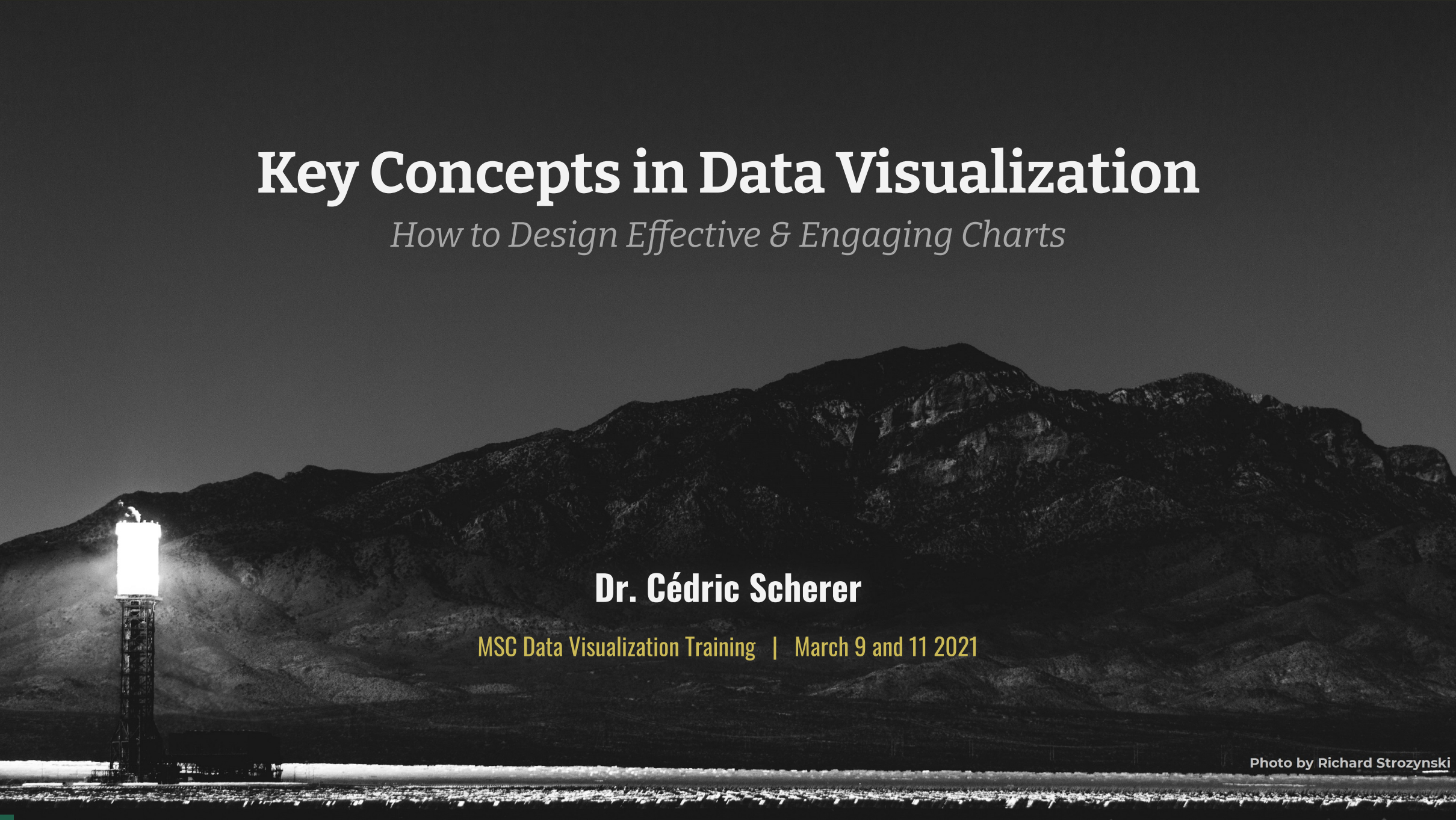
Key Concepts in Data Visualization

How to Design Effective & Engaging Charts



Dr. Cédric Scherer

MSC Data Visualization Training | March 9 and 11 2021

Photo by Richard Strozynski

RECAP

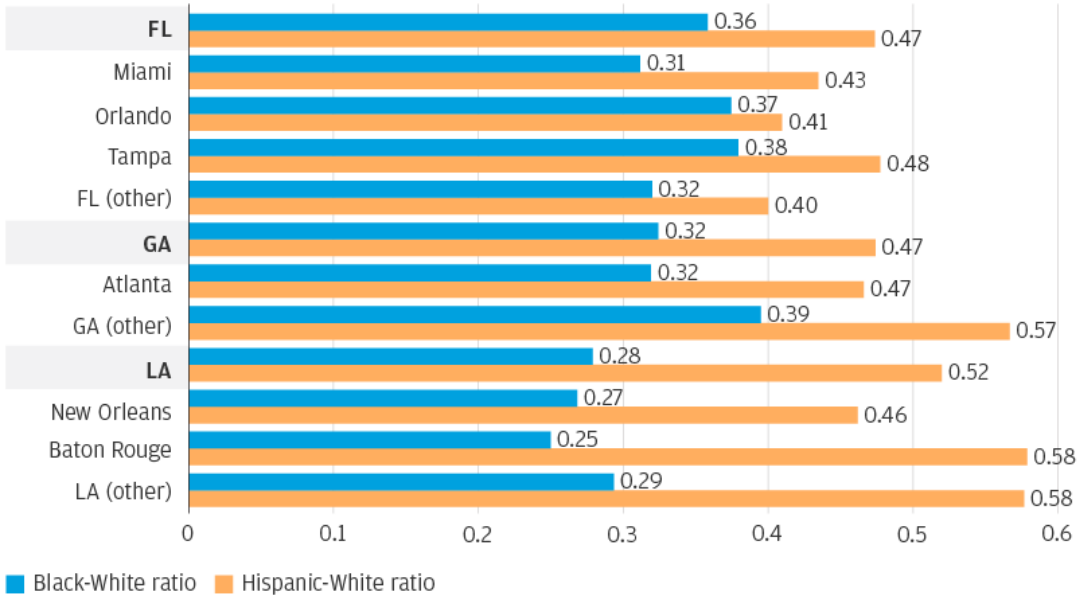
Data Visualization

helps to amplify cognition, gain insights, discover, explain, and make decisions.

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

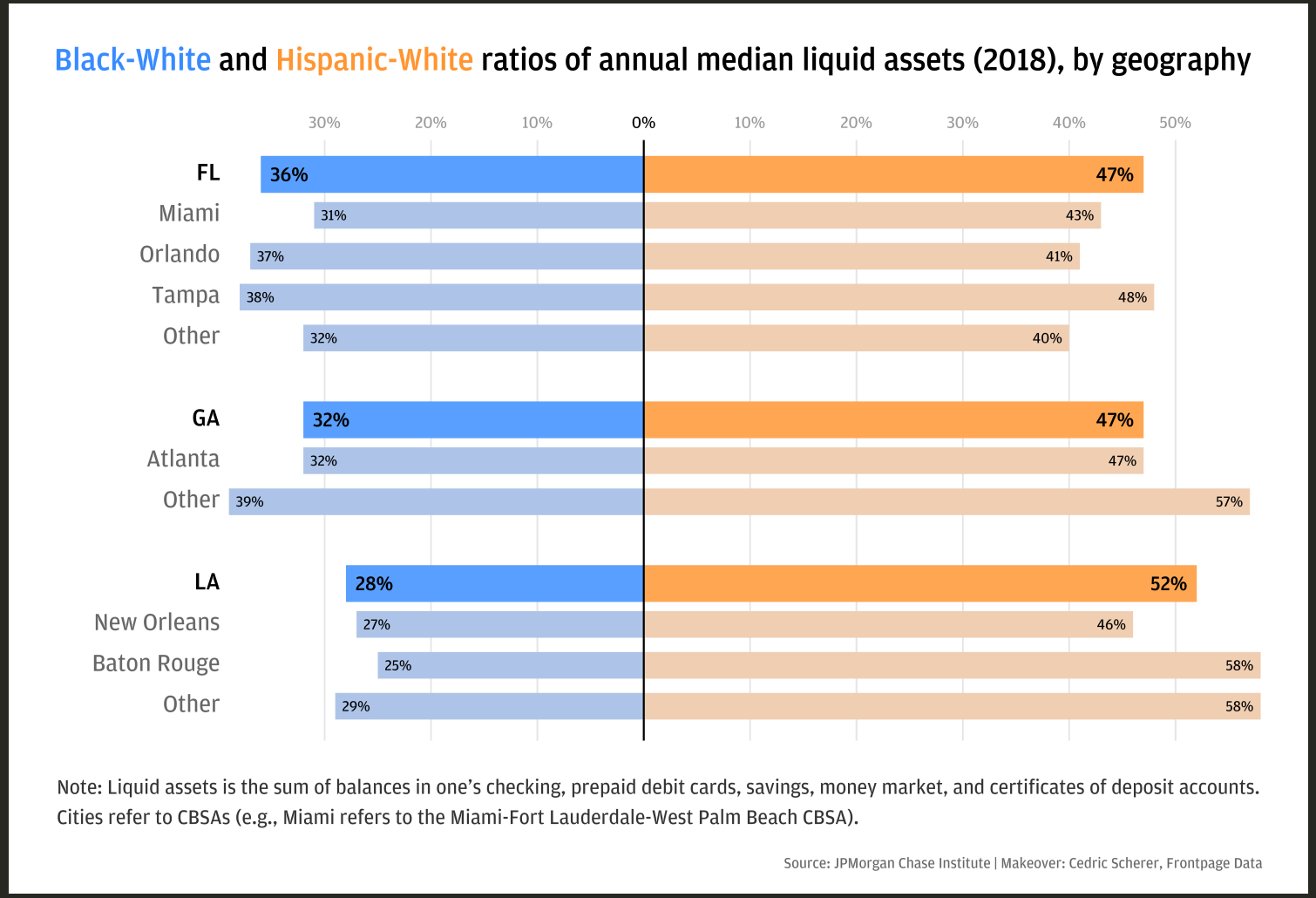


Note: Liquid assets is the sum of balances in one's checking, prepaid debit cards, savings, money market, and certificates of deposit accounts. Cities refer to CBSAs (e.g., Miami refers to the Miami-Fort Lauderdale-West Palm Beach CBSA).

Source: JPMorgan Chase Insitute

View the Text Version >

How to improve this visualization?



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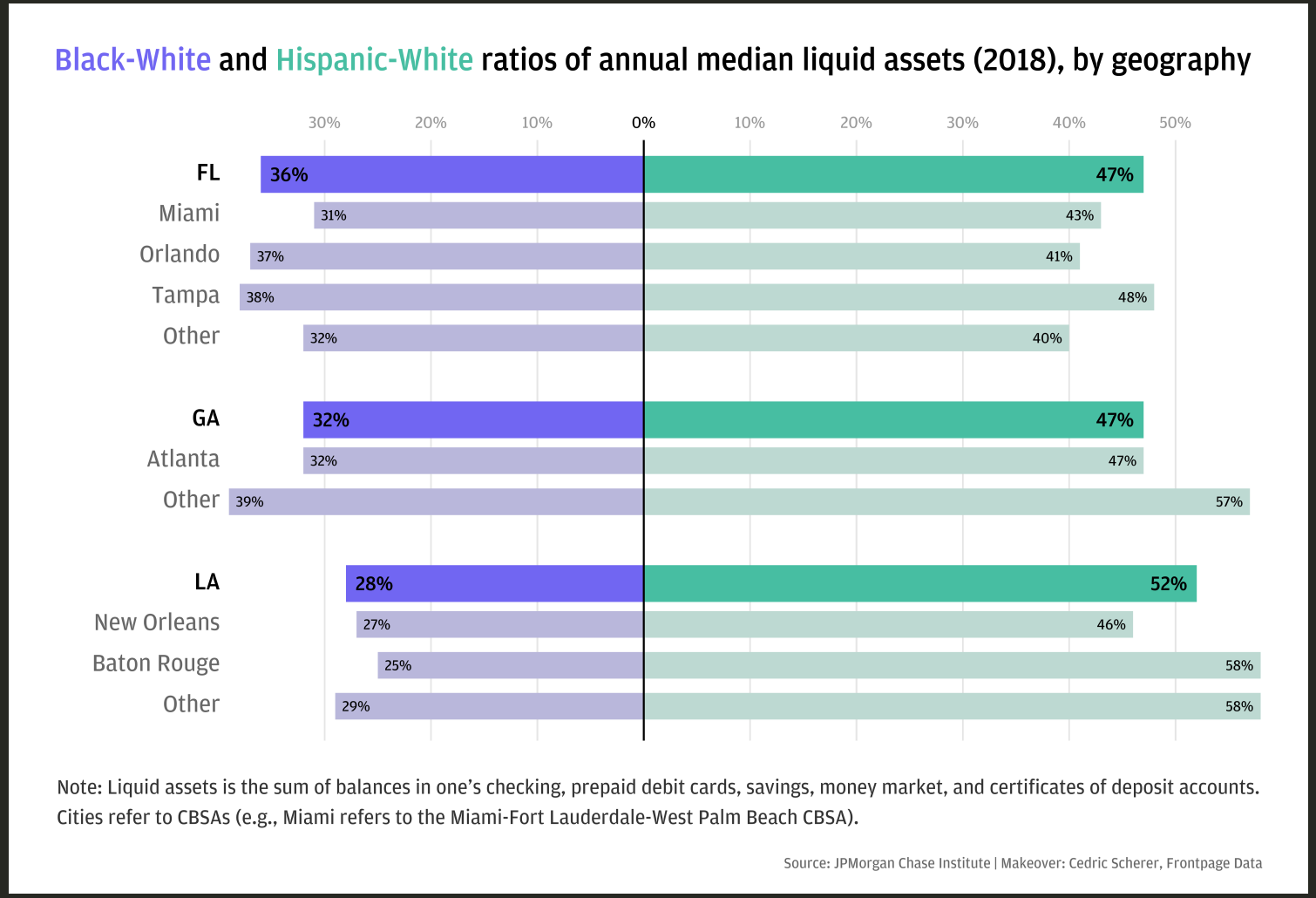

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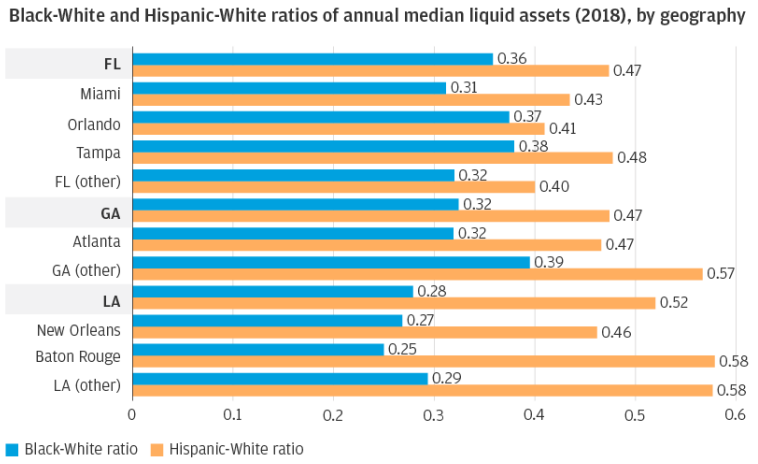

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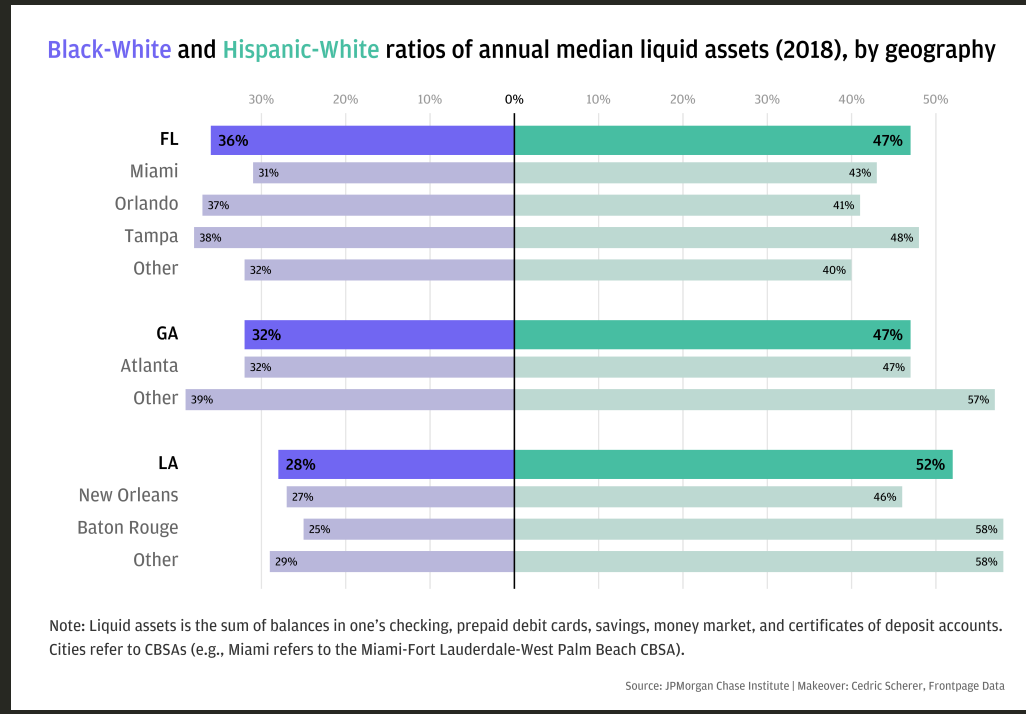
Source: JPMorgan Chase Insitute

View the Text Version >



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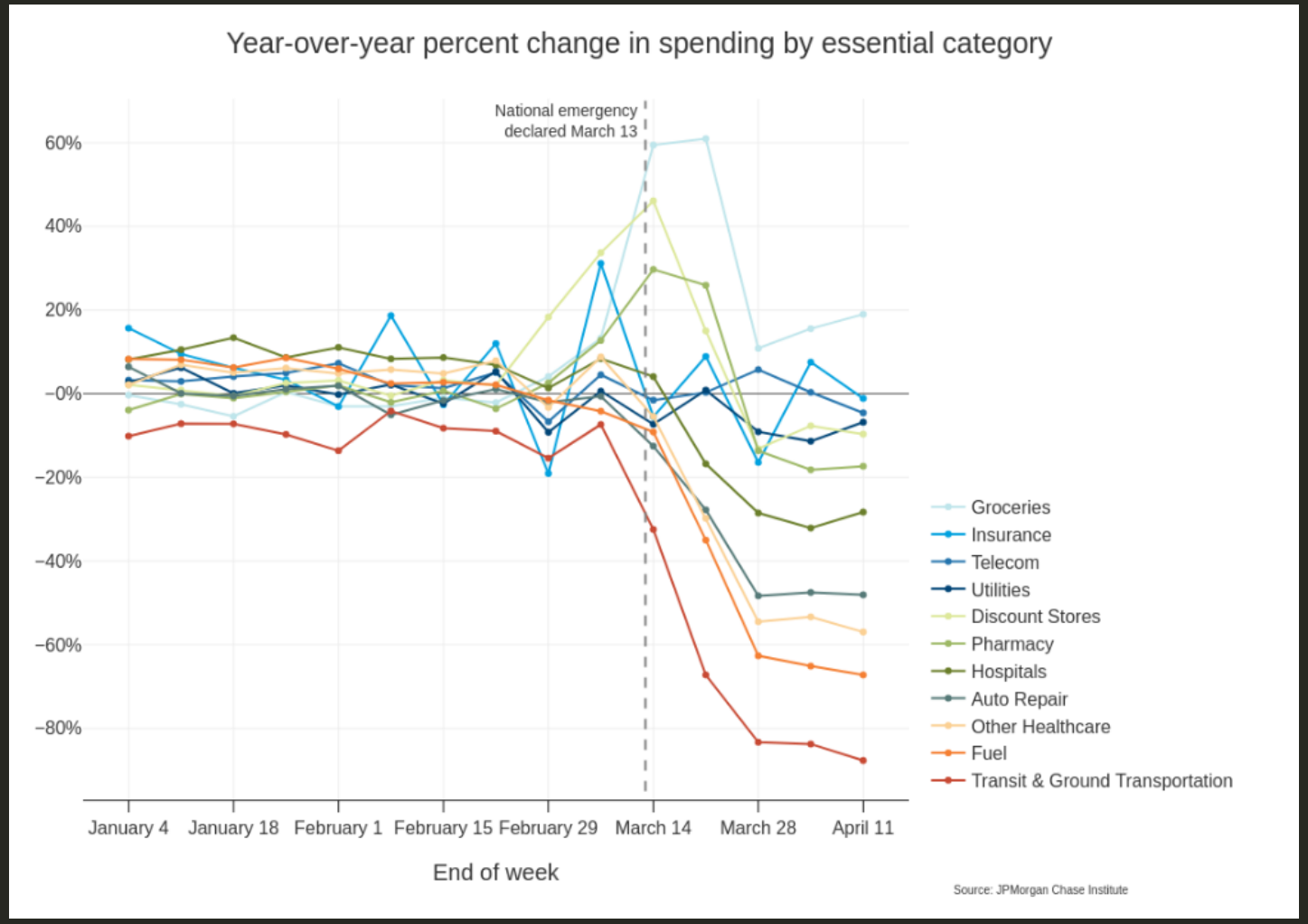
Source: JPMorgan Chase Institute | Makeover: Cedric Scherer, Frontpage Data

How to improve this visualization?



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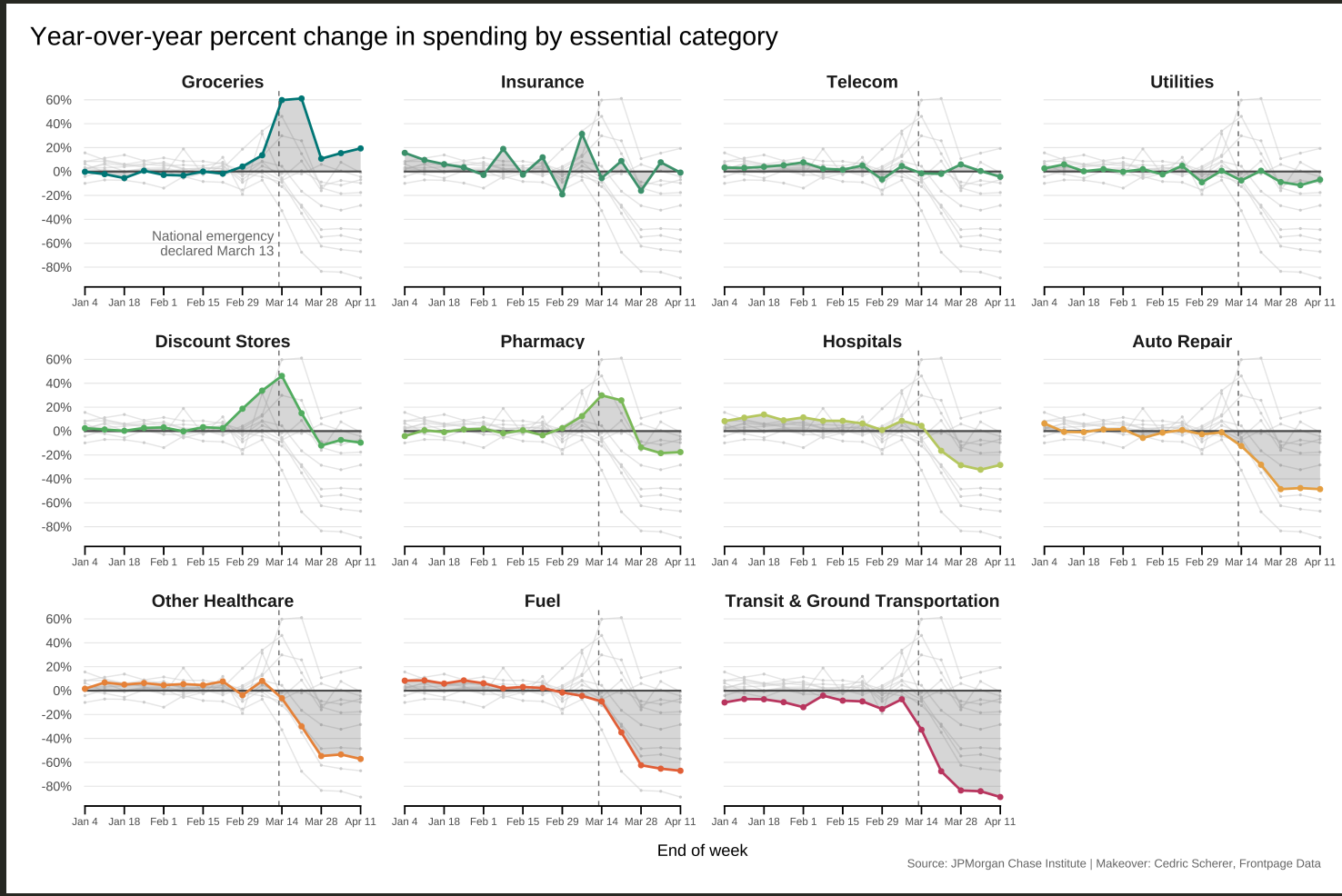

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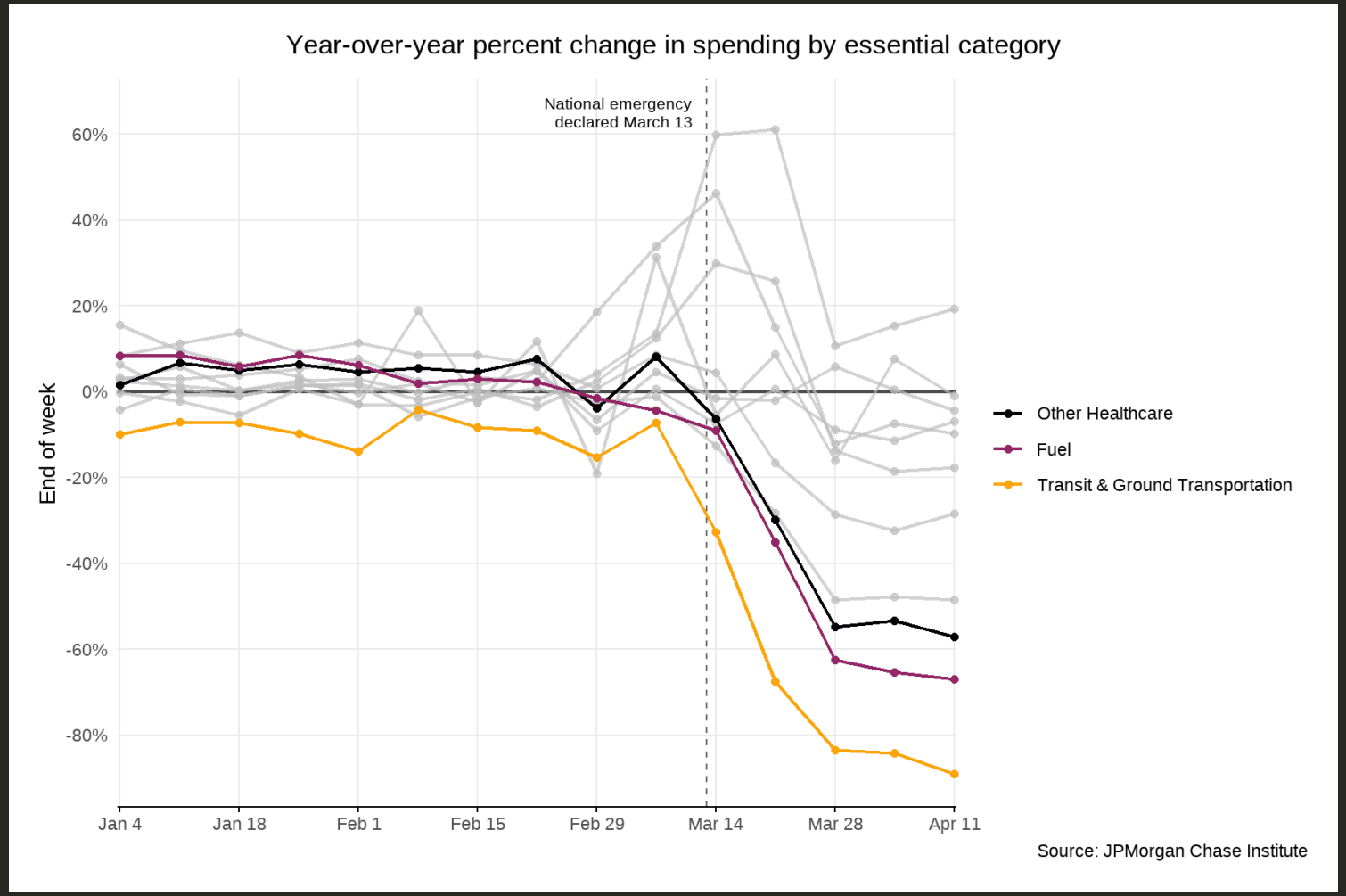

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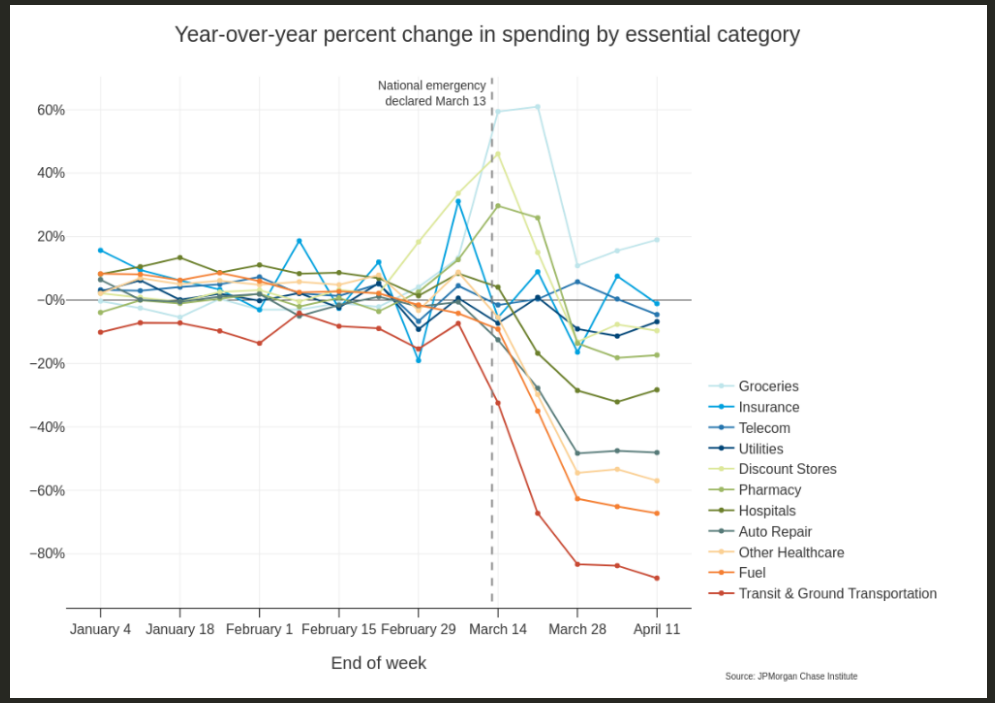

