Data Visualizations & Graphical Storytelling for Data Analysts and Data Scientists

Guide the View(er)

Dr Cédric Scherer

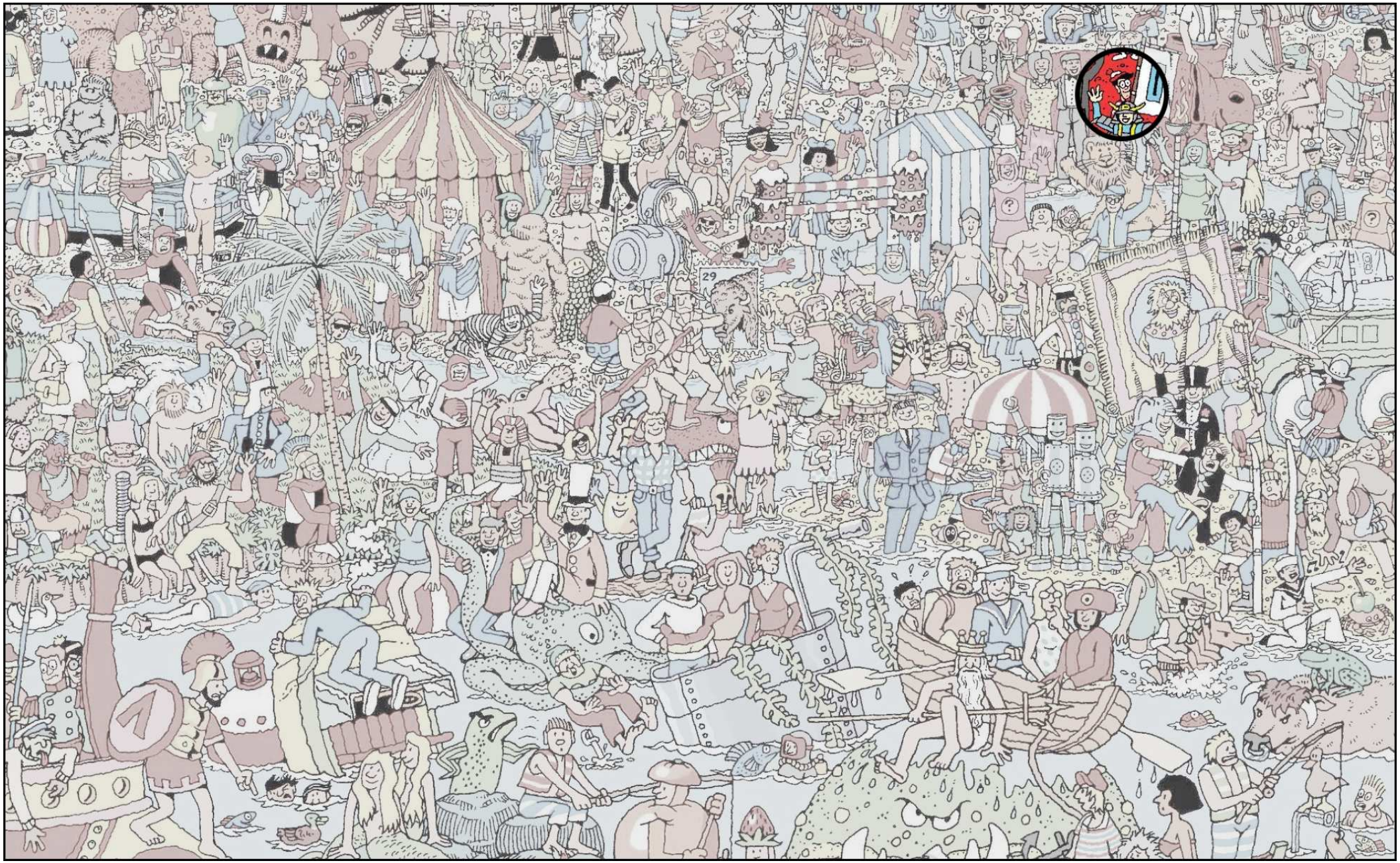
Hello Heart // March 2024


ONE
WAY
ONE
WAY
Guide the
Viewer

Principles of Visual Perception

Cédric Scherer @ Hello Heart // Data Visualization & Information Design

Source: “Where’s Waldo?” by Martin Handford © Kilburn & Strode LLP



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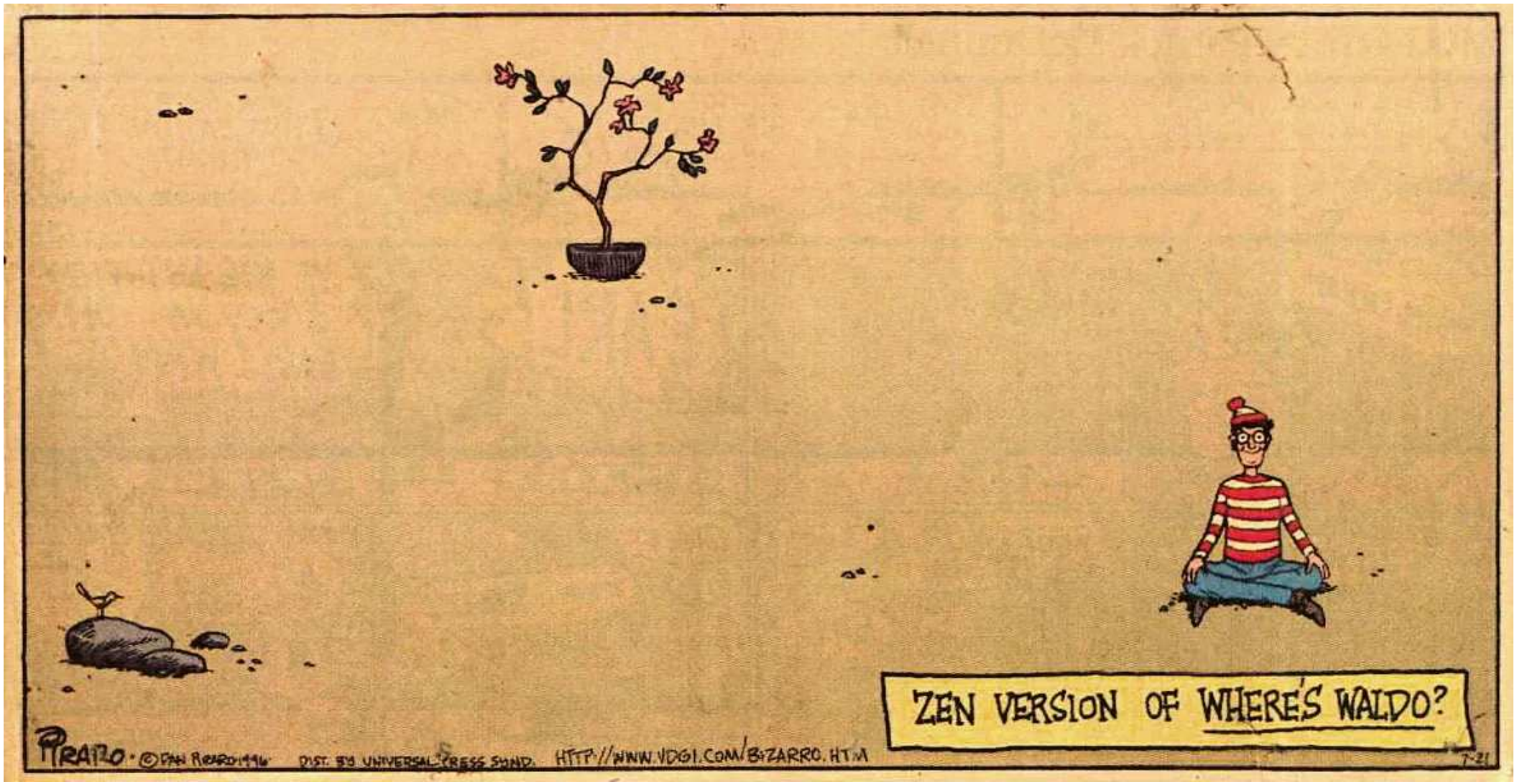

Source: Zen Version of “Where’s Waldo?” by Dan Piraro

5 3 7 2 0 9 4 8 1 3

4 9 5 4 3 5 2 5 4 6

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7 3 2 9 6 0 2 5 9 1

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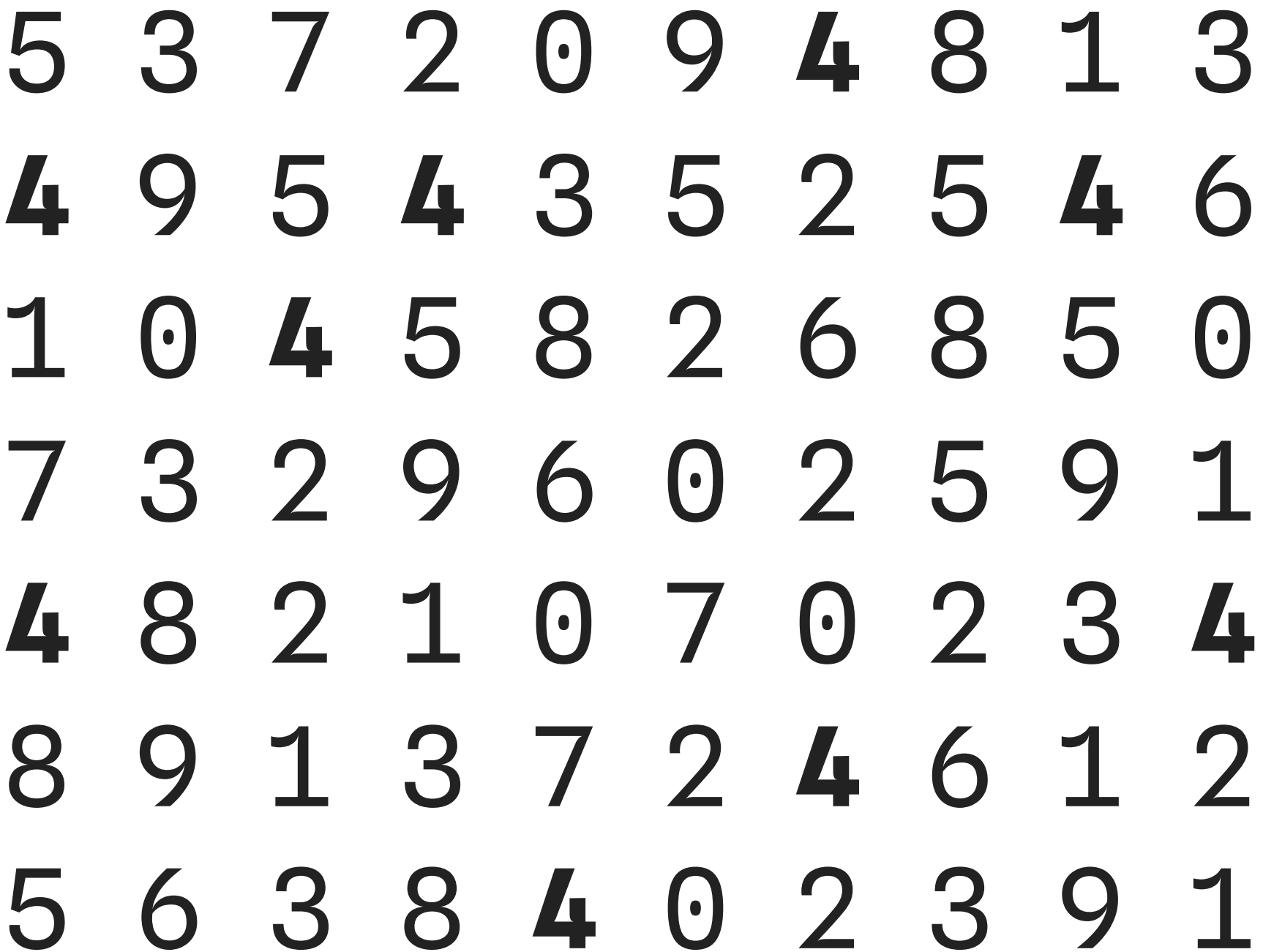
8 9 1 3 7 2 4 6 1 2

5 6 3 8 4 0 2 3 9 1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Iconic Memory

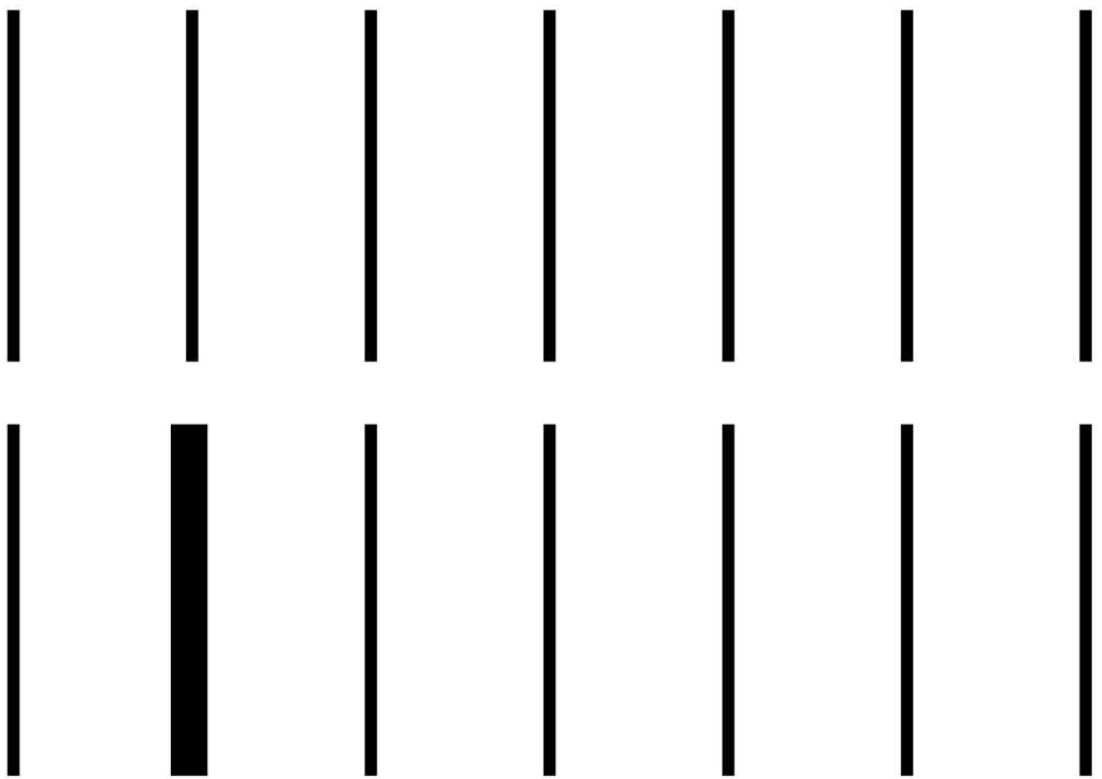
is a type of **sensory memory** that
briefly retains visual information
for a very short period.

Iconic memory *operates at a* ***pre-attentive level***,
meaning that it functions before conscious attention
is directed toward the visual stimuli.

Preattentive Attributes

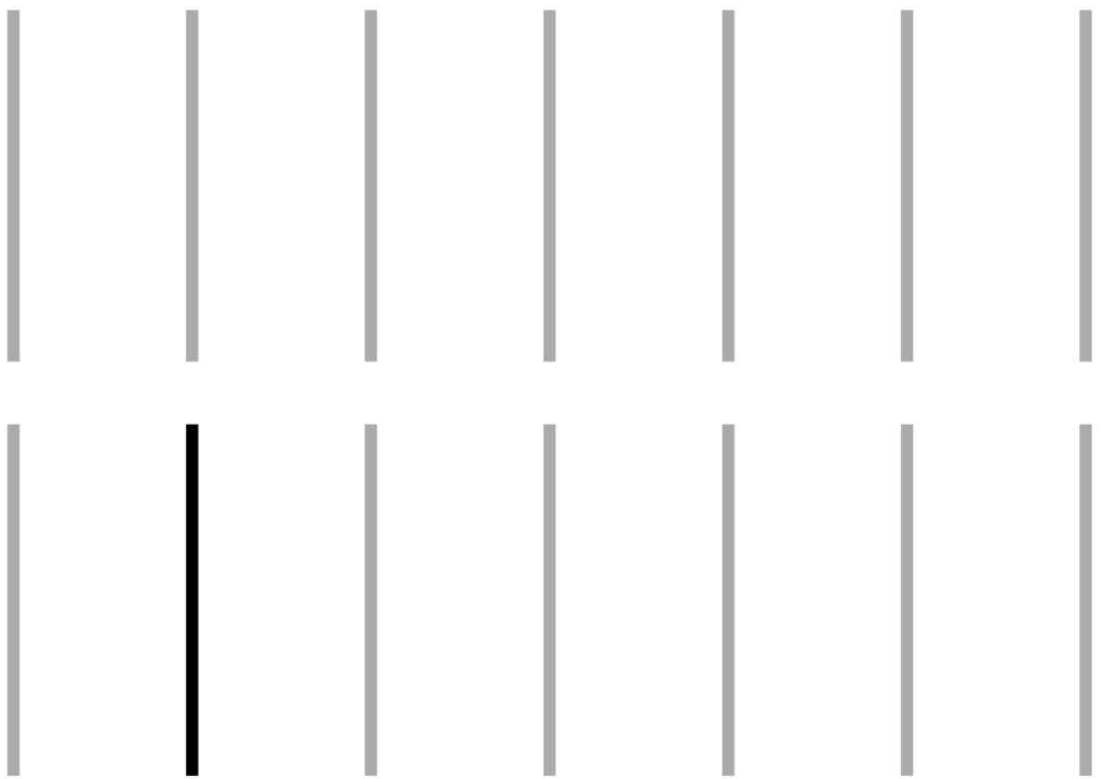
Visual properties that the human brain can instantly and subconsciously perceive.

Width / Size



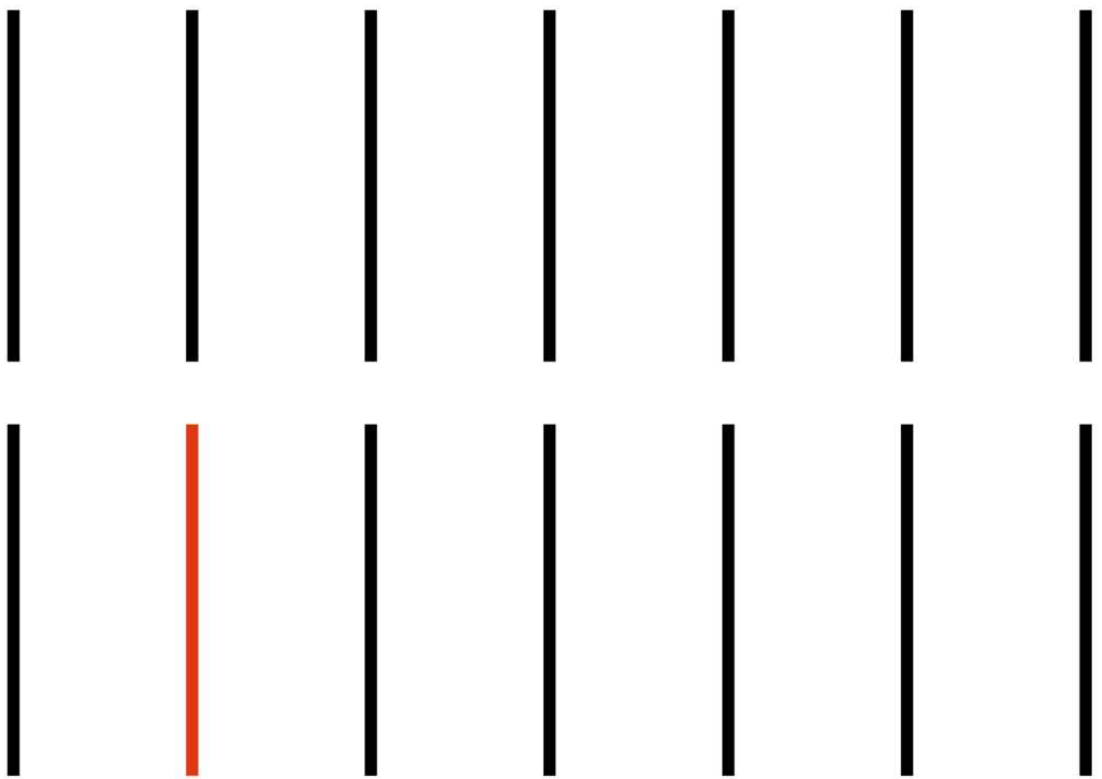
Adapted from Stephen Few and others

Intensity



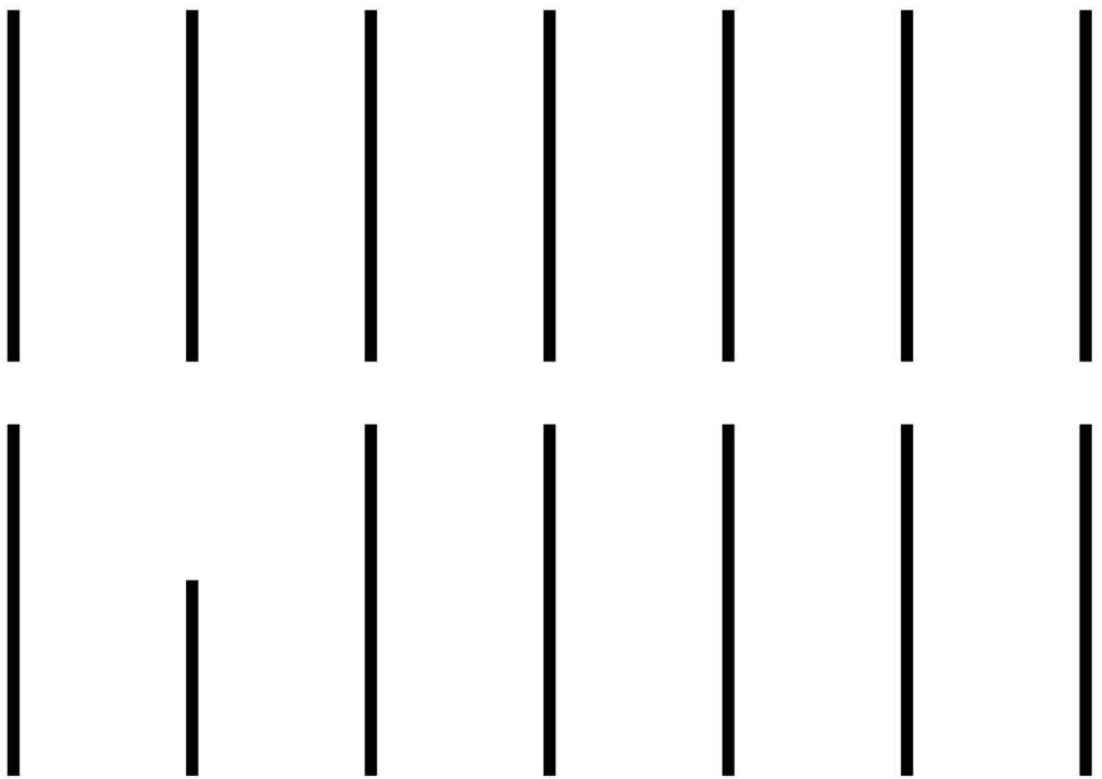
Adapted from Stephen Few and others

Hue



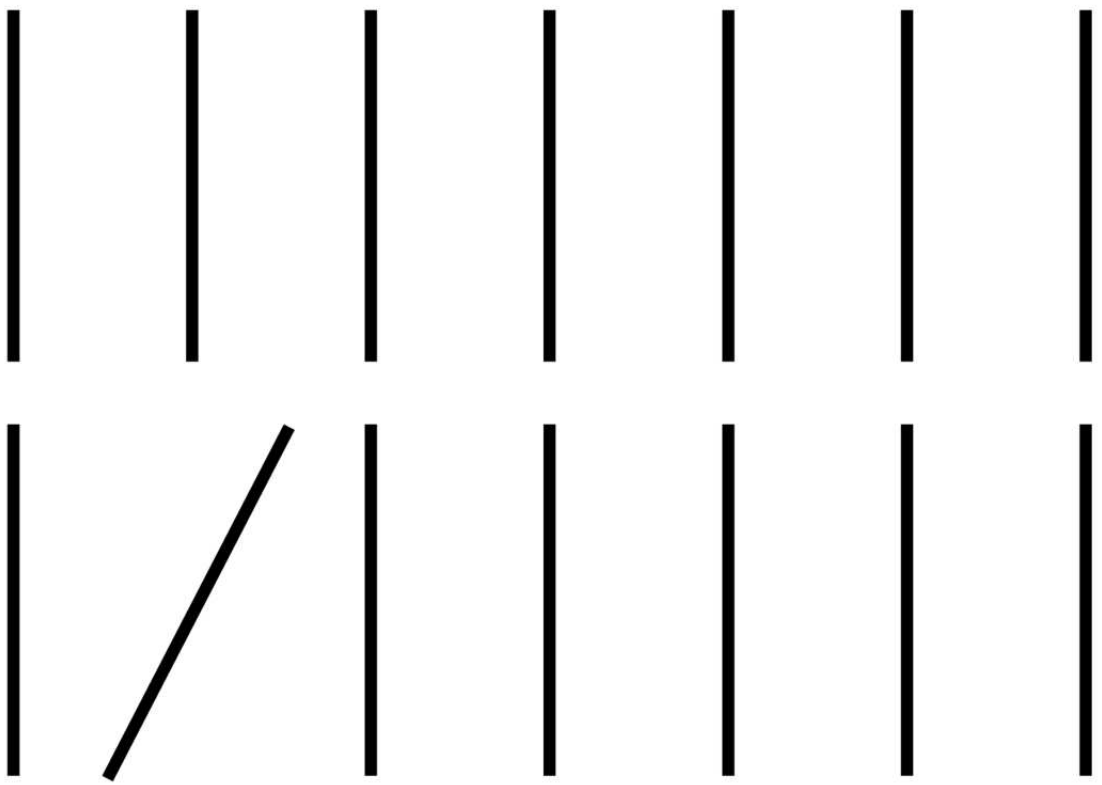
Adapted from Stephen Few and others

Length



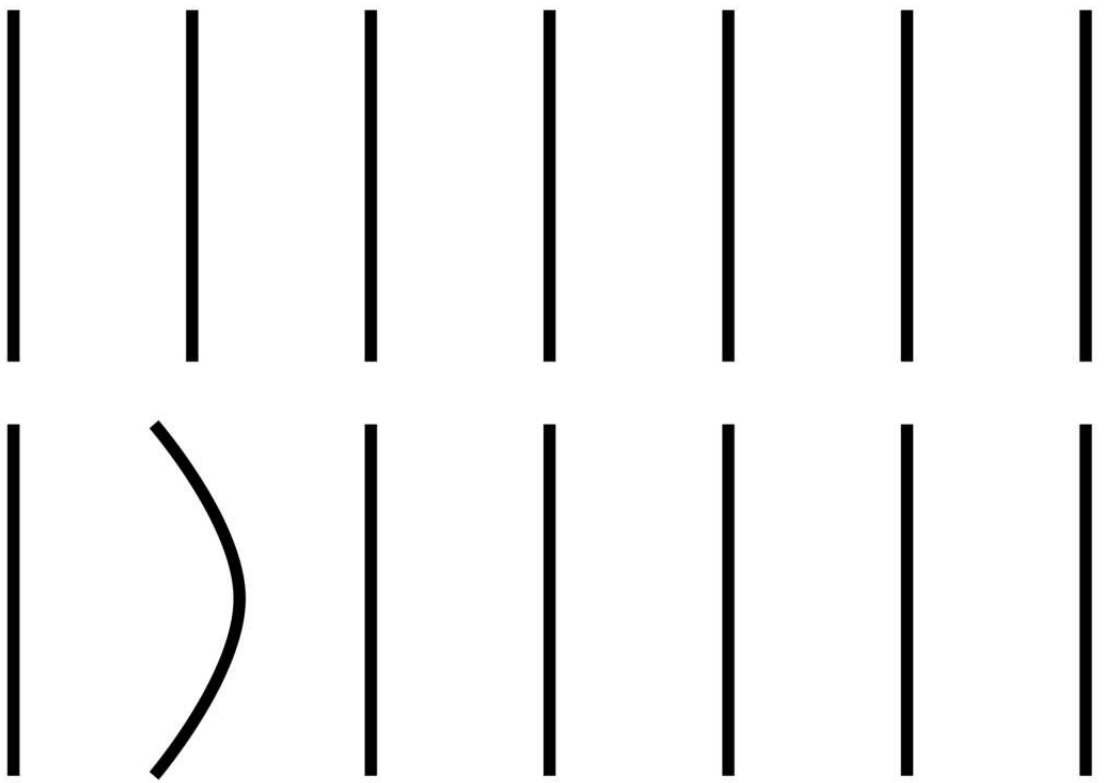
Adapted from Stephen Few and others

Orientation



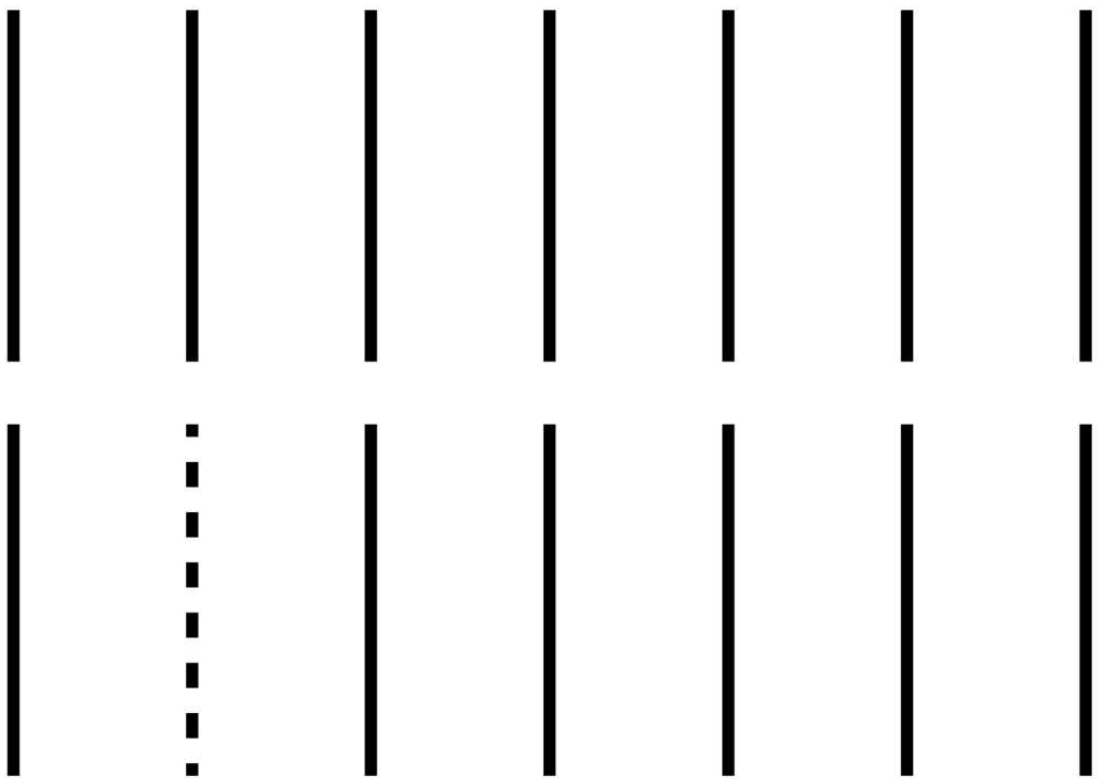
Adapted from Stephen Few and others

Curvature



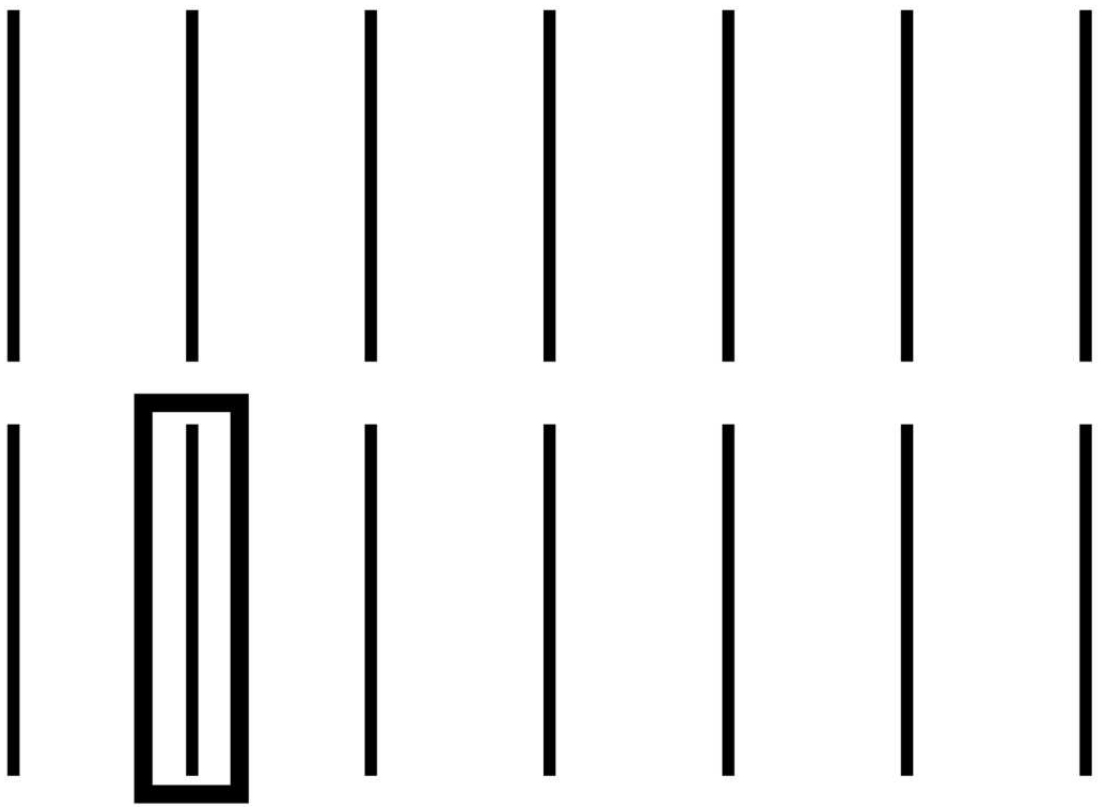
Adapted from Stephen Few and others

Shape / Linetype



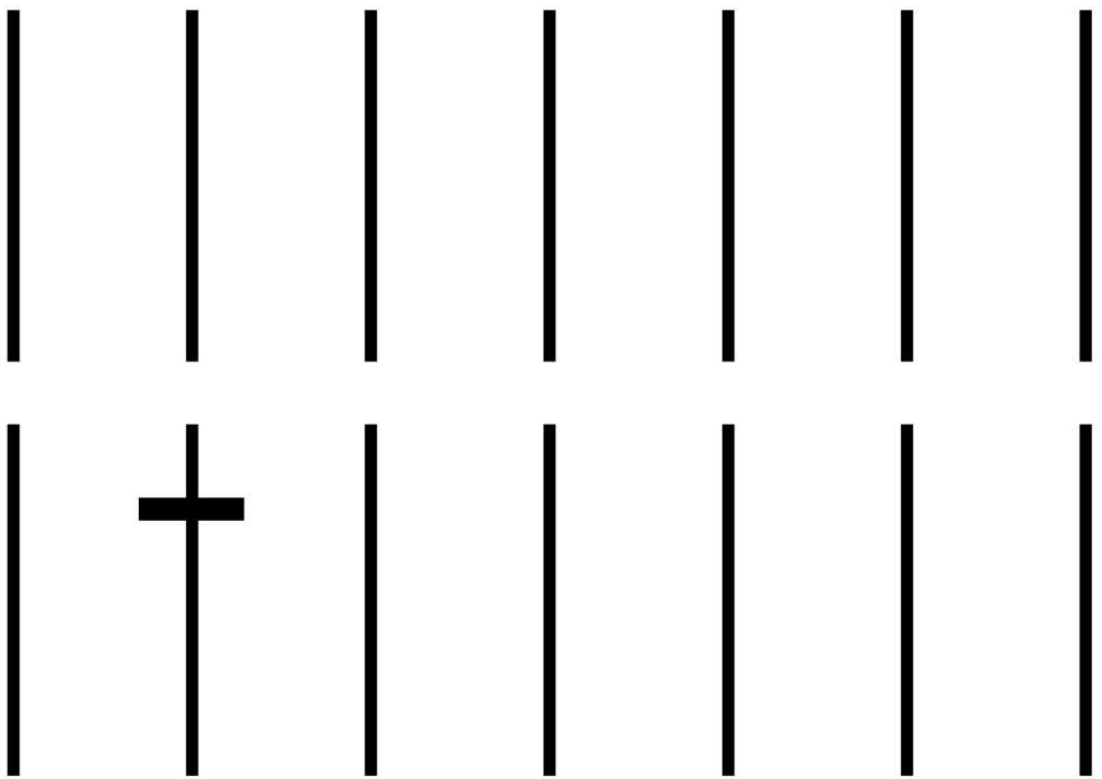
Adapted from Stephen Few and others

Enclosure



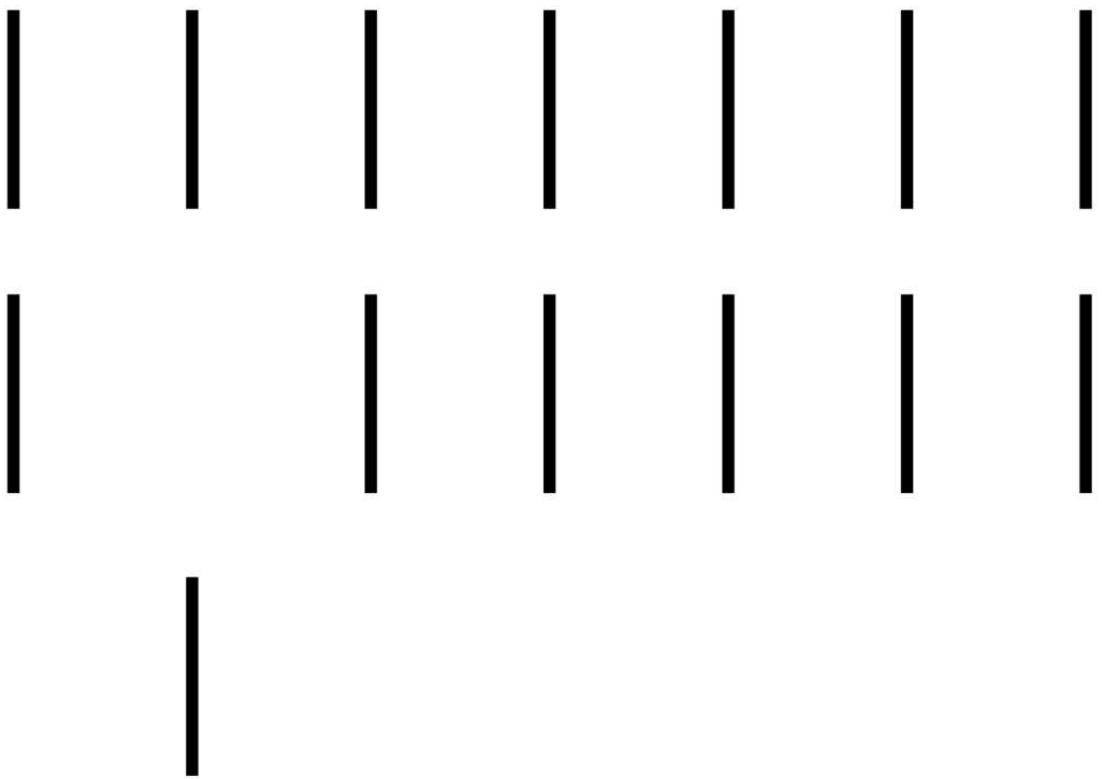
Adapted from Stephen Few and others

Added Marks



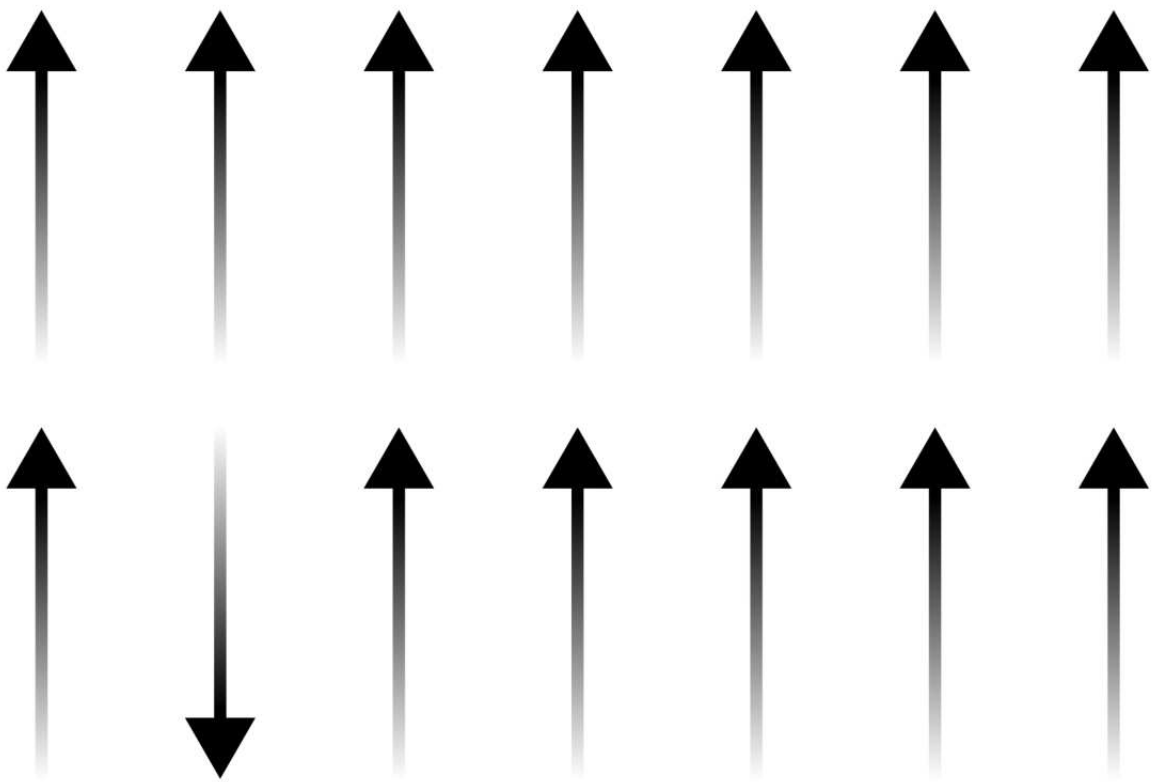
Adapted from Stephen Few and others

Position



Adapted from Stephen Few and others

Direction of Motion



Adapted from Stephen Few and others

Keep it simple

In his book Information Visualization: Perception for Design, Colin Ware states:

> *"It is easy to spot a hawk in a sky full of pigeons, but as the variety of birds increases the hawk becomes harder to pick out."*

In other words, **the more things are made different, the less any of them stand out**.

So, it is *good practice* to start with figuring out an item of interest you want to emphasise, and then trying to make it the one thing that is different, thus leveraging your contrast strategically.

Source: Deya Milcheva (5rdata.com)

Keep it simple

size, weight, type + spacing

color + added mark

In his book Information Visualization: Perception for Design, Colin Ware states:

added mark

spacing

> *"It is easy to spot a hawk in a sky full of pigeons, but as the variety of birds increases the hawk becomes harder to pick out."*

type + style

↔ position

spacing

In other words, **the more things are made different, the less any of them stand out**.

style

spacing

weight

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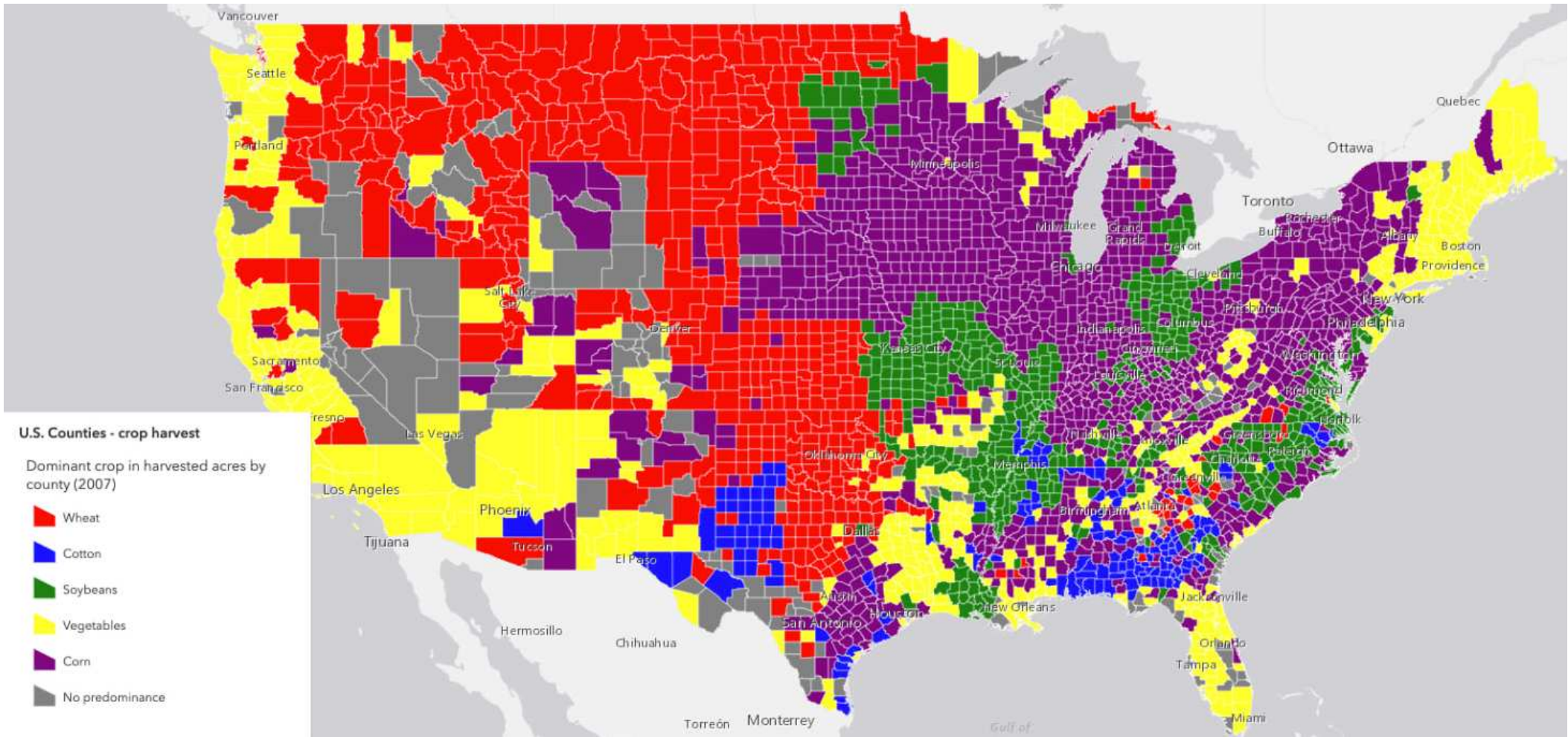
size, color + spacing


U.S. Counties - crop harvest
Dominant crop in harvested acres by county (2007)
Wheat
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Soybeans
Vegetables
Corn
No predominance
Vancouver
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Ottawa
Toronto
Minneapolis
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Rochester
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Chicago
Cleveland
New York
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Philadelphia
Salt Lake City
Denver
Indianapolis
Columbus
Kansas City
St. Louis
Louisville
Cincinnati
Washington
Richmond
Norfolk
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San Francisco
Fresno
Las Vegas
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Greensboro
Charlotte
Raleigh
Oklahoma City
Memphis
Greenville
Los Angeles
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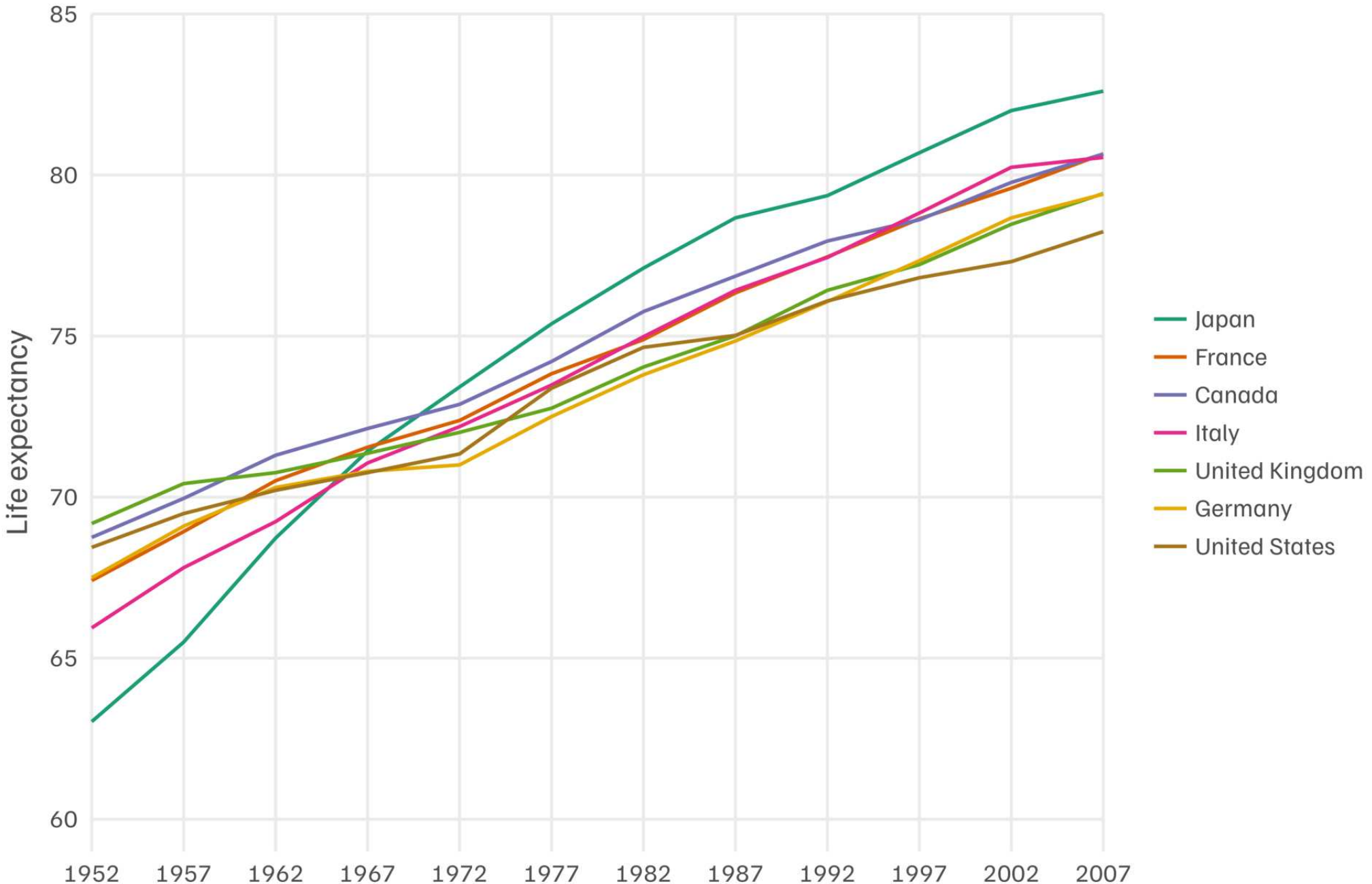
Monterrey
Miami
Gulf of

Source: ESRI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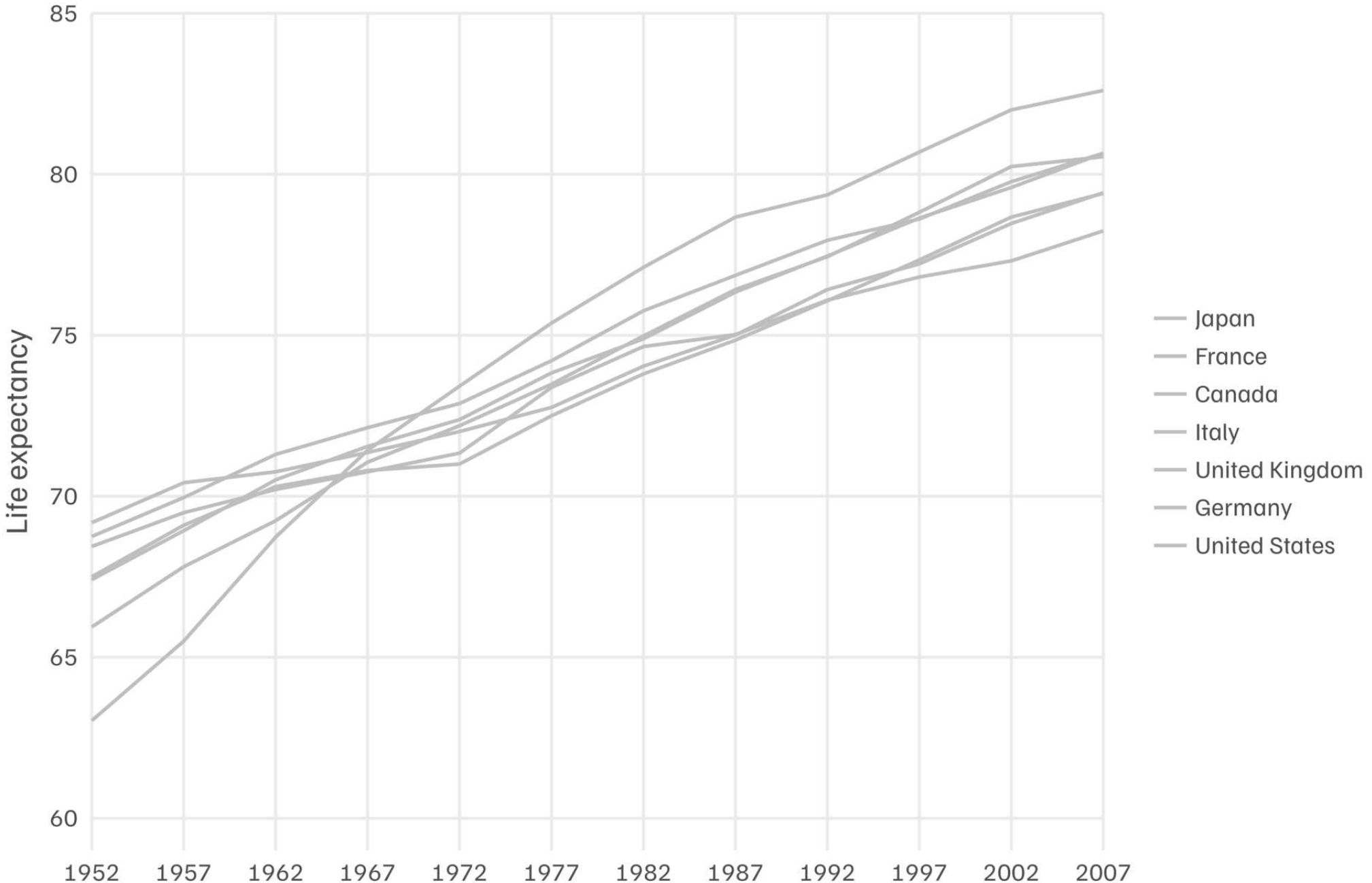
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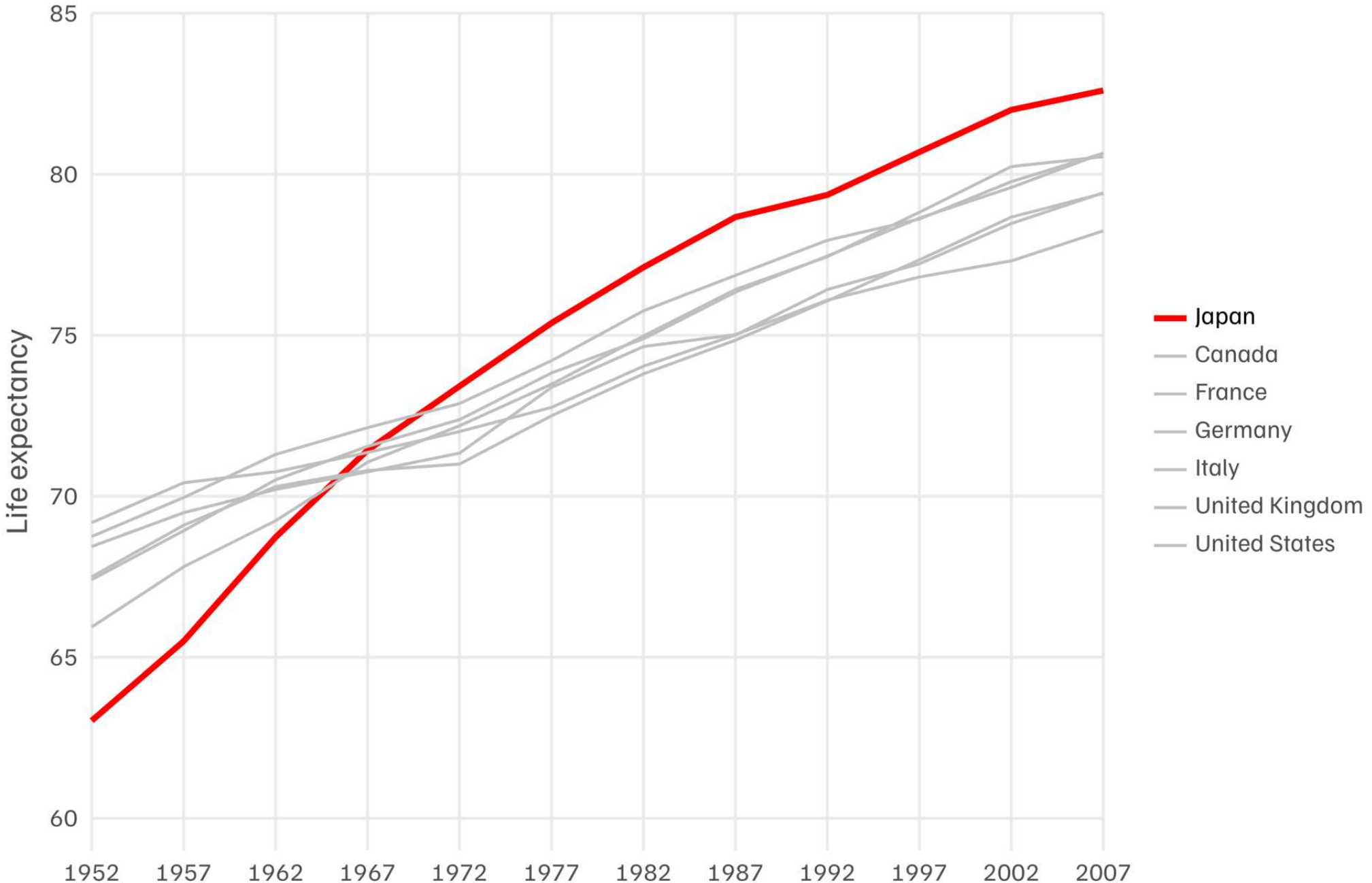
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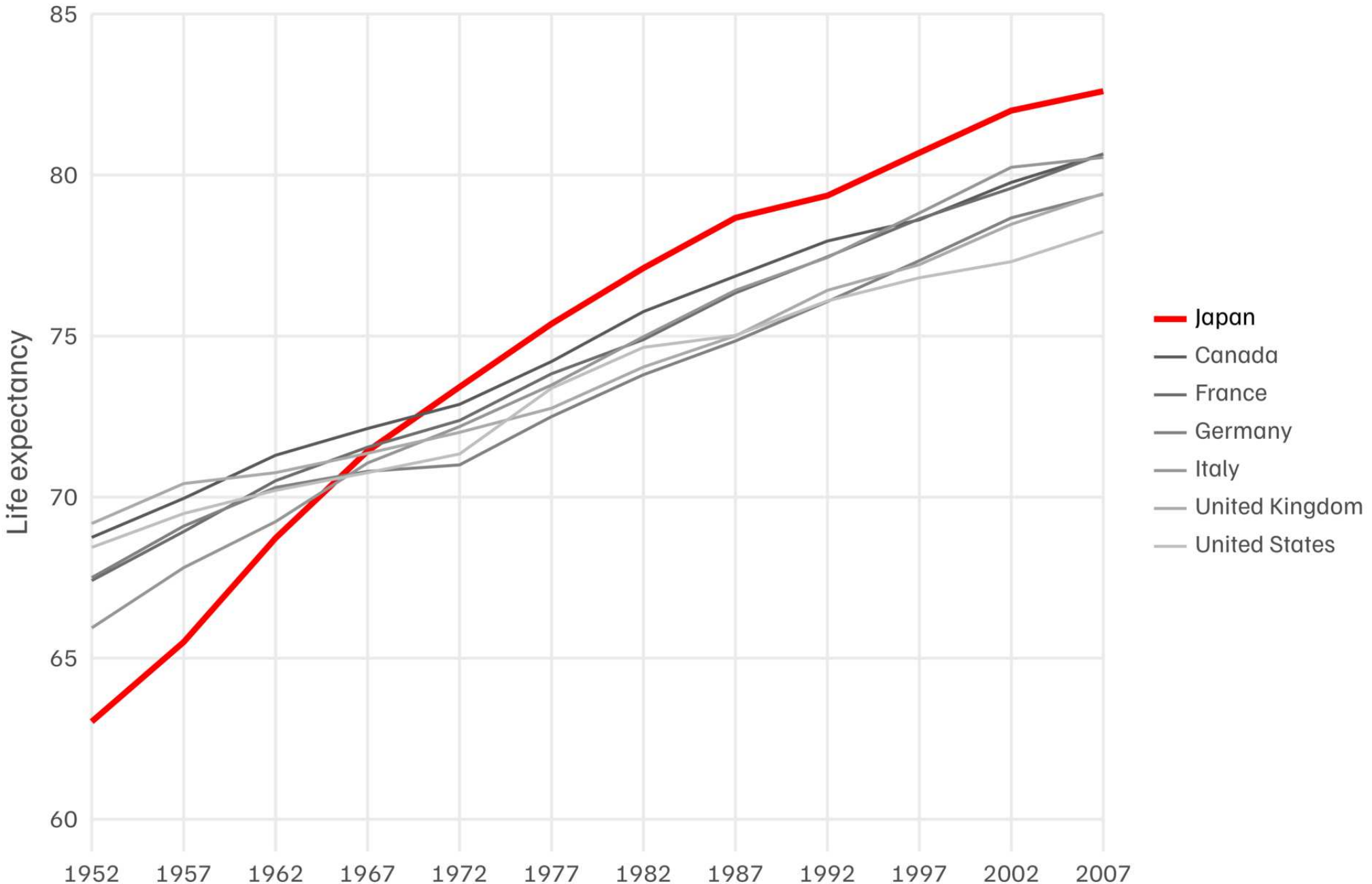
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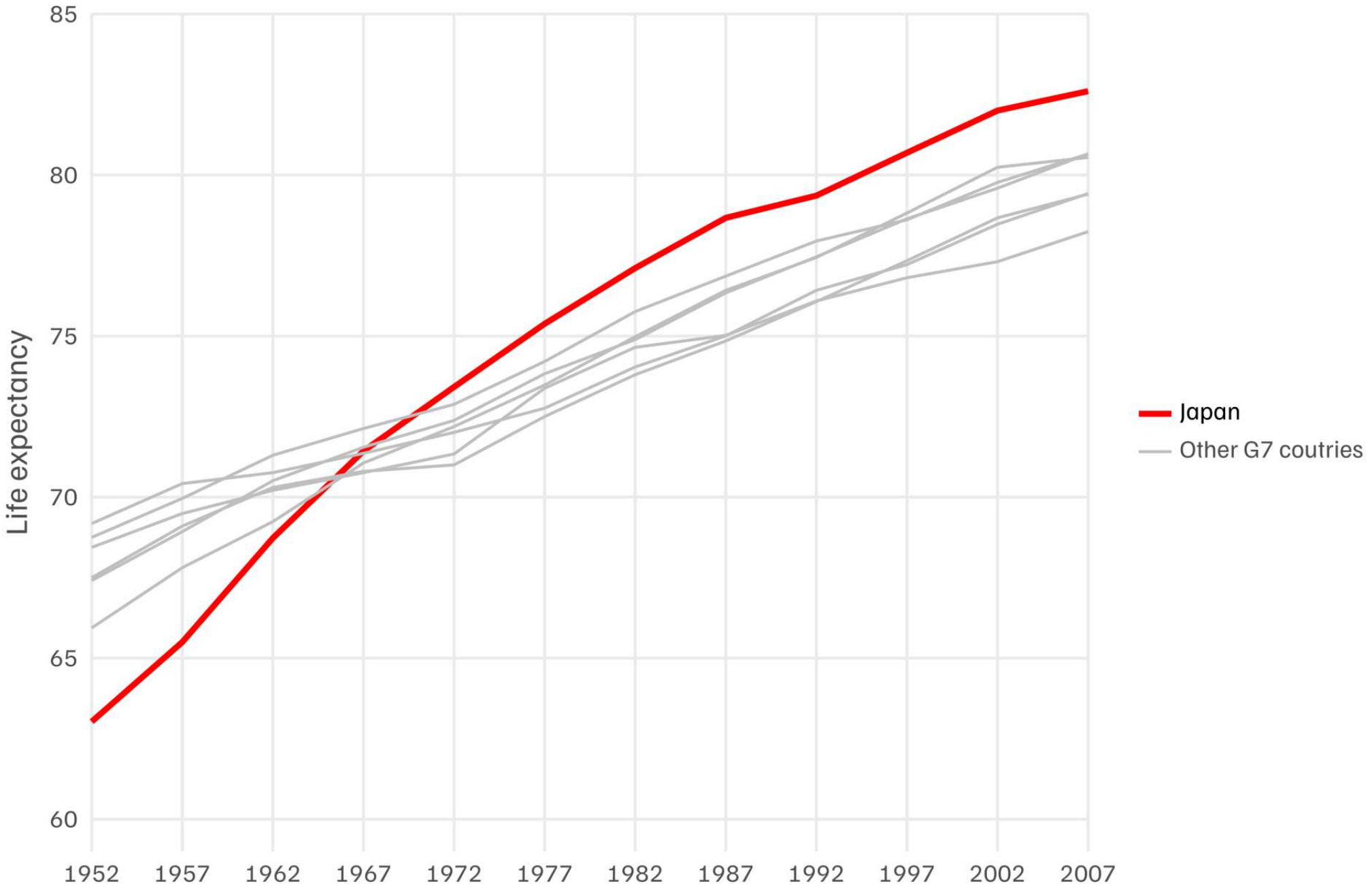
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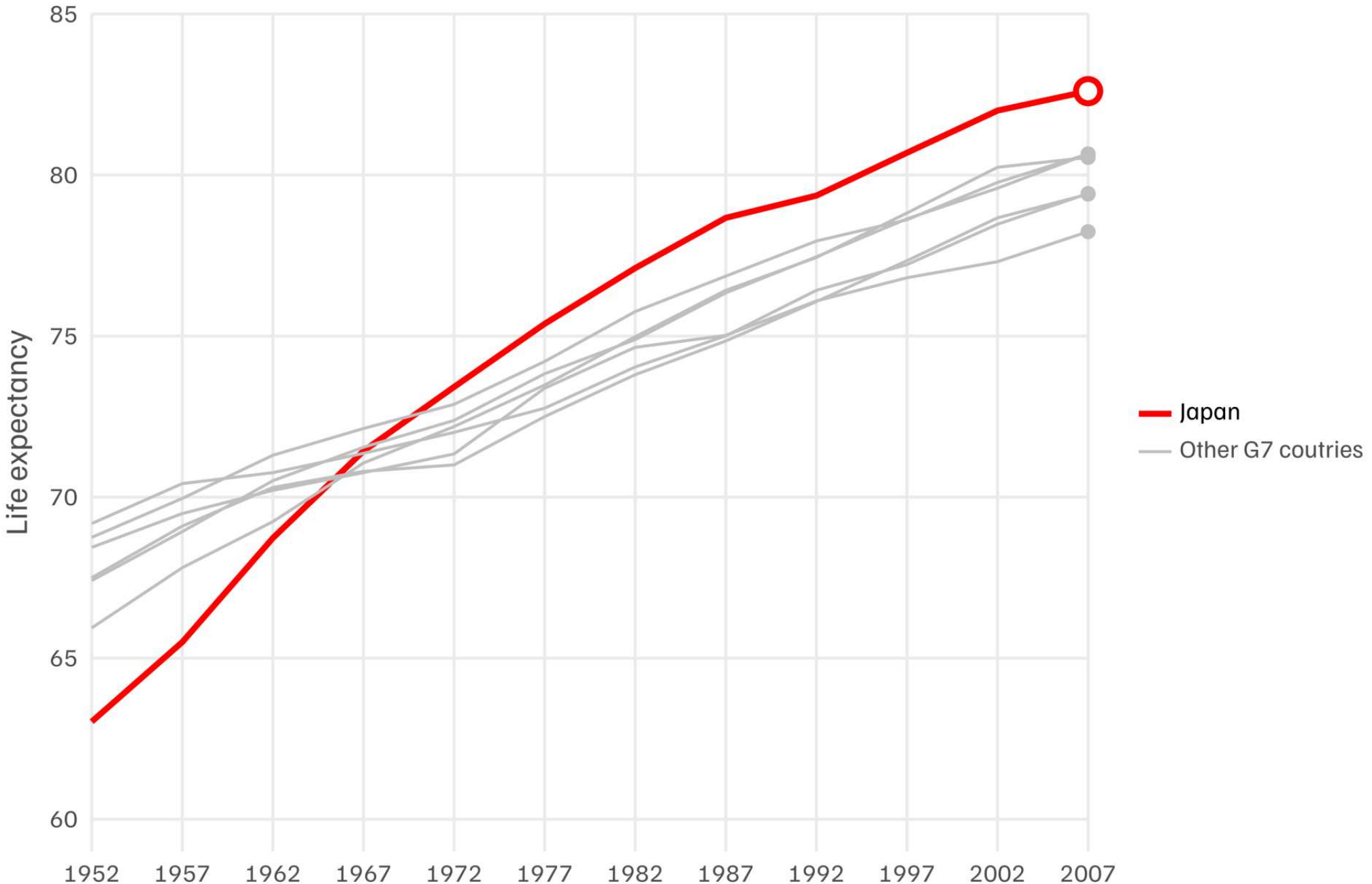
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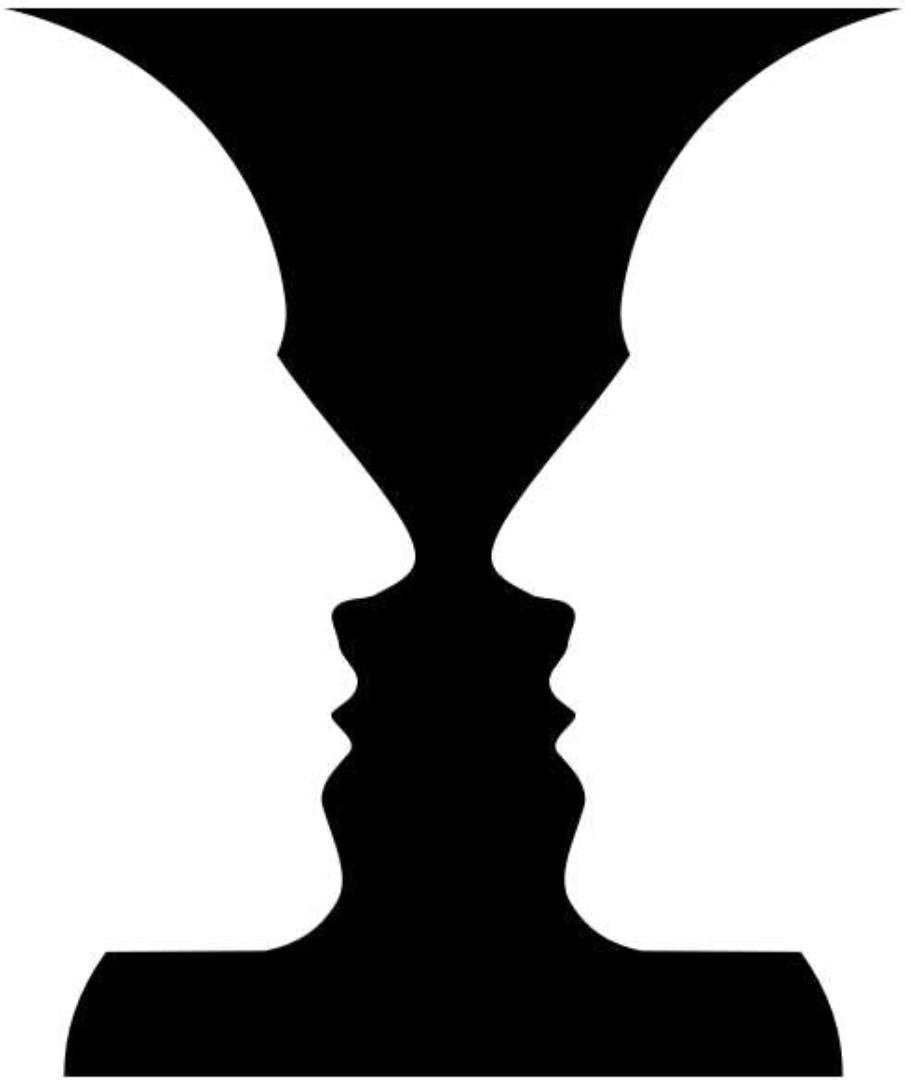
Other G7 coutries

