

Voyager: Exploratory Analysis via Faceted Browsing of Visualization Recommendations

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Dominik Moritz, Bill Howe, Jeffrey Heer
University of Washington

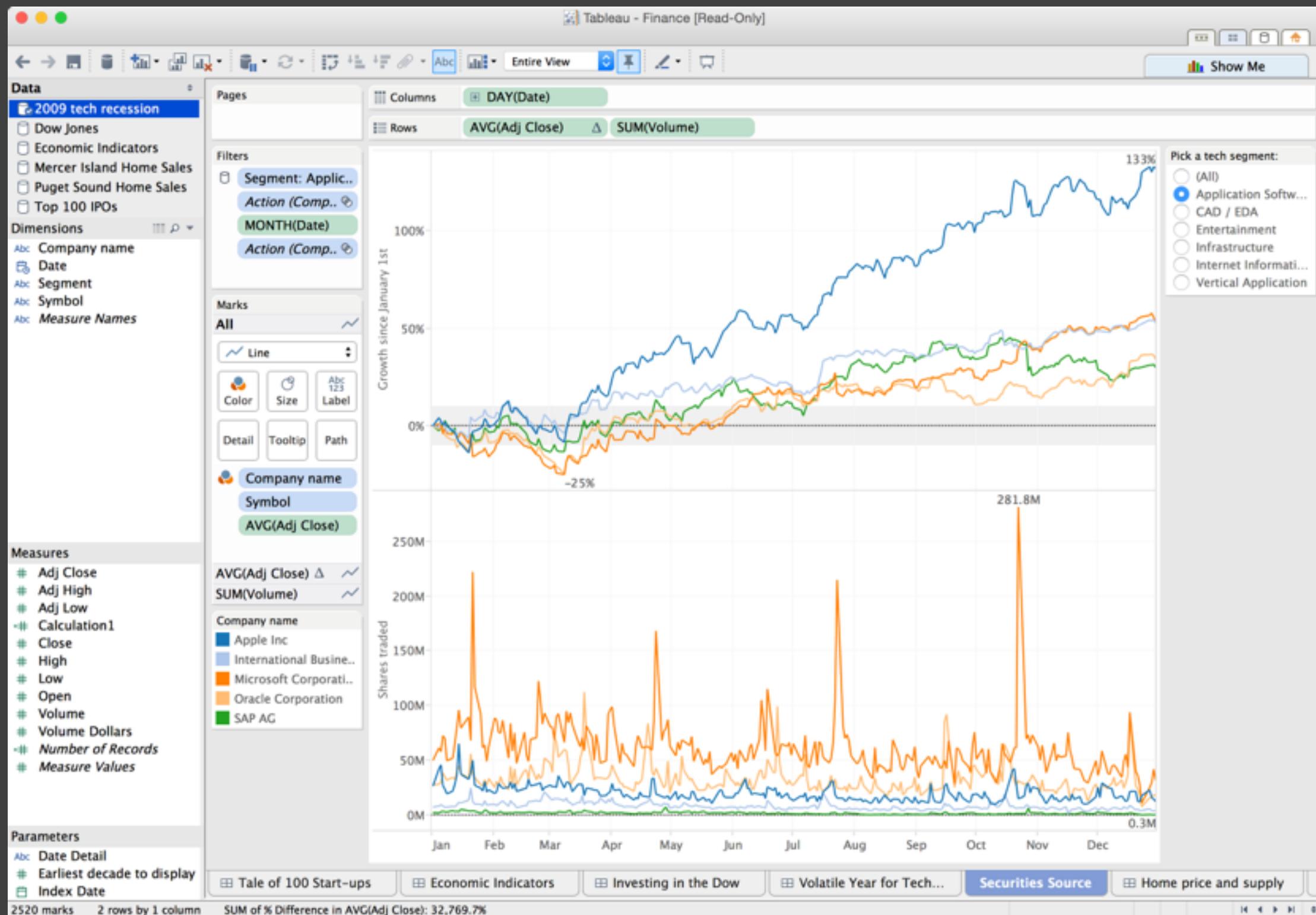
Anushka Anand, Jock Mackinlay
Tableau Research

@kanitw
@domoritz
@uwdata



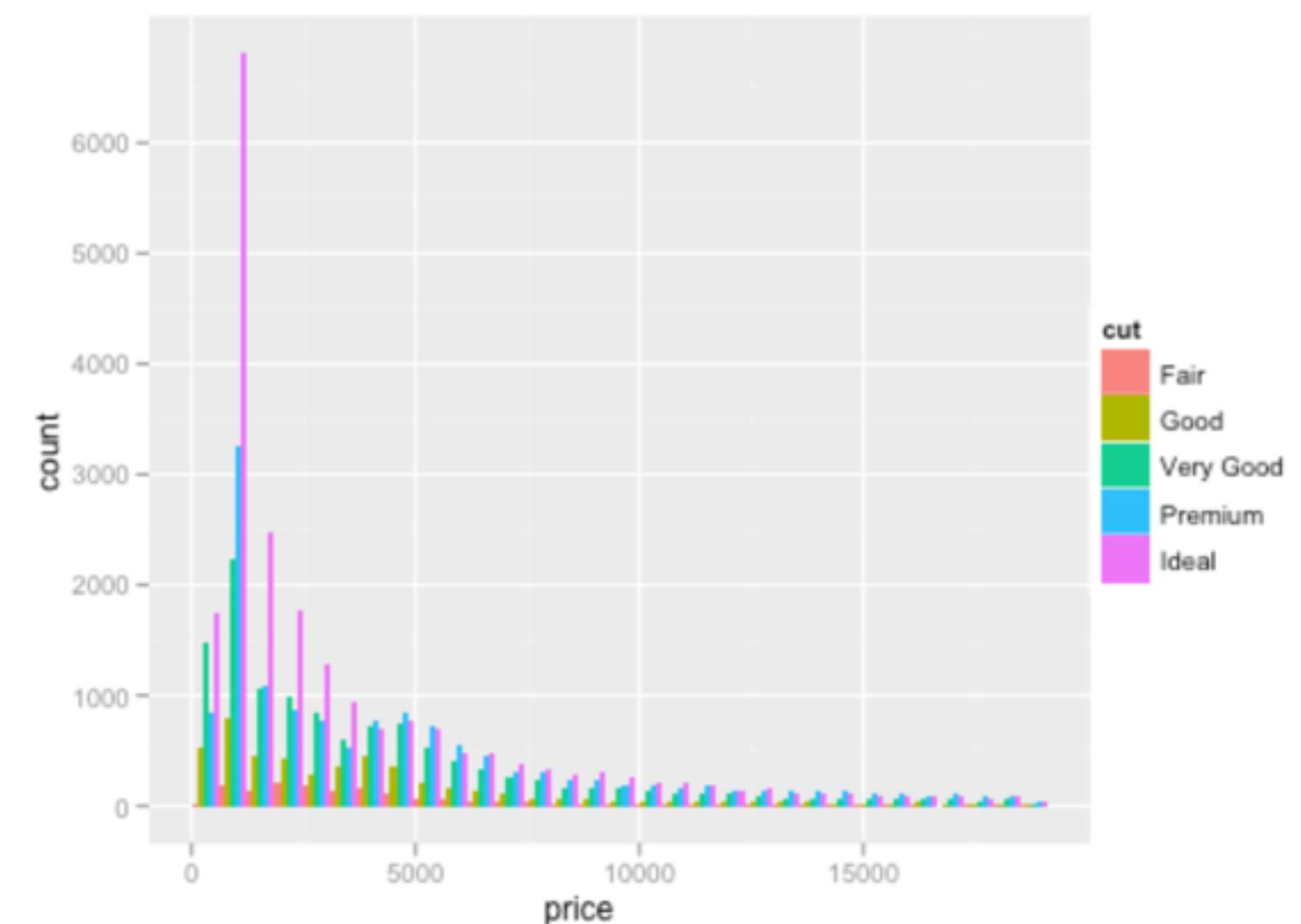
Interaction Method for Exploratory Analysis

Manual View Specification



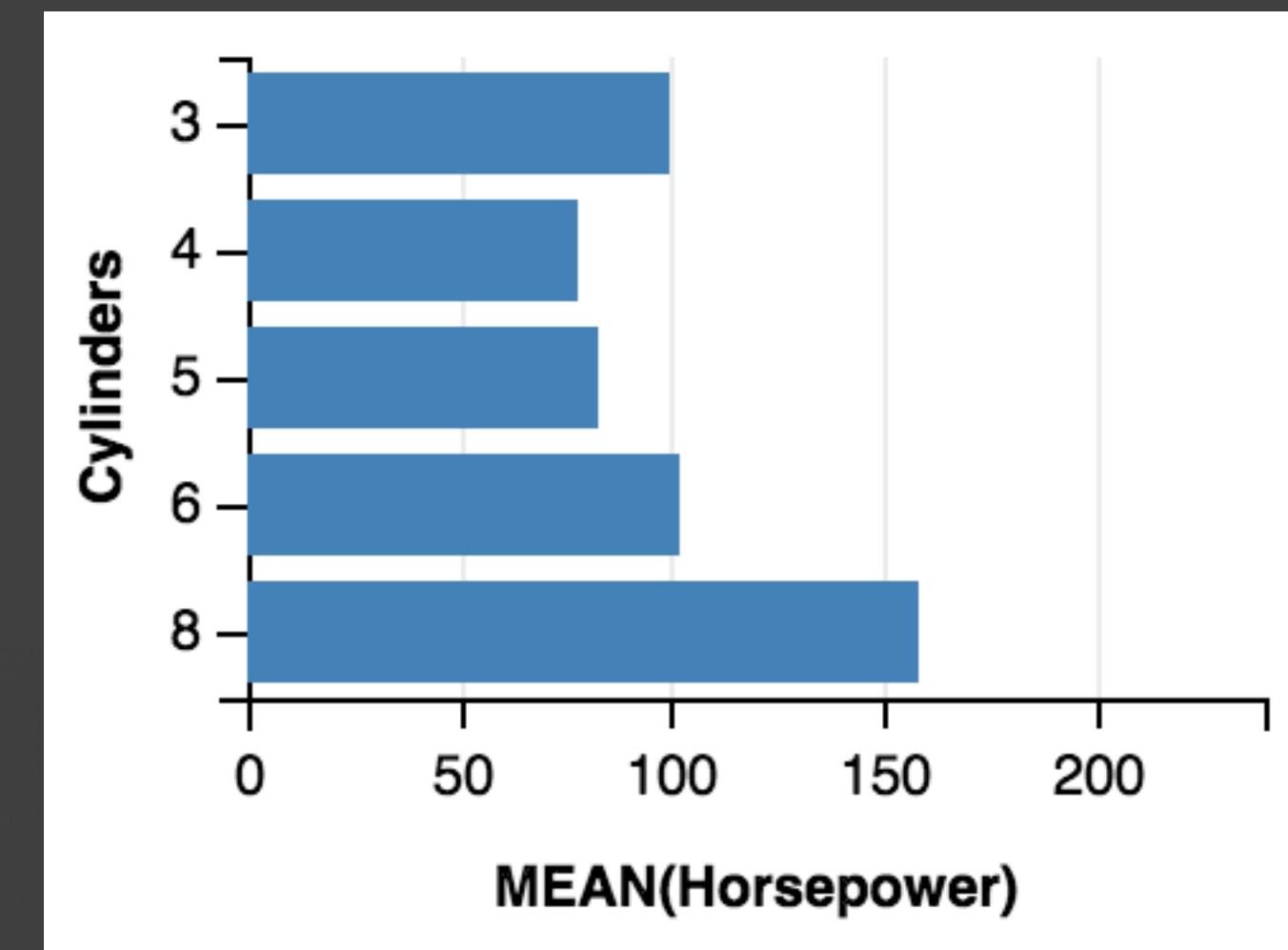
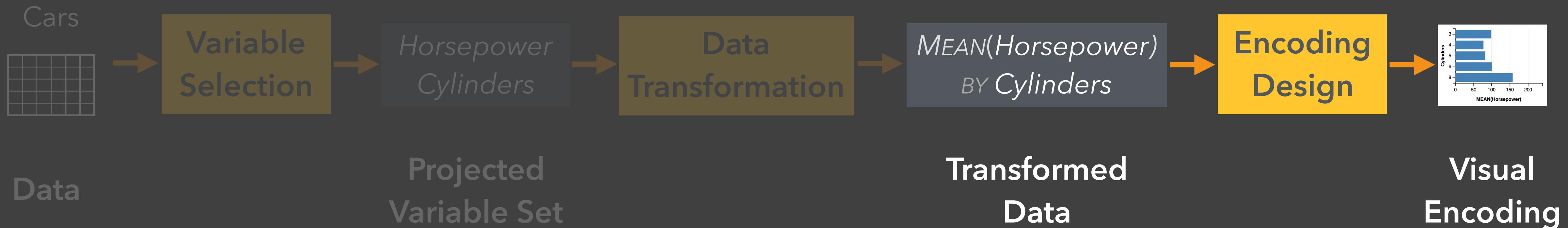
Graphical Interface
Tableau

```
ggplot(diamonds, aes(x=price, fill=cut))  
+ geom_bar(position="dodge")
```

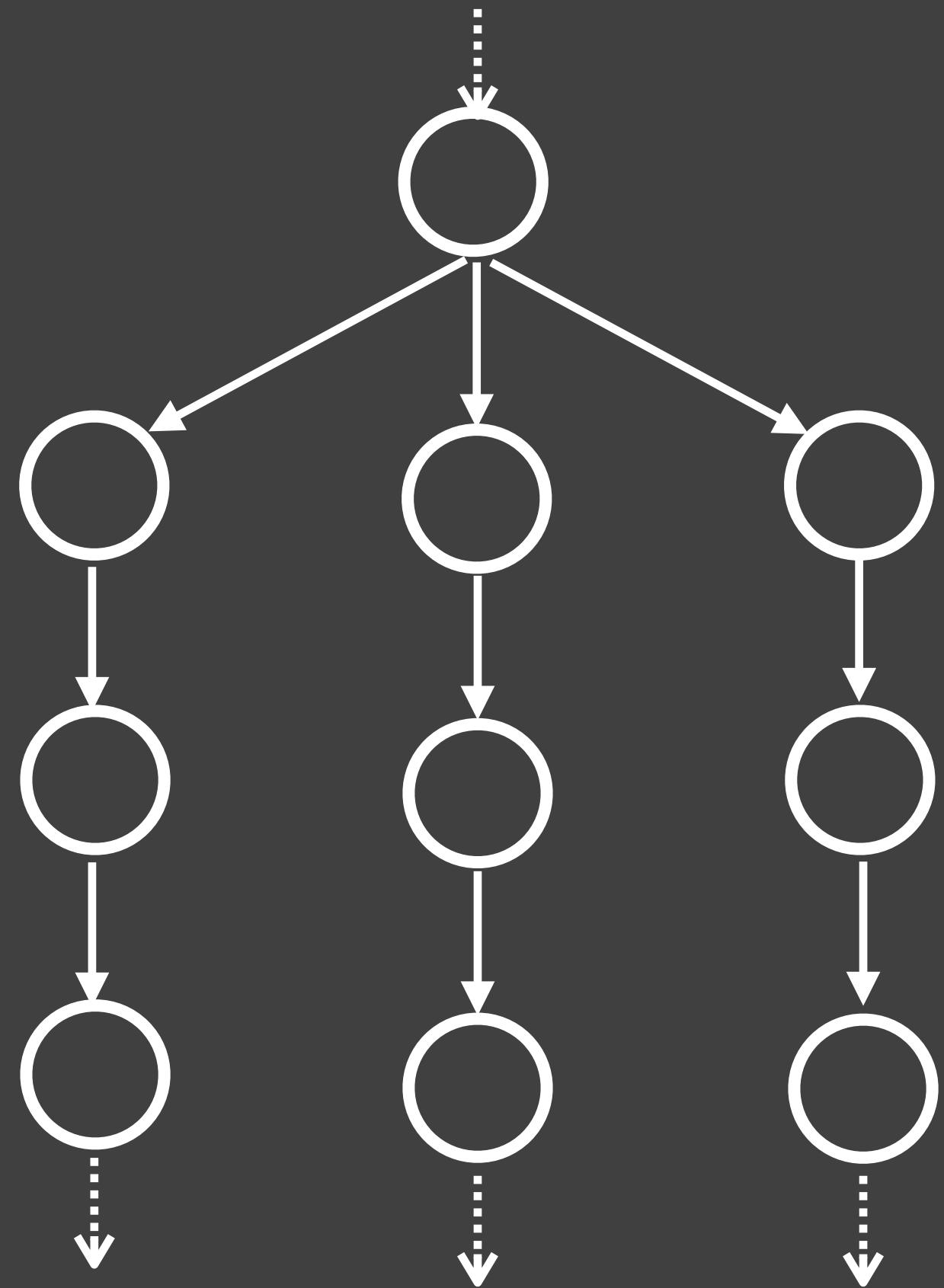


Programming Language
Grammar of Graphics, ggplot2

Manual View Specification



Manual View Specification



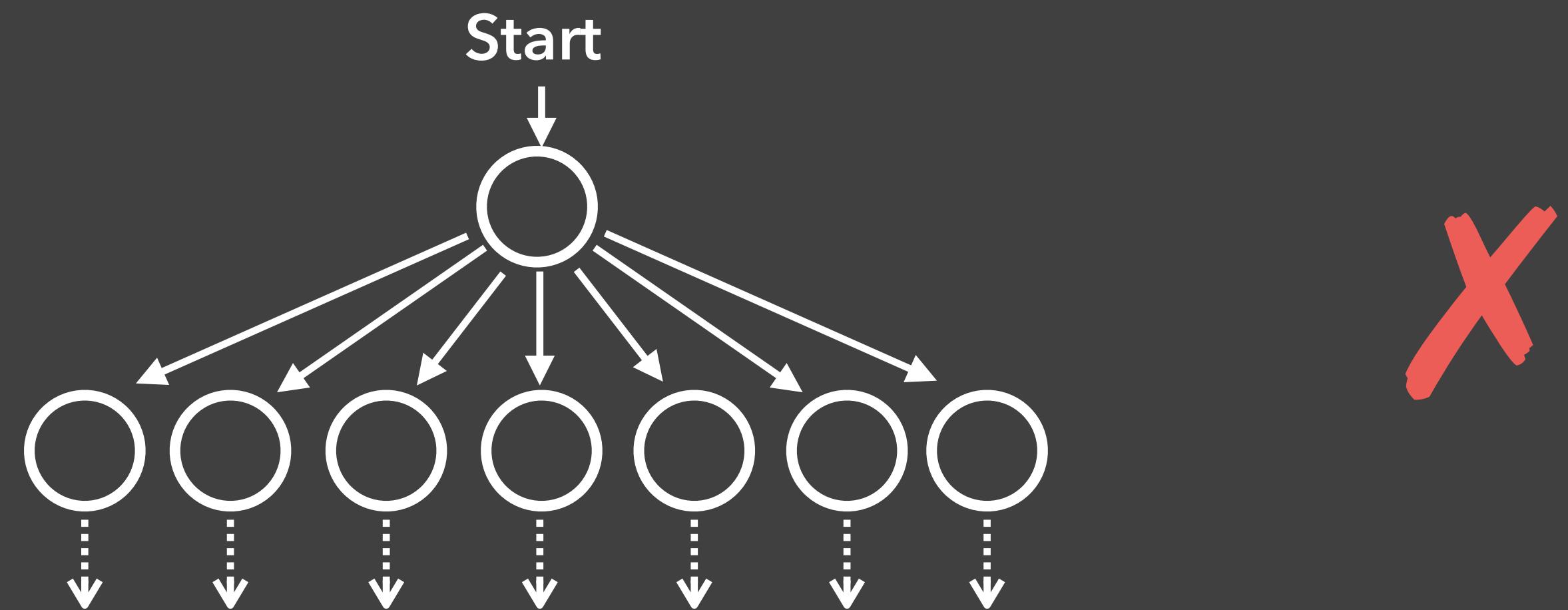
**Targeted Question
Answering**

But...

in early stages of exploration, analysts might

- (1) **lack prior exposure to the data**
- (2) begin with **vague analysis goals.**

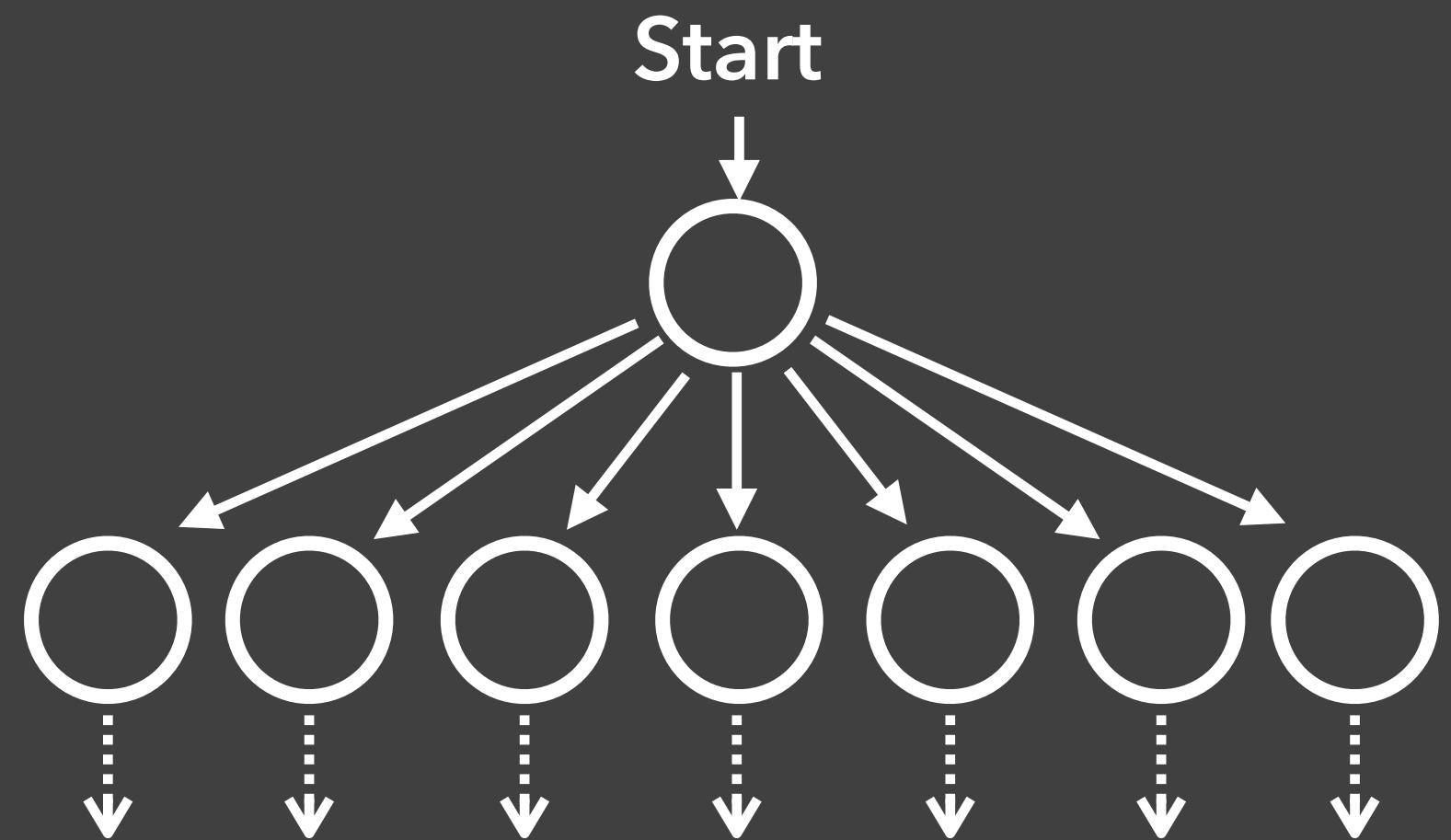
Manual View Specification



**Breadth-oriented
Exploration**

Tedium & fixation!

Browsing Recommended Charts



Breadth-oriented
Exploration

~~Tedium & fixation!~~

Voyager

Exploratory Analysis via Faceted Browsing of Visualization Recommendations

Introduction
The Design of Voyager
System Architecture
Evaluation
Future Work

Background

Exploratory Search

*Faceted Browsing Yee et al.'01
Recommender System*

Flamenco

Refine your search further within these categories: These terms define your current search. Click the to remove a term.

Media (group results)
costume (3), drawing (2),
lithograph (1), woodcut (6), woven object (2)

Location: Asia **start a new search**

Shapes, Colors, and Materials: fabrics

Date (group results)
17th century (3), 18th century (3),
19th century (10), 20th century (3),
date ranges spanning multiple centuries (7), date unknown (2)

Themes (group results)
music, writing, and sport (5),
nautical (1), religion (2)

Objects (group results)
clothing (5), food (1), furnishings (4),
timepieces (1)

Nature (group results)
bodies of water (3), fish (1),
flowers (2), geological formations (1), heavens (3),
invertebrates and arthropods (1),
mammals (2), plant material (3),
trees (1)

Places and Spaces (group results)
bridges (1), buildings (1),
dwellings (1)

Location: Asia **start a new search**

Shapes, Colors, and Materials: fabrics

Date (group results)
Search all items within current results

28 items (grouped by location) [view ungrouped items](#)

Afghanistan

Girl's Ceremonial...
no artist
20th century

China

4 boats on lake,...
Anonymous
post World War II


Embroidery
no artist
19th century


Embroidery
no artist
19th century


Embroidery :
no artist
19th century

Background

Exploratory Search

Faceted Browsing Yee et al.'01
Recommender System

Flamenco

Refine your search further within these categories:

- Media (group results)
costume (3), drawing (2), lithograph (1), woodcut (6), woven object (2)
- Location: all > Asia
Afghanistan (1), China (4), China or Tibet? (3), India (2), Japan (13), Russia (1), Turkey (3), Turkmenistan (1)
- Date (group results)
17th century (3), 18th century (3), 19th century (10), 20th century (3), date ranges spanning multiple centuries (7), date unknown (2)
- Themes (group results)
music, writing, and sport (5), nautical (1), religion (2)
- Objects (group results)
clothing (5), food (1), furnishings (4), timepieces (1)
- Nature (group results)
bodies of water (3), fish (1), flowers (2), geological formations (1), heavens (3), invertebrates and arthropods (1), mammals (2), plant material (3), trees (1)
- Places and Spaces (group results)
bridges (1), buildings (1), dwellings (1)

These terms define your current search. Click the to remove a term.

Location: Asia
Shapes, Colors, and Materials: fabrics

start a new search

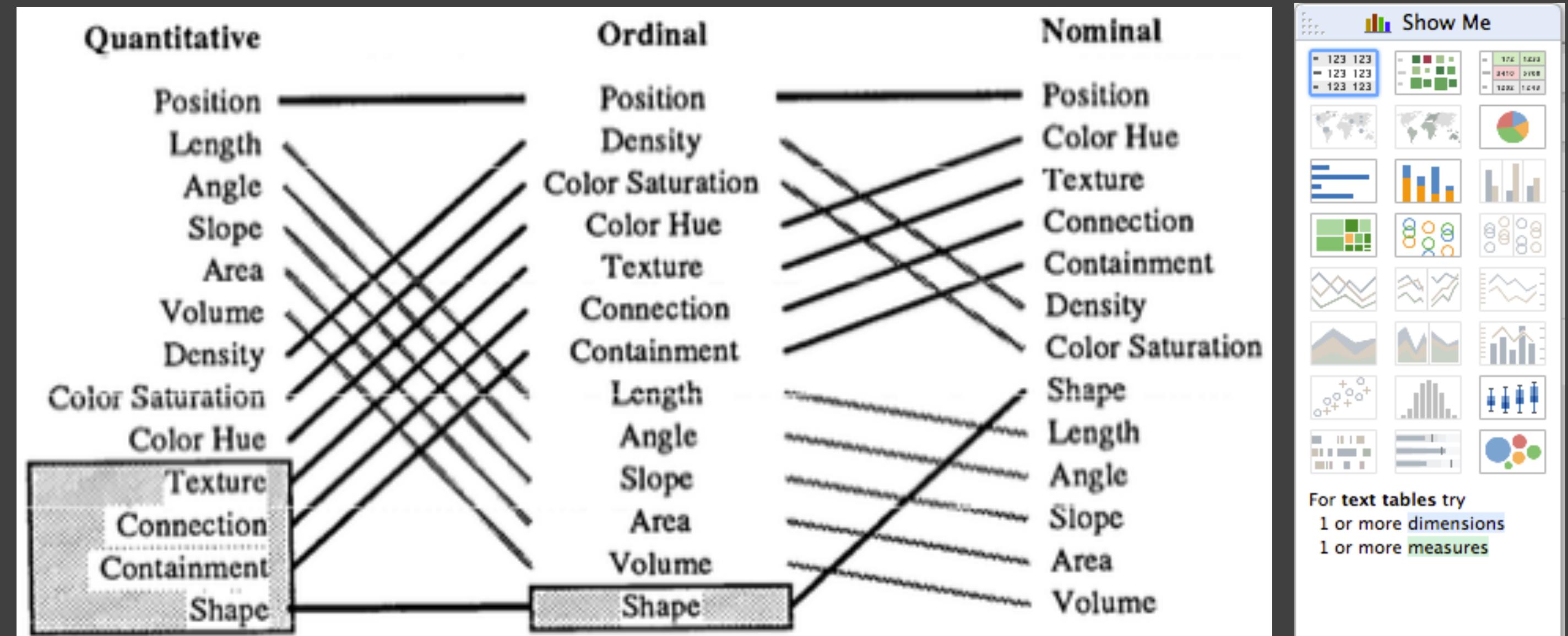
Search all items within current results

28 items (grouped by location) [view ungrouped items](#)

Afghanistan
China
4 boats on lake...
Anonymous post World War II
Embroidery no artist 19th century
Embroidery no artist 19th century
Embroidery : no artist 19th century

Automated Visualization Design

APT Mackinlay'87
Show Me Mackinlay et al. '06



Data

Cars

Change

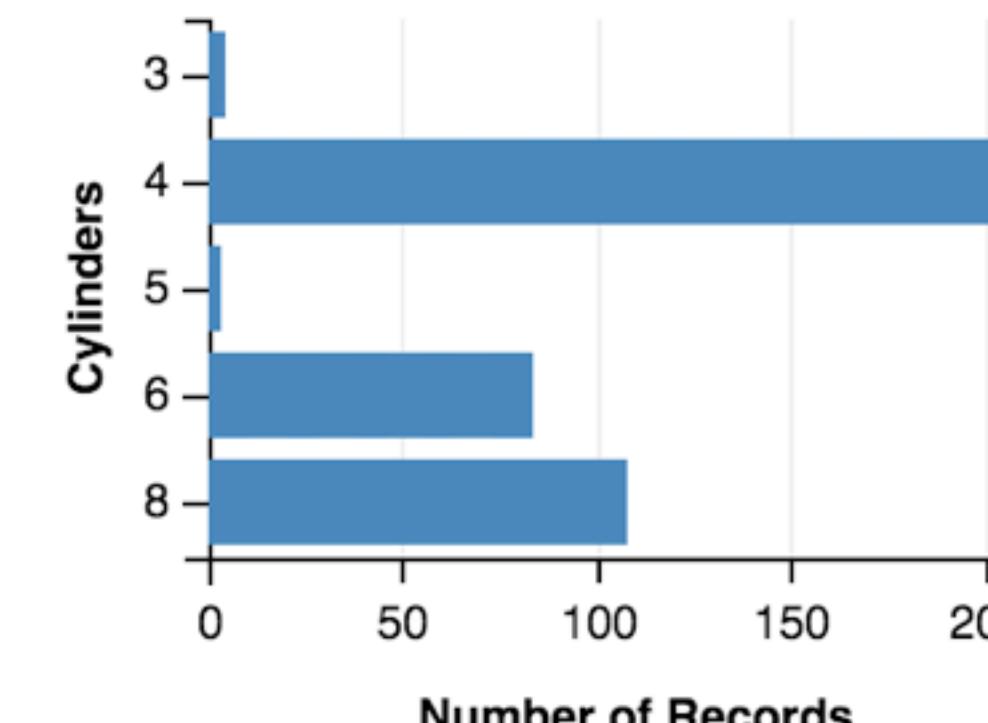
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

 Reset

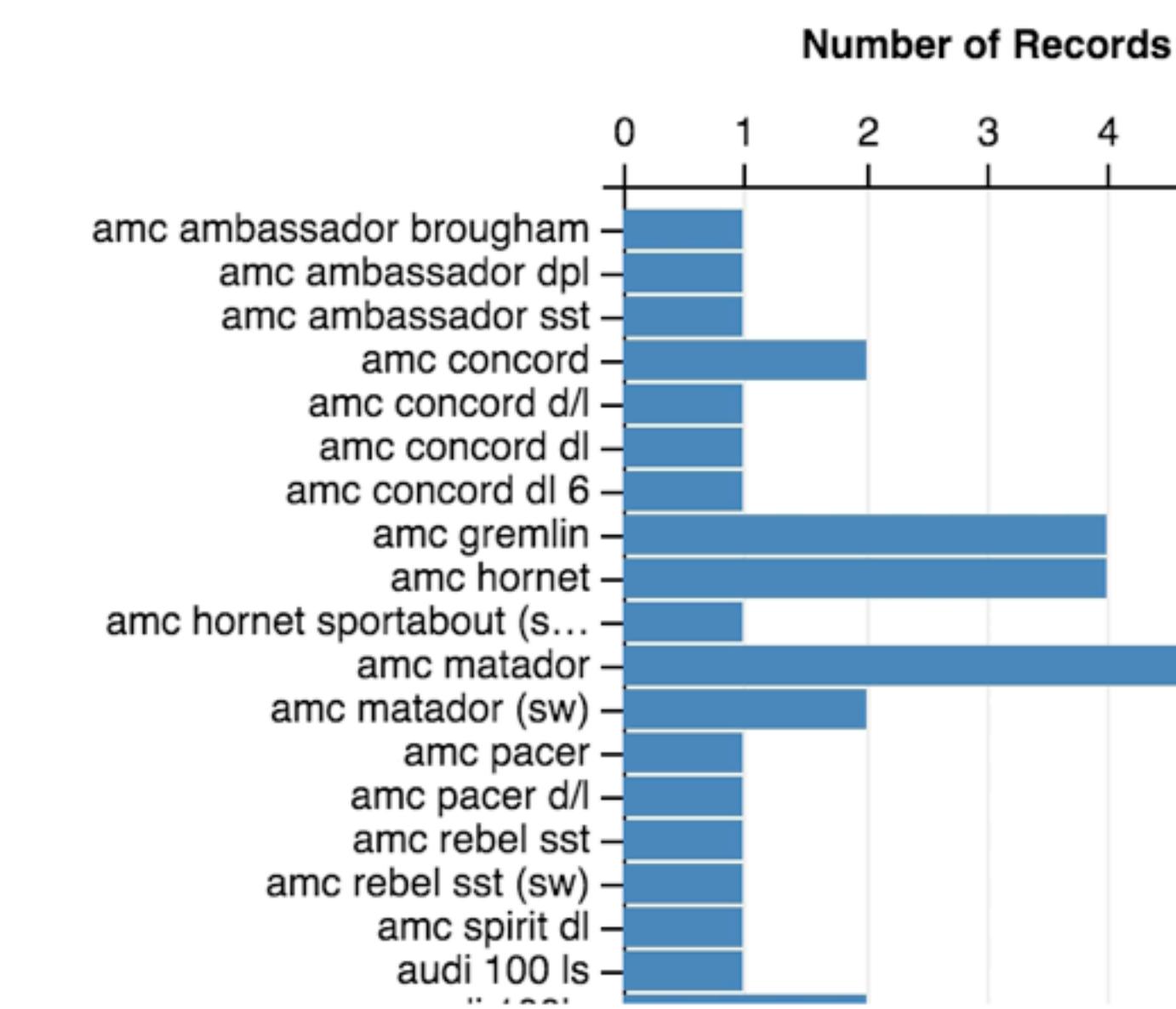
Explore univariate summaries of each field

Start exploring data by examining each field and continue by selecting interesting data fields in data selector panel.

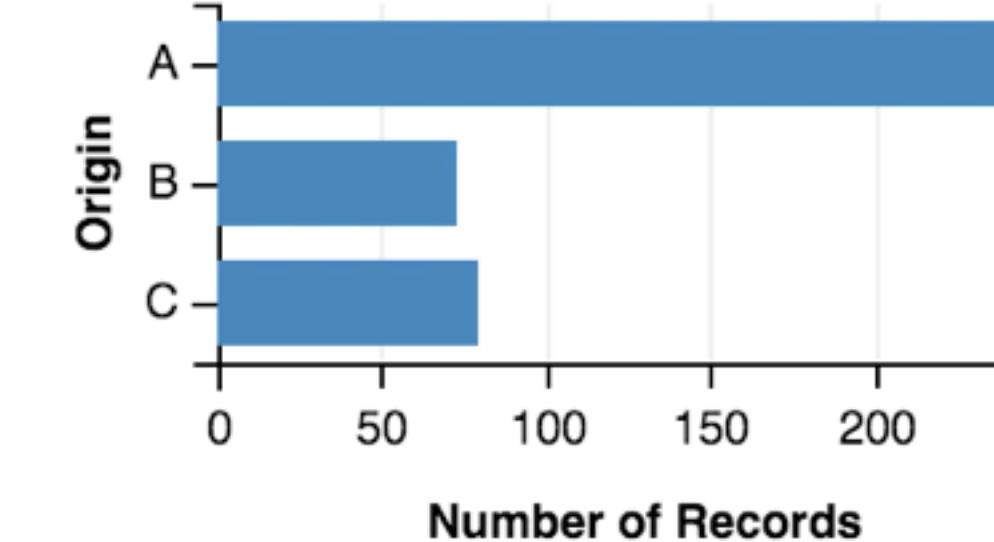
A Cylinders # COUNT



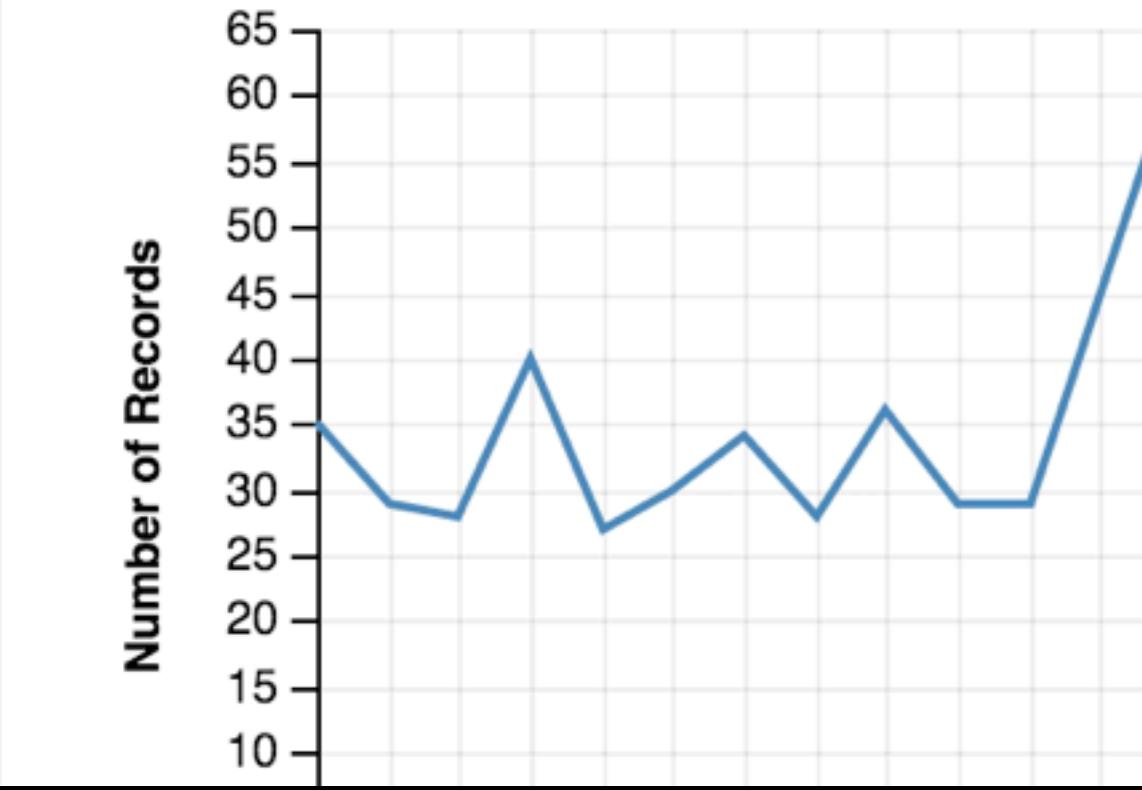
A Name # COUNT



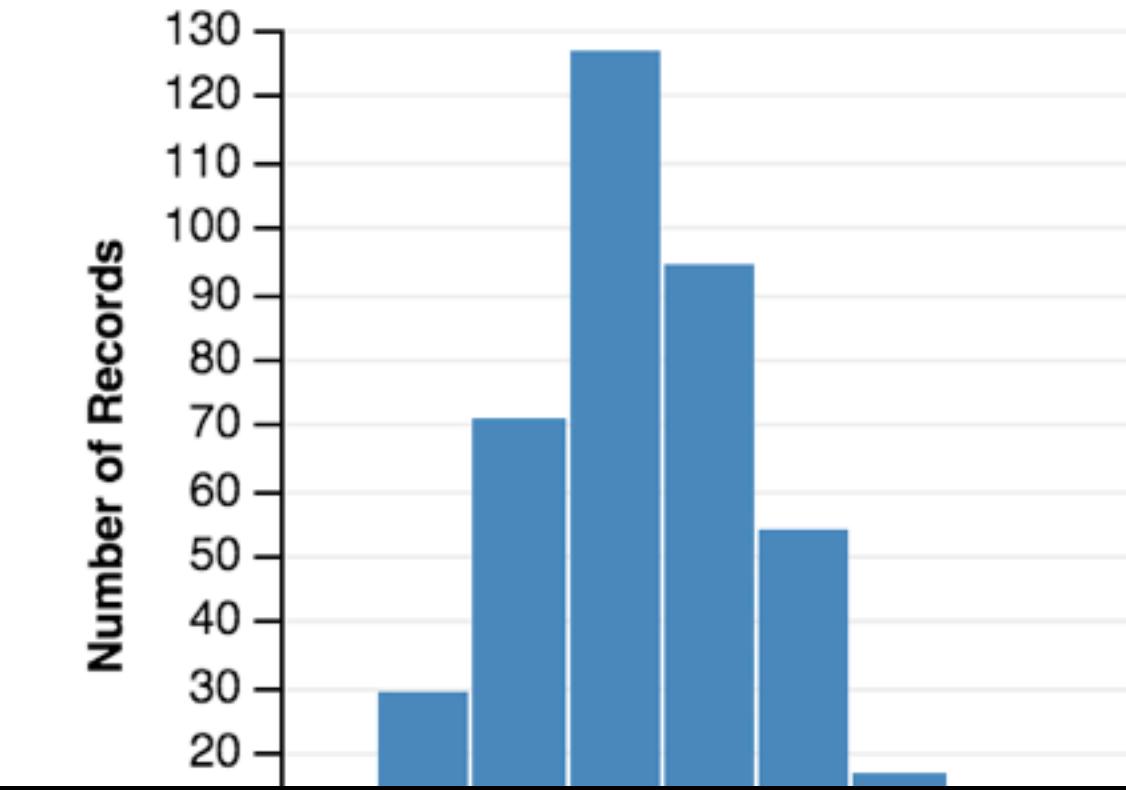
A Origin # COUNT



YEAR (Year) # COUNT



BIN (Acceleration) # COUNT



Data

Cars

Change

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

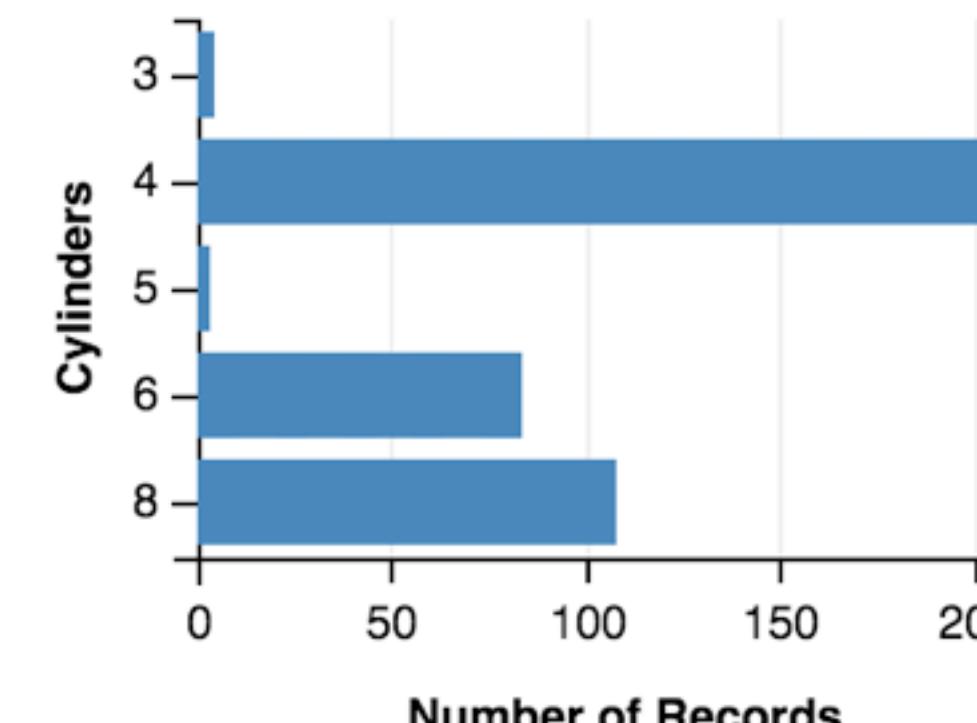
Reset



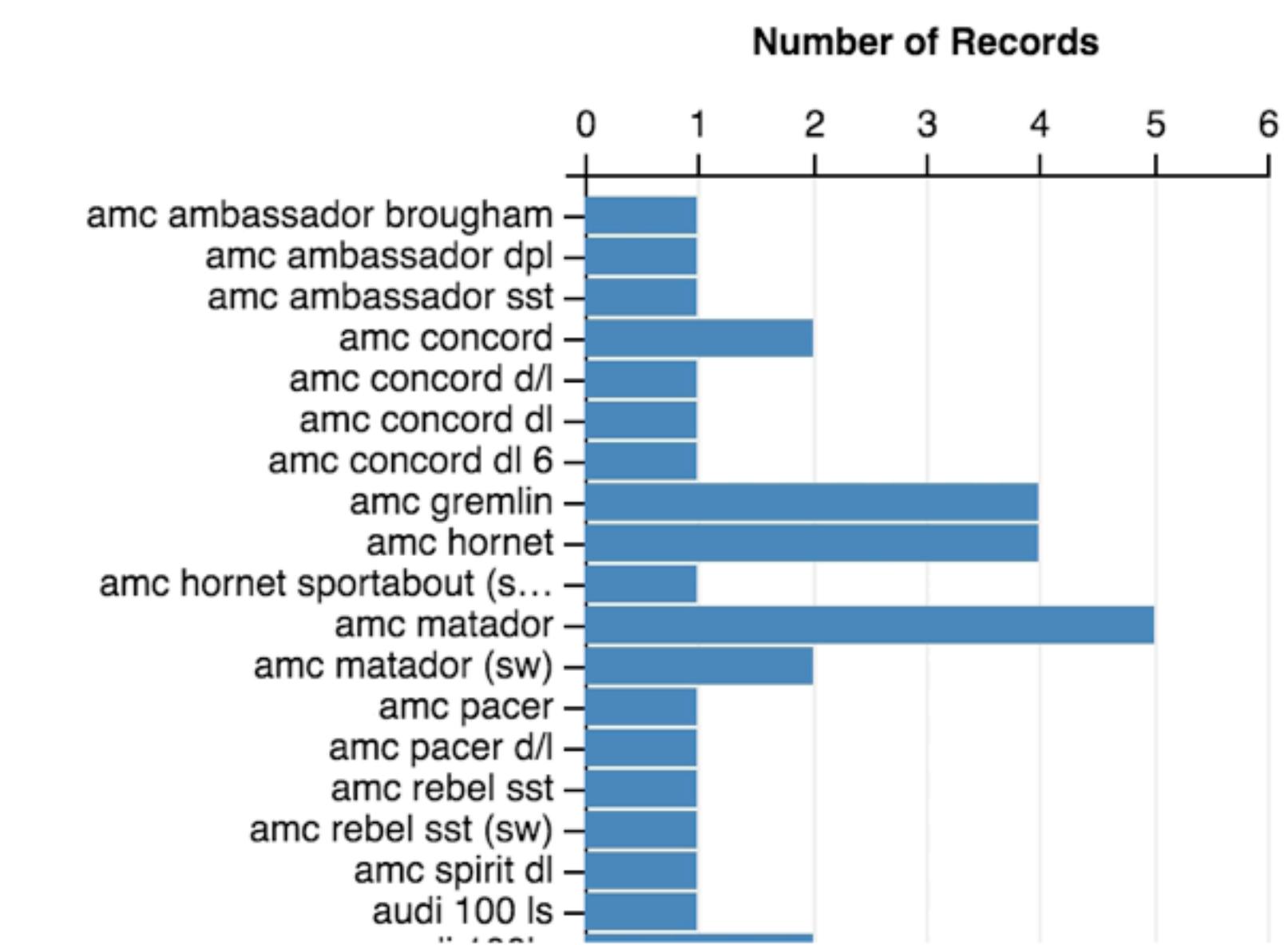
Explore univariate summaries of each field

Start exploring data by examining each field and continue by selecting interesting data fields in data selector panel.

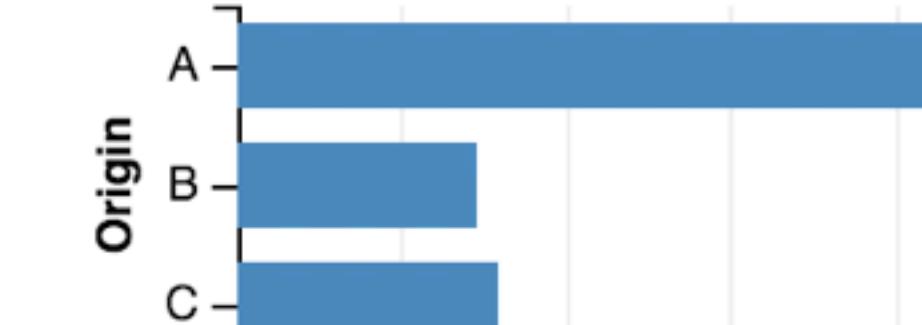
A Cylinders # COUNT



A Name # COUNT



A Origin # COUNT



YEAR (Year) # COUNT



BIN (Acceleration) # COUNT



#1 Show data variation over design variation.

