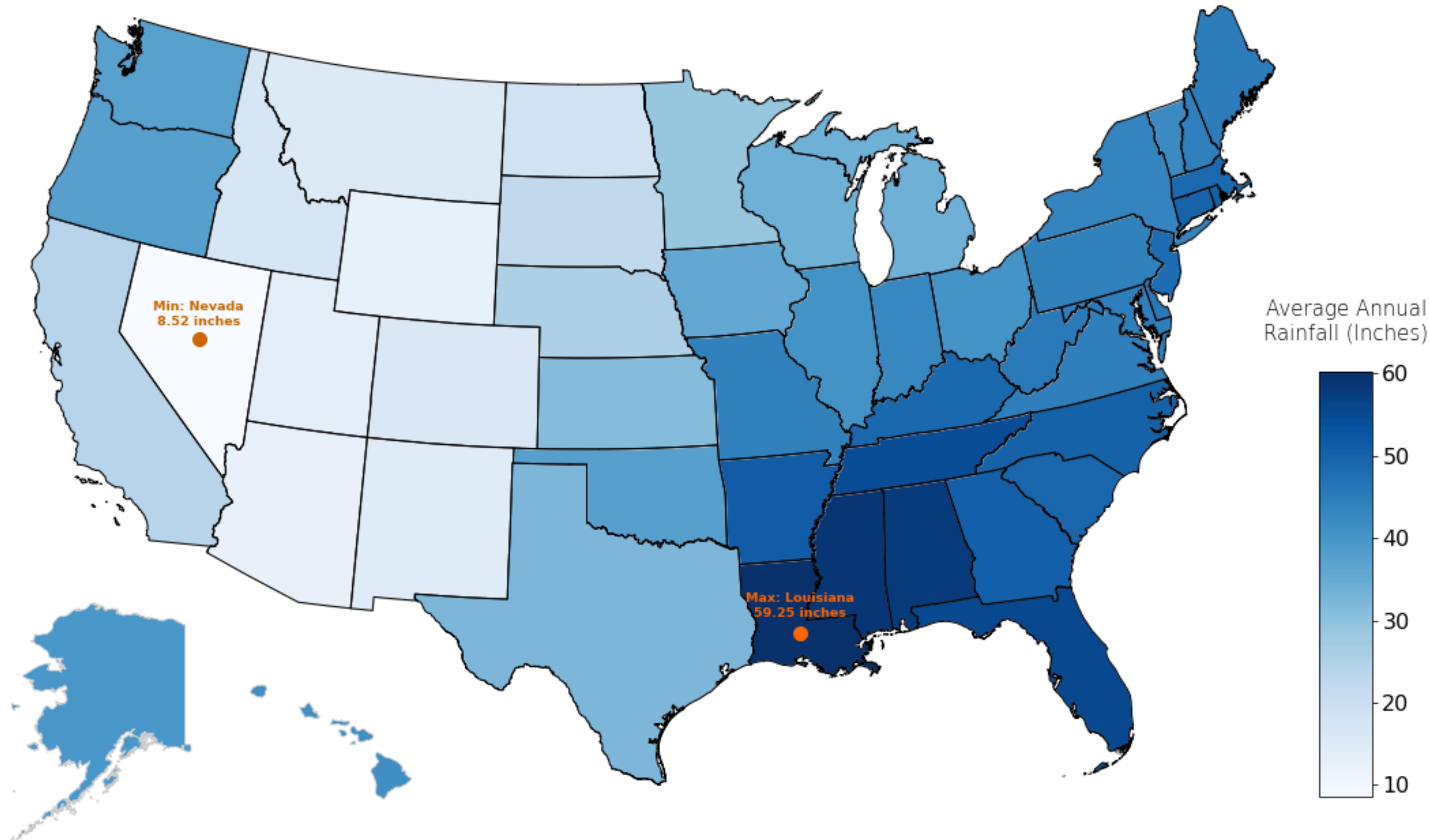
The size of the line represents the average inches of rainfall for that month



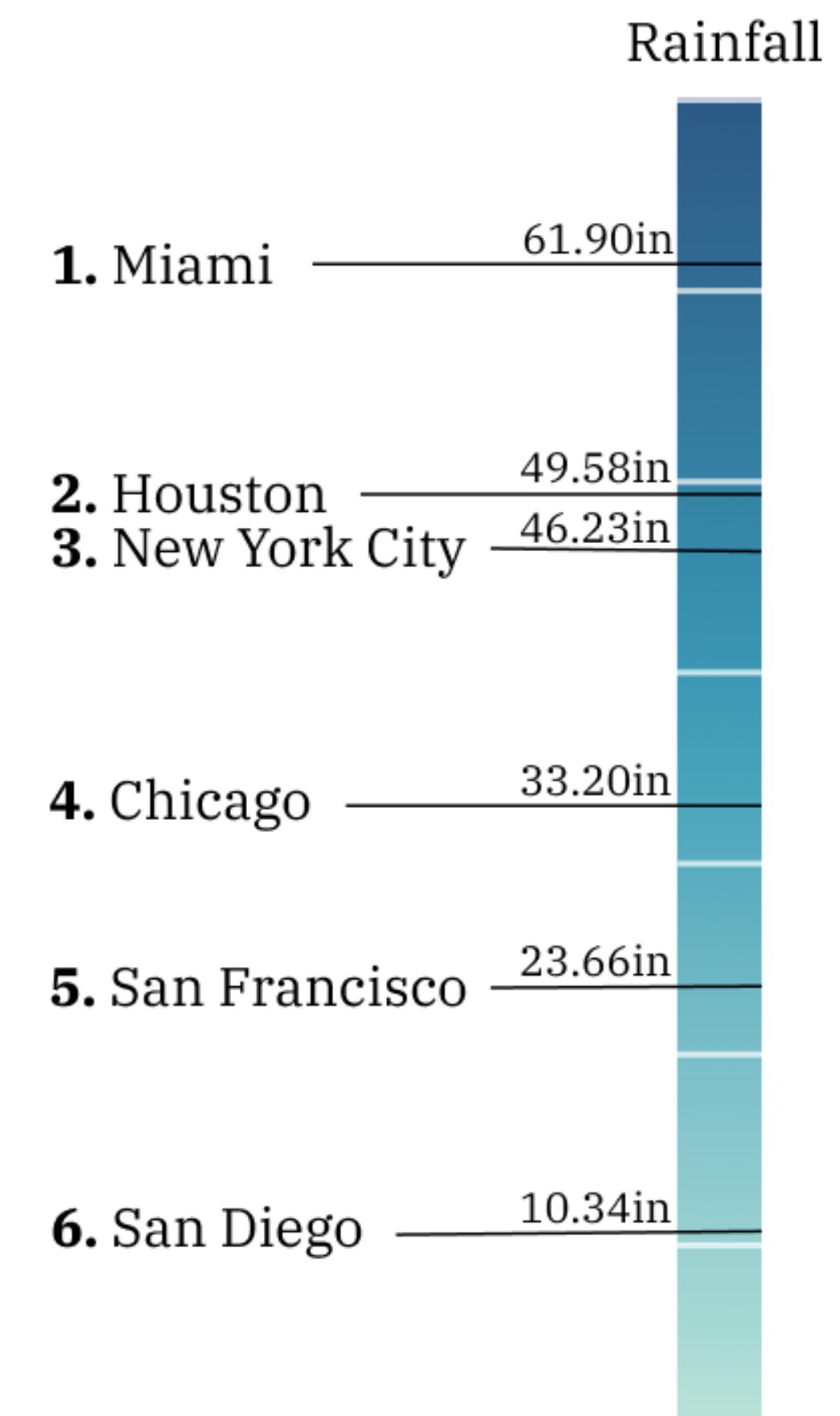
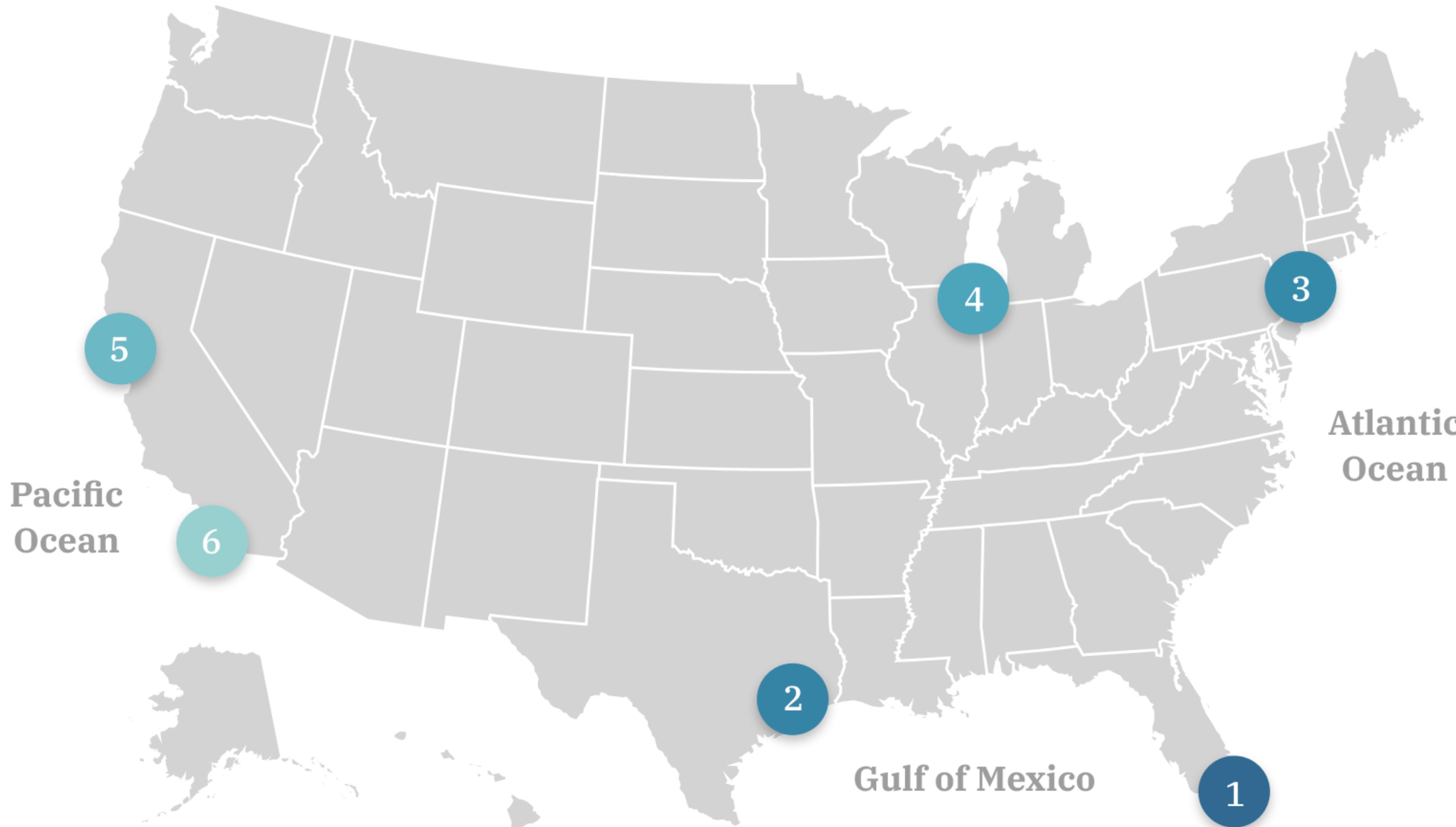
Sunshine Distribution Across Months



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?

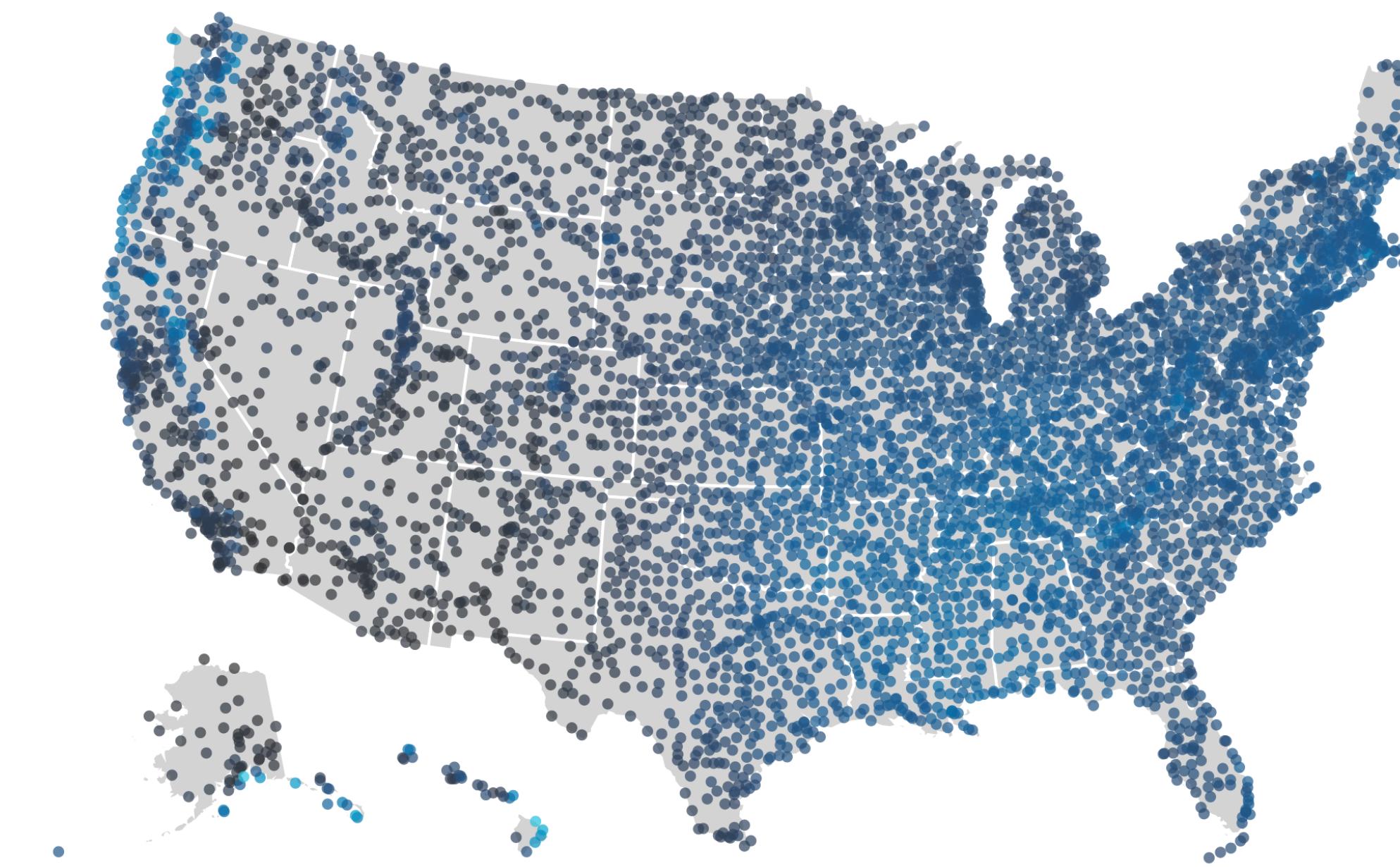


"My Husband Hates Rain. I Love Rain and Hate My Husband. Where's the Best Place to Live in the US?"

WINTER Avg. Precipitation



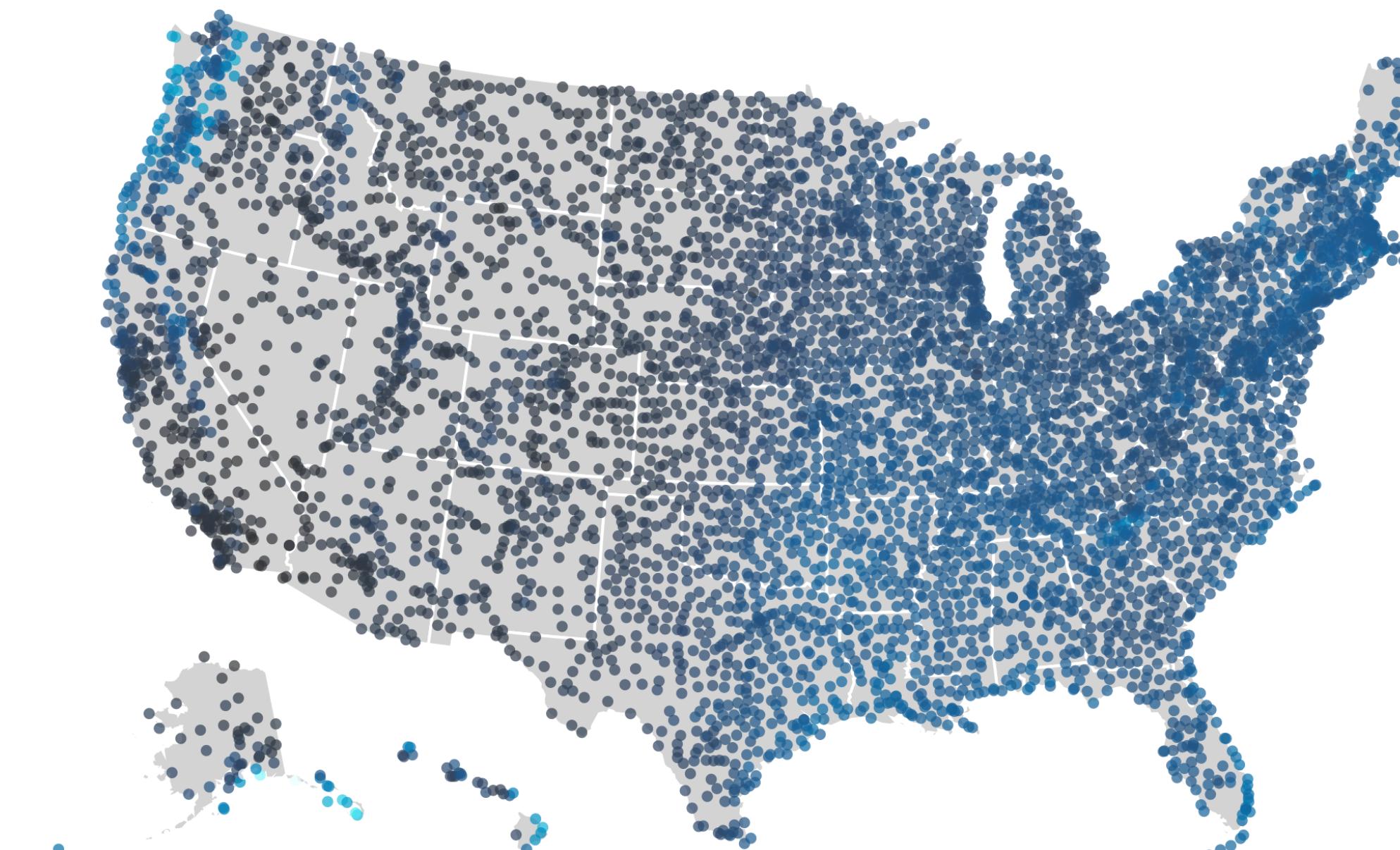
SPRING Avg. Precipitation



SUMMER Avg. Precipitation

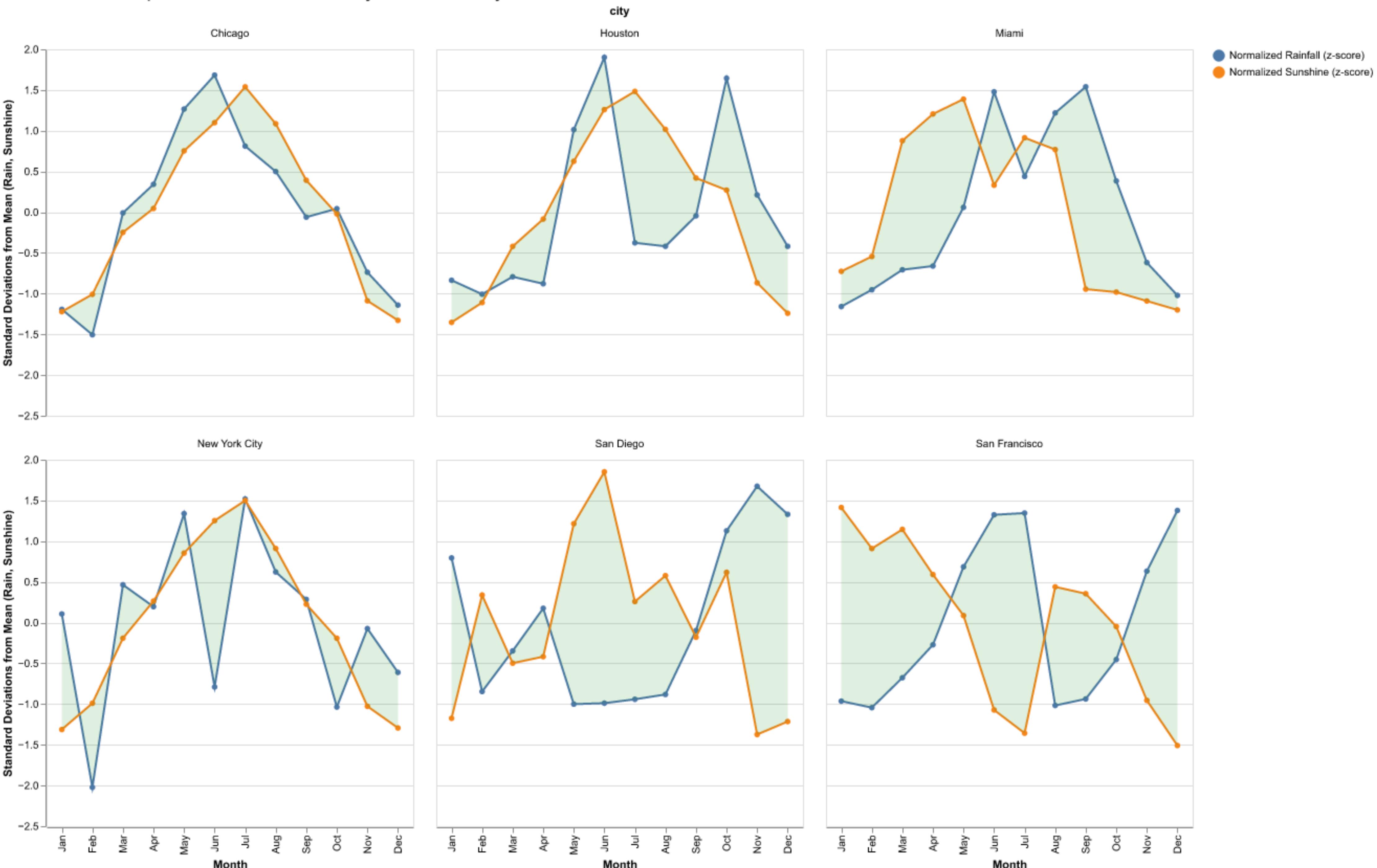


FALL Avg. Precipitation



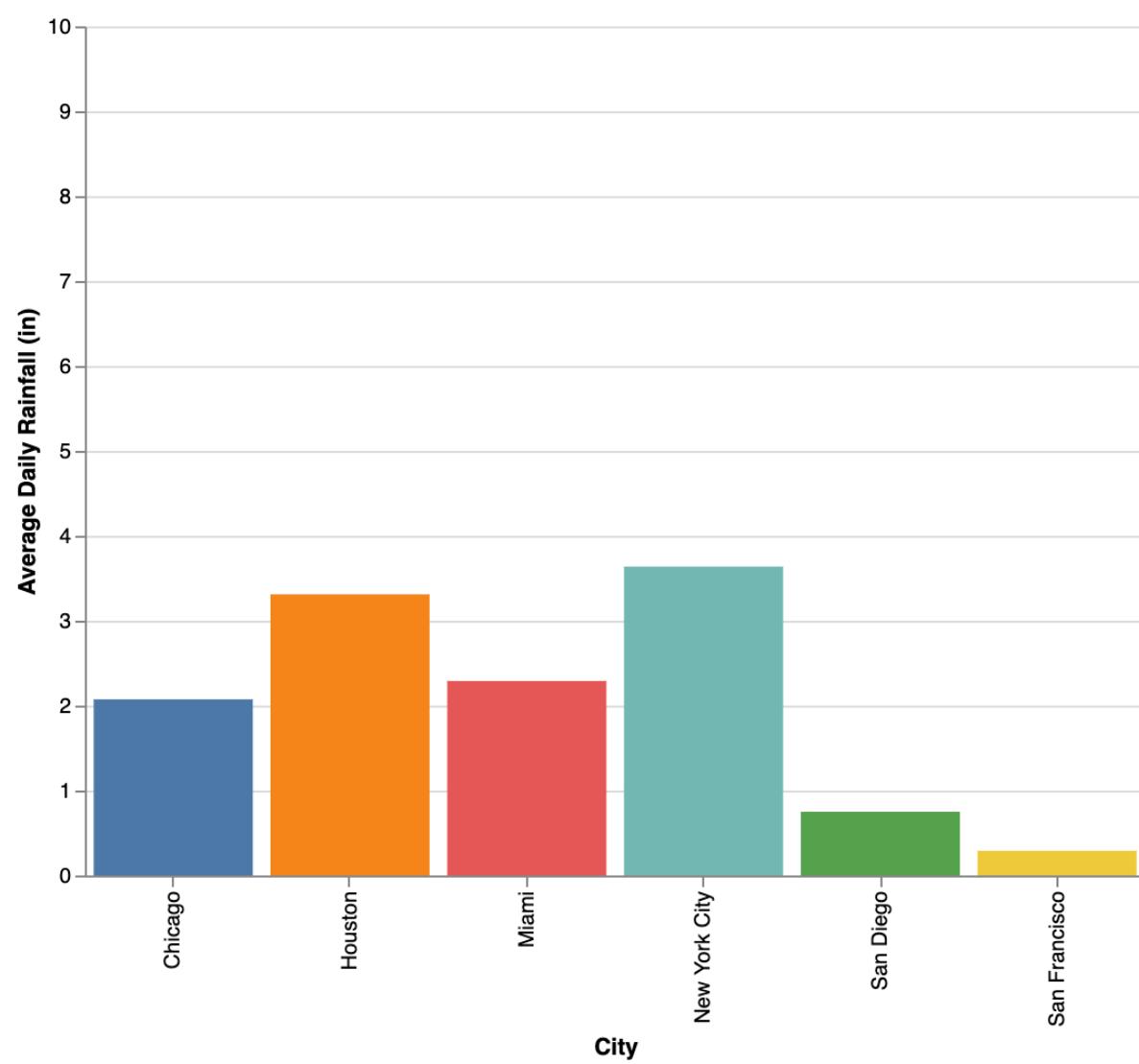
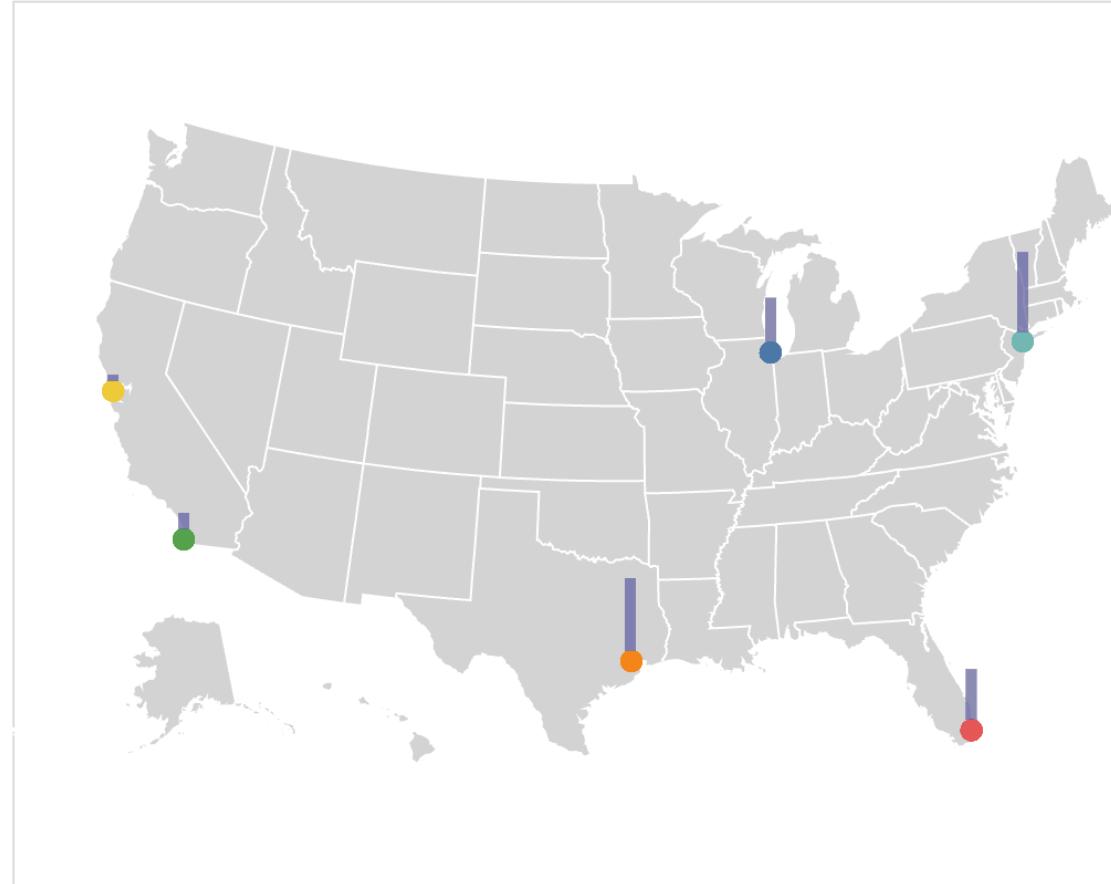
Precip. In.
15
10
5

