



2024 Spring Meeting

ATL | **Adapt Transform Lead**

May 5-8 2024 • Atlanta, Georgia

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Be a Visuary

Data Visualization for Actuaries

2024.05.07

Enbo Jiang, FCAS, CERA



Agenda

- Introduction
- Theories and Principles
- Applications
 - Design Execution
 - Contextual Awareness

Poll: How good are you at data visualization?

- A. I am a data viz wiz
- B. I am decently good at it
- C. I get the job done but am pretty basic
- D. I don't visualize data but is a consumer of data visualizations
- E. What is data?!

Poll: What is your go-to data visualization tool?

- A. Spreadsheet
- B. The likes of Power BI / Tableau
- C. R ggplot & friends
- D. Python matplotlib & friends
- E. Paint (!)

Introduction



Not a new topic...

Death by Chartjunk? Graphical Excellence In Insurance

CAS 2012 Annual Meeting

Data Visualization

Visual Thinking

- Data Visualization for Actuaries and Data Scientists

The importance of principles

Keith Quigley, Actuary

Picture This:
Using Data Visualization

A graph is worth a thousand words

The effective use of visualization

CLRS 2022 St. Louis

Jamie Mackay

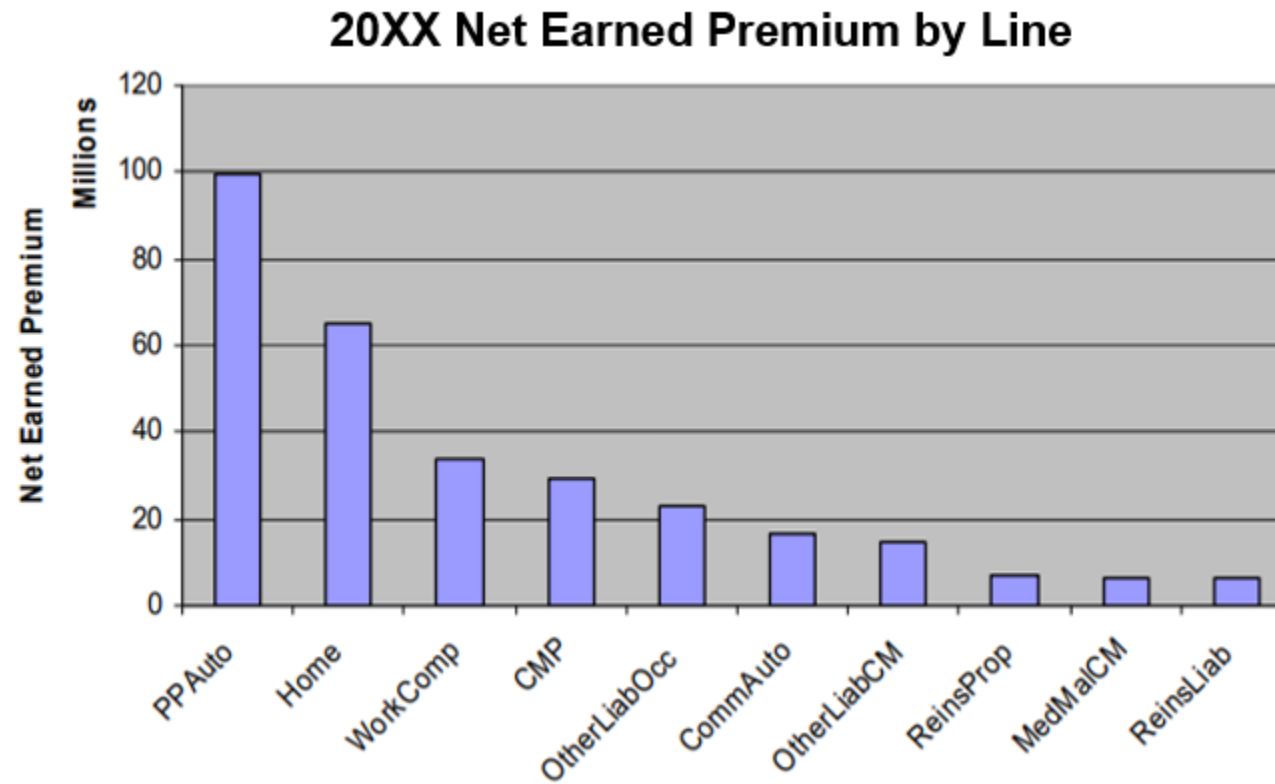
Introduction to Data Visualization

John Deacon, Annie Fan, Brian Fannin, Jennifer Levine, Keith Quigley, Patrick Yu

Abstract: This paper summarizes some of the literature on the topic of basic data visualization techniques. We emphasize the importance of knowing the audience, and focusing on what message is intended to be sent. We provide visual examples of graph types and describe when to use the different types for different situations. We identify several decluttering and accentuating techniques and we share some of the basic research on how the human eye and brain work to interpret visual information. We provide a before-and-after example of the basic data visualization techniques, to show how much improvement can be achieved in delivering the intended message.

keywords: data visualization, communication, gestalt principles

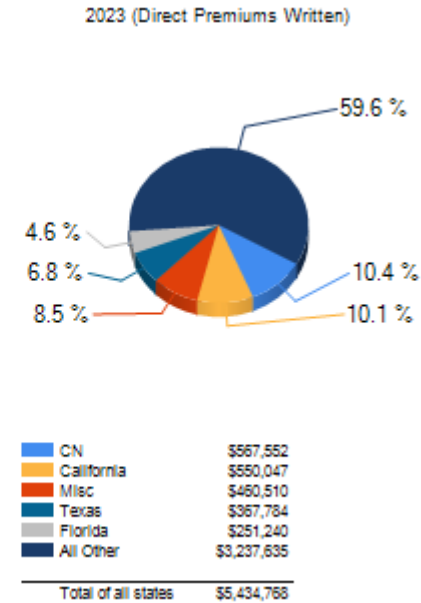
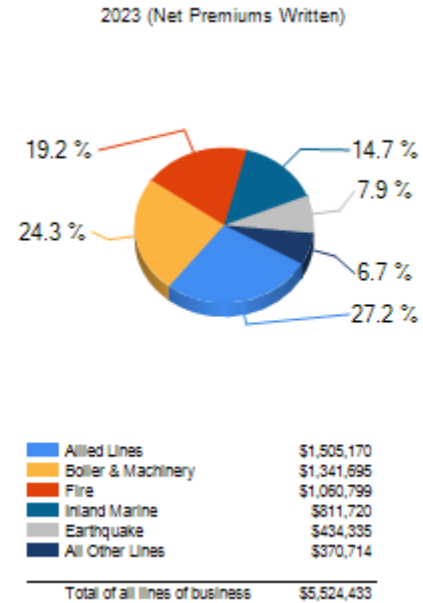
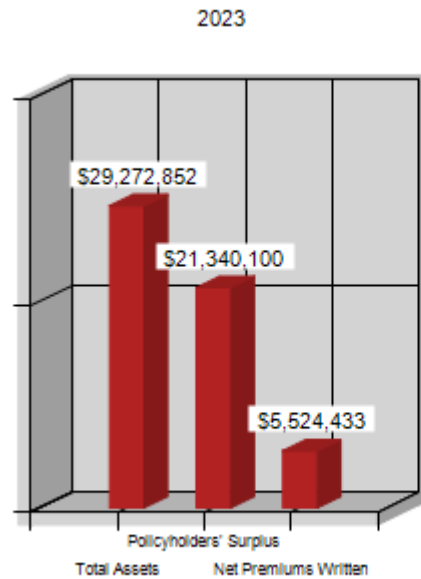
But still seeing this?



Annual Statement Data



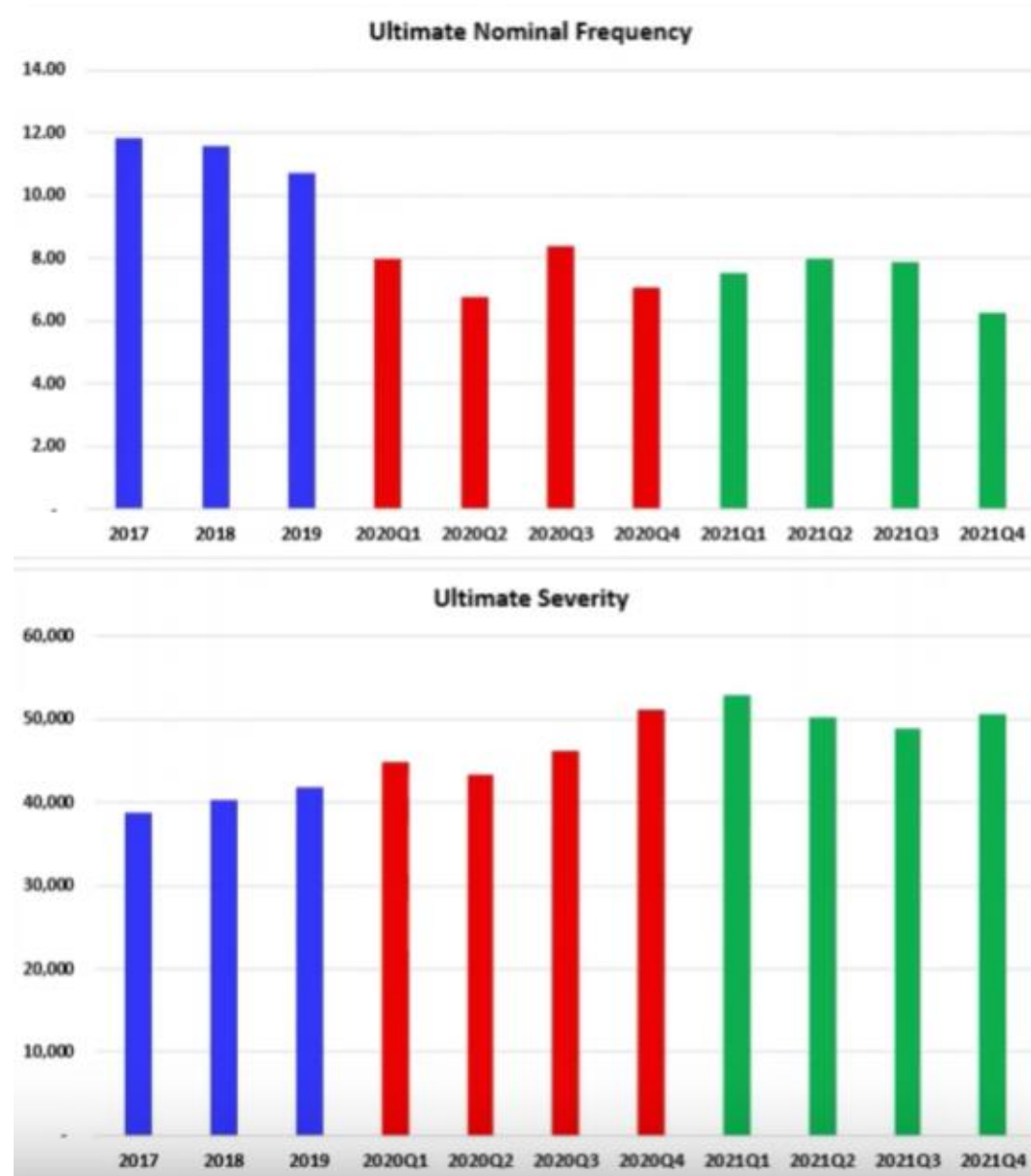
Or this?



An unnamed rating agency



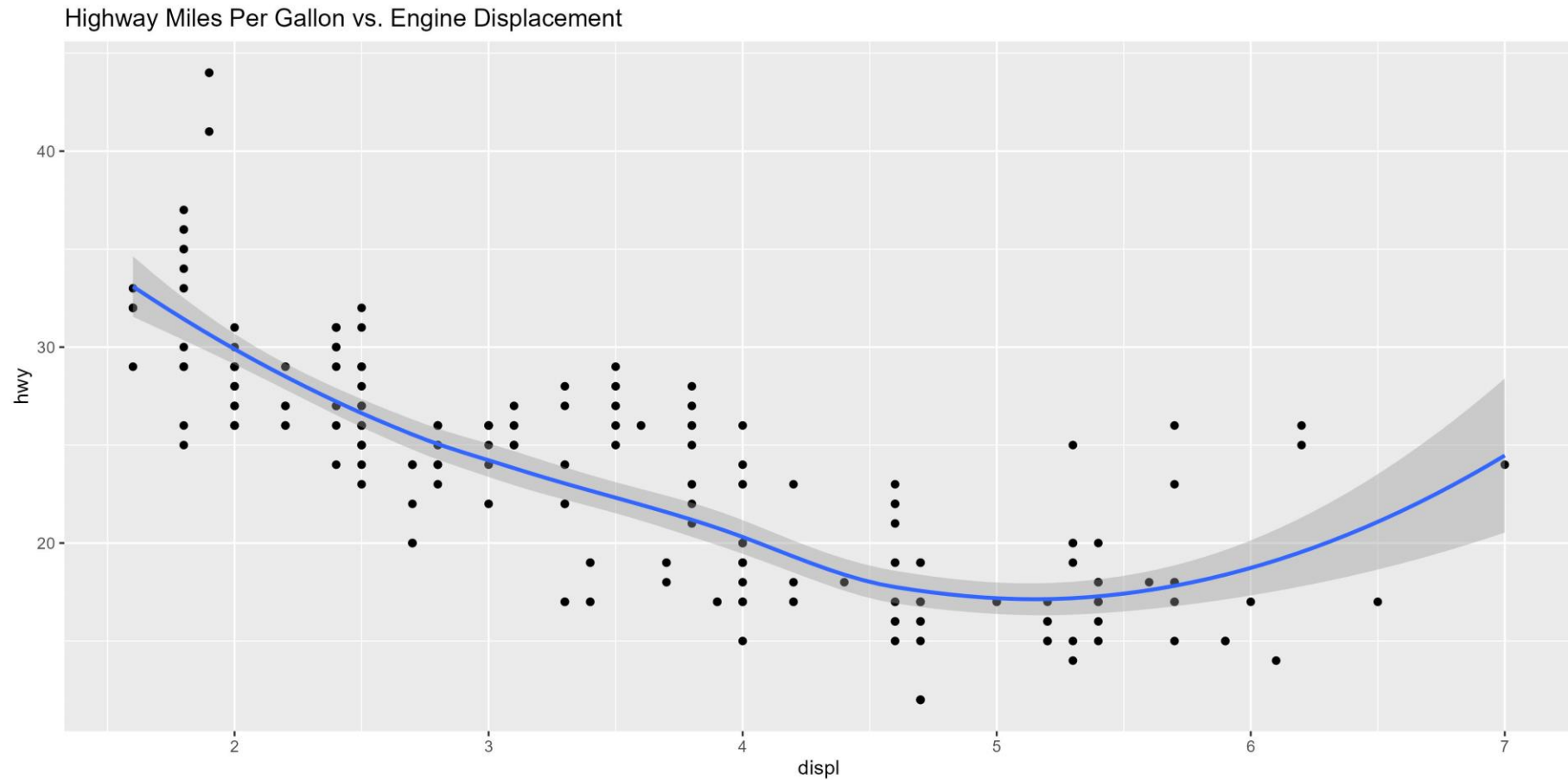
Or this?