Data

Cars

Change

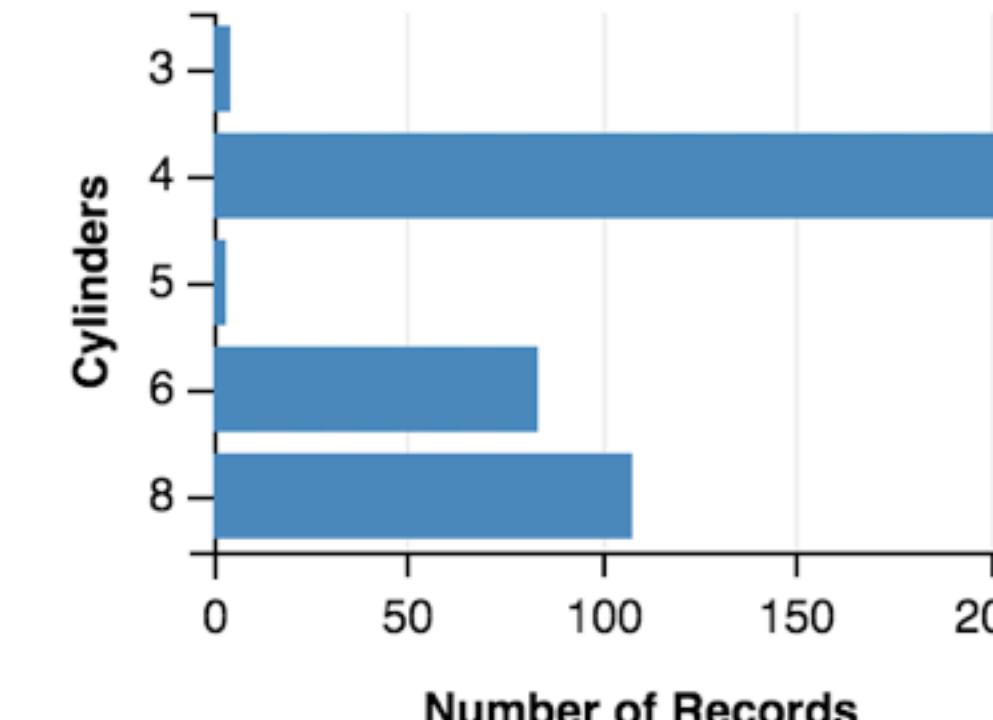
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

 Reset

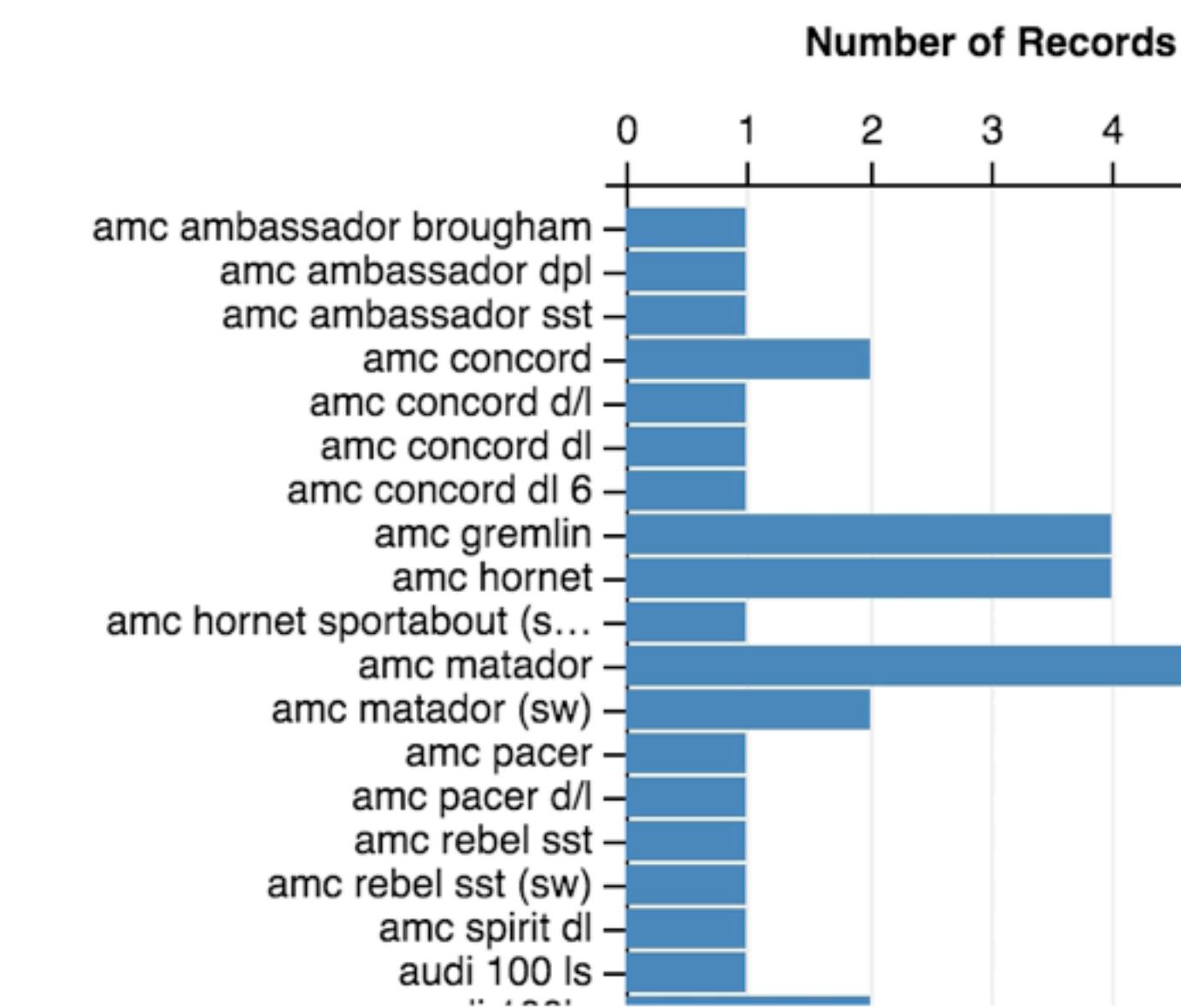
Explore univariate summaries of each field

Start exploring data by examining each field and continue by selecting interesting data fields in data selector panel.

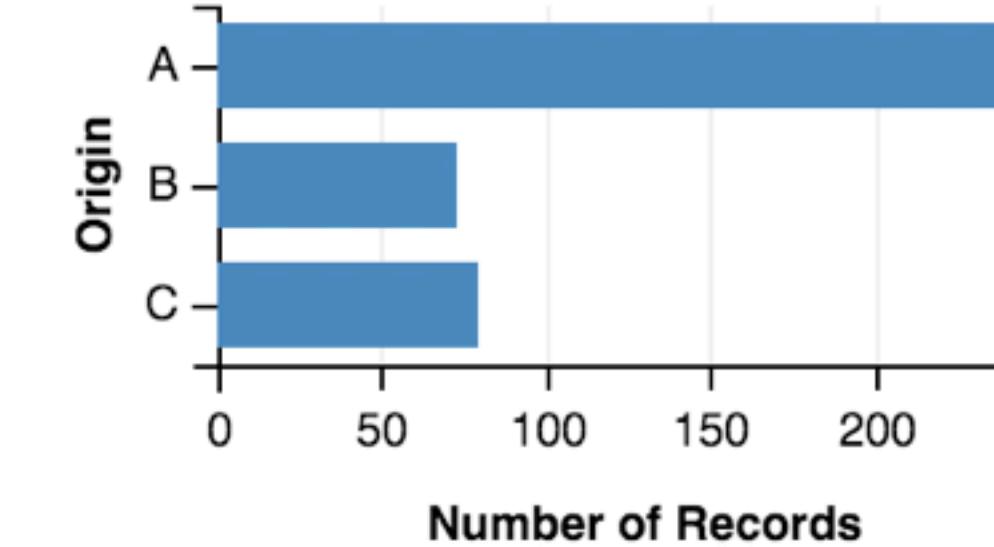
A Cylinders # COUNT



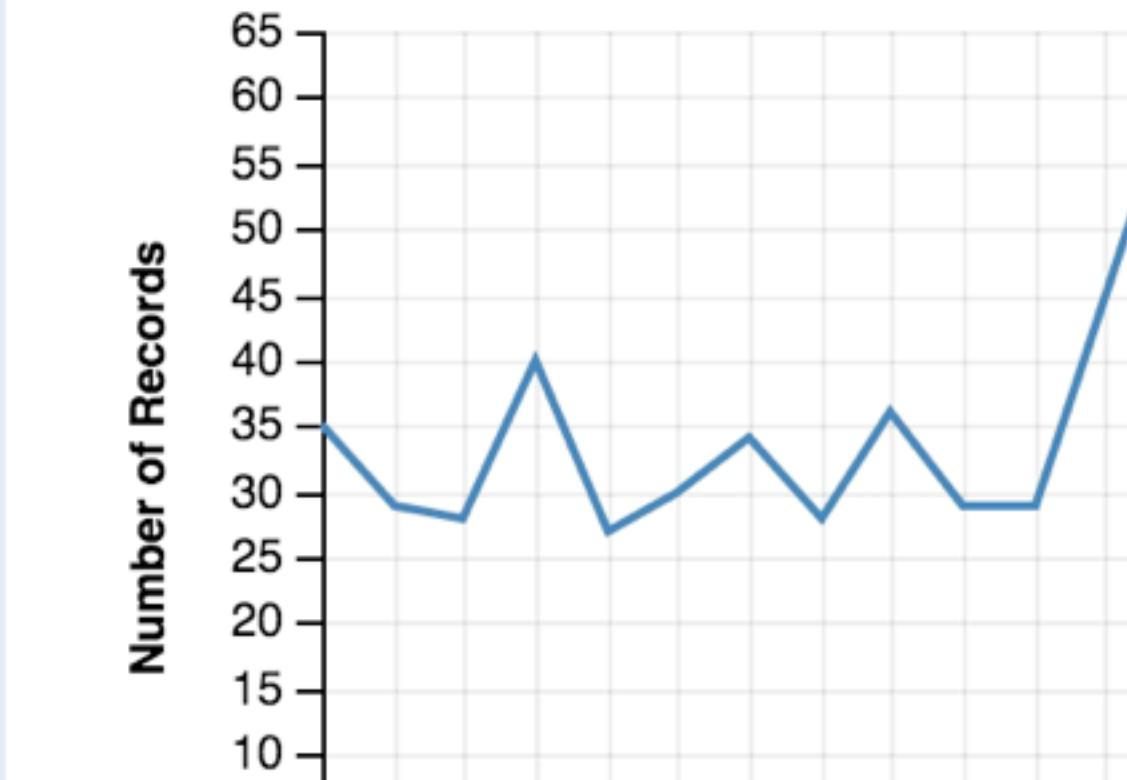
A Name # COUNT



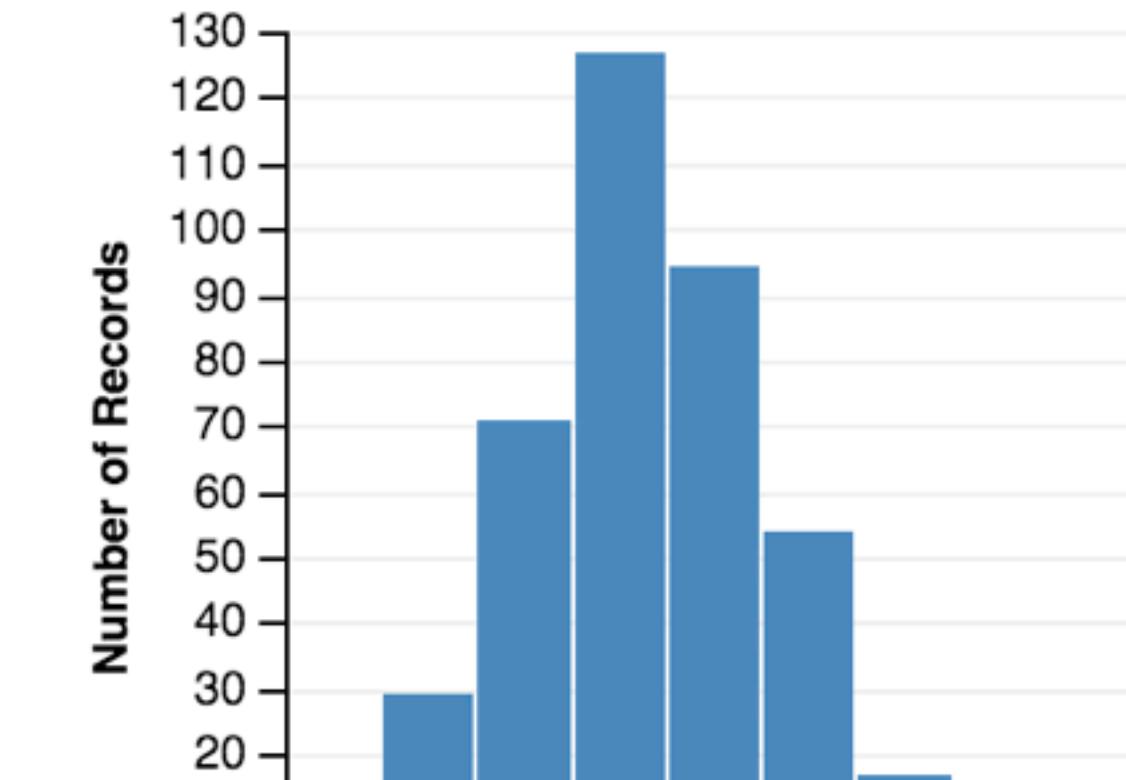
A Origin # COUNT



YEAR (Year) # COUNT



BIN (Acceleration) # COUNT



Data

Cars

Change

A Cylinders

i

A Name

i

A Origin

i

AUTO (Year)

i

AUTO (Acceleration)

i

AUTO (Displacement)

i

AUTO (Horsepower)

i

AUTO (Miles per Gallon)

i

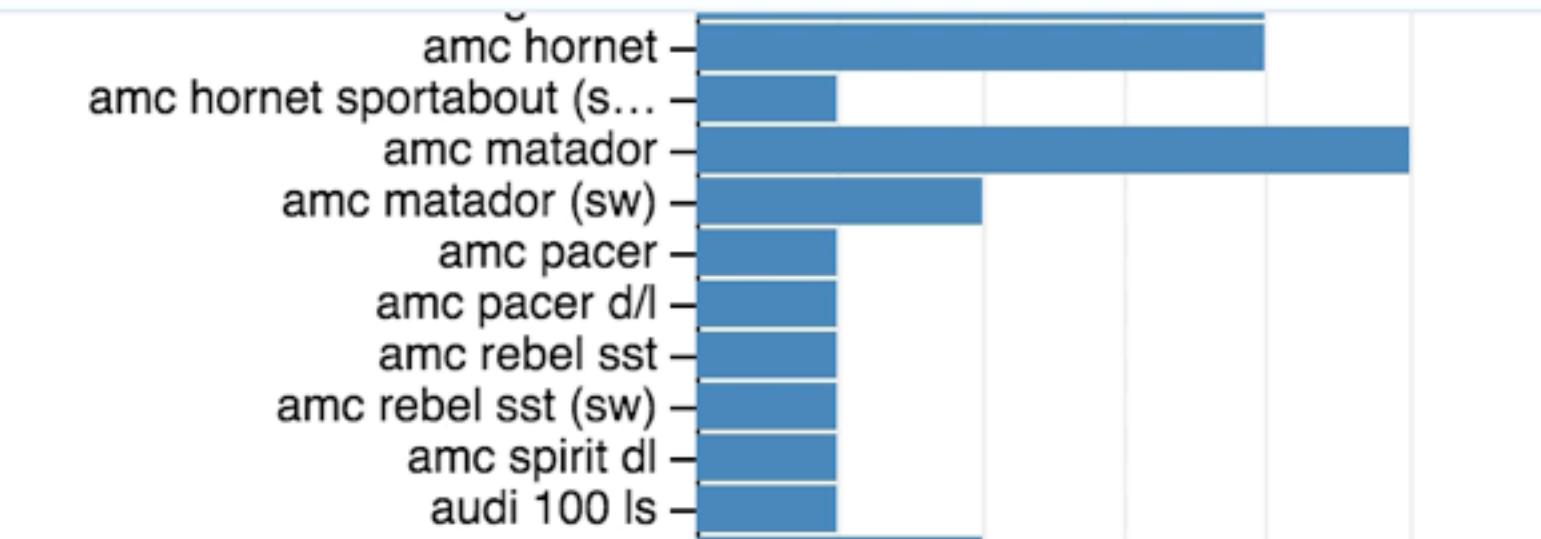
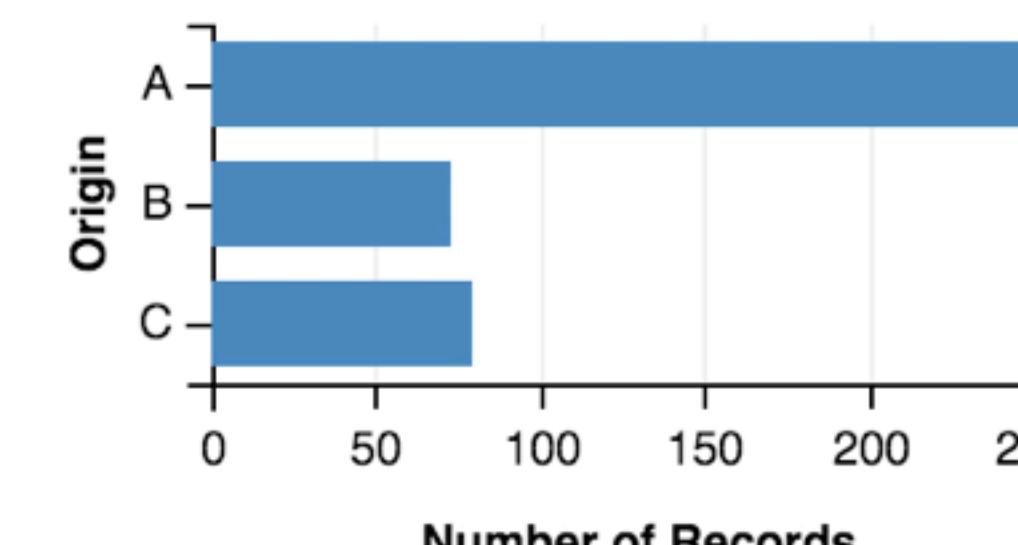
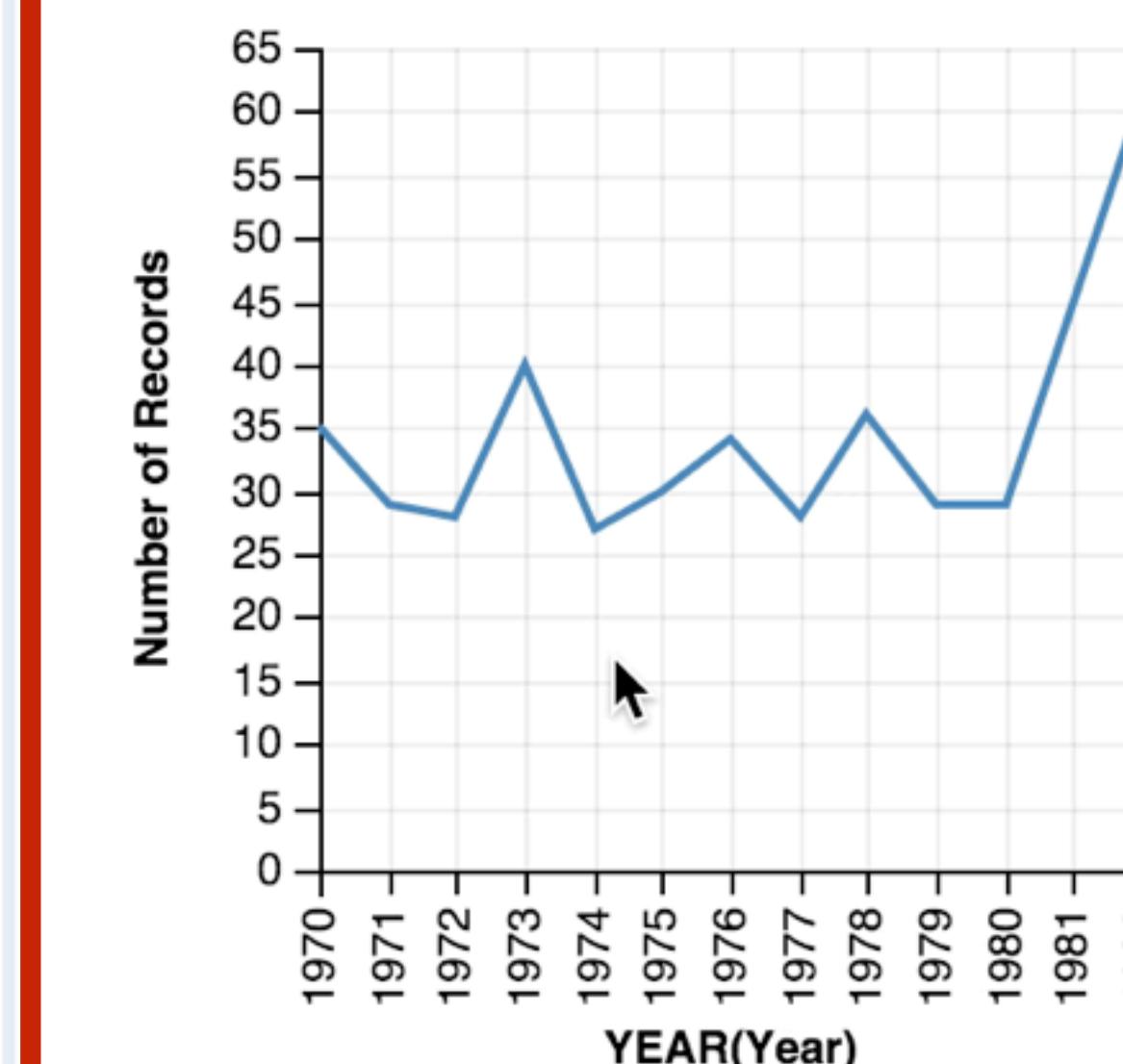
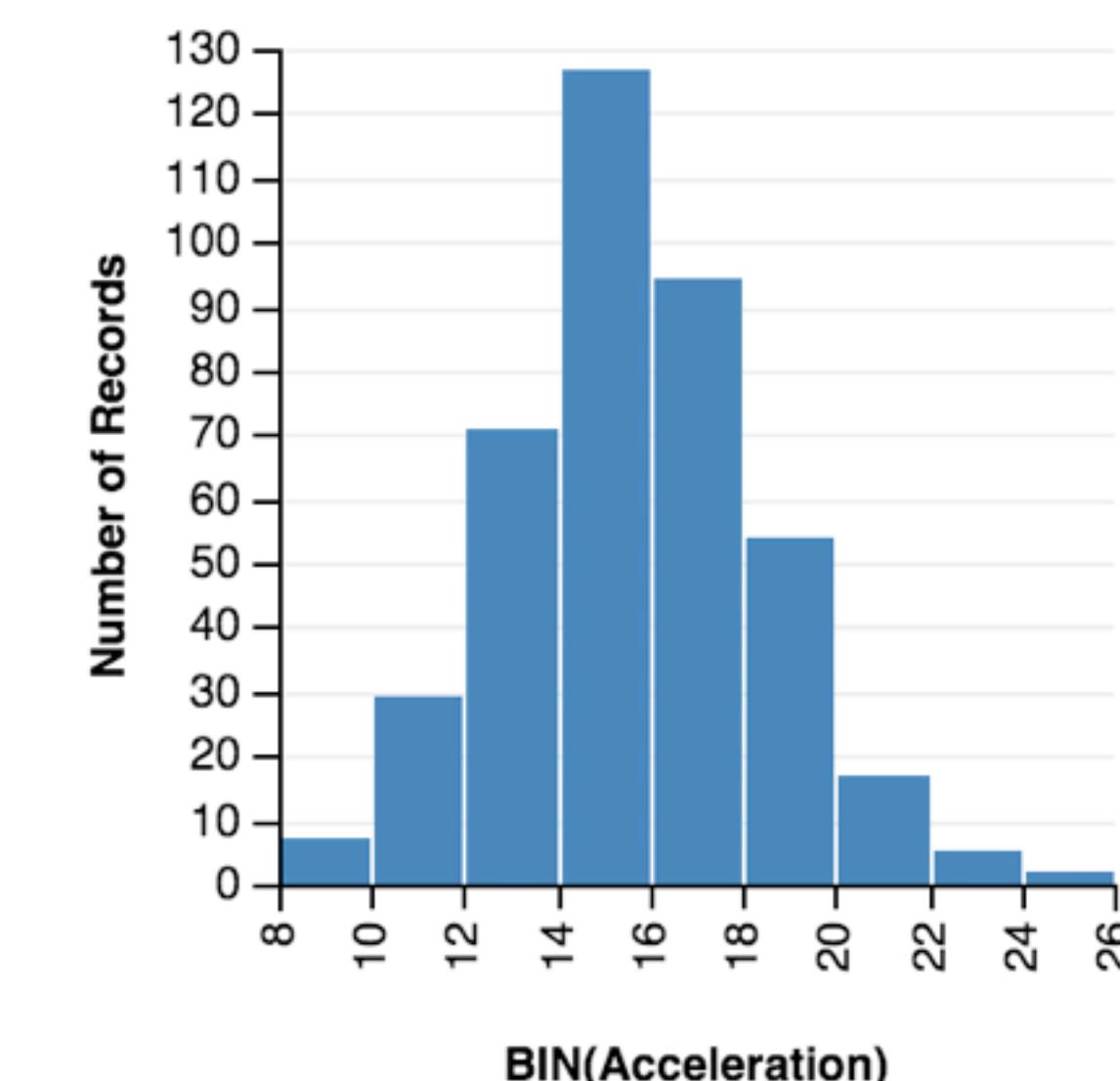
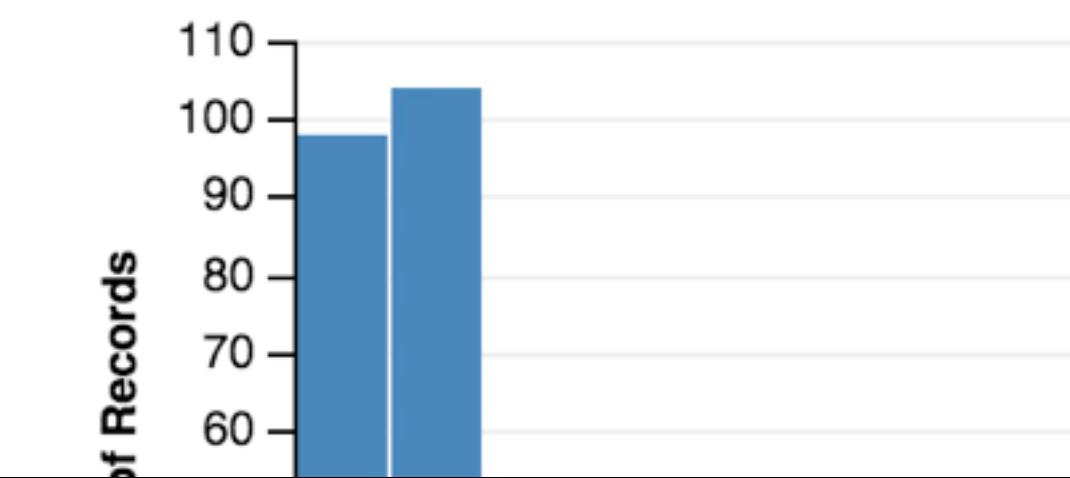
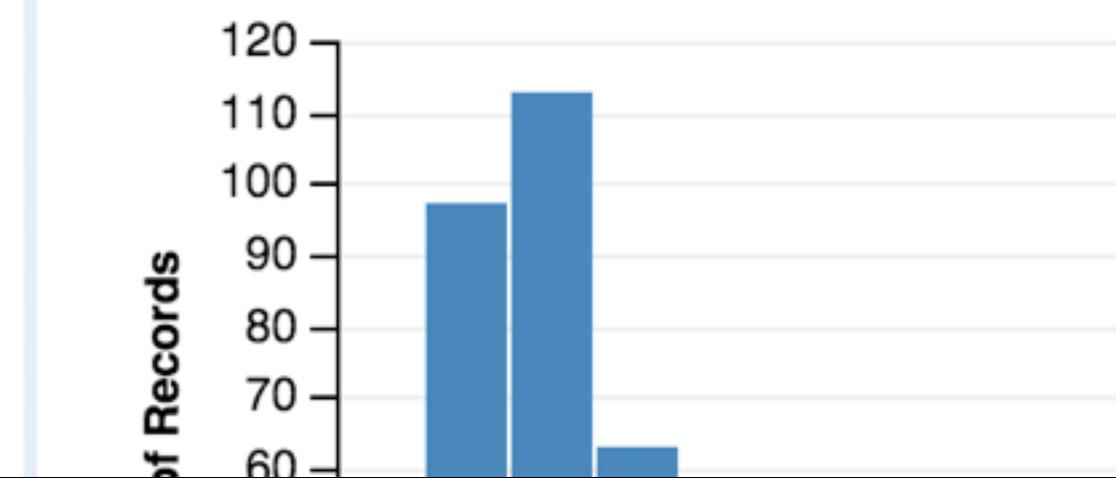
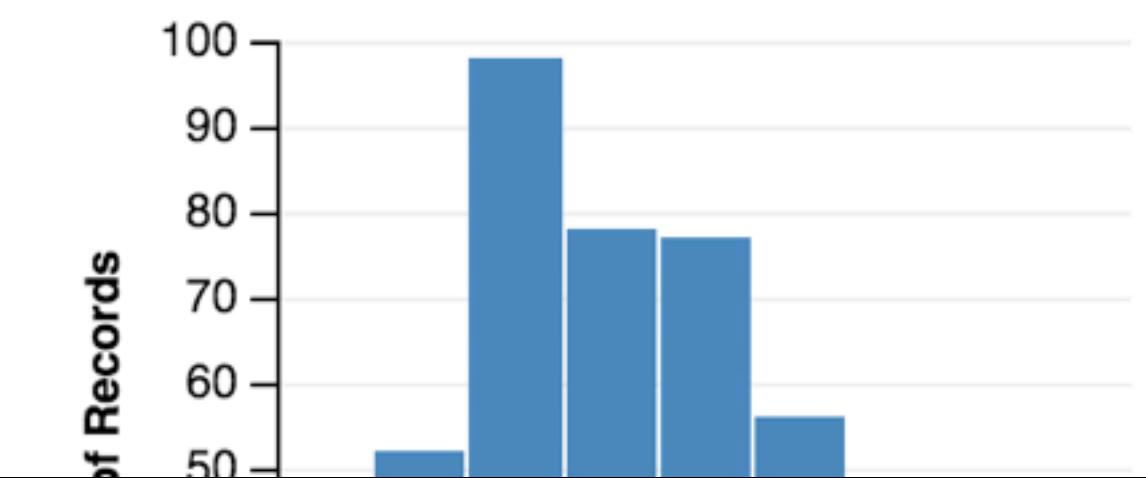
AUTO (Weight in lbs)

i

COUNT

i

Reset

Number of Records**A Origin # COUNT****YEAR (Year) # COUNT****# BIN (Acceleration) # COUNT****# BIN (Displacement) # COUNT****# BIN (Horsepower) # COUNT****# BIN (Miles per Gallon) # COUNT**

Data

Cars

Change

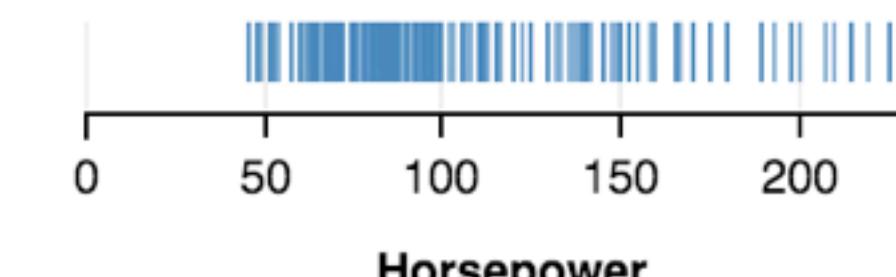
- A Cylinders
- A Name
- A Origin
- AUTO (Year)
- # AUTO (Acceleration)
- # AUTO (Displacement)
- # AUTO (Horsepower)
- # AUTO (Miles per Gallon)
- # AUTO (Weight in lbs)
- COUNT

Reset

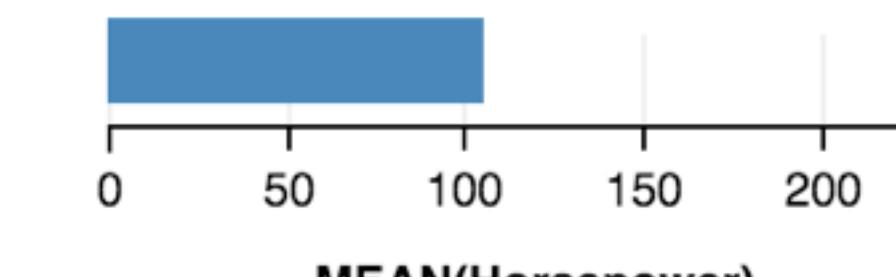
Explore visualizations of # AUTO (Horsepower)

Here are some recommended visualizations of the fields you have selected

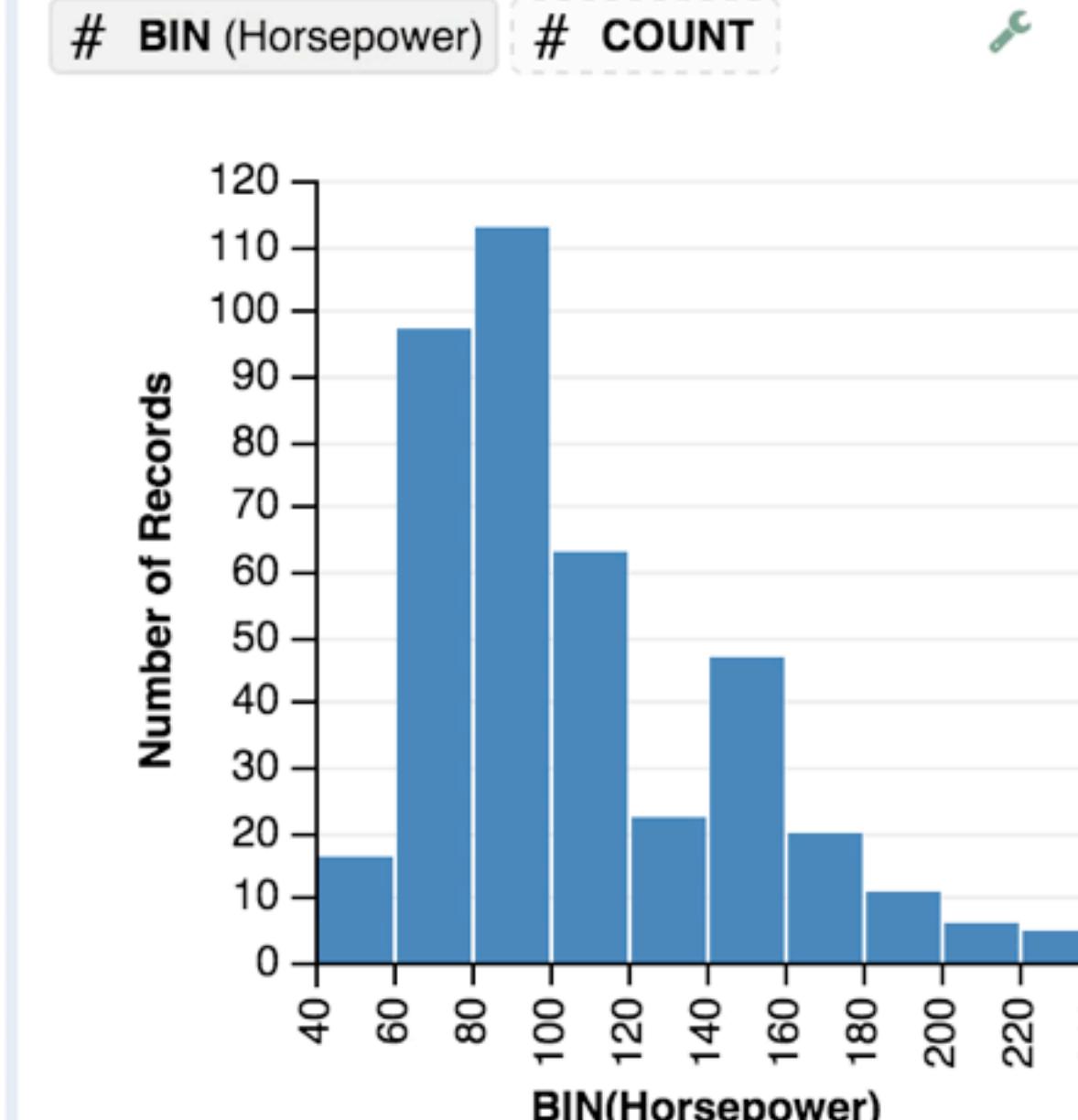
Horsepower



MEAN (Horsepower)



BIN (Horsepower)



COUNT

Explore visualizations of # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

Horsepower

A Cylinders

3

Cyl

6

8

MEAN (Horsepower)

A Cylinders

3

Cyl

6

8

#2 Allow interactive steering to drive recommendations.

Data

Cars

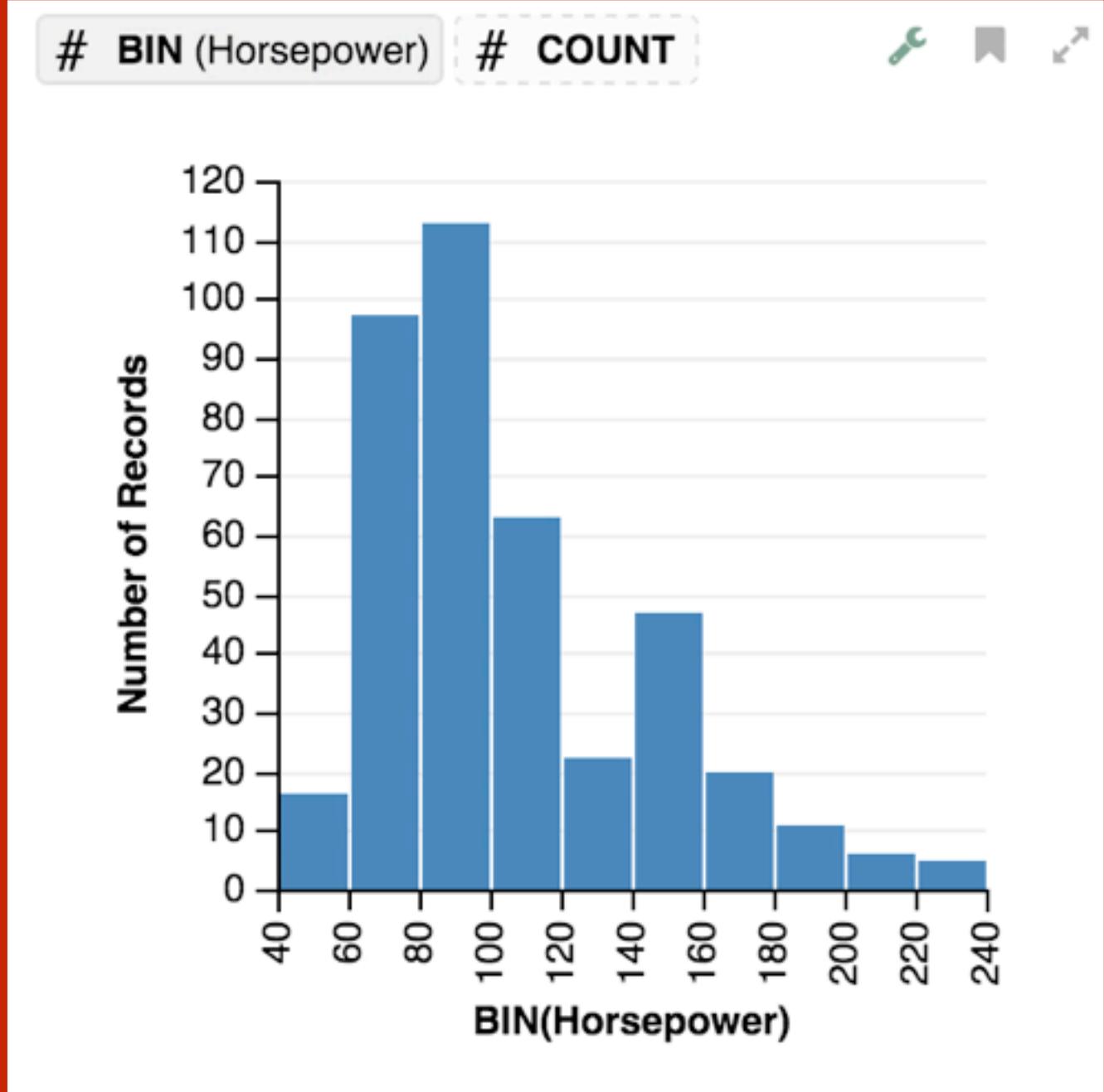
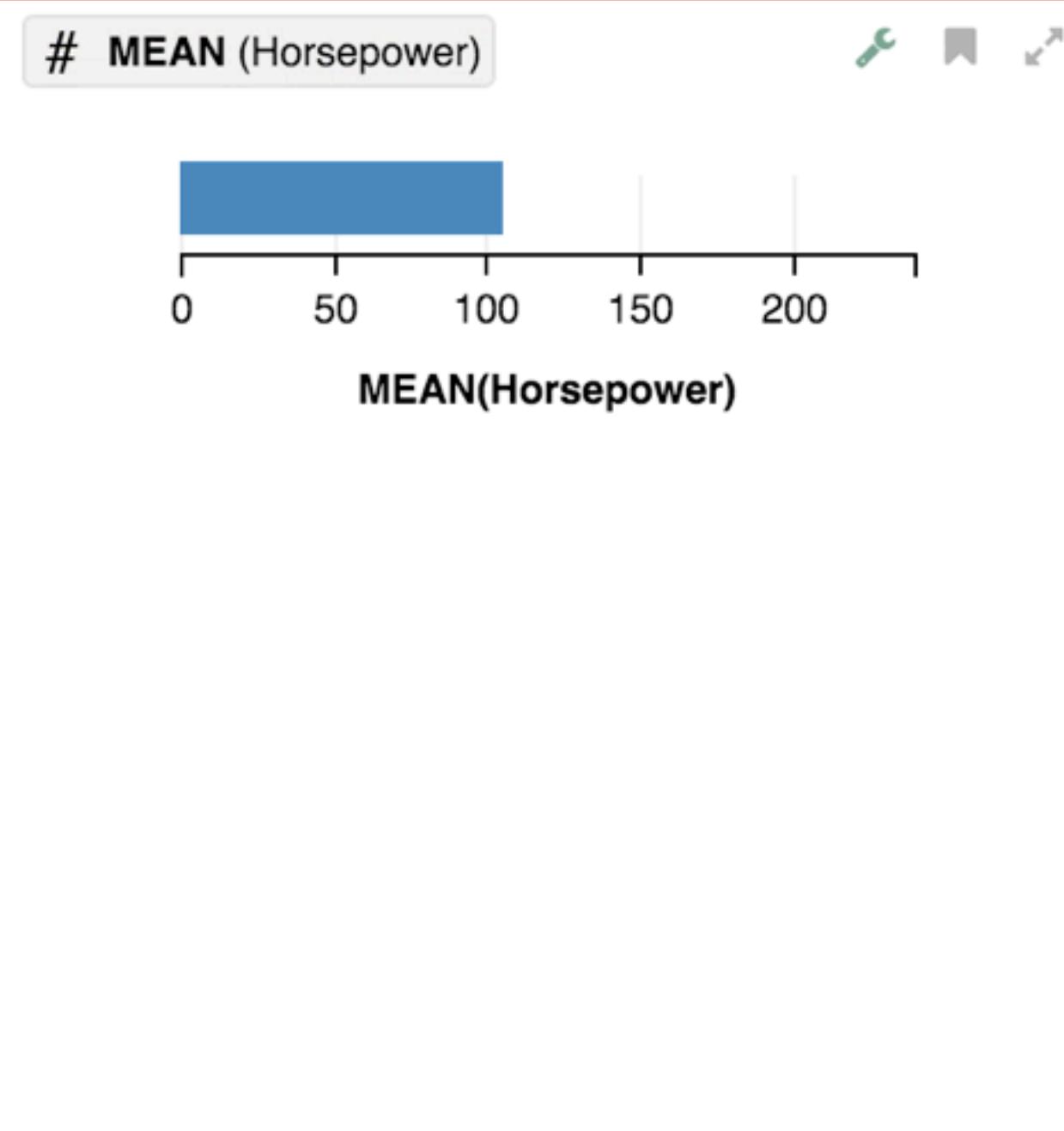
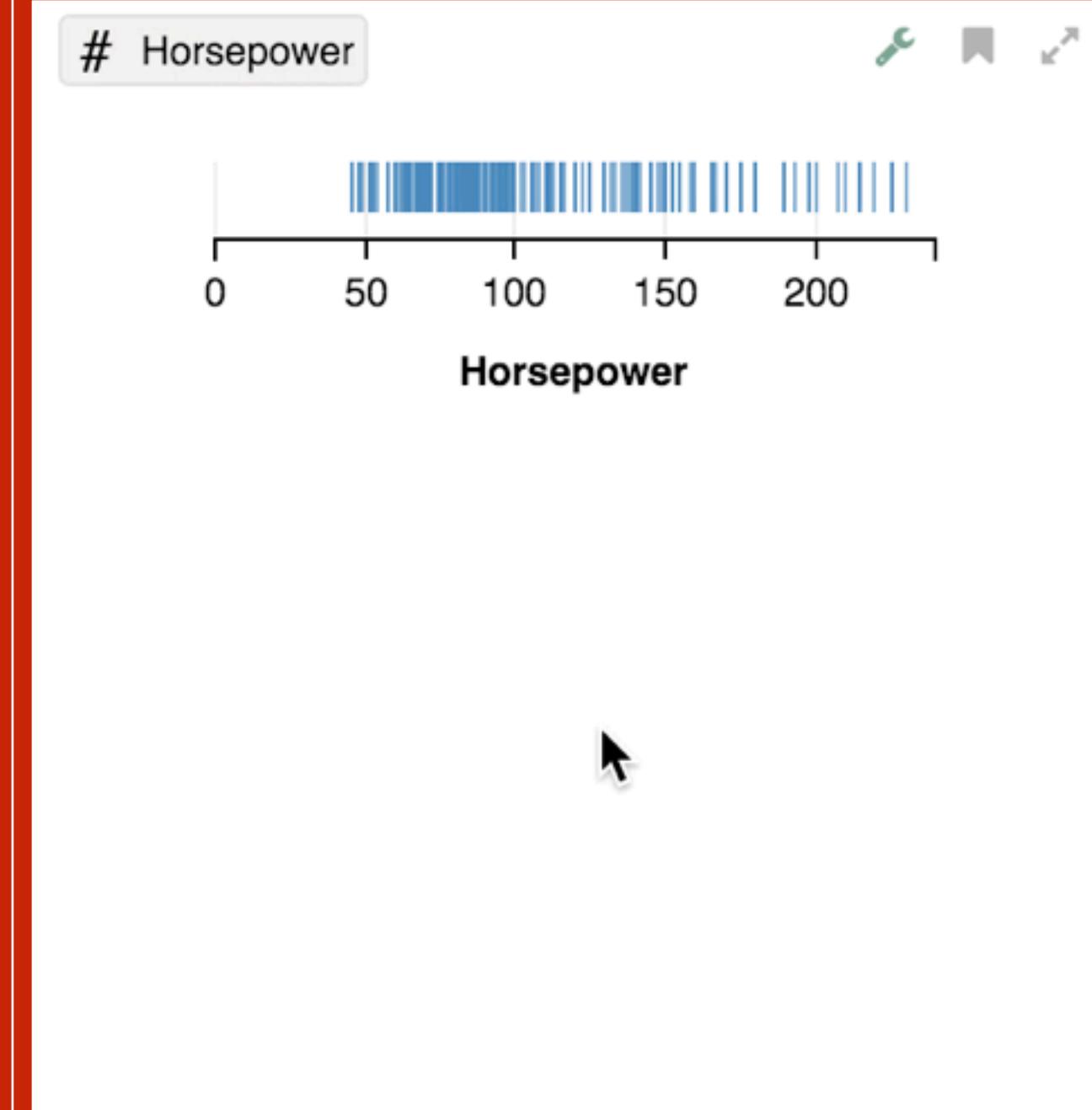
Change

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

Reset

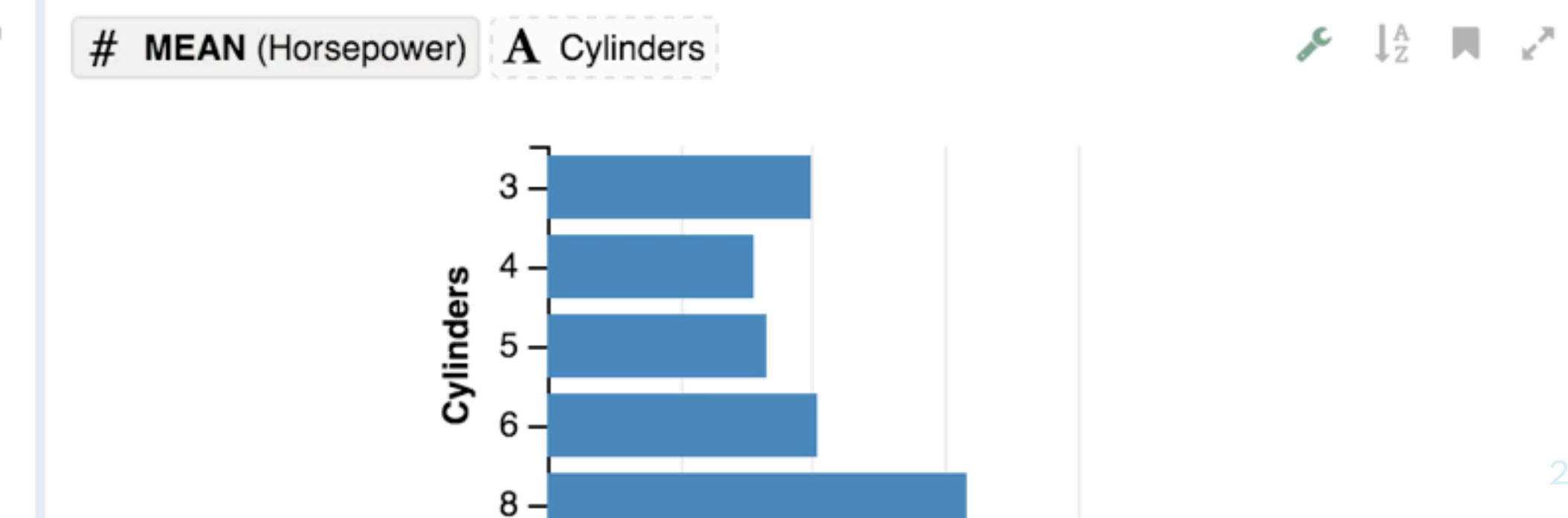
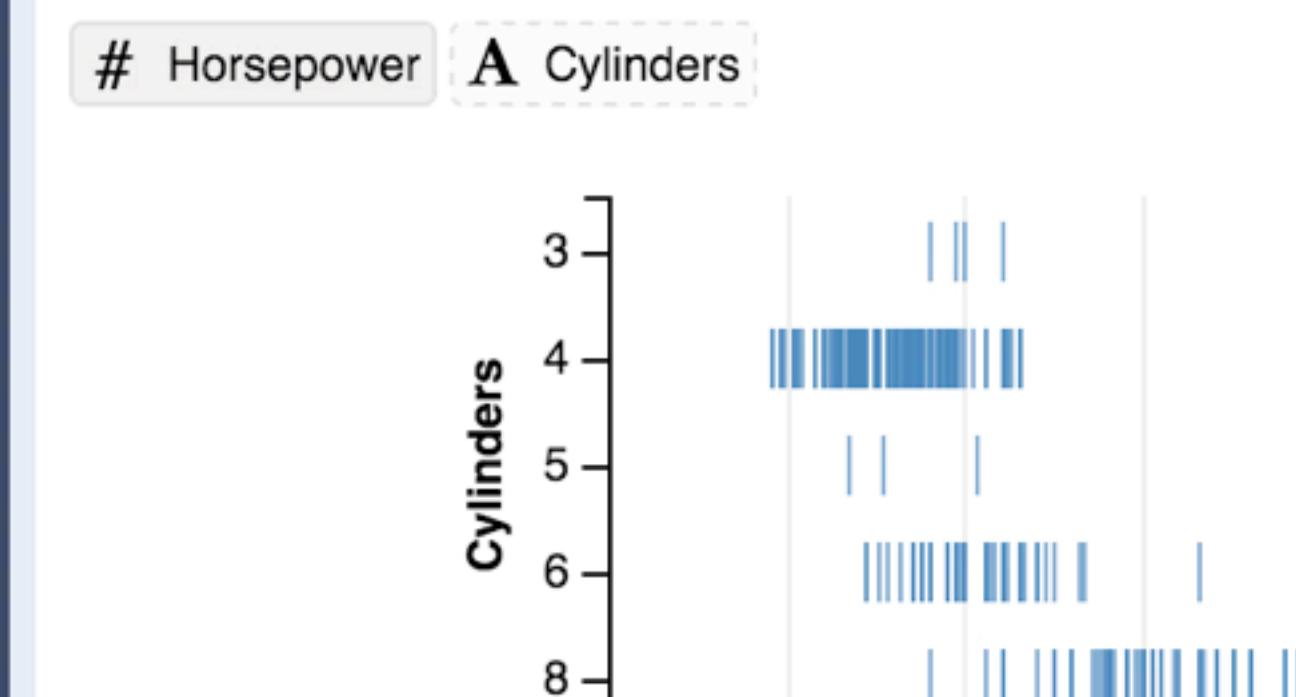
Explore visualizations of # AUTO (Horsepower)

Here are some recommended visualizations of the fields you have selected



Explore visualizations of # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected



Data

Cars

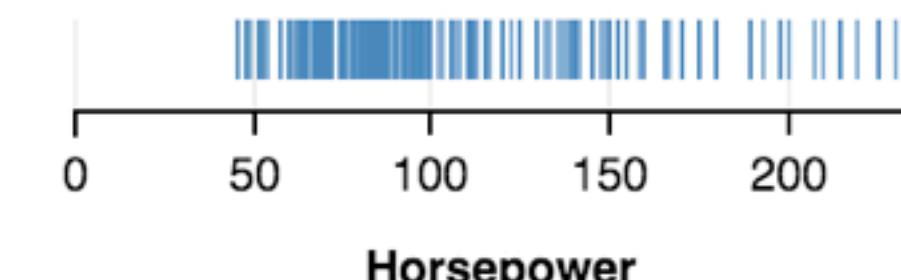
Change

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

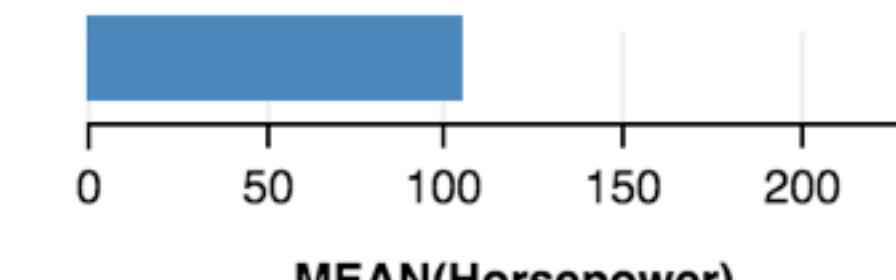
Reset

Here are some recommended visualizations of the fields you have selected

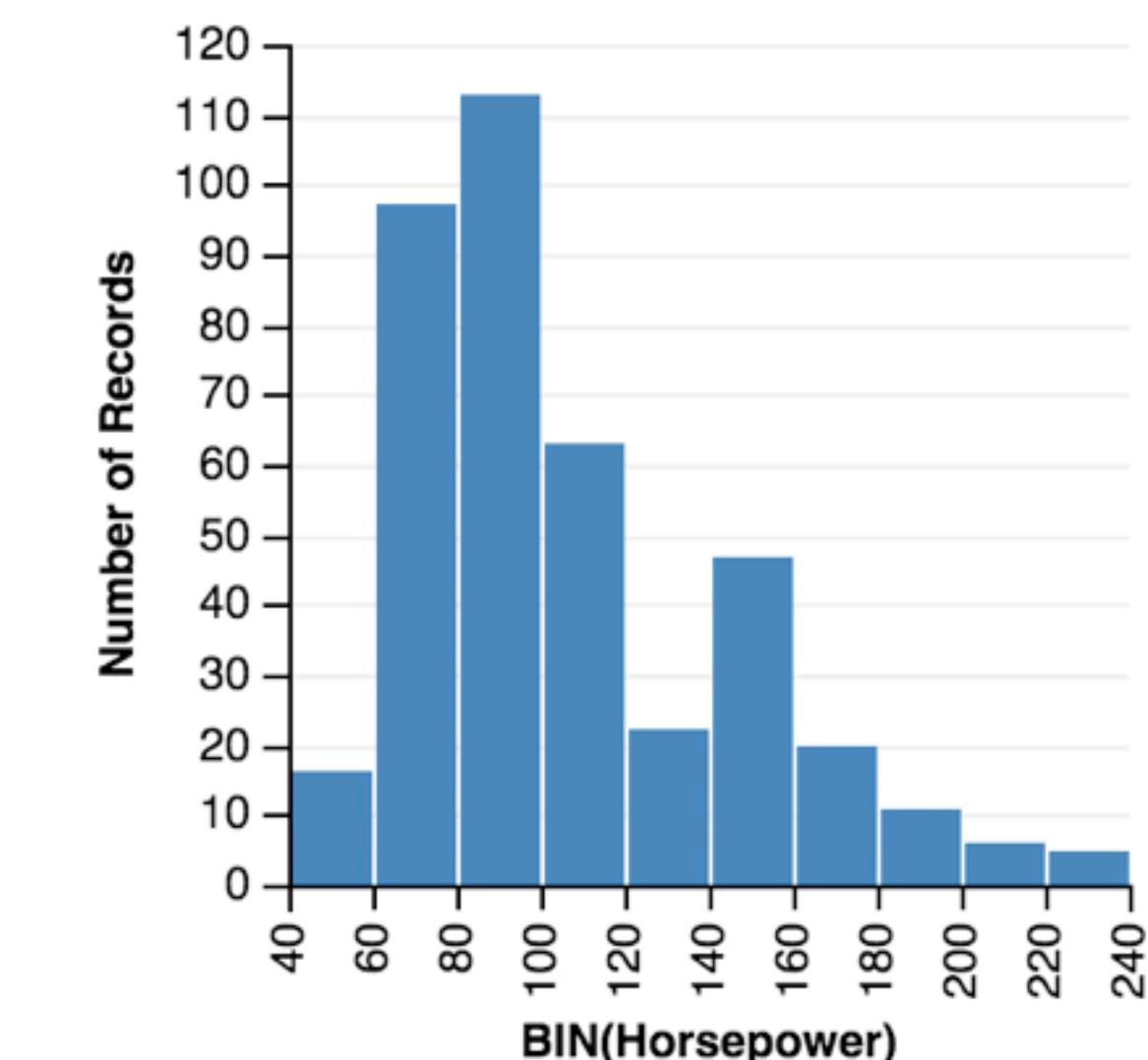
Horsepower



MEAN (Horsepower)



BIN (Horsepower)



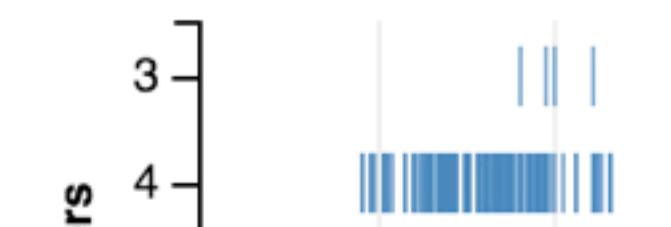
COUNT

Explore visualizations of # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

Horsepower

A Cylinders



MEAN (Horsepower)

A Cylinders



#1 Show data variation over design variation.