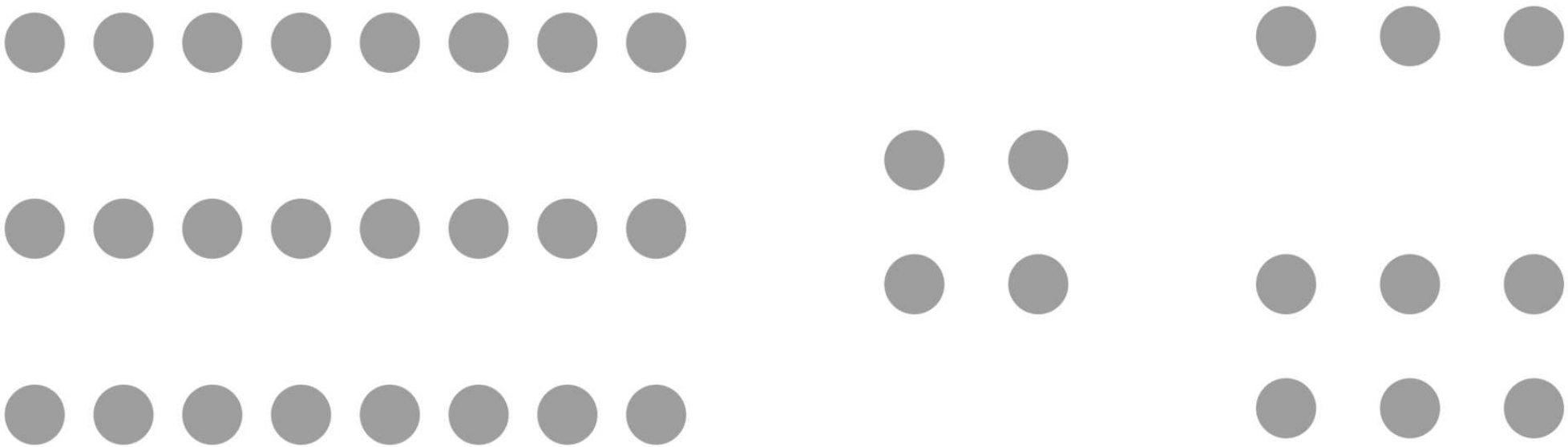
Gestalt Principles

A set of (varying) principles that describe how humans perceive and make sense of visual information and stimuli.

Principle of Figure and Ground

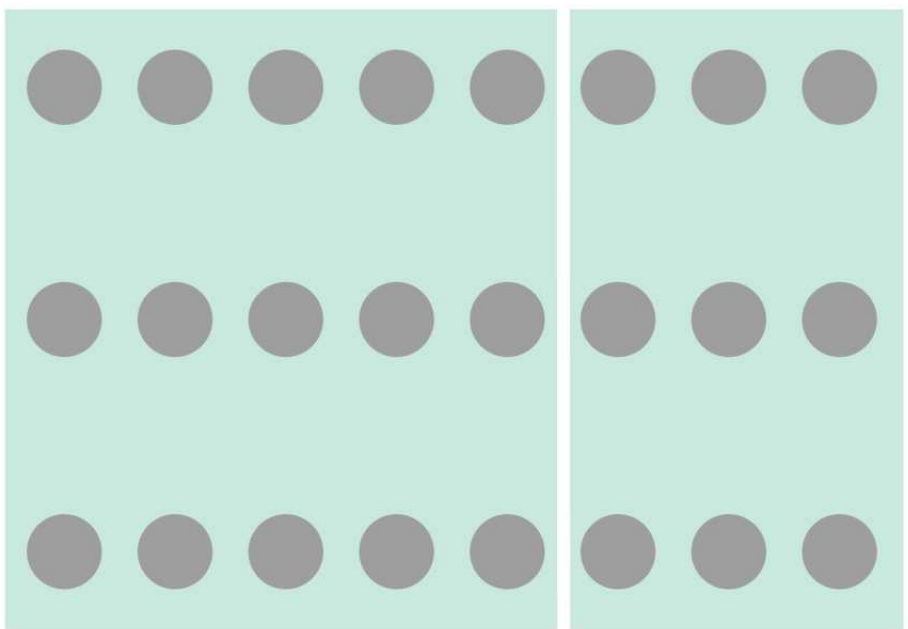


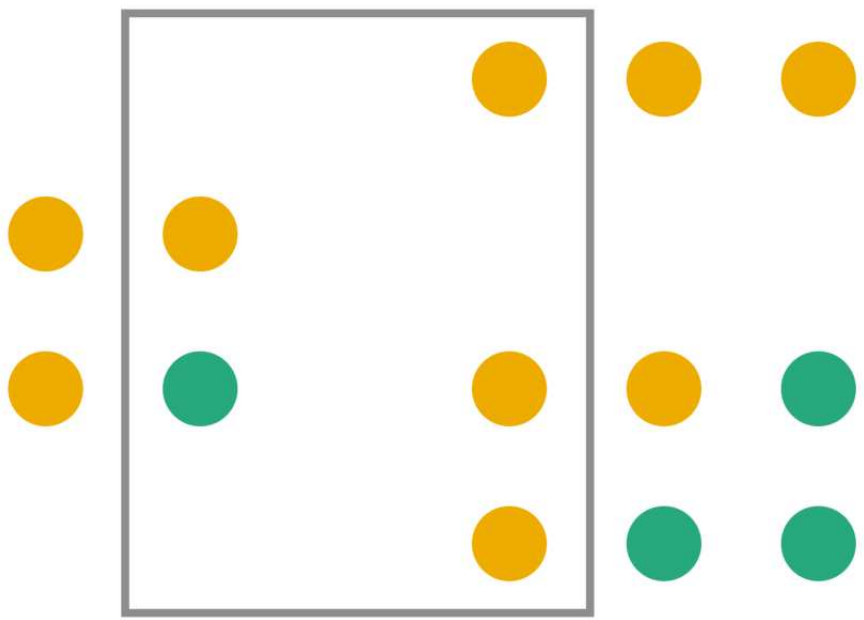
Principle of Proximity



Principle of Similarity

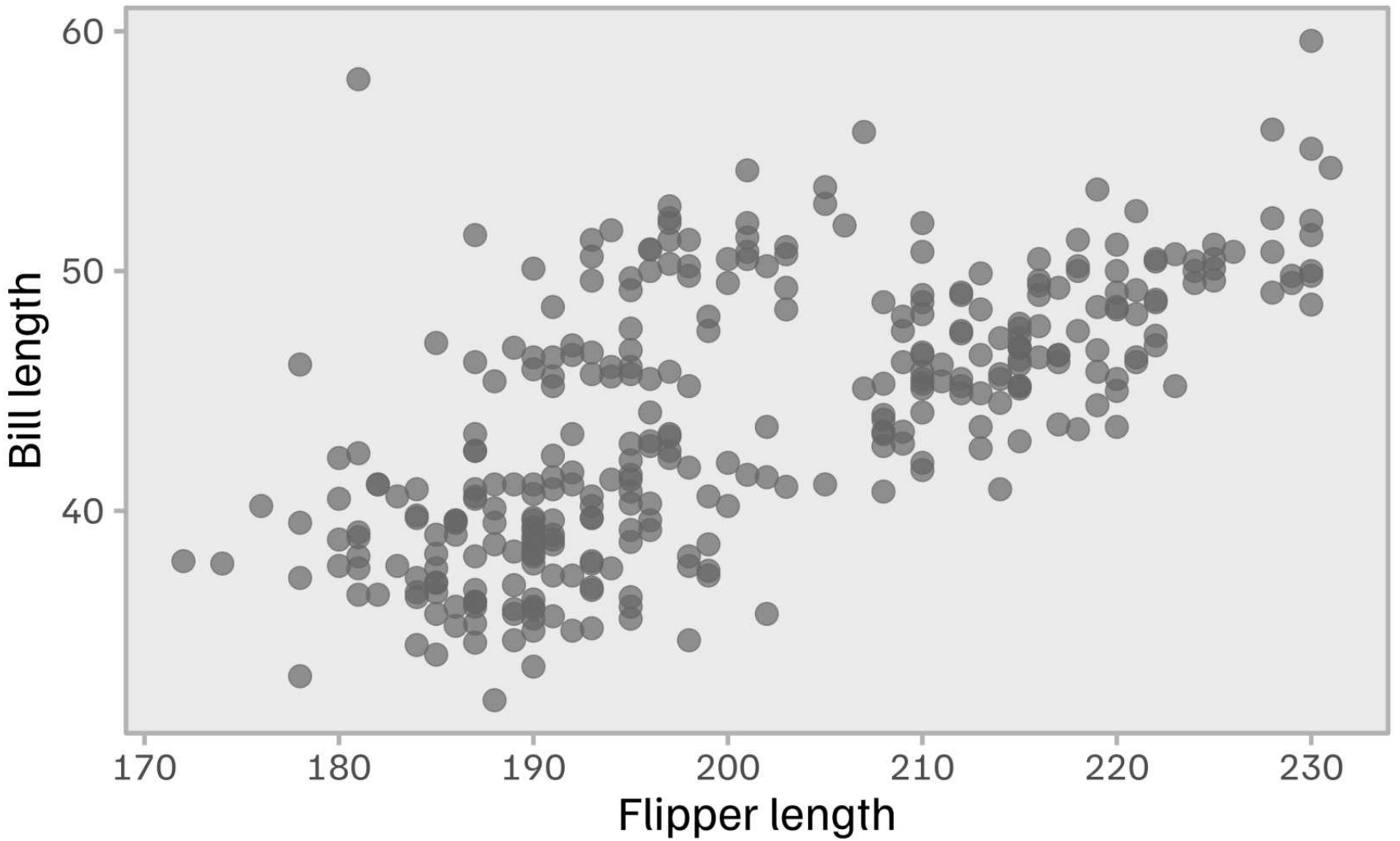
Principle of Common Region



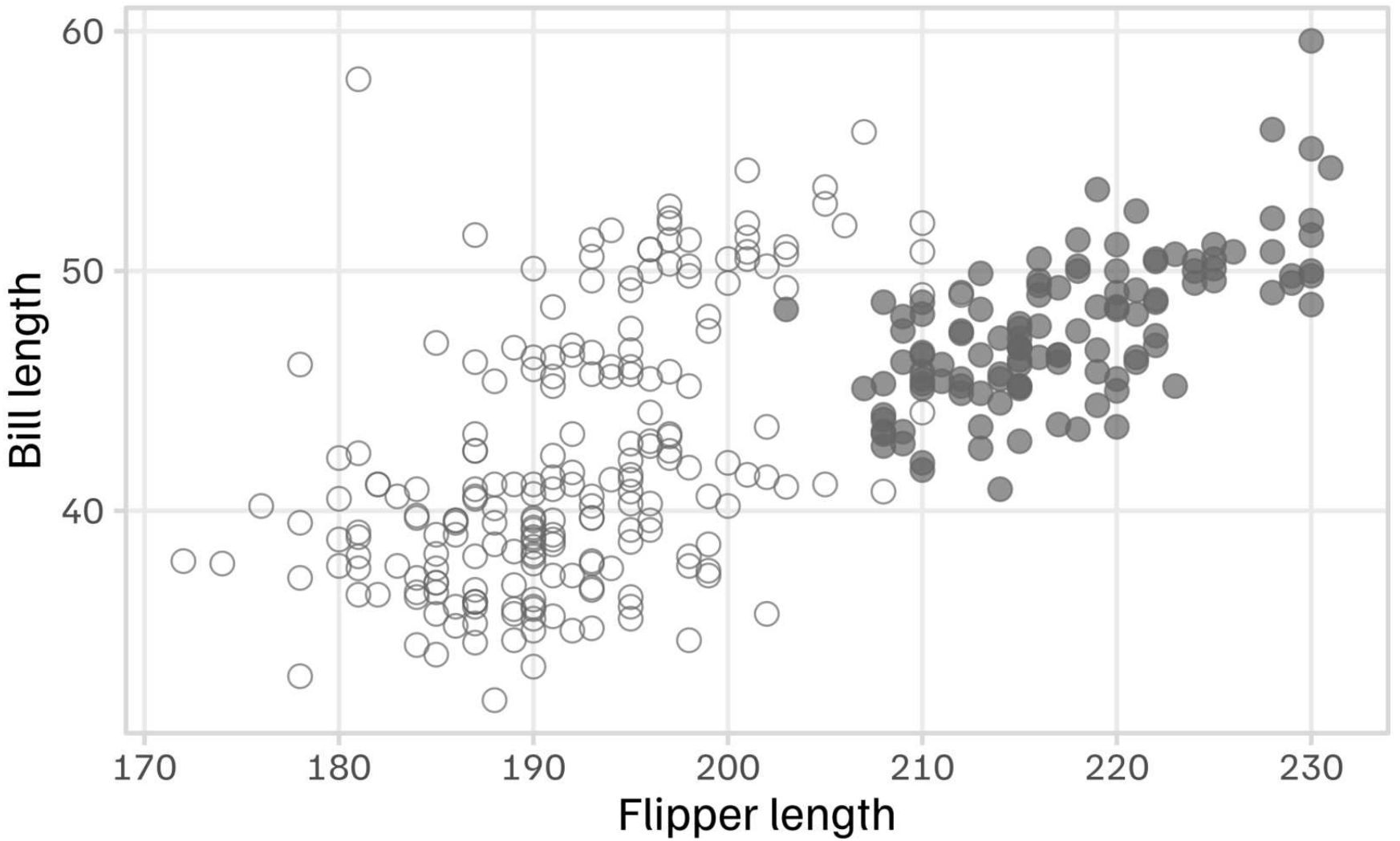


Principles of Continuity and Closure

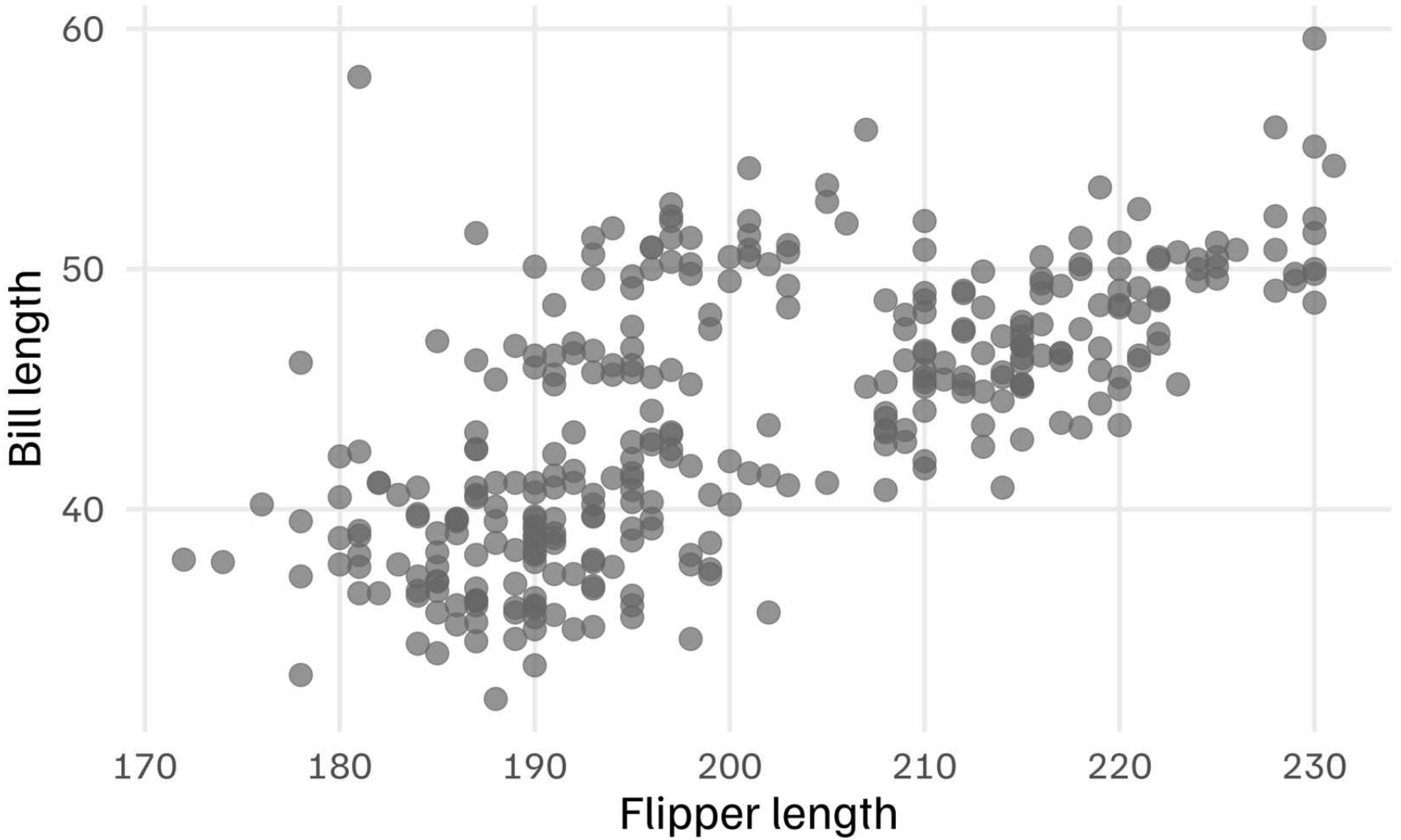
Principle of Figure and Ground



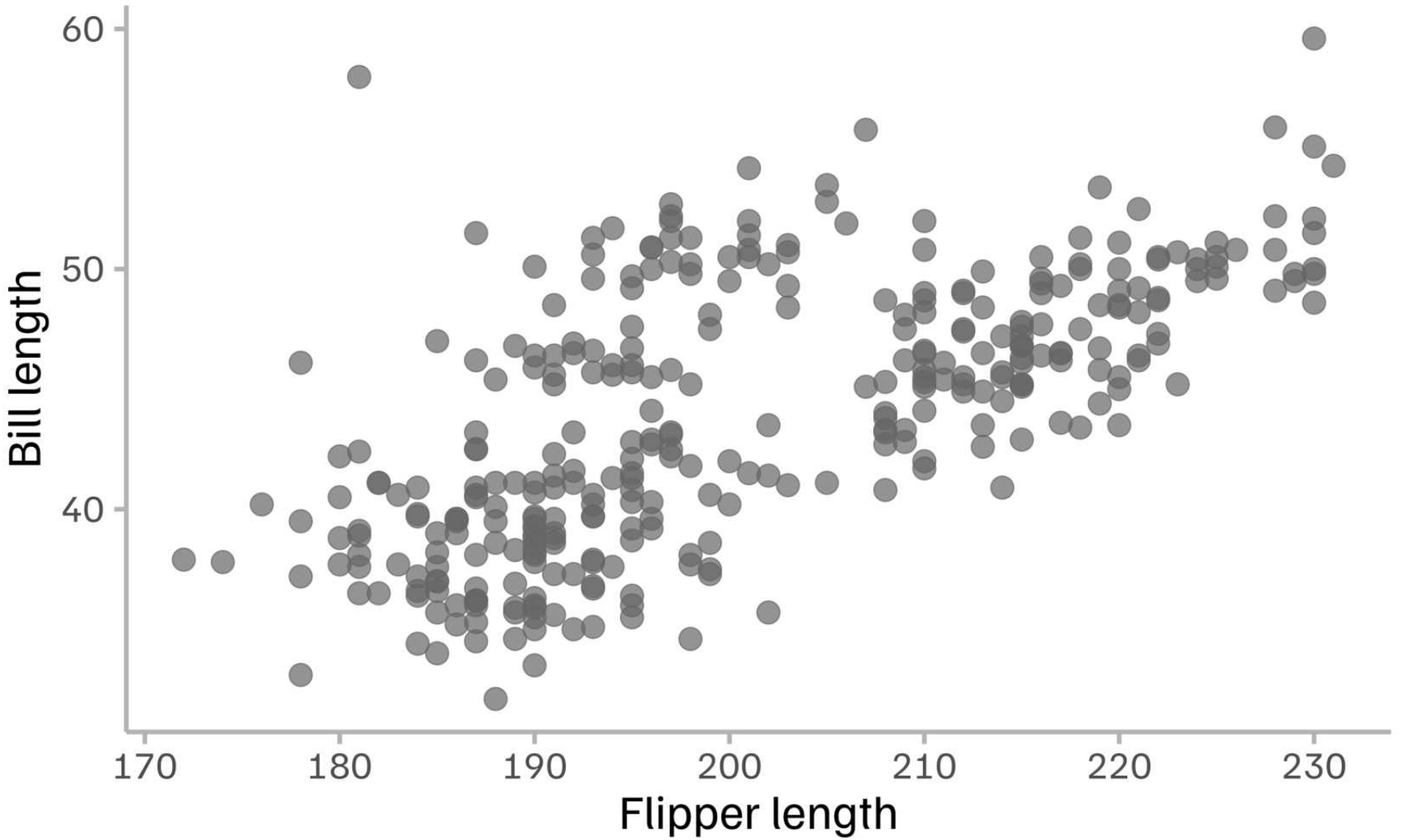
Principle of Figure and Ground



Principle of Closure



Principle of Closure



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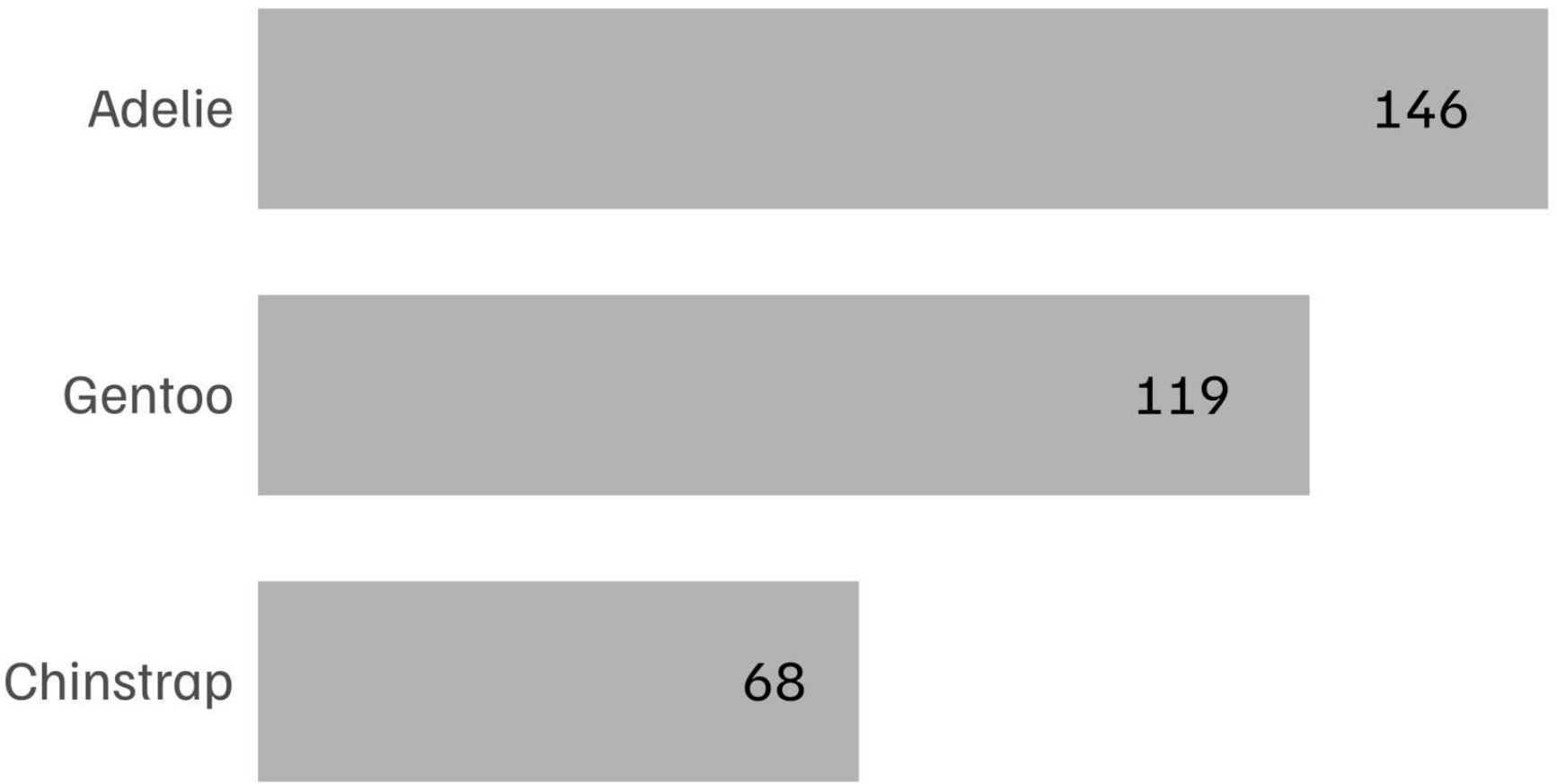
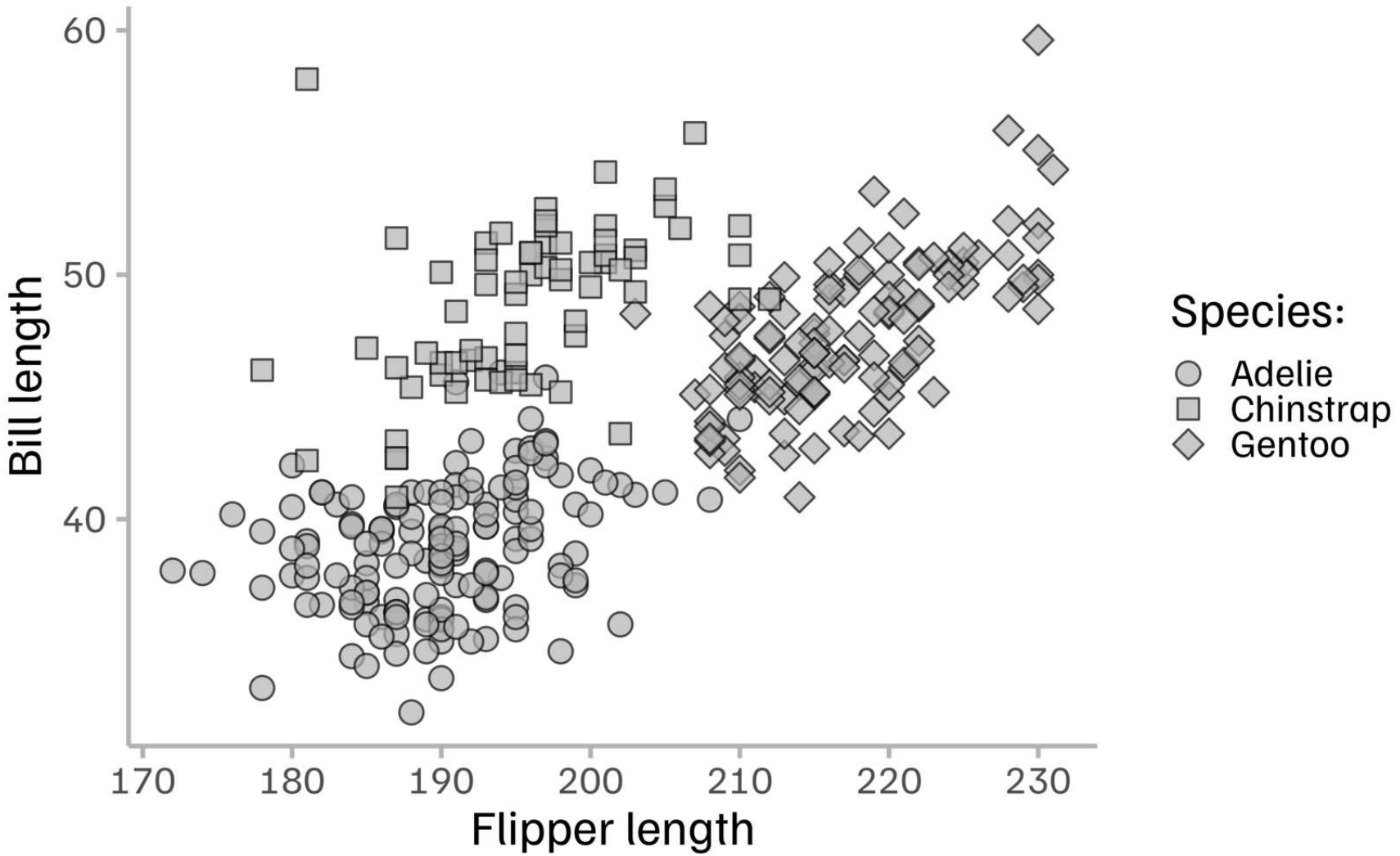


Principle of Similarity



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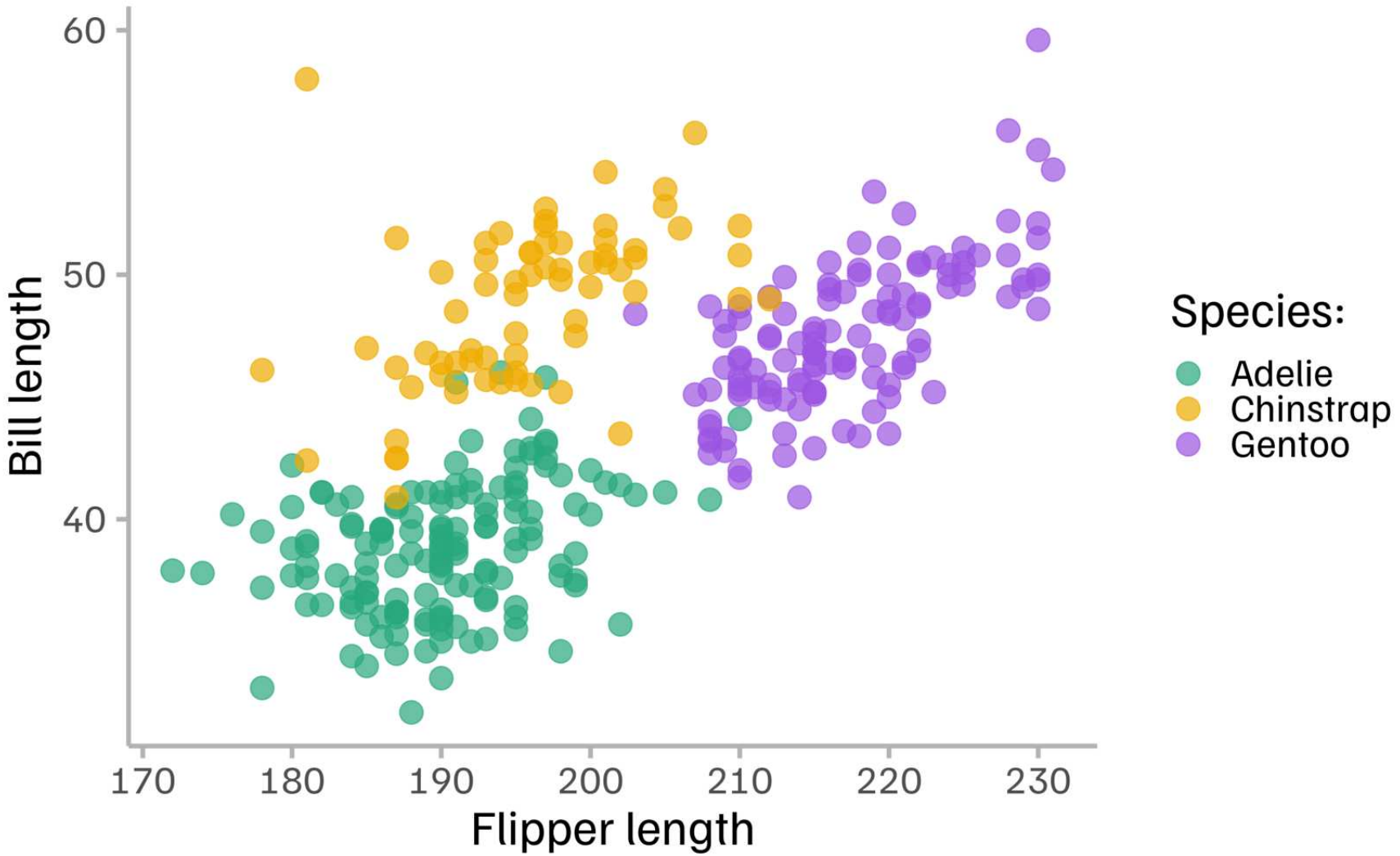

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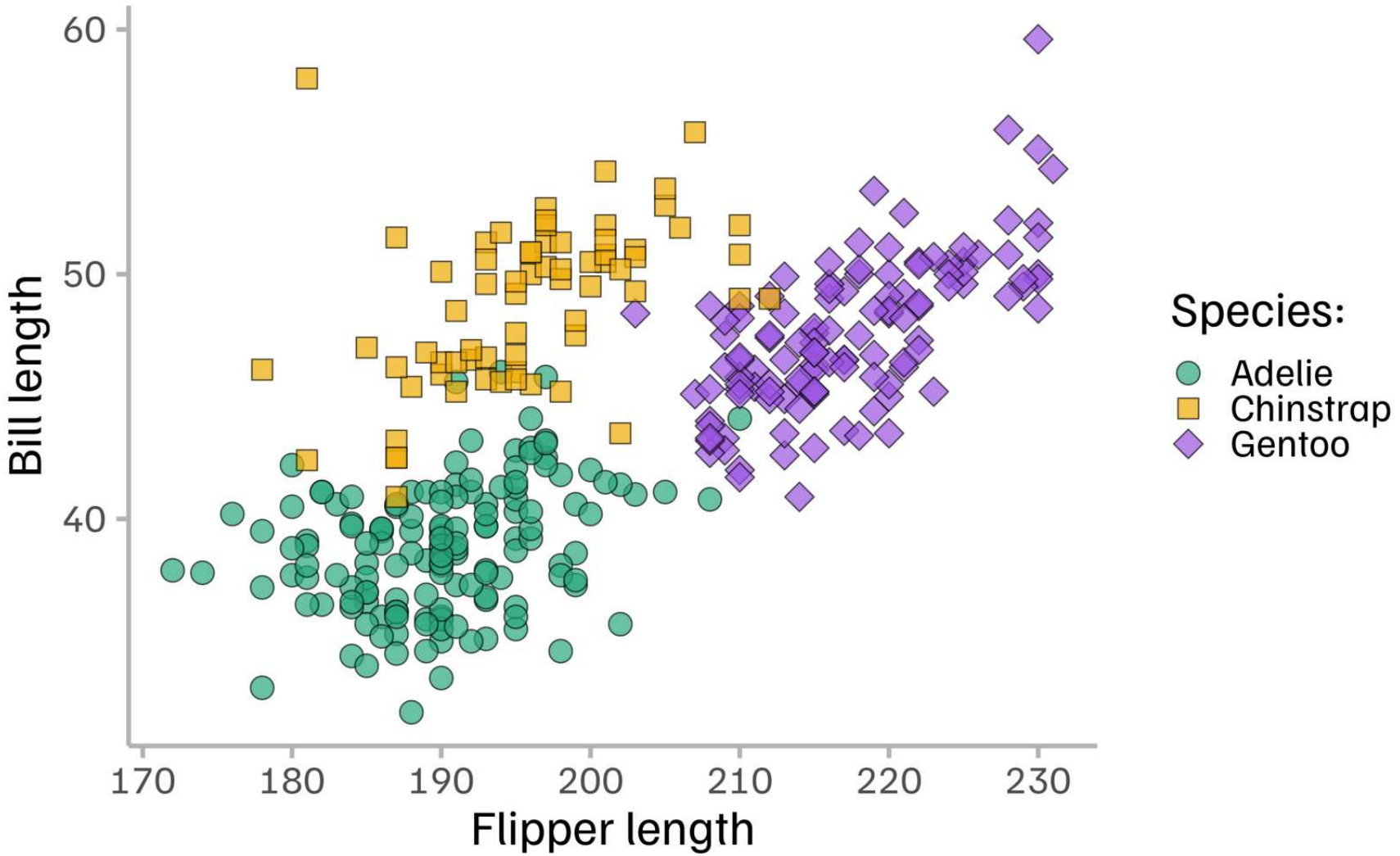
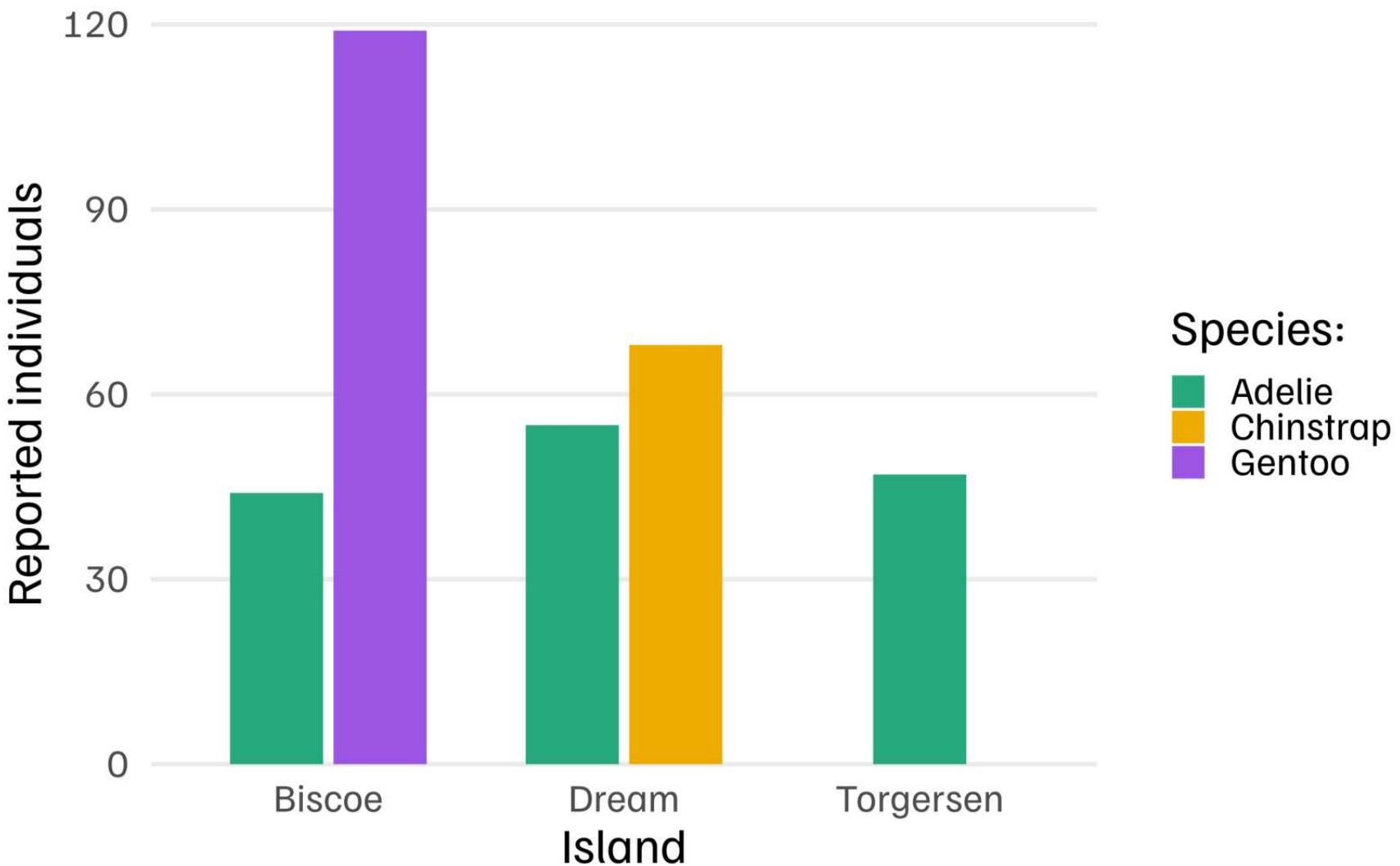
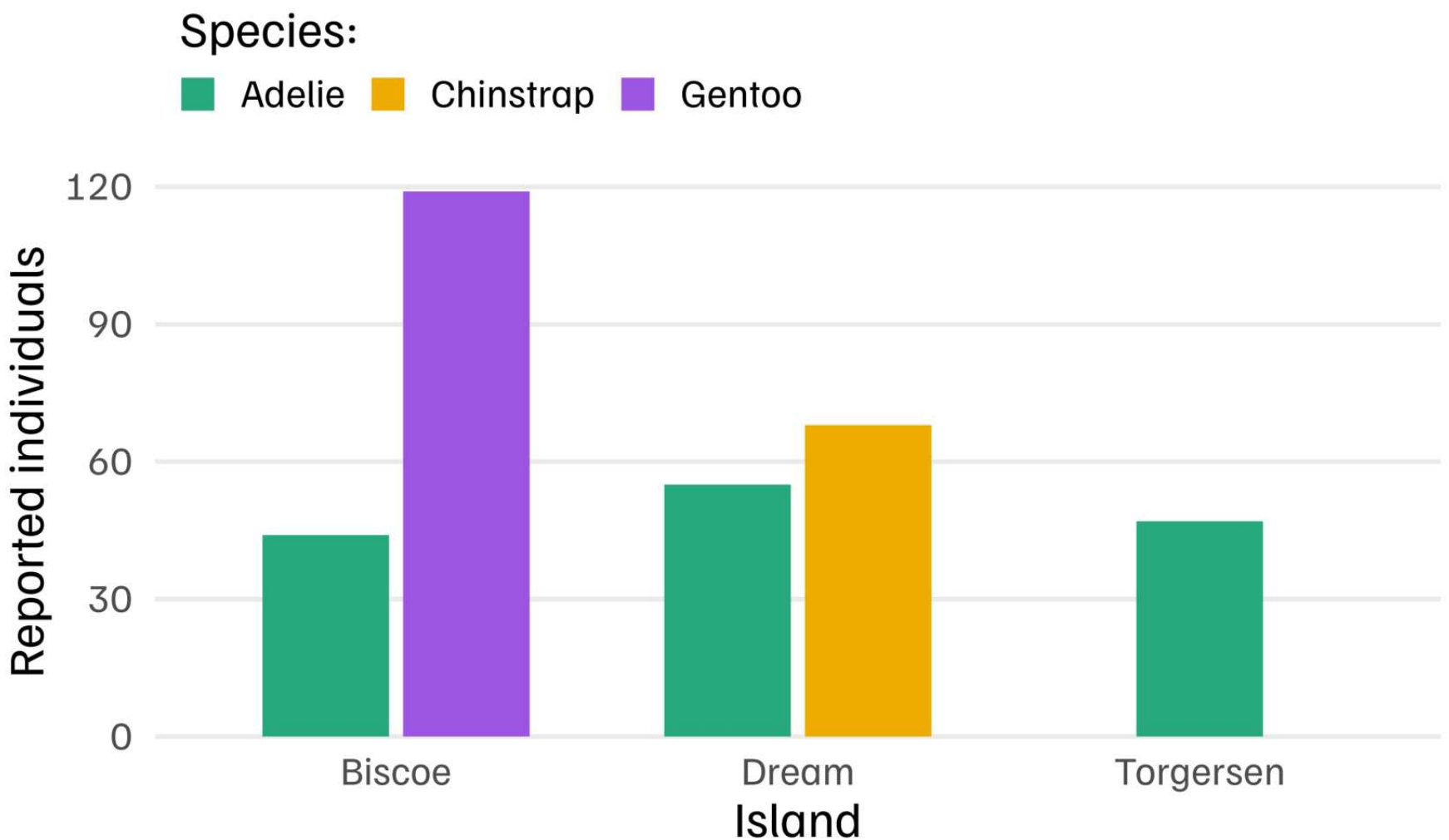


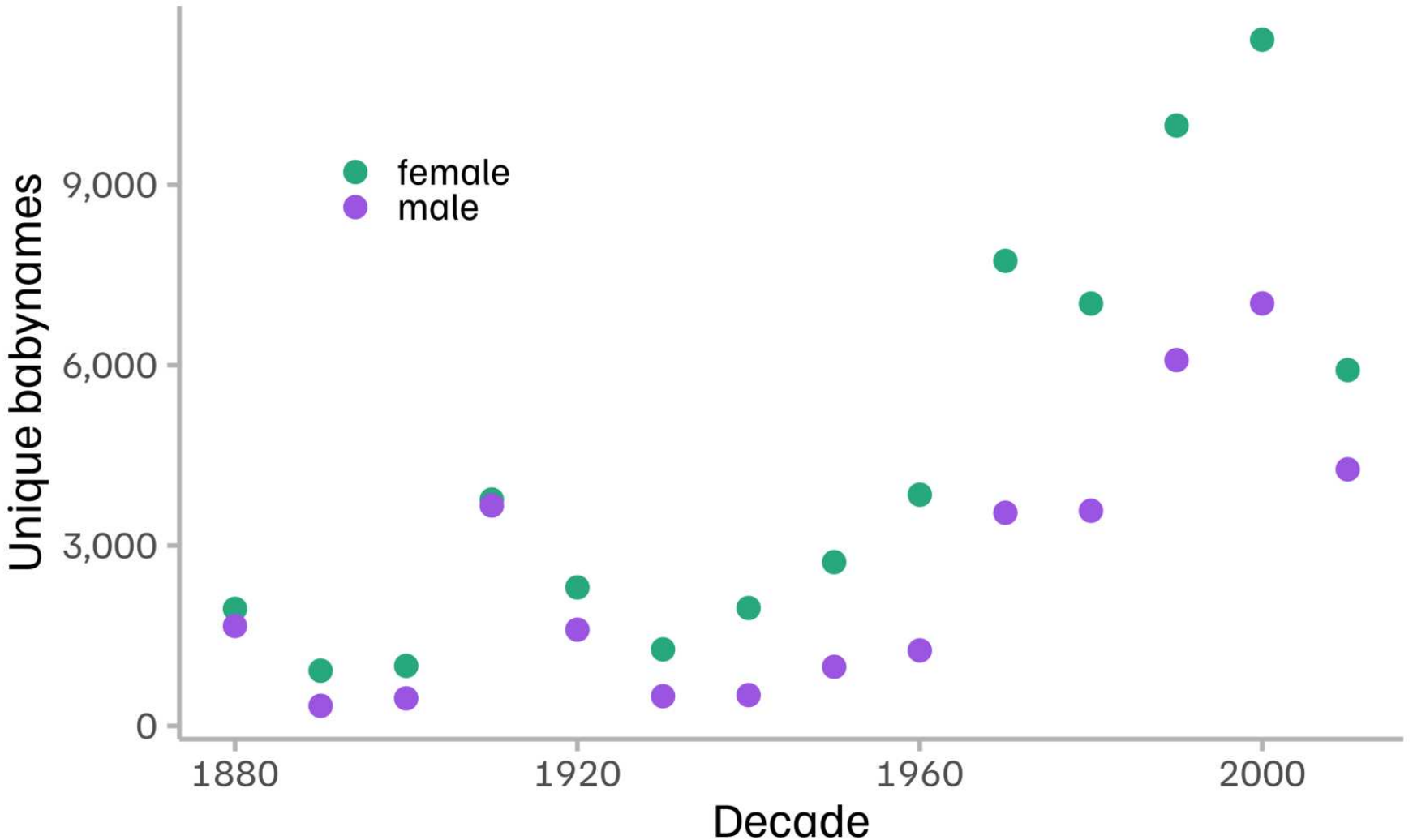
Principle of Proximity



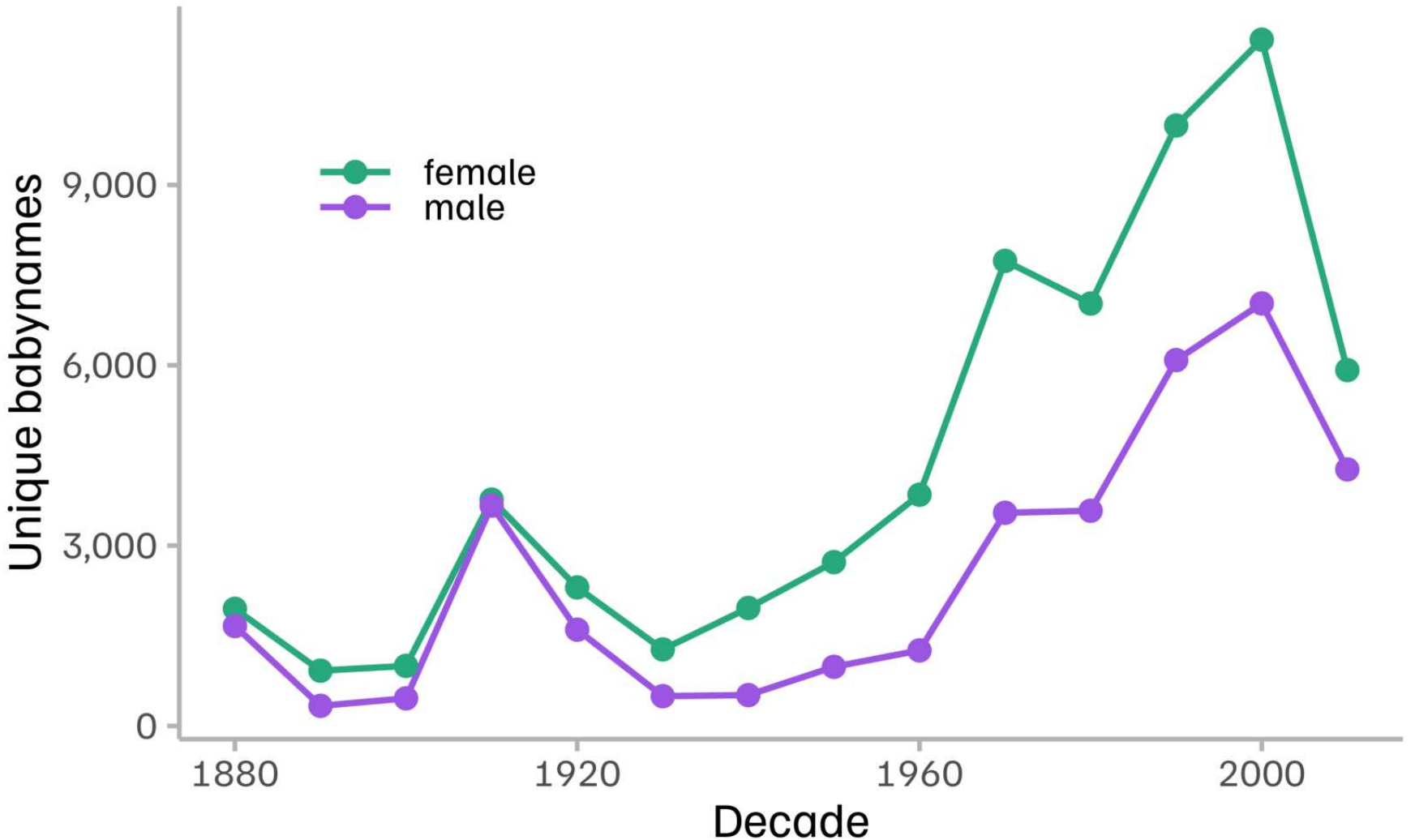
Principle of Proximity

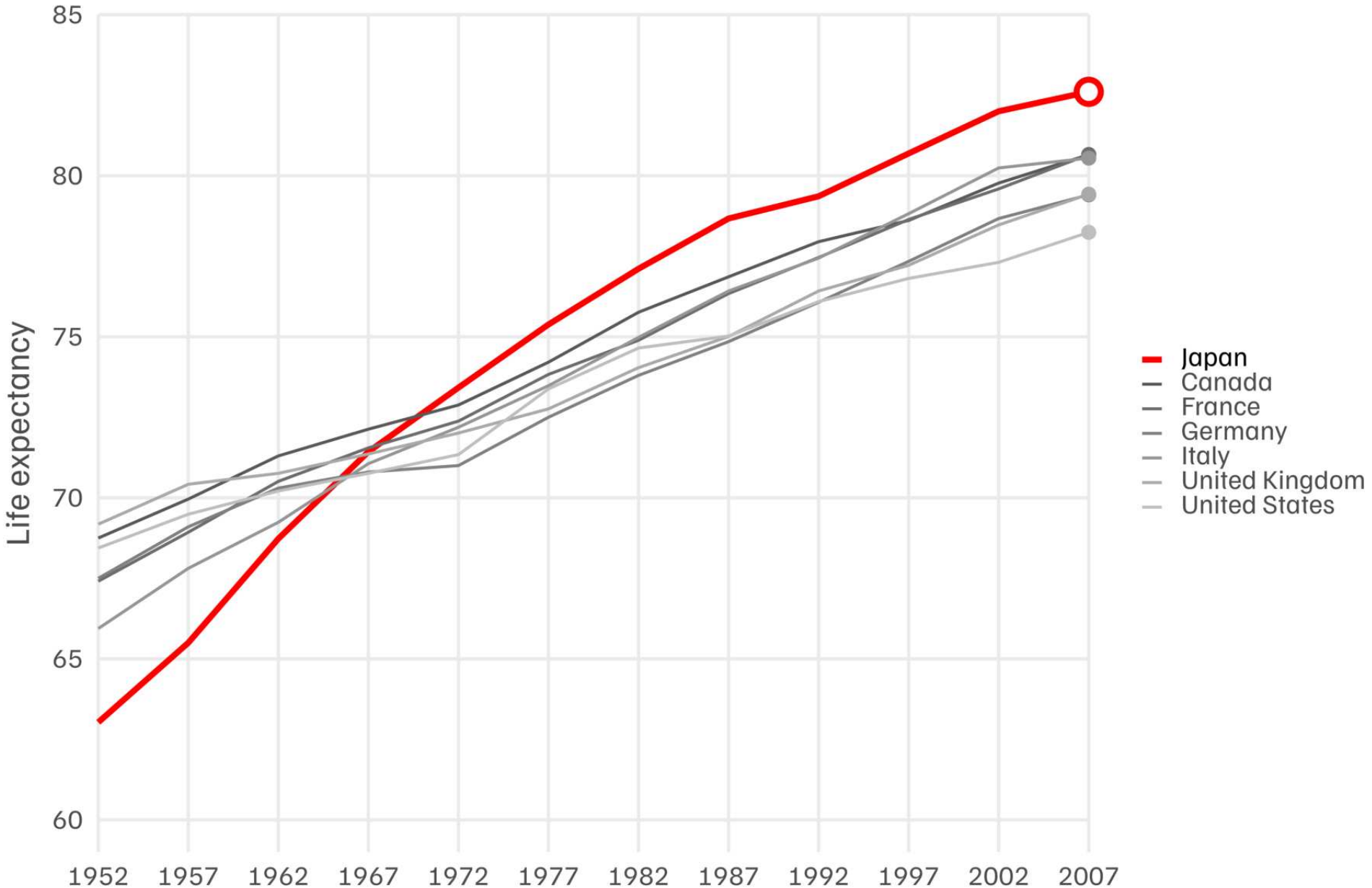


Principle of Connectivity



Principle of Connectivity

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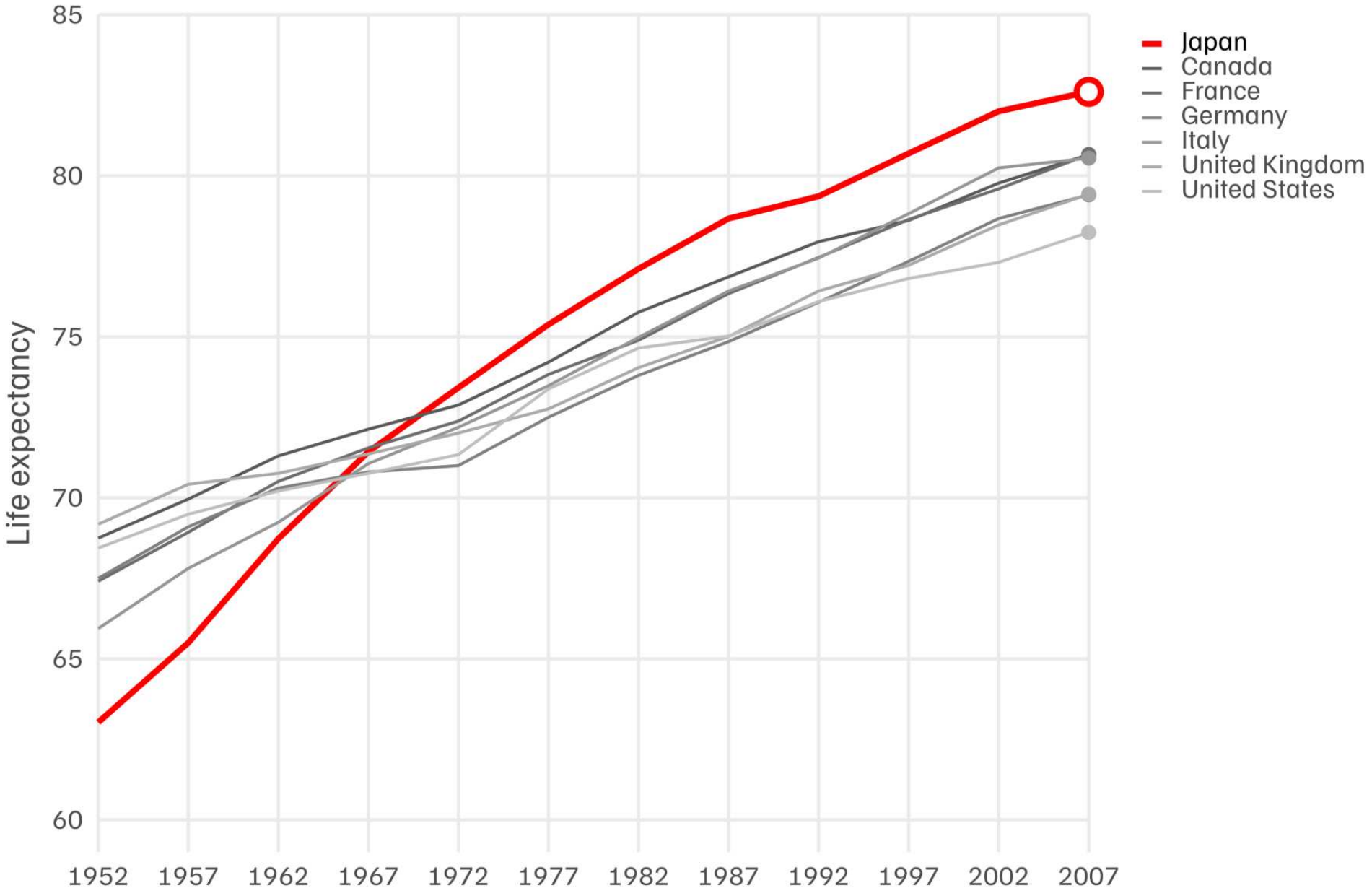
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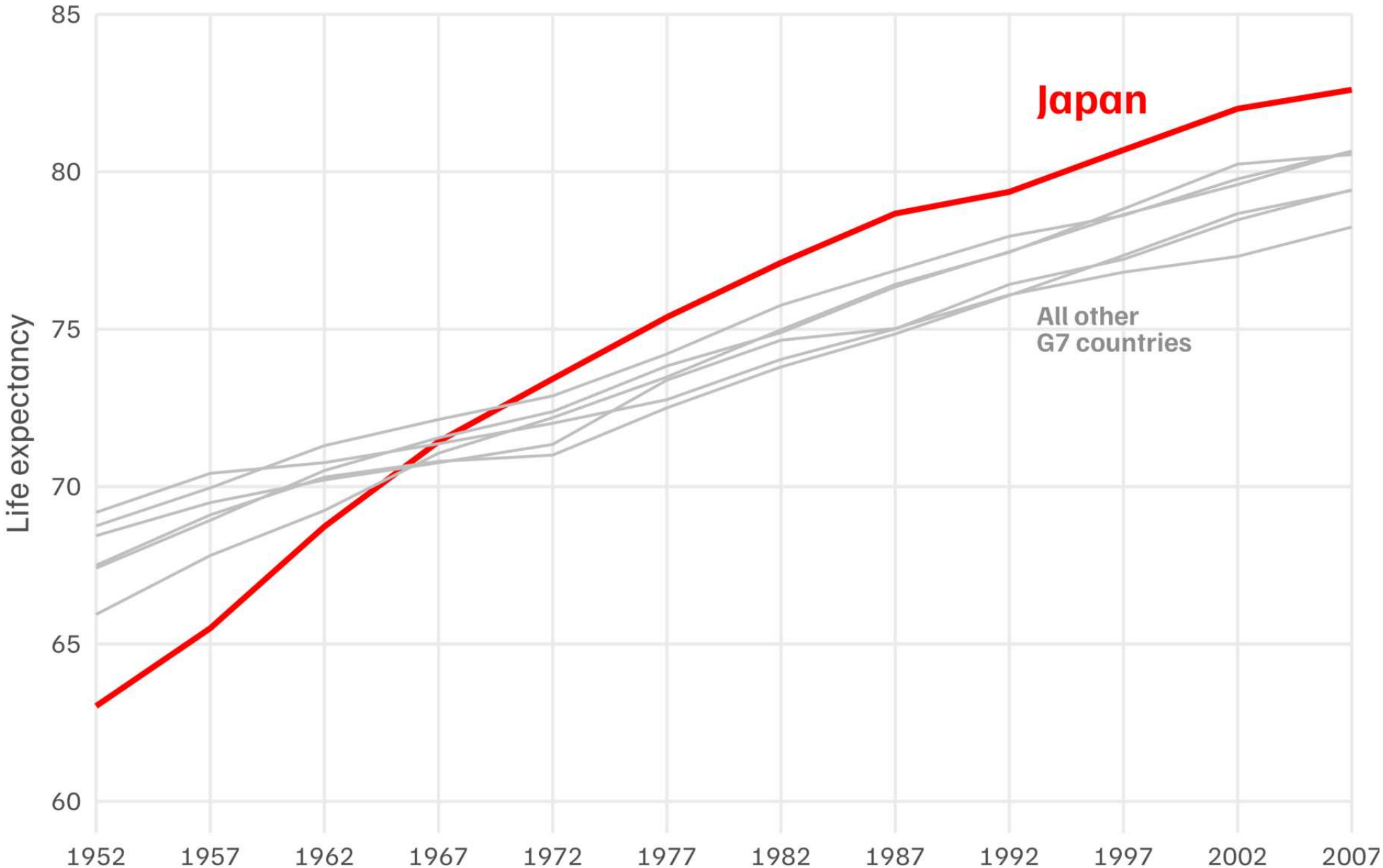
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All other
G7 countries