An unnamed industry
benchmark provider

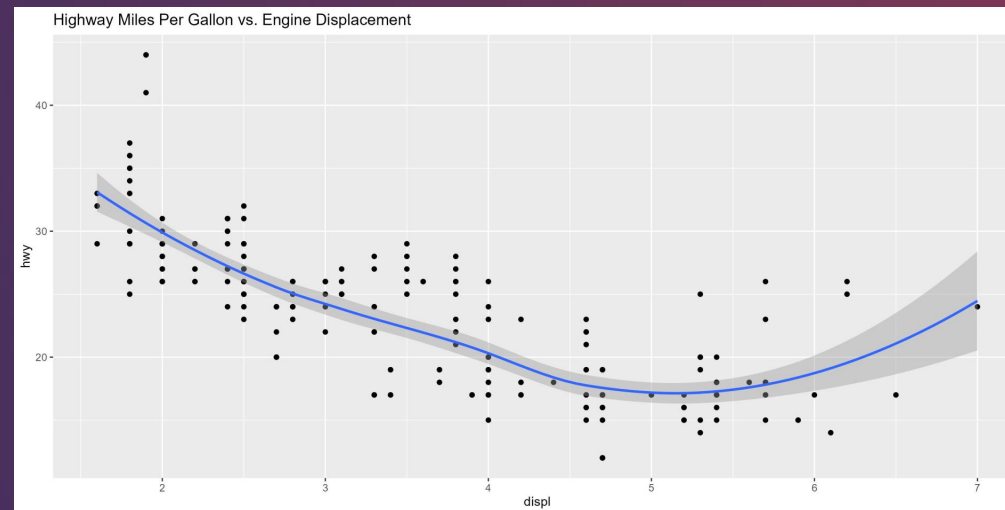
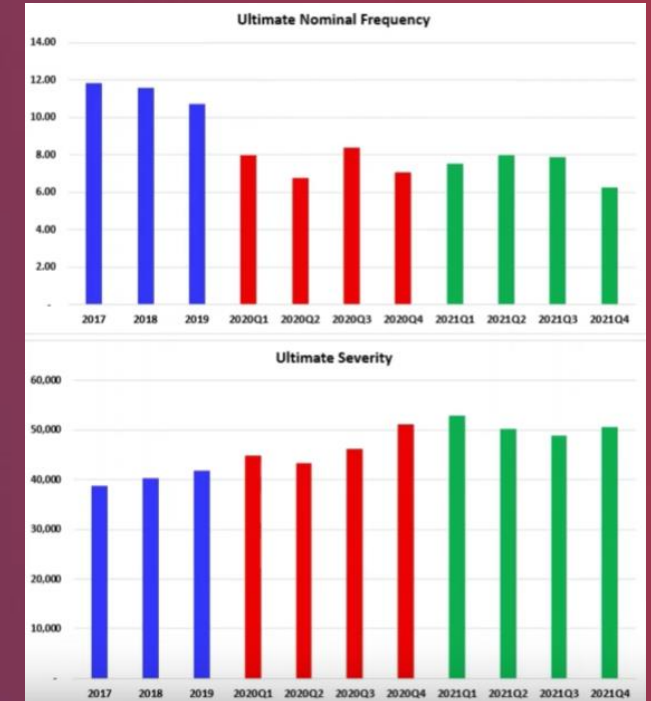
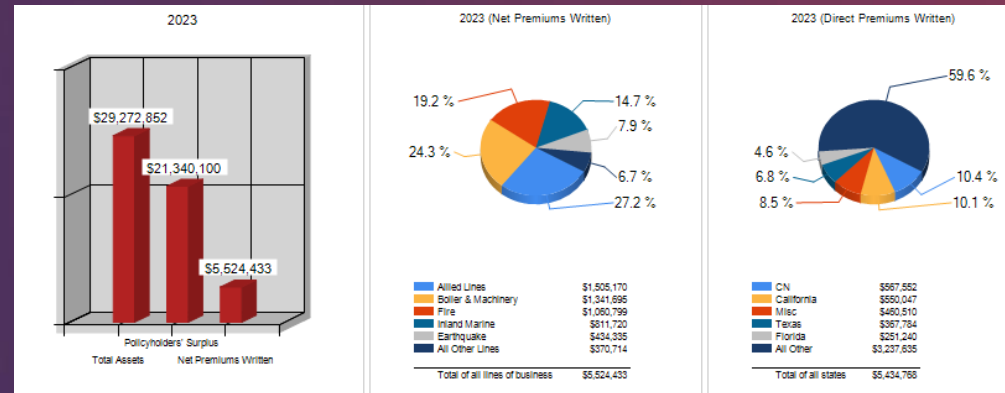
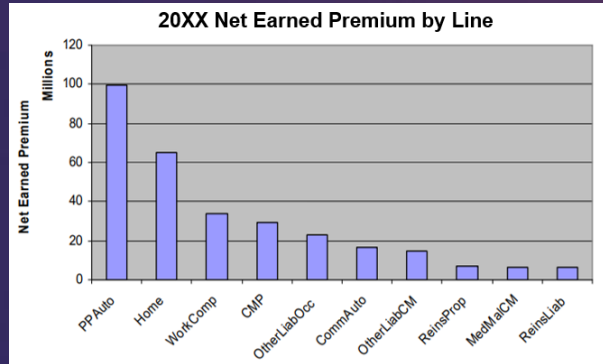


What about this?



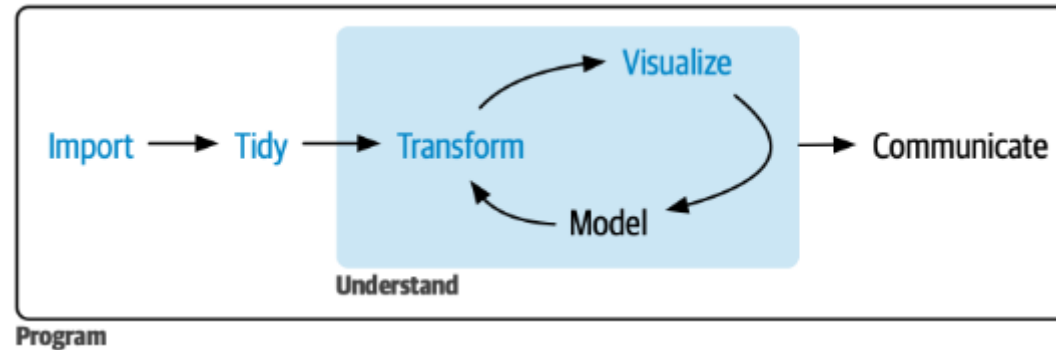
<https://ggplot2.tidyverse.org/reference/mpg.html>

Question: What are their problems?



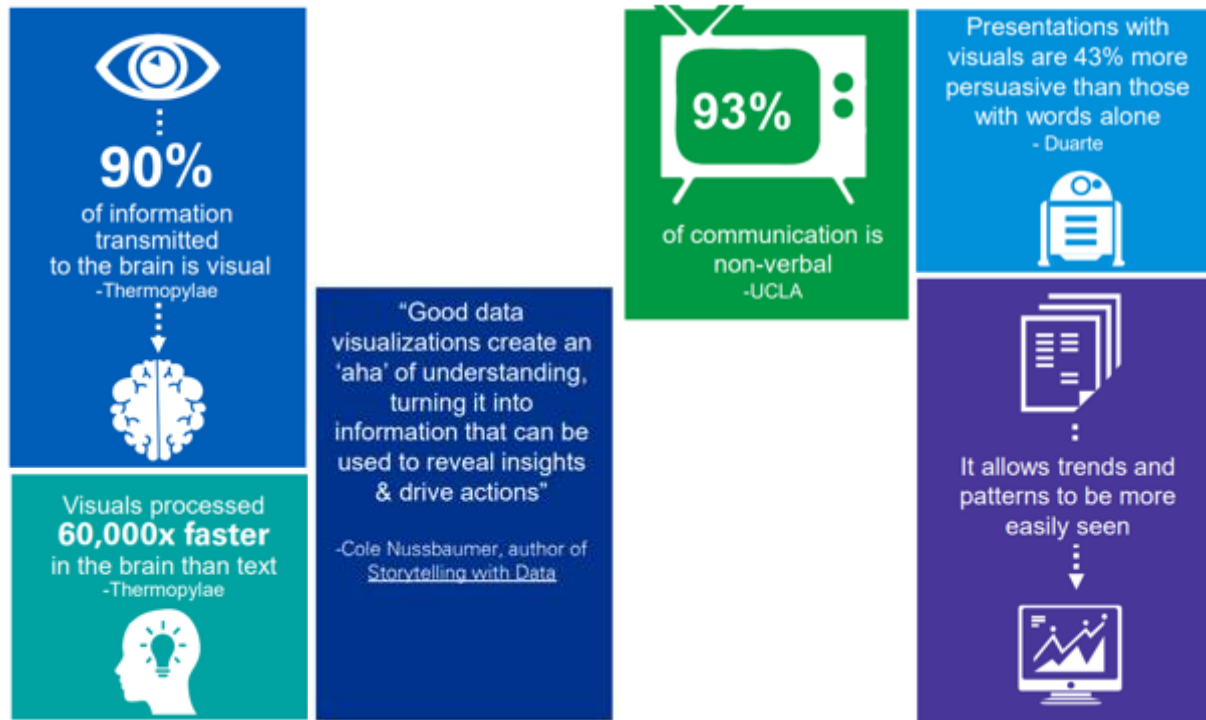
Why should we care?

- Because “visualize” is an integral part of the actuarial/data modeling process, and arguably it’s critical to every step of the process



Why should we care?

- Because **good** visualization **could** enhance effectiveness of communication



Why should we care?

- Because we are actuaries and ASOPs says...

3.1 REQUIREMENTS FOR ACTUARIAL COMMUNICATIONS

The performance of a specific actuarial engagement or assignment typically requires significant and ongoing communications between the actuary and the intended users regarding the following: the scope of the requested work; the methods, procedures, assumptions, data, and other information required to complete the work; and the development of the communication of the actuarial findings.

3.1.1 FORM AND CONTENT

The actuary should take appropriate steps to ensure that the form and content of each actuarial communication are appropriate to the particular circumstances, taking into account the intended users.

3.1.2 CLARITY

The actuary should take appropriate steps to ensure that each actuarial communication is clear and uses language appropriate to the particular circumstances, taking into account the intended users.

Visualization may be the most appropriate “language” in certain circumstances for the intended users

Not a new topic, so what's new(-ish)?

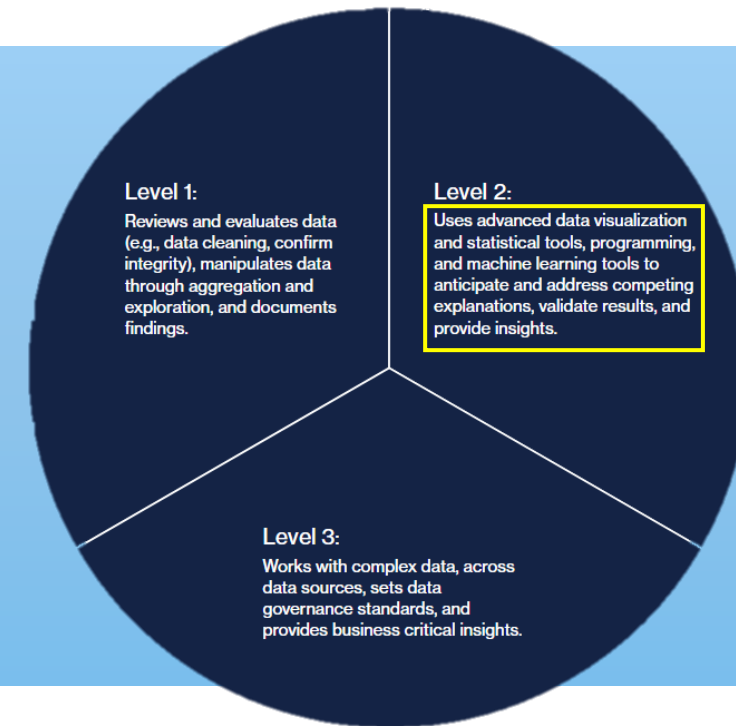
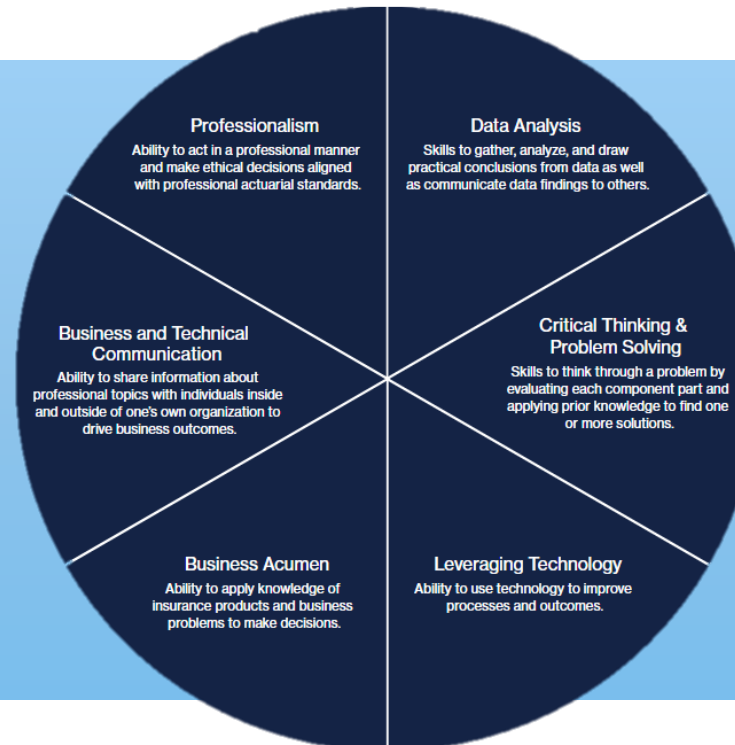
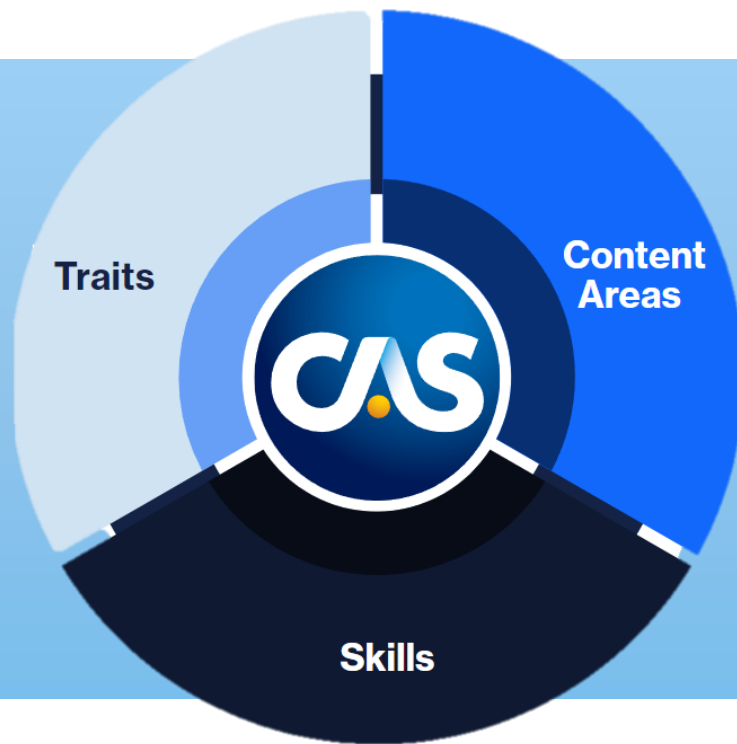
- Data visualization wasn't part of the exam syllabus at all until very recently through the new online course