Data

Cars

Change

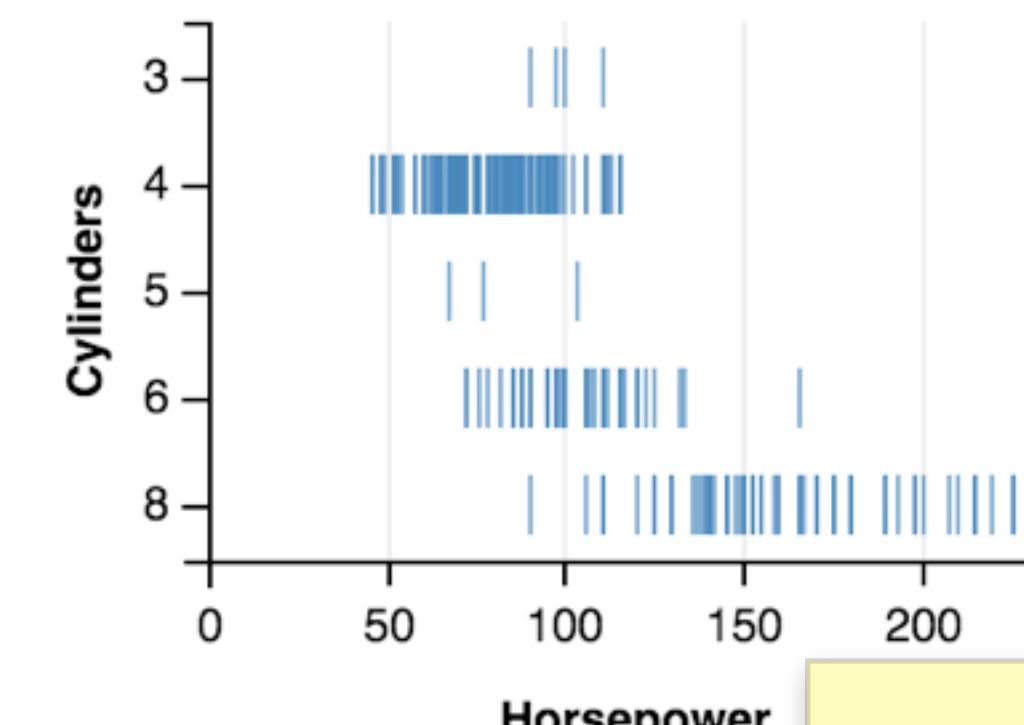
- A Cylinders
- A Name
- A Origin
- AUTO (Year)
- # AUTO (Acceleration)
- # AUTO (Displacement)
- # AUTO (Horsepower)
- # AUTO (Miles per Gallon)
- # AUTO (Weight in lbs)
- COUNT

Reset

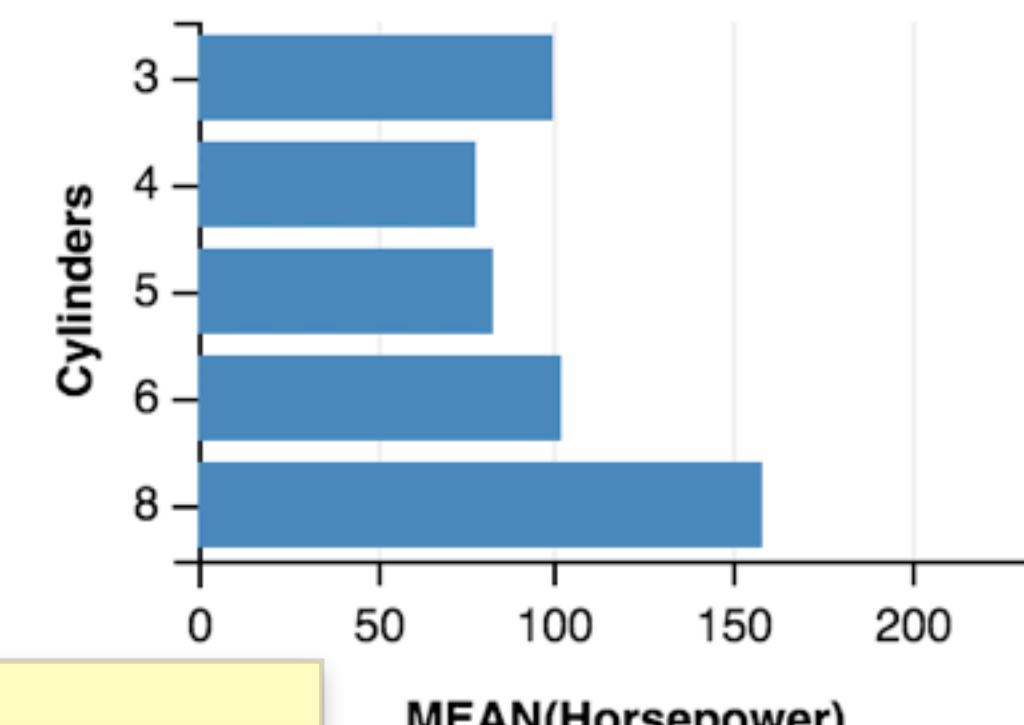
Explore visualizations of # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

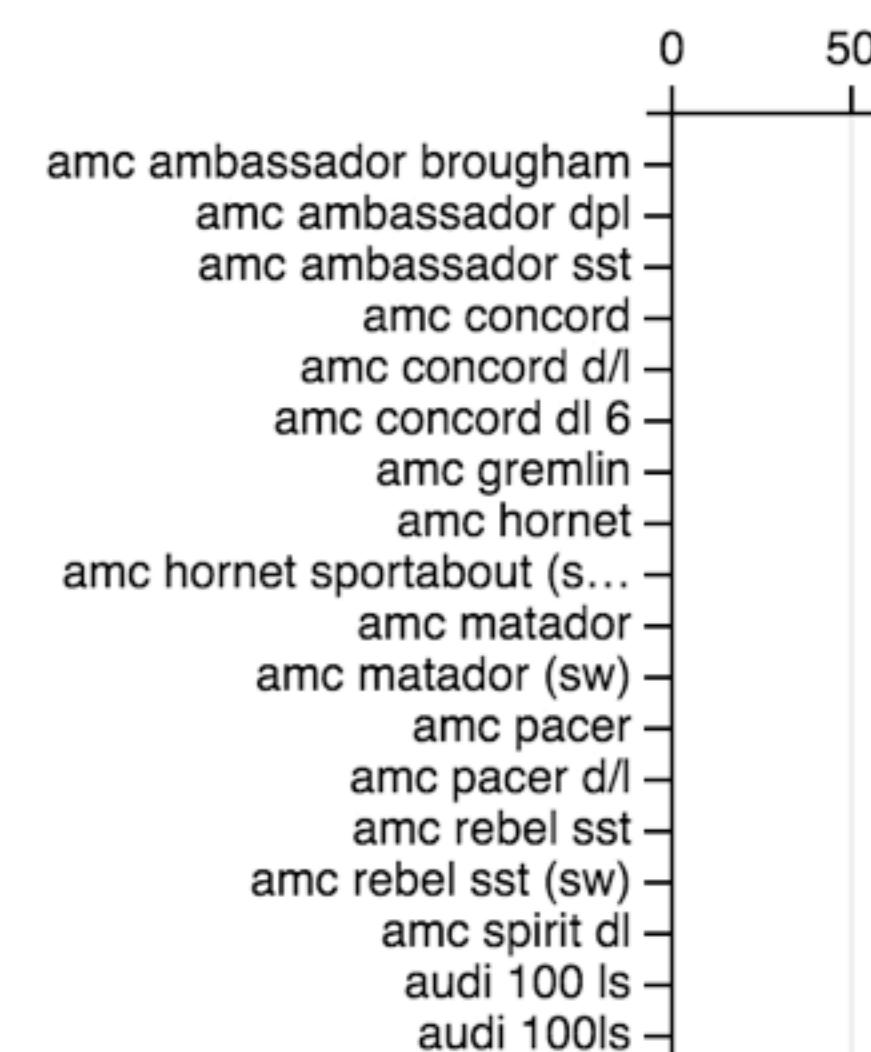
Horsepower A Cylinders



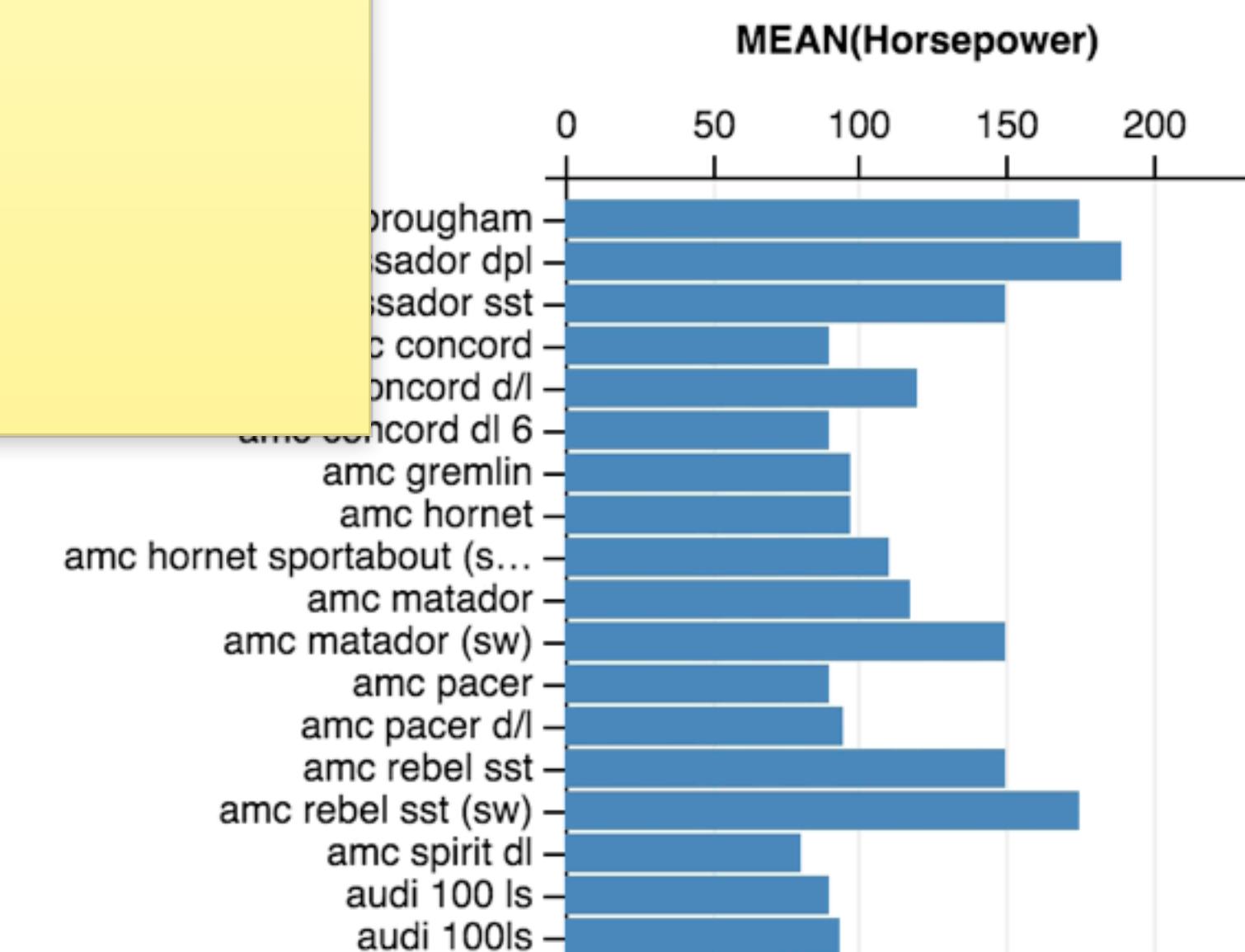
MEAN (Horsepower) A Cylinders



Horsepower A Name



Name



"I'm interested in whether there are other variables that are correlated with those two. " is weird

Data

Cars

Change

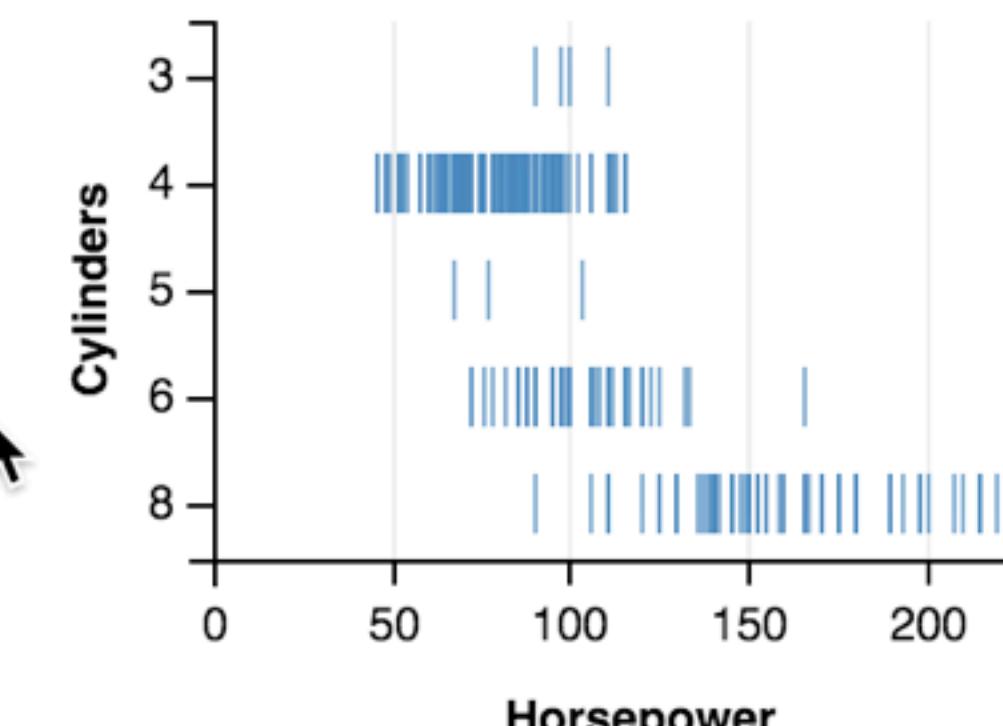
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

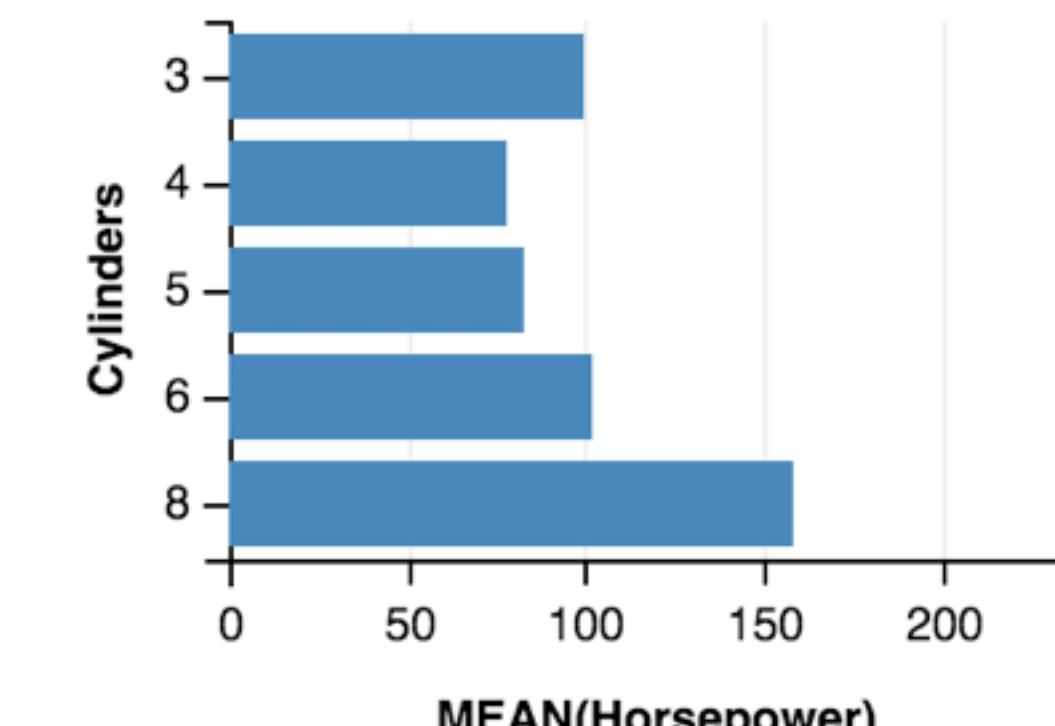
Explore visualizations of A Cylinders # AUTO (Horsepower)

Here are some recommended visualizations of the fields you have selected

A Cylinders # Horsepower



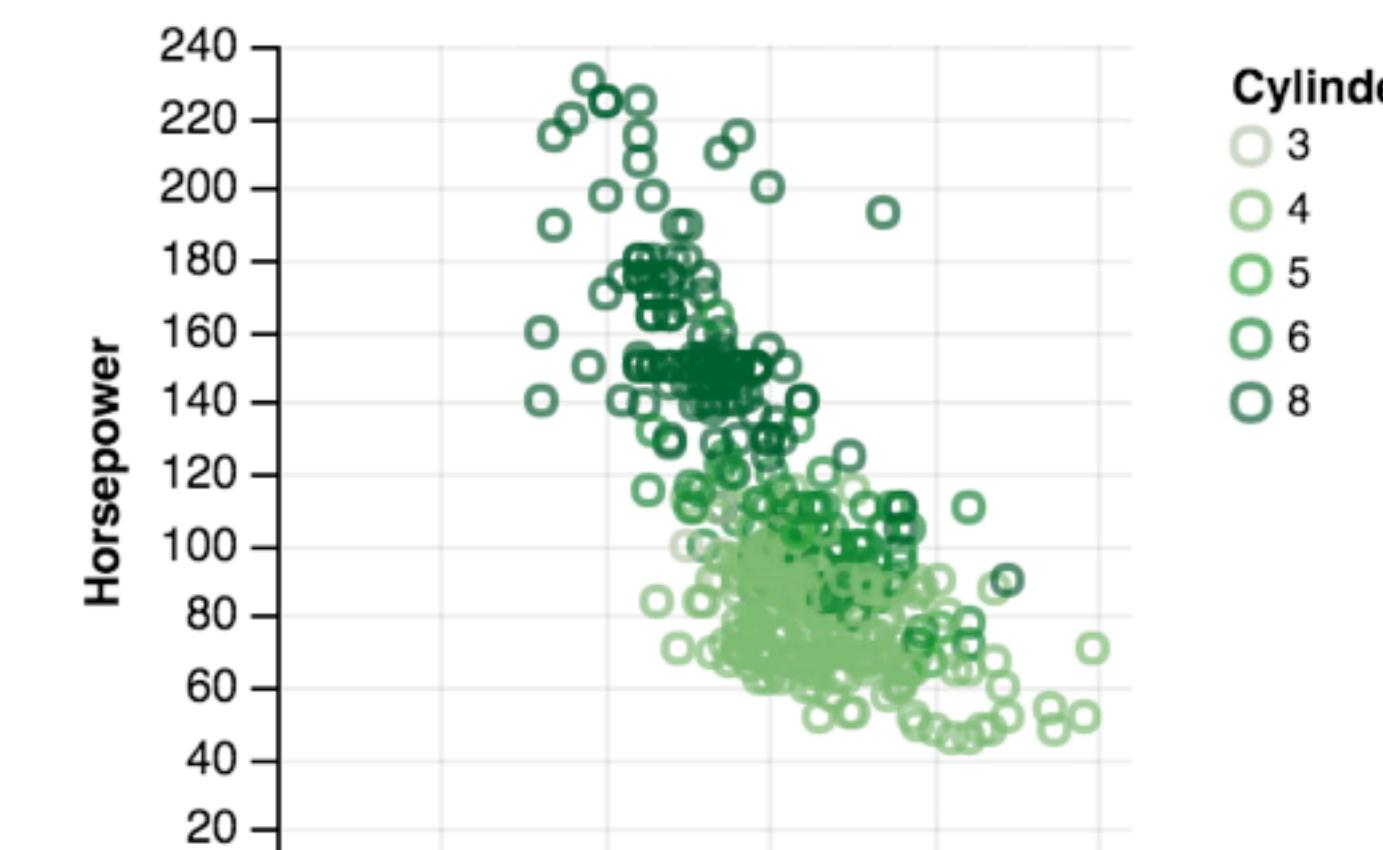
A Cylinders # MEAN (Horsepower)



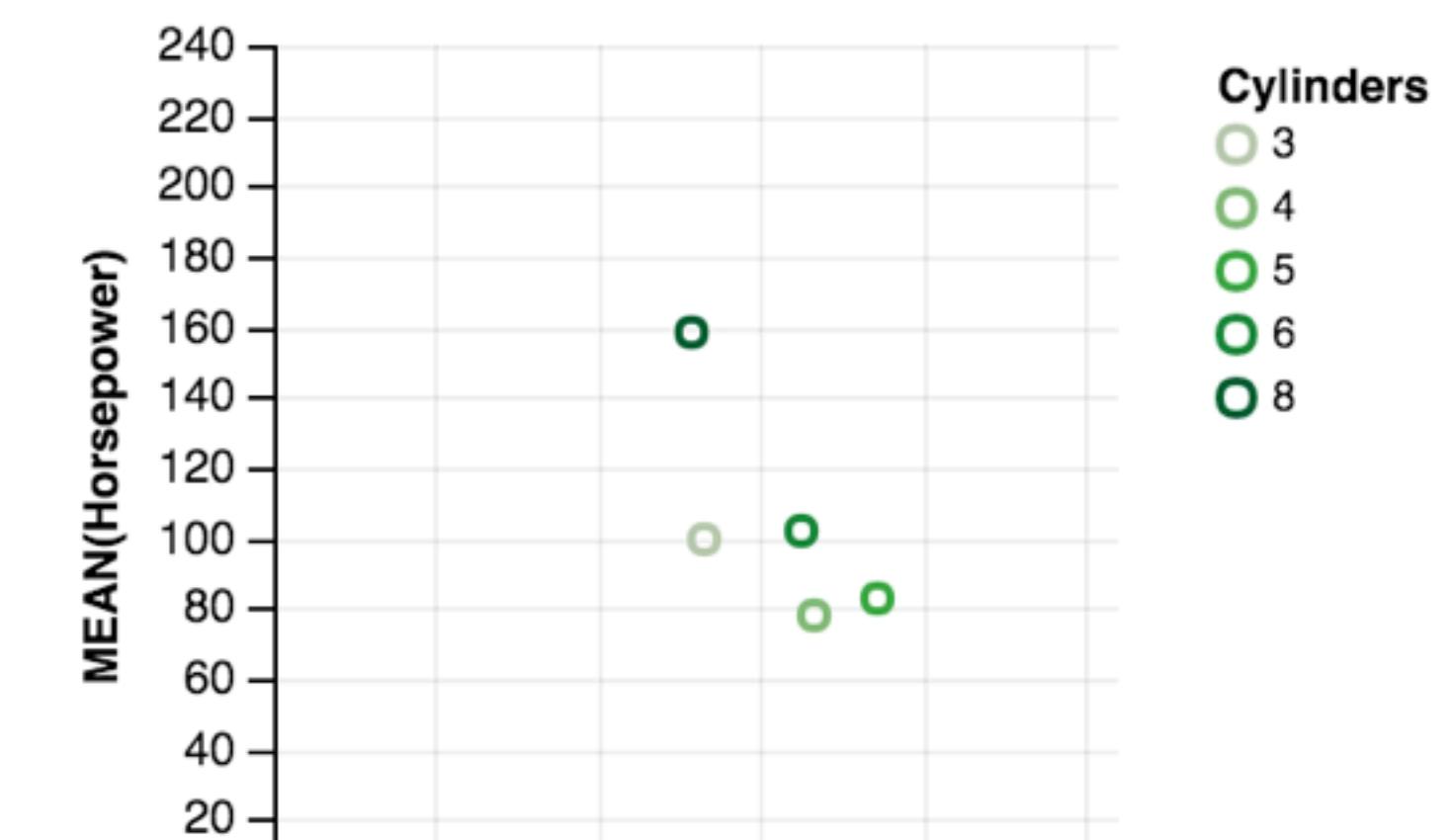
Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

A Cylinders # Horsepower # Acceleration



A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



Data

Cars

Change

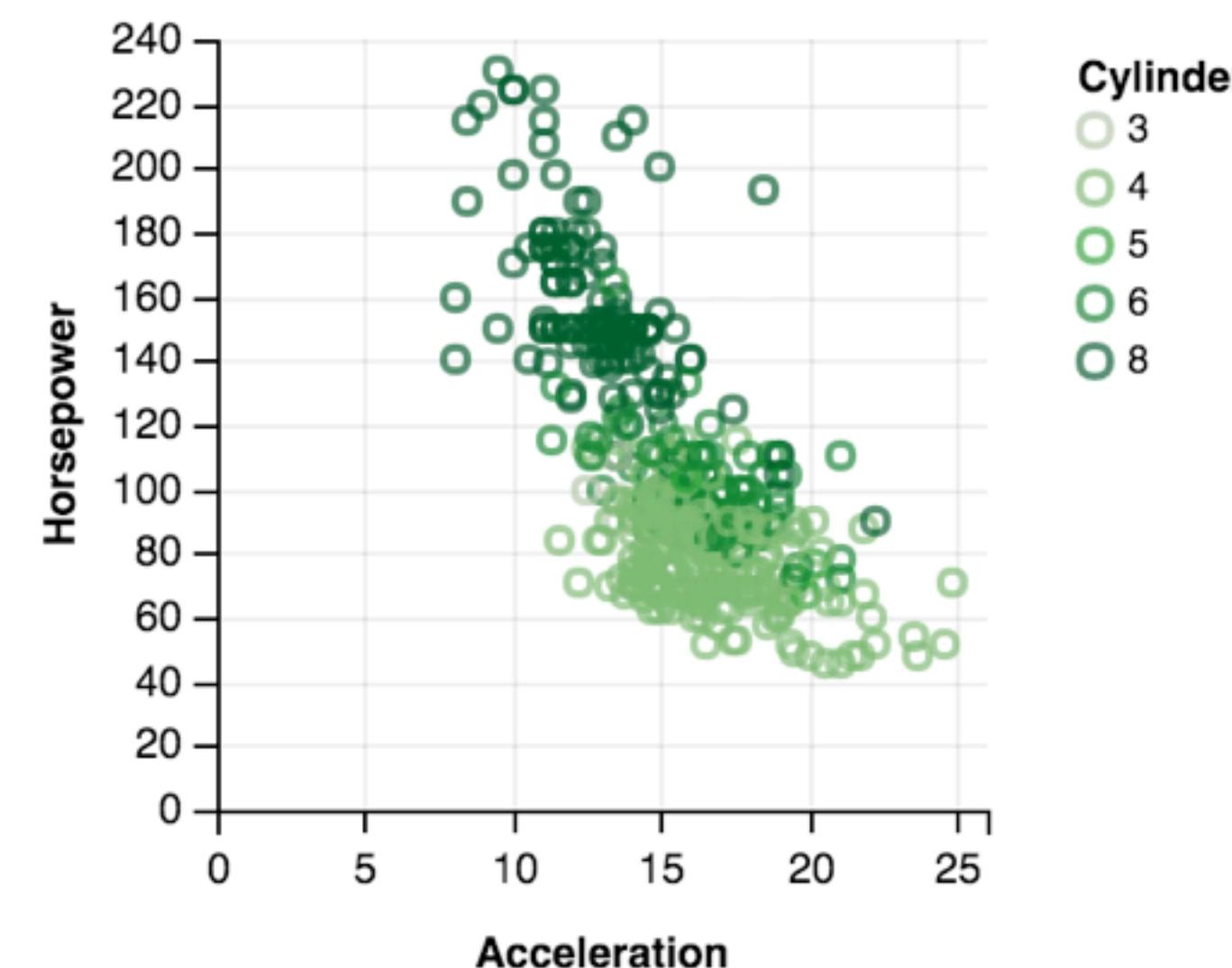
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

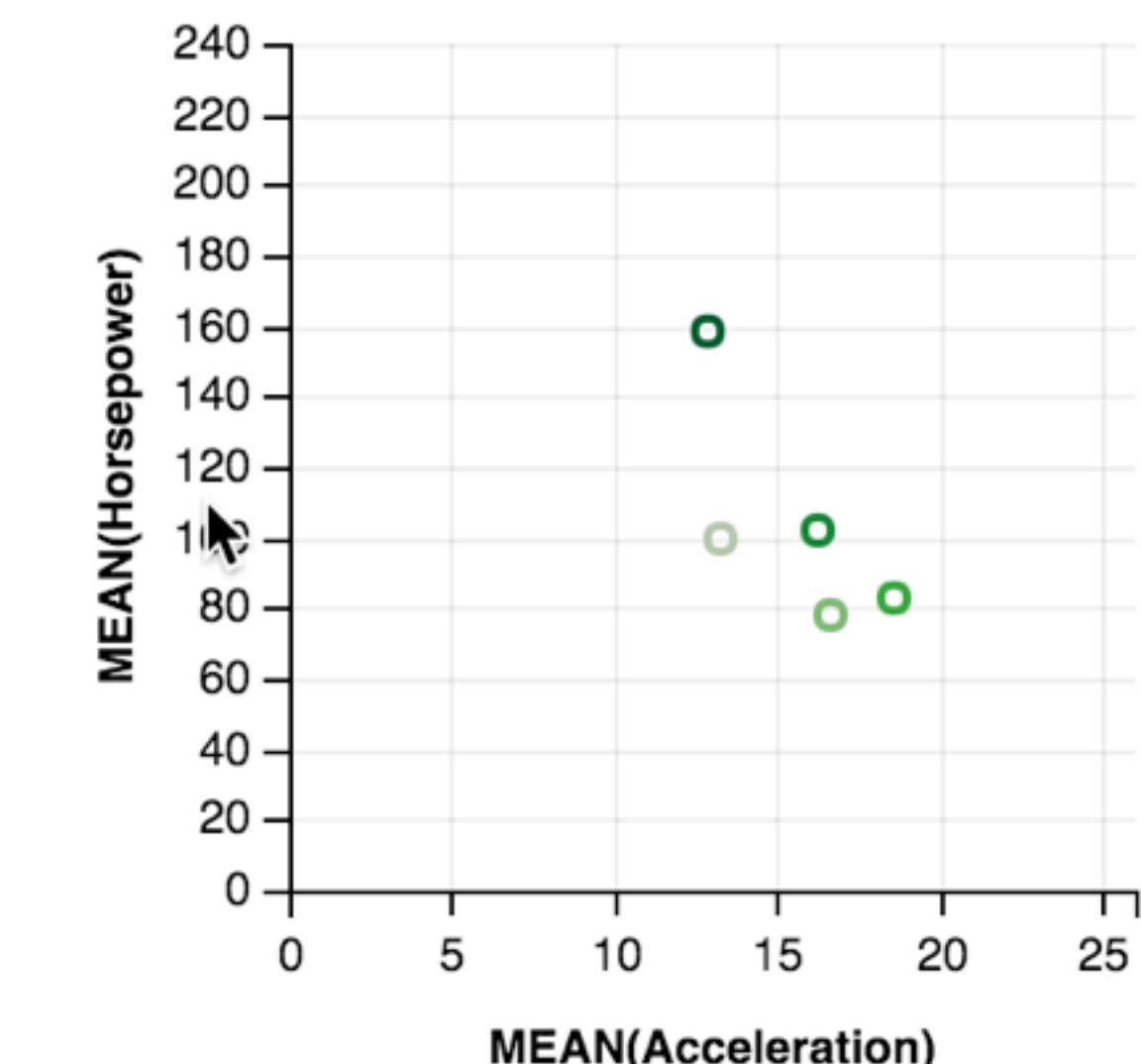
Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

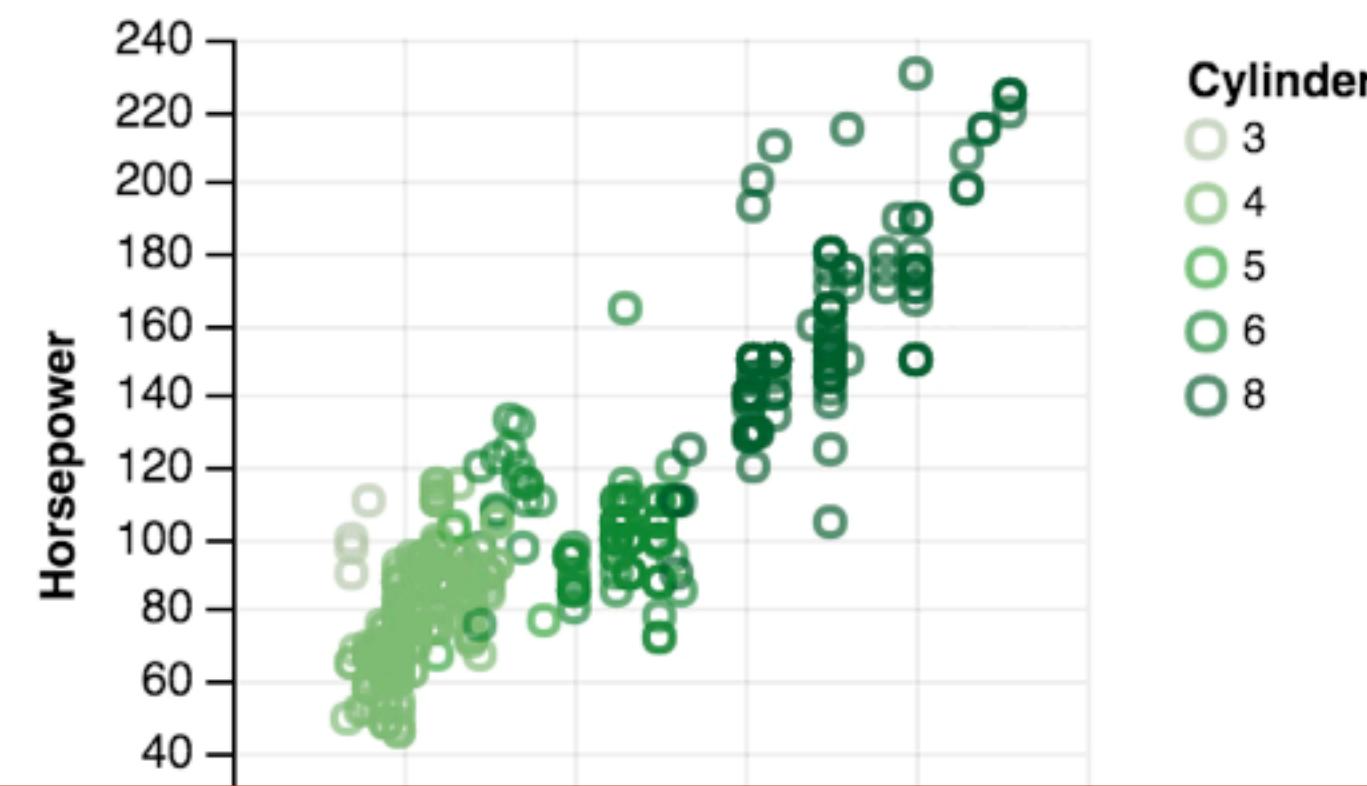
A Cylinders # Horsepower # Acceleration



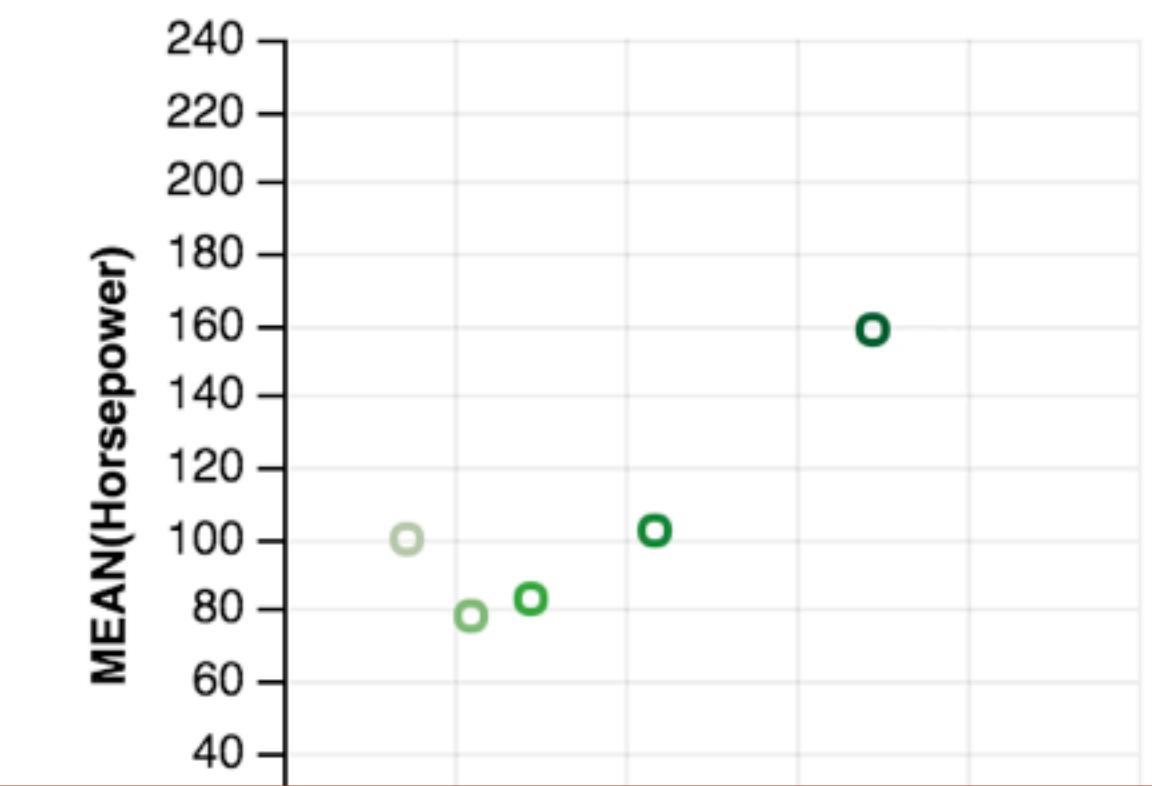
A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



A Cylinders # Horsepower # Displacement



A Cylinders # MEAN (Horsepower) # MEAN (Displacement)



Data

Cars

Change

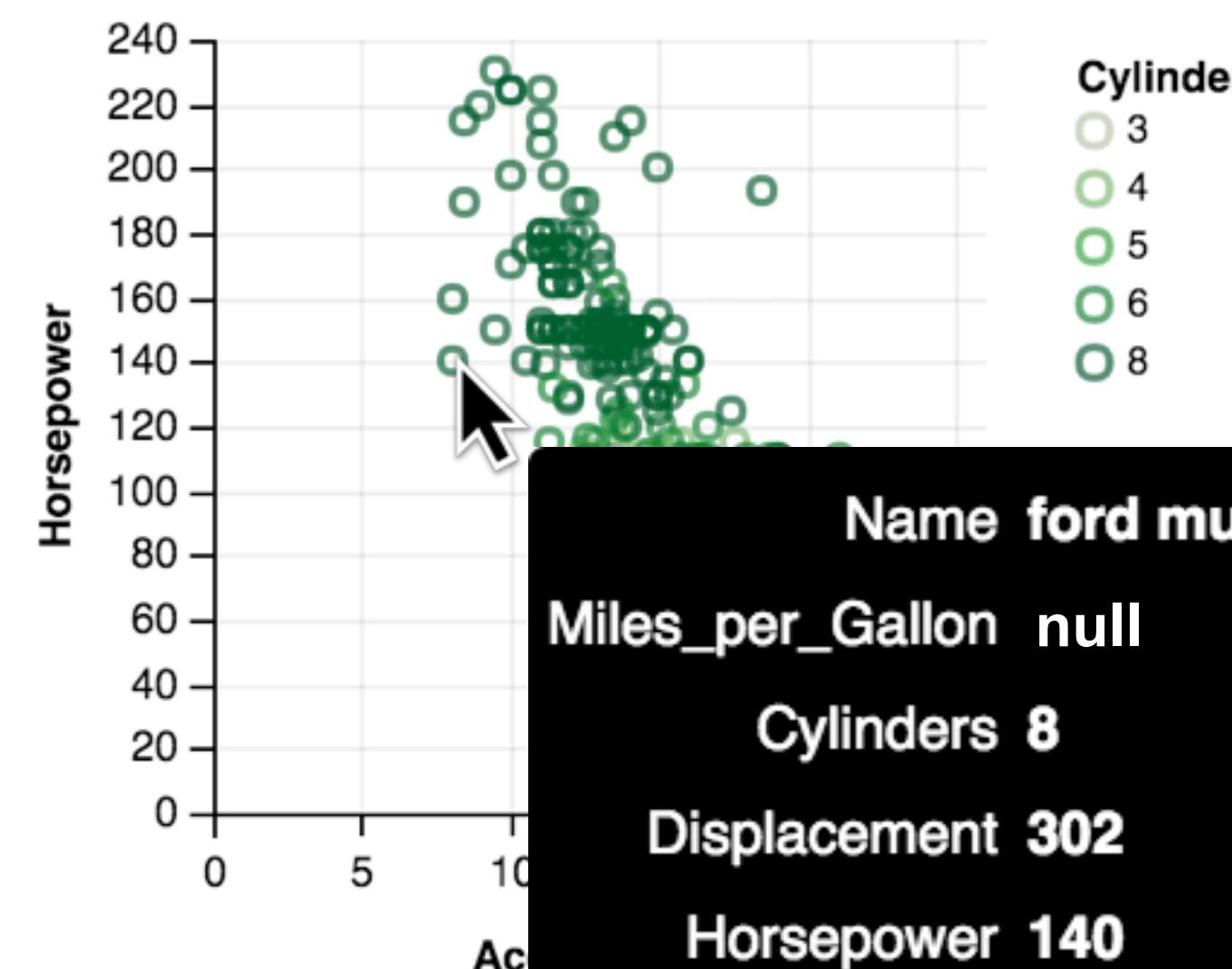
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

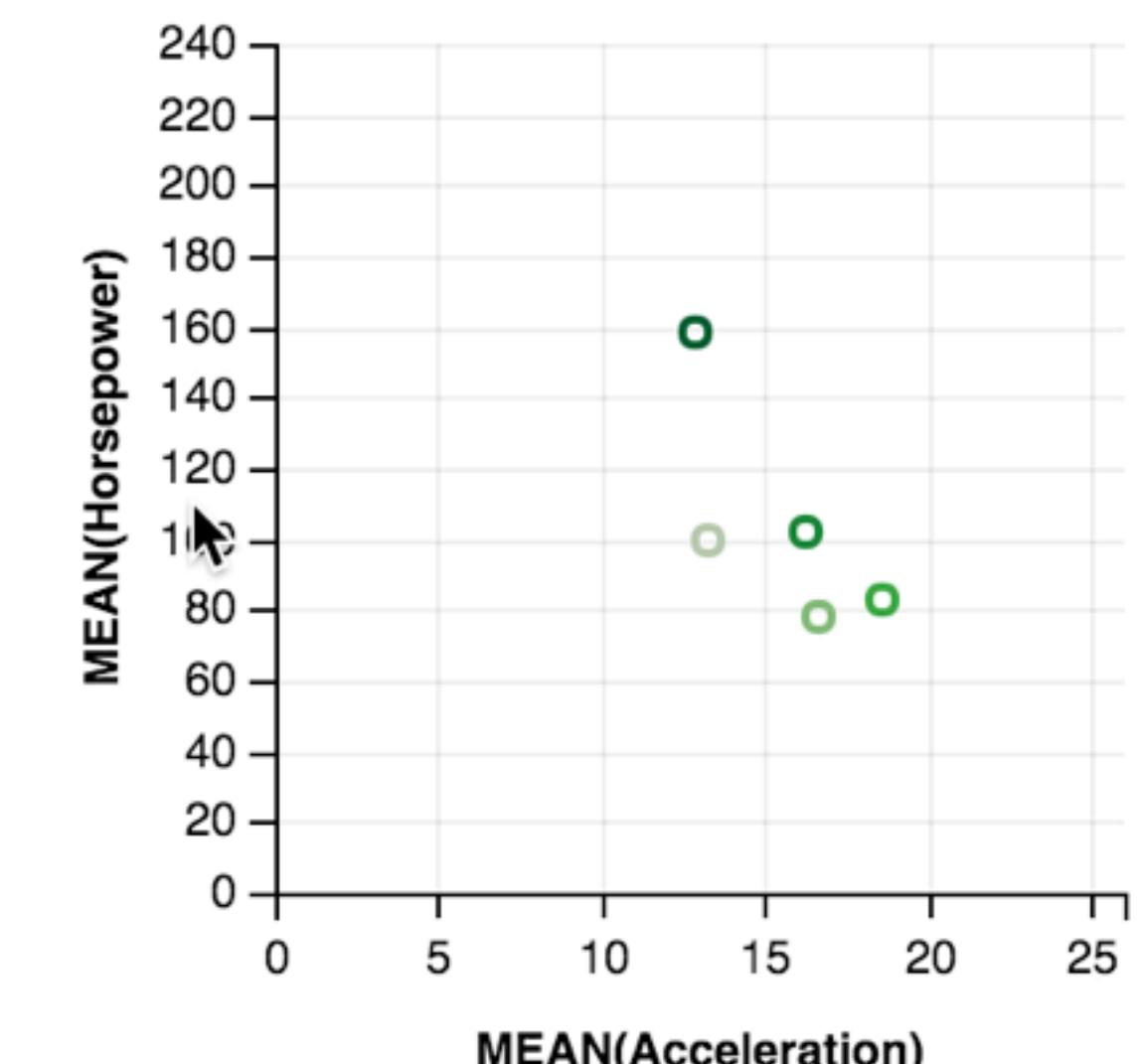
A Cylinders # Horsepower # Acceleration



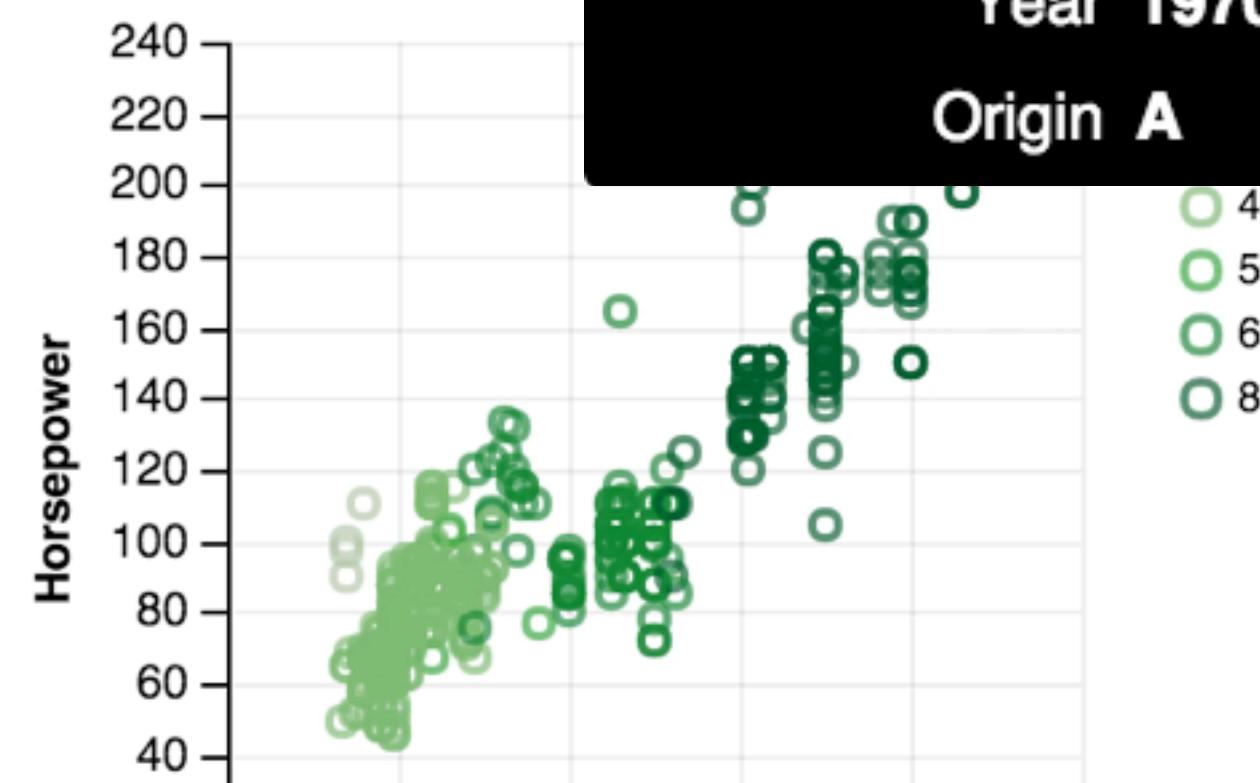
Name **ford mustang boss 302**
Miles_per_Gallon null
Cylinders **8**
Displacement **302**
Horsepower **140**
Weight_in_lbs **3353**
Acceleration **8**

