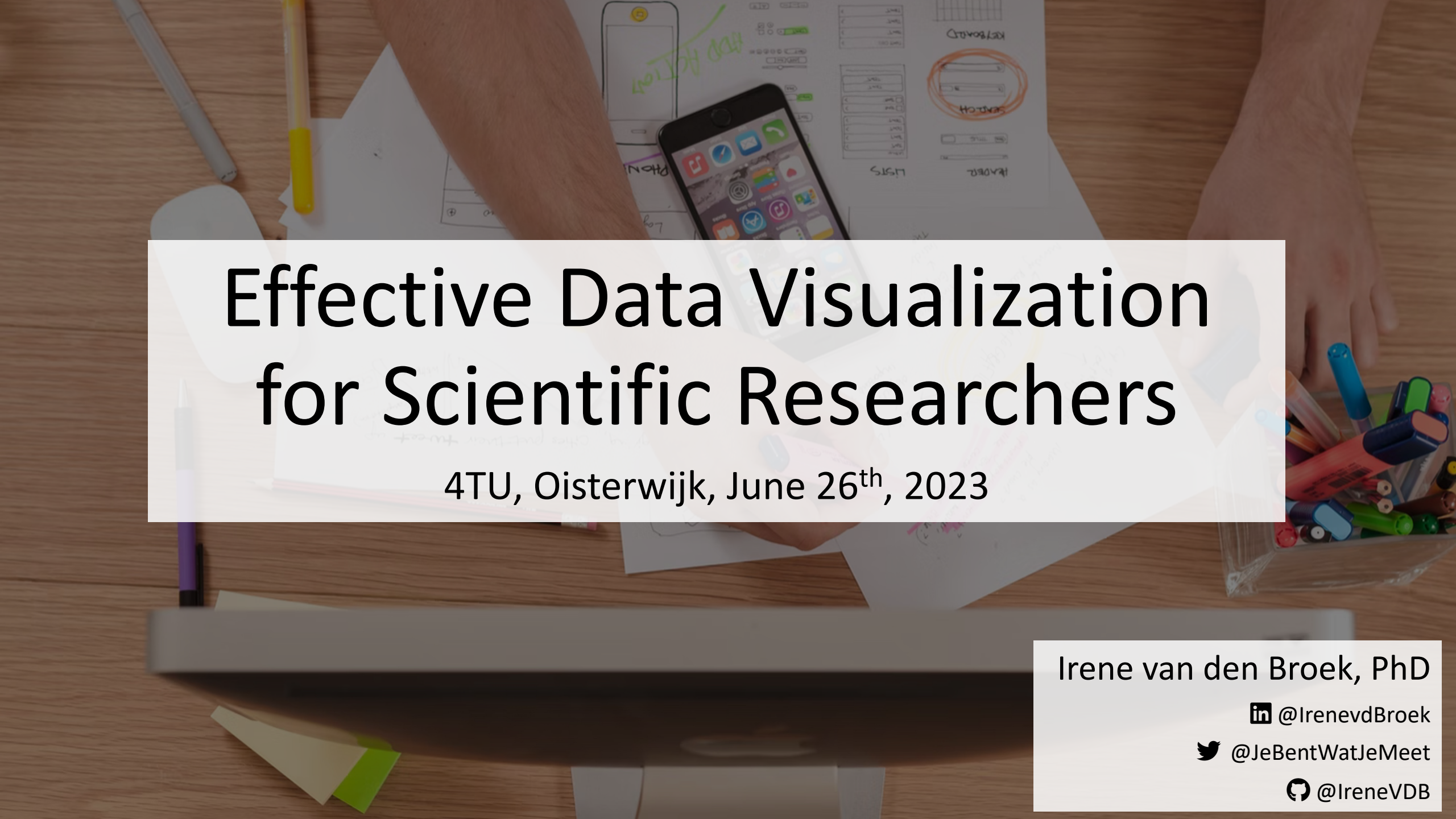


Effective Data Visualization for Scientific Researchers

4TU, Oisterwijk, June 26th, 2023

Irene van den Broek, PhD

@IrenevdBroek

@JeBentWatJeMeet

@IreneVDB

Hi there, I’m Irene!

Irene van den Broek

irenevandenbroek@gmail.com

I have a background in biomarker research

Liquid chromatography coupled to tandem mass spectrometry for the **quantitative bioanalysis** of bioactive and potential **biomarker peptides**

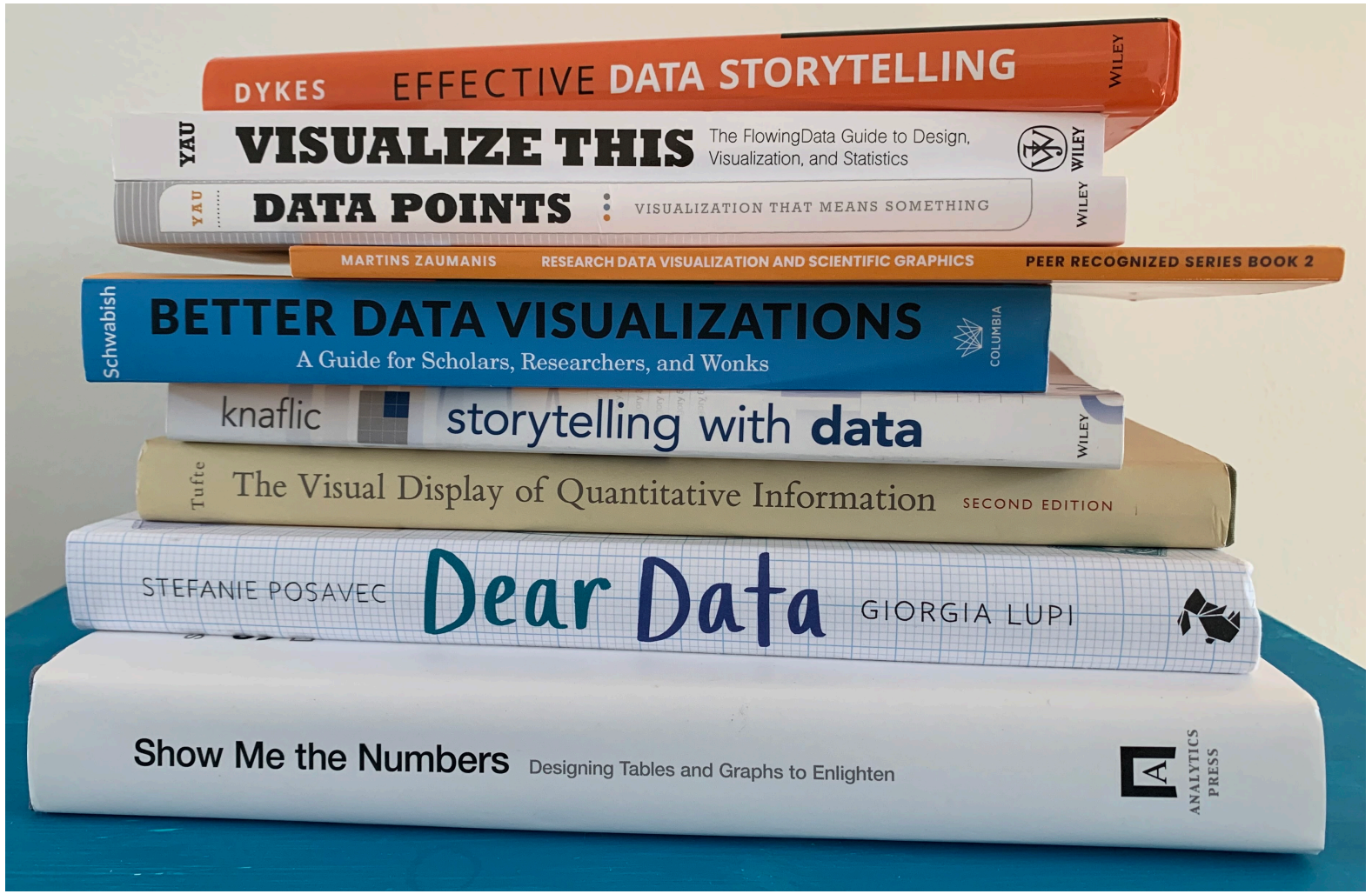
Irene van den Broek 2010

2005-2010
Utrecht University

2013-2015
Leiden University Medical Center

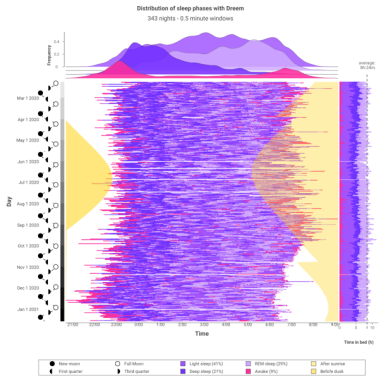
2015-2019
Cedars-Sinai Medical Center

But when I learned Data Viz is a field on its own, I was hooked!

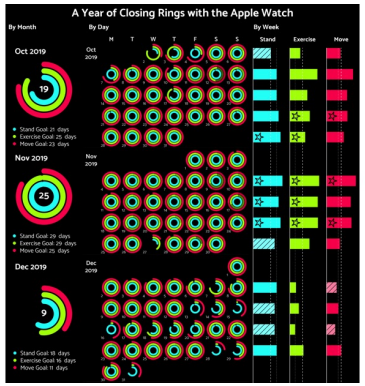


I started visualizing my Health and Habits.

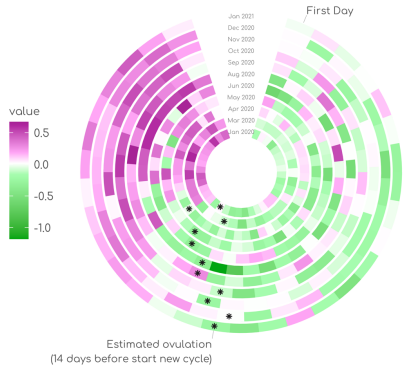
Sleep



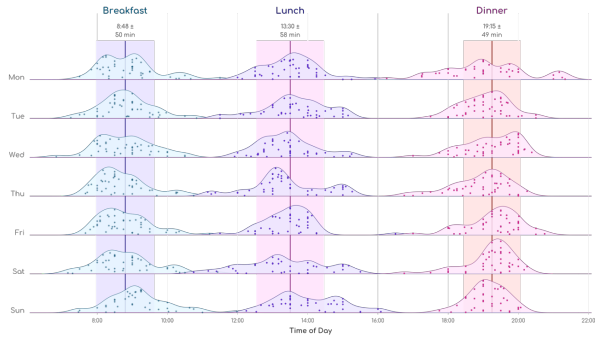
Activity



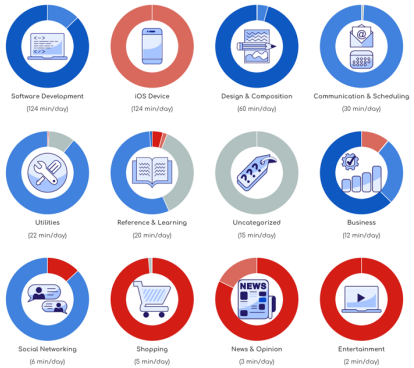
Body



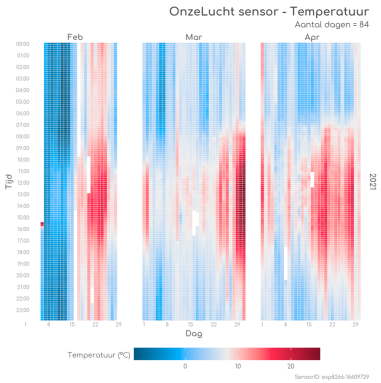
Food



Habits

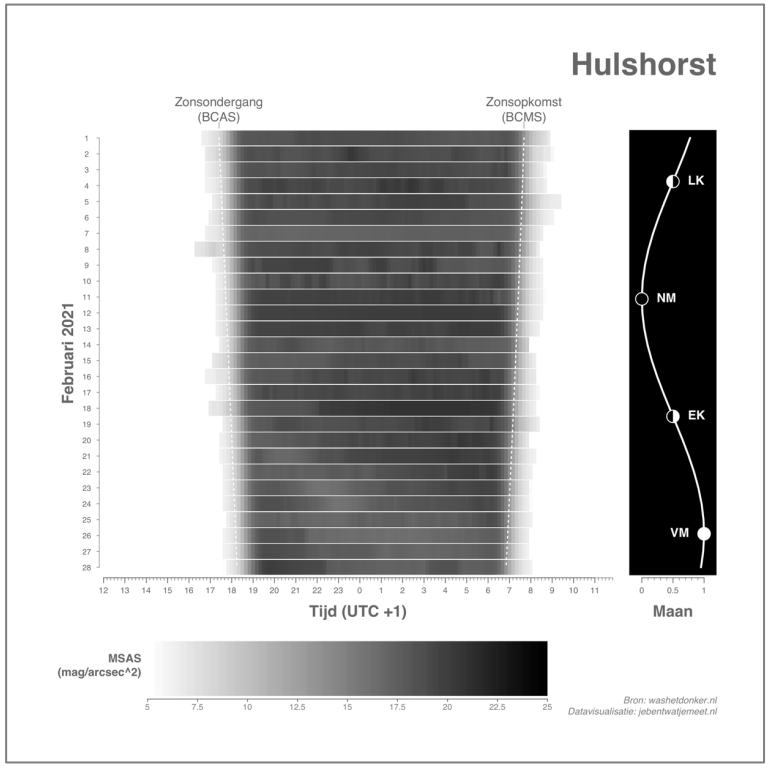


Environment



https://www.jebentwatjemeet.nl
https://irenevdb.rbind.io

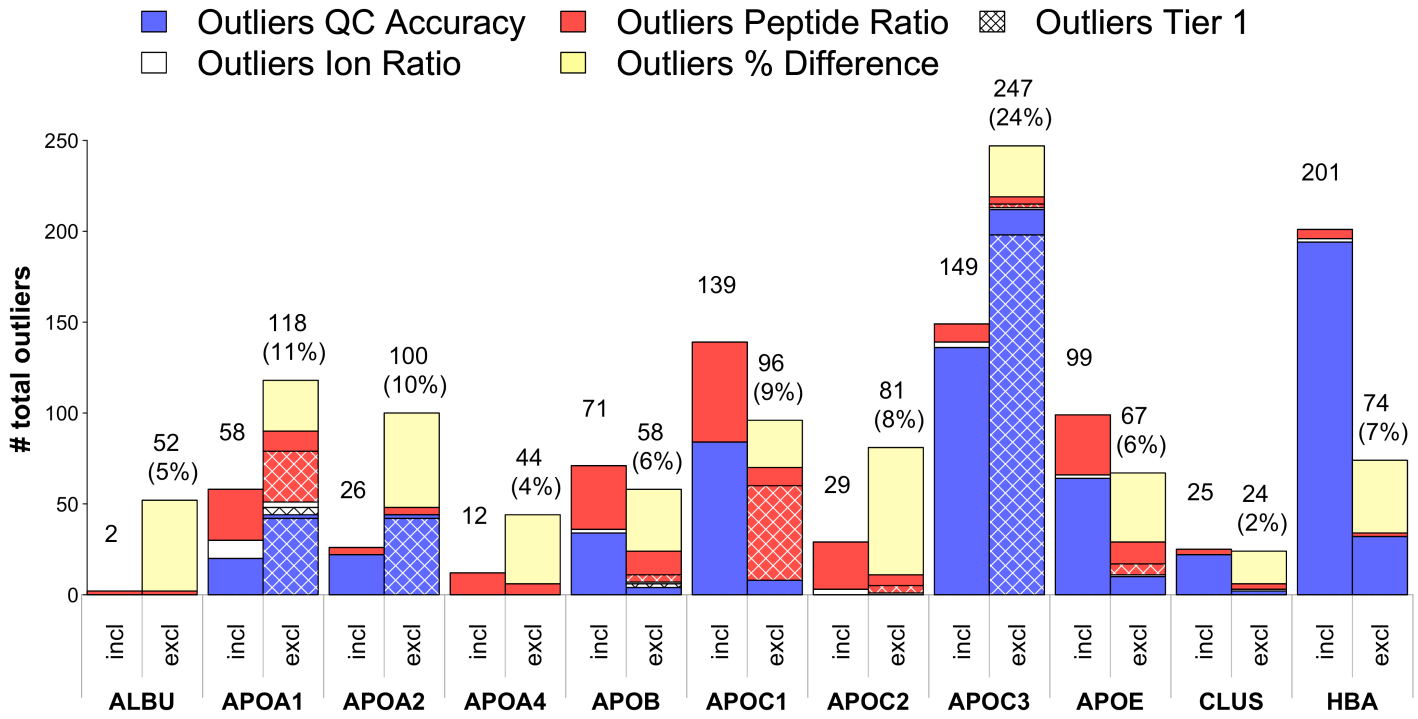
And now combine my passions for teaching and data visualization

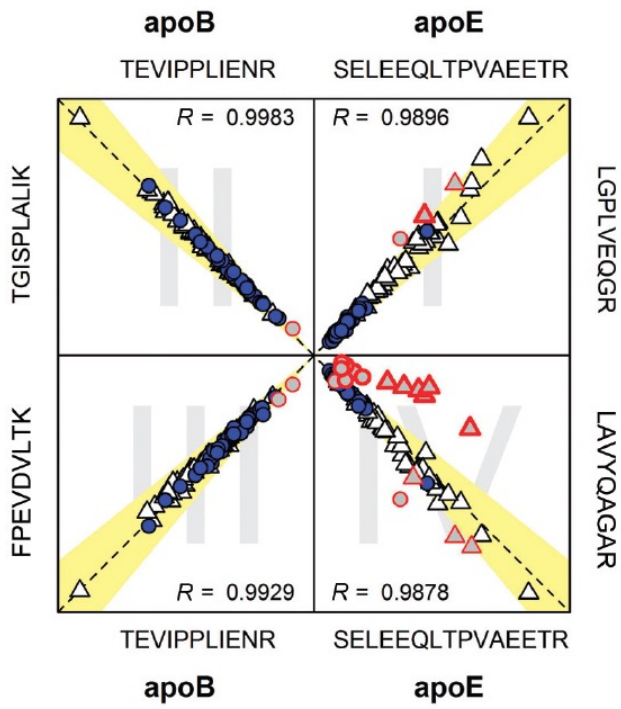


www.washetdonker.nl

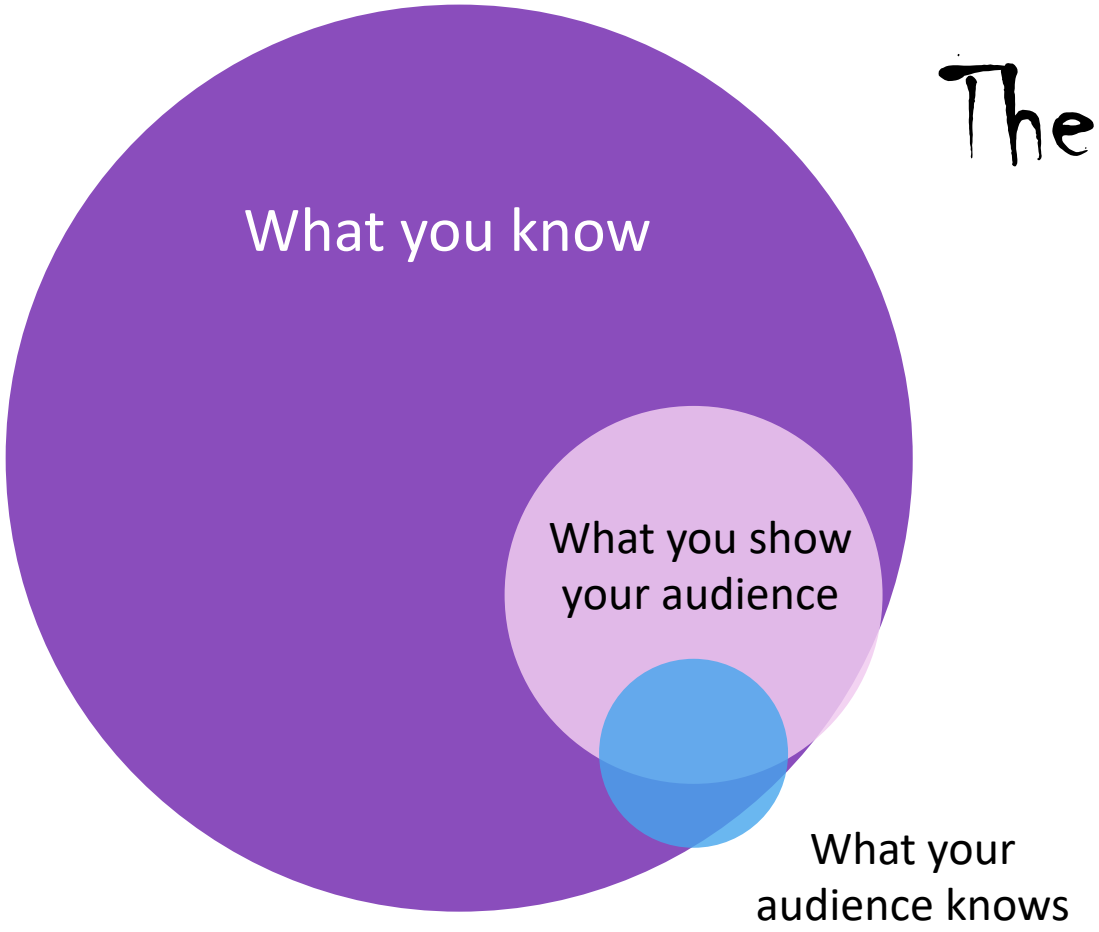
www.onzelucht.nl

I’m excited to share with you what I wish I’d learned during my PhD!





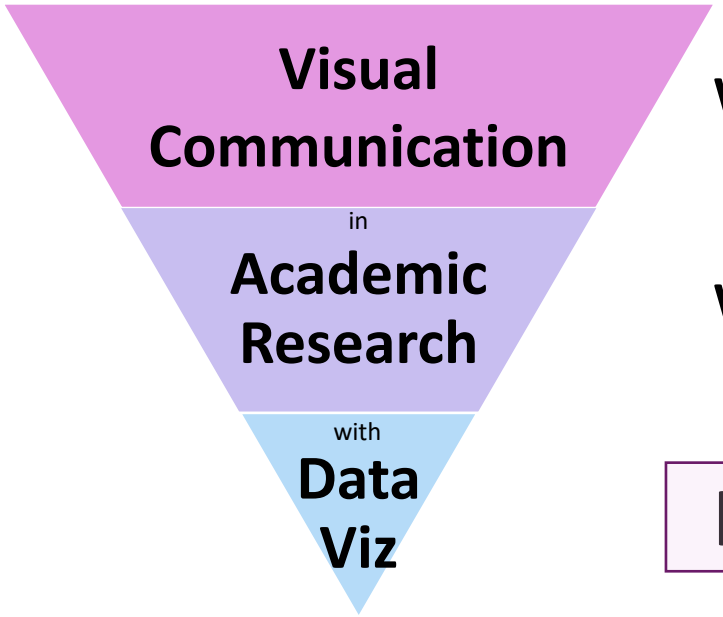
Don’t underestimate how smart you are!



The curse of knowledge

Resist the urge to show *everything*!

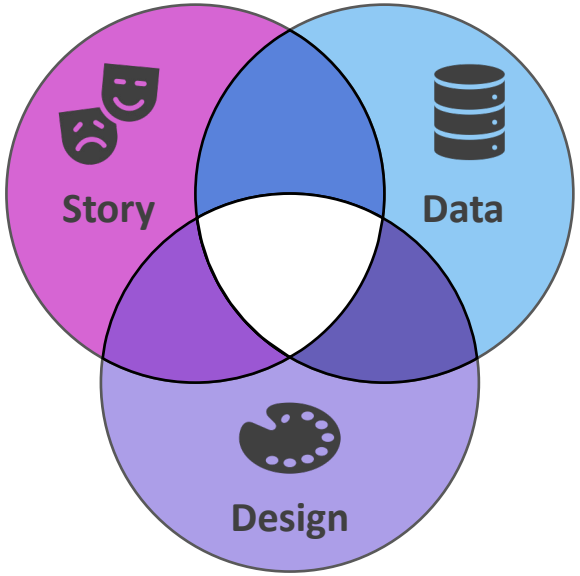
An overview for today:



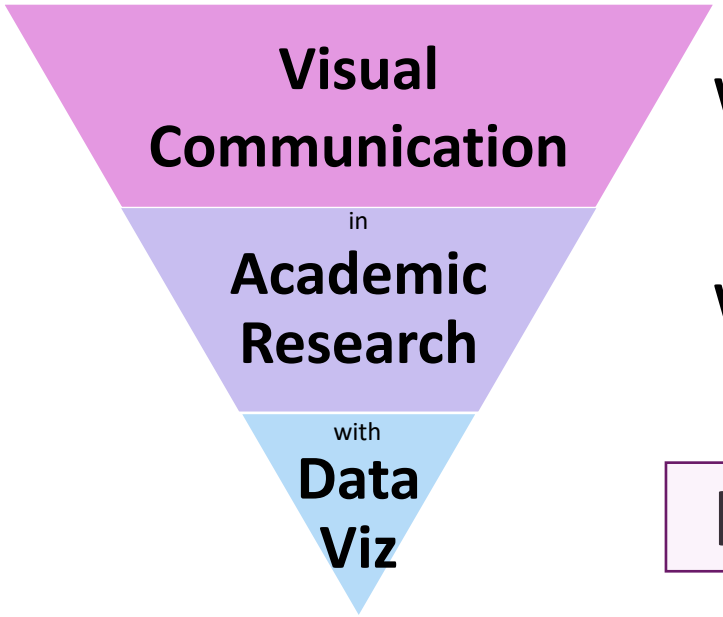
WHY?

WHAT?

HOW?



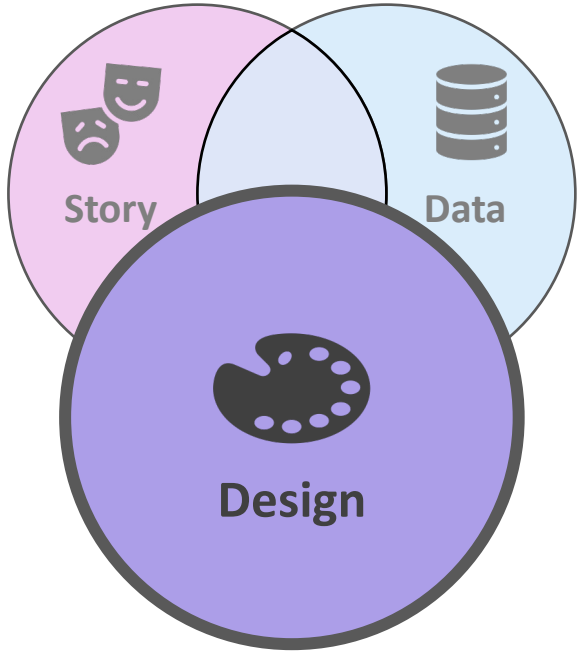
An overview for today:



WHY?

WHAT?

HOW?



Understand the brain

Do's and Don'ts

Practice

Your turn!

A look at your work.

Nice to meet YOU!

Explain in 1-2 sentences:

- The **topic** of your PhD as explained to your neighbor, friend, or family member
- How do you use (data-)visualization(s) for your work?

- Your selected **visual:** (if applicable)
  - One thing you **like** or **dislike** about it

Warm-up!

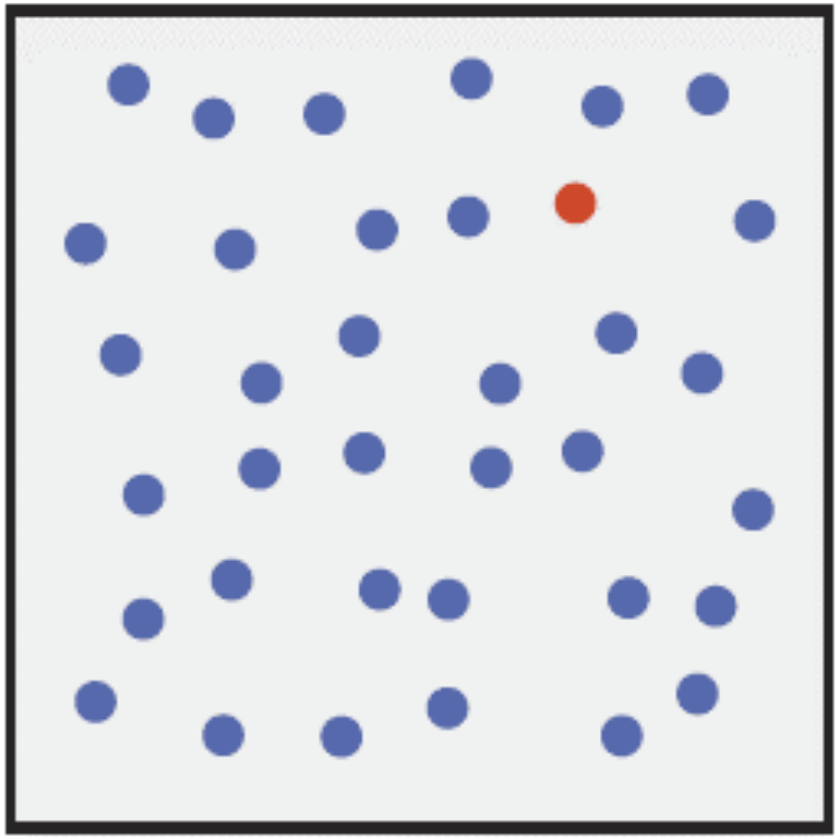
And stand up

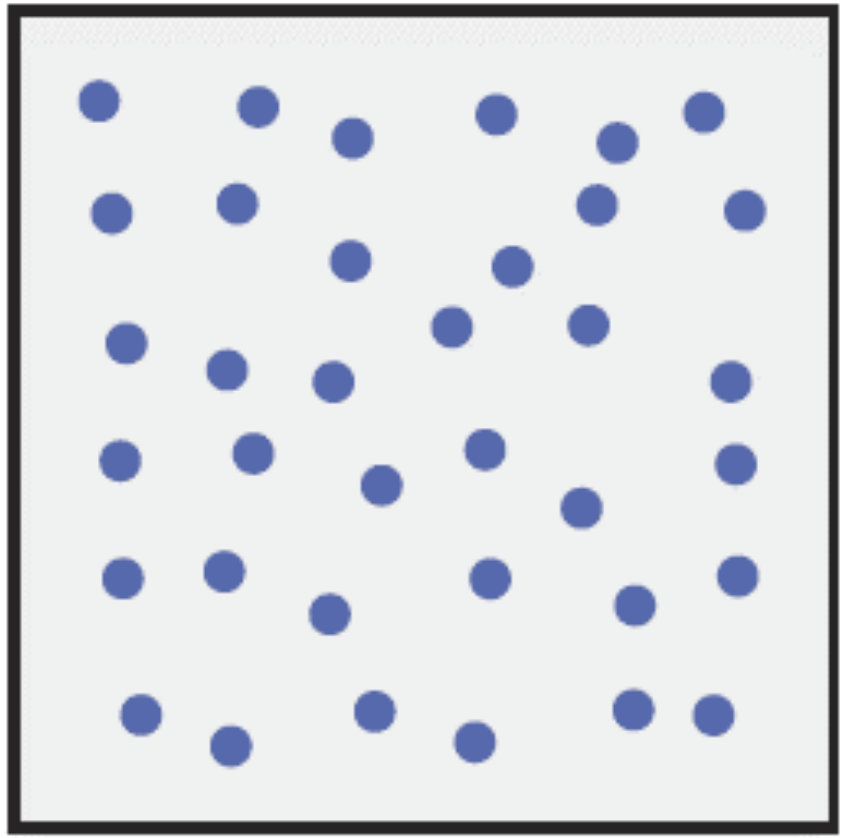
LEFT?

YES?

Which panel has a red dot?

A





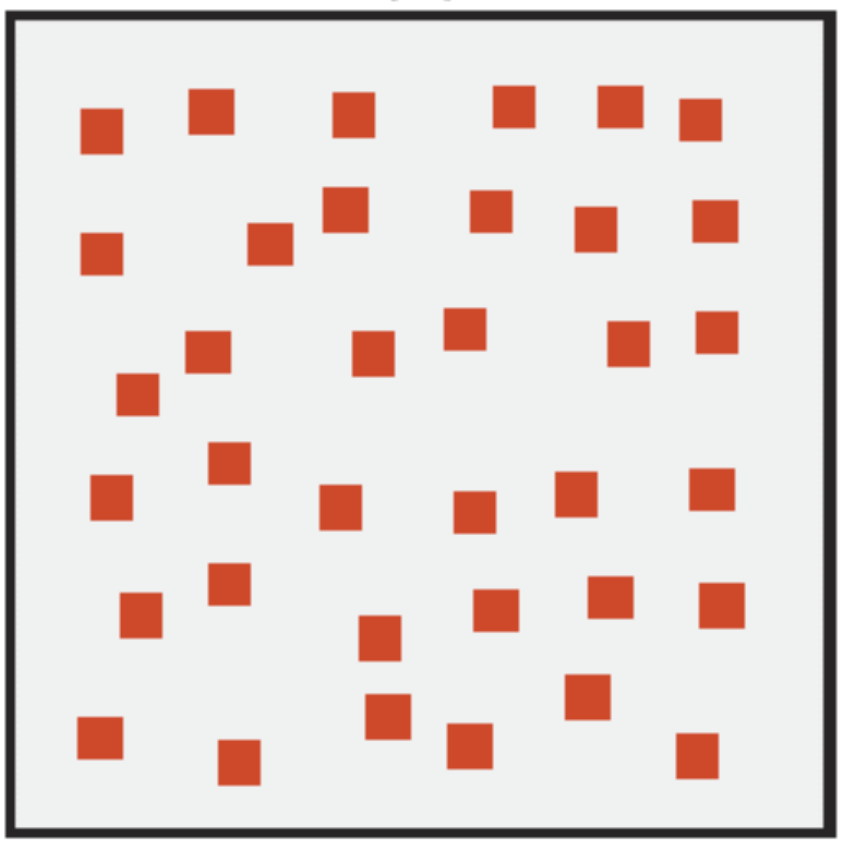
B

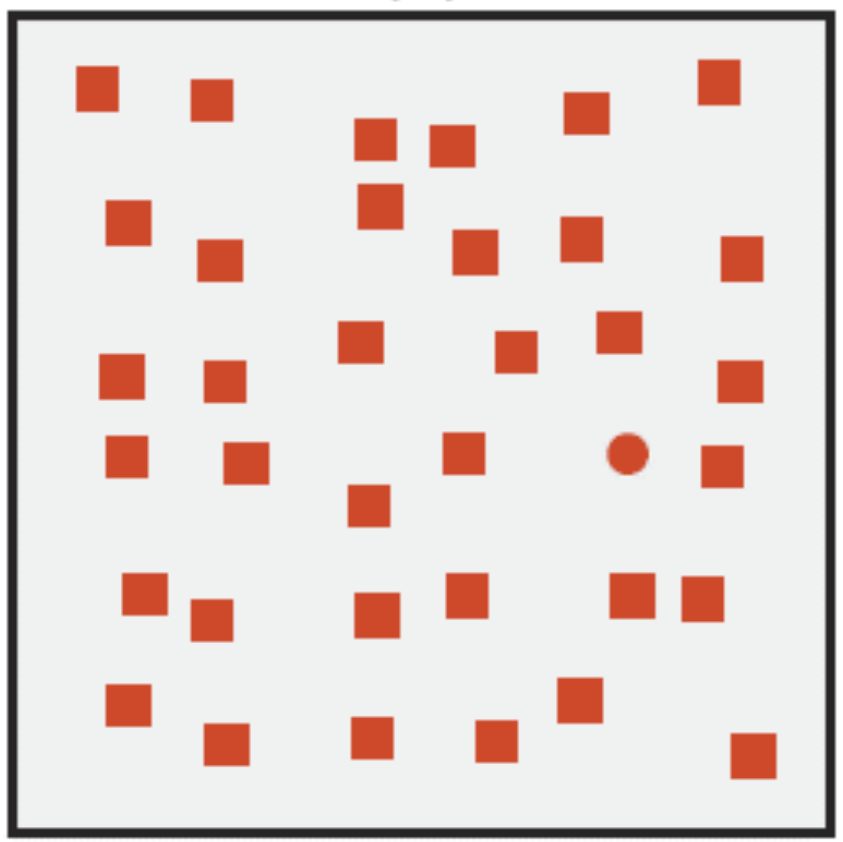
LEFT? = **UP!**

Healey CG and Enns JT (2012) IEEE TVCG 18:1170.

Which panel has a red dot?

A





B

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Which panel has a red dot?

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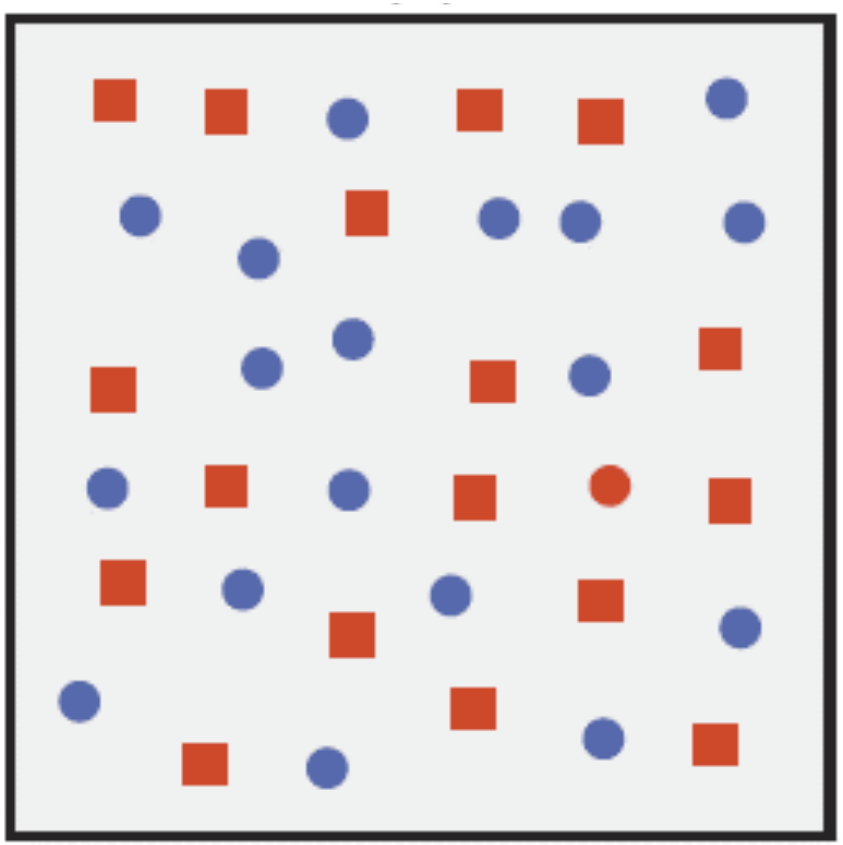
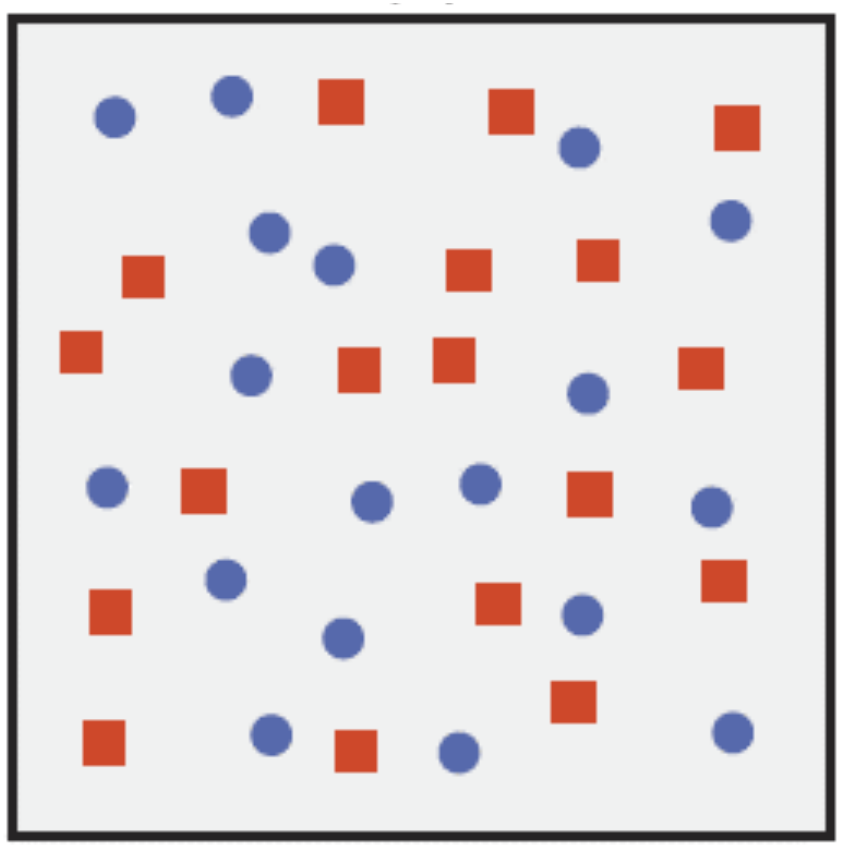


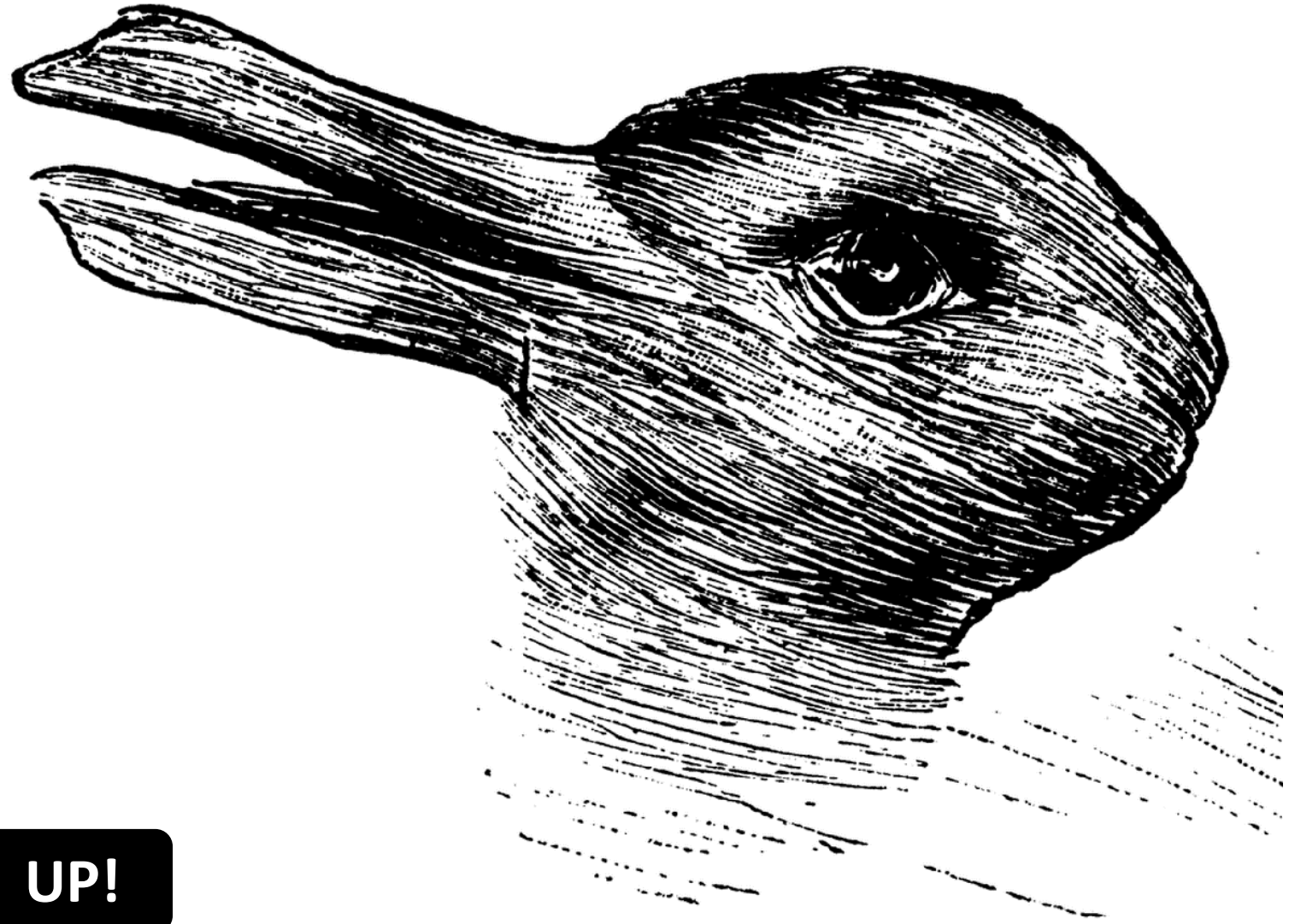


B

LEFT? = **UP!**

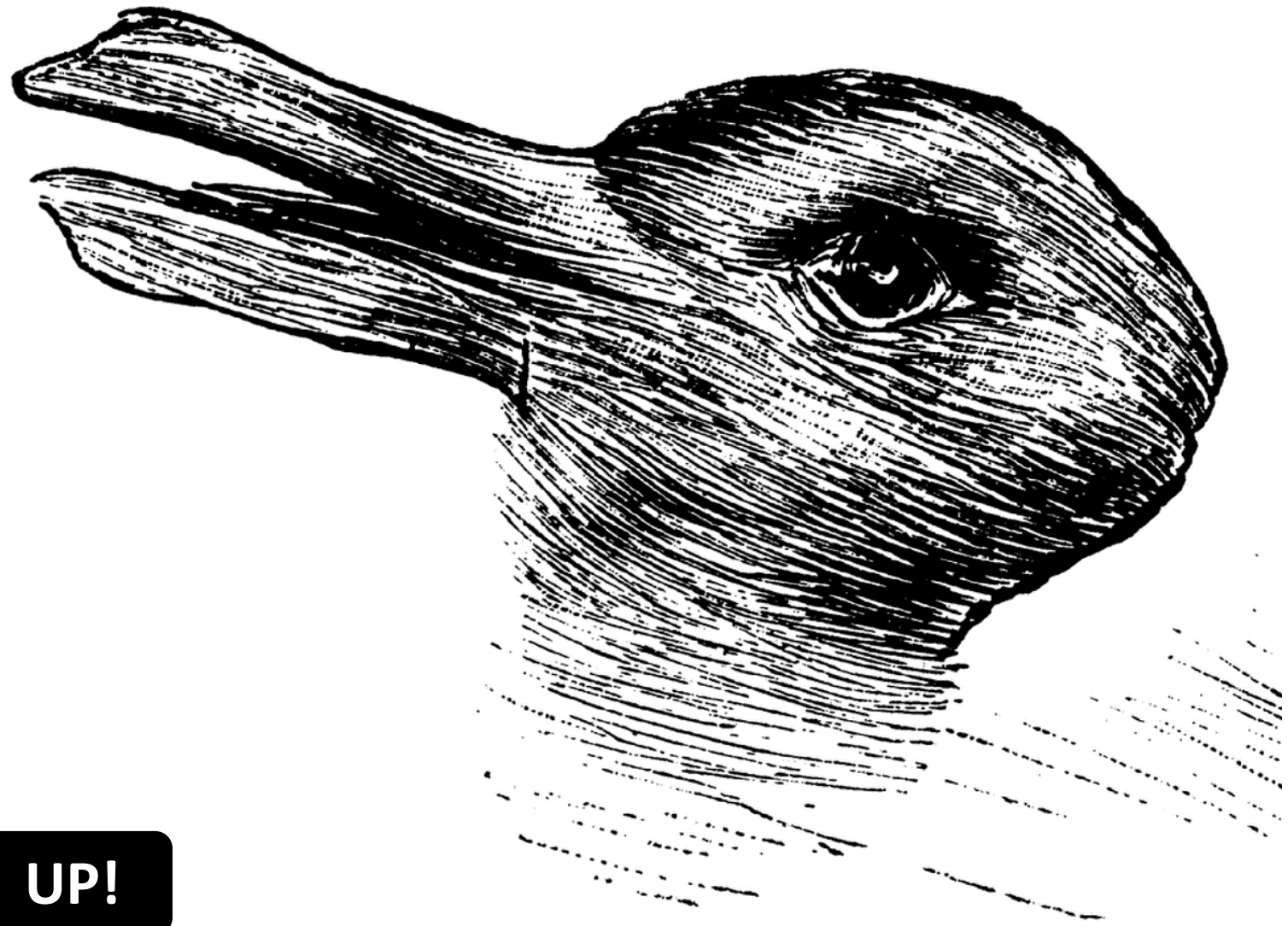
Healey CG and Enns JT (2012) IEEE TVCG 18:1170.

