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Data Visualisation in Data Science :: Presentation/Communication ::



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(c) Jan Aerts, 2024-2026

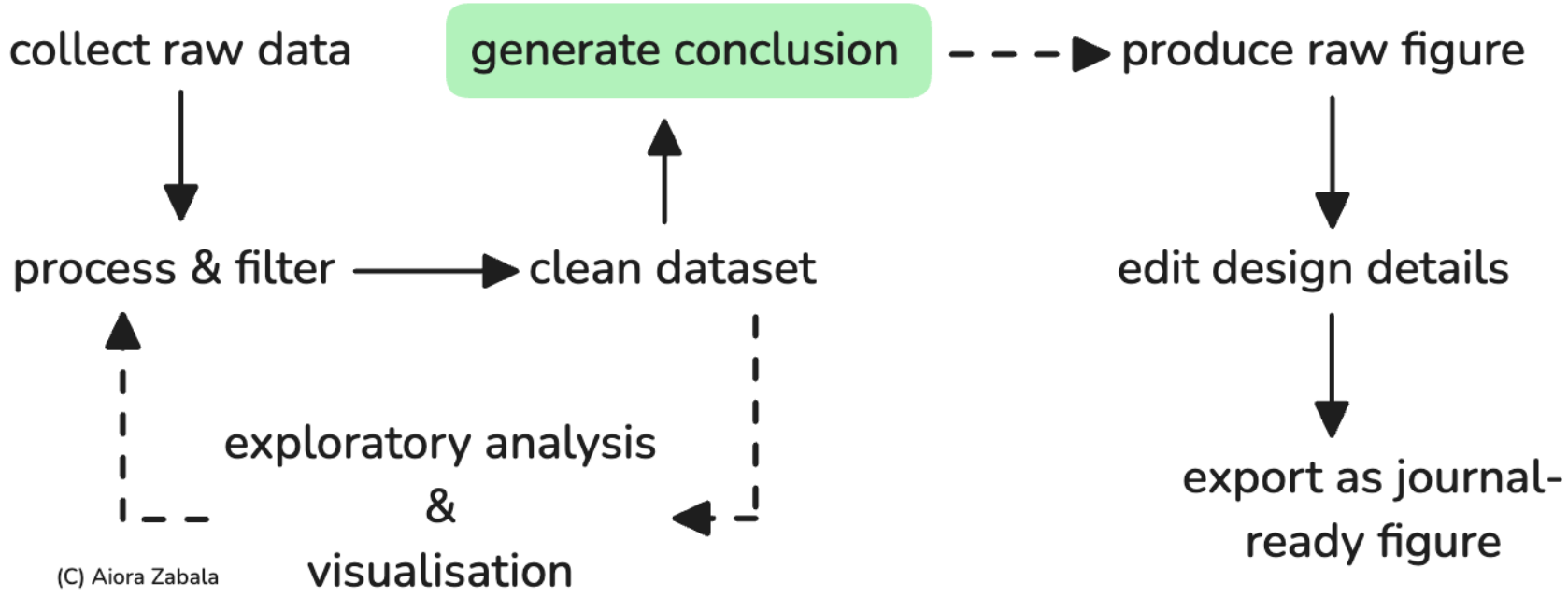
Exploration vs Communication

	Exploration	Explanation/Communication
Audience	Analyst	General/specific audience
Purpose	Discovery	Communication/persuasion
Message	Uncovering insights	Conveying specific findings
Explanation	Often implicit	Explicit and contextual
Visualisations	Complex, interactive	Simple, intuitive
Interactivity	High	Low/controlled
Level of detail	Potentially granular	Curated

Design should never say, "Look at me."
It should always say, "Look at this."

(David Craib)

Data visualisation process



Practitioner guides

- argue that business-as-usual visualisations are ineffective, confusing, or misleading
- e.g. (taken from Ajani et al, TVCG 2021)
  - Info We Trust (Andrews)
  - The Functional Art (Cairo)
  - The Truthful Art (Cairo)
  - slide:ology (Duarte)
  - Effective Data Storytelling (Dykes)
  - Now You See It (Few)
  - Data Visualisation (Kirk)
  - Storytelling With Data (Knaflic)
  - Visual Display of Quantitative Information (Tufte)
  - ...



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General dos and don'ts

Don't

- assume that great science speaks for itself
- confuse design with decoration or meaningless visual elements
- be intimidated by the concept of design
- confuse a simple scientific presentation with one that is easy, mediocre, or boring
- consider design principles as rules that limit freedom or creativity
- consider the design of a presentation something that will be perfect when finished

Do

- complement great content with a well-designed and well-delivered presentation
- embrace simplicity: eliminate unimportant visual elements and anything that distracts from your message
- embrace design as a process, a way for you to improve communication with your audience
- appreciate the benefits of subtracting meaningless elements from presentations so that only important details remain
- learn the value of design guidelines and realise that it is okay to break them when it benefits your presentation

Source: Designing Science Presentations - A Visual Guide to Figures, Papers, Slides, Posters, and More (M Carter)

3 laws of visual communication for the quantitative scientist

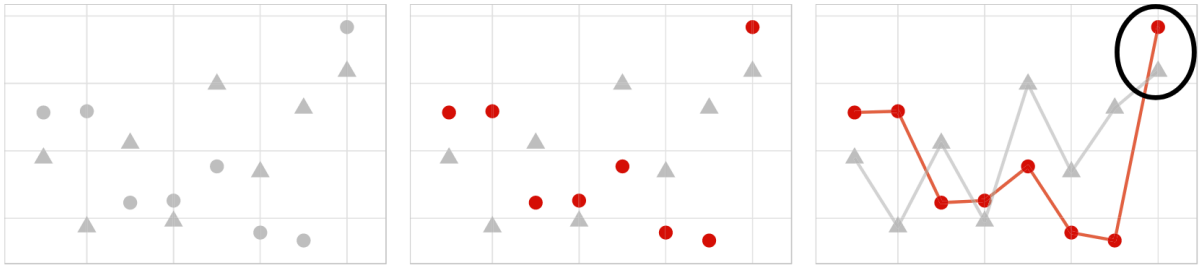
Source: Vandemeulebroecke M et al. Effective visual communication for the quantitative scientist. doi:10.1002/psp4.12455

1. Have a clear purpose
    - Let the scientific question determine what data to display and why.
    - Always helps to ask "compared to what"?
    - Know your audience
2. Show the data clearly
    - E Tufte "Above all else, show the data"
    - Display the data itself, not just summary statistics

3. Make the message obvious

- M Krzywiński: "inviting readers to draw their own conclusions is risky" => make it impossible to miss
- Know your principles of effectiveness (see below): what marks/channels work best for which data
- Exploit preattentive processing
- Avoid mental arithmetic: if differences or ratios are the main focus, show them directly. If both raw values and differences are of interest, show both.
- Minimise viewer's eye movement.
- Exploit visual grouping

https://graphicsprinciples.github.io/



Source: Vandemeulebroecke M et al. Effective visual communication for the quantitative scientist. doi:10.1002/psp4.12455

1. Your message

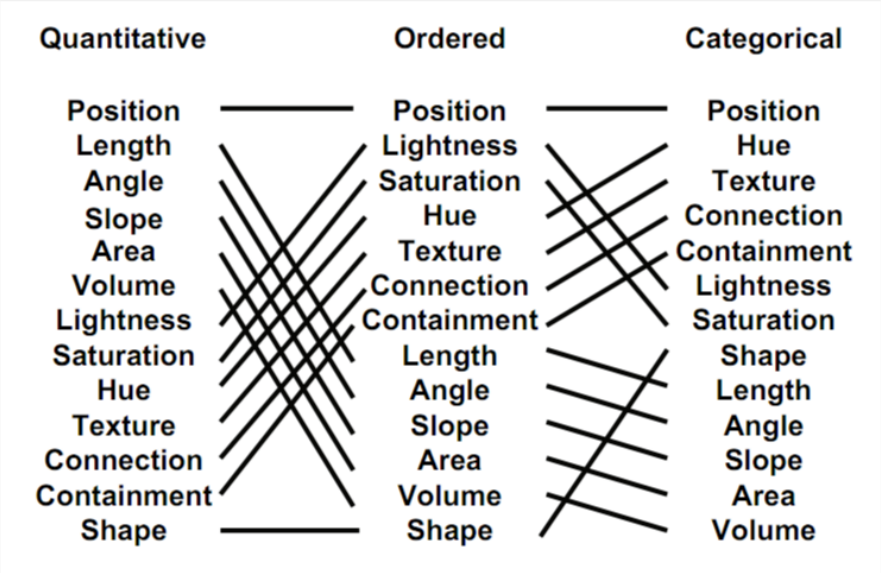
- Focus on a single message: a good visual should convey a single key idea; multiple images dilute the impact and can confuse the viewer.
- Define the message before designing: start with the insight or point you want the audience to take away.
- Know your audience: what is their prior knowledge, interest and context?
- Message must be truthful and transparent => show the data
- Message should drive design choices:
  - which data to show
  - what chart type to use
  - which comparisons to highlight

(Source: Better Data Visualisations, J Schwabish)

2. Marks & channels

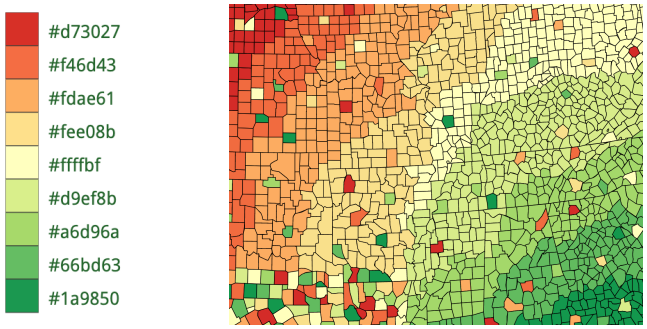
Principles

- **Effectiveness**: encode the most important information with the most effective channel
  - focus is on human perception and ease of understanding: can people easily understand?



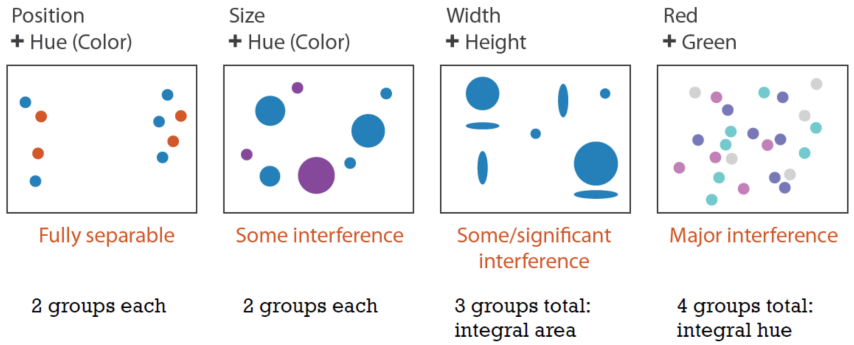
- **Expressiveness**: show *all and only* the information in the data
  - focus is on completeness and accuracy of representation: does it show the right things?