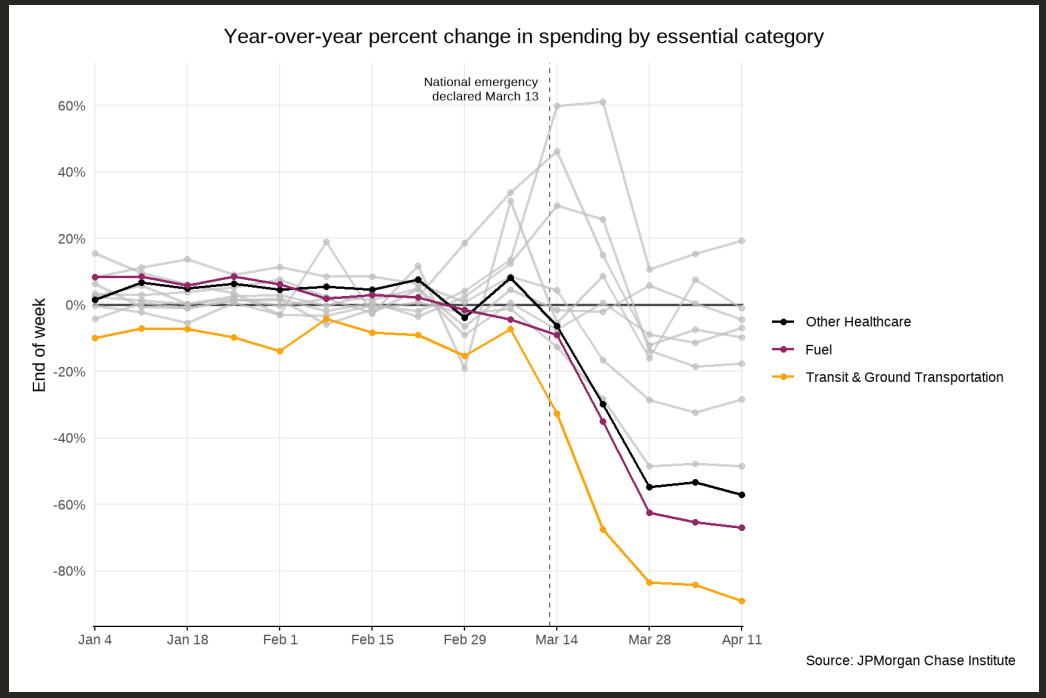

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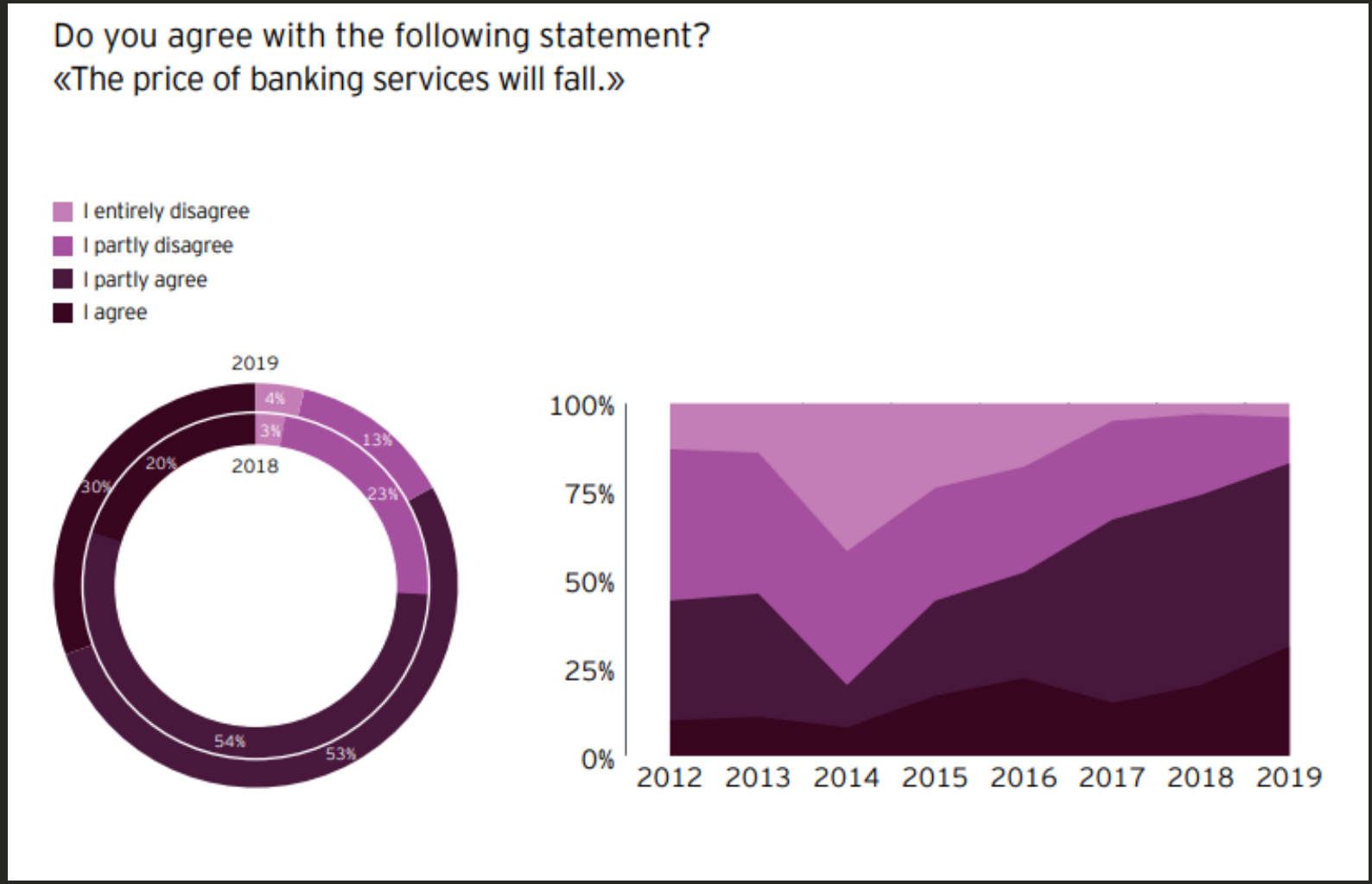

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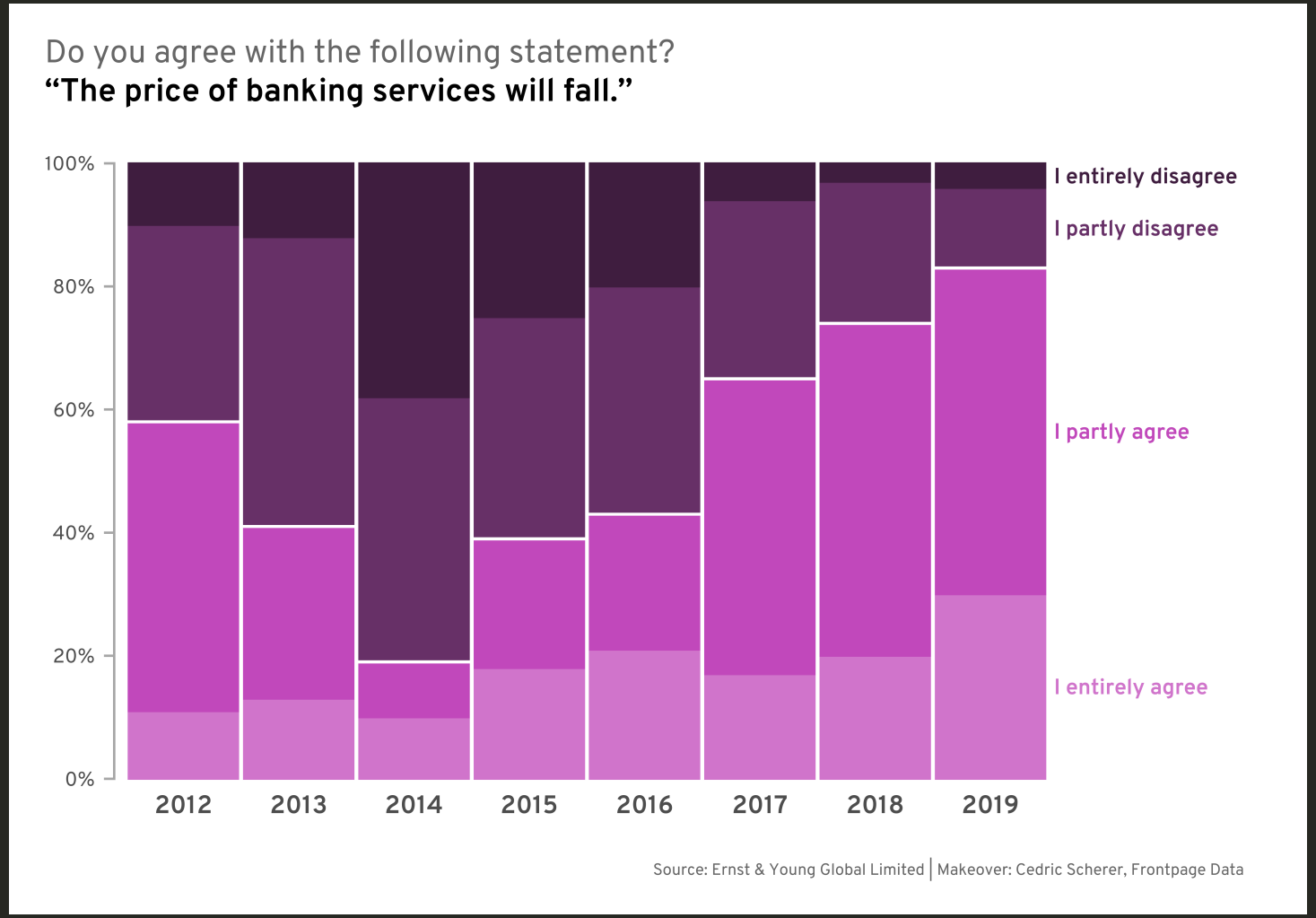

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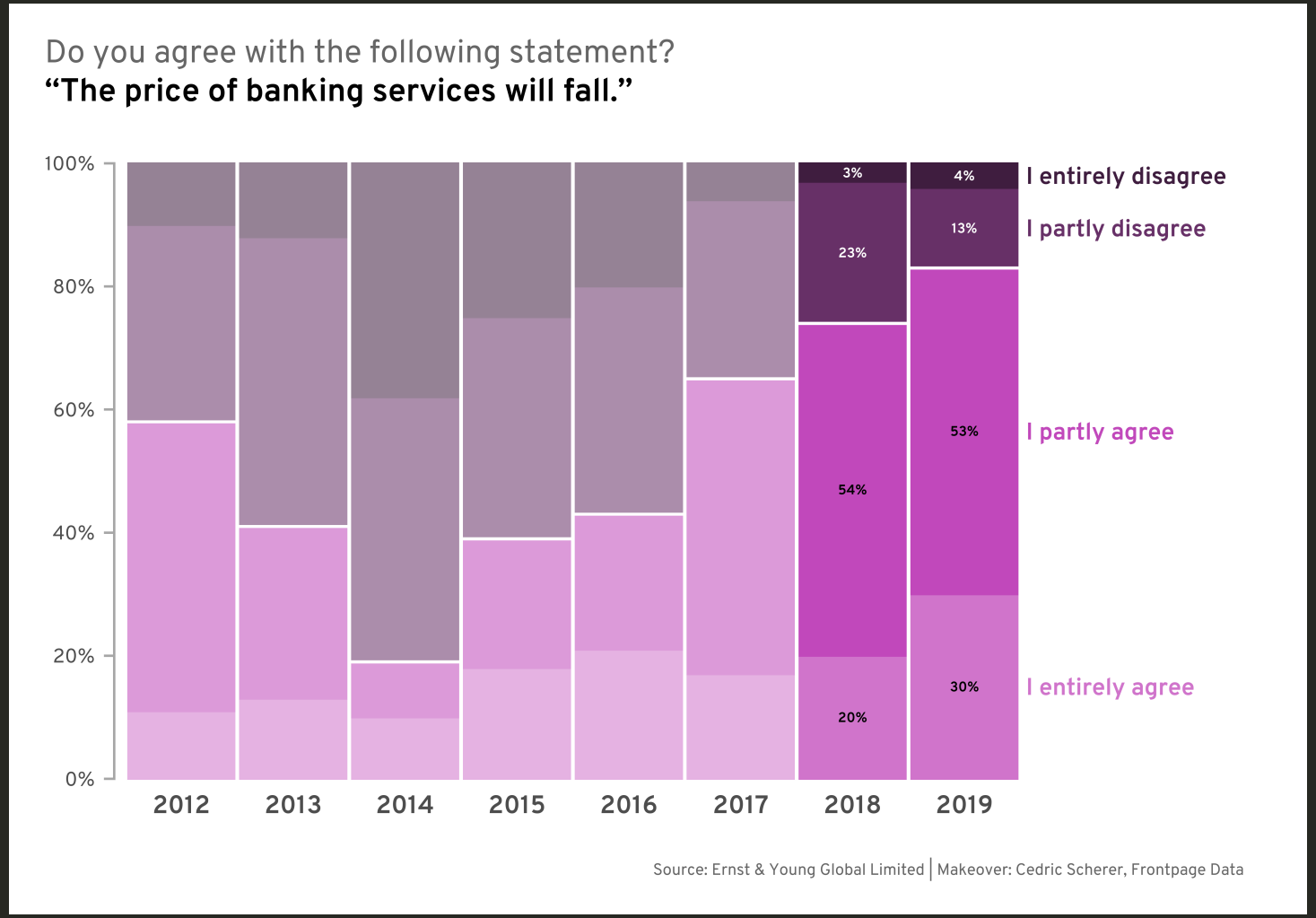

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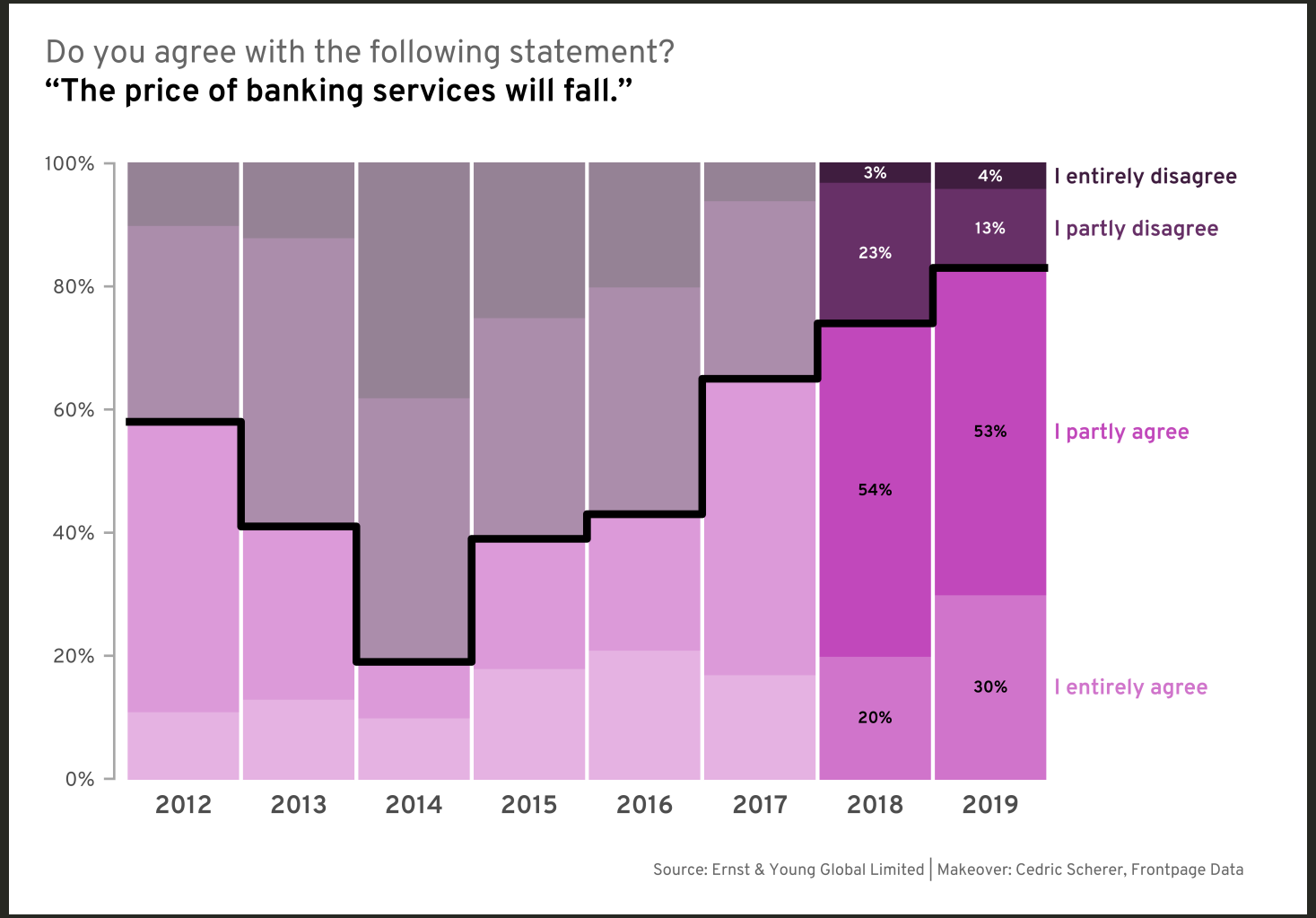

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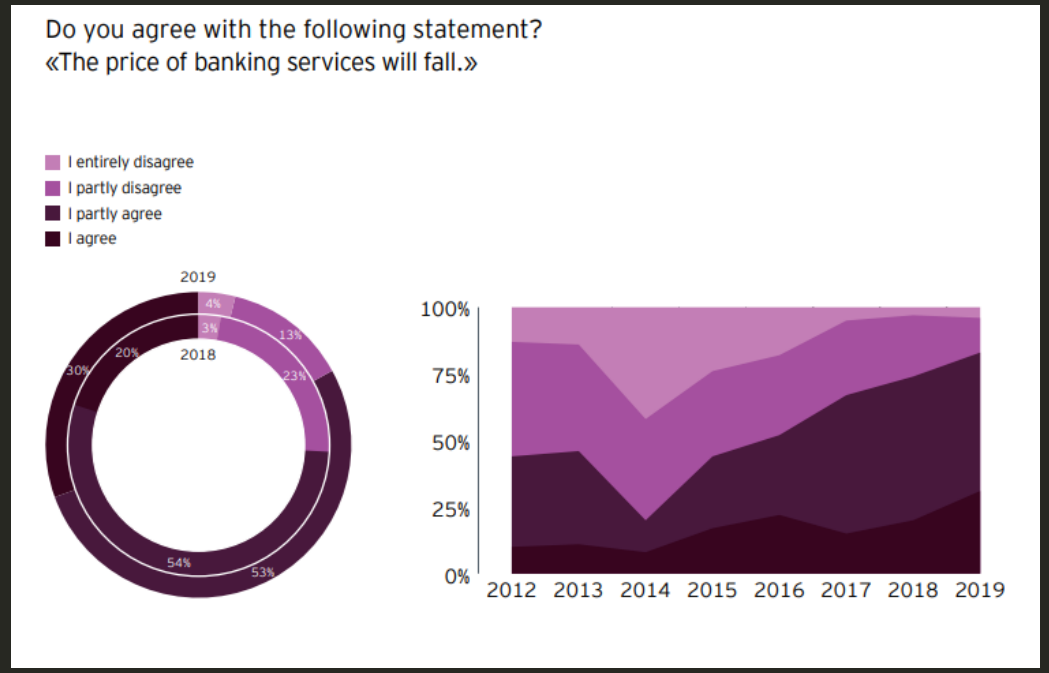
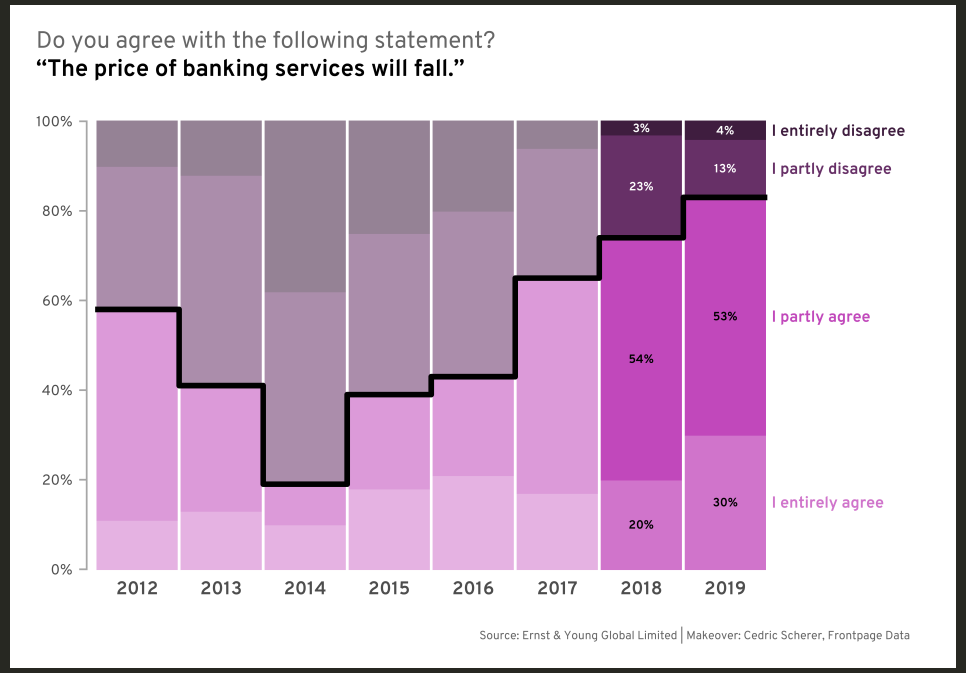




What Makes It a Good Data Visualization

→ **Information** (Integrity)

→ **Story** (Interestingness)

→ **Goal** (Usefulness)

→ **Visual Form** (Beauty)

VISUAL FORM

Follow design rules and data visualization principles

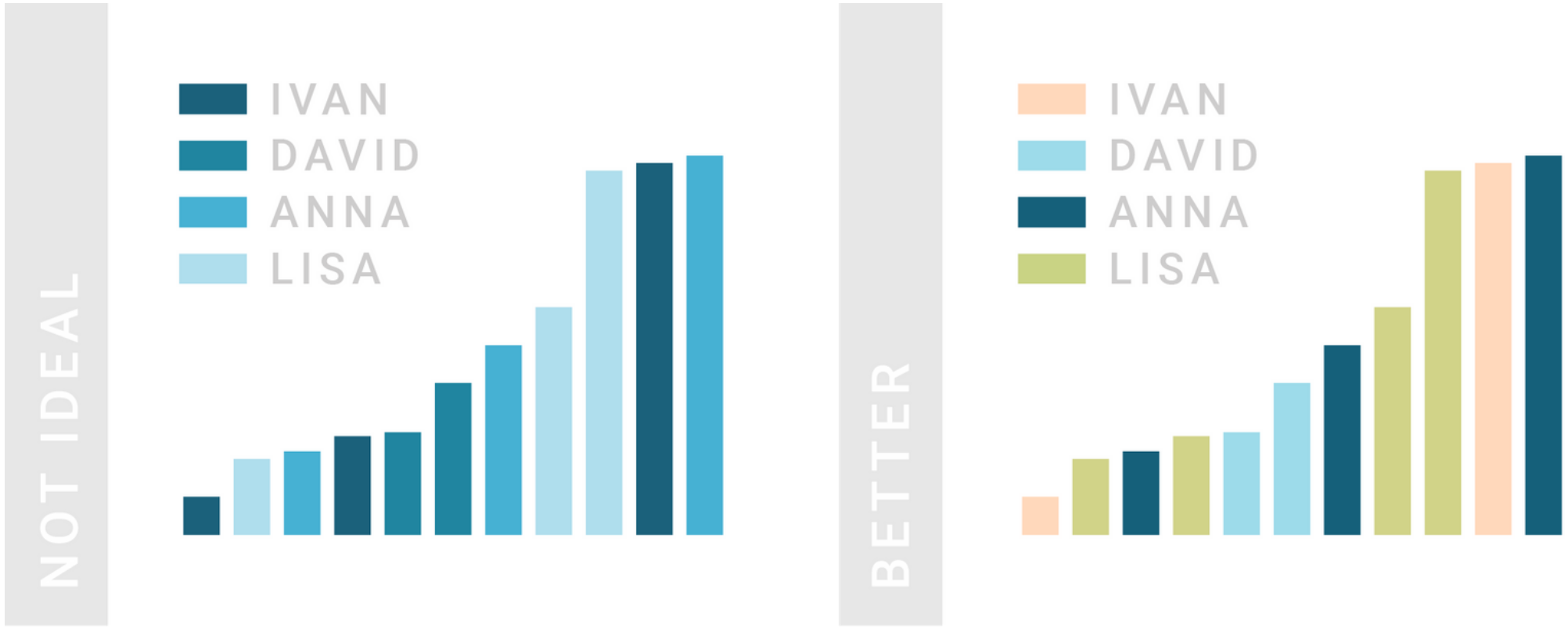

Colors
and Common Pitfalls

Color Choice & Accessibility

NOT IDEAL

What to consider when choosing colors for data visualization *by Lisa Charlotte Rost/DataWrapper*

Color Choice & Accessibility



What to consider when choosing colors for data visualization *by Lisa Charlotte Rost/DataWrapper*

Color Palette Types

Categorical

Color Palette Types

Categorical

Sequential: Single-Hue

Color Palette Types

Categorical

default_uchicago

Sequential: Single-Hue

cyan_material

Sequential: Multi-Hue

Sunset

Color Palette Types

Categorical

default_uchicago

Sequential: Single-Hue

cyan_material

Sequential: Multi-Hue

Sunset

Diverging

Geyser

Color Palette Types

Categorical

default_uchicago

Sequential: Single-Hue

cyan_material

Sequential: Multi-Hue

Sunset

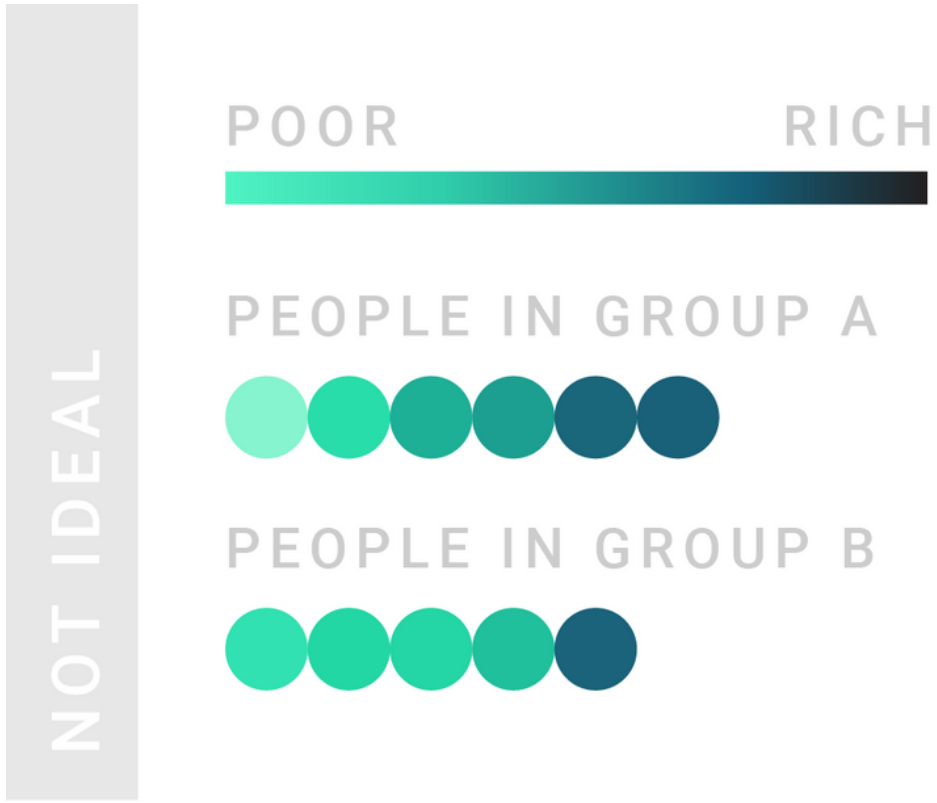
Diverging

Geyser

Cyclical

ocean.phase

Color Choice & Accessibility



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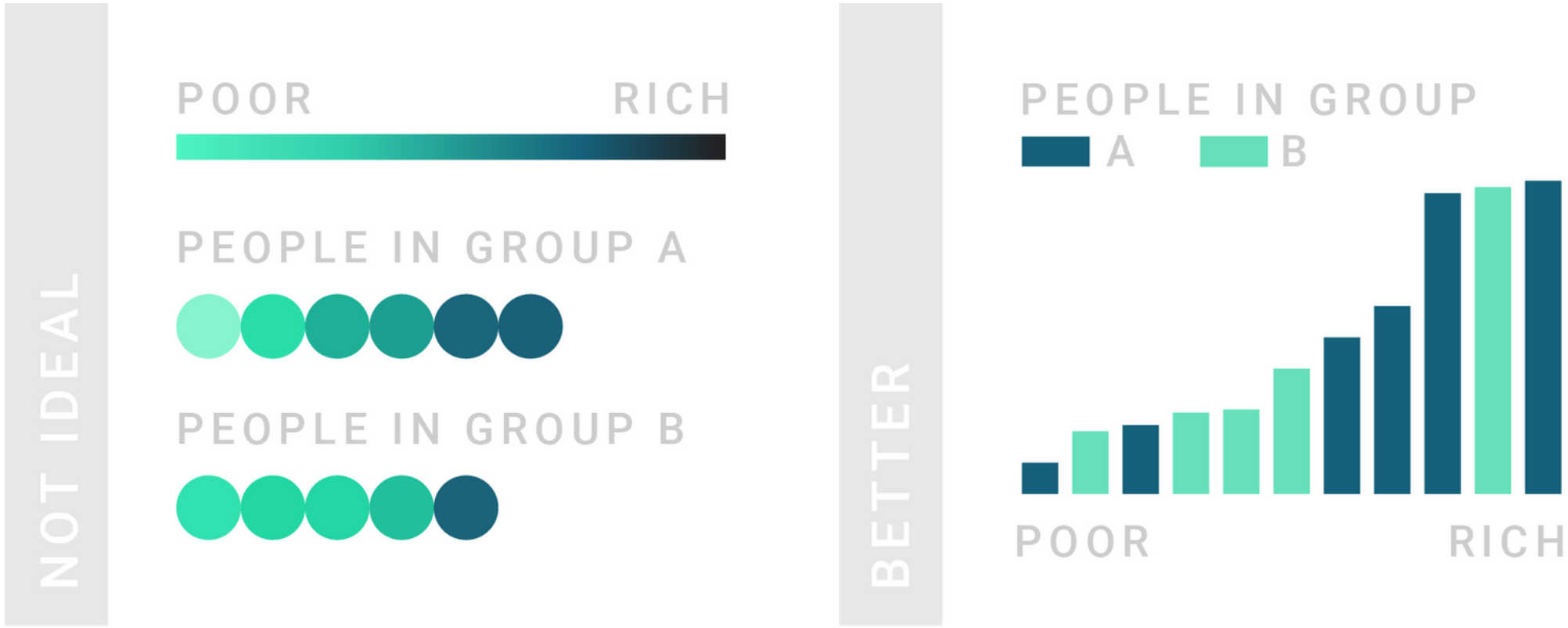