Do you see a Rabbit?



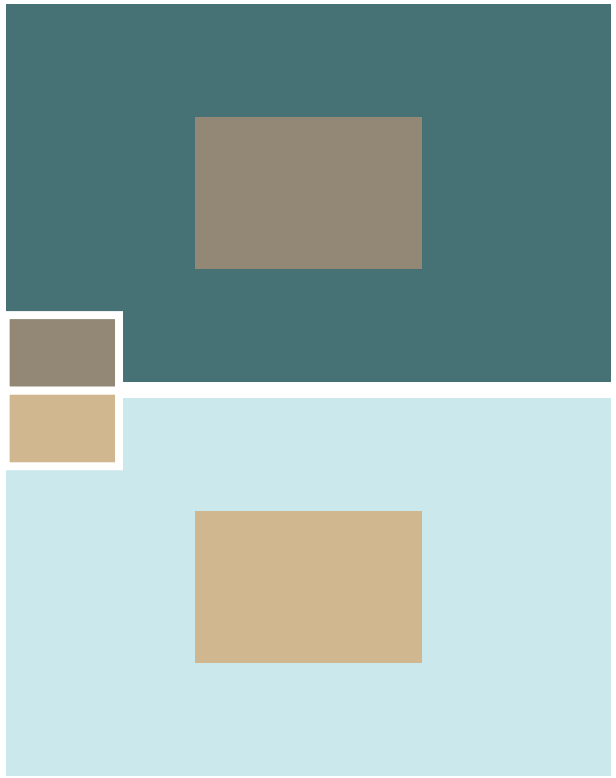
YES? = **UP!**

Do you see a Duck?



YES? = **UP!**

The inner squares have the same color

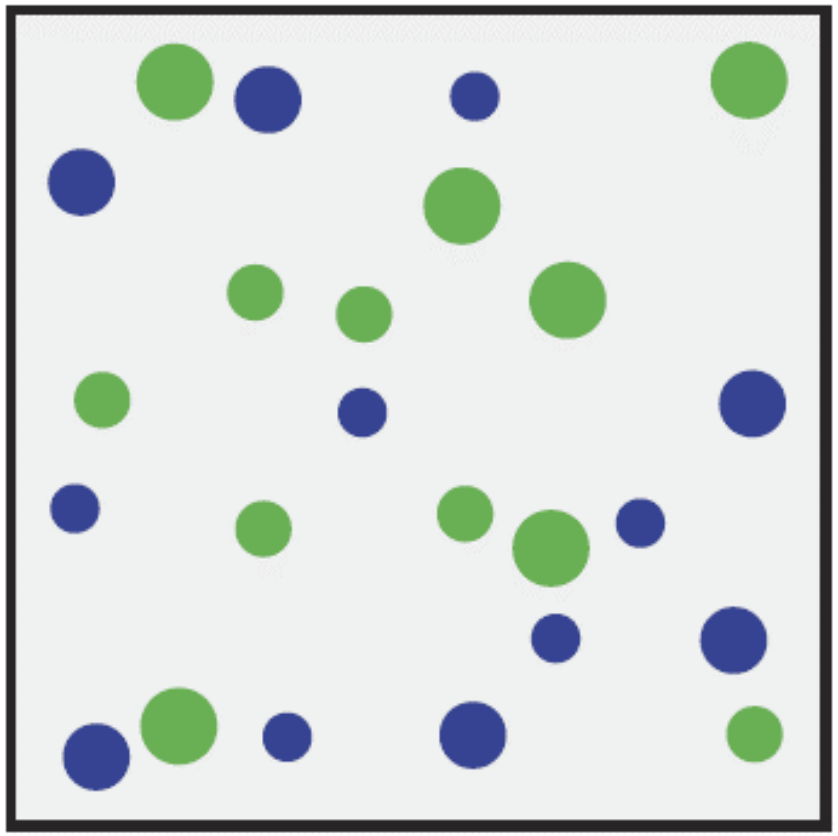


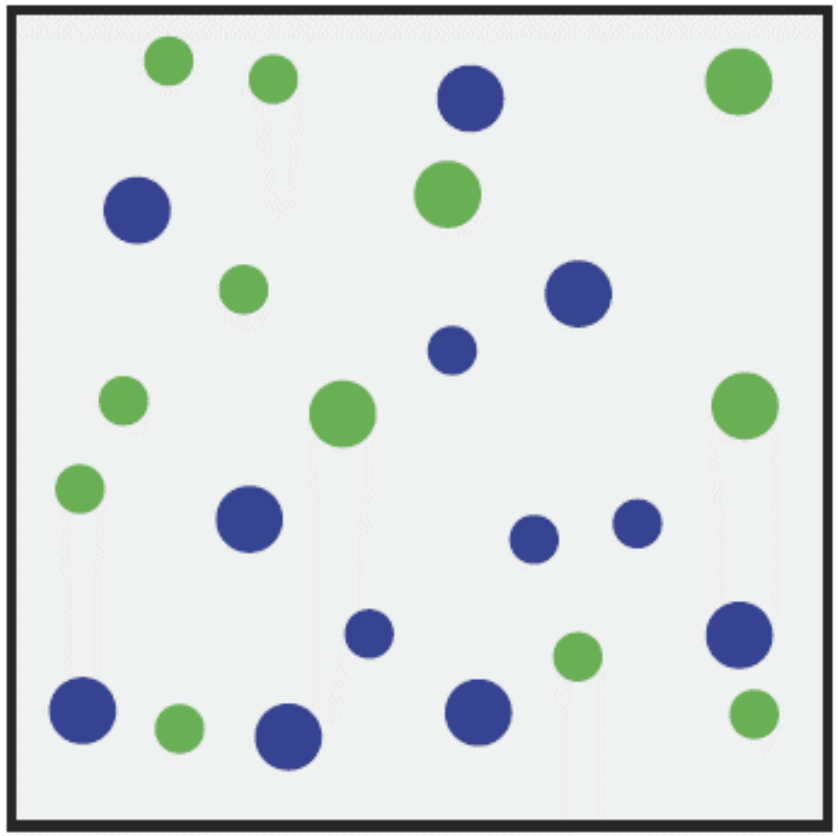
YES? = **UP!**

Adapted from **Wong B**, Color Coding, Nat Methods 7, 573 (2010)

Which panel has the biggest green dots?

A



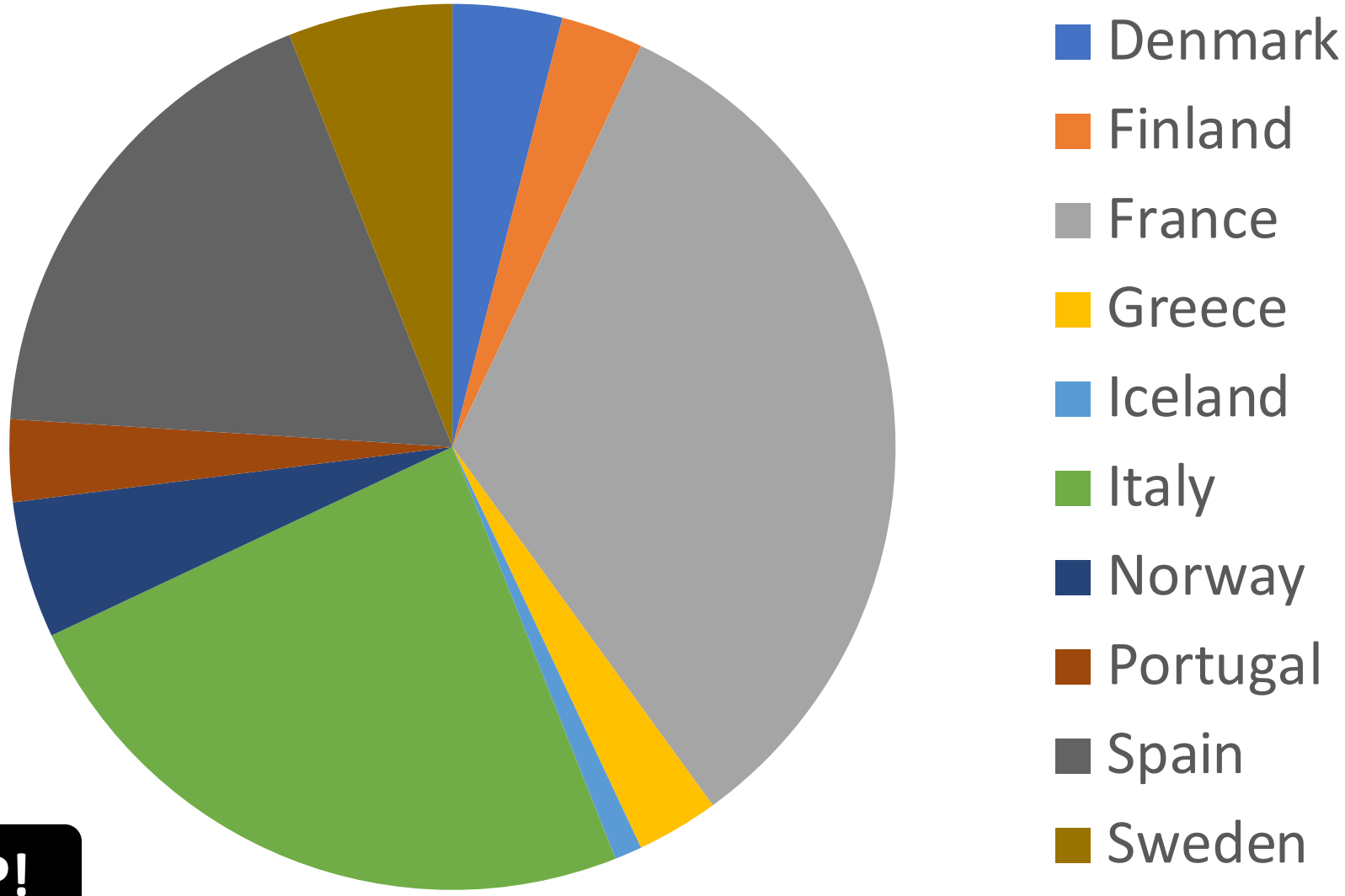


B

LEFT? = **UP!**

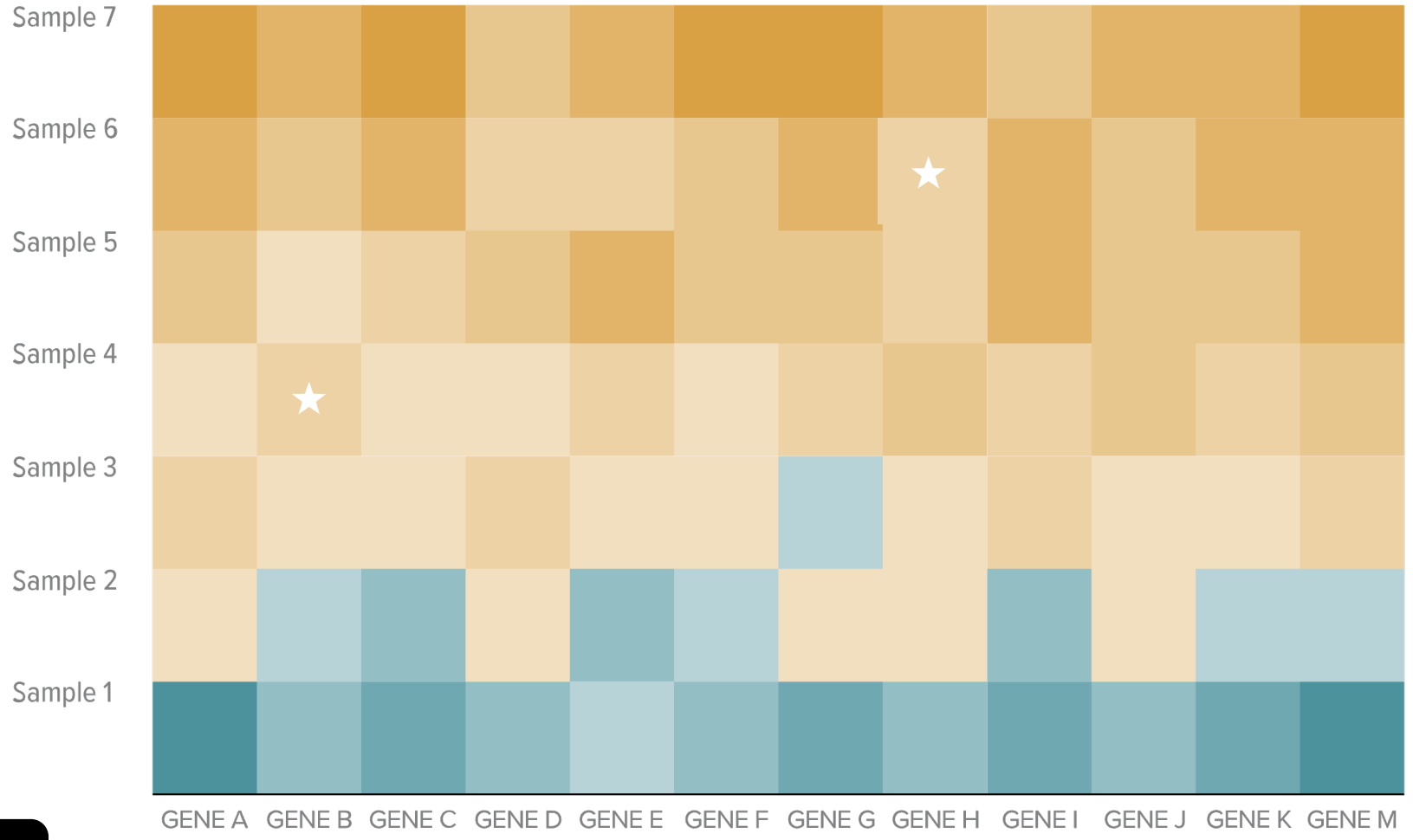
Healey CG and Enns JT (2012) IEEE TVCG 18:1170.

Norway has more widgets than Finland



YES? = **UP!**

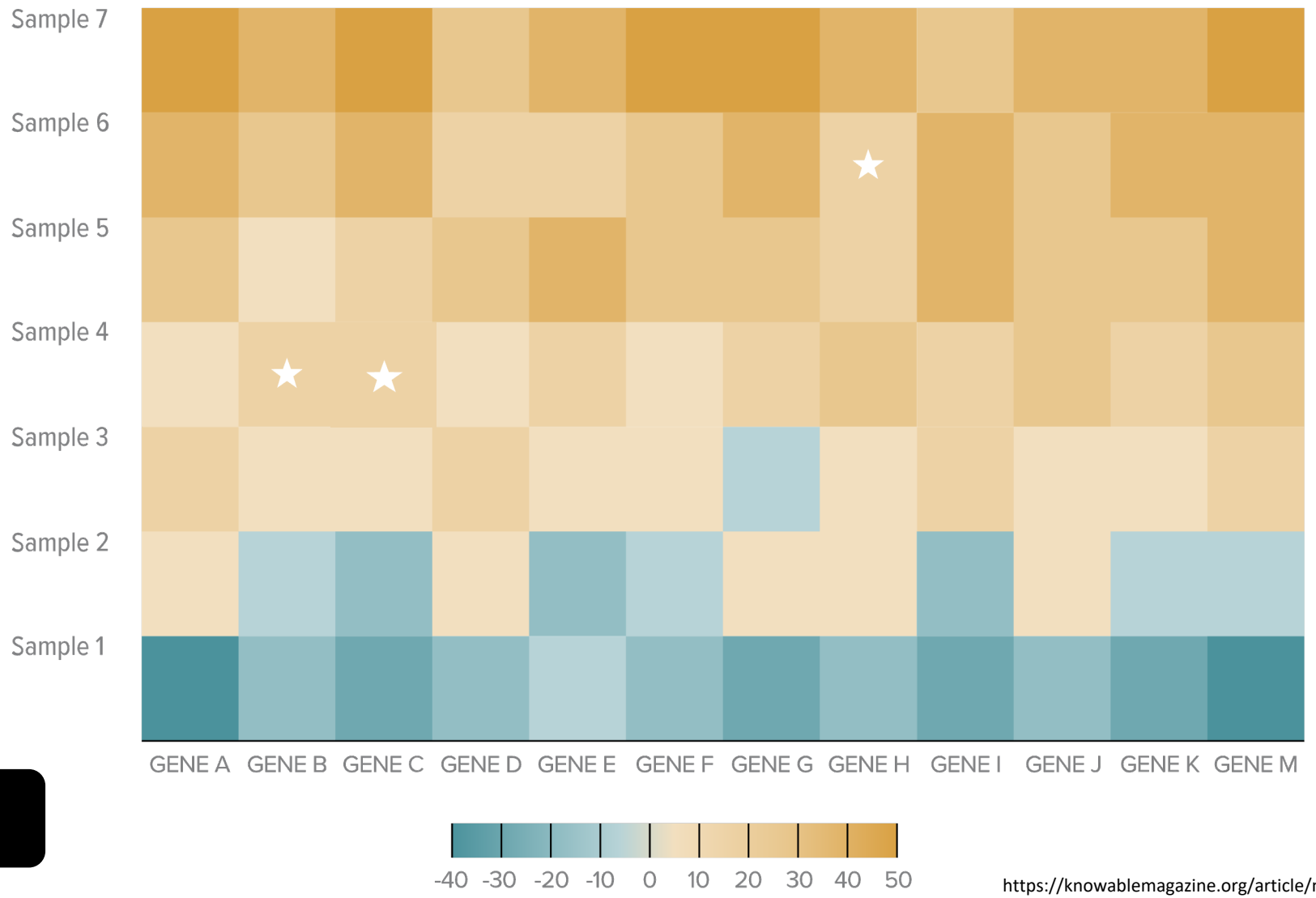
The areas with a star have the same color



YES? = **UP!**

https://knowablemagazine.org/article/mind/2019/science-data-visualization

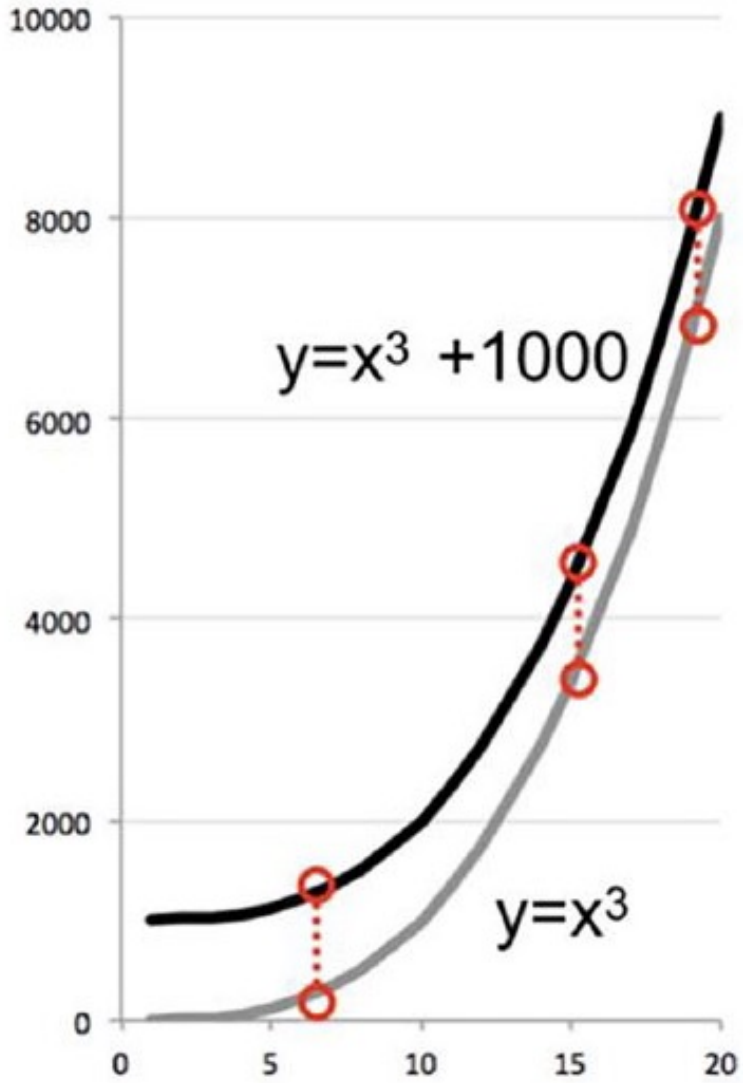
The areas with a star have the same color



YES? = **UP!**

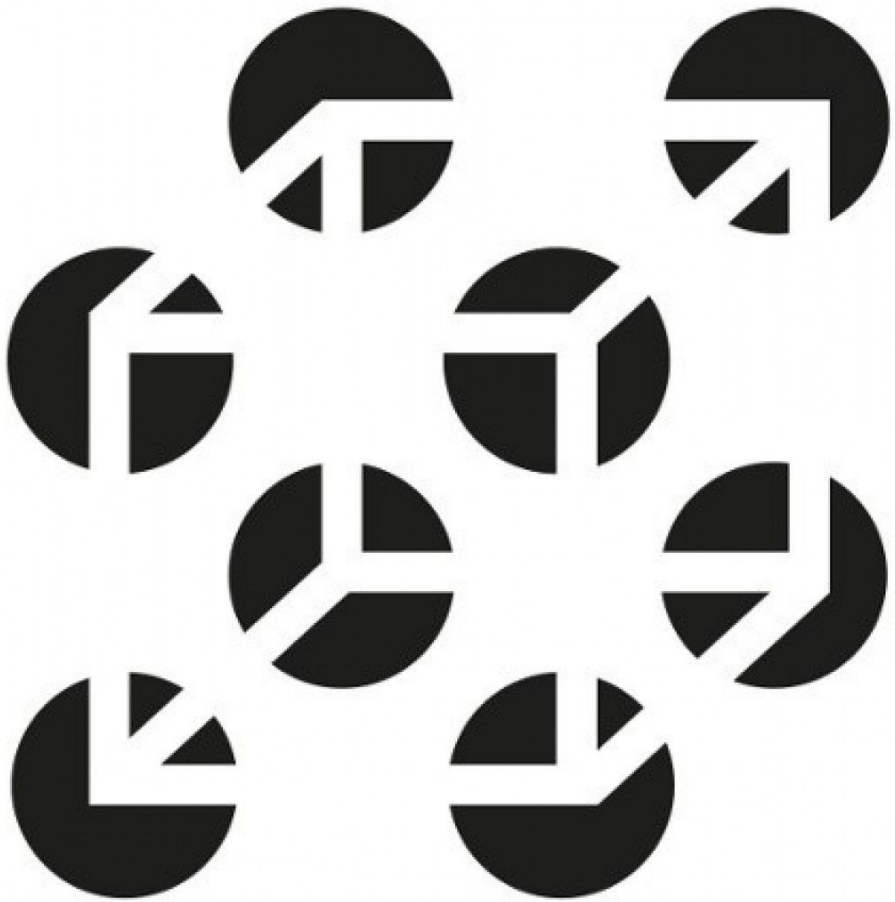
https://knowablemagazine.org/article/mind/2019/science-data-visualization

Where is the difference between the lines bigger? Left or right?



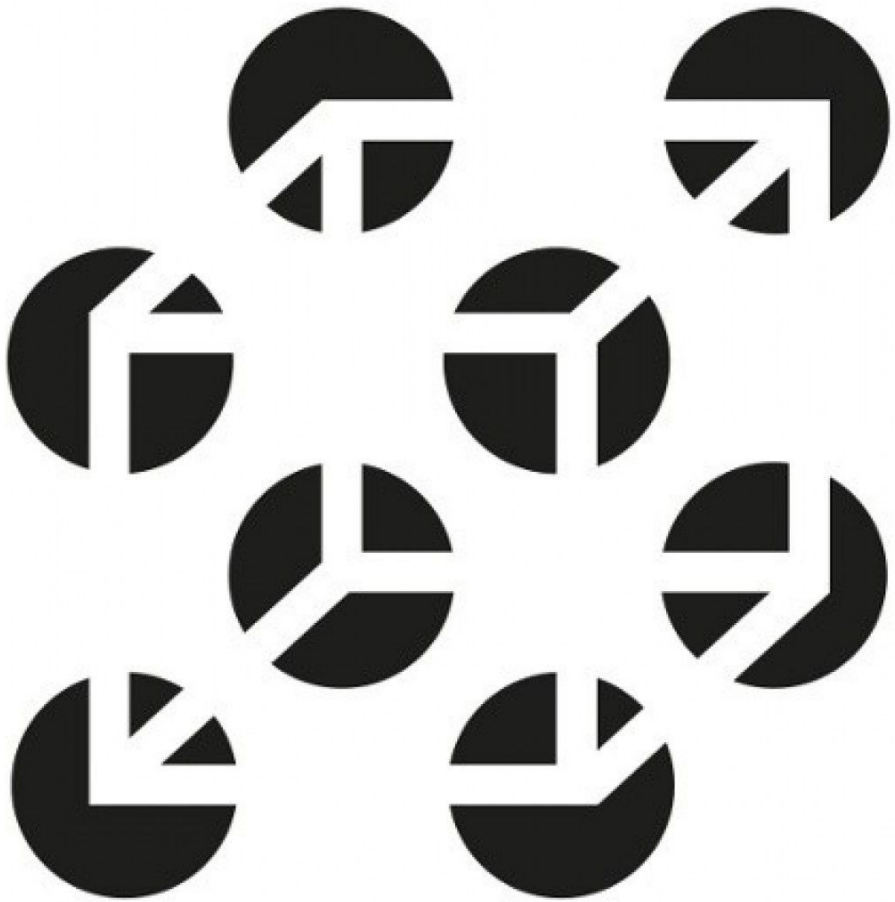
LEFT? = **UP!**

Do you *see* a cube?



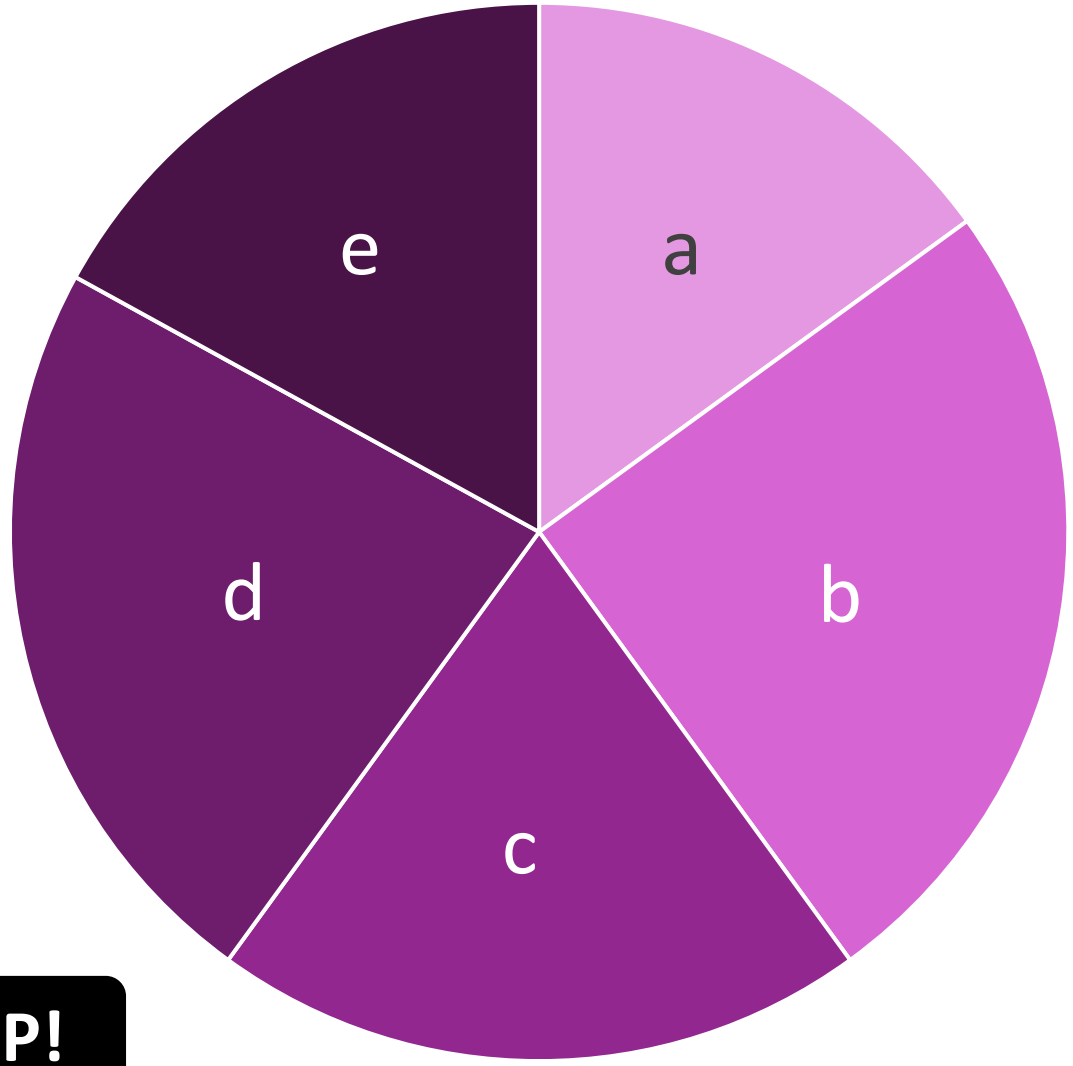
YES? = **UP!**

Is there a cube?



YES? = **UP!**

The order from high to low is b > d > c > e > a

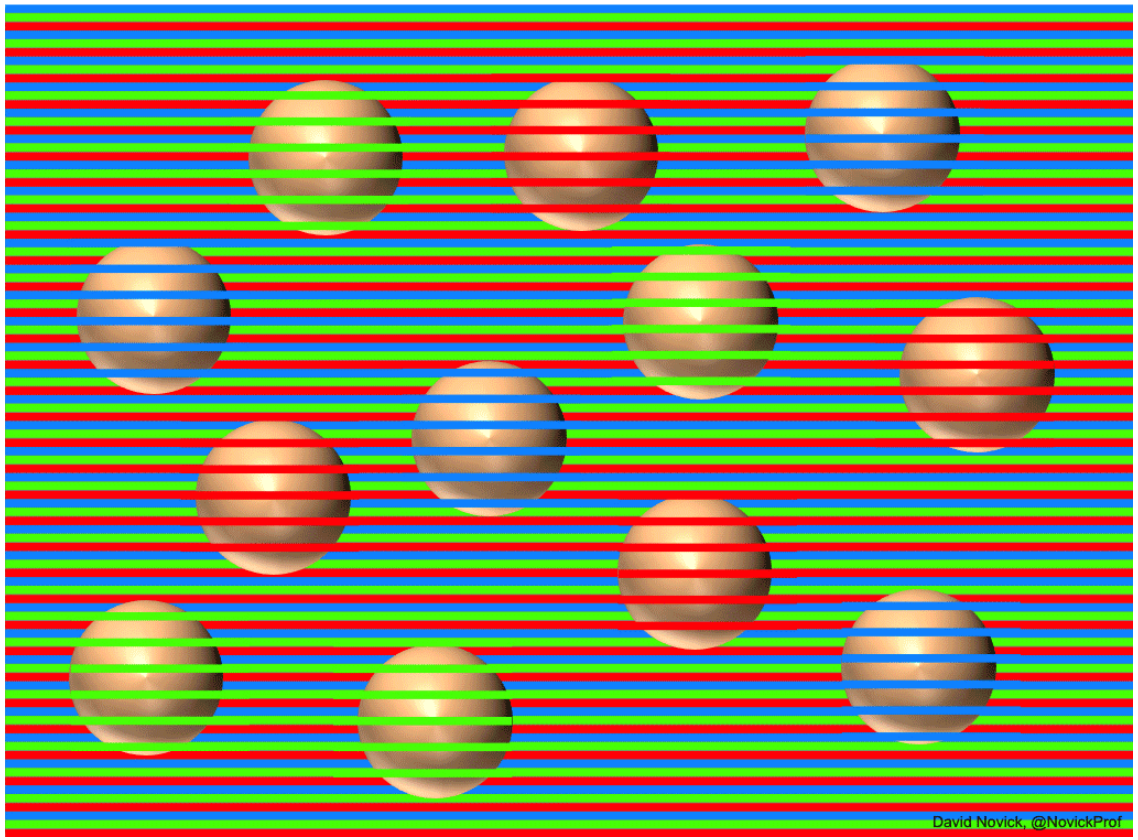


YES? = **UP!**

These speres have the same color

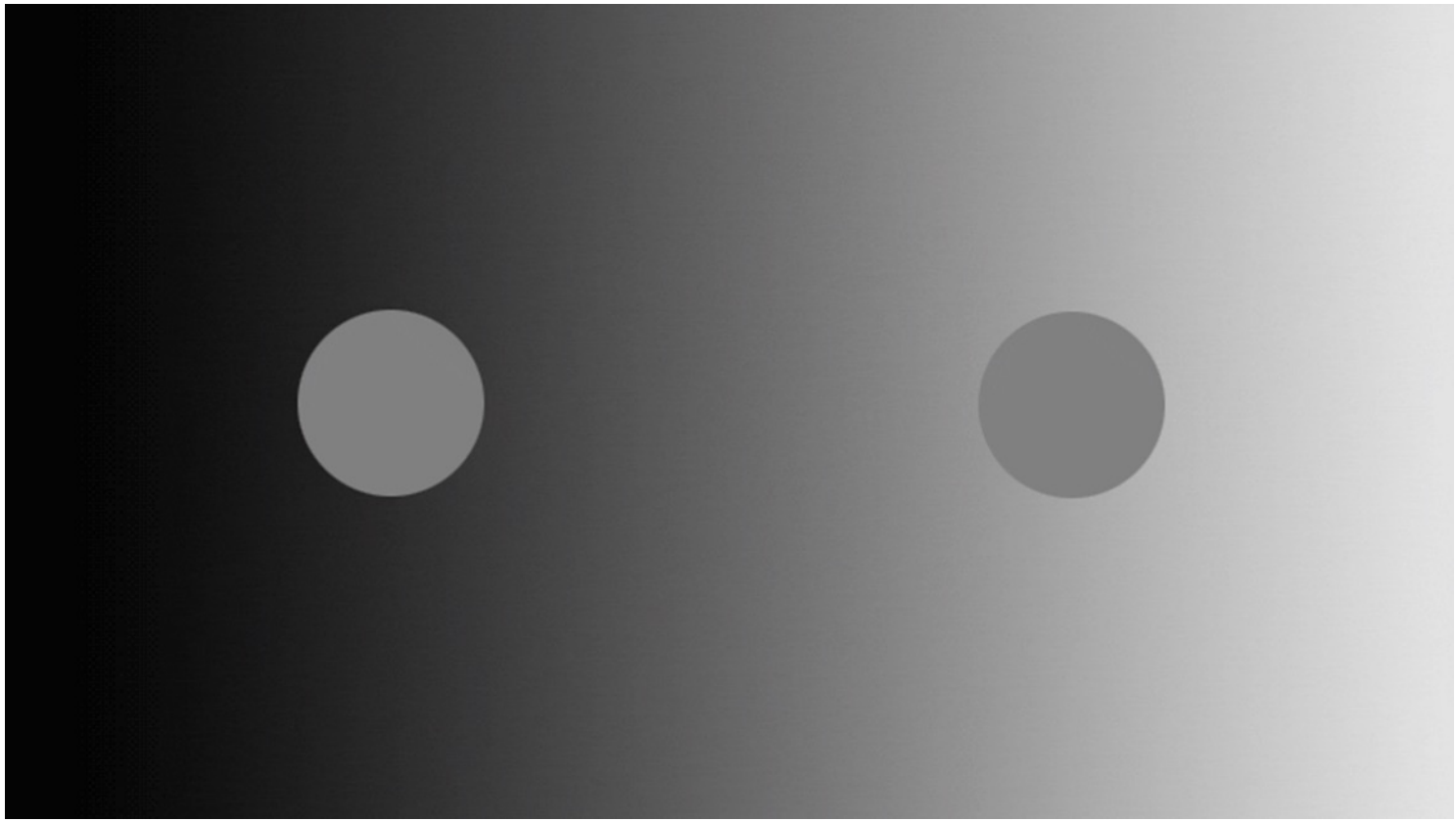
YES? = **UP!**

These speres have the same color



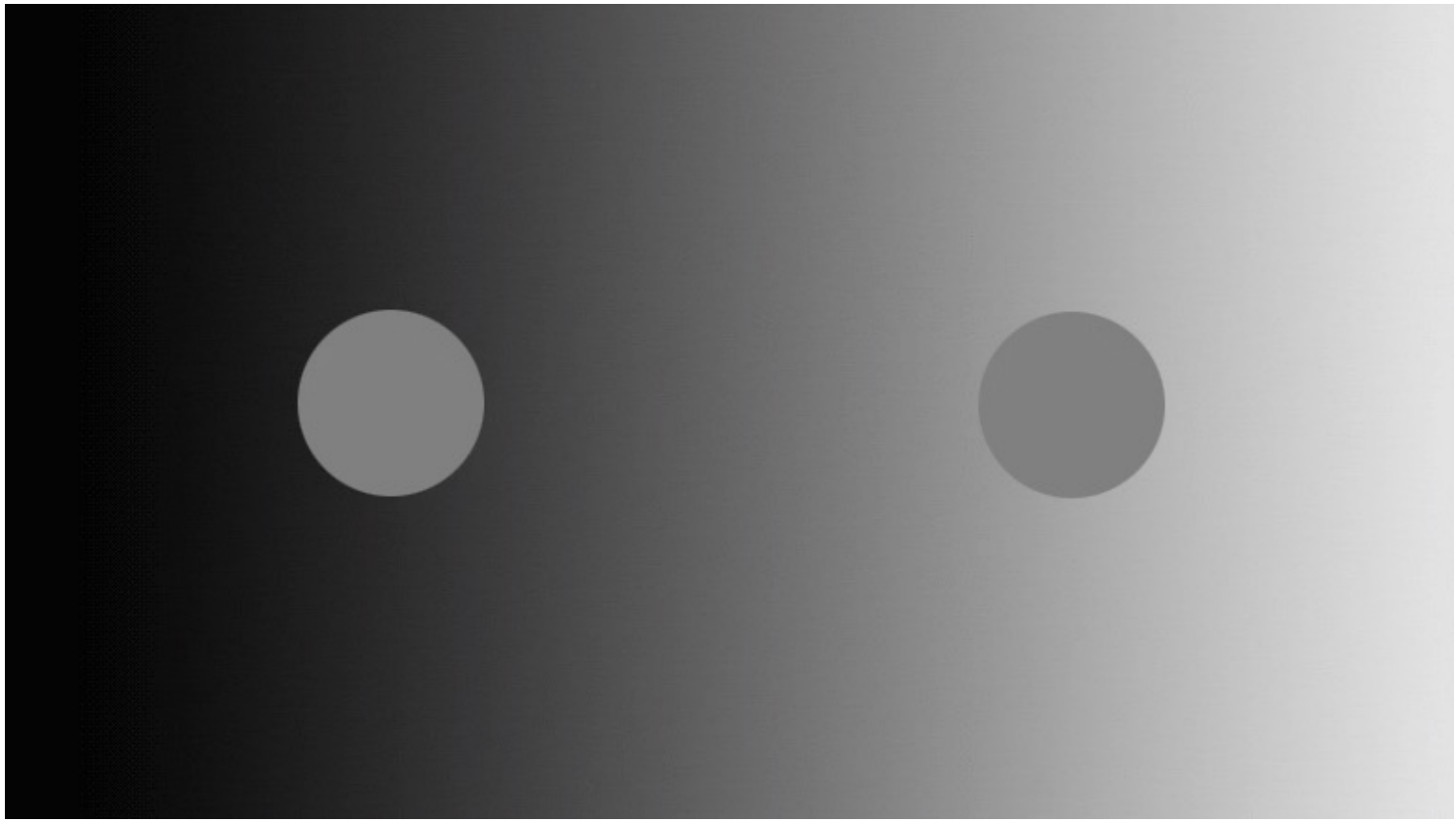
YES? = **UP!**

Which dot is darker?



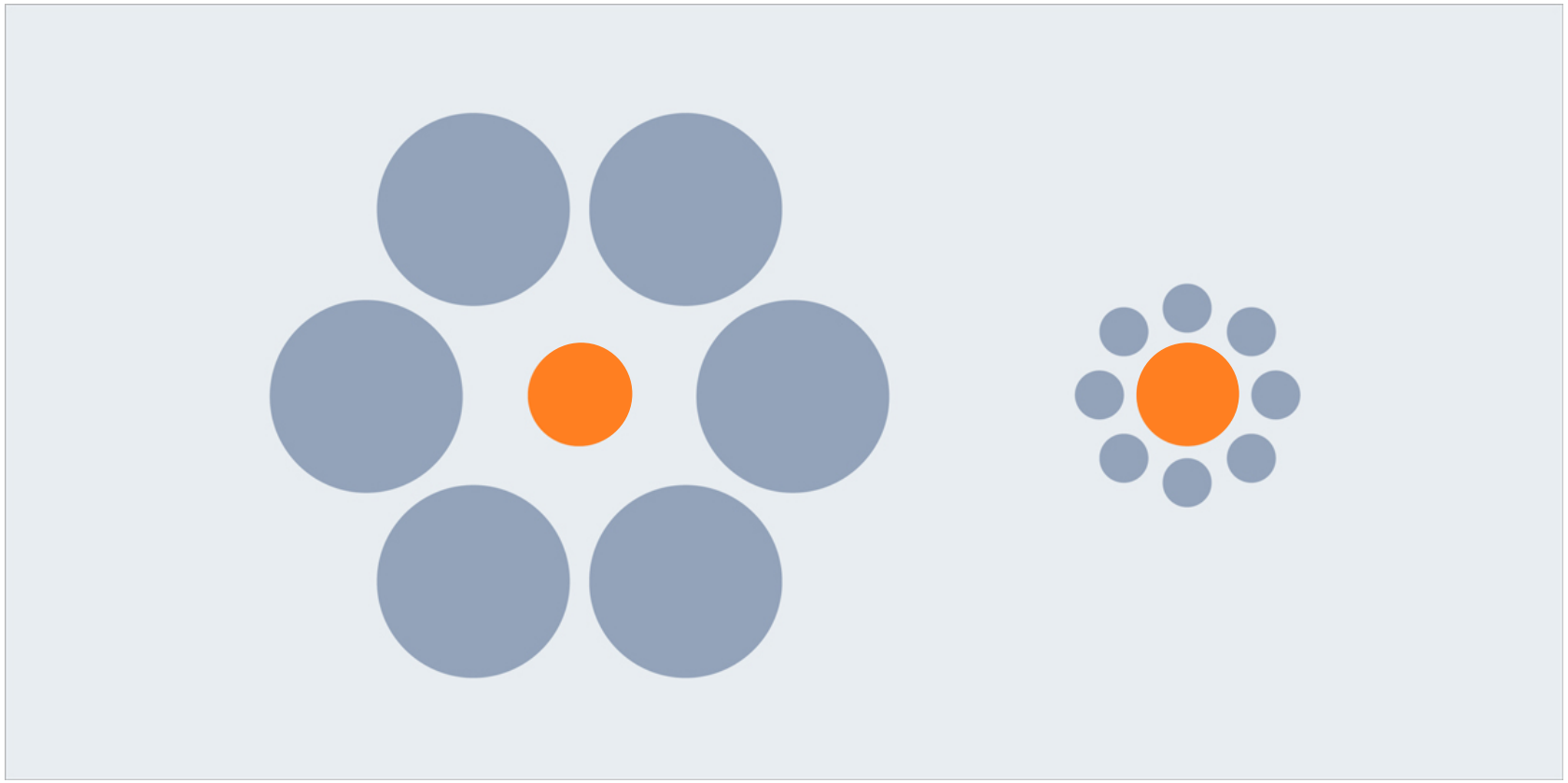
LEFT? = **UP!**

Are you sure…?



