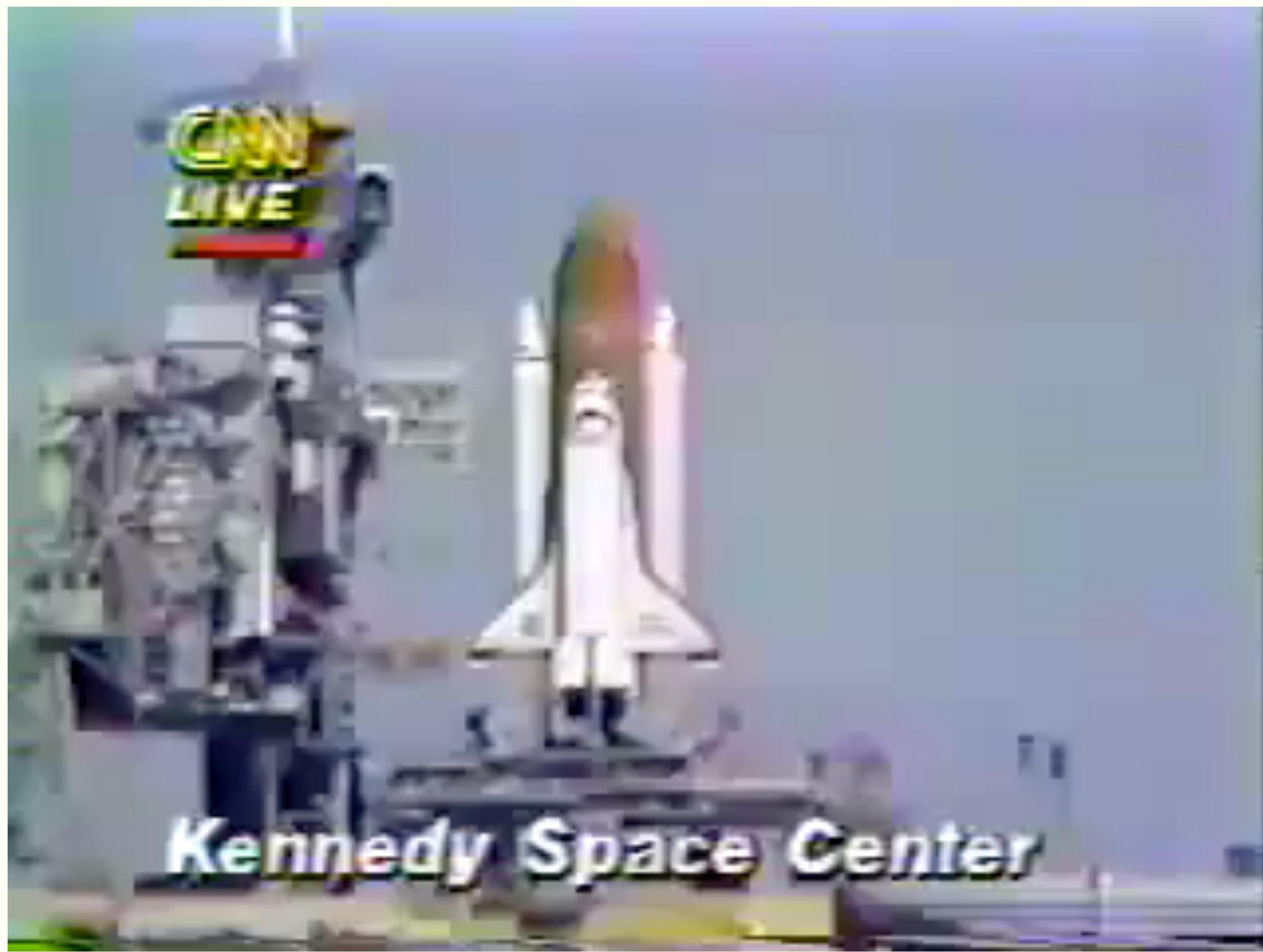


# Visualization For Communication

Rahul Dave, Chief Scientist, Univ.AI

# Today's plan

- Why Visualize?
- Best Practices for Visualization
- Hands-on Exercise
- Best Practices for Visualization(counted)
- Storytelling



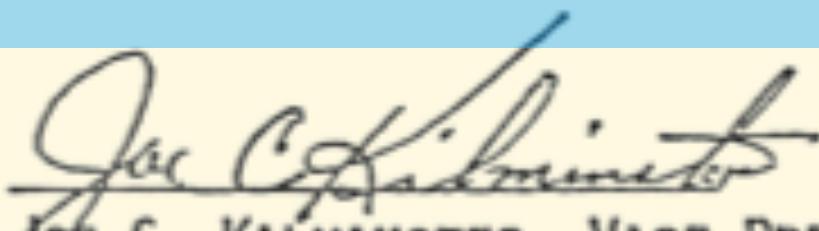
(CNN)

Univ. Al

the previous day...

#### MTI ASSESSMENT OF TEMPERATURE CONCERN ON SRM-25 (51L) LAUNCH

- 0 CALCULATIONS SHOW THAT SRM-25 O-RINGS WILL BE 20° COLDER THAN SRM-15 O-RINGS
- 0 TEMPERATURE DATA NOT CONCLUSIVE ON PREDICTING PRIMARY O-RING BLOW-BY
- 0 ENGINEERING ASSESSMENT IS THAT:
  - 0 COLDER O-RINGS WILL HAVE INCREASED EFFECTIVE DUROMETER ("HARDER")
  - 0 "HARDER" O-RINGS WILL TAKE LONGER TO "SEAT"
  - 0 MORE GAS MAY PASS PRIMARY O-RING BEFORE THE PRIMARY SEAL SEATS (RELATIVE TO SRM-15)
    - 0 DEMONSTRATED SEALING THRESHOLD IS 3 TIMES GREATER THAN 0.038" EROSION EXPERIENCED ON SRM-15
  - 0 IF THE PRIMARY SEAL DOES NOT SEAT, THE SECONDARY SEAL WILL SEAT
    - 0 PRESSURE WILL GET TO SECONDARY SEAL BEFORE THE METAL PARTS ROTATE
      - 0 O-RING PRESSURE LEAK CHECK PLACES SECONDARY SEAL IN OUTBOARD POSITION WHICH MINIMIZES SEALING TIME
- 0 MTI RECOMMENDS STS-51L LAUNCH PROCEED ON 28 JANUARY 1986
  - 0 SRM-25 WILL NOT BE SIGNIFICANTLY DIFFERENT FROM SRM-15

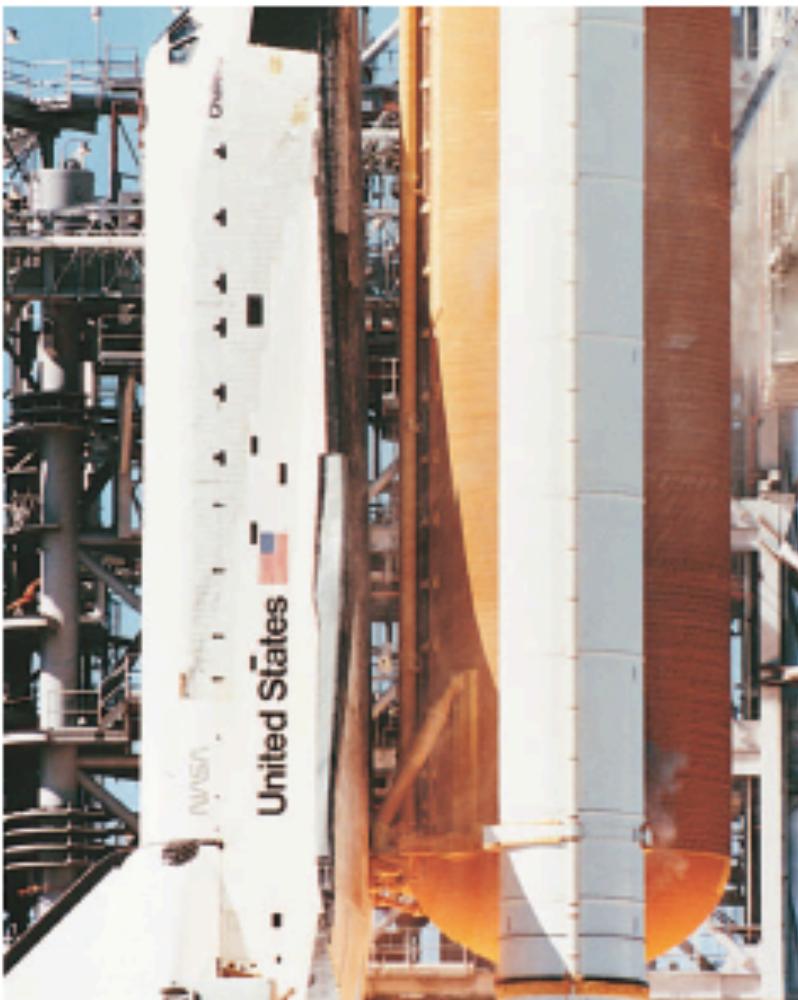


Joe C. Kilminster  
JOE C. KILMINSTER, VICE PRESIDENT  
SPACE BOOSTER PROGRAMS

MORTON THIOKOL INC.

Wasatch Division

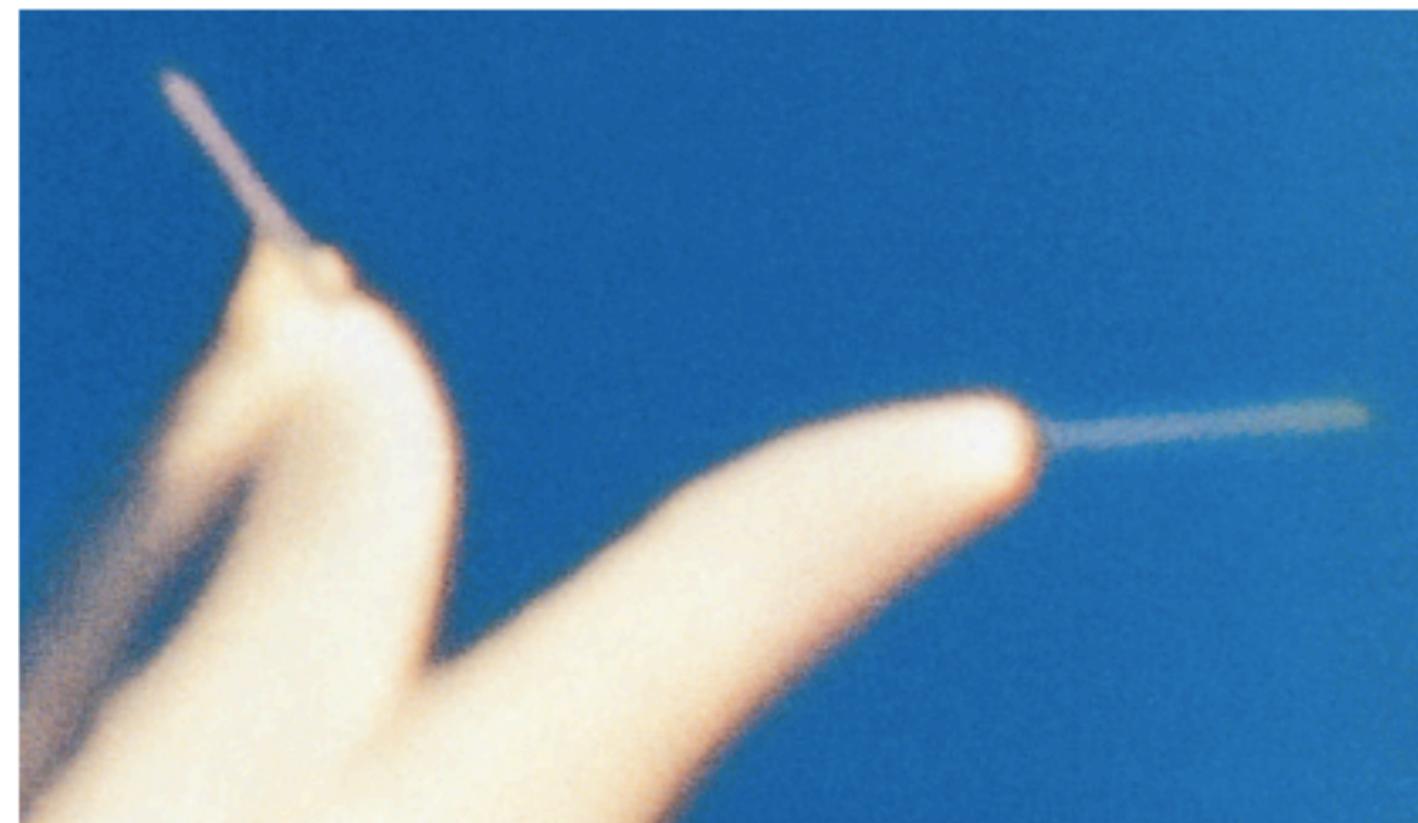
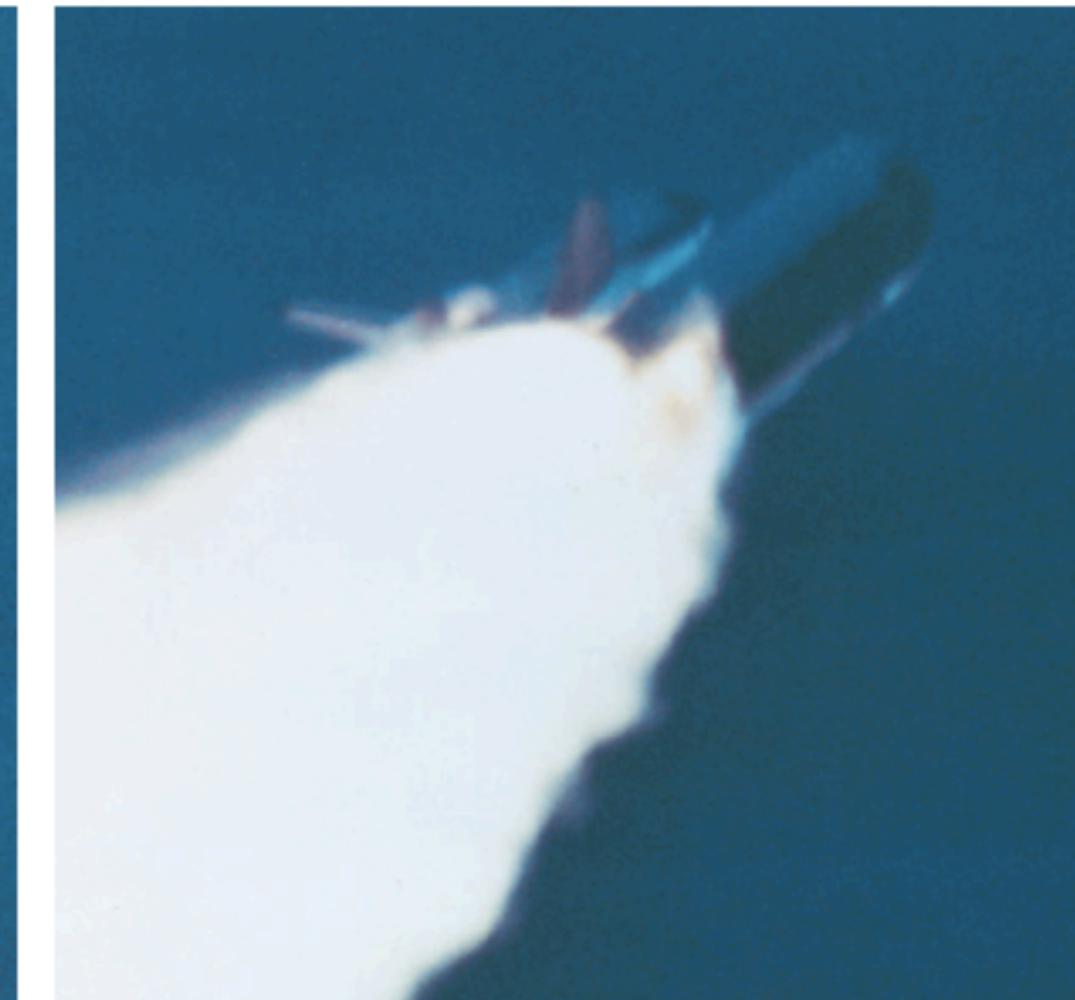
INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION  
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION



Less than 1 second after ignition, a puff of smoke appeared at the aft joint of the right booster, indicating that the O-rings burned through and failed to seal. At this point, all was lost.



On the launch pad, the leak lasted only about 2 seconds and then apparently was plugged by putty and insulation as the shuttle rose, flying through rather strong cross-winds. Then 58.788 seconds after ignition, when the Challenger was 6 miles up, a flicker of flame emerged from the leaky joint. Within seconds, the flame grew and engulfed the fuel tank (containing liquid hydrogen and liquid oxygen). That tank ruptured and exploded, destroying the shuttle.



As the shuttle exploded and broke up at approximately 73 seconds after launch, the two booster rockets crisscrossed and continued flying wildly. The right booster, identifiable by its failure plume, is now to the left of its non-defective counterpart.



The flight crew of Challenger 51-L. Front row, left to right: Michael J. Smith, pilot; Francis R. (Dick) Scobee, commander; Ronald E. McNair. Back row: Ellison S. Onizuka, S. Christa McAuliffe, Gregory B. Jarvis, Judith A. Resnik.

(VST, Tufte)

Univ. AI

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

	SRM No.	Cross Sectional View			Top View			Clocking Location (deg)
		Erosion Depth (in.)	Perimeter Affected (deg)	Nominal Dia. (in.)	Length Of Max Erosion (in.)	Total Heat Affected Length (in.)		
61A LH Center Field**	22A	None	None	0.280	None	None	36°--66°	
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°	
51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163	
51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354	
51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354	
41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275	
41C LH Aft Field*	11A	None	None	0.280	None	None	--	
41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351	
STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90	

\*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.

\*\*Soot behind primary O-ring.

\*\*\*Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

Engineer deck, the previous day...

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

### Blow By History

#### SRM-15 WORST Blow-By

- 2 CASE JOINTS (80°), (110°) Arc
- MUCH WORSE VISUALLY THAN SRM-22

#### SRM 22 Blow-By

- 2 CASE JOINTS (30-40°)

#### SRM-13A, 15, 16A, 18, 23A 24A

- NOZZLE Blow-By

(PCSSCA)

### HISTORY OF O-RING TEMPERATURES (DEGREES - F)

MOTOR	MBT	AMB	O-RING	WIND
DM-4	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29 27	10 MPH 25 MPH

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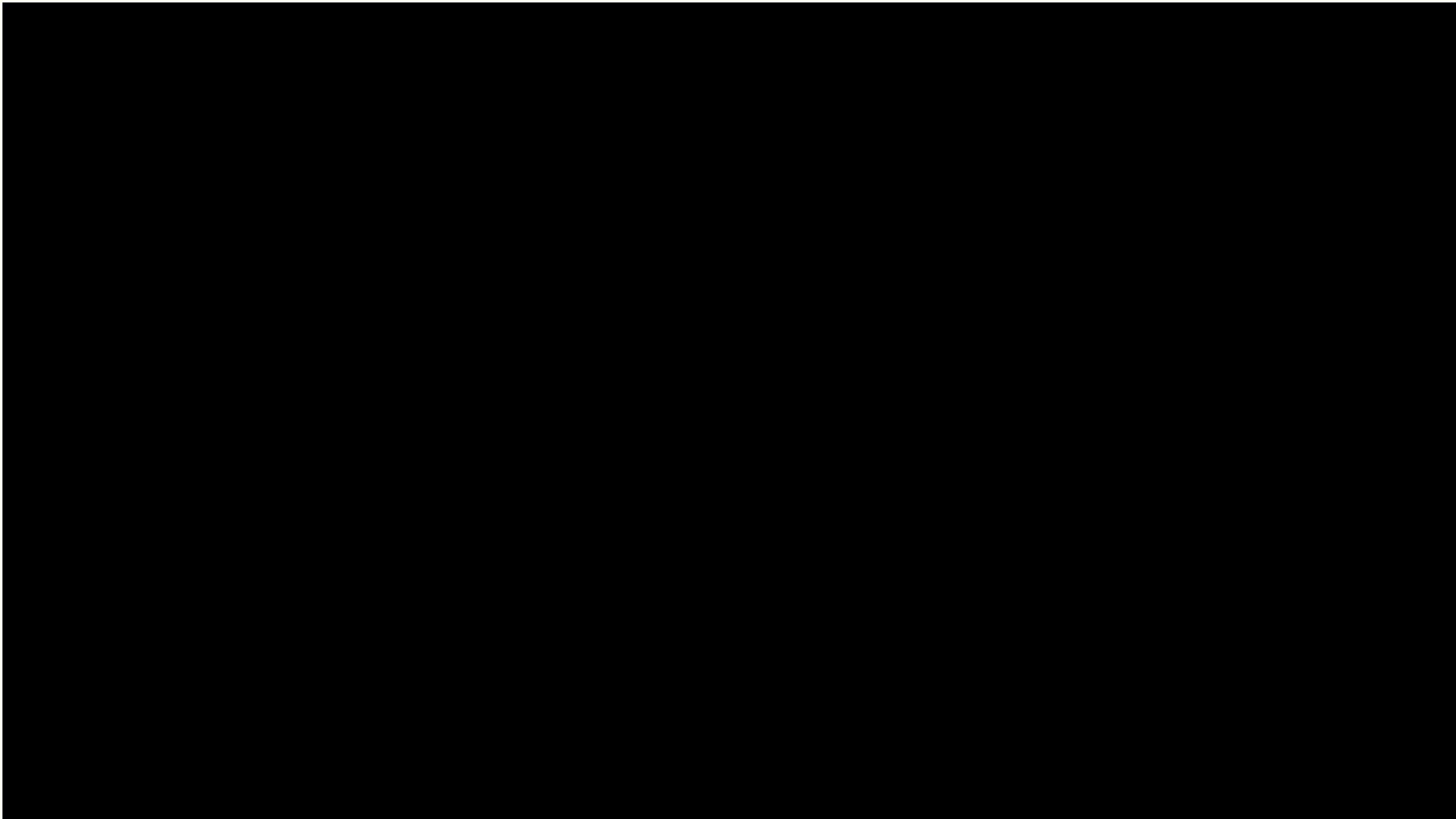
CONCLUSIONS :

- o TEMPERATURE OF O-RING IS NOT ONLY PARAMETER CONTROLLING BLOW-BY  
SRM 15 WITH BLOW-BY HAD AN O-RING TEMP AT 53°F  
SLM 2L WITH BLOW-BY HAD AN O-RING TEMP AT 75°F  
FOUR DEVELOPMENT MOTORS WITH NO BLOW-BY  
WERE TESTED AT O-RING TEMP OF 47° TO 52°F
- DEVELOPMENT MOTORS HAD PUTTY PACKING WHICH RESULTED IN BETTER PERFORMANCE
- o AT ABOUT 50°F BLOW-BY COULD BE EXPERIENCED IN CASE JOINTS
- o TEMP FOR SRM 25 ON 1-28-86 LAUNCH WILL BE 29°F 9 AM  
38°F 2 PM
- o HAVE NO DATA THAT WOULD INDICATE SRM 25 IS DIFFERENT THAN SRM 15 OTHER THAN TEMP

RECOMMENDATIONS :

- o O-RING TEMP MUST BE  $\geq$  53°F AT LAUNCH  
DEVELOPMENT MOTORS AT 47° To 52°F WITH PUTTY PACKING HAD NO BLOW-BY  
SRM 15 (THE BEST SIMULATION) WORKED AT 53°F
- o PROJECT AMBIENT CONDITIONS (TEMP & WIND)  
To DETERMINE LAUNCH TIME

(PCSSCA)



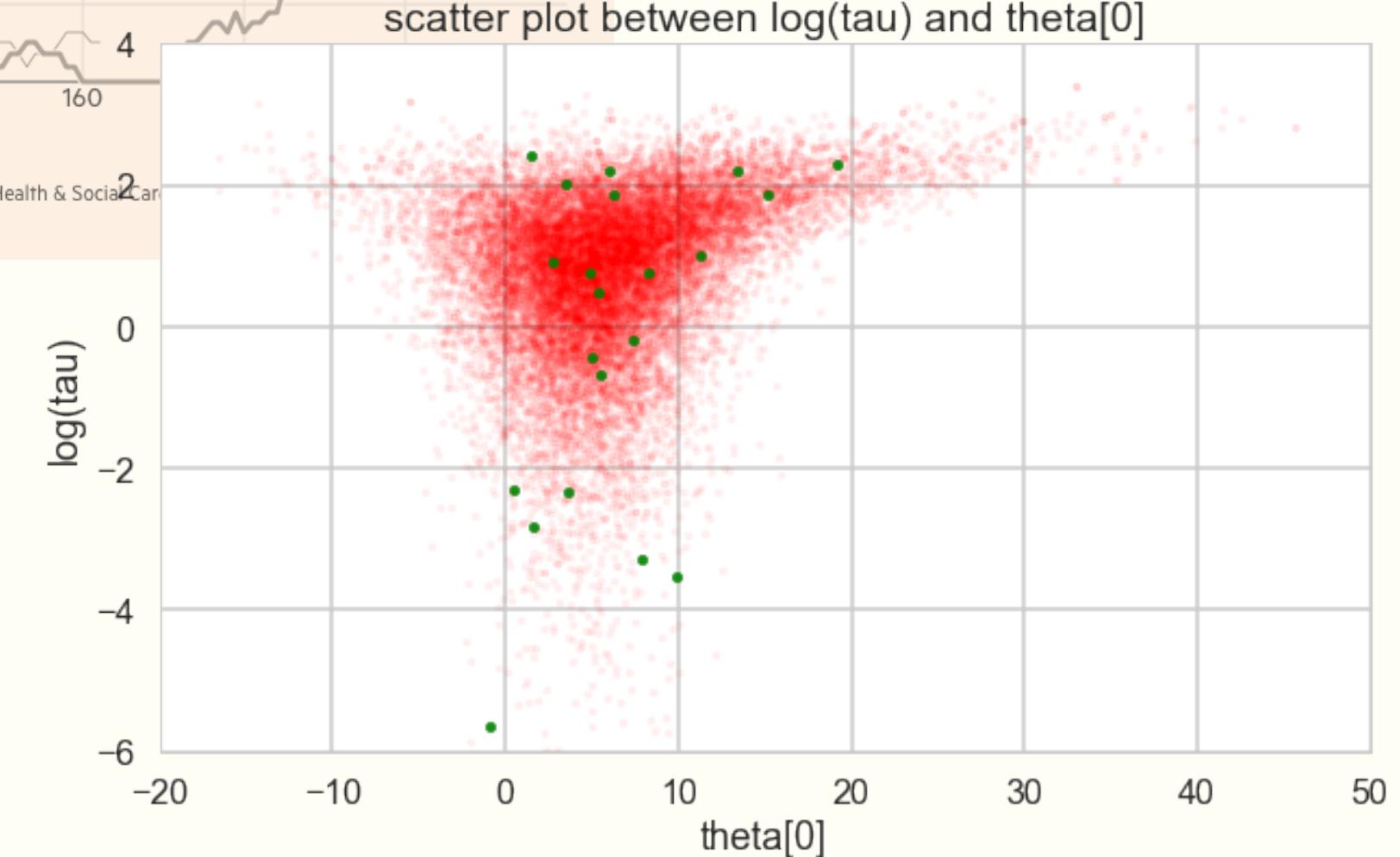
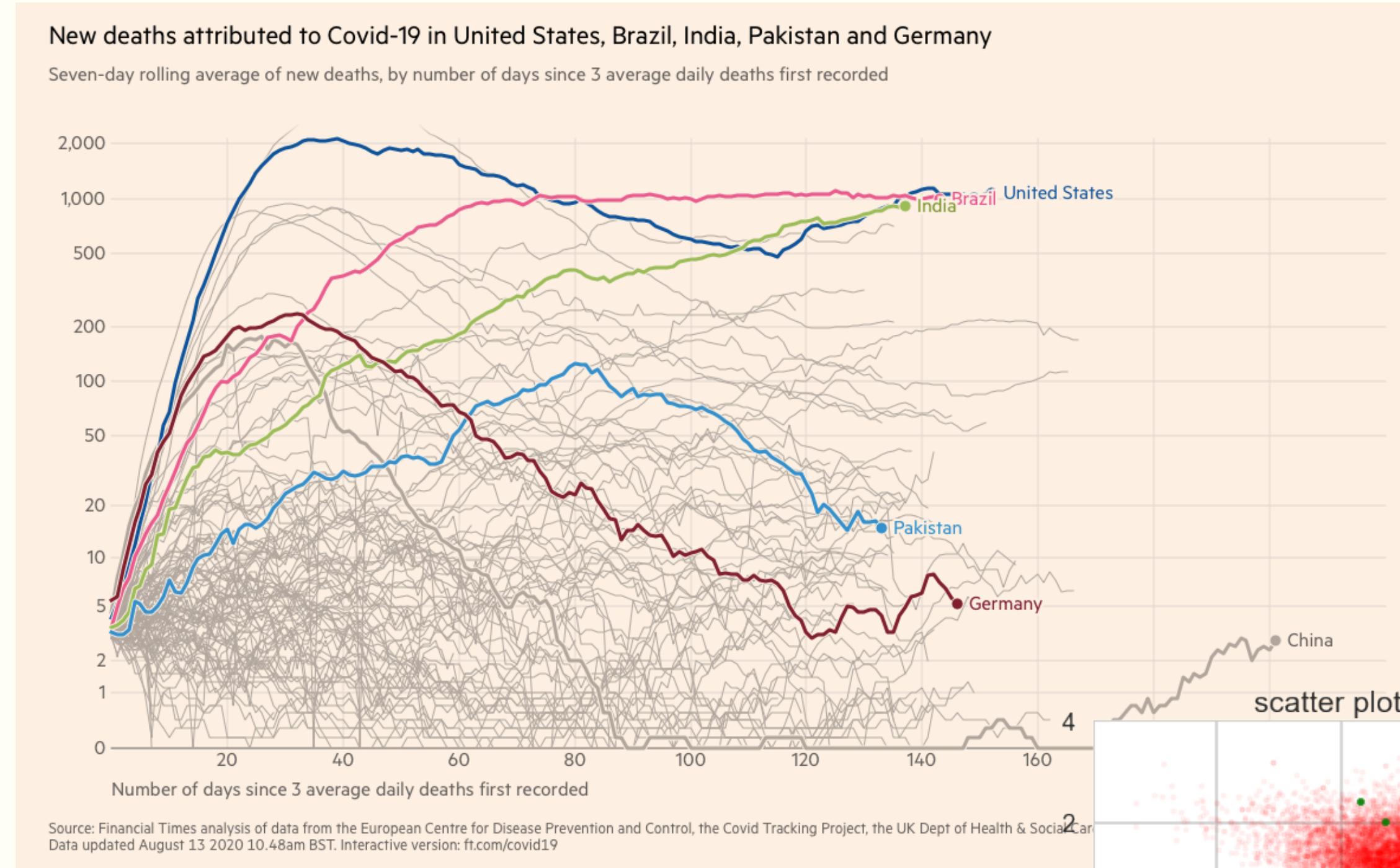
# Visualization Goals

- Communicate

- Present data and ideas
- Explain and inform
- Provide evidence and support
- Influence and persuade

- Analyze

- Explore the data, model
- Assess a situation
- Determine how to proceed
- Decide what to do



# Key Considerations

- Who is your **audience**?
- What **questions** are you answering?
- Why should the audience **care**?
- What are your major **insights** and surprises?
- What **change** to you want to affect?

