

Effective Data Visualization

Convert information into visual forms—and tell a story

Dr. Cédric Scherer

cedricscherer.com    CedScherer  z3tt

Senckenberg Young Scientist Annual Retreat

November 12, 2021

Photo by Richard Strozyński

CÉDRIC SCHERER

Independent Data Visualization Specialist
Computational Ecologist at IZW Berlin



Consulting

Coaching

Coding



cedricscherer.com



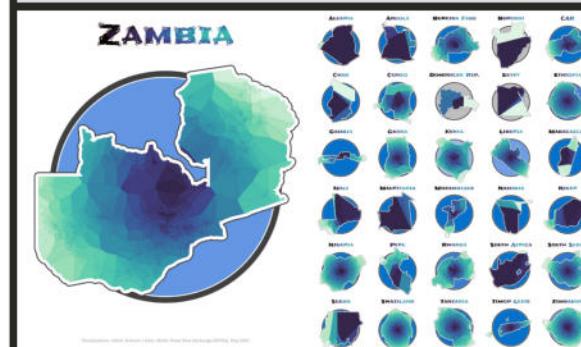
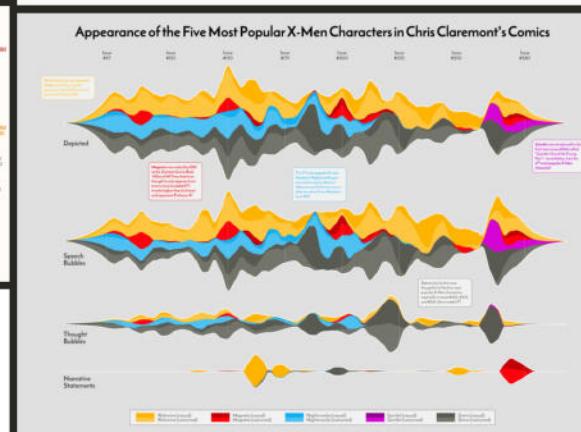
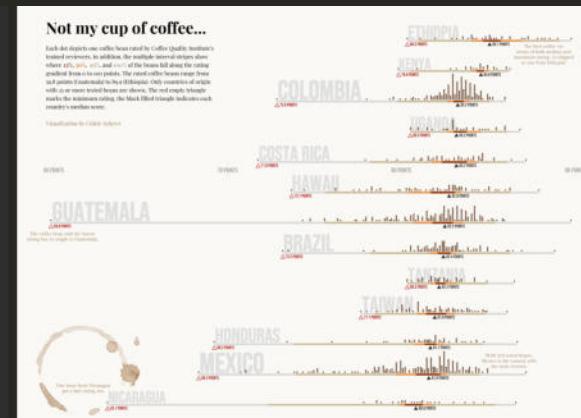
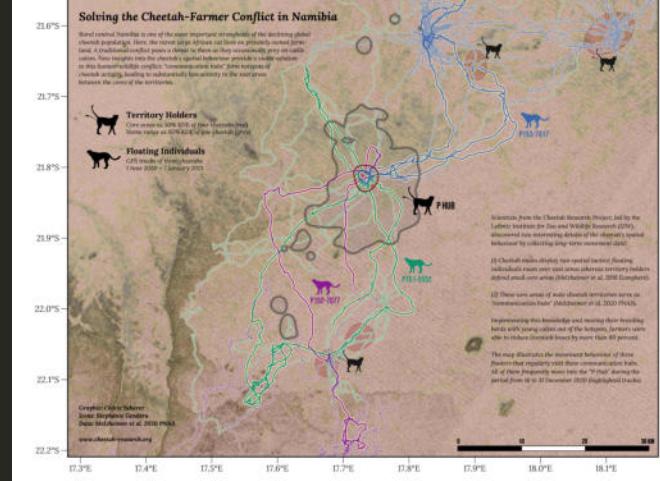
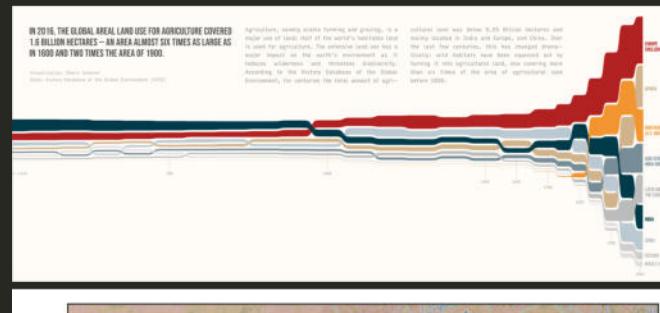
@CedScherer



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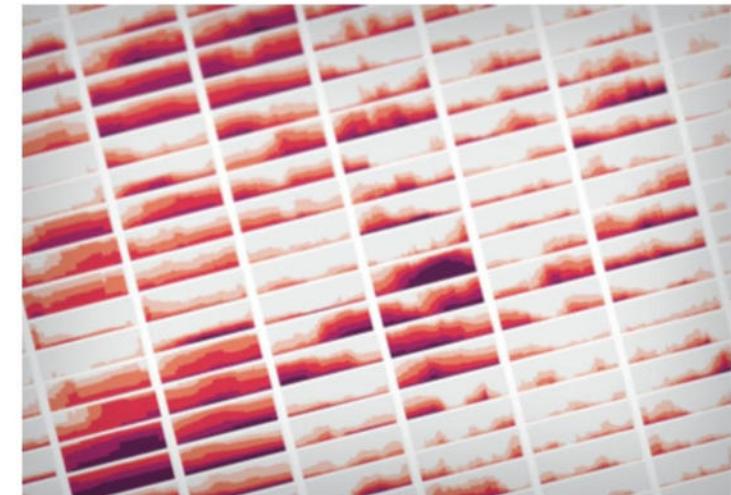


CLIMATE CHANGE

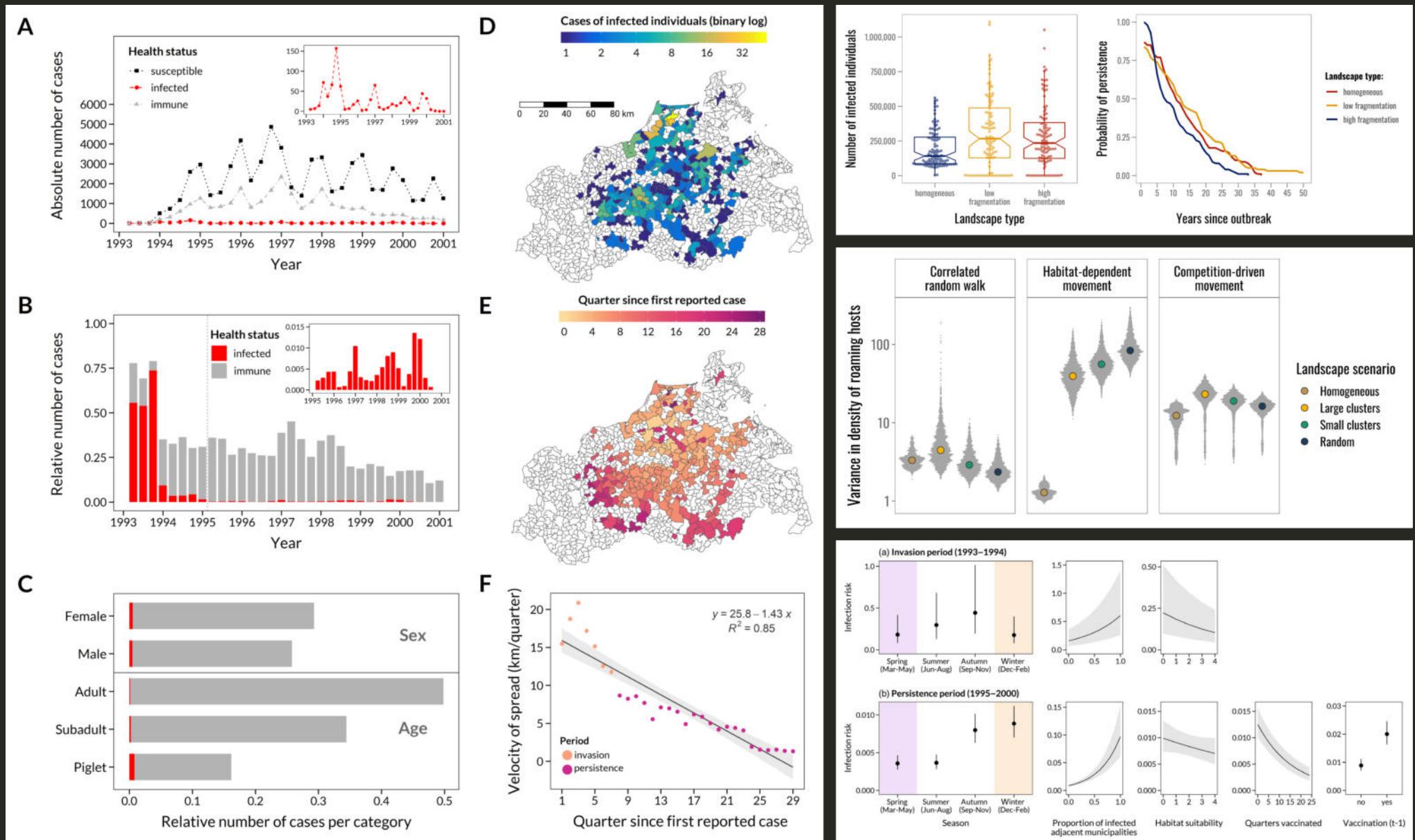
Climate Change Drives Escalating Drought

The past two decades have seen some of the most extreme dry periods in U.S. history

By Clara Moskowitz, Cédric Scherer, Georgios Karamanis
| Scientific American November 2021 Issue



Credit: Cédric Scherer and Georgios Karamanis



CÉDRIC SCHERER

Data Visualization & Computational Ecology



The World's Countries Colored by Their First Letter

While preparing the mapping section for a Pearson-O'Reilly training, I got the idea to visualize the first letter of each country. And got especially curious about how much landmass each letter covers. Turns out: A, C and R are covering the largest areas!

Posted by Cédric • Friday, August 27, 2021



Always coding. Passionate about design. Worried about nature. Proud dad.



A Quick How-to on Labelling Bar Graphs in ggplot2

Bar charts are likely the most common chart type out there and come in several varieties. Most notably, Direct labels can increase accessibility of a bar graph. I got a request how one can add percentage labels inside the bars and how to highlight specific bars with {ggplot2}. This short tutorial shows you multiple ways how to do so.

Posted by Cédric • Monday, July 5, 2021

QUICK LINKS

ggplot2 Tutorial

DATAVIZ TUTORIAL R TIDYVERSE GGPLOT2

A GGPLOT2 TUTORIAL FOR BEAUTIFUL PLOTTING IN R

POSTED BY CÉDRIC ON MONDAY, AUGUST 5, 2019

Last update: 2019-11-01

INTRODUCTORY WORDS

I don't care, just show me the content!

Begin of 2016, I had to prepare my PhD introductory talk and I started using `ggplot2` to visualize my data since I never liked the syntax and style of base plots in R. Because I was short on time, I plotted these figures by try'n'error and with the help of lots of googling. The resource I came always back to was a blog entry called [Beautiful plotting in R: A ggplot2 cheatsheet](#) by Zev Ross, posted on 4. August 2014, updated last in January 2016. After giving the talk which contained some quite beautiful plots thanks to the blog post, I decided to go through this tutorial step-by-step. I learned so much from it and directly started modifying the codes and over the time I added some additional code snippets, chart types and resources.

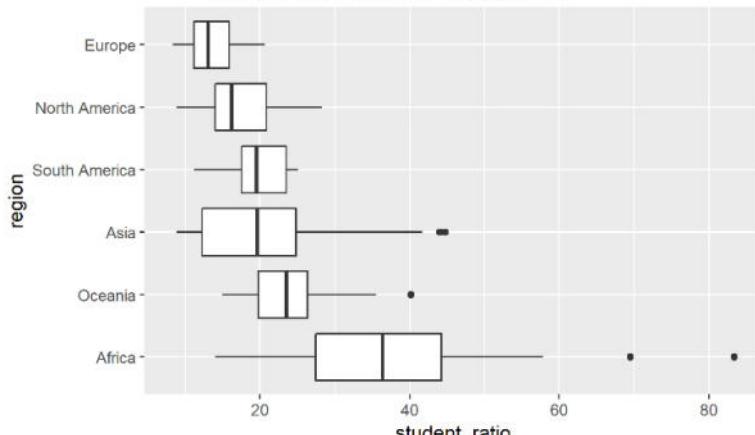
Since the blog entry by Zev Ross was not updated for some years, I hosted the updated version on my GitHub. Now it finds its proper place on this homepage! (Plus I added some updates for example the fantastic `patchwork` and `enforce` packages. And pie charts.

DATAVIZ TUTORIAL ANIMATIONS GGPLOT EVOLUTION R GGPLOT2 TIDYVERSE TIDYTUESDAY

THE EVOLUTION OF A GGPLOT (EP. 1)

POSTED BY CÉDRIC ON FRIDAY, MAY 17, 2019

The Evolution of a ggplot



Data: UNESCO Institute for Statistics
Visualization by Cédric Scherer

- Aim of this Tutorial
- Data Preparation
- The Default Boxplot

Data Visualizations

are any graphical representation
of information and data

Data Visualizations

convert information into visual forms
as quantifiable features

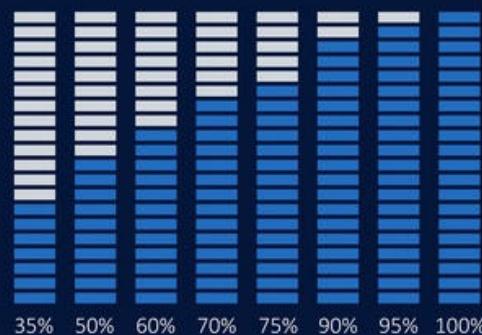
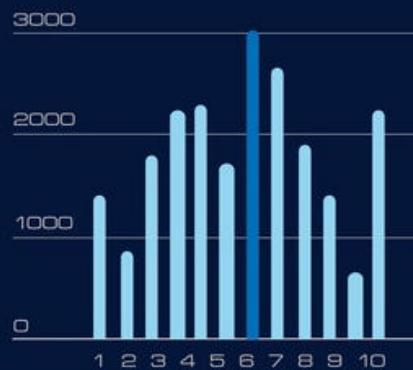
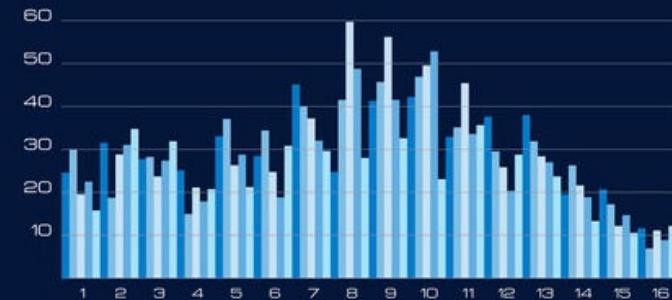
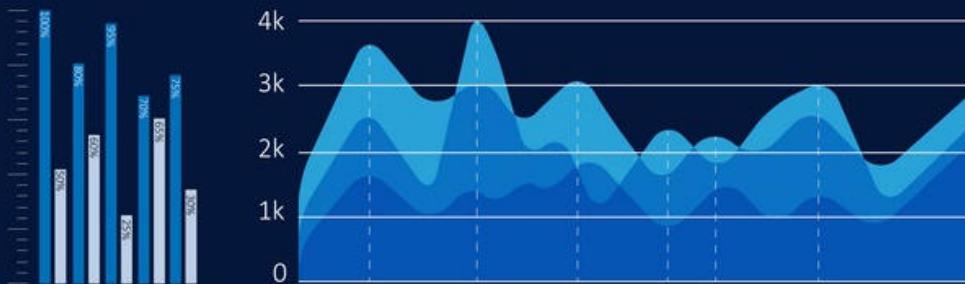
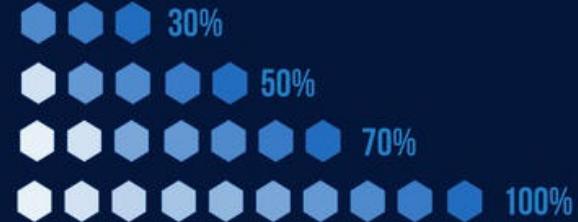
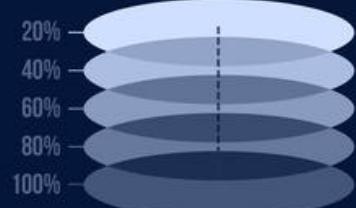
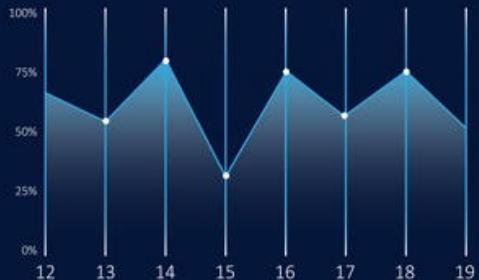
Data Visualizations

help to amplify cognition, gain insights,
discover, explain, and make decisions

Data Visualizations

are part art and part science





Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.

Dessiné par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en lettres des zones. Le rouge désigne les hommes qui entrent en Russie; le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été pris dans les ouvrages de M. Chiers, de Séguir, de Fezensac, de Chambray et le journal médical de Jacob, pharmacien de l'Armée depuis le 28 Octobre.

Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Napoléon et du Maréchal Davout, qui avaient été détachés sur Minsk et Mohilow et se rejoignaient vers Orscha et Witebsk, avaient toujours marché avec l'armée.

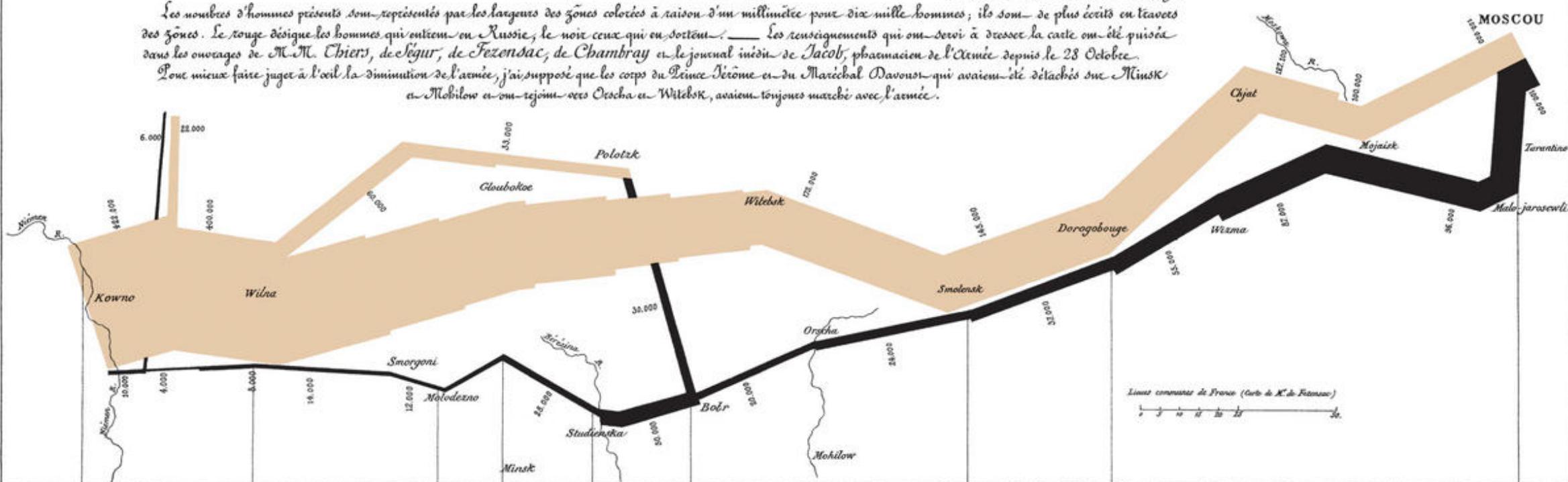


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

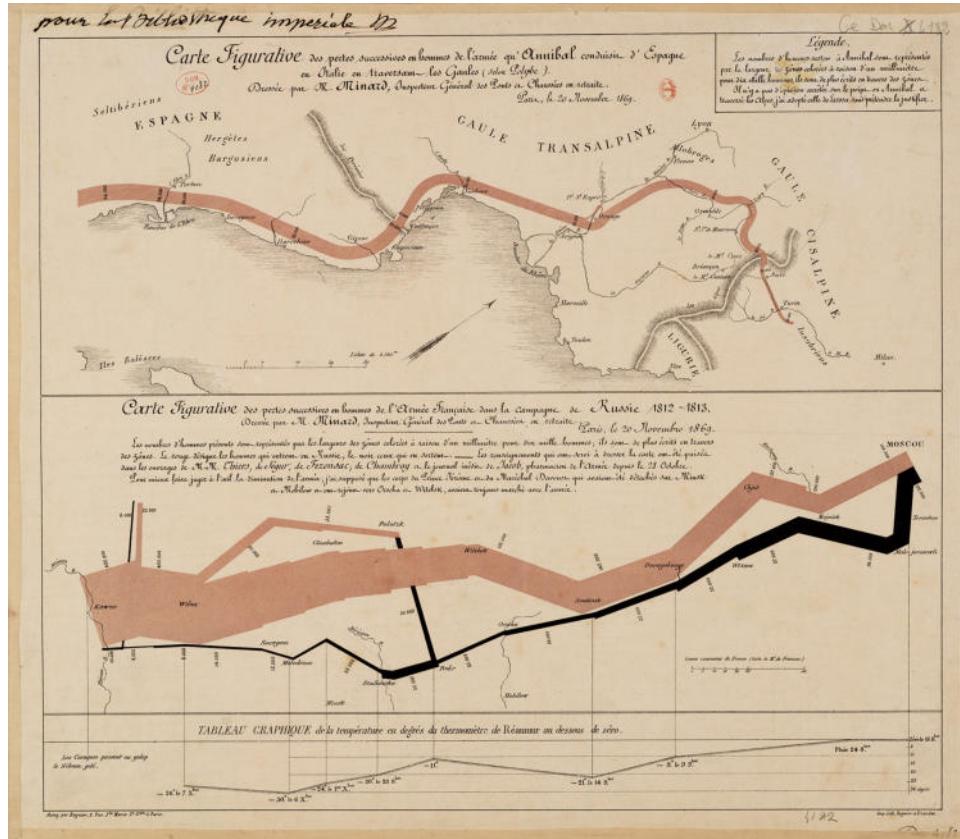
Les Cosaques passent au galop
le Niemen gelé.



Autog. par Regnier, 8, Rue S^e Marie 5^e G^e à Paris.

Imp. Litt. Regnier et Durand.

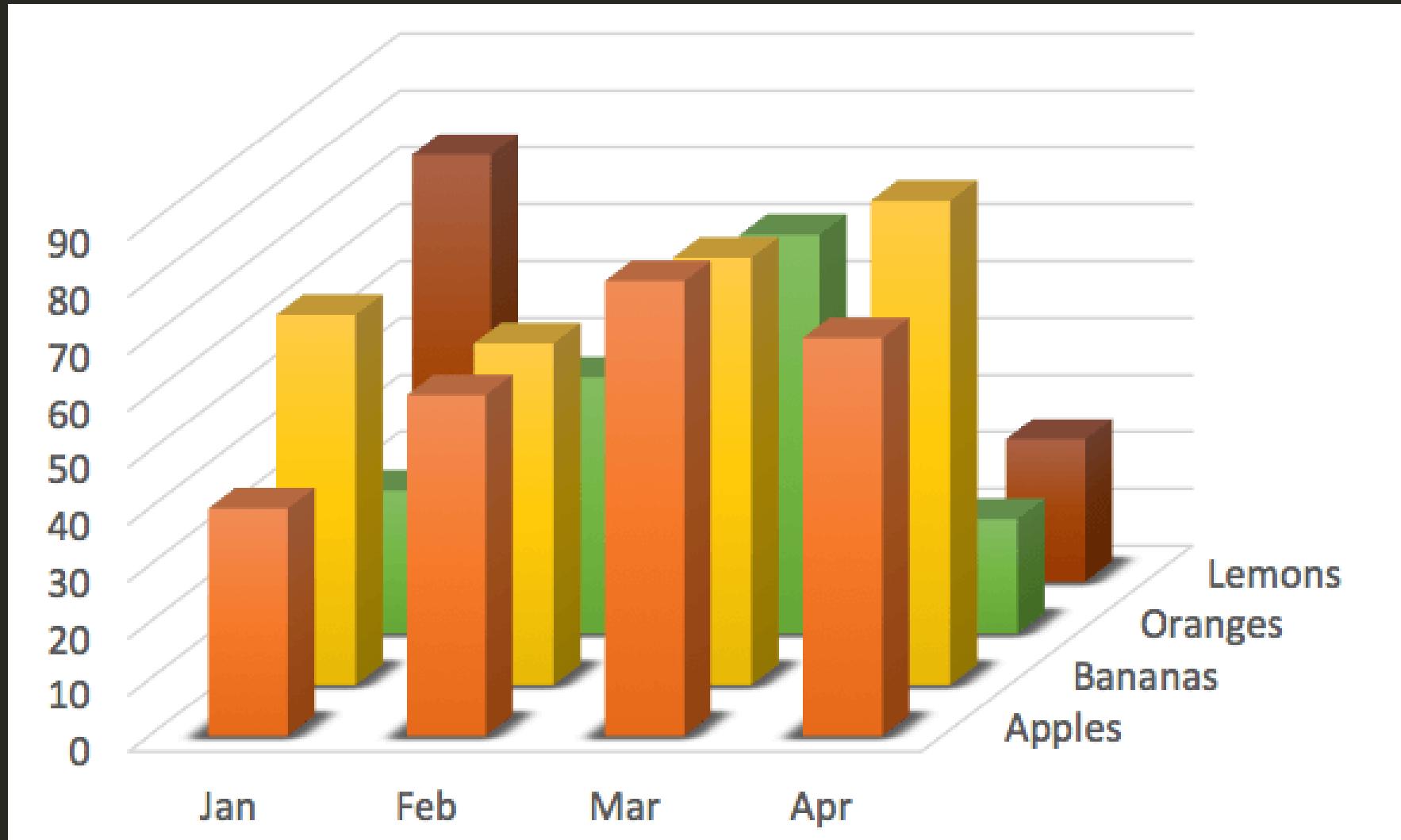
Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813 by Charles Joseph Minard



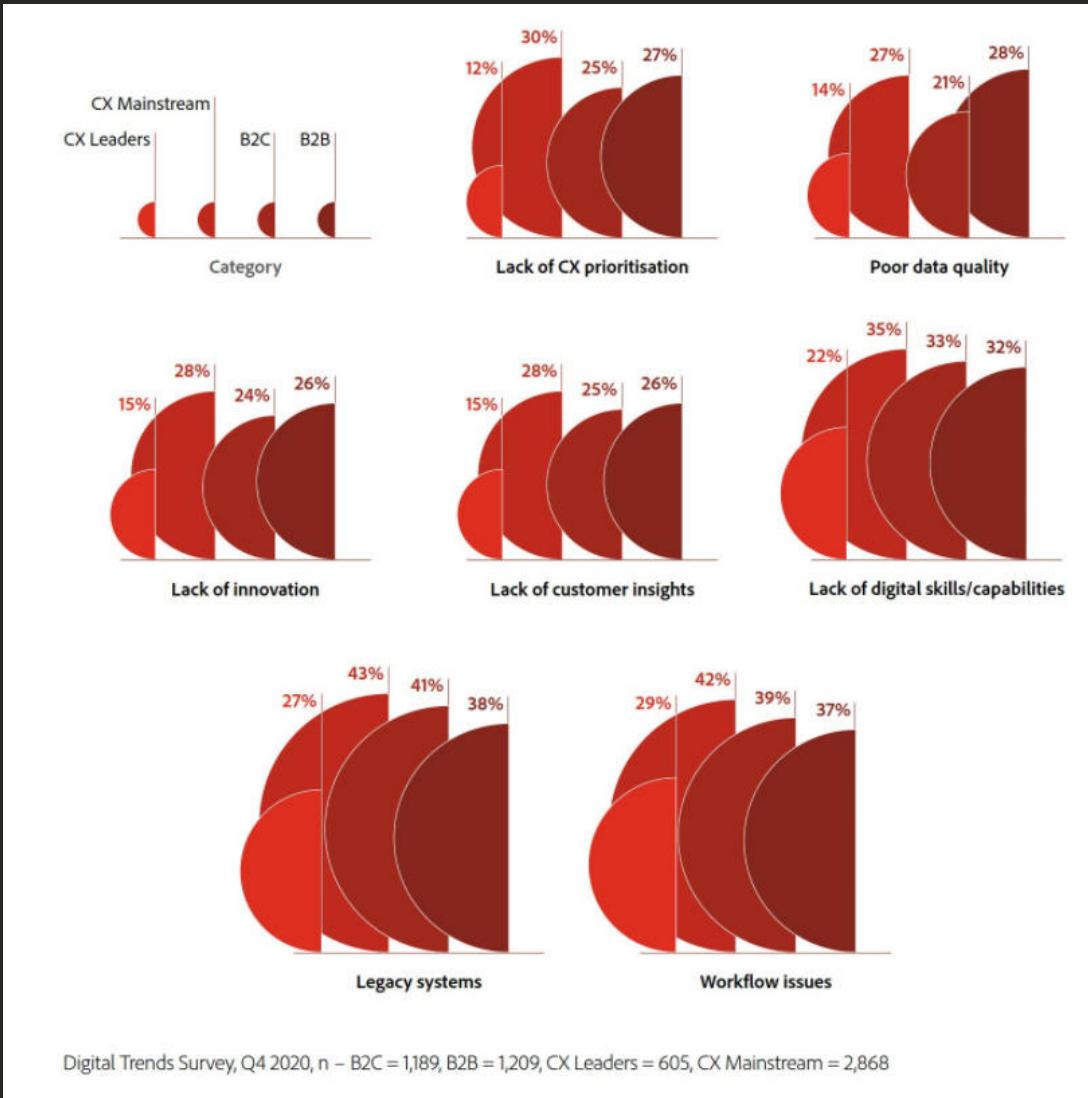
Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813 and Carte figurative des pertes successives en hommes de l'Armée qu'Annibal conduisit d'Espagne en Italie en traversant les Gaules (selon Polybe) by Charles Joseph Minard

- displays the progress of the troops of Hannibal (218 BC) and Napoleon (1812-1813) in the form of a stream
- often considered as the **best statistical graphic ever drawn**

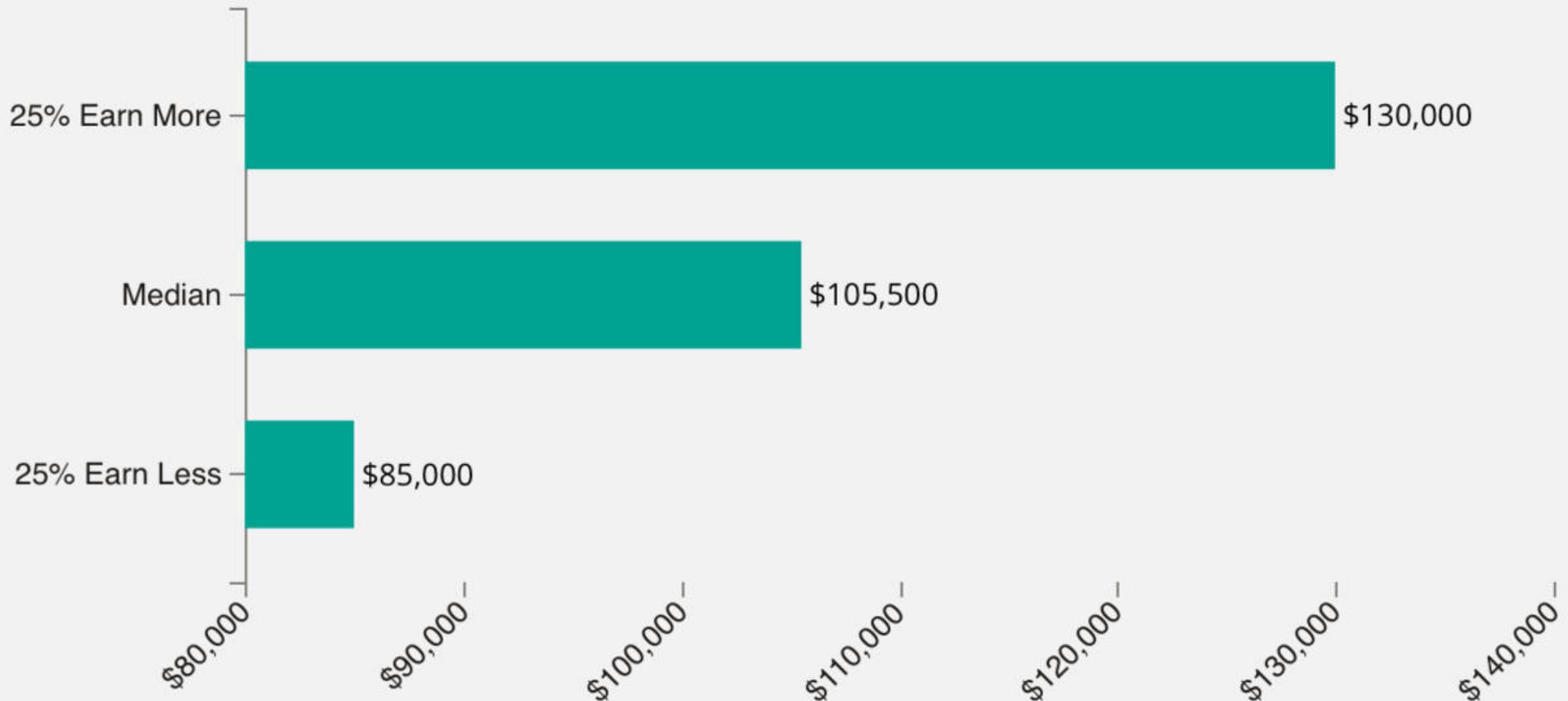
What Makes It a Bad Data Visualization?



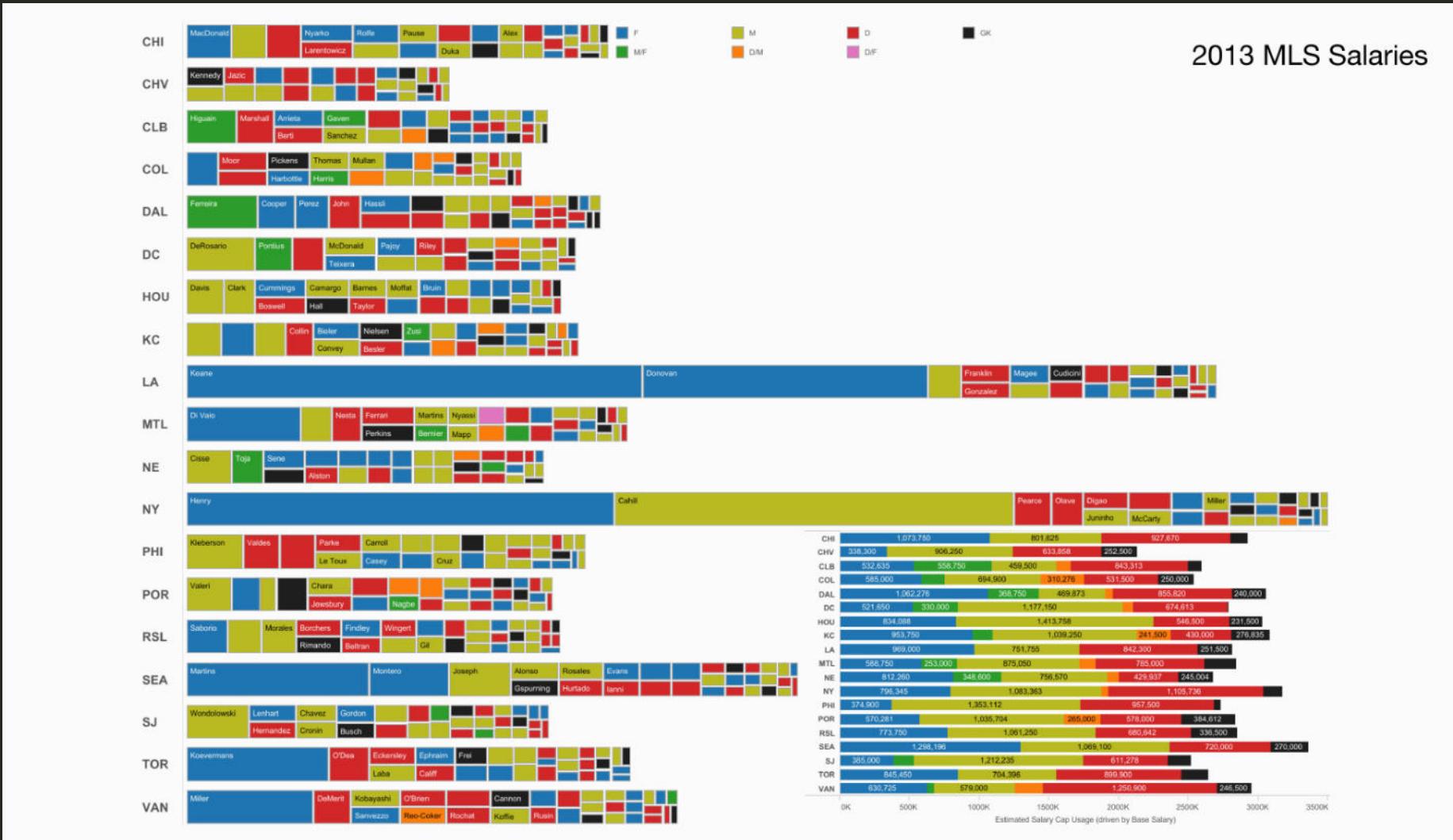
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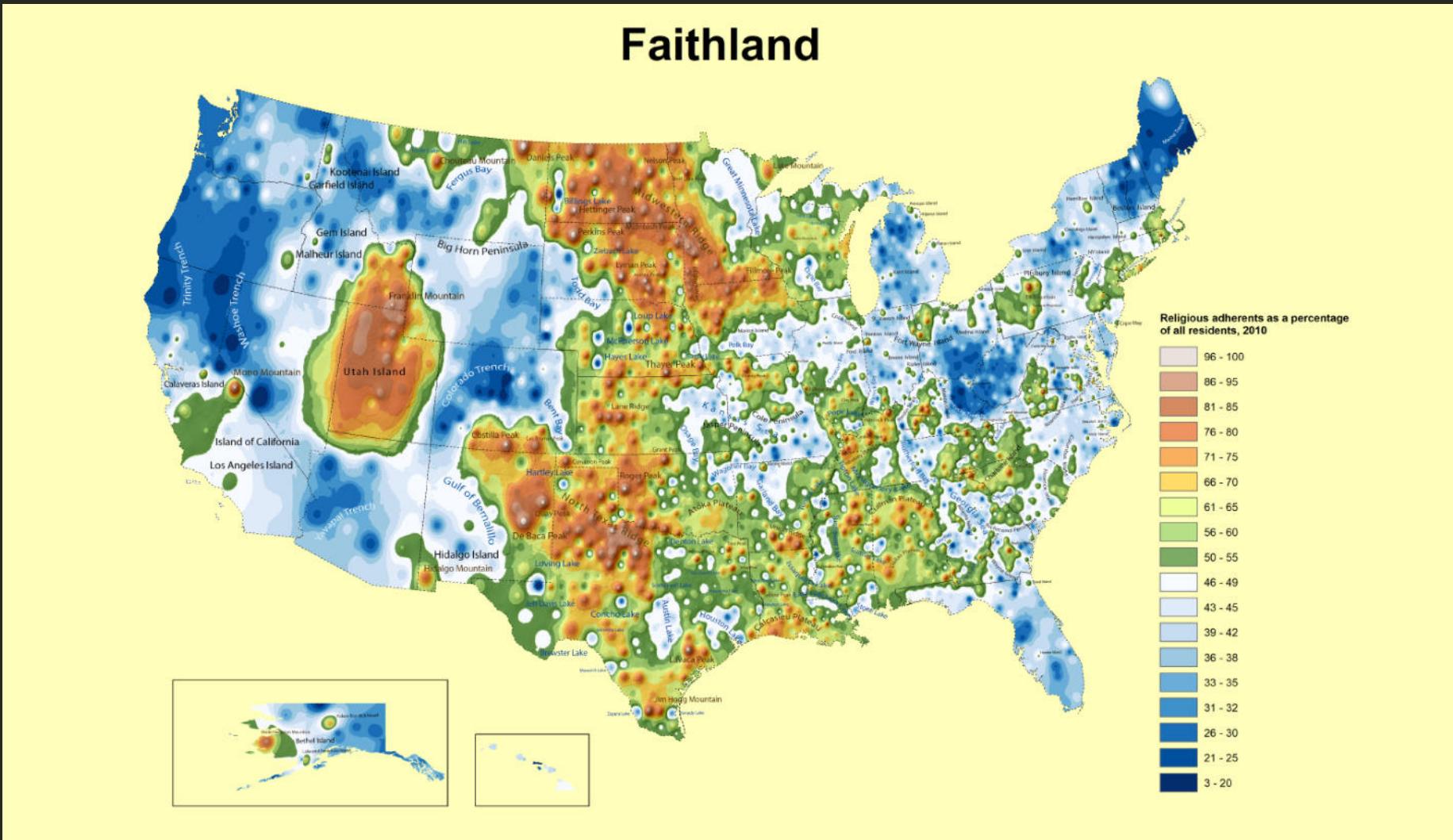
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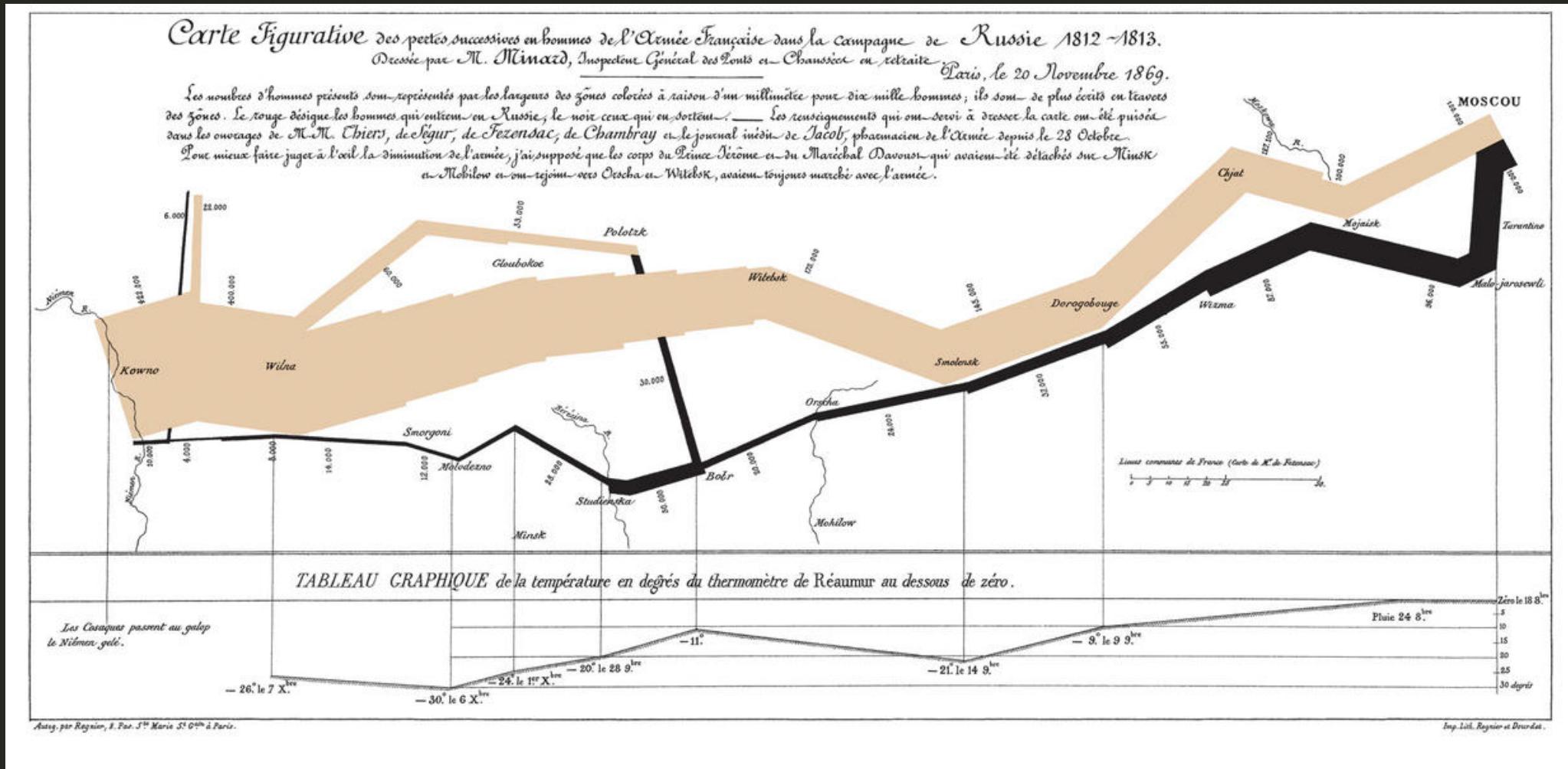
What Makes It a Bad Data Visualization?



What Makes It a Bad Data Visualization

- **Substantive problems** (bad data/story)
- **Aesthetic problems** (bad design)
- **Perceptual problems** (bad perception)

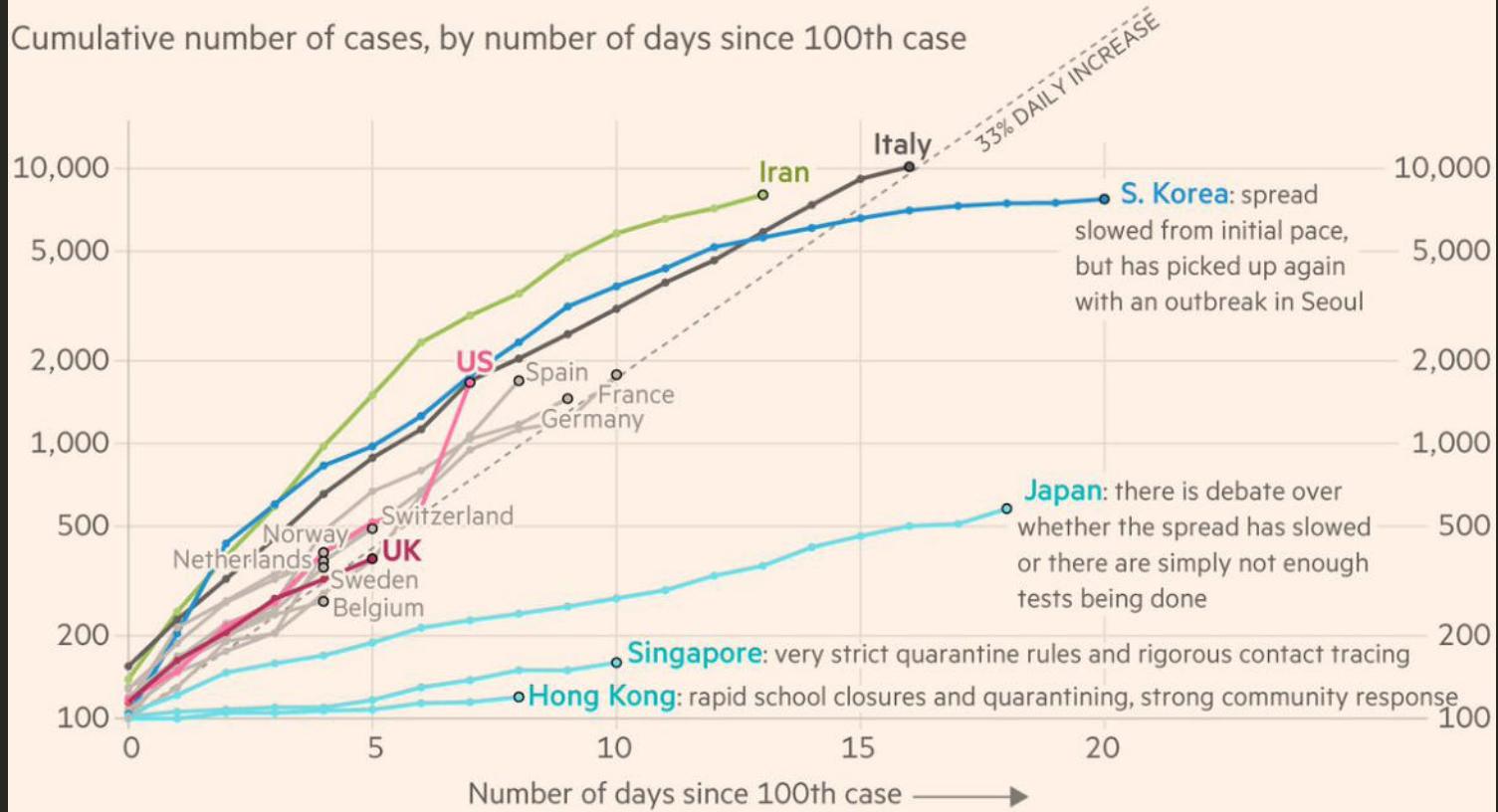
What Makes It a Good Data Visualization?



What Makes It a Good Data Visualization?

Most western countries are on the same coronavirus trajectory. Hong Kong and Singapore have managed to slow the spread

Cumulative number of cases, by number of days since 100th case

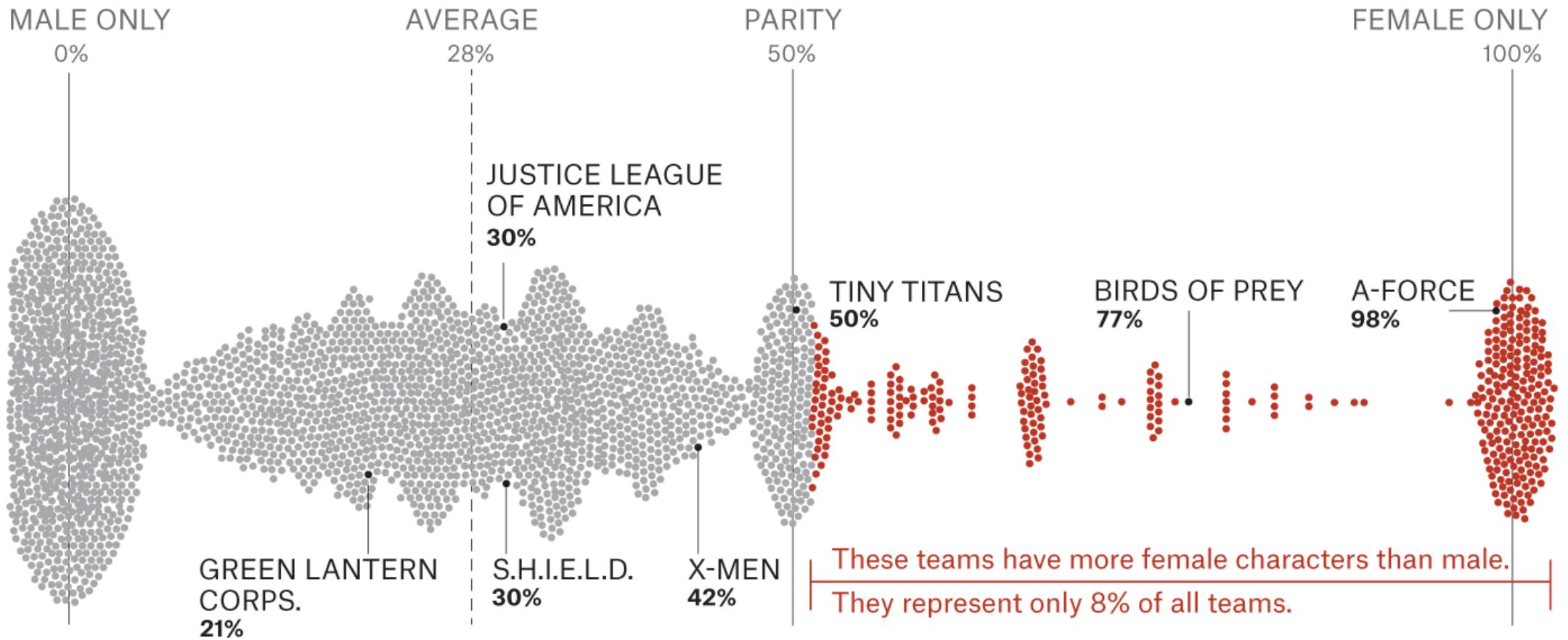


Source: FT analysis of Johns Hopkins University, CSSE

FT graphic: John Burn-Murdoch / @jburnmurdoch

© FT

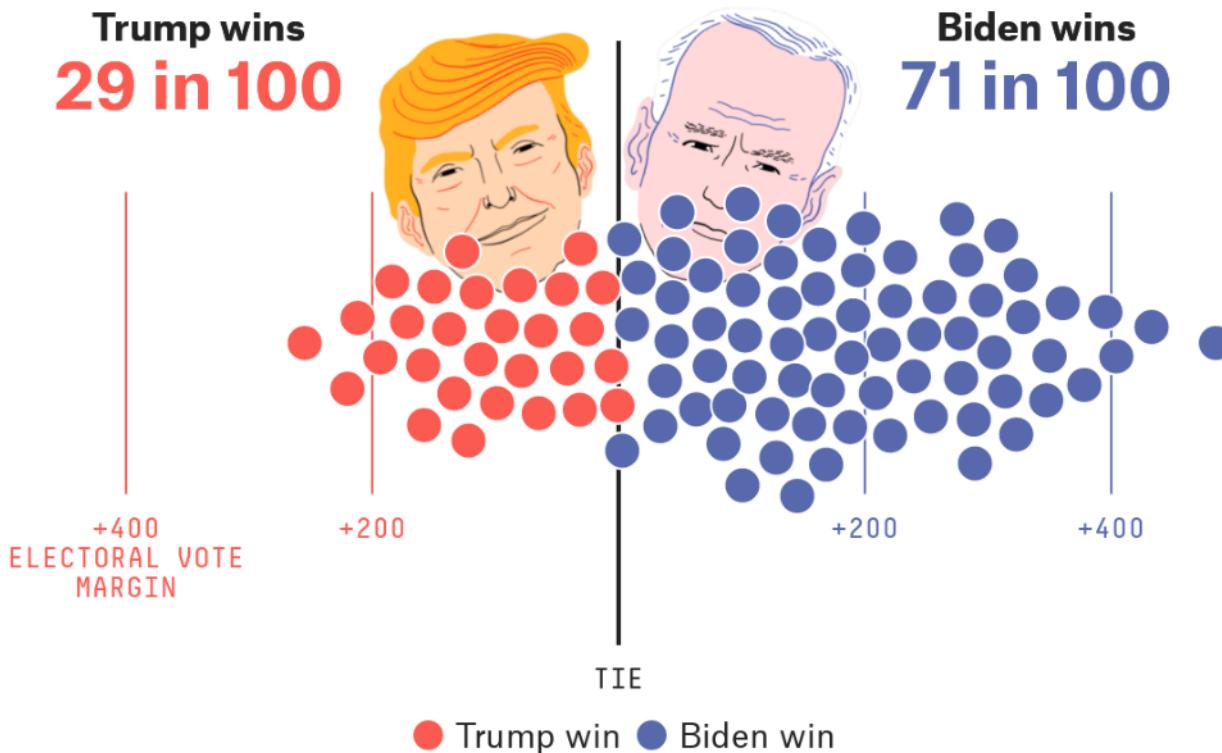
What Makes It a Good Data Visualization?



What Makes It a Good Data Visualization?

Biden is *favored* to win the election

We simulate the election 40,000 times to see who wins most often. The sample of 100 outcomes below gives you a good idea of the range of scenarios our model thinks is possible.



What Makes It a Good Data Visualization

- **Information** (Integrity)
- **Story** (Interestingness)
- **Goal** (Usefulness)
- **Visual Form** (Beauty)

Information

Understand your data and be accurate

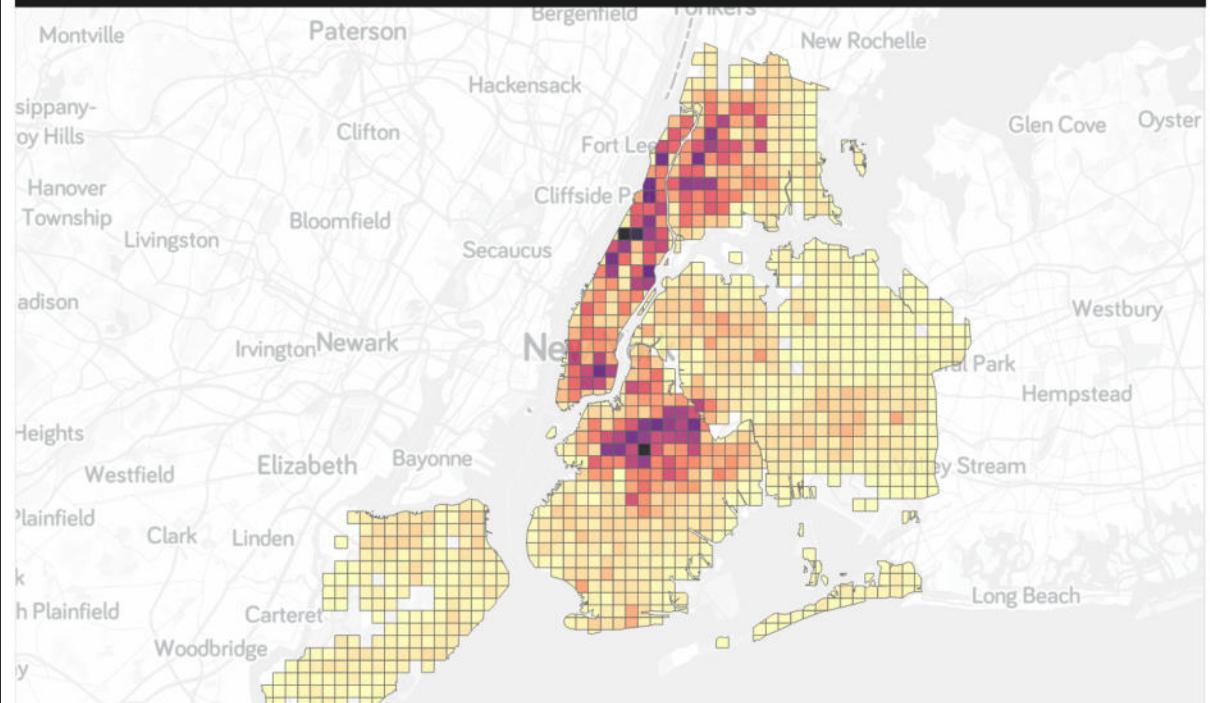
Our data is never a perfect reflection of the real world.

- **Only a subset:** Not crime but reported crime
- **Collected by humans:** guesstimation, precision and errors
- **Collected by machines:** precision and errors

Where are New York's rats?

Choose a Borough

(All)



2010 2011 2012 2013 2014 2015 2016 2017



DATA SOURCE: NYC Open Data | DESIGNED BY: Andy Kriebel @VizWizBI

The best use of data is to
teach us what isn't true.



Source: inhomelandsecurity.com/risk-management-and-black-swan-events

A photograph of a flock of white swans swimming in a body of water. The swans are mostly white with some black on their wings and orange bills. The background shows a cloudy sky.

Don't form a **singular statement**:
"The swan is white"

Instead, confront yourself with a
falsifiable universal statement:

"All swans are white"

Know Your Types of Data

Quantitative Data
versus
Qualitative Data

Quantitative Data (Numerical)

CONTINUOUS

measured data, can have ∞ values within possible range.



I AM 3.1" TALL
I WEIGH 34.16 grams

DISCRETE

OBSERVATIONS CAN ONLY EXIST AT LIMITED VALUES, OFTEN COUNTS.



I HAVE 8 LEGS
and
4 SPOTS!

@allison_horst

Illustration by Allison Horst

Qualitative Data (Categorical)

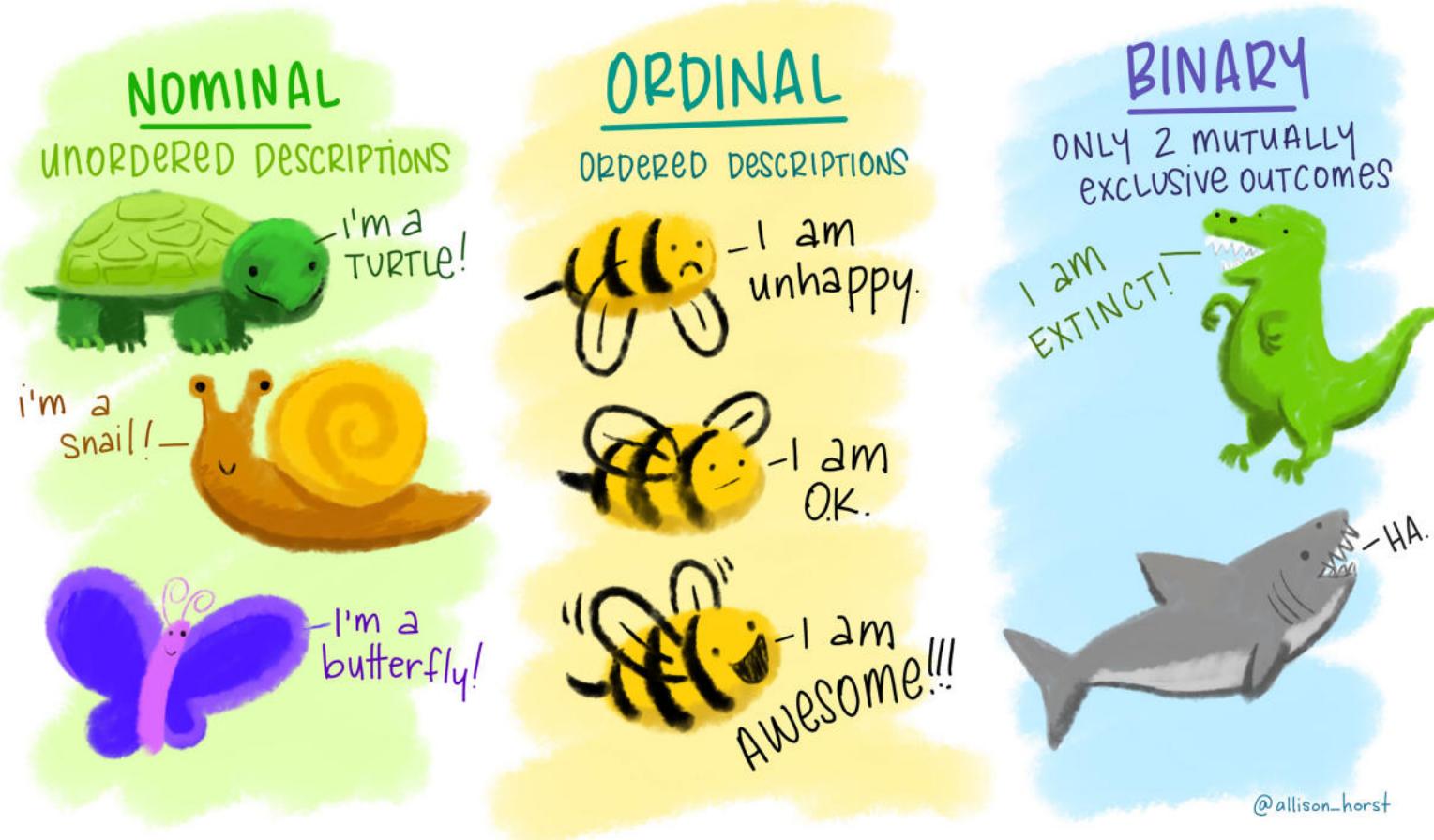


Illustration by Allison Horst

Types of Data

- **Quantitative (numerical)** versus **qualitative (categorical)** data
- **Ordered (ordinal)** versus **unordered (nominal)** data
- **Continuous** versus **discrete** data

Types of Data – Your Turn!