Eliminating Distractions

Clutter

also known as

“Chart Junk”

are visual elements that take up space

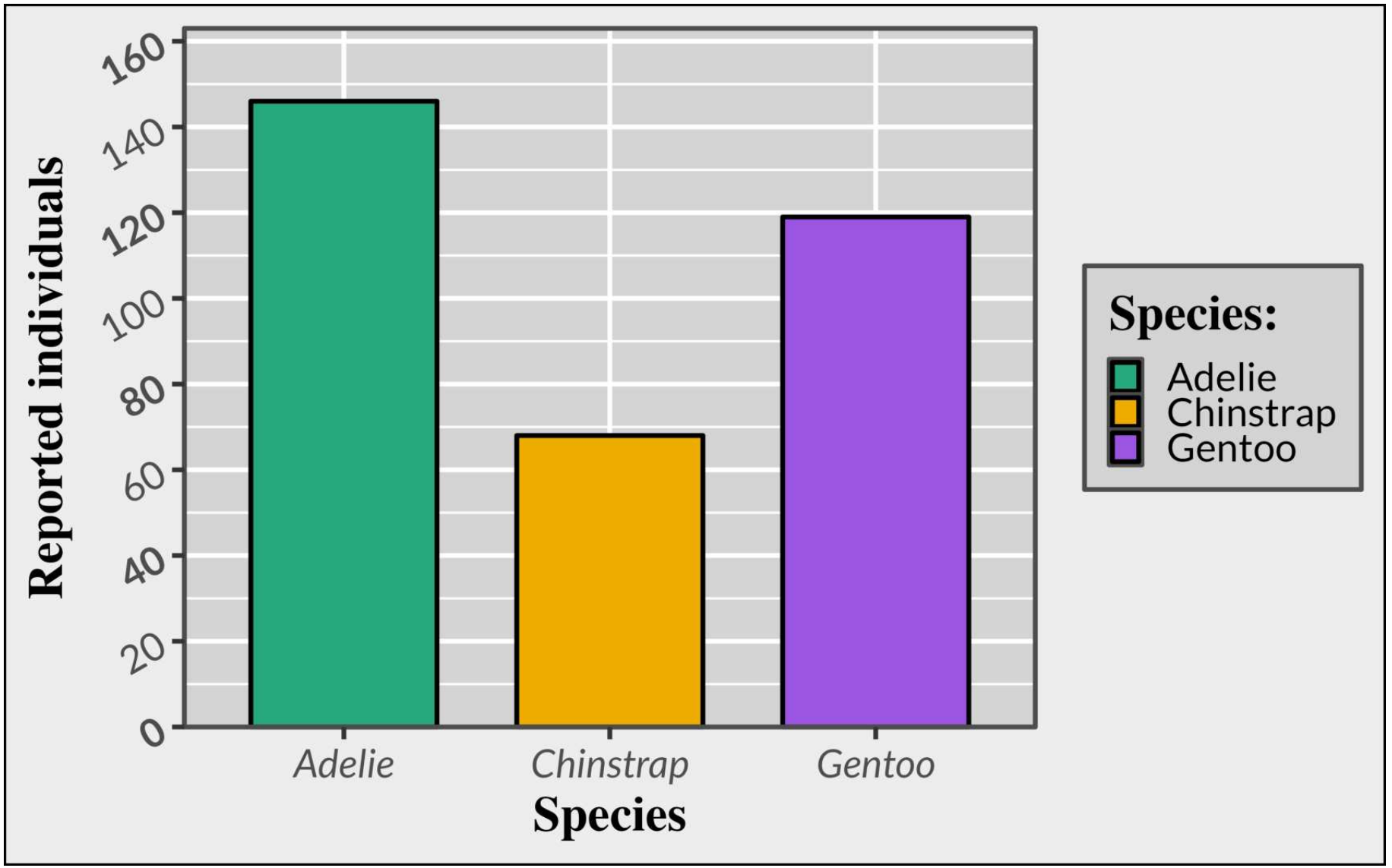
but do not increase understanding.

Even worse, they increase cognitive load.

“The larger the share of a graphic’s ink devoted to data, the better.”

E. Tufte (1983)

Clutter!


Reported individuals
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Species:
Adelie
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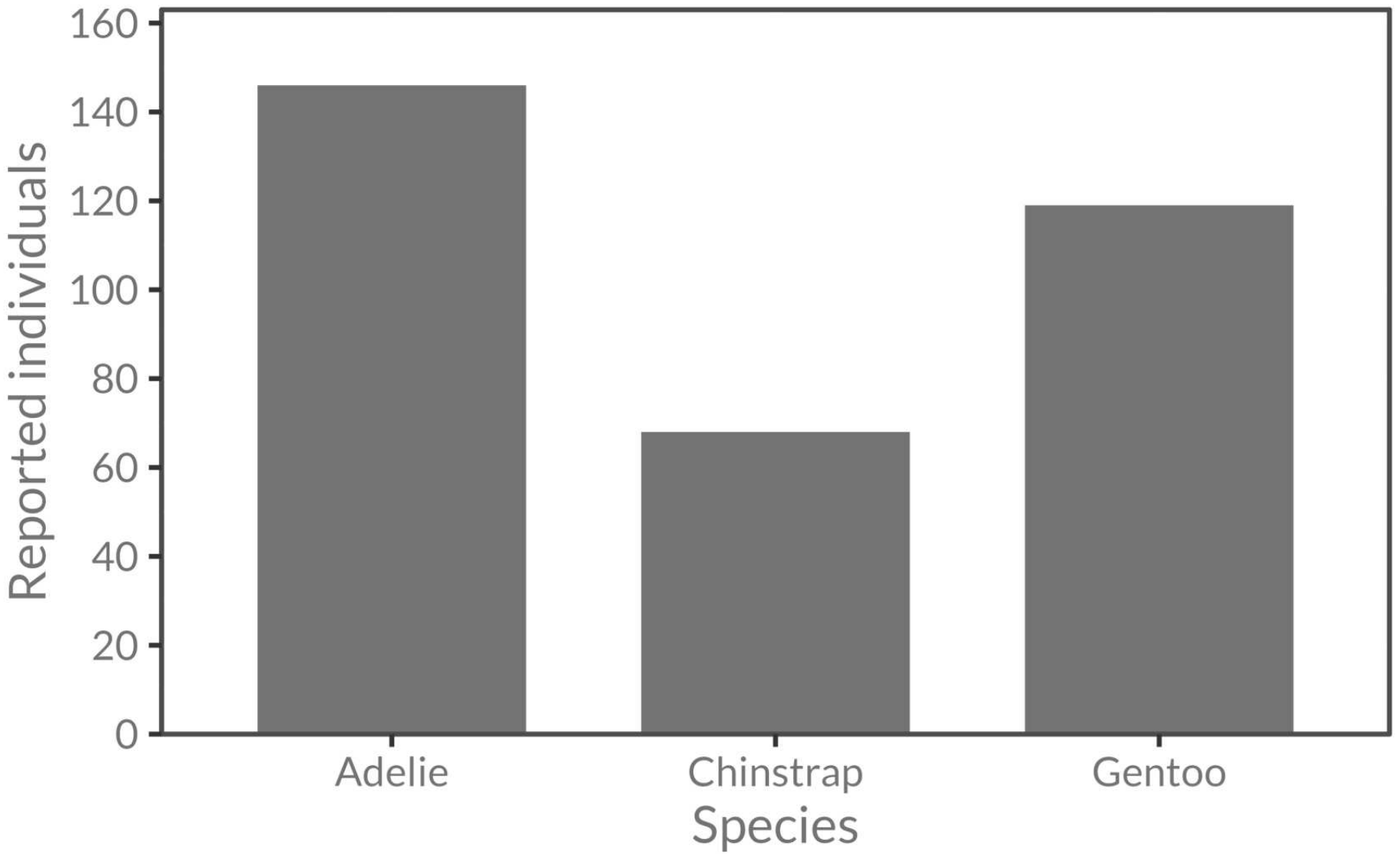
Gentoo

Declutter!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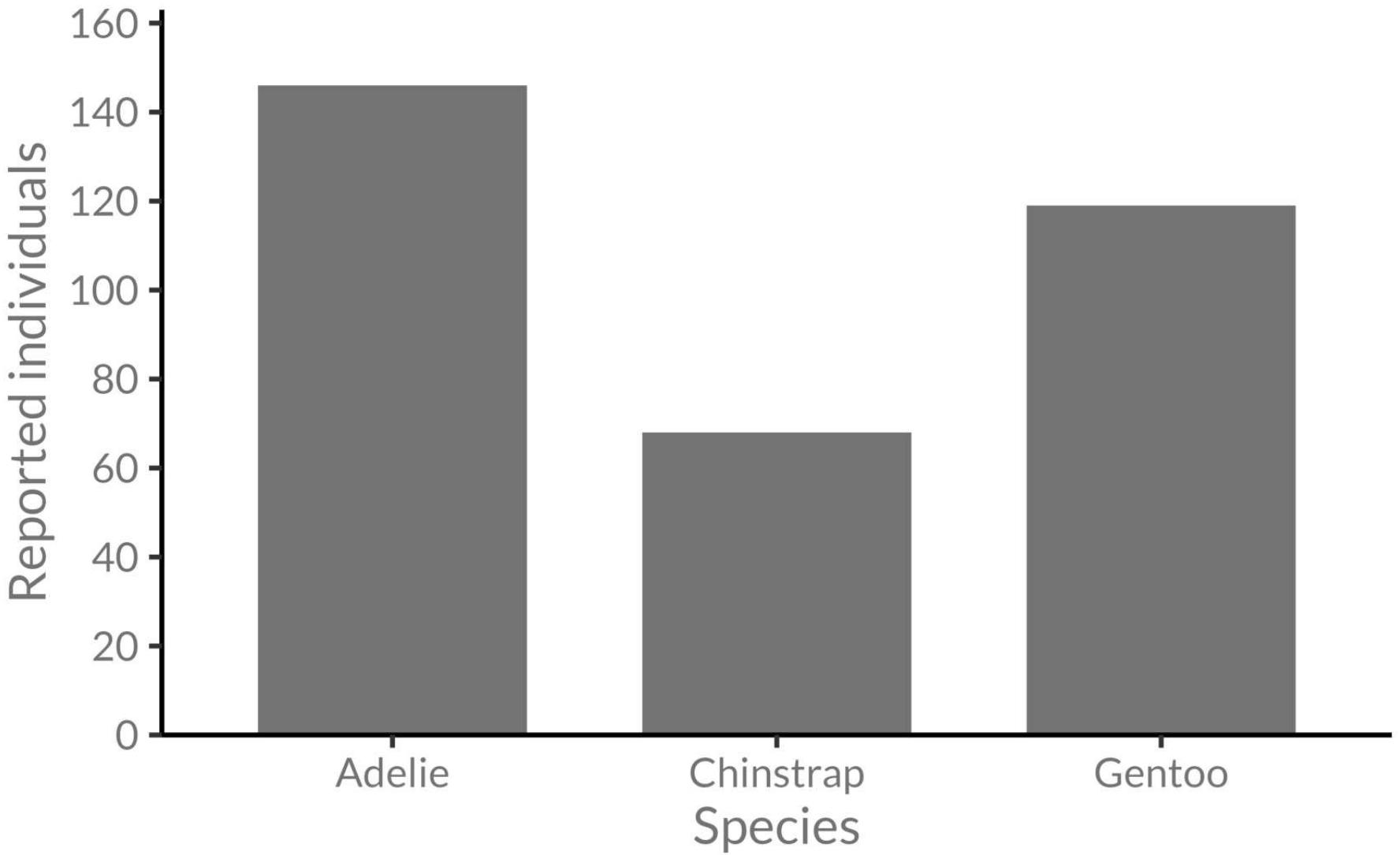
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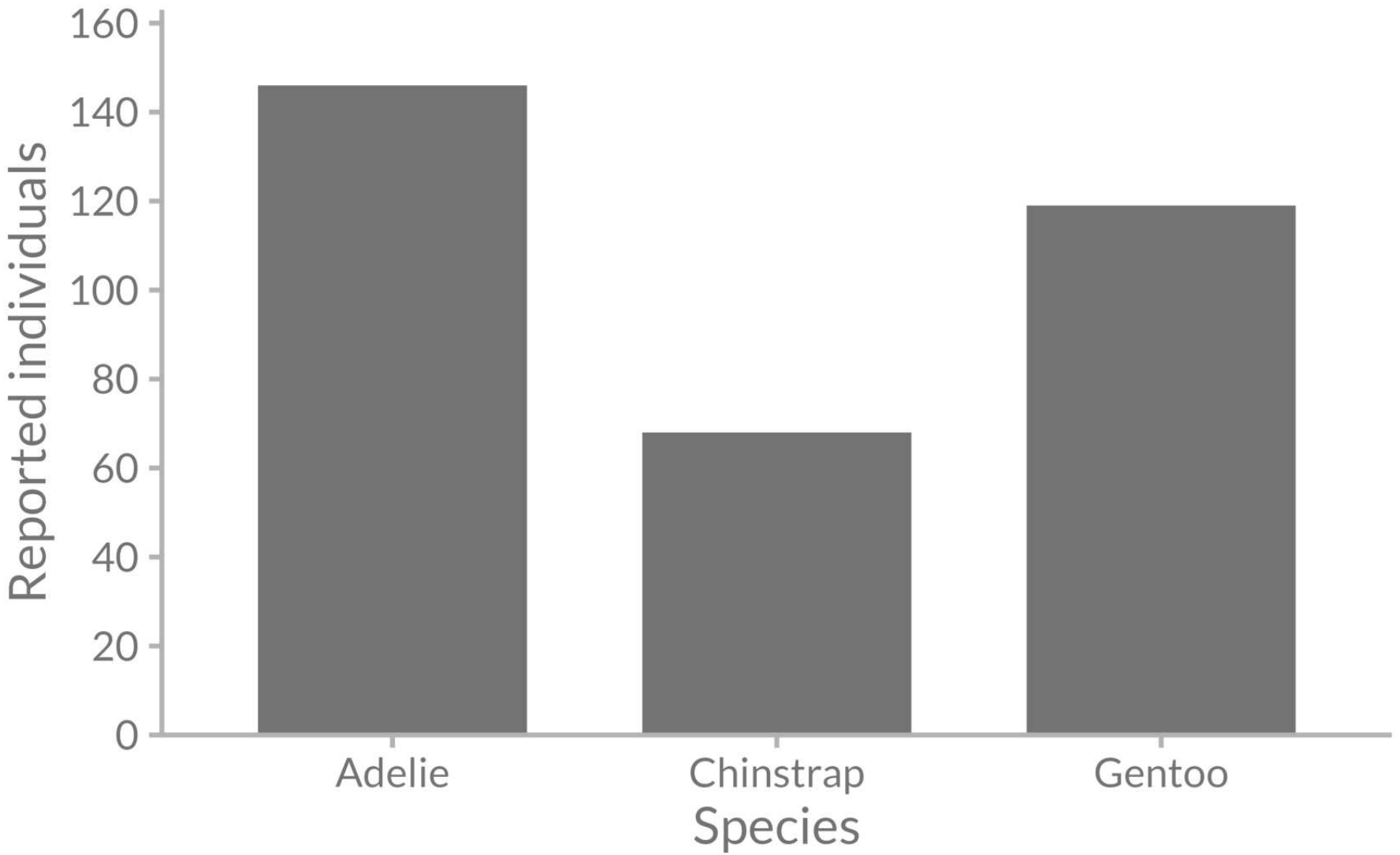
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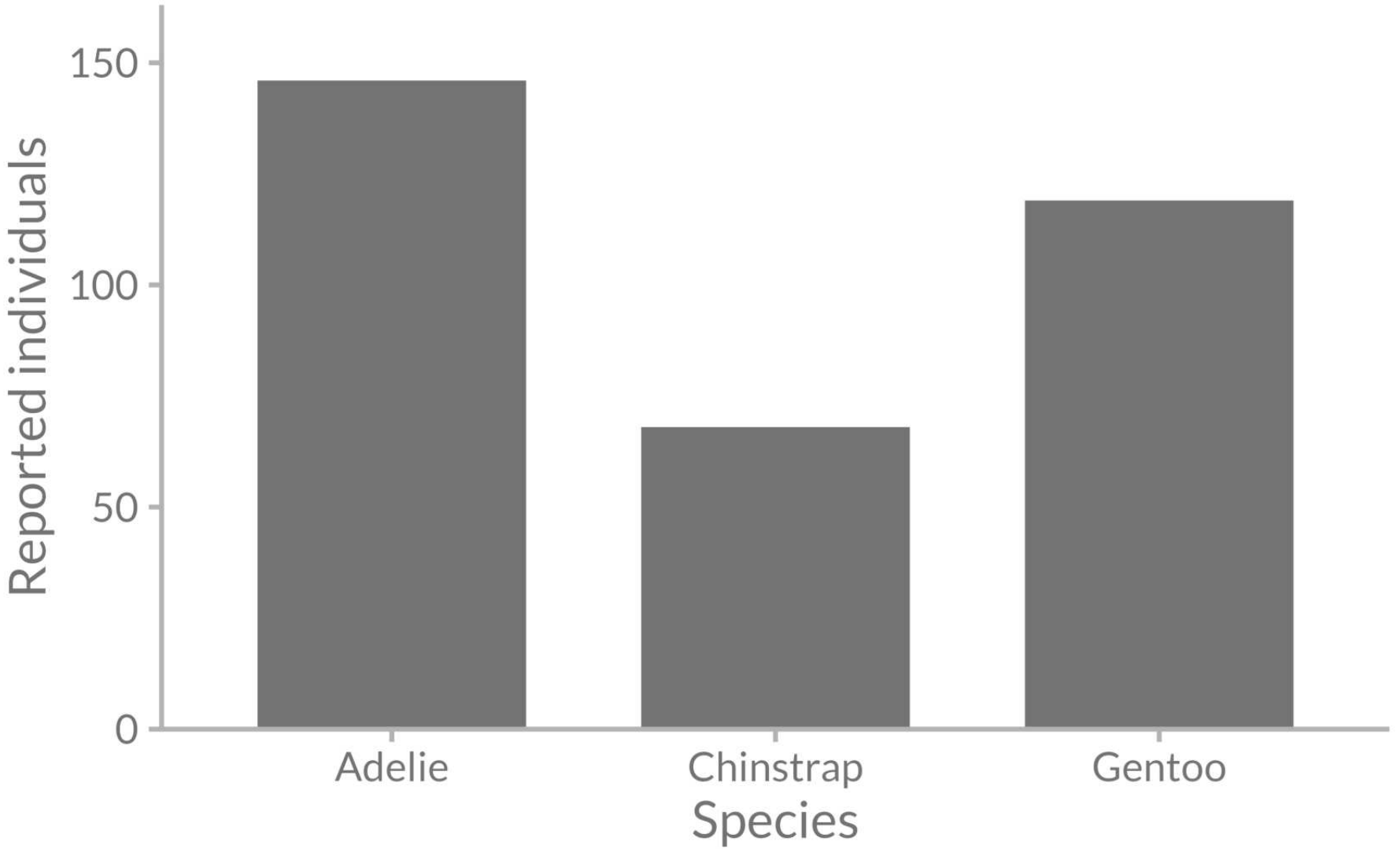
Species

Declutter!


150
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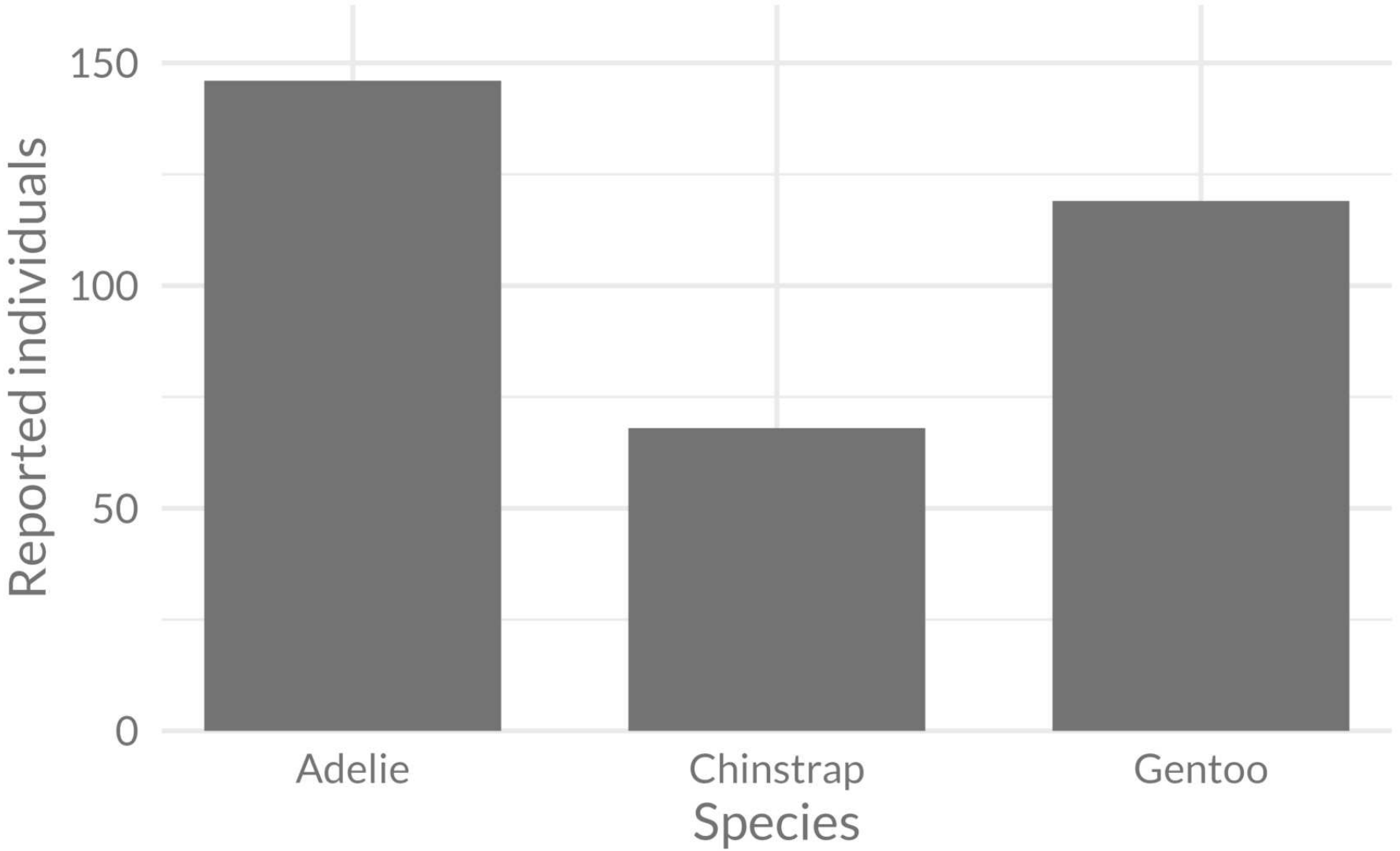
Reported individuals
Adelie
Chinstrap
Gentoo
Species

Declutter!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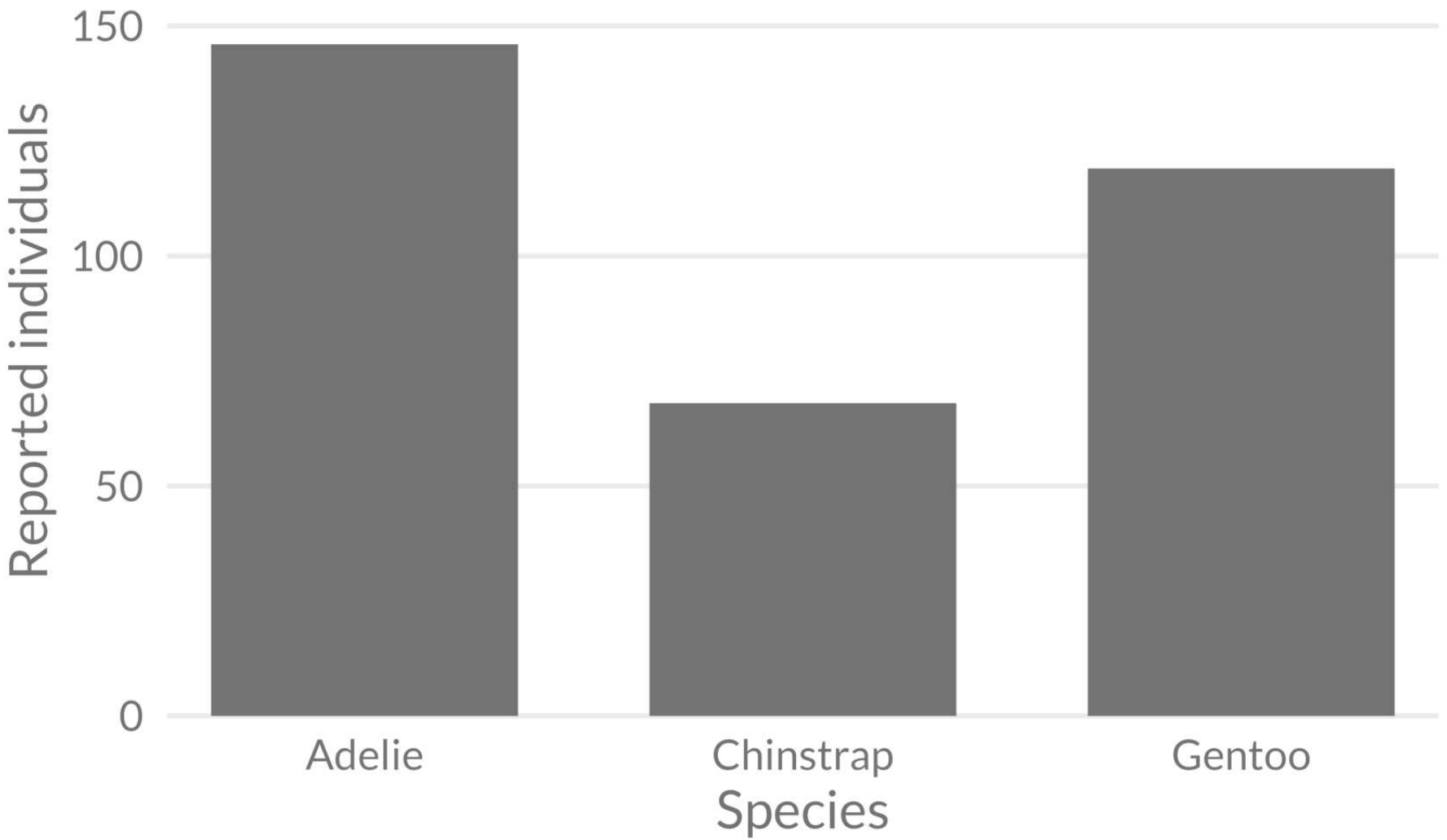
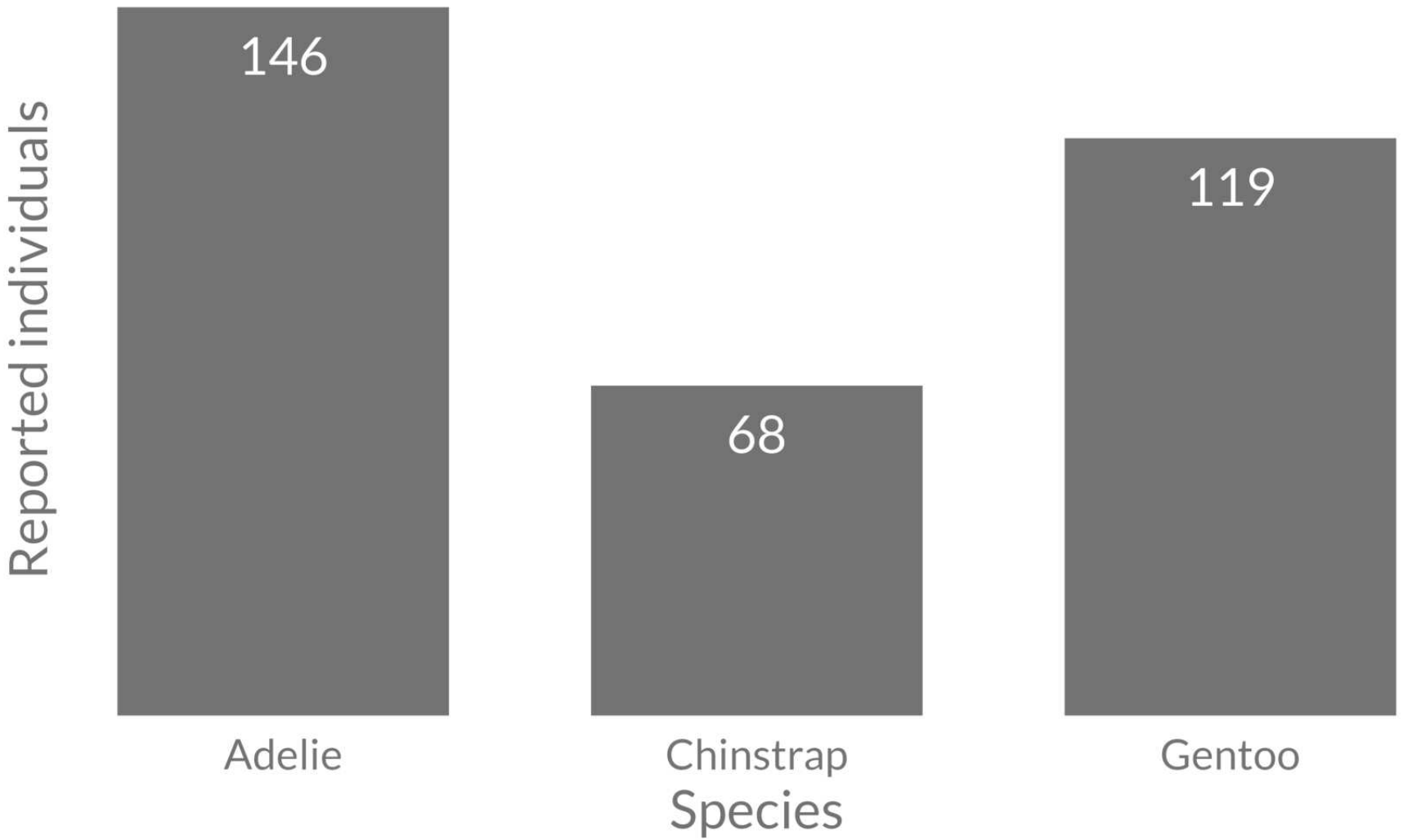
100
50
0
Reported individuals
Adelie
Chinstrap
Gentoo
Species

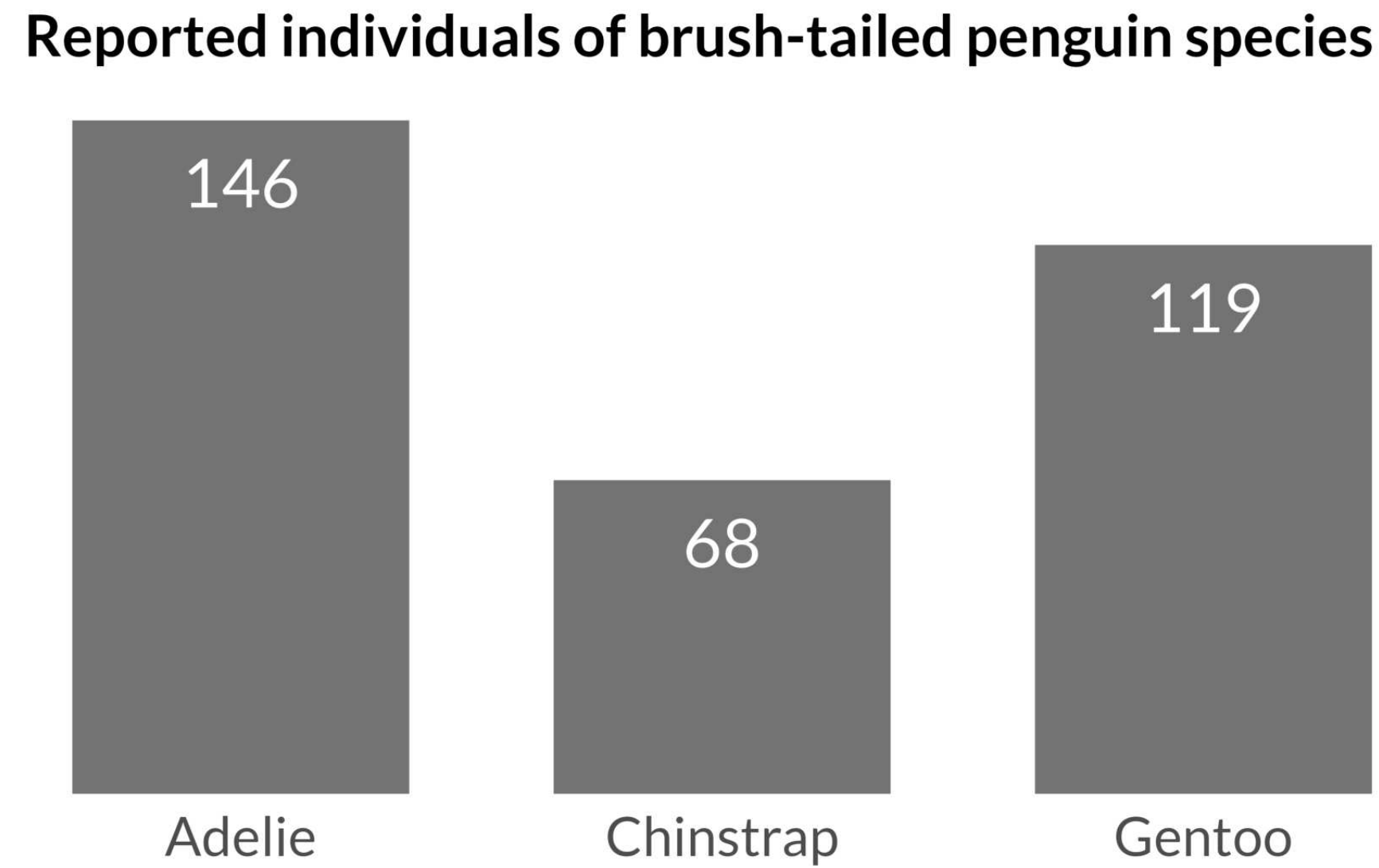
Declutter!


150
100
50
0
Reported individuals
Adelie
Chinstrap
Gentoo
Species

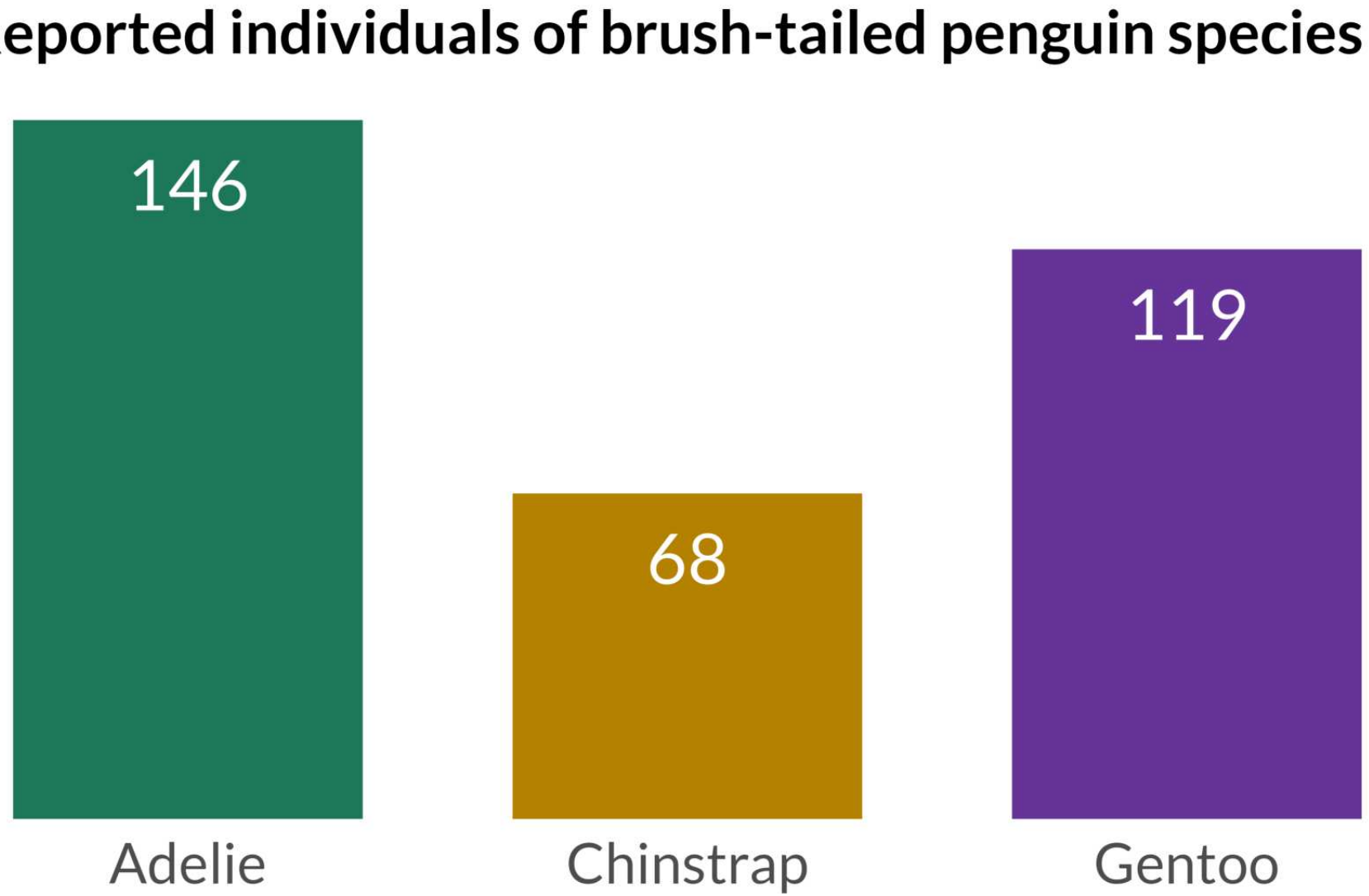
Declutter!


Reported individuals
146
68
119
Adelie
Chinstrap
Gentoo
Species

Declutter!


Reported individuals of brush-tailed penguin species
146
68
119
Adelie
Chinstrap
Gentoo

Declutter!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68
119
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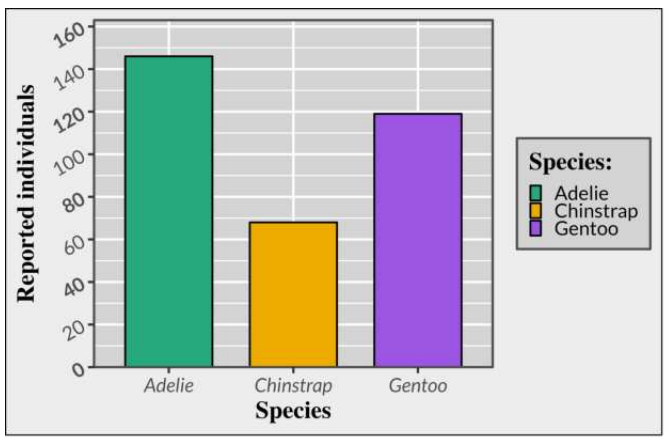
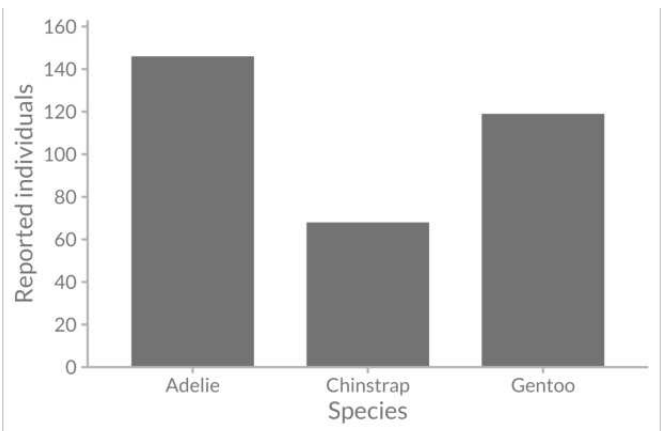
Gentoo

Declutter!


Reported individuals
160
140
120
100
80
60
40
20
0
Adelie
Chinstrap
Gentoo
Species
Species:
Adelie
Chinstrap
Gentoo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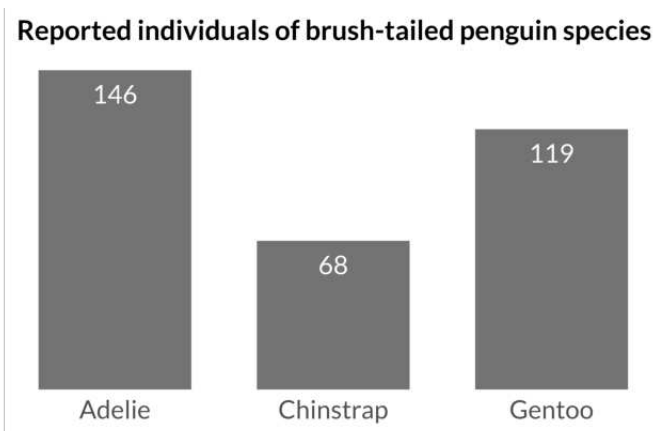
140
120
100
80
60
40
20
0
Adelie
Chinstrap
Gentoo
Species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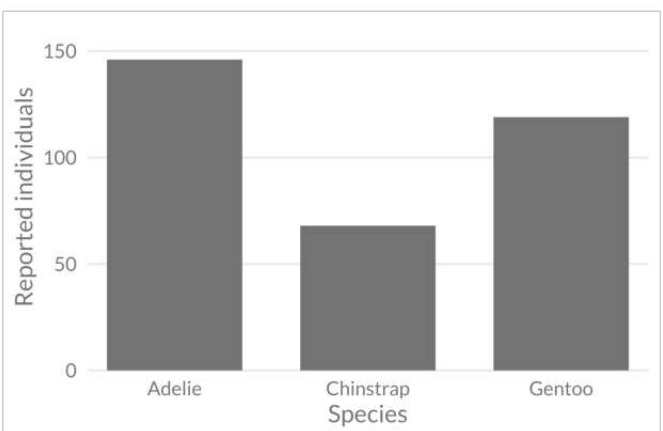
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150
100
50
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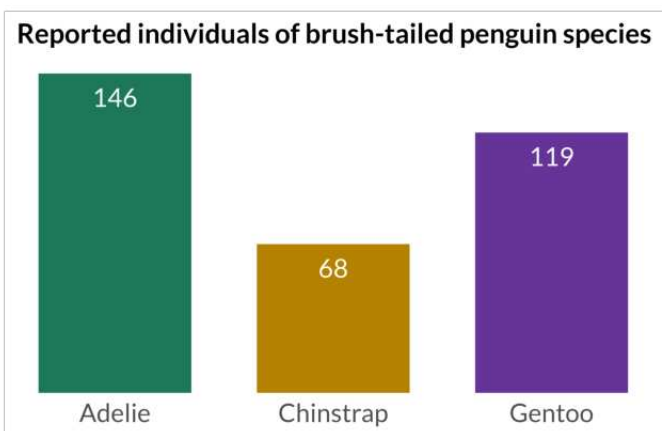
Adelie
Chinstrap
Gentoo
Species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Creating Layouts

Main Principles of Graphic Design

→ *Unity*
→ *Variety*
→ *Hierarchy*

The good balance between **unity** and **variety** creates **hierarchy**.

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	6,466	0.4	1	0.1	164	6.6	35	7.7
Asia-Pacific	64,778	825	1.3	54,211	-0.3	599	1.5	672	1.9	386	4.2
China	63,627	1,889	3.1	58,544	2.6	88	0.2	2,278	7.5	471	10.9
Europe	90,752	1,093	1.2	153,979	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	3,394	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	1,896	4.0

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

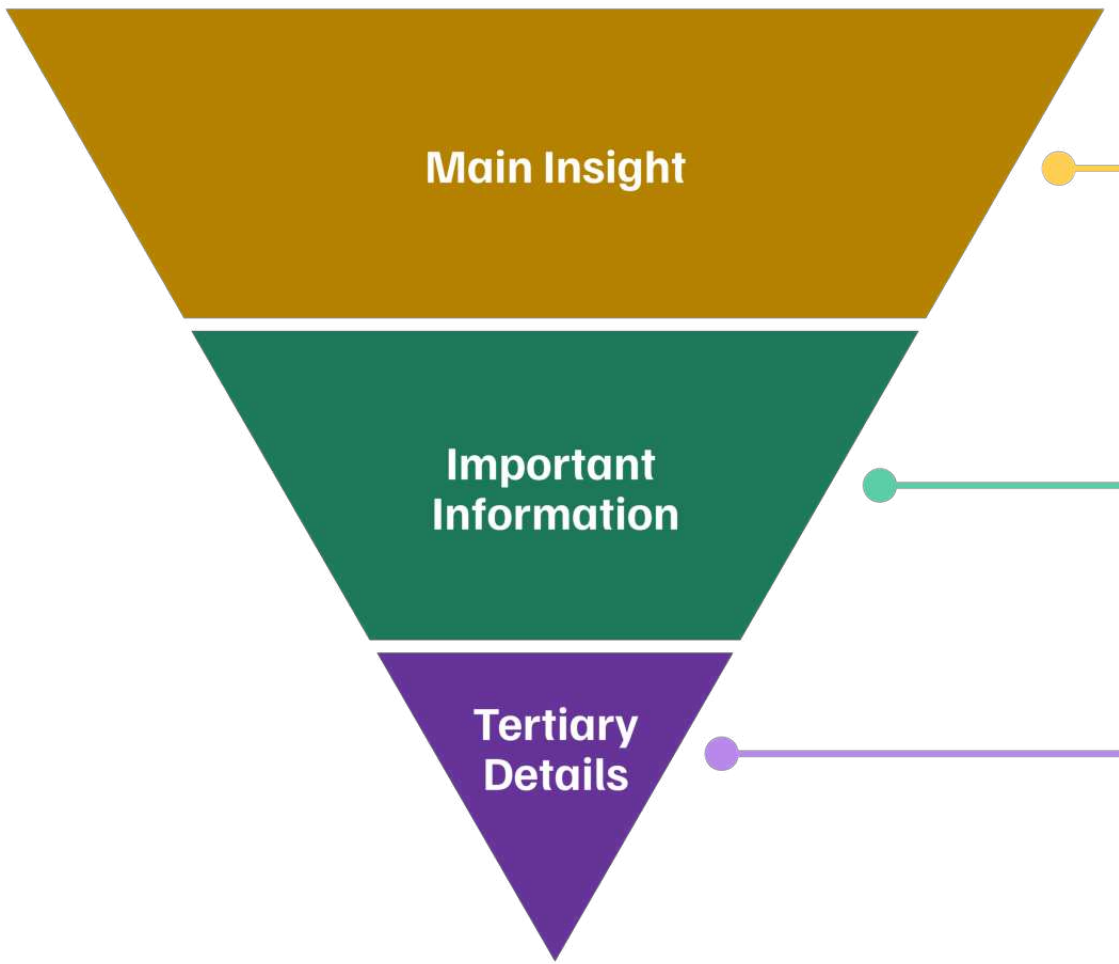
Table 1: Change in household wealth 2018–2019 by region