# The Persuasive Power of Data Visualization

Anshul Vikram Pandey

*New York University*

Anjali Manivannan

*New York University*

Oded Nov

*New York University*

Margaret L. Satterthwaite

*NYU School of Law*, satterth@exchange.law.nyu.edu

Enrico Bertini

*New York University*

After looking into common effects in attitude formation and change we searched for specific mentions to the graphical appearance of charts as a driver for persuasion. Some of the comments we collected seem to back up the findings we found in our results. Some participants explicitly mention the charts as being the main reason for their change: "*I already knew that increased incarceration didn't lower crime, but I wasn't sure of the statistics. To see it on the graphs is really eye opening.*"; "*I was influenced by the bar graph showing the reasons why the survey respondents played video games.*"; "*I would not know exact numbers on this issue - the graphs gave a visual and helped identify the numbers*"; "*Seeing the graphs conflicted with my previous opinion, so I feel like I need to reevaluate my stance in a way.*"

It is also important to mention that the graphical appearance of charts is not the only factor that has a strong impact on people's attitude. In our collected feedback, we found numerous references to statistics and numbers, suggesting that mere exposure to data does have a persuasive effect – maybe at least partially due to the increased sense of objectivity evidence supported by numbers carries. We found comments like: "*It was concrete data that seemed compelling.*"; "*Seeing numbers is a good indicator of change rather than just reading what someone has to say*"; "*It showed a large amount of different sources, which made it more credible*". More research is needed to disentangle what kind of specific effects each of these components have on persuasion.

[http://lsr.nellco.org/cgi/viewcontent.cgi?article=1476&context=nyu\\_plltwp](http://lsr.nellco.org/cgi/viewcontent.cgi?article=1476&context=nyu_plltwp)

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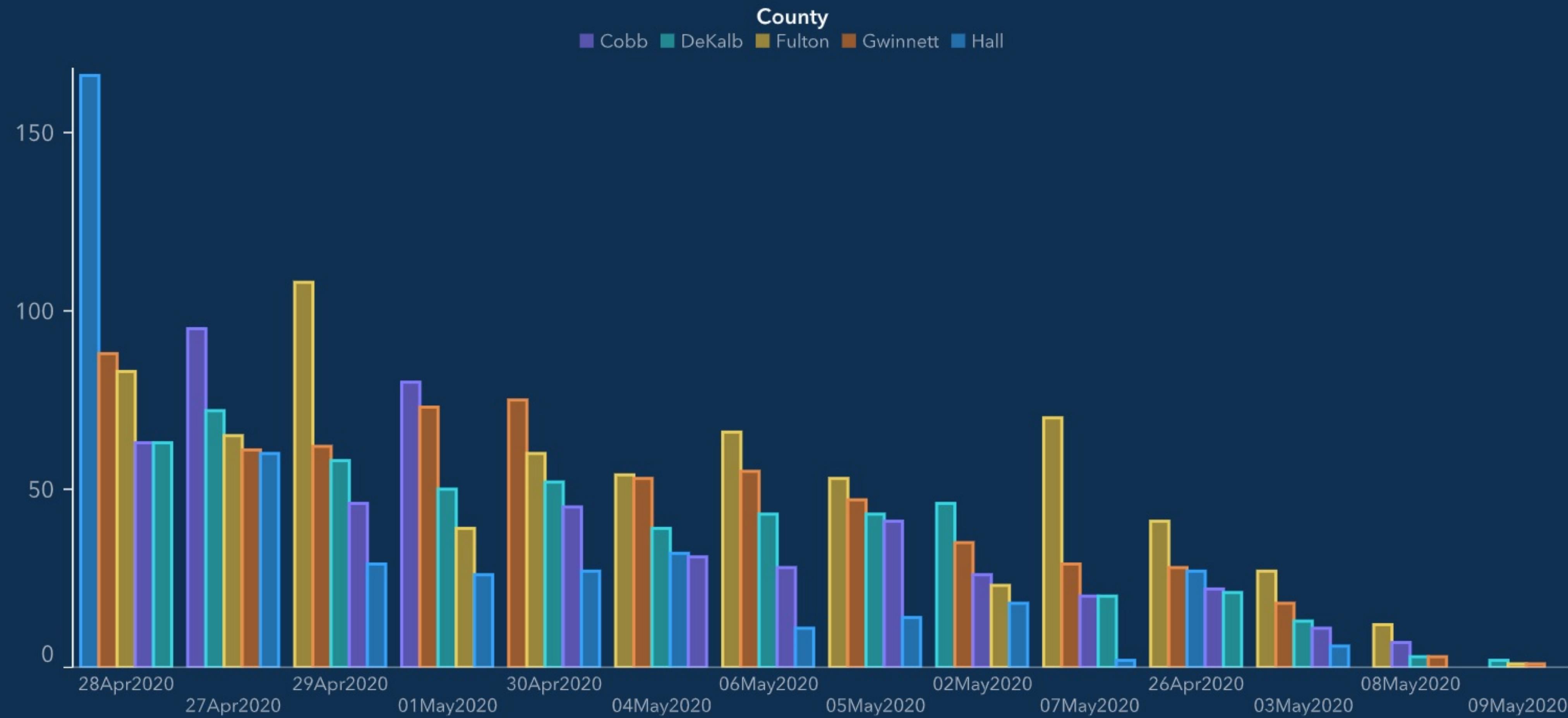
# Best Practices for Visualizations

1. Have graphical integrity
2. Keep it simple
3. Use the right display
4. Use color strategically
5. Know your audience

# 1. Have Graphical Integrity

## Top 5 Counties with the Greatest Number of Confirmed COVID-19 Cases

The chart below represents the most impacted counties over the past 15 days and the number of cases over time. The table below also represents the number of deaths and hospitalizations in each of those impacted counties.

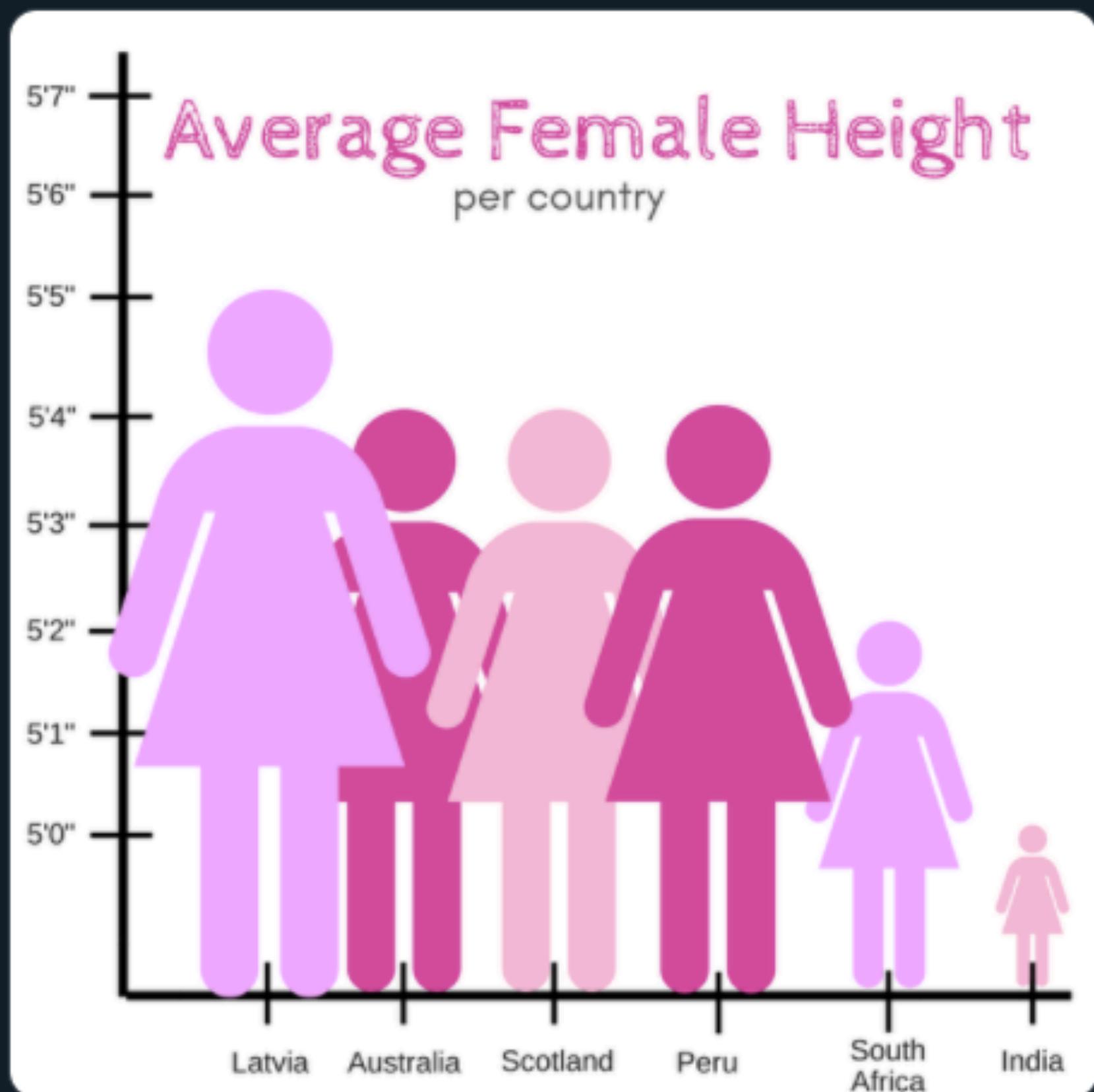


← Thread

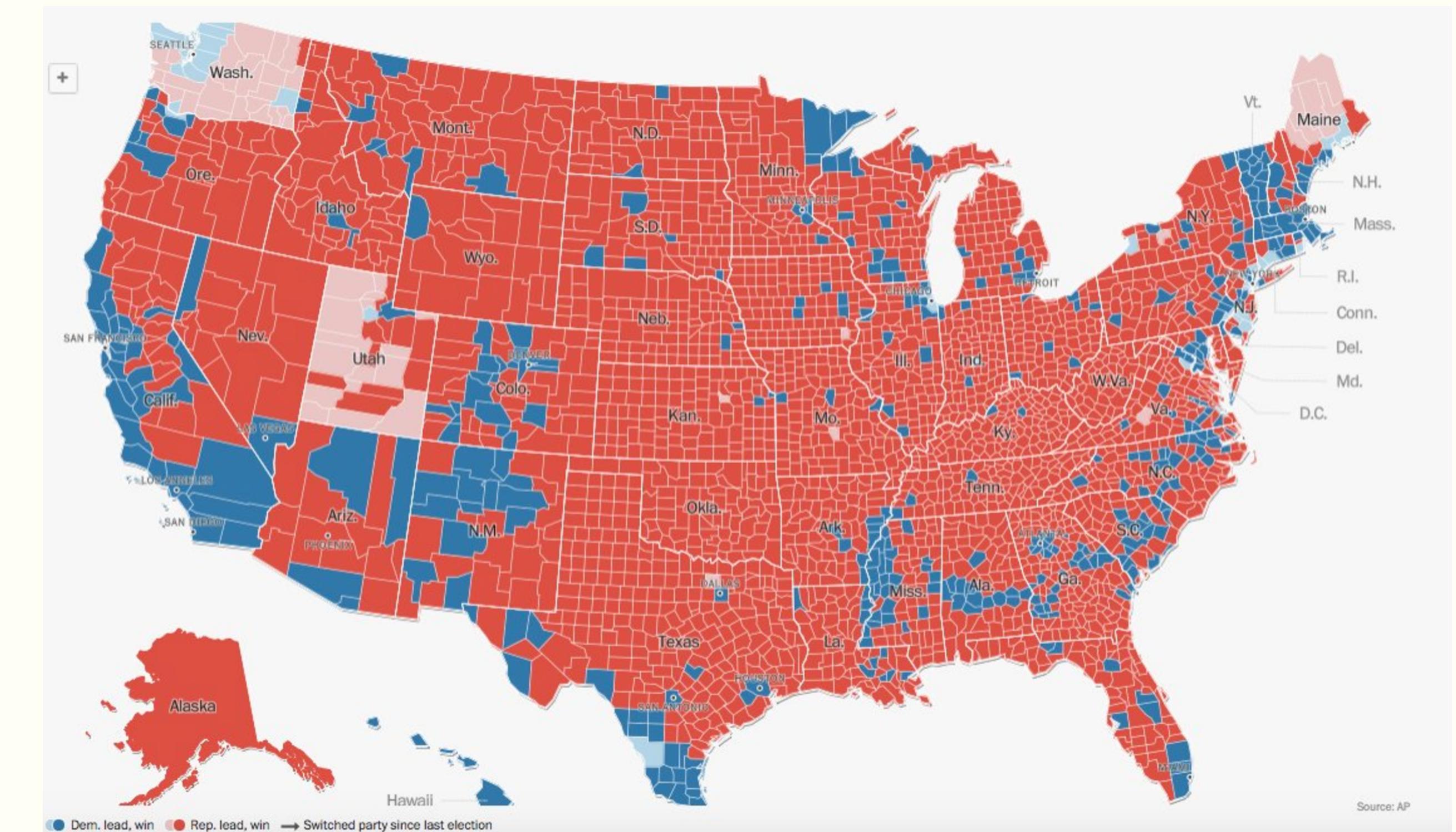


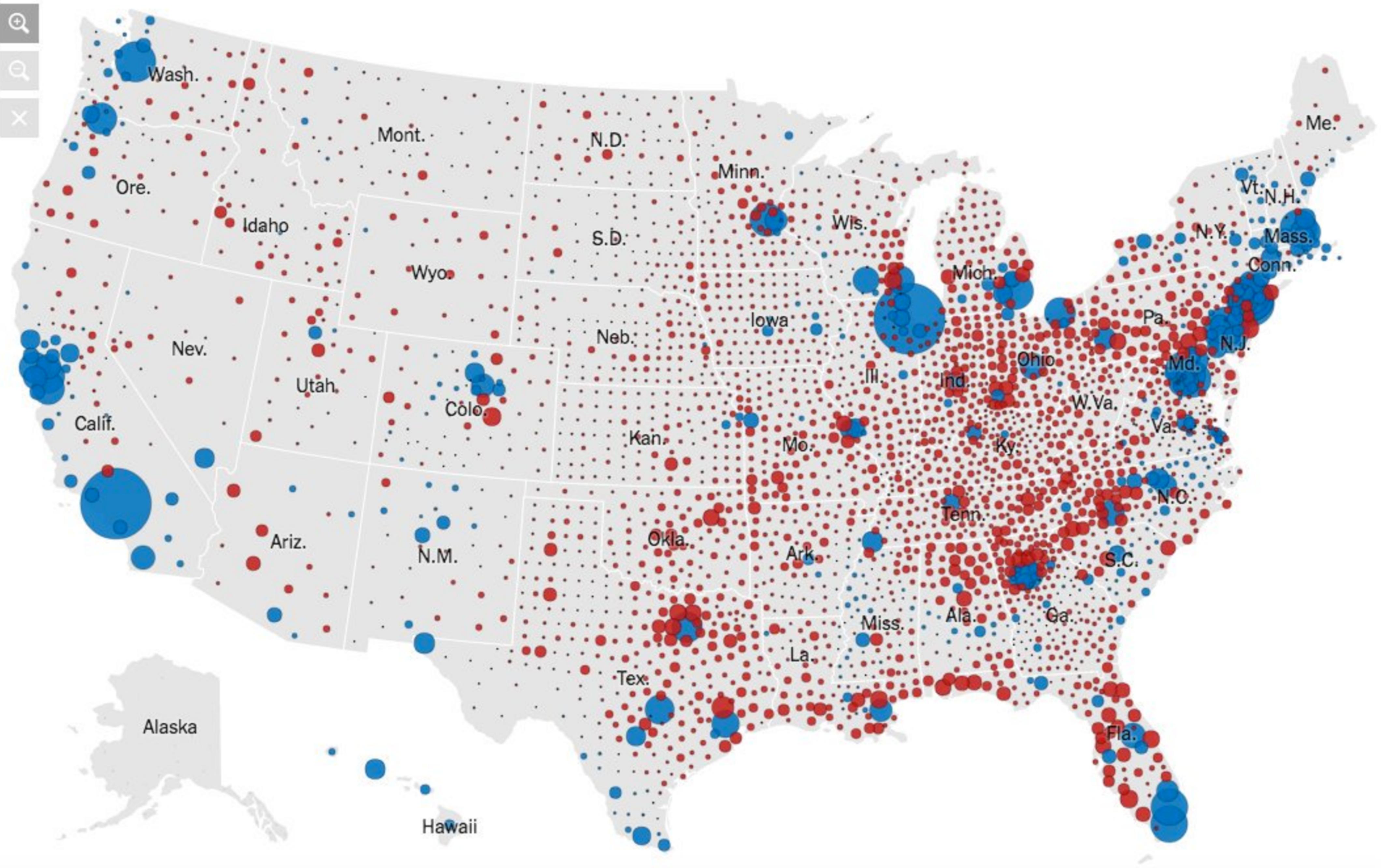
Sabah Ibrahim  
@reina\_sabah

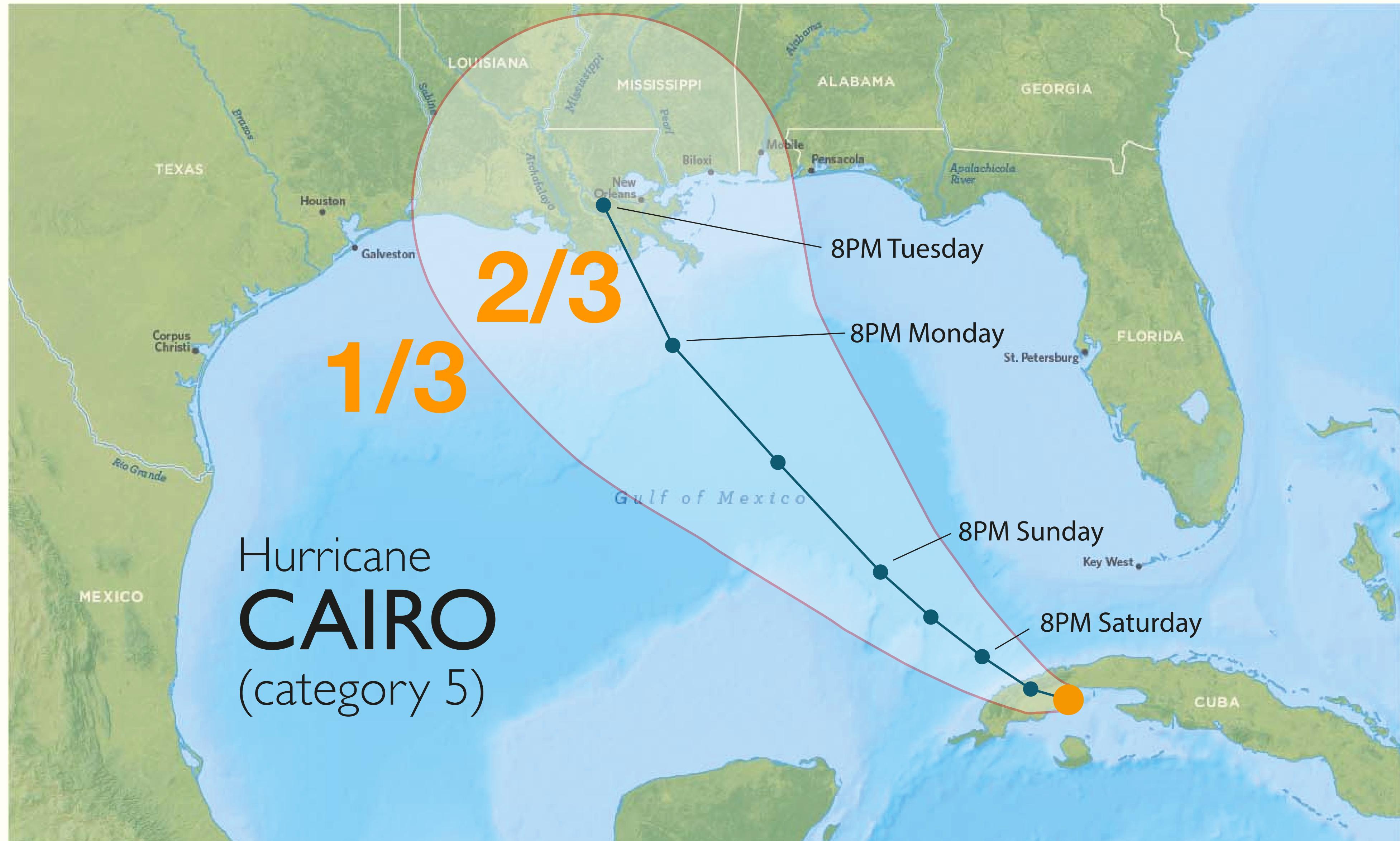
As an Indian woman, I can confirm that too much of my time is spent hiding behind a rock praying the terrifying gang of international giant ladies and their Latvian general don't find me



4:28 AM · Aug 7, 2020 · Twitter Web App







What non-scientists are not aware of (cone is just 66% probability region for the eye of the storm)

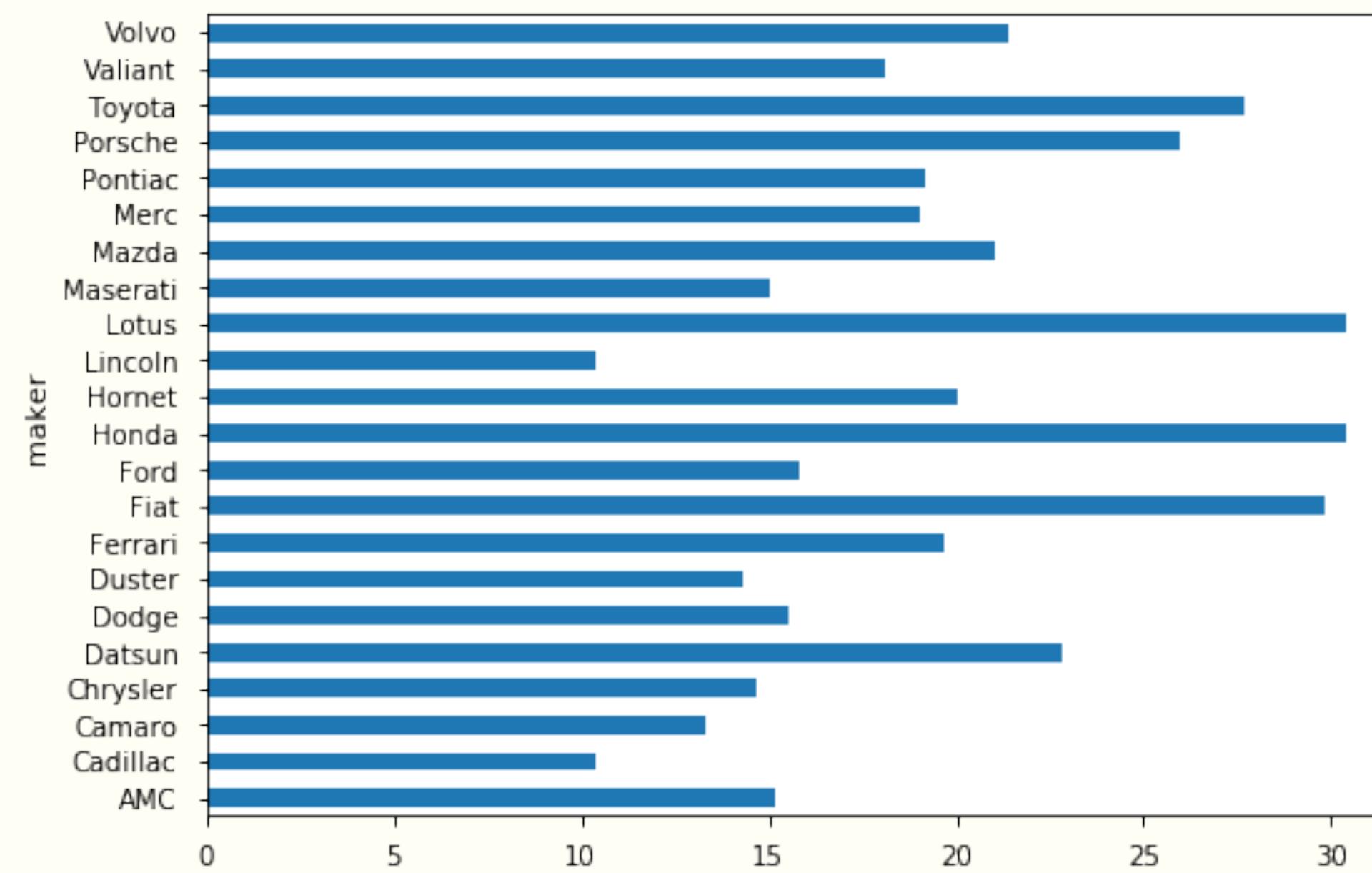


What we could be showing instead

# 2. Keep it Simple

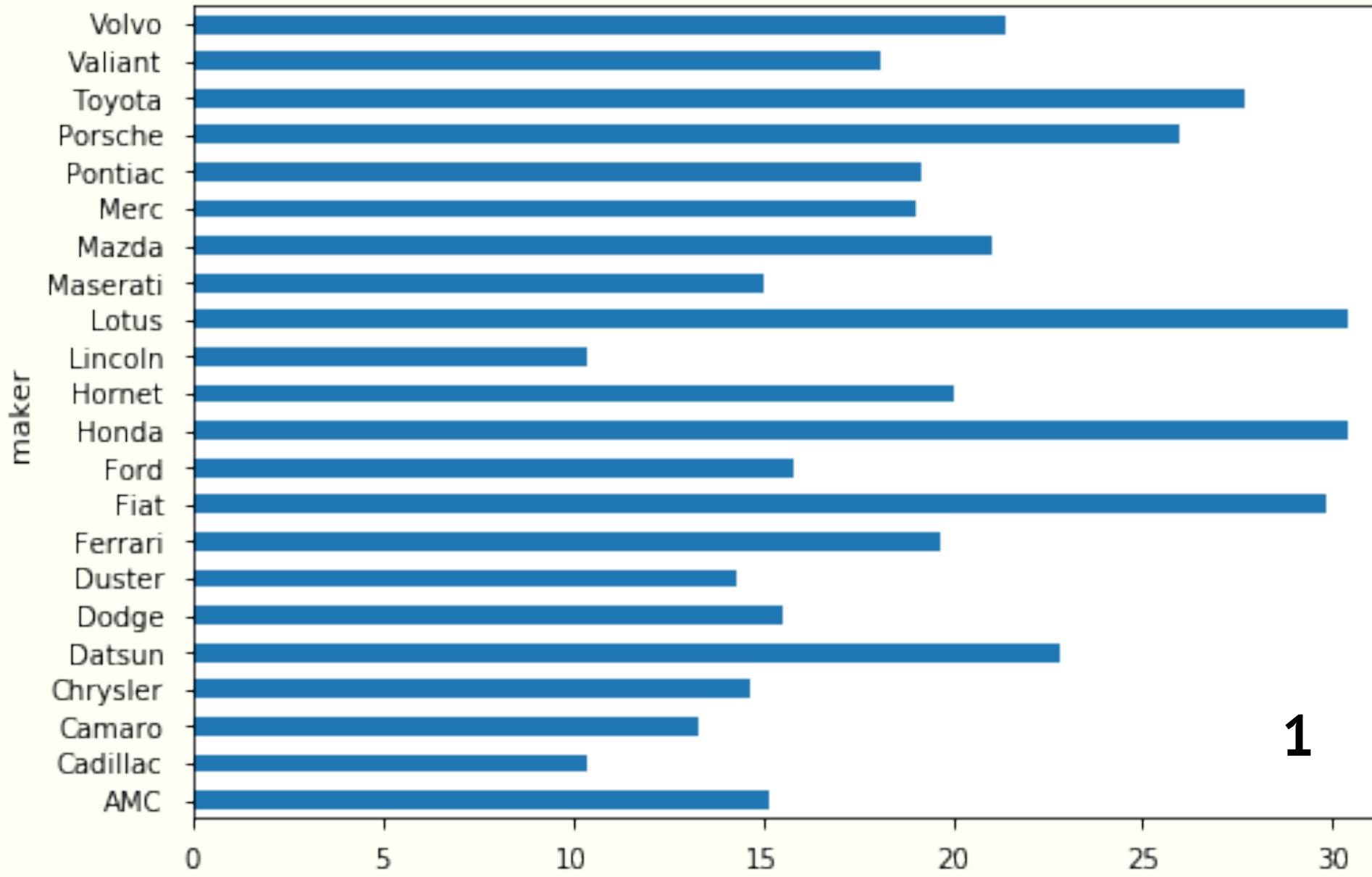
# Avoid Chartjunk

Extraneous visual elements that distract from the message should be removed.

