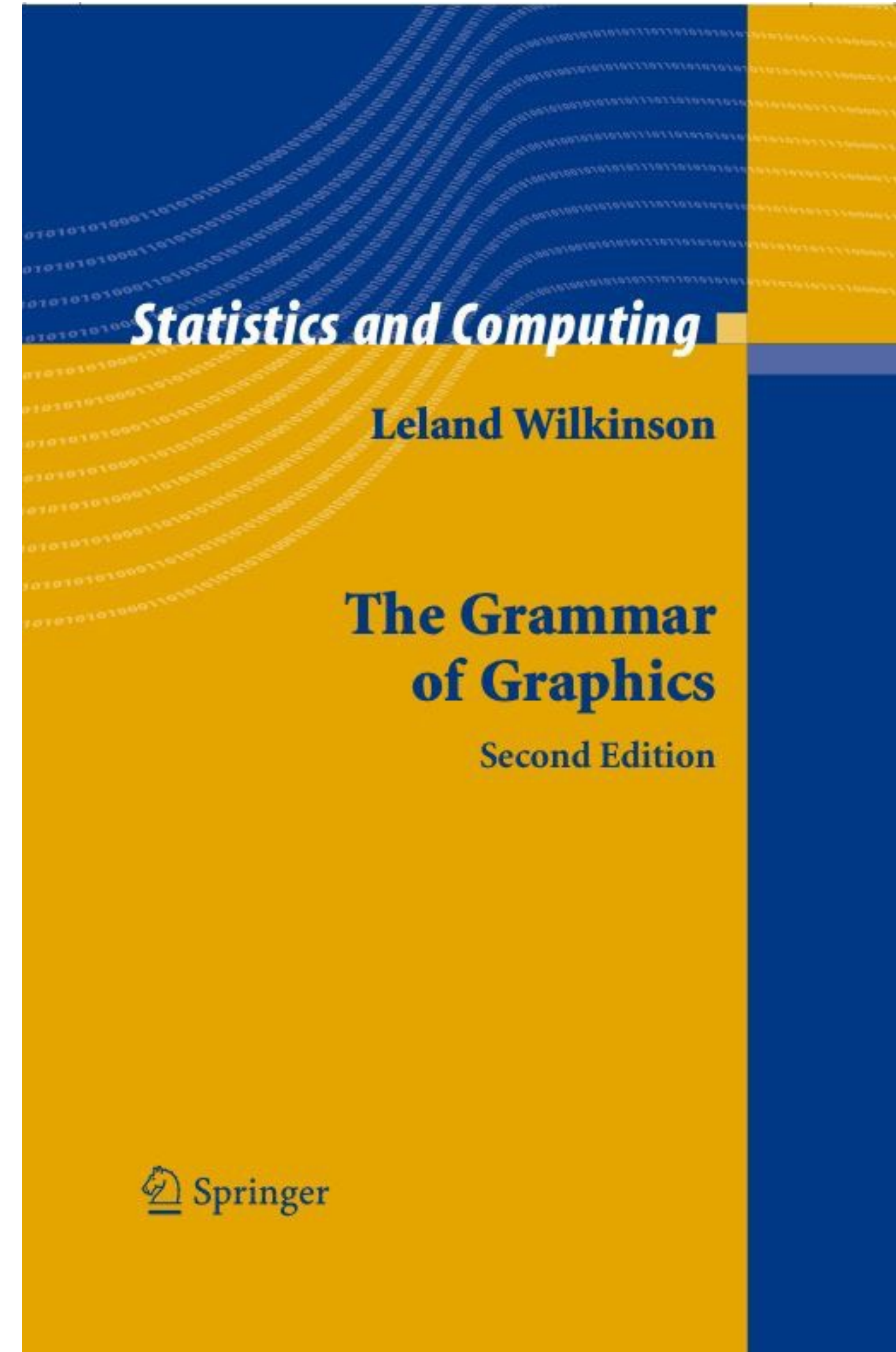


Grammar of graphics

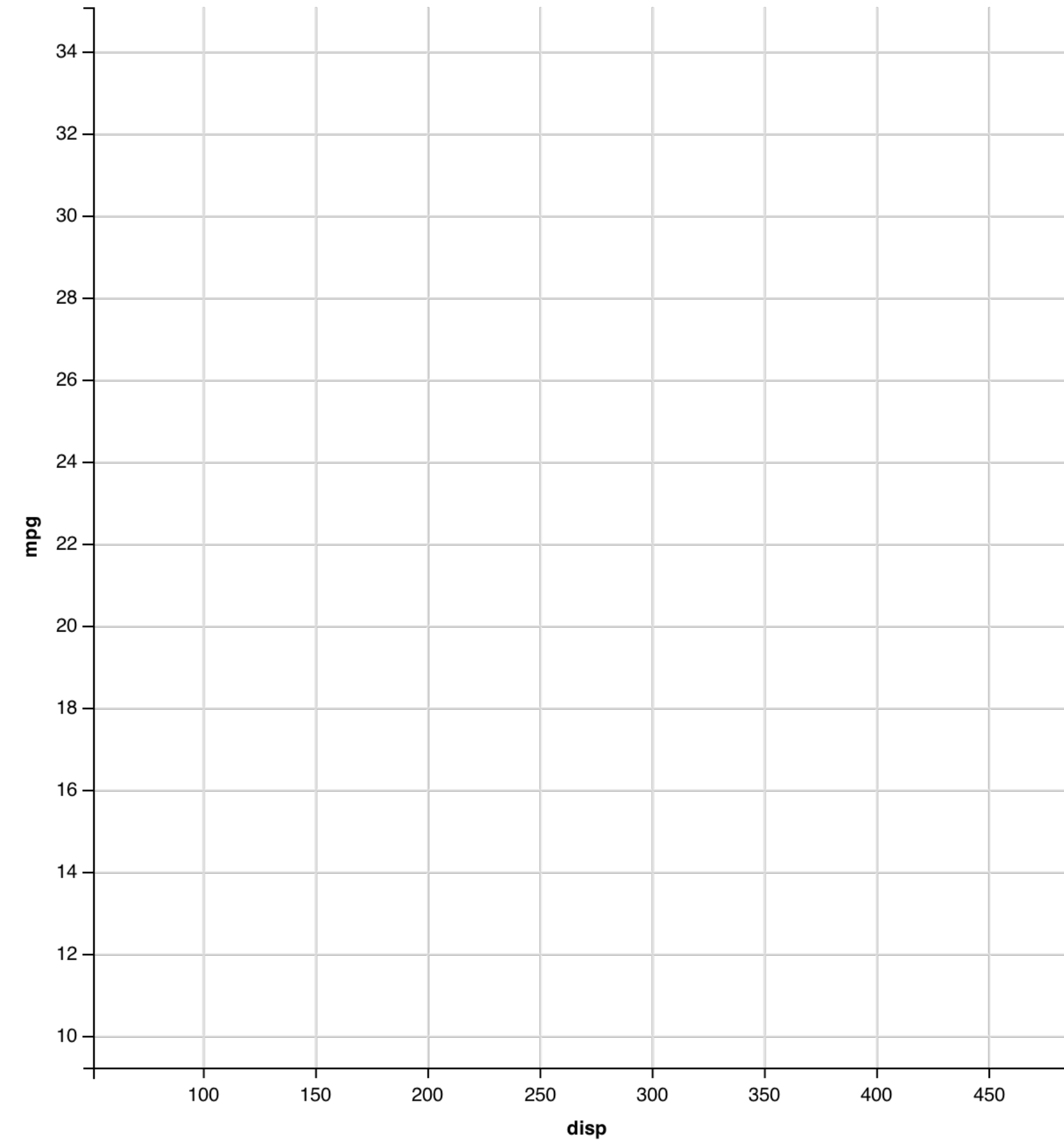


The Grammar of Graphics

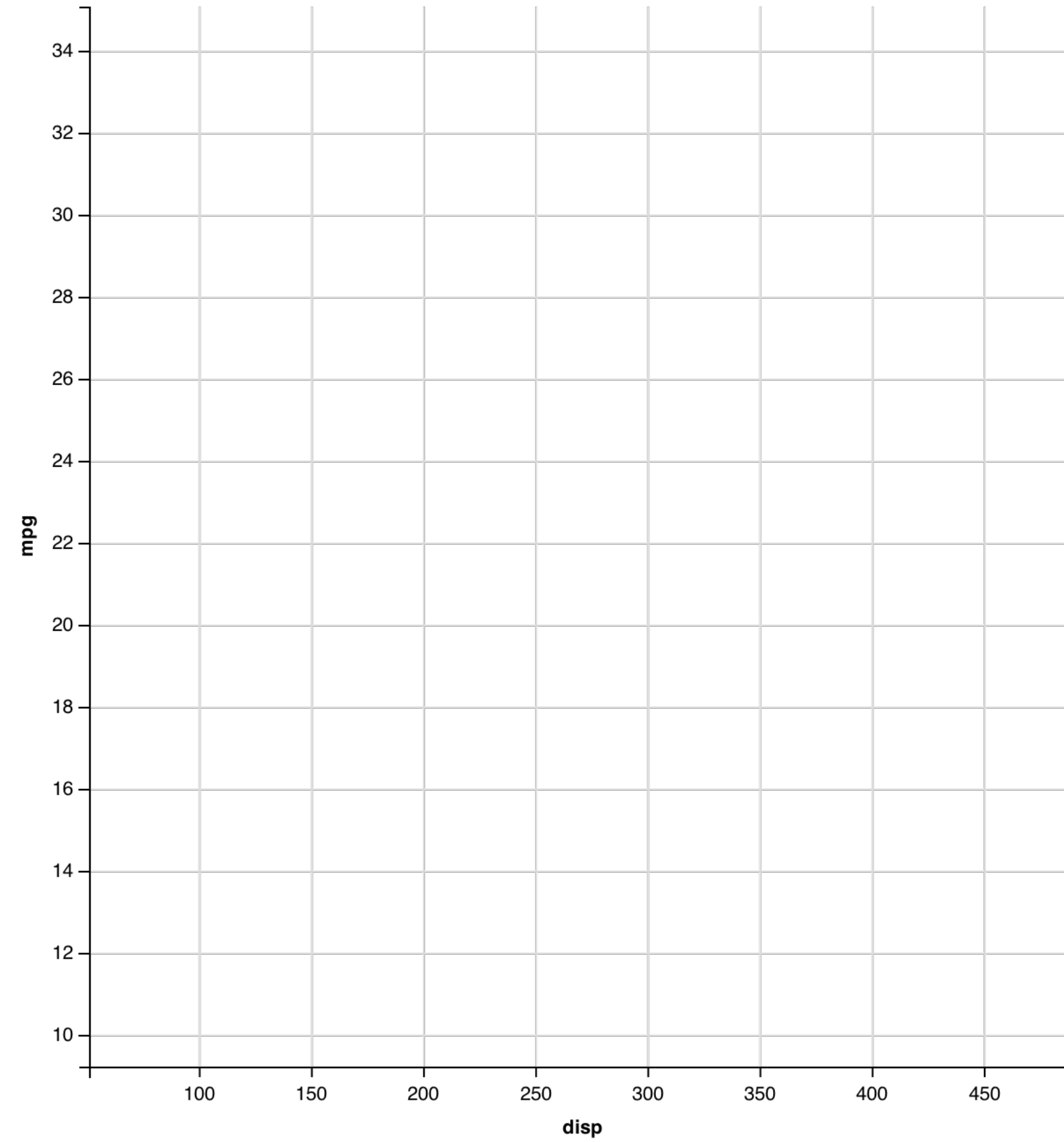
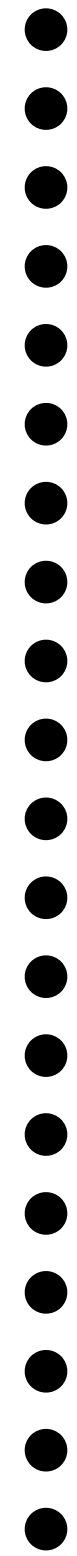


mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

data

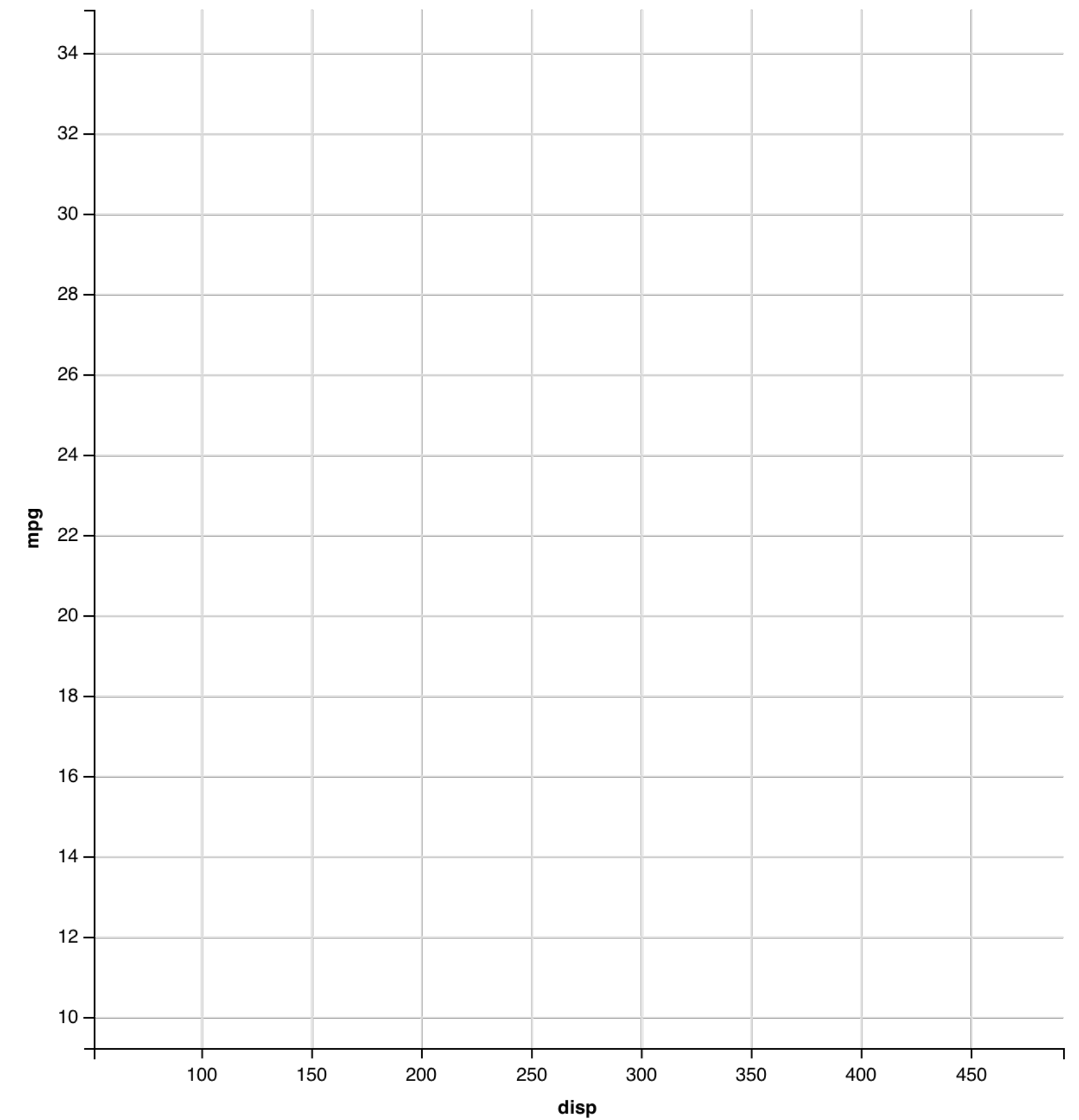
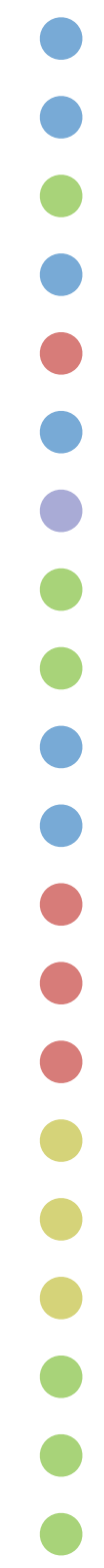


mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data **geom**

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

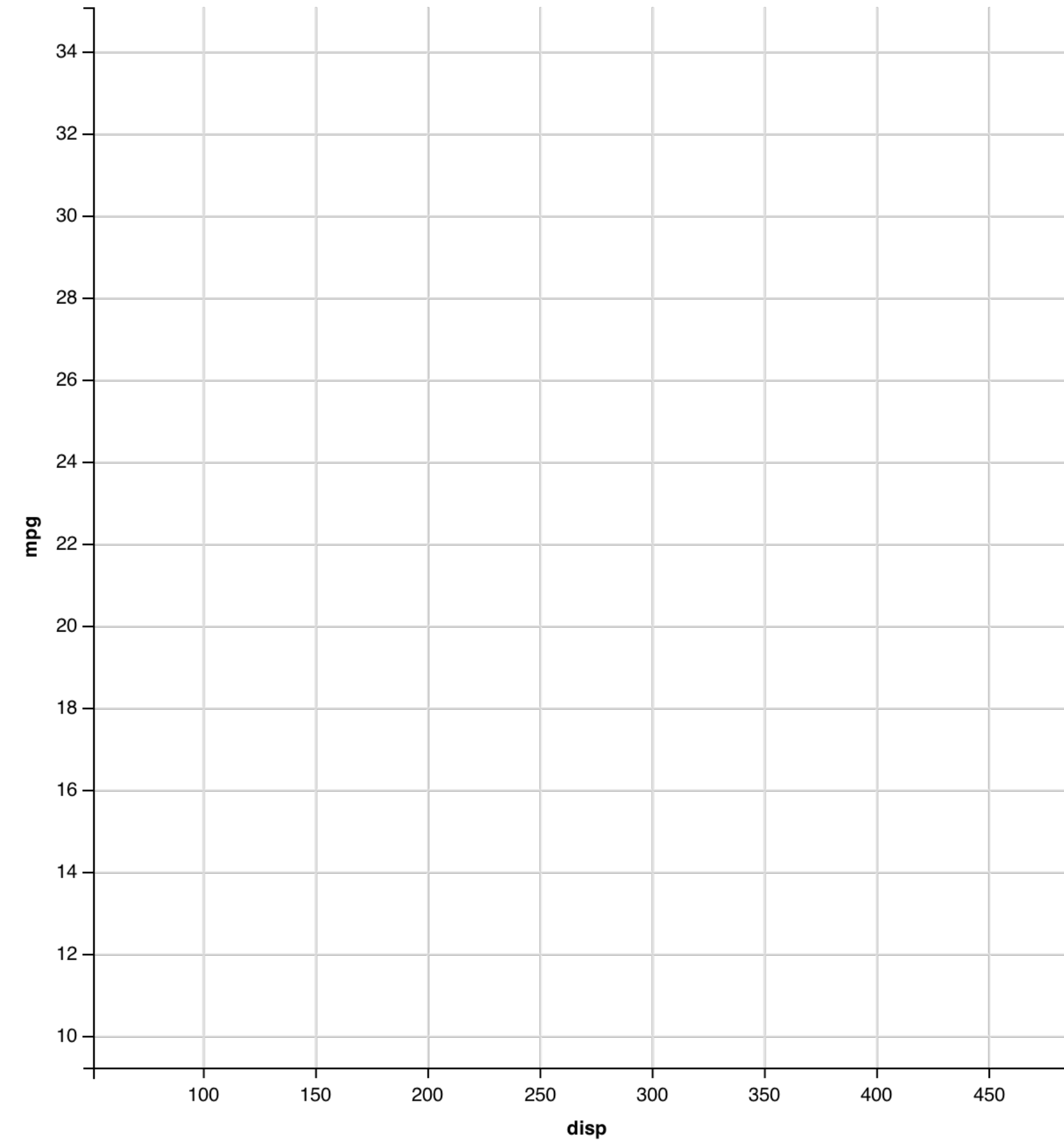


data **geom**

mappings

fill
↑↓

mpg	cyl	disp	hp	geom
21.0	6	160.0	2	●
21.0	6	160.0	2	●
22.8	4	108.0	1	●
21.4	6	258.0	2	●
18.7	8	360.0	3	●
18.1	6	225.0	2	●
14.3	8	360.0	5	●
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	●
17.8	6	167.6	2	●
16.4	8	275.8	3	●
17.3	8	275.8	3	●
15.2	8	275.8	3	●
10.4	8	472.0	4	●
10.4	8	460.0	4	●
14.7	8	440.0	4	●
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●