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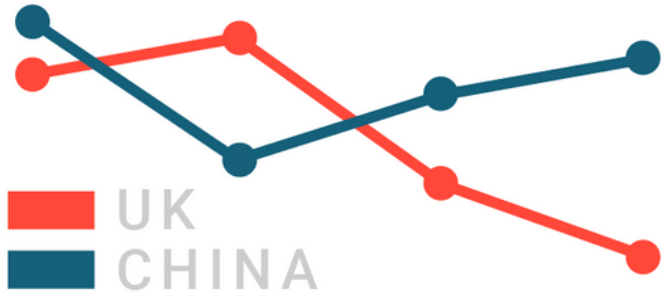

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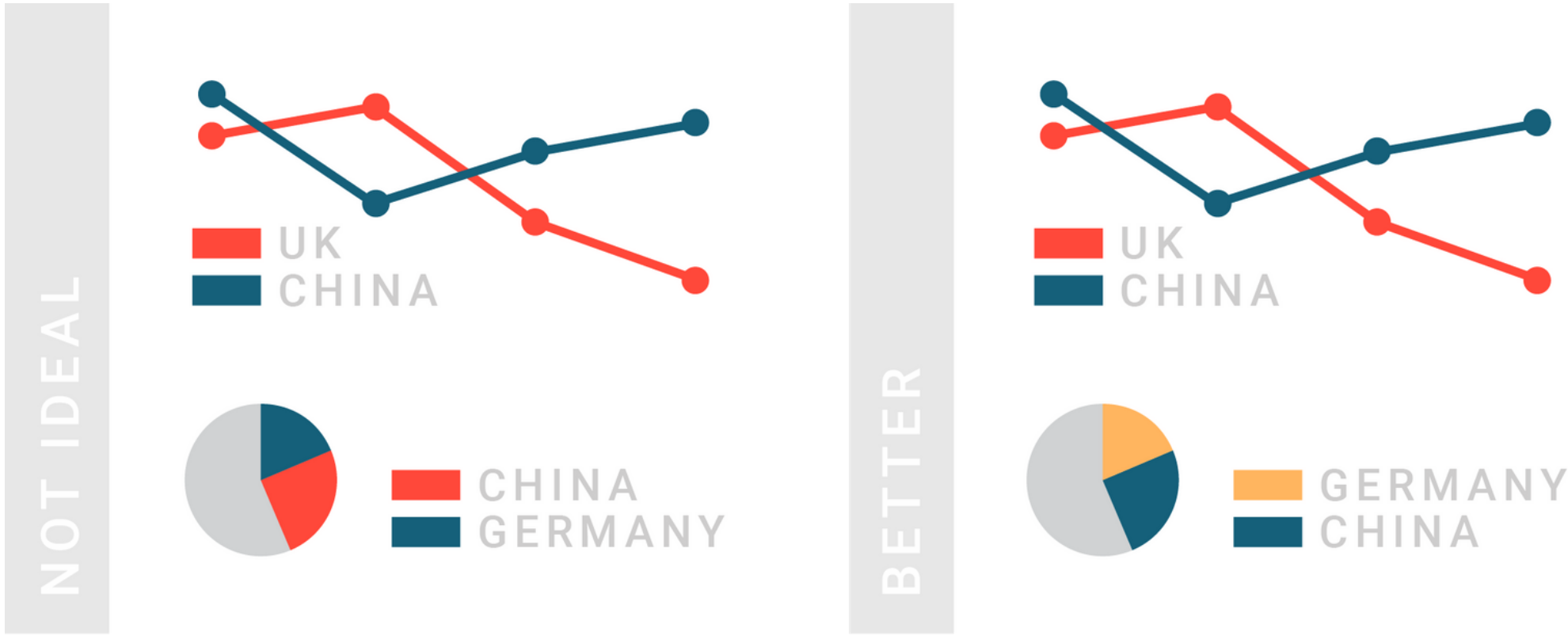

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Journals & Magazines > IEEE Computer Graphics and Ap... > Volume: 27 Issue: 2

Rainbow Color Map (Still) Considered Harmful

Publisher: IEEE

2 Author(s) David Borland ; Russell M. Taylor Ii **View All Authors**

172	3	9091
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Medical Physics

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Med Phys. 2015 Jun; 42(6): 2942–2954.
Published online 2015 May 20. doi: 10.1118/1.4921125
PMCID: PMC5148121
PMID: 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

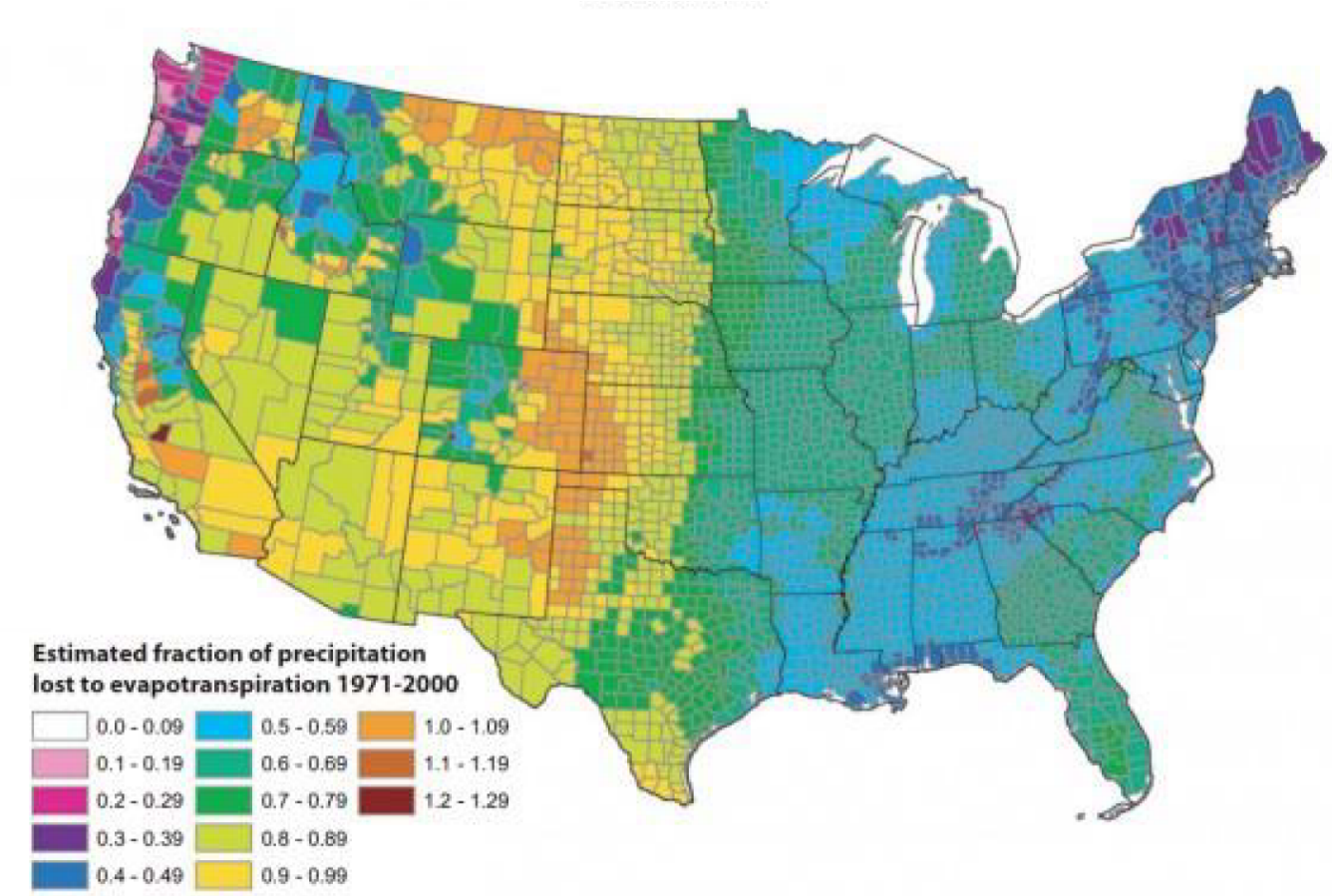
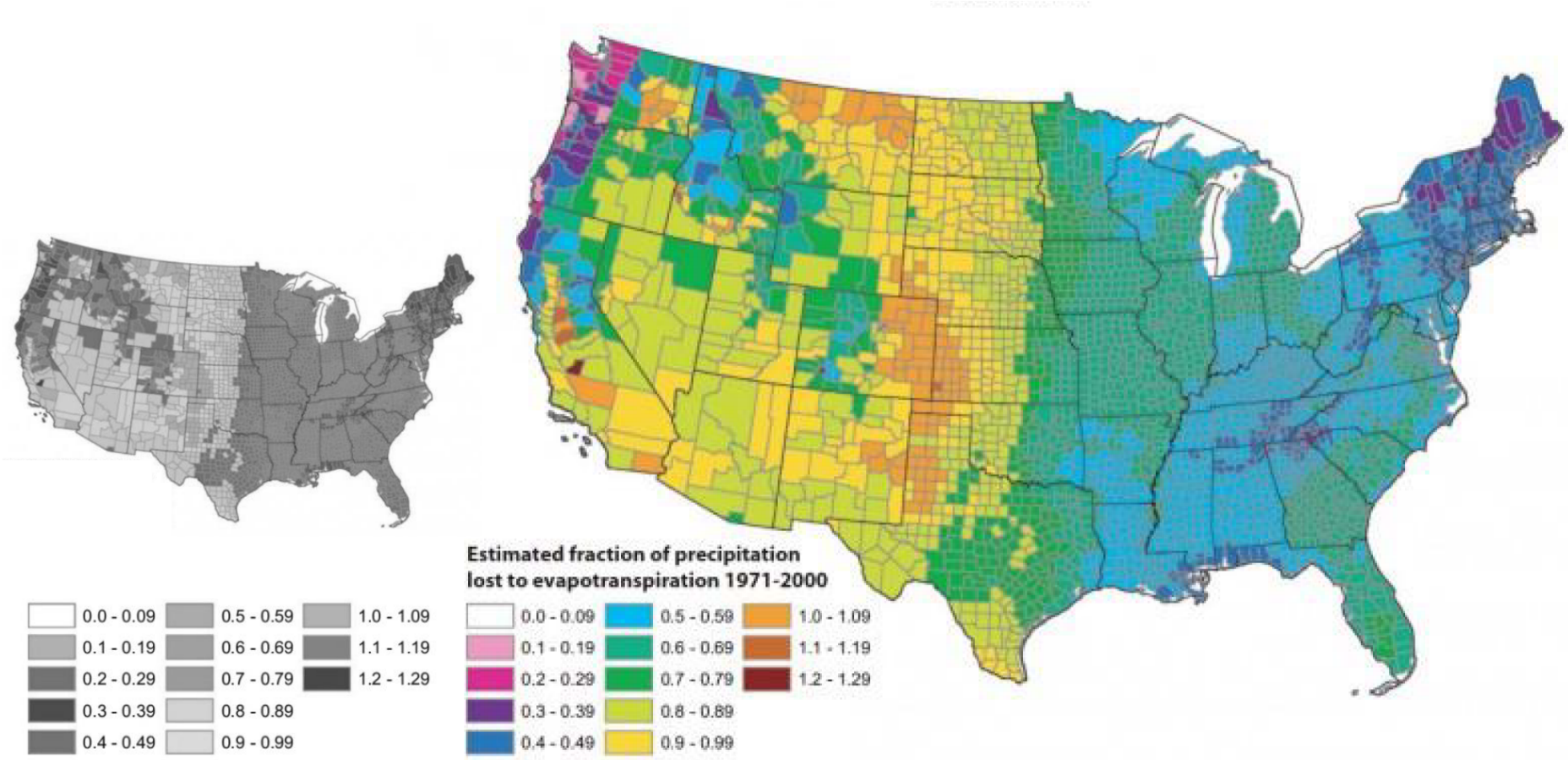


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM 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.

eagereyes.org/basicss/rainbow-color-map



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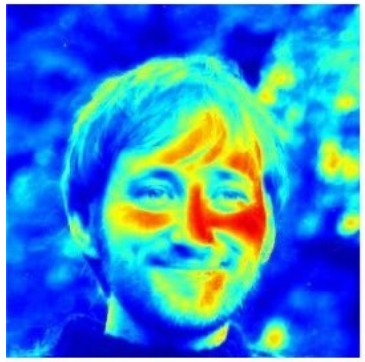
Modified from eagereyes.org/basicss/rainbow-color-map

true-colour Phil

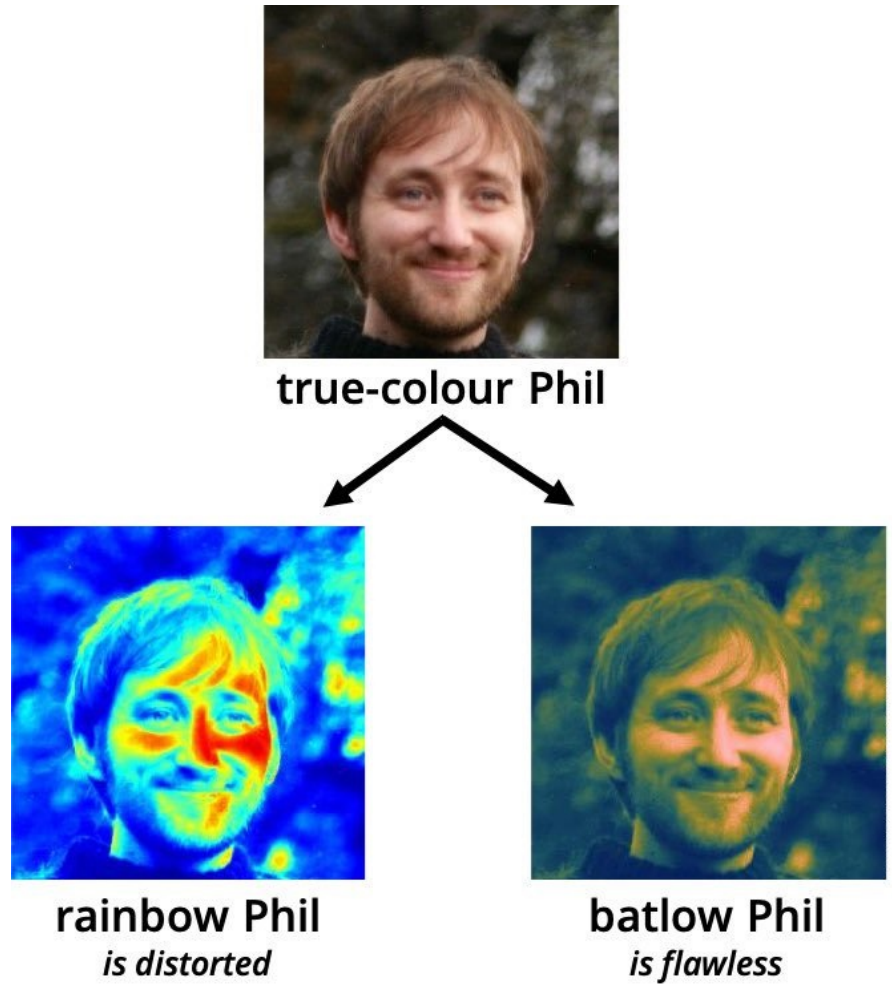
true-colour Phil



rainbow Phil

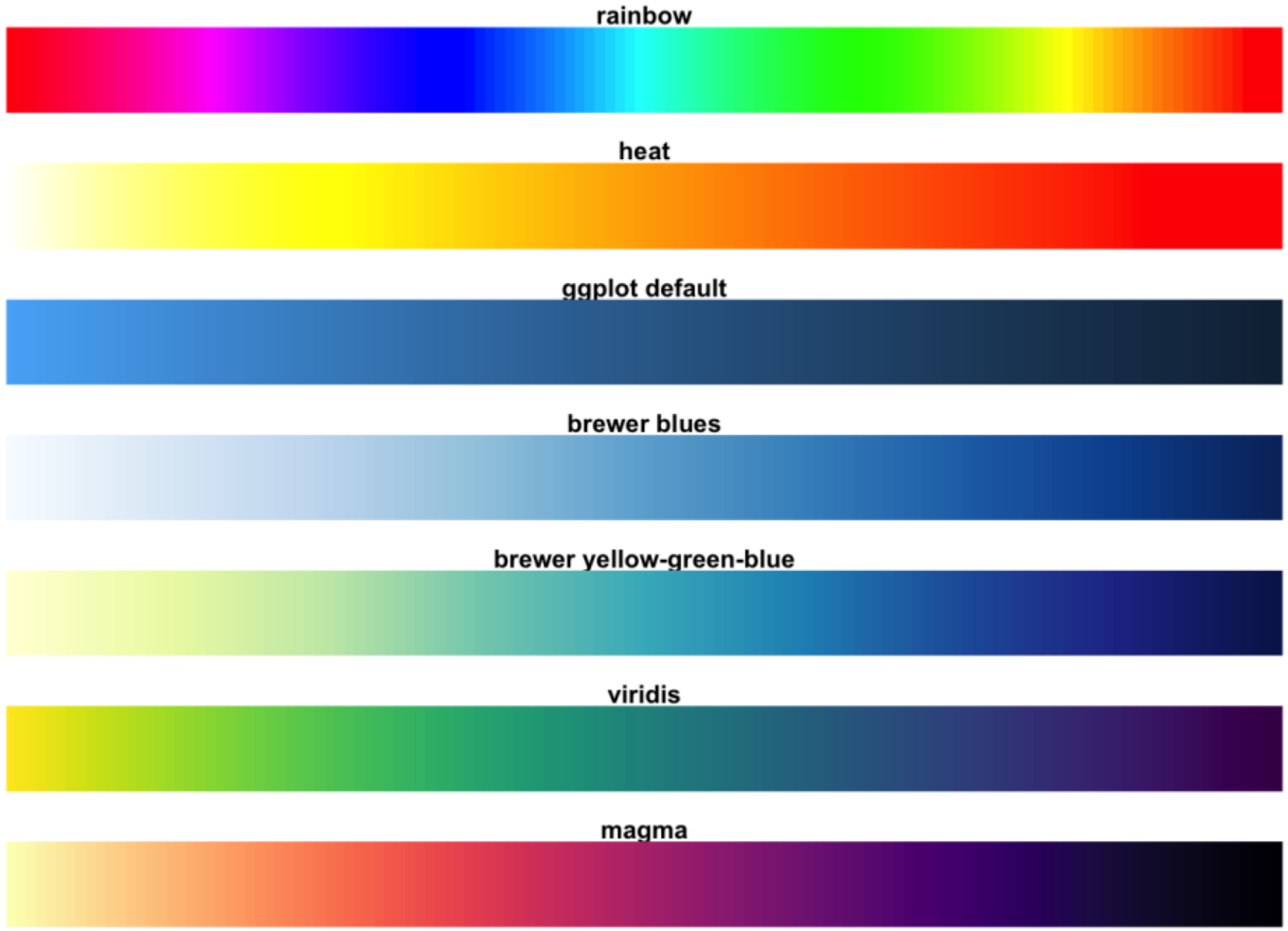
is distorted

Fabio Crameri



Fabio Crameri

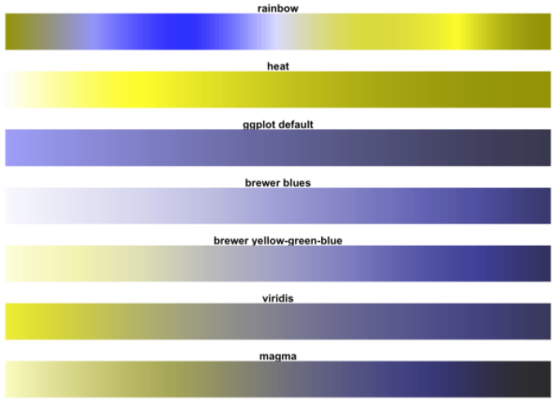
Color Choice & Accessibility



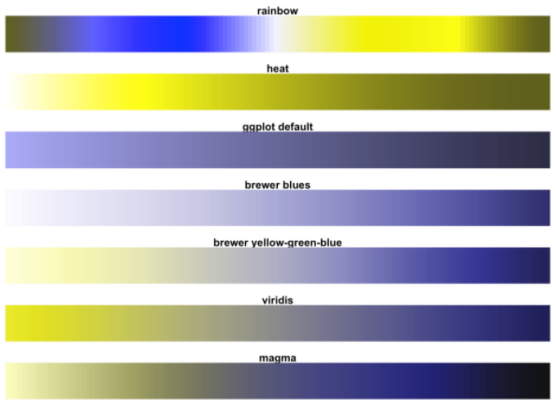
Vignette {viridis} package

Color Choice & Accessibility

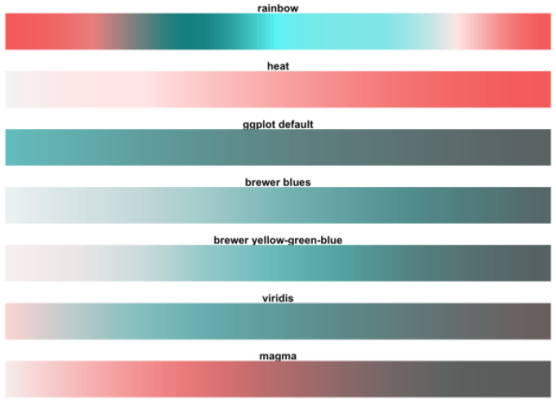
Deutranopia: present in 6% of males



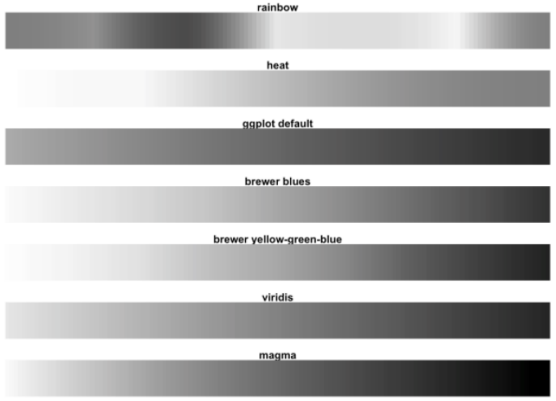
Protanopia: present in 1% of males



Tritanopia: present in 0.008% of humans

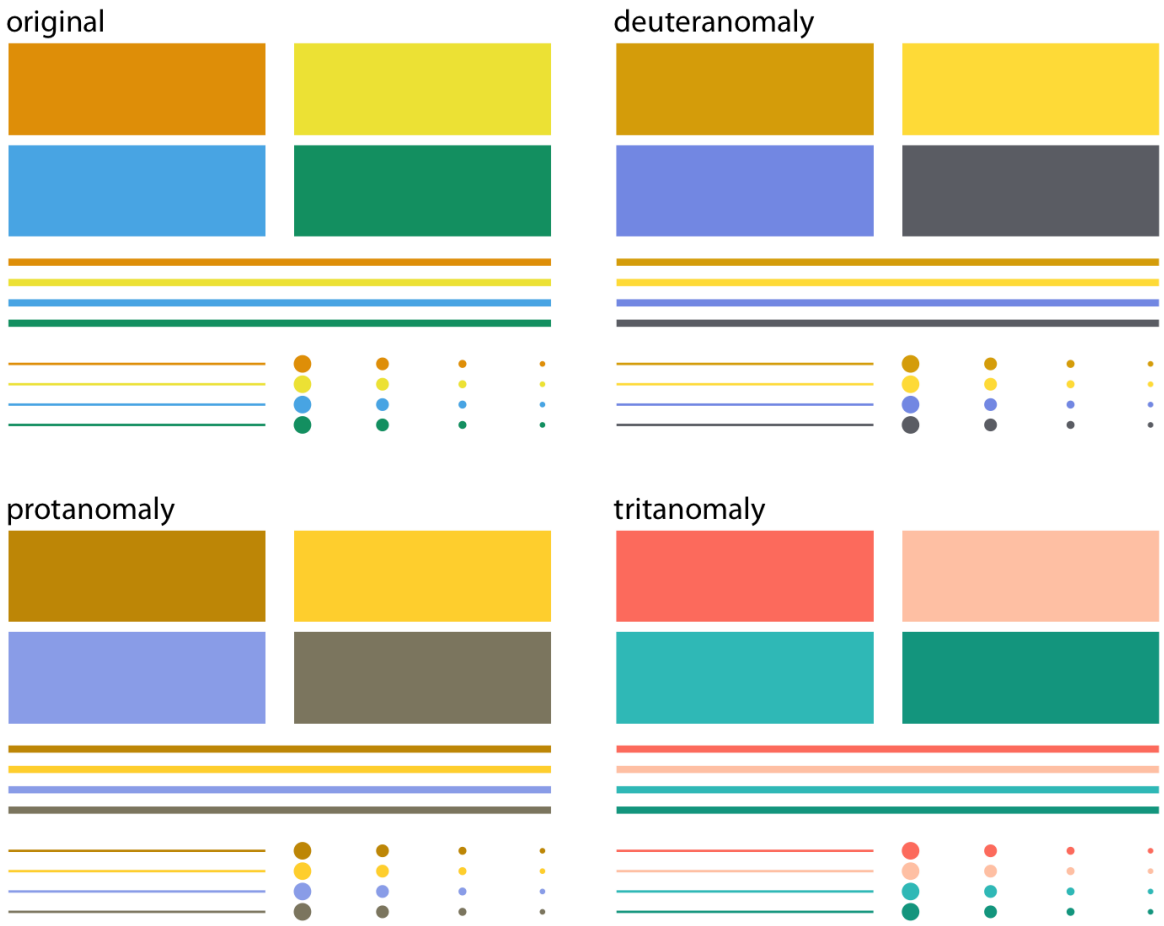


Monochromacy: present in 0.001% of humans



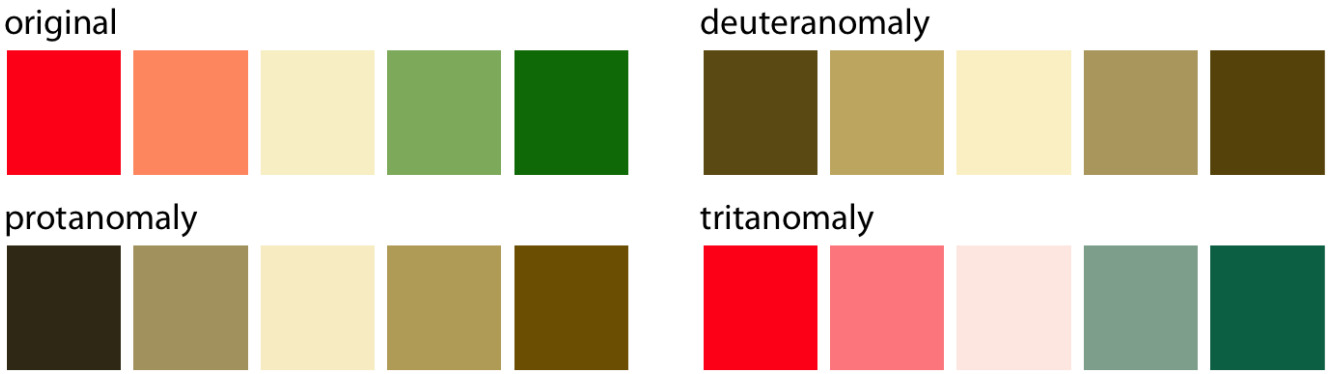
... and present in ~75% of university printers! ☺

Choice of the Color Palette & Accessibility



"Fundamentals of Data Visualization" by Claus Wilke

Choice of the Color Palette & Accessibility



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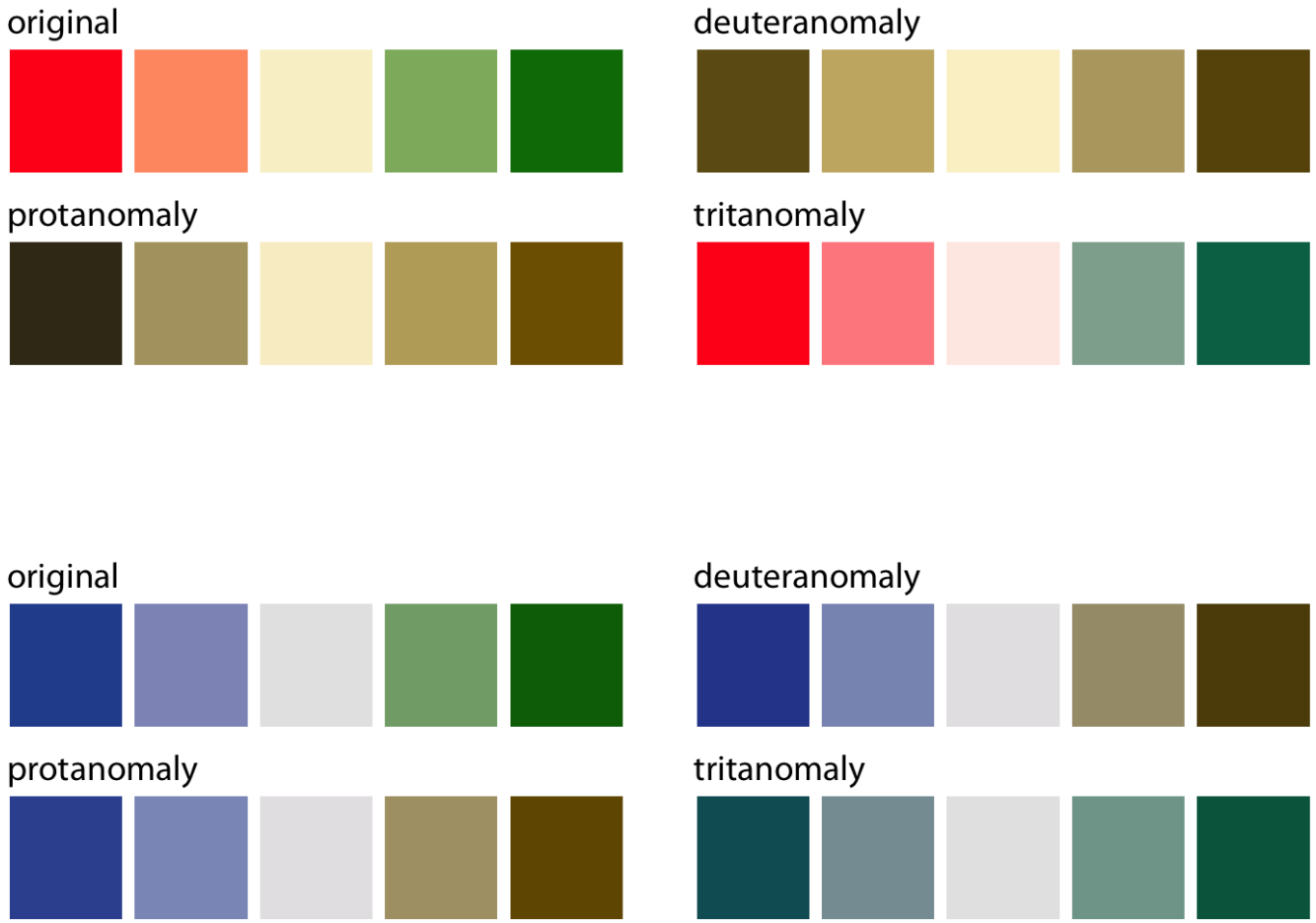


"Fundamentals of Data Visualization" by Claus Wilke

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!

