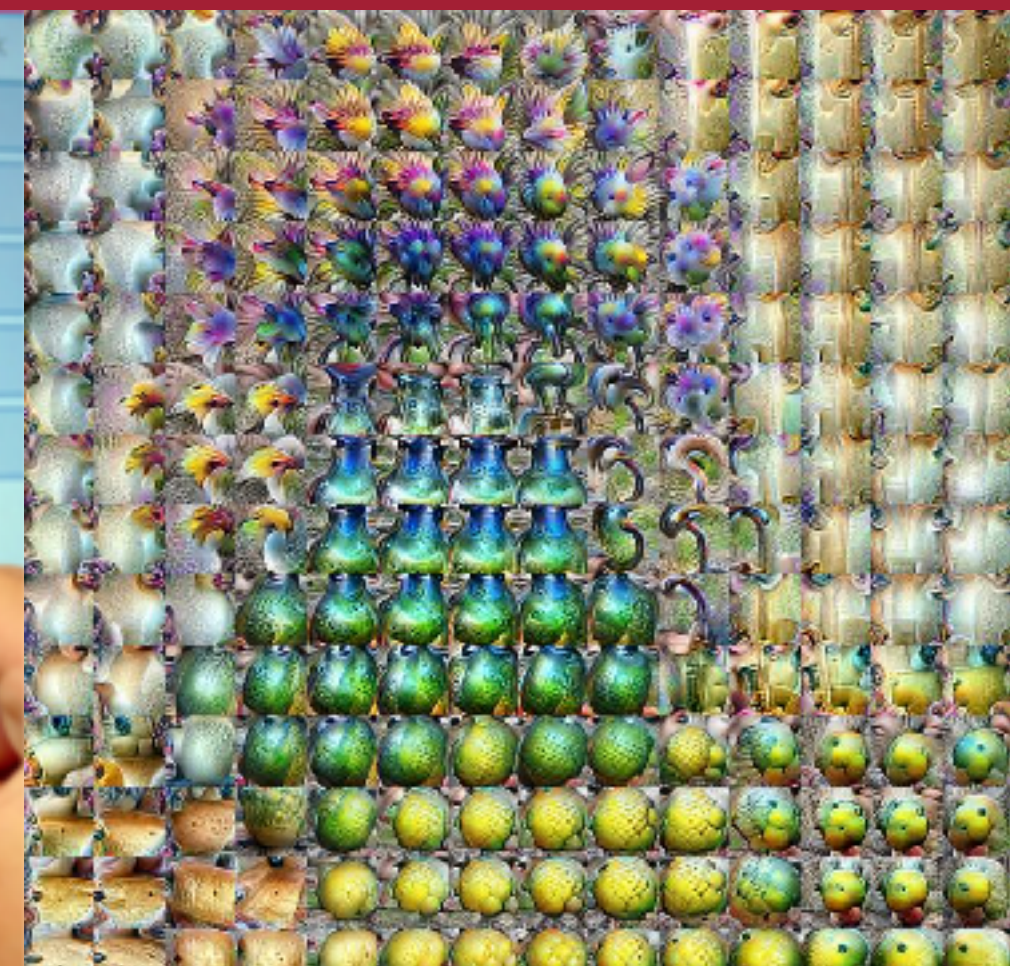
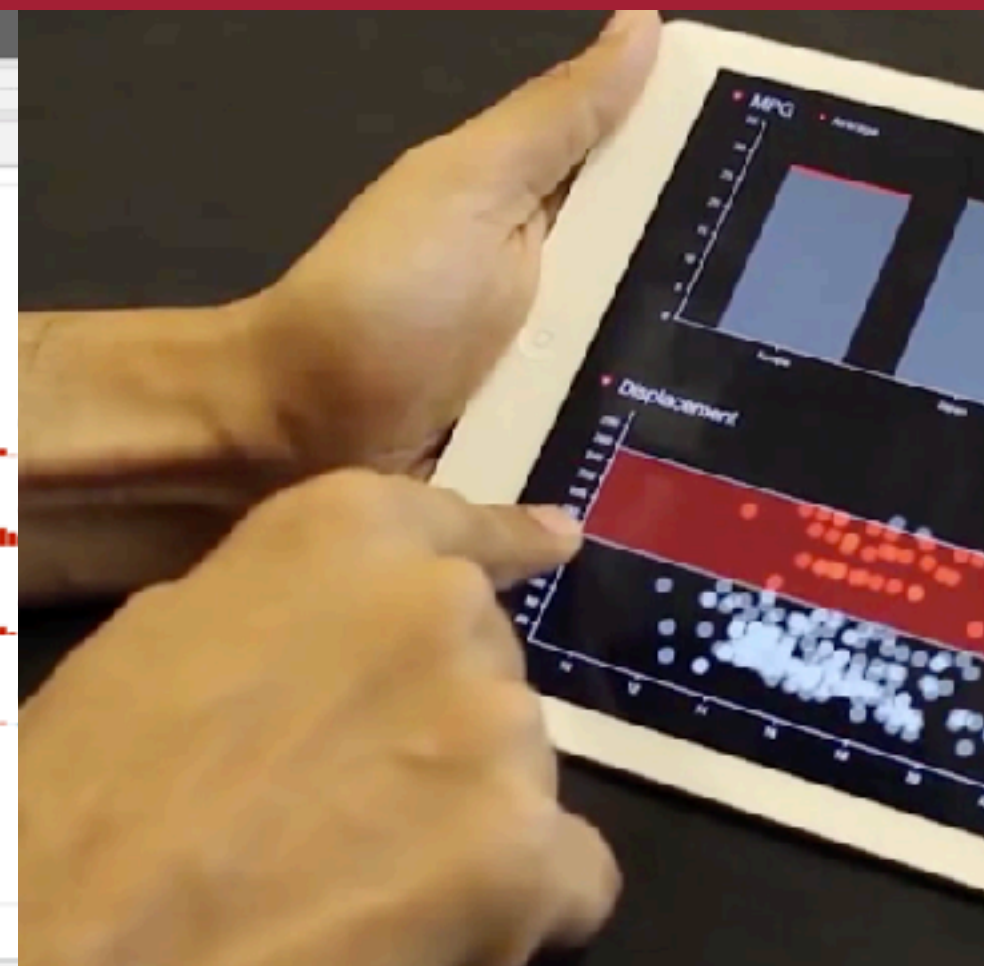
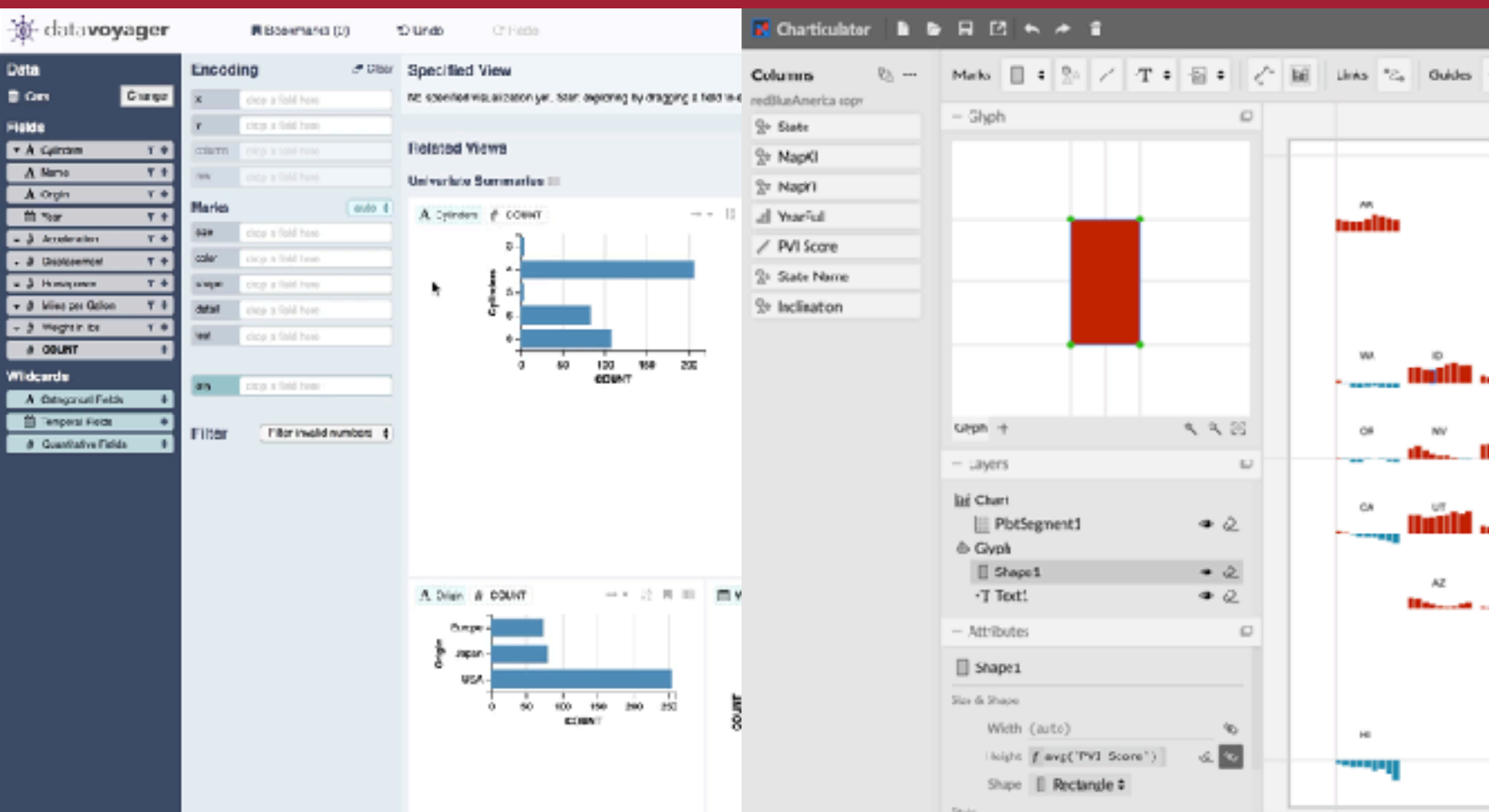


# 6.894: Interactive Data Visualization

## Research Frontiers in Data Visualization

Arvind Satyanarayan



# Visualization Authoring Tools

GROUPS +

GROUP 1

Edit Scene

▼ Group 1

GUIDES

MARKS

INTERACTIONS

WIDGETS

SCALES

PIPELINE None

X POSITION

Left ▾ 0

Set to group width

Width ▾ 640

Y POSITION

Top ▾ 0

Set to group height

Height ▾ 360

FILL

Color transparent

Opacity  1

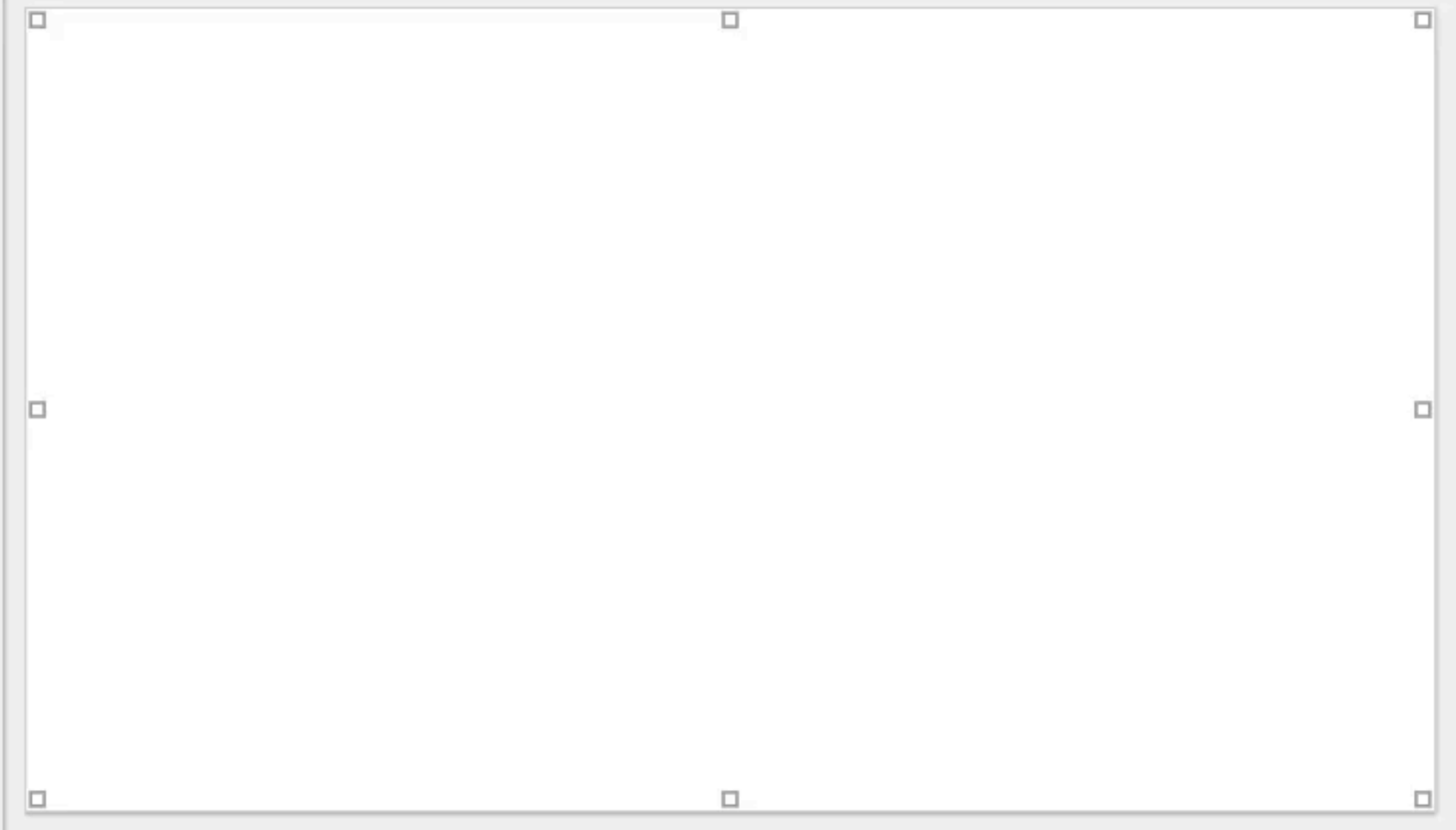
STROKE

Color

Width  0

DATA PIPELINES + New

Add a new data pipeline to get started.



RECT

SYMBOL

TEXT

LINE

AREA

EXPORT

459 rows in total

Abc **State** (51 values)

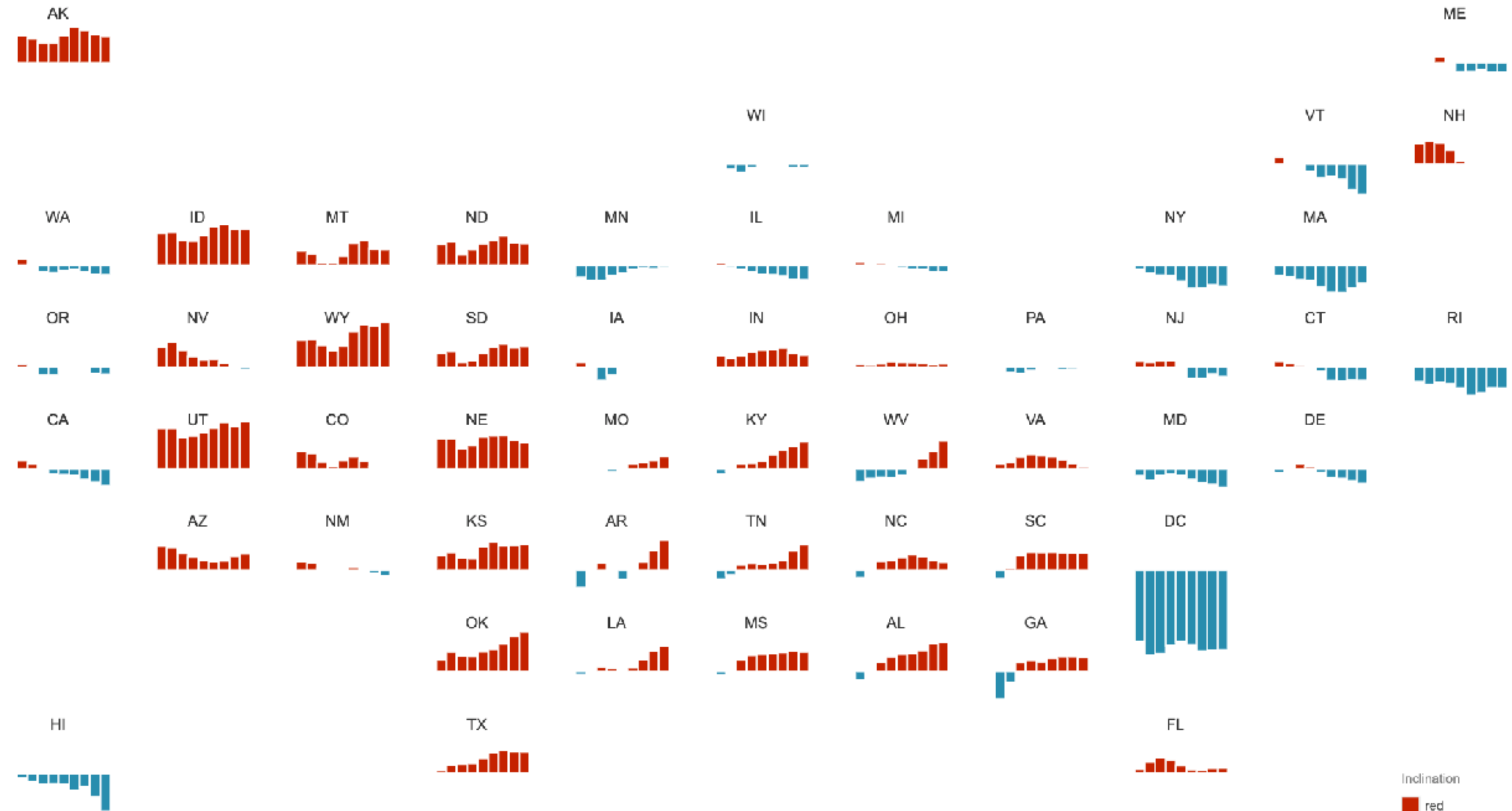
# **MapX** (0 - 10)

# **MapY** (0 - 7)

Abc **Year** (9 values)

# **PVI Score** (-42.70 - 22.40)

- LAYERS**
- Partition 2: AK
  - Partition 3: ME
  - Partition 4: VT
  - Partition 5: NH
  - Partition 6: WA
  - Partition 7: ID
  - Partition 8: MT
  - Partition 9: ND
  - Partition 10: MN
  - Partition 11: MI
  - Partition 12: NY
  - Partition 13: MA
  - Partition 14: RI
  - Partition 15: OR
  - Partition 16: UT
  - Partition 17: WY
  - Partition 18: SD
  - Partition 19: IA
  - Partition 20: WI
  - Partition 21: IN
  - Partition 22: OH
  - Partition 23: PA
  - Partition 24: NJ



Repeat

Partition

Break

Group

**CANVAS**

Background #ffffff



Data: all 459 rows

Abc	Row_ID	Abc	State	#	MapX	#	MapY	Abc	Year	#	PVI Score	Abc	State Na...	Abc	Inclination	#	id
	1		AK	0		7		'80		12.5		Alaska		red		0	
	2		AK	0		7		'84		10.9		Alaska		red		1	
	3		AK	0		7		'88		9.1		Alaska		red		2	
	4		AK	0		7		'92		9.1		Alaska		red		3	
	5		AK	0		7		'96		12.2		Alaska		red		4	
	6		AK	0		7		'00		16.7		Alaska		red		5	
	7		AK	0		7		'04		15.1		Alaska		red		6	
	8		AK	0		7		'08		13.4		Alaska		red		7	

Data Illustrator. Liu et al, CHI 2018.

- Columns
- redBlueAmerica copy
  - State
  - MapXI
  - MapYI
  - YearFull
  - PVI Score
  - State Name
  - Inclination

Marks

Links

Guides

Plot Segments

Scaffolds

- Glyph

Glyph +

- Layers

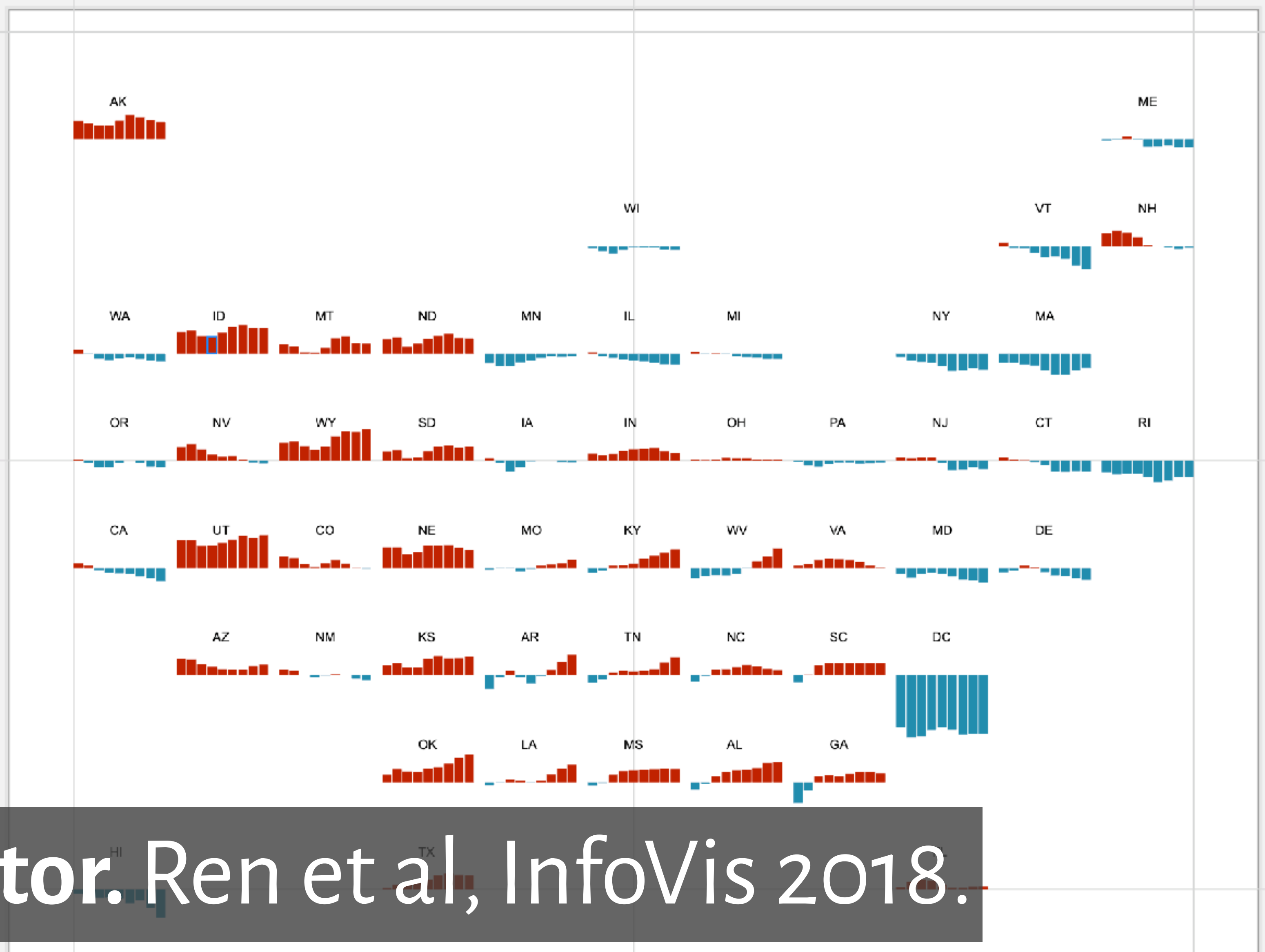
- Chart
  - PlotSegment1
- Glyph
  - Shape1
  - Text1

- Attributes

Shape1

Size & Shape

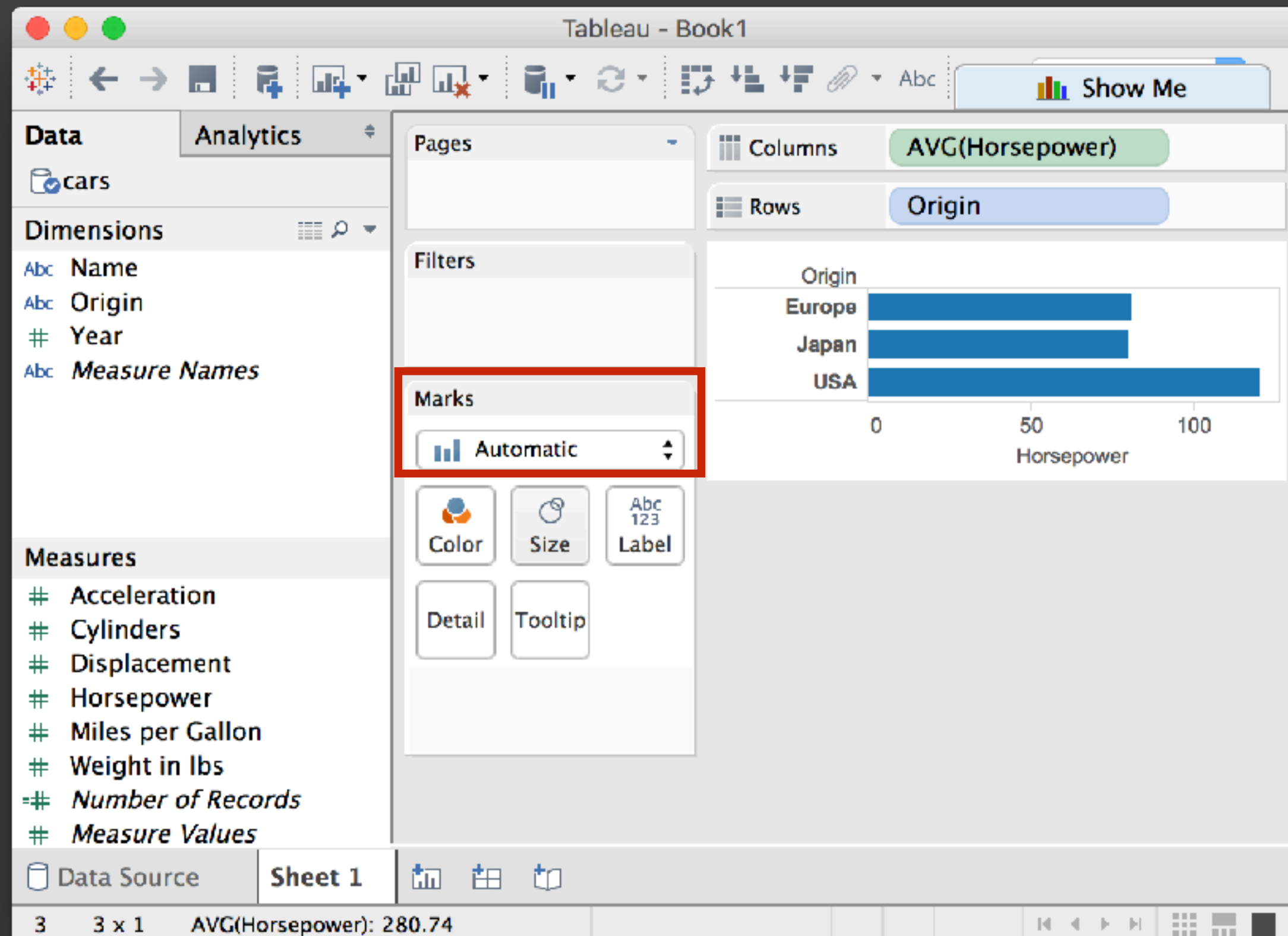
Style



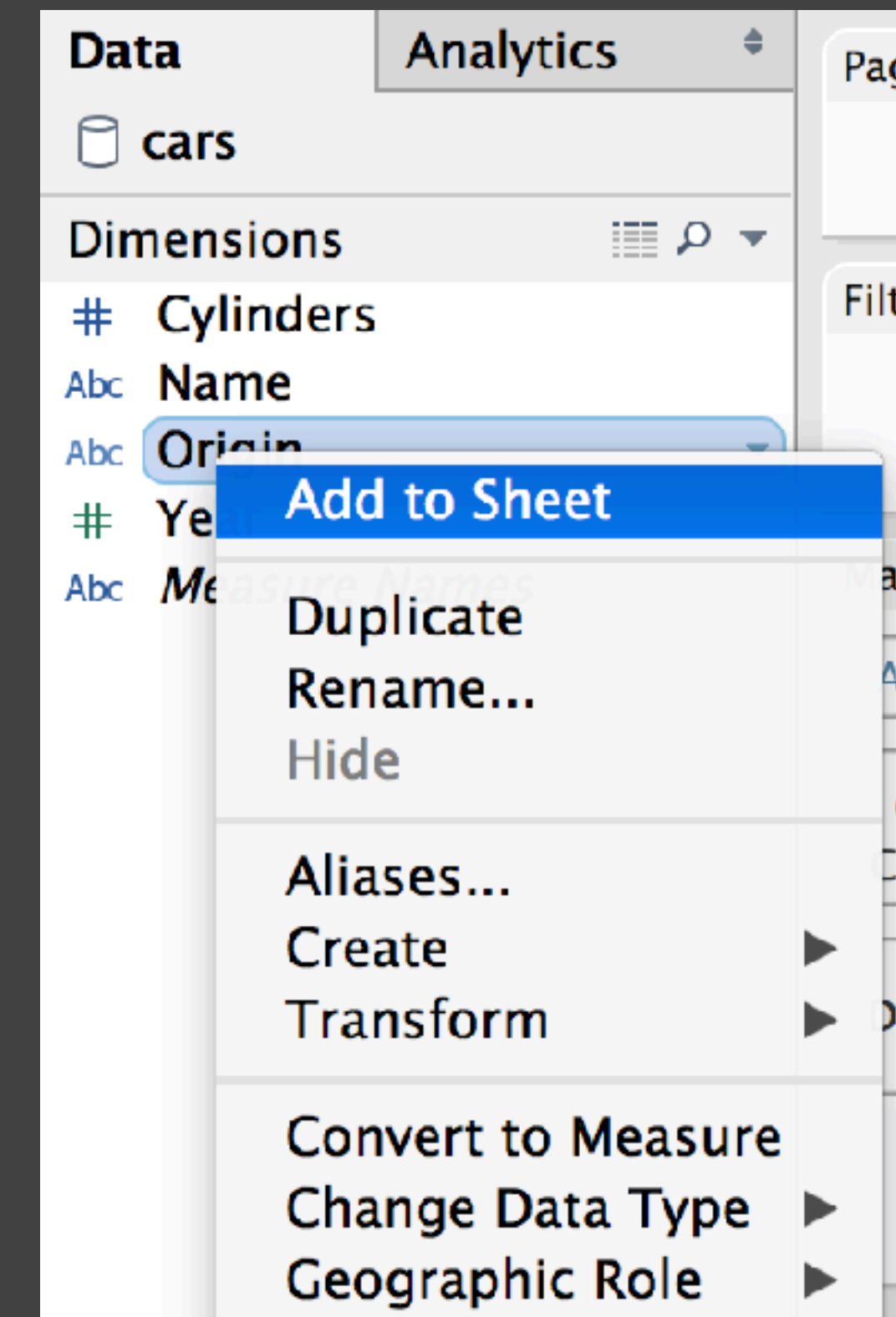
Charticulator. Ren et al, InfoVis 2018.

# Visualization Recommendation

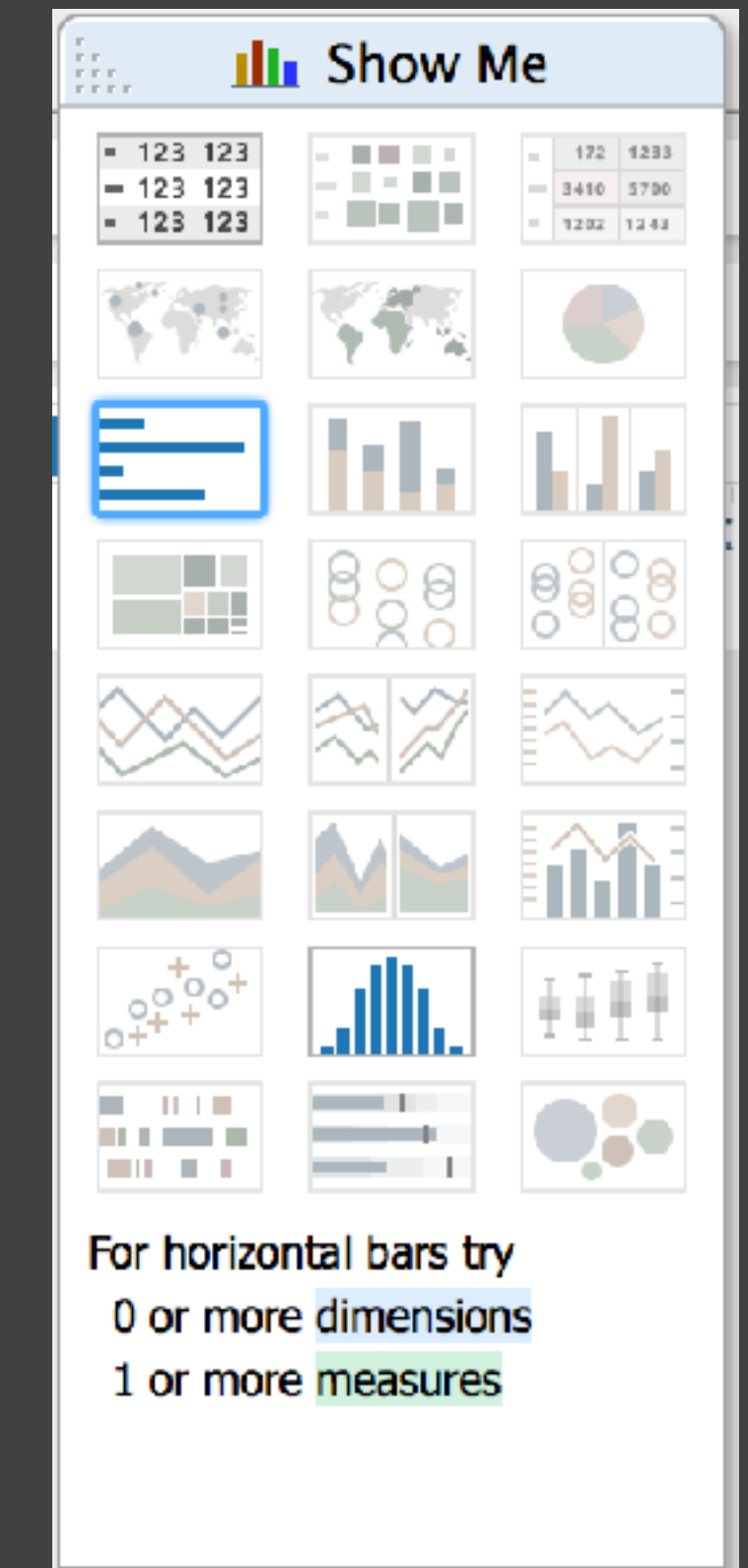
# Tableau's Show Me



Automatic Mark



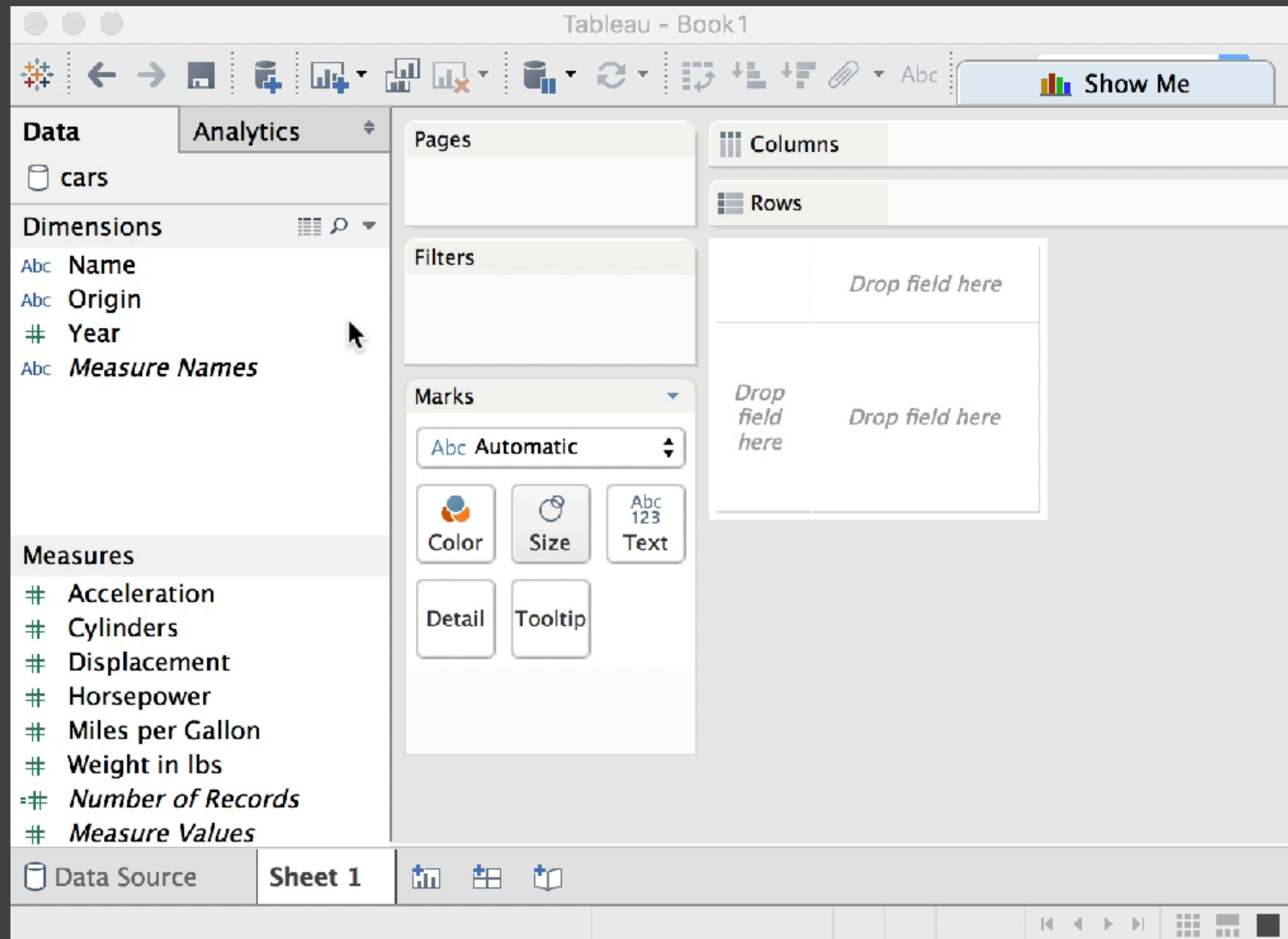
Add (field) to sheet



Alternatives  
(Chart types)

Mackinlay et al (2007). Show Me: Automatic Presentation for Visual Analysis.

# Tableau's Automatic Mark





# CompassQL

## Visualization Query Language & Engine

Use **partial** Vega-Lite specification to describe a recommendation query

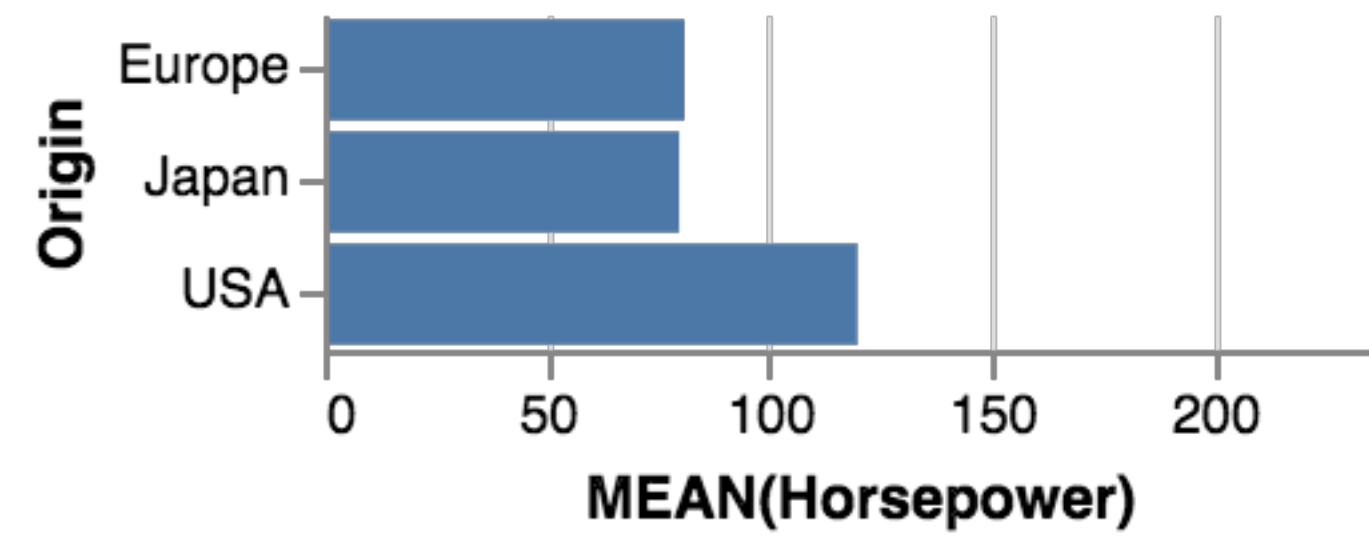
**Goal:** Reduce the need for a complete specification,  
while giving user fined-grained control over the recommendation

Towards a general-purpose query language for visualization recommendation *Wongsuphasawat et al. (HILDA'17)*

# Complete Specification (Single Chart)

## Specification

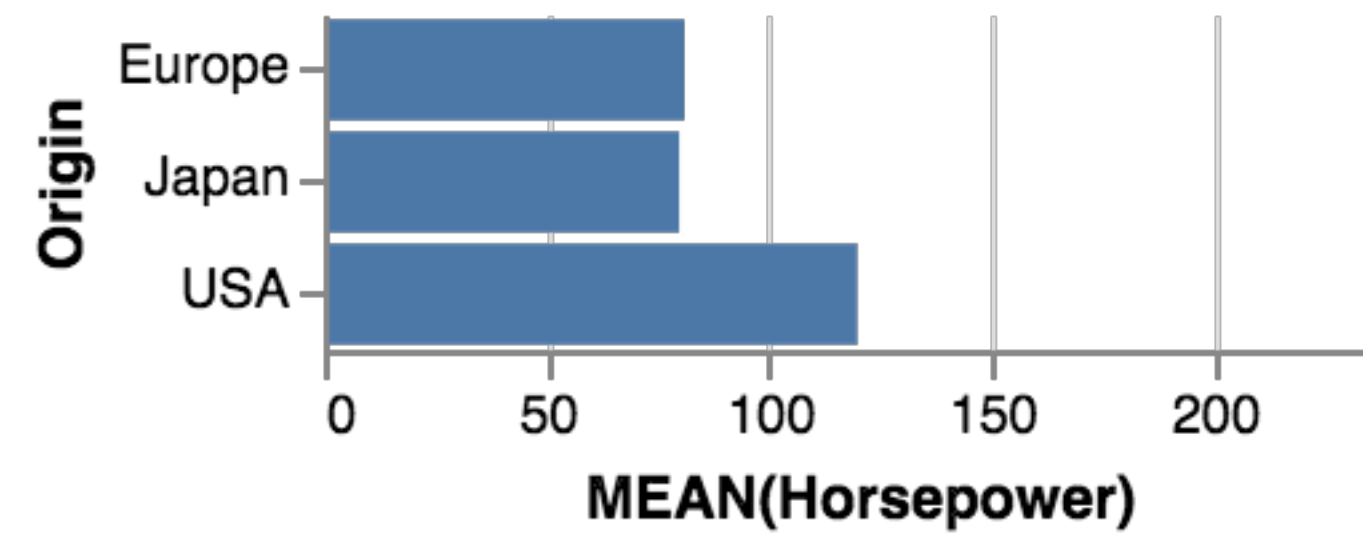
<i>Mark</i>	bar
<i>Encoding</i>	x: Mean(Horsepower) y: Origin



# Partial Specification

## Specification Wildcard

Mark	?
Encoding	x: Mean(Horsepower) y: Origin



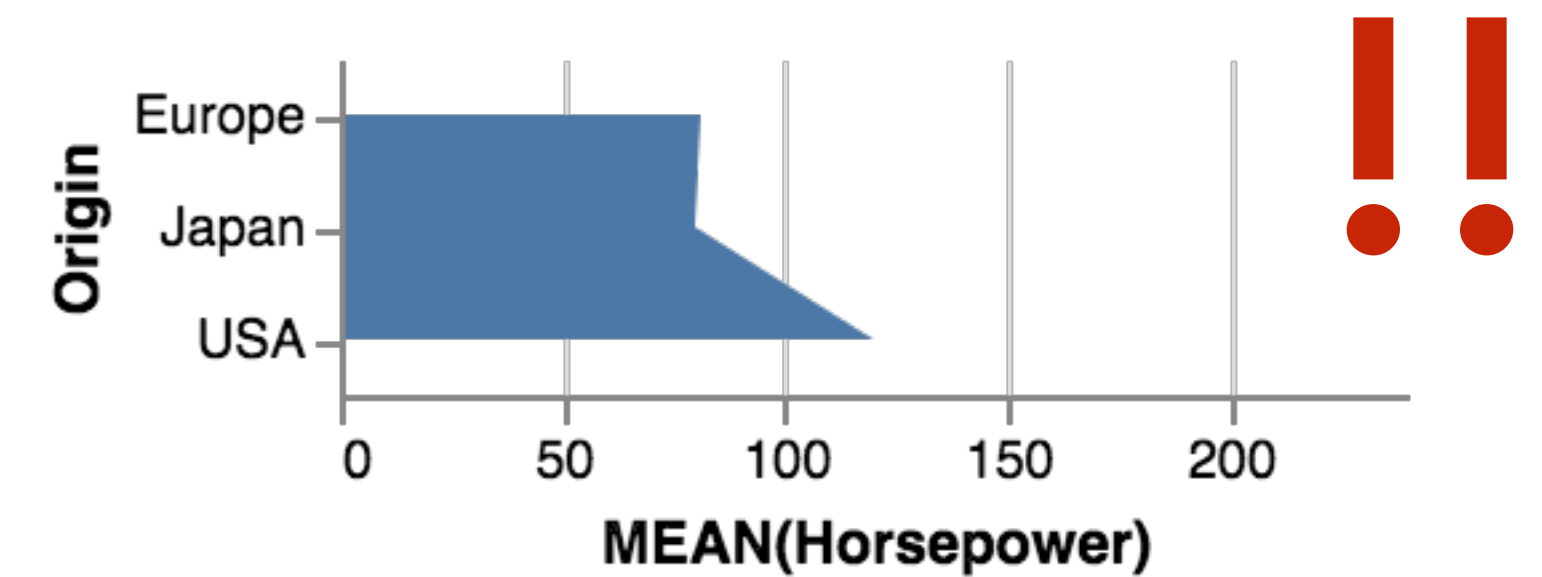
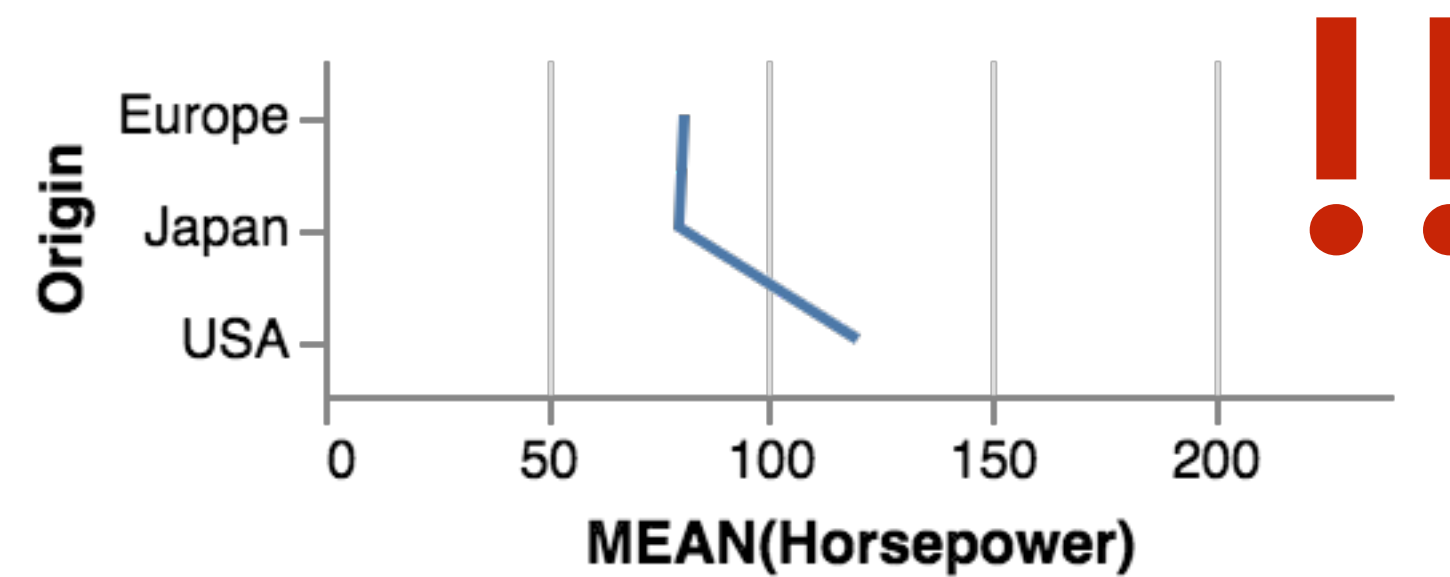
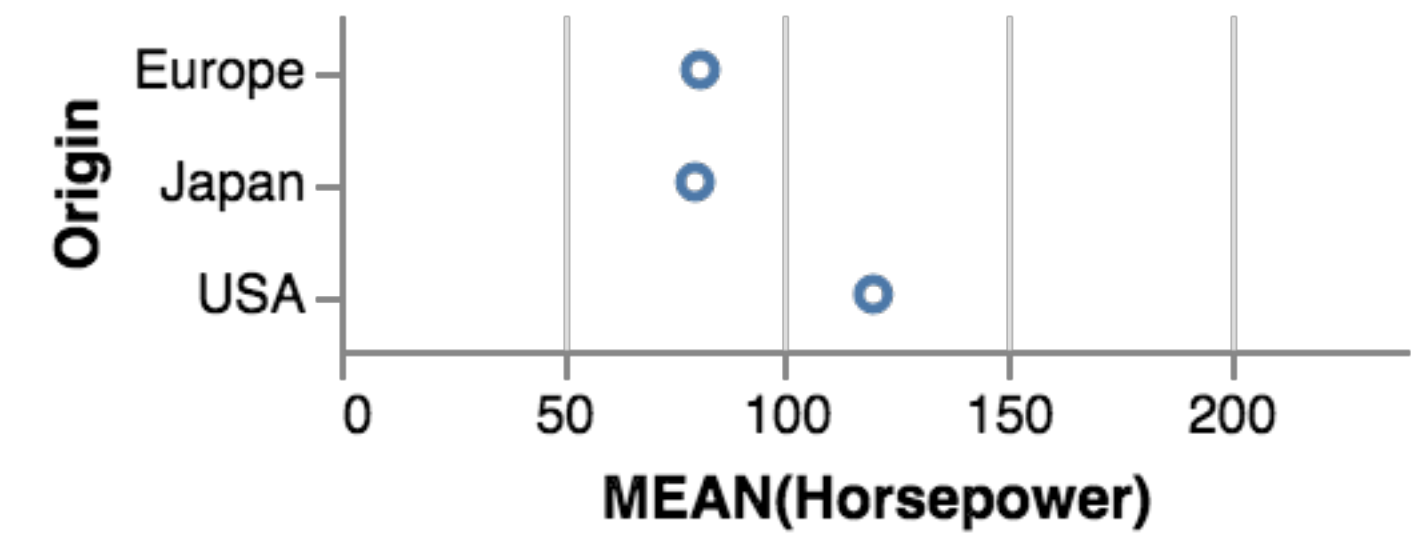
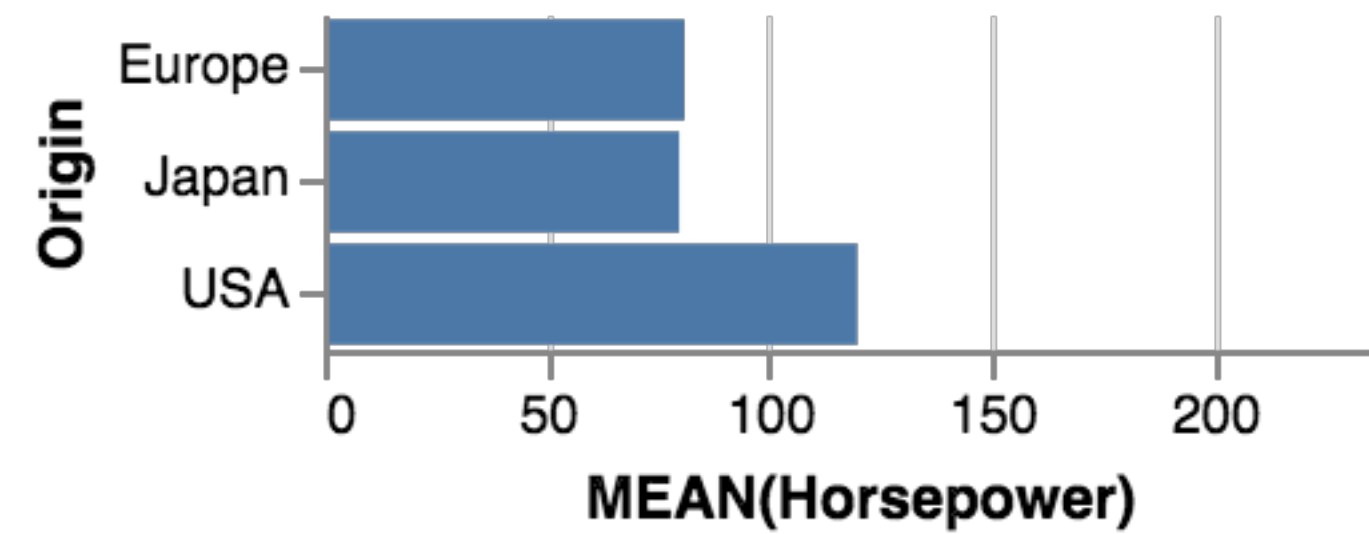
## Recommendation Process in the CompassQL engine

- 1) Enumerate candidate charts by replacing wildcard(s) with concrete values

# Partial Specification (Multiple Charts)

## Specification

Mark	?
Encoding	x: Mean(Horsepower) y: Origin



Using **line** or **area** to encode a **nominal** field like *Origin* is **misleading**, suggesting nonexistent trends!