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

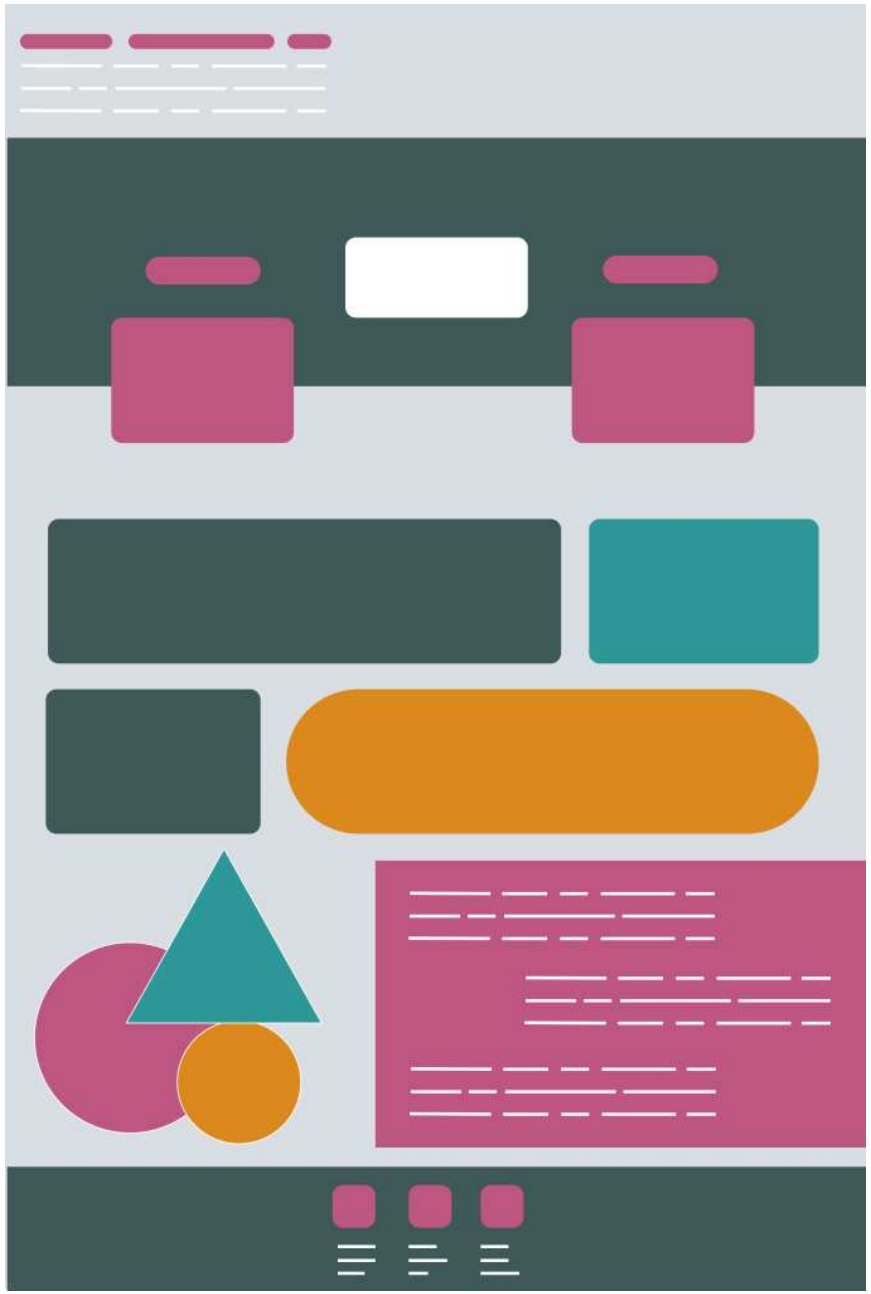
Hierarchy



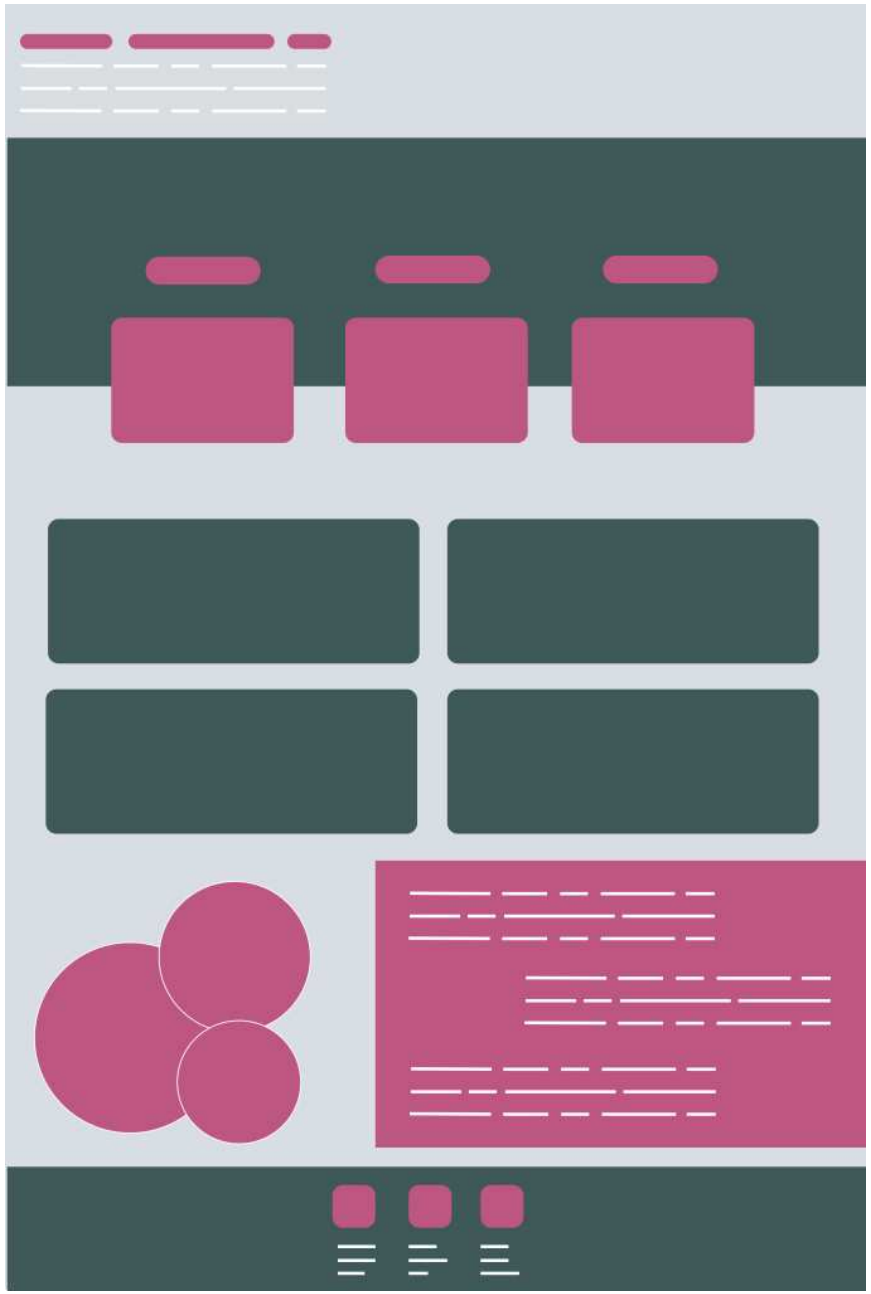
state most significant, high-level insights
e.g. KPIs and BANs

provide context and evidence
e.g. main trend chart

allow for more granular exploration
e.g. user inputs and additional charts



Created by Lindsay Betzendahl



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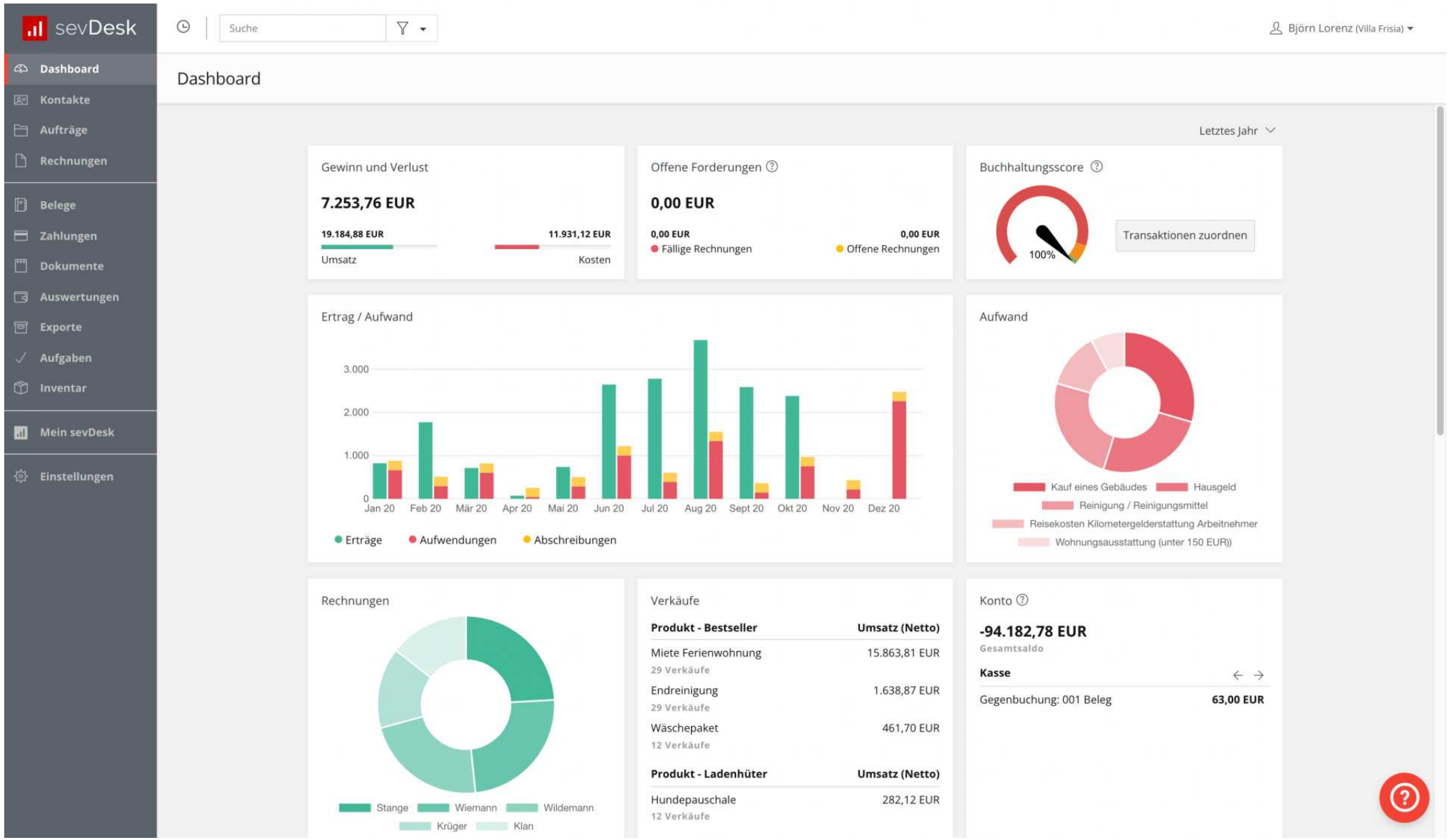
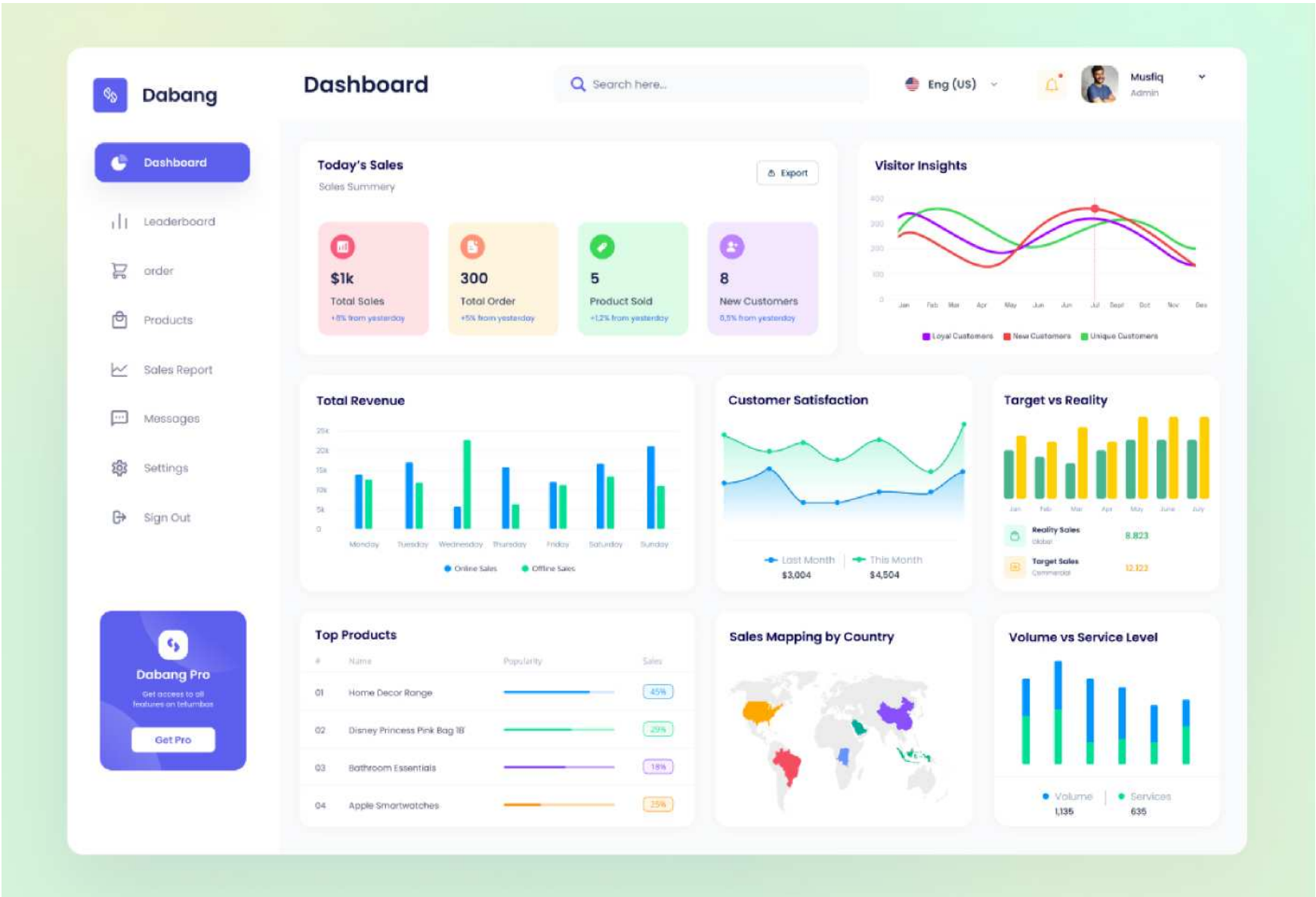


Source: sevDesk



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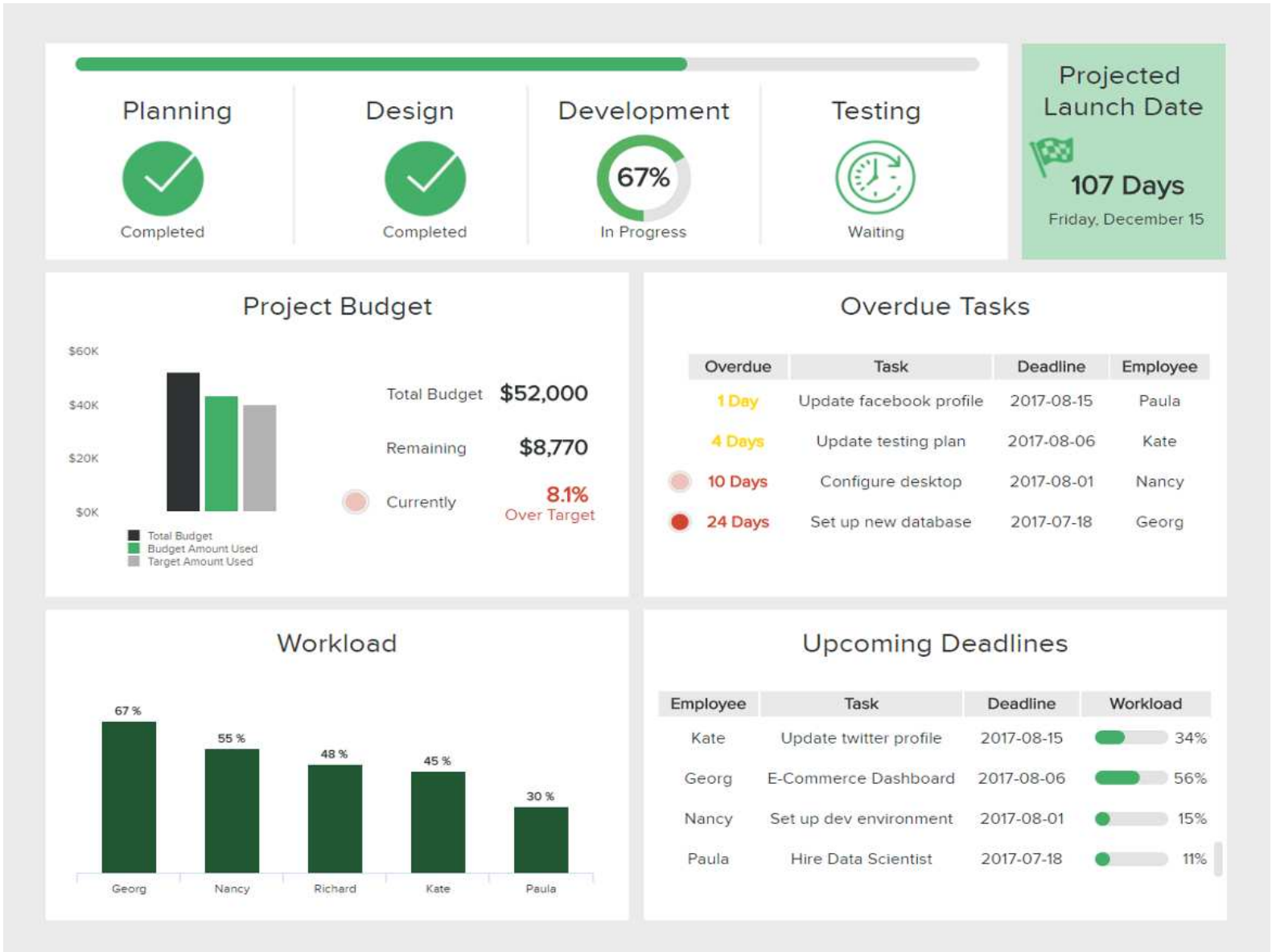
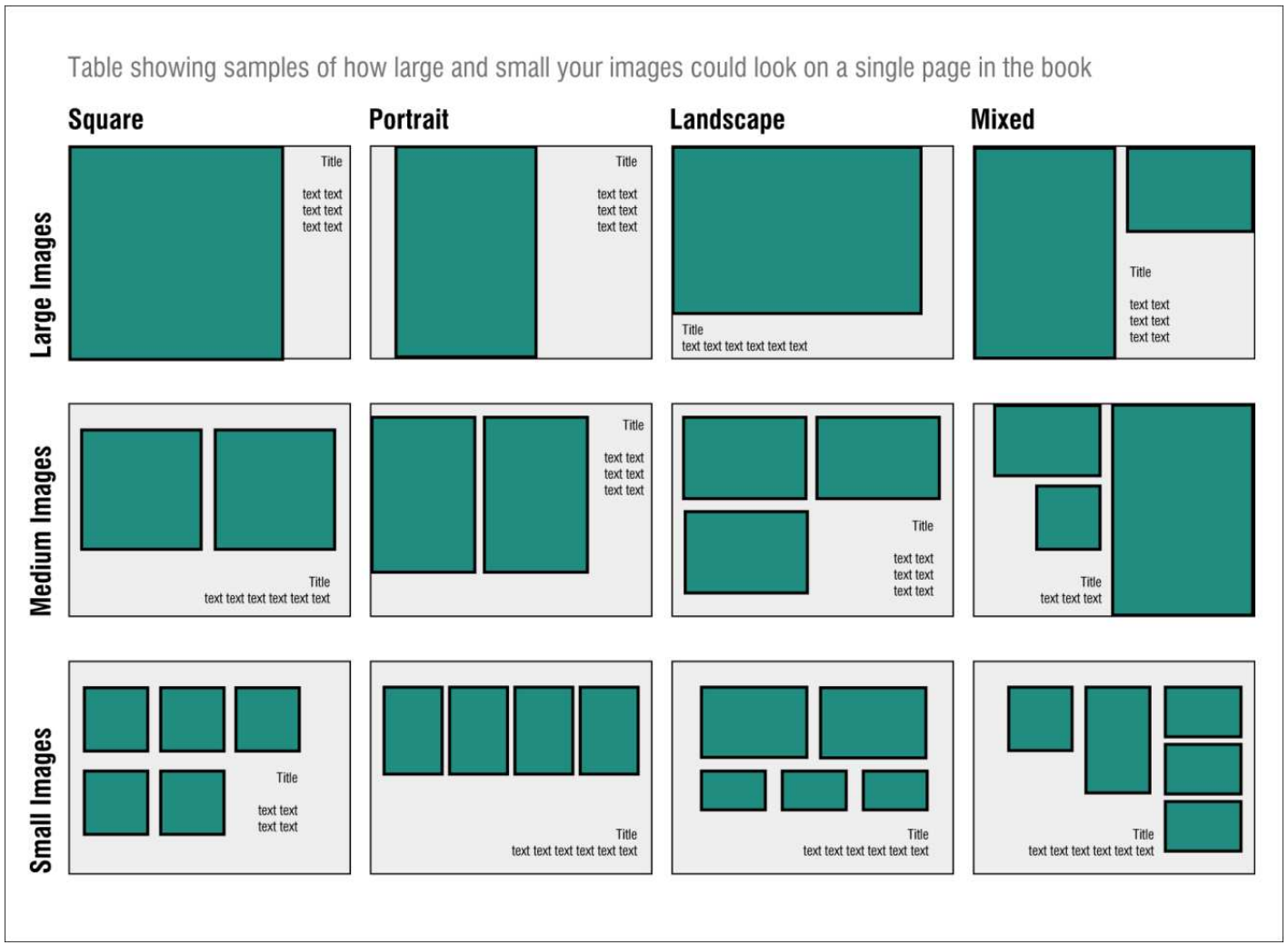


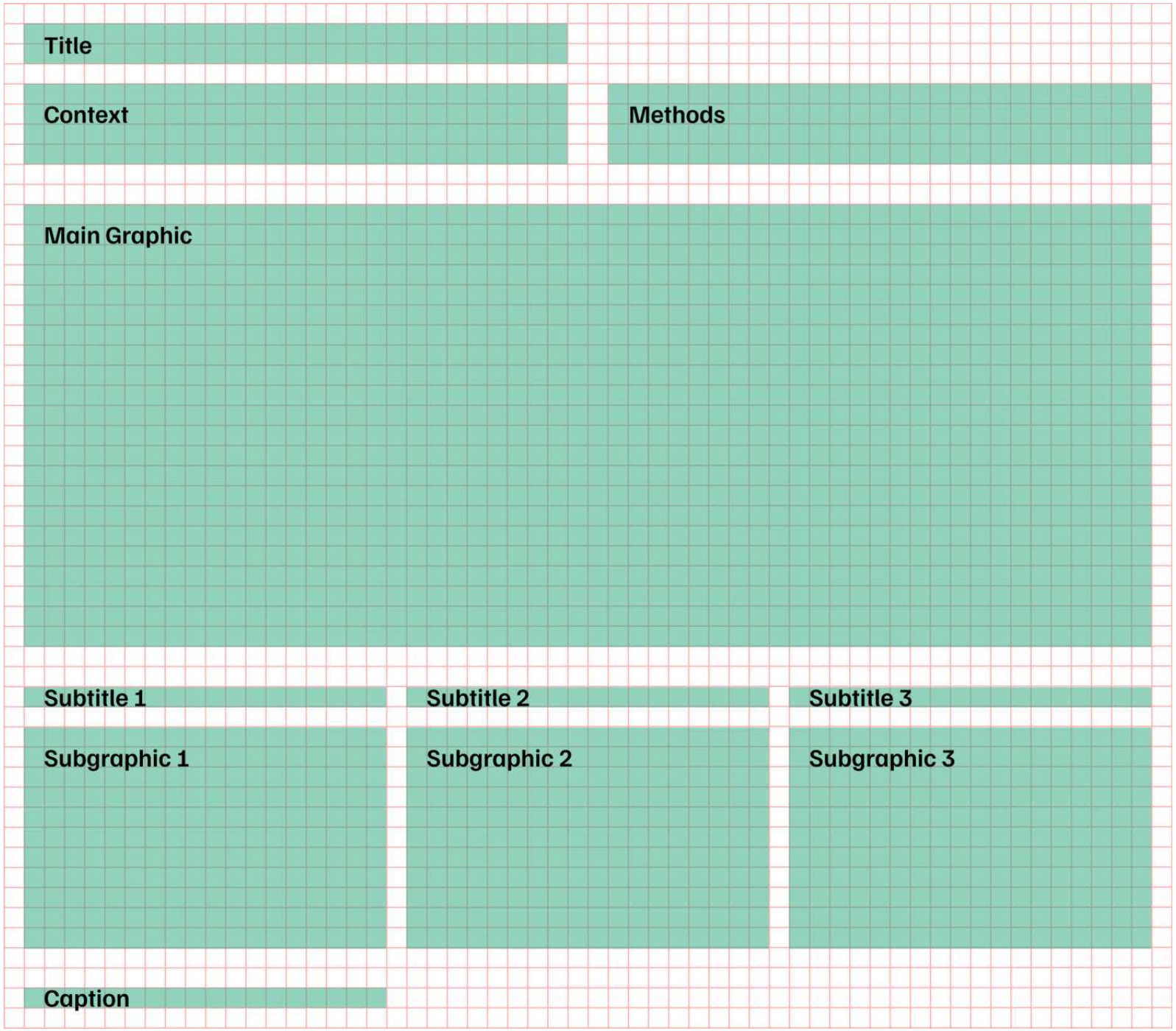
Source: Datapine

Modular Design

Modular Design



Source: londonphotography.org.uk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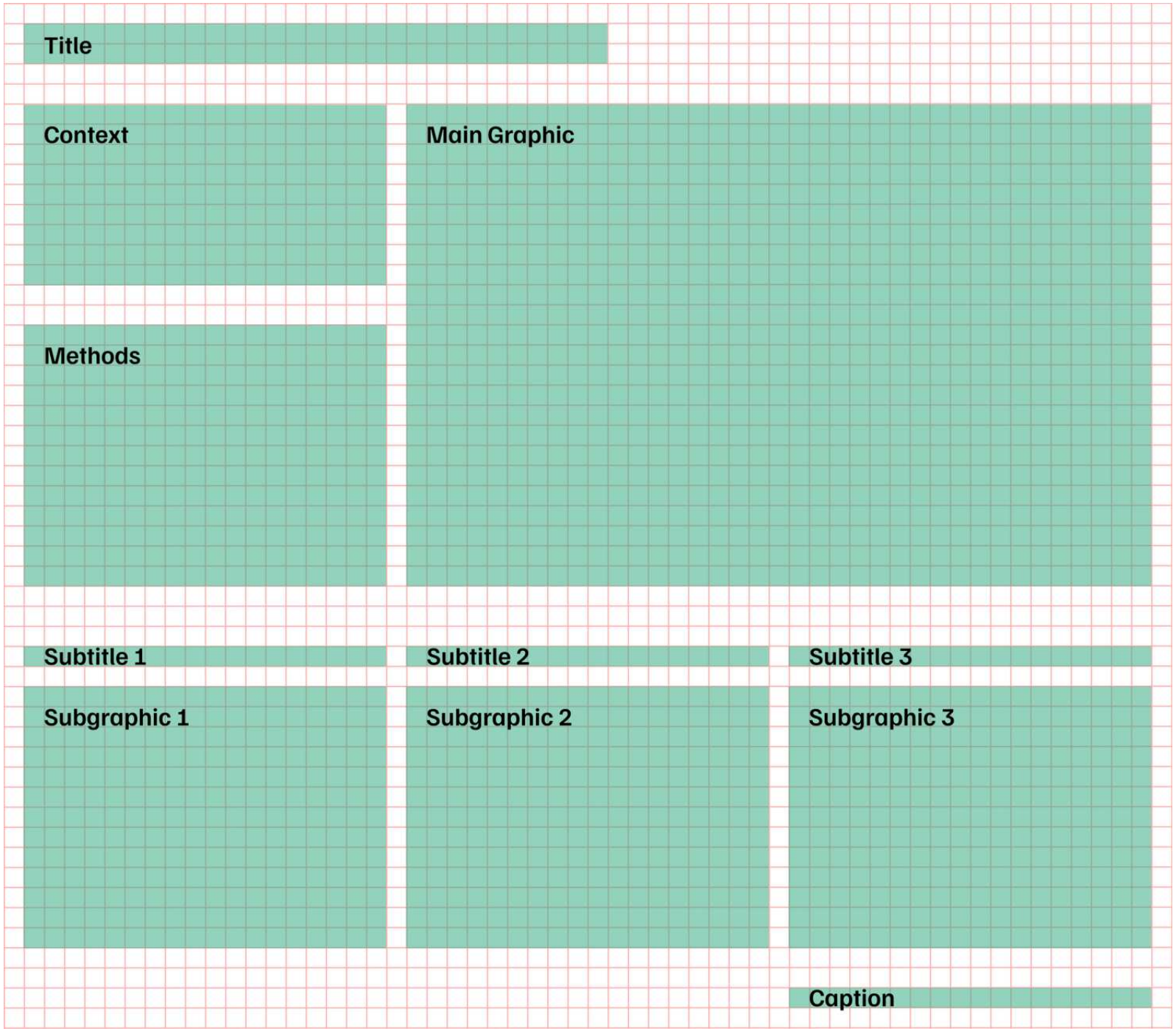
Subtitle 1
Subtitle 2
Subtitle 3
Subgraphic 1
Subgraphic 2
Subgraphic 3
Caption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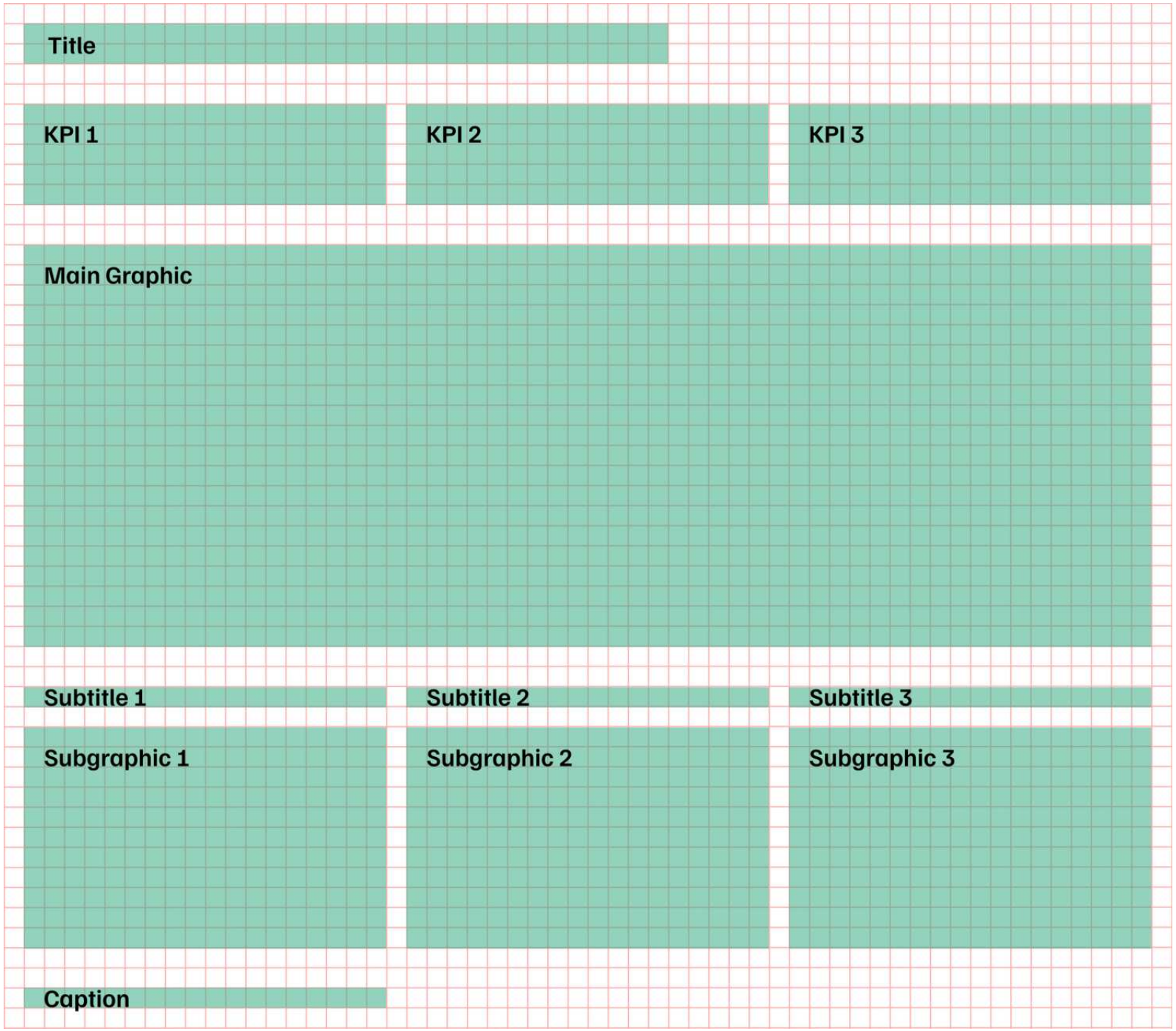
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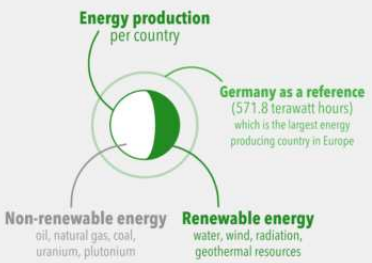
Subtitle 3
Subgraphic 1
Subgraphic 2
Subgraphic 3
Caption

How European countries generated electricity in 2018

Germany is the largest energy producing country in Europe. It generates the most renewable and conventional thermal energy, representing 31% and 56% of its overall production respectively. **France** is the second largest energy European producer and by far the largest nuclear energy provider; 71% of its production is based on nuclear fission to generate heat.

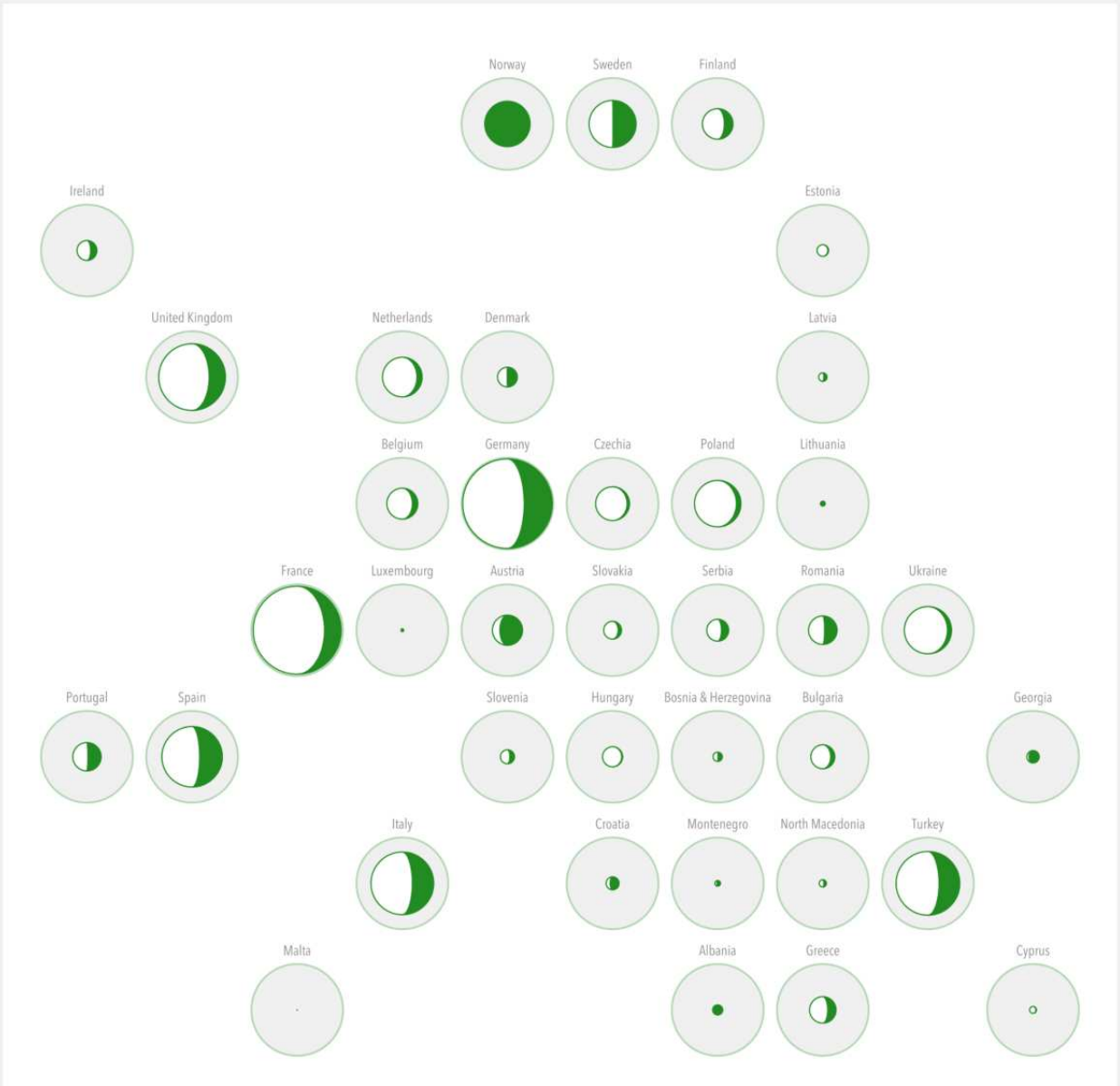
Renewable:	Nuclear:	Conventional thermal:
Germany	**France**	**Germany**
179.1 TWh	393.2 TWh	320.4 TWh
(31% of its production)	(71% of its production)	(56% of its production)

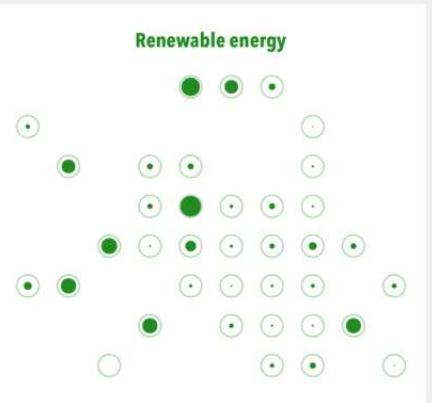
Renewable energy is energy that comes from resources that are naturally replenished such as sunlight, wind, water, and geothermal heat. Unlike fossil fuels, such as oil, natural gas and coal, or nuclear power sources such as uranium and plutonium, renewable energy regenerates naturally in a short period of time.

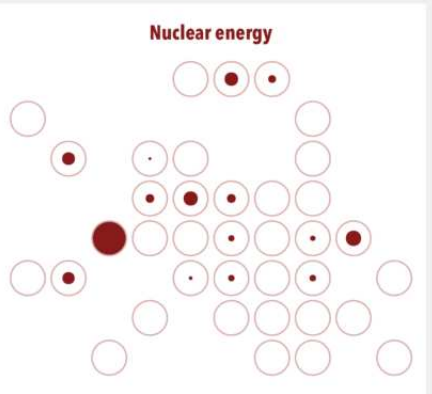


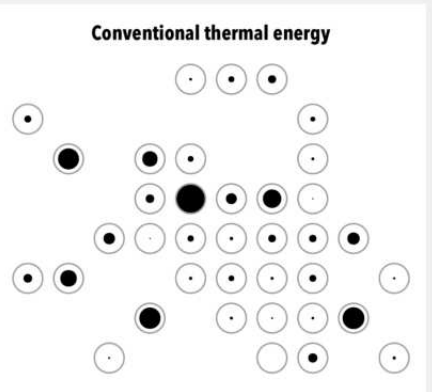
Norway had an electricity production almost entirely made up of renewable energy (98%). This makes Norway the second largest producer of this energy type in Europe. Interestingly, most of the renewable energy is produced by hydro power that take up 95% and only 3% by wind. In contrast, twelve European countries were reported to produce less than 20% of their energy with renewable resources: **Malta** (0%), **Hungary** (5%), **Estonia** (6%), **Czechia** (7%), **Cyprus** (9%), **Ukraine** (9%), **Poland** (10%), **Netherlands** (13%), **Bulgaria** (17%), **Belgium** (18%), **Slovakia** (19%), and **France** (19%).

Note: Energy production is mapped to the area of the circles.
Visualization by Cédric Scherer • Data by Eurostat









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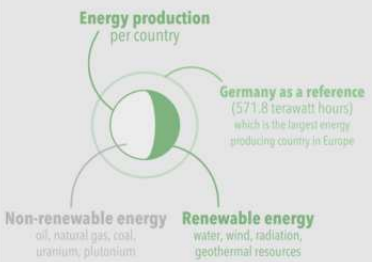

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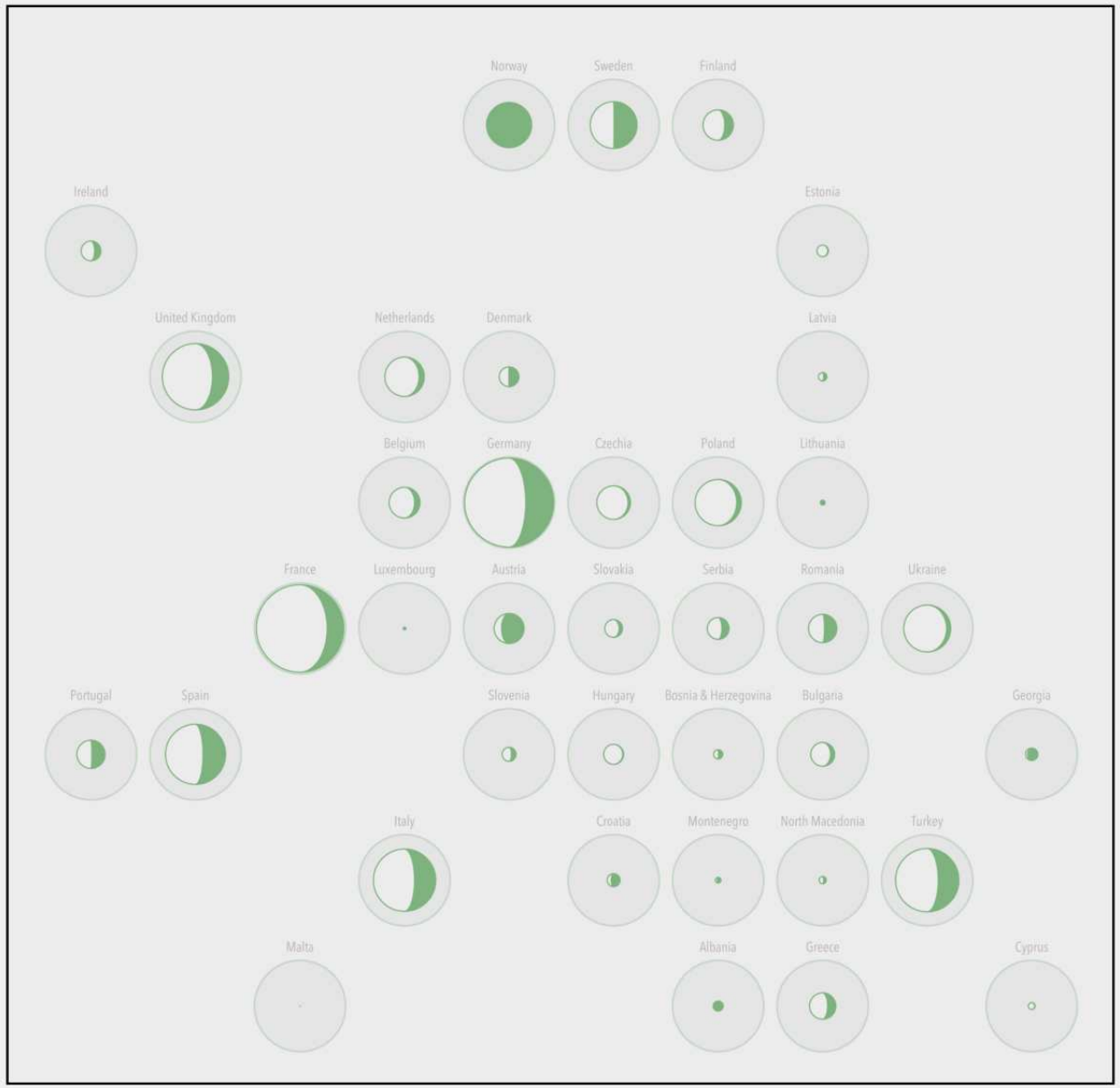

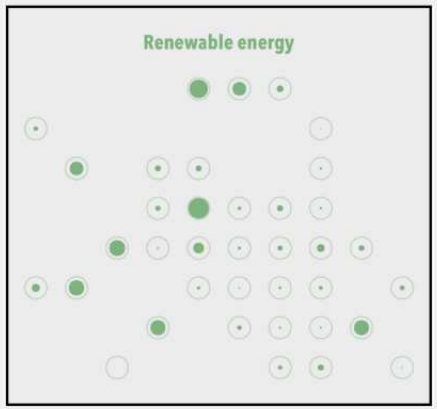

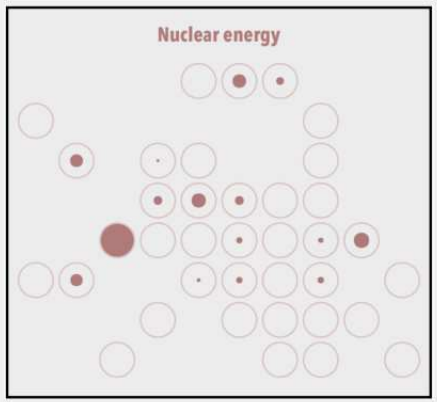

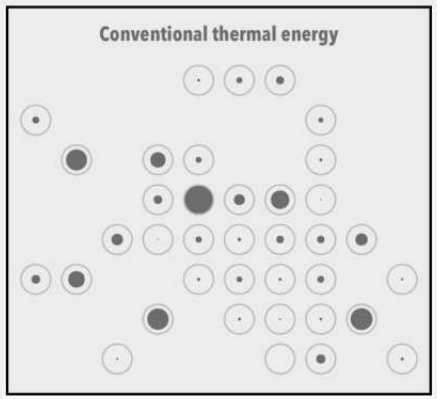

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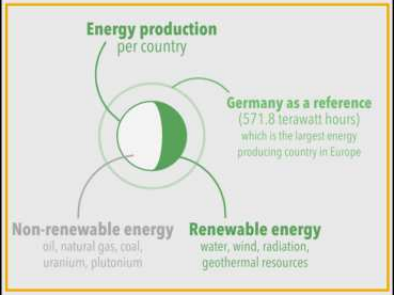

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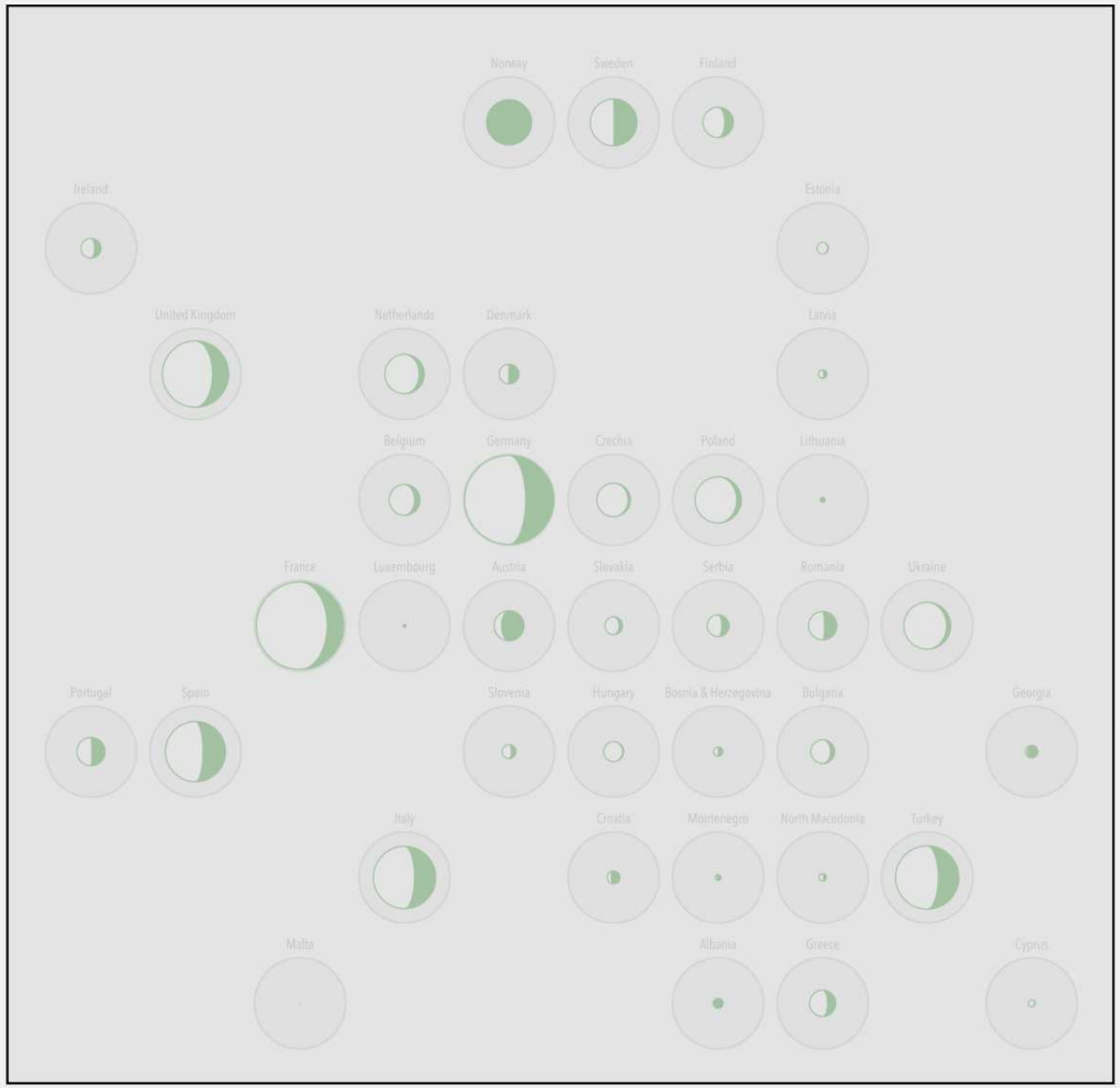
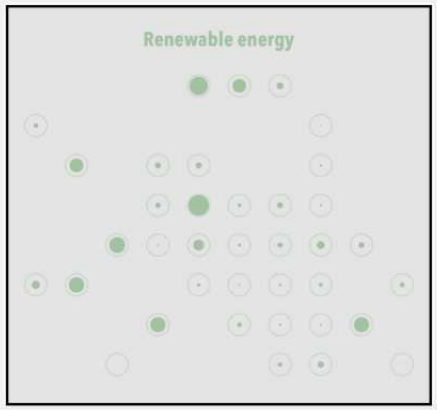
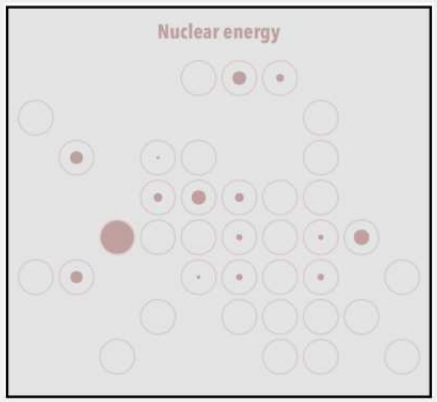
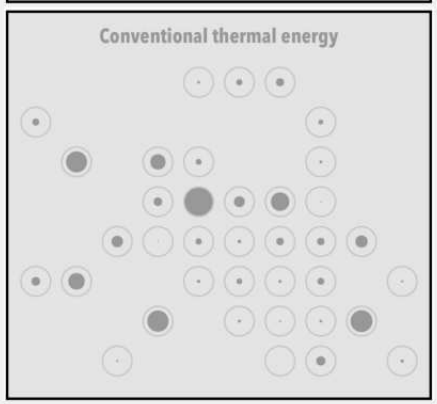


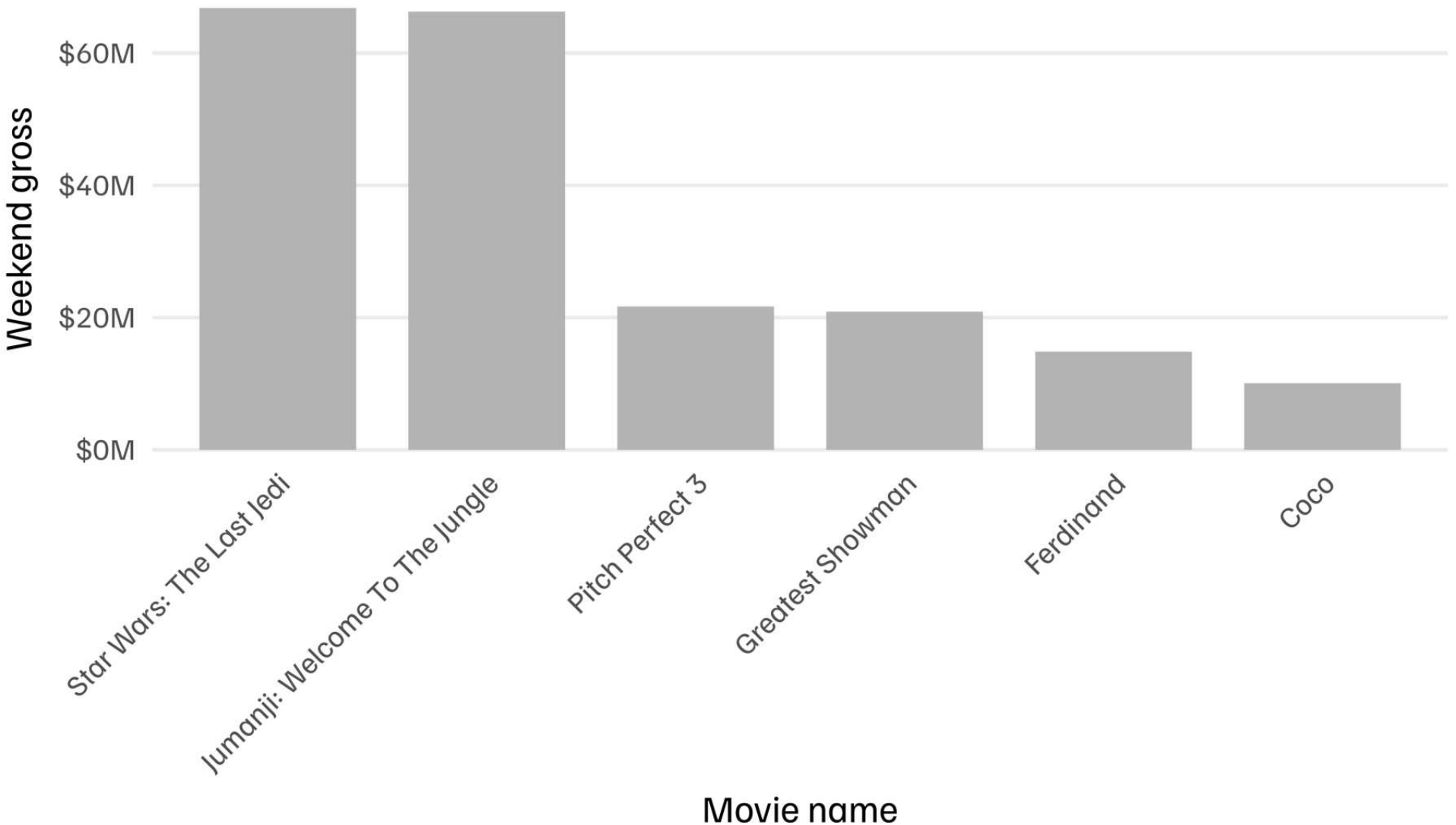




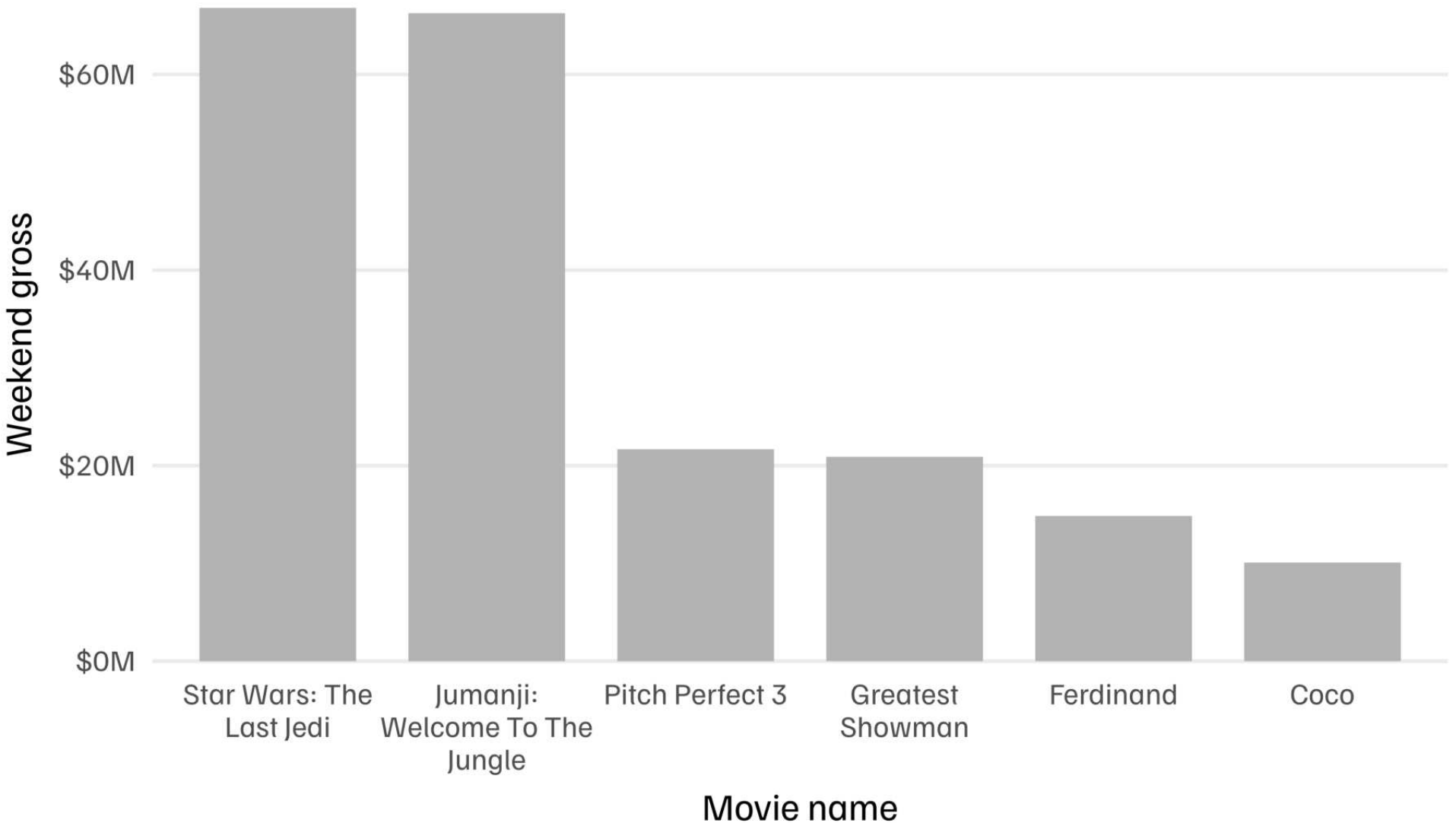


Alignment

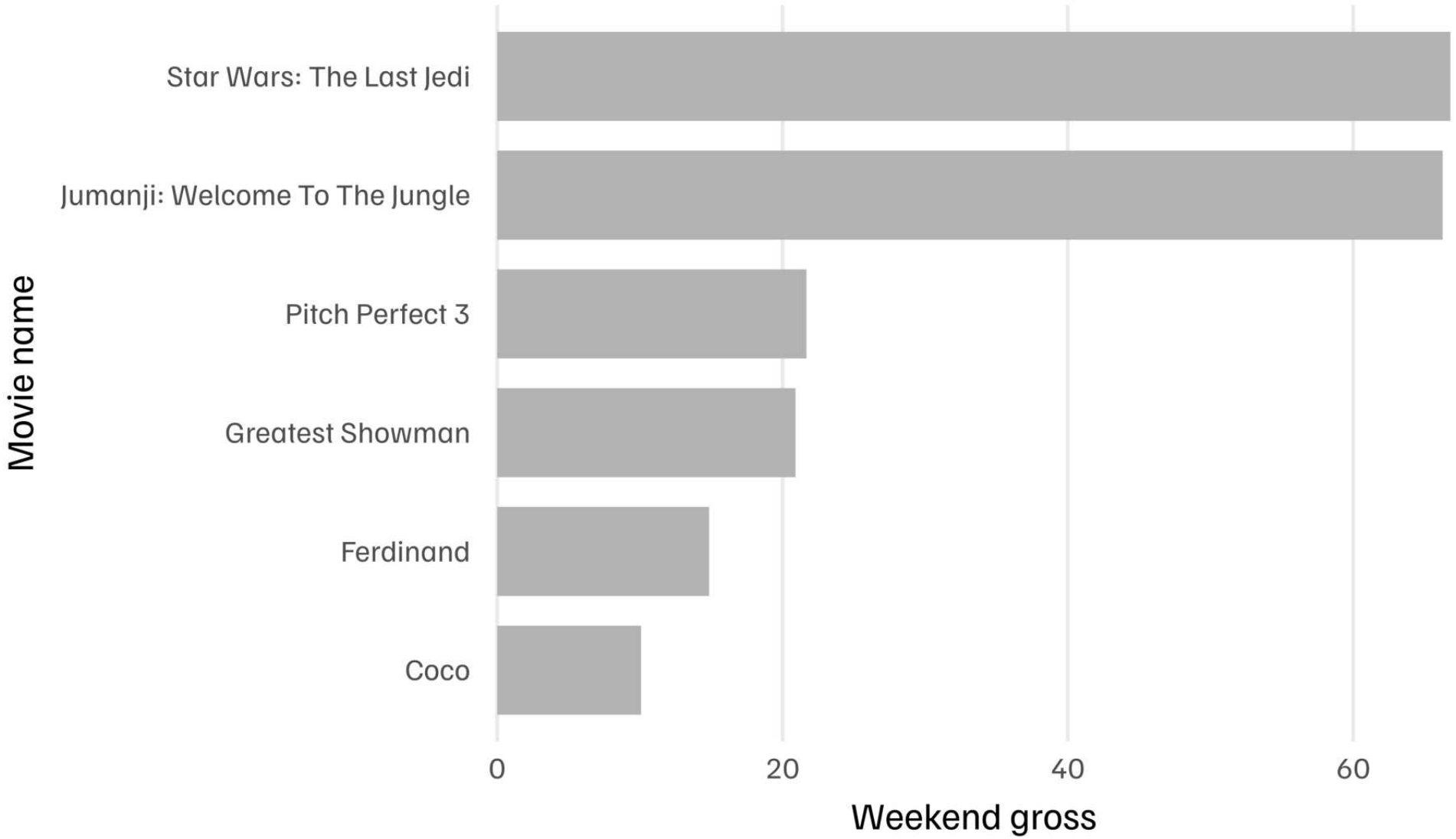
Alignment of Text Elements



Alignment of Text Elements



Alignment of Text Elements



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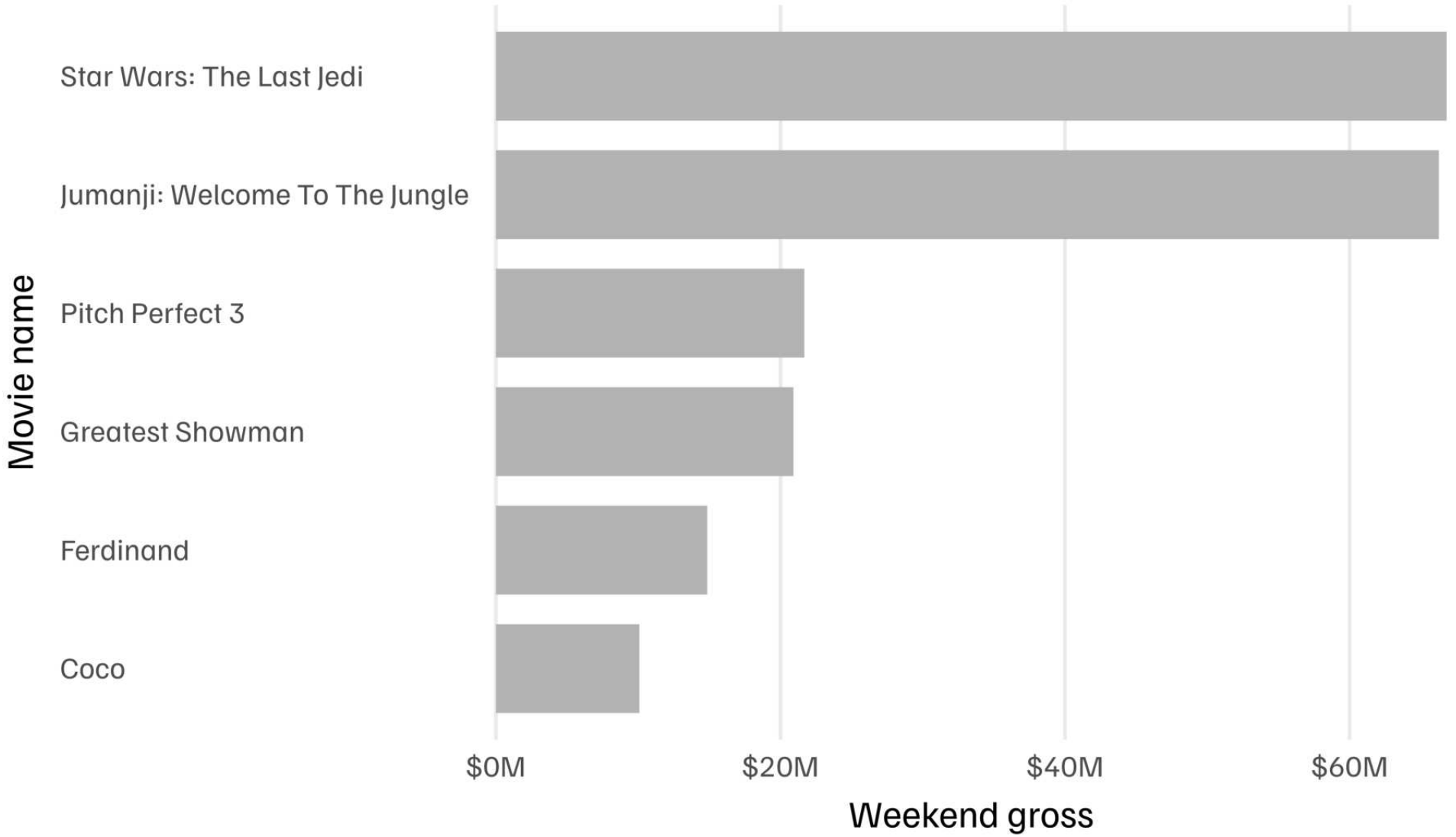

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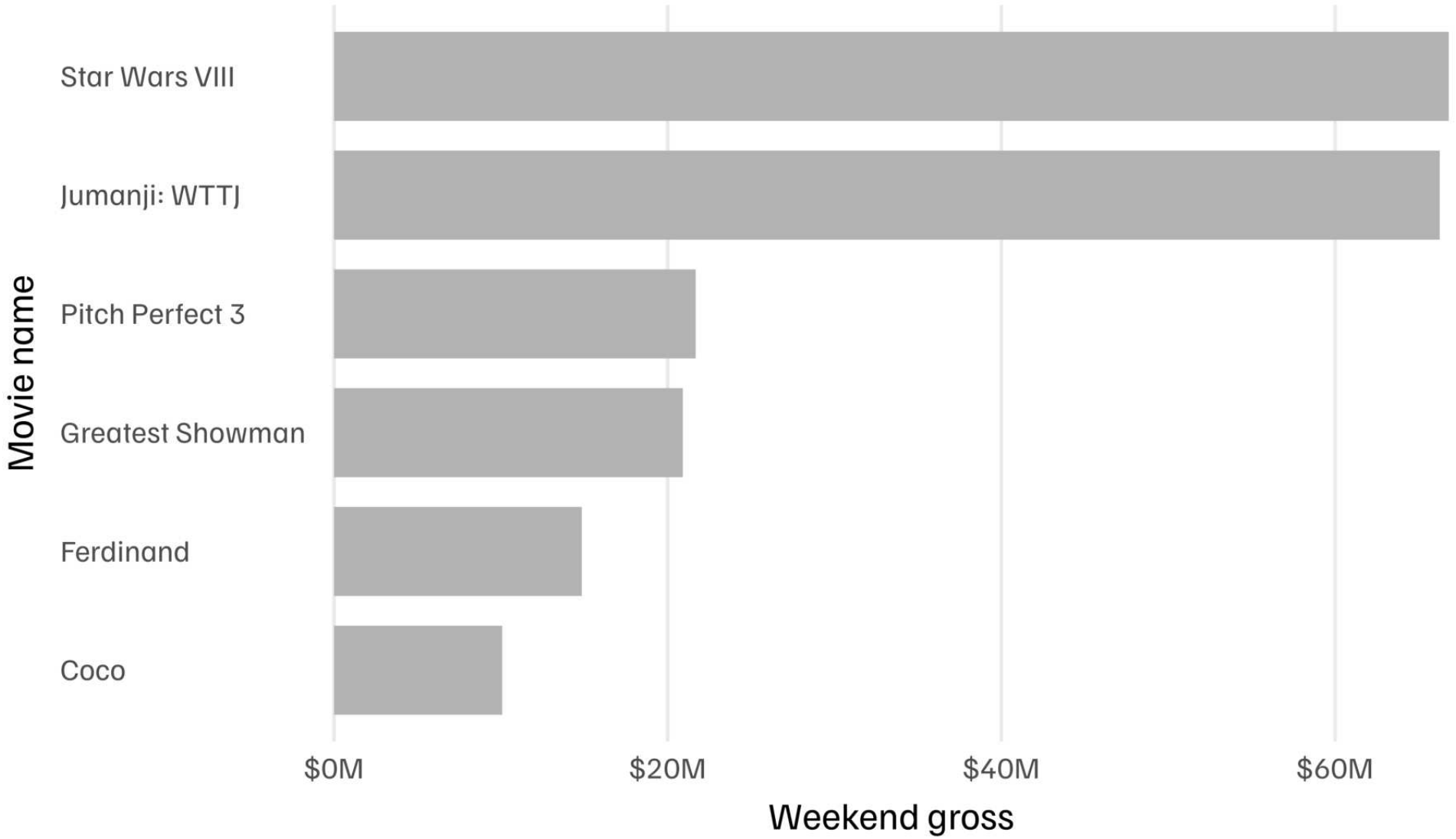