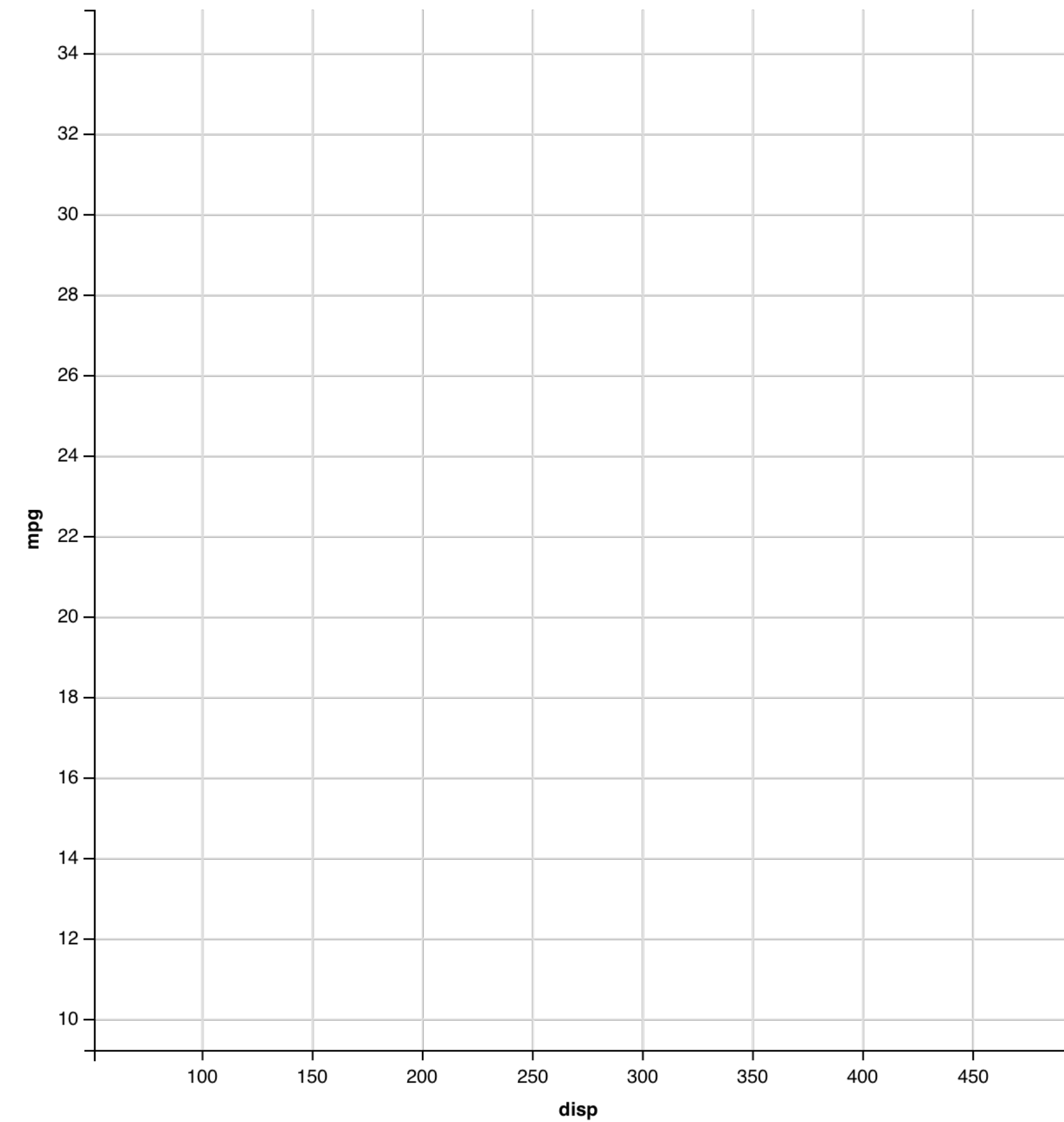
data **geom**

mappings

fill
↑↓

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

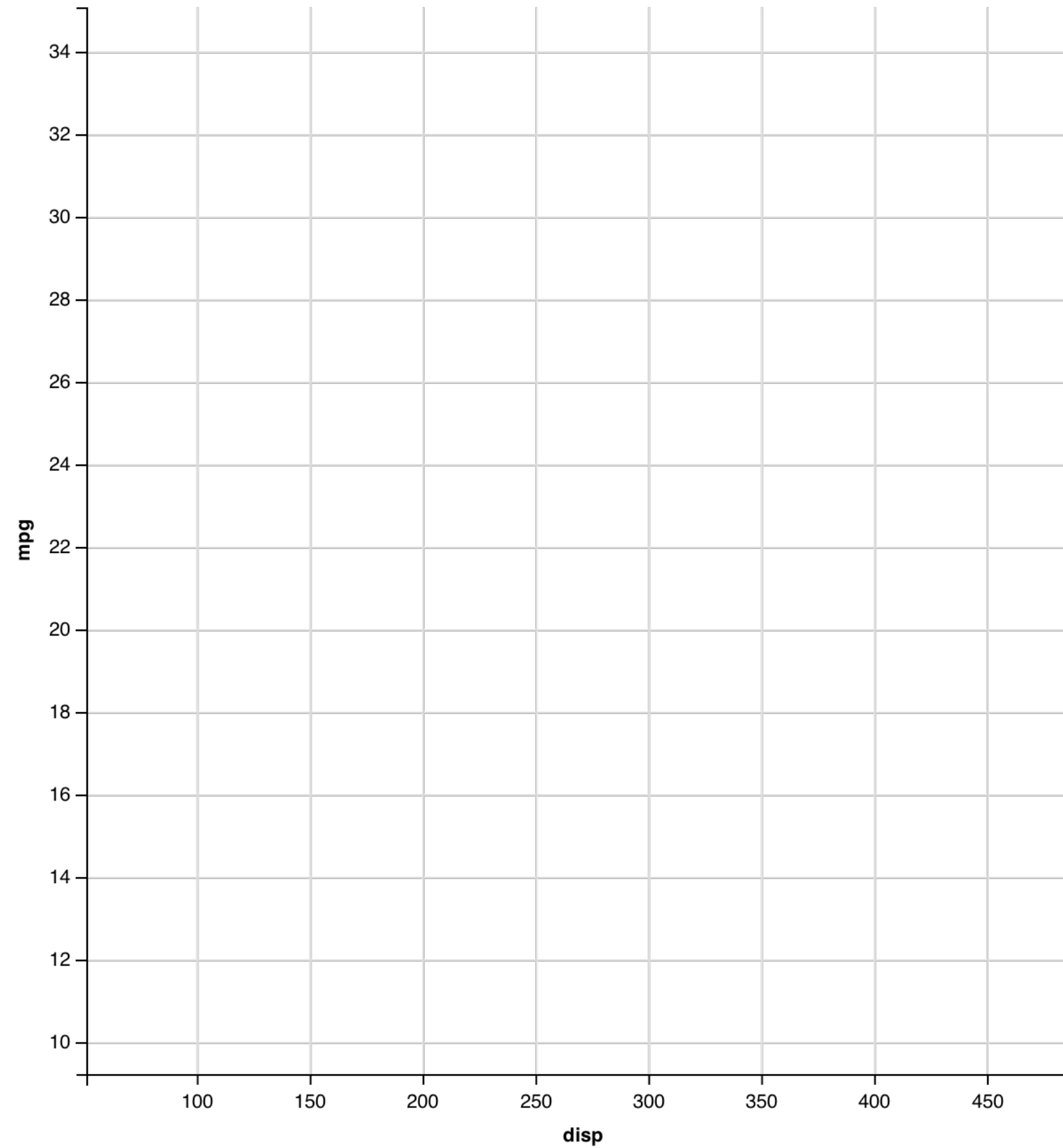
- +
- +
-
- +
- ◆
- +
- ◆
-
-
- +
- +
- ◆
- ◆
- ◆
- ◆
-
-
-



data **geom**

mappings

mpg	shape ↕ cyl	disp	fill ↕ hp	
21.0	6 +	160.0	2	+
21.0	6 +	160.0	2	+
22.8	4 ●	108.0	1	●
21.4	6 +	258.0	2	+
18.7	8 ◆	360.0	3	◆
18.1	6 +	225.0	2	+
14.3	8 ◆	360.0	5	◆
24.4	4 ●	146.7	1	●
22.8	4 ●	140.8	1	●
19.2	6 +	167.6	2	+
17.8	6 +	167.6	2	+
16.4	8 ◆	275.8	3	◆
17.3	8 ◆	275.8	3	◆
15.2	8 ◆	275.8	3	◆
10.4	8 ◆	472.0	4	◆
10.4	8 ◆	460.0	4	◆
14.7	8 ◆	440.0	4	◆
32.4	4 ●	78.7	1	●
30.4	4 ●	75.7	1	●
33.9	4 ●	71.1	1	●



data **geom**

mappings

mpg	cyl	disp	hp	
21.0	6	160.0	2	+
21.0	6	160.0	2	+
22.8	4	108.0	1	●
21.4	6	258.0	2	+
18.7	8	360.0	3	◆
18.1	6	225.0	2	+
14.3	8	360.0	5	◆
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	+
17.8	6	167.6	2	+
16.4	8	275.8	3	◆
17.3	8	275.8	3	◆
15.2	8	275.8	3	◆
10.4	8	472.0	4	◆
10.4	8	460.0	4	◆
14.7	8	440.0	4	◆
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●

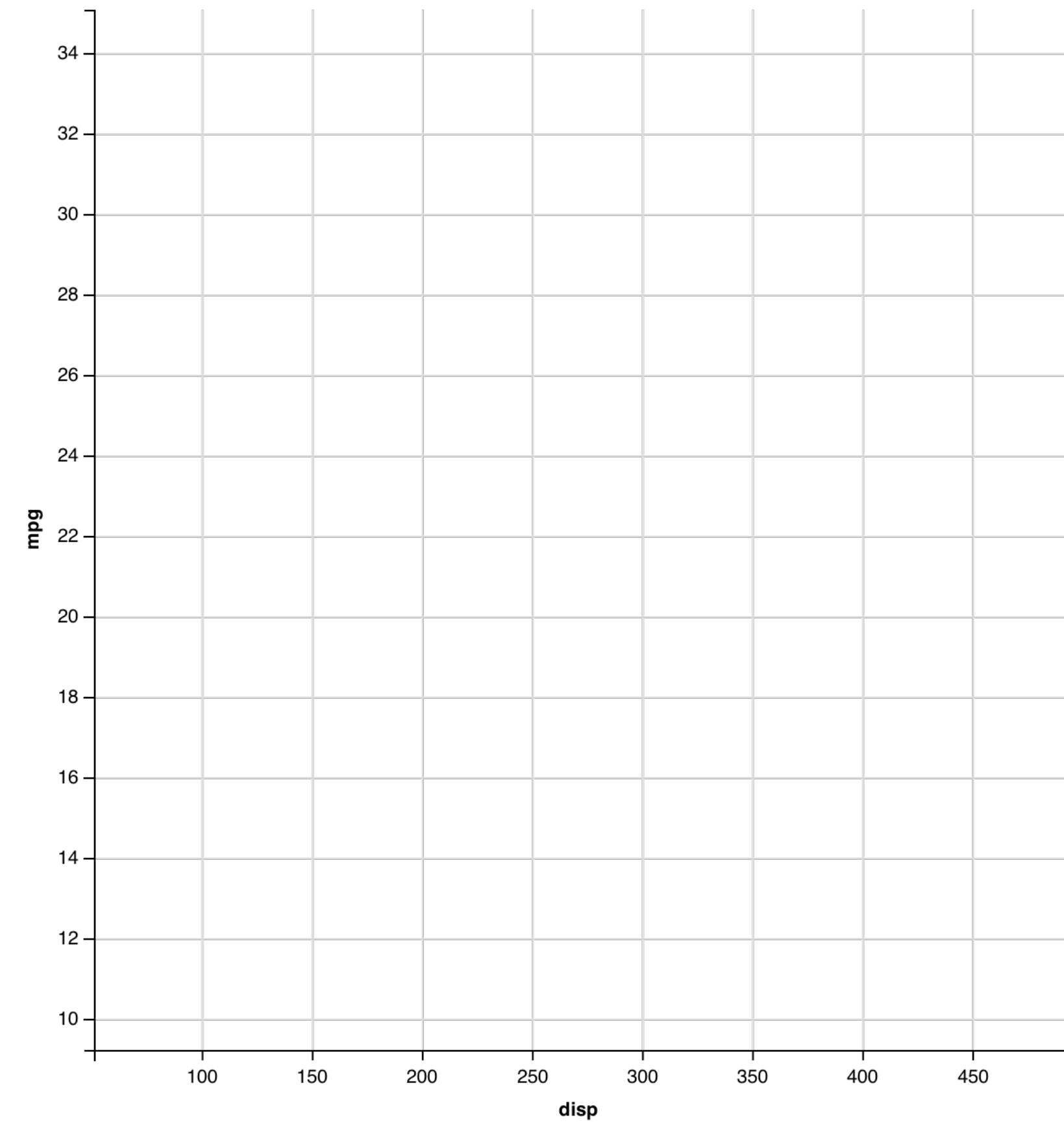
shape

fill



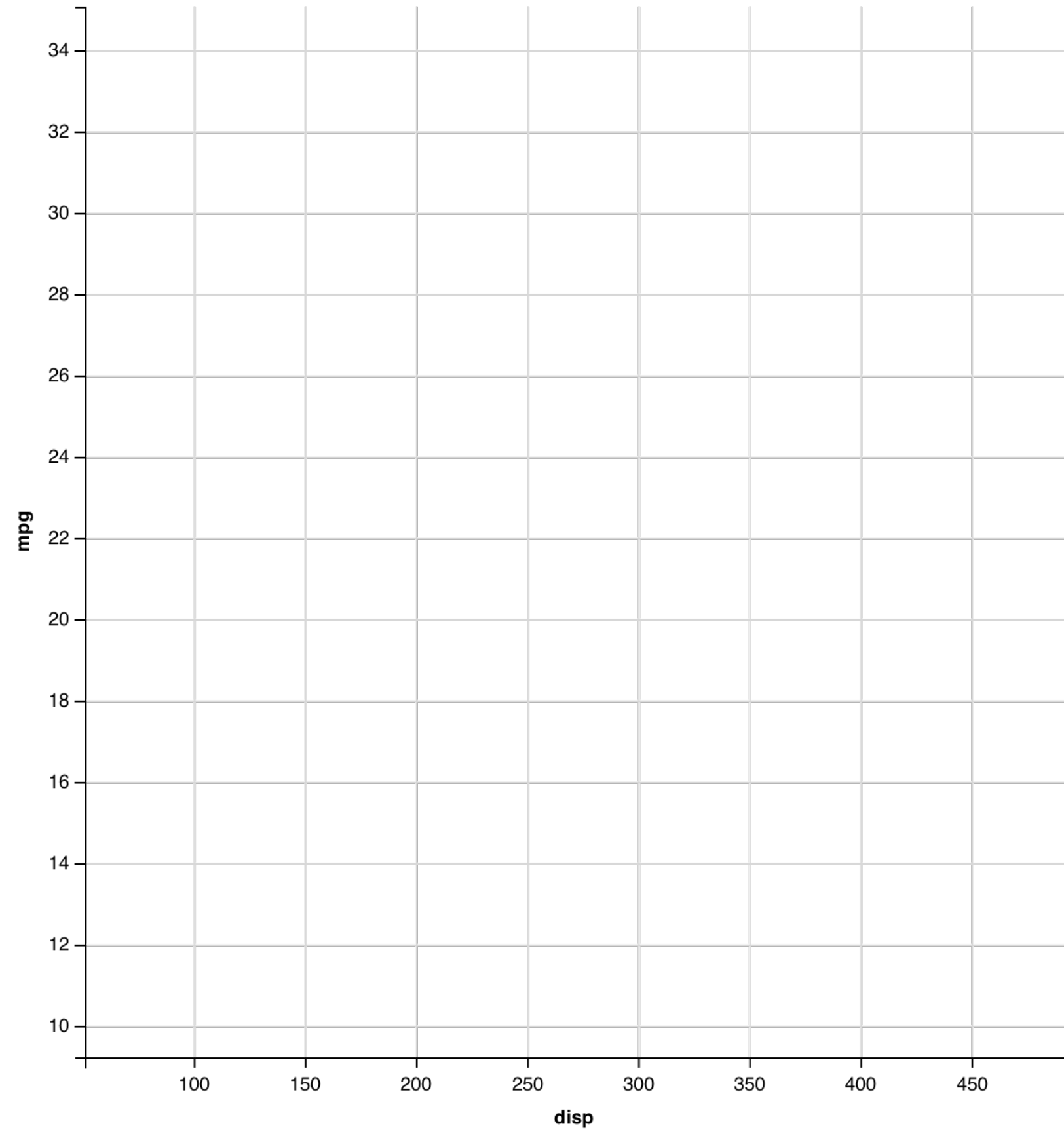
data

geom



mappings

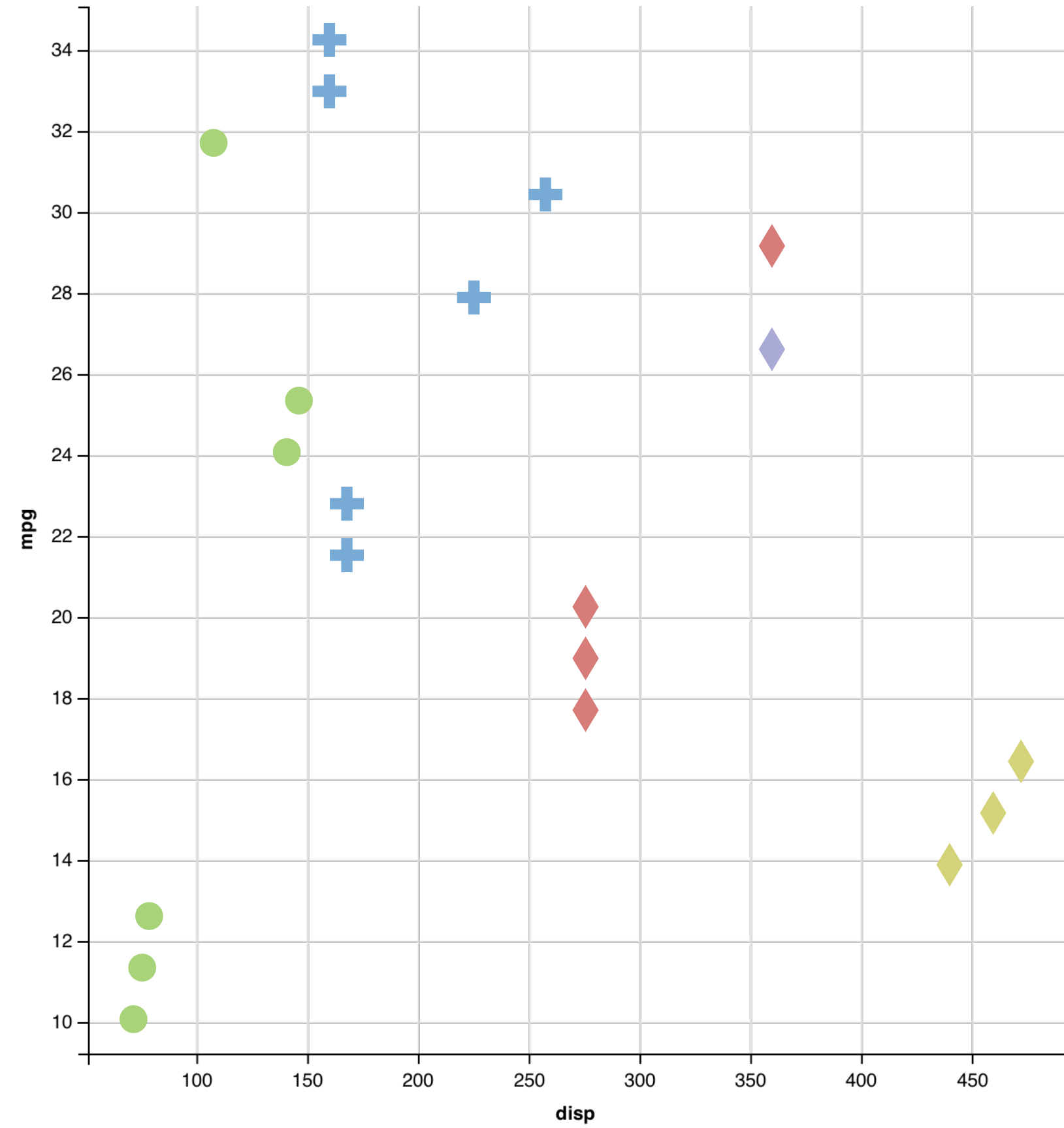
	shape	x	fill	
mpg	cyl	disp	hp	
21.0	6	160.0	2	+
21.0	6	160.0	2	+
22.8	4	108.0	1	●
21.4	6	258.0	2	+
18.7	8	360.0	3	◆
18.1	6	225.0	2	+
14.3	8	360.0	5	◆
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	+
17.8	6	167.6	2	+
16.4	8	275.8	3	◆
17.3	8	275.8	3	◆
15.2	8	275.8	3	◆
10.4	8	472.0	4	◆
10.4	8	460.0	4	◆
14.7	8	440.0	4	◆
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●