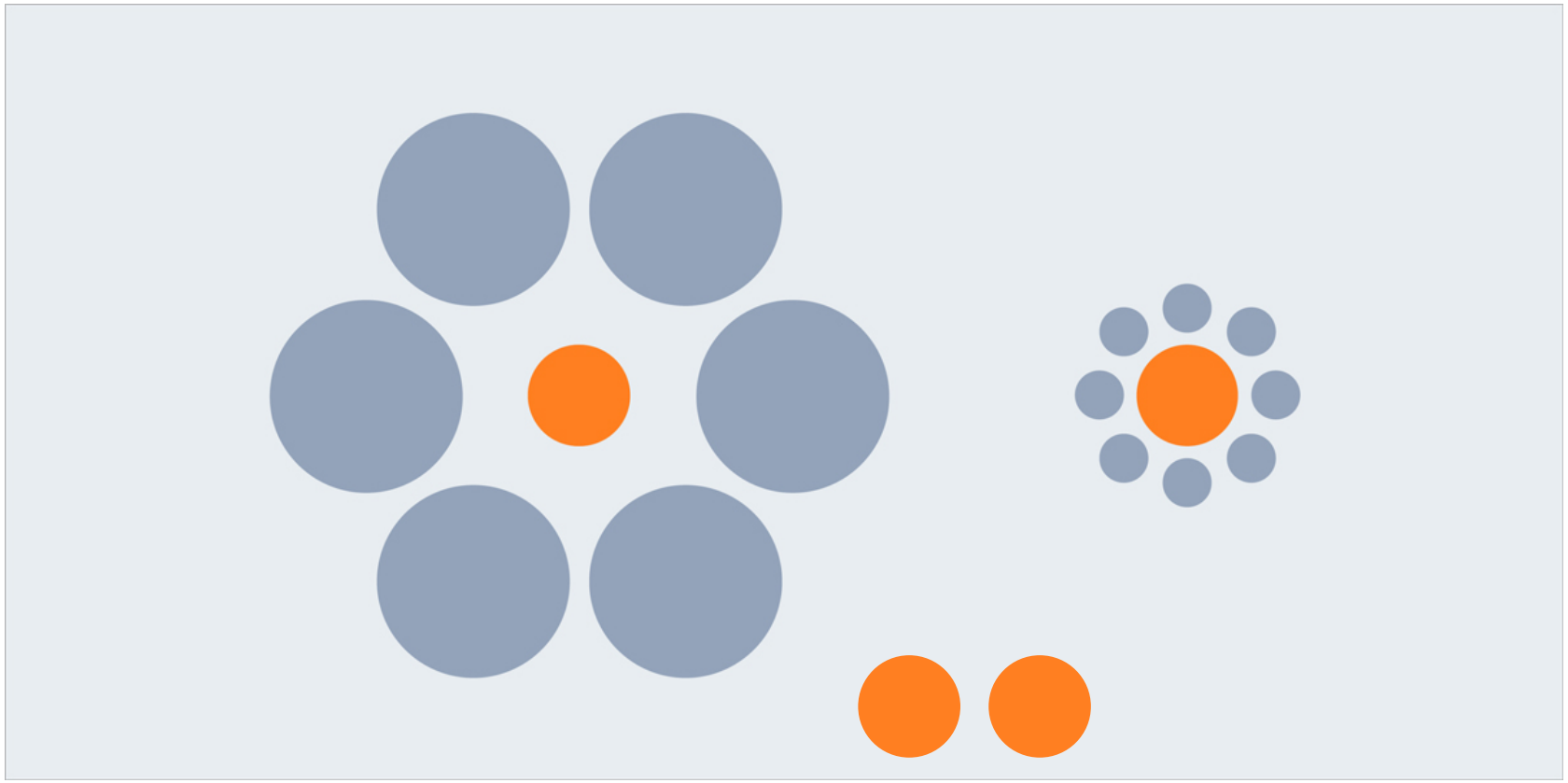
LEFT? = **UP!**

Which orange circle is smaller?



LEFT? = **UP!**

Which orange circle is smaller?



LEFT? = **UP!**

“It’s not what you look at that matters, it’s what you see”

Henry David Thoreau

Why visual communication?

What can you see in these numbers?

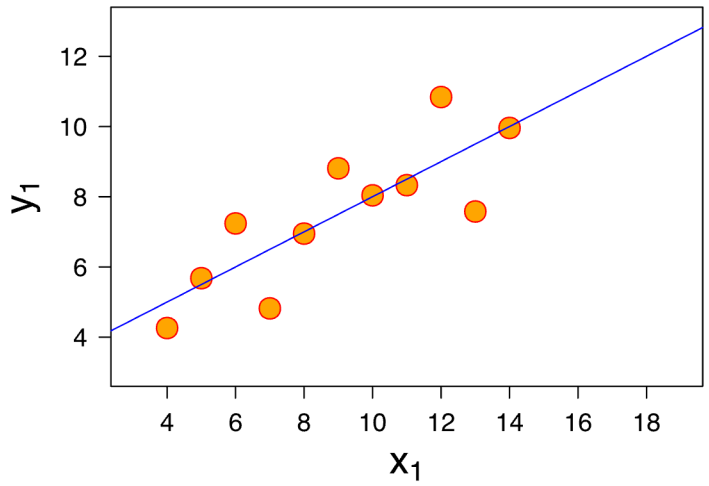
Anscombe's quartet:
4 datasets
11 x-values
11 y-values
Same total
Same mean
Same standard deviation

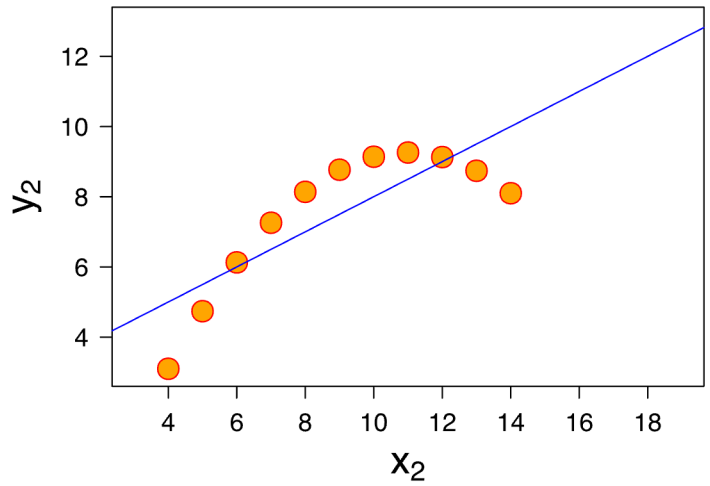
	I		II		III		IV	
	x	y	x	y	x	y	x	y
	10	8,04	10	9,14	10	7,46	8	6,58
	8	6,95	8	8,14	8	6,77	8	5,76
	13	7,58	13	8,74	13	12,74	8	7,71
	9	8,81	9	8,77	9	7,11	8	8,84
	11	8,33	11	9,26	11	7,81	8	8,47
	14	9,96	14	8,1	14	8,84	8	7,04
	6	7,24	6	6,13	6	6,08	8	5,25
	4	4,26	4	3,1	4	5,39	19	12,5
	12	10,84	12	9,13	12	8,15	8	5,56
	7	4,82	7	7,26	7	6,42	8	7,91
	5	5,68	5	4,74	5	5,73	8	6,89
SUM	99,00	82,51	99,00	82,51	99,00	82,50	99,00	82,51
AVG	9,00	7,50	9,00	7,50	9,00	7,50	9,00	7,50
STDEV	3,32	2,03	3,32	2,03	3,32	2,03	3,32	2,03

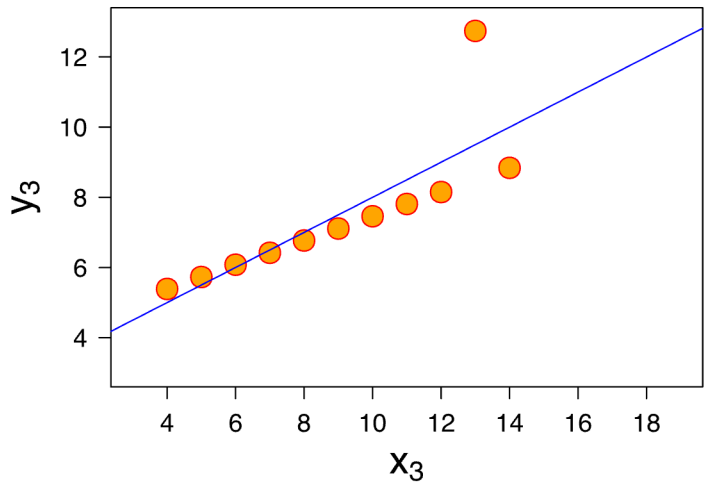
Anscombe FJ (1973). *Graphs in Statistical Analysis*. The American Statistician 27, 1, 17–21.

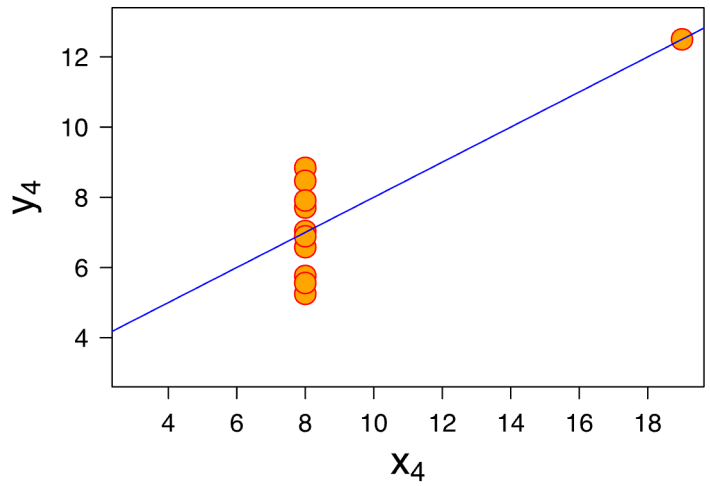
A picture is worth a thousand words!

Anscombe's quartet:
4 datasets
11 x-values
11 y-values
Same total
Same mean
Same standard deviation



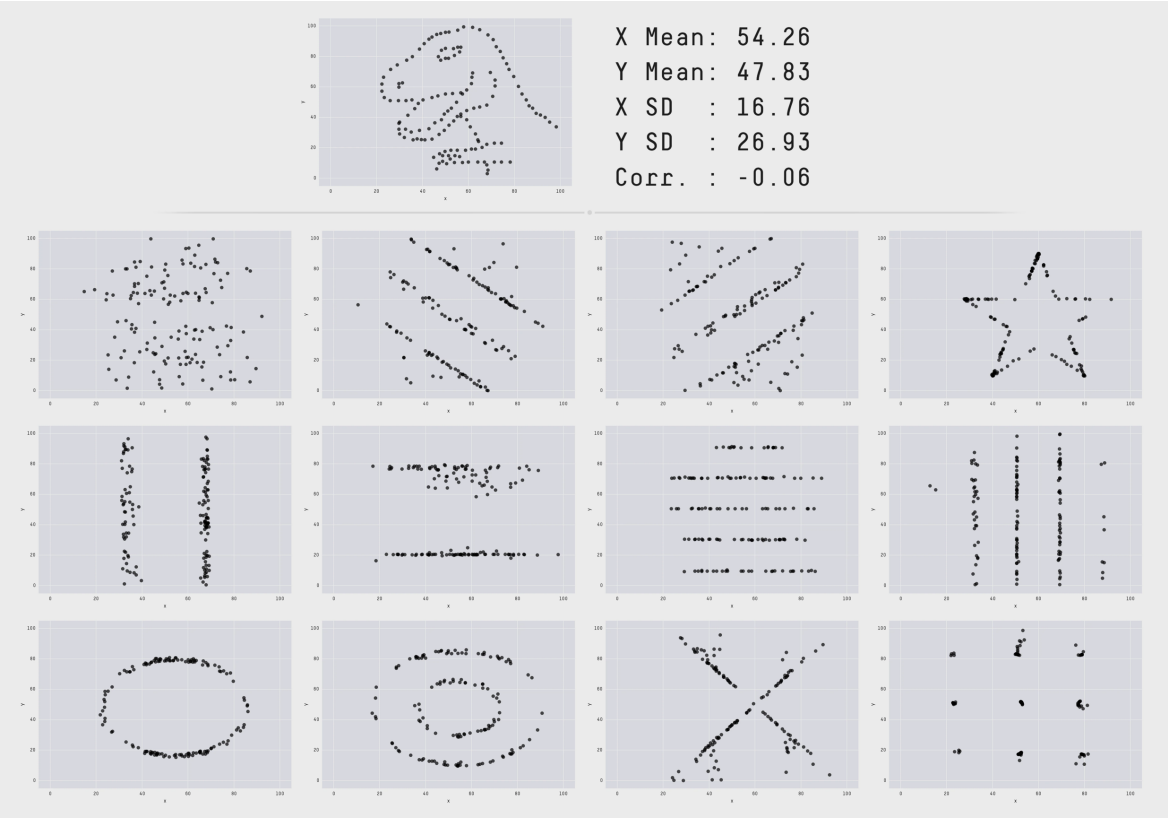


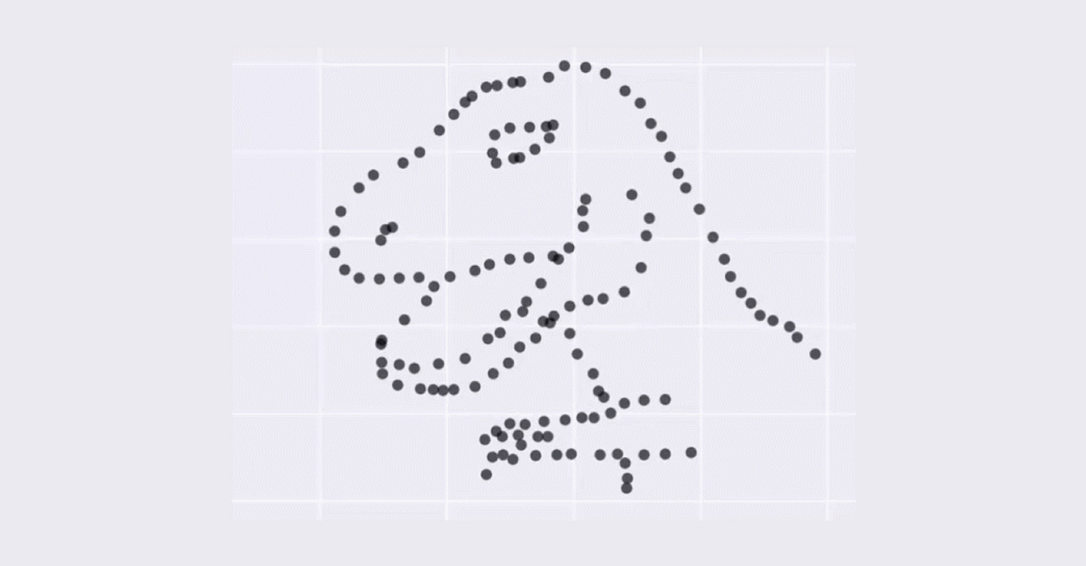




Anscombe FJ (1973). *Graphs in Statistical Analysis*. The American Statistician 27, 1, 17–21.

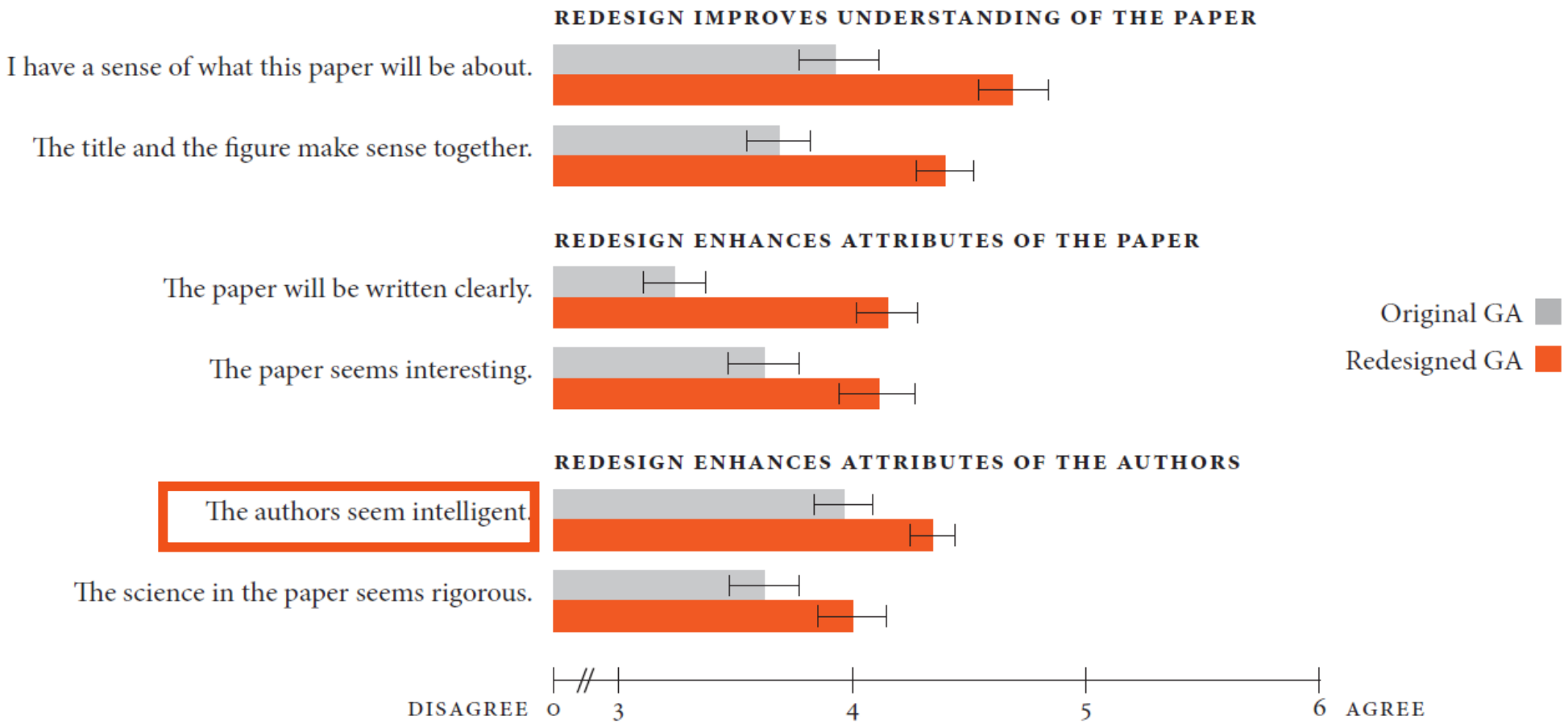
The Datasaurus Dozen ☺:
Never trust summary statistics alone!





Matejka J & Fitzmaurice G (2017). *Same Stats, Different Graphs: Generating Datasets with Varied Appearance and Identical Statistics through Simulated Annealing*. https://www.autodeskresearch.com/publications/samestats.

A good visual makes you (look) smarter!



Cheng K *et al*. (2017). *Proving the value of visual design on scientific communication*. Information Design Journal 23, 80-95.

Why use visuals in academic research?

Provide **insight**

- Publications
- Oral presentations
- Poster presentations

Grab **attention**

- Graphical abstracts
- Social media
- General media

Show **competence**

- Grant applications
- Portfolio / CV
- Pitch

What is visual communication **?**

Four types of visualizations

DECLARATIVE

CONCEPTUAL

DATA-DRIVEN

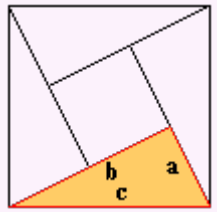
EXPLORATORY

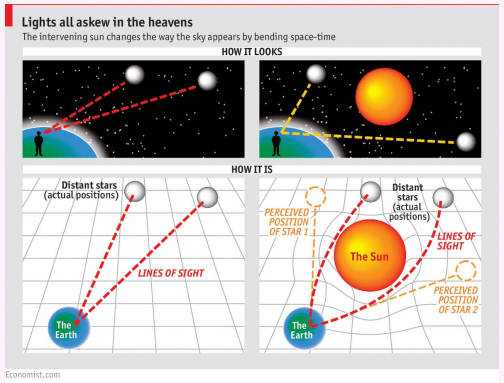
Idea illustration

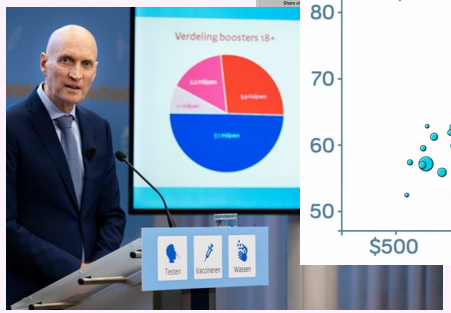
Idea generation

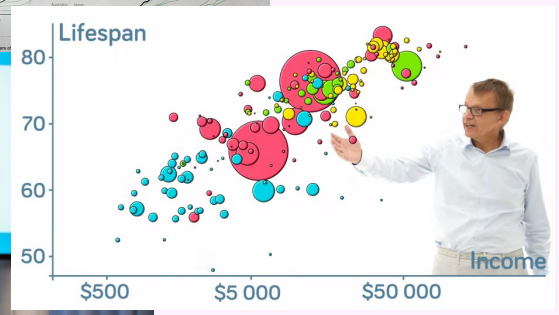
'Everyday' DataViz

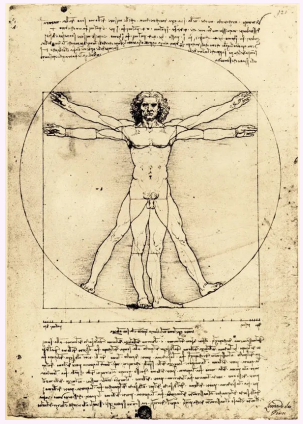
Visual discovery

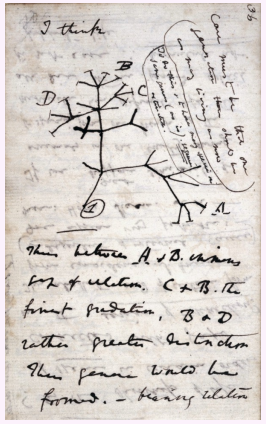








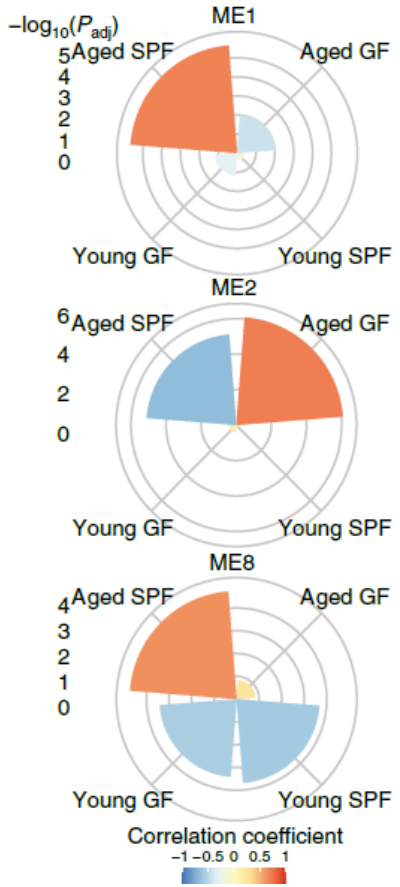


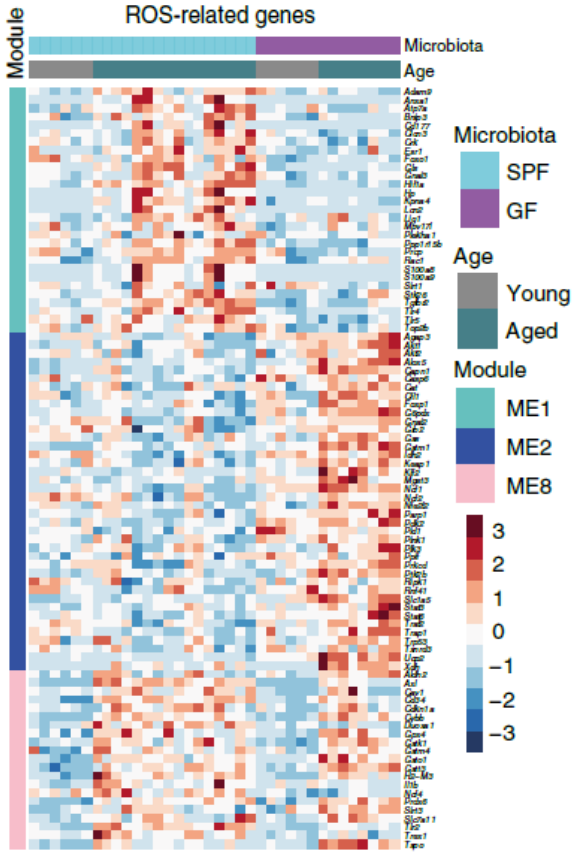


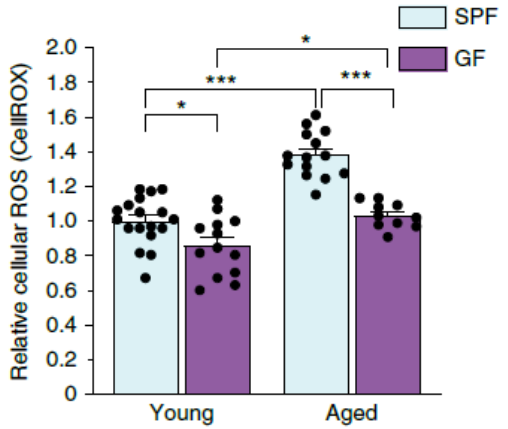
sebastiz.github.io/

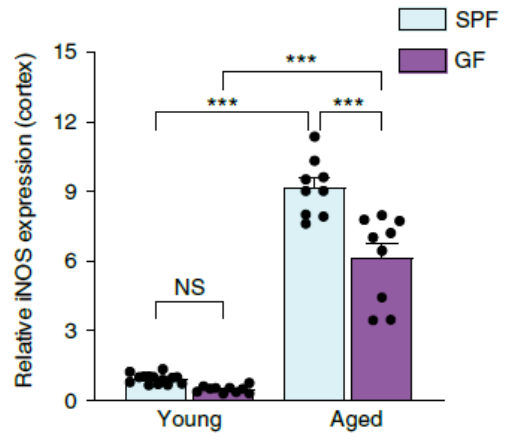
Good Charts by Harvard Business Review.

Visual communication in academic research is not *just* **data** charts…



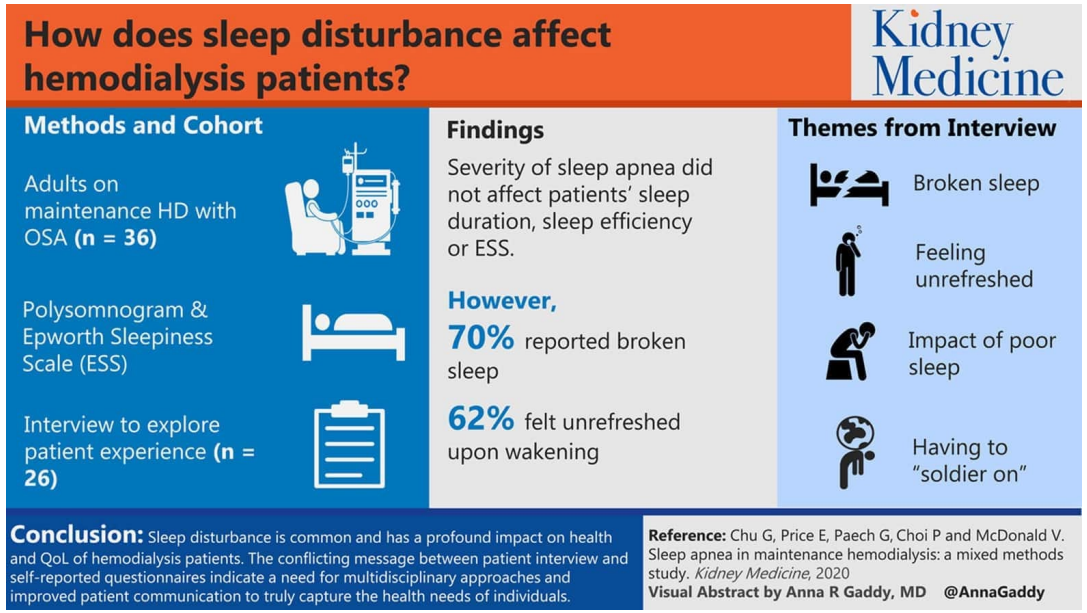


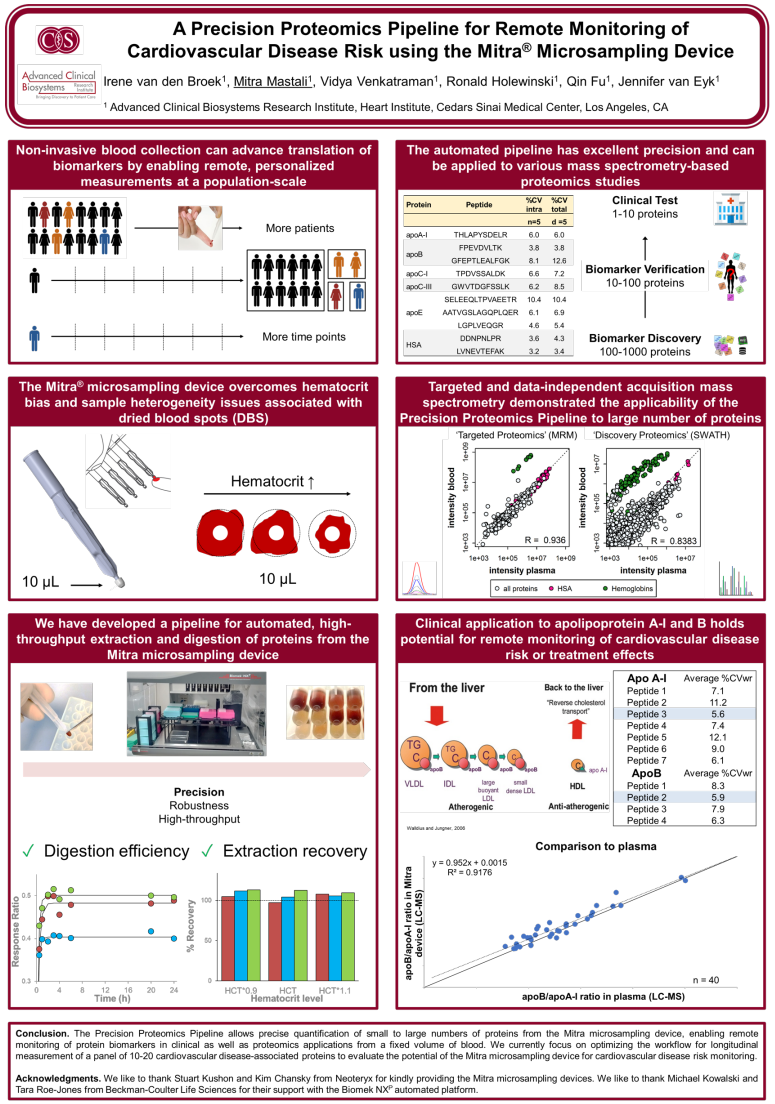




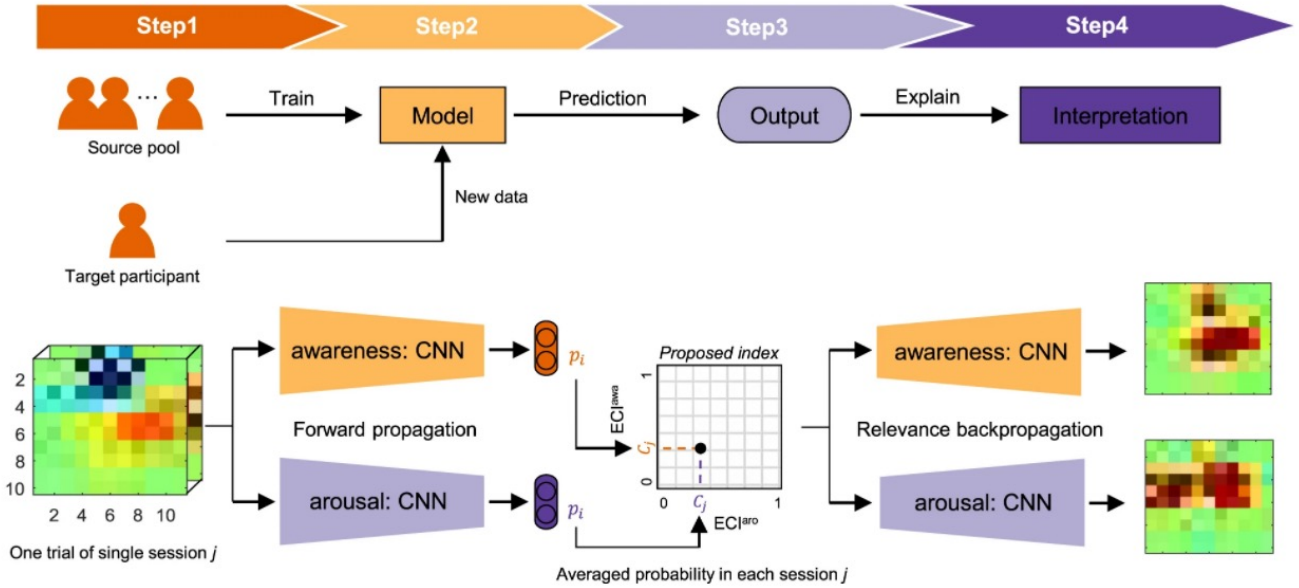
Mossad *et. al* (2022) Nature Neuroscience 25:295–305.

You can also think of graphical abstracts or posters…

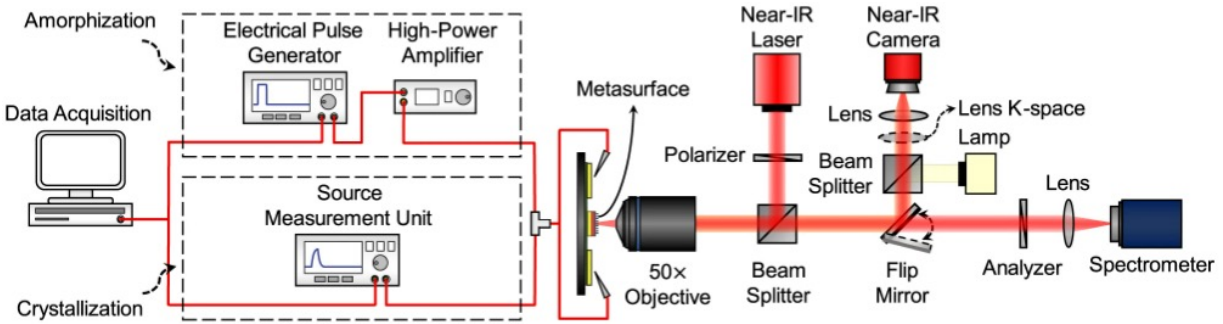




Flow charts or schematics…

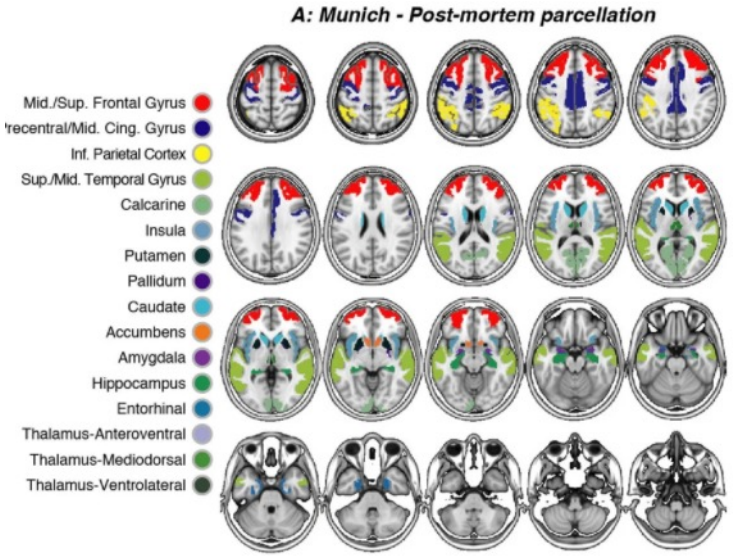


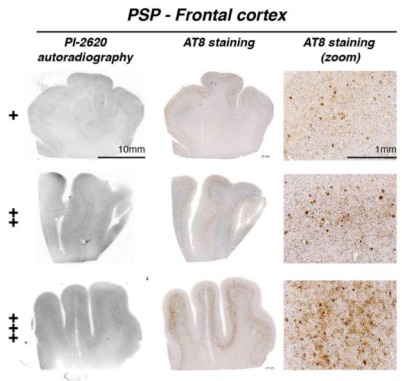
Lee M *et al.* (2022) Nat Commun **13,** 1064.

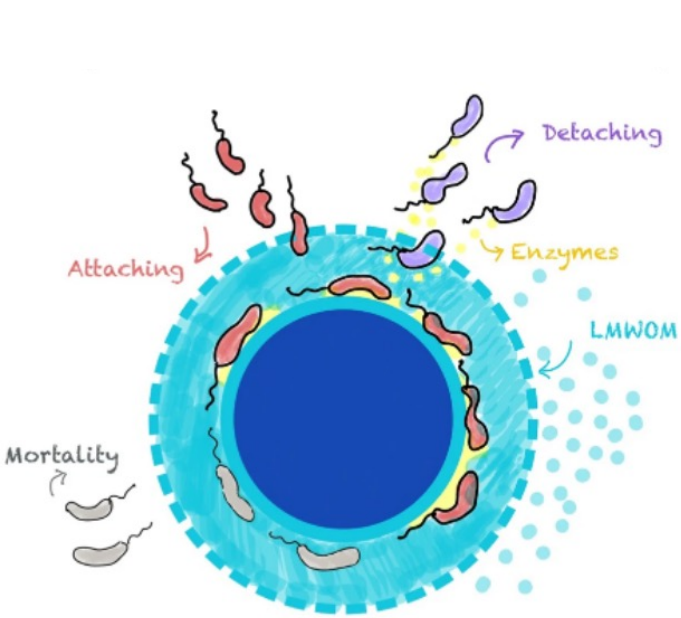


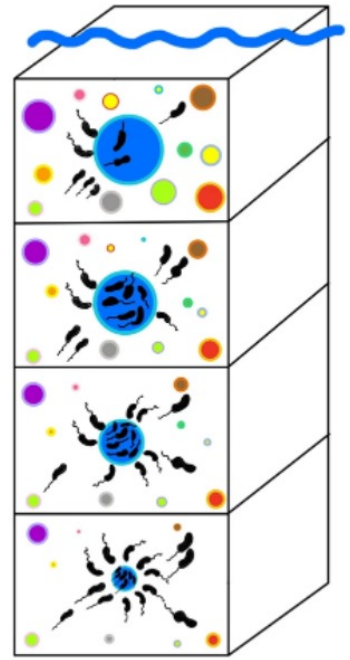
Abdollahramezani, S *et al. Nat Commun* **13,** 1696 (2022).

Illustrations, drawings, images…



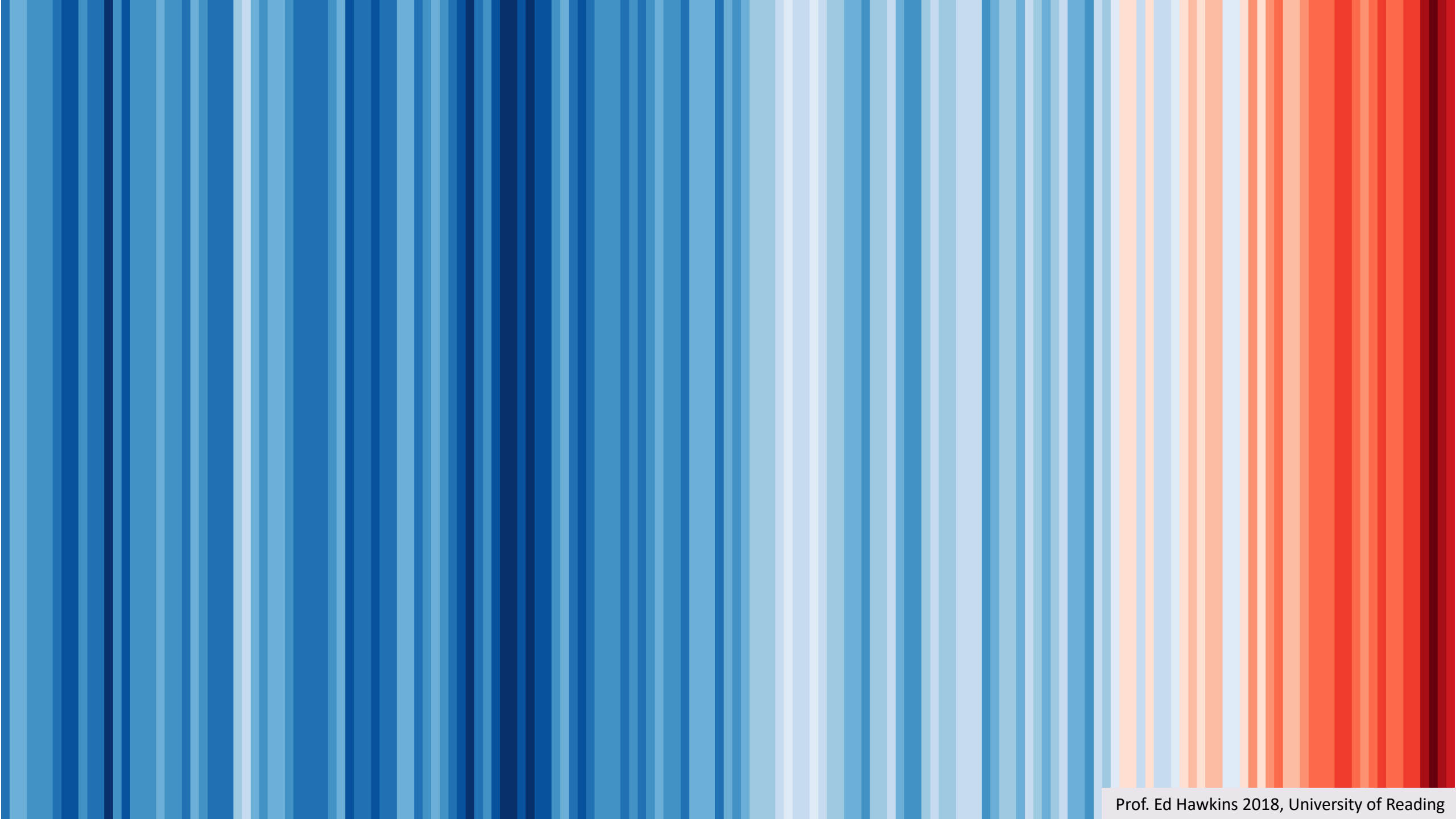






Franzmeier N *et al.* (2022) *Nat Commun* **13,** 1362.

Nguyen TTH *et al. Nat Commun* **13,** 1657 (2022).



Prof. Ed Hawkins 2018, University of Reading

Talking about reaching a broad public!

Prof. Ed Hawkins
#showyourstripes

HOW visual communication?

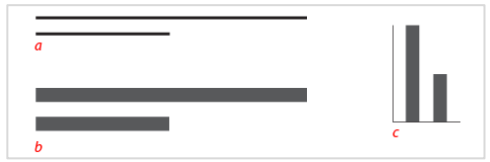
Encode: *Choose a chart*

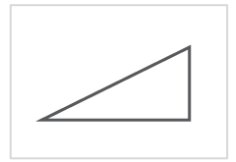
Exercise: In how many ways can you visualize two numbers?

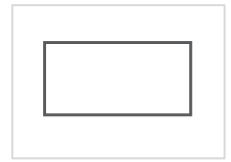
75 and **37**

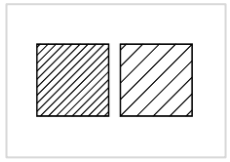
5 min

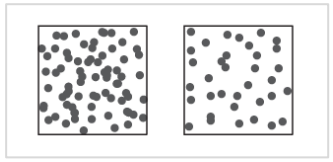
45 ways to communicate two quantities…

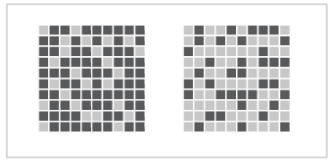


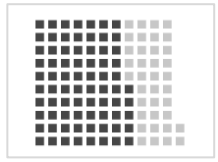


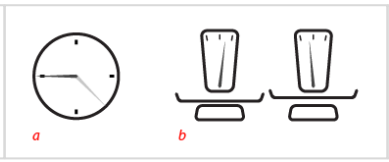


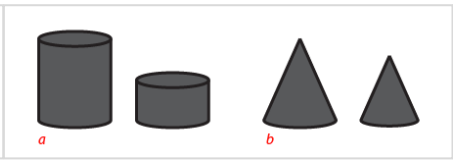


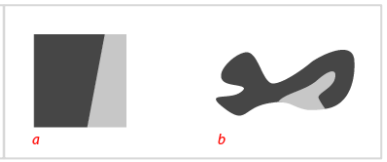


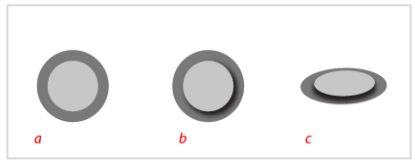


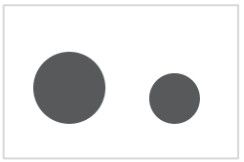


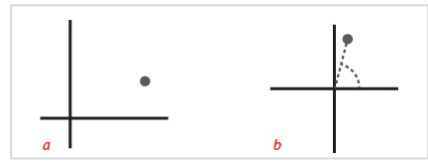


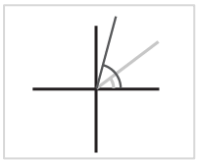


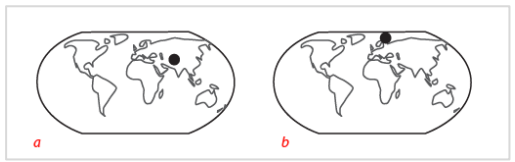


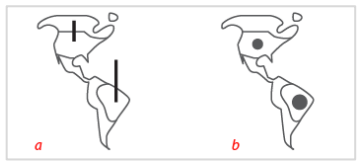


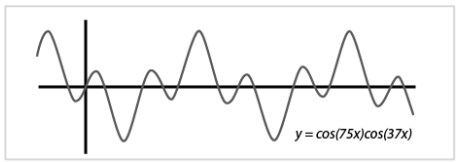


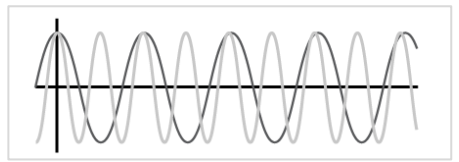


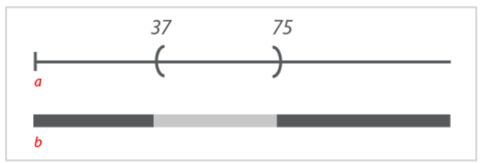


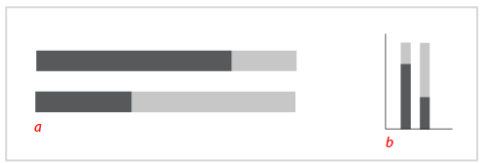


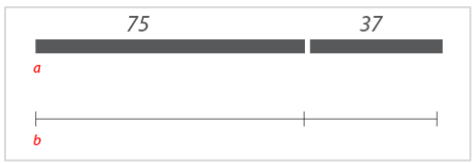


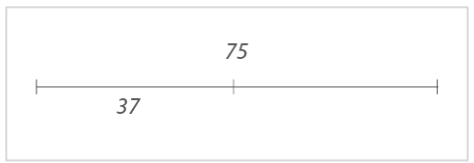










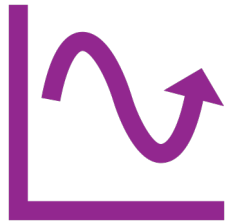


Santiago Ortiz, https://rockcontent.com/blog/45-ways-to-communicate-two-quantities/

So many possibilities. How to choose?