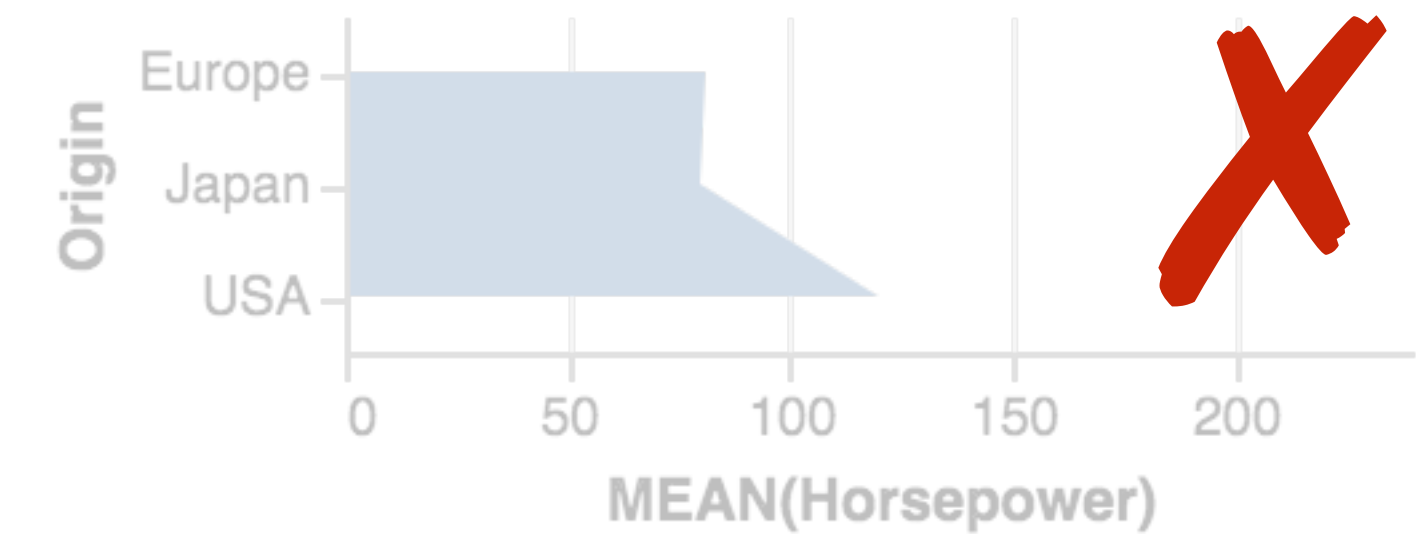
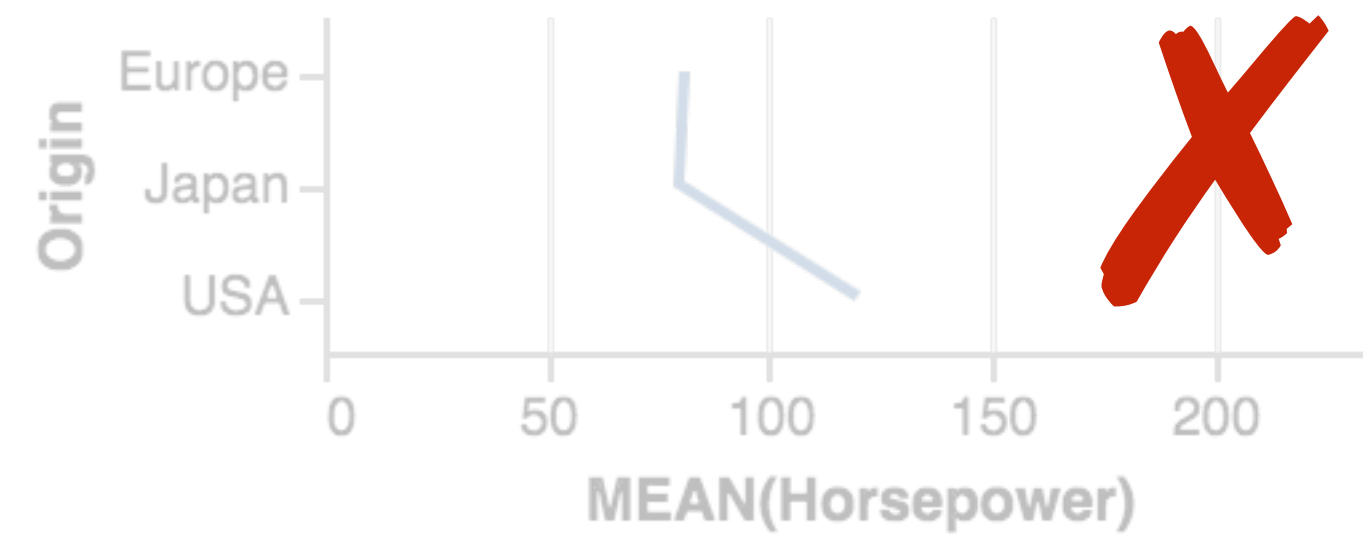
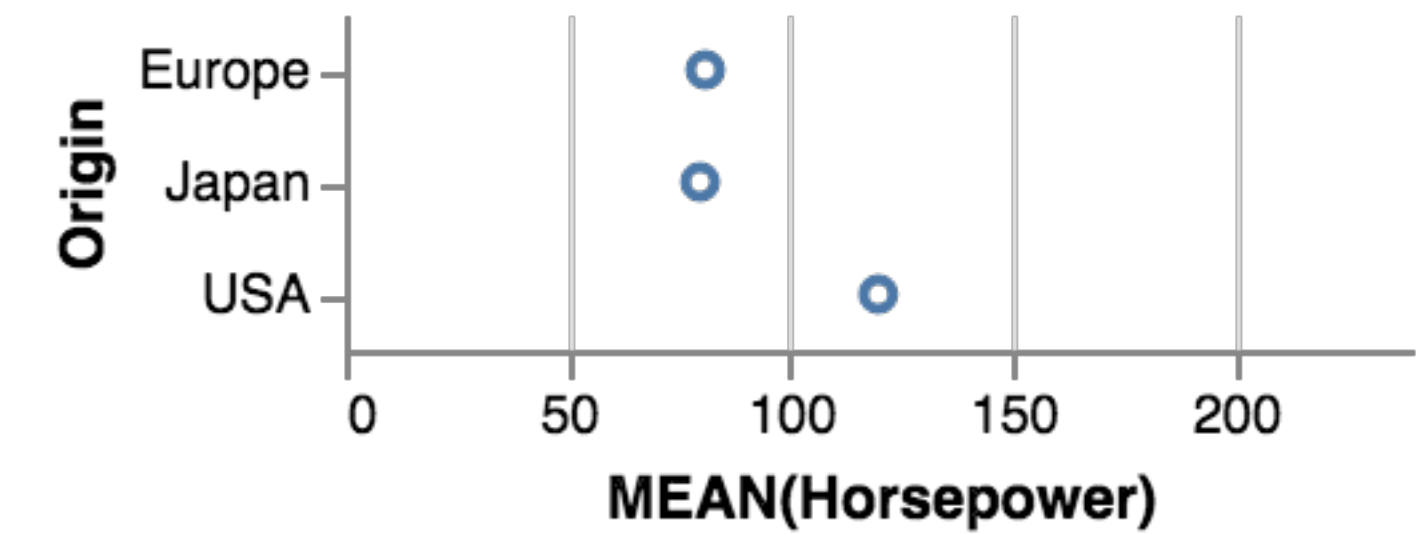
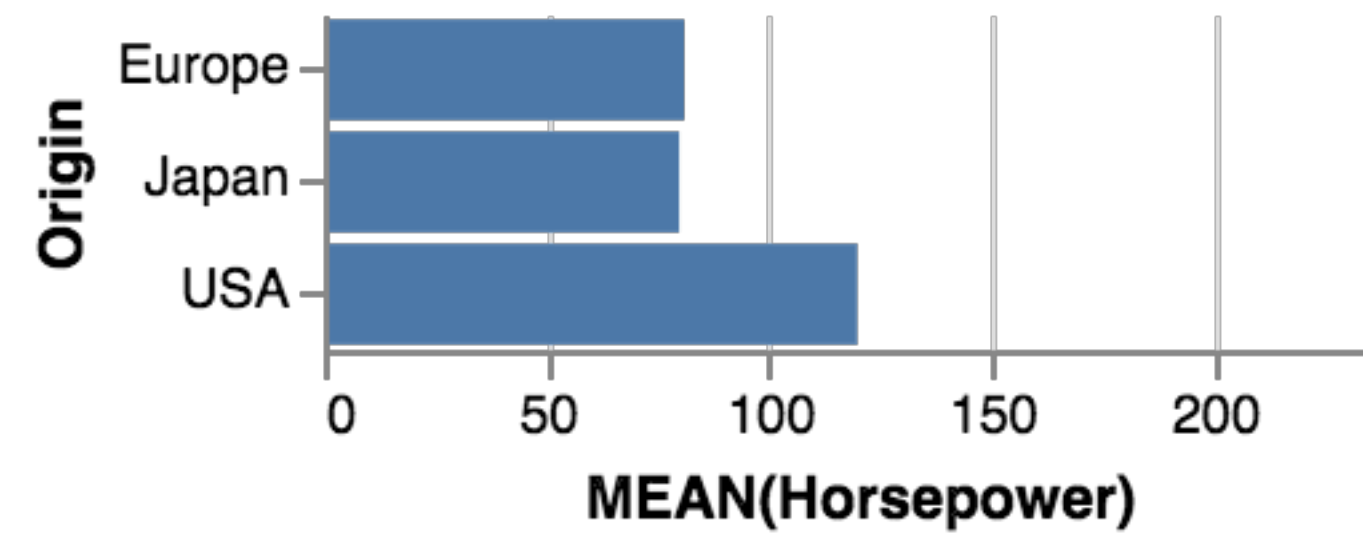
## Recommendation Process in the CompassQL engine

1) Enumerate candidate charts by replacing wildcard(s) with concrete values

# Partial Specification (Multiple Charts)

## Specification

Mark	?
Encoding	x: Mean(Horsepower) y: Origin



Using **line** or **area** to encode a **nominal** field like *Origin* is **misleading**, suggesting nonexistent trends!

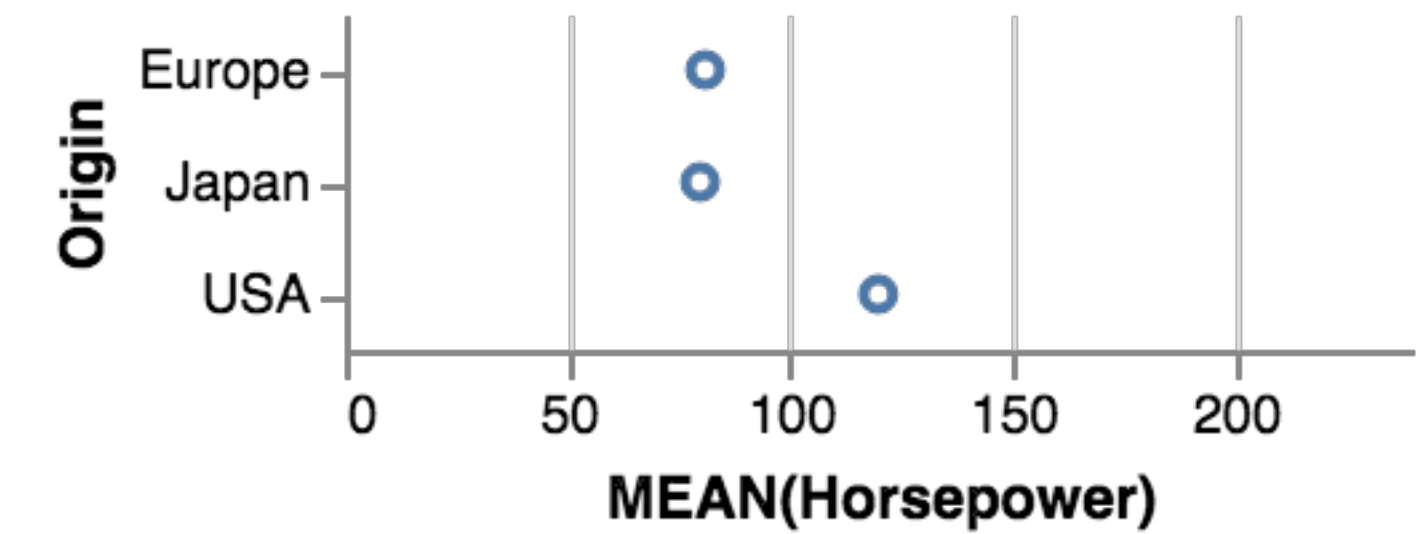
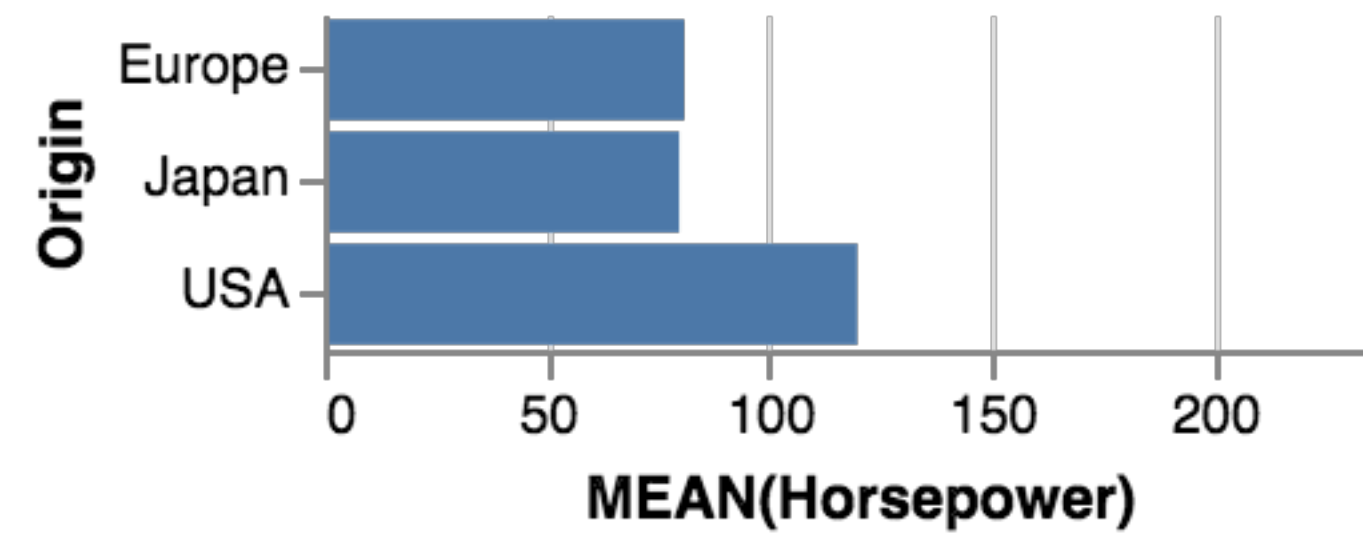
## Recommendation Process in the CompassQL engine

- 1) Enumerate candidate charts by replacing wildcard(s) with concrete values
- 2) Prune misleading charts using built-in constraints

# Partial Specification (Multiple Charts)

## Specification

<i>Mark</i>	?
<i>Encoding</i>	x: Mean(Horsepower) y: Origin



## Recommendation Process in the CompassQL engine

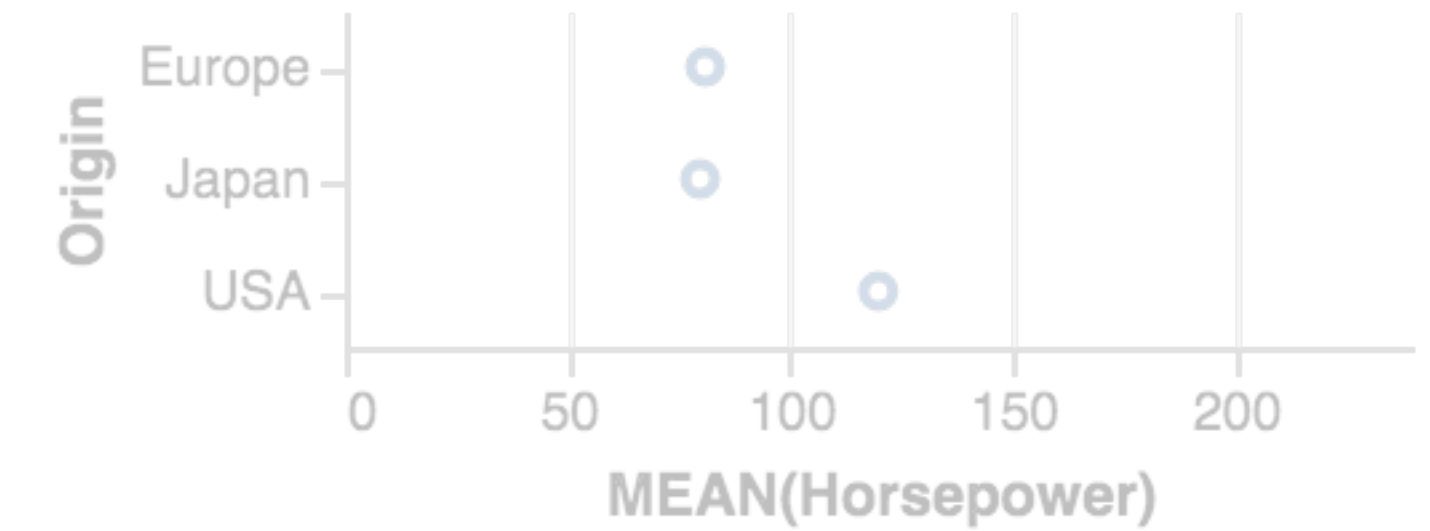
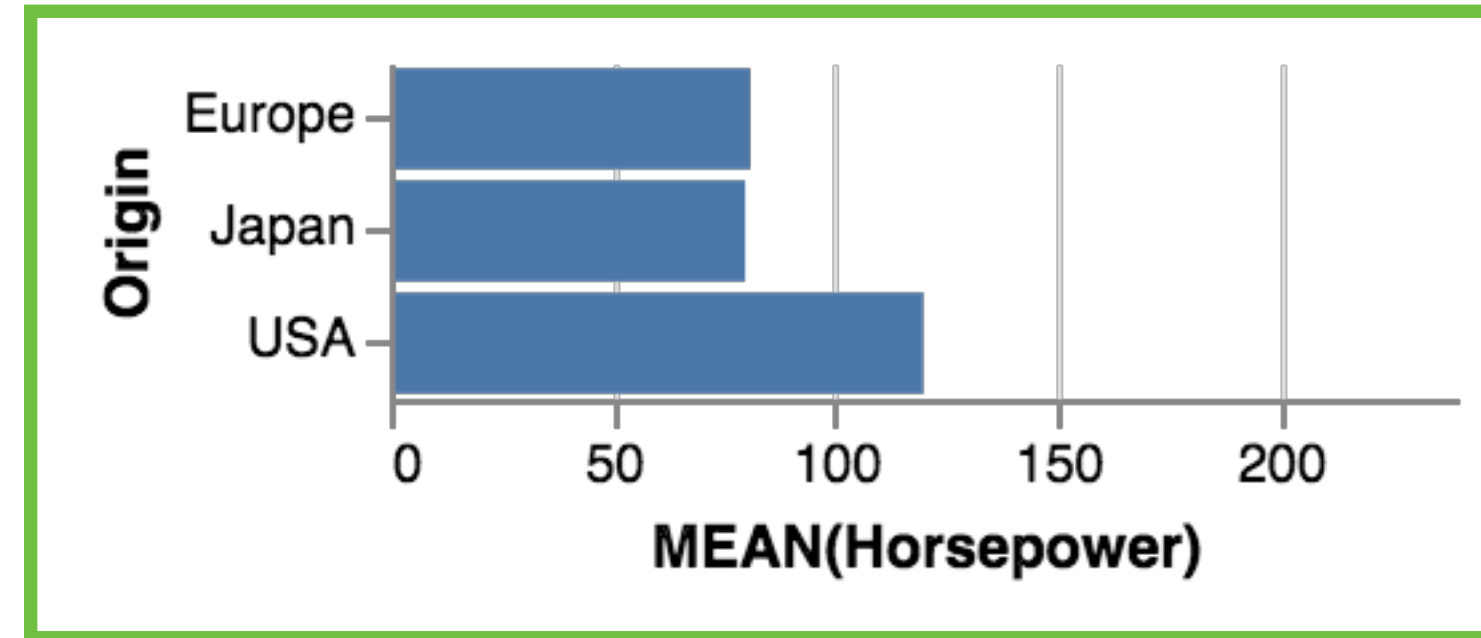
- 1) **Enumerate candidate charts** by replacing wildcard(s) with concrete values
- 2) **Prune** misleading charts using **built-in constraints**

# Query = Partial Specification + Recommendation Method

## Specification

Mark	?
Encoding	x: Mean(Horsepower) y: Origin

Effectiveness of  
mark type?



Bar is better for encoding quantitative x categorical

## Recommendation Method

ChooseBy	Effectiveness
----------	---------------

## Perceptual Effectiveness Ranking

(derived from prior work on graphical perception)

## Recommendation Process in the CompassQL engine

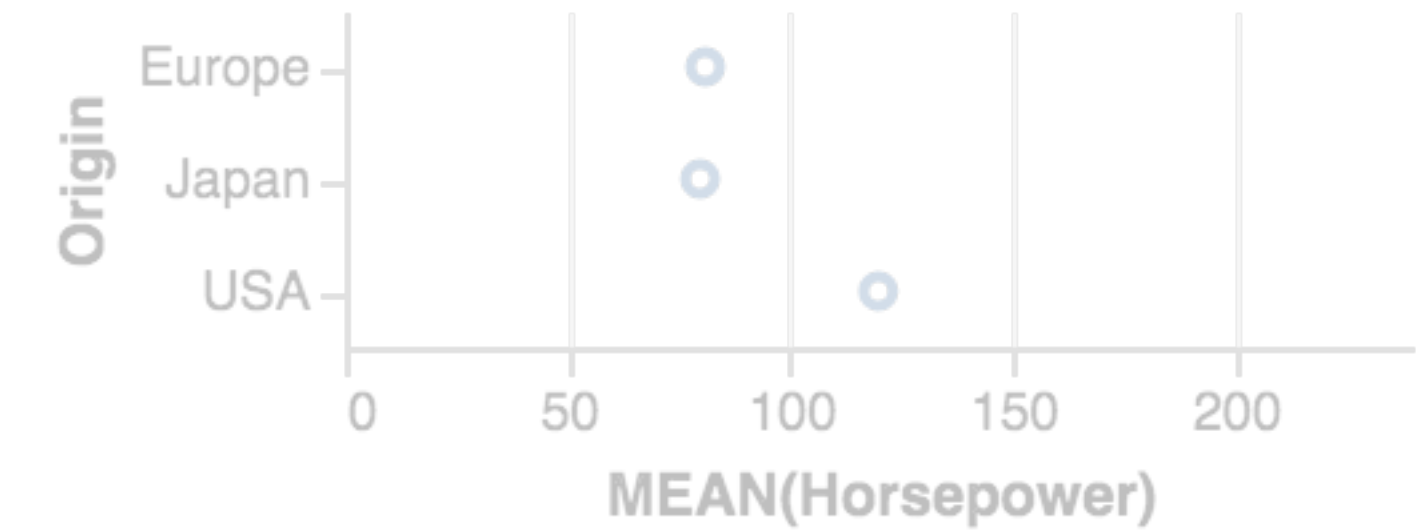
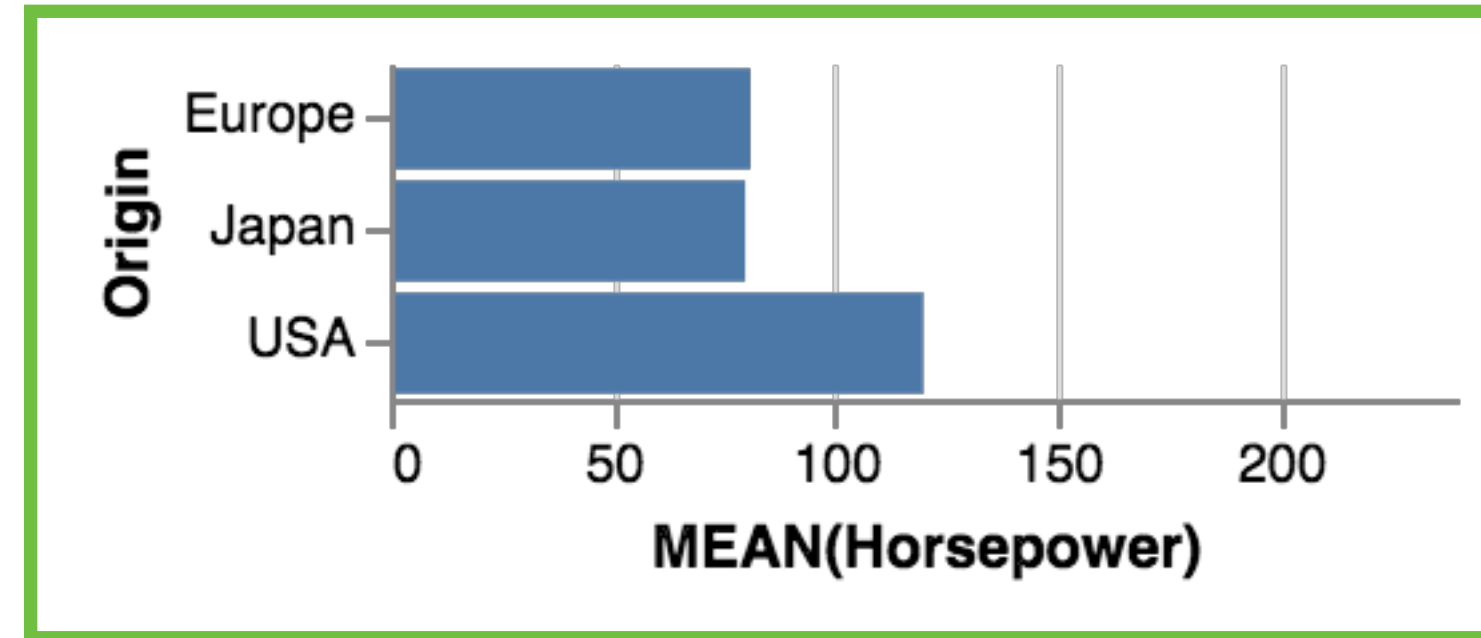
- 1) Enumerate candidate charts by replacing wildcard(s) with concrete values
- 2) Prune misleading charts using built-in constraints
- 3) Organize the results based on specified grouping & ranking methods

# Query for replicating Tableau's Automatic Mark

## Specification

<i>Mark</i>	<b>?</b>
<i>Encoding</i>	x: Mean(Horsepower) y: Origin

Effectiveness of  
**mark type?**



Bar is better for encoding quantitative x categorical

## Recommendation Method

<i>ChooseBy</i>	Effectiveness
-----------------	---------------

## Perceptual Effectiveness Ranking

(derived from prior work on graphical perception)

## Recommendation Process in the CompassQL engine

- 1) **Enumerate candidate charts** by replacing wildcard(s) with concrete values
- 2) **Prune** misleading charts using **built-in constraints**
- 3) **Organize** the results based on specified **grouping & ranking methods**



# Query for Pairwise Relationships between All Quantitative Fields

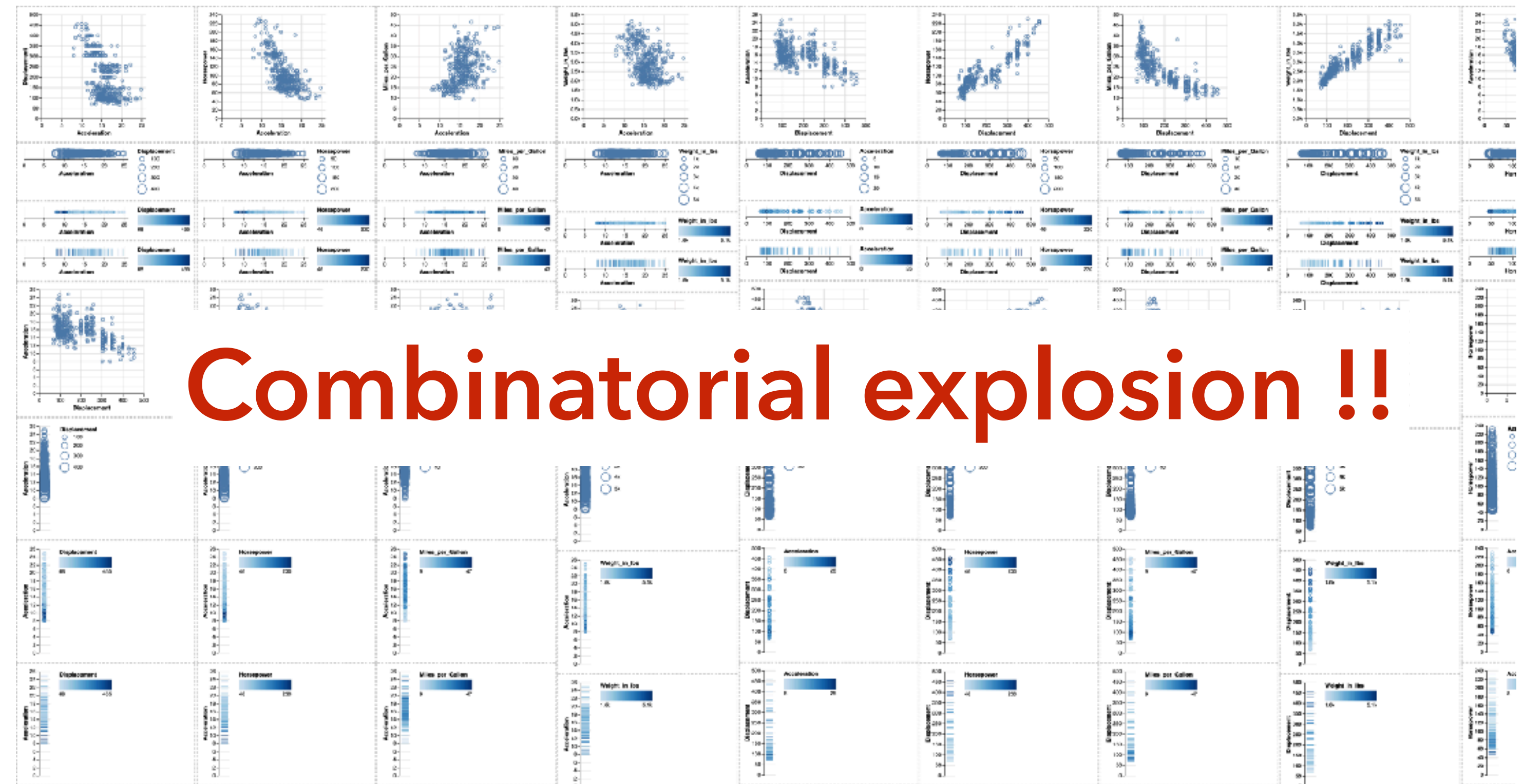
## Specification

<i>Mark</i>	?		Constraining Field to be quantitative
<i>Encoding</i>	?:	?quantitative	
	?:	?quantitative	

# Query for Pairwise Relationships between All Quantitative Fields

## Specification

<i>Mark</i>	?
<i>Encoding</i>	? : ?quantitative
	? : ?quantitative



## Recommendation Method

<i>GroupBy</i>	Data Fields
----------------	-------------

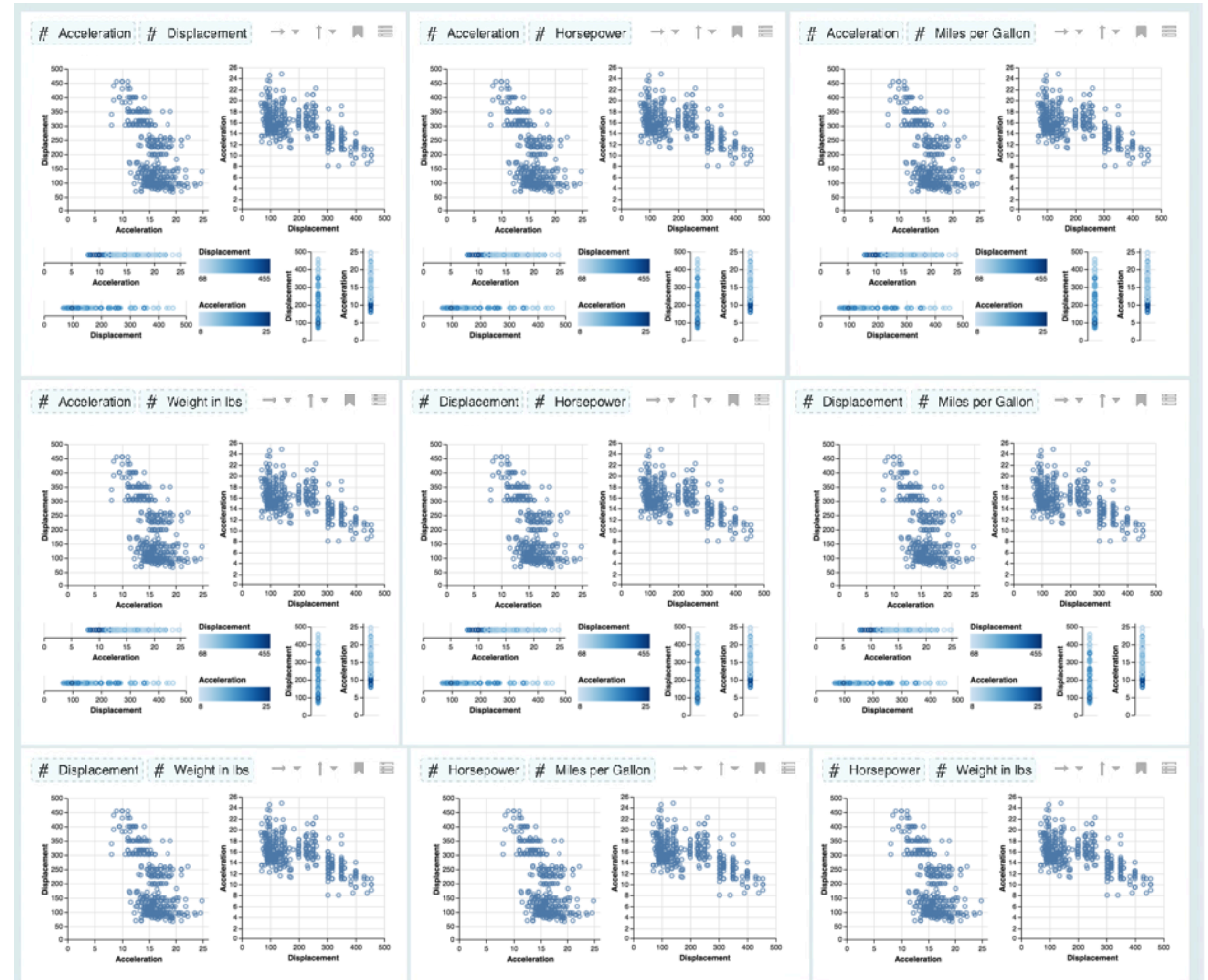
# Query for Pairwise Relationships between All Quantitative Fields

## Specification

<i>Mark</i>	?
<i>Encoding</i>	? : ? quantitative ? : ? quantitative

## Recommendation Method

<i>GroupBy</i>	Data Fields
<i>ChooseBy</i>	Effectiveness



# Query for Pairwise Relationships between All Quantitative Fields

Point is the best for quantitative x quantitative

Specification Effectiveness of mark type?

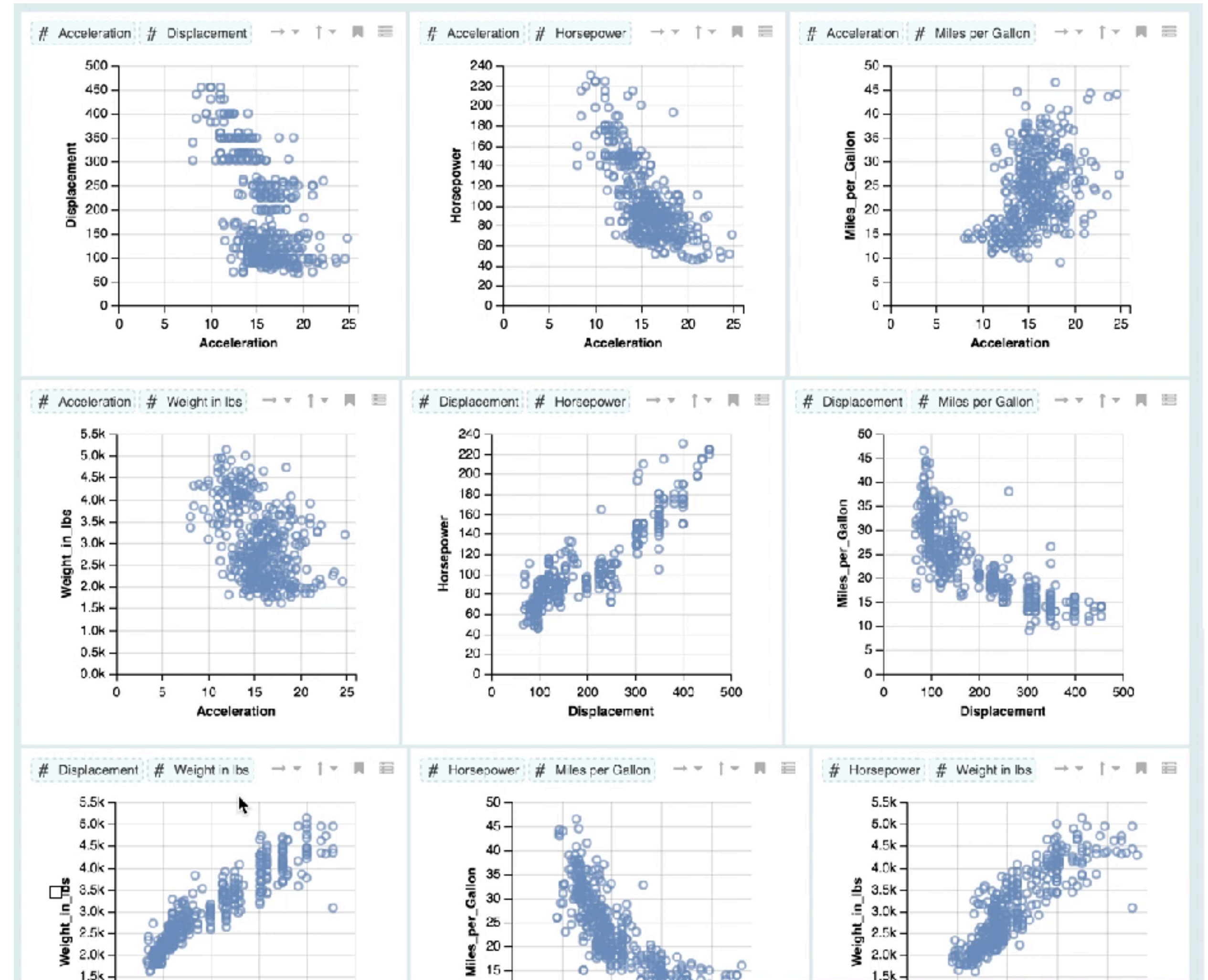
Mark	?
Encoding	? : ?quantitative
	? : ?quantitative

Effectiveness of encoding mappings?

X, Y are the most effective for quantitative

## Recommendation Method

GroupBy	Data Fields
ChooseBy	Effectiveness





Data

Cars Change

Fields

- ▼ A Cylinders ⌵ +
- A Name ⌵ +
- A Origin ⌵ +
- 📅 Year ⌵ +
- ▼ # Acceleration ⌵ +
- ▼ # Displacement ⌵ +
- ▼ # Horsepower ⌵ +
- ▼ # Miles per Gallon ⌵ +
- ▼ # Weight in lbs ⌵ +
- # COUNT +

Wildcards

- A Categorical Fields +
- 📅 Temporal Fields +
- # Quantitative Fields +

Encoding Clear

x

y

column

row

size

color

shape

detail

text

any

Marks auto

Filter Filter invalid numbers

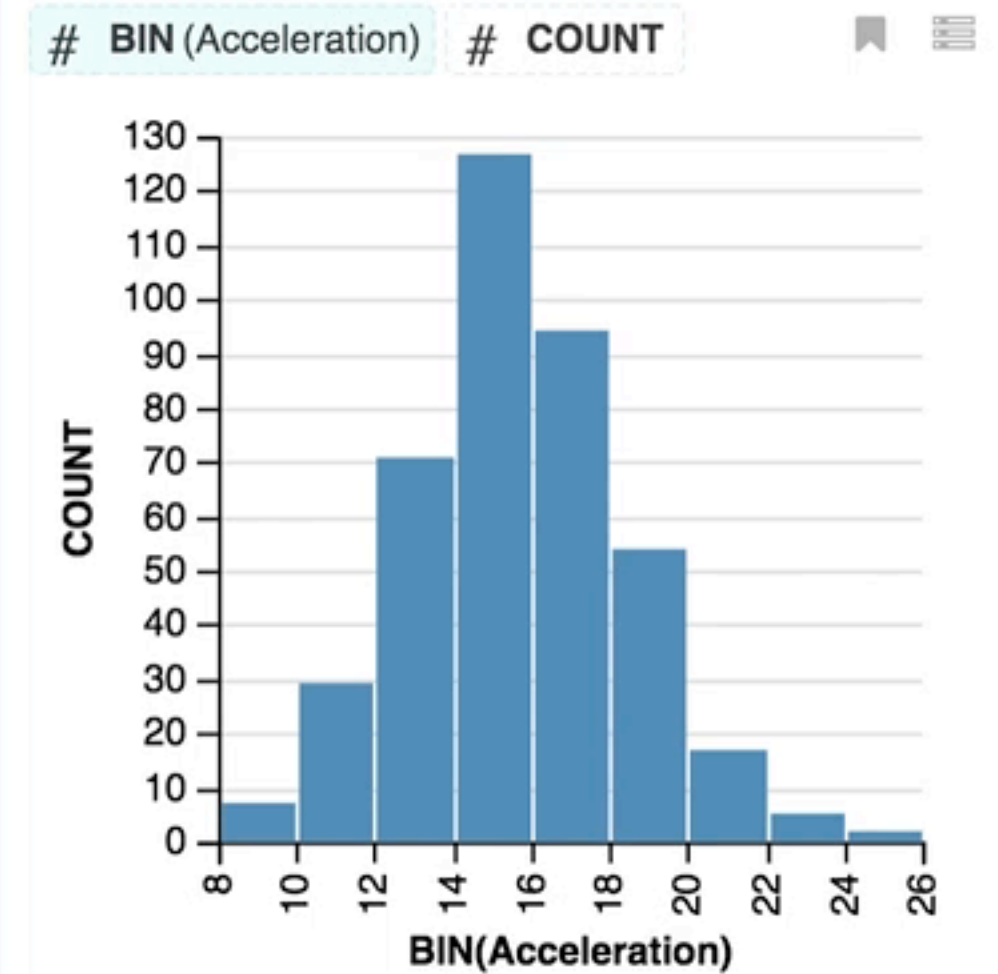
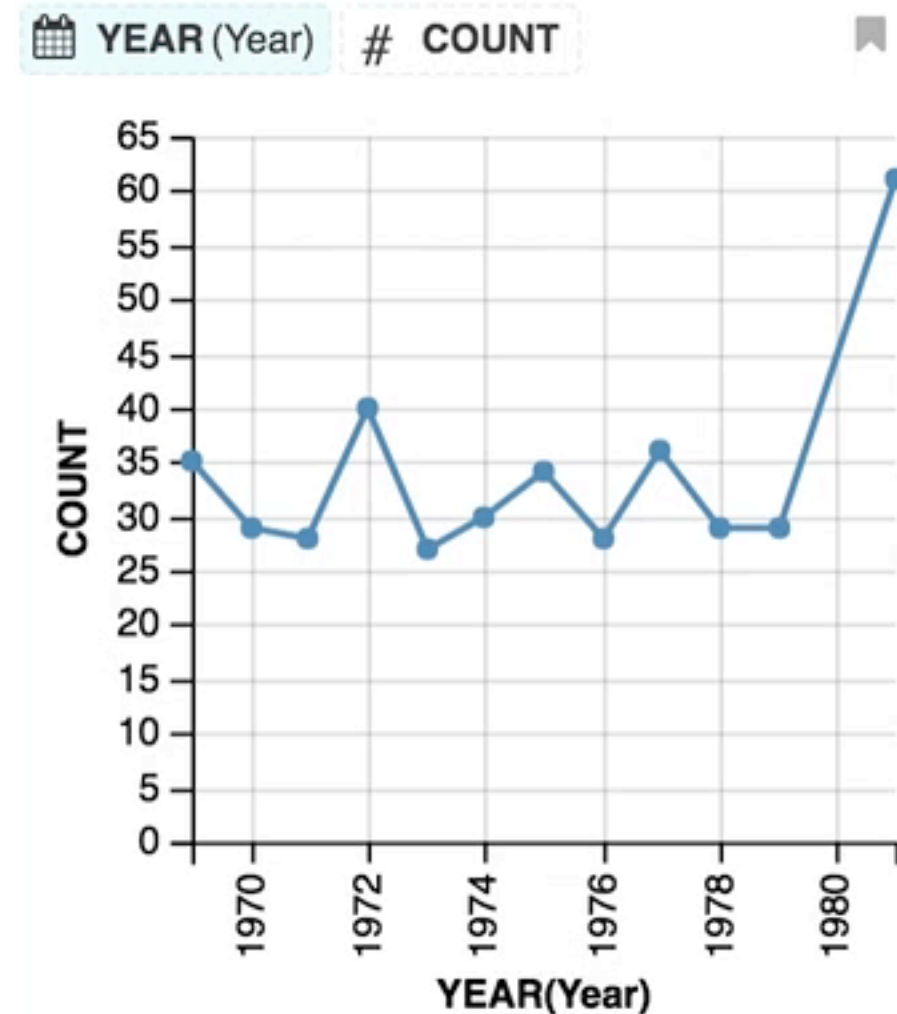
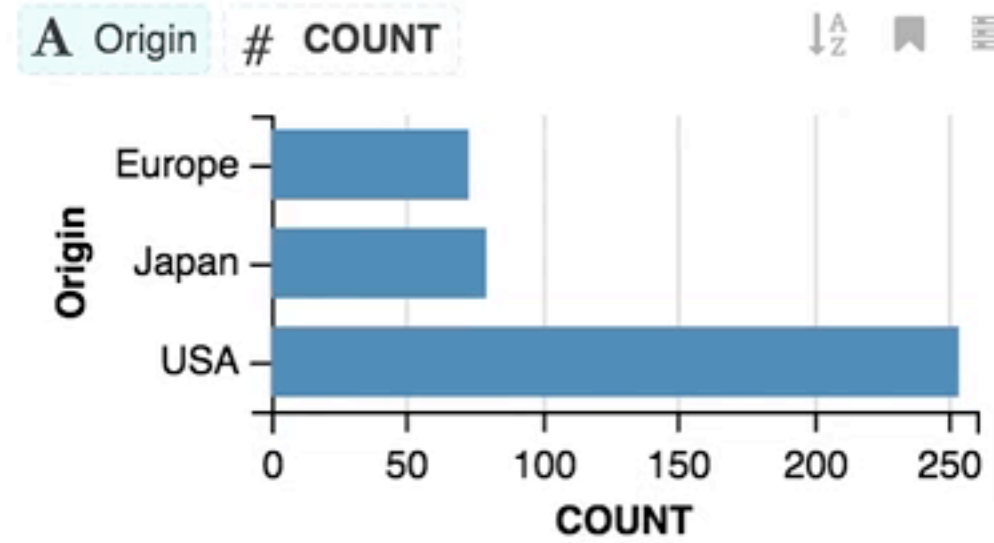
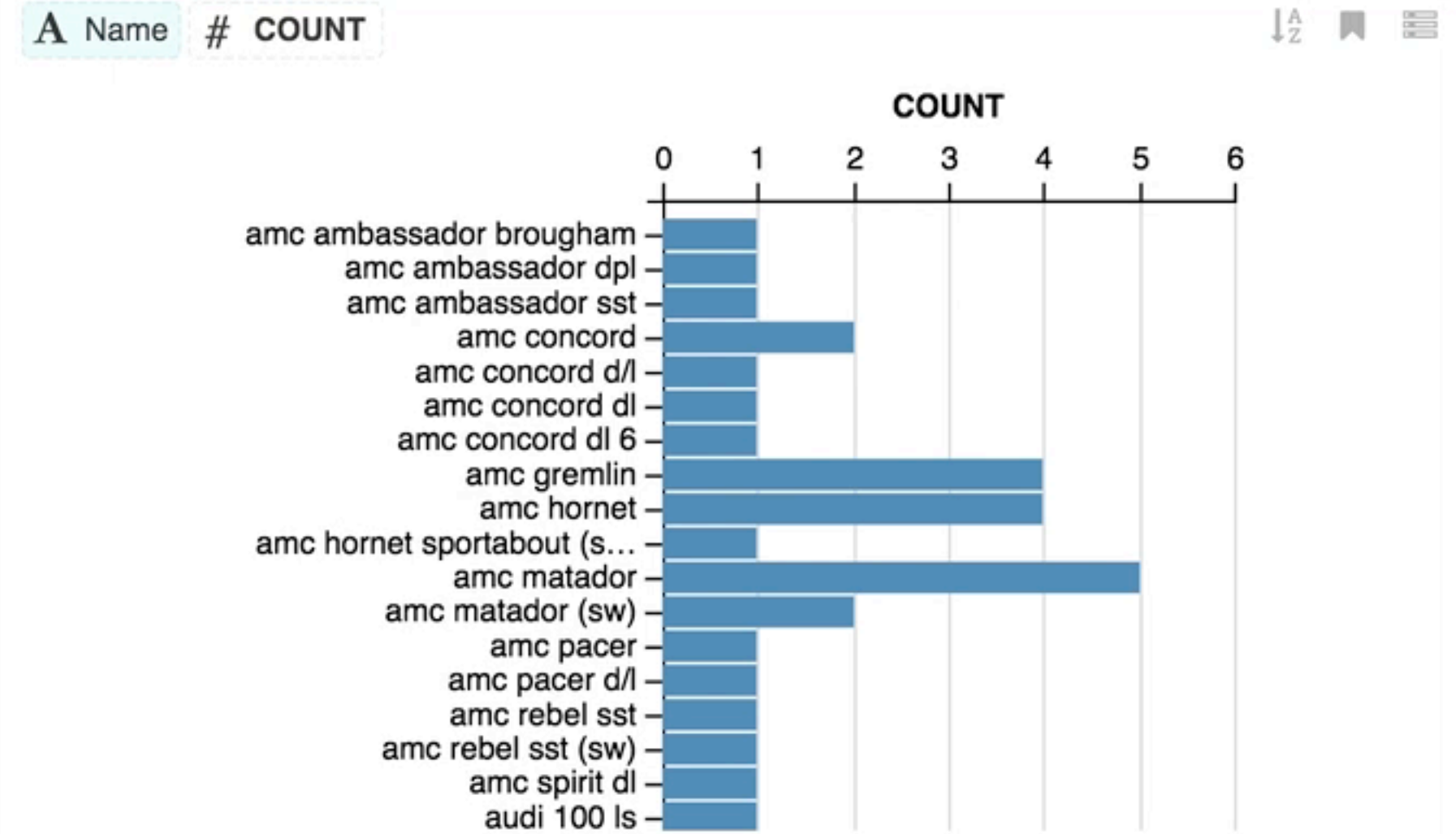
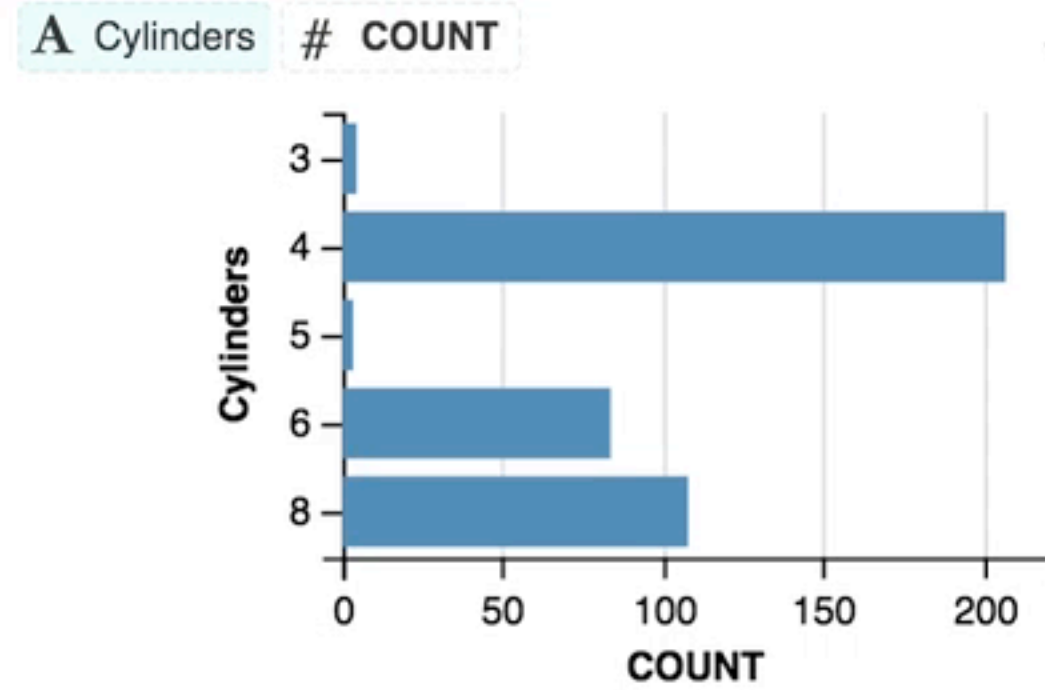
Specified View

No specified visualization yet. Start exploring by dragging a field to encoding pane on the left or examining univariate summaries below.