data **geom**

mappings

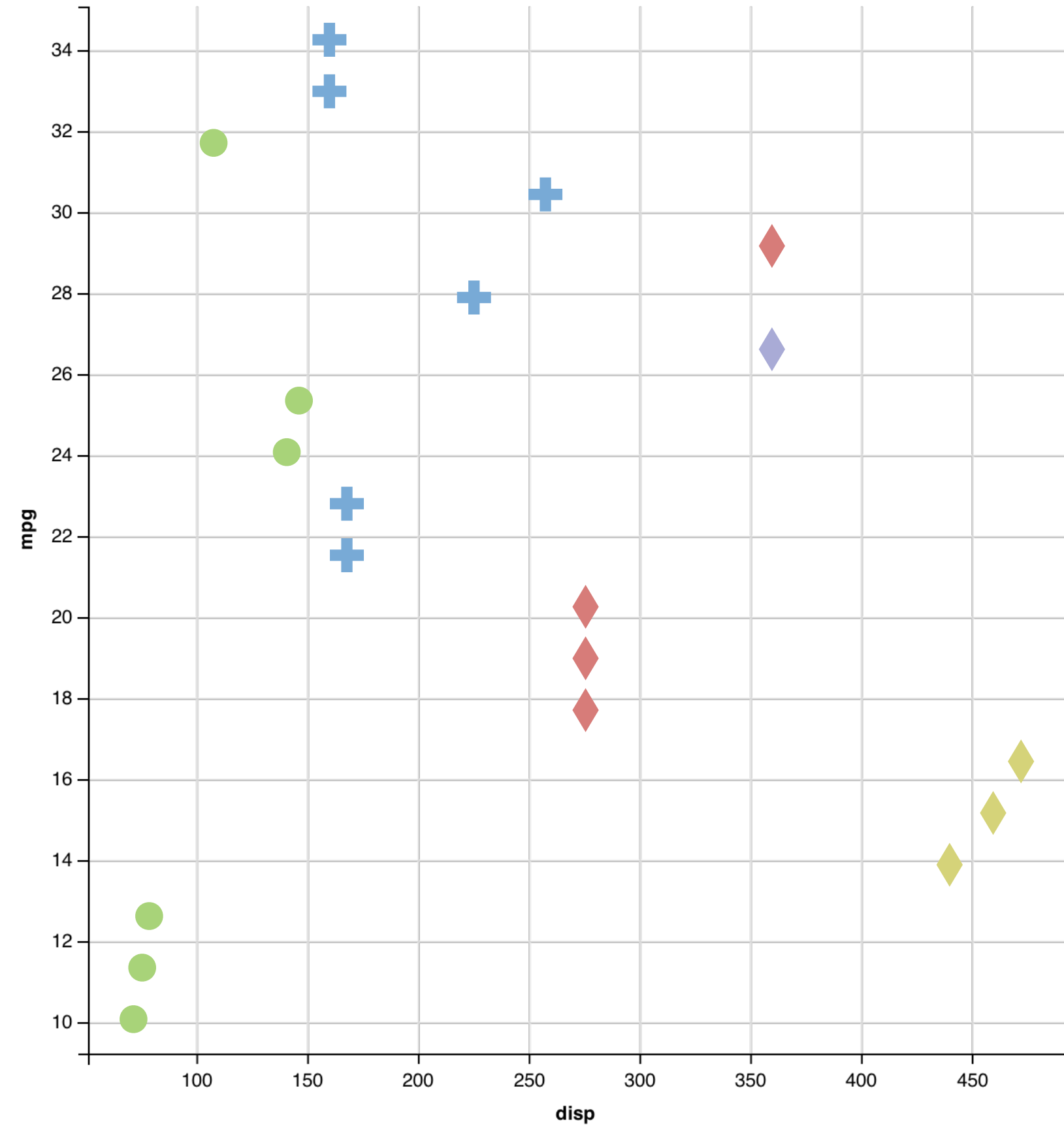
	shape	x	fill	
mpg	cyl	disp	hp	
21.0	6	160.0	2	+
21.0	6	160.0	2	+
22.8	4	108.0	1	●
21.4	6	258.0	2	+
18.7	8	360.0	3	◇
18.1	6	225.0	2	+
14.3	8	360.0	5	◇
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	+
17.8	6	167.6	2	+
16.4	8	275.8	3	◇
17.3	8	275.8	3	◇
15.2	8	275.8	3	◇
10.4	8	472.0	4	◇
10.4	8	460.0	4	◇
14.7	8	440.0	4	◇
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●



data **geom**

mappings

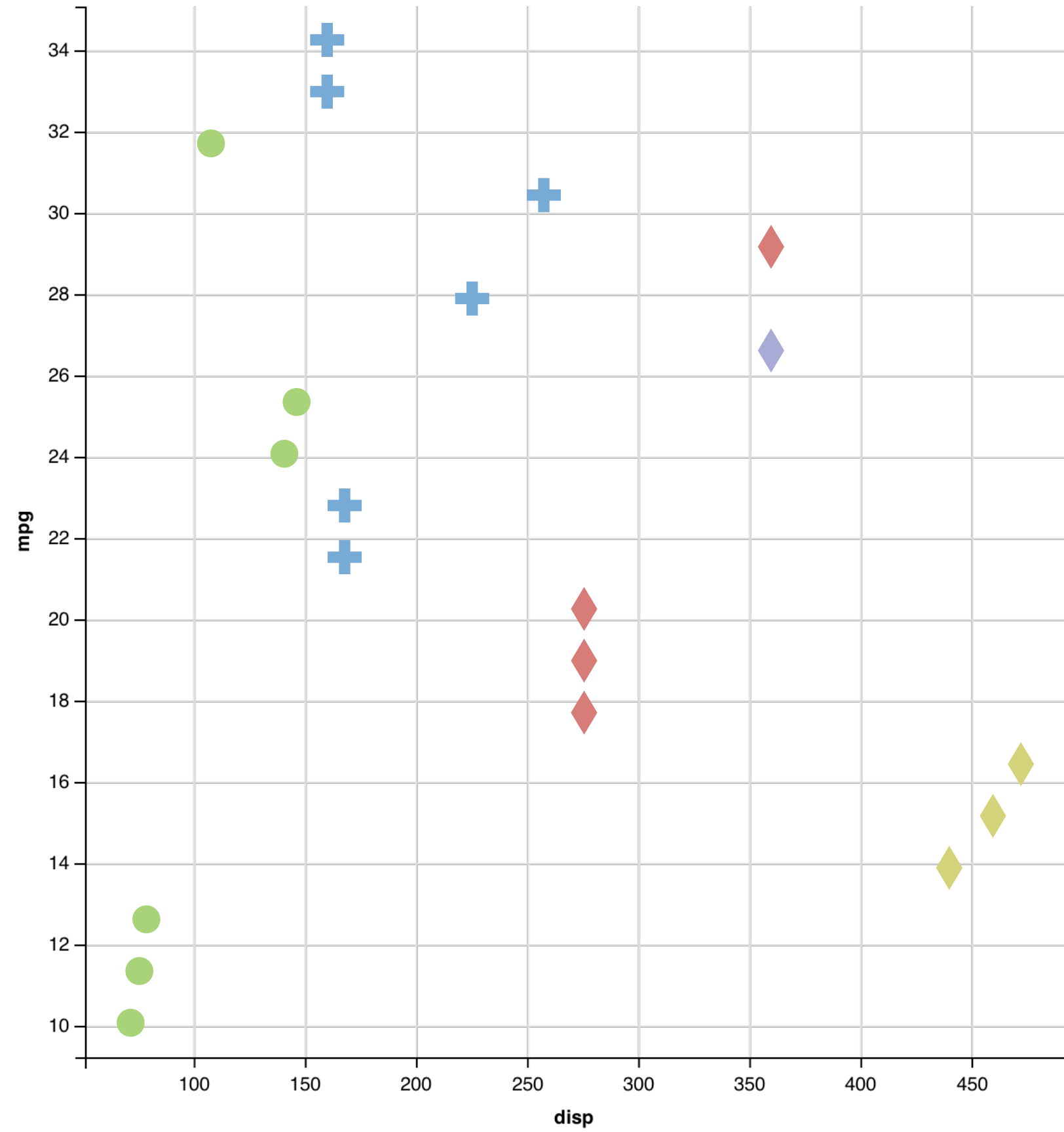
	shape	x	fill	
mpg	cyl	disp	hp	
21.0	6	160.0	2	+
21.0	6	160.0	2	+
22.8	4	108.0	1	●
21.4	6	258.0	2	+
18.7	8	360.0	3	◇
18.1	6	225.0	2	+
14.3	8	360.0	5	◇
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	+
17.8	6	167.6	2	+
16.4	8	275.8	3	◇
17.3	8	275.8	3	◇
15.2	8	275.8	3	◇
10.4	8	472.0	4	◇
10.4	8	460.0	4	◇
14.7	8	440.0	4	◇
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●



data **geom**

mappings

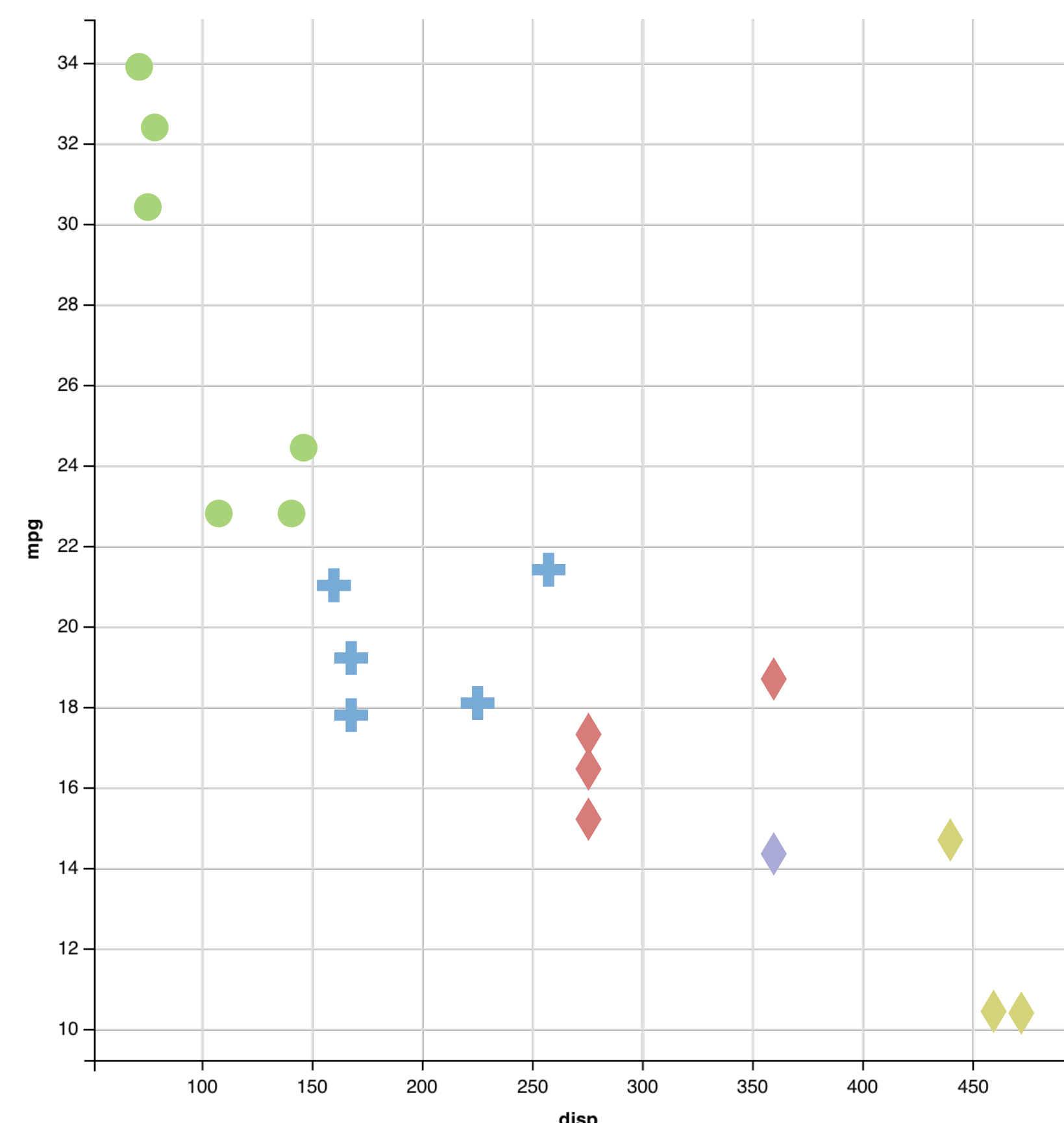
y	shape	x	fill	
↕	↕	↕	↕	
mpg	cyl	disp	hp	
21.0	6	160.0	2	+
21.0	6	160.0	2	+
22.8	4	108.0	1	●
21.4	6	258.0	2	+
18.7	8	360.0	3	◇
18.1	6	225.0	2	+
14.3	8	360.0	5	◇
24.4	4	146.7	1	●
22.8	4	140.8	1	●
19.2	6	167.6	2	+
17.8	6	167.6	2	+
16.4	8	275.8	3	◇
17.3	8	275.8	3	◇
15.2	8	275.8	3	◇
10.4	8	472.0	4	◇
10.4	8	460.0	4	◇
14.7	8	440.0	4	◇
32.4	4	78.7	1	●
30.4	4	75.7	1	●
33.9	4	71.1	1	●



data **geom**

mappings

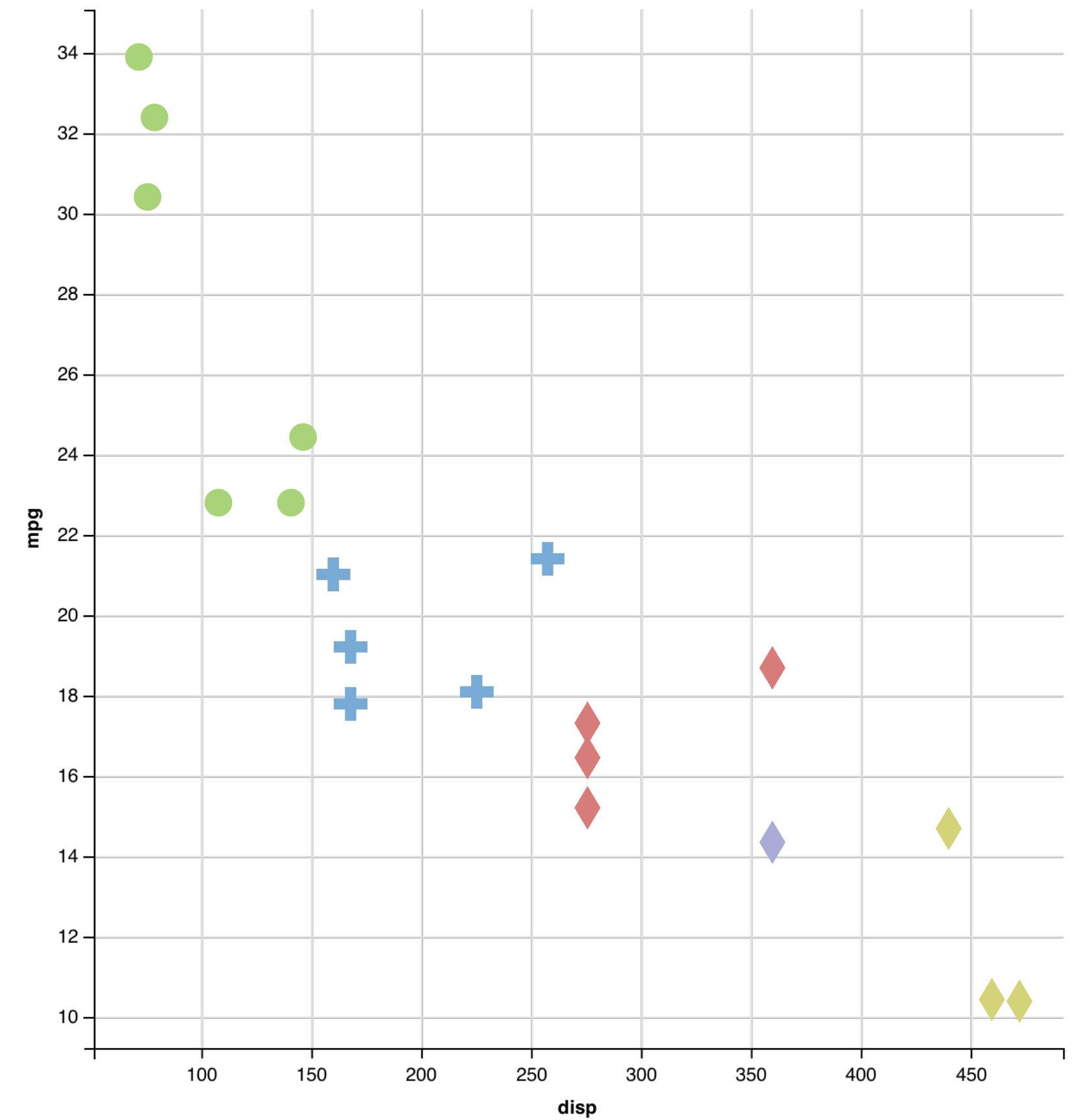
y	shape	x	fill
↕	↕	↕	↕
mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data **geom**