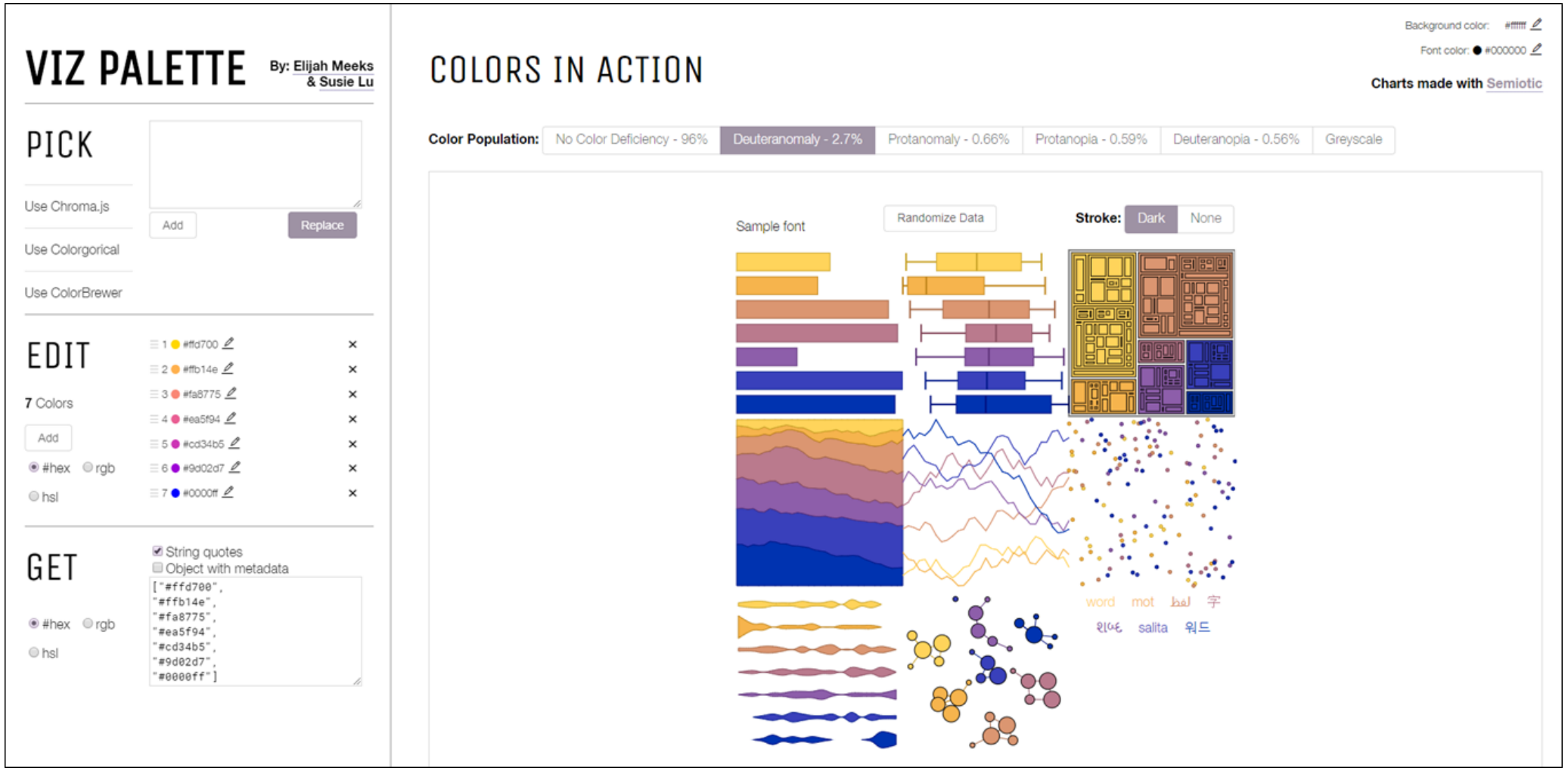
Color Choice & Accessibility

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

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

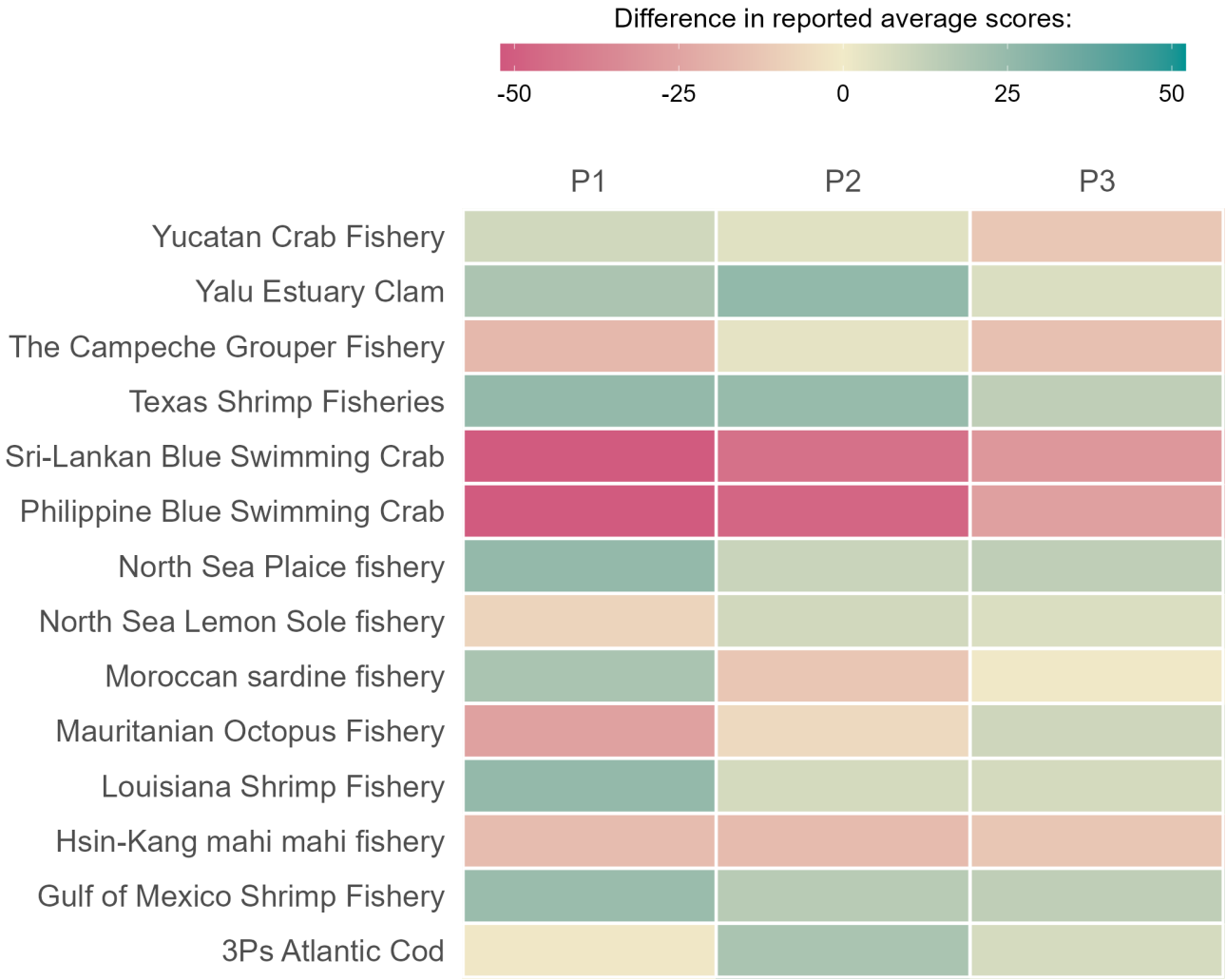
Create a CVD-version of your ggplot in R:
github.com/clauswilke/colorblindr

Color Choice & Accessibility

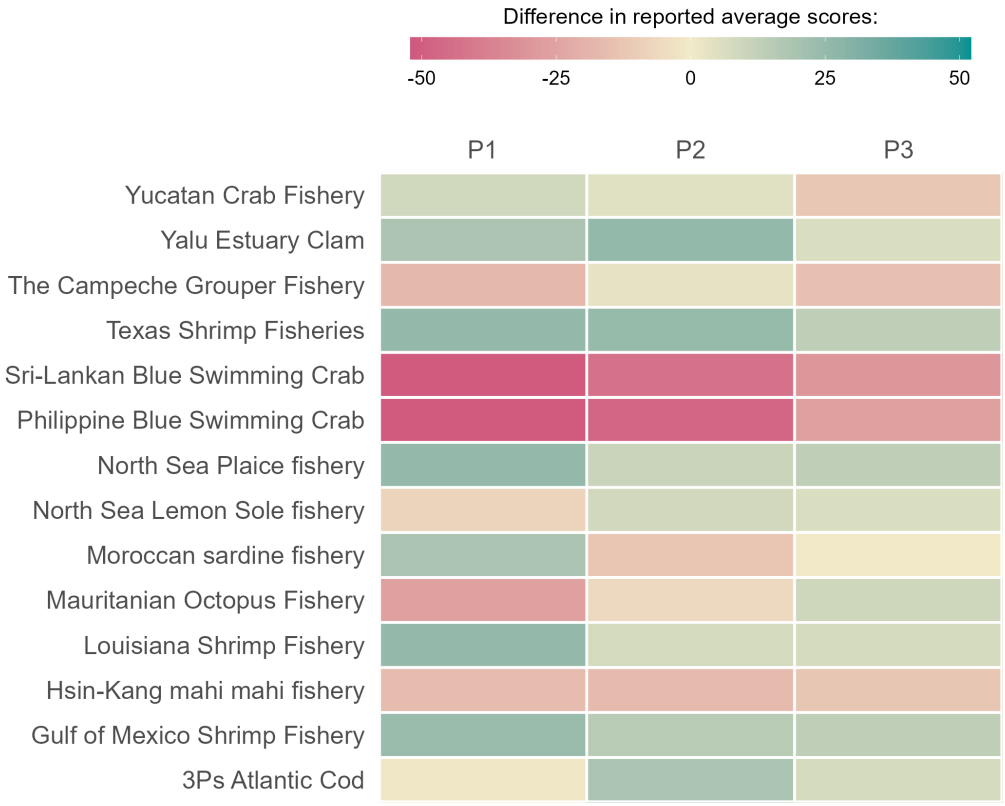


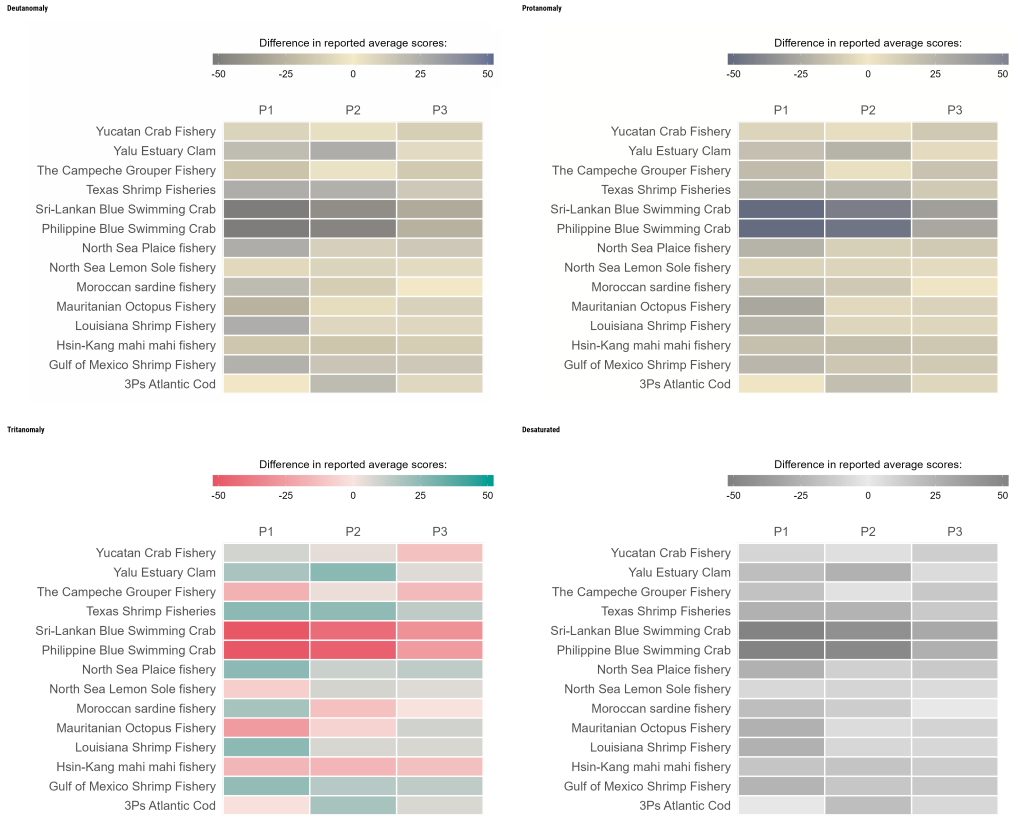
projects.susielu.com/viz-palette

Color Choice & Accessibility



Color Choice & Accessibility





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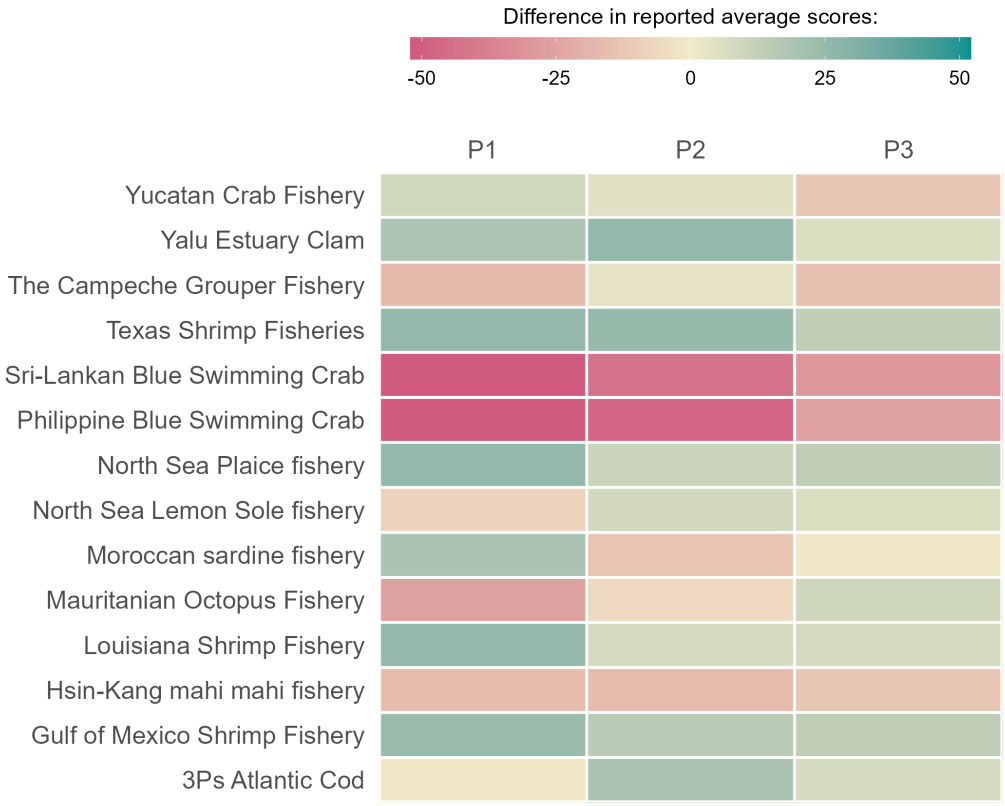
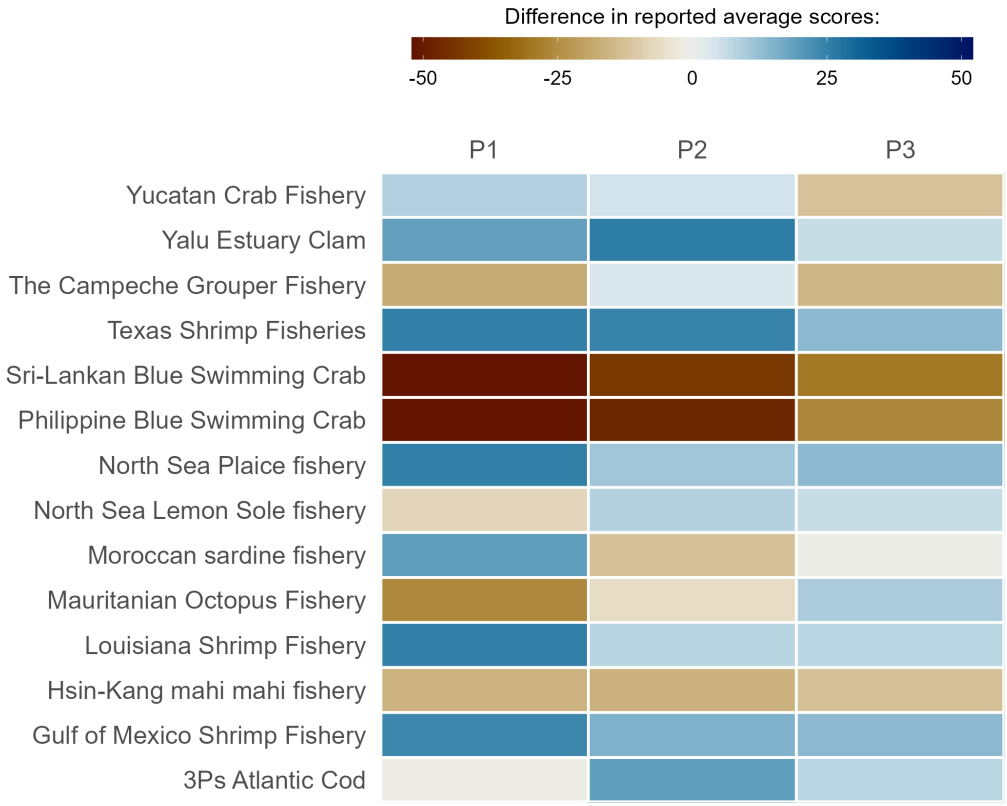
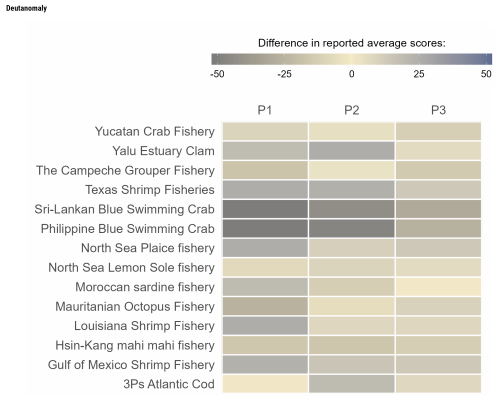
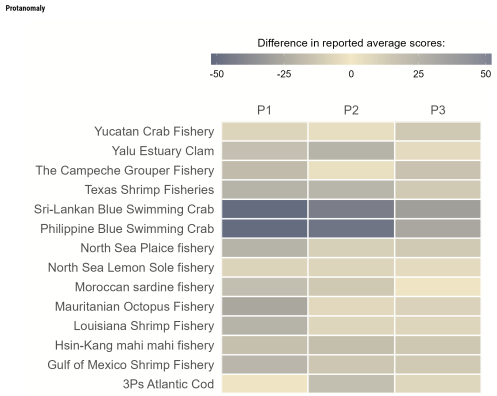
Color Choice & Accessibility

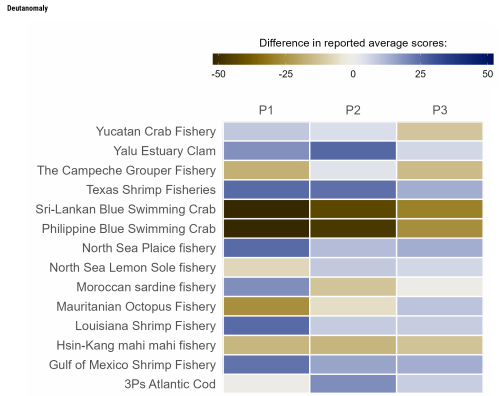


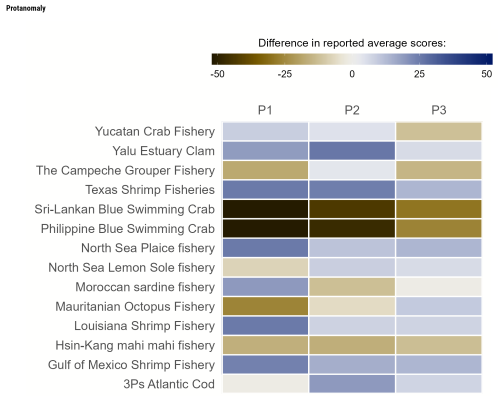


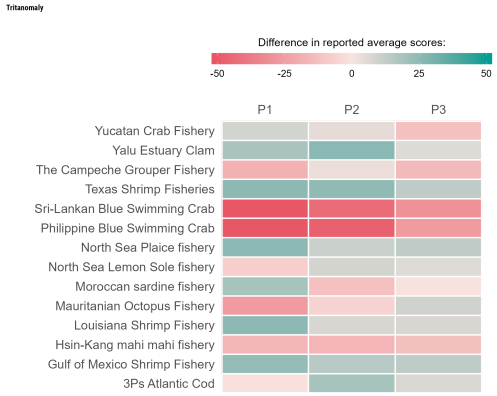
Color Choice & Accessibility

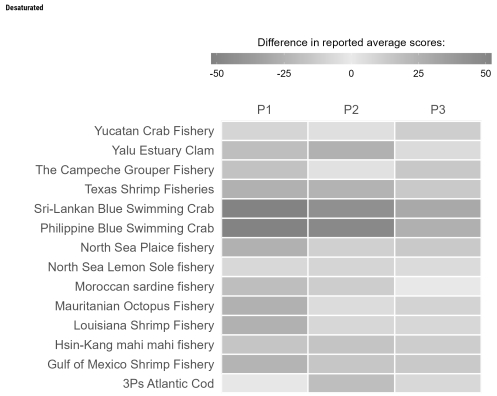


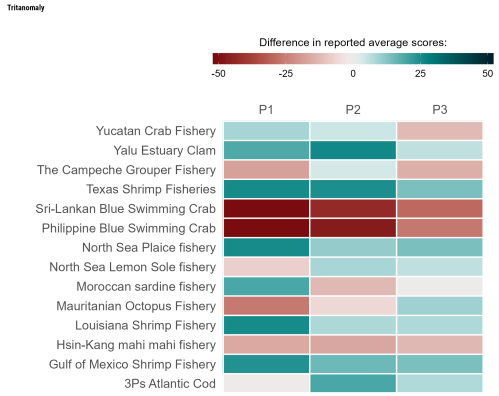


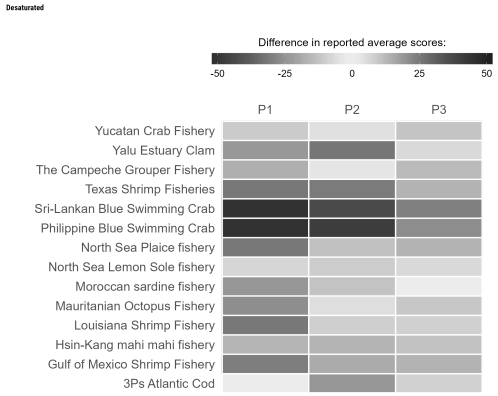






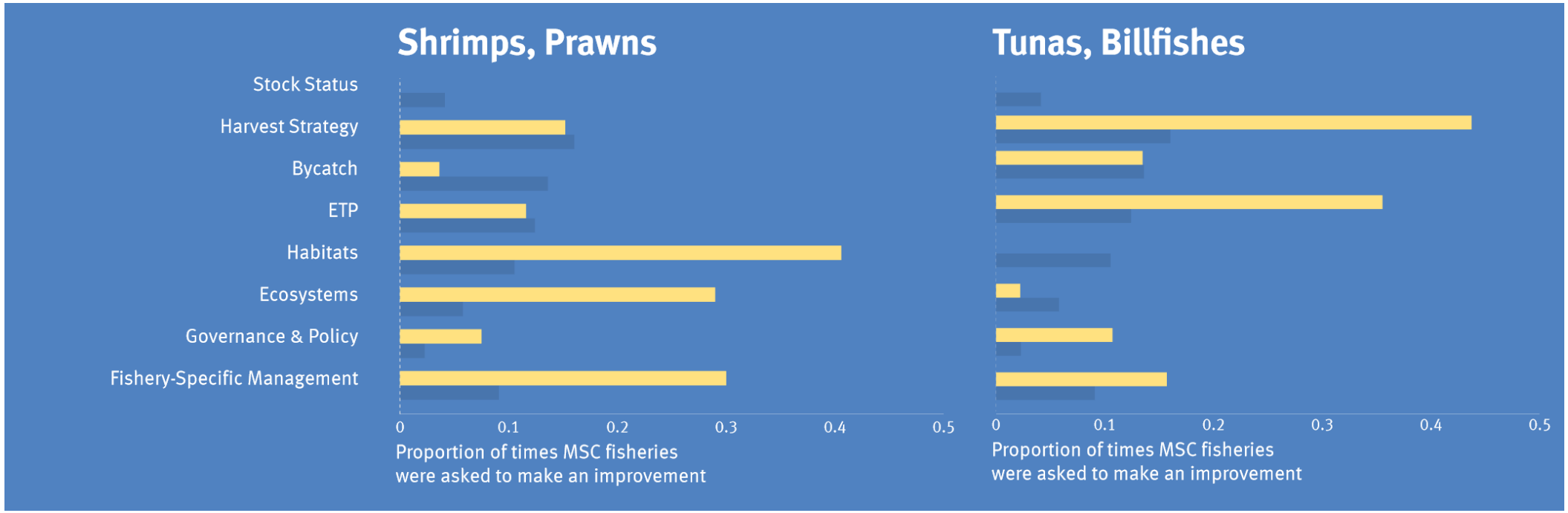


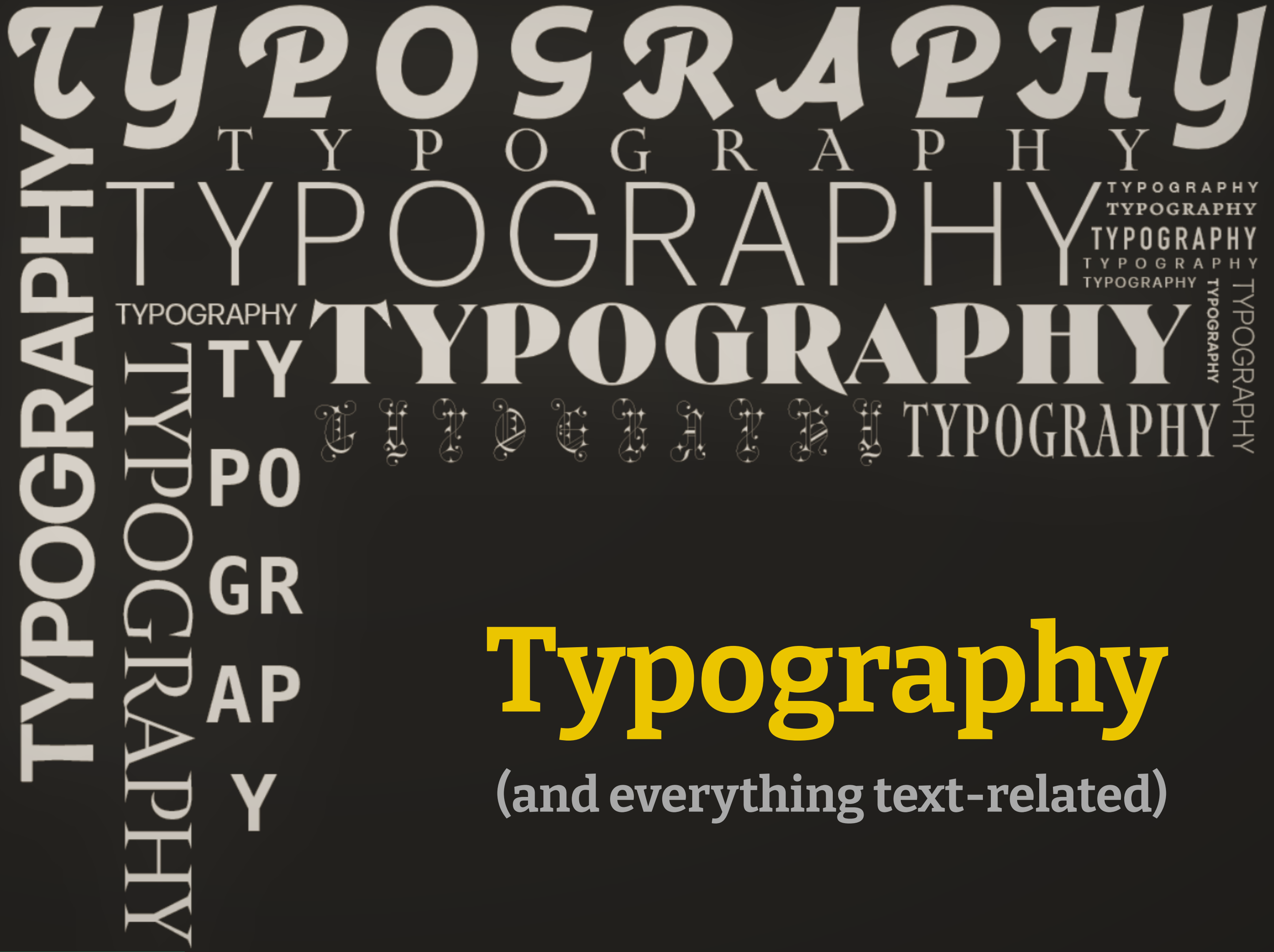




Created with {colorblindr}

Color Choice & Accessibility





Typography

(and everything text-related)

The Choice of the Font(s)

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

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- 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.

