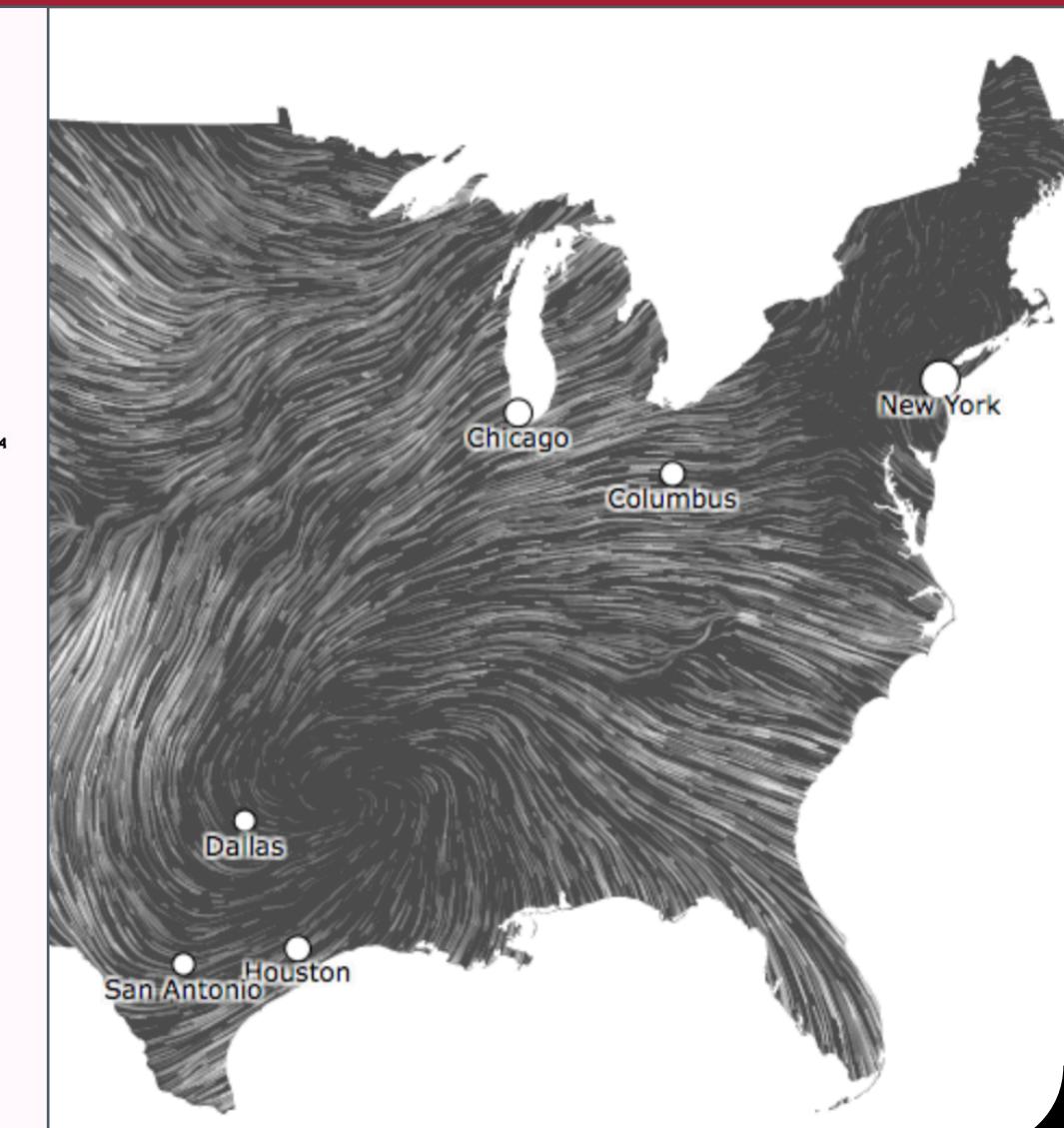
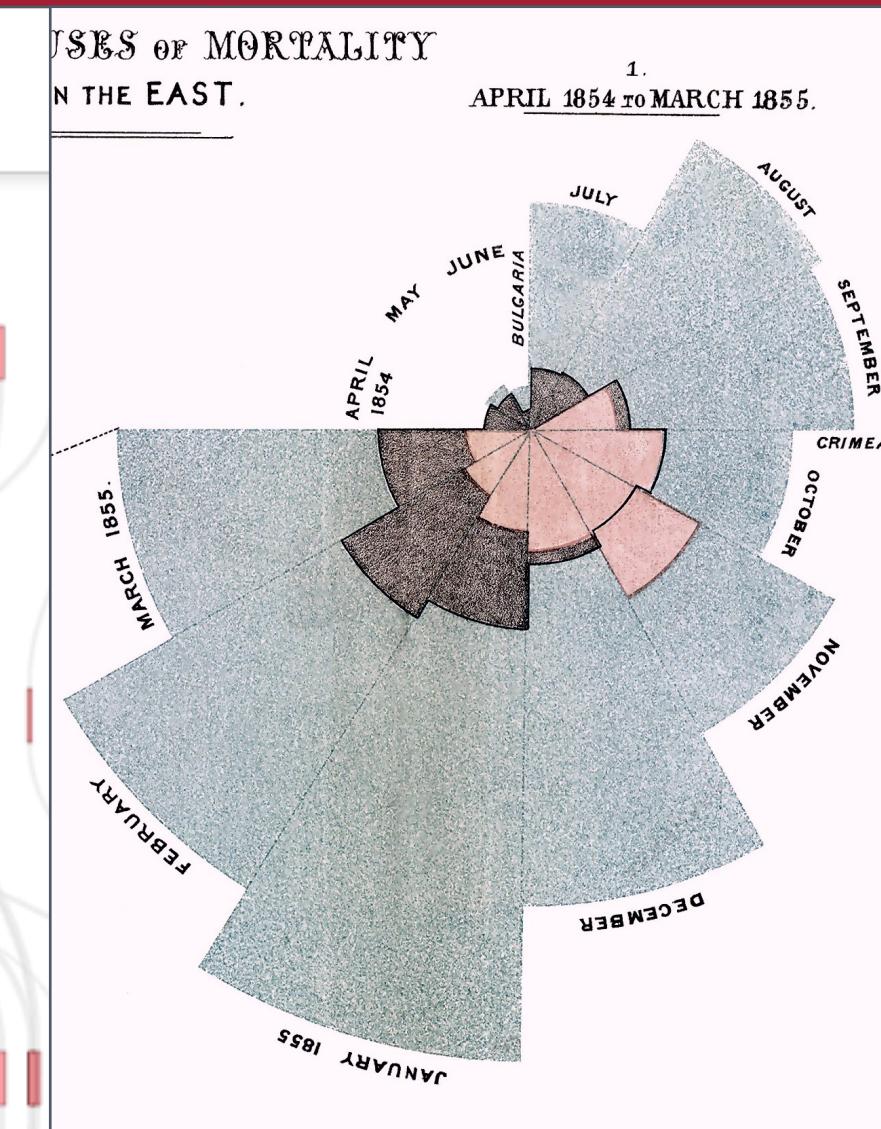
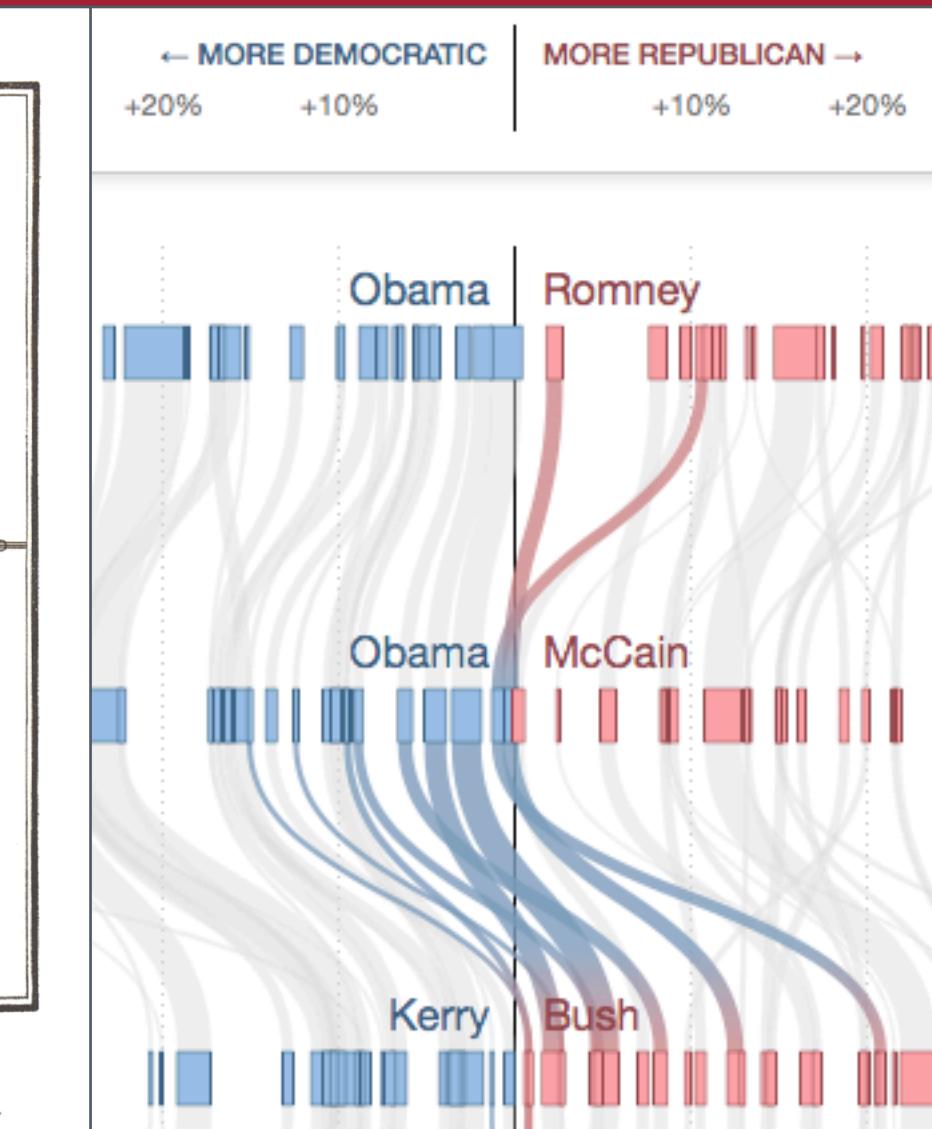
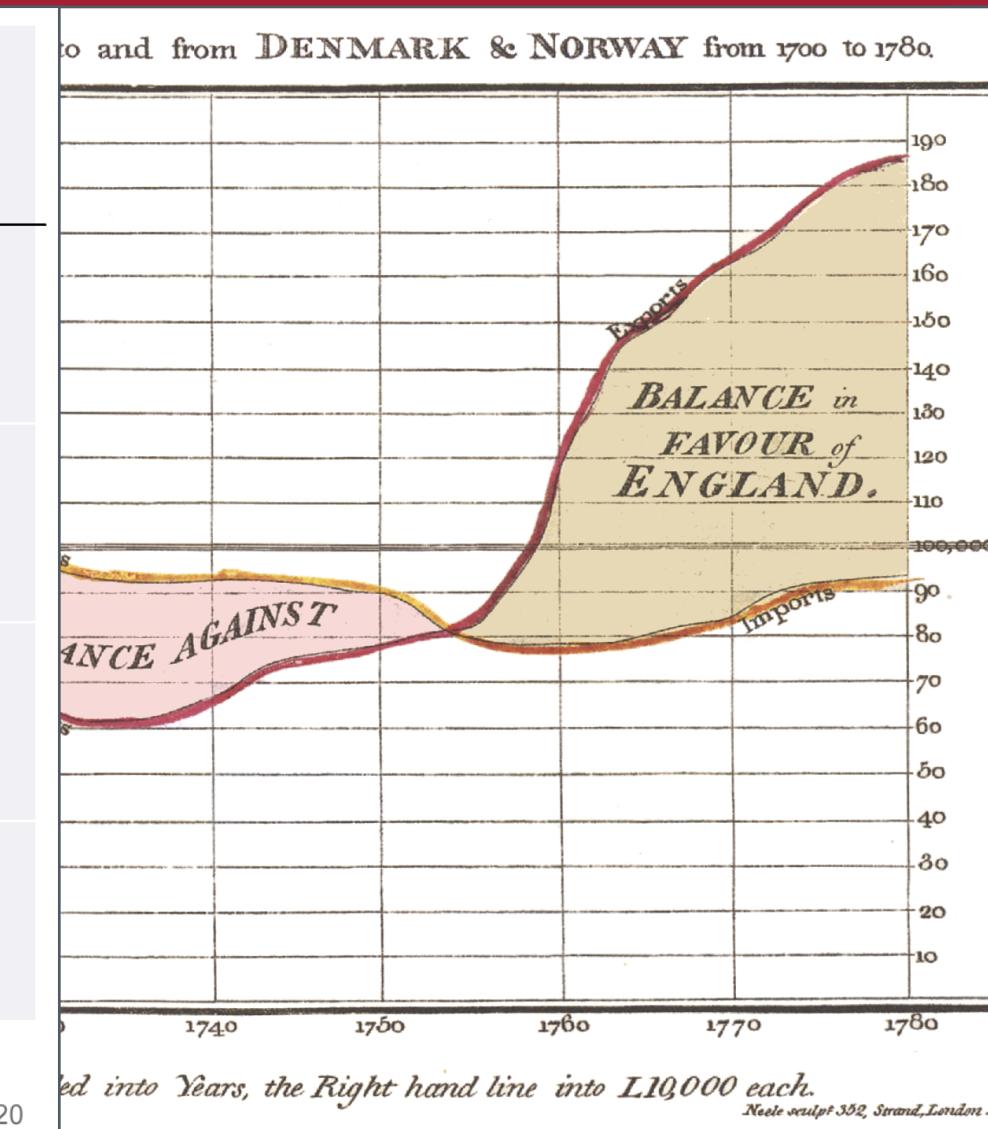
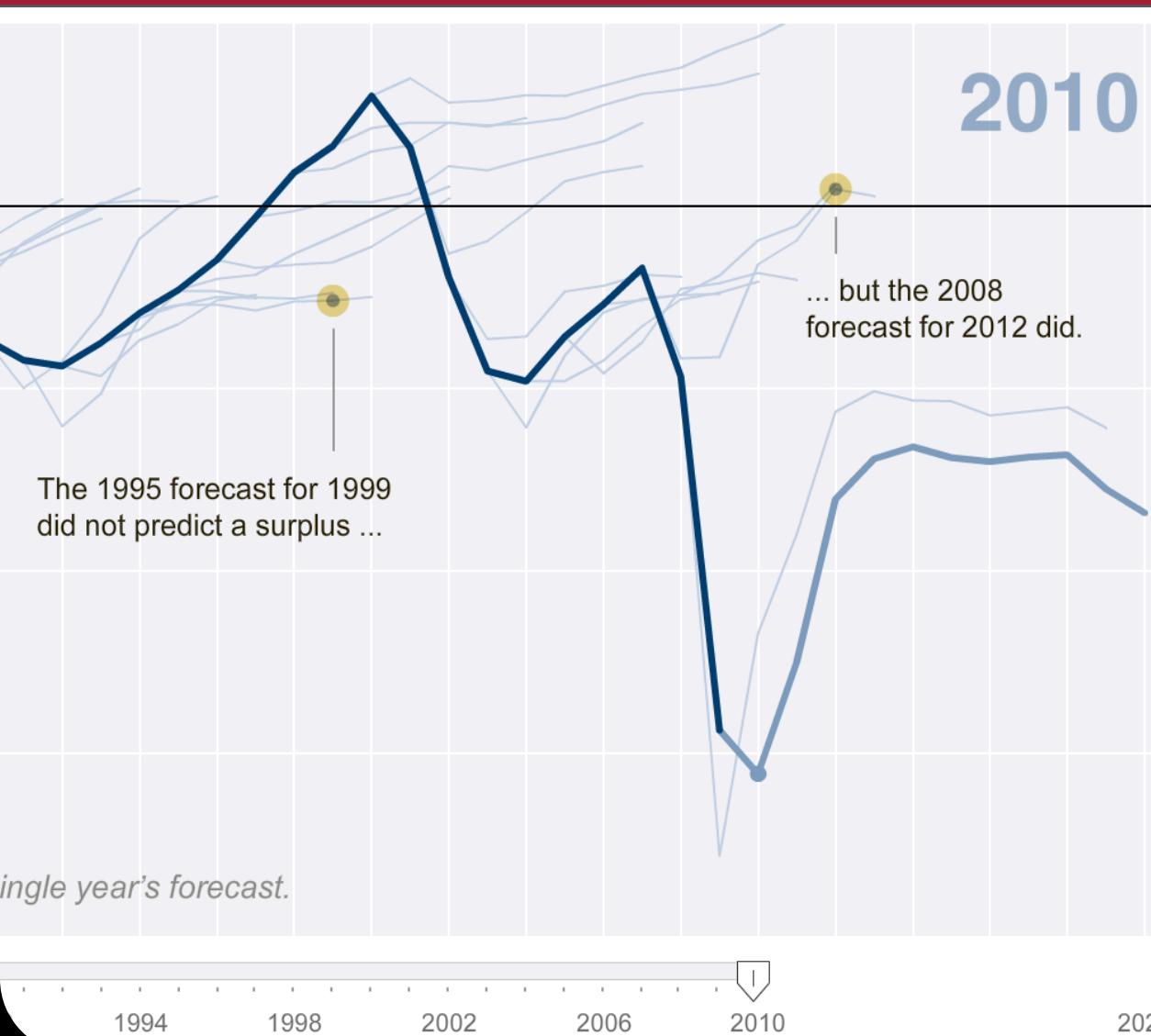
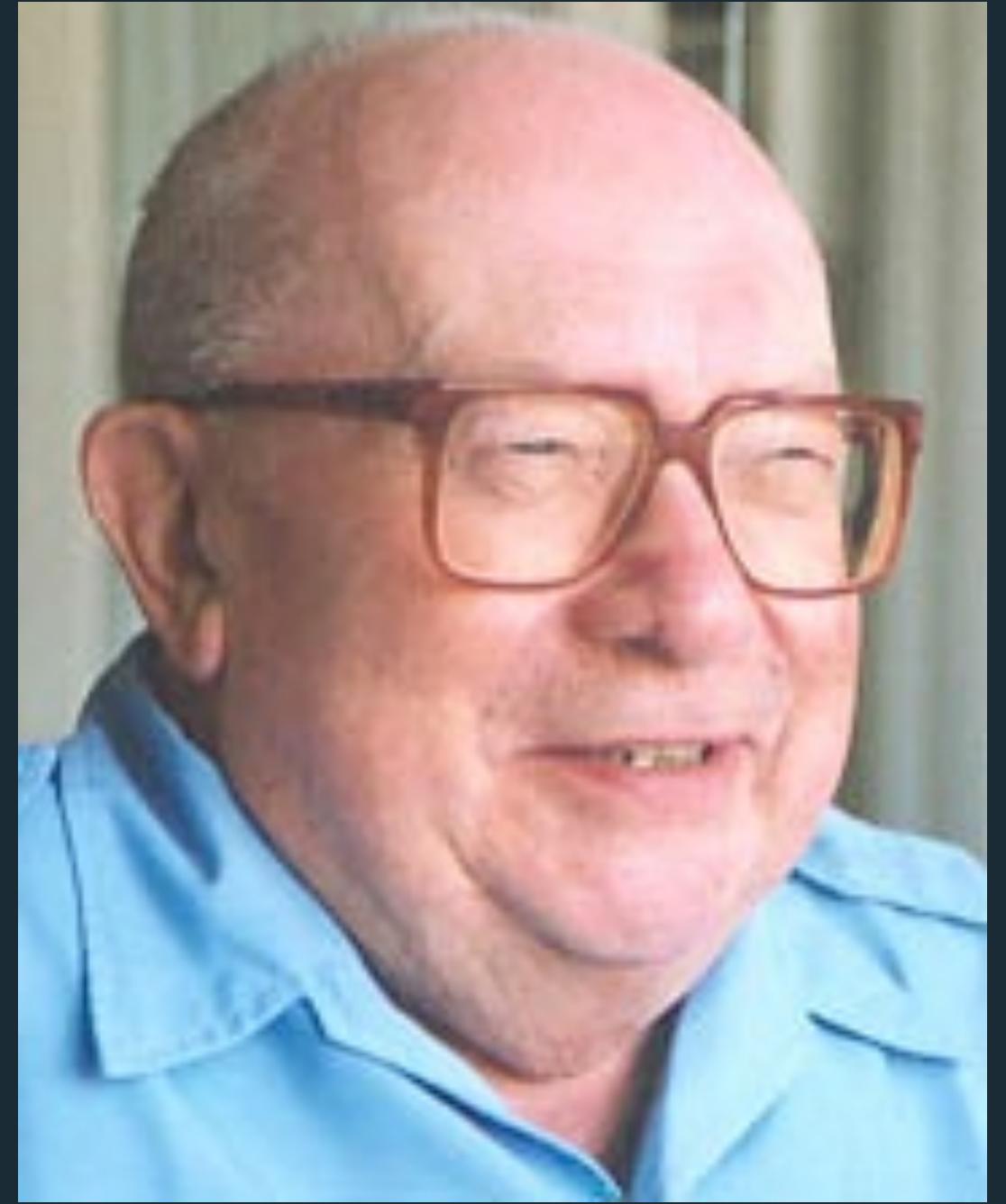