mappings

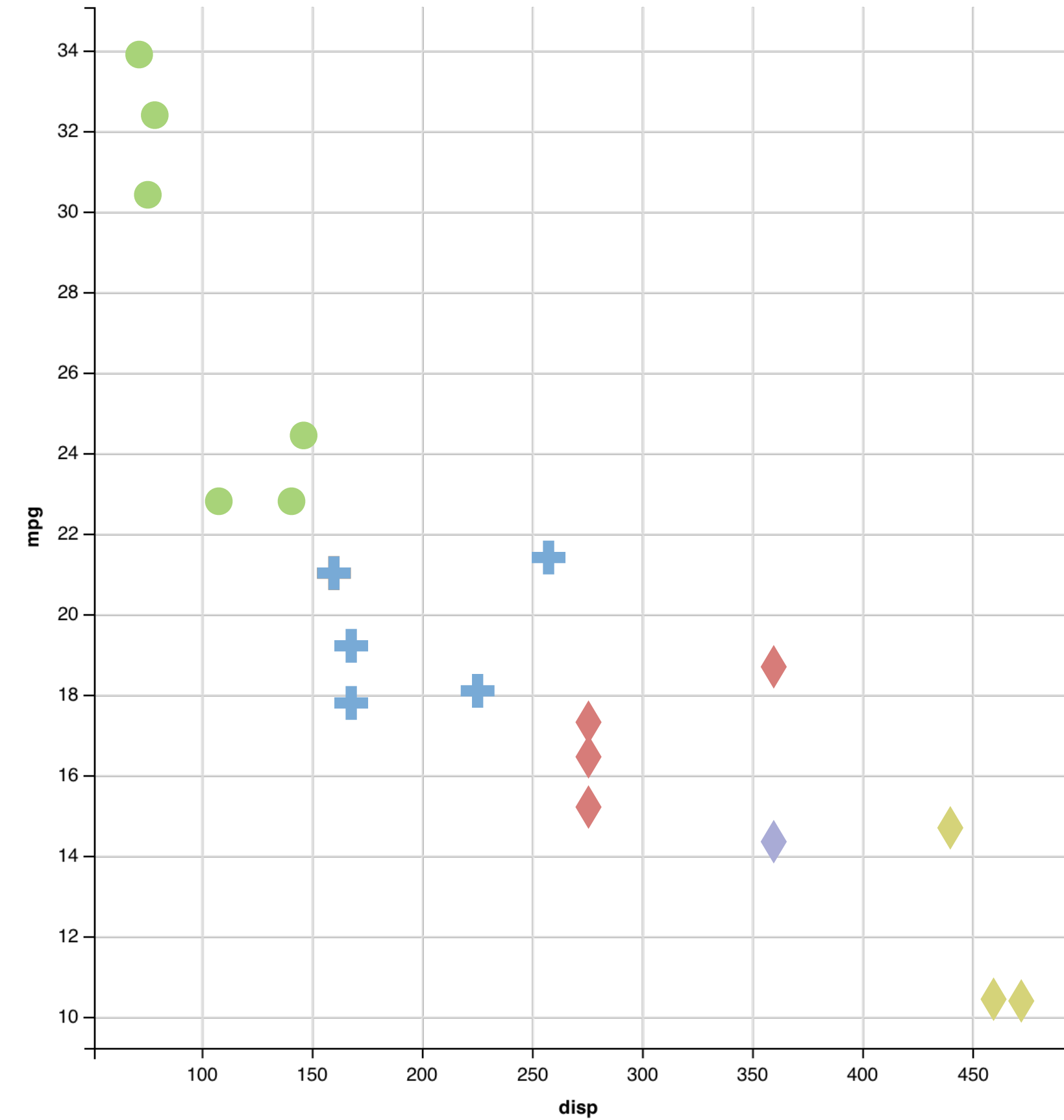
mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data **geom**

mappings

 mpg	cyl	 disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data

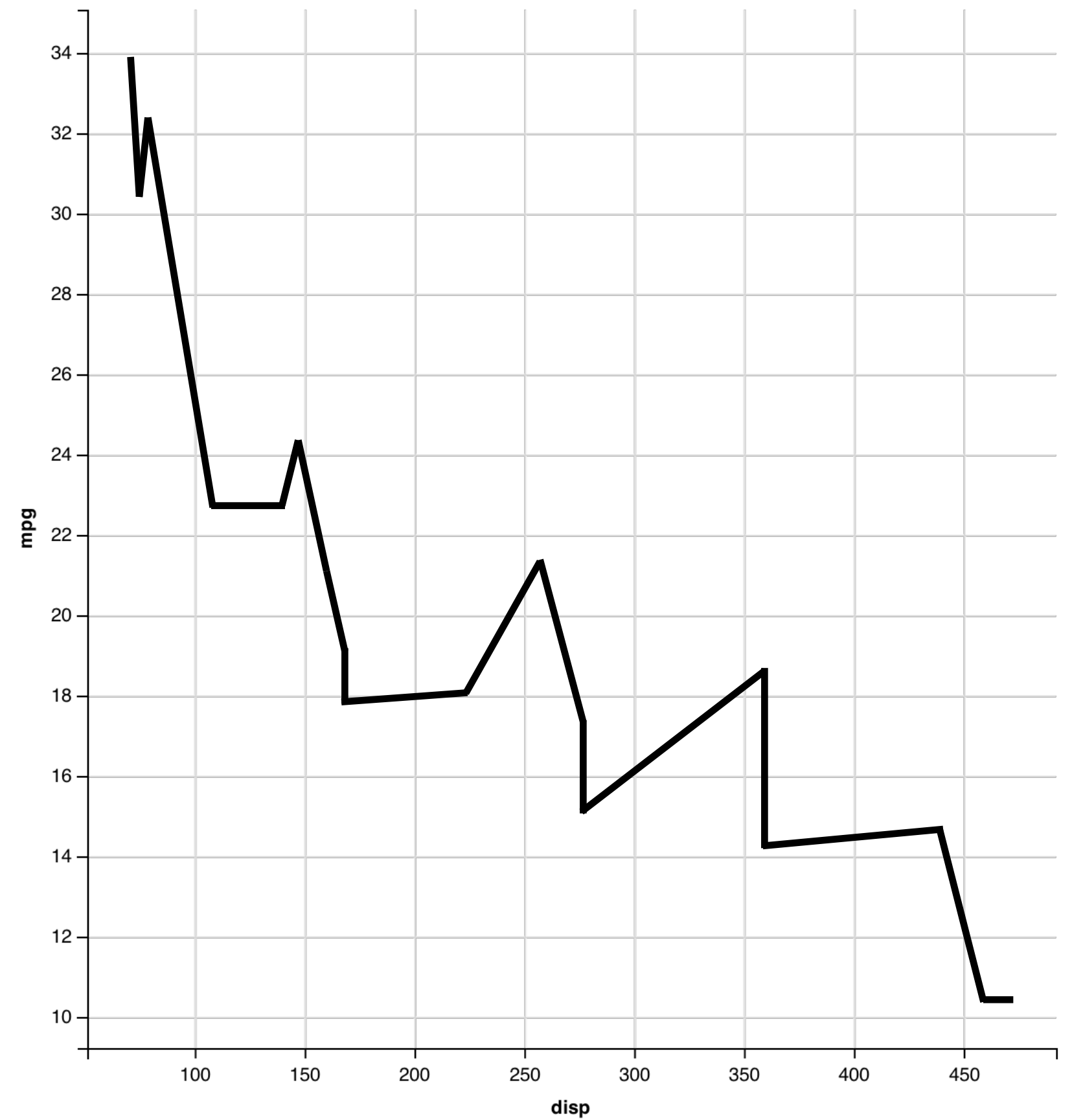
geom

points

lines

mappings

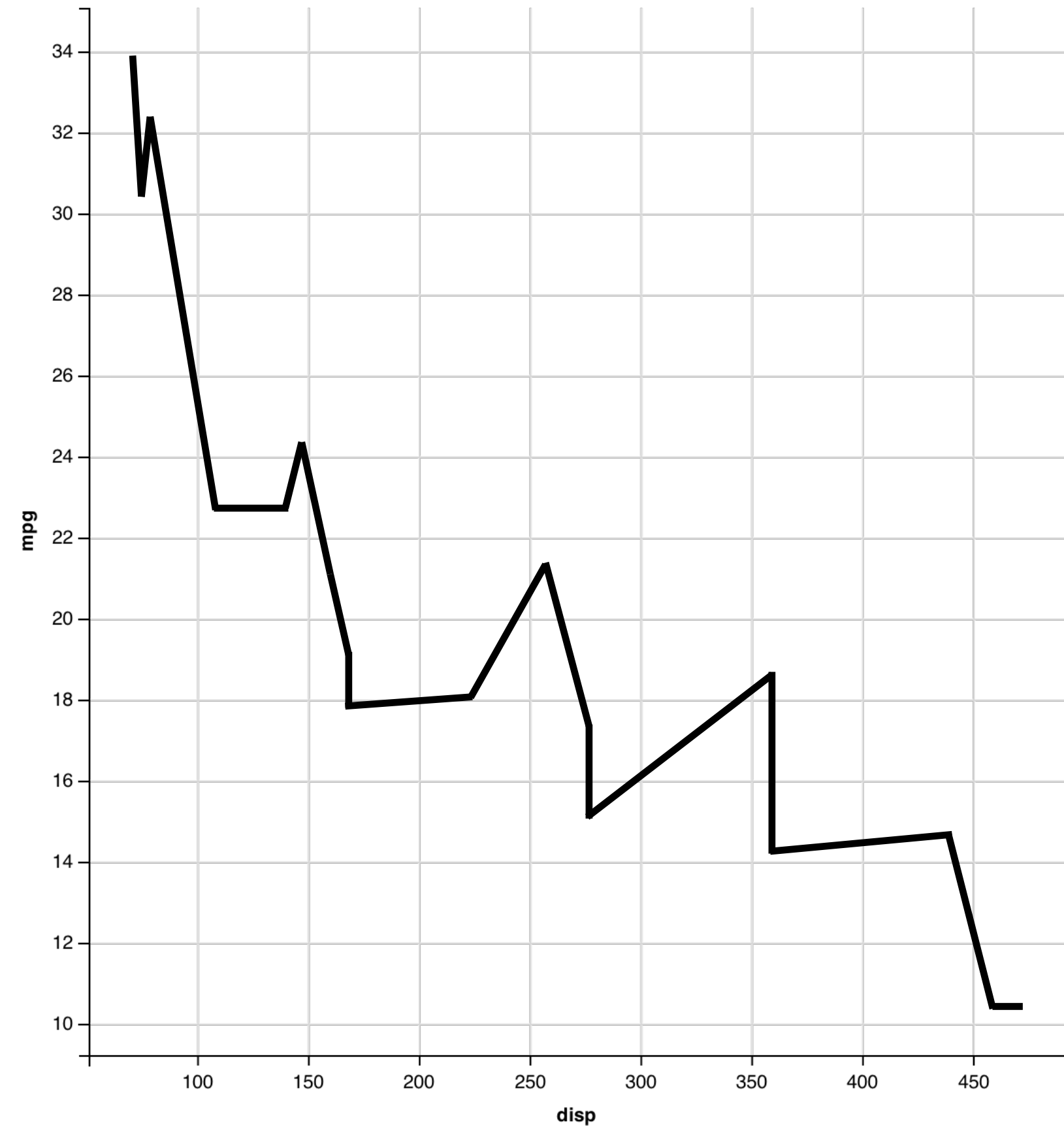
mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data **geom**
points
lines

mappings

mpg	cyl	disp	hp	
21.0	6	160.0	2	—
21.0	6	160.0	2	—
22.8	4	108.0	1	—
21.4	6	258.0	2	—
18.7	8	360.0	3	—
18.1	6	225.0	2	—
14.3	8	360.0	5	—
24.4	4	146.7	1	—
22.8	4	140.8	1	—
19.2	6	167.6	2	—
17.8	6	167.6	2	—
16.4	8	275.8	3	—
17.3	8	275.8	3	—
15.2	8	275.8	3	—
10.4	8	472.0	4	—
10.4	8	460.0	4	—
14.7	8	440.0	4	—
32.4	4	78.7	1	—
30.4	4	75.7	1	—
33.9	4	71.1	1	—





data

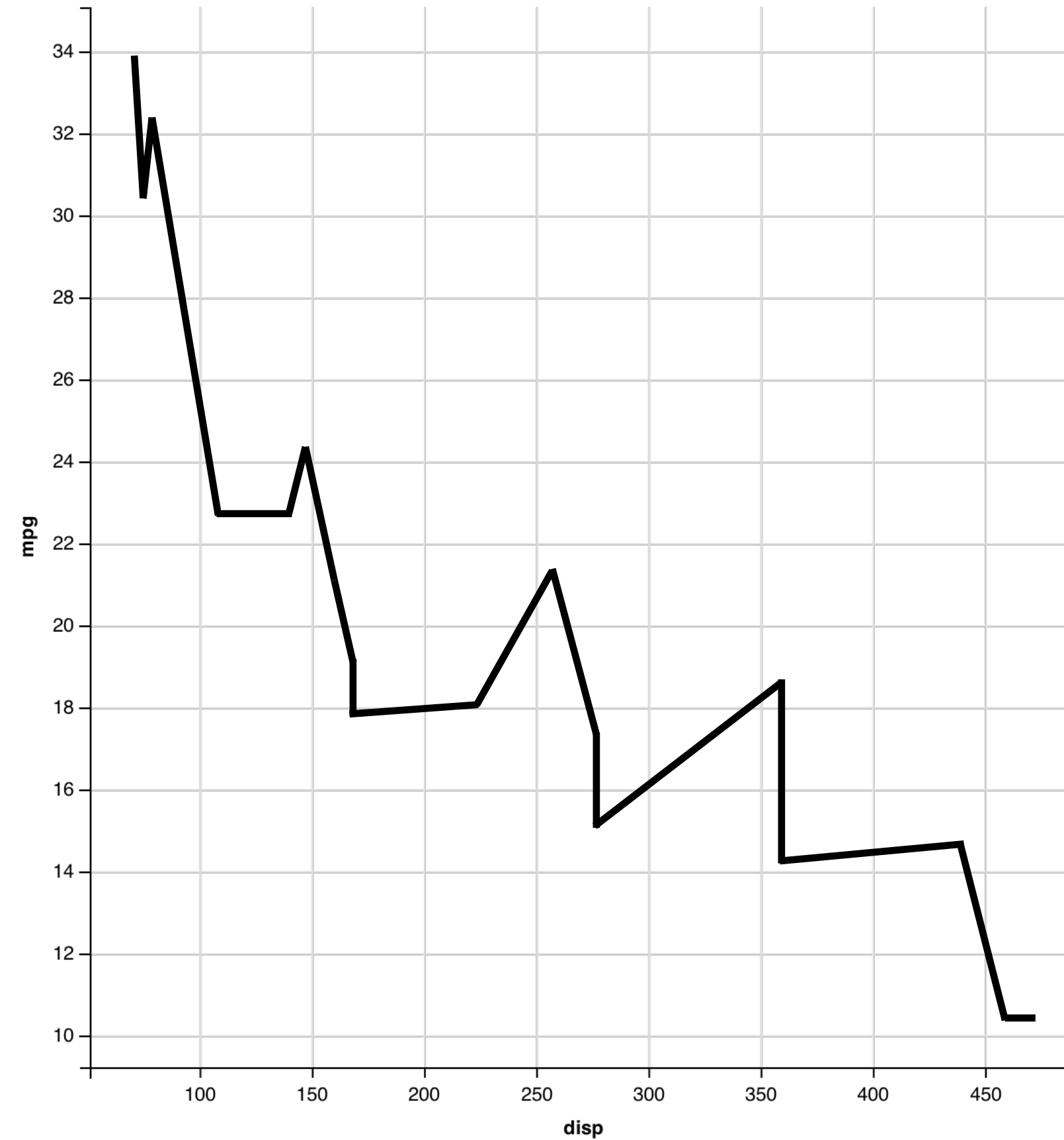
geom

points

lines

mappings

 mpg	cyl	 disp	hp	
21.0	6	160.0	2	█
21.0	6	160.0	2	█
22.8	4	108.0	1	█
21.4	6	258.0	2	█
18.7	8	360.0	3	█
18.1	6	225.0	2	█
14.3	8	360.0	5	█
24.4	4	146.7	1	█
22.8	4	140.8	1	█
19.2	6	167.6	2	█
17.8	6	167.6	2	█
16.4	8	275.8	3	█
17.3	8	275.8	3	█
15.2	8	275.8	3	█
10.4	8	472.0	4	█
10.4	8	460.0	4	█
14.7	8	440.0	4	█
32.4	4	78.7	1	█
30.4	4	75.7	1	█
33.9	4	71.1	1	█