- Quantitative (numerical) versus qualitative (categorical) data
- Ordered (ordinal) versus unordered (nominal) data
- Continuous versus discrete data
- What are the data types of:
 - "female" → qualitative + discrete + unordered
 - 2019/09/26 "17:01:35" → quantitative + continuous + ordered
 - 1 → quantitative + continuous + ordered
 - or: quantitative + discrete + ordered
 - or: qualitative + discrete + ordered
 - or: qualitative + discrete + unordered

Story

Be clear about the message of your visualization

It is hard to effectively design for others.

It is harder if you don't even care to try.

Andy Kirk

Who is my audience?

Who is my audience?

Which story is **interesting** for my audience?

What are **relevant** details to include?

Which variables are **meaningful** to my audience?

How will they **encounter** the visualization?

Who is my audience?

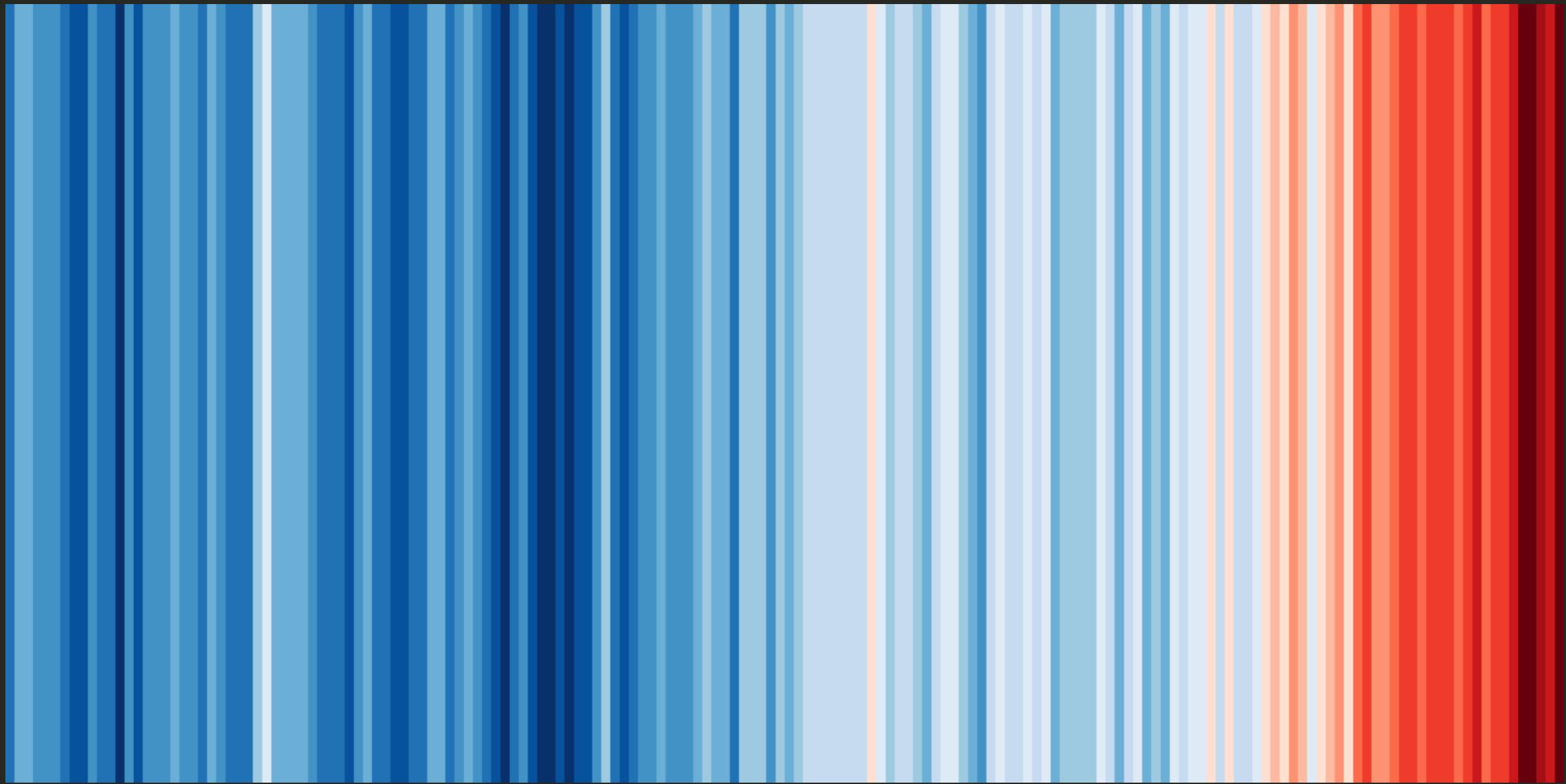
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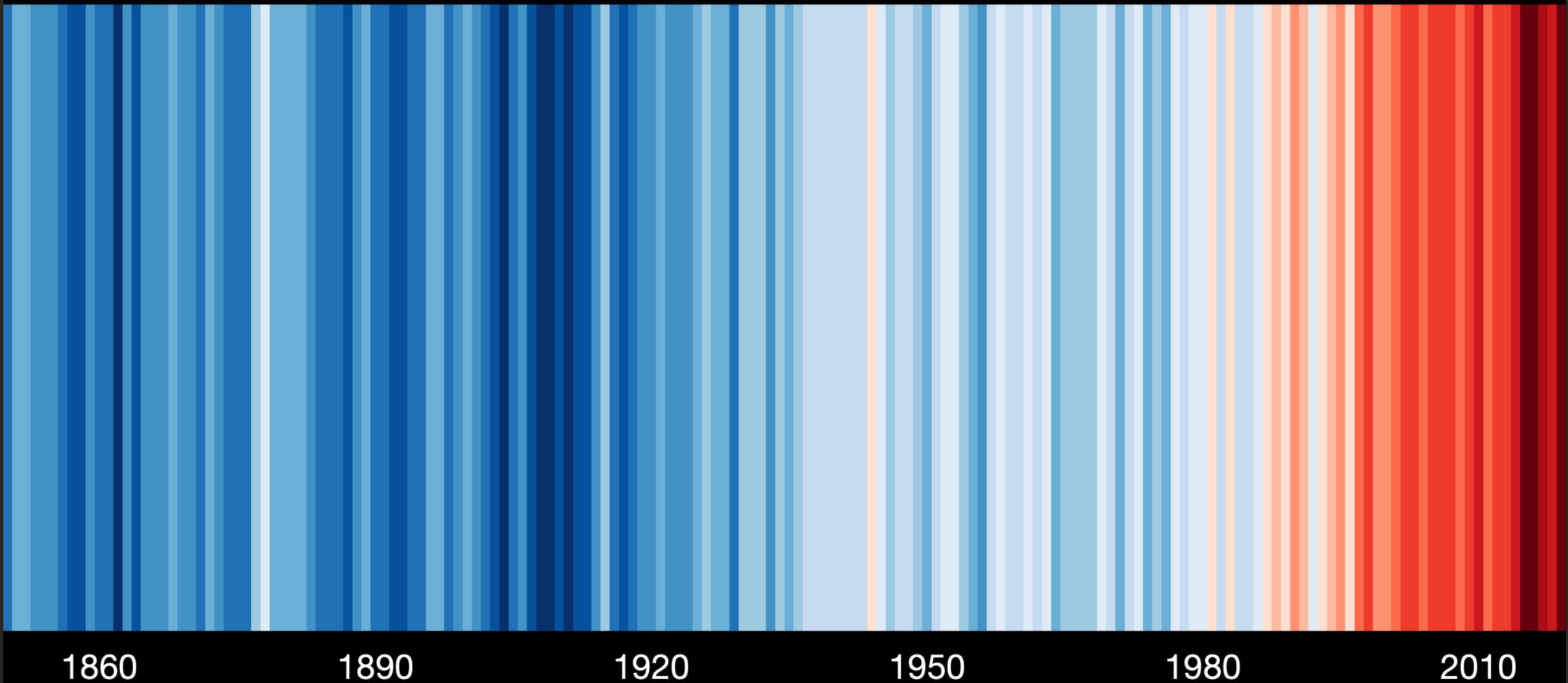
How will they **encounter** the visualization?

Do I need a visualization at all??



Warming Stripes by Ed Hawkins

Global temperature change (1850-2019)



Warming Stripes by Ed Hawkins

FAQ : Frequently asked questions

What are these graphics? ▼

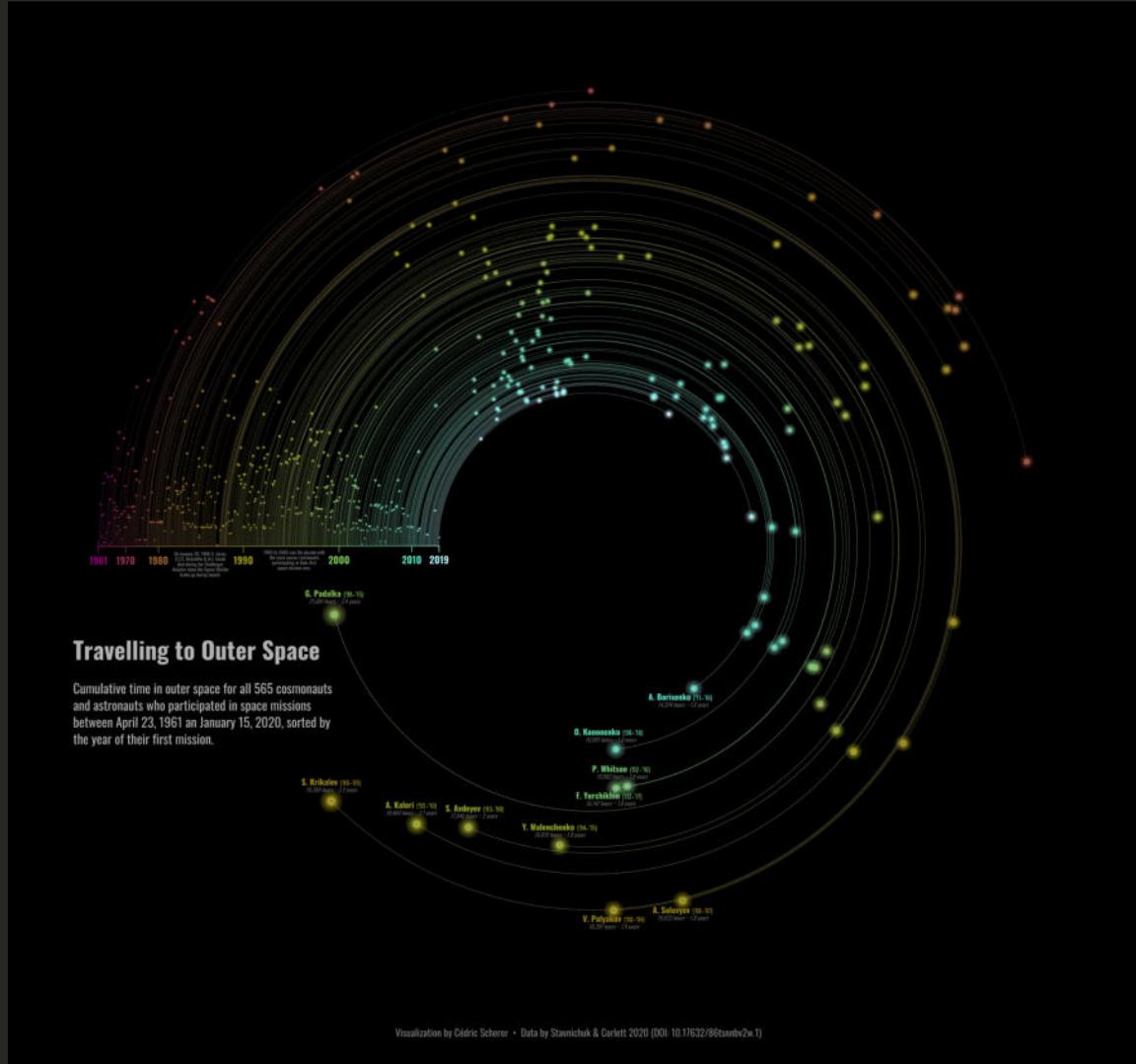
What do the graphics show? ▼

Why are there no numbers on the graphics? ^

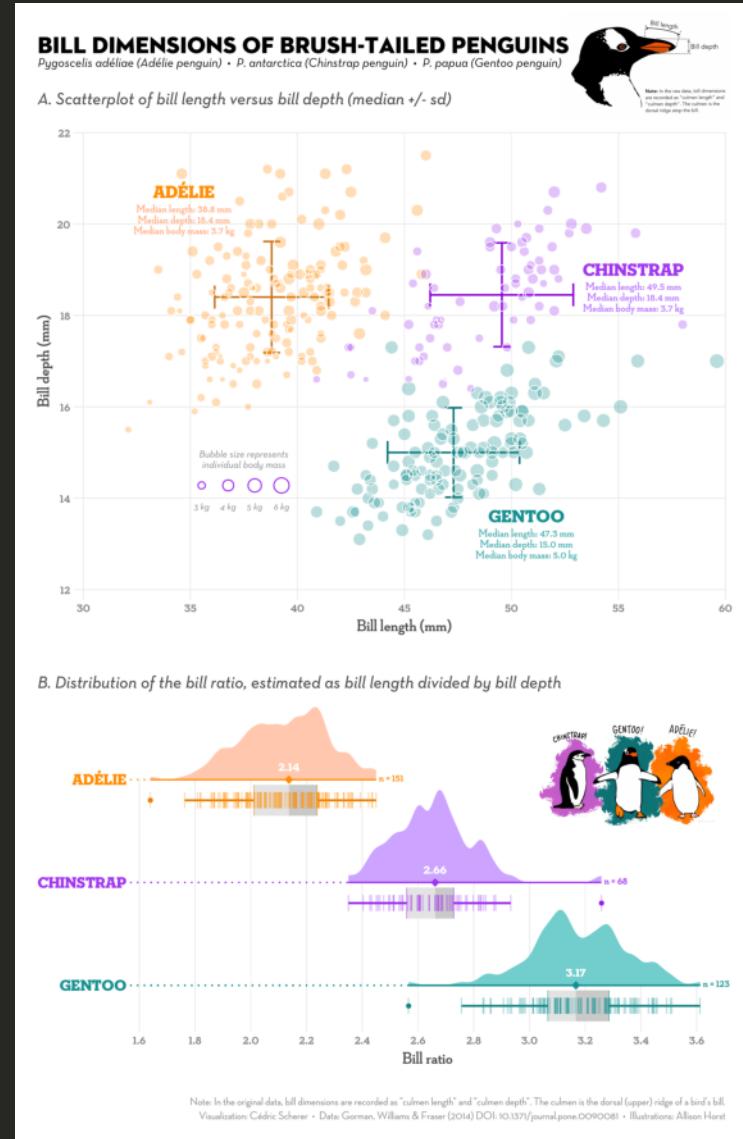
» These graphics are specifically designed to be as simple as possible, and to start conversations about our warming world and the risks of climate change. There are numerous sources of information which provide more specific details about how temperatures have changed, so these graphics fill a gap and enable communication with minimal scientific knowledge required to understand their meaning.

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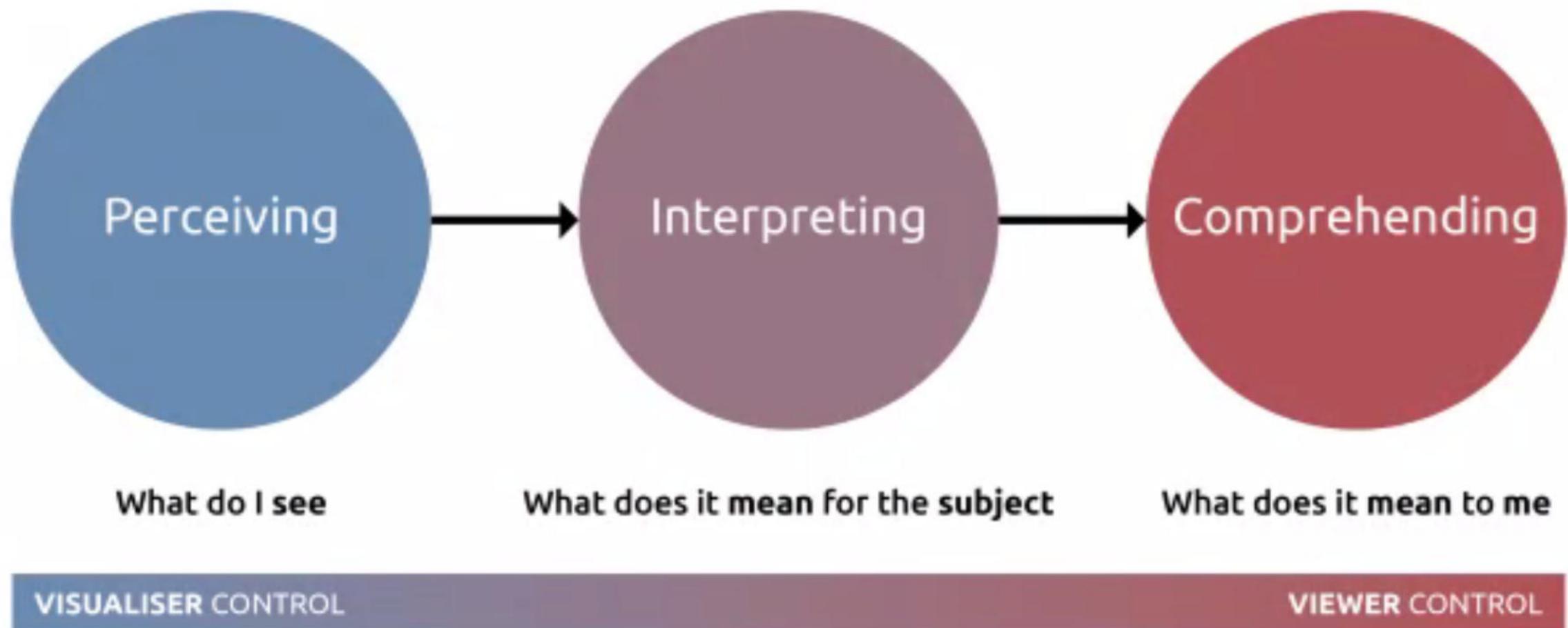
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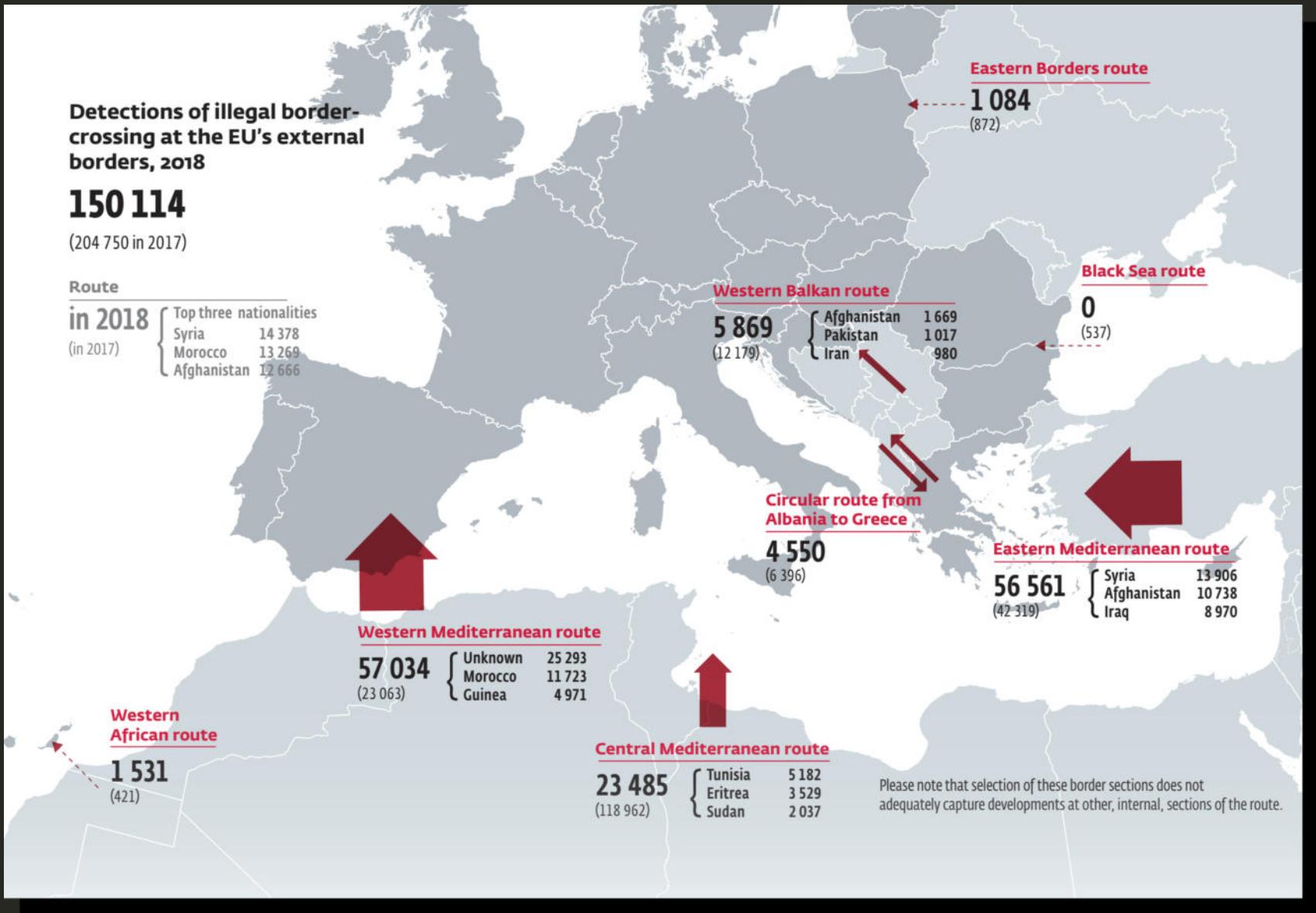
#TidyTuesday contribution Week 2020/29

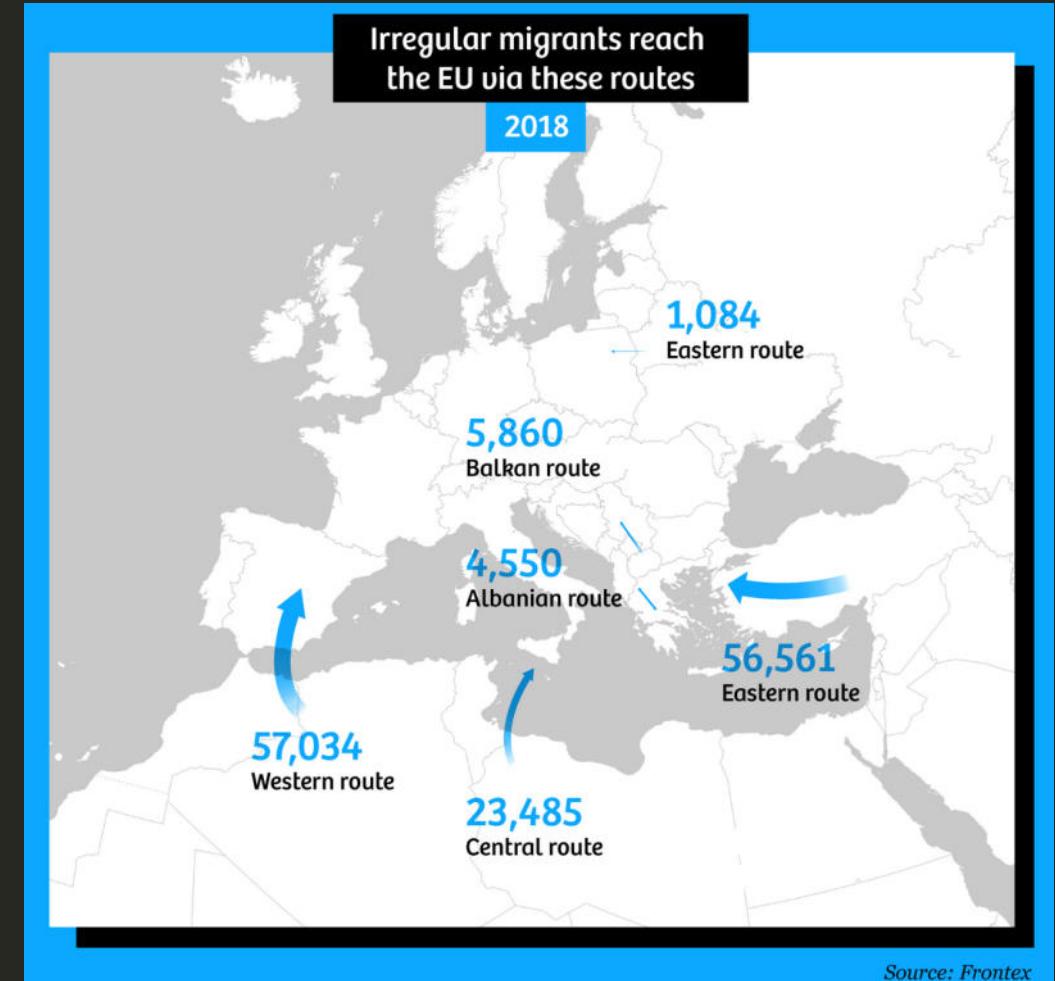


#TidyTuesday contribution Week 2020/31



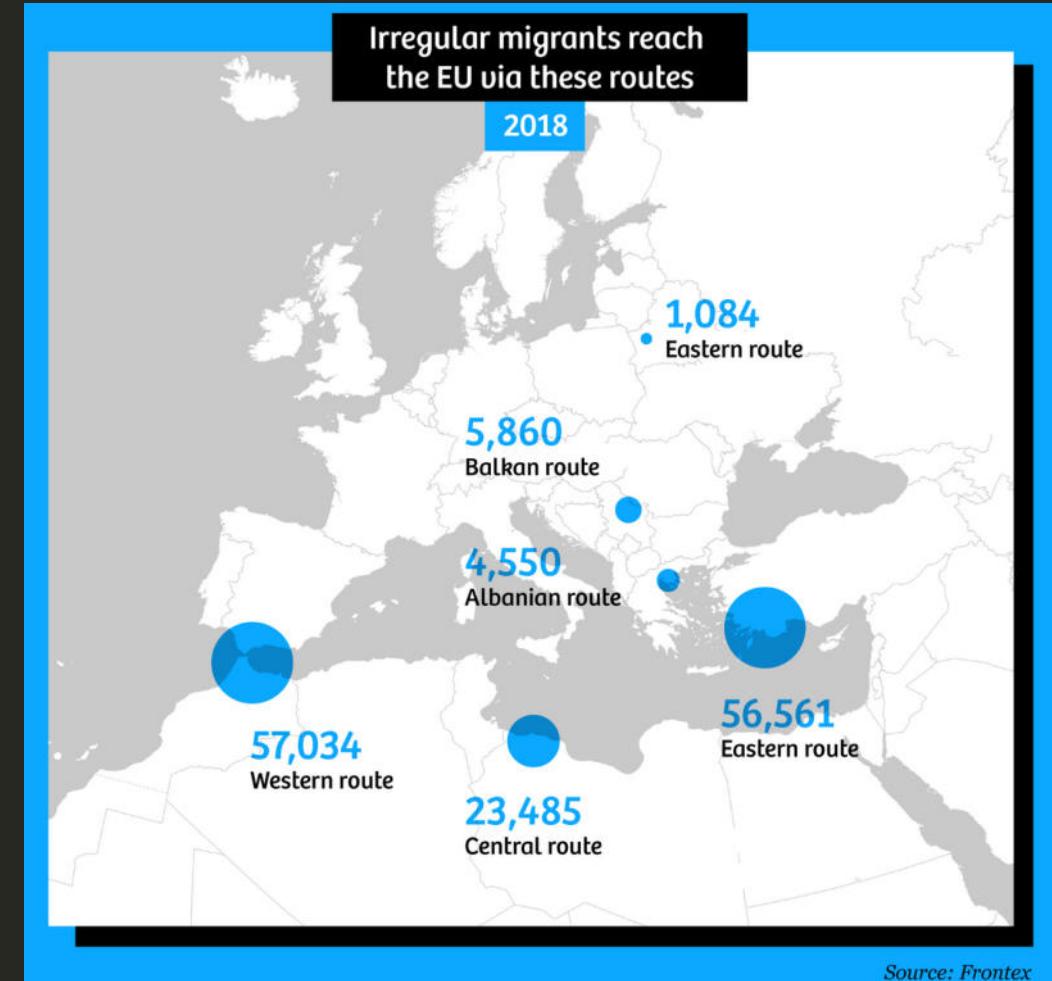
Source: Andy Kirk, S-H-O-W Feb 2021





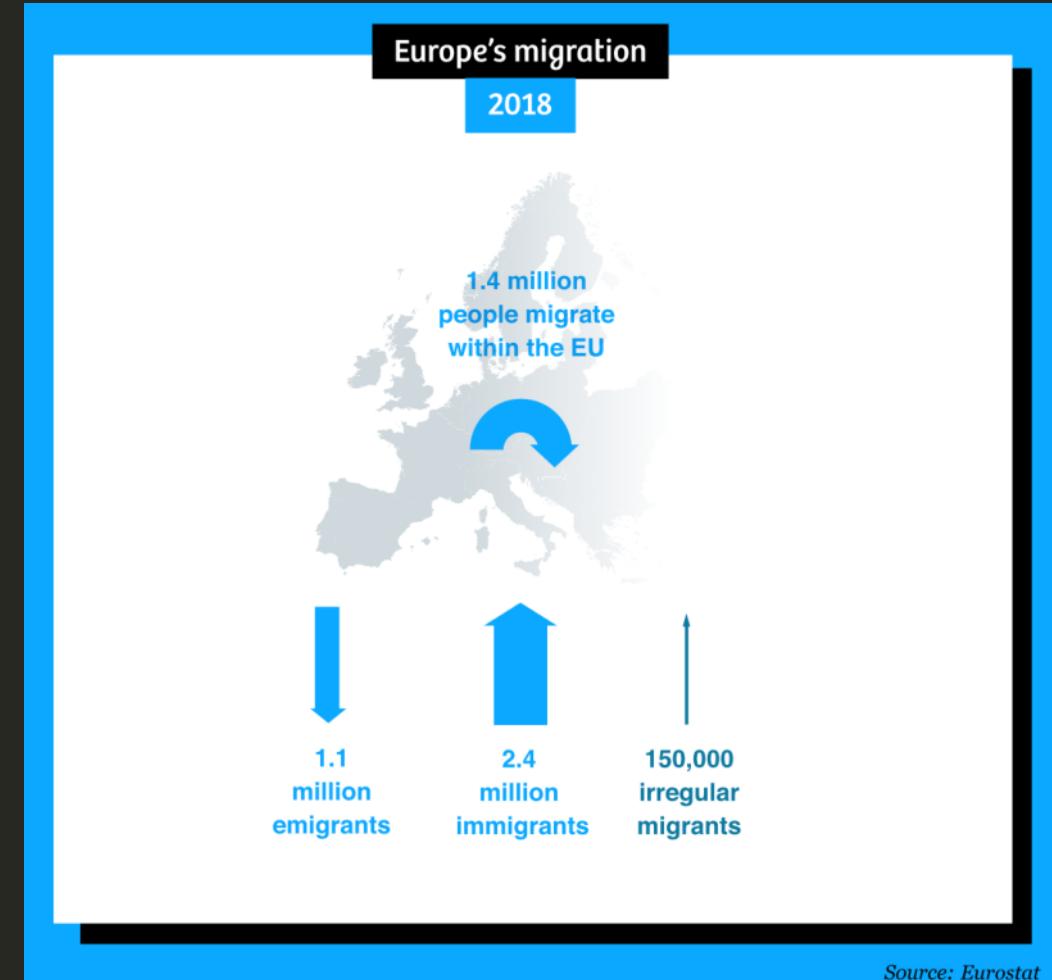
How maps in the media make us more negative about migrants

by Maite Vermeulen, Leon de Korte & Henk van Houtum



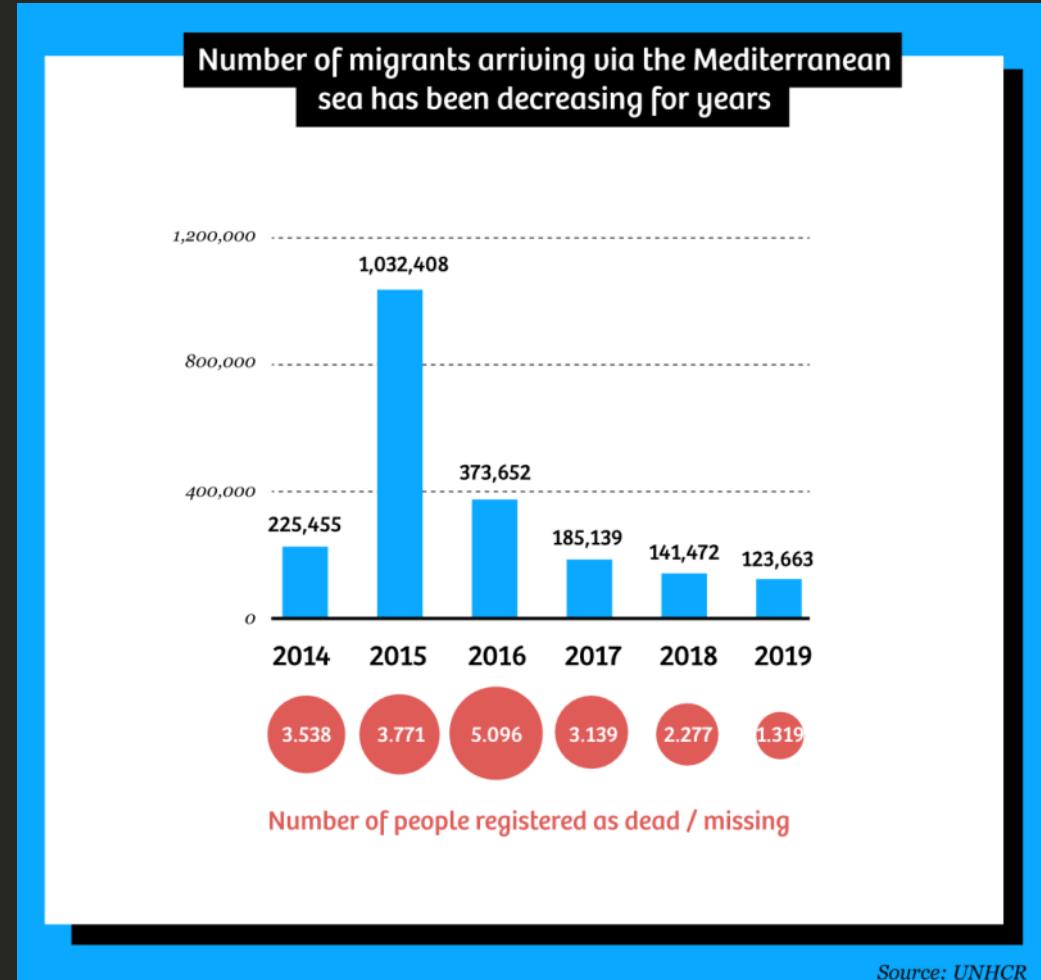
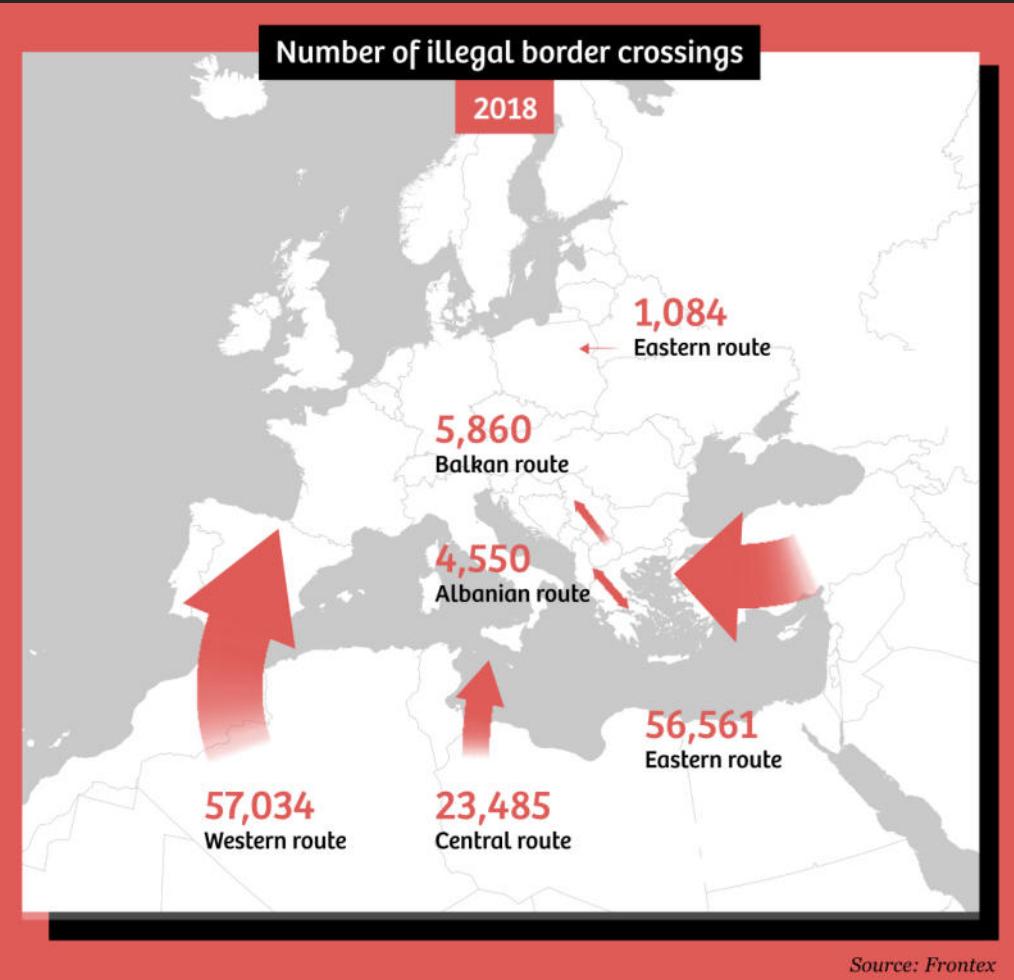
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Goal

Select charts that successfully transport your story

Typology of Information Graphics

by Scott Berinato, "Good Charts" (2016), pp. 54–63

Is the information **conceptual or **data-driven**?**

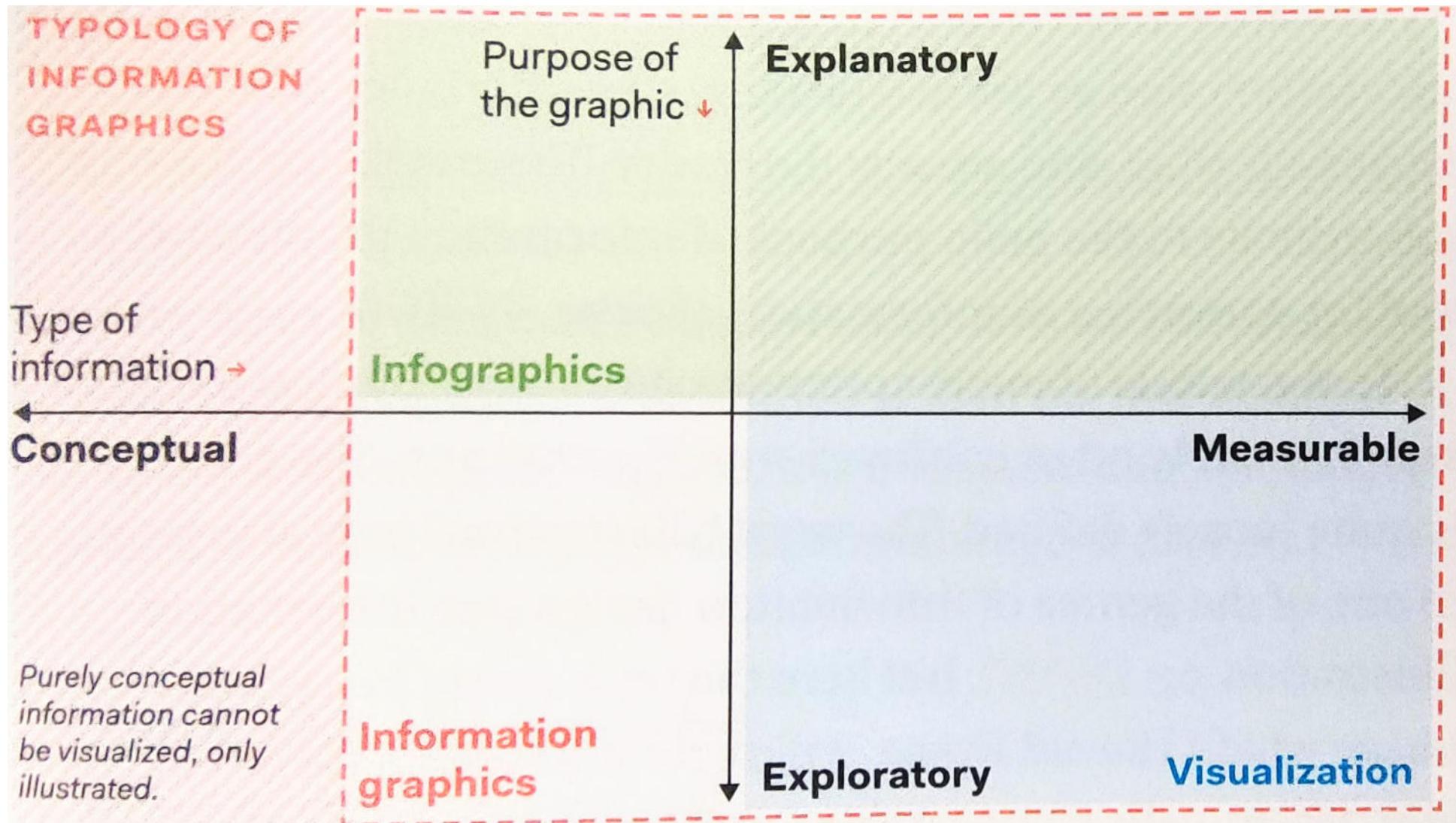
Is the purpose to **declare or to **explore** the information?**

Typology of Information Graphics

by Juuso Koponen & Jonatan Hildén, "Data Visualization Handbook" (2020), p. 25

Is the information **conceptual or **measurable**?**

Is the purpose to **explain or to **explore** the information?**



Juuso Koponen & Jonatan Hildén, "Data Visualization Handbook" (2020), p. 27 (Aalto University Press)

Typology of Information Graphics

by Juuso Koponen & Jonatan Hildén, "Data Visualization Handbook" (2020), p. 25

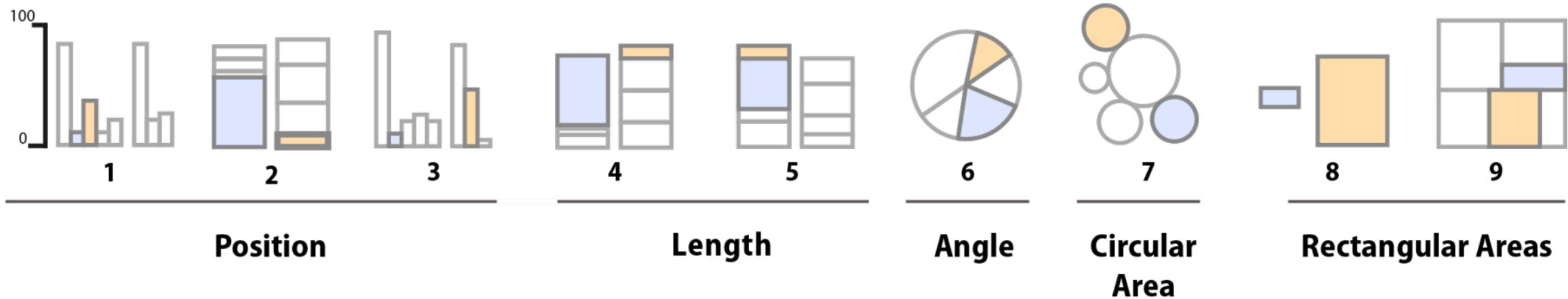
Is the information **conceptual** or **measurable**?

→ **Type of Information** — depict conceptual information *versus* convert information into visual forms

Is the purpose to **explain** or to **explore** the information?

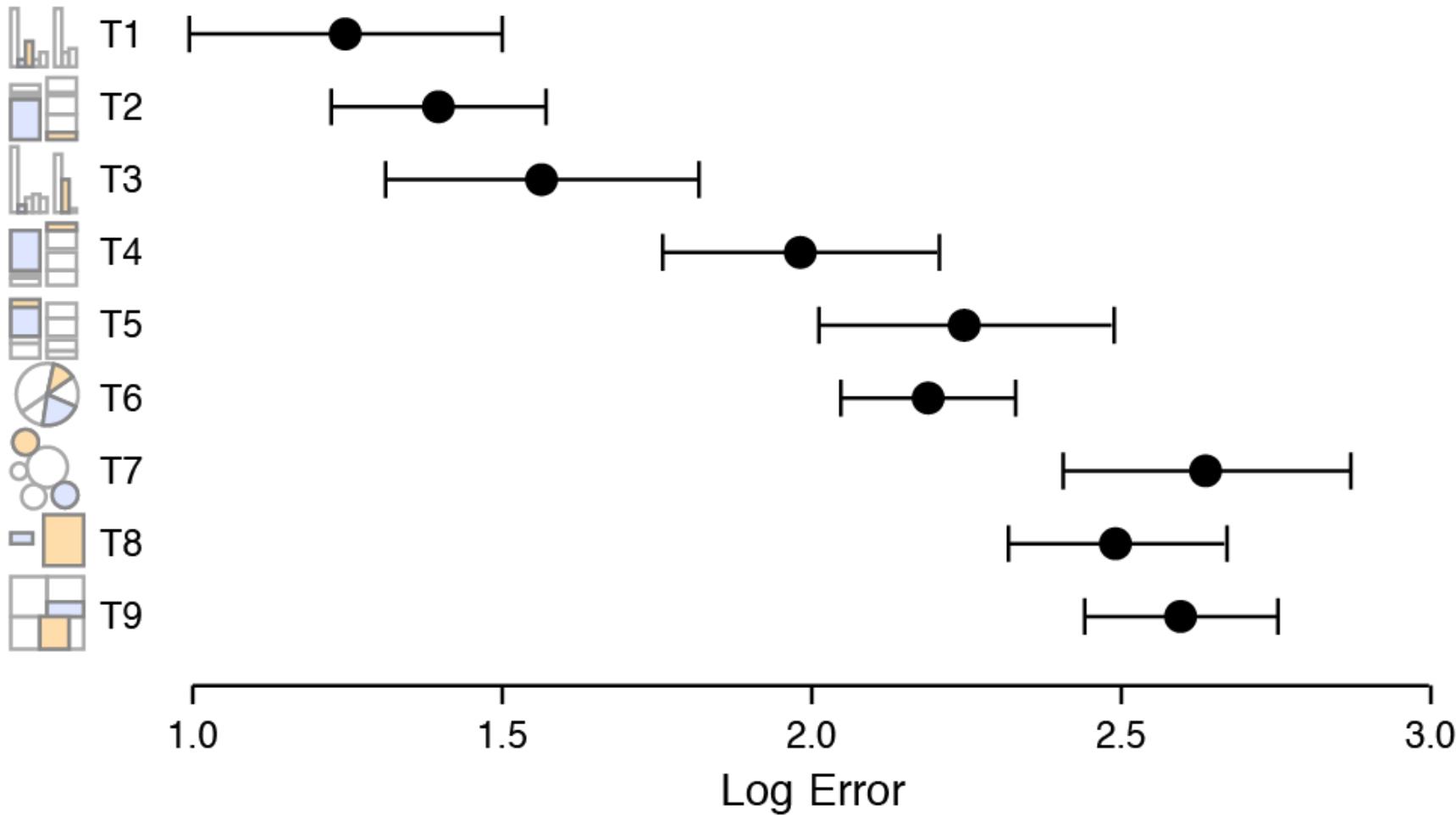
→ **Purpose of the Graphic** — communicate information *versus* facilitate discovery

Data visualizations convert information into visual forms as quantifiable features

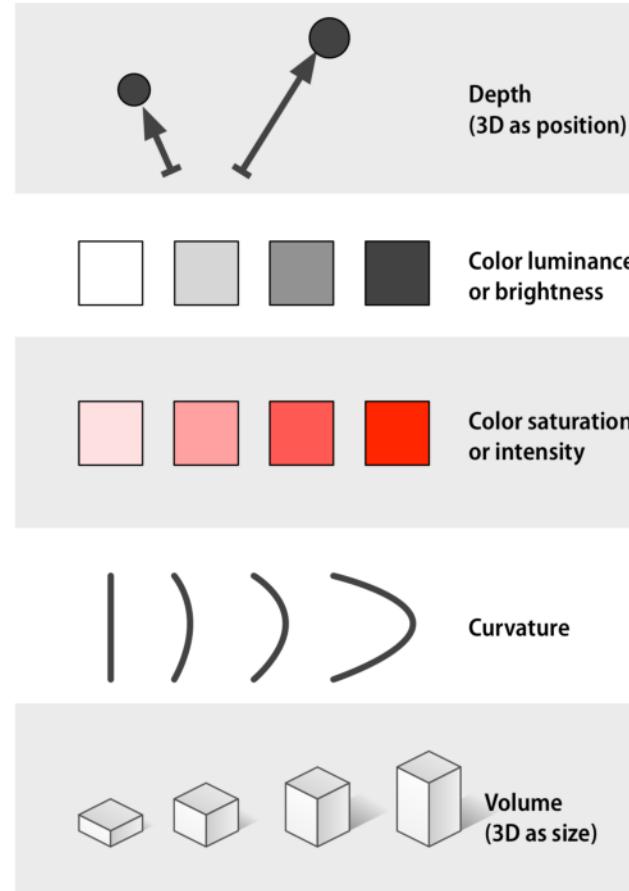
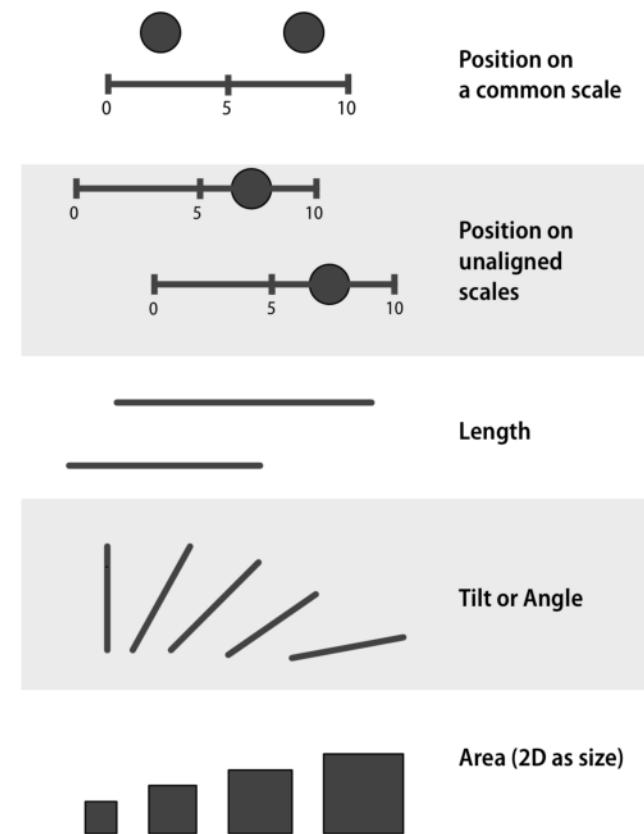


Kieran Healy based on Heer and Bostock, following Cleveland and McGill

Crowdsourced Results



Data visualizations convert information into visual forms as quantifiable features



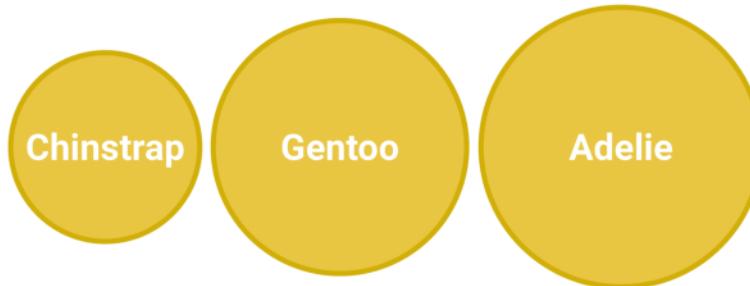
Qualitative Nominal	Qualitative Ordinal	Quantitative Interval/Ratio
Position	Position	Position
Colour (Hue)	Pattern (Density)	Size (Length)
Pattern (Texture)	Colour (Lightness)	Angle
Connection	Colour (Hue)	Size (Area)
Pattern (Density)	Pattern (Texture)	Size (Volume)
Colour (Lightness)	Connection	Pattern (Density)
Symbol	Size (Length)	Colour (Lightness)
Size (Length)	Angle	Colour (Hue)
Angle	Size (Area)	Pattern (Texture)
Size (Area)	Size (Volume)	Connection
Size (Volume)	Symbol	Symbol

Qualitative Nominal	Qualitative Ordinal	Quantitative Interval/Ratio
Position	Position	Position
Colour (Hue)	Pattern (Density)	Size (Length)
Pattern (Texture)	Colour (Lightness)	Angle
Connection	Colour (Hue)	Size (Area)
Pattern (Density)	Pattern (Texture)	Size (Volume)
Colour (Lightness)	Connection	Pattern (Density)
Symbol	Size (Length)	Colour (Lightness)
Size (Length)	Angle	Colour (Hue)
Angle	Size (Area)	Pattern (Texture)
Size (Area)	Size (Volume)	Connection
Size (Volume)	Symbol	Symbol

Chinstrap

Gentoo

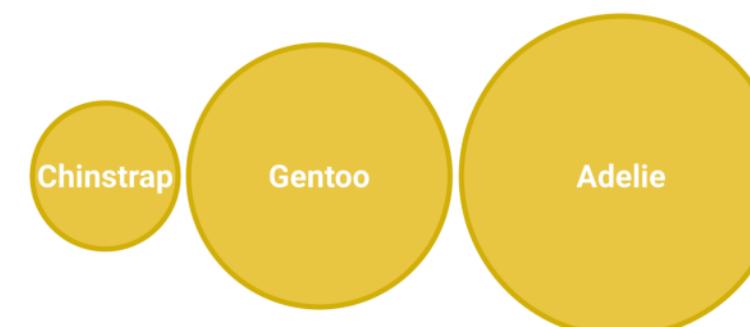
Adelie



Adelie

Gentoo

Chinstrap



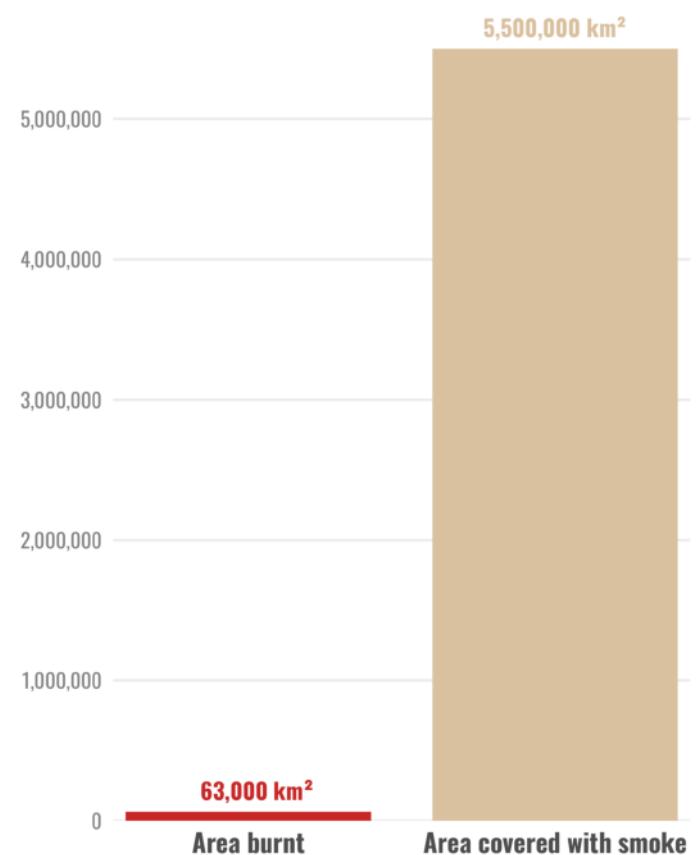
Adelie

Gentoo

Chinstrap

Always use area. Never use radius!

**Burnt land and plume of smoke caused
by the Australian bushfires in 2019/20**
(as of 6th of January 2020)

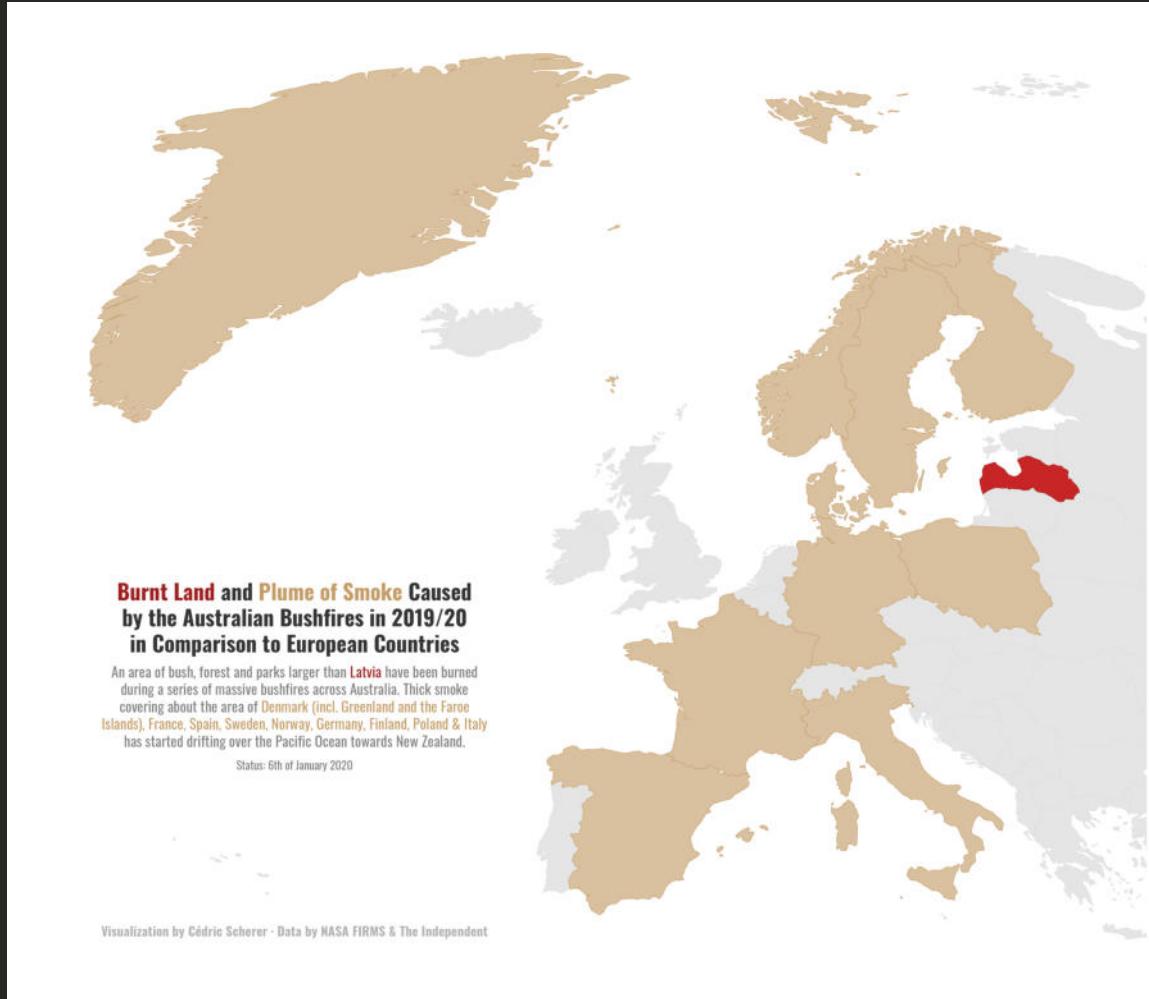


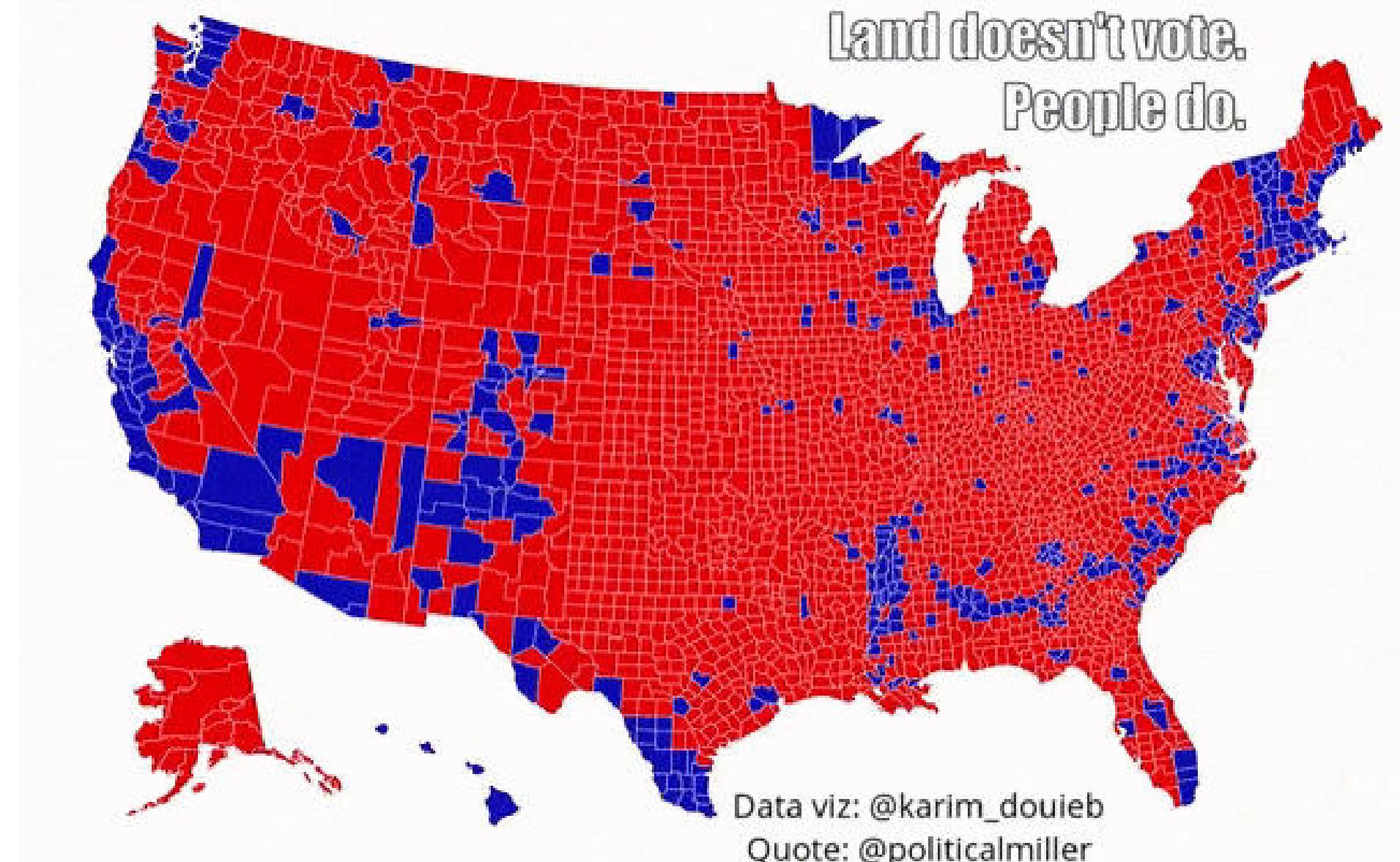
**Burnt Land and Plume of Smoke Caused
by the Australian Bushfires in 2019/20
in Comparison to European Countries**

An area of bush, forest and parks larger than [Latvia](#) have been burned during a series of massive bushfires across Australia. Thick smoke covering about the area of Denmark (incl. Greenland and the Faroe Islands), France, Spain, Sweden, Norway, Germany, Finland, Poland & Italy has started drifting over the Pacific Ocean towards New Zealand.