Year **1970-01-01**Origin **A**

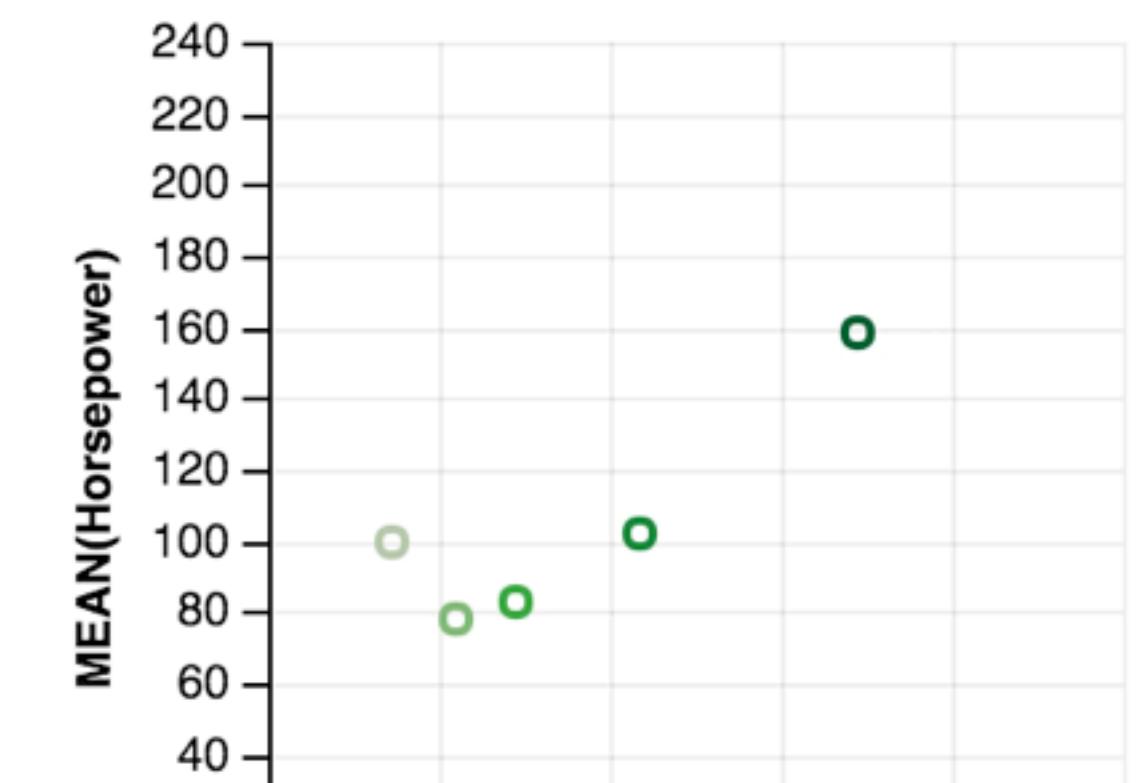
A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



A Cylinders # Horsepower



A Cylinders # MEAN (Horsepower) # MEAN (Displacement)



**BOSS
302**



Data

Cars

Change

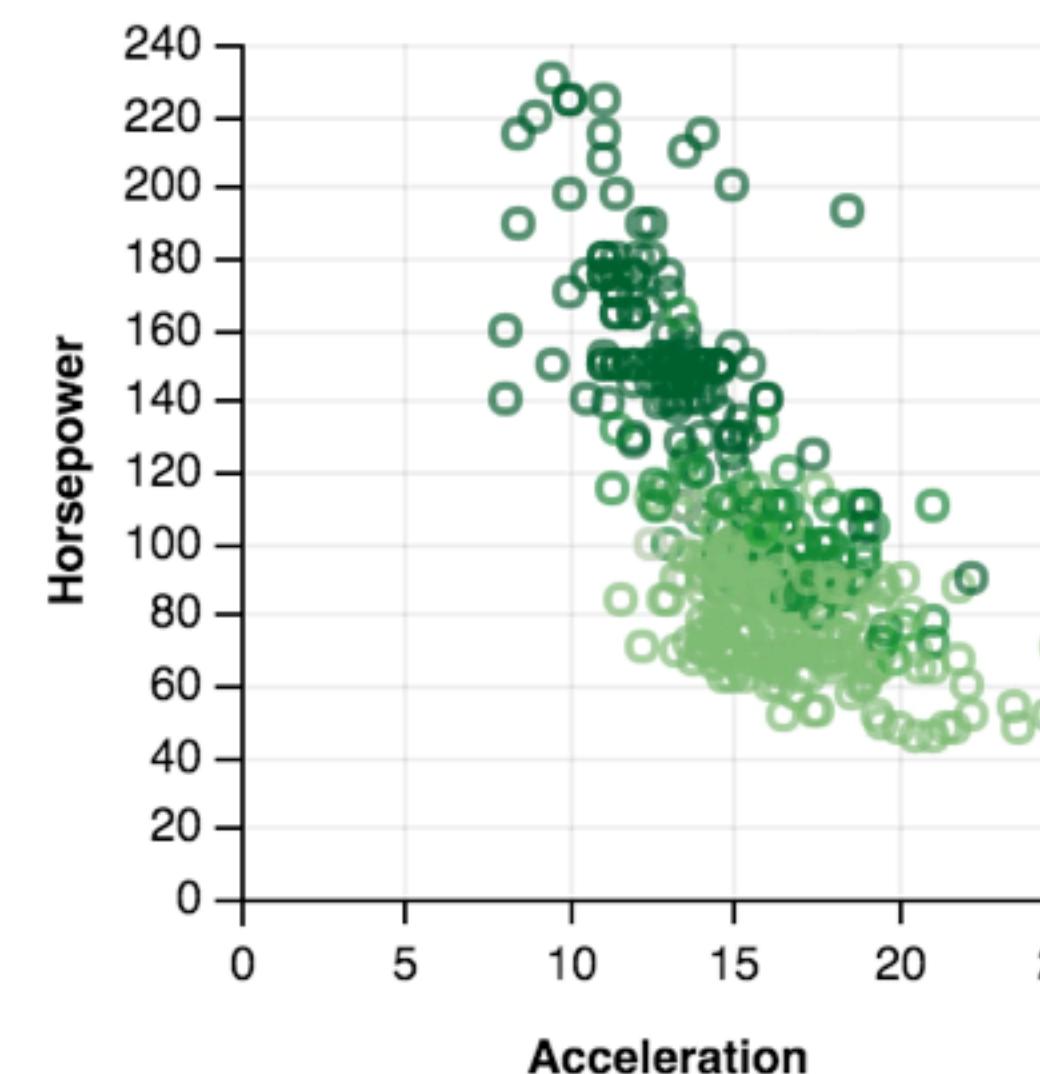
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected.

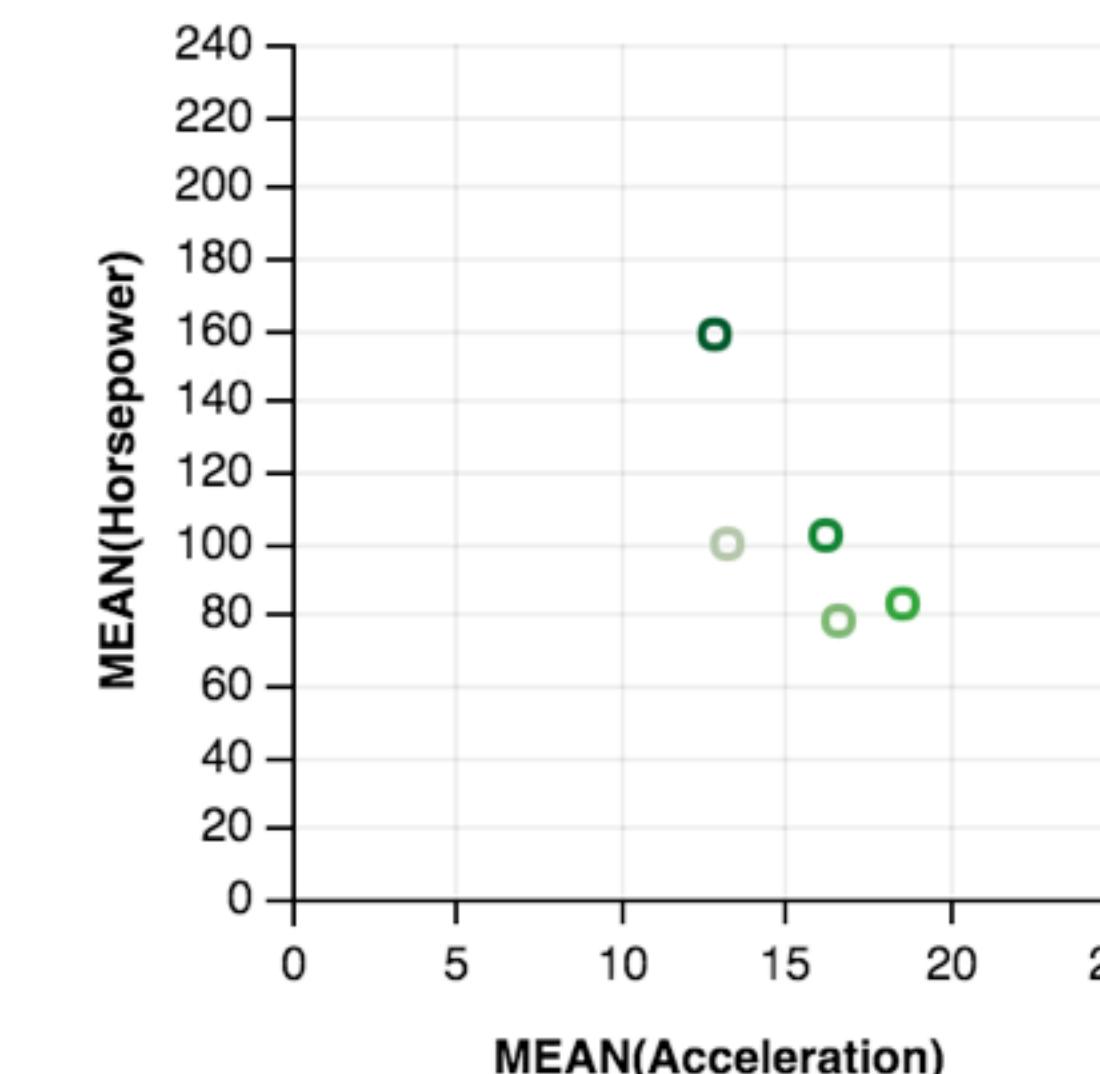
A Cylinders # Horsepower # Acceleration



Cylinders

- 3
- 4
- 5
- 6
- 8

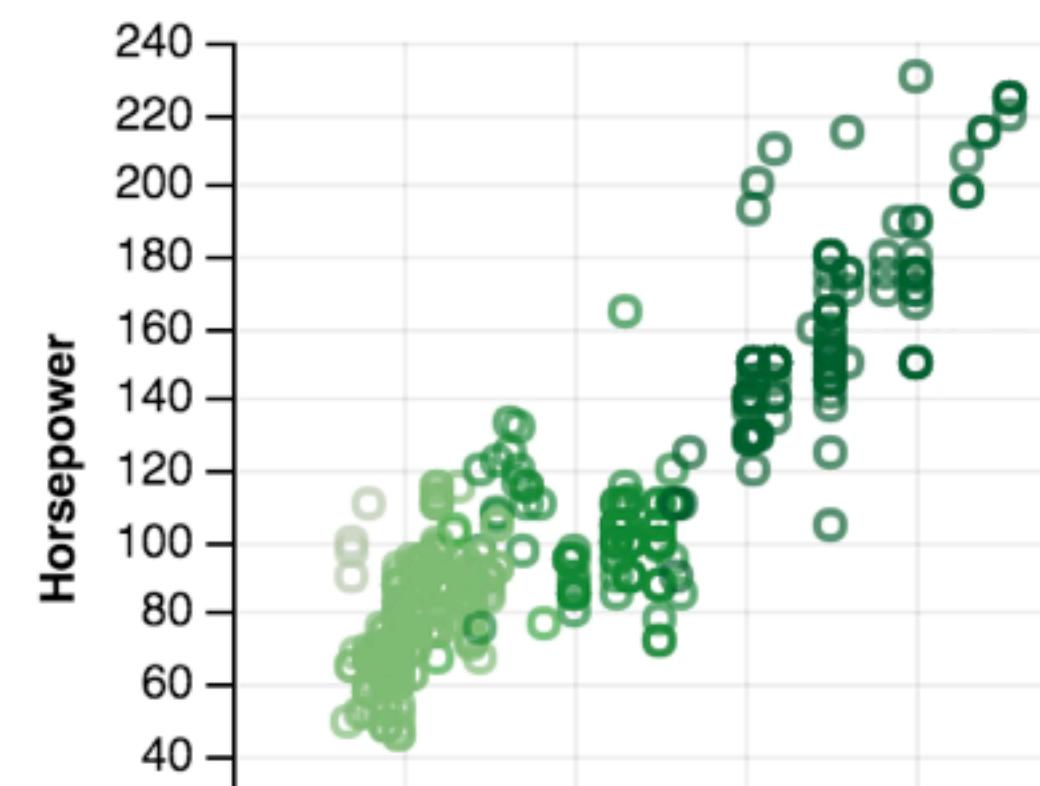
A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



Cylinders

- 3
- 4
- 5
- 6
- 8

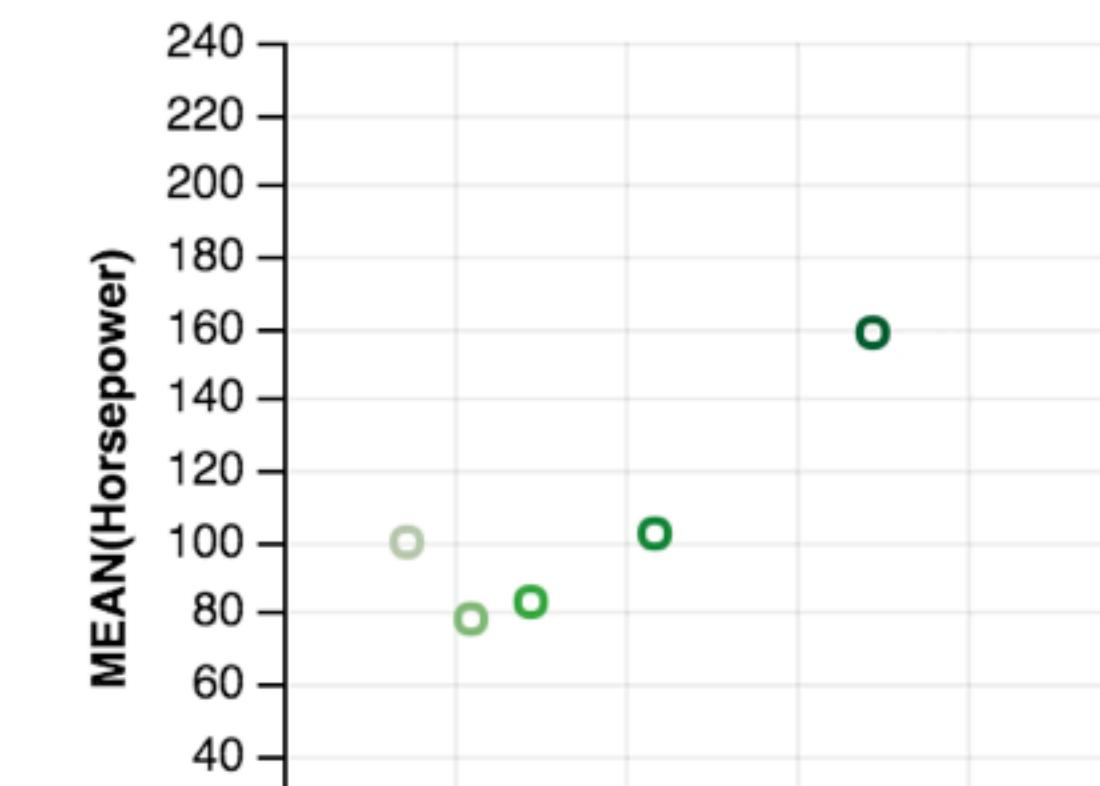
A Cylinders # Horsepower # Displacement



Cylinders

- 3
- 4
- 5
- 6
- 8

A Cylinders # MEAN (Horsepower) # MEAN (Displacement)



Cylinders

- 3
- 4
- 5
- 6
- 8

Data

Cars

Change

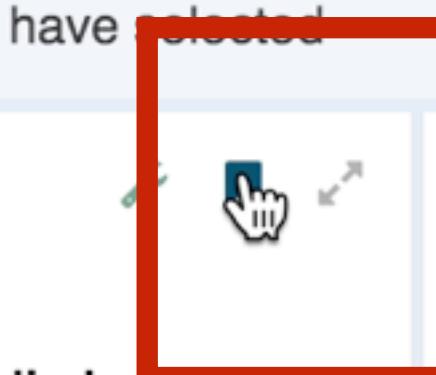
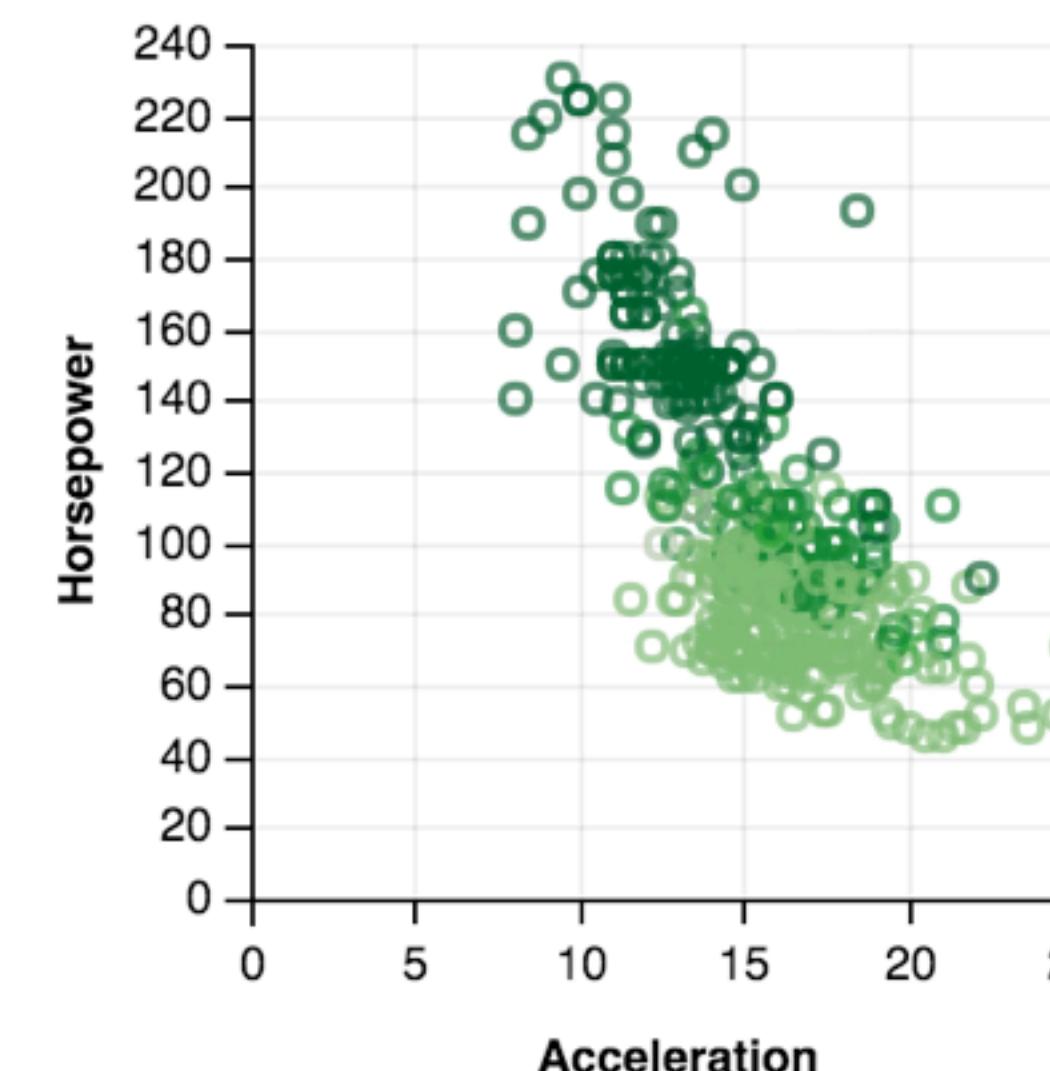
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

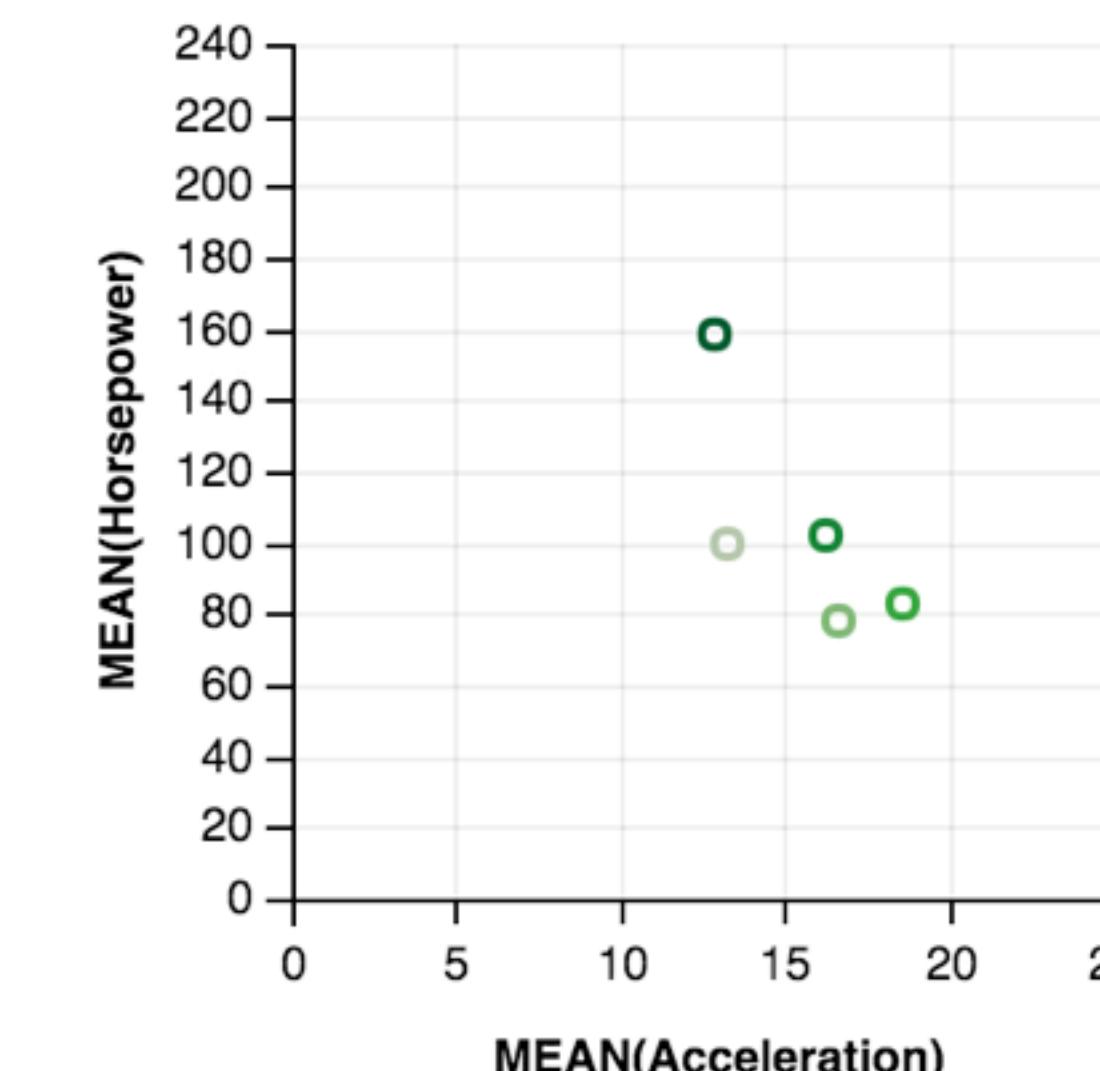
Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

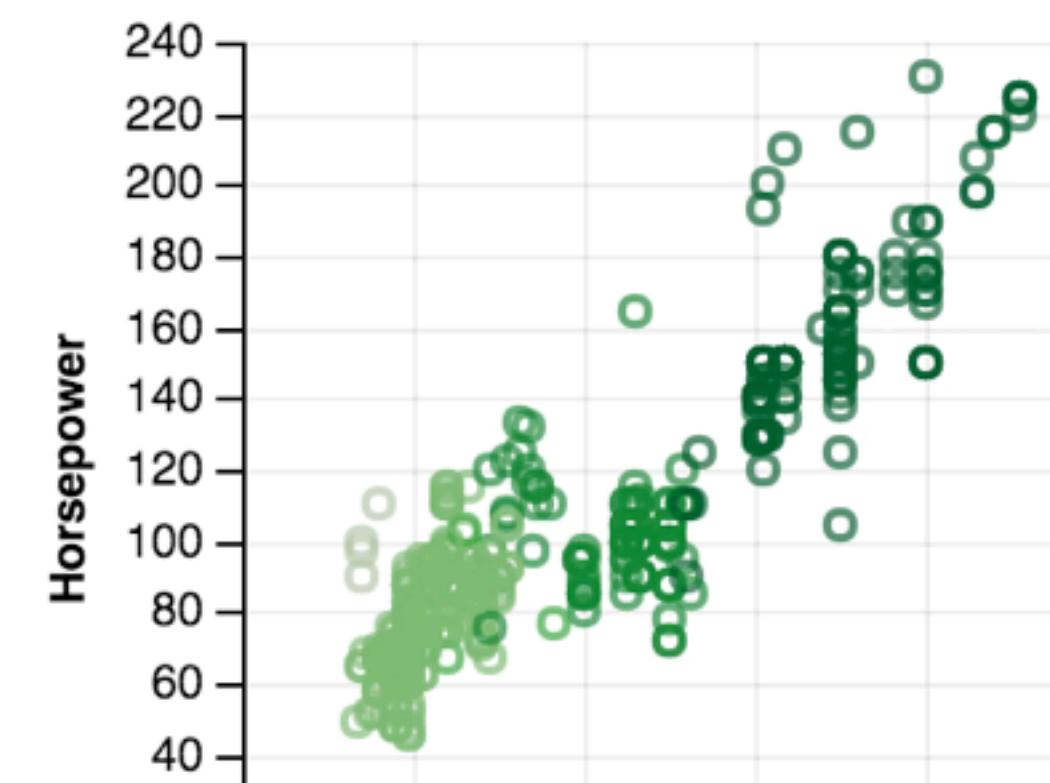
A Cylinders # Horsepower # Acceleration



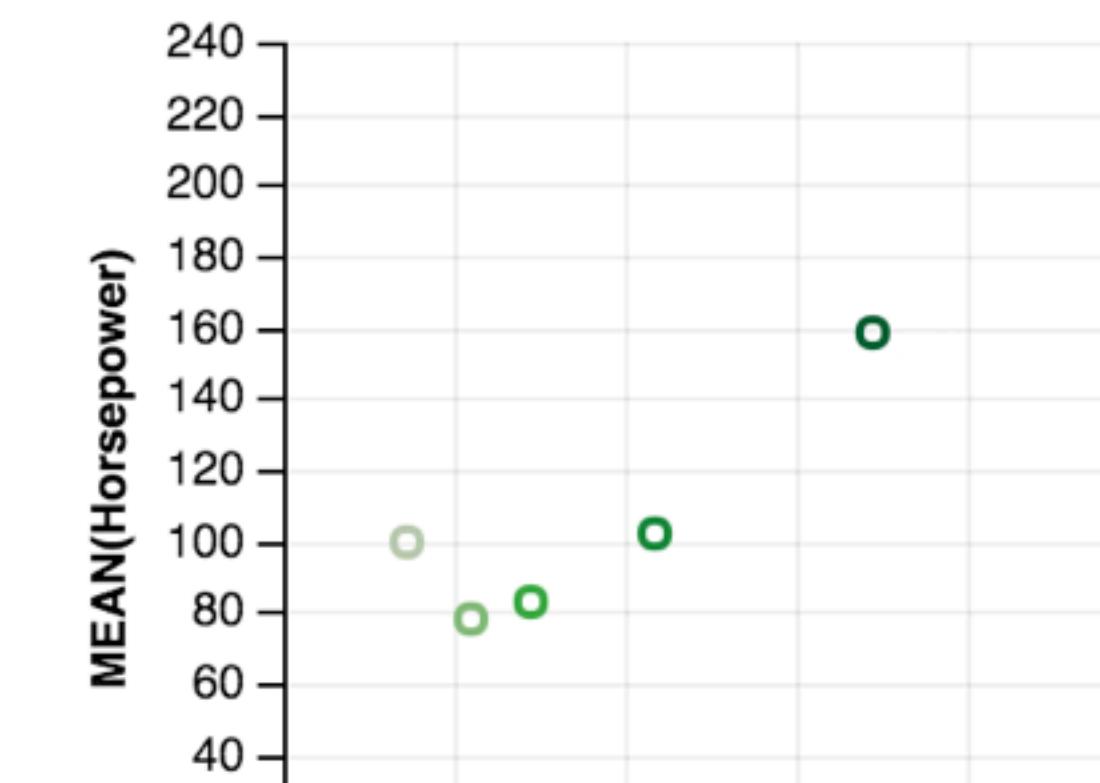
A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



A Cylinders # Horsepower # Displacement



A Cylinders # MEAN (Horsepower) # MEAN (Displacement)



Data

Cars

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J
- K
- L
- M
- N
- O

Rese

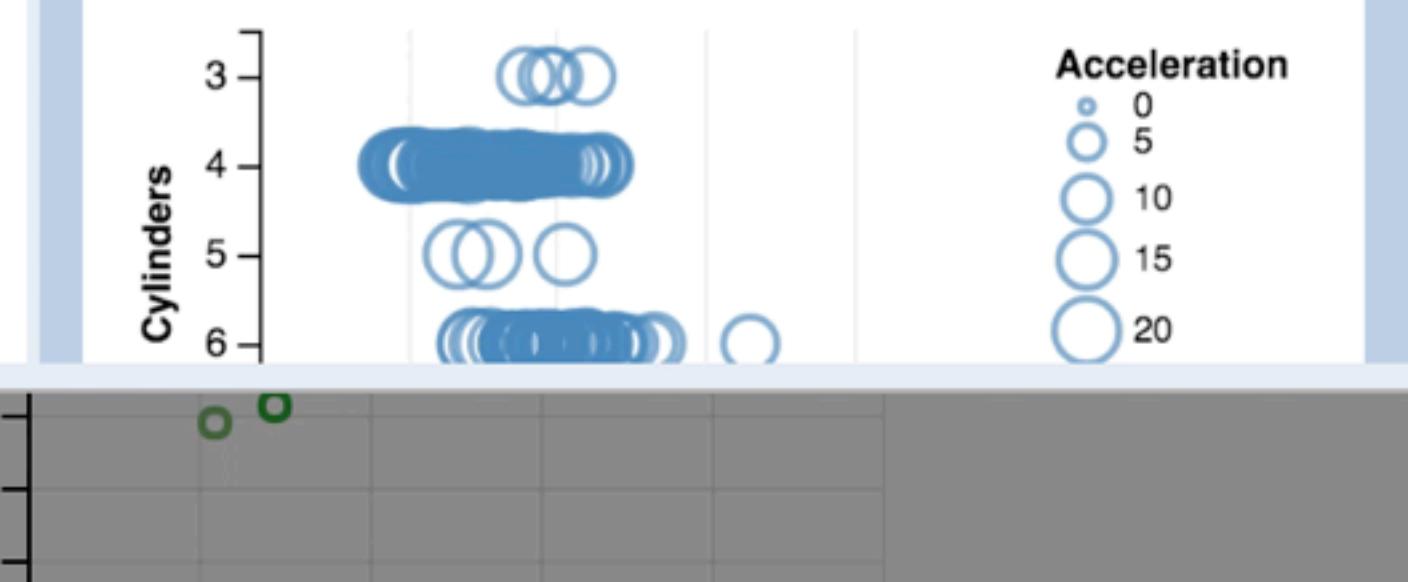
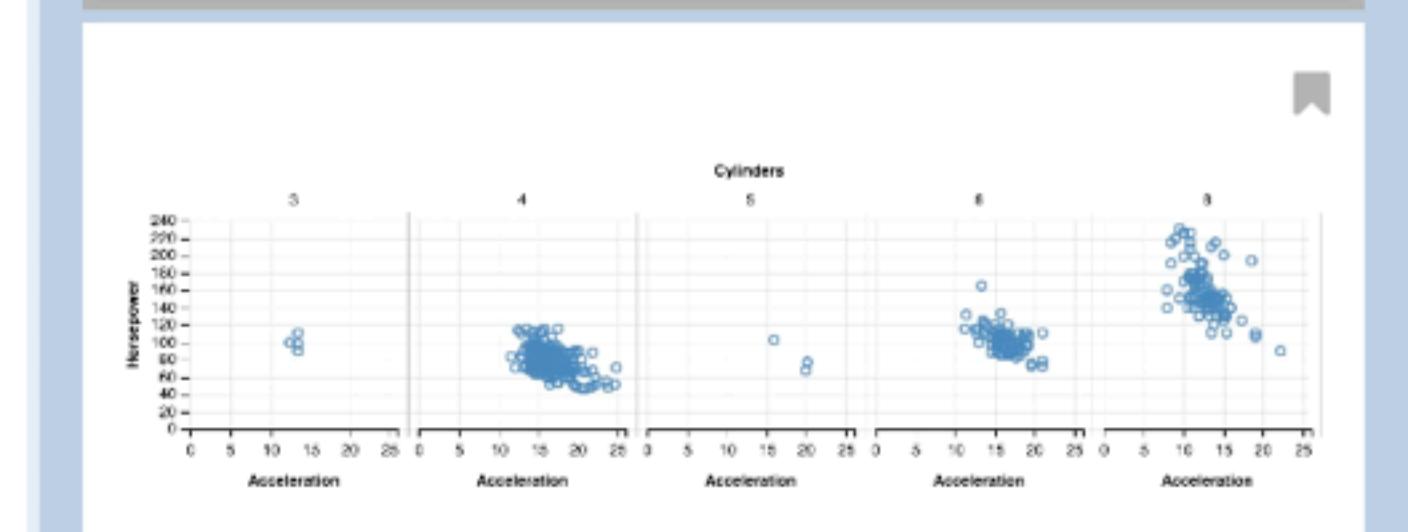
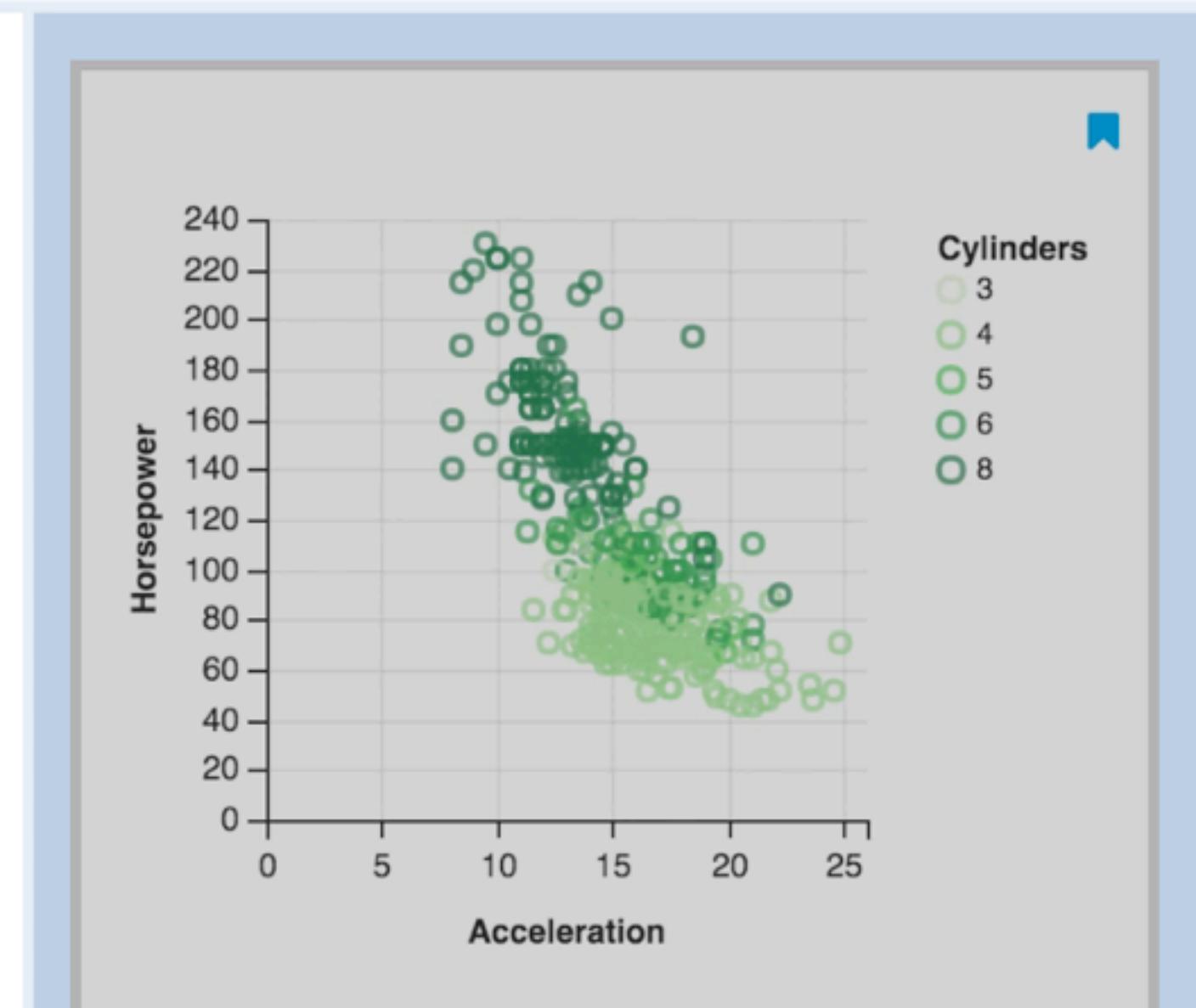
Various Visualizations Showing

A Cylinders

Horsepower

Acceleration

Close



Data

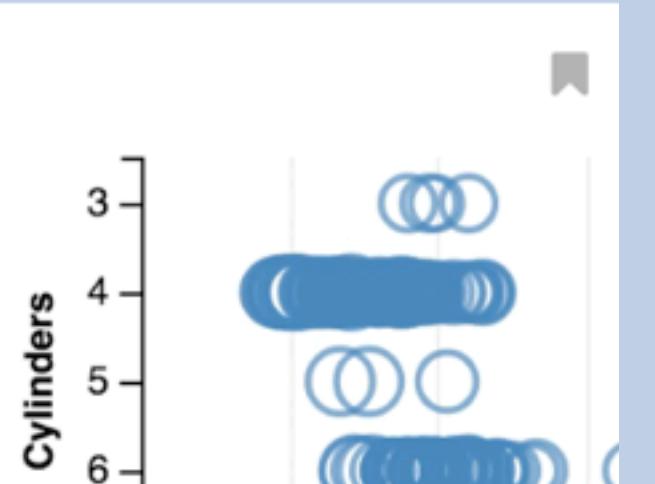
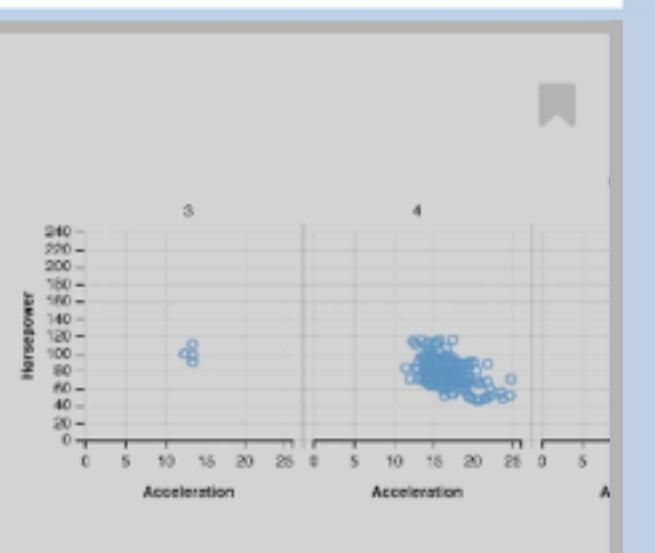
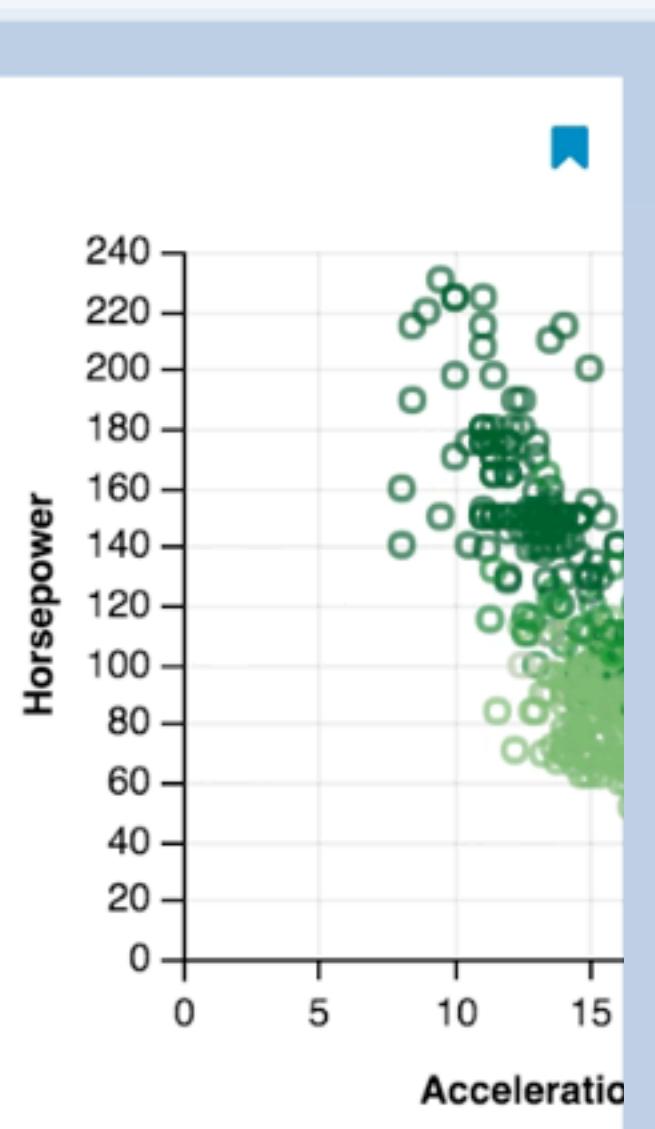
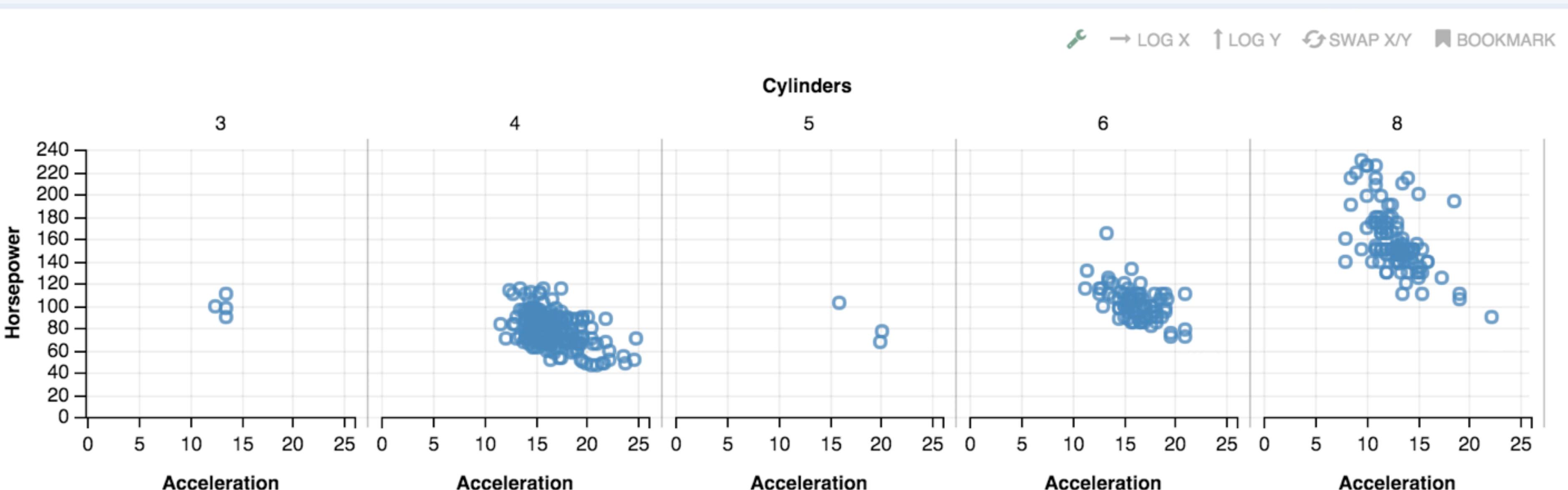
Various Visualizations Showing

Activity A Cylinders

Horsepower

Acceleration

Close



Data

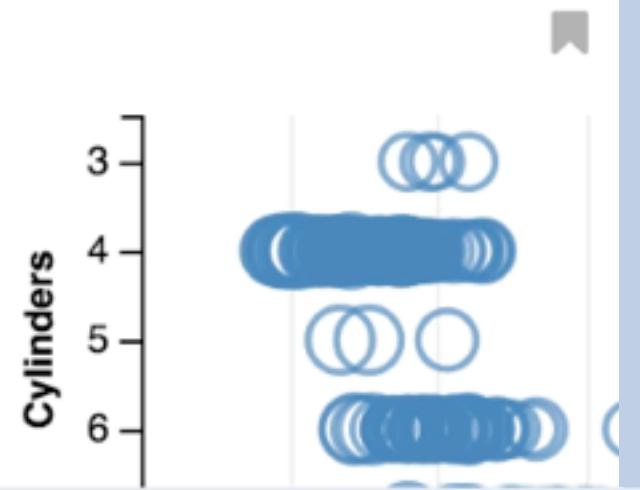
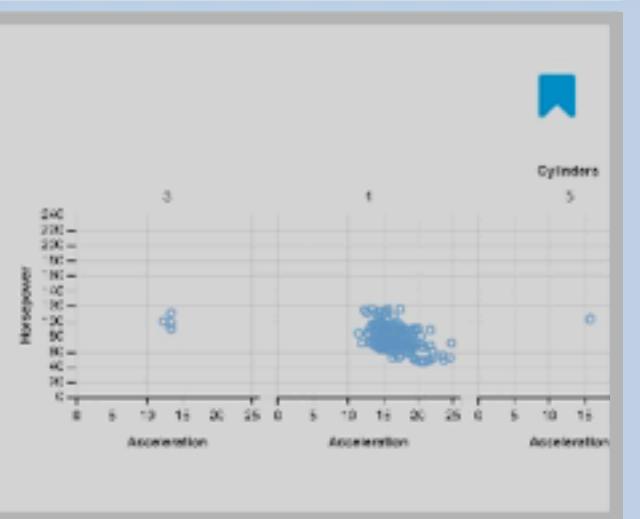
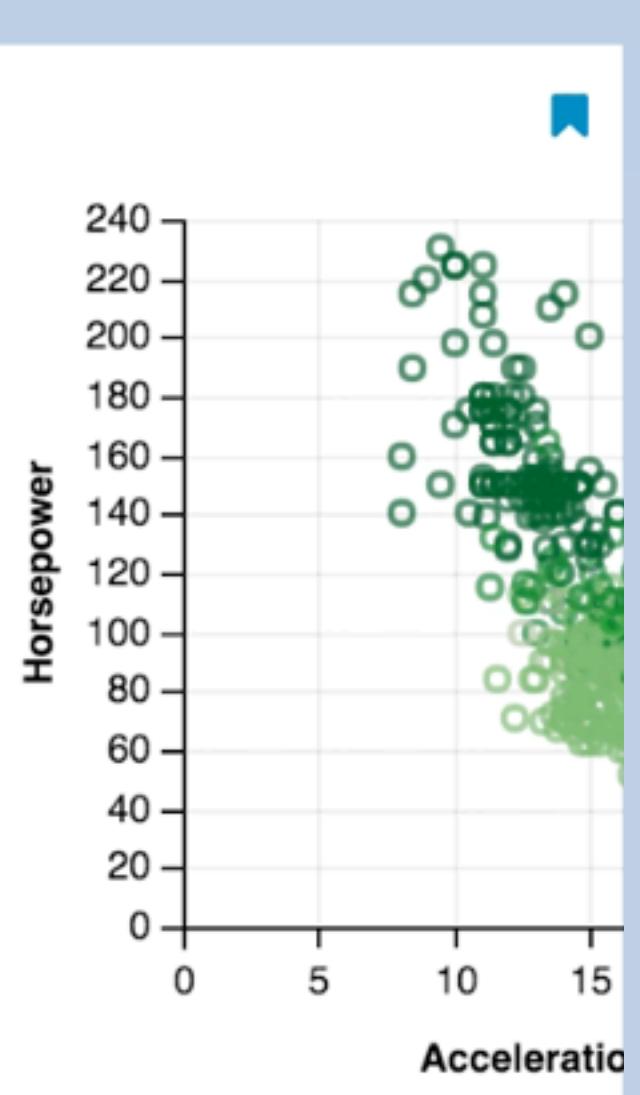
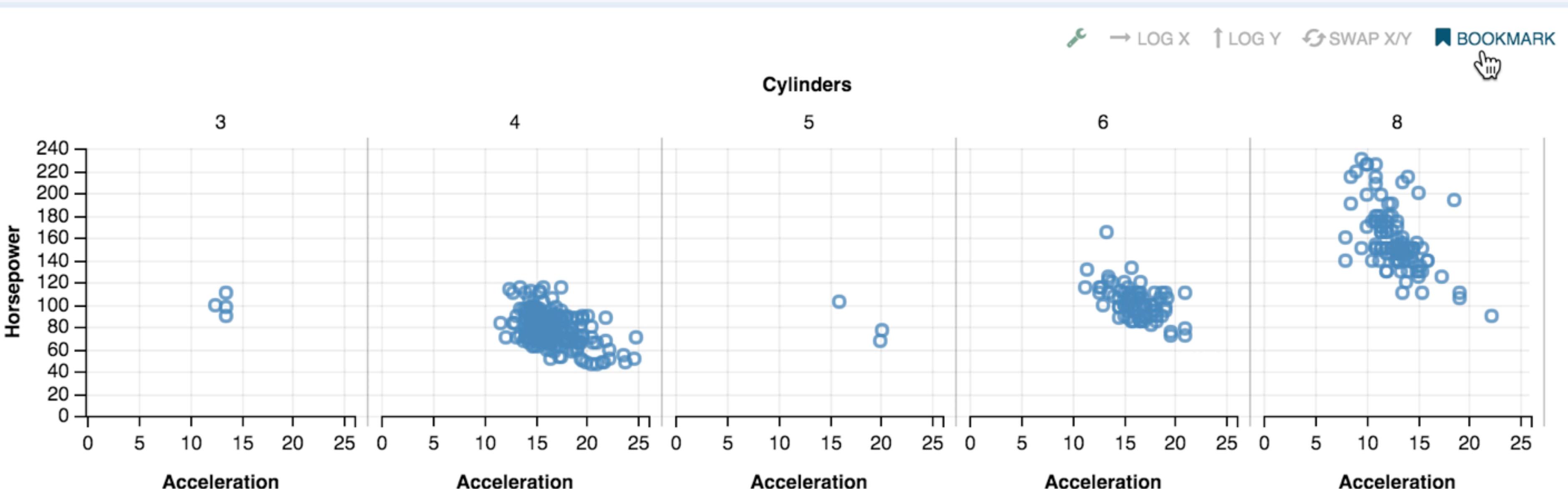
Various Visualizations Showing