data

geom

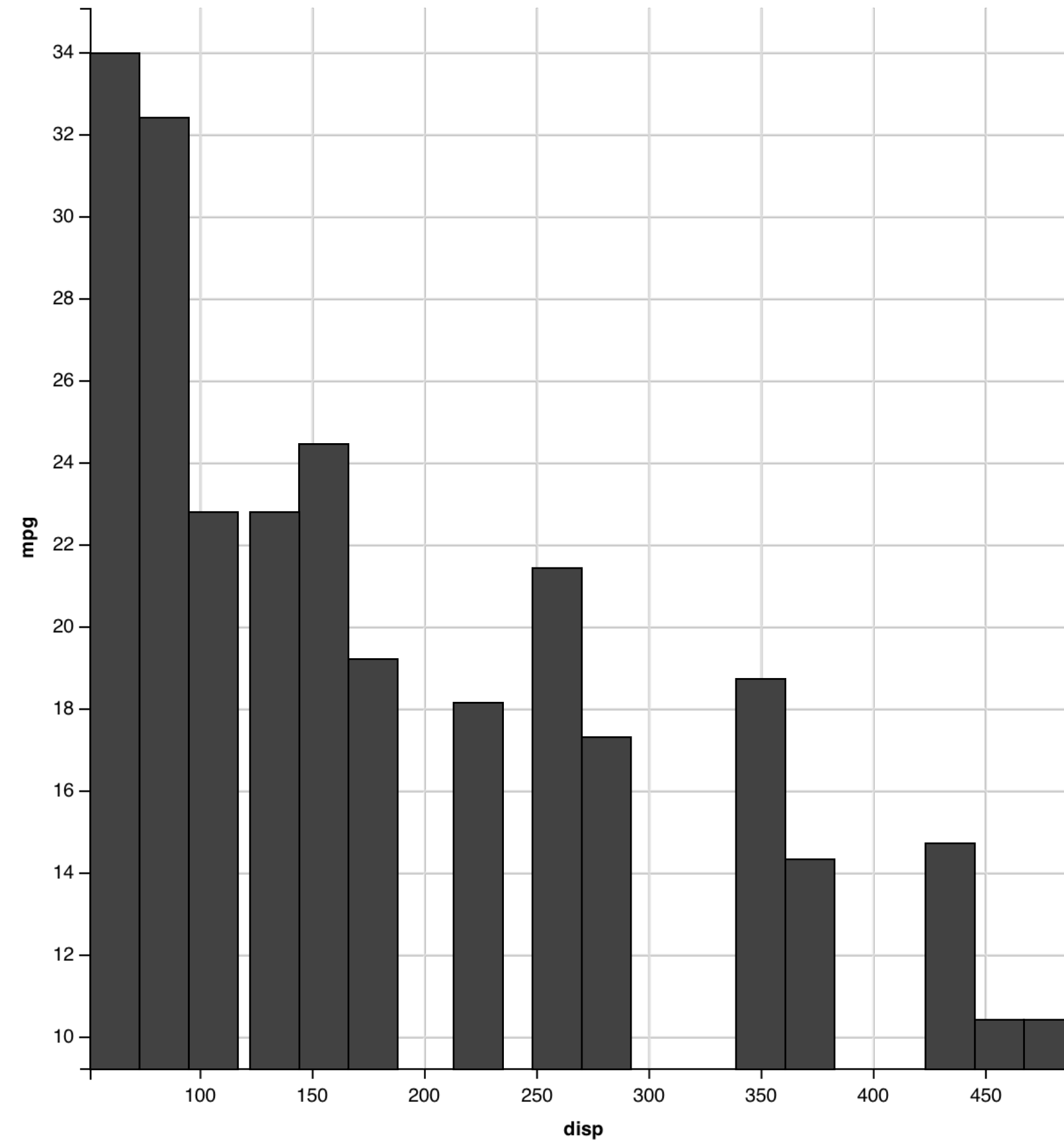
points

lines

bars

mappings

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data

geom

points

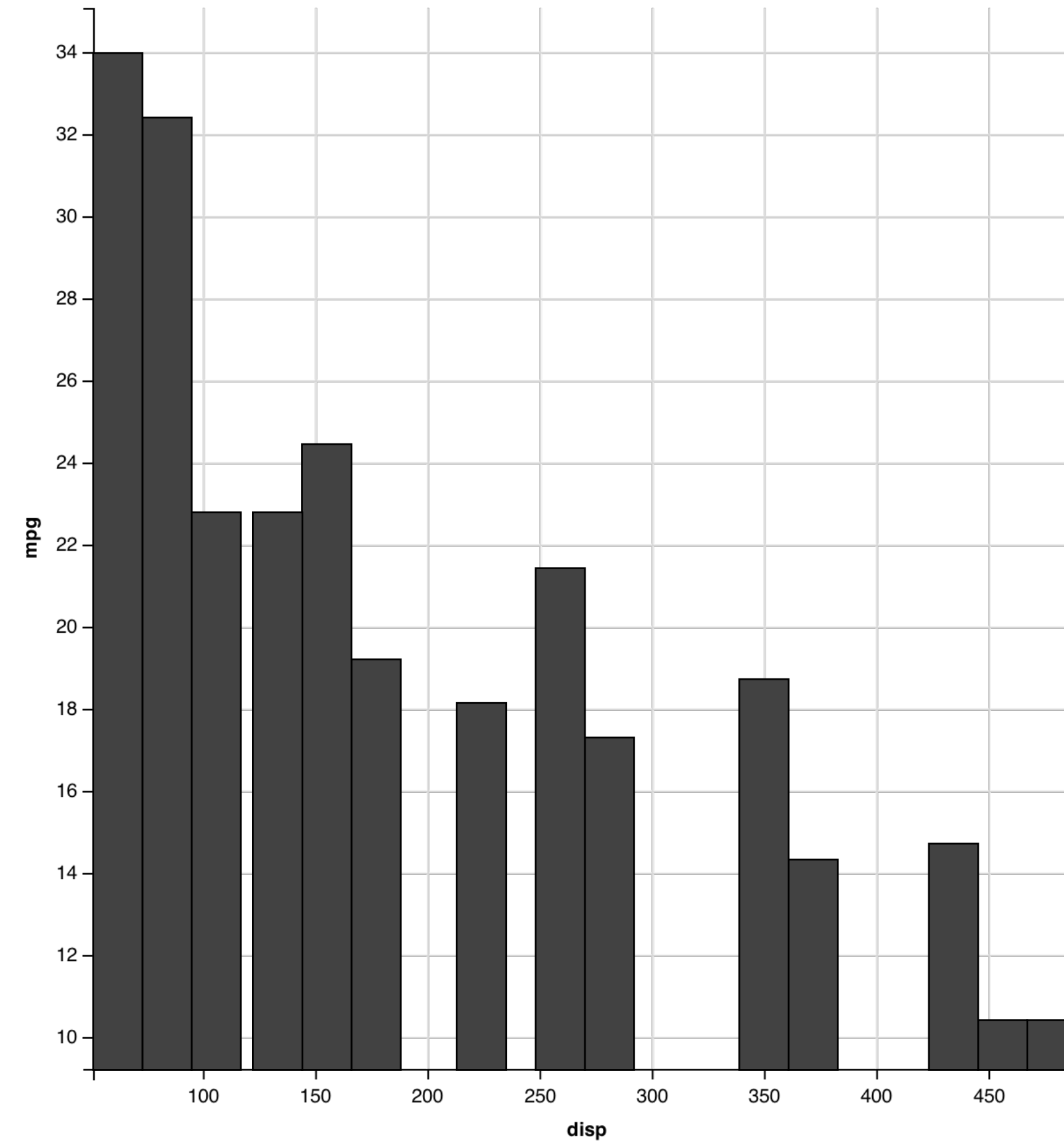

lines

bars

mappings

↑ y ↑ x

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1



data

geom

points

lines

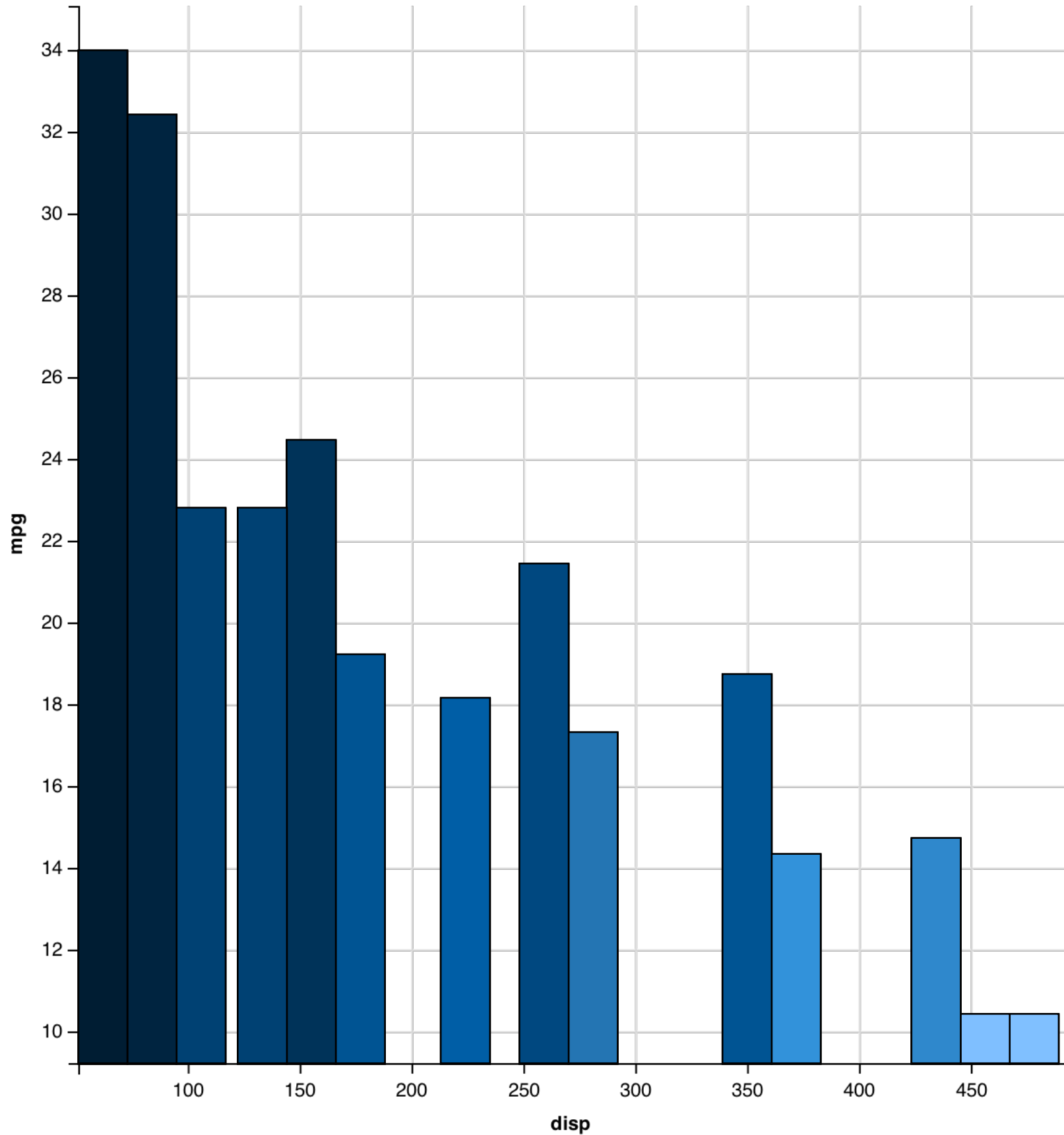
bars

mappings

mpg	cyl	disp	hp
21.0	6	160.0	2
21.0	6	160.0	2
22.8	4	108.0	1
21.4	6	258.0	2
18.7	8	360.0	3
18.1	6	225.0	2
14.3	8	360.0	5
24.4	4	146.7	1
22.8	4	140.8	1
19.2	6	167.6	2
17.8	6	167.6	2
16.4	8	275.8	3
17.3	8	275.8	3
15.2	8	275.8	3
10.4	8	472.0	4
10.4	8	460.0	4
14.7	8	440.0	4
32.4	4	78.7	1
30.4	4	75.7	1
33.9	4	71.1	1

y

x fill



data

geom

points

lines

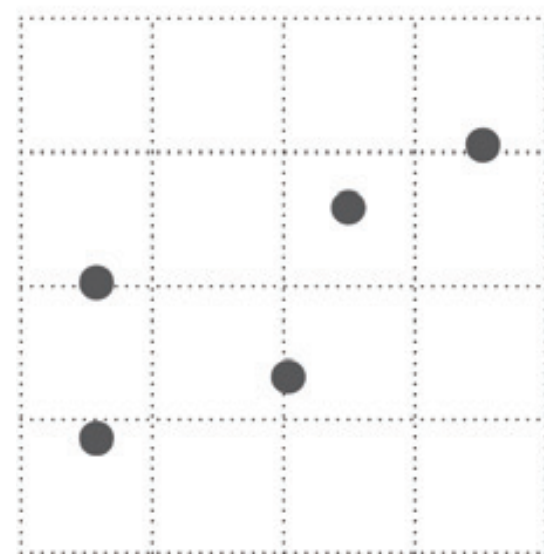
bars

Visual cues

When you visualize data, you encode values to shapes, sizes, and colors.