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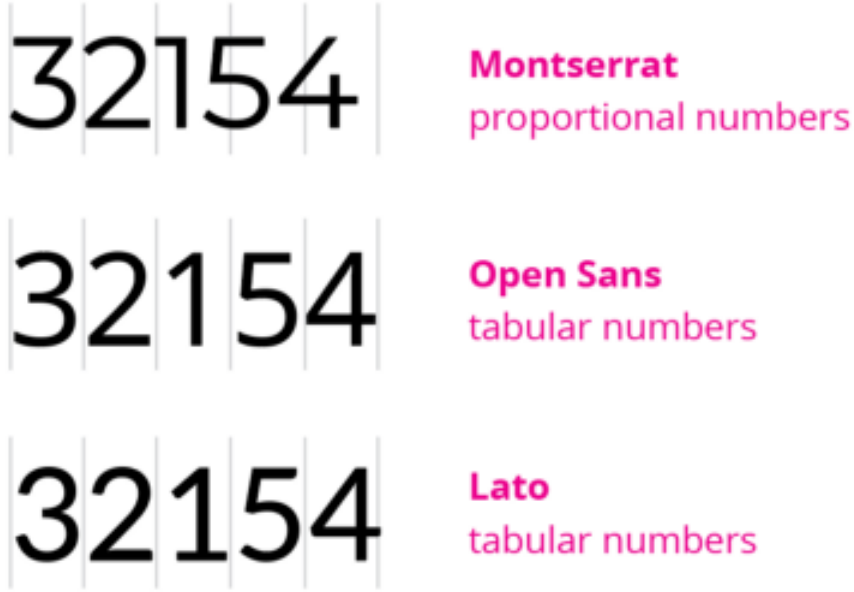
Keep it Simple

canva.com

The `1Il` Test

1Il	Calibri
1Il	Open Sans
1Il	Roboto
1Il	Avenir Next Condensed
1Il	Lato
1Il	Oswald
1Il	Bitter
1Il	Monda
1Il	Chivo
1Il	Fira Sans
1Il	Noto Sans
1Il	Bahnschrift

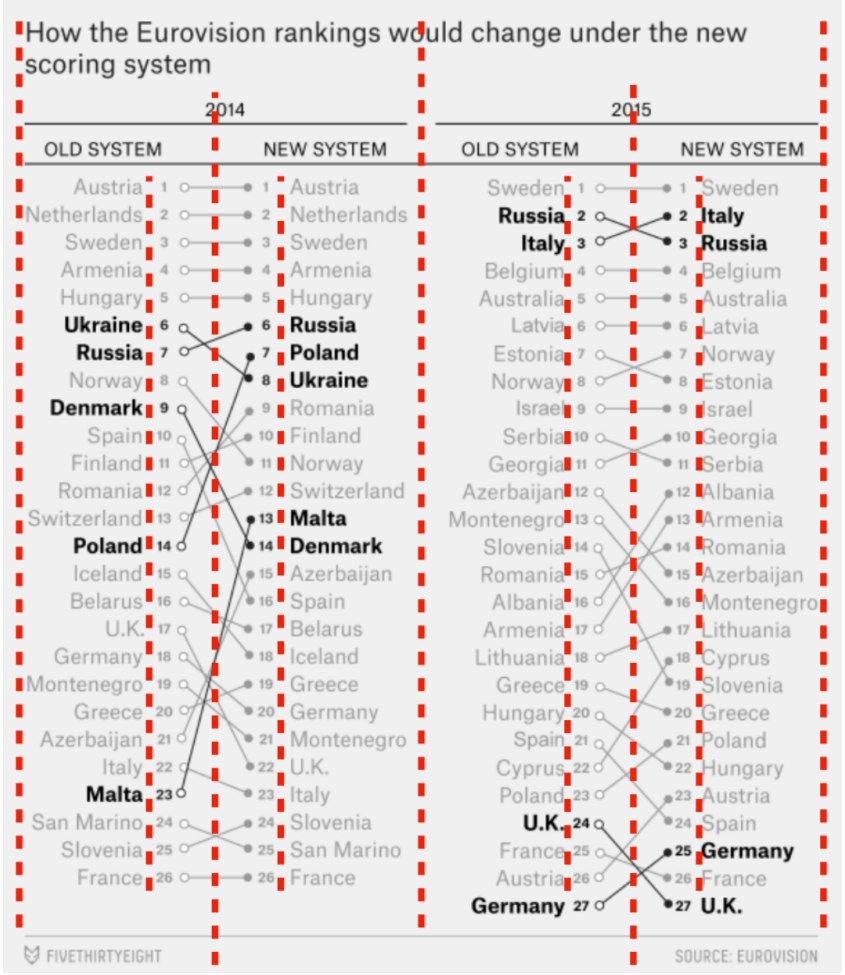
Tabular (Monospaced) Numbers



Choosing Fonts for Your Data Visualization by Tiffany France

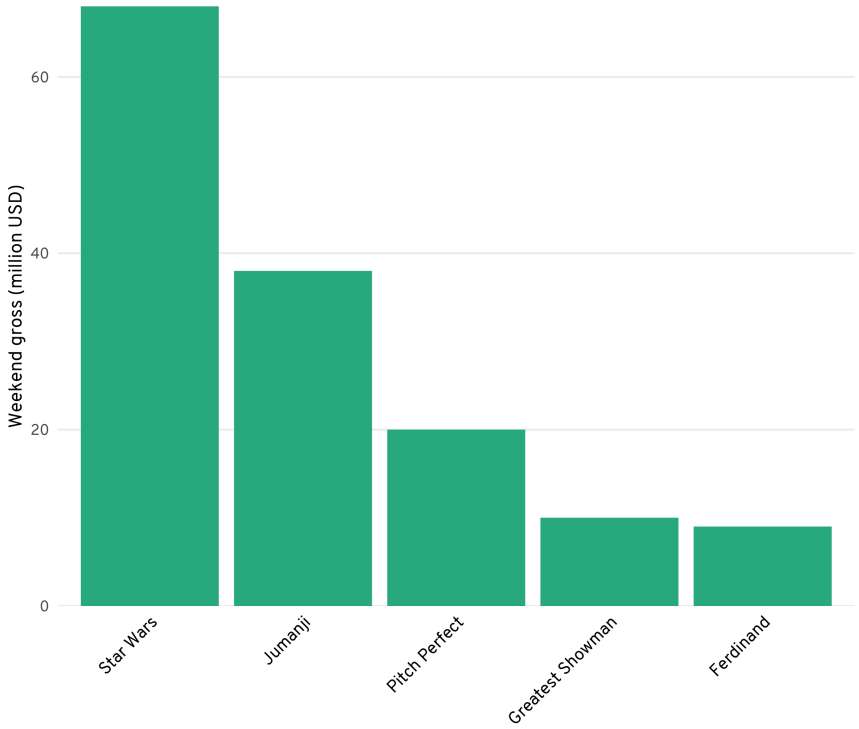
Allign Your Text

- Left-align most text
- Title should be left alligned
- Labels and subtitles can be center or right alligned

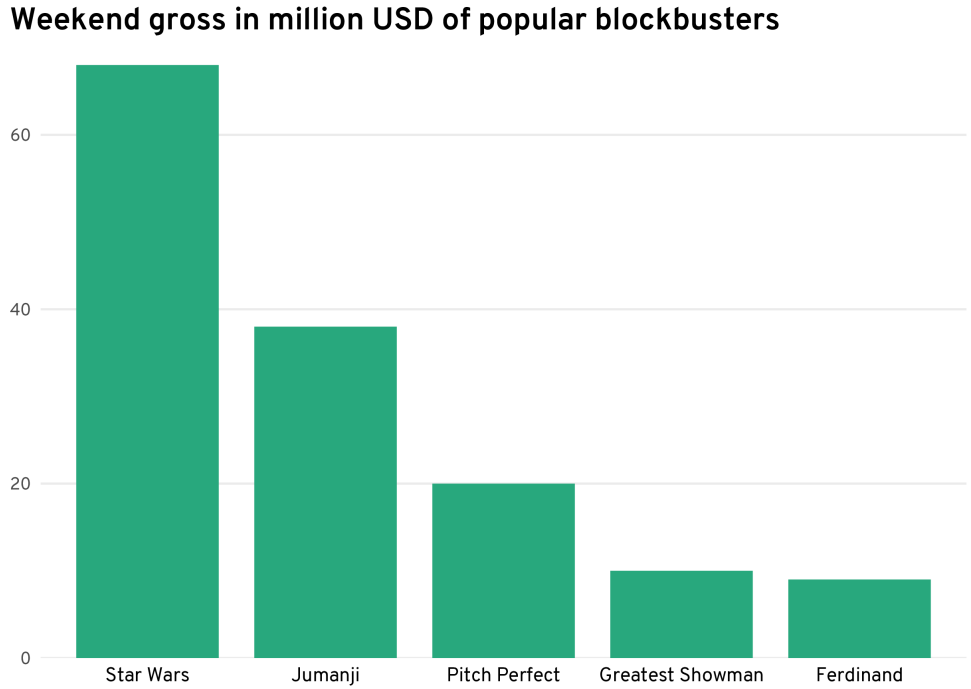


Will R. Chase

(Don't) Rotate Your Text



choice



*Modified from **"Fundamentals of Data Visualization"** by Claus Wilke*

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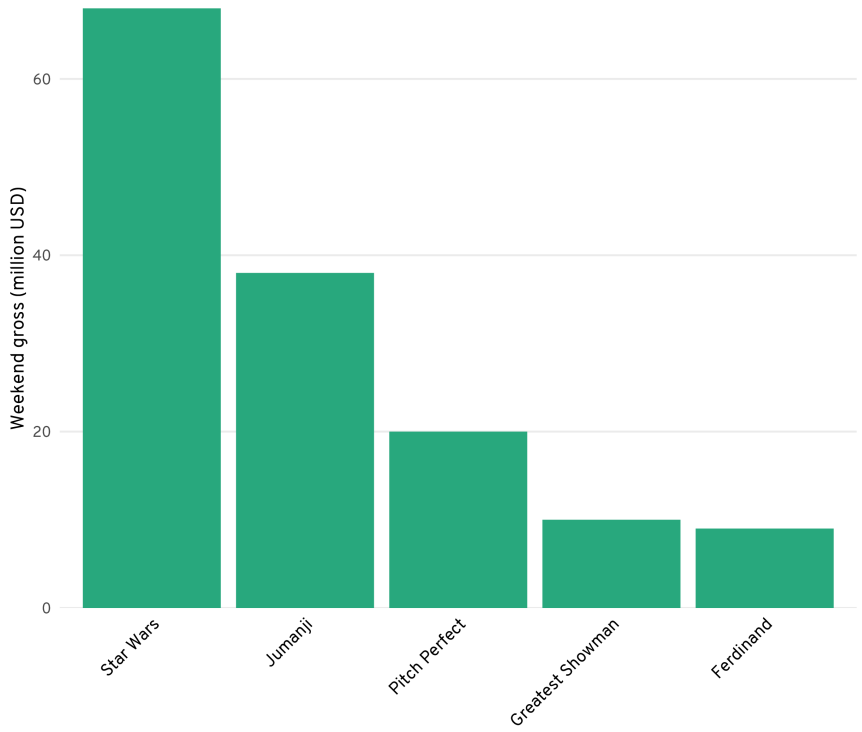
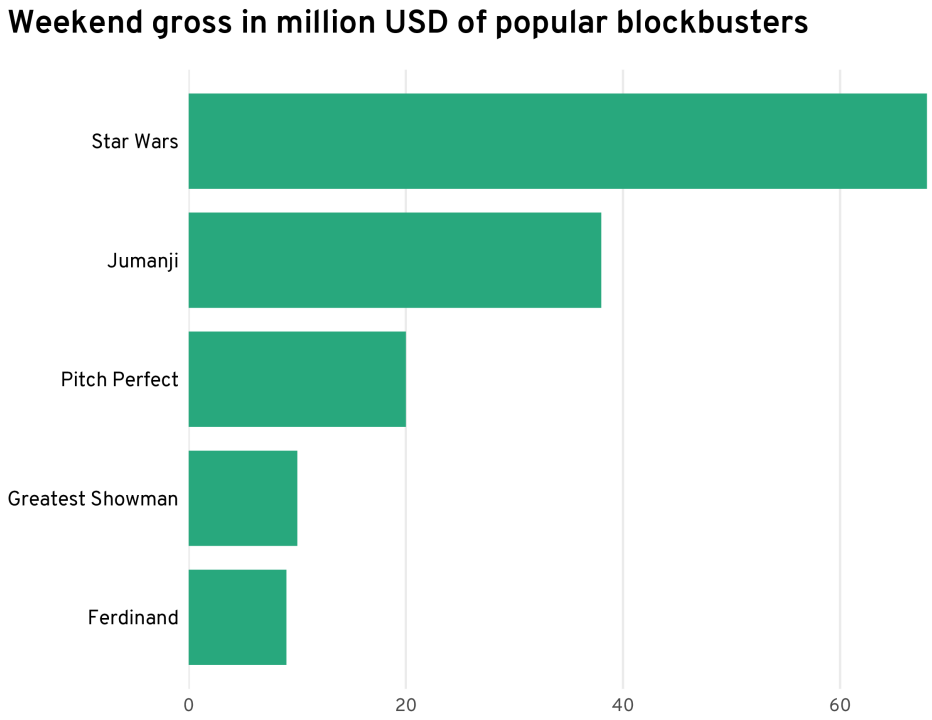
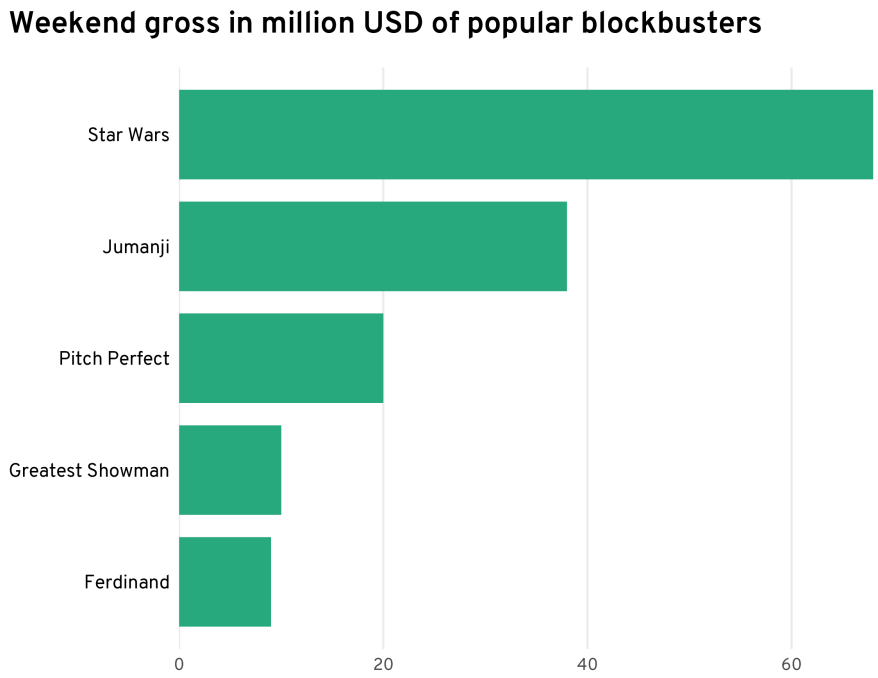
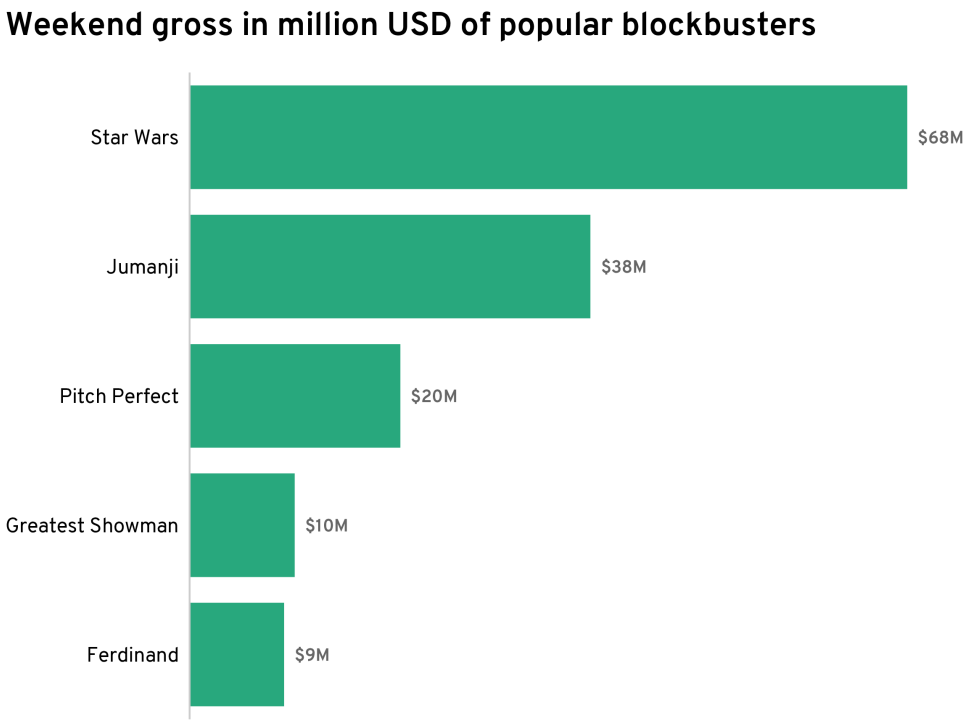




Use Annotations





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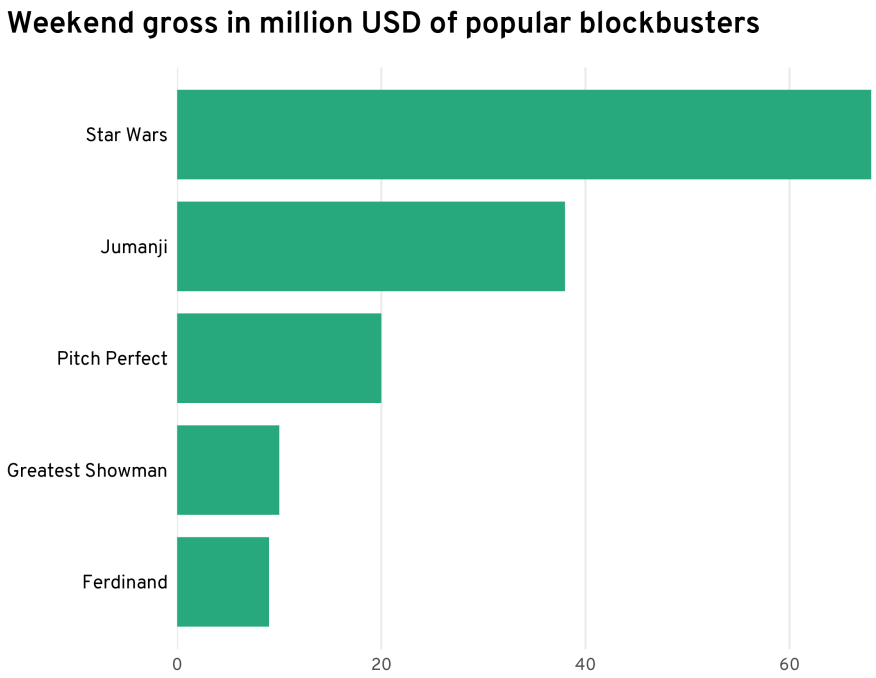
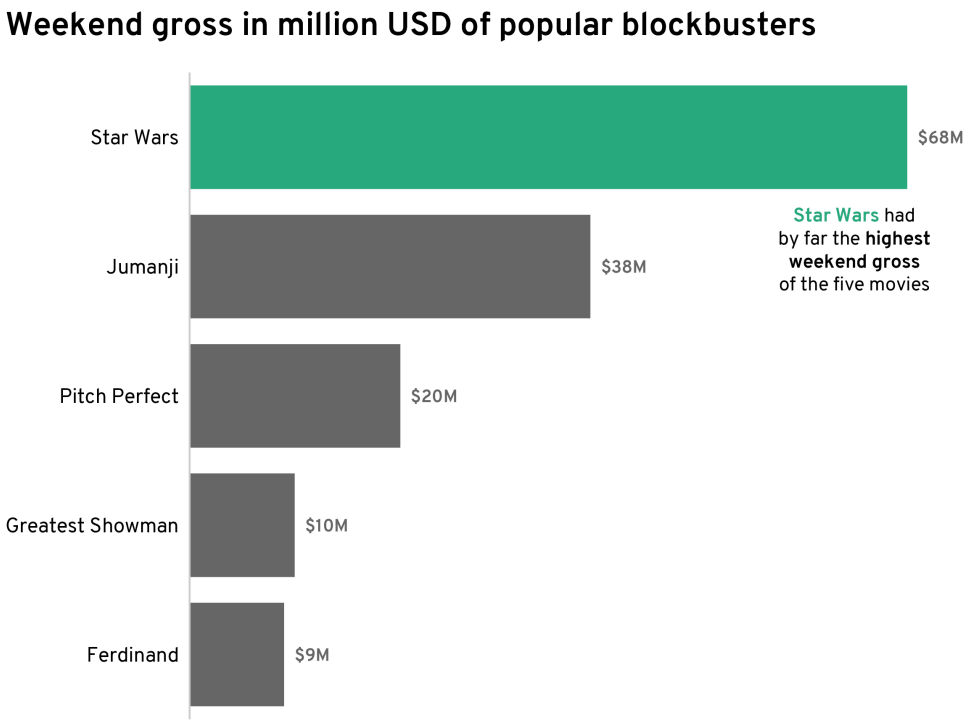
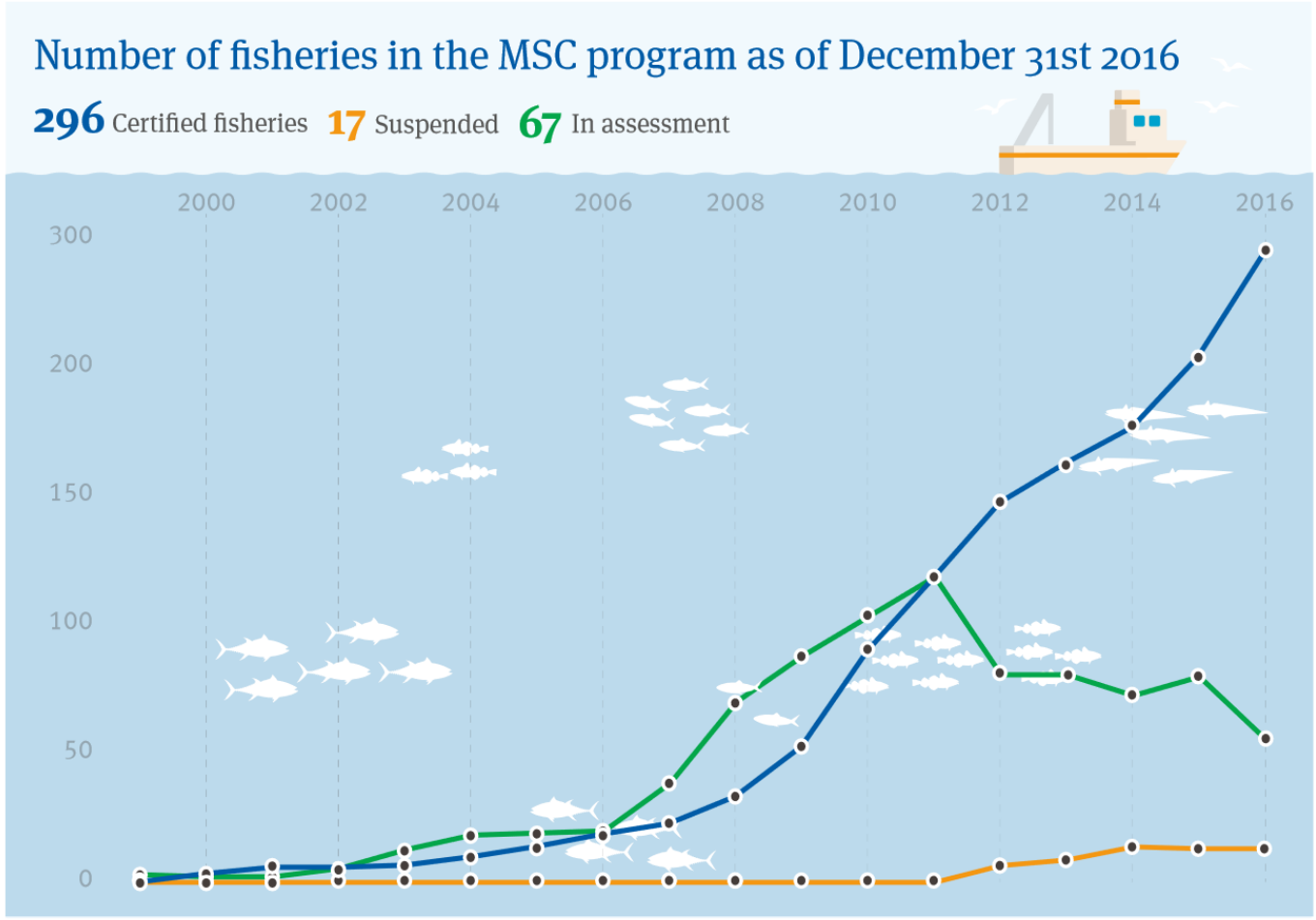




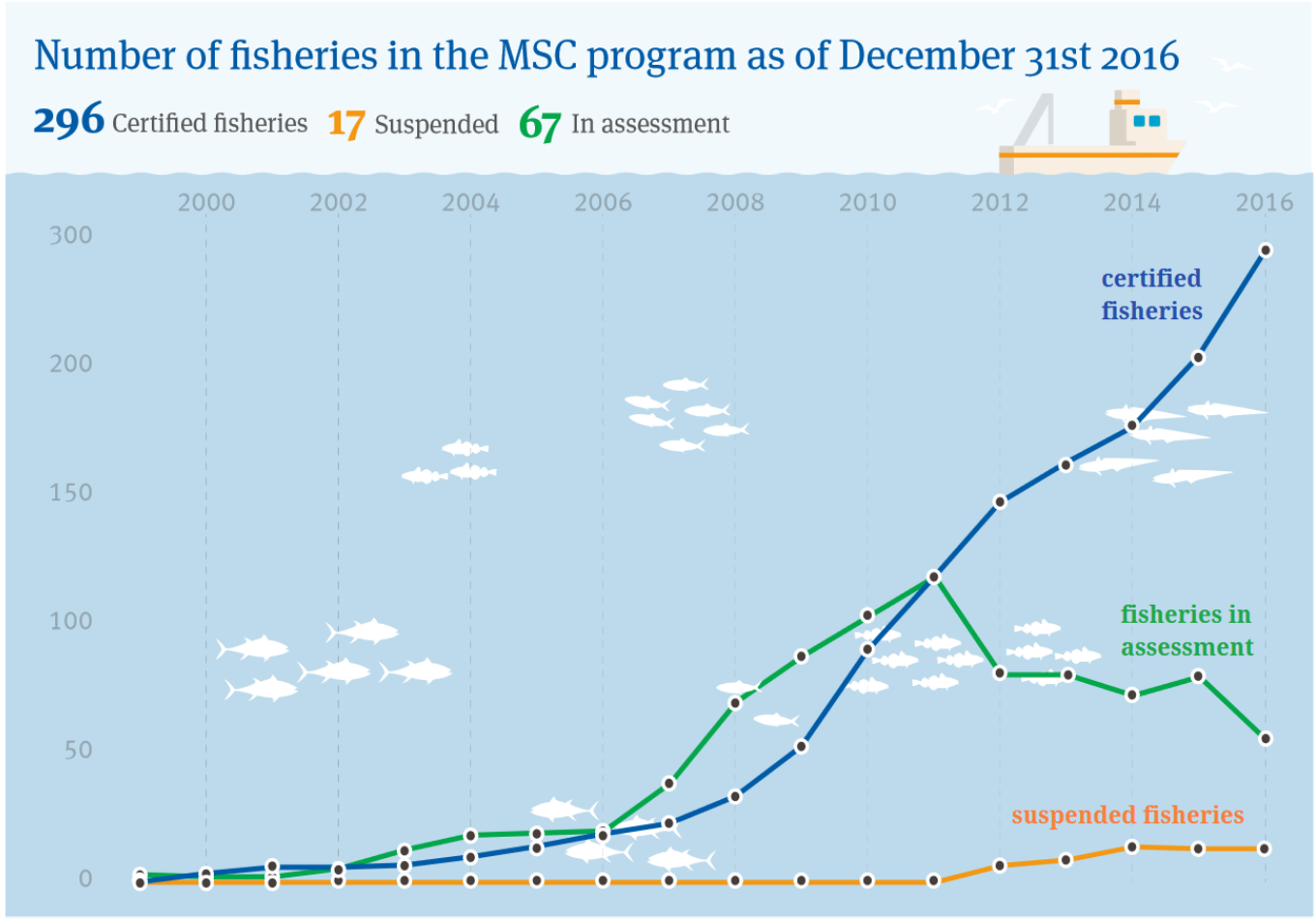
Use Annotations



100s

of fisheries are not yet ready for assessment and are engaged in pre-assessment activities and FIPs

Use Annotations



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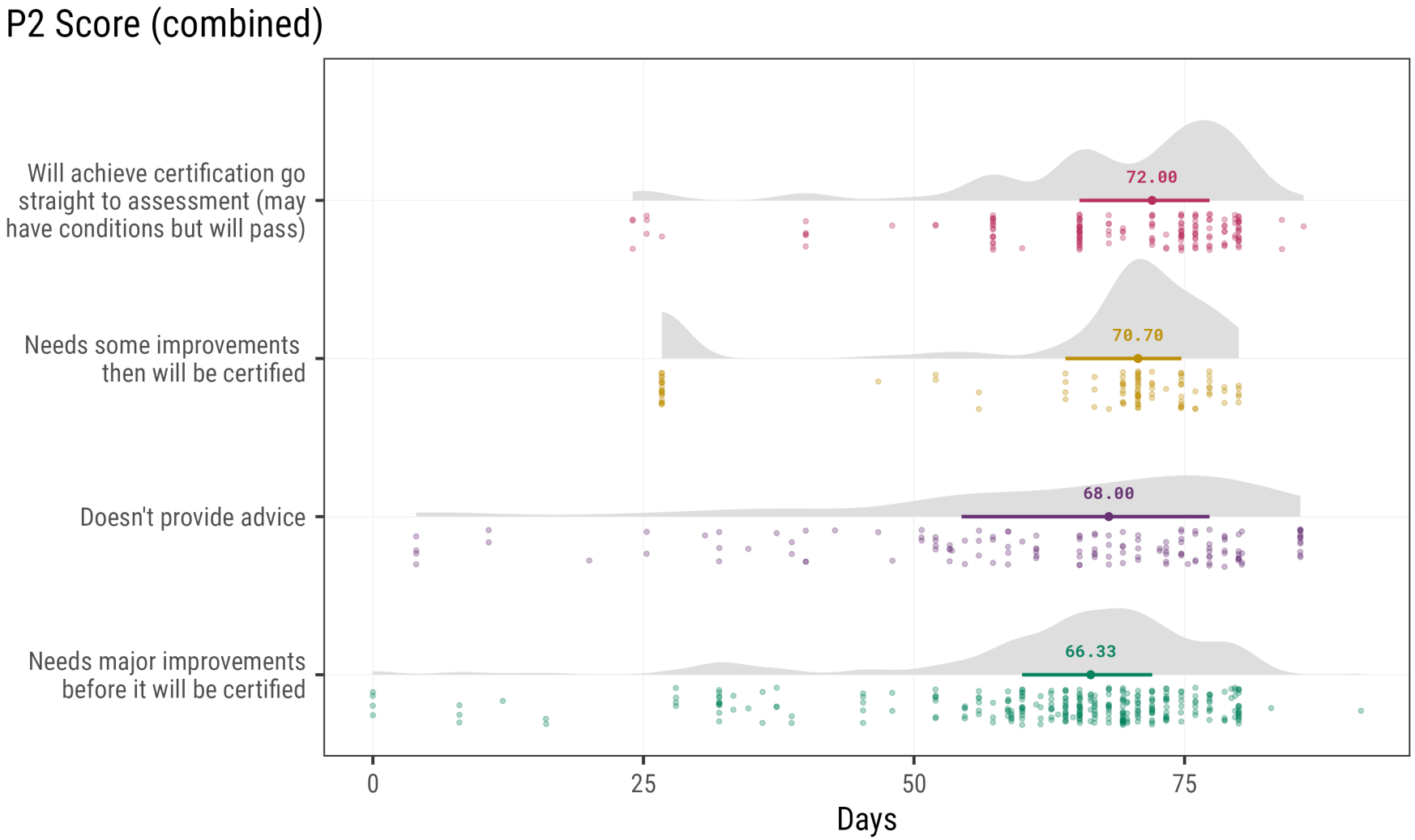
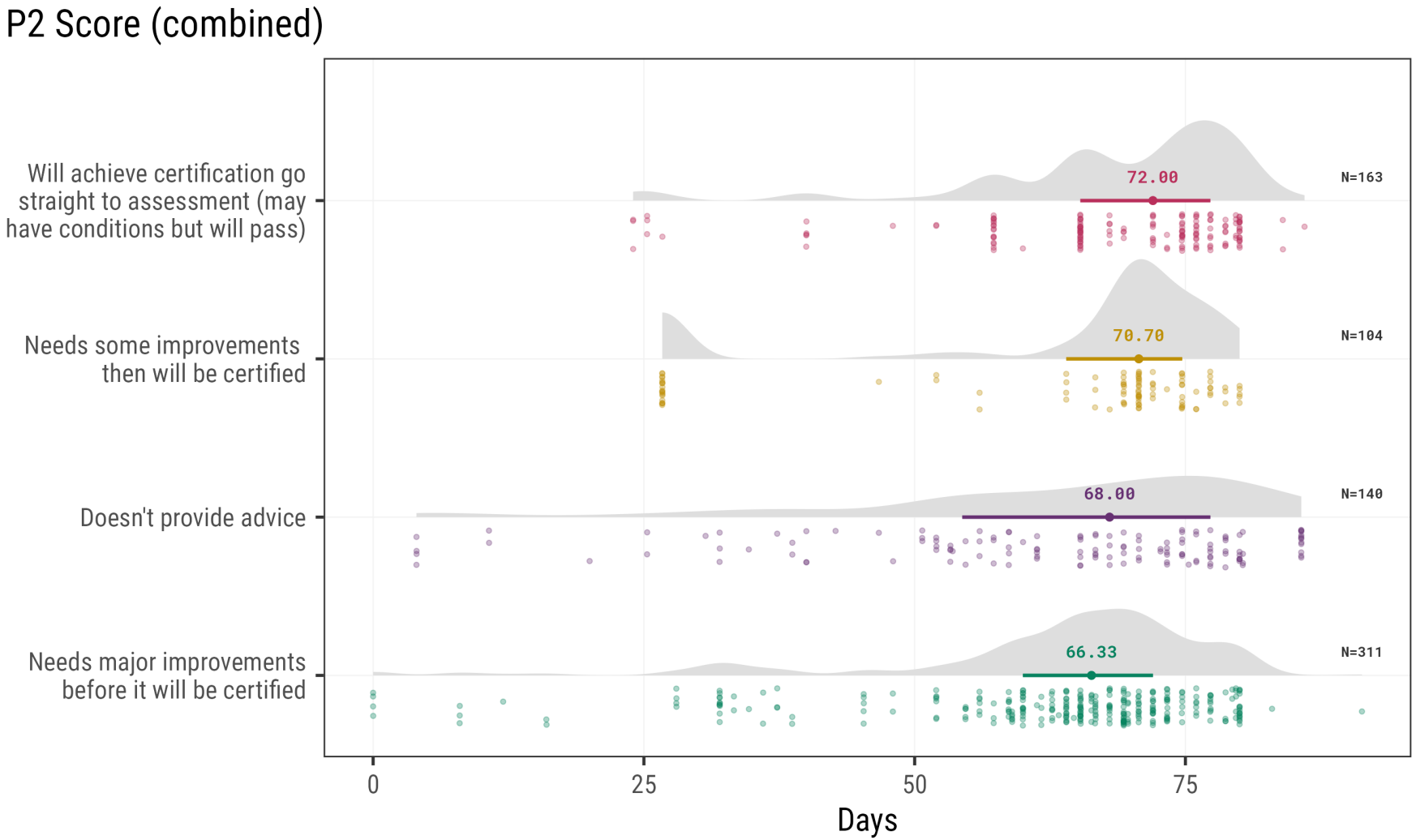