5. Analyzing Data With Visualizations

- a. Planning an Effective Data Exploration
- b. Data Exploration Fundamentals
- c. Fundamentals of Exploratory Data Visualizations
- d. Creating Plots

- Growing popularity of new and free tools (i.e., R, Python) that come with much more robust visualization libraries than Excel

CAS Capability Model



Main learning objectives

1. Understand basic theories and principles of data visualization and what constitutes a “Good Chart”
2. Apply the learning from this session to create desired visuals. We will use R ggplot for practical demonstration, but the same principles can be extended to other platforms
3. Evaluate the appropriateness of a visualization in a given context and propose ways to improve it

What this session is not

- A tutorial/workshop for *ggplot*, *Power BI*, etc.
 - Choose your favorite tool, though we will be using *ggplot* for demonstration of the principles discussed herein
- A sales pitch on why and how your organization should set up a more efficient dashboard system
 - Consultants are more than happy to take your money and help you with that

Theories and Principles

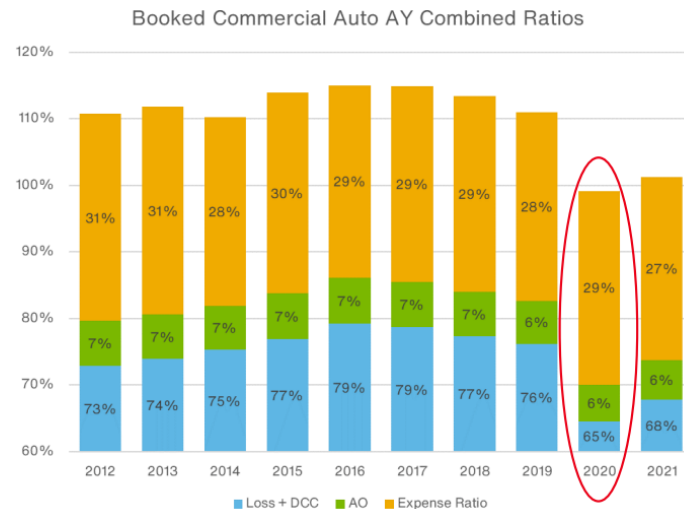
Tufte's Graphical Excellence

- Graphical excellence is that which gives to the viewer the **greatest number of ideas** in the shortest time with the least ink in the smallest space
 - The famous “data-ink ratio” stems from this
- Graphical excellence requires telling the **truth**
- ...
- “...above all else, show the data”

Good viz is not misleading

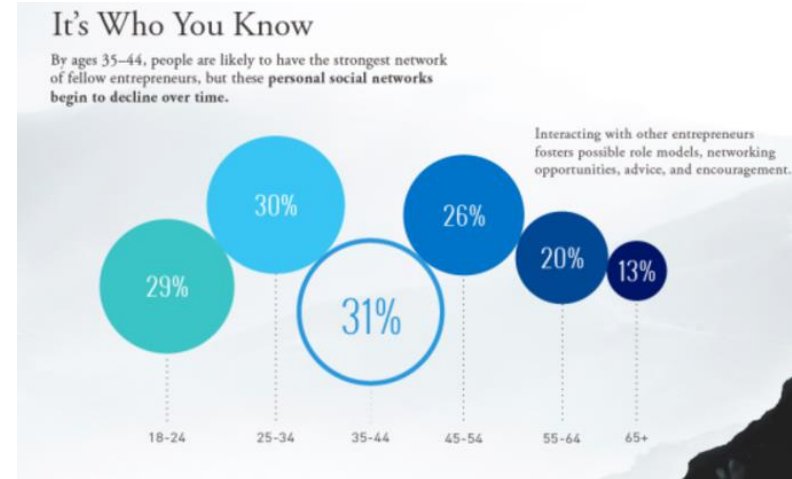
- “Graphical excellence requires telling the truth about the data.”
 - Visual Display of Quantitative Information pg. 51

Obvious



[PowerPoint Presentation \(casact.org\)](https://casact.org)

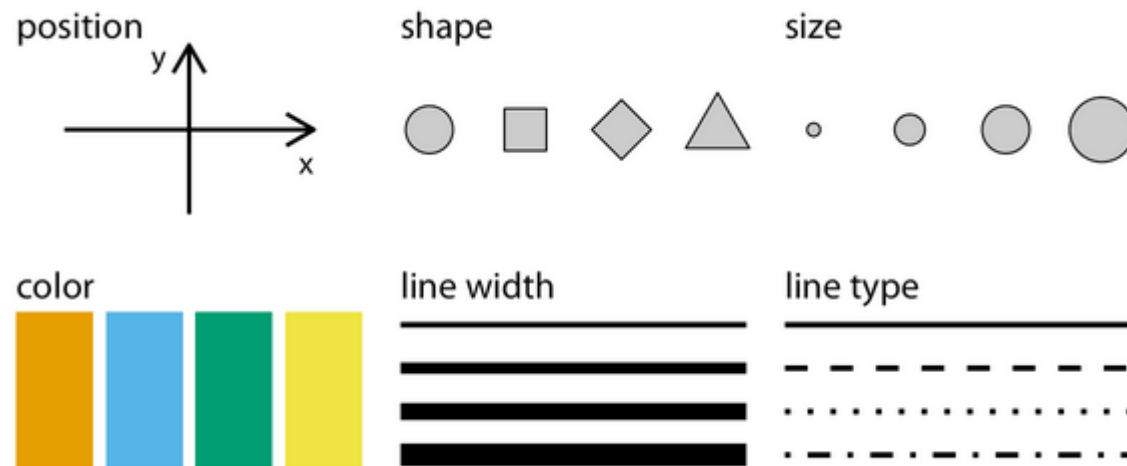
Subtle



[Tools - Proportional Ink \(callingbullshit.org\)](https://callingbullshit.org)

Good viz employs intentional aesthetics

- “Aesthetics”
 - *aes()* in *ggplot*
 - Combine color with others aesthetics to ensure plot remains interpretable when printed black-and-white and for colorblind audience
 - There are also colorblind-proof palettes available, e.g., [Okabe-Ito](#)



Color Considerations

- Usually dictated by your companies' themes
 - If so, be on-brand!

Primary

Support

Secondary

	Black	White	Blue	Dark Grey	Light Grey	Pink	Green	Yellow	Orange
CMYK	40, 40, 40, 100	0, 0, 0, 0	100, 0, 0, 0	45, 25, 16, 59	21, 11, 9, 23	0, 83, 3, 0	85, 0, 88, 0	0, 15, 89, 0	0, 56, 90, 0
RGB	0, 0, 0	255, 255, 255	0, 174, 239	91, 103, 112	162, 170, 173	239, 83, 153	0, 174, 94	255, 213, 52	246, 138, 51
HEX	000000	FFFFFF	00AEF	5B677D	A2A9AD	EF5399	00AE5E	FFD534	F6BA33

Tints

	70% CMYK	40% CMYK	20% CMYK	70% RGB	40% RGB	20% RGB
Blue	70, 0, 0, 0	40, 0, 0, 0	20, 0, 0, 0	0, 192, 243	142, 216, 249	199, 234, 251
Dark Grey	9, 5, 3, 12	16, 10, 6, 24	31, 18, 11, 41	115, 127, 139	165, 173, 182	204, 208, 213
Pink	0, 96, 2, 0	0, 33, 1, 0	0, 17, 1, 0	243, 138, 180	248, 187, 210	251, 220, 231
Green	60, 0, 62, 0	34, 0, 35, 0	17, 0, 18, 0	105, 194, 137	170, 217, 183	211, 234, 216
Yellow	0, 11, 62, 0	0, 6, 36, 0	0, 3, 18, 0	255, 224, 123	255, 235, 177	255, 244, 213
Orange	0, 39, 63, 0	0, 22, 36, 0	0, 11, 18, 0	250, 170, 108	253, 204, 164	254, 228, 205

Shades

	CMYK	RGB	HEX
Blue	100, 24, 0, 11	0, 131, 194	0084C2
Dark Grey	45, 25, 16, 75	52, 45, 76	34414C
Light Grey	21, 11, 9, 40	133, 142, 148	858E94
Pink	13, 89, 11, 0	212, 64, 138	D4408A
Green	85, 17, 84, 4	1, 148, 91	01945B
Yellow	5, 22, 94, 0	243, 195, 43	F3C32B
Orange	8, 67, 100, 0	227, 115, 38	E37328

Note: The following red value can be used to show negative values in data visualization (RGB = 203, 51, 59 / CMYK = 2, 97, 85, 7).

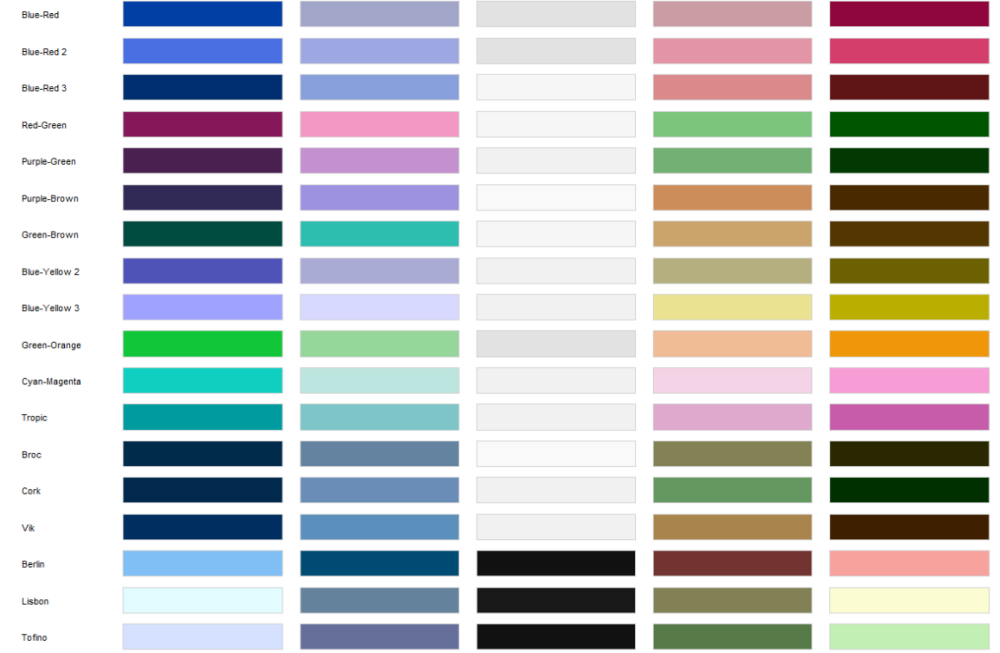
- If not, understand the use cases:
 - Categories (qualitative), numeric values (sequential/diverging), highlight

Color Considerations

```
colorspace::hcl_palettes(type = "Sequential", plot = TRUE)
colorspace::hcl_palettes(type = "Diverging", plot = TRUE)
colorspace::hcl_palettes(type = "Qualitative", plot = TRUE)
```