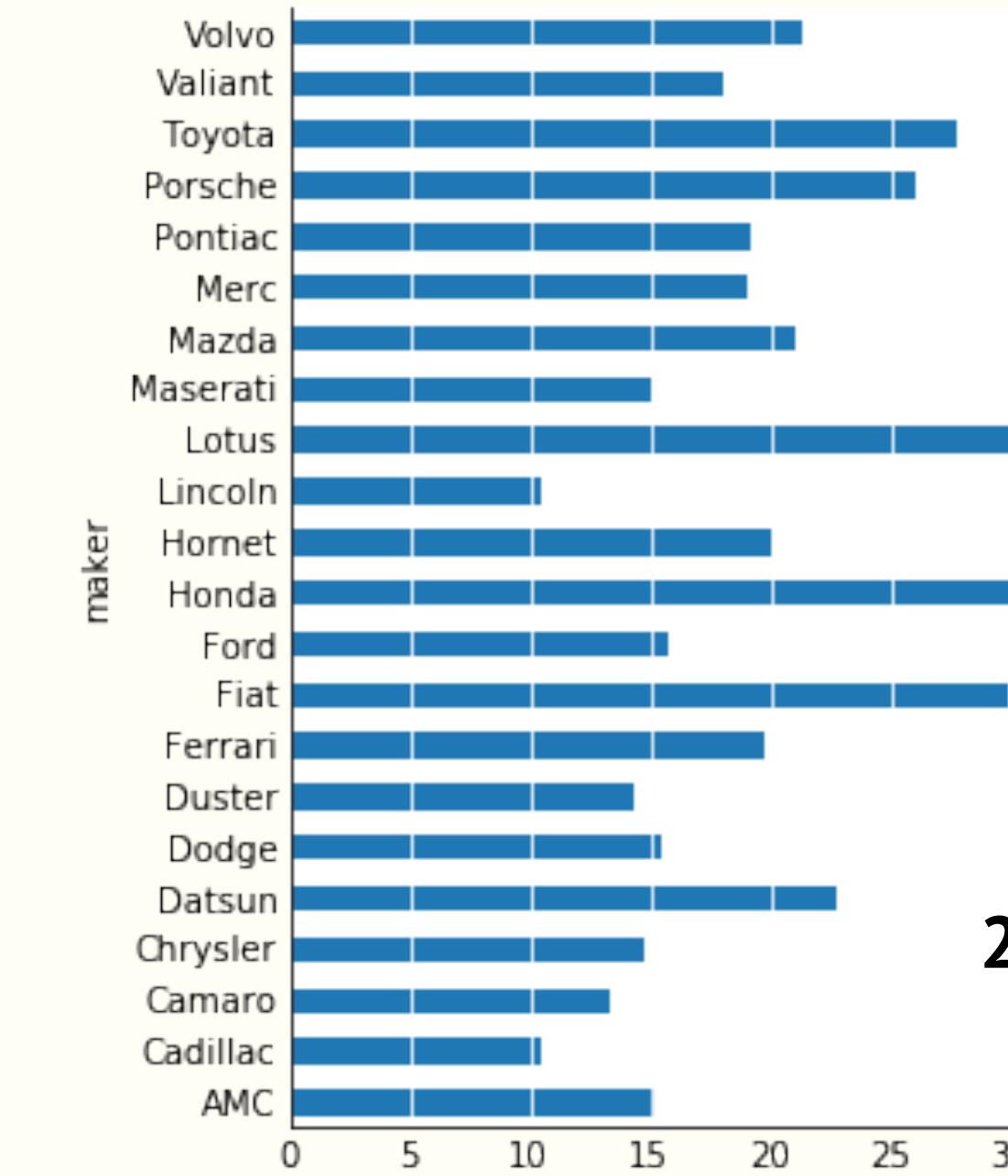


For example: tick-marks, frames, even numbers

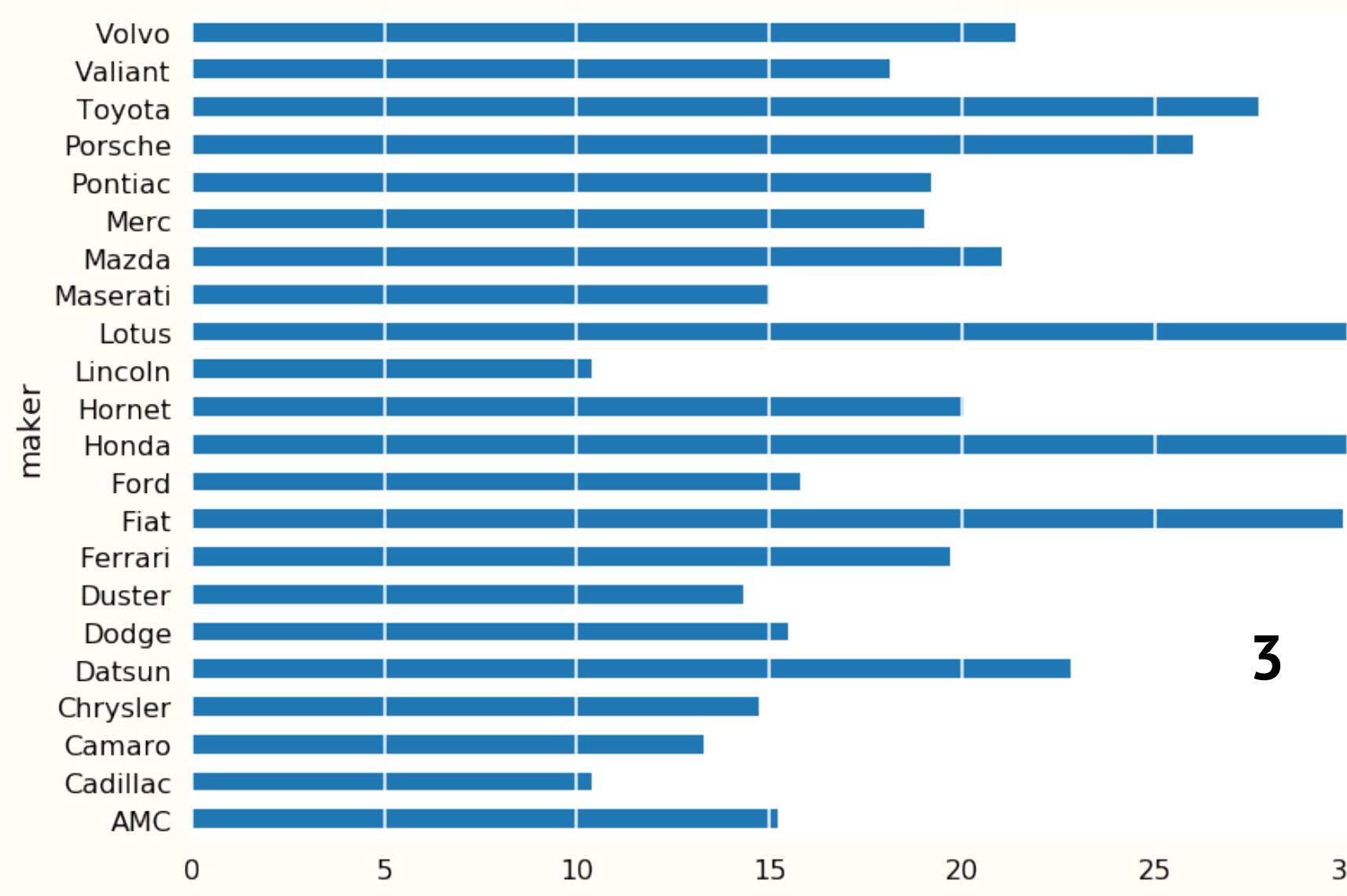
# The process of improvement.



1



2



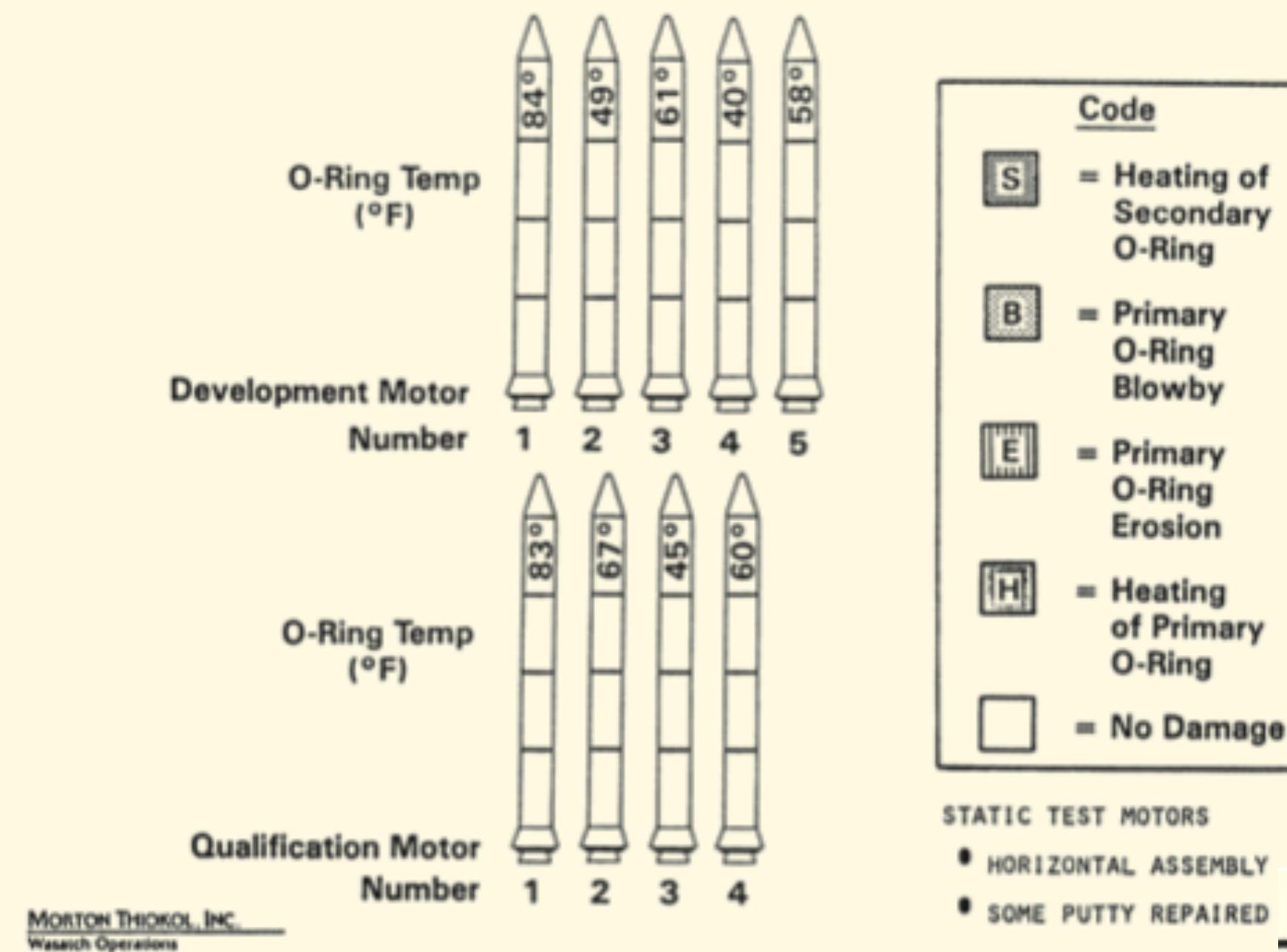
3

Honda	30.4
Lotus	30.4
Fiat	29.85
Toyota	27.7
Porsche	26.0
Datsun	22.8
Volvo	21.4
Mazda	21.0
Hornet	20.05
Ferrari	19.7
Pontiac	19.2
Merc	19.0142857143
Valiant	18.1
Ford	15.8
Dodge	15.5
AMC	15.2
Maserati	15.0
Chrysler	14.7
Duster	14.3
Camaro	13.3
Lincoln	10.4
Cadillac	10.4

4

# CODE EXERCISE

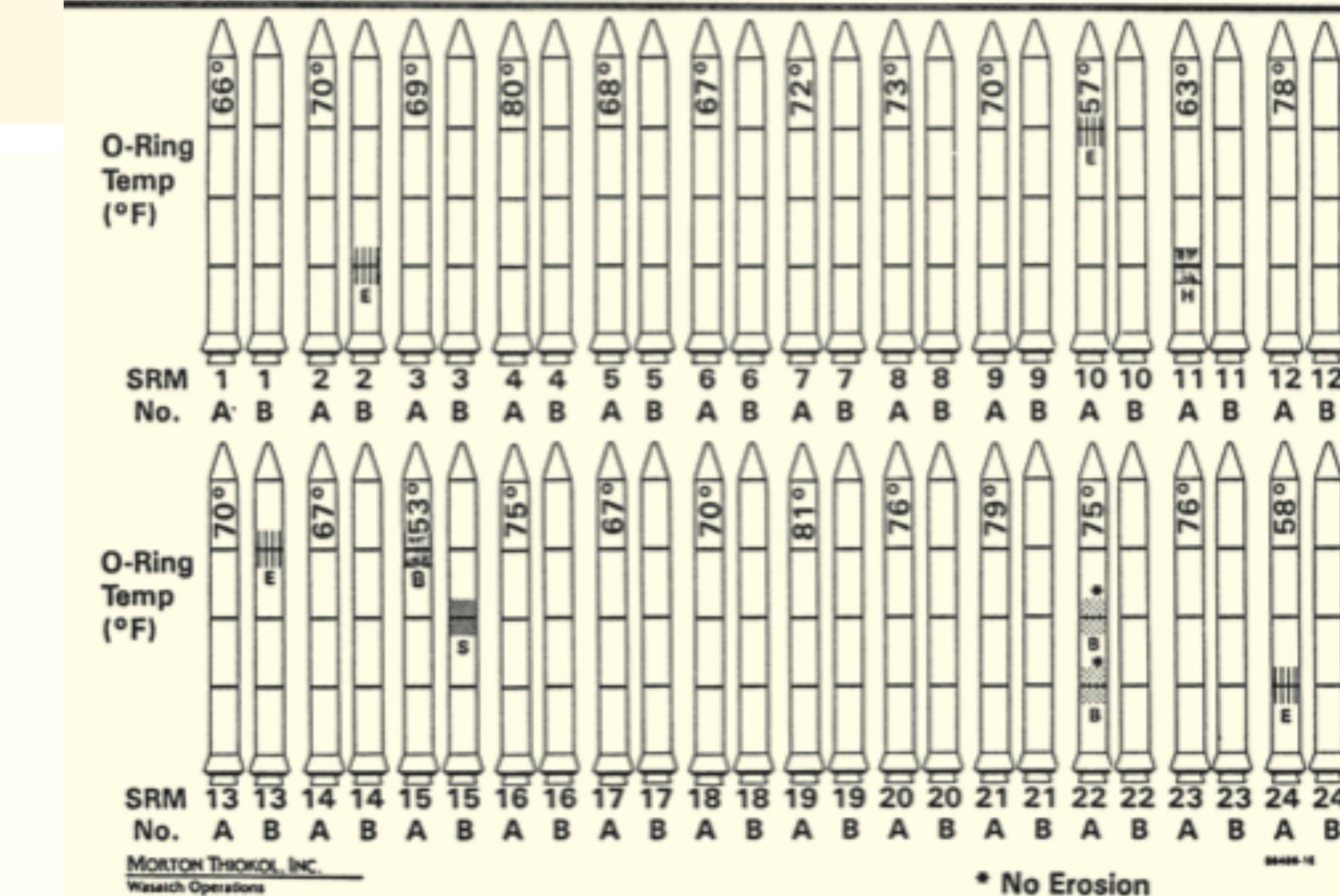
## History of O-Ring Damage in Field Joints



INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION  
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

## Chartjunk at hearings

## History of O-Ring Damage in Field Joints (Cont)



INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION  
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

(PCSSCA)

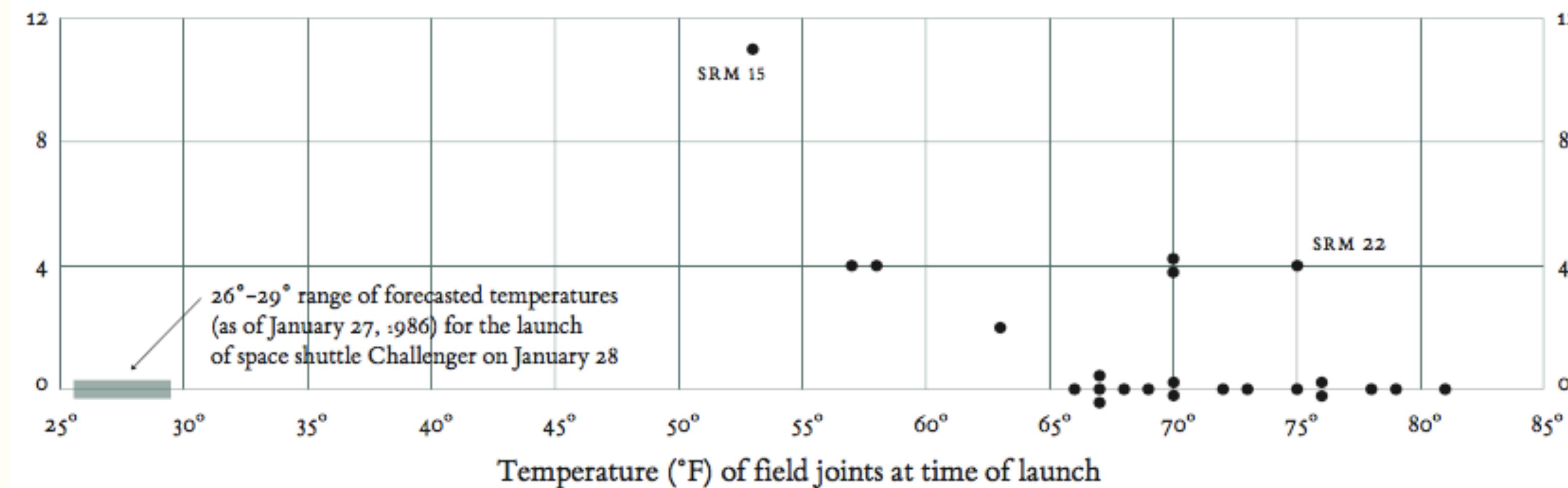
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Flight	Date	Temperature °F	Erosion incidents	Blow-by incidents	Damage index	Comments
51-C	01.24.85	53°	3	2	11	Most erosion any flight; blow-by; back-up rings heated.
41-B	02.03.84	57°	1		4	Deep, extensive erosion.
61-C	01.12.86	58°	1		4	O-ring erosion on launch two weeks before Challenger.
41-C	04.06.84	63°	1		2	O-rings showed signs of heating, but no damage.
1	04.12.81	66°			0	Coolest (66°) launch without O-ring problems.
6	04.04.83	67°			0	
51-A	11.08.84	67°			0	
51-D	04.12.85	67°			0	
5	11.11.82	68°			0	
3	03.22.82	69°			0	
2	11.12.81	70°	1		4	Extent of erosion not fully known.
9	11.28.83	70°			0	
41-D	08.30.84	70°	1		4	
51-G	06.17.85	70°			0	
7	06.18.83	72°			0	
8	08.30.83	73°			0	
51-B	04.29.85	75°			0	
61-A	10.30.85	75°	2		4	No erosion. Soot found behind two primary O-rings.
51-I	08.27.85	76°			0	
61-B	11.26.85	76°			0	
41-G	10.05.84	78°			0	
51-J	10.03.85	79°			0	
	06.27.82	80°			?	O-ring condition unknown; rocket casing lost at sea.
51-F	07.29.85	8				

O-ring damage index, each launch



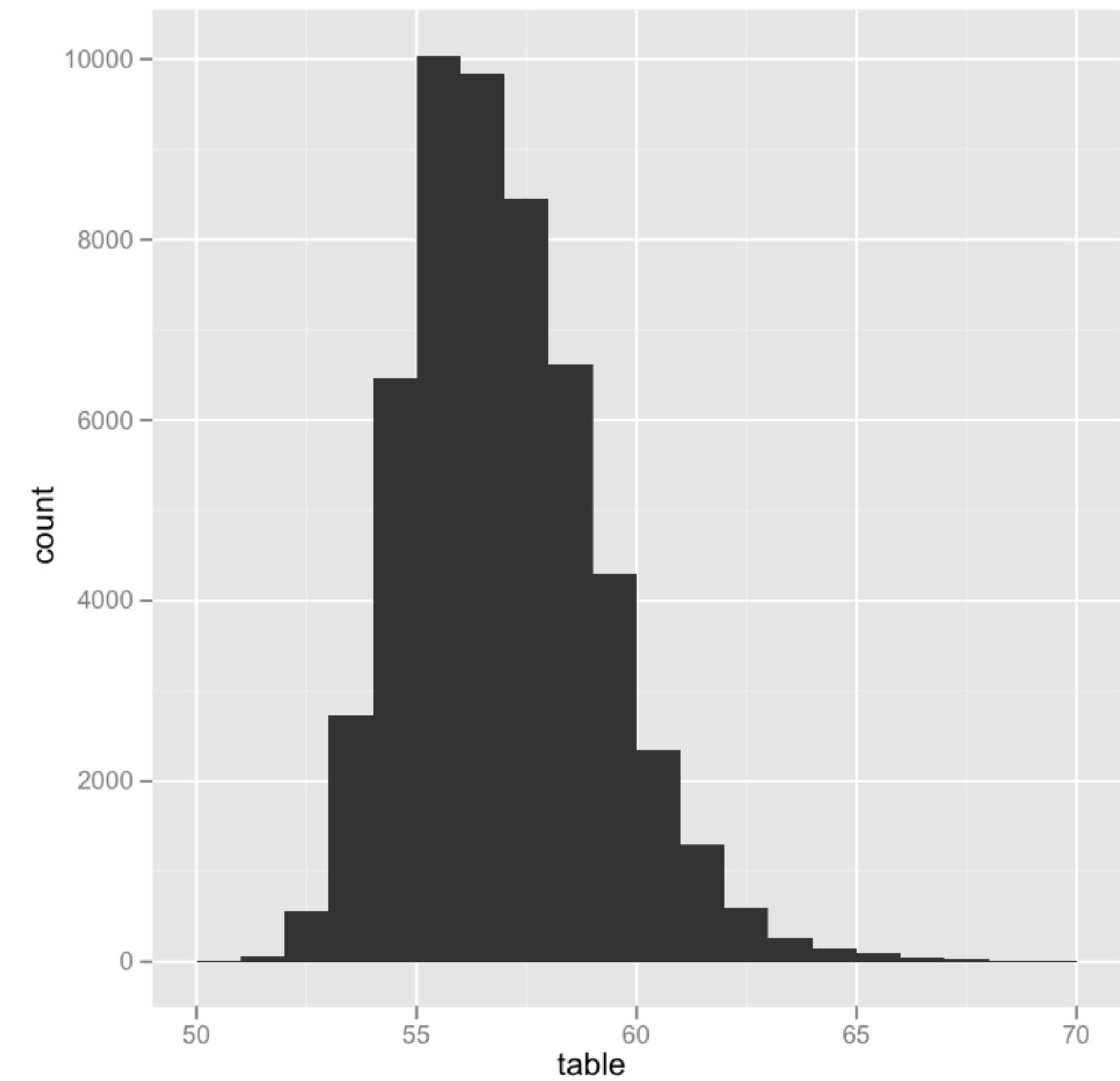
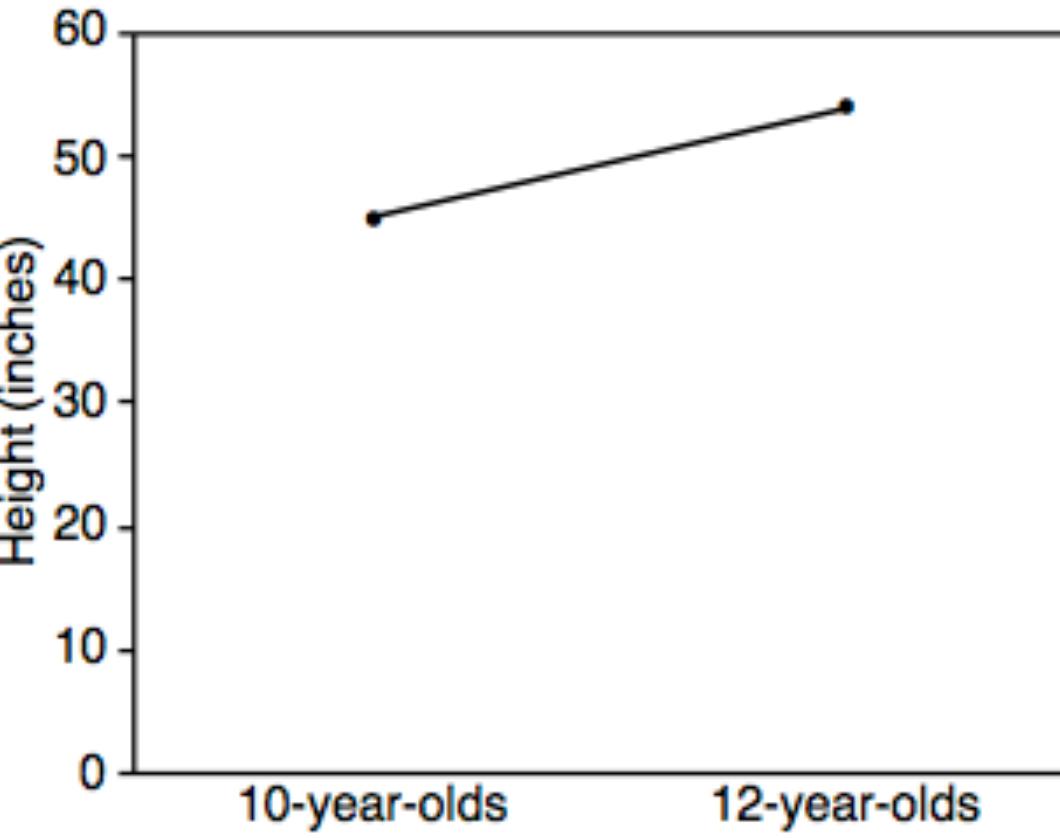
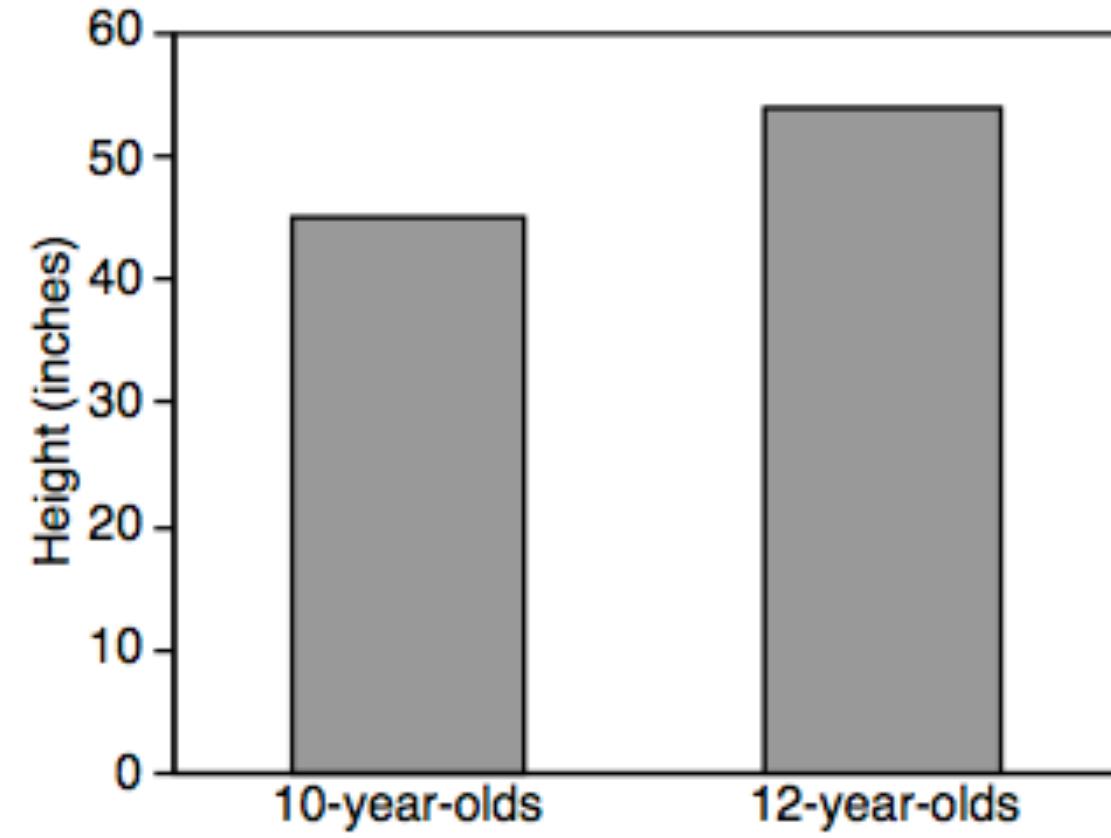
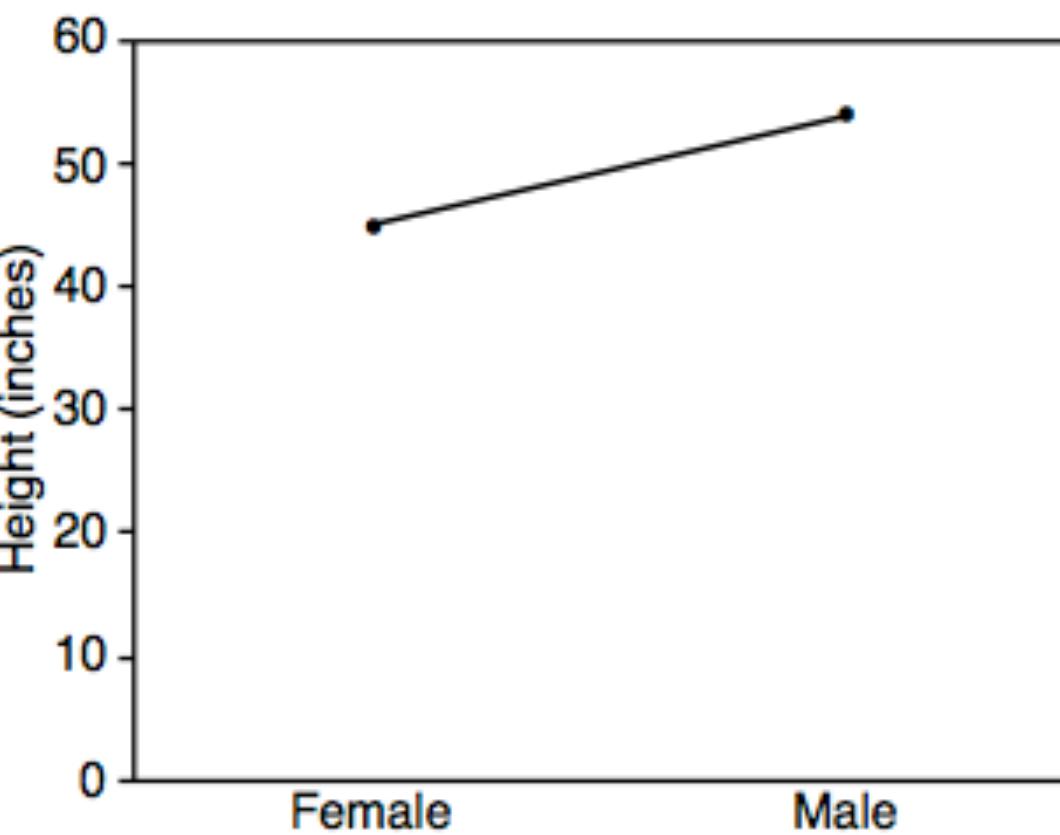
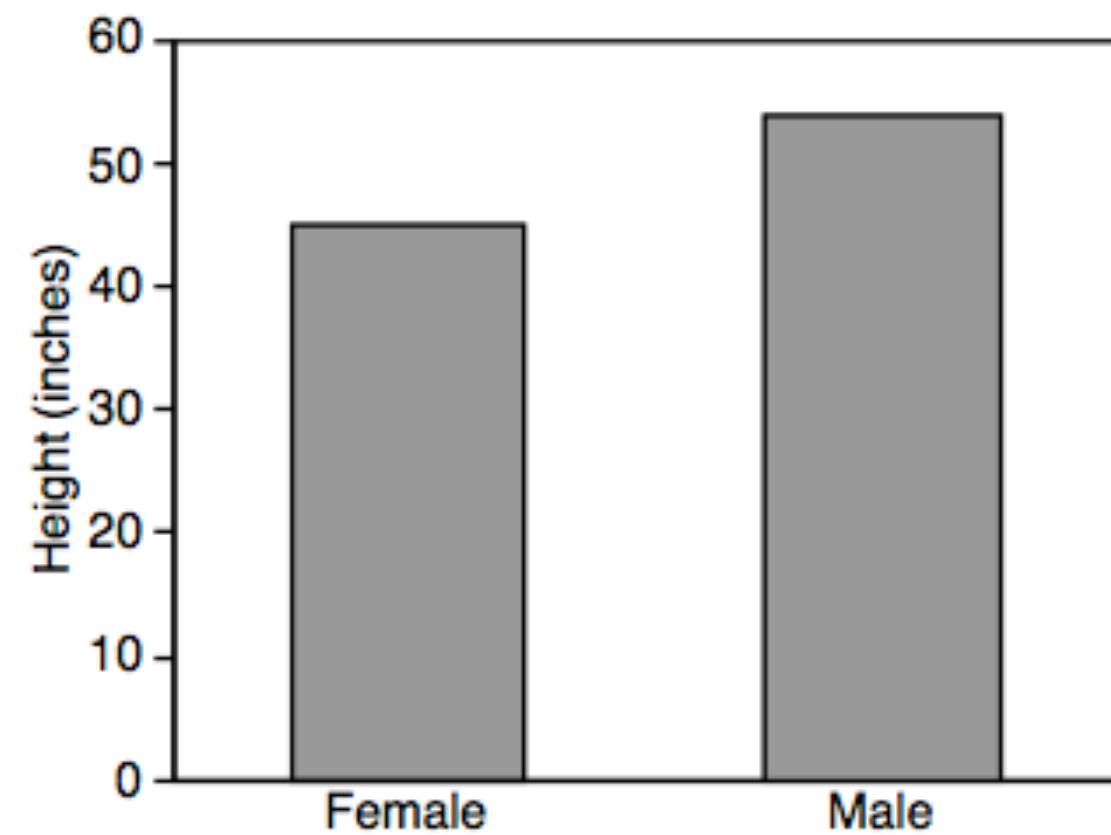
## SIMPLE RISK ASSESSMENT!