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

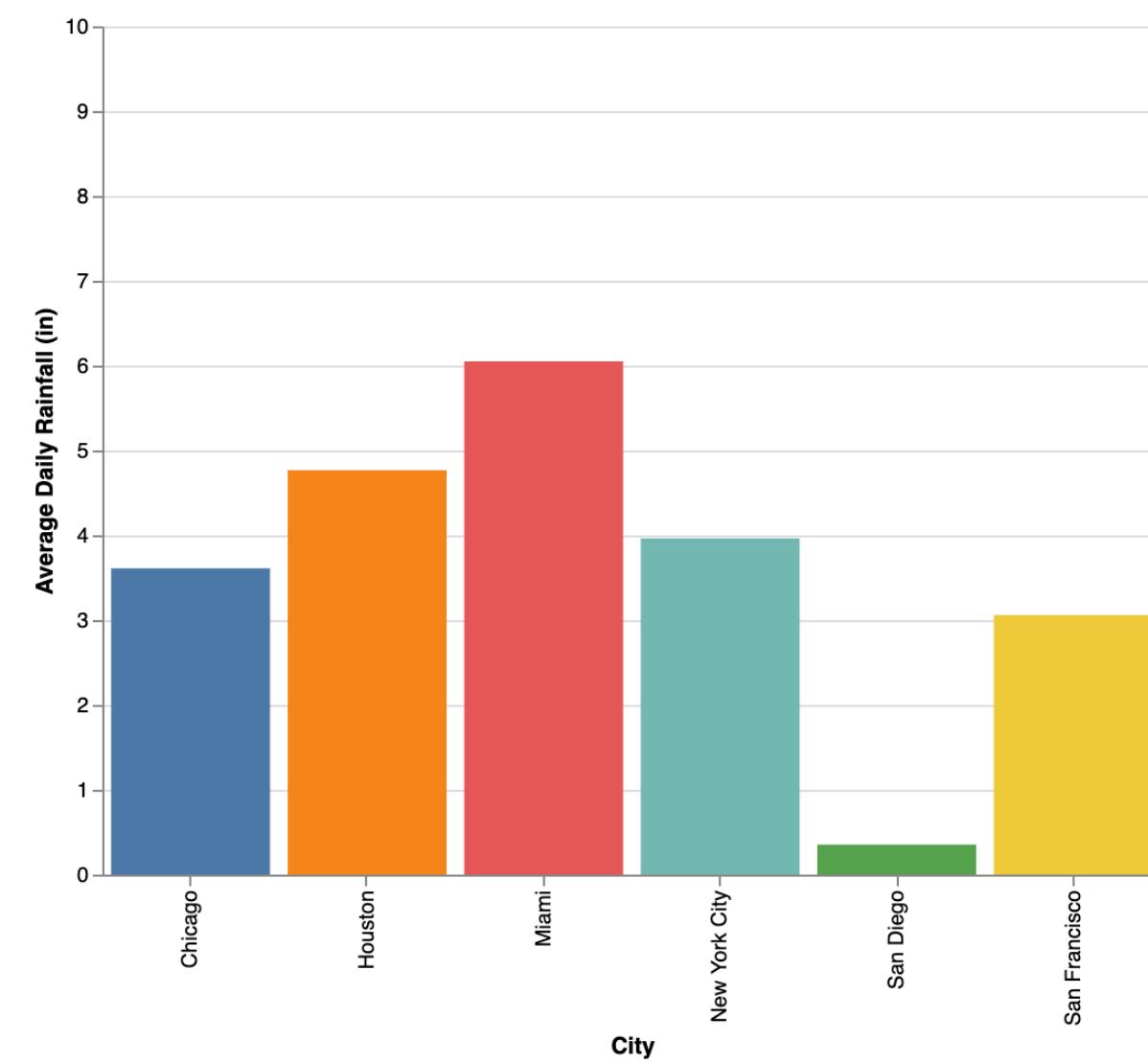
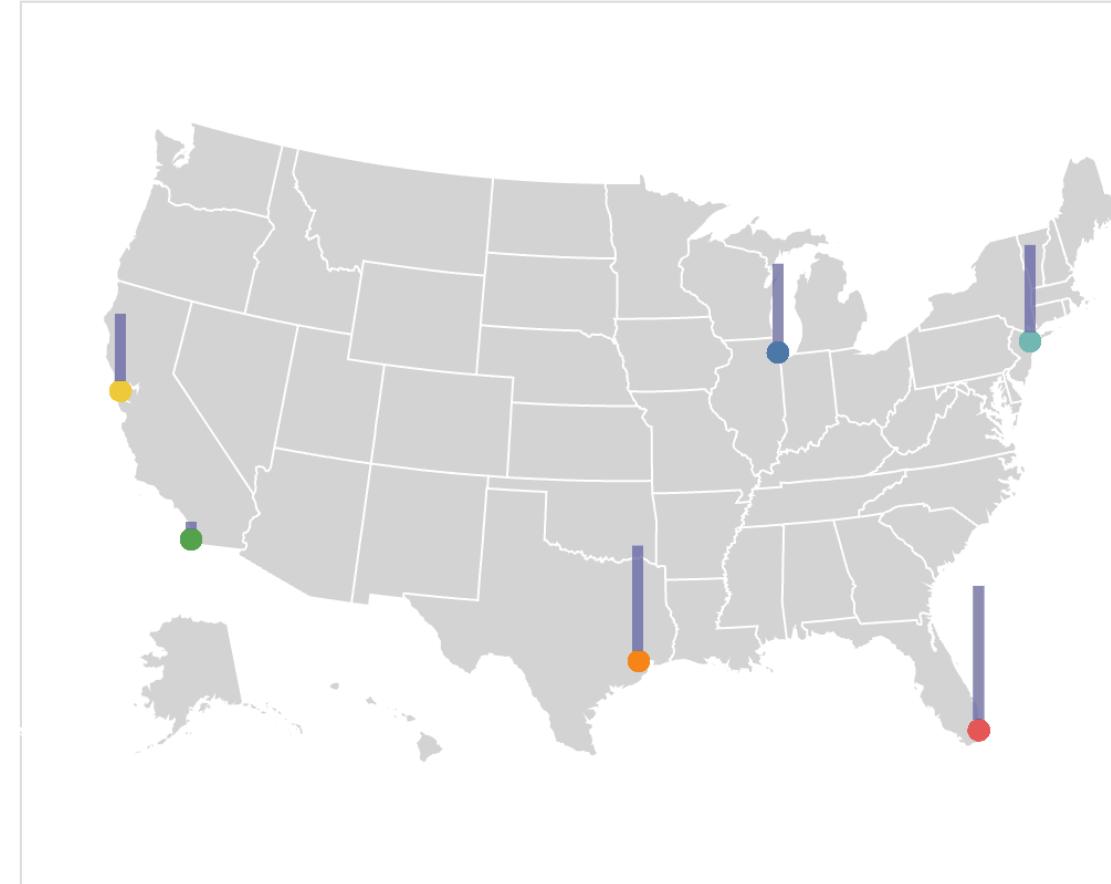


US Rainfall in Major Cities By Season

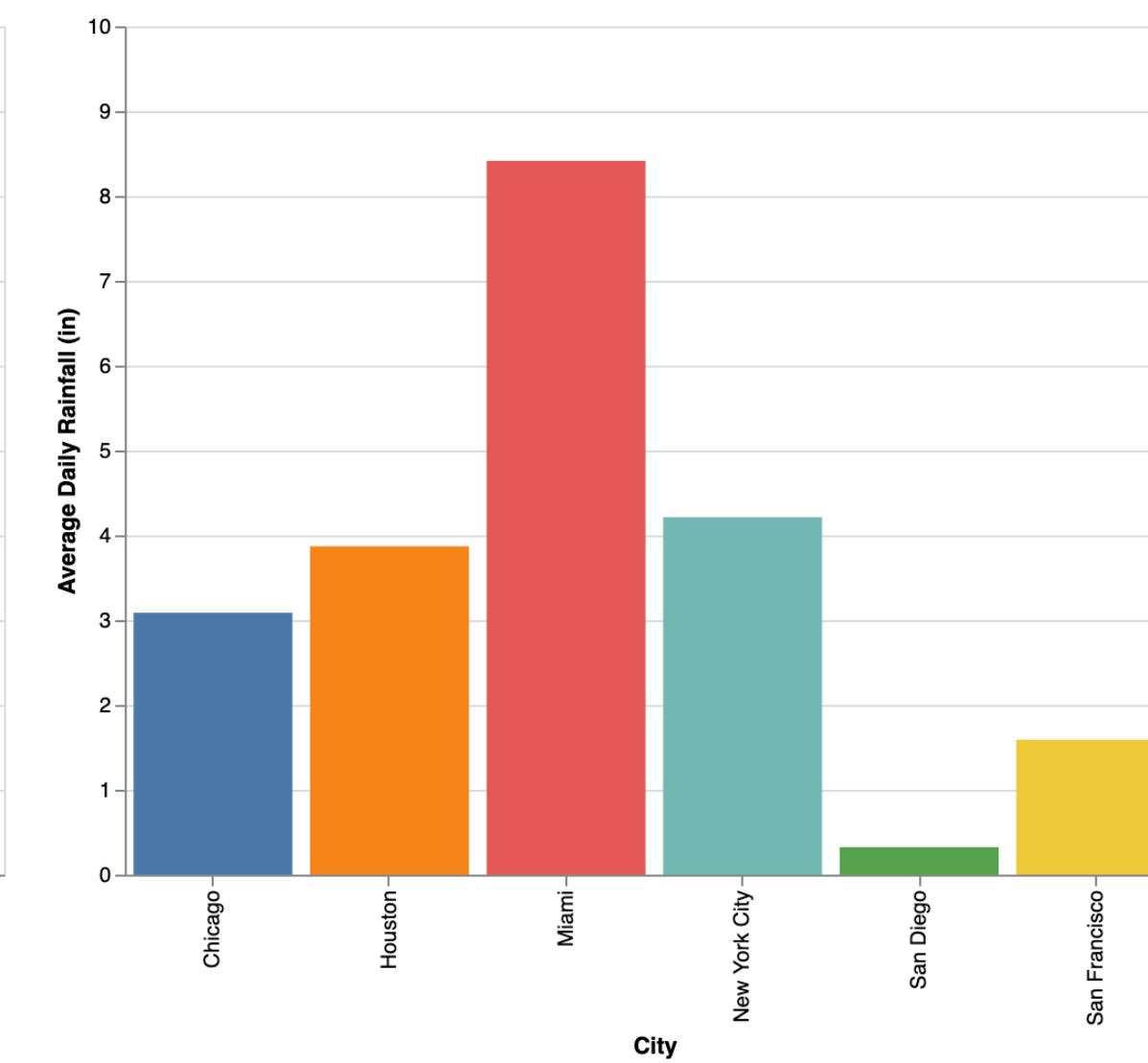
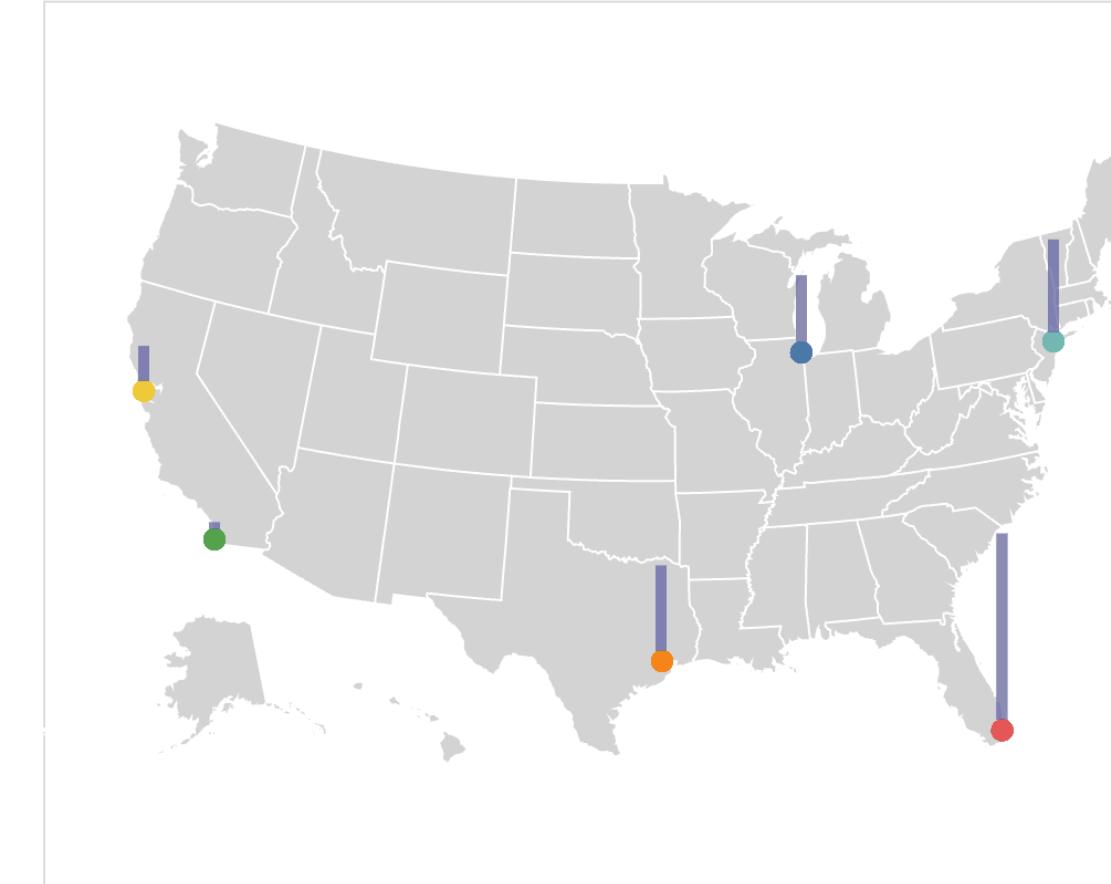
Average Winter Rainfall



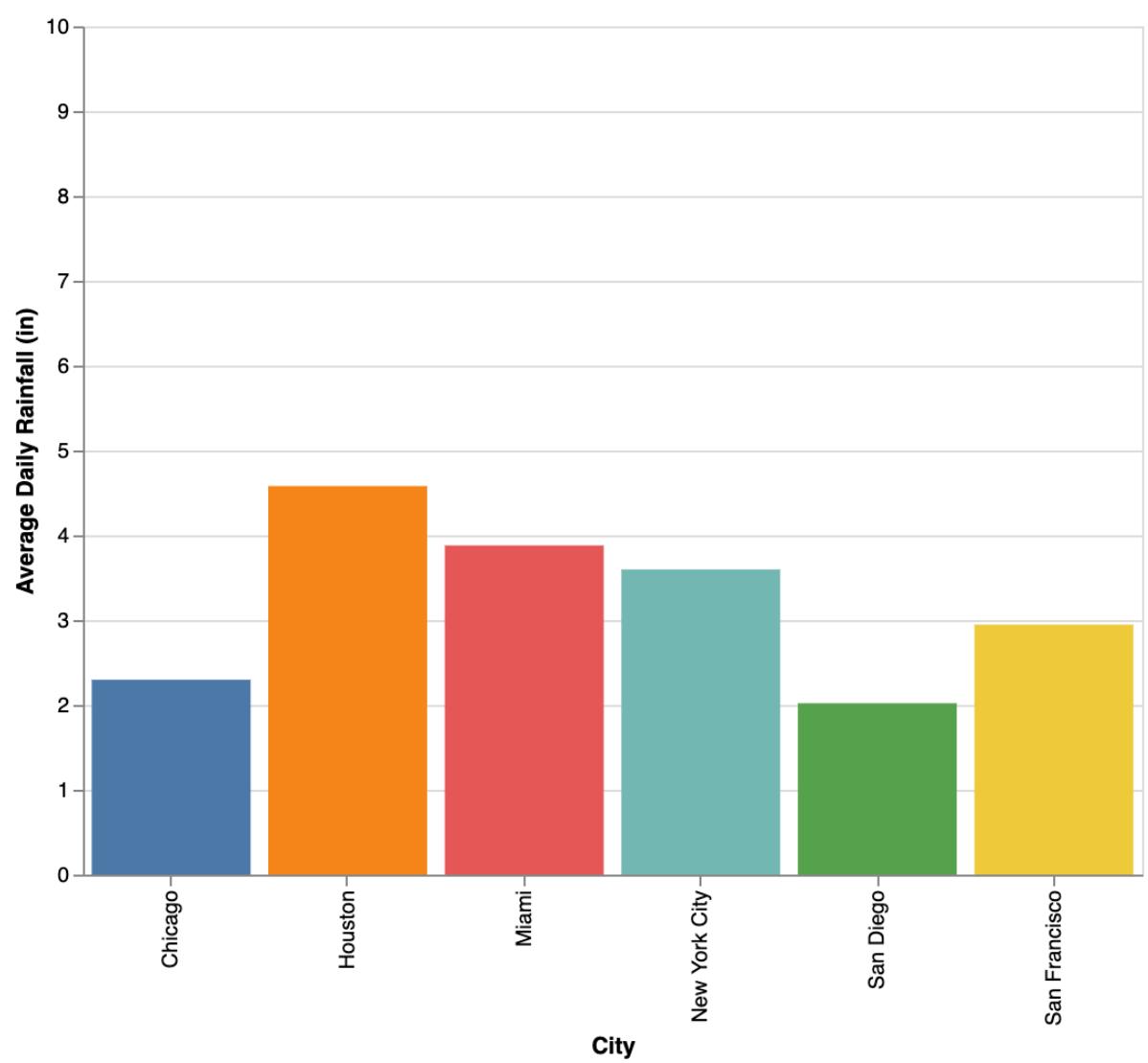
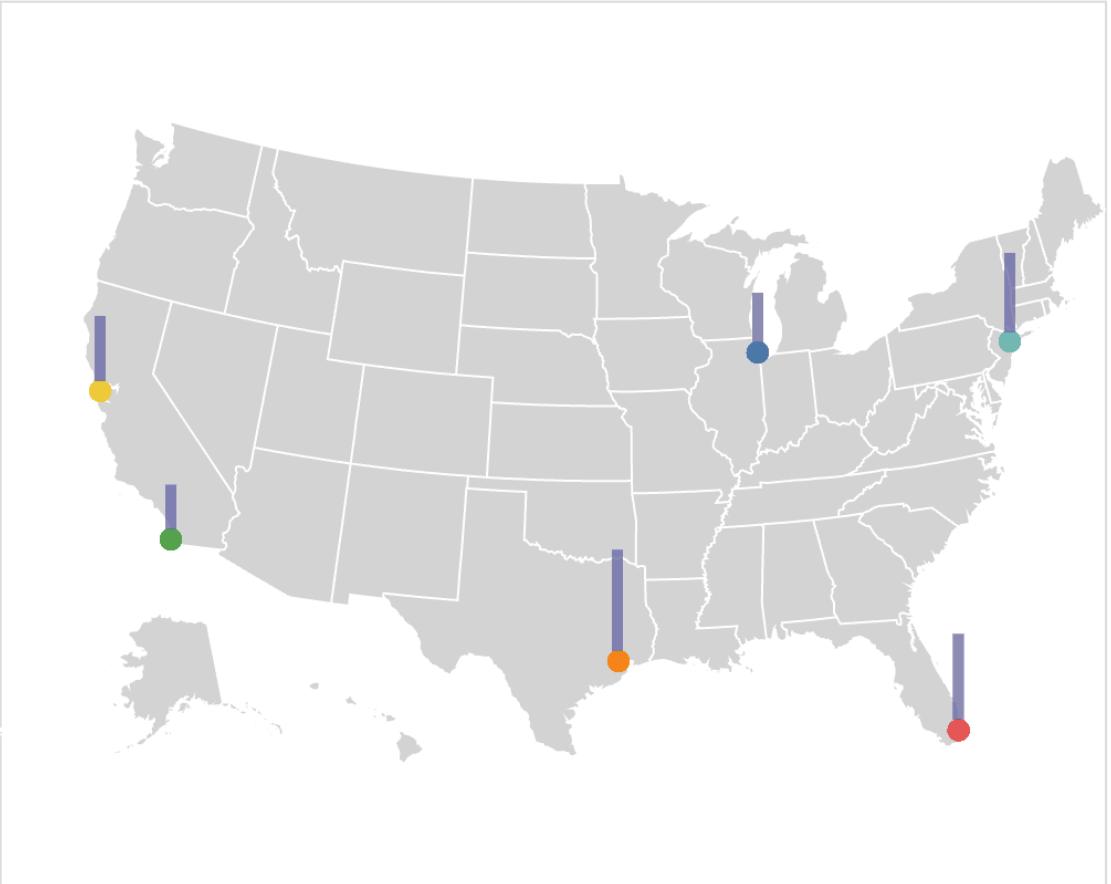
Average Spring Rainfall



Average Summer Rainfall

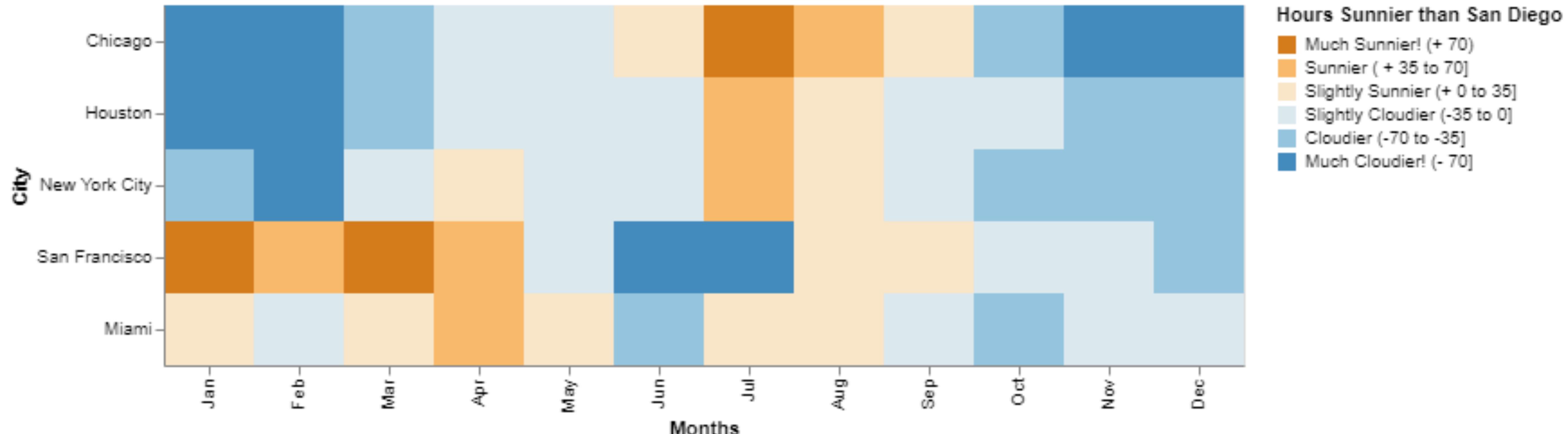


Average Fall Rainfall



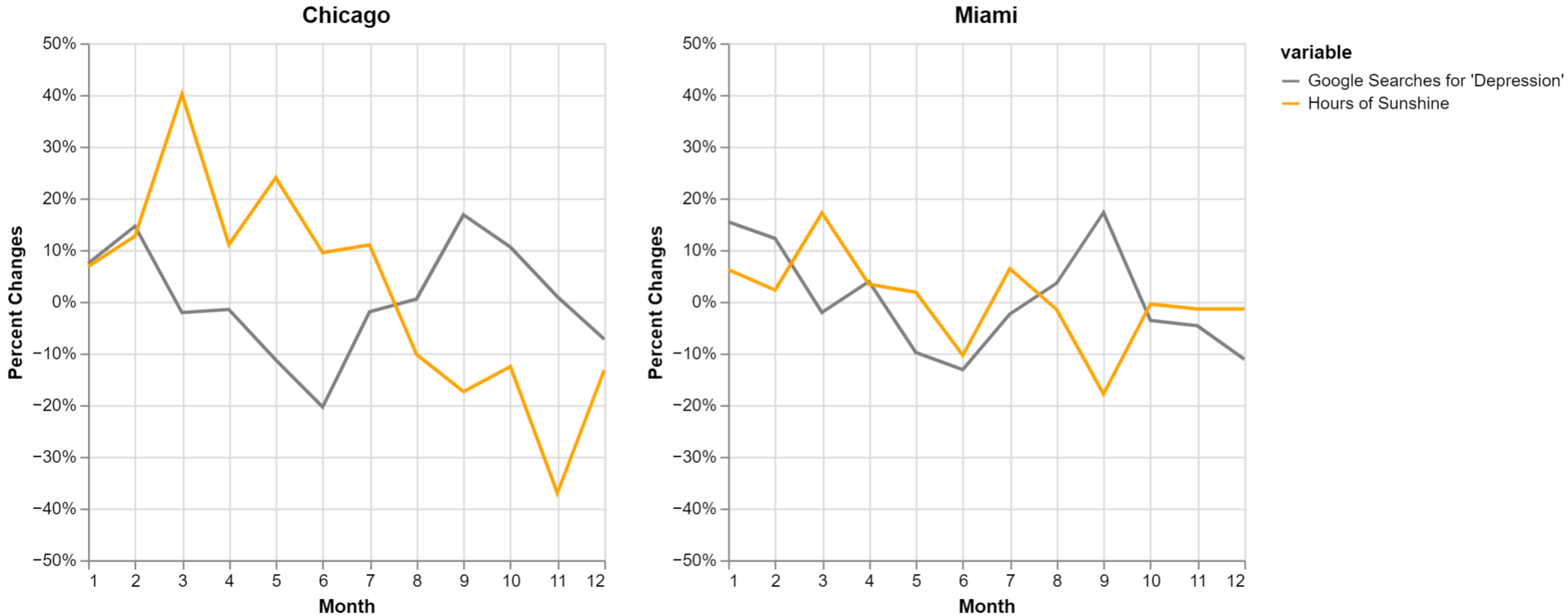
city
Chicago
Houston
Miami
New York City
San Diego
San Francisco

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

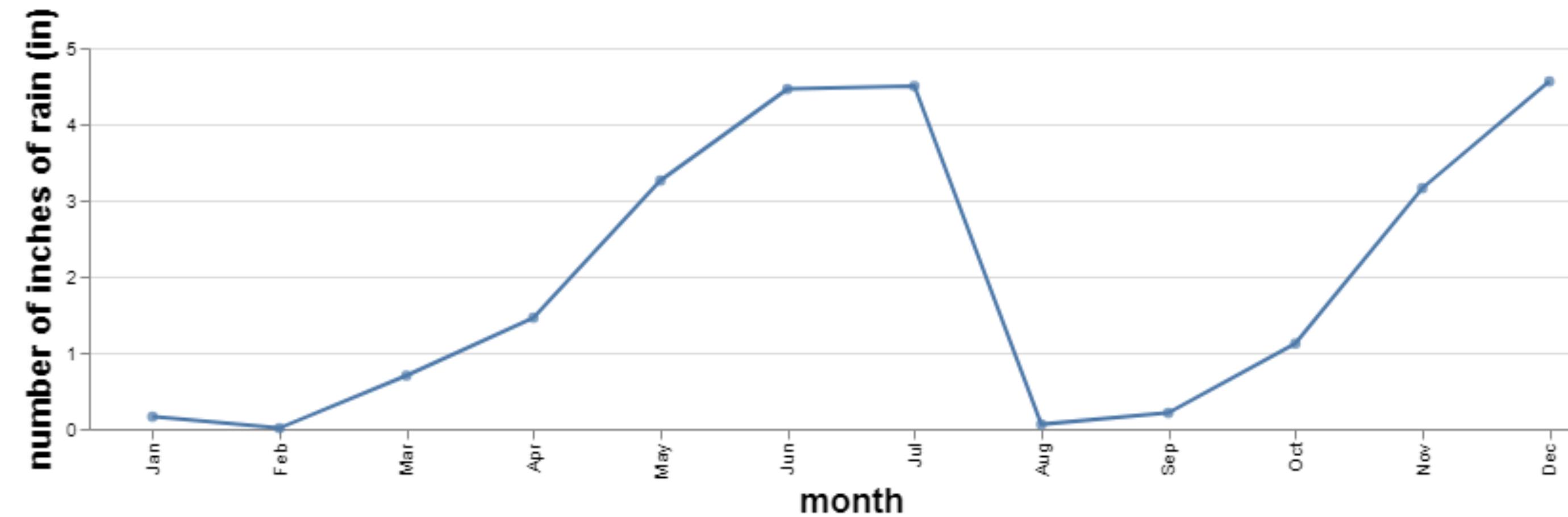
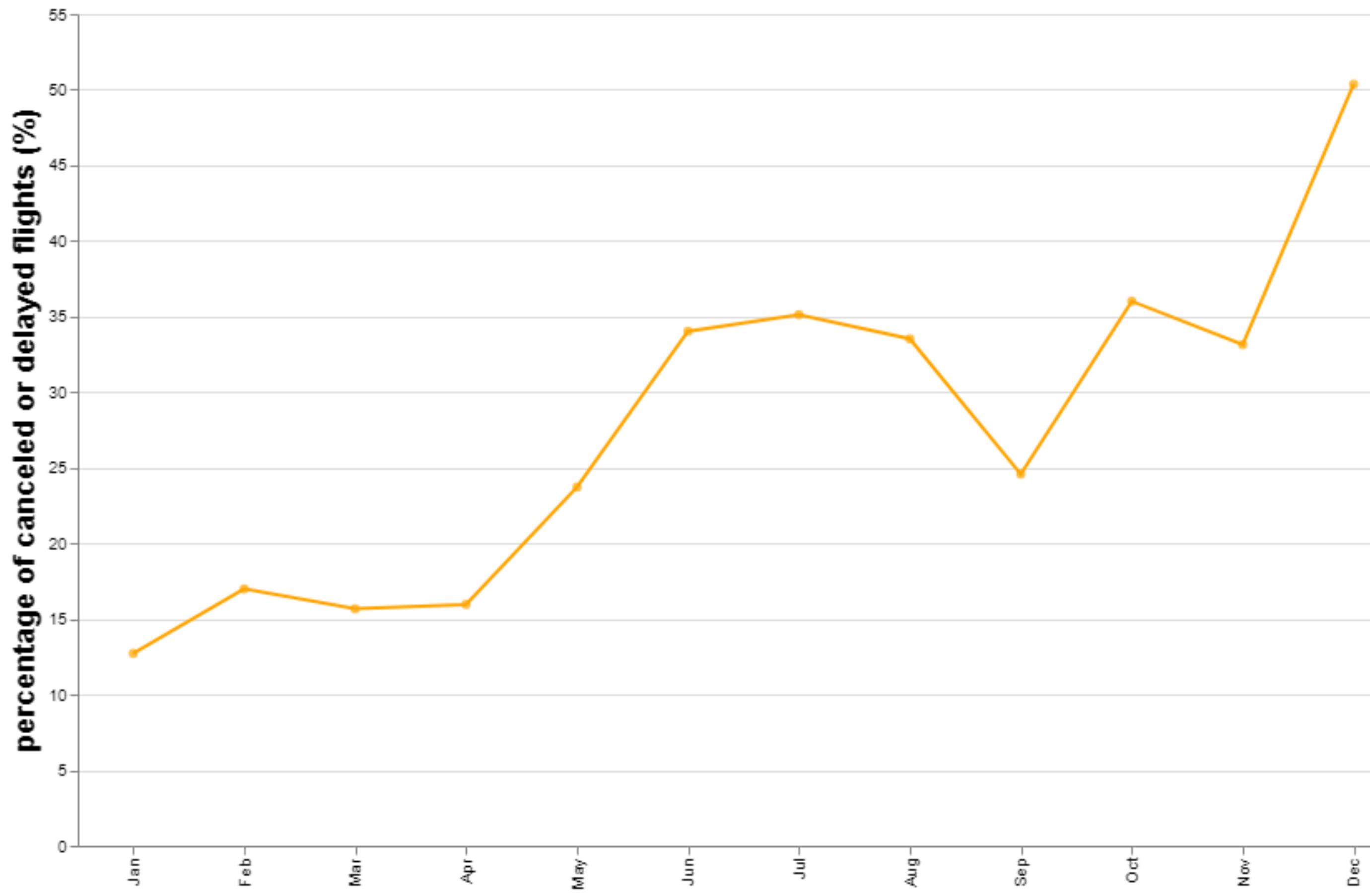


A Tale of Two Cities: How Dramatic are the Effects of Seasonal Depression?