A Cylinders

Horsepower

Acceleration

Close



Data

Cars

- A
- A
- A
- A
- A
- i
- i
- i
- i

Rese

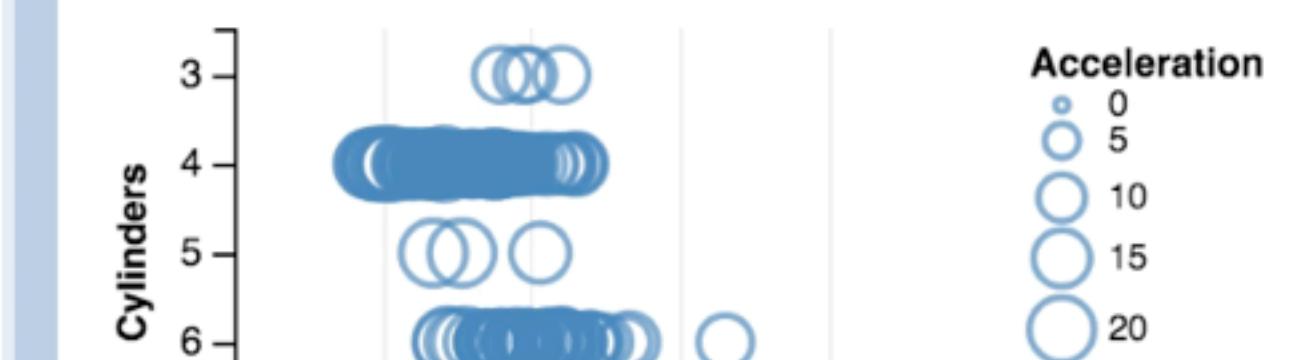
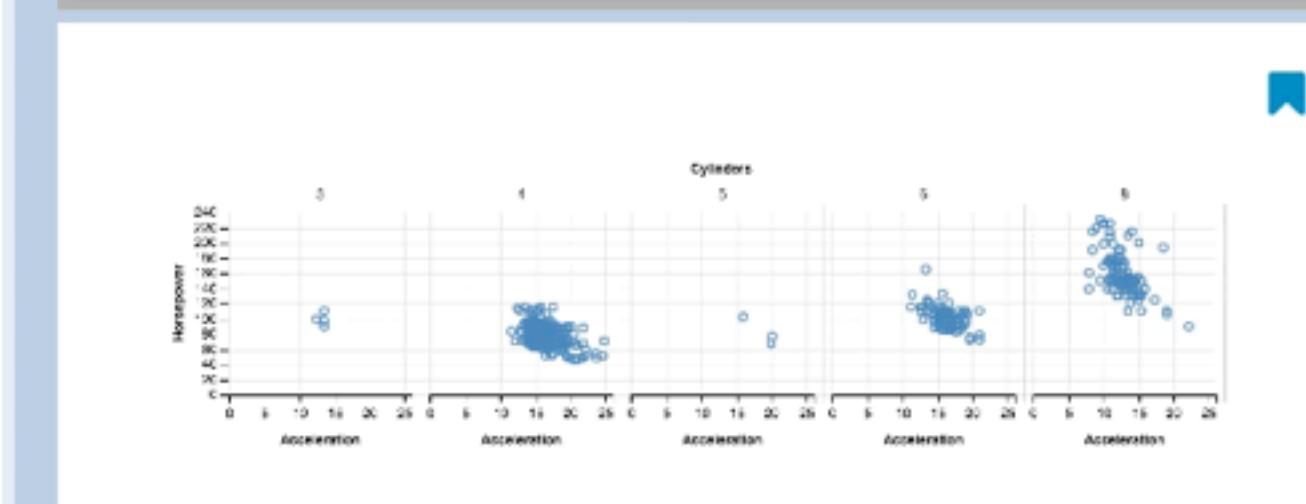
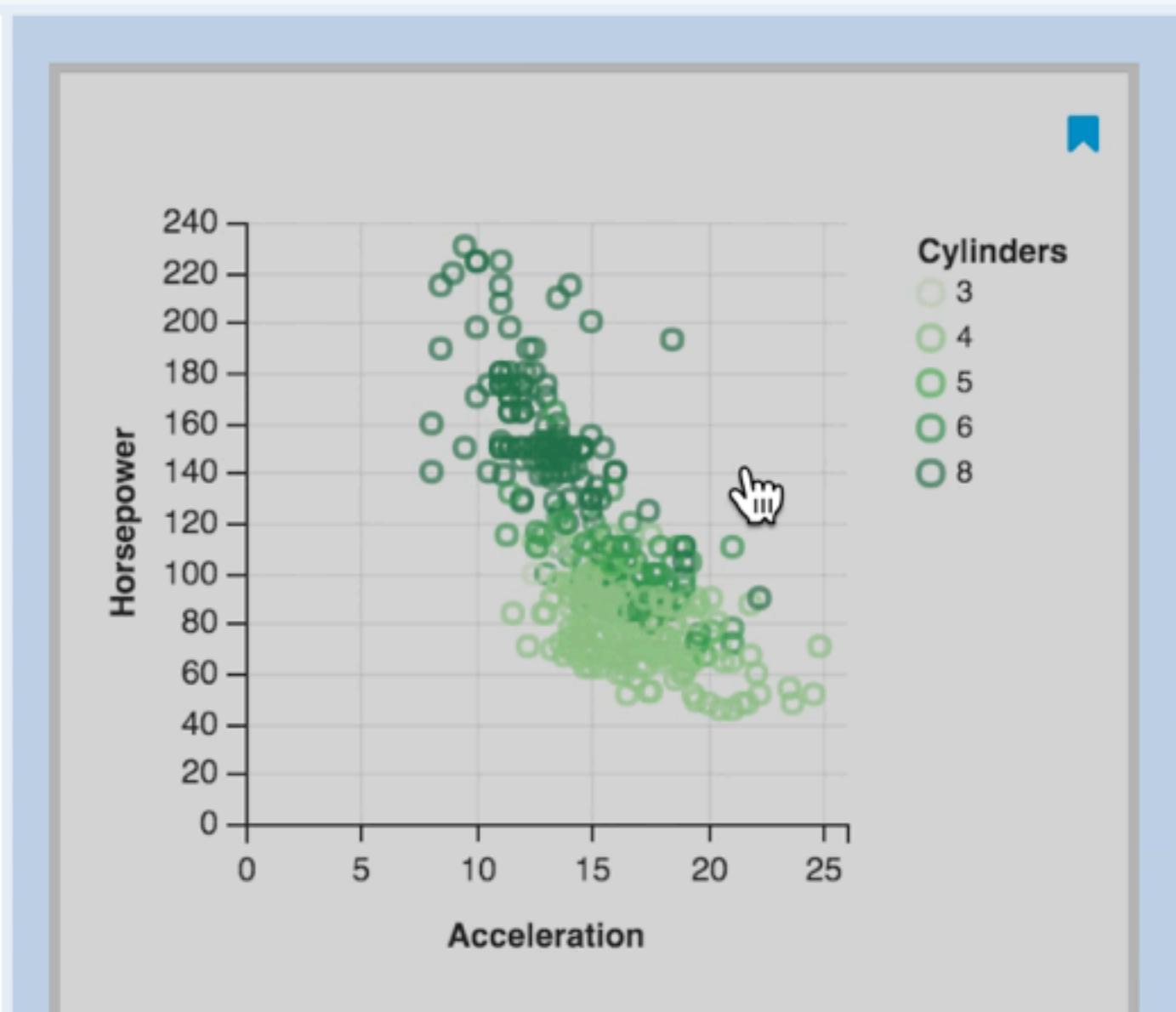
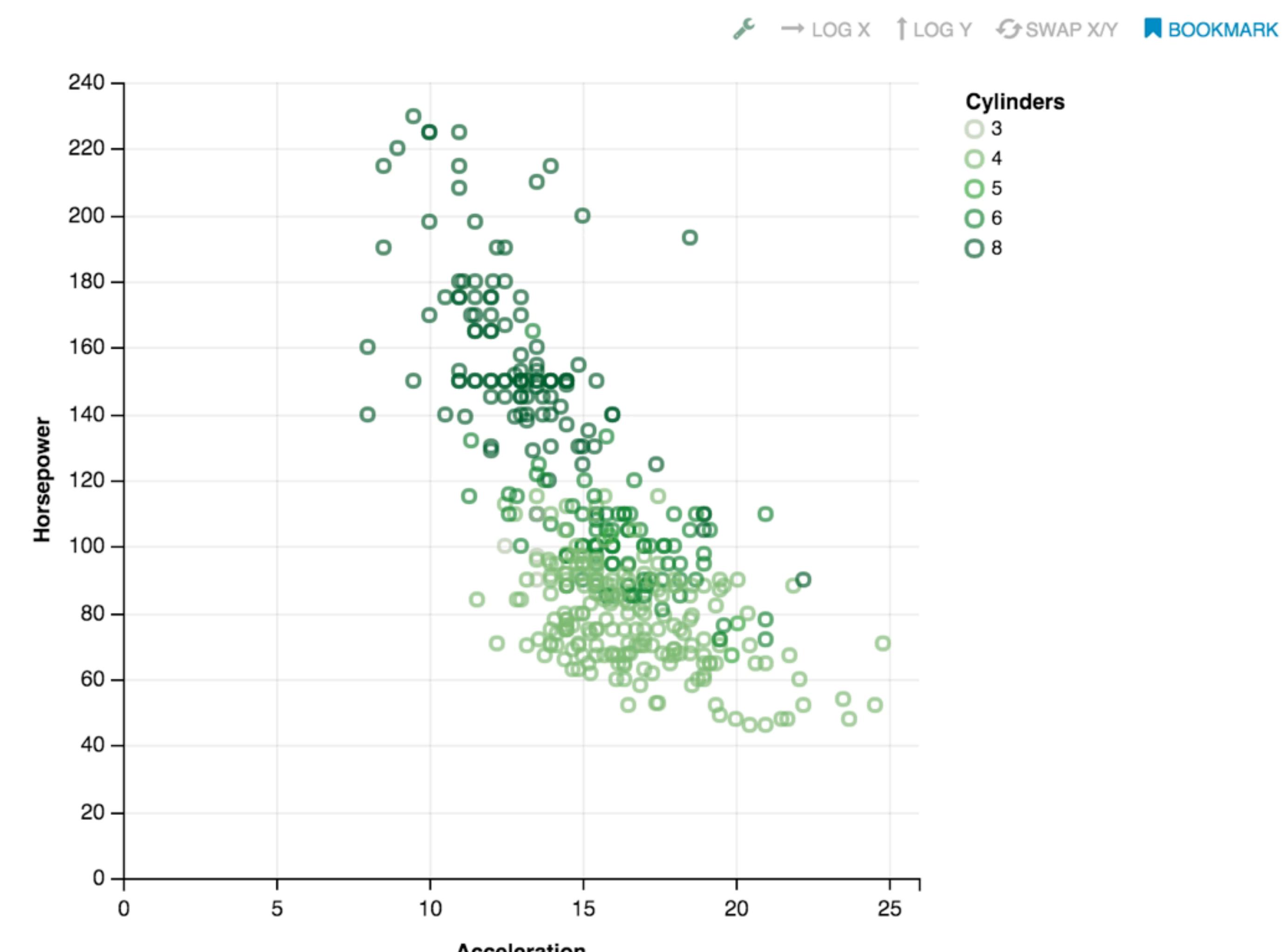
Various Visualizations Showing

A Cylinders

Horsepower

Acceleration

Close



Data

Cars

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J
- K
- L
- M
- N
- O

Rese

Various Visualizations Showing

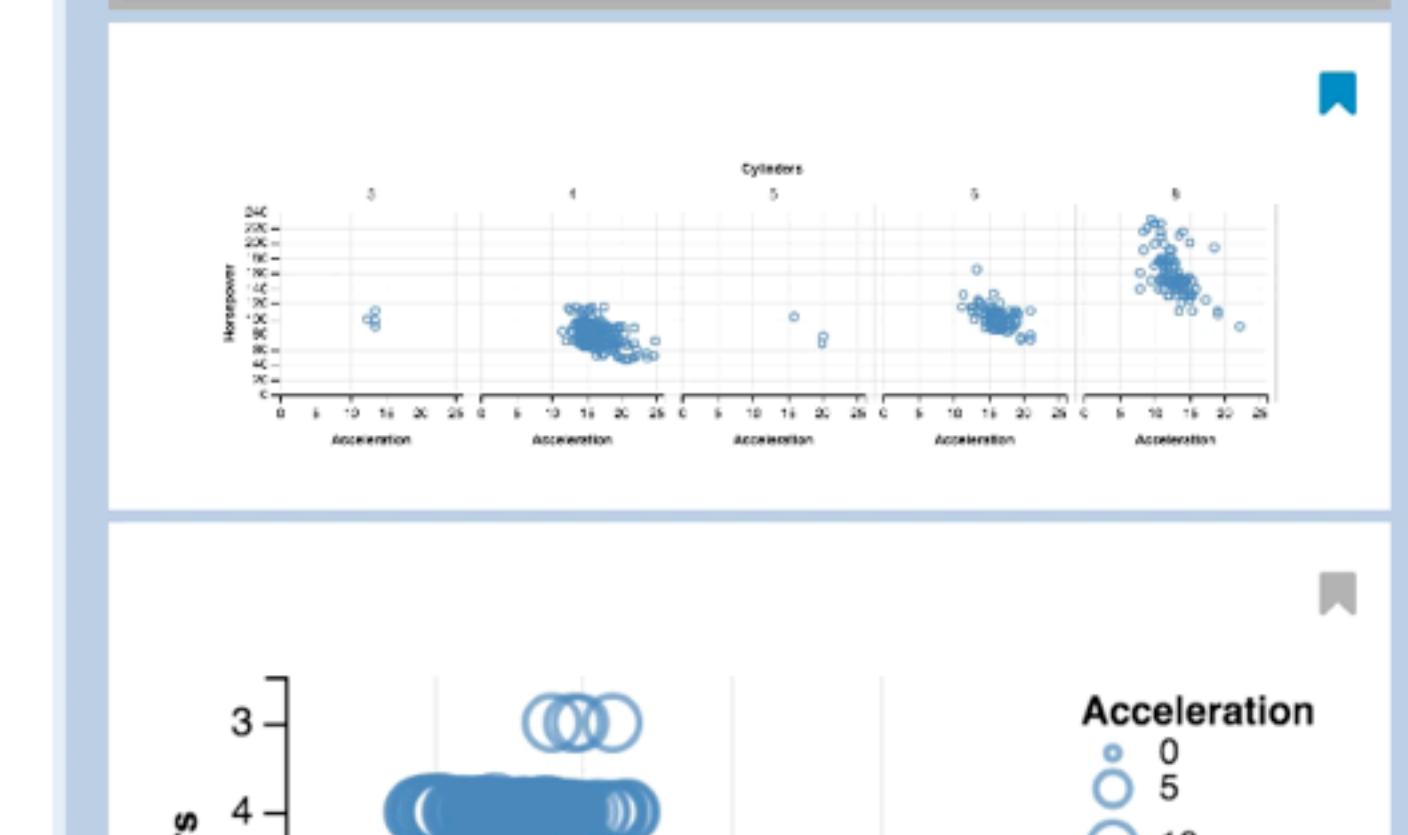
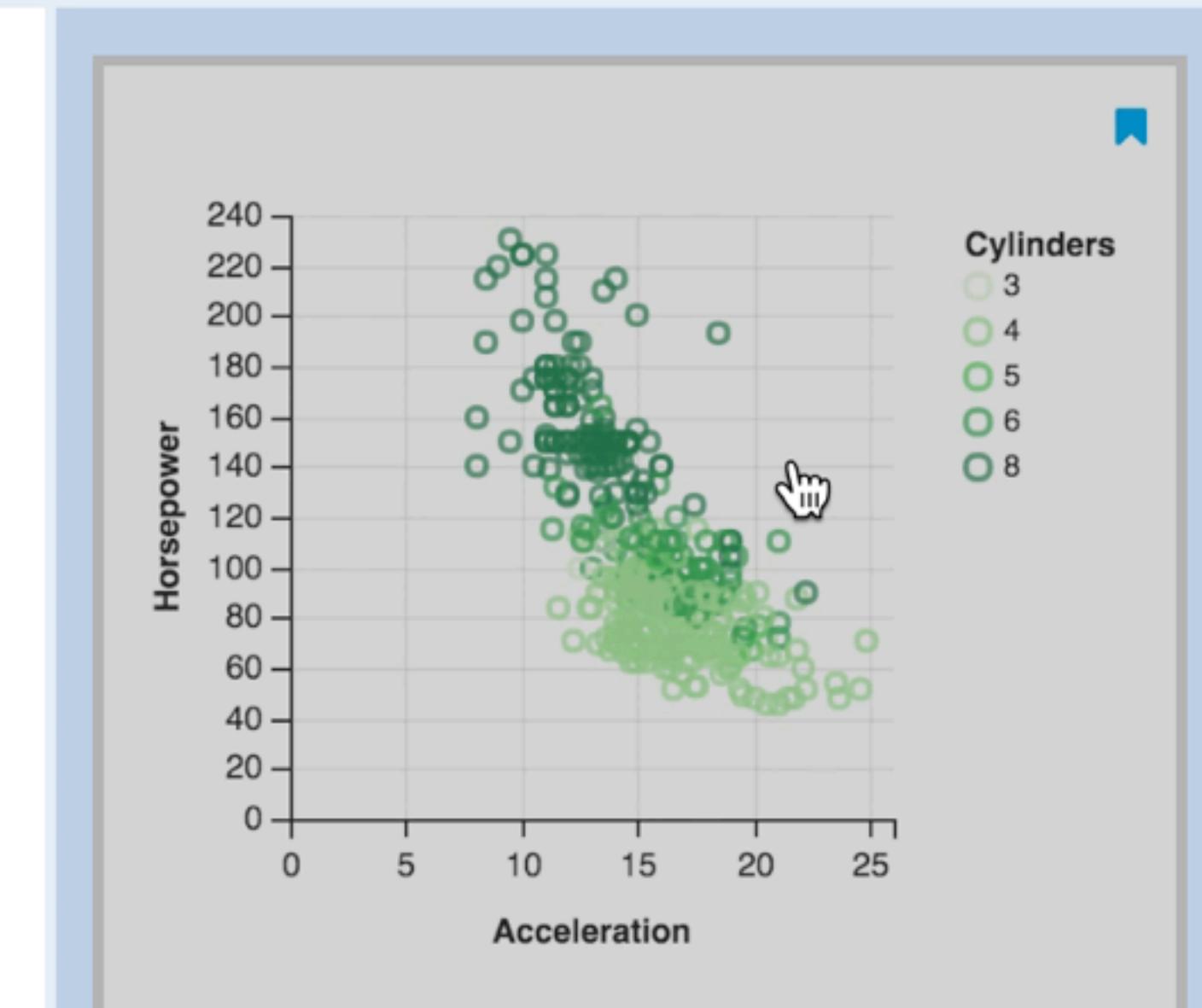
A Cylinders

Horsepower

Acceleration

Close

→ LOG X ↑ LOG Y ⚡ SWAP X/Y BOOKMARK



#4 Prefer fine-tuning to exhaustive enumeration

Data

Cars

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J
- K
- L
- M
- N
- O

Rese

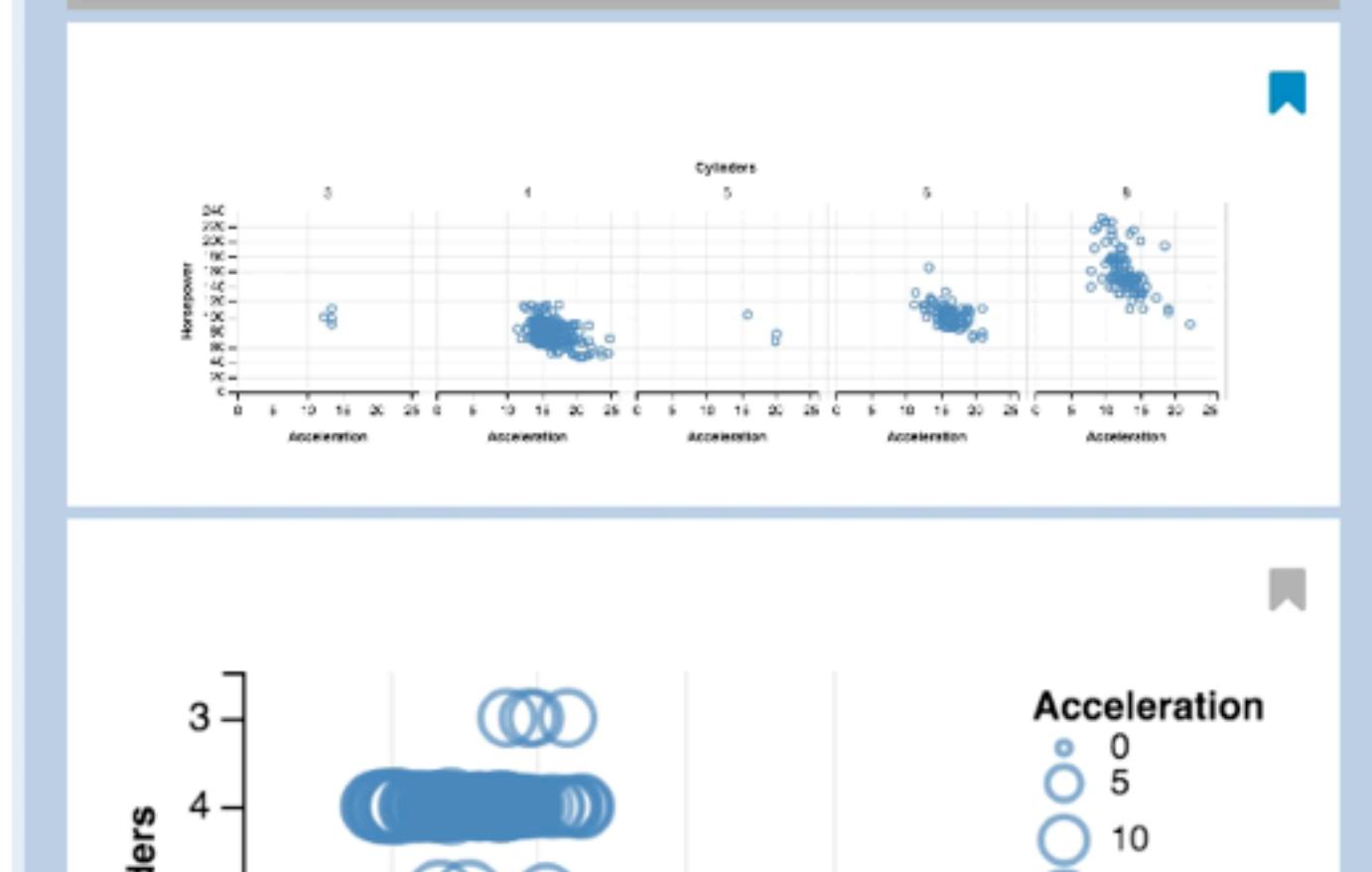
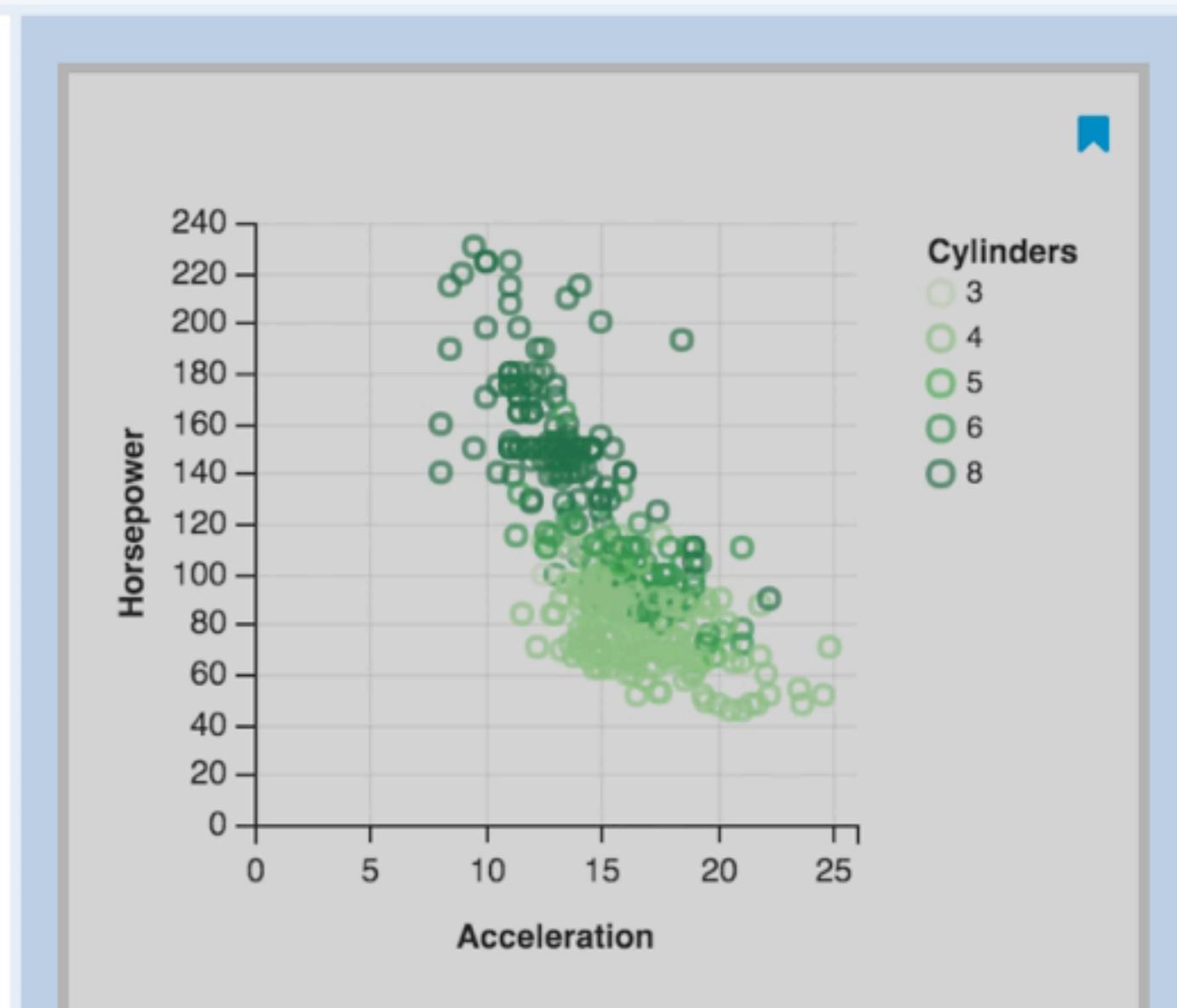
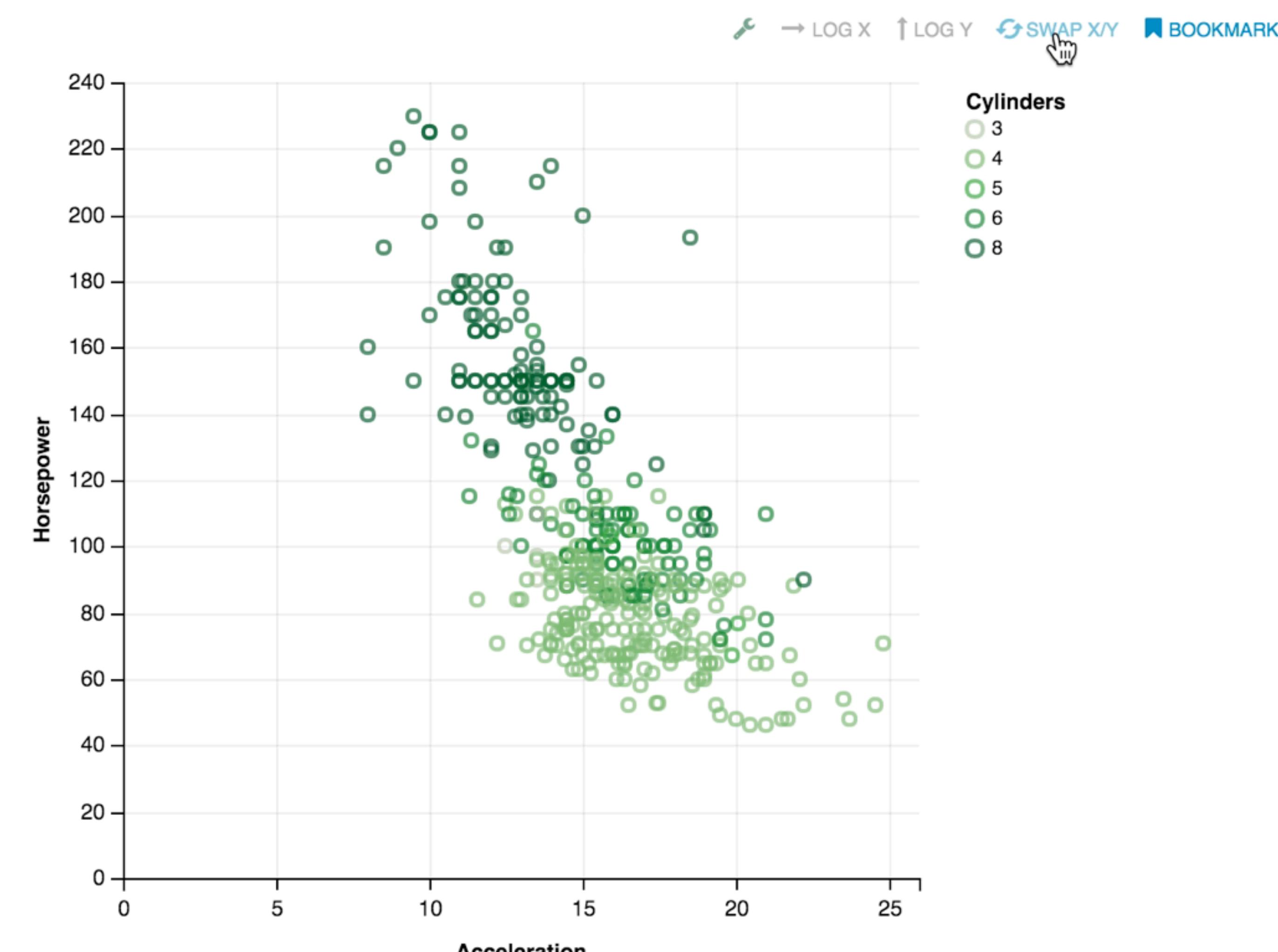
Various Visualizations Showing

A Cylinders

Horsepower

Acceleration

Close



Data

Cars

Change

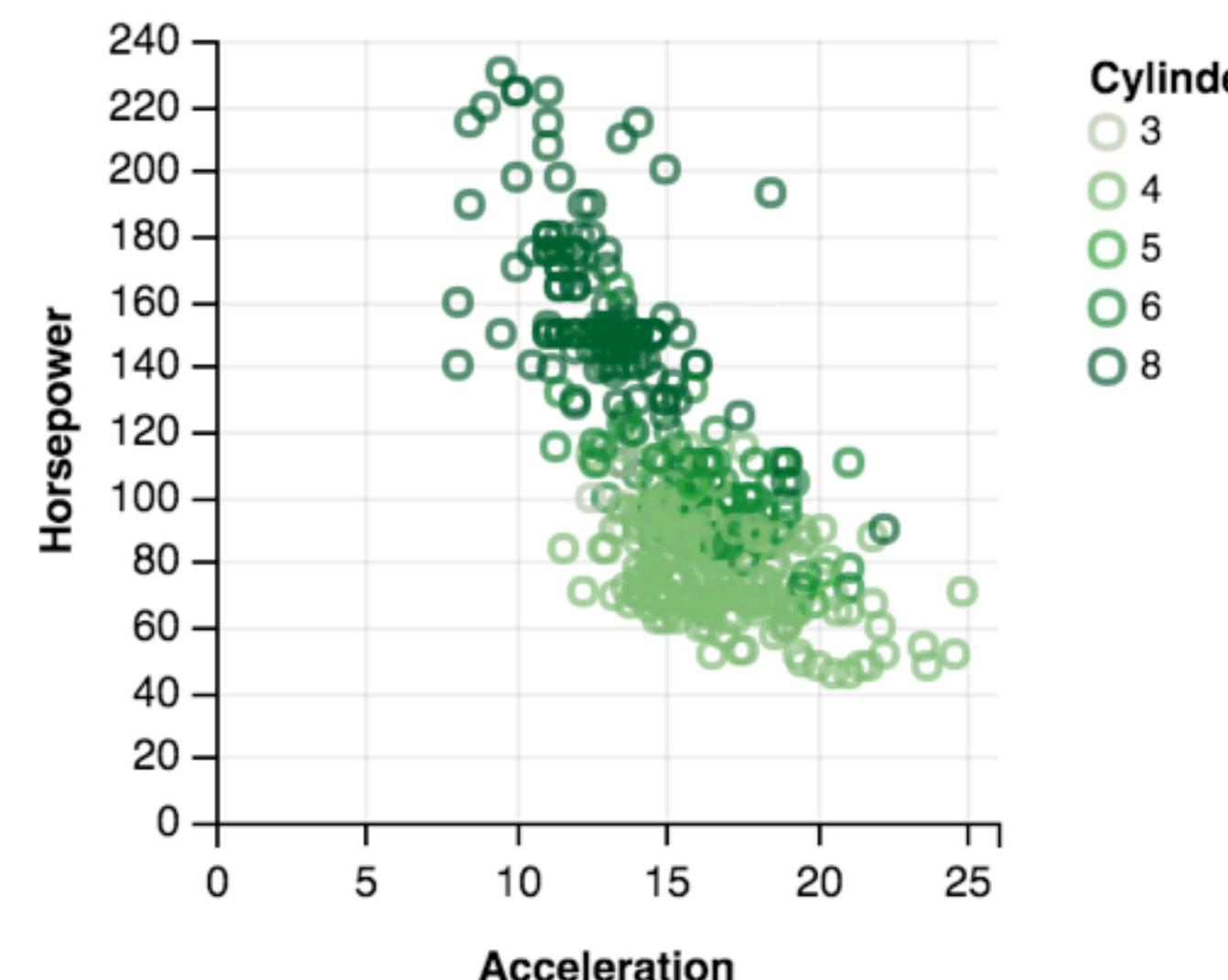
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

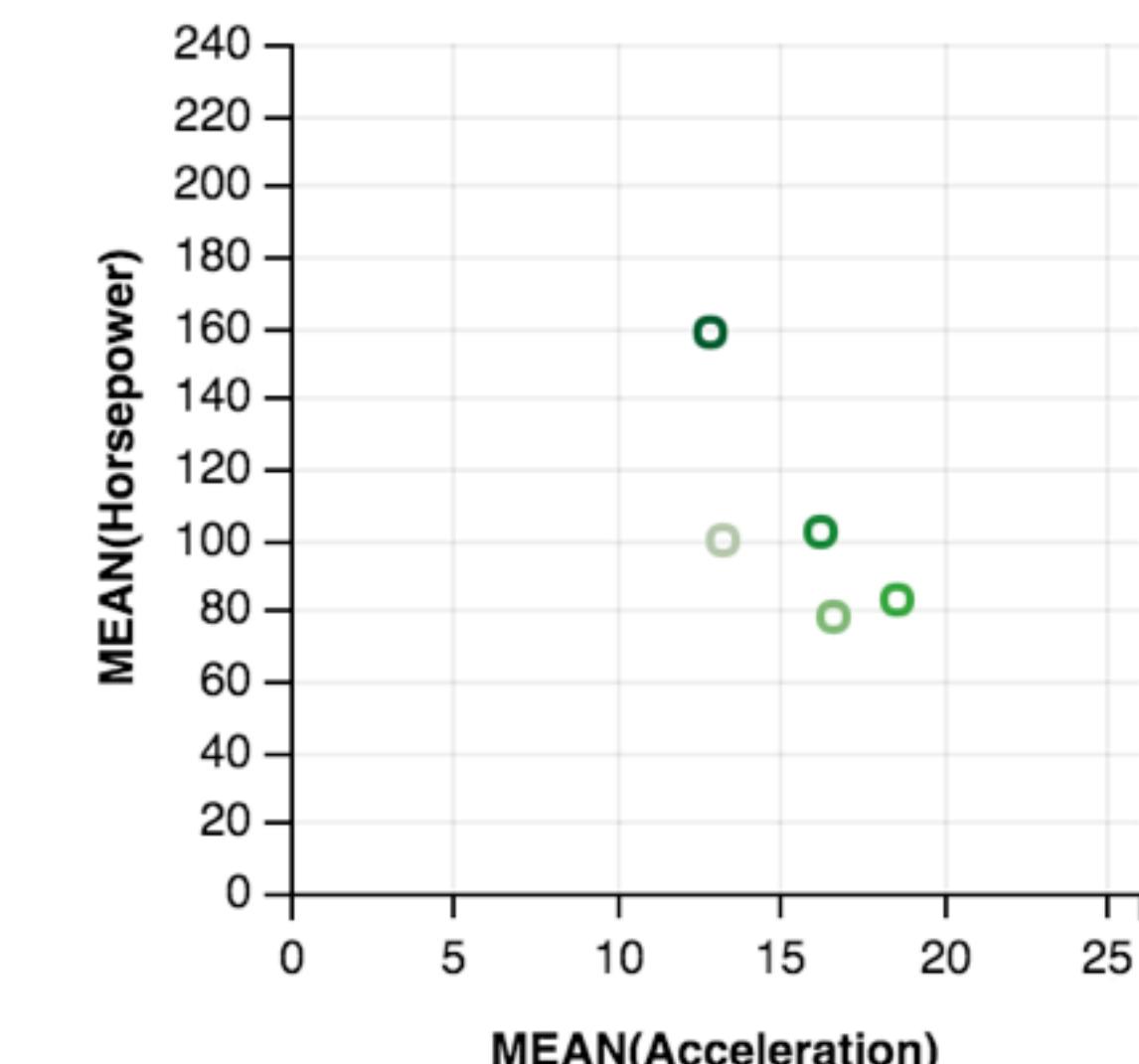
Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

A Cylinders # Horsepower # Acceleration



A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



A Cylinders # Horsepower # Displacement



A Cylinders # MEAN (Horsepower) # MEAN (Displacement)



#3 Use expressive and effective visual encodings.

Data

Cars

Change

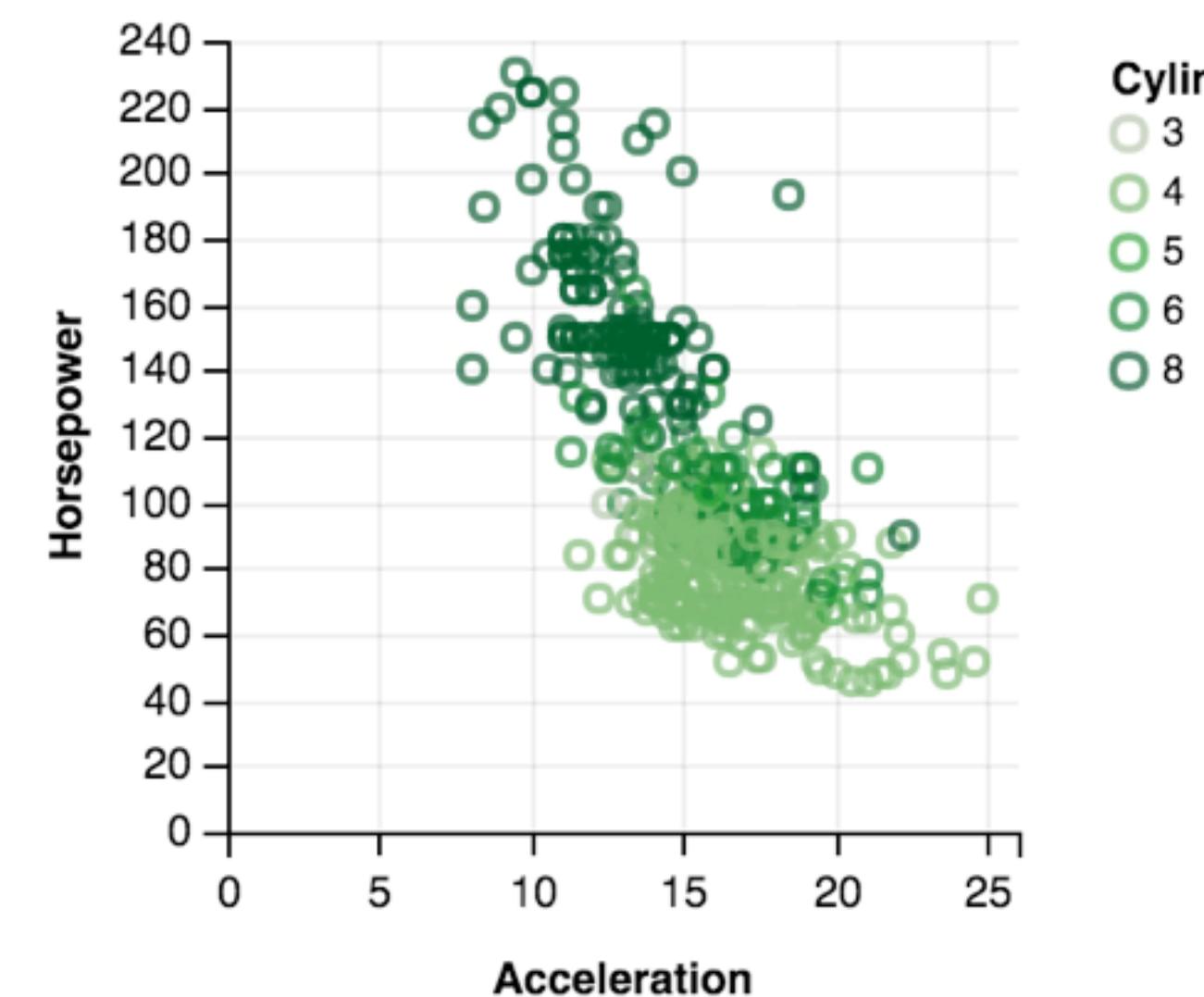
- A Cylinders
- A Name
- A Origin
- AUTO (Year)
- # AUTO (Acceleration)
- # AUTO (Displacement)
- # AUTO (Horsepower)
- # AUTO (Miles per Gallon)
- # AUTO (Weight in lbs)
- # COUNT

Reset

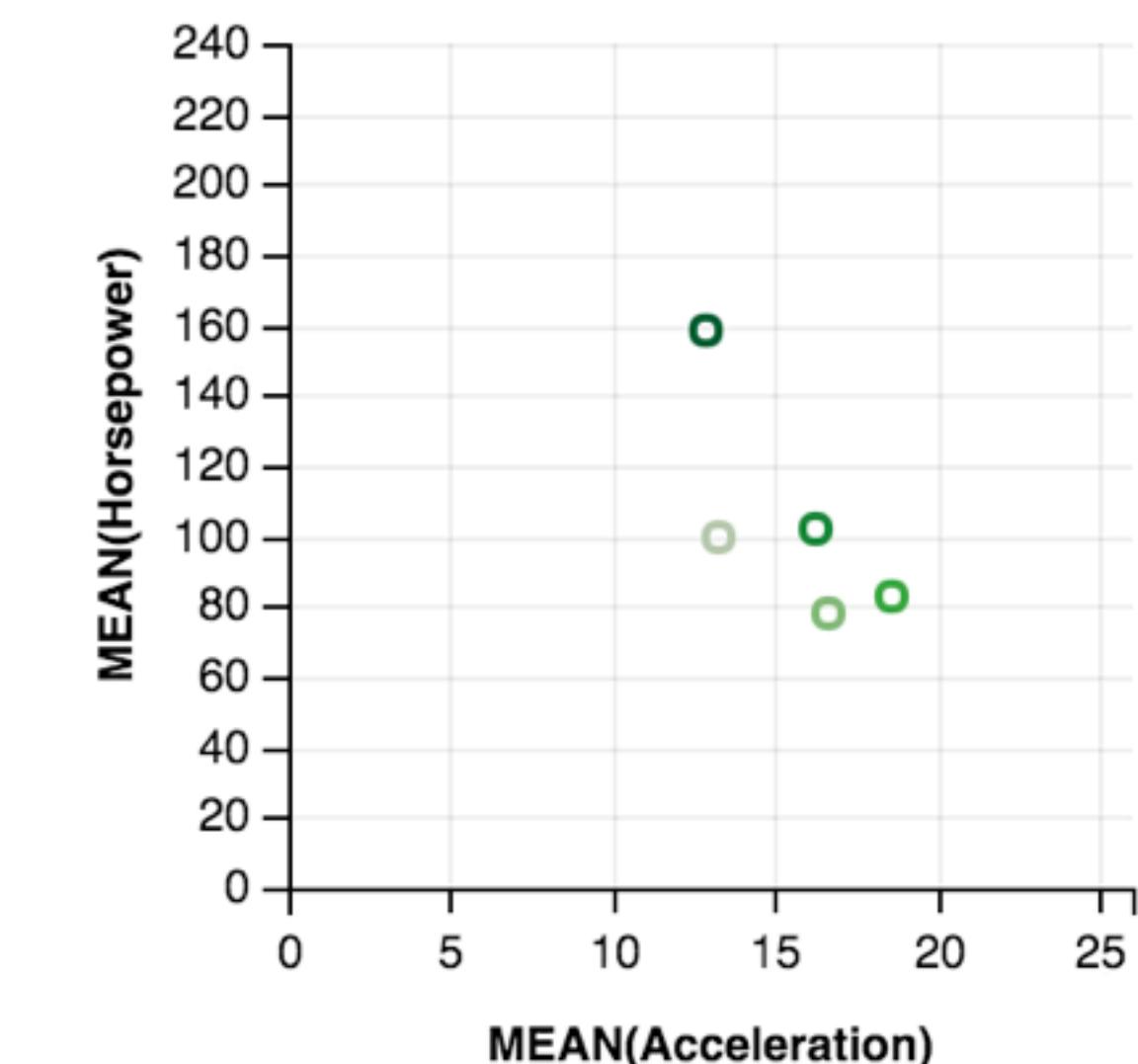
Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

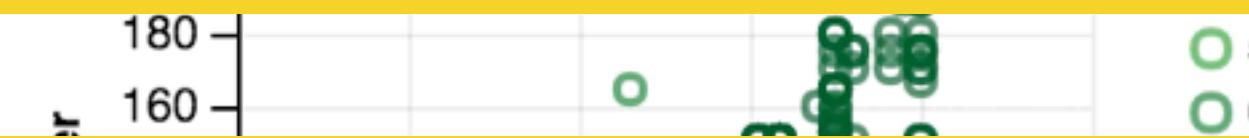
A Cylinders # Horsepower # Acceleration



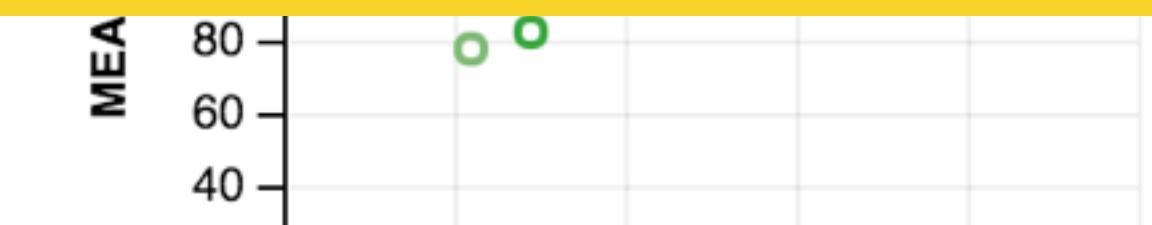
A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



#5 Promote reading of multiple charts in context



#3 Use expressive and effective visual encodings.



Data

Cars

Change

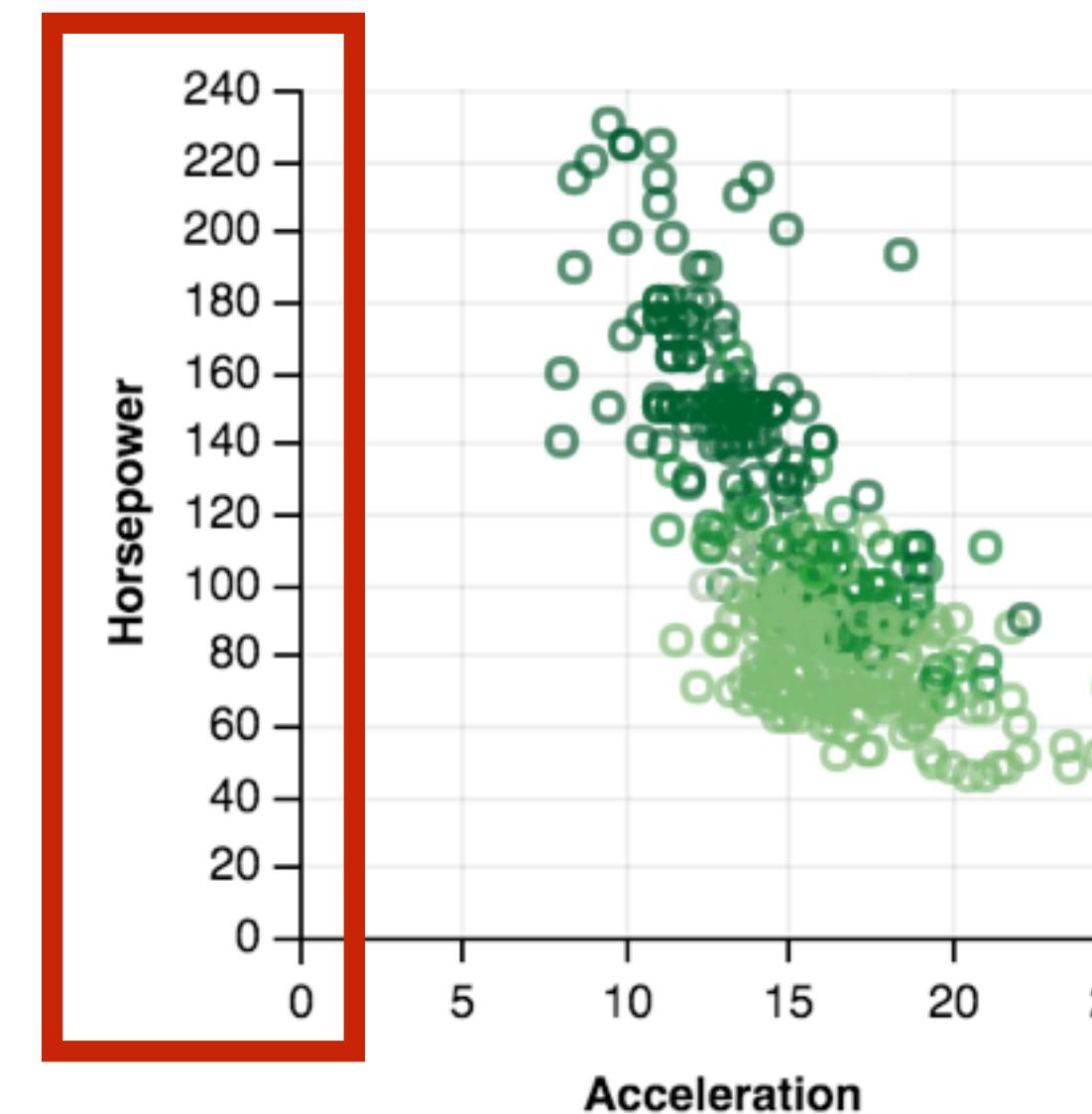
- A Cylinders i
- A Name i
- A Origin i
- AUTO (Year) i
- # AUTO (Acceleration) i
- # AUTO (Displacement) i
- # AUTO (Horsepower) i
- # AUTO (Miles per Gallon) i
- # AUTO (Weight in lbs) i
- # COUNT i

Reset

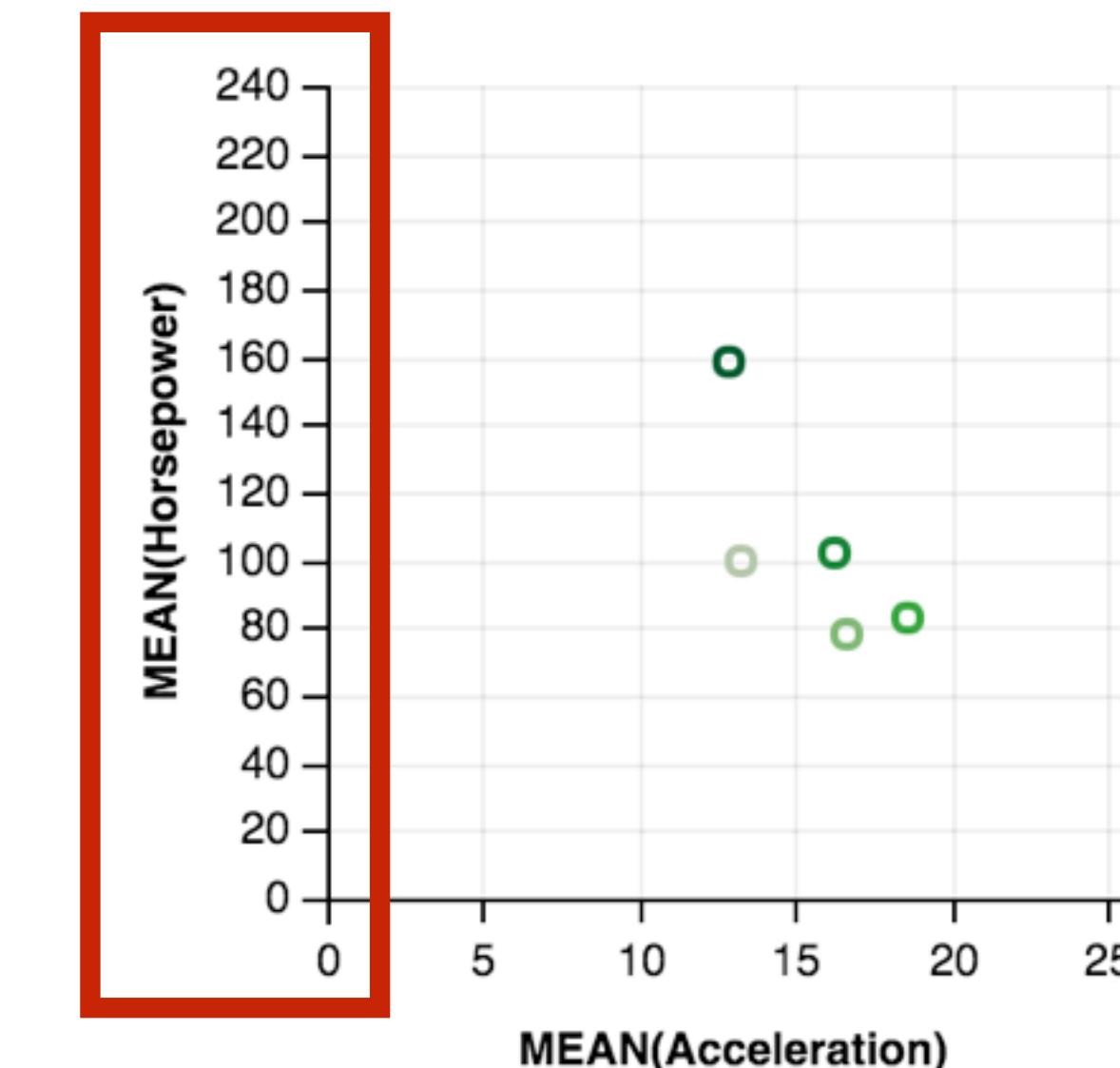
Explore visualizations of A Cylinders # AUTO (Horsepower) + other fields

Here are some recommended visualizations of the fields you have selected

A Cylinders # Horsepower # Acceleration



A Cylinders # MEAN (Horsepower) # MEAN (Acceleration)



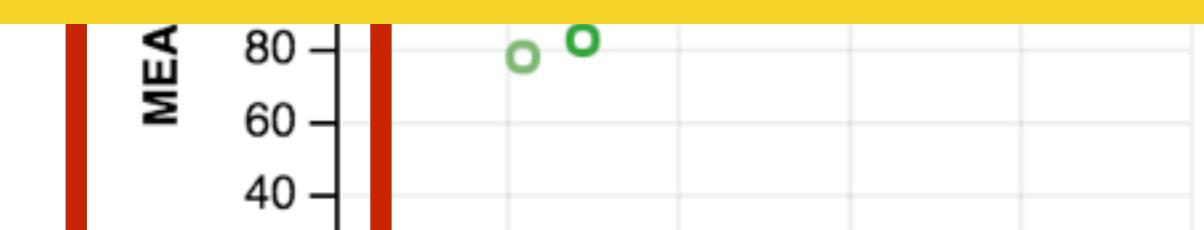
A Cylinders # Horsepower # Displacement

A Cylinders # MEAN (Horsepower) # MEAN (Displacement)

#5 Promote reading of multiple charts in context



#3 Use expressive and effective visual encodings.