# 6.894: Interactive Data Visualization

## A Tour through the Interaction Zoo

# Arvind Satyanarayan

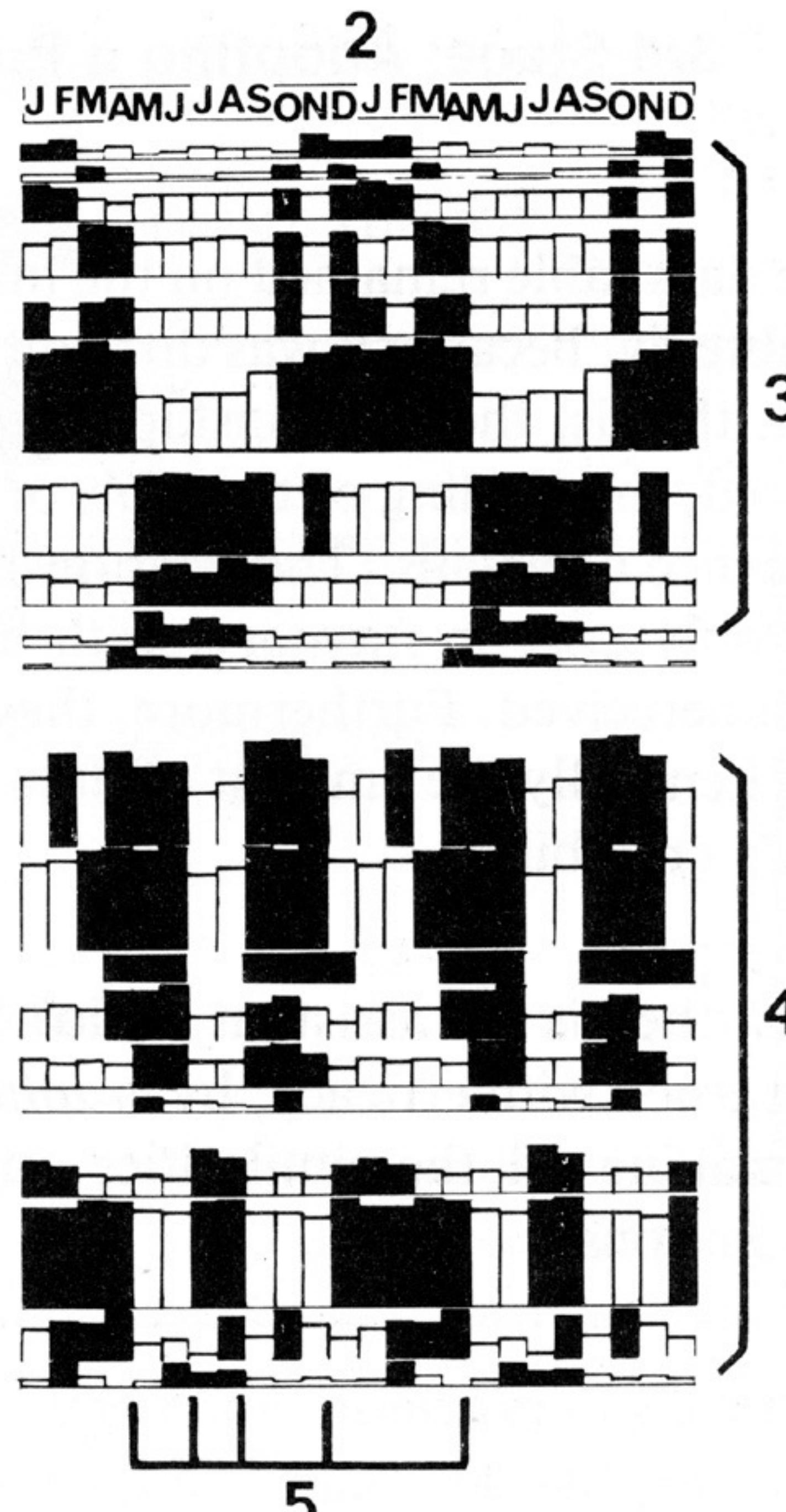
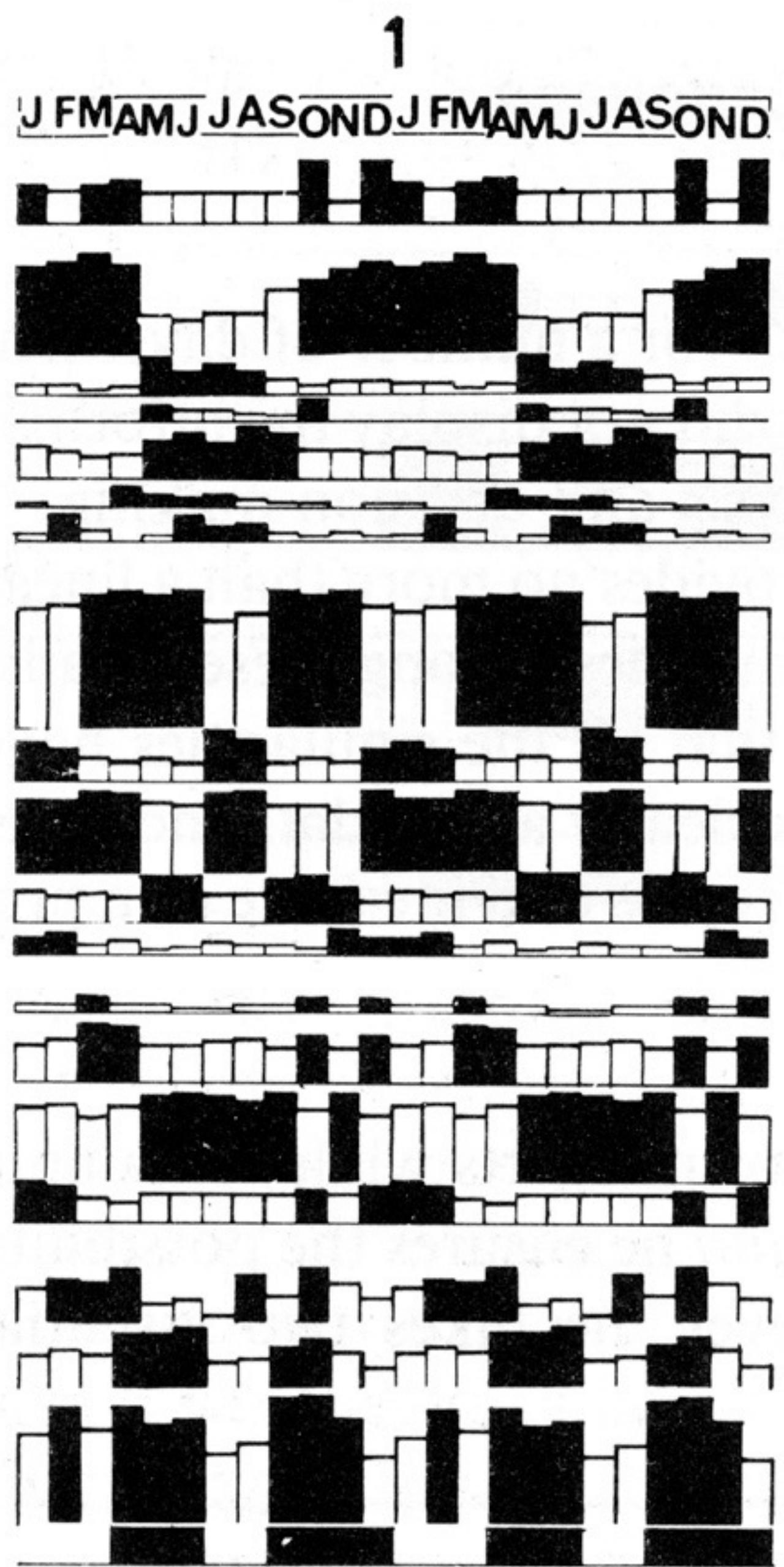




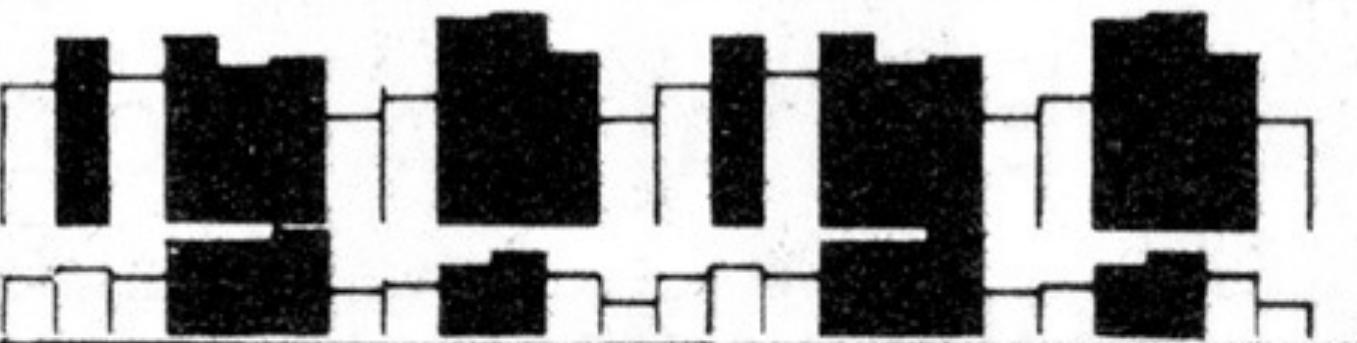
*A graphic is not “drawn” once and for all; it is “constructed” and reconstructed until it reveals all the relationships constituted by the interplay of the data. The best graphic operations are those carried out by the decision-maker [themselves].*

Jacques Bertin (1918 – 2010)  
French cartographer

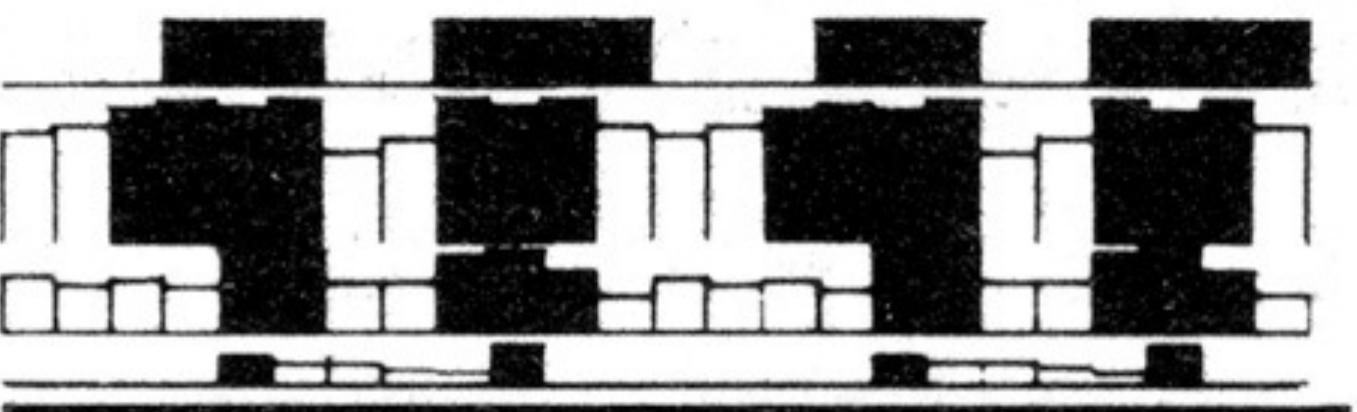
J	F	M	A	M	J	J	A	S	O	N	D								
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE						
69	70	77	71	37	36	39	39	55	60	68	72	2	% —" LOCAL						
7	6	3	6	23	14	19	14	9	6	8	8	3	% —" U.S.A.						
0	0	0	0	8	6	6	4	2	12	0	0	4	% —" SOUTH AMERICA						
20	15	14	15	23	27	22	30	27	19	19	17	5	% —" EUROPE						
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	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	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