Status: 6th of January 2020

Visualization by Cédric Scherer - Data by NASA FIRMS & The Independent

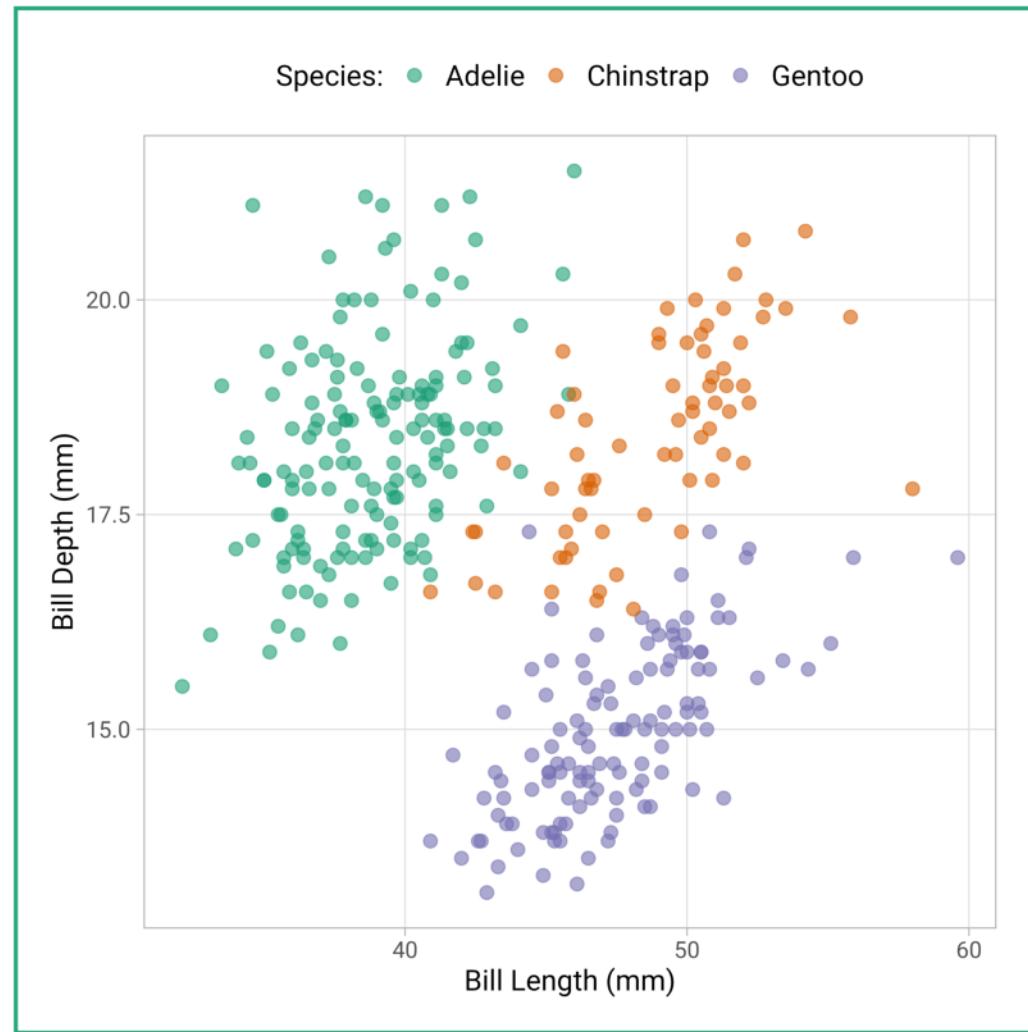
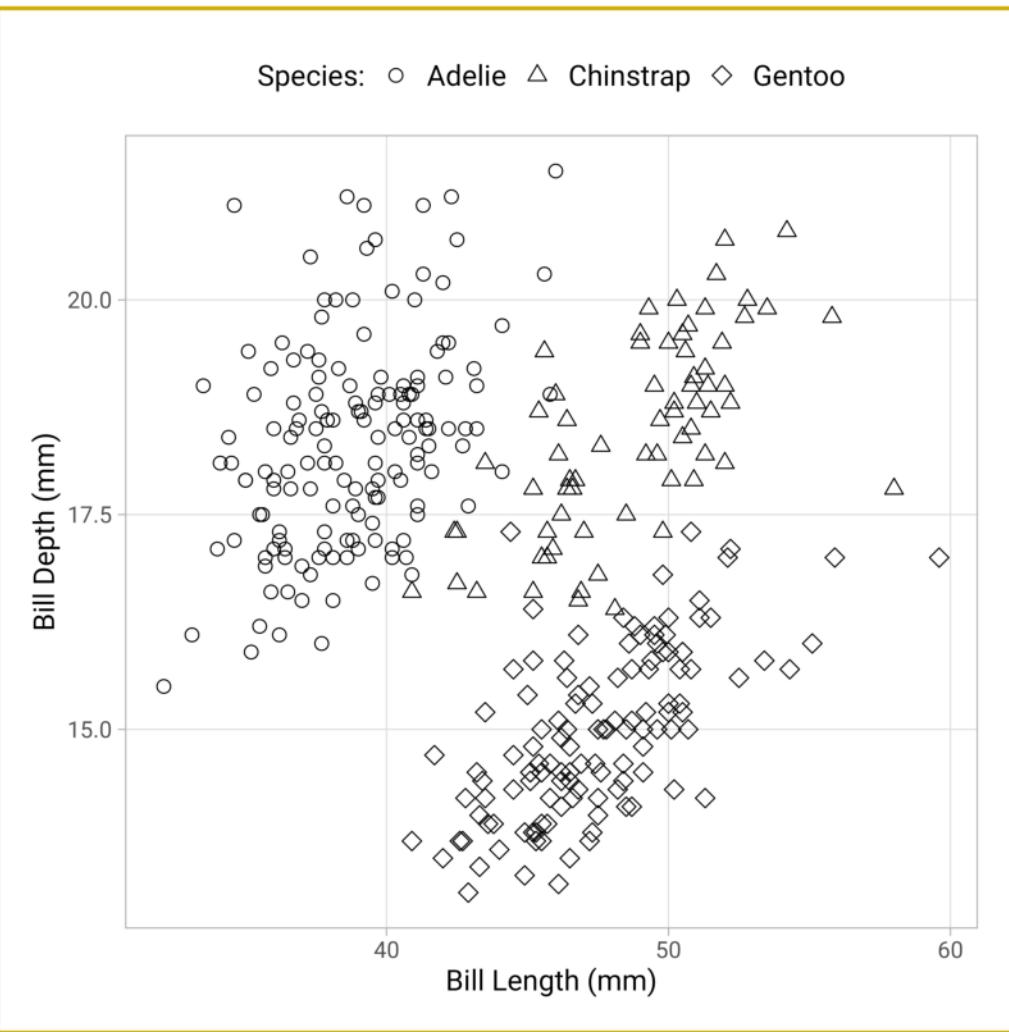




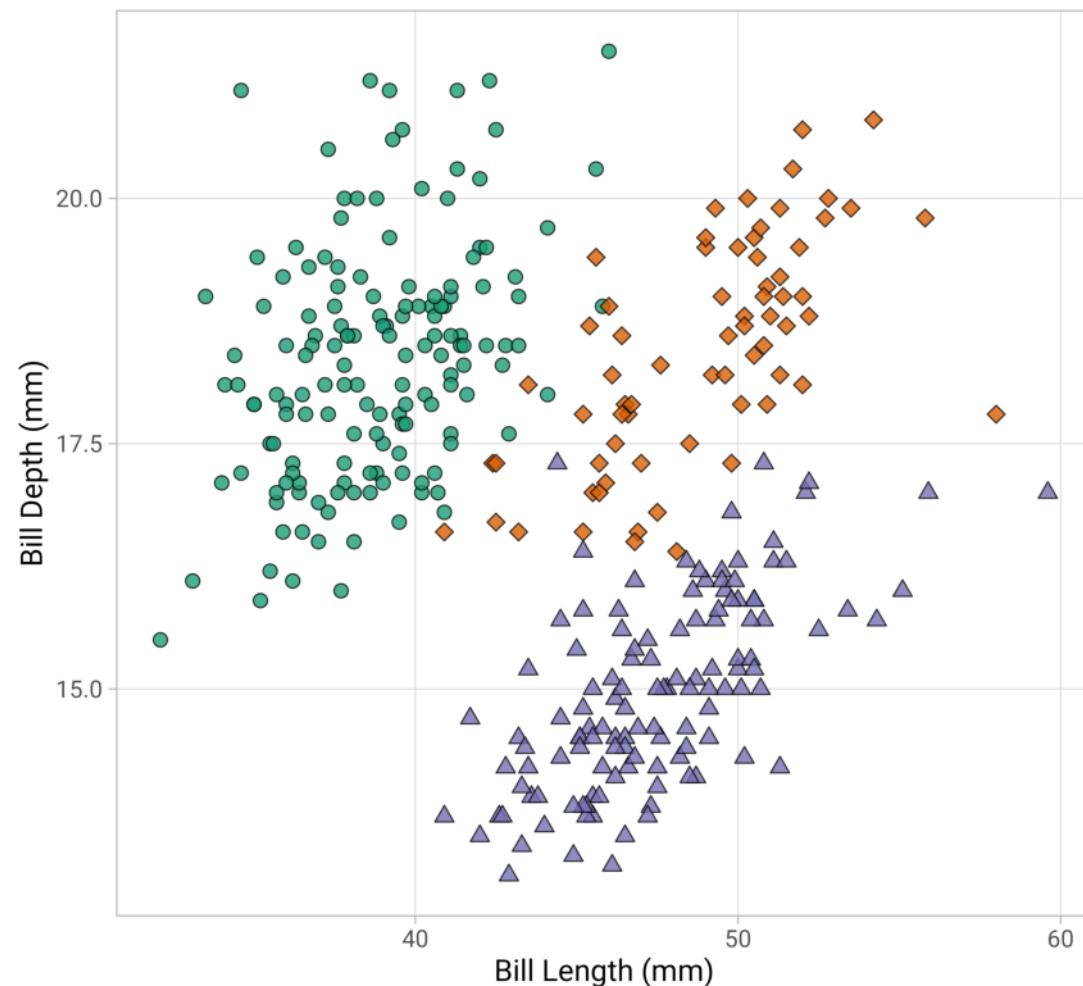
Land doesn't vote.
People do.

Data viz: @karim_douieb
Quote: @politicalmiller

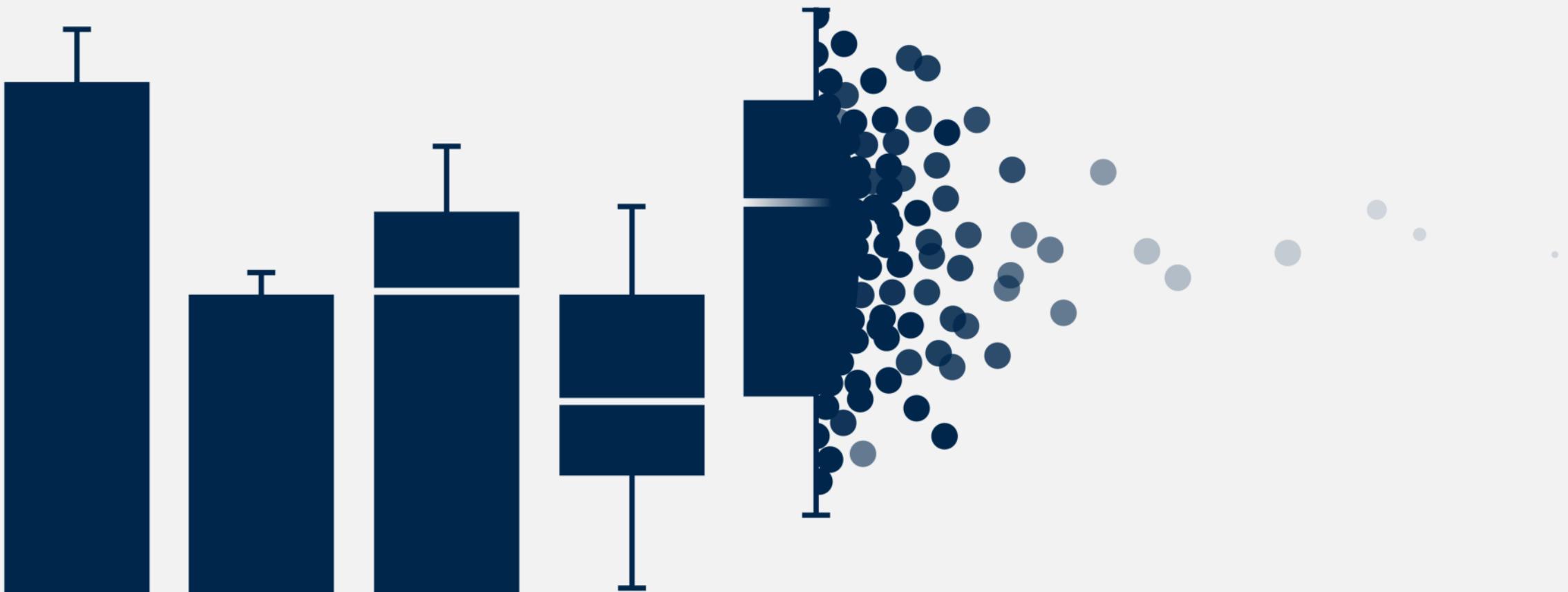
Qualitative Nominal	Qualitative Ordinal	Quantitative Interval/Ratio
Position	Position	Position
Colour (Hue)	Pattern (Density)	Size (Length)
Pattern (Texture)	Colour (Lightness)	Angle
Connection	Colour (Hue)	Size (Area)
Pattern (Density)	Pattern (Texture)	Size (Volume)
Colour (Lightness)	Connection	Pattern (Density)
Symbol	Size (Length)	Colour (Lightness)
Size (Length)	Angle	Colour (Hue)
Angle	Size (Area)	Pattern (Texture)
Size (Area)	Size (Volume)	Connection
Size (Volume)	Symbol	Symbol