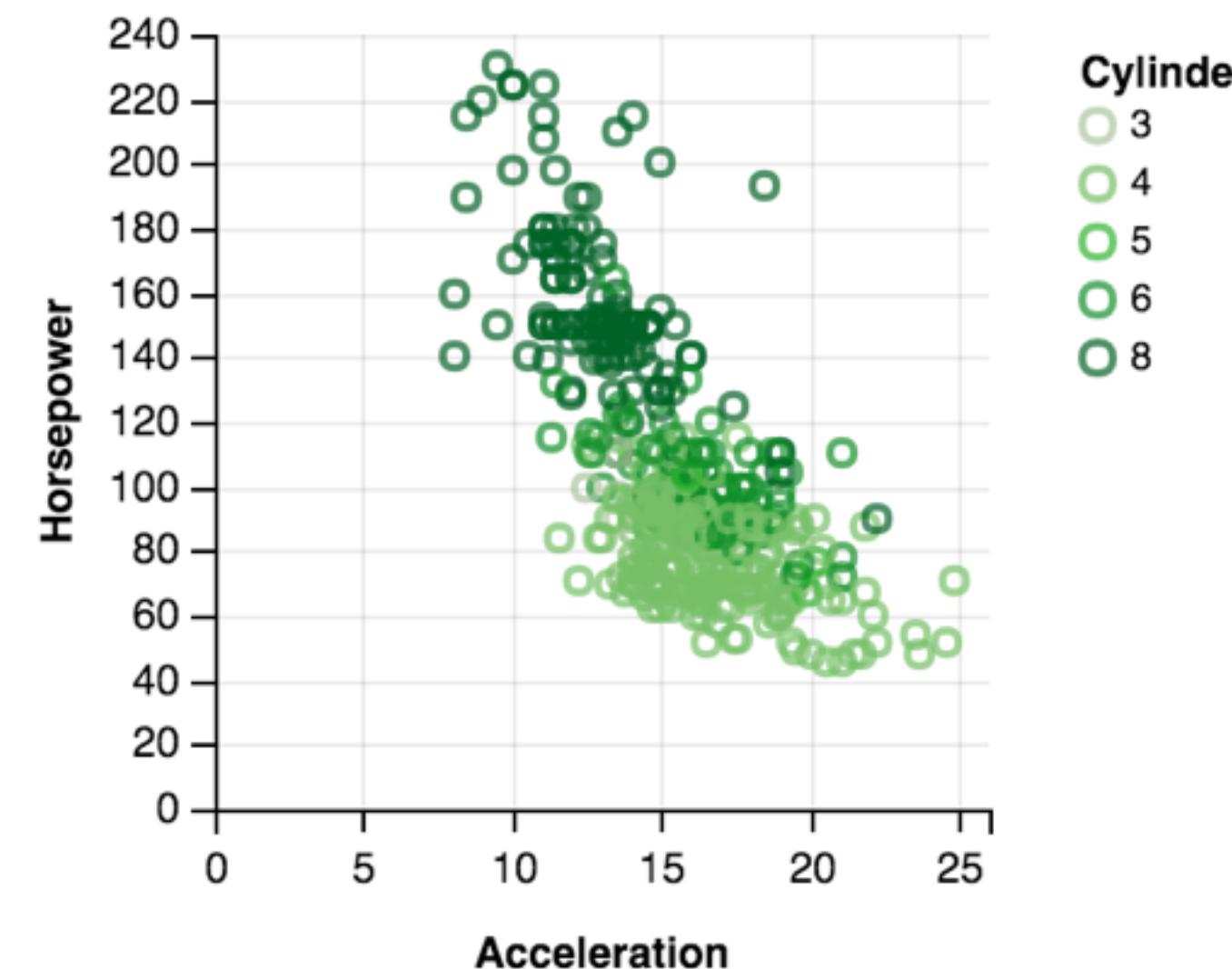
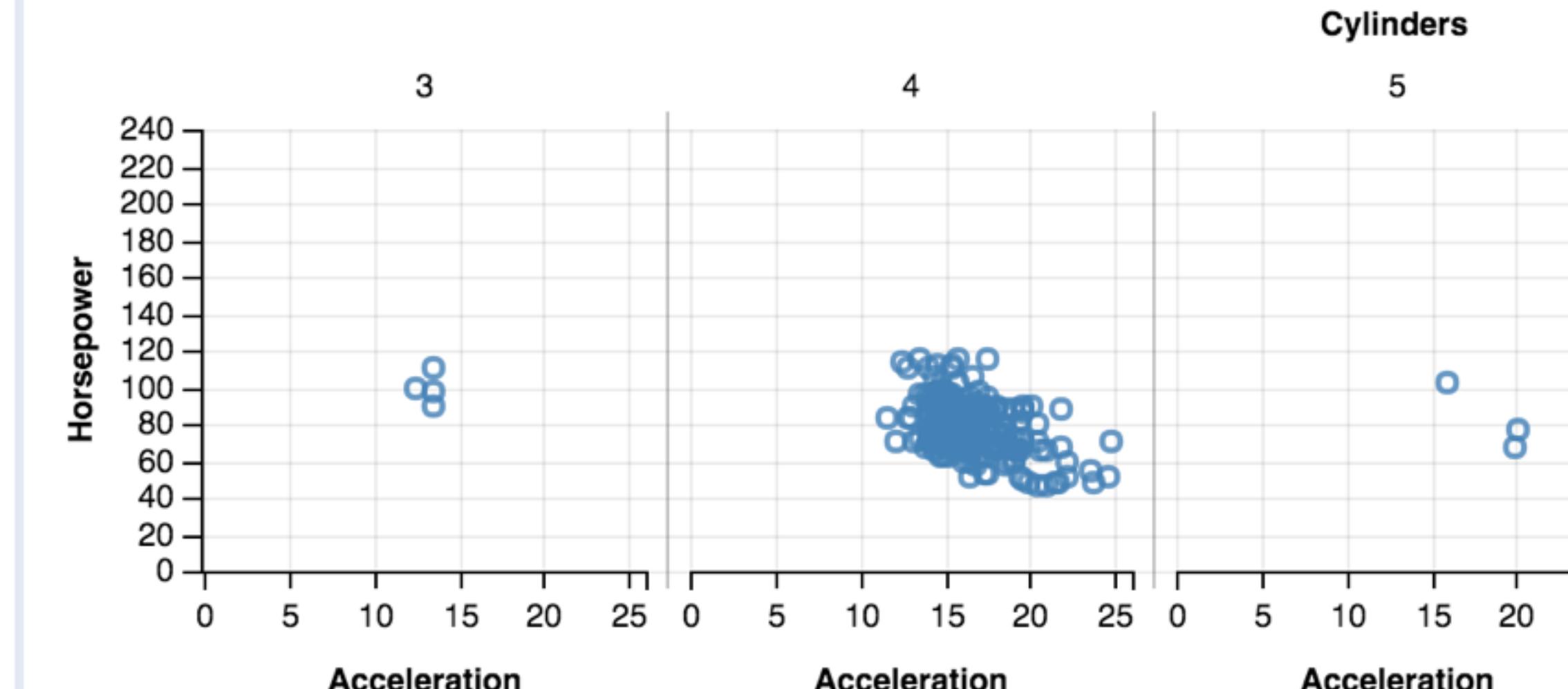
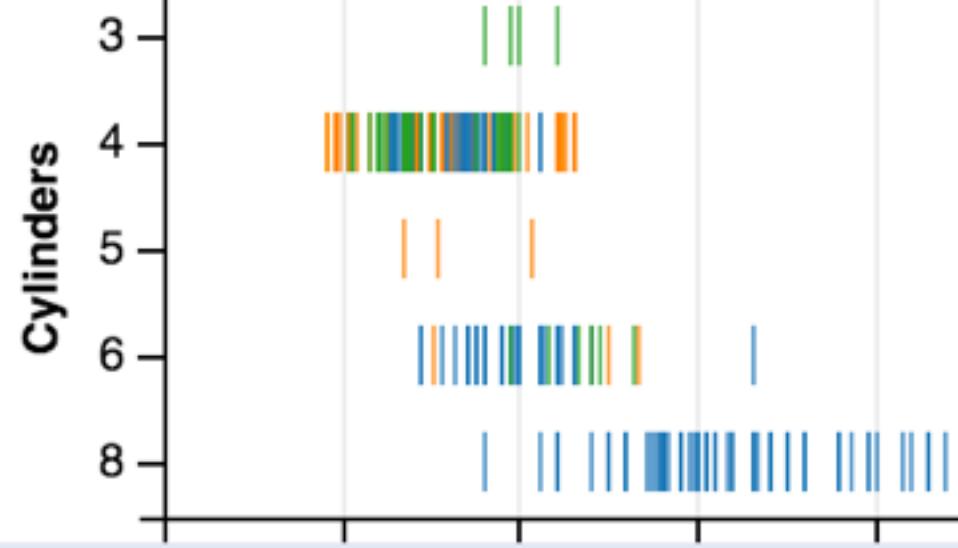
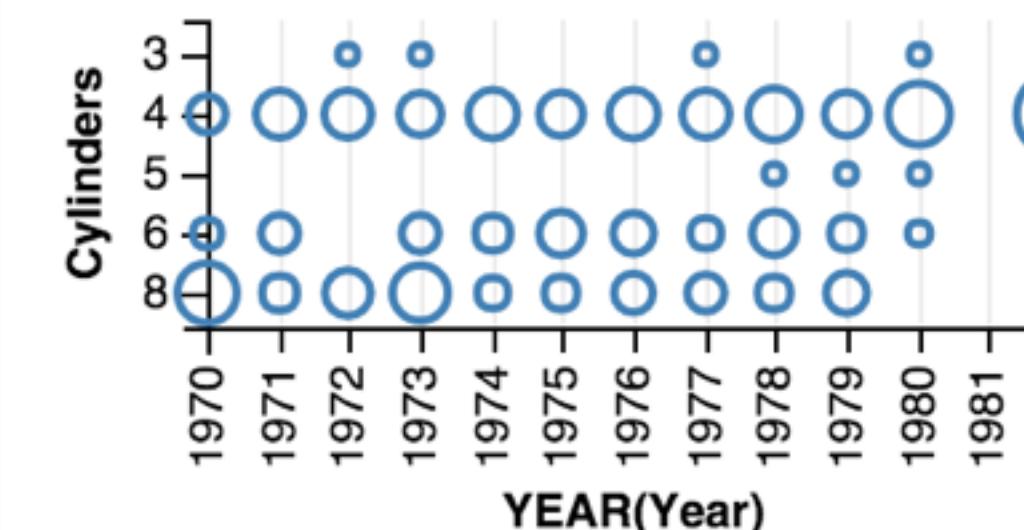
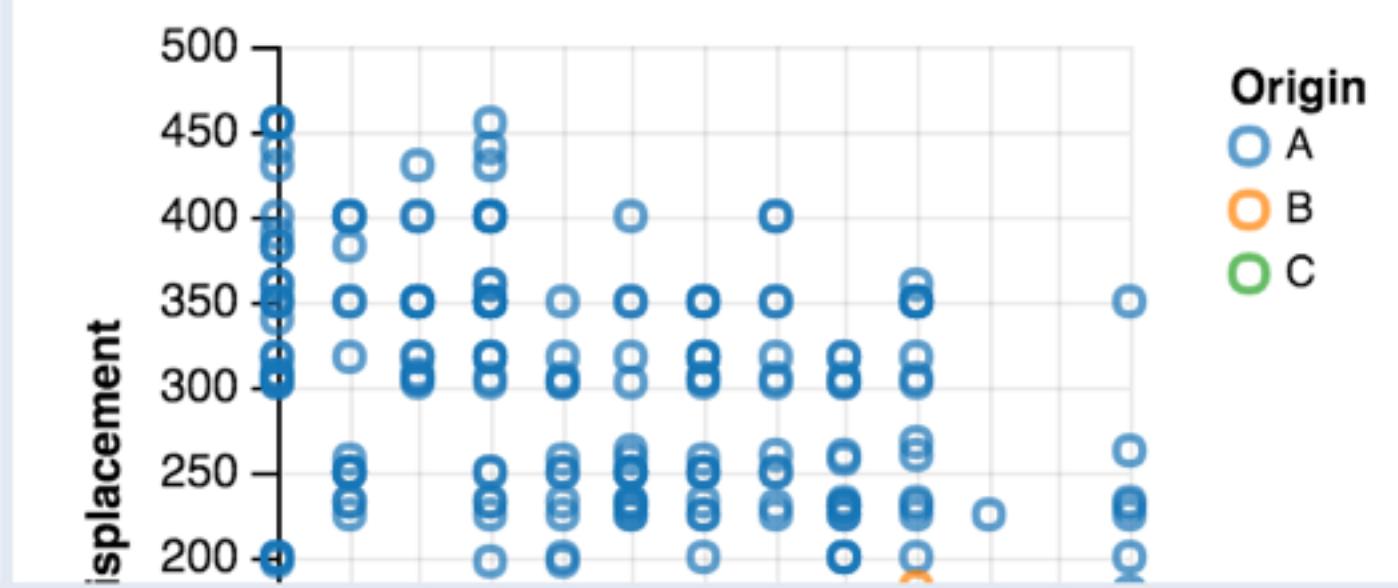
Data

Cars

Rese

Bookmarks (5)

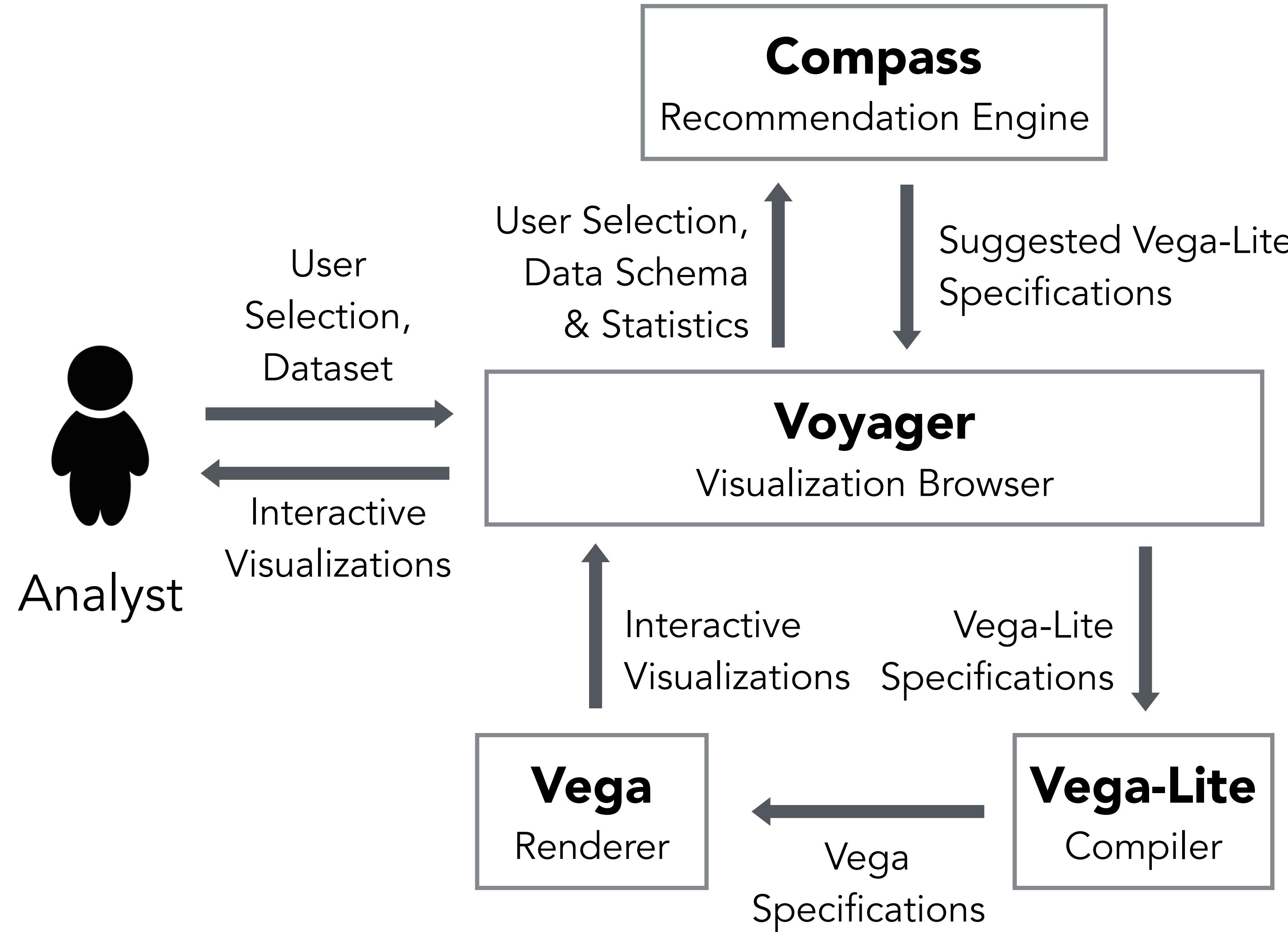
Close

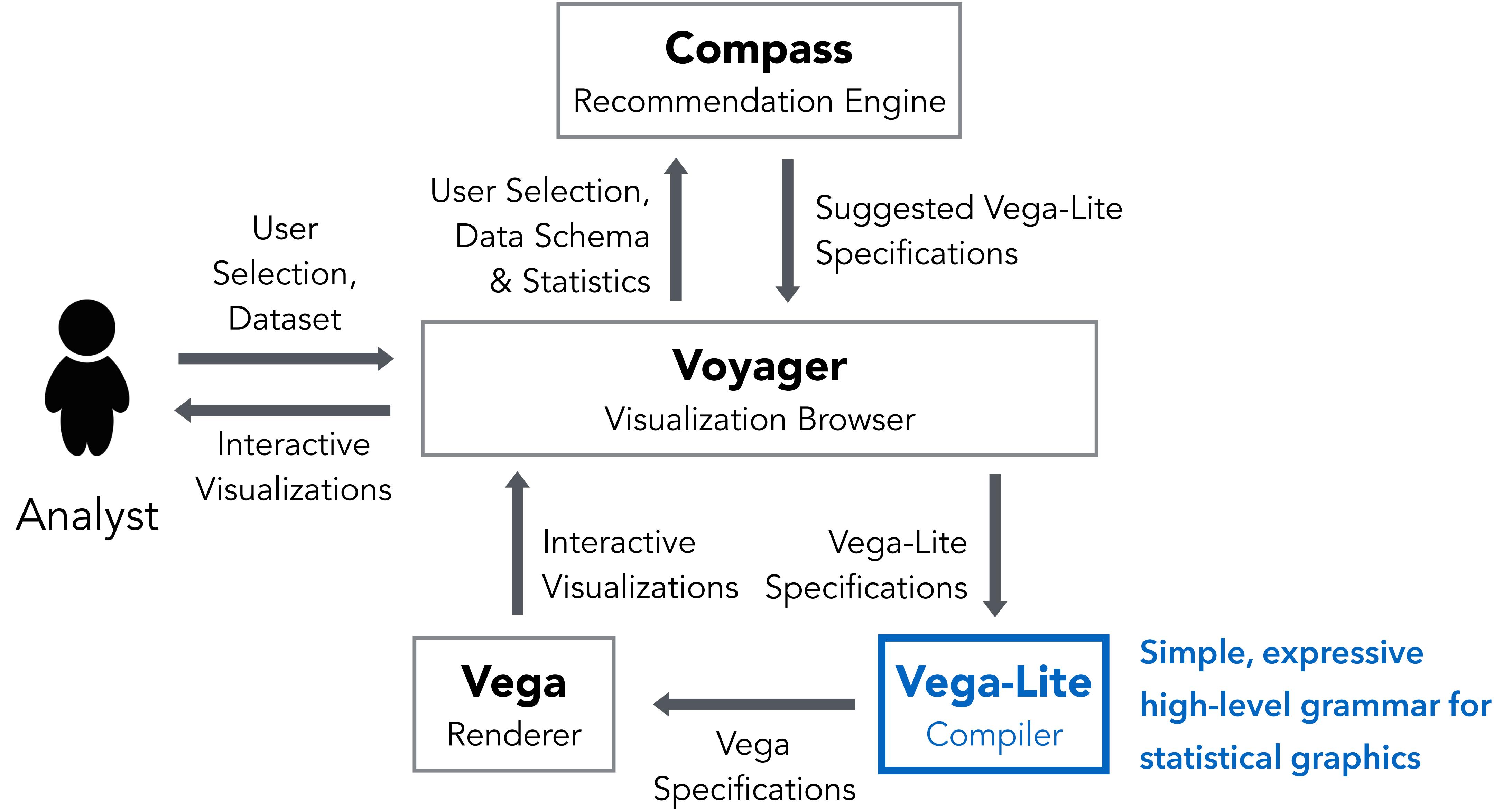
[Clear all](#)[A Cylinders](#) [# Horsepower](#) [# Acceleration](#)[Edit](#) [Bookmark](#)[A Cylinders](#) [# Horsepower](#) [# Acceleration](#)[Edit](#) [Bookmark](#)[A Cylinders](#) [# Horsepower](#) [A Origin](#)[Edit](#) [Bookmark](#)[YEAR \(Year\)](#) [A Cylinders](#) [# COUNT](#)[Edit](#) [Bookmark](#)[A Origin](#) [YEAR \(Year\)](#) [# Displacement](#)[Edit](#) [Bookmark](#)[A Origin](#) [YEAR \(Year\)](#) [# MEAN \(Displacement\)](#) [# MEAN \(Acceleration\)](#)[Edit](#) [Bookmark](#)

Voyager

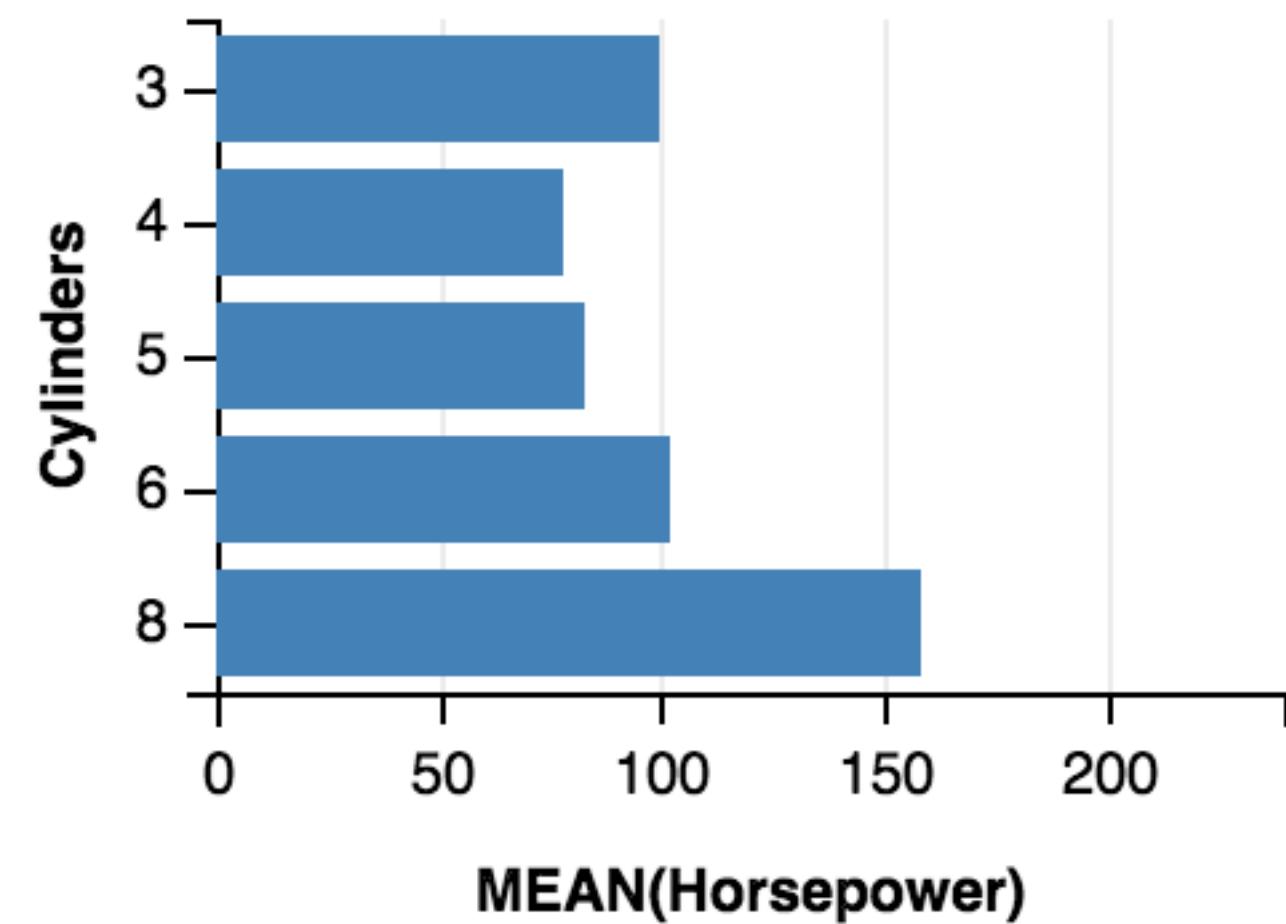
Exploratory Analysis via Faceted Browsing of Visualization Recommendations