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

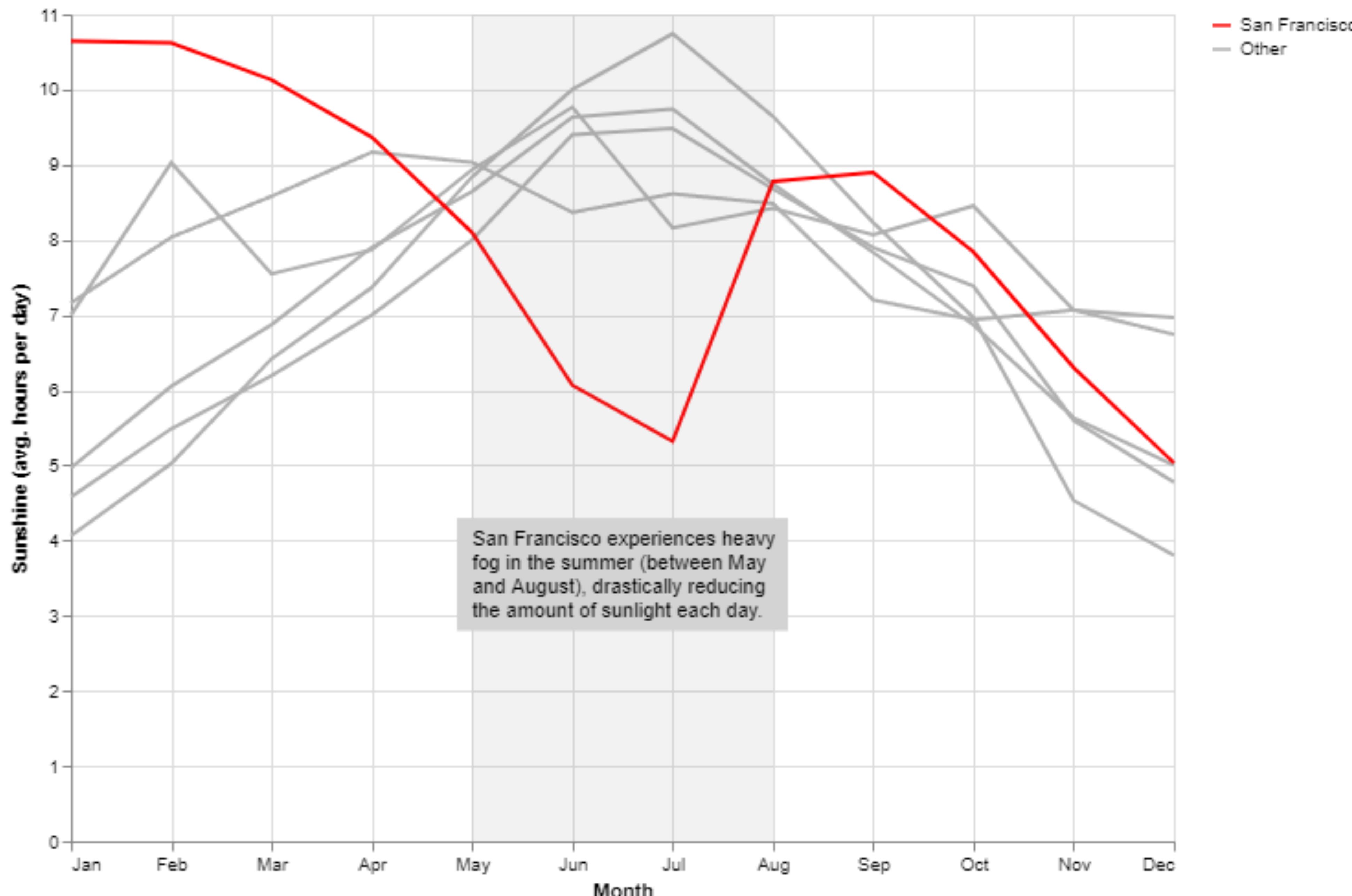


Percentage of canceled or delayed flights and inches of rain by month in San Francisco



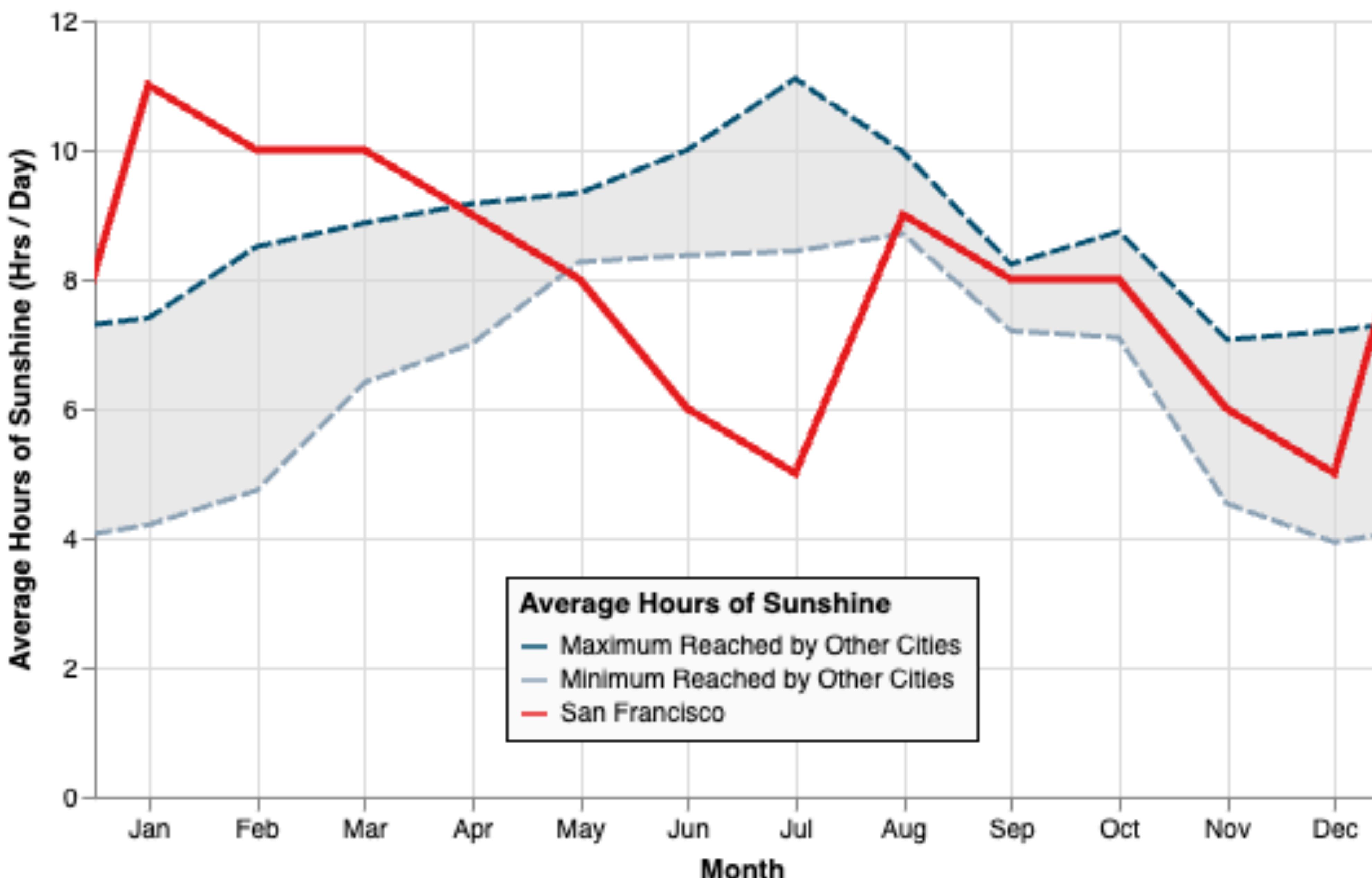
Does San Francisco receive less sunlight in the summer than other US cities?

San Francisco's famous summer fog can block sunlight.



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?

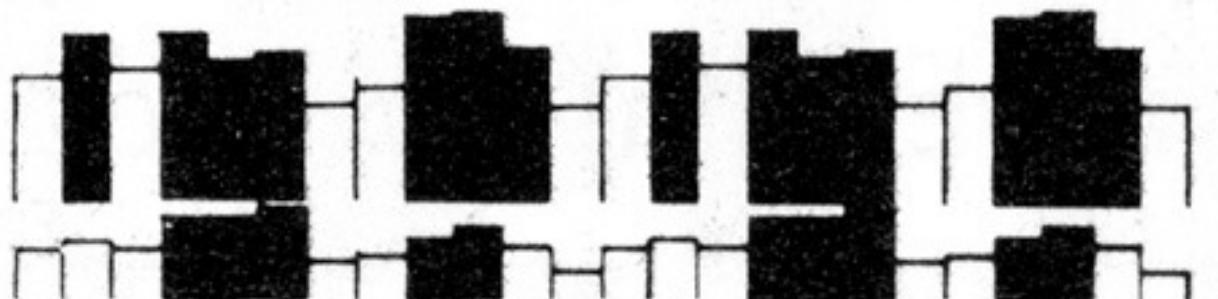
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Example: Bertin's Hotel Data

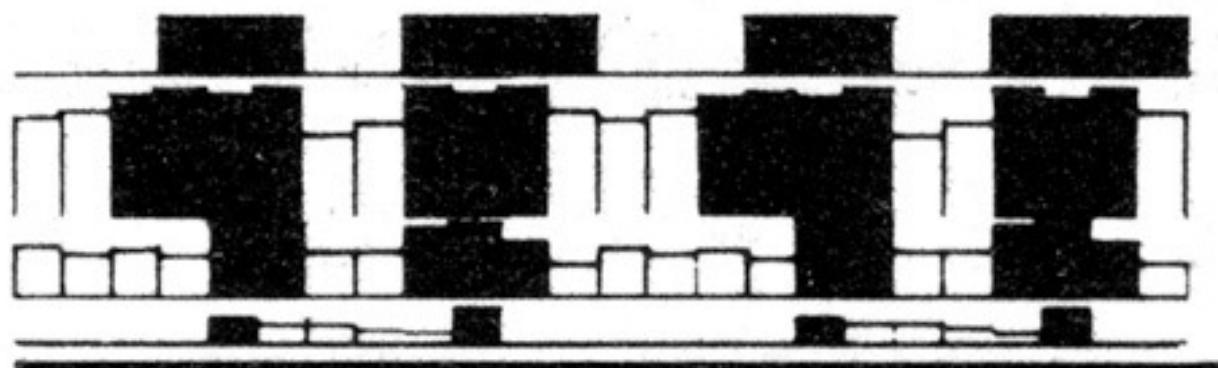
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26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE						
69	70	77	71	37	36	39	39	55	60	68	72	2	% —" LOCAL						
7	6	3	6	23	14	19	14	9	6	8	8	3	% —" U.S.A.						
0	0	0	0	8	6	6	4	2	12	0	0	4	% —" SOUTH AMERICA						
20	15	14	15	23	27	22	30	27	19	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	20	19	22	16	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 CONVENTIONS						
		X	X	X			X	X	X	X	X	20							

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



20 CONVENTIONS

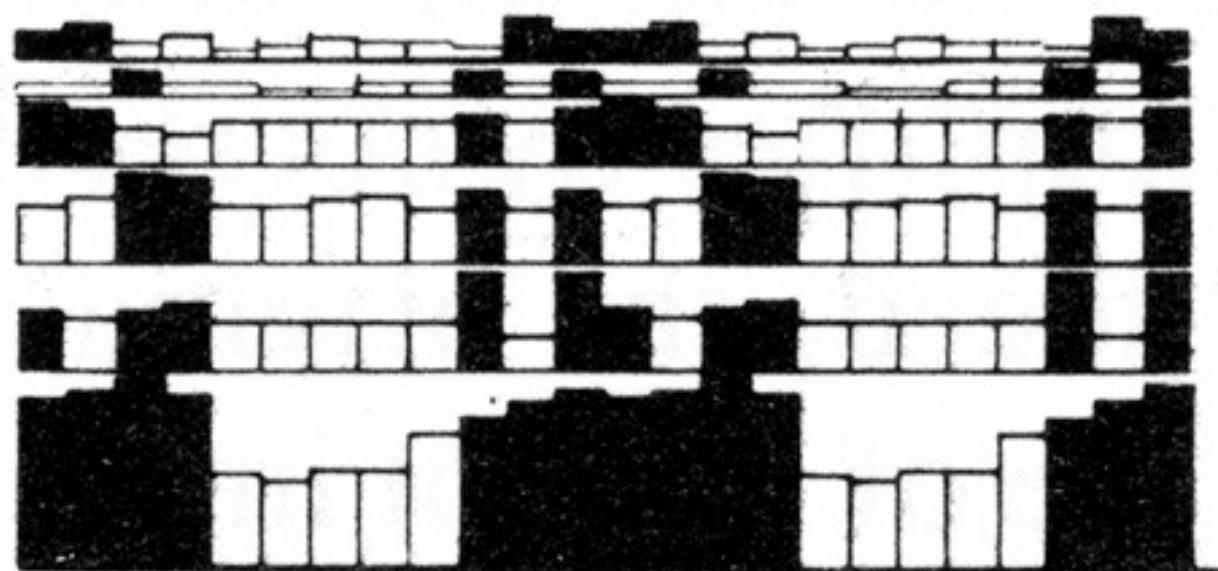
• BUSINESSMEN

11 AGENCY RESERVATIONS

4 SOUTH AMERICA

ACTIVE AND
SLOW PERIODS

DISCOVERY FACTORS



12 AIR CREWS

13 CLIENTS UNDER 20 YEARS

16 CLIENTS MORE THAN 55 YEARS

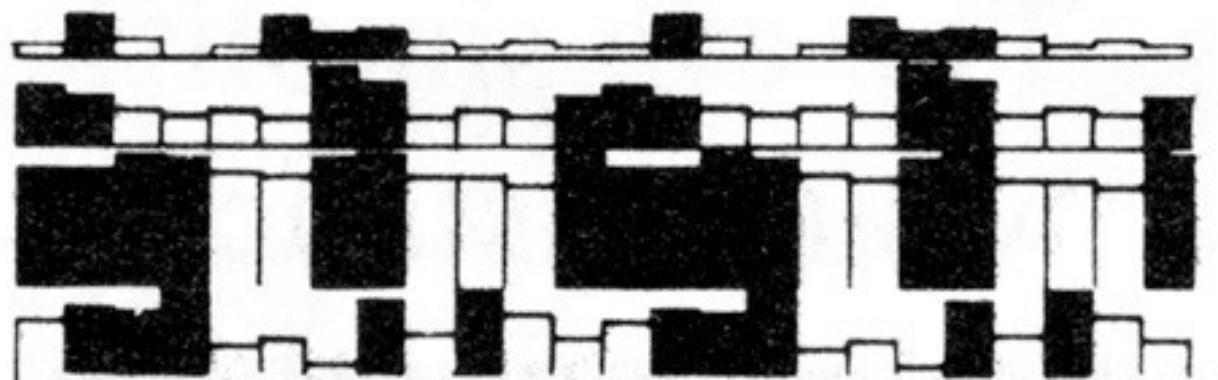
14 CLIENTS FROM 20-35 YEARS

1 FEMALE CLIENTELE

2 LOCAL CLIENTELE

RECOVERY FACTORS

WINTER

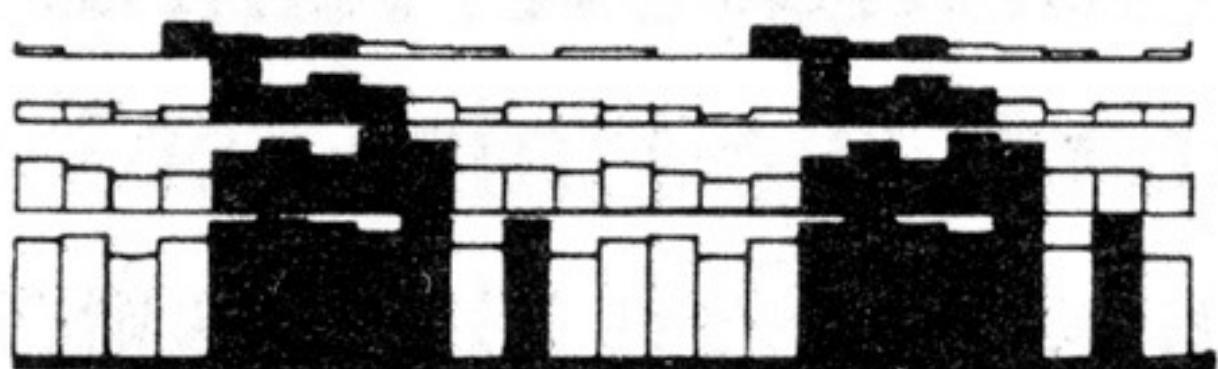


7 ASIA

9 TOURISTS

10 DIRECT RESERVATION

17 PRICE OF ROOMS



6 MIDDLE EAST, AFRICA

3 U. S. A.

5 EUROPE

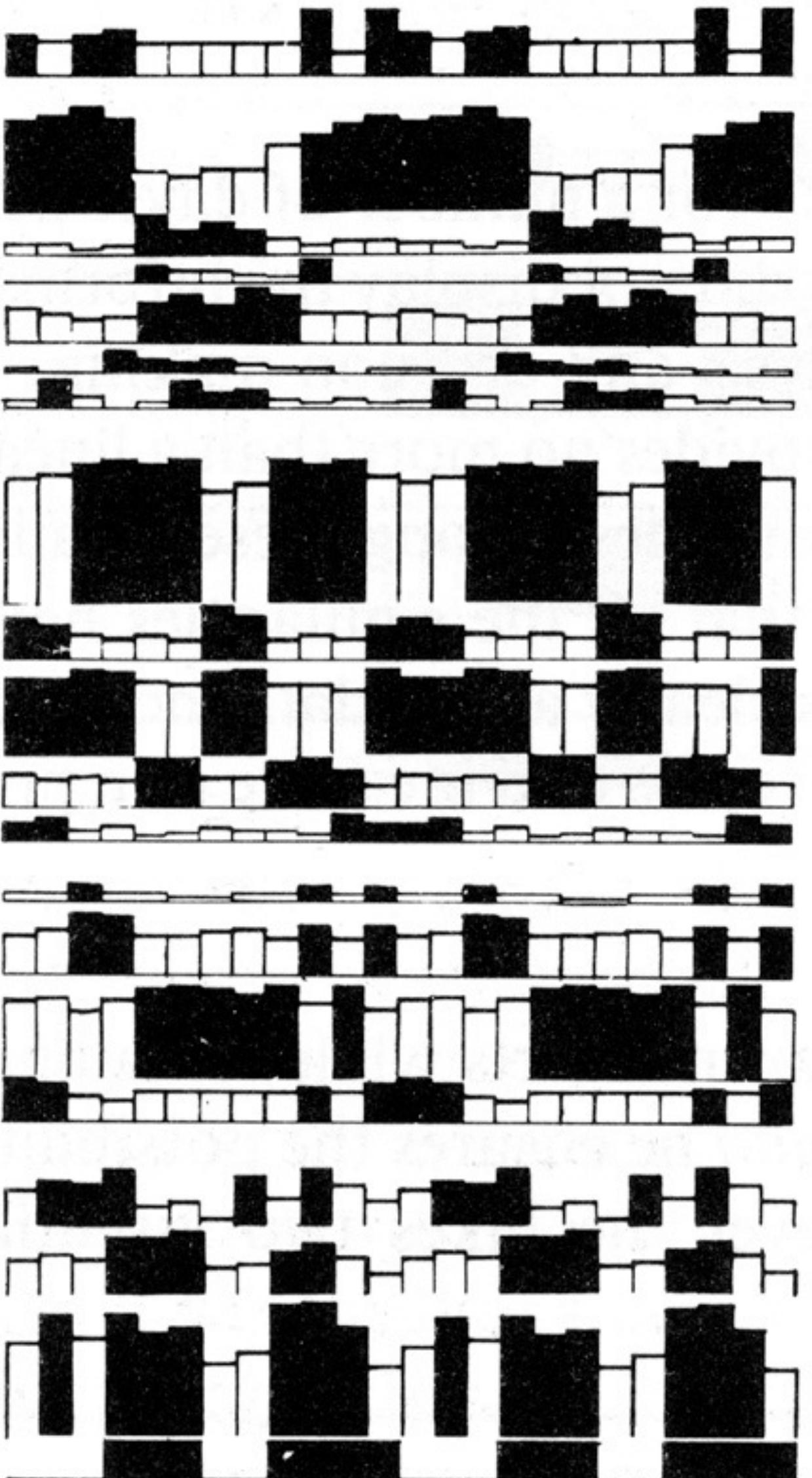
15 CLIENTS FROM 35-55 YEARS

WINTER-SUMMER

SUMMER

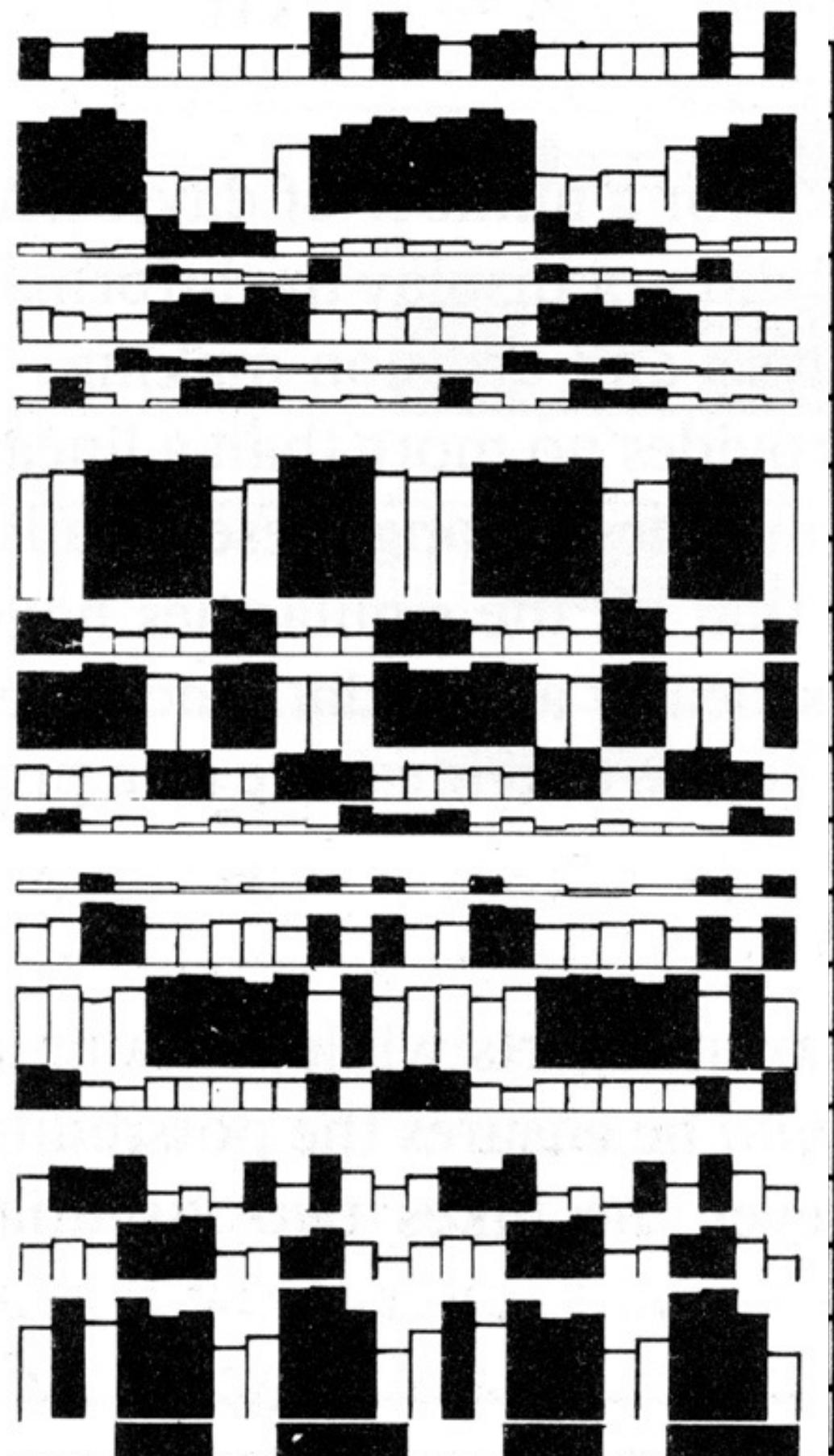
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0	0	0	0	8	6	6	4	2	12	0	0	4	% —" SOUTH AMERICA						
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1	0	0	8	6	4	6	4	2	1	0	1	6	% —" M.EAST, AFRICA						
3	10	6	0	3	13	8	9	5	2	5	2	7	% —" ASIA						
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67	82	70	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY CONVENTIONS						
		X	X	X			X	X	X	X	X	20							

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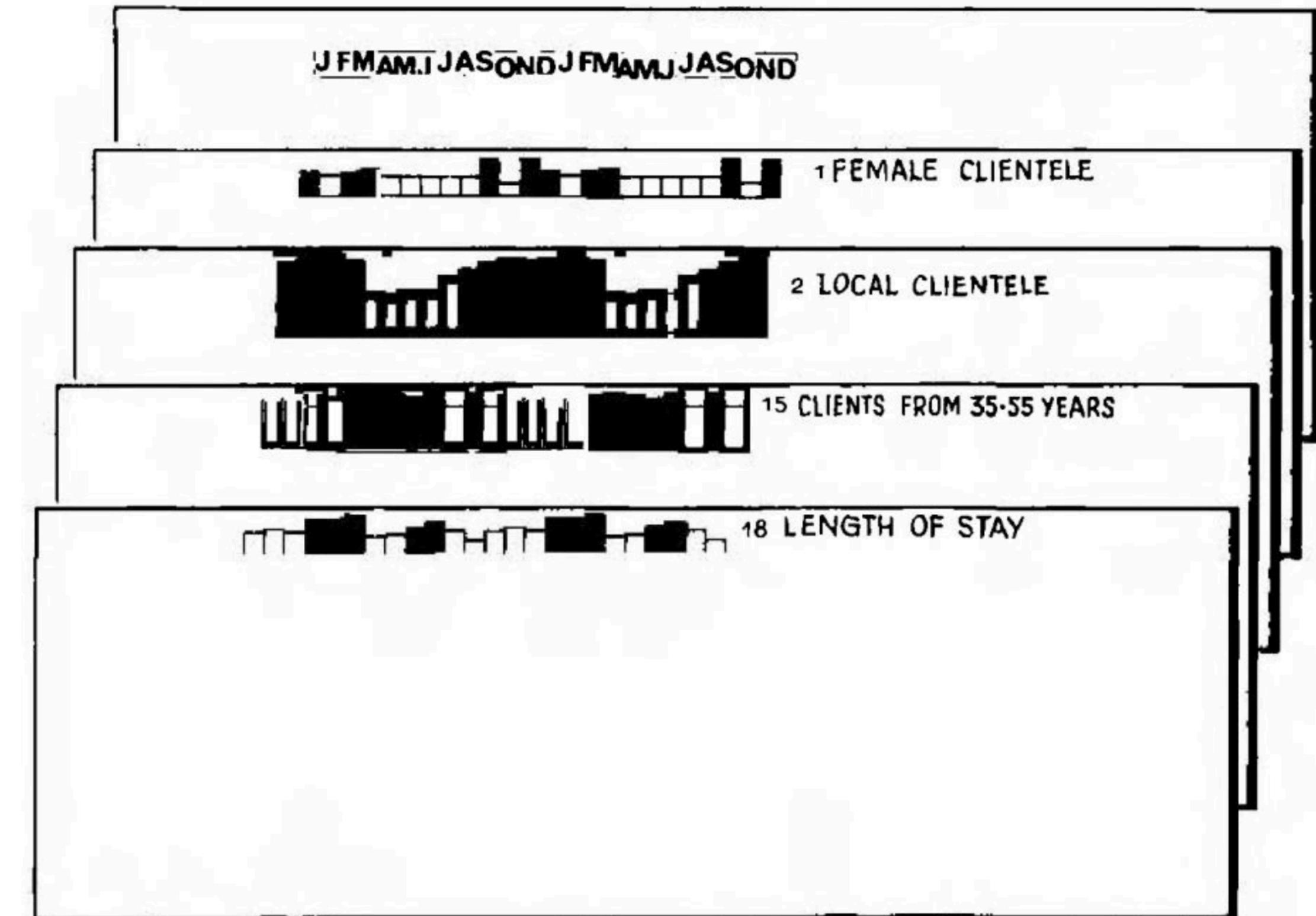
- | | |
|----|--------------------------|
| 1 | % CLIENTELE FEMALE |
| 2 | % —" LOCAL |
| 3 | % —" U.S.A. |
| 4 | % —" SOUTH AMERICA |
| 5 | % —" EUROPE |
| 6 | % —" M.EAST, AFRICA |
| 7 | % —" ASIA |
| 8 | % BUSINESSMEN |
| 9 | % TOURISTS |
| 10 | % DIRECT RESERVATIONS |
| 11 | % AGENCY —" —" |
| 12 | % AIR CREWS |
| 13 | % CLIENTS UNDER 20 YEARS |
| 14 | % —" 20-35 —" —" |
| 15 | % —" 35-55 —" —" |
| 16 | % —" MORE THAN 55 —" —" |
| 17 | PRICE OF ROOMS |
| 18 | LENGTH OF STAY |
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| 20 | |