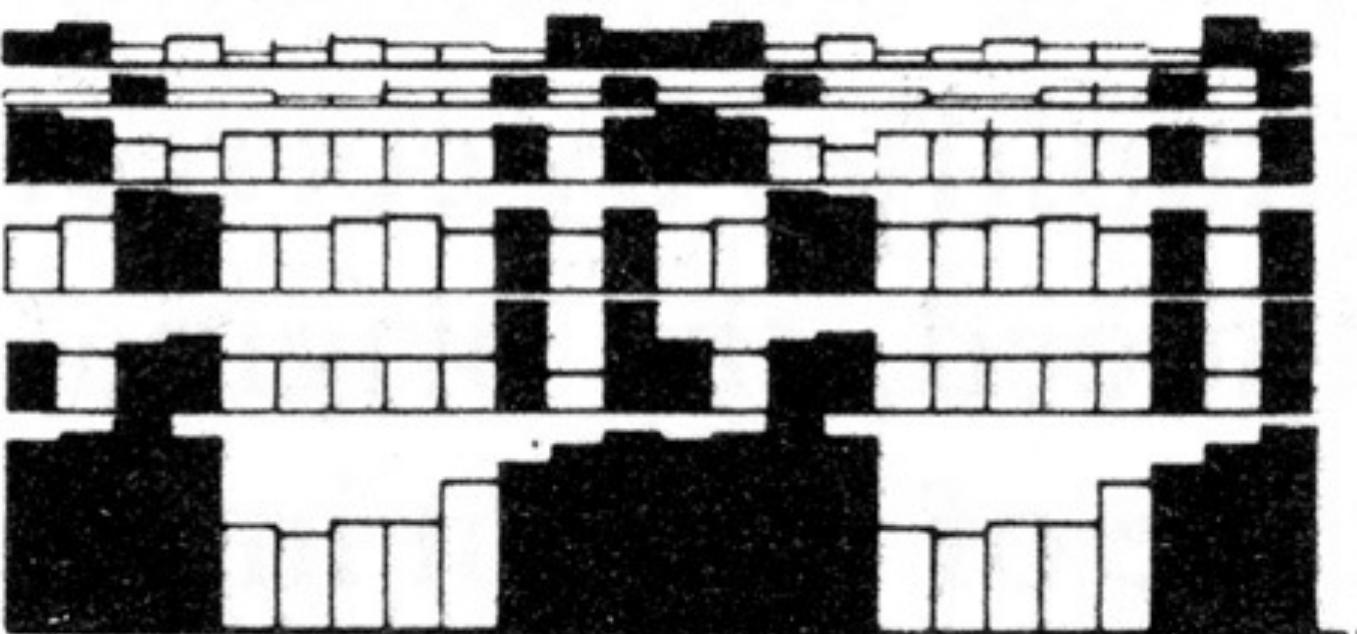


18 LENGTH OF STAY

ACTIVE AND  
SLOW PERIODS

- 20 CONVENTIONS  
• BUSINESSMEN  
11 AGENCY RESERVATIONS  
4 SOUTH AMERICA

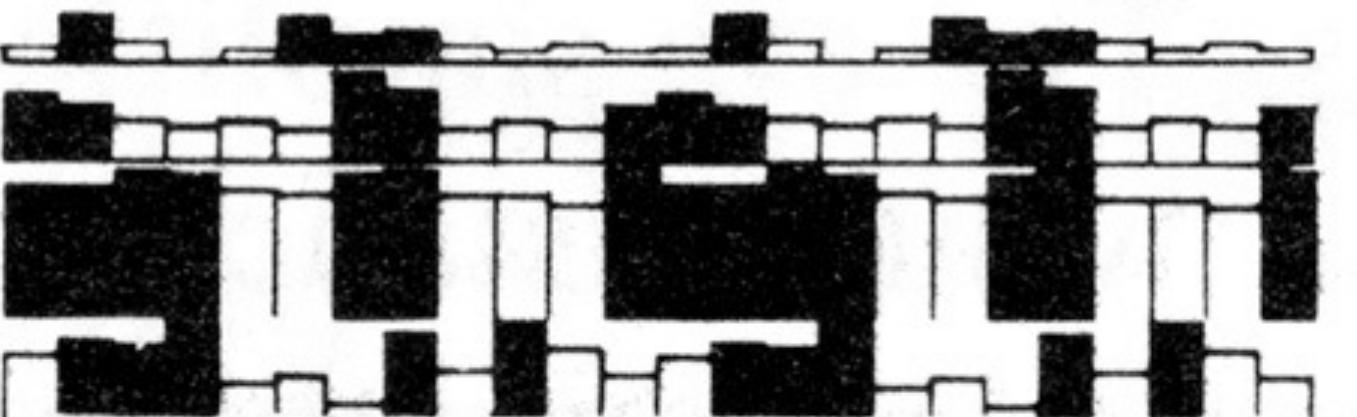
DISCOVERY FACTORS



- 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

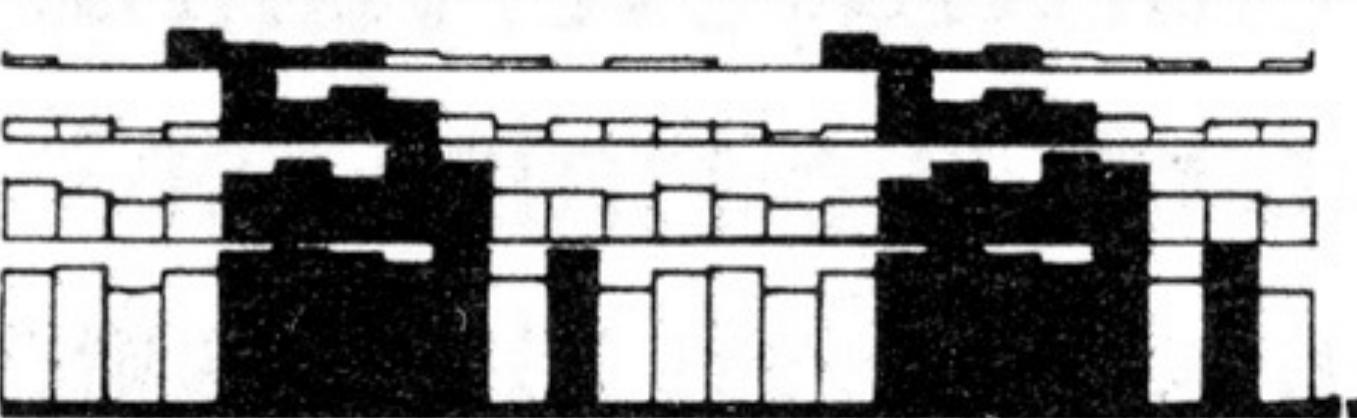
RECOVERY FACTORS

WINTER



- 7 ASIA  
9 TOURISTS  
10 DIRECT RESERVATION  
17 PRICE OF ROOMS

WINTER-SUMMER



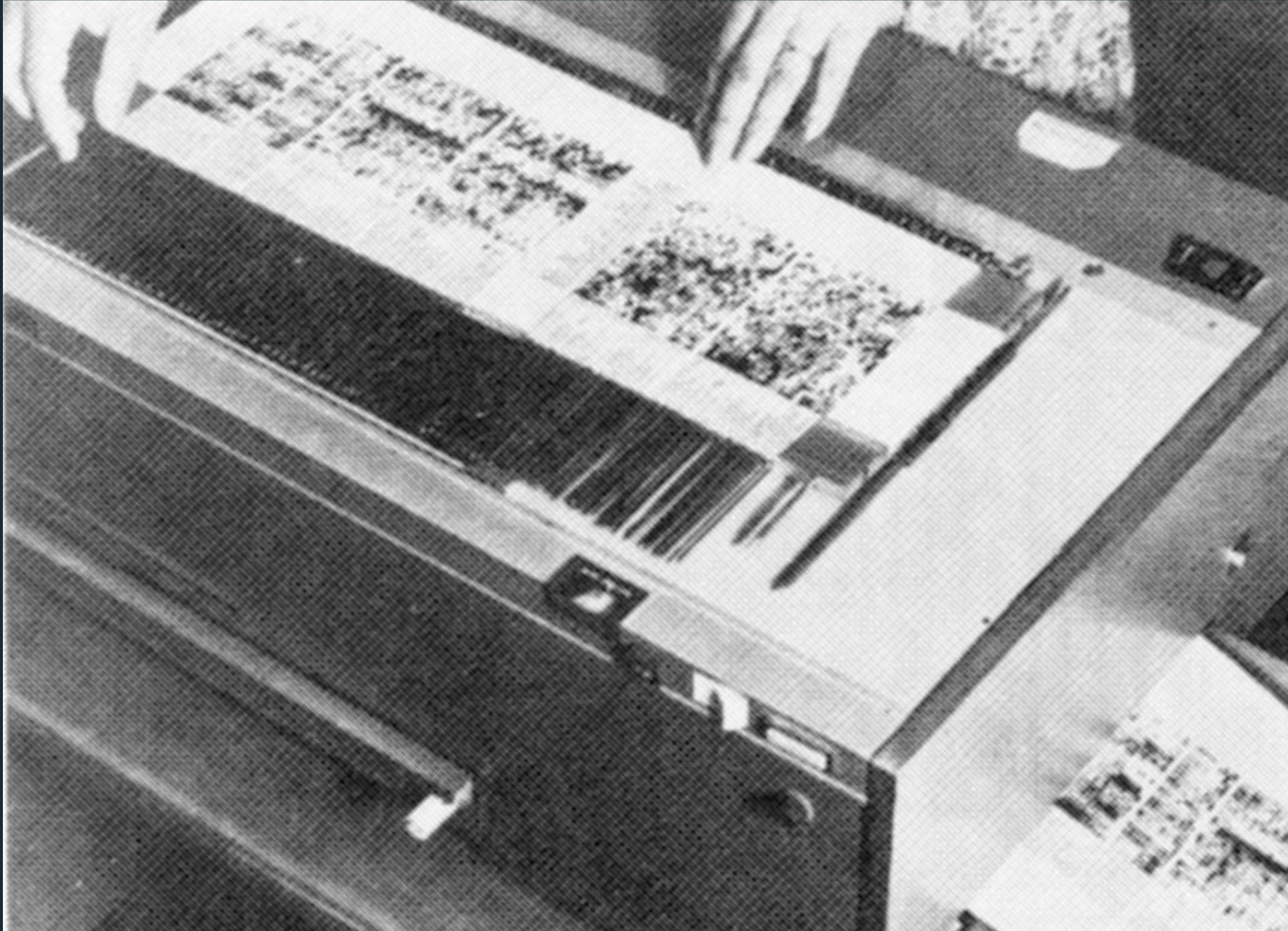
- MIDDLE EAST, AFRICA  
3 U. S. A.  
5 EUROPE  
15 CLIENTS FROM 35-55 YEARS

SUMMER

[Bertin. Graphics and Graphic Information Processing. 1981]



[Bertin. Graphics and Graphic Information Processing. 1981]

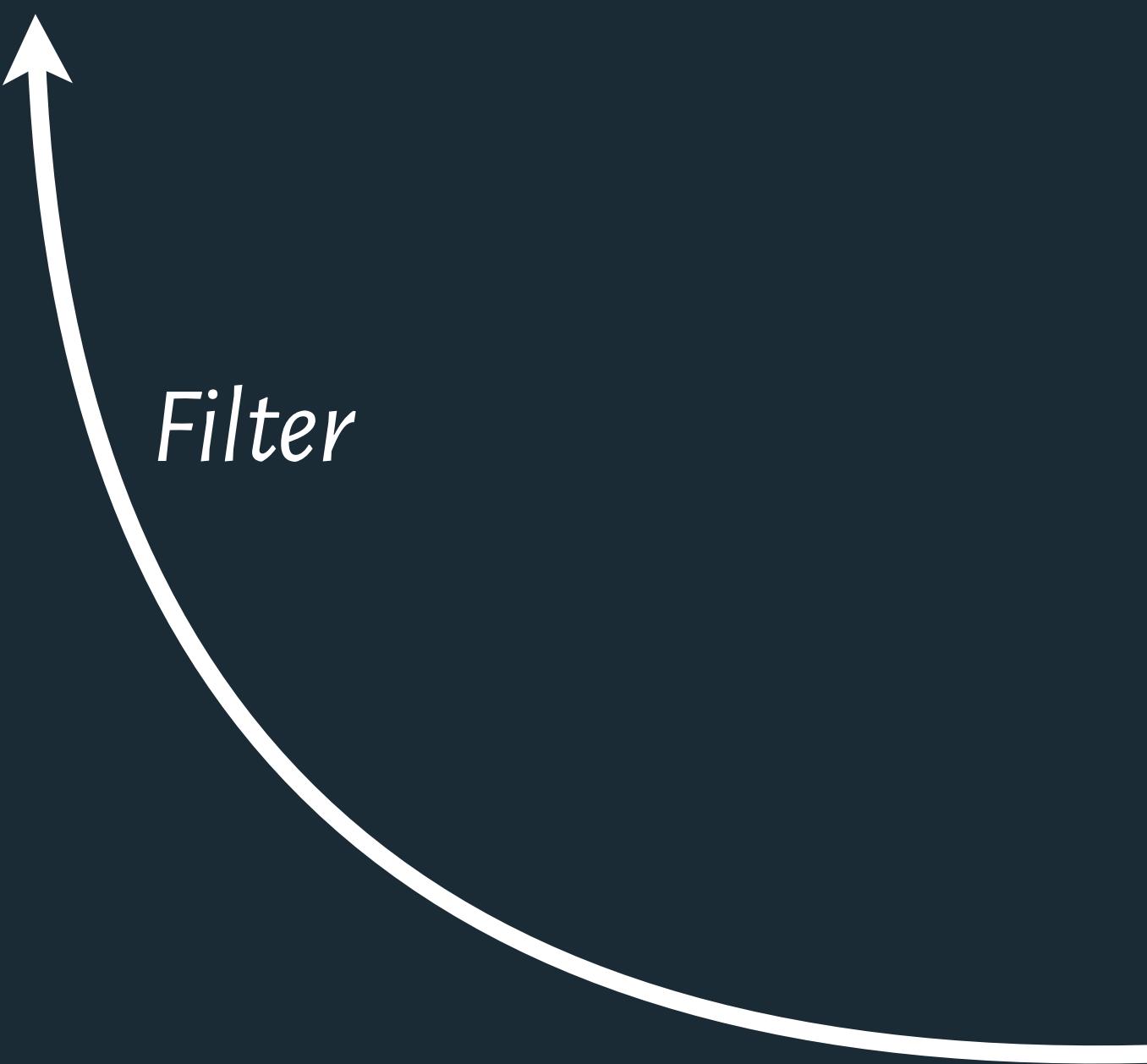


day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

select \* from stocks

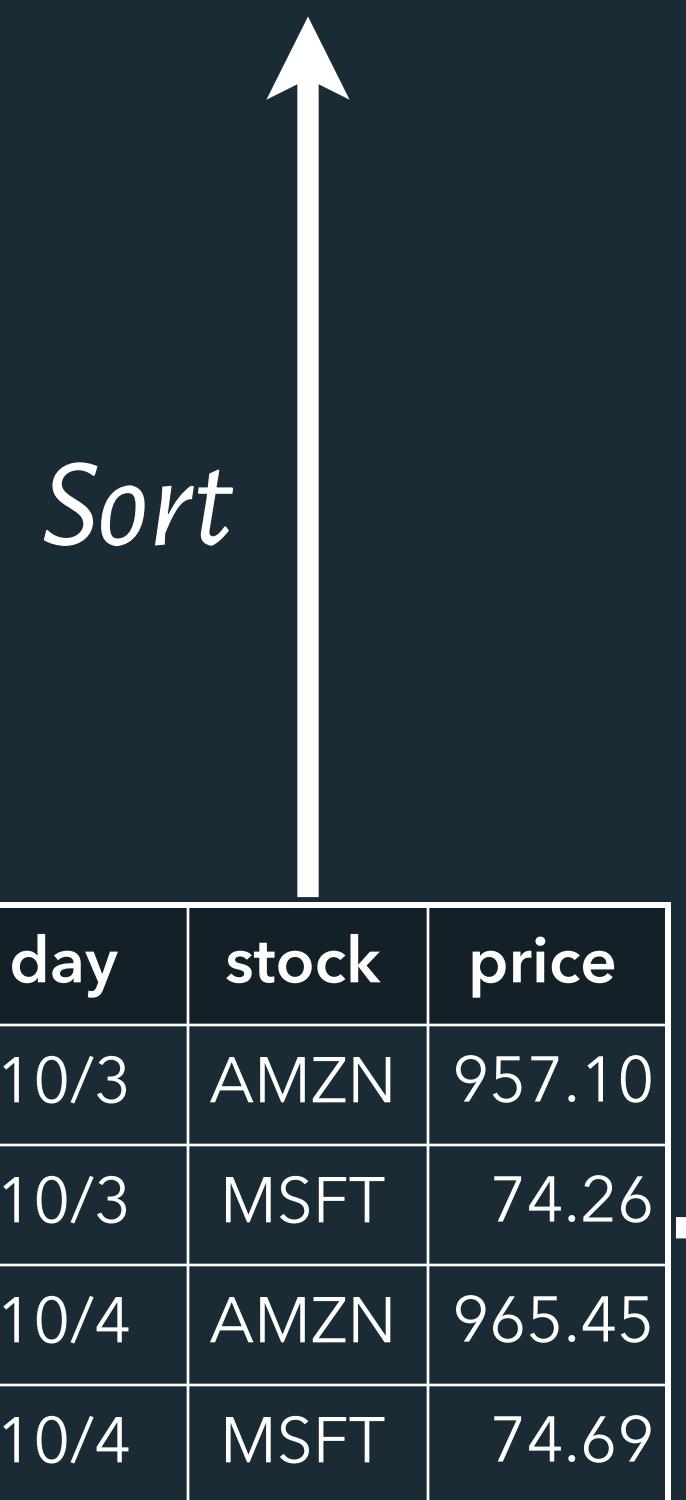
day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45

```
select * from stocks  
where price > 900
```



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

```
select * from stocks  
order by price desc
```



```
select * from stocks
```

symbol	avg(price)
AMZN	961.275
MSFT	74.475

```
select avg(price)  
from stocks  
group by symbol
```

*"Small Multiples" +  
Aggregation*

## Gulf of Evaluation

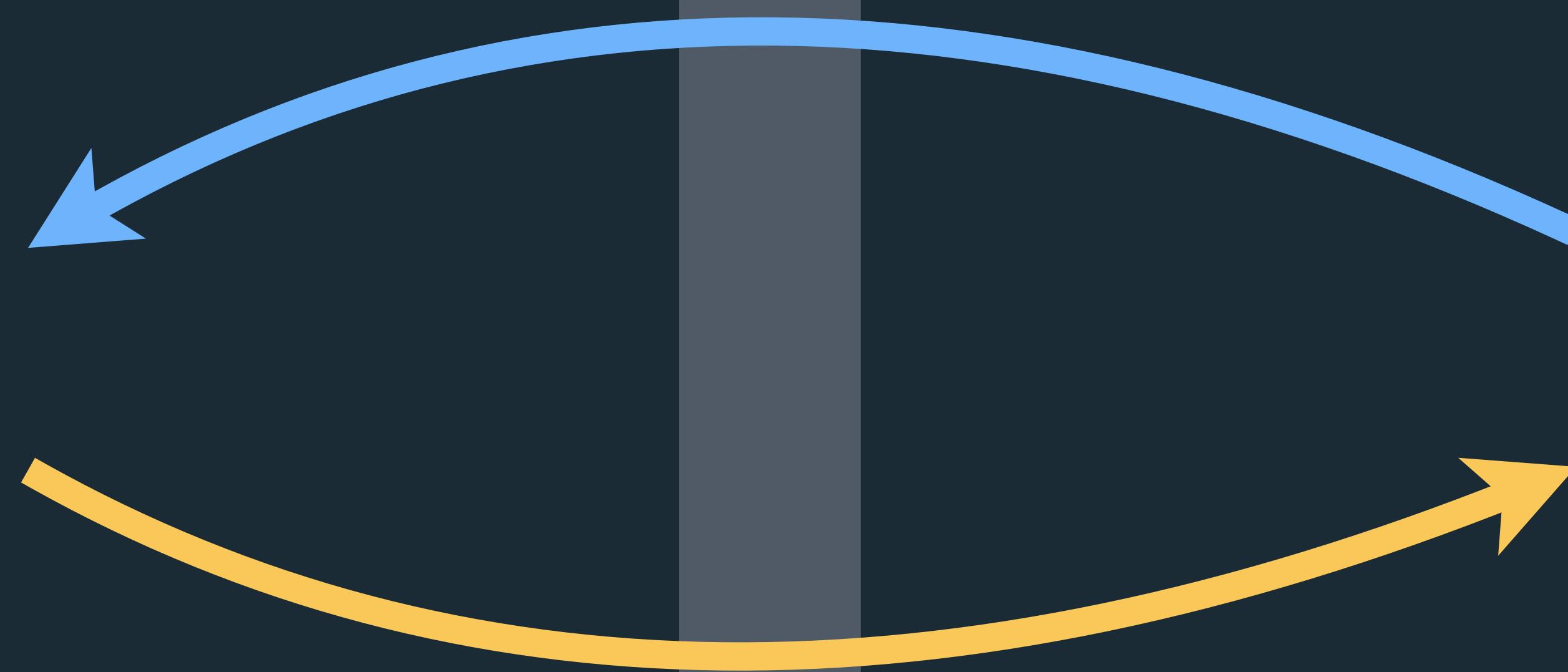
The level of difficulty in interpreting the system and assessing if goals were met.