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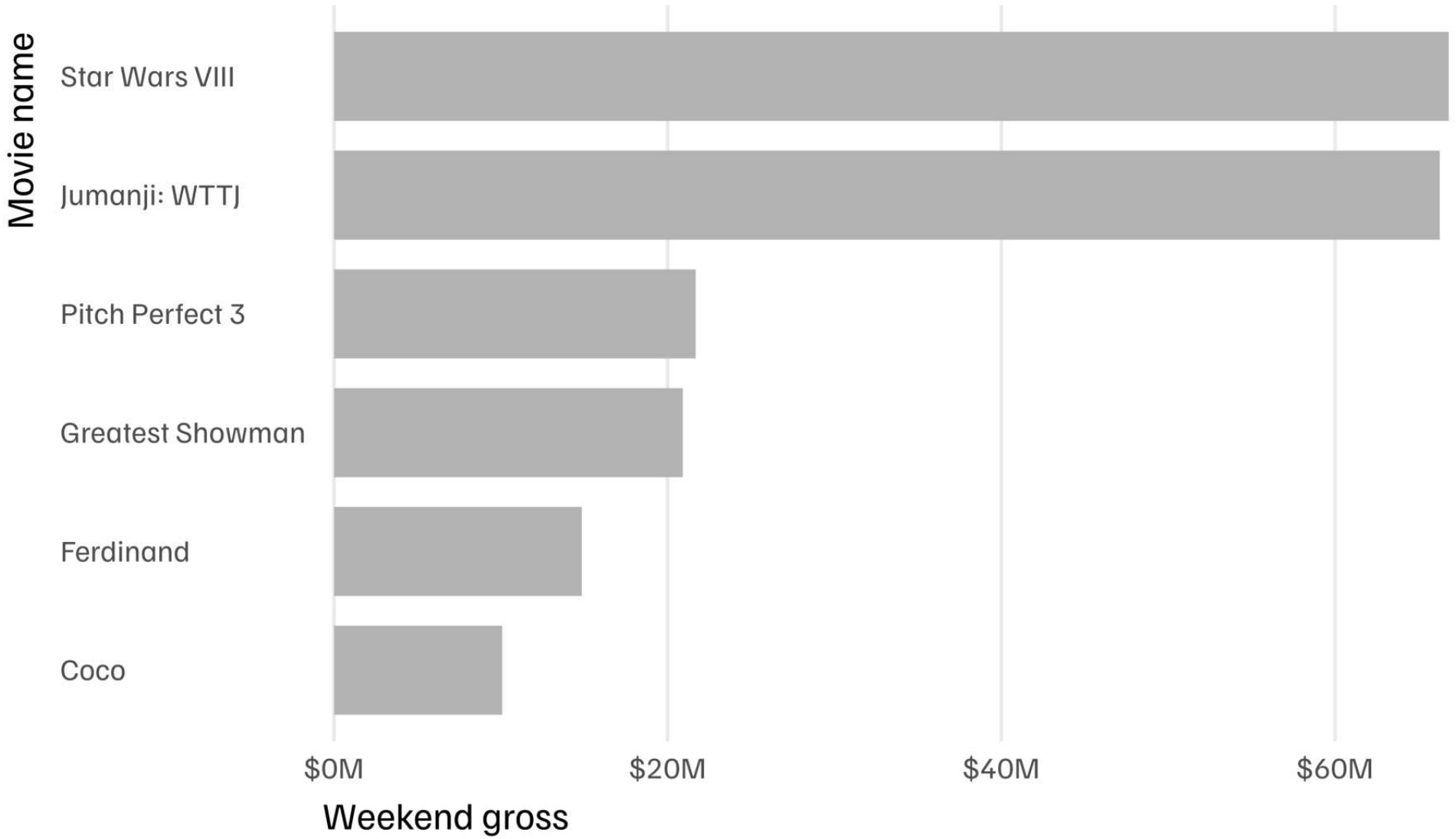

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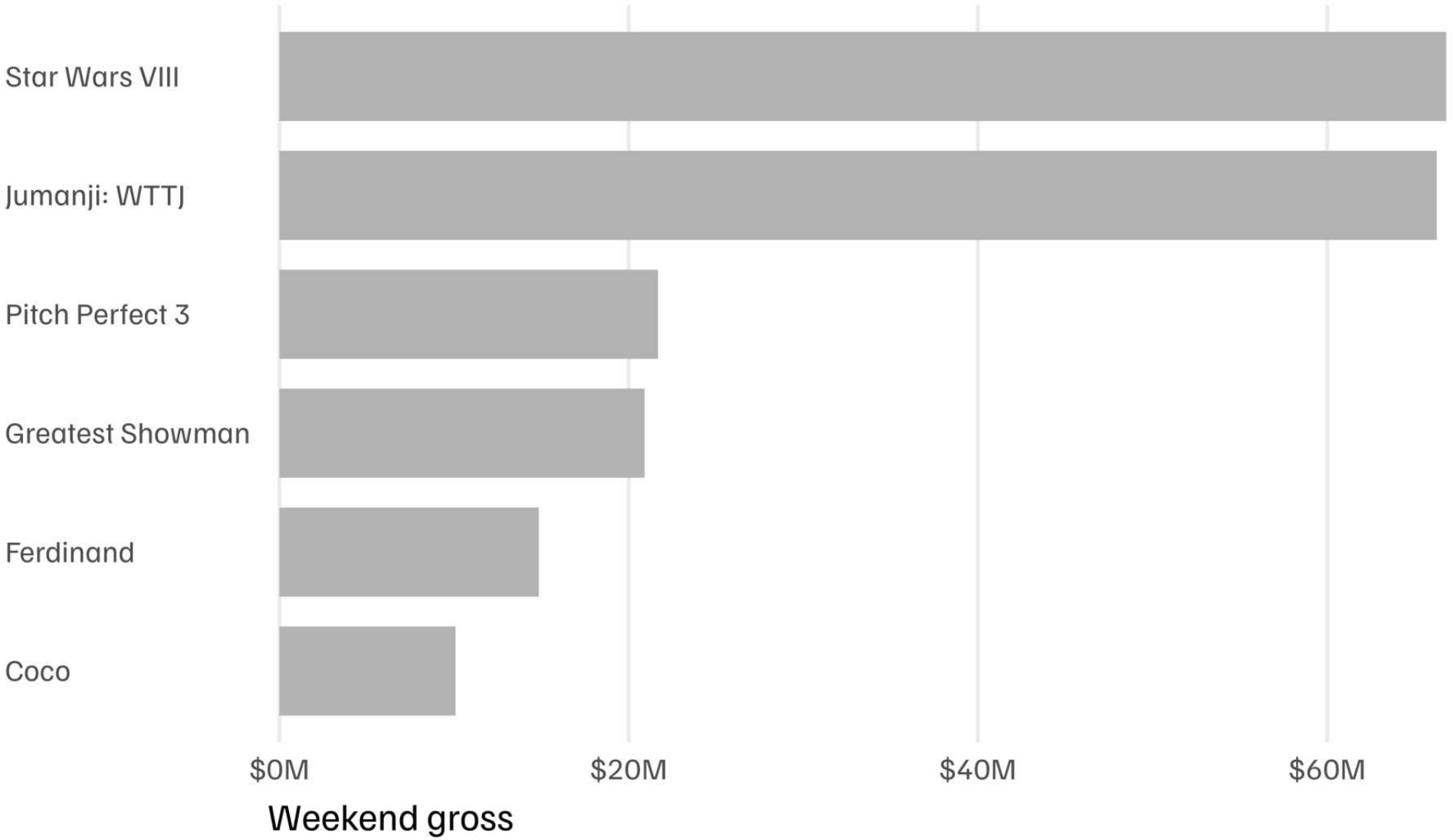

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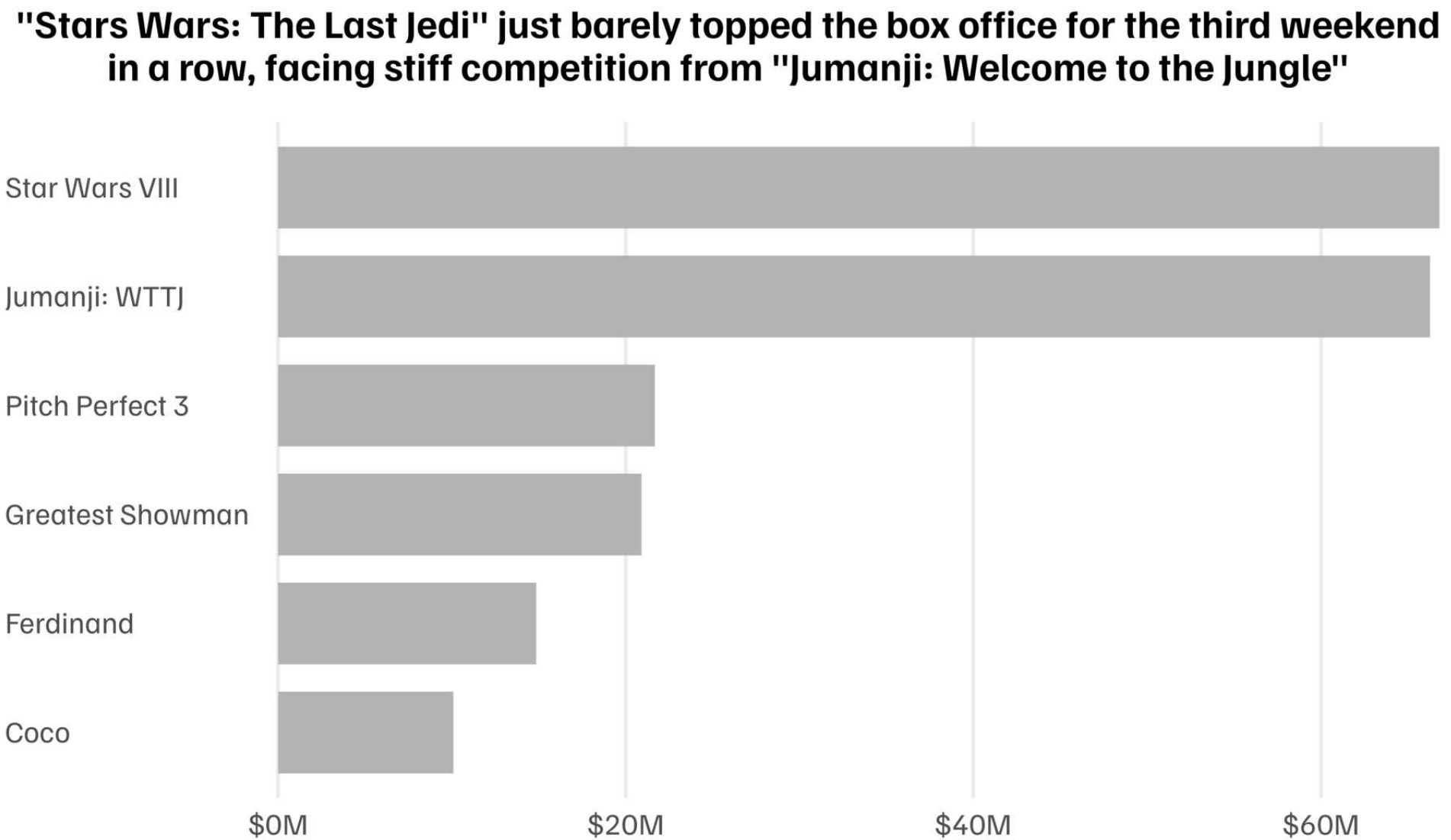

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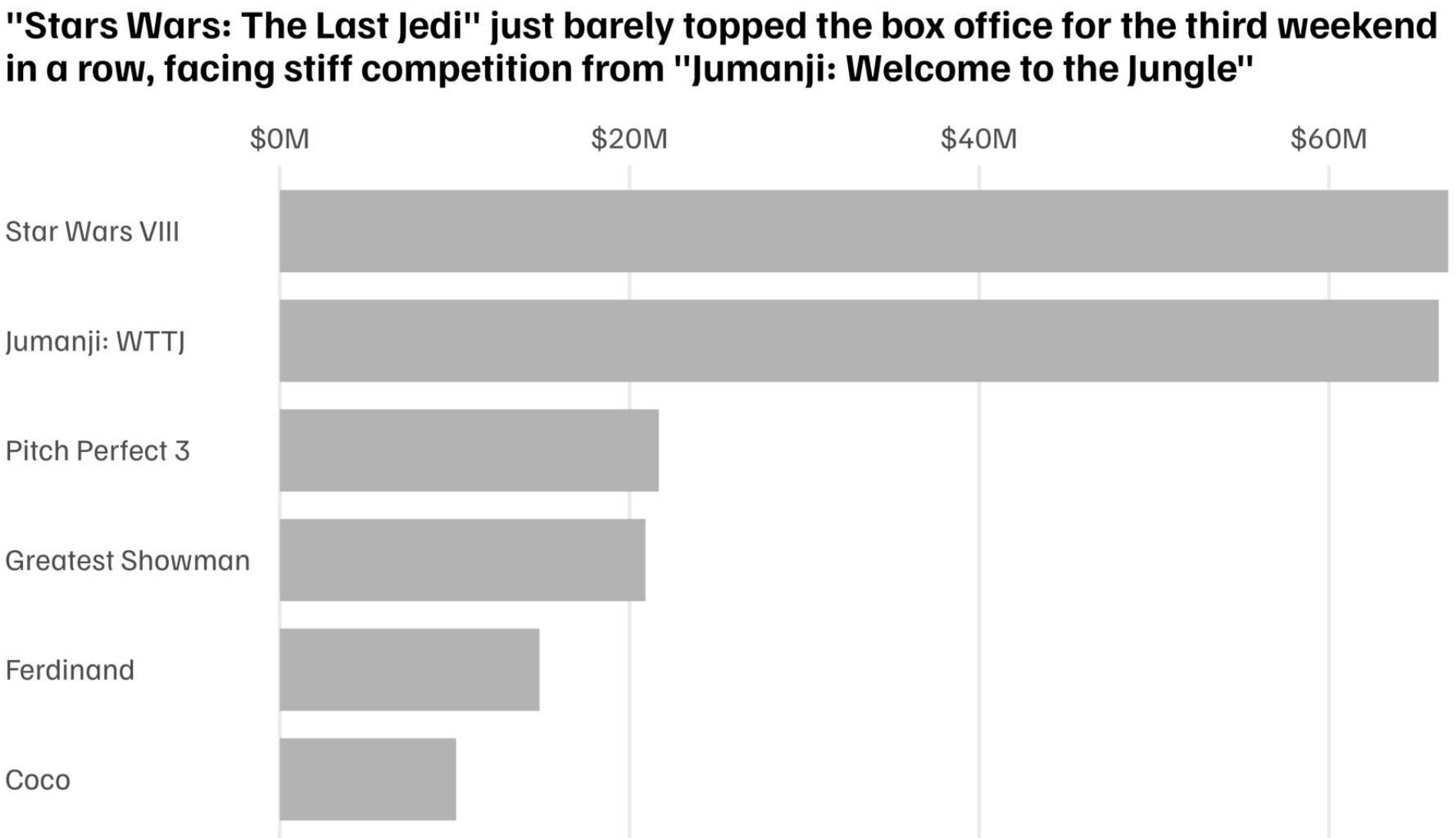

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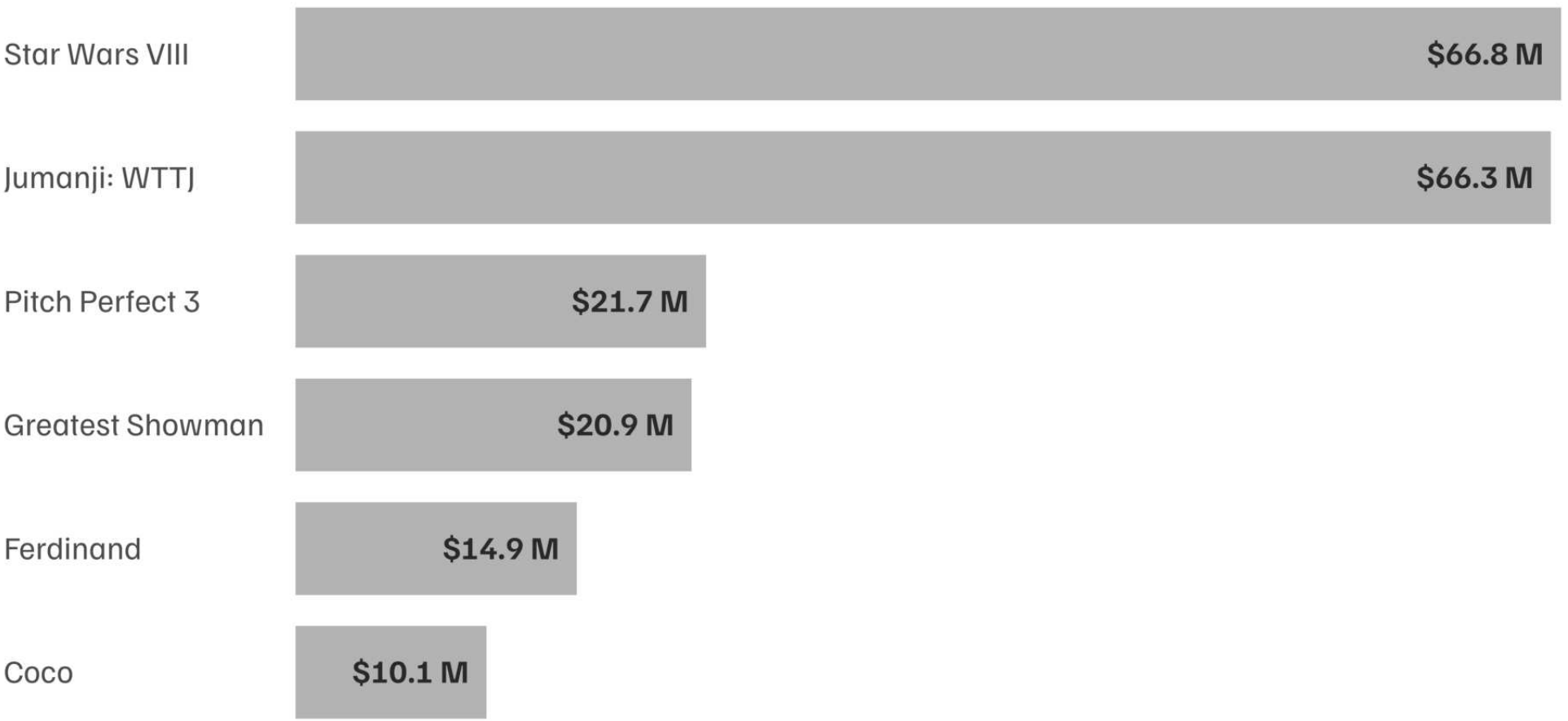

Proportional Numbers

Tabular Numbers

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The Power of Annotations

Peak Break-Up Times

According to Facebook status updates

David McCandless & Lee Byron, Information is Beautiful (modified)

Peak Break-Up Times

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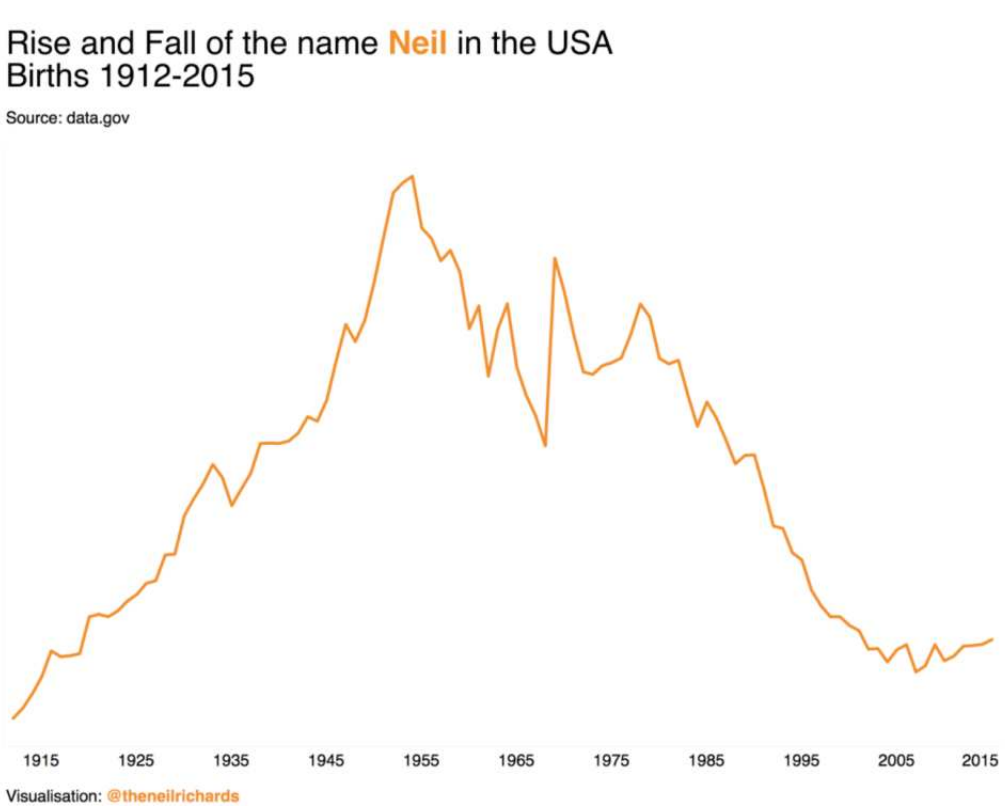
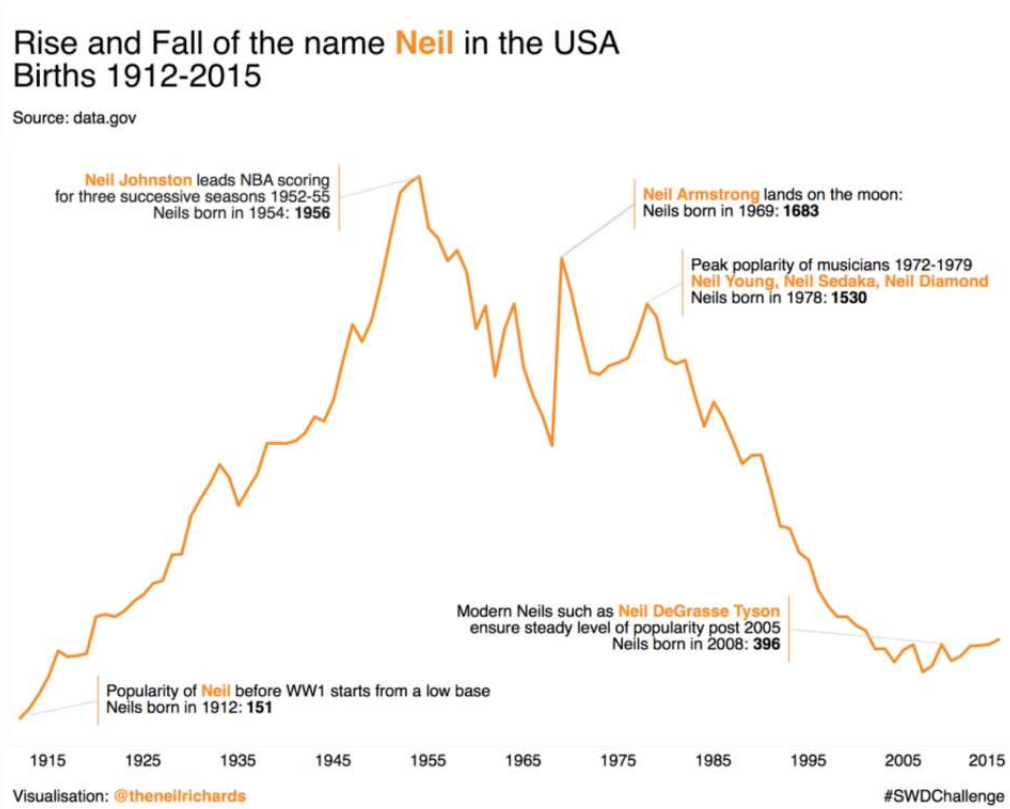
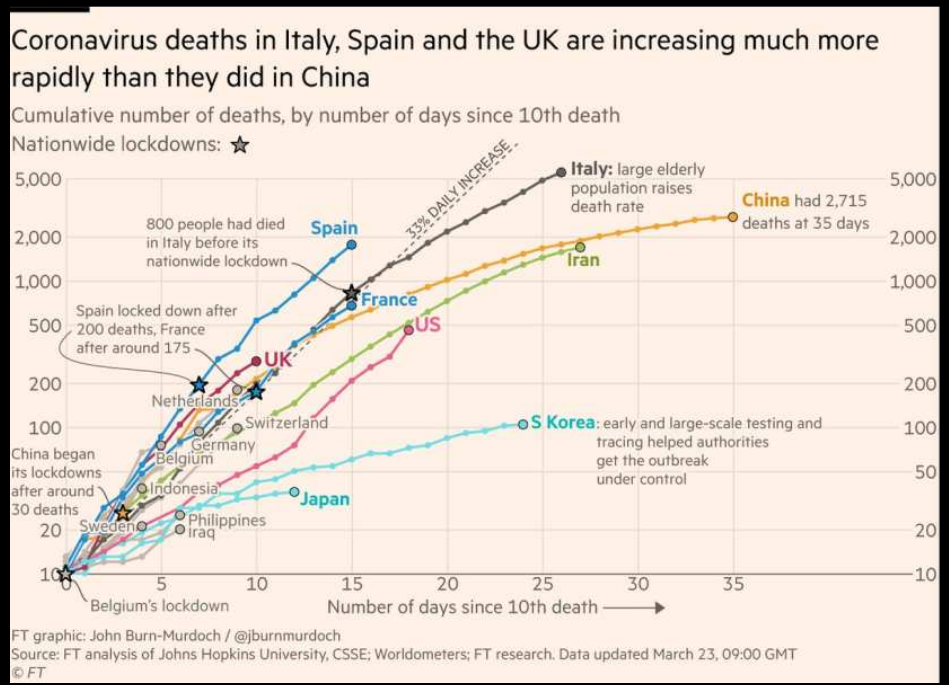


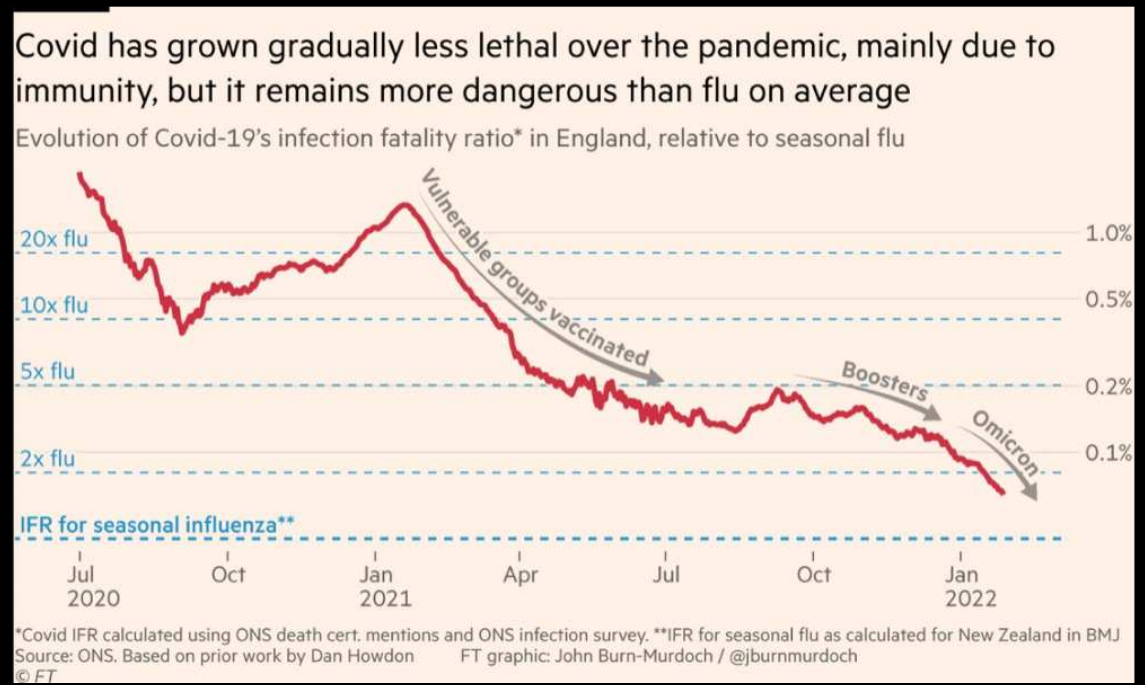


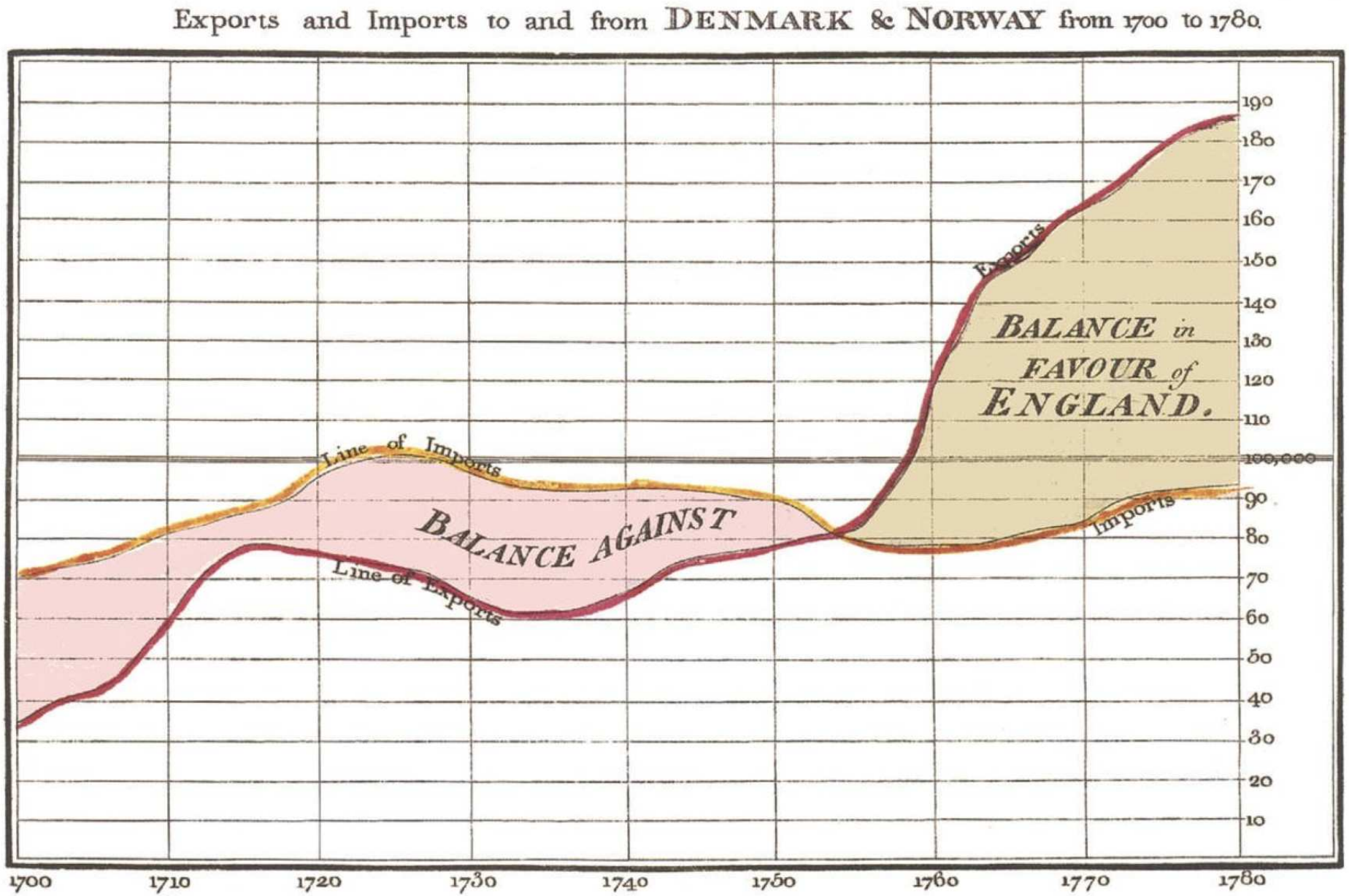
"Is white space always your friend?" by Neil Richards

"The key thing we do is to add a title to the chart, as an entry point. [...]
Text and other annotations add enormous value for non-chart people."

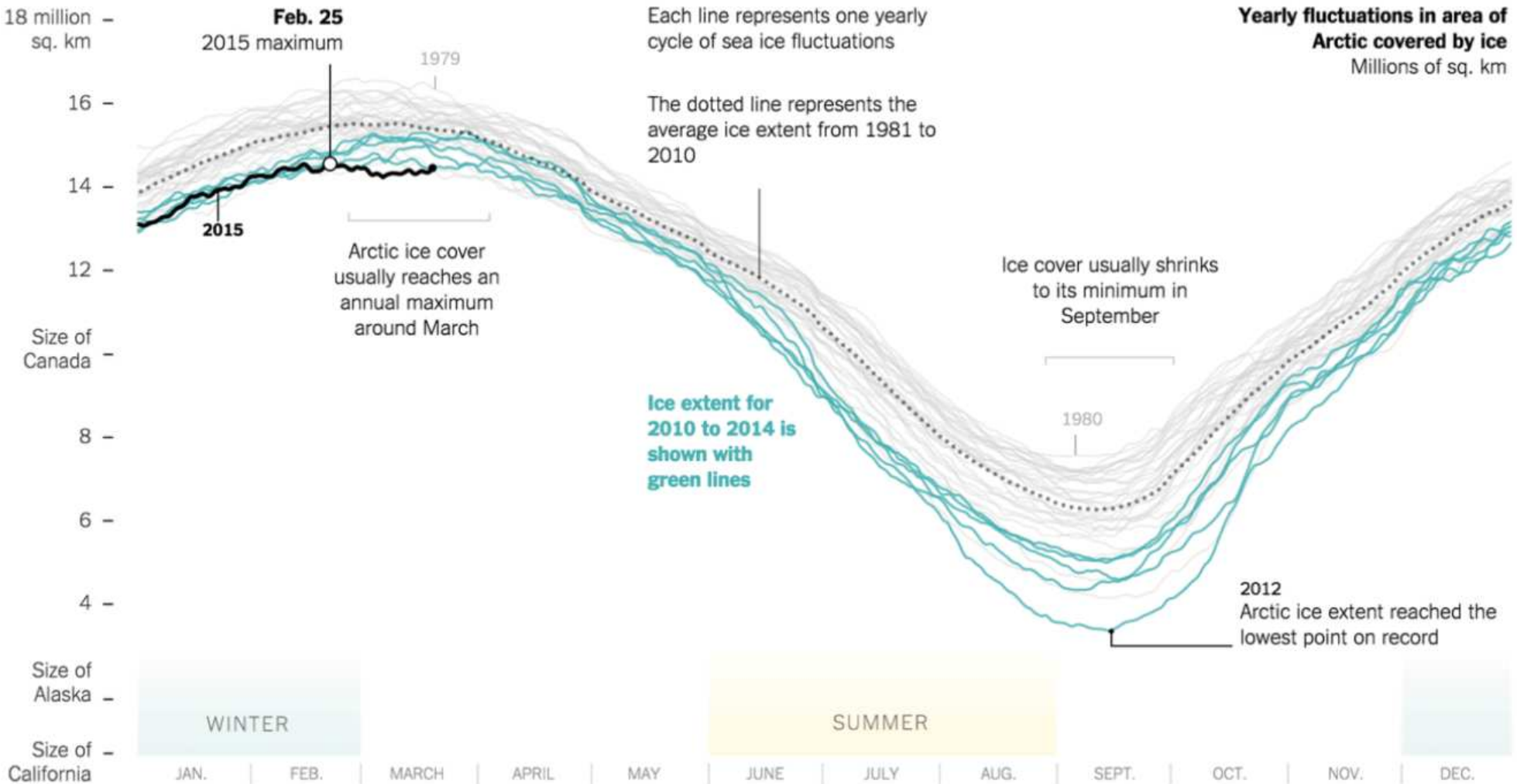
John Burn-Murdoch, Financial Times



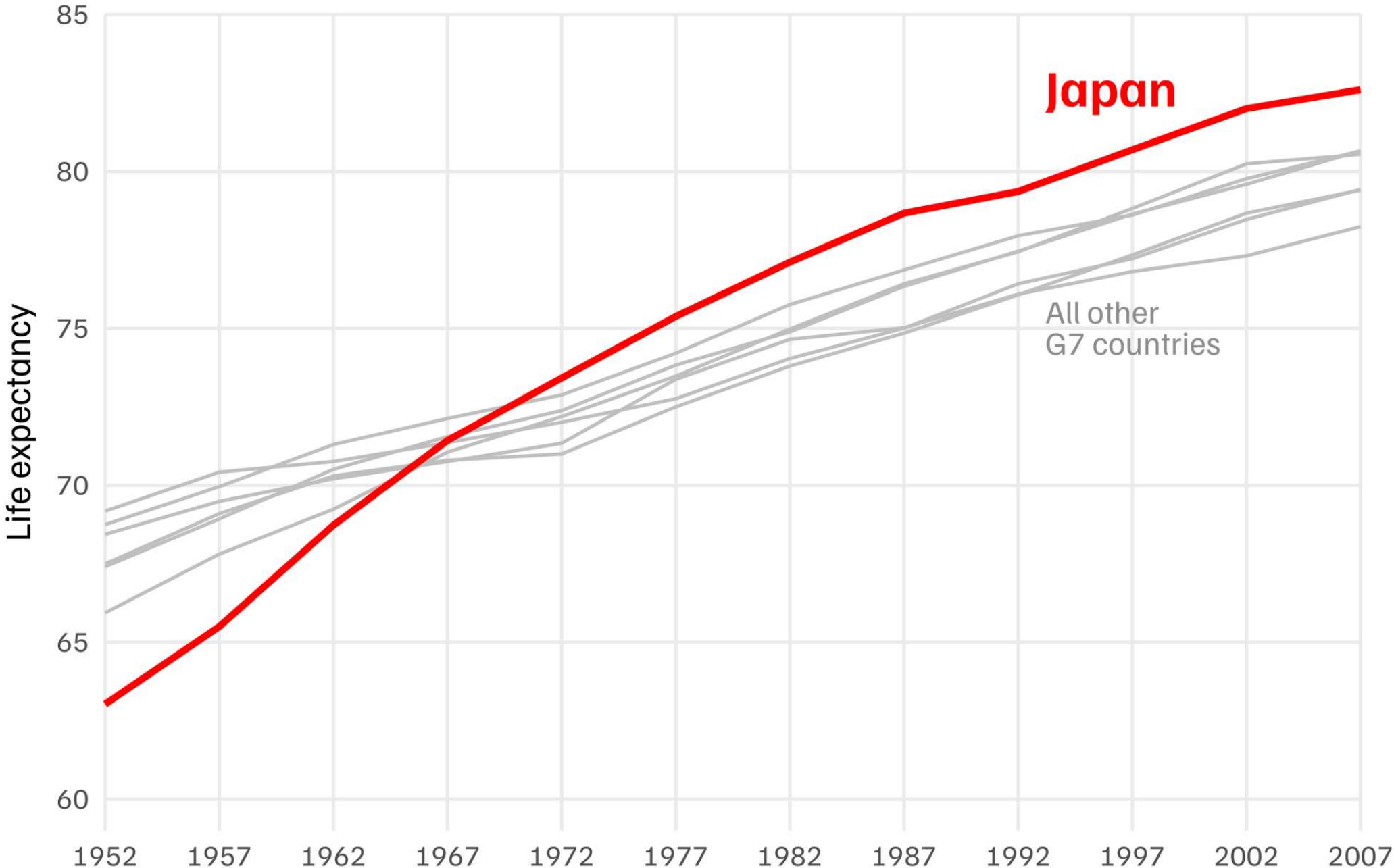




Time series with annotations by William Playfair from “The Commercial and Political Atlas and Statistical Breviary” (1786)



"Yearly Fluctuations in Area of Arctic Covered by Ice" by Derek Watkins (New York Times)


Japan
All other
G7 countries
Life expectancy
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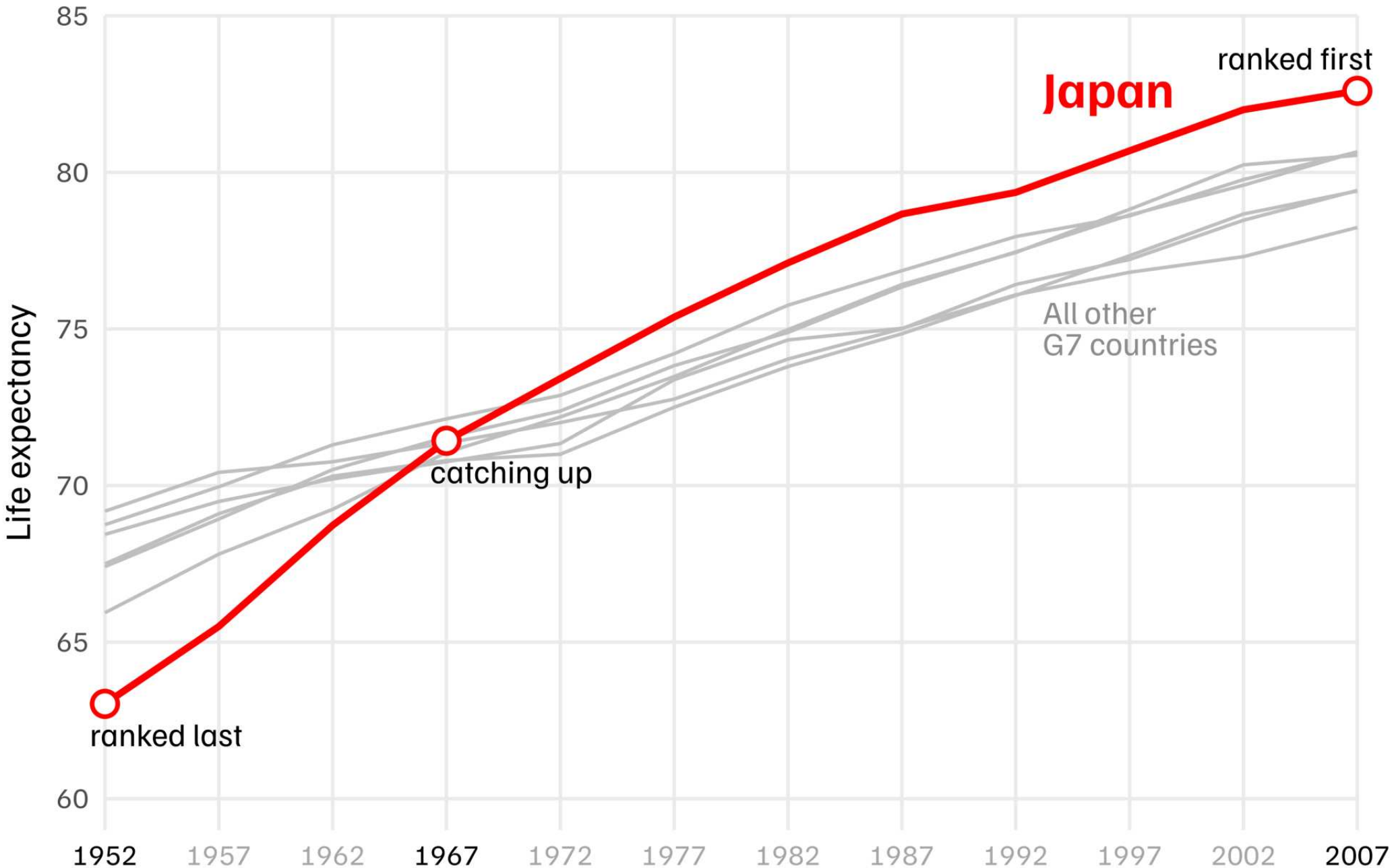
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Life expectancy
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Japan
ranked first
ranked last
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All other
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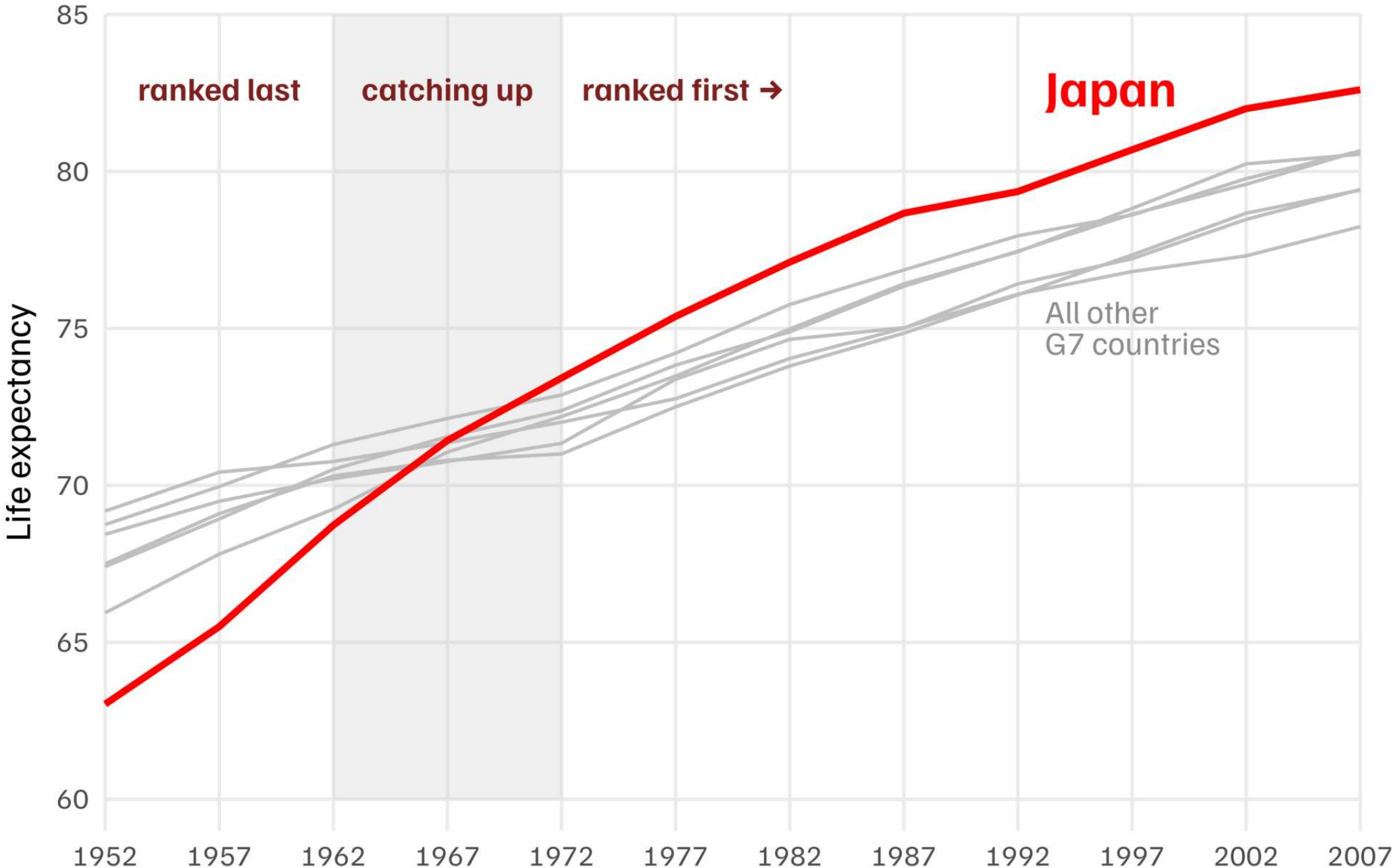
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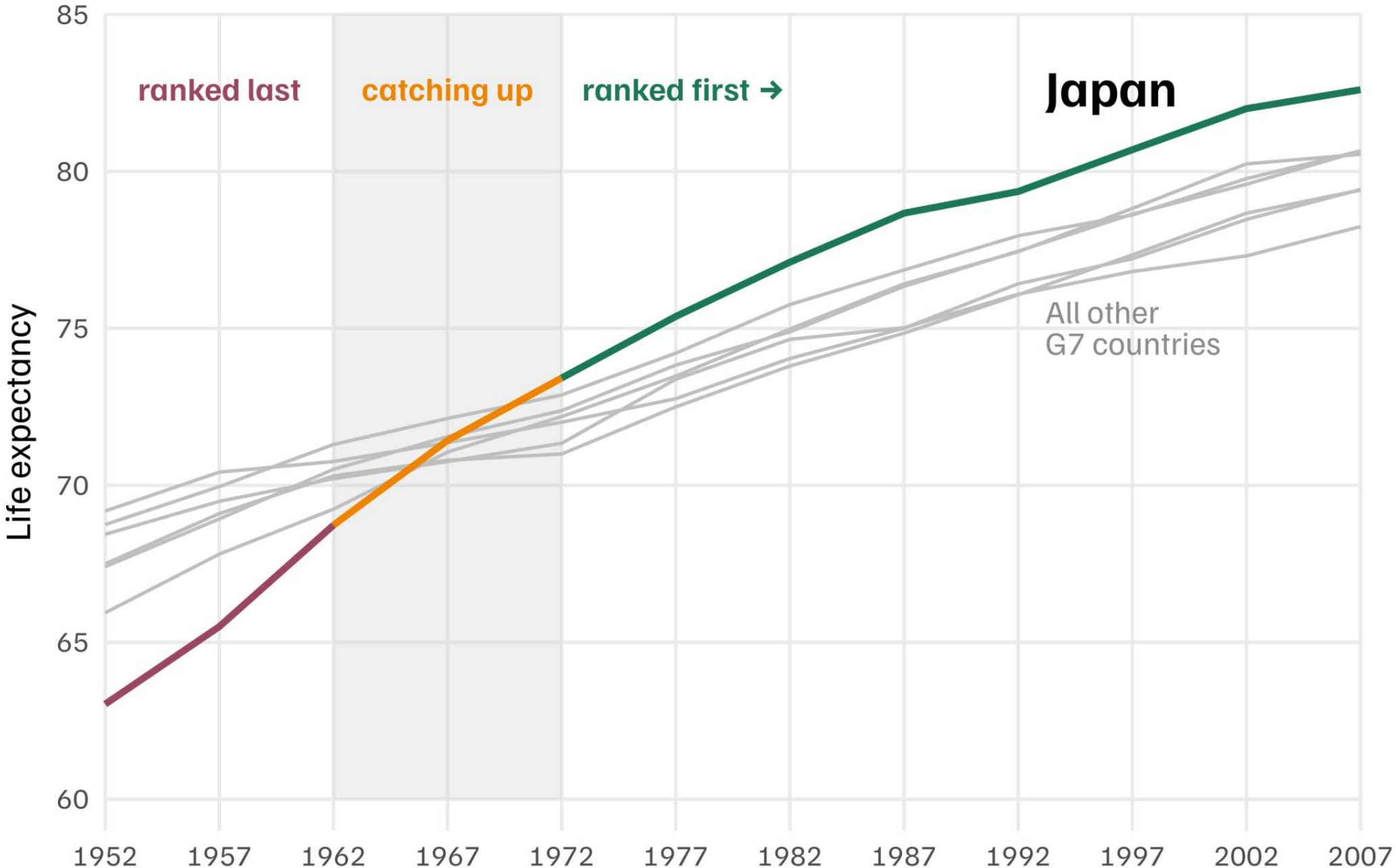
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All other
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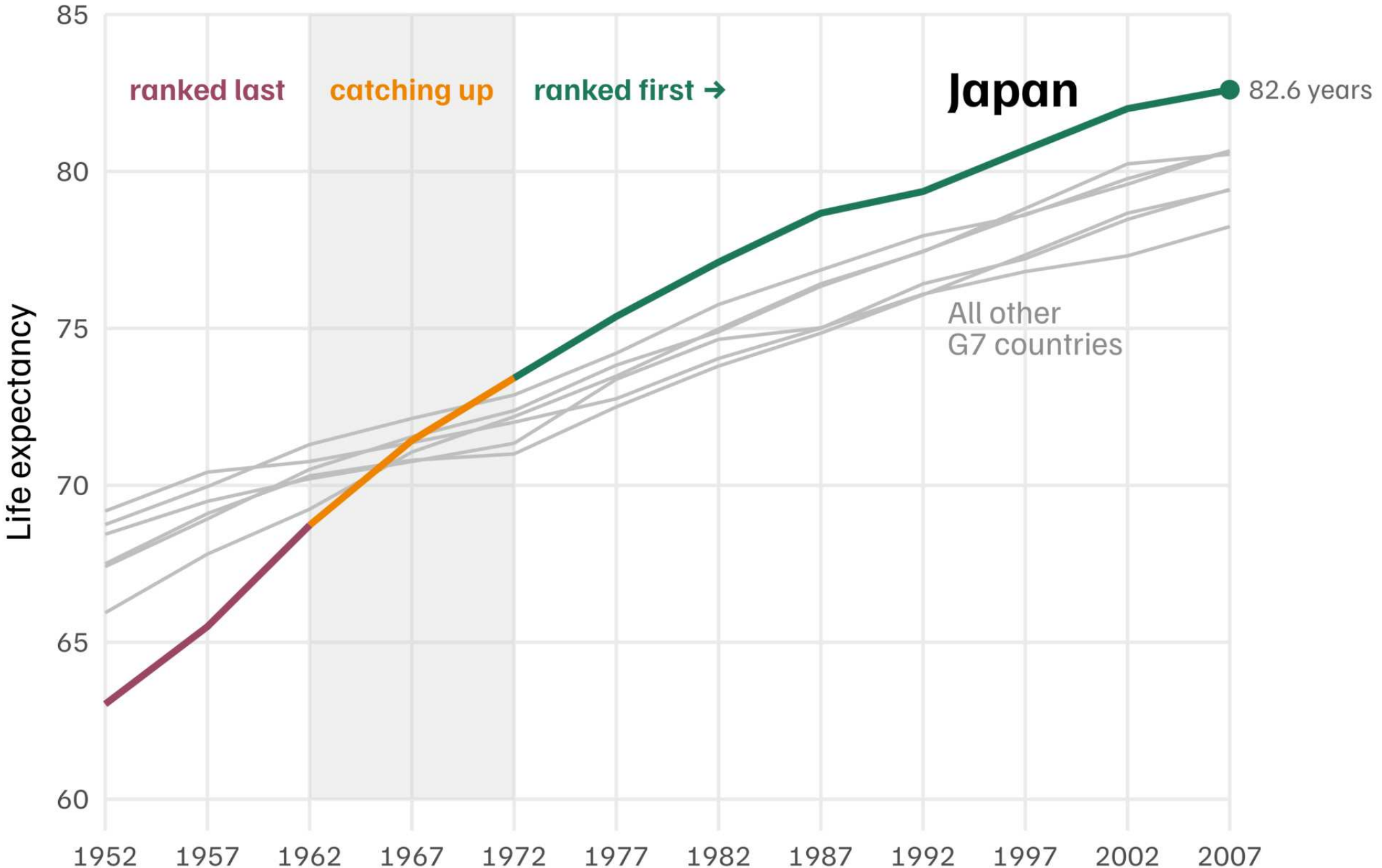
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Life expectancy
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catching up
ranked first →
Japan
82.6 years
All other
G7 countries
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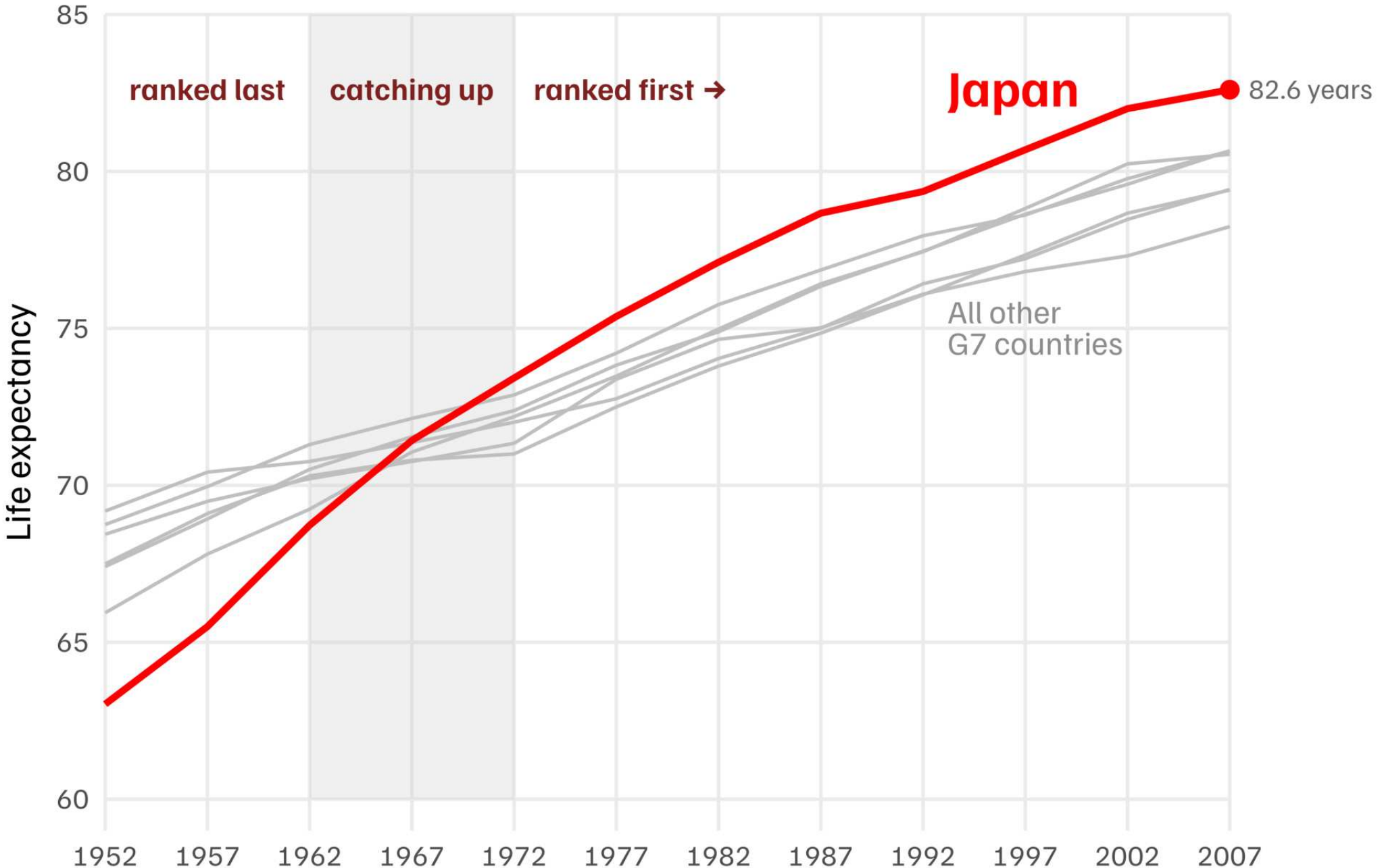
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Life expectancy
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Japan
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All other
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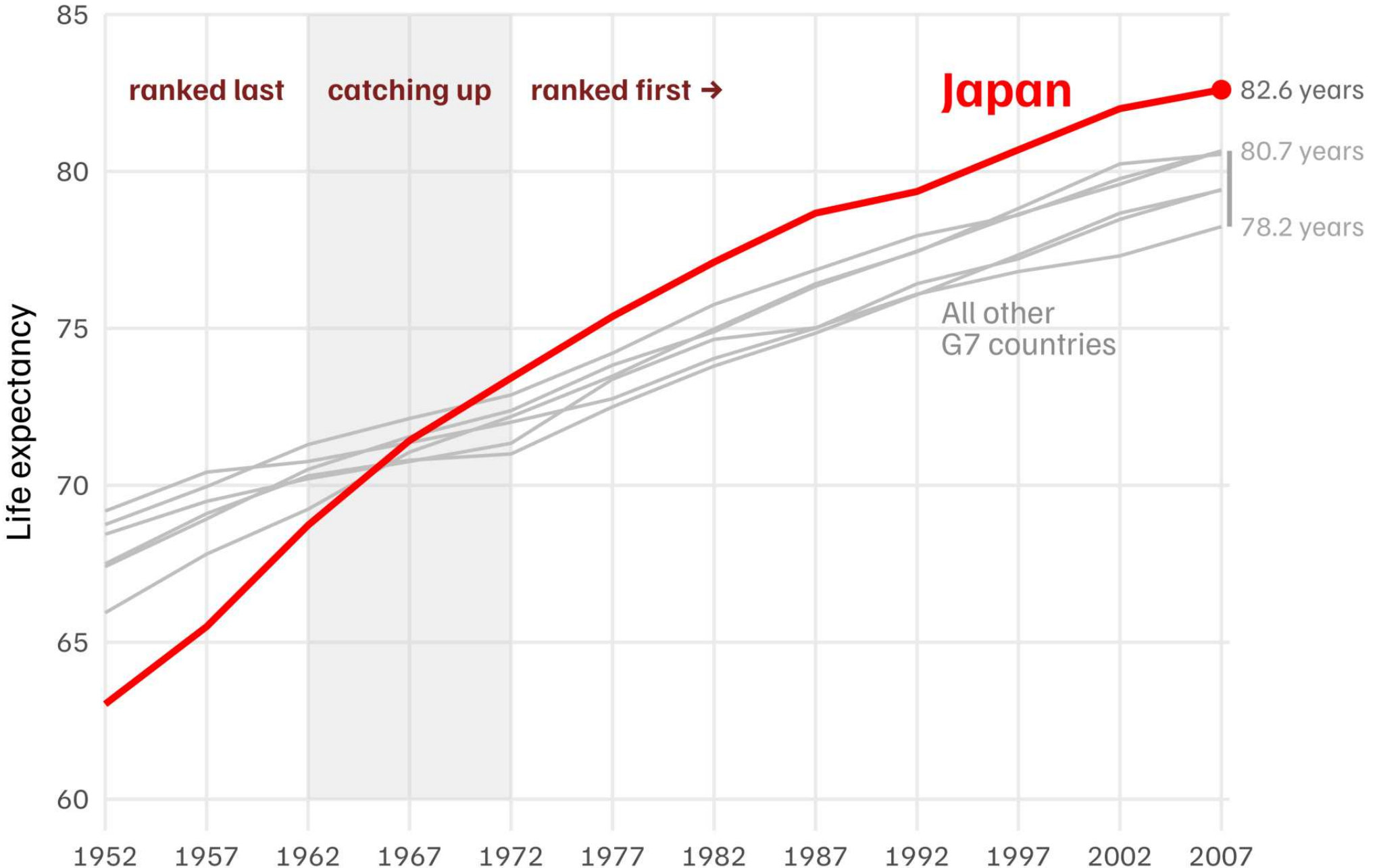
ranked last
catching up
ranked first →
Japan
82.6 years
80.7 years
78.2 years
All other
G7 countries
Life expectancy
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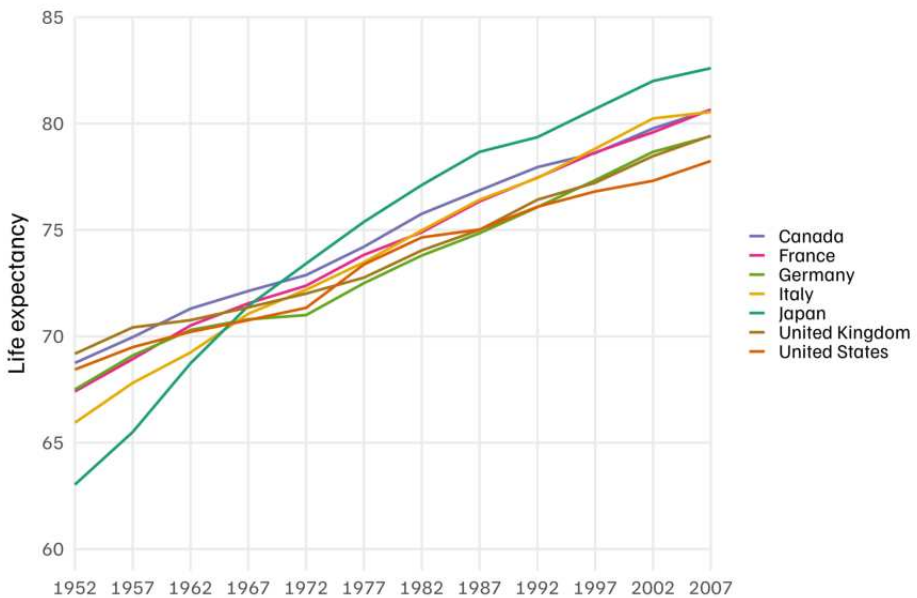
Life expectancy
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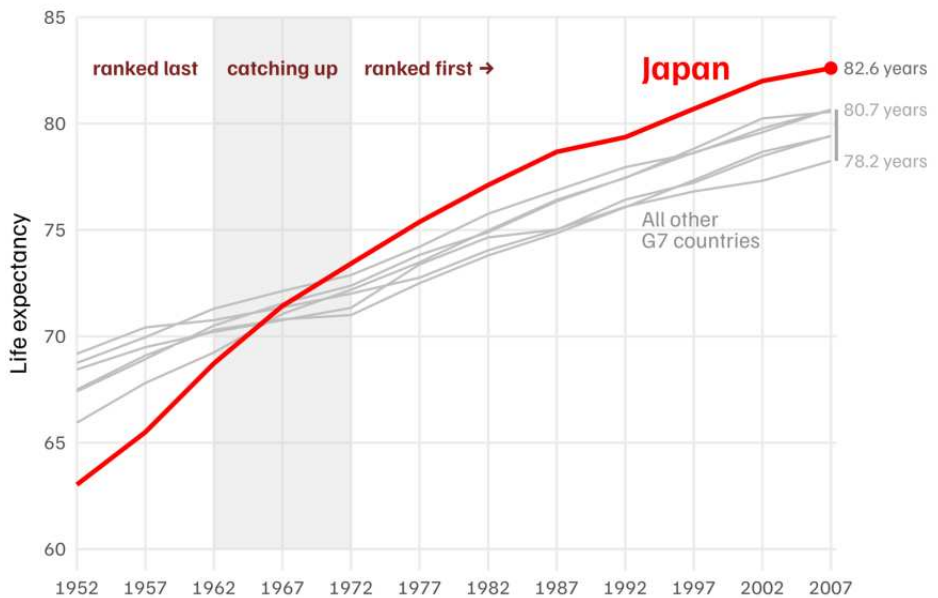
France
Germany
Italy
Japan
United Kingdom
United States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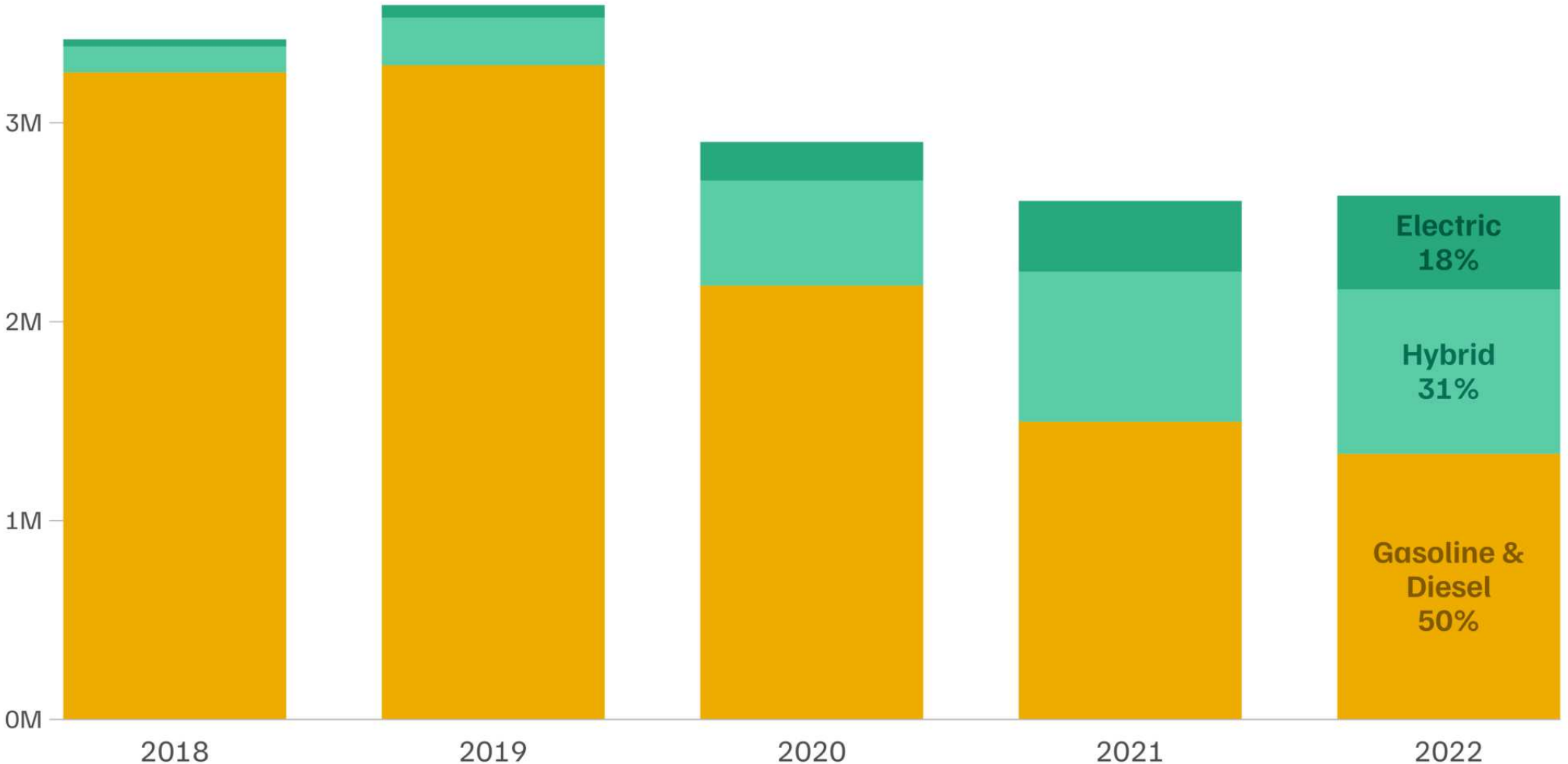
In 2022, gasoline and diesel vehicles account for only half of all new registrations in Germany – hybrid and electric continue to increase.