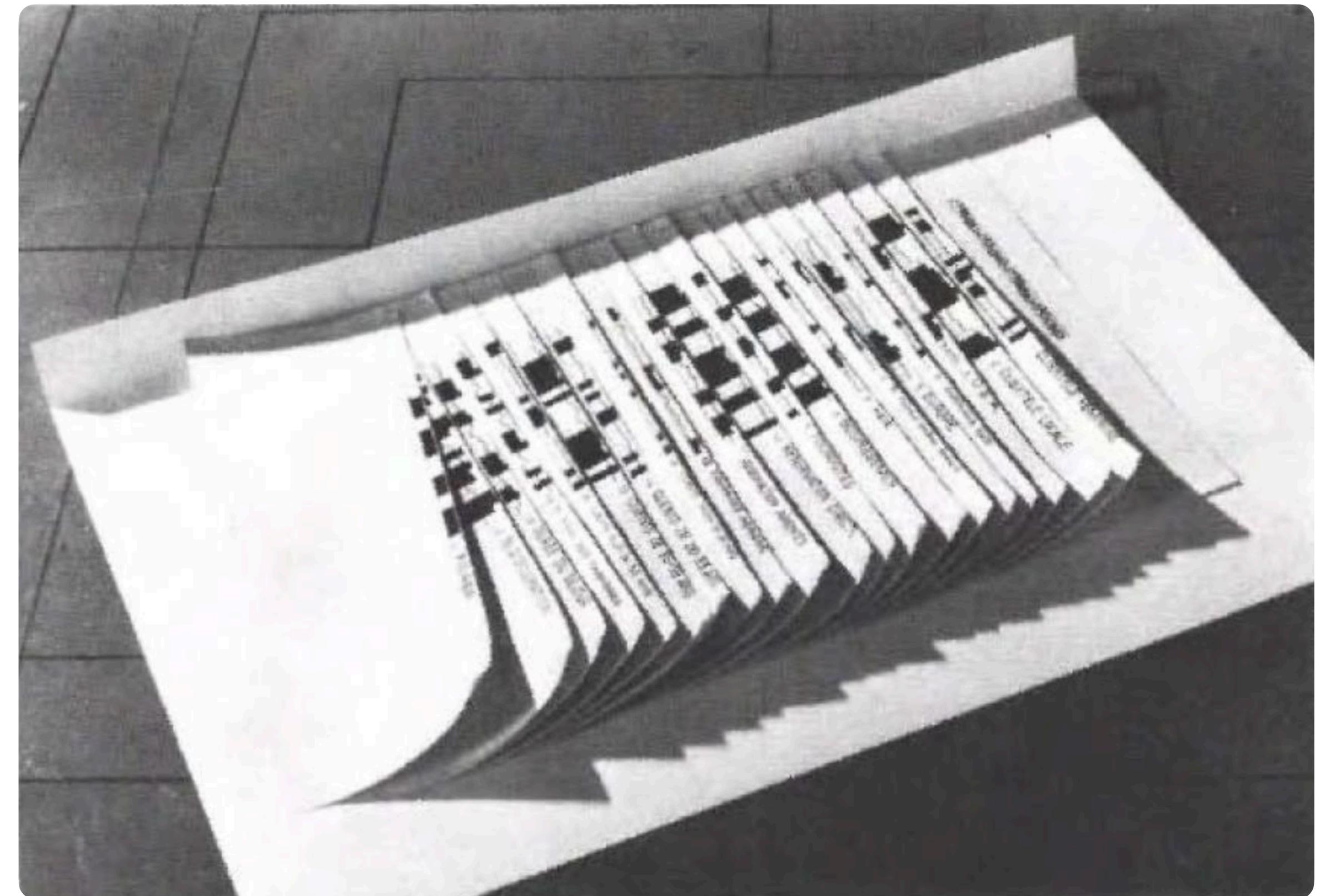
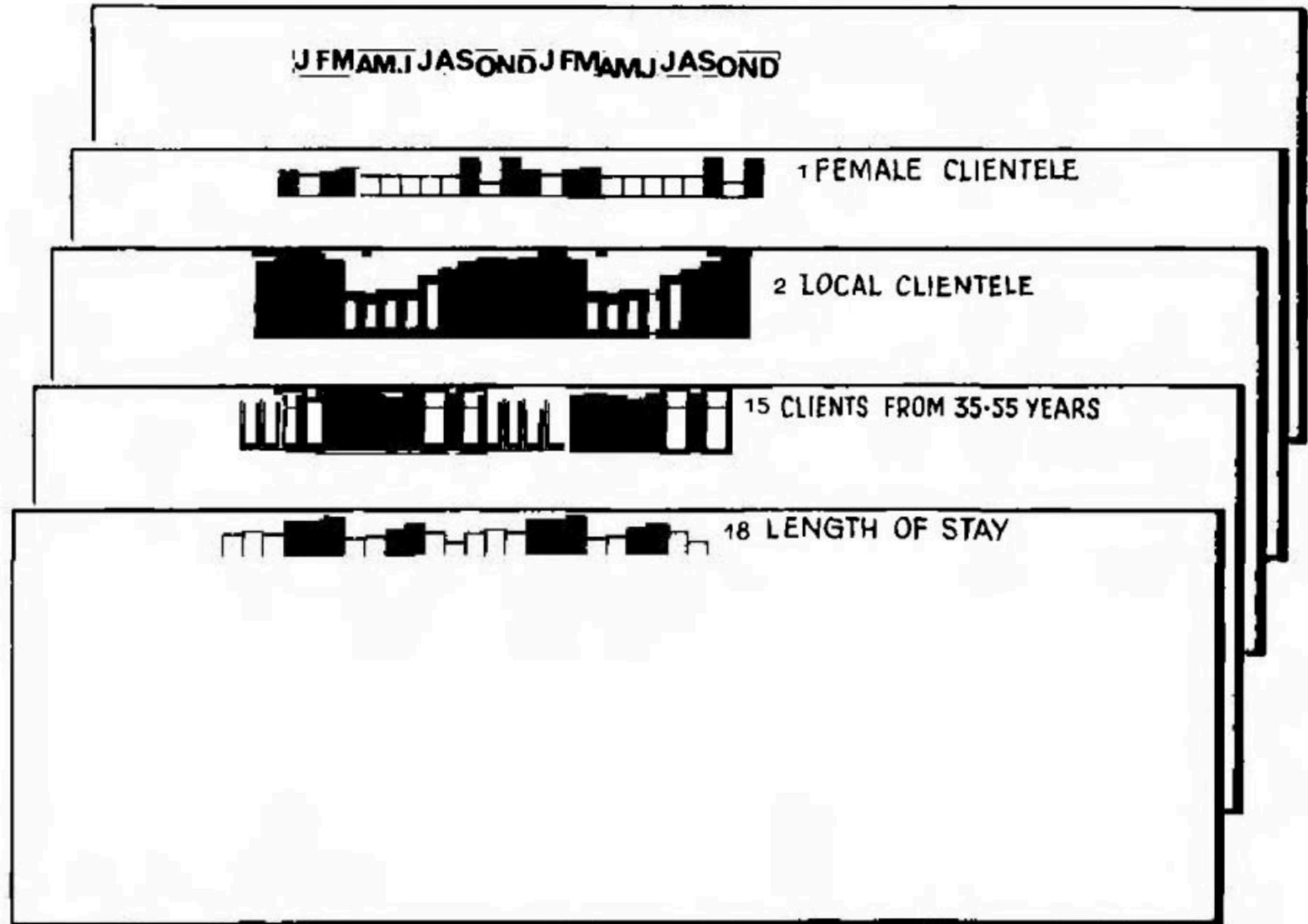
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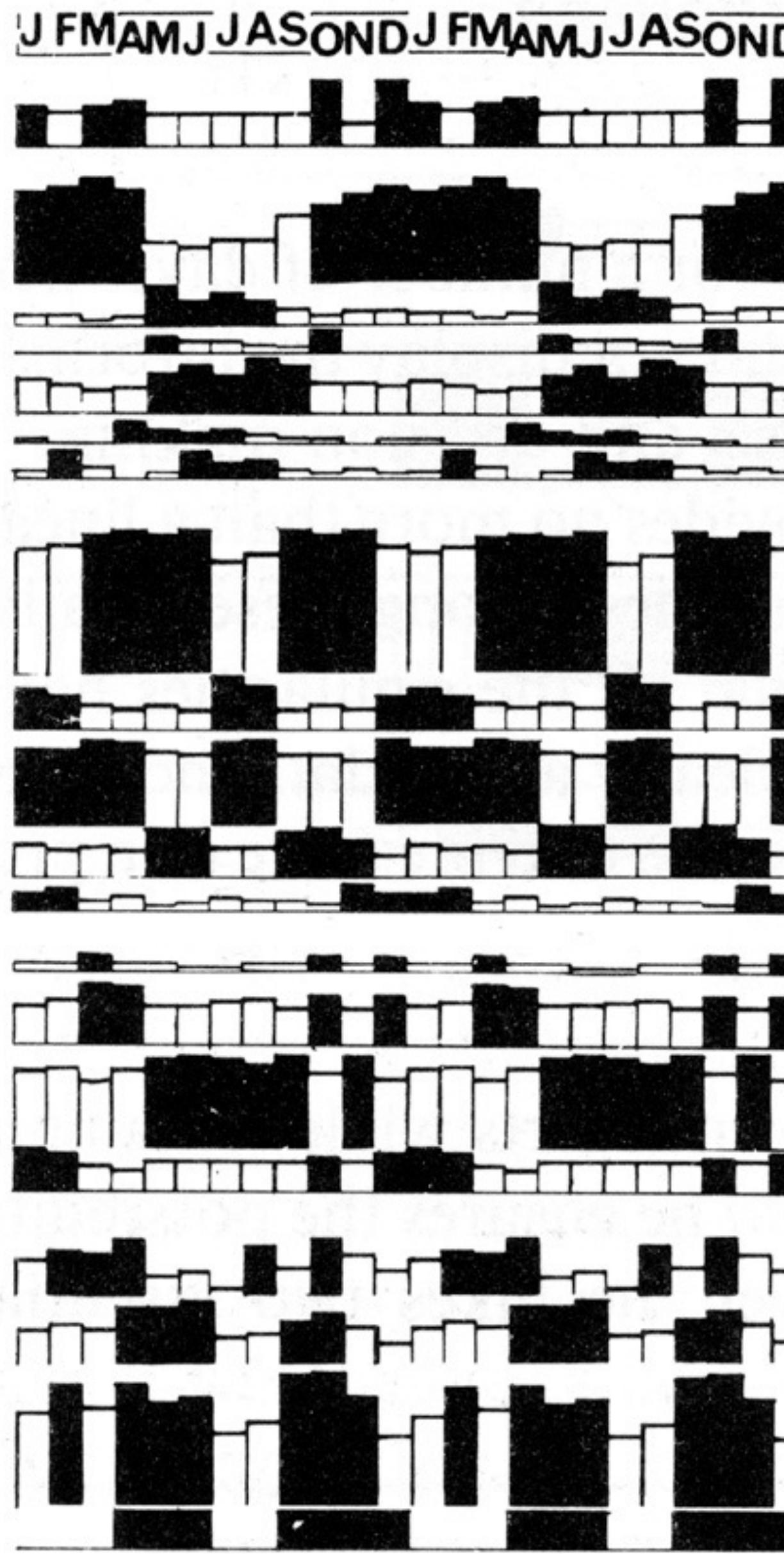
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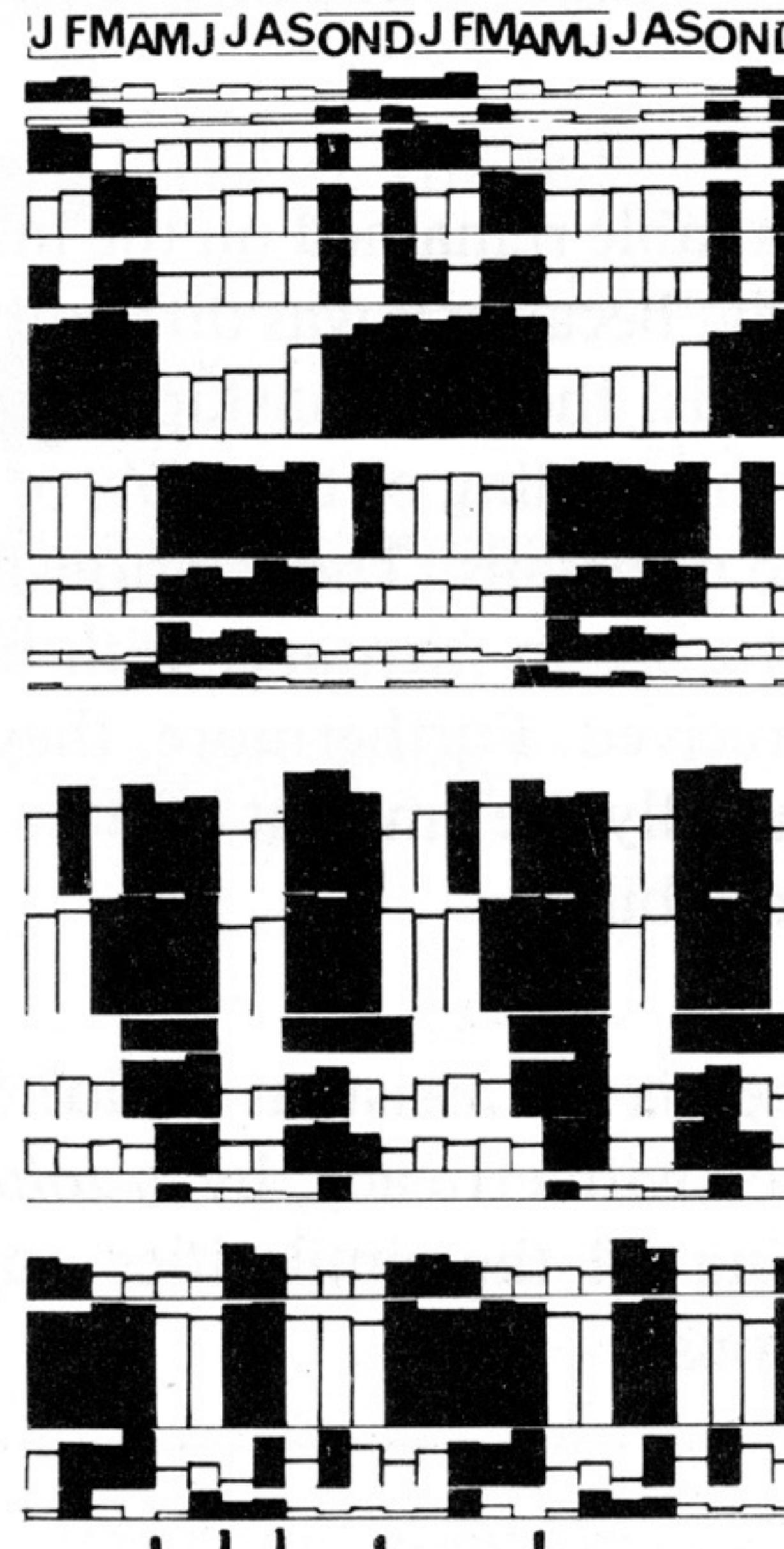




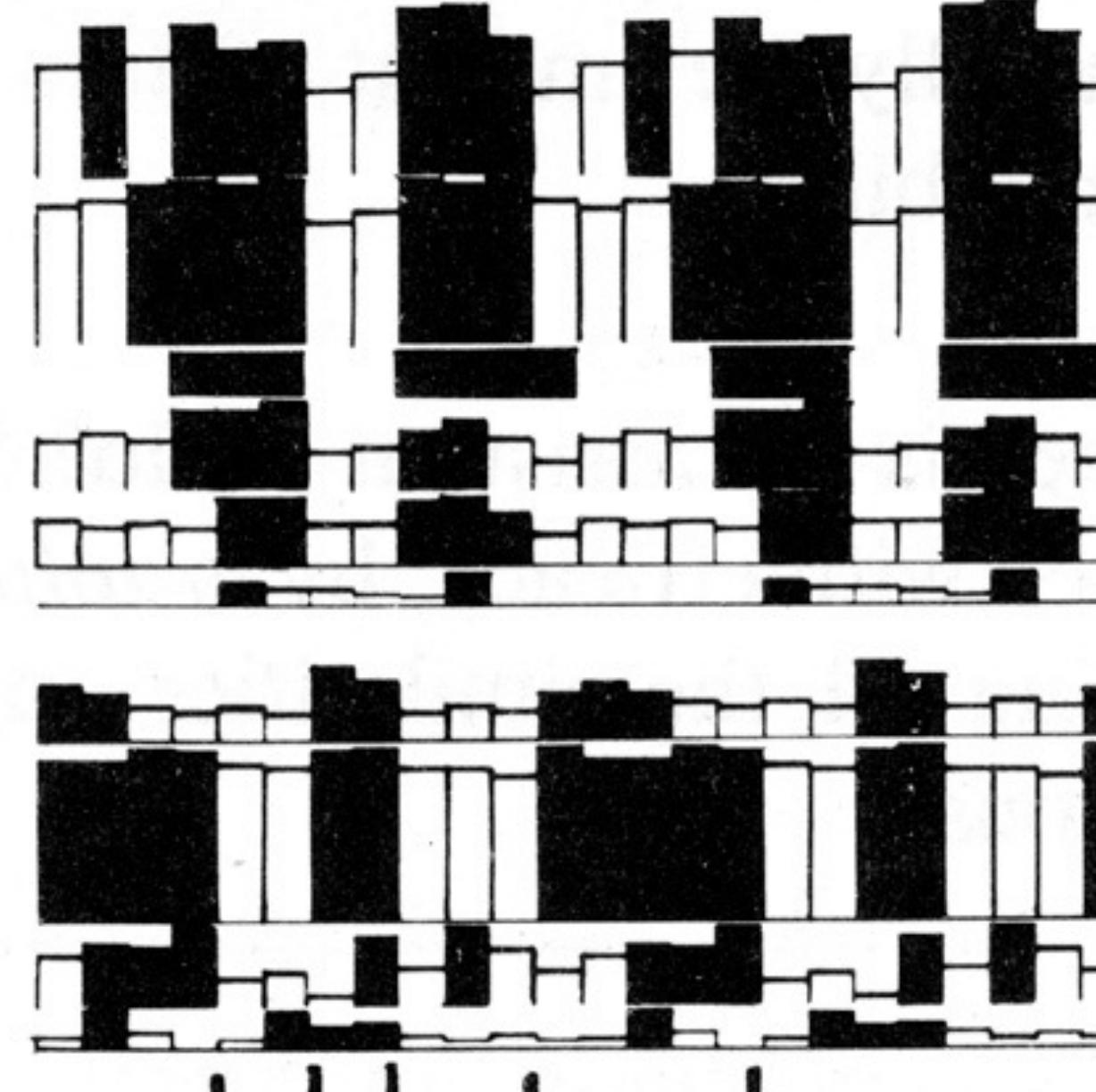
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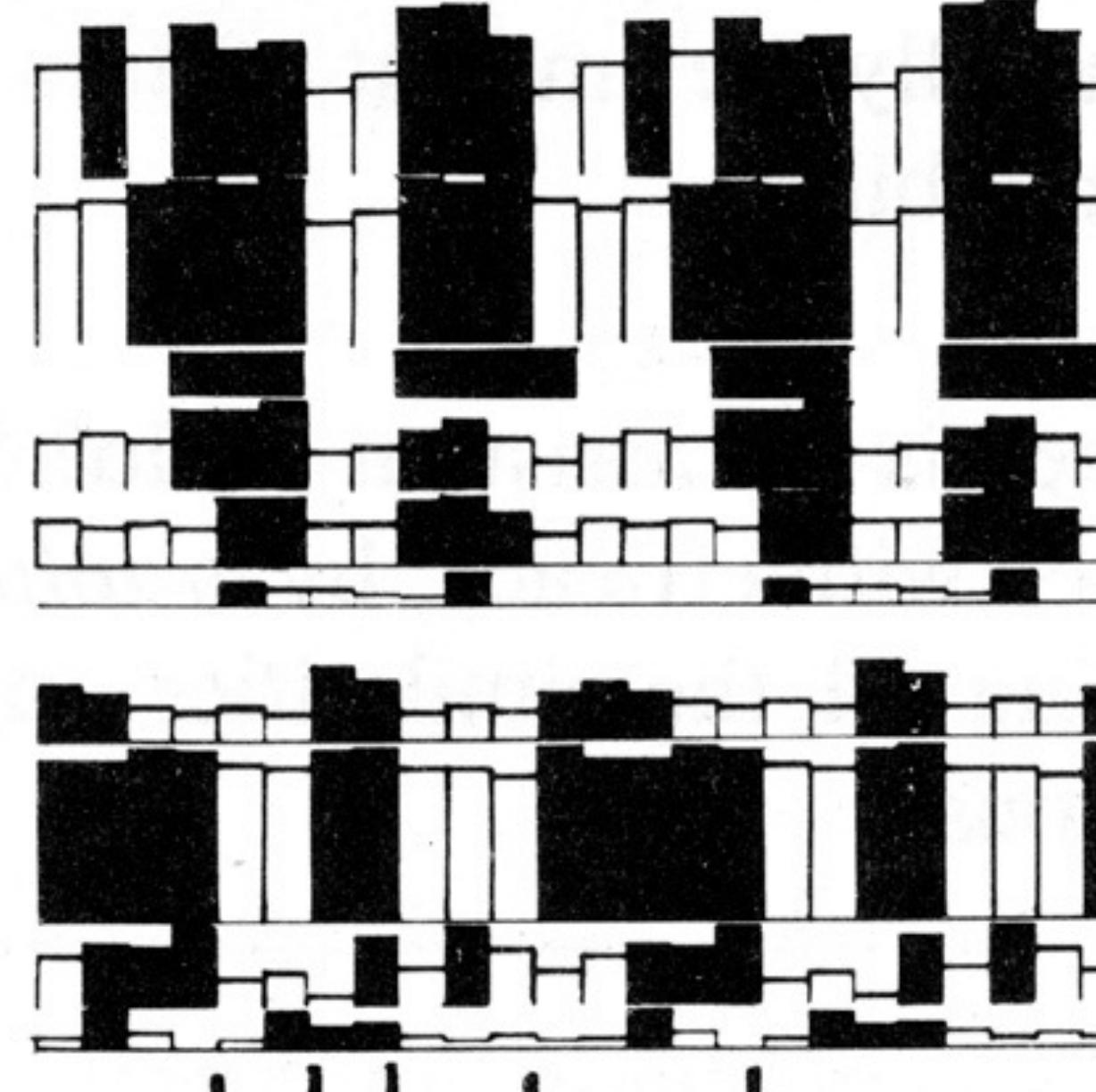
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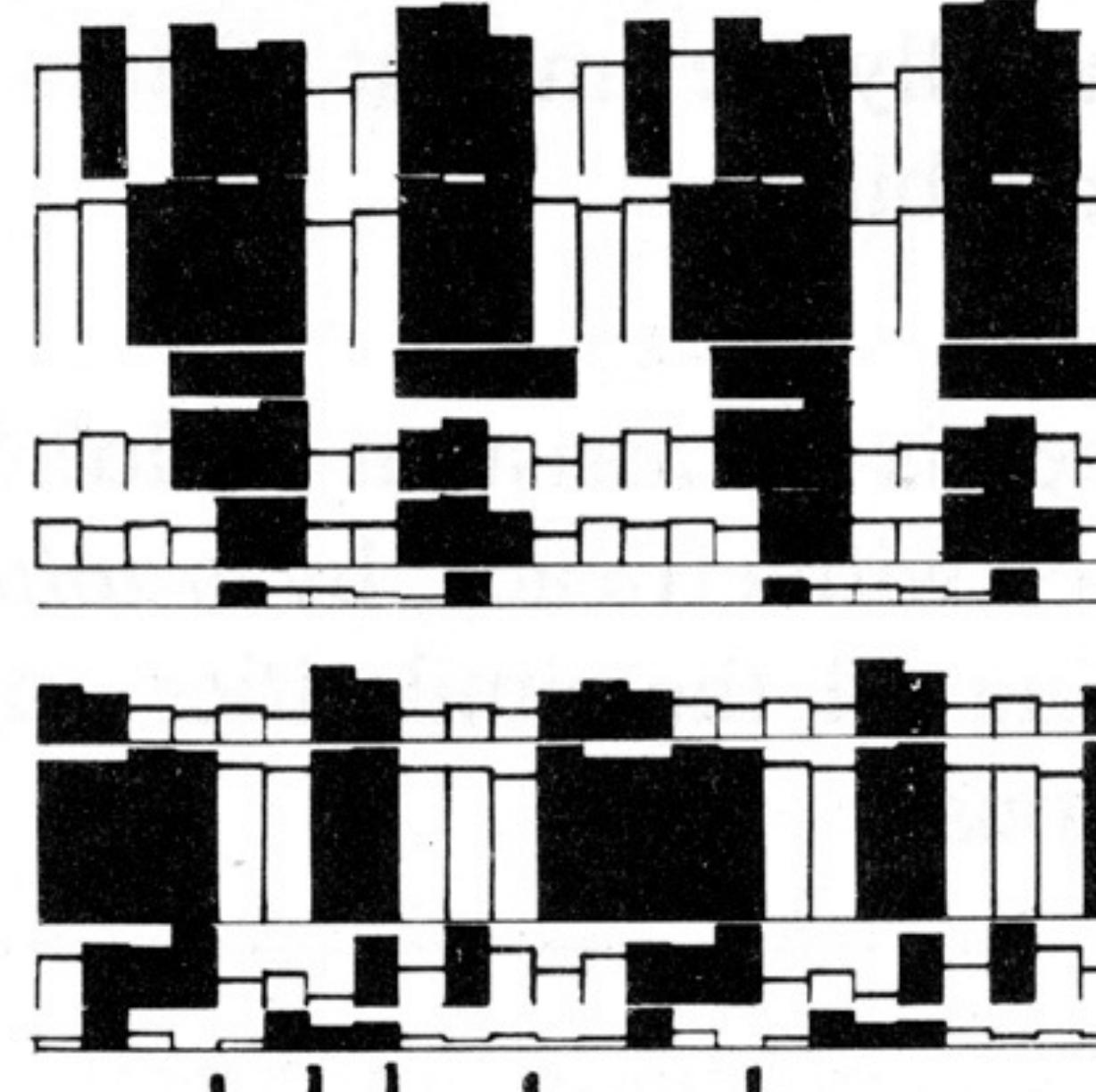
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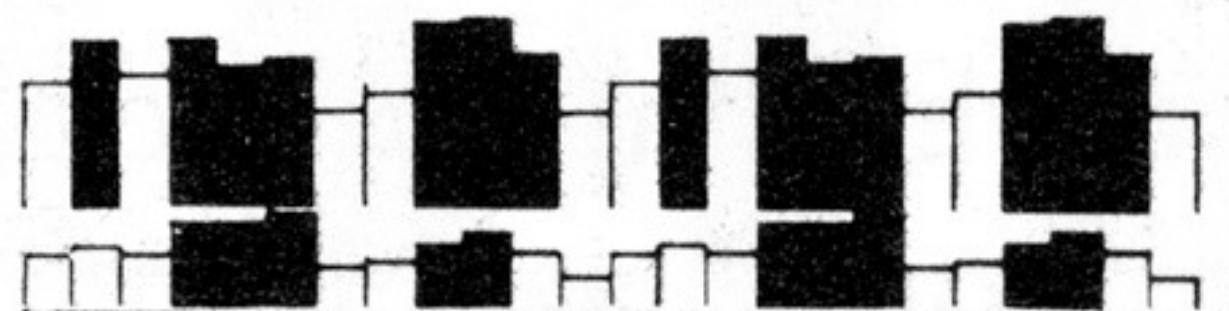
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5

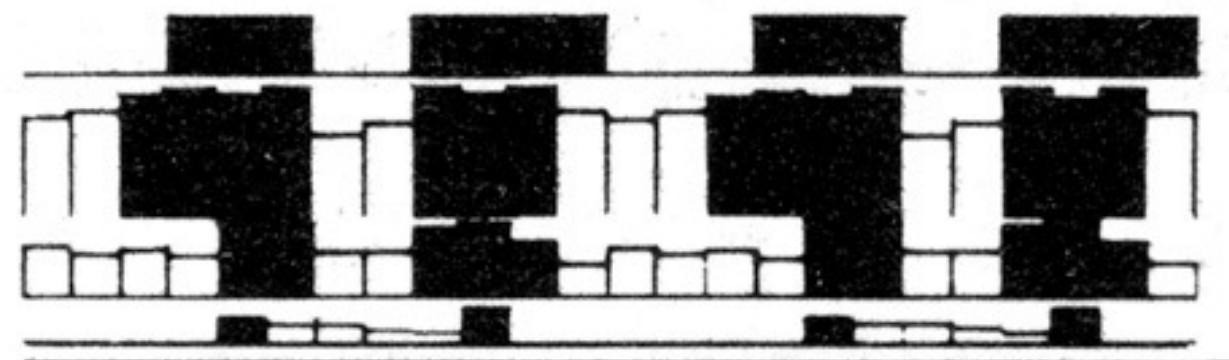


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18 % OCCUPANCY

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20 CONVENTIONS

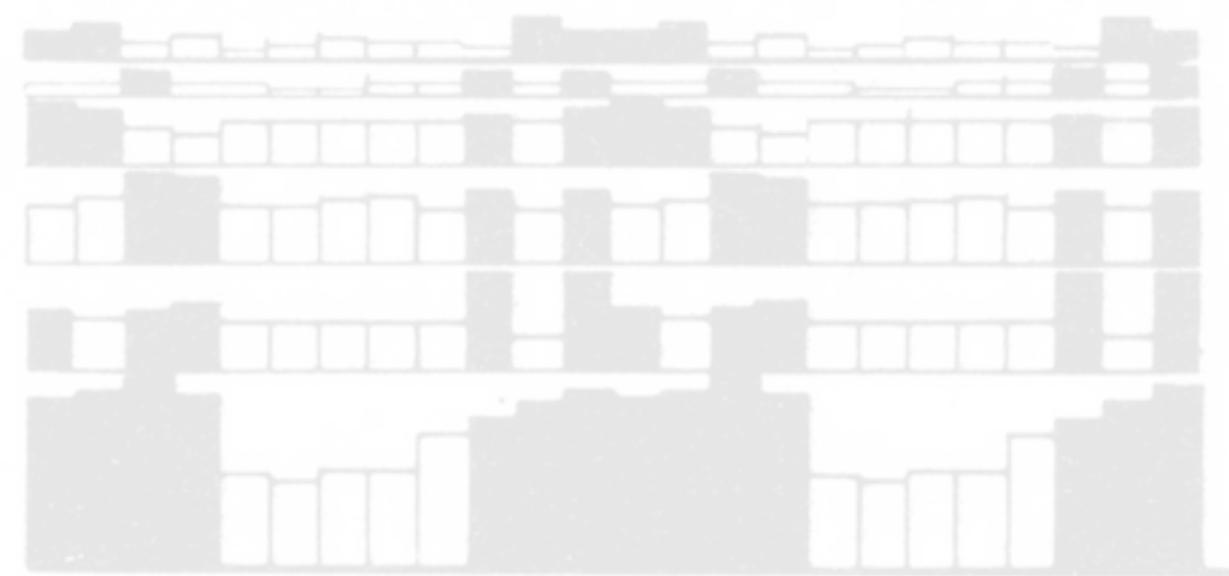
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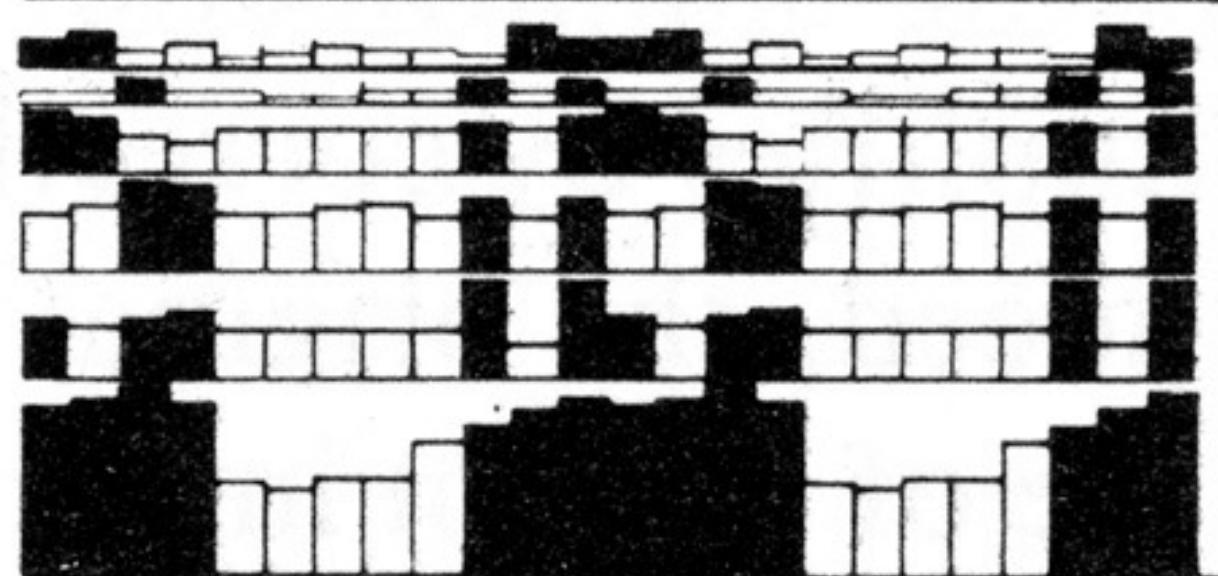
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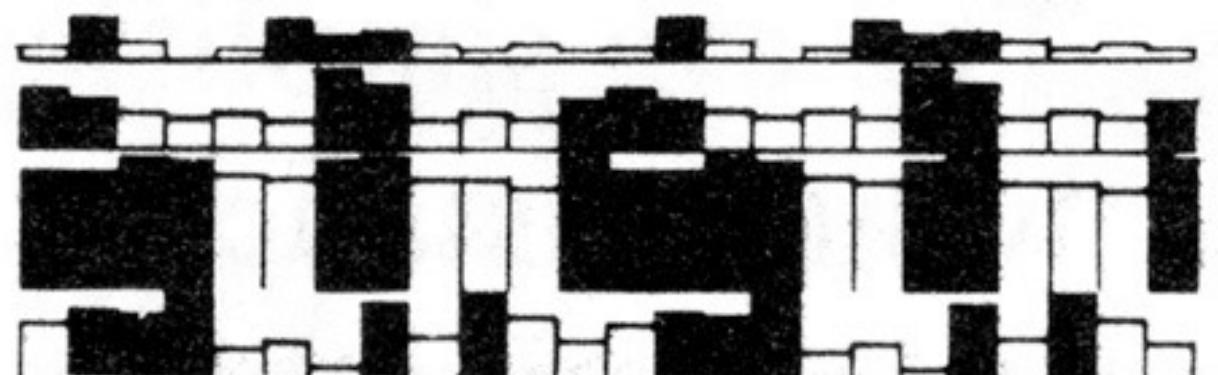
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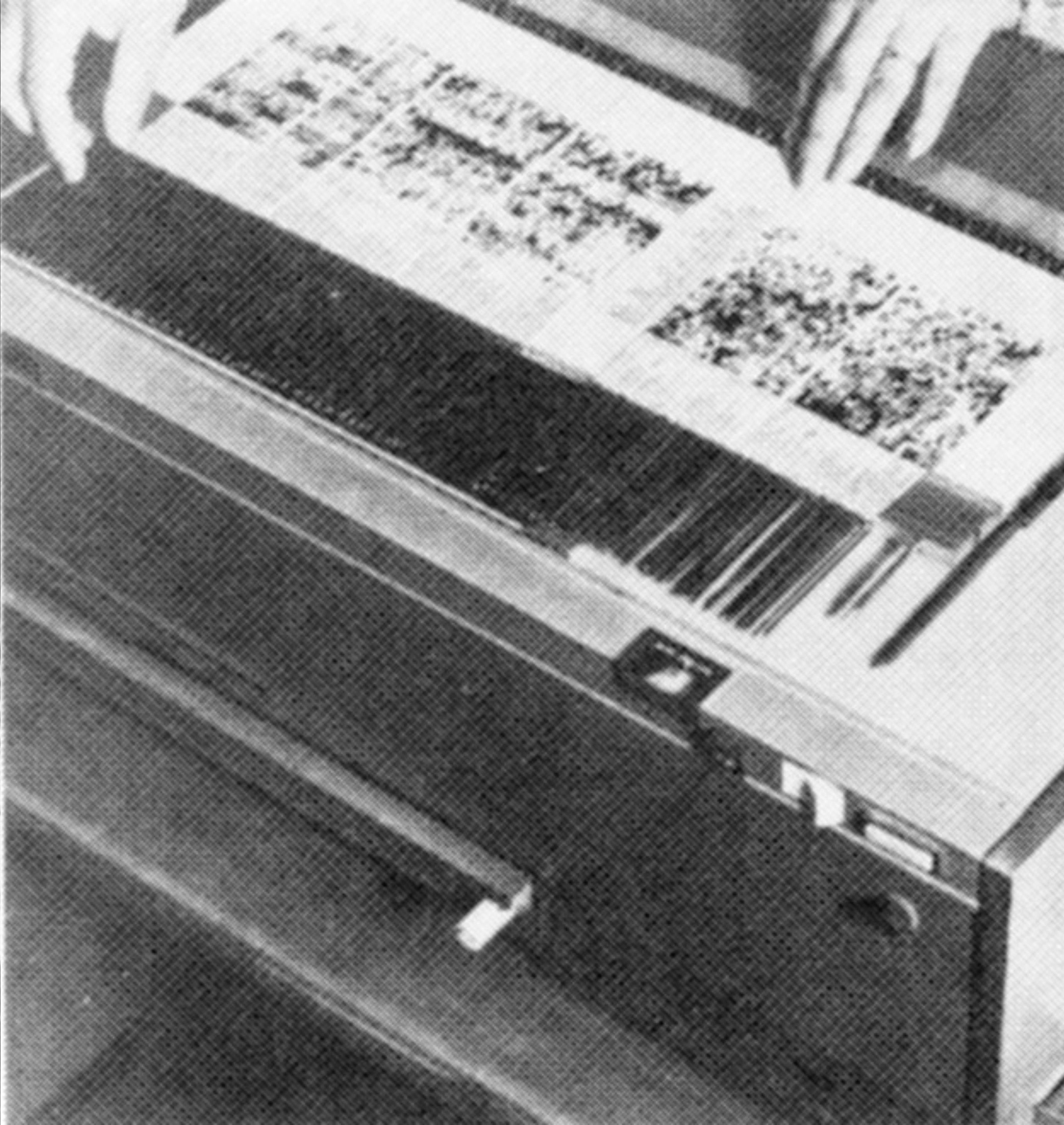
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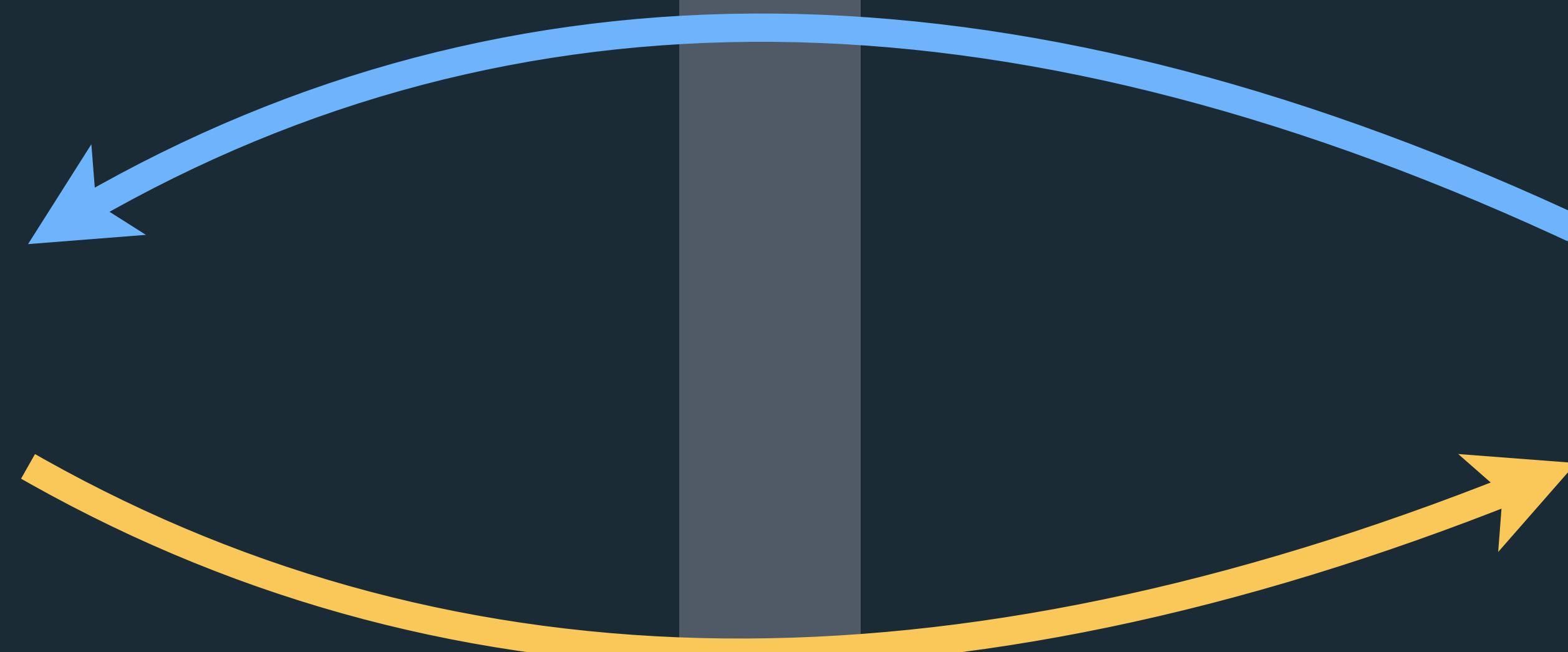