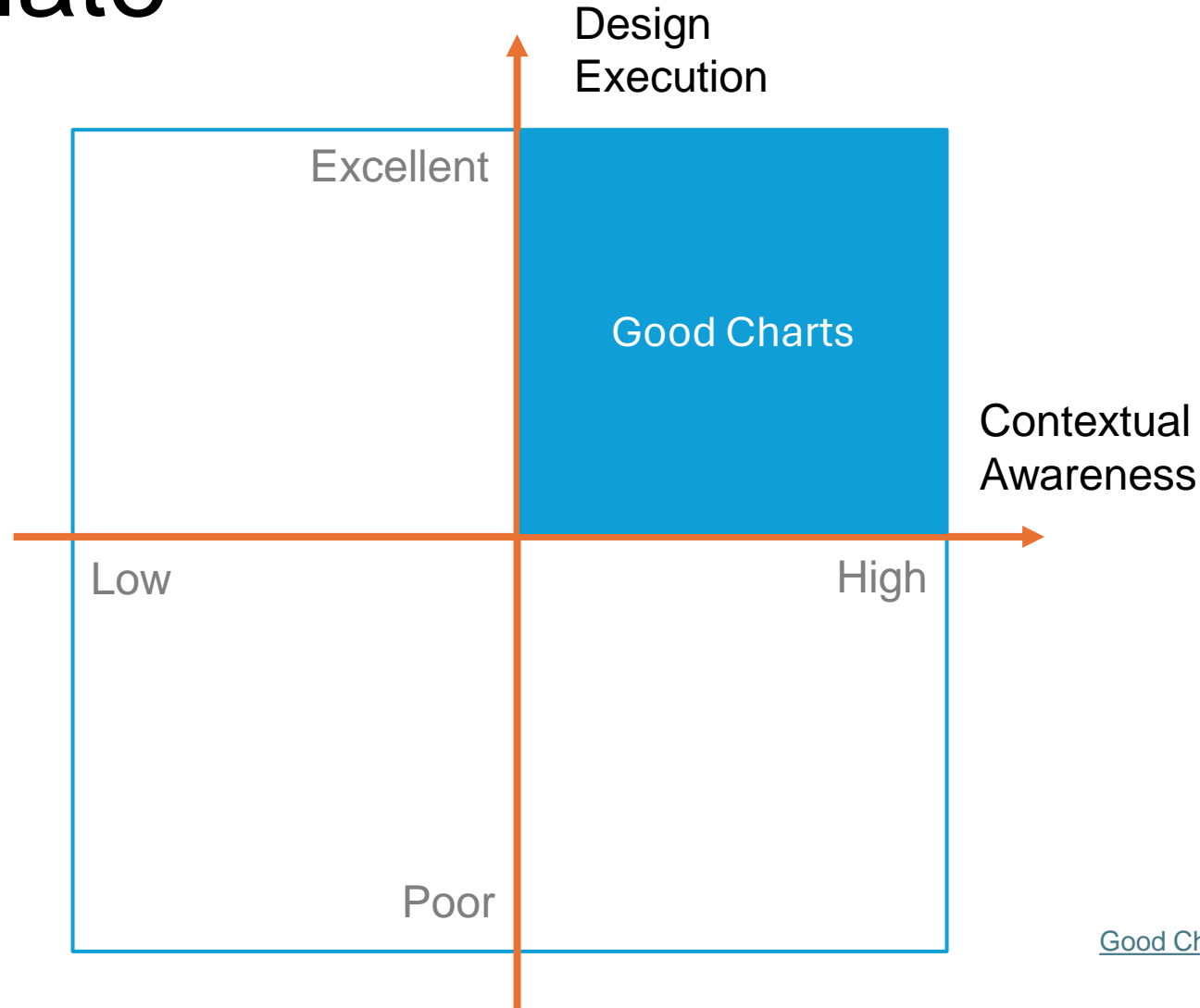
Diverging



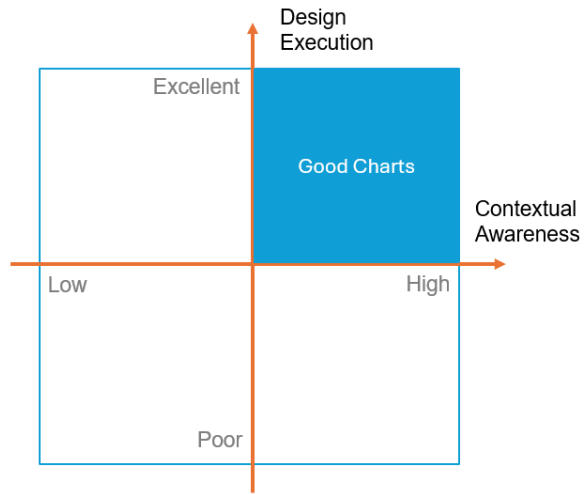
Qualitative



Good viz is well designed and context-appropriate



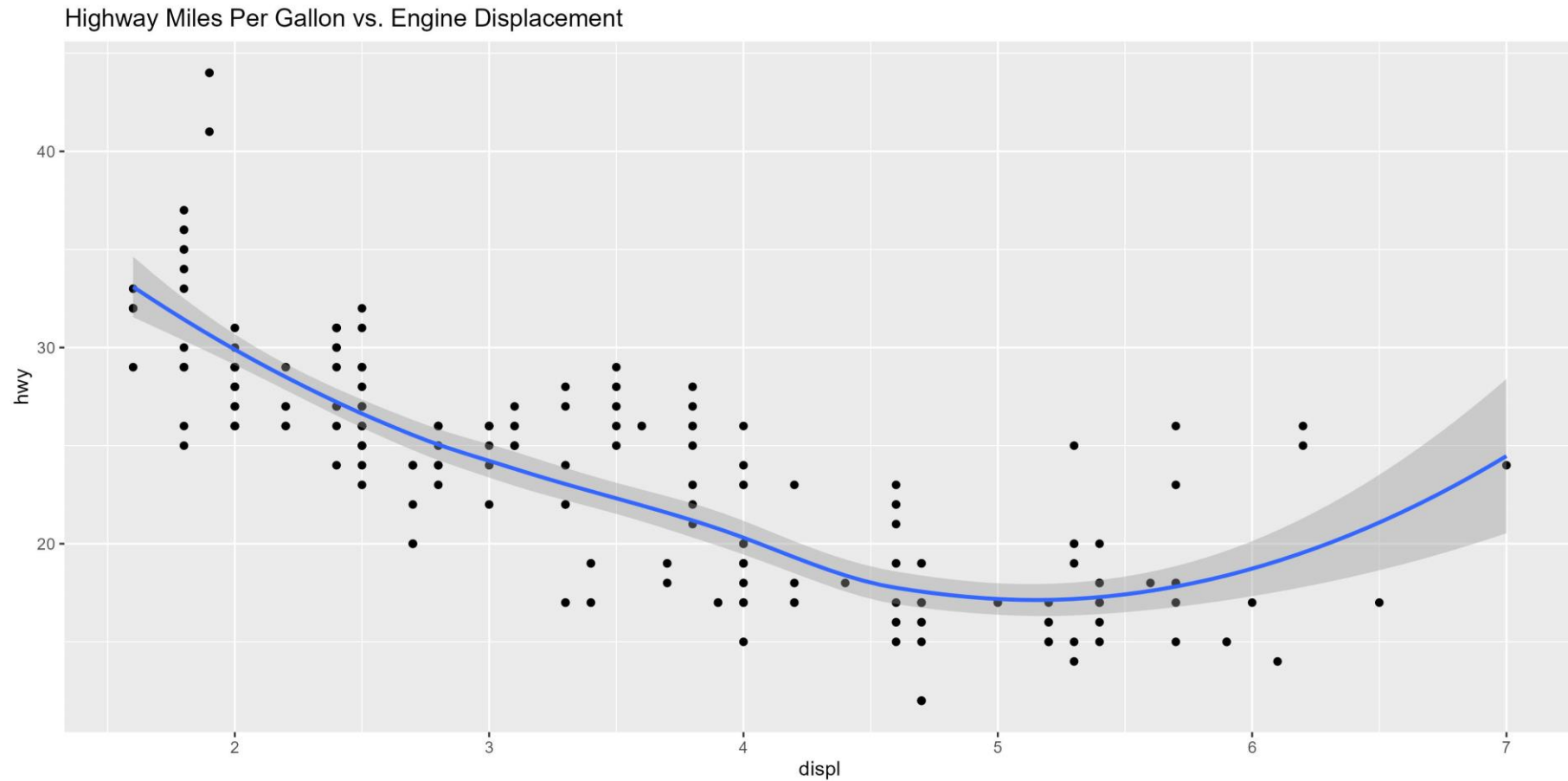
[Good Charts \(scottberinato.com\)](http://scottberinato.com)



Design Execution

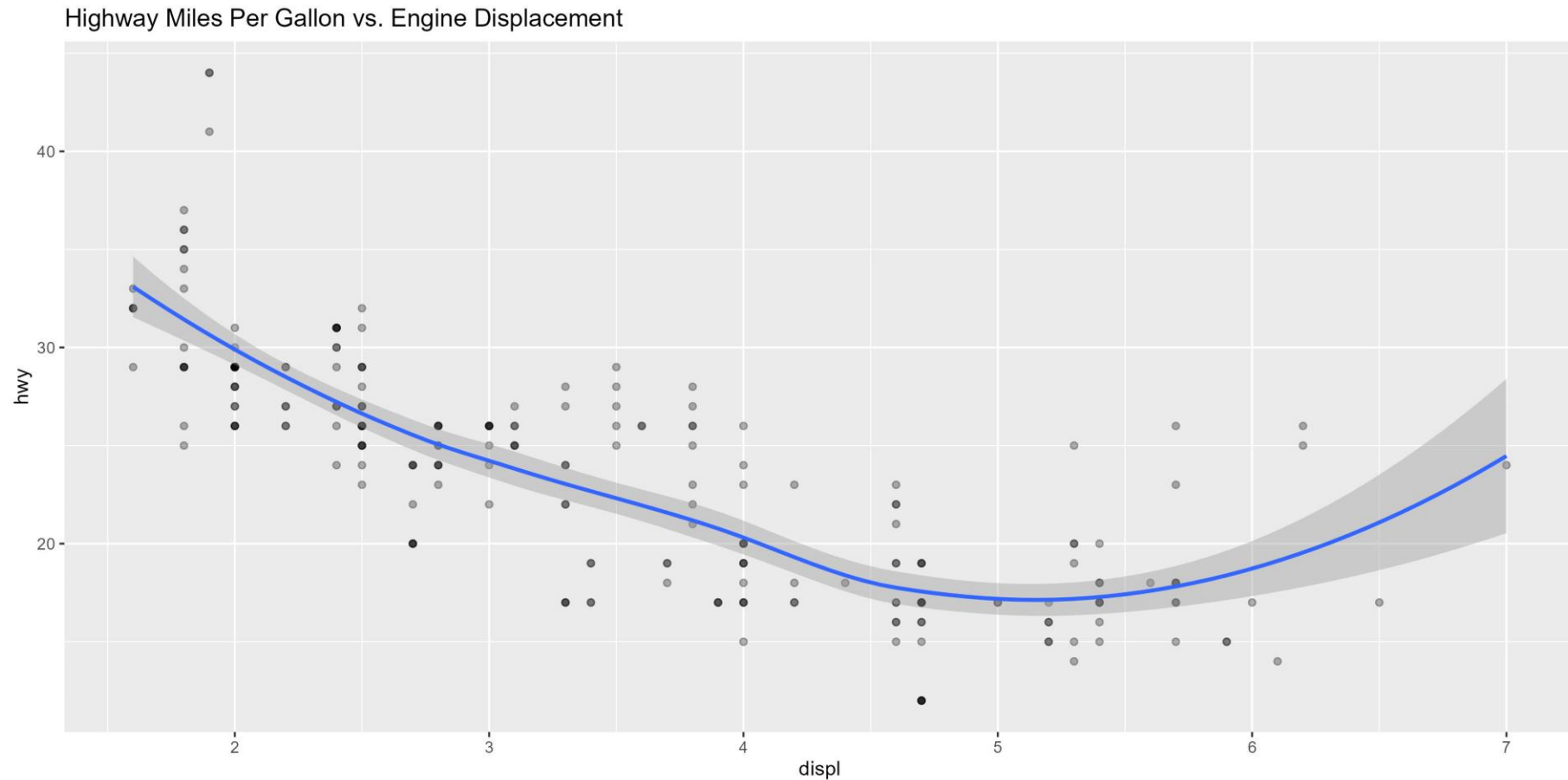
Reproducible R script available on GitHub

Original



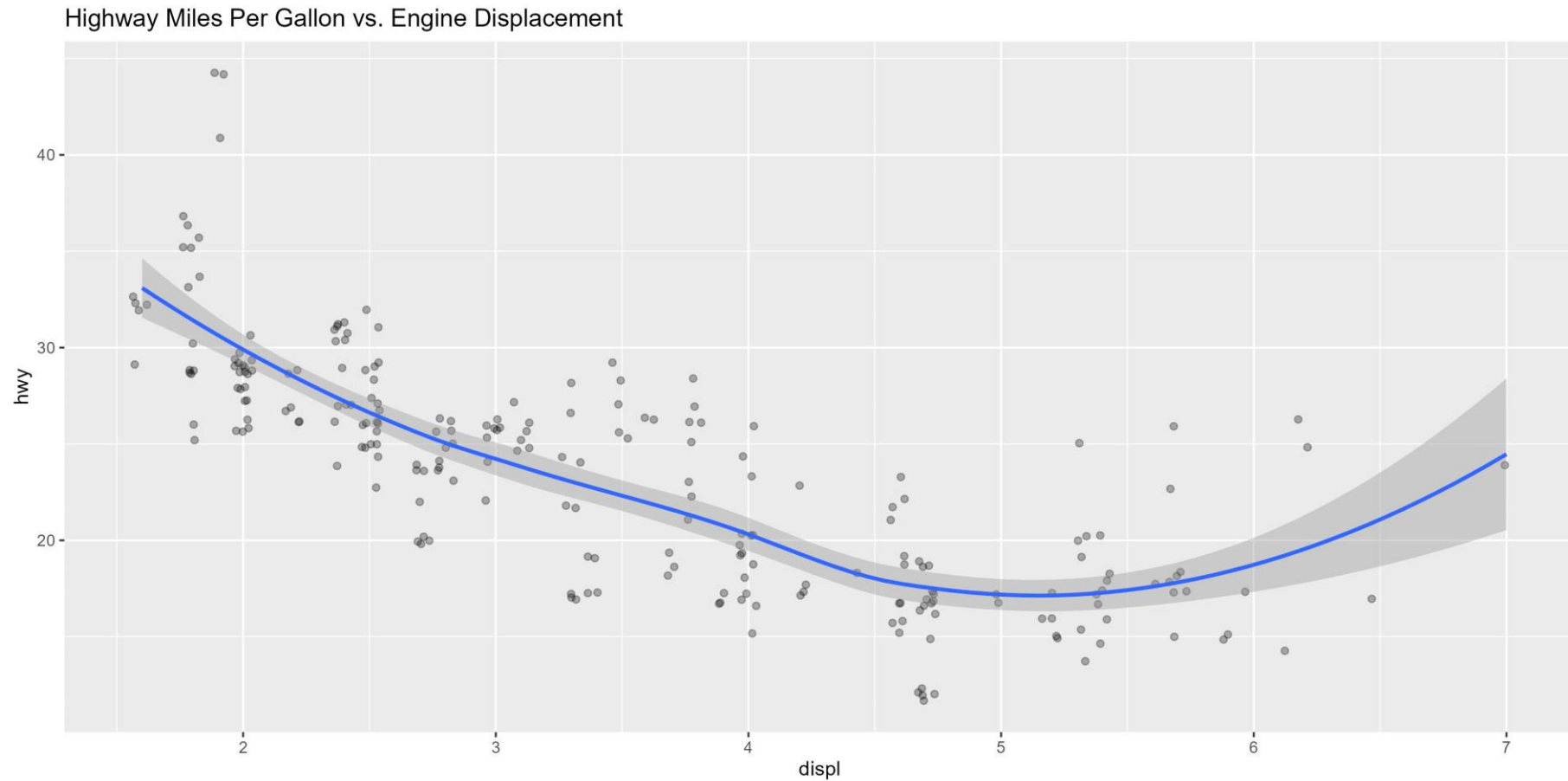
> How would you improve this plot?