What do you want to show?

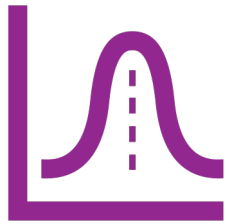
Comparison



Trend

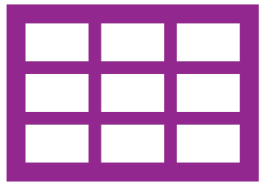
Part of a whole

Relationship



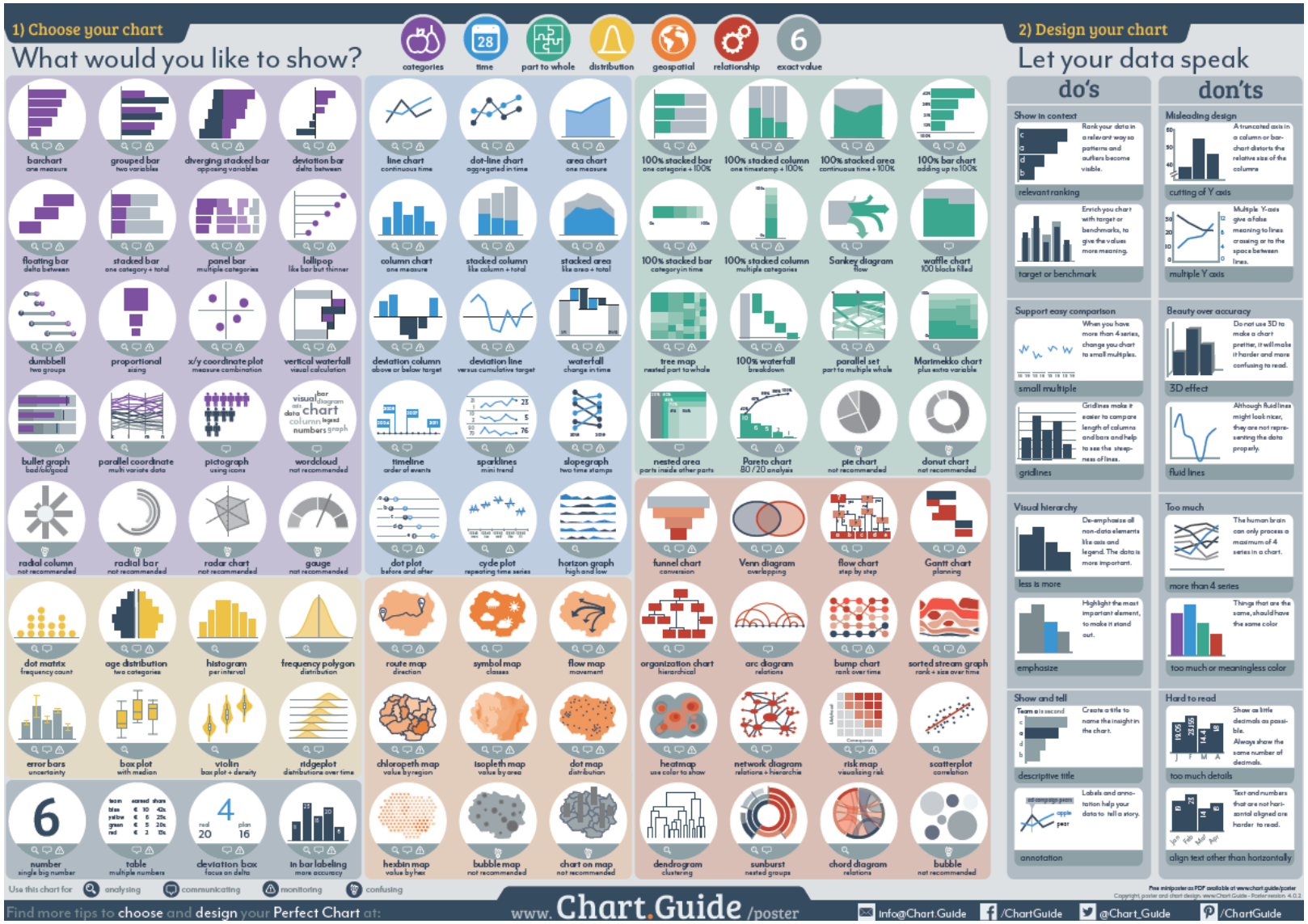
Distribution

Location

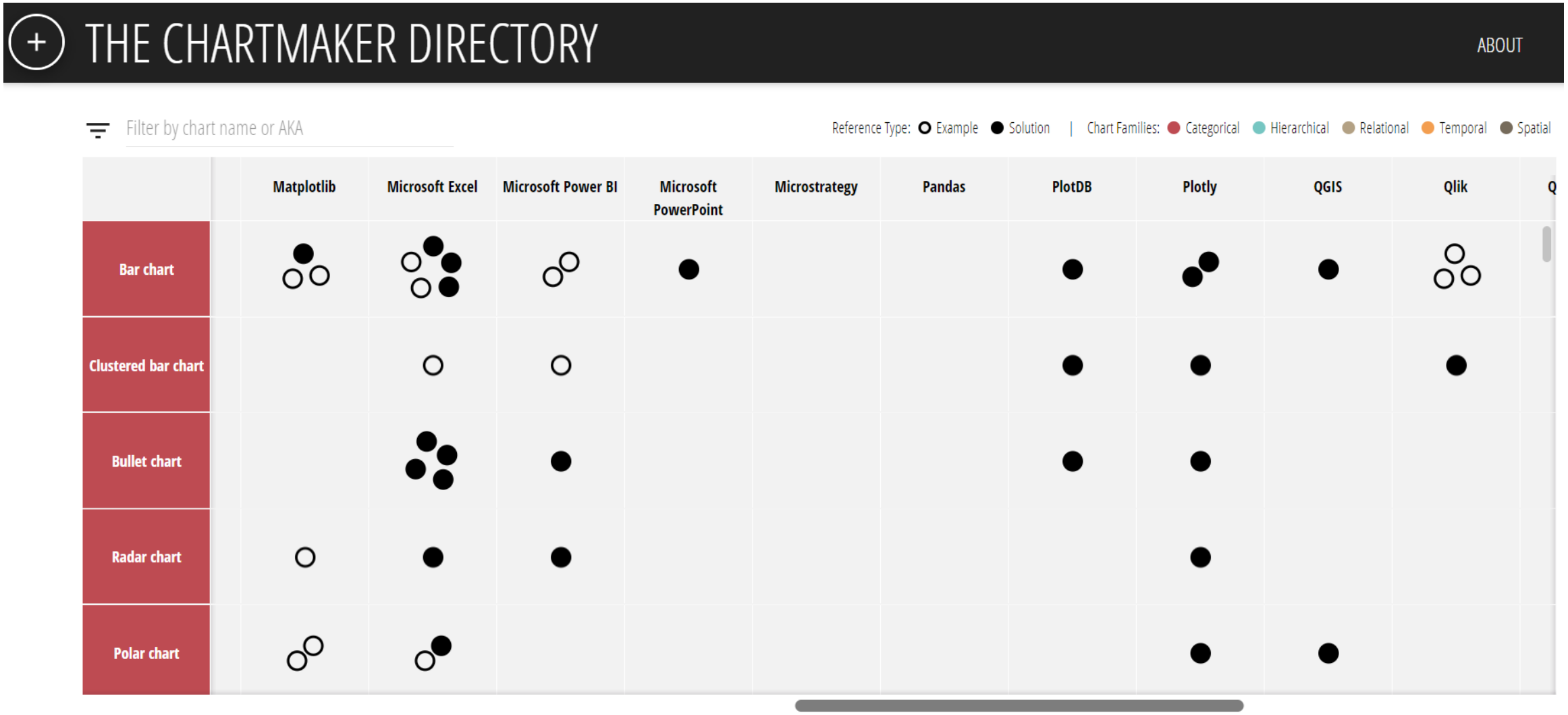


Exact values

Chart.Guide


1) Choose your chart
What would you like to show?
categories
time
part to whole
distribution
geospatial
relationship
exact value
2) Design your chart
Let your data speak
do's
don'ts
barchart
grouped bar
diverging stacked bar
deviation bar
line chart
dot-line chart
area chart
100% stacked bar
100% stacked column
100% stacked area
100% bar chart
floating bar
stacked bar
panel bar
lollipop
column chart
stacked column
stacked area
100% stacked bar
100% stacked column
Sankey diagram
waffle chart
dumbbell
proportional
x/y coordinate plot
vertical waterfall
deviation column
deviation line
waterfall
tree map
100% waterfall
parallel set
Marimekko chart
bullet graph
parallel coordinate
pictograph
wordcloud
timeline
sparklines
slopegraph
nested area
Pareto chart
pie chart
donut chart
radial column
radial bar
radar chart
gauge
dot plot
cycle plot
horizon graph
funnel chart
Venn diagram
flow chart
Gantt chart
dot matrix
age distribution
histogram
frequency polygon
route map
symbol map
flow map
organization chart
arc diagram
bump chart
sorted stream graph
error bars
box plot
violin
ridgeplot
chloropeth map
isopleth map
dot map
heatmap
network diagram
risk map
scatterplot
number
table
deviation box
in bar labeling
hexbin map
bubble map
chart on map
dendrogram
sunburst
chord diagram
bubble
Use this chart for
analysing
communicating
monitoring
confusing
Show in context
relevant ranking
target or benchmark
Support easy comparison
small multiple
gridlines
Visual hierarchy
less is more
emphasize
Show and tell
descriptive title
annotation
Misleading design
cutting of Y axis
multiple Y axis
Beauty over accuracy
3D effect
fluid lines
Too much
more than 4 series
too much or meaningless color
Hard to read
too much details
align text other than horizontally
Find more tips to choose and design your Perfect Chart at:
www.Chart.Guide/poster
Info@Chart.Guide
/ChartGuide
@Chart_Guide
/ChartGuide

The Chartmaker directory



https://chartmaker.visualisingdata.com/

from Data to Viz

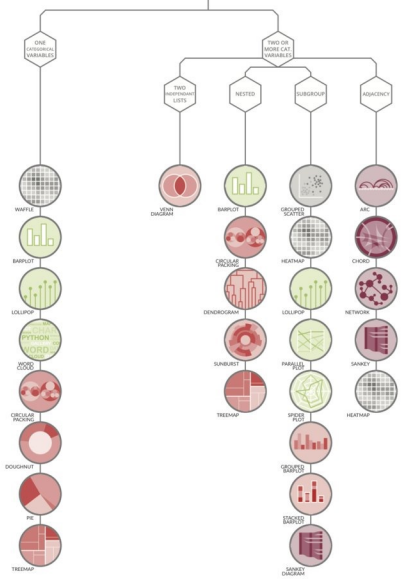
'From Data to Viz' is a classification of chart types based on input data format. It will help you find the perfect chart in three simple steps :

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

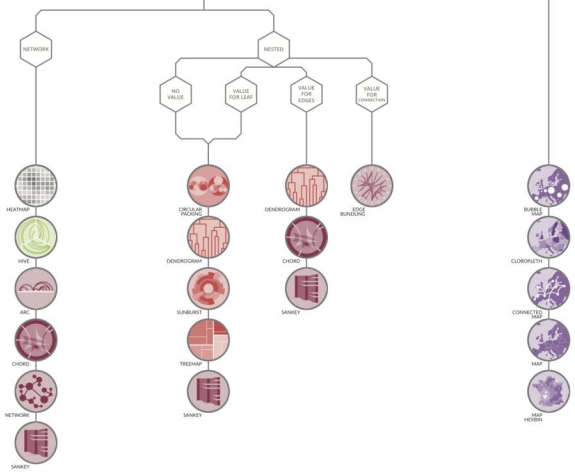
Dataviz is a world with endless possibilities and this project does not claim to be exhaustive. However it should provide you with a good starting point. For an interactive version and much more, visit:

data-to-viz.com

CATEGORIC

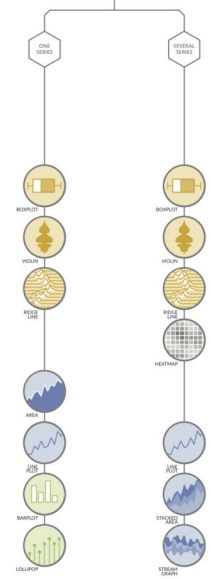


RELATIONAL



MAP

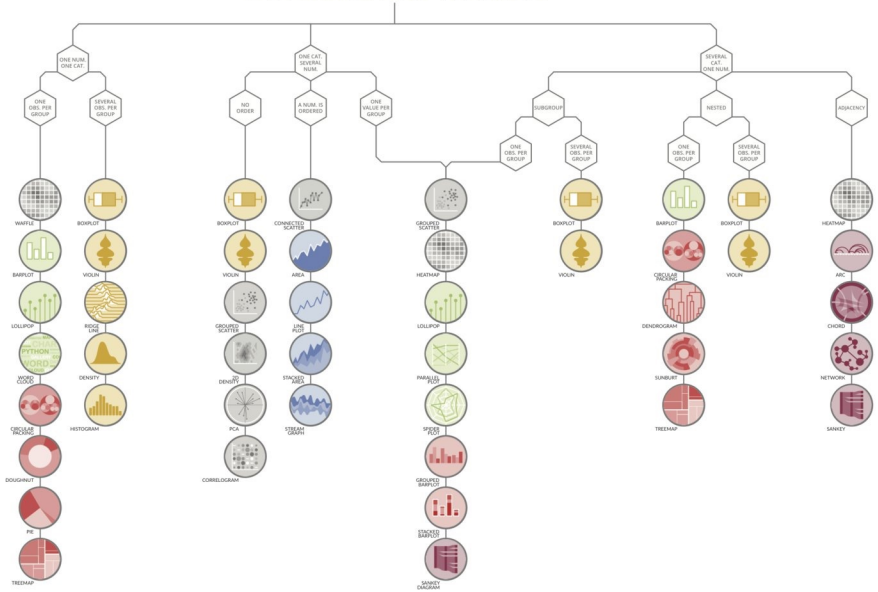
TIME SERIES



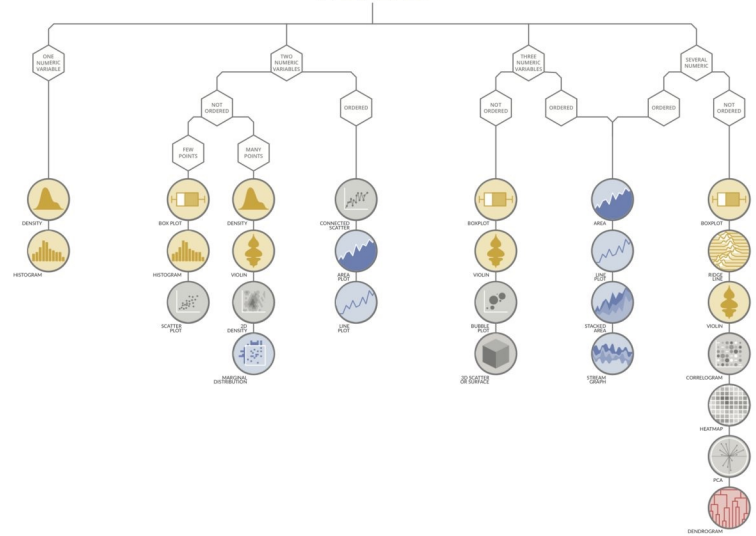
WHAT DO YOU WANT TO SHOW ?

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

CATEGORIC AND NUMERIC



NUMERIC



Visual perception

The **strengths** of our brain

“The eyes only see what the mind is prepared to comprehend.” – Henri Bergson.

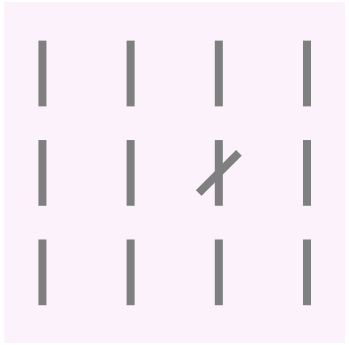
How many fives do you see?

3216546432164651321684613216464321367486513496874631236689432616266984892536496874651687964649843616984616957465167412323161689312439873421432875943869234987596387

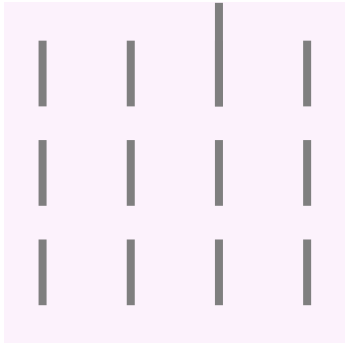
How many fives do you see?

3216546432164651321684613216432136748651349687463123668432616266984892536496874651687964649843616984616957465167412323161689312439873214328759438692349875963876

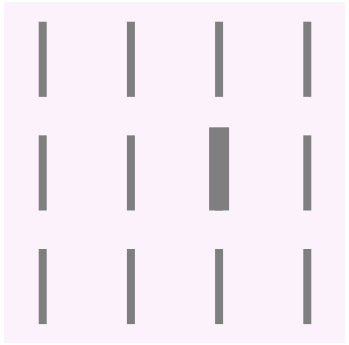
Pre-attentive attributes make your audience see what you want them to see before even seeing it!



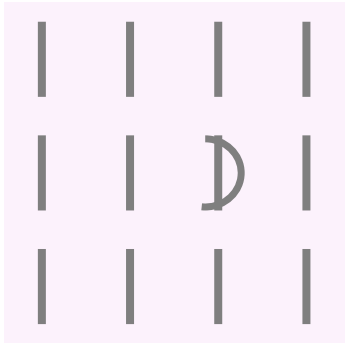
Orientation



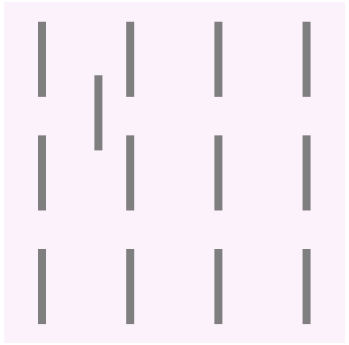
Length



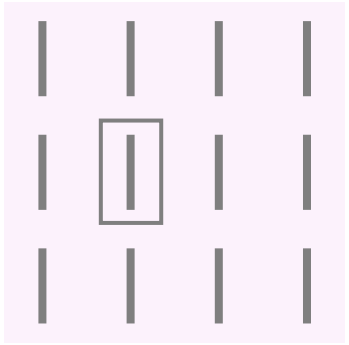
Width



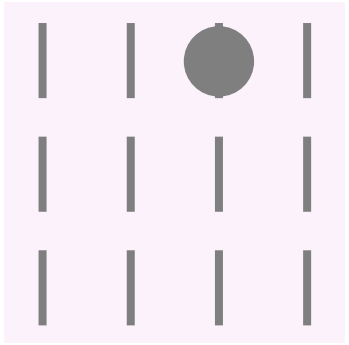
Curvature



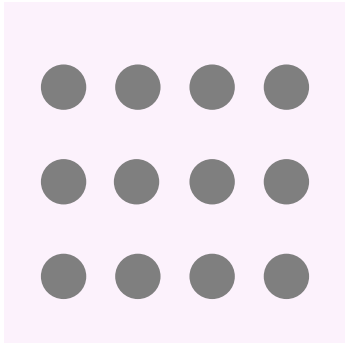
Position



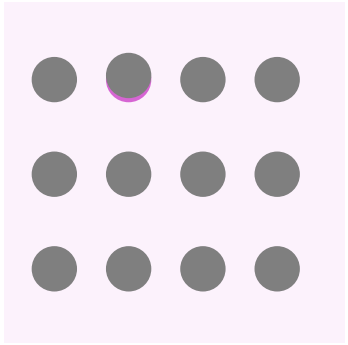
Enclosure



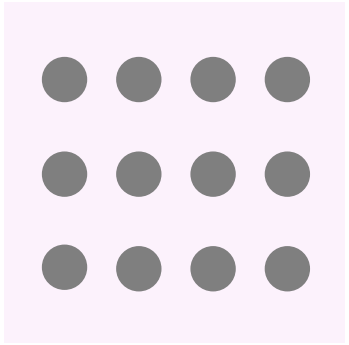
Shape



Size



Color



Motion

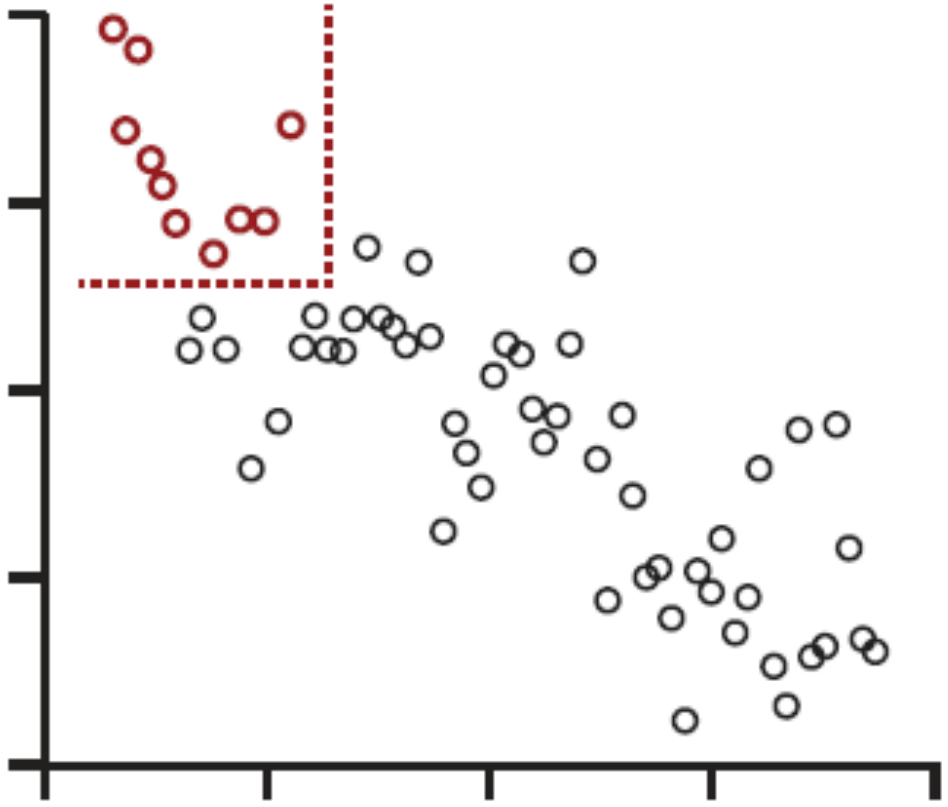
You can use pre-attentive attributes in tables

Color name	RGB (1–255)
Black	0, 0, 0
Orange	230, 159, 0
Sky blue	86, 180, 233
Bluish green	0, 158, 115
Blue	0, 114, 178
Vermillion	213, 94, 0

Wong. B. Salience to relevance. *Nat Methods* 8, 889 (2011).

You can use pre-attentive attributes in tables and charts

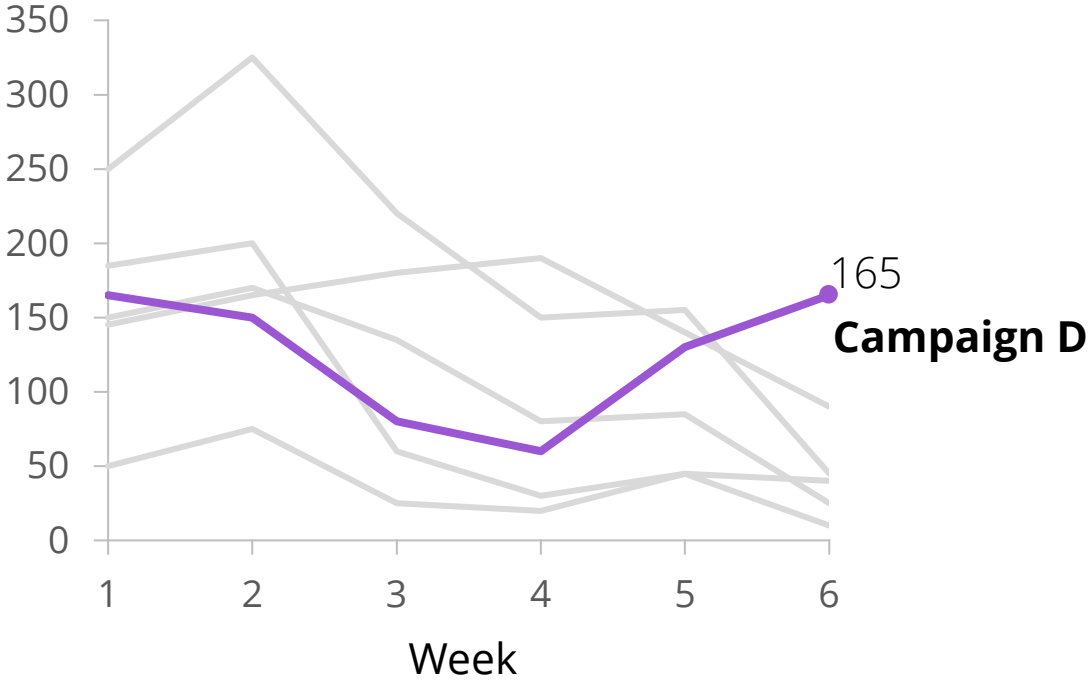
Color name	RGB (1–255)
Black	0, 0, 0
Orange	230, 159, 0
Sky blue	86, 180, 233
Bluish green	0, 158, 115
Blue	0, 114, 178
Vermillion	213, 94, 0



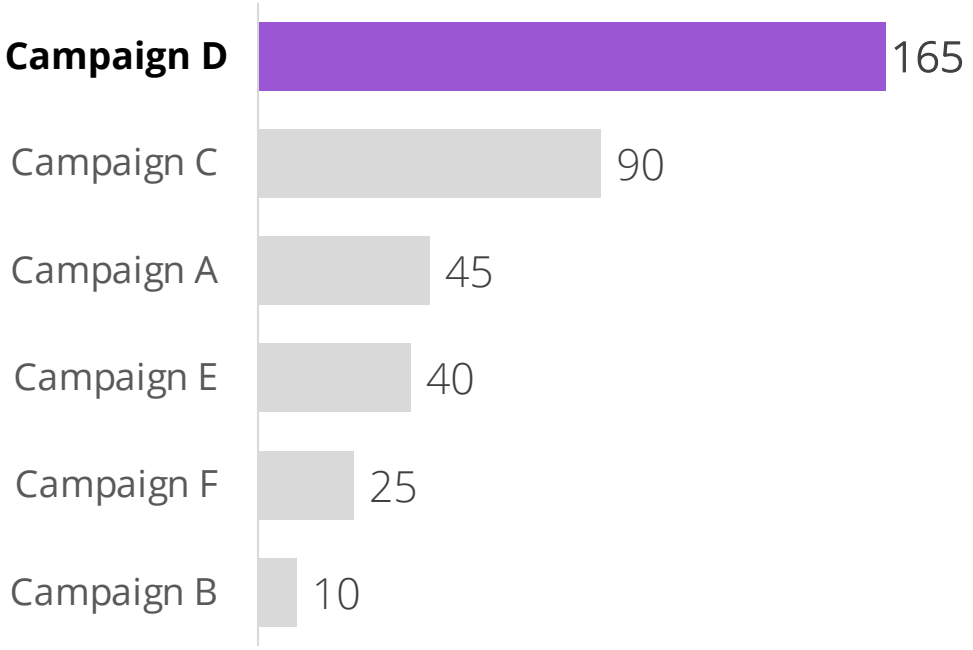
Wong. B. Salience to relevance. *Nat Methods* 8, 889 (2011).

To draw attention to what's important

Leads Generated by Campaign



Leads Generated by Campaign in Sixth Week



You can also use pre-attentive attributes in text.

How can you leverage the use of pre-attentive attributes?

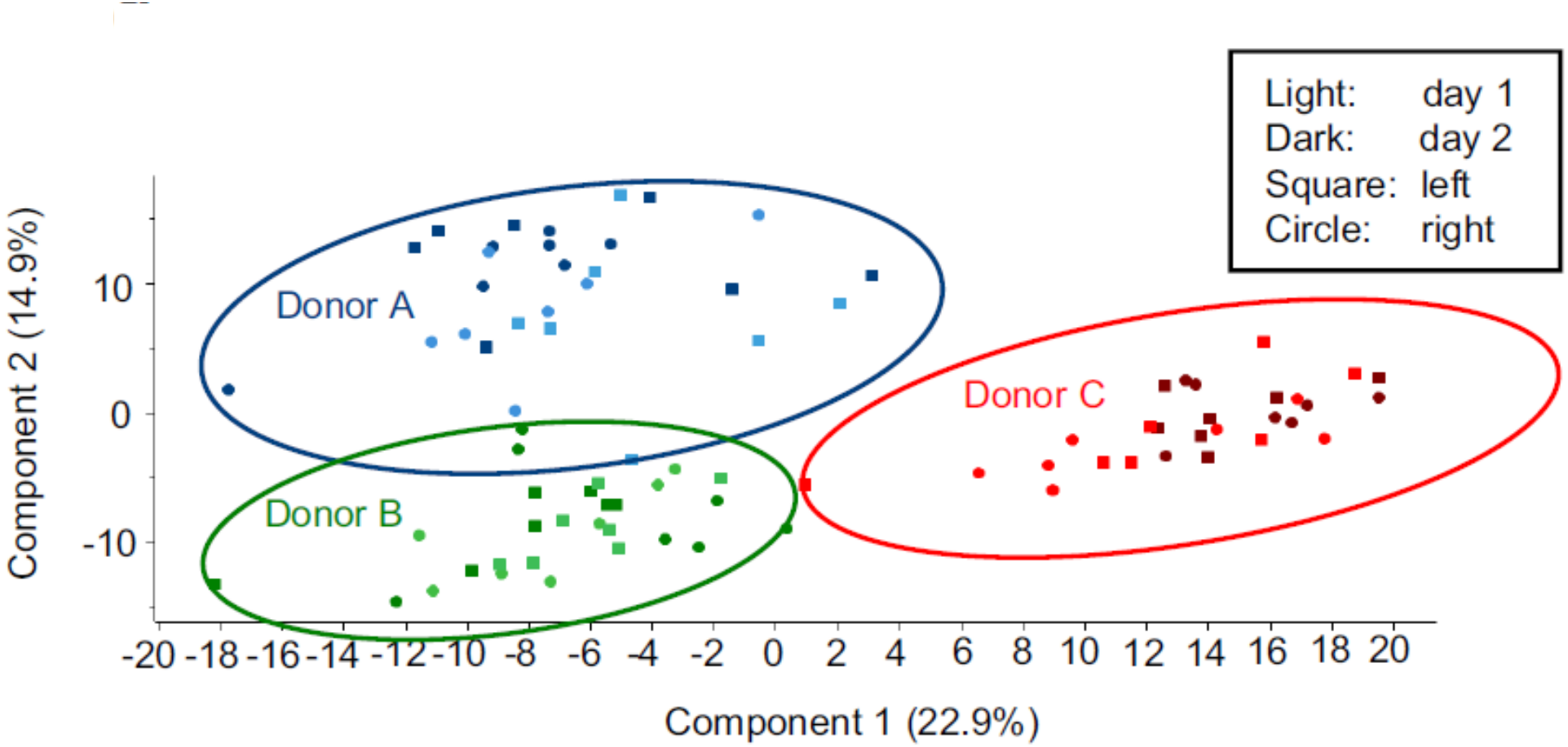
Without pre-attentive attributes you just have plain text. Or a plain figure. There is no guidance for the reader or viewer.

With pre-attentive attributes, you can:

(1) Draw your audience attention to where you want them to look, and
(2) Create a visual hierarchy of information

This counts for **graphs** as well as **text**!

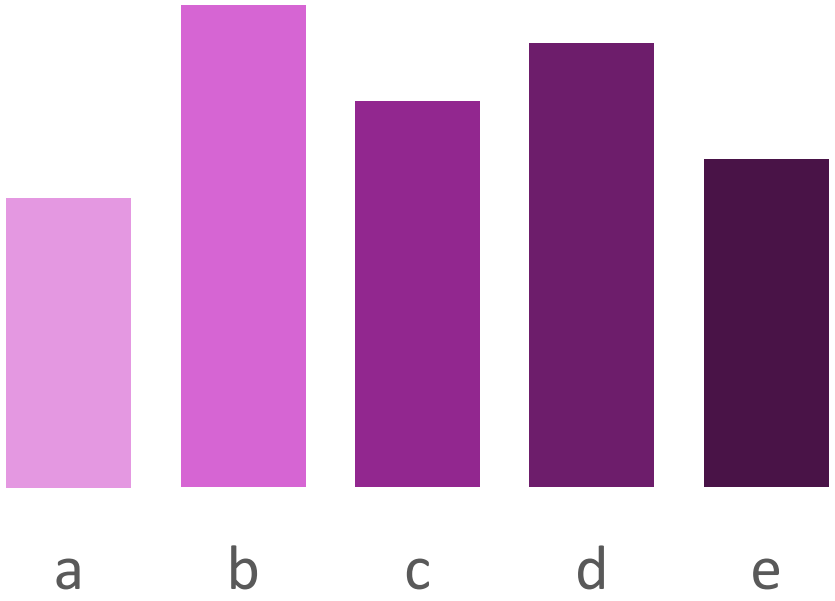
Pre-attentive attributes can create a visual hierarchy



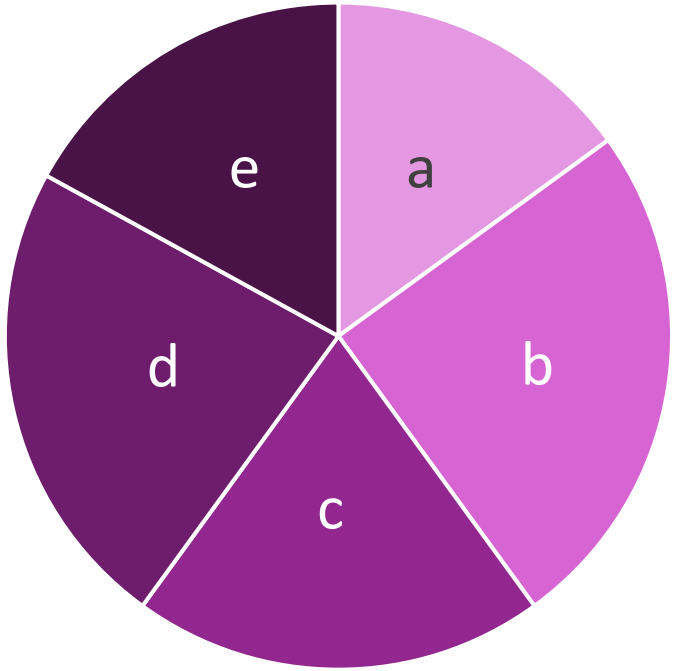
Brunmair, J. *et al. Nat Commun* **12,** 5993 (2021).

Pre-attentive attributes can be used to map quantities, e.g. by length or by angle

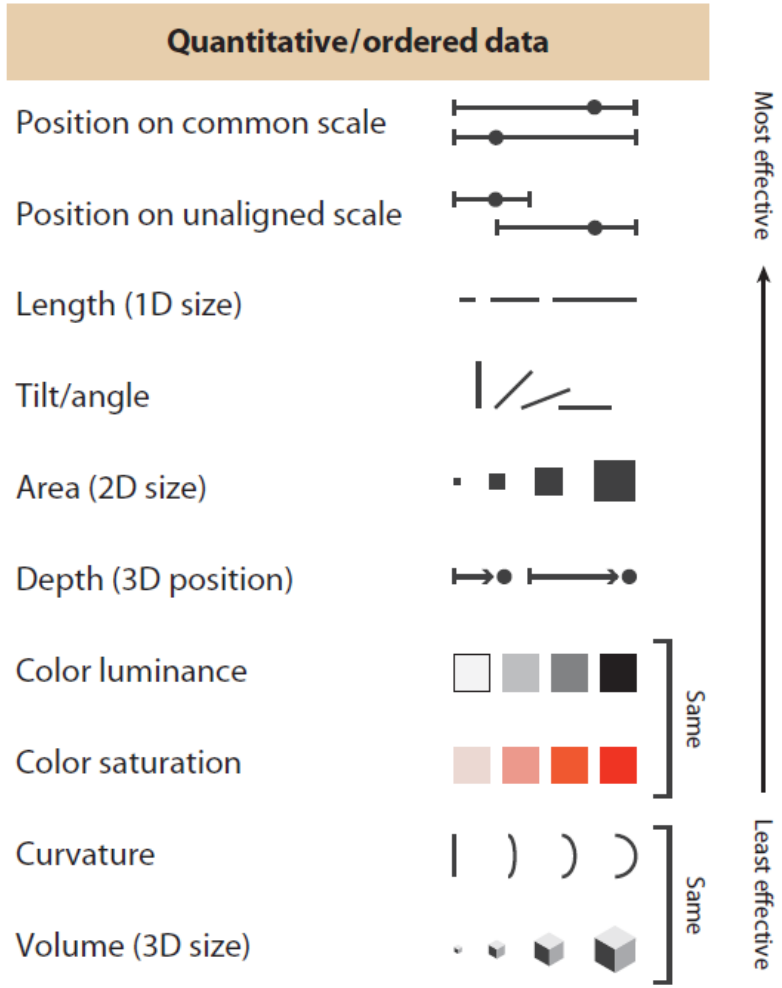
Which bar is highest?



Which slice is biggest?

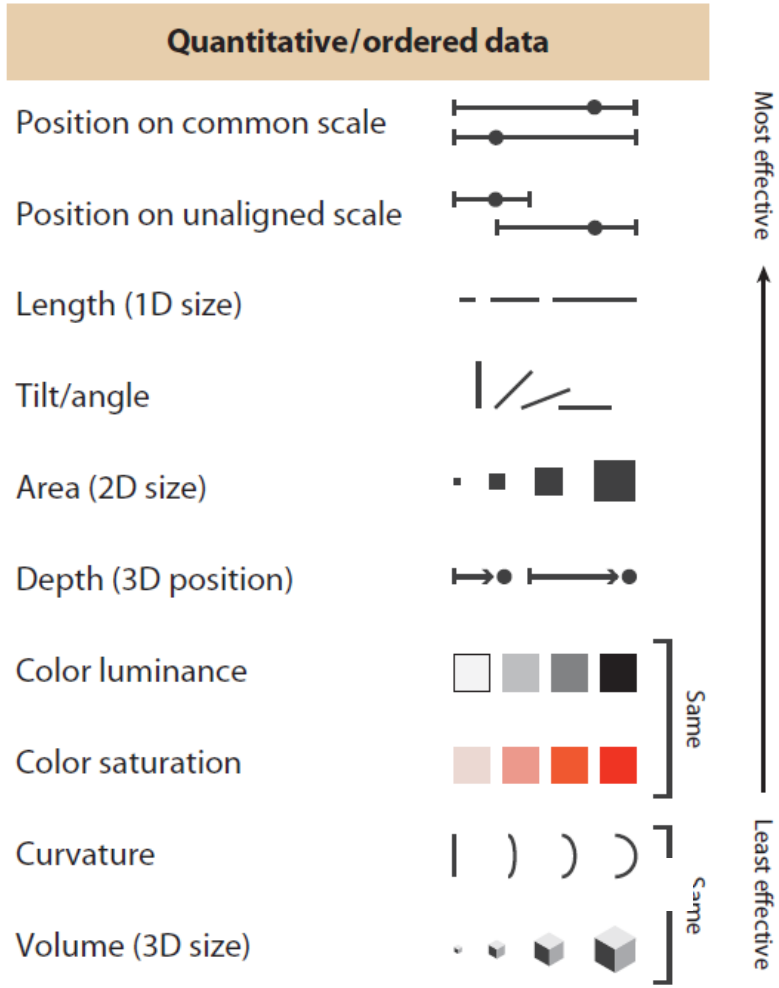


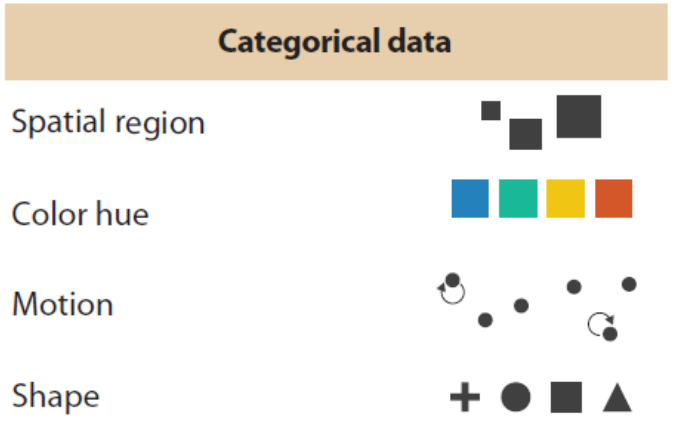
Some attributes are more effective to differentiate **quantities**

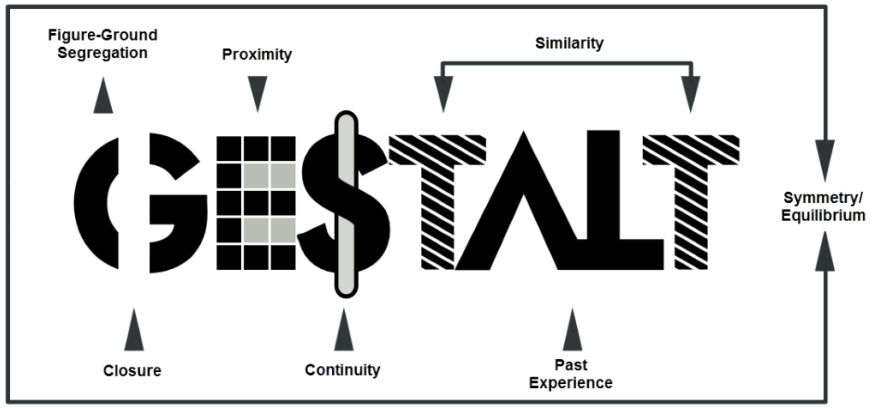


O'Donoghue SI *et al.* (2018) Visualization of biomedical data. Annu. Rev. Biomed. Data Sci 1: 275-304

Some attributes are more effective to differentiate **quantities** or **categories**





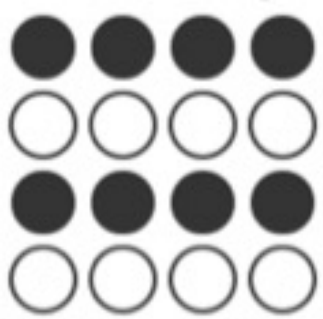


O'Donoghue SI *et al.* (2018) Visualization of biomedical data. Annu. Rev. Biomed. Data Sci 1: 275-304

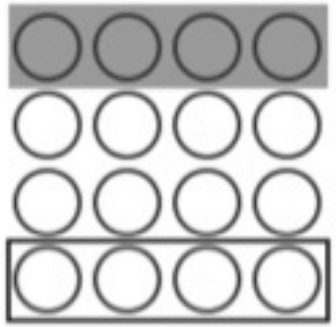
Gestalt principes: The whole is other than the sum of the parts.