Gulf of Evaluation

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



User Goals



Interface

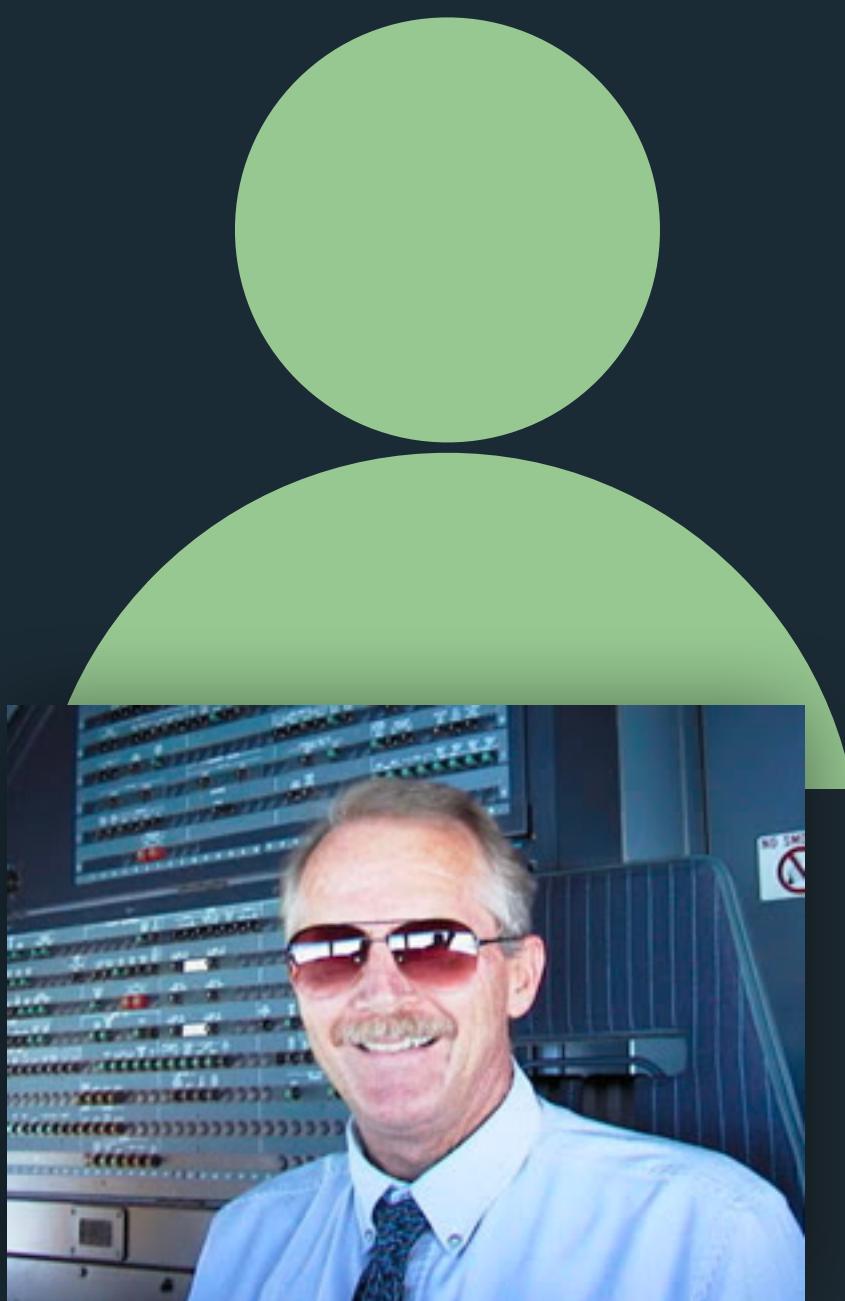
Gulf of Execution

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

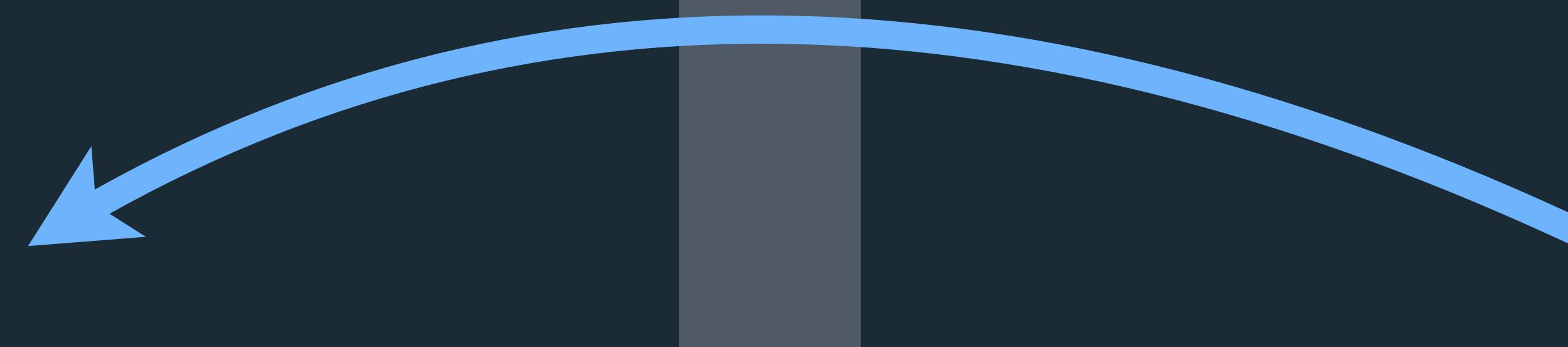


Gulf of Evaluation

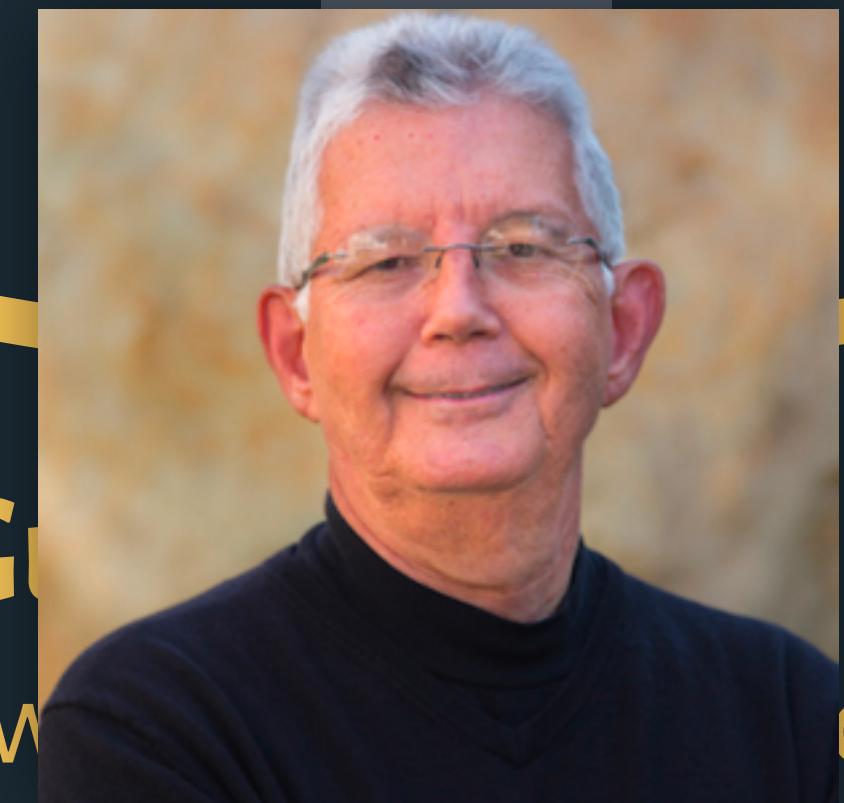
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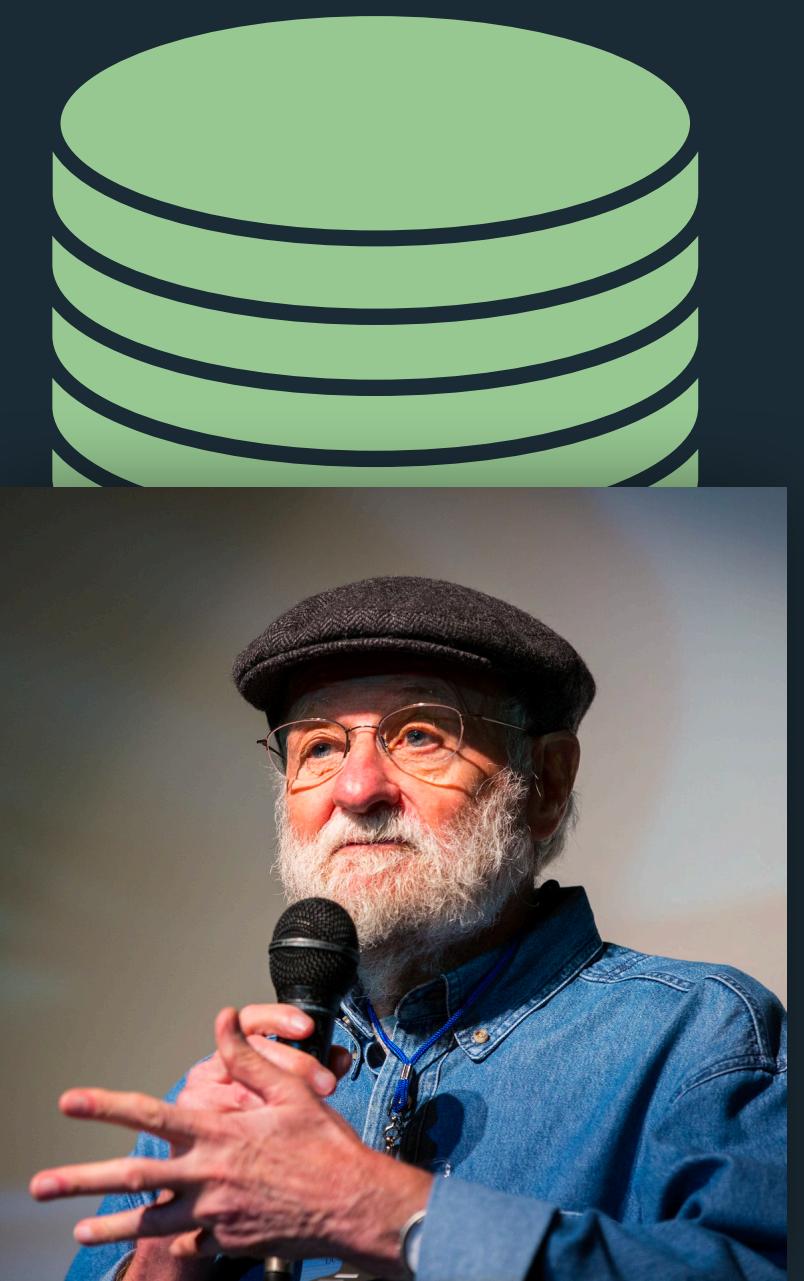
Edwin Hutchins



Gulf of Evaluation
The gap between the user's ability to achieve their goals and their understanding of how to do so given the system.



Jim Hollan



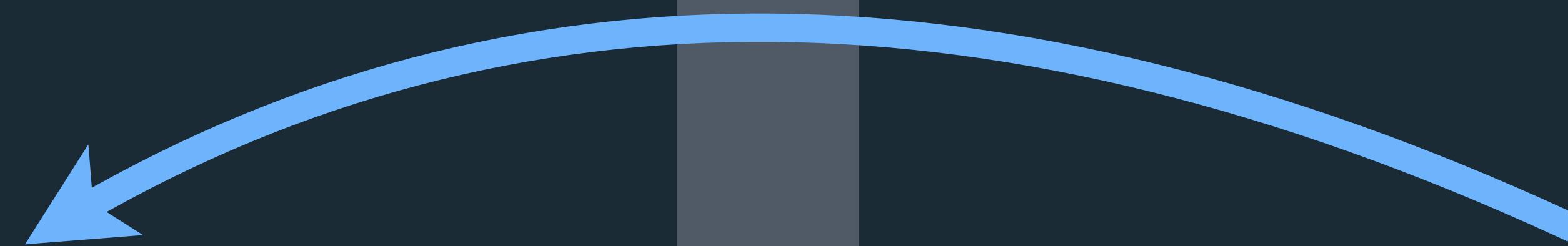
Don Norman

Gulf of Evaluation

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



User Goals



Interface

Gulf of Execution

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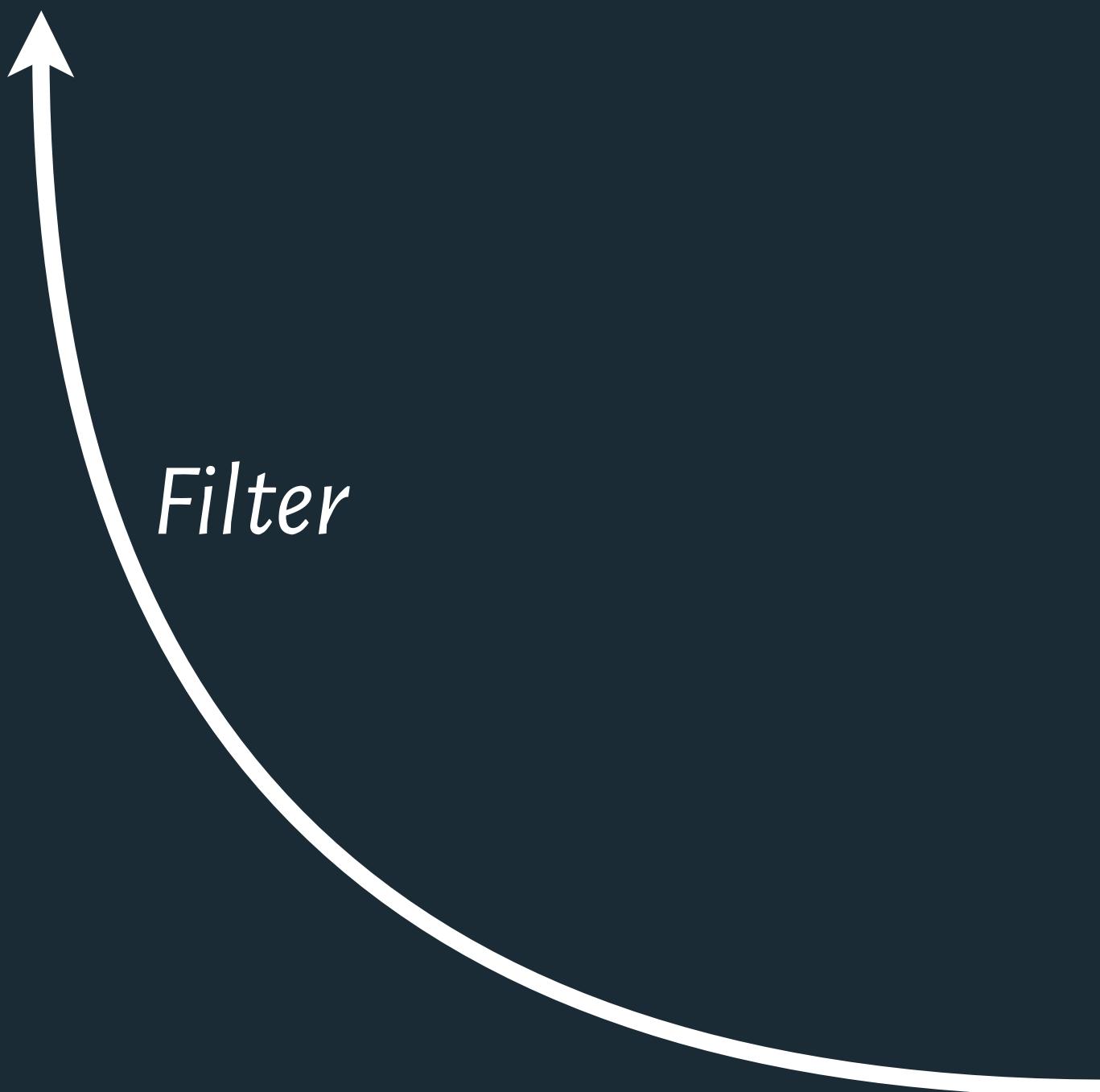
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10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

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]
```



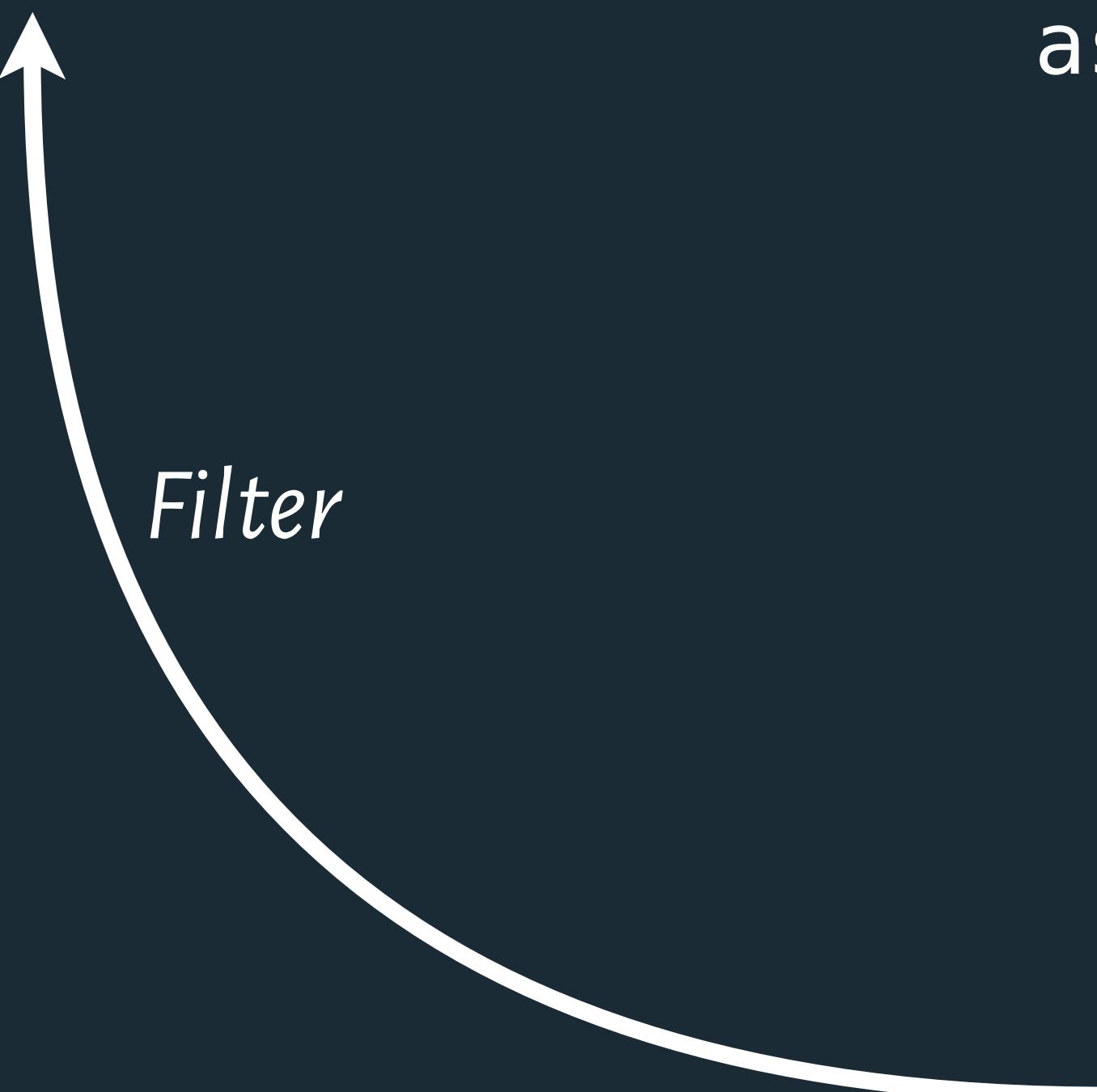
day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

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

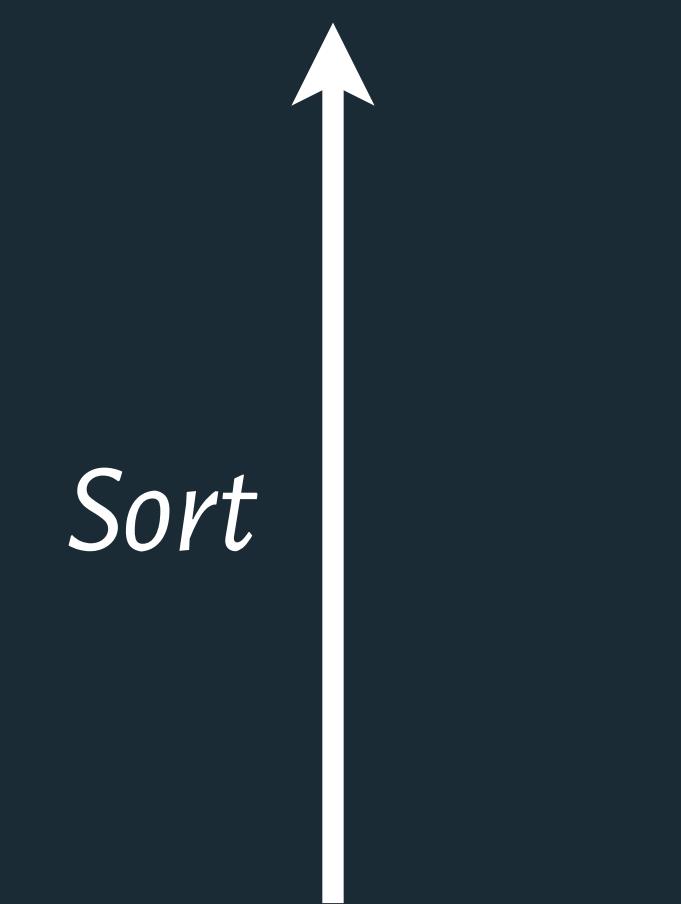
day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45

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

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



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



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	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45
10/3	MSFT	74.26
10/4	MSFT	74.69

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

Sort

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')
```

symbol	avg(price)
AMZN	961.275
MSFT	74.475

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

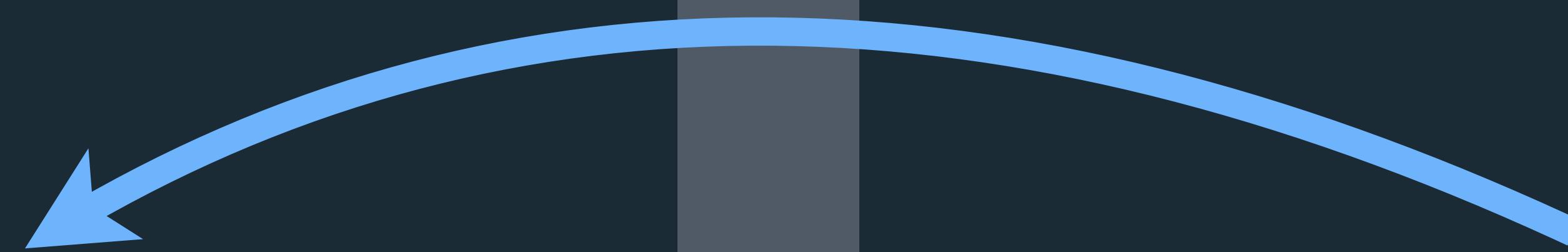
*"Small Multiples" +
Aggregation*

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.



User Goals

Gulf of Evaluation



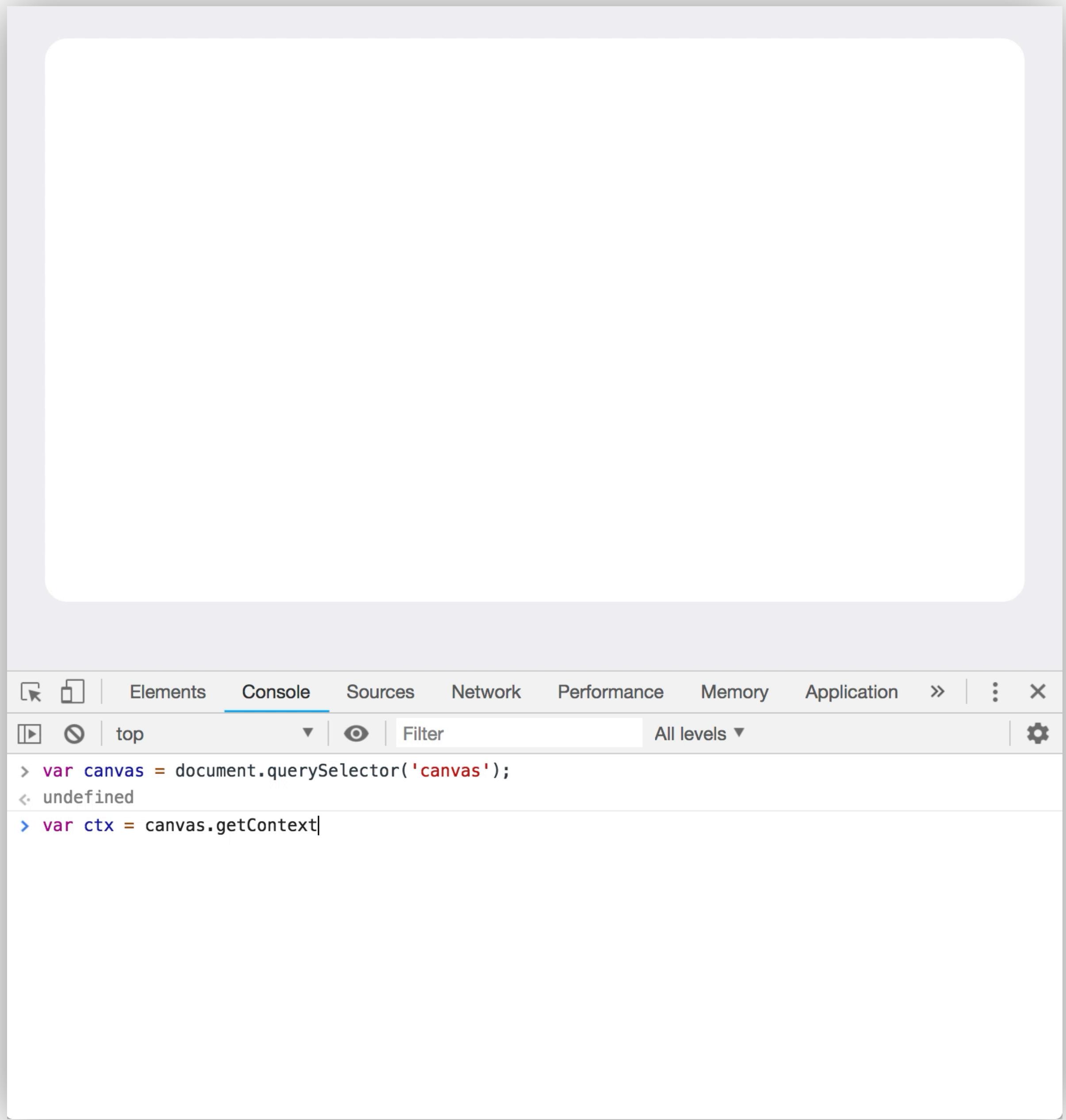
Python



Interface

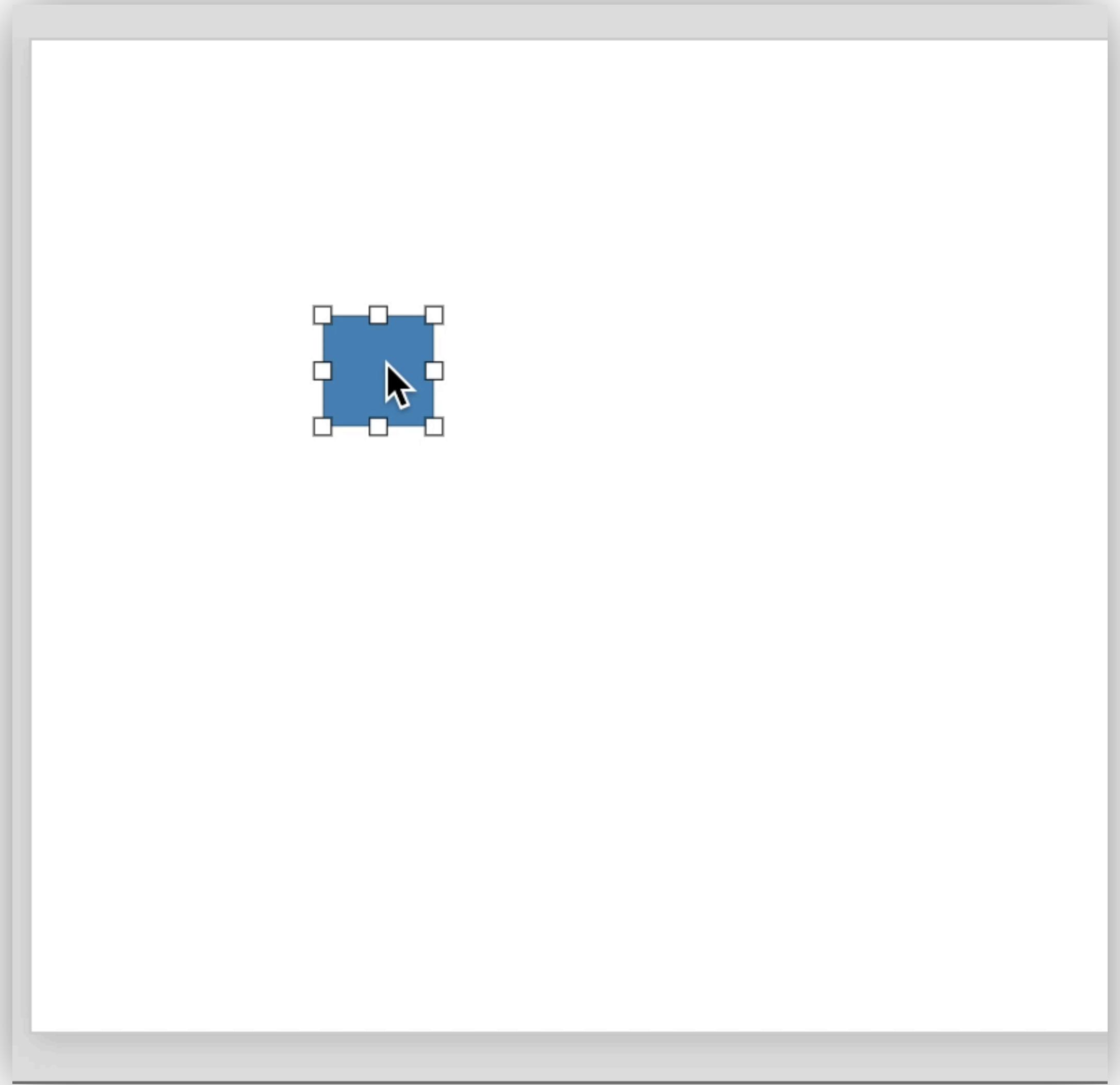
Gulf of Execution

- ✗ Results returned as a table.
 - ✗ No hint on how to reformulate query.
 - ✗ Slow question-answer loop.
- ✗ A rigid syntax designed by/for programmers.
 - ✗ Difficult to do "fuzzy" matching.