Use Annotations



Use Color Consistency in Labels

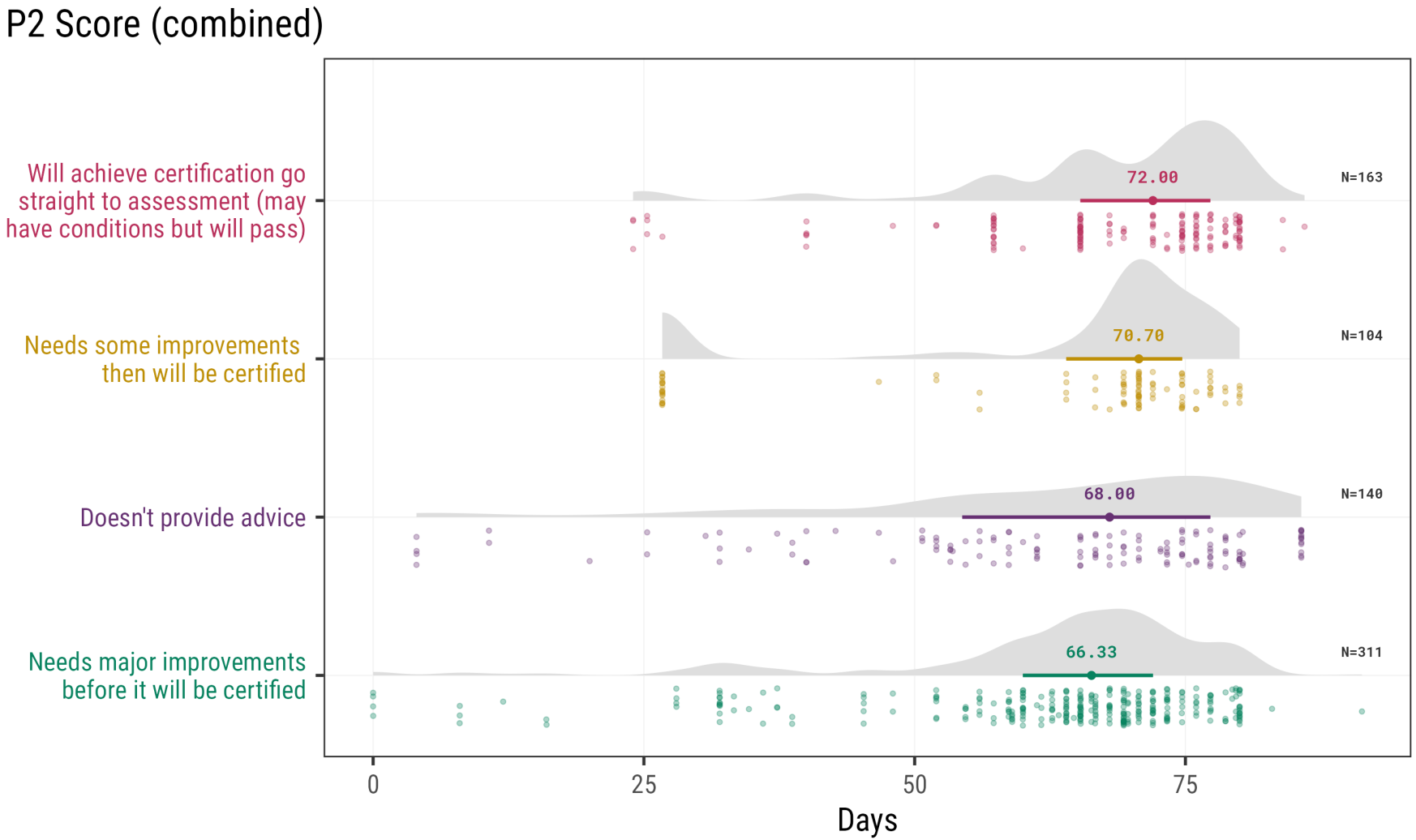
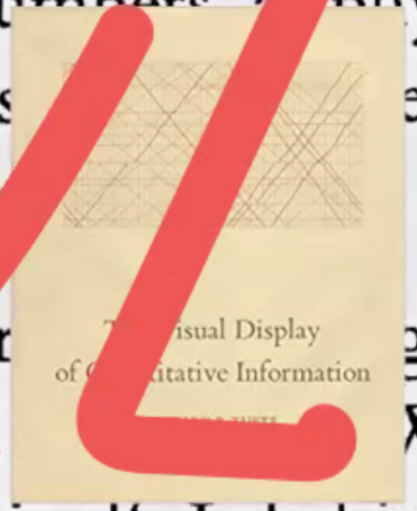


Chart Design Principles

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

The ...presenta...on ...f nu...bers ...physically measured on ...
su... ...the grap...ic its ...e direc... proporti...al to
t... ...merical qua...tities

...lear, de...iled, a...d ...or... ...g s...ould be used to ...efeat graphical di...tortion and ... ...te ...xplanation... of the data on the graphic itself. Label important eve... ...in th... data.

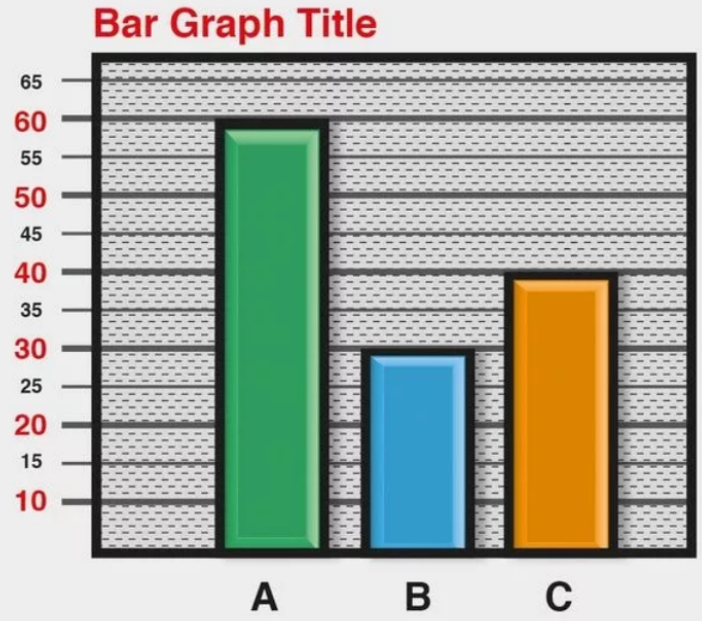


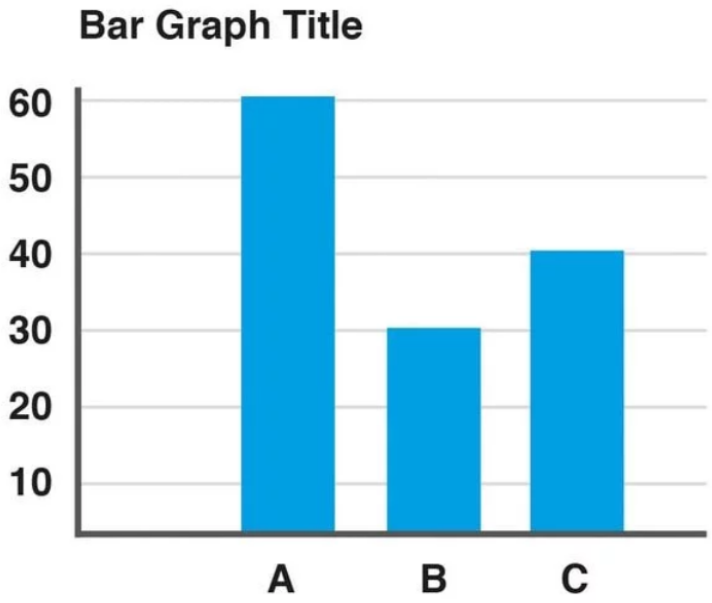
RULES

Show data variation, not design variation.

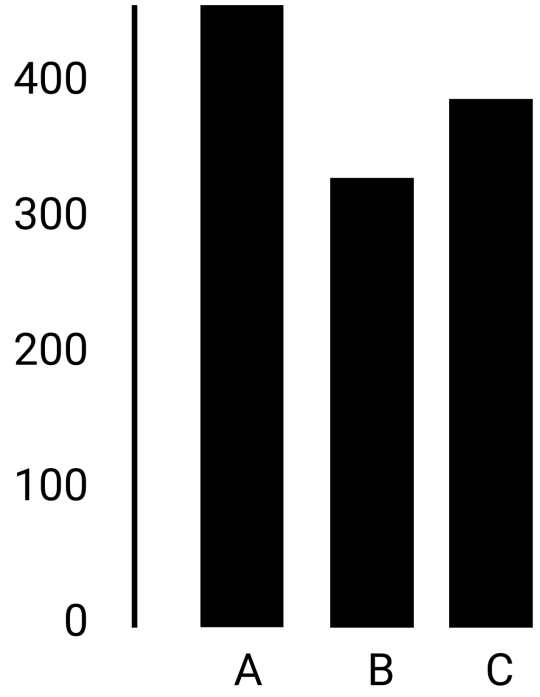
In time-series displays of money, deflated and standardized units

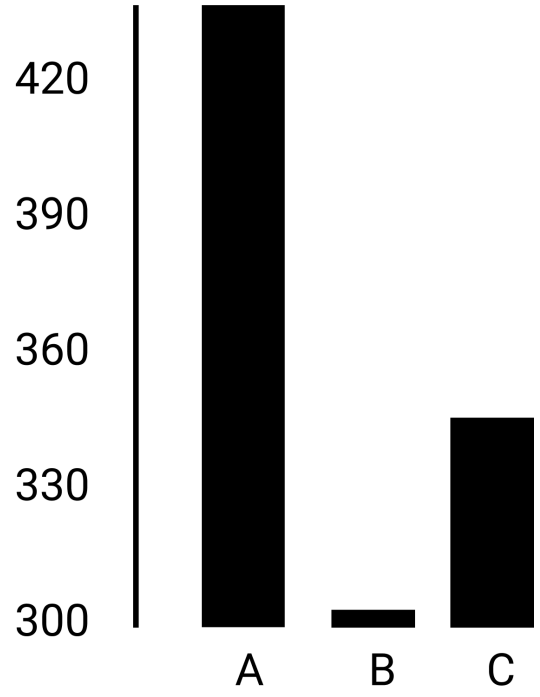
Don't Clutter Your Plot





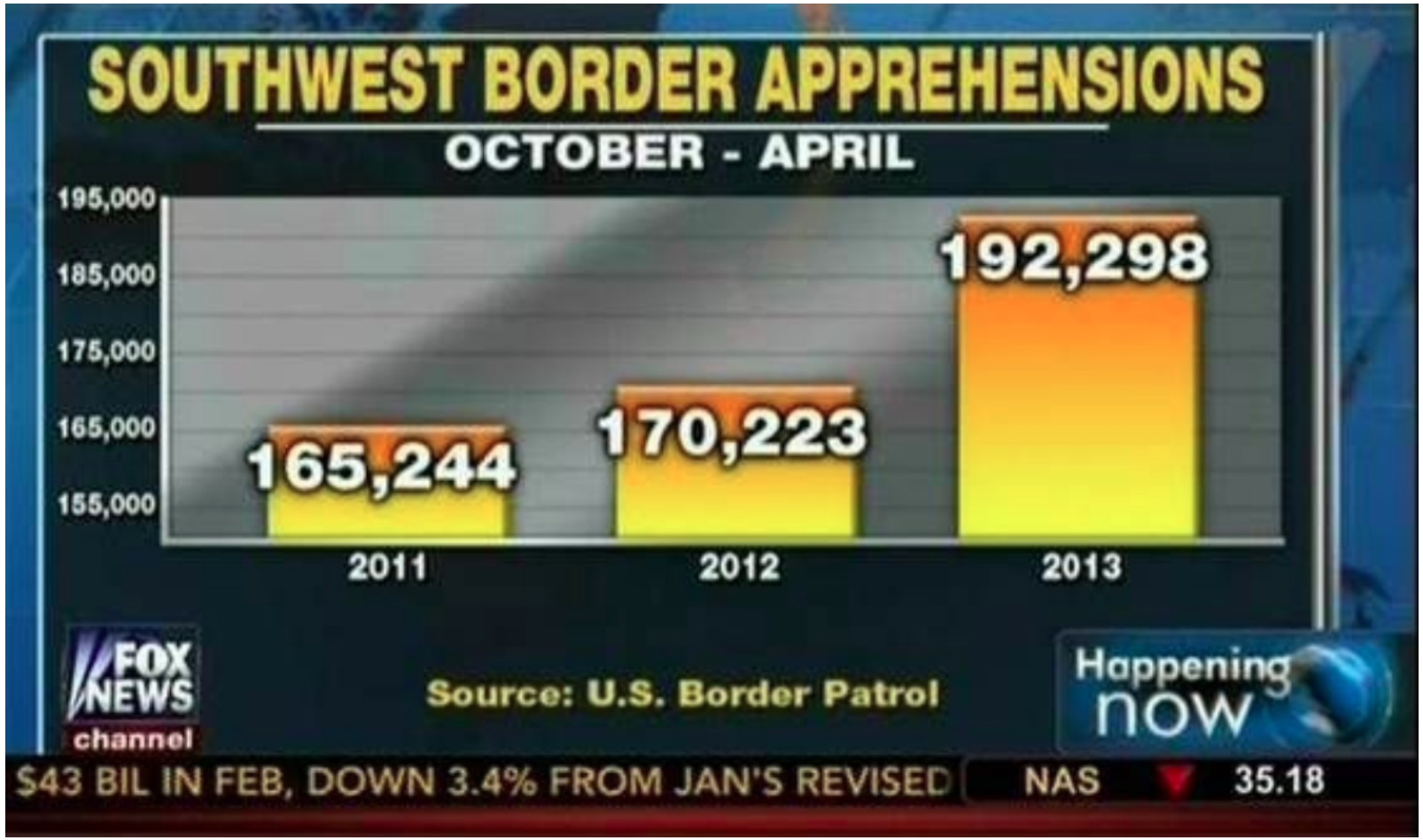
Start at Zero





"Hands-On Data Visualization" by Jack Dougherty & Ilya Ilyankou

Always Start at Zero

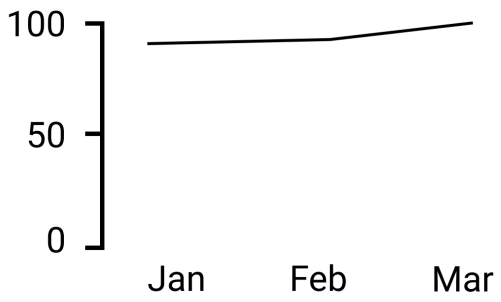


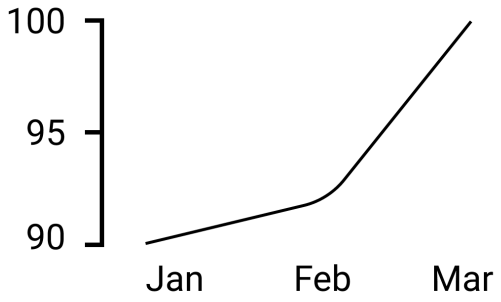
Fox News

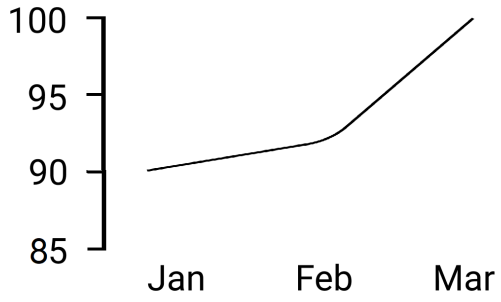
Always Start at Zero?

Fox News

(Always) Start at Zero?







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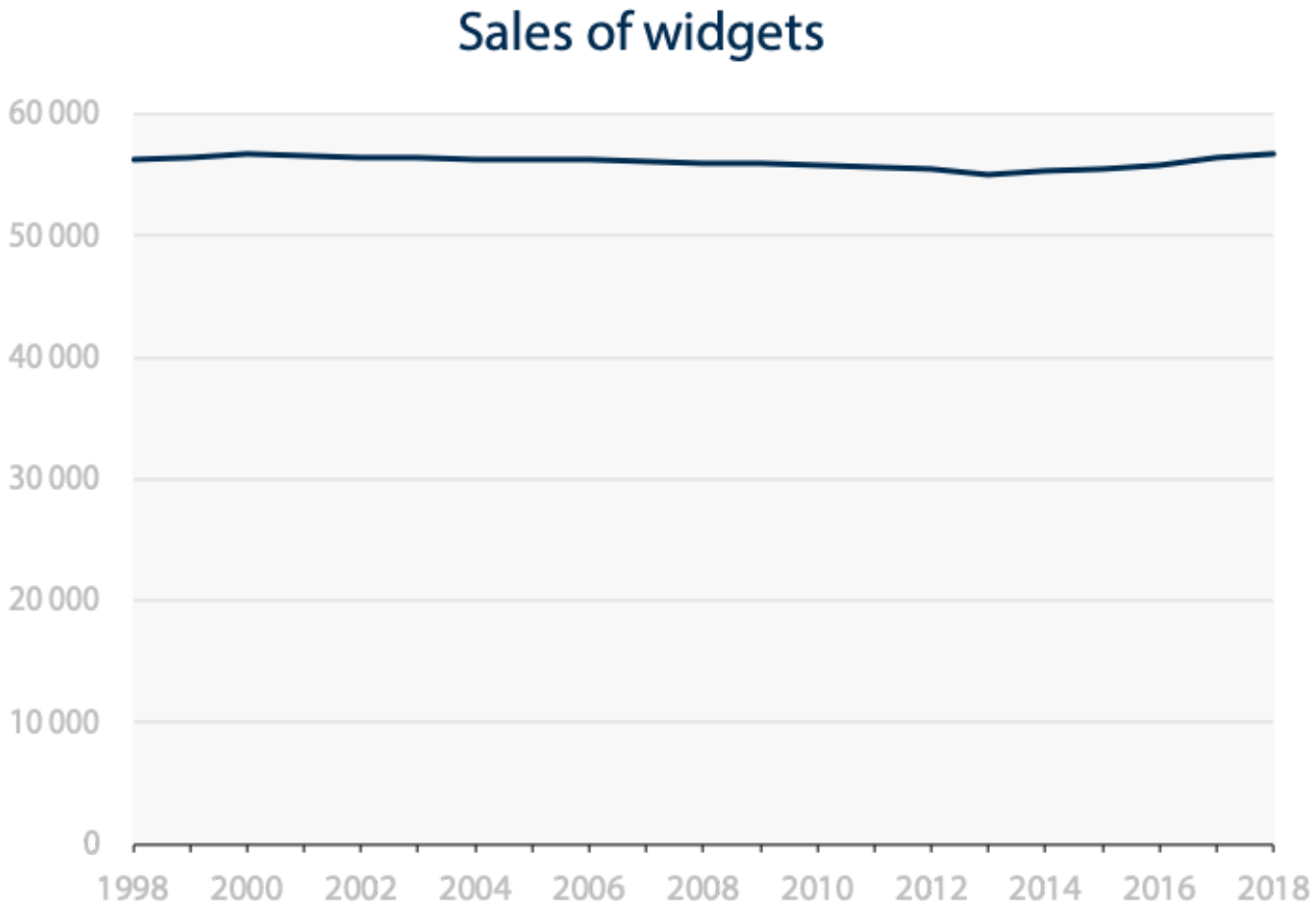

Francis Gagnon, Voilà

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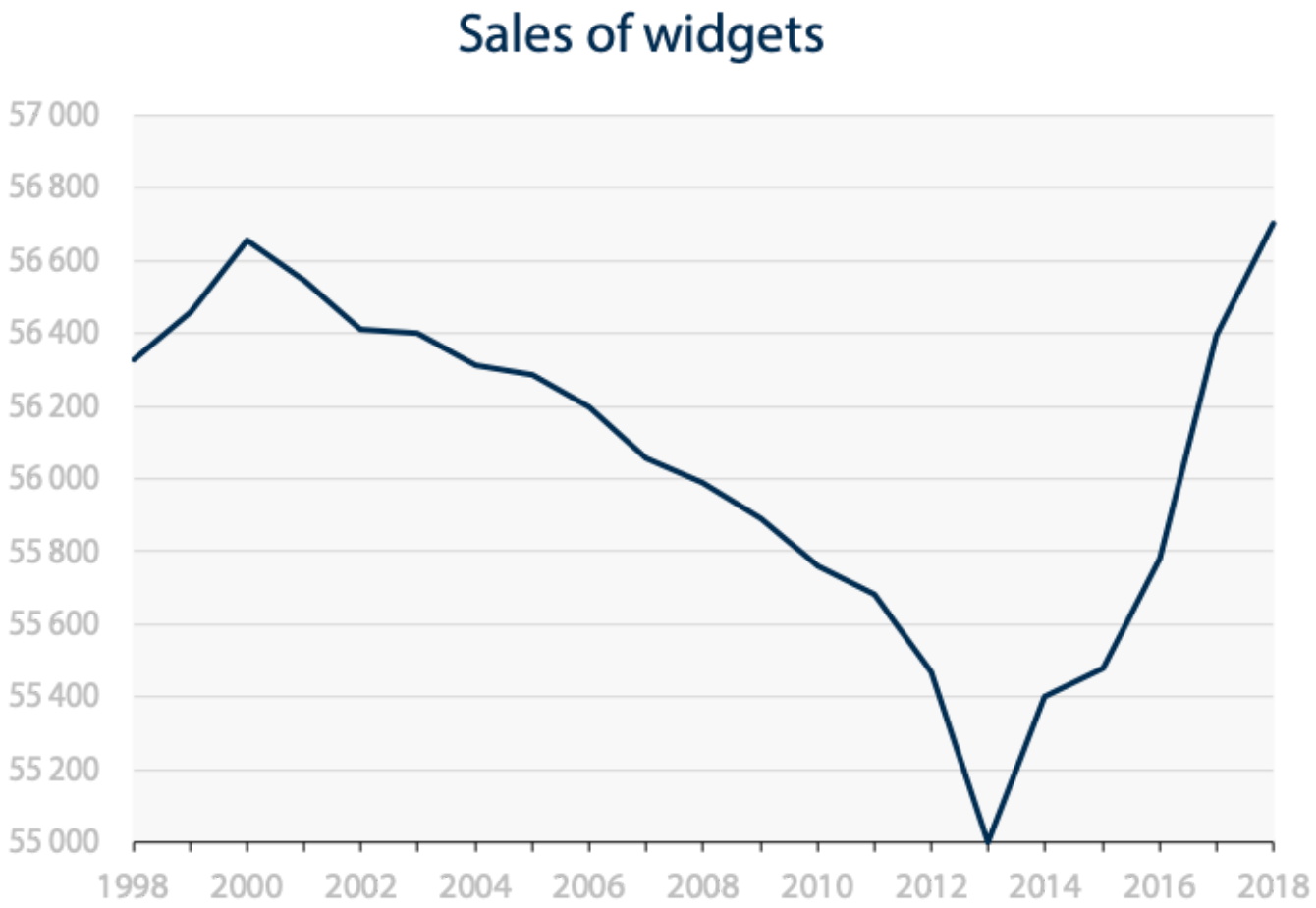
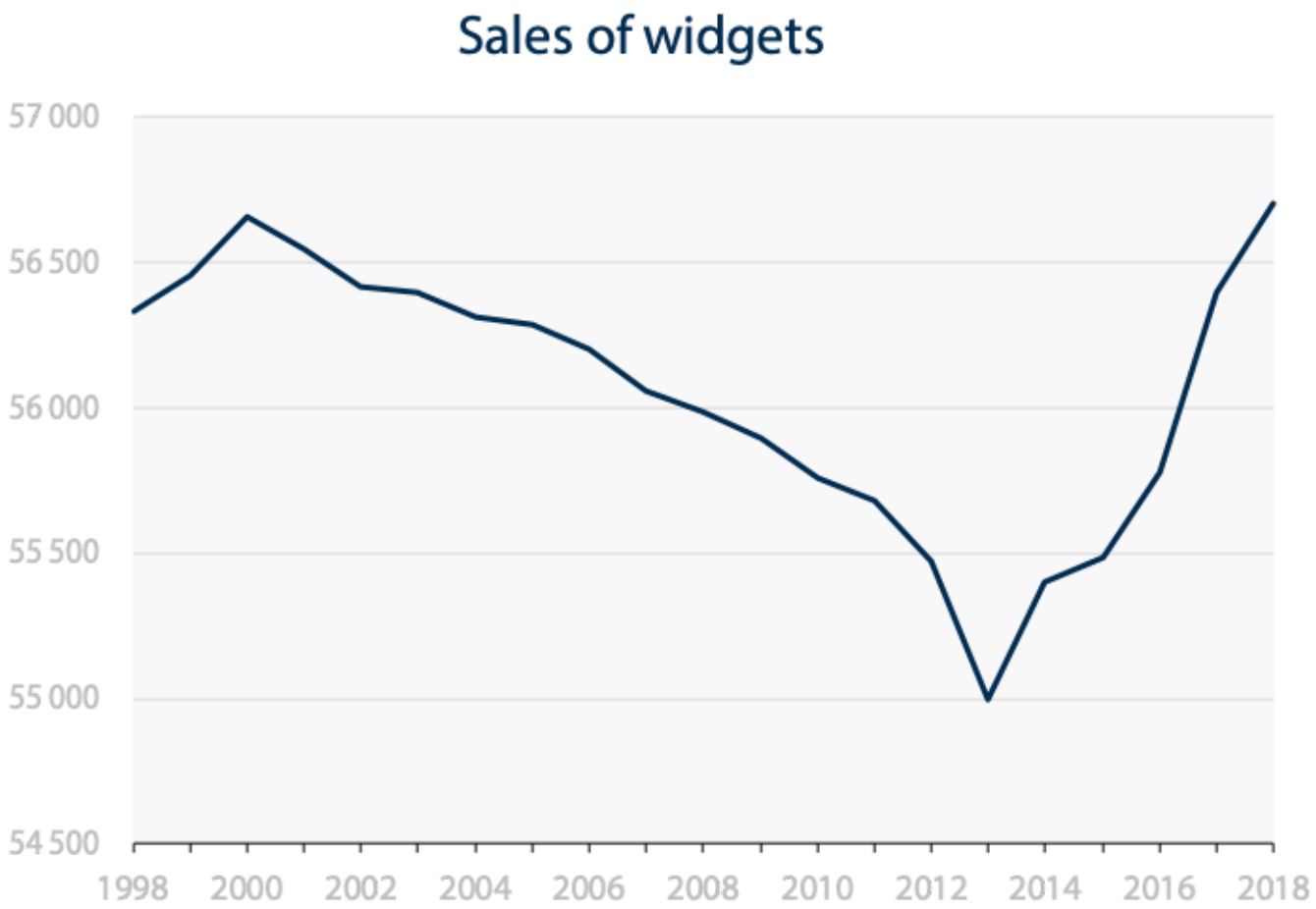