Position

Where in space the data is



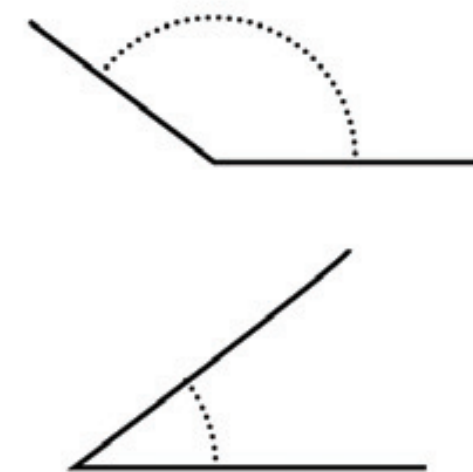
Length

How long the shapes are



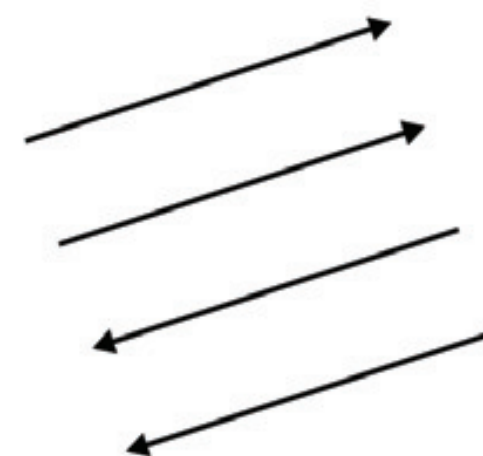
Angle

Rotation between vectors



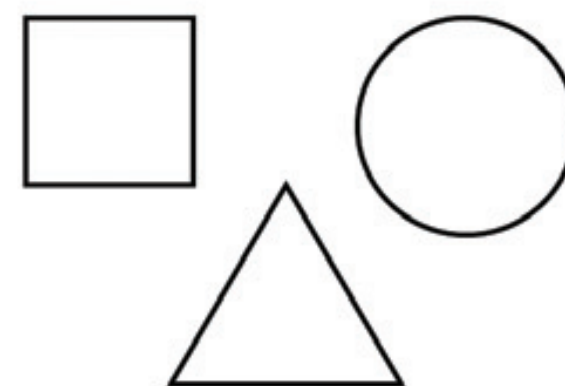
Direction

Slope of a vector in space



Shapes

Symbols as categories



Area

How much 2-D space



Volume

How much 3-D space



Color saturation

Intensity of a color hue



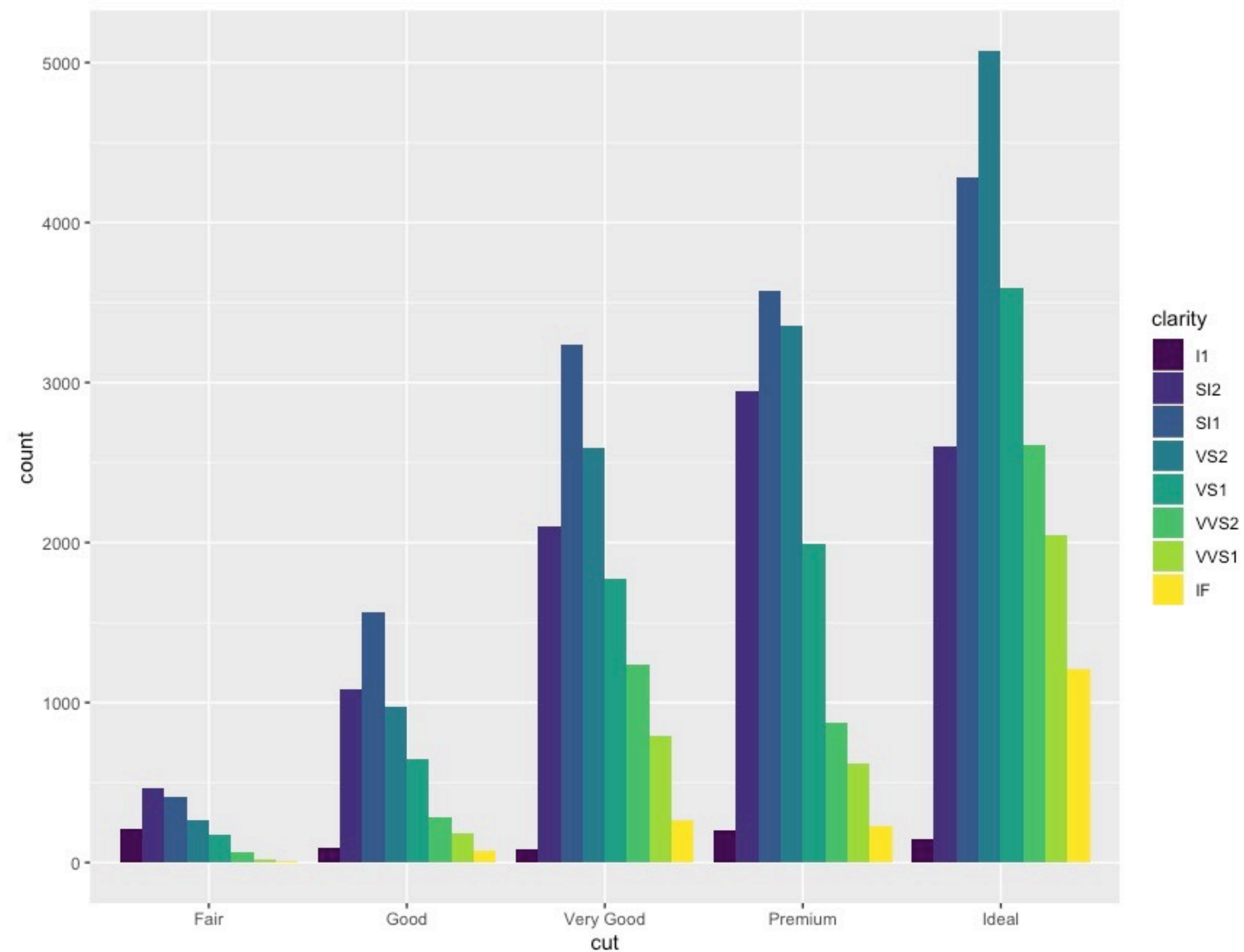
Color hue

Usually referred to as color



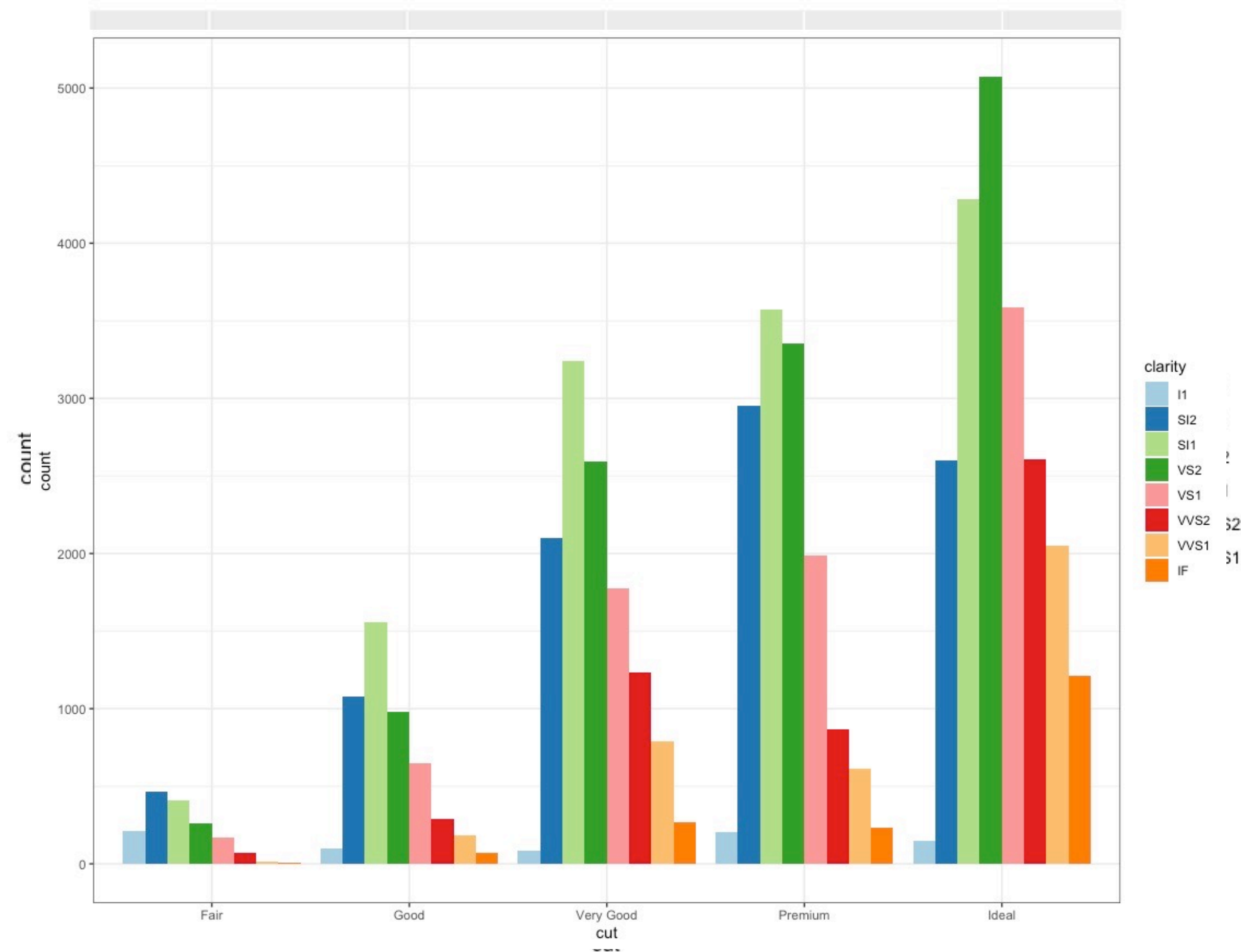
Position Adjustments

How overlapping objects are arranged



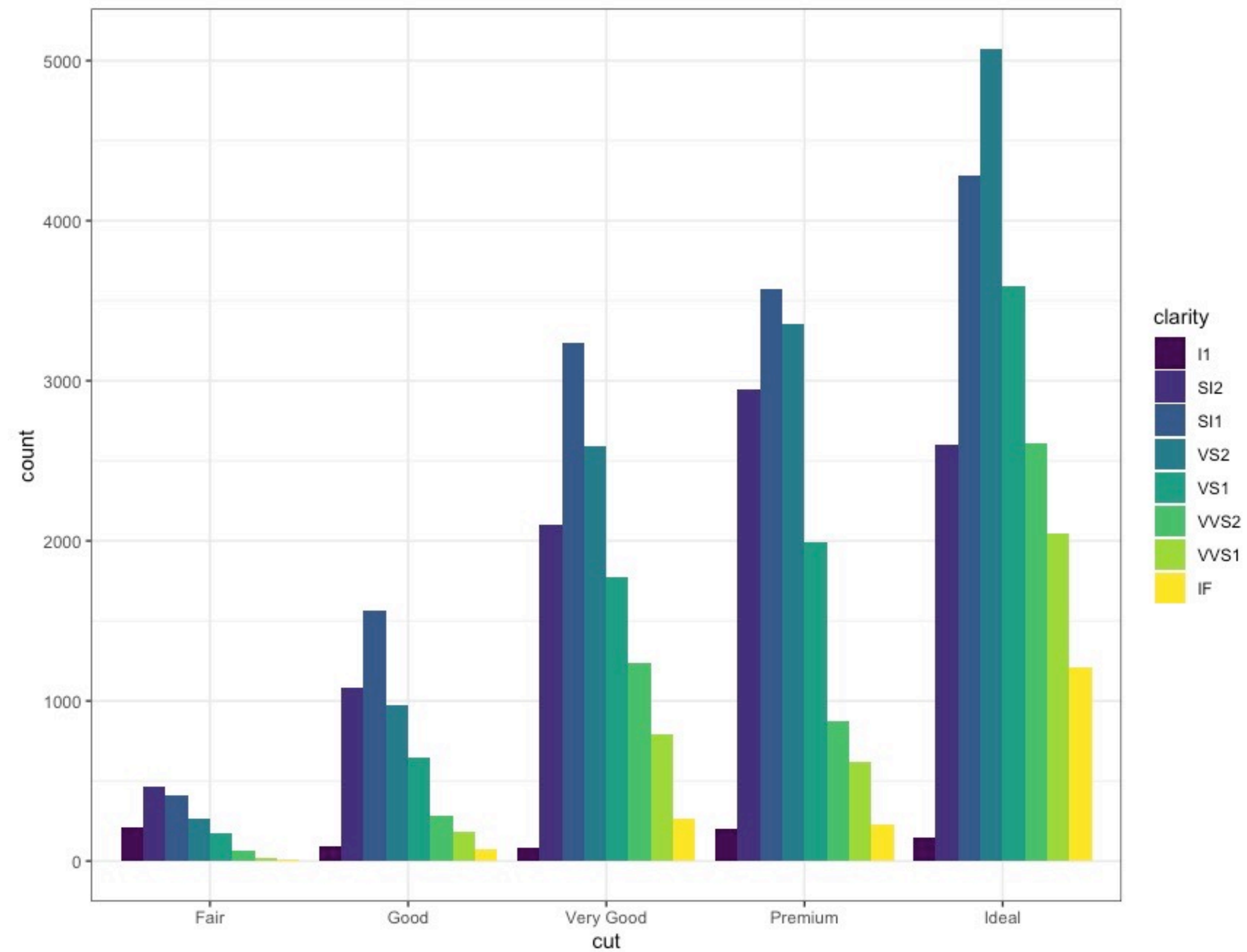
Scales

Customize color scales, other mappings

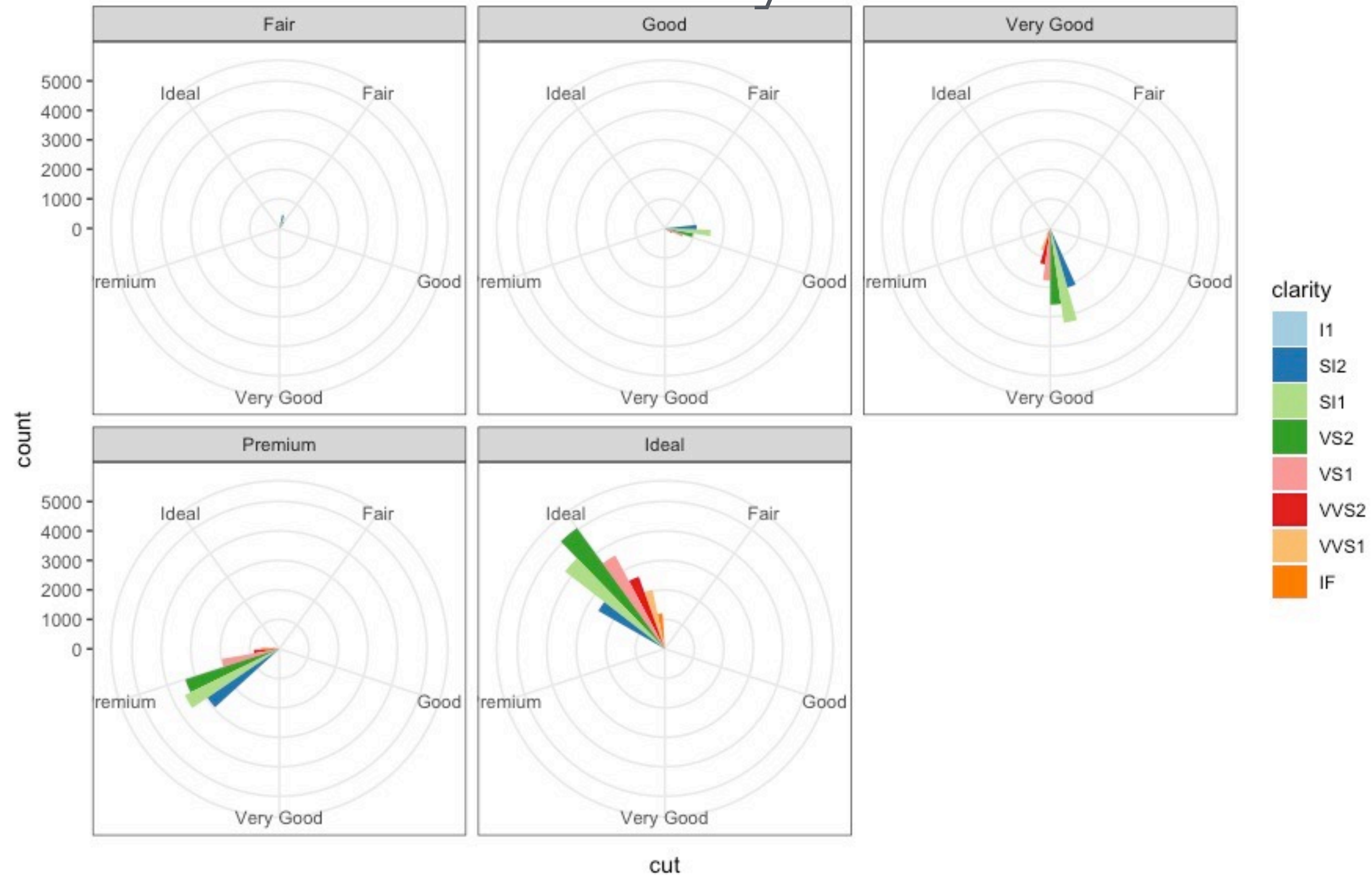


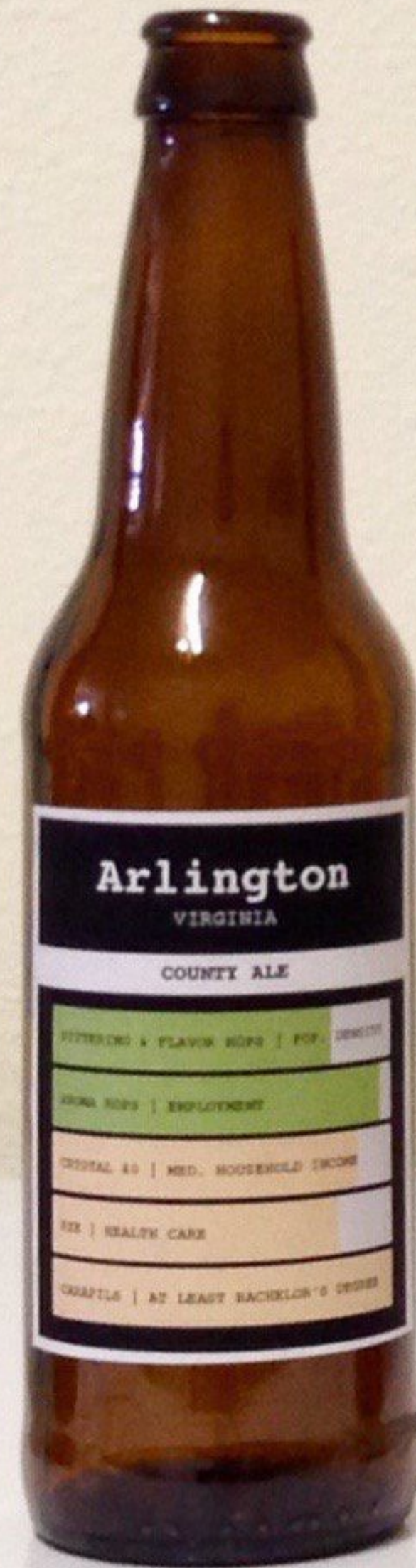
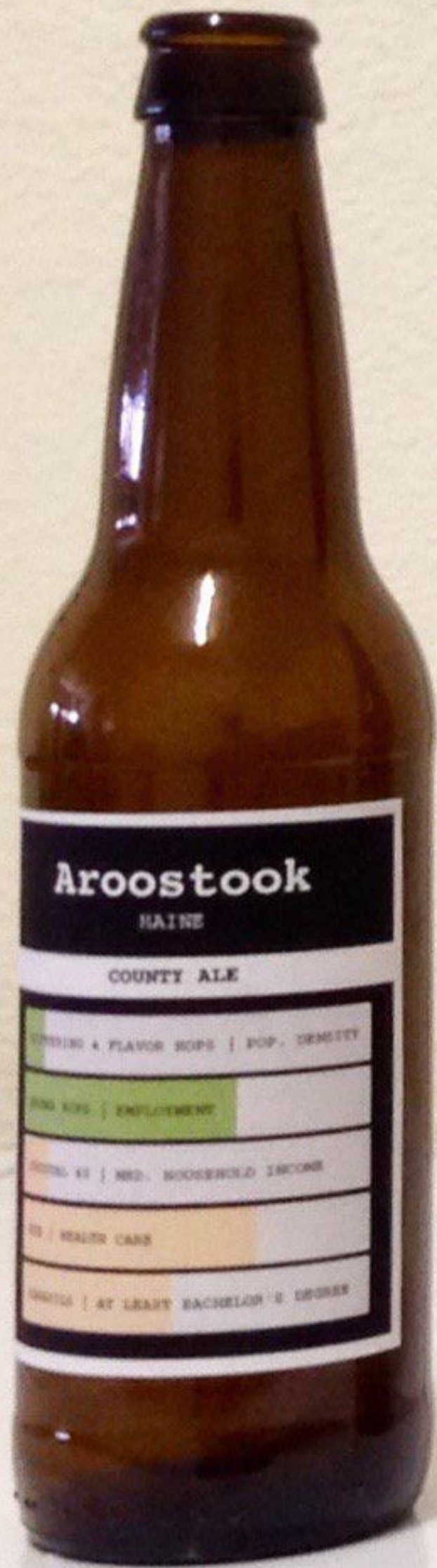
Themes

Visual appearance of non-data elements



Coordinate systems

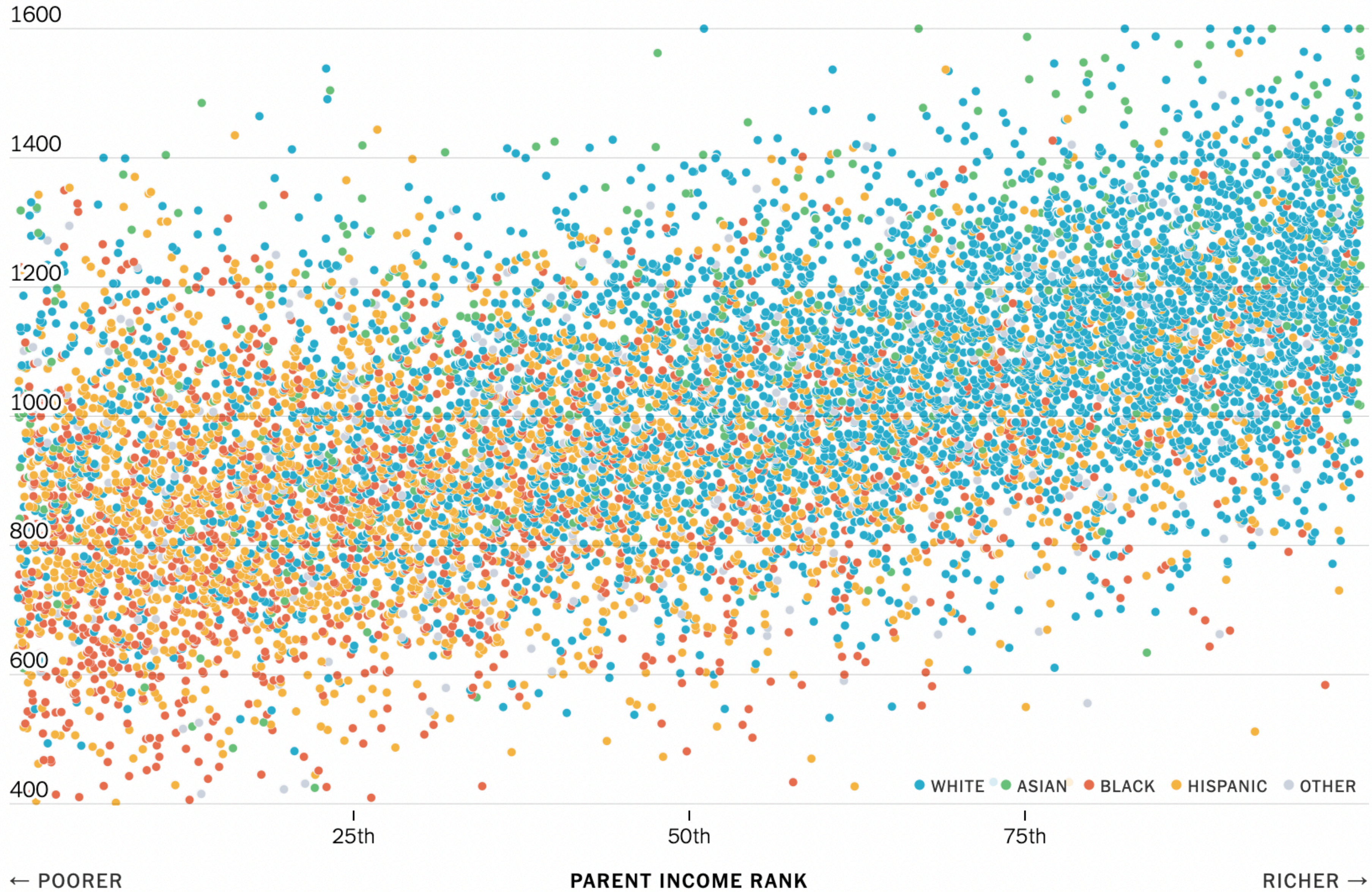




Many implementations of the grammar of graphics

- [ggplot2](#) (R package)
- [d3.js](#) (JavaScript package)
- [Vega-lite](#) (easier to use d3)
- [Tableau](#) (data visualization enterprise software)
- [Plotly](#) (Python library with ports to other languages)

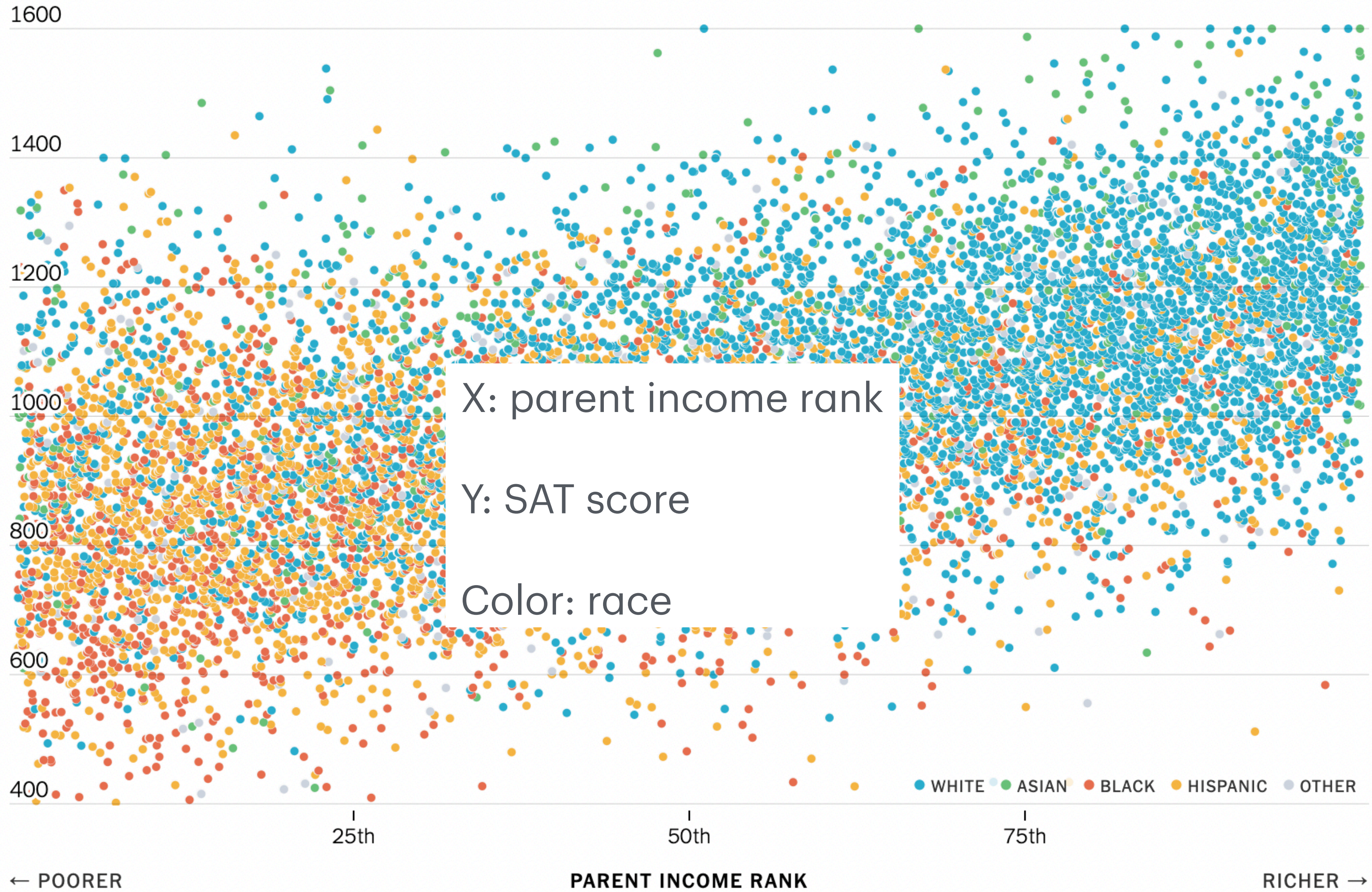
SAT scores



Can You Create a Diverse College Class Without Affirmative Action? Aatish Bhatia and Emily Badger

<https://www.nytimes.com/interactive/2024/03/09/upshot/affirmative-action-alternatives.html>

SAT scores

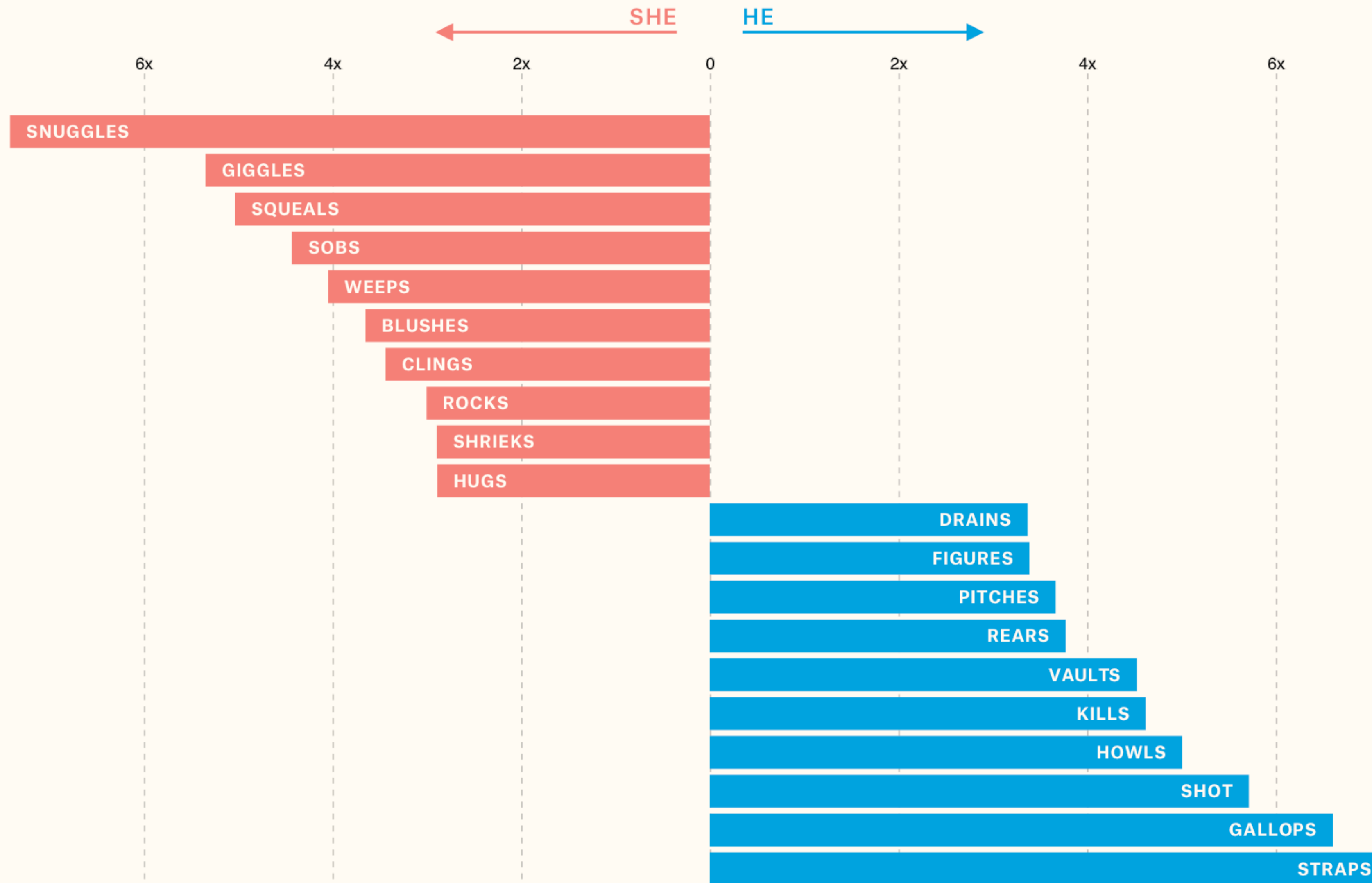


Can You Create a Diverse College Class Without Affirmative Action? Aatish Bhatia and Emily Badger