- **Discriminability**: the ability to tell apart distinct values along a single visual channel
  - focus: resolution within 1 channel
  - e.g. small differences in colour can make values hard to distinguish <-> shape = better



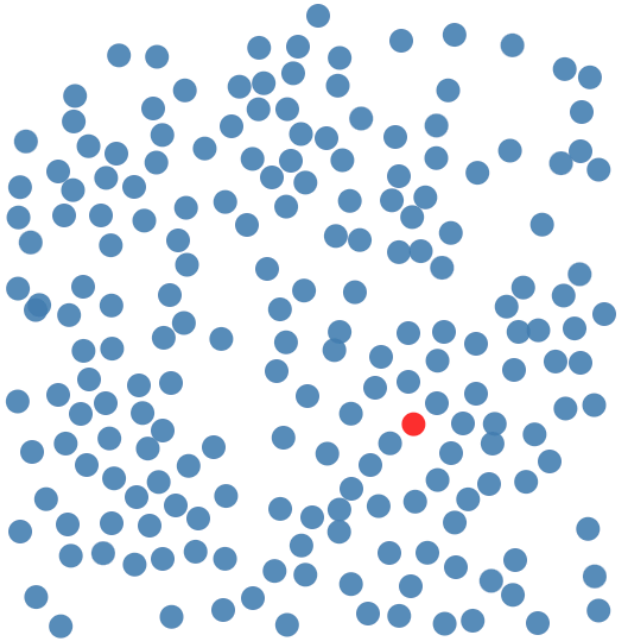


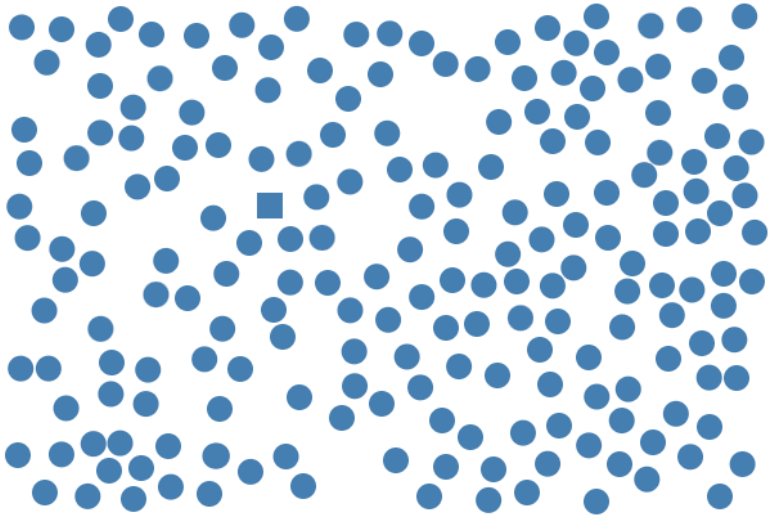
- **Separability**: ability to perceive multiple channels independently when they are used together
  - focus: interference between channels



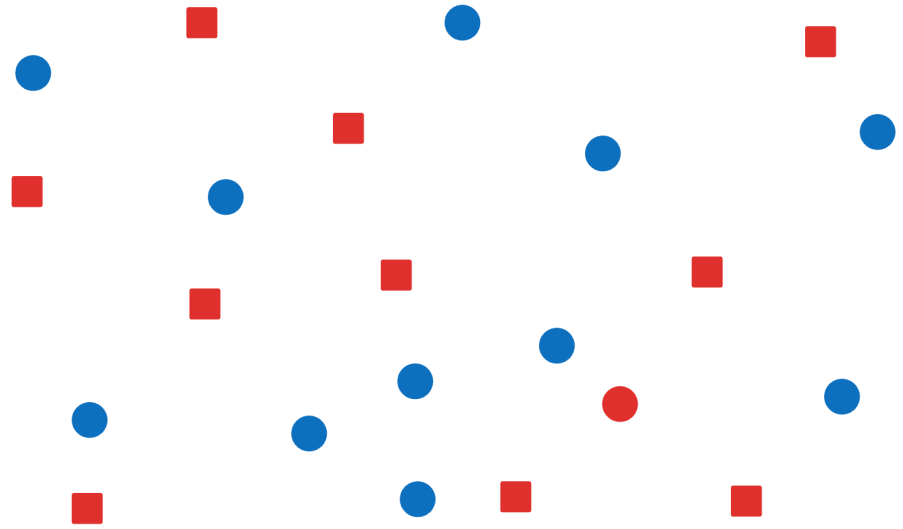
Source: T Munzner

- **pop out effect**: The automatic, preattentive detection of a visual element that differs strongly from others
  - focus: speed and ease of noticing a feature without conscious effort



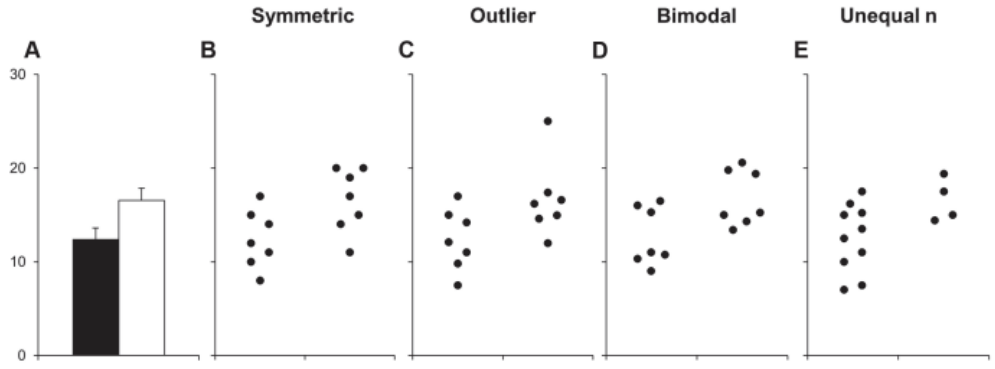


Caution: mixing the channels removes the effect



Make clear what is most important

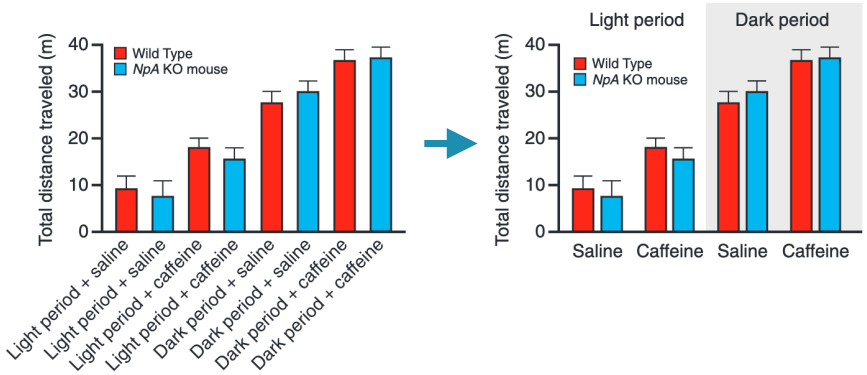
Show the data (no barcharts with error bars...)



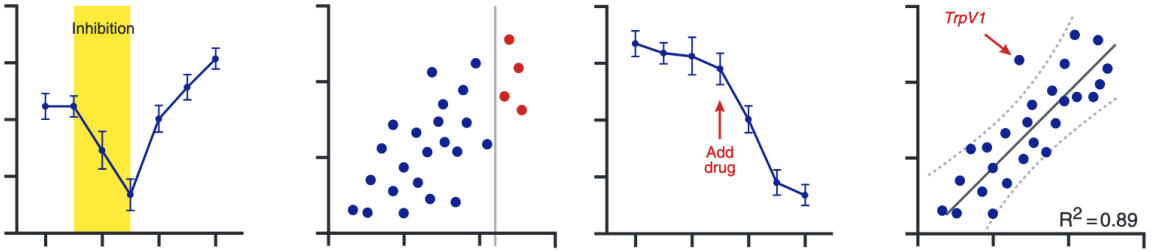
Weissgerber et al, 2015

but do not assume that the reader will pay attention to everything in your visual

- Draw the reader's attention to what you want them to focus on

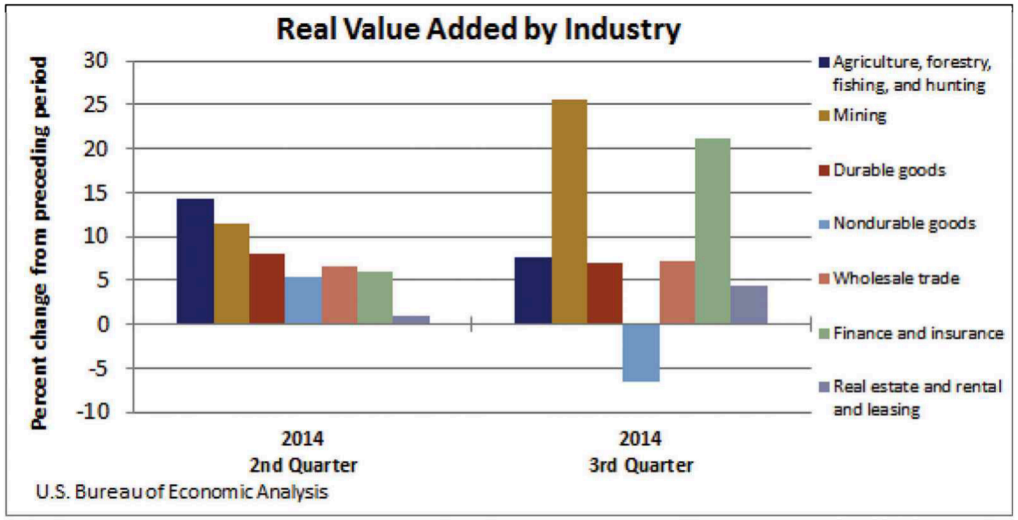


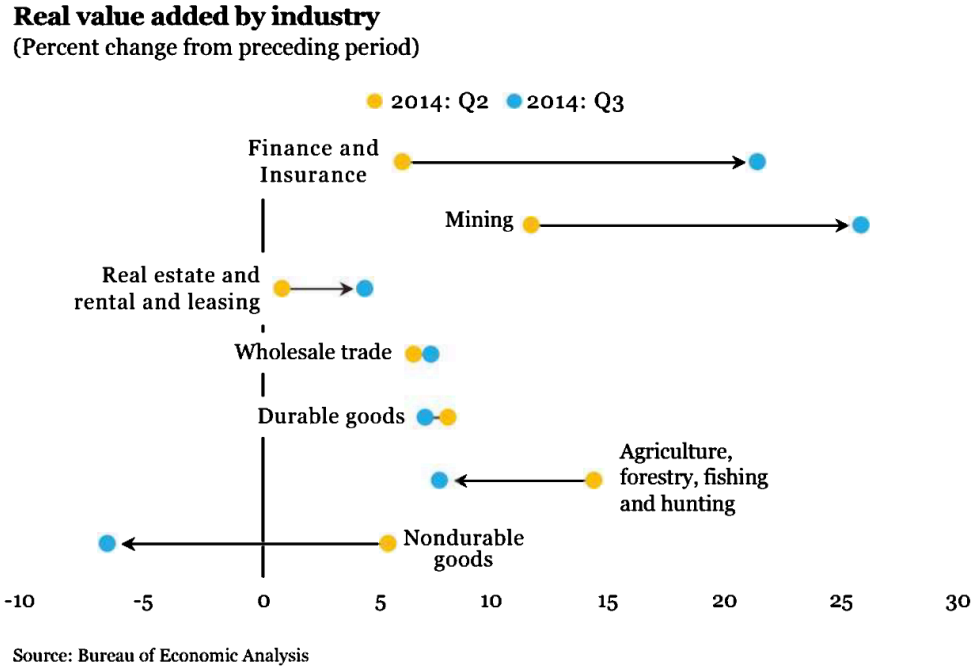
- Highlight data points that are particularly meaningful