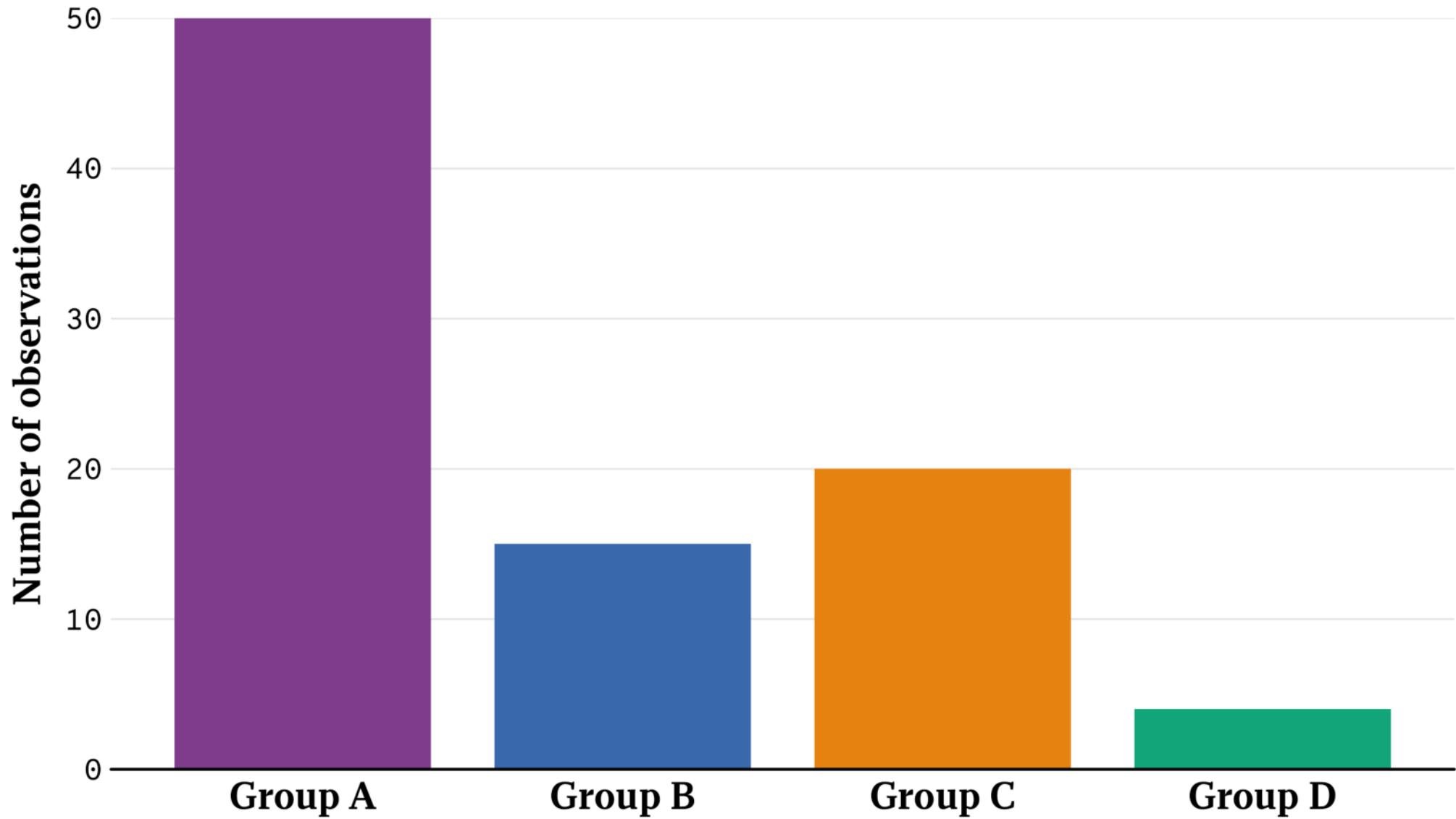


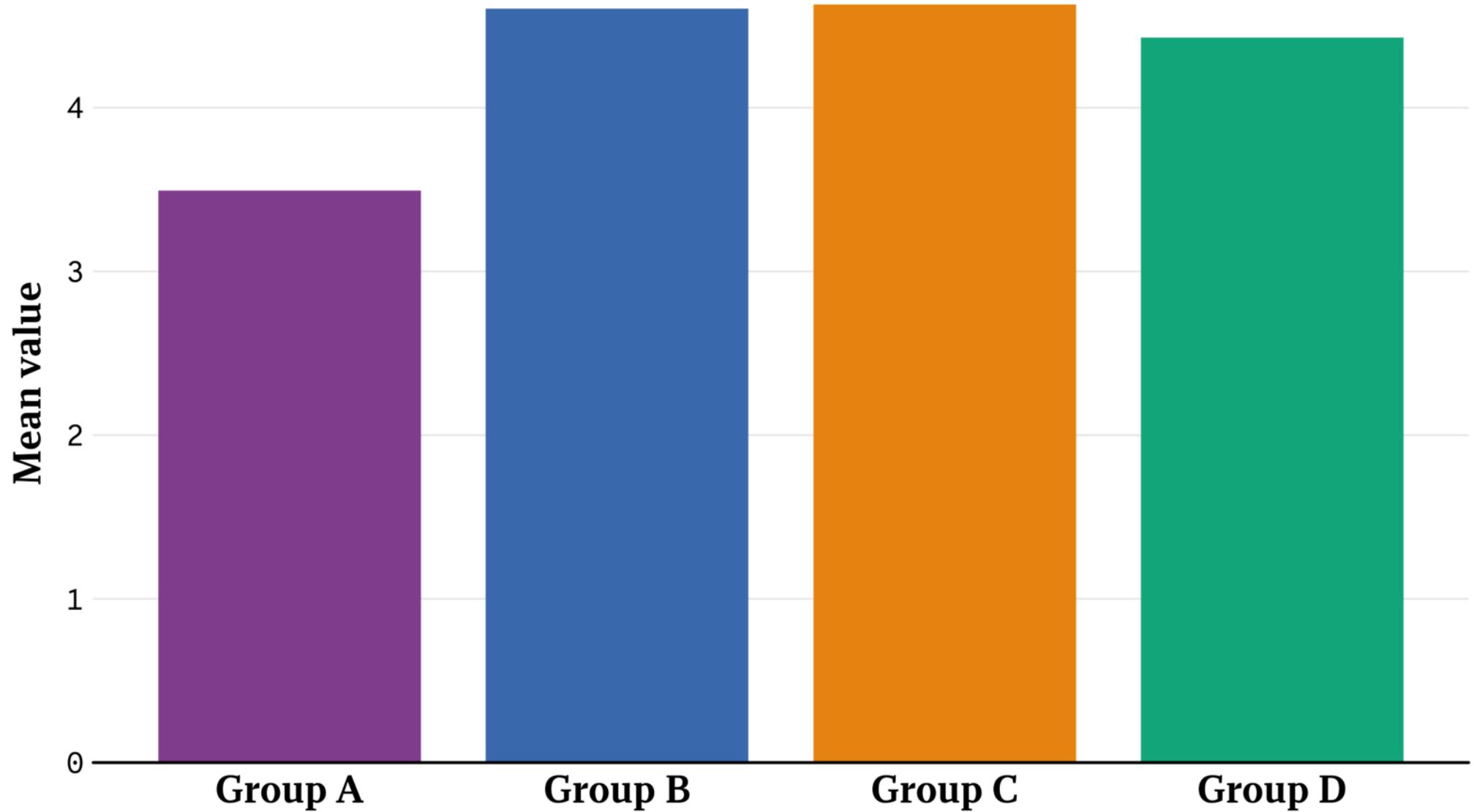
Species: ● Adelie ◆ Chinstrap ▲ Gentoo

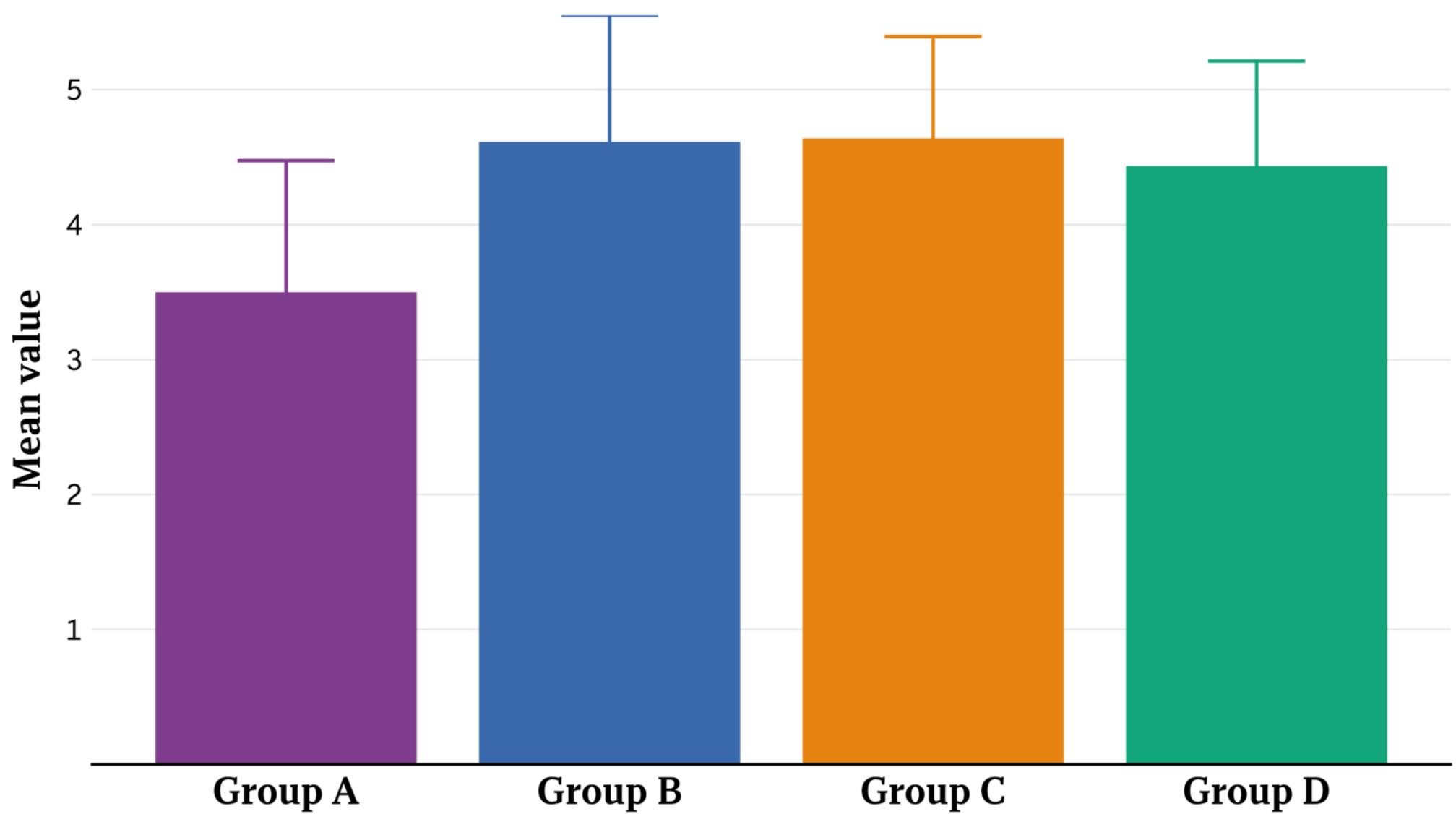


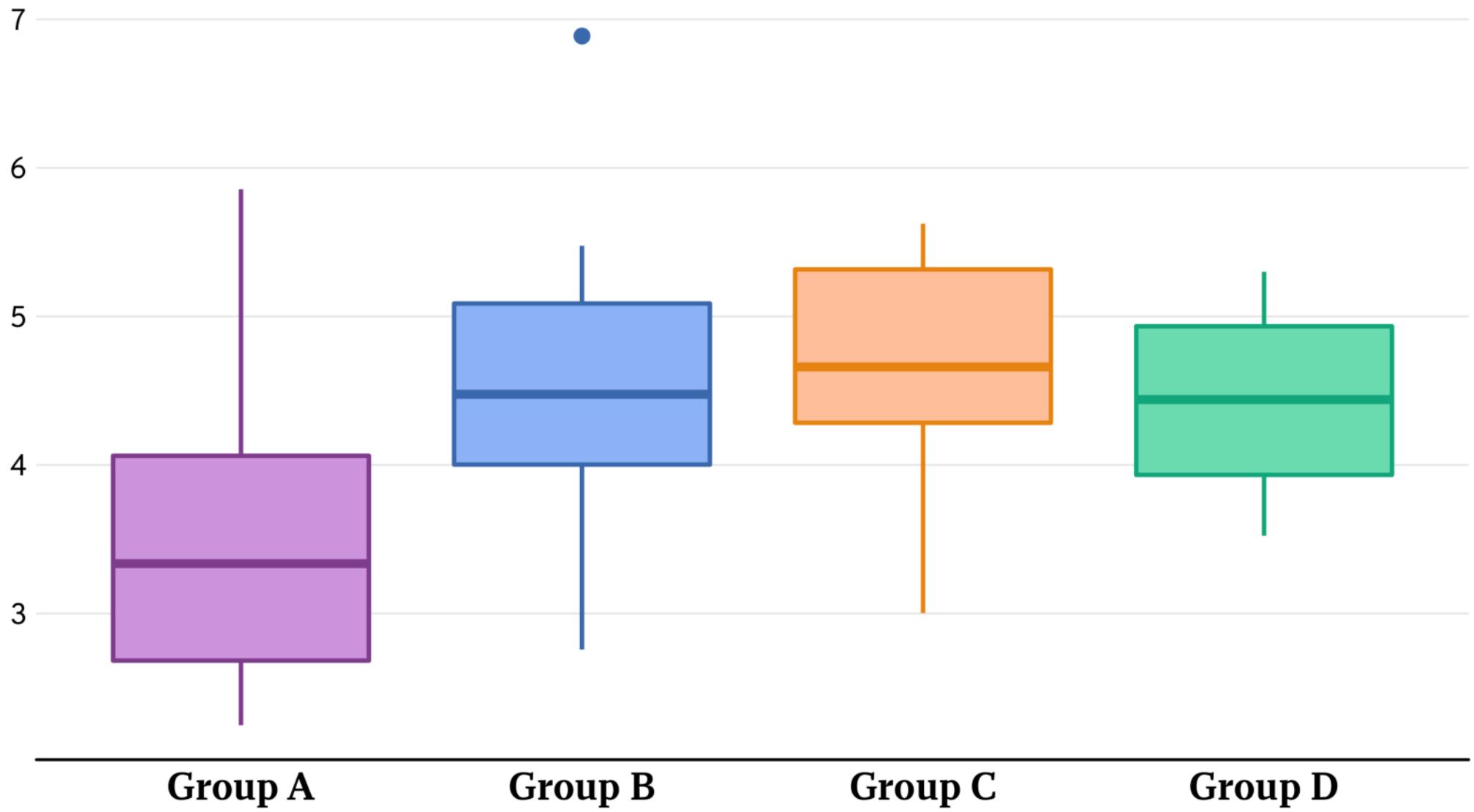
Beyond Bar and Box Plots

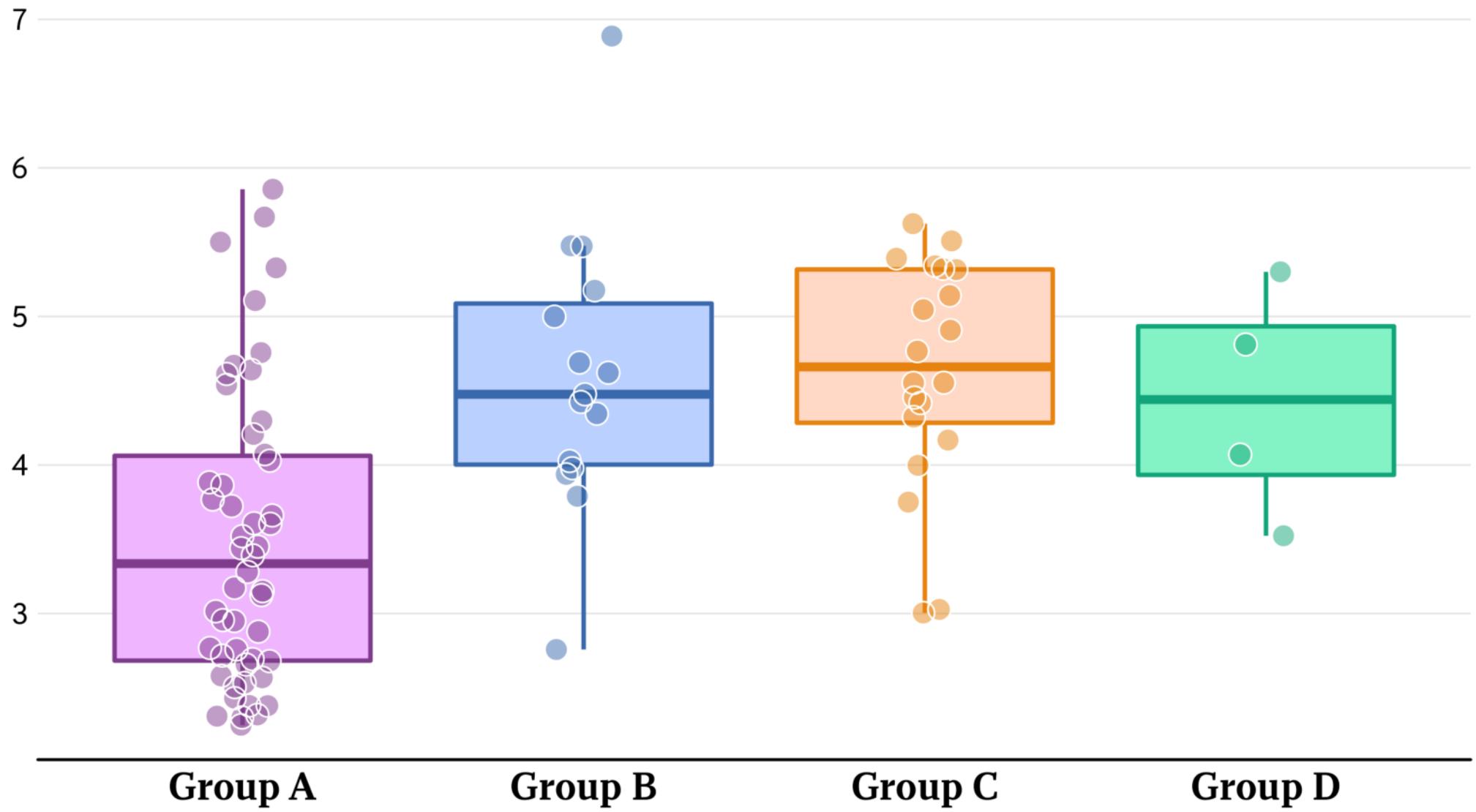


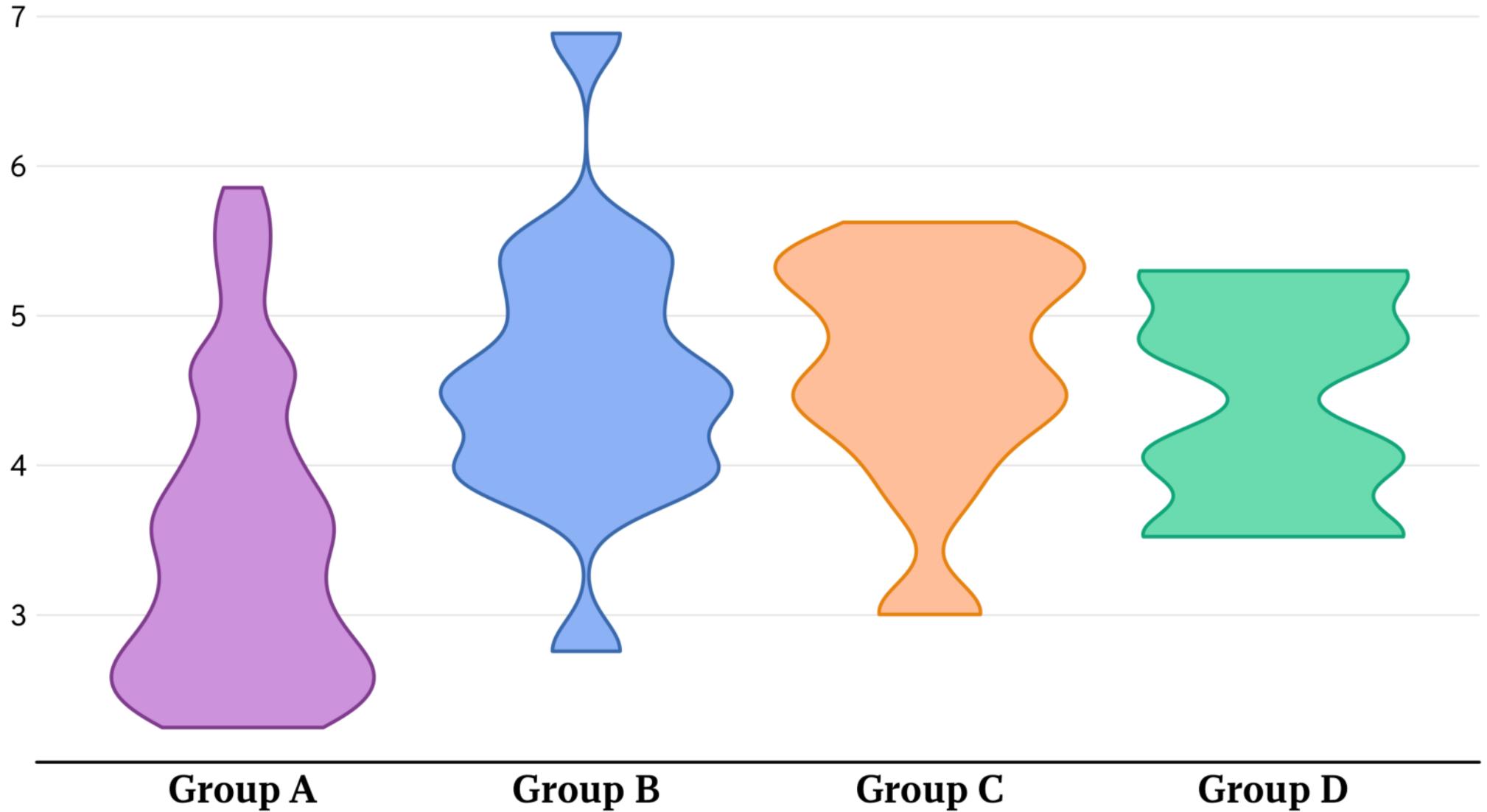


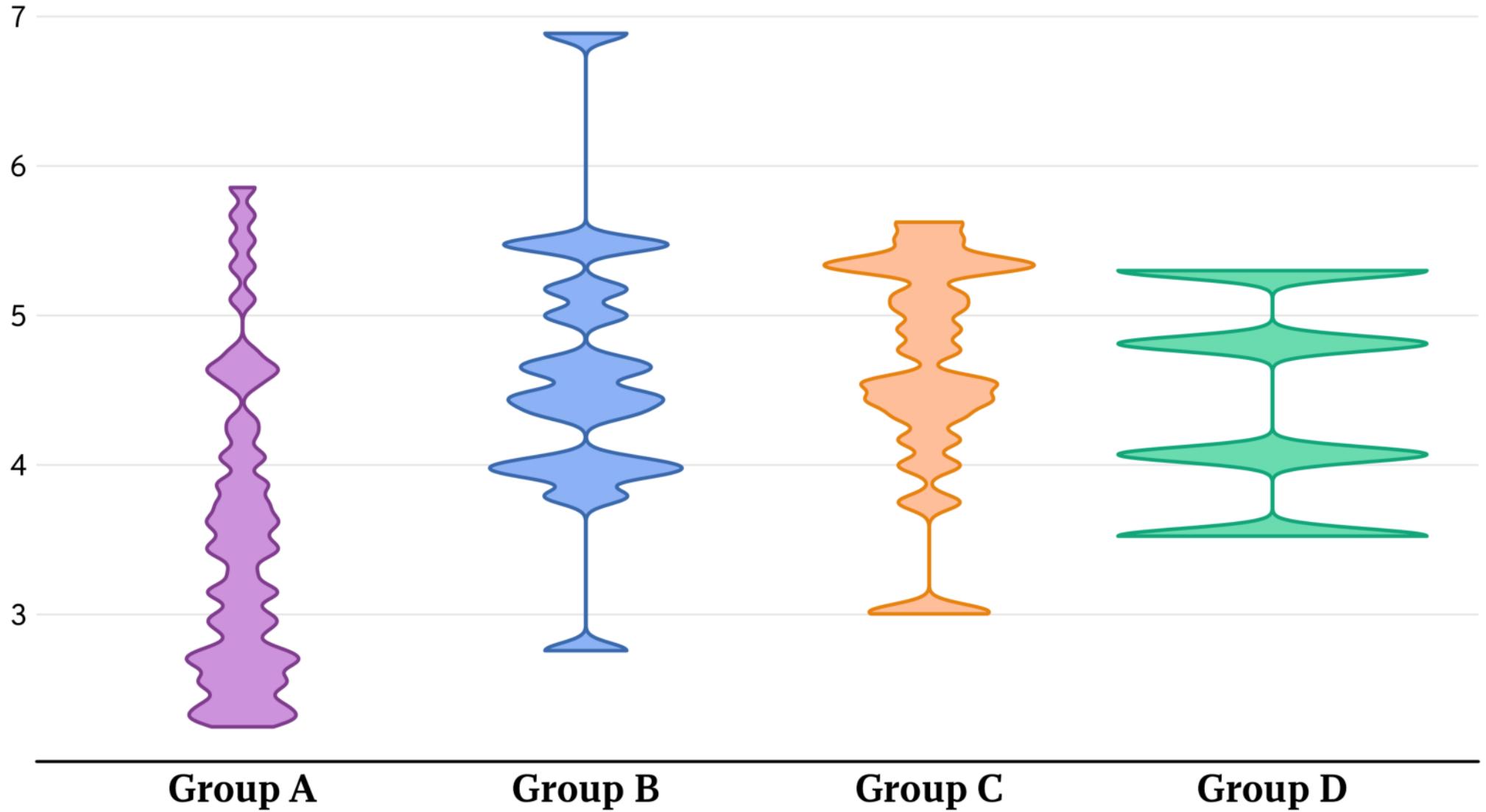


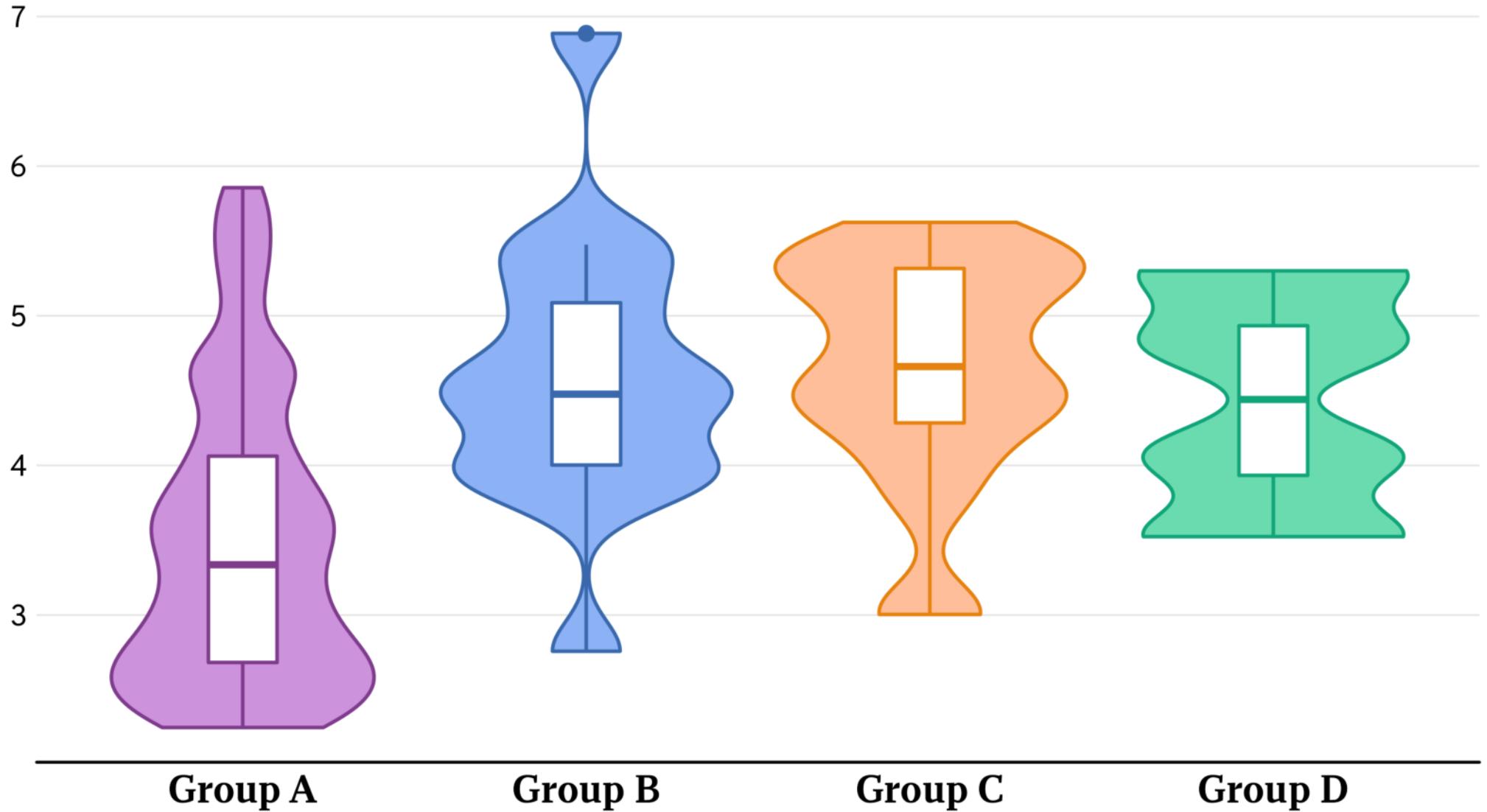


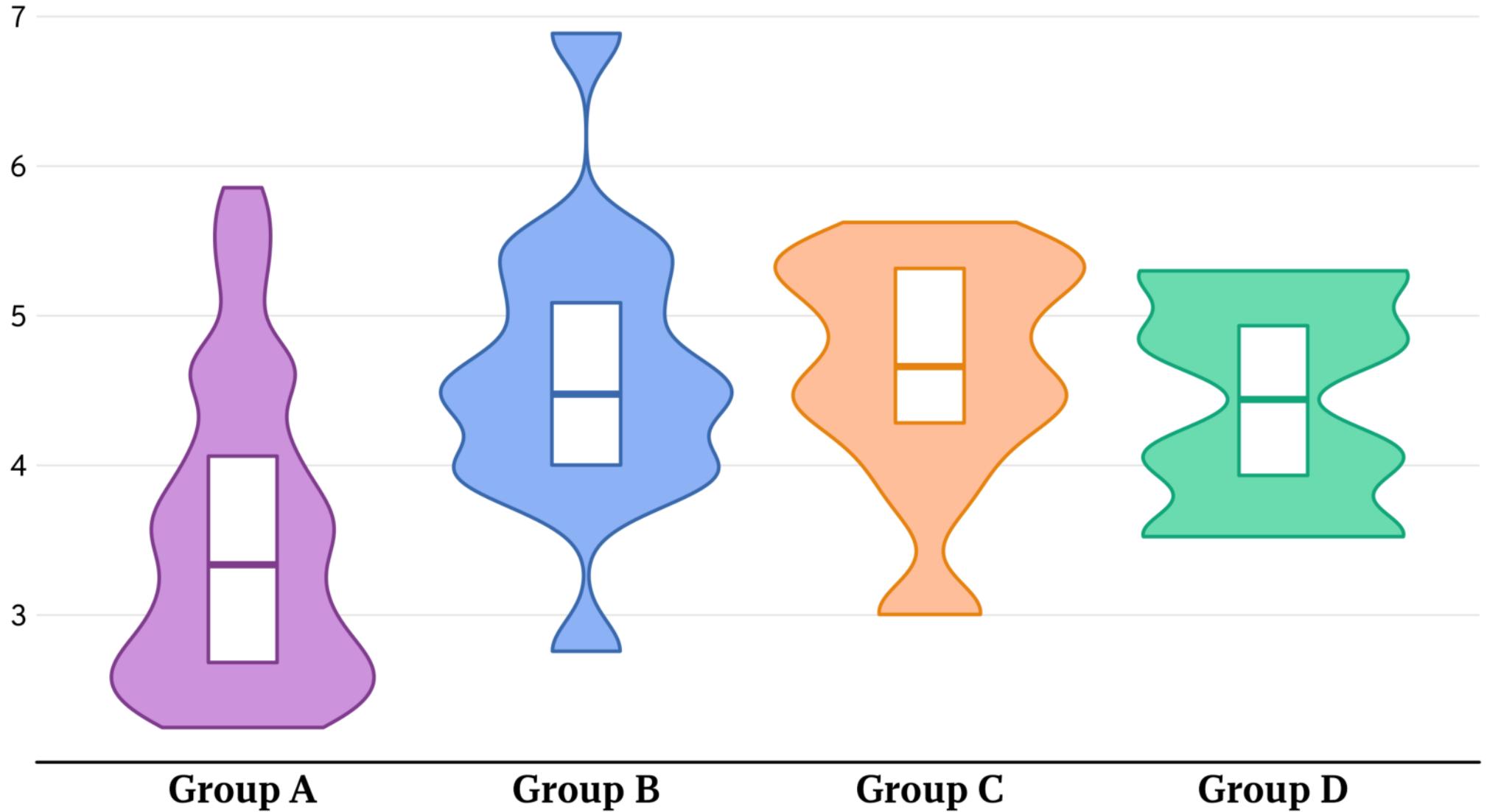


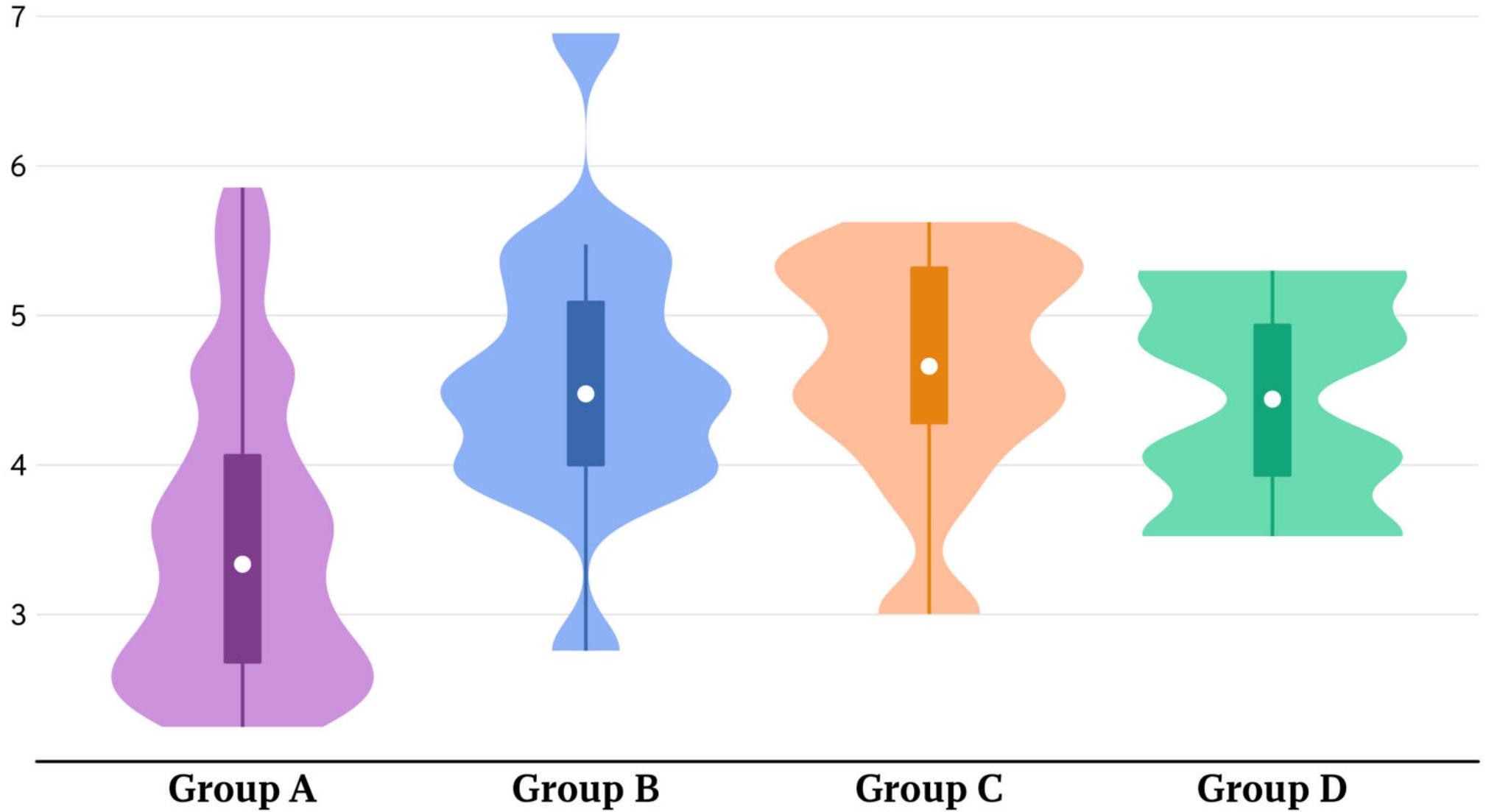


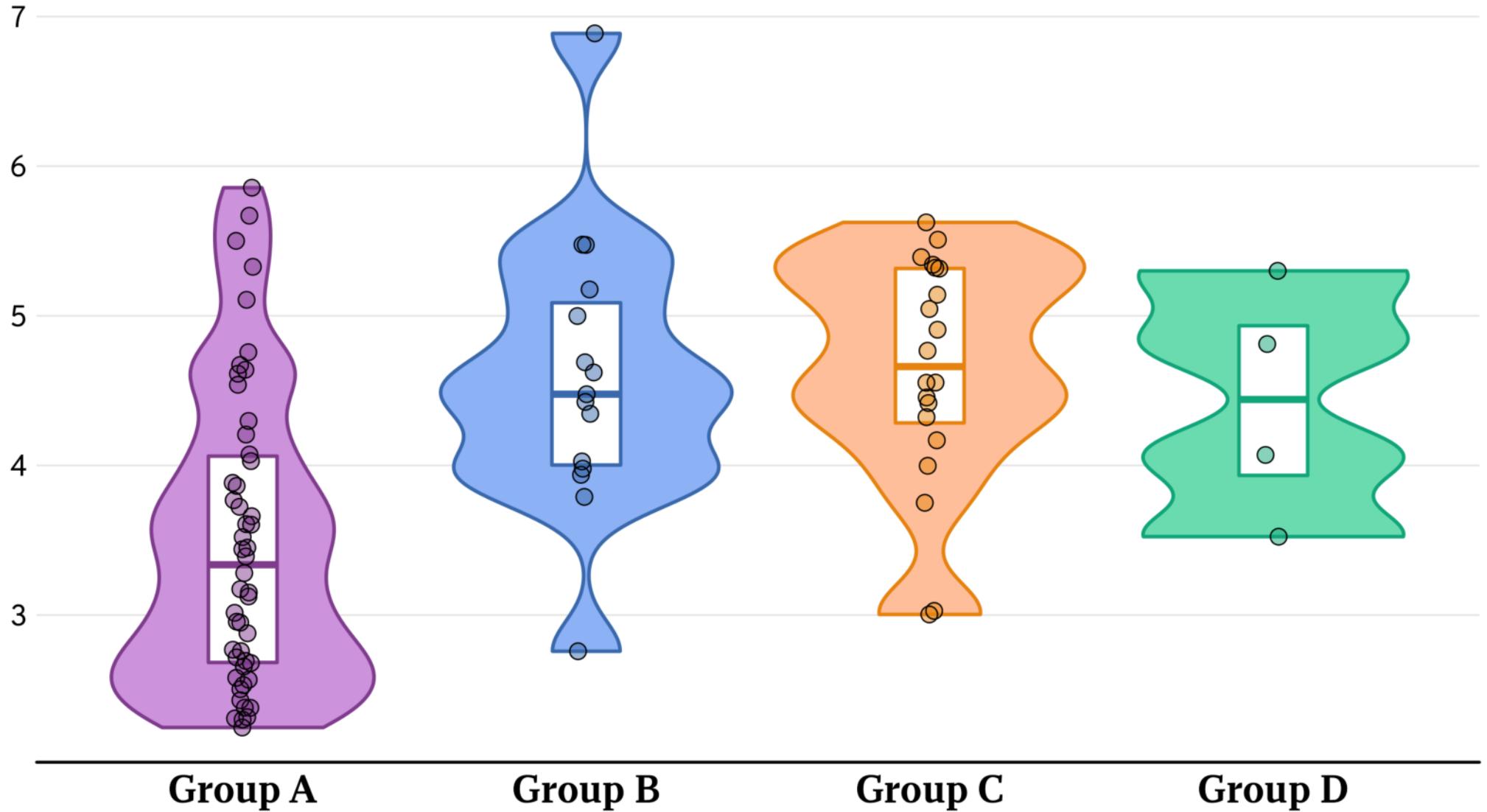


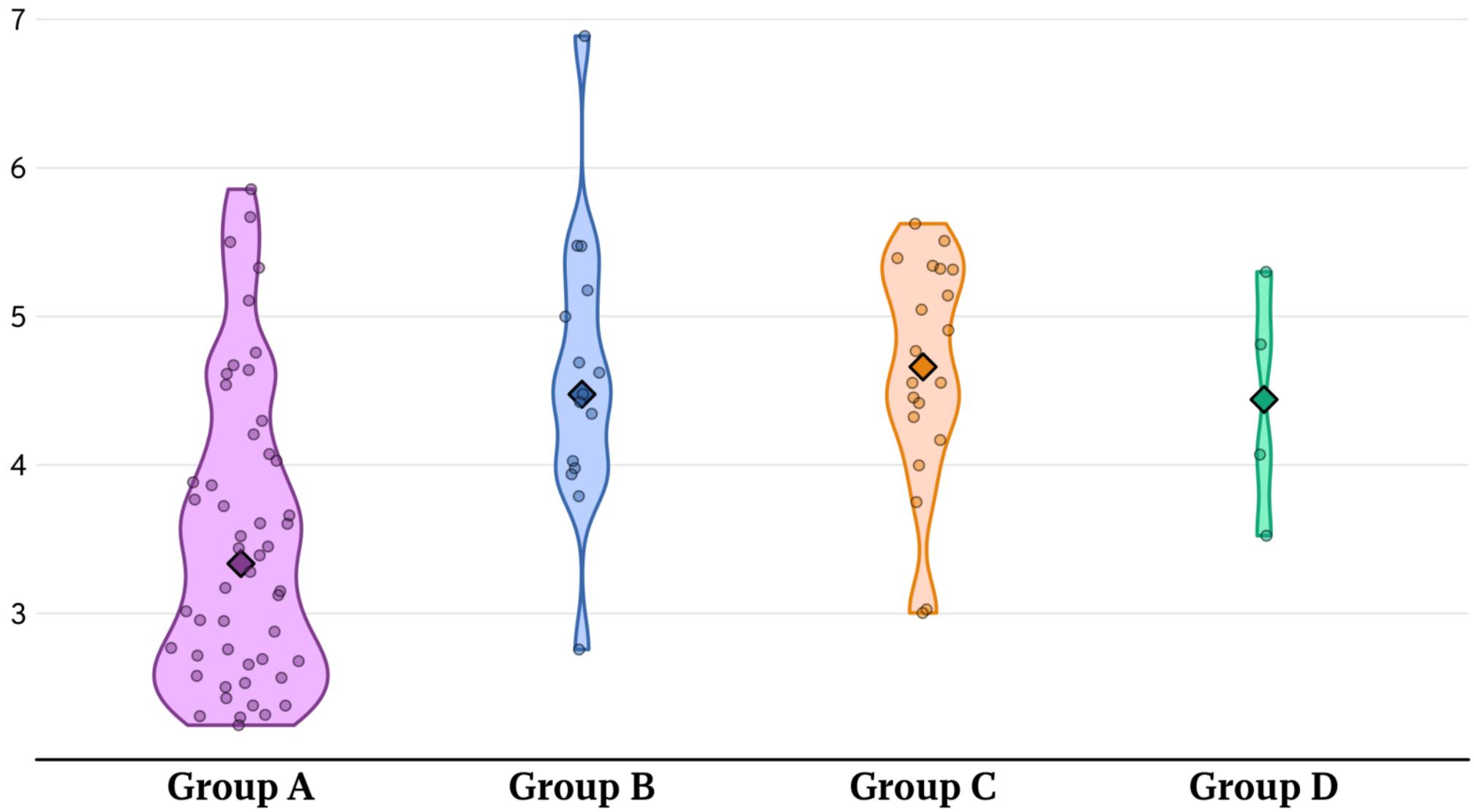










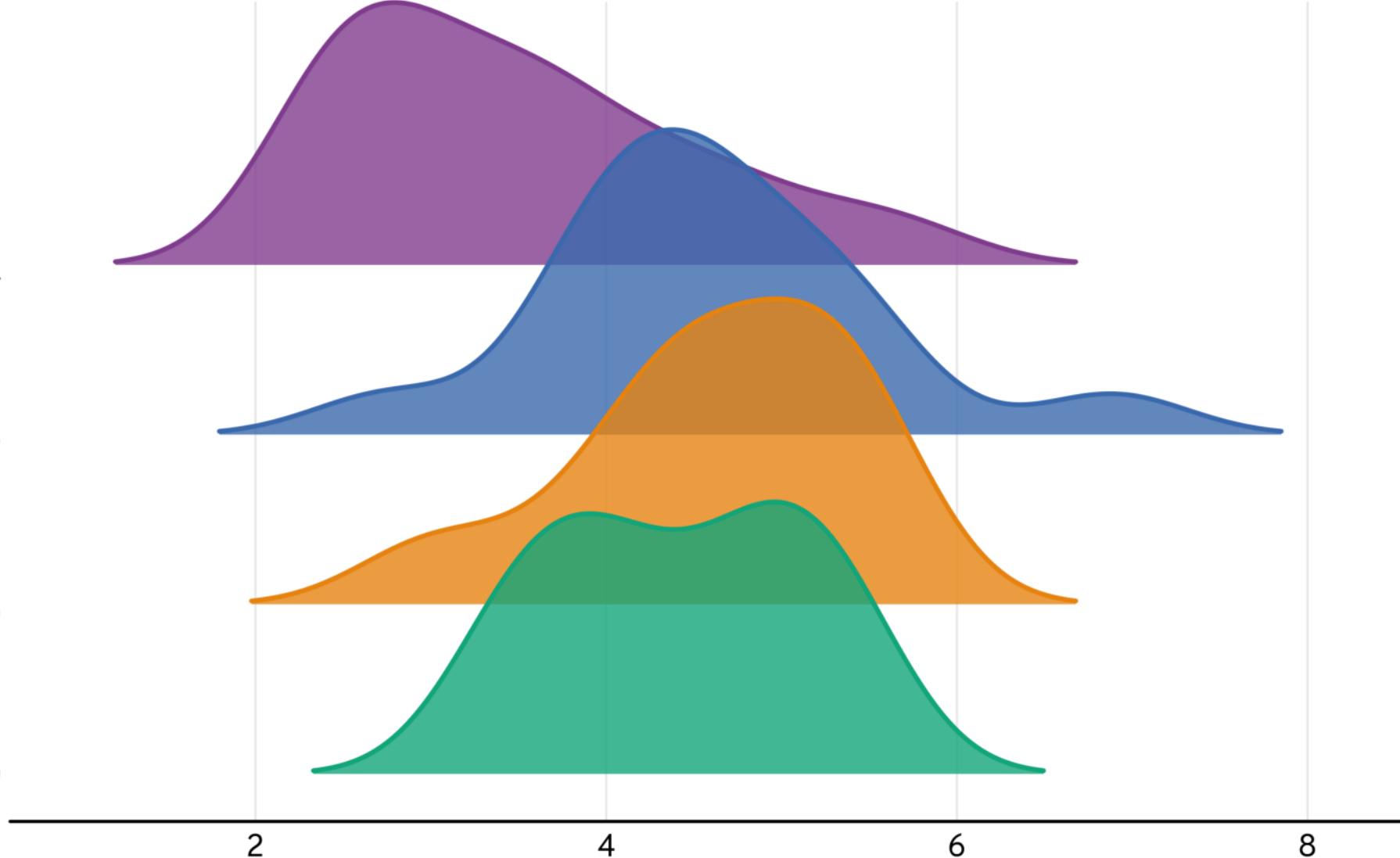


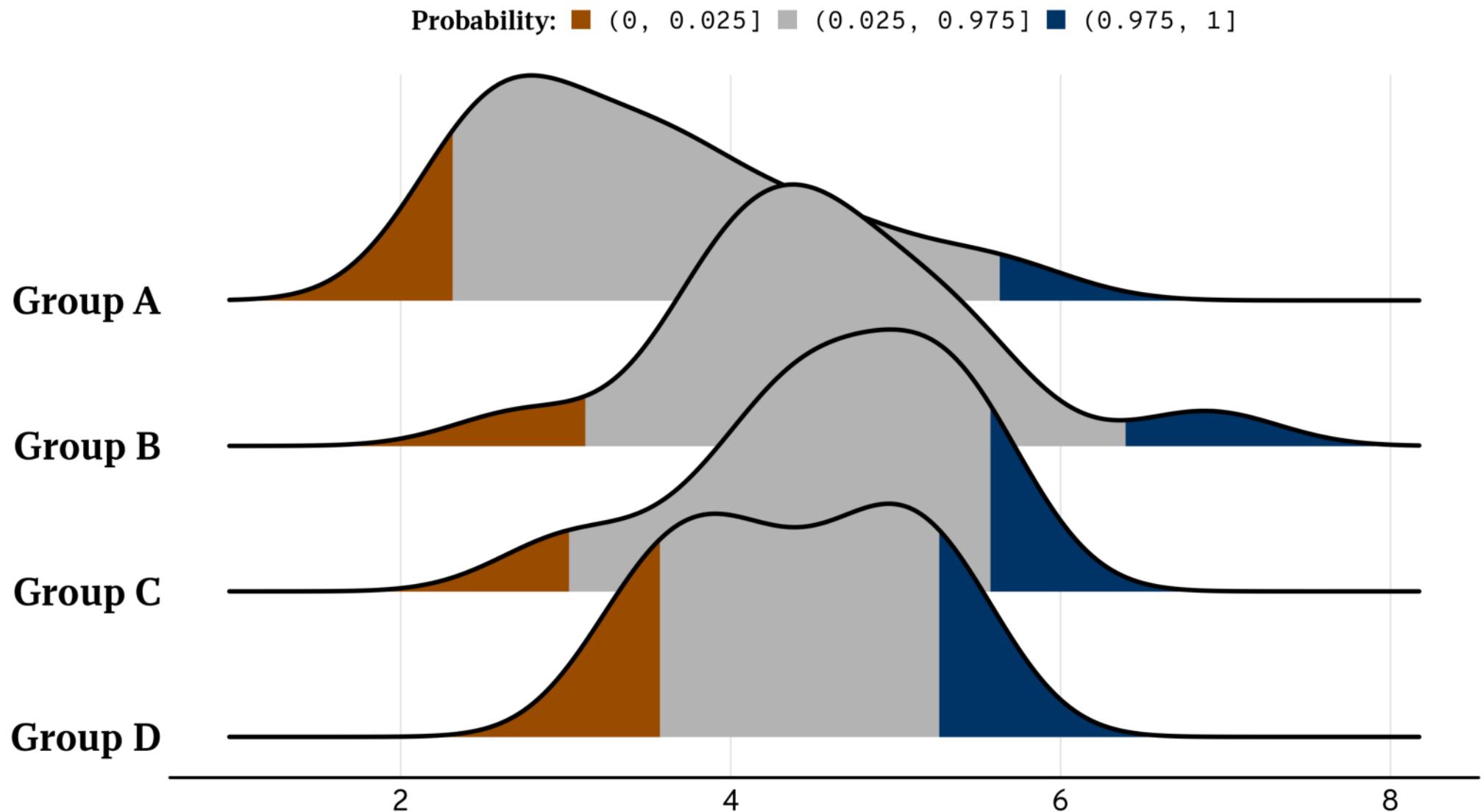
Group A

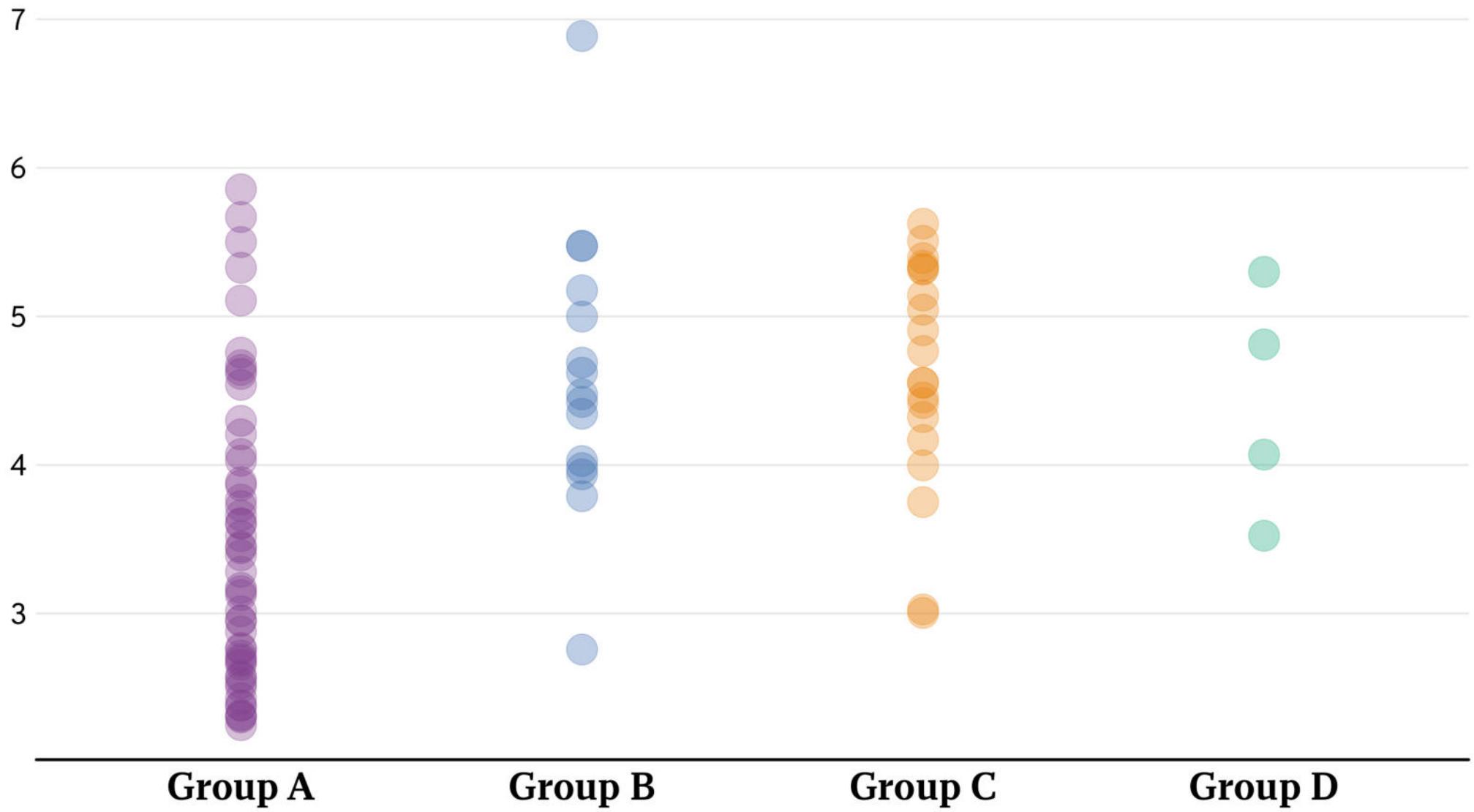
Group B

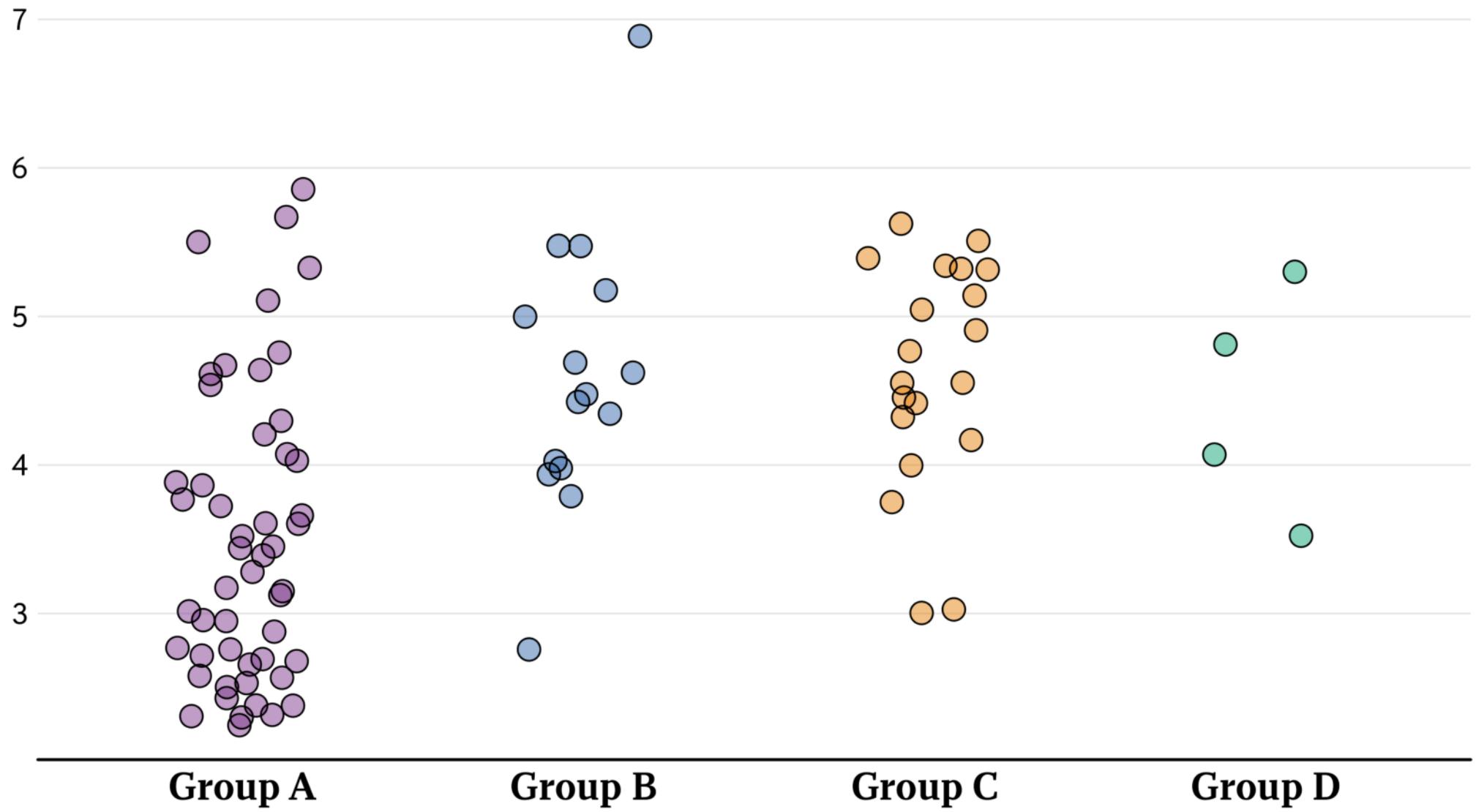
Group C

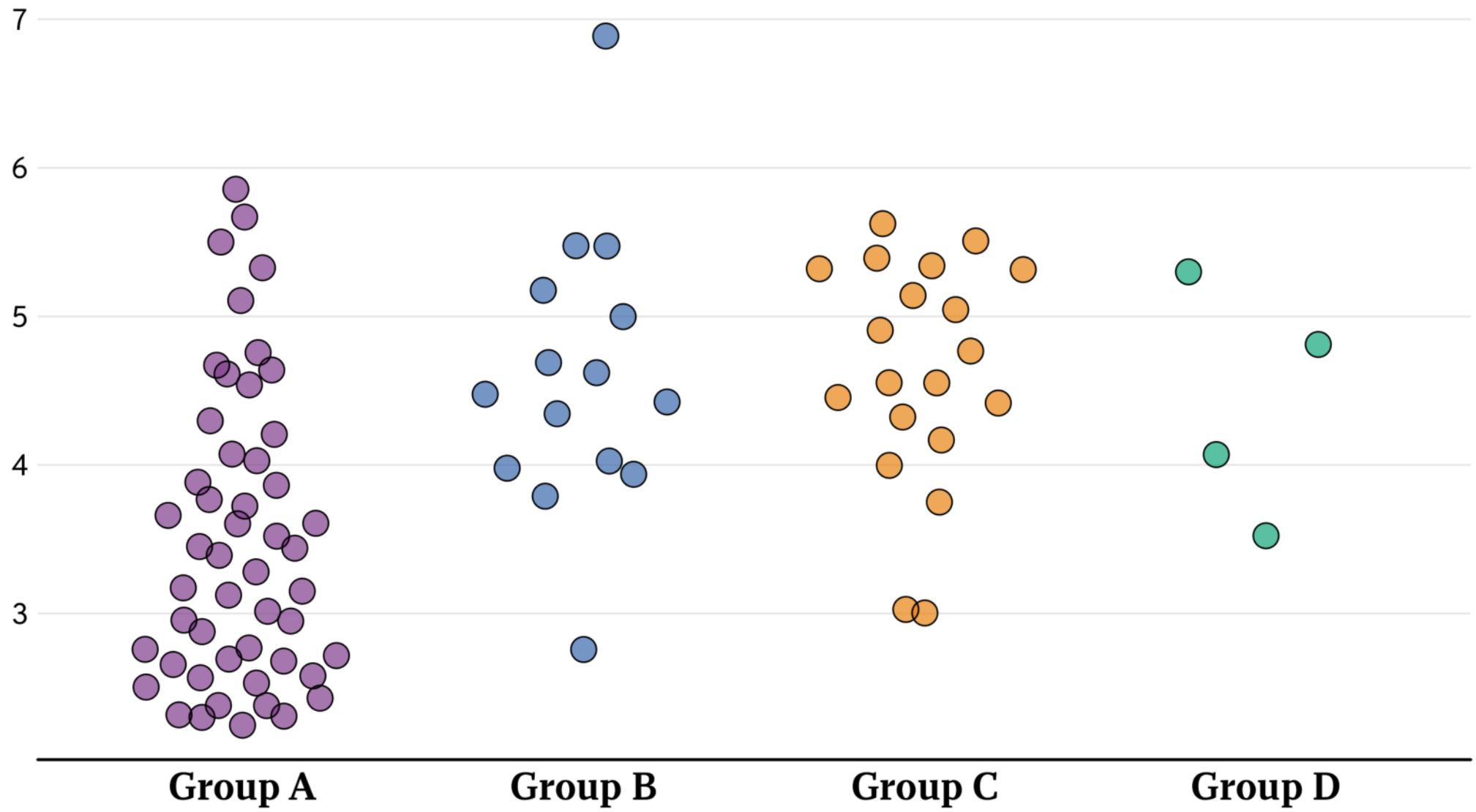
Group D

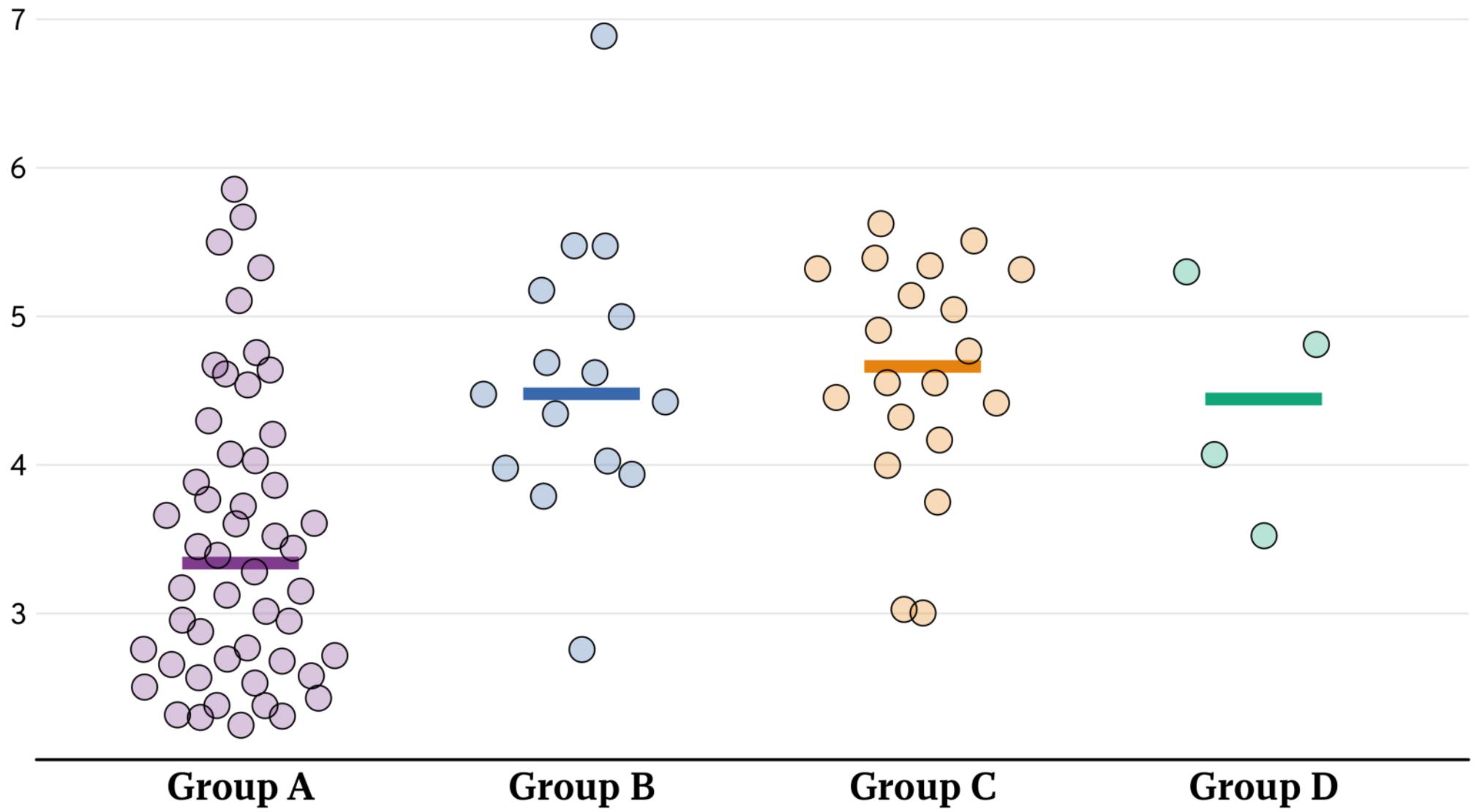


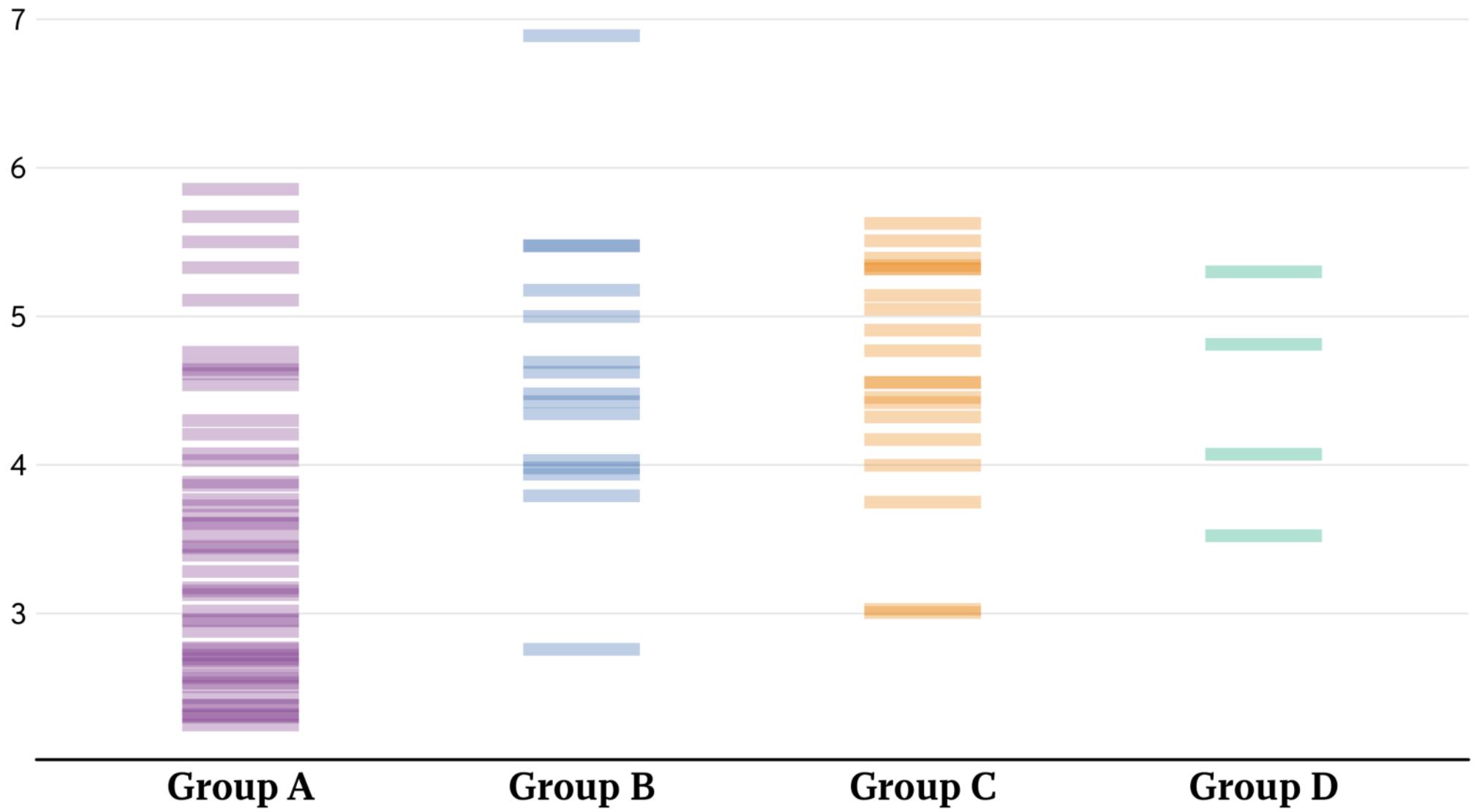


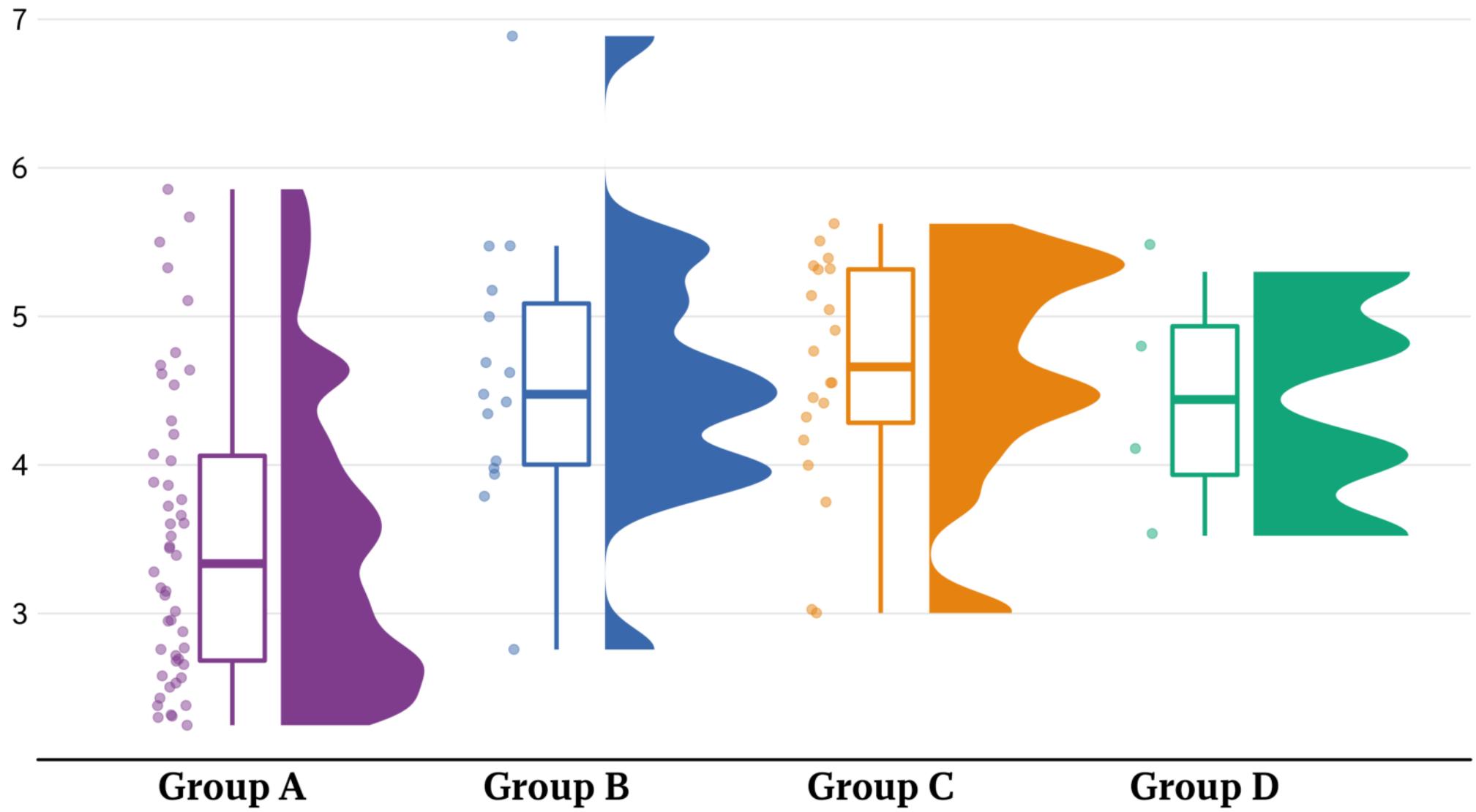






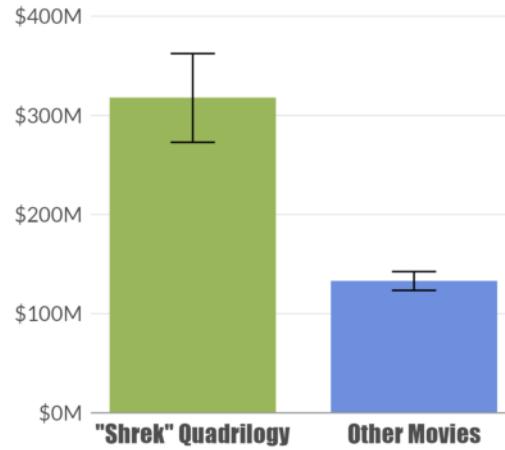




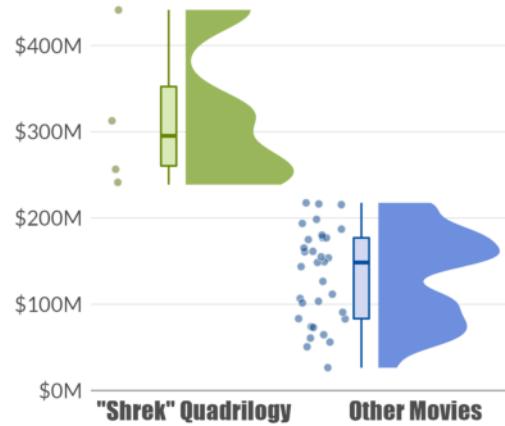


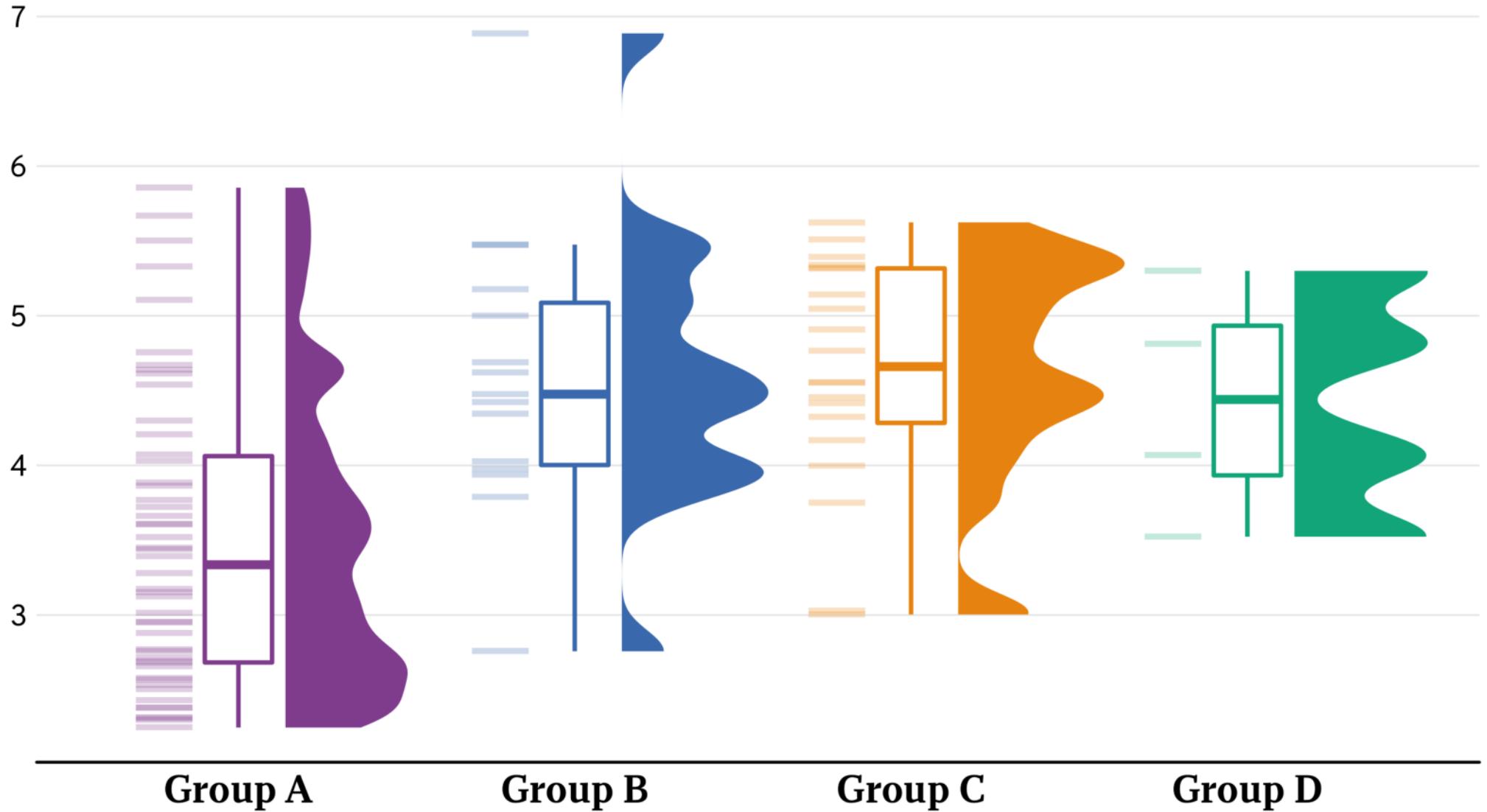


Domestic Box Office of DreamWorks Movies

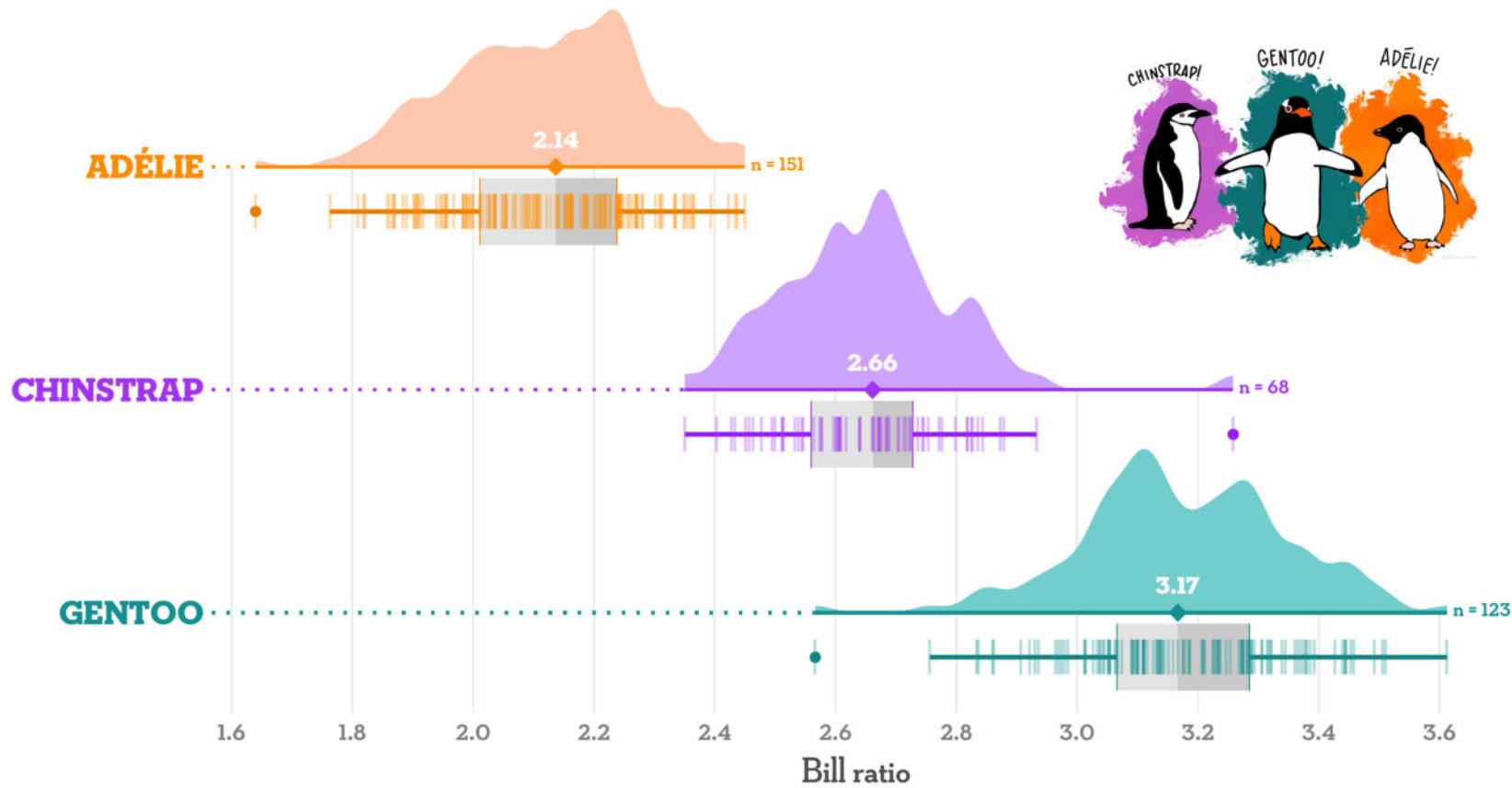


Domestic Box Office of DreamWorks Movies

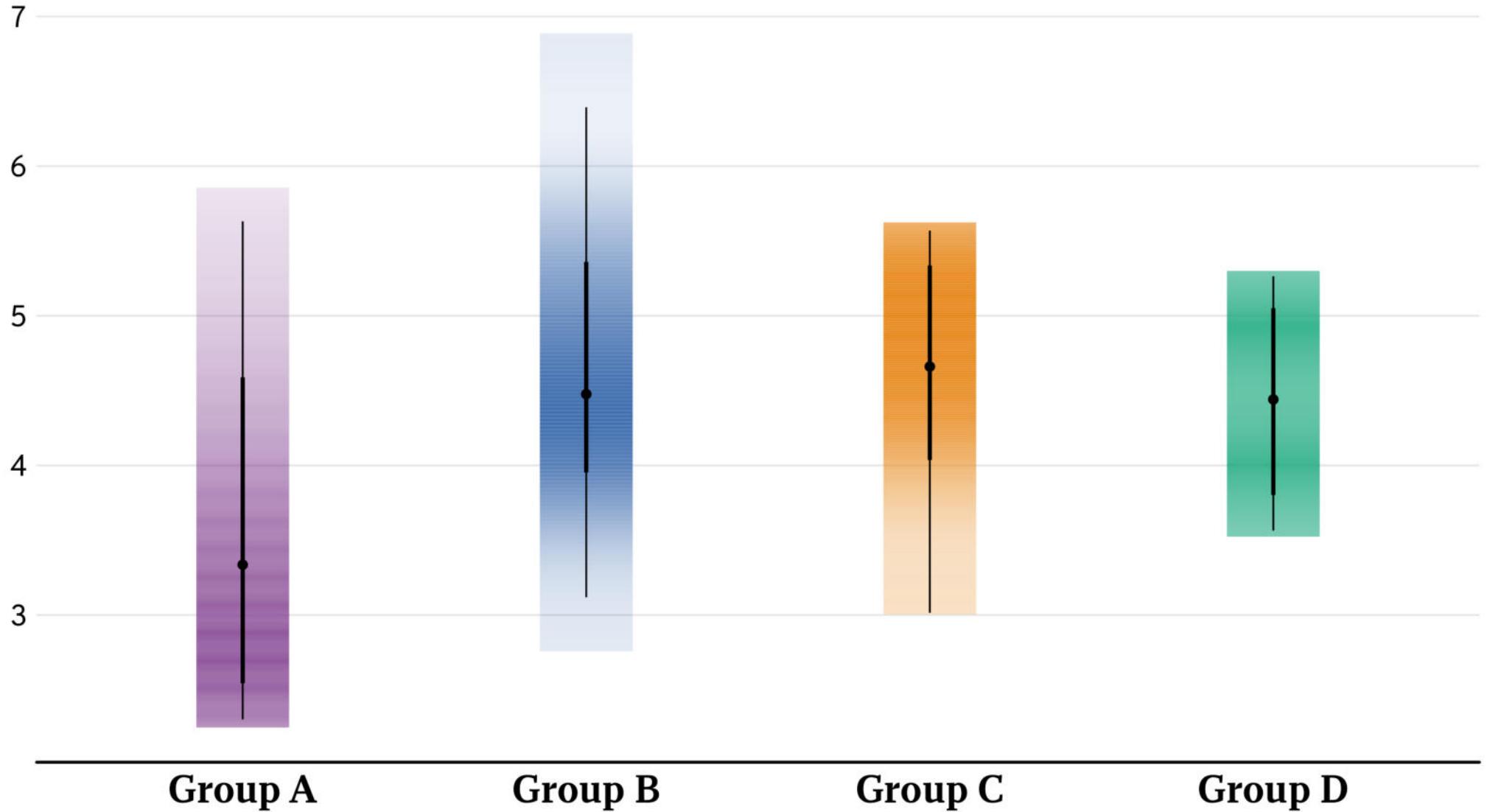


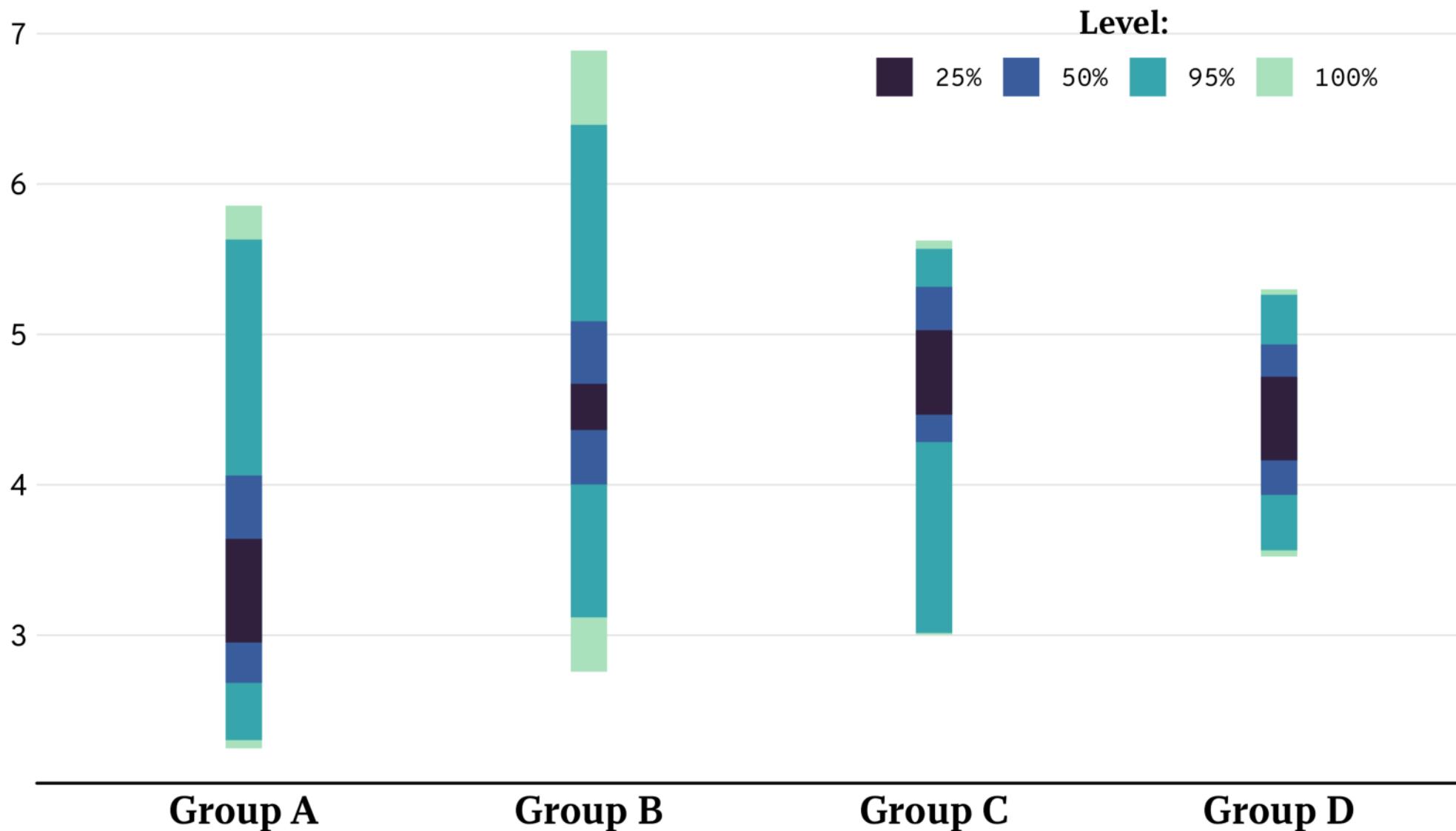


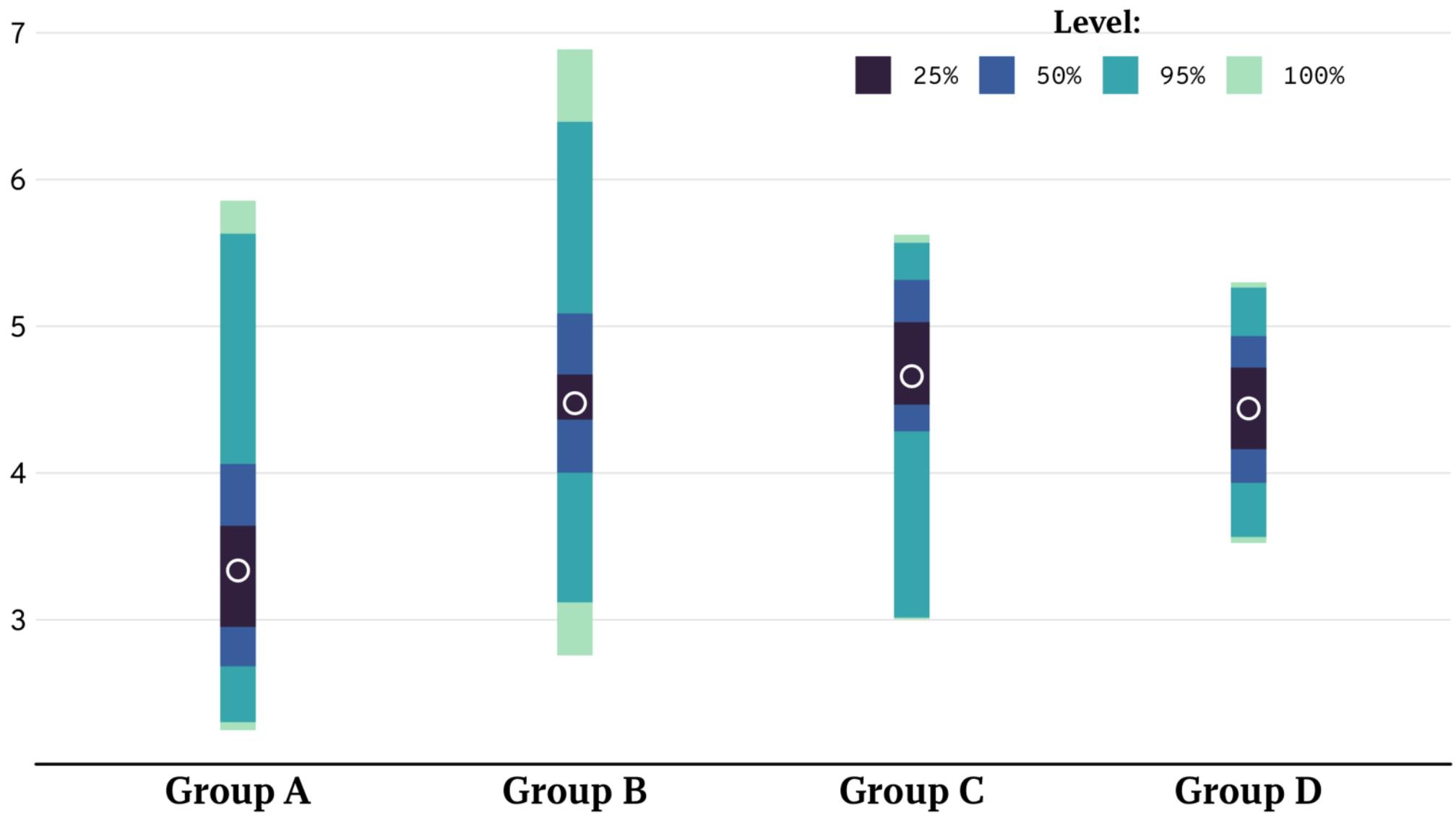
B. Distribution of the bill ratio, estimated as bill length divided by bill depth

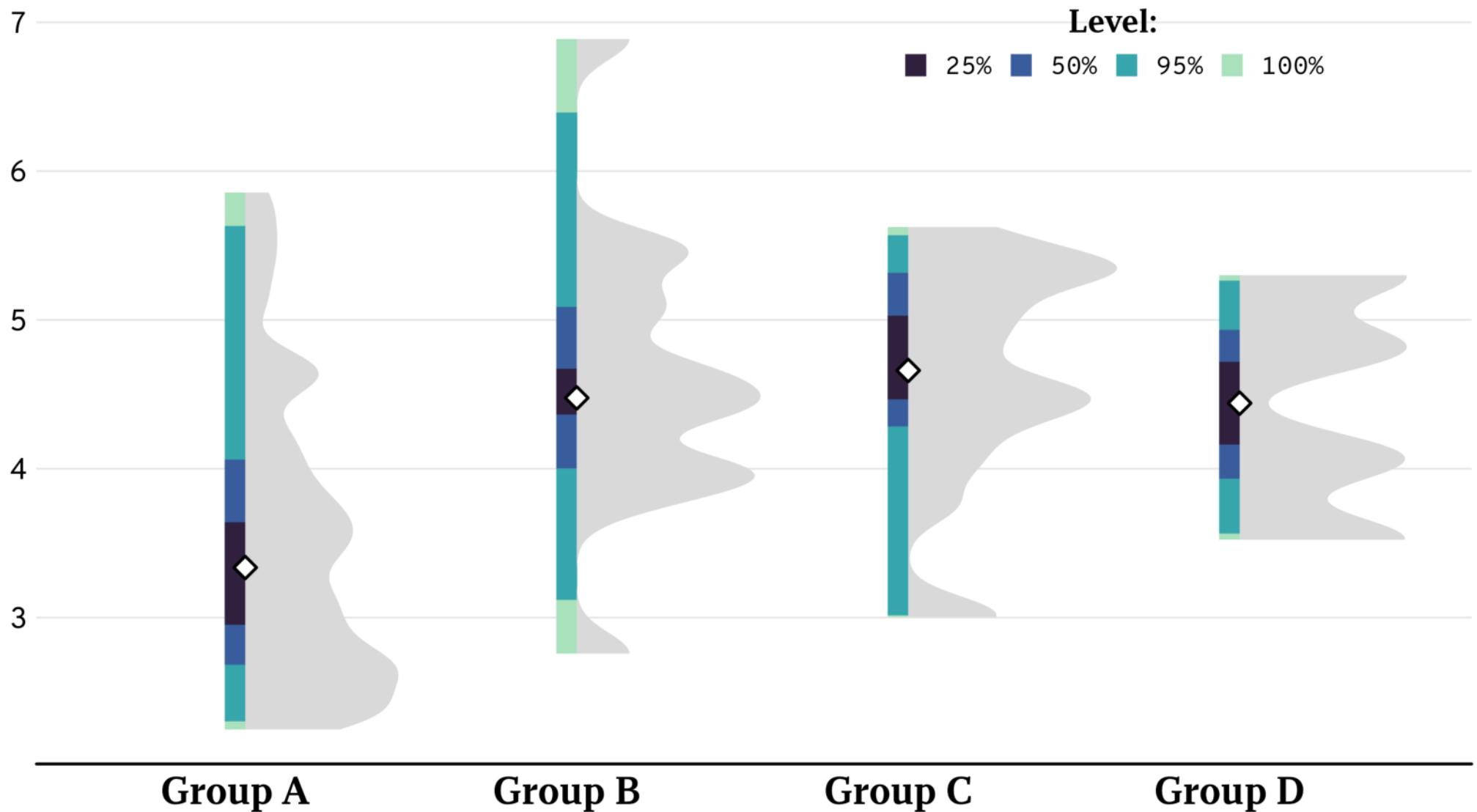


Note: In the original data, bill dimensions are recorded as "culmen length" and "culmen depth". The culmen is the dorsal (upper) ridge of a bird's bill.
Visualization: Cédric Scherer • Data: Gorman, Williams & Fraser (2014) DOI: 10.1371/journal.pone.0090081 • Illustrations: Allison Horst



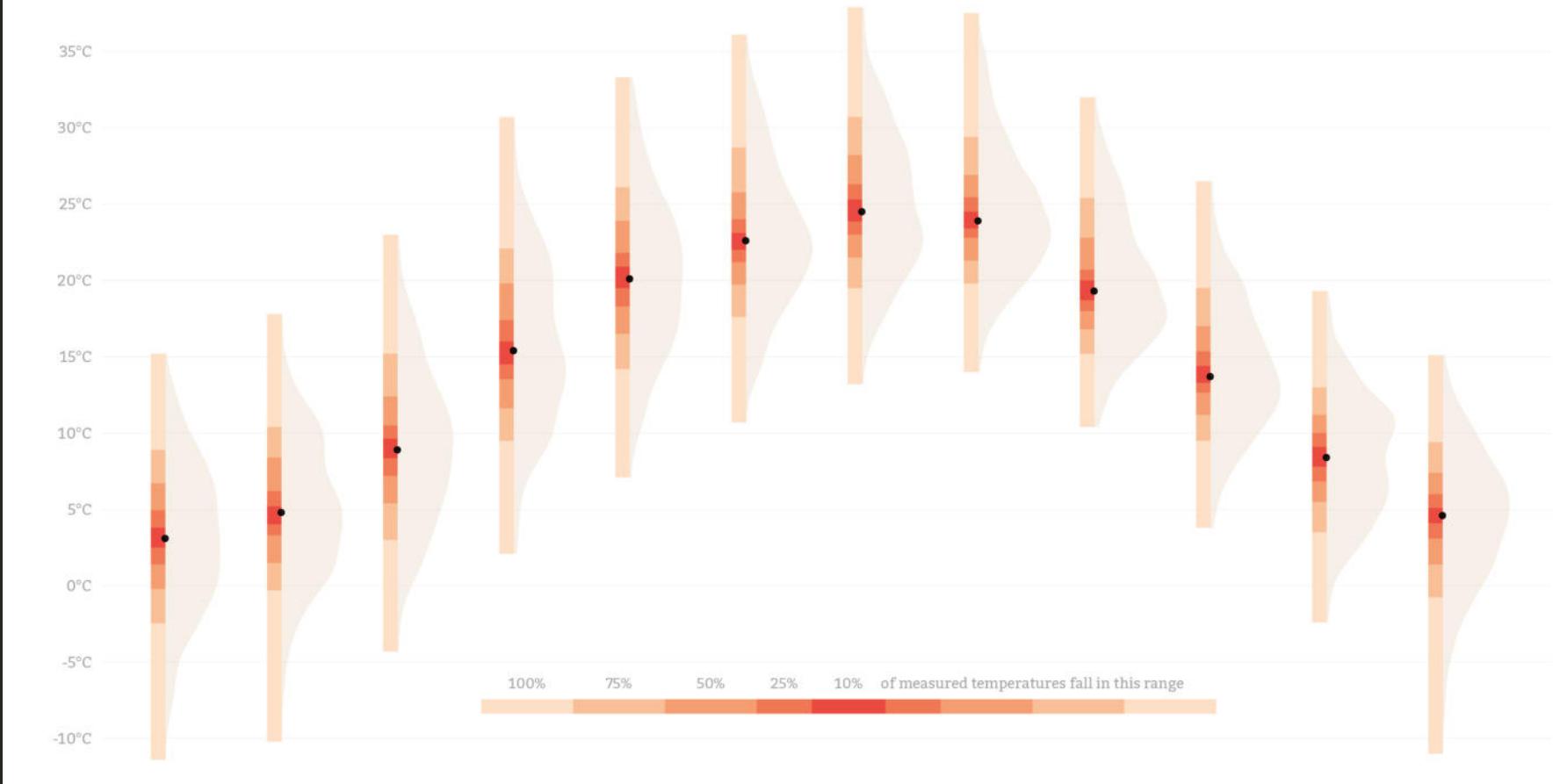






Daily Temperatures in Berlin, Germany

Range and distribution of maximum daily temperatures in Celsius per month from 2000 to 2018 measured in Berlin-Dahlem, Germany



Visualization by Cédric Scherer | Data: DWD (Deutscher Wetterdienst)

#SWDchallenge contribution September 2019

Not my cup of coffee...

Each dot depicts one coffee bean rated by Coffee Quality Institute's trained reviewers. In addition, the multiple interval stripes show where 25%, 50%, 95%, and 100% of the beans fall along the rating gradient from 0 to 100 points. The rated coffee beans range from 59.8 points (Guatemala) to 89.9 (Ethiopia). Only countries of origin with 25 or more tested beans are shown. The red empty triangle marks the minimum rating, the black filled triangle indicates each country's median score.

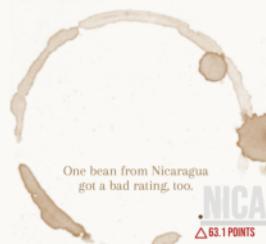
Visualization by Cédric Scherer

60 POINTS

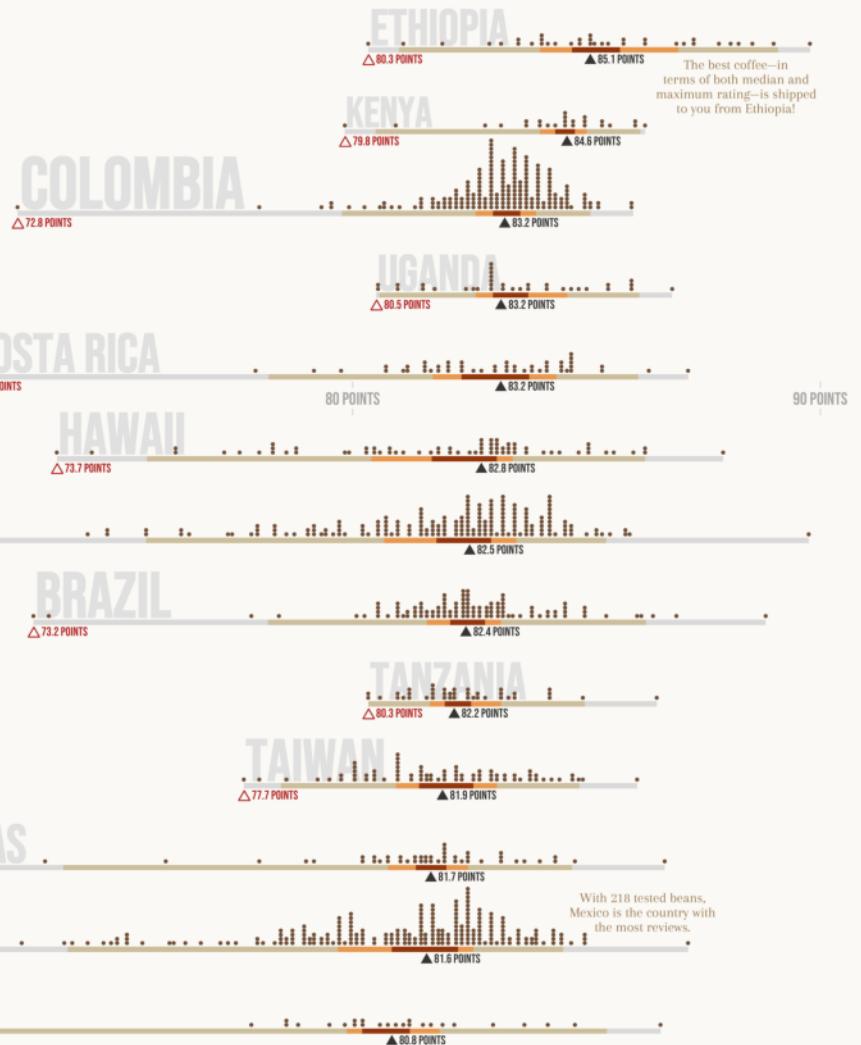
70 POINTS

GUATEMALA

△ 59.8 POINTS
The coffee bean with the lowest rating has its origin in Guatemala.