Related Views

Univariate Summaries Hide

Univariate Summaries





Data

Cars Change

Fields

- A Cylinders
- A Name
- A Origin
- Year
- # Acceleration
- # Displacement
- # Horsepower
- # Miles per Gallon
- # Weight in lbs
- # COUNT

Wildcards

- A Categorical Fields
- Temporal Fields
- # Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Filter: Filter invalid numbers

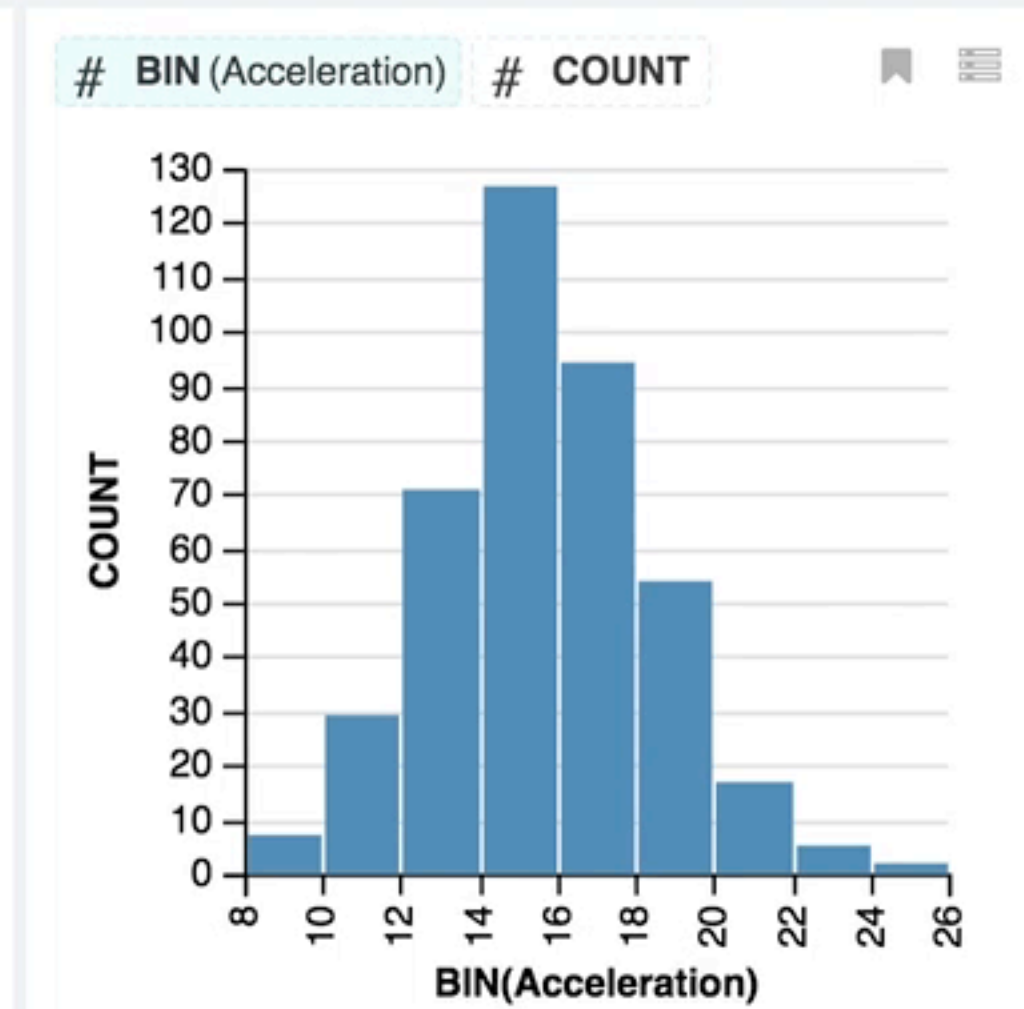
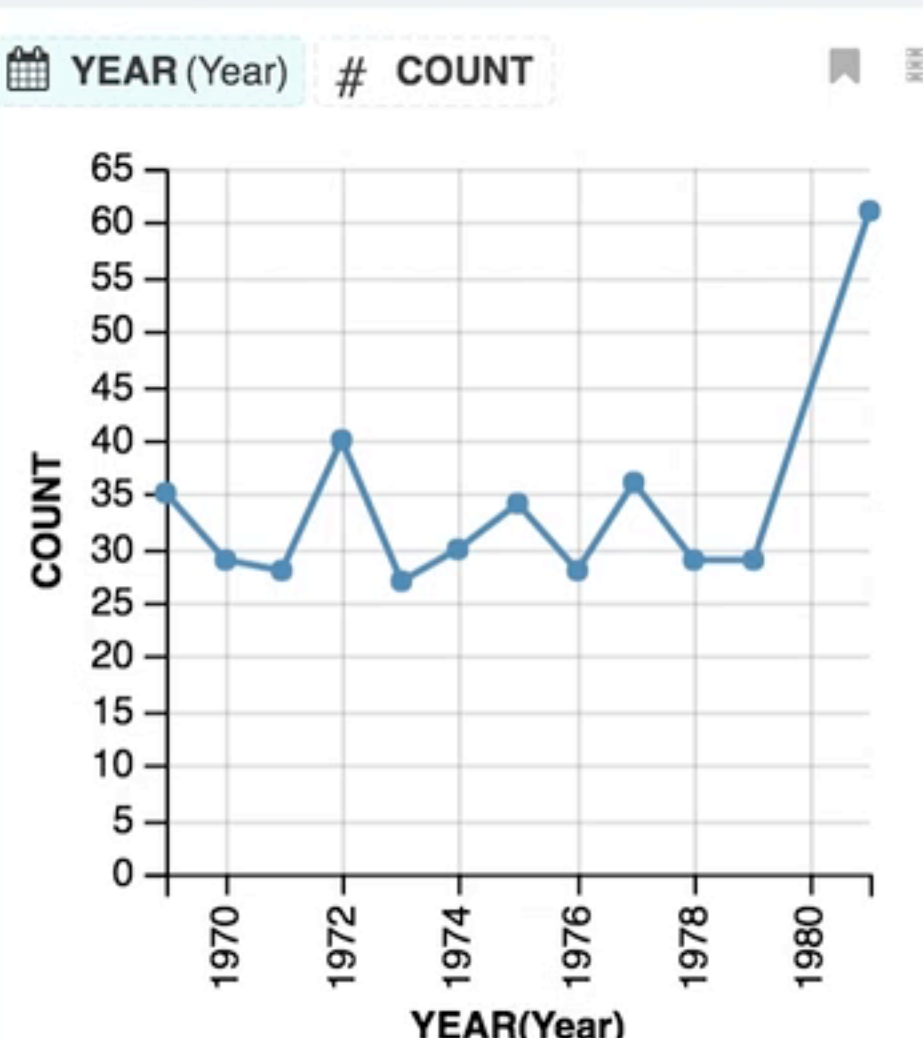
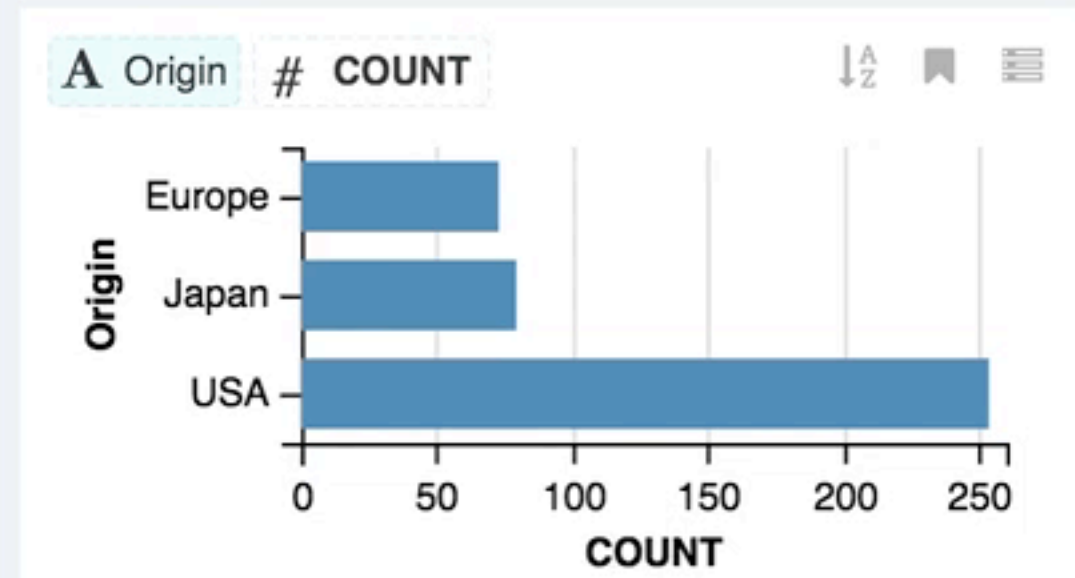
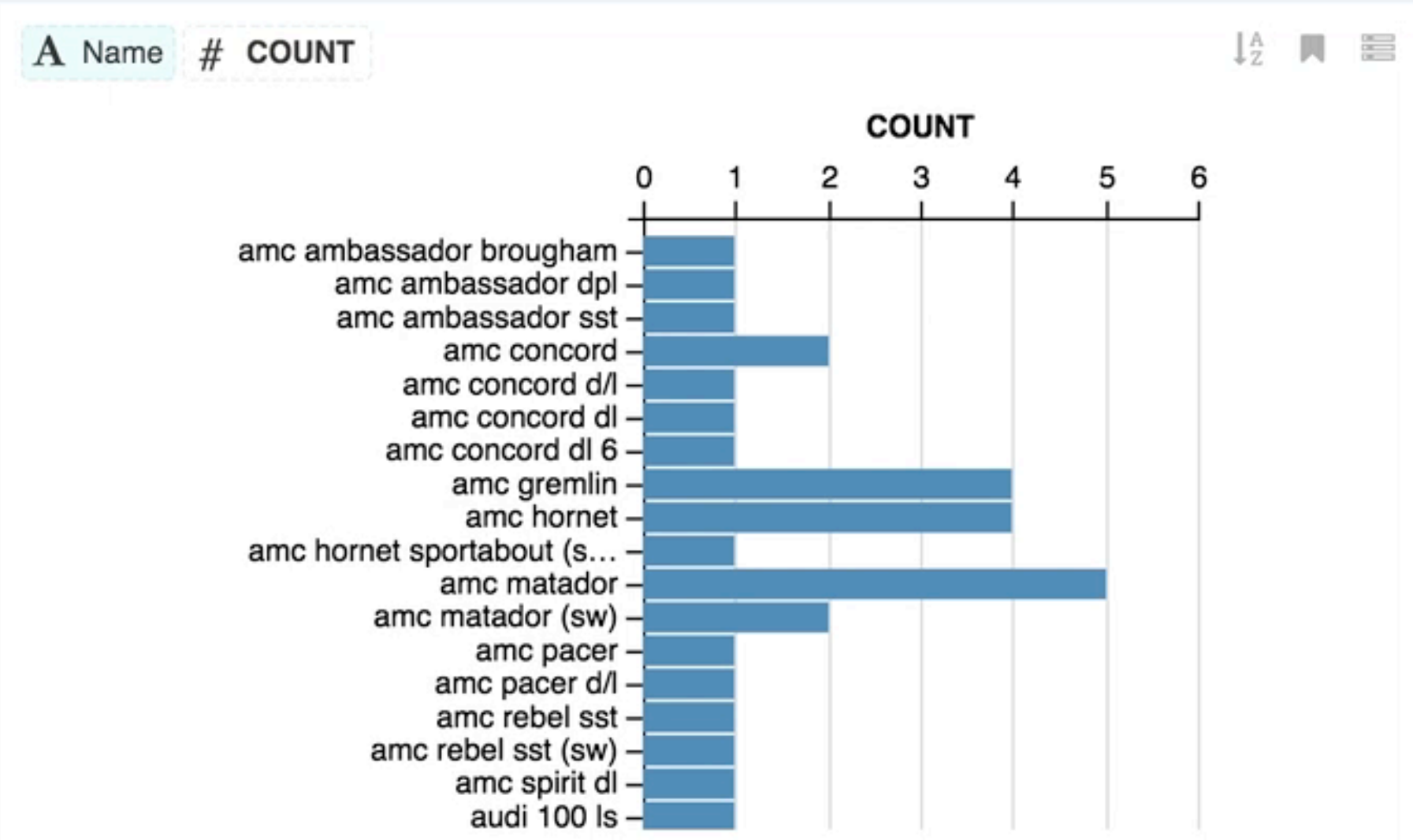
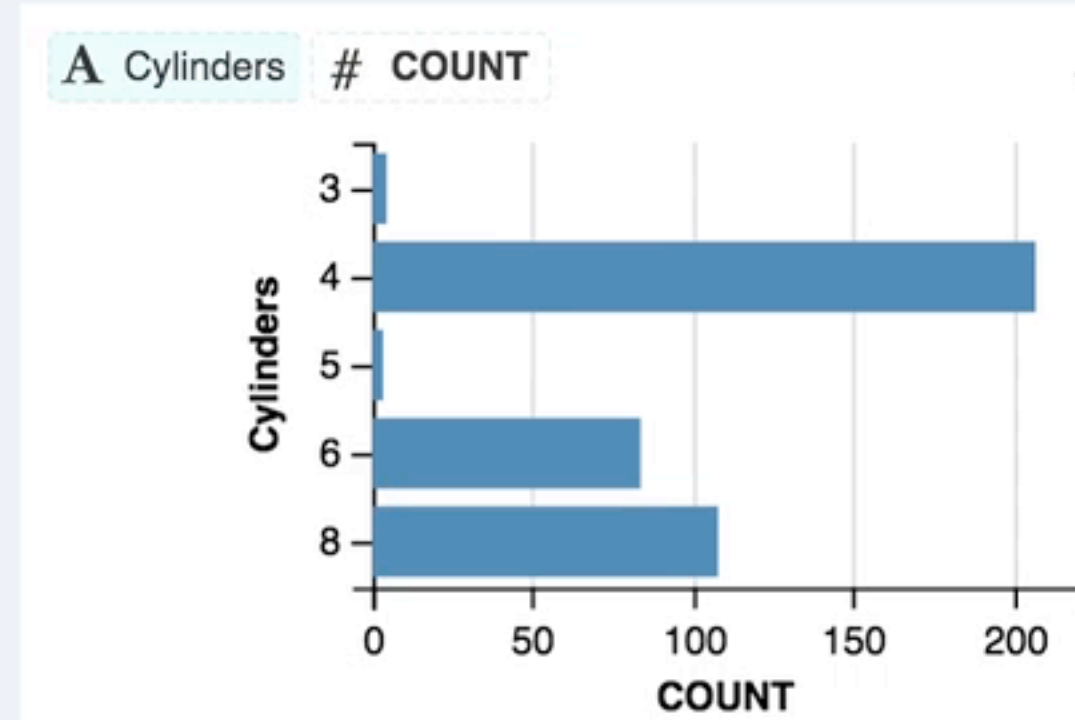
Specified View

No specified visualization yet. Start exploring by dragging a field to encoding pane on the left or examining univariate summaries below.

Related Views

Univariate Summaries Hide

Univariate Summaries





Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Specified View

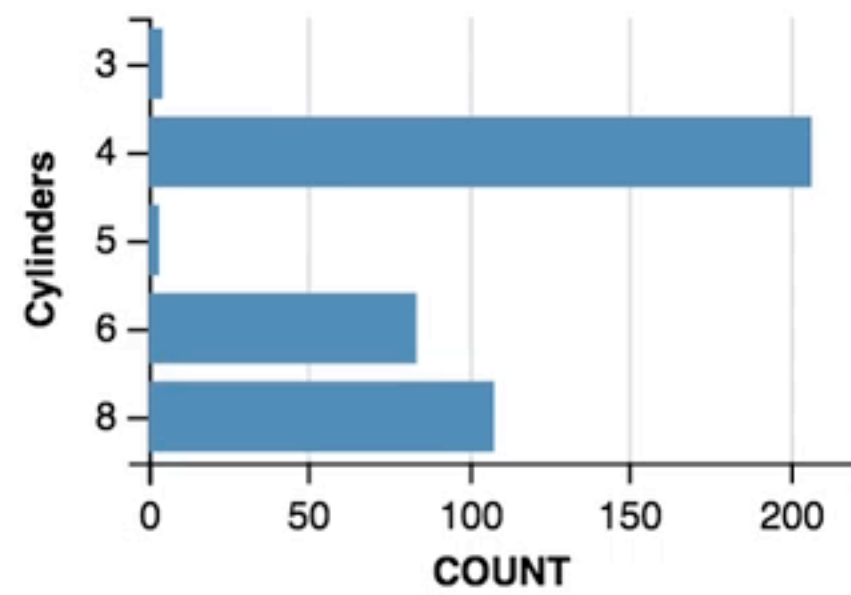
No specified visualization yet. Start exploring by dragging a field to encoding pane on the left or examining univariate summaries below.

Related Views

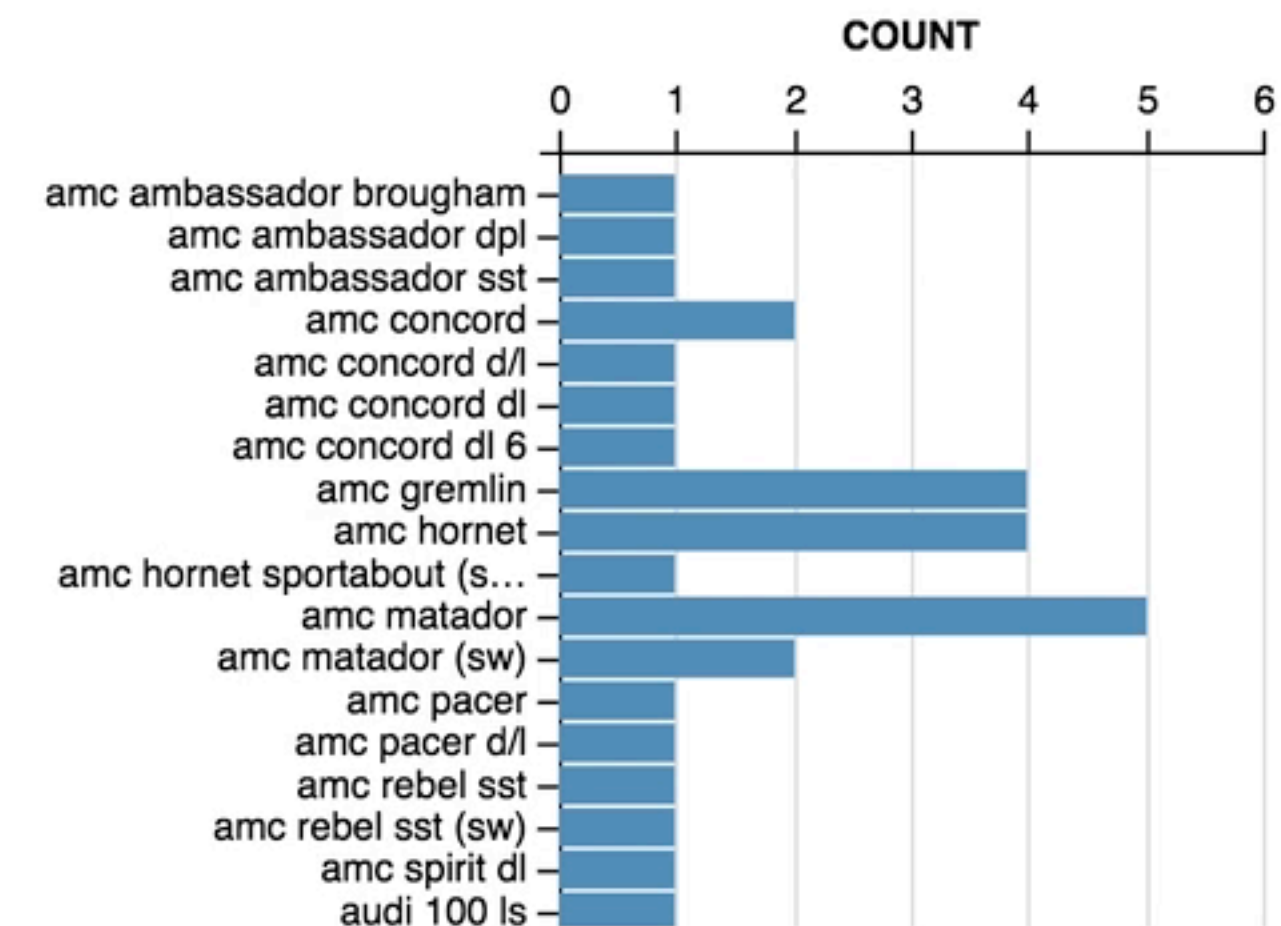
Univariate Summaries Hide

Univariate Summaries

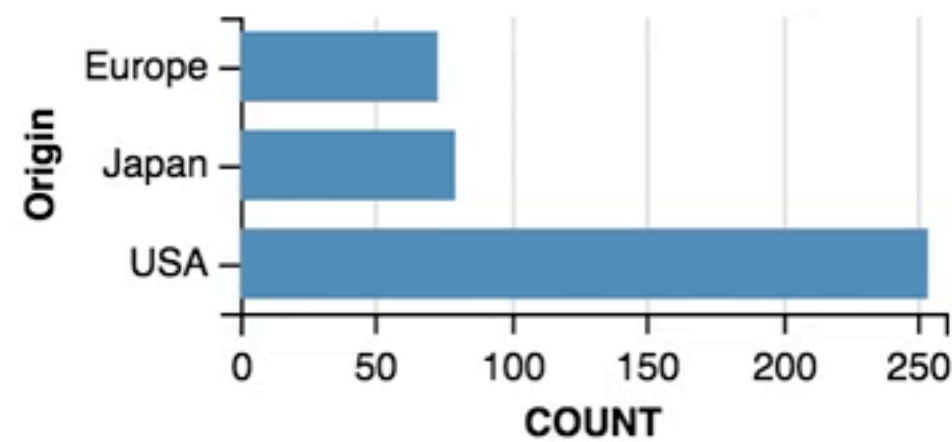
Cylinders # COUNT



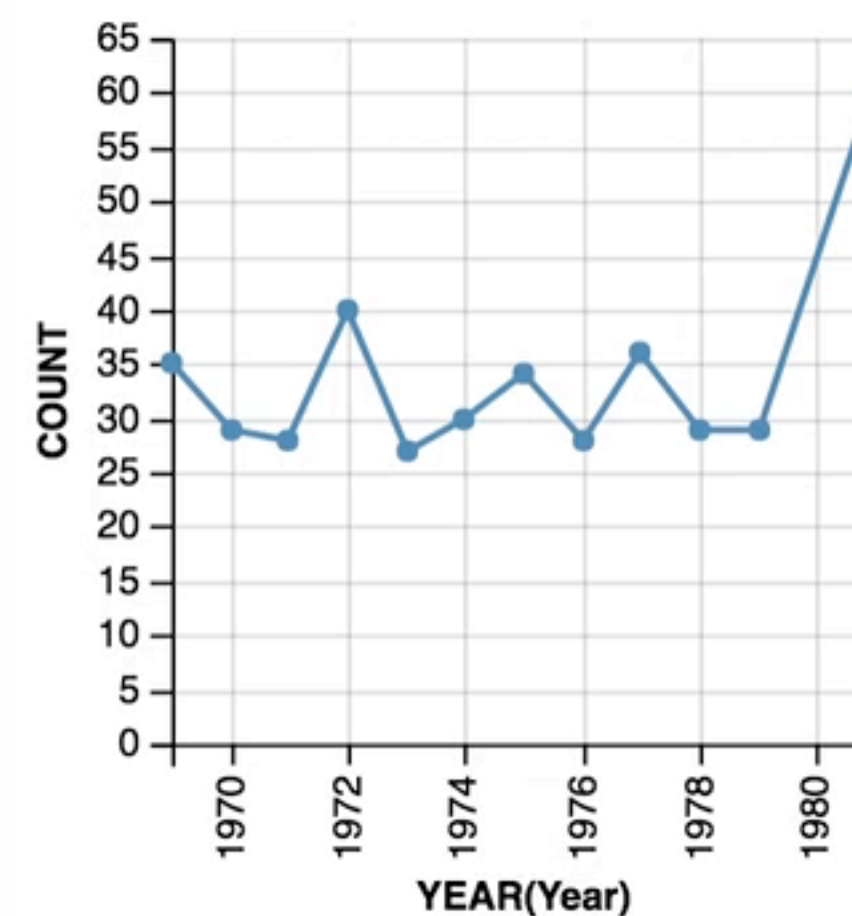
Name # COUNT



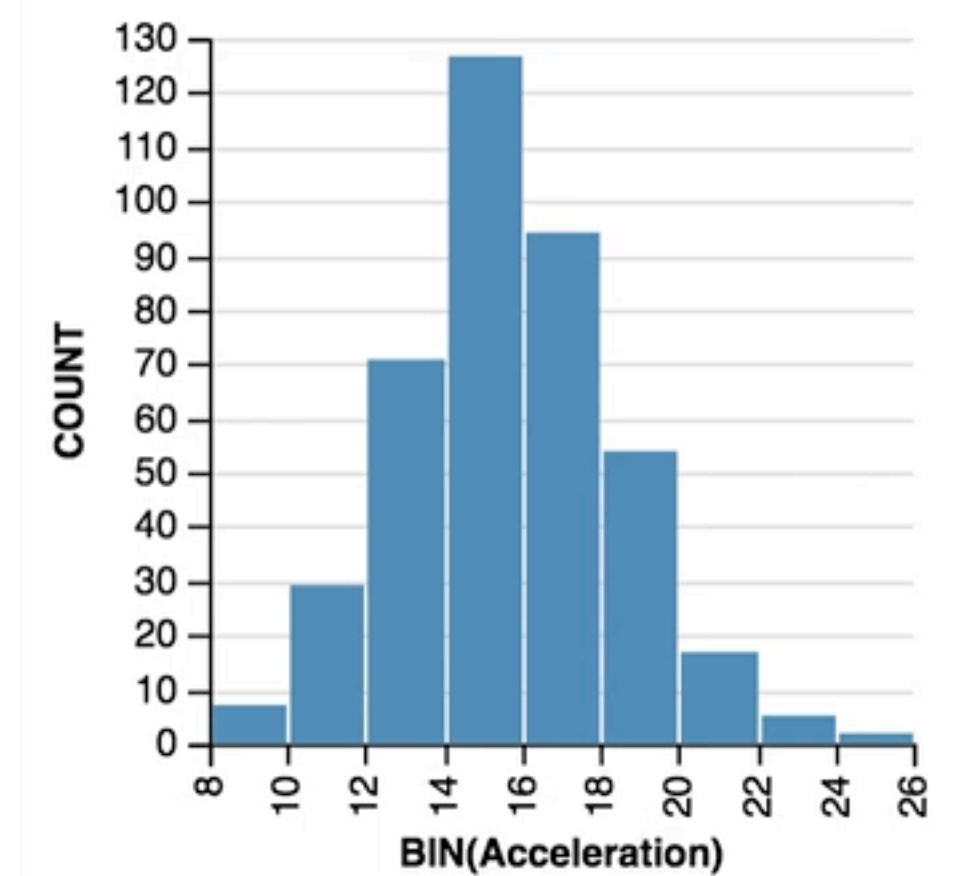
Origin # COUNT



YEAR (Year) # COUNT



# BIN (Acceleration) # COUNT



Related Views (Univariate Summaries)



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

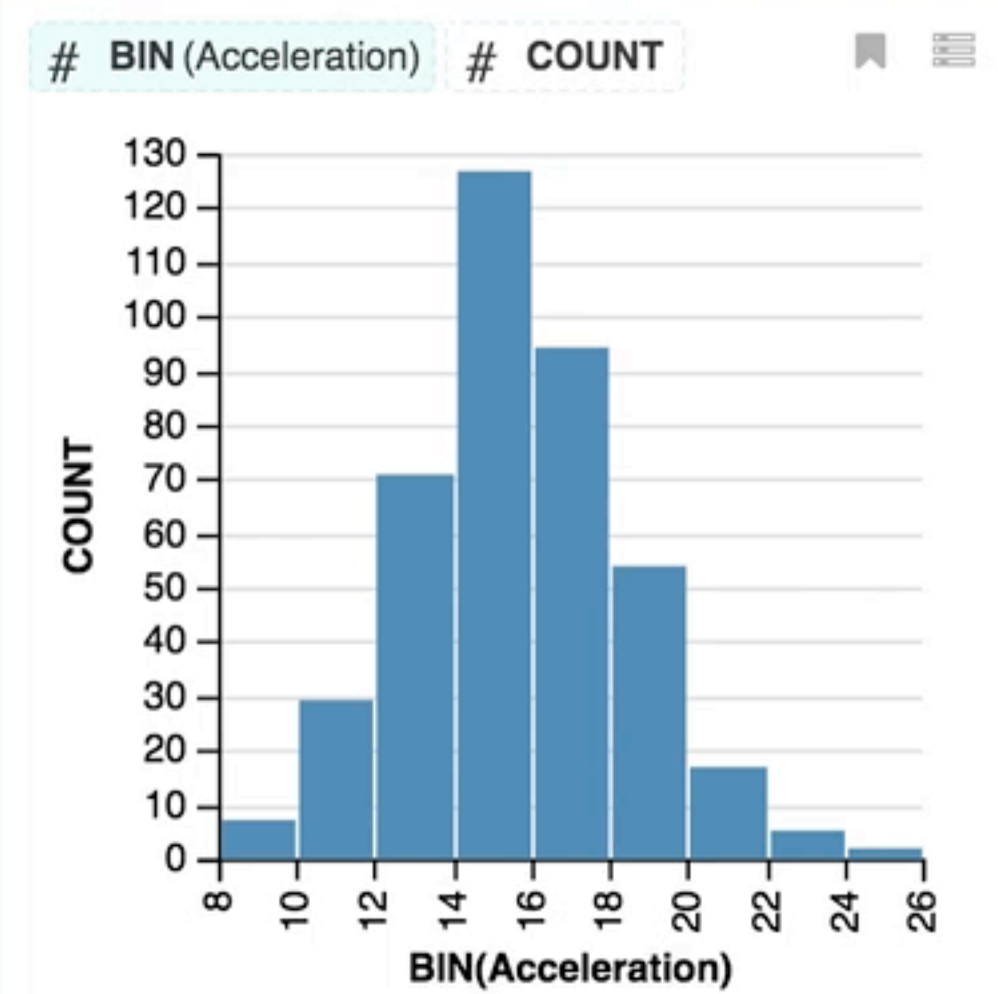
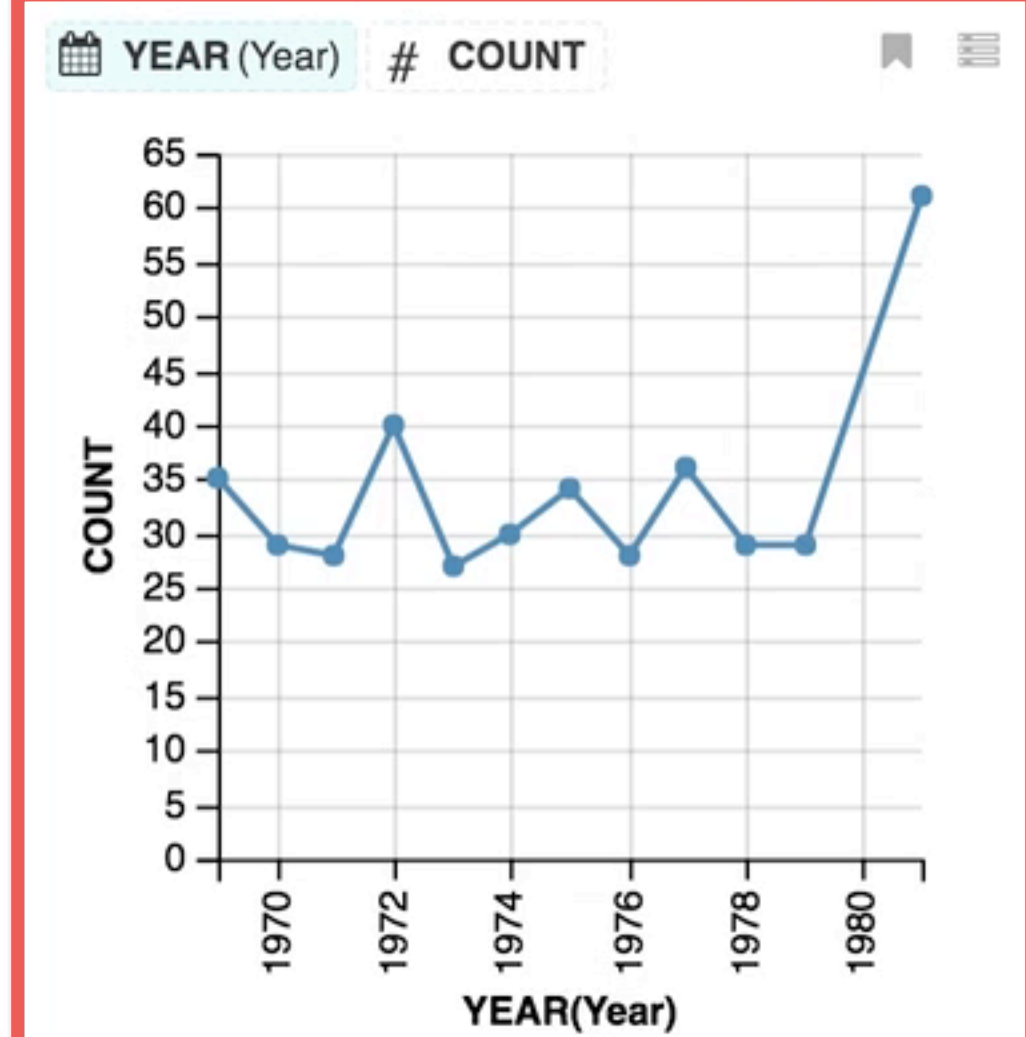
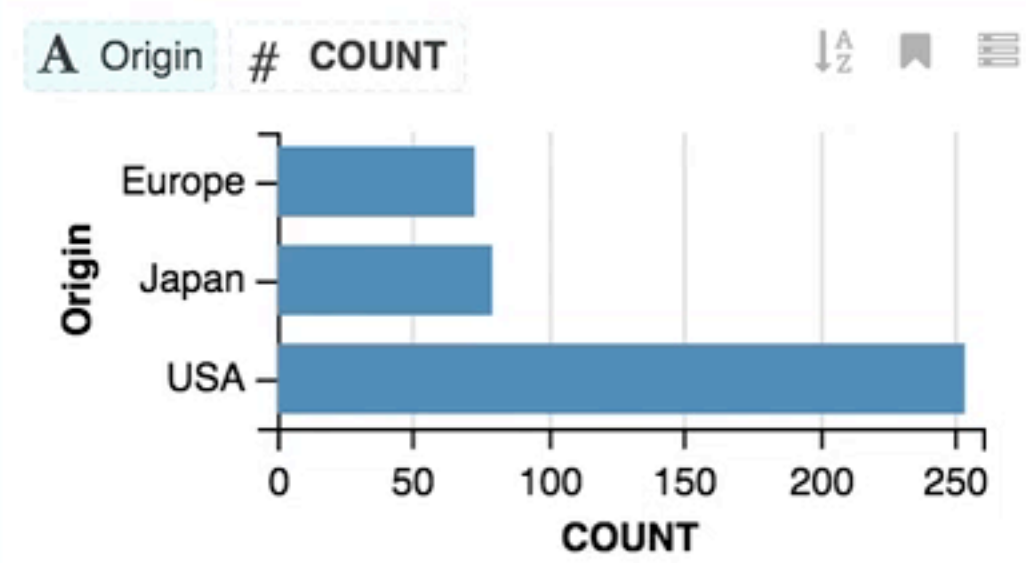
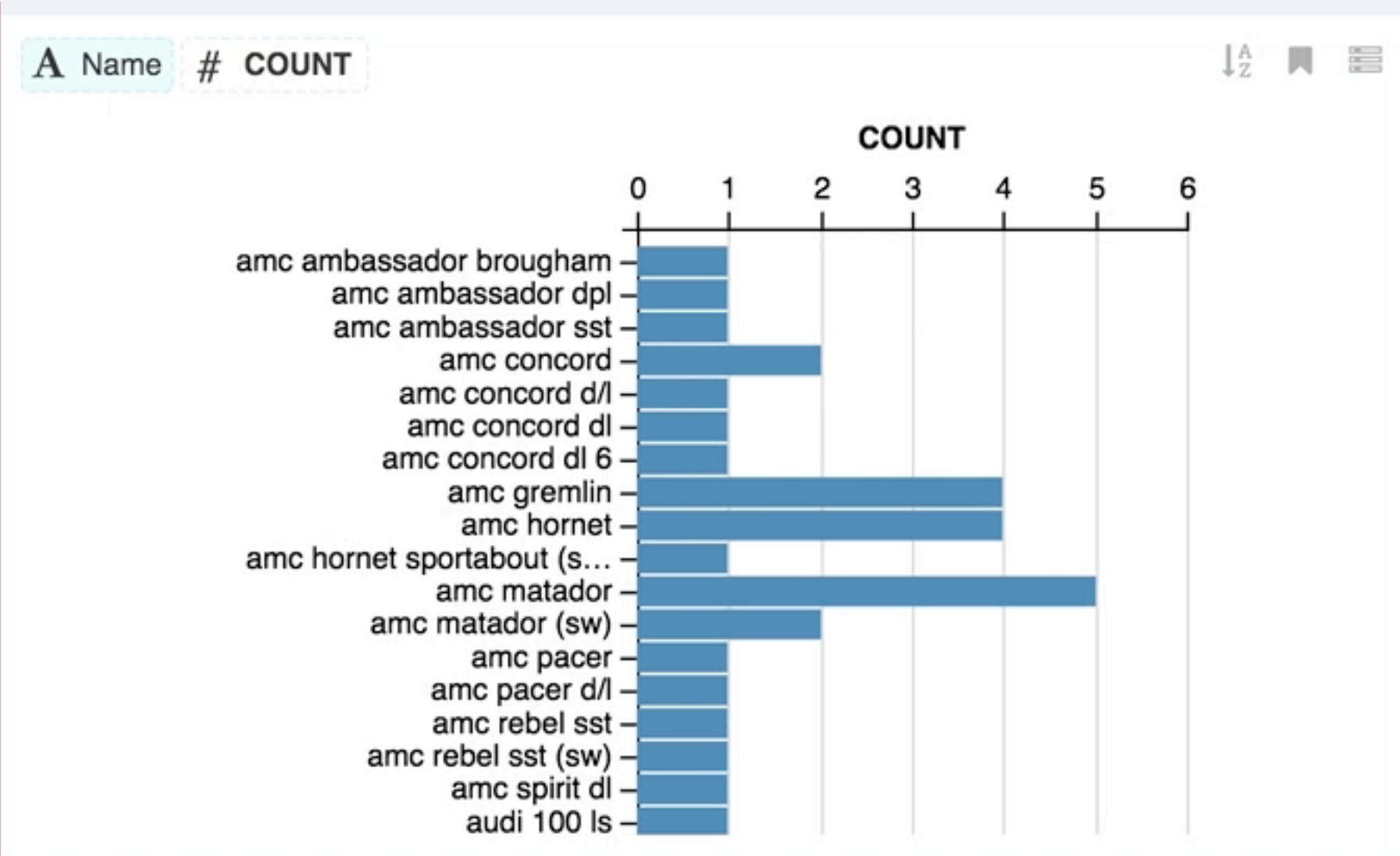
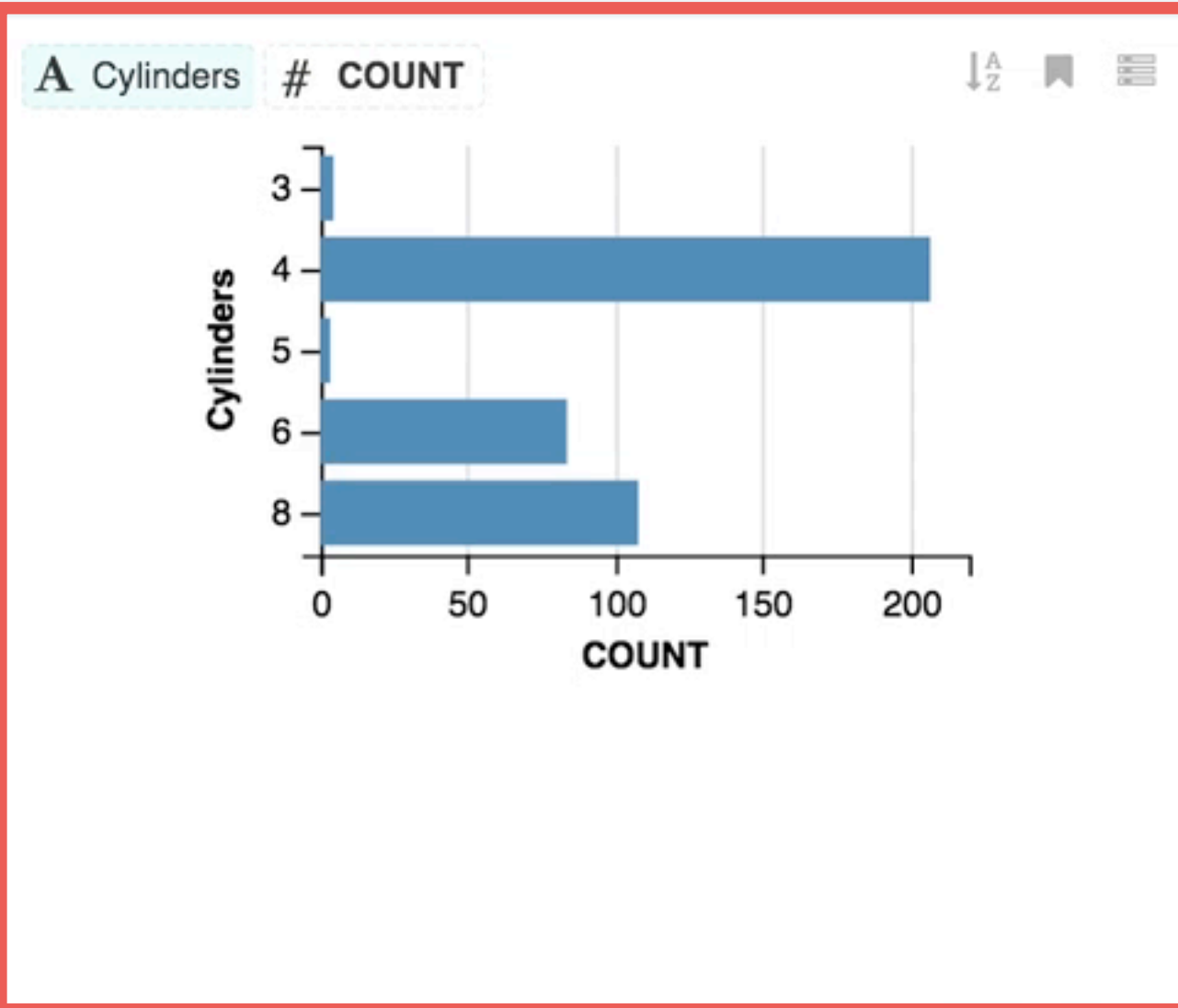
Specified View

No specified visualization yet. Start exploring by dragging a field to encoding pane on the left or examining univariate summaries below.

Related Views

Univariate Summaries Hide

Univariate Summaries



Related Views (Univariate Summaries)





Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

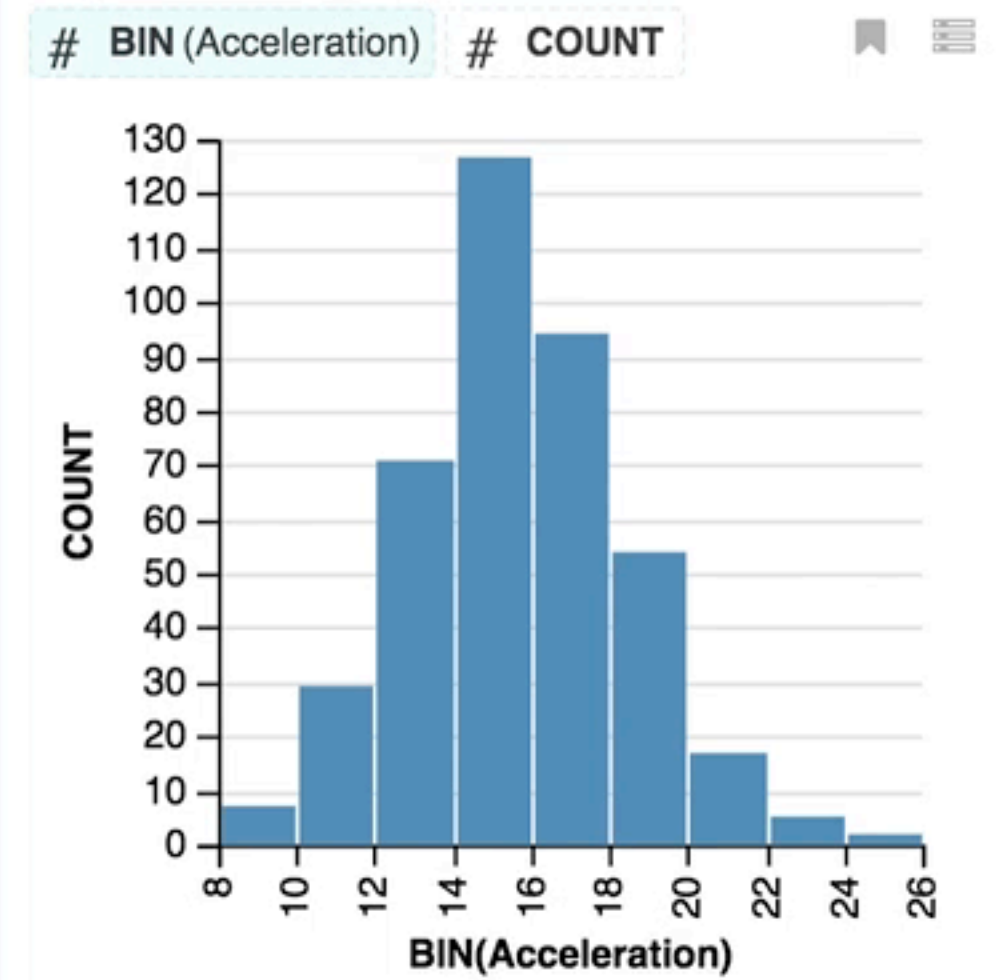
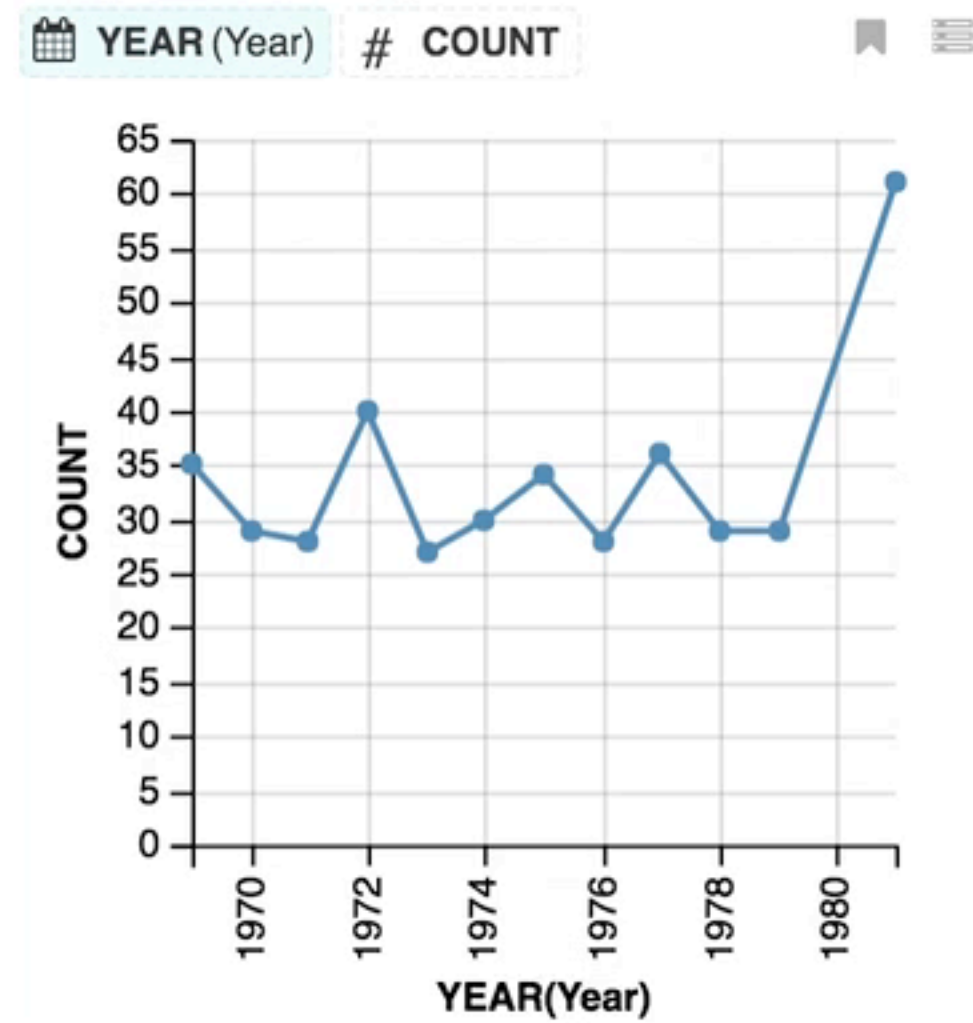
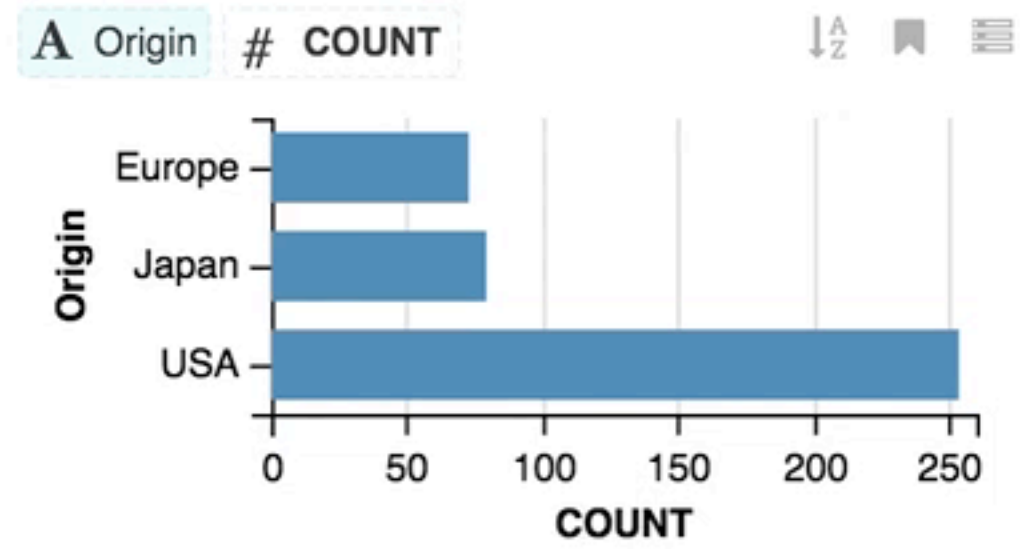
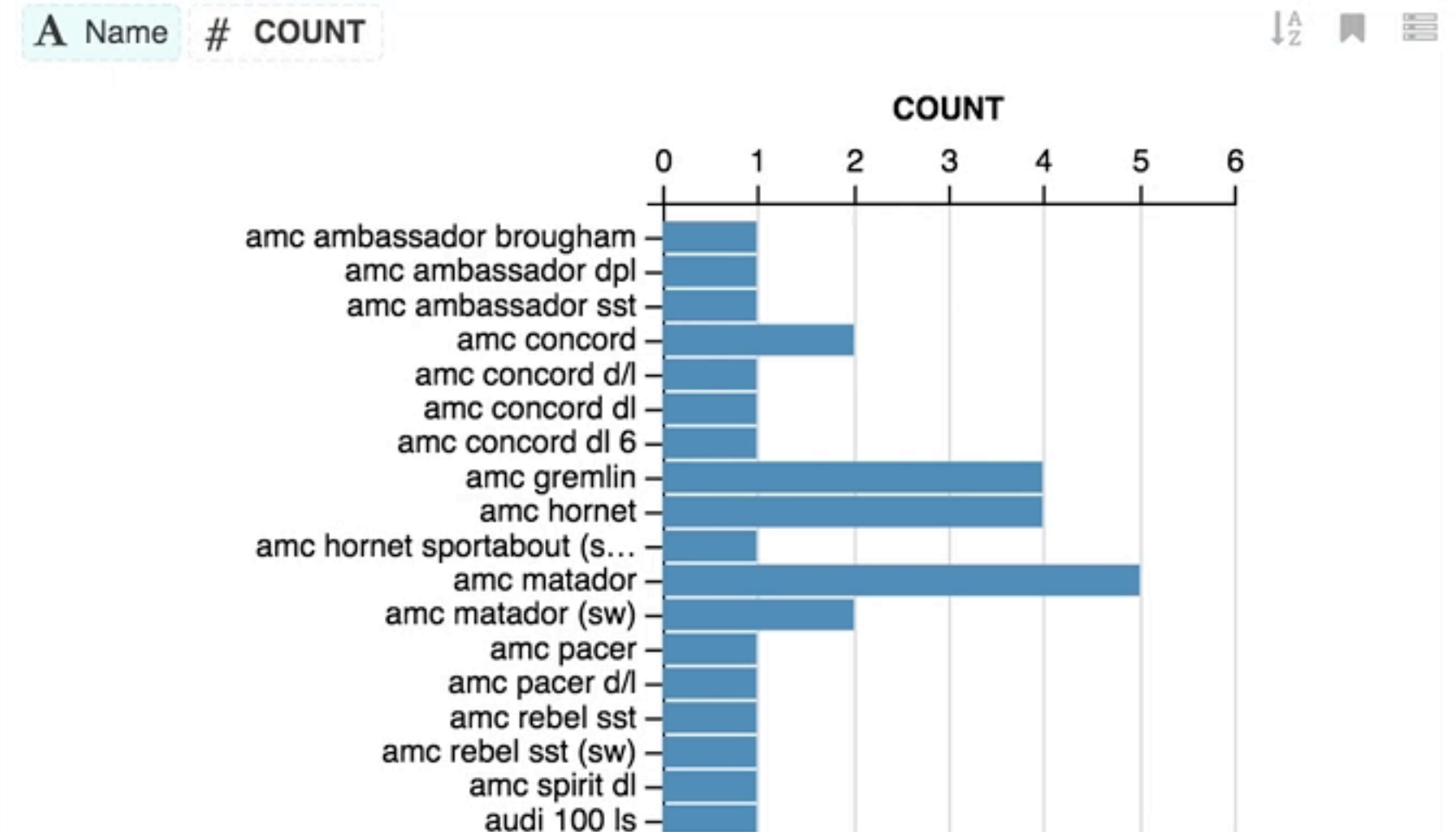
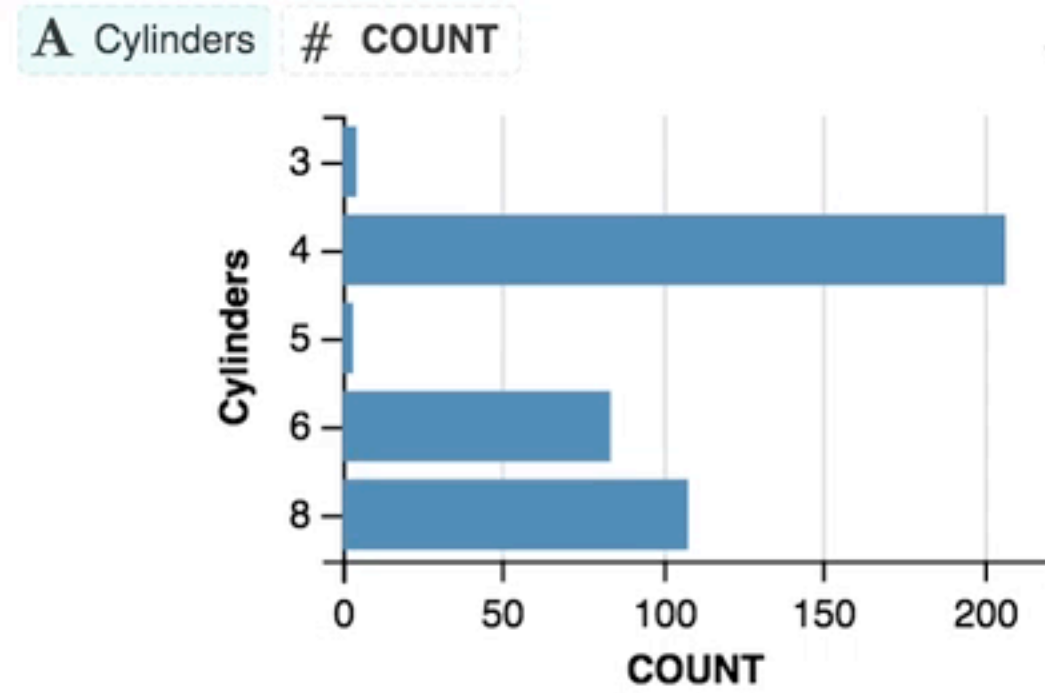
Specified View

No specified visualization yet. Start exploring by dragging a field to encoding pane on the left or examining univariate summaries below.