Proximity

Similarity



Enclosure



Symmetry

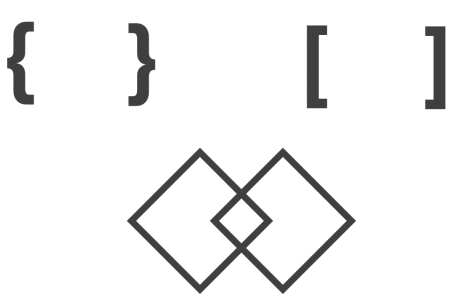
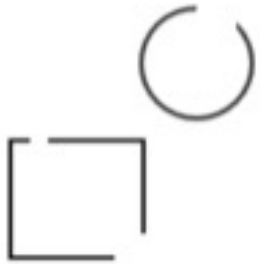


Figure-ground

Closure

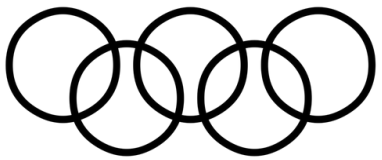


Continuity

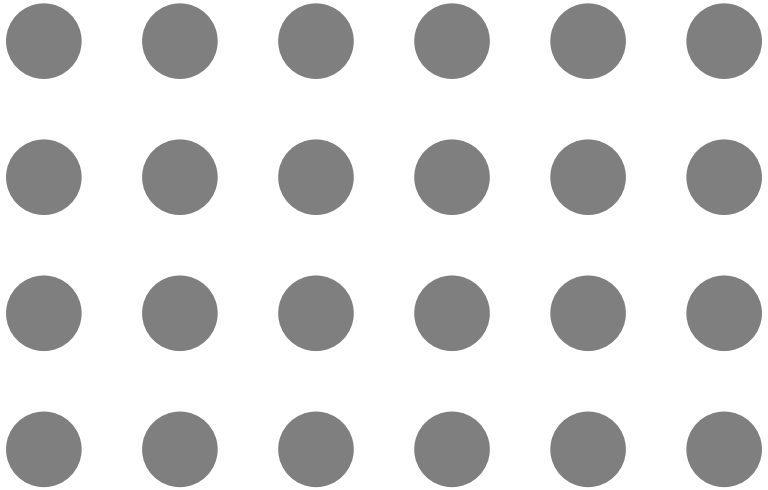
Connection

Common Fate

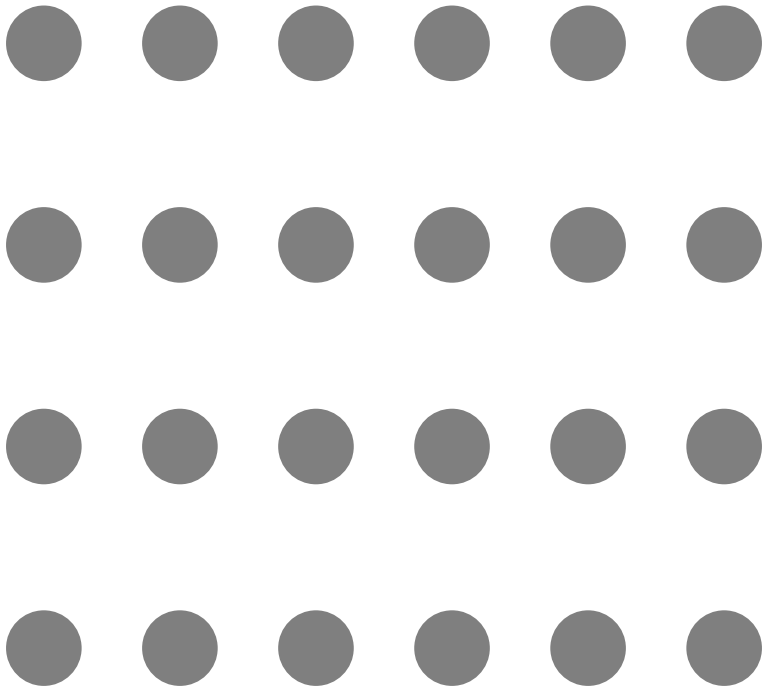
Simplicity



The **Gestalt** principles describe how our brain *groups* information

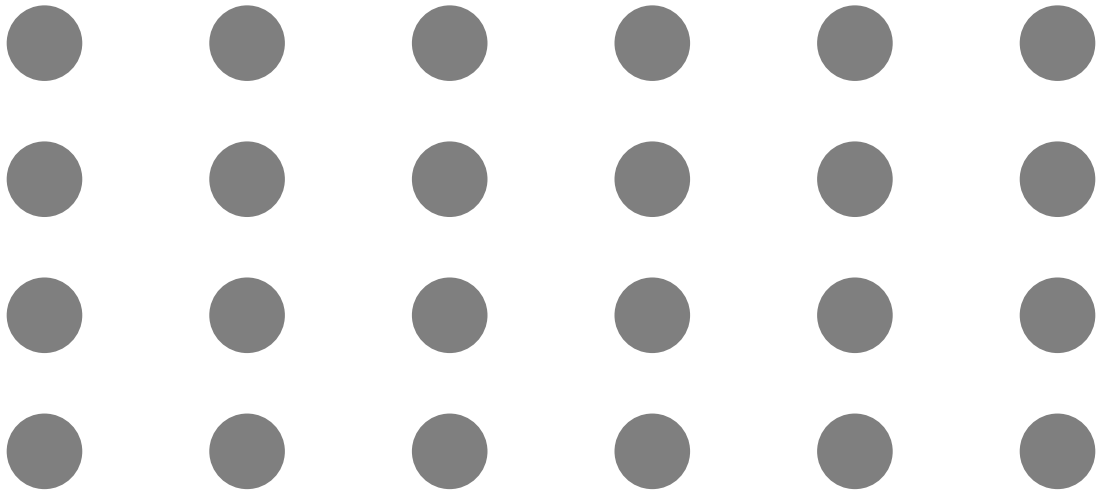


The **Gestalt** principles describe how our brain *groups* information



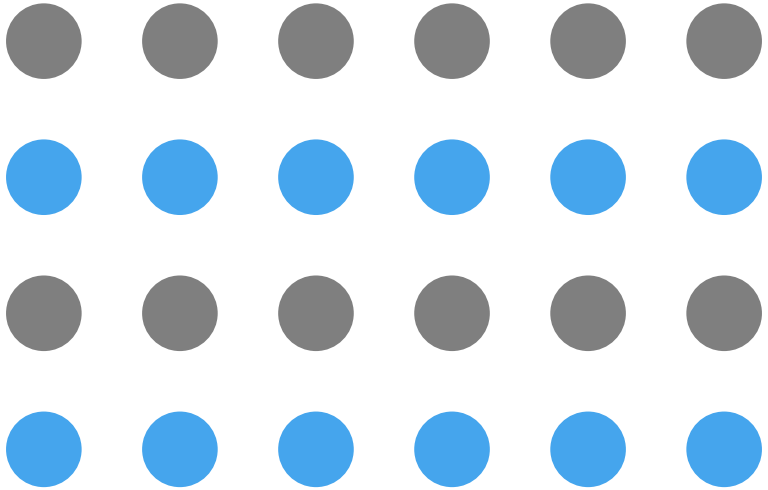
Proximity

The **Gestalt** principles describe how our brain *groups* information



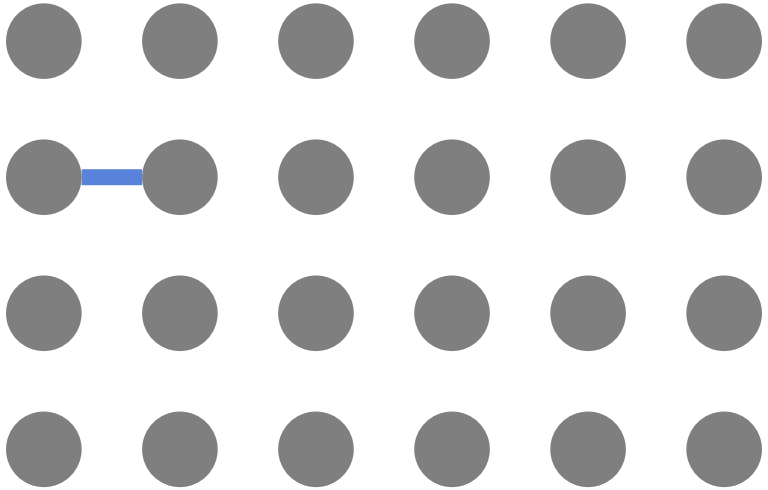
Proximity

The **Gestalt** principles describe how our brain *groups* information



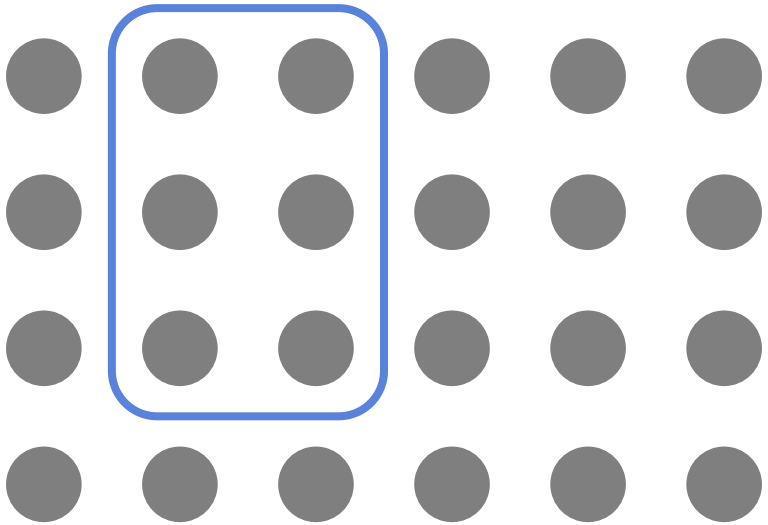
Similarity

The **Gestalt** principles describe how our brain *groups* information



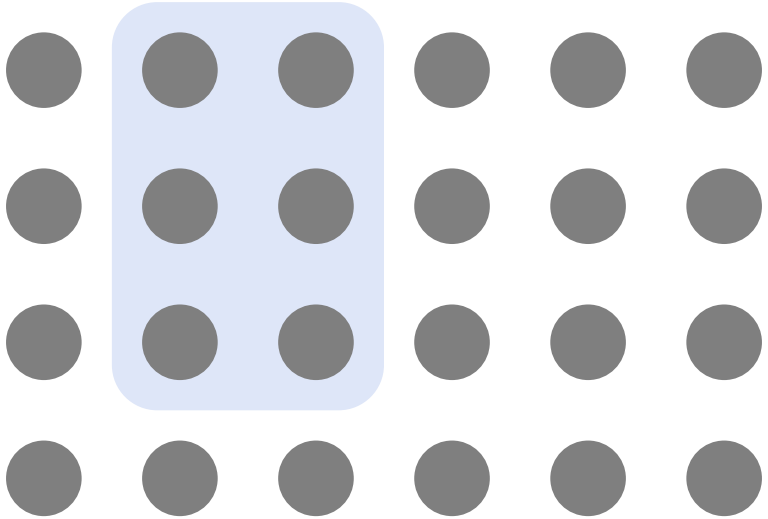
Connection

The **Gestalt** principles describe how our brain *groups* information



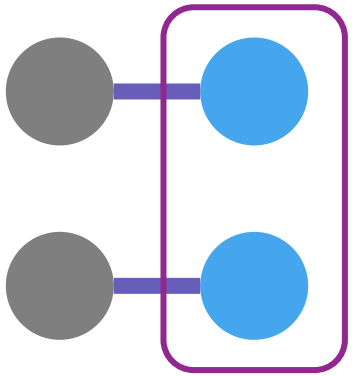
Enclosure

The **Gestalt** principles describe how our brain *groups* information



Enclosure

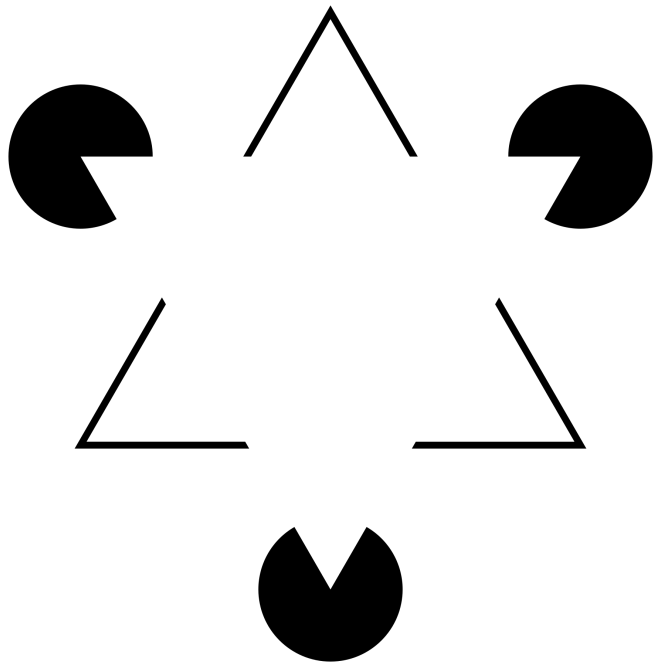
Some visual properties have stronger associative values than others…



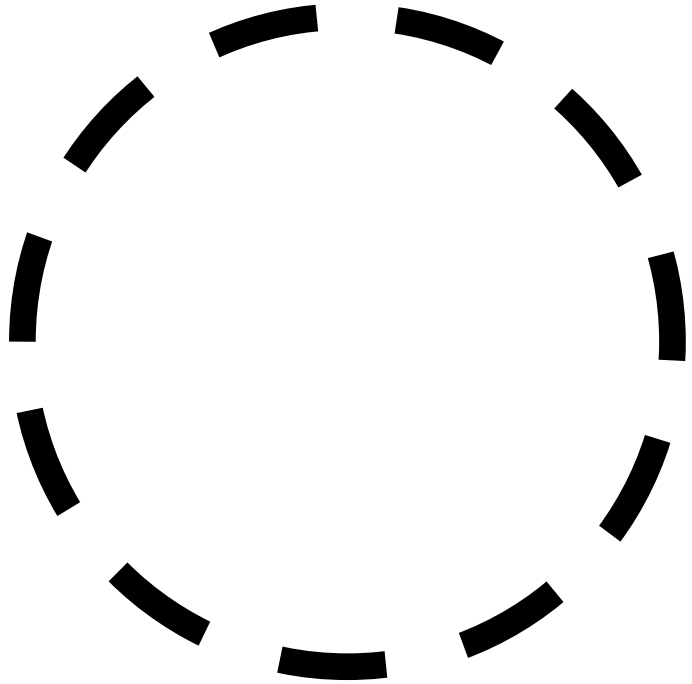
Can you read this?

Aoccdrnig to a rsceearh at Cmabrgide Uinervtisy, it deosn’t mttaer in what order the ltteers in a wrod are, the olny iprmoatnt tnihg is taht the frsit and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can siltl raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

We’re also good at seeing things that may not explicitly exist!

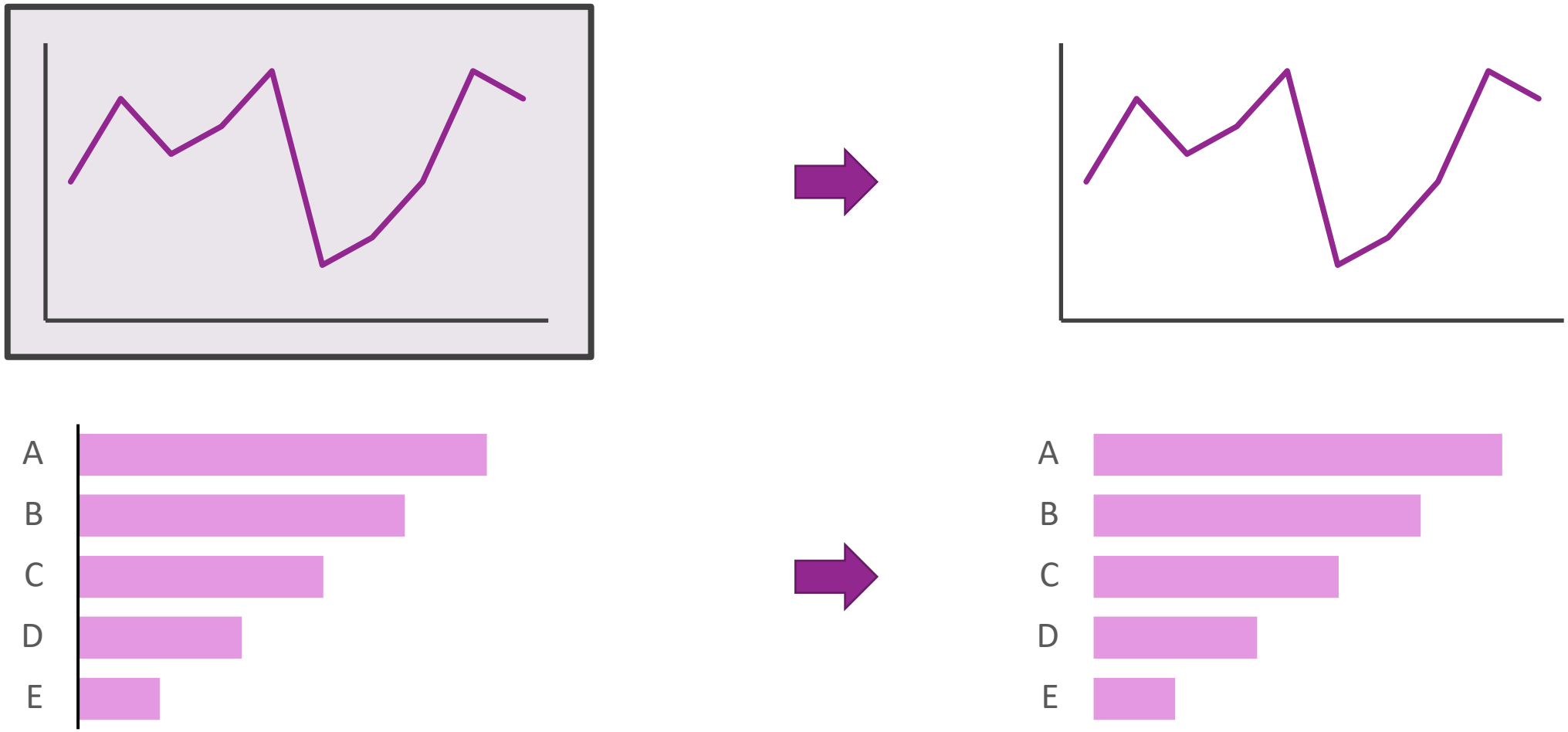


Continuity

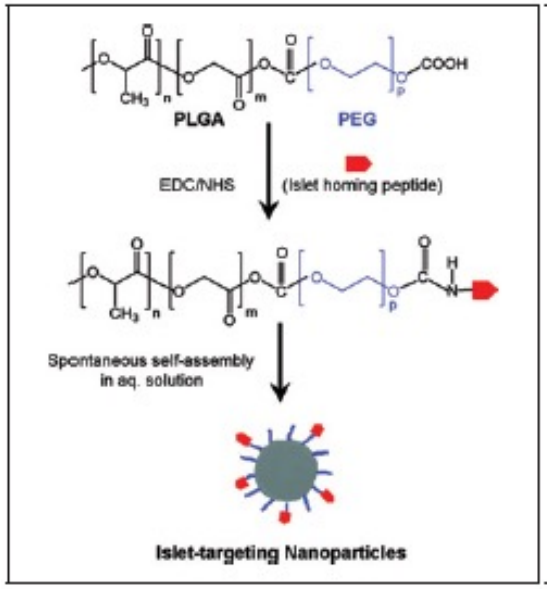


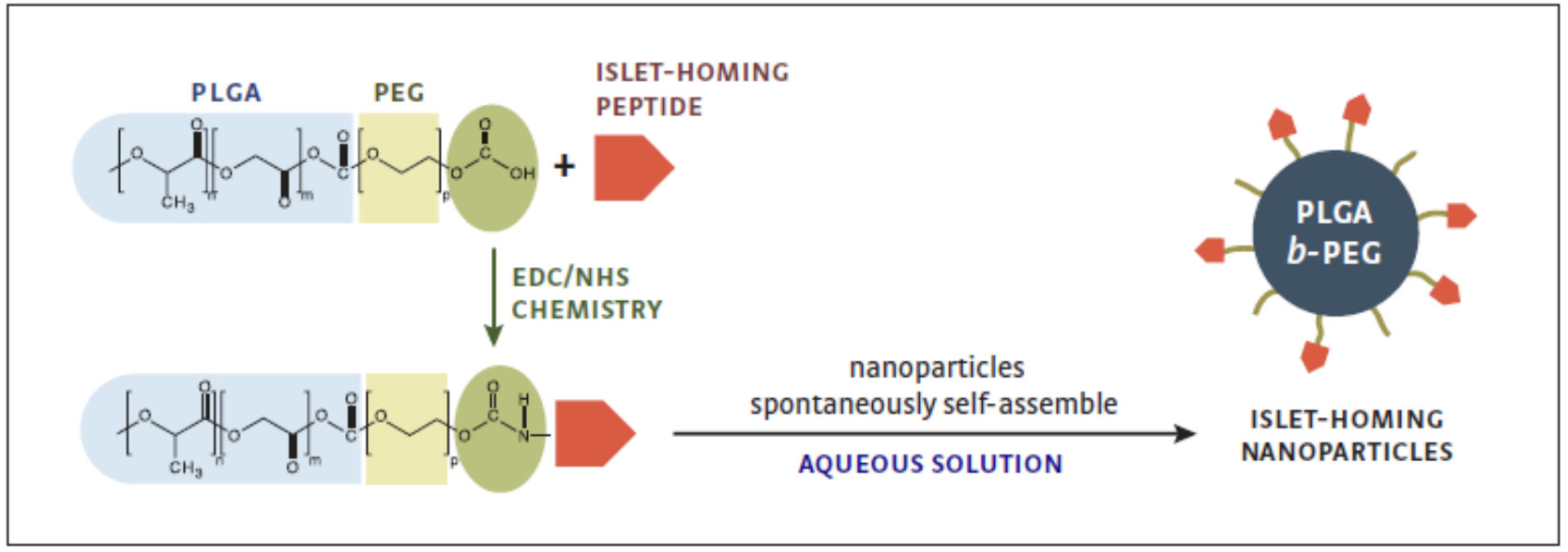
Closure

You can use the **Continuity** and **Closure** principle to remove unnecessary elements in your chart



The **Gestalt principles** also apply to graphical abstracts





Shapes and colors used to identify similar structures.

Cheng K *et al*. (2017). *Proving the value of visual design on scientific communication*. Information Design Journal 23, 80-95.

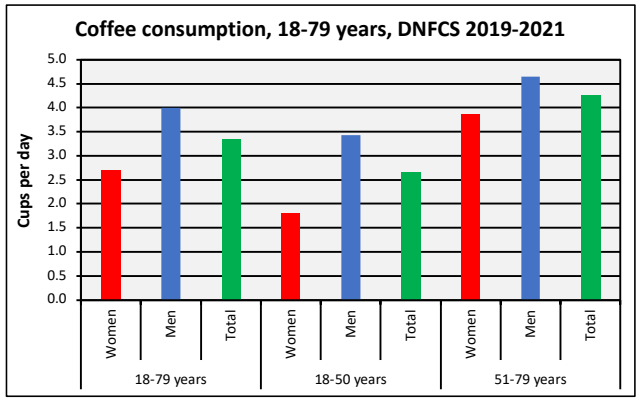
But…

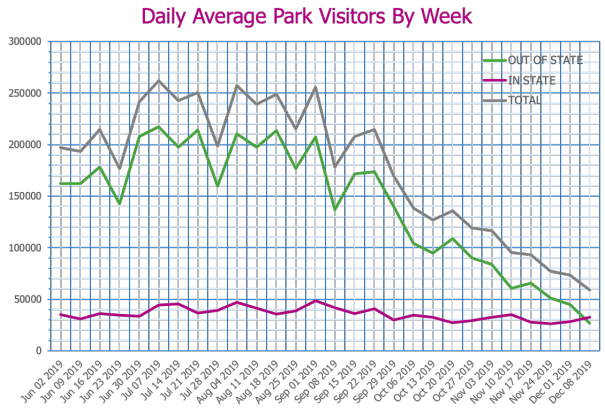
Exercise

I Notice. I Wonder.

I Notice. I Wonder

Use your **own visual** or one of the examples:





Notice: (<10 sec)

- ☐ What is the first thing that catches your eye?
- ☐ What is your first impression?

Wonder: (< 1 min)

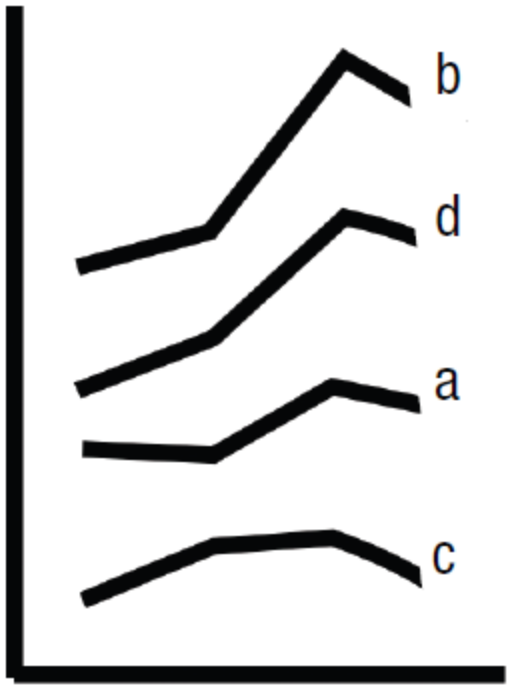
- ☐ Do you get an idea about the message? What is it?
- ☐ What questions come to mind?

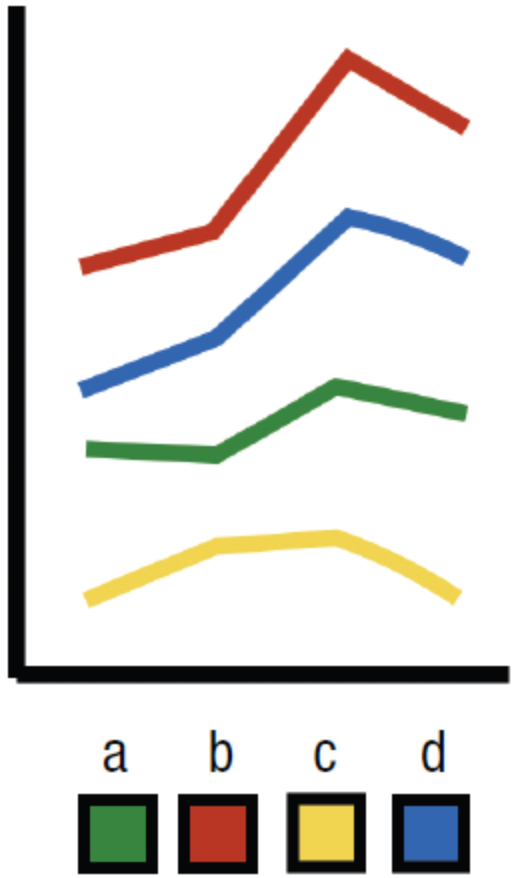
Visual perception

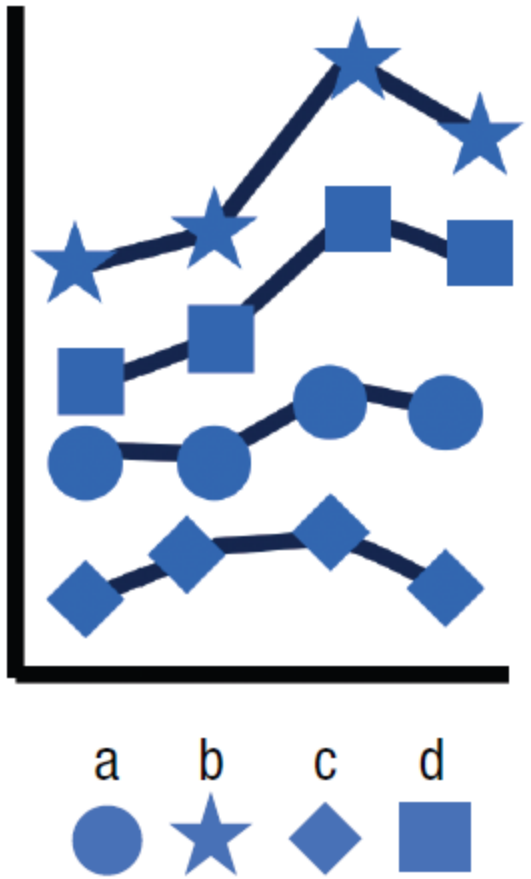
The **weaknesses** of our brain

“The eyes only see what the mind is prepared to comprehend.” – Henri Bergson.

What is the order from top-to-bottom?







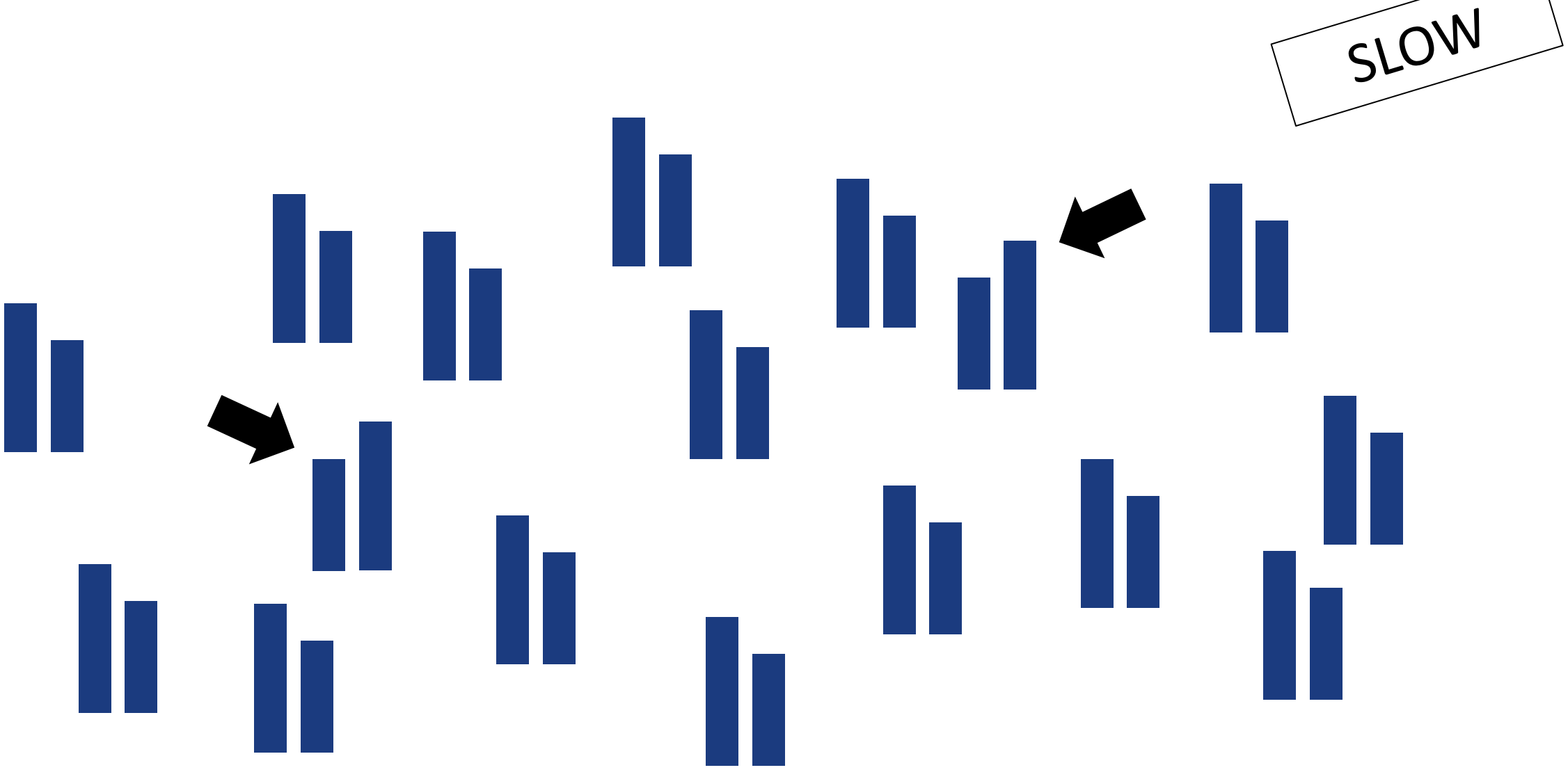
Franconeri SL *et al.* (2021) *The science of visual data communication: what works*. J. Psychol sci Public Interest 22: 110-161

Do you see small-big or big-small?

FAST

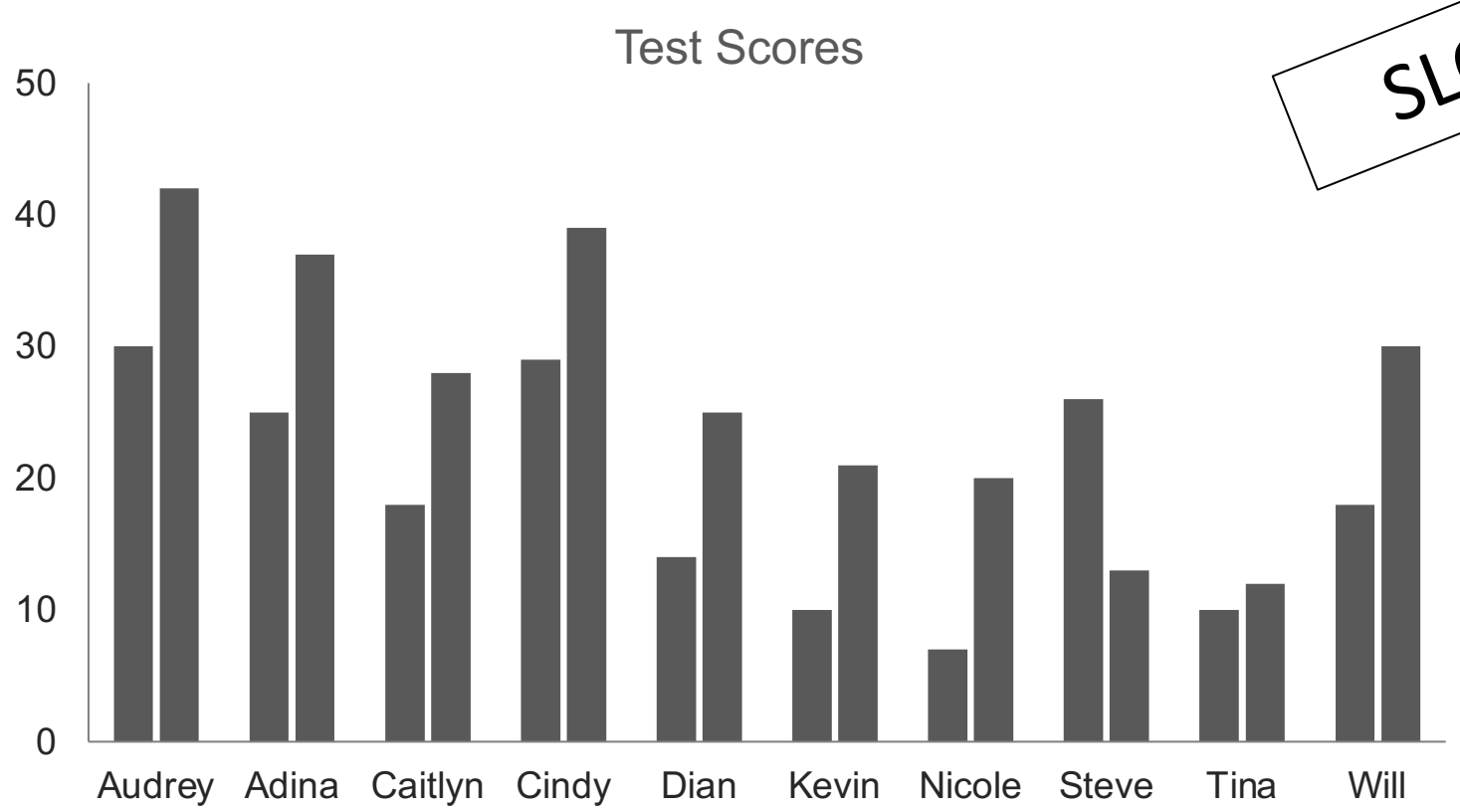
Steven Franconeri, OpenVis Conf 2018, Thinking with data visualizations: fast and slow

Which one is not like the others?



Steven Franconeri, OpenVis Conf 2018, Thinking with data visualizations: fast and slow

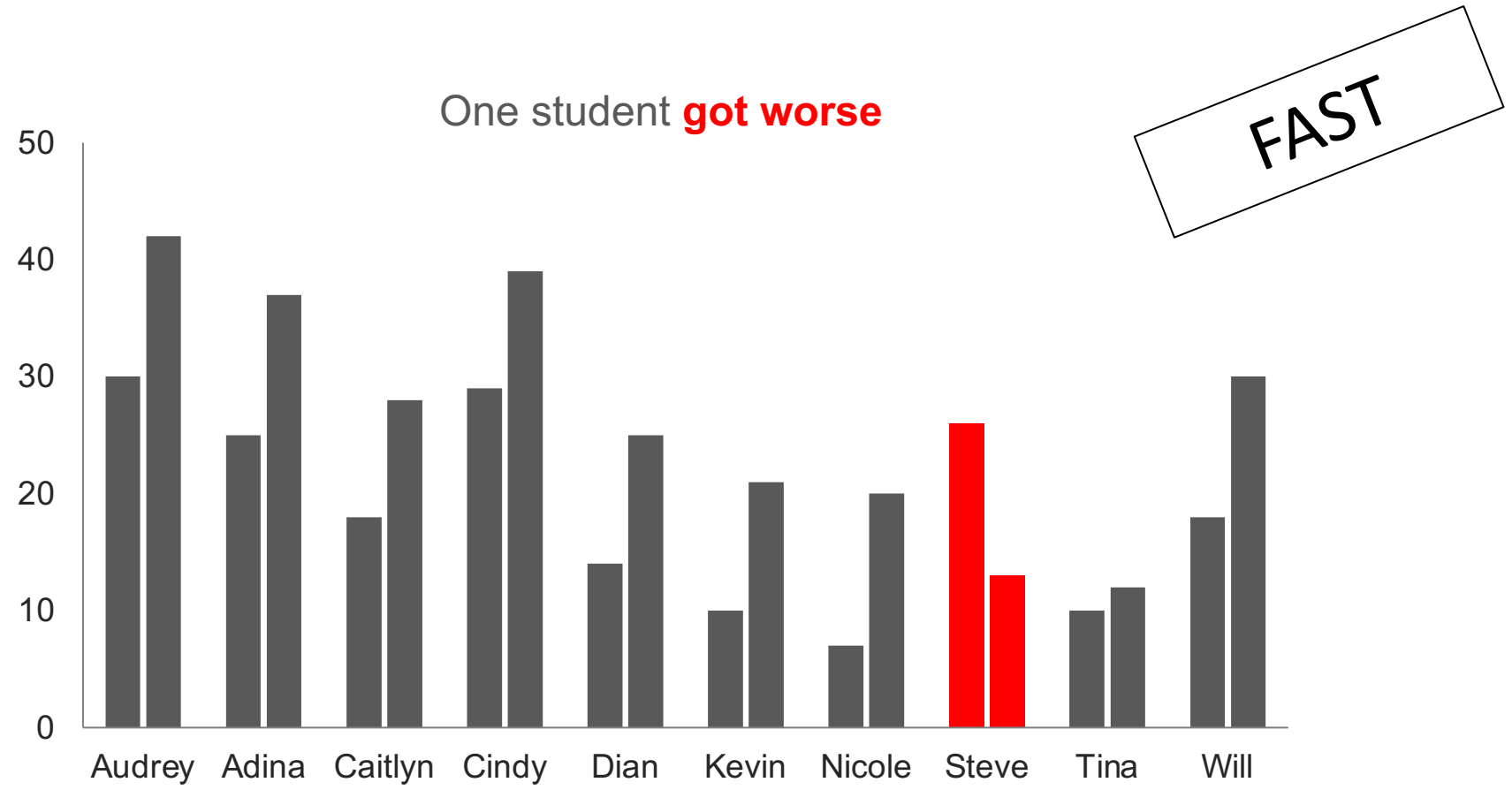
Which student got worse?



SLOW

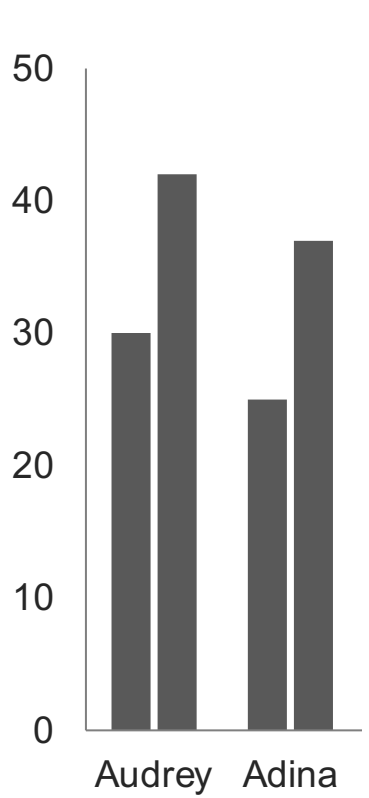
Adapted from Franconeri SL *et al.* J. Psychol sci Public Interest (2021) 22: 110

Which student got worse?



Adapted from Franconeri SL *et al.* J. Psychol sci Public Interest (2021) 22: 110

What is the average improvement?



FAST

Adapted from Franconeri SL *et al.* J. Psychol sci Public Interest (2021) 22: 110

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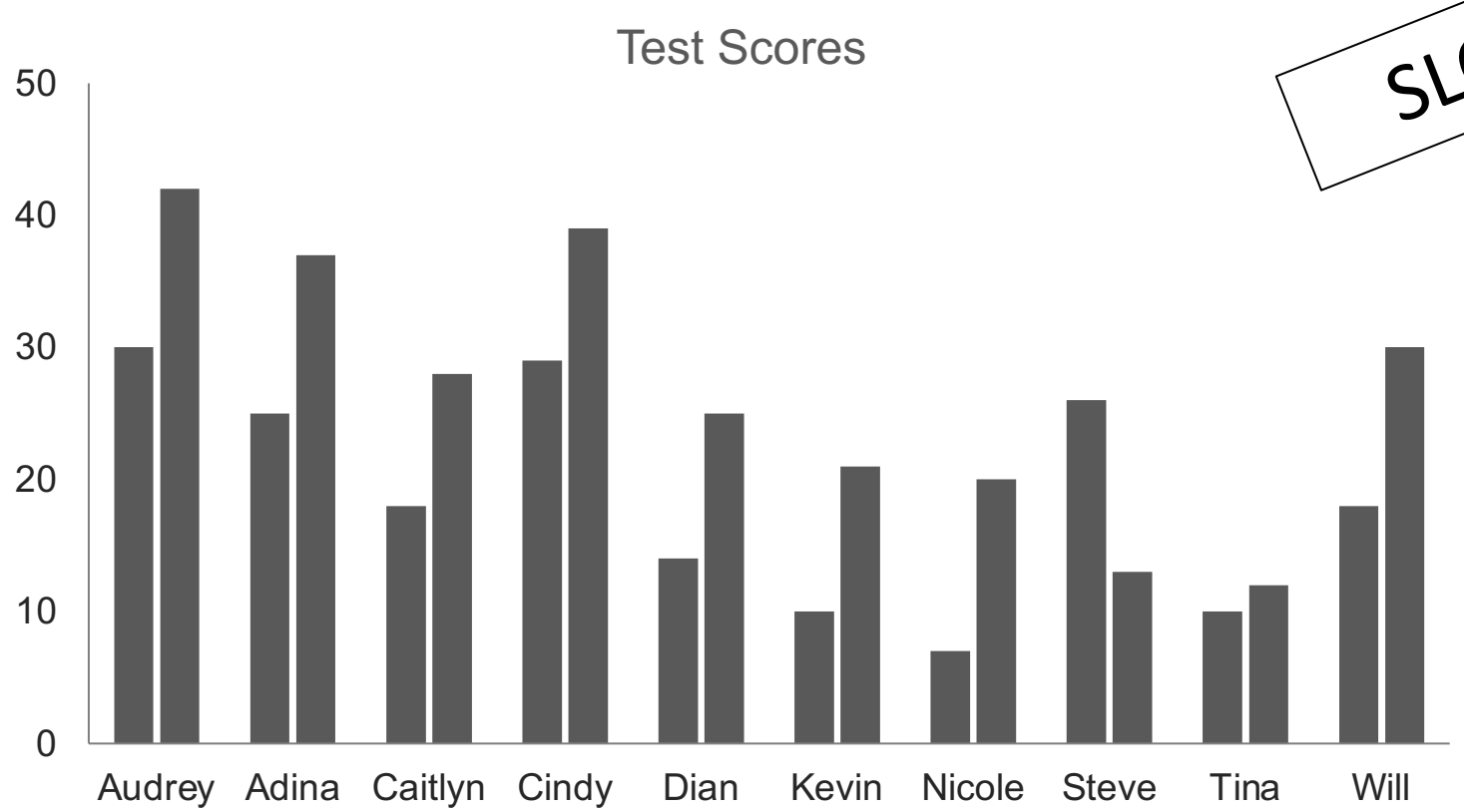
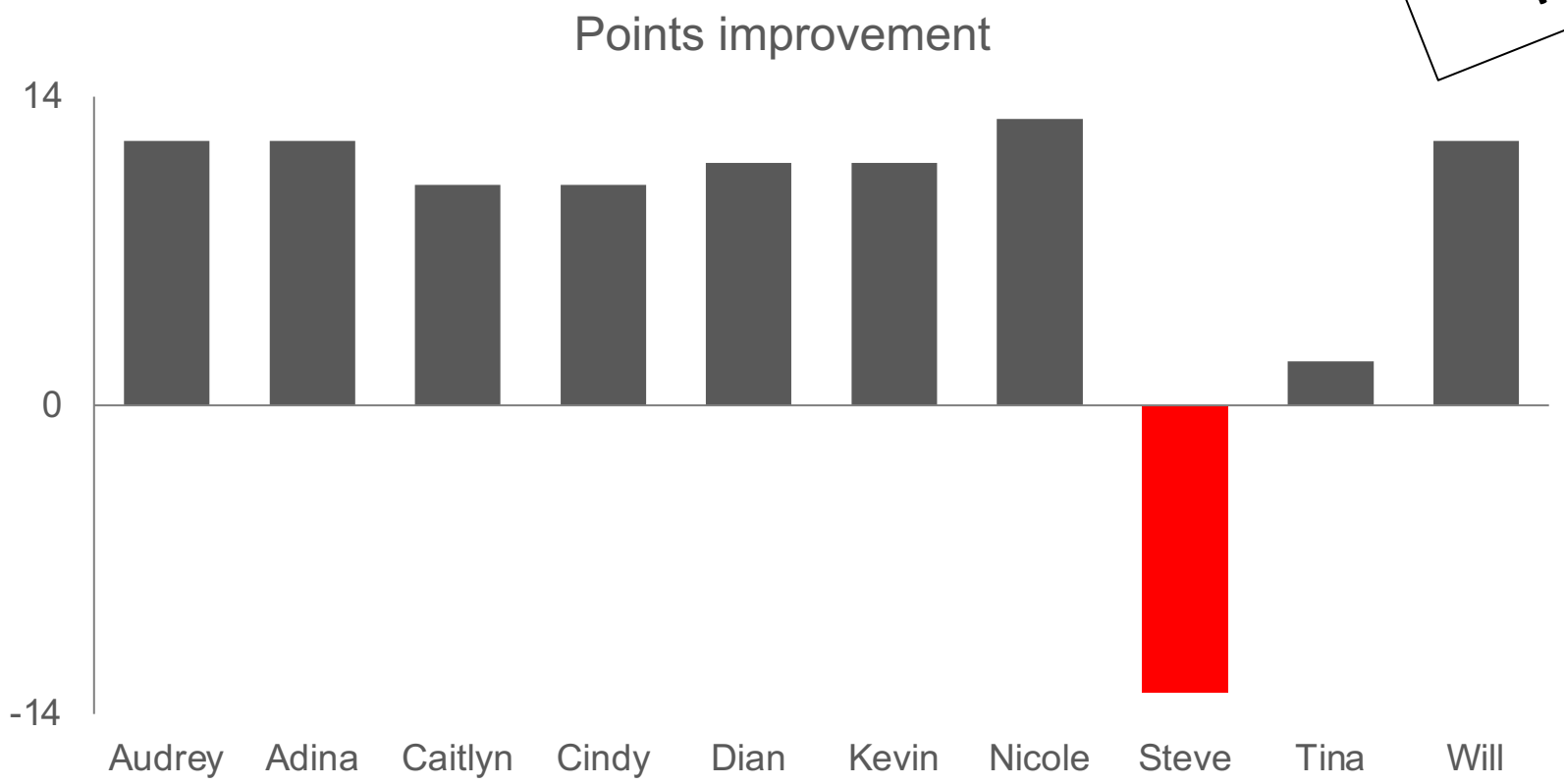


SLOW

Adapted from Franconeri SL *et al.* J. Psychol sci Public Interest (2021) 22: 110

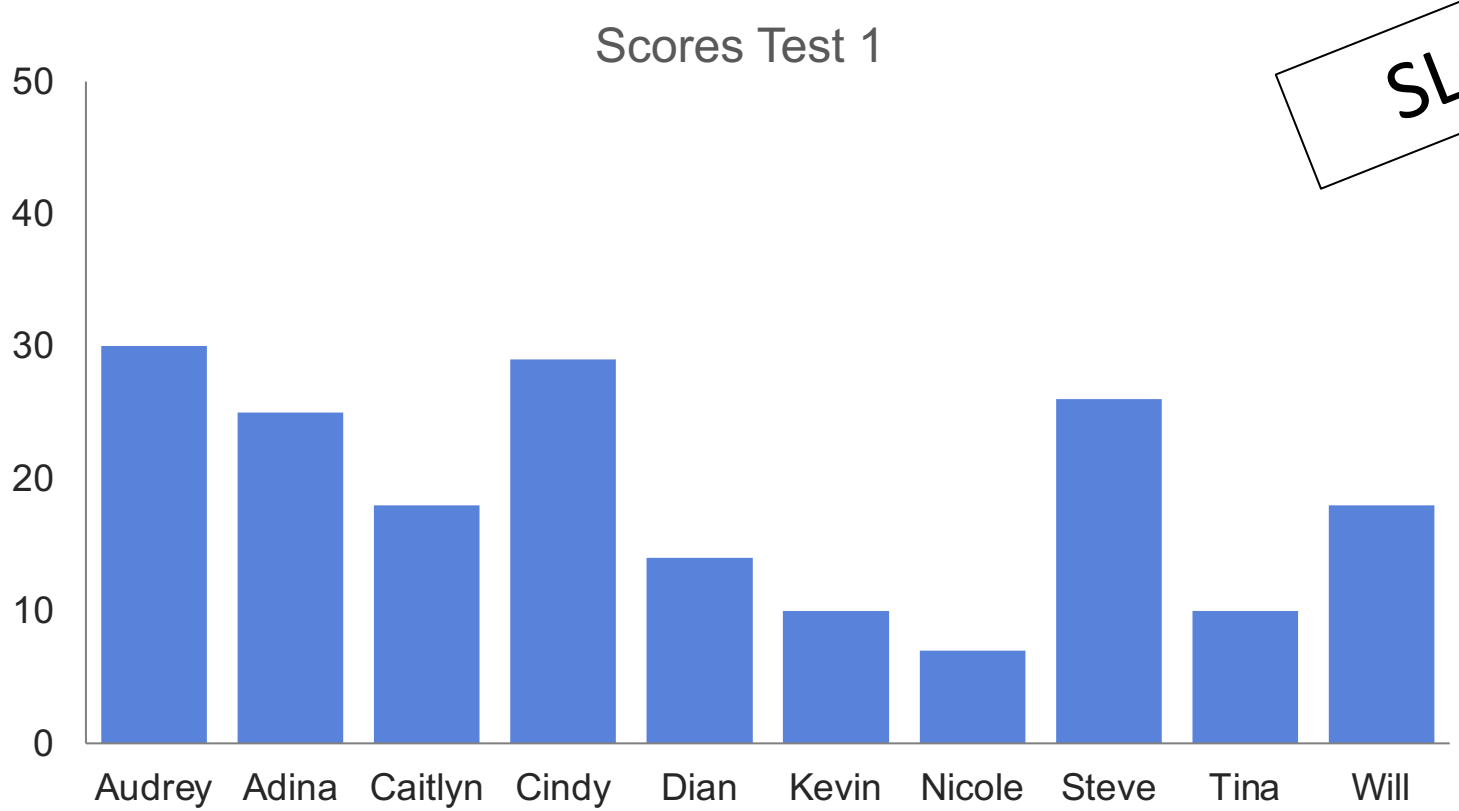
What is the average improvement?