Francis Gagnon, Voilà

The Golden Ratio



Francis Gagnon, Voilà

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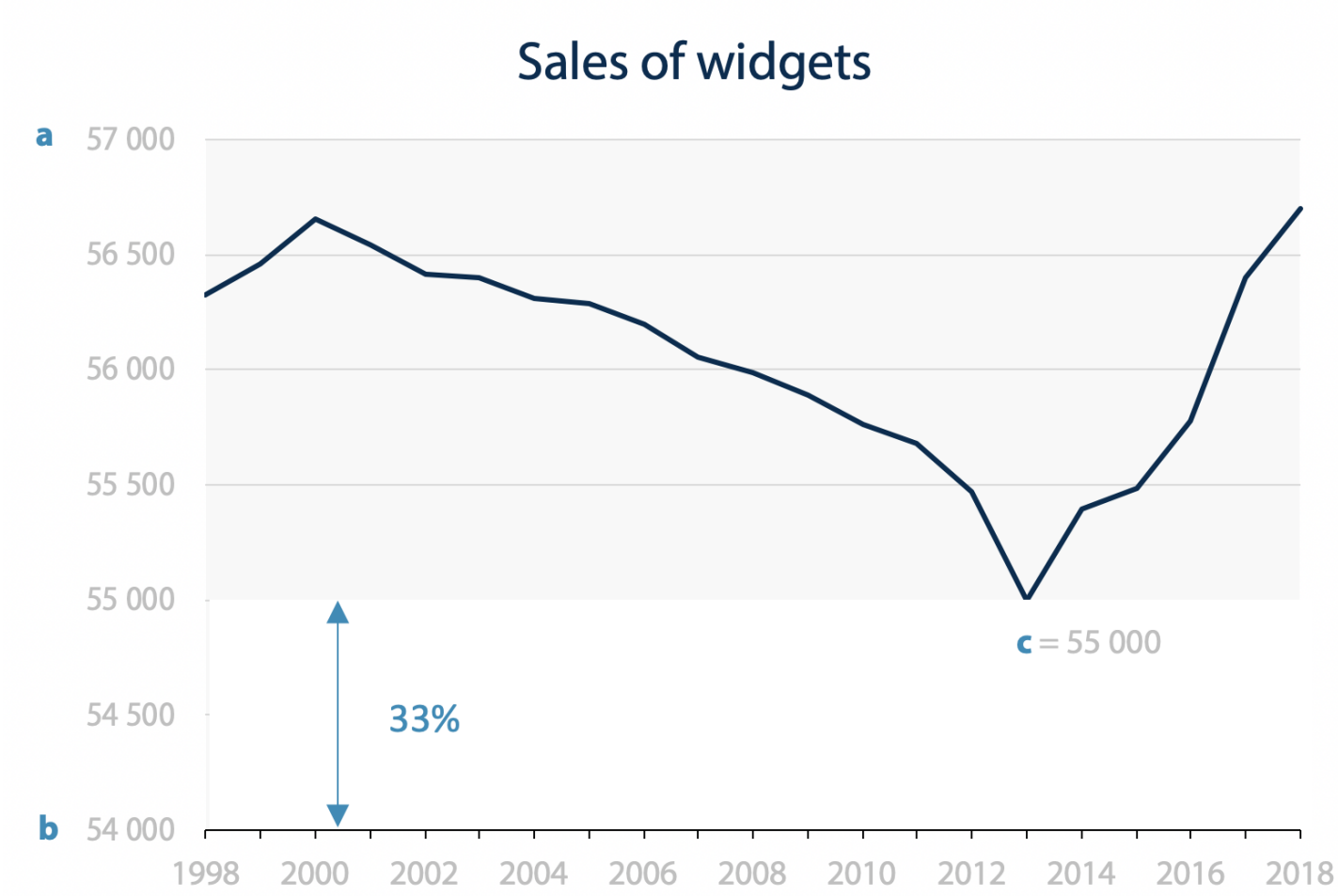
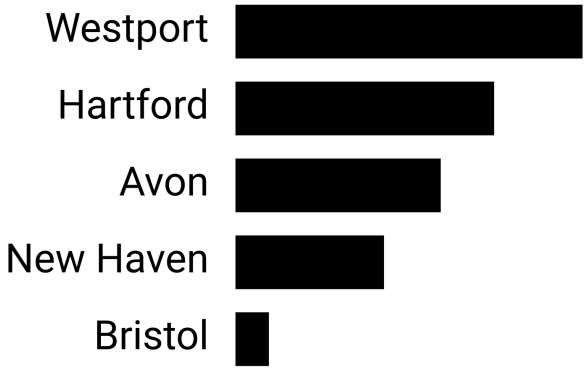
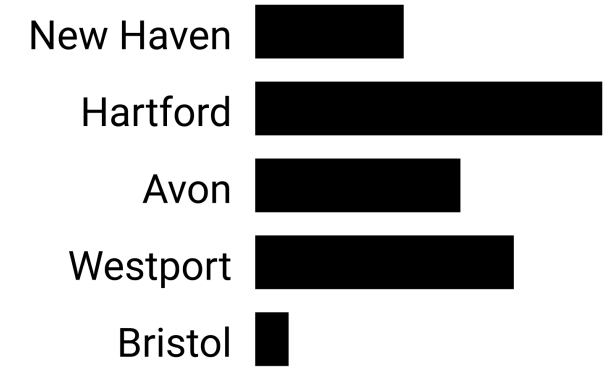


Francis Gagnon, Voilà

Order Your Data





"Hands-On Data Visualization" by Jack Dougherty & Ilya Ilyankou

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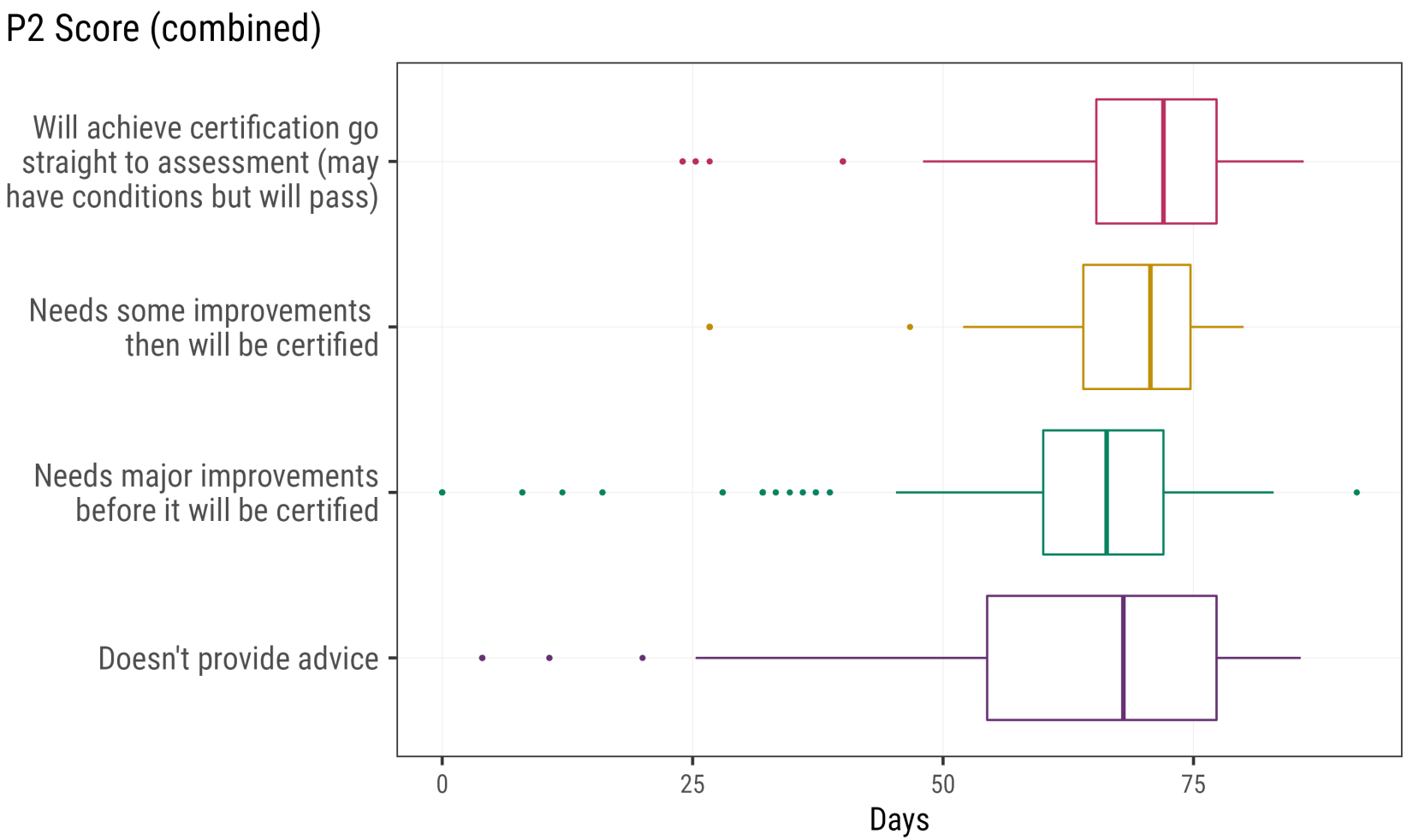

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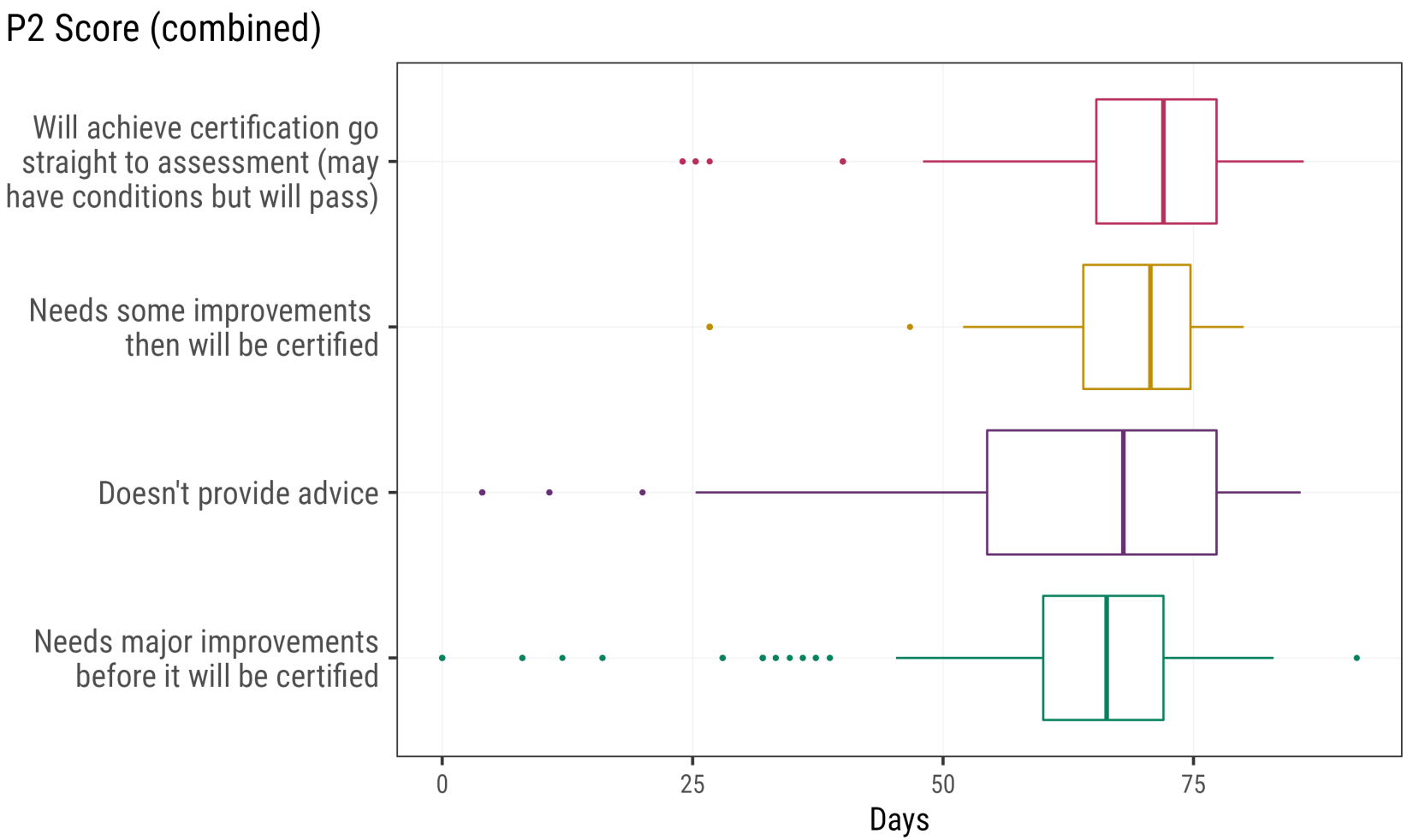

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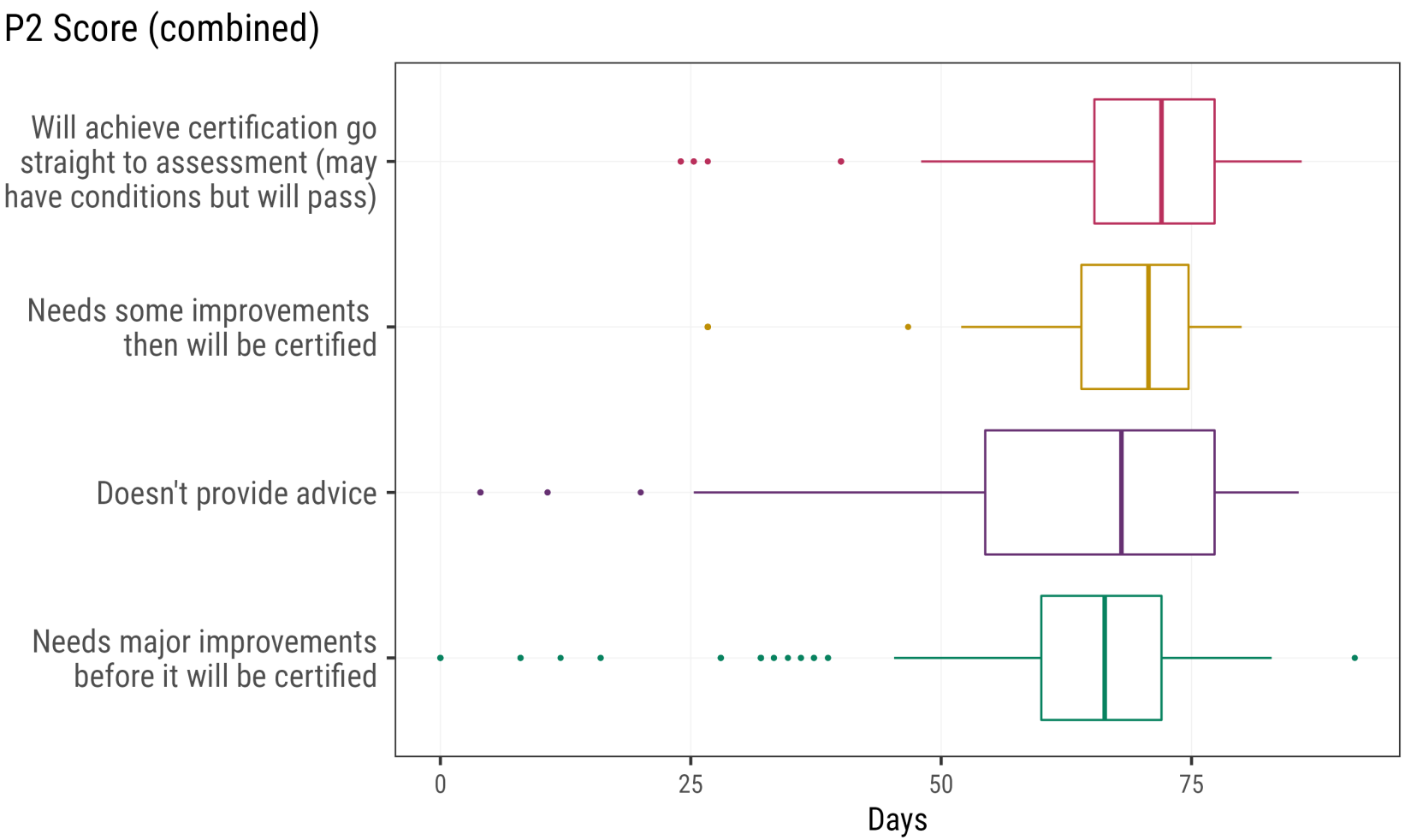
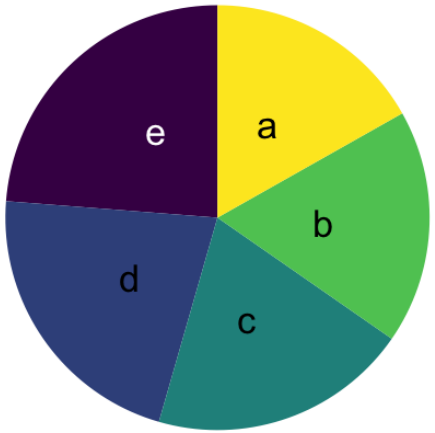
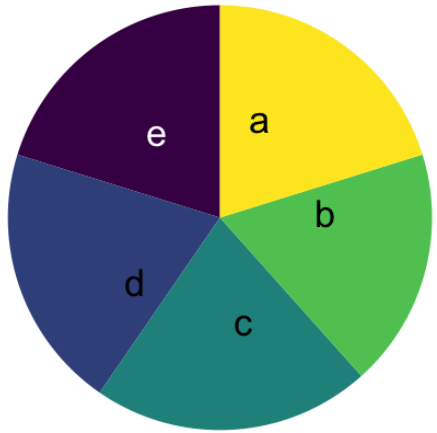
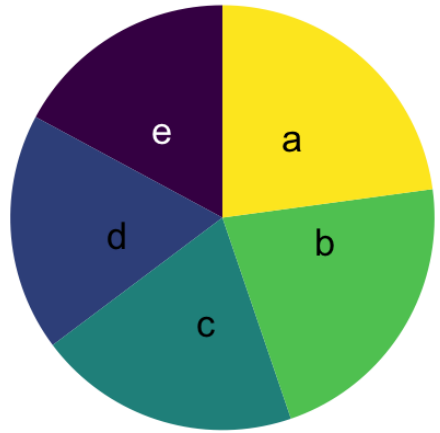


Beware of Pie Charts (almost ever)

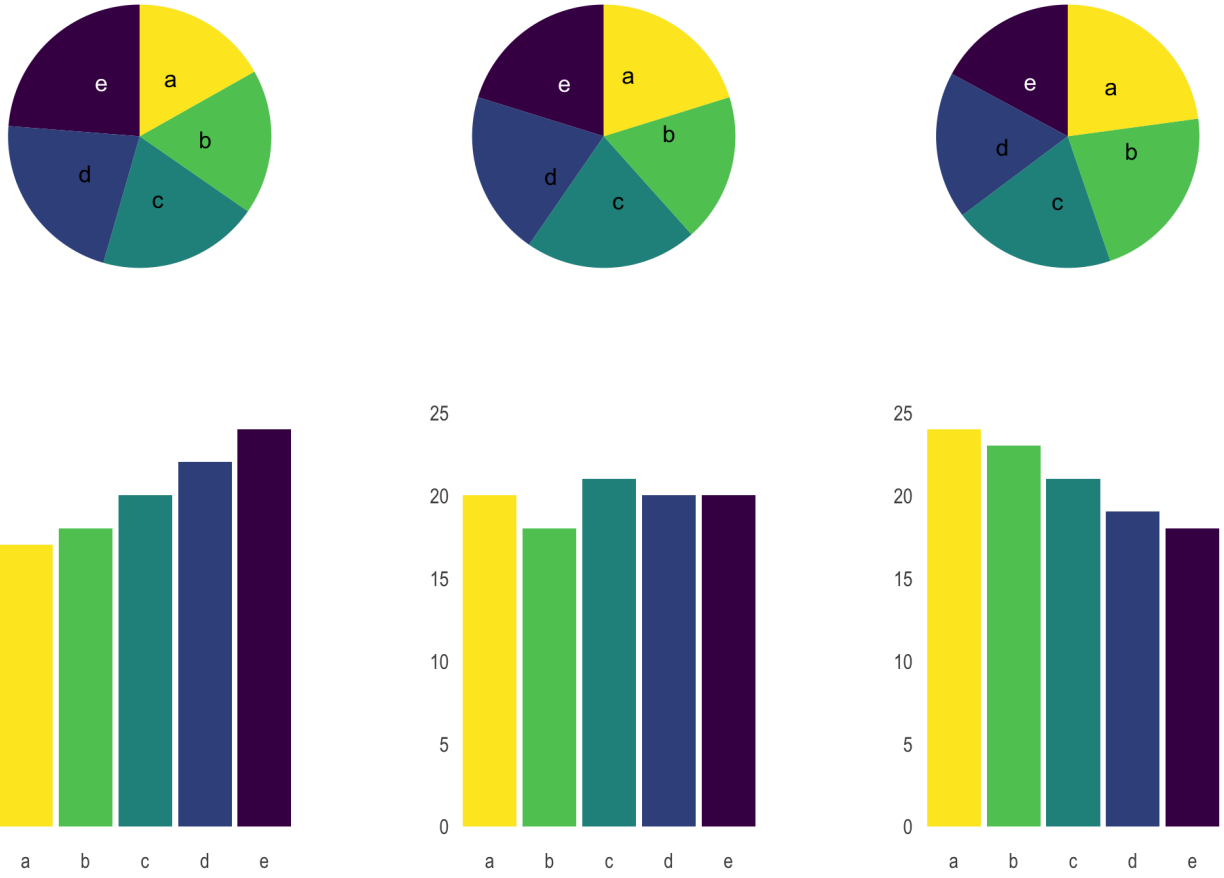






From Data to Viz

Beware of Pie Charts (almost ever)



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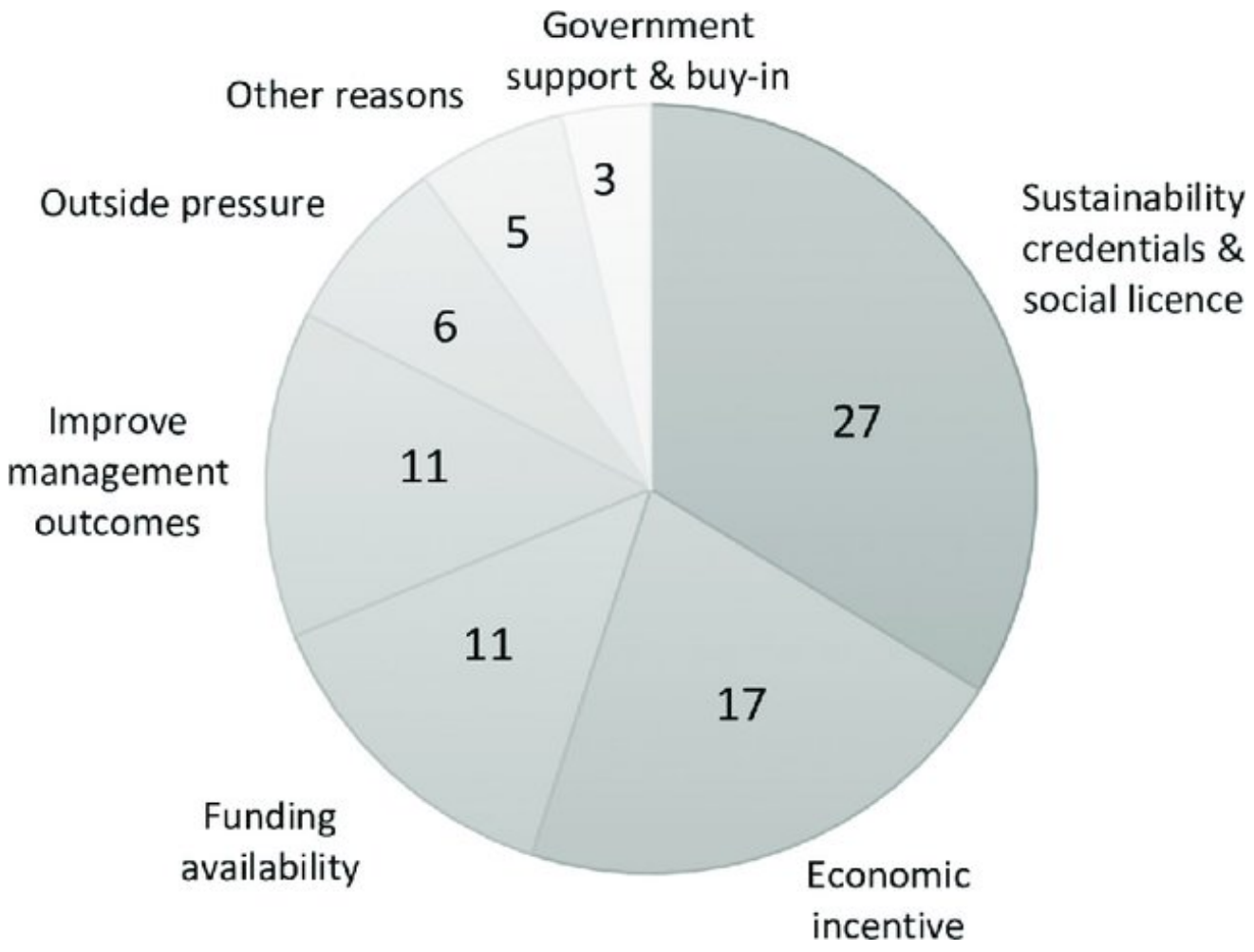
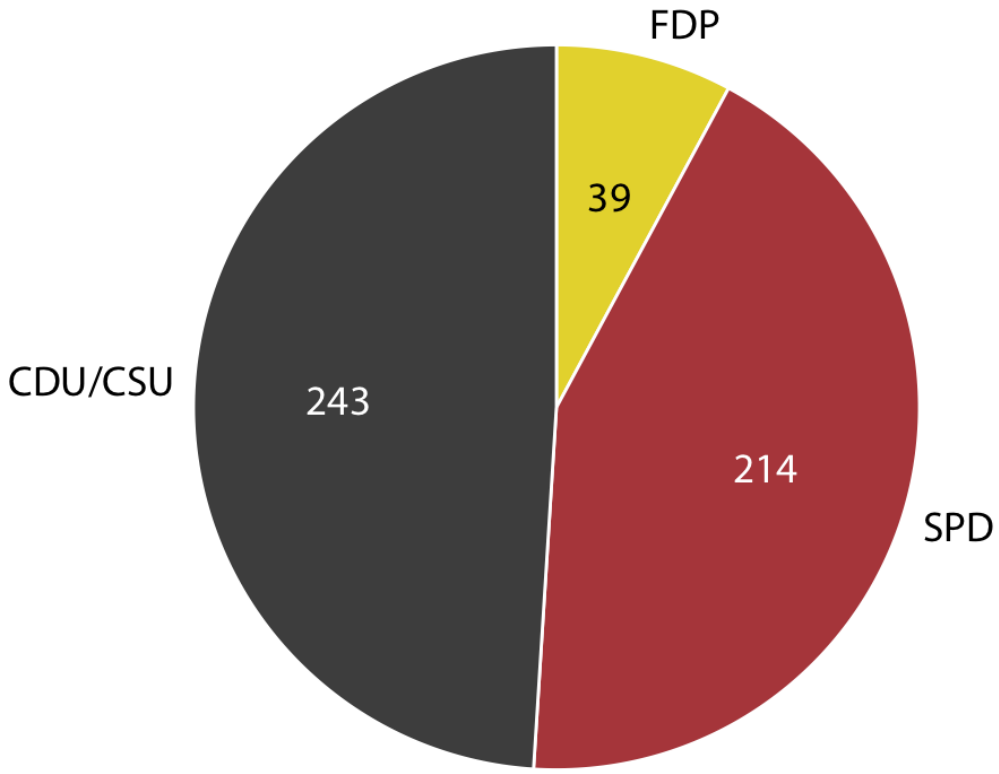
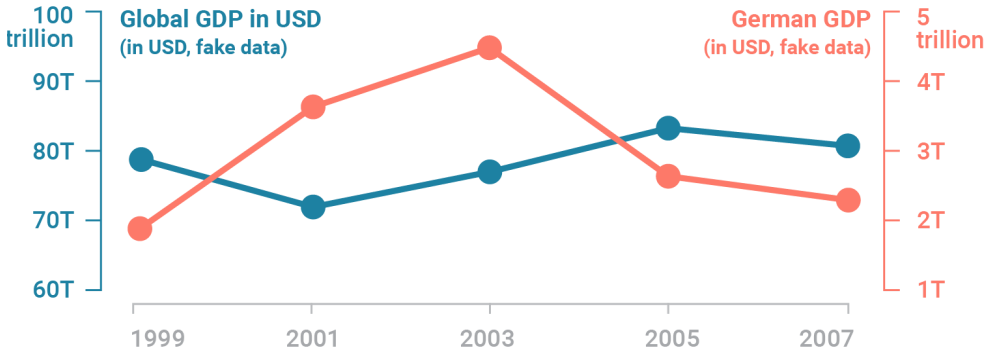


An Use Case for a Pie Chart



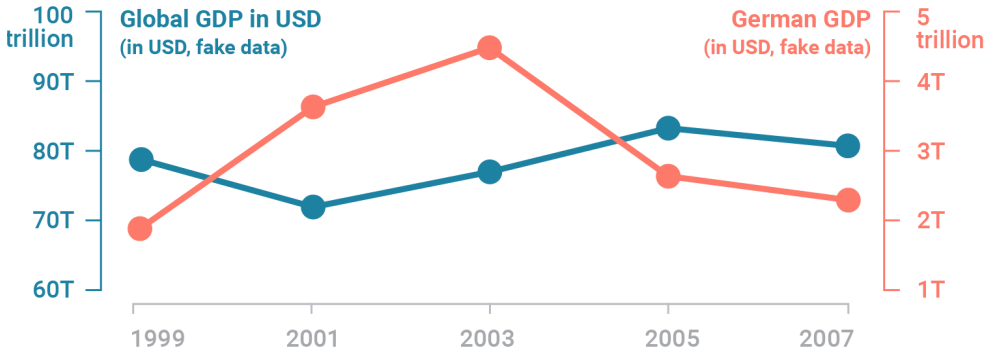
"Fundamentals of Data Visualization" by Claus Wilke

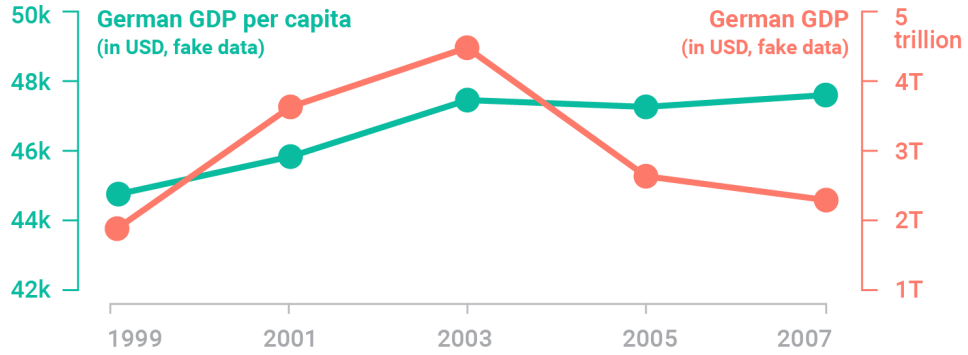
Avoid Dual Axes



Why not to use two axes, and what to use instead *by Lisa Charlotte Rost/DataWrapper*

Avoid Dual Axes





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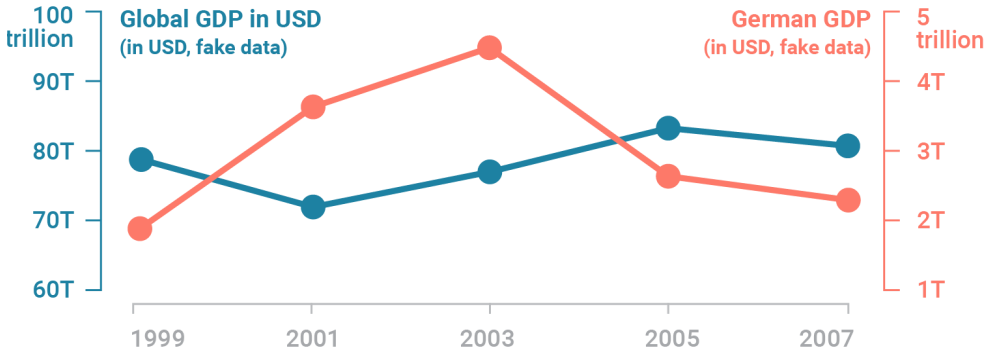