Federal ministry for digital and transport / Kraftfahrt-Bundesamt • Graphic: Cédric Scherer

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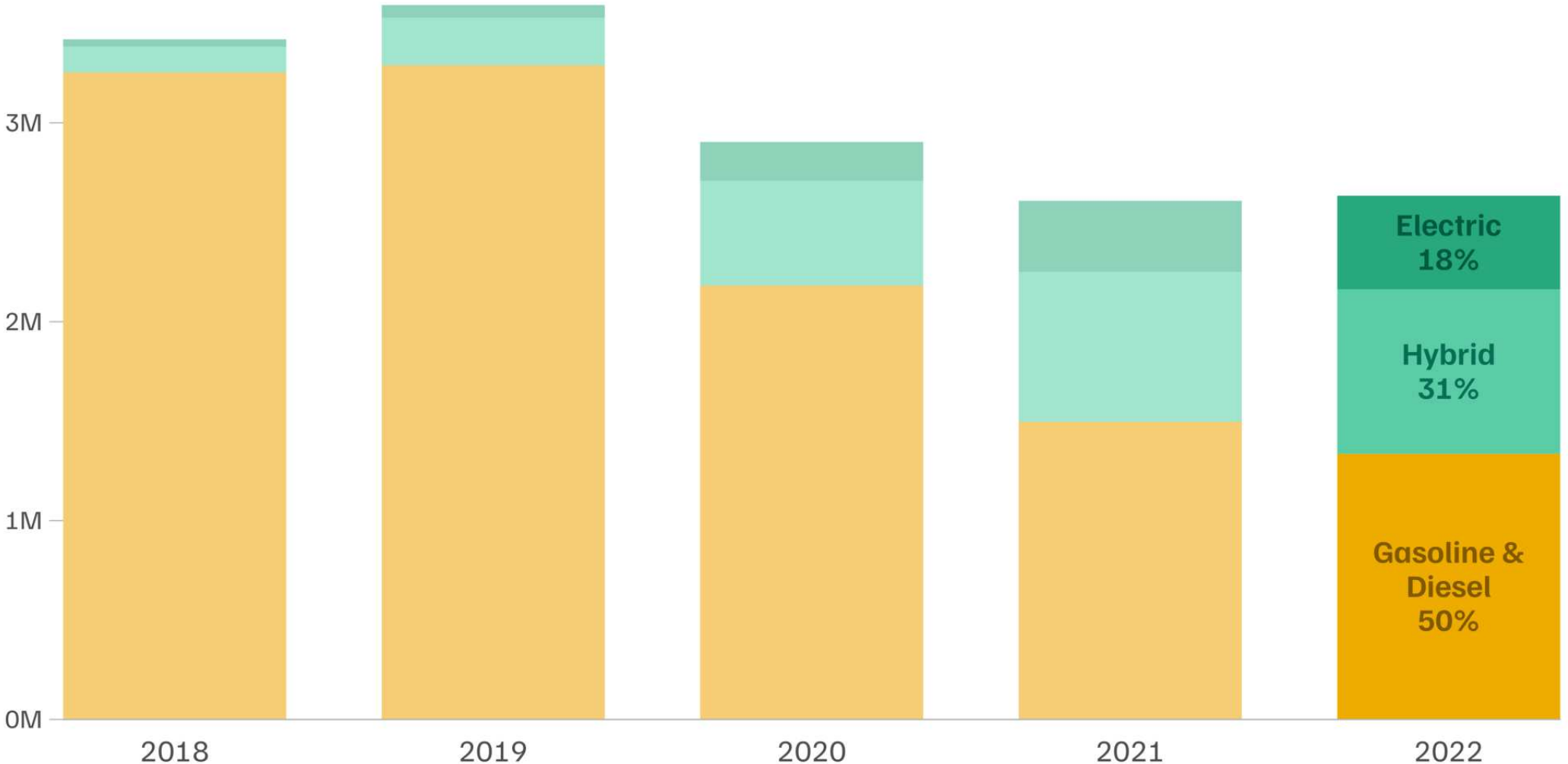
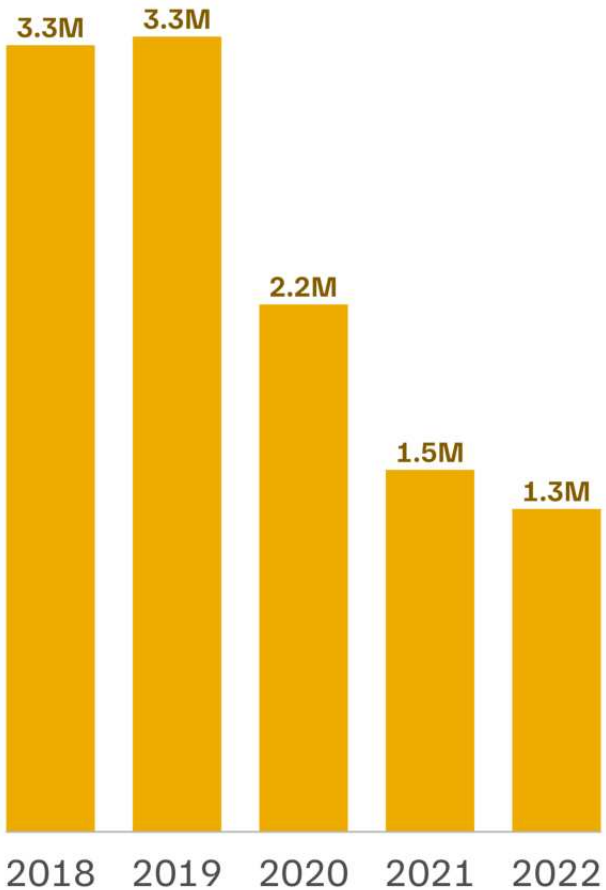
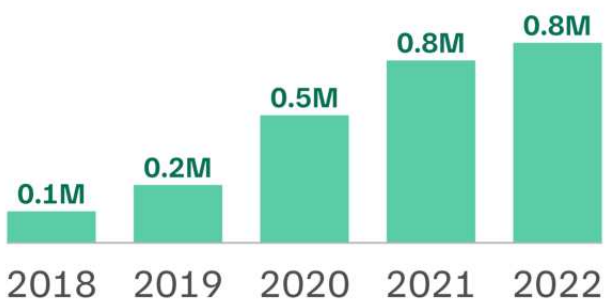


Federal ministry for digital and transport / Kraftfahrt-Bundesamt • Graphic: Cédric Scherer

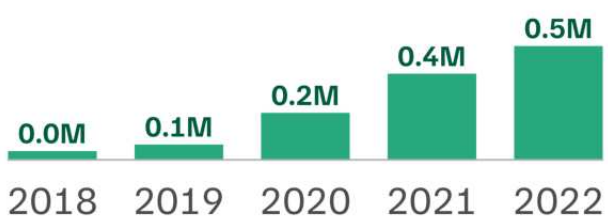
Registrations of gasoline and diesel vehicles drop in Germany while those of new hybrid and electric cars are steadily increasing.



Gasoline & Diesel



Hybrid



Electric

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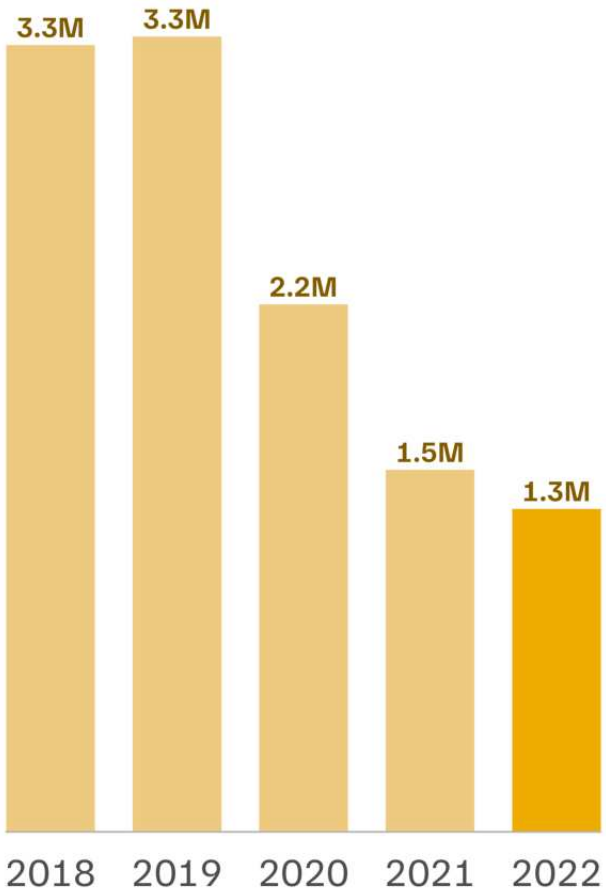

Gasoline & Diesel

Hybrid

Electric

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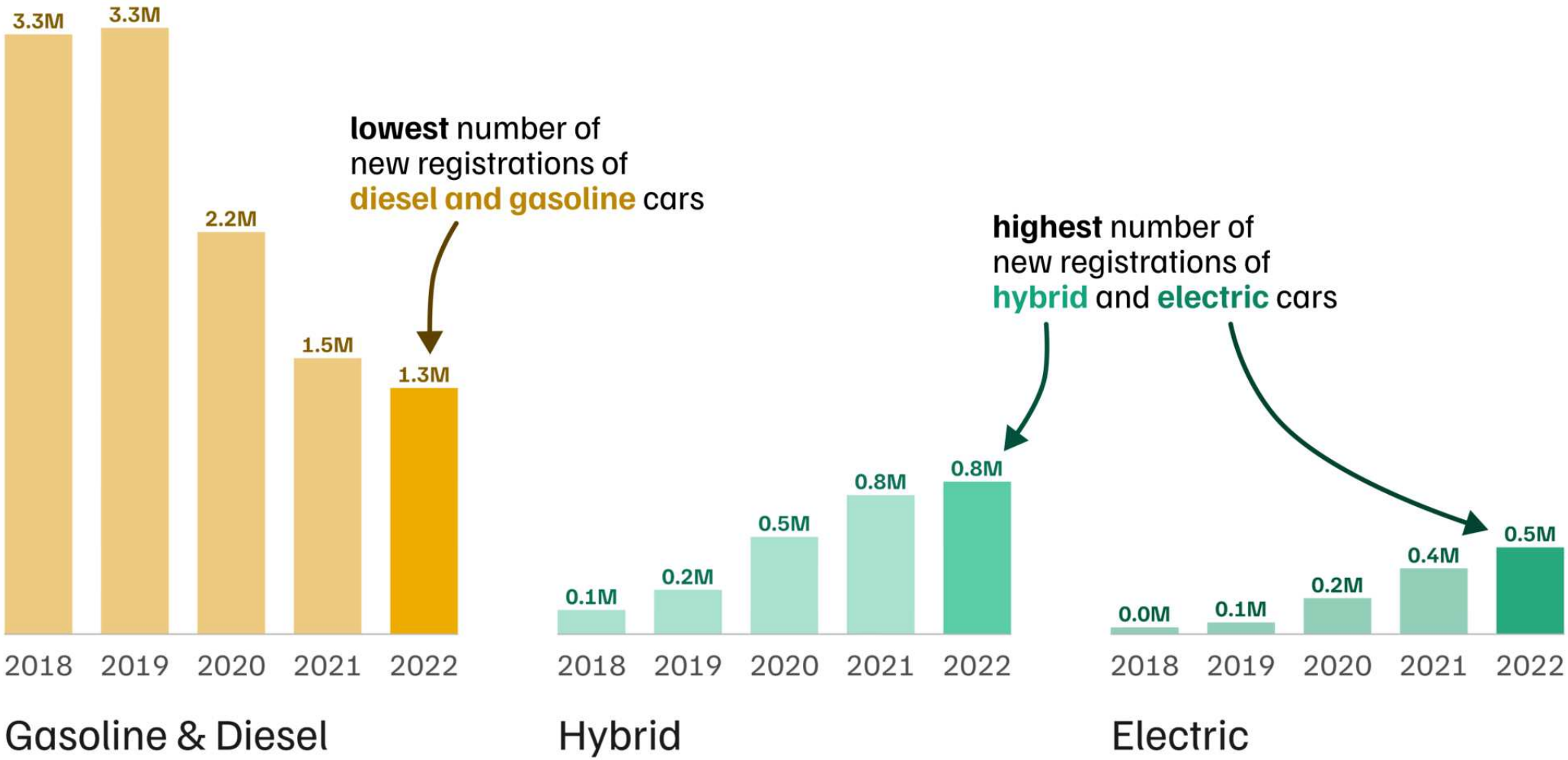
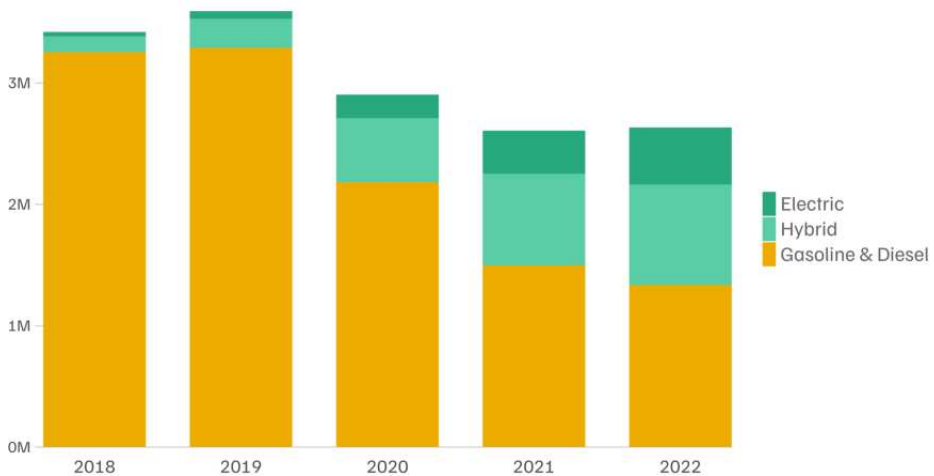


Federal ministry for digital and transport / Kraftfahrt-Bundesamt • Graphic: Cédric Scherer

New vehicle registrations in Germany



Source: Federal ministry for digital and transport / Kraftfahrt-Bundesamt • Graphic: Cédric Scherer

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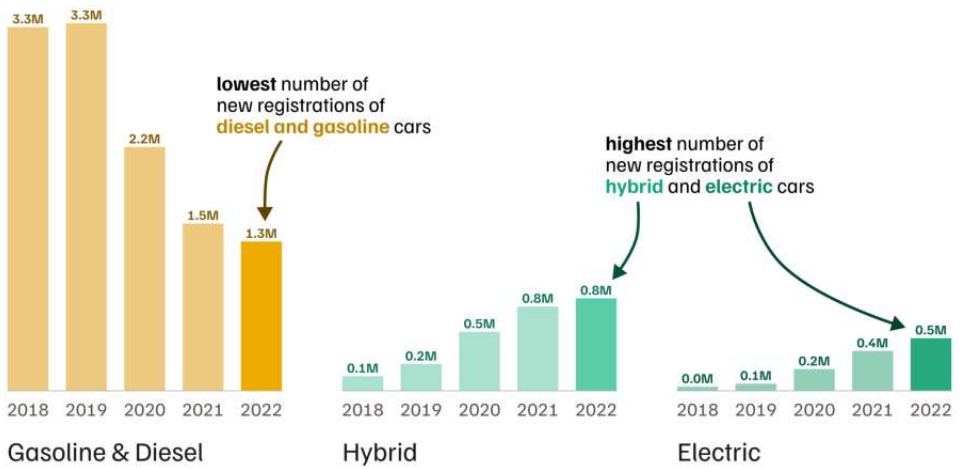
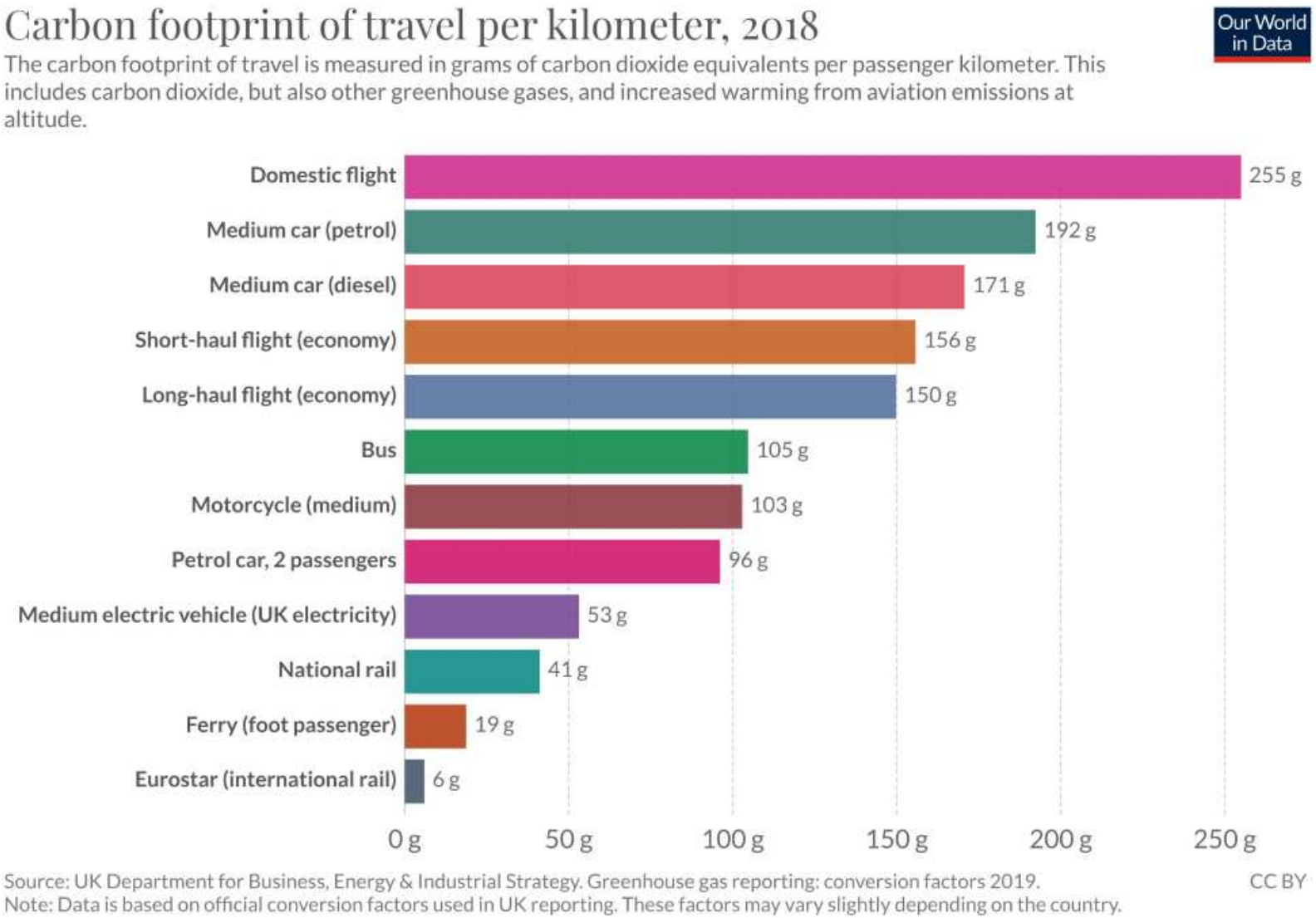


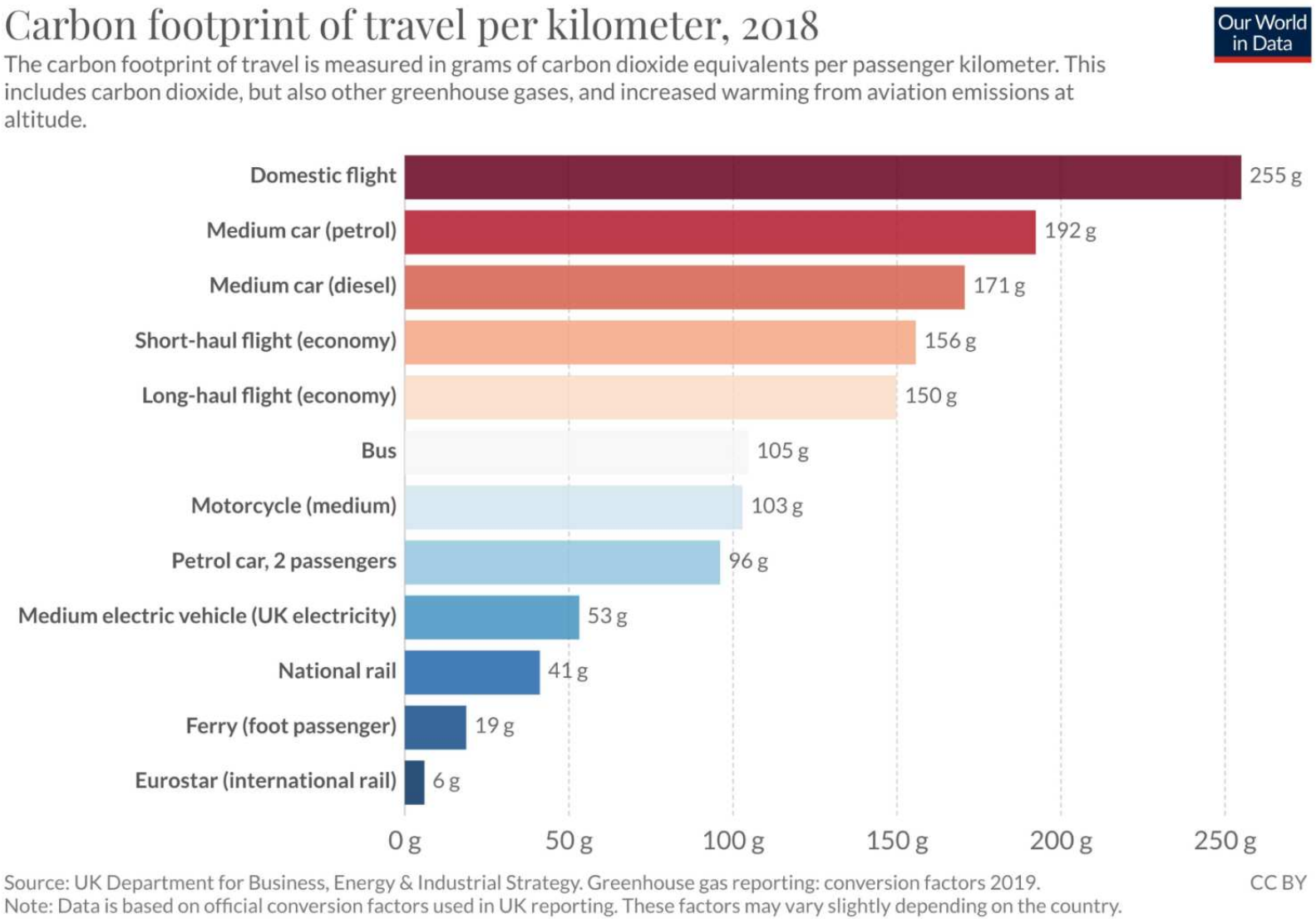
Federal ministry for digital and transport / Kraftfahrt-Bundesamt • Graphic: Cédric Scherer

Confuse with Colors



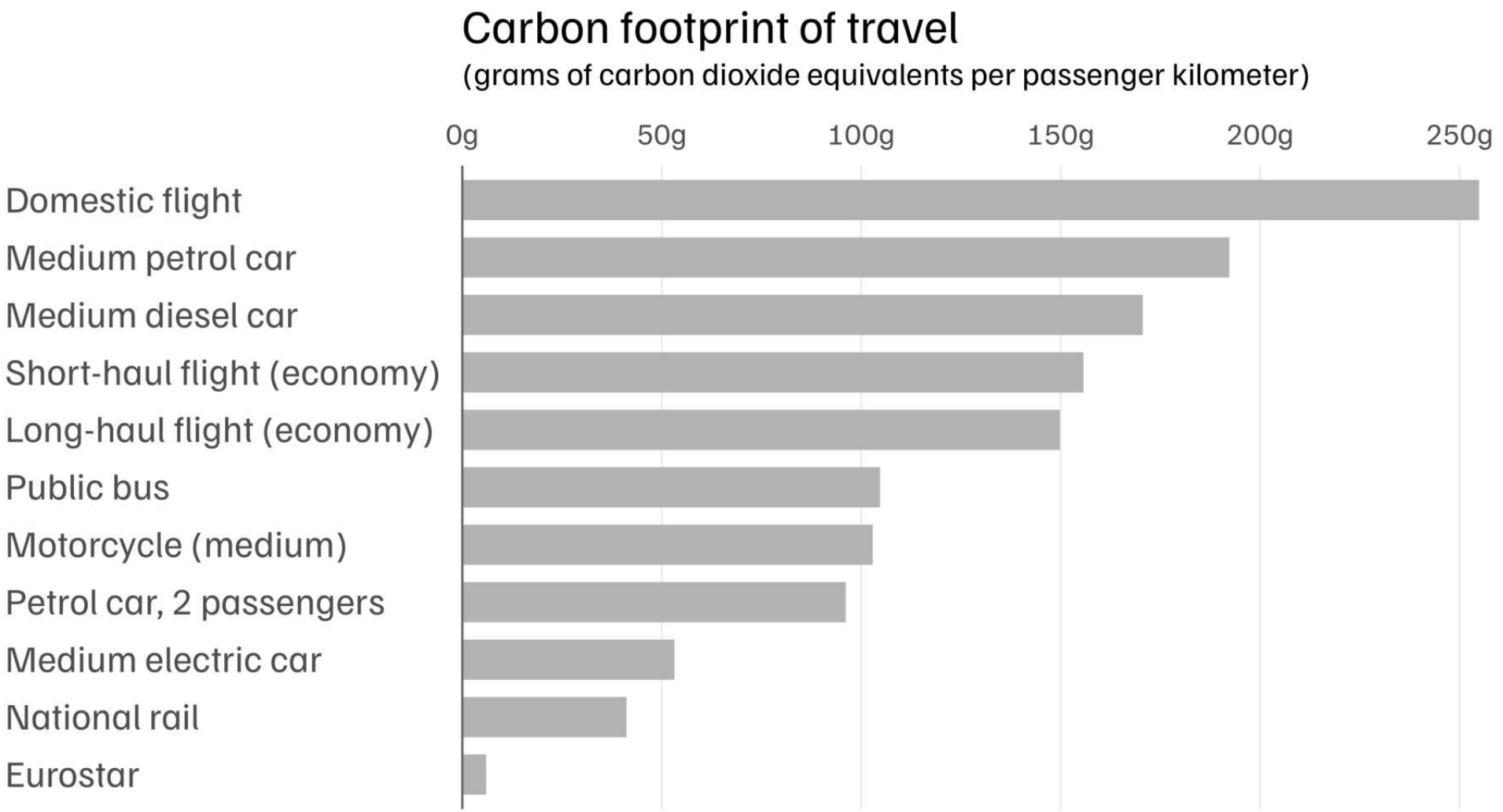
OurWorldInData 2020 (new version)

Confuse with Colors



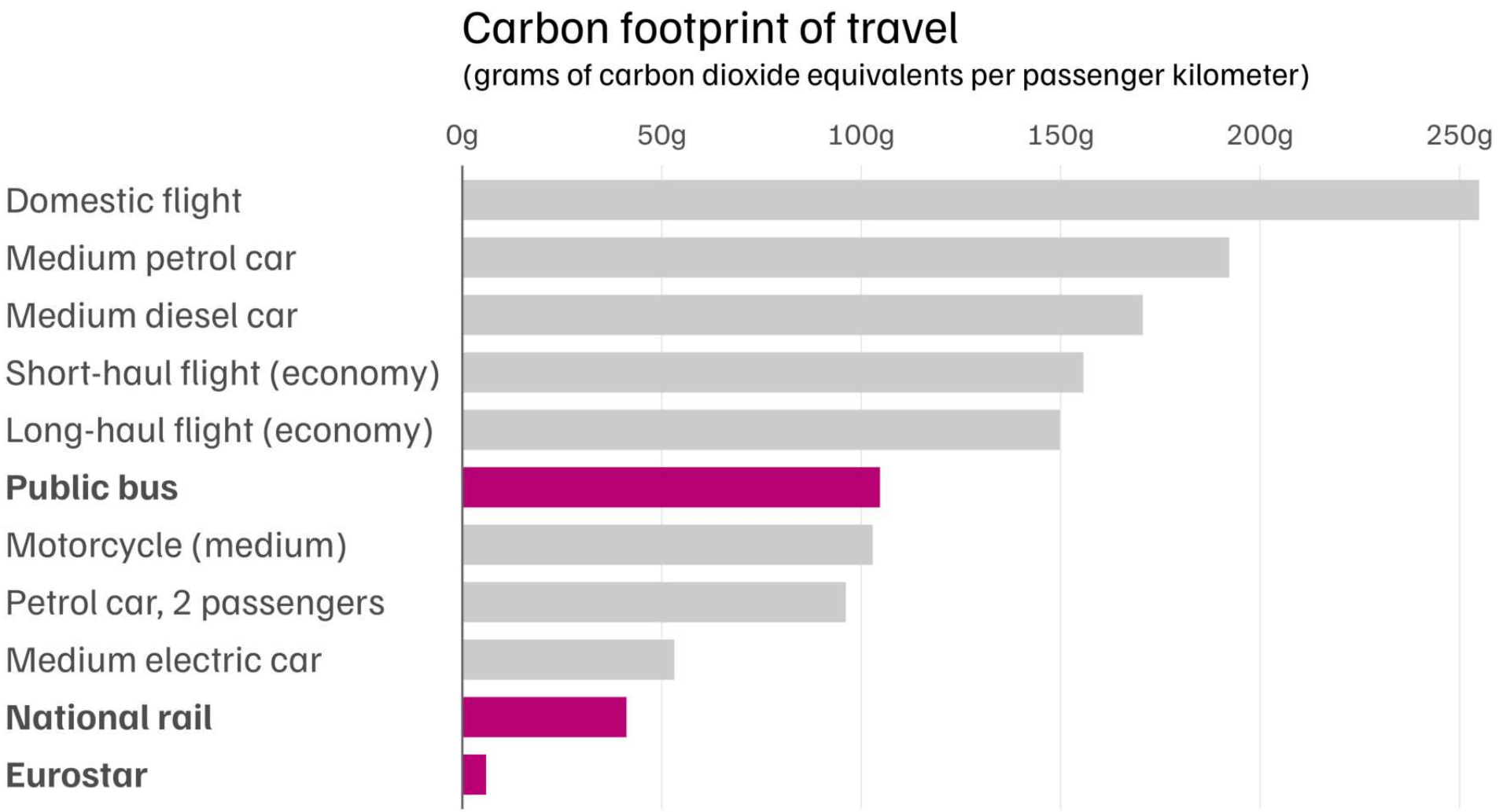
OurWorldInData 2020, suggested fix

Don’t Confuse with Color



UK Department for Business, Energy & Industrial Grenhouse gas reporting: conversion factors 2019.

Guide with Colors



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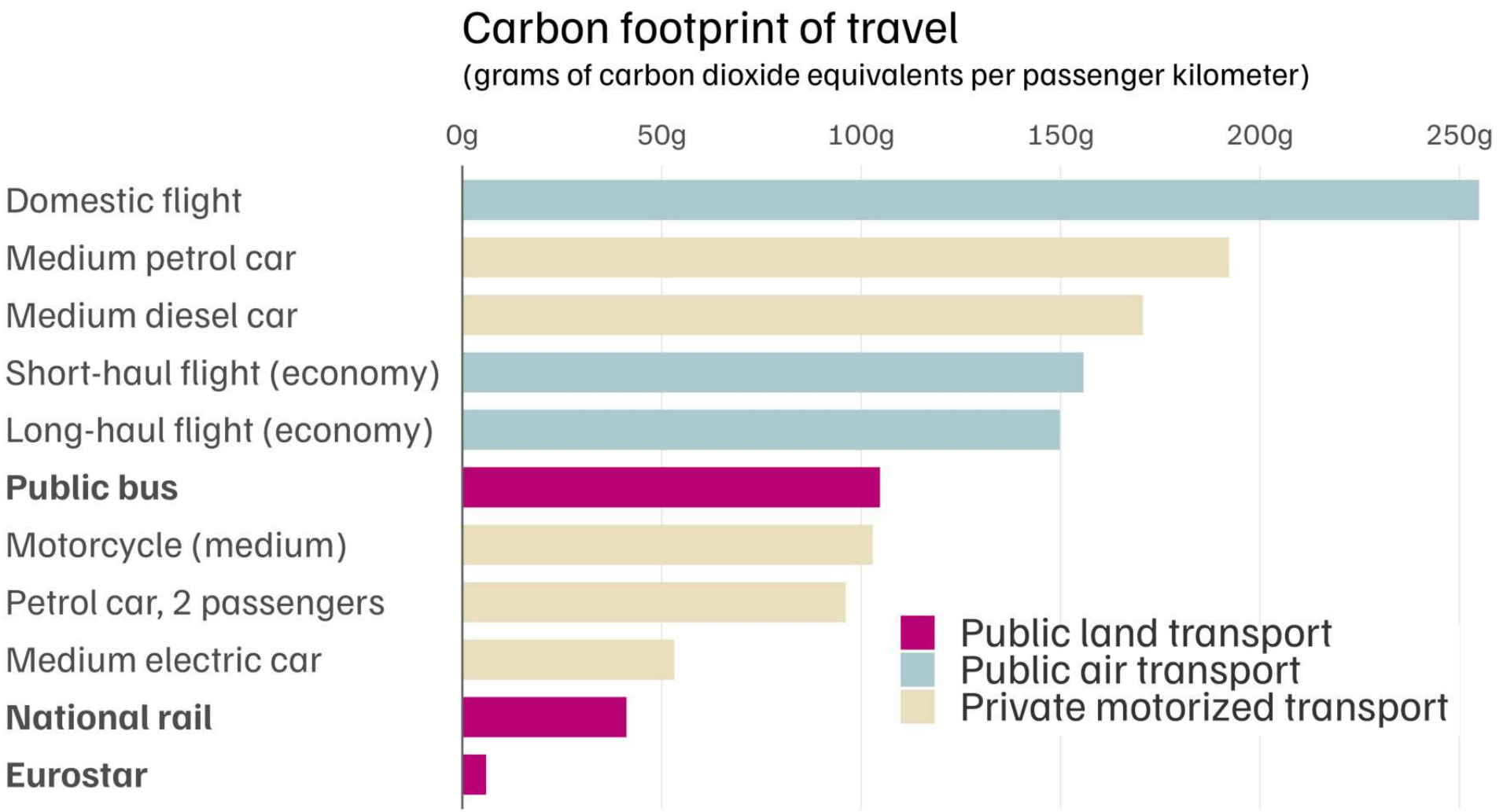

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Guide with Colors

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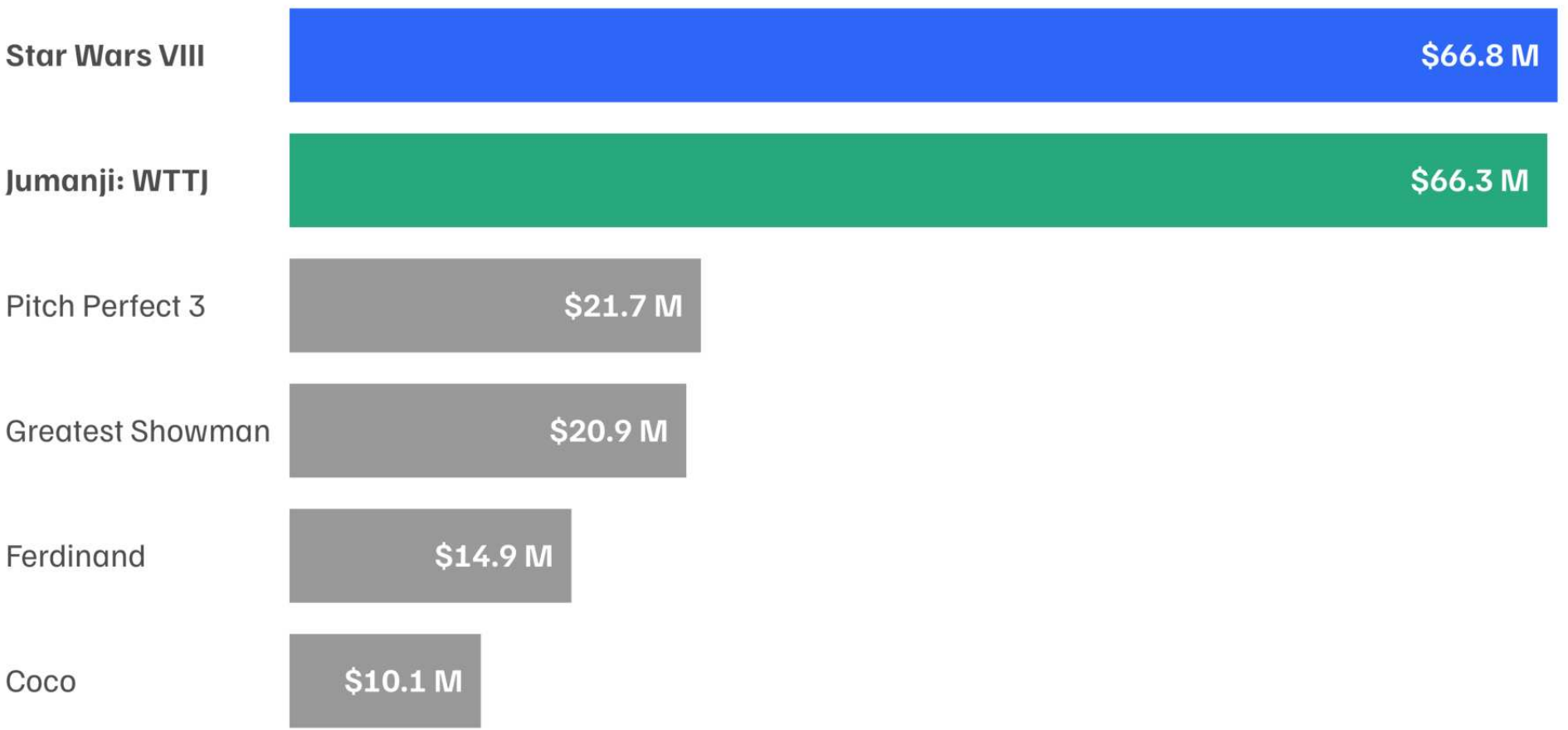

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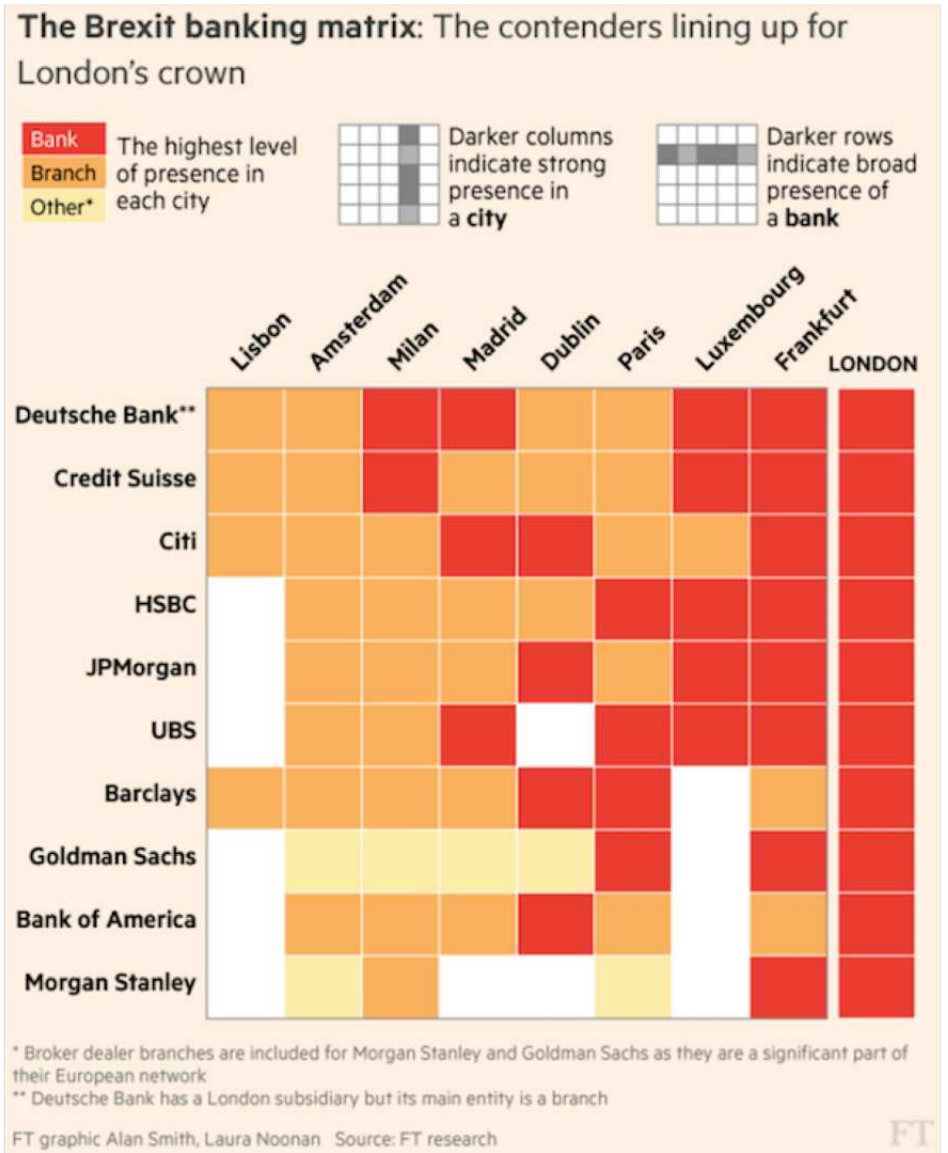

"Frankfurt vies for UK banking jobs post-Brexit" by Alan Smith & Laura Noonan (Financial Times)

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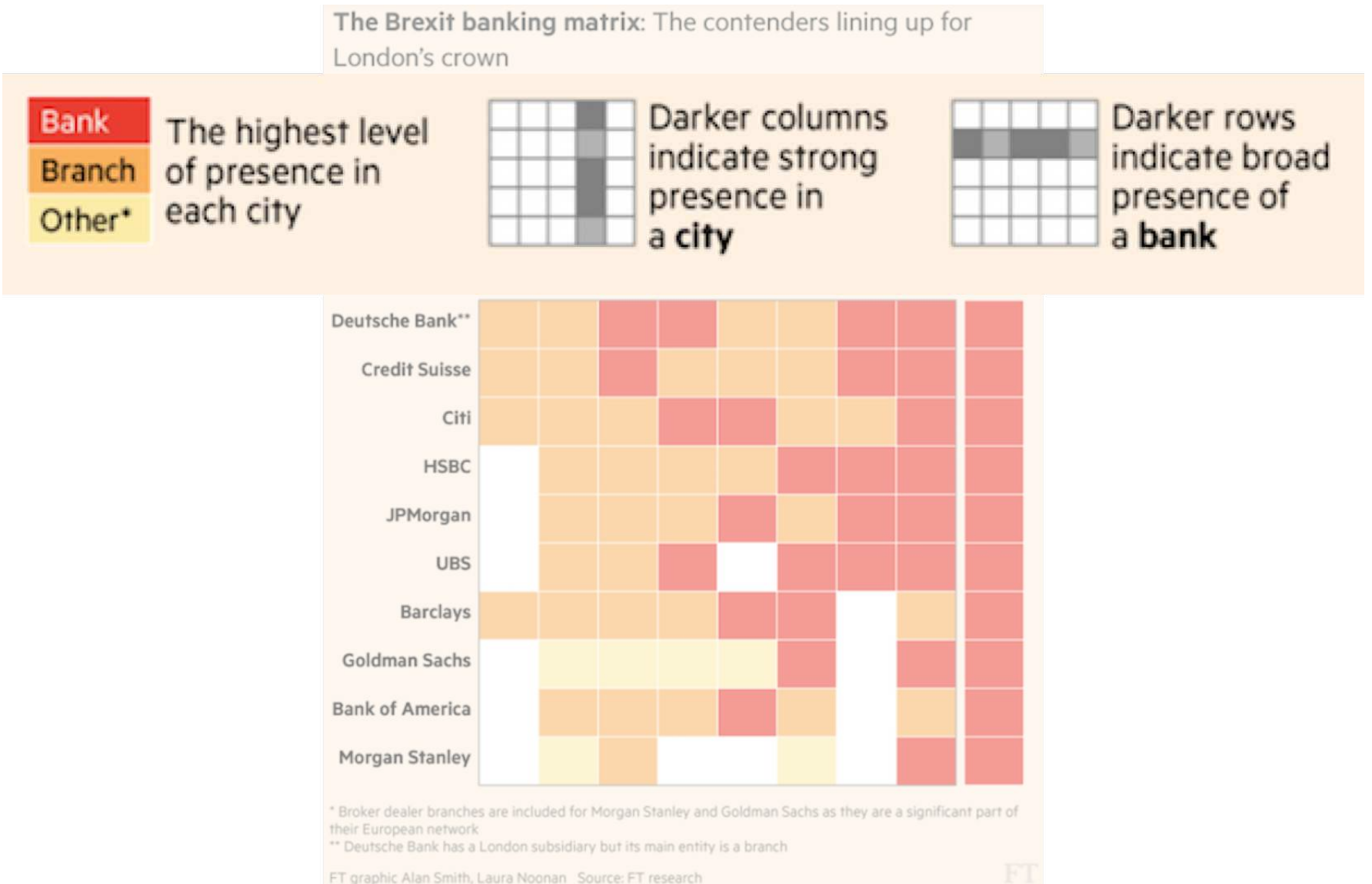

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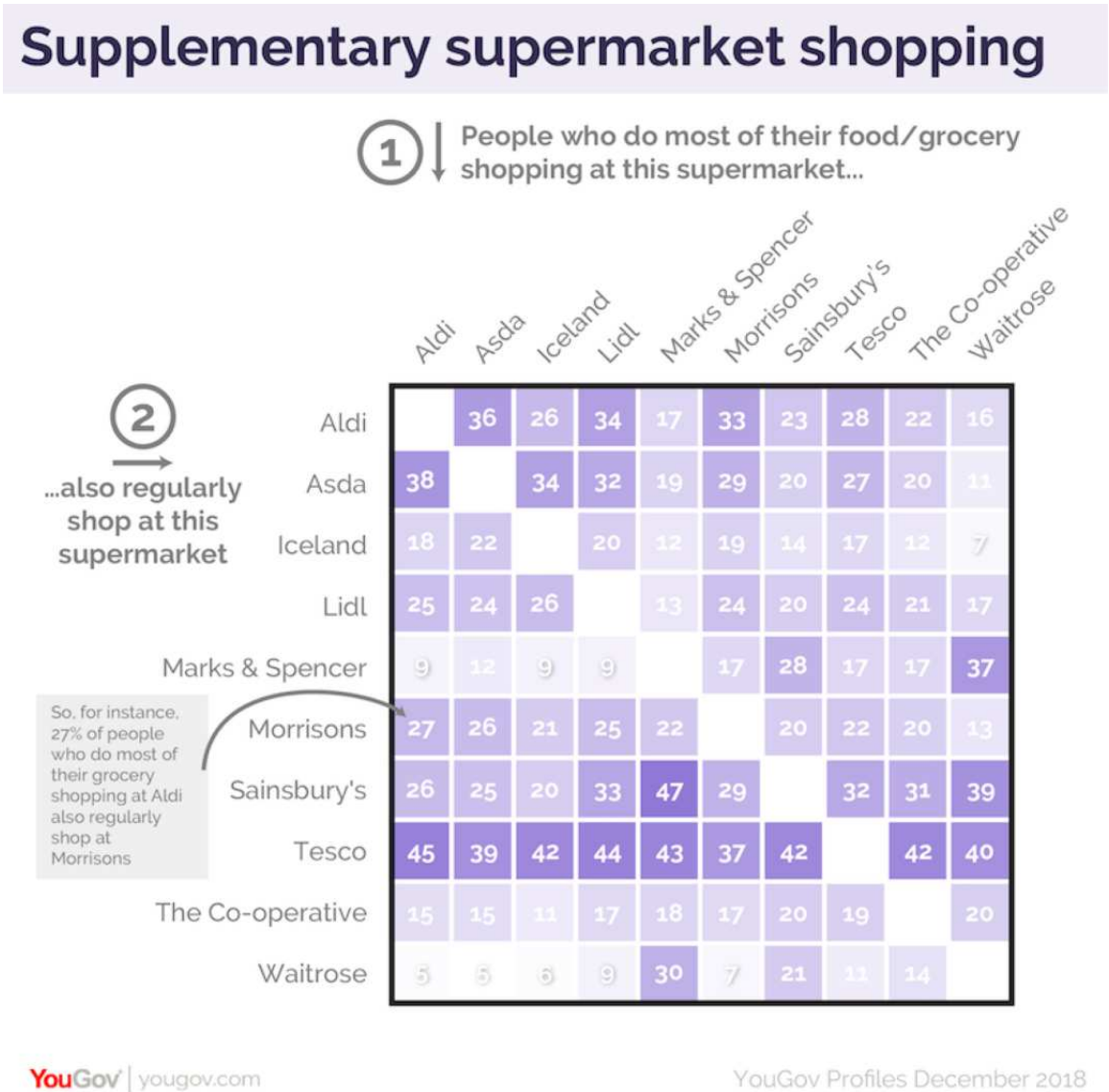
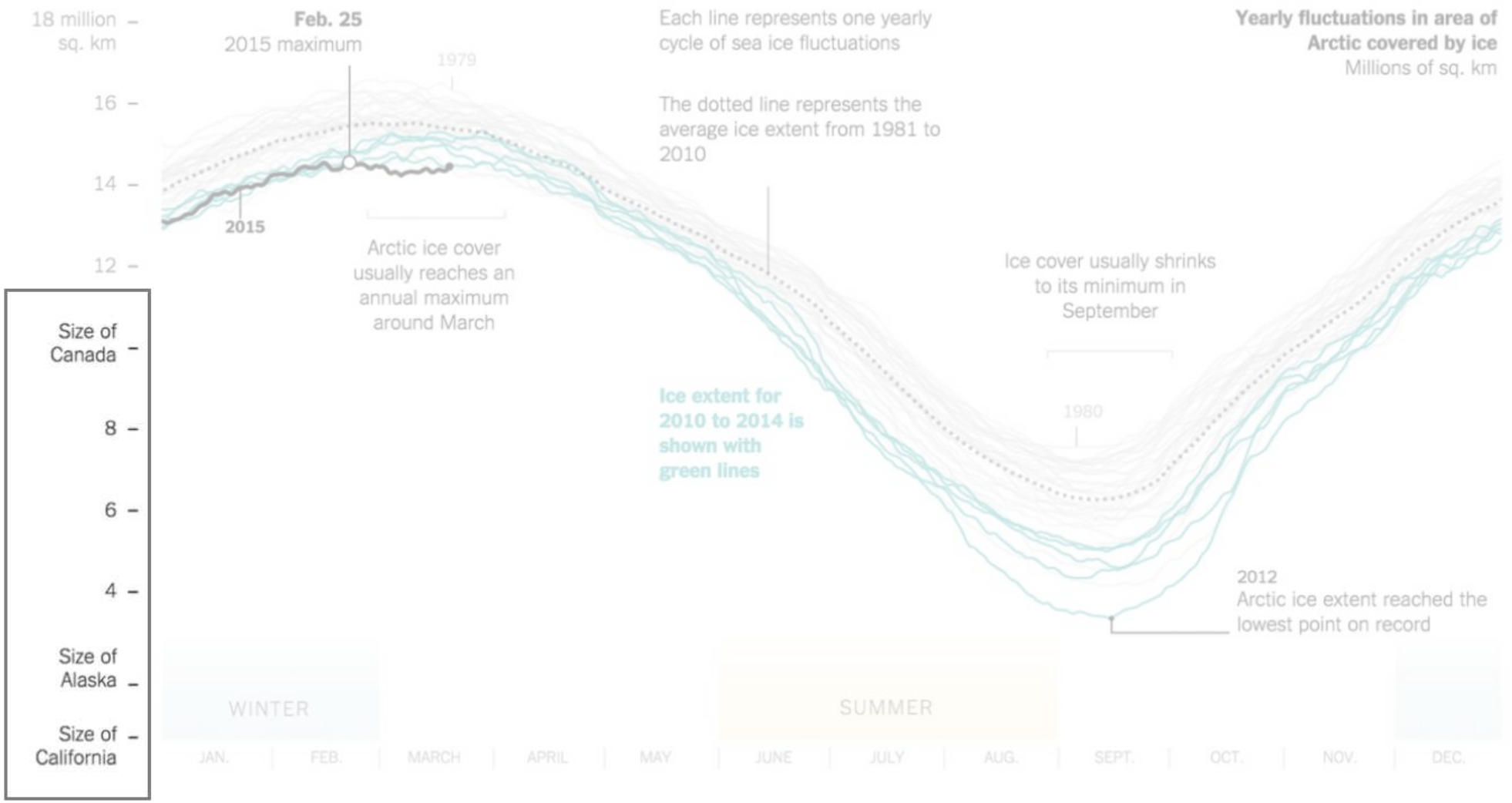


"Tesco is the nation's primary AND secondary supermarket" by Matthew Smith (YouGov)

Assist the Viewer



"Yearly Fluctuations in Area of Arctic Covered by Ice" by Derek Watkins (New York Times)