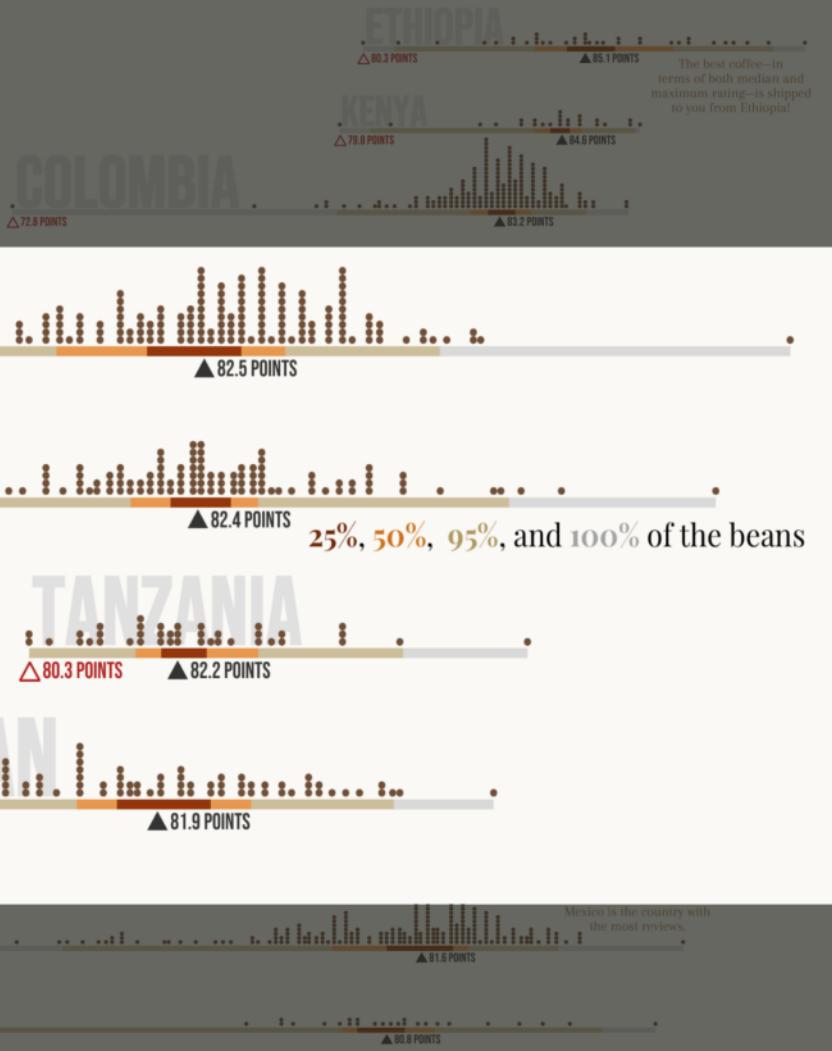


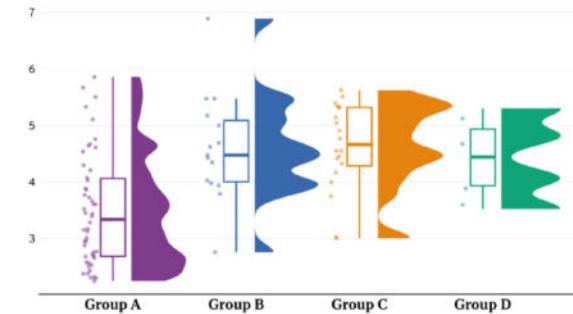
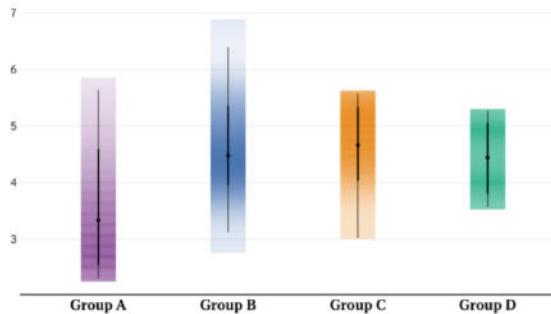
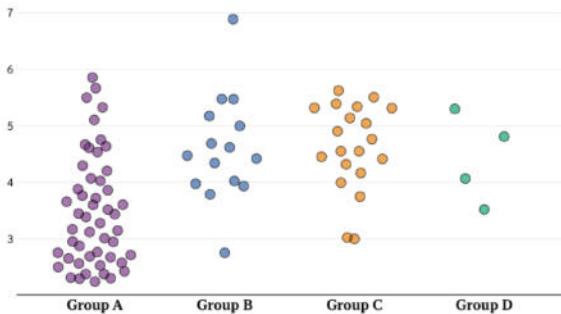
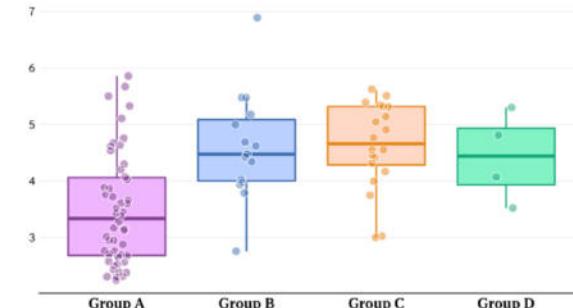
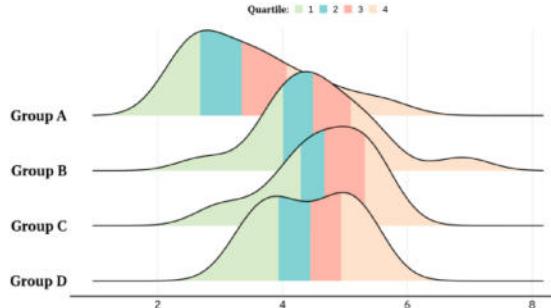
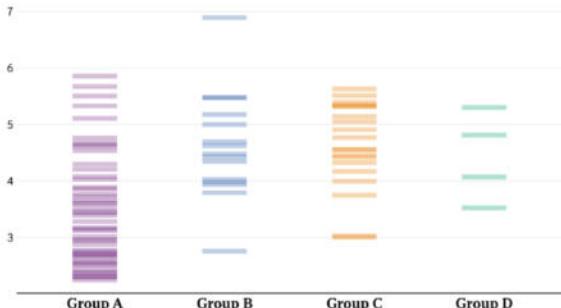
NICARAGUA
△ 63.1 POINTS



Not my cup of coffee...

Each dot depicts one coffee bean rated by Coffee Quality Institute's trained reviewers. In addition, the multiple interval stripes show where 25%, 50%, 95%, and 100% of the beans fall along the rating gradient from 0 to 100 points. The rated coffee beans range from 59.8 points (Guatemala) to 89.9 (Ethiopia). Only countries of origin with 25 or more tested beans are shown. The red empty triangle marks the minimum rating, the black filled triangle indicates each country's median score.





- Always check raw data and sample size
- Try several chart types
- Be open to combine chart types
- Choose chart type with your audience in mind

PERSPECTIVE

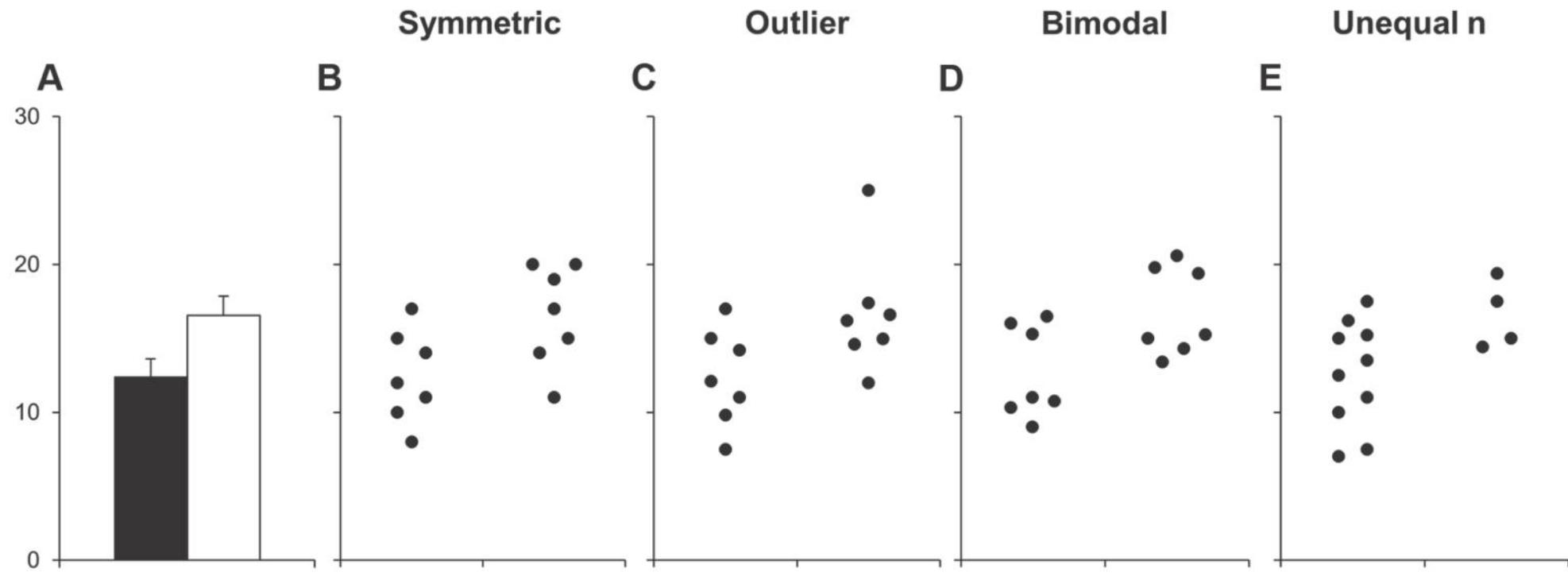
Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm

Tracey L. Weissgerber^{1*}, Natasa M. Milic^{1,2}, Stacey J. Winham³, Vesna D. Garovic¹

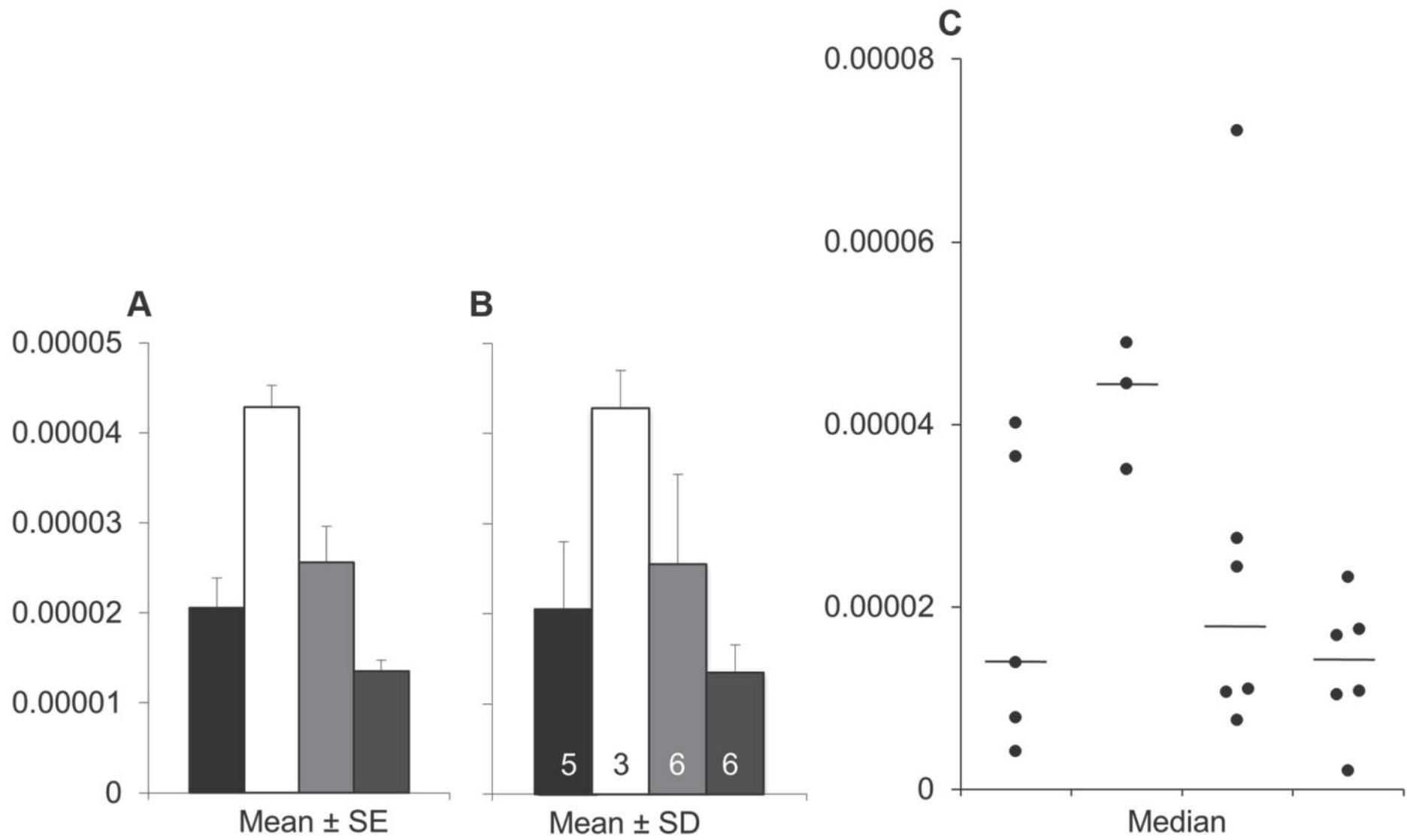
1 Division of Nephrology & Hypertension, Mayo Clinic, Rochester, Minnesota, United States of America,

2 Department of Biostatistics, Medical Faculty, University of Belgrade, Belgrade, Serbia, **3** Division of Biomedical Statistic and Informatics, Mayo Clinic, Rochester, Minnesota, United States of America

* weissgerber.tracey@mayo.edu



Test	p value			
T-test: Equal var.	0.035	0.050	0.026	0.063
T-test: Unequal var.	0.035	0.050	0.026	0.035
Wilcoxon	0.054	0.073	0.128	0.103



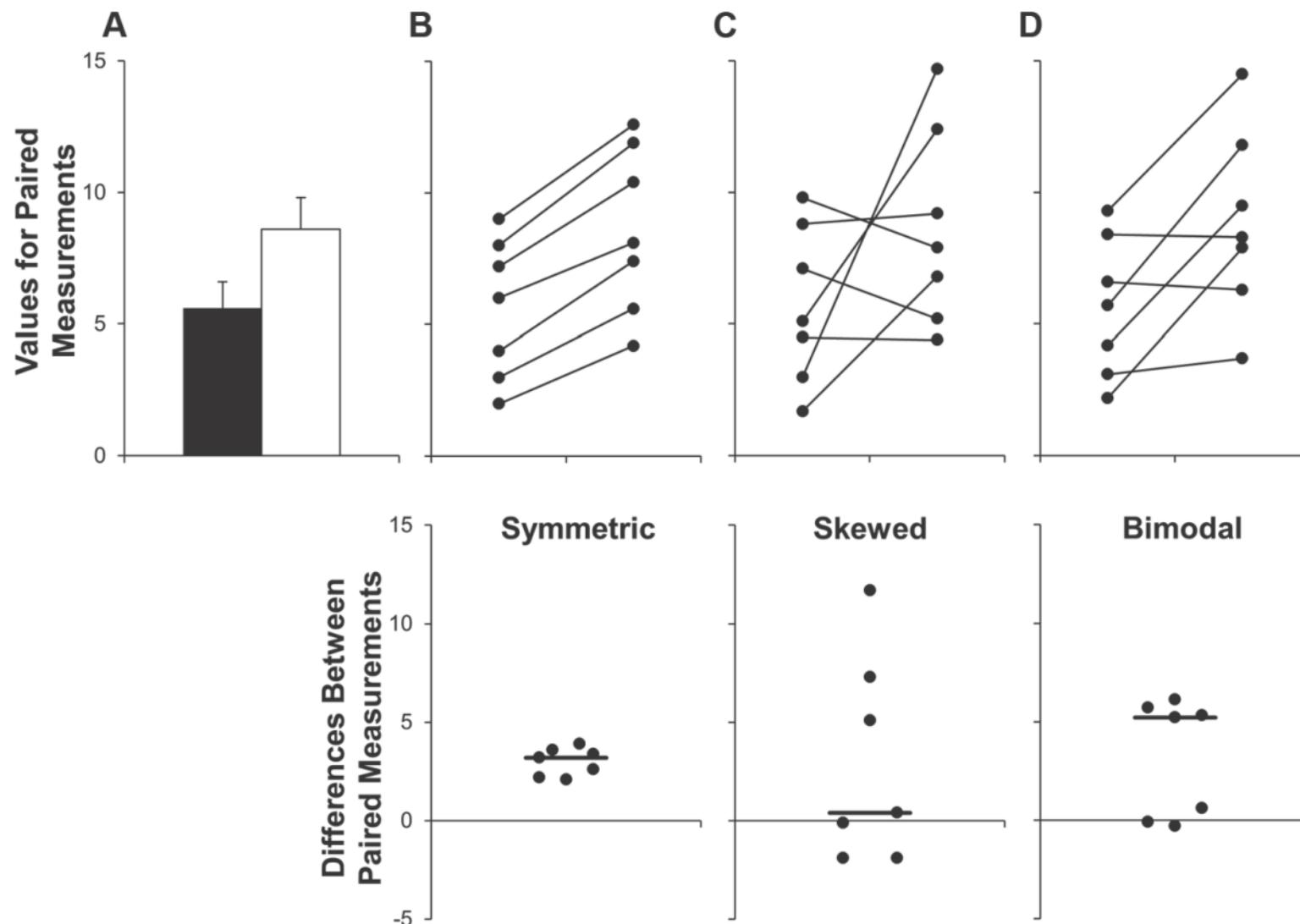
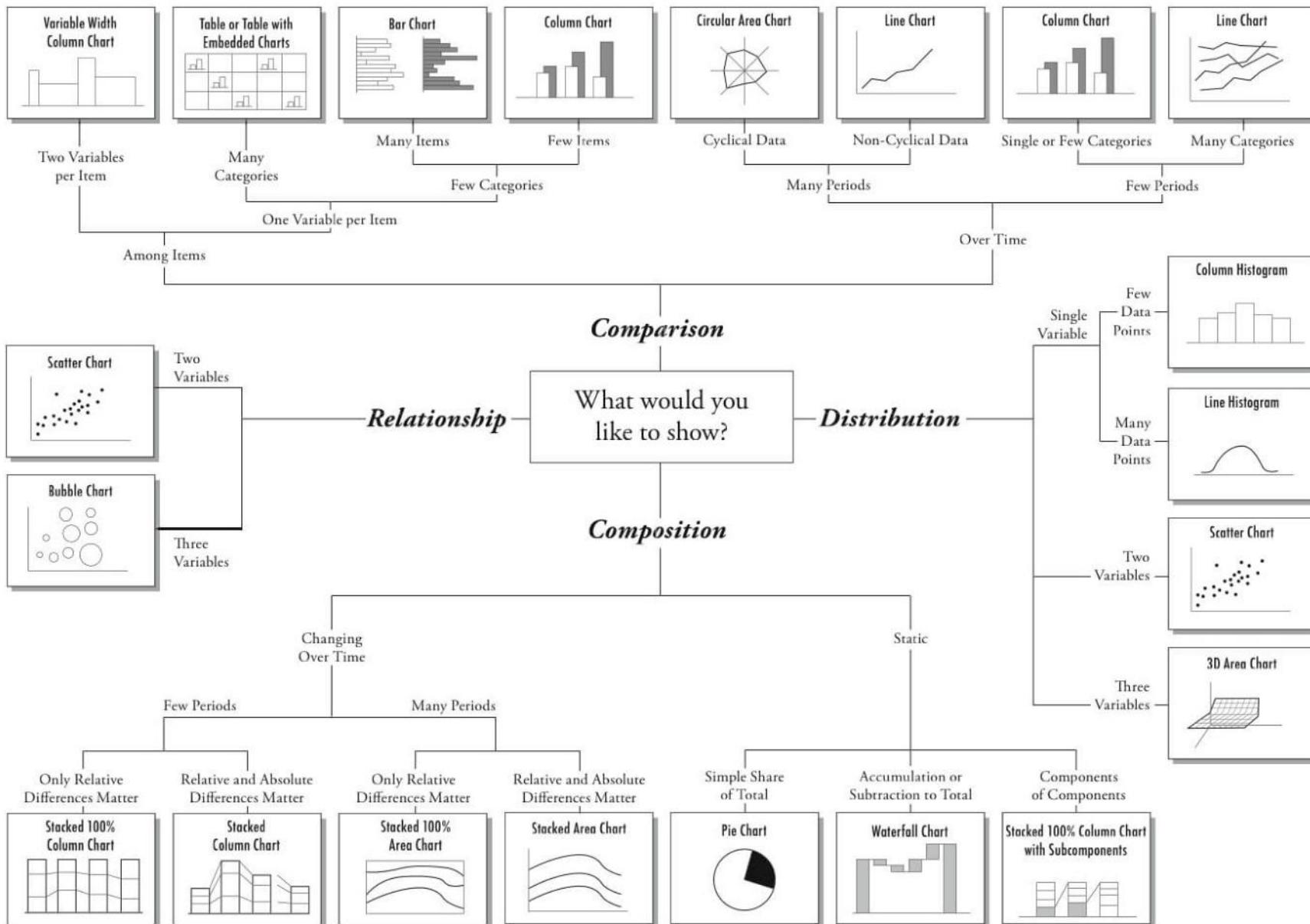
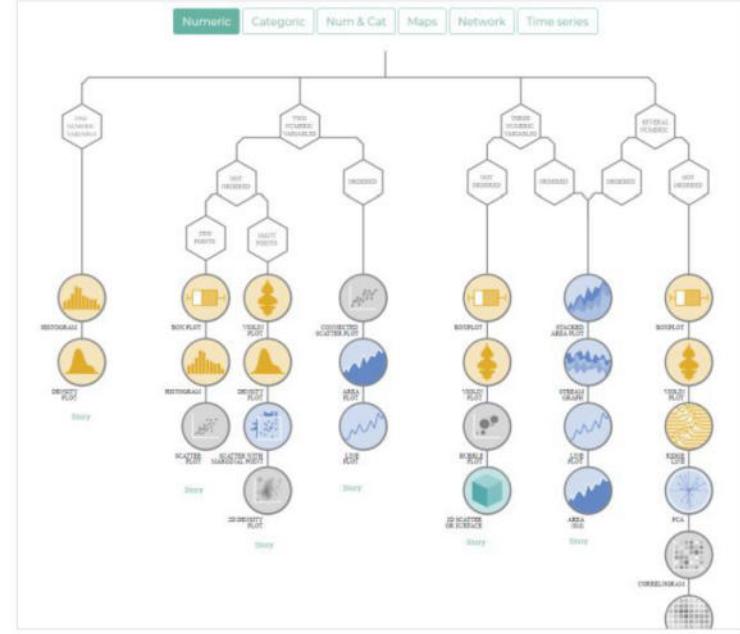
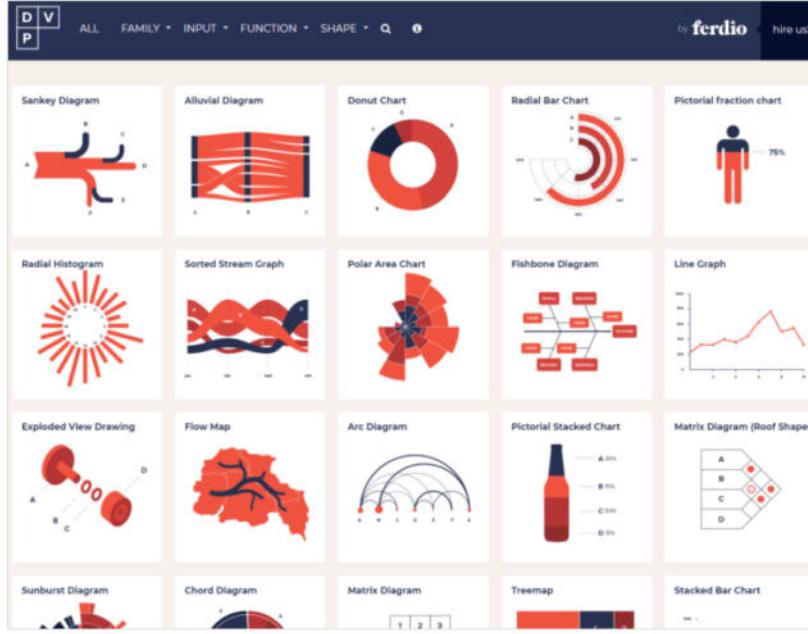


Chart Suggestions—A Thought-Starter

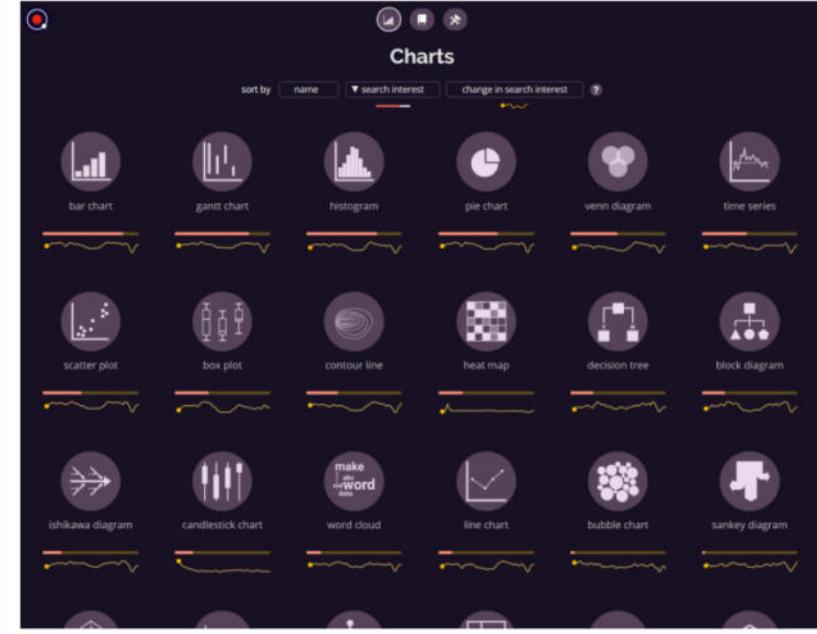




data-to-viz.com



datavizproject.com



visualizationuniverse.com/charts



from Data
to Viz

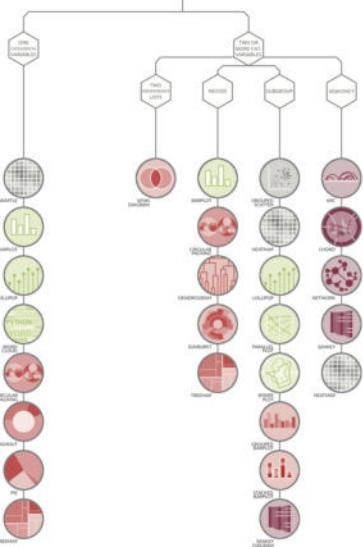
"From Data to Viz" is a classification of chart types based on input data format. It will help you find the perfect chart in three simple steps:

- 1 Identify what type of data you have.
 - 2 Go to the corresponding decision tree and follow it down to a set of possible charts.
 - 3 Choose the chart from the set that will suit your data and your needs best.

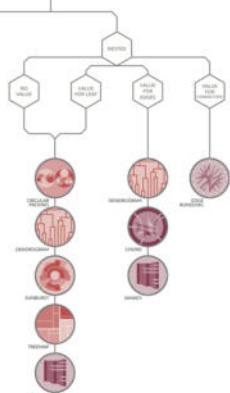
Dataviz is a world with endless possibilities and this project does not claim to be exhaustive. However it should provide you with a good starting point. For an interactive version and much more, visit:

data-to-viz.com

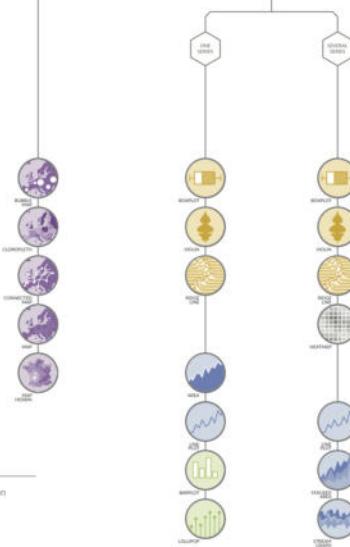
CATEGORIC



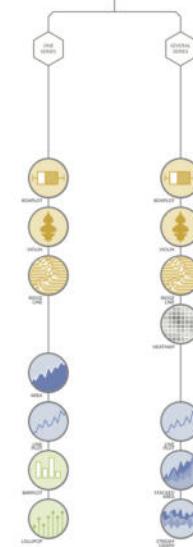
RELATIONAL



MAP



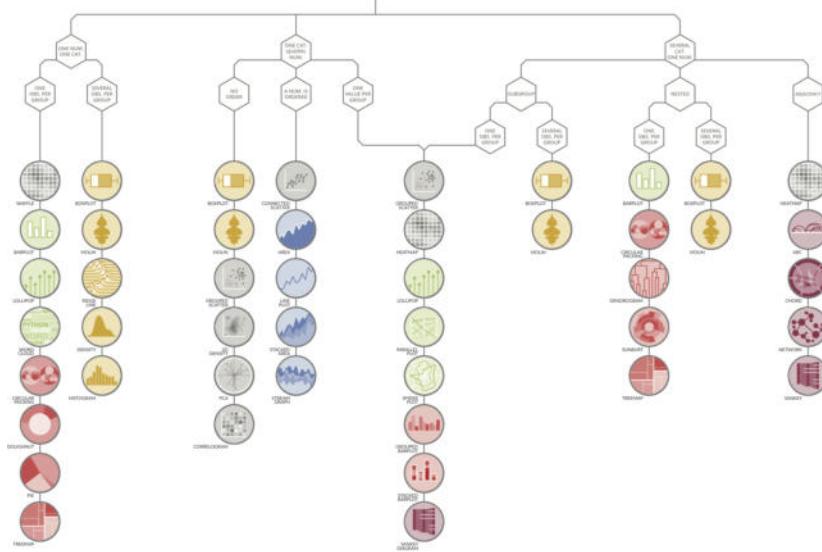
TIME SERIES



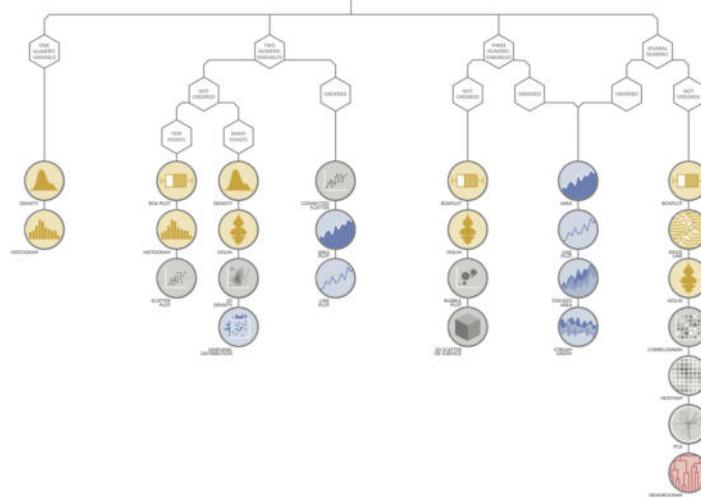
WHAT DO YOU WANT TO SHOW?

- Distribution
 - Correlation
 - Ranking
 - Part of a whole
 - Evolution
 - Maps
 - Flow

CATEGORIC AND NUMERIC



NUMERIC



The image shows a screenshot of a data visualization website. At the top left is a yellow circular icon containing a boxplot. Below it is the word "BOXPLOT" in green capital letters. A sub-header "Summarize the distribution of numeric variables" follows. A "About" section provides a brief explanation of what a boxplot is. A "Common Mistakes" section lists three items: "Boxplot hides the sample size of each group, show it with annotation or box width", "Boxplot hides the underlying distribution. Use jitter if low number of data points, or use violin with bigger data.", and "Order your boxplot by median can make it more insightful". A "Code" section includes links to R graph gallery, Python gallery, D3.js gallery, and Flourish. A "Read More" section links to a dedicated page. On the right side, there is a grid of 18 circular icons, each representing a different type of chart. The categories are: Boxplot, Ridgeline, Scatter, Connected scatter, Density 2d, Barplot, Lollipop, Circular Barplot, Treemap, Venn diagram, Doughnut, Pie chart, Dendrogram, Circular packing, Sunburst, Line chart, Area chart, Stacked area chart, and Choropleth map.

POSSIBILITIES

presented in this website.

part of a whole Evolution Map Flow

Boxplot Ridgeline Scatter

Connected scatter Density 2d Barplot

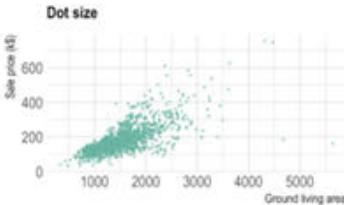
Lollipop Circular Barplot Treemap

Venn diagram Doughnut Pie chart Dendrogram Circular packing Sunburst

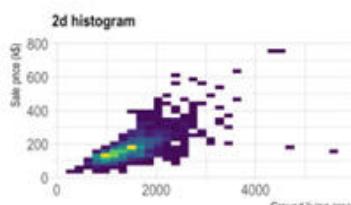
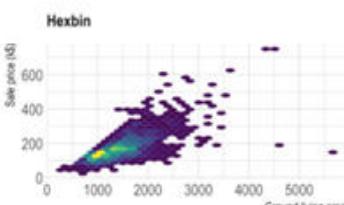
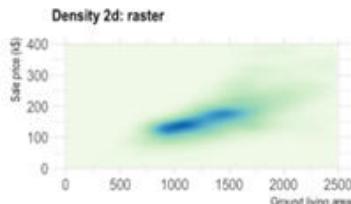
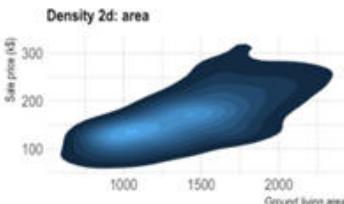
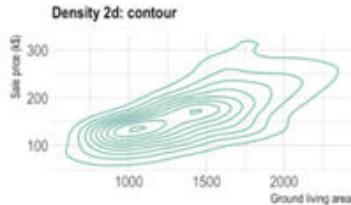
Line chart Area chart Stacked area chart Choropleth map

Overplotting

The most common pitfall with scatterplot is overplotting: when the sample size gets big, dots are plotted on top of each other what makes the chart unreadable. There are several work around to avoid this issue as describe in this [specific post](#). Here is a summary of the different offered techniques:



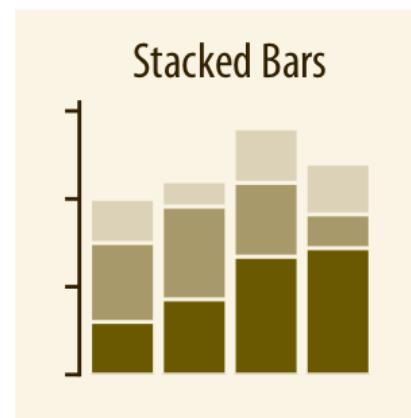
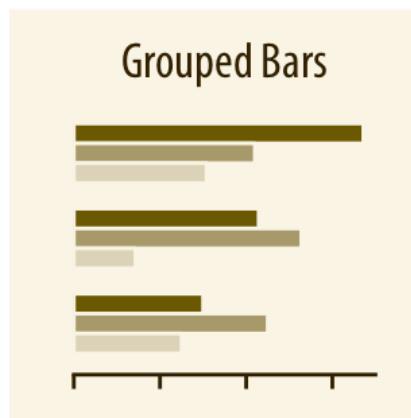
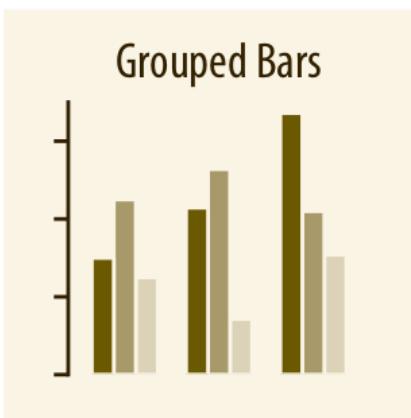
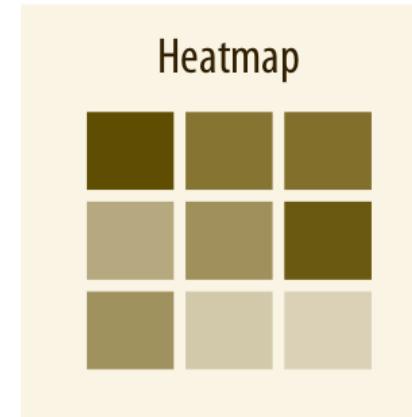
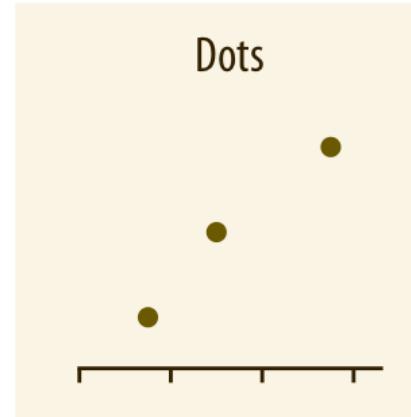
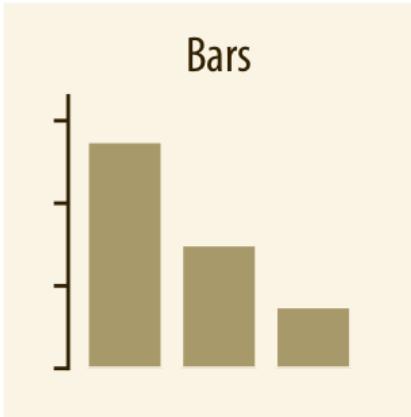
CODE



Going further

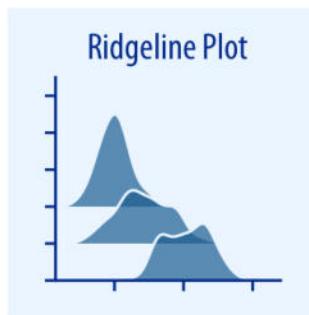
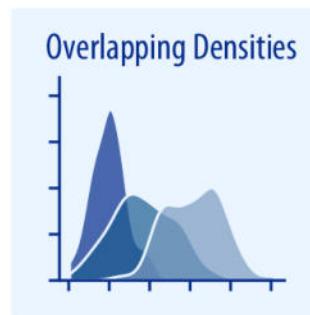
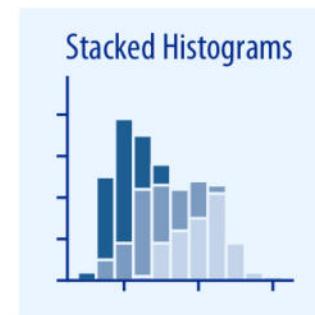
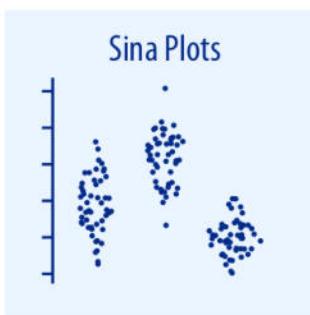
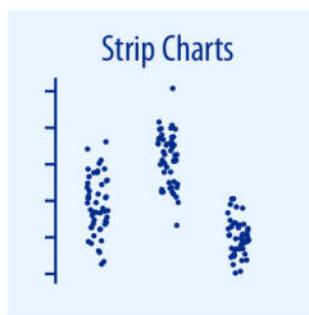
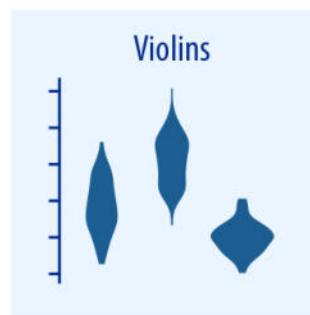
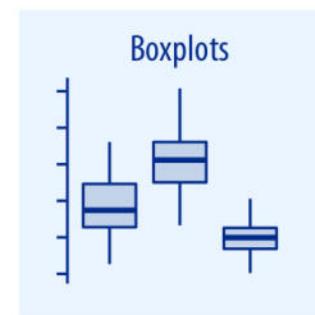
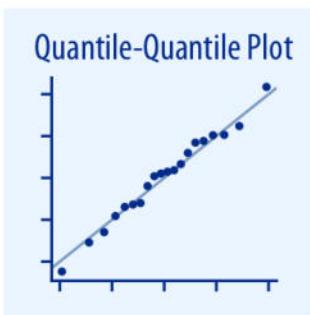
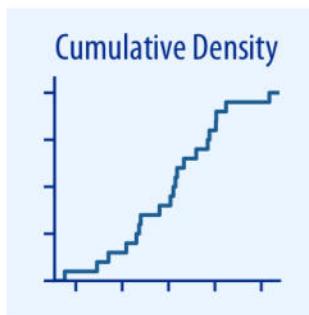
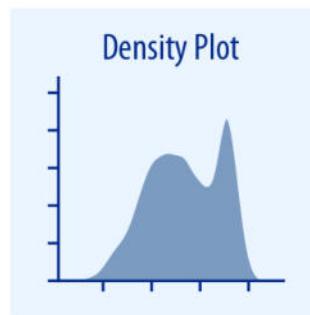
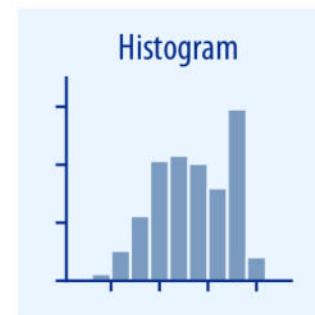
You can learn more about each type of graphic presented in this story in the dedicated

Charts to Visualize Amounts

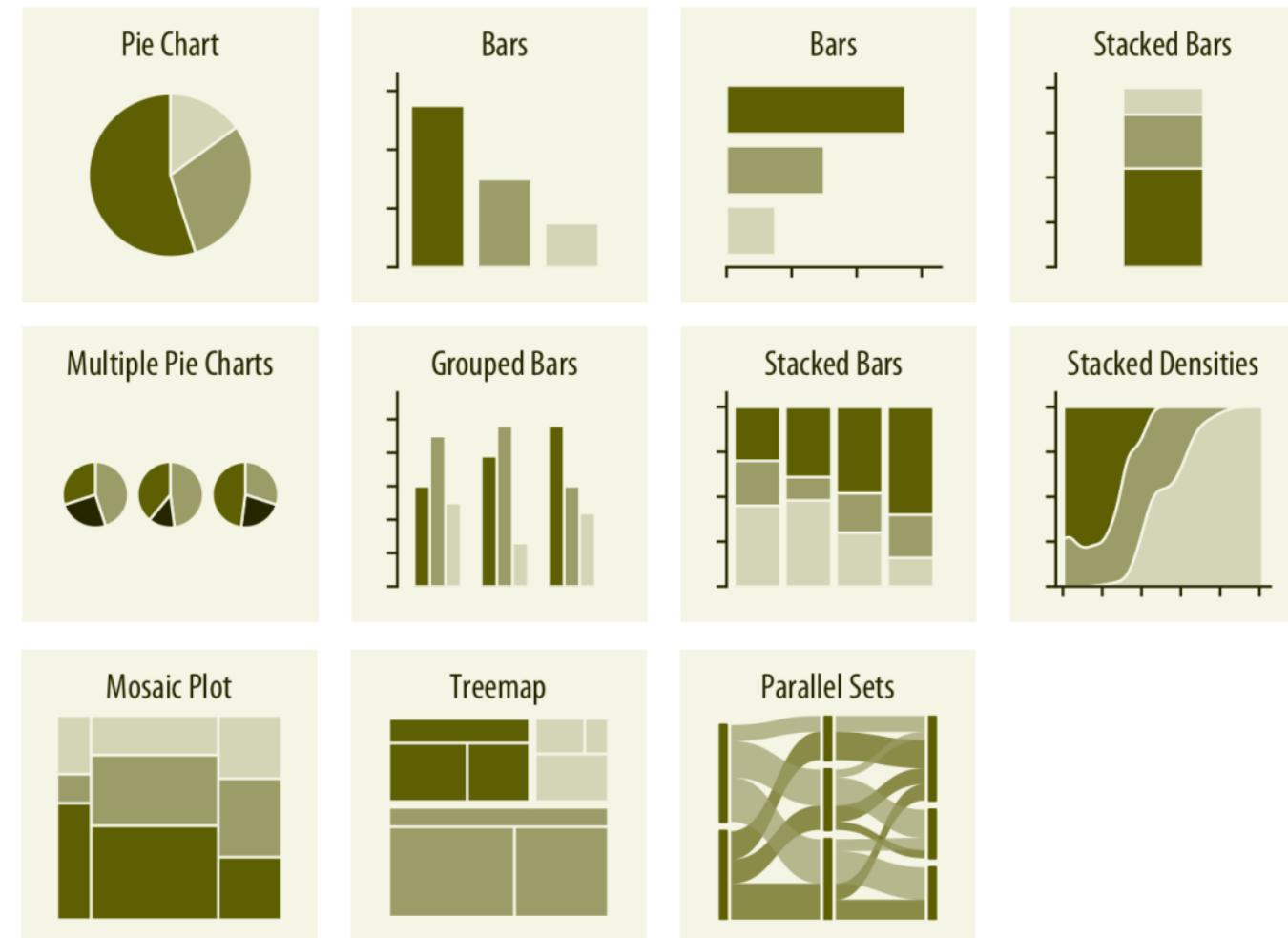


“Fundamentals of Data Visualization” by Claus Wilke

Charts to Visualize Distributions

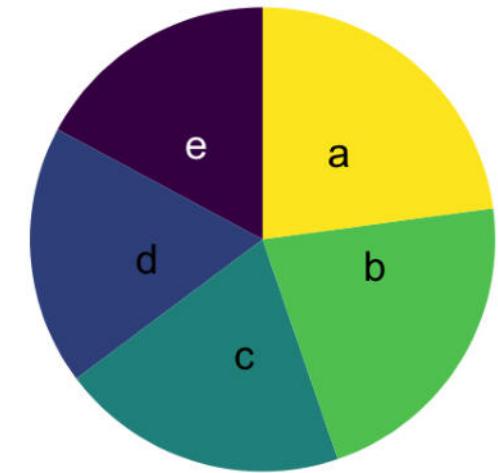
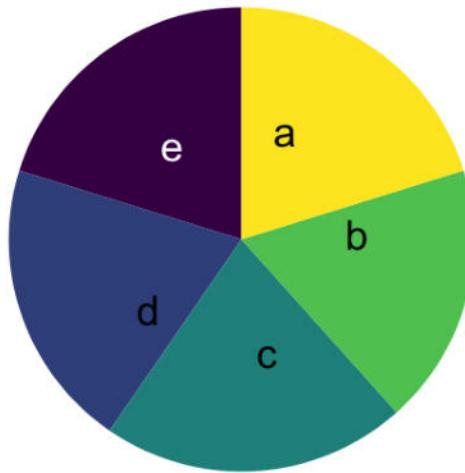
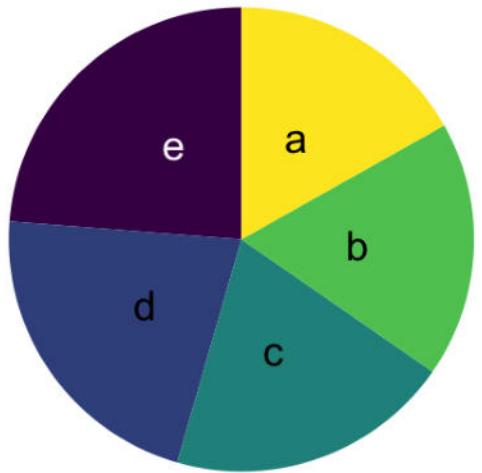


Charts to Visualize Proportions



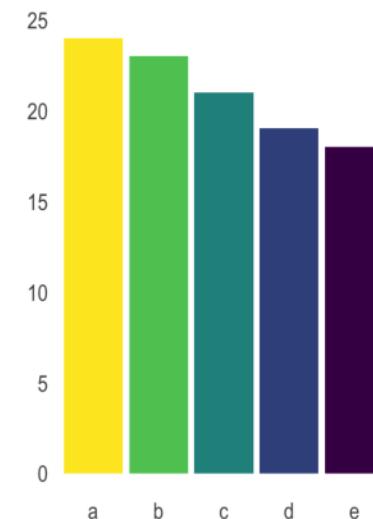
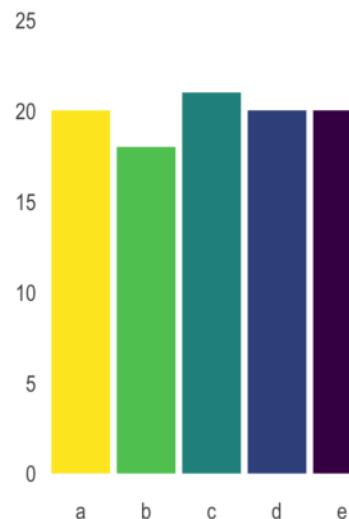
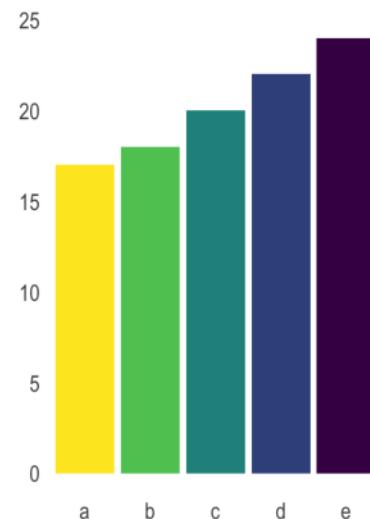
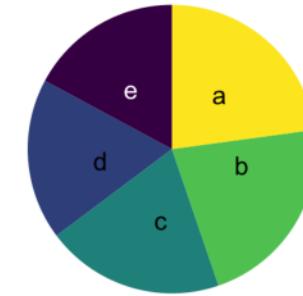
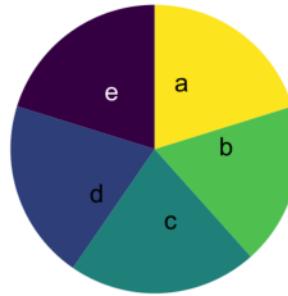
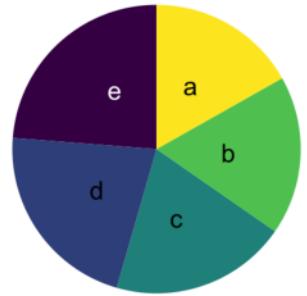
“Fundamentals of Data Visualization” by Claus Wilke

Beware of Pie Charts

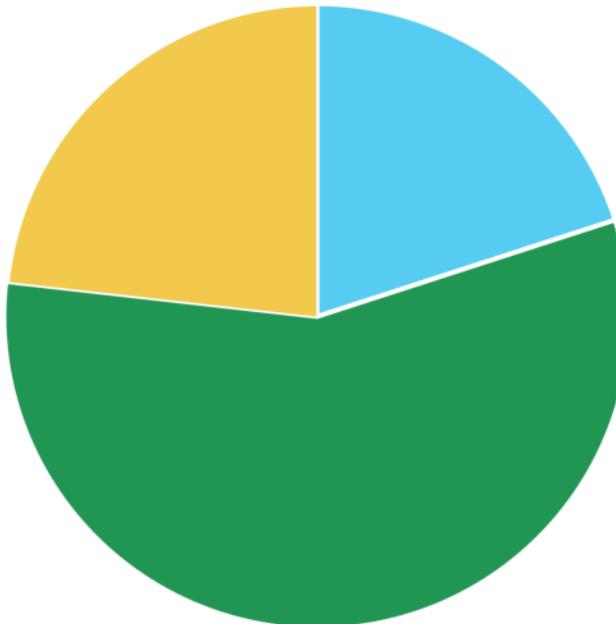
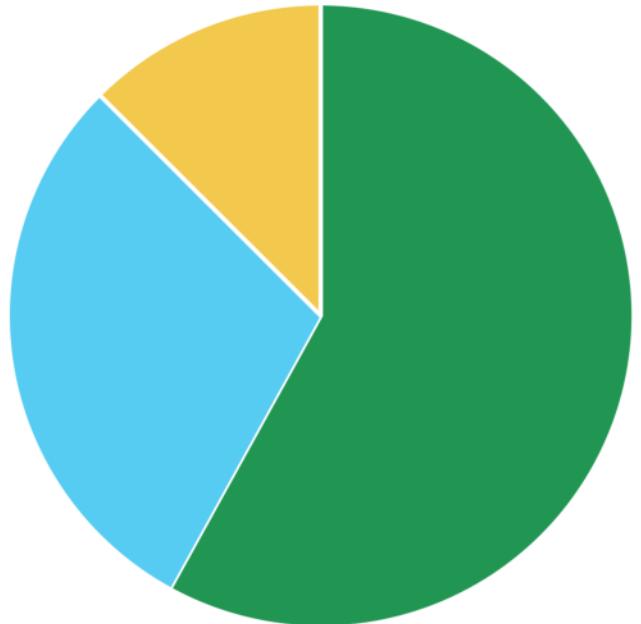


From Data to Viz

Beware of Pie Charts

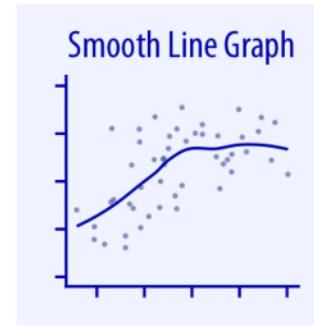
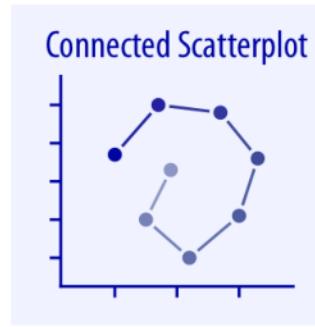
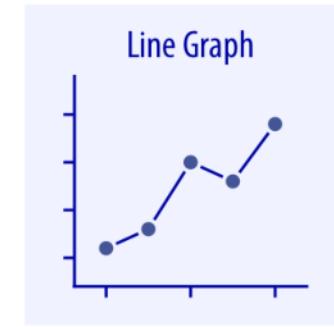
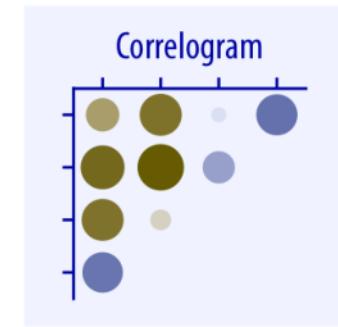
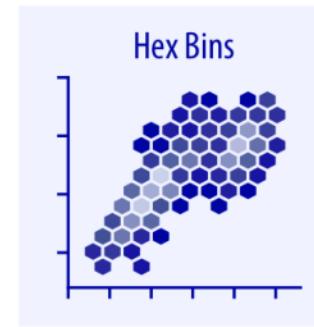
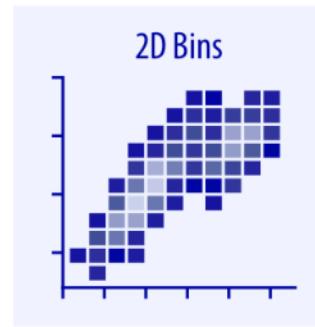
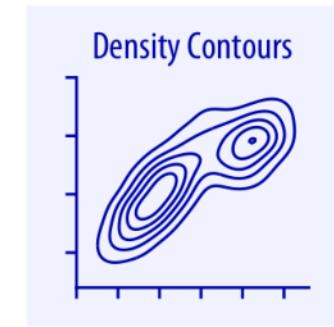
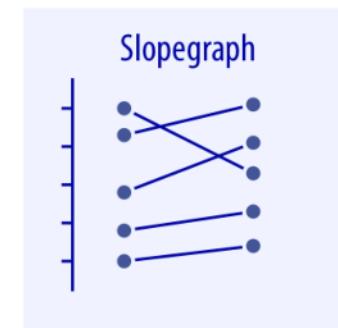
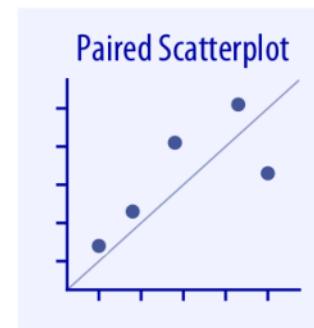
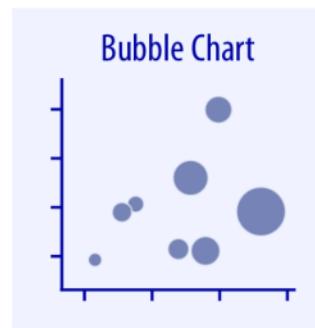
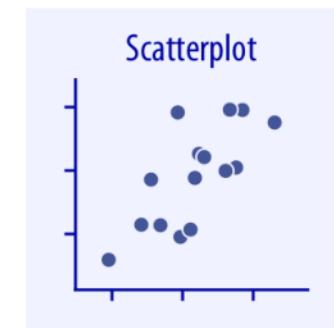


Beware of Pie Charts

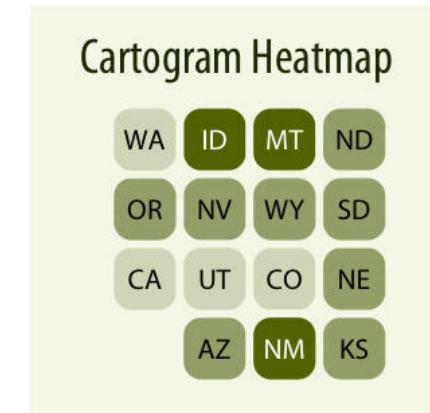
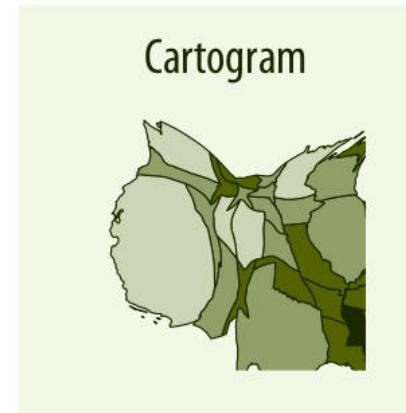
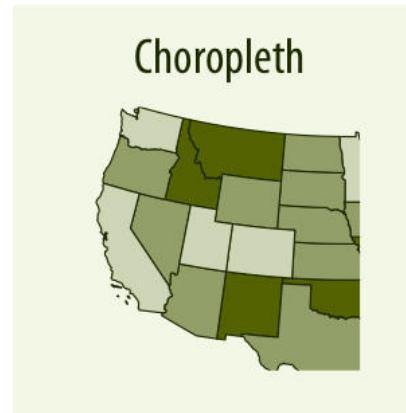


“Hands-On Data Visualization” by Jack Dougherty & Ilya Ilyankou

Charts to Visualize x-y Relationships

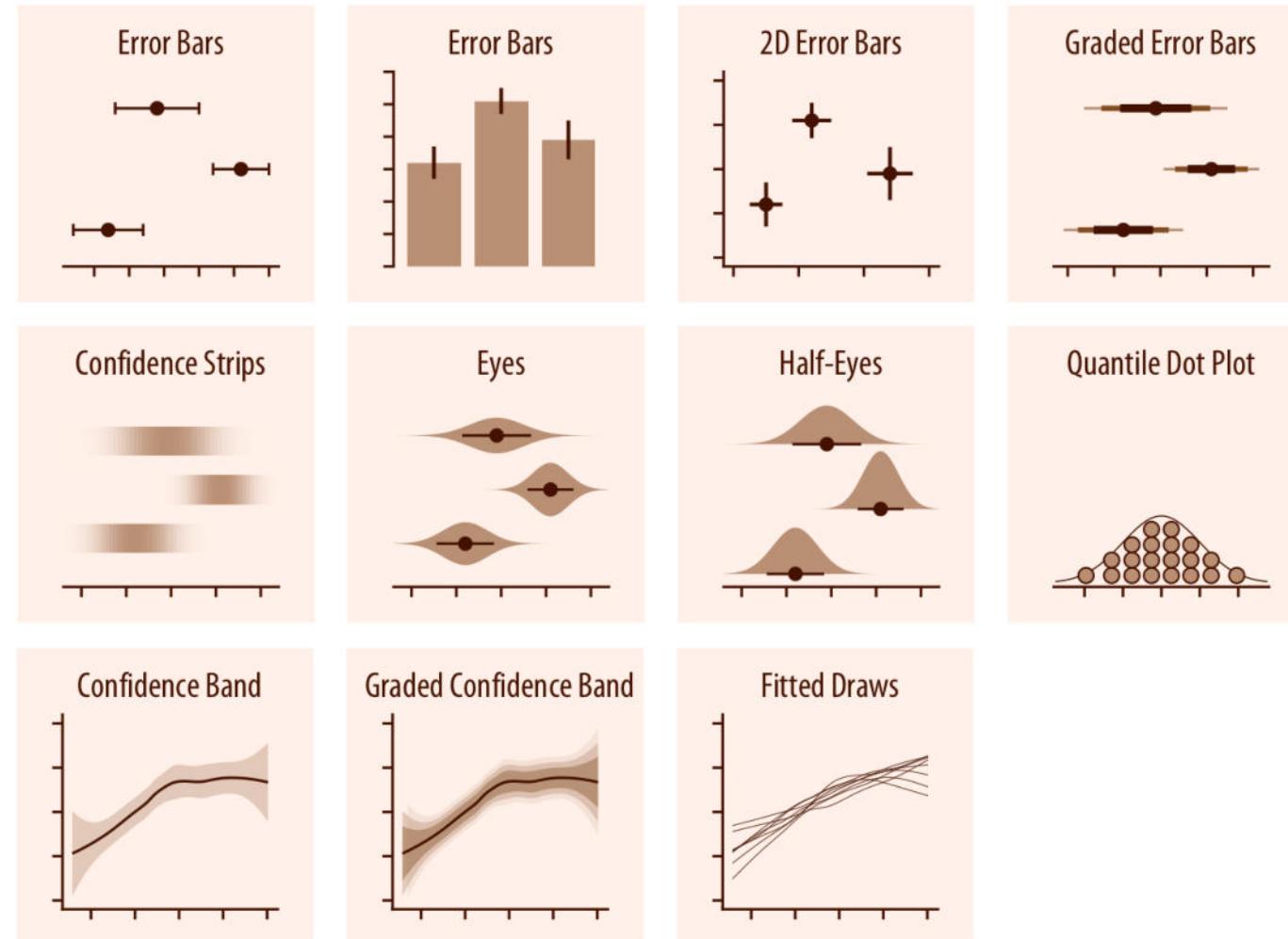


Charts to Visualize Geospatial Data



“Fundamentals of Data Visualization” by Claus Wilke

Charts to Visualize Uncertainty



“Fundamentals of Data Visualization” by Claus Wilke

Visual Form

Follow design rules and data visualization principles



Colors and Common Pitfalls

Color Choice & Accessibility

NOT IDEAL



BETTER



"What to consider when choosing colors for data visualization" by Lisa Charlotte Muth/DataWrapper

Color Palette Types

Categorical



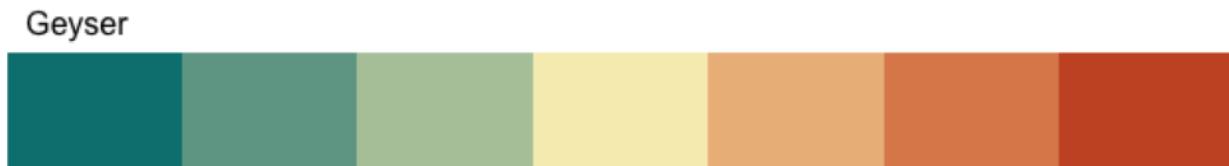
Sequential: Single-Hue



Sequential: Multi-Hue



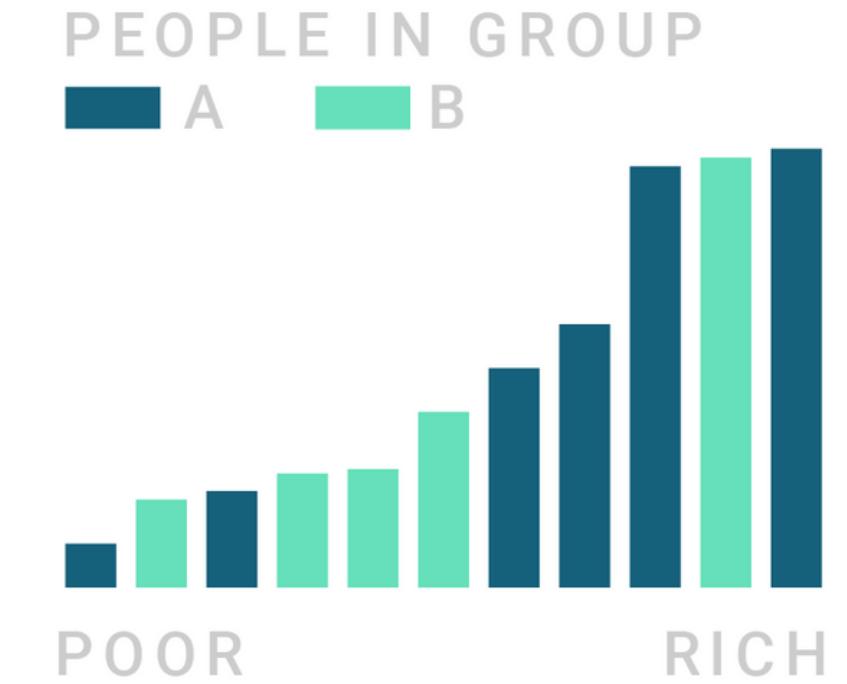
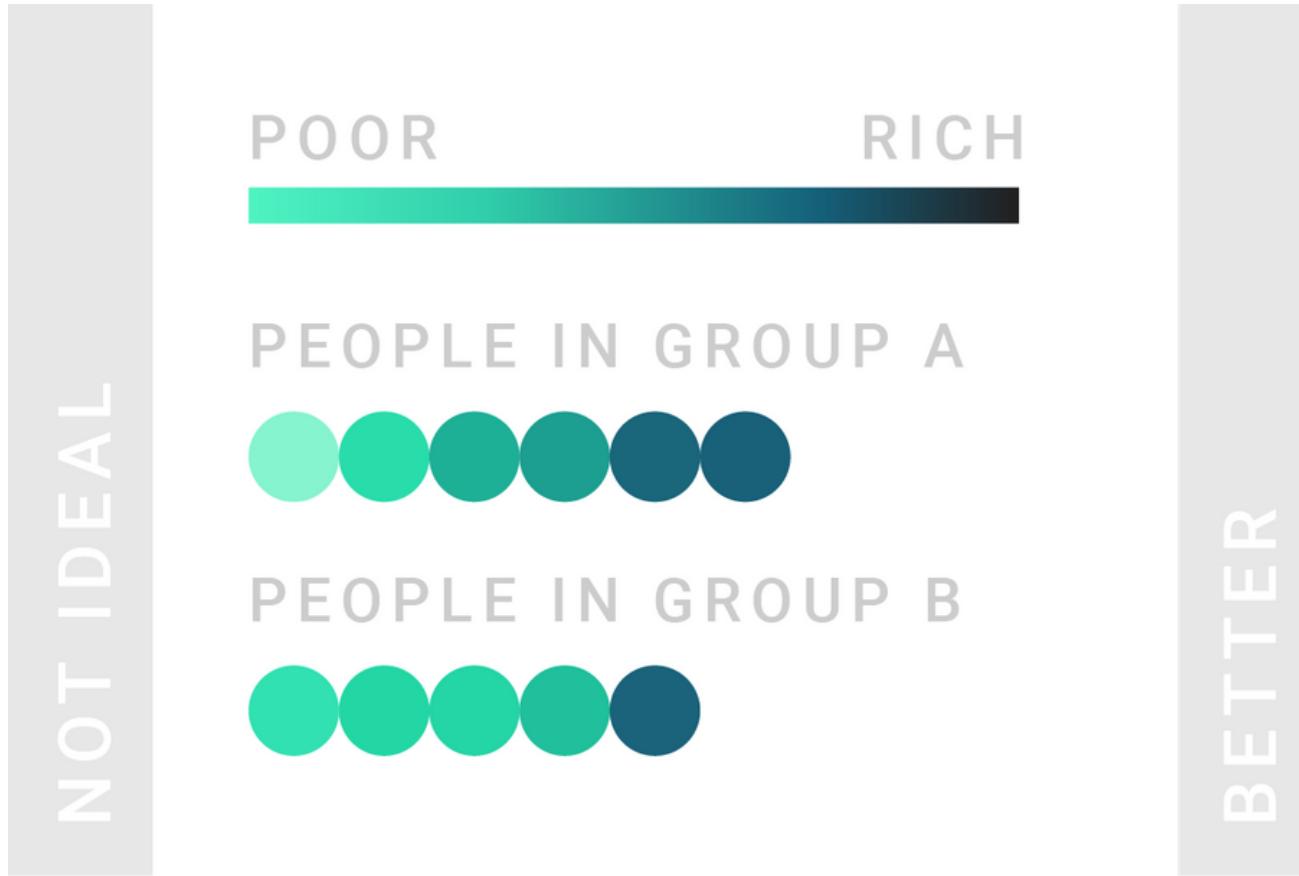
Diverging



Cyclical



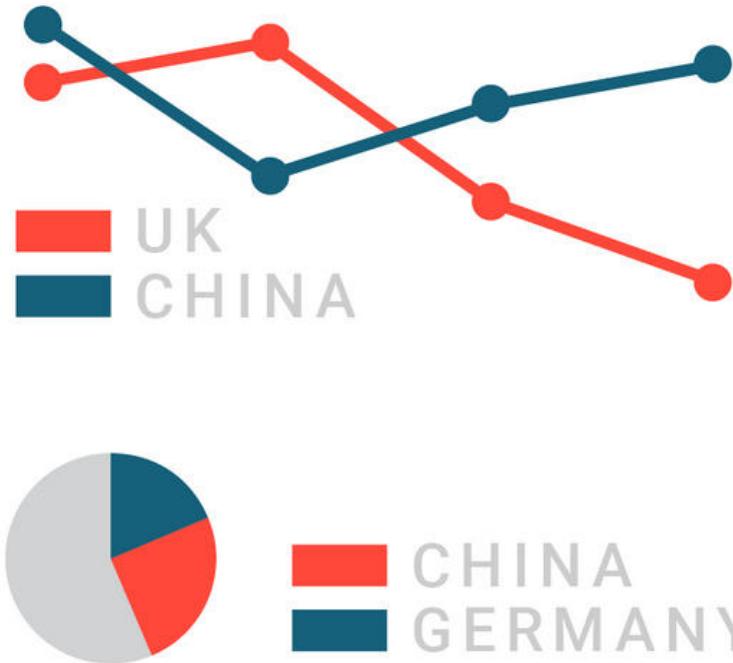
Color Choice & Accessibility



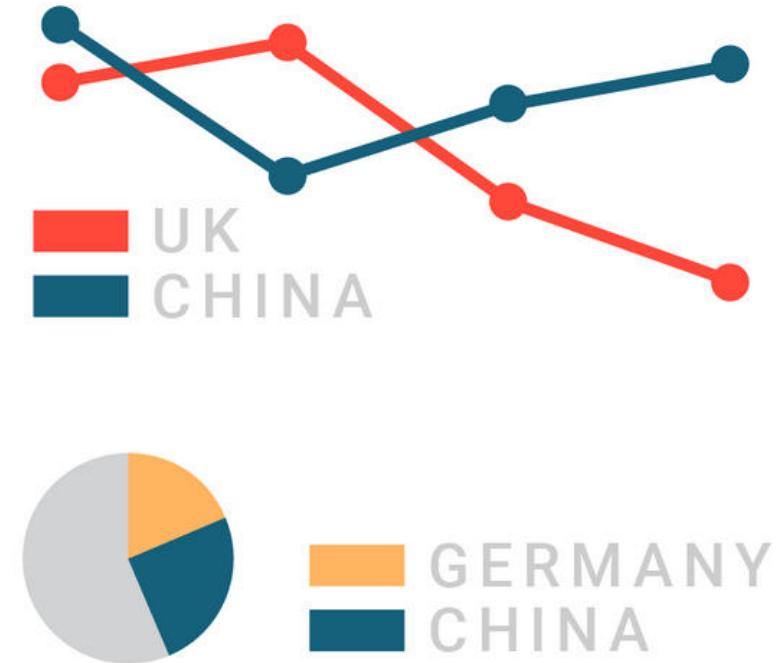
"What to consider when choosing colors for data visualization" by Lisa Charlotte Muth/DataWrapper

Color Choice & Accessibility

NOT IDEAL



BETTER



Rainbow Color Map (Still) Considered Harmful

Publisher: IEEE

2 Author(s)

David Borland ; Russell M. Taylor II [View All Authors](#)

172
Paper Citations

3
Patent Citations

9091
Full
Text Views



Medical Physics

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[Med Phys.](#) 2015 Jun; 42(6): 2942–2954.