The screenshot shows the Chrome DevTools interface with the "Console" tab selected. The console window displays the following JavaScript code:

```
> var canvas = document.querySelector('canvas');
< undefined
> var ctx = canvas.getContext()
```





User Goals

Gulf of Evaluation

Direct Manipulation



Interface

Gulf of Execution

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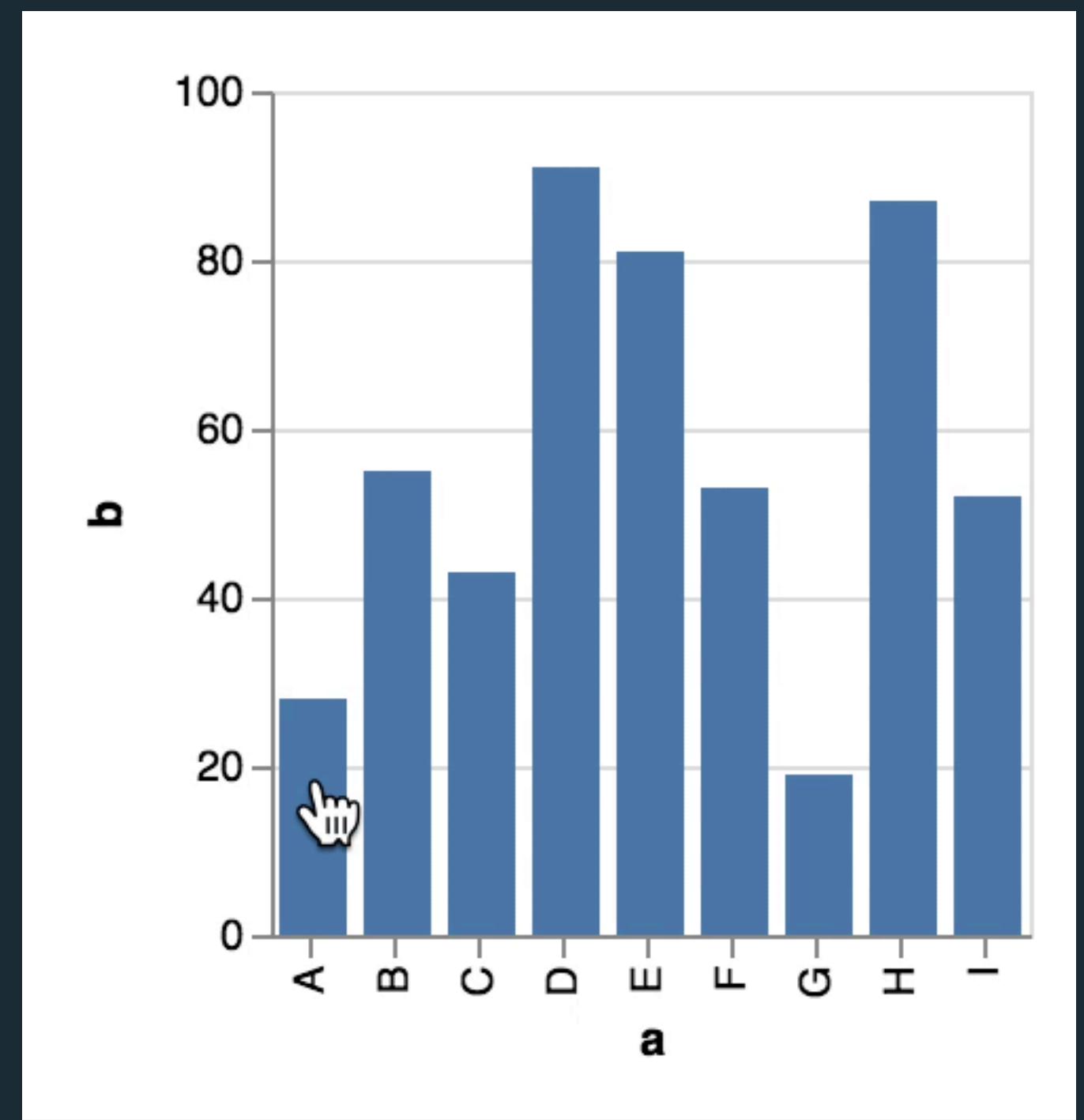
Point Selection

Select discrete data values.

Point Selection

Select discrete data values.

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

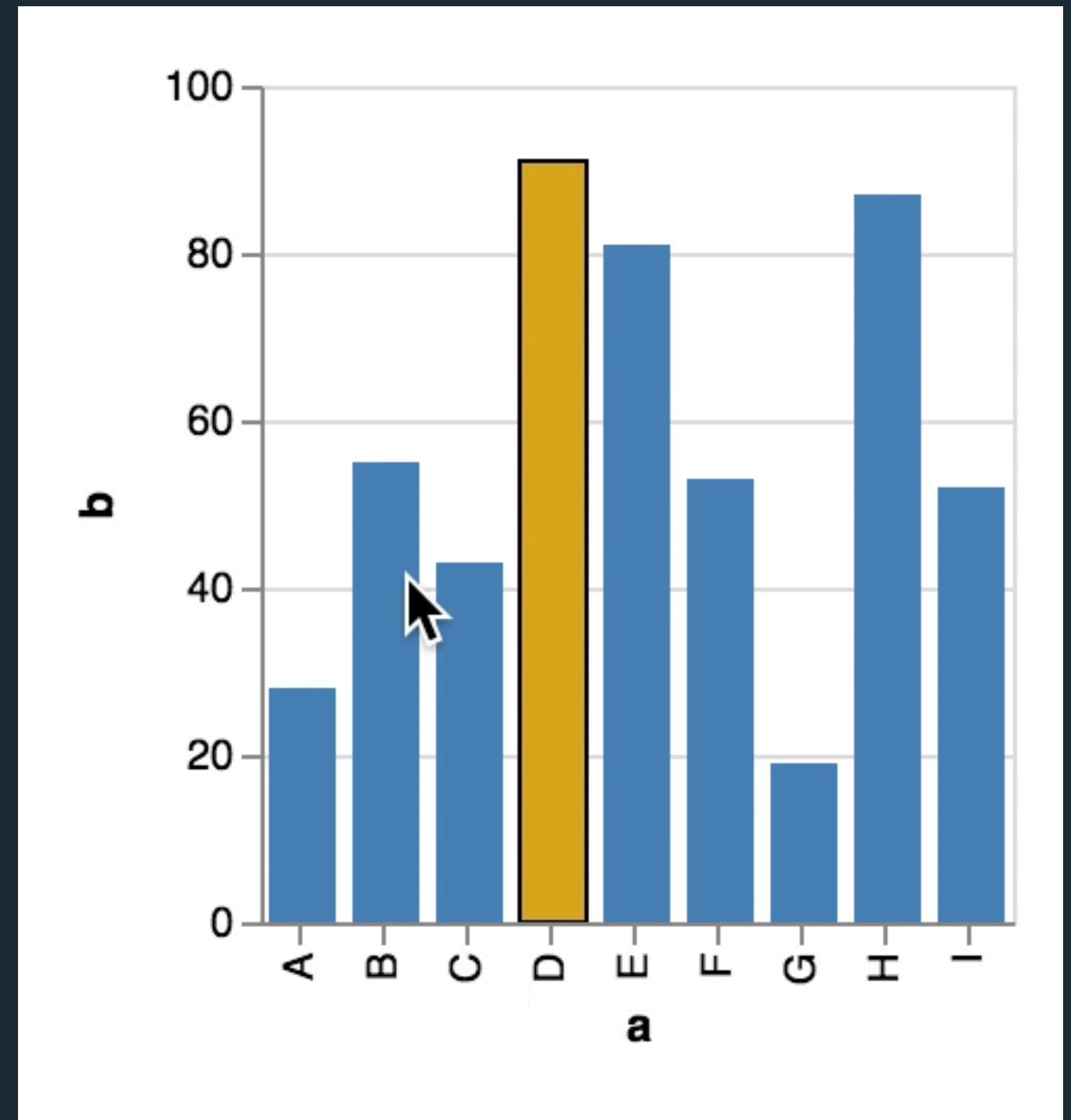


Point Selection

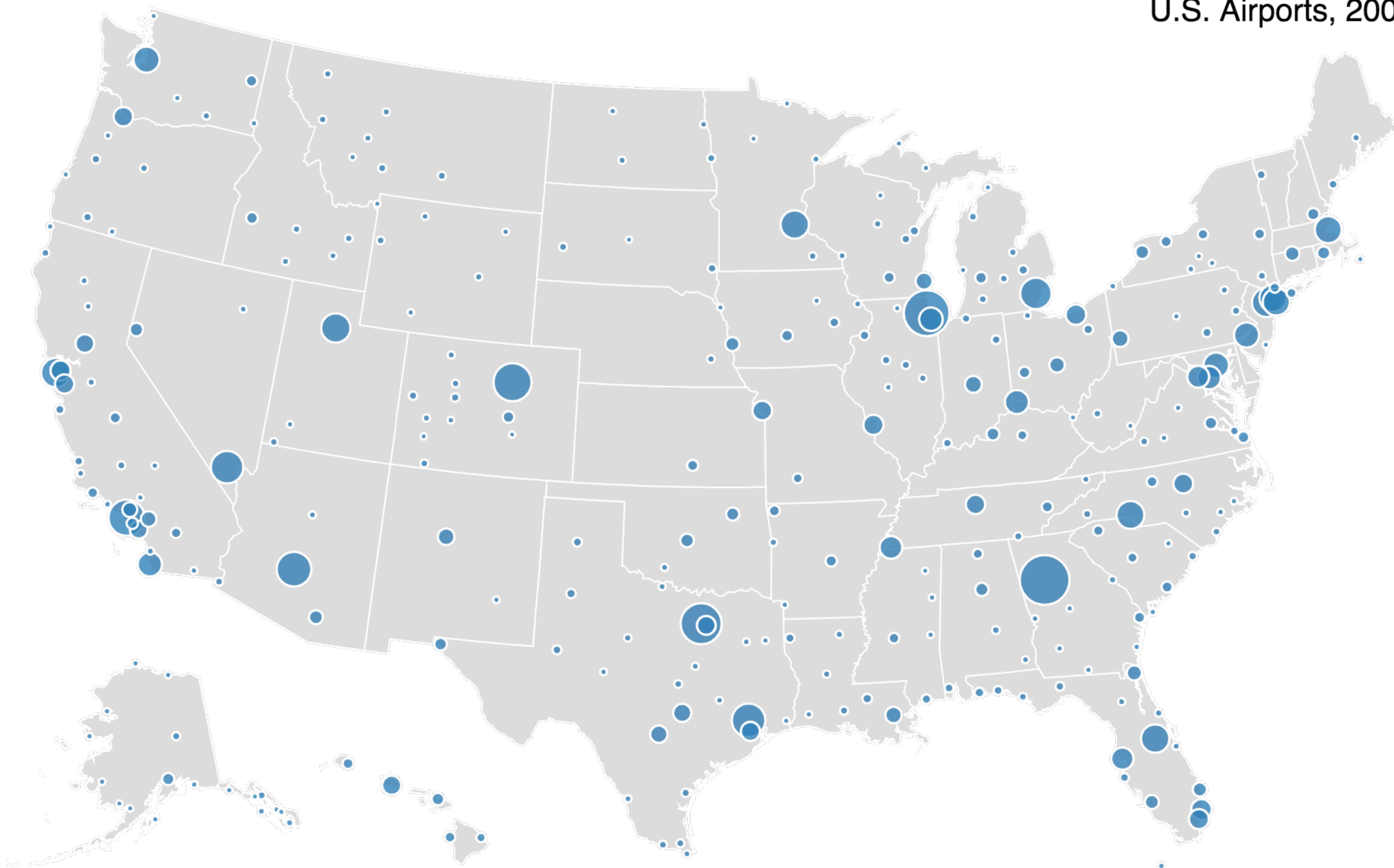
Select discrete data values.

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

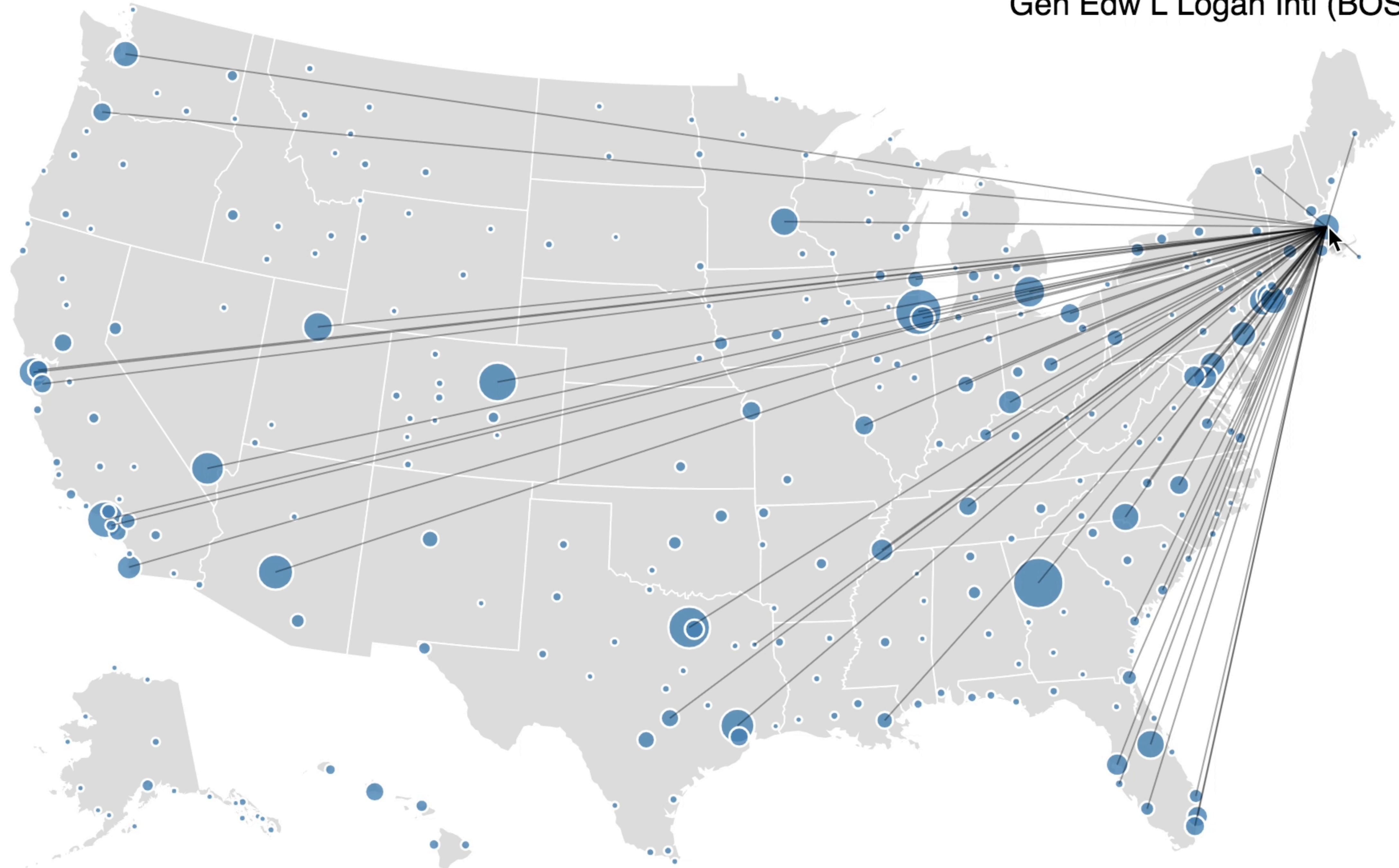
How are points selected? Mouse hover, click, tap, ...



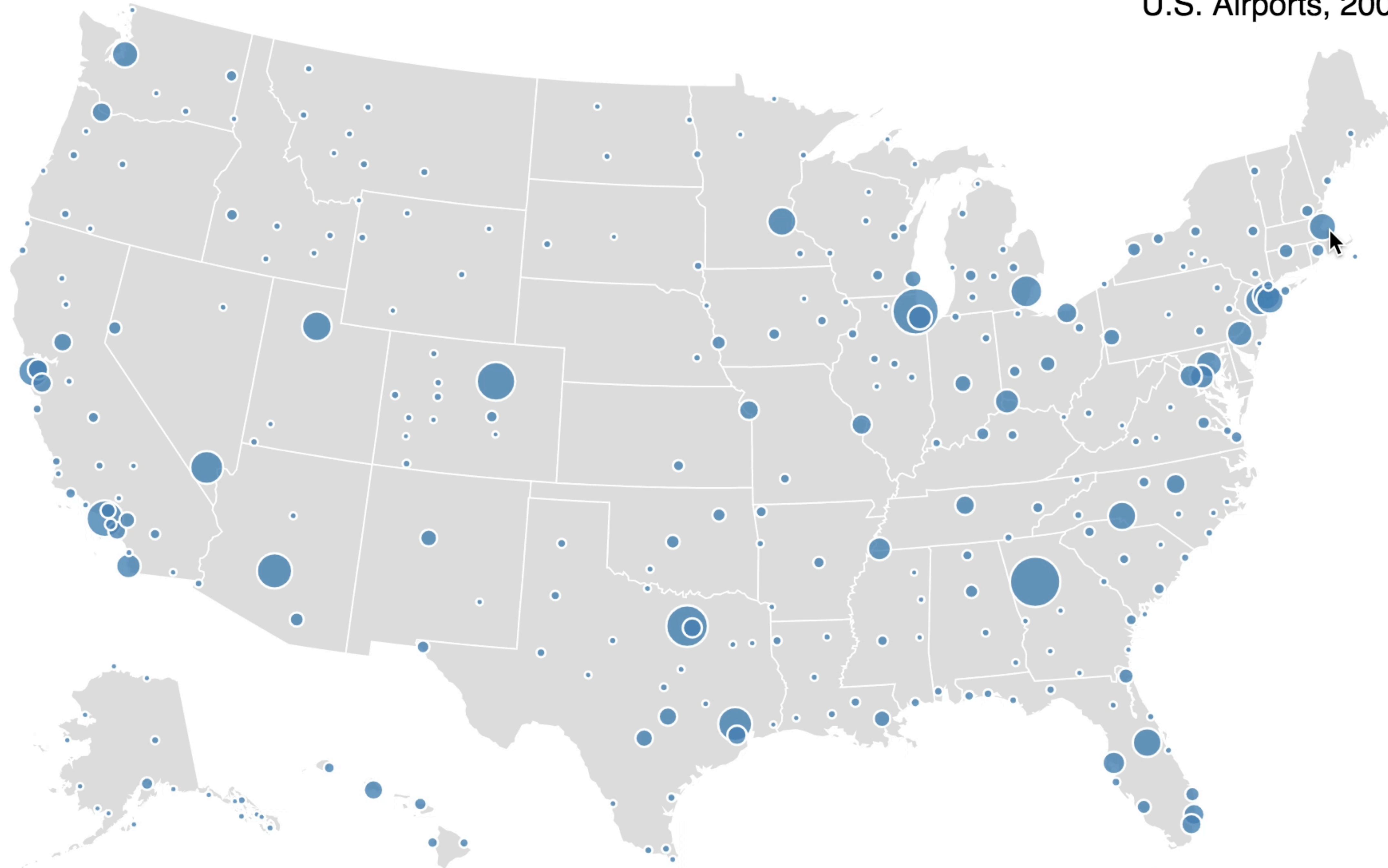
U.S. Airports, 2008



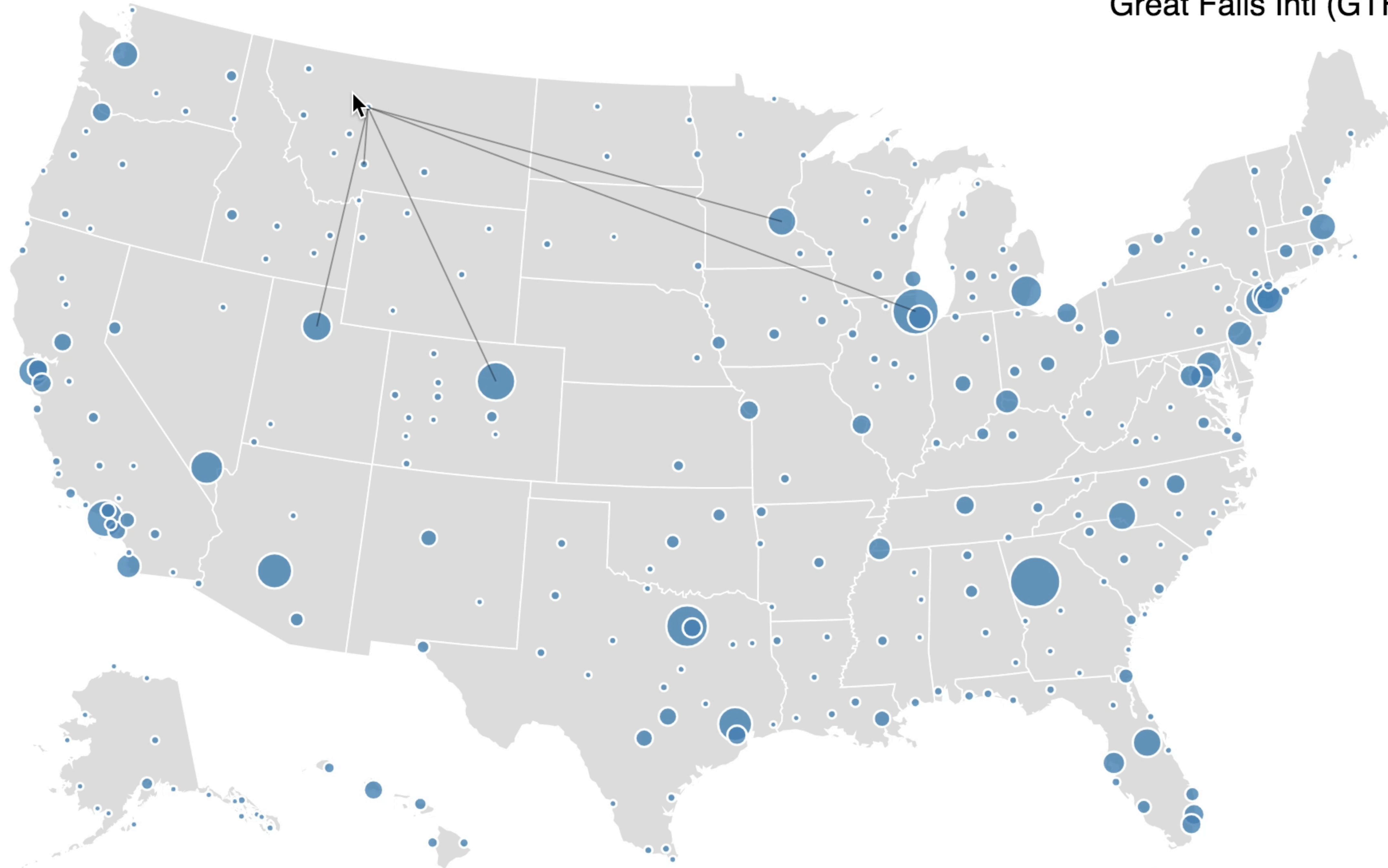
Gen Edw L Logan Intl (BOS)



U.S. Airports, 2008



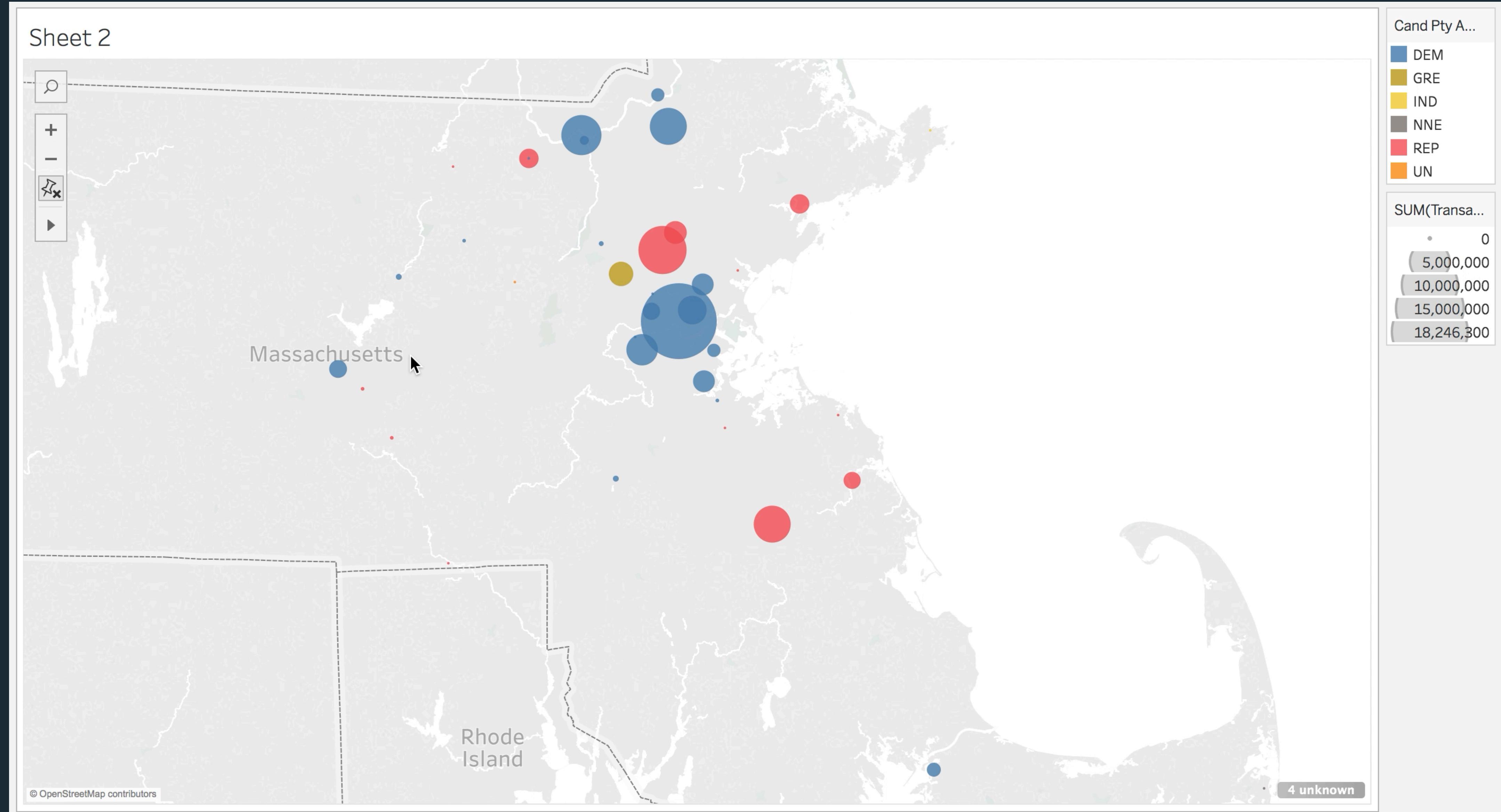
Great Falls Intl (GTF)



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

Interaction in Visualization

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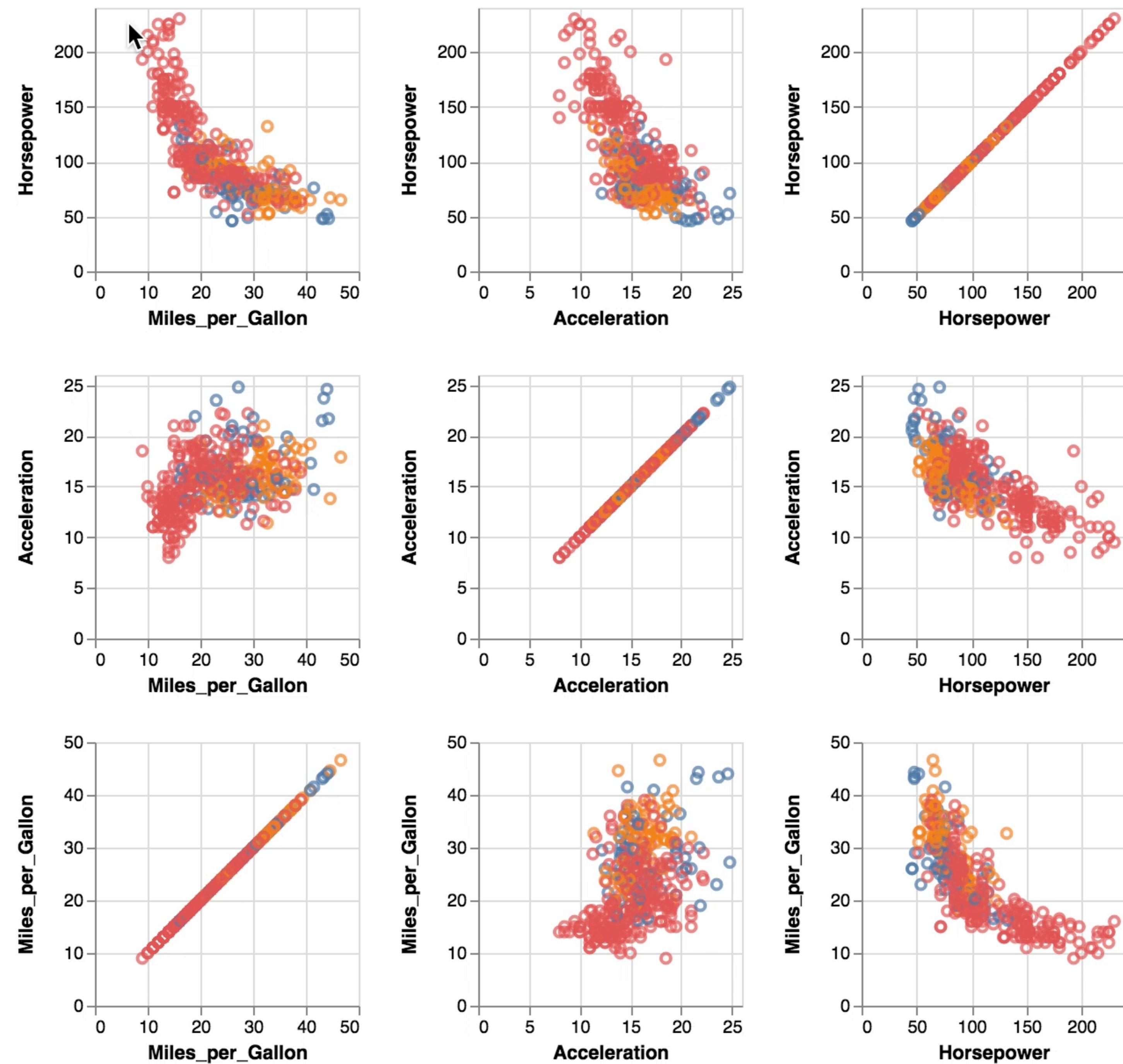
Explore show me something else.

Encode show me a different visual representation.