Source: Designing Science Presentations - A Visual Guide to Figures, Papers, Slides, Posters, and More (M Carter)

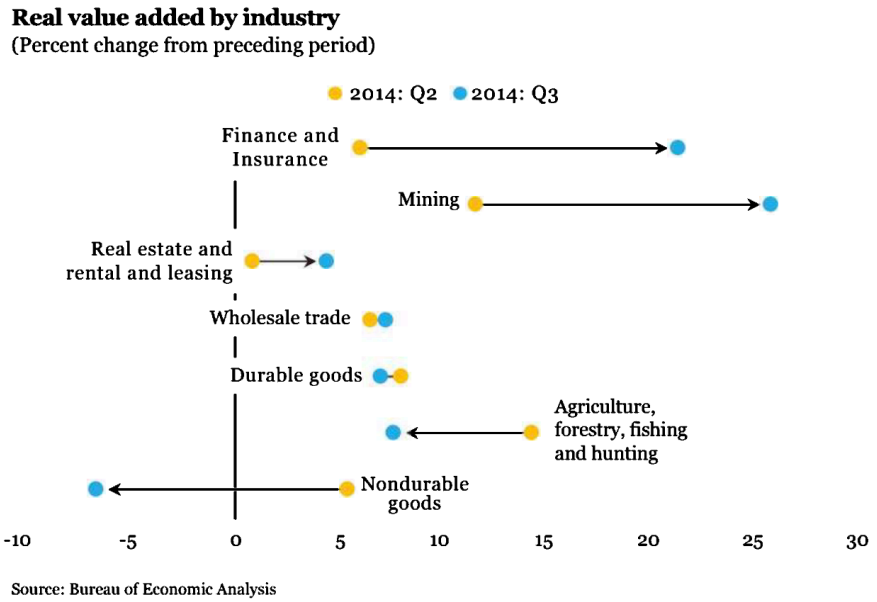
Show what you want to show (i.e. when you want to show change, show the change)

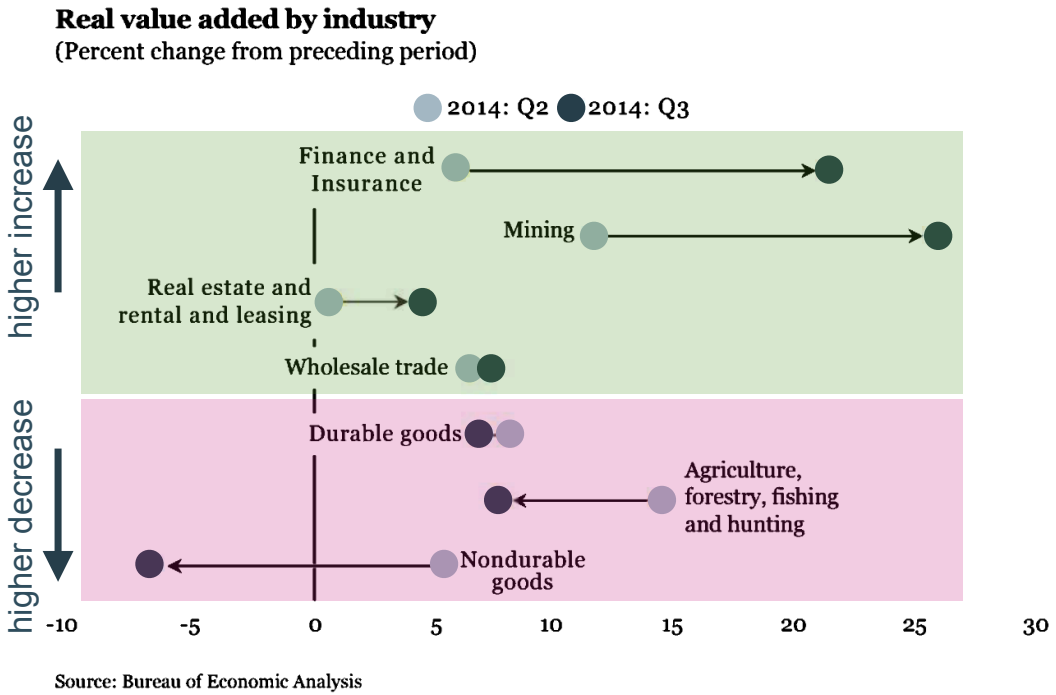




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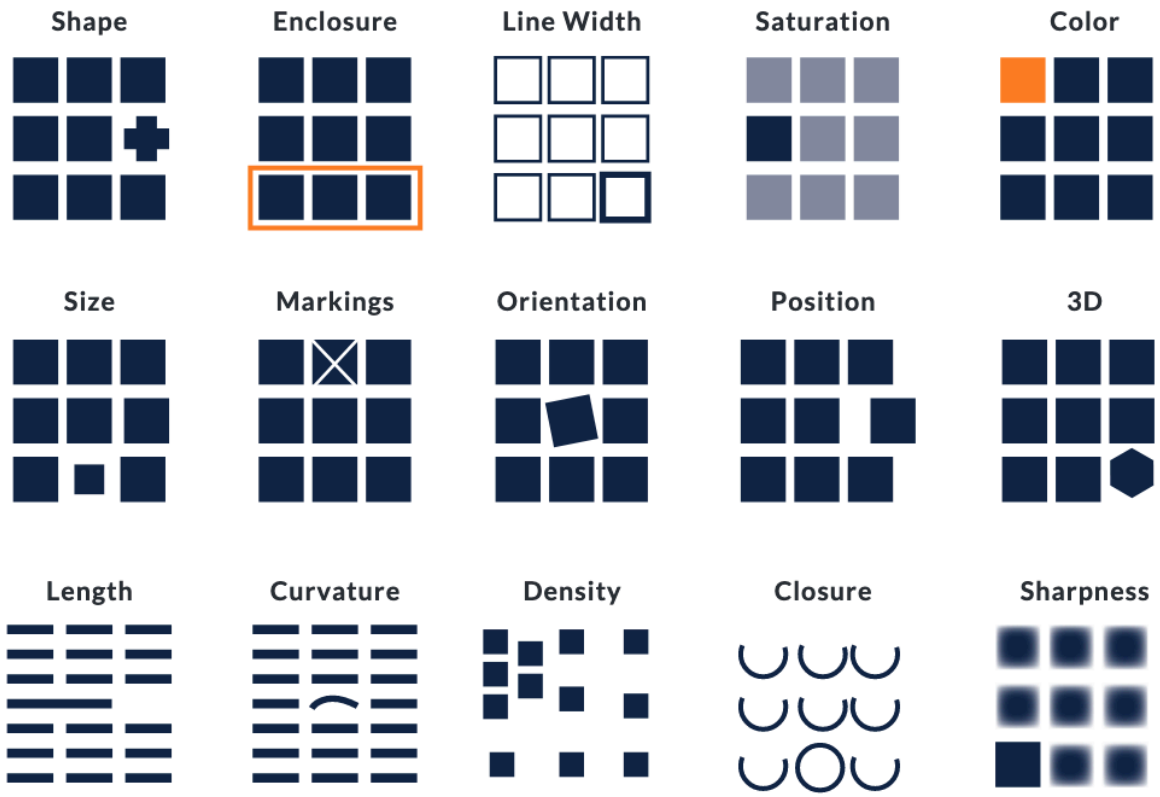
But we can do even better





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Use preattentive vision



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find the largest numbers in the table

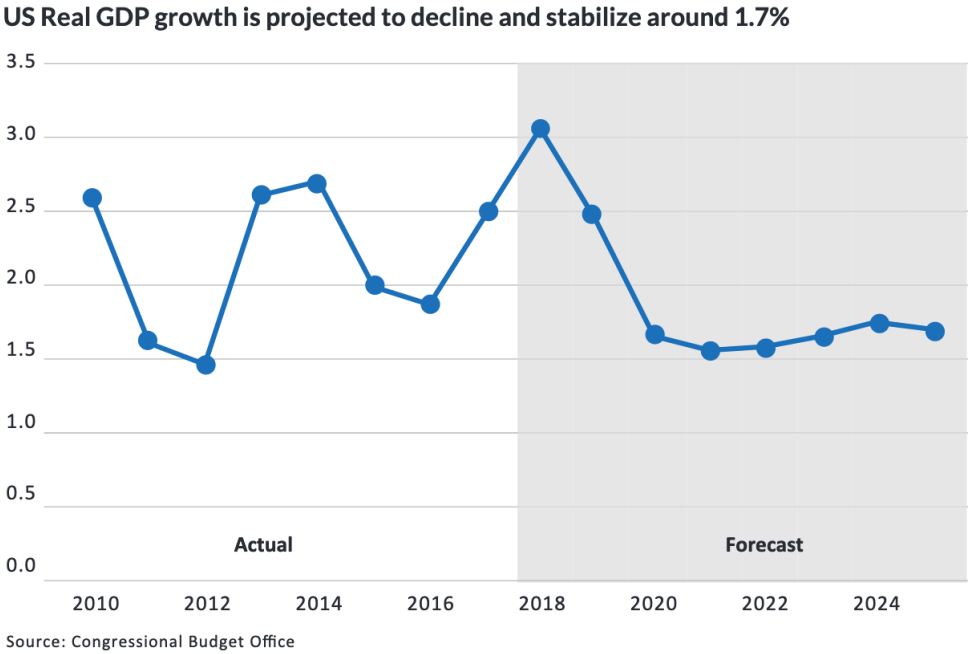
Table 1. Our sales grew to $600 million this year

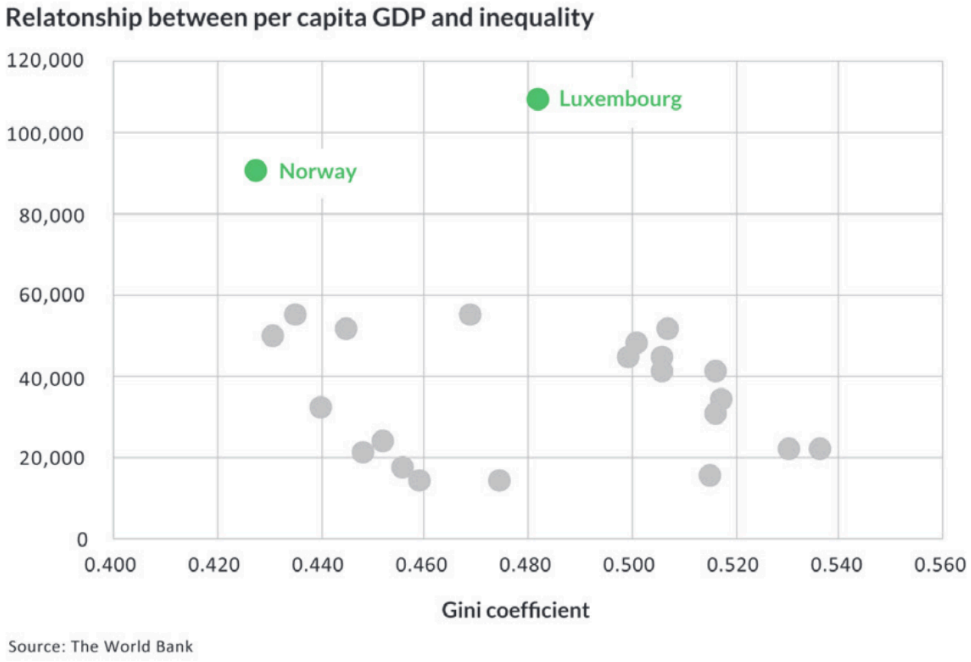
	Q1	Q2	Q3	Q4
Bob	26	35	72	84
Ellie	22	15	61	35
Gerrie	19	20	71	55
Jack	22	95	13	64
Jon	83	62	46	48
Karen	30	65	98	82
Ken	38	28	45	71
Lauren	98	81	41	63
Steve	16	50	23	41
Valerie	46	24	30	57
Total	**$400**	**$475**	**$500**	**$600**