Published online 2015 May 20. doi: [10.1118/1.4921125](https://doi.org/10.1118/1.4921125)

PMCID: PMC5148121

PMID: [26127048](https://pubmed.ncbi.nlm.nih.gov/26127048/)

Effect of color visualization and display hardware on the visual assessment of pseudocolor medical images

[Silvina Zabala-Travers](#), [Mina Choi](#), [Wei-Chung Cheng](#), and [Aldo Badano^a](#)

10 March 2017

Interpretation of the rainbow color scale for quantitative medical imaging: perceptually linear color calibration (CSDF) versus DICOM GSDF

[Frédérique Chesterman](#); [Hannah Manssens](#); [Céline Morel](#); [Guillaume Serrell](#); [Bastian Piepers](#); [Tom Kimpe](#)

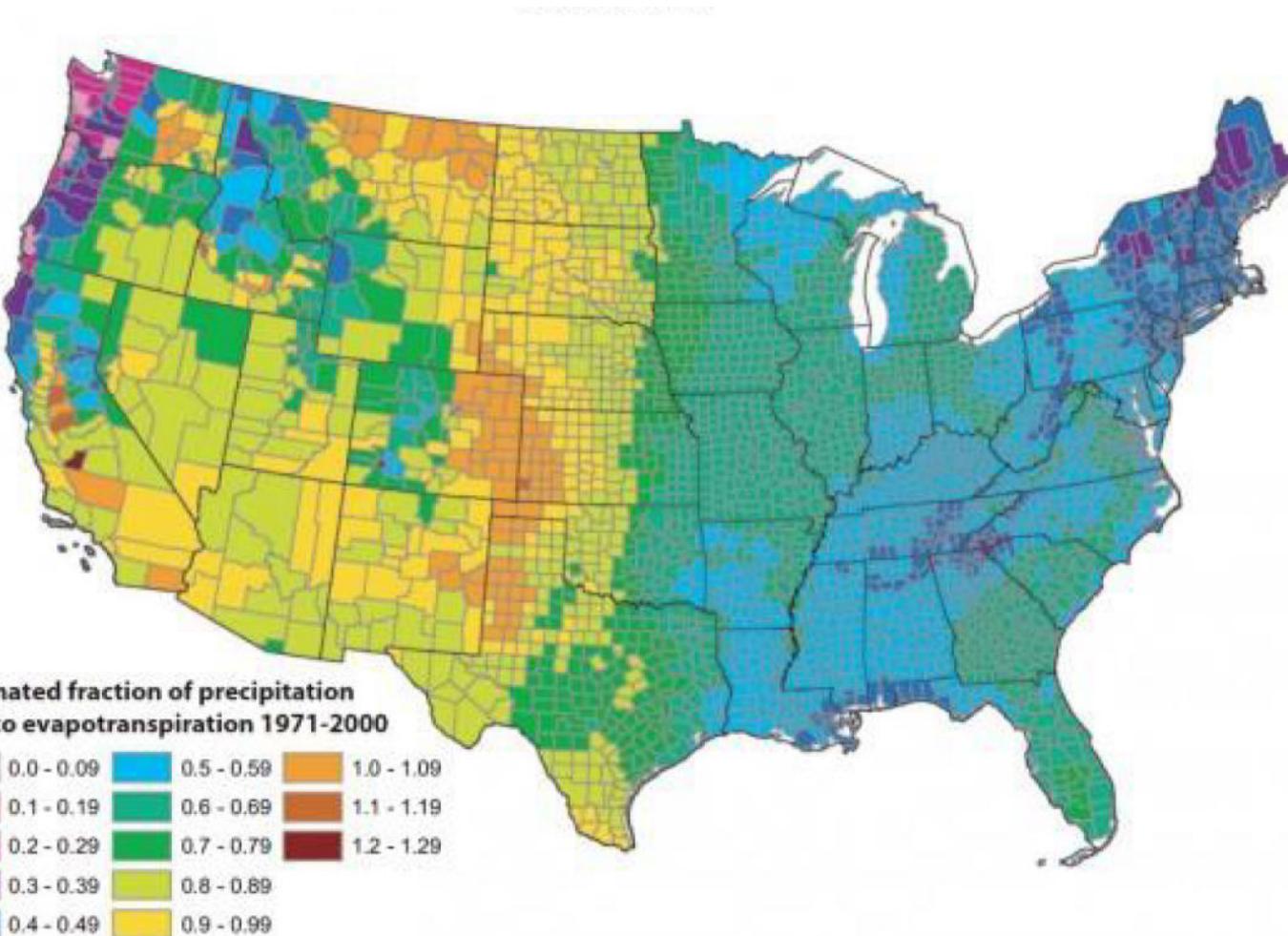
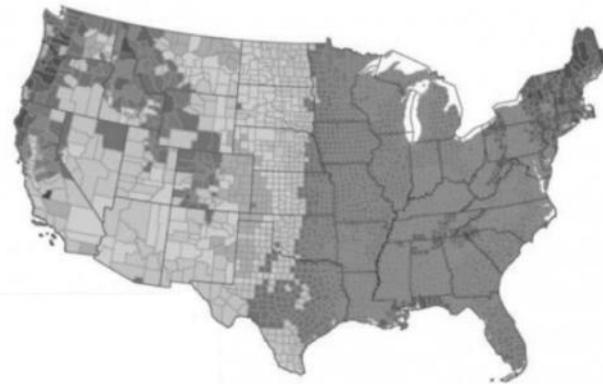
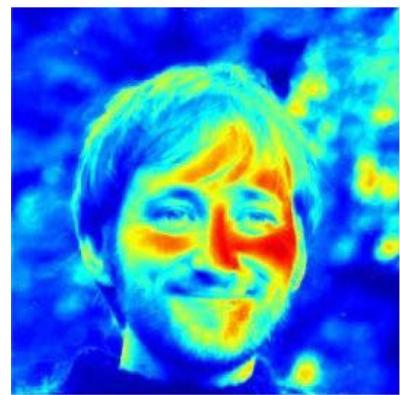


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.



true-colour Phil



rainbow Phil
is distorted



batlow Phil
is flawless

Color Choice & Accessibility

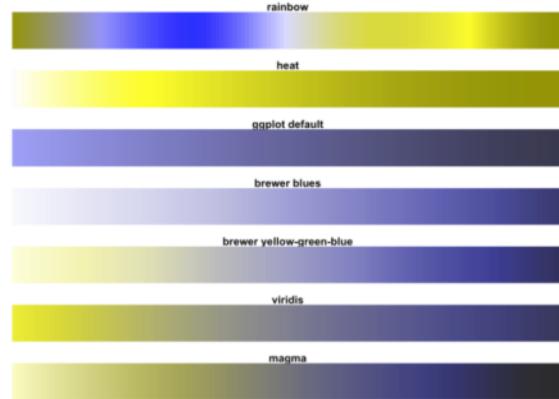


Vignette *{viridis}* package

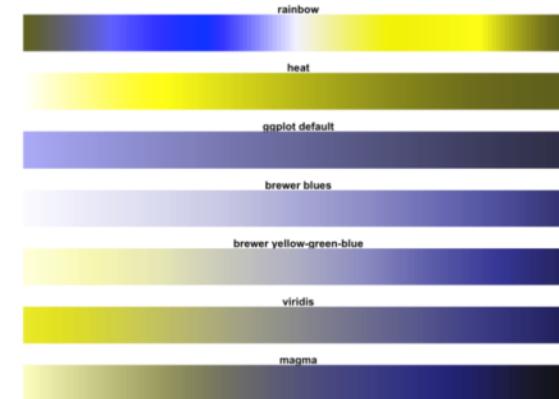
Color Choice & Accessibility



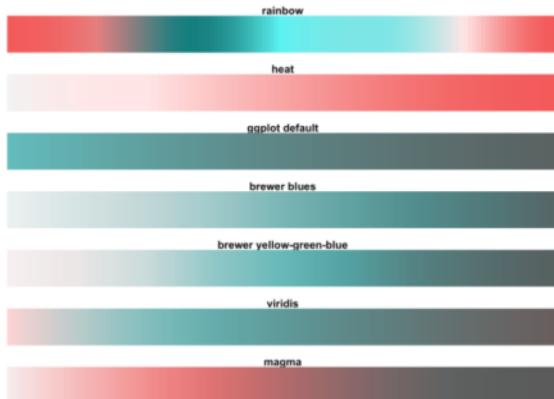
Deutranopia: present in 6% of males



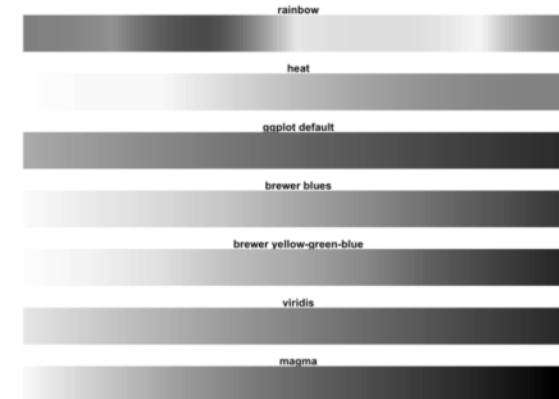
Protanopia: present in 1% of males



Tritanopia: present in 0.008% of humans

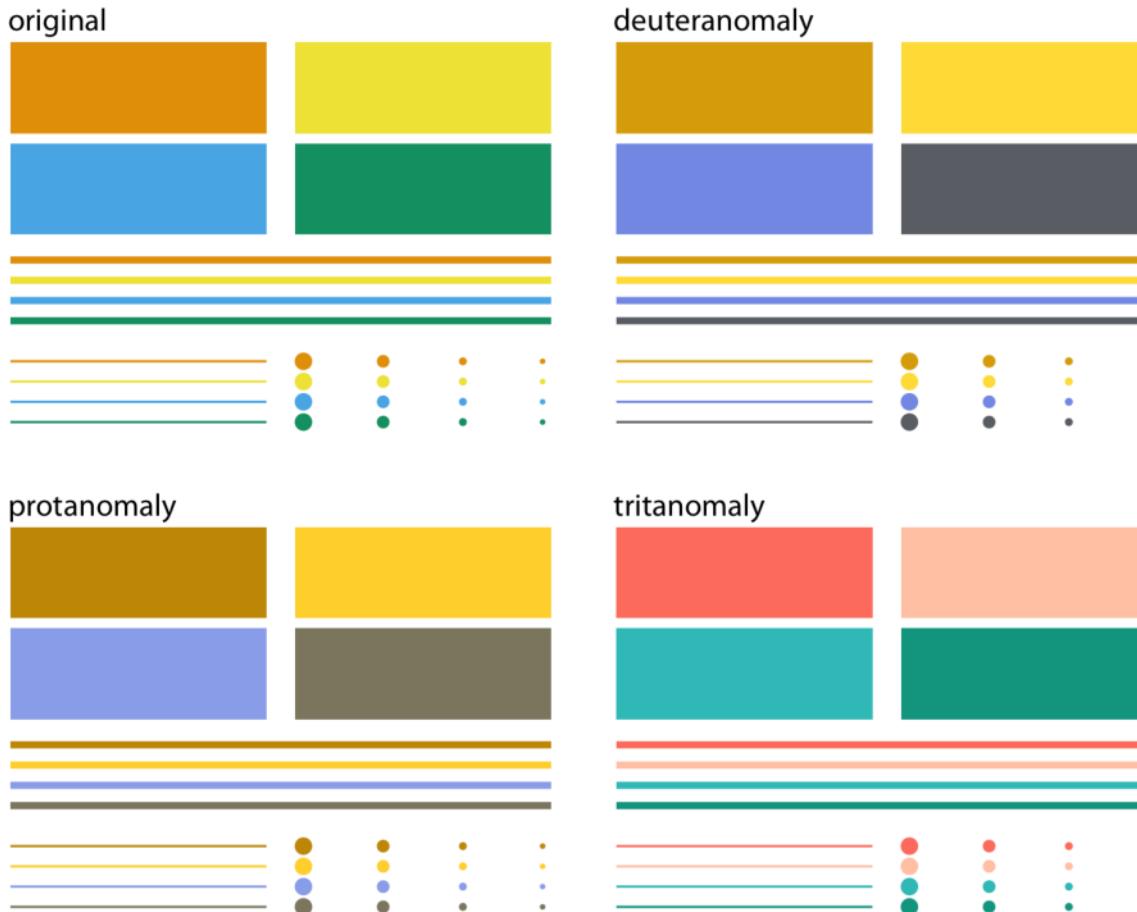


Monochromacy: present in 0.001% of humans



... and present in ~75% of university printers! 😊

Choice of the Color Palette & Accessibility



“Fundamentals of Data Visualization” by Claus Wilke

Choice of the Color Palette & Accessibility



To make sure your visualizations work for people with CVD don't just rely on provided color palettes.

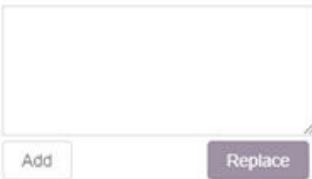
Instead, test your figures in a color-blindness simulator!

VIZ PALETTE

By: Elijah Meeks
& Susie Lu

PICK

Use Chroma.js



Add

Replace

Use Colorgorical

Use ColorBrewer

EDIT

- ≡ 1 ● #ffd700 [🔗](#) ×
- ≡ 2 ● #ffb14e [🔗](#) ×
- ≡ 3 ● #fa8775 [🔗](#) ×
- ≡ 4 ● #ea5f94 [🔗](#) ×
- ≡ 5 ● #cd34b5 [🔗](#) ×
- hex rgb ≡ 6 ● #9d02d7 [🔗](#) ×
- hsl ≡ 7 ● #0000ff [🔗](#) ×

GET

String quotes
 Object with metadata

```
[ "#ffd700",
  "#ffb14e",
  "#fa8775",
  "#ea5f94",
  "#cd34b5",
  "#9d02d7",
  "#0000ff" ]
```

COLORS IN ACTION

Color Population:

No Color Deficiency - 96%

Deuteranomaly - 2.7%

Protanomaly - 0.66%

Protanopia - 0.59%

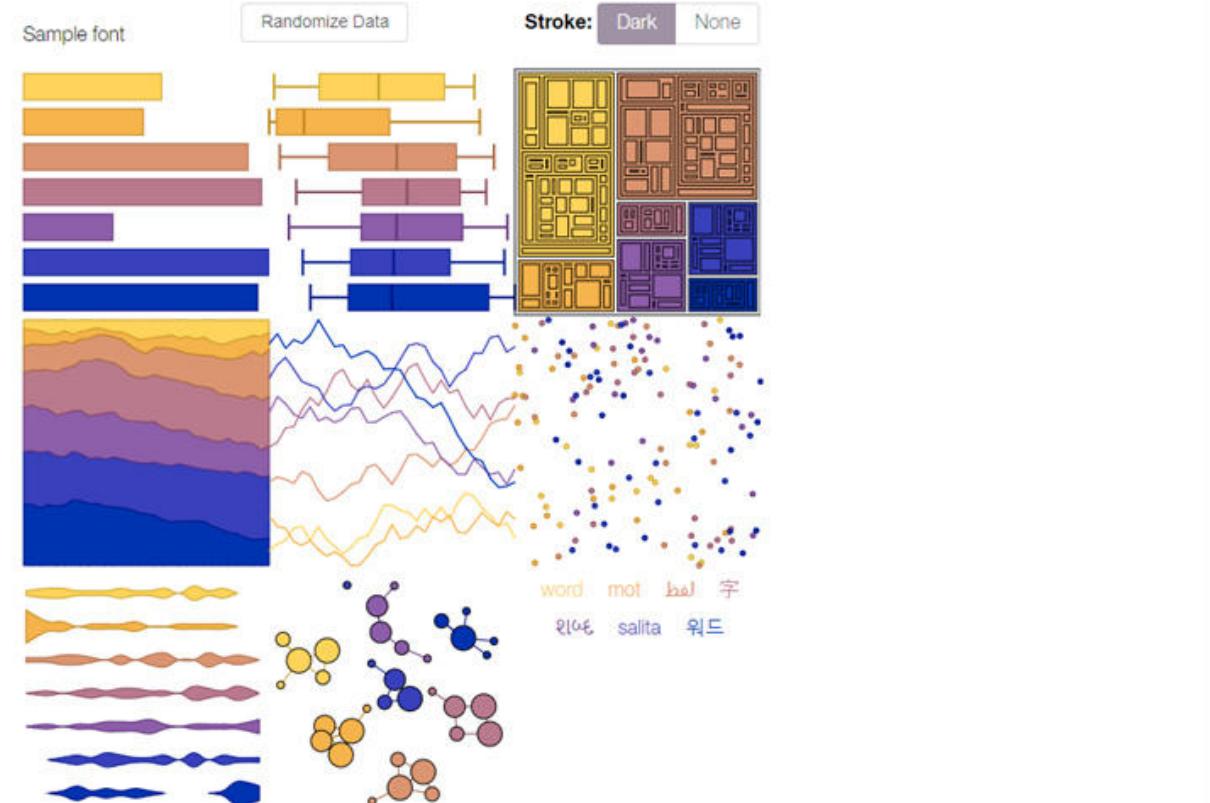
Deuteranopia - 0.56%

Greyscale

Background color: #ffffcc [🔗](#)

Font color: ● #000000 [🔗](#)

Charts made with [Sembiotic](#)



Which countries are on track to have vaccinated 40% of their population with at least 1 dose by the end of 2021?

Based on our international [COVID-19 vaccination data](#), we have made projections of which countries are on track to achieve this.

This map shows which countries have already surpassed this 40% target; those that are on track to meet it by the end of 2021 based on recent vaccination rates; and those that are not on track.

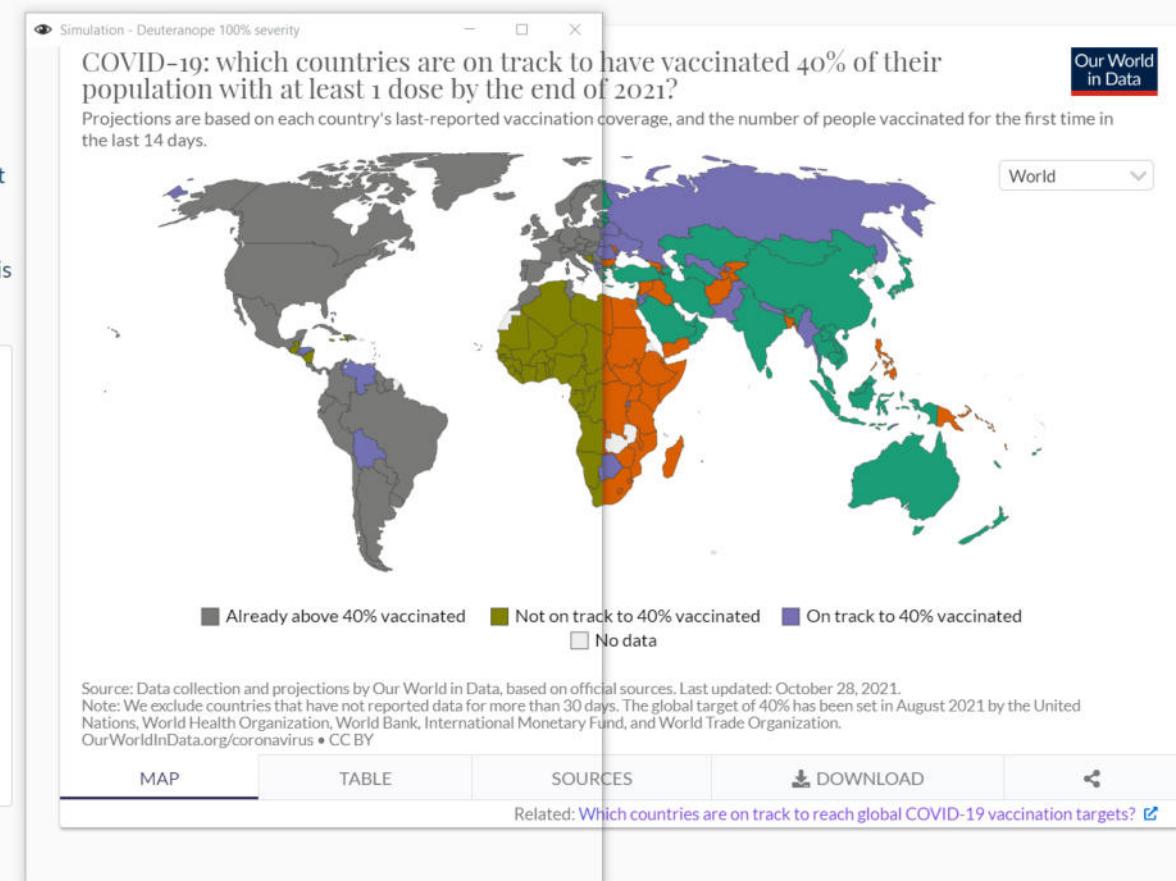
We will update these projections weekly to continue to monitor global progress towards this goal.

💡 How does Our World in Data calculate these projections?

For each country, we calculate the current vaccination rate as the average number of people who received their first dose of a vaccine per day, *over the last 14 days*.

We then assume that this recent vaccination rate remains constant for the remainder of the year. By adding this expected share to the share of the population that have already been vaccinated, we project what share of people will have received at least one dose by January 1, 2022. We exclude from our projections countries that have not reported figures for more than 30 days.

This method means that the projections do not take into account future increases or decreases in the speed of vaccination, which could result from changes in eligibility criteria, vaccine deliveries or shortages, or new government policies.



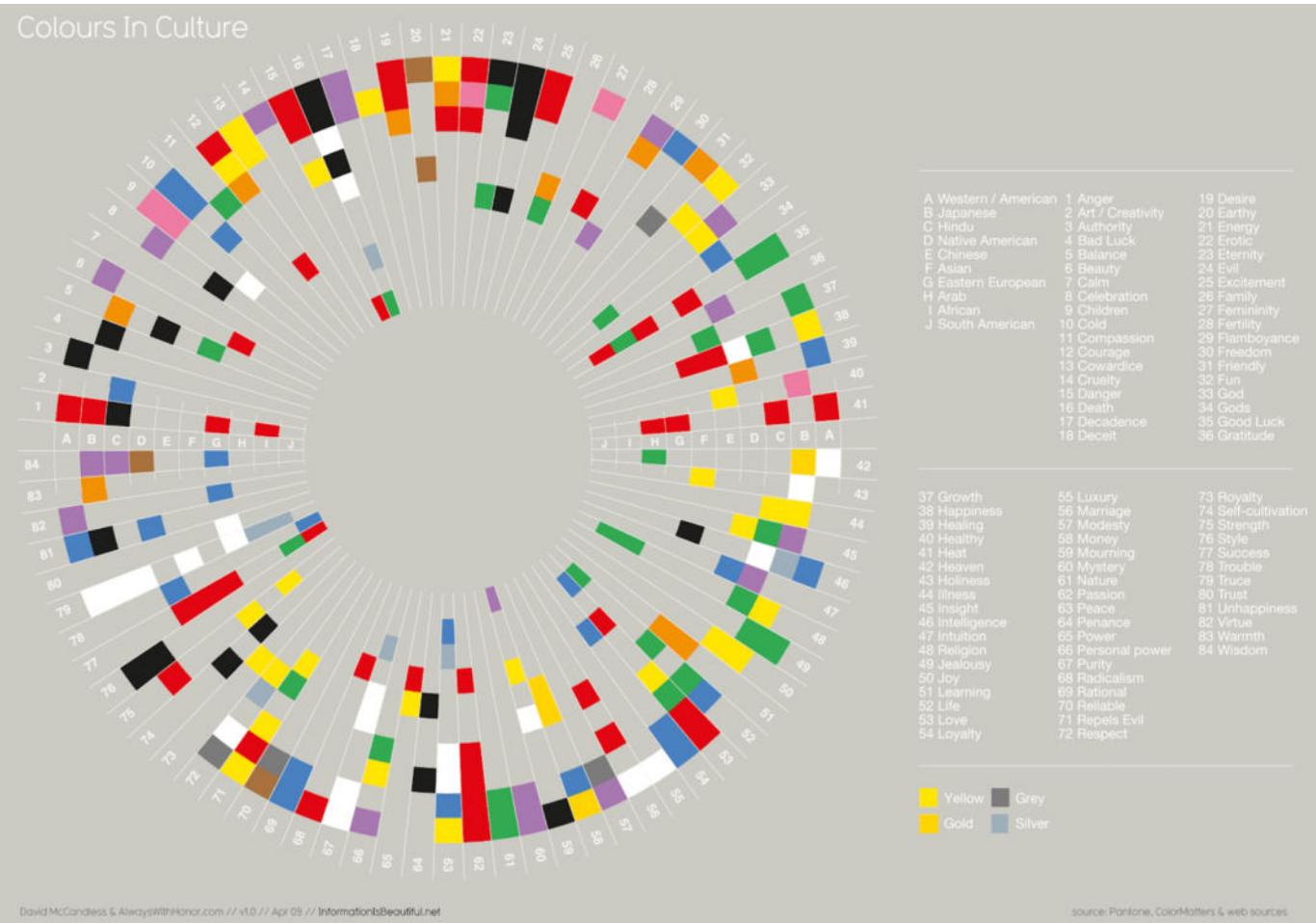
Color Choice & Accessibility

Choose color-blind friendly palettes:
projects.susielu.com/viz-palette

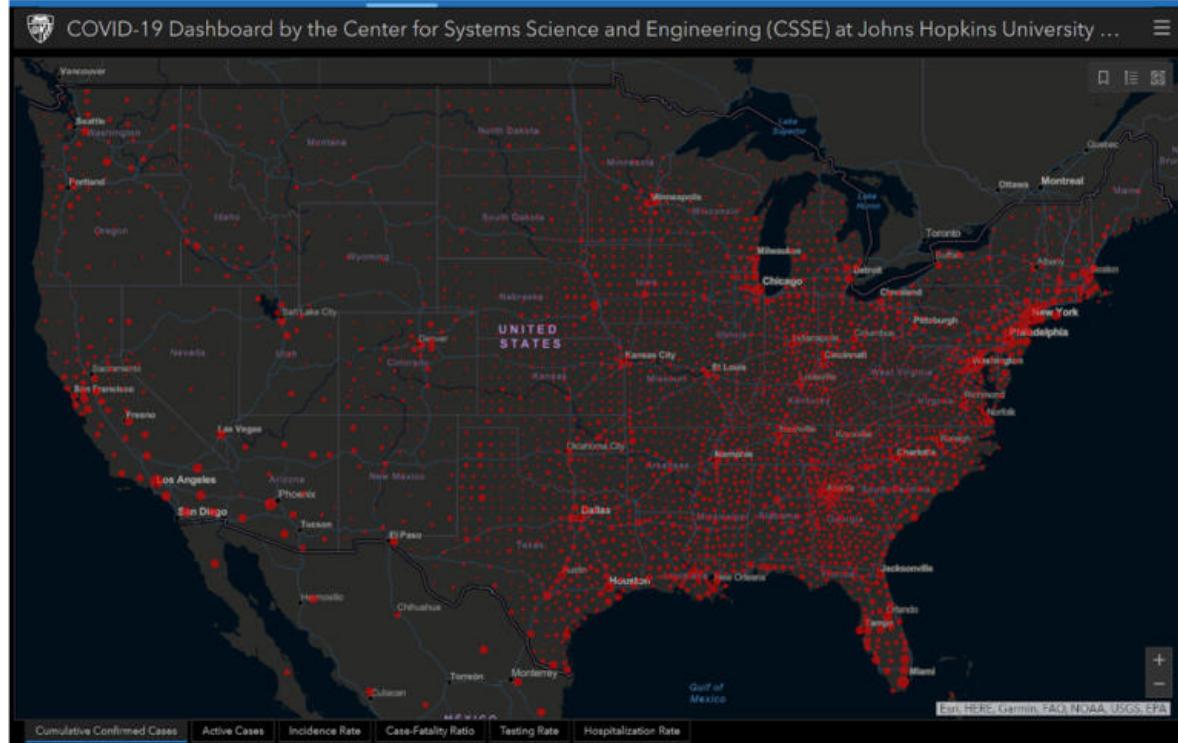
Simulate color deficient users:
coloursimulations.com

Test your final visualization:
color-blindness.com/coblis-color-blindness-simulator

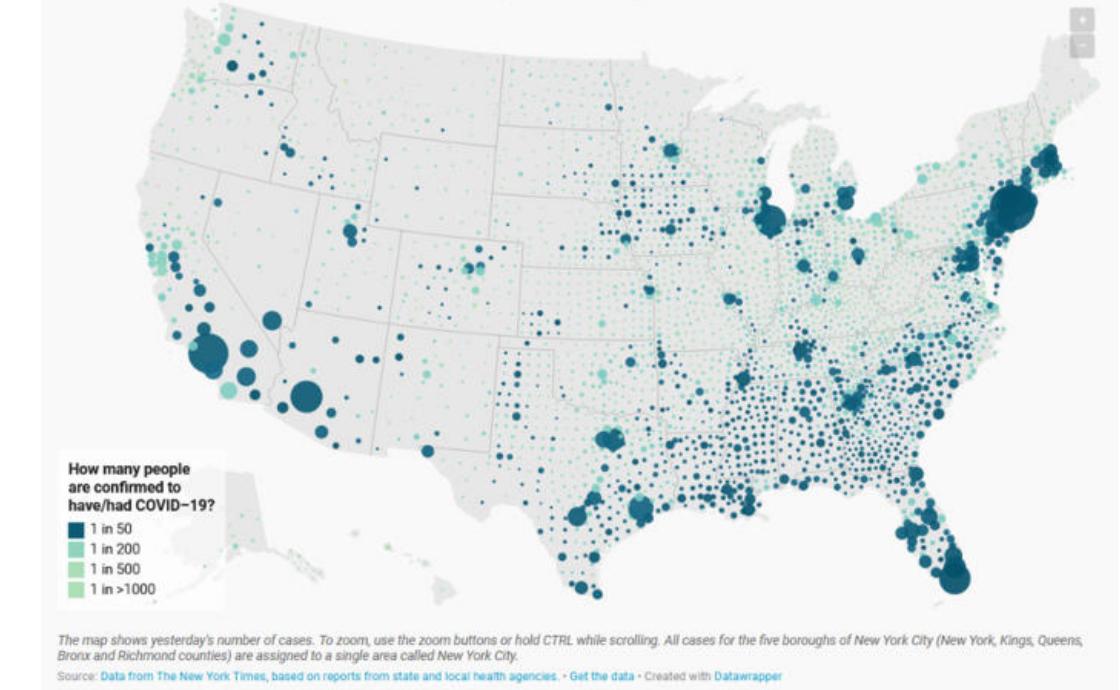
Color Choice & Emotions



Color Choice & Emotions



Number of confirmed COVID-19 cases in US counties



The image is a dense collage of typography-related text elements. At the top, the word 'TYPOGRAPHY' is written in large, bold, white serif letters. Below it, several smaller 'TYPOGRAPHY' words are arranged in a grid-like pattern, each accompanied by a small, stylized letter symbol (such as 'G', 'H', 'P', 'E', 'F', 'J', 'L', 'R', 'S', 'T', 'U', 'V', 'W', 'X', 'Y', 'Z') to its right. To the left of the main title, the word 'TYPOGRAPHY' is repeated vertically in a smaller, lighter font. In the bottom right corner, the word 'Typography' is written in a large, bold, yellow sans-serif font, followed by the phrase '(and everything text-related)' in a smaller, white sans-serif font.

Typography (and everything text-related)

I'LL BE WAITING FOR YOU!

I'll be waiting for you!

The Choice of the **Font(s)**

- The font(s) should fit the topic and audience - **context matters**.
- **Avoid fancy** fonts and squiggle letters.
- Use ways to **visualize hierarchy**.
- Avoid using **ALL CAPS**.
- Use a **monospaced** font with lining for numbers.

The Choice of the **Font(s)**

- The font(s) should fit the topic and audience - **context matters**.
- **Avoid fancy** fonts and squiggle letters.
- Use ways to **visualize hierarchy**.
- Avoid using **ALL CAPS**.
- Use a **monospaced** font with lining for numbers.
- **Consistency is key!**

How to Visualize Hierarchy

I am important!

I am important, too!

Oh, hi there. Thanks for reading me...

Yeah, I know I am kinda boring. Sorry.

How to Visualize Hierarchy

I am important!

I am important, too!

Oh, hi there. Thanks for reading me...

Yeah, I know I am kinda boring. Sorry.

How to Visualize Hierarchy

I am important!

I am important, too!

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How to Visualize Hierarchy

I am important!

I am important, too.

Oh, hi there. Thanks for reading me...
Yeah, I know I am kinda boring. Sorry.

The 1I1 Test

1II Calibri

1II Bitter

1II Open Sans

1II Monda

1II Roboto

1II Chivo

1II Avenir Next Condensed

1II Fira Sans

1II Lato

1II Noto Sans

1II Oswald

1II Bahnschrift

Keep it Simple

**Using lots of fonts
can make for a design
that is cluttered,
overcomplicated,
AND JUST NOT VERY NICE**

*But if you just use
a small selection,
you can keep your
design cleaner, clearer
and just much easier
to digest*

Tabular (Monospaced) Numbers



32154

A vertical ruler graphic is positioned to the left of the first set of numbers, with tick marks at each digit and a longer tick mark at the end.

Montserrat
proportional numbers



32154

A vertical ruler graphic is positioned to the left of the second set of numbers, with tick marks at each digit and a longer tick mark at the end.

Open Sans
tabular numbers



32154

A vertical ruler graphic is positioned to the left of the third set of numbers, with tick marks at each digit and a longer tick mark at the end.

Lato
tabular numbers

Quality of Number Symbols

NEUTON

\$123,456,789.00%

% is smaller than
other figures

ECONOMICA

\$123,456,789.00%

\$ is smaller than
other figures

SOURCE CODE PRO

\$123,456,789.00%

% has an
uncommon design

MARVEL

\$123,456,789.00☒

It doesn't have the
% symbol

Droid Serif

REGULAR

\$123,456,789.00%

BOLD

\$123,456,789.00%

Copse

REGULAR

\$123,456,789.00%

Crimson Text

REGULAR

\$123,456,789.00%

SEMIBOLD

\$123,456,789.00%

BOLD

\$123,456,789.00%

Kameron

REGULAR

\$123,456,789.00%

BOLD

\$123,456,789.00%

Open Sans

LIGHT \$123,456,789.00%
REGULAR \$123,456,789.00%
BOLD \$123,456,789.00%

Lato

LIGHT \$123,456,789.00%
REGULAR \$123,456,789.00%
BOLD \$123,456,789.00%

Roboto Condensed

LIGHT \$123,456,789.00%
REGULAR \$123,456,789.00%
BOLD \$123,456,789.00%

Varela Round

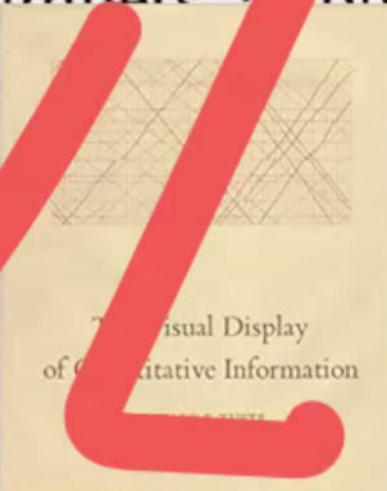
REGULAR \$123,456,789.00%

Chart Design Principles

Graphical integrity is more likely to result if these six principles are followed:

The presentation of numbers or physically measured on the surface of the graphic itself should be directly proportional to the numerical quantities.

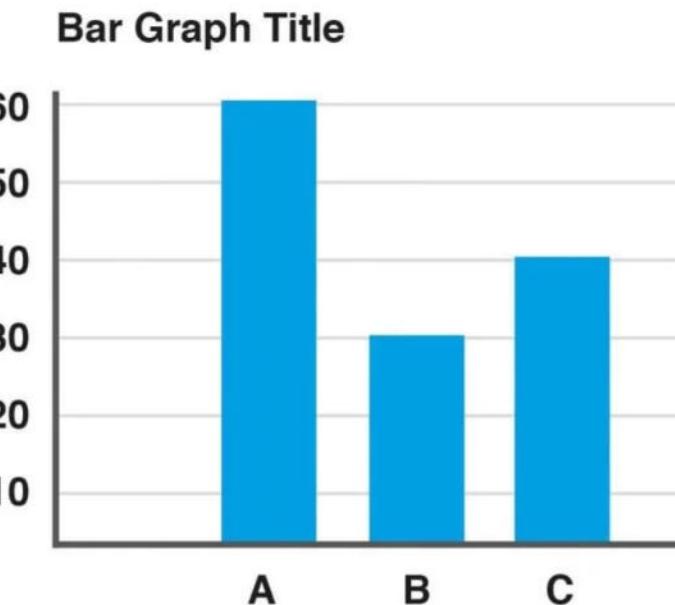
Clear, detailed, and thorough labeling should be used to defeat graphical distortion and the data on the graphic itself. Label important events in the data.

The image shows the front cover of a book titled 'The Visual Display of Quantitative Information' by Edward R. Tufte. The cover is light yellow with a grid pattern. The title and author's name are printed in a small, dark font at the top. Below the title, there is some smaller text and a small graphic of a bar chart.

Show data variation, not design variation.

In time-series displays of money, deflated and standardized units

Don't Clutter Your Plot



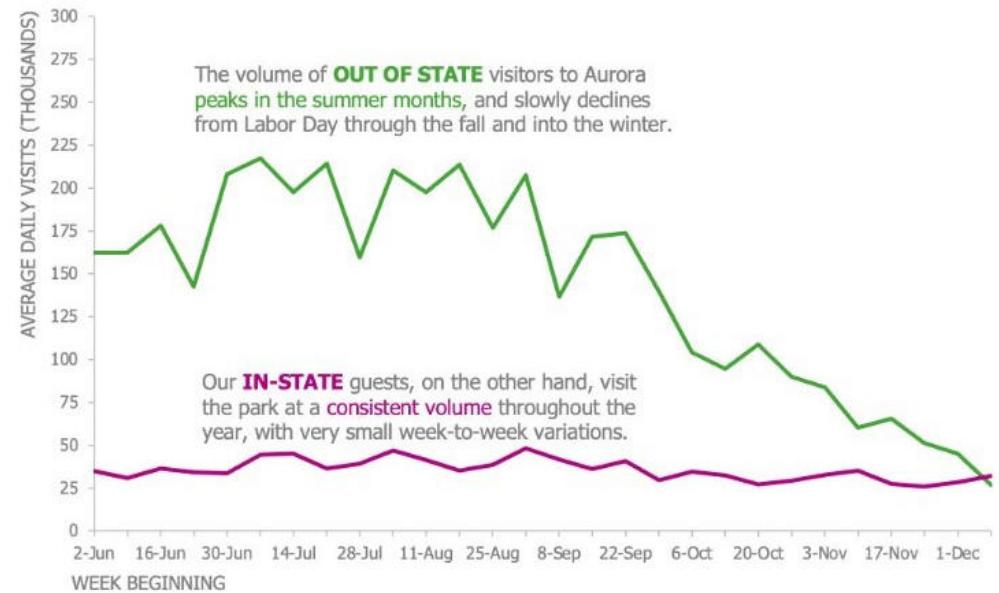
Don't Clutter Your Plot

BEFORE: SPOOKY SKELETON

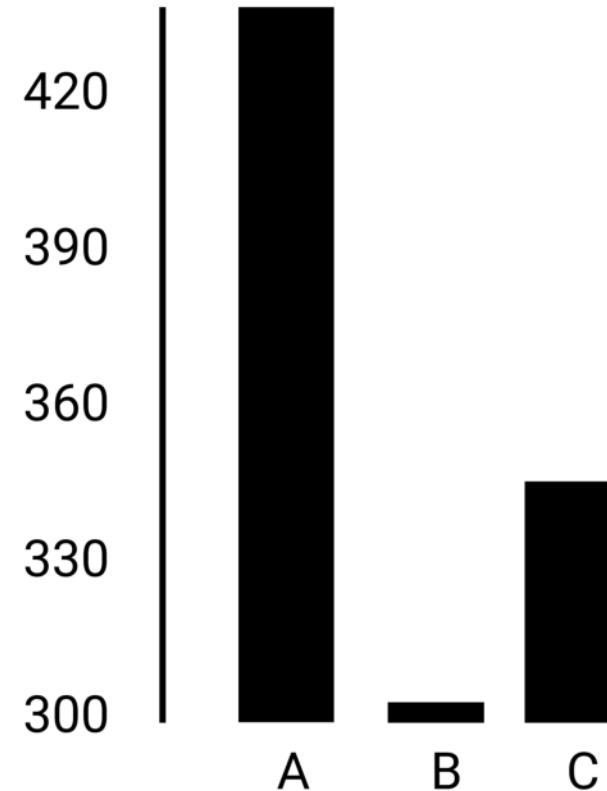
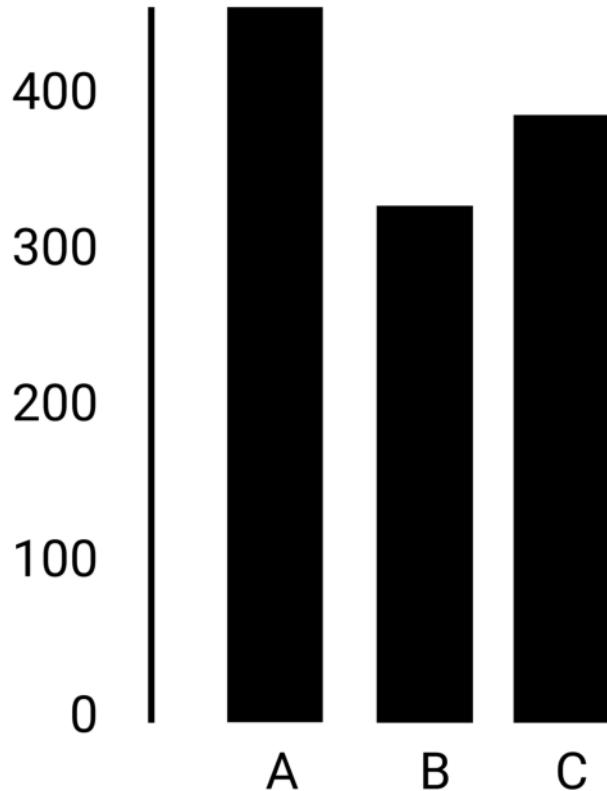


AFTER: GOOD BONES

Daily visitors to Aurora Park in summer/fall 2019
VALUES ARE CALCULATED WEEKLY AS A 7-DAY AVERAGE

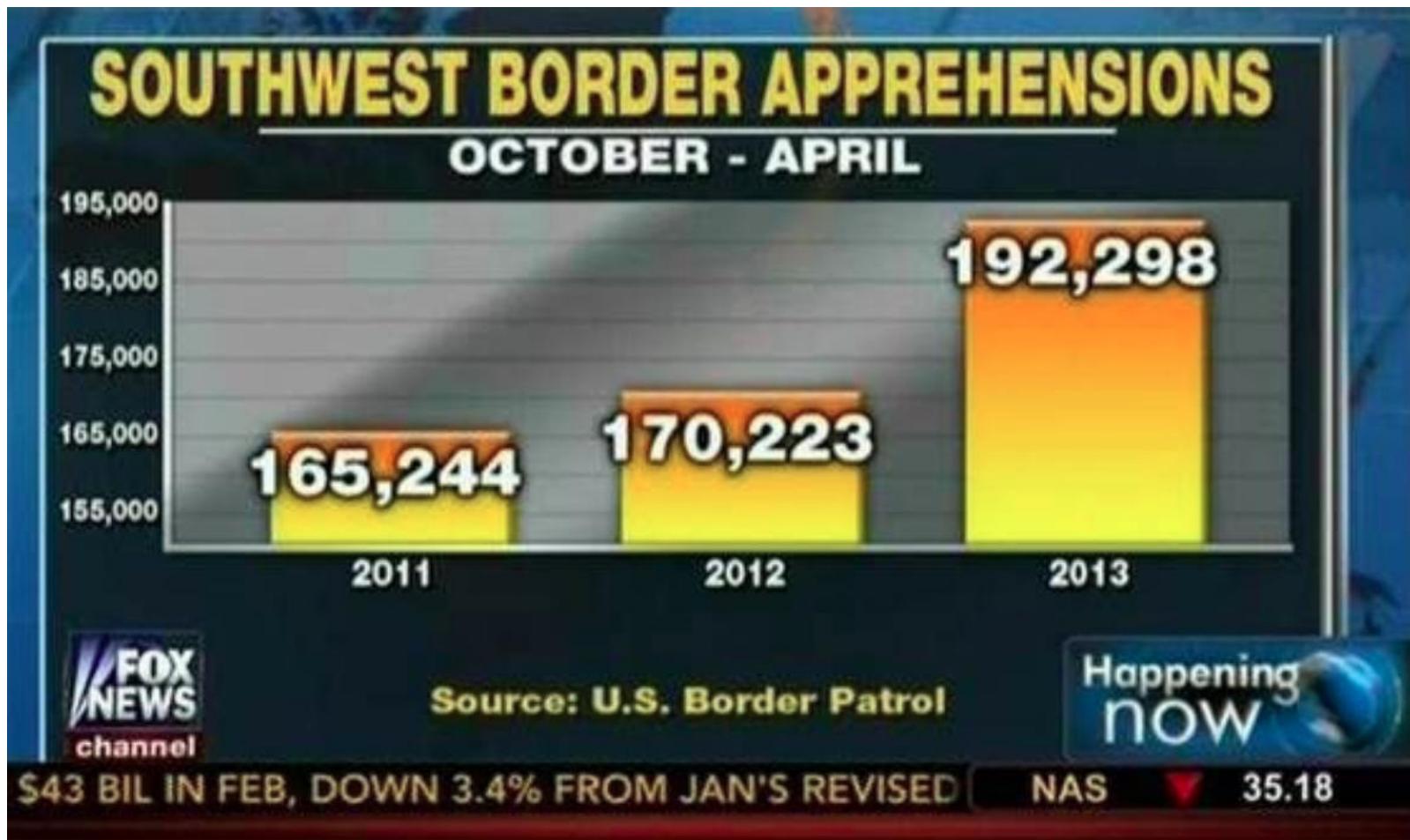


Start at Zero



“Hands-On Data Visualization” by Jack Dougherty & Ilya Ilyankou

Always Start at **Zero**



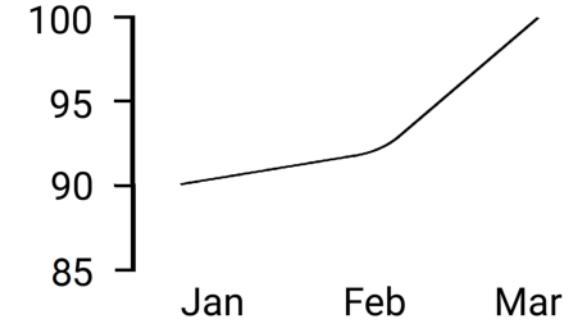
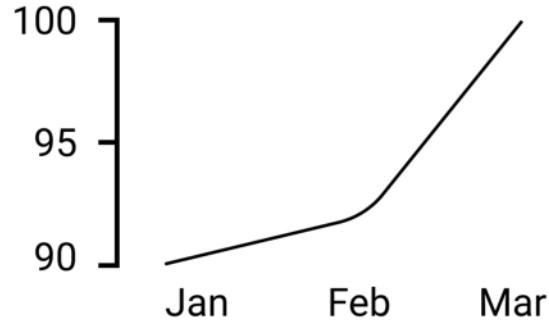
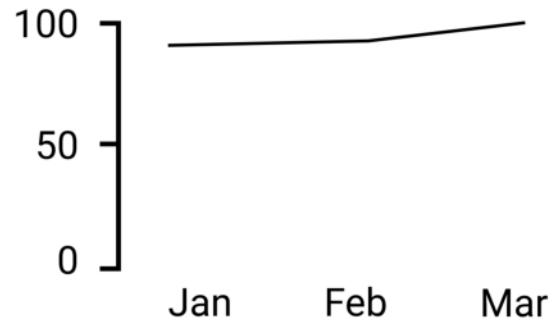
Fox News

Always Start at **Zero**?



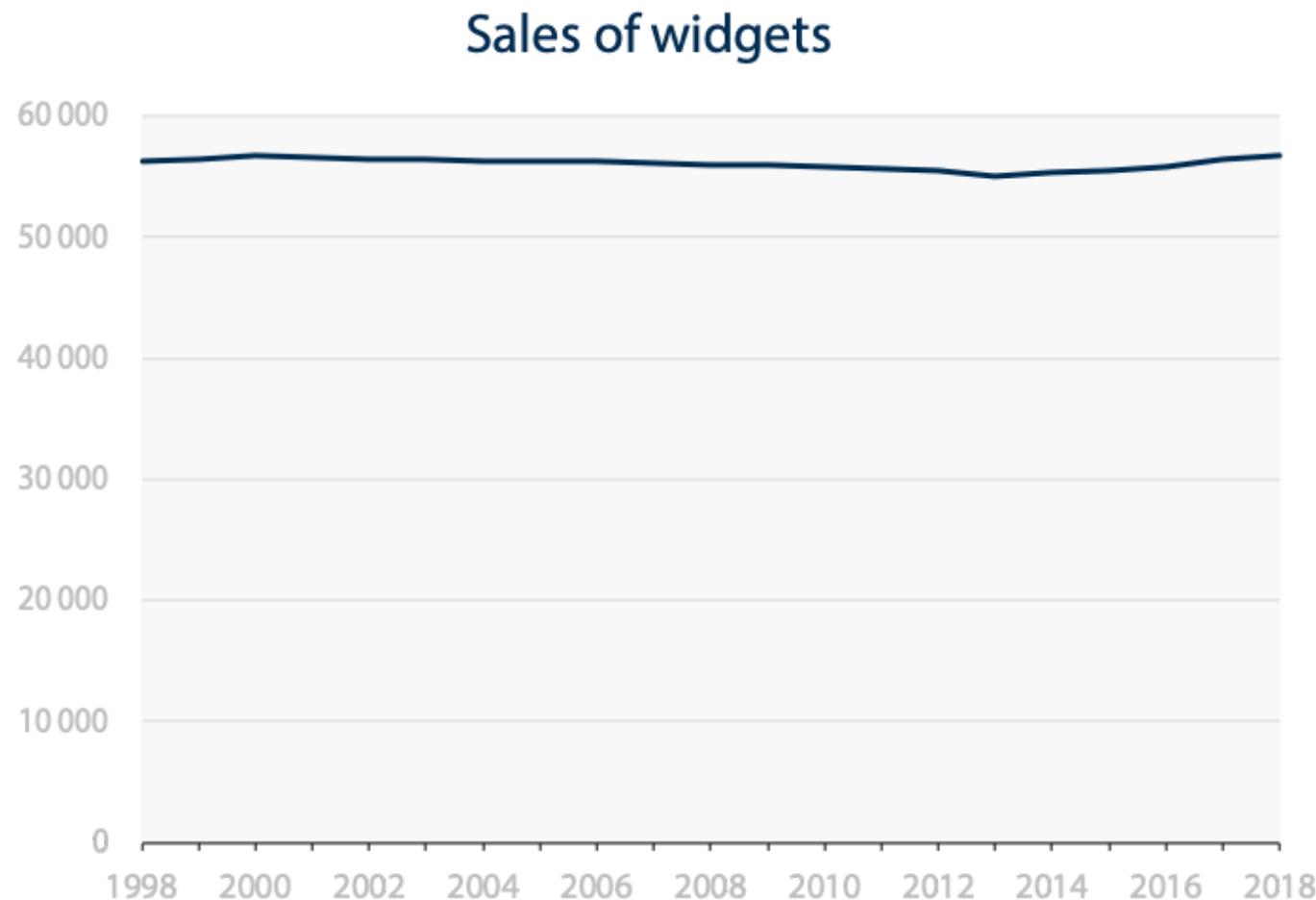
Fox News

Always Start at Zero?