Related Views

Univariate Summaries Hide

Univariate Summaries



Related Views (Univariate Summaries)



Data

Cars Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Encoding Clear

x drop a field here

drop a field here

drop a field here

drop a field here

marks auto

size drop a field here

color drop a field here

shape drop a field here

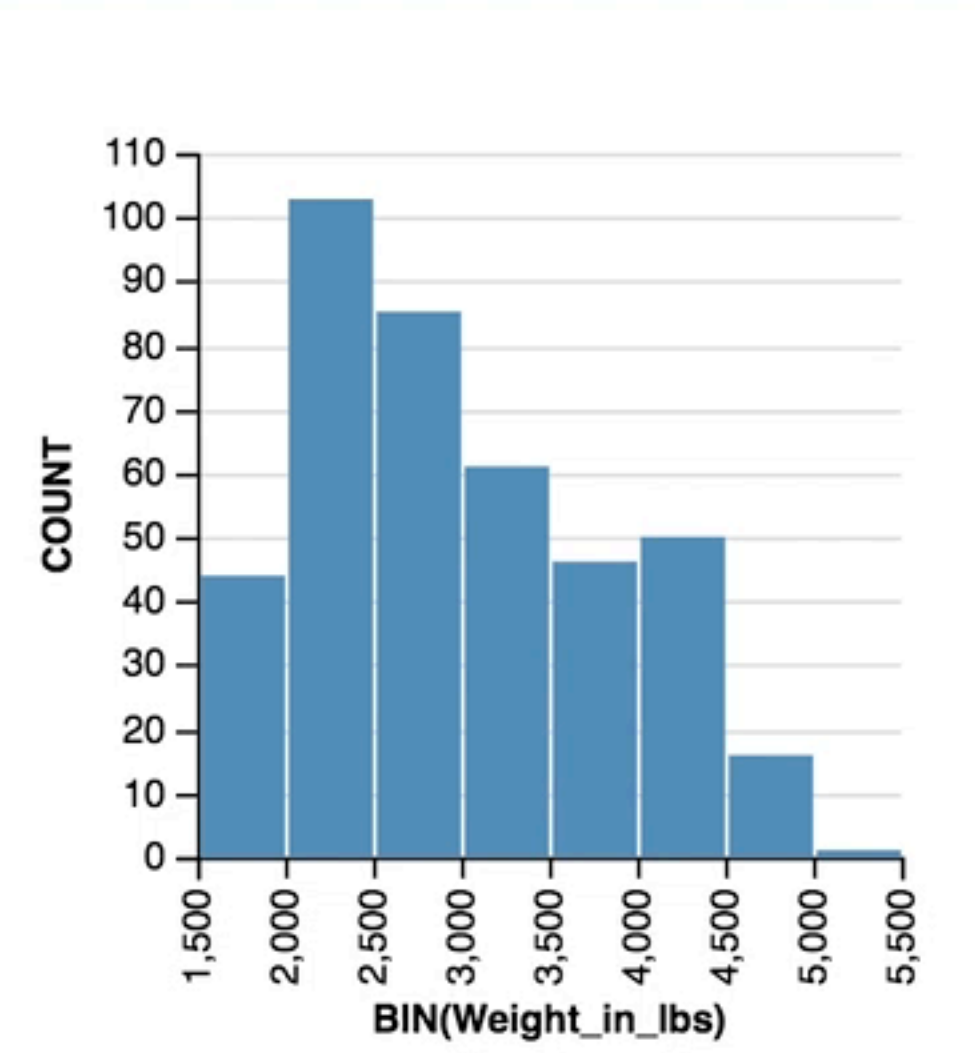
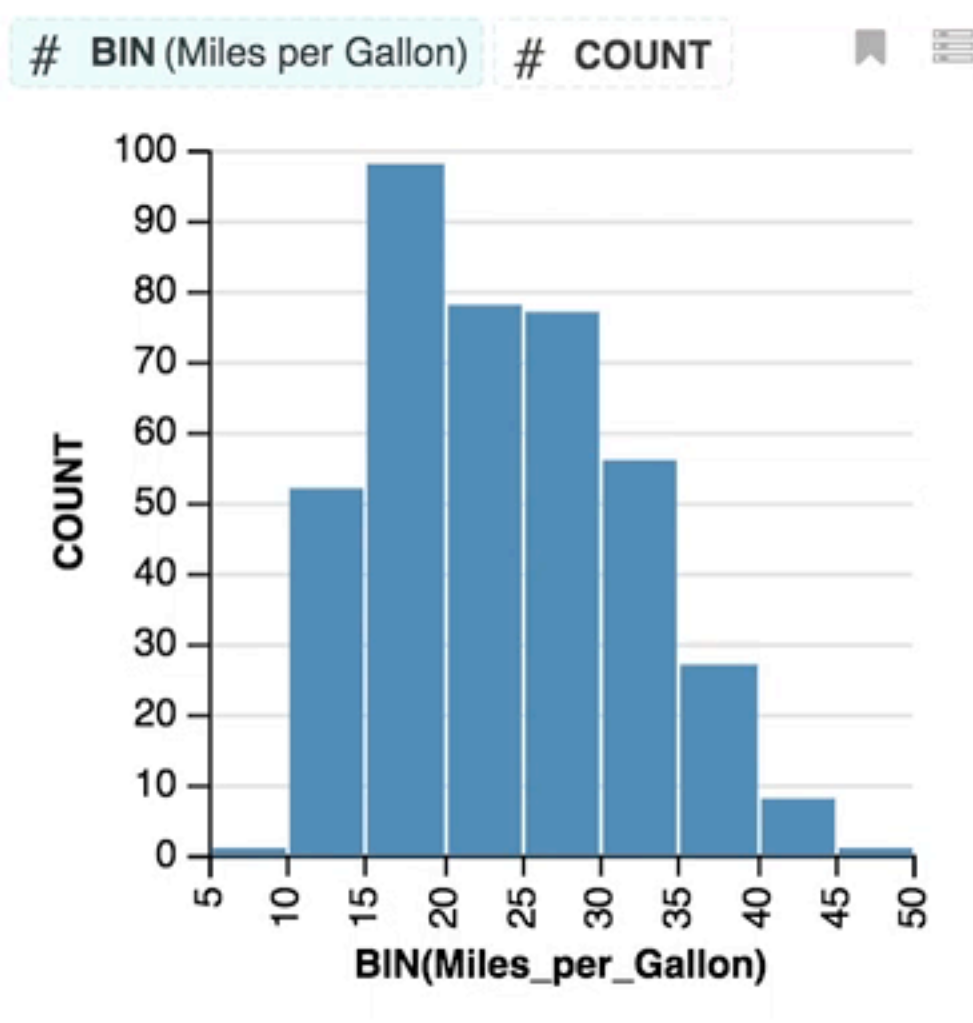
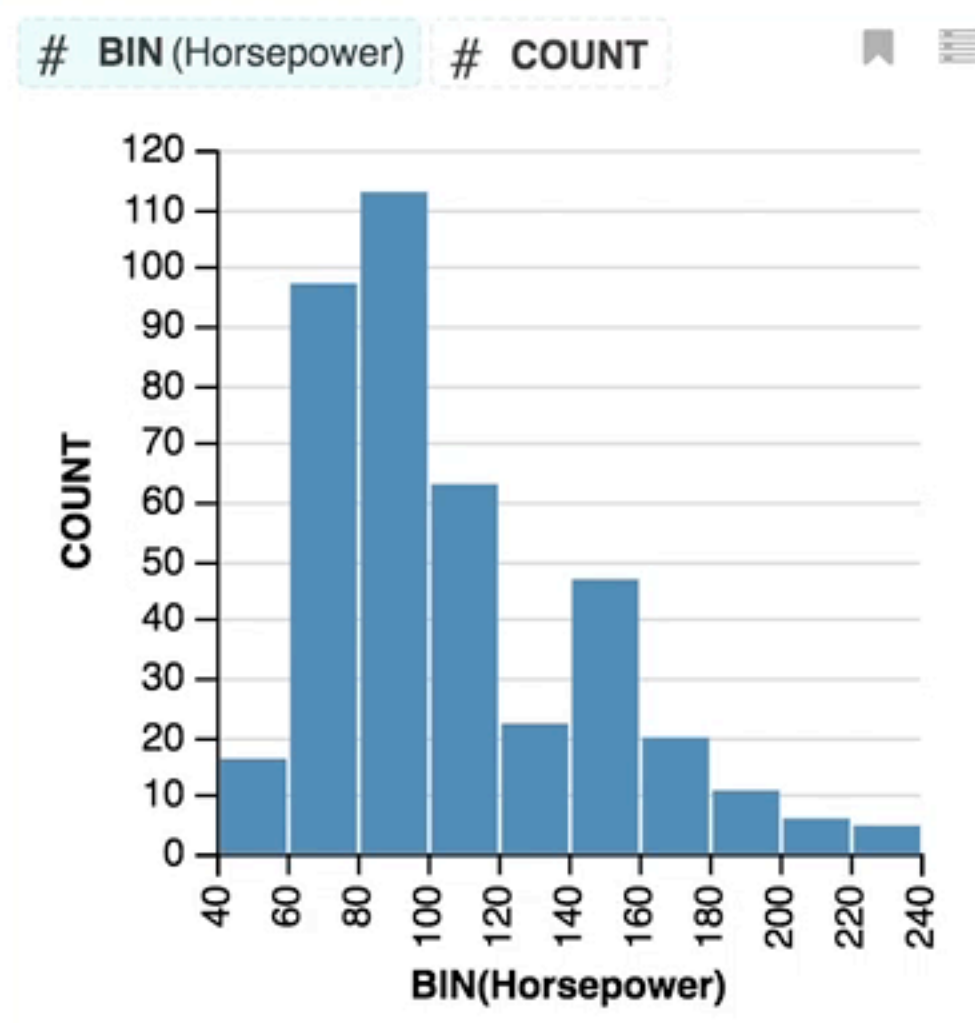
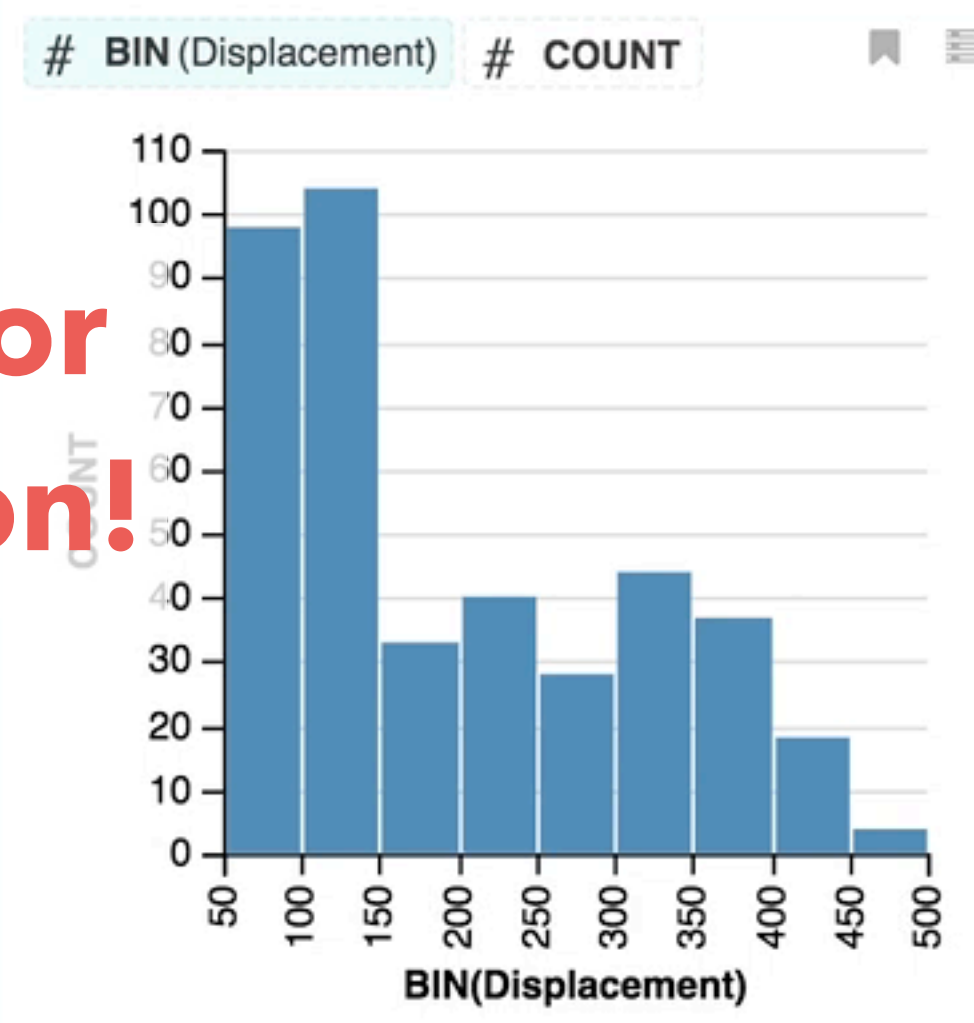
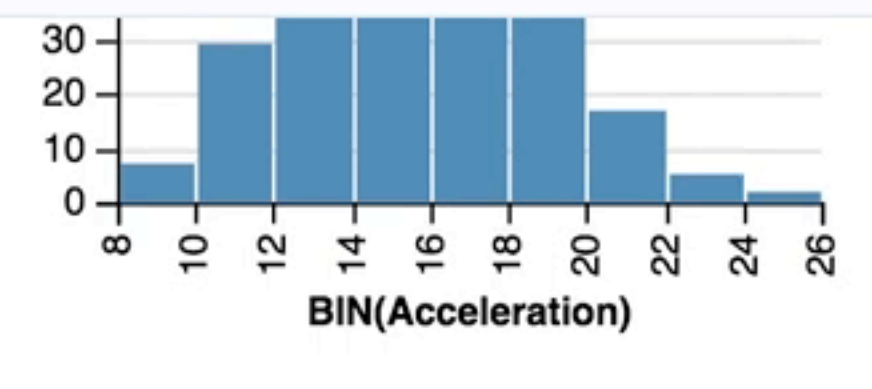
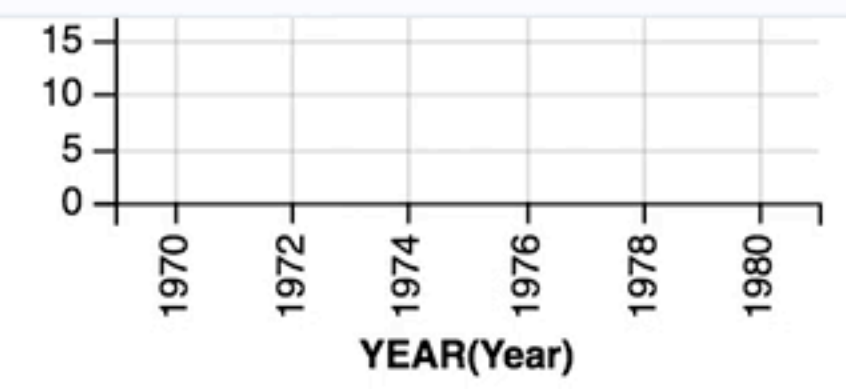
detail drop a field here

text drop a field here

any drop a field here

Tedious for exploration!

Manual Specification





Data

Cars Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcard Fields

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

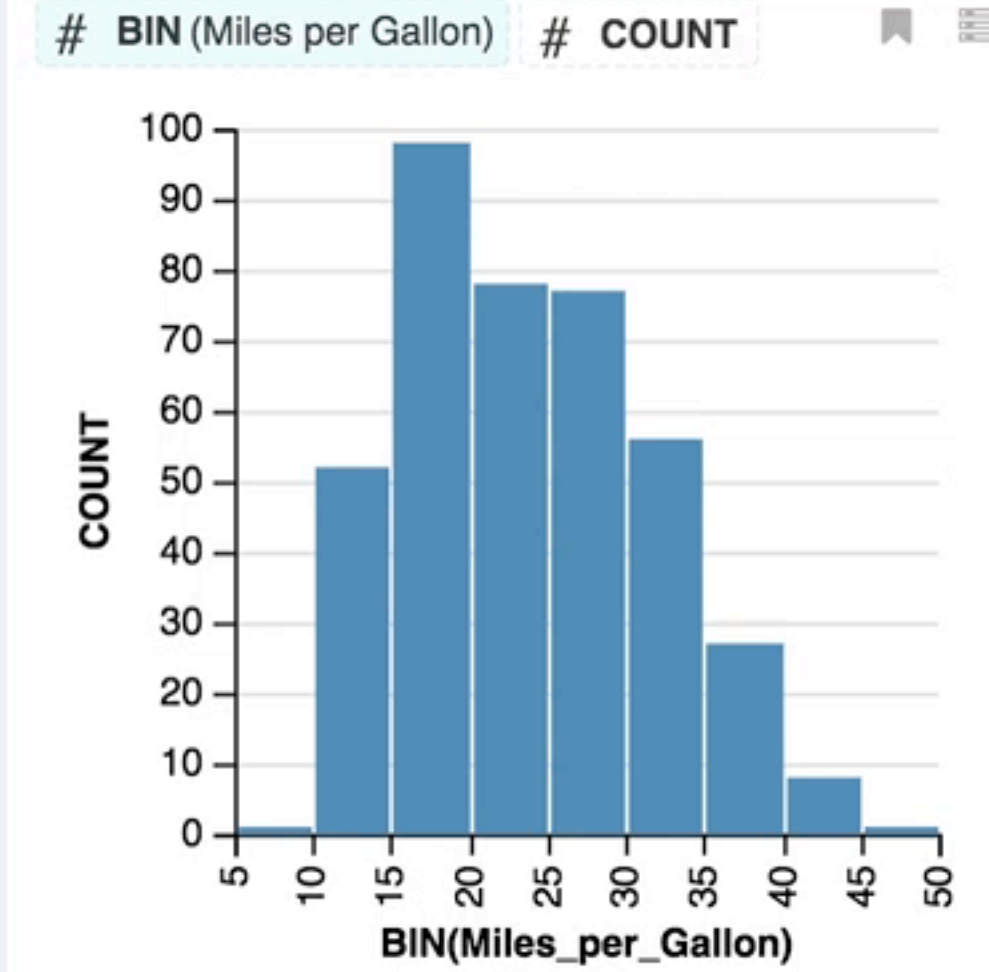
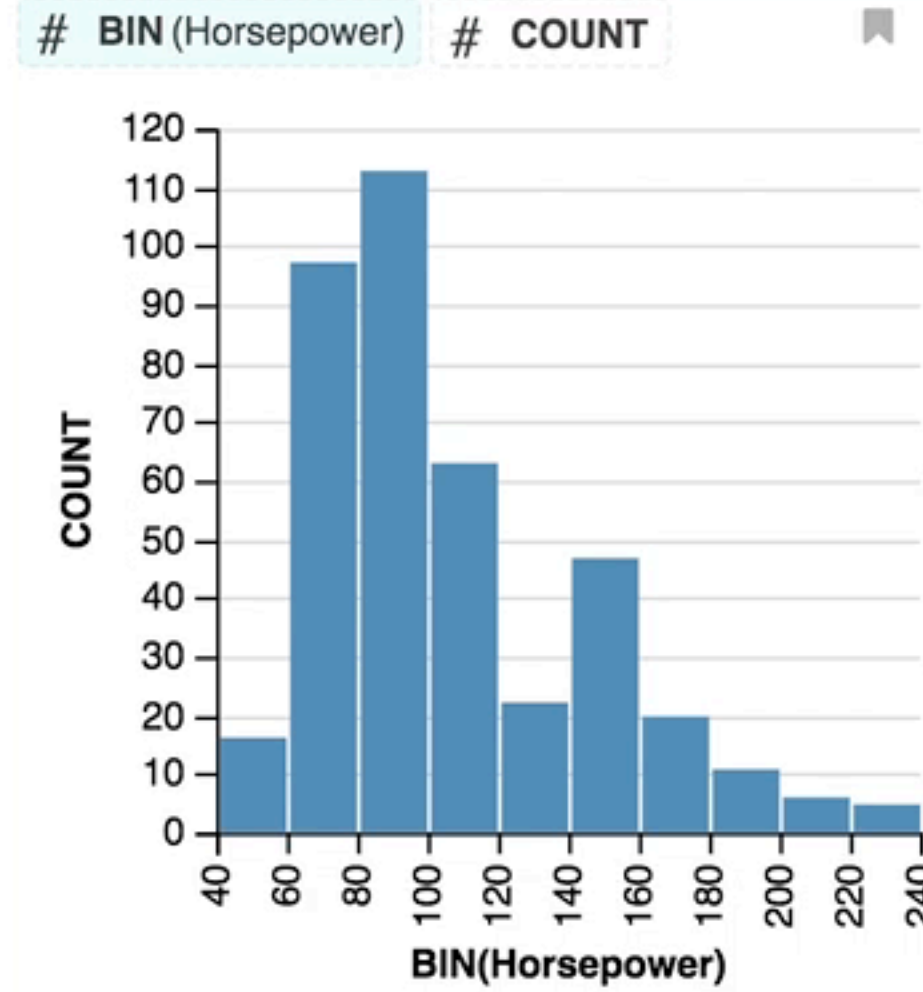
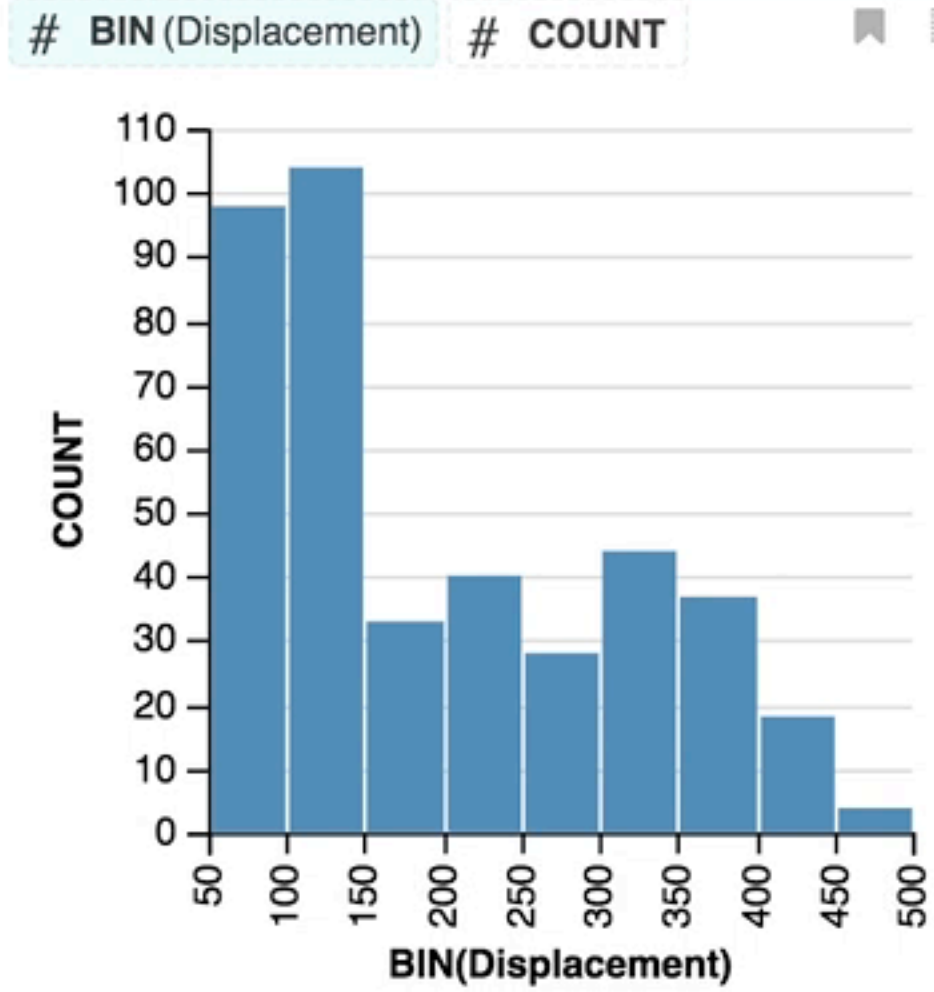
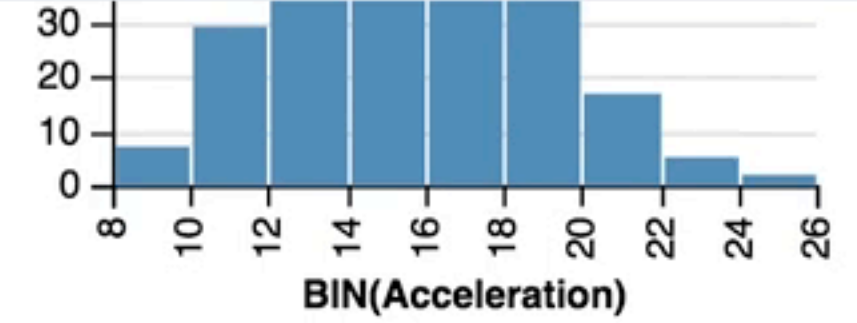
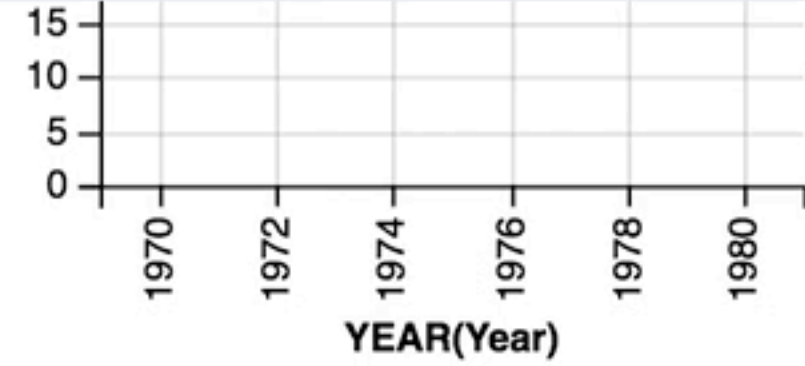
shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Filter: Filter invalid numbers



# Wildcard Specification



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks

auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

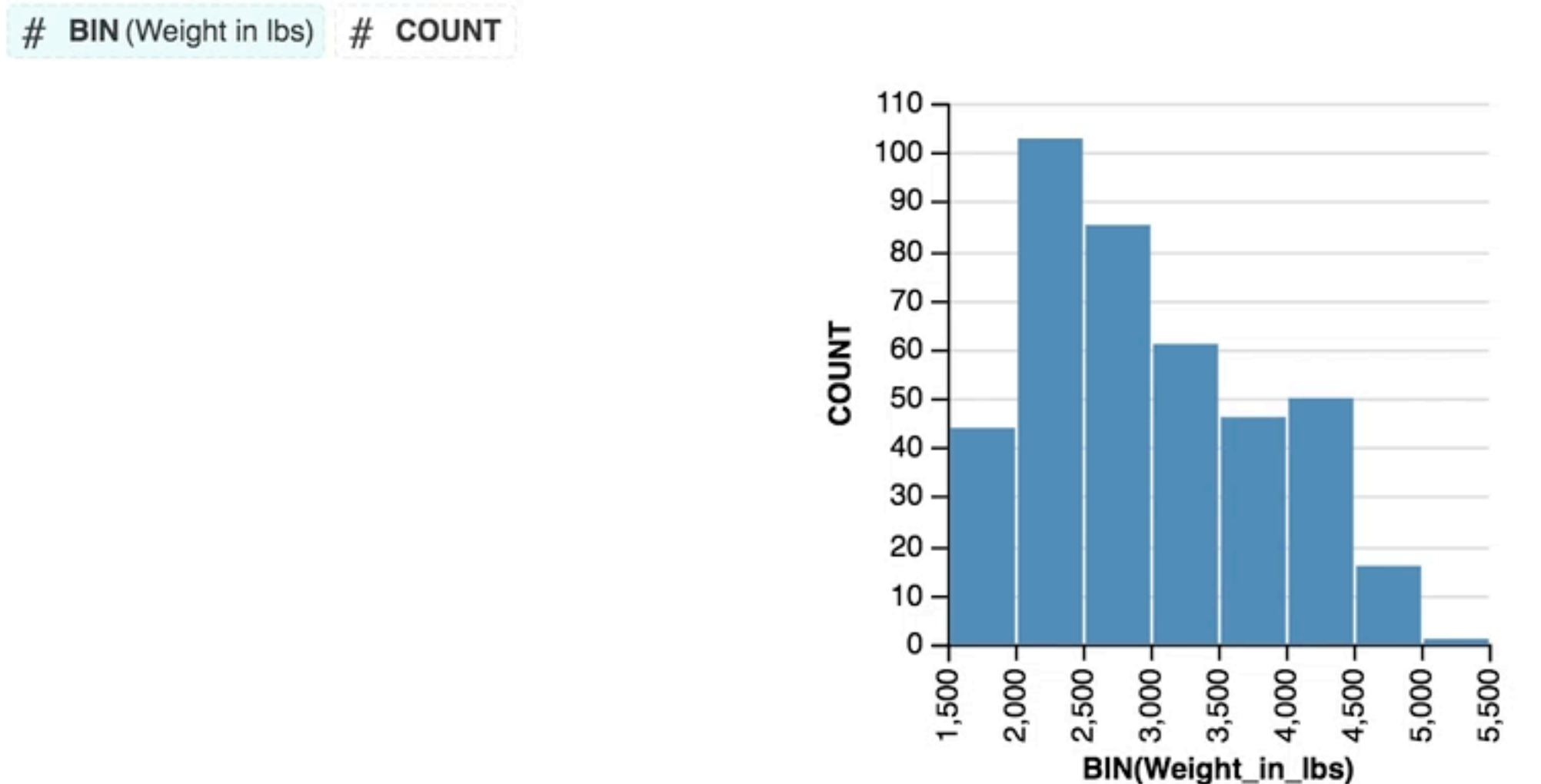
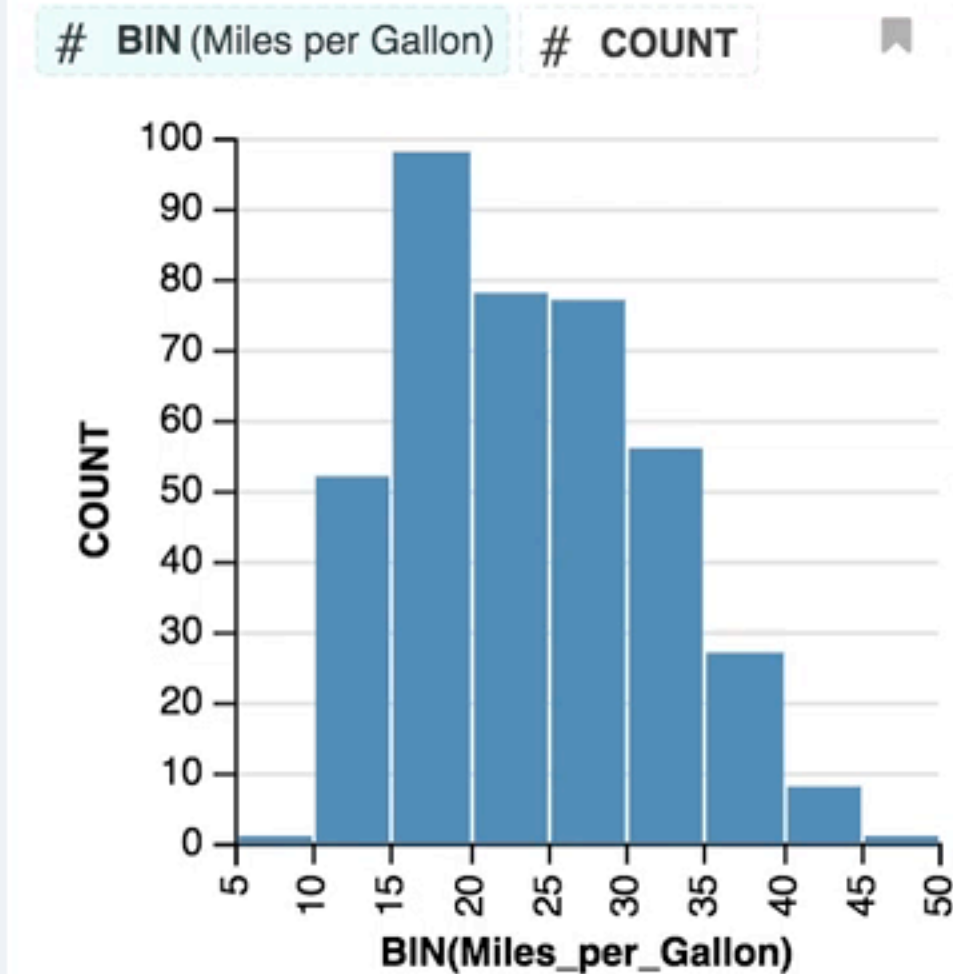
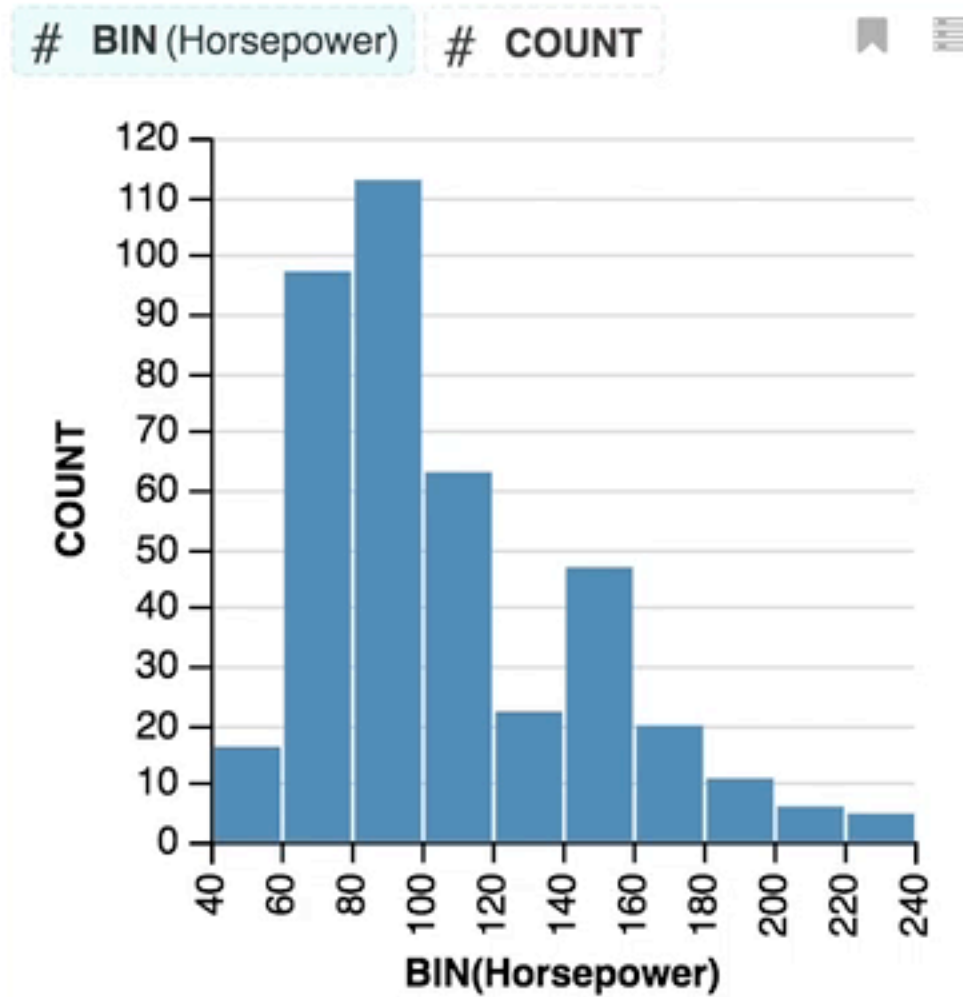
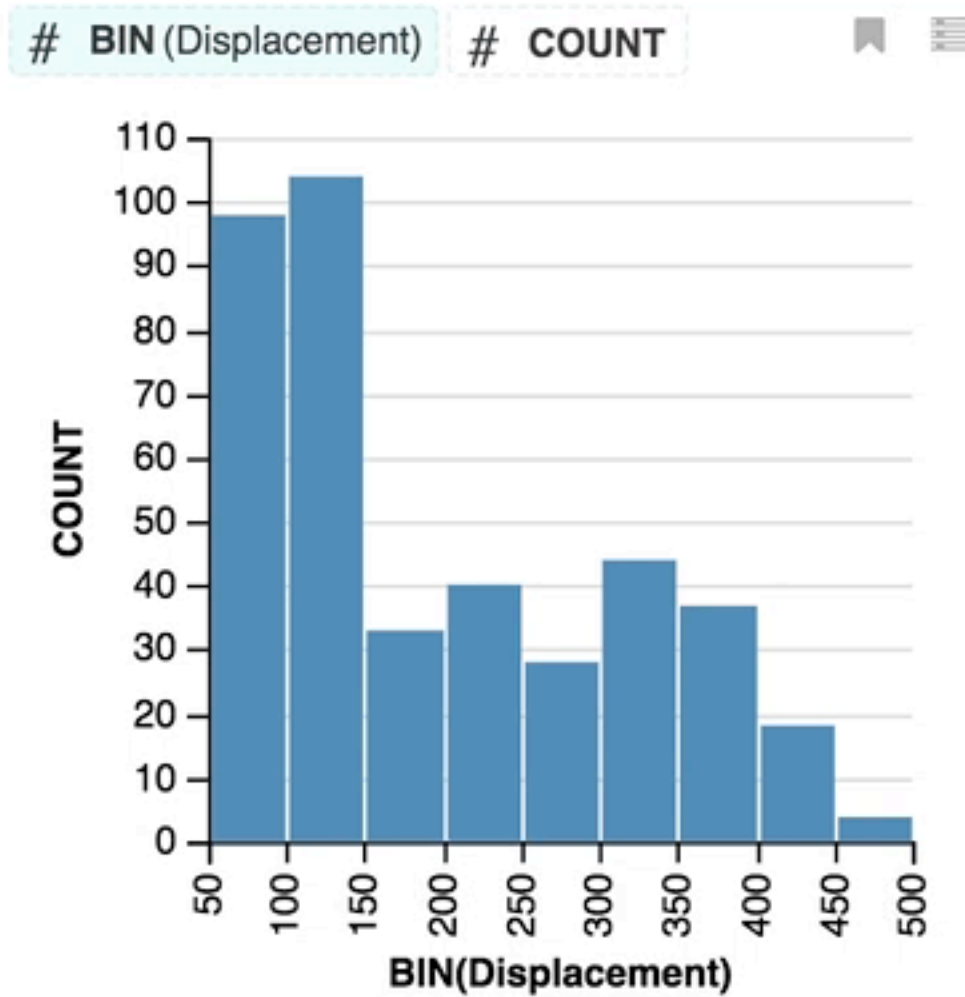
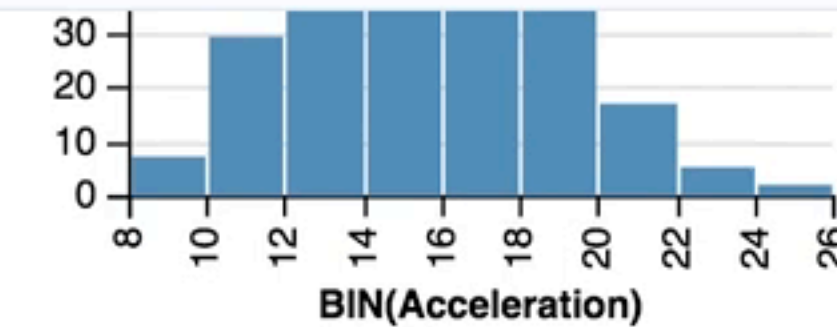
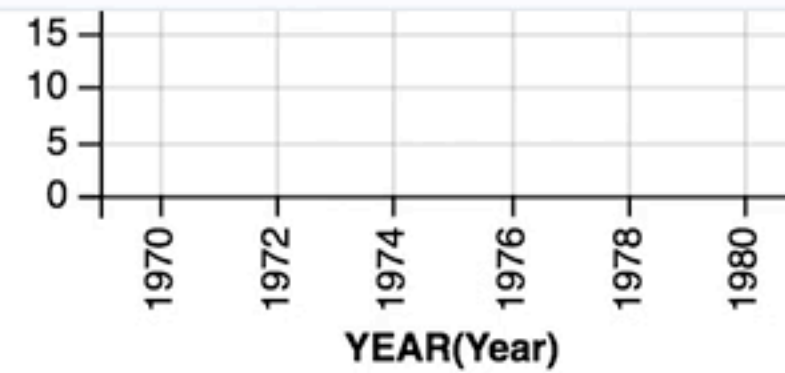
text: drop a field here

any: drop a field here

Filter: Filter invalid numbers

Wildcard Shelf

# Wildcard Specification





Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks

auto

size: drop a field here

color: drop a field here

shape: drop a field here

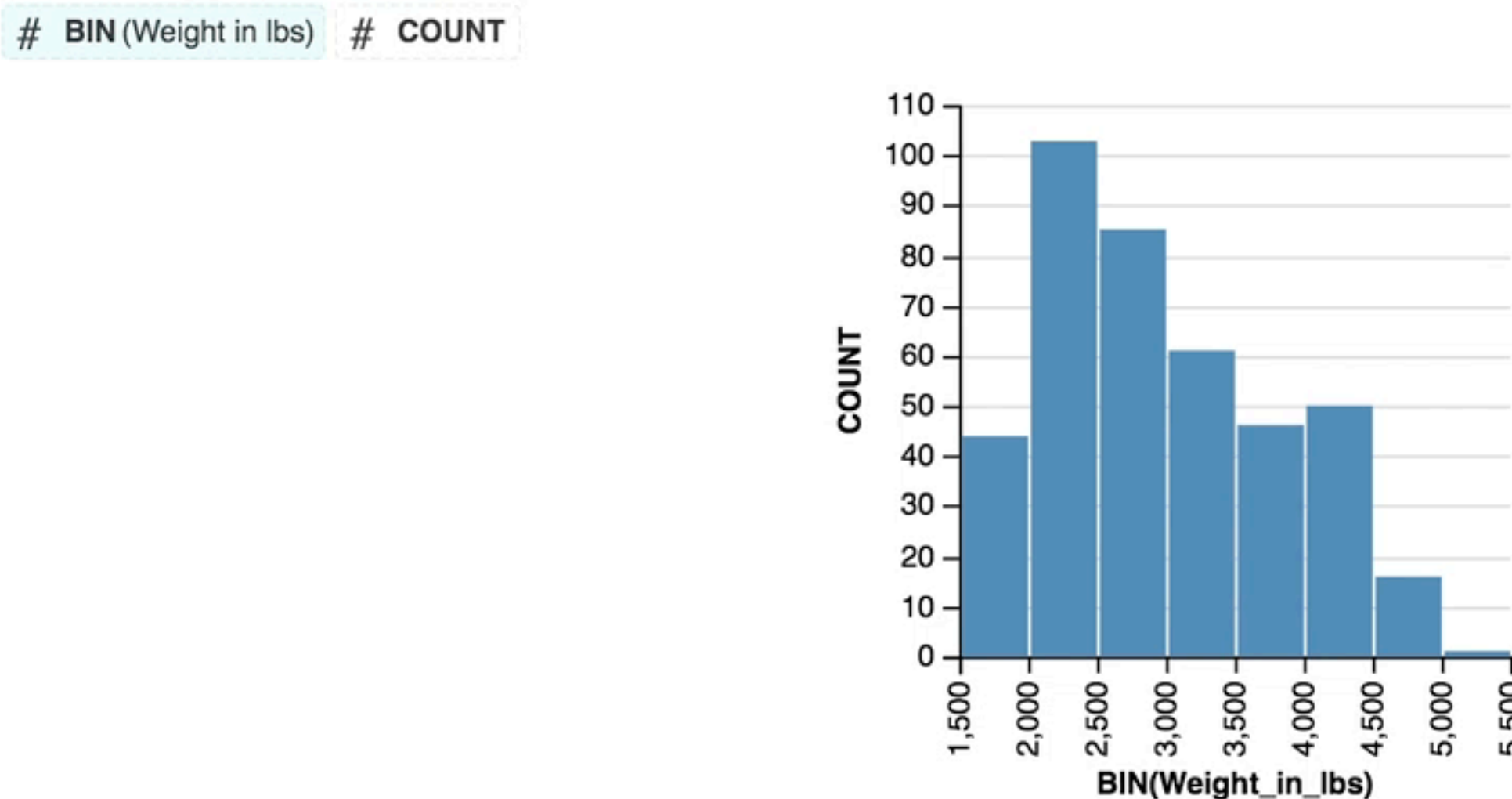
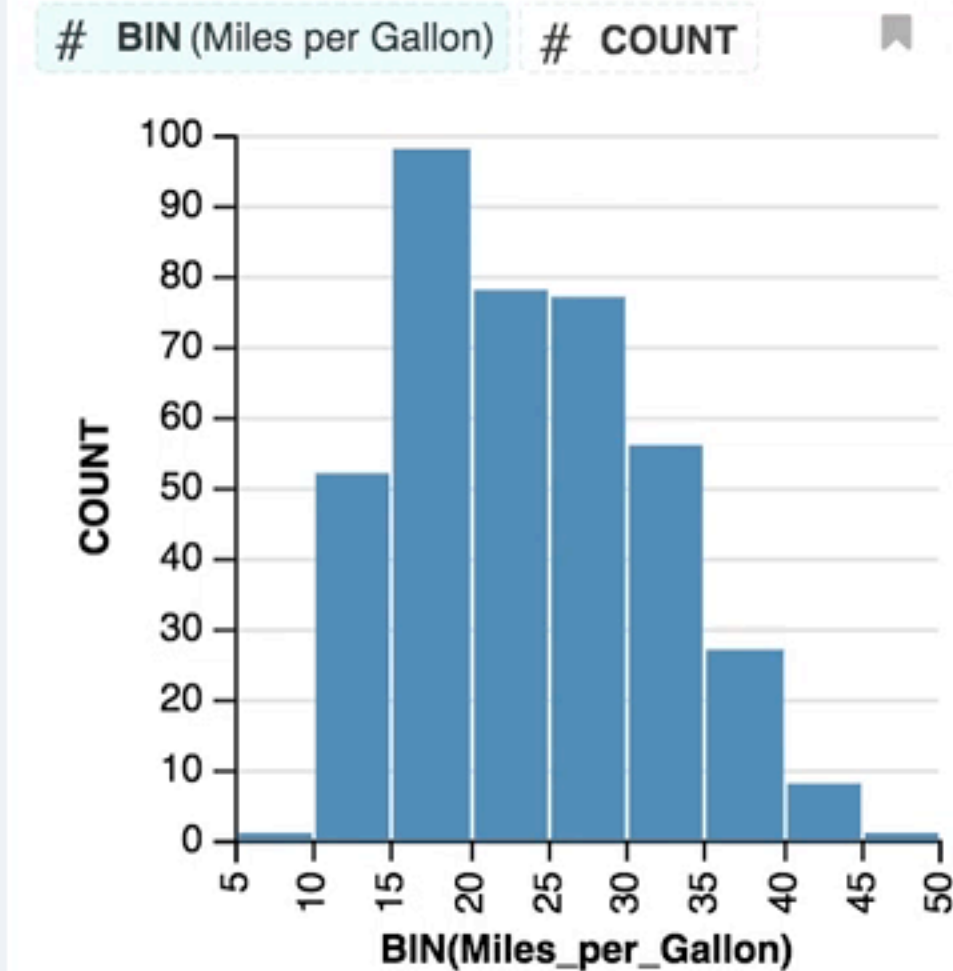
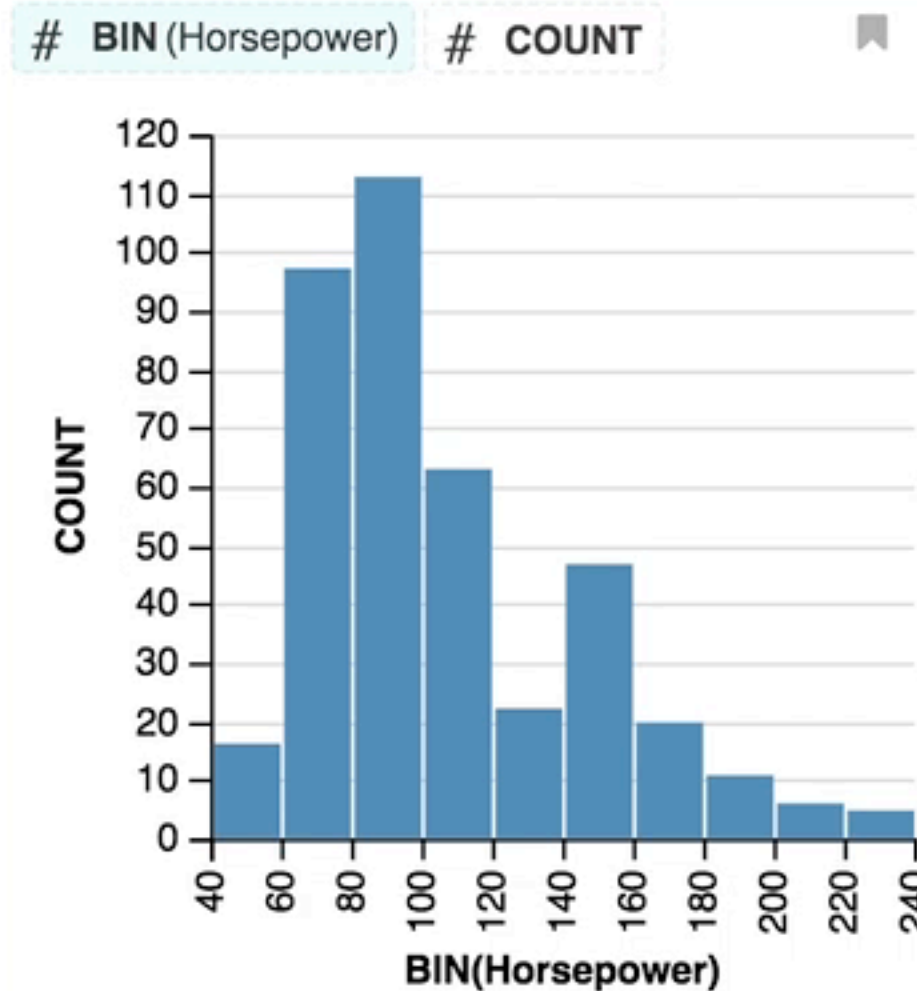
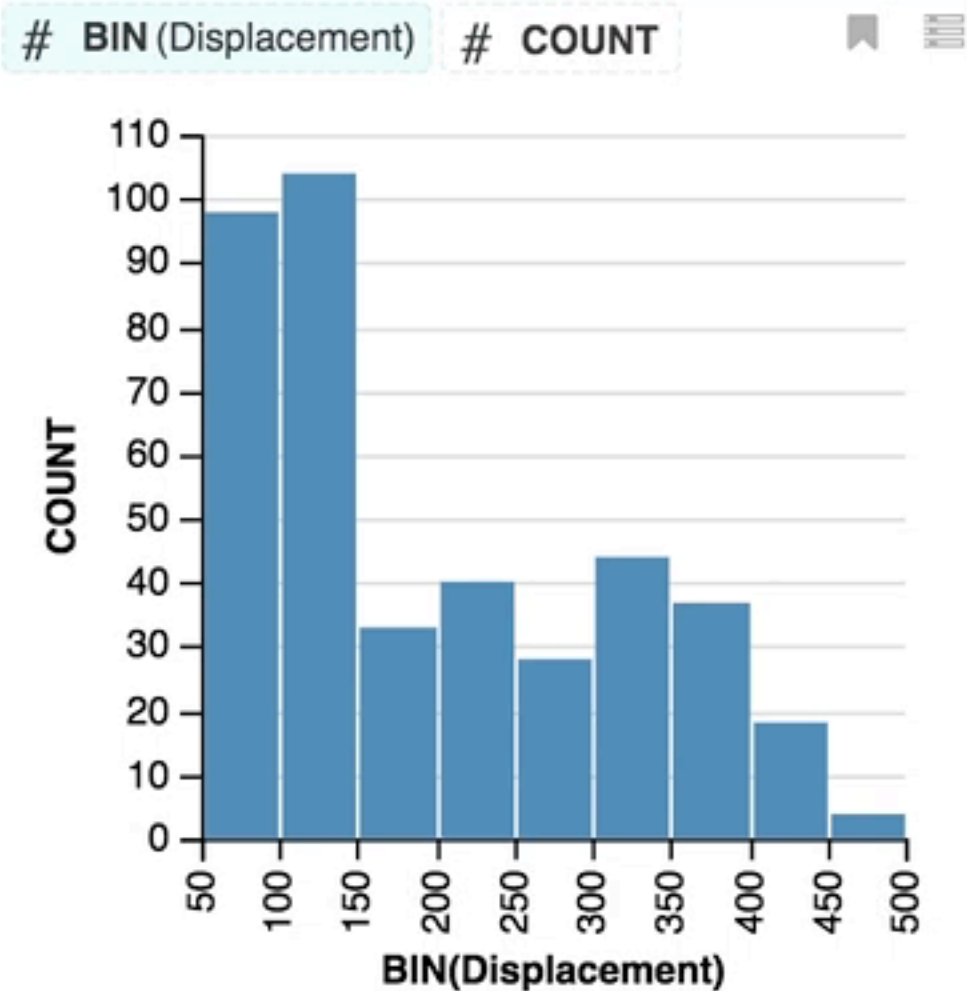
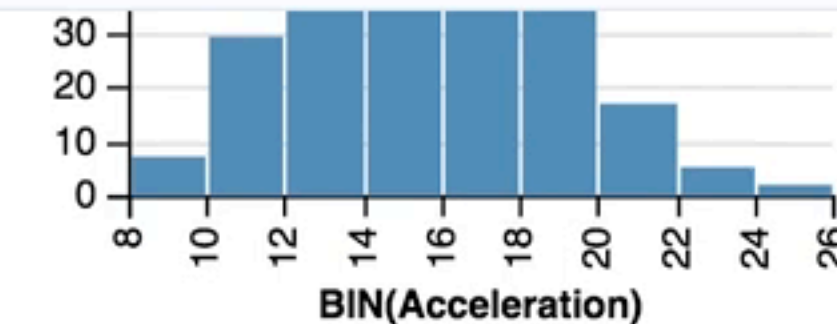
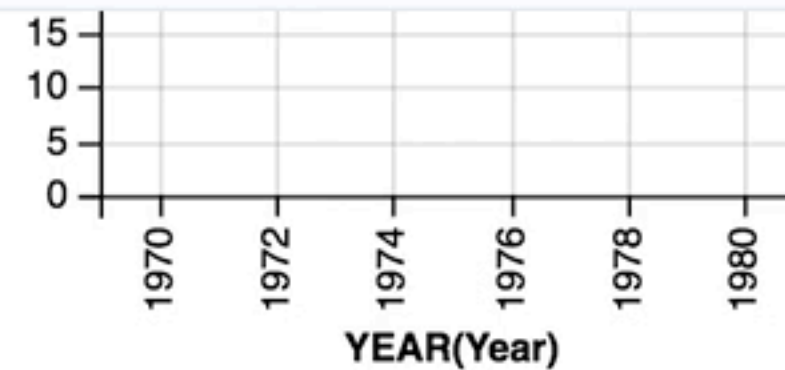
detail: drop a field here

text: drop a field here

any: drop a field here

Filter

Filter invalid numbers



# Wildcard Specification



Data

Cars Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

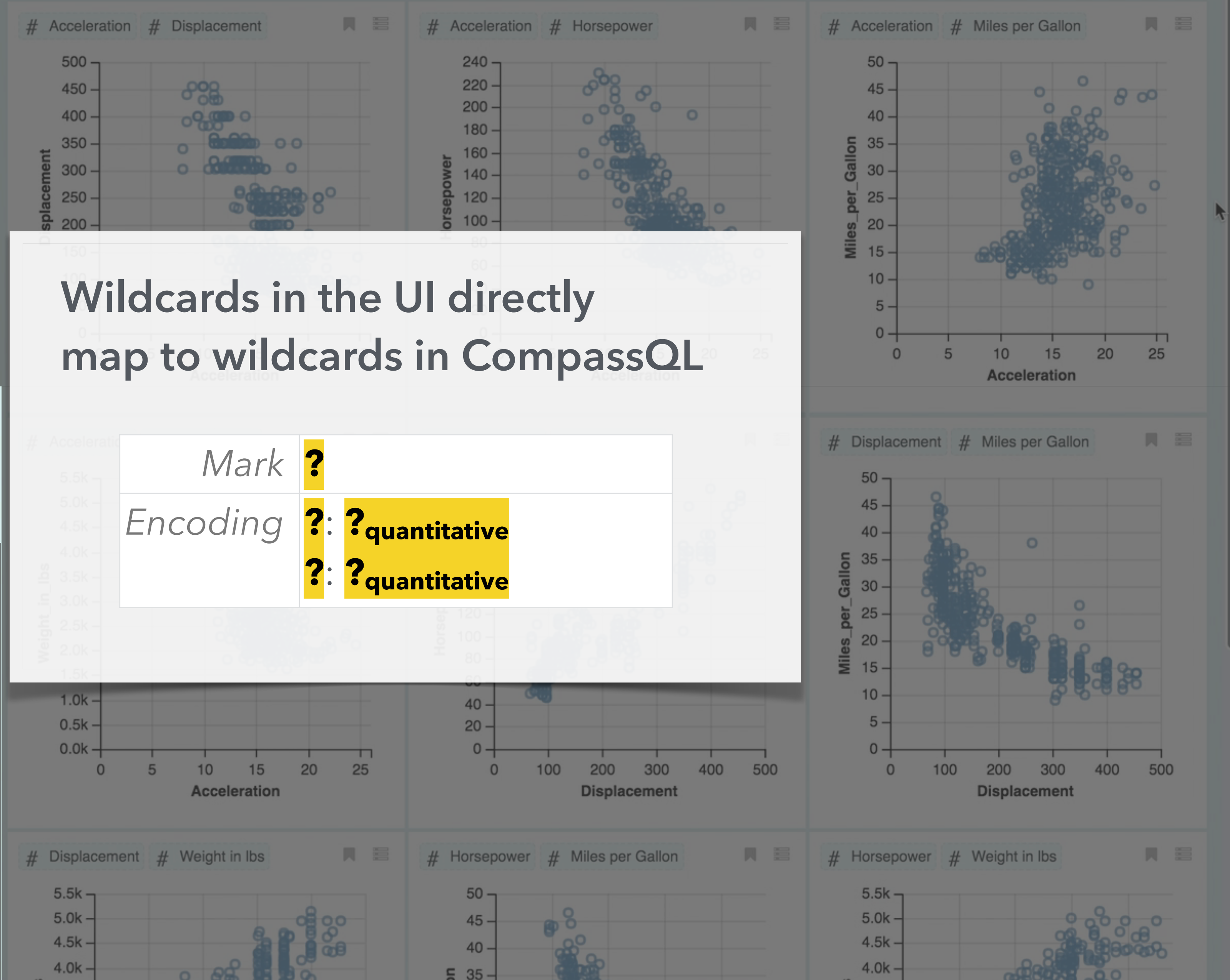
text: drop a field here

- any # Quantitative
- any # Quantitative
- any drop a field here

Filter: Filter invalid numbers

Specified Views

(Showing views with different fields) Auto-Add Count



## Wildcards in the UI directly map to wildcards in CompassQL

<i>Mark</i>	?
<i>Encoding</i>	?: ?quantitative
	?: ?quantitative

# Wildcard Specification



Data

Cars

Change

Fields

- A Cylinders
- A Name
- A Origin
- Year
- # Acceleration
- # Displacement
- # Horsepower
- # Miles per Gallon
- # Weight in lbs
- # COUNT

Wildcards

- A Categorical Fields
- Temporal Fields
- # Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks: auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