FAST



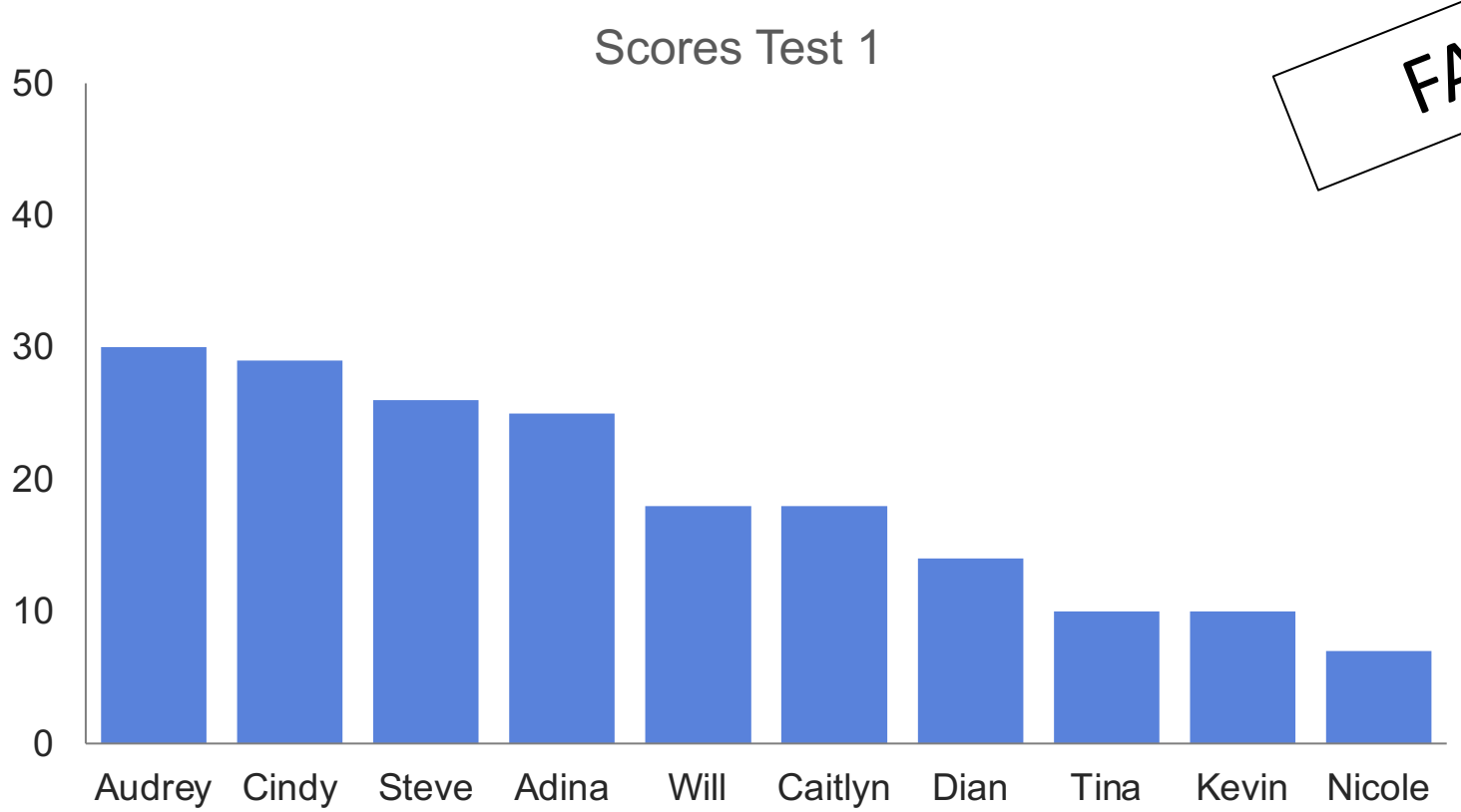
Adapted from Franconeri SL *et al.* J. Psychol sci Public Interest (2021) 22: 110

What are the top 5 students?



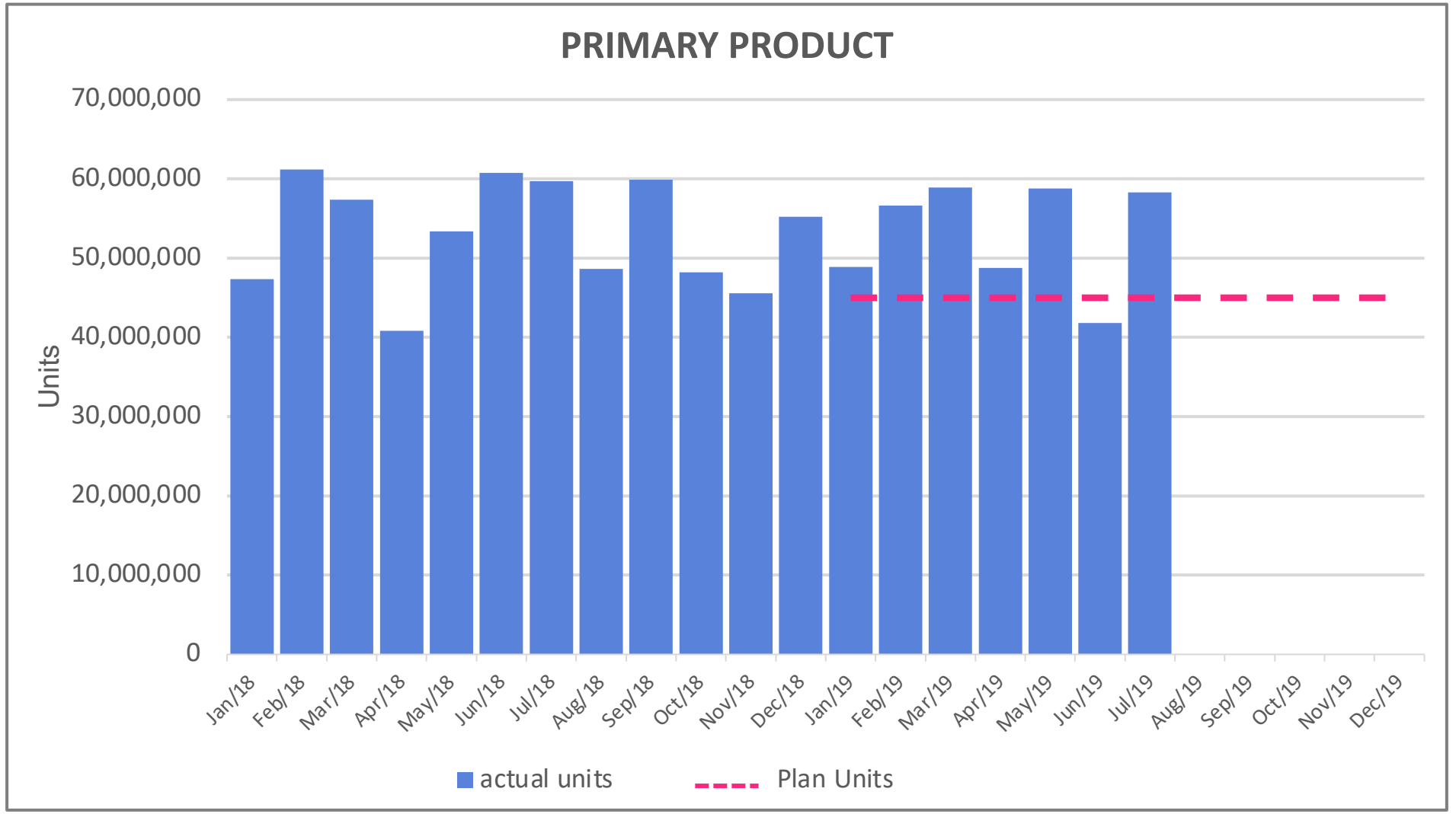
SLOW

What are the top 5 students?

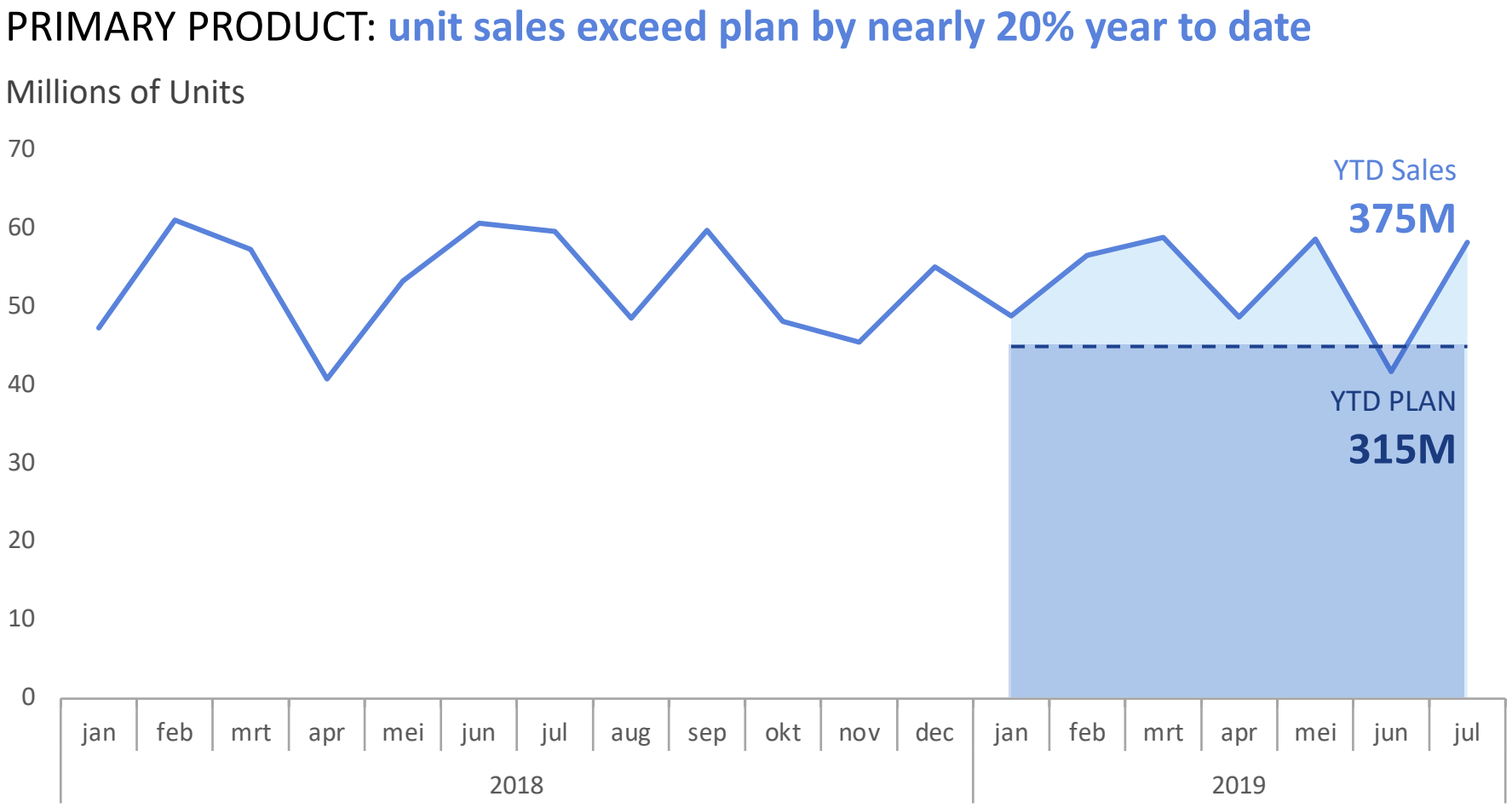


FAST

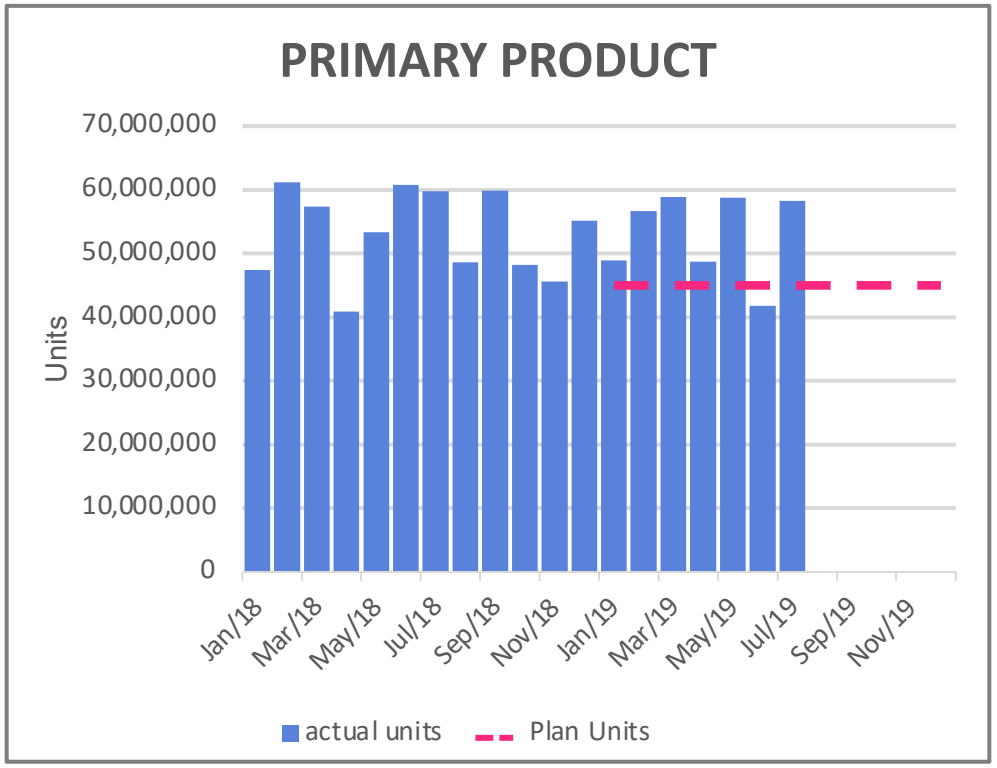
What is the message?

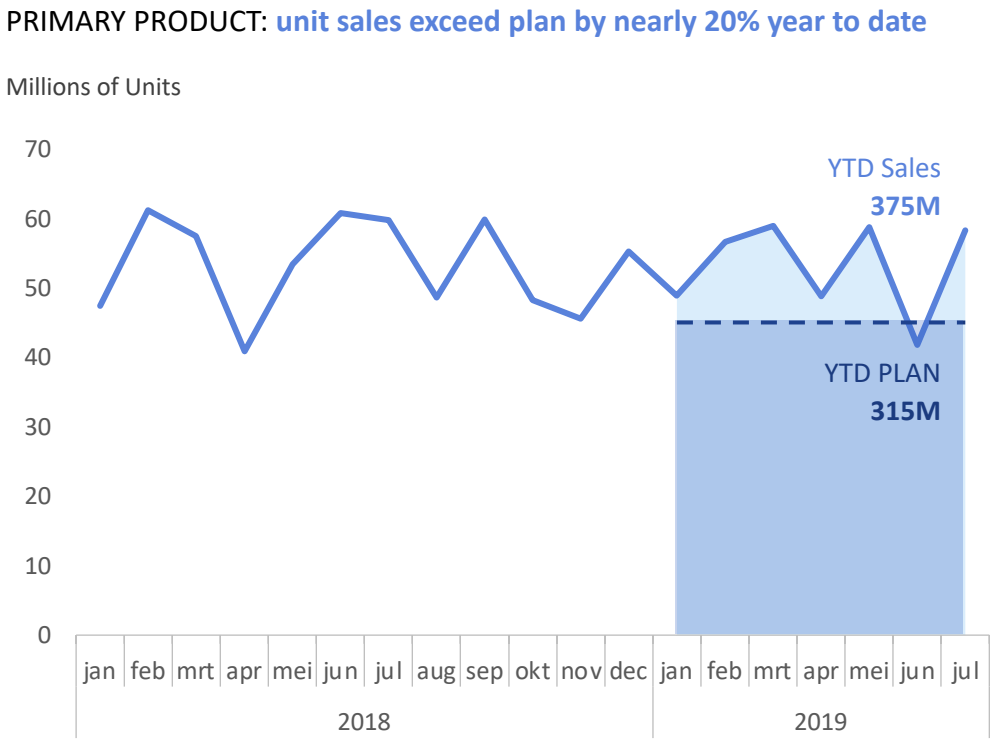


What is the message?



Make-over: Simplify, declutter and add focus





Minimize distraction: reduce ‘nondata ink’

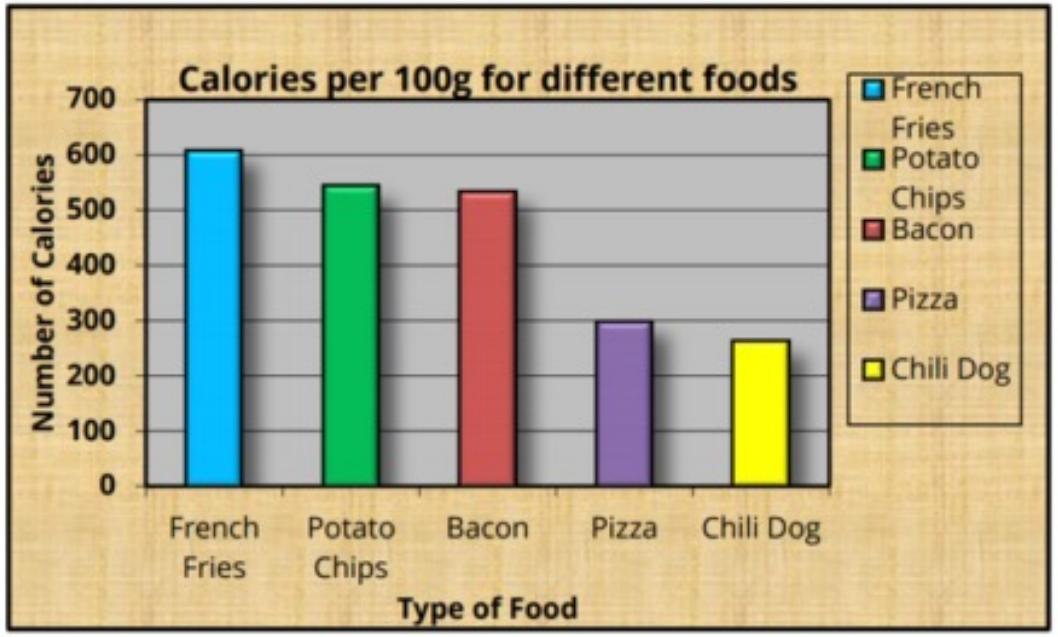
Effective. Not optimal.

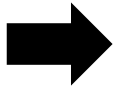
Simple, effective, optimal.

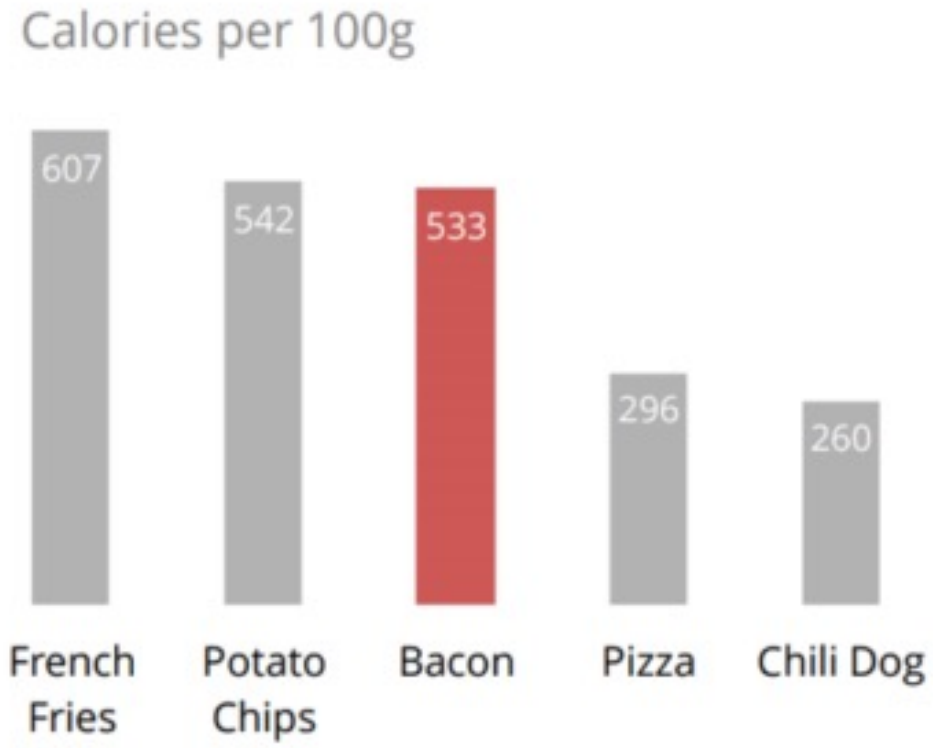
Bad.

Karina Korpela, The art of data visualization, a gift or a skil? Part 2. Isaca journal 2 (2016) 1-9.

Minimize distraction: maximize **data-ink ratio**





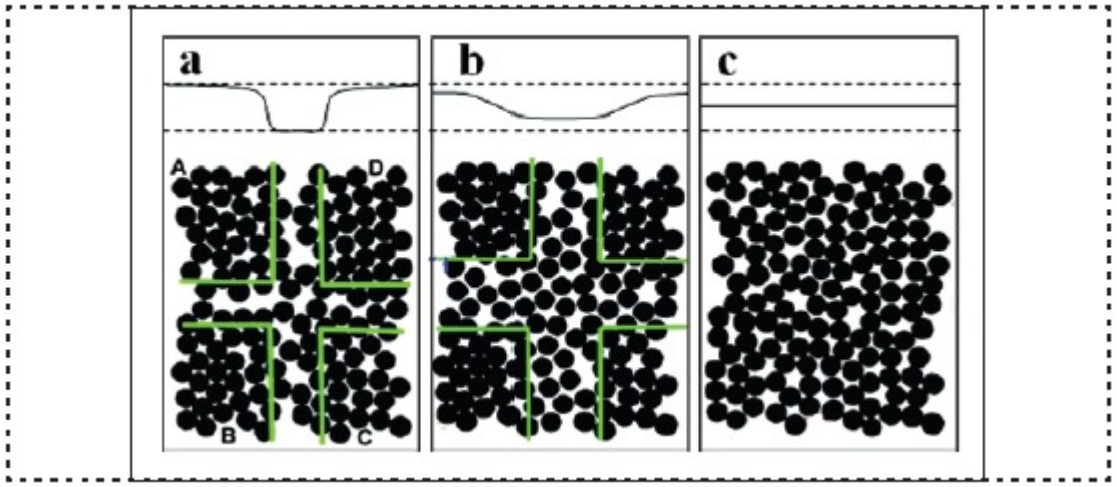


Data-ink ratio also applies to tables

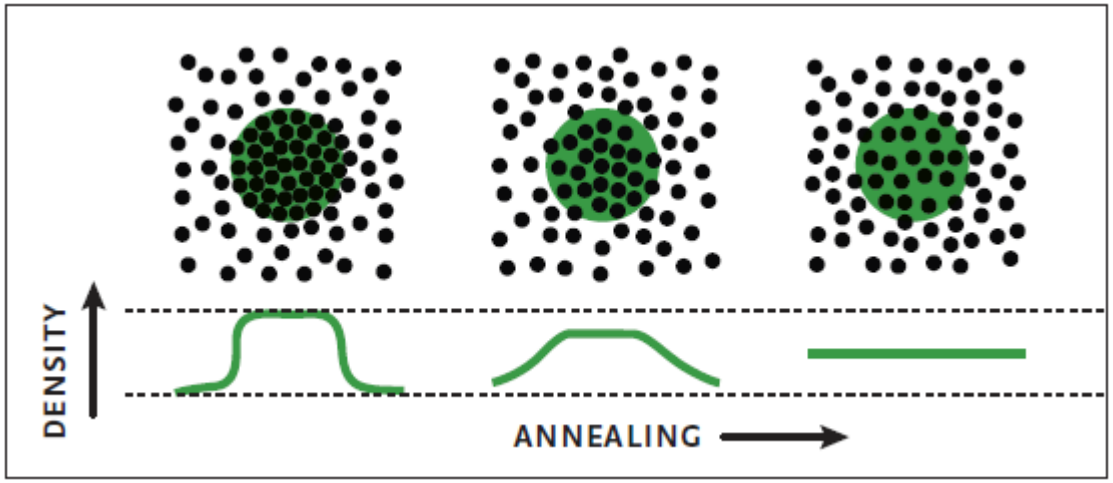
Student	Test1	Test2	Difference
Audrey	30.00	42.00	12.00 pts
Adina	25.00	37.00	12.00 pts
Caitlyn	18.00	28.00	10.00 pts
Cindy	29.00	39.00	10.00 pts
Dian	14.00	25.00	11.00 pts
Kevin	10.00	21.00	11.00 pts
Nicole	7.00	20.00	13.00 pts
Steve	**26.00**	**13.00**	**-13.00 pts**
Tina	10.00	12.00	2.00 pts
Will	18.00	30.00	12.00 pts

Student	Test1	Test2	Difference (pts)
Audrey	30	42	12
Adina	25	37	12
Caitlyn	18	28	10
Cindy	29	39	10
Dian	14	25	11
Kevin	10	21	11
Nicole	7	20	13
Steve	**26**	**13**	**-13**
Tina	10	12	2
Will	18	30	12

And to graphical abstracts



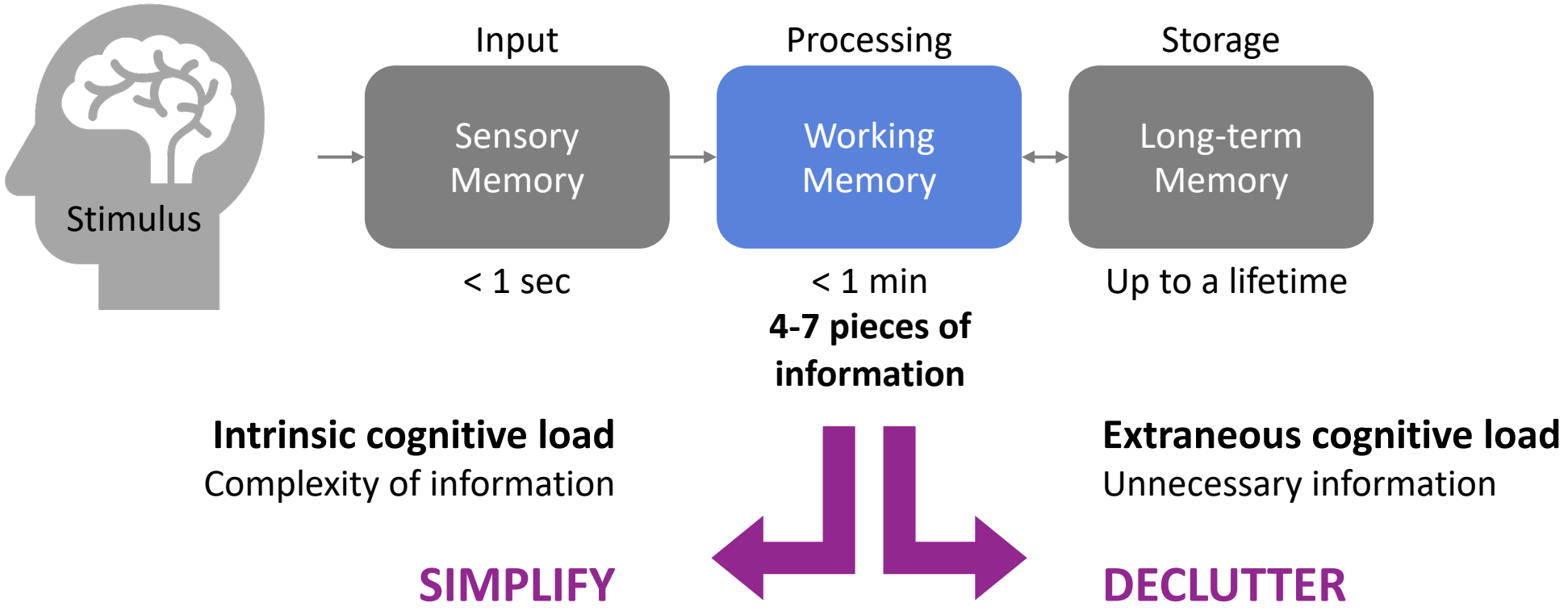
Too many interior boxes clutter the layout.

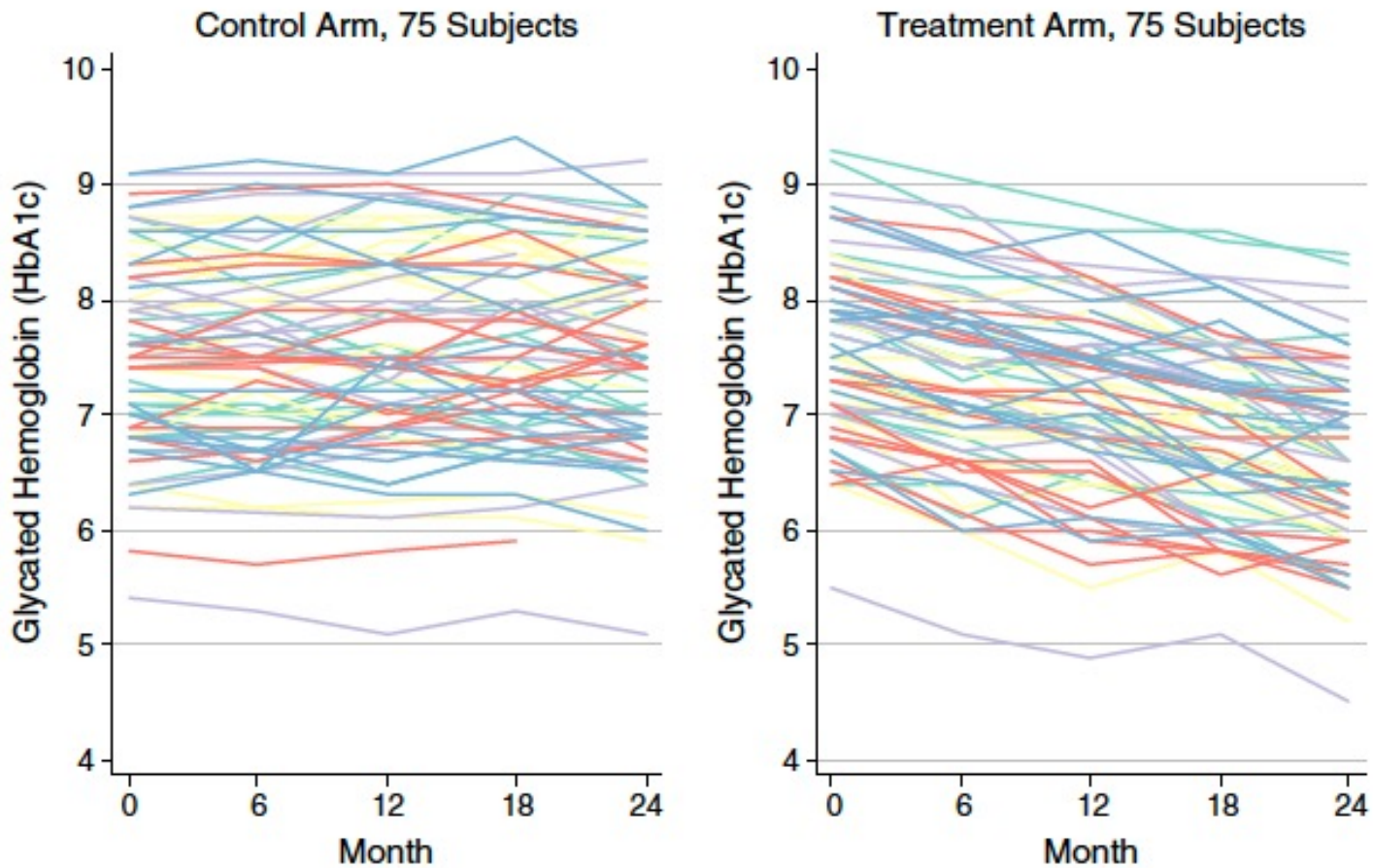


Boxes removed and arrows simplified.

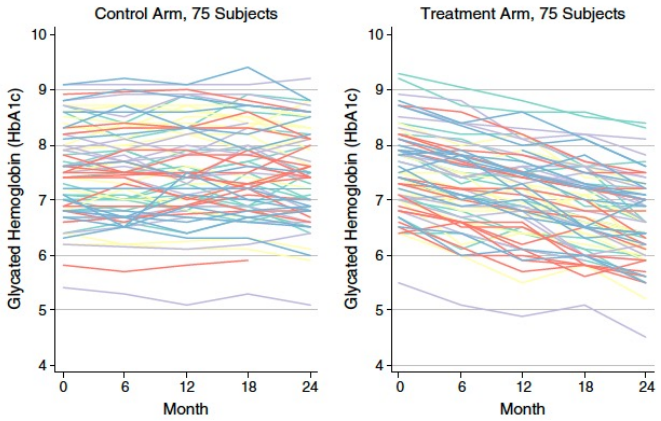
Cheng K *et al*. (2017). *Proving the value of visual design on scientific communication*. Information Design Journal 23, 80-95.

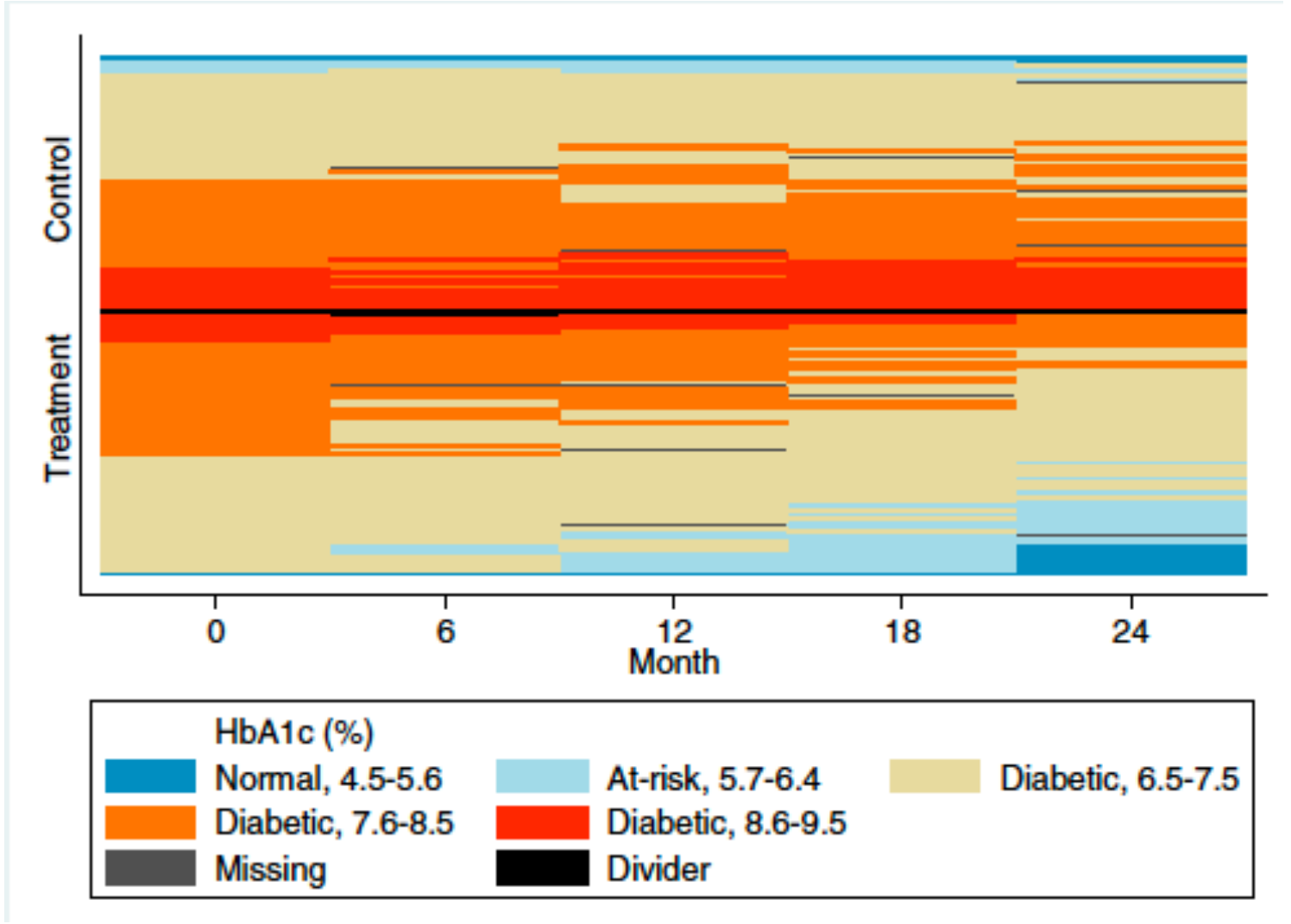
Optimize visual perception: minimize *intrinsic* and *extraneous* **cognitive load**



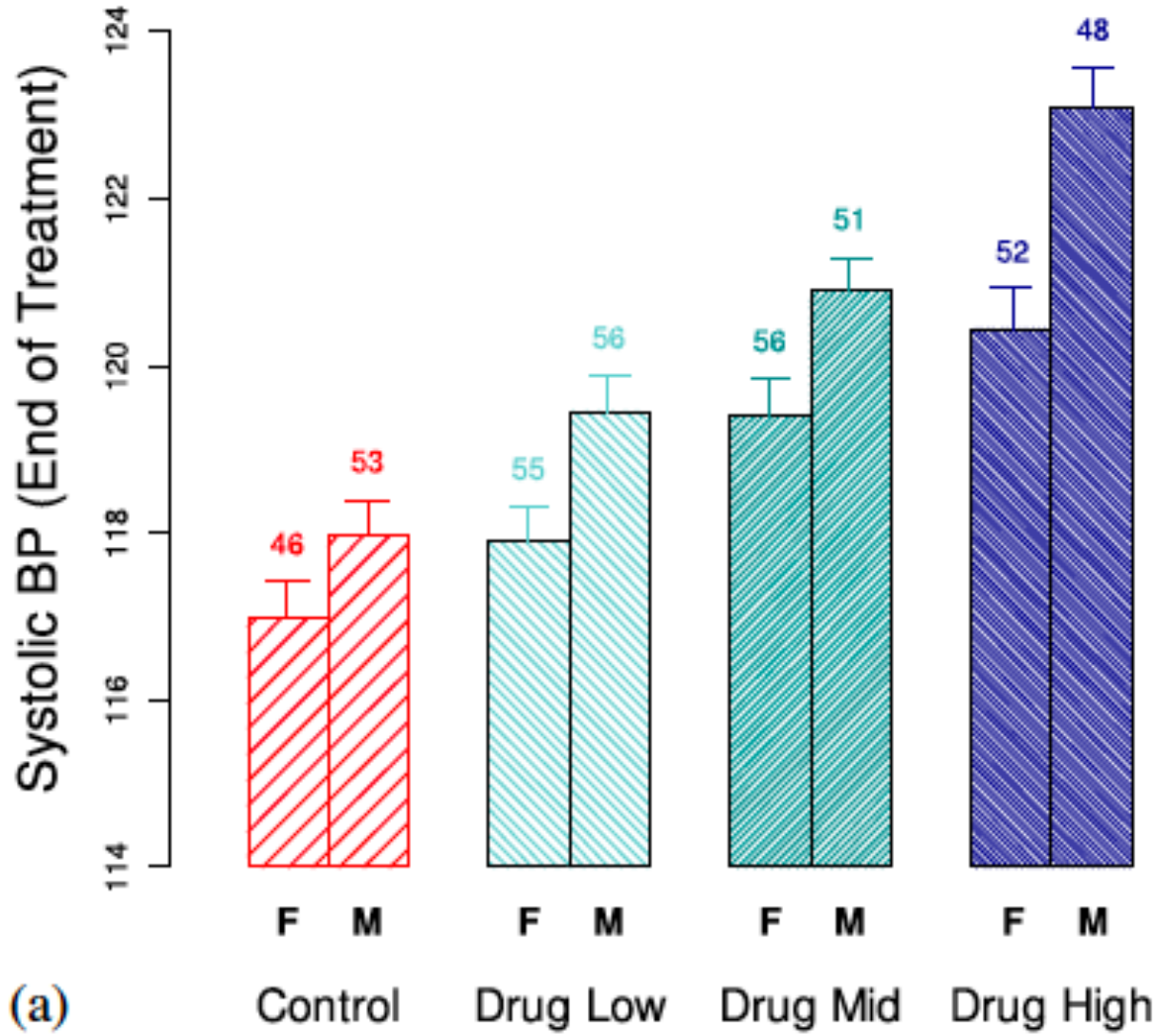


Duke SP et al. Seeing is believing: good graphic design principles for medical research. Statist Med 2015, 34: 3040-59

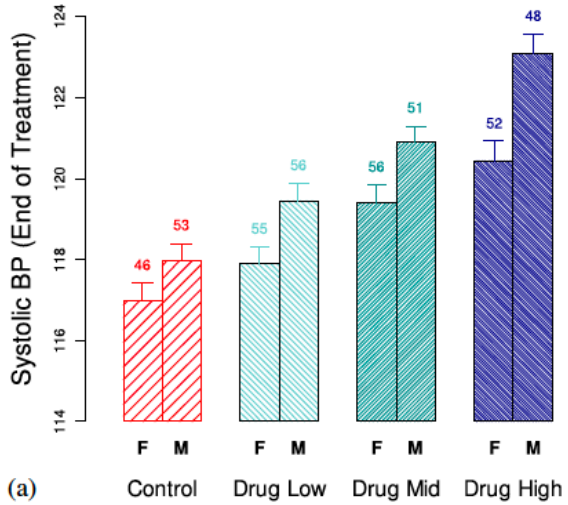




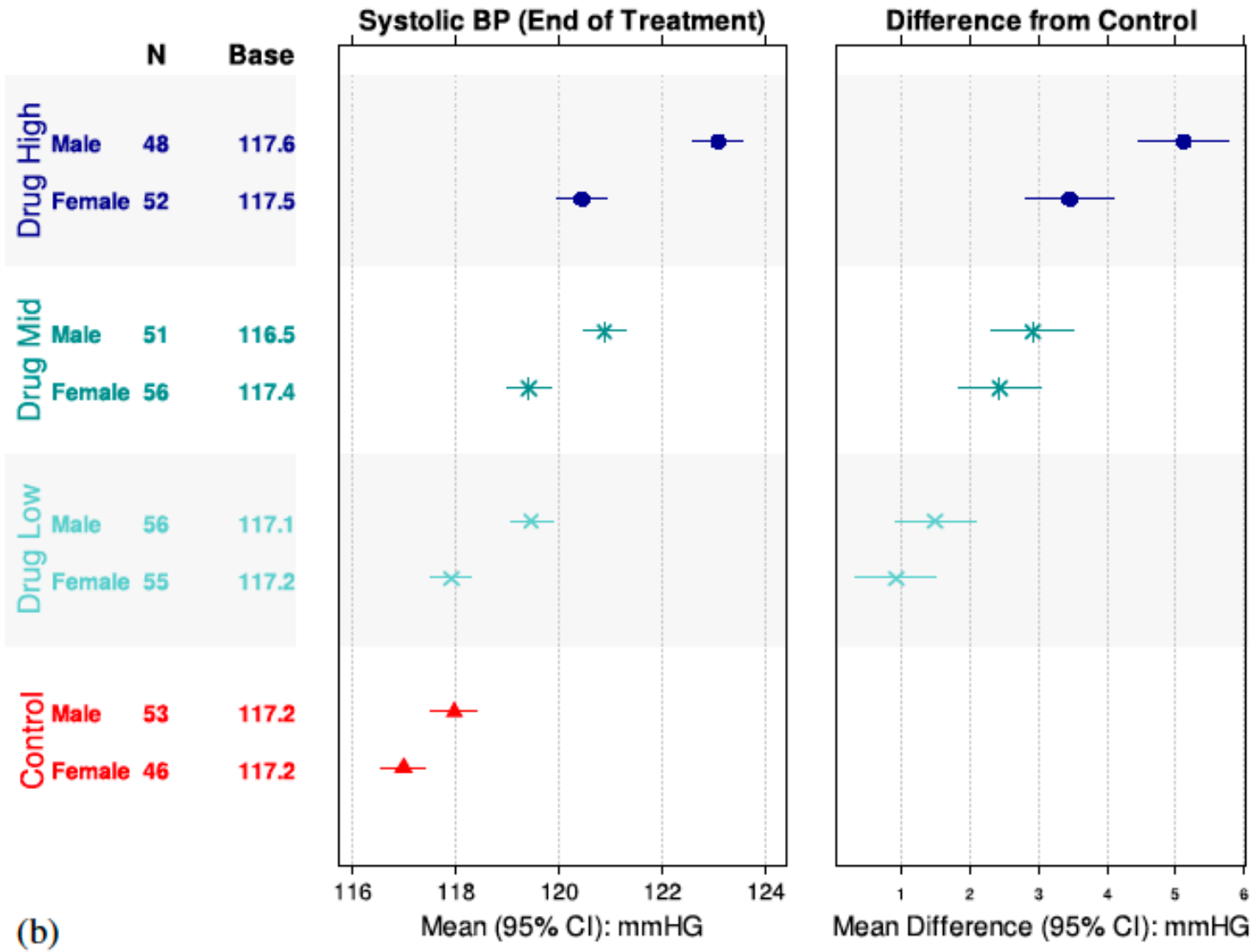
Duke SP et al. Seeing is believing: good graphic design principles for medical research. Statist Med 2015, 34: 3040-59