Modified from “*Hands-On Data Visualization*” by Jack Dougherty & Ilya Ilyankou

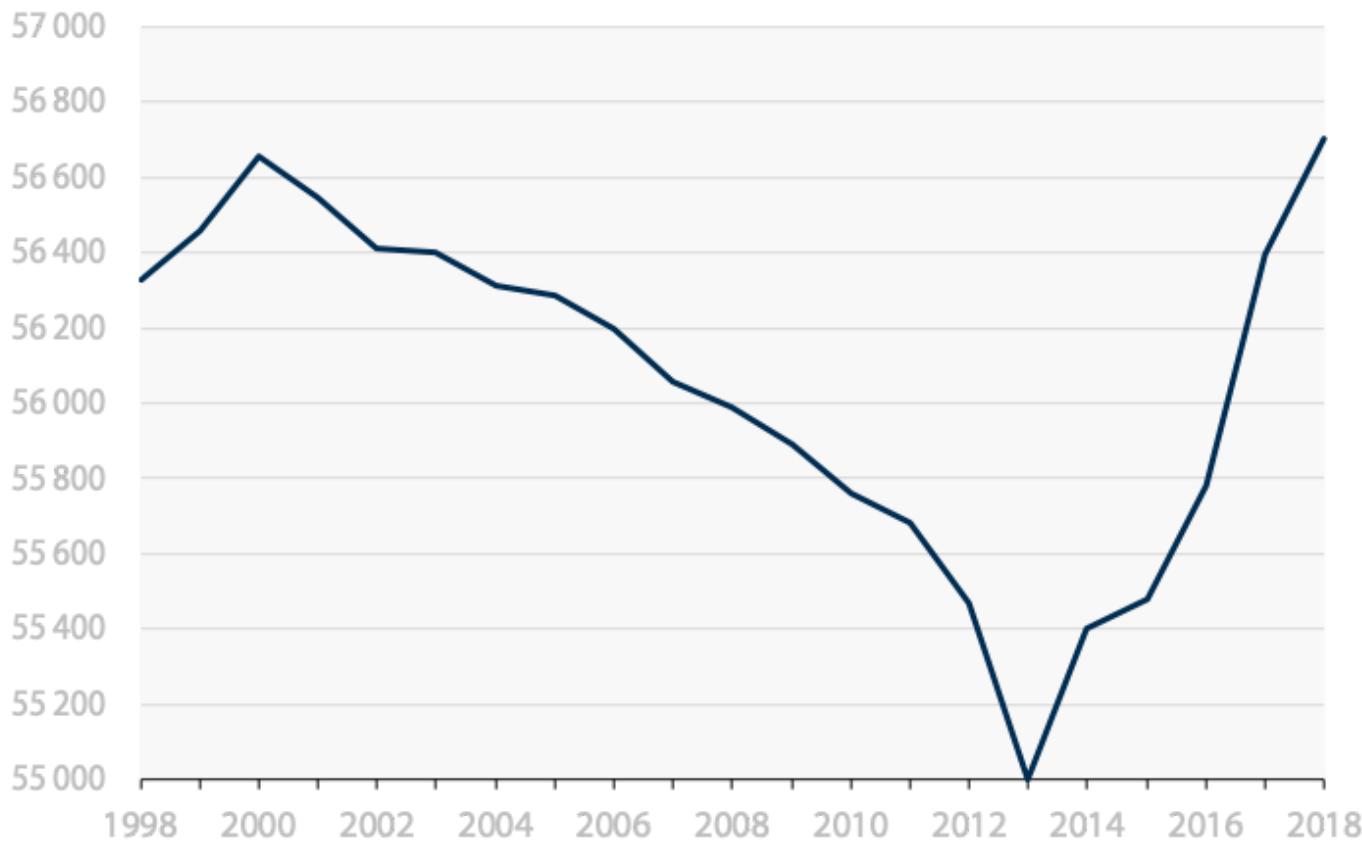
Always Start at Zero?



Francis Gagnon, Voilà

Always Start at Zero?

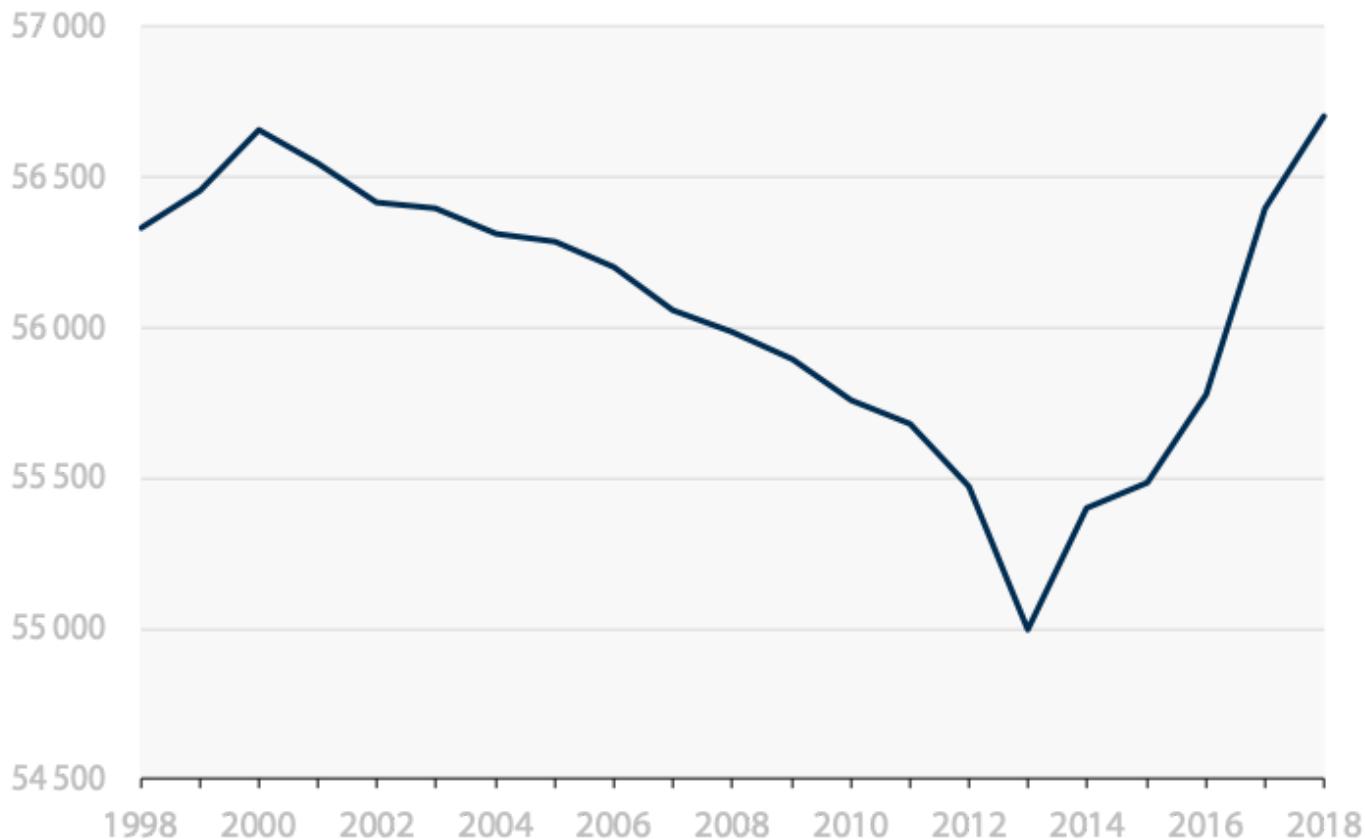
Sales of widgets



Francis Gagnon, Voilà

The Golden Ratio

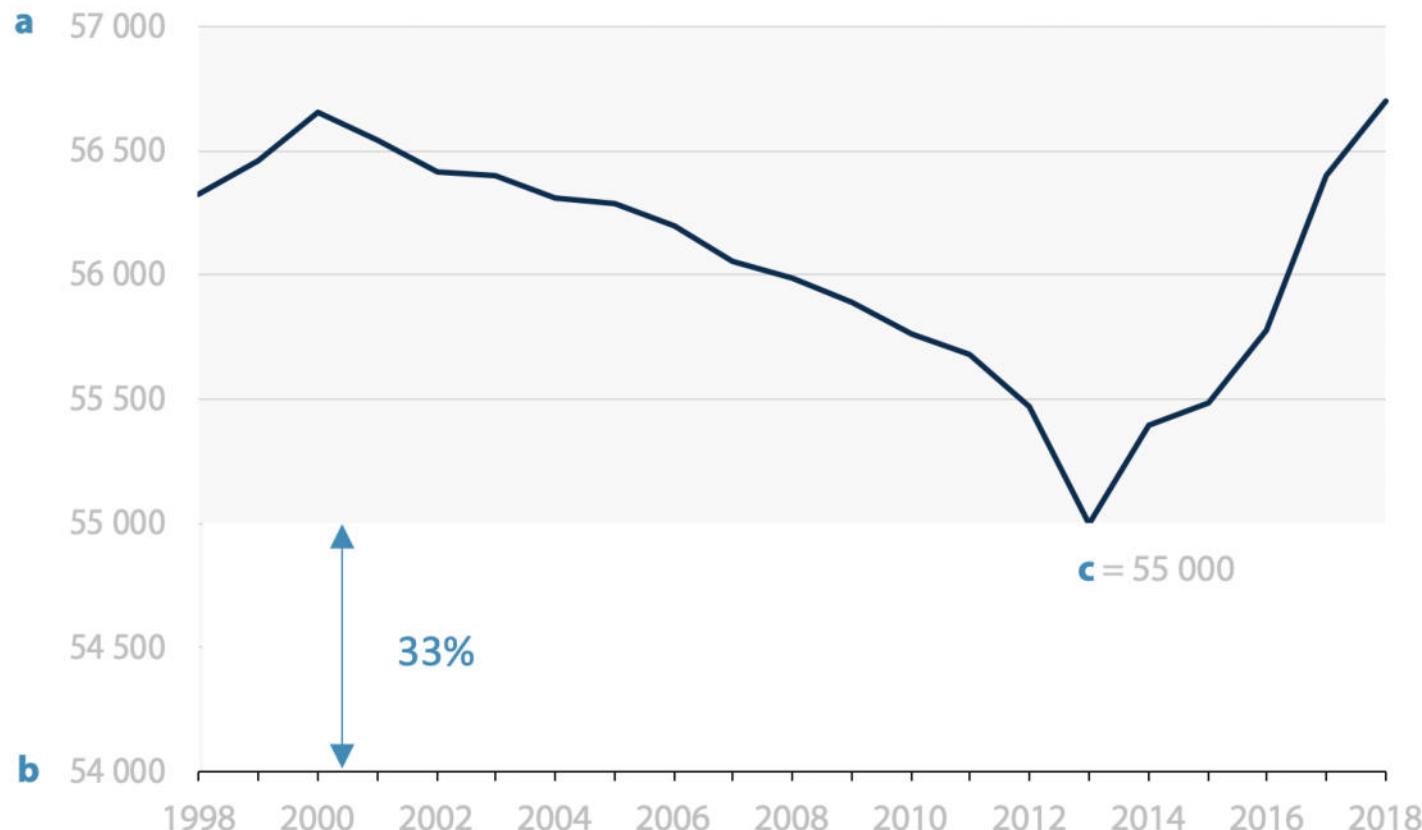
Sales of widgets



Francis Gagnon, Voilà

The Golden Ratio

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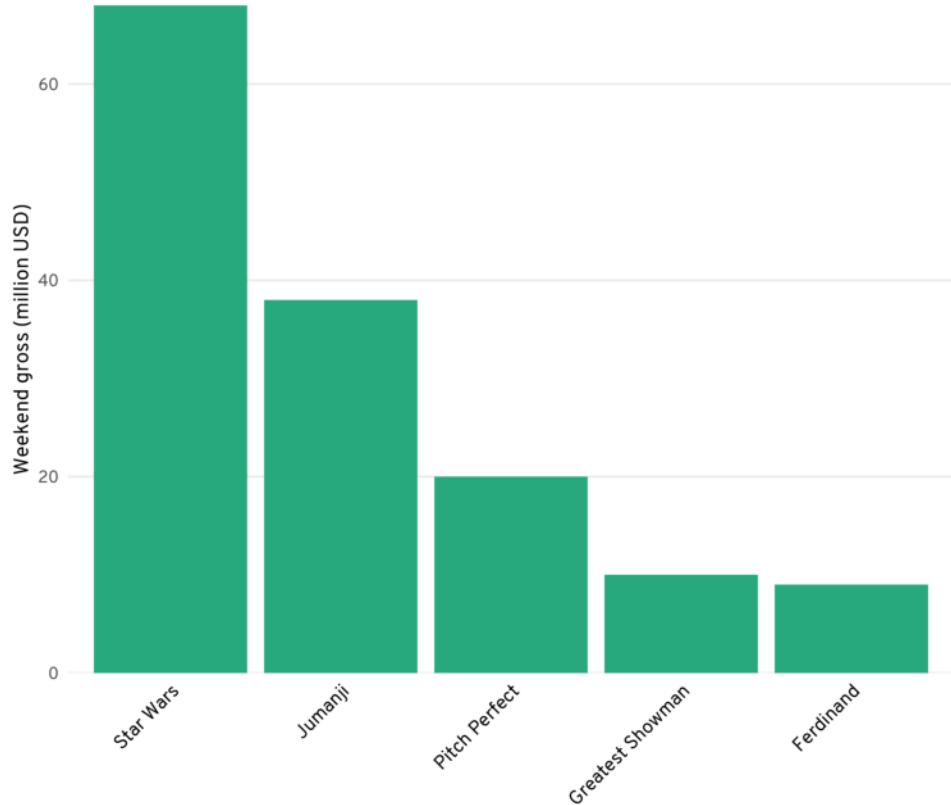
Francis Gagnon, Voilà

Order Your Data

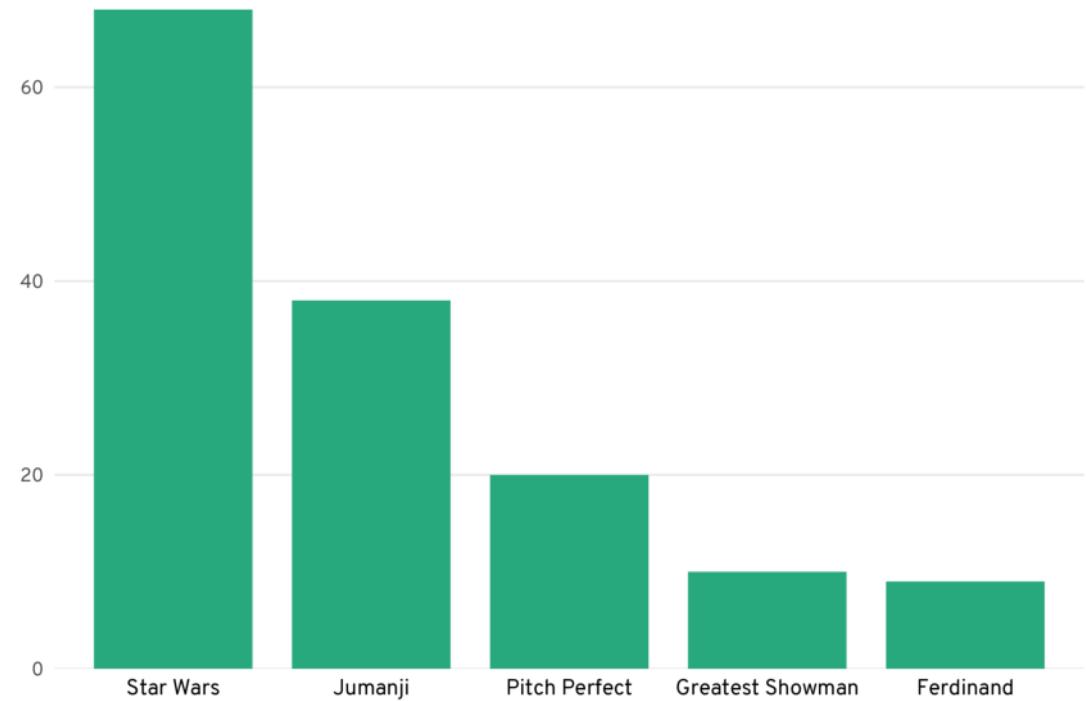


“Hands-On Data Visualization” by Jack Dougherty & Ilya Ilyankou

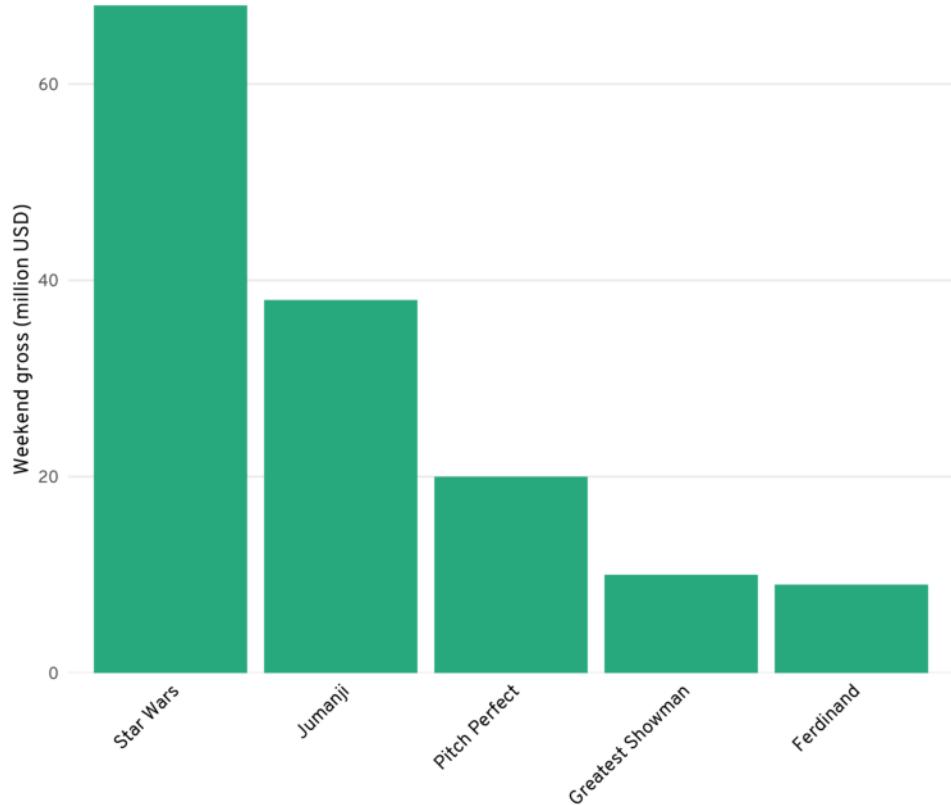
(Don't) Rotate Your Text



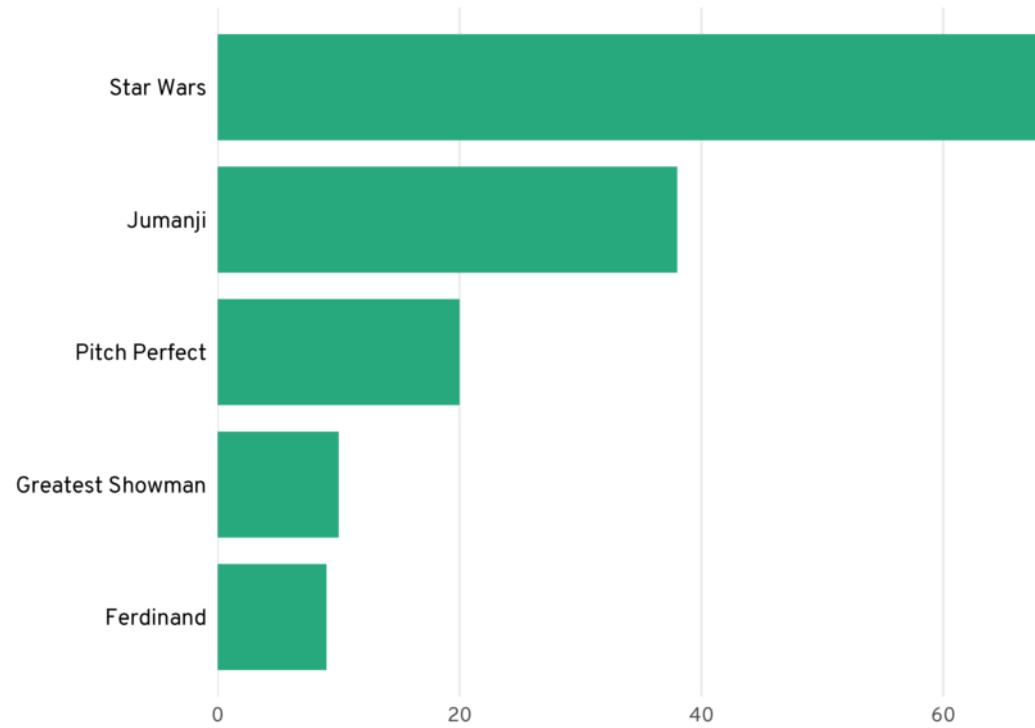
Weekend gross in million USD of popular blockbusters



(Don't) Rotate Your Text

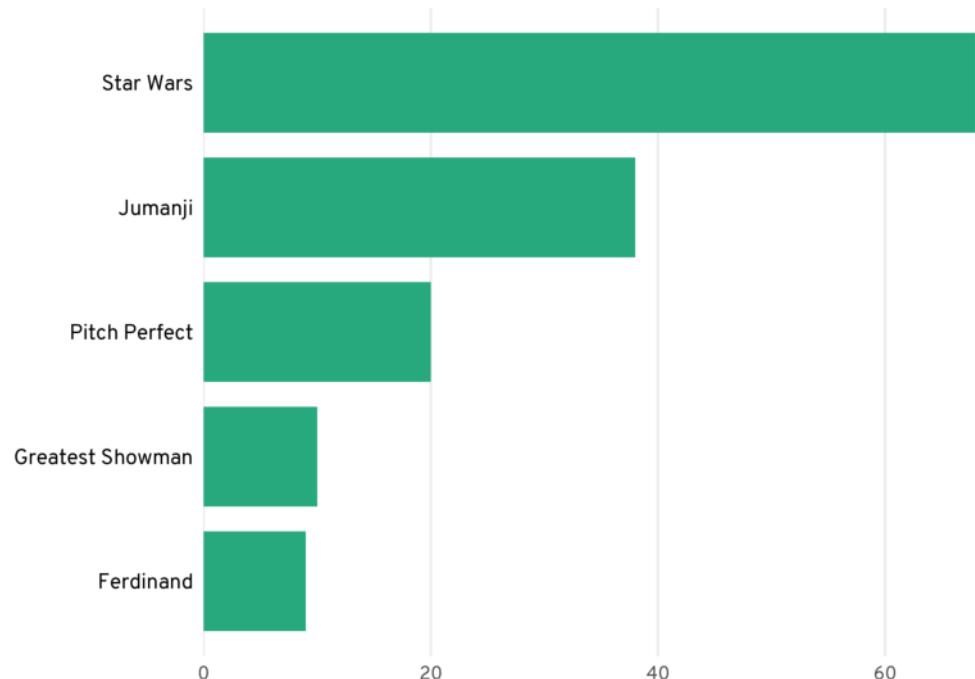


Weekend gross in million USD of popular blockbusters

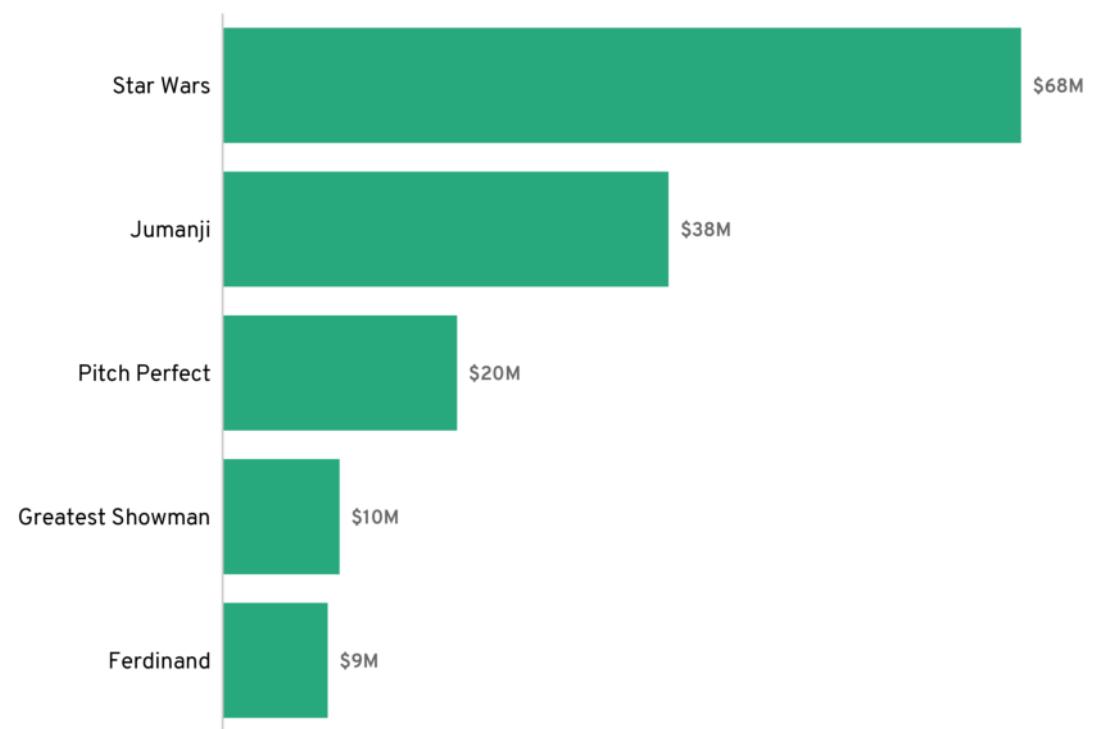


Use Annotations

Weekend gross in million USD of popular blockbusters



Weekend gross in million USD of popular blockbusters

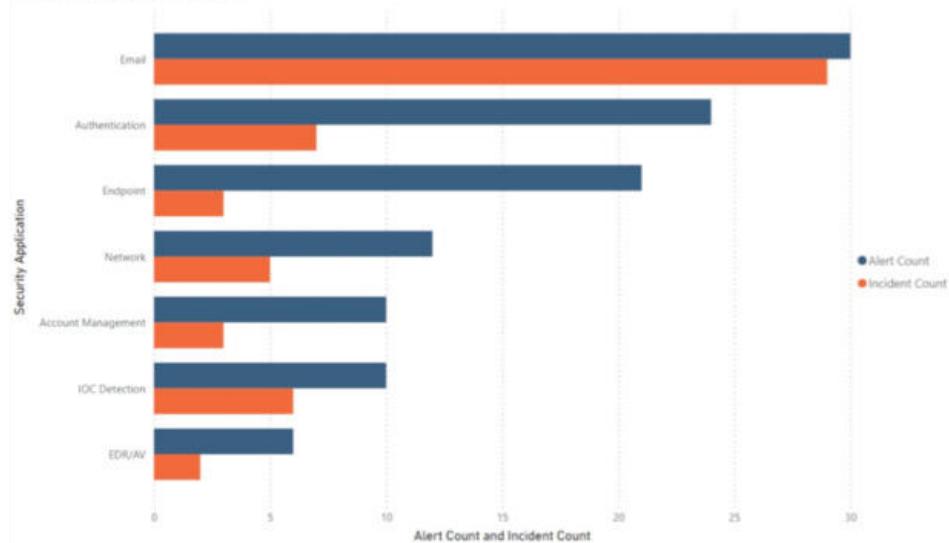


Use Annotations

BEFORE:

Security Application Alerts and Escalations

Total Alerted / Escalated

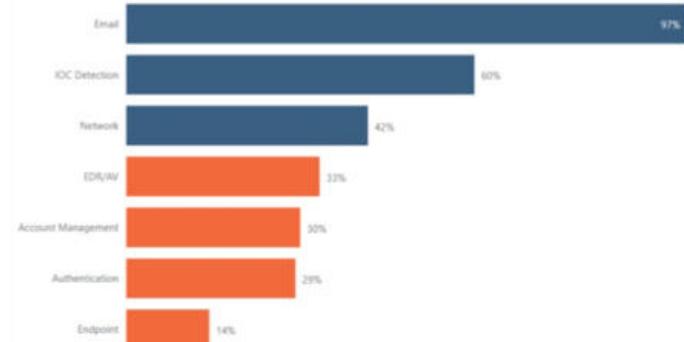


AFTER:

Security Application Performance for week 20

Discussion: What % of alerts are escalated to security incidents by security application?

Security applications generate security alerts. Not all alerts are security issues and only a subset of alerts become security incidents. Alerts become security incidents when a security analyst determines that an alert is a genuine security incident.



Applications that record a **conversion rate** of 40% or greater are **performing efficiently**. For report week these applications performed as expected.

Please focus engineering resources on **these applications**.

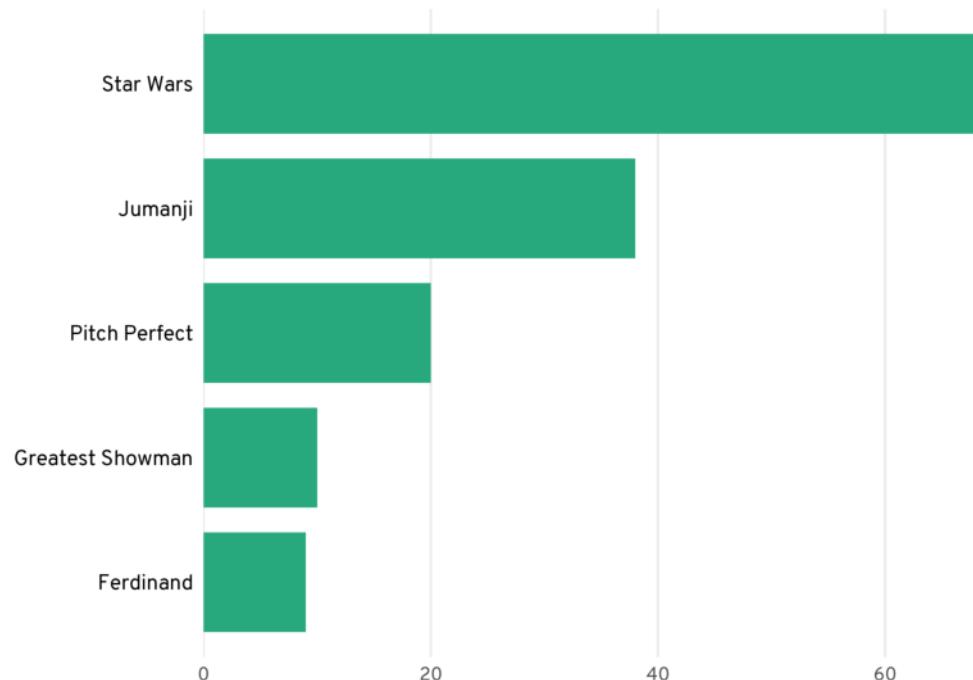
Applications that record a **conversion rate** of 40% or lower are **performing in-efficiently**. For report week these applications did not meet performance expectations.

Data Source: Security metric data from client XYZ environment for the week beginning 10th May 2021

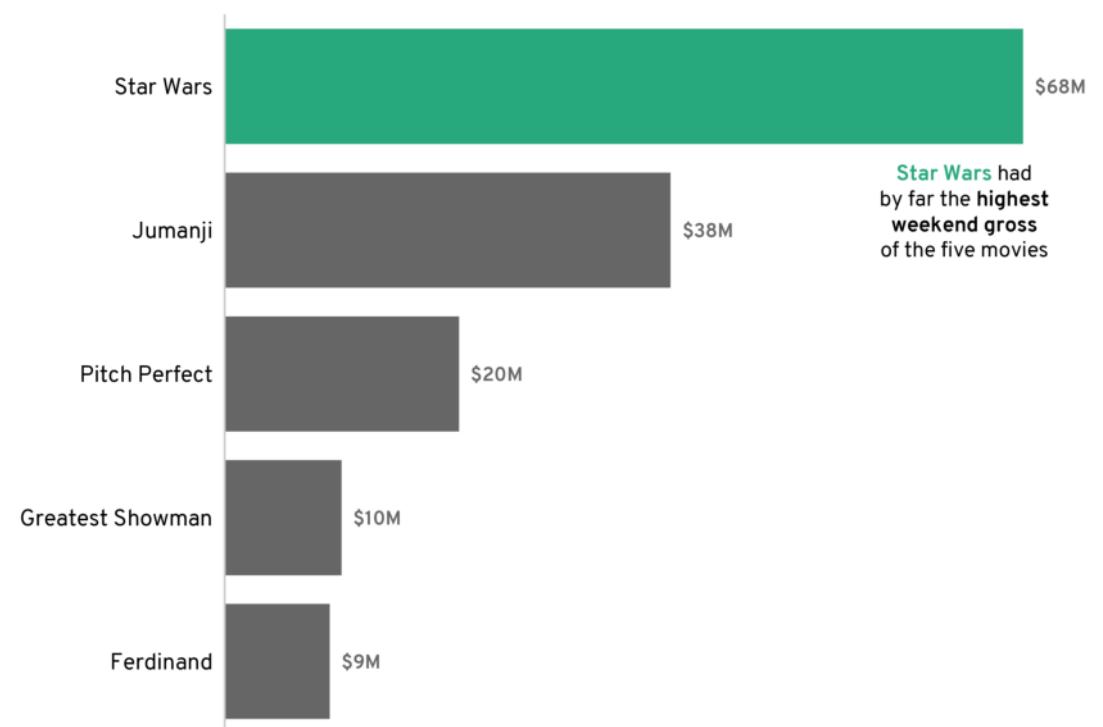
storytellingwithdata.com

Use Annotations

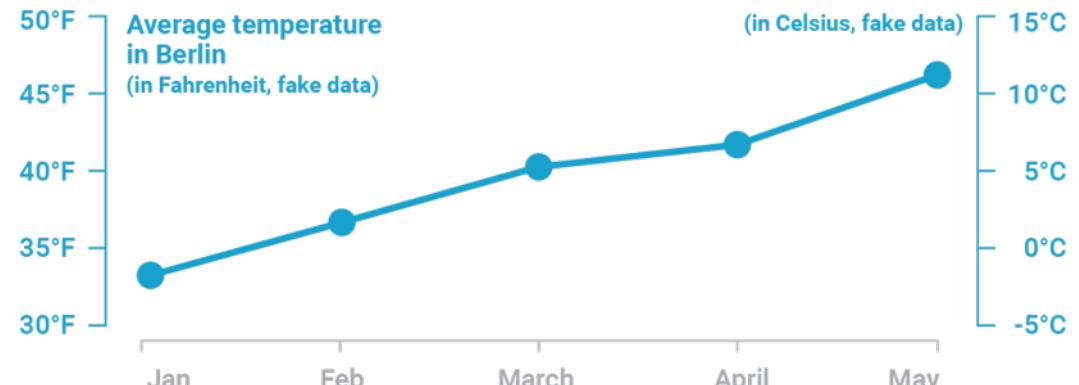
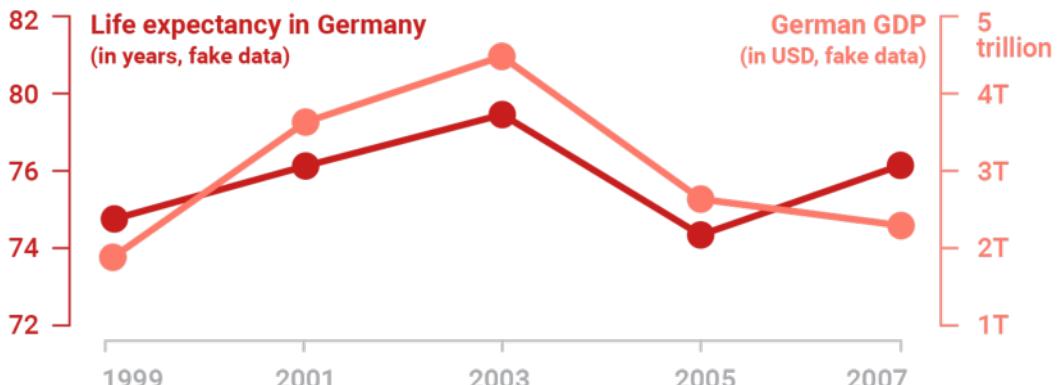
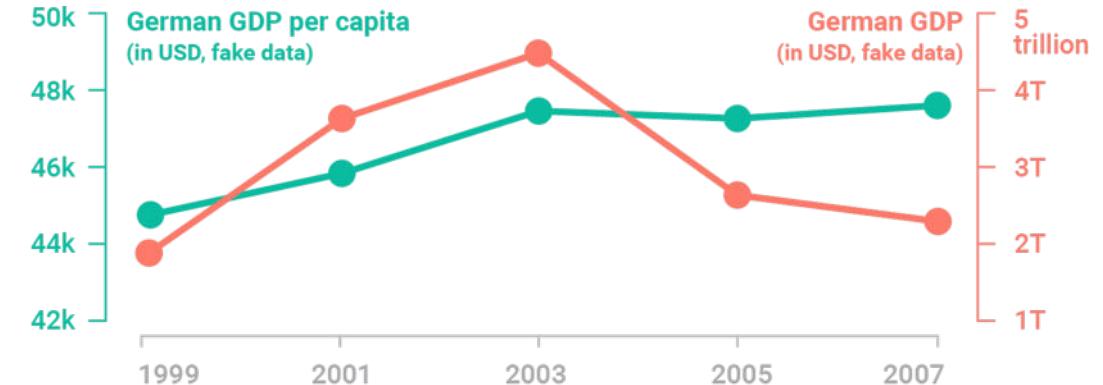
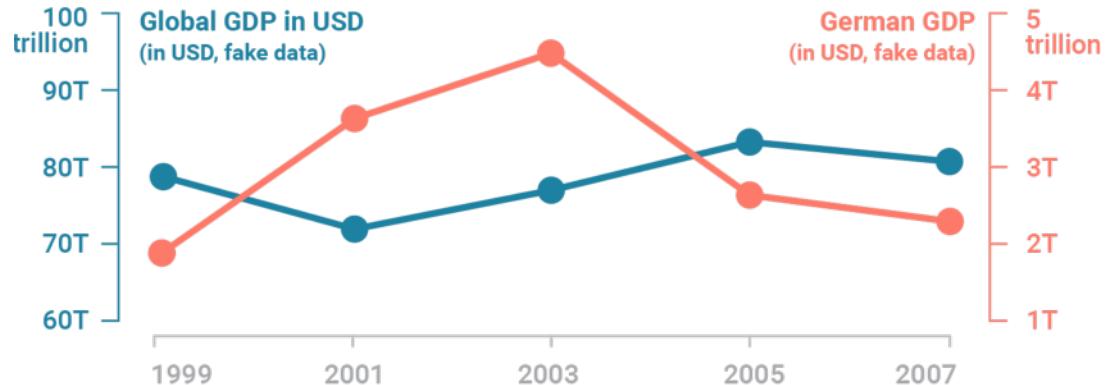
Weekend gross in million USD of popular blockbusters



Weekend gross in million USD of popular blockbusters



Avoid Dual Axes



"Why not to use two axes, and what to use instead" by Lisa Charlotte Muth/DataWrapper

Avoid Dual Axes



"Why not to use two axes, and what to use instead" by Lisa Charlotte Muth/DataWrapper

Avoid Dual Axes



Orange steady,
Blue massively increasing.



Blue steady,
Orange increasing.



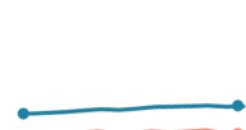
Both started at the same
level, but Orange increased
far more than Blue.



Both started at the same
level, but Blue increased
far more than Orange.



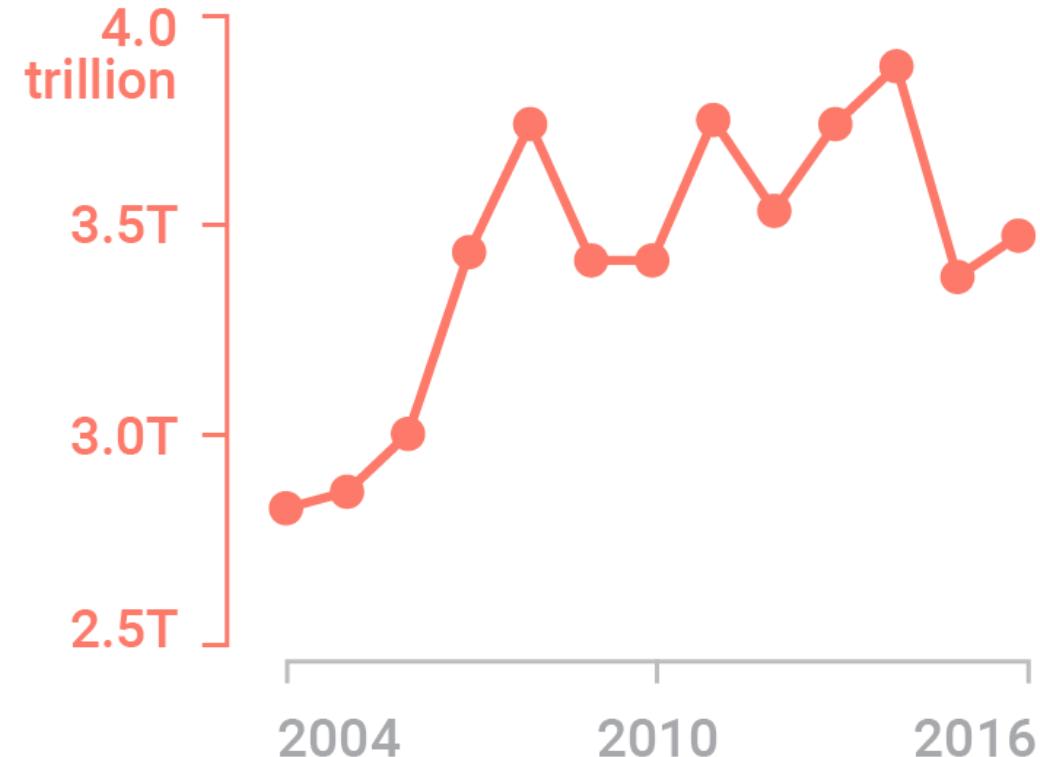
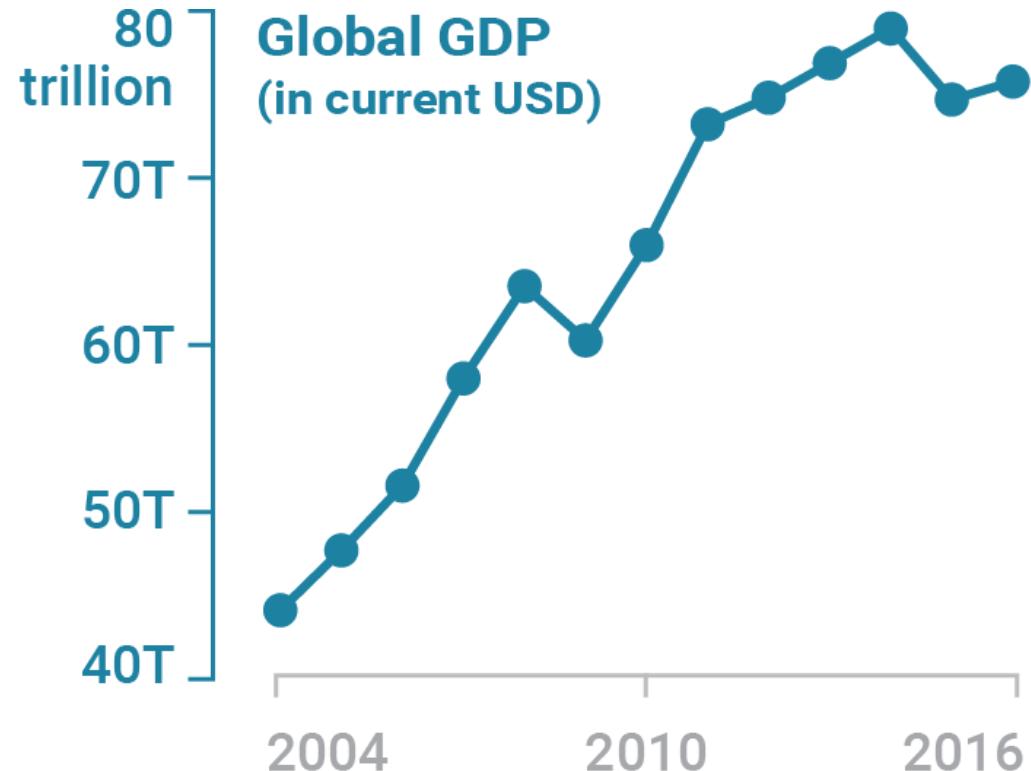
Both started with the
same increase, then Blue
raced to the top.



Both steady.

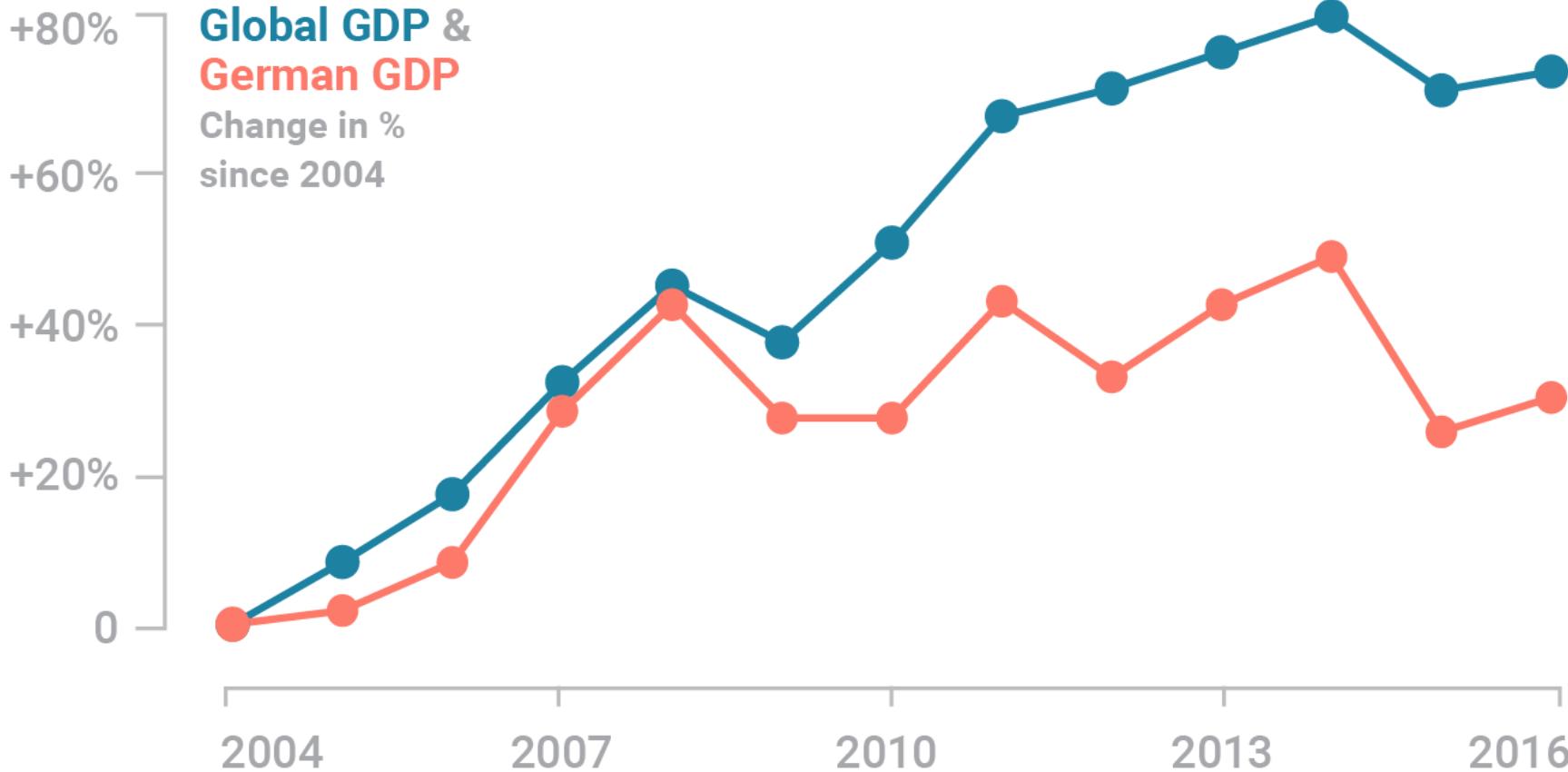
"Why not to use two axes, and what to use instead" by Lisa Charlotte Muth/DataWrapper

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Avoid Dual Axes



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A word about Tables

Jonathan A. Schwabish

Ten Guidelines for Better Tables

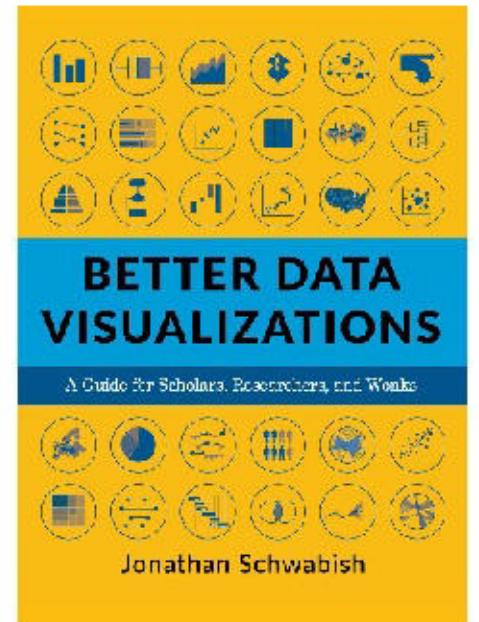
Abstract: Tables are a unique form of visualizing data because, unlike many charts, they are not usually intended to give a quick, visual representation of data. Instead, tables are useful when you want to show the exact values of your data or estimates. They are not the best solution if you want to show a lot of data or if you want to show the data in a compact space, but a well-designed table can help your reader find specific numbers and discover patterns and outliers. In this article, I present 10 guidelines for creating better, more effective tables; I then model these lessons by redesigning six tables from articles previously published in the *Journal of Benefit-Cost Analysis*.



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Country	Potato Yield in Tonnes/Hectare		
	2013	2017	2013-2017
Brazil	27.75	30.94	
China	17.09	18.21	
Denmark	41.57	43.68	
El Salvador	42.60	29.22	
France	43.16	44.05	
Germany	39.83	46.79	
India	22.76	22.31	
Indonesia	16.02	15.40	
Ireland	38.33	44.83	
Italy	25.25	27.73	
Lebanon	26.08	25.14	
Mexico	26.78	28.95	
Netherlands	42.21	45.97	
Pakistan	21.81	21.45	
United States	46.36	48.39	

Table: @thomas_mock | Data: OurWorldInData.org

Inspiration: @jschwabish

Country	Potato Yield in Tonnes/Hectare				
	2013	2014	2015	2016	2017
United States	46.36	47.15	46.90	48.64	48.39
France	43.16	47.98	42.51	38.83	44.05
El Salvador	42.60	26.25	26.01	25.54	29.22
Netherlands	42.21	45.66	42.73	42.00	45.97
Denmark	41.57	43.12	41.41	42.48	43.68
Germany	39.83	47.42	43.81	44.40	46.79
Ireland	38.33	40.32	42.36	39.11	44.83
Brazil	27.75	27.94	29.32	29.66	30.94
Mexico	26.78	27.34	27.14	27.93	28.95
Lebanon	26.08	25.23	24.82	25.07	25.14
Italy	25.25	26.08	27.16	28.44	27.73
India	22.76	22.92	23.13	20.51	22.31
Pakistan	21.81	18.15	23.44	22.43	21.45
China	17.09	17.14	17.27	17.69	18.21
Indonesia	16.02	17.67	18.20	18.25	15.40

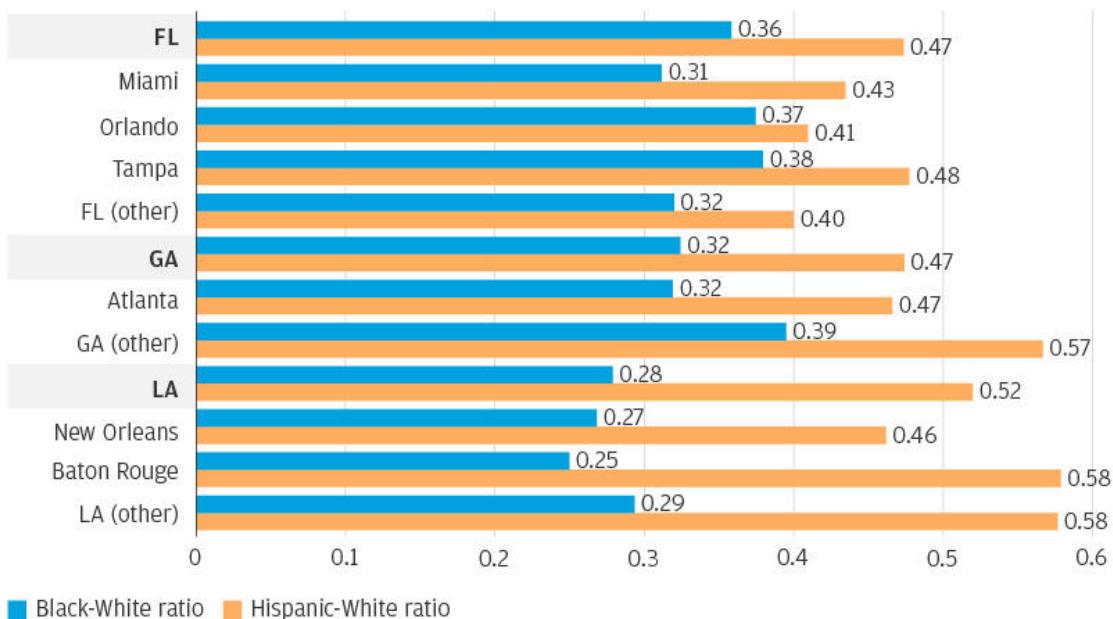
Table: @thomas_mock | Data: OurWorldInData.org

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How to improve this visualization?

Finding Four: Across geographies, the financial outcomes of Hispanic families vary the most, while the financial outcomes of Black families vary the least. Black-White gaps in financial outcomes are largest in Louisiana, while Hispanic-White gaps are largest in Florida.

Black-White and Hispanic-White ratios of annual median liquid assets (2018), by geography



■ Black-White ratio ■ Hispanic-White ratio

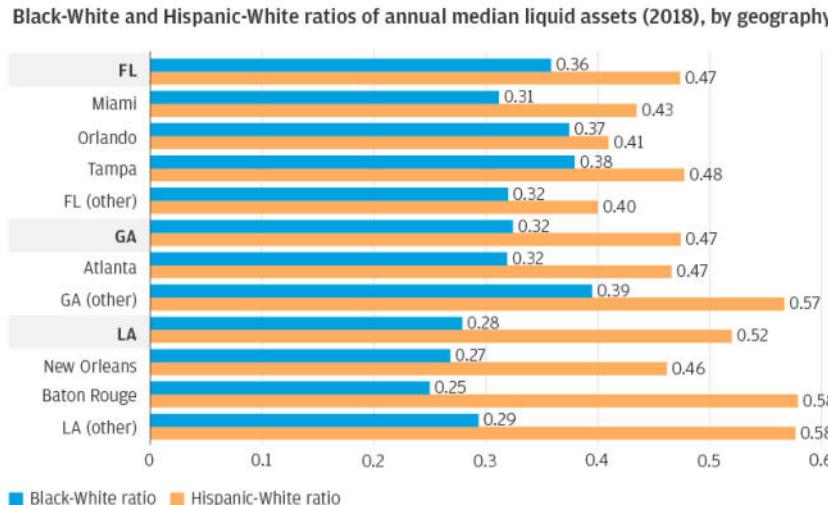
Note: Liquid assets is the sum of balances in one's checking, prepaid debit cards, savings, money market, and certificates of deposit accounts. Cities refer to CBSAs (e.g., Miami refers to the Miami-Fort Lauderdale-West Palm Beach CBSA).

Source: JPMorgan Chase Institute

[View the Text Version >](#)

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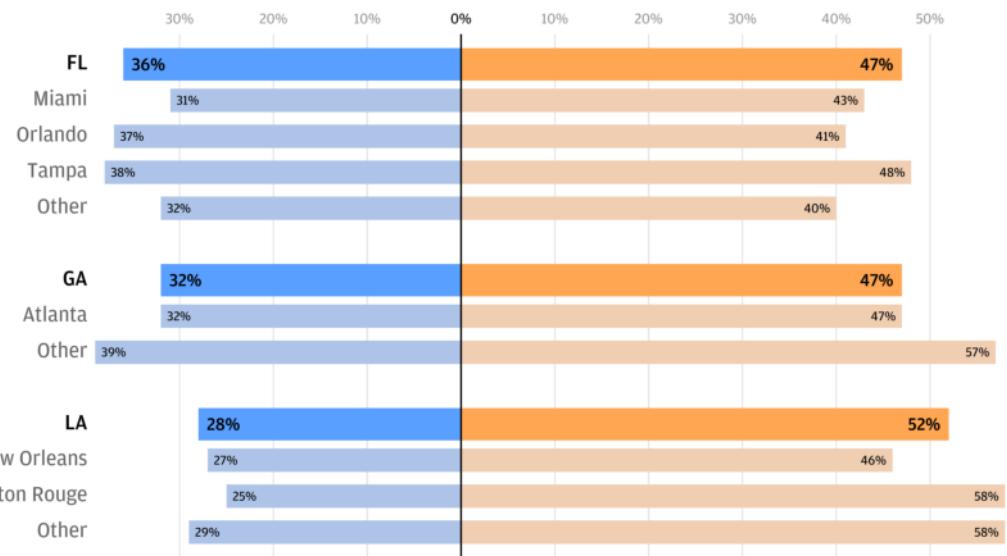


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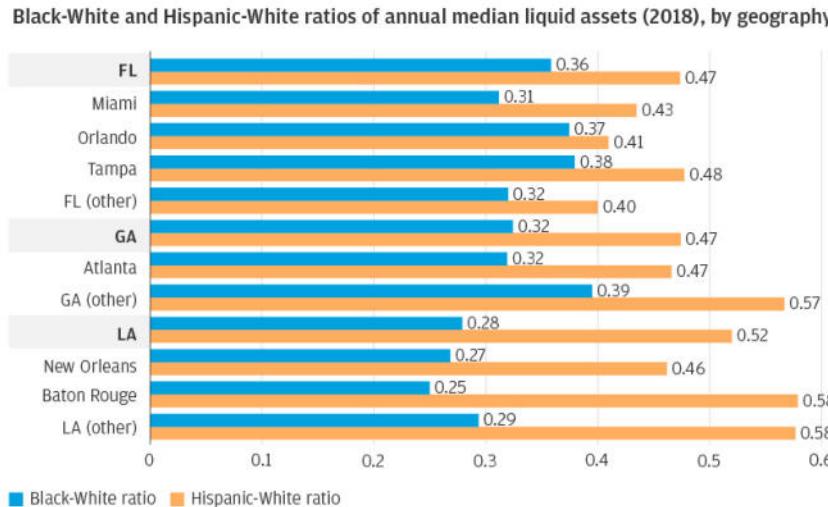


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Source: JPMorgan Chase Institute | Makeover: Cedric Scherer, Frontpage Data

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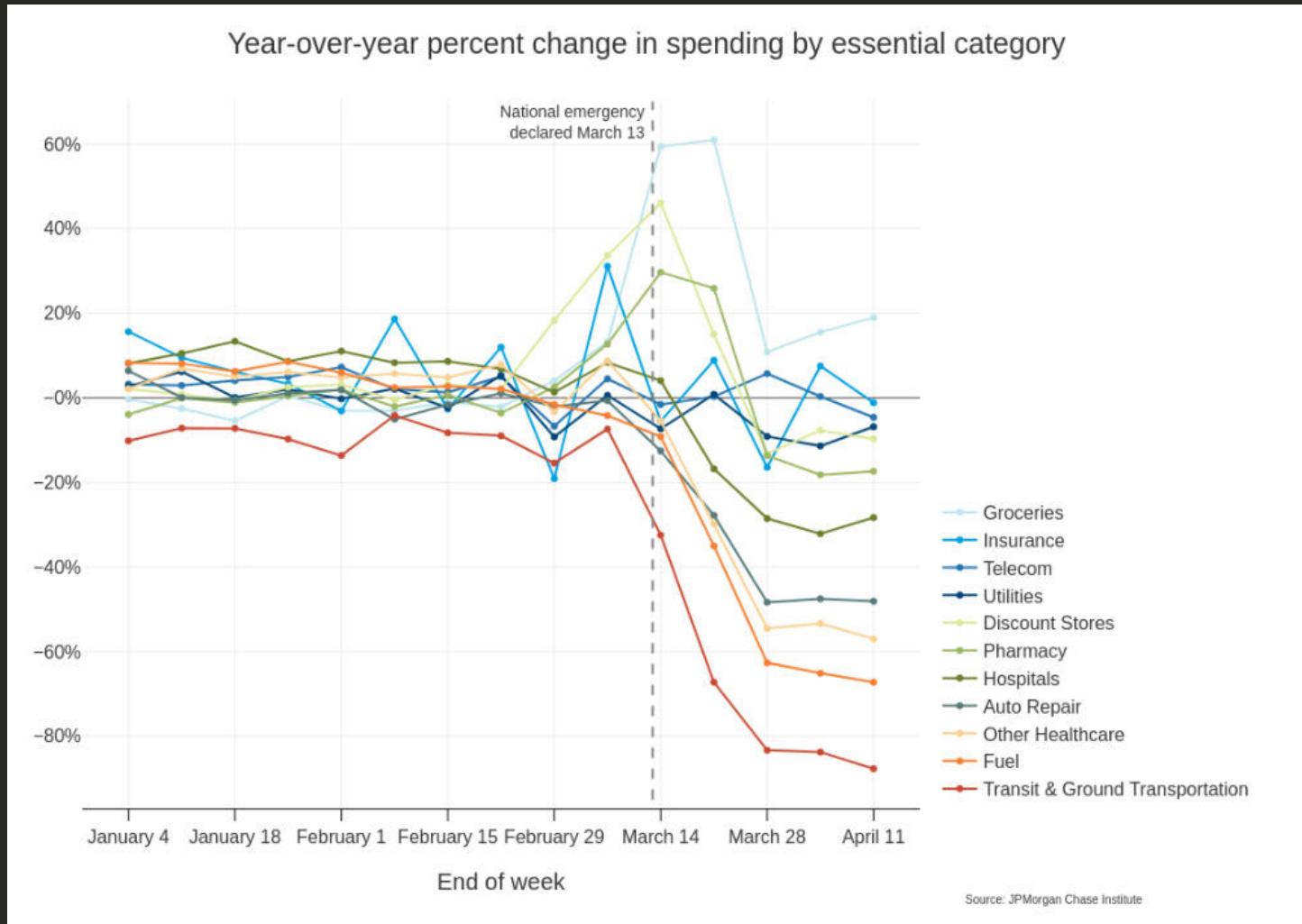
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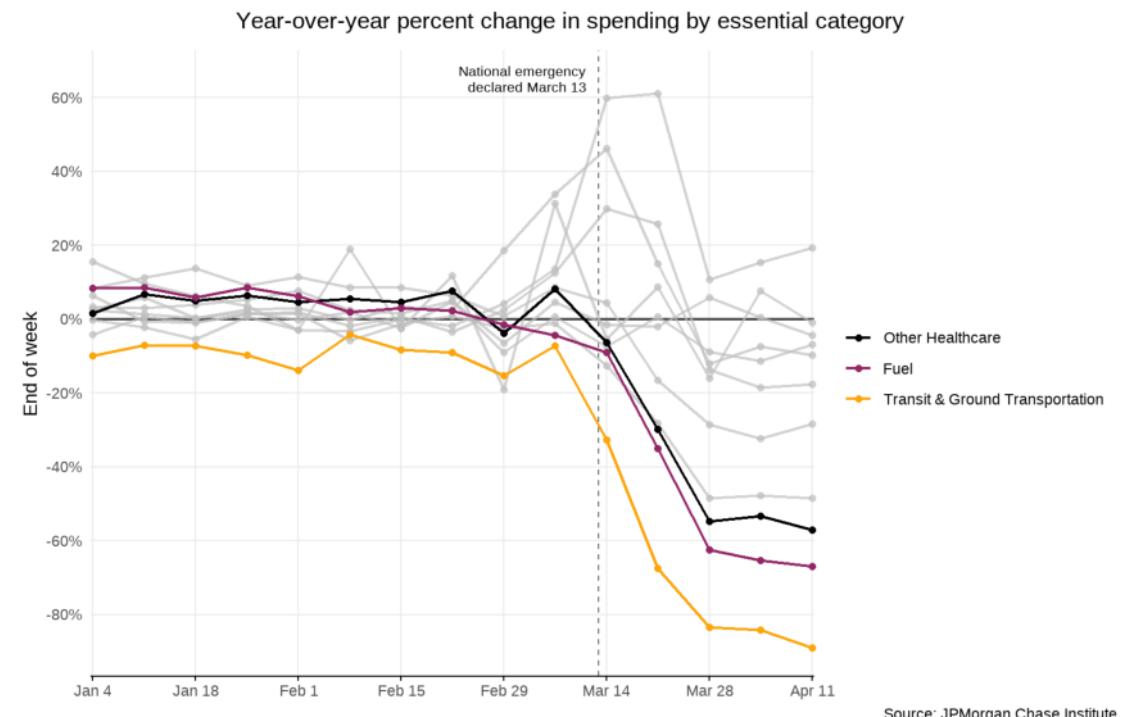
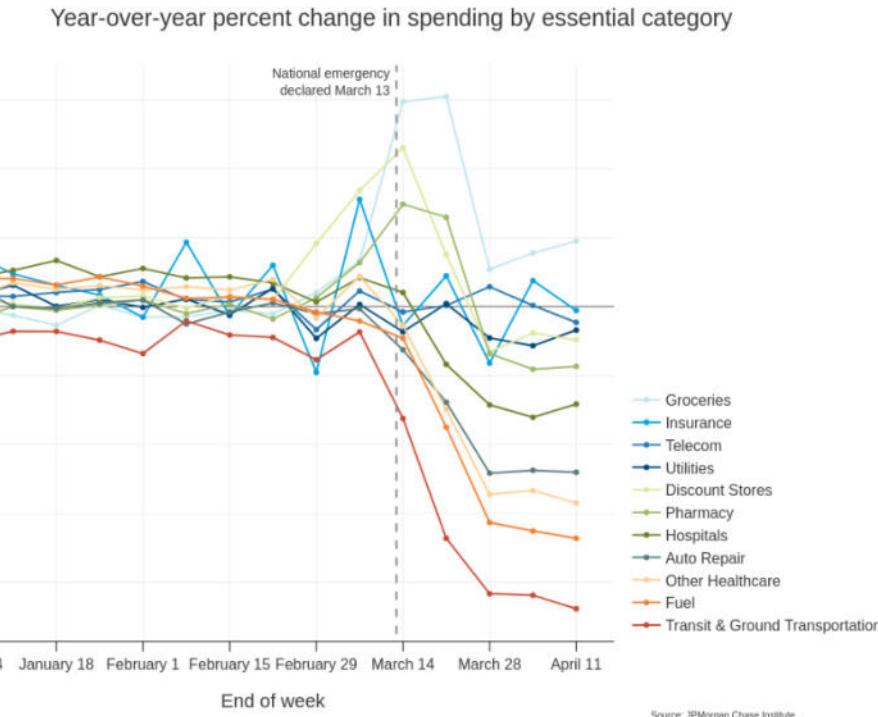
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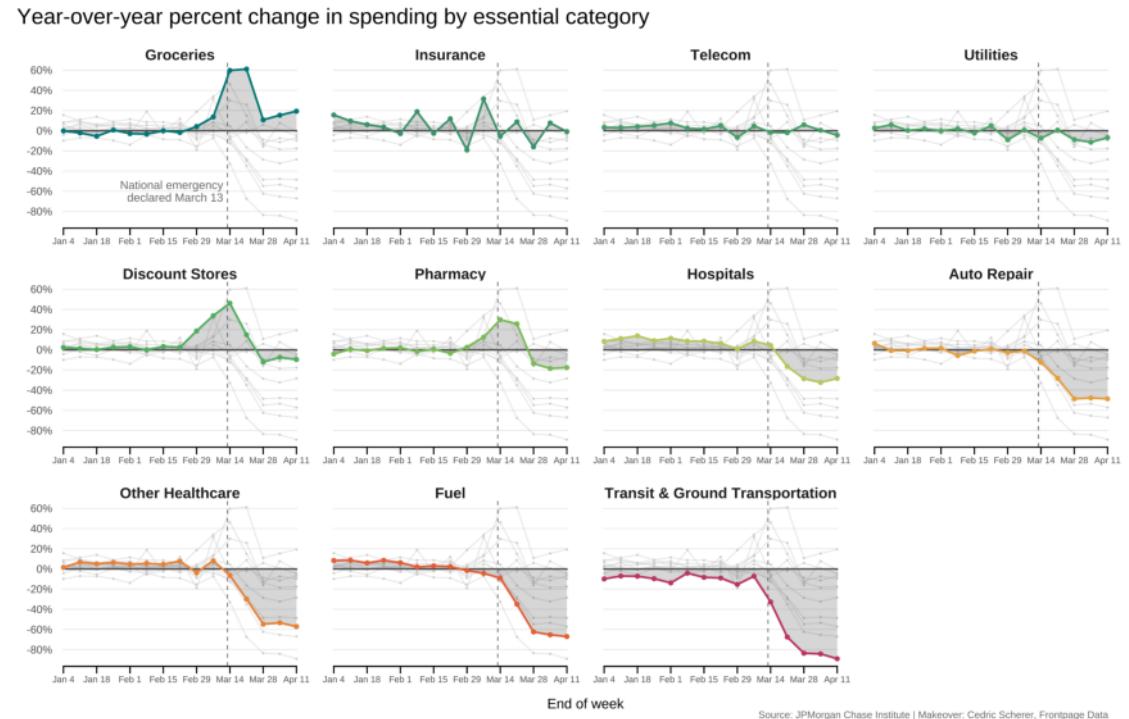
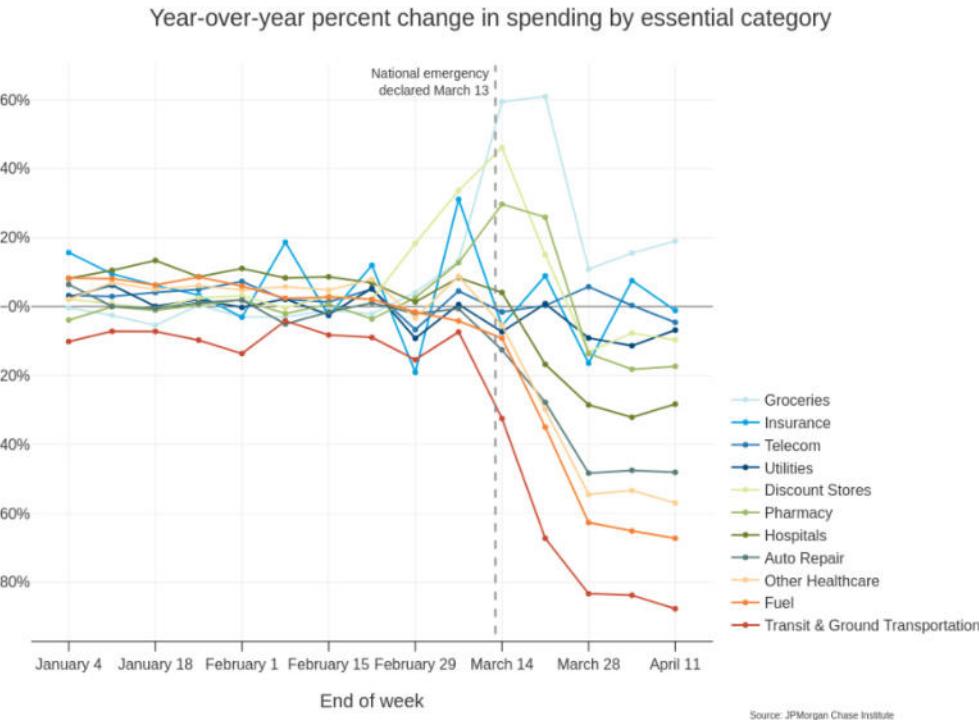
How to improve this visualization?