(VST, Tufte)

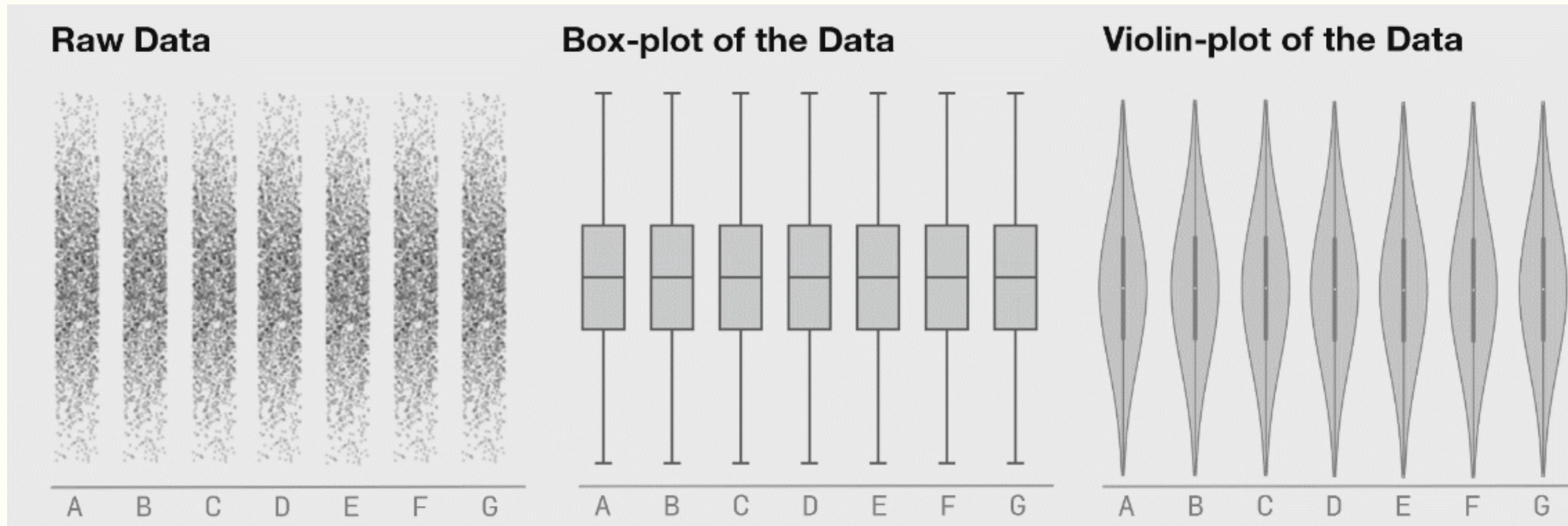
Univ. Al

3. Use the right display



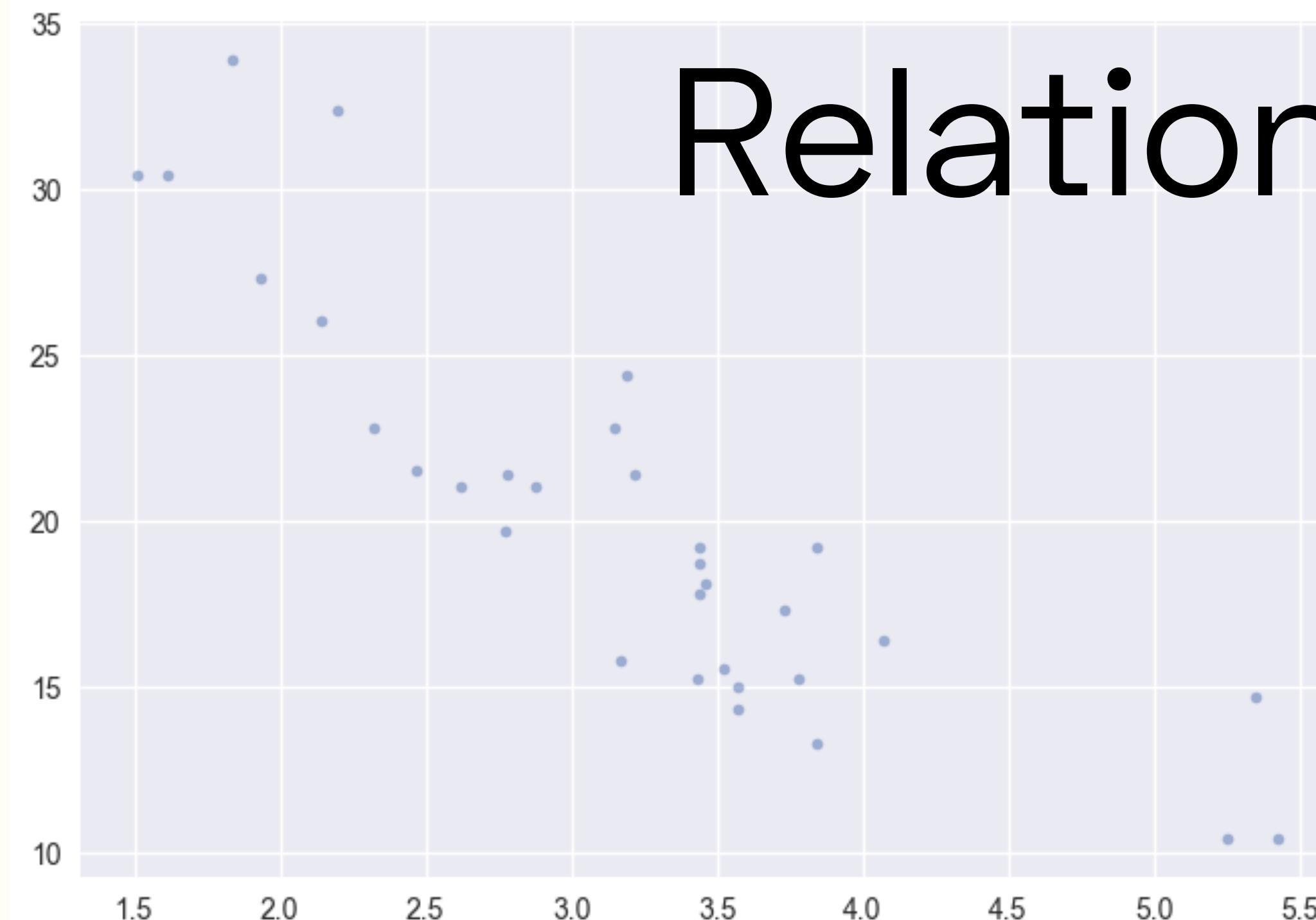
# Description

# Summary: Density Plots



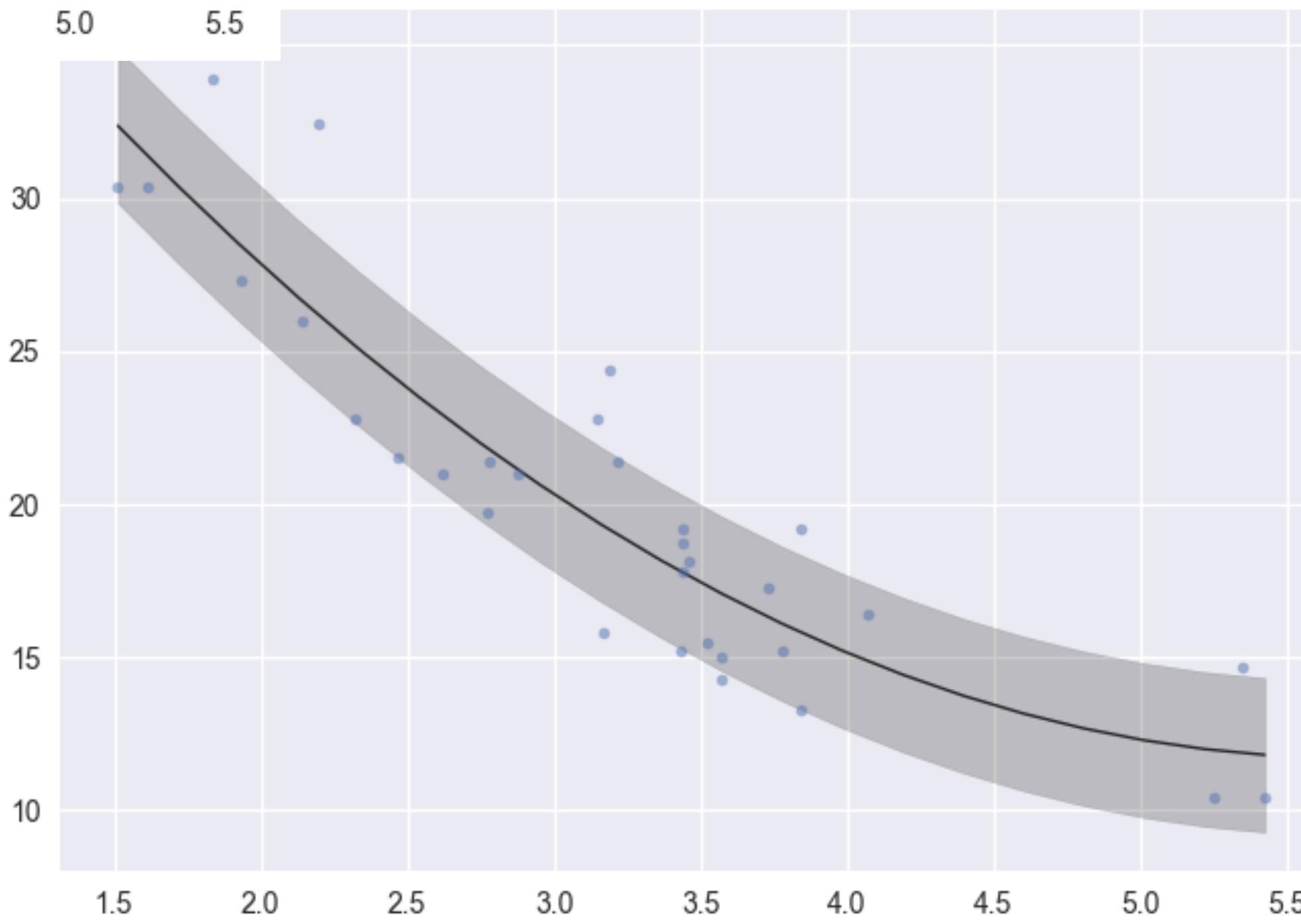
<https://www.autodeskresearch.com/publications/samestats>

# Relationships



Scatter Plots to discover relationships.

Use lines when adjoining points involve some continuity  
e.g. time



**Most  
Efficient**



Position



Length



Slope



Angle



Area



Intensity



Color



Shape



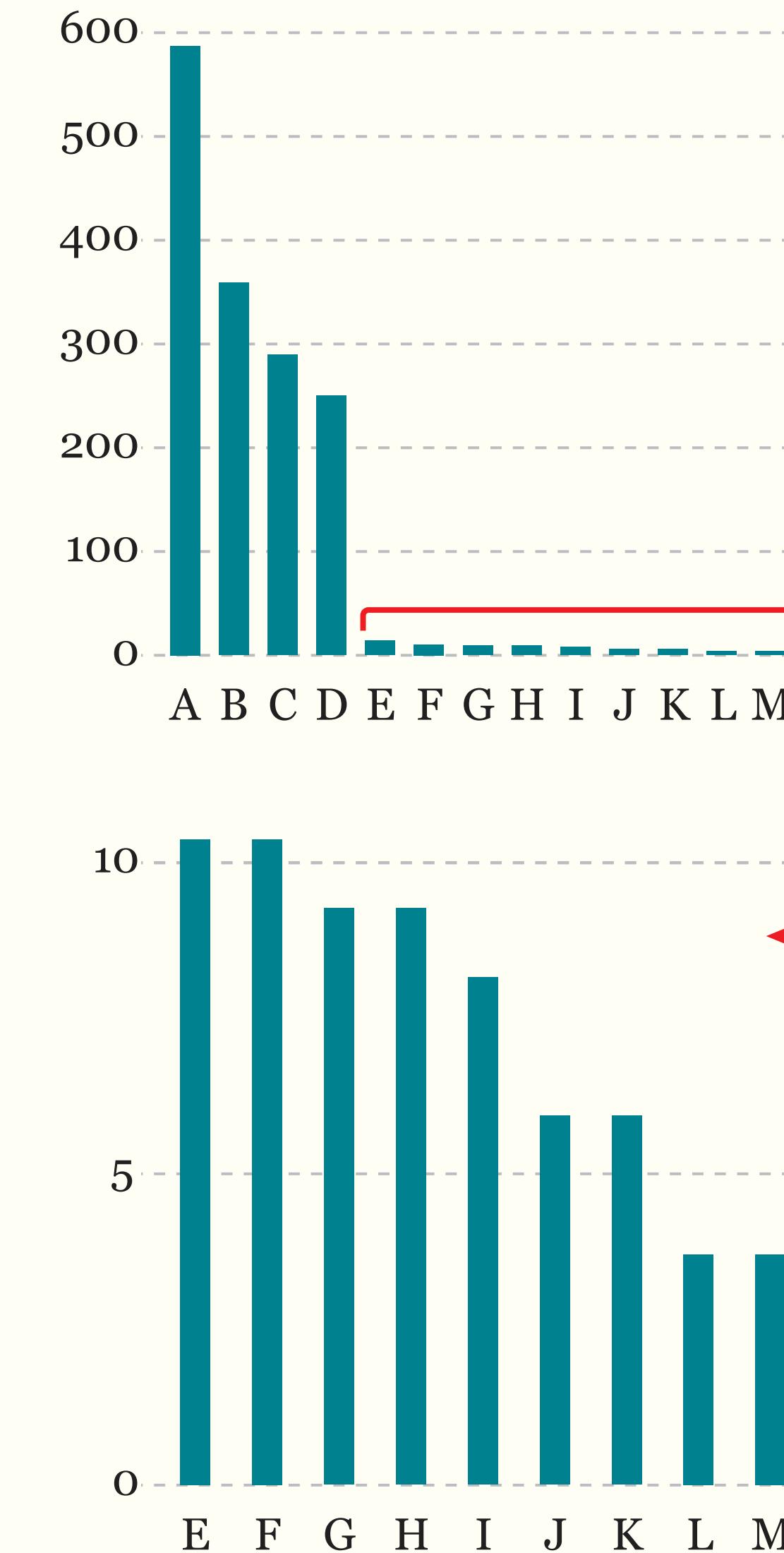
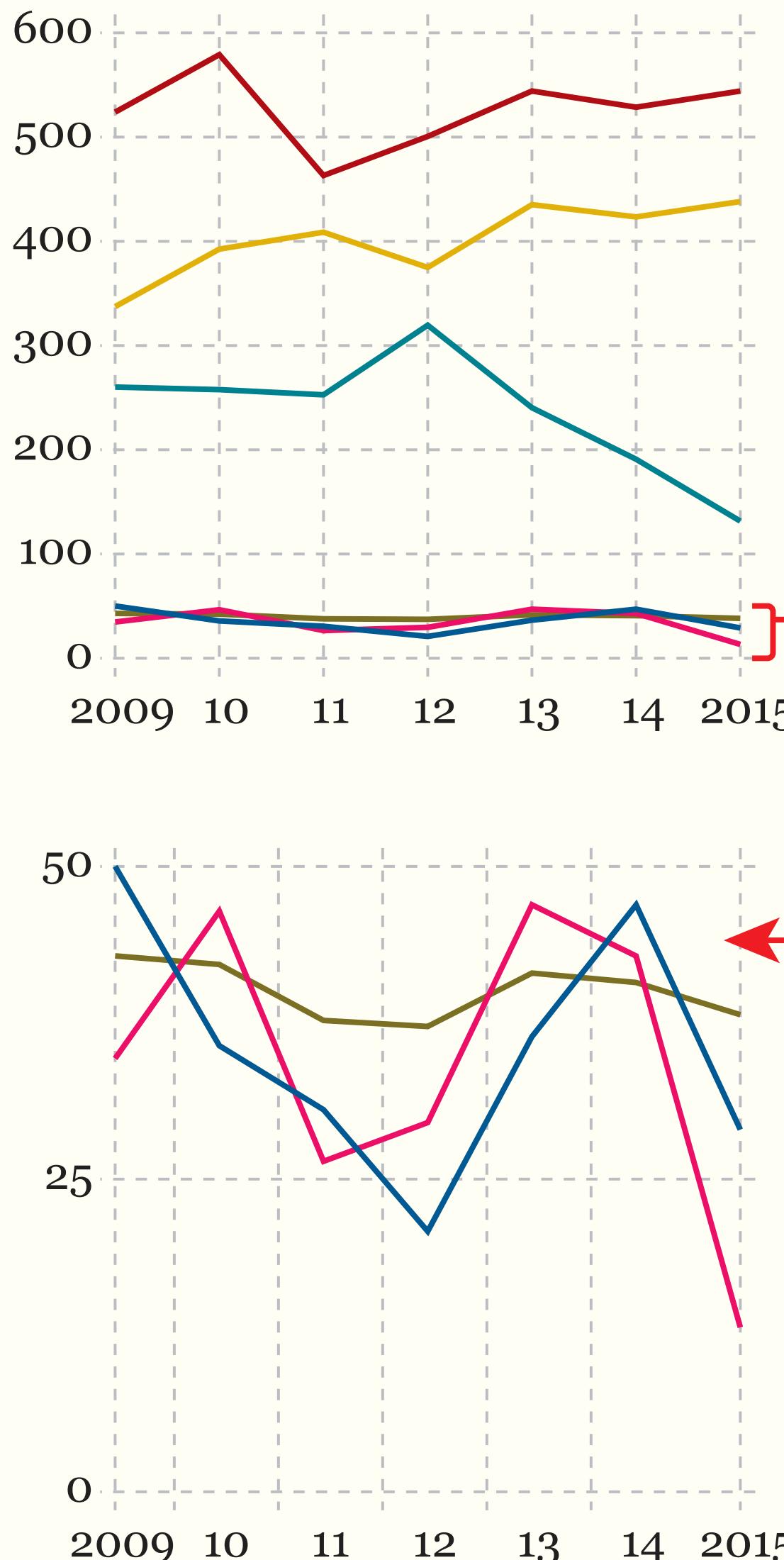
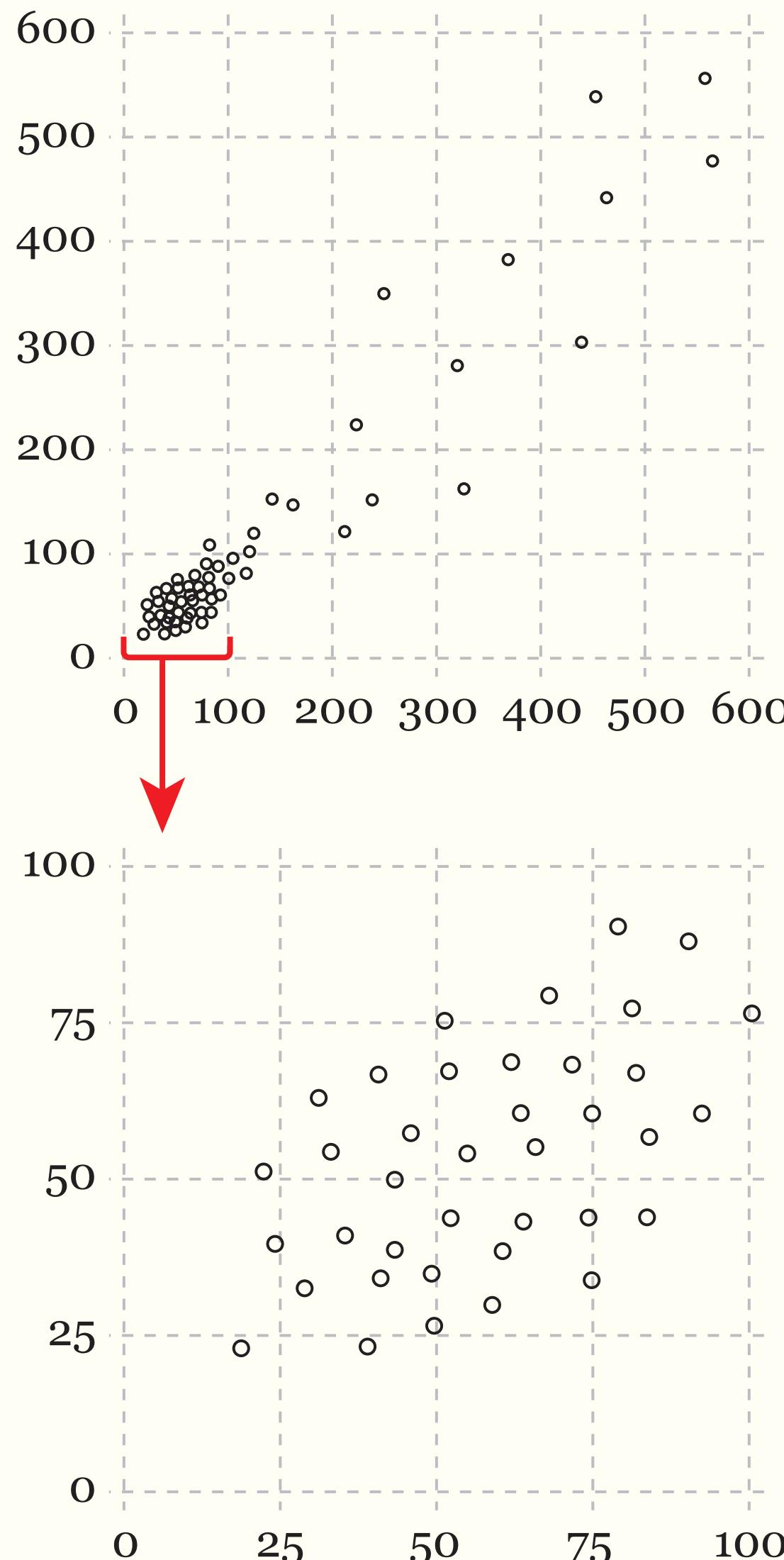
**Least  
Efficient**