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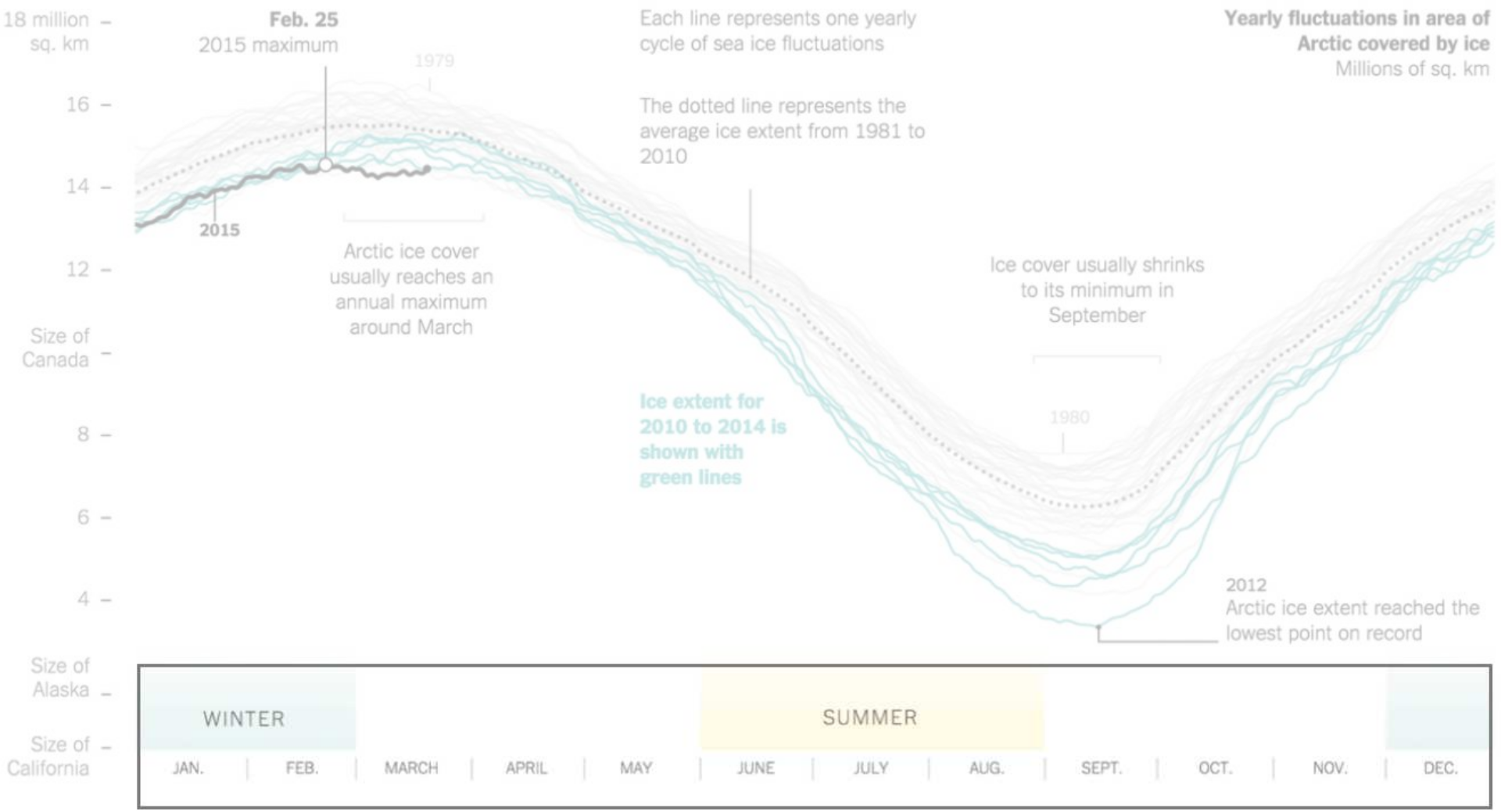

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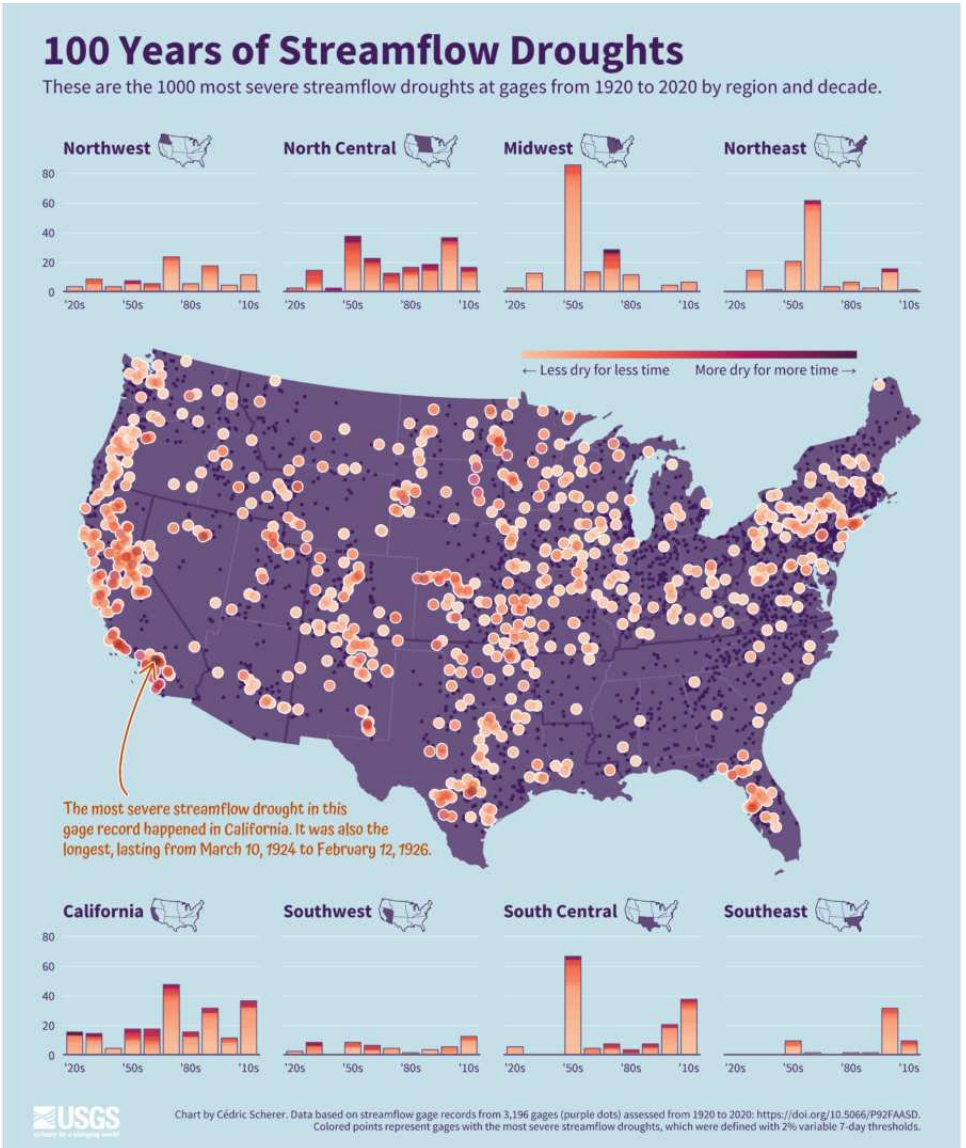
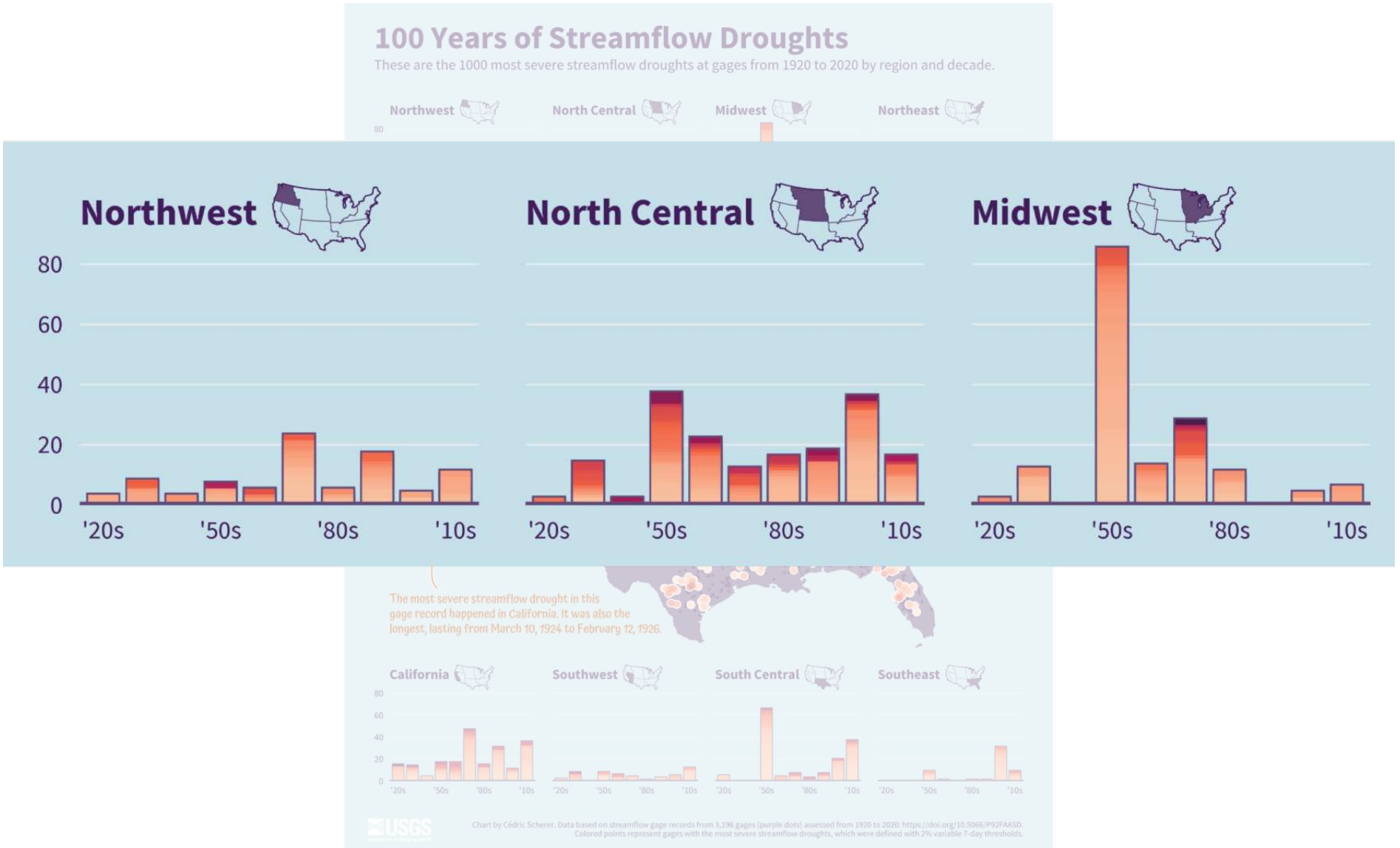


"100 Years of Streamflow Drought", in collaboration with USGS

Assist the Viewer



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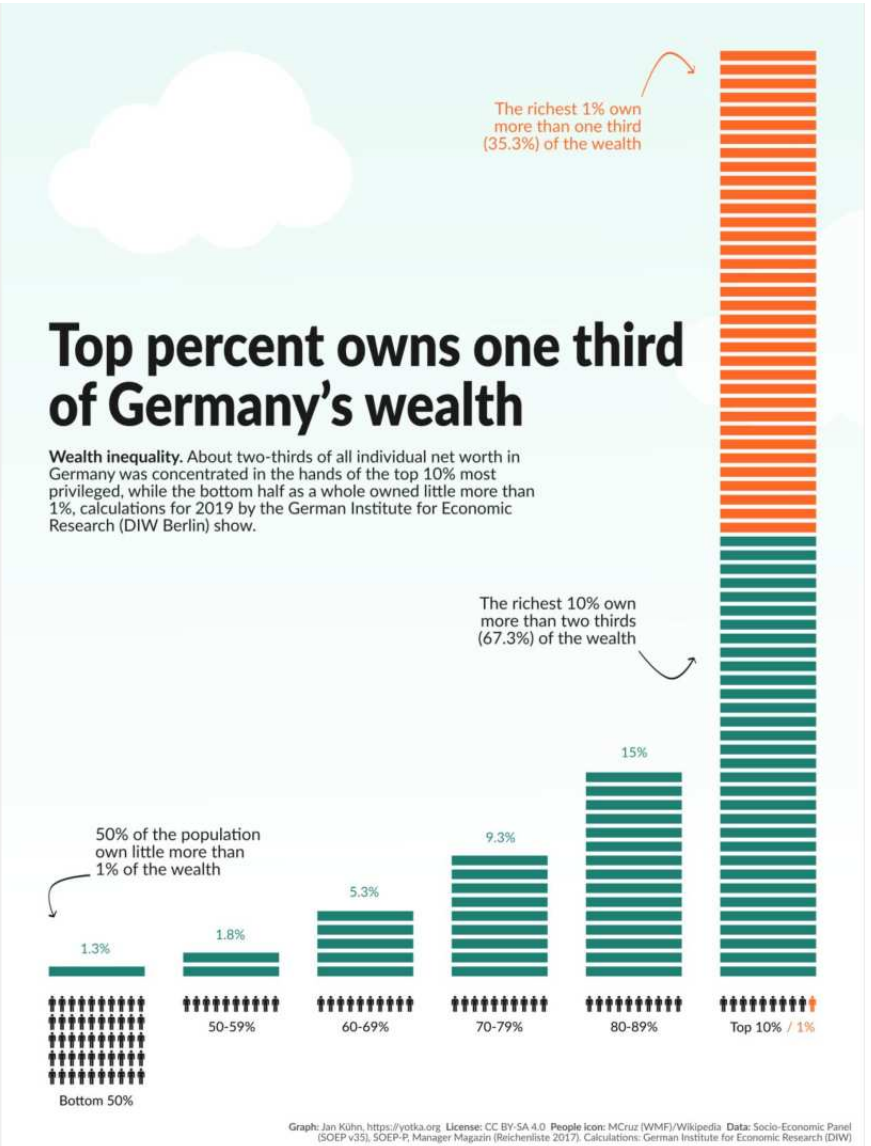
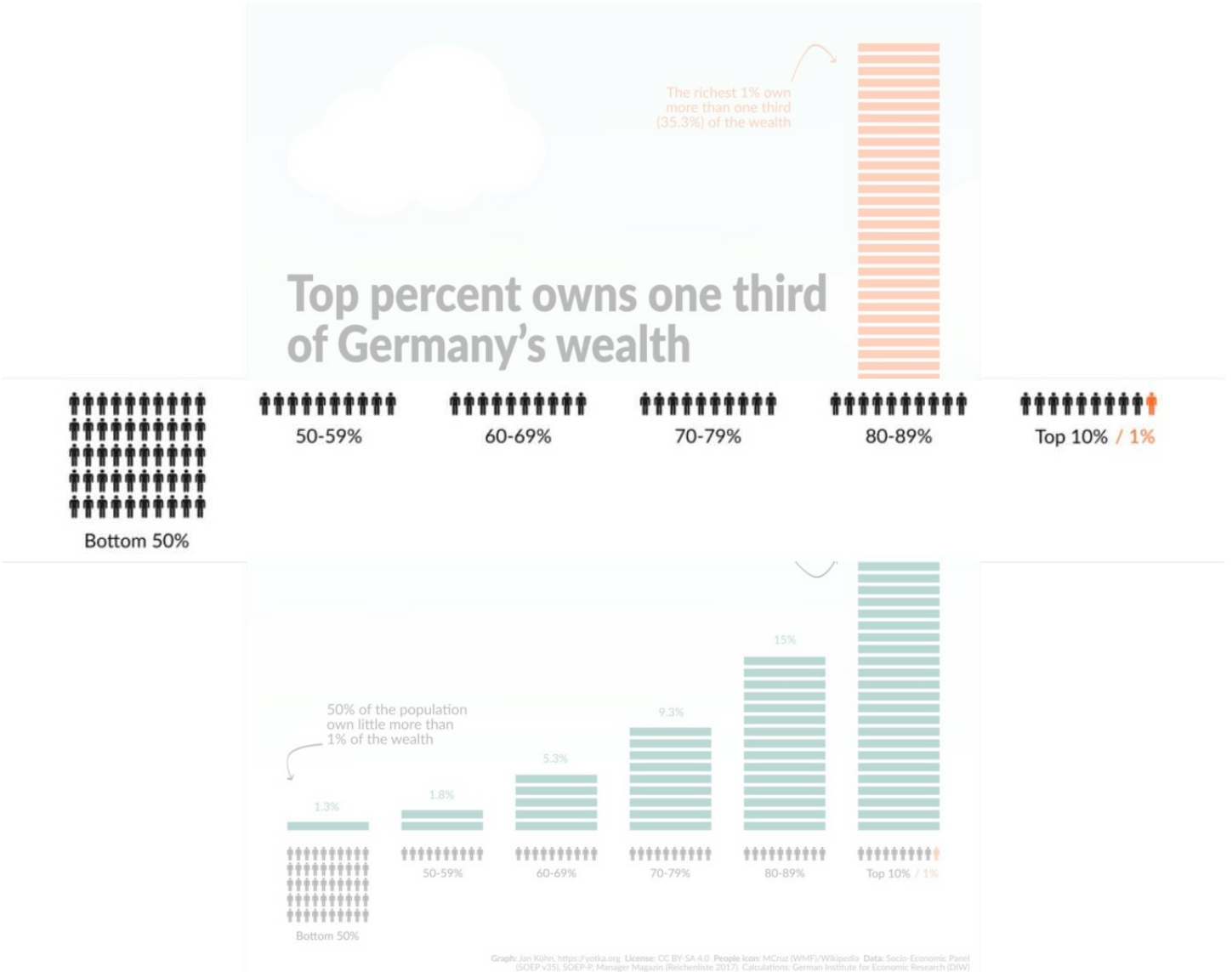


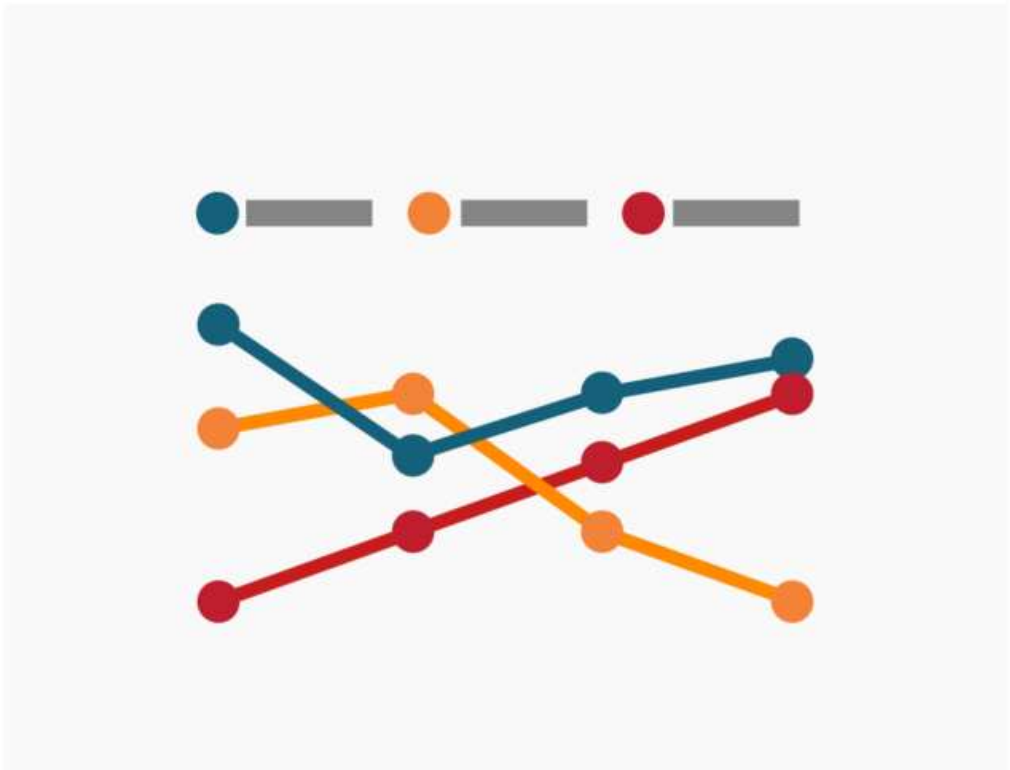
Source: Jan Kühn

Assist the Viewer



Source: Jan Kühn

Assist the Viewer



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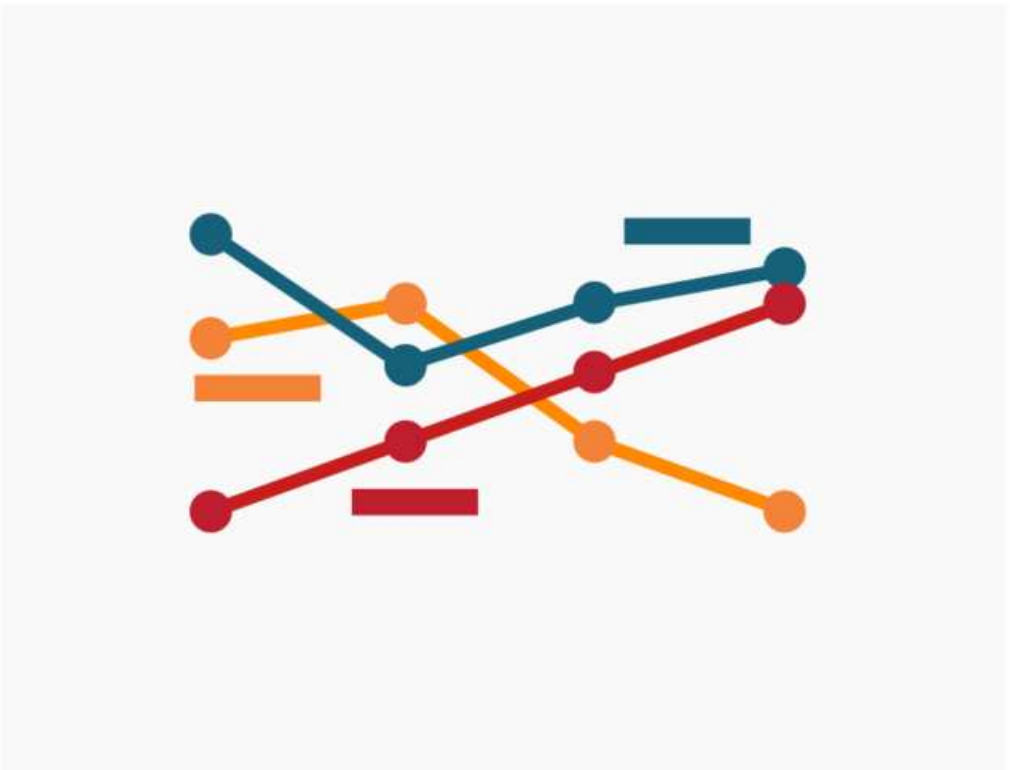
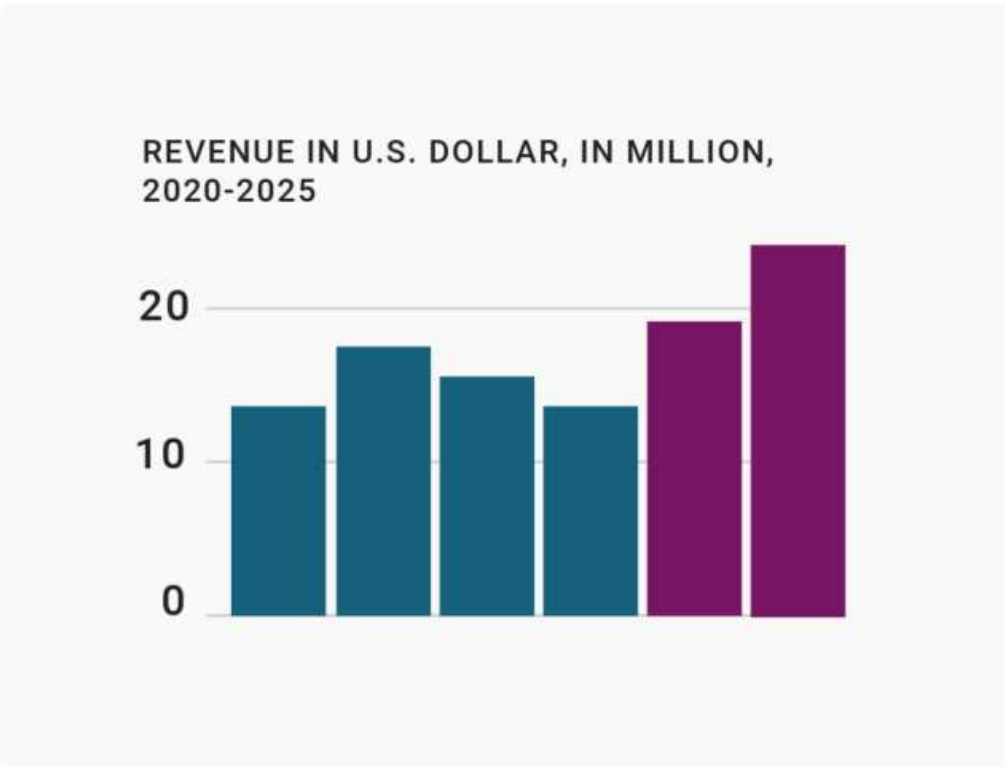


BETTER

Source: Lisa Charlotte Muth, DataWrapper Blog

Assist the Viewer



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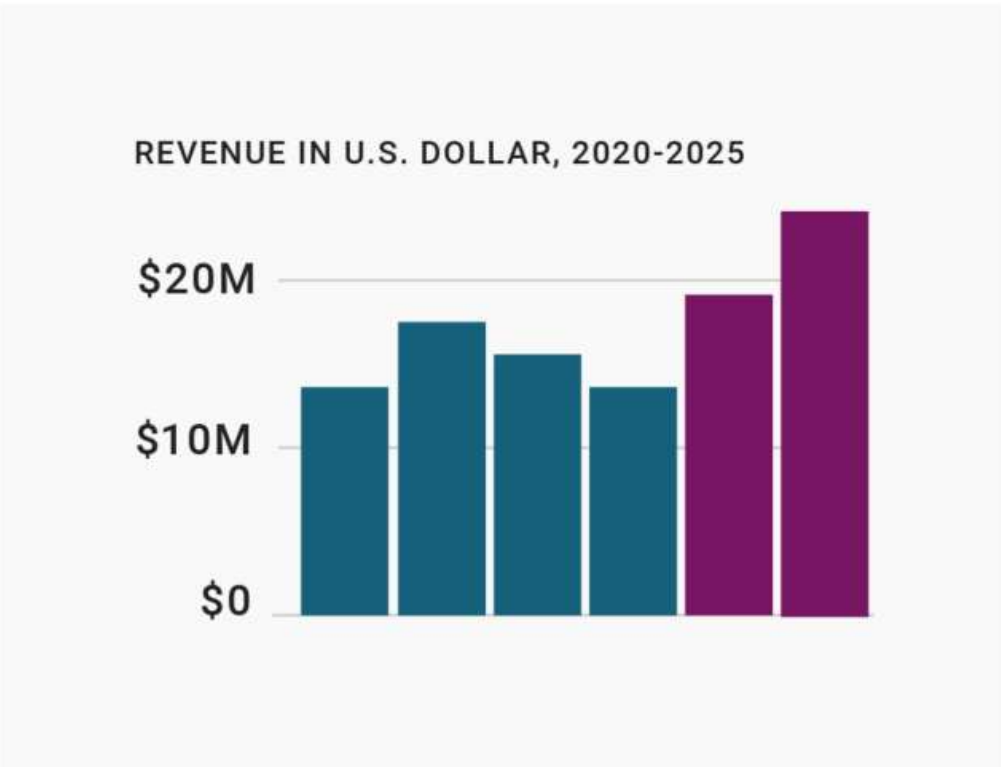
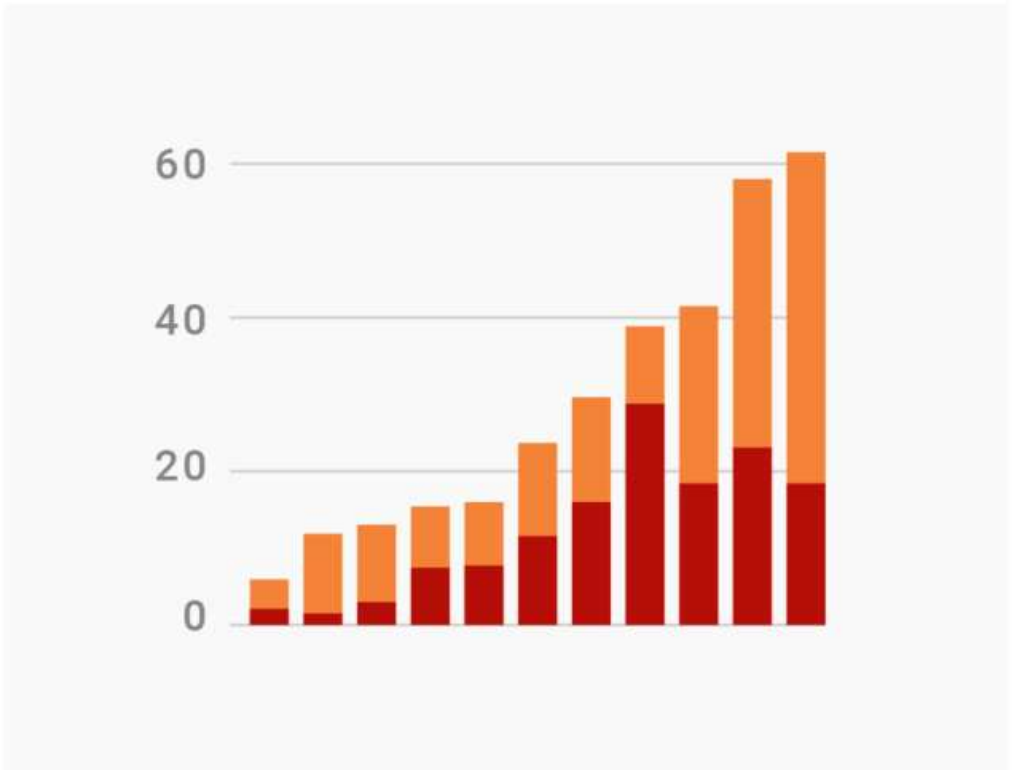


BETTER

Source: Lisa Charlotte Muth, DataWrapper Blog

Assist the Viewer



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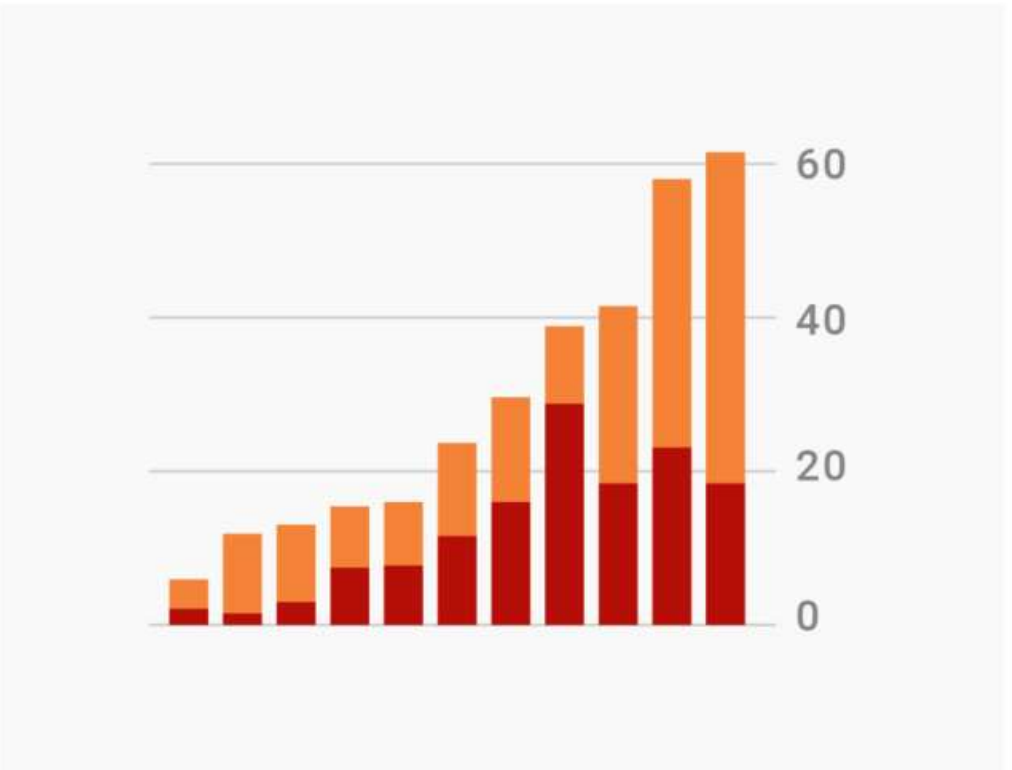
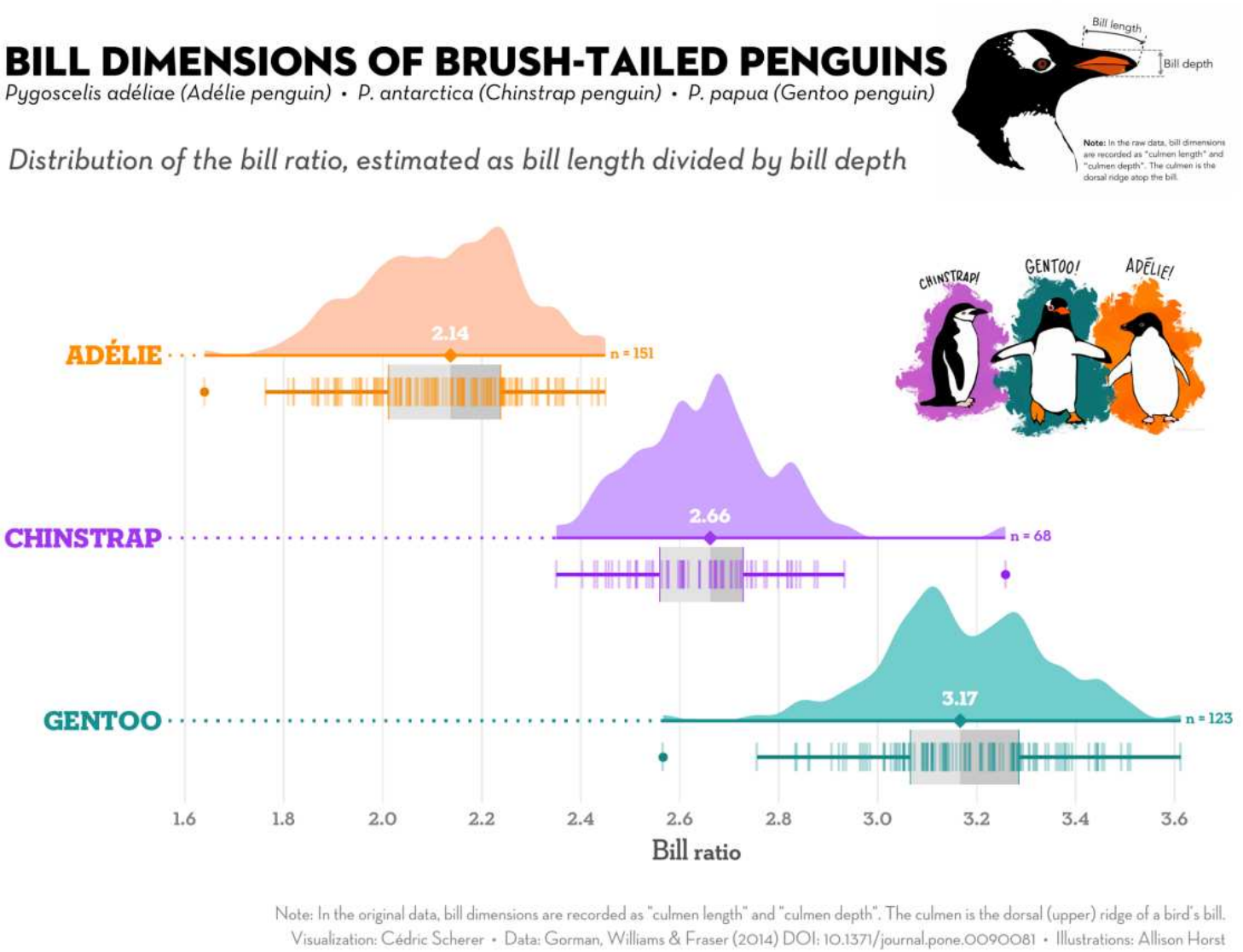


BETTER

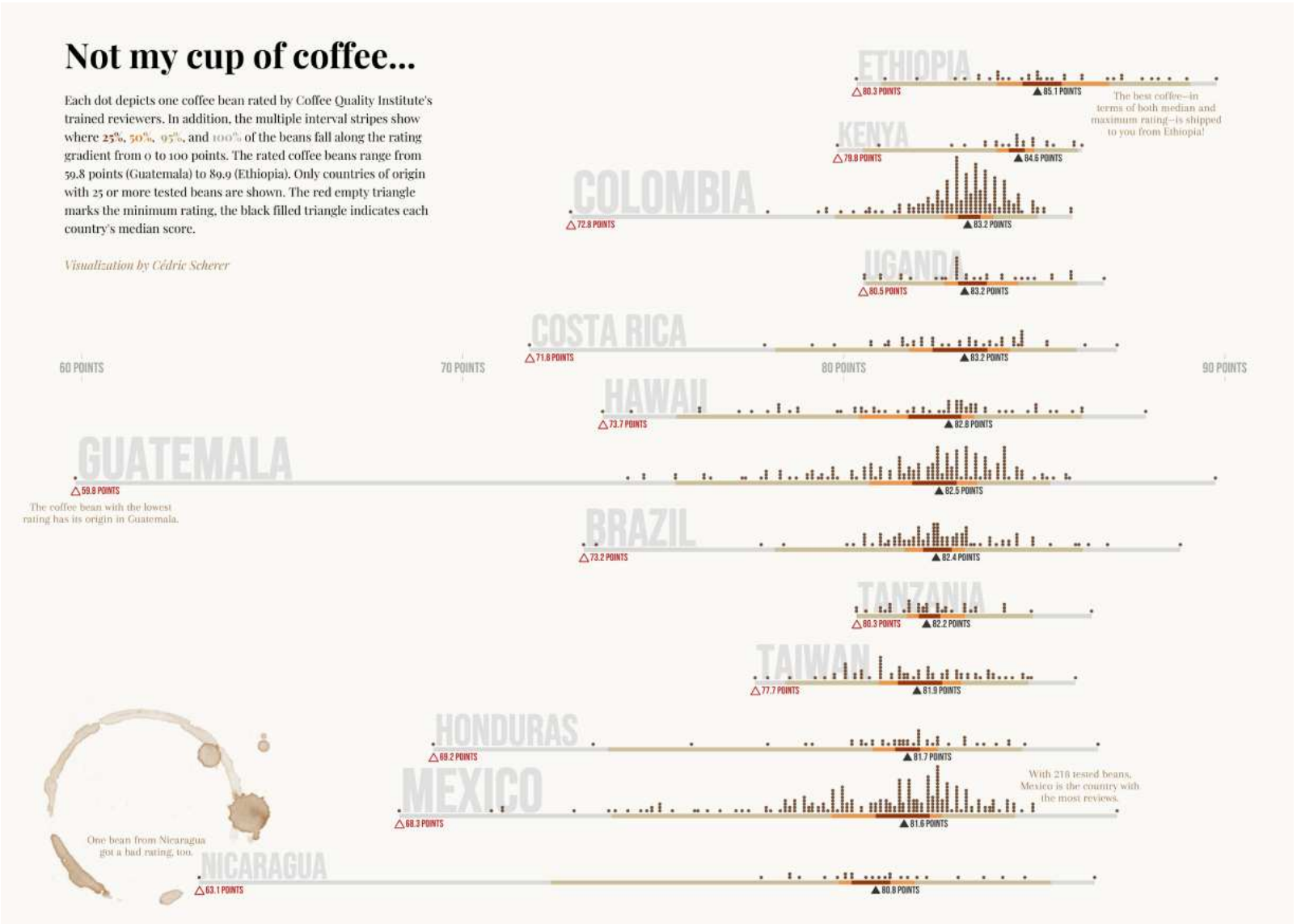
Source: Lisa Charlotte Muth, DataWrapper Blog

Illustrate with Images



Modified #TidyTuesday Contribution | Images: Allison Horst

Illustrate with Images



"Not my Cup of Coffee" (#TidyTuesday Contribution)

Wrap-Up

How to Design Good

Dashboards & Data Visualizations

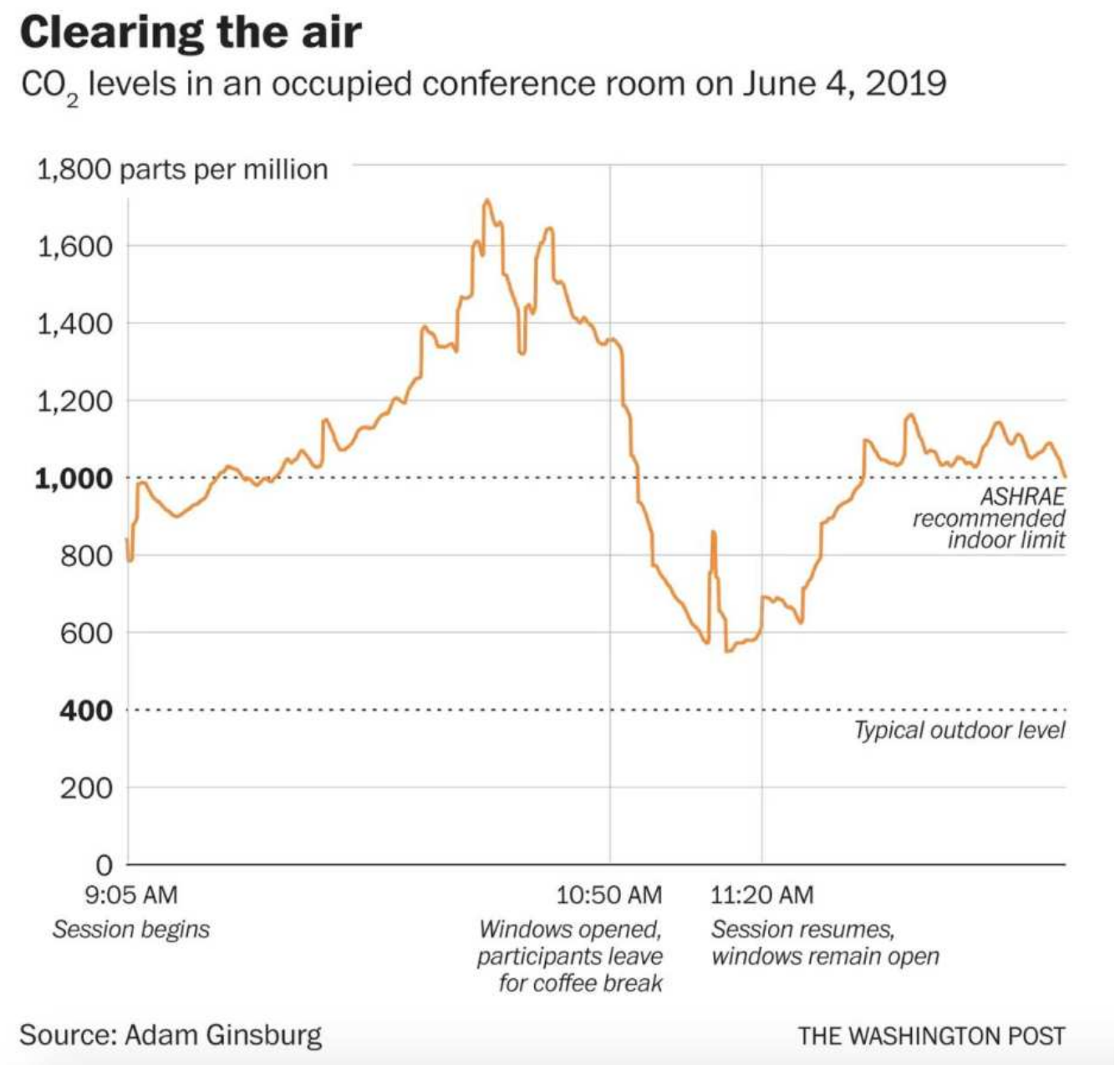
→ understand visual perception

→ know the audience

→ define meaningful objectives

→ condense information

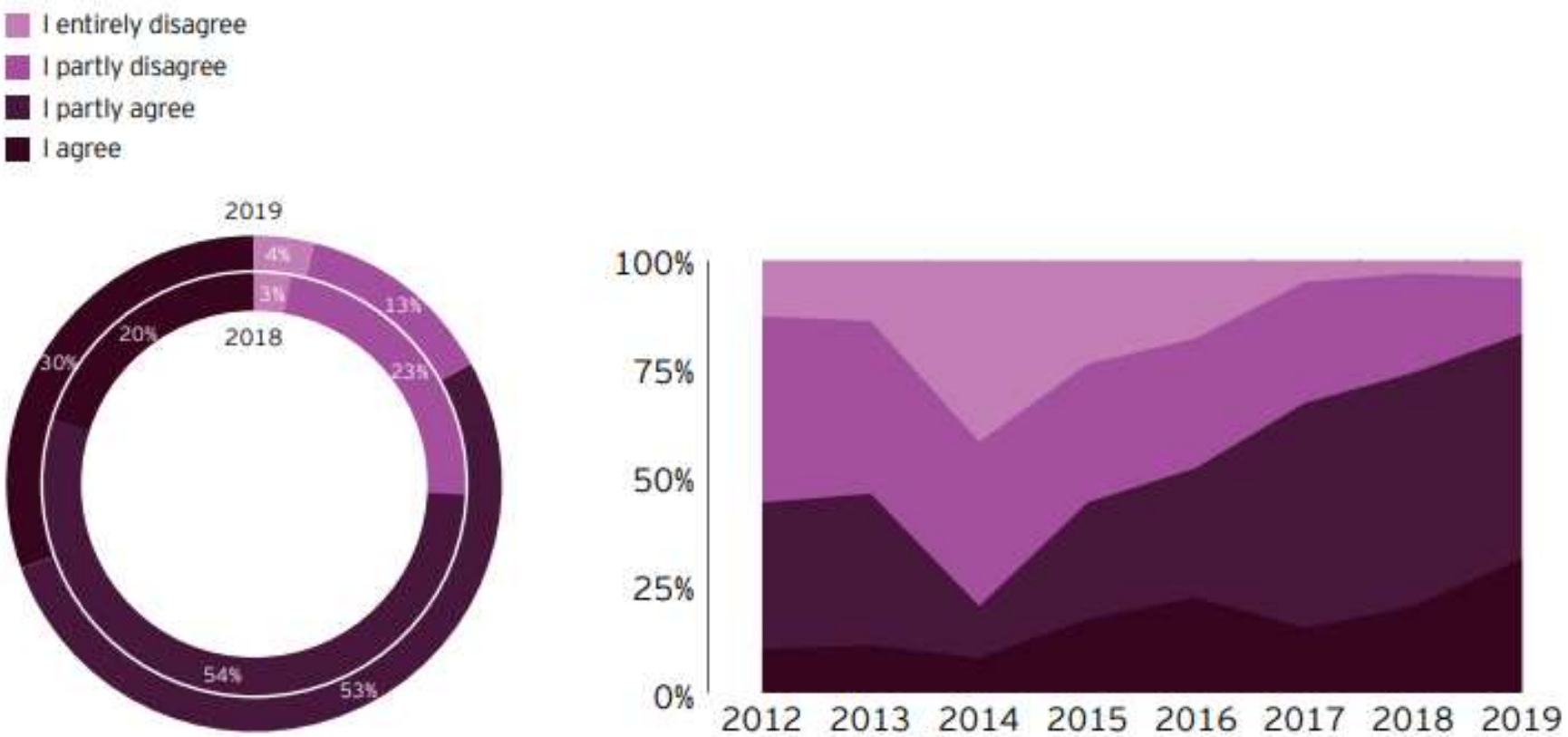
→ follow design guidelines



Source: "Clearing the Air" by Adam Ginsburg (Washington Post)

Notes by Francis Gagnon (Voilà)

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



Source: Ernest & Young

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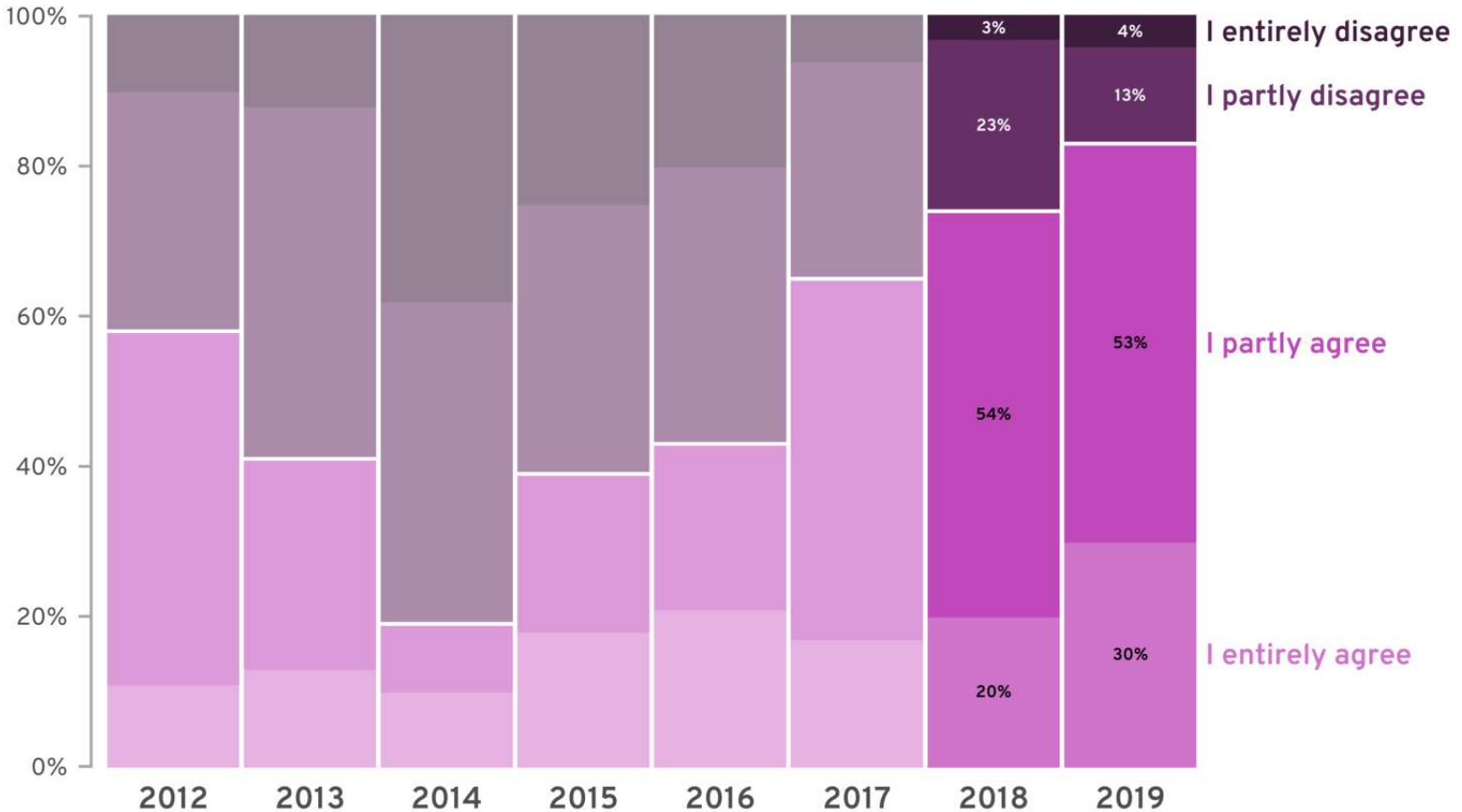


Source: Ernst & Young Global Limited | Makeover: Cedric Scherer, Frontpage Data

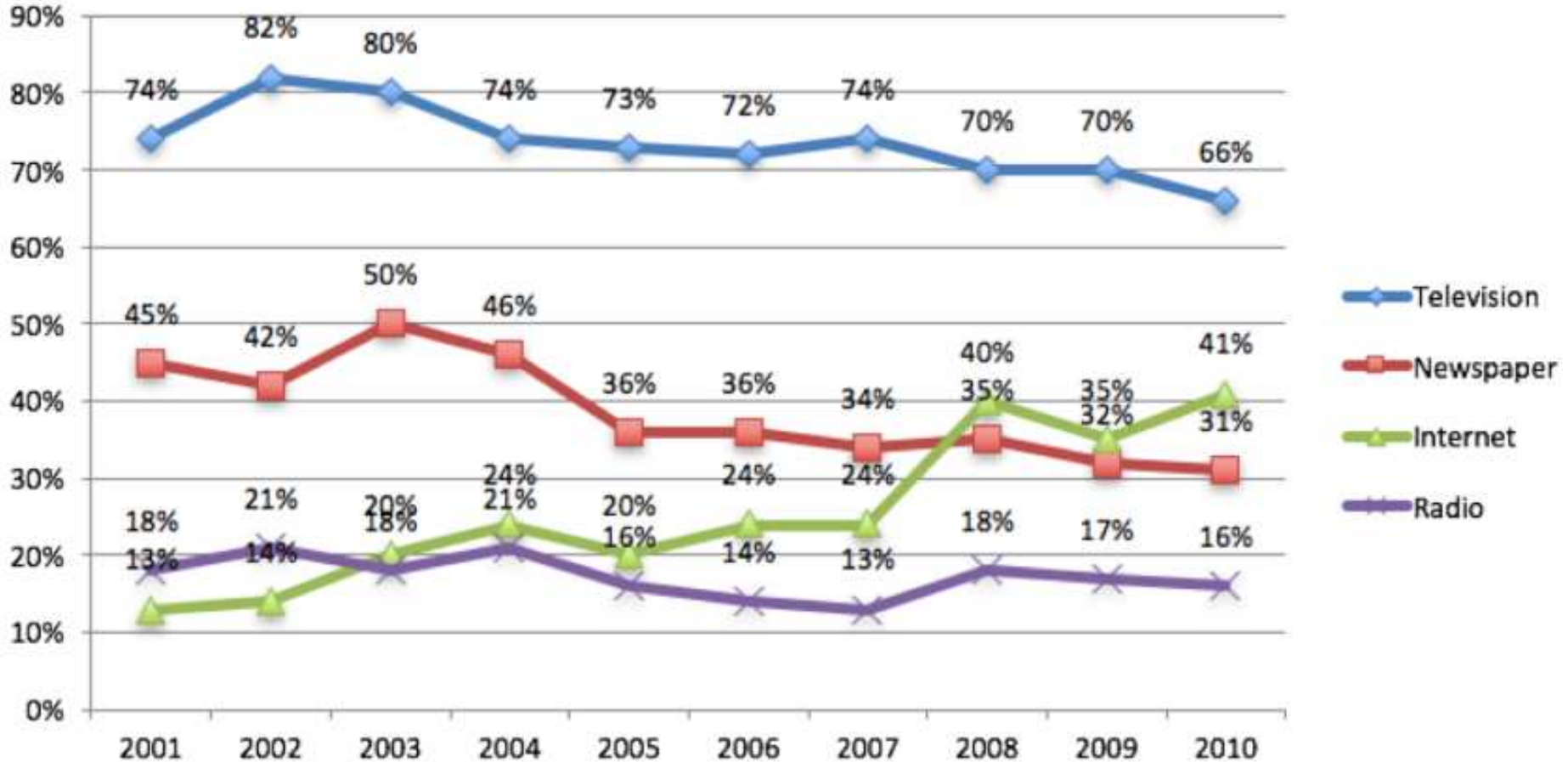
Reworked version of the charts by Ernest & Young

Exercises

Exercise 1

- **Inspect the line chart “How People Get Their News”.**
  - Identify the main message of the chart.
  - What are details that distract you as an viewer?
  - Is all the information relevant?
- **Improve the graphic to focus attention.**
  - Make use of preattentive attributes to emphasize the main message.
  - Eliminate the clutter from the graphic.
  - Apply Gestalt principles if possible.

How People Get Their News



AN INCREASING PROPORTION CITE THE INTERNET AS THEIR PRIMARY NEWS SOURCE.
DATA SOURCE: PEW RESEARCH CENTER. RESPRESENTS RESPONSES TO THE QUESTION, "WHERE DO YOU GET MOST OF YOUR NEWS ABOUT NATIONAL AND INTERNATIONAL ISSUES? FIGURES SUM TO MORE THAN 100% BECAUSE RESSPONDENTS COULD VOLUNTEER UP TO TWO MAIN SOURCES.

Exercise 2

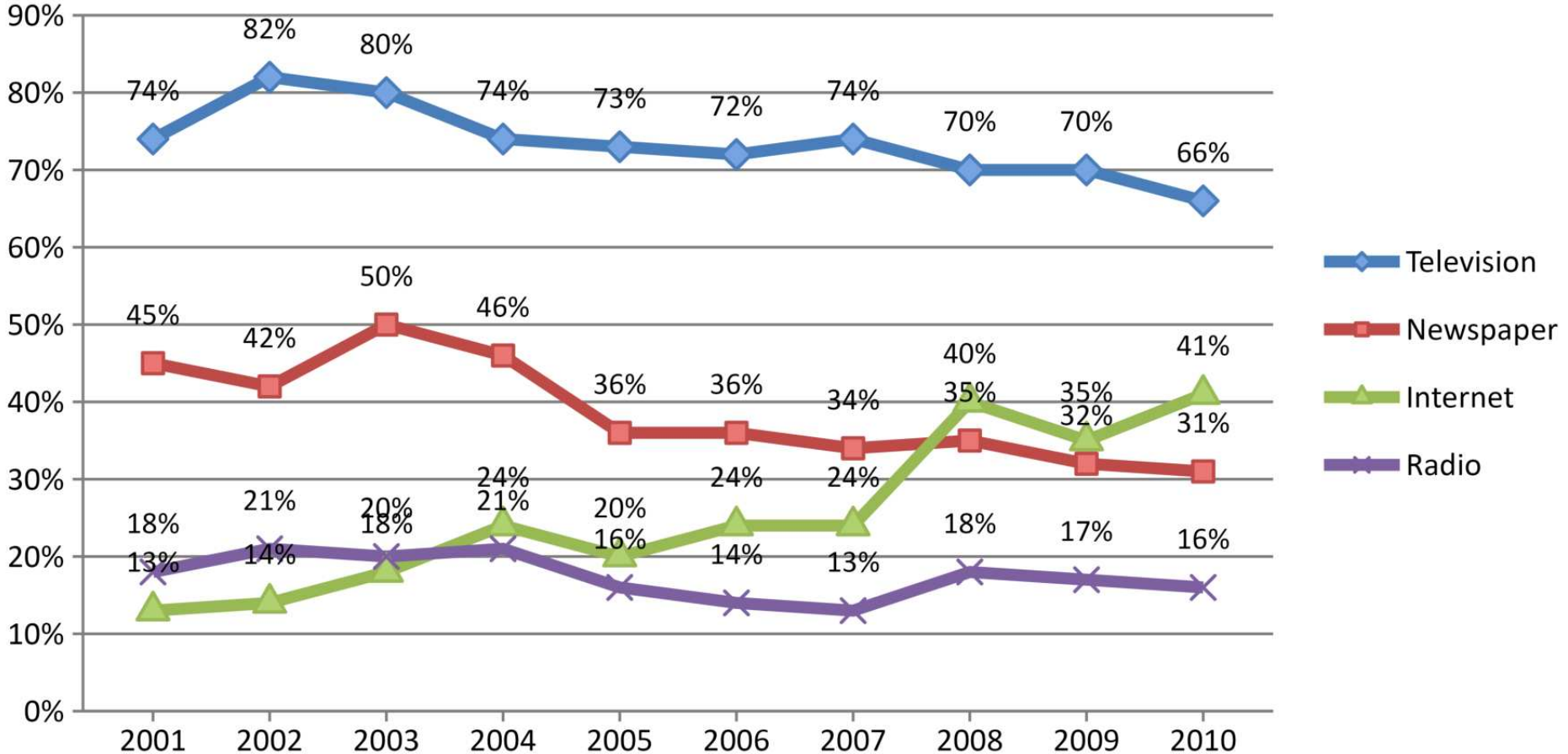
- **Work on your current data sets and visualization(s).**
  - Note which (a) preattentive attributes and
    (b) Gestalt principles are currently applied.
  - How would you rate the cognitive load of your charts?
  - Can you decrease the cognitive load for the viewer?
    - Make use of other preattentive attributes to guide the viewer.
    - Apply Gestalt principles to declutter your graphic(s).
    - Is it possible to replace or simplify the legend?
    - Consider to add direct annotations, call-outs, and more meaningful labels.

Suggested Solutions

Exercise 1

- **Inspect the line chart “How People Get Their News”.**
  - Identify the main message of the chart.
  - What are details that distract you as an viewer?
  - Is all the information relevant?
- **Improve the graphic to focus attention.**
  - Make use of preattetive attributes to emphasize the main message.
  - Eliminate the clutter from the graphic.
  - Apply Gestalt principles if possible.