User Goals



Data



## 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



User Goals



## Gulf of Execution

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



Data



User Goals



Data

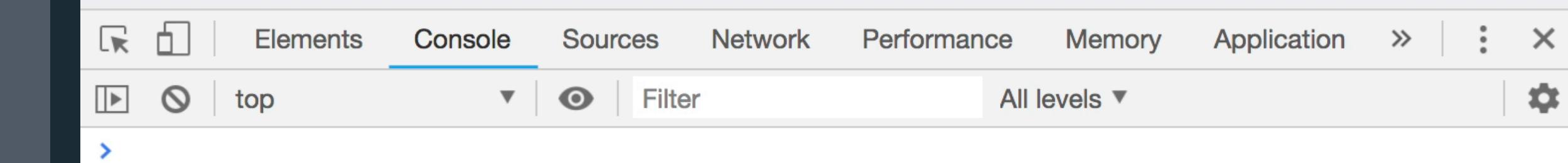
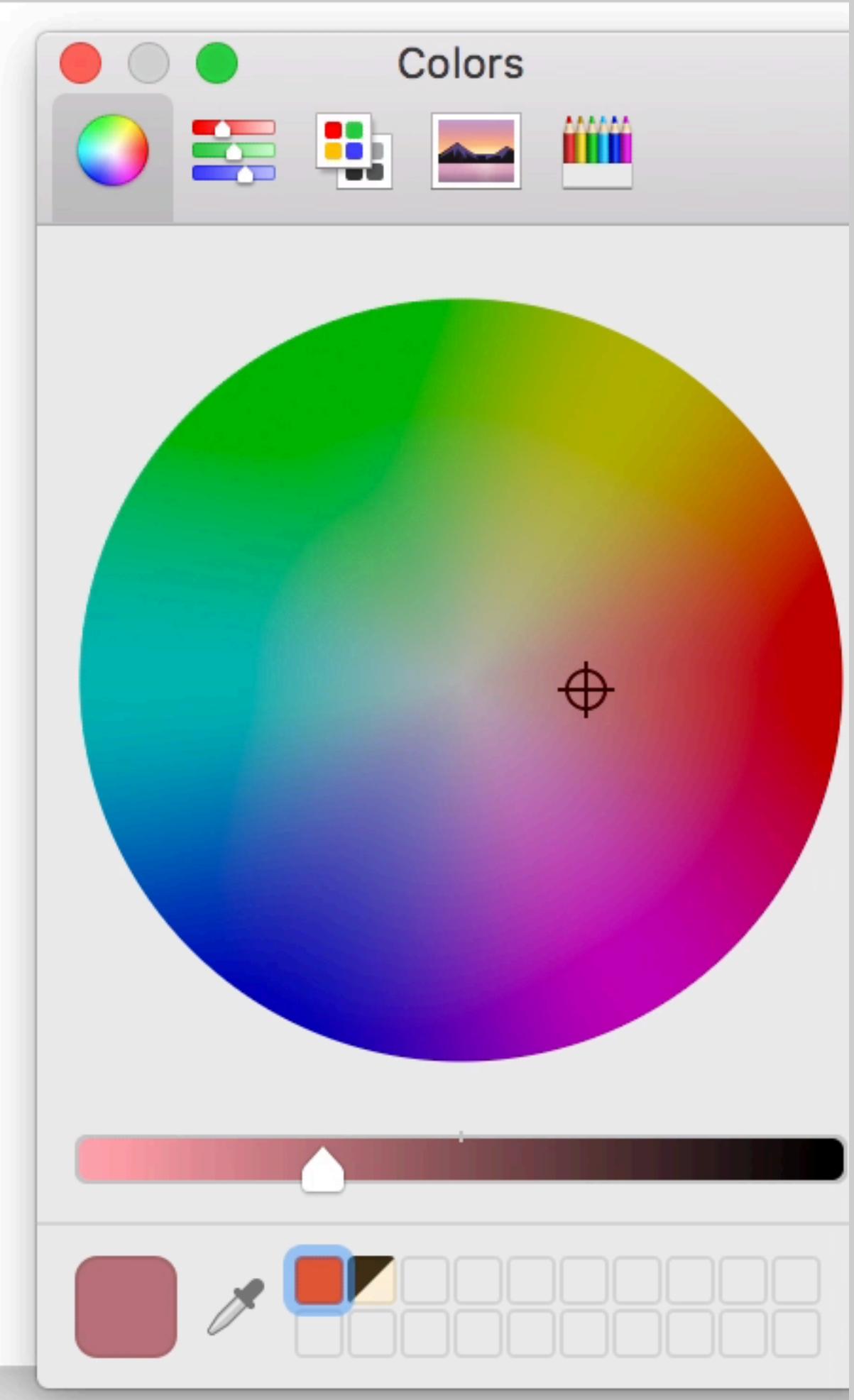
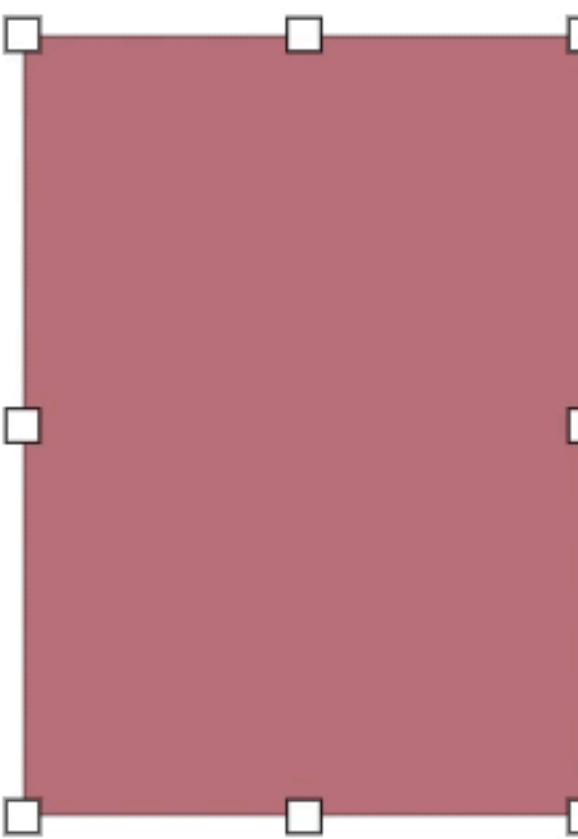
## Gulf of Evaluation

### Direct-Manipulation



## 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 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.

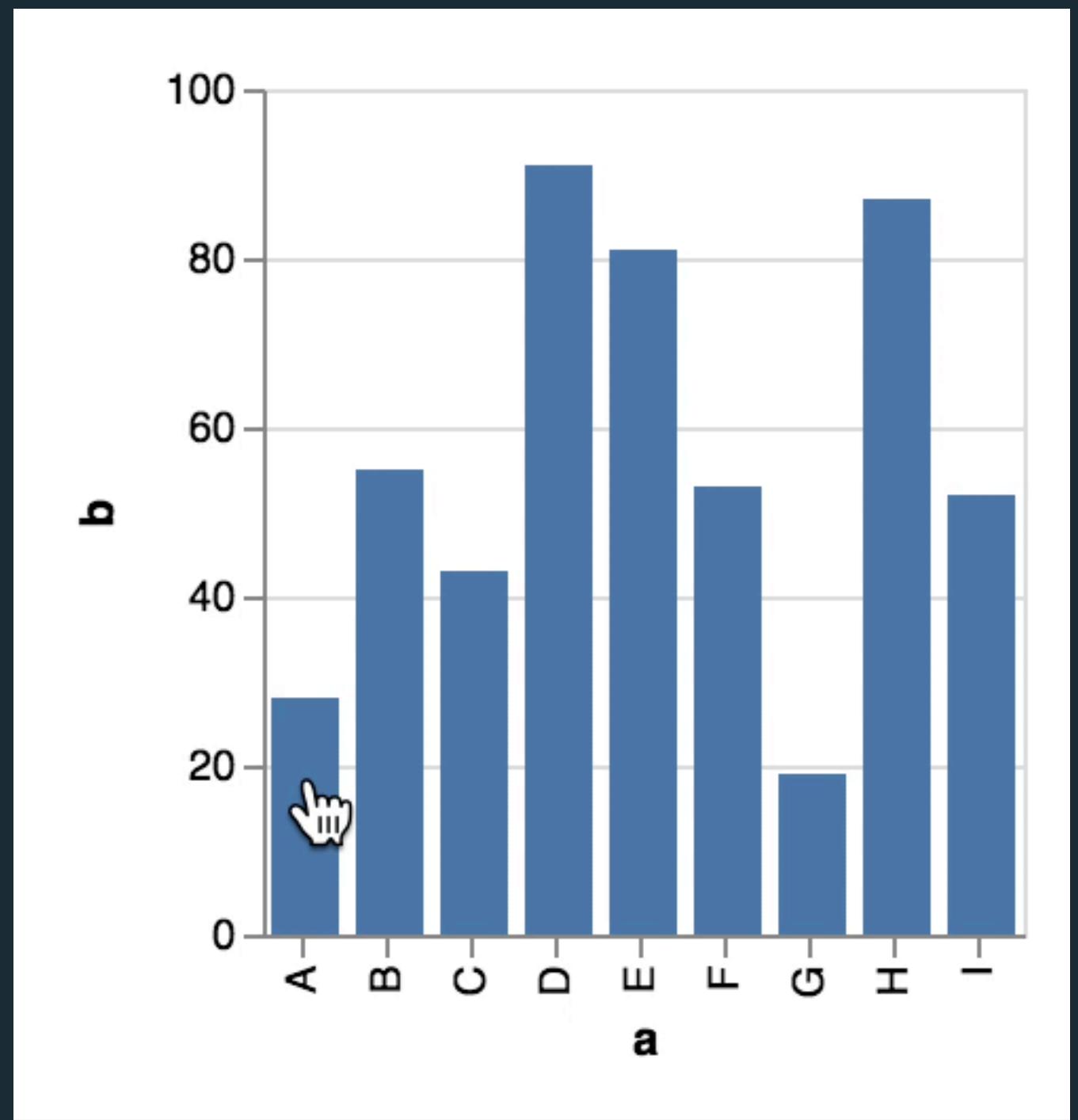
**Explore** – show me something else.

**Encode** – show me a different visual representation.

# Point Selection

Select discrete data values.

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

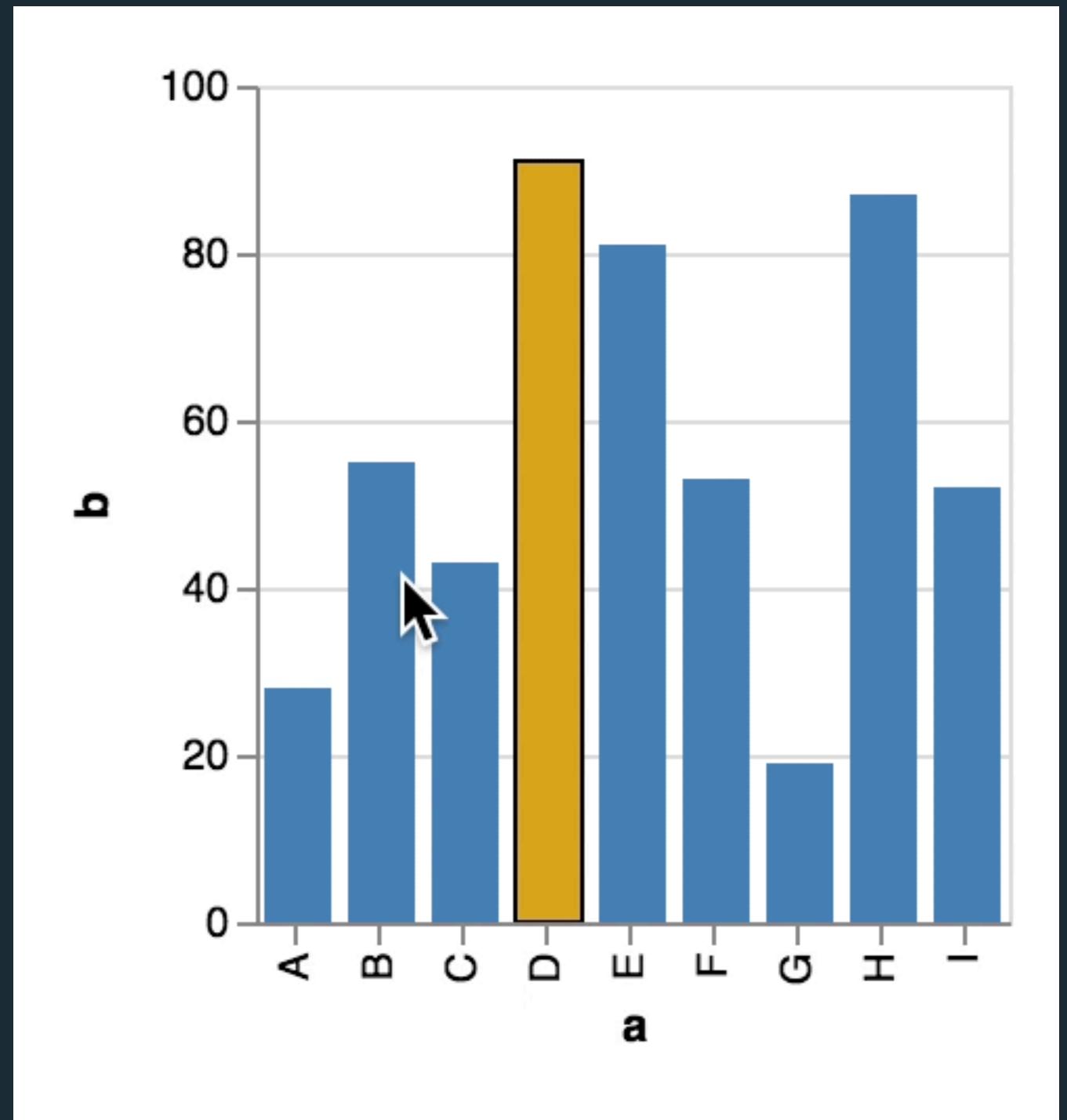


# Point Selection

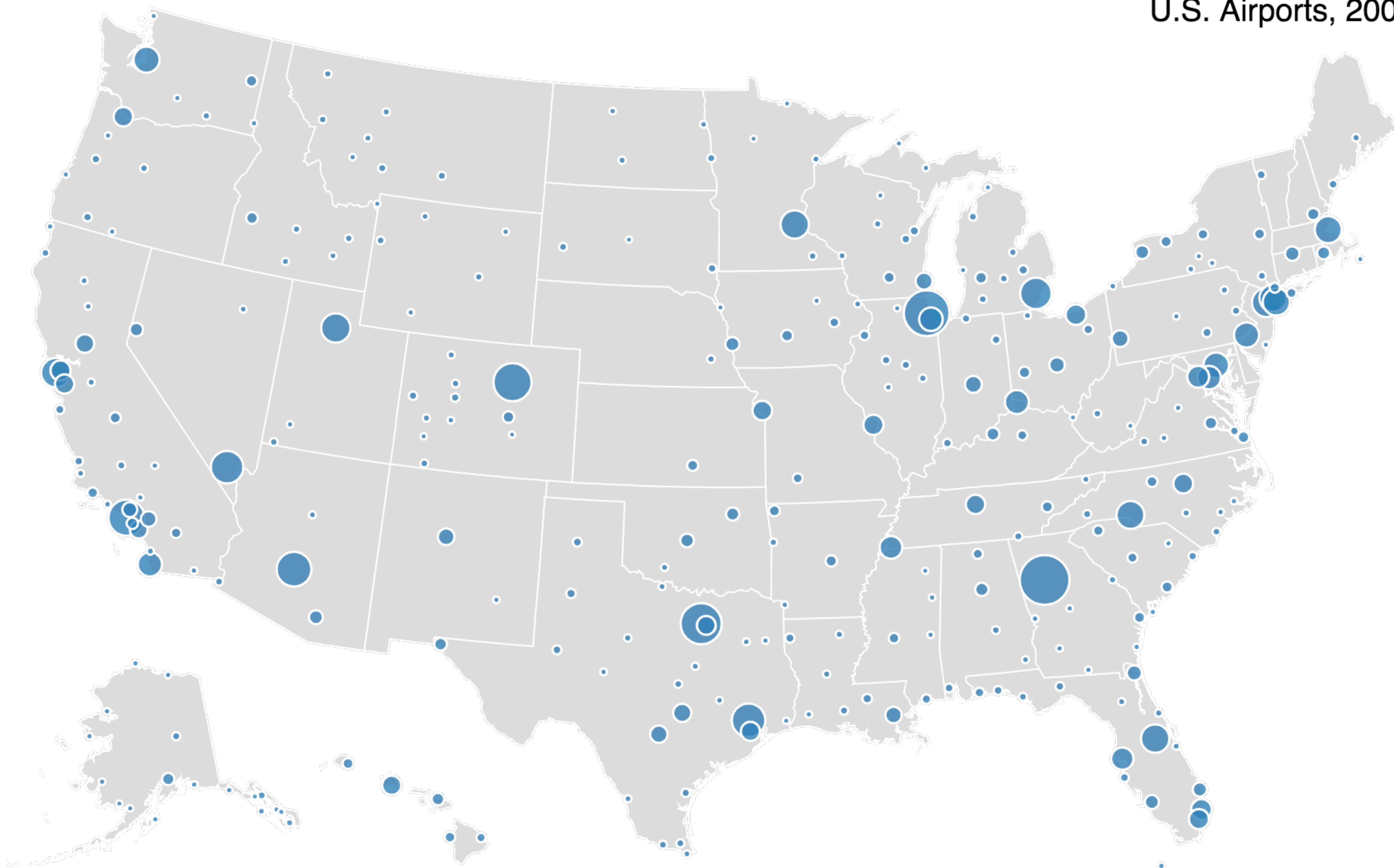
Select discrete data values.

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

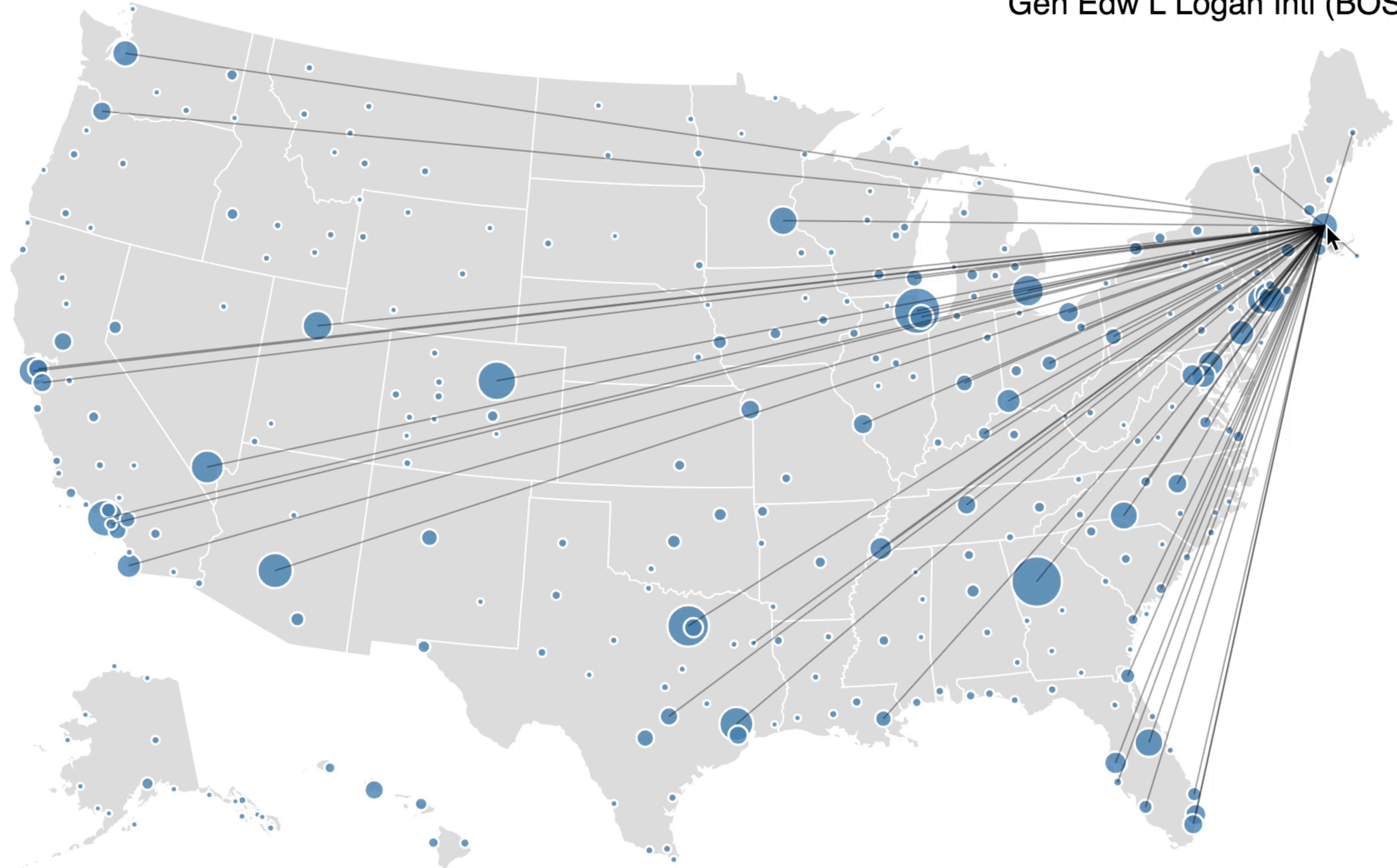
How are points selected? Mouse hover, click, tap, ...