**Quantitative**

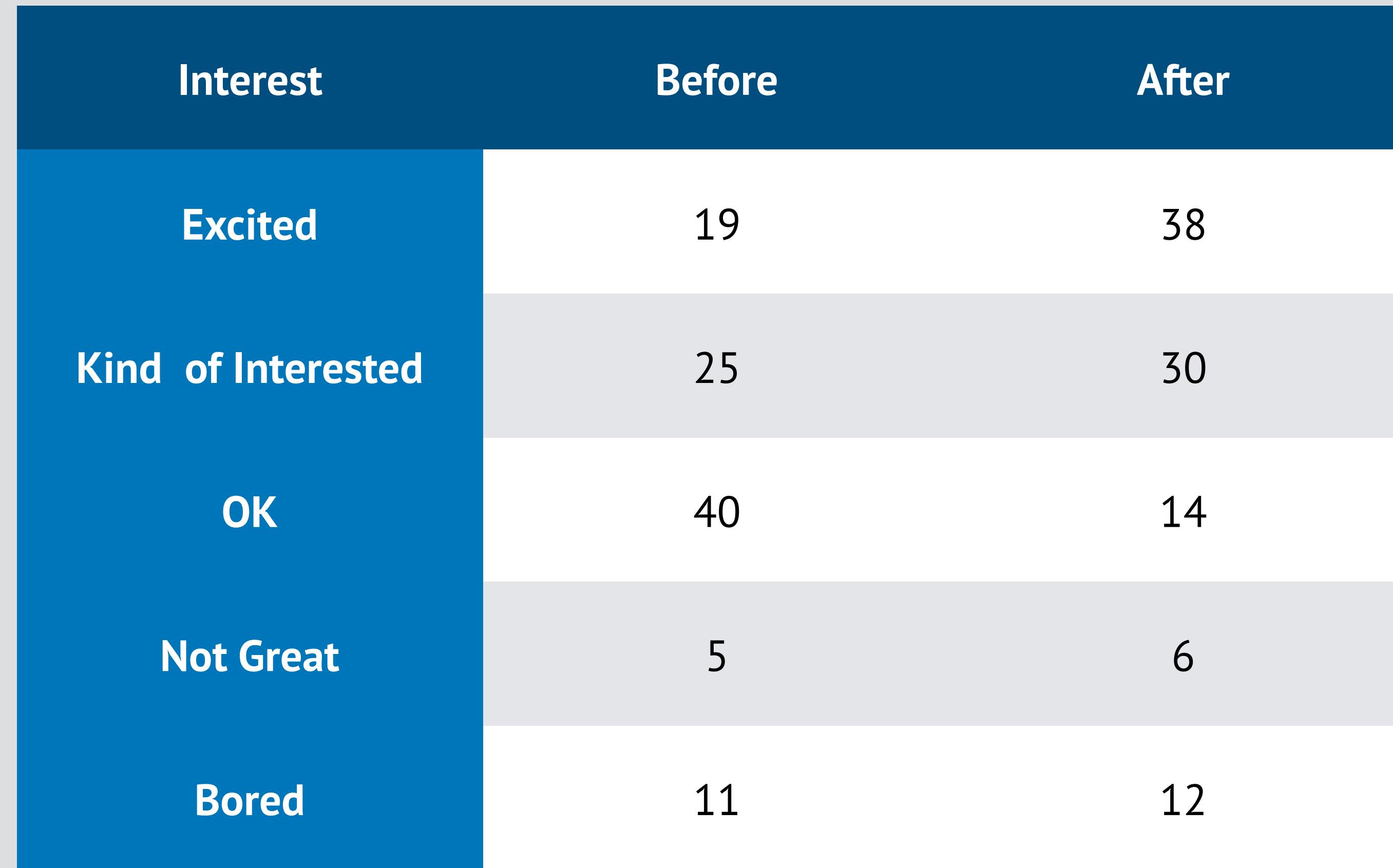
**Ordered**

**Categories**

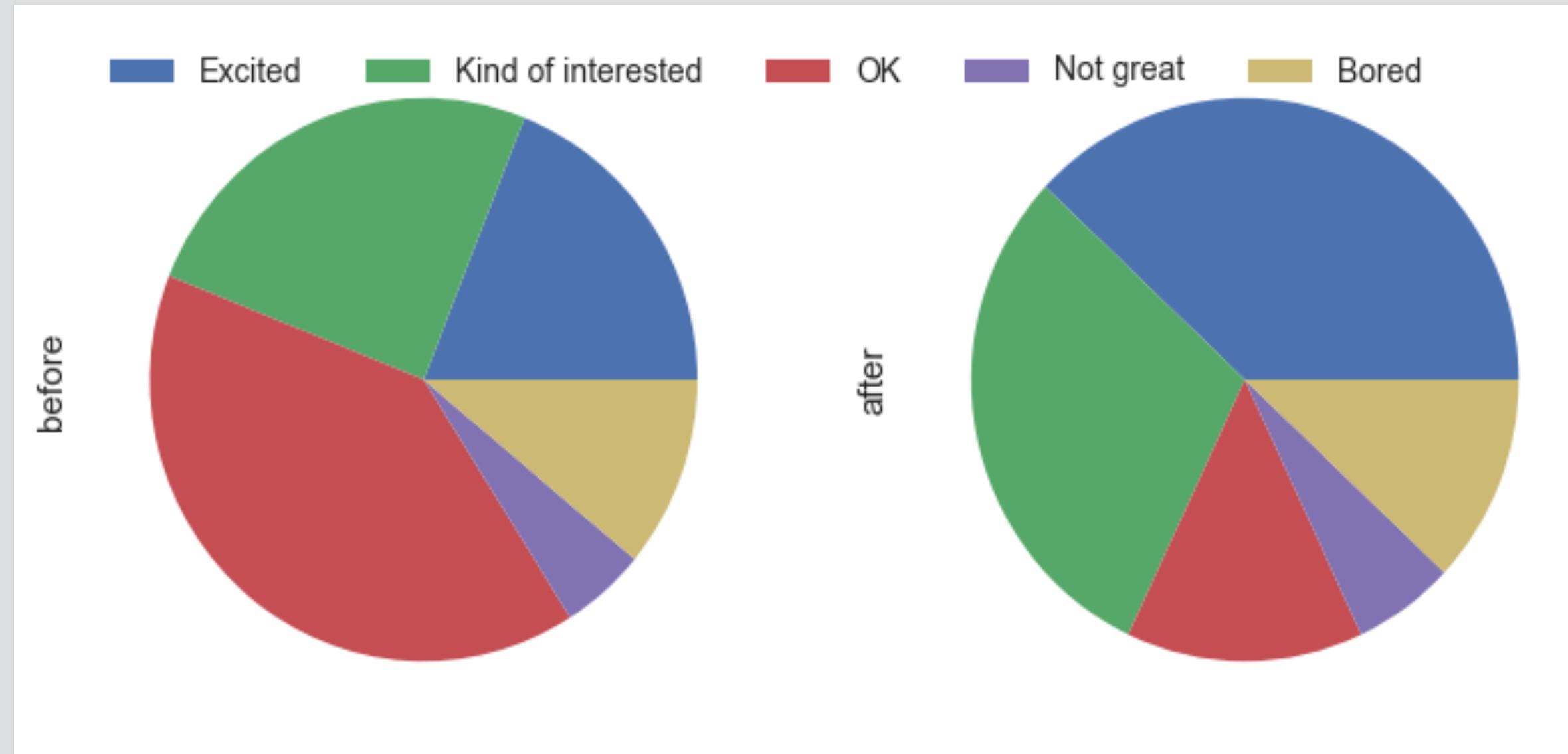


Possible solution to cases when you have data that diverge a lot

# How do you feel about doing science?

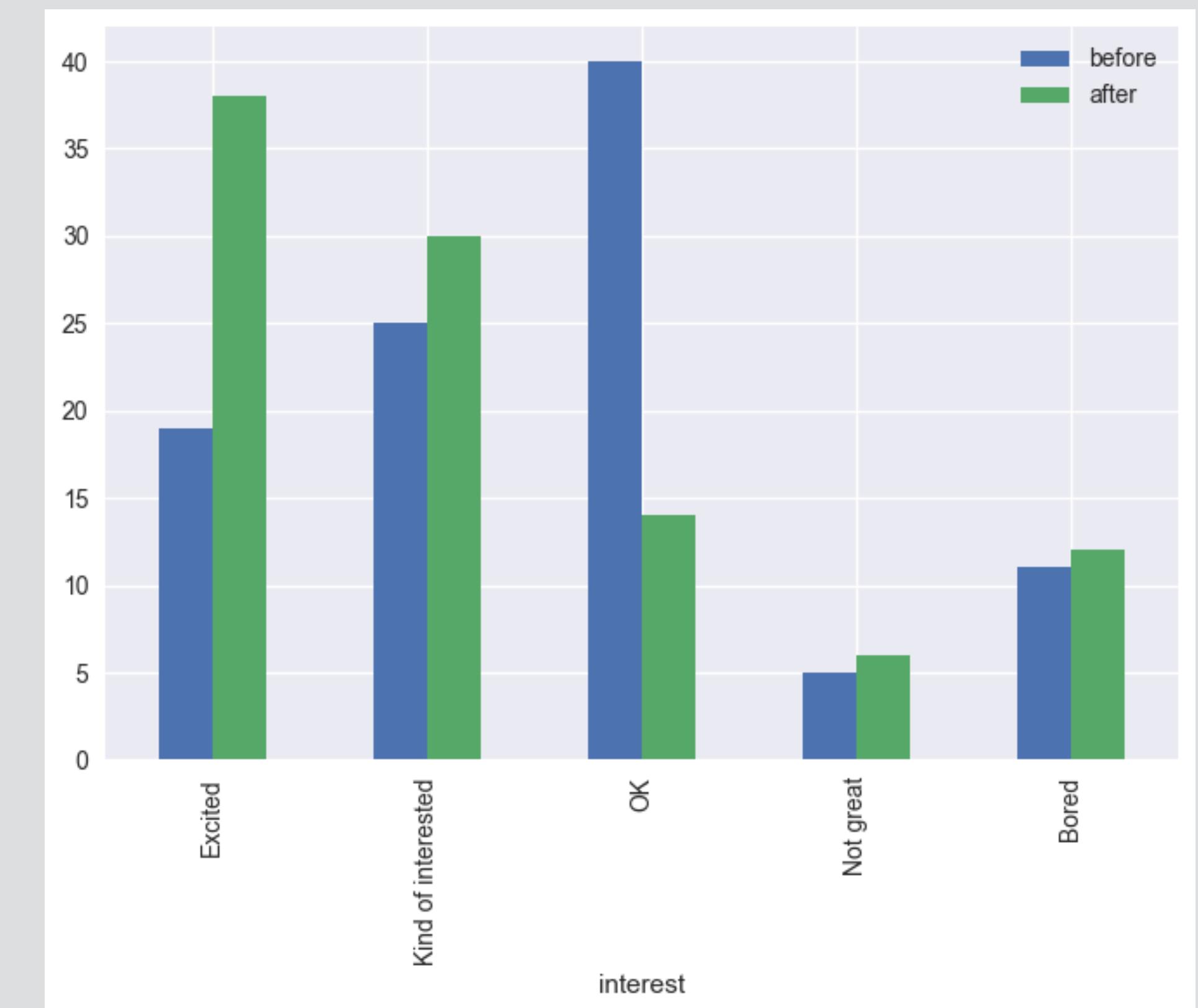


Data courtesy of Cole Nussbaumer

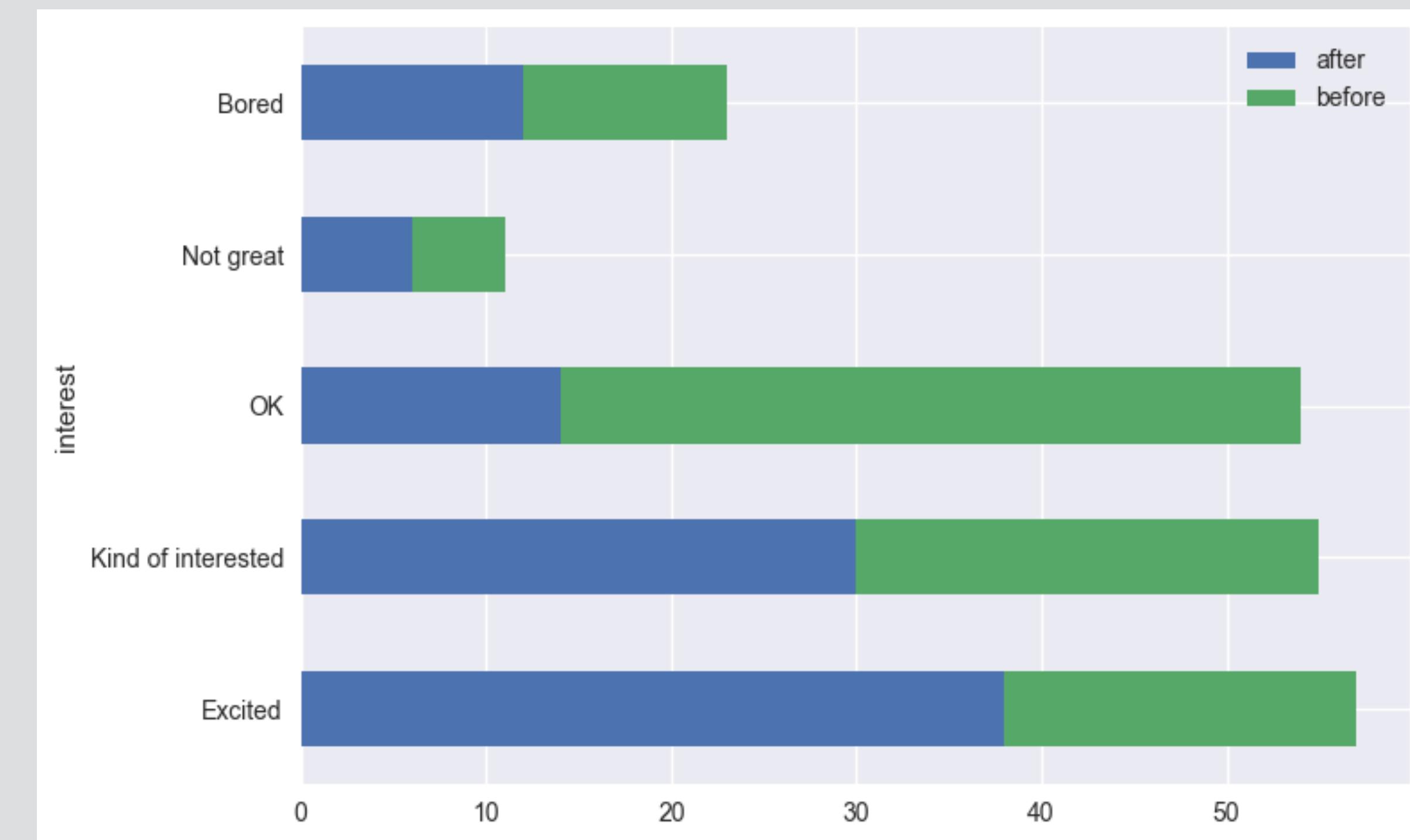
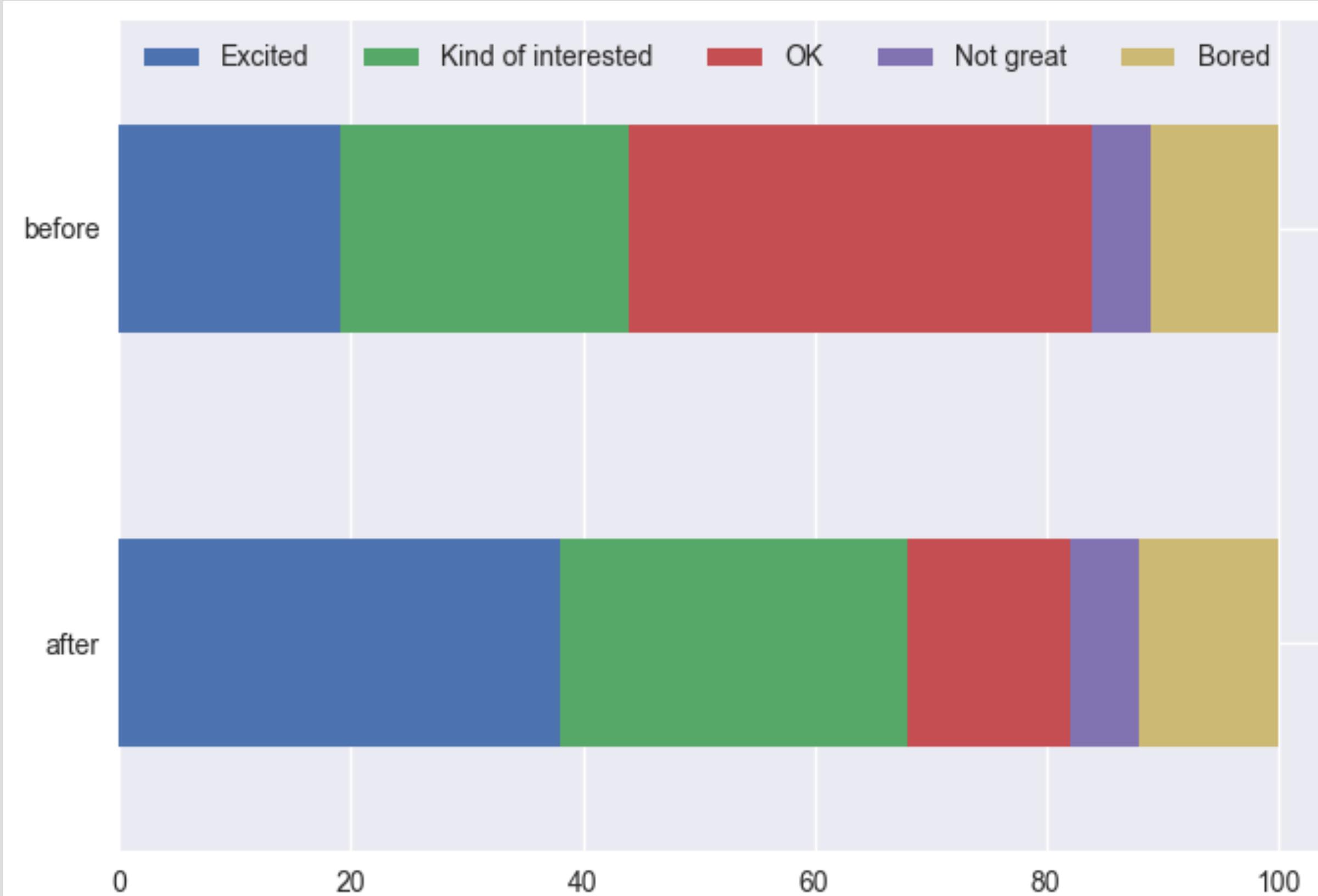


## Side by side bar

Pie

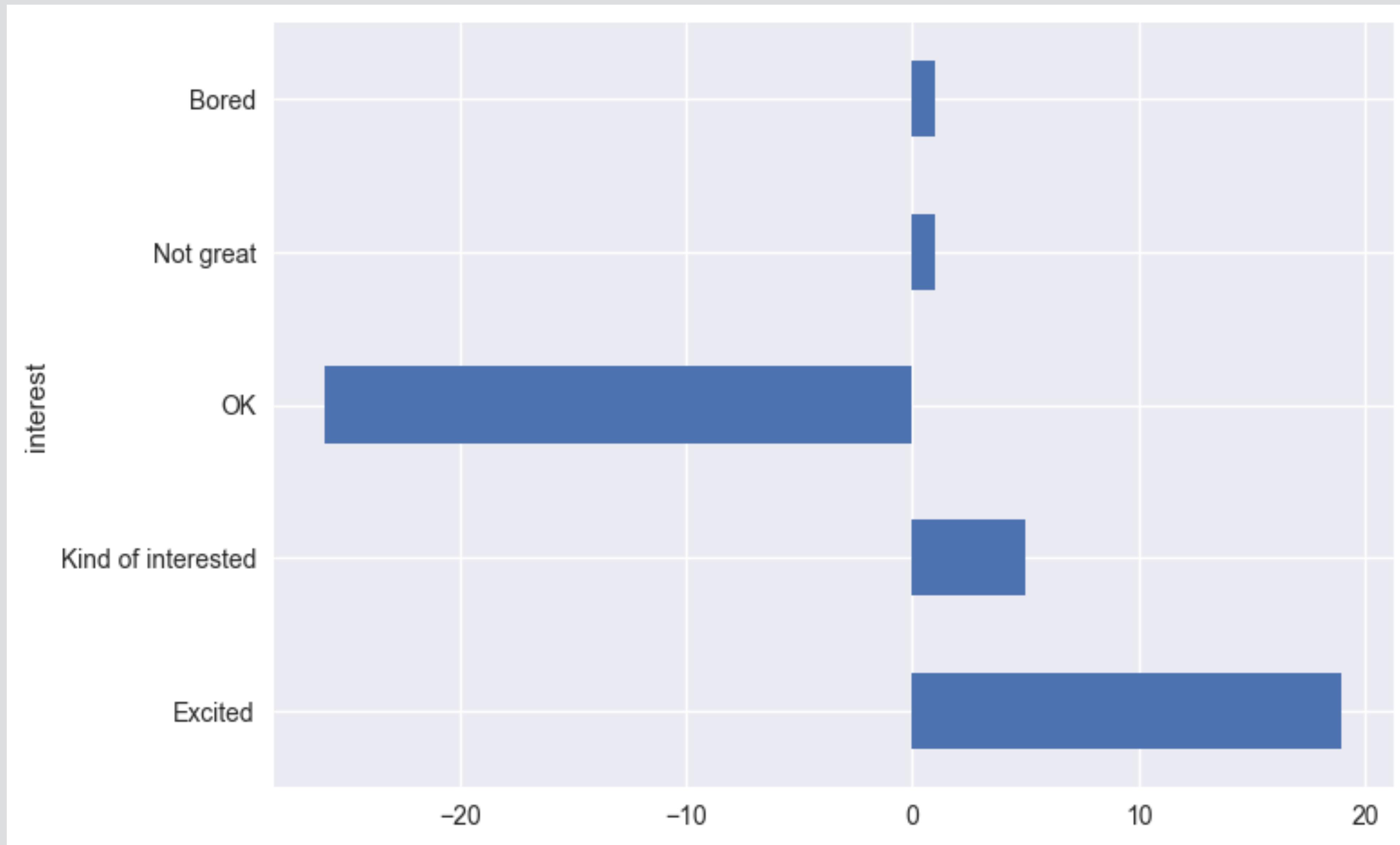


# Stacked bar, not very useful

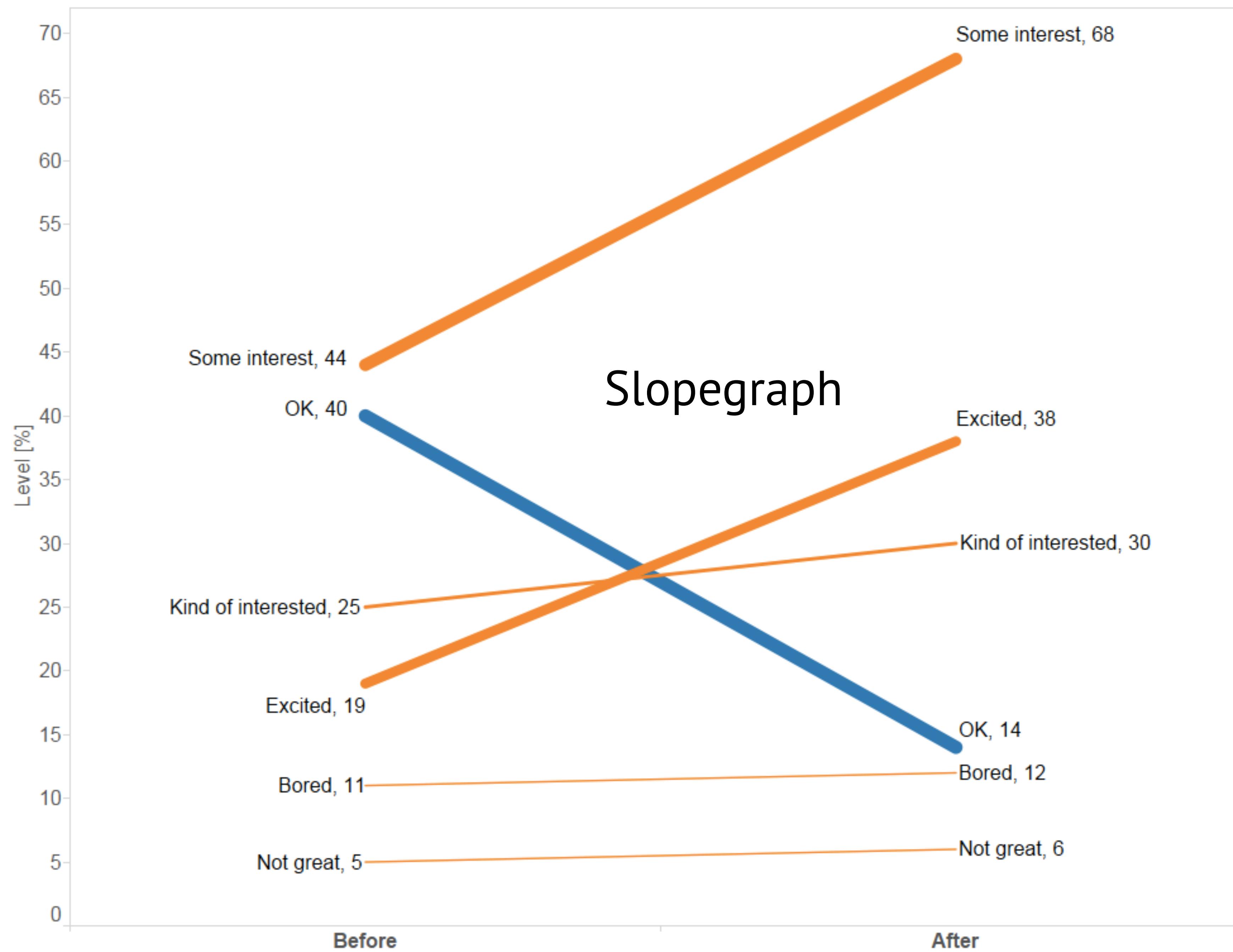


Data Transposed Bar Chart

# Difference Bar Chart



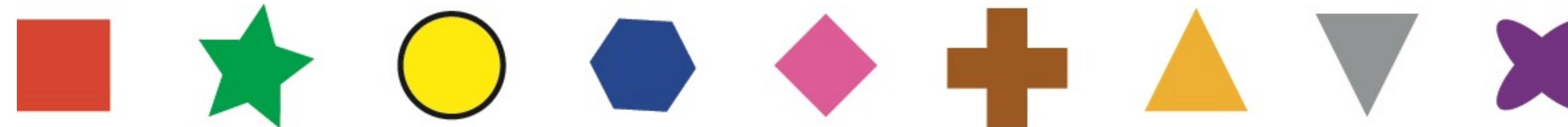
## How do you feel about doing science?



# 4. Use Color Sensibly

# Colors for Categories

Do not use more than 5-8 colors at once



# Colors for Ordinal Data

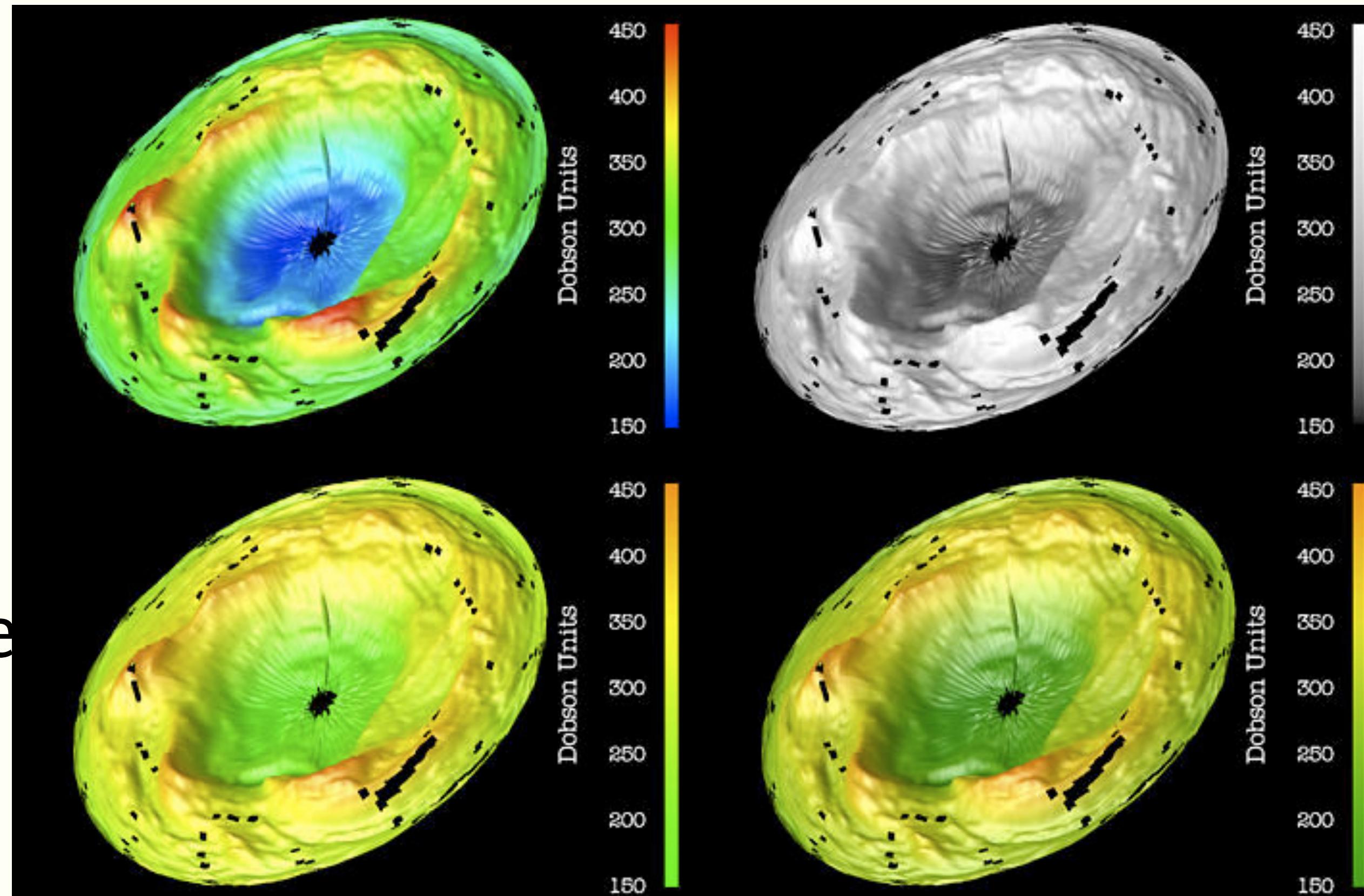
Vary luminance and saturation



Zeilis et al, 2009, "Escaping RGBland: Selecting Colors  
for Statistical Graphics"

# Colors for Quantitative Data

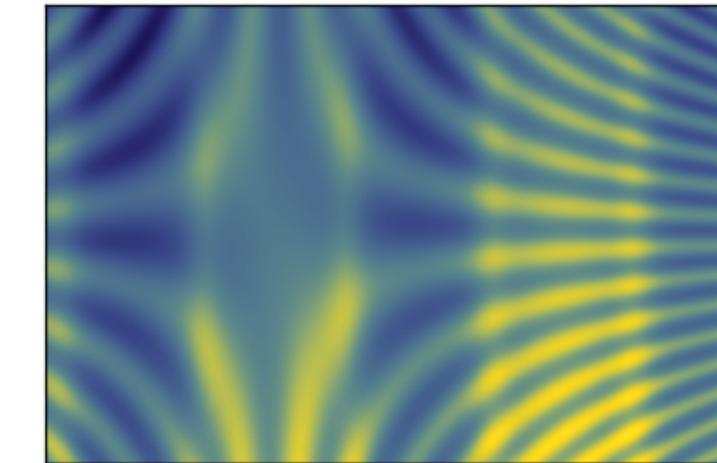
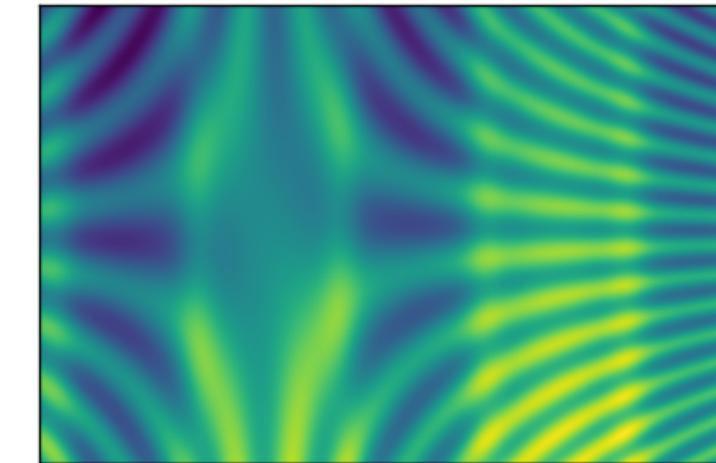
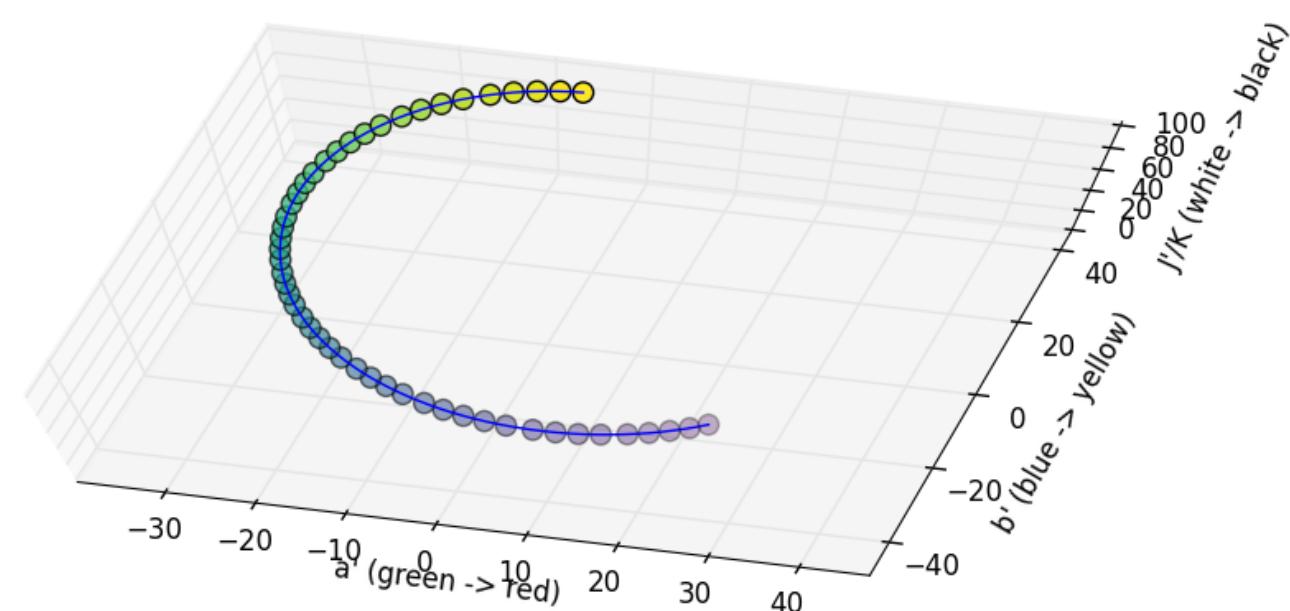
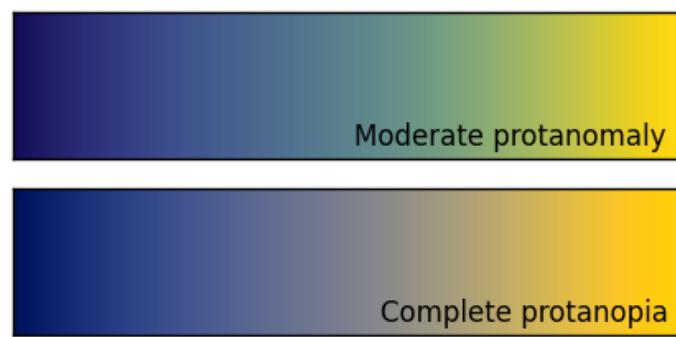
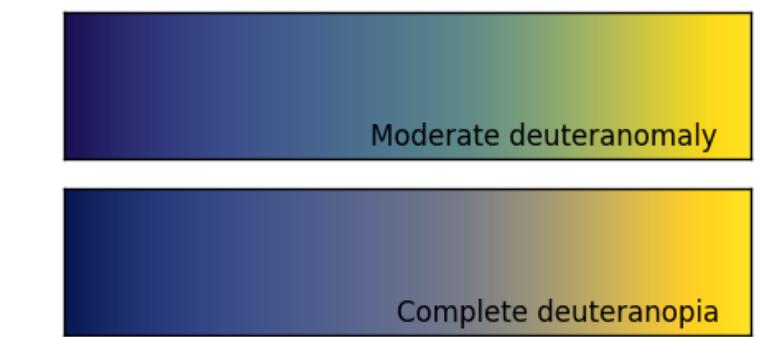
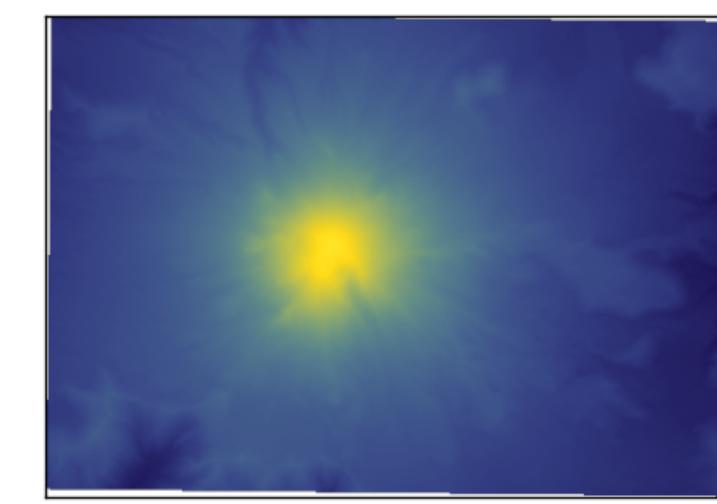
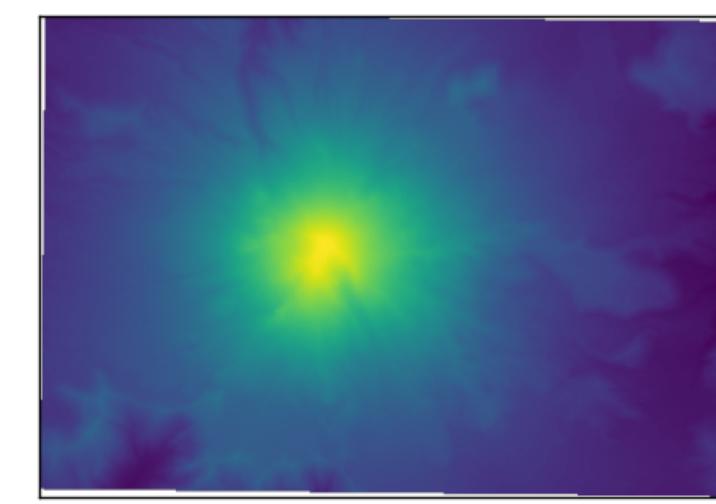
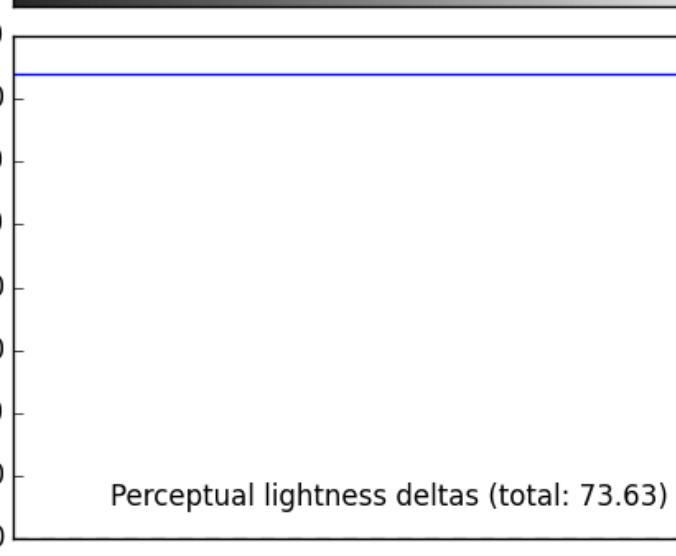
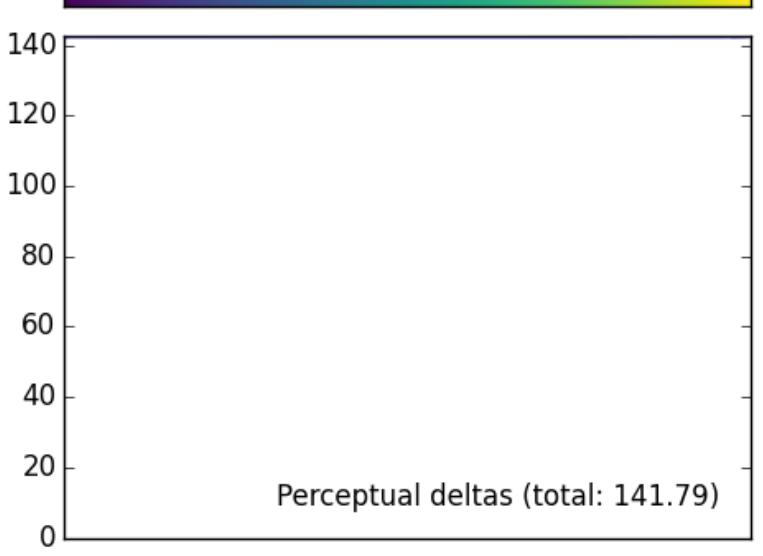
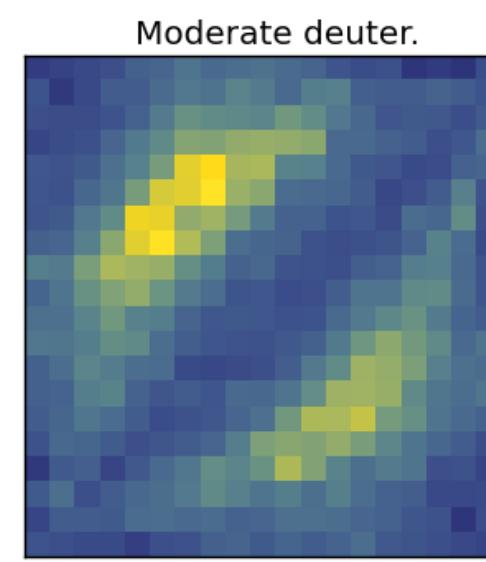
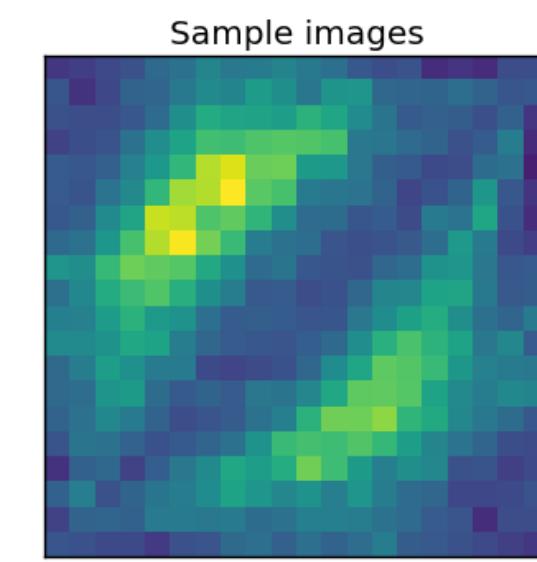
Hue  
(Rainbow)