Table 1. Our sales grew to $600 million this year

	Q1	Q2	Q3	Q4
Bob	26	35	72	**84**
Ellie	22	15	61	35
Gerrie	19	20	71	55
Jack	22	**95**	13	64
Jon	83	62	46	48
Karen	30	65	**98**	82
Ken	38	28	45	71
Lauren	**98**	81	41	63
Steve	16	50	23	41
Valerie	46	24	30	57
Total	**$400**	**$475**	**$500**	**$600**

pre-attentive features help to focus on forecast (left) and 2 countries (right)





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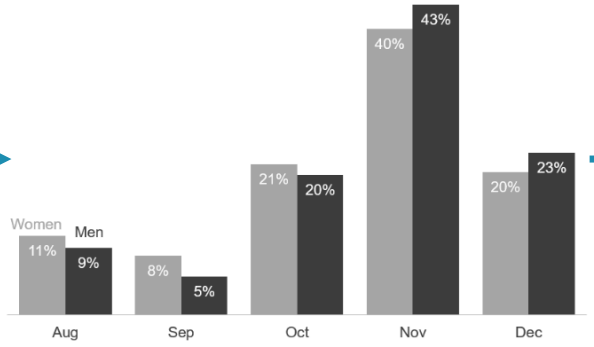
Declutter and focus

Consider data-to-ink ratio



declutter

When people begin shopping for the holidays



Source: US Consumer Retail Reporting Agency, 2017 Q3 and Q4

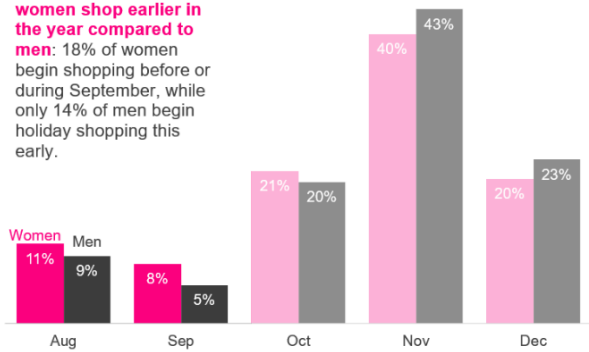
Declutter

- removed background
- removed colour
- changed axes/labels
- changed font
- changed text orientation
- moved numbers inside bars
- changed title to reflect narrative

focus

When people begin shopping for the holidays

A higher proportion of women shop earlier in the year compared to men: 18% of women begin shopping before or during September, while only 14% of men begin holiday shopping this early.



Source: US Consumer Retail Reporting Agency, 2017 Q3 and Q4

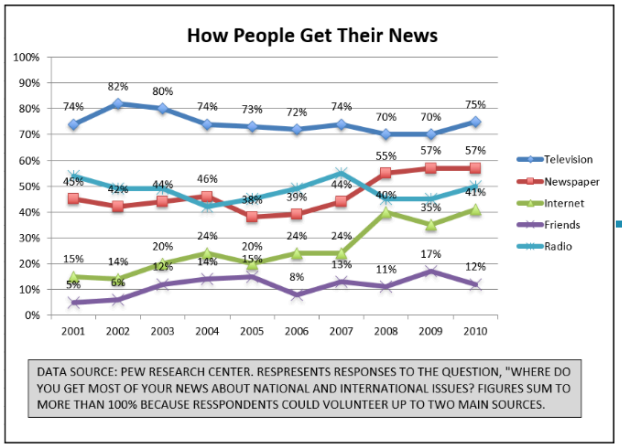
Focus

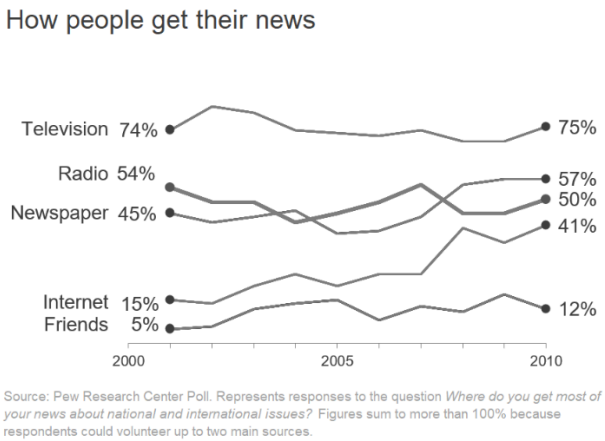
- added annotation
- added colour to highlight
- matched highlight colour to annotation
- added darker shade to highlight August and September

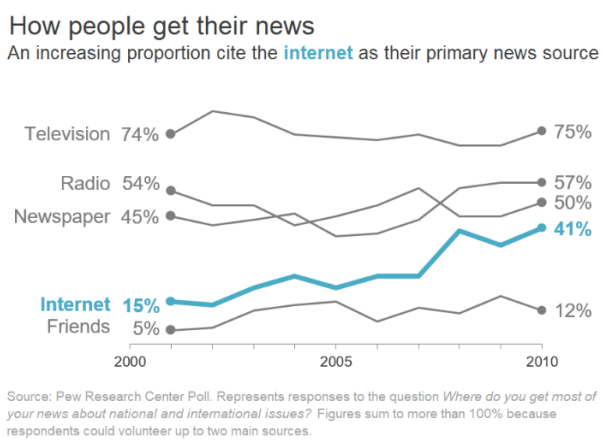
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declutter

focus







Declutter

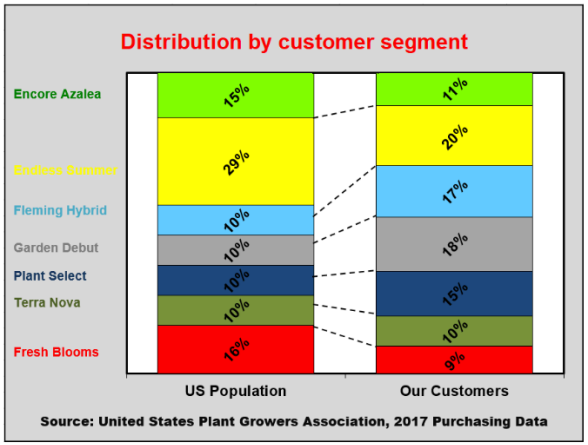
- removed background
- removed colour
- changed axes/labels
- left-aligned title
- removed legend
- removed data markers

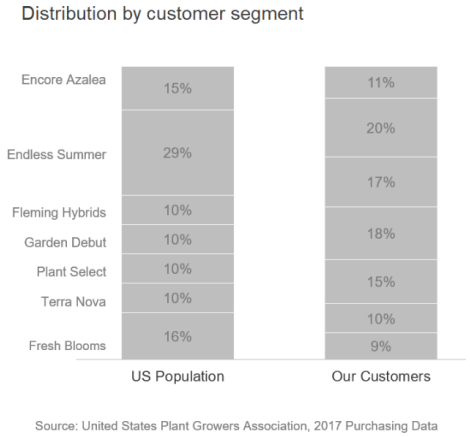
Focus

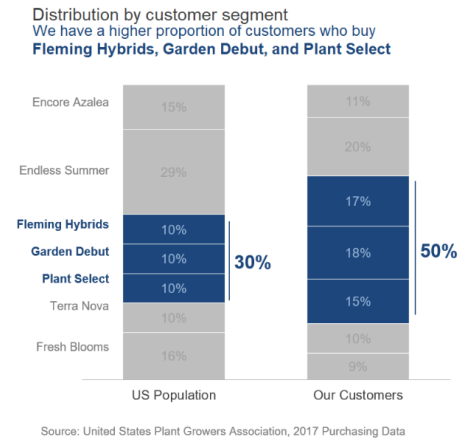
- added annotation
- added colour to highlight
- matched highlight colour to annotation

declutter

focus







Declutter

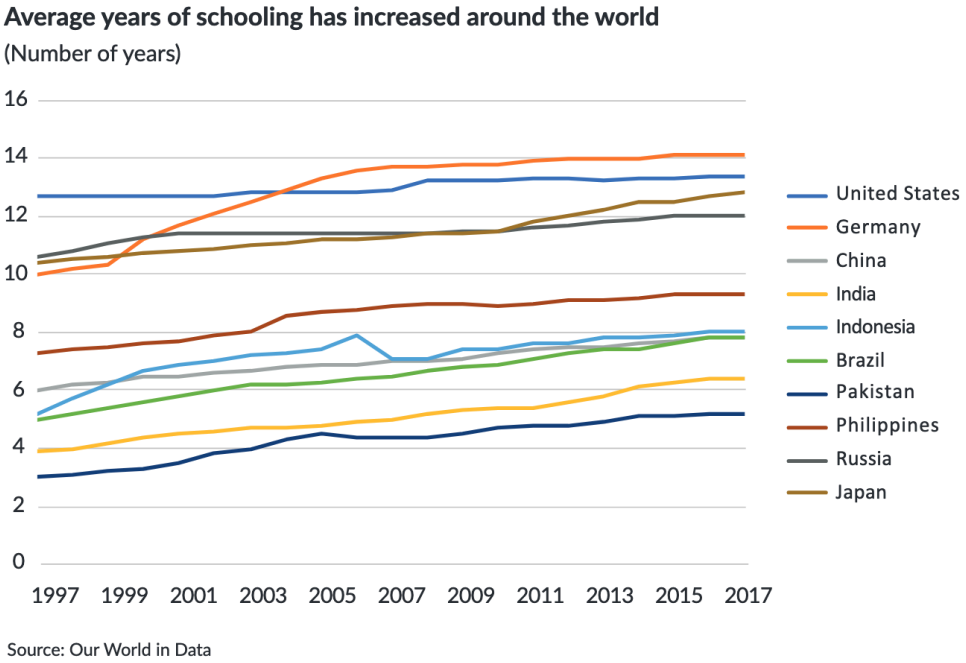
- removed background
- removed colour
- changed axes/labels
- changed font
- changed text orientation
- left-aligned title
- removed dotted lines

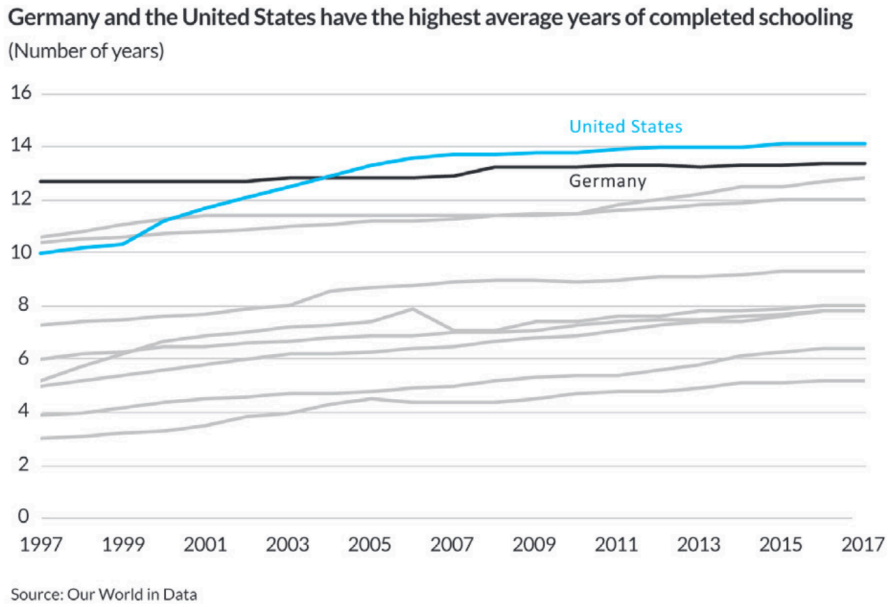
Focus

- added annotation
- added colour to highlight
- matched highlight colour to annotation
- added total percentage of proportions (30% and 50%)

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In short: **start with grey**!