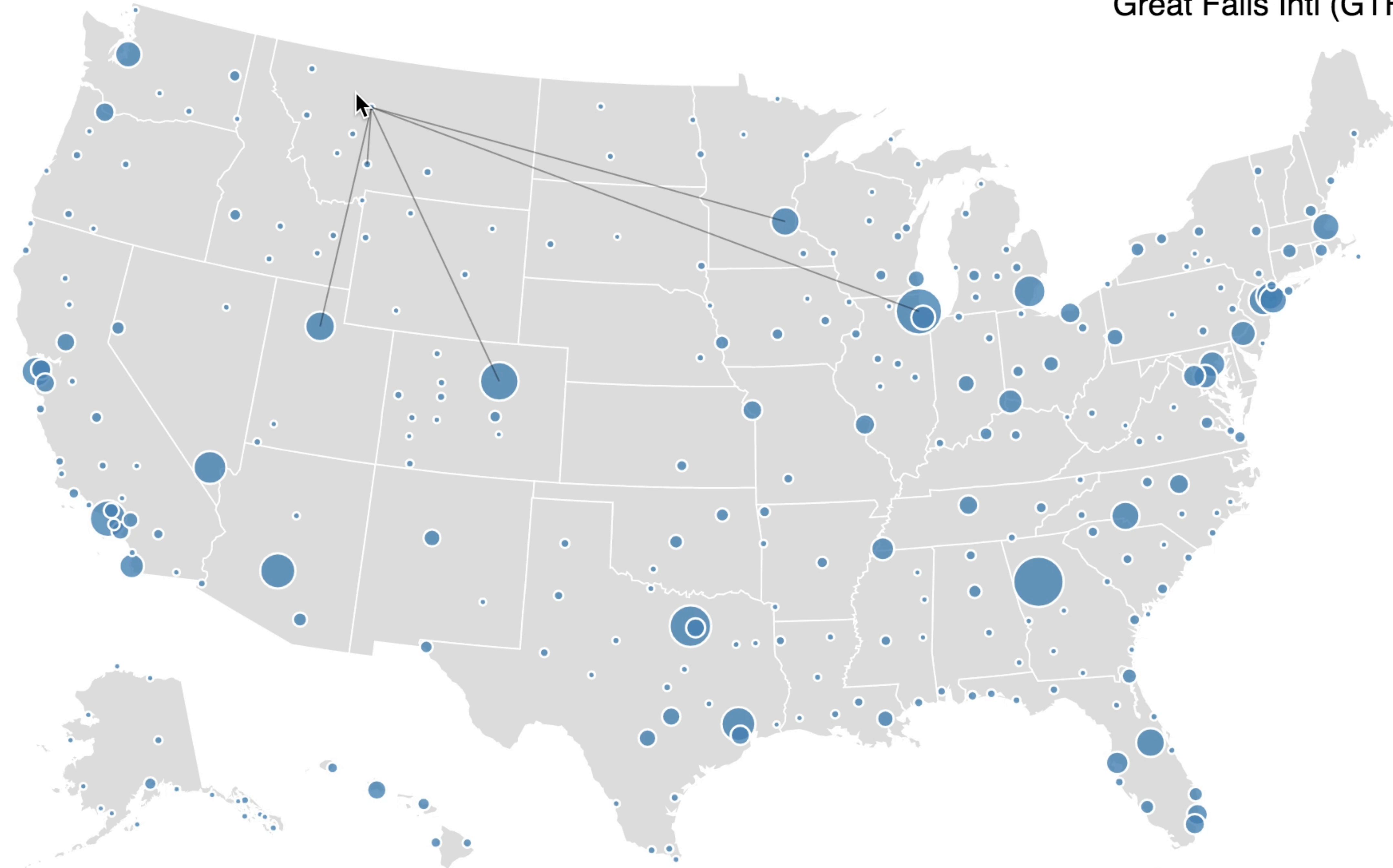
# U.S. Airports, 2008



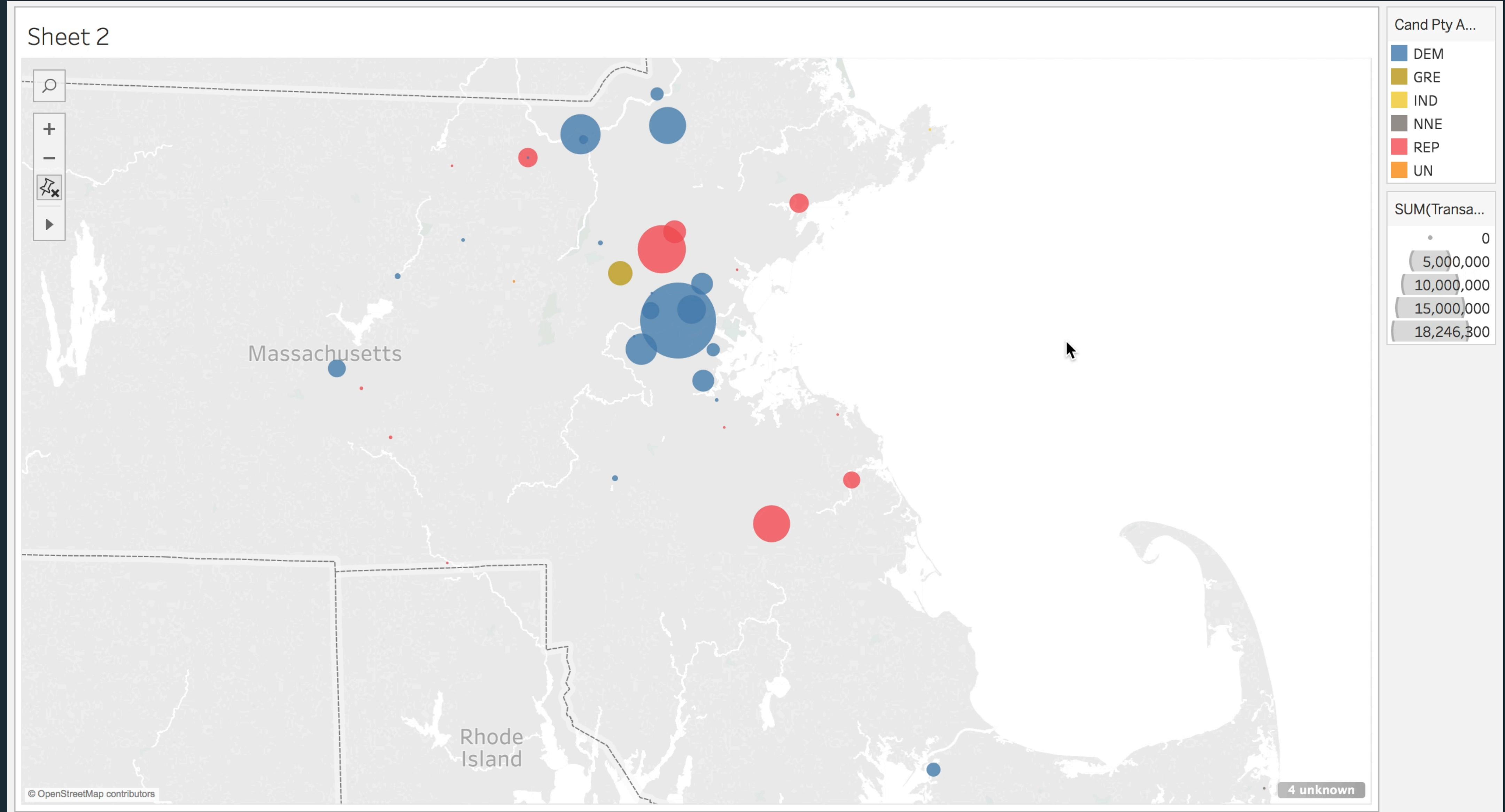
# Gen Edw L Logan Intl (BOS)



# Great Falls Intl (GTF)



# Region Selection



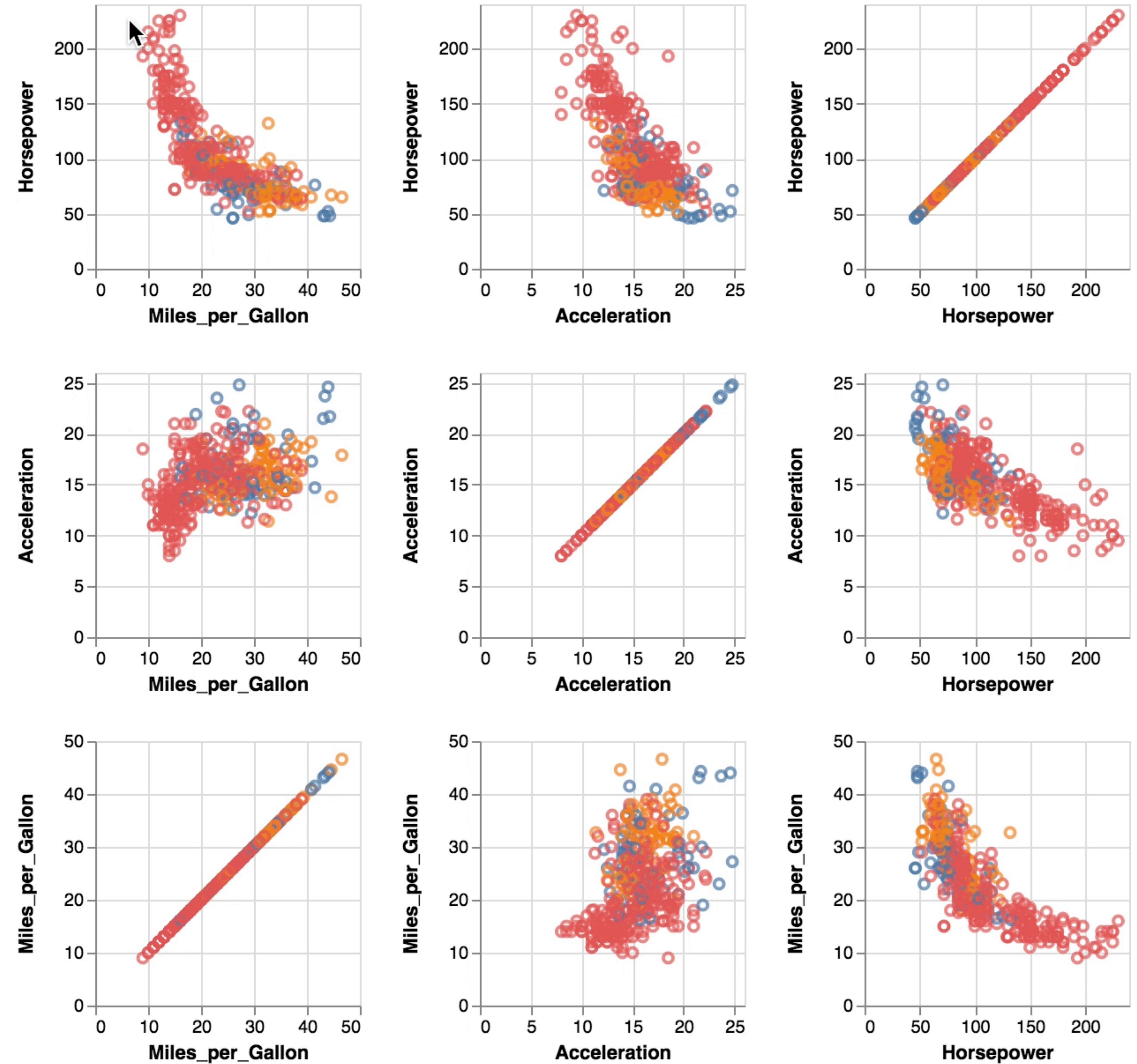
# **Generalized Selection via Interactive Query Relaxation**

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

# Connect

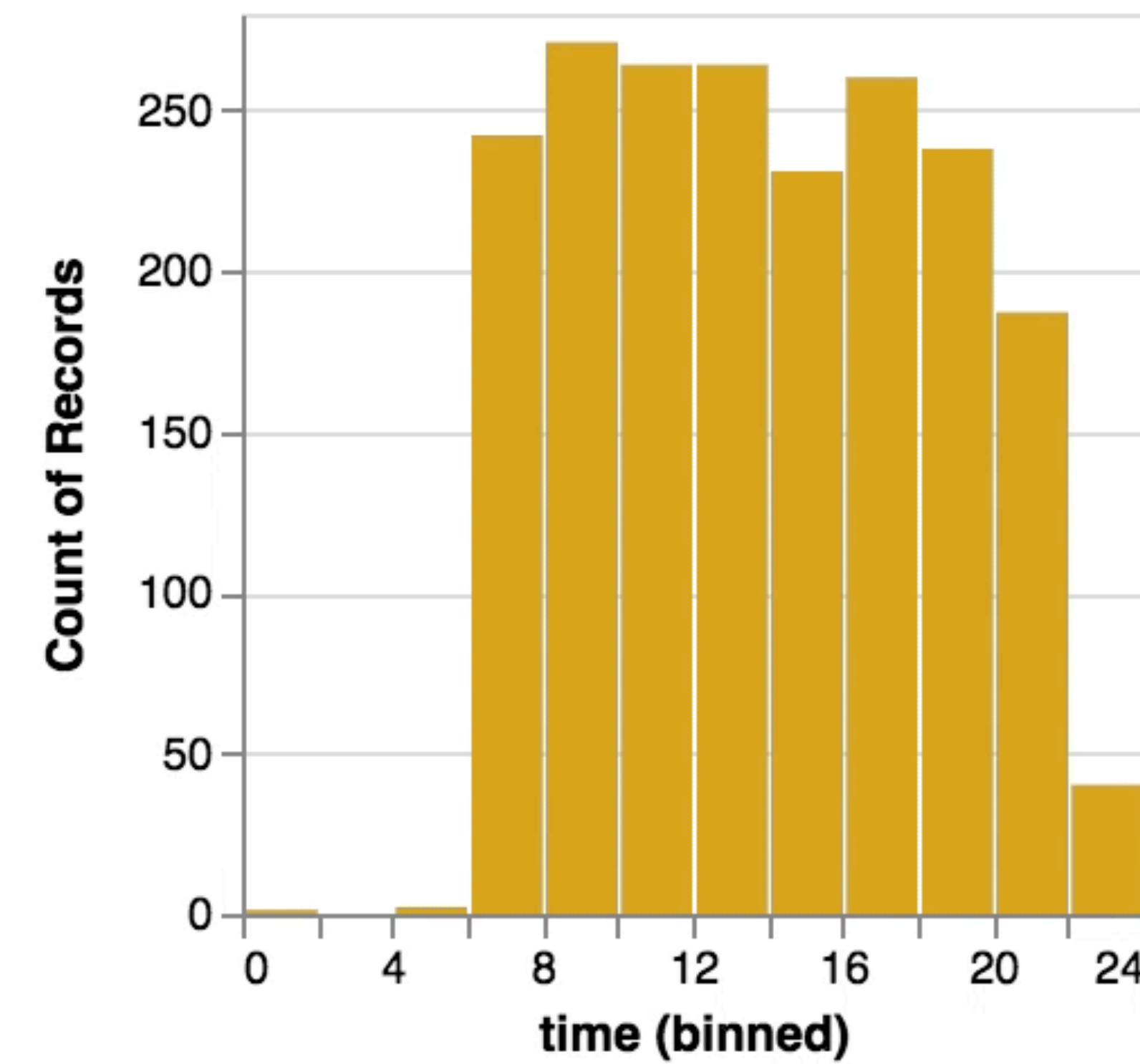
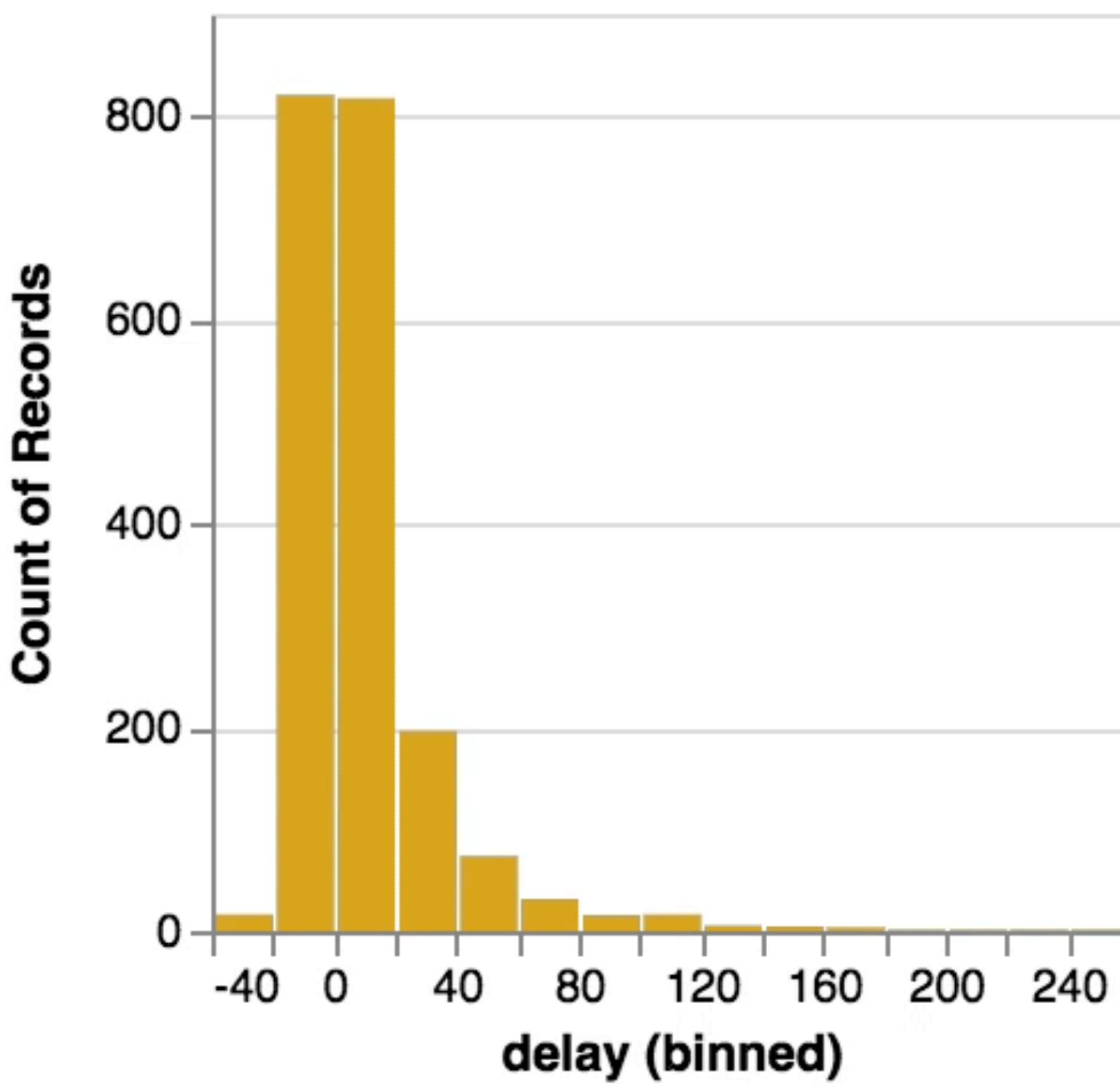
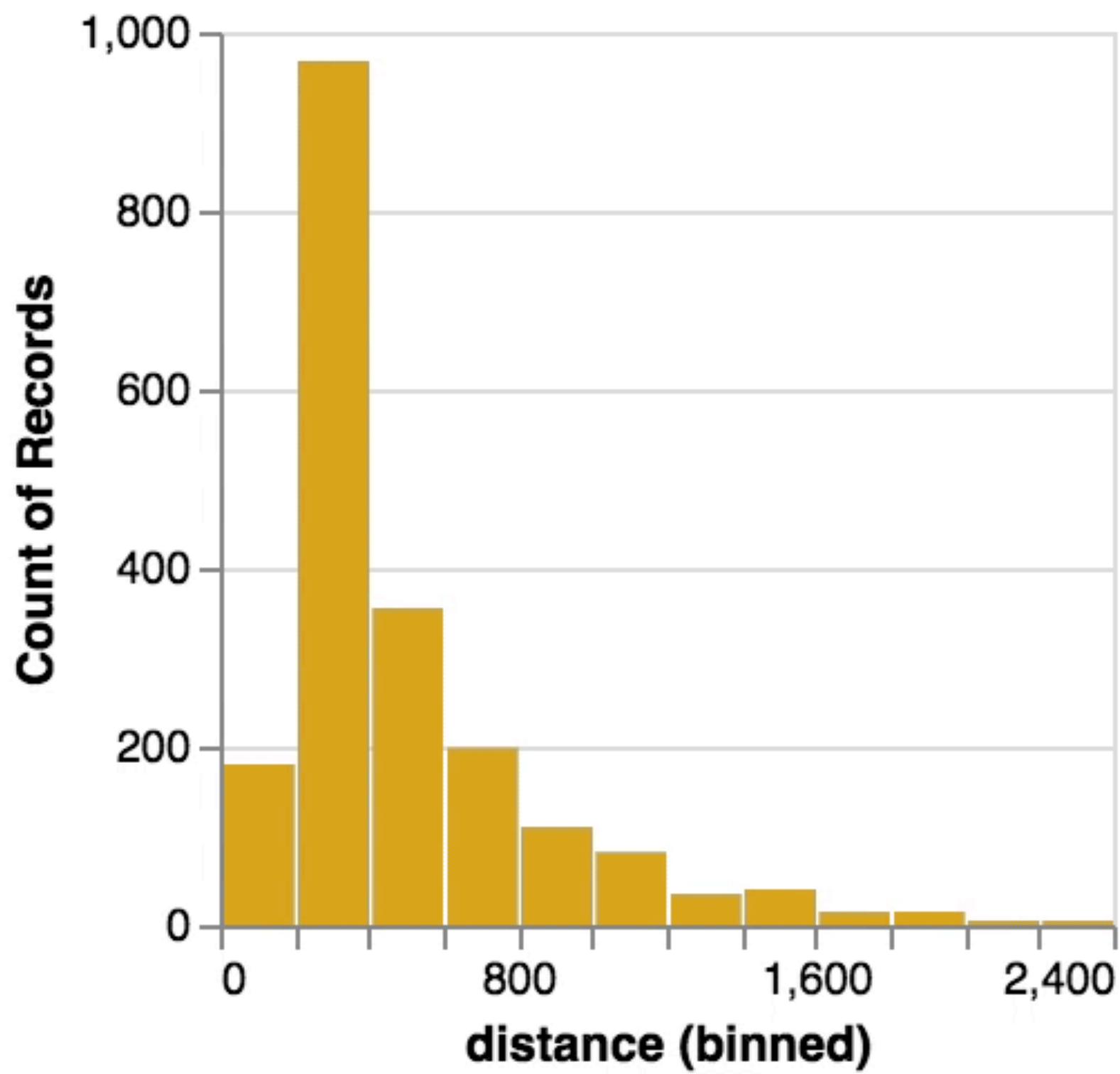
Brushing & linking:  
selection is called a  
"brush", and the selected  
data is shown ("linked")  
in other views.