Introduction
The Design of Voyager
System Architecture
Evaluation
Future Work





Vega-Lite



```
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      type: "quantitative",  
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      type: "ordinal"  
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}
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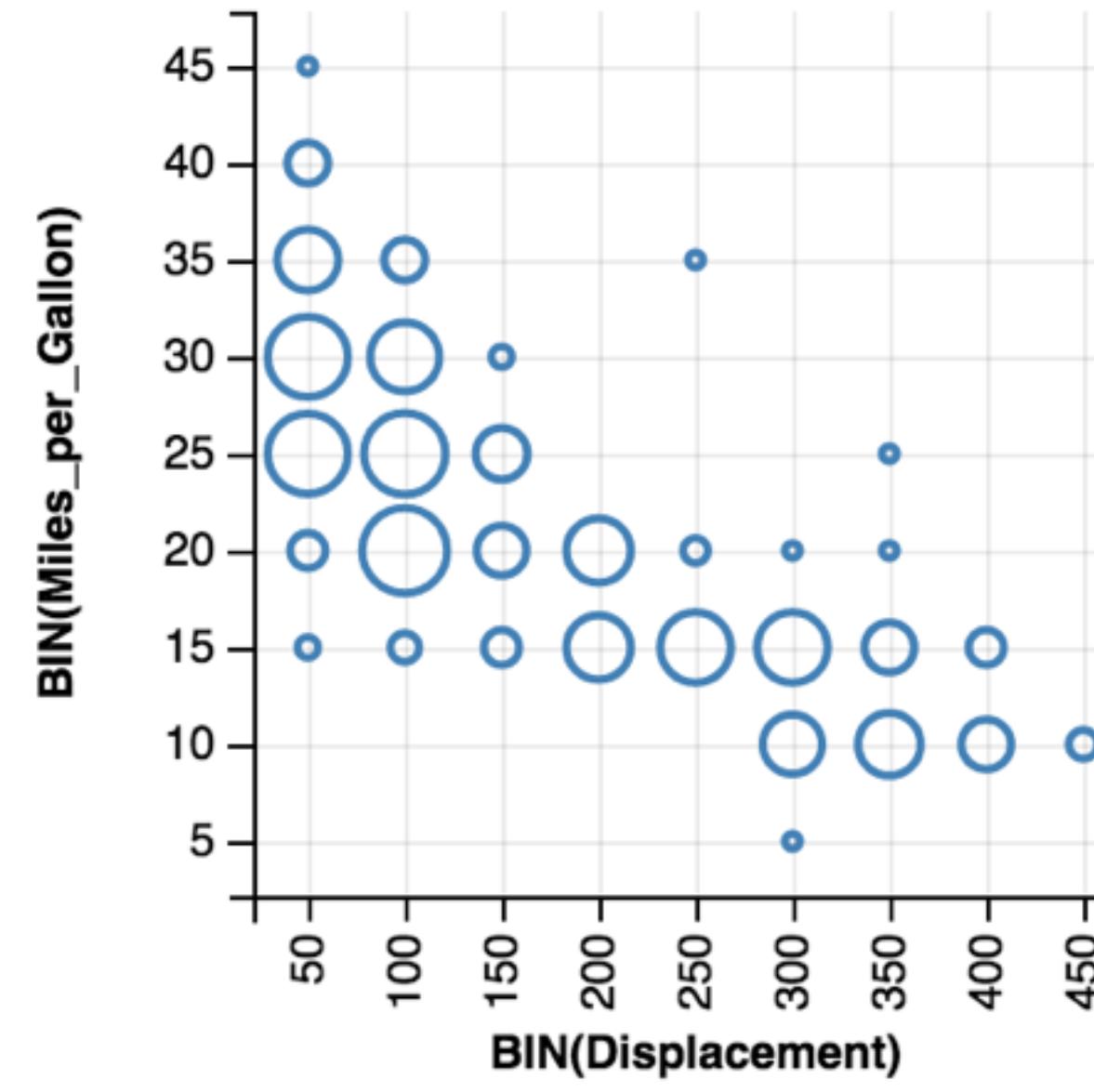
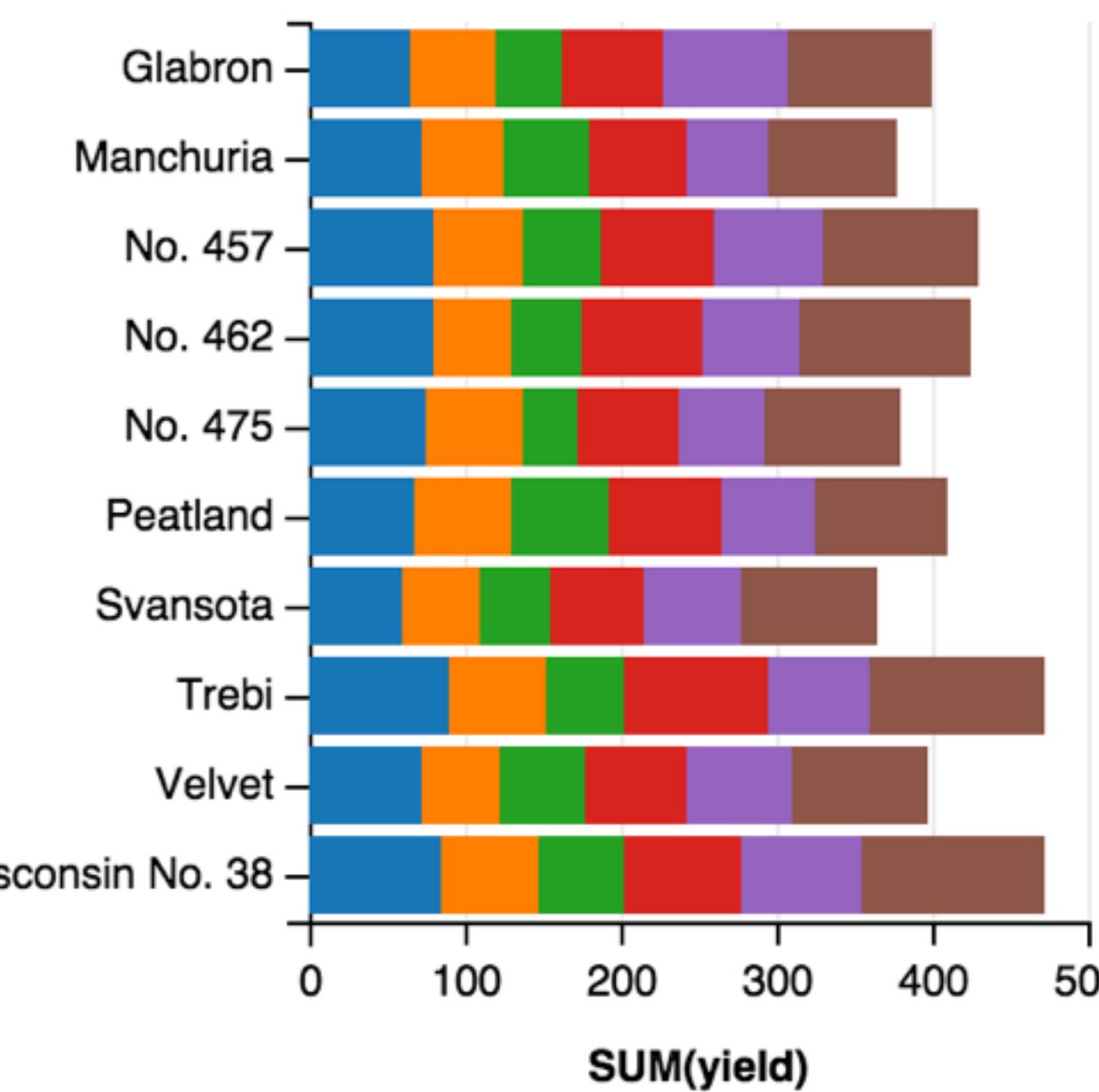
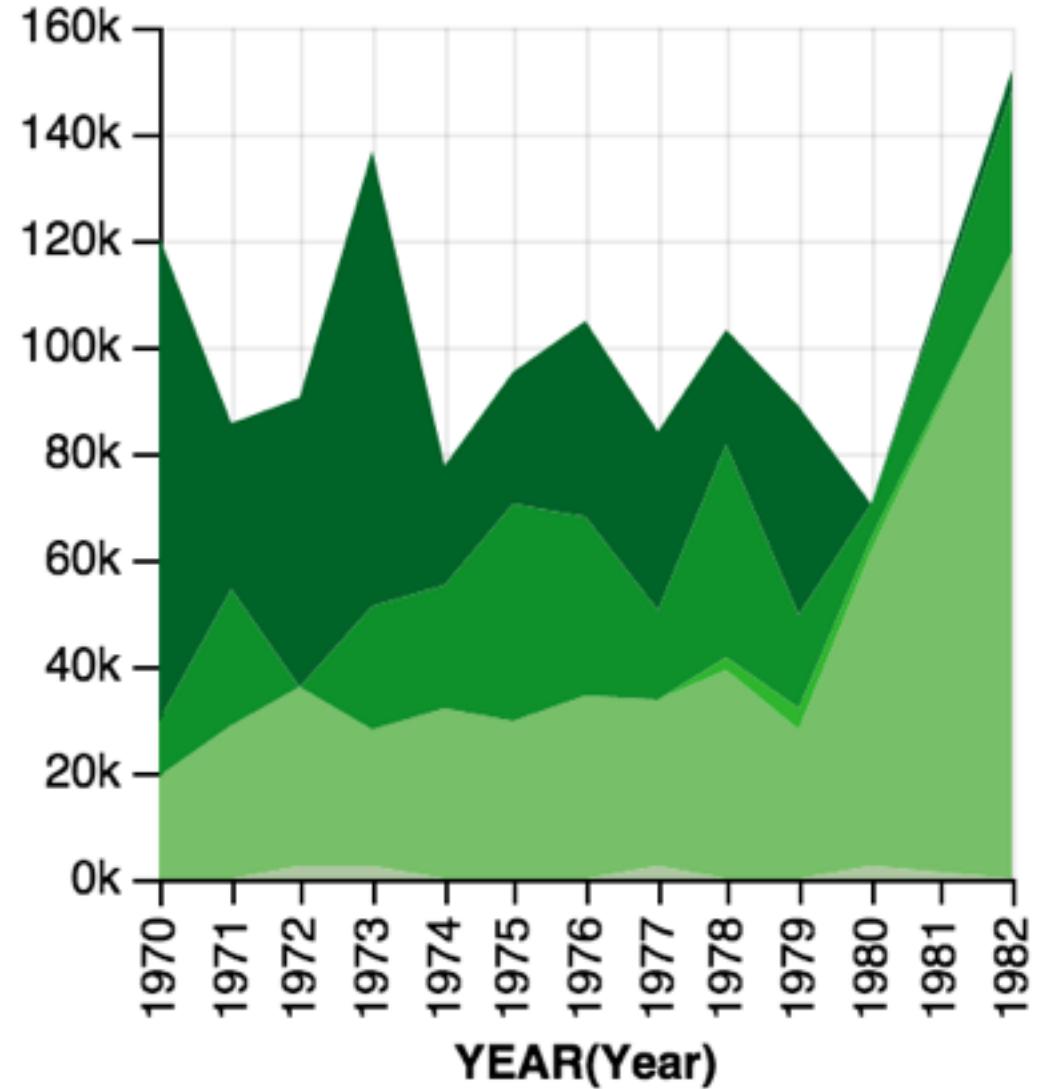
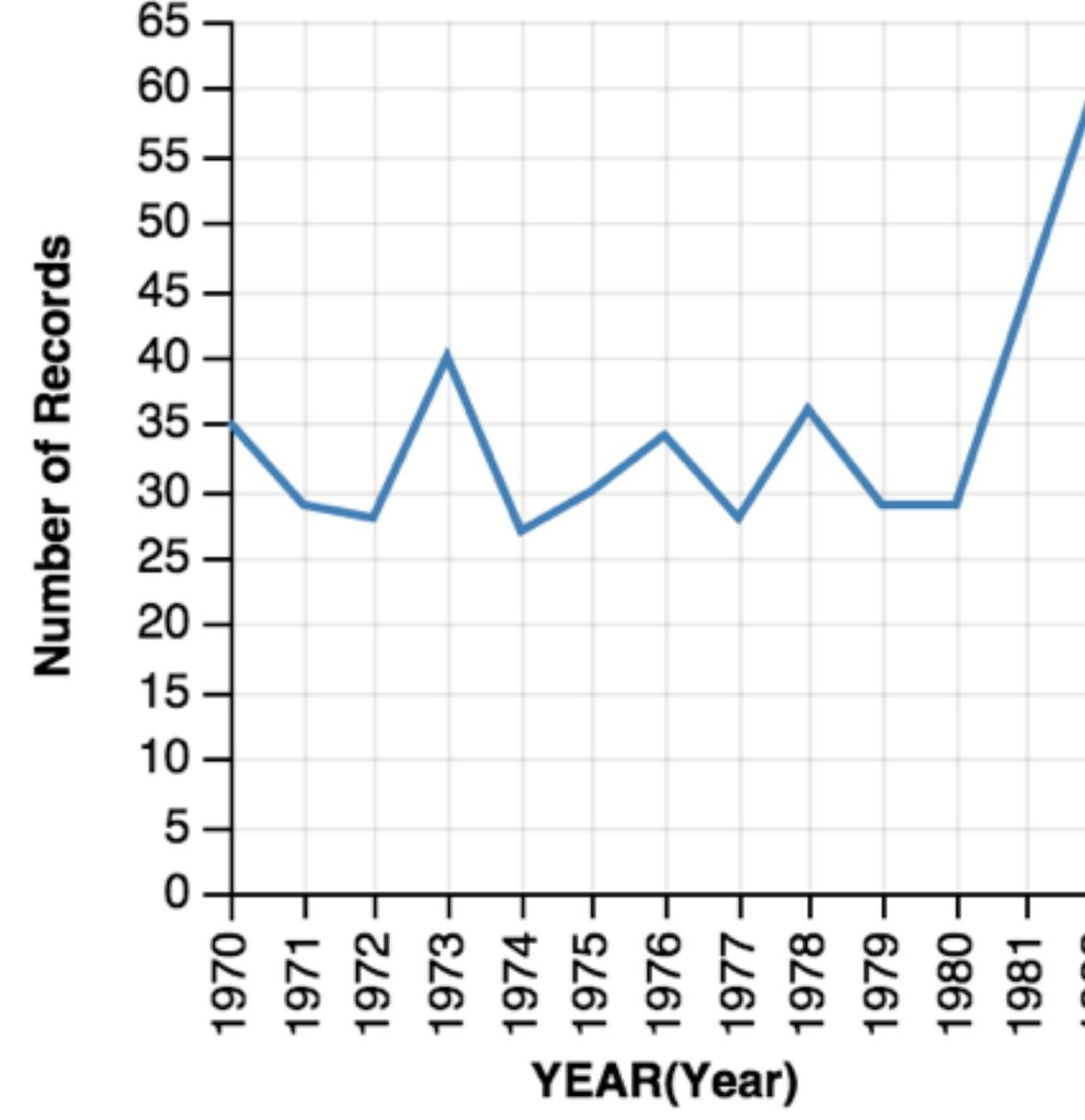
Data source

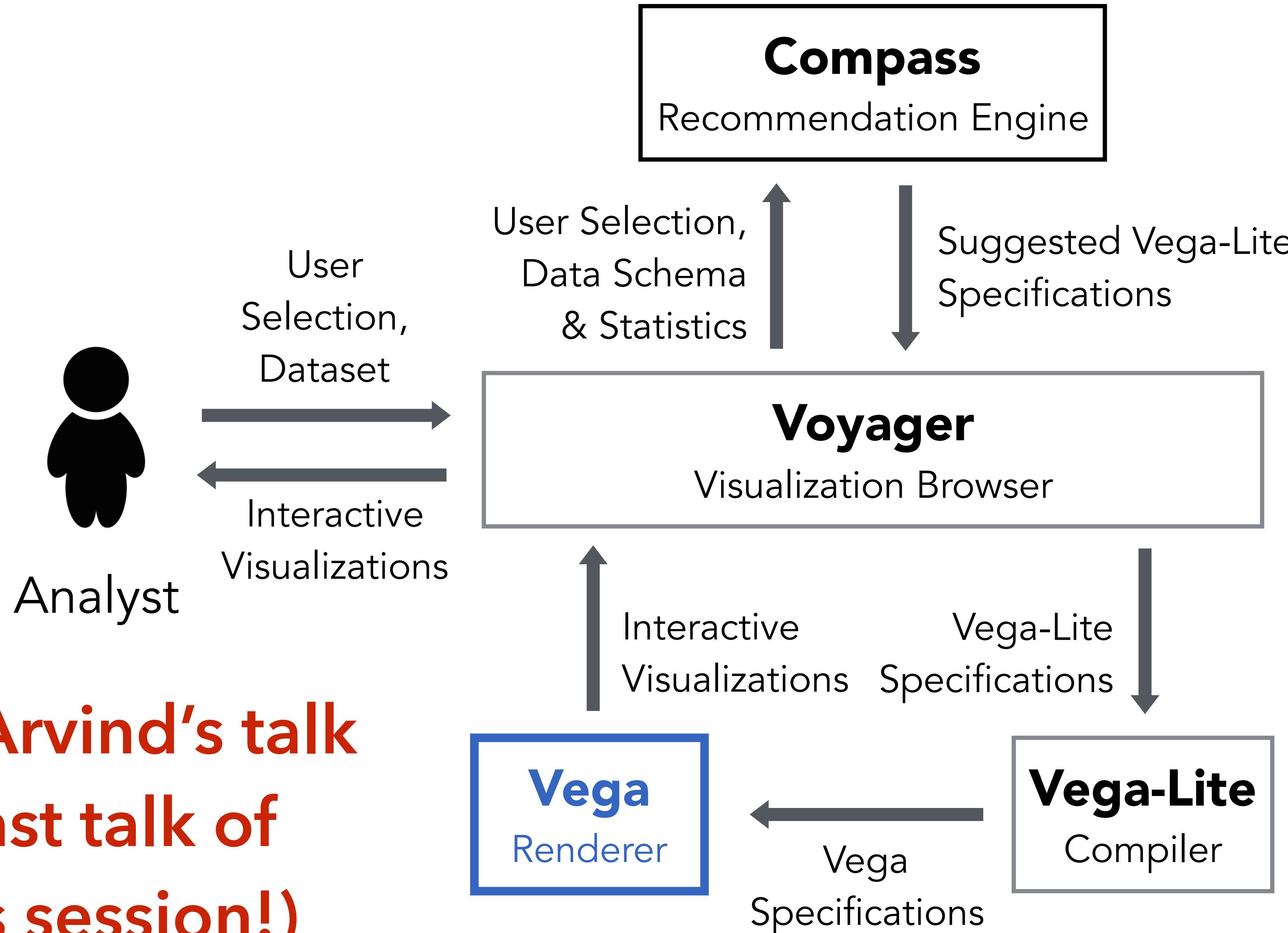
Encoding Mapping

Selected Variables

Transformation

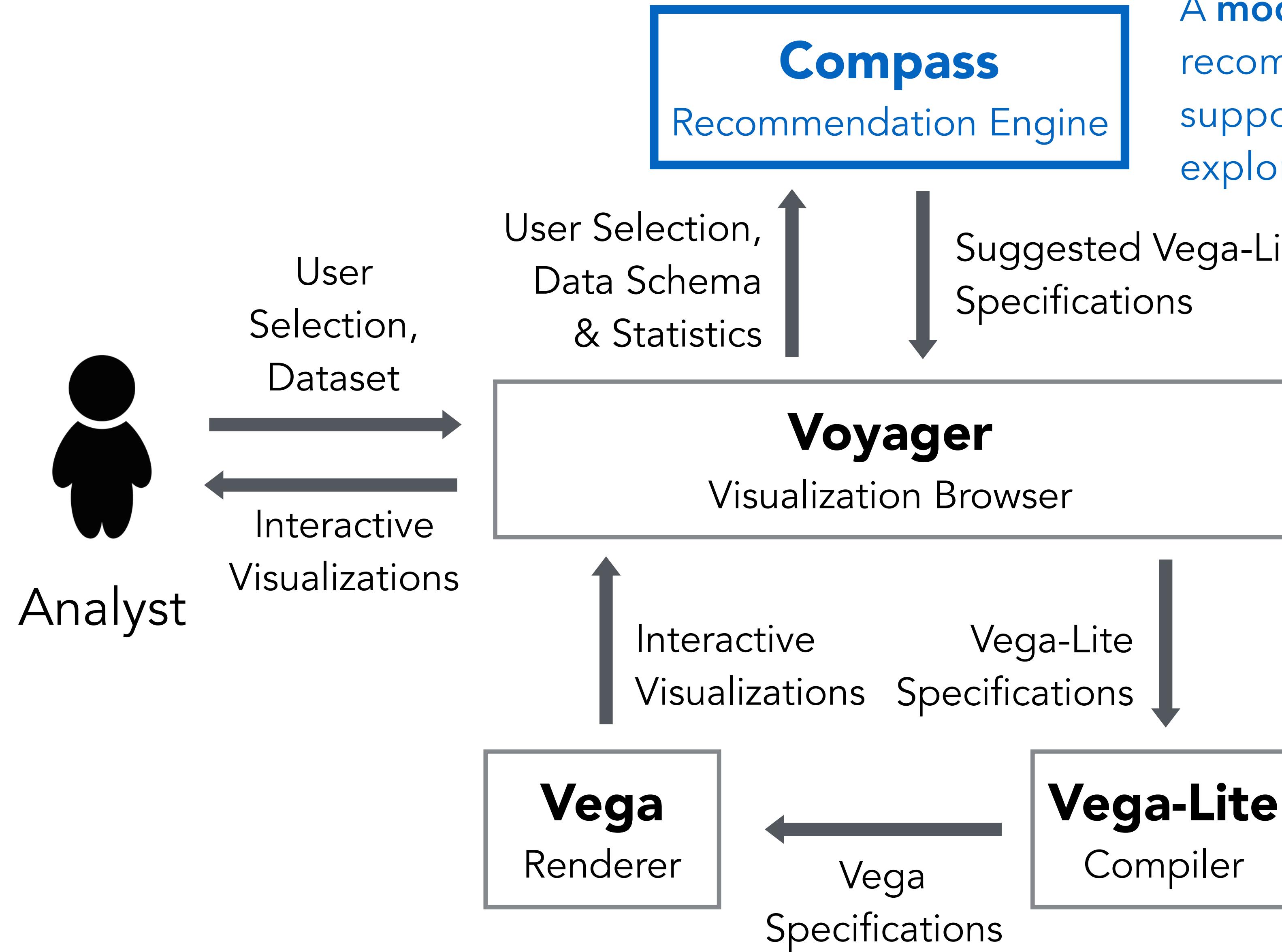
Mark type





**See Arvind's talk
(Last talk of
this session!)**

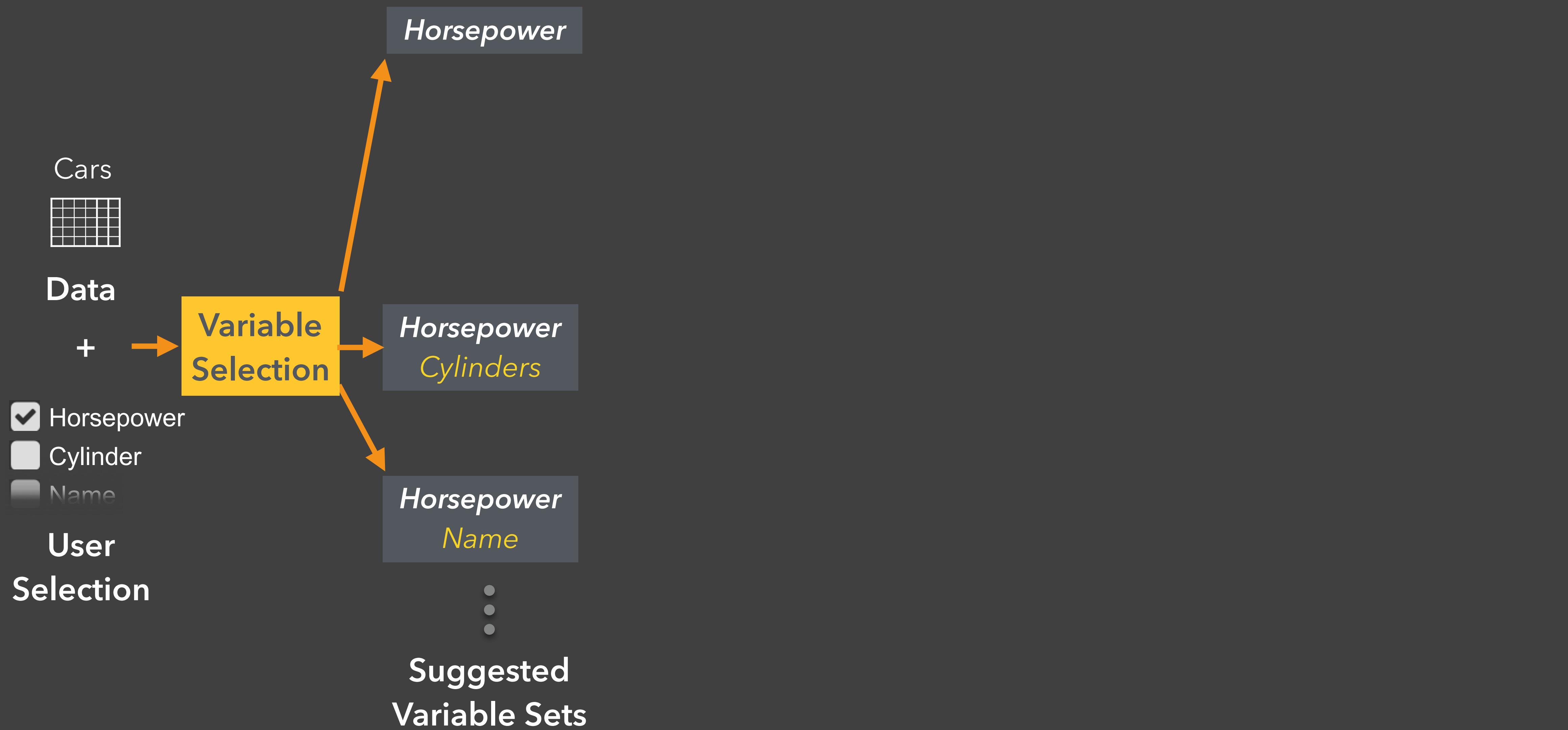
A **modest** visualization recommender that helps support breadth-oriented exploration.



Compass's recommendation phases

1. Variable Selection
2. Data Transformation
3. Design Encodings

Compass



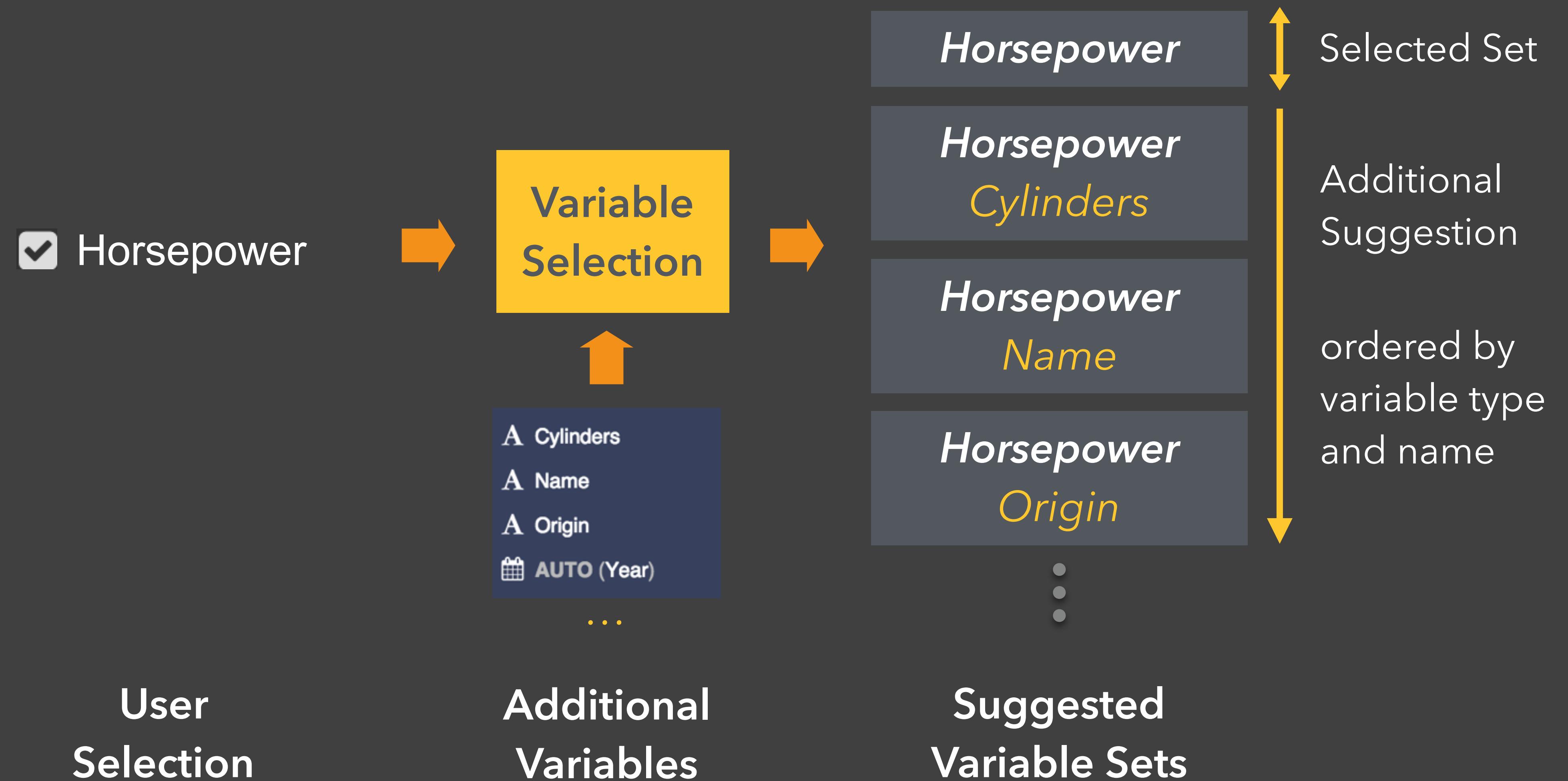
1. Variable Selection

Goal suggest additional variables that might be overlooked

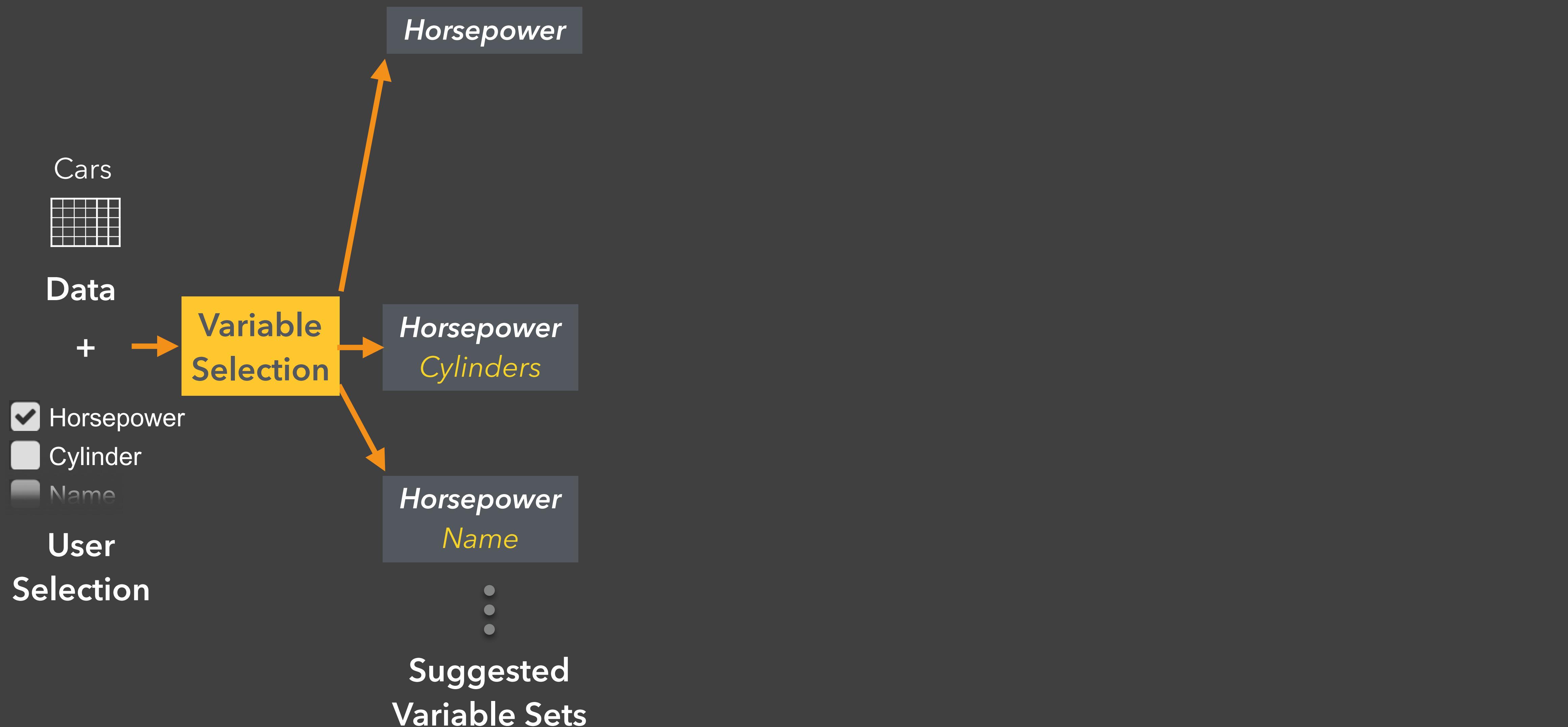
Strategy suggest univariate summaries when data is first loaded

add only **one variable** at a time

1. Variable Selection

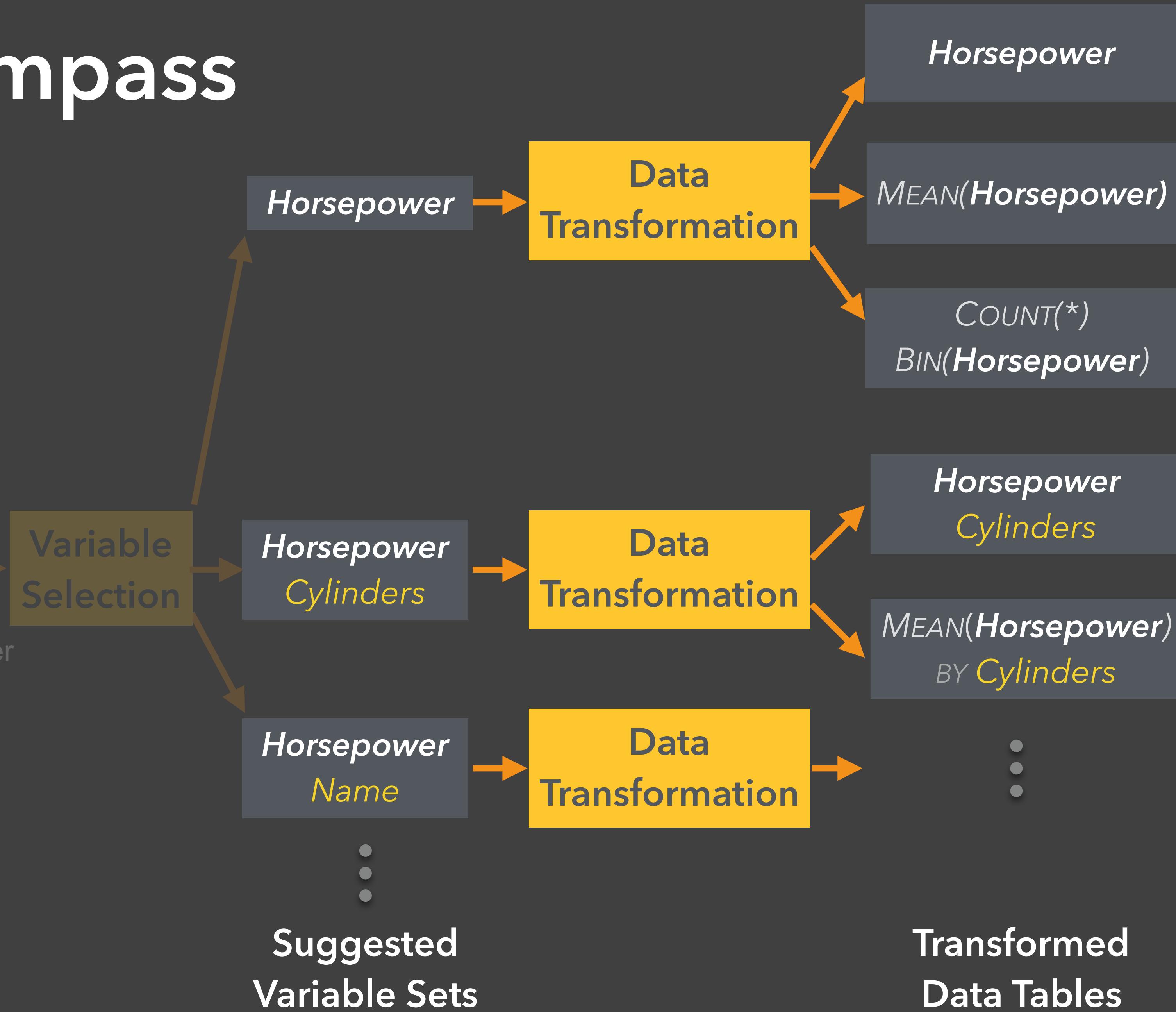


Compass



Compass

Cars
Data
+
 Horsepower
 Cylinder
 Name
User Selection

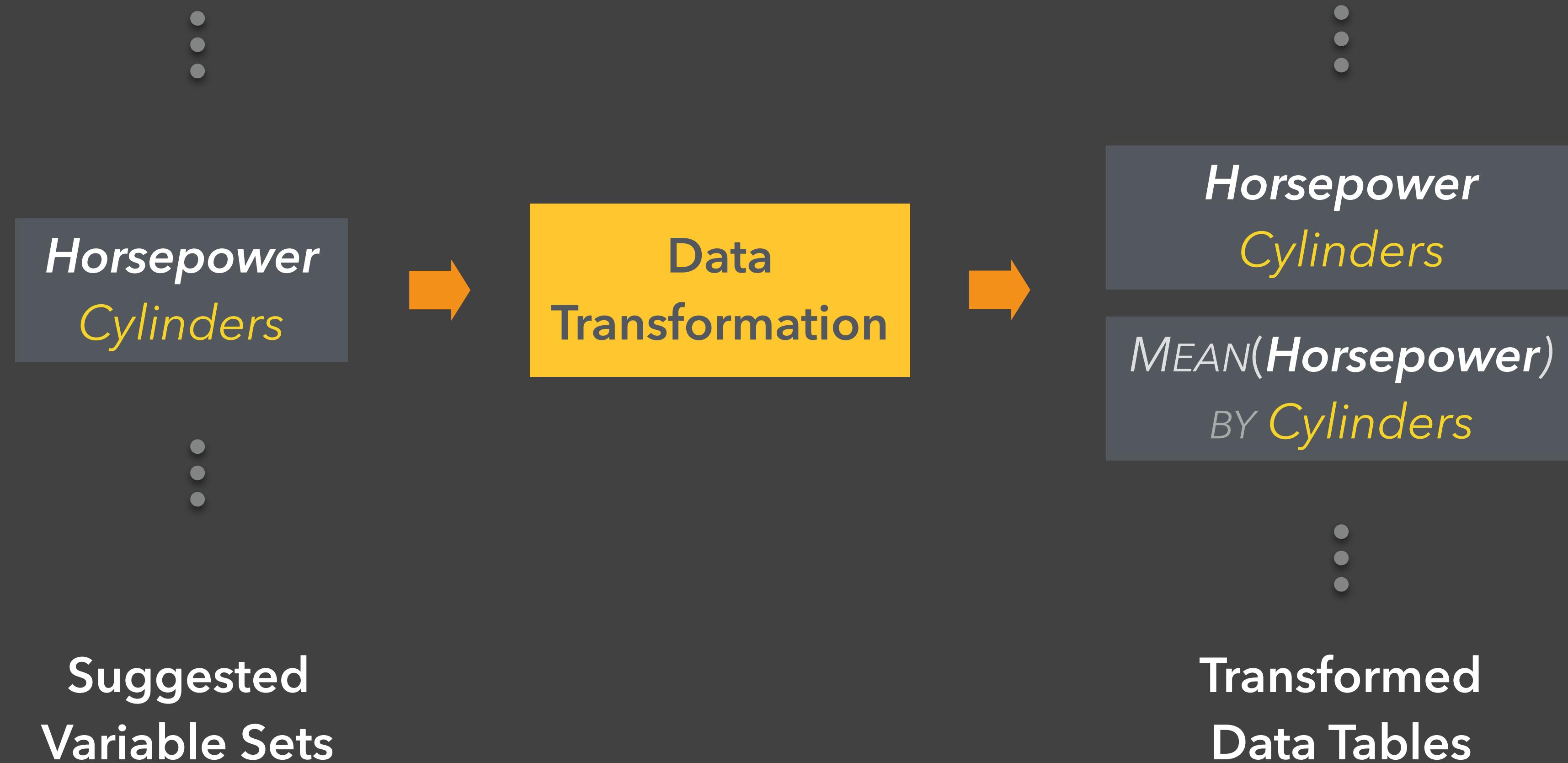


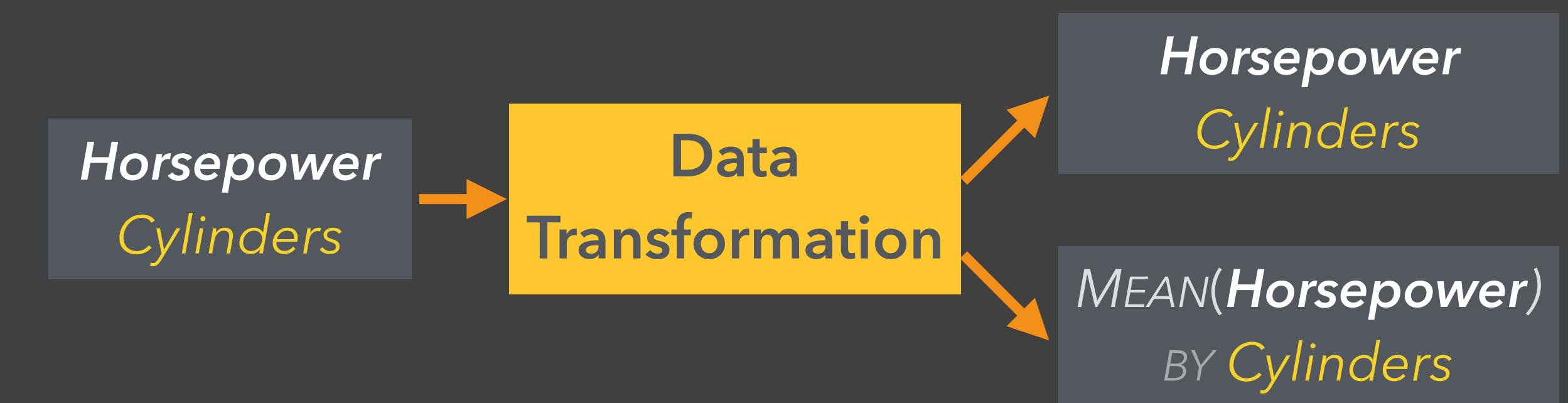
2. Data Transformation

Goal provide both **detail** and **summary**

Strategy generate a **raw table** (no aggregation) and a **summary table** using default set of transformations.

2. Data Transformation





Suggested
Variable Sets

Transformed
Data Tables

Compass

Cars
Data
+
 Horsepower
 Cylinder
 Name
User Selection

Variable Selection

Suggested Variable Sets

Horsepower

Horsepower Cylinders

Horsepower Name

Data Transformation

Data Transformation

Data Transformation

Horsepower

MEAN(Horsepower)

COUNT(*)
BIN(Horsepower)

Horsepower
Cylinders

MEAN(Horsepower)
BY Cylinders

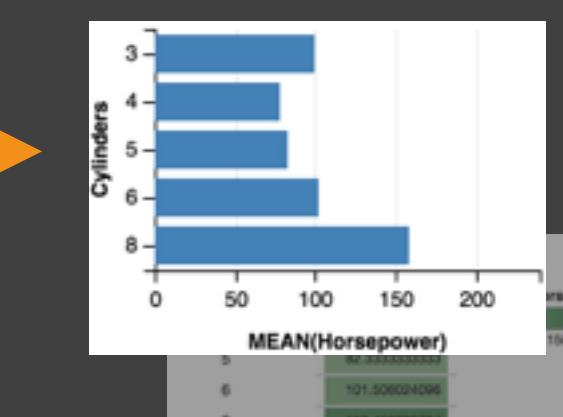
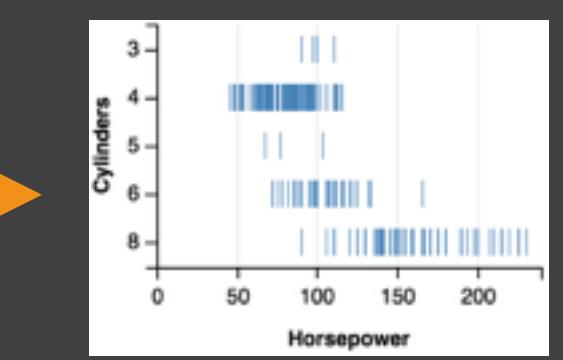
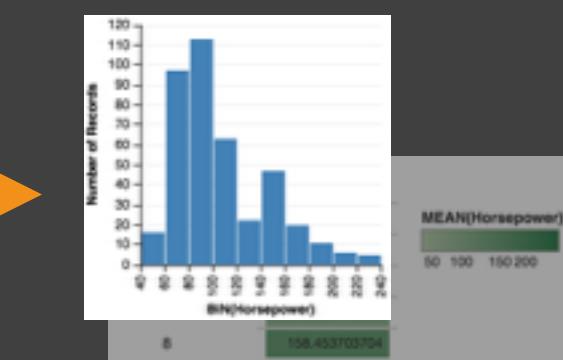
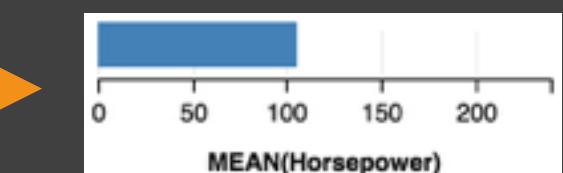
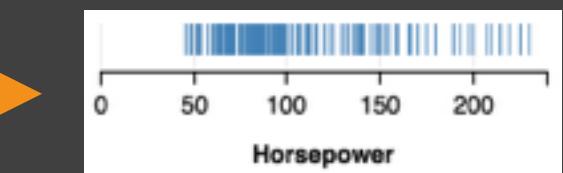
Encoding Design

Encoding Design

Encoding Design

Encoding Design

Encoding Design



Transformed Data Tables

Visual Encodings

3. Encoding Design

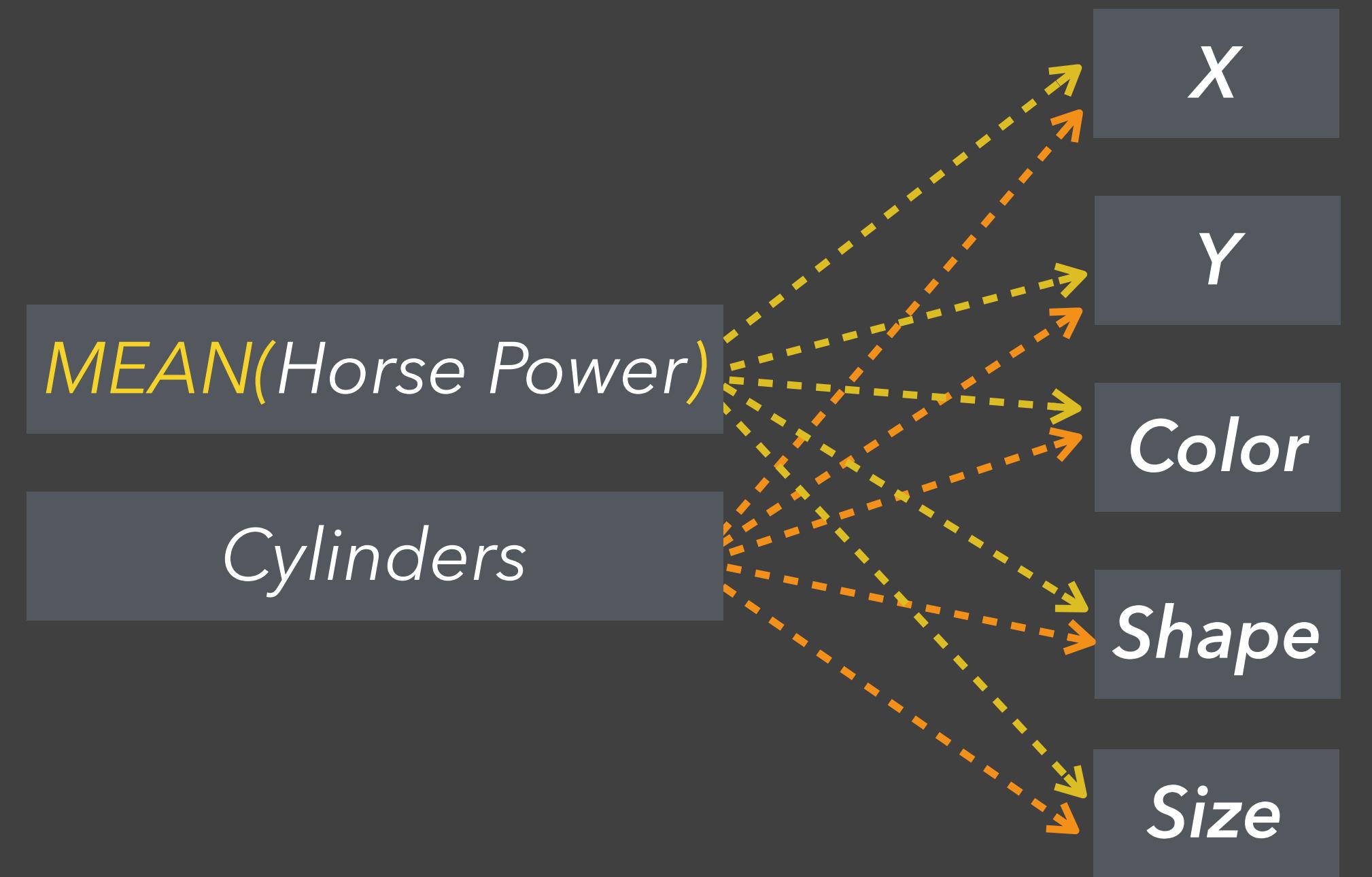
Space ing for
strategy sucks

Goal suggest an **expressive** and **effective set of visual encodings** that shows various aspects of the data

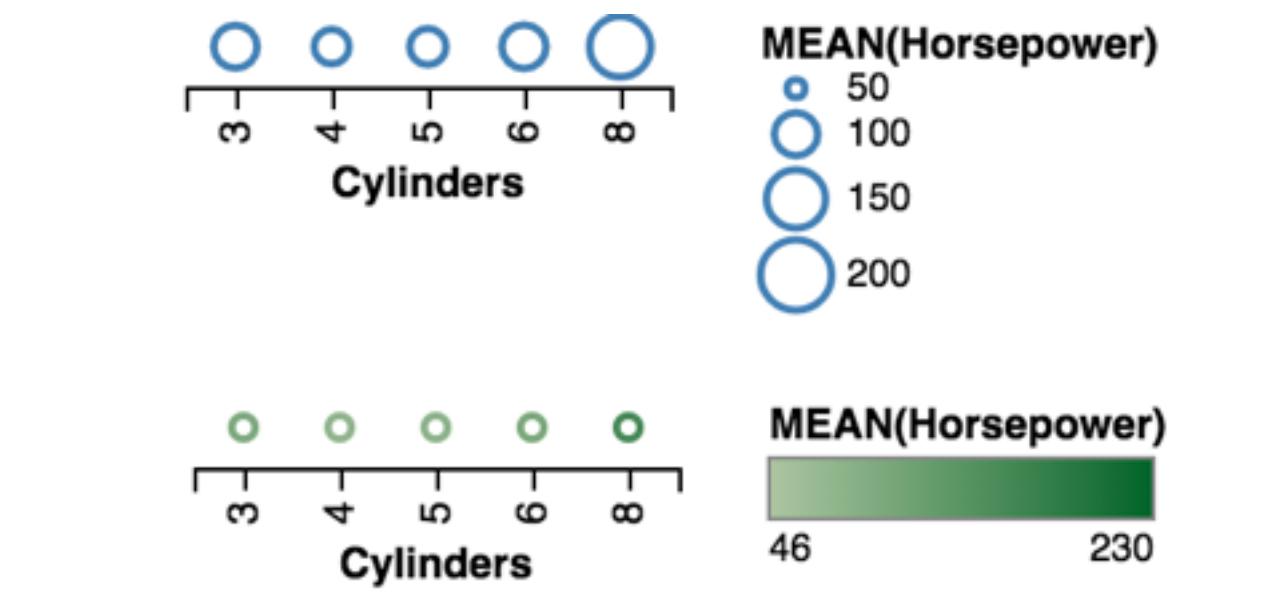
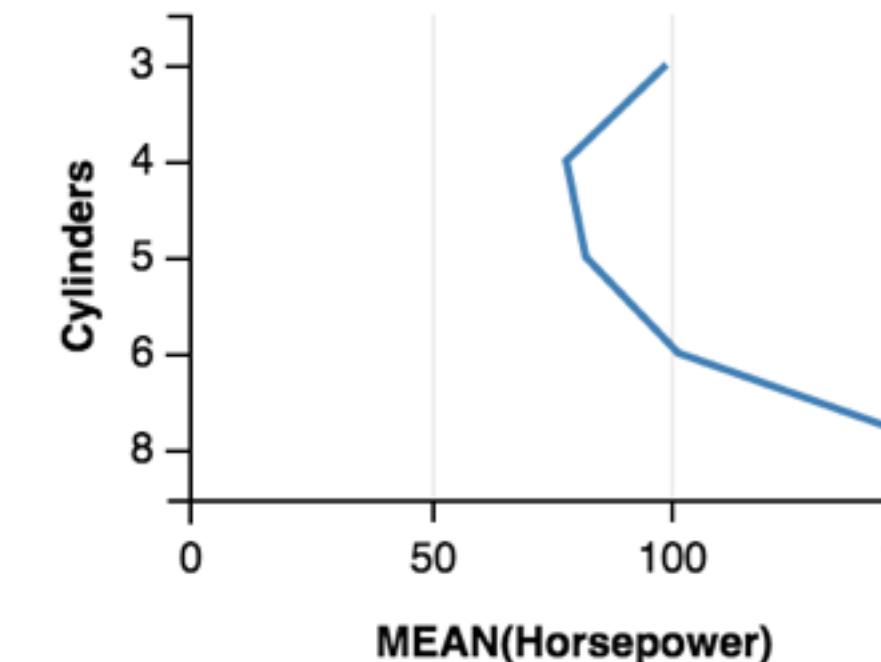
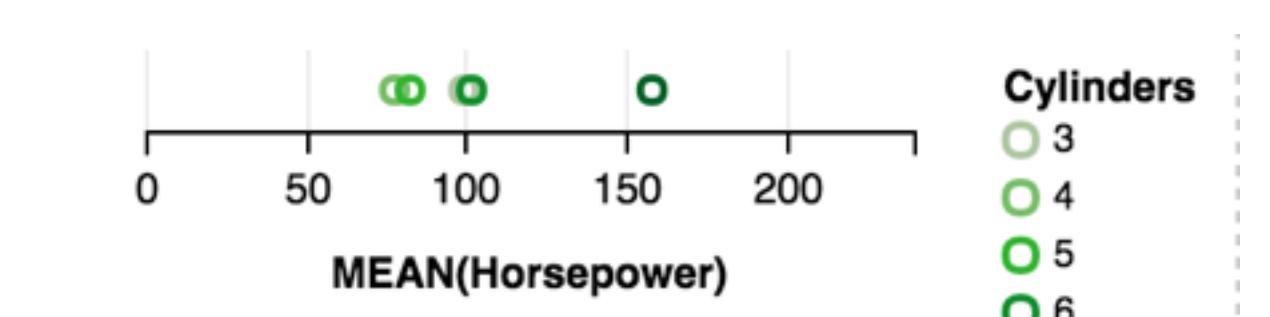
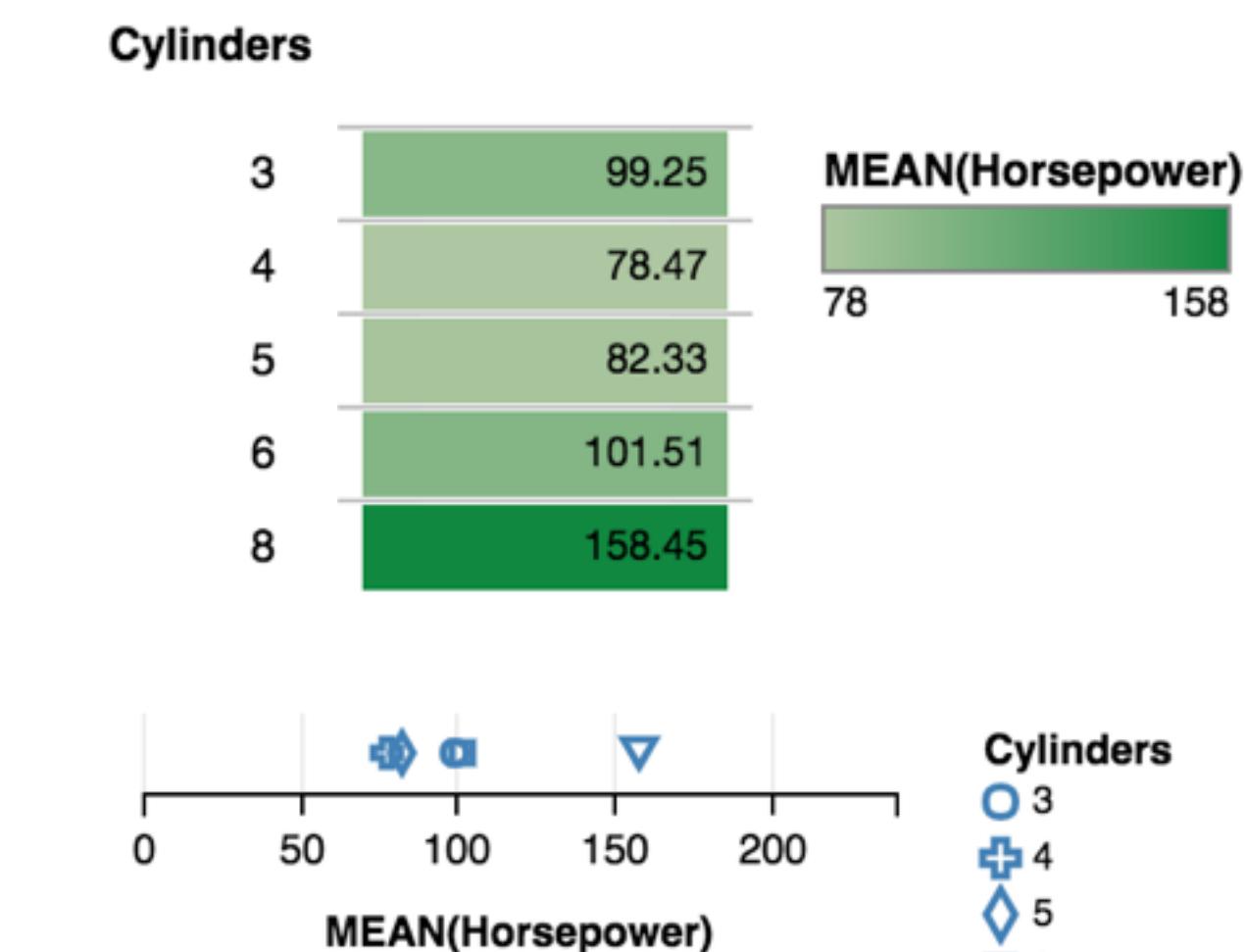
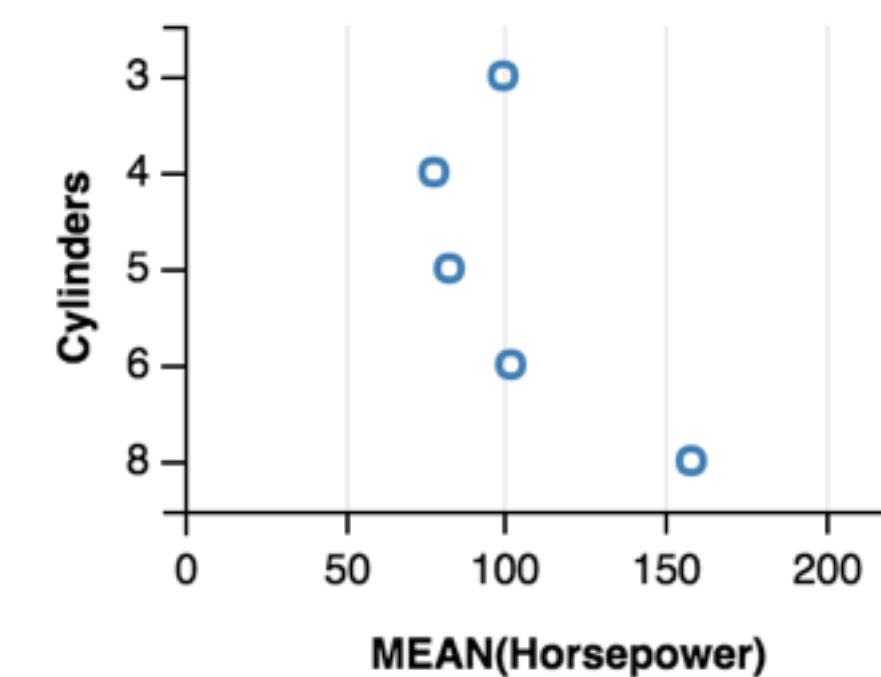
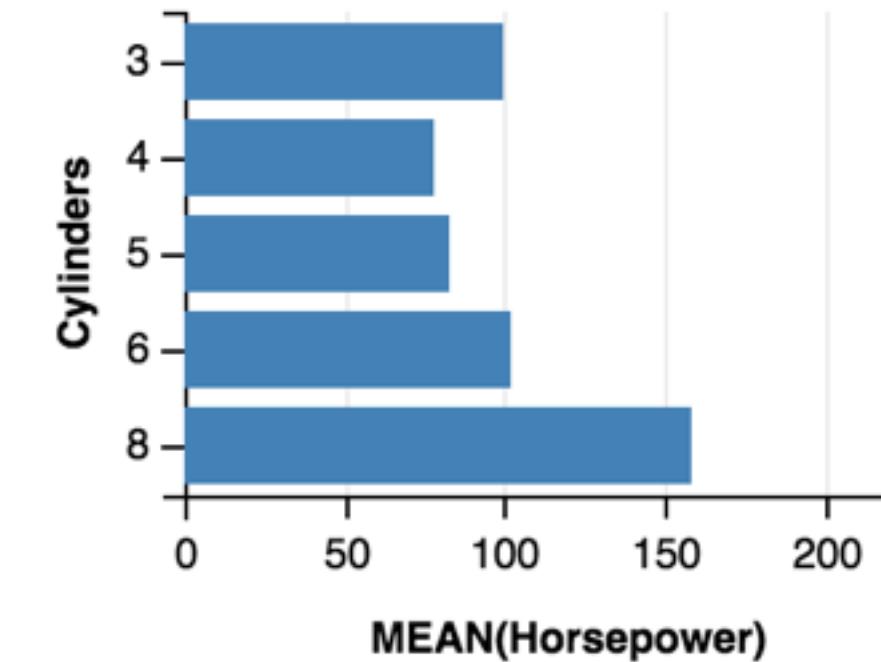
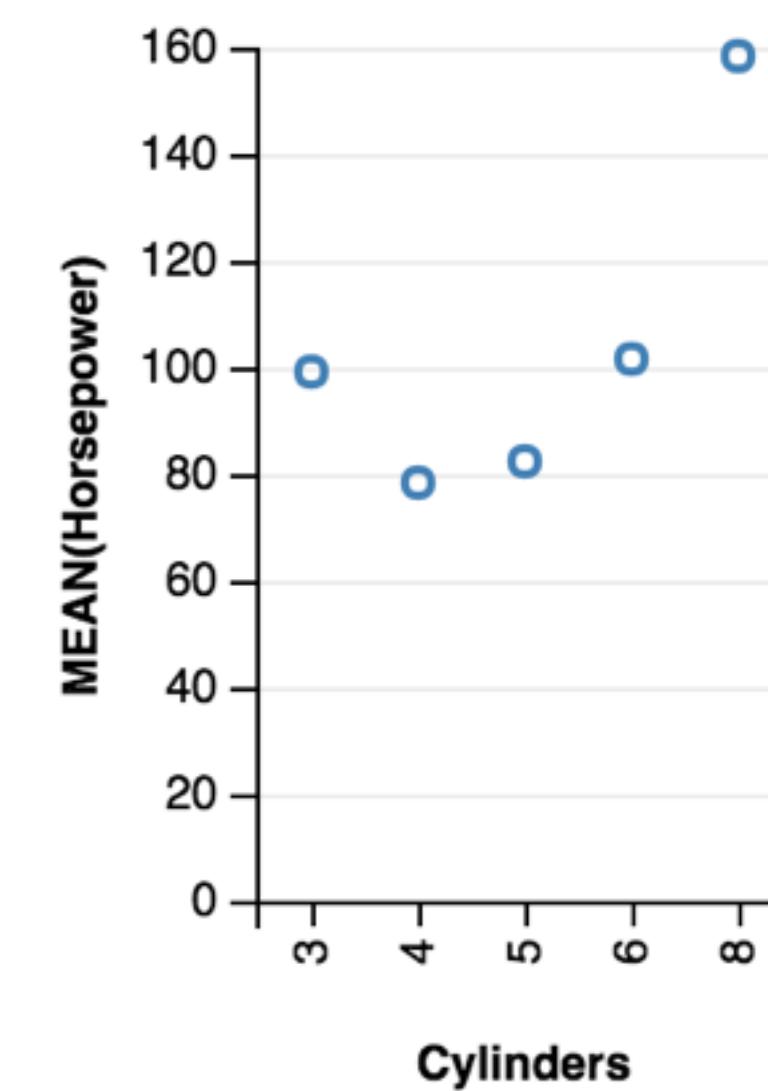
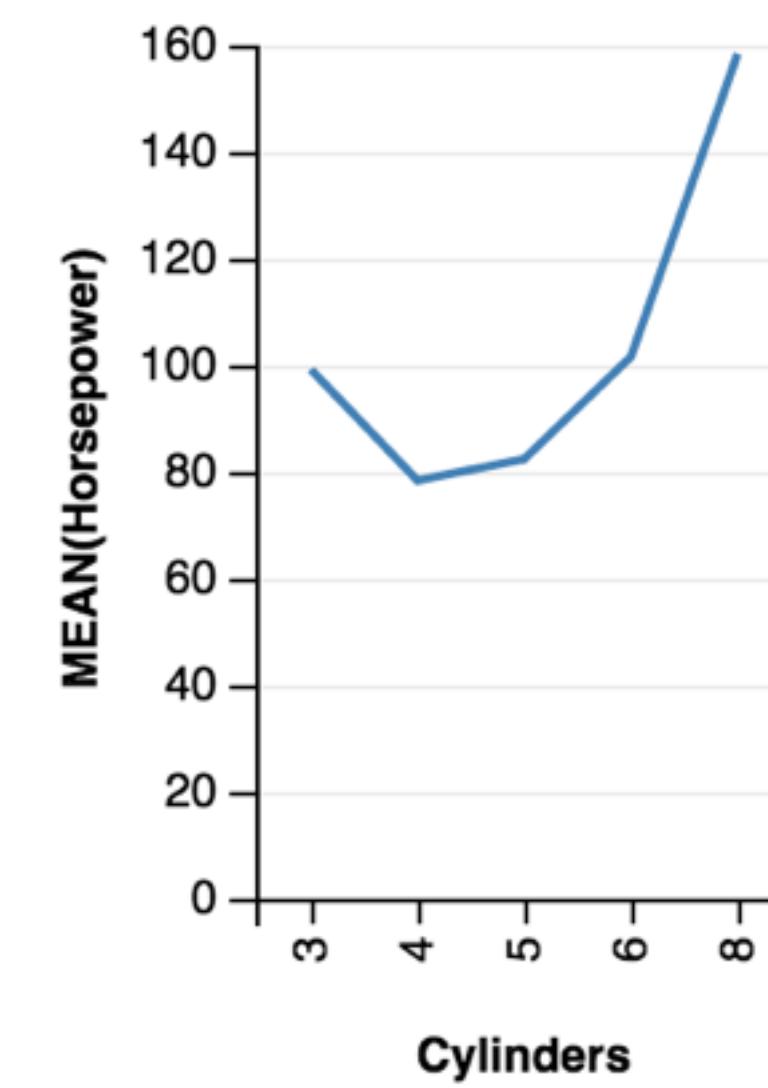
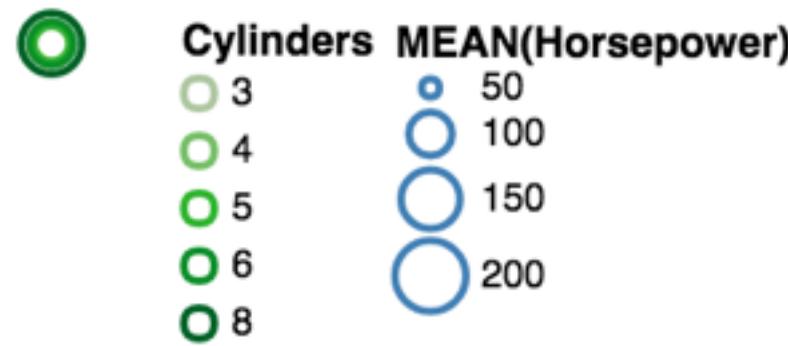
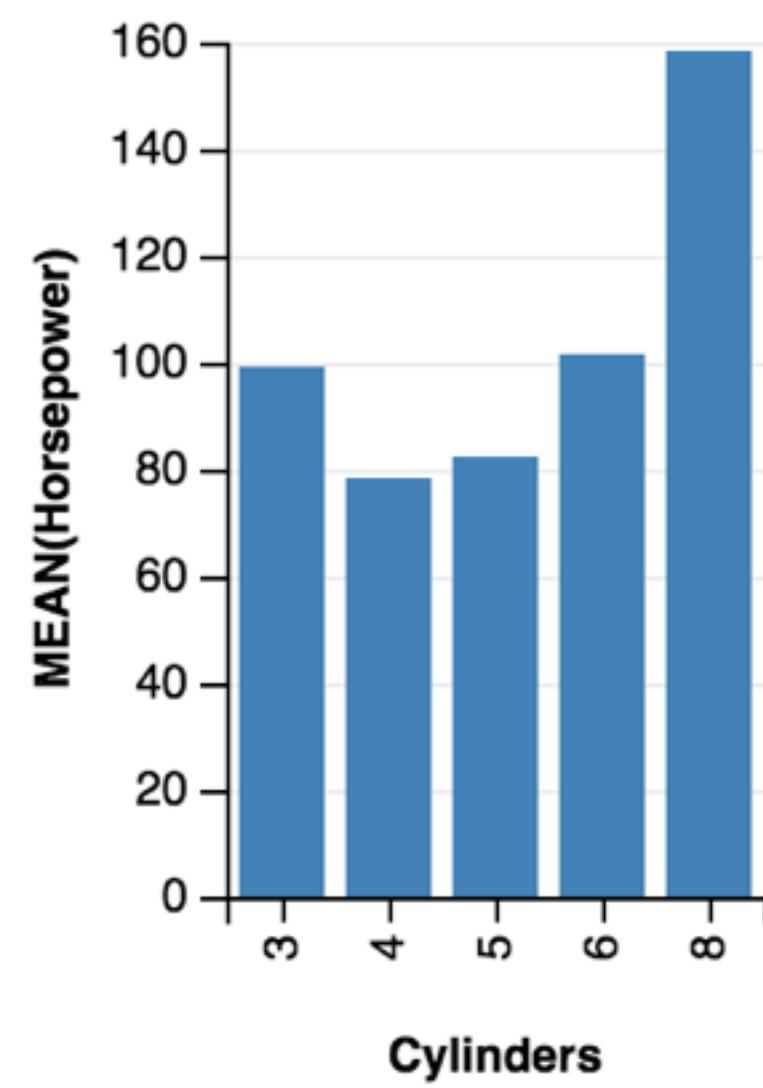
Strategy use pruning and ranking heuristics based on data type, and perceptual effectiveness

cluster similar encodings & only show unique ones

Enumerate Encodings



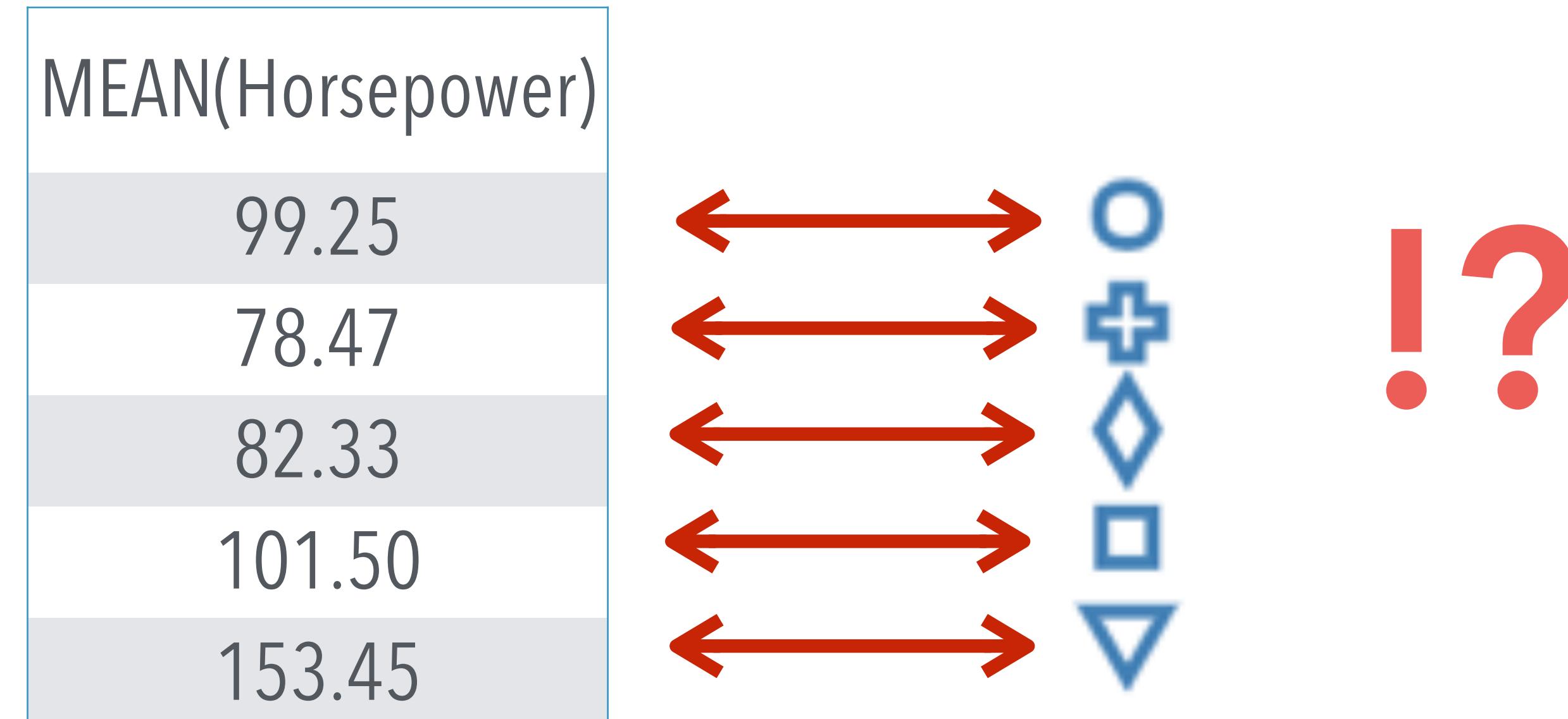
Mark Type *Point* *Bar* *Line* *Text*



Prune Encodings

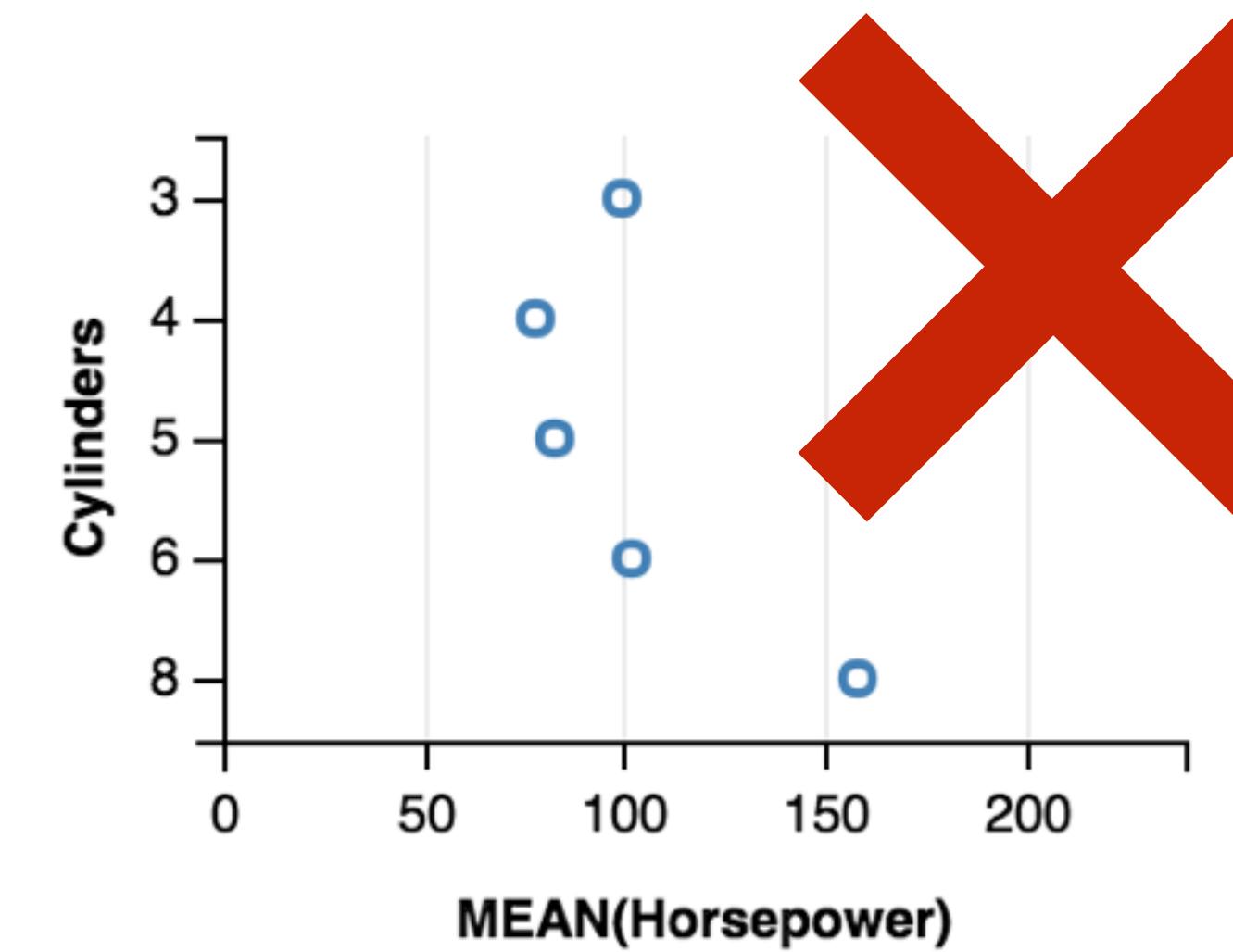
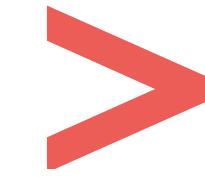
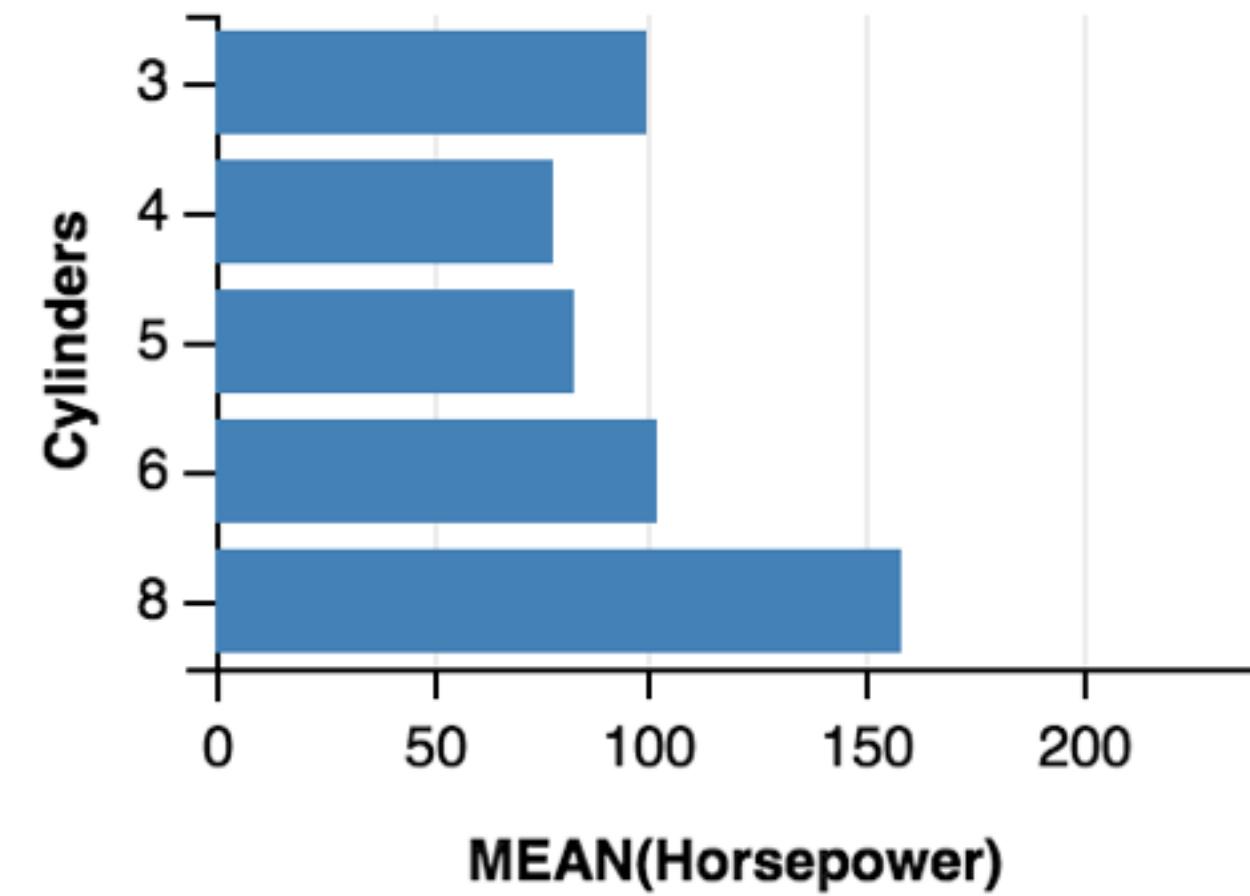
Expressiveness:

*Visualizations should express
all the facts in the data.*



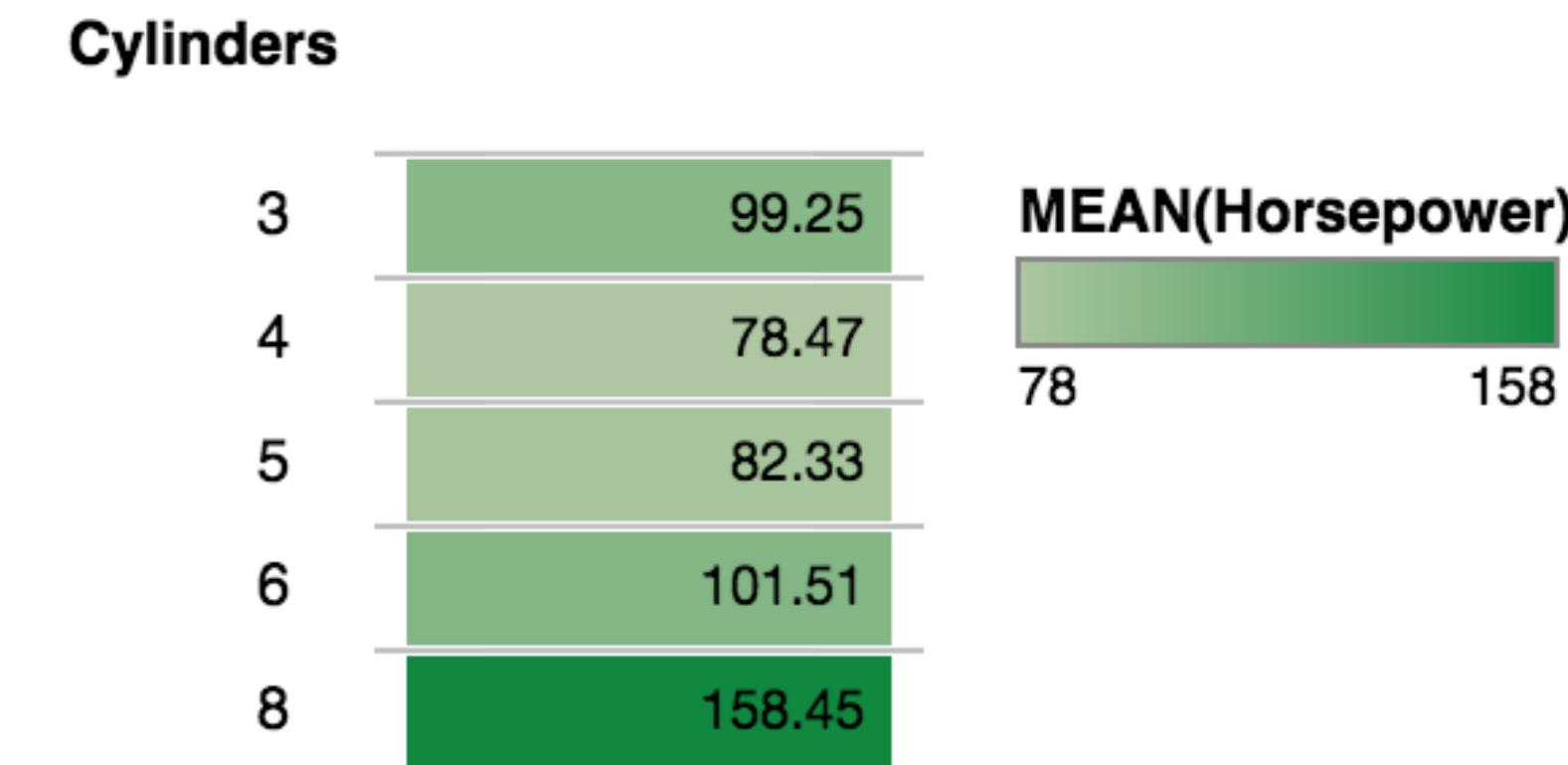
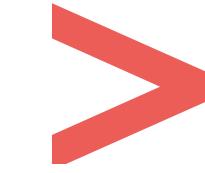
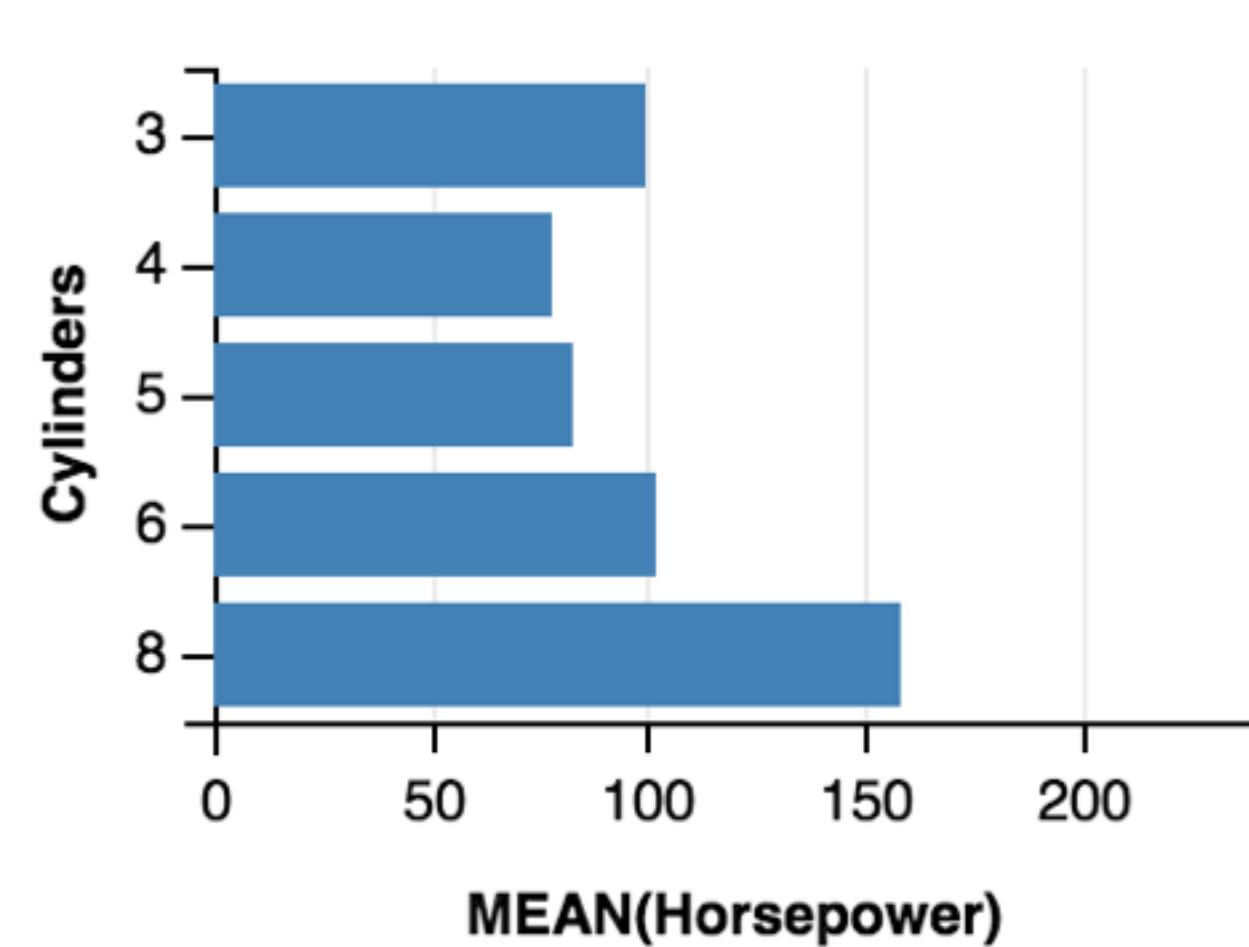
Prune Encodings

Cluster similar charts and only suggest only the best one



Rank Encodings

Using **perceptual effectiveness score** inspired by prior work on automated visualization design.



Compass

Cars
Data
+
 Horsepower
 Cylinder
 Name
User Selection

Variable Selection

Suggested Variable Sets

Horsepower

Horsepower Cylinders

Horsepower Name

Data Transformation

Data Transformation

Data Transformation

Horsepower

MEAN(Horsepower)

COUNT(*)