Intentional aesthetics - transparency

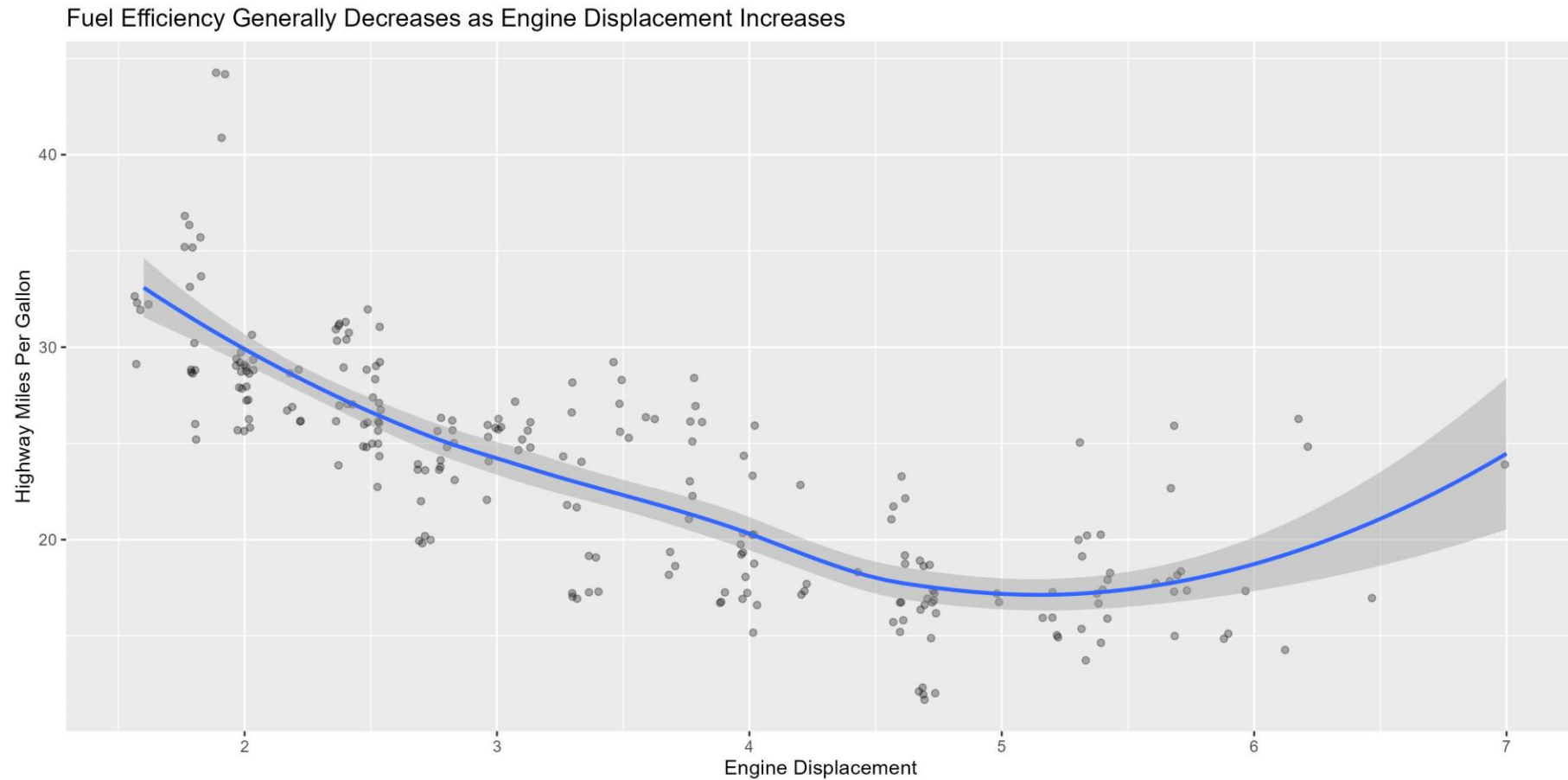


> “...above all else, show the data”