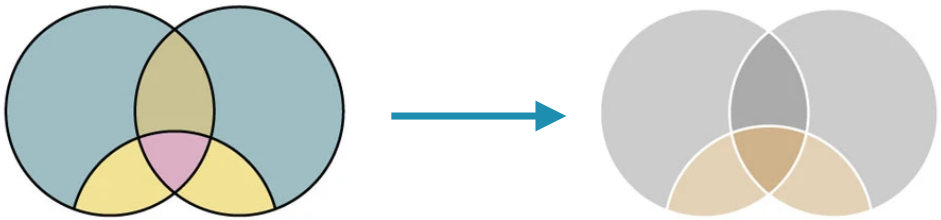


(note: annotation is wrong...)

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Appeal to intuition

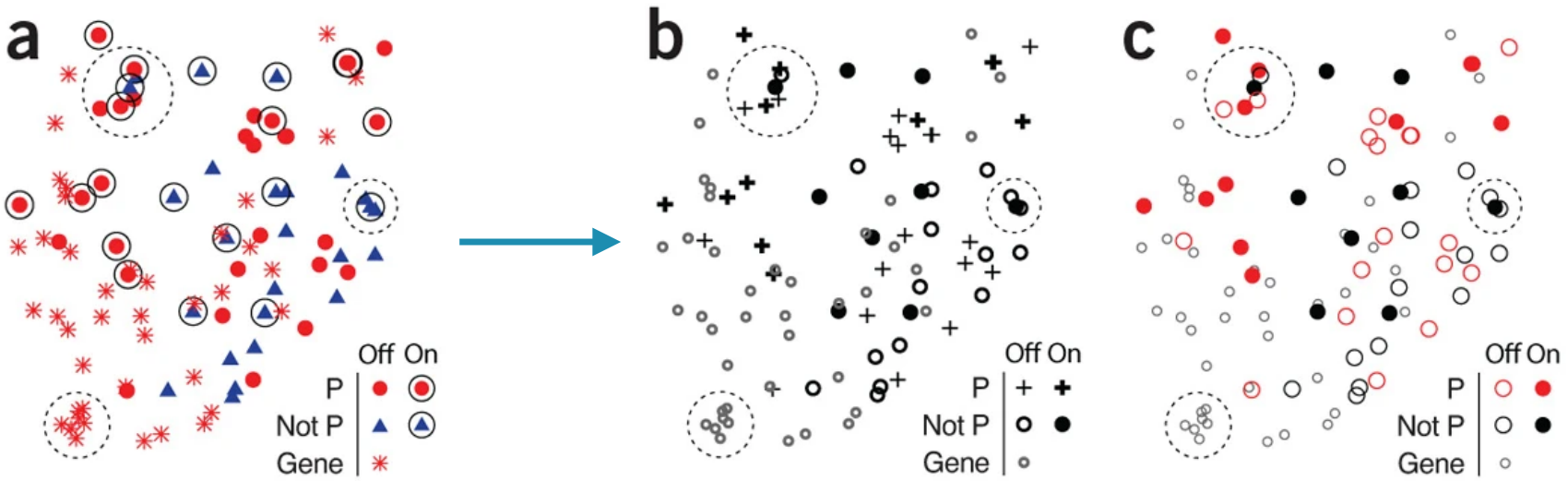
"Objects that interact or share common meaning should be formatted in a similar way" (M Krzywinski, Nature Methods, 2013)





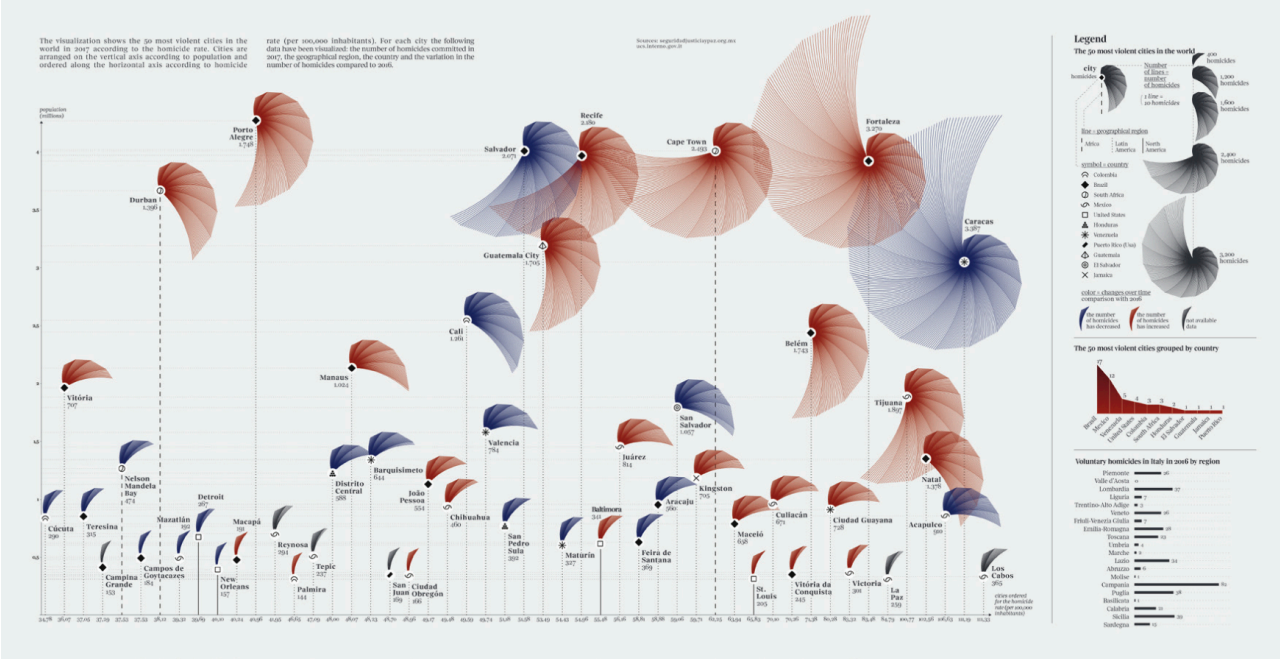
Natural hierarchies in data should be reflected in marks

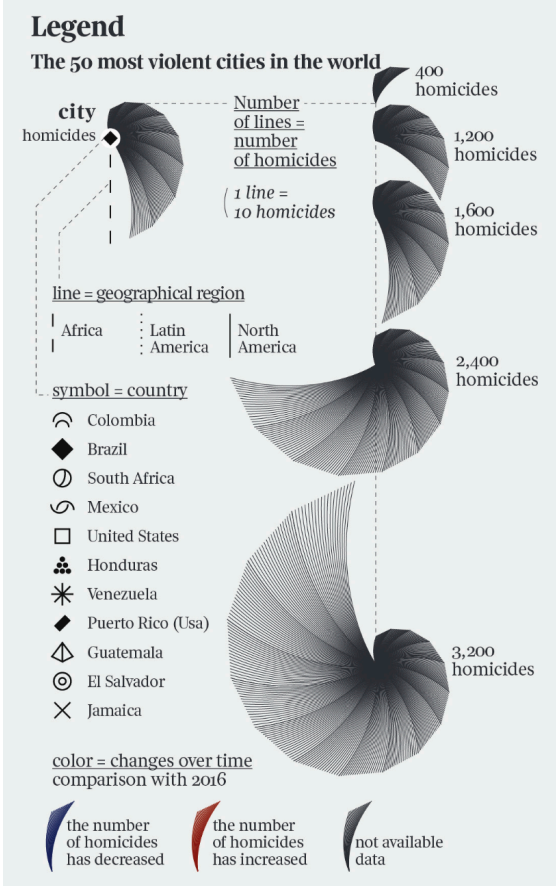
(M Krzywinski & B Wong; Nature Methods 2013)



- more relevant states ("background" gene vs P/Not P gene; transcription on vs transcription off) get higher salience
- use less prominent symbols for data that is less relevant