Duke SP et al. Seeing is believing: good graphic design principles for medical research. Statist Med 2015, 34: 3040-59

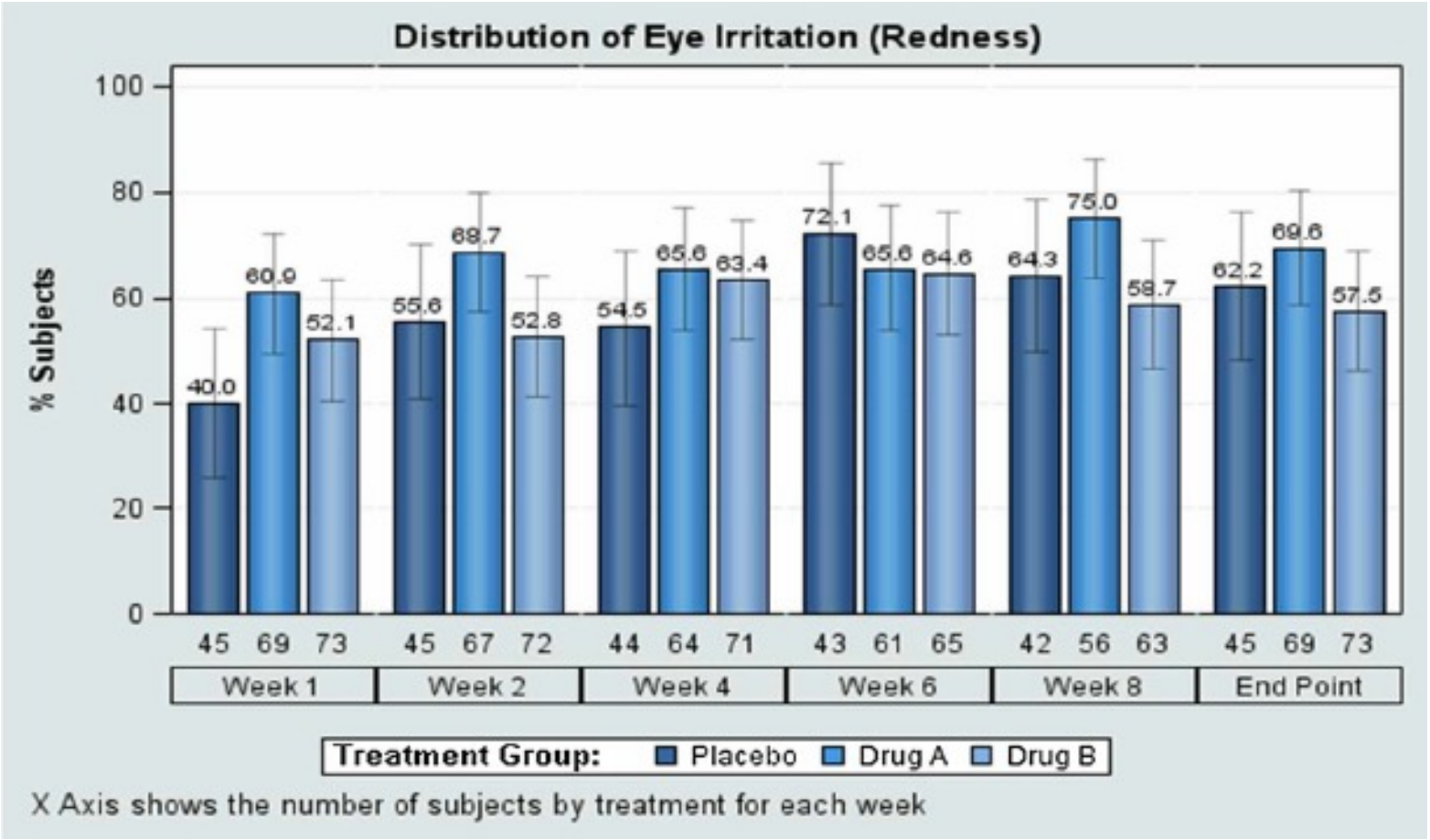


(a)

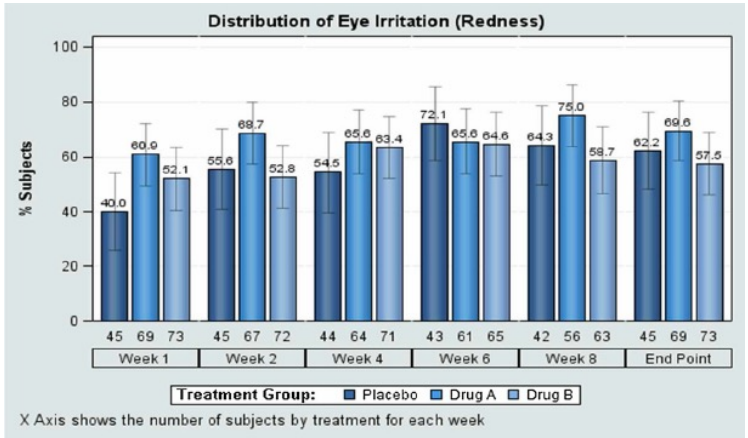


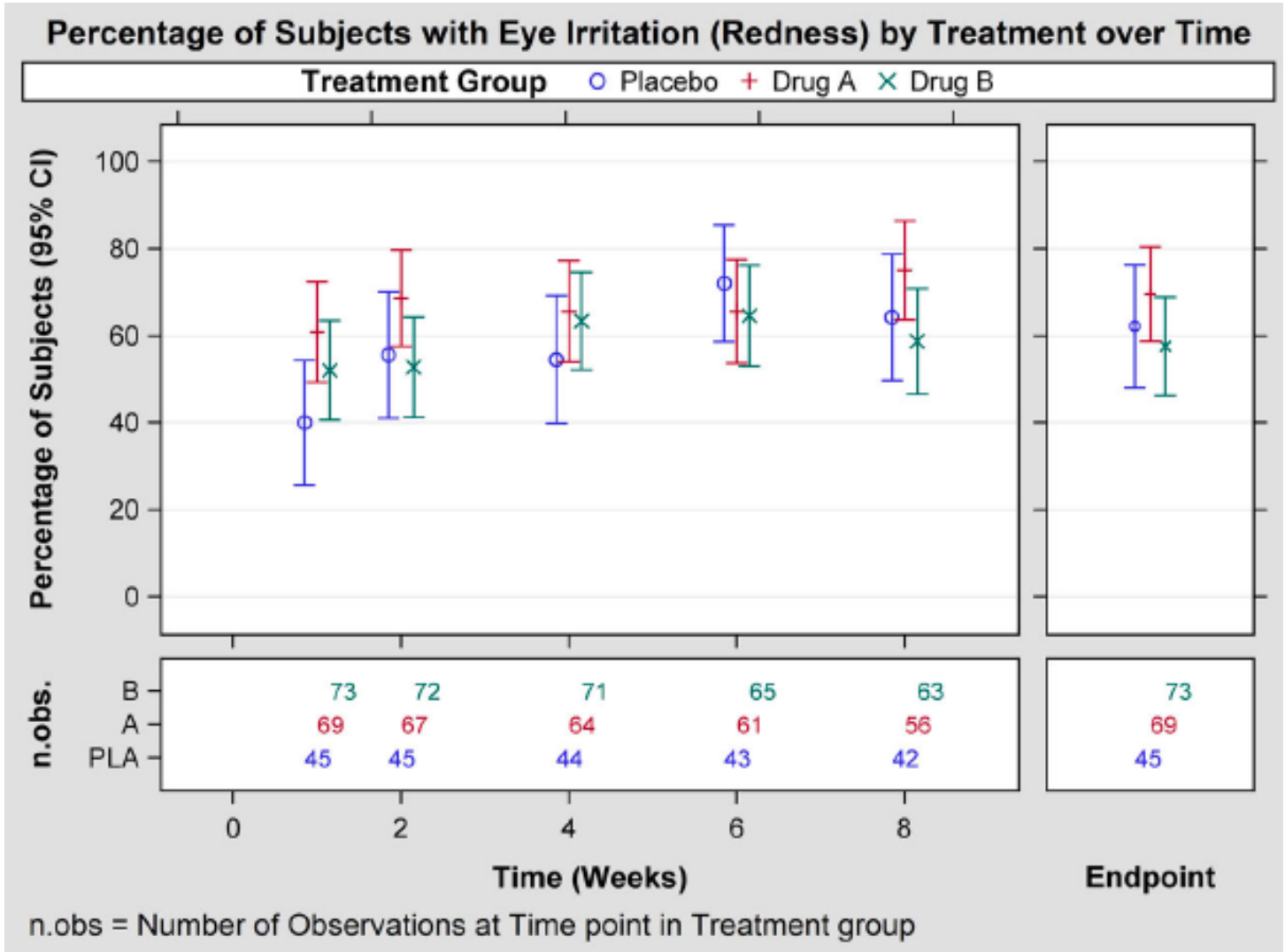
(b)

Duke SP et al. Seeing is believing: good graphic design principles for medical research. Statist Med 2015, 34: 3040-59



Duke SP et al. Seeing is believing: good graphic design principles for medical research. Statist Med 2015, 34: 3040-59





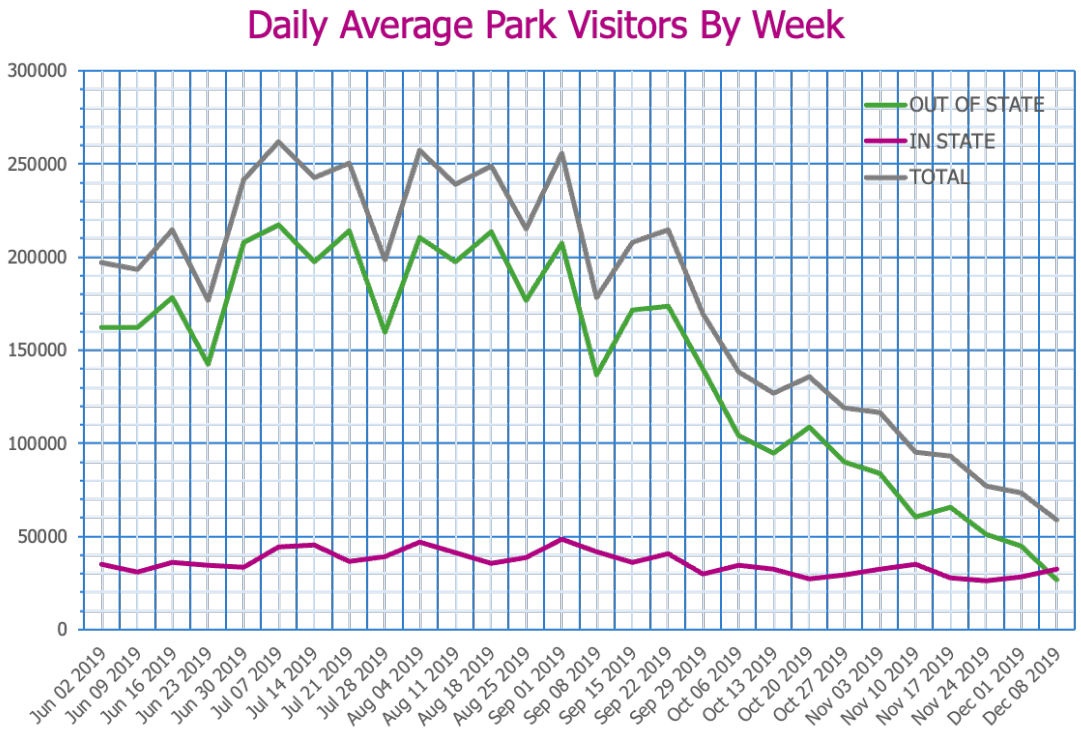
Duke SP et al. Seeing is believing: good graphic design principles for medical research. Statist Med 2015, 34: 3040-59

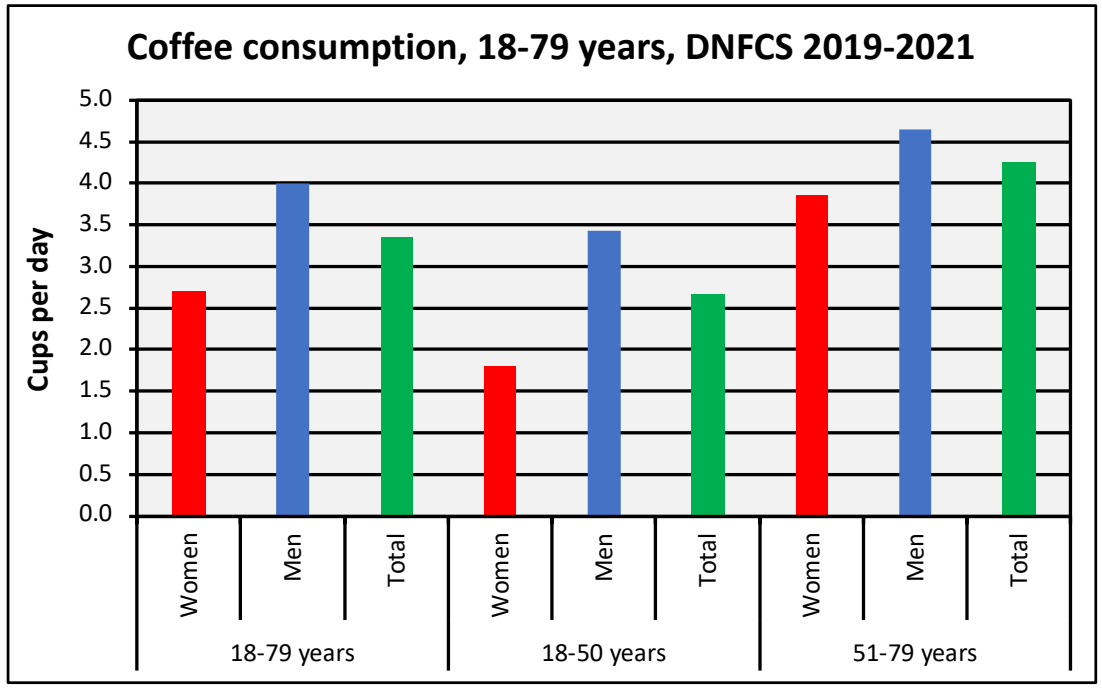
https://declutterme.london

Exercise: Simplify and Declutter

Exercise: Simplify and Declutter

Use your **own visual** or choose one of the examples:





Notice. Wonder. Improve.

Notice: (<10 sec)

- ☐ What is the first thing that catches your eye?
- ☐ What is your first impression?

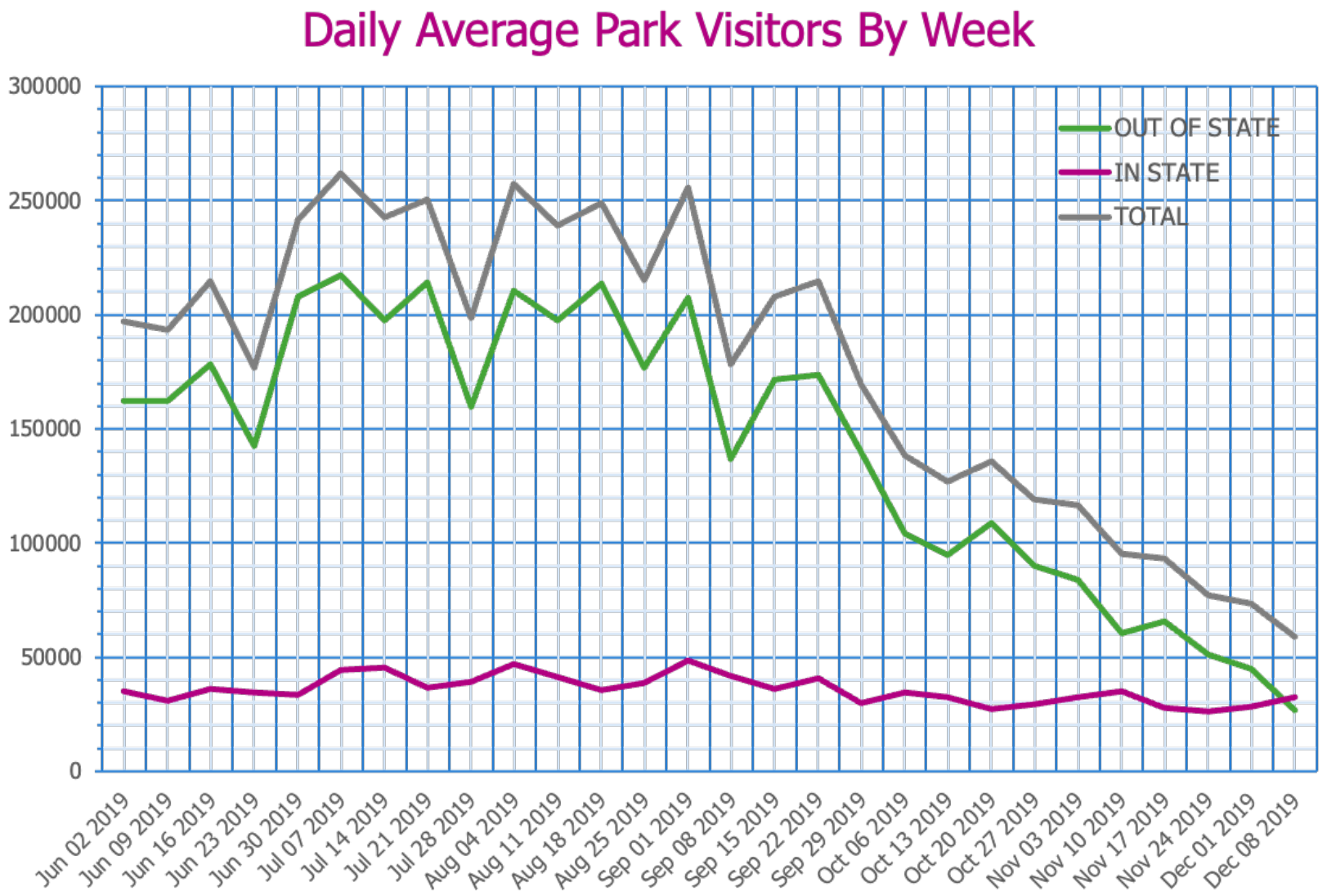
Wonder: (< 1 min)

- ☐ Do you get an idea about the message? What is it?
- ☐ What questions come to mind?

Improve: Simplify and Declutter

- ☐ Is the most appropriate chart type used to present the data/message?
- ☐ What takes up most time to process? Could this process be simplified?
- ☐ Are there any unnecessary, redundant or distracting elements that can be removed/reduced?
- ☐ How could the message be more emphasized?
- ☐ Are all text and labels legible?

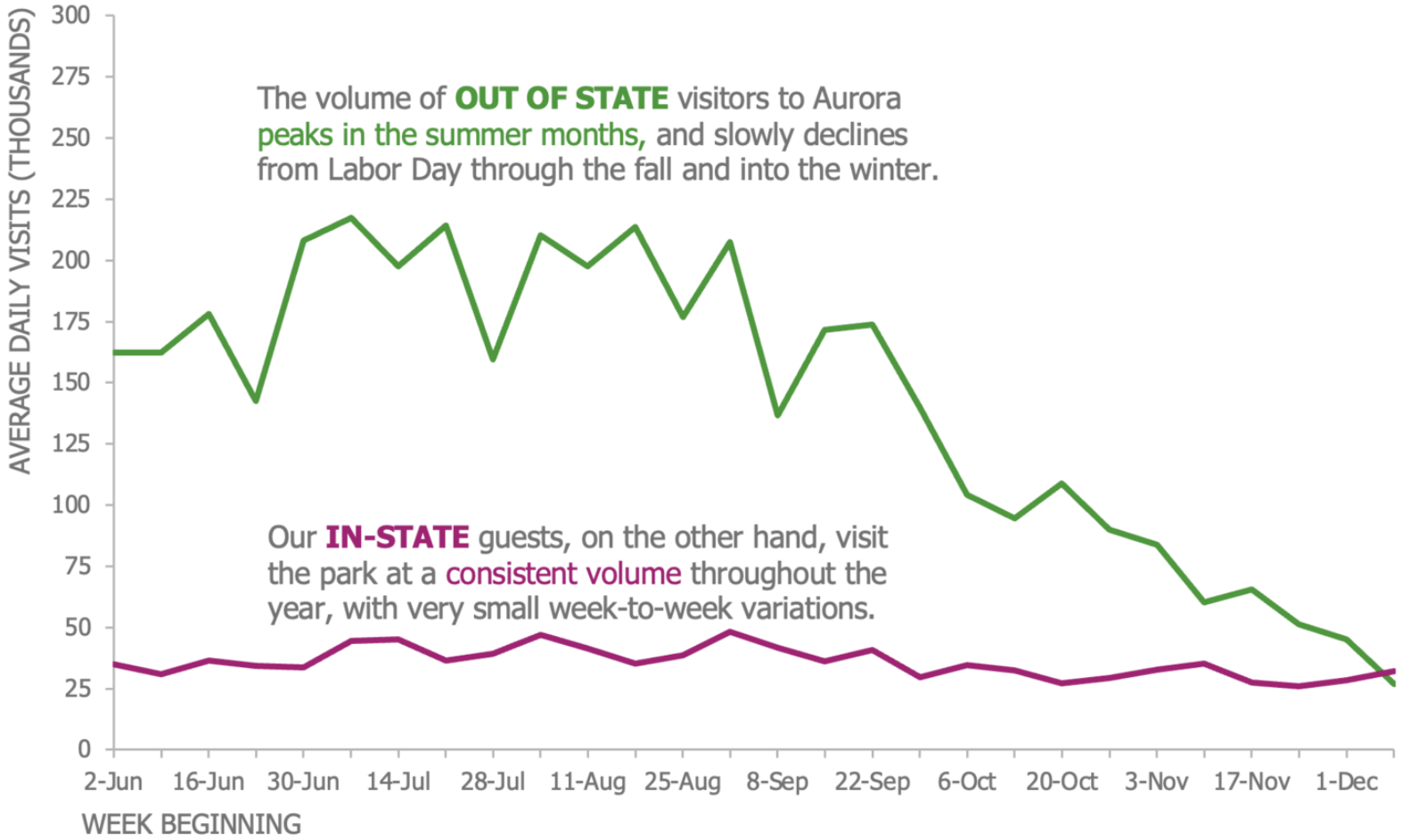
10 min



Storytelling with data
https://www.storytellingwithdata.com/blog/2021/10/13/your-graph-skeleton-shouldnt-be-spooky

Daily visitors to Aurora Park in summer/fall 2019

VALUES ARE CALCULATED WEEKLY AS A 7-DAY AVERAGE



Storytelling with data

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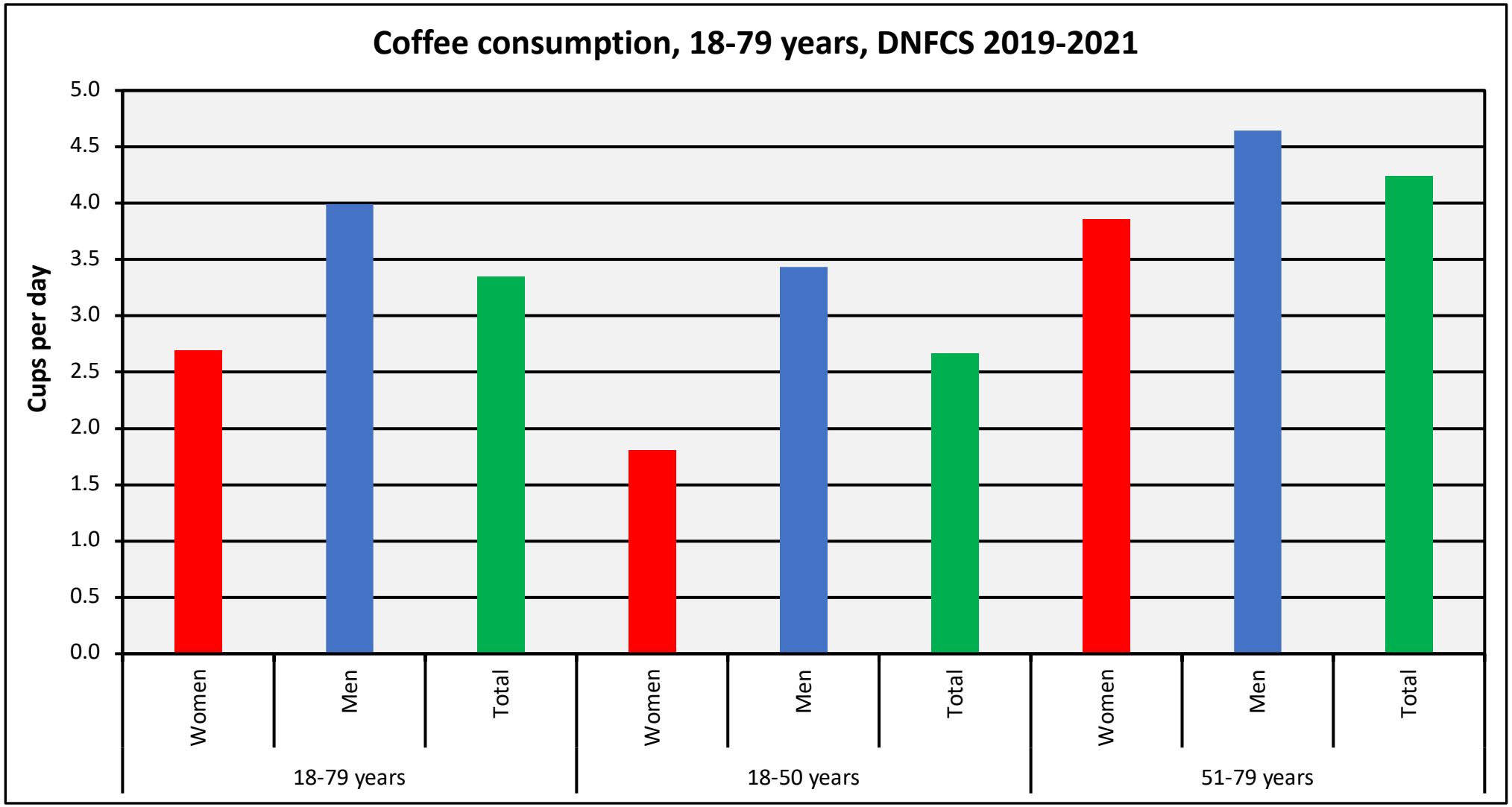
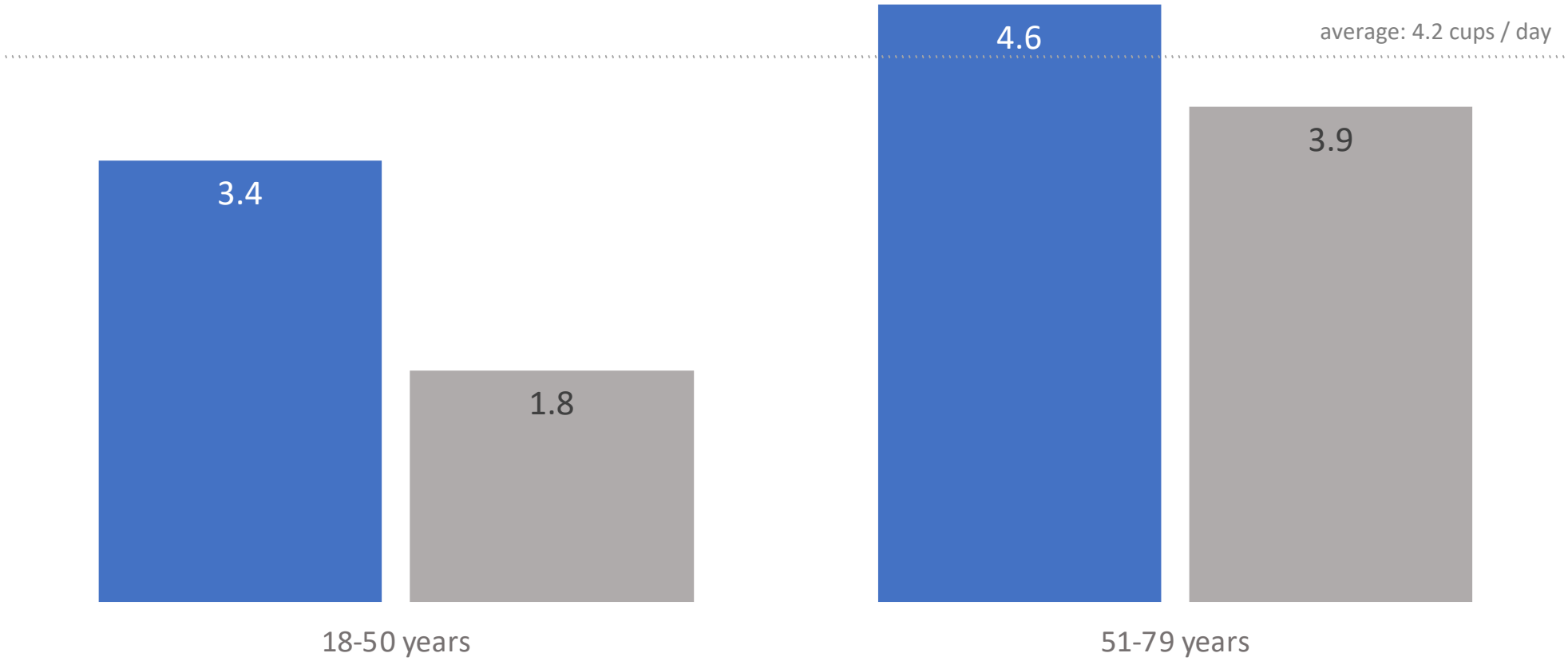

Coffee consumption, 18-79 years, DNFCS 2019-2021
Cups per day
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Women
Men
Total
Women
Men
Total
Women
Men
Total
18-79 years
18-50 years
51-79 years

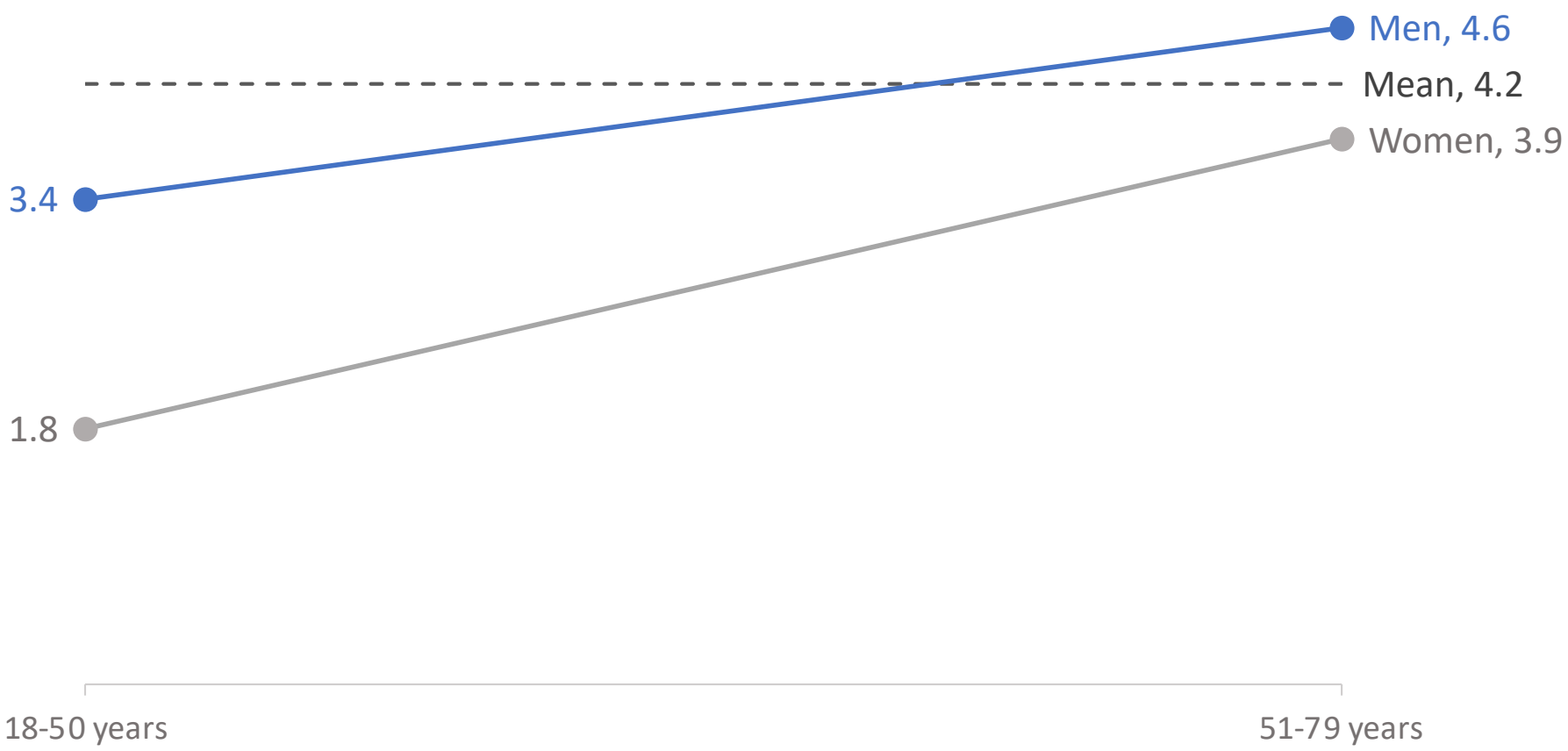
Men drink more coffee than **women**

No. of cups per day increases with age (Dutch National Food Survey 2019-2021)



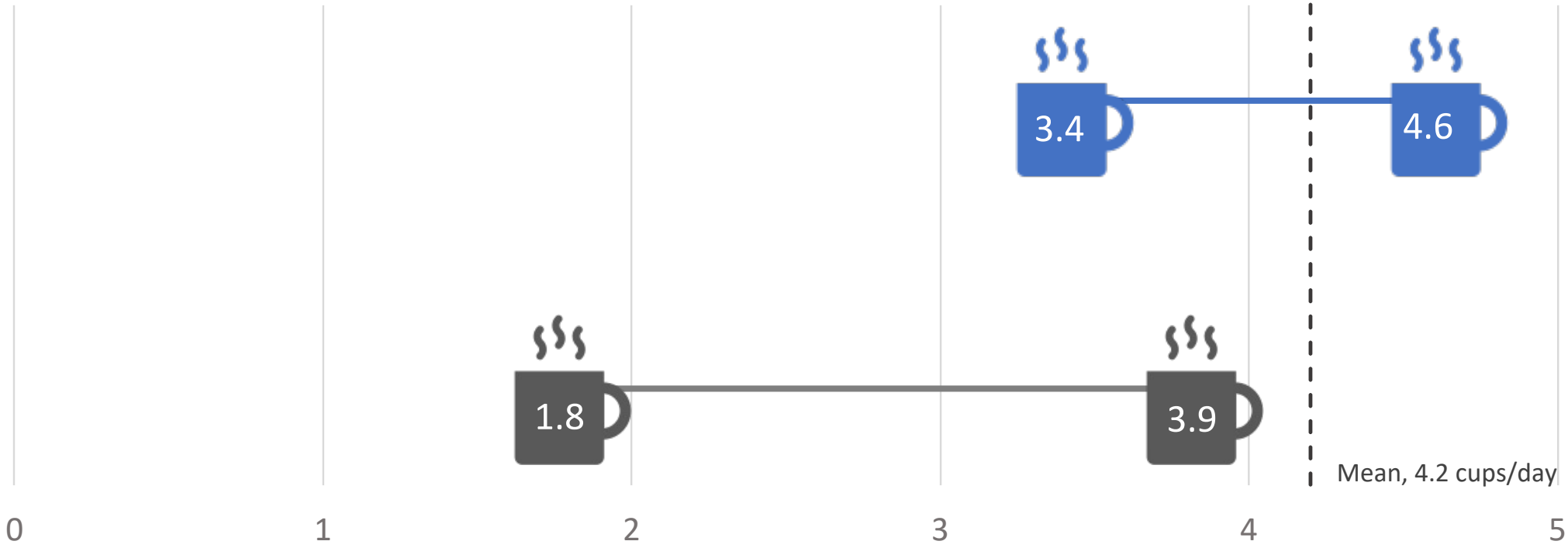
Men drink more coffee than **women**

No. of cups per day increases with age (Dutch National Food Survey 2019-2021)



Men drink more coffee than **women**

No. of cups per day increases with age (Dutch National Food Survey 2019-2021)

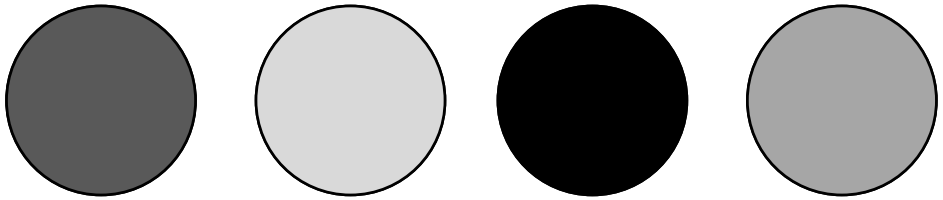


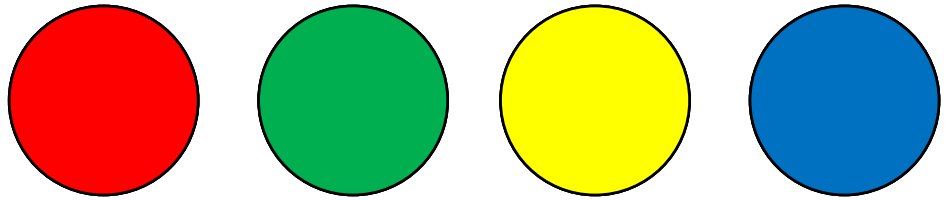
Color!

Notice. Wonder. Improve.

A look at your work.

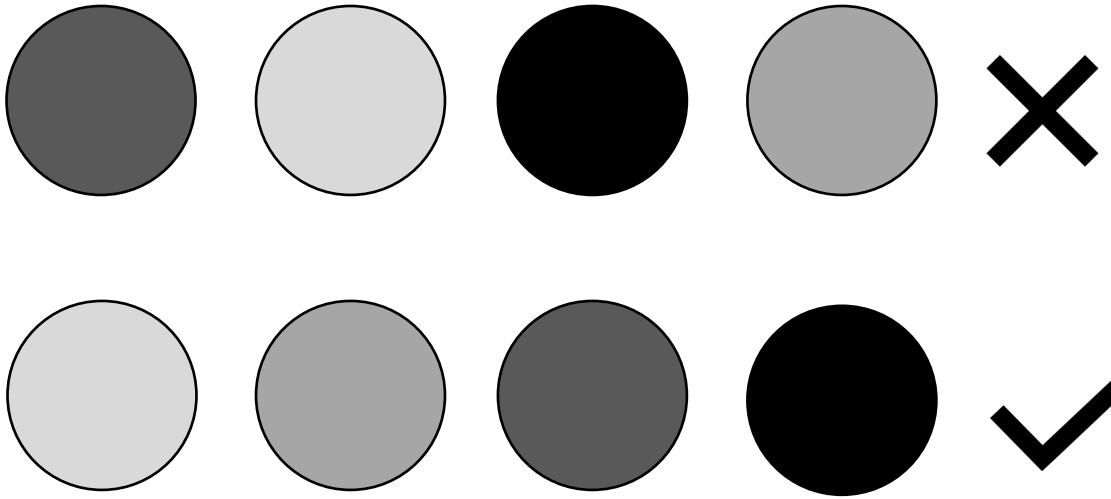
How to rank those circles from low to high?

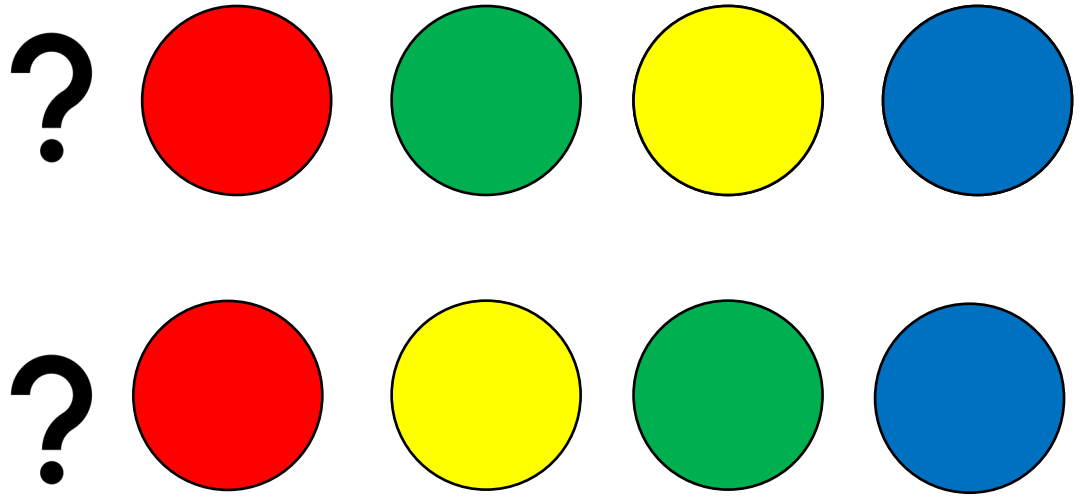




Adapted from Borland D and Russell M, *Rainbow color map (still) considered harmful*, IEEE Computer graphics and applications (2007) 27.

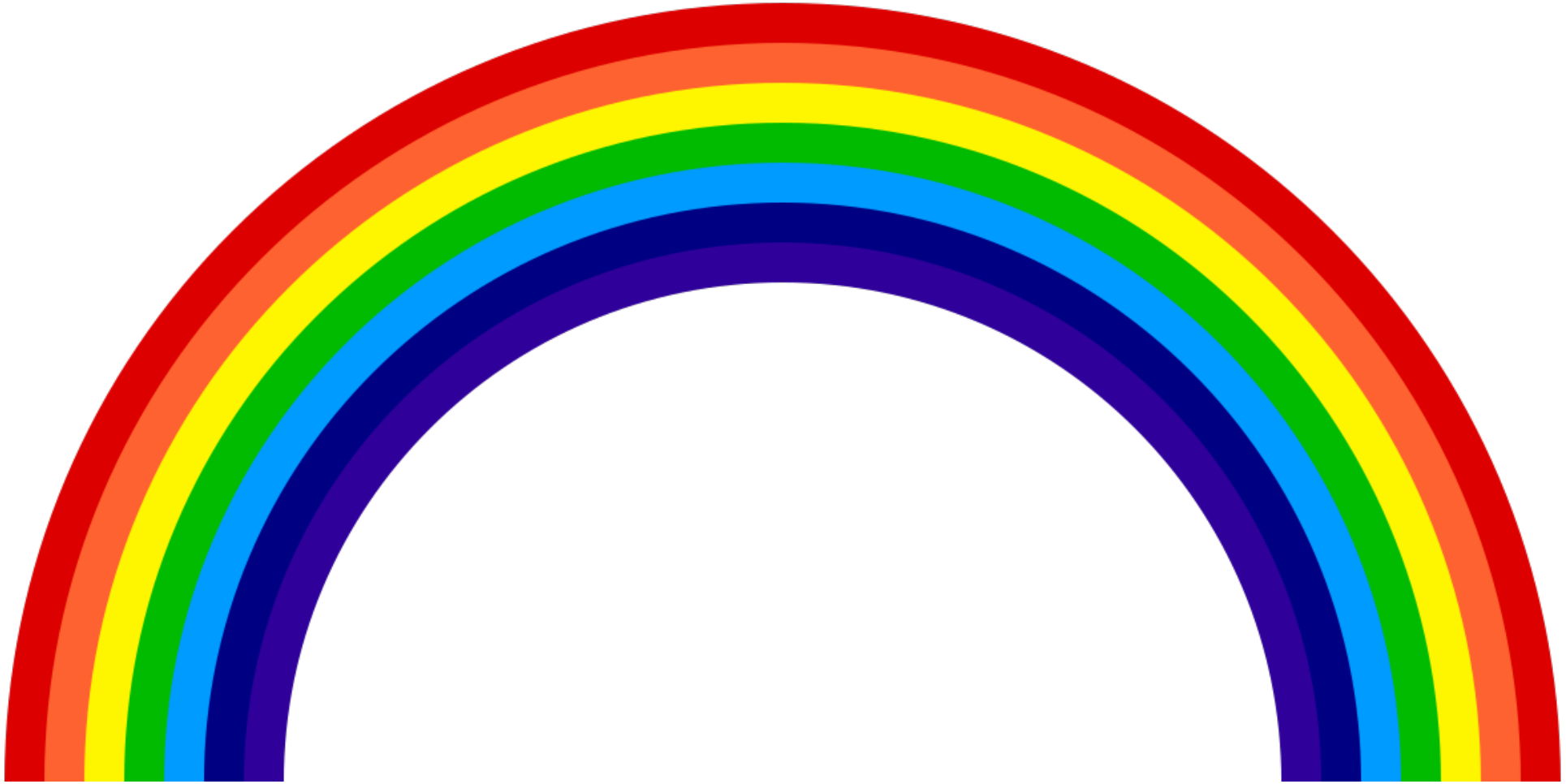
How to rank those circles from low to high?