BIN(Horsepower)

Horsepower
Cylinders

MEAN(Horsepower)
BY Cylinders

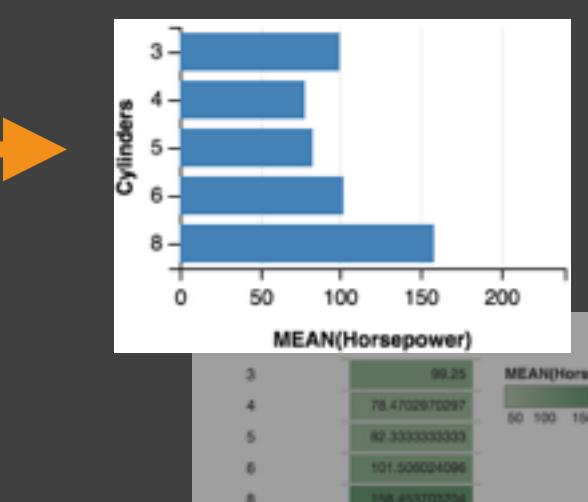
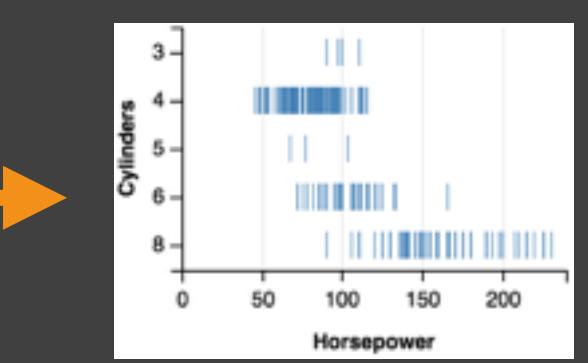
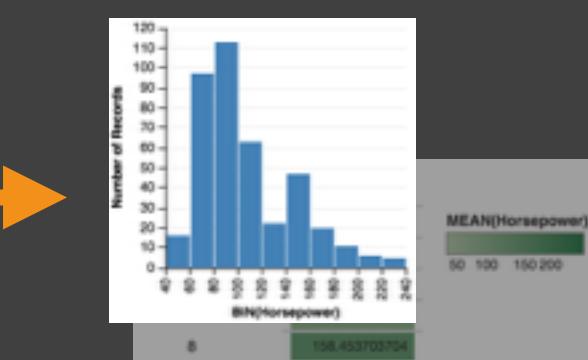
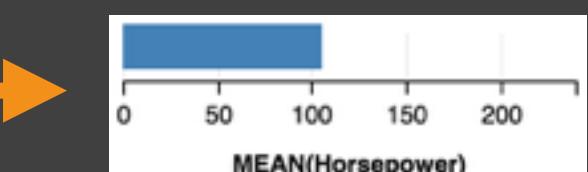
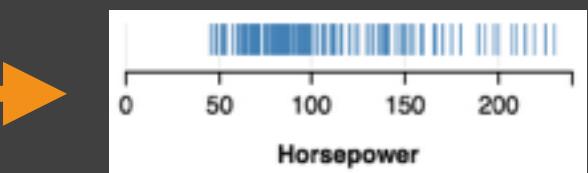
Encoding Design

Encoding Design

Encoding Design

Encoding Design

Encoding Design

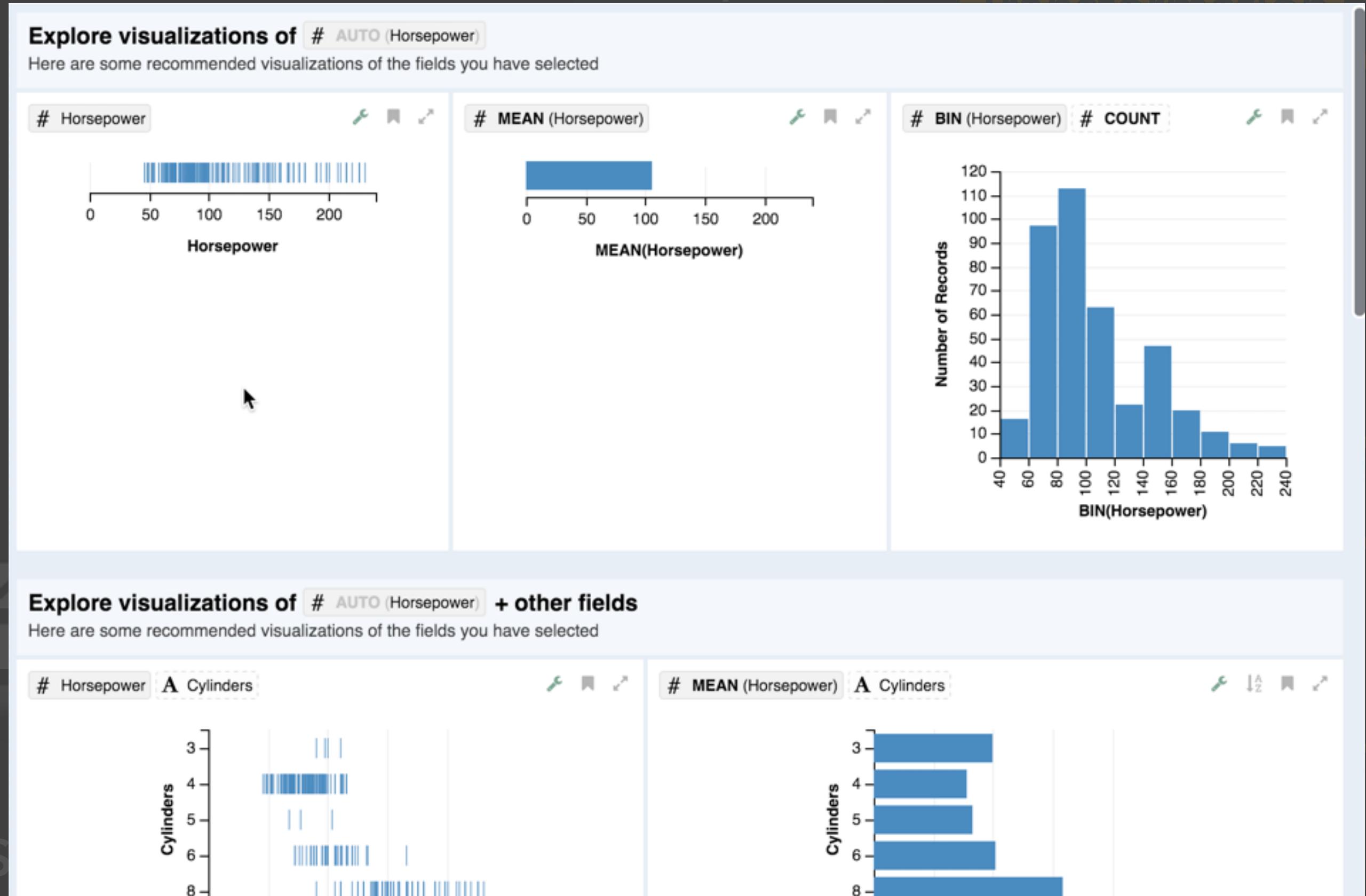


⋮

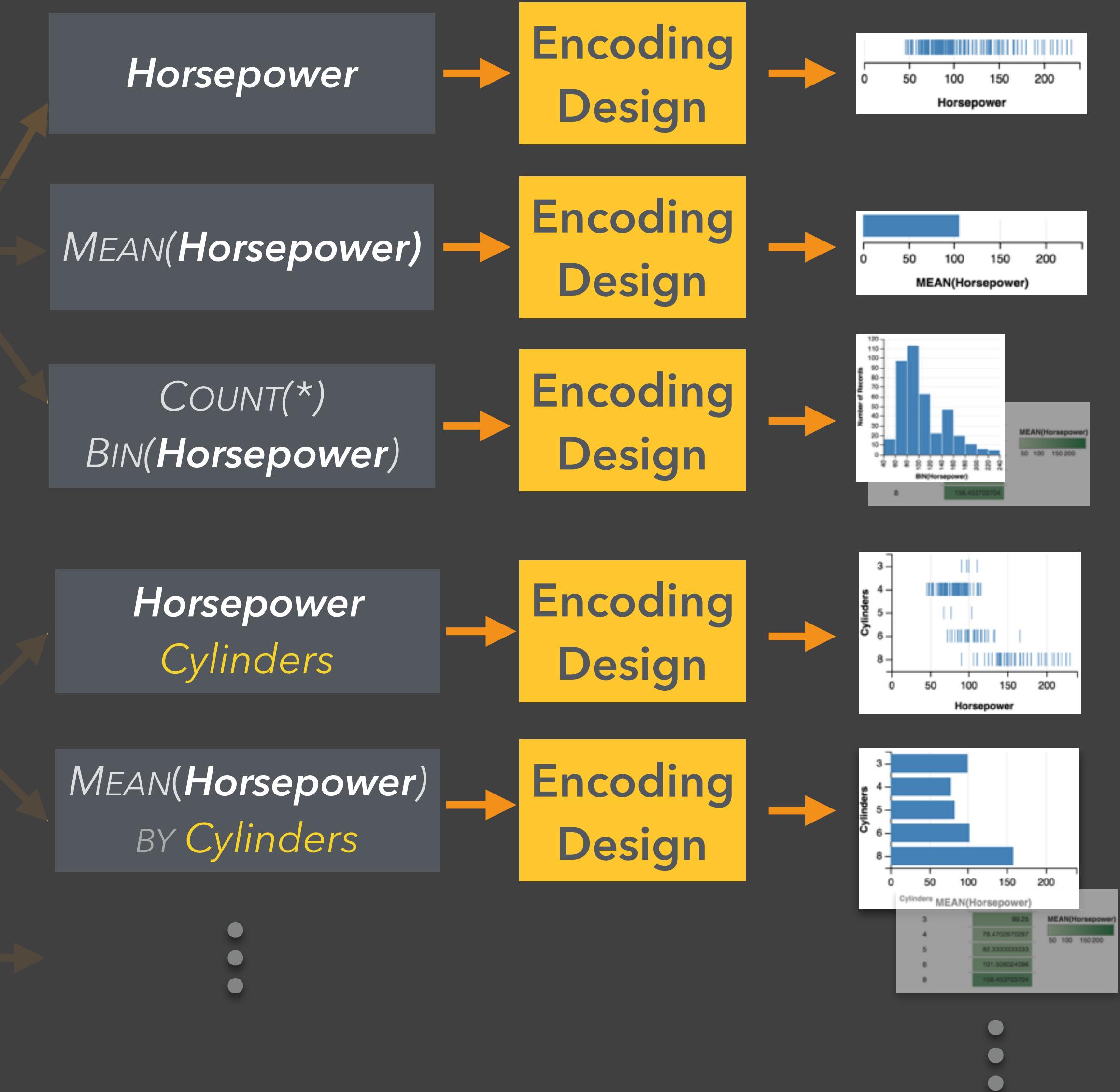
Transformed Data Tables

Visual Encodings

Compass



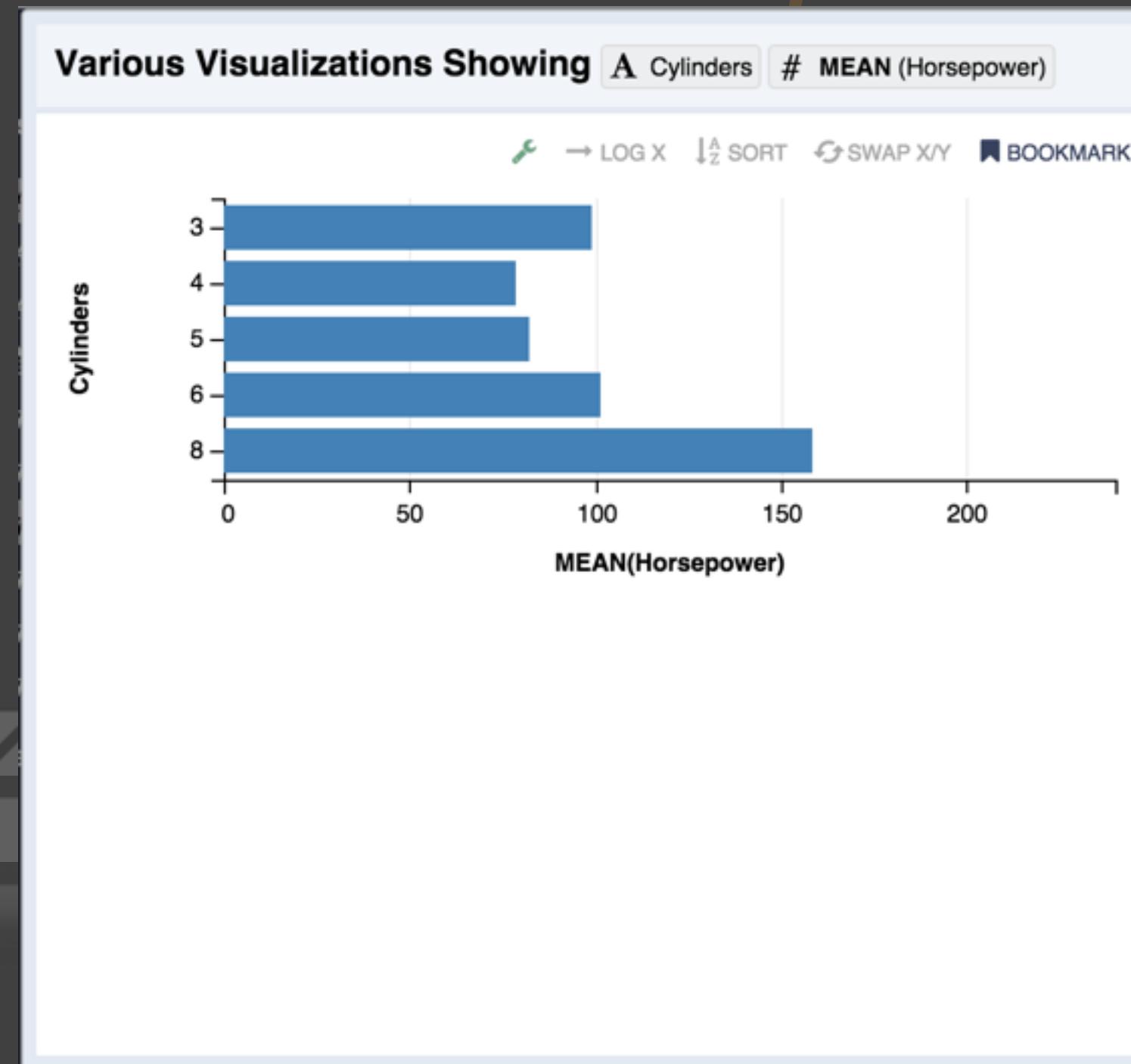
Suggested
Variable Sets



Transformed
Data Tables

Visual
Encodings

Compass



Suggested
Variable Sets

Horsepower

Data Transformation

Horsepower

MEAN(Horsepower)

COUNT(*)

BIN(Horsepower)

Horsepower
Cylinders

MEAN(Horsepower)
BY Cylinders

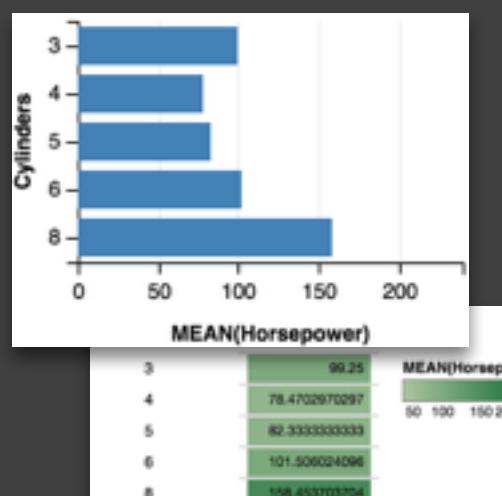
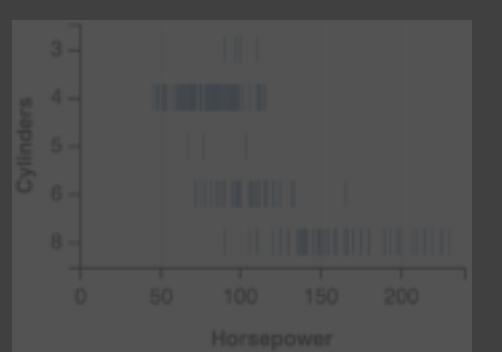
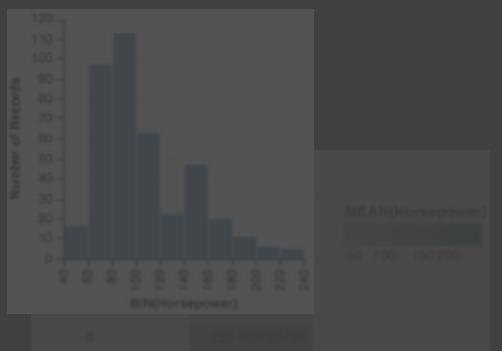
Encoding
Design

Encoding
Design

Encoding
Design

Encoding
Design

Encoding
Design



Transformed
Data Tables

Visual
Encodings

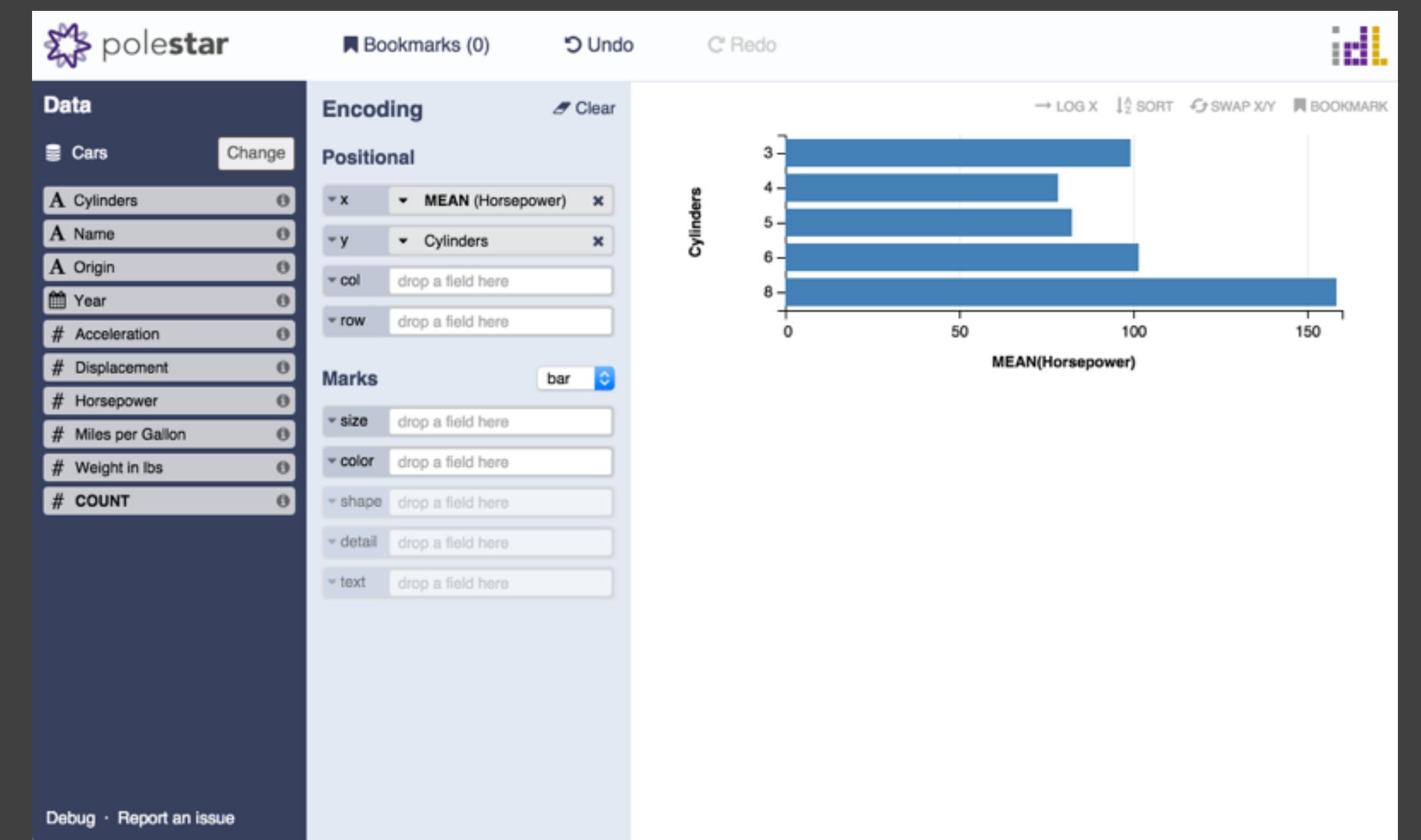
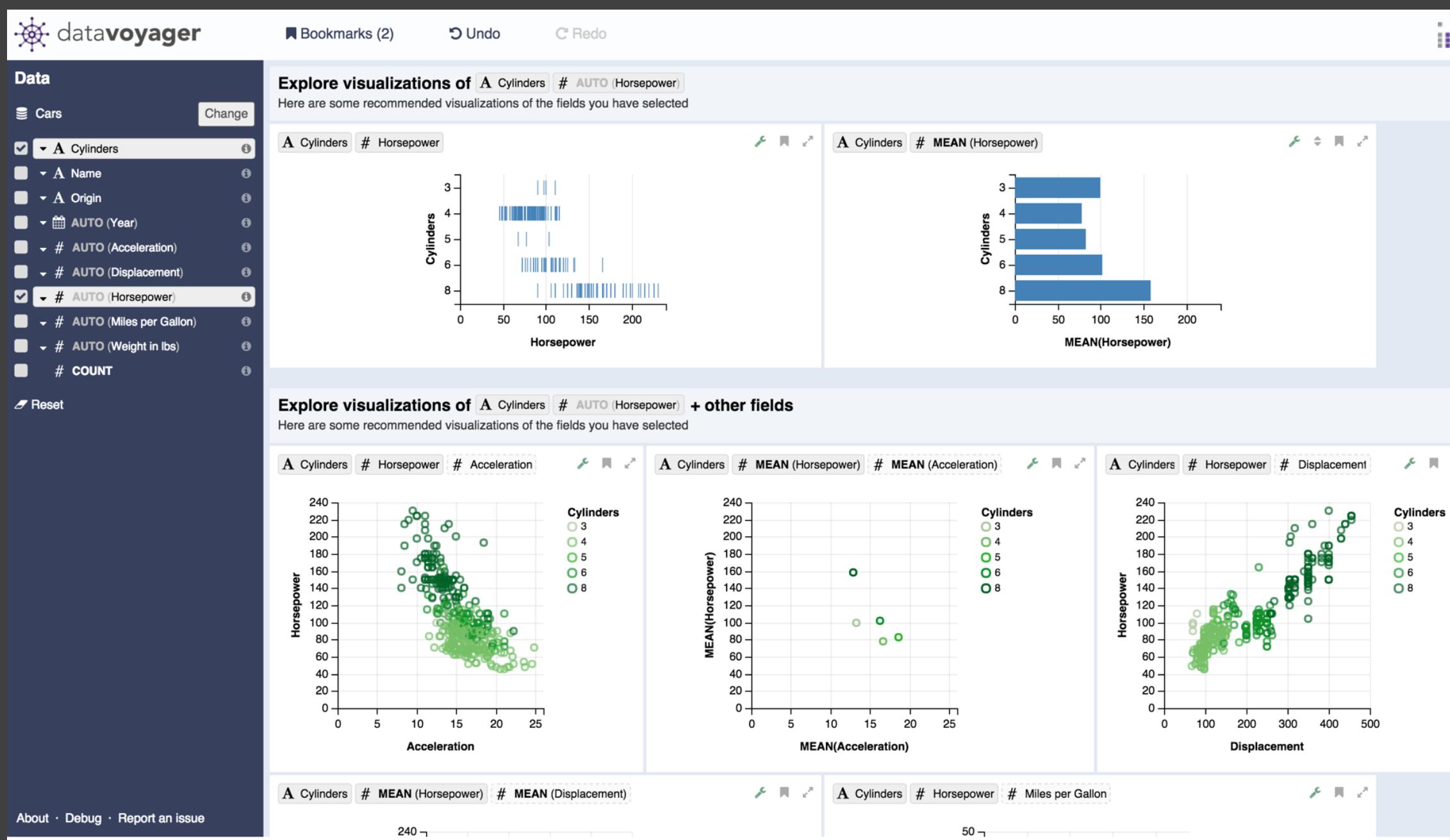
Voyager

Exploratory Analysis via Faceted Browsing of Visualization Recommendations

Introduction
The Design of Voyager
System Architecture
Evaluation
Future Work

Evaluation: Exploring Unseen Data

Voyager Browsing Recommendation



Data

Cars

Change

A Cylinders



A Name



A Origin



Year



Acceleration



Displacement



Horsepower



Miles per Gallon



Weight in lbs



COUNT



Encoding

Clear

Positional

▼ x

drop a field here

▼ y

drop a field here

▼ col

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

SWAP X/Y

BOOKMARK

Study Design

Subjects: 16 students with data analysis experience

Conditions: 2 (Tool) \times 2 (Dataset) mixed design.

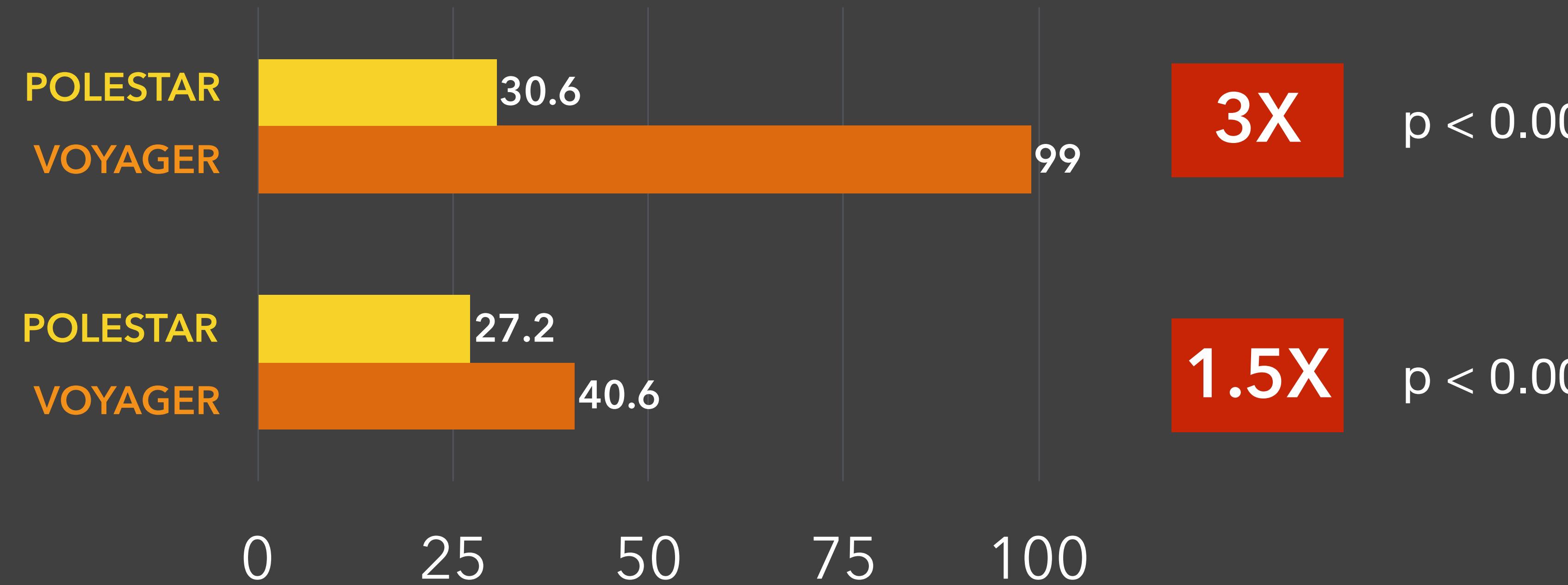
Task: Explore unfamiliar data, bookmark
“interesting” visualizations (30 min/task)

Analysis: Linear mixed-effects models

- Fixed effect: **visualization tool** and **session order**
- Random effect: **dataset** and **participant**

Does Voyager promote broader exploration?

Unique
variable sets
shown

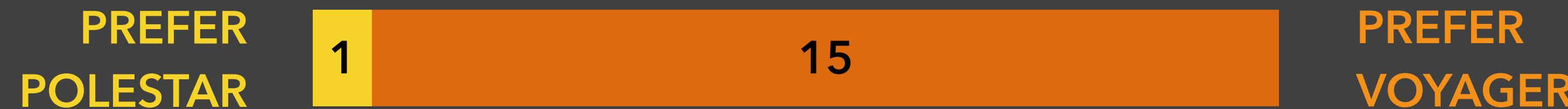


Unique
variable sets
interacted

Voyager leads to improved data coverage.

Is Voyager more preferable?

Breadth-oriented exploration



Targeted question answering



User preferences depend on tasks

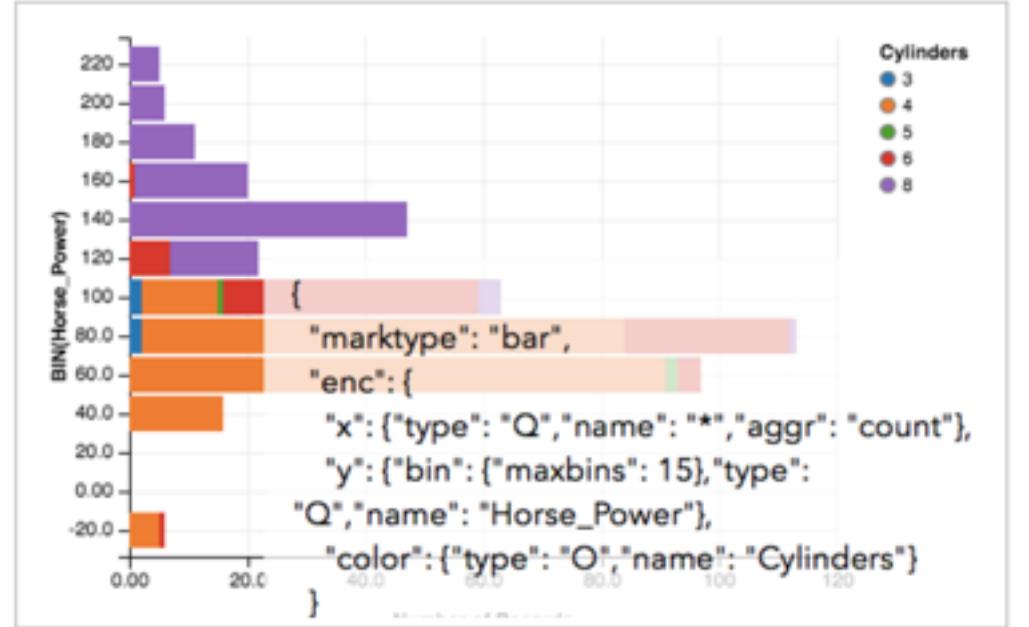
Qualitative Feedback

[Voyager] encouraged me to look more deeply at data, even data I didn't know a lot about

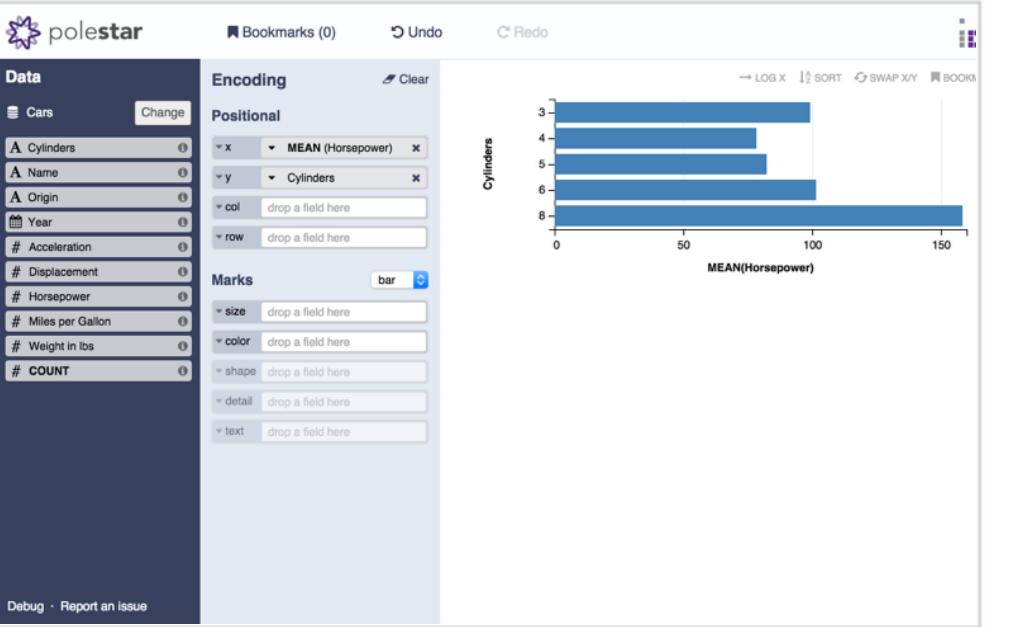
*I would **start with Voyager** but want to go and **switch to Polestar** to **dive into my question**. Once that question was answered, I would like to switch back to Voyager.*

All system components are open-sourced!

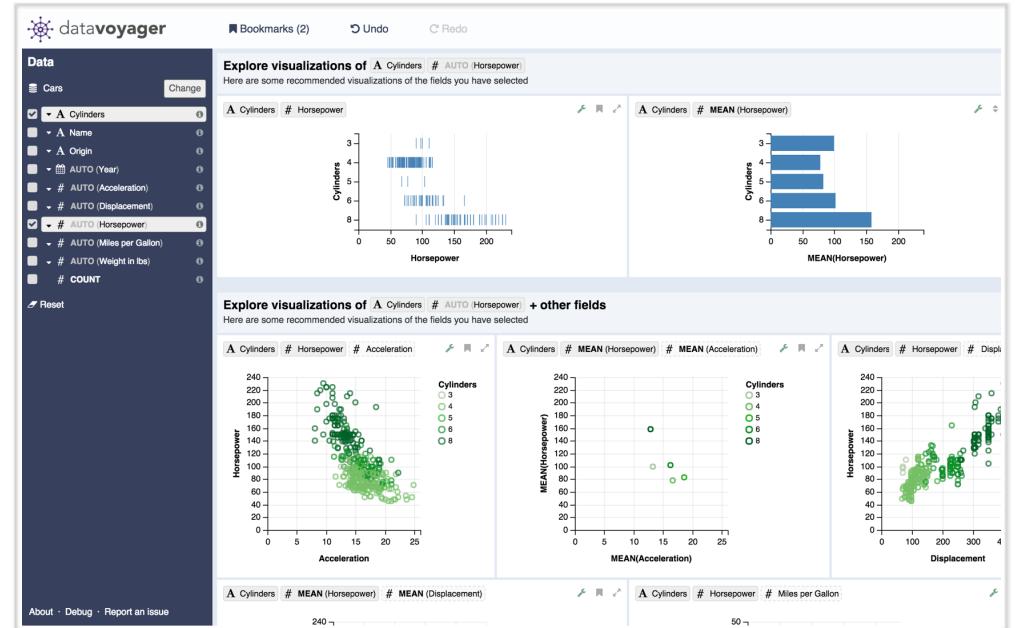
<http://vega.github.io>



Vega-Lite
NEW VEGA-LITE provides a higher-level grammar for visual analysis, comparable to ggplot or Tableau, that generates complete JSON specifications.
[Online Editor](#) | [GitHub](#)



PoleStar
NEW POLESTAR is a web-based visualization specification interface, inspired by Tableau. Analysts can rapidly generate visualizations as part of the data exploration process.
[Online App](#) | [GitHub](#)



Voyager
NEW VOYAGER is a visualization browser for open-ended data exploration. It provides a gallery of recommended visualizations produced by Compass visualization recommendation engine.
[Online App](#) | [GitHub](#)



Compass
NEW COMPASS is a visualization recommendation engine. Given user query, it recommends visualizations based on data properties and perceptual principles.
[GitHub](#)

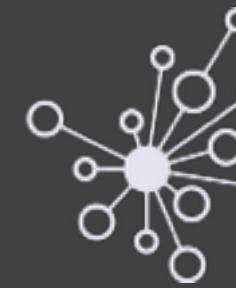
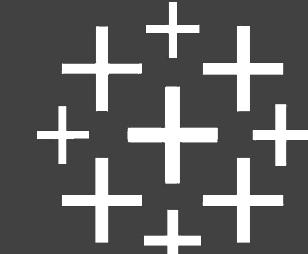
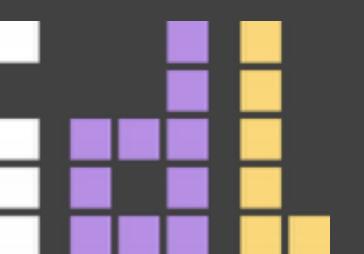
They have been used and built on !

Voyager & Polestar are used in workshops and are integrated with iPython

Vega-lite implemented in Python (Altair)

Knight Prototype Grant funds Bocoup to help improve usability of Voyager

Thanks



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