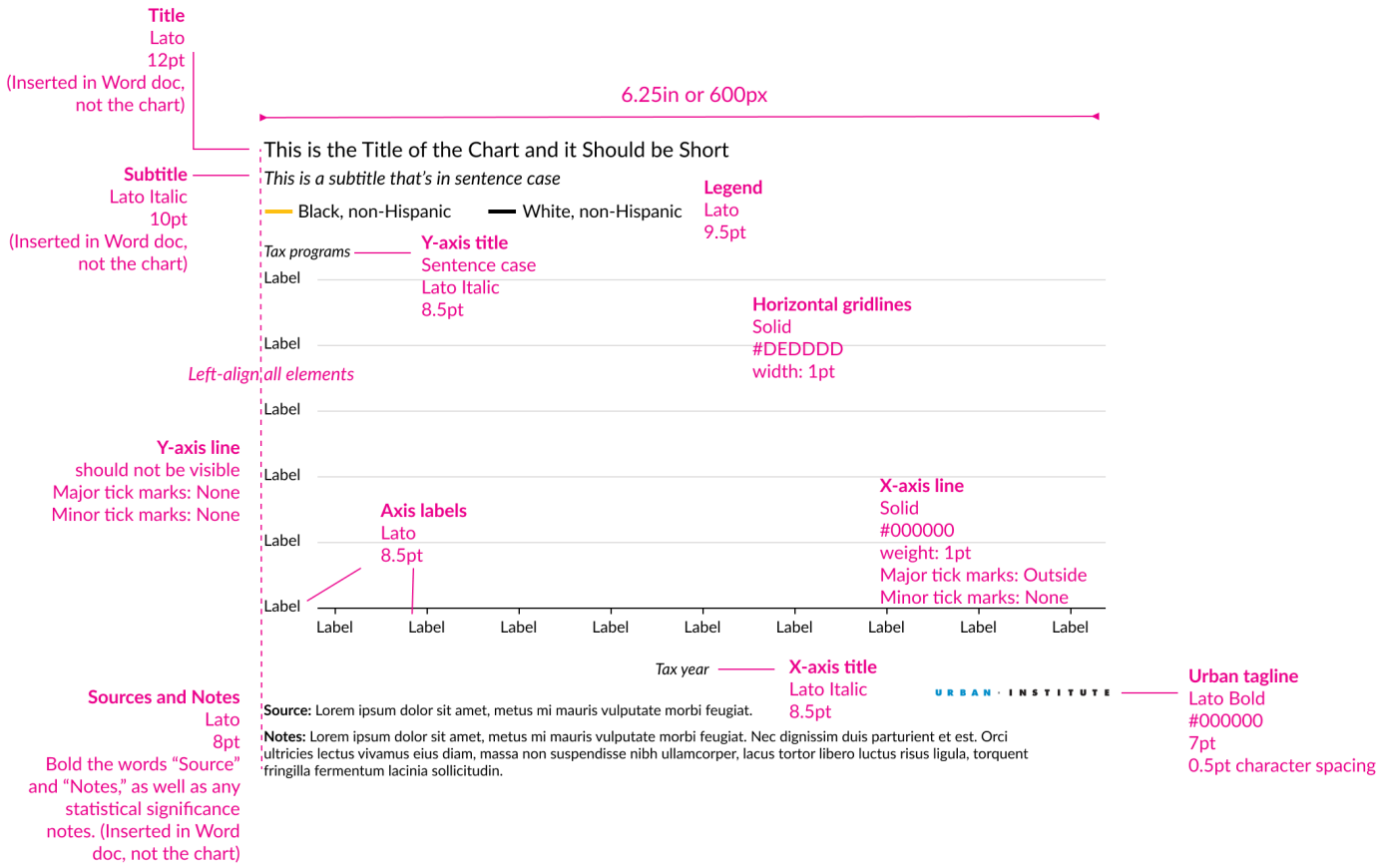
Perceptual accuracy is not always the goal: letting readers engage with a graph can be just as important





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Be consistent (as if using a style guide)



Source: Urban Institute Graphics Style Guide https://urbaninstitute.github.io/graphics-styleguide/

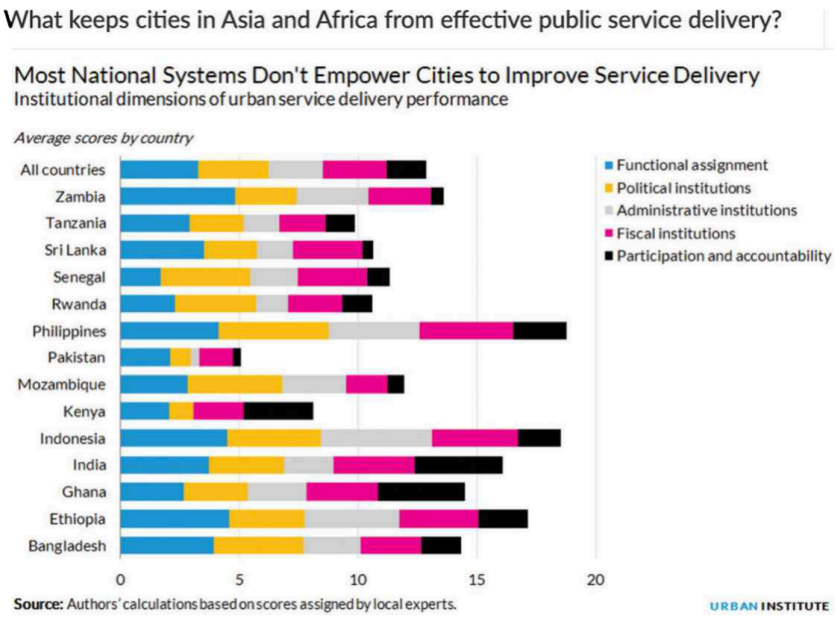
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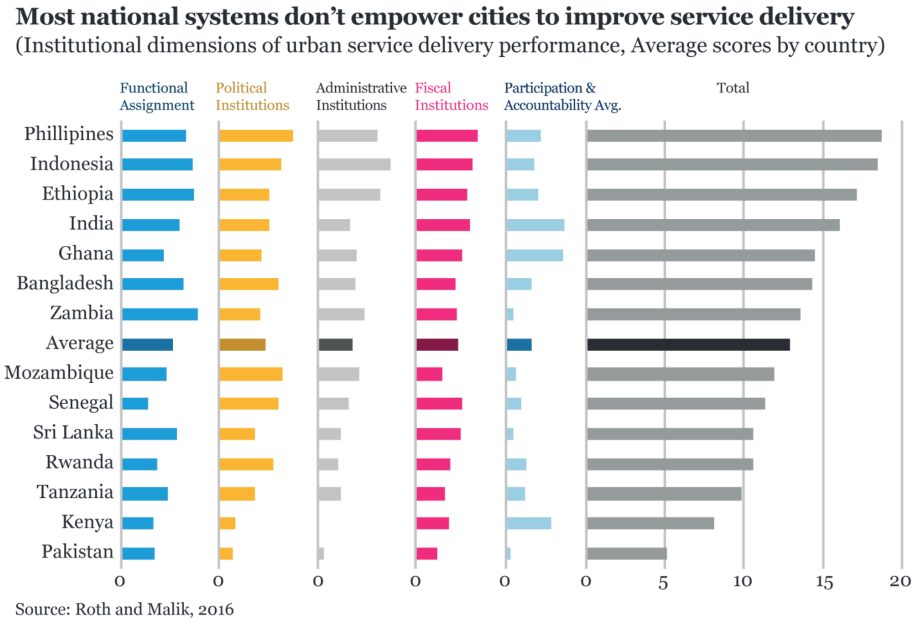
3. Composition

- grid and alignments
- balance
- hierarchy and focus
- order

small multiples

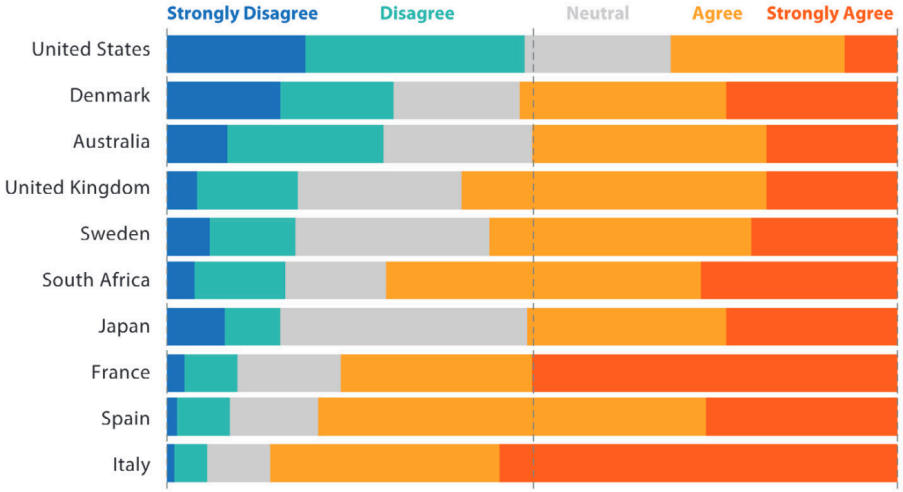
sorted by total score





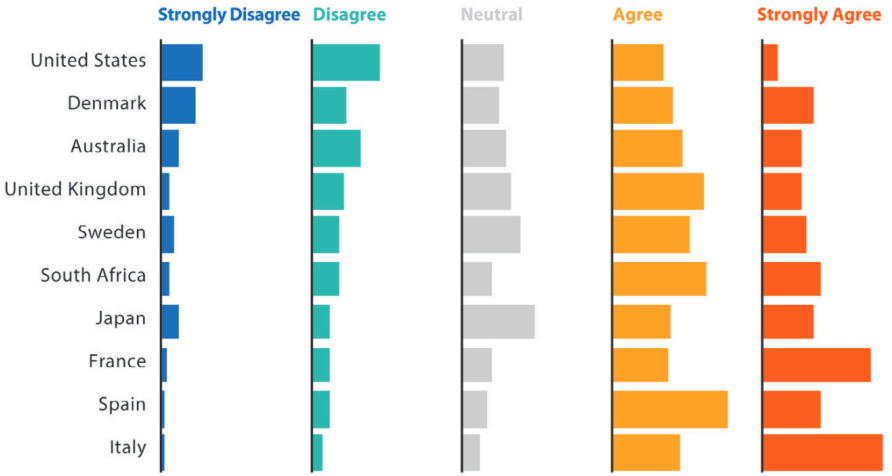
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It is the responsibility of government to reduce differences in income between people with high & low incomes
(Percent)



Source: International Social Survey Programme, 2009

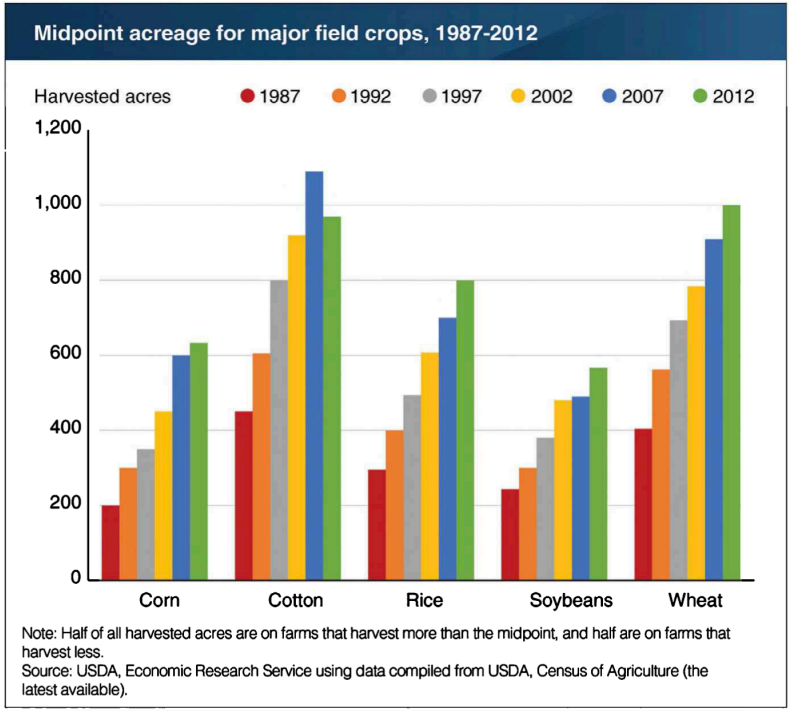
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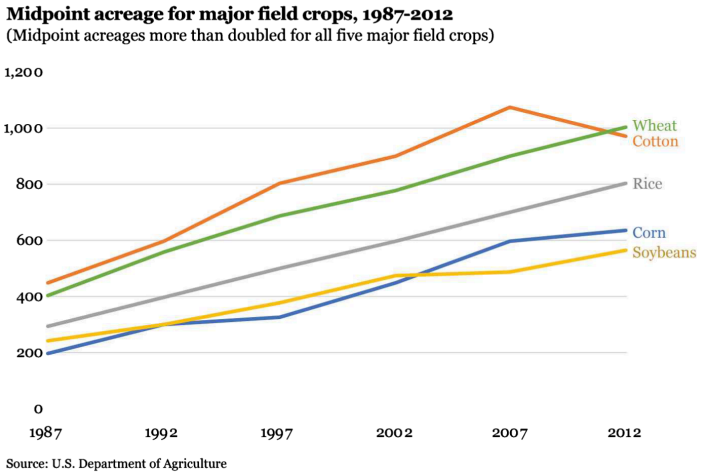