<https://www.nytimes.com/interactive/2024/03/09/upshot/affirmative-action-alternatives.html>

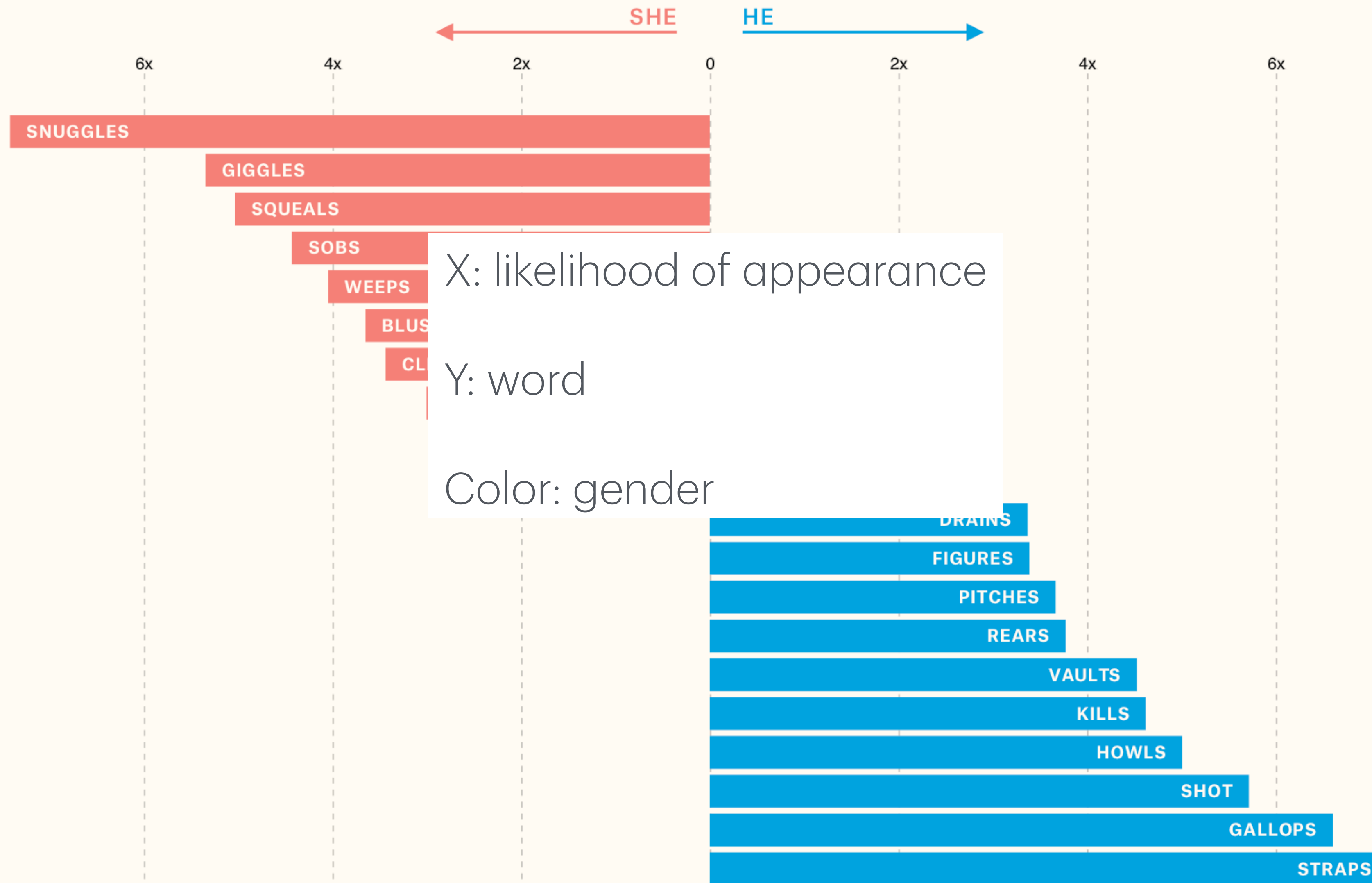
The most used words for women vs. men

Likelihood that certain words appear after "he" vs. "she" in screen direction.



The most used words for women vs. men

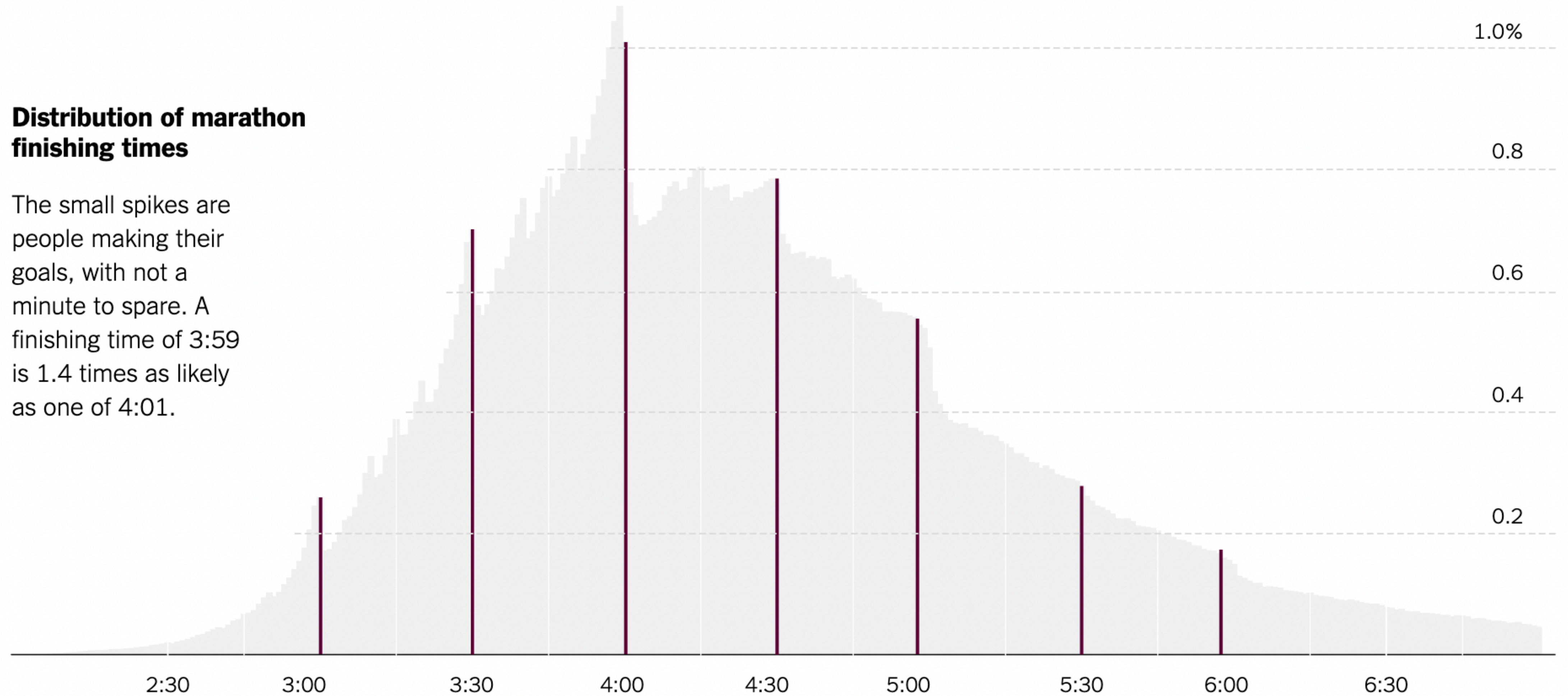
Likelihood that certain words appear after "he" vs. "she" in screen direction.



Arbitrary goals, like round numbers, can be motivating – just ask 9 million marathoners.

Distribution of marathon finishing times

The small spikes are people making their goals, with not a minute to spare. A finishing time of 3:59 is 1.4 times as likely as one of 4:01.



Based on data from Eric Allen, USC, Patricia Dechow, U.C. Berkeley, Devin Pope and George Wu, University of Chicago.

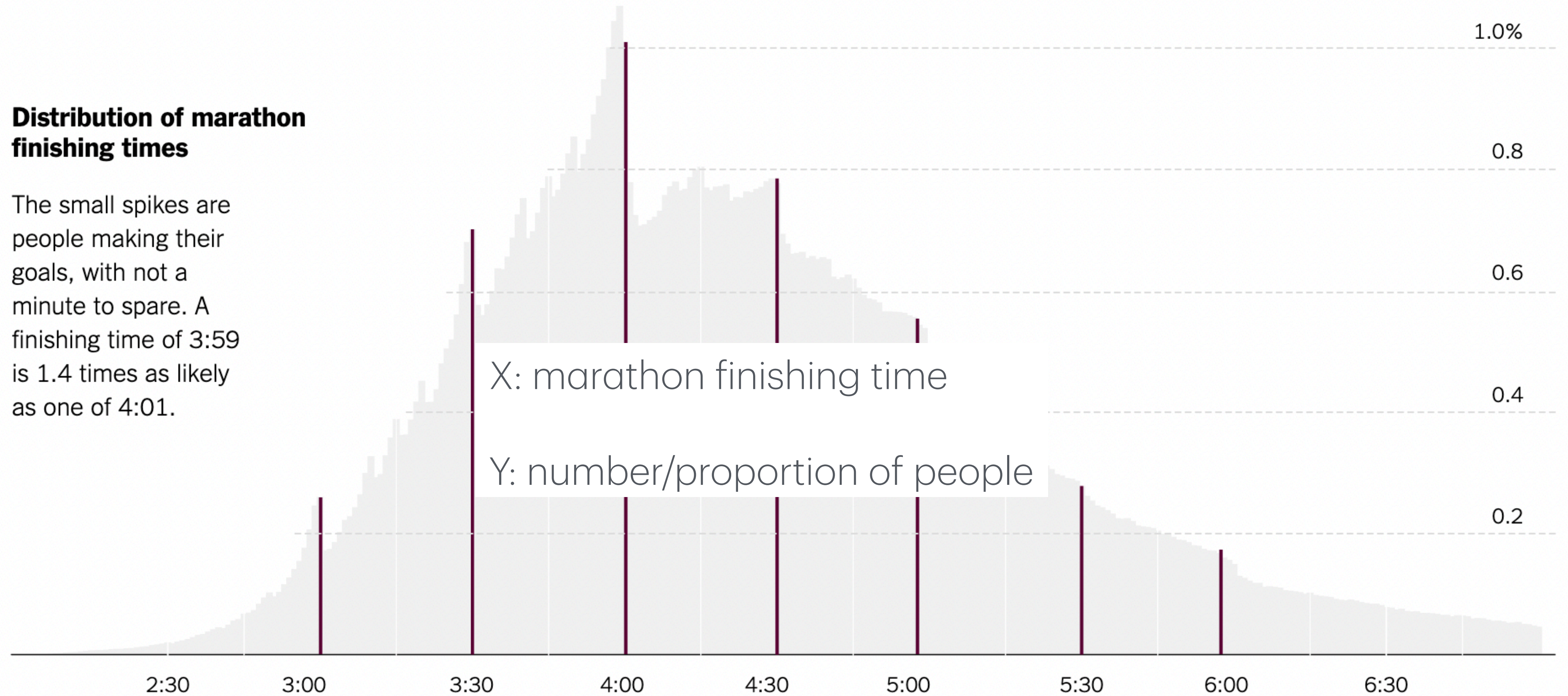
What Good Marathons and Bad Investments Have in Common. Justin Wolfers

<https://www.nytimes.com/2014/04/23/upshot/what-good-marathons-and-bad-investments-have-in-common.html>

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Graphical perception

Cleveland and McGill, 1984

The following are the 10 elementary tasks in Figure 1, ordered from most to least accurate:

1. Position along a common scale
2. Positions along nonaligned scales
3. Length, direction, angle
4. Area
5. Volume, curvature
6. Shading, color saturation

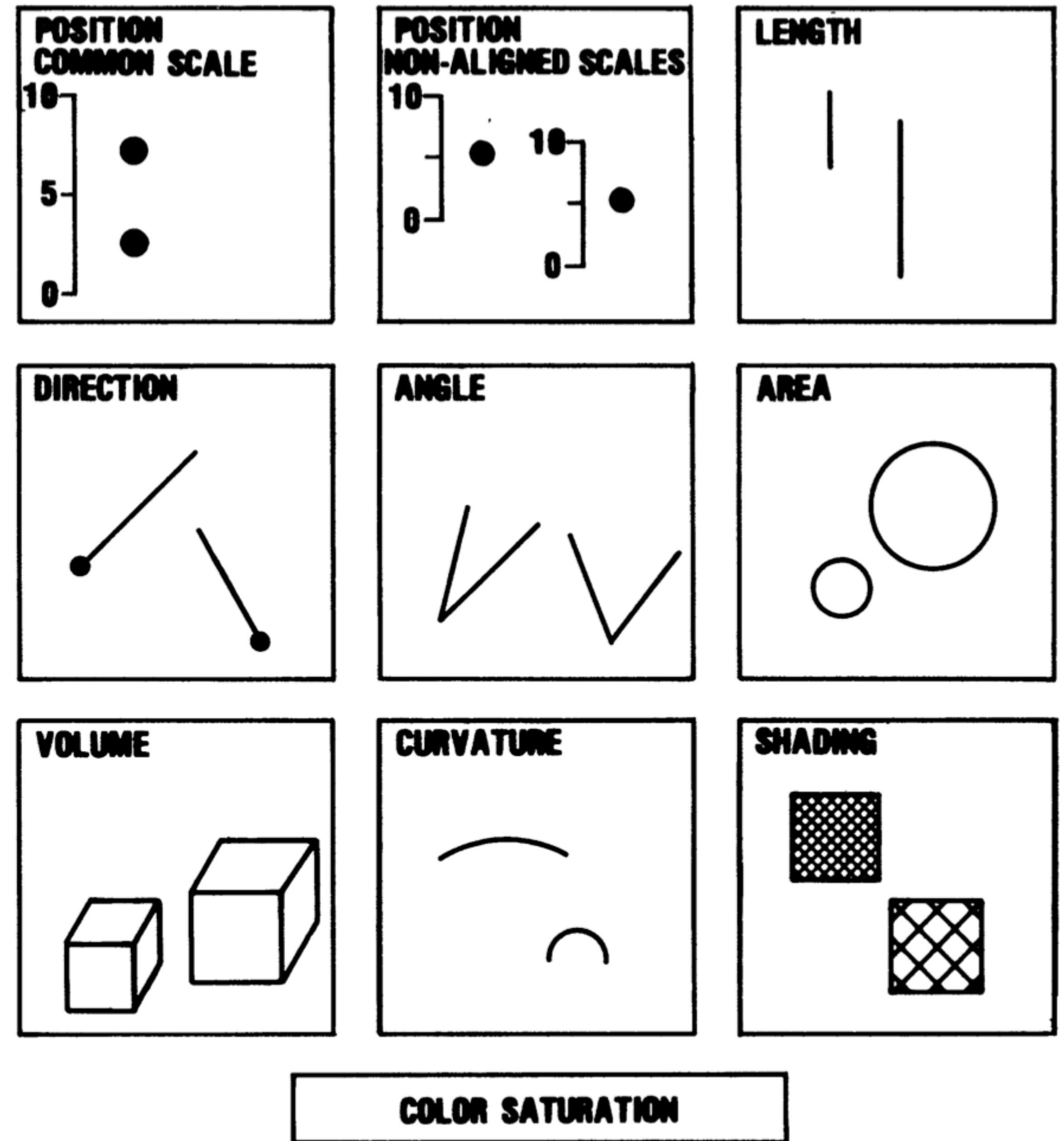


Figure 1. Elementary perceptual tasks.

William Cleveland and Robert McGill. "Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods." *Journal of the American Statistical Association*, 79(387). 1984.

<http://info.slis.indiana.edu/~katy/S637-S11/cleveland84.pdf>

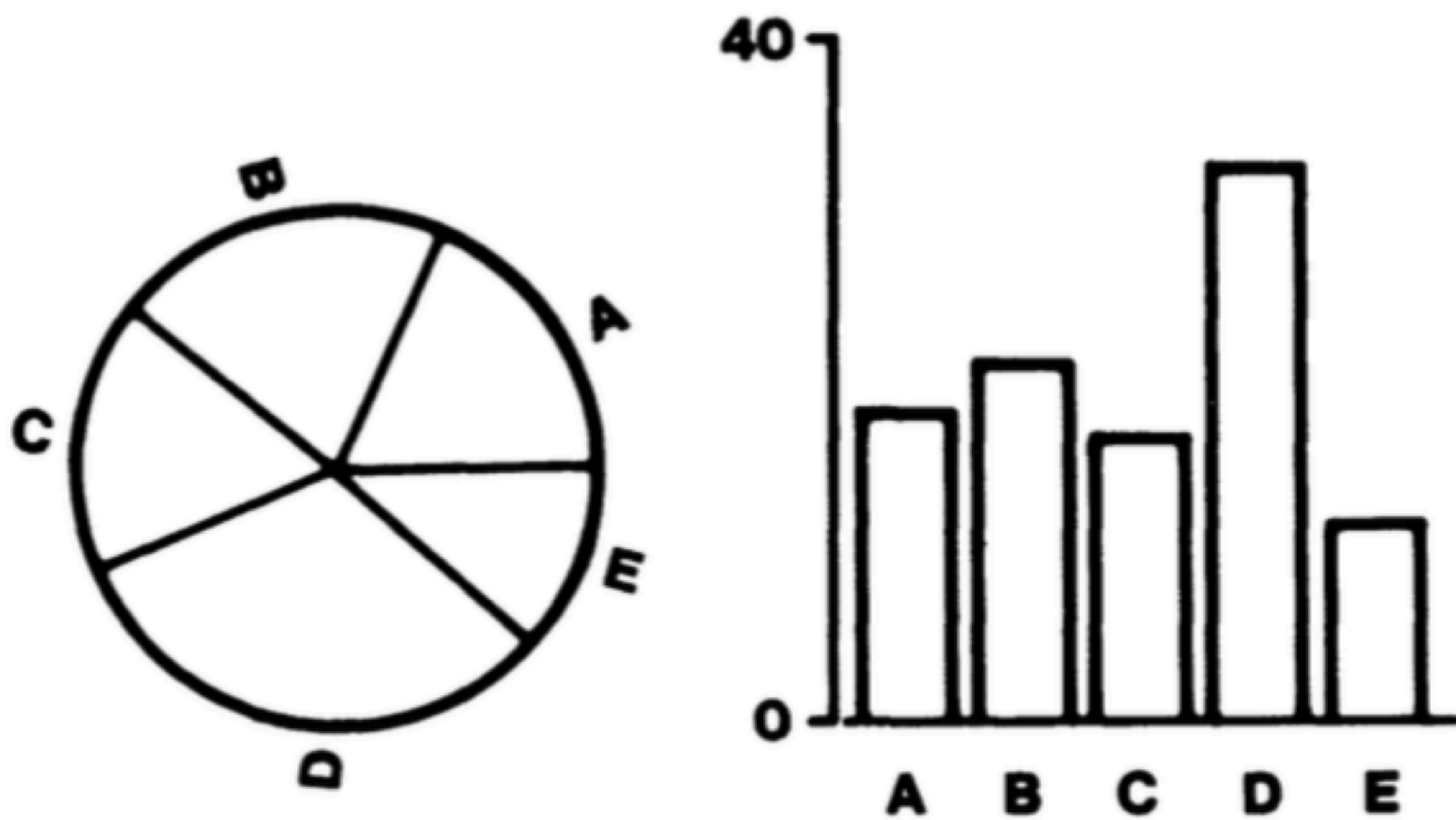


Figure 3. Graphs from position-angle experiment.