Luminance  
& Hue

# Viridis

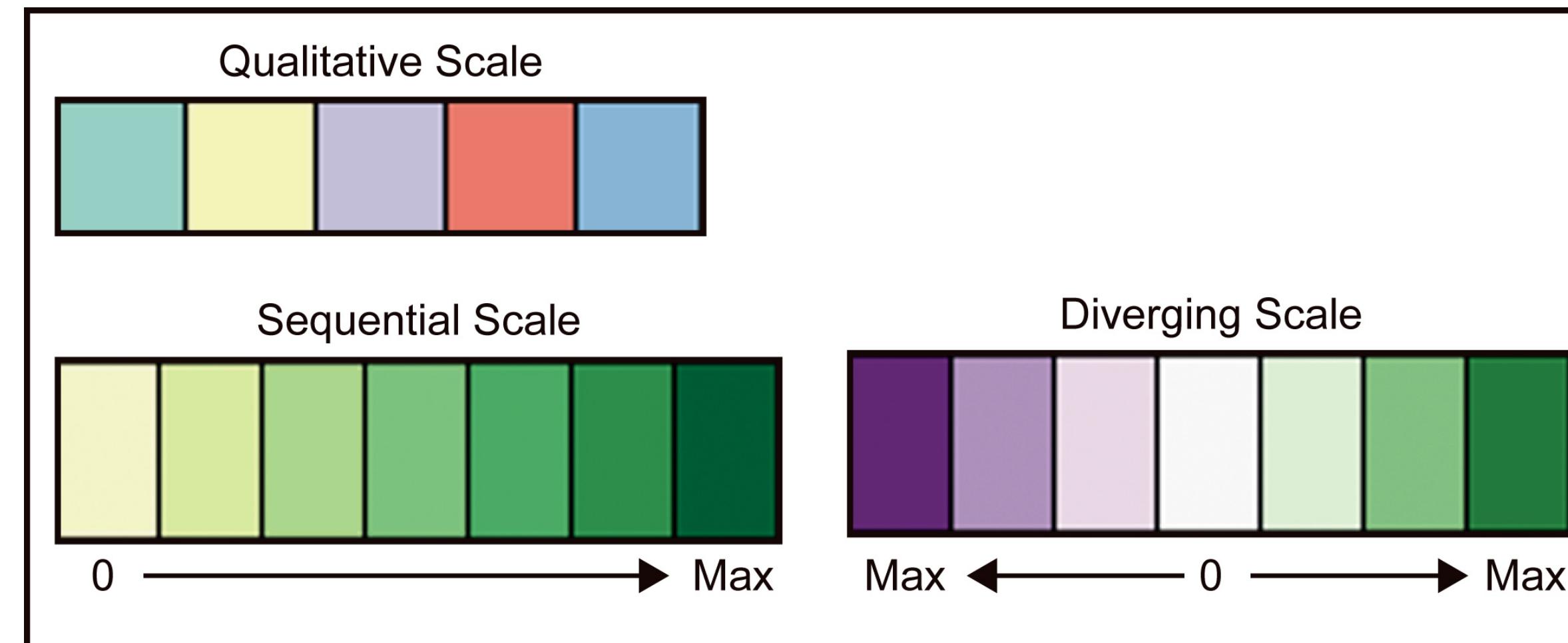
Colormap evaluation: option\_d.py



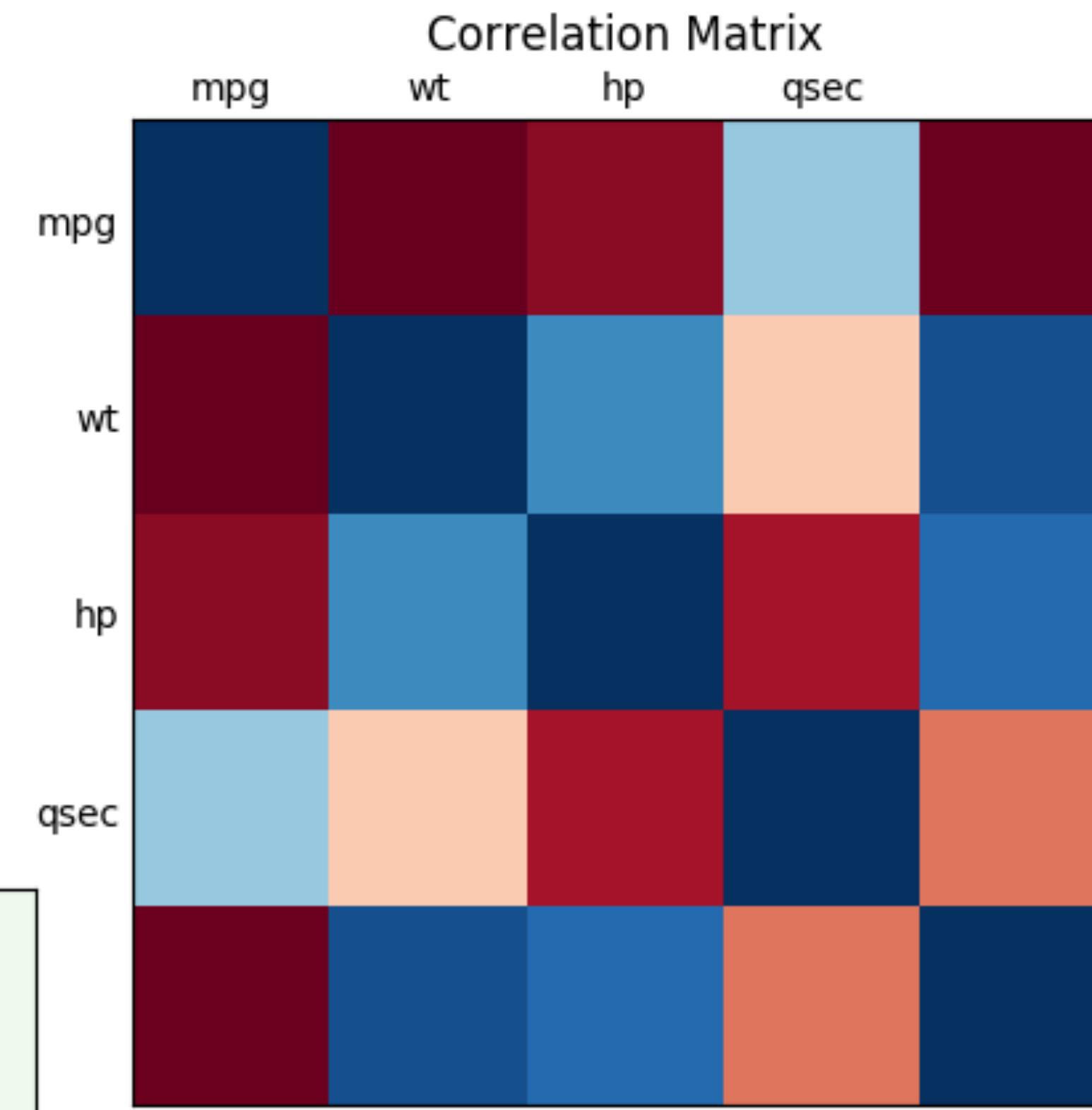
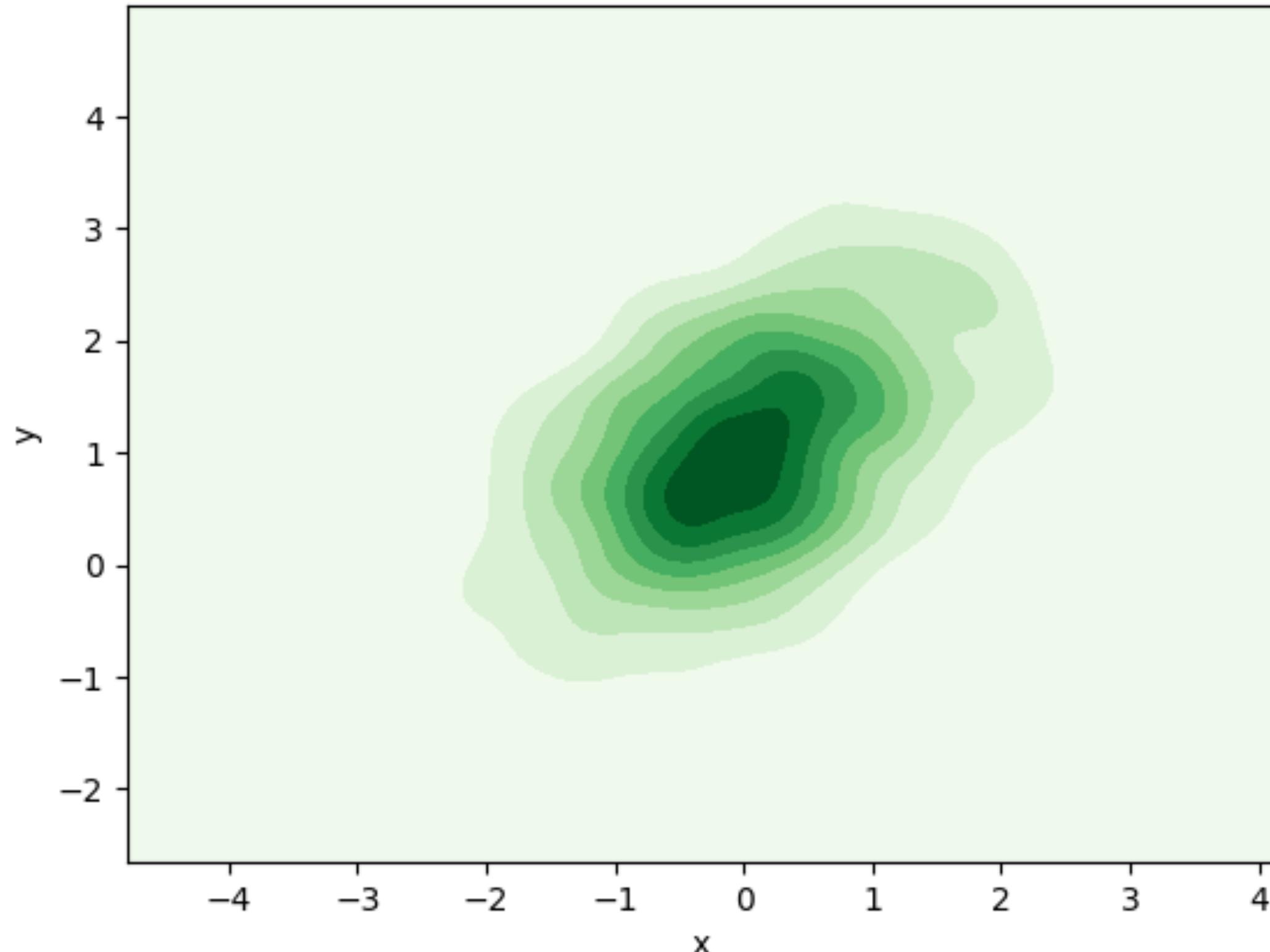
# Color Brewer

**Qualitative palettes are used for multiple curves in a plot or categoricals**

Nominal



Ordinal

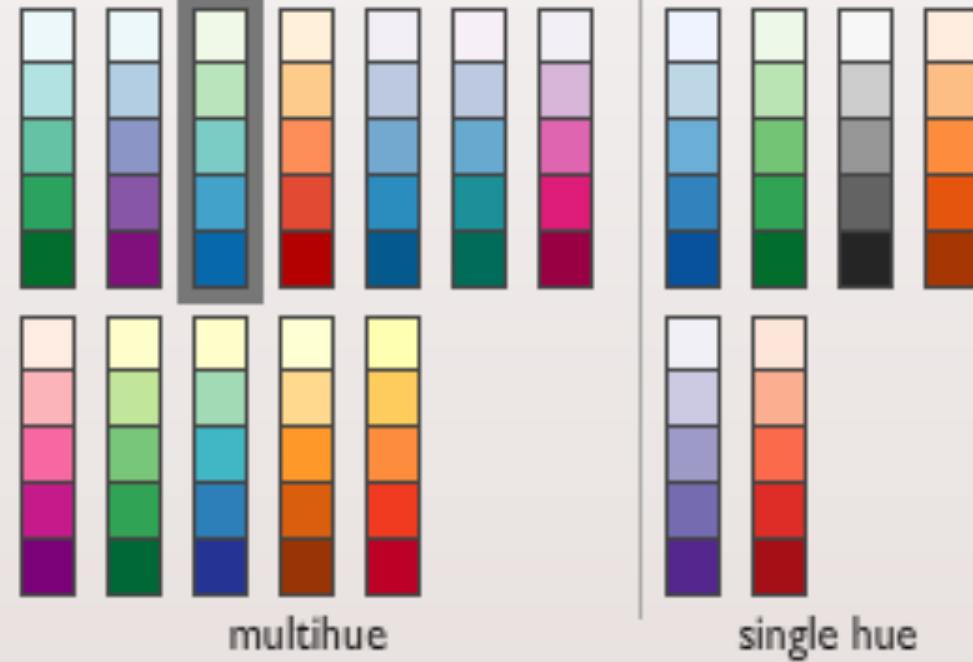


**Sequential Palette for Densities (all positive)**

number of data classes on your map  
3 | [learn more >](#)

the nature of your data  
sequential | [learn more >](#)

pick a color scheme: GnBu



(optional) only show schemes that are:

- colorblind safe
- print friendly
- photocopy-able

[learn more >](#)

pick a color system

224, 243, 219	<input checked="" type="radio"/> RGB	<input type="radio"/> CMYK	<input type="radio"/> HEX
168, 221, 181			
67, 162, 202			

adjust map context

- roads
- cities
- borders

select a background

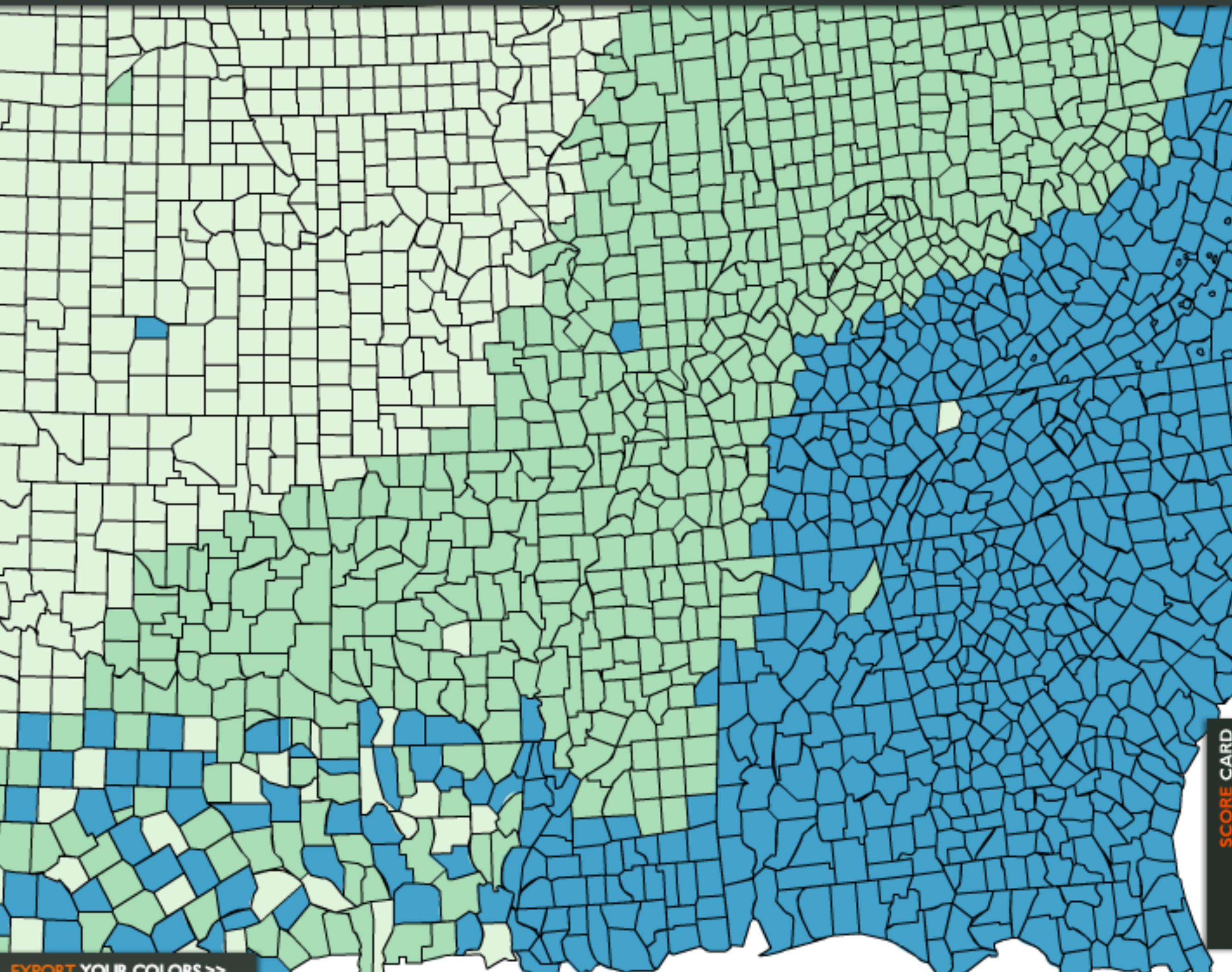
- solid color
- terrain

[color transparency](#)

[learn more >](#)

EXPORT YOUR COLORS >>

SCORE CARD



© Cynthia Brewer, Mark Harrower and The Pennsylvania State University  
[Support](#)  
[Back to ColorBrewer 1.0](#)

**COLORBREWER 2.0**  
color advice for cartography

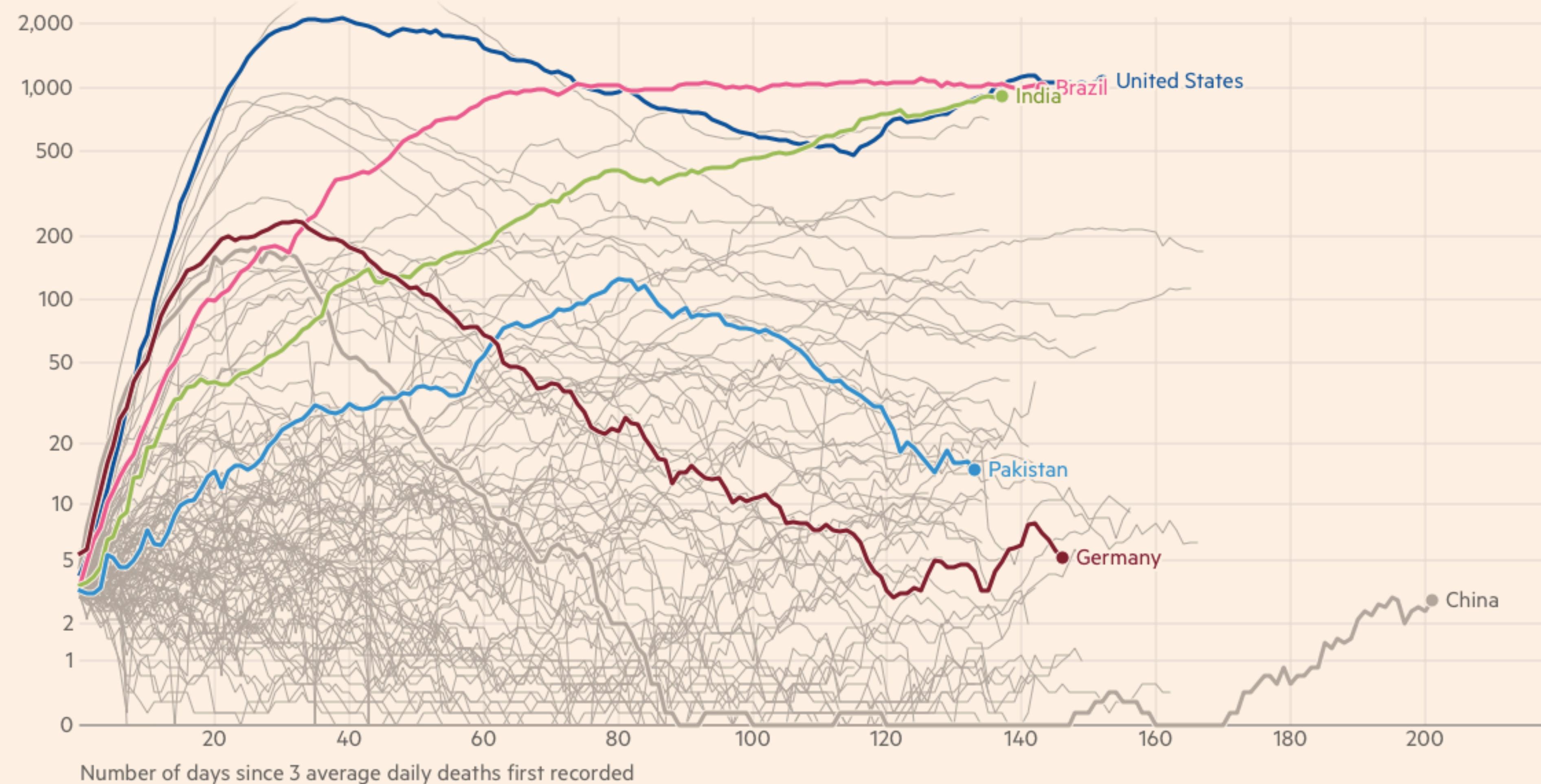


# 5. Know your audience

- What do they know?
- What motivates them? What do they desire?
- What experiences do you share? What are common goals?
- What insights can you give them? What tools and “magical gifts”?