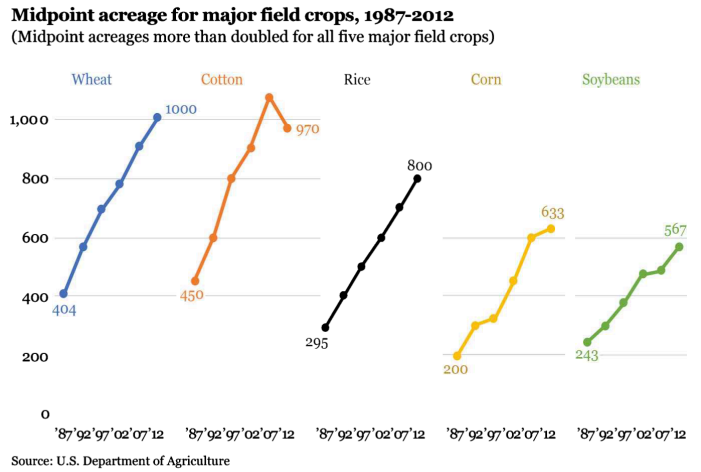
Source: International Social Survey Programme, 2009

show the change

small multiples

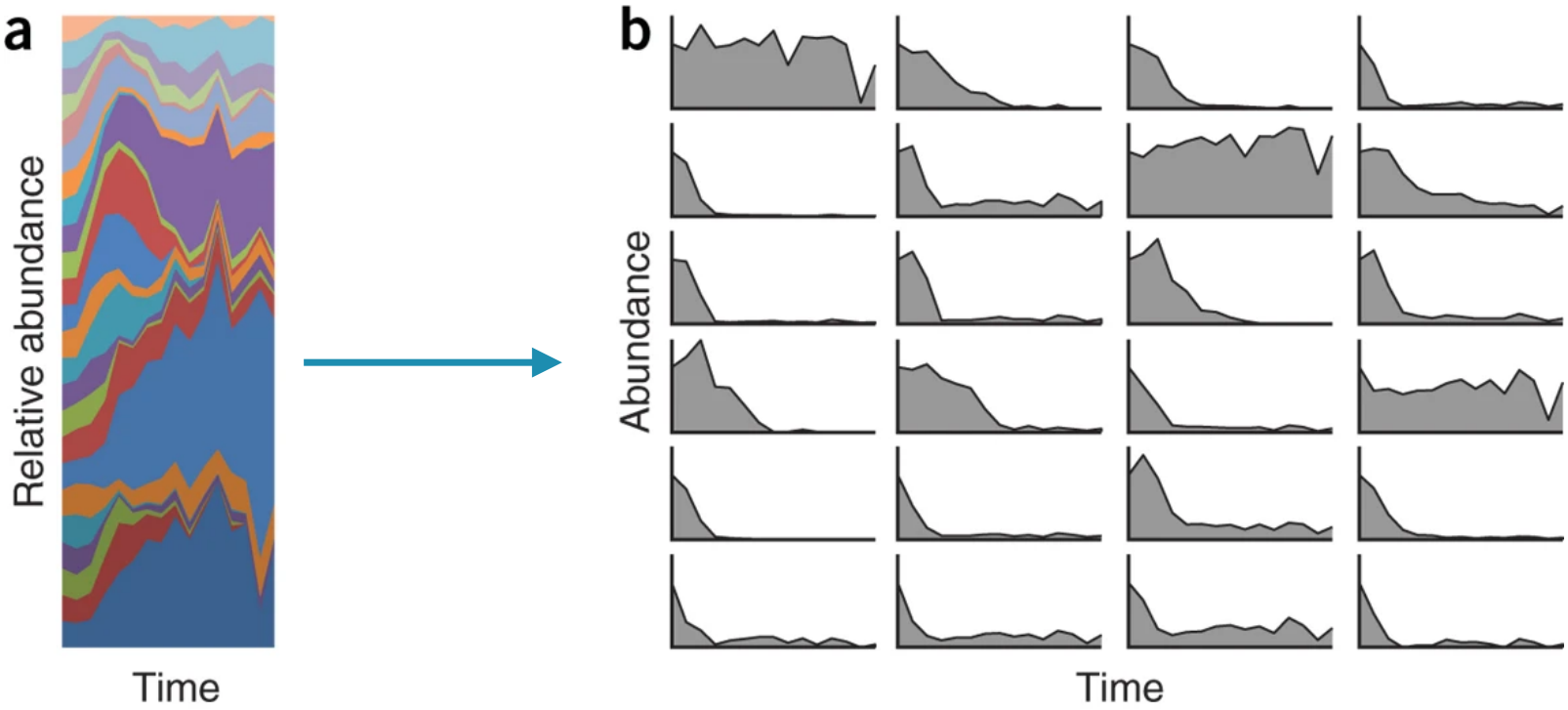






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small multiples



relative proportions of 24 cell lines over time

Source: Shoresh & Wong, Nature Methods, 2012

4. Visuals and text

"The annotation layer is the most important thing we do...
otherwise it's a case of 'here it is, you go figure it out'"

(Amanda Cox, Data Editor at New York Times)

Best chart titles are conclusions

Vague

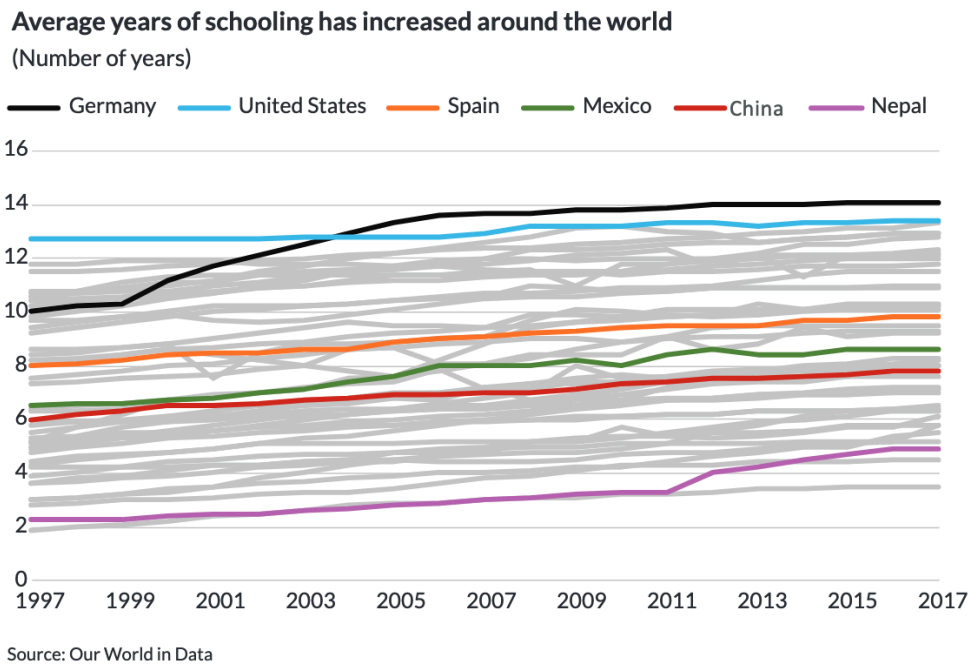
- Mass of rats over time
- Annual income versus socioeconomic background
- Effects of microstimulation of FEF on visual perception
- Flies lacking *Smu2*
- Three-year prognosis after treatment

Conclusive

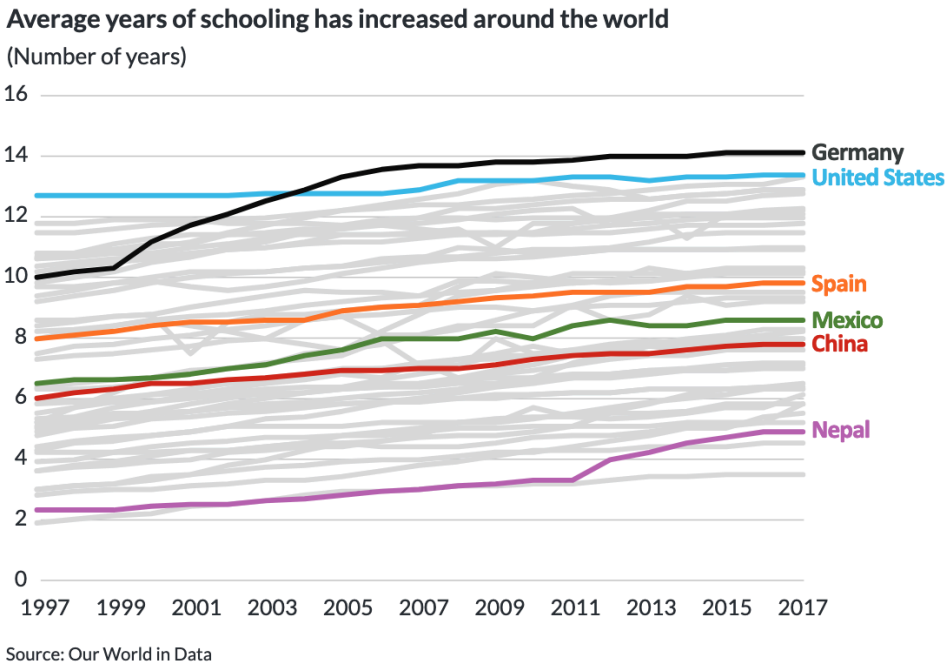
- Rats on a high fat diet statistically increase mass over time compared to rats fed normal chow
- Annual income positively correlates with socioeconomic background
- Microstimulation of the FEF statistically increases performance on a visual perception task
- *Smu2*-null flies show no preference for sucrose versus quinine
- Increase in survival rate 3 years after treatment

Source: Designing Science Presentations - A Visual Guide to Figures, Papers, Slides, Posters, and More (M Carter)