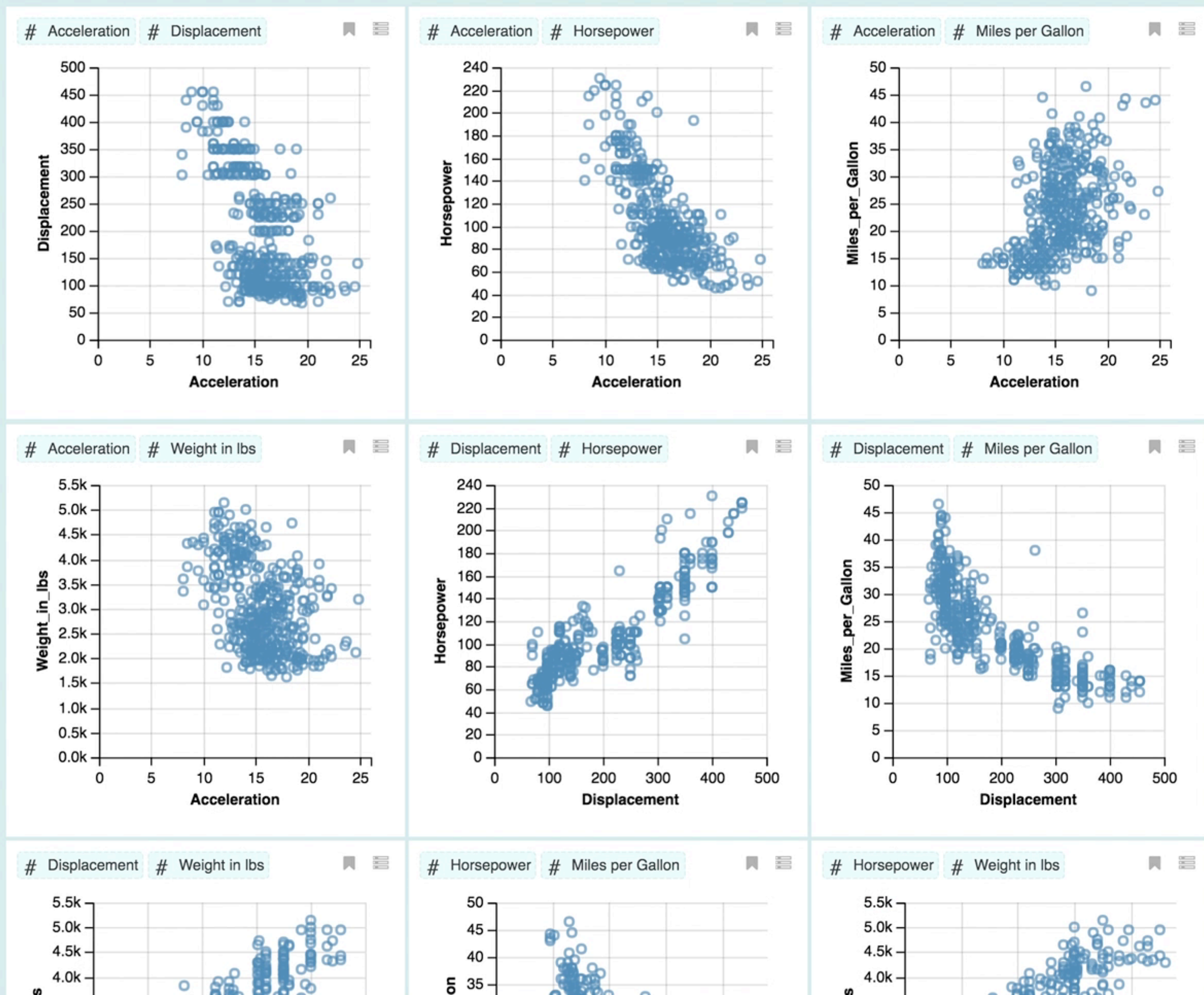
text: drop a field here

- any # Quantitative
- any # Quantitative
- any drop a field here

Filter: Filter invalid numbers

Specified Views

(Showing views with different fields) Auto-Add Count



Wildcard Specification



Data

Cars

Change

Fields

- Cylinders
  - Name
  - Origin
  - Year
  - Acceleration
  - Displacement
  - Horsepower
  - Miles per Gallon
  - Weight in lbs
  - COUNT
- Wildcards
- Categorical Fields
  - Temporal Fields
  - Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks

auto

size: drop a field here

color: drop a field here

shape: drop a field here

detail: drop a field here

text: drop a field here

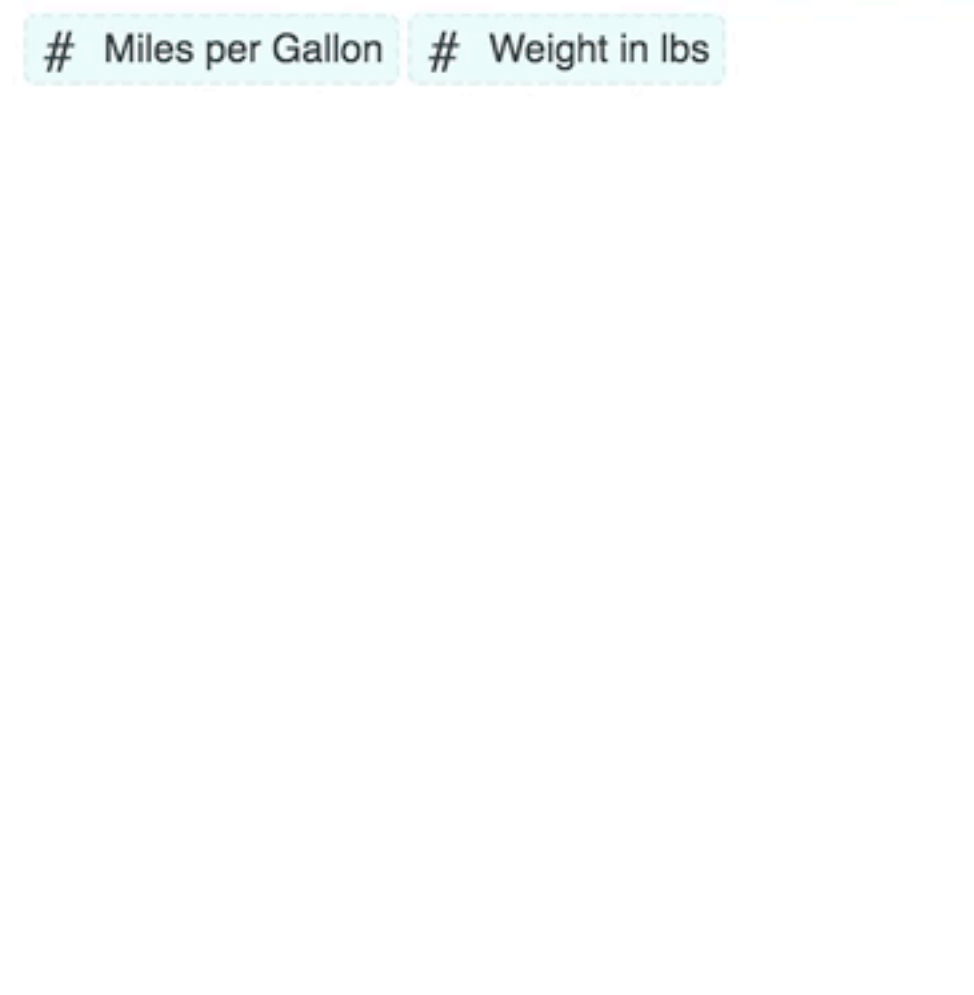
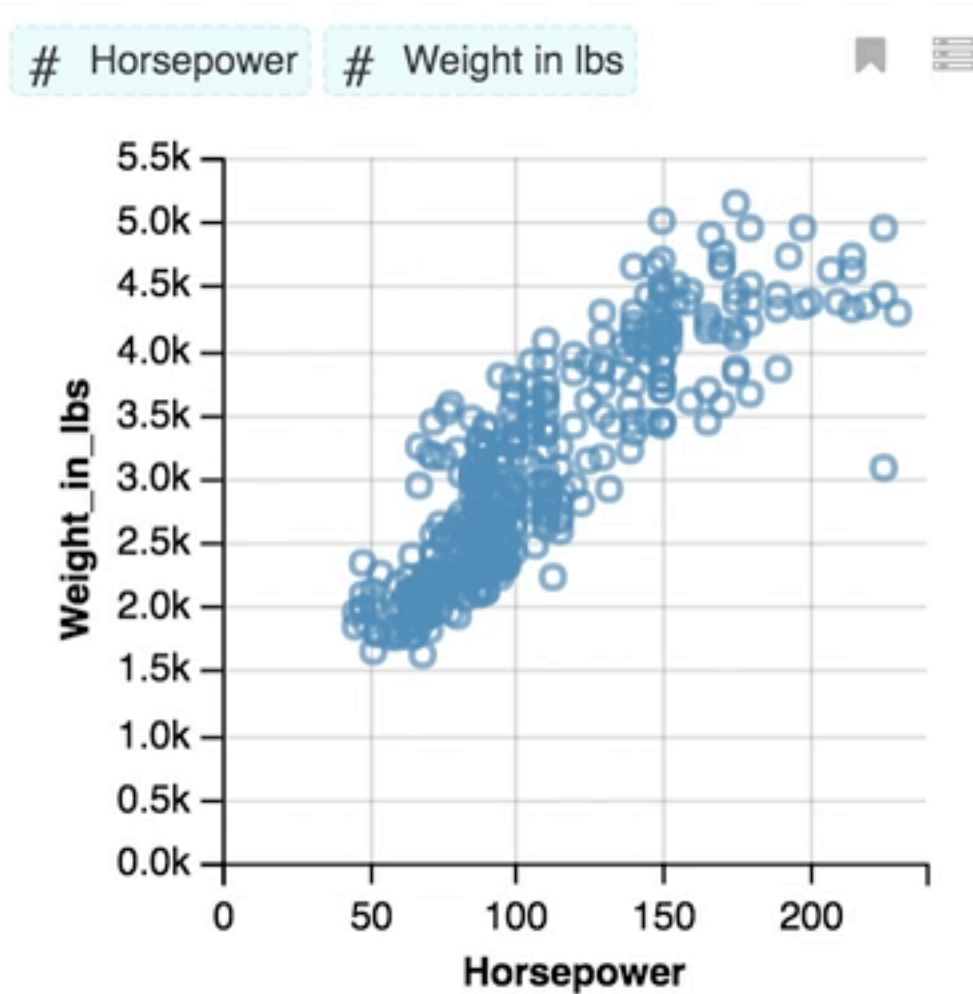
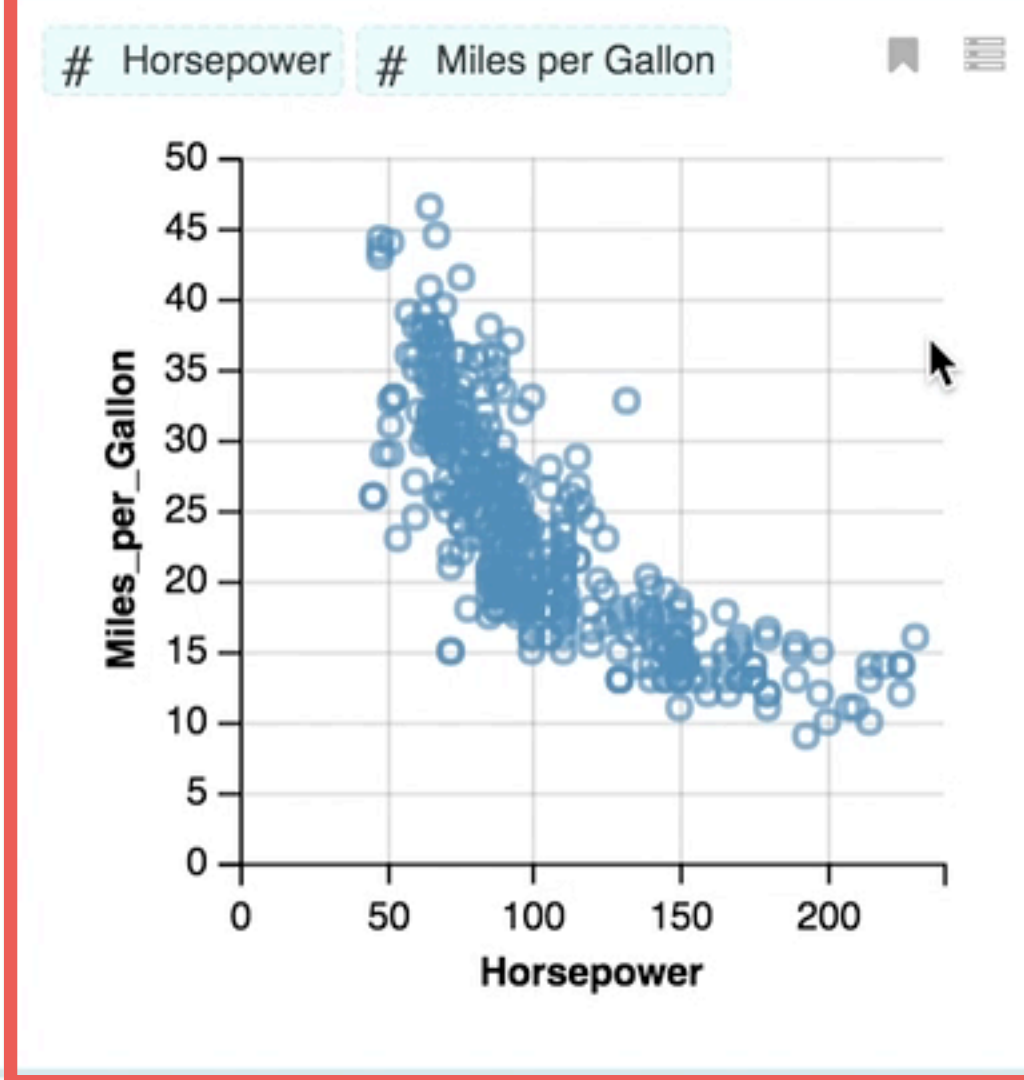
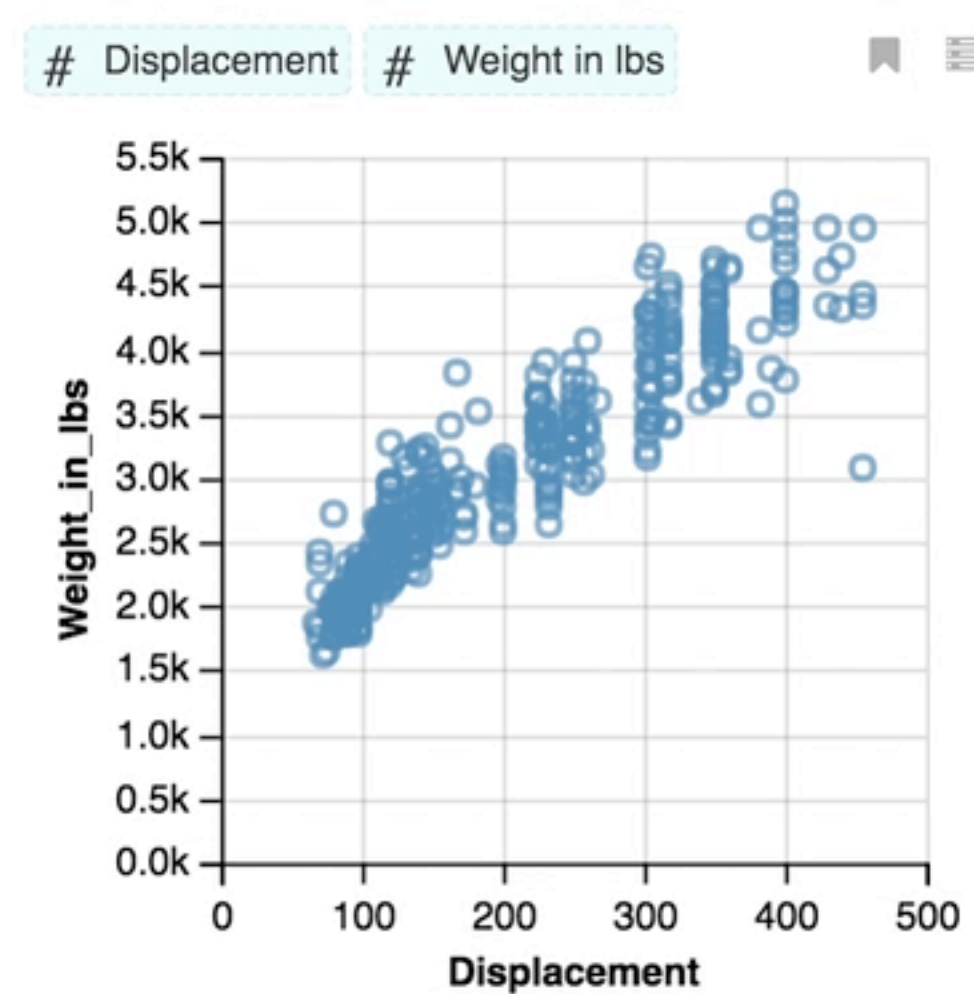
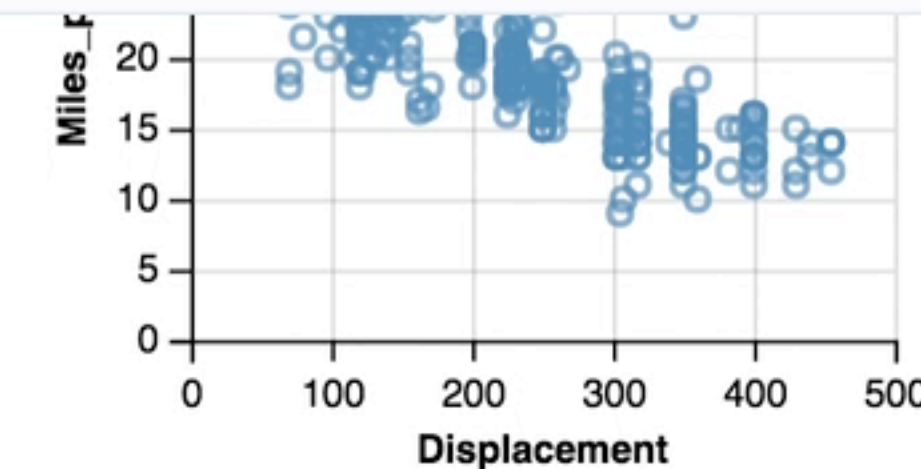
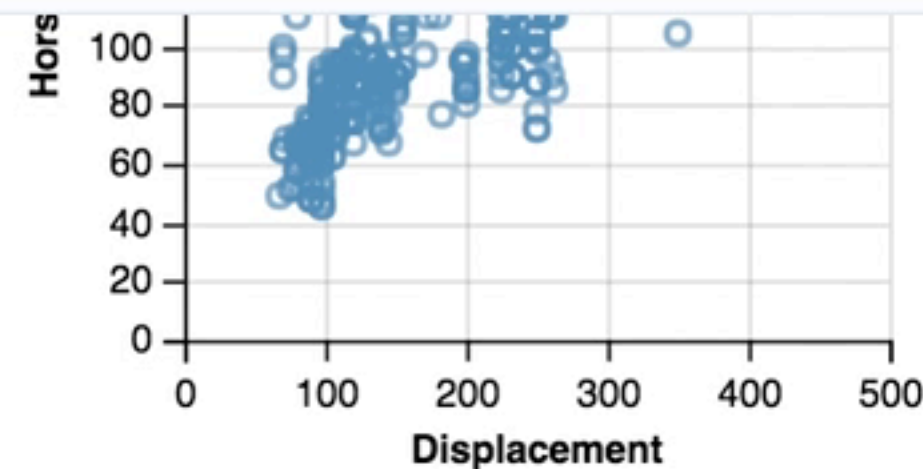
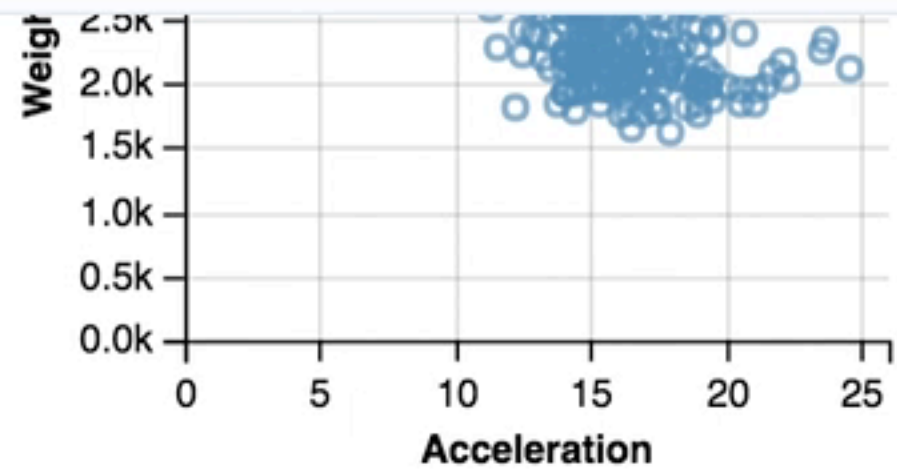
any: # Quantitative

any: # Quantitative

any: drop a field here

Filter

Filter invalid numbers



# Wildcard Specification





Data

Cars

Change

Fields

- A Cylinders
- A Name
- A Origin
- Year
- # Acceleration
- # Displacement
- # Horsepower
- # Miles per Gallon
- # Weight in lbs
- # COUNT

Wildcards

- A Categorical Fields
- Temporal Fields
- # Quantitative Fields

Encoding

Clear

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks

auto

size: drop a field here

color: drop a field here

shape: drop a field here

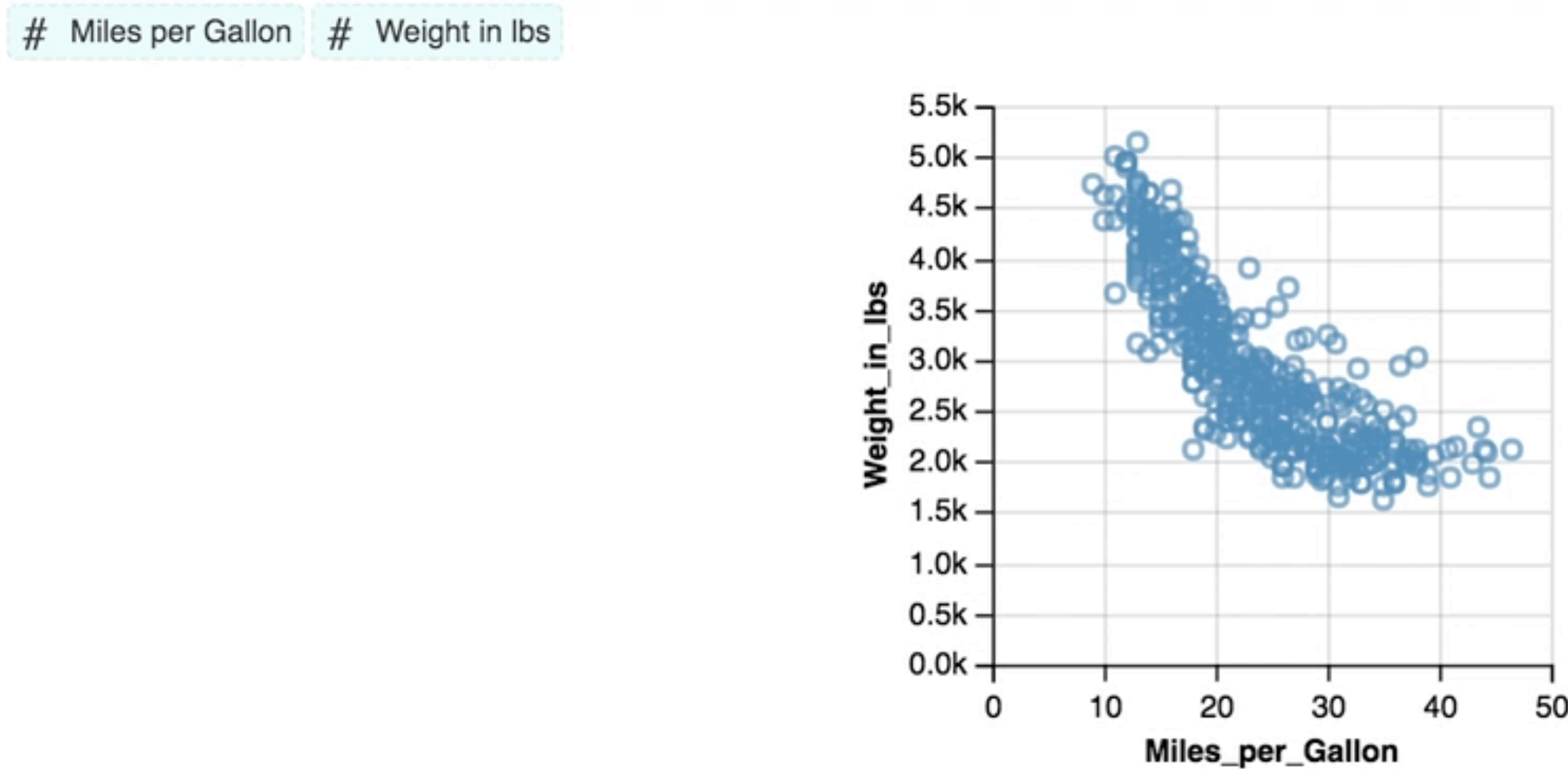
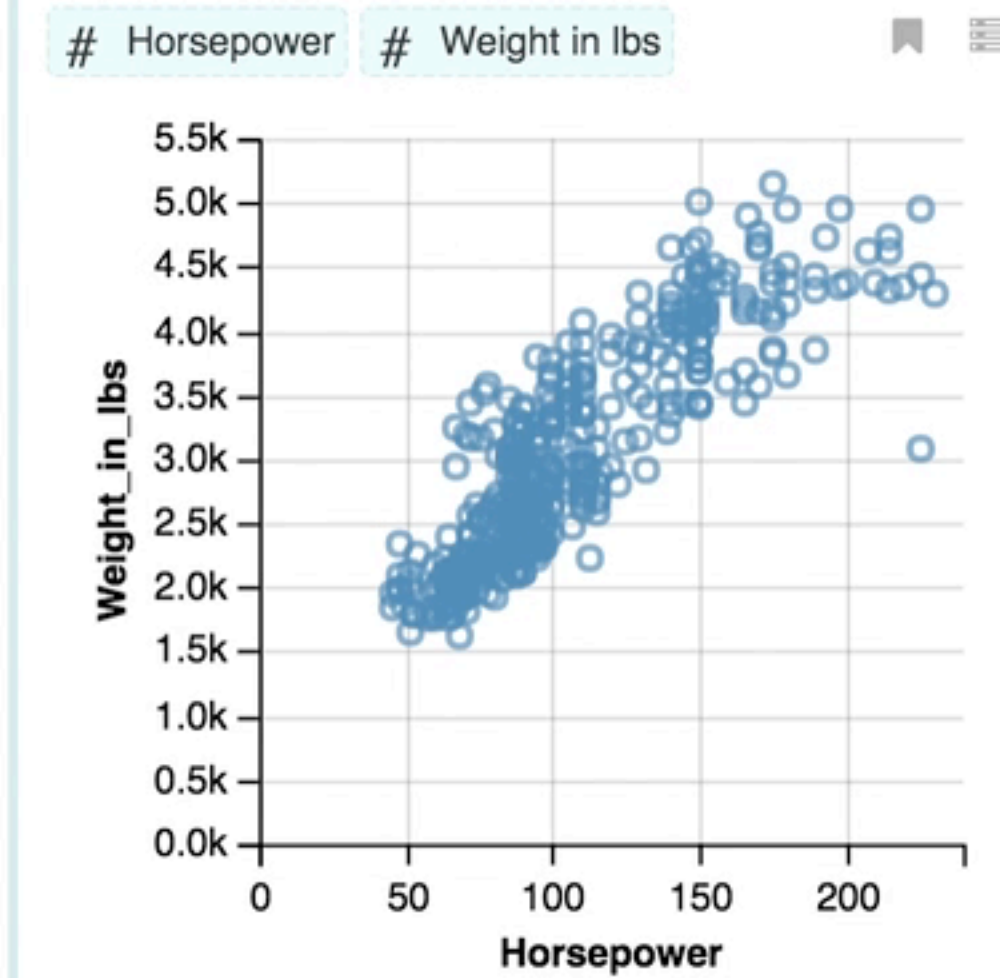
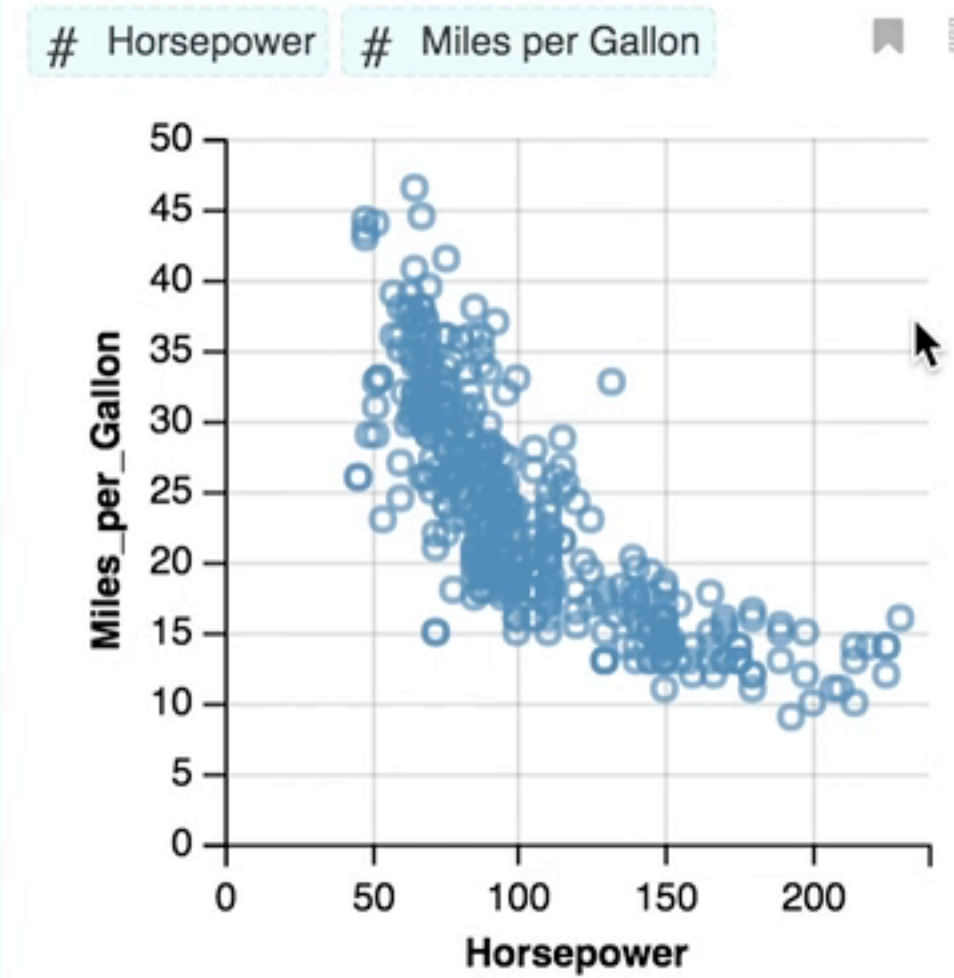
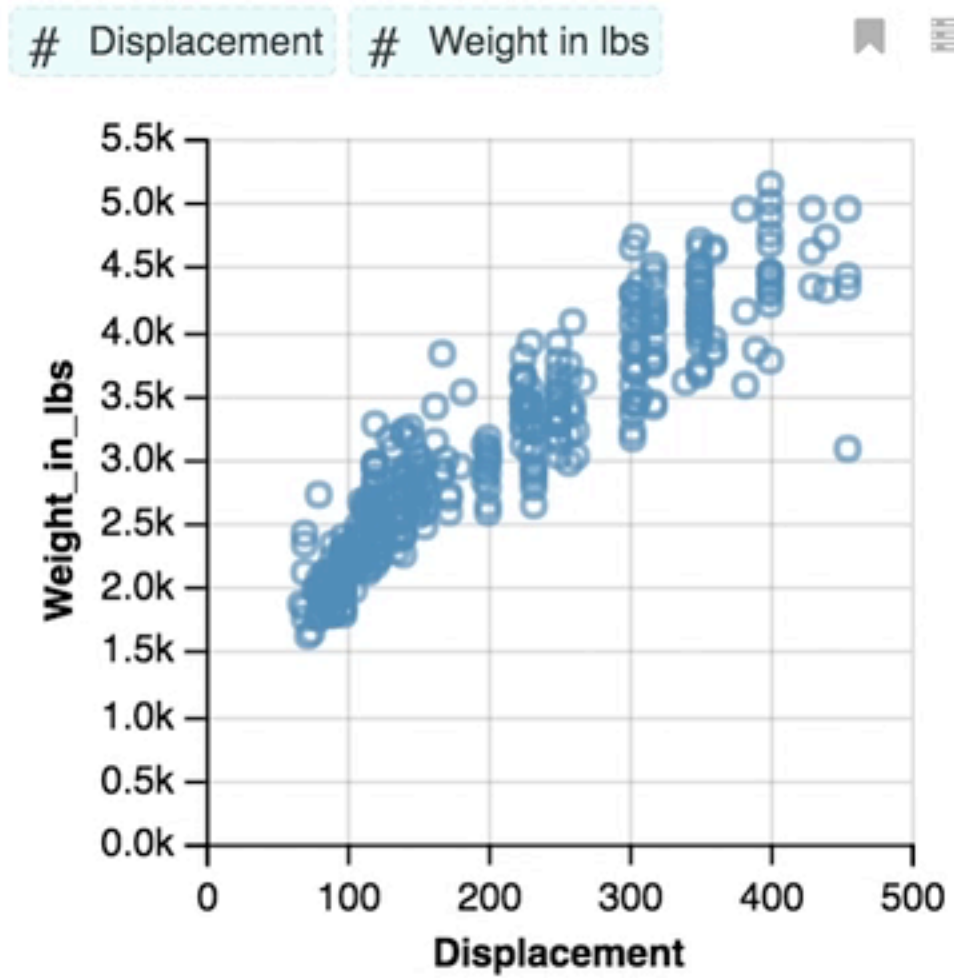
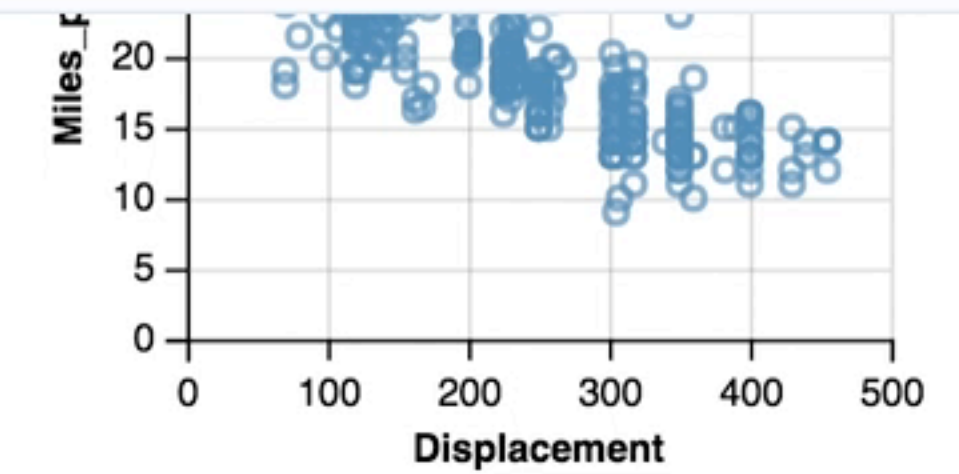
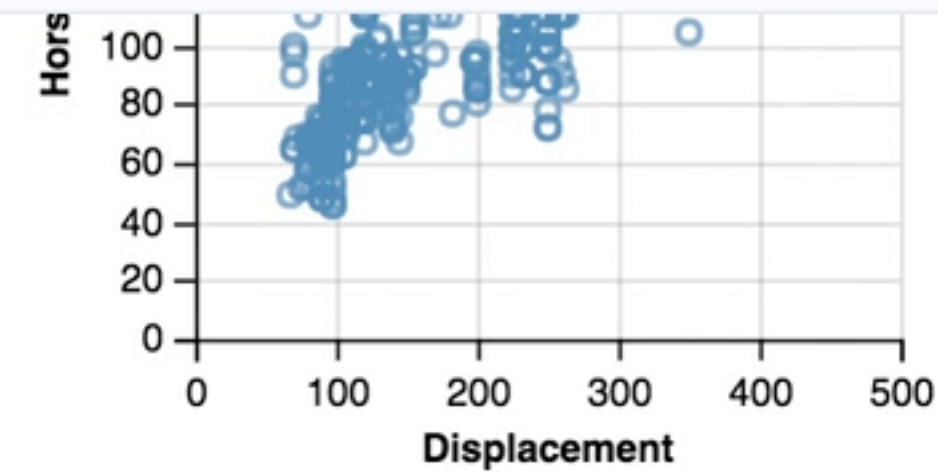
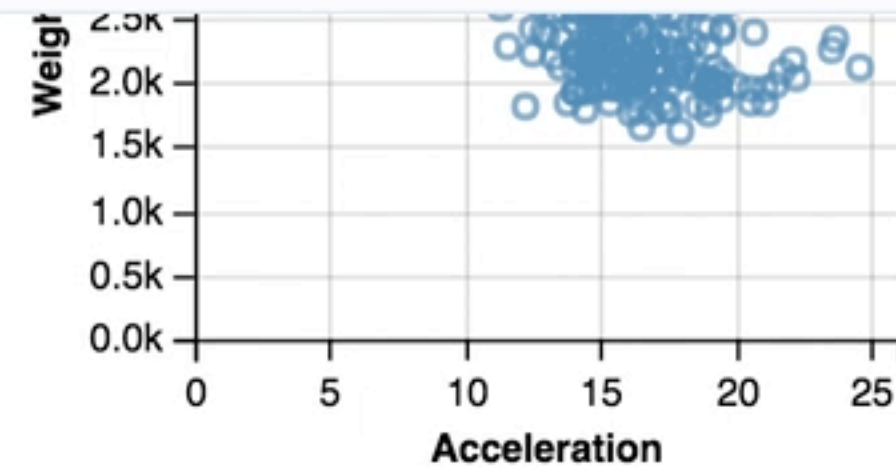
detail: drop a field here

text: drop a field here

- any # Quantitative
- any # Quantitative
- any drop a field here

Filter

Filter invalid numbers



# Wildcard Specification



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

x: drop a field here

y: drop a field here

column: drop a field here

row: drop a field here

Marks

size: drop a field here

color: drop a field here

shape: drop a field here

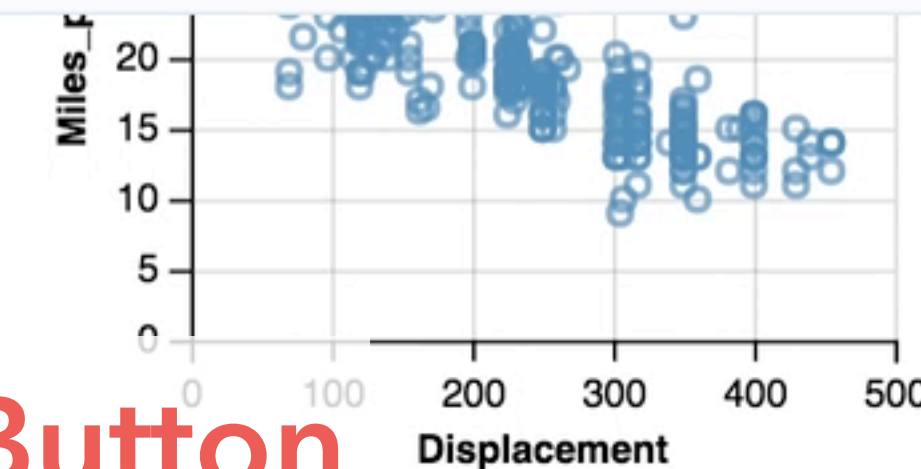
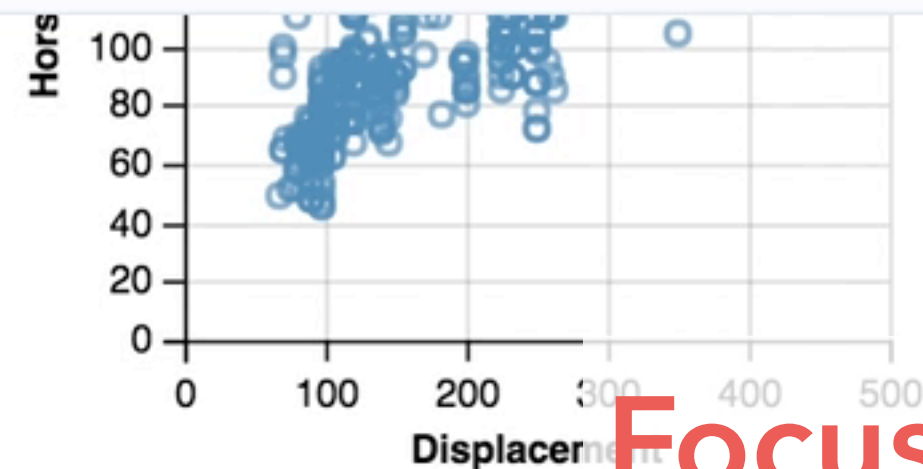
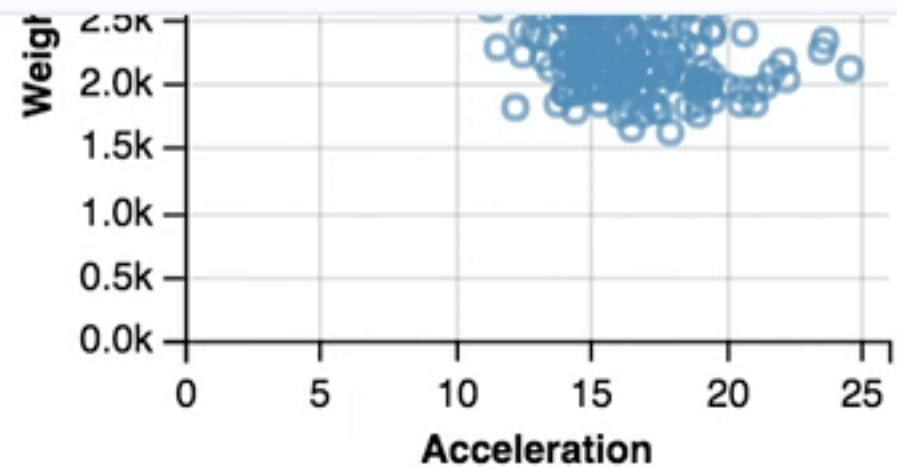
detail: drop a field here

text: drop a field here

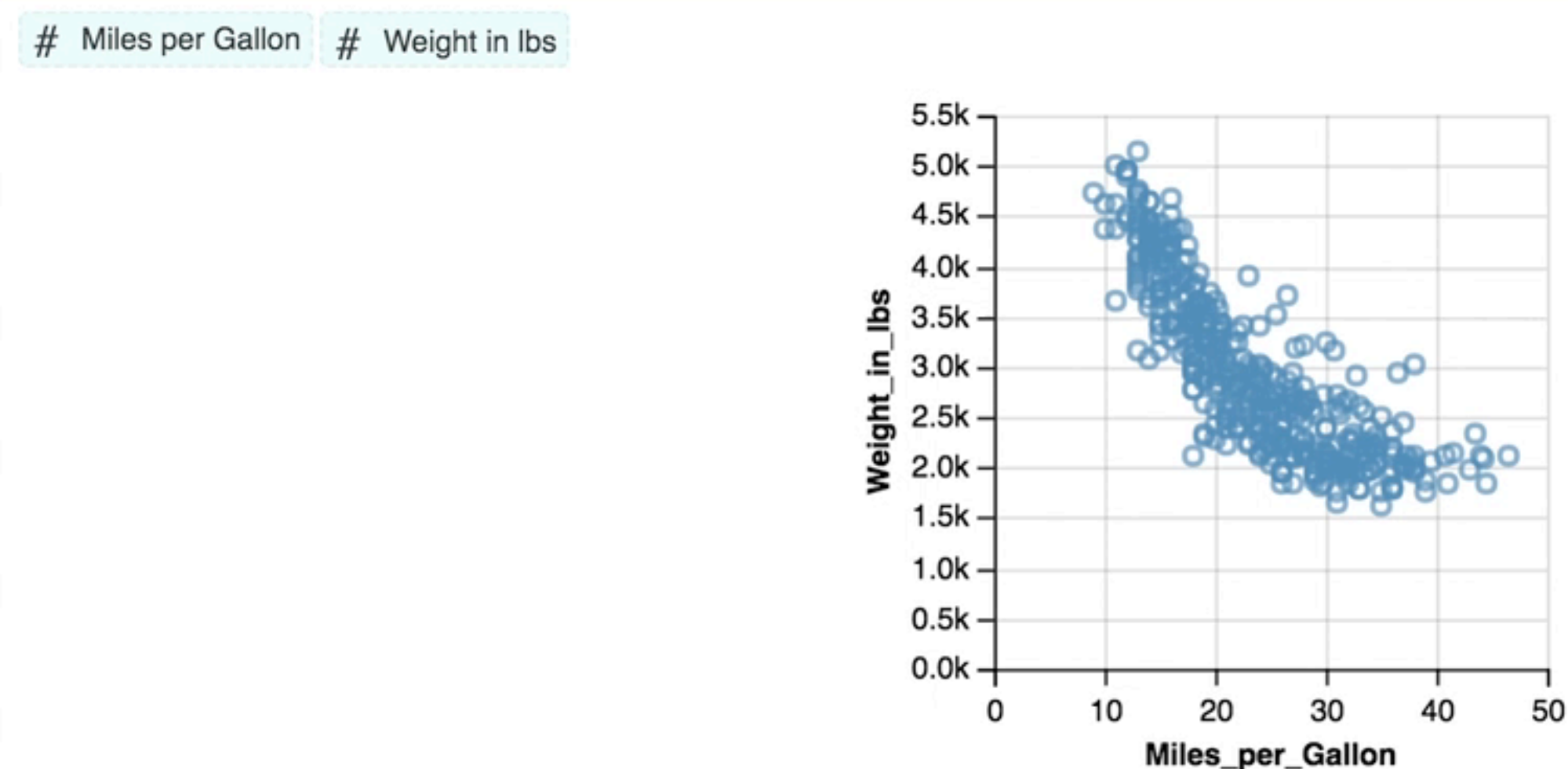
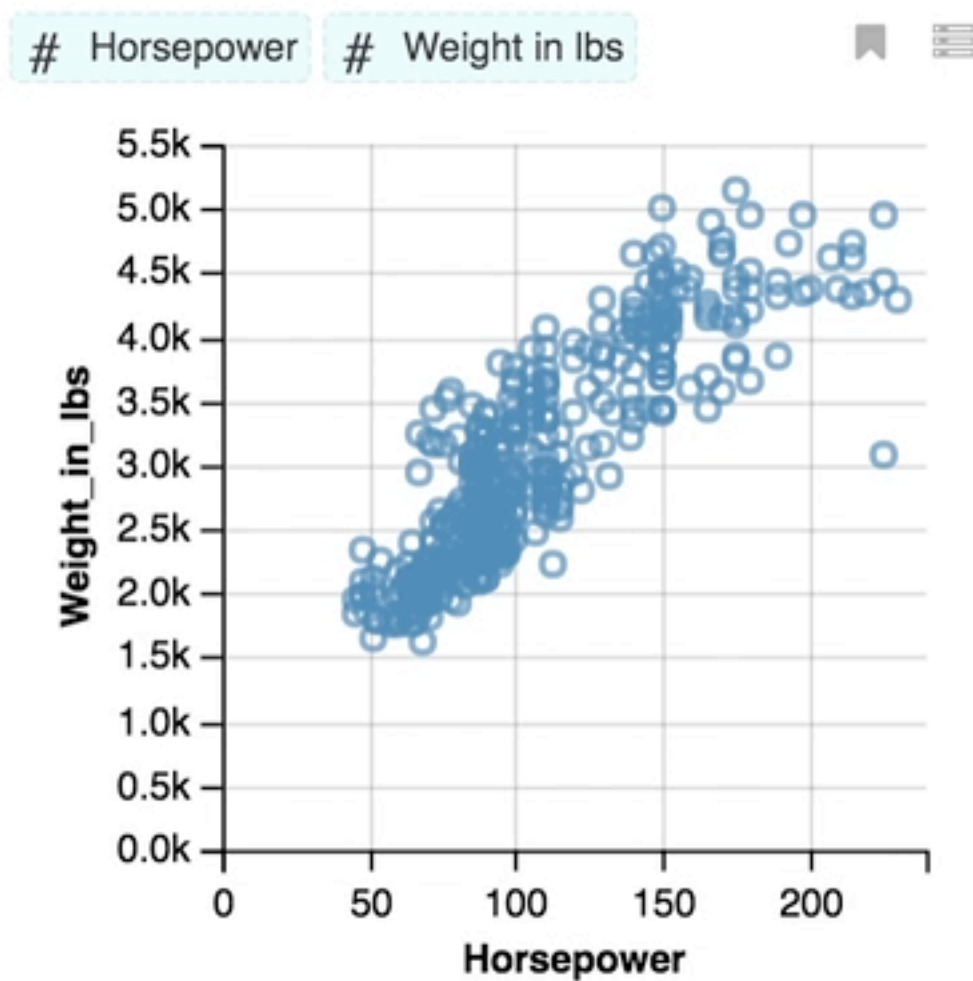
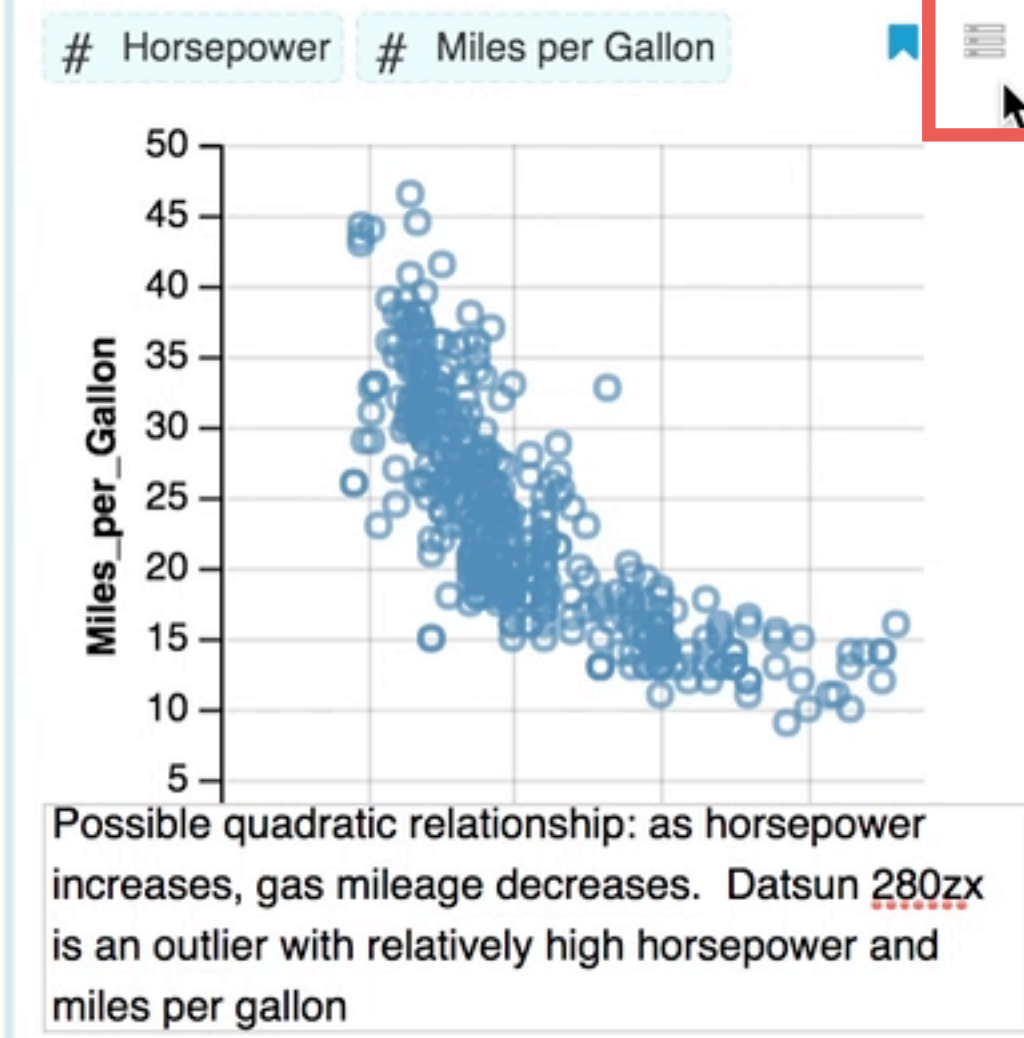
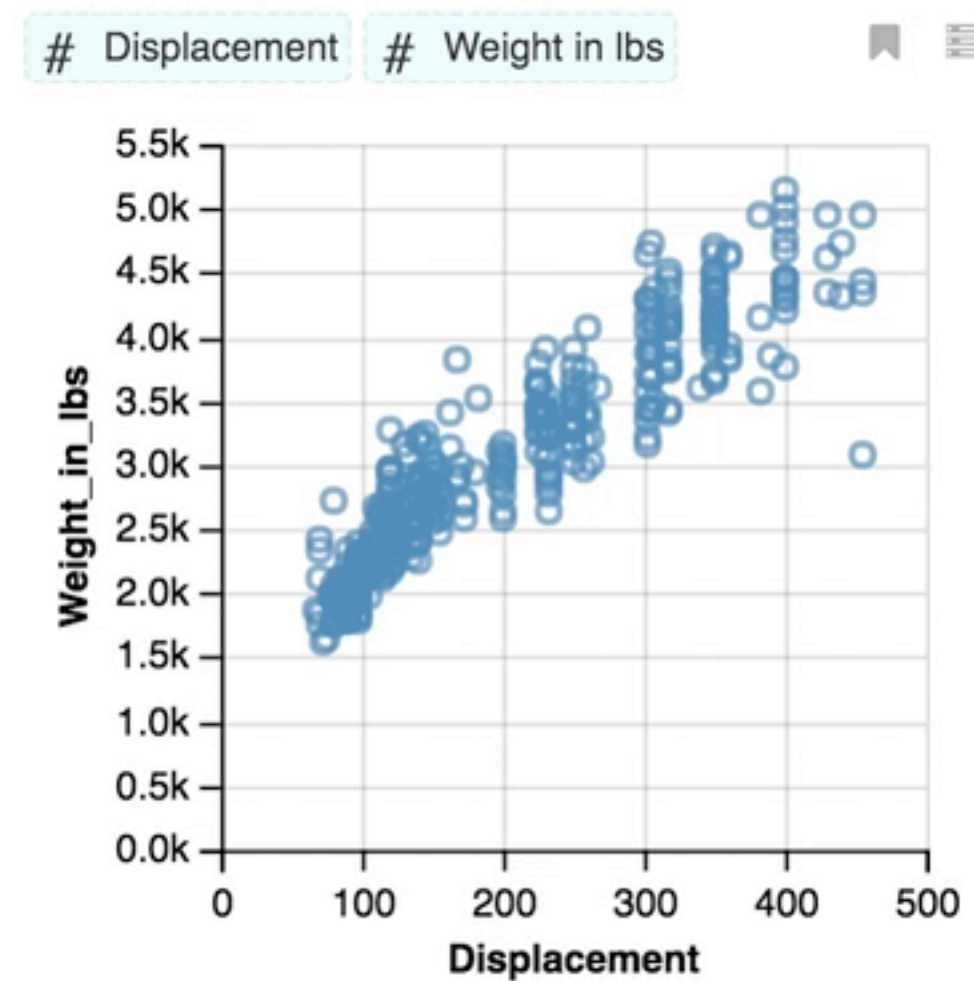
any # Quantitative