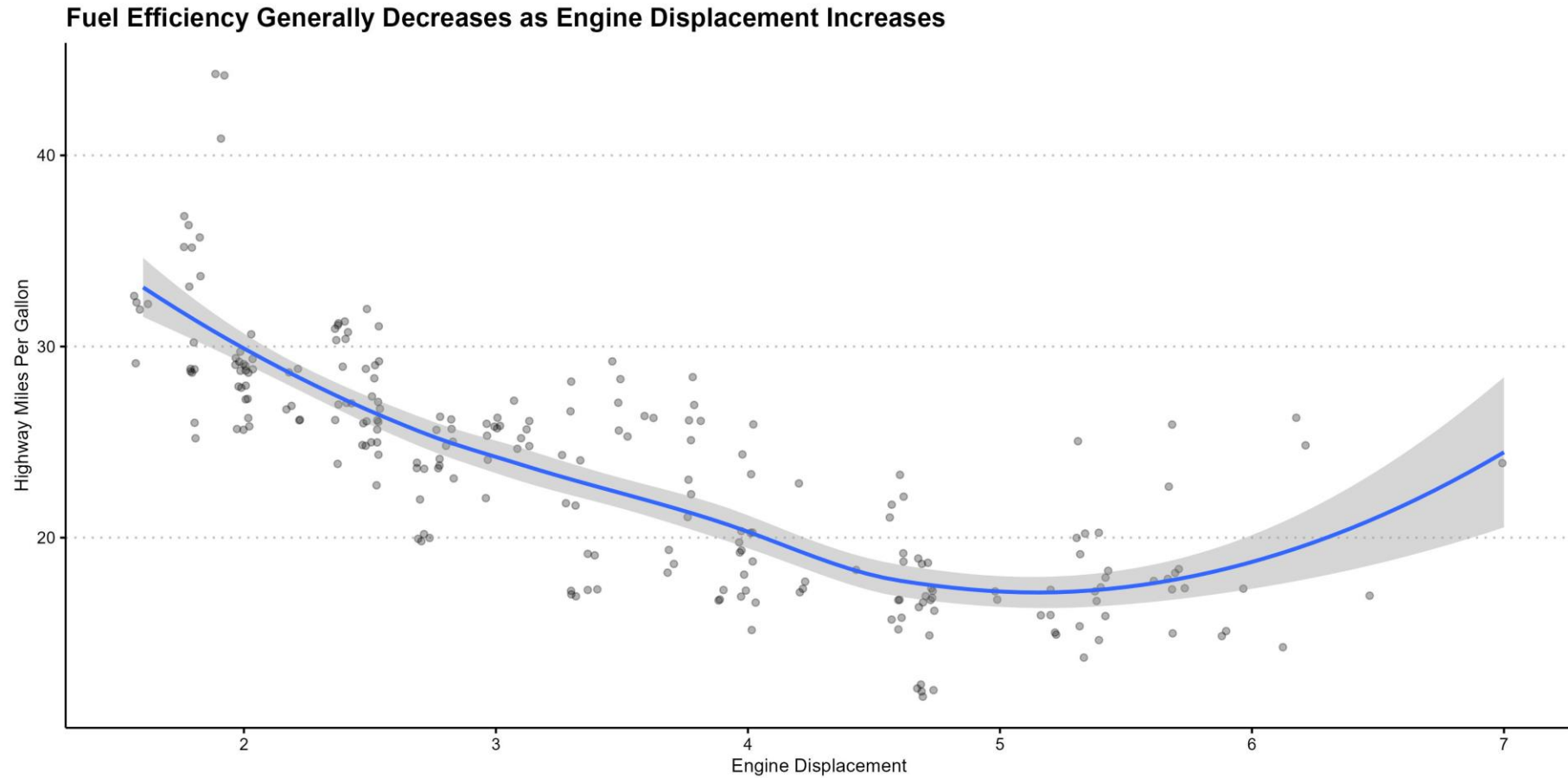
Intentional aesthetics - position



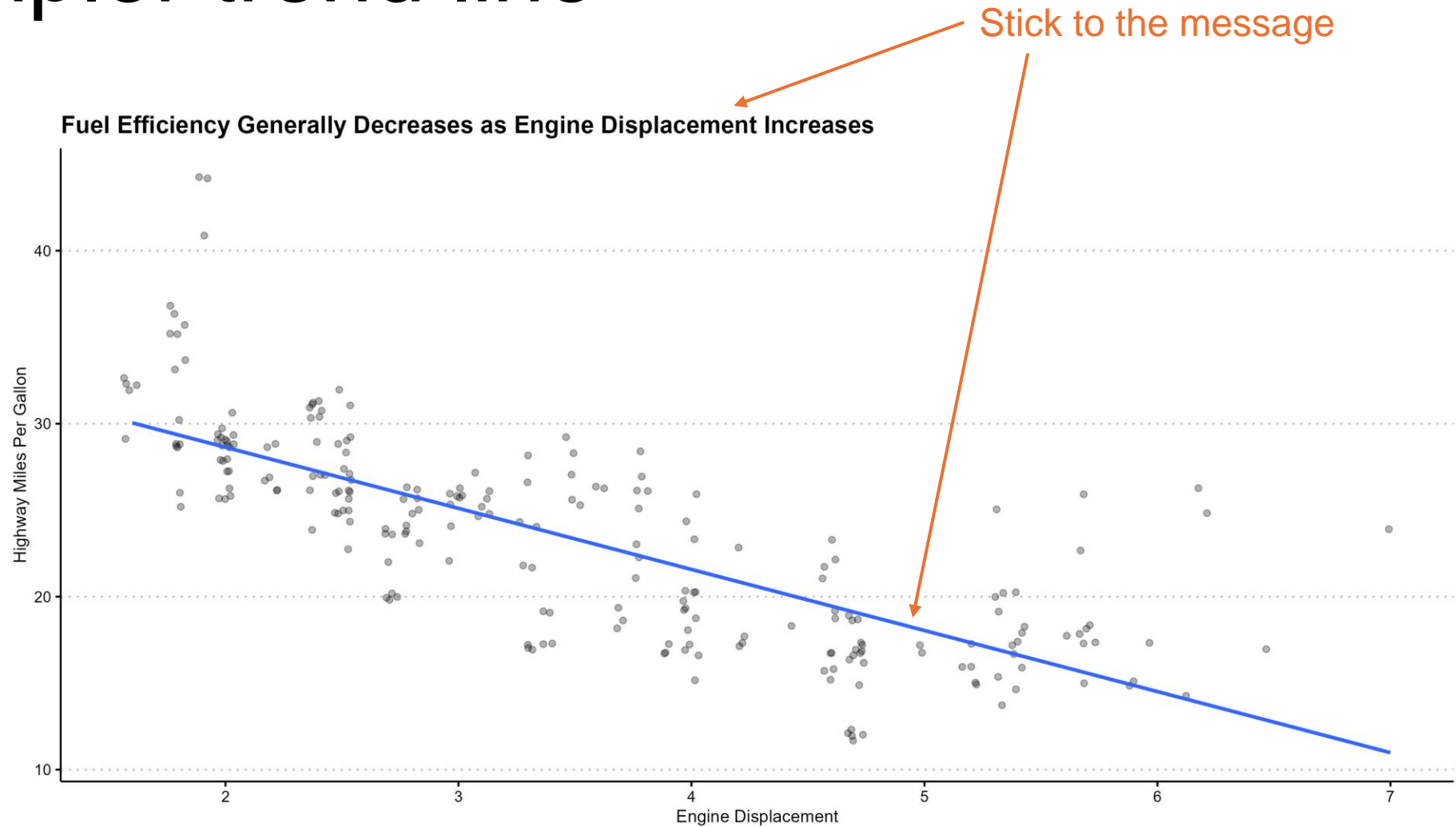
Descriptive labels and title



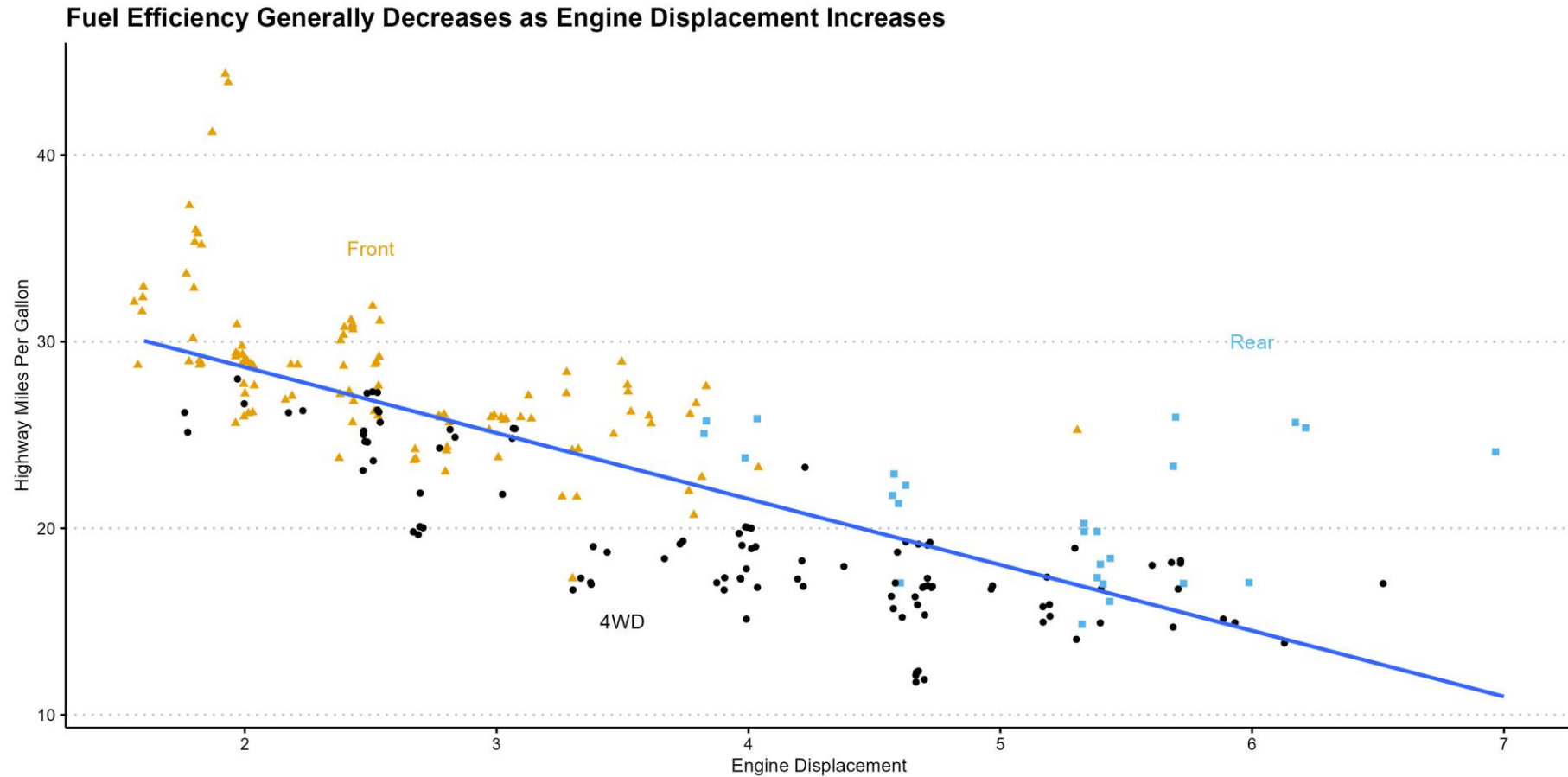
Remove distractions



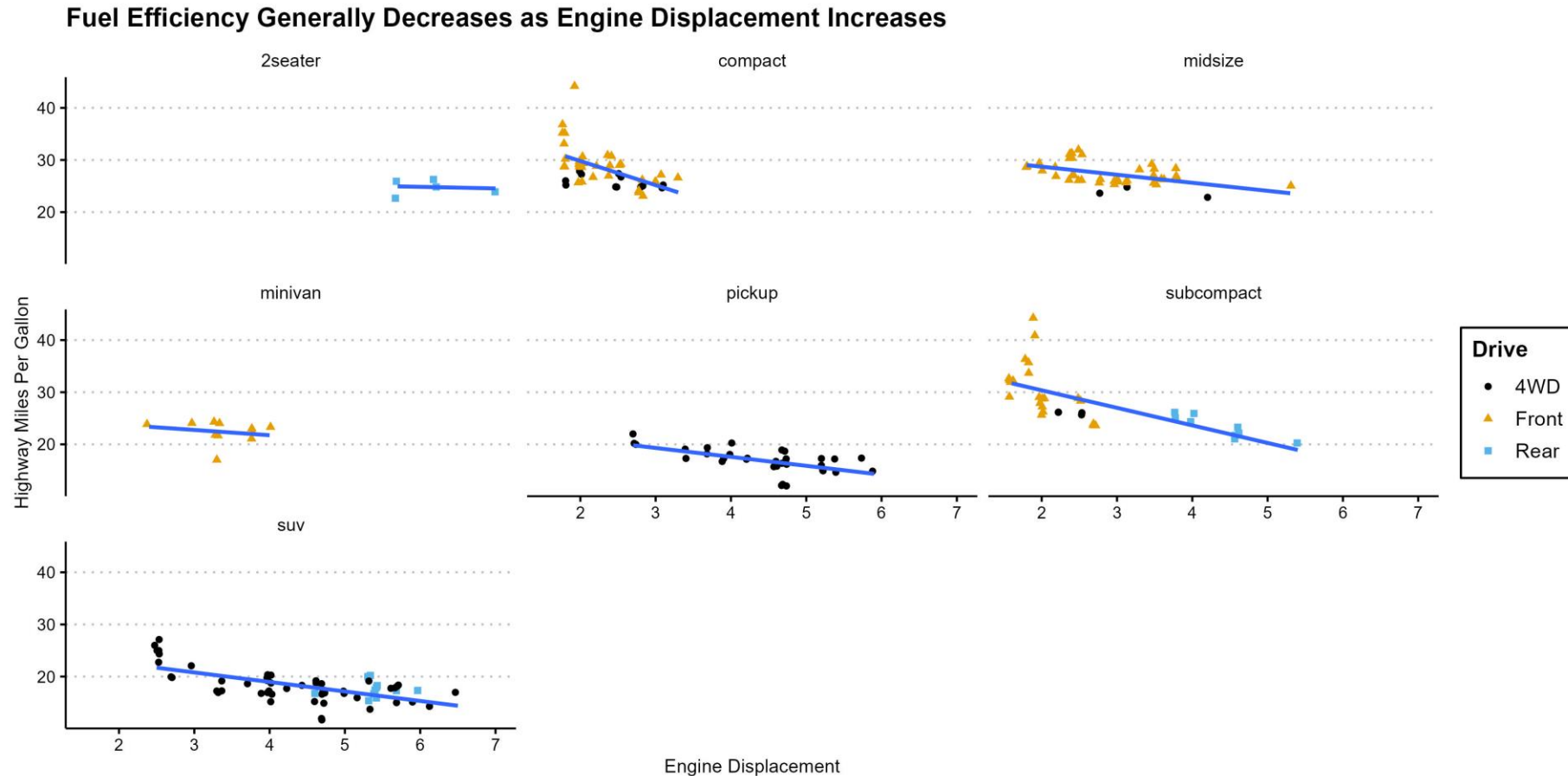
Simpler trend line



Increase data density – via aesthetics

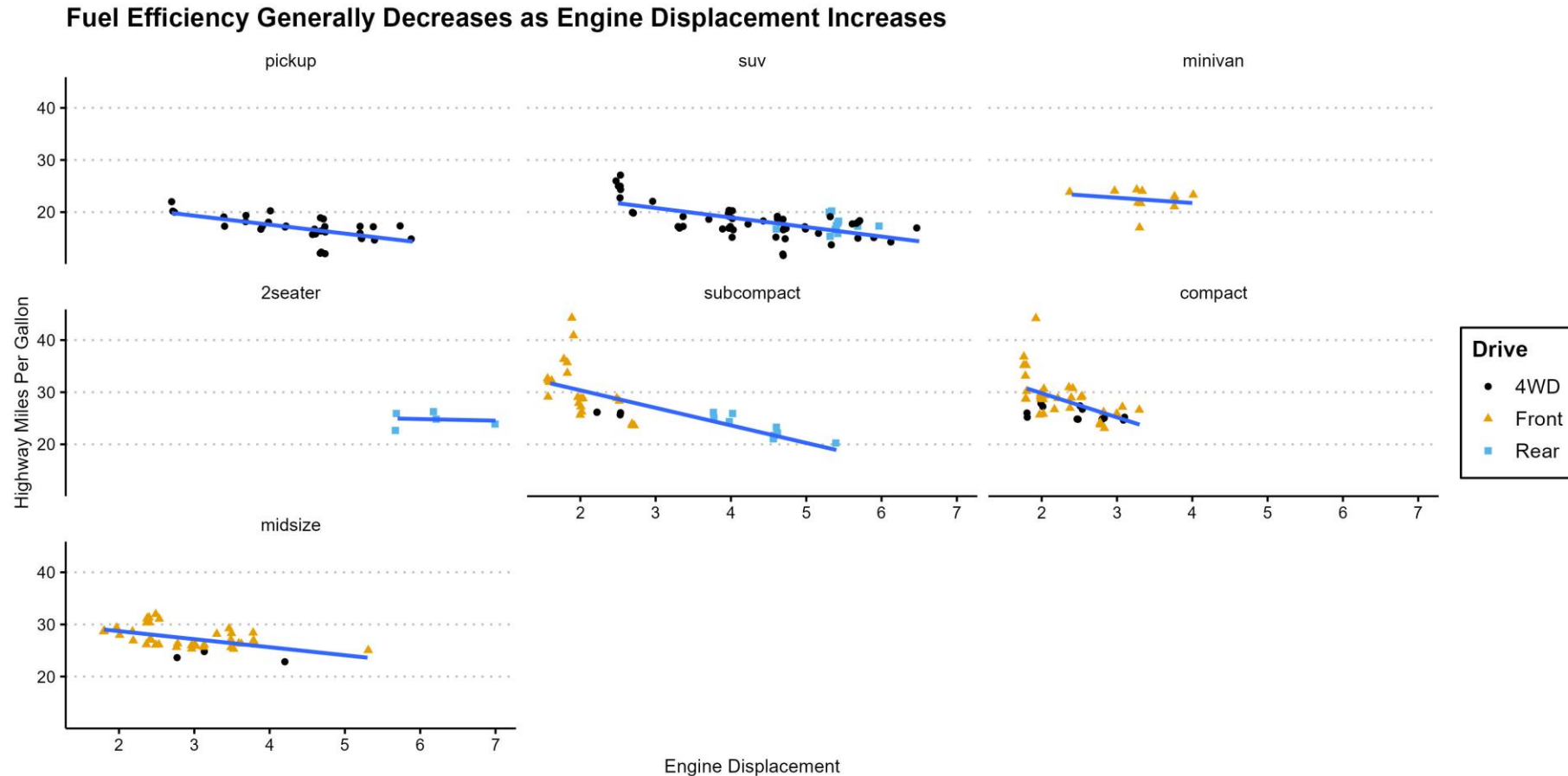


Increase data density – via facets



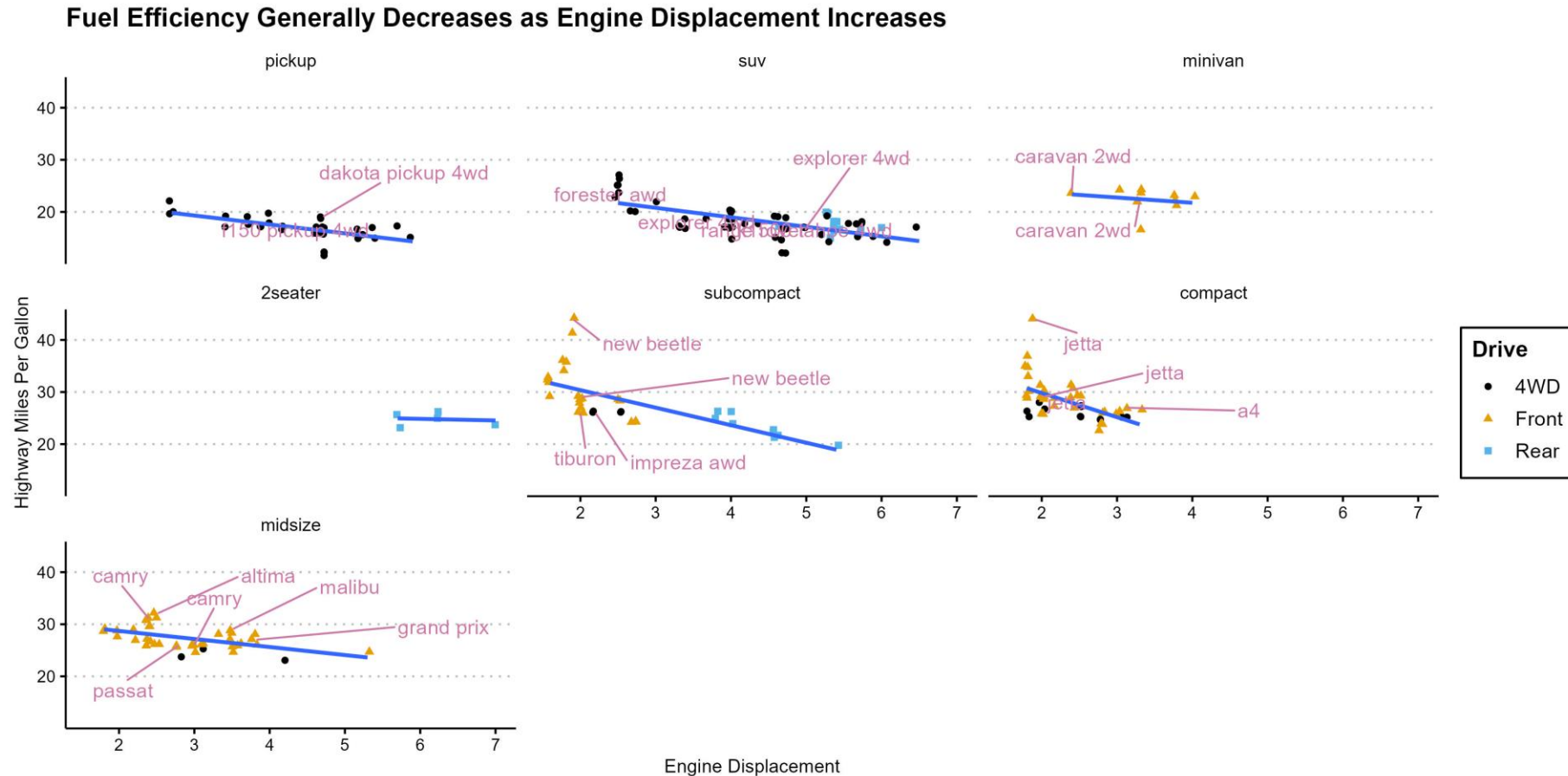
> Why should we not use alphabetical ordering for the panels?