## New deaths attributed to Covid-19 in United States, Brazil, India, Pakistan and Germany

Seven-day rolling average of new deaths, by number of days since 3 average daily deaths first recorded



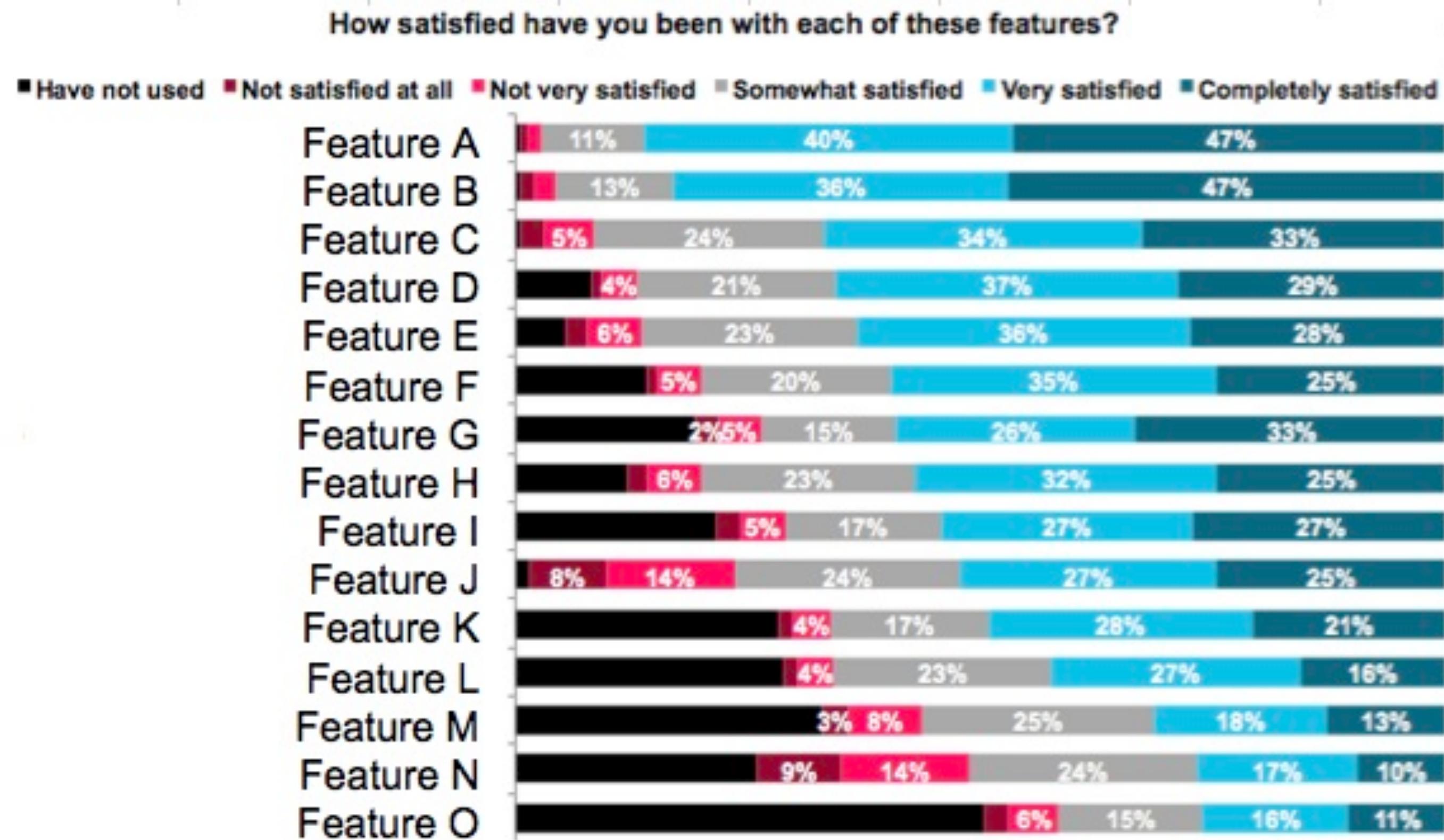
Source: Financial Times analysis of data from the European Centre for Disease Prevention and Control, the Covid Tracking Project, the UK Dept of Health & Social Care and the Spanish Ministry of Health.  
Data updated August 13 2020 10.48am BST. Interactive version: [ft.com/covid19](http://ft.com/covid19)

# Don't Make Them Think!



- Your audience does not want to spend cognitive effort on things you know and can just show them
- Lead them through the major steps of your story
- Point out interesting key facts and insights using captions and annotations

# Don't Bury the Lead

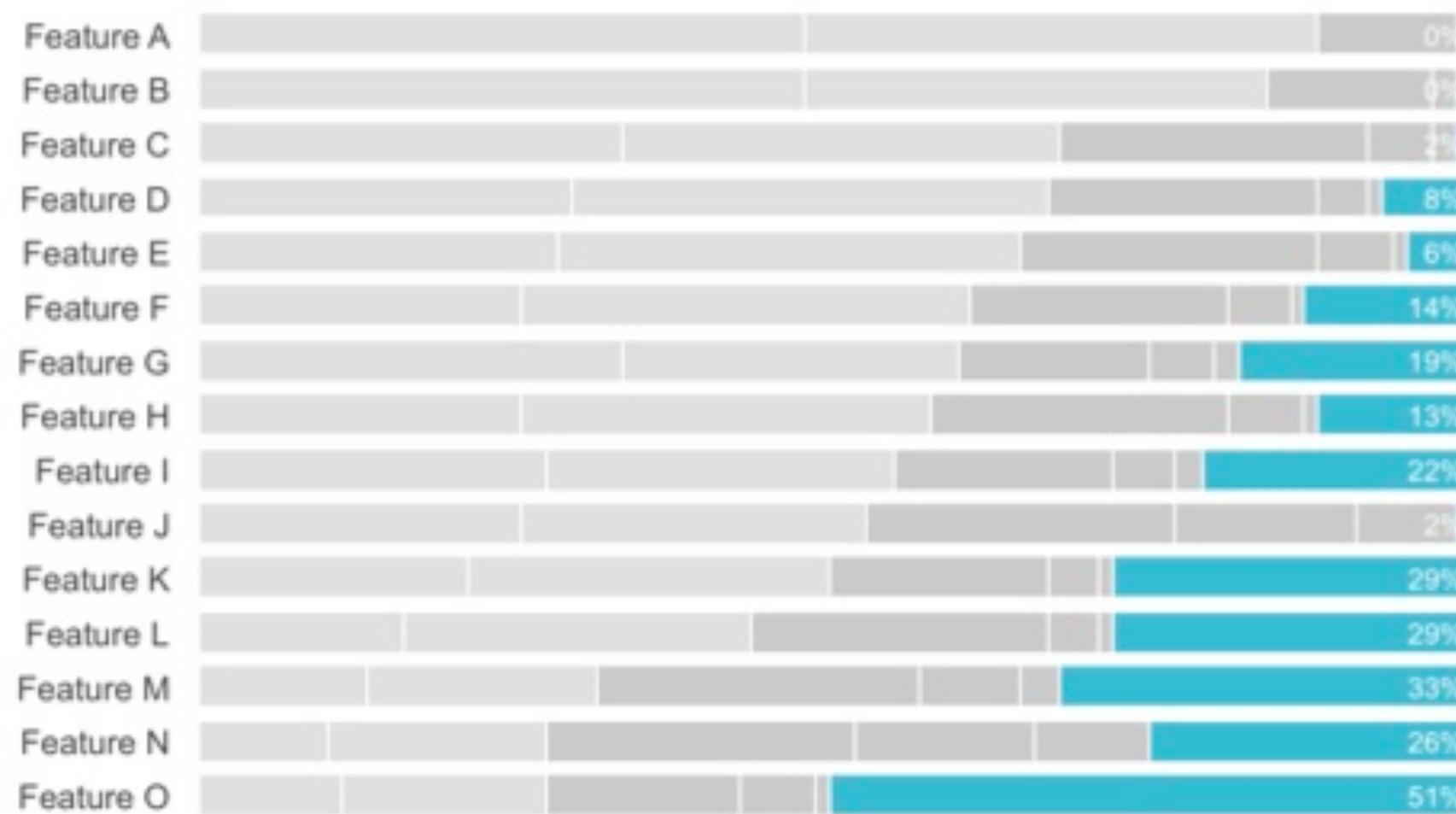


# Don't Bury the Lead

User satisfaction varies greatly by feature

Product X User Satisfaction: Features

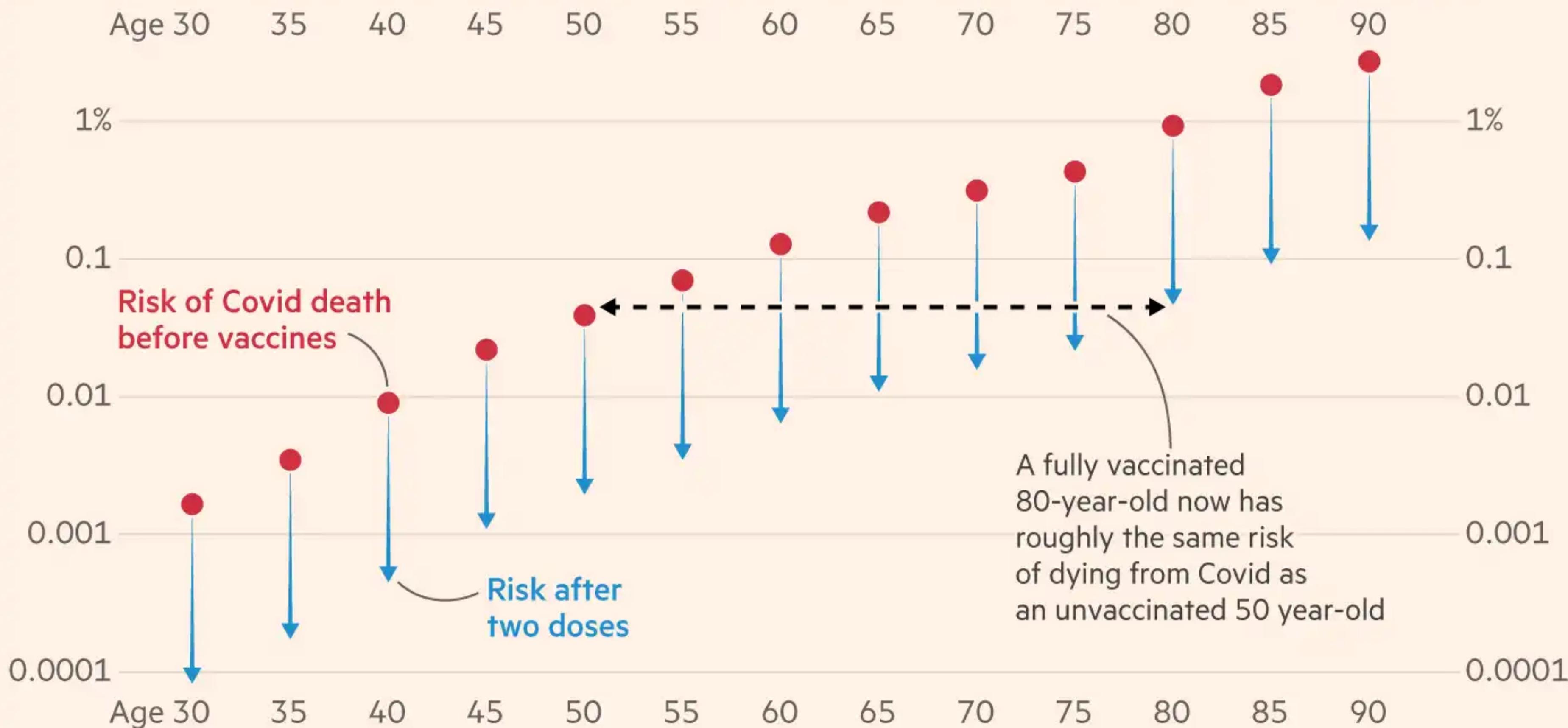
\* Completely satisfied   \* Very satisfied   \* Somewhat satisfied   \* Not very satisfied   \* Not satisfied at all   \* Have not used



Feature O is least-used feature; what steps can we proactively take with existing users to increase use?

Vaccines have made Covid-19 far less lethal. A fully-vaccinated 80-year-old now has the same mortality risk as an unvaccinated 50-year-old

Risk of catching and dying from Covid\* (log scale), by age group, before and after full vaccination



\*Risk is the population fatality rate, e.g. before vaccines roughly 1% of all 80-year-olds in England had died from Covid

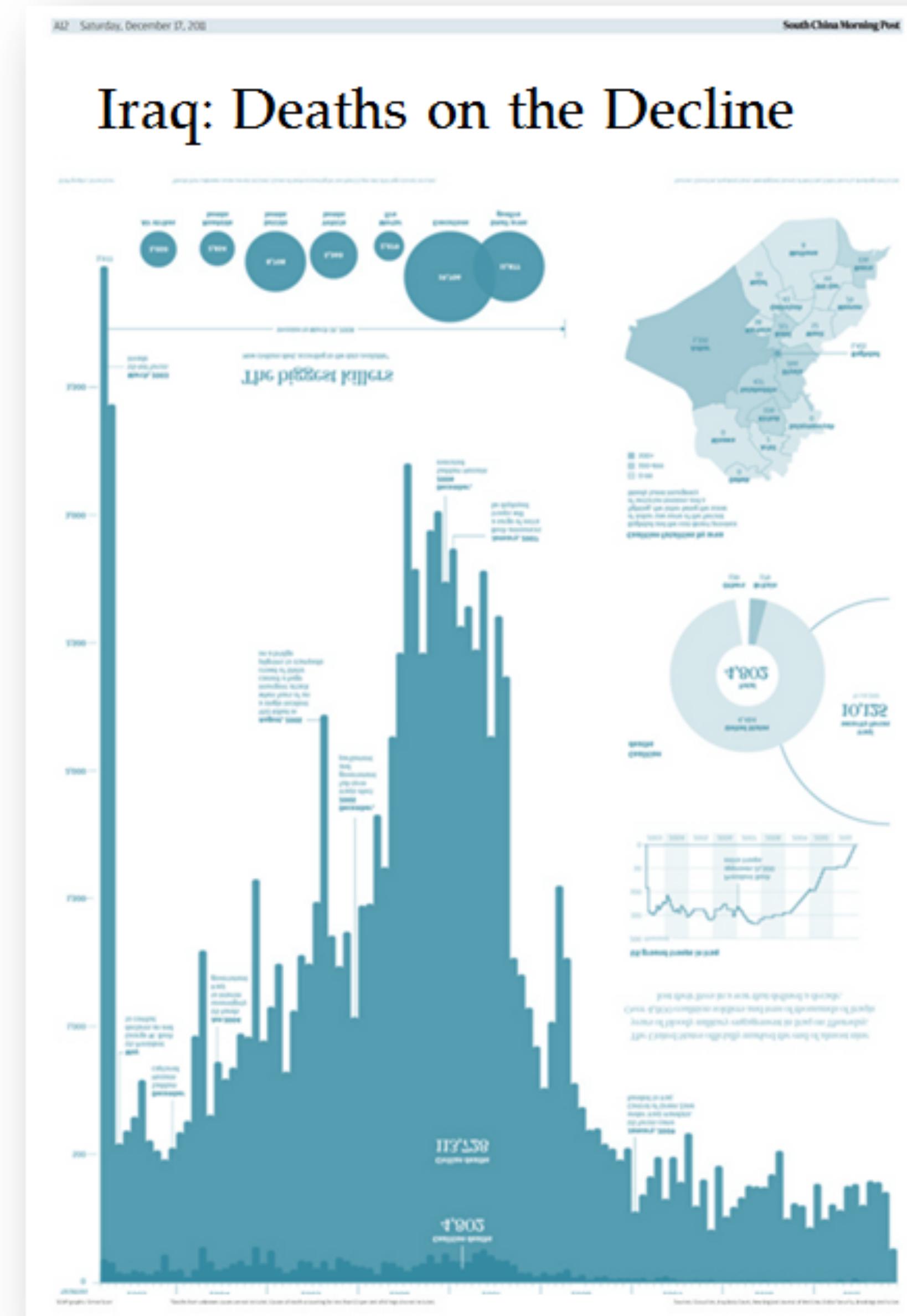
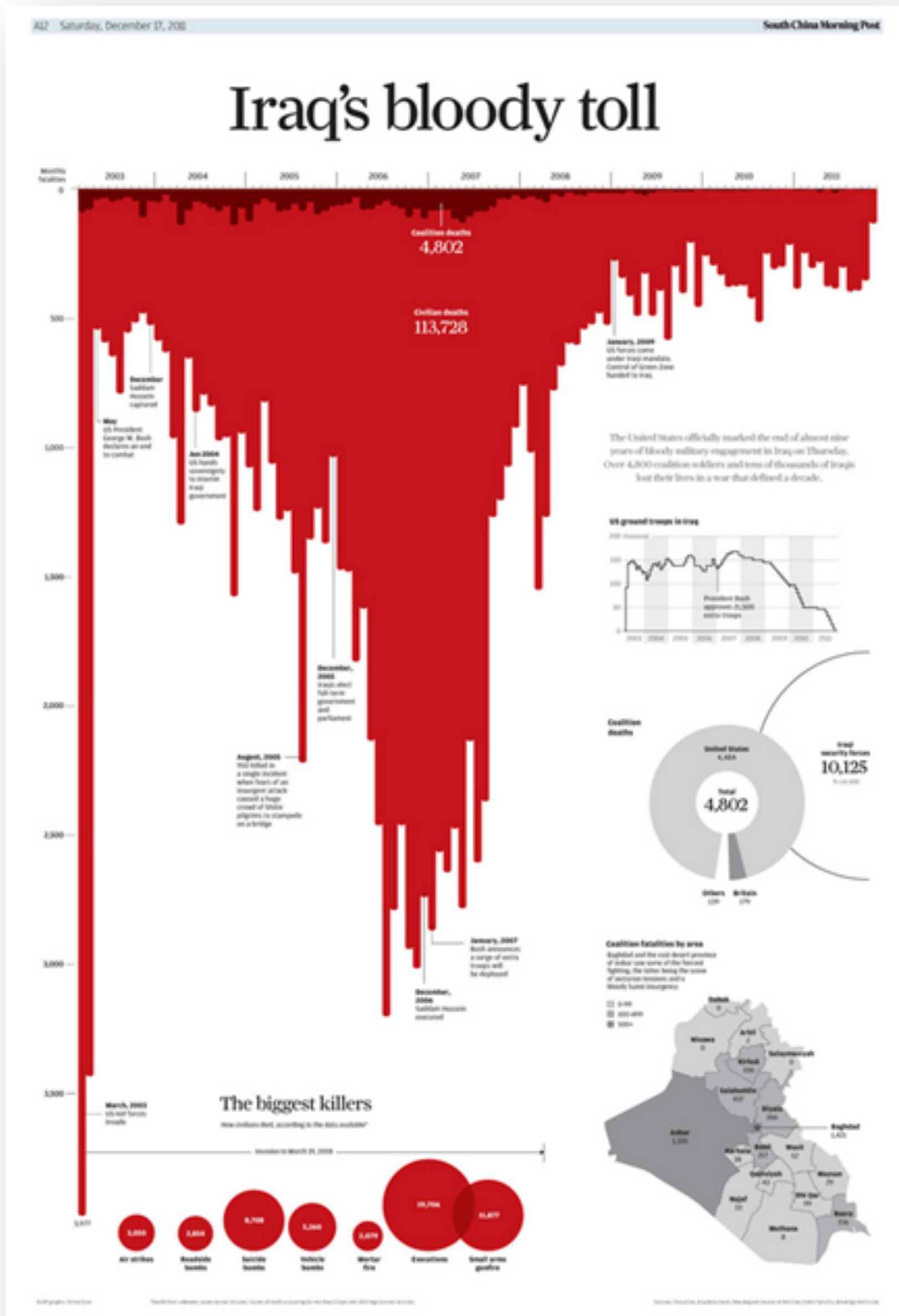
Source: FT analysis of data from Public Health England

© FT

# CODE EXERCISE

# Framing - Why should I care?

- Tell the audience: “Here is the right way to think about the problem I was trying to solve.”
- Catch the audience’s attention and frame the story using captions and annotations
- If done well, your insights will seem obvious given this framing. And that’s a good thing!



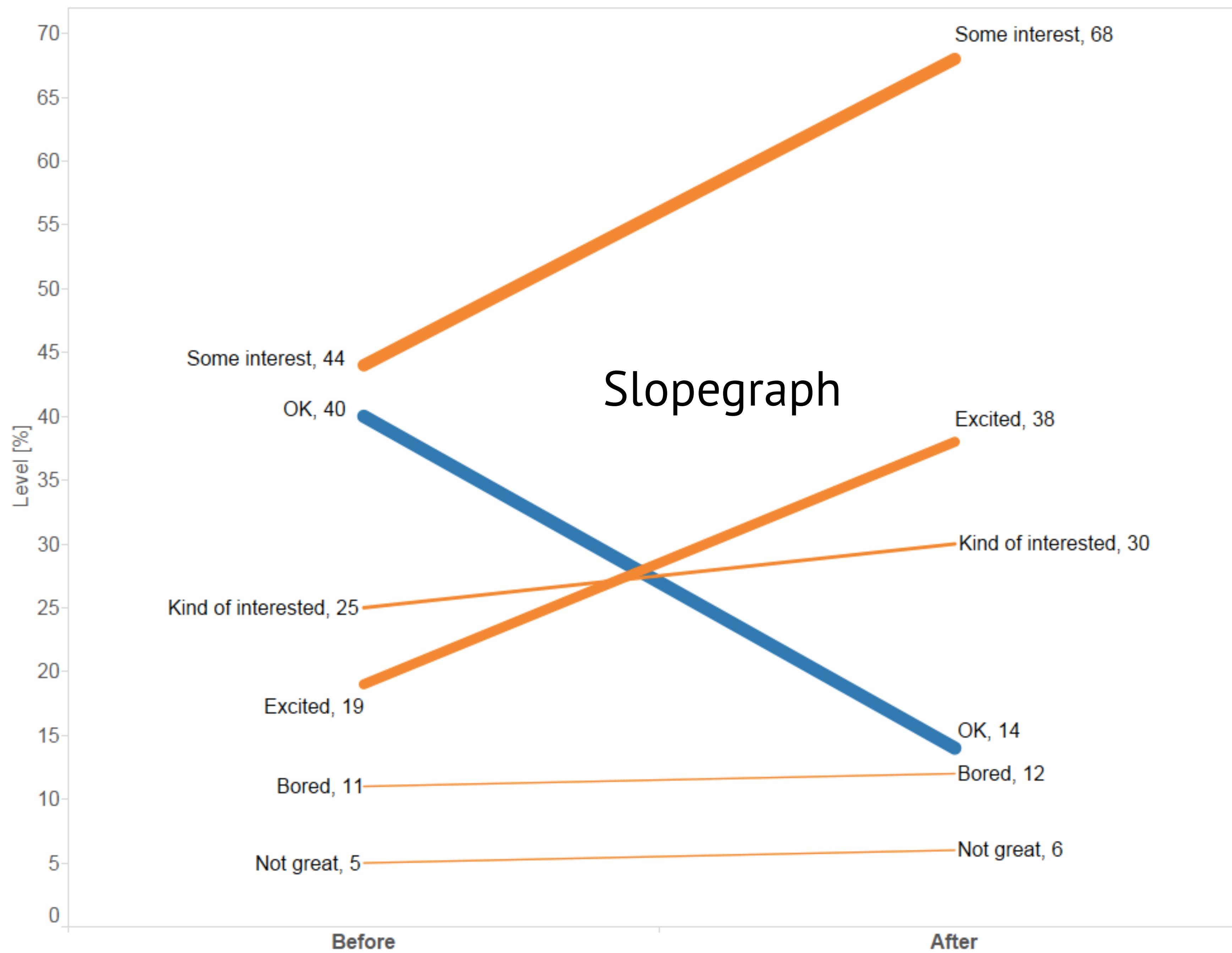
# Andy Cotgreave, Tableau

Univ.AI

# Is there a story?

Surface it....even if it is incomplete

## How do you feel about doing science?



After the pilot program,

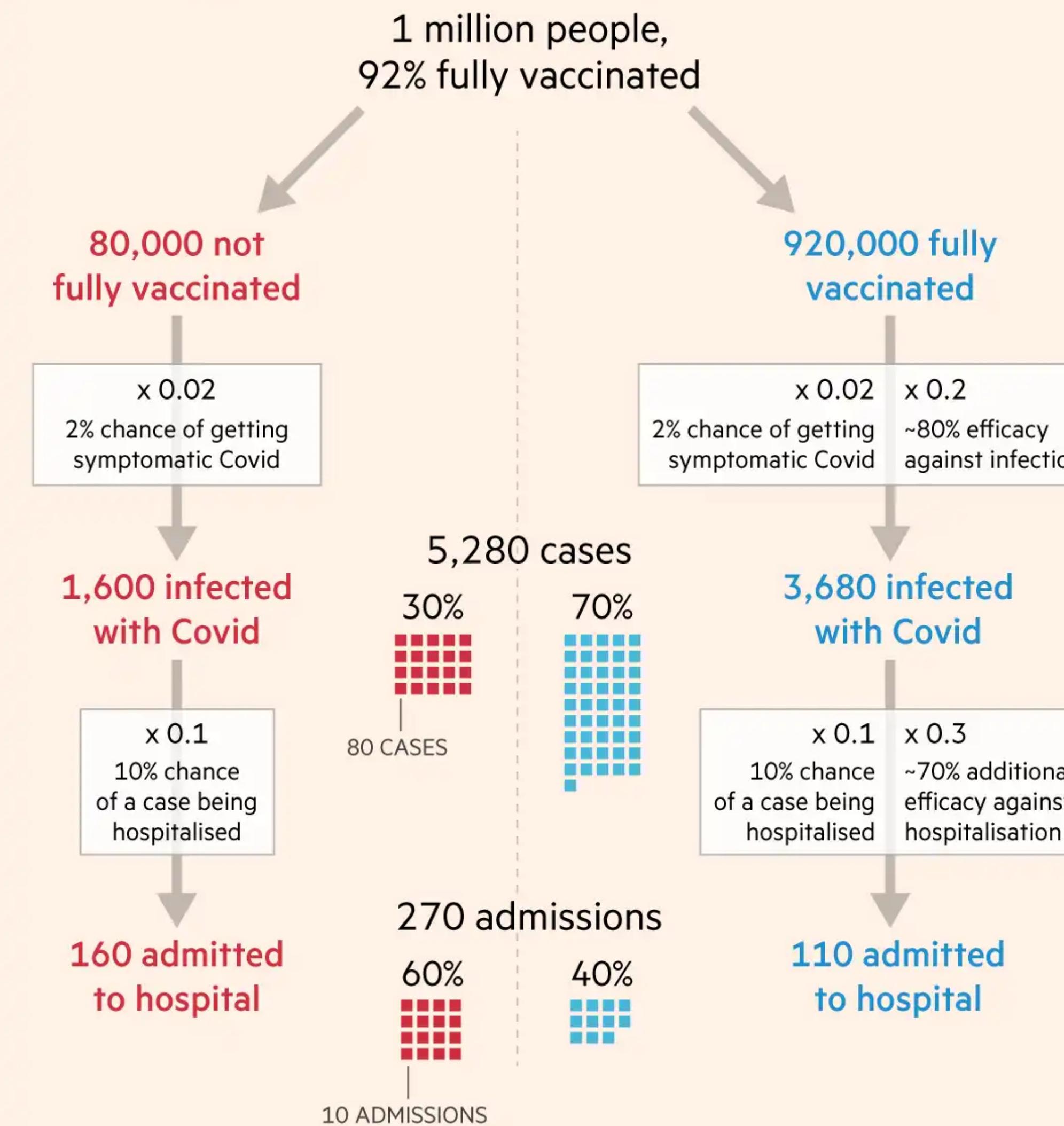
**68%**

of kids expressed interest towards science,  
compared to 44% going into the program.

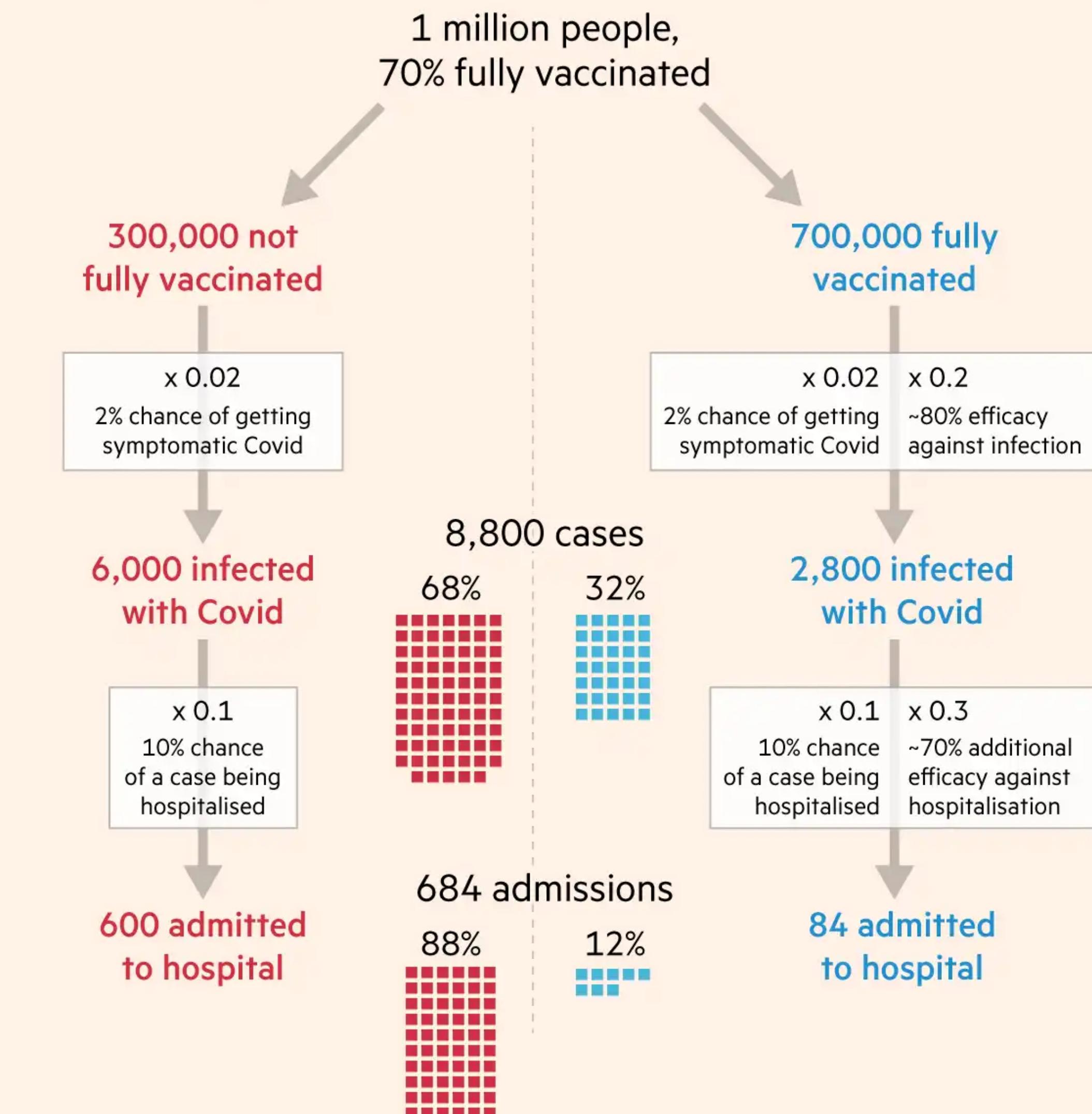
# Use storytelling

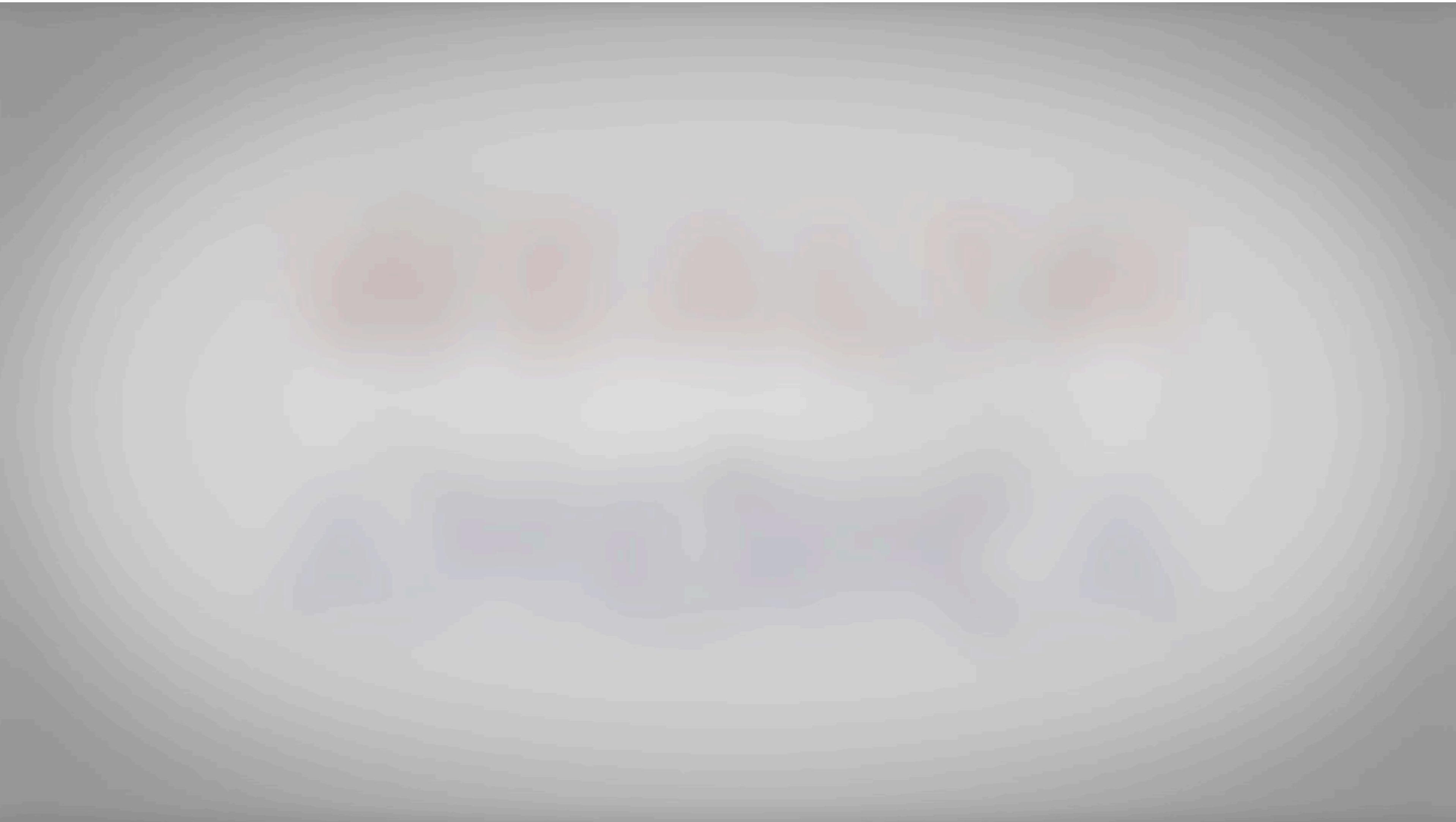
## Why a high proportion of double-jabbed people among hospitalisations does not mean the vaccines are failing