Remove legends if possible and label data directly



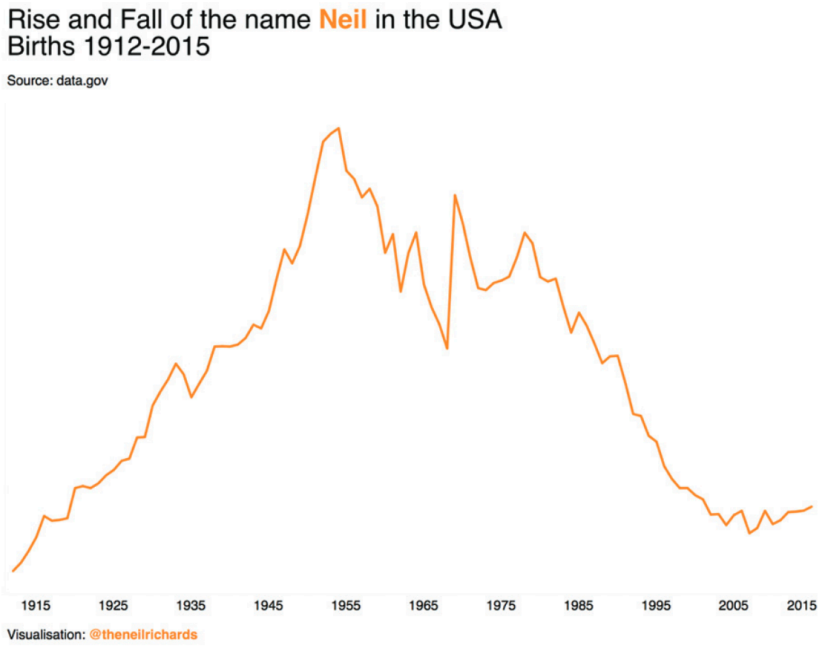
Source: Our World in Data

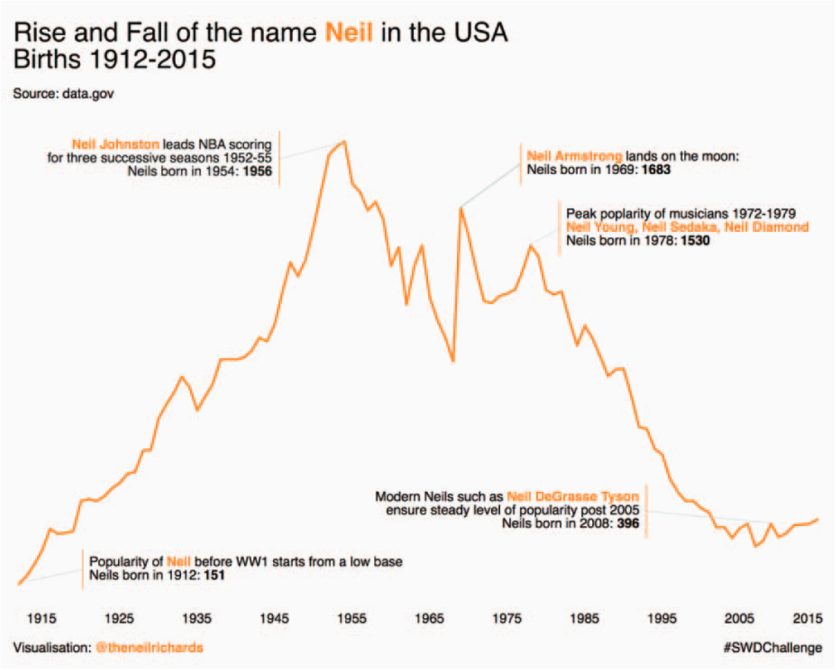


Source: Our World in Data

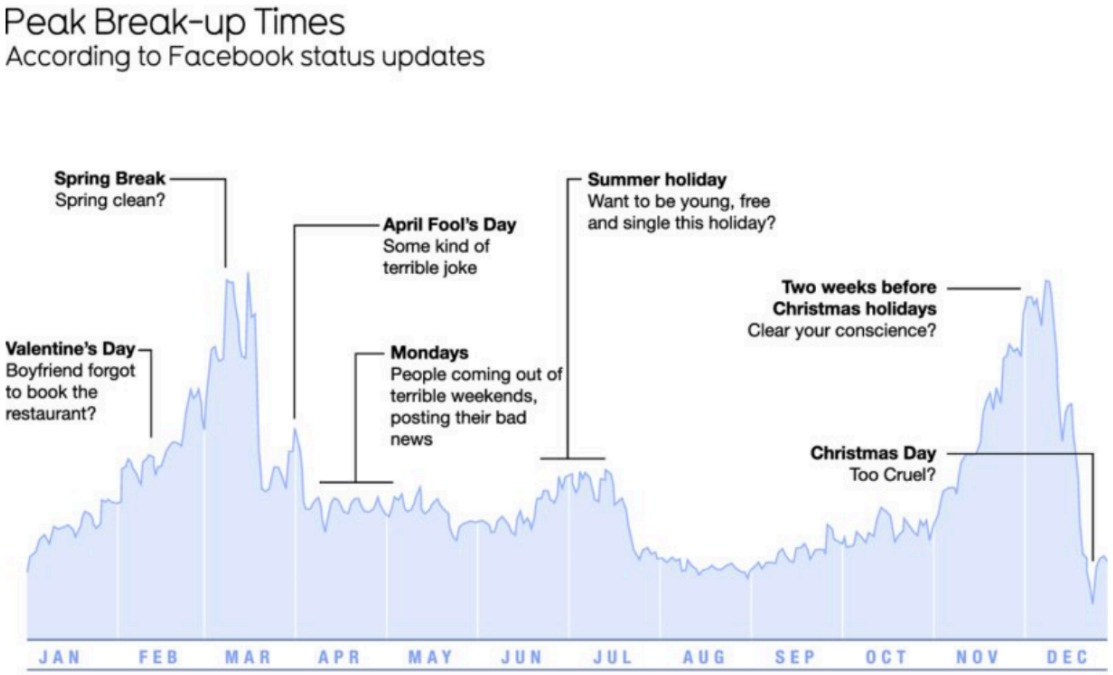
Add explainers

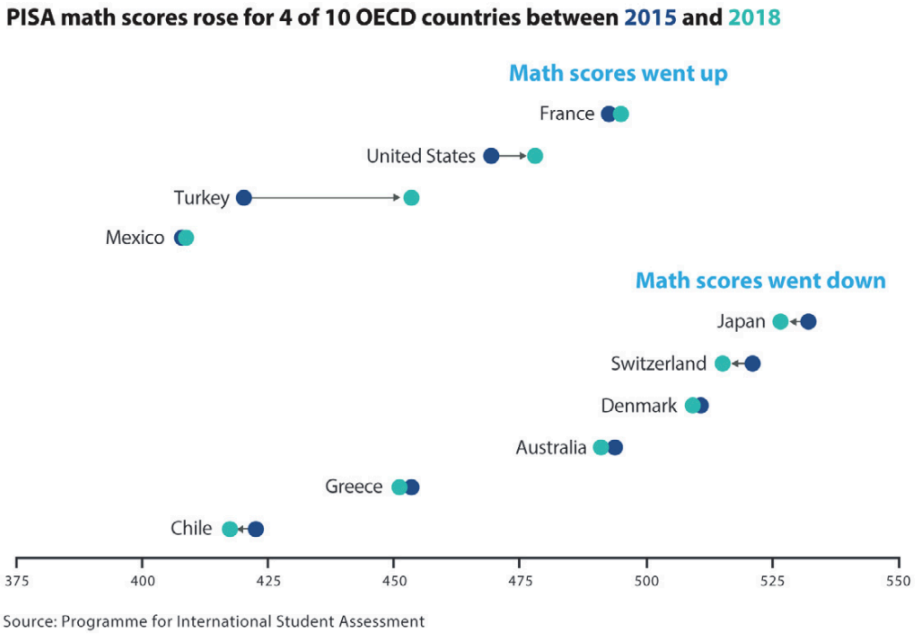
- push your argument
- highlight points of interest (outliers, variations, insights, ...)
- explain how to read it





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Source: Programme for International Student Assessment

Tools

SVG editing software

- manipulate objects
  - select, move, scale, rotate, group, layer
- style and change appearance
  - stroke, fill
- handle text
  - add/remove text, change font
- align and define layout
  - align & distribute objects
- layers and grouping
  - control visibility, order and locking

often aimed for user interface design

Figma

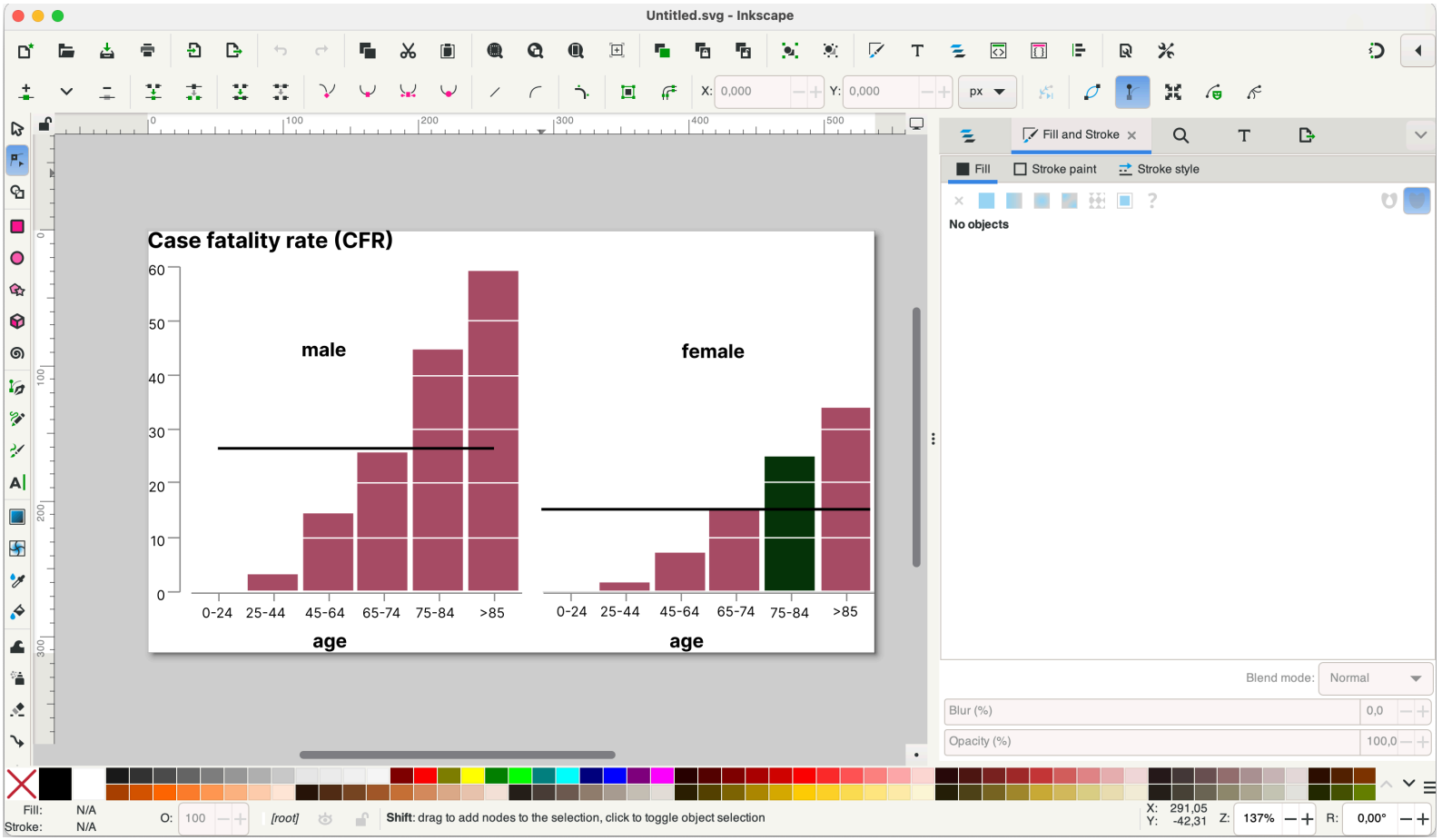
figma.com



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Inkscape

inkscape.org



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