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



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

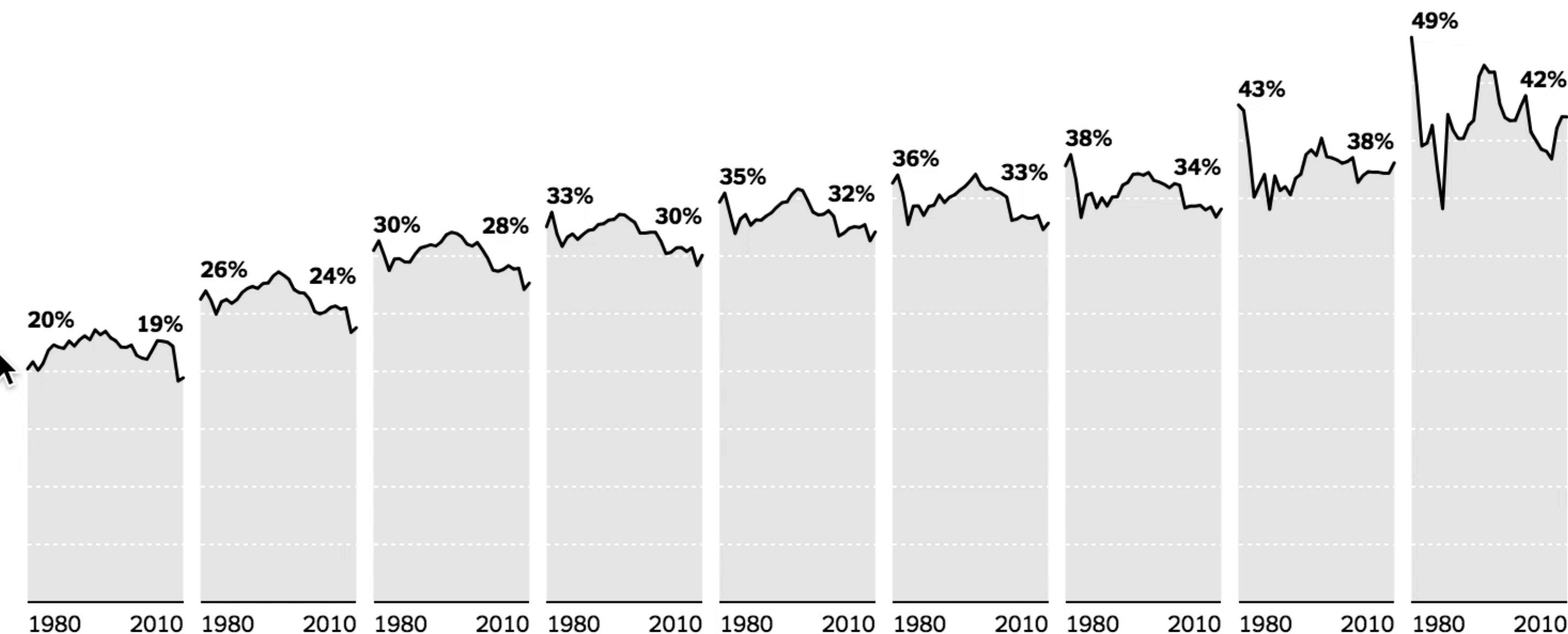
## How the Tax Burden Has Changed

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 »](#)

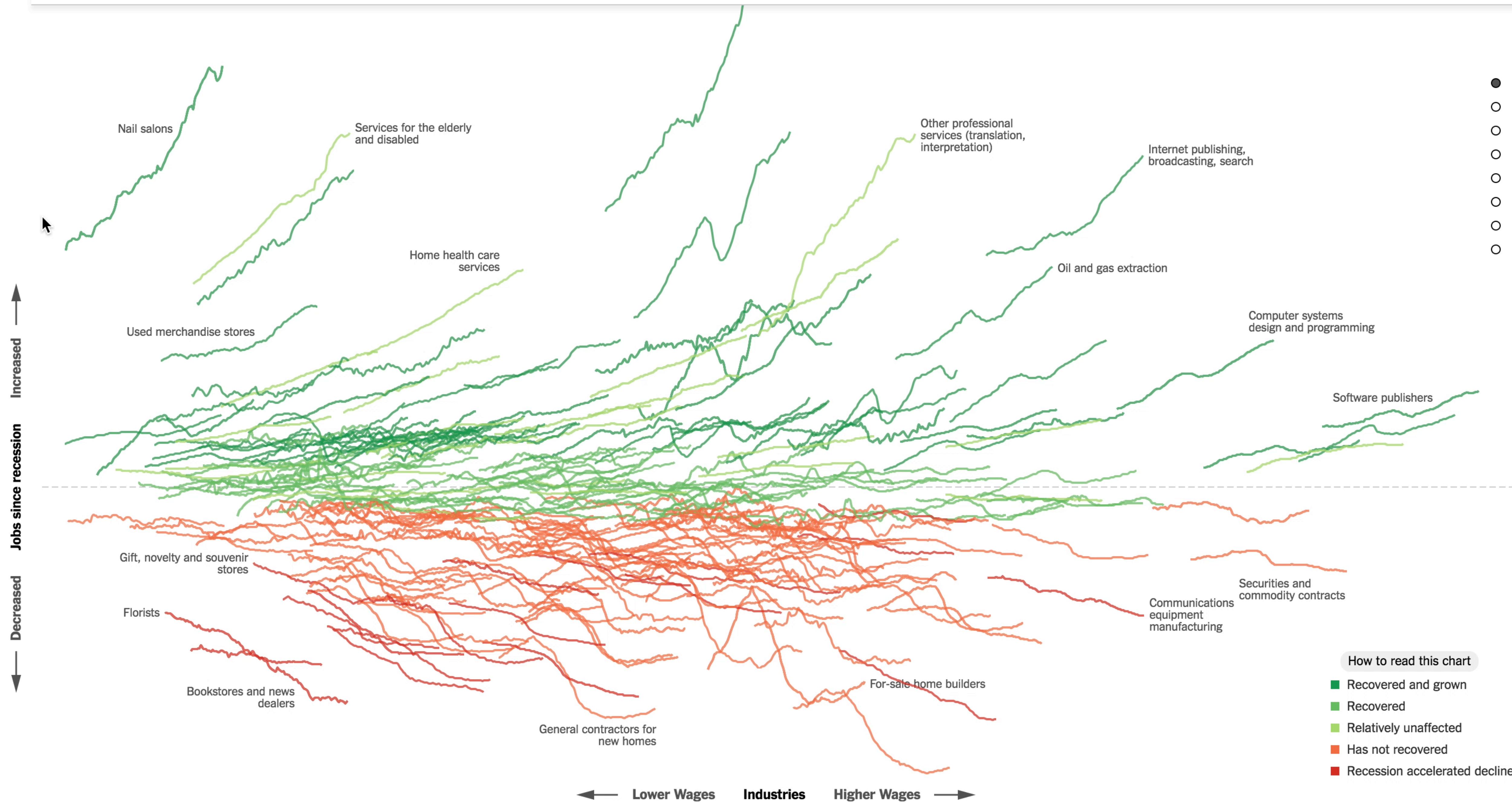
\$0-25k    \$25-50k    \$50-75k    \$75-100k    \$100-125k    \$125-150k    \$150-200k    \$200-350k    \$350k+

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

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

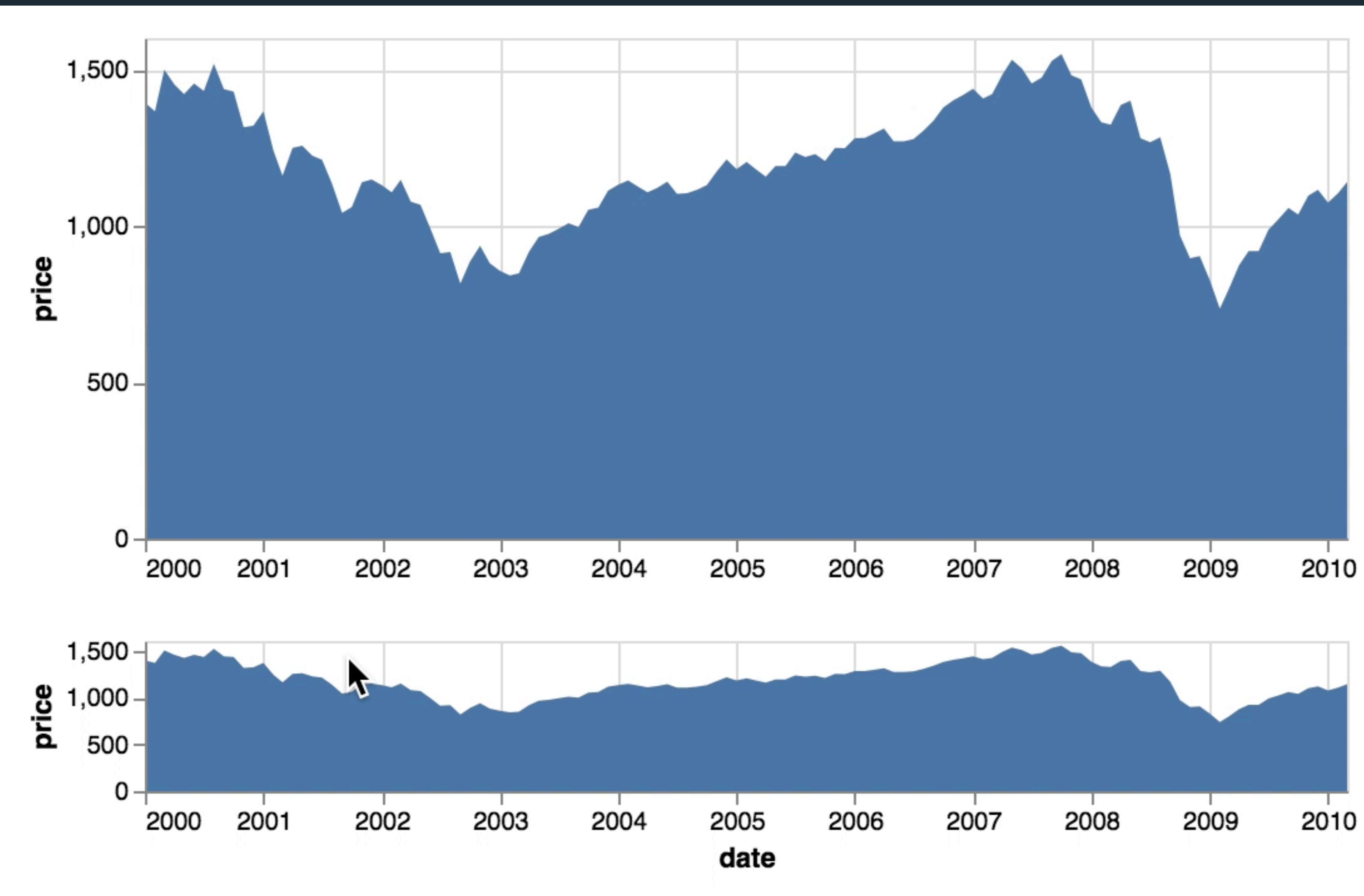


# Abstract/Elaborate



# Abstract/Elaborate

Overview + Detail



# SchemeLens

## A Content-Aware Vector-Based Fisheye Technique for Navigating Large Systems Diagrams

**Aurélie Cohe, Bastien Liutkus, Gilles Bailly, James Eagan, Eric Lecolinet**

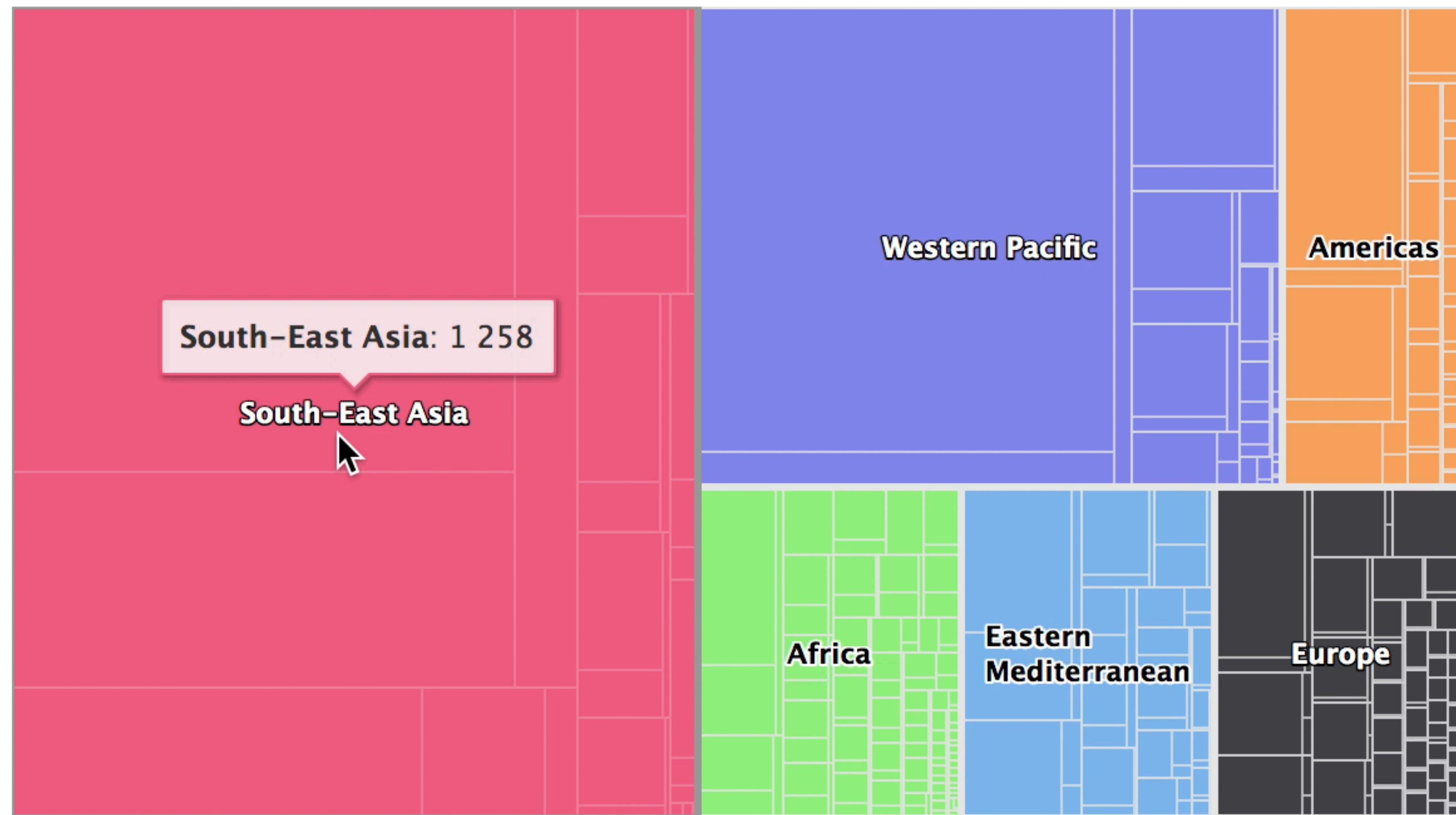
**Télécom ParisTech - CNRS LTCI - VIA Group**

**InfoVis 2015**

# Abstract/Elaborate

## Global Mortality Rate 2012, per 100 000 population

Click points to drill down. Source: WHO.