any # Quantitative

any drop a field here



Focus Button



Choose New Focus



Data

Cars

Change

Fields

Cylinders

Name

Origin

Year

Acceleration

Displacement

Horsepower

Miles per Gallon

Weight in lbs

COUNT

Wildcards

Categorical Fields

Temporal Fields

Quantitative Fields

Encoding

Clear

x # Horsepower

y # Miles per Gallon

column drop a field here

row drop a field here

Marks

point

size drop a field here

color drop a field here

shape drop a field here

detail drop a field here

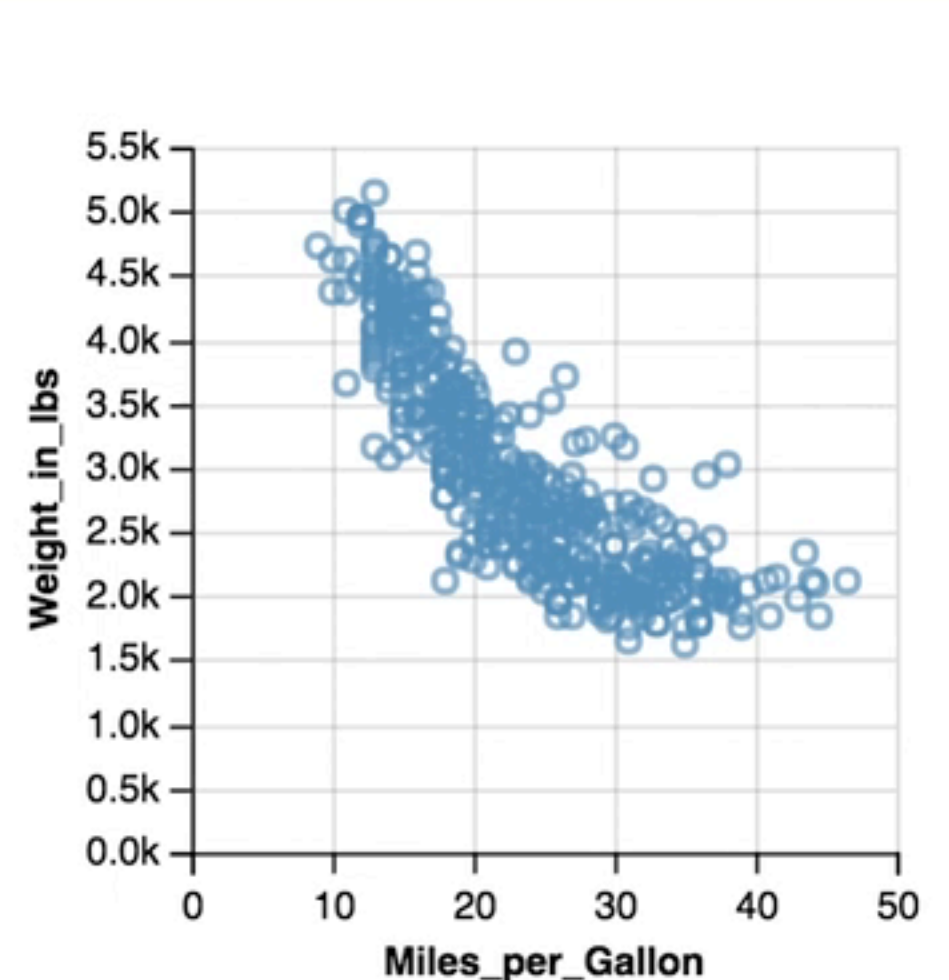
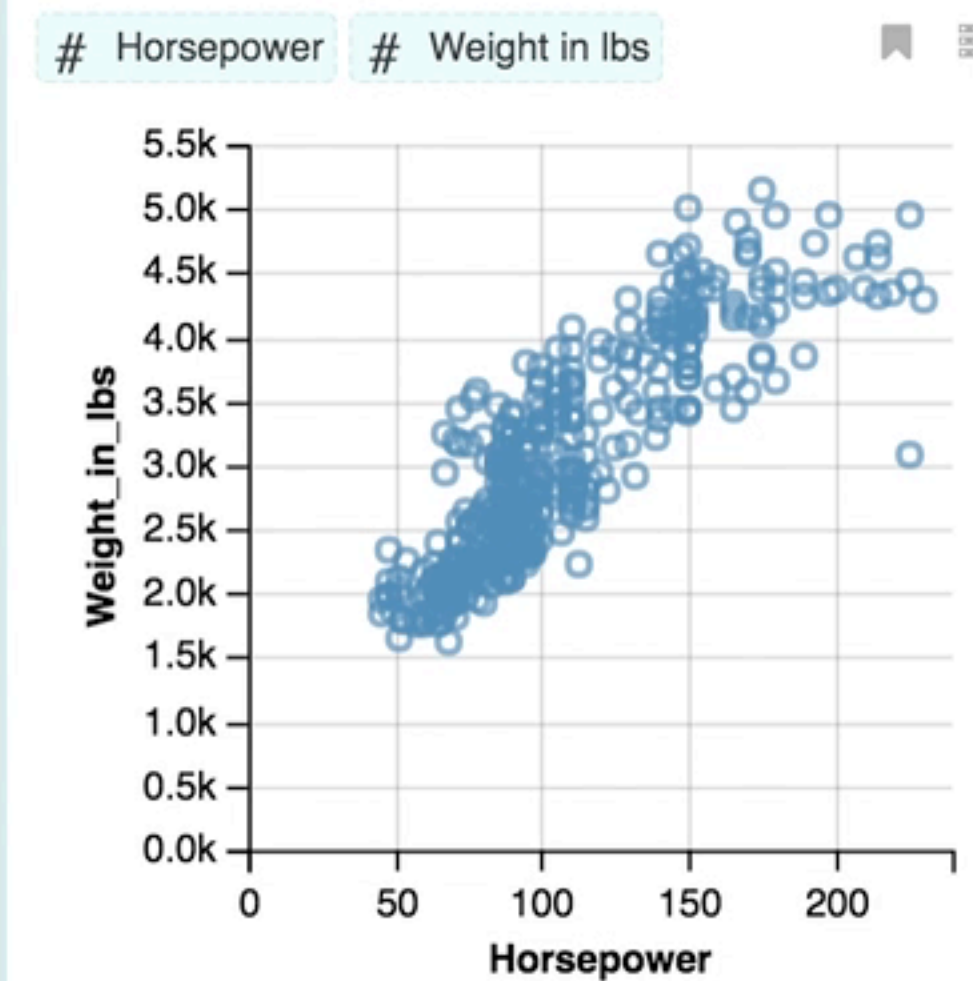
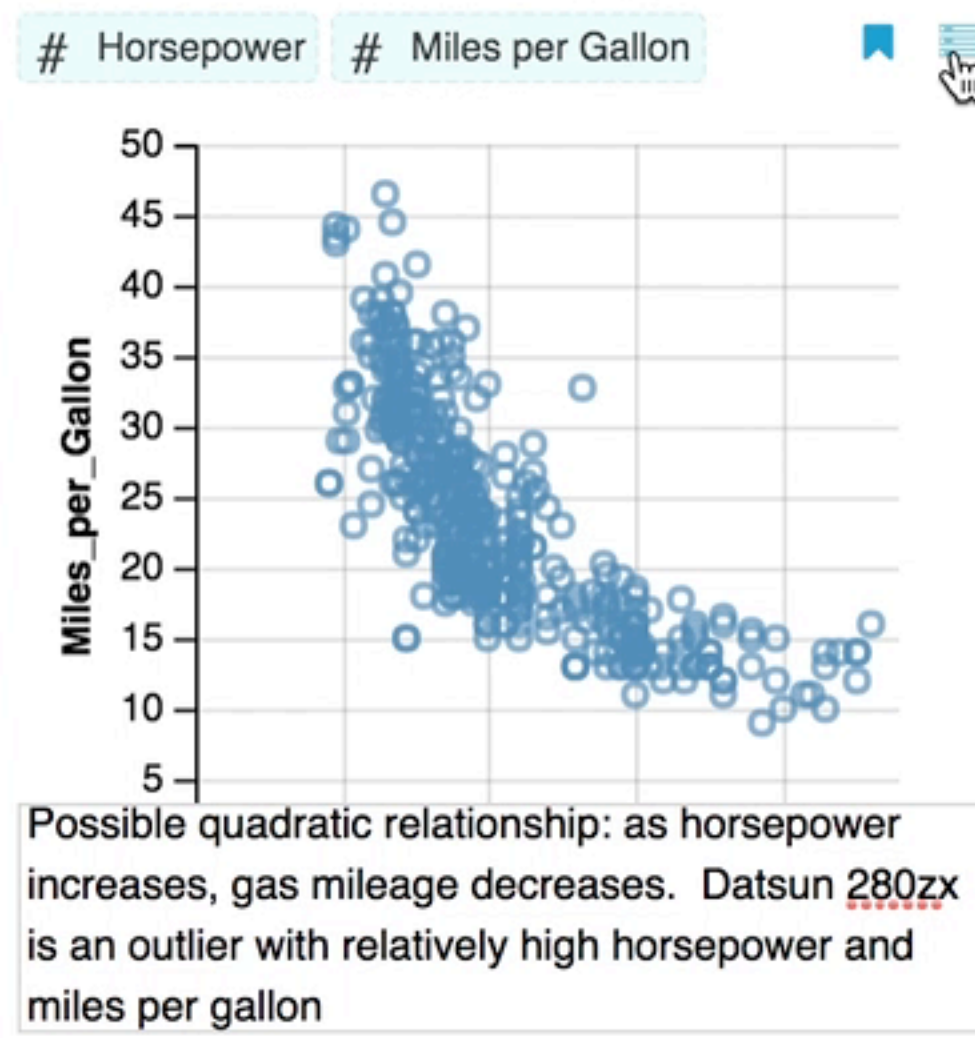
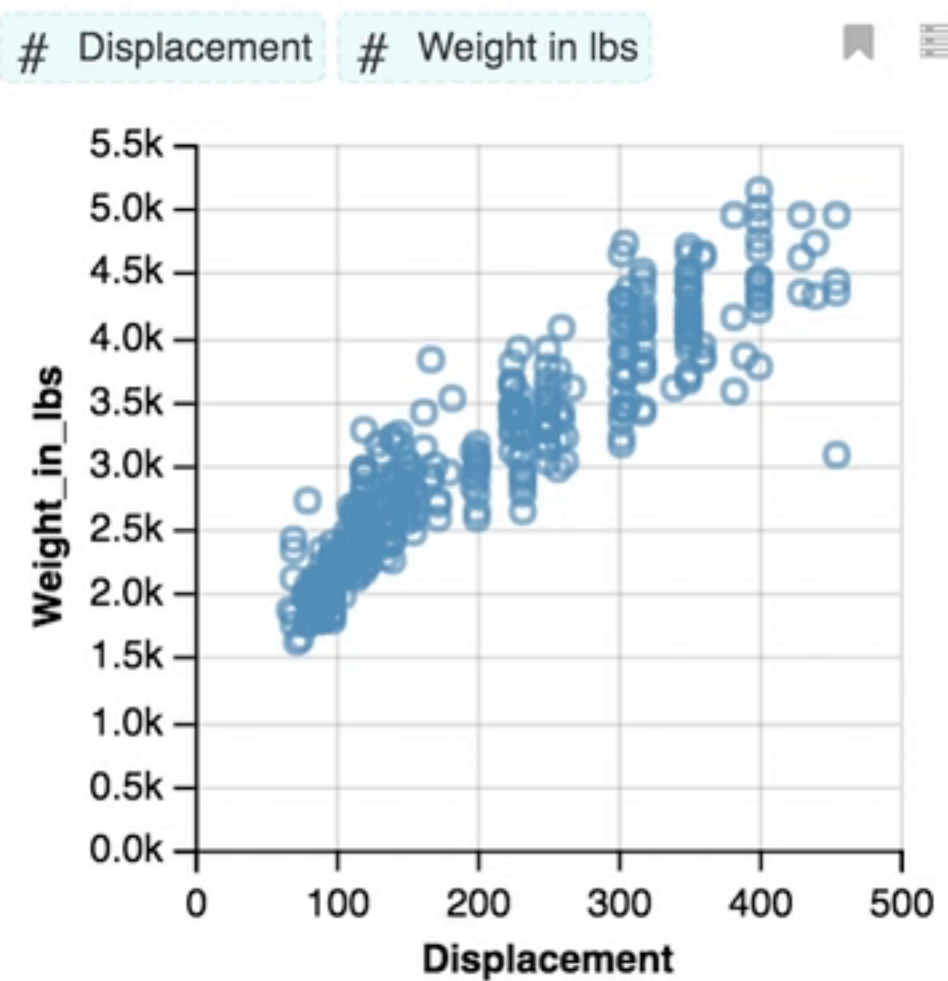
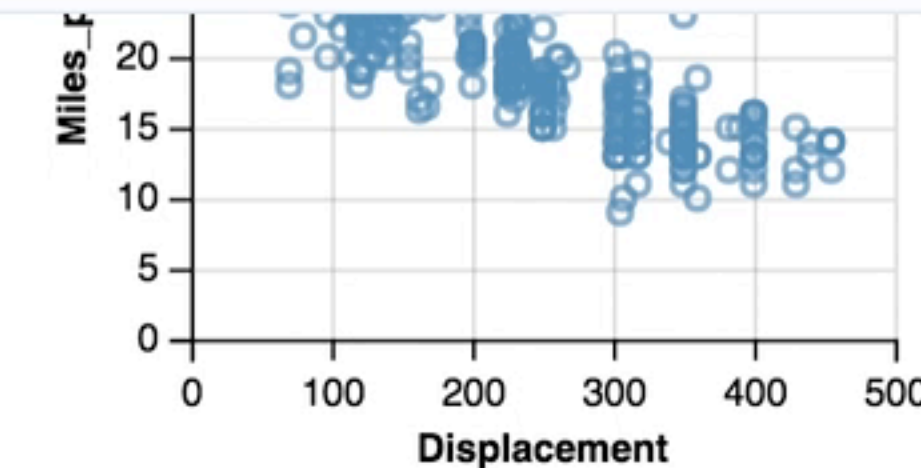
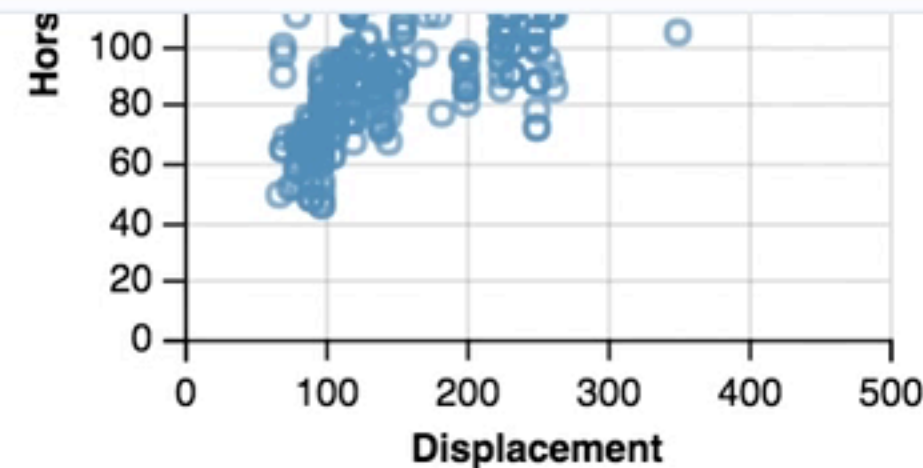
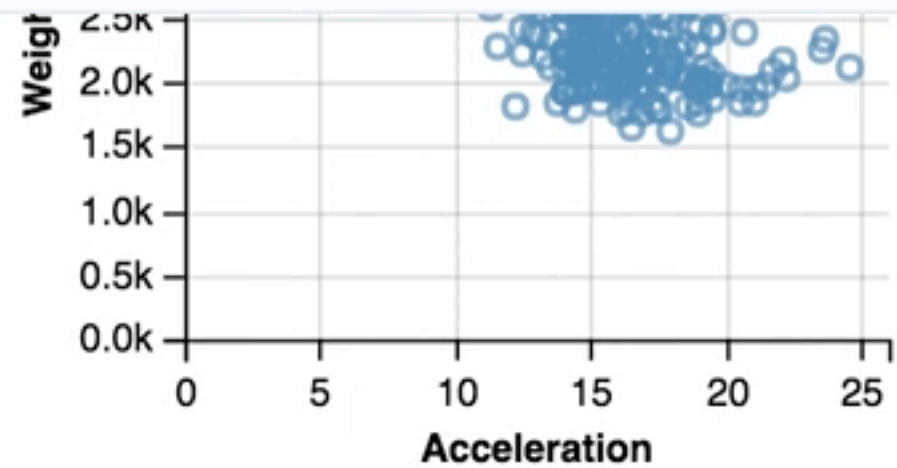
text drop a field here

any drop a field here

any # Quantitative

any drop a field here

Filter Filter invalid numbers



Choose New Focus



Data

Cars

Change

Fields

- Cylinders
  - Name
  - Origin
  - Year
  - Acceleration
  - Displacement
  - Horsepower
  - Miles per Gallon
  - Weight in lbs
  - COUNT
- Wildcards
- Categorical Fields
  - Temporal Fields
  - Quantitative Fields

Encoding

Clear

x # Horsepower

y # Miles per Gallon

column drop a field here

row drop a field here

Marks

point

size drop a field here

color drop a field here

shape drop a field here

detail drop a field here

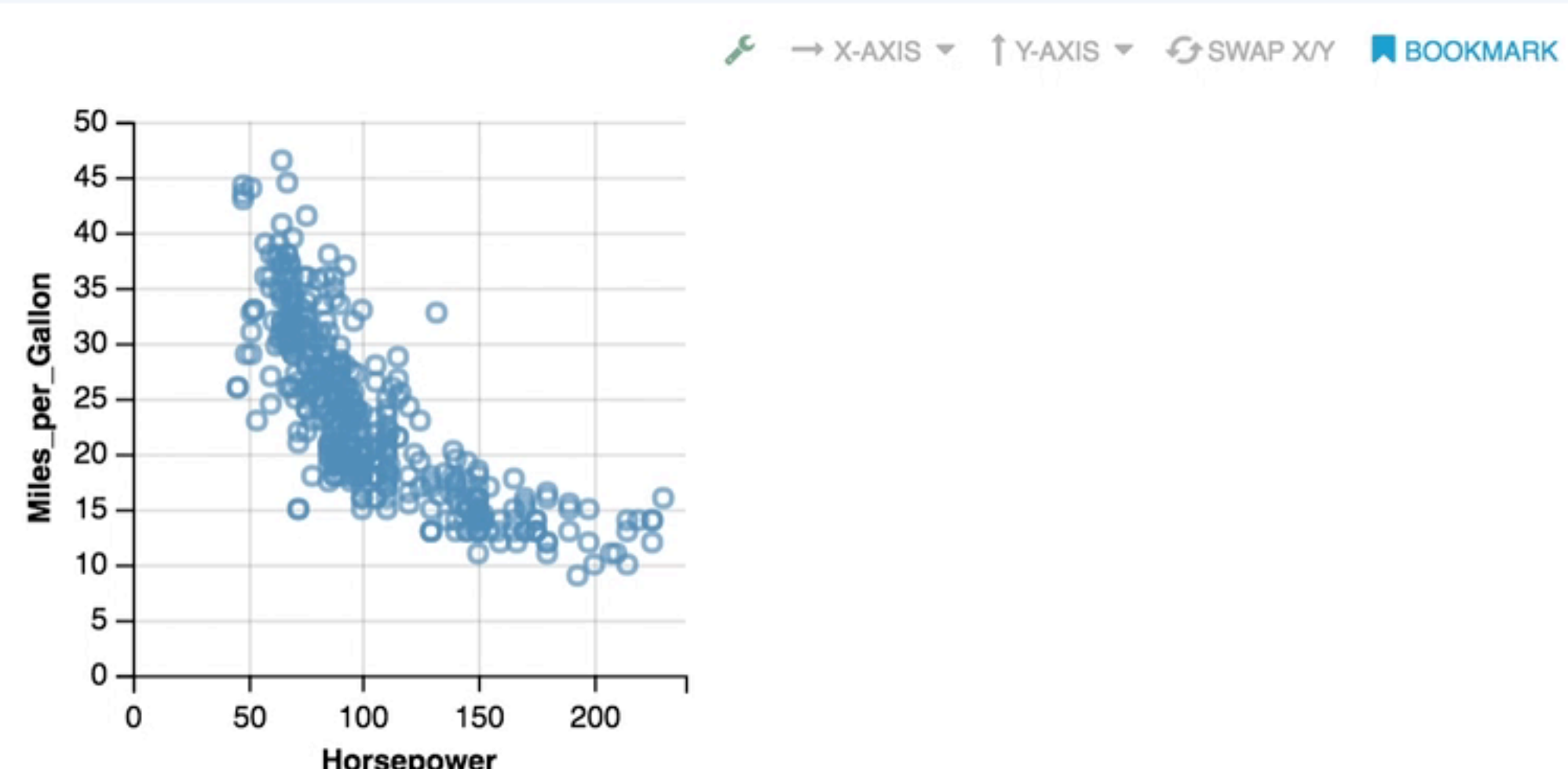
text drop a field here

any drop a field here

Filter

Filter invalid numbers

Specified View



Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

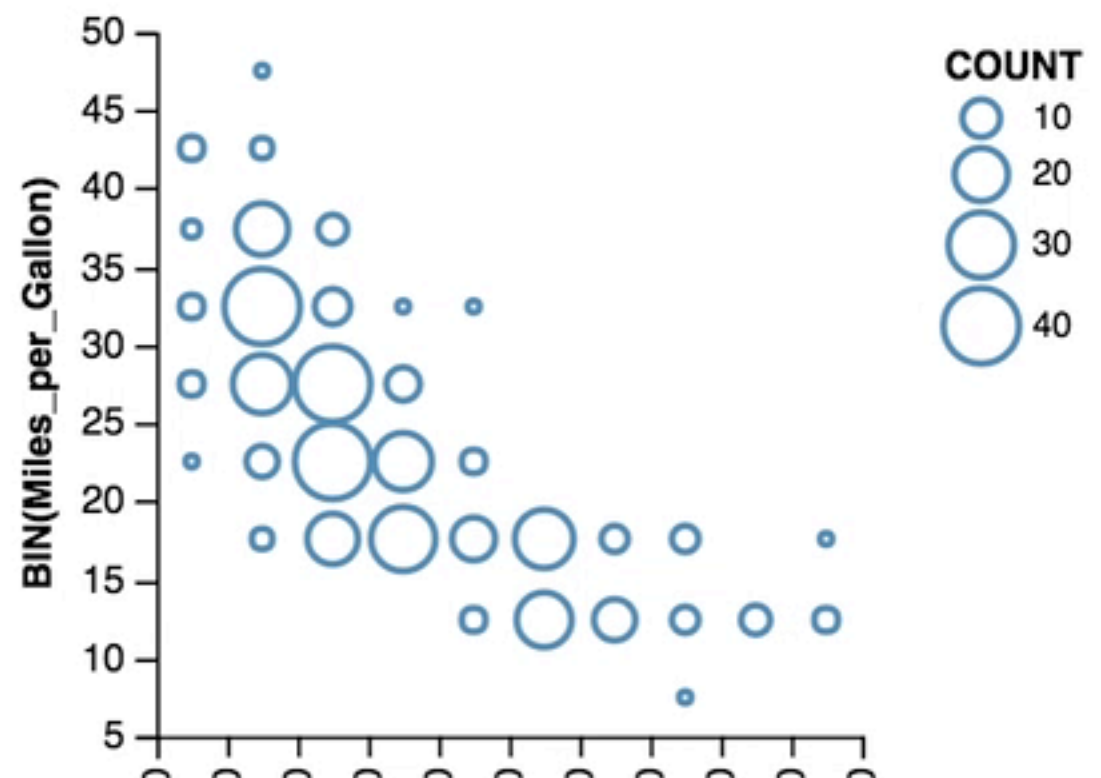
Choose New Focus

Related Views

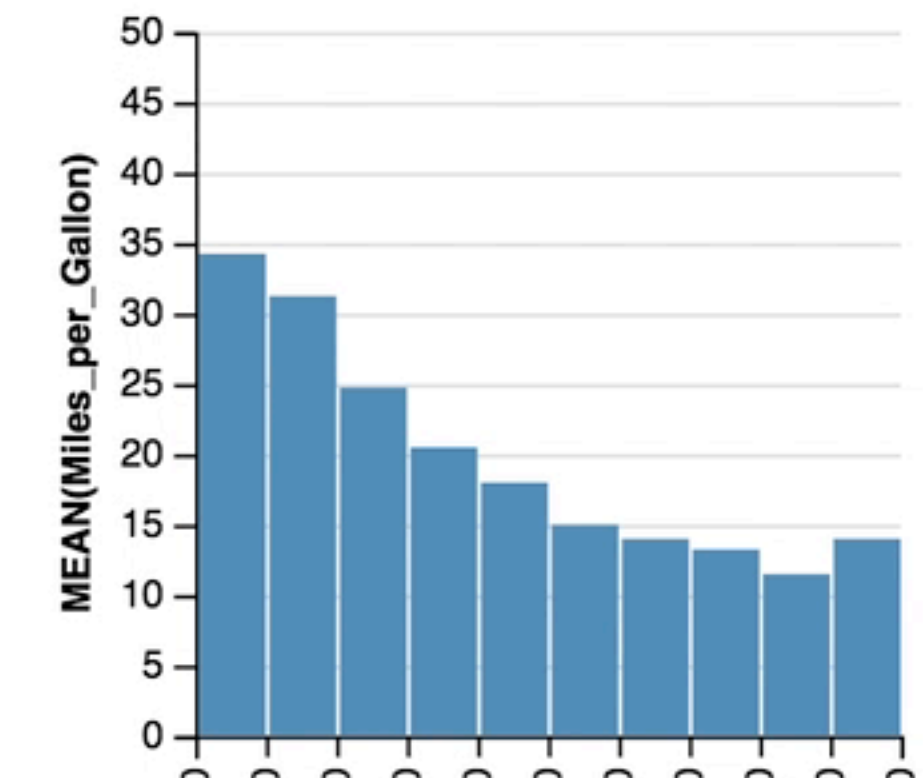
All Summaries Add Categorical Field Add Quantitative Field Hide

Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)





Data

Cars Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x # Horsepower

y # Miles per Gallon

column drop a field here

row drop a field here

Marks point

size drop a field here

color drop a field here

shape drop a field here

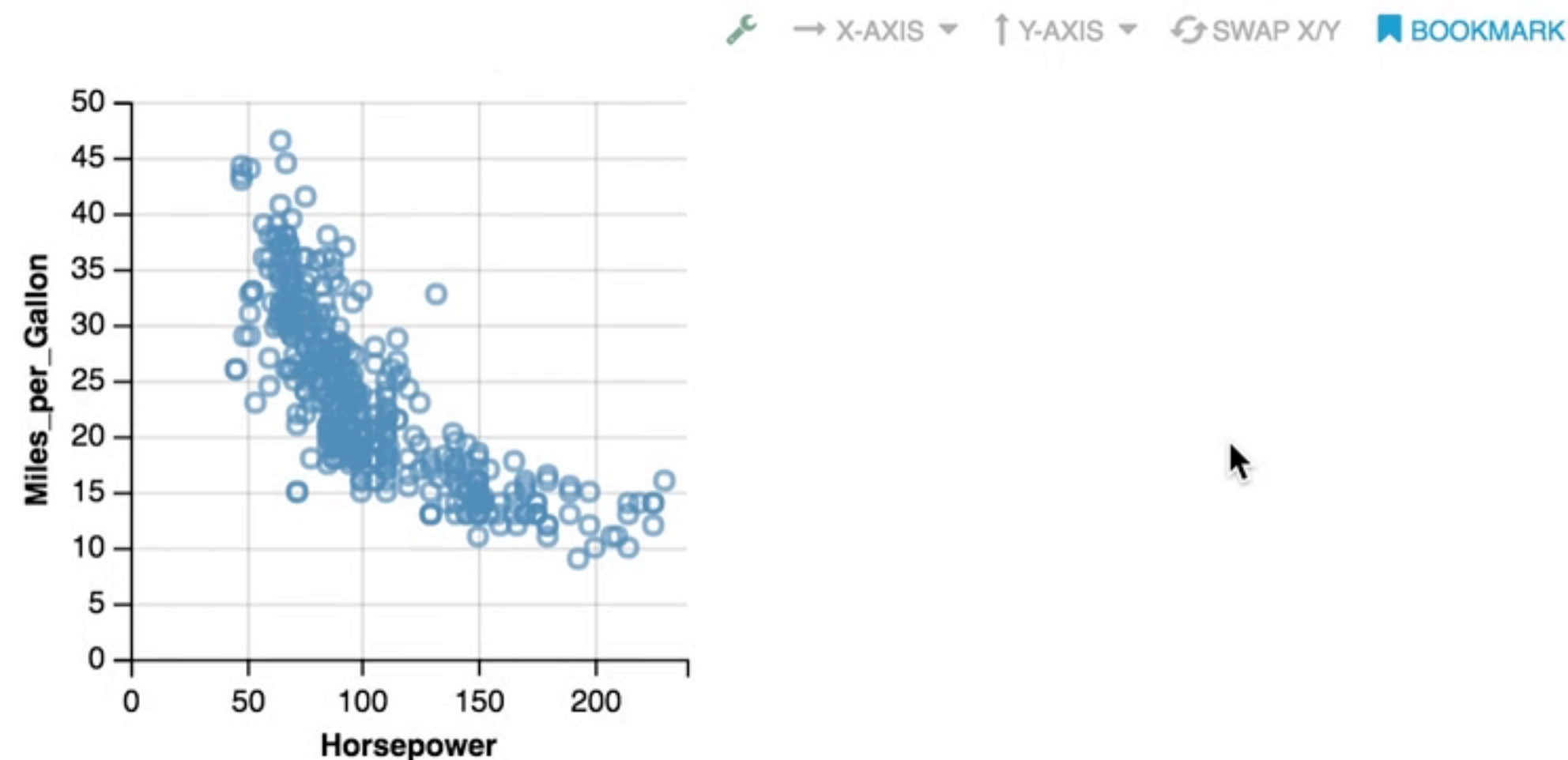
detail drop a field here

text drop a field here

any drop a field here

Filter Filter invalid numbers

Specified View



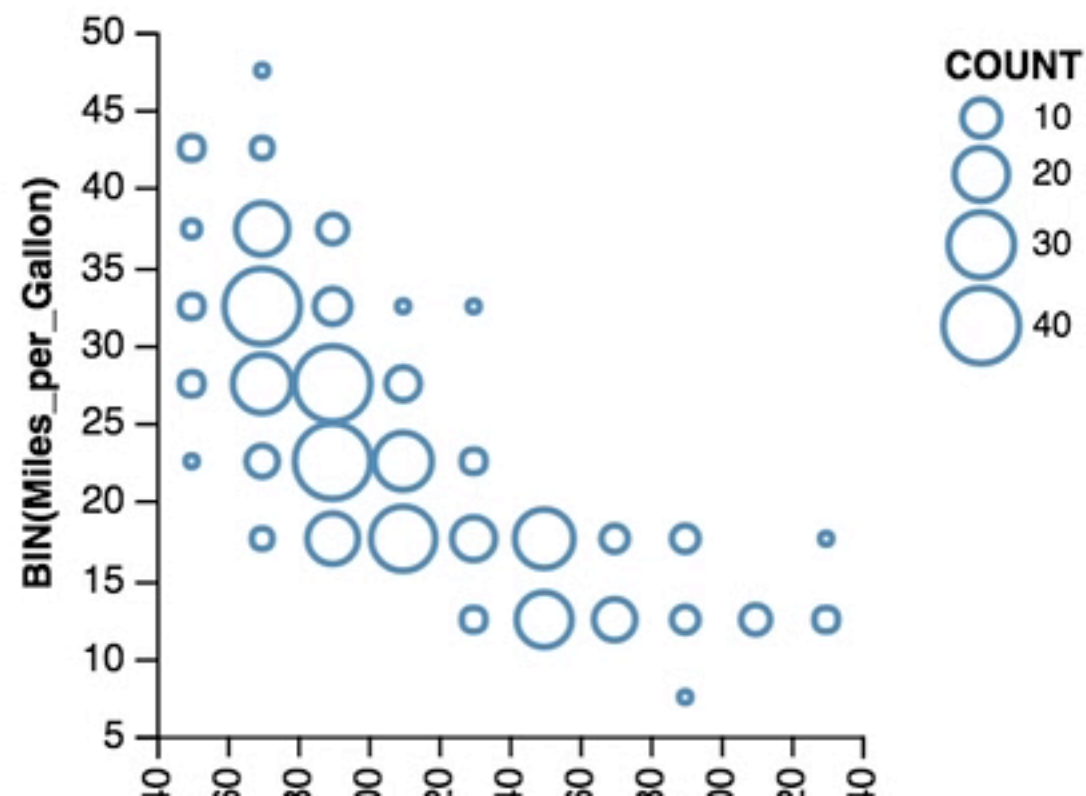
Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

Related Views

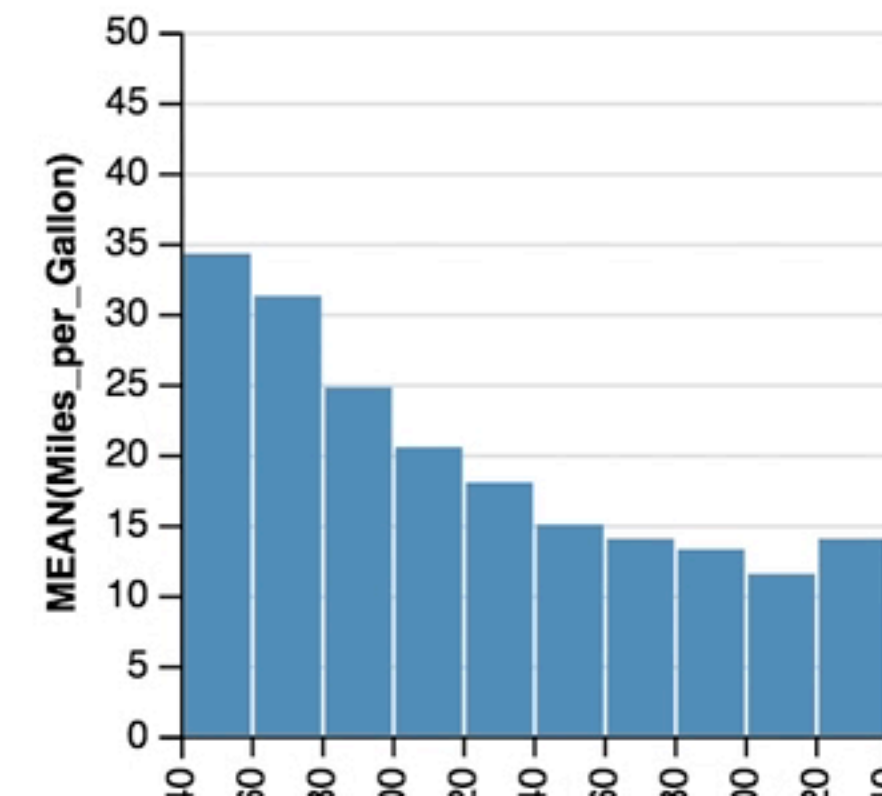
All Summaries Add Categorical Field Add Quantitative Field Hide

Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)





Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: # Horsepower

y: # Miles per Gallon

column: drop a field here

row: drop a field here

Marks: point

size: drop a field here

color: drop a field here

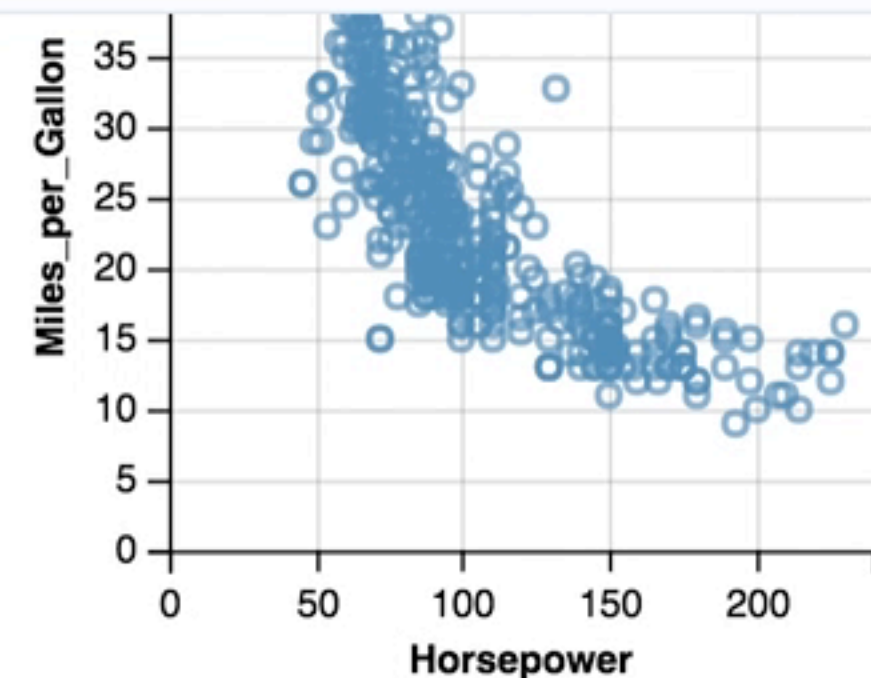
shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Filter: Filter invalid numbers



Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

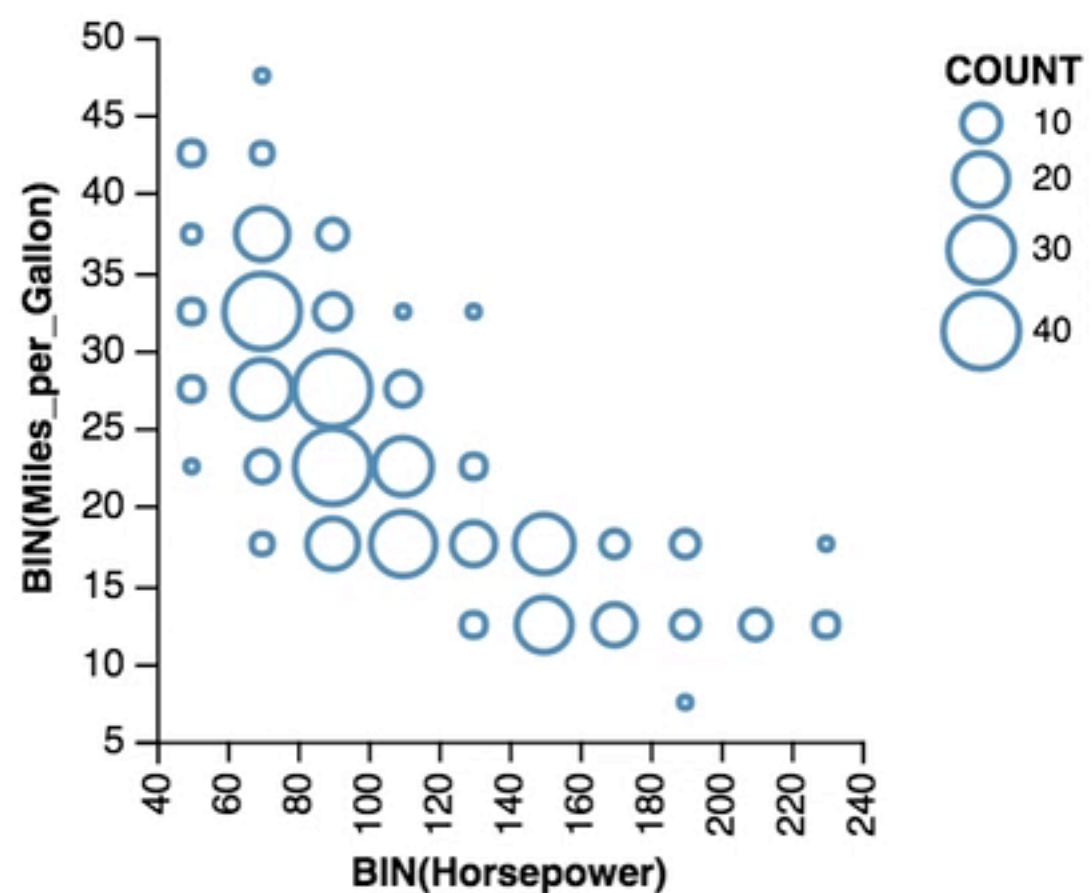


Related Views

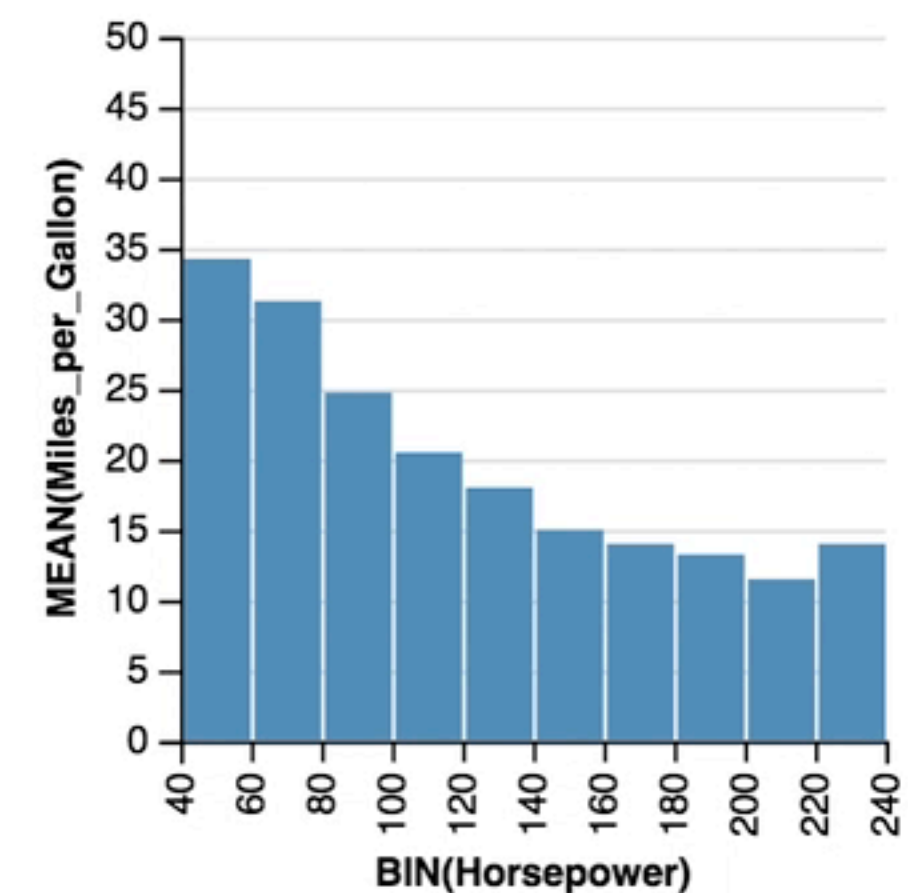
All Summaries Add Categorical Field Add Quantitative Field Hide

Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)



Load more...

Related Views (Summaries)



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: # Horsepower

y: # Miles per Gallon

column: drop a field here

row: drop a field here

Marks: point

size: drop a field here

color: drop a field here

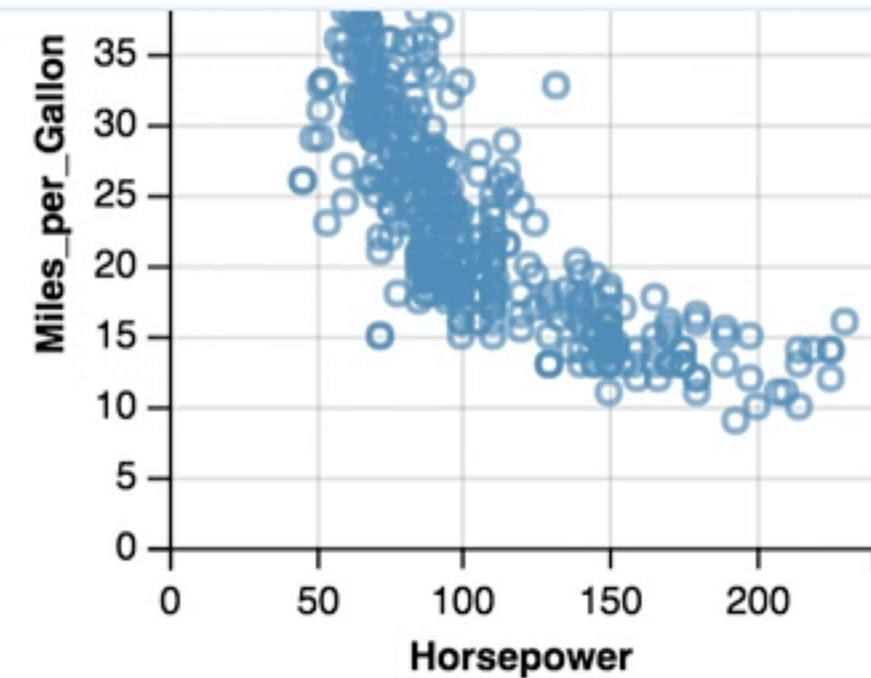
shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Filter: Filter invalid numbers



Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

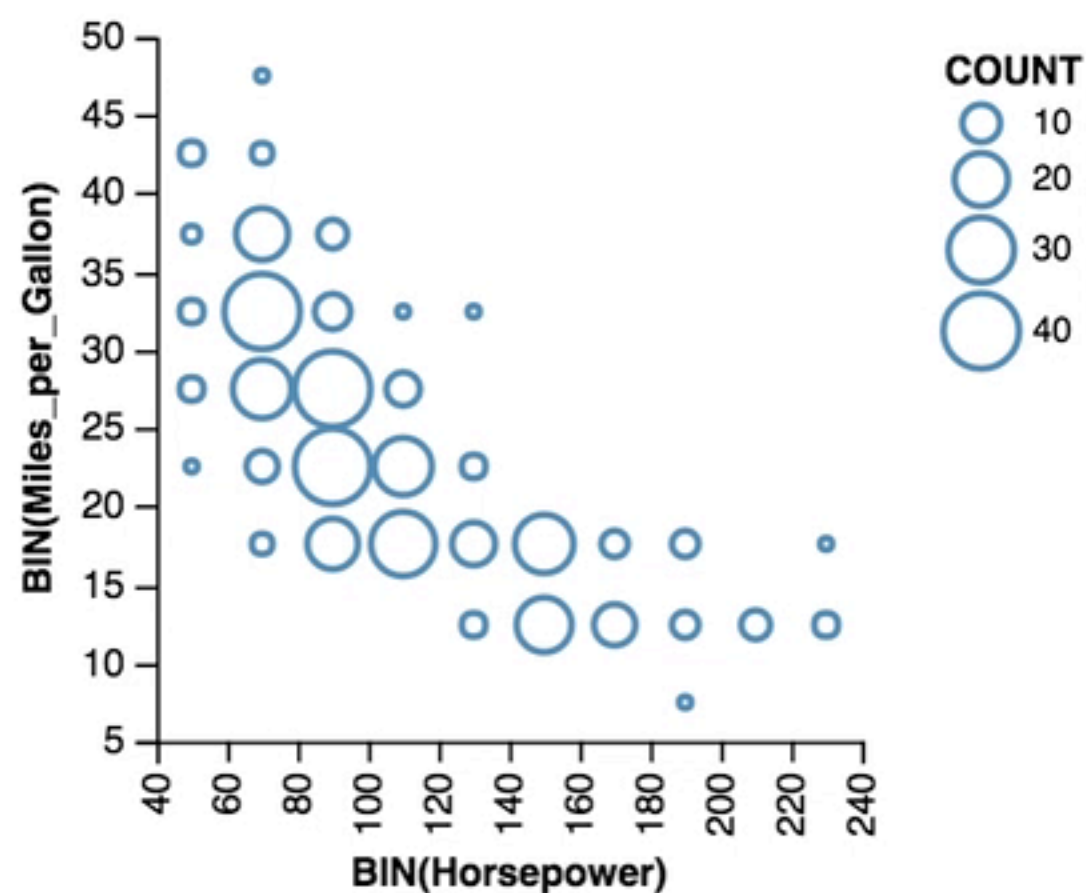


Related Views

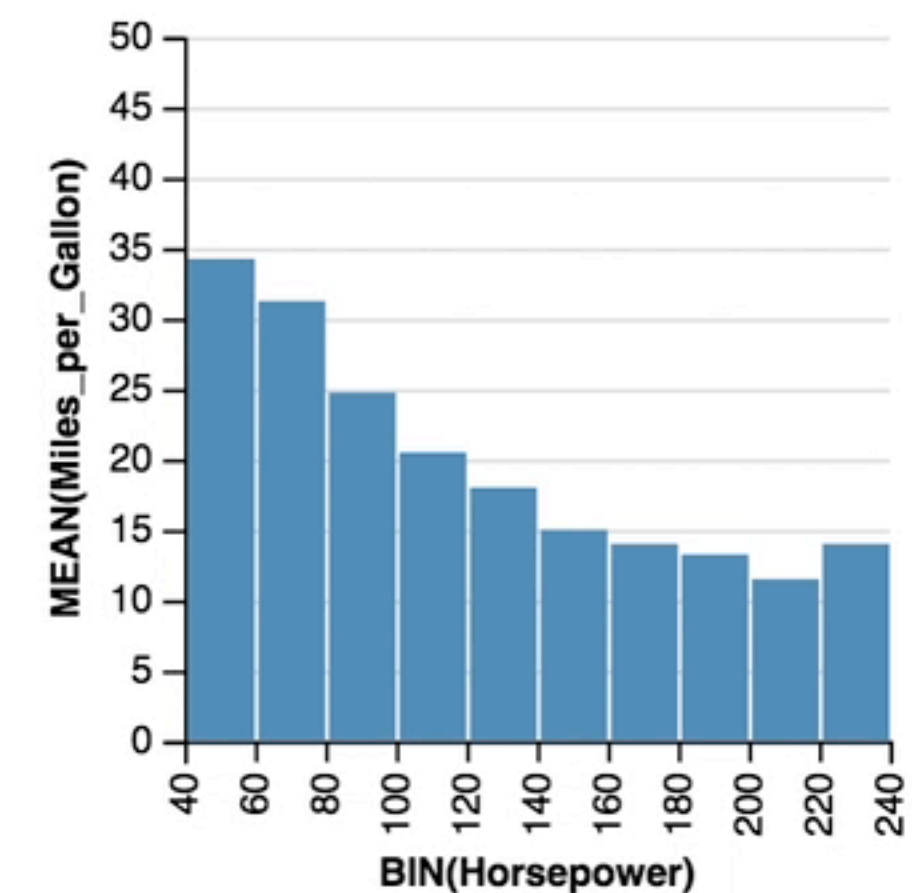
All Summaries Add Categorical Field Add Quantitative Field Hide

Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)



Related Views (Summaries)

Load more...



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: # Horsepower

y: # Miles per Gallon

column: drop a field here

row: drop a field here

Marks: point

size: drop a field here

color: drop a field here

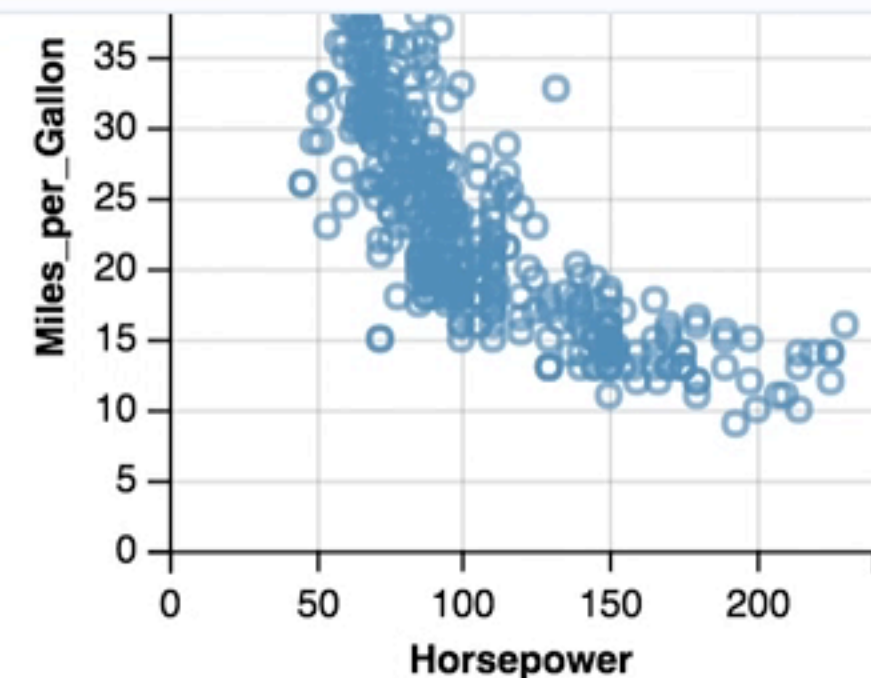
shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Filter: Filter invalid numbers



Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

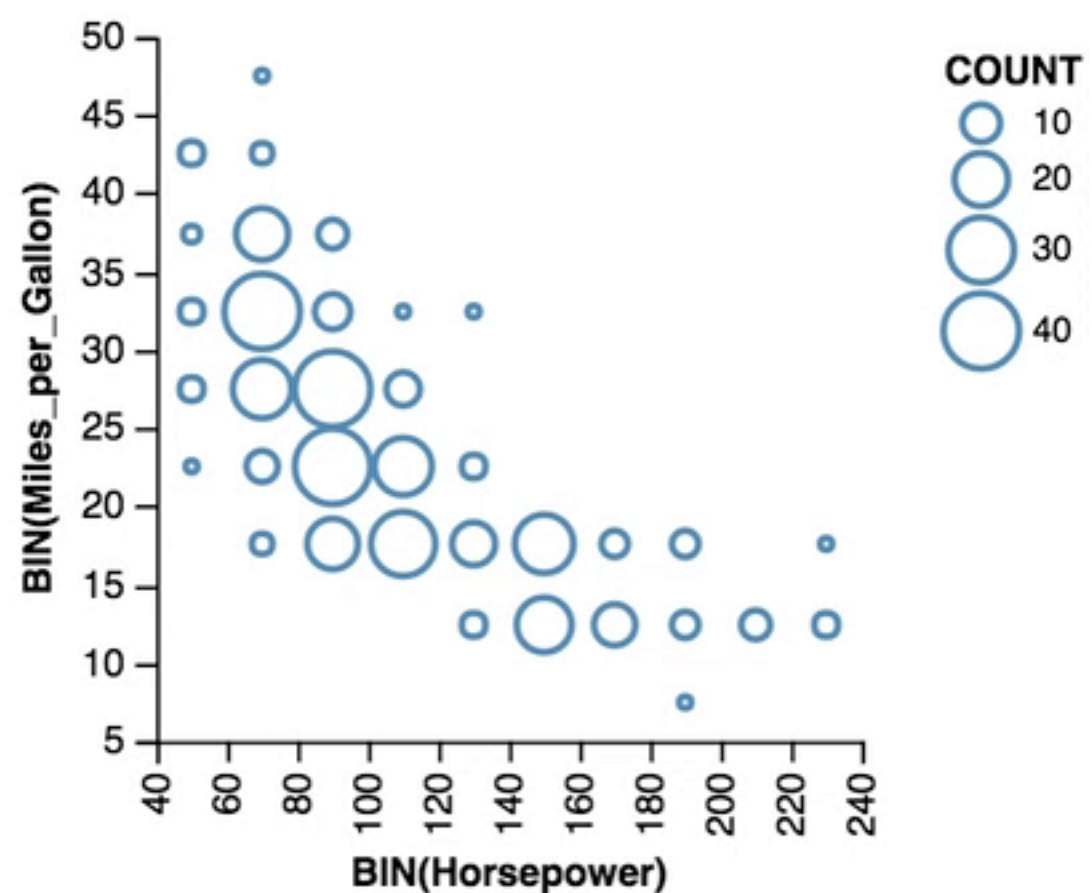


Related Views

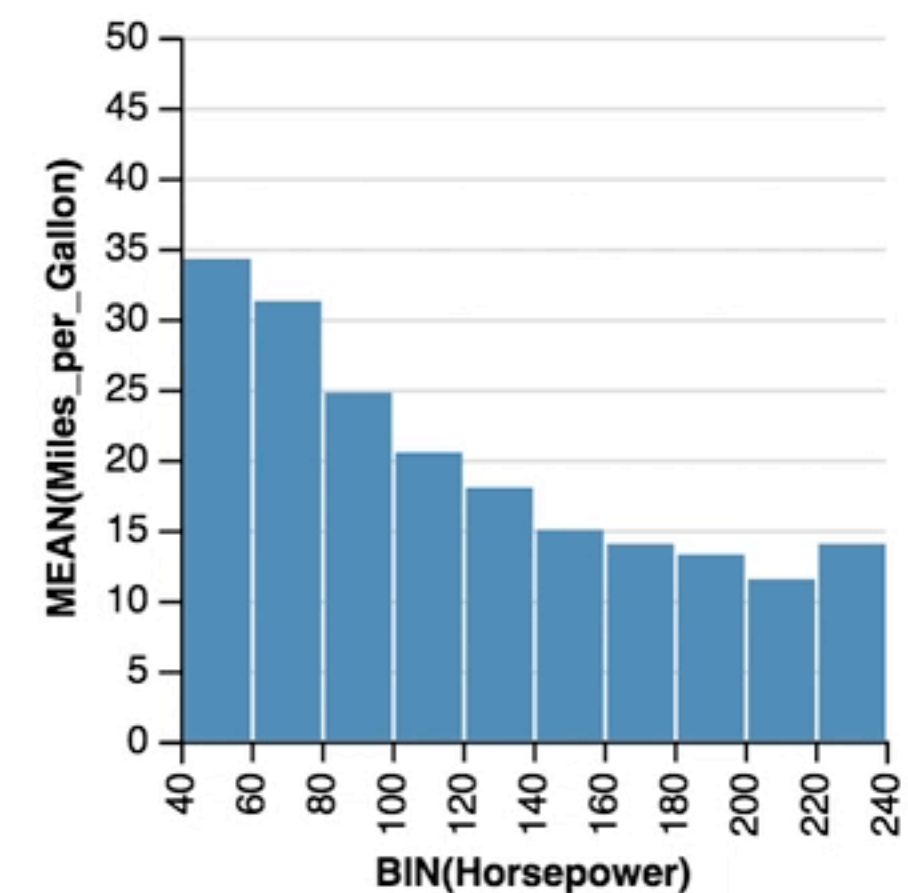
All Summaries Add Categorical Field Add Quantitative Field Hide

Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)



Related Views (Summaries)

Load more...