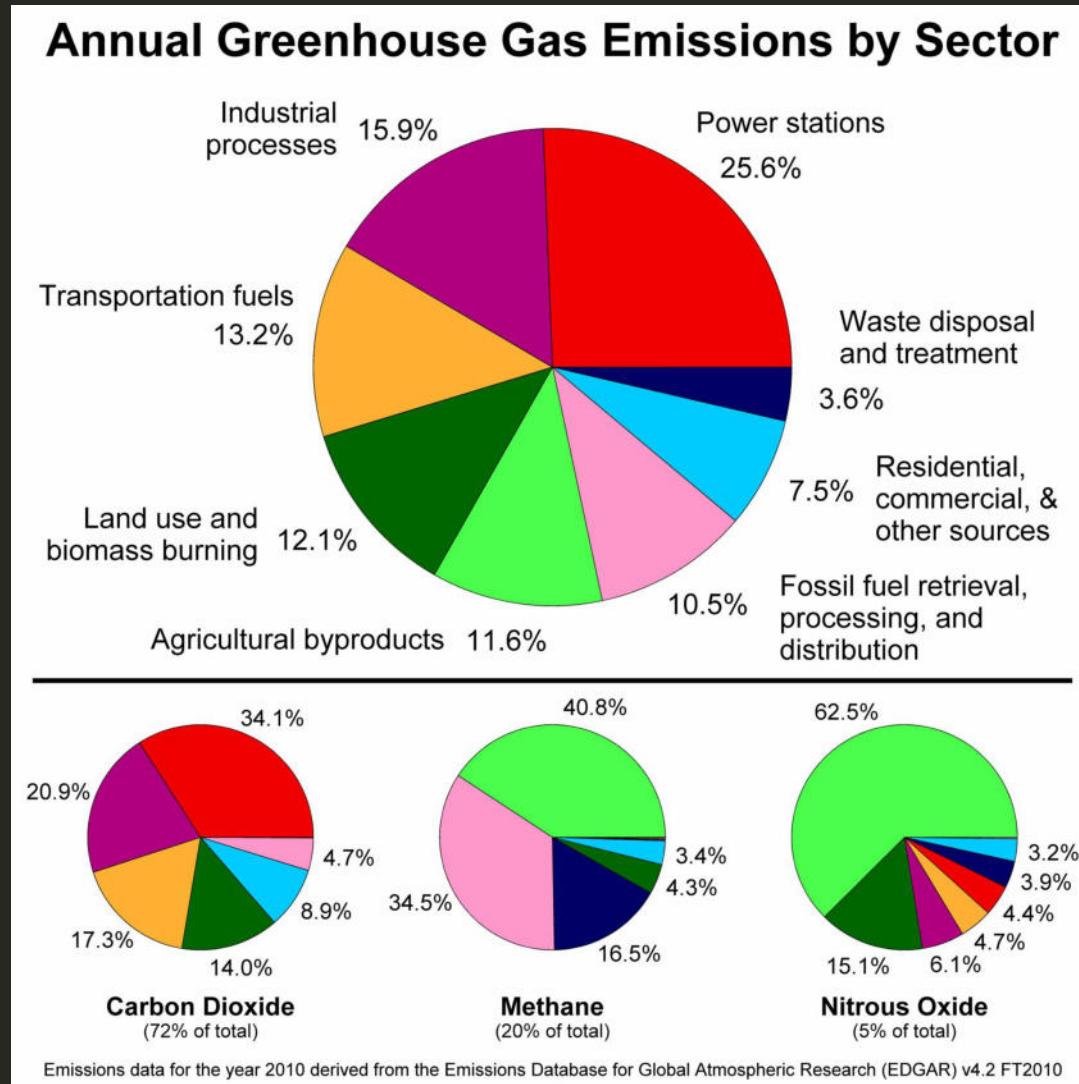
How to improve this visualization?



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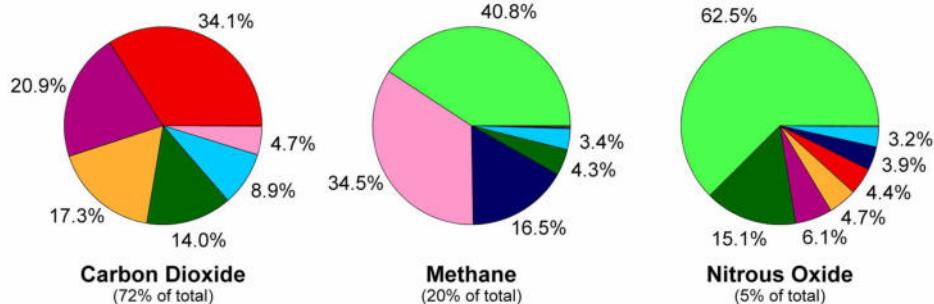
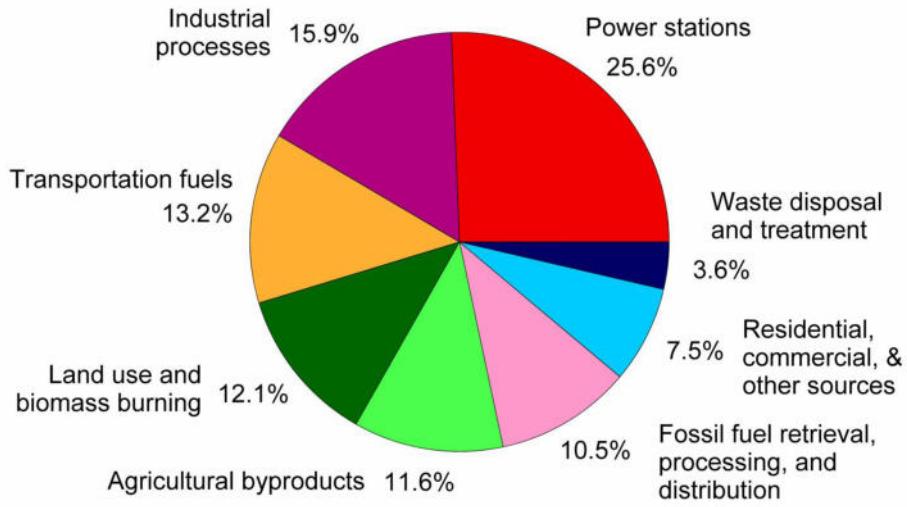


How to improve this visualization?



How to improve this visualization?

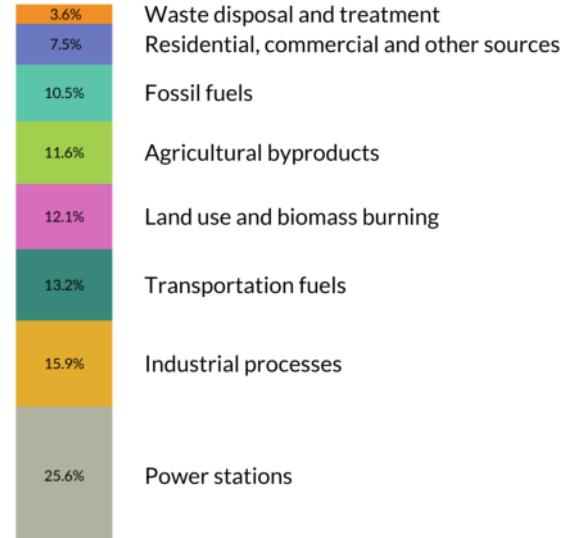
Annual Greenhouse Gas Emissions by Sector



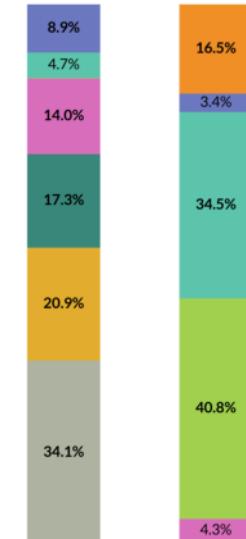
Emissions data for the year 2010 derived from the Emissions Database for Global Atmospheric Research (EDGAR) v4.2 FT2010

Annual Greenhouse Gas Emissions by Sector

All Greenhouse Gases



Carbon Dioxide (72% of total)



Methane (20% of total)



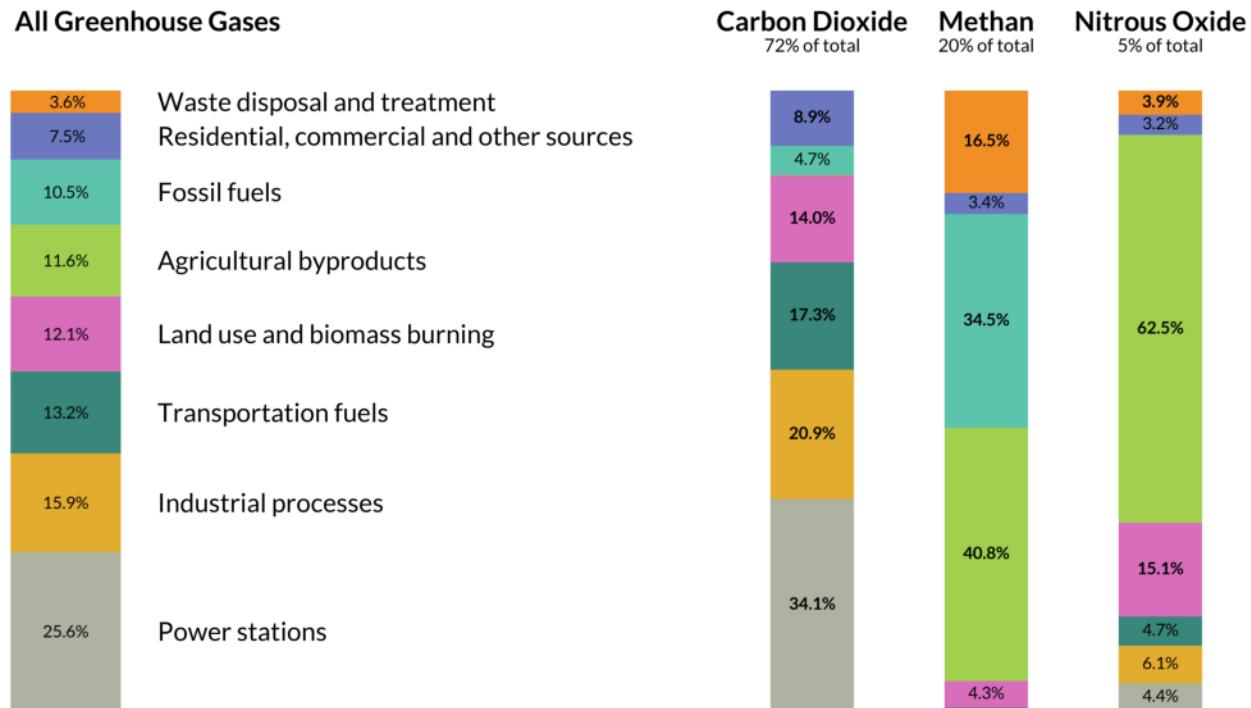
Nitrous Oxide (5% of total)



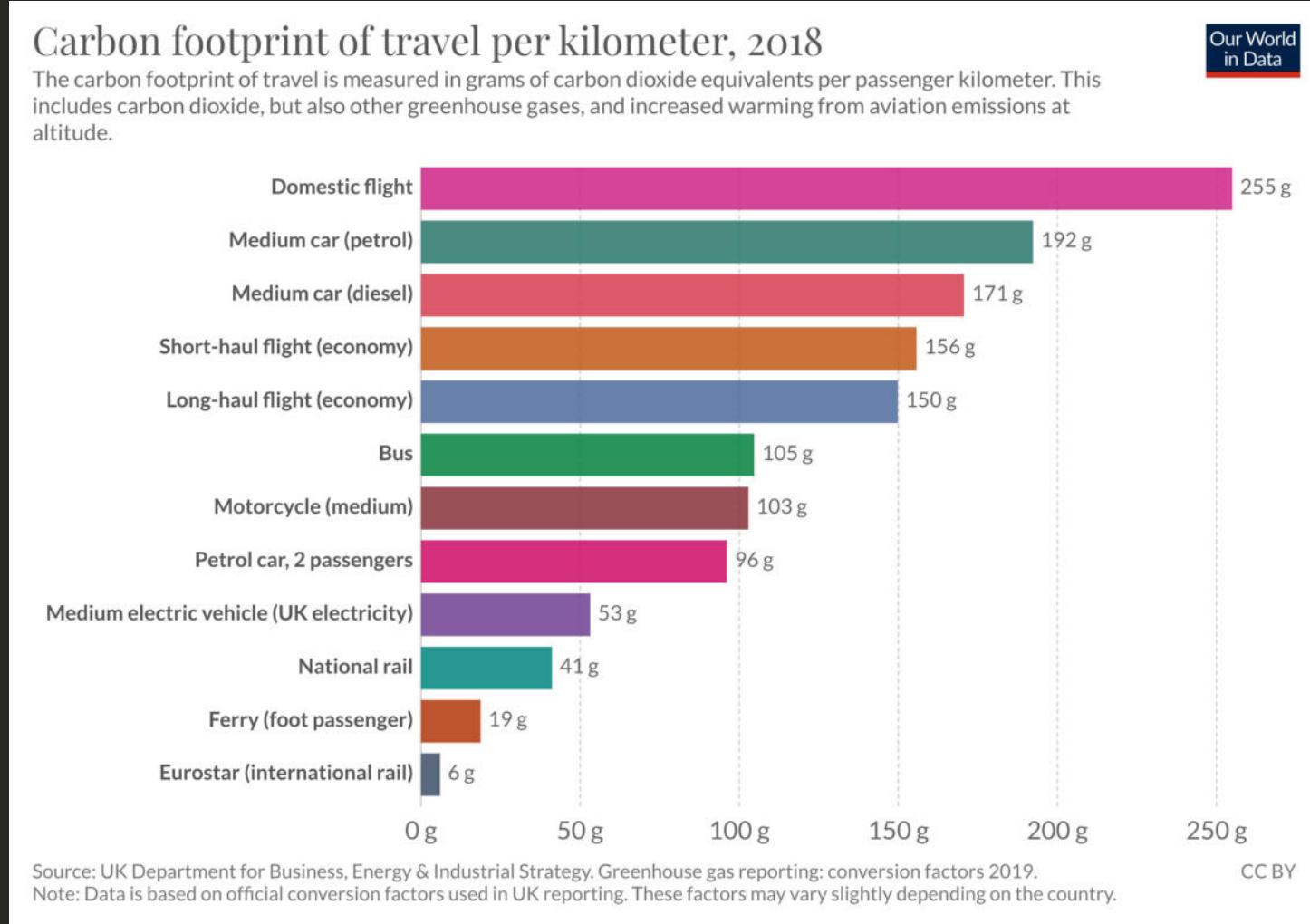
Emissions data for the year 2010 derived from the Emissions Database for Global Atmospheric Research (EDGAR) v4.2 FT2010
Bold labels indicate higher proportions than in the overall breakdown. Values below 1% are not labelled.
Graphic: Cédric Scherer

How to improve this visualization?

Annual Greenhouse Gas Emissions by Sector



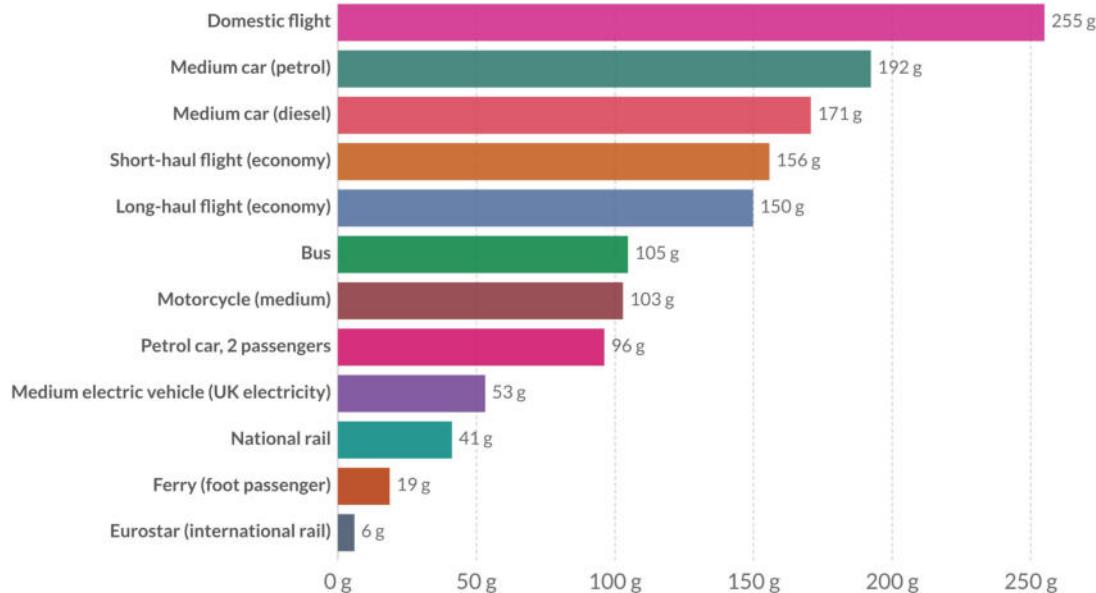
How to improve this visualization?



How to improve this visualization?

Carbon footprint of travel per kilometer, 2018

The carbon footprint of travel is measured in grams of carbon dioxide equivalents per passenger kilometer. This includes carbon dioxide, but also other greenhouse gases, and increased warming from aviation emissions at altitude.



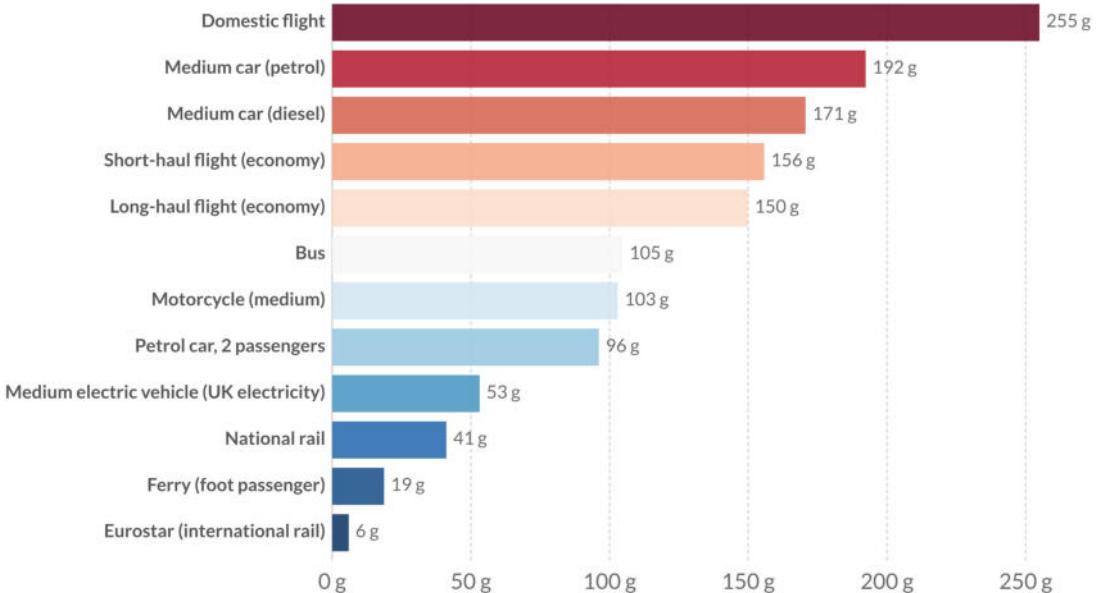
Source: UK Department for Business, Energy & Industrial Strategy. Greenhouse gas reporting: conversion factors 2019.
Note: Data is based on official conversion factors used in UK reporting. These factors may vary slightly depending on the country.

Our World
in Data

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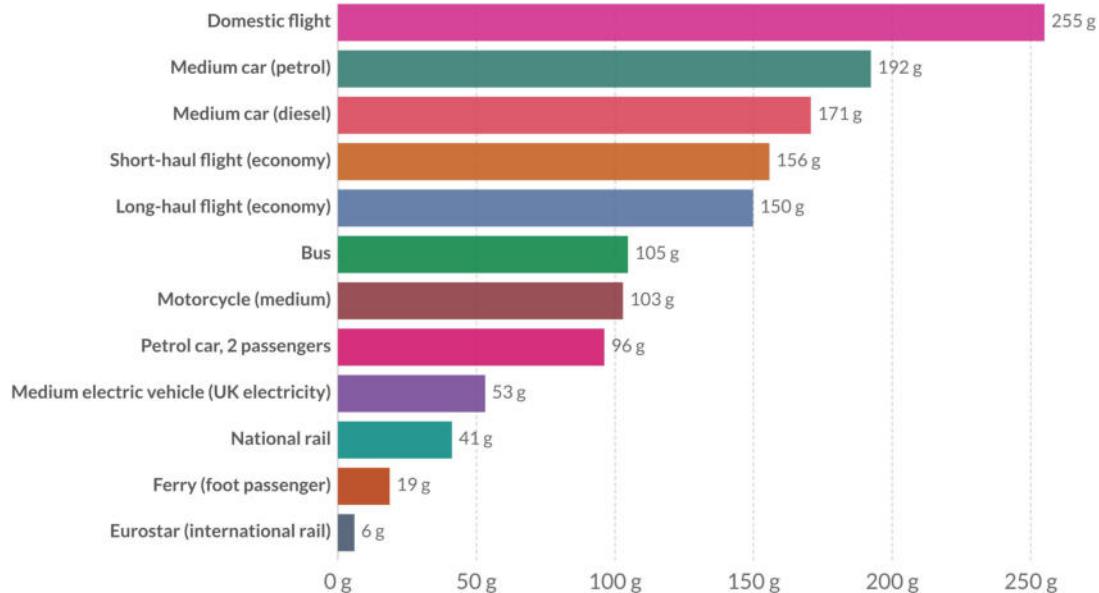
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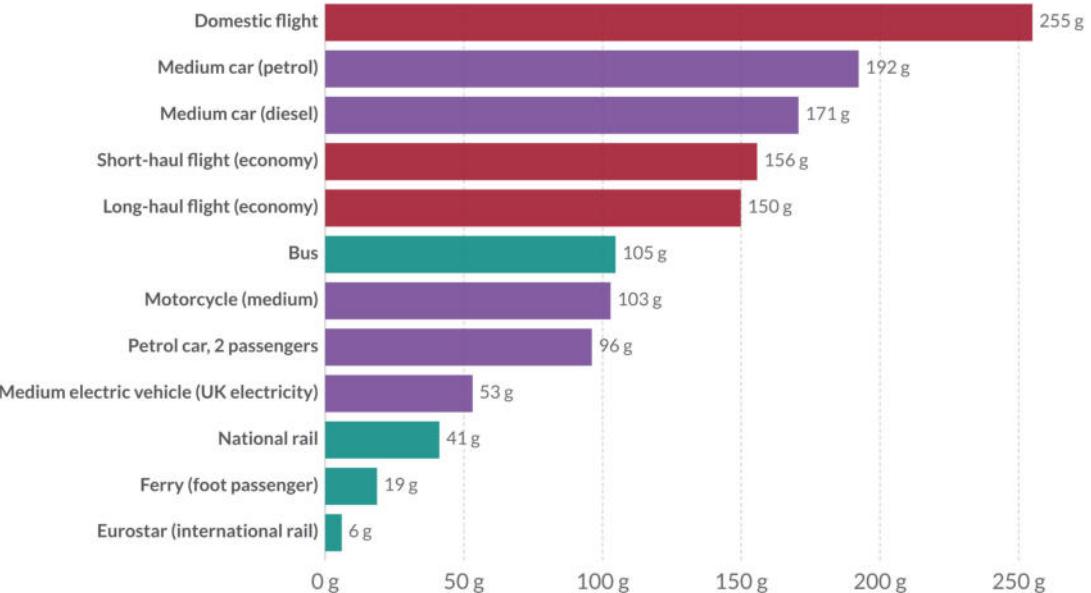
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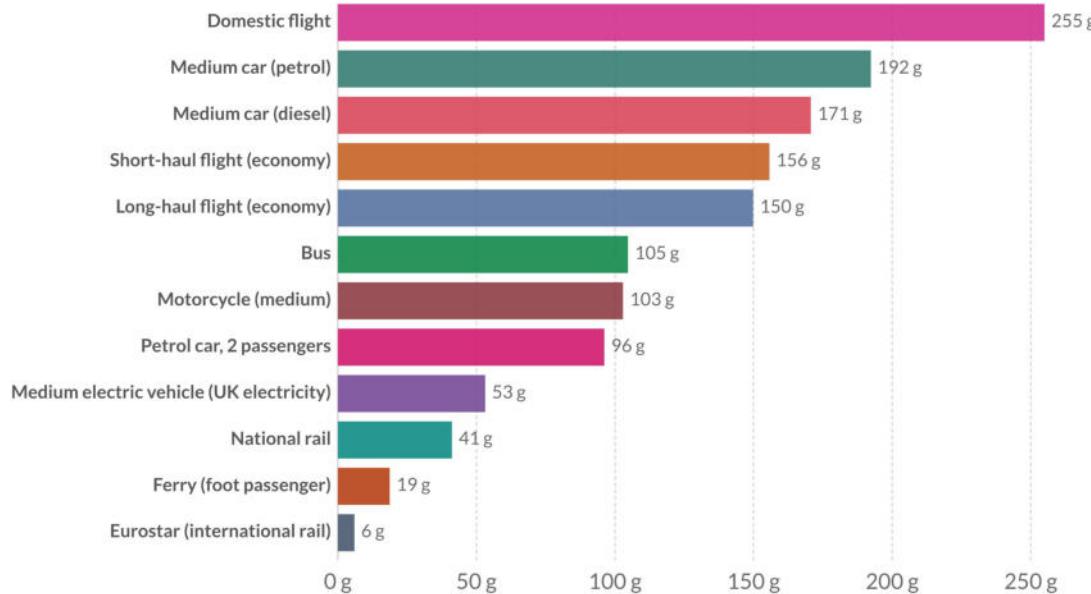
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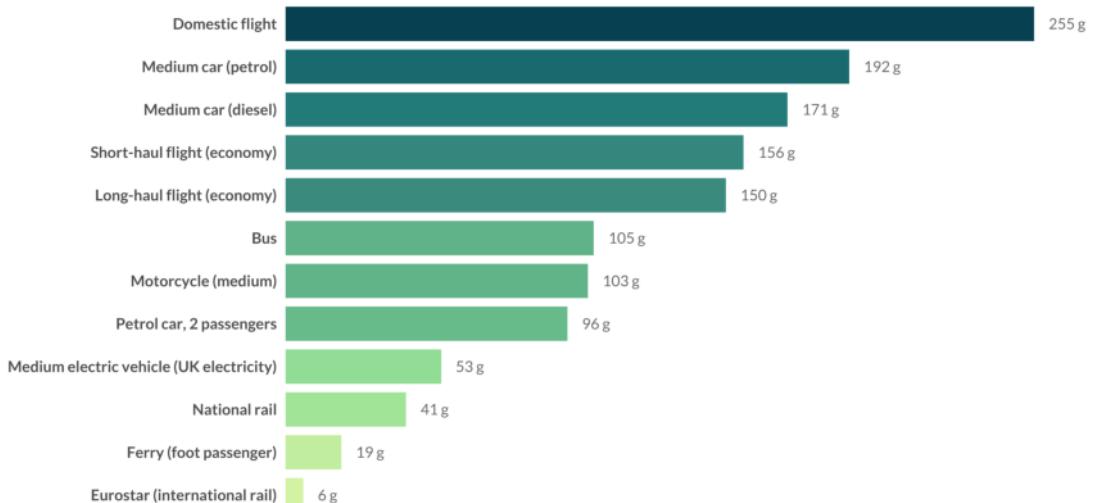
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CC BY

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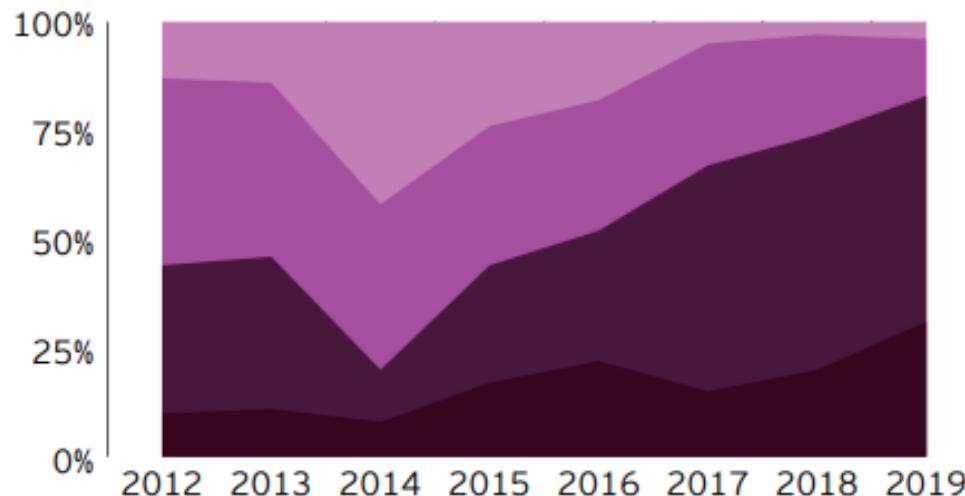
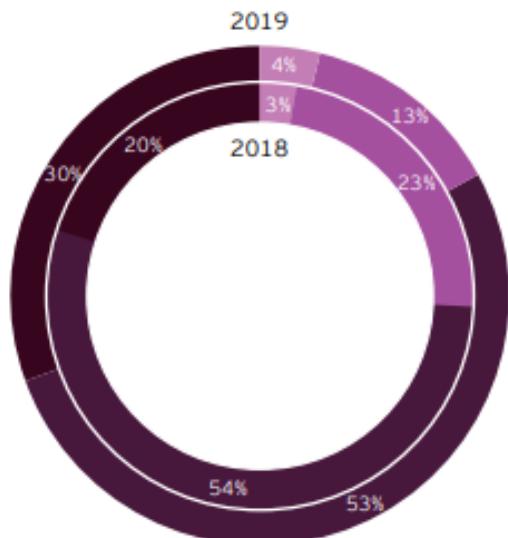
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Original visualization by Hannah Ritchie, OurWorldInData.org | Makeover by Cédric Scherer

How to improve this visualization?

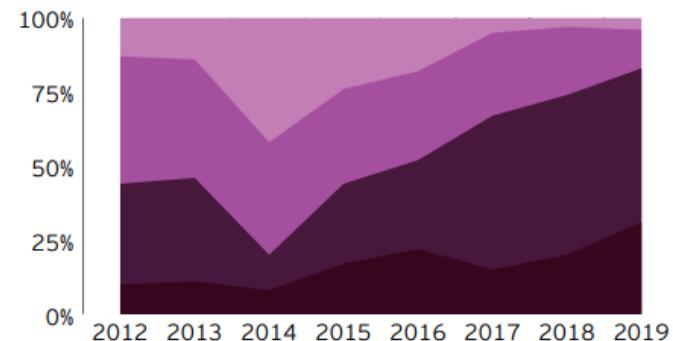
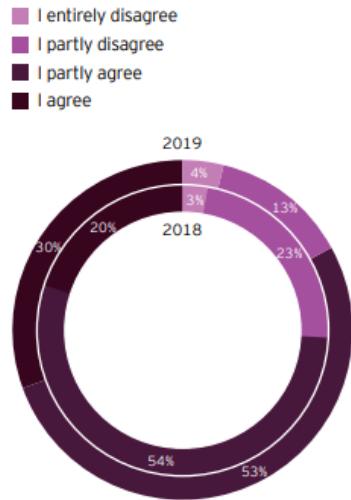
Do you agree with the following statement?
«The price of banking services will fall.»

- I entirely disagree
- I partly disagree
- I partly agree
- I agree

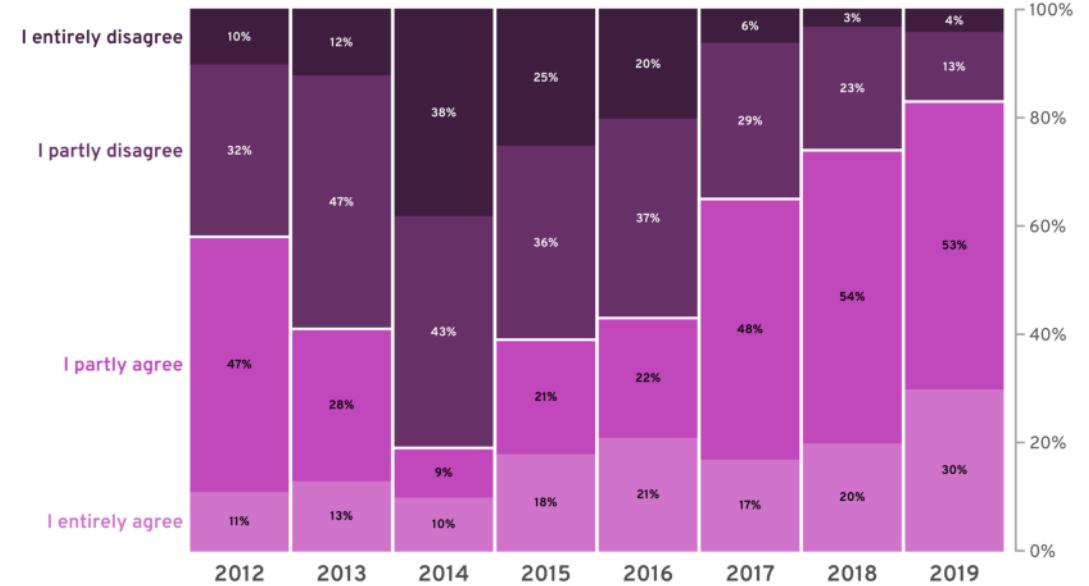


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«The price of banking services will fall.»

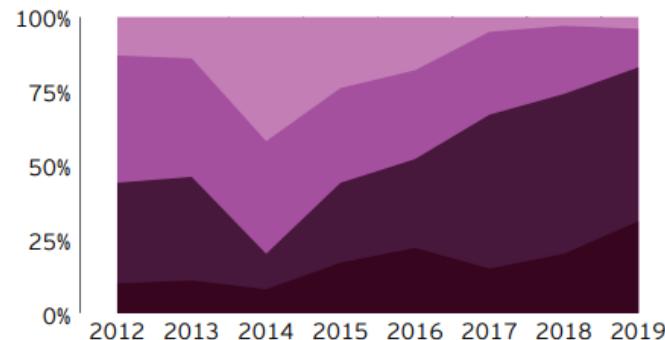
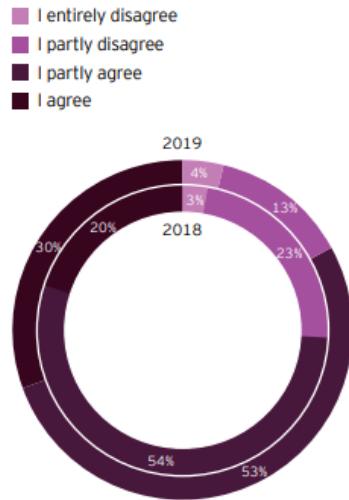


Do you agree with the following statement?
“The price of banking services will fall.”

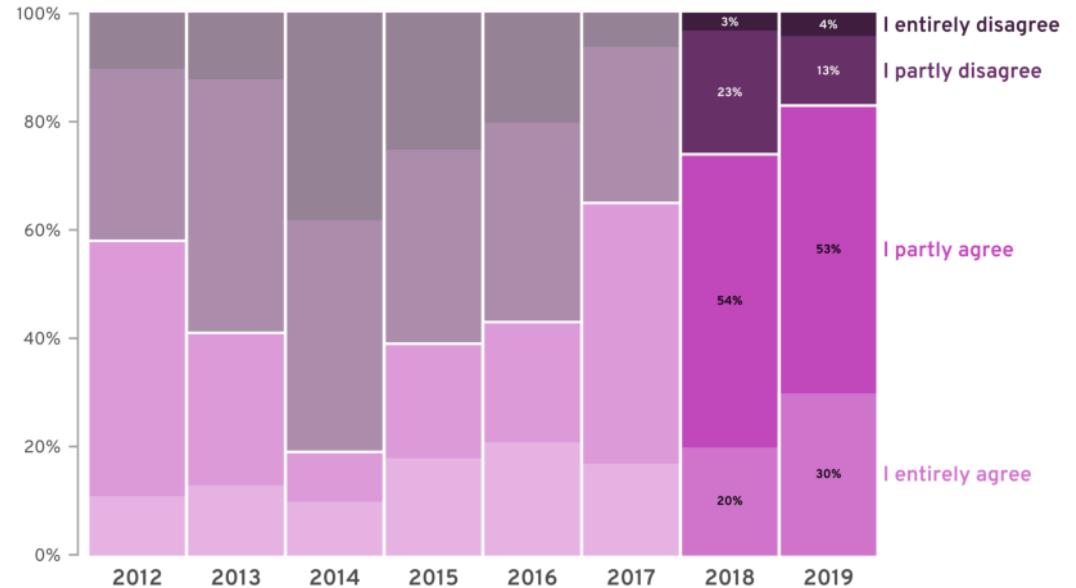


How to improve this visualization?

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«The price of banking services will fall.»

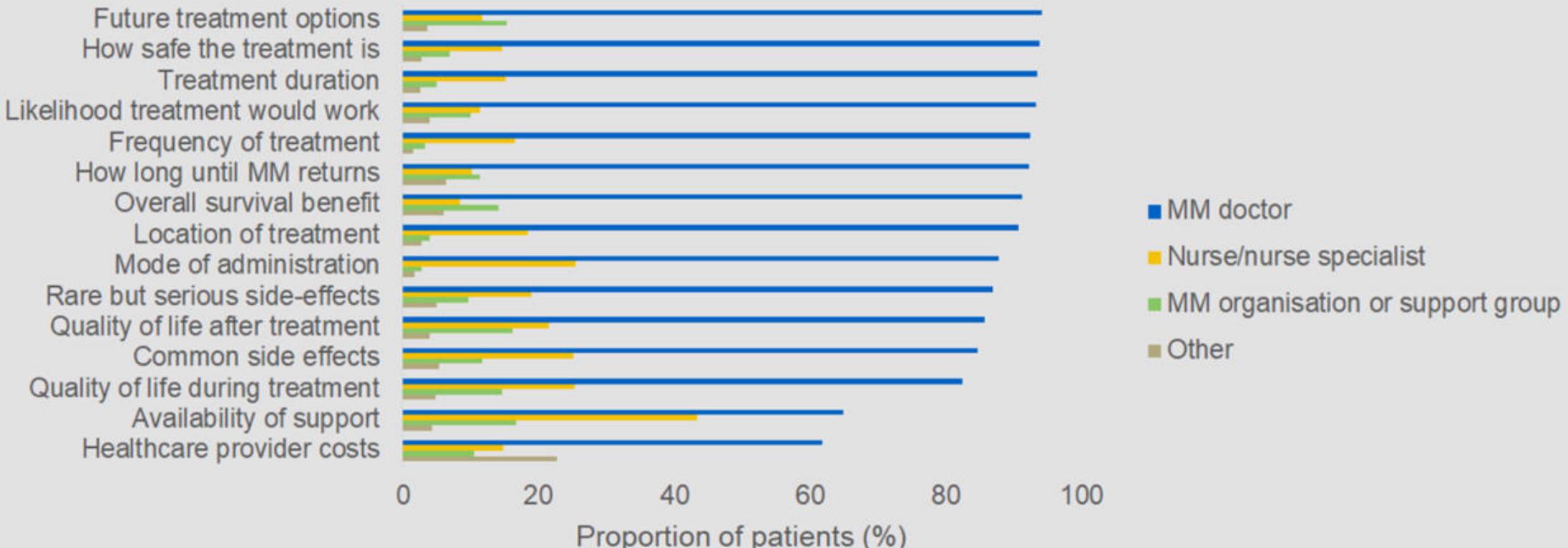


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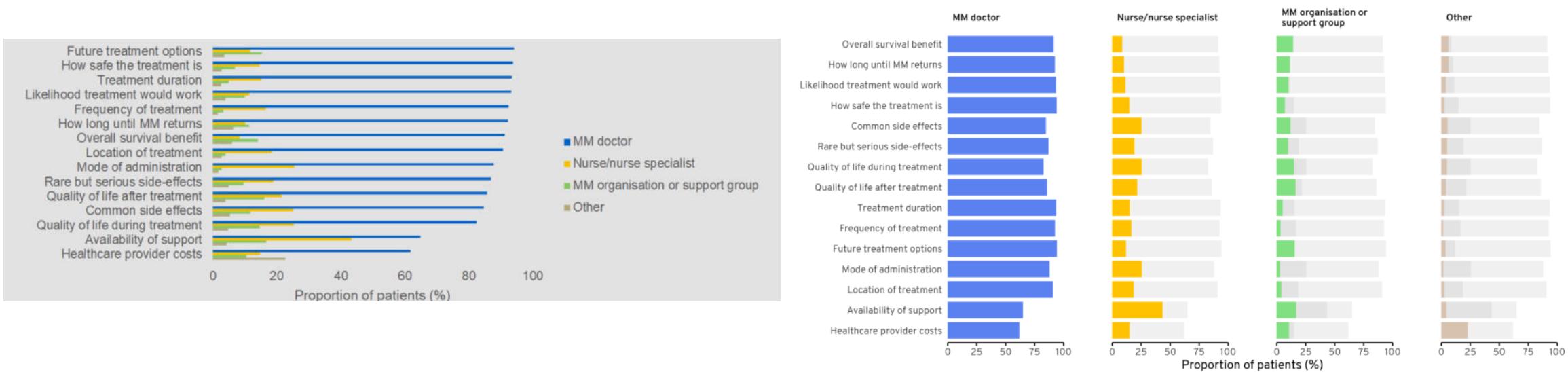


Source: Ernst & Young Global Limited | Makeover: Cedric Scherer, Frontpage Data

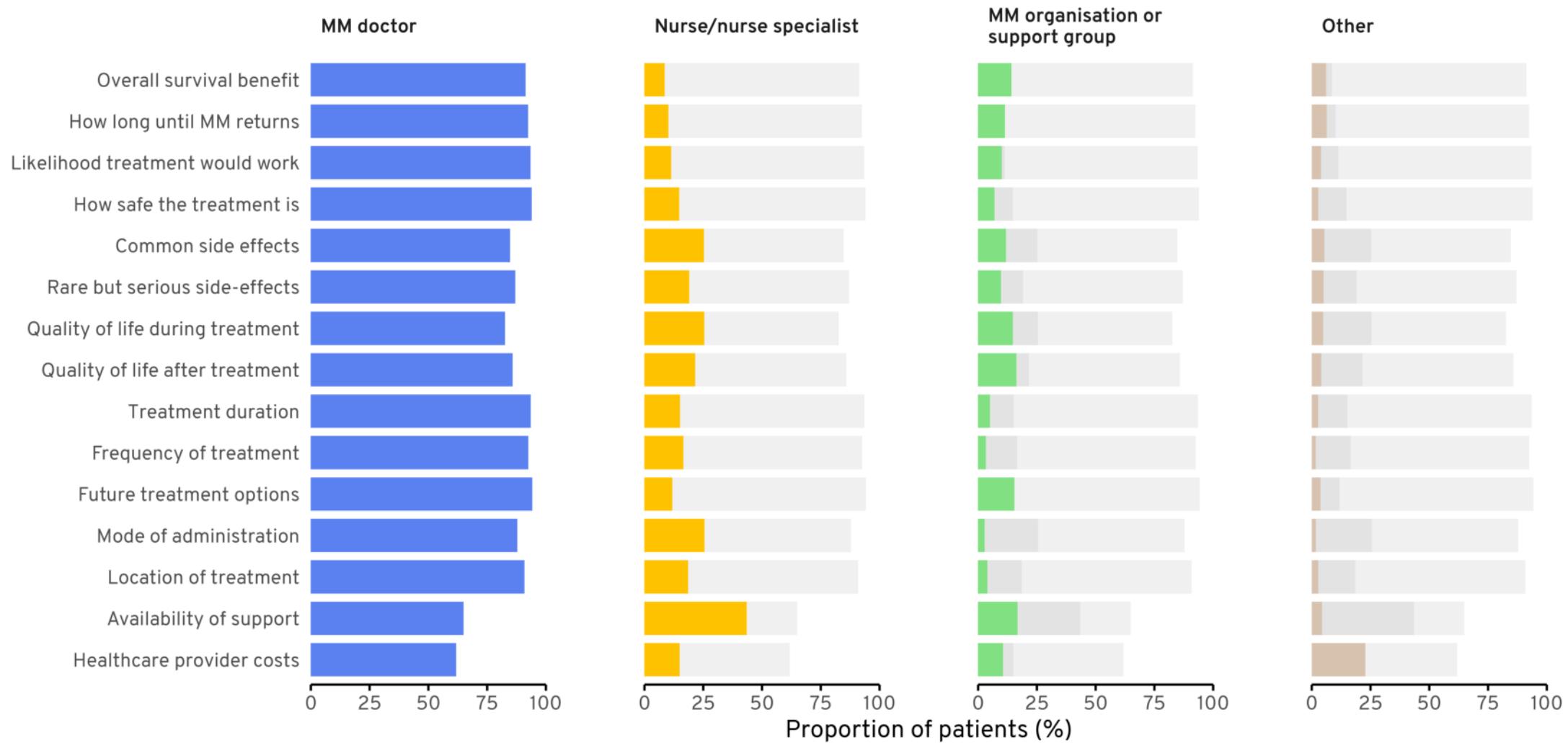
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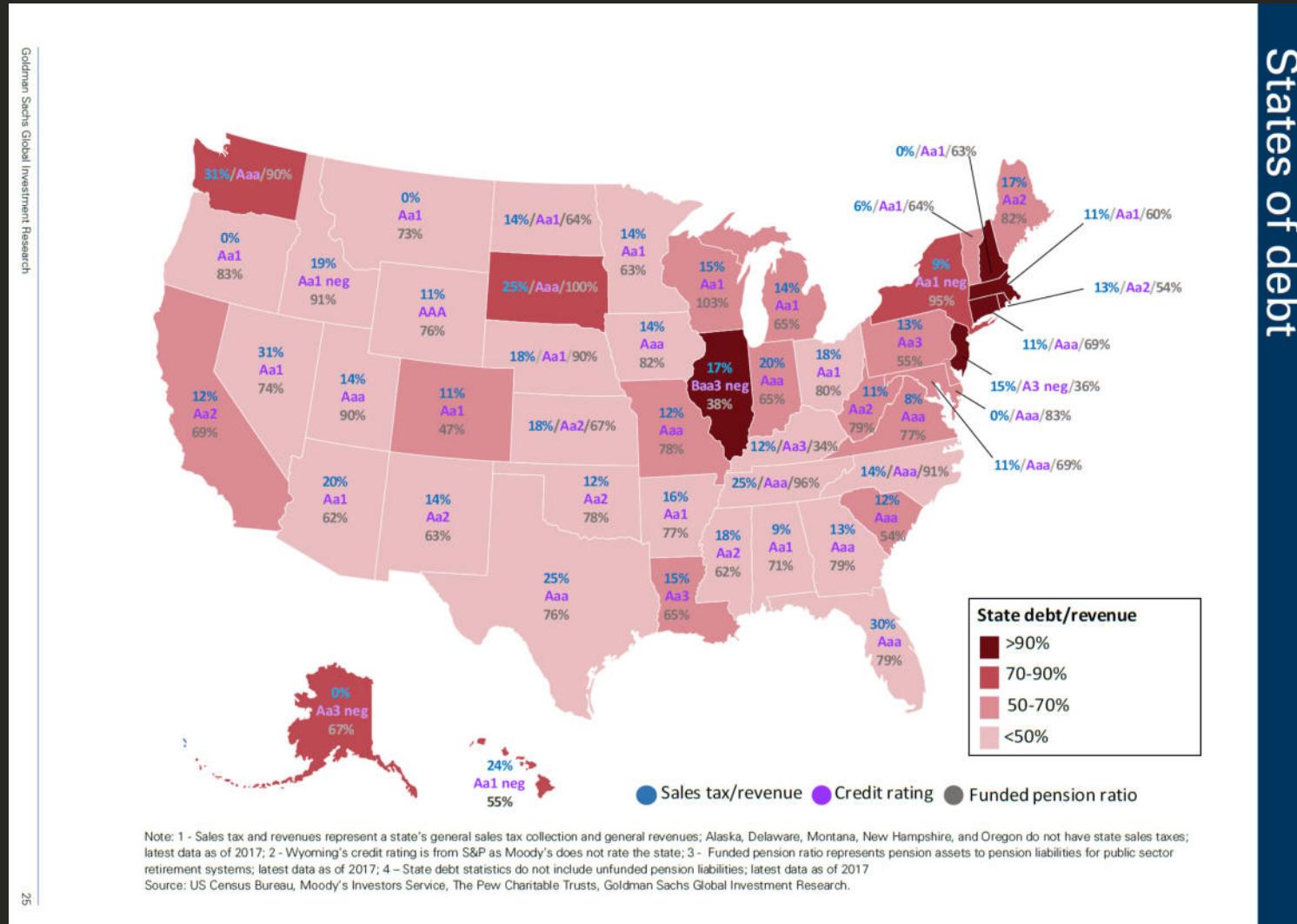
How to improve this visualization?



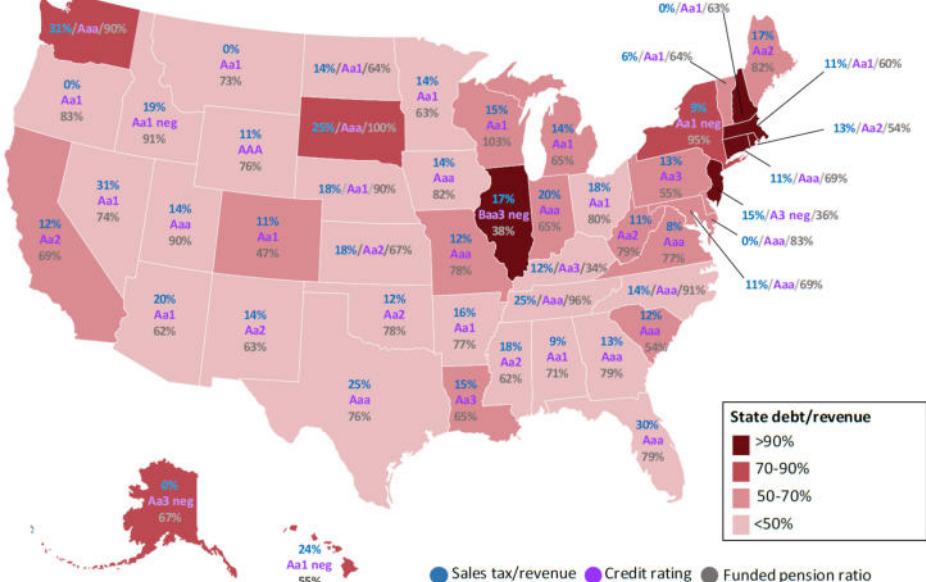
How to improve this visualization?



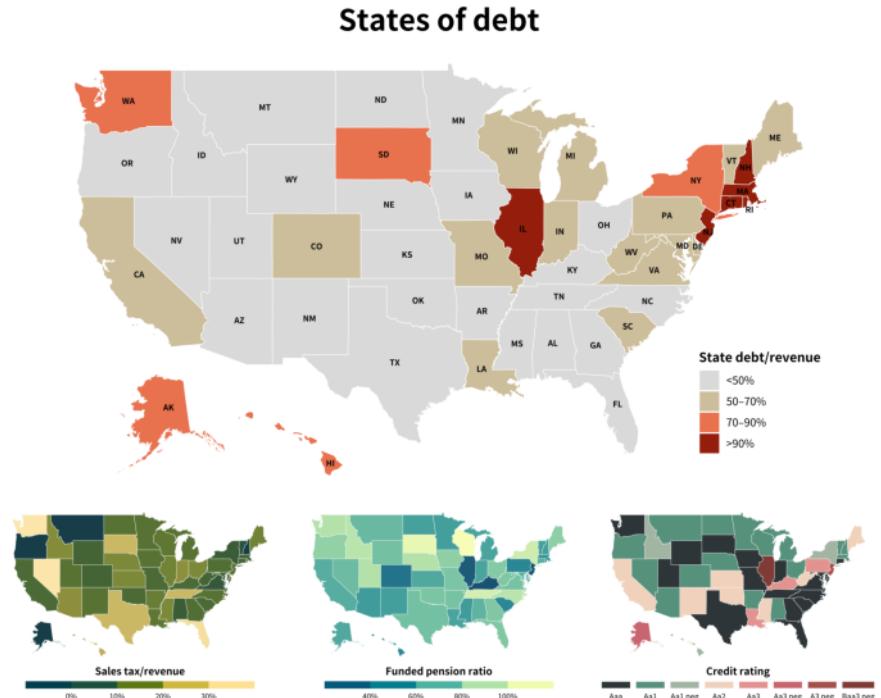
How to improve this visualization?



How to improve this visualization?



States of debt



Wrap-Up

Information

→ Understand your data and be accurate.

Story

→ Be clear about the message of your visualization.

Goal

→ Select charts that successfully transport your story.

Visual Form

→ Follow design rules and data visualization principles.

Design for Your Audience

- Choose charts based on your goal not tradition or novelty (only).
- Make sure your visualization is accessible for everyone (colors, readability).
- Use visual contrast to highlight important information.
- Provide meaningful labels and titles.

Be Honest

- Show raw data if possible.
- Don't truncate bar charts. Add spacing to truncated axes.
- Be consistent with axis scaling.

Lend A Helping Hand

- Use annotations and direct labels instead of/in addition to text and legends.
- Order your data, either by value or intrinsic ranking.
- Reveal information step by step (if applicable).

Books

- “[Avoiding Data Pitfalls](#)” by Ben Jones
- “[Data Visualization](#)”, an open-access book by Kieran Healy
- “[The Functional Art](#)”, “[The Truthful Art](#)”, and “[How Charts Lie](#)” by Alberto Cairo
- “[Better Data Visualizations](#)” by John Schwabisch
- “[Storytelling with Data](#)” by Cole Nussbaumer Knaflic
- “[Data Visualization Handbook](#)” by Juuso Koponen & Jonatan Hildén
- “[Fundamentals of Data Visualization](#)”, an open-access book by Claus Wilke

Blogs

- “[Nightingale](#)”, the journal of the Data Visualization Society
- “[Chartable](#)”, the blog by DataWrapper

Chart Choice Helpers

- [From Data to Viz](#)
- [DataViz Project](#)
- [Visualizaiton Universe](#)
- [Material Design](#)

Color Choice Helpers

- [Viz Palette](#) by Elijah Meeks & Susie Lu
- “[How to pick more beautiful colors for your data visualizations](#)” by Lisa Charlotte Muth/Data Wrapper