How People Get Their News



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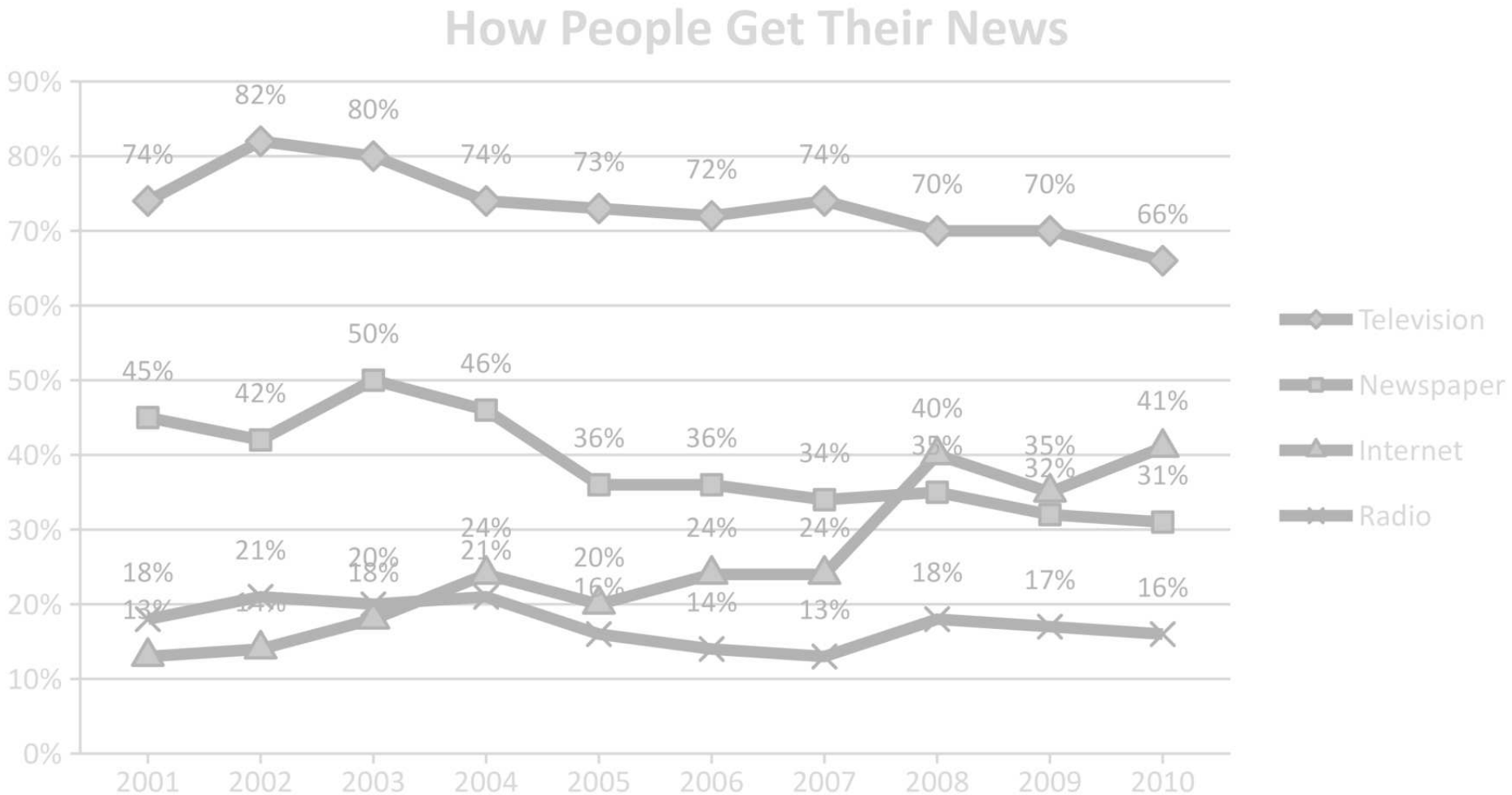

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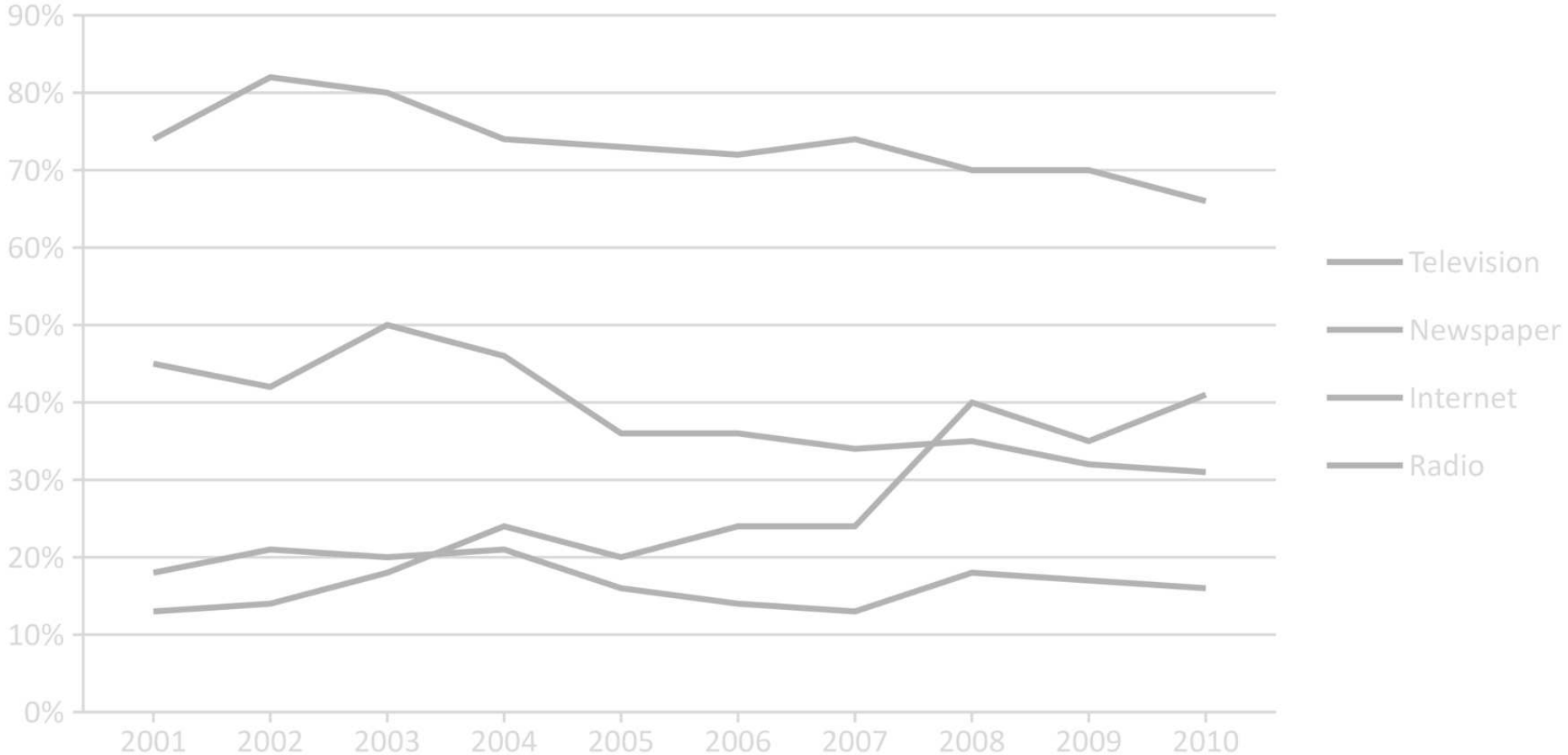

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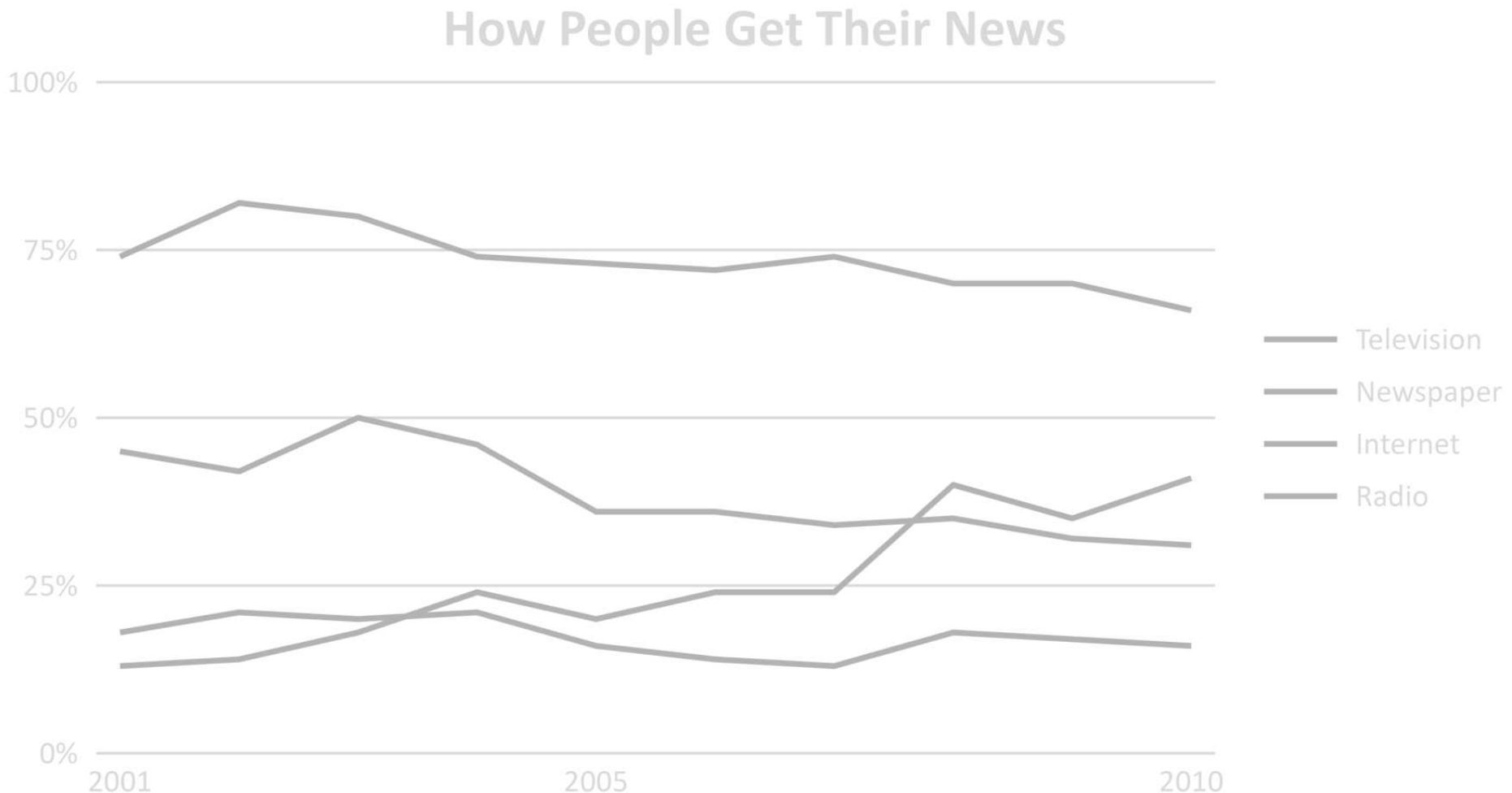

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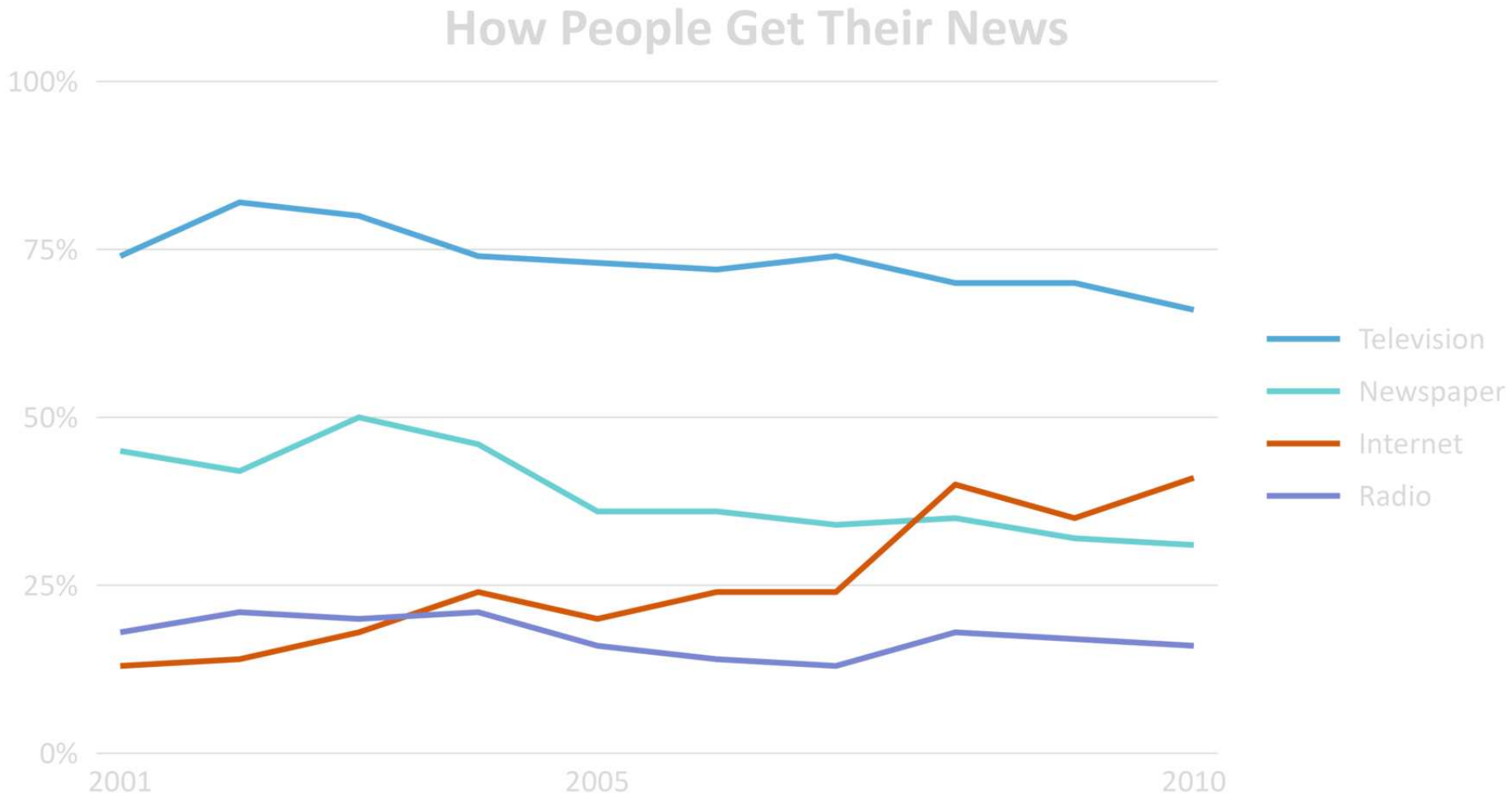

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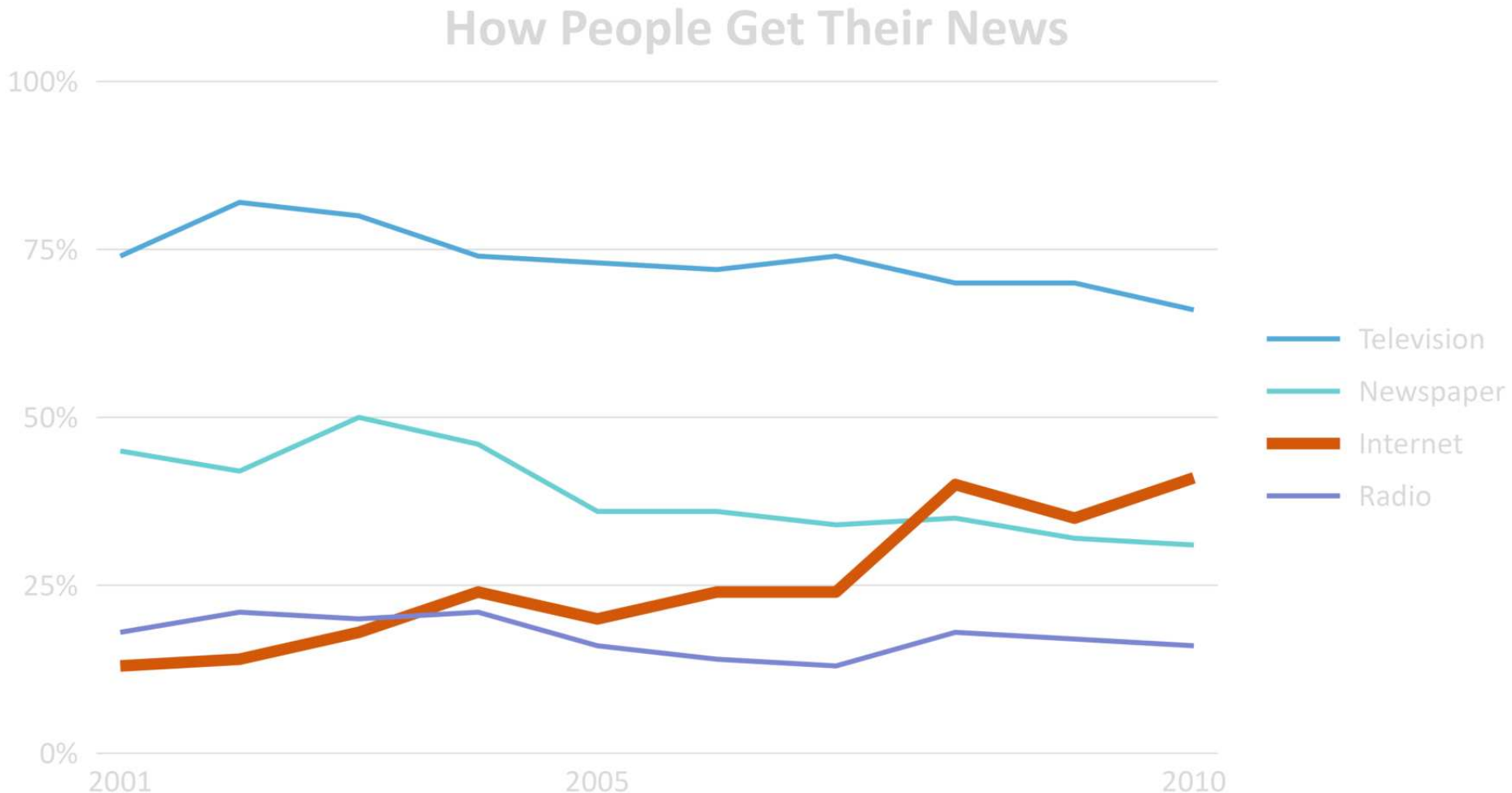

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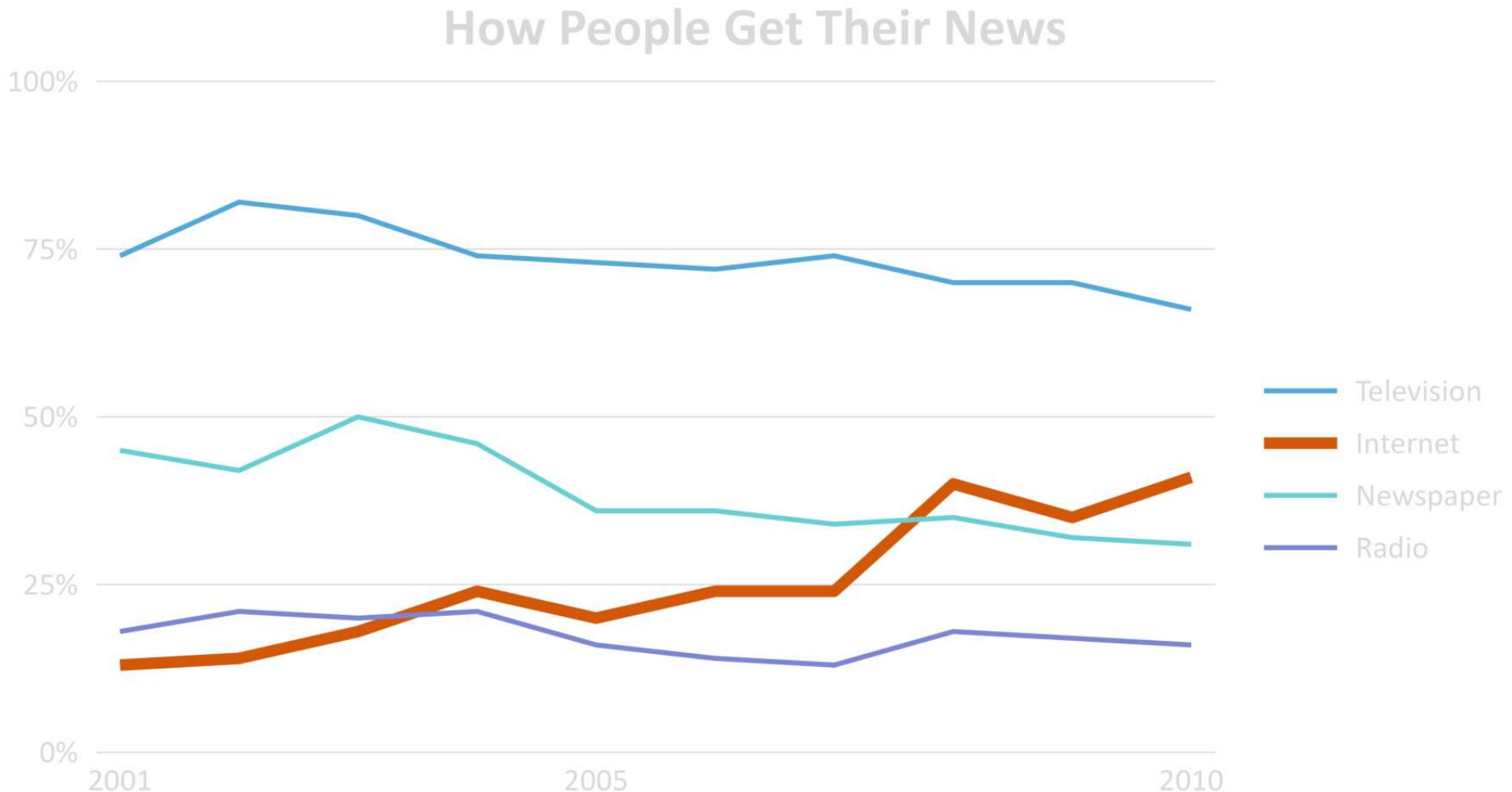

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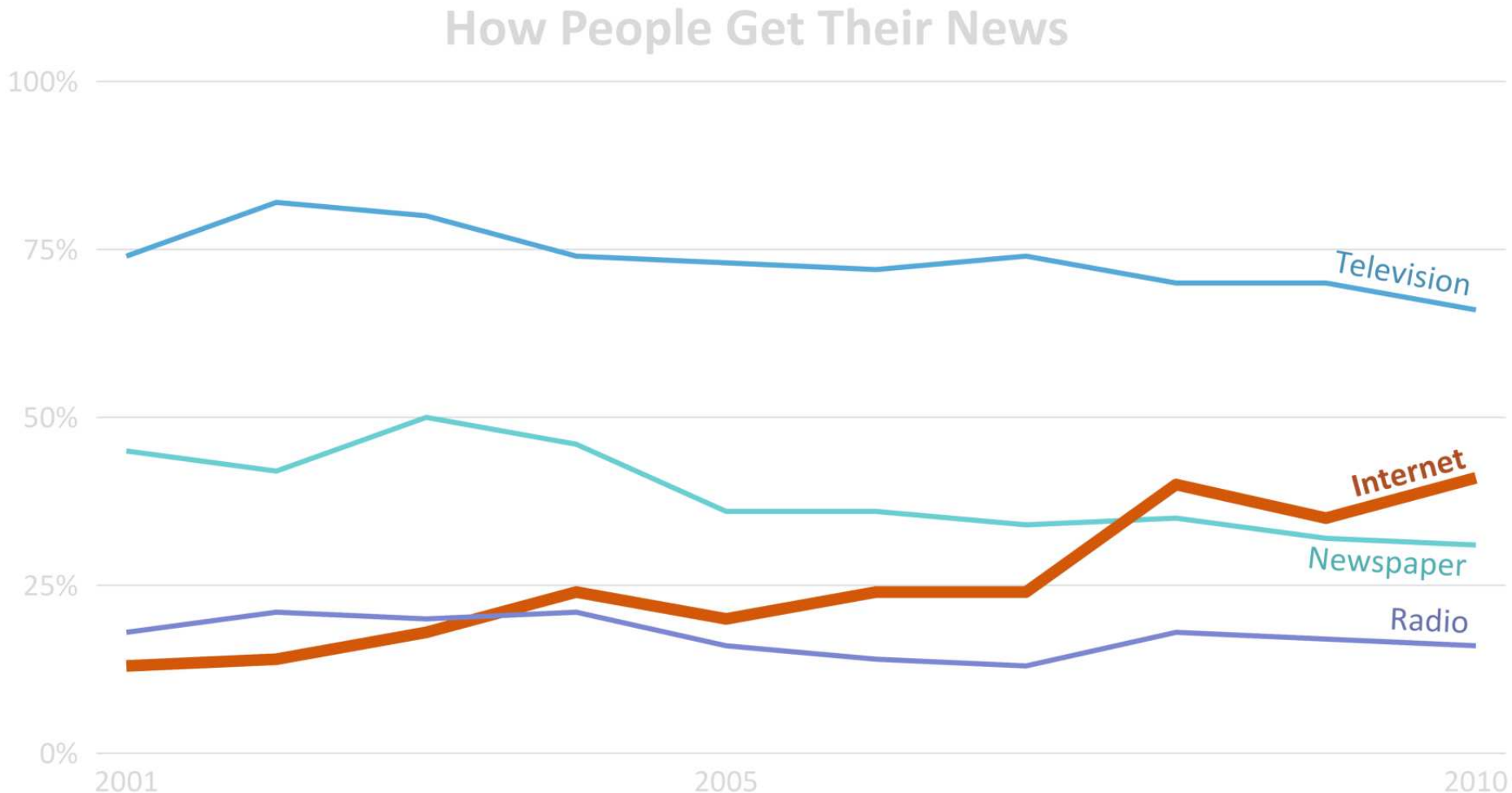

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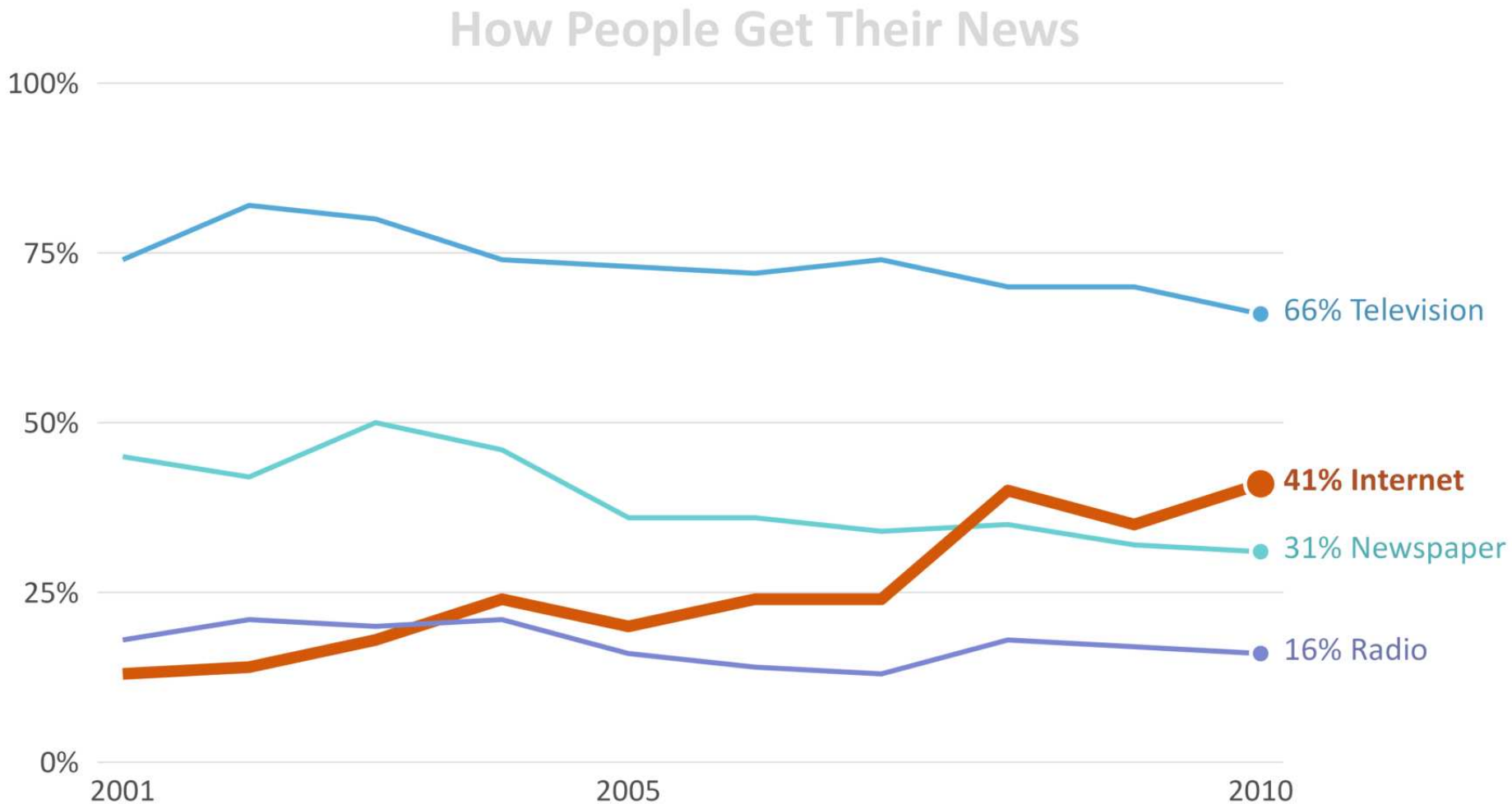

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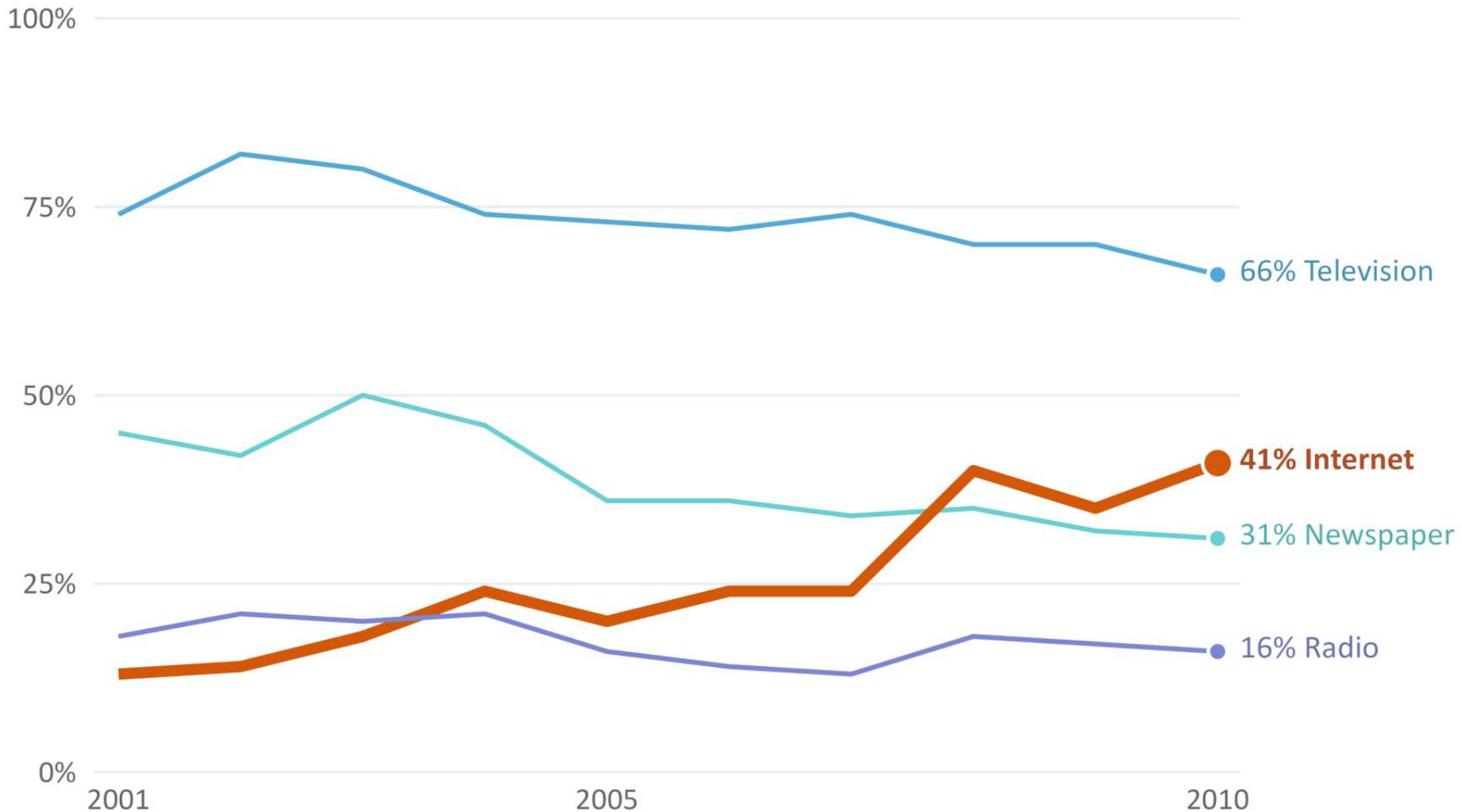

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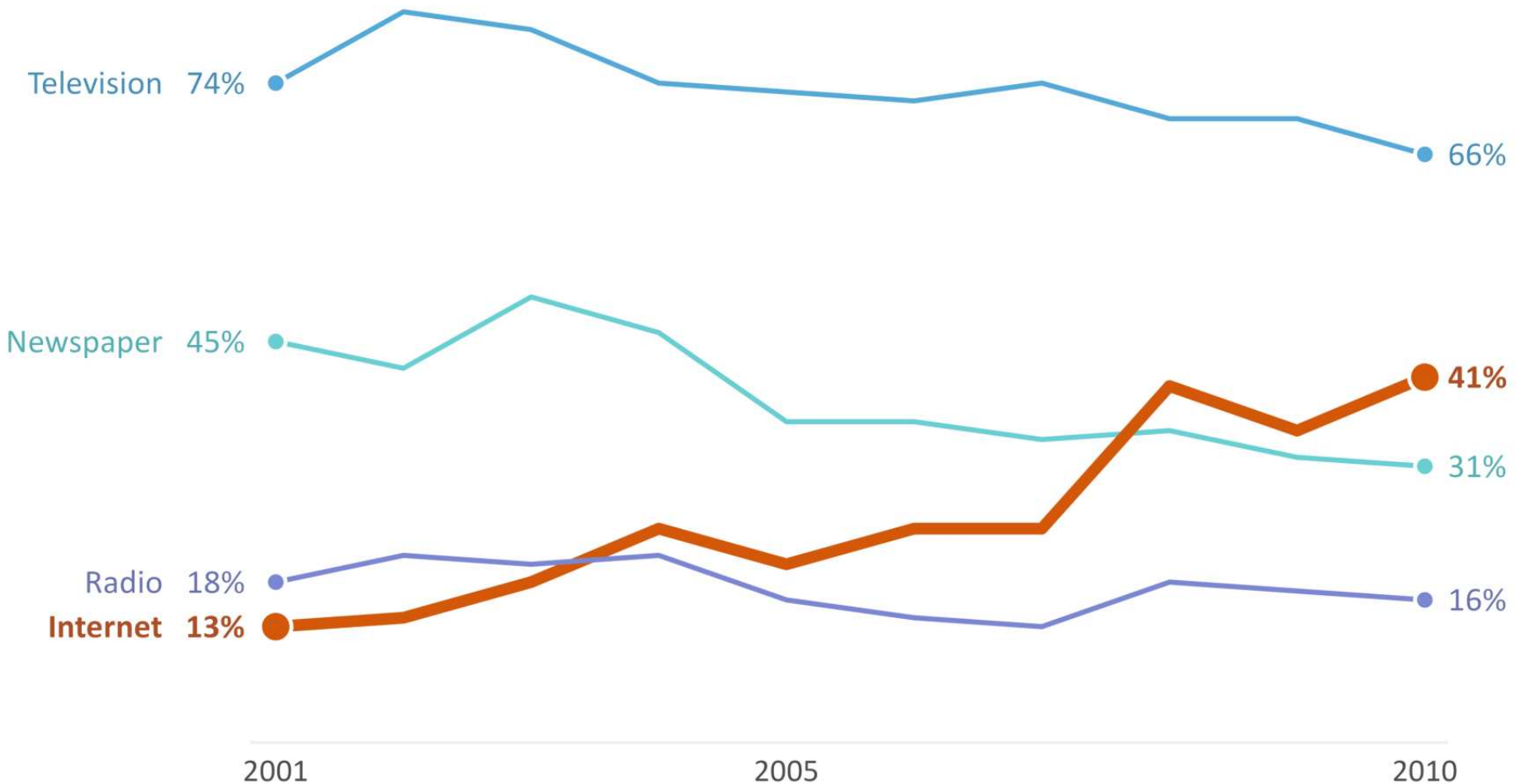

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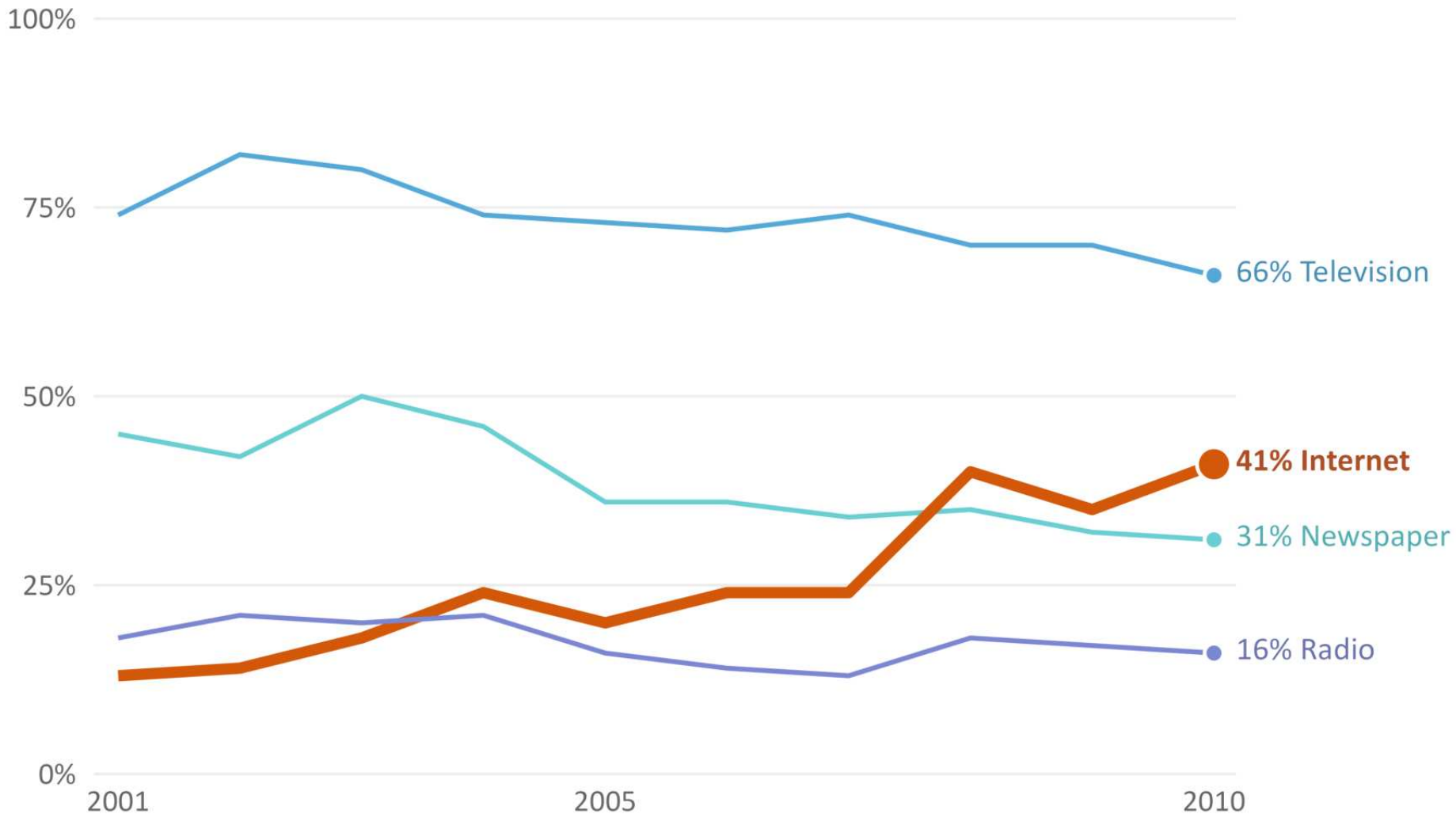
An increasing proportion cite the internet as their primary news source

Responses to the question "where do you get most of your news about national and international issues?"



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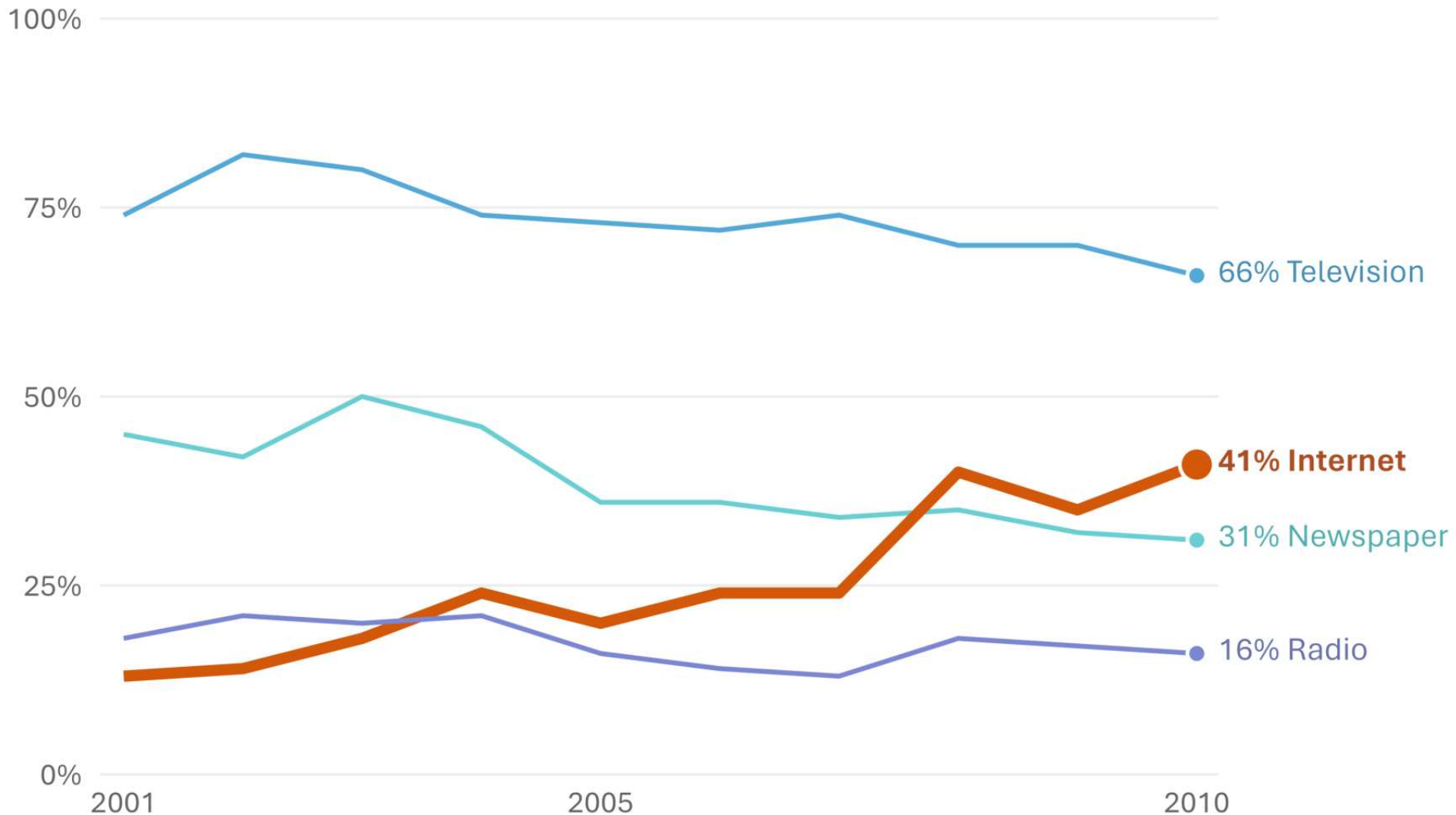

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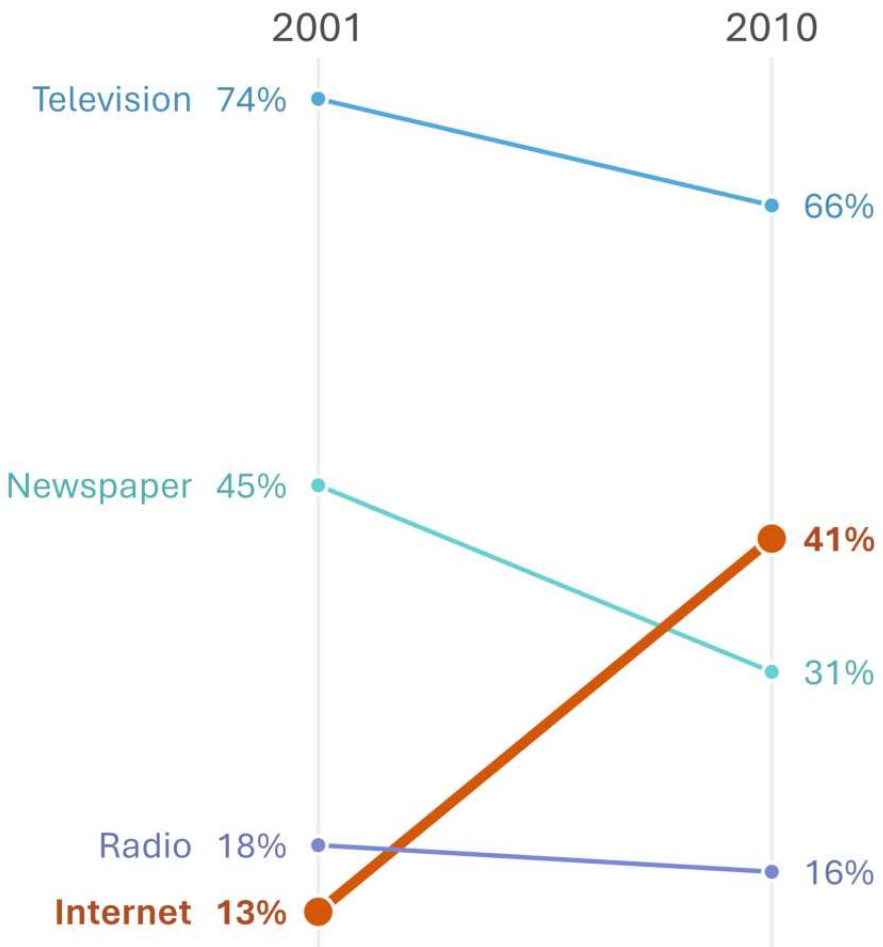

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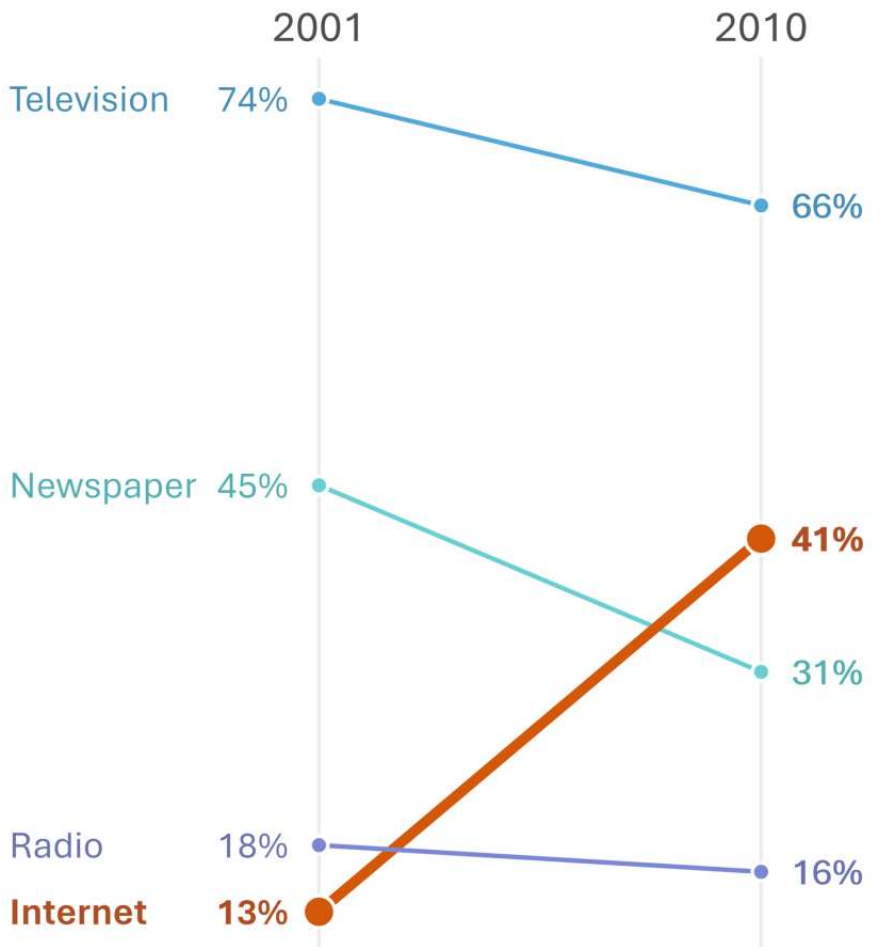

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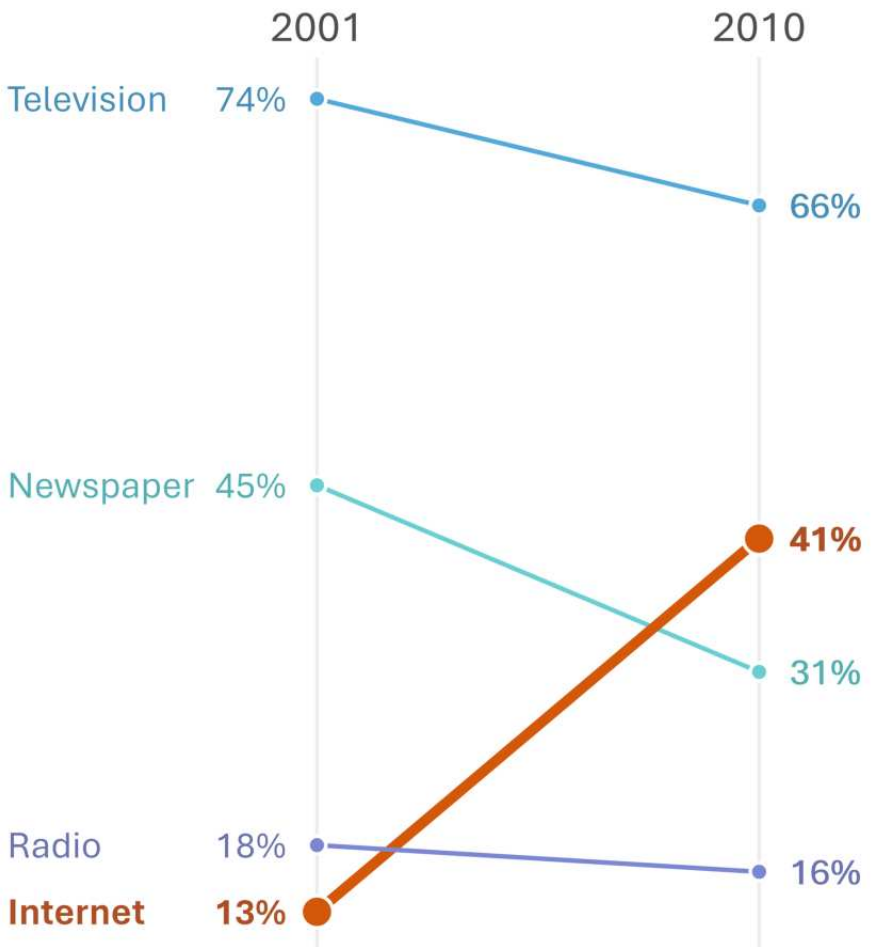

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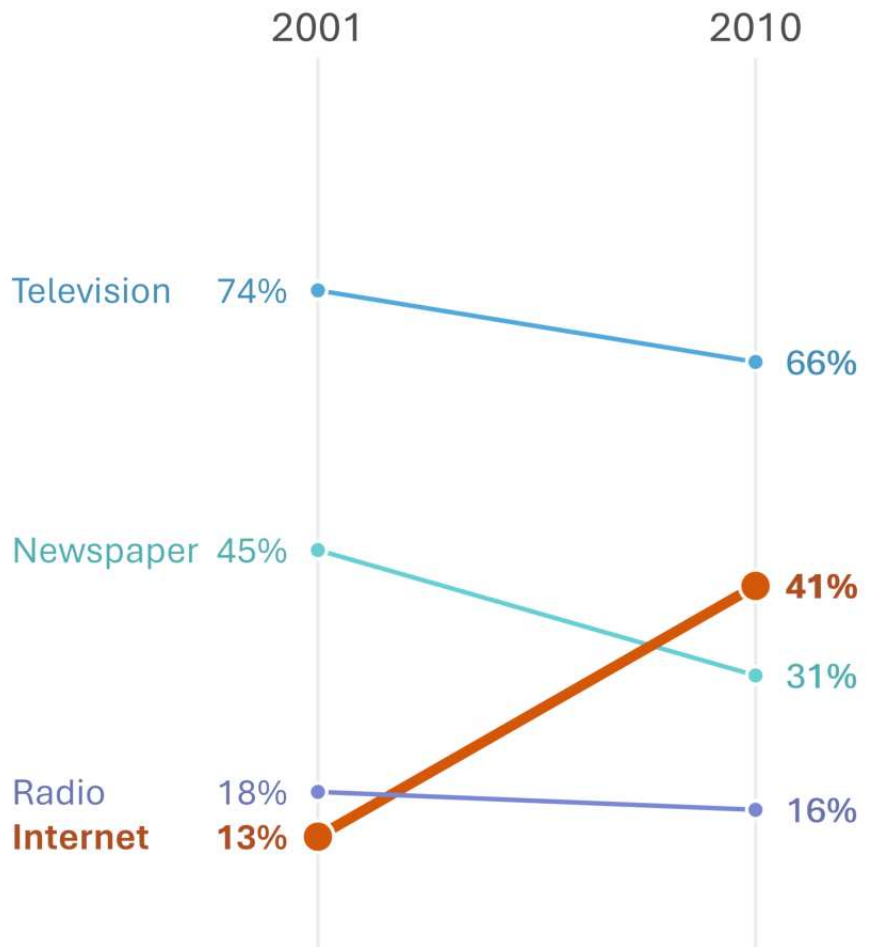

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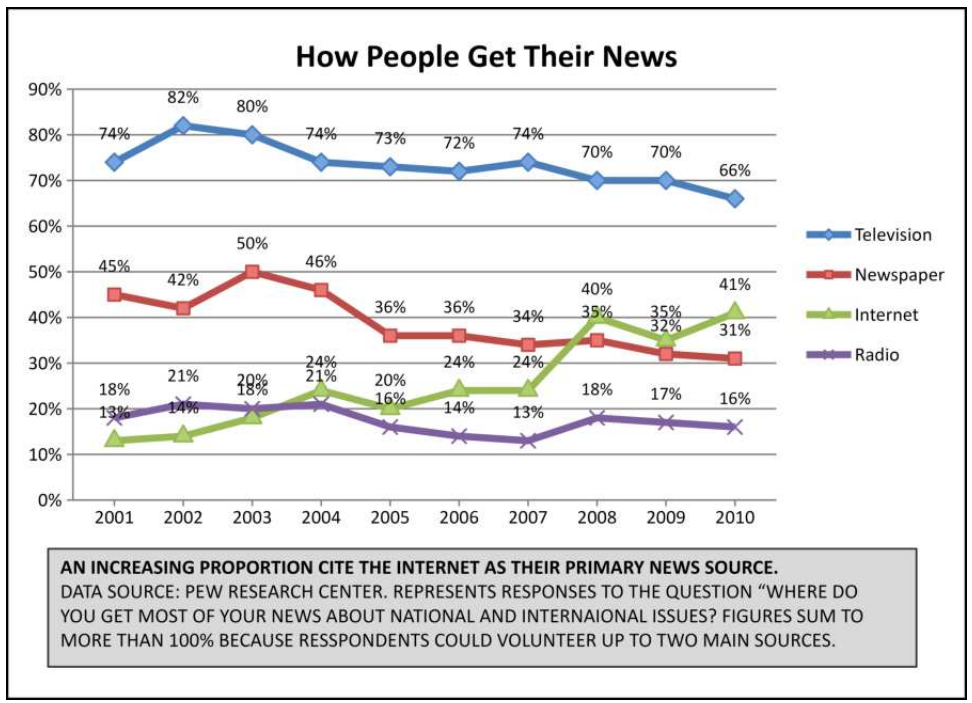
How People Get Their News
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
74%
82%
80%
74%
73%
72%
74%
70%
70%
66%
45%
42%
50%
46%
36%
36%
34%
35%
32%
41%
18%
21%
20%
24%
20%
24%
24%
40%
35%
31%
13%
14%
18%
21%
16%
14%
13%
18%
17%
16%
Television
Newspaper
Internet
Radio
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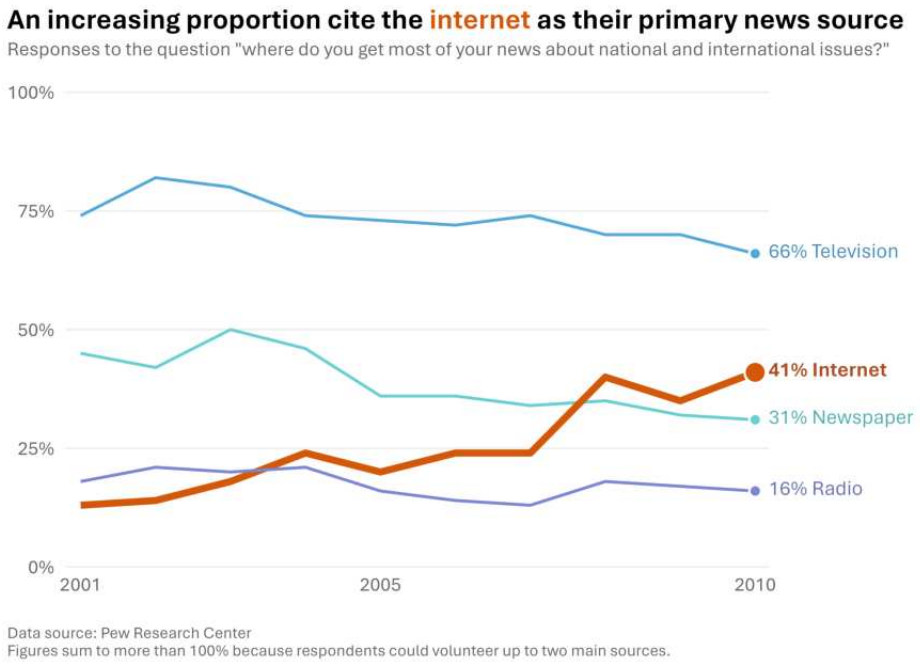
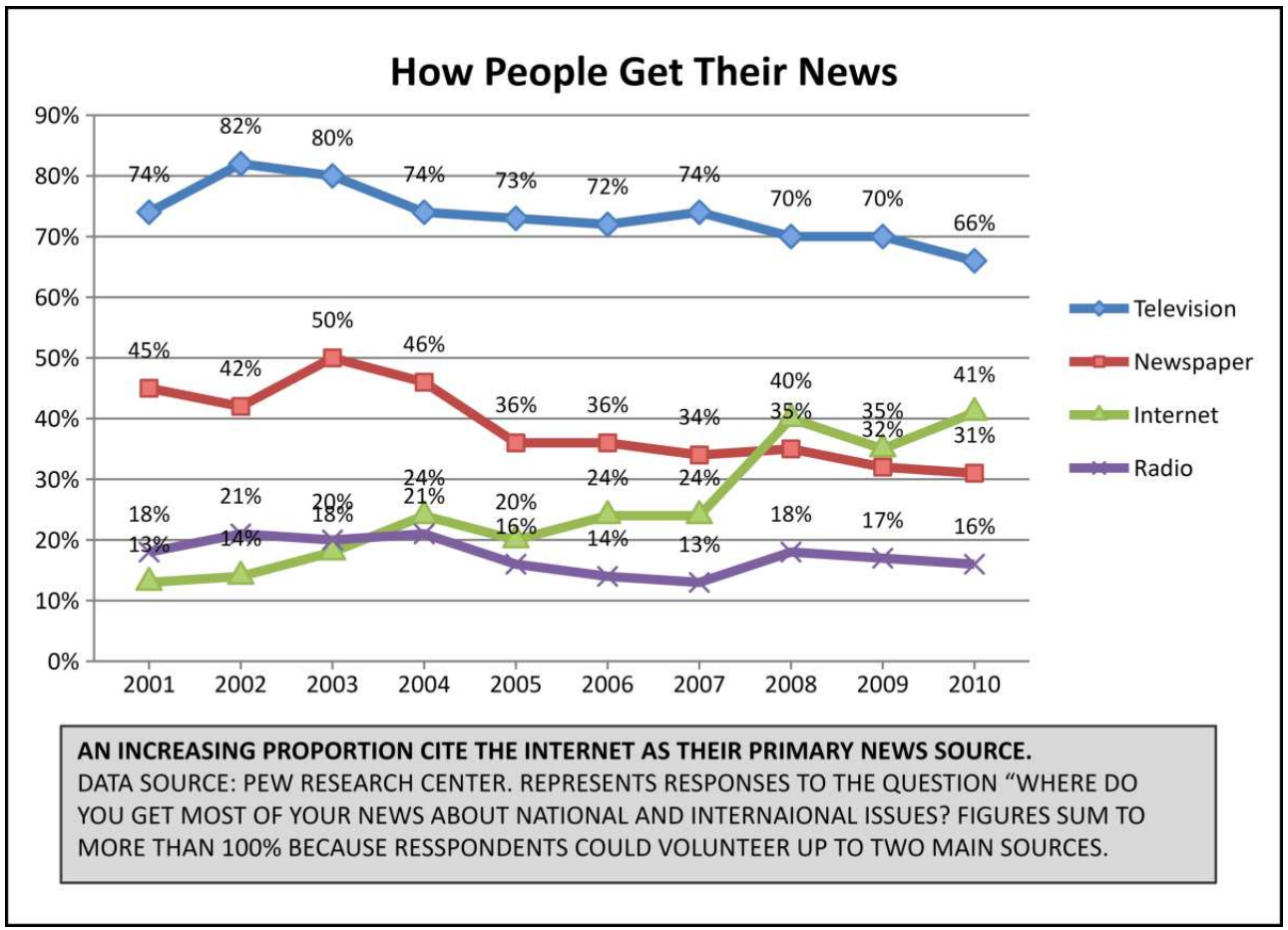

An increasing proportion cite the internet as their primary news source
Responses to the question "where do you get most of your news about national and international issues?"
100%
75%
50%
25%
0%
2001
2005
2010
66% Television
41% Internet
31% Newspaper
16% Radio
Data source: Pew Research Center
Figures sum to more than 100% because respondents could volunteer up to two main sources.


How People Get Their News
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2001
2002
2003
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2005
2006
2007
2008
2009
2010
74%
82%
80%
74%
73%
72%
74%
70%
70%
66%
45%
42%
50%
46%
36%
36%
34%
35%
32%
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18%
21%
20%
24%
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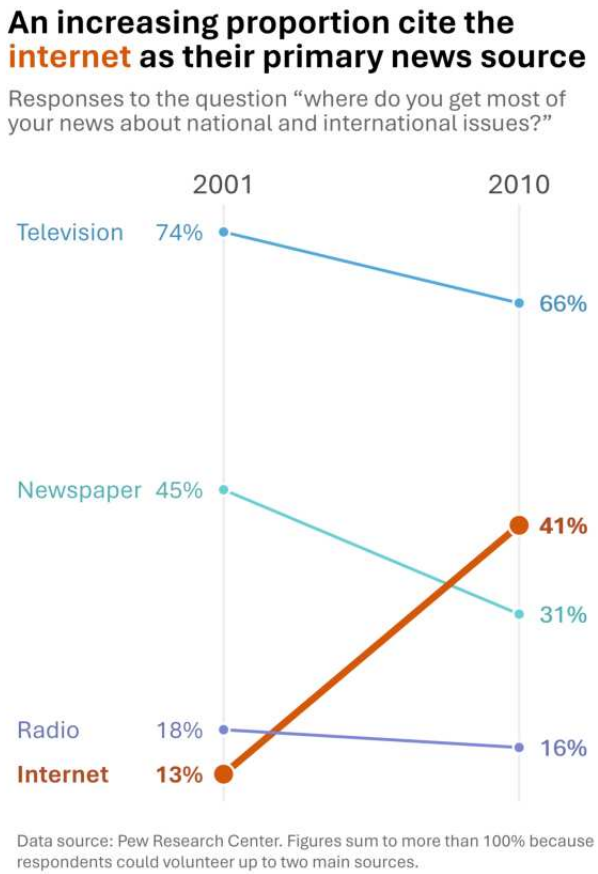
An increasing proportion cite the internet as their primary news source
Responses to the question "where do you get most of your news about national and international issues?"
2001
2010
Television 74%
66%
Newspaper 45%
31%
41%
Radio 18%
16%
Internet 13%
Data source: Pew Research Center. Figures sum to more than 100% because respondents could volunteer up to two main sources.

Thank You!

www.cedricscherer.com // www.linktr.ee/CedScherer