Data

Cars

Change

Fields

- A Cylinders
- A Name
- A Origin
- Year
- # Acceleration
- # Displacement
- # Horsepower
- # Miles per Gallon
- # Weight in lbs
- # COUNT

Wildcards

- A Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x # Horsepower

y # Miles per Gallon

column drop a field here

row drop a field here

Marks

point

size drop a field here

color drop a field here

shape drop a field here

detail drop a field here

text drop a field here

any drop a field here

Filter

Filter invalid numbers

# Specified View

Mark	point
Encoding	x: Horsepower y: Miles per Gallon

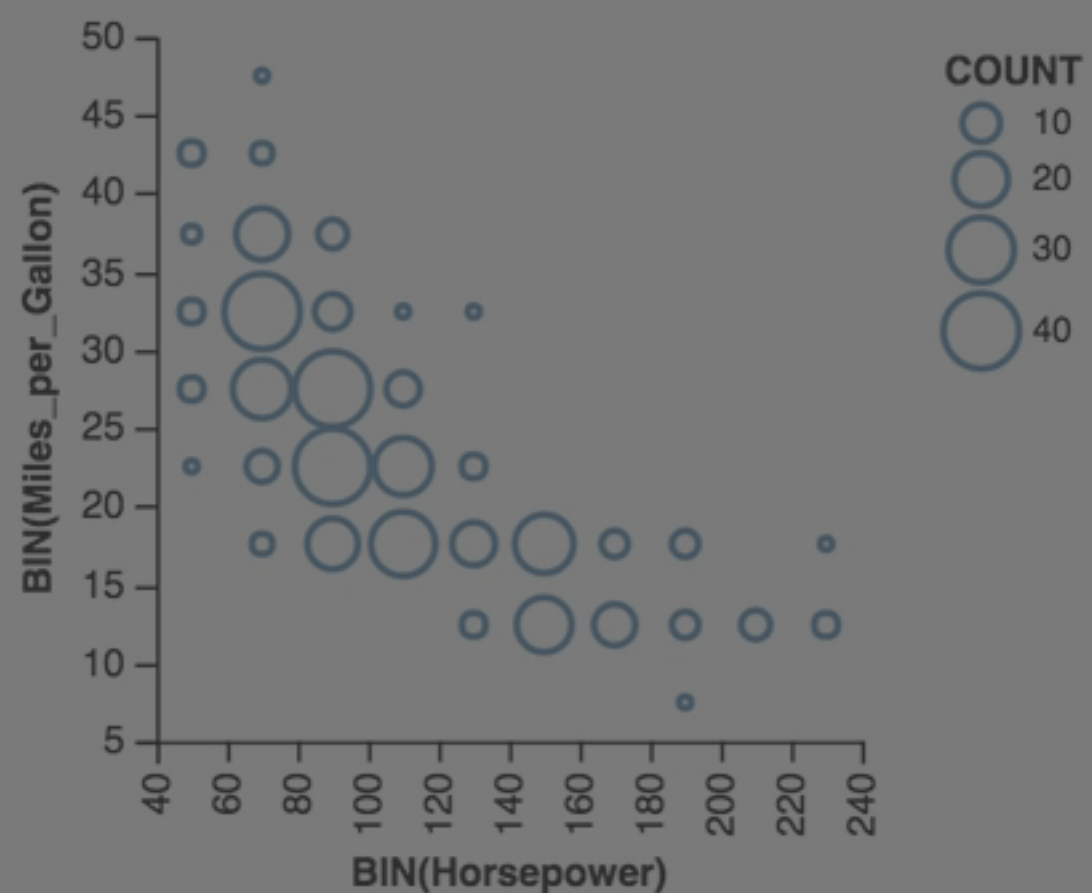
Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

## Related Views

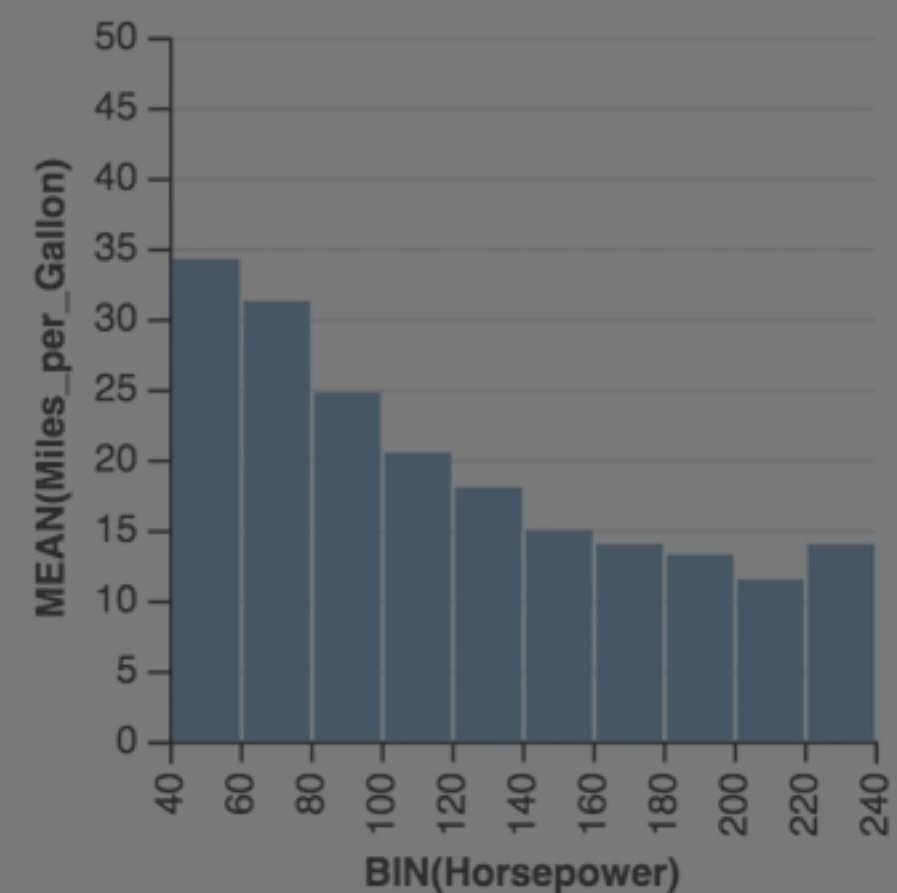
All Summaries Add Categorical Field Add Quantitative Field Hide

### Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)



# Related Views (Summaries)

Load more...

Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x # Horsepower

y # Miles per Gallon

column drop a field here

row drop a field here

Marks

point

size drop a field here

color drop a field here

shape drop a field here

detail drop a field here

text drop a field here

any drop a field here

Filter

Filter invalid numbers

# Specified View

Mark	point
Encoding	x: Horsepower y: Miles per Gallon

# Related Summaries

	?
x:	? mean,bin (Horsepower)
y:	? mean,bin (Miles per Gallon)



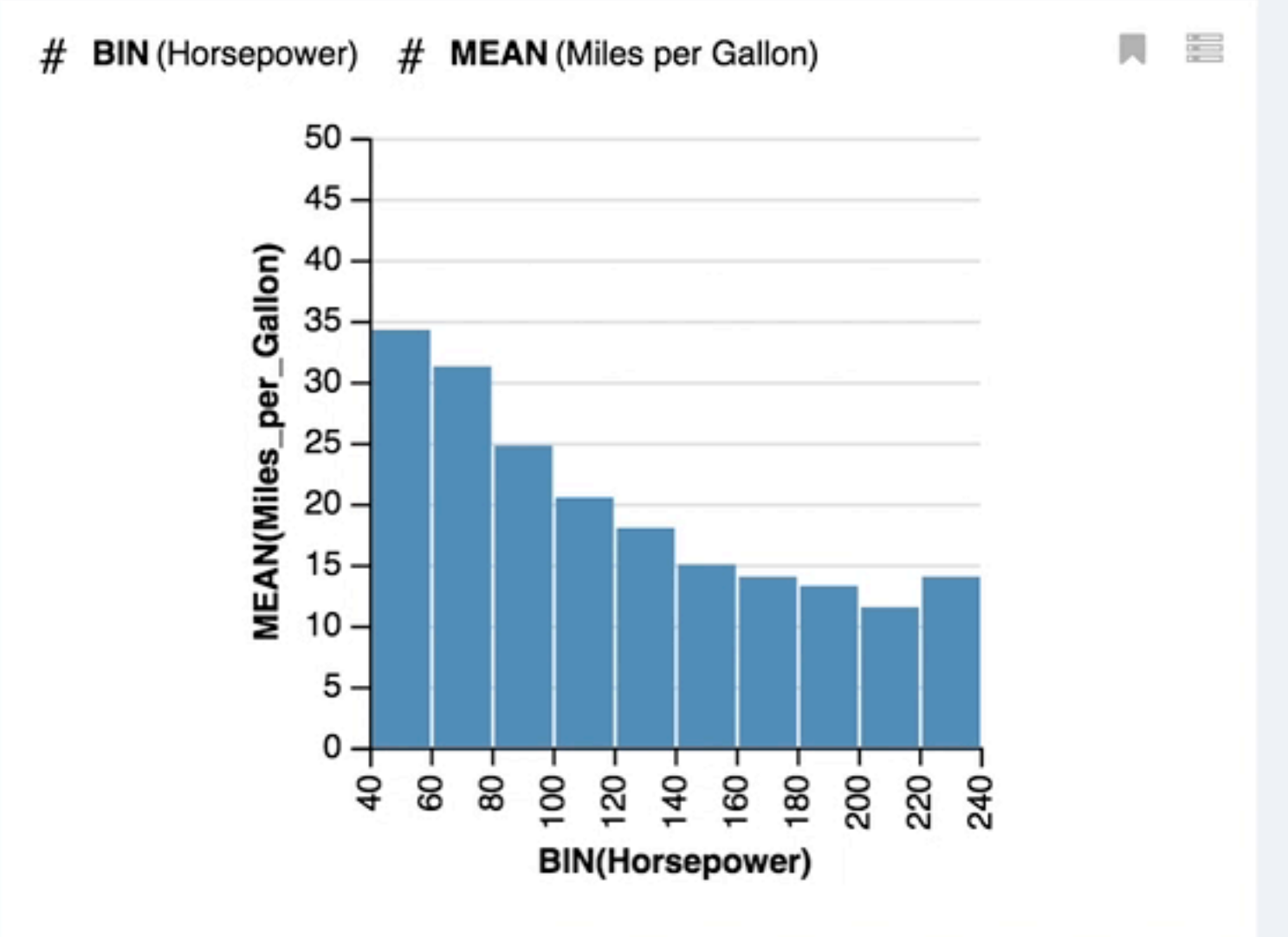
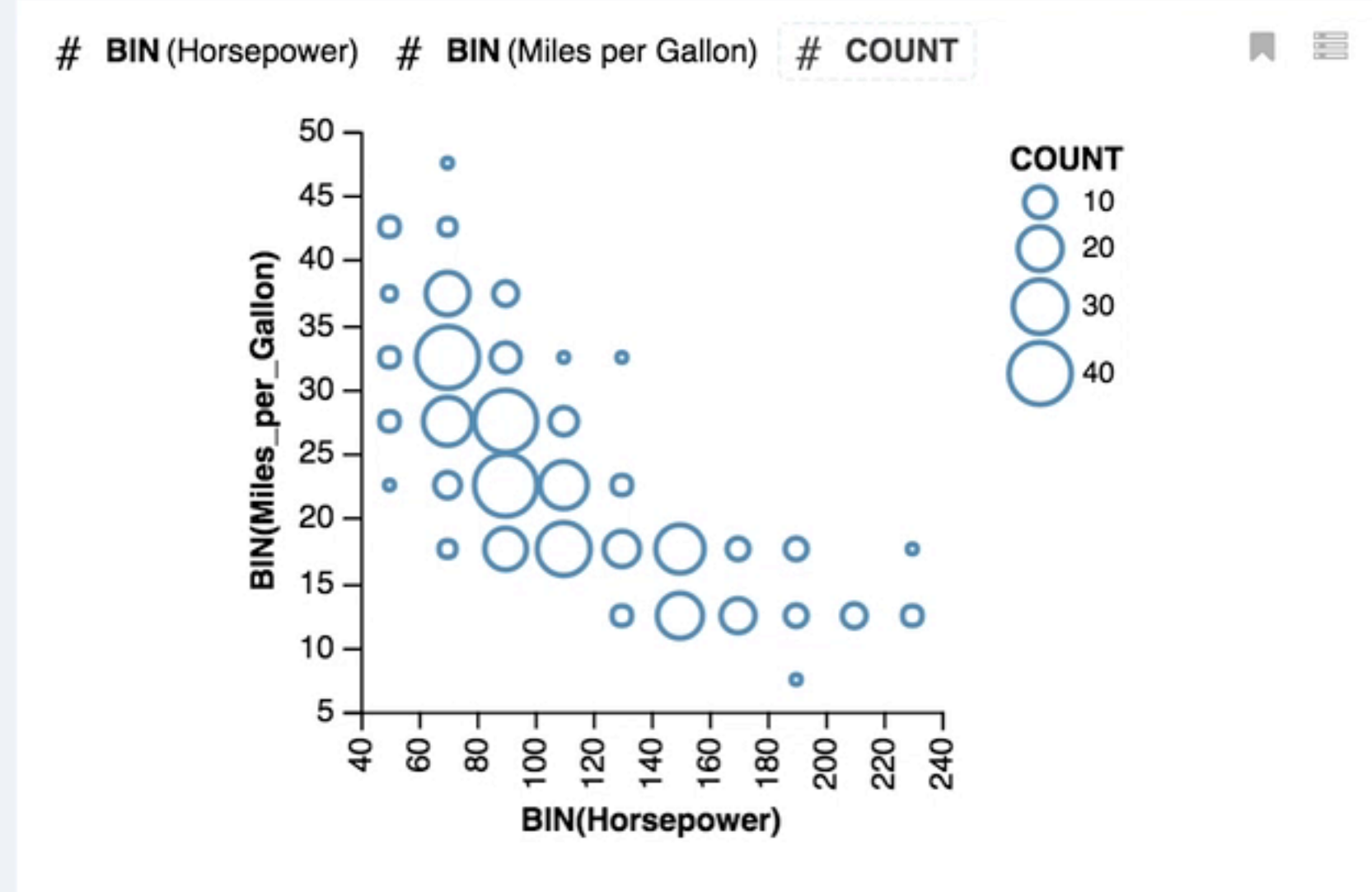
Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 200zx is an outlier with relatively high horsepower and miles per gallon

**Related Views**  
(Summaries)

## Related Views

All Summaries Add Categorical Field Add Quantitative Field Hide

### Summaries



Load more...



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Wildcards

- Categorical Fields
- Temporal Fields
- Quantitative Fields

Encoding

Clear

x: # Horsepower

y: # Miles per Gallon

column: drop a field here

row: drop a field here

Marks: point

size: drop a field here

color: drop a field here

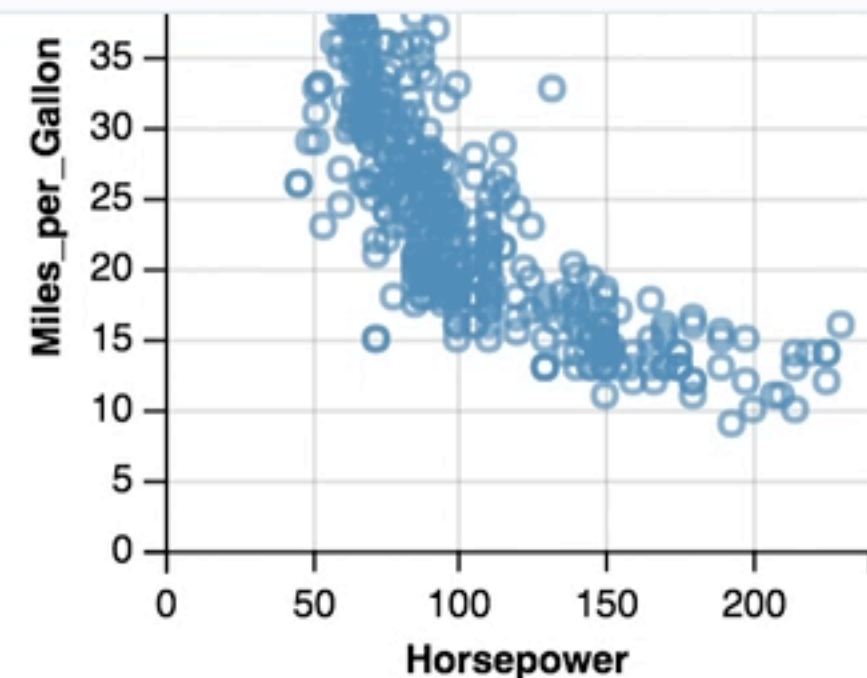
shape: drop a field here

detail: drop a field here

text: drop a field here

any: drop a field here

Filter: Filter invalid numbers



Possible quadratic relationship: as horsepower increases, gas mileage decreases. Datsun 280zx is an outlier with relatively high horsepower and miles per gallon

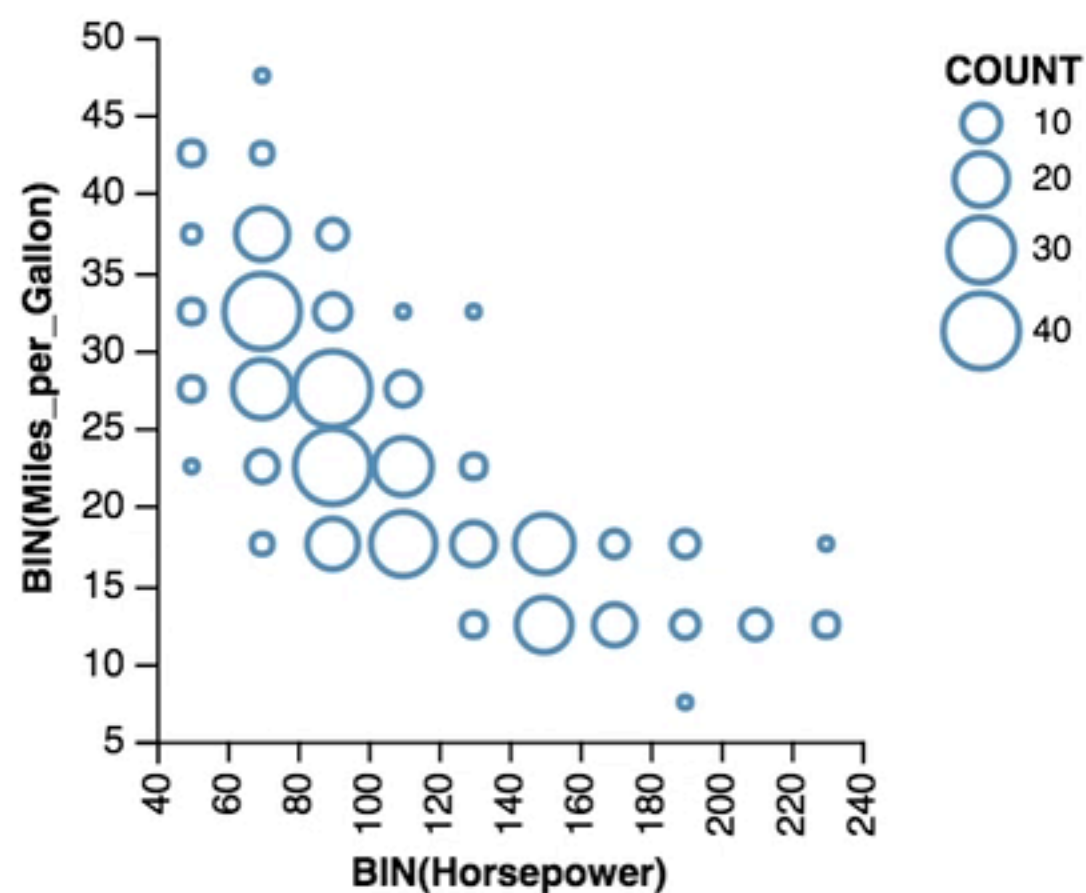


Related Views

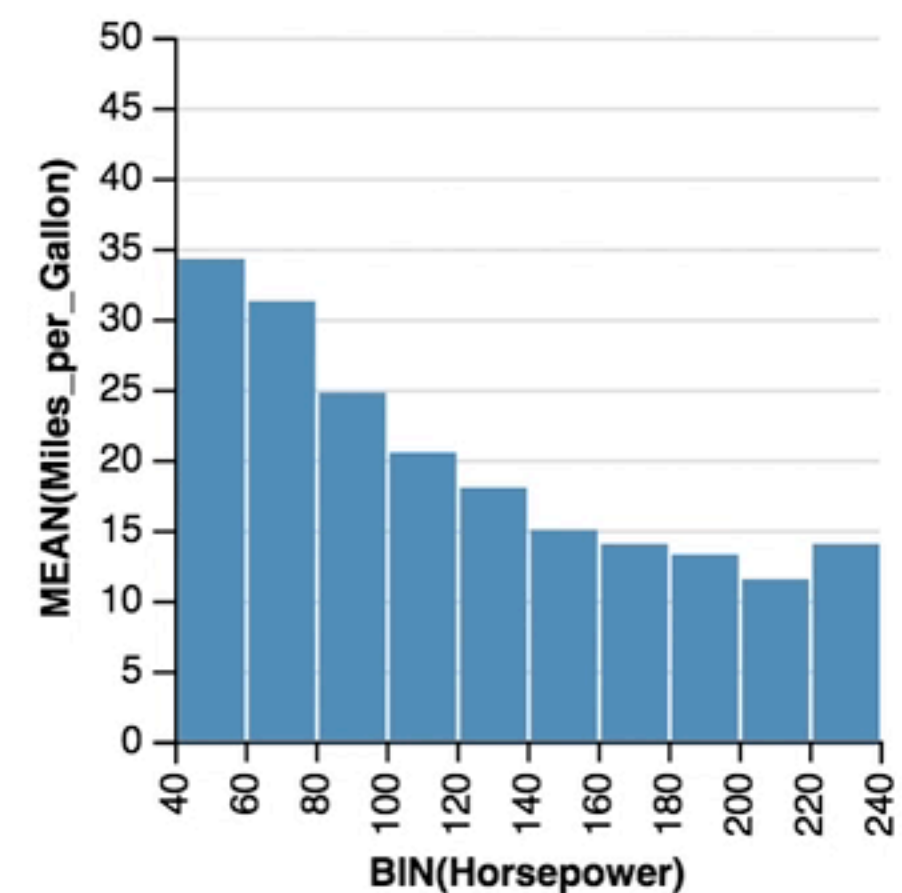
All Summaries Add Categorical Field Add Quantitative Field Hide

Summaries

# BIN (Horsepower) # BIN (Miles per Gallon) # COUNT



# BIN (Horsepower) # MEAN (Miles per Gallon)



Load more...



Data

Cars

Change

Fields

- Cylinders
- Name
- Origin
- Year
- Acceleration
- Displacement
- Horsepower
- Miles per Gallon
- Weight in lbs
- COUNT

Encoding

Clear

x # Horsepower

y # Miles per Gallon

column drop a field here

row drop a field here

Marks auto

size drop a field here

color drop a field here

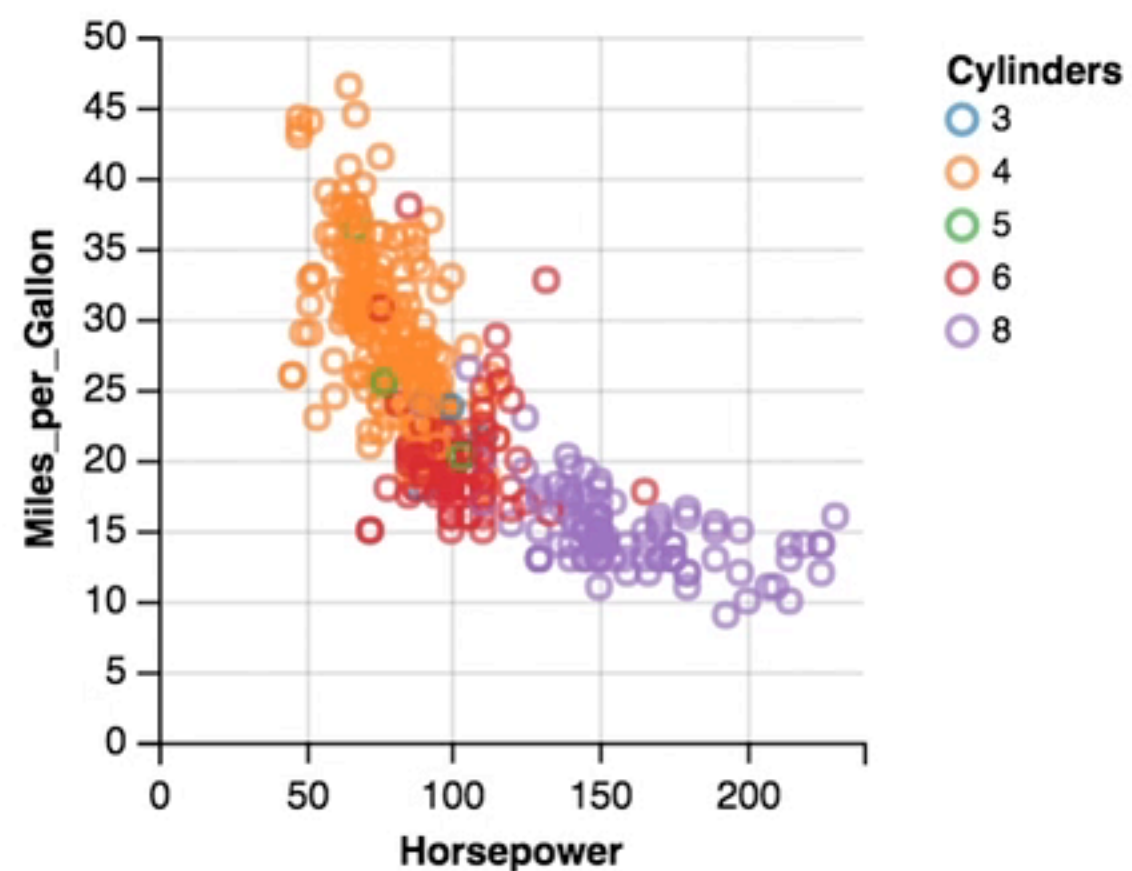
shape drop a field here

detail drop a field here

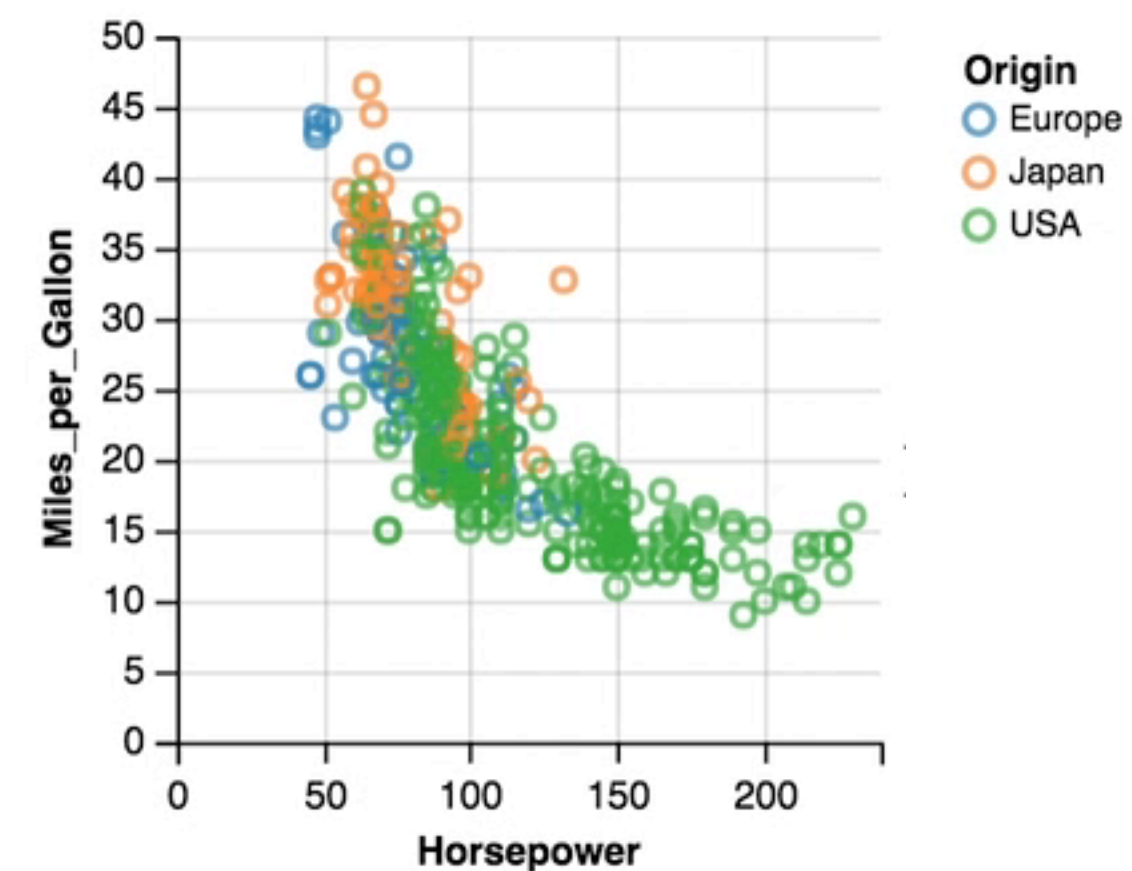
text drop a field here

Add Categorical Field

# Horsepower # Miles per Gallon A Cylinders

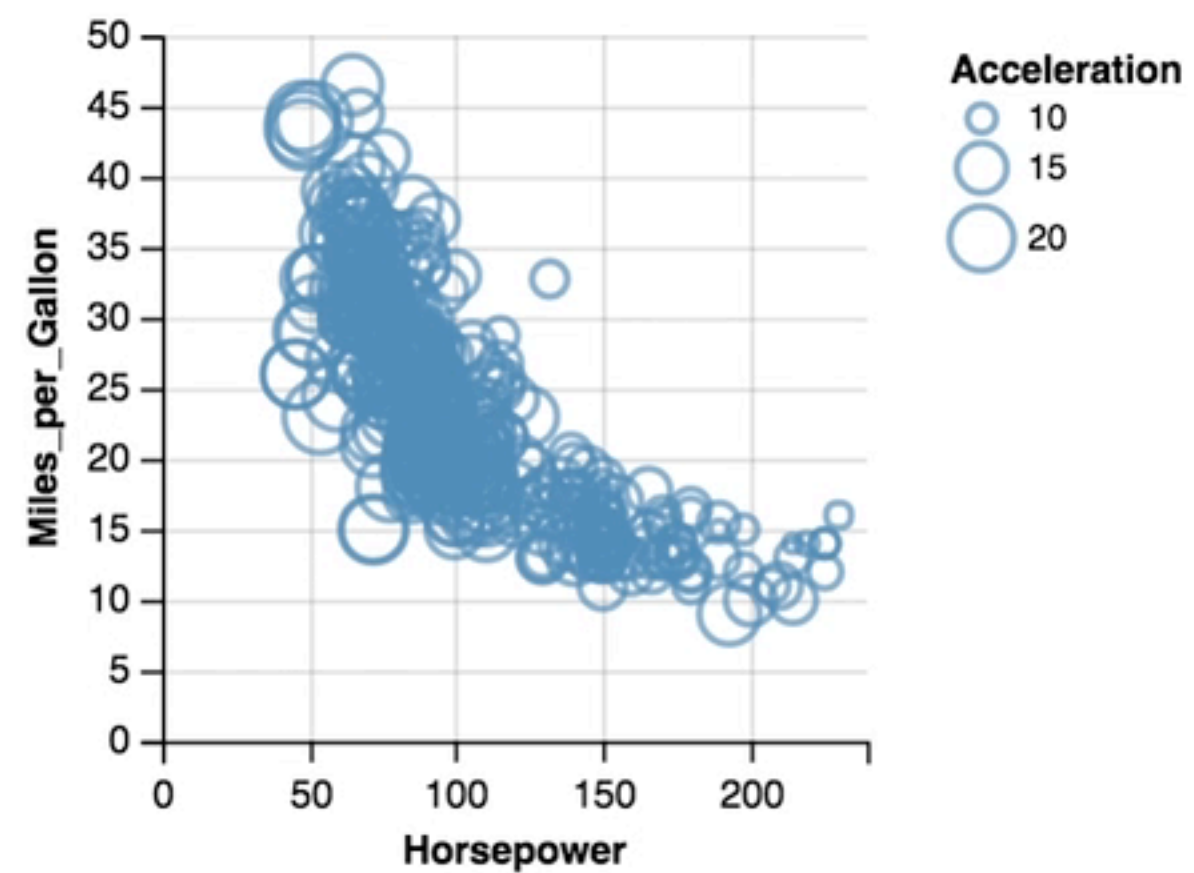


# Horsepower # Miles per Gallon A Origin

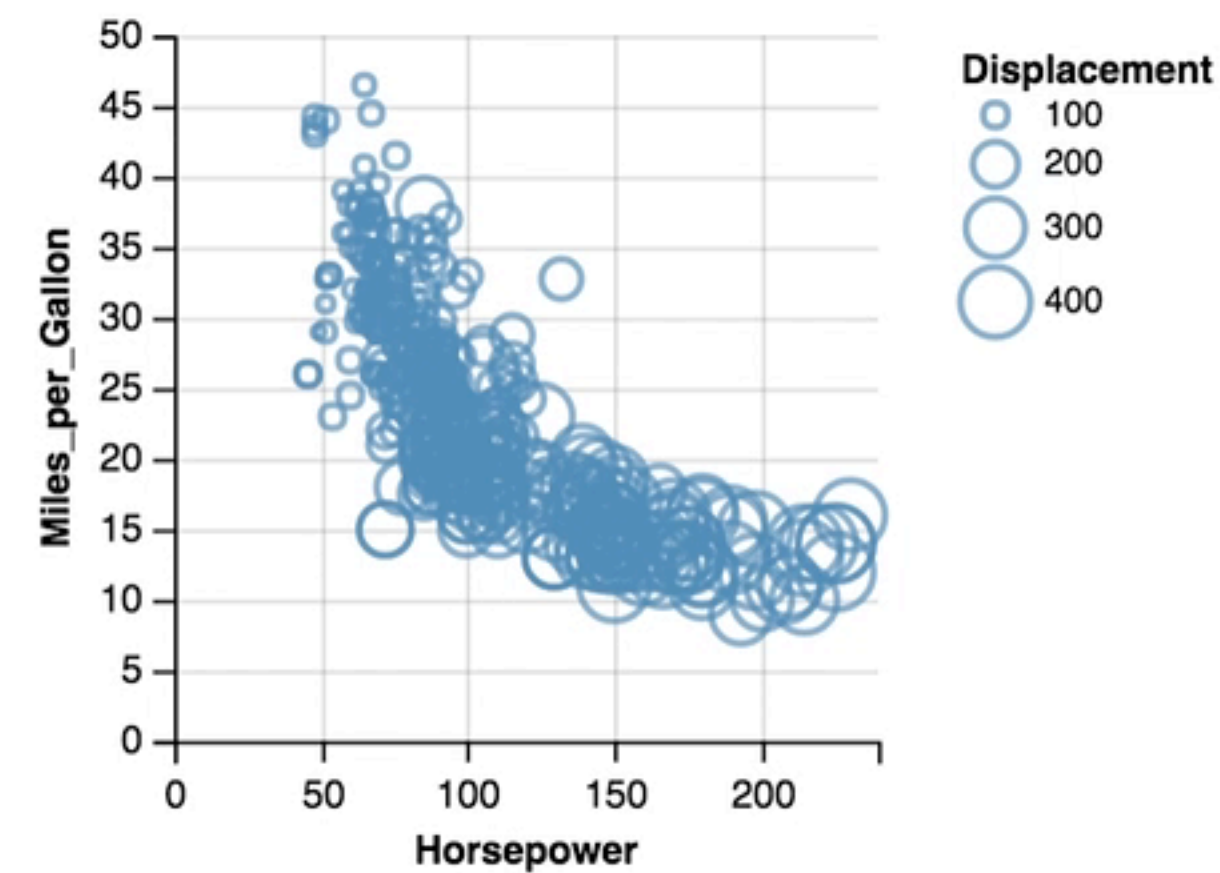


Add Quantitative Field

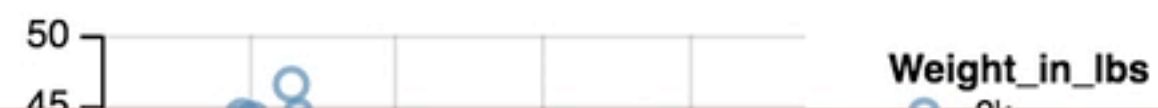
# Horsepower # Miles per Gallon # Acceleration



# Horsepower # Miles per Gallon # Displacement



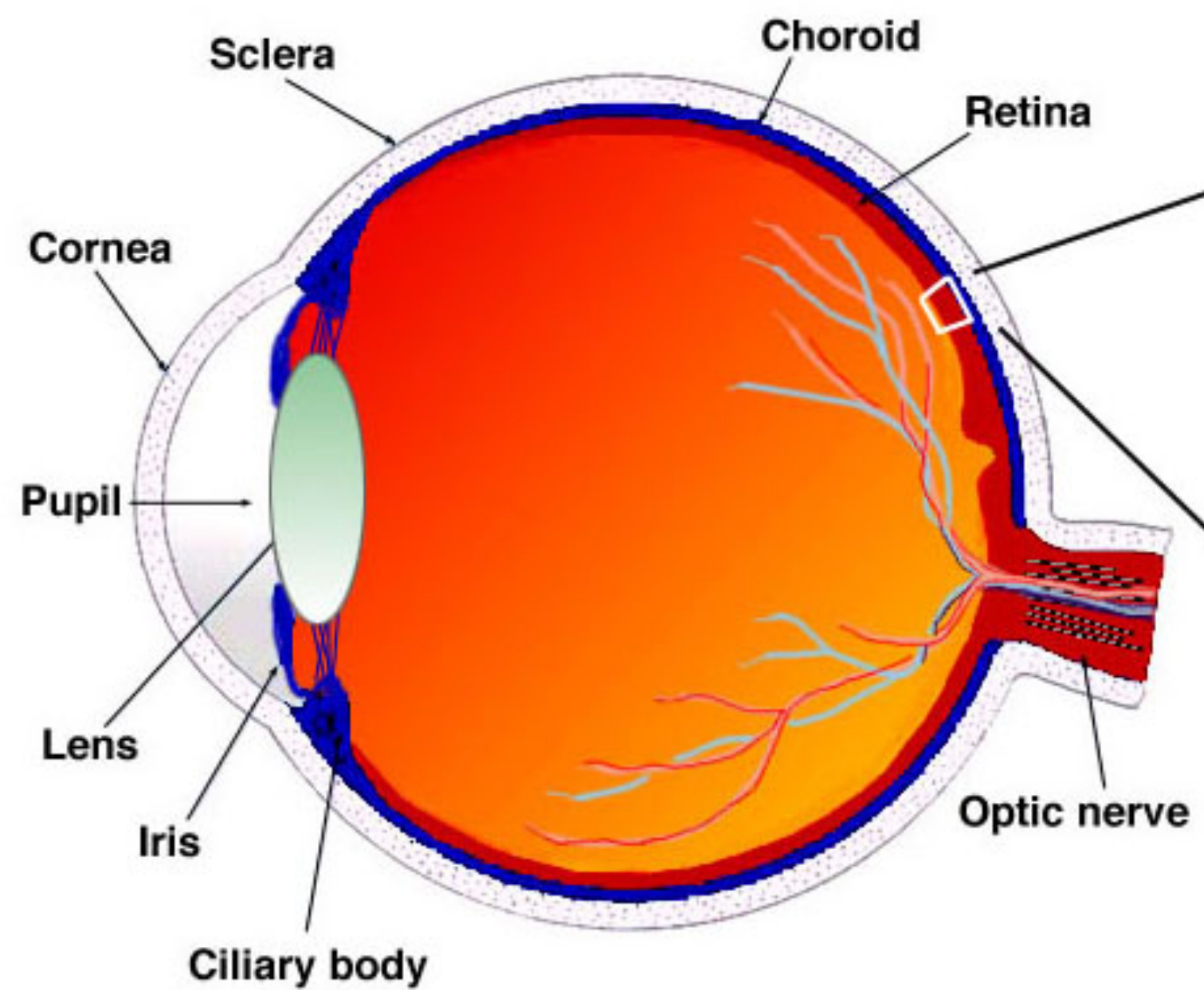
# Horsepower # Miles per Gallon # Weight in lbs



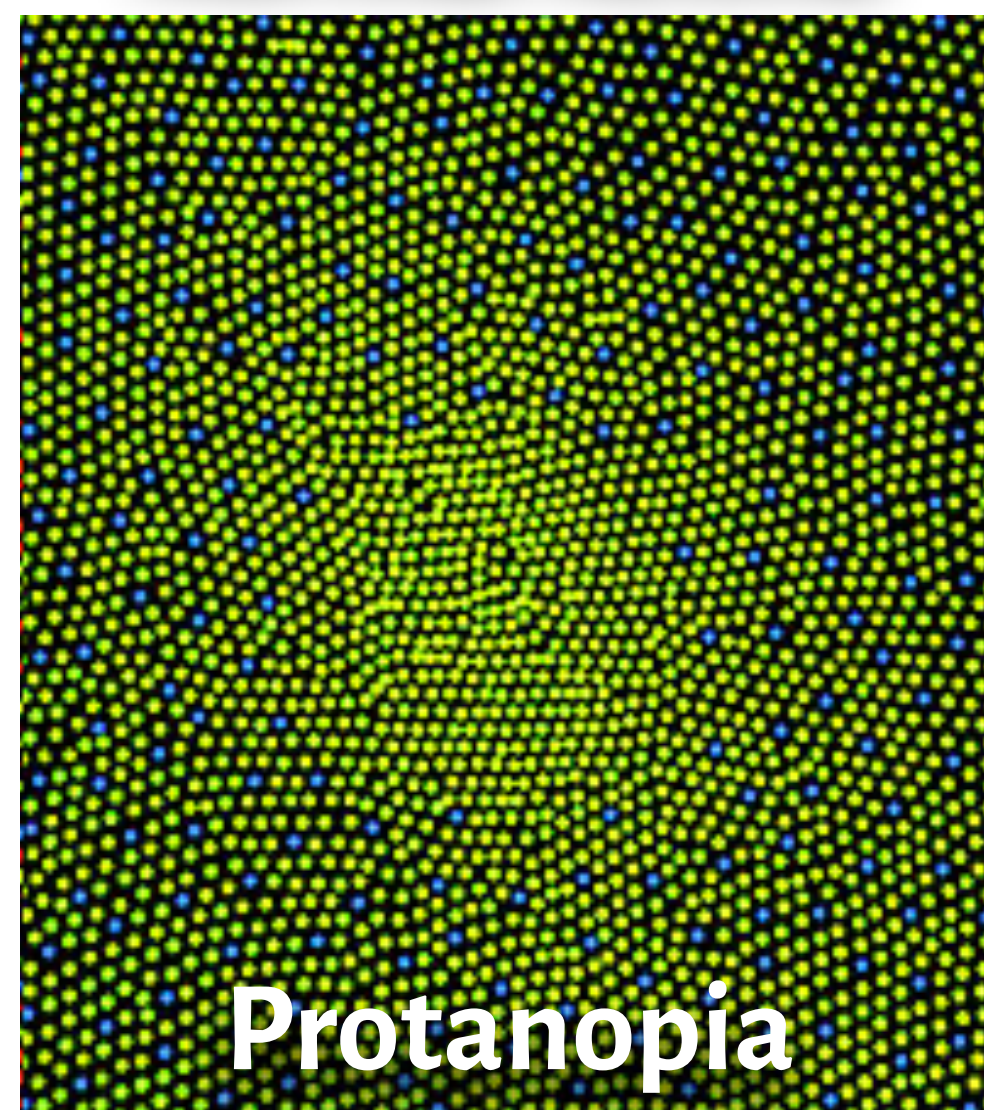
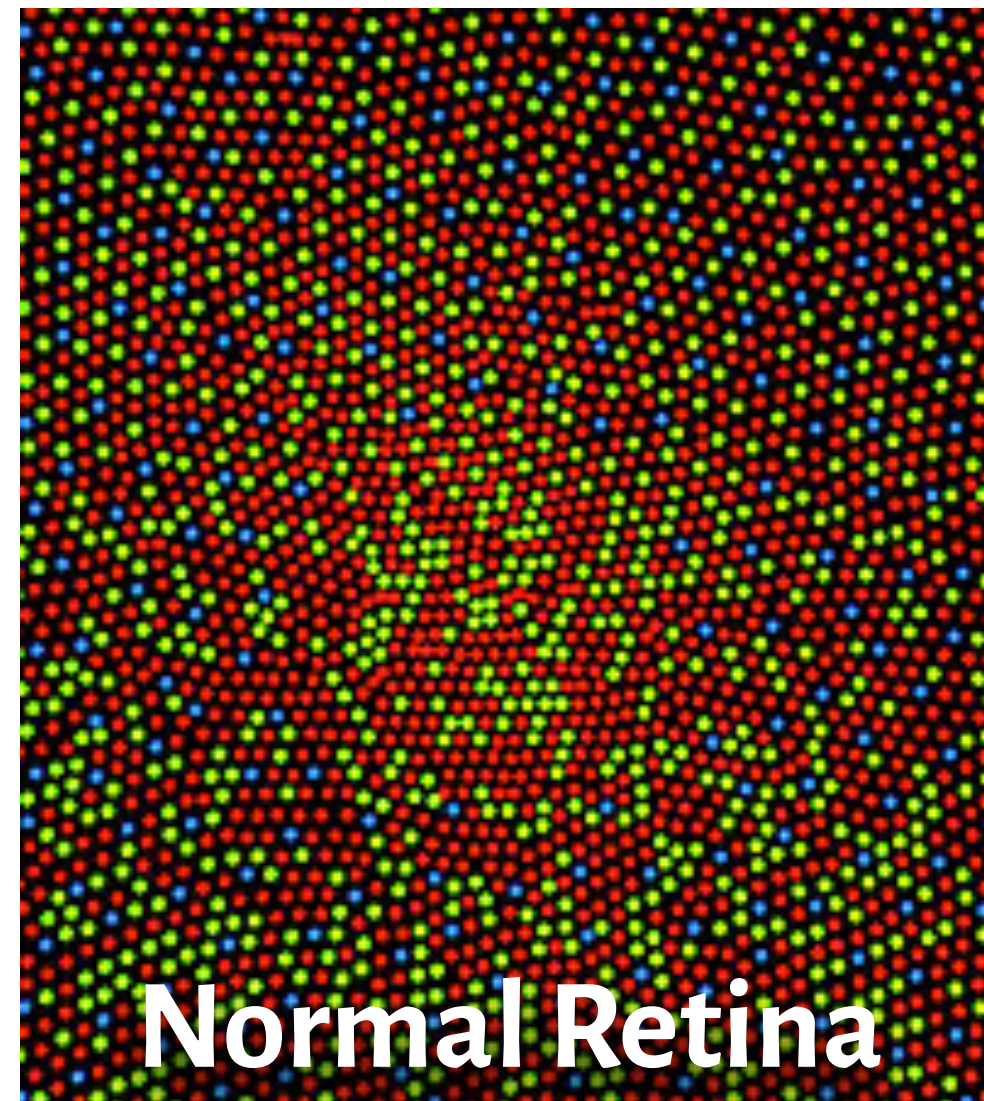
Related Views (Field Suggestions)

# Accessibility

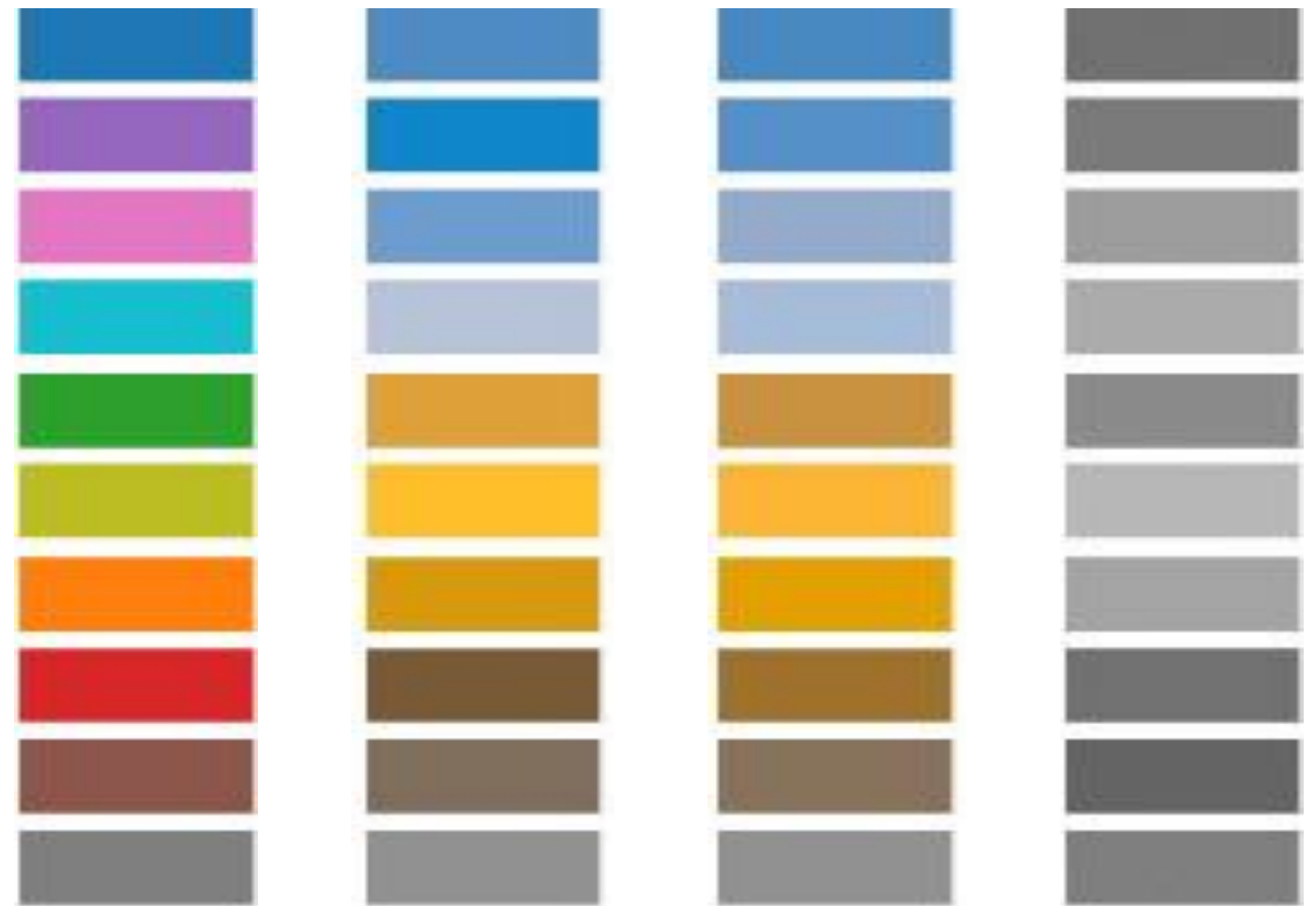
# The Retina



[Helga Kolb *Simple Anatomy of the Retina*.]



Firefox and Chrome have built in simulators.



Protanope

Deuteranope

Luminance

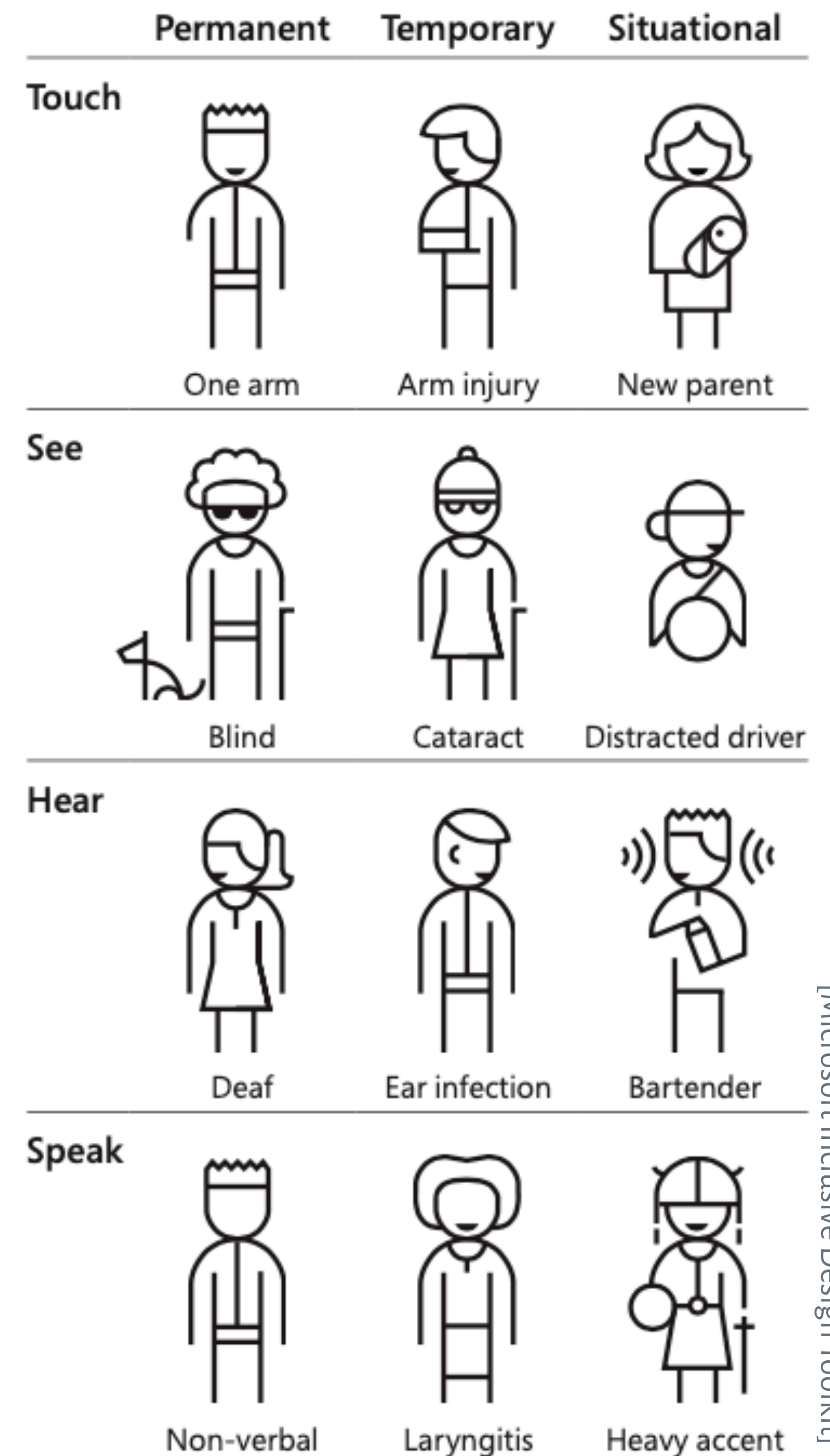
**Medical (or deficit) model** of disability: disability is something "wrong" with a person's body or mind (i.e., they are "suffering" and need to be "cured").

Criticized for seeing impairment as most important part of the person, and that they're helpless to do anything about it.

Promotes **technosolutionism**.

**Social model** of disability: people with impairments are being disabled by society's choices and attitudes. They are not having their needs met.

Recognizes that **all technology is assistive**.