Increase data density – order matters



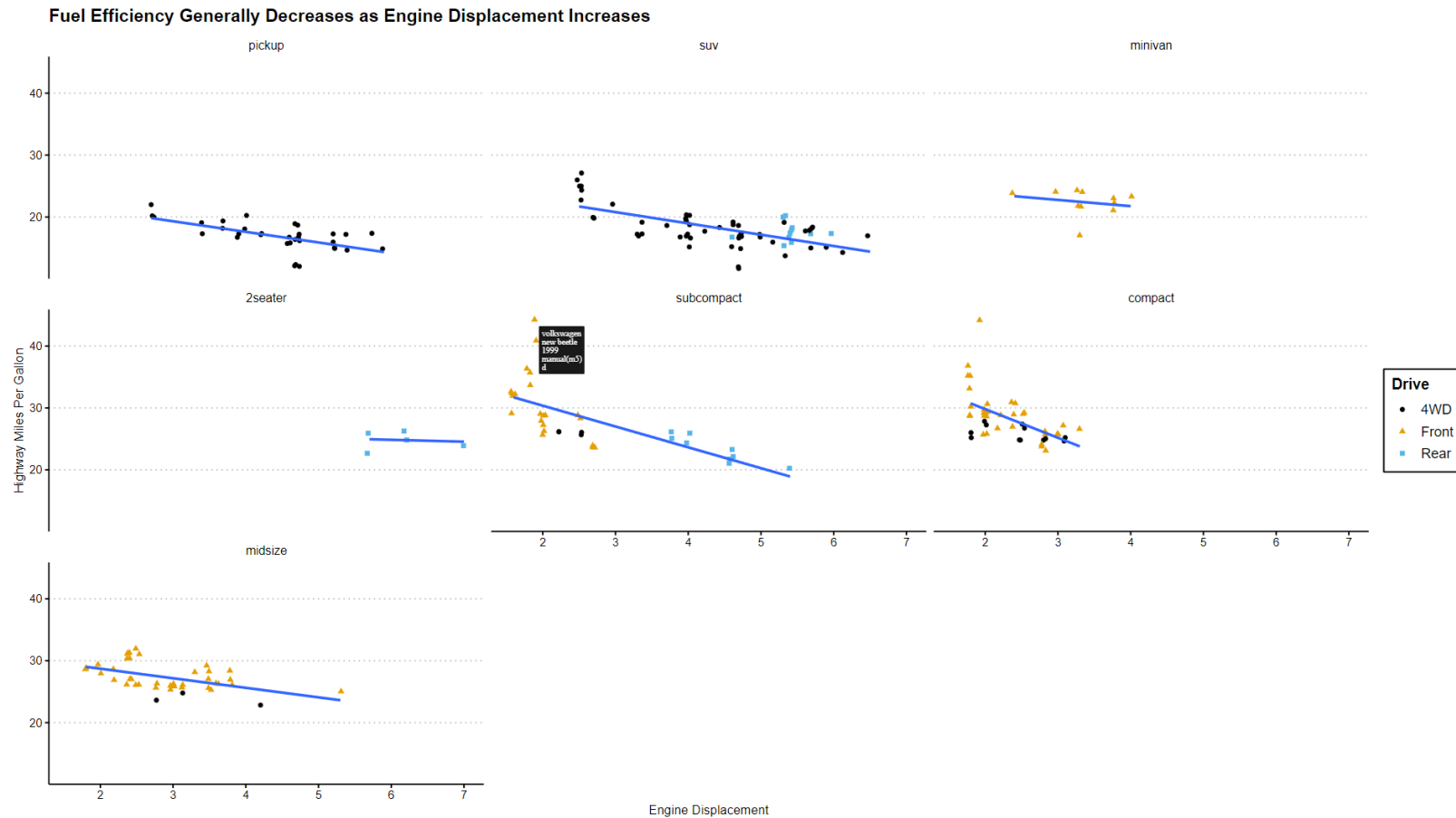
> Order panels by median Highway MPG of each class

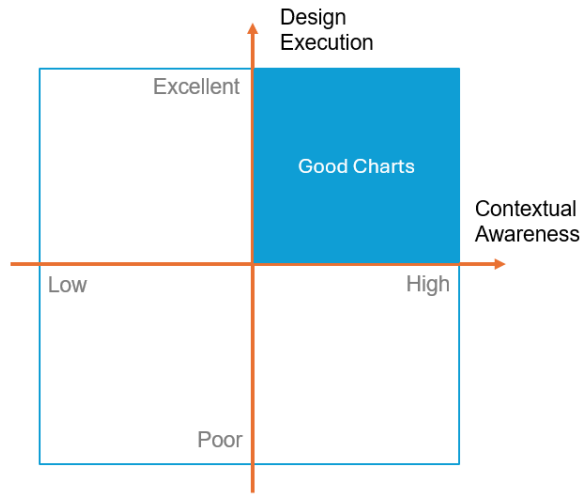
Labels - static



> Helpful but too busy. Anything else we could do?

Labels - interactive



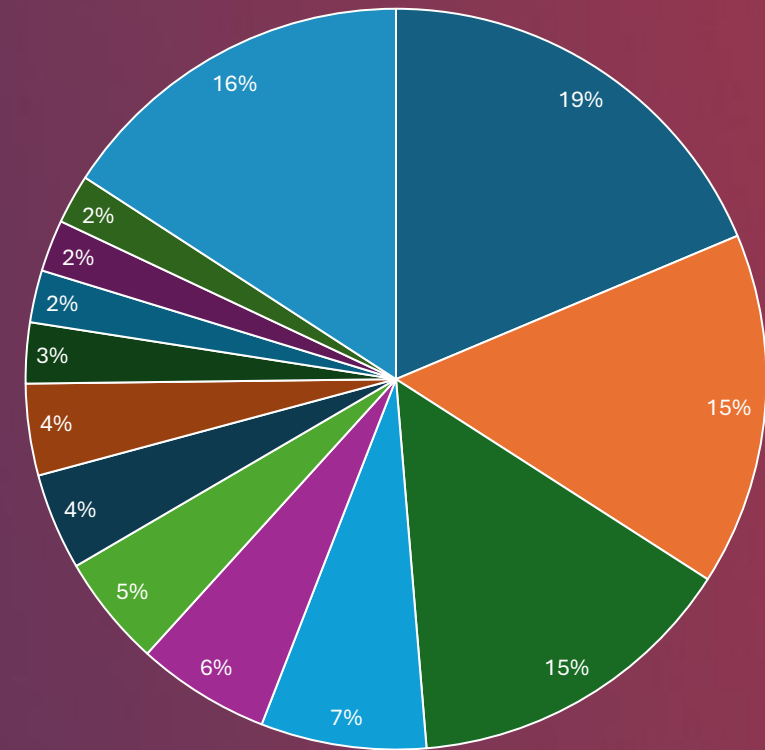
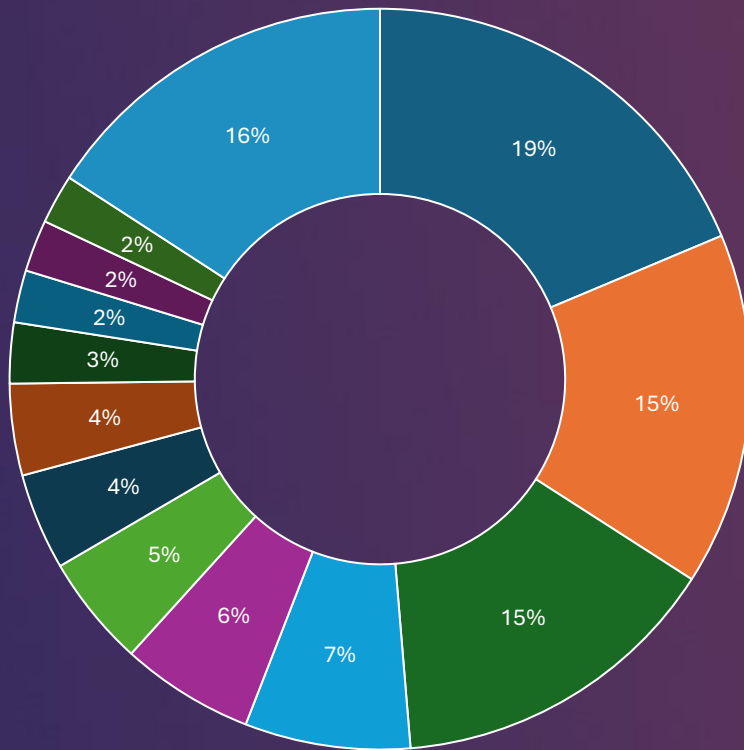


Contextual Awareness

Contextual Awareness

What?	Who?	When?	Where?	How?
<ul style="list-style-type: none">• Amounts• Distributions• Proportions• Multivariate relationship• Geospatial• Uncertainty	<ul style="list-style-type: none">• Actuaries• Non-actuaries (UW, brokers, management)• Regulators	<ul style="list-style-type: none">• Data exploration phase• Results communication phase	<ul style="list-style-type: none">• Board meeting• Industry conference• Internal team standup call	<ul style="list-style-type: none">• Oral presentation (verbally explained)• Written report (textually explained)• Infographics (self-explanatory)

Is doughnut chart just pie chart with arbitrarily better data-ink ratio?



Poll: Should doughnuts and pies be avoided?

- A. Yes, avoid at all costs
- B. They are mostly useless, but...
- C. They work well most of the time, but...
- D. Don't avoid, they are very useful



You may strongly dislike pie charts...

But if your principal loves pie charts, use pie charts despite your “visuarial” judgment.

“...taking into account of the intended users.” – ASOP No. 41

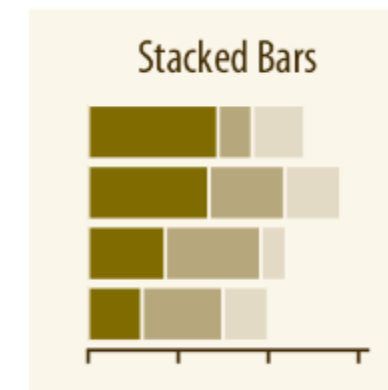
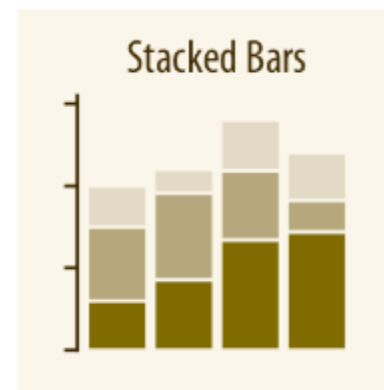
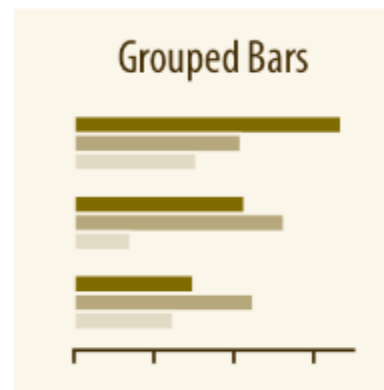
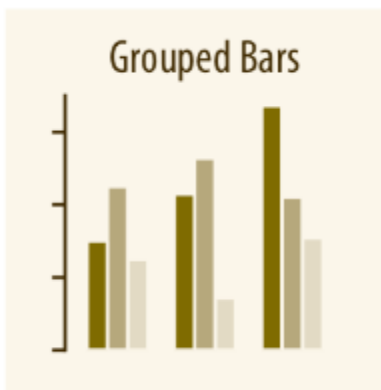
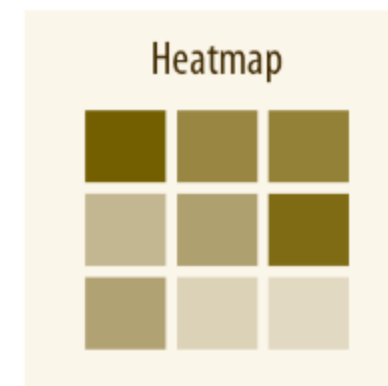
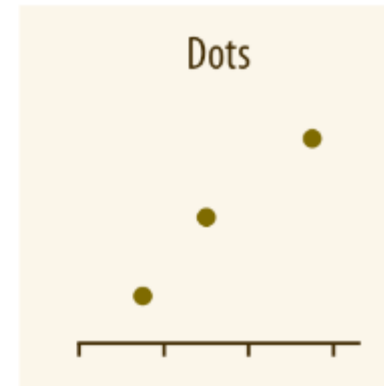
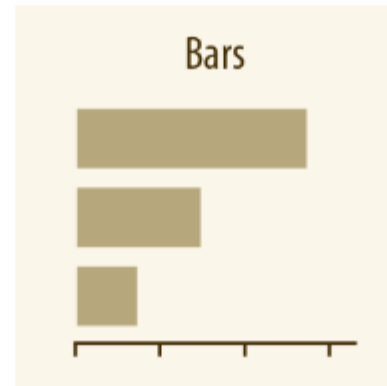
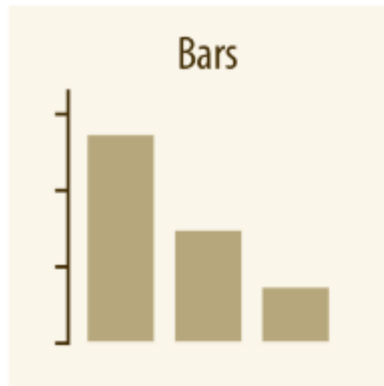
The “what”



Practice thoughtfulness:

As we flip through these chart types, consider the “who, when, where, and how” to which each of these charts would be appropriate and effective.

- Amounts



The “what”



Practice thoughtfulness:

As we flip through these chart types, consider the “who, when, where, and how” to which each of these charts would be appropriate and effective.

- Distributions



The “what”



Practice thoughtfulness:

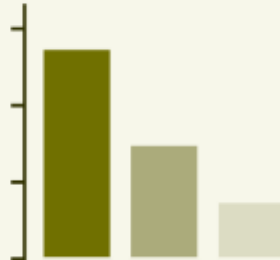
As we flip through these chart types, consider the “who, when, where, and how” to which each of these charts would be appropriate and effective.