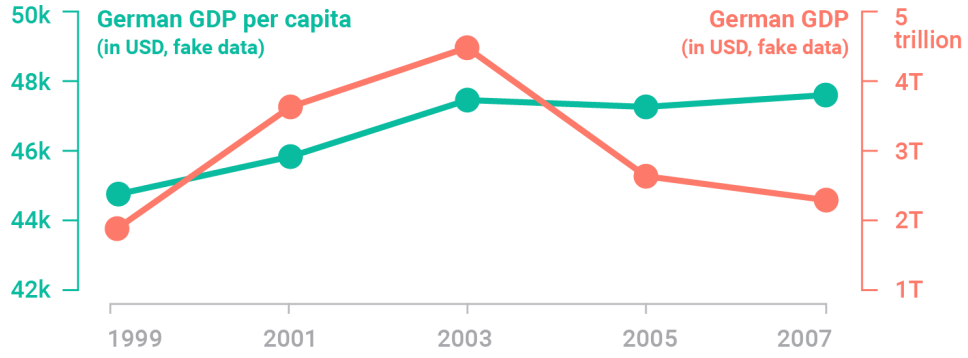

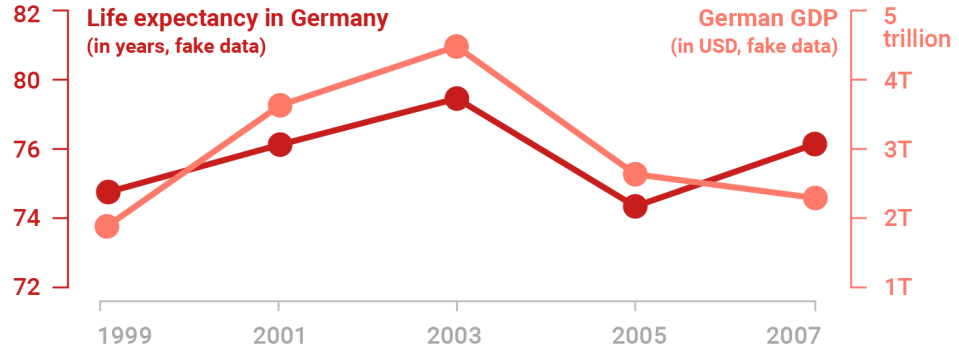

Why not to use two axes, and what to use instead *by Lisa Charlotte Rost/DataWrapper*

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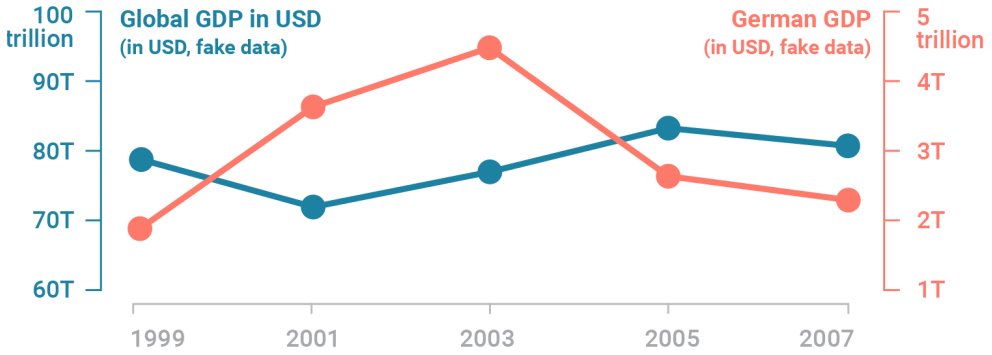

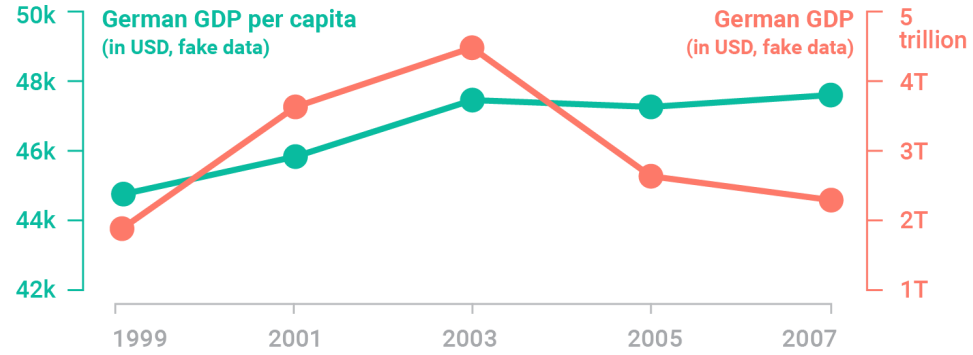

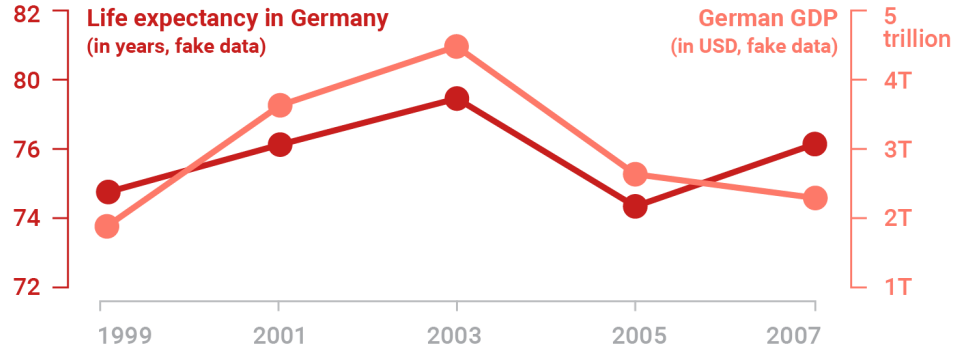

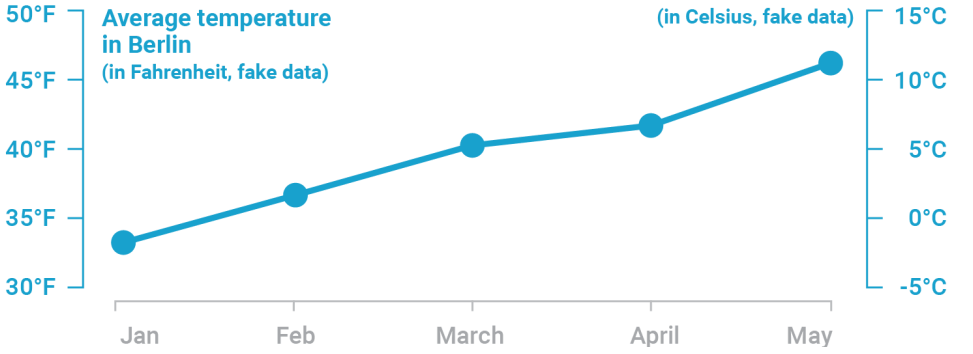

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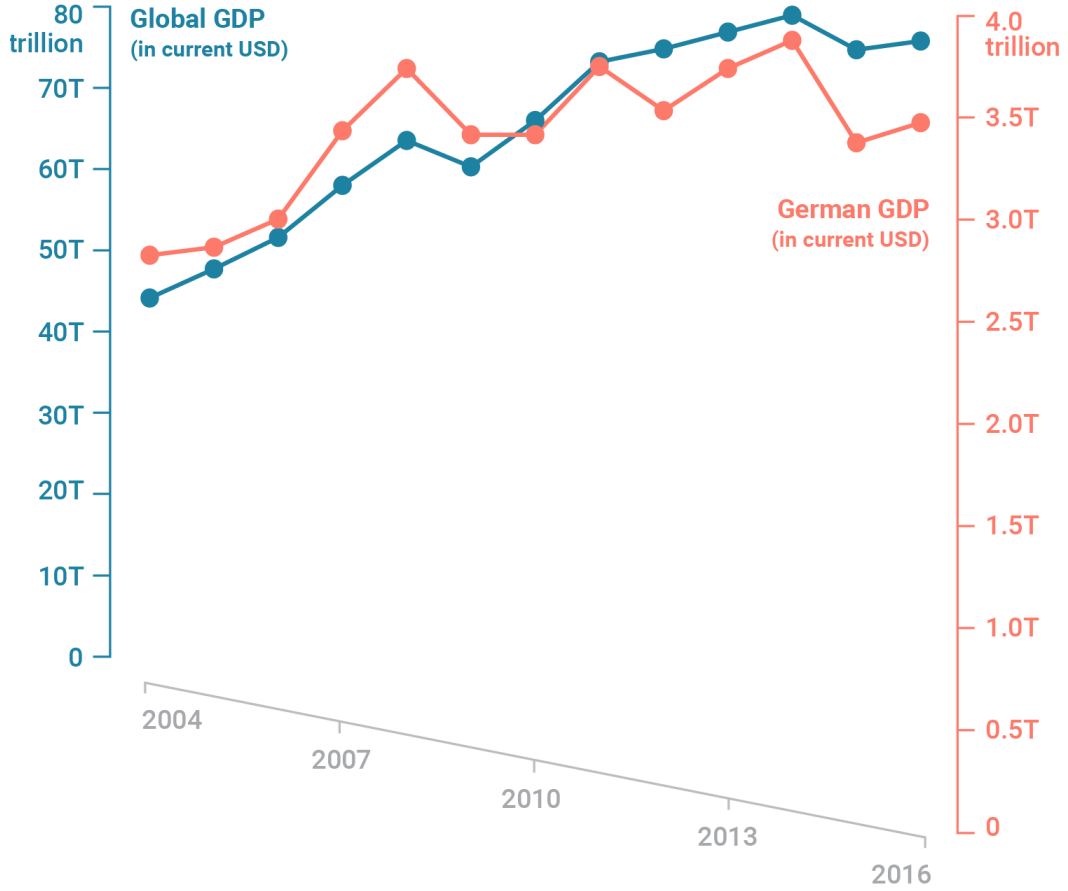
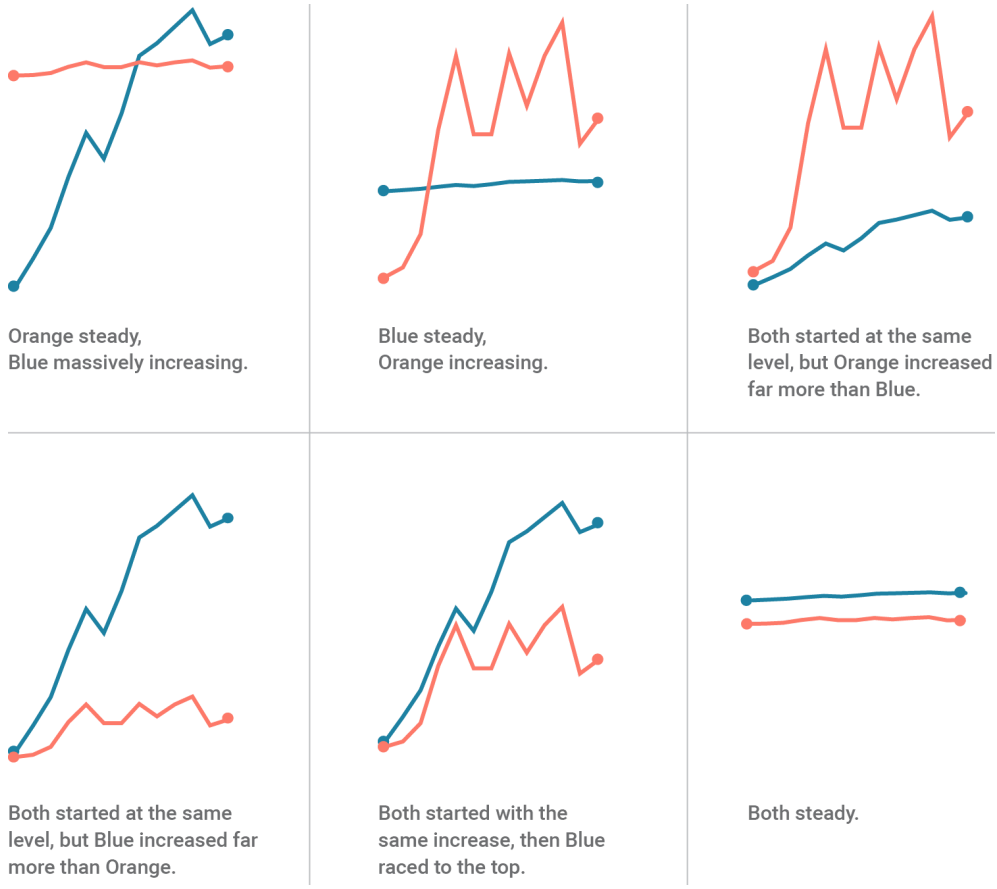


Why not to use two axes, and what to use instead by Lisa Charlotte Rost/DataWrapper

Avoid Dual Axes



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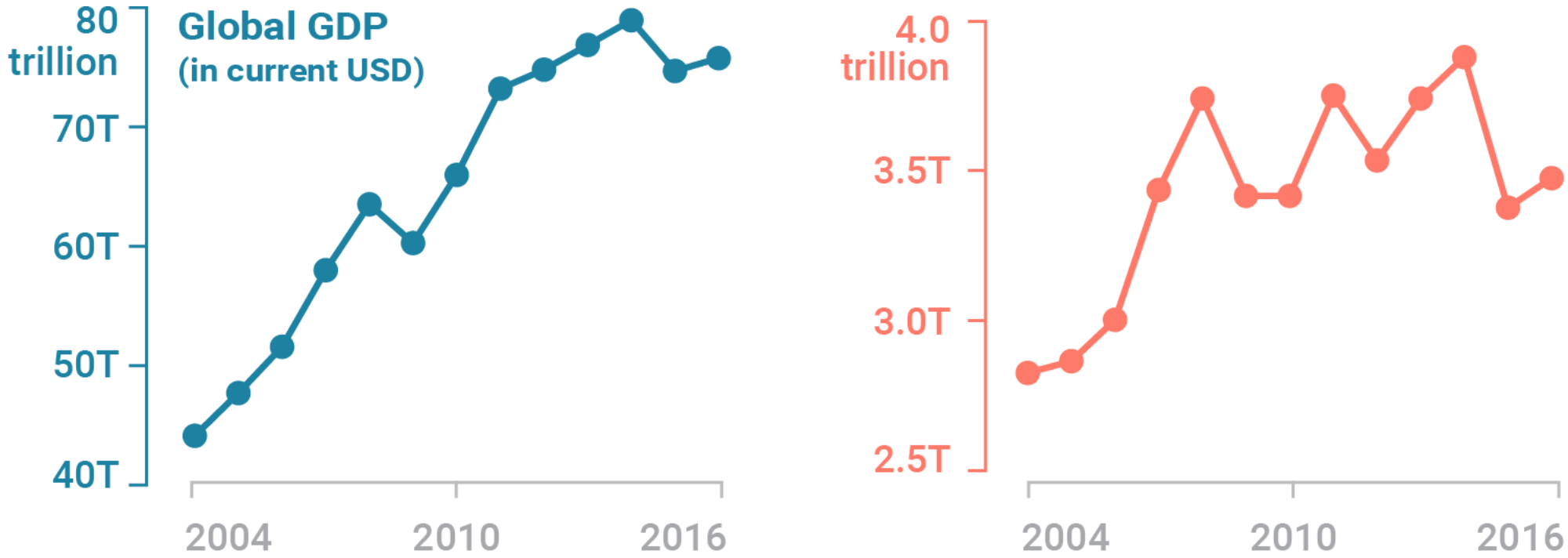

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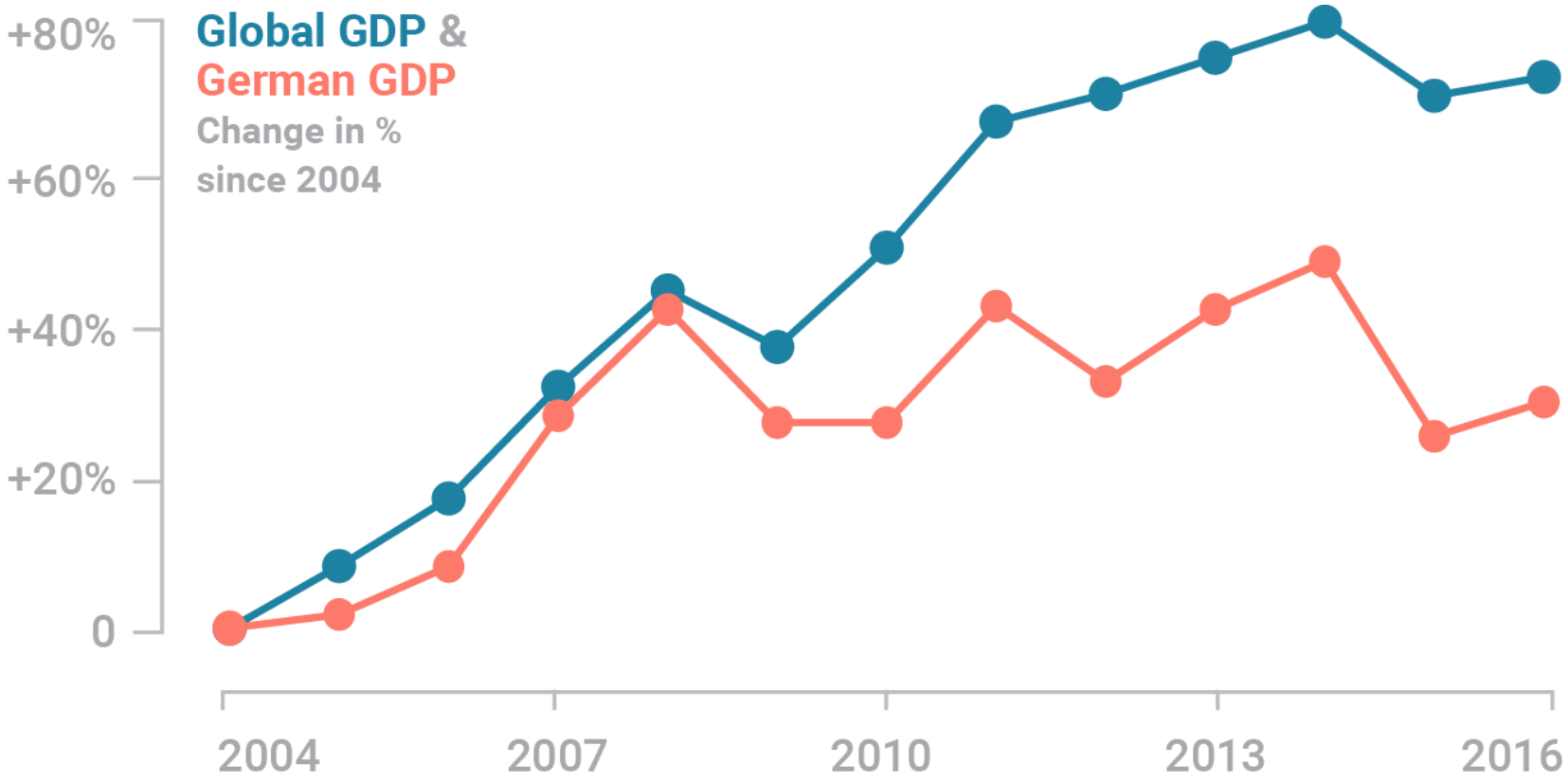

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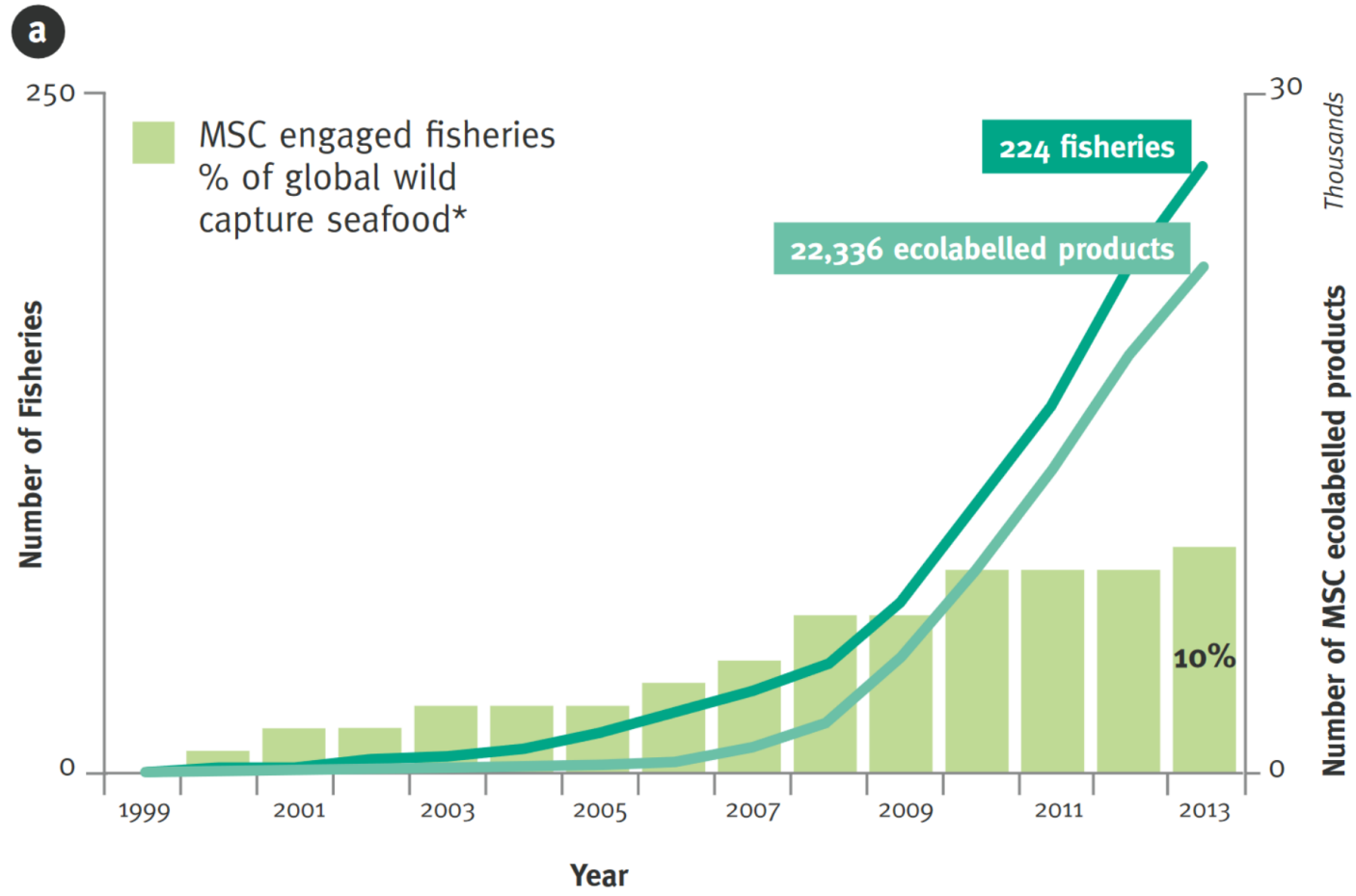

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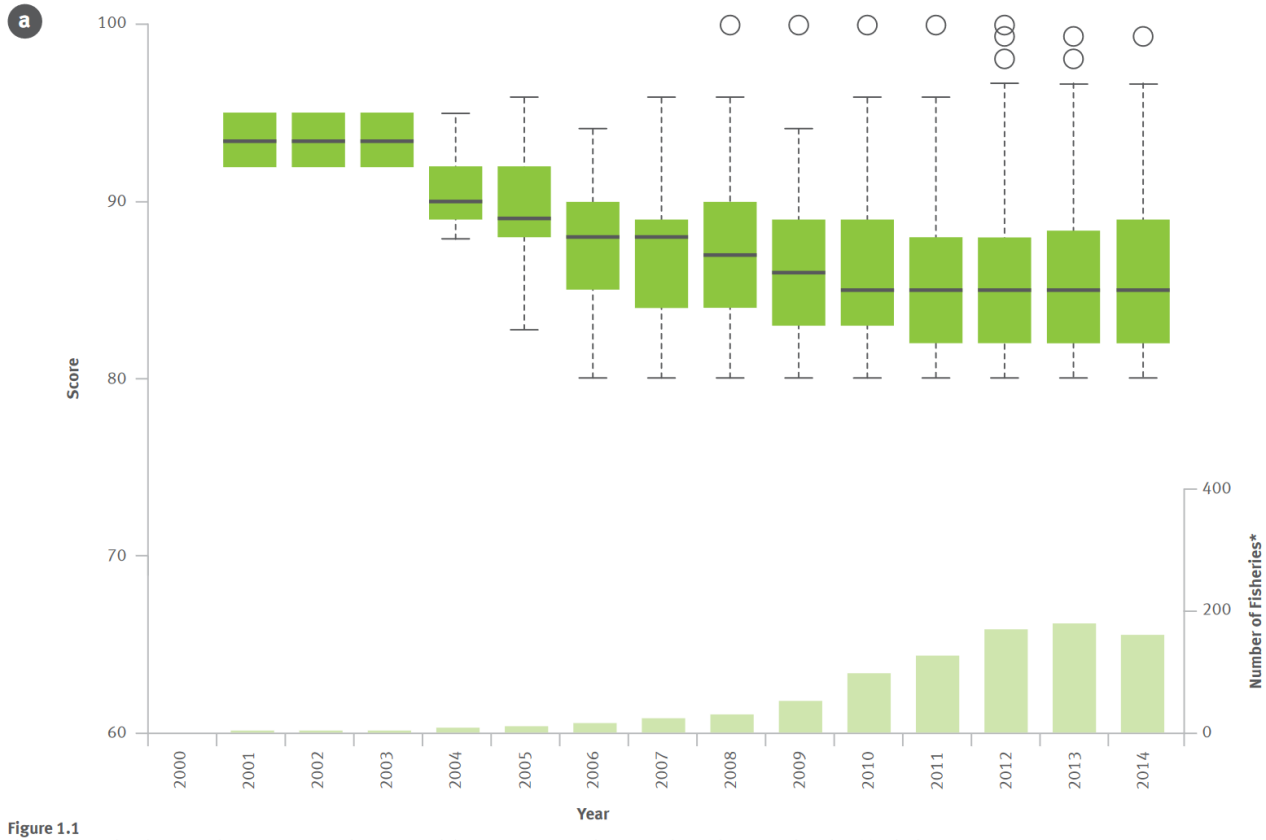

Figure 1.1
Figure 1.1 Median, interquartile range, and maximum and minimum scores of certified fisheries at time of certification (a) Principle 1: Sustainable fish stocks; (b) Principle 2: Minimising environmental impact; and (c) Principle 3: Effective management. Pale green bars represent the number of fisheries* scored by year.

A word about Tables

Make Your Data Tables More Visual

Table 1: Change in household wealth 2018–19 by region

	Total wealth	Change in total wealth		Wealth per adult	Change in wealth per adult	Change in financial assets		Change in non-financial assets		Change in debts	
	2019	2018-19	2018-19	2019	2018-19	2018-19	2018-19	2018-19	2018-19	2018-19	2018-19
	USD bn	USD bn	%	USD	%	USD bn	%	USD bn	%	USD bn	%
Africa	4,119	130	3.3	6,488	0.4	1	0.1	164	6.6	35	7.7
Asia-Pacific	64,778	825	1.3	54,211	-0.3	539	1.5	672	1.9	386	4.2
China	63,827	1,889	3.1	58,544	2.6	88	0.2	2,273	7.5	471	10.9
Europe	90,752	1,098	1.2	153,973	1.2	127	0.3	1,156	2.0	190	1.4
India	12,614	625	5.2	14,569	3.3	37	1.4	708	6.9	120	11.5
Latin America	9,906	463	4.9	22,502	3.2	198	4.0	340	5.7	70	5.0
North America	114,607	4,061	3.7	417,694	2.7	3,334	3.6	1,353	3.8	626	3.8
World	360,603	9,087	2.6	70,849	1.2	4,319	2.0	6,666	3.7	1,898	4.0

Source: James Davies, Rodrigo Lluberas and Anthony Shorrocks, Global wealth databook 2019

Make Your Data Tables More Visual

Table 1: Change in household wealth 2018–2019 by region

Overall total wealth and mean wealth per adult refer to 2019 only. Triangles pointing upwards indicate the highest proportional change per category triangles pointing downwards the lowest change.

	TOTAL WEALTH			WEALTH PER ADULT		FINANCIAL ASSETS		NON-FINANCIAL ASSETS		DEBTS	
	OVERALL	CHANGE^		MEAN	CHANGE	CHANGE		CHANGE		CHANGE	
	(USD bn)	(USD bn)	(prop.)	(USD)	(prop.)	(USD bn)	(prop.)	(USD bn)	(prop.)	(USD bn)	(prop.)
World	360,603	9,087	2.6%	70,849	1.2%	4,319	2.0%	6,666	3.7%	1,898	4.0%
North America	114,607	4,061	3.7%	417,694	2.7%	3,334	3.6%	1,353	3.8%	626	3.8%
Europe	90,752	1,093	1.2% ▽	153,973	1.2%	127	3.0%	1,156	2.0%	190	1.4% ▽
Asia-Pacific	64,778	825	1.3%	54,211	-0.3% ▽	539	1.5%	672	1.9% ▽	386	4.2%
China	63,827	1,889	3.1%	58,544	2.6%	88	2.0%	2,273	7.5% △	471	10.9%
India	12,614	615	5.2% △	14,569	3.3% △	37	1.4%	708	6.9%	120	11.5% △
Latin America	9,906	463	4.9%	22,502	3.2%	193	4.0% △	340	5.7%	70	5.0%
Africa	4,119	130	3.3%	6,488	0.4%	1	1.0% ▽	164	6.6%	35	7.7%

Source: James Davies, Rodrigo Lluberas and Anthony F. Shorrocks, Global Wealth Databook, 2019 | Makeover: Cedric Scherer, Frontpage Data

J. Benefit Cost Anal. 2020; 11(2):151–178
doi:10.1017/bca.2020.11

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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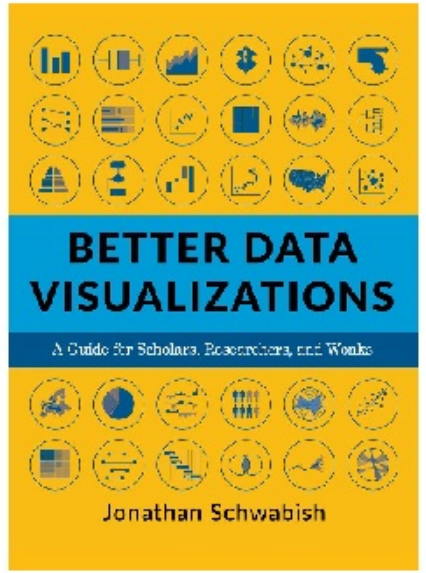

John Schwabisch

Potato Yield in Tonnes/Hectare			
Country	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

Potato Yield in Tonnes/Hectare					
Country	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

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Inspiration: @jschwabish

Thomas Mock

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).

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Books

- **“Fundamentals of Data Visualization”**, an open-access book by Claus Wilke
- **“Data Visualization”**, an open-access book by Kieran Healy
- **“Avoiding Data Pitfalls”** by Ben Jones
- **“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

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 Rost