# Abstract/Elaborate

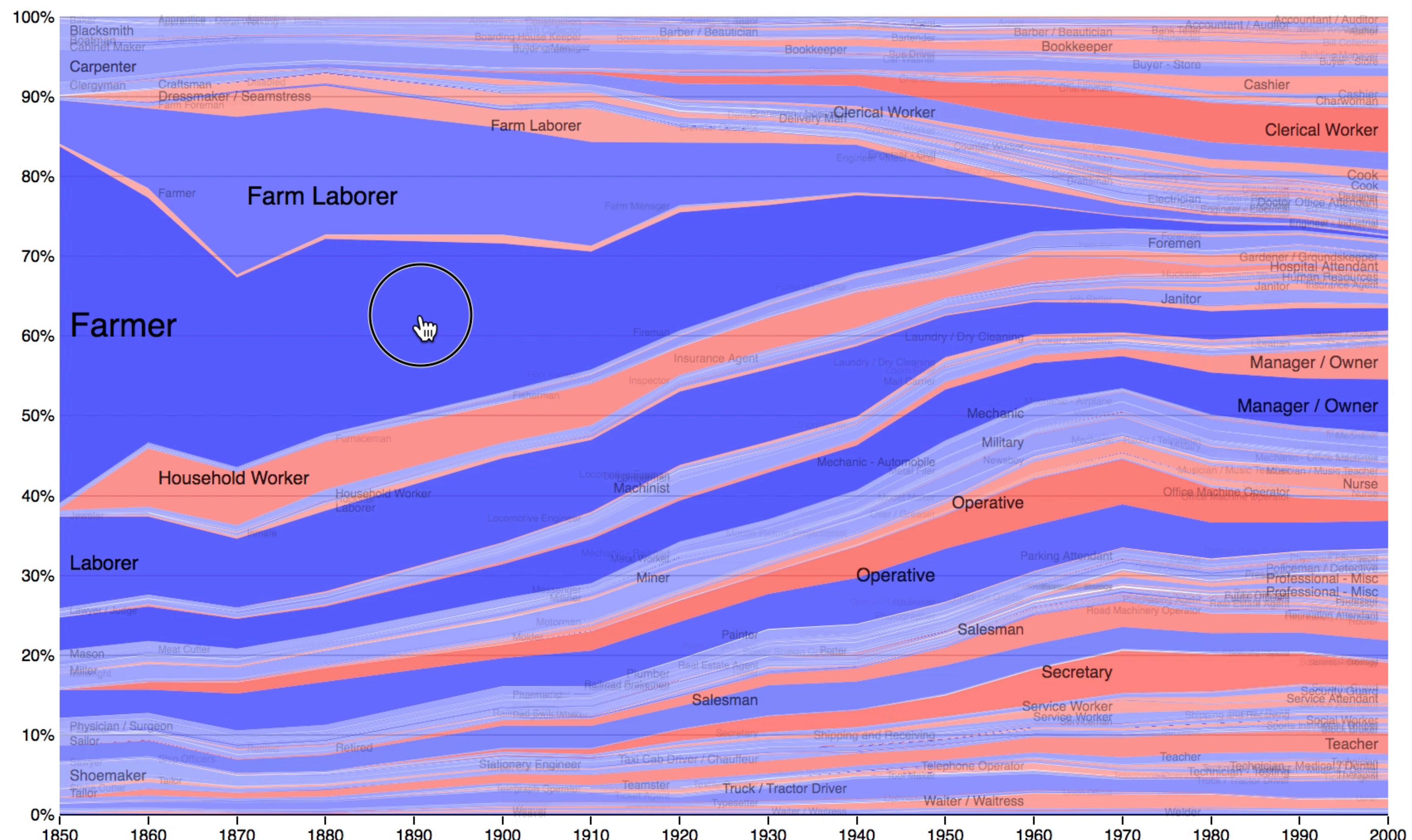
Mike Bostock, April 2018.



# Filter

# Job Voyager

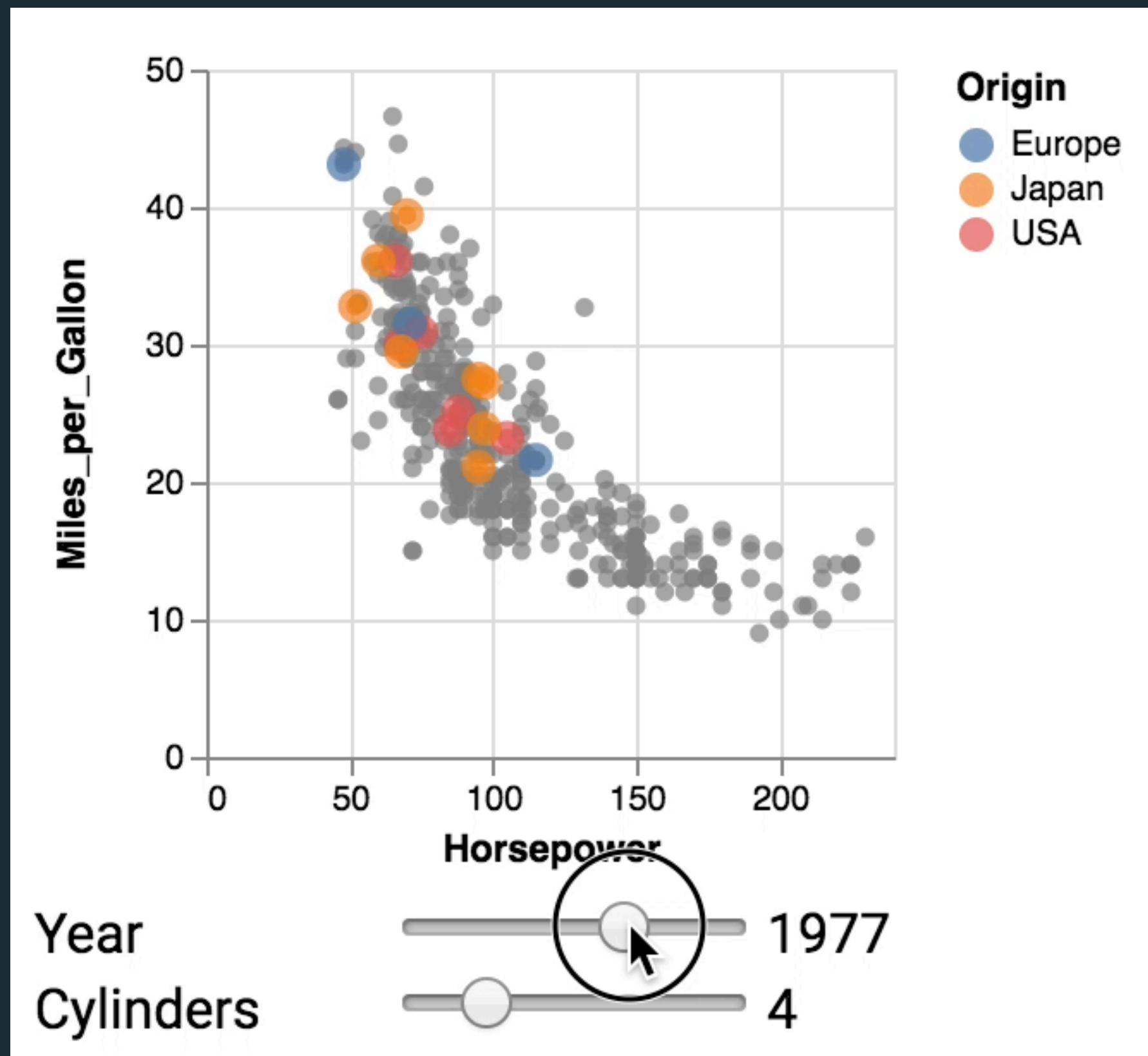
Gender:  Men  Women  Any



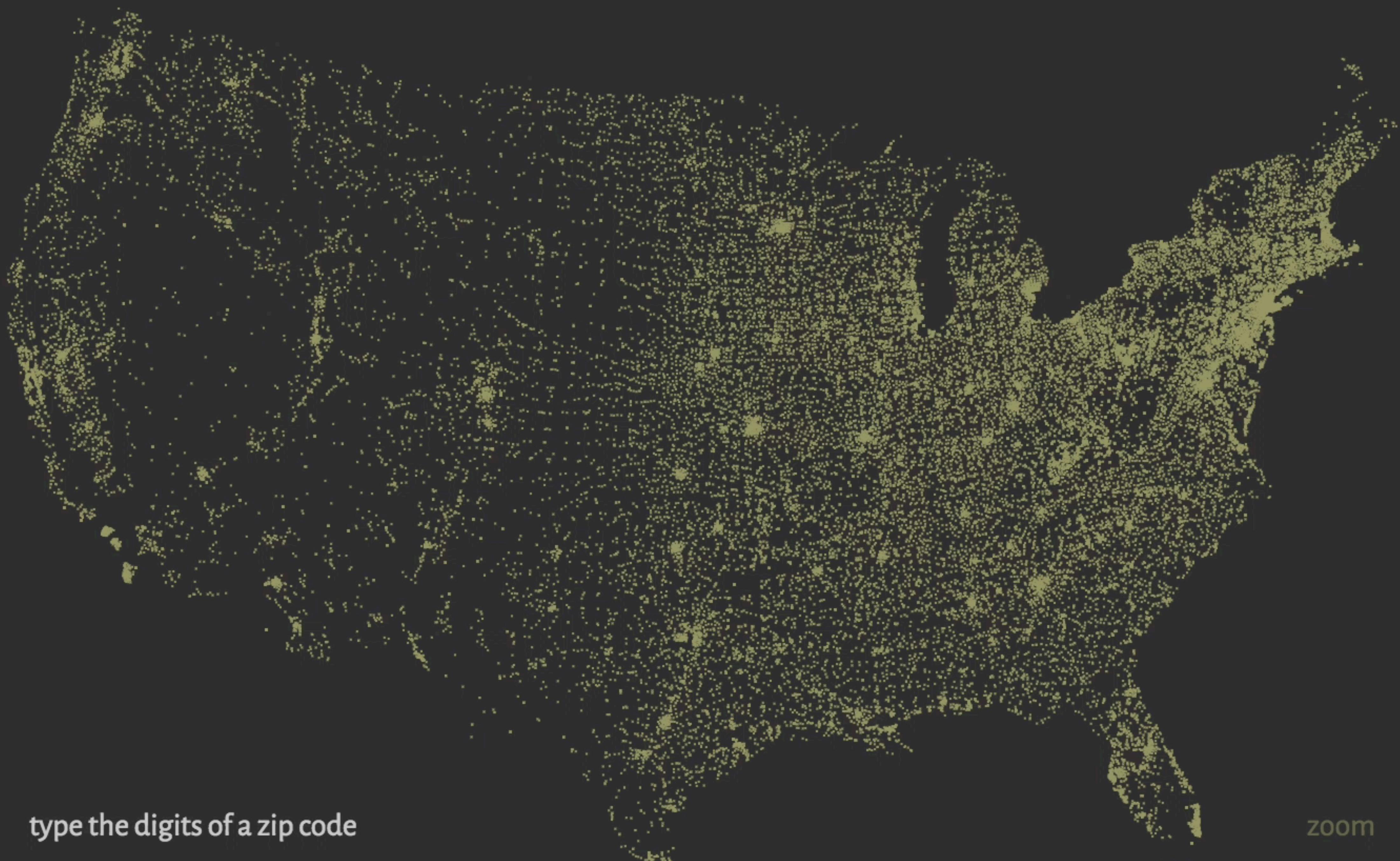
Mike Bostock, 2010.

search: |

# Filter



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



type the digits of a zip code

zoom



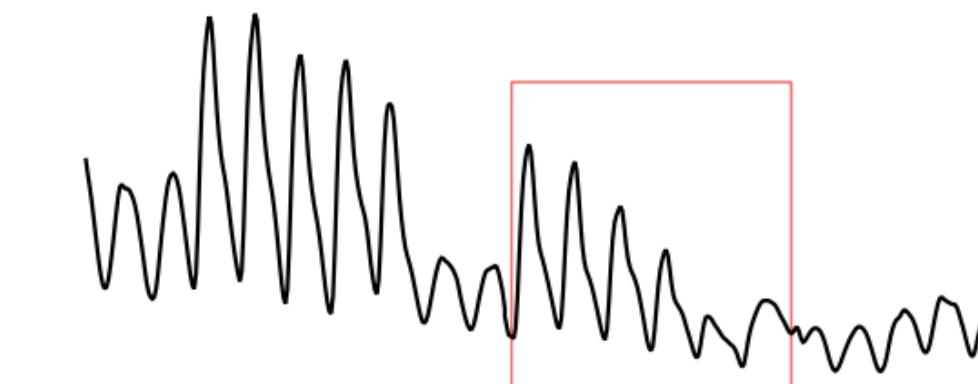


(a) **Head-and-shoulders** in Amazon stock prices, 150 days 10/99 to 3/00

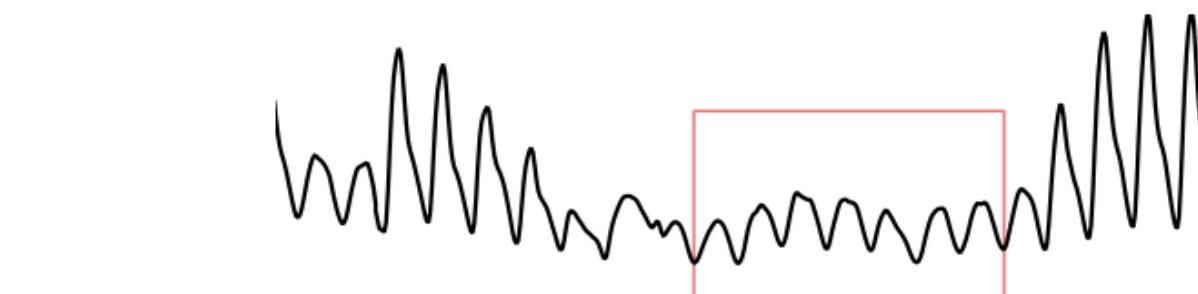


(b) **Inverted head-and-shoulders** in Alaska Air Group stock prices, 108 days 08/98 to 12/98

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



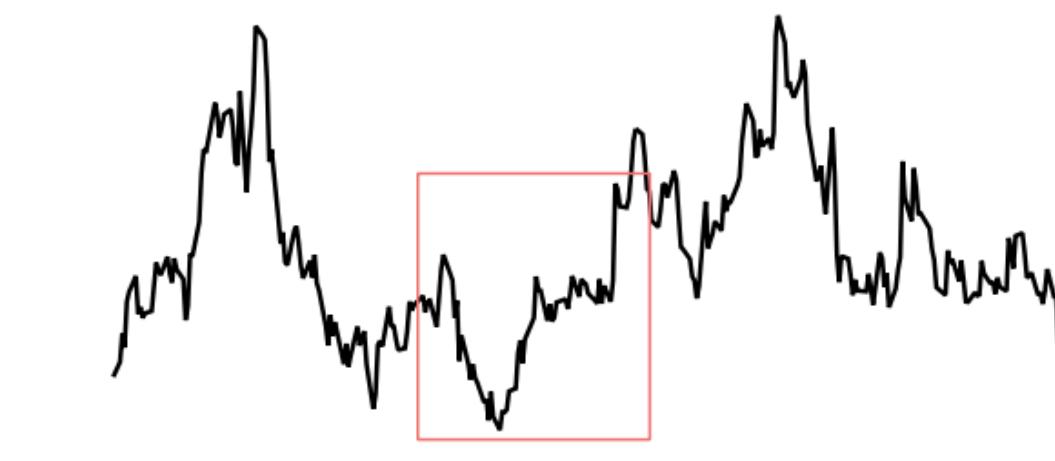
(e) **Falling peaks:** a six day decrease in traffic before 12/25/04 (Christmas)



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

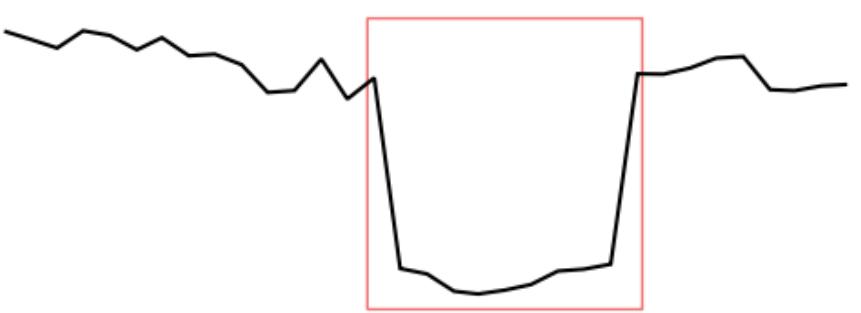
[Mannino and Abouzied. Qetch. CHI, 2018]

Daily stock prices in 8 year data sets



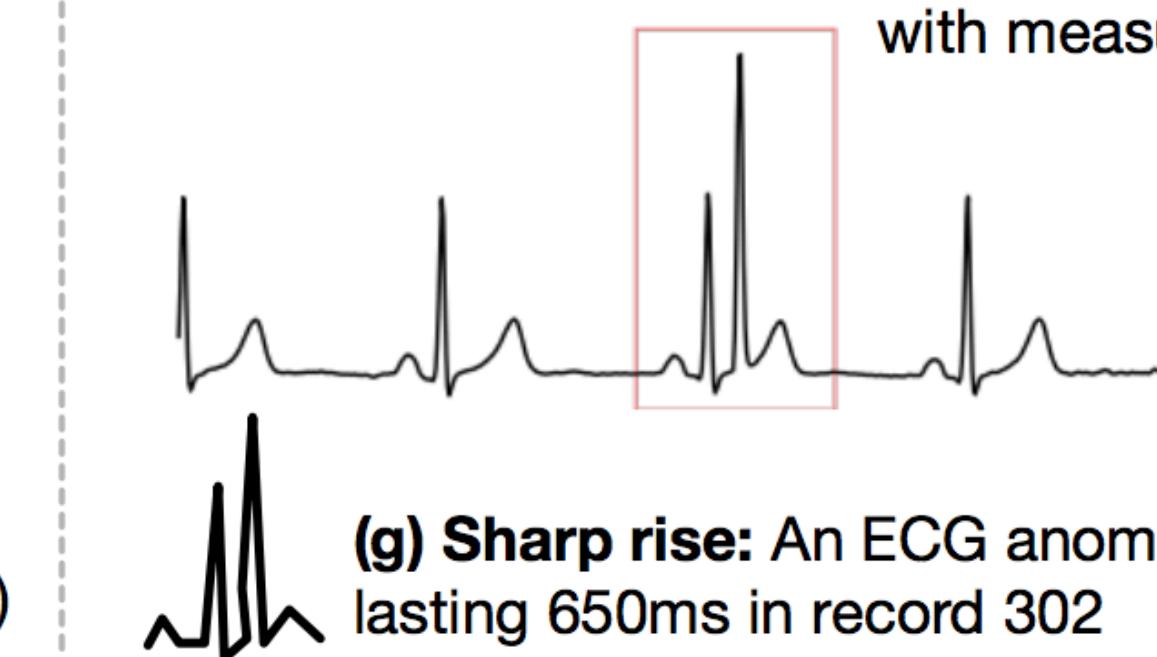
(c) **Cup-with-handle** in Amazon stock prices, 95 days 7/99 to 11/99