Connect

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

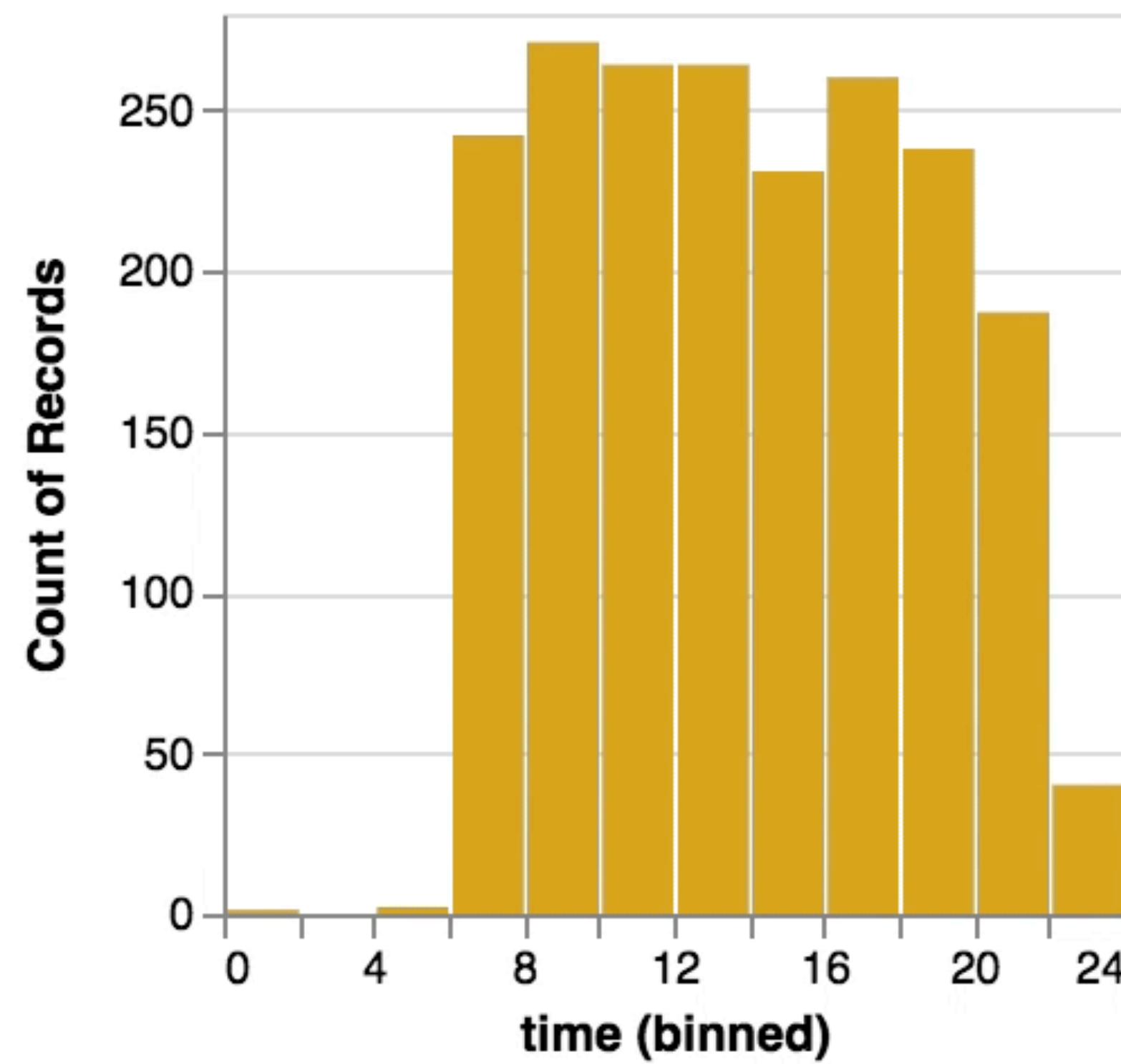
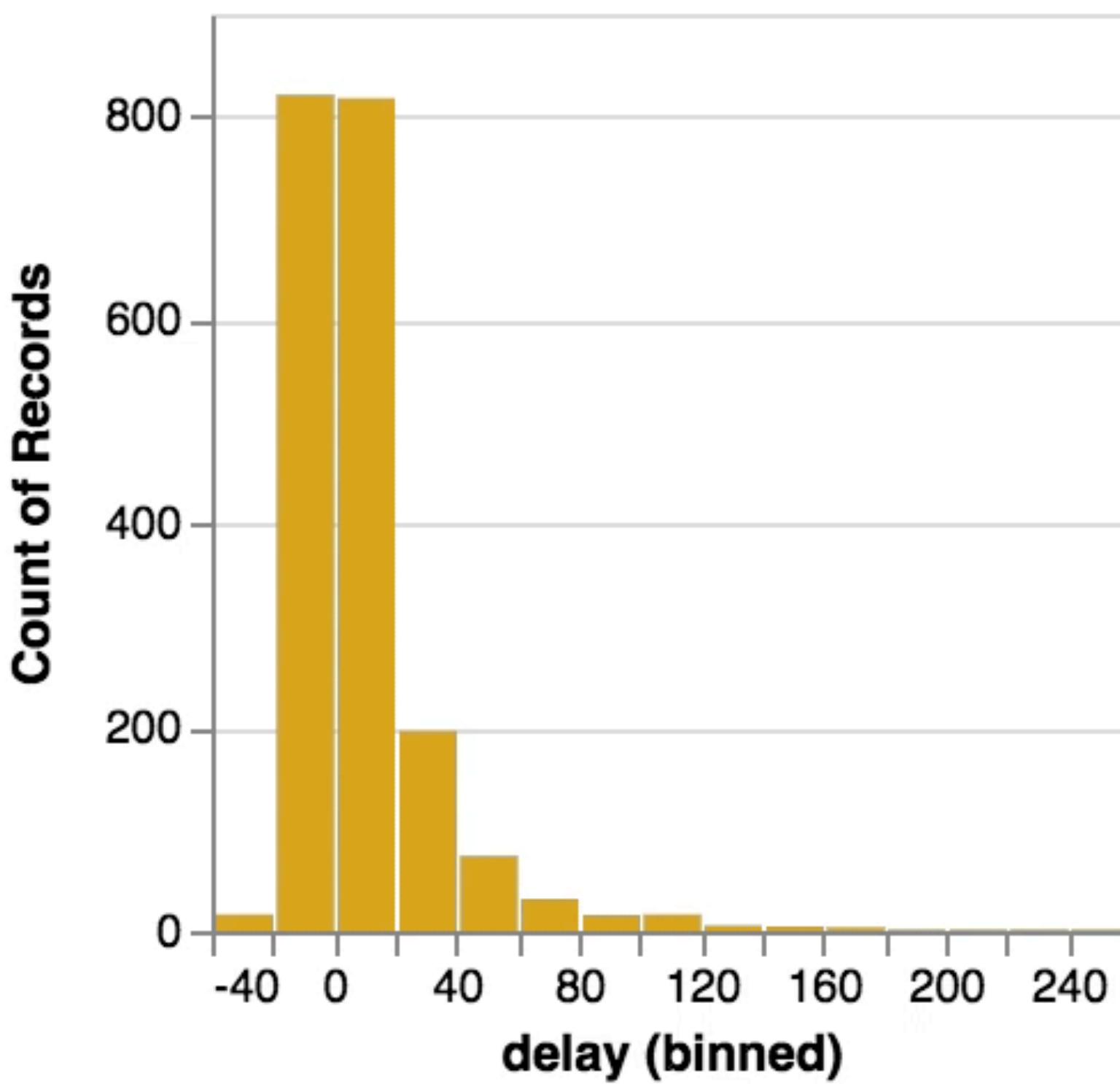
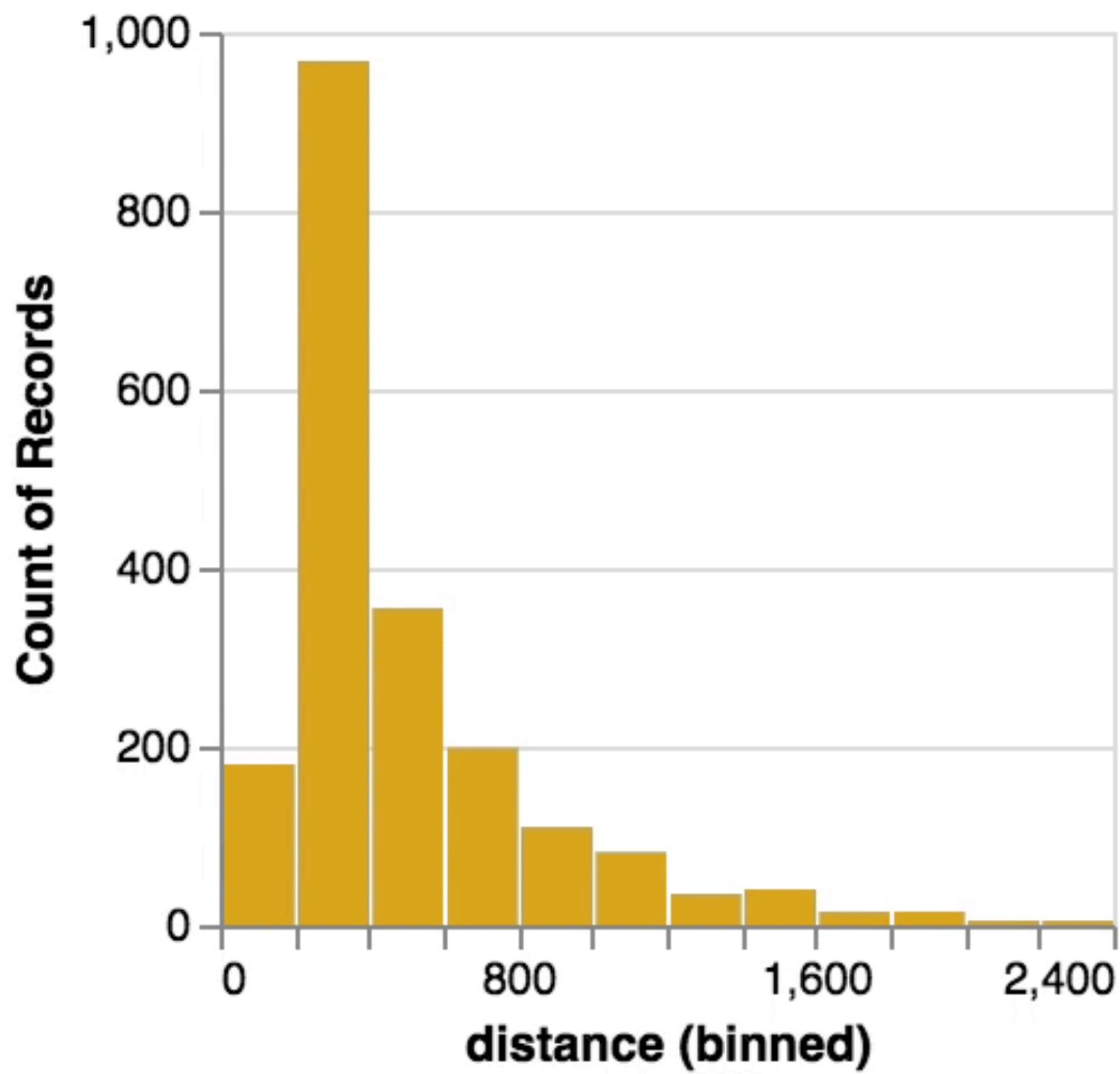
Link by *tuple* (i.e.,
explicitly identify and
match the same data
values across every
view).



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).



Connect

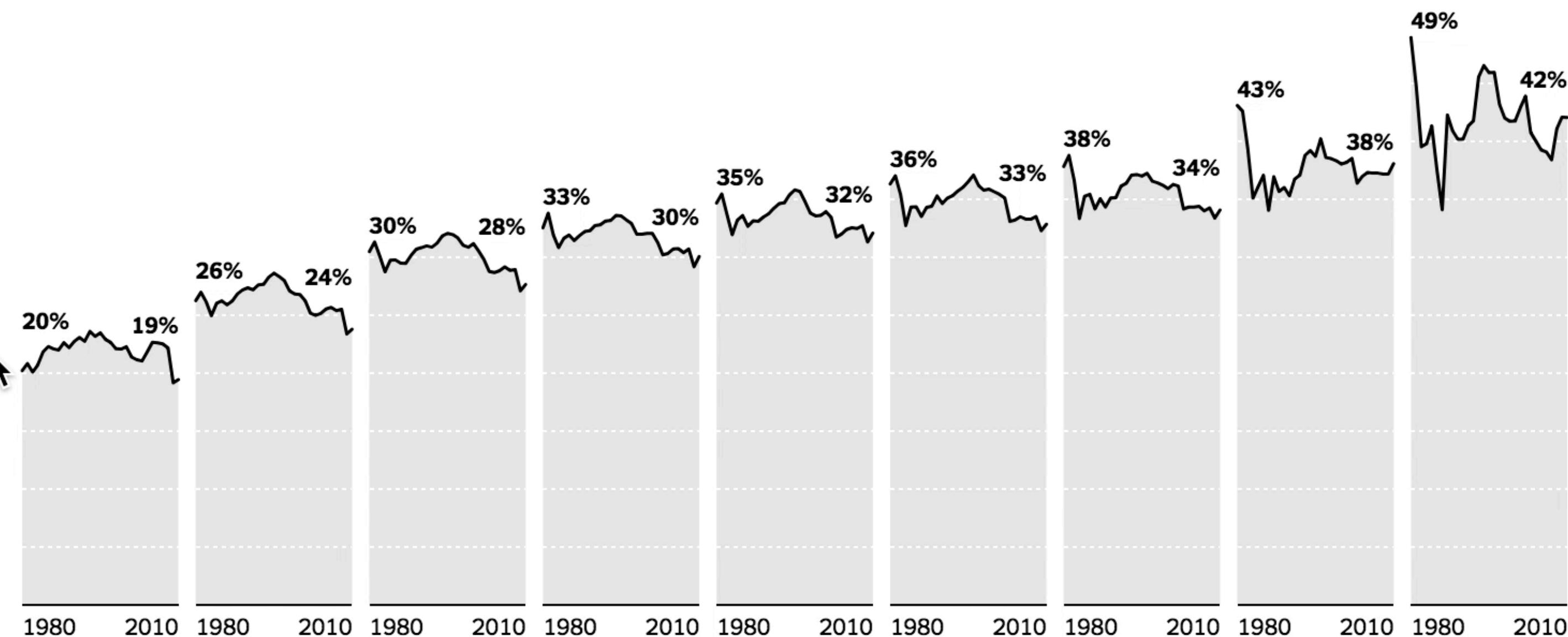
How the Tax Burden Has Changed

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.



Interaction in Visualization

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Encode show me a different visual representation.

Interaction in Visualization

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Connect show me something conditionally.

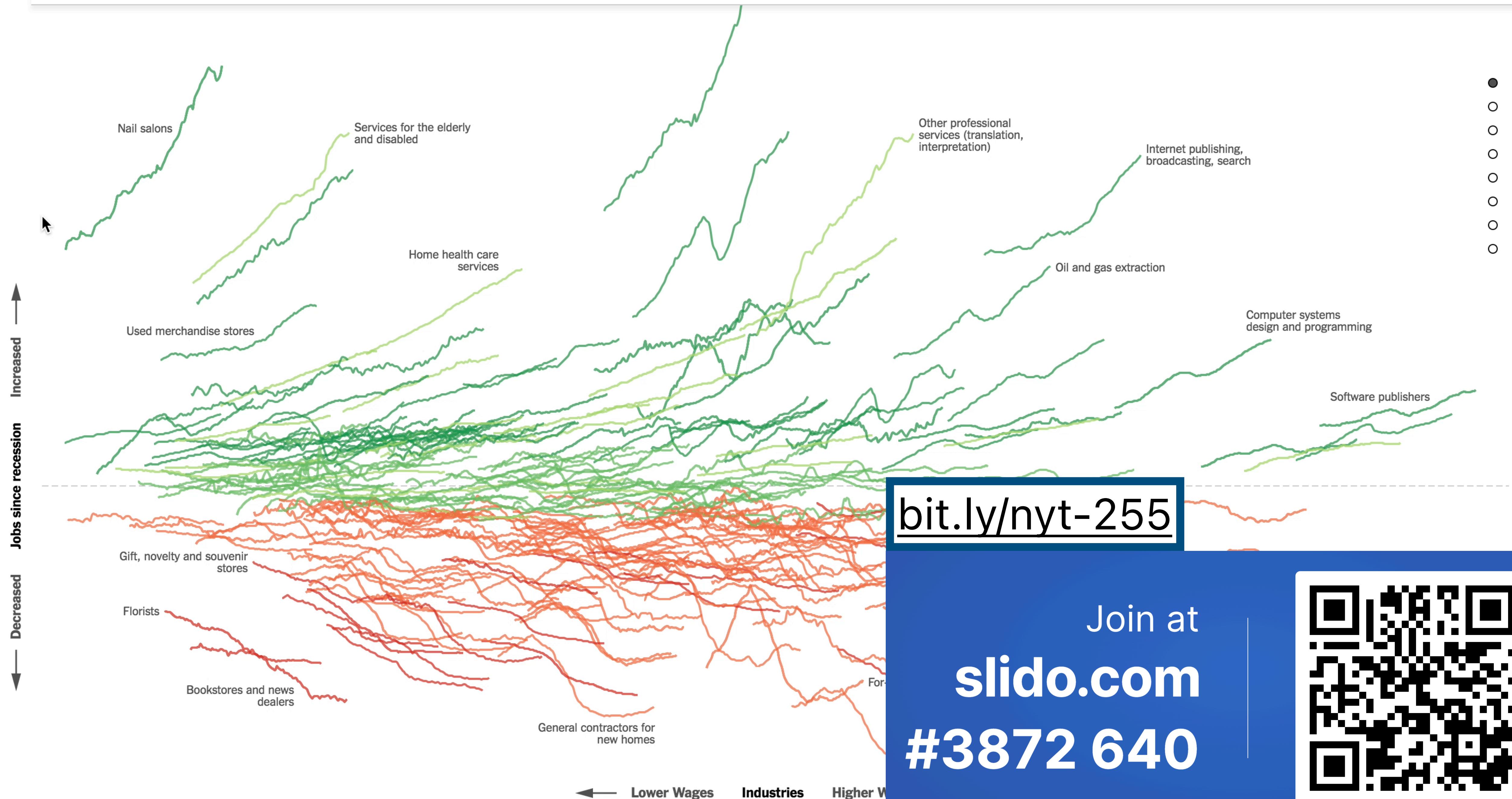
Abstract/Elaborate show me related items.

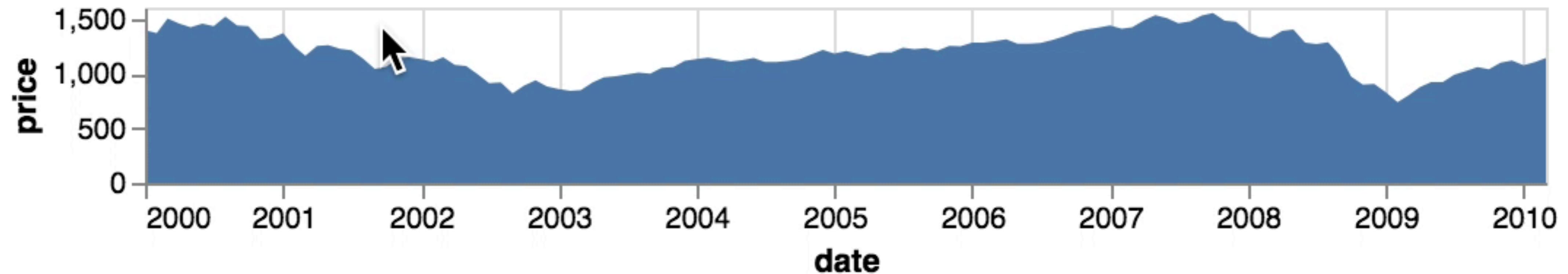
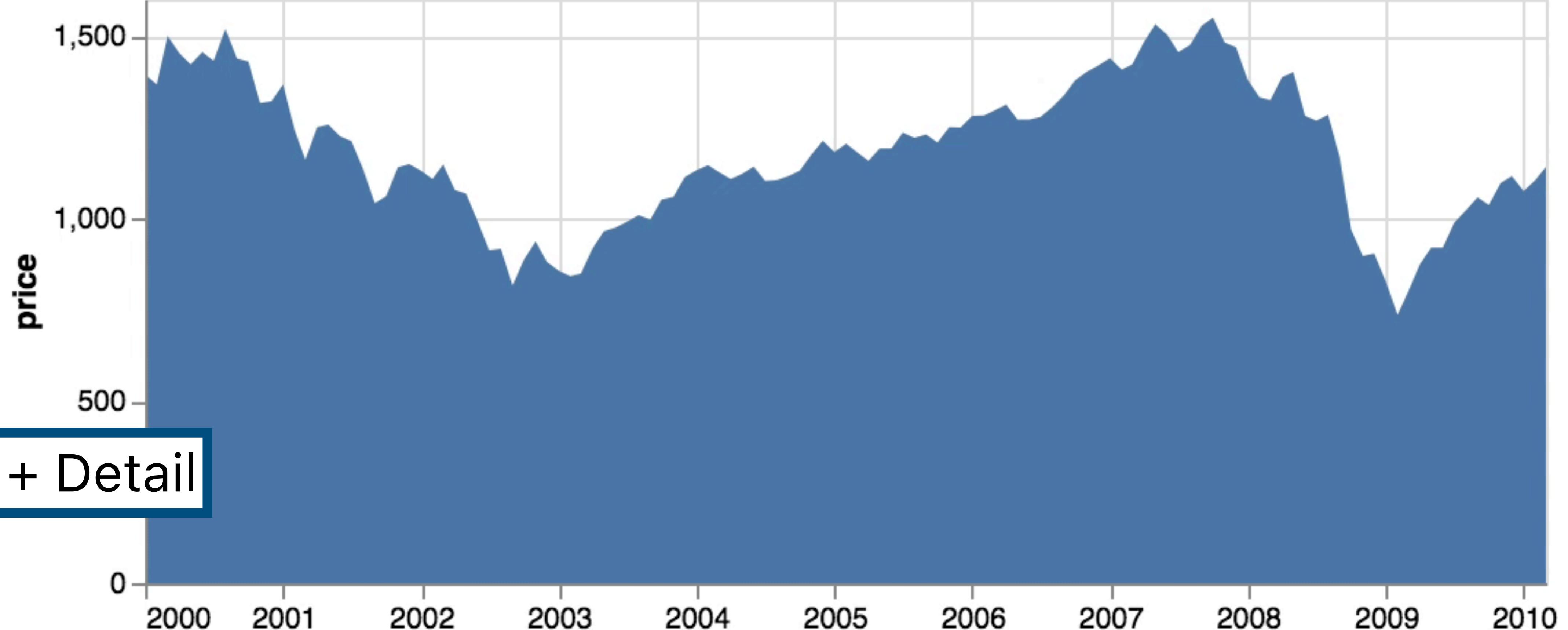
Filter show me more or less detail.

Reconfigure show me a different arrangement.

Explore show me something else.

Encode show me a different visual representation.







Interaction in Visualization

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Encode show me a different visual representation.

Interaction in Visualization

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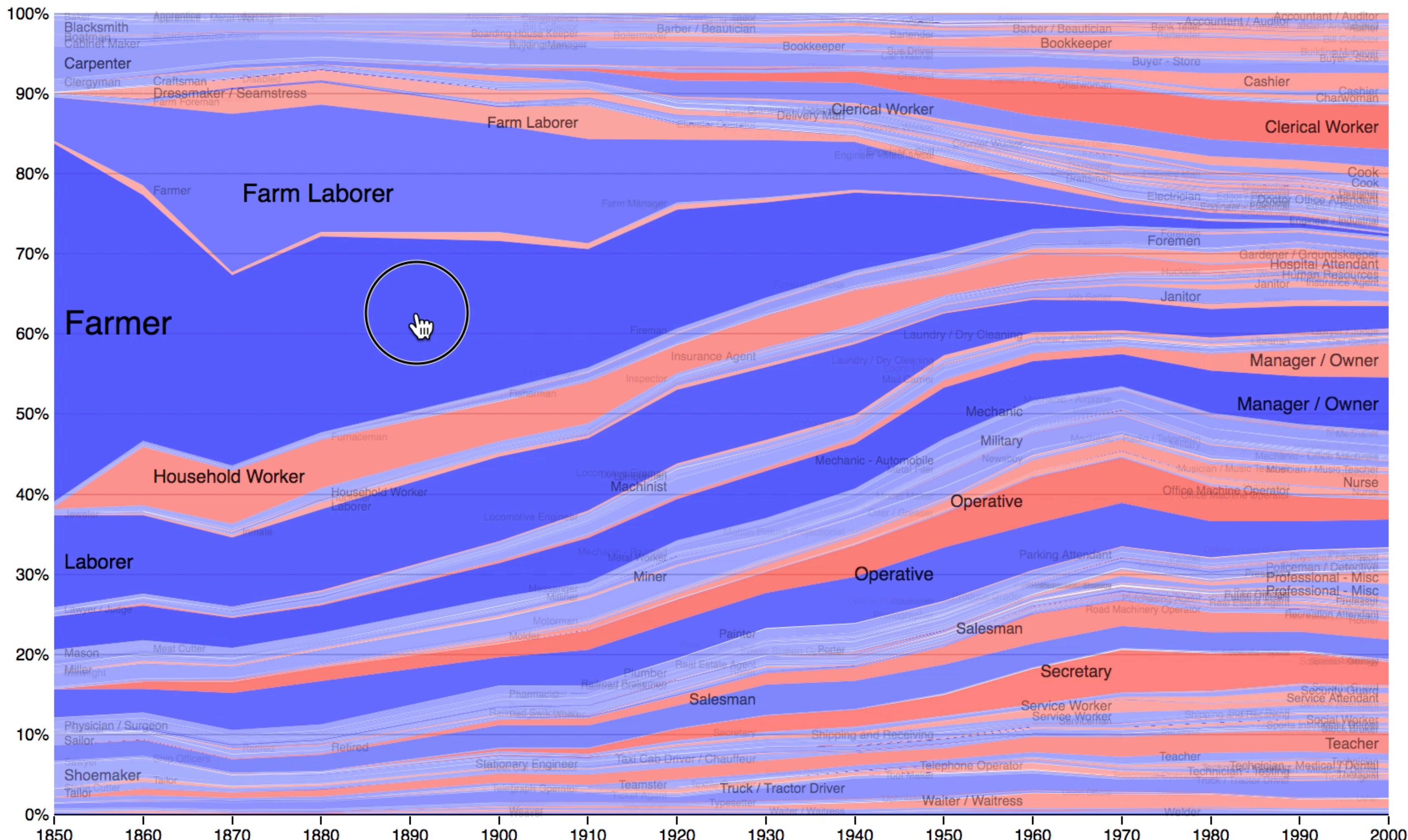
Reconfigure show me a different arrangement.

Explore show me something else.

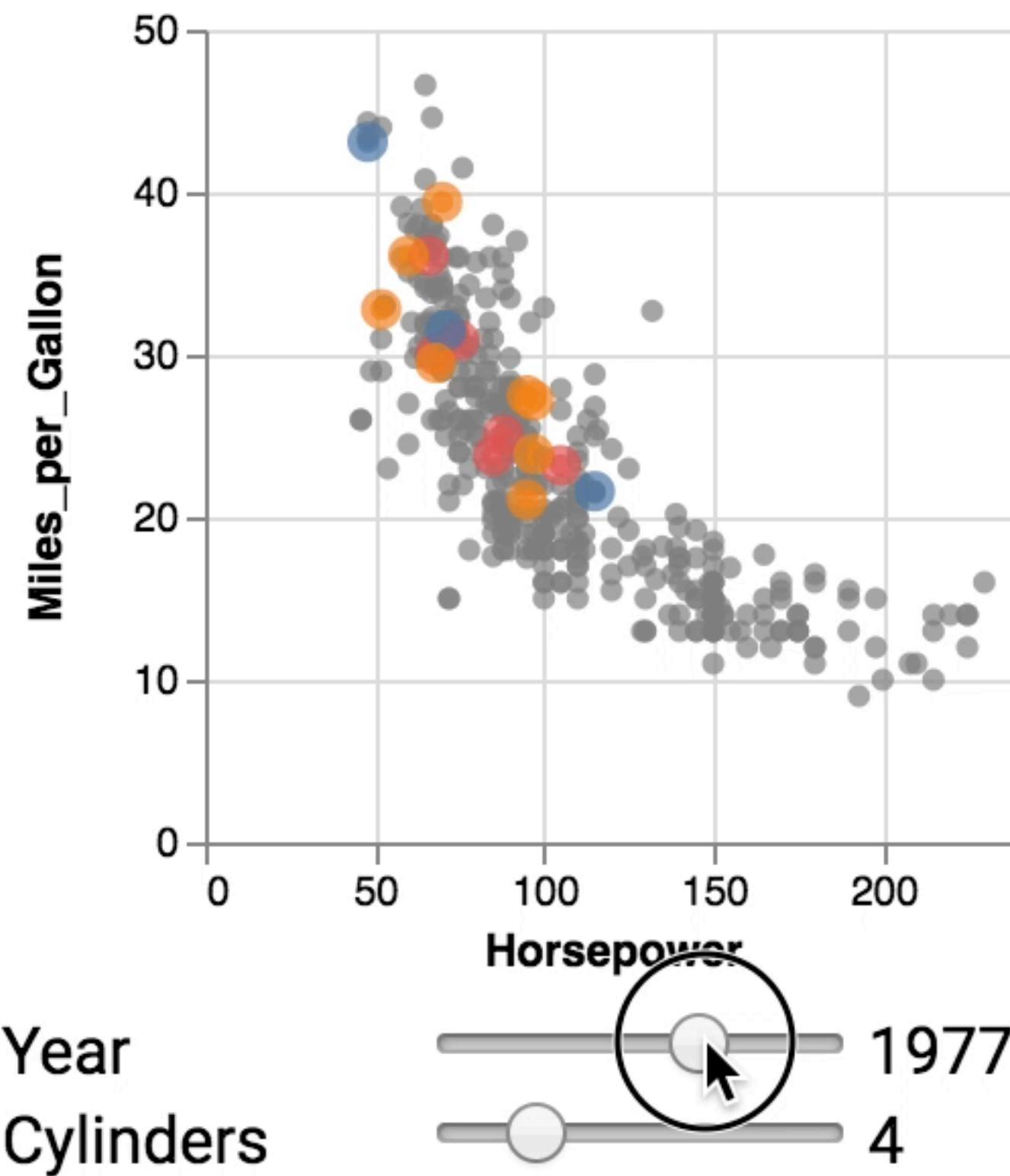
Encode show me a different visual representation.