- Proportions

Pie Chart



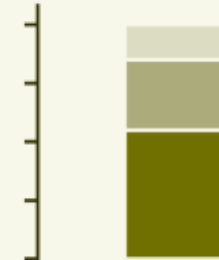
Bars



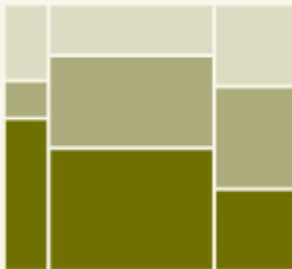
Bars



Stacked Bars



Mosaic Plot



Treemap



Parallel Sets



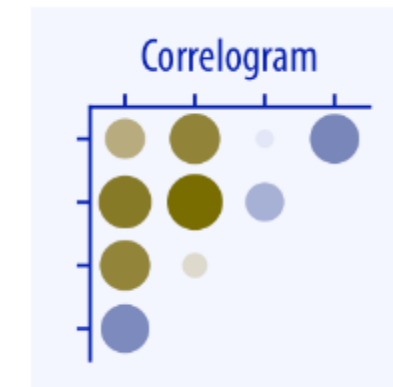
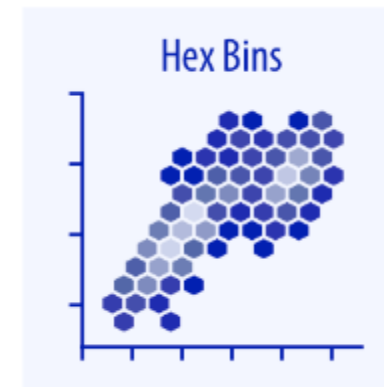
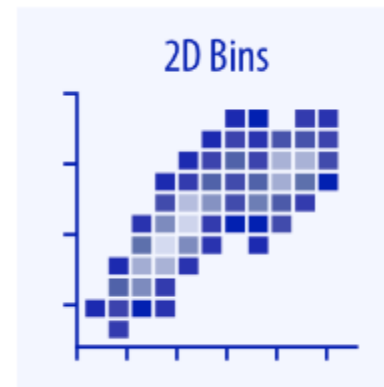
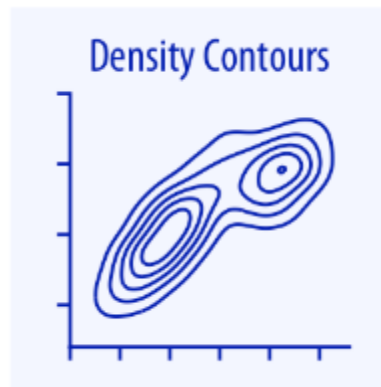
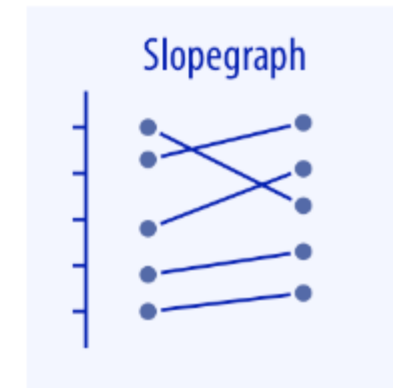
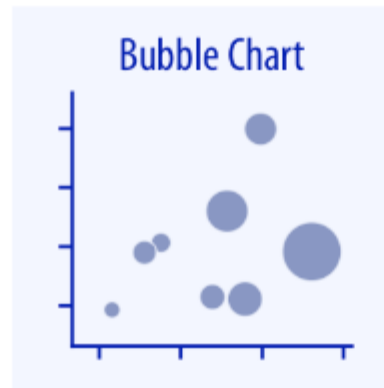
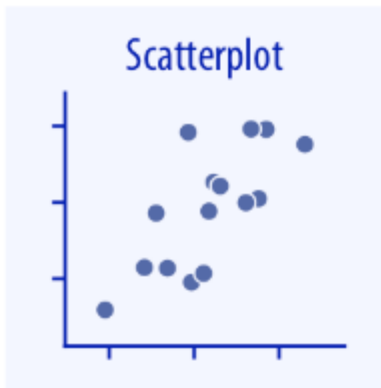
The “what”



Practice thoughtfulness:

As we flip through these chart types, consider the “who, when, where, and how” to which each of these charts would be appropriate and effective.

- Multivariate relationships



The “what”

- Geospatial



Practice thoughtfulness:

As we flip through these chart types, consider the “who, when, where, and how” to which each of these charts would be appropriate and effective.

Map



Choropleth



Cartogram



Cartogram Heatmap



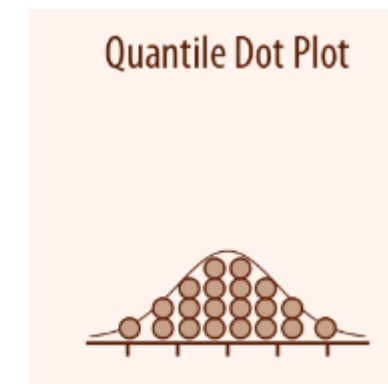
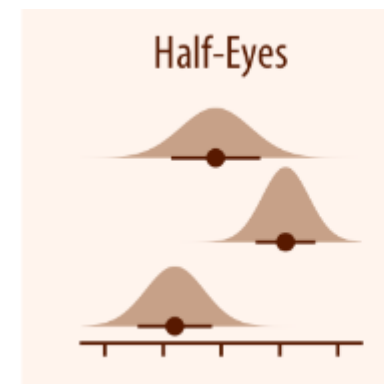
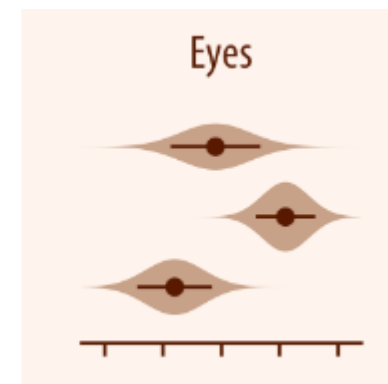
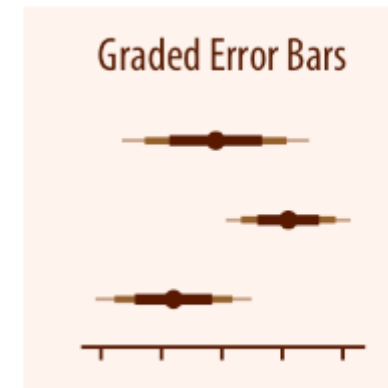
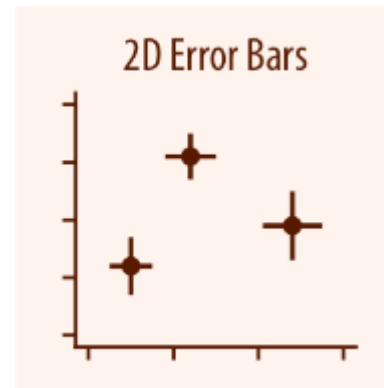
The “what”



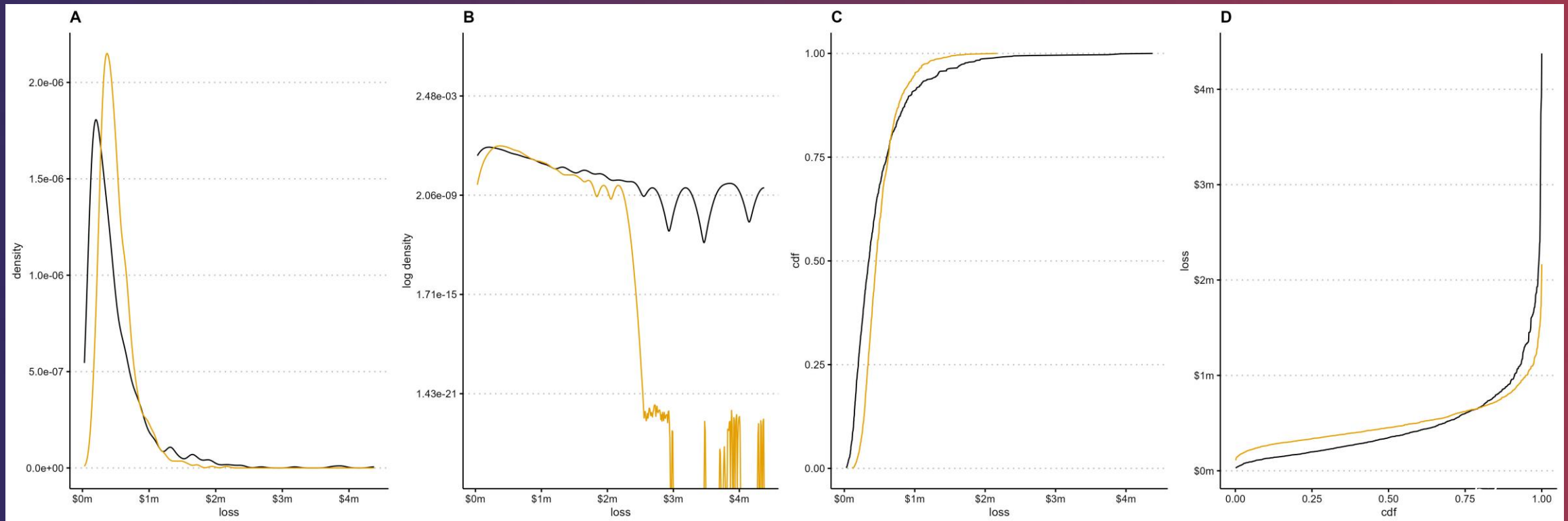
Practice thoughtfulness:

As we flip through these chart types, consider the “who, when, where, and how” to which each of these charts would be appropriate and effective.

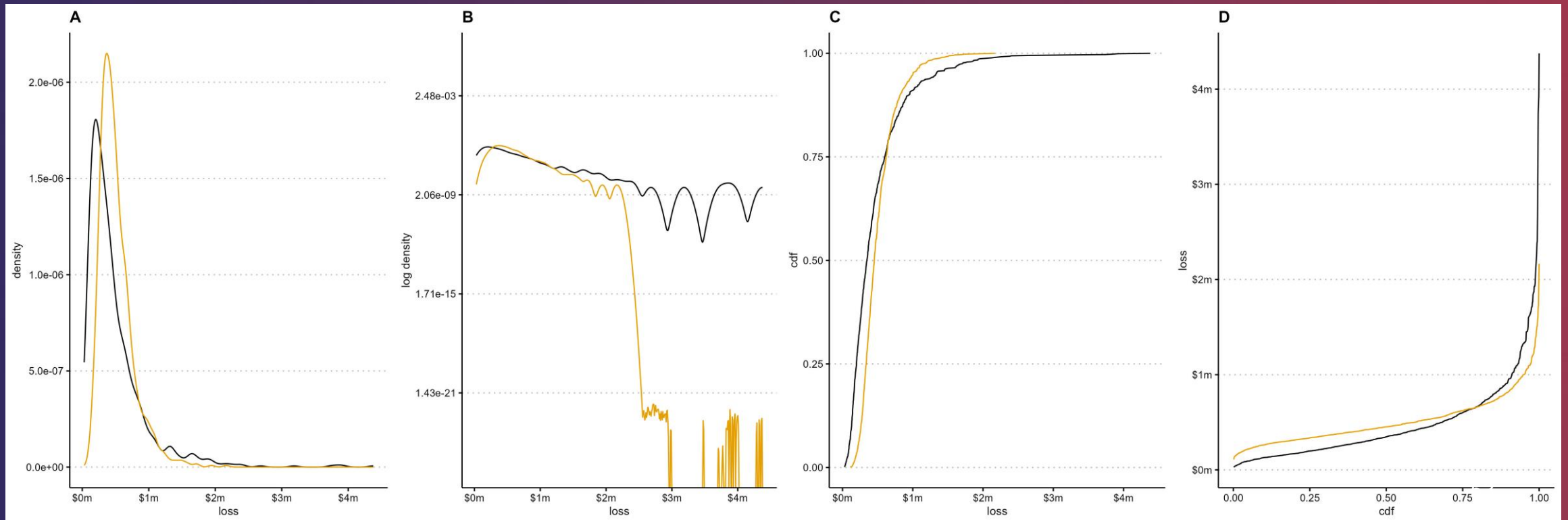
- Uncertainty



Poll: You want to communicate that a distribution is more heavy-tailed than the other. Which plot below would you choose for an actuarial audience?

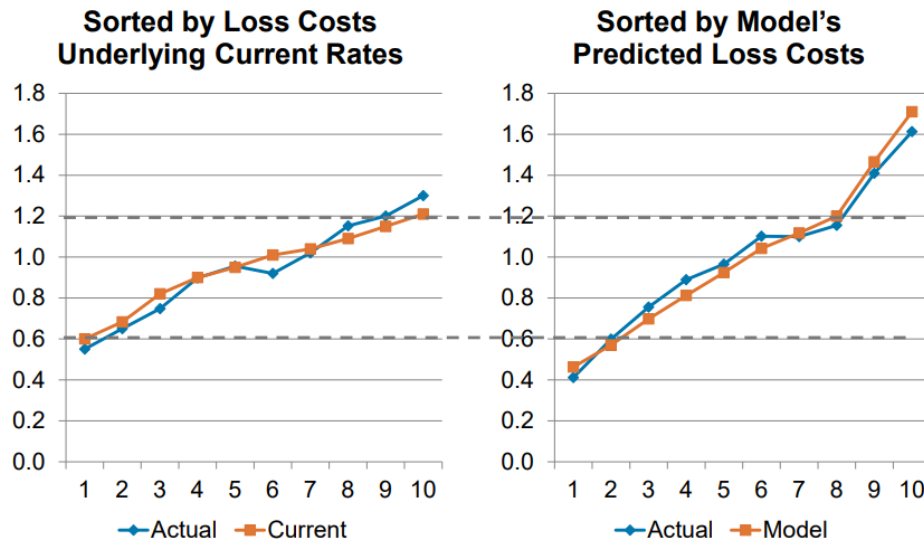


Poll: You want to communicate that a distribution is more heavy-tailed than the other. Which plot below would you choose for a non-actuarial audience?



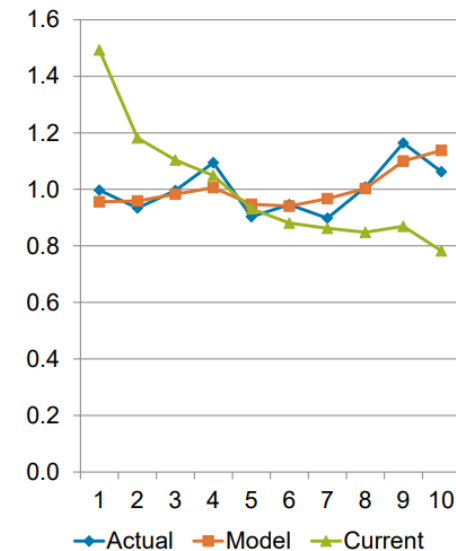
Poll: You want to communicate to management that your new predictive model is superior at differentiating high-cost policyholders from the low-cost ones. Which plot would you choose?

Model Lift – Simple Quantile Plots



Model Lift – Double Lift Charts

- Creating a double lift chart
 - Sort data by ratio of model prediction to current premium.
 - Subdivide sorted data into quantiles with equal exposure.
 - For each quantile calculate average actual loss cost, average model predicted loss cost and the average loss cost underlying the current manual premium.
 - Index the quantile averages to the overall averages.



Thank you!

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 <https://www.linkedin.com/in/enbojiang/>

 <https://github.com/enbojiang/cas-talks>

Remove
to improve
(the **data-ink** ratio)

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