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

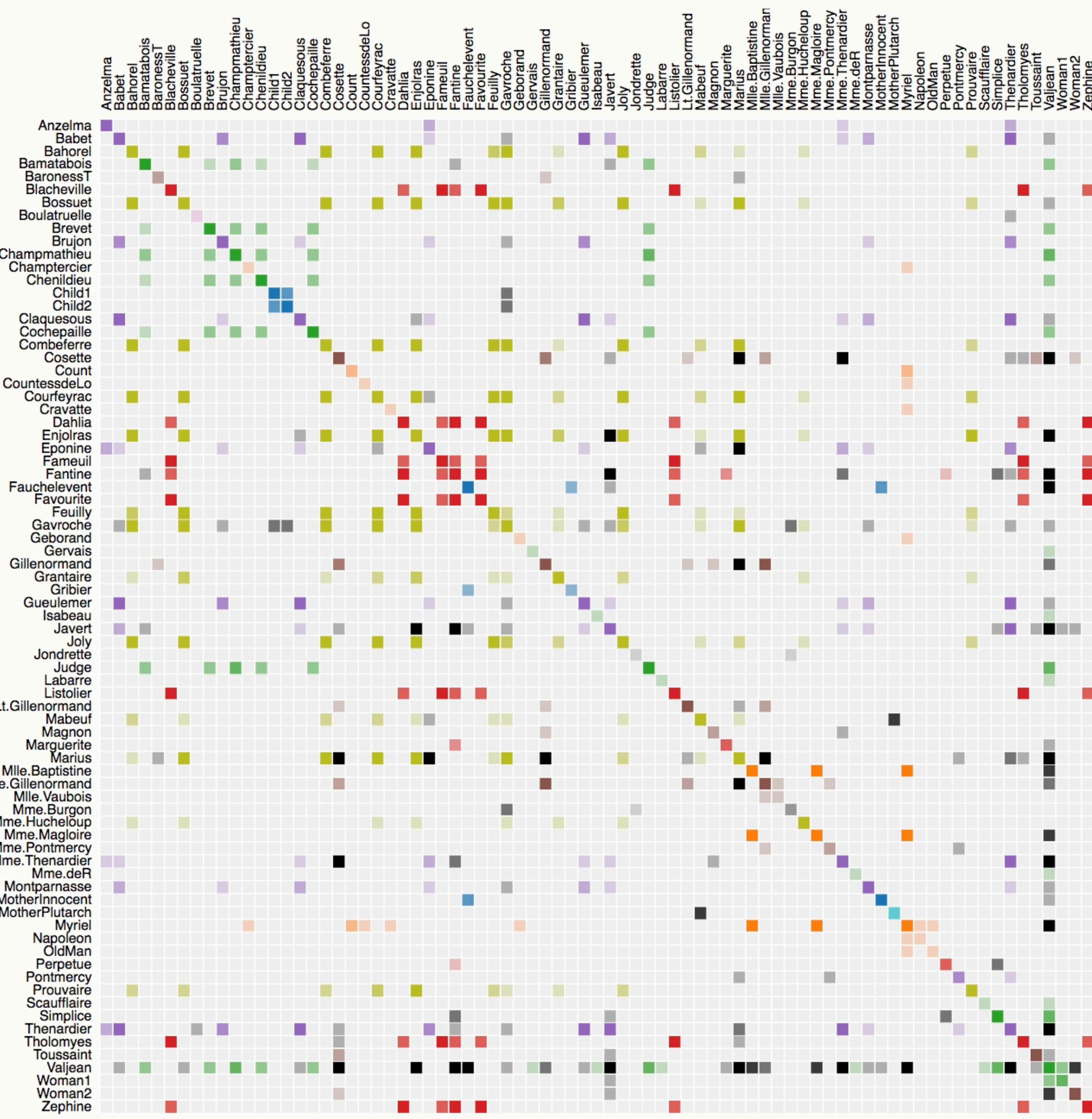


(g) **Sharp rise:** An ECG anomaly lasting 650ms in record 302



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

# Reconfigure



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.

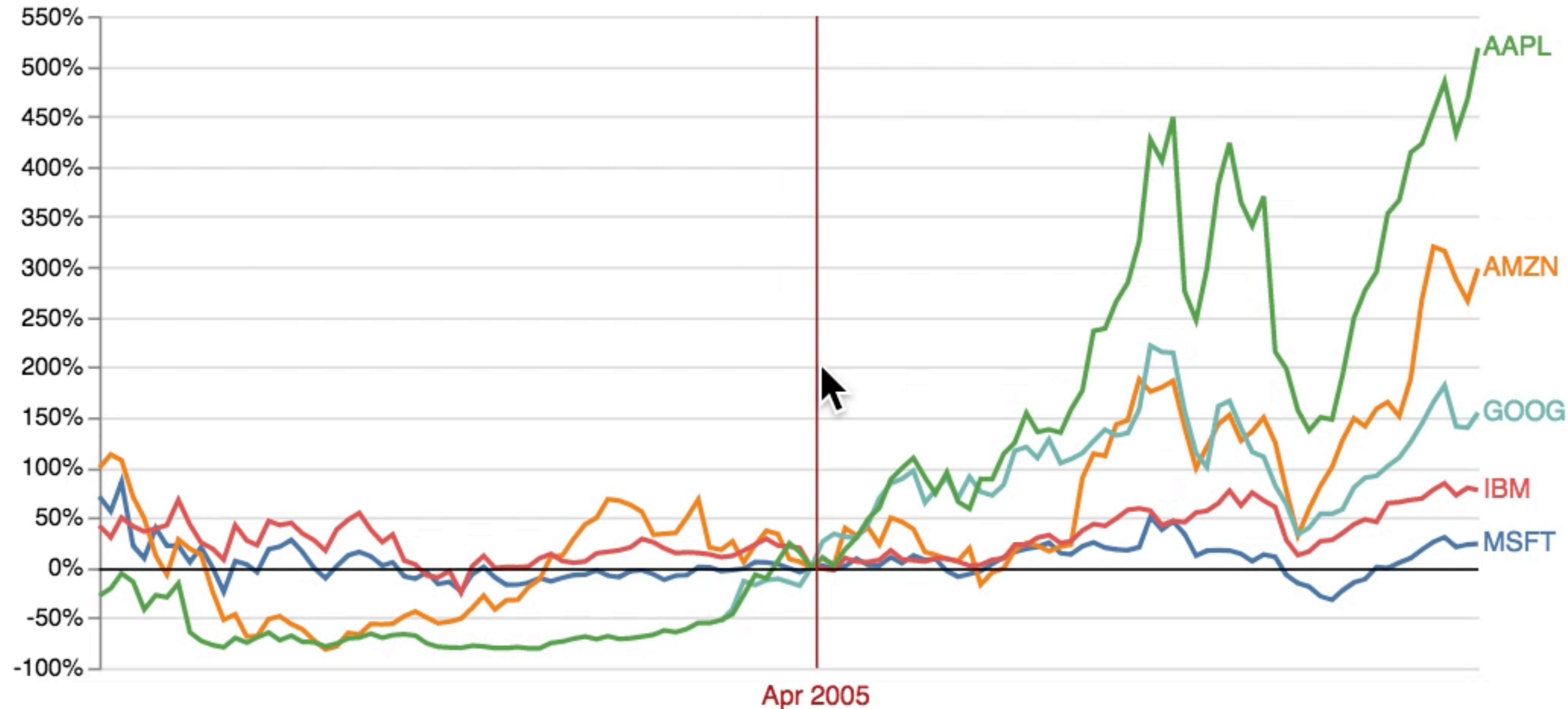
Use the drop-down menu to reorder the matrix and explore the data.

Built with [d3.js](#).

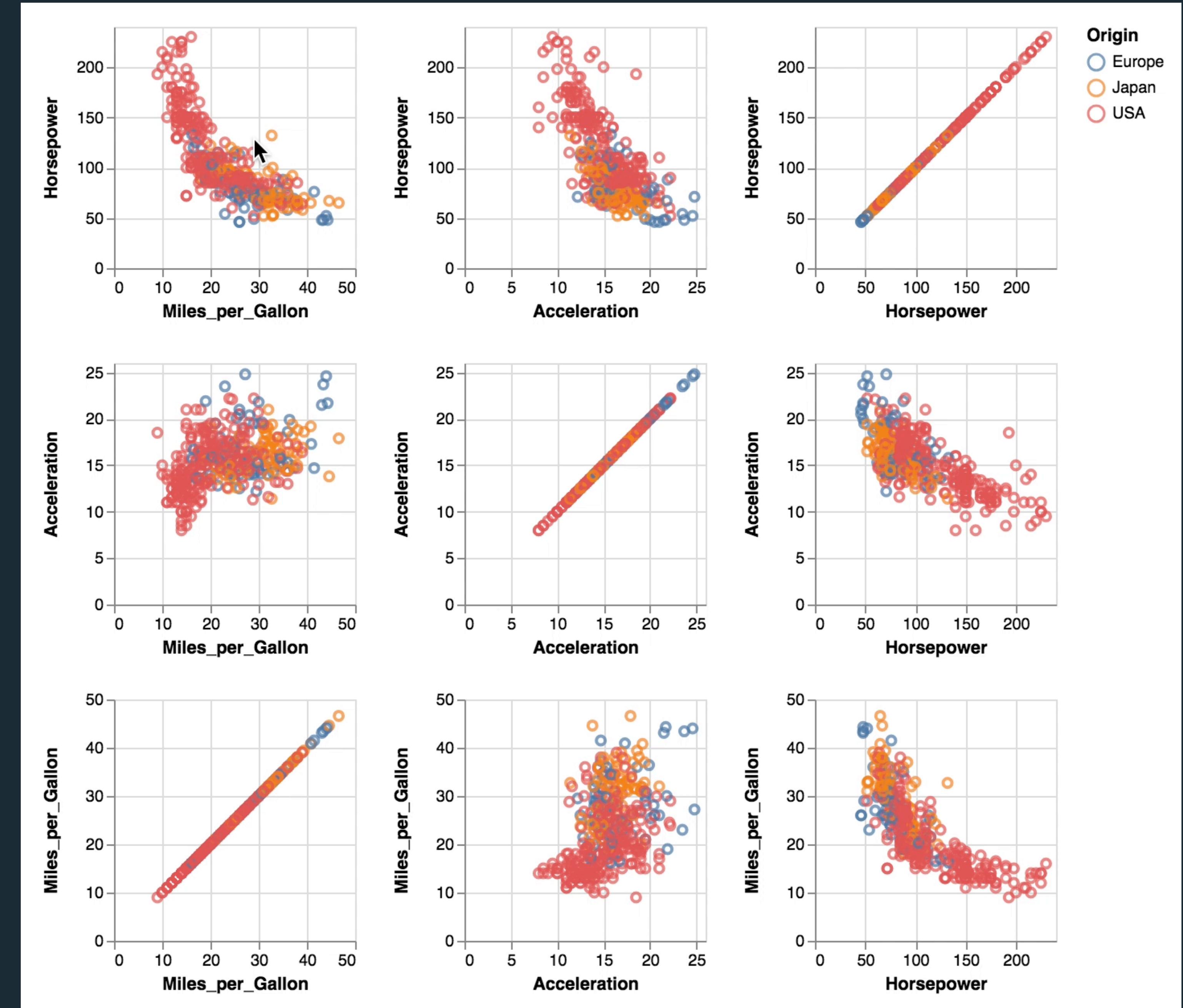
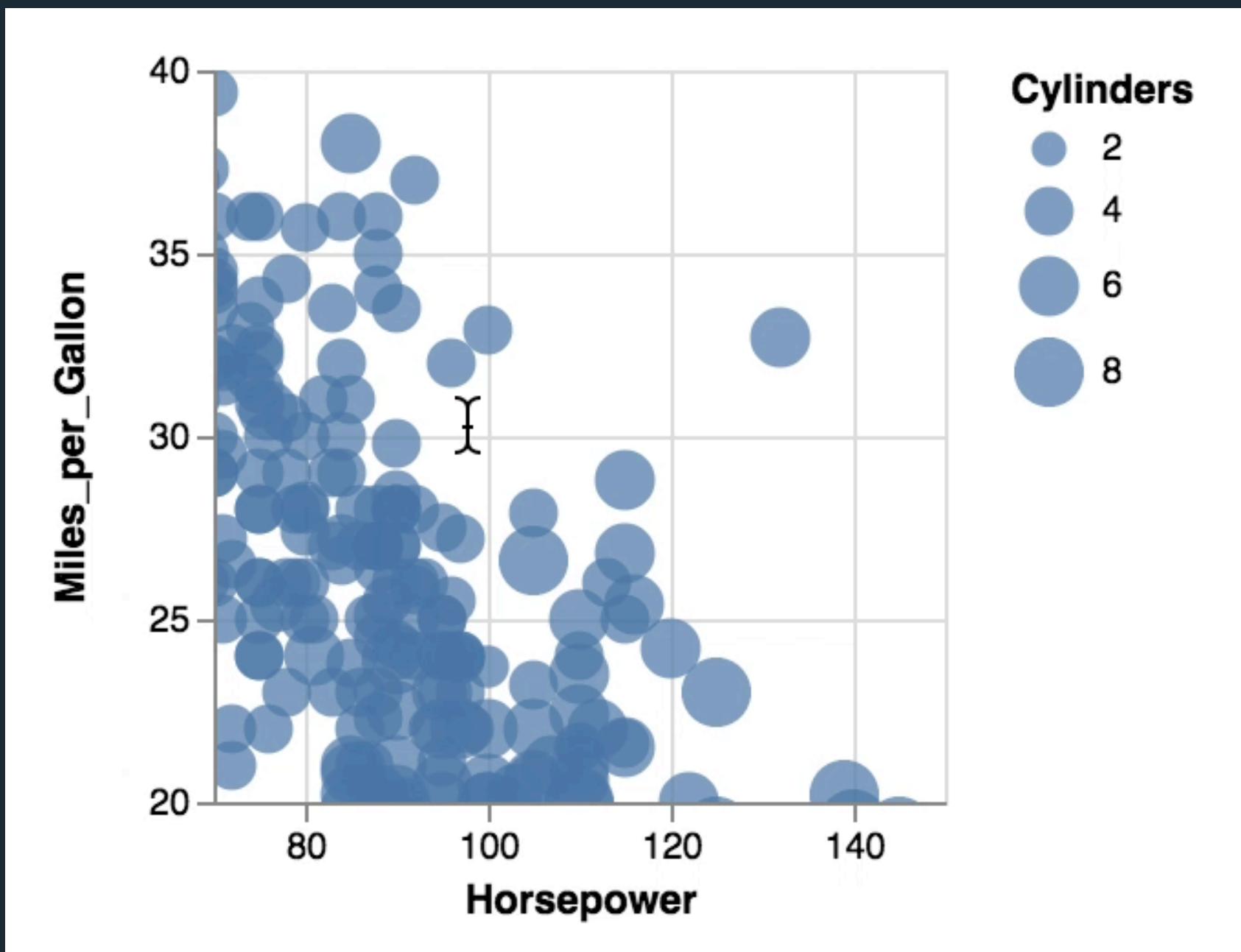
# Reconfigure



# Reconfigure



# Explore



# Explore

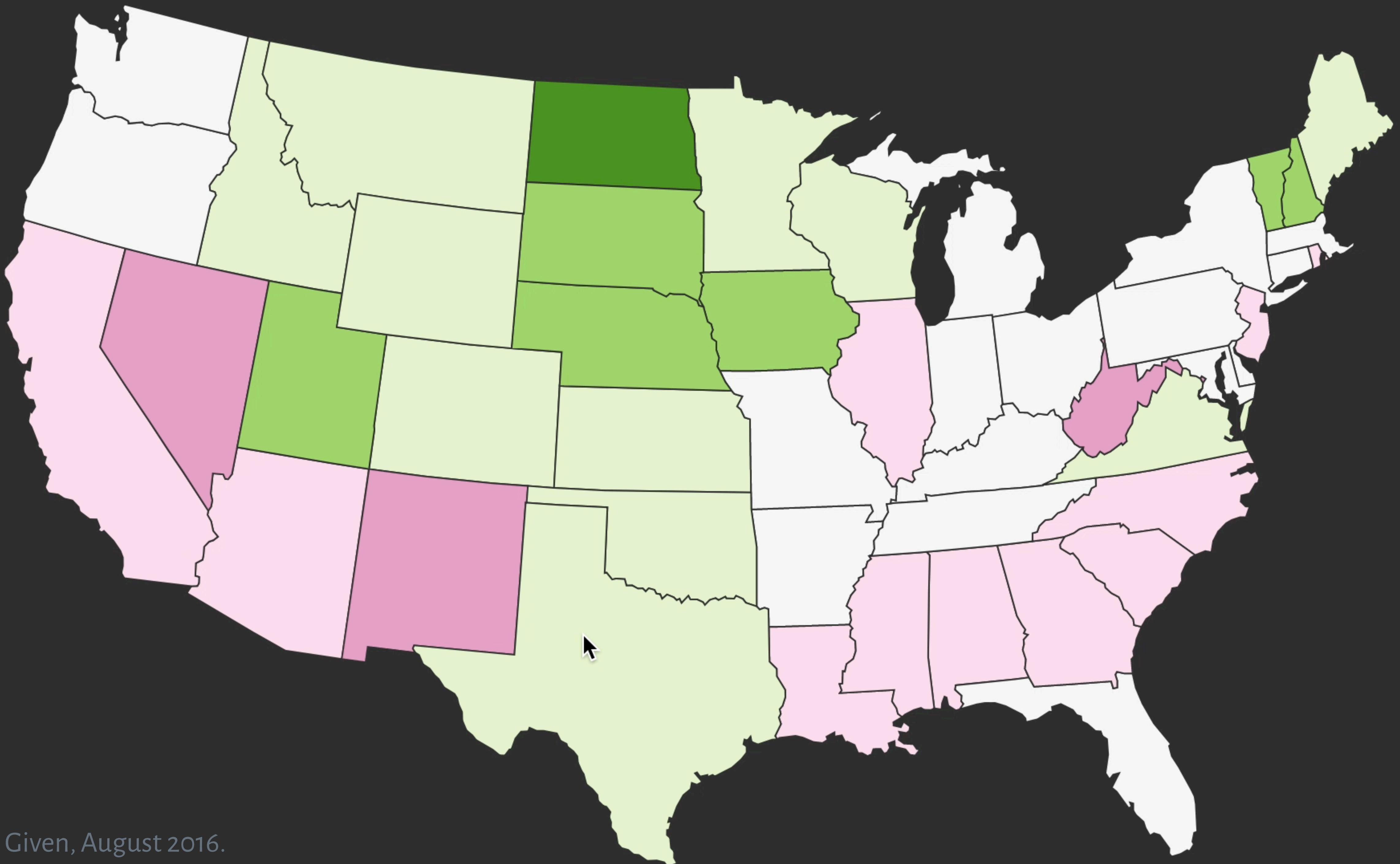
**Geometric** zoom: transforms the *physical view* (i.e., objects get larger as they get "closer").



# Explore

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





Chris Given, August 2016.

[Bederson and Hollan. Pad++. UIST 1994.]