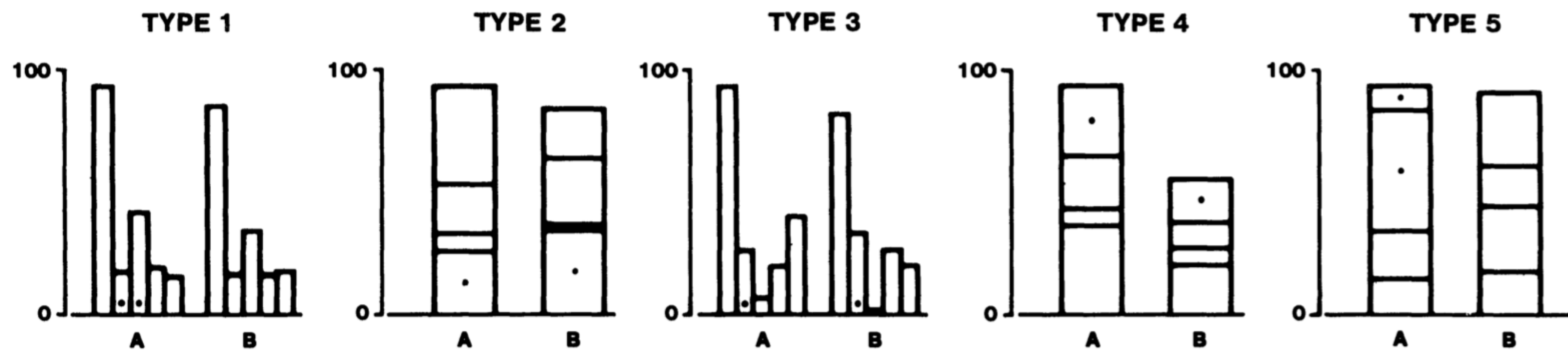
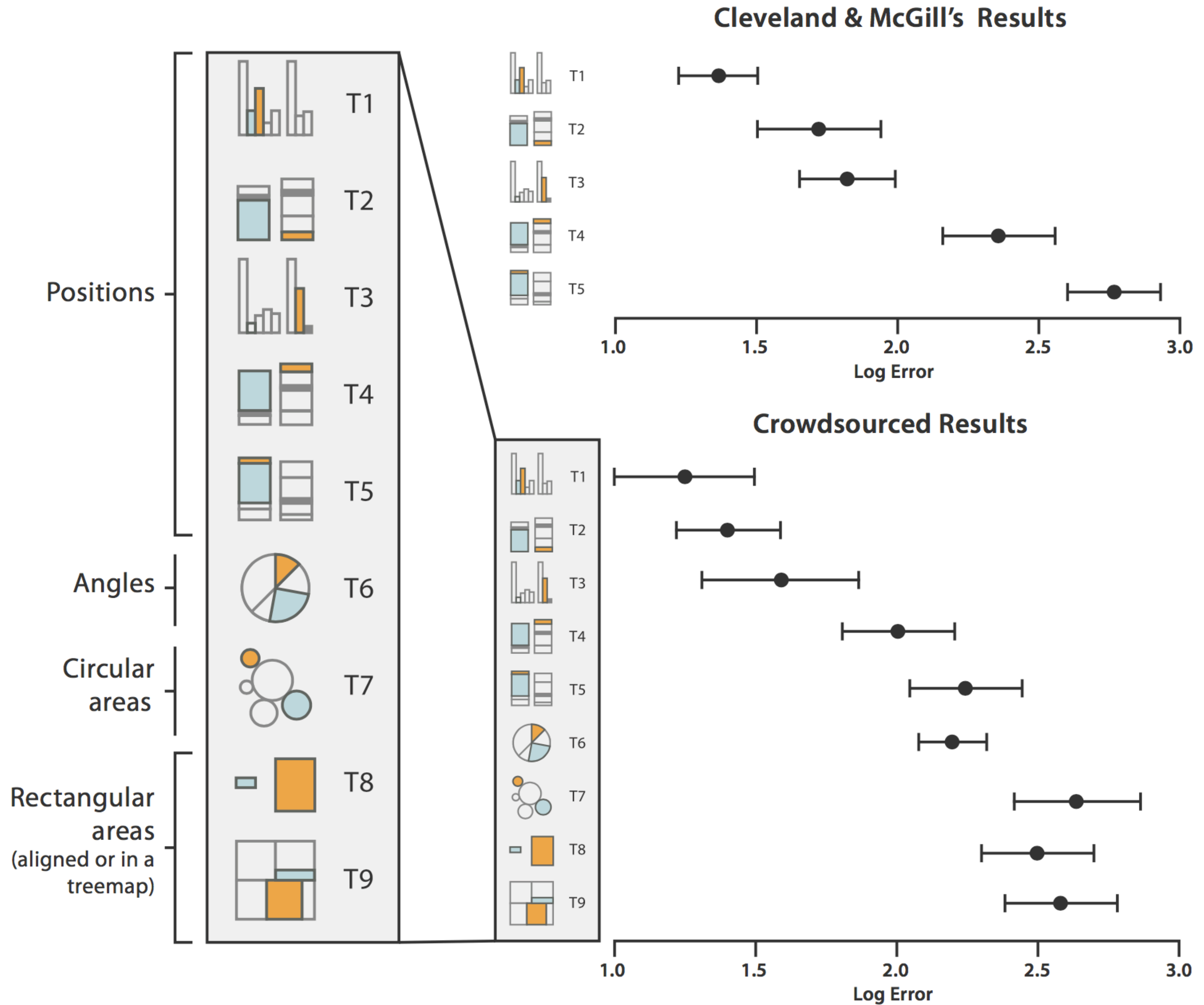
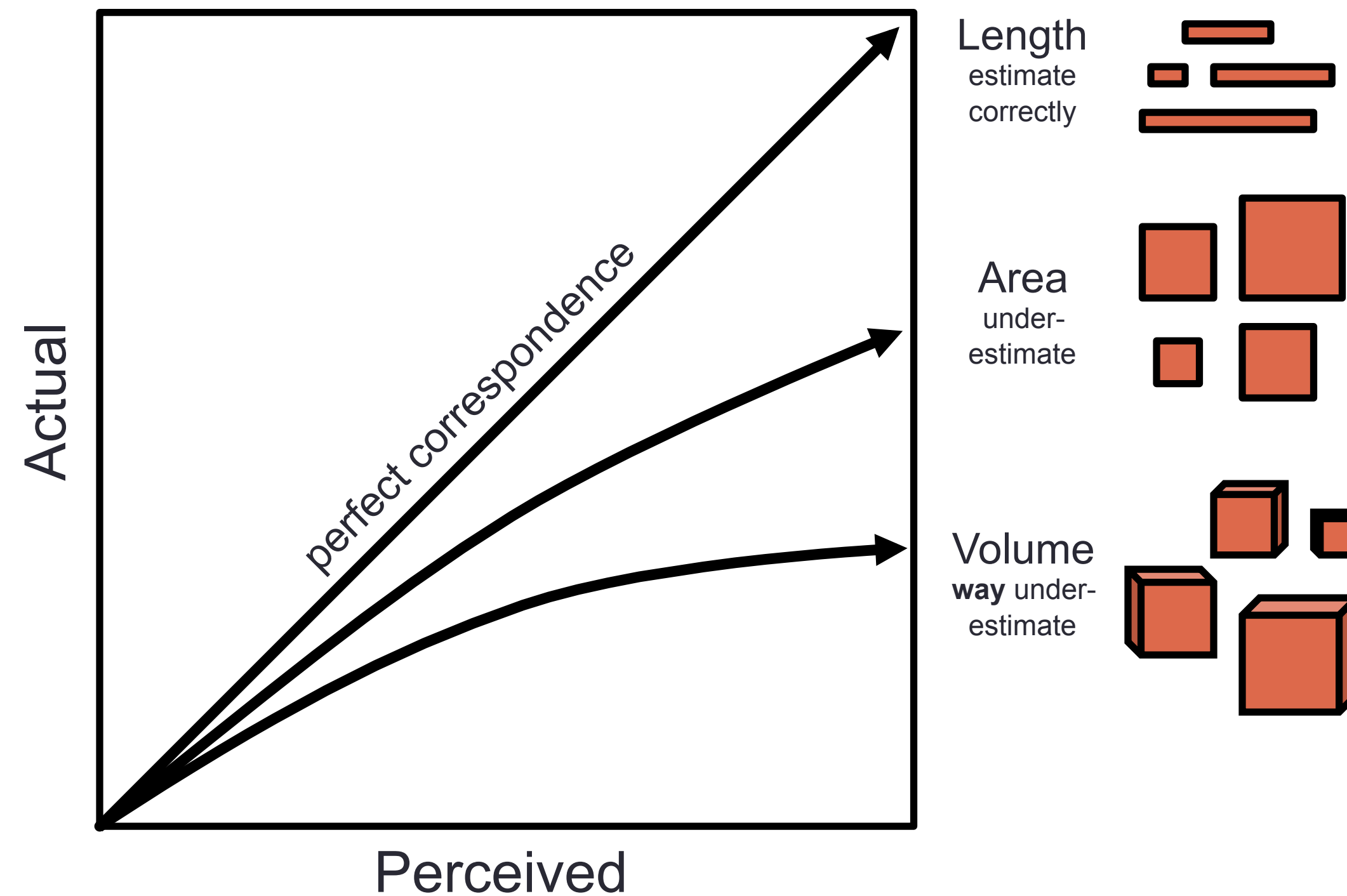


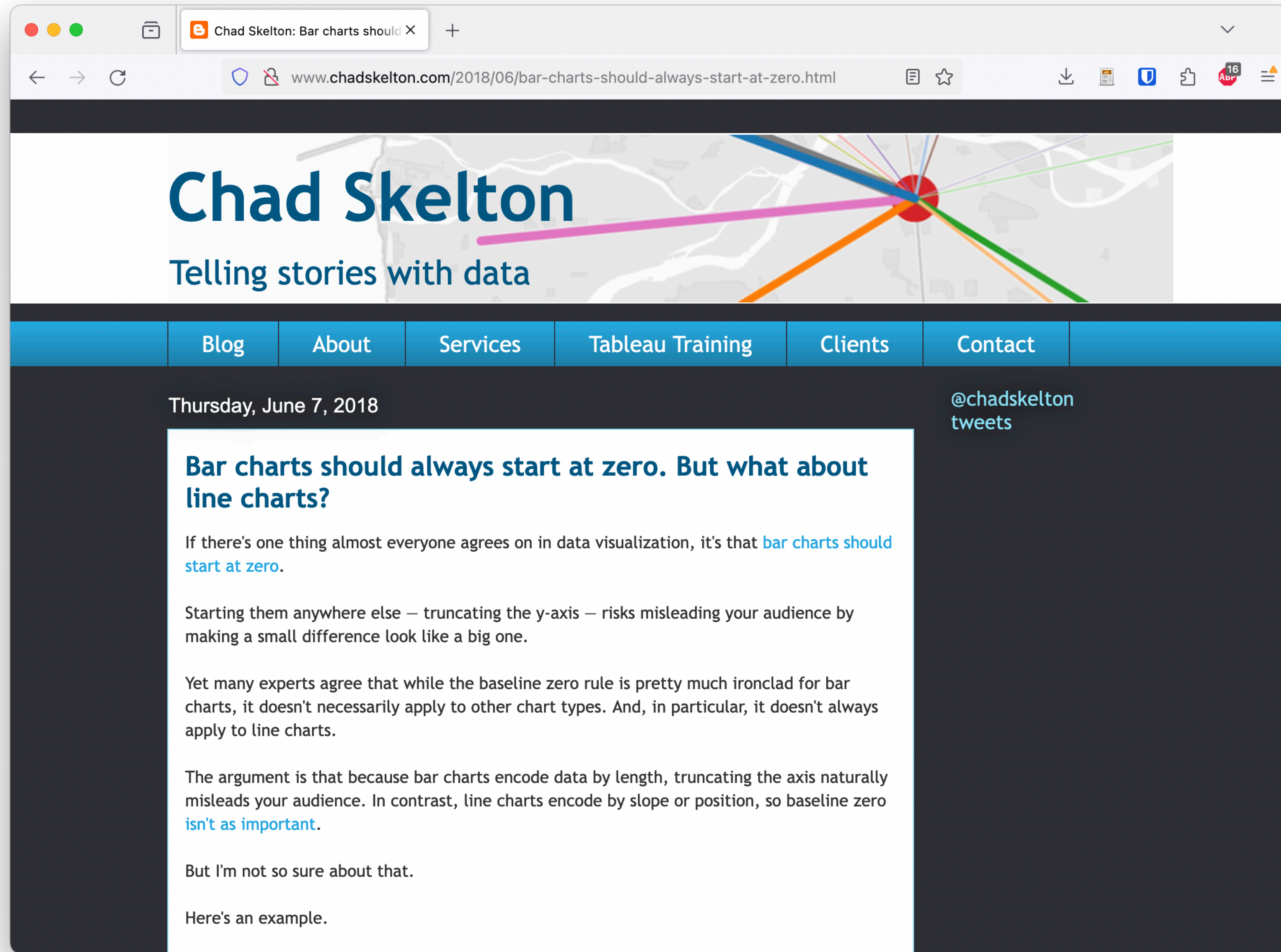
Figure 4. Graphs from position-length experiment.



Jeff Heer and Mike Bostock. "Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design" <http://vis.stanford.edu/files/2010-MTurk-CHI.pdf>

“Apparent” magnitude





Chad Skelton
Telling stories with data

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Thursday, June 7, 2018

@chadskelton tweets

Bar charts should always start at zero. But what about line charts?

If there's one thing almost everyone agrees on in data visualization, it's that [bar charts should start at zero](#).

Starting them anywhere else – truncating the y-axis – risks misleading your audience by making a small difference look like a big one.

Yet many experts agree that while the baseline zero rule is pretty much ironclad for bar charts, it doesn't necessarily apply to other chart types. And, in particular, it doesn't always apply to line charts.

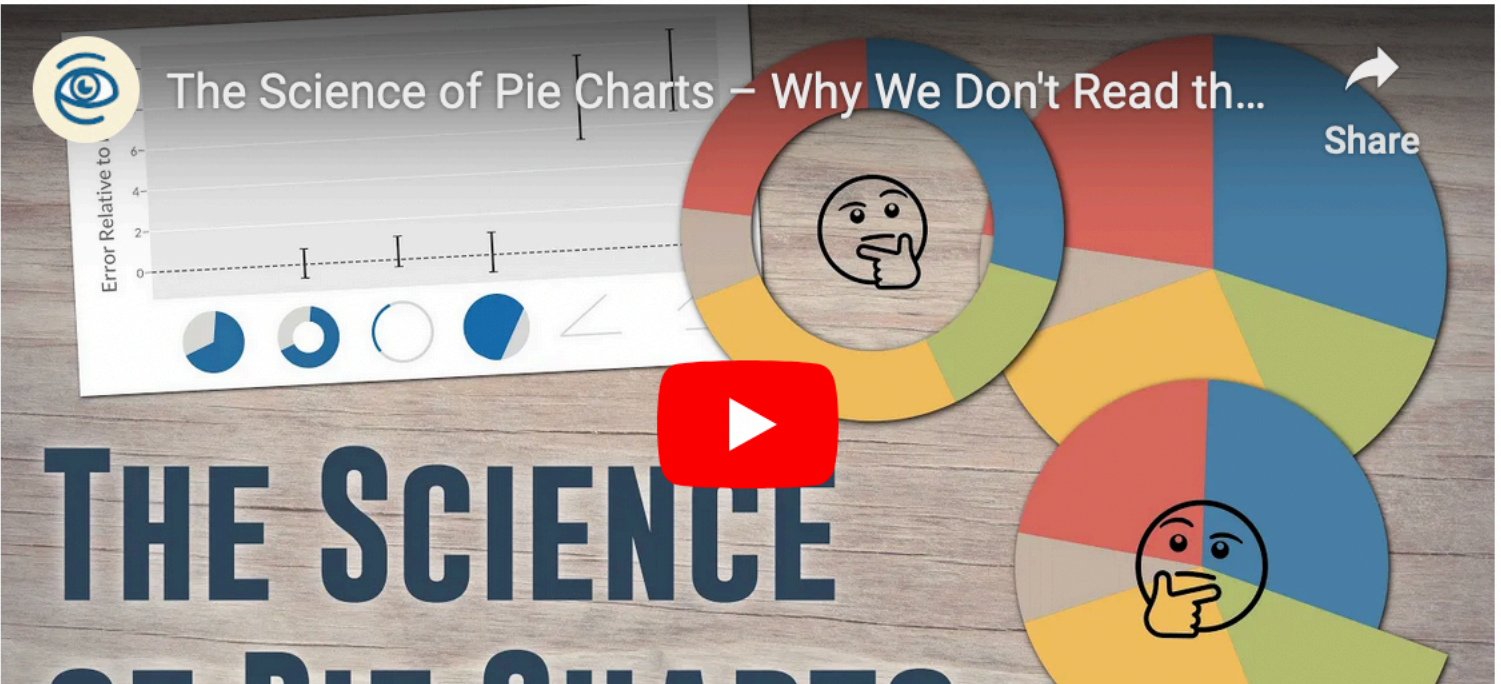
The argument is that because bar charts encode data by length, truncating the axis naturally misleads your audience. In contrast, line charts encode by slope or position, so [baseline zero isn't as important](#).

But I'm not so sure about that.

Here's an example.

Bar charts should always start at zero. But what about line charts? Chad Skelton
<http://www.chadskelton.com/2018/06/bar-charts-should-always-start-at-zero.html>

The screenshot shows a web browser window with the following elements:

- Browser Tab:** "New Video: The Science of Pie Charts"
- Address Bar:** "https://eagereyes.org/blog/2021/new-video-the-science-of-pie-charts"
- Page Header:** "eagereyes" logo, a search bar with "Search" and "K" icons, and navigation menus for "Practical", "Academic", and "Admin".
- Sidebar (Blog):**
 - Blog 2024 >
 - Blog 2023 >
 - Blog 2022 >
 - Blog 2021 ▾
 - New Video: The Science of Pie Charts
 - Paper: From Jam Session to Recital: Synchronous Communication and Collaboration Around Data in Organizations
 - EagerEyes Turns 15
 - Can A Timeline Pie Chart Work?
 - New video: Chart Appreciation, Iraq's Bloody Toll by Simon Scarr
 - When the Wrong Chart Is the Right Choice
 - New Video: Linear vs. Quadratic Change
 - New video: Florence Nightingale's Famous Rose Chart (aka "Coxcomb")
- Main Content:**
 - ## # New Video: The Science of Pie Charts
 - The common explanation for how pie charts work is that we read them by angle. That of course would mean that donut charts would be bad, because you can't see the angle when you take away the center of the pie. Changing the radius of a slice wouldn't matter though, because that doesn't change the angle. But there is no evidence that angle is how we read pie charts, quite the opposite actually. In this new video, I walk through five reasons why angle is not how we read pies, and what that means for other things we like to assume about them.
 - If you've been following this blog, you've seen me talk about [my pie chart papers](#). This video summarizes them in a way that I hope is interesting, informative, and entertaining. You can watch it below or [over on YouTube](#) (the latter is preferred so you can leave a comment, subscribe, etc.).
 - 

The Science of Pie Charts, Robert Kosara

<https://eagereyes.org/blog/2021/new-video-the-science-of-pie-charts>