Job Voyager

Gender: Men Women Any

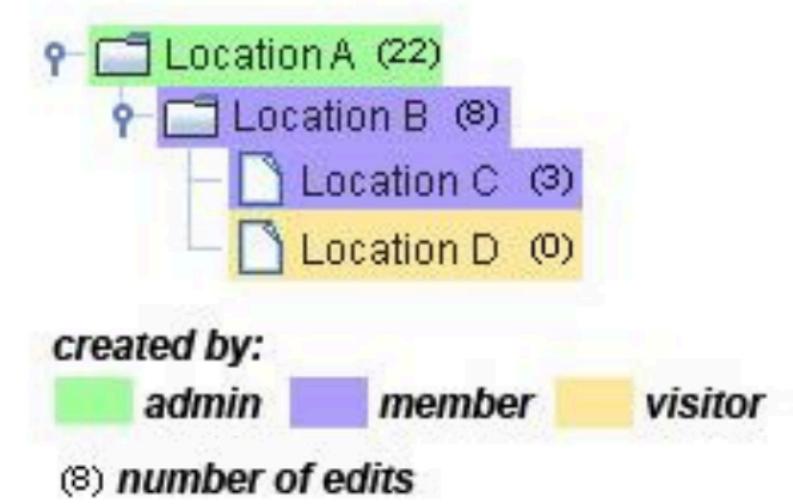
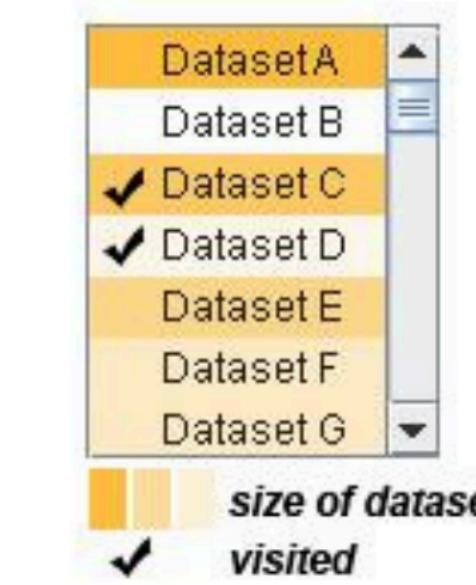
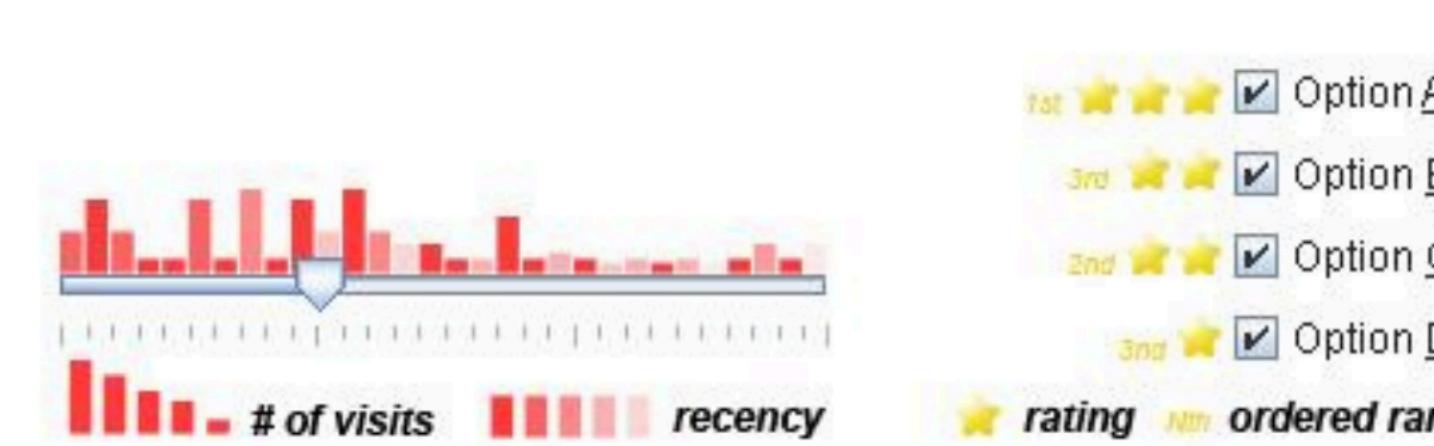


search:

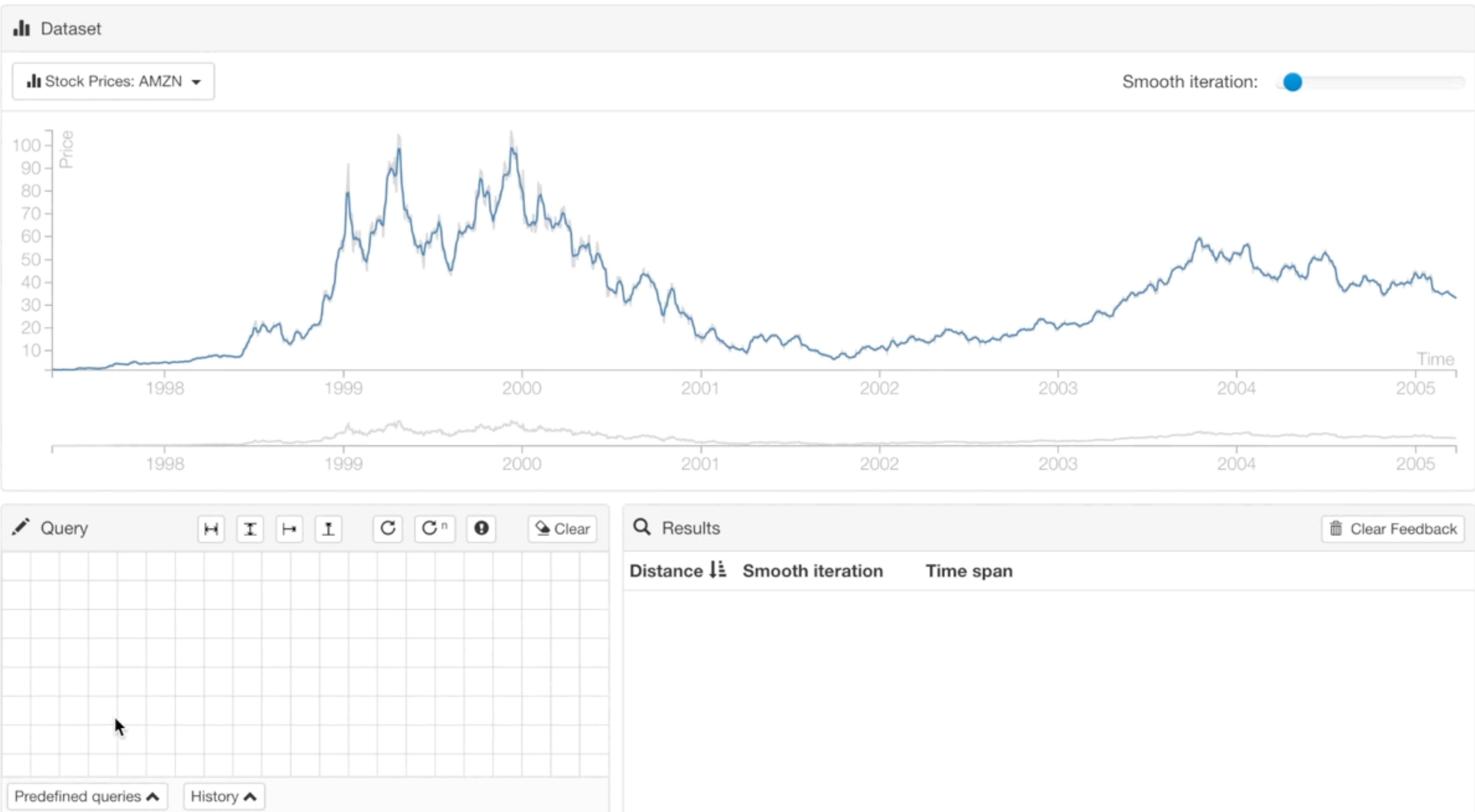


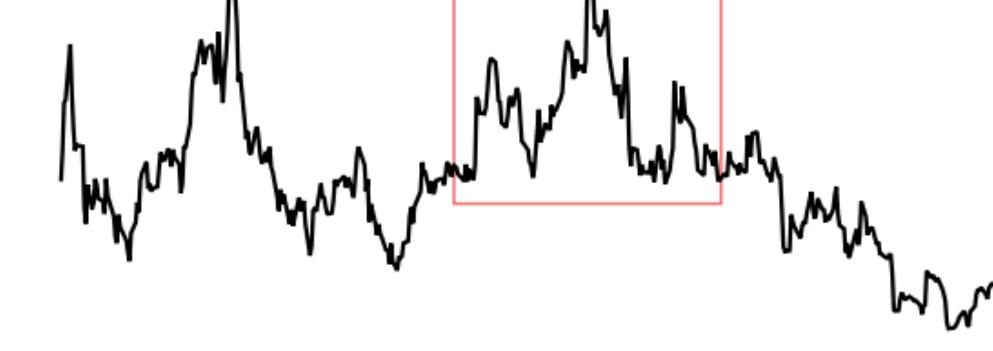
Origin

- Europe
- Japan
- USA



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



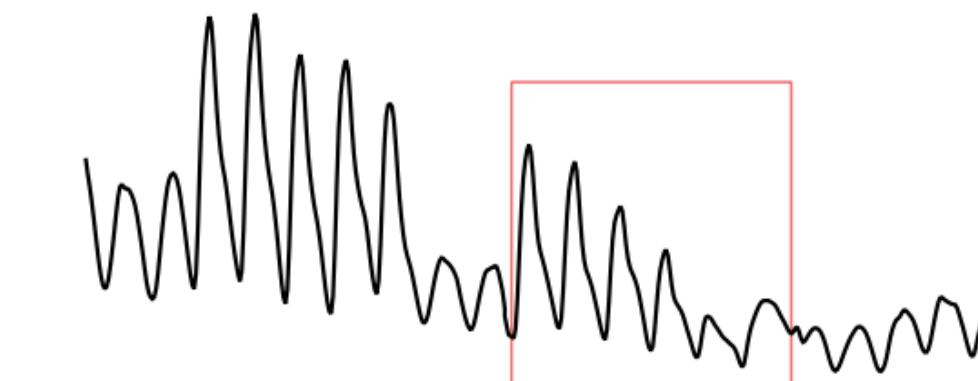


(a) Head-and-shoulders in Amazon stock prices, 150 days 10/99 to 3/00

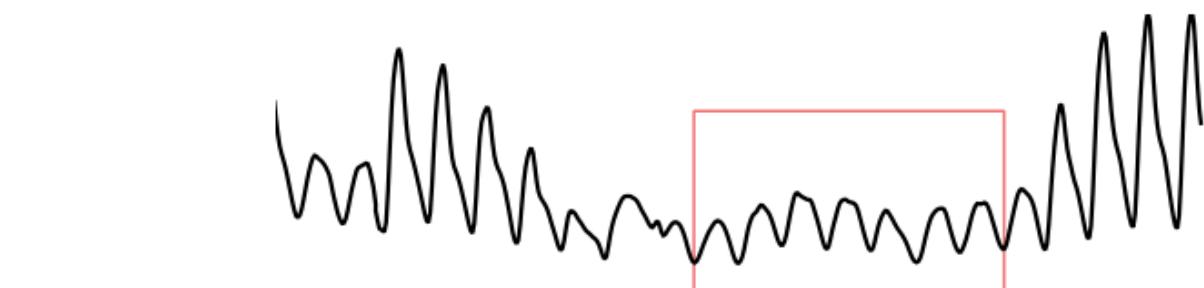


(b) Inverted head-and-shoulders in Alaska Air Group stock prices, 108 days 08/98 to 12/98

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

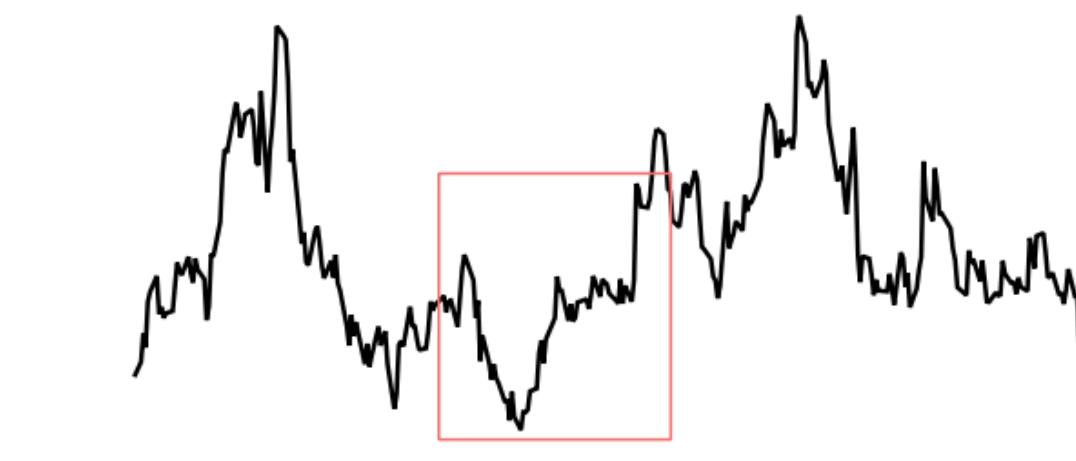


(e) Falling peaks: a six day decrease in traffic before 12/25/04 (Christmas)



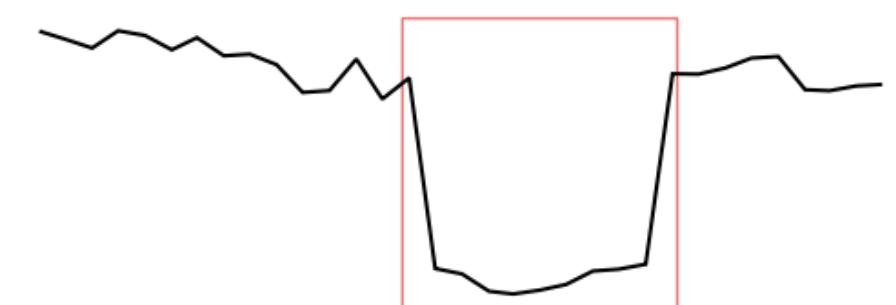
(f) Seven peaks: Low traffic from 12/26/04 to 1/3/05 (Christmas to New Year's Eve)

Daily stock prices in 8 year data sets



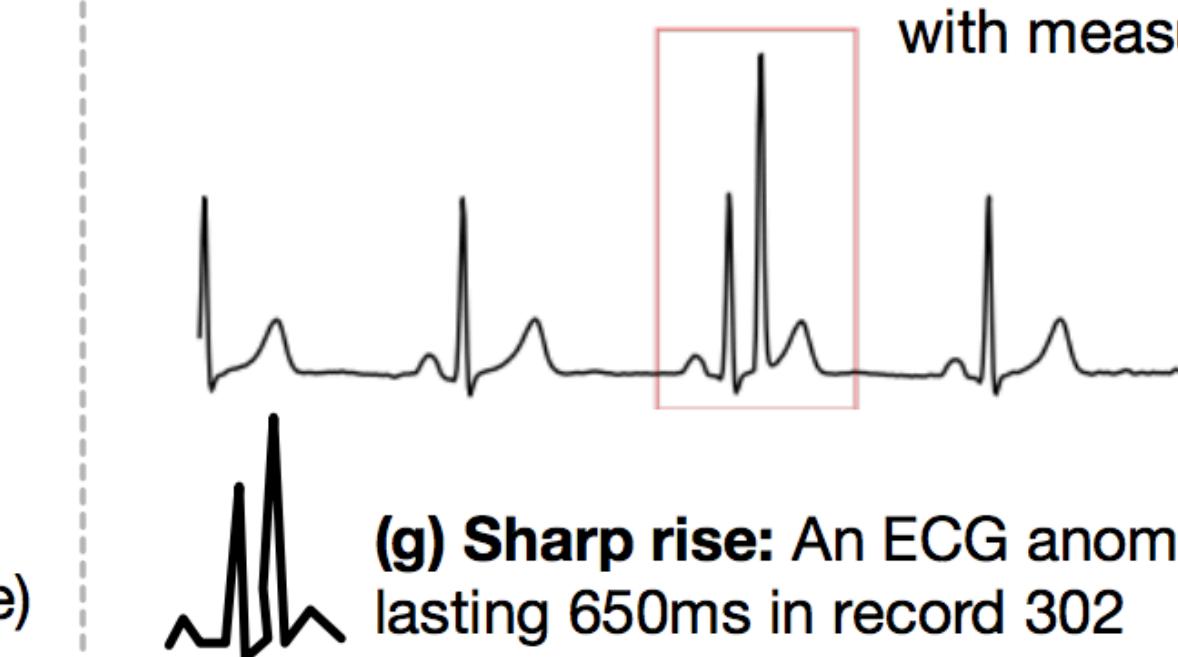
(c) Cup-with-handle in Amazon stock prices, 95 days 7/99 to 11/99

Monthly Insurance Equity from the Central Bank of Iceland



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

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

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.

Interaction in Visualization

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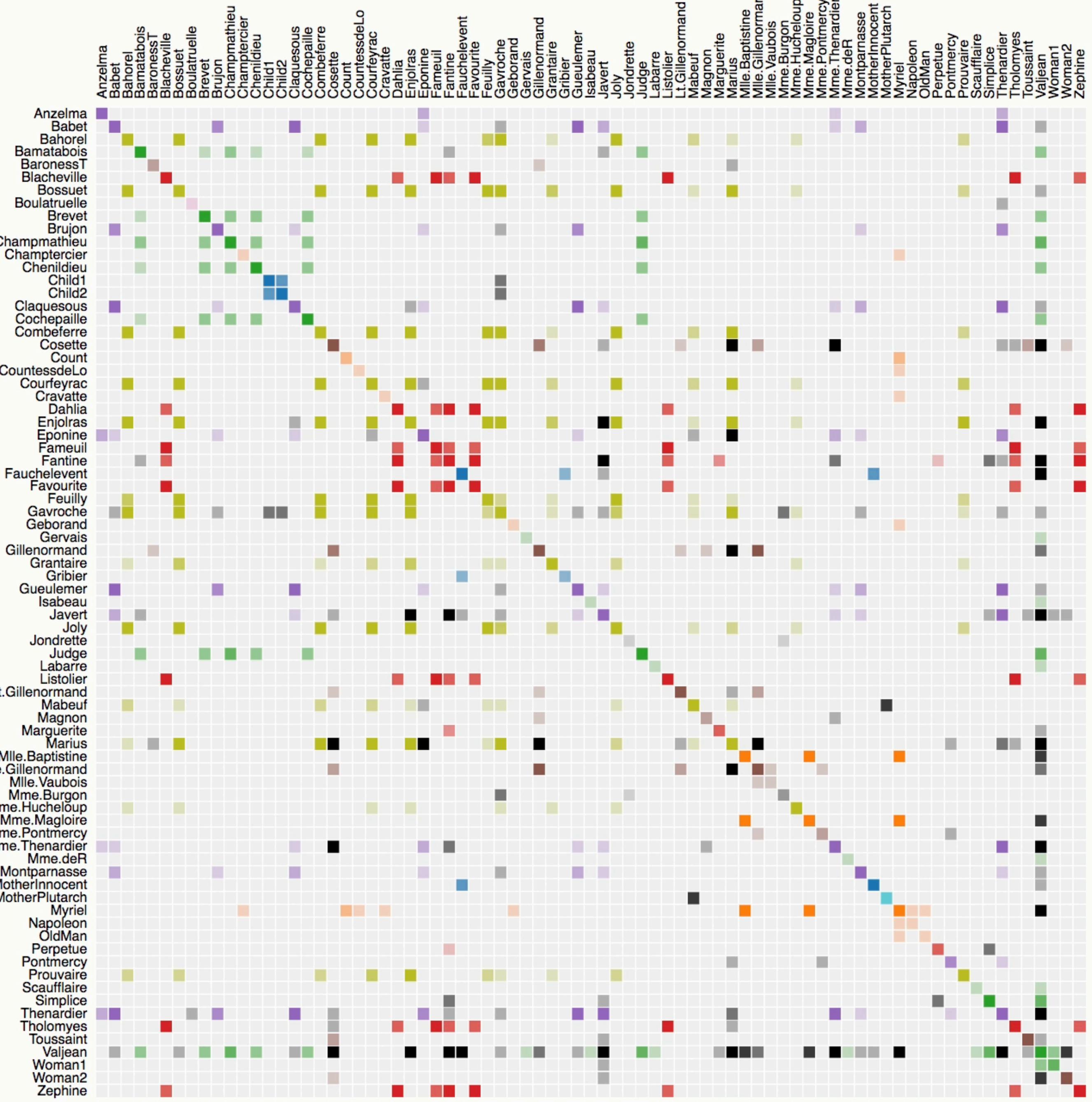
Reconfigure show me a different arrangement.

Explore show me something else.

Encode show me a different visual representation.

Reconfigure

[Mike Bostock. April 2012.]



Source: [The Stanford GraphBase](#).

Order: [by Name](#)

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.

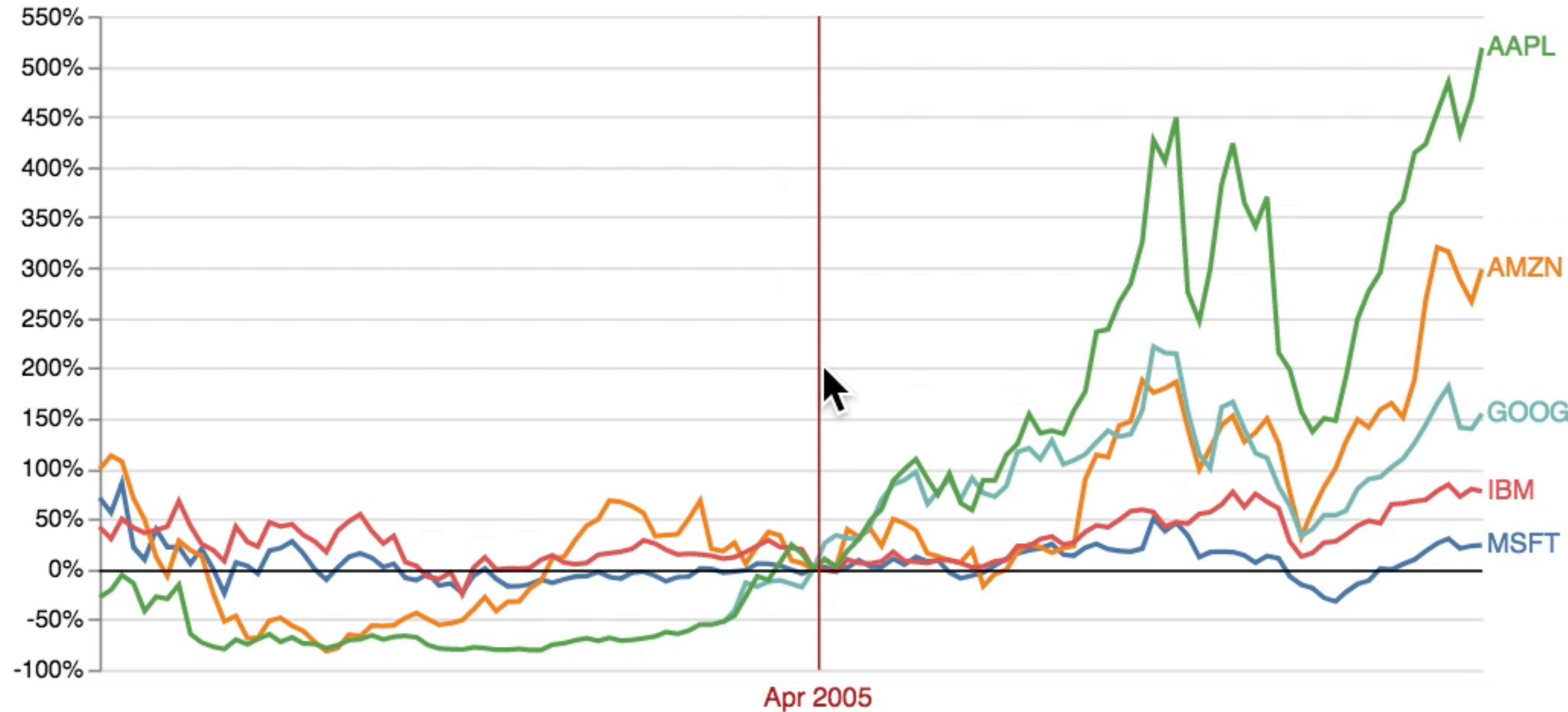
Use the drop-down menu to reorder the matrix and explore the data.

Built with [d3.js](#).

Reconfigure



Reconfigure



Interaction in Visualization

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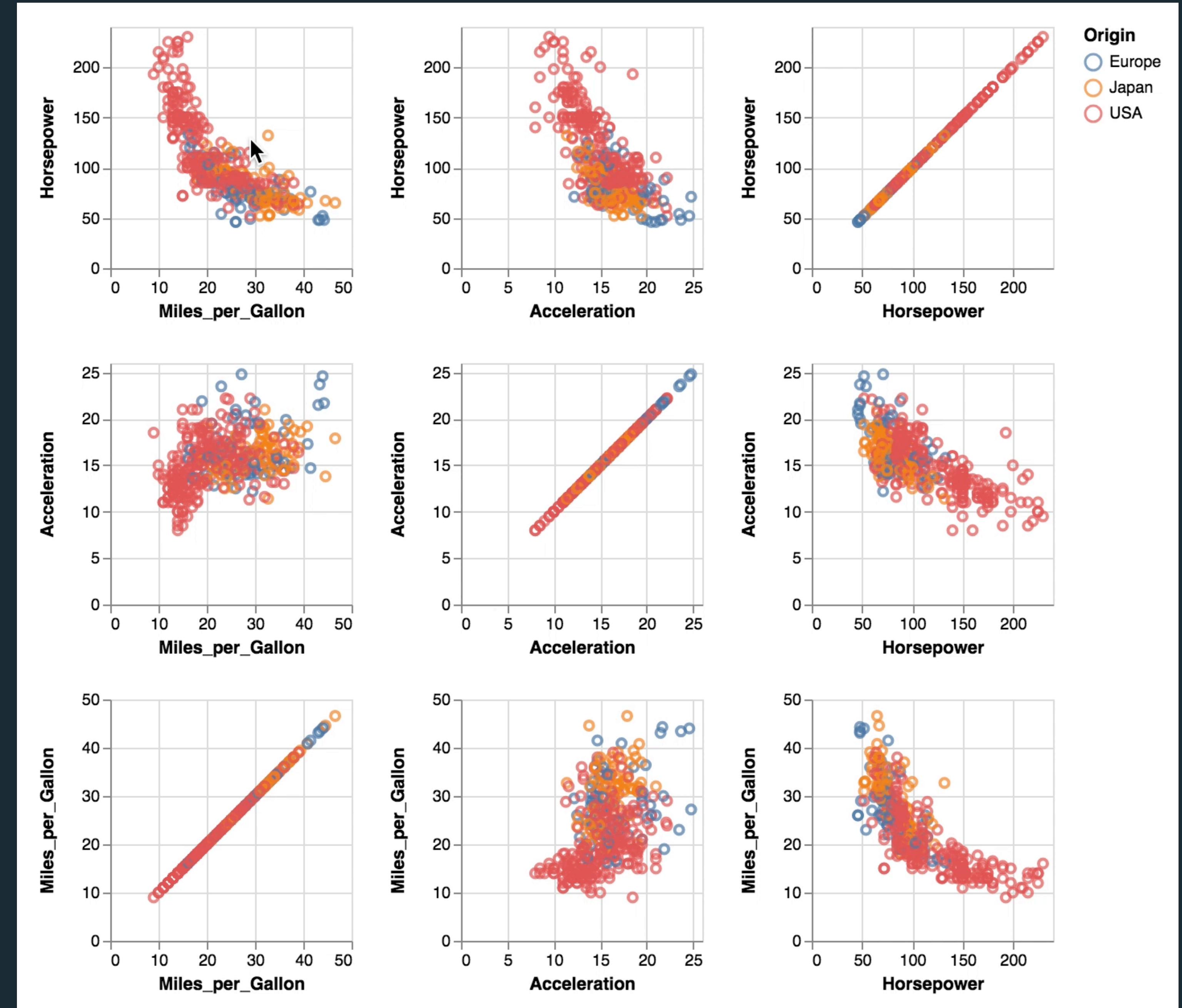
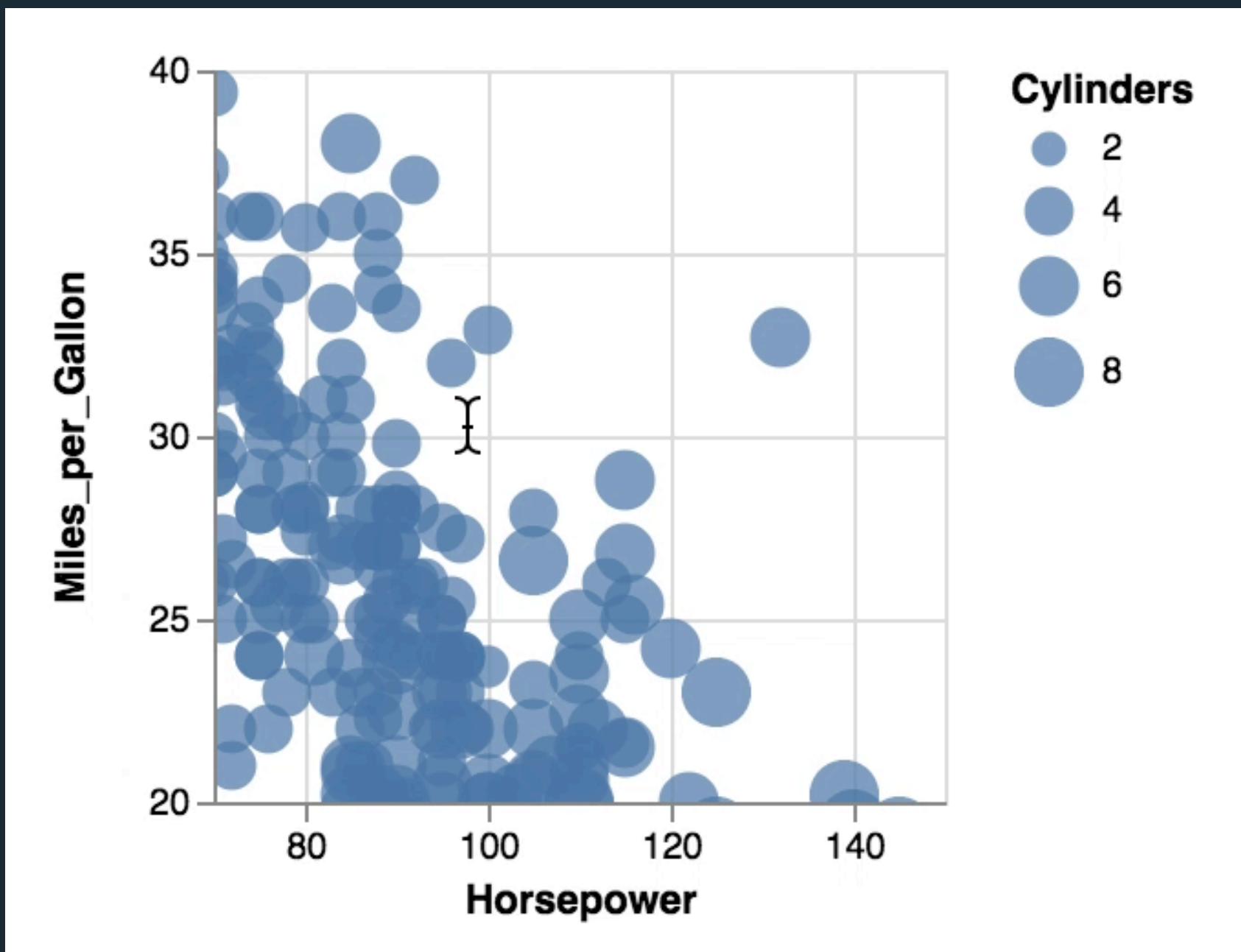
Filter show me more or less detail.

Reconfigure show me a different arrangement.

Explore show me something else.

Encode show me a different visual representation.

Explore



Explore

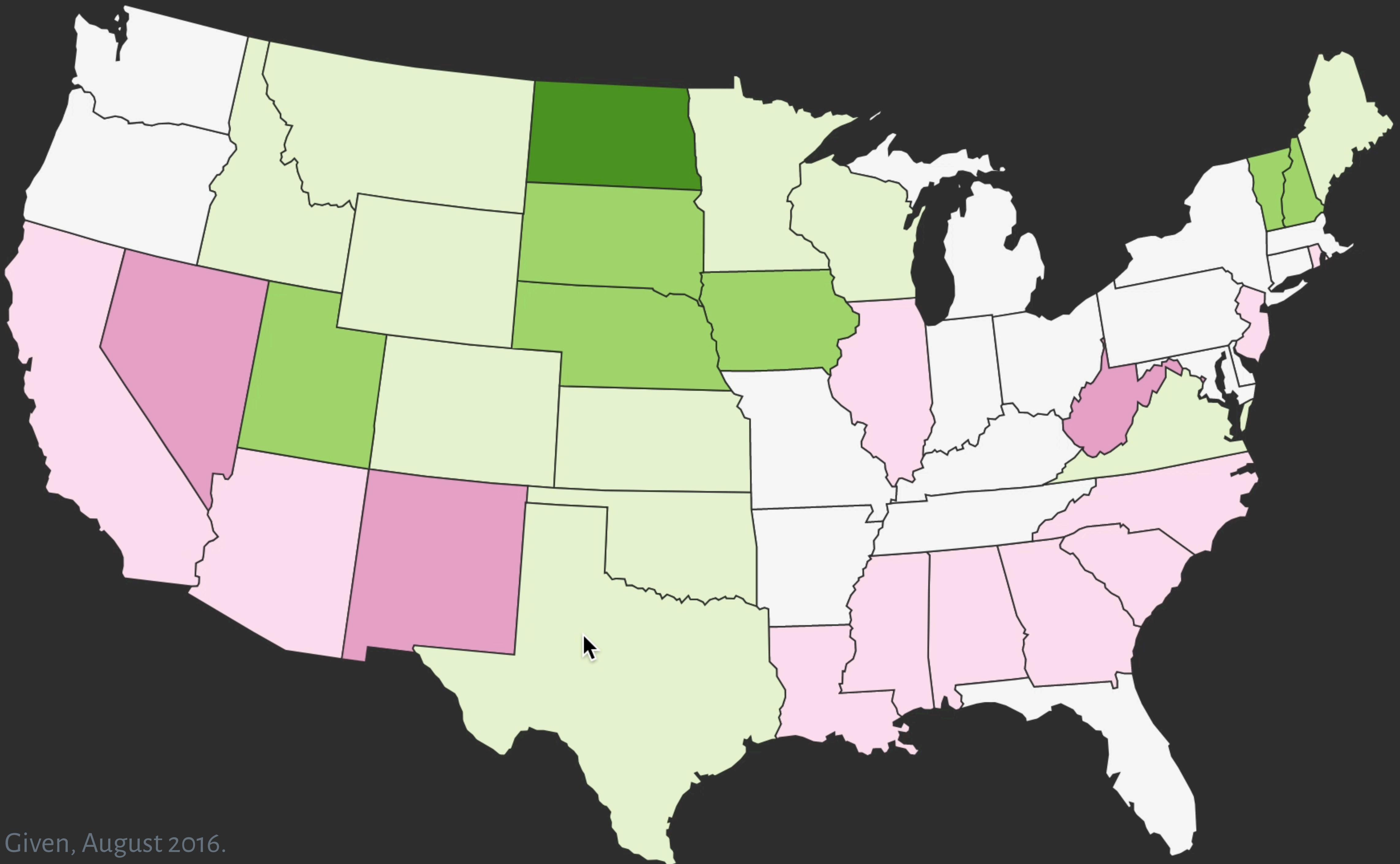
Geometric zoom: transforms the *physical view* (i.e., objects get larger as they get "closer").



Explore

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





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.

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 change the interface management.

No time, but see interactive systems
like Tableau / Voyager

Encode show me a different visual representation.

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 way.

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