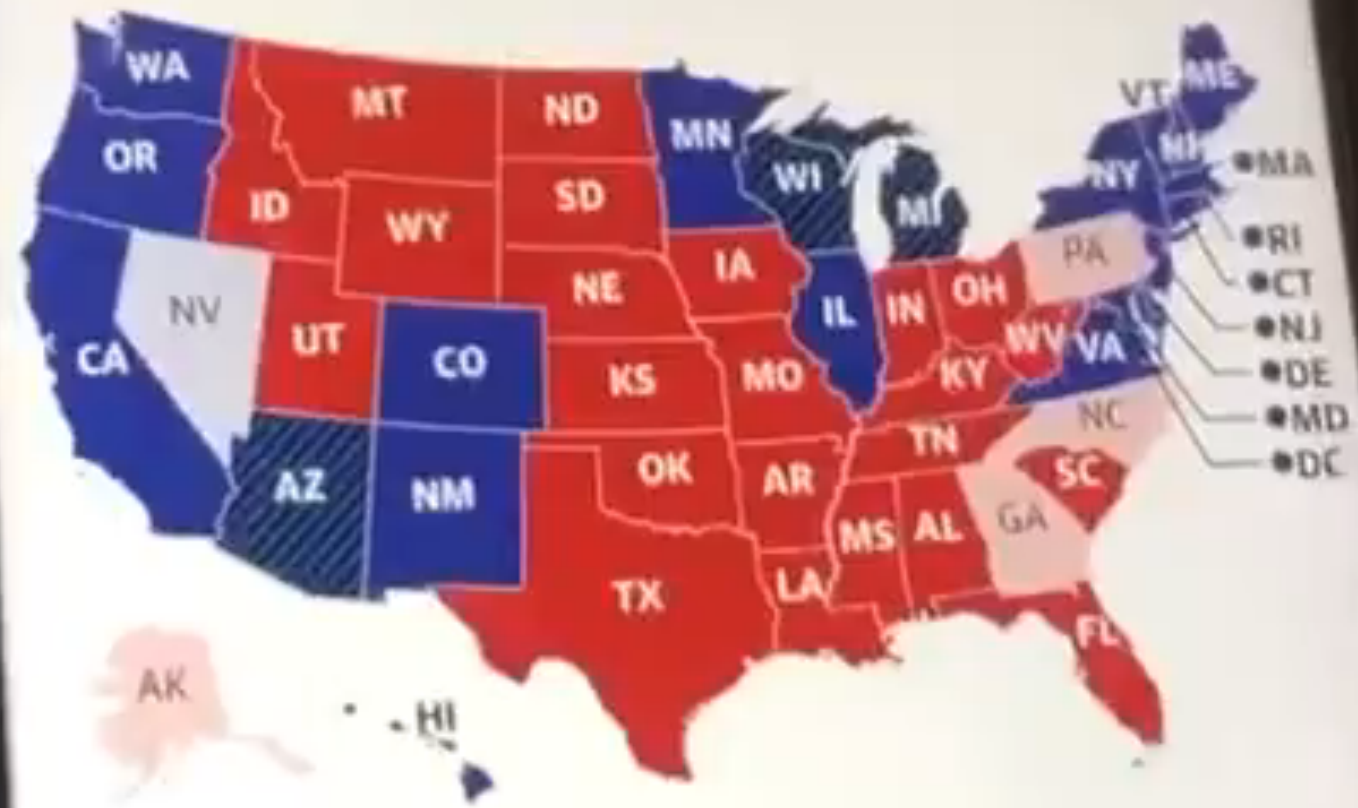
19:44

theguardian.com

### Which states haven't been called yet?

← Montana 2 days ago **Trump wins Ohio** 2 days ago Biden wins Minnesota

Zoom into a state ▾



**Biden** ● Lead ● Win ● Flip  
**Trump** ● Flip ● Win ● Lead

**i** How do I read this map?





10

BA  
238.01  
+2.54

BRK-B  
293.83  
+2.90

# Dow Jones

Dow Jones Industrial Average

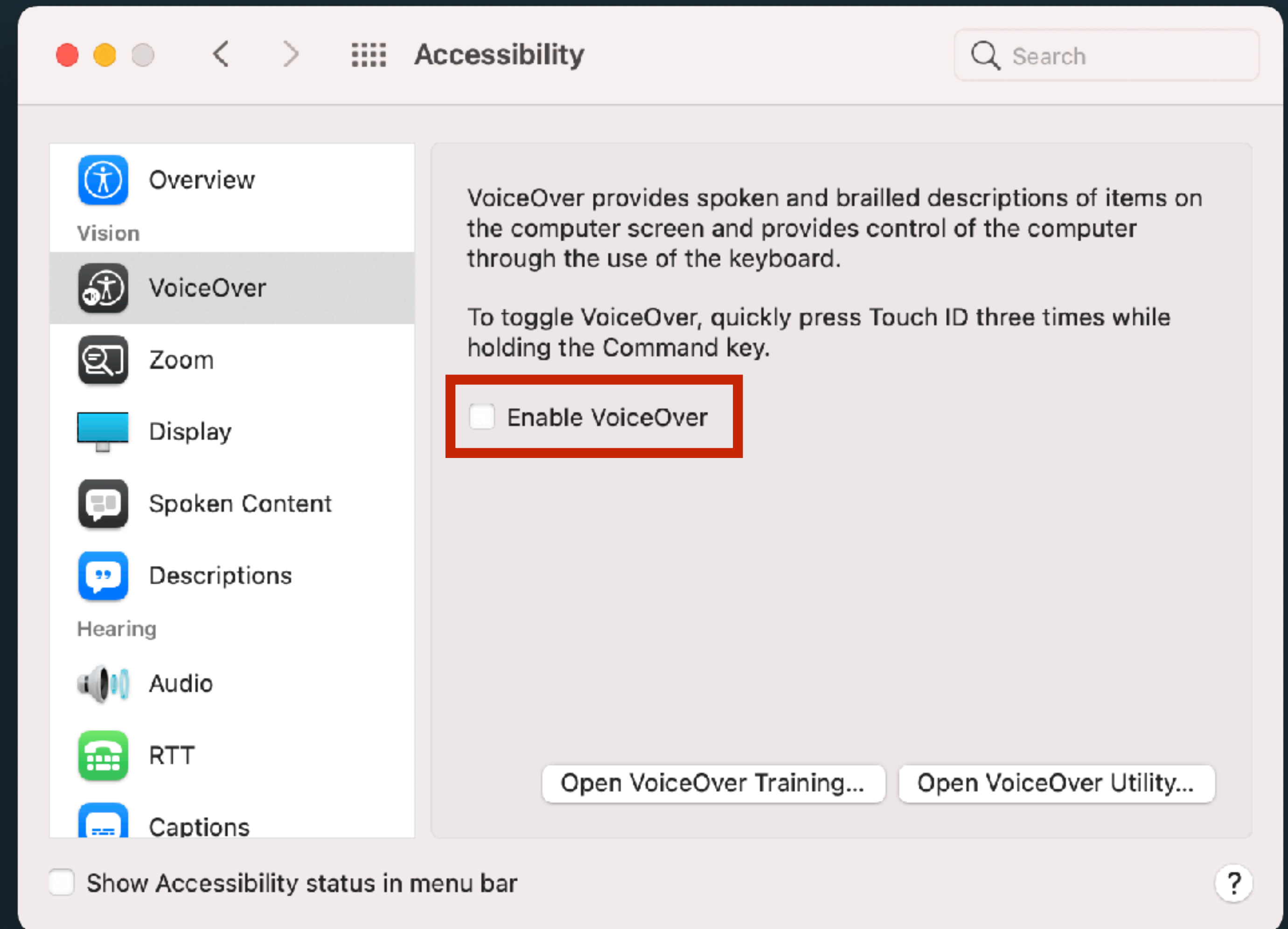
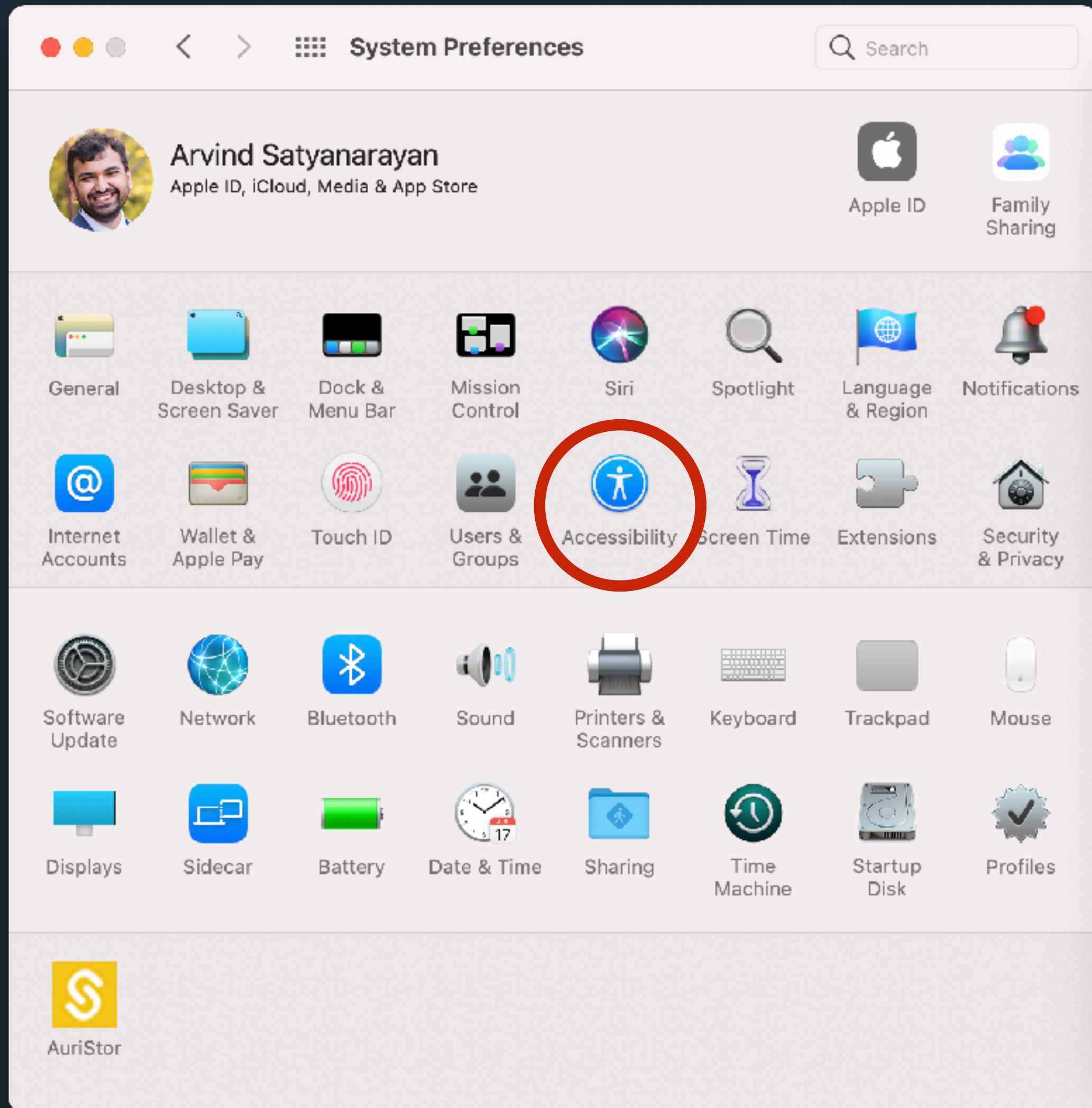
35,037.68 +259.92

1D 1W 1M 3M 6M 1Y 2Y



Open	34,785.27	Vol	112.1M	52W H	35,
High	35,043.58	P/E	-	52W L	22,
Low	34,785.27	Mkt Cap	-	Avg Vol	

[More Data from Yahoo Finance](#)



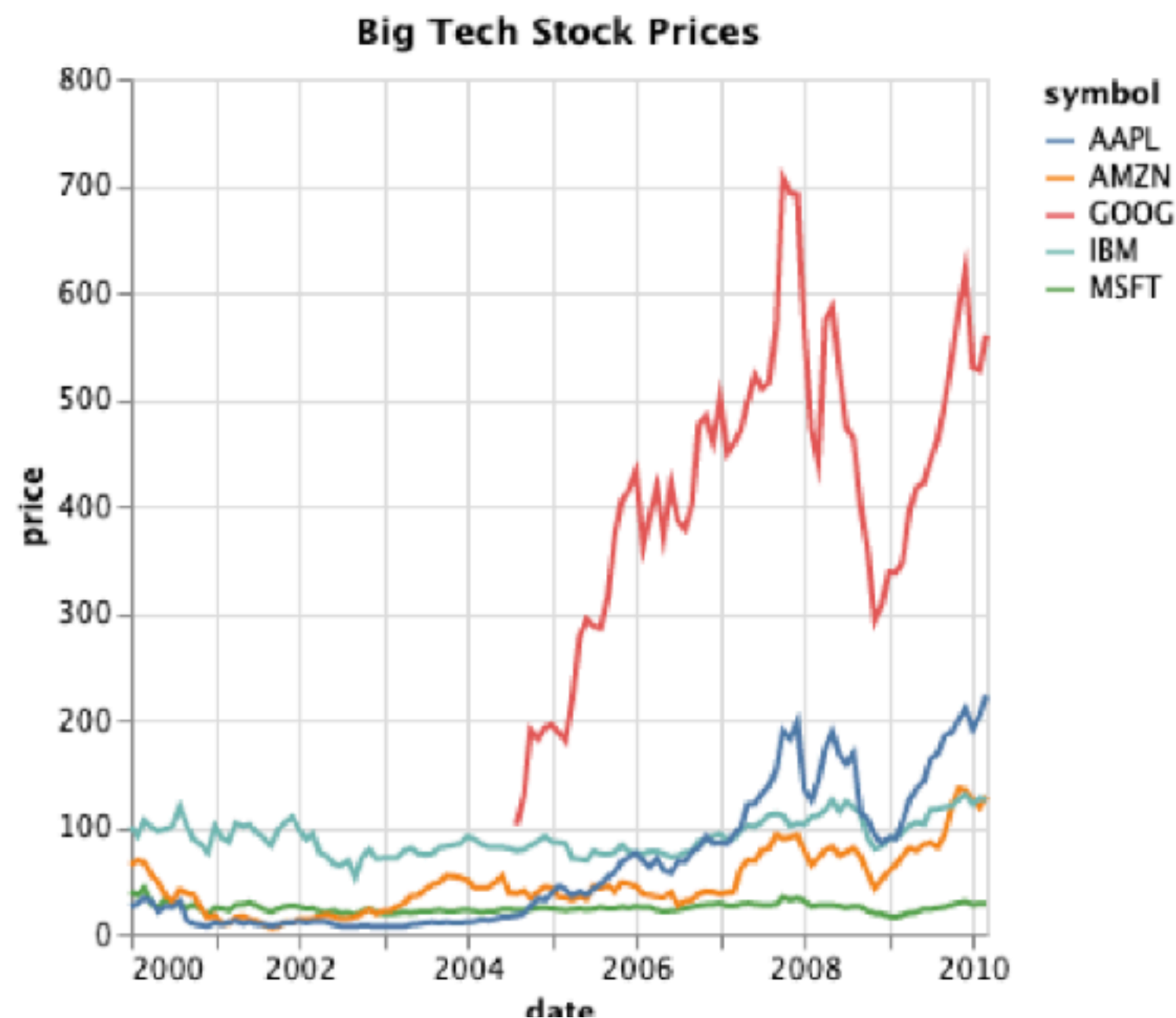
ChromeVox extension

Accessible Rich Internet Application (ARIA)

Case Study: Implementing Accessible Data Charts for Khan Academy by Sara Soueidan

# Captions and Alt-Text

#	LEVEL KEYWORDS	SEMANTIC CONTENT	COMPUTATIONAL CONSIDERATIONS
4	contextual and domain-specific	<i>causal inferences and explanations, cultural and political relationships, current events</i>	<i>reader-dependent: contextual knowledge and domain-specific insights</i>
3	perceptual and cognitive	<i>complex trends and patterns, “natural” articulation, commonplace concepts</i>	<i>reader-agnostic: reference to the rendered visualization and “common knowledge”</i>
2	statistical and comparative	<i>descriptive statistics, extrema, outliers, correlations, point-wise comparisons</i>	<i>reader-independent: access to the visualization specification and backing dataset</i>
1	elemental and encoded	<i>chart type, encoding channels, title, axis ranges, labels, colors</i>	<i>reader-independent: access to the visualization specification or rasterized image</i>

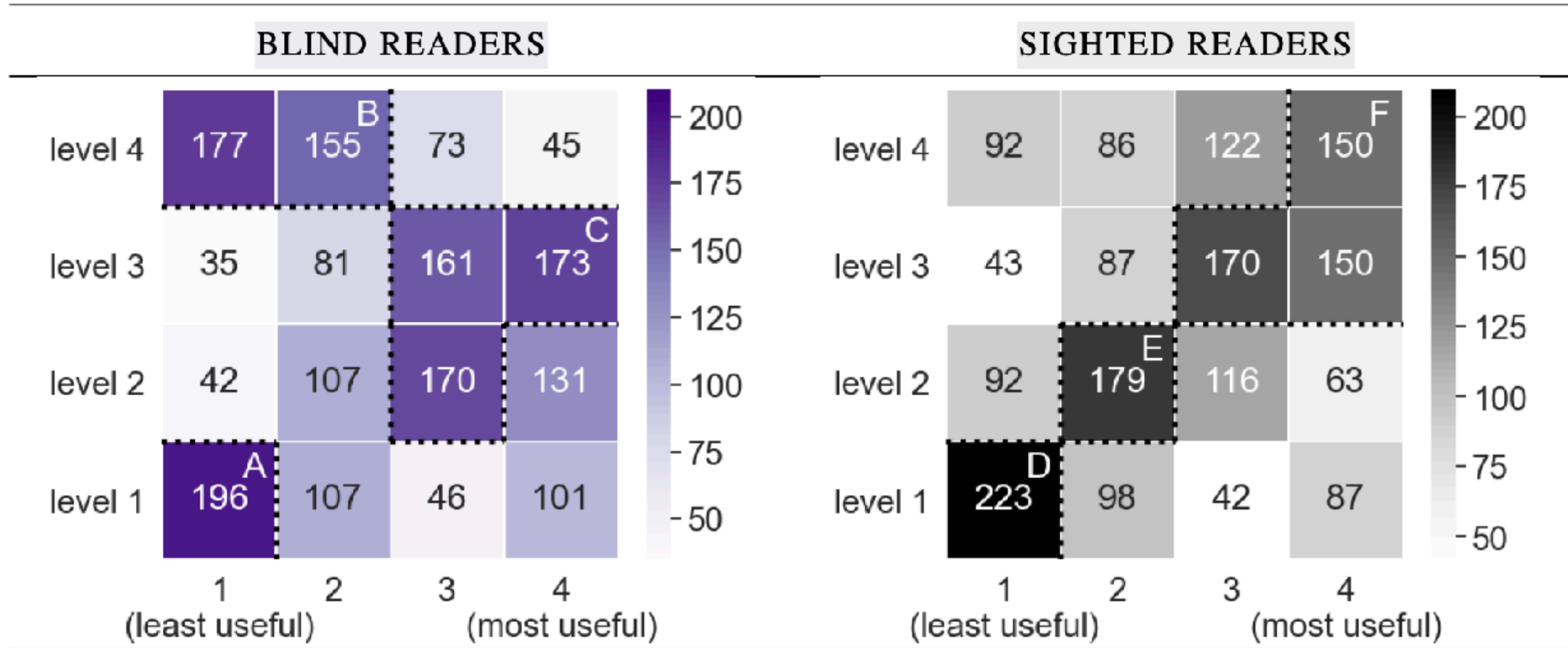


- [1] This is a multi-line chart entitled “Big Tech Stock Prices” that plots price by date. The corporations include AAPL (Apple), AMZN (Amazon), GOOG (Google), IBM (IBM), and MSFT (Microsoft). The years are plotted on the horizontal x-axis from 2000 to 2010 with an increment of 2 years. The prices are plotted on the vertical y-axis from 0 to 800 with an increment of 200.
- [2] GOOG has the greatest price over time. MSFT has the lowest price over time.
- [3] Prices of particular Big Tech corporations seem to fluctuate but nevertheless increase over time. Years 2008-2009 are exceptions as we can see an extreme drop in prices of all given corporations.
- [4] The big drop in prices was caused by financial crisis of 2007-2008. The crisis culminated with the bankruptcy of Lehman Brothers on September 15, 2008 and an international banking crisis.
- [5] At the beginning of 2008, every of this stock price went down, likely due to the financial crisis.
- [6] Then they have risen again and dropped again, more so than previously.
- [7] GOOG has the highest price over the years. MSFT has the lowest price over the years.
- [8] GOOG quickly became the richest one of the Big Tech corporations.
- [9] GOOG had experienced some kind of a crisis in 2009, because their prices drop rapidly, but then rebounded.

[Alan Lundgard & Arvind Satyanarayan, in submission to VIS 2021]

# Captions and Alt-Text

#	LEVEL KEYWORDS	SEMANTIC CONTENT	COMPUTATIONAL CONSIDERATIONS
4	contextual and domain-specific	<i>causal inferences and explanations, cultural and political relationships, current events</i>	<i>reader-dependent: contextual knowledge and domain-specific insights</i>
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[Alan Lundgard & Arvind Satyanarayan, in submission to VIS 2021]

[skip to main content](#)

# CHARTABILITY

[What is Chartability?](#) [Get the Workbook](#) [Get Help](#) [Learn More](#) [Support Us](#) [Credits](#)

## What is Chartability?

Chartability is a methodology for ensuring that data visualizations, systems, and interfaces are accessible. Chartability is organized into principles with testable criteria and focused on creating an outcome that is an inclusive data experience for people with disabilities.

### What is Accessibility?

Accessibility (also sometimes abbreviated as *a11y*) is the practice of ensuring that as many people as possible can use, understand, and have access to a technology, infrastructure, tool, product, or service.

### What is Data Visualization?

Data Visualization (also sometimes abbreviated as *dataviz* or *datavis*) is presenting data in a structured, symbolic way. The structure and semantics go beyond the visual, however, so we prefer to call these **data experiences**.

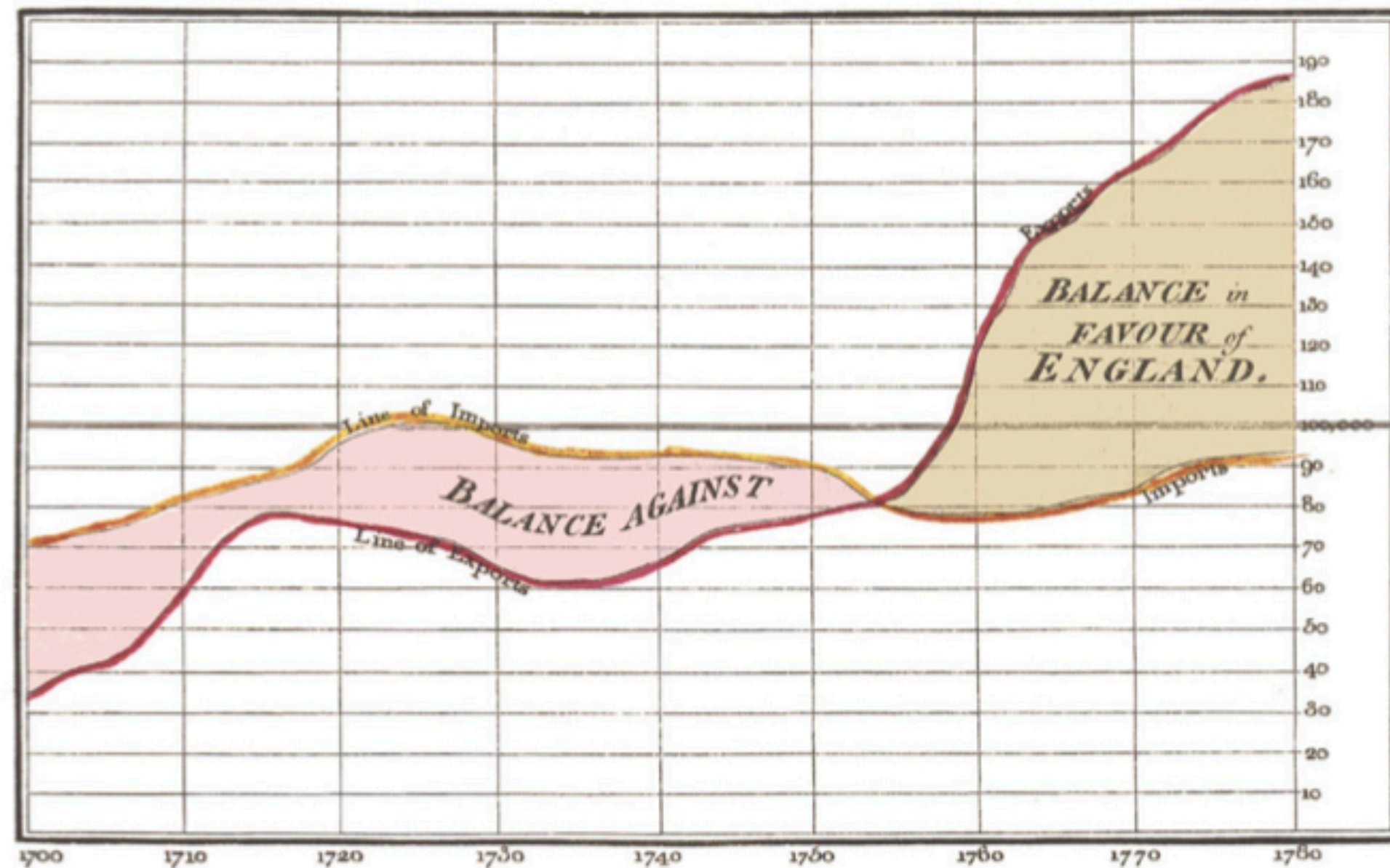
With the massive rise in data-driven journalism, the ease and availability of charting and analytical solutions, and data's near-ubiquitous appearance in public life, more thorough and robust accessibility considerations are overdue.

**Chartability's Principles**

**Why use Chartability?**

# Alternate Modalities

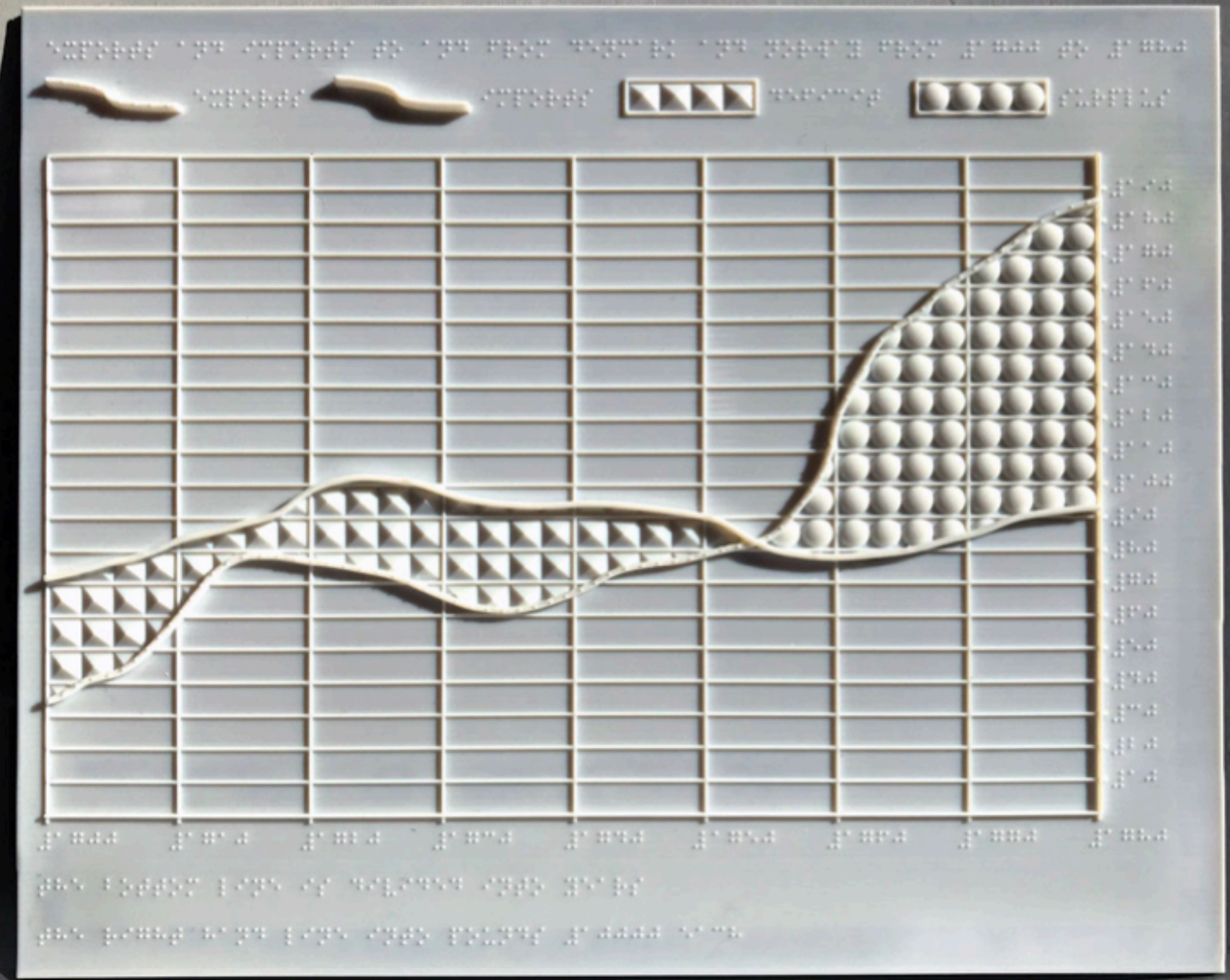
Exports and Imports to and from DENMARK & NORWAY from 1700 to 1780



The Bottom line is divided into Years, the Right hand line into L10000 each.

Published as the Act done, 17<sup>th</sup> May 1786, by W<sup>th</sup> Playfair

Printed and sold by S. Smith, Strand, London.



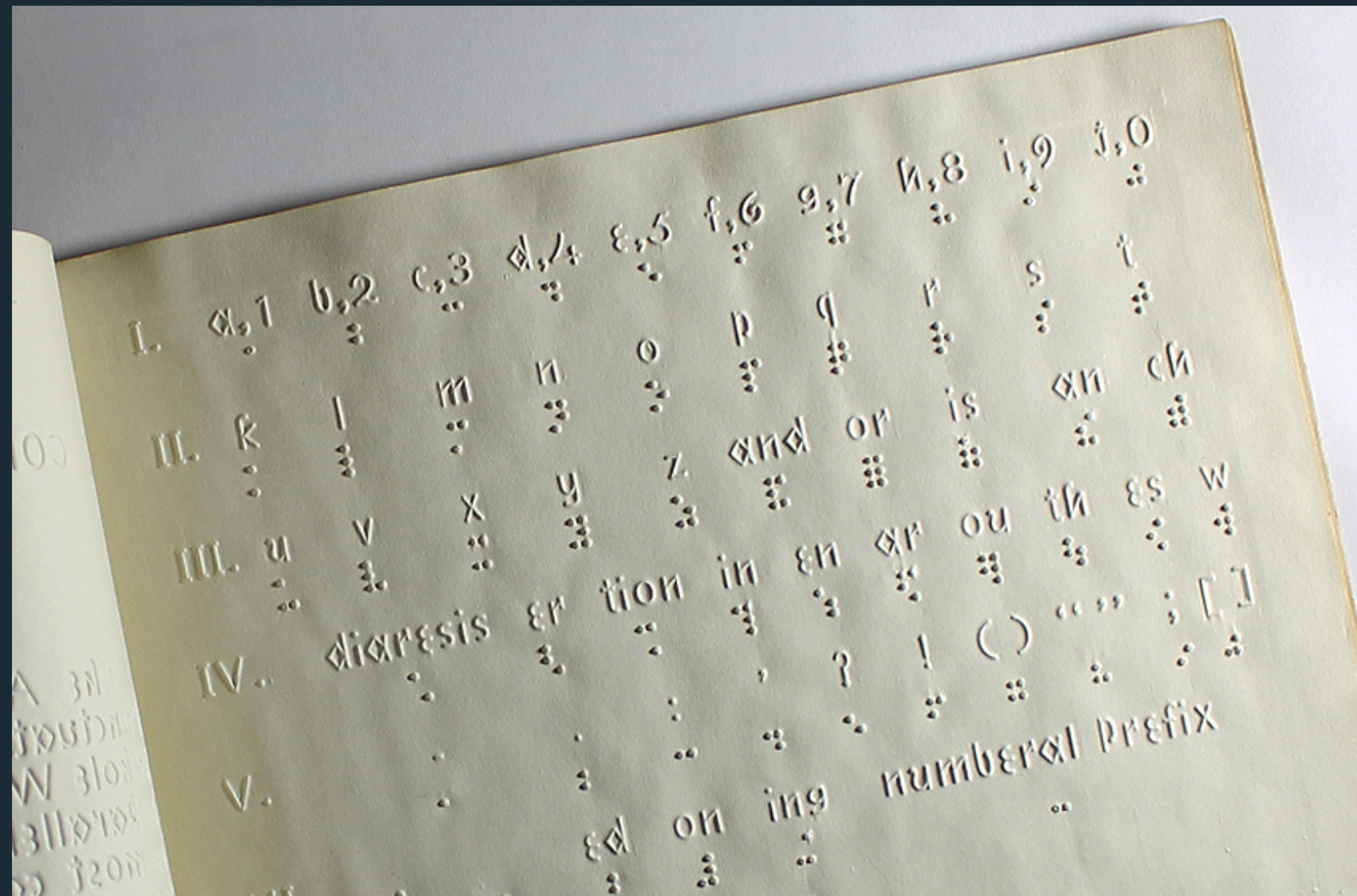


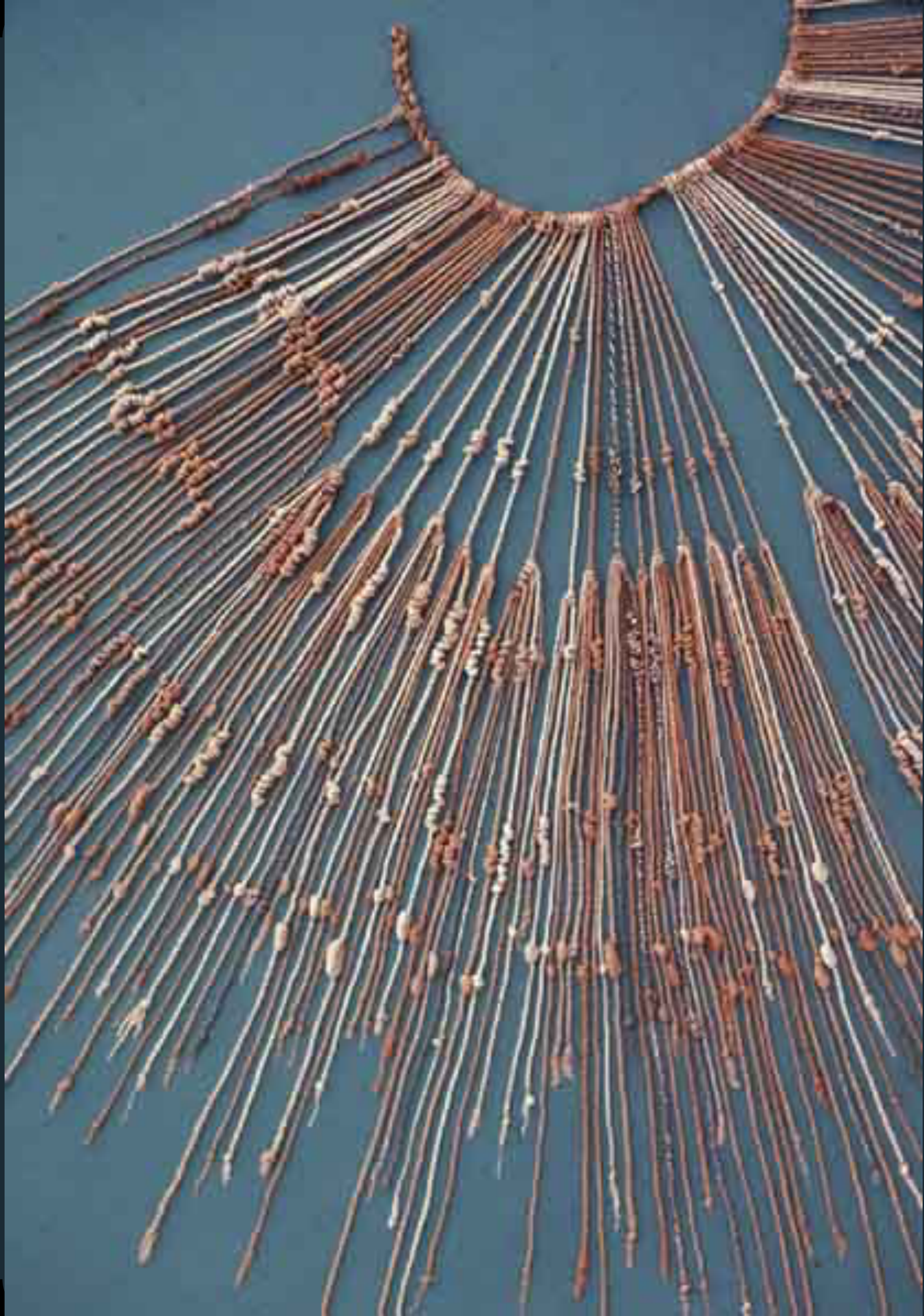
Perkins Institution for the Blind  
 Workshop Department  
 Salesroom—133 Newbury Street

The Perkins workshop makes new and renovates old hair mattresses, pillows, and down puffs, and repairs all cane chairs; it supplies wood and metal bedsteads, and upholstered springs.

Our Salesroom is used in the interests of blind people and of the patrons of their work. Anyone having poor sight may find there special appliances for writing, also clear type books, checkers, cards and other games, etc.

*1000 copies  
 Printed  
 3/25/22*



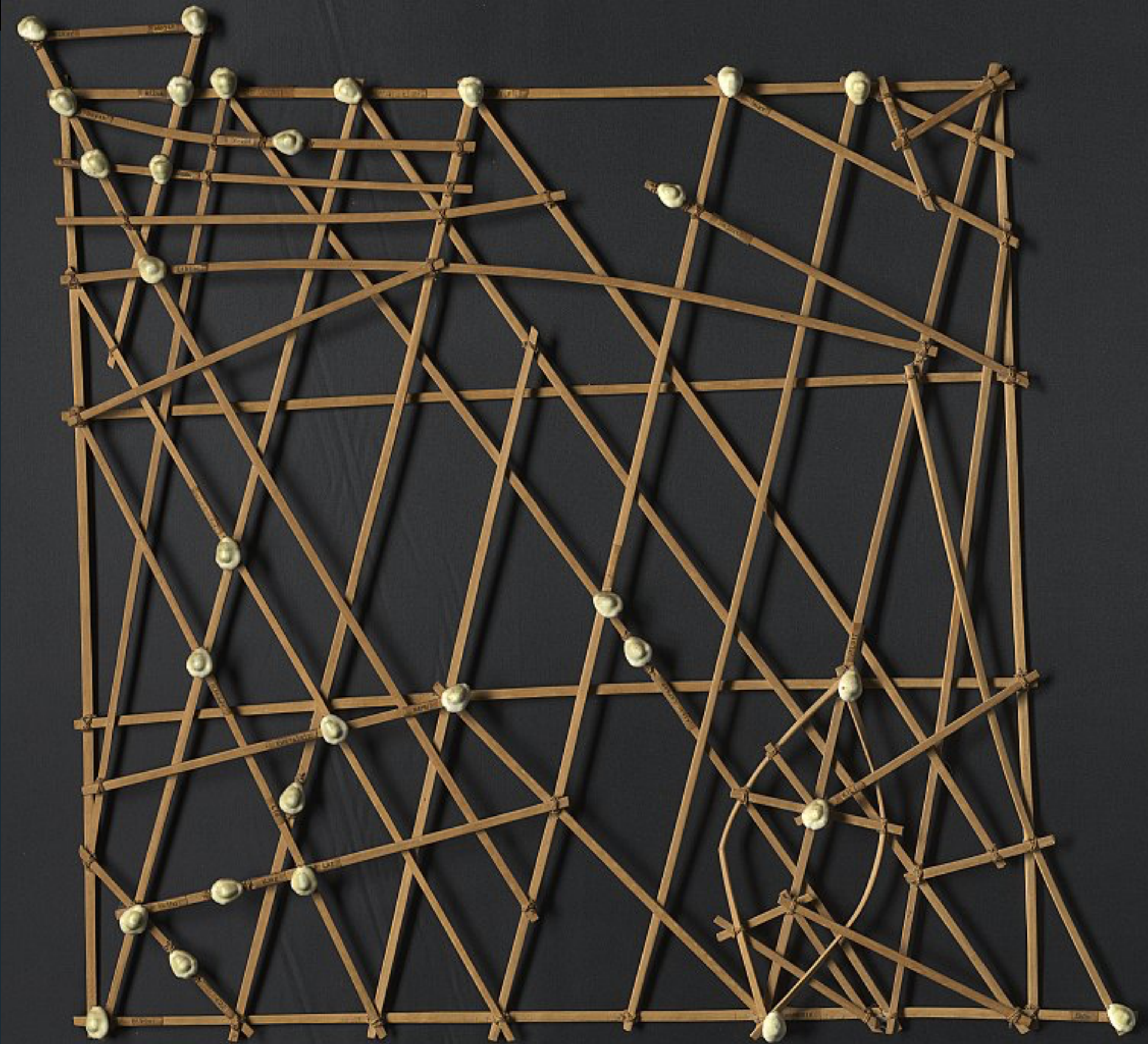


# Quipus (c. 2600 BC)

Complex knotted ropes used in South America as data storage devices.

Played an important role in Inca administration.

From the *Gallery of Physical Visualization and Related Artifacts* by Pierre Dragicevic and Yvonne Jansen.



# Marshall Islands Stick Charts (c.1862)

Physical visualization show  
ocean swell patterns.

Built by native Micronesians  
from the Marshall Islands to  
facilitate canoe navigation.

*From the Gallery of Physical Visualization and  
Related Artifacts by Pierre Dragicevic and  
Yvonne Jansen.*



# Polynesian Genealogical Instrument

Served as a memory aid for reciting genealogies during ceremonies.

Made of woven coconut fiber.

Each thread is a genealogical line, each knot is a generation.

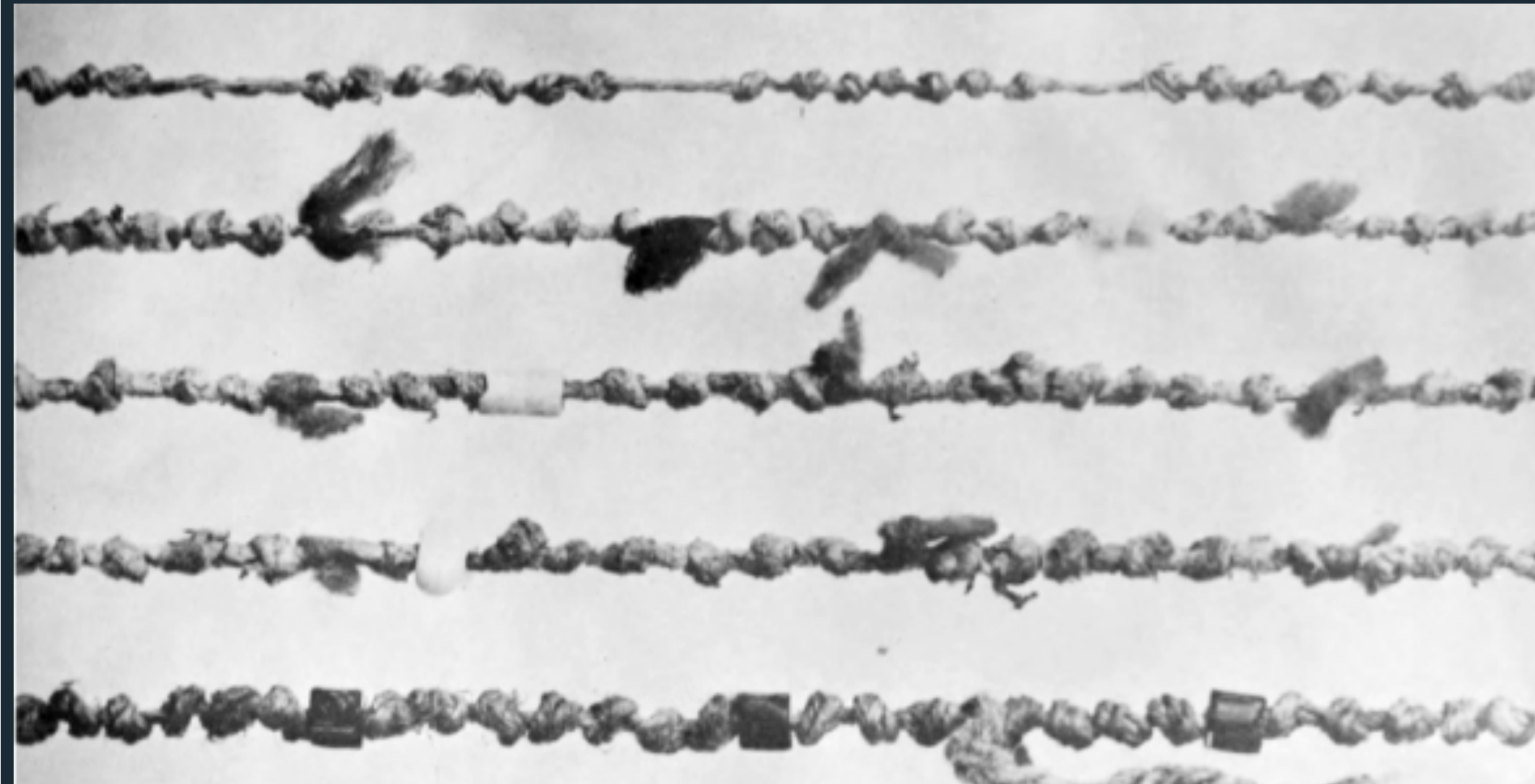
Goes back to mythical origins of Earth (materialized by oblong ball on top made of wood).

*From the Gallery of Physical Visualization and Related Artifacts by Pierre Dragicevic and Yvonne Jansen.*

# Yakama Time Ball

Women from the Yakama Native America tribe used strings of hemp as personal diaries.

Each major event in their life was represented by a knot, bead, or shell.



From the *Gallery of Physical Visualization and Related Artifacts* by Pierre Dragicevic and Yvonne Jansen.

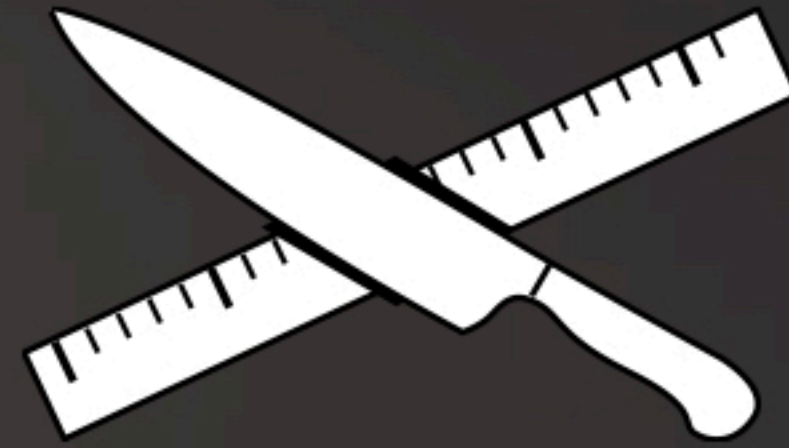




# DATA CUISINE

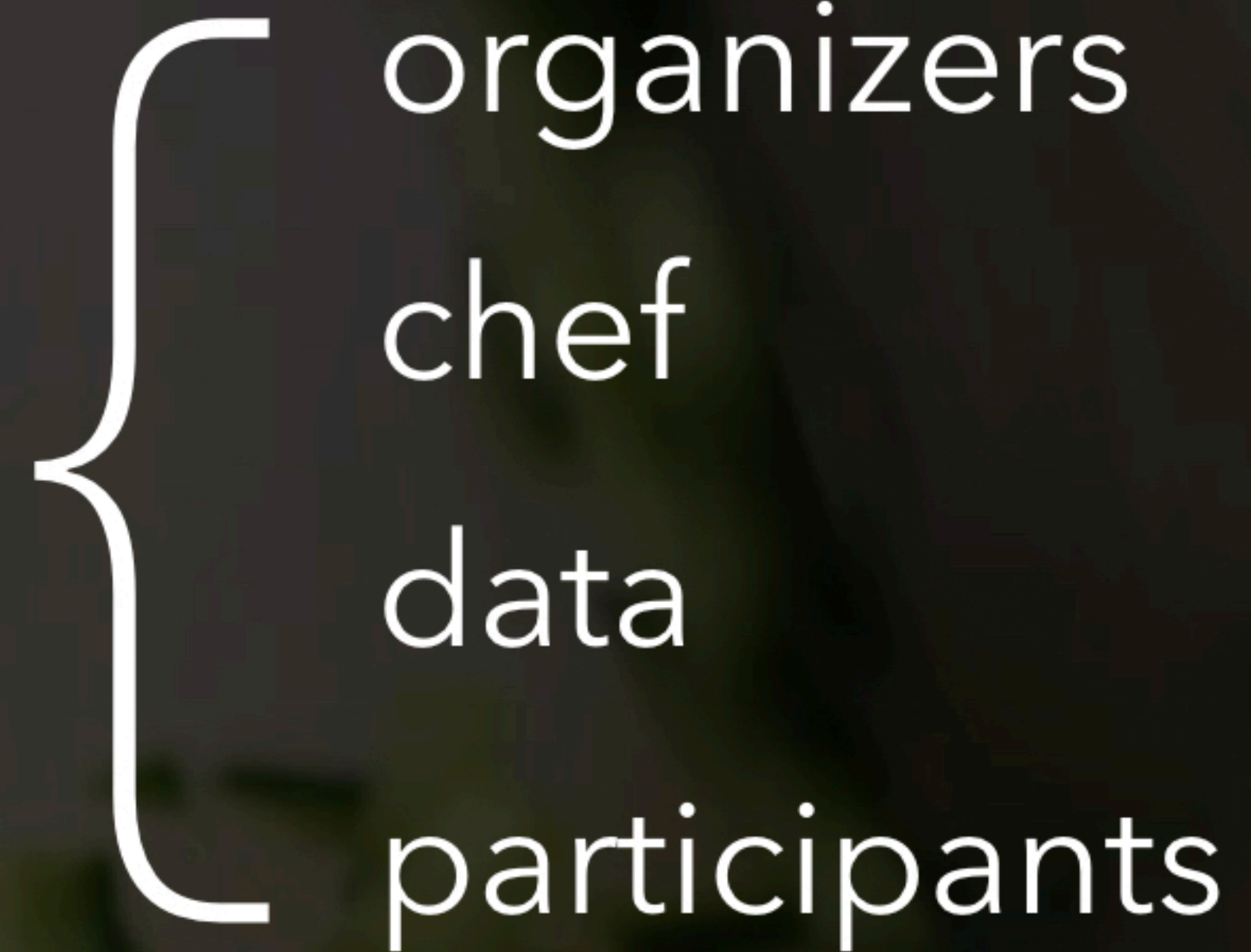
# DATA CUISINE

## WORKSHOP



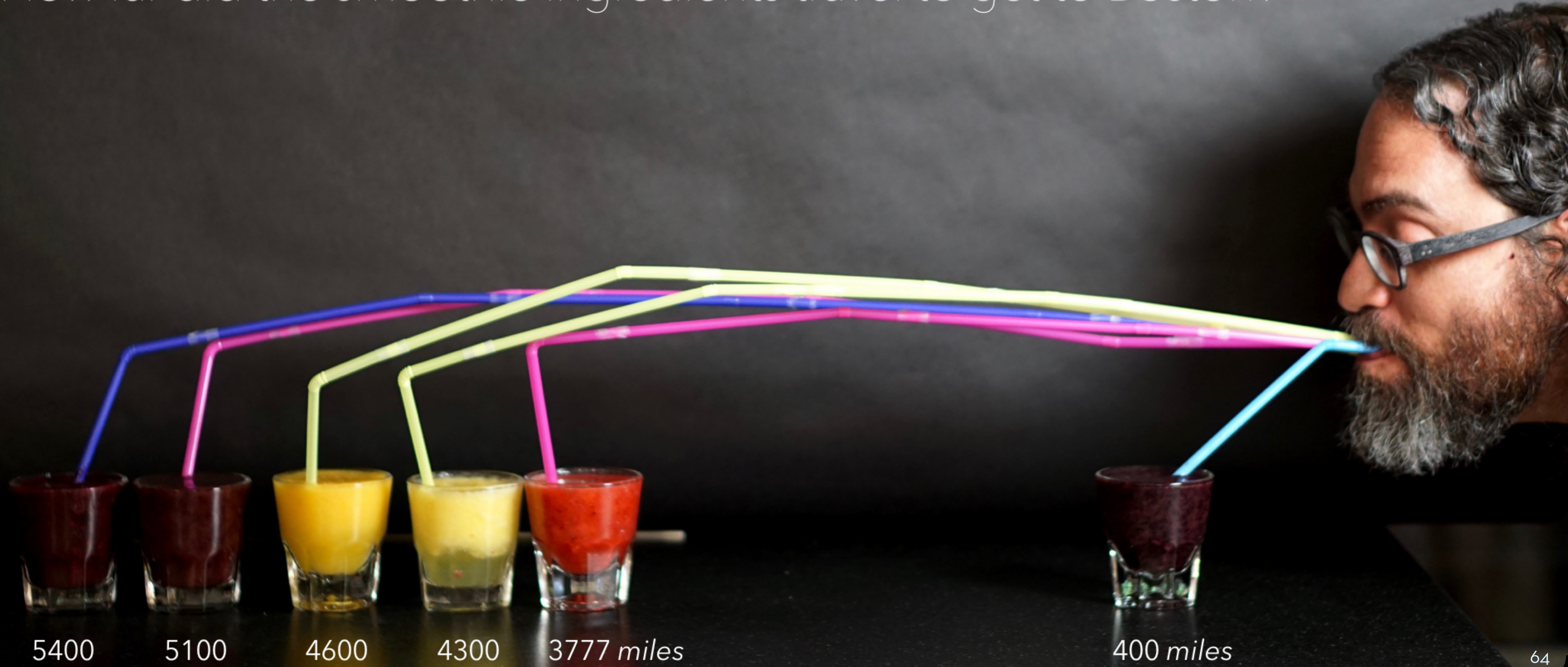
Susanne Jaschko  
Moritz Stefaner

+ local



# Deconstructed Food Miles Smoothie

How far did the smoothie ingredients travel to get to Boston?





# Liquid assets

Which parts of the population have access to liquid assets?

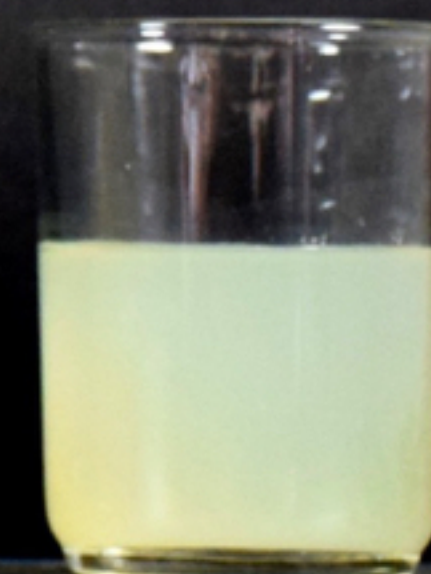
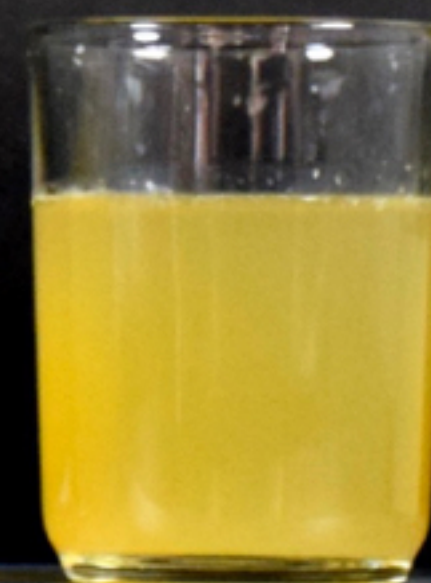
95.7%

82.6%

84.8%

63.3%

57.2%



**US white**

*Privateer Silver Serve  
Rum*

**US black**

*GrandTen Distilling  
Medford*

**Caribbean Black**

*Plantation 5-  
Year Grand  
Reserve*

**Dominican**

*Brugal Anejo Superior*

**Puerto Rican**

*Bacardi  
Superior*



# Sea Change

The effects of climate change on fish and shellfish populations



Lobster

Cod

1948t  
2014