When a **very high share of people are fully vaccinated**, a large share of cases and hospitalisations will be double-jabbed people despite the vaccines working very well

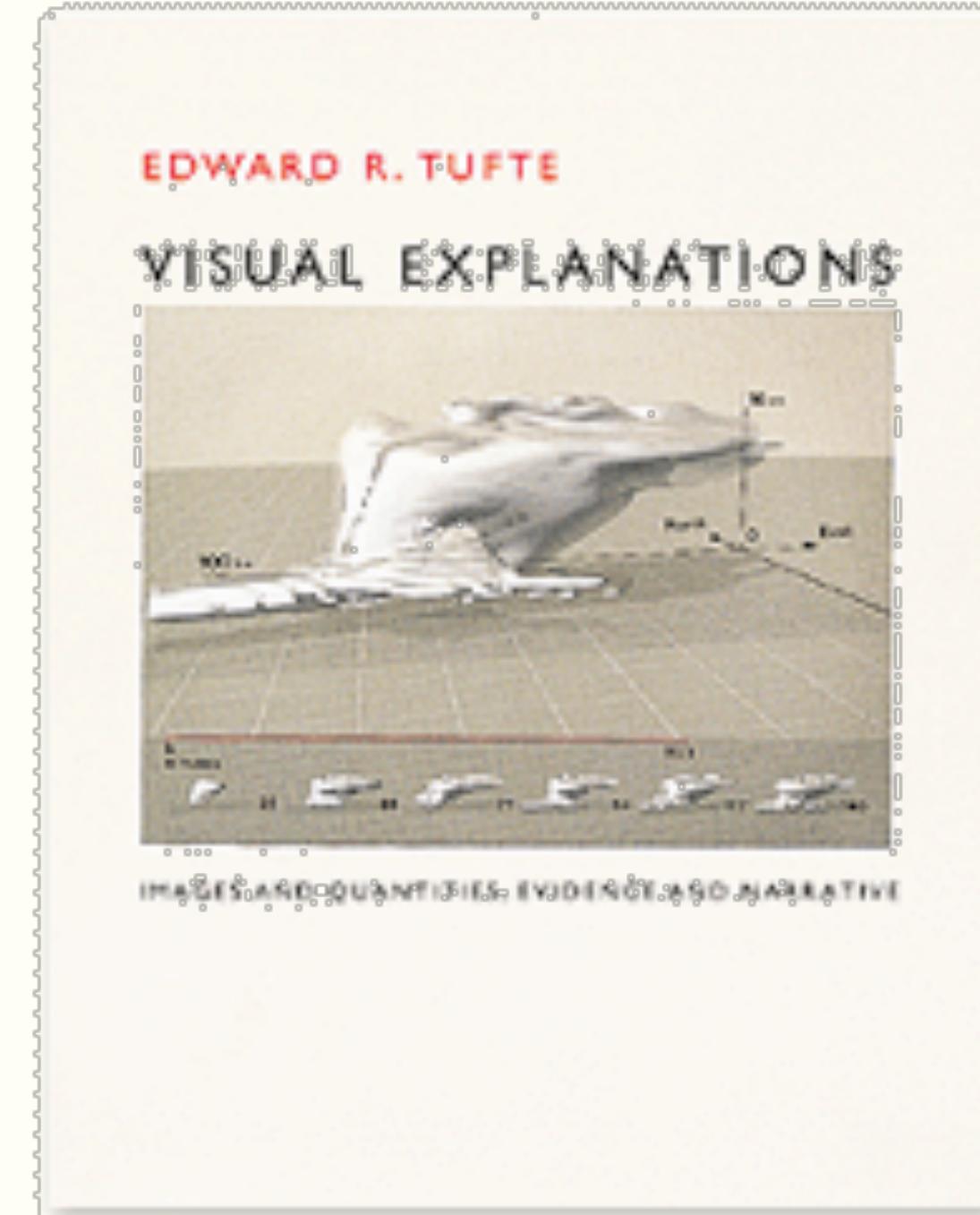
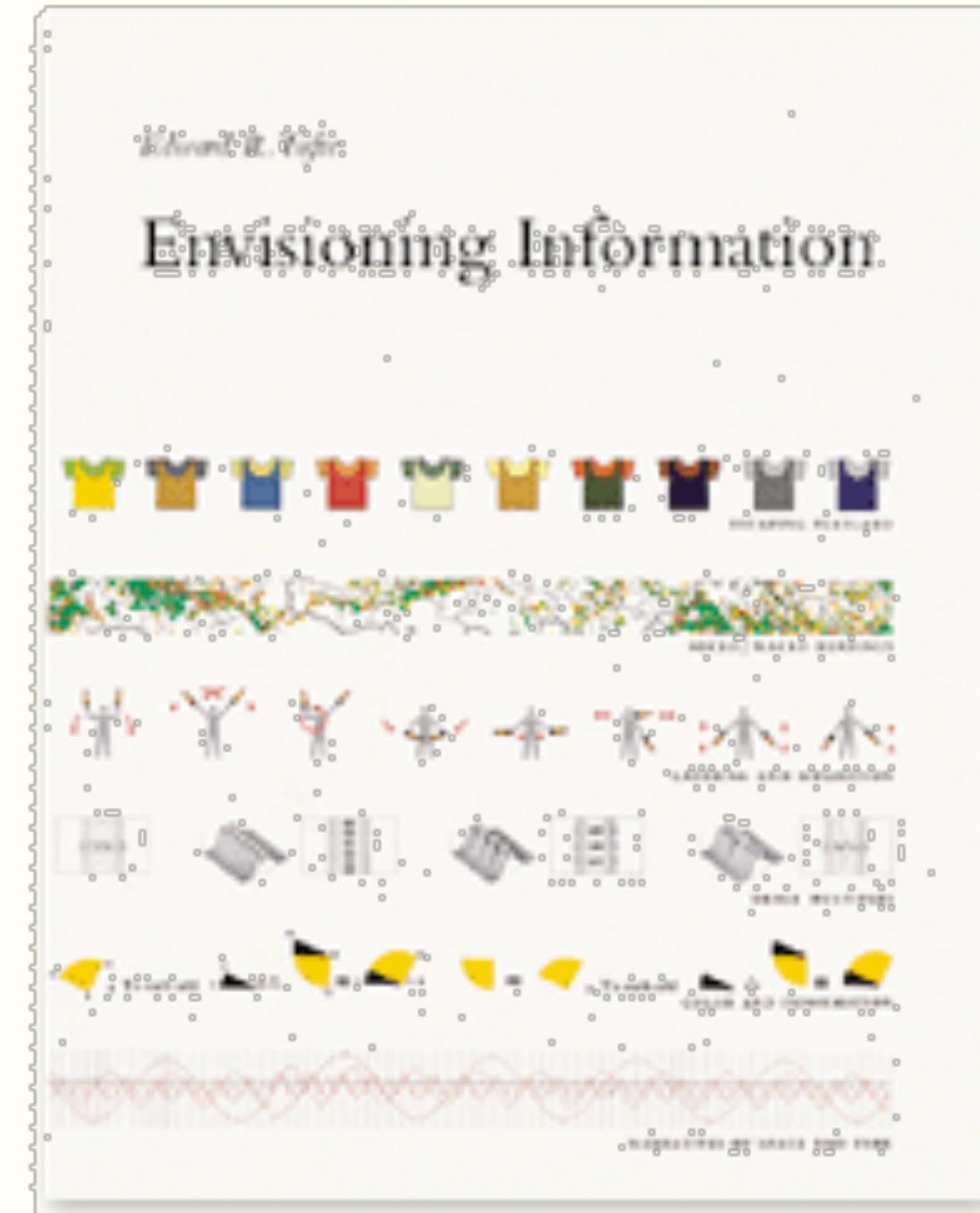
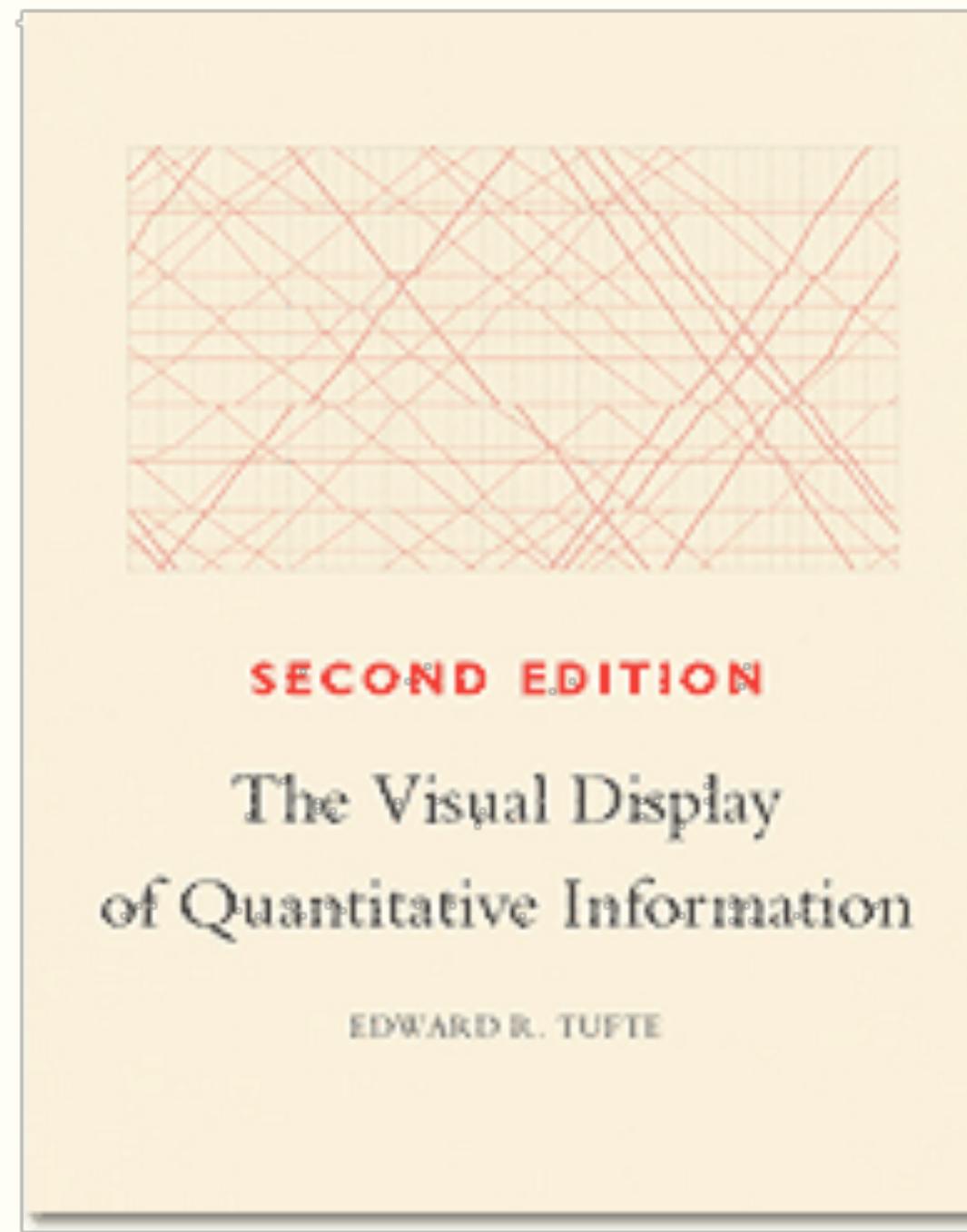


When a **lower share are fully vaccinated**, the double-jabbed are a smaller share of cases and hospitalisations, but far more people end up in hospital overall

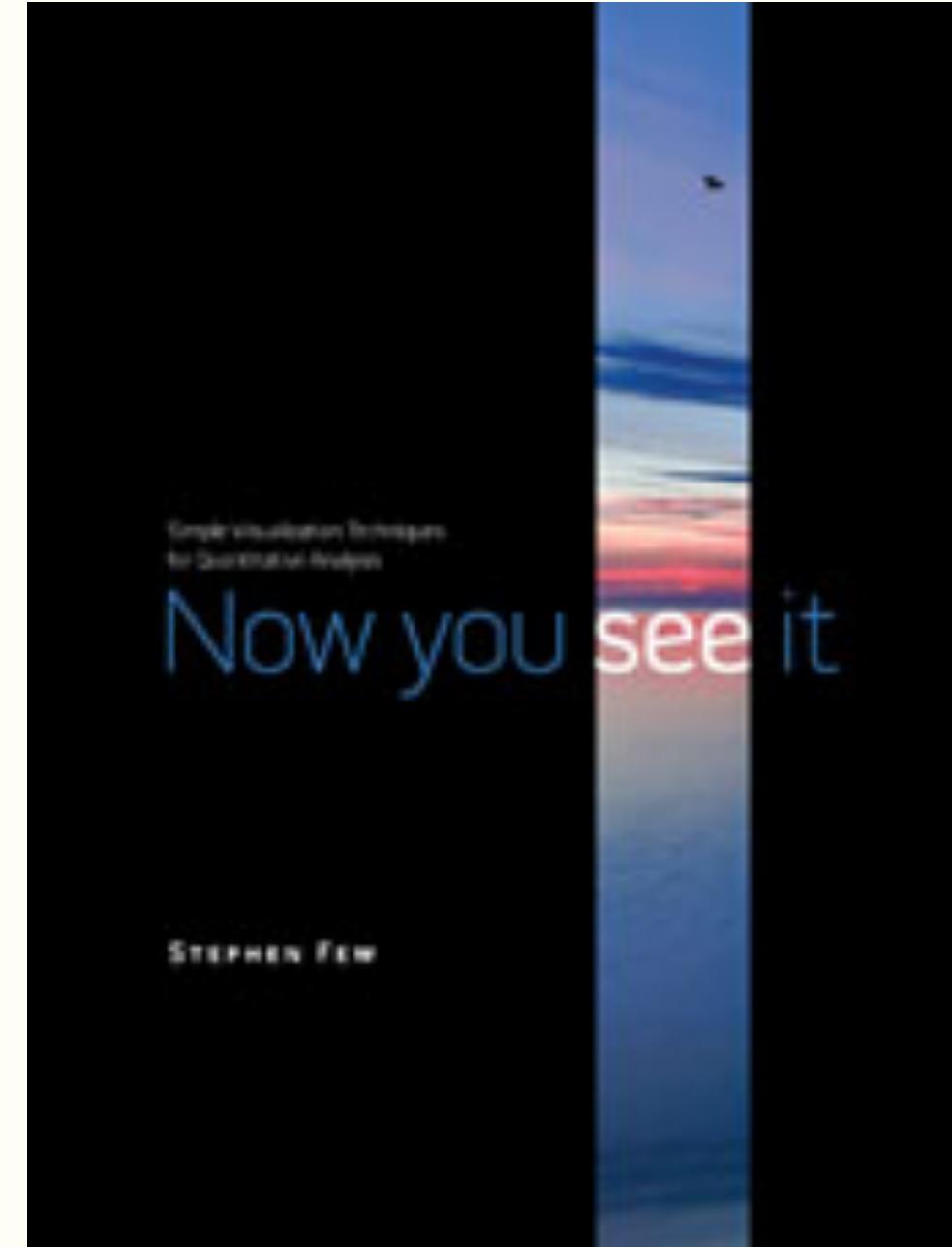
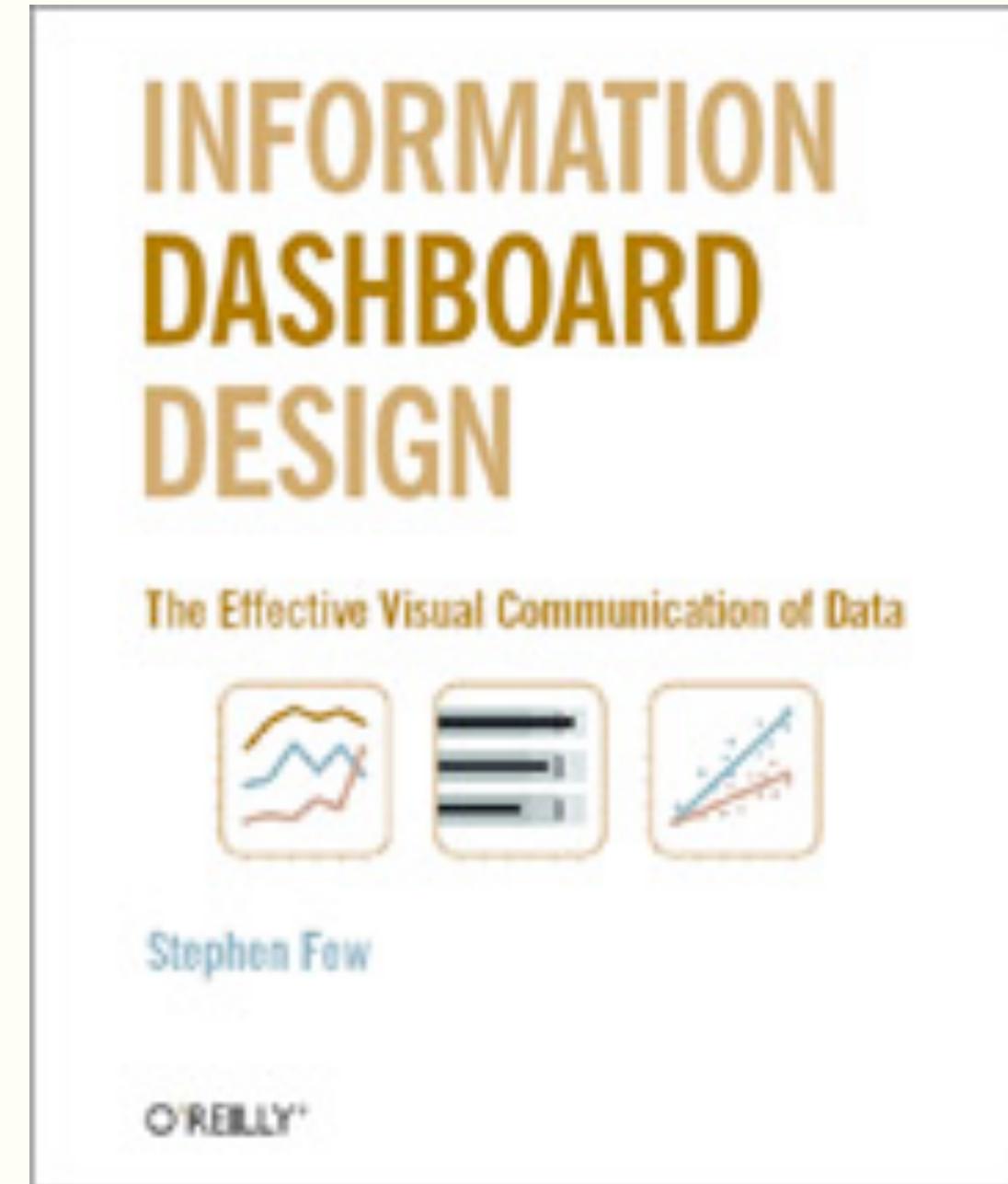
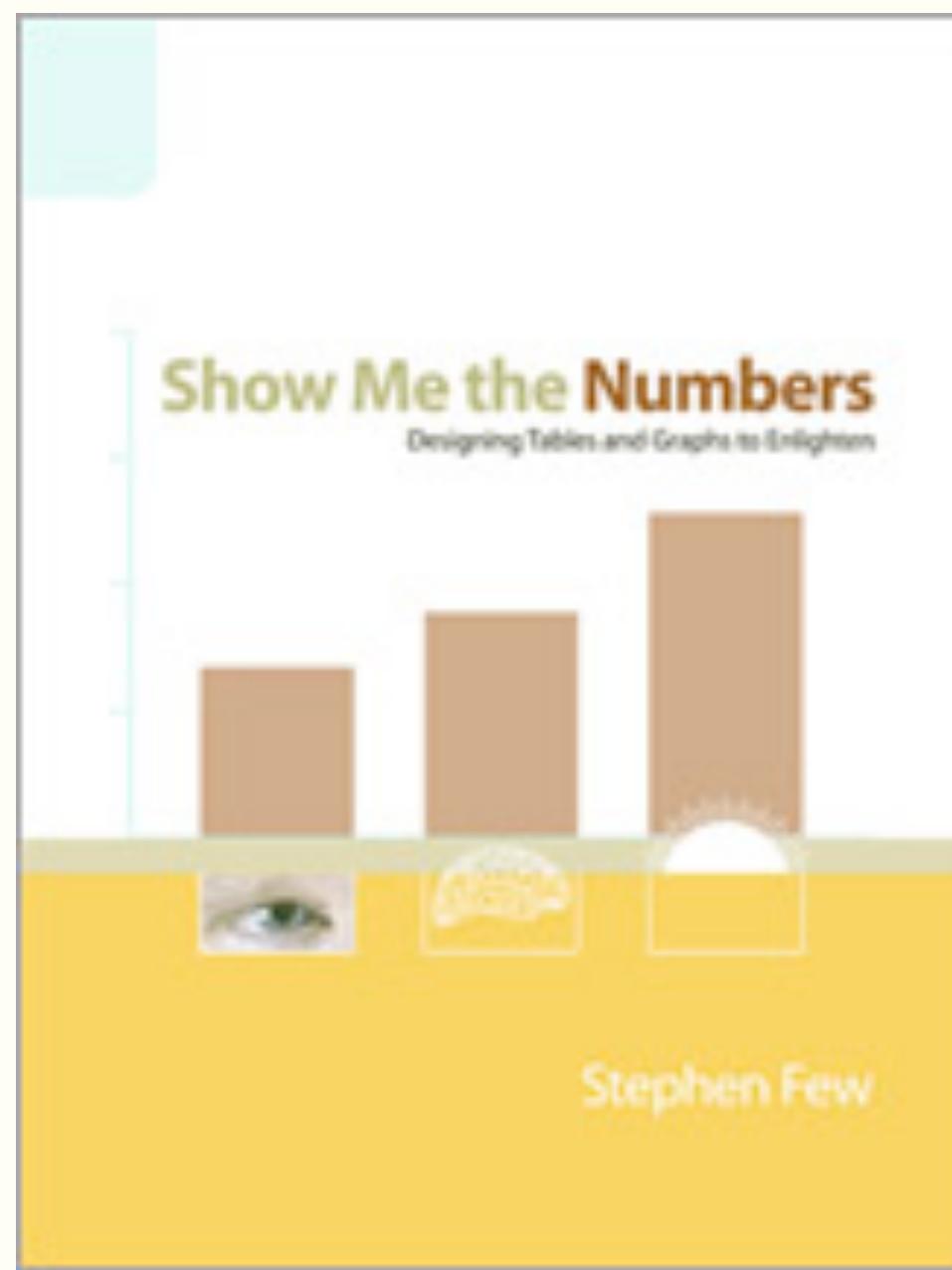


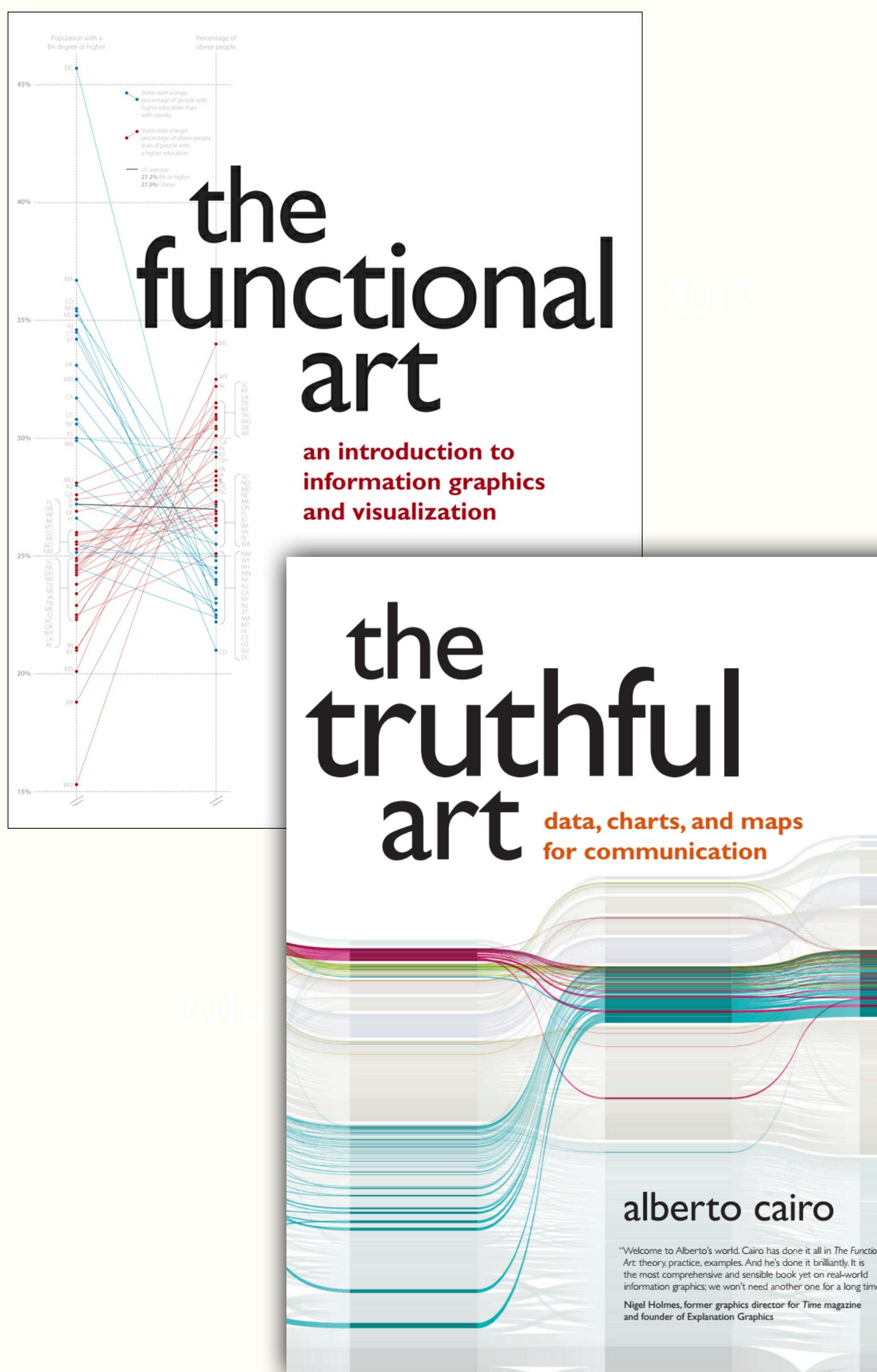


# Edward Tufte



# Stephen Few



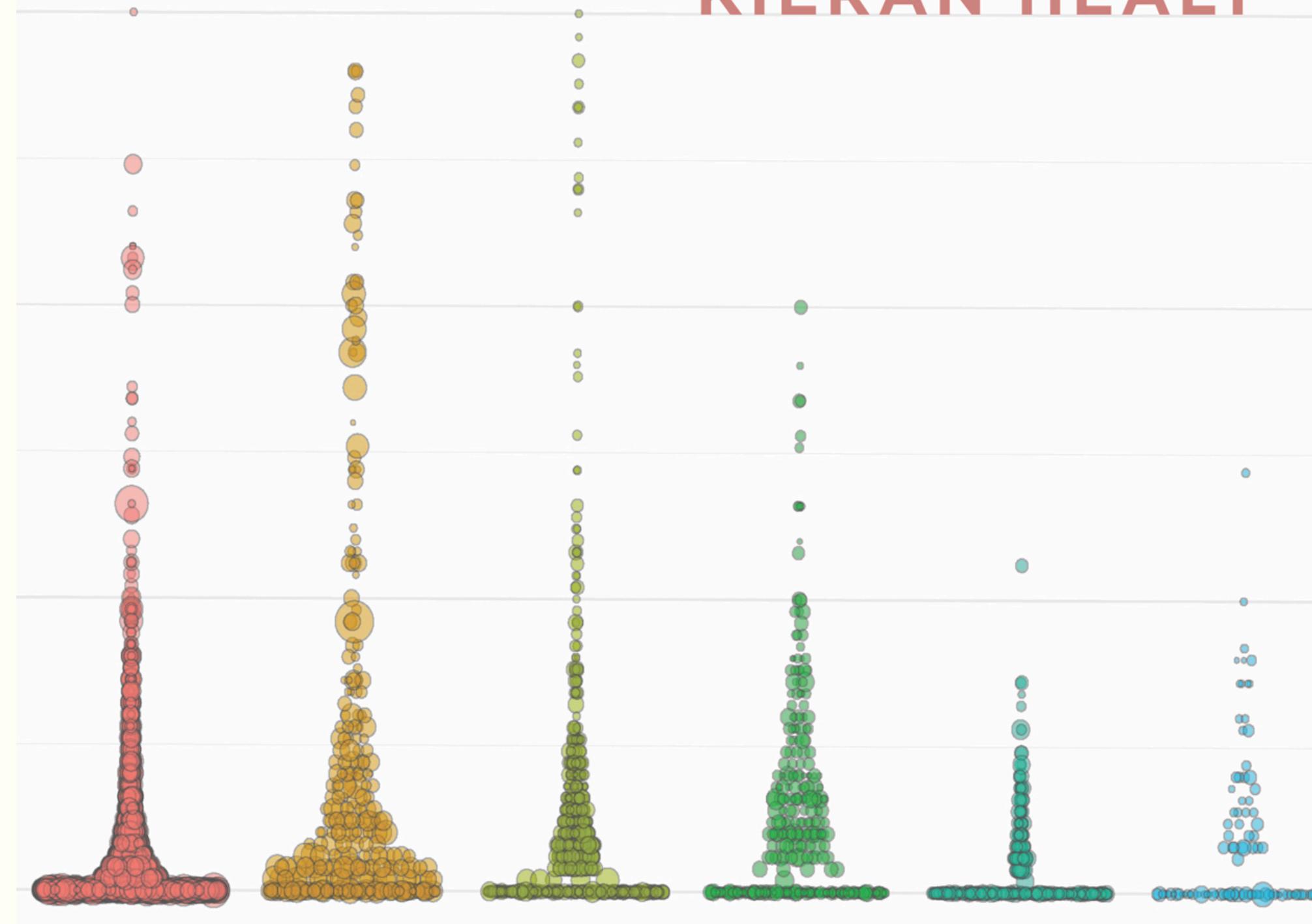


I've always believed in the power of data visualization  
 (the representation of information by means of charts, diagrams, maps, etc.)  
 to enable understanding

# DATA VISUALIZATION

A PRACTICAL INTRODUCTION

KIERAN HEALY



Draft Manuscript at <https://socviz.co>