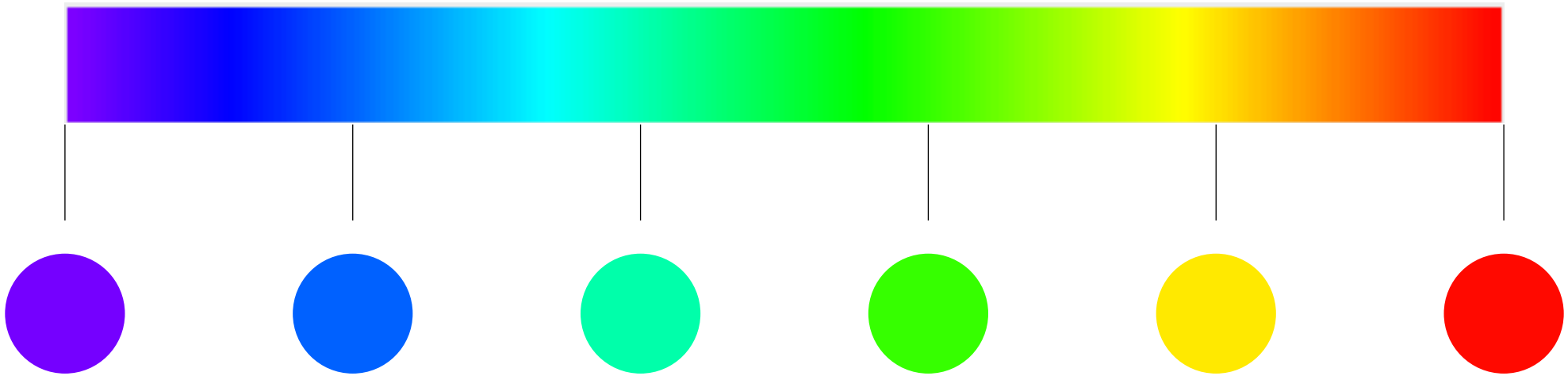


Adapted from Borland D and Russell M, *Rainbow color map (still) considered harmful*, IEEE Computer graphics and applications (2007) 27.

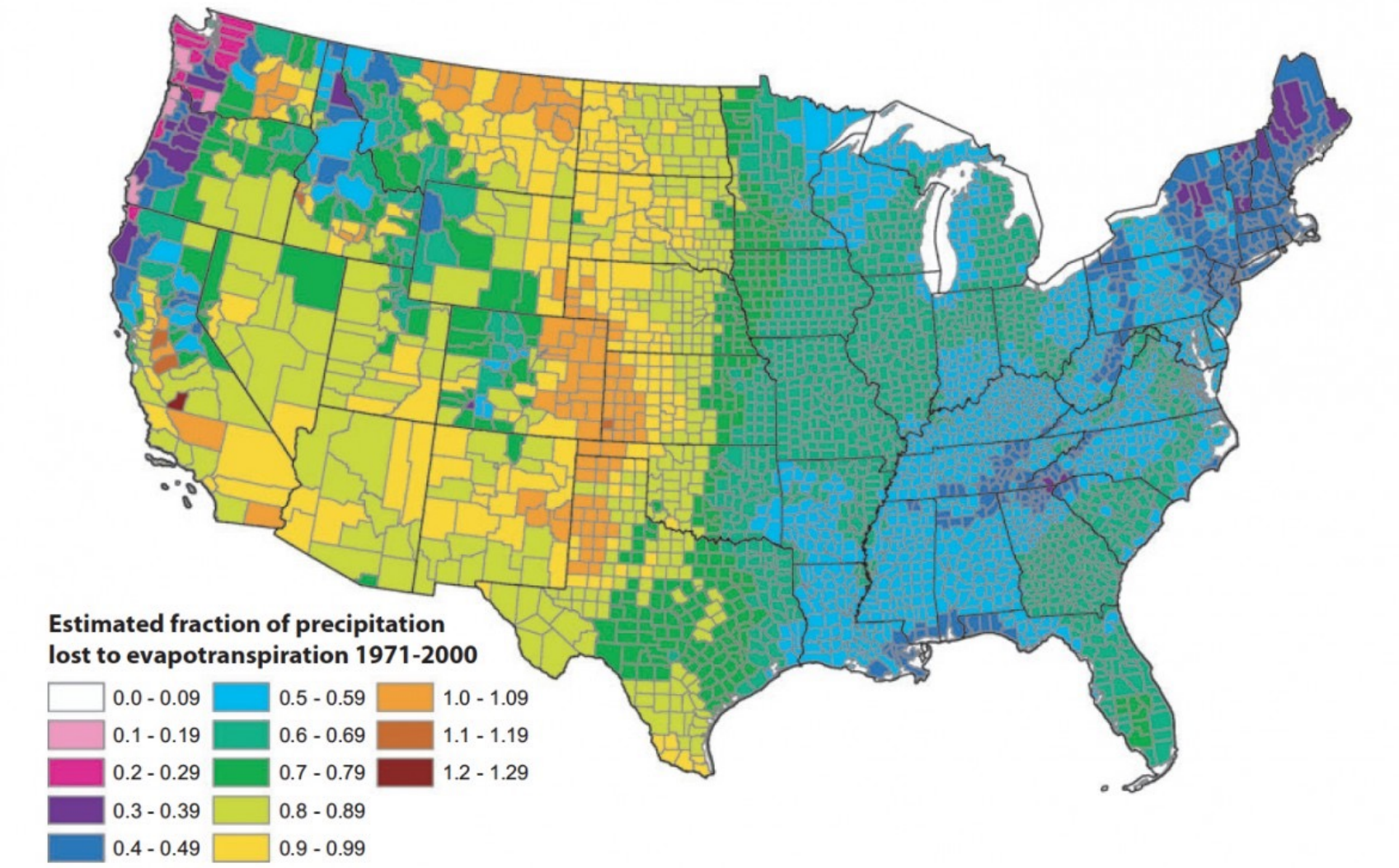
What’s wrong with the rainbow color scale?



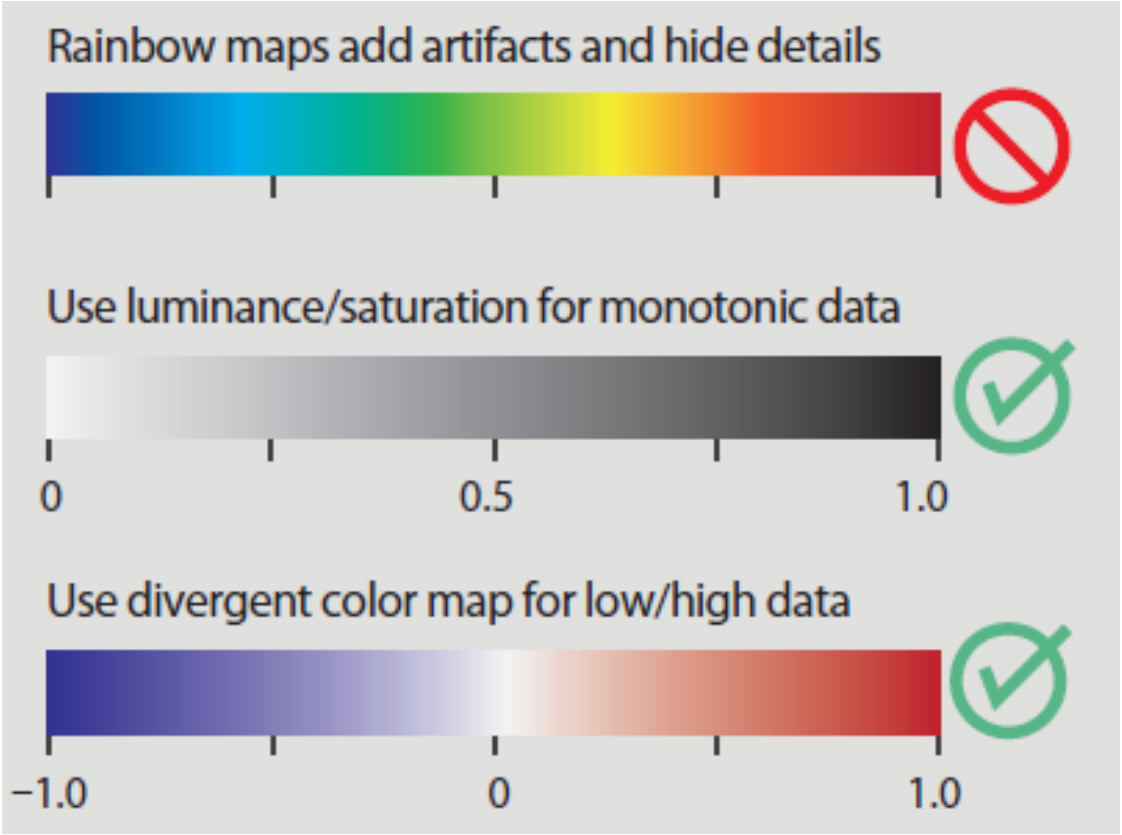
What’s wrong with the rainbow color scale?



Avoid rainbow color maps for quantities!

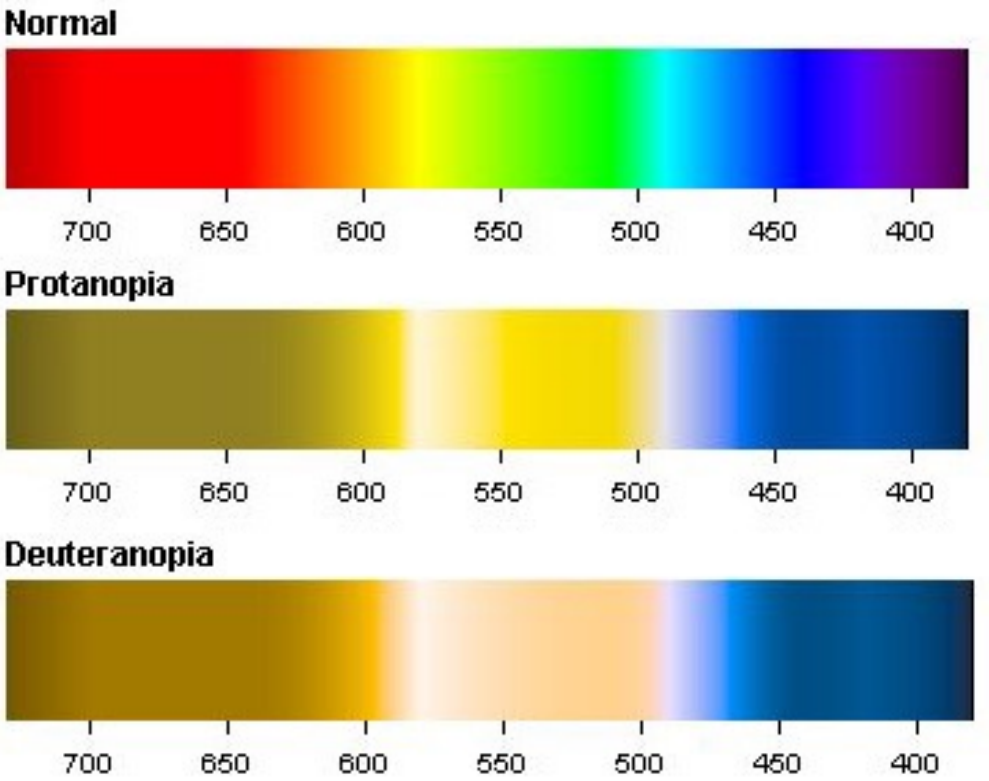


Use a monochromatic or a diverging color scale instead



O'Donoghue SI *et al.* (2018) Annu. Rev. Biomed. Data Sci 1: 275.

Another issue with color: color vision deficiency

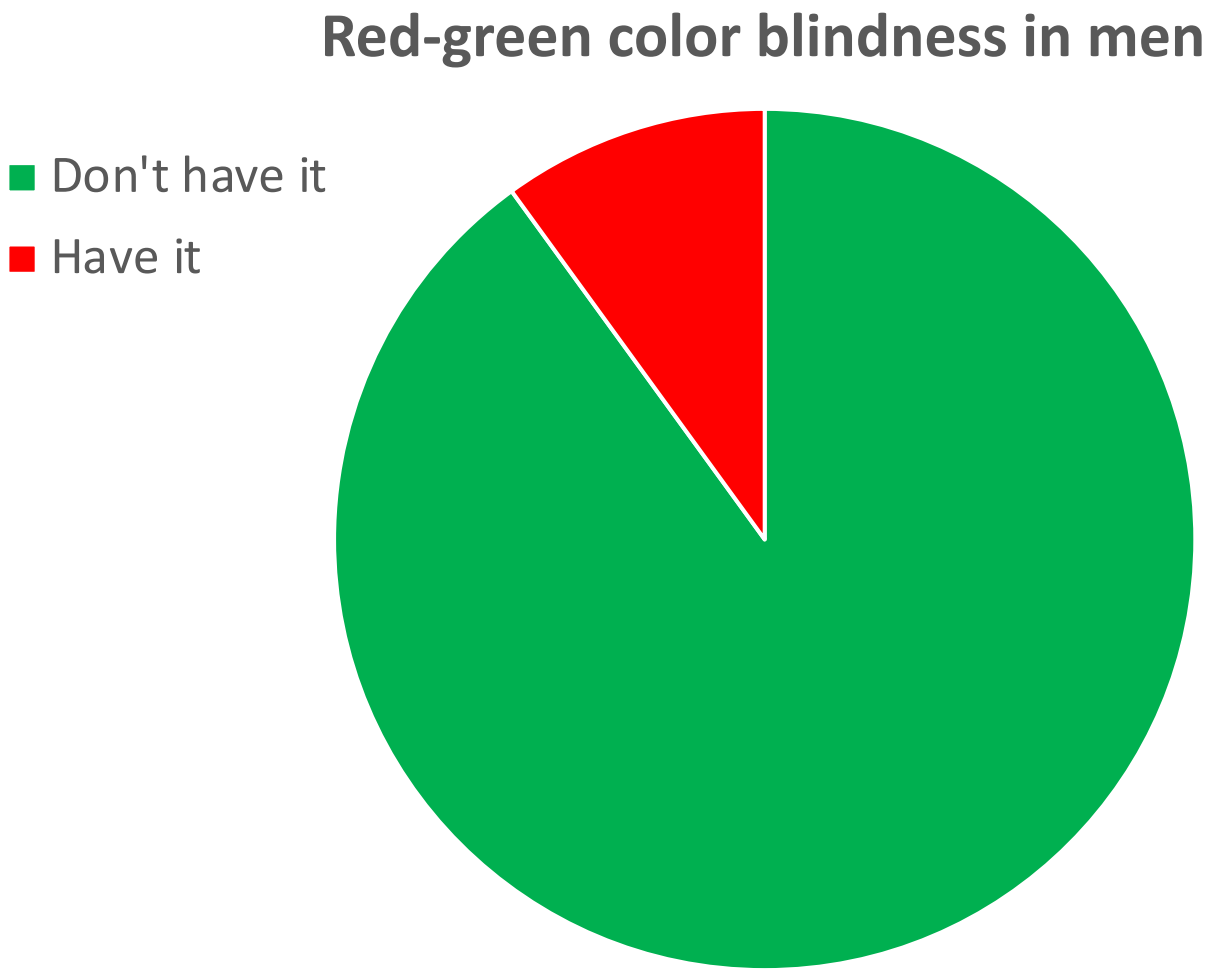


~2% male population

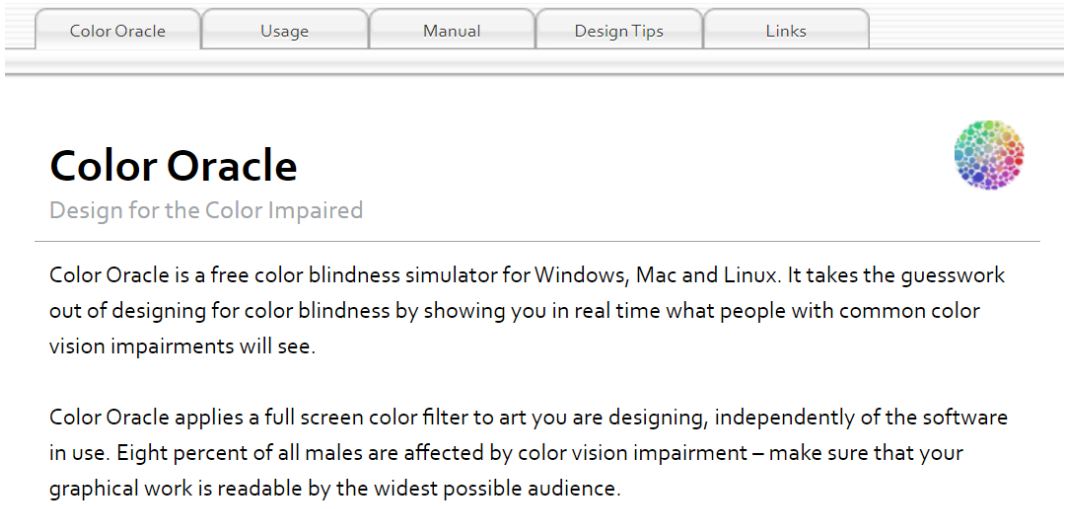
~6% male population

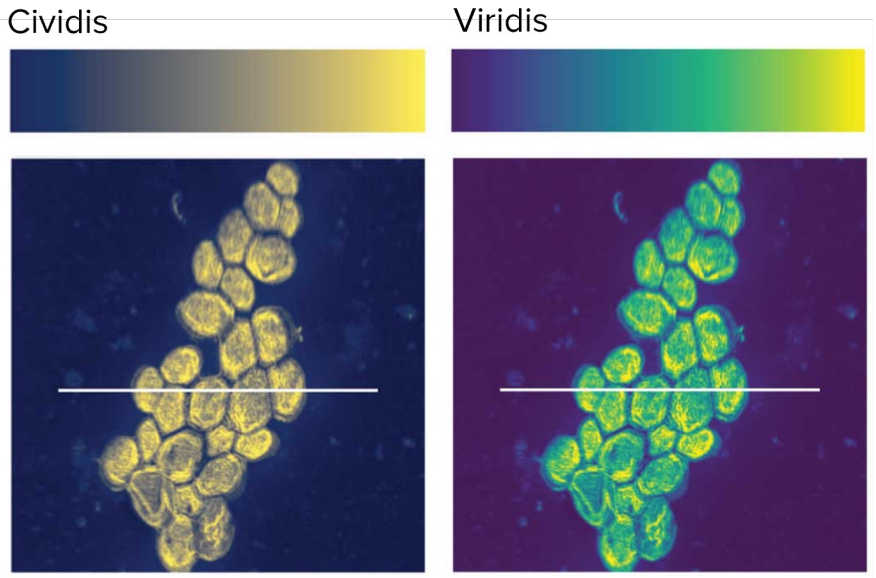
https://www.color-blindness.com

Avoid red-green color palettes



Use a color blindness simulator or colorblindness-friendly color scales instead

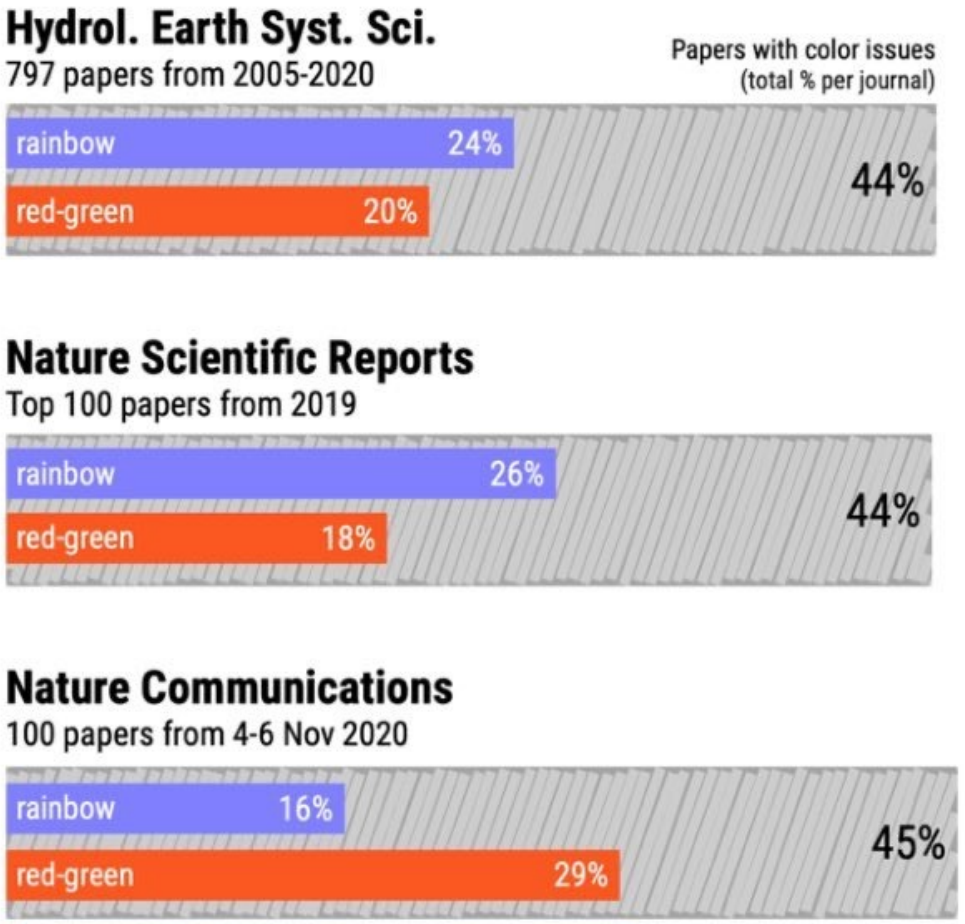




https://colororacle.org/

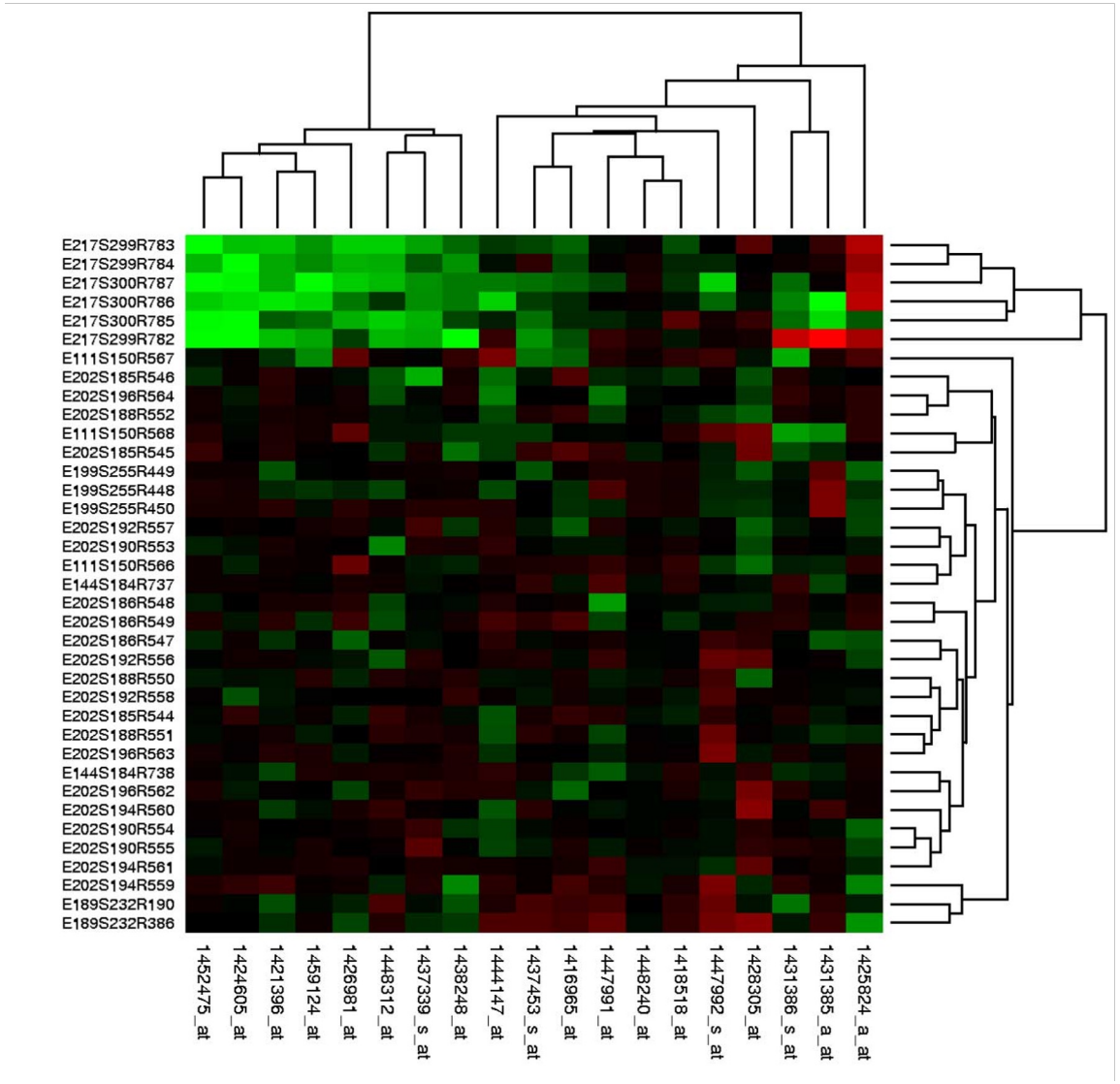
Nunez JR *et al.* PLoS One 2018

Color issues are common in science communications!



Stoezle M and Stein L, *Rainbow color map distorts and misleads research in hydrology – guidance for better visualizations and science communication*. Hydrol. Earth Syst. Sci., 25, 4549–4565, 2021

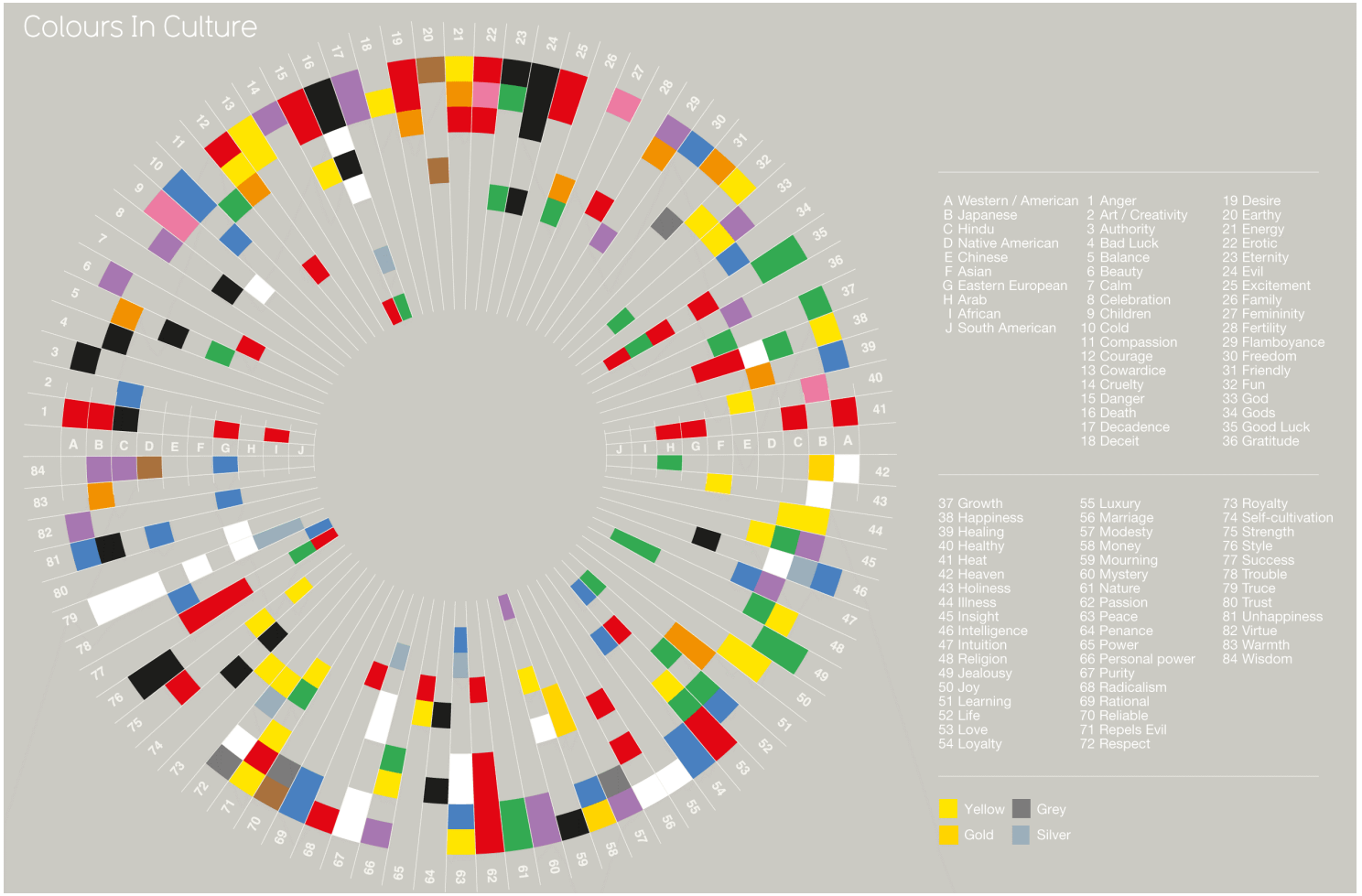
Be aware: contrast can create illusions!



https://knowablemagazine.org/article/mind/2019/science-data-visualization

Lastly, be aware how color is associated to feelings…

…and differs between cultures



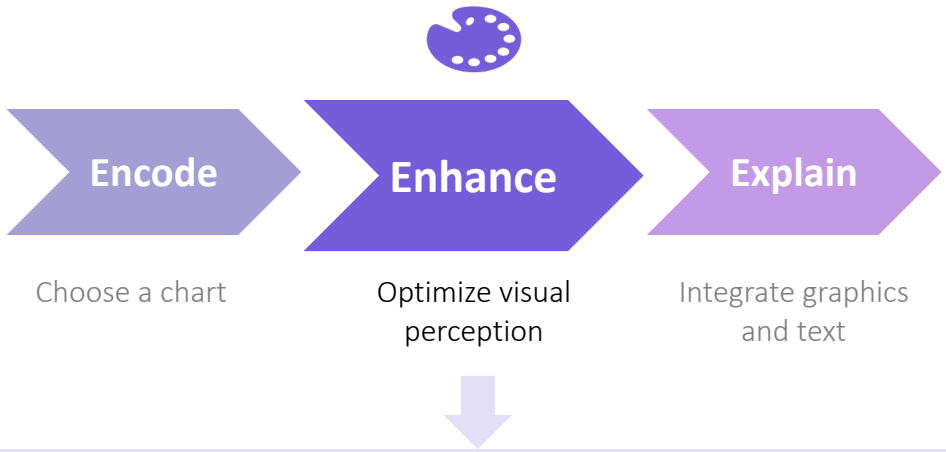
David McCandless, Colours in Culture
https://www.informationisbeautiful.net/visualizations/colours-in-cultures/

Wrapping up

The 5 key steps in visual design

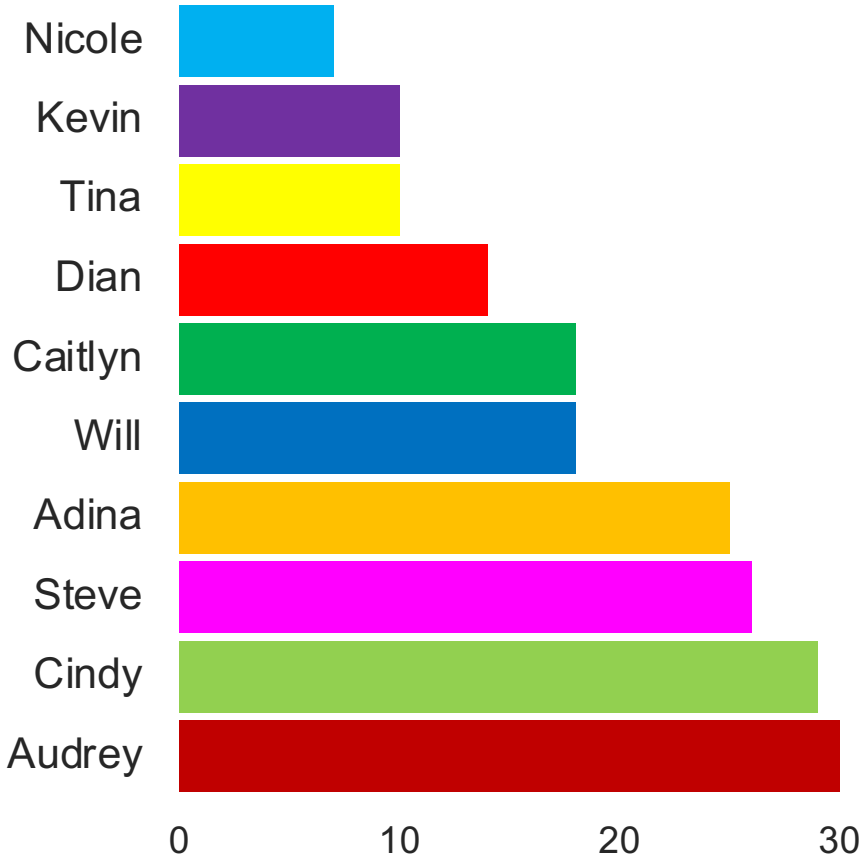
Do’s and Don’ts

Pulling it all together: **5 steps** to optimize visual perception

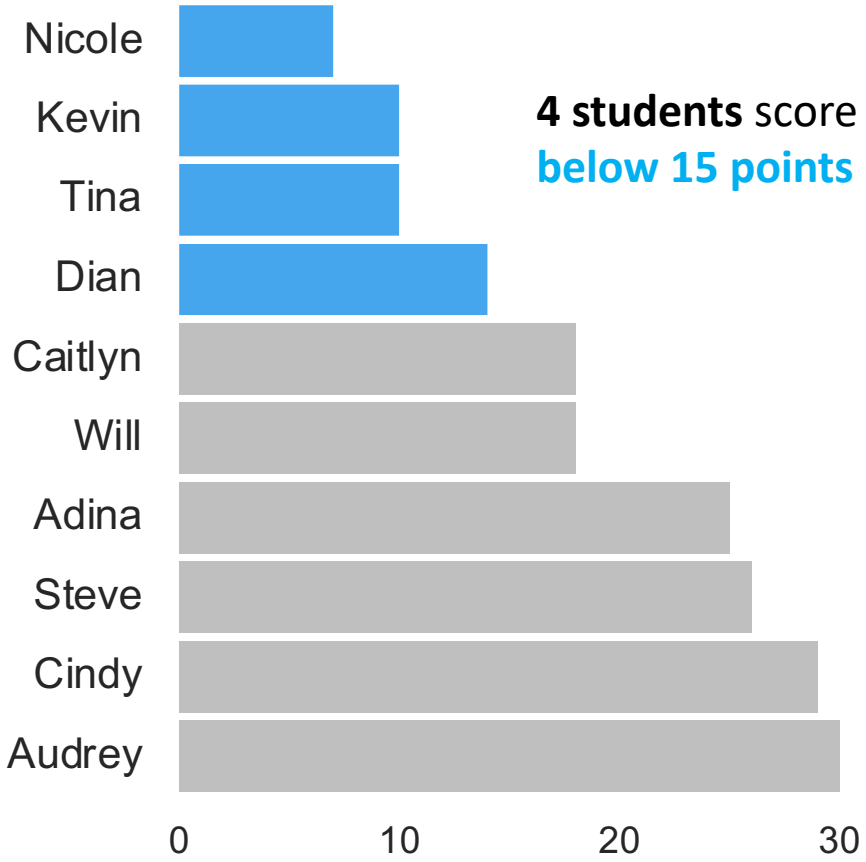


1. **Simplify:** Enable direct (fast) comparisons
2. **Declutter:** Eliminate irrelevant distractions
3. **Add focus:** Draw attention to where you want it
4. **Ensure intuitive design:** Do the visual elements follow a natural flow?
5. **Verify accessibility:** Is the visual readable to all?

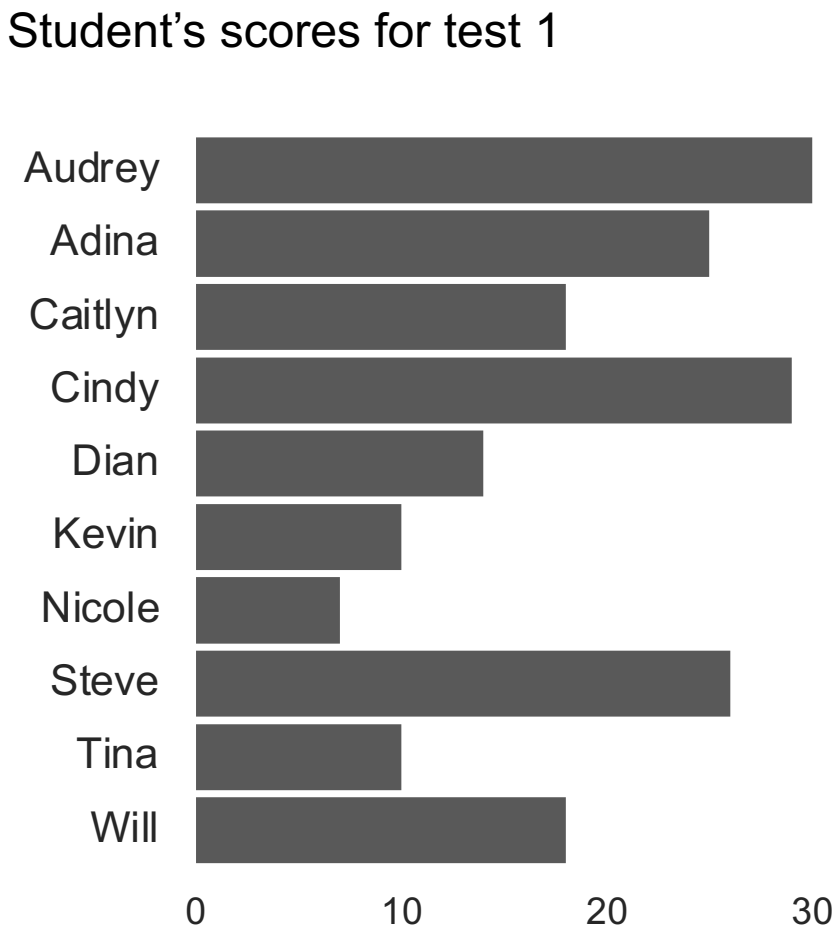
Don’t: Use too many (useless) colors

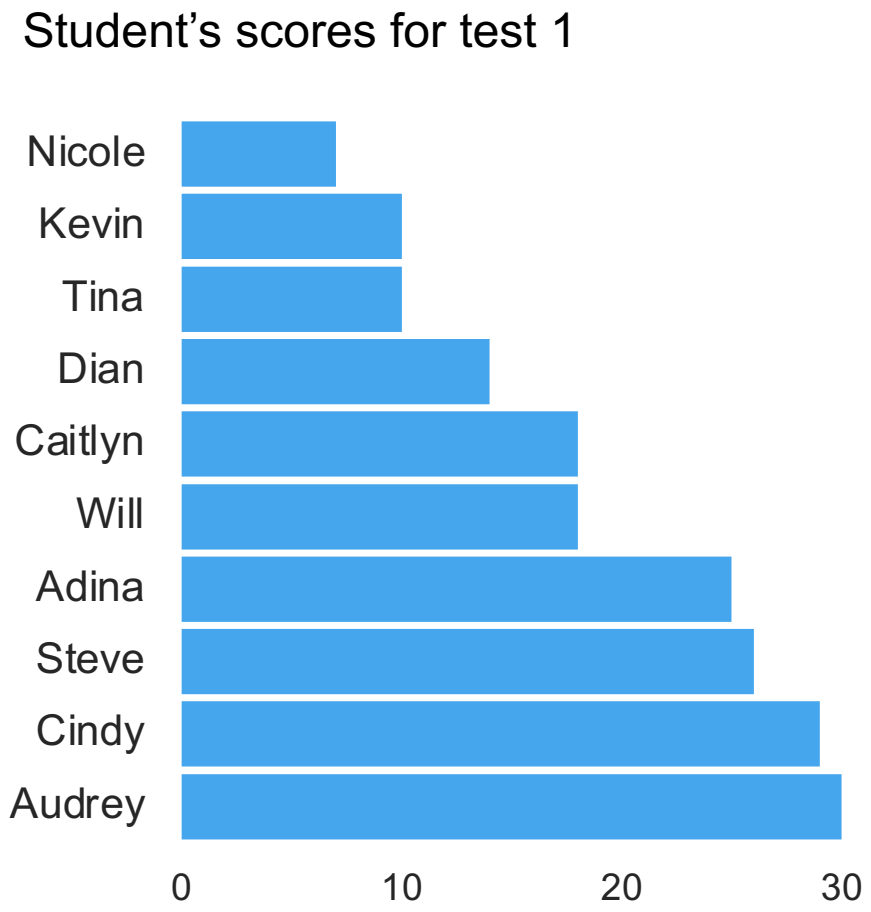


Do: Highlight and annotate your key findings

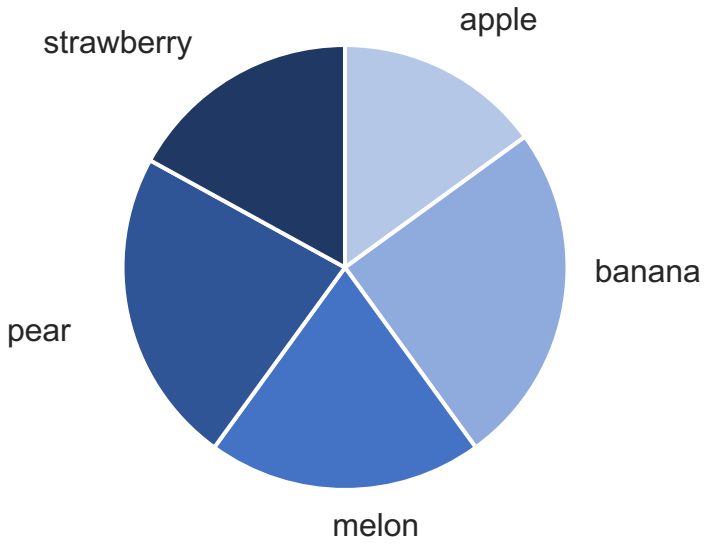


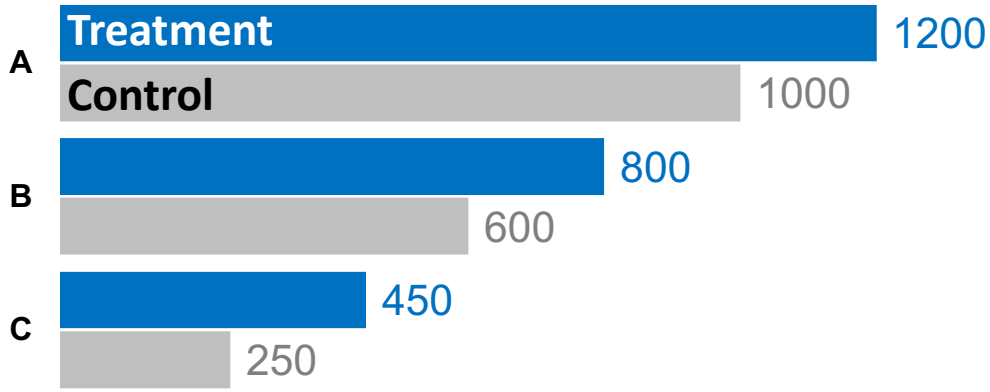
Do: Order your data logically, e.g., alphabetically or by number





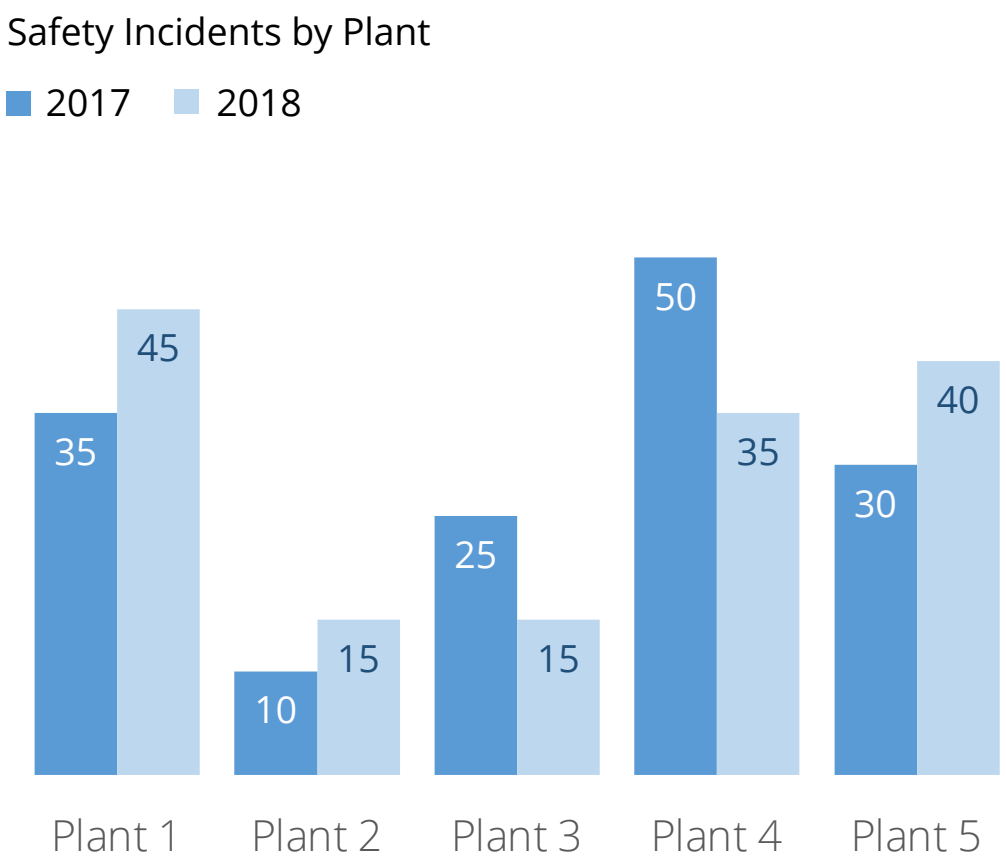
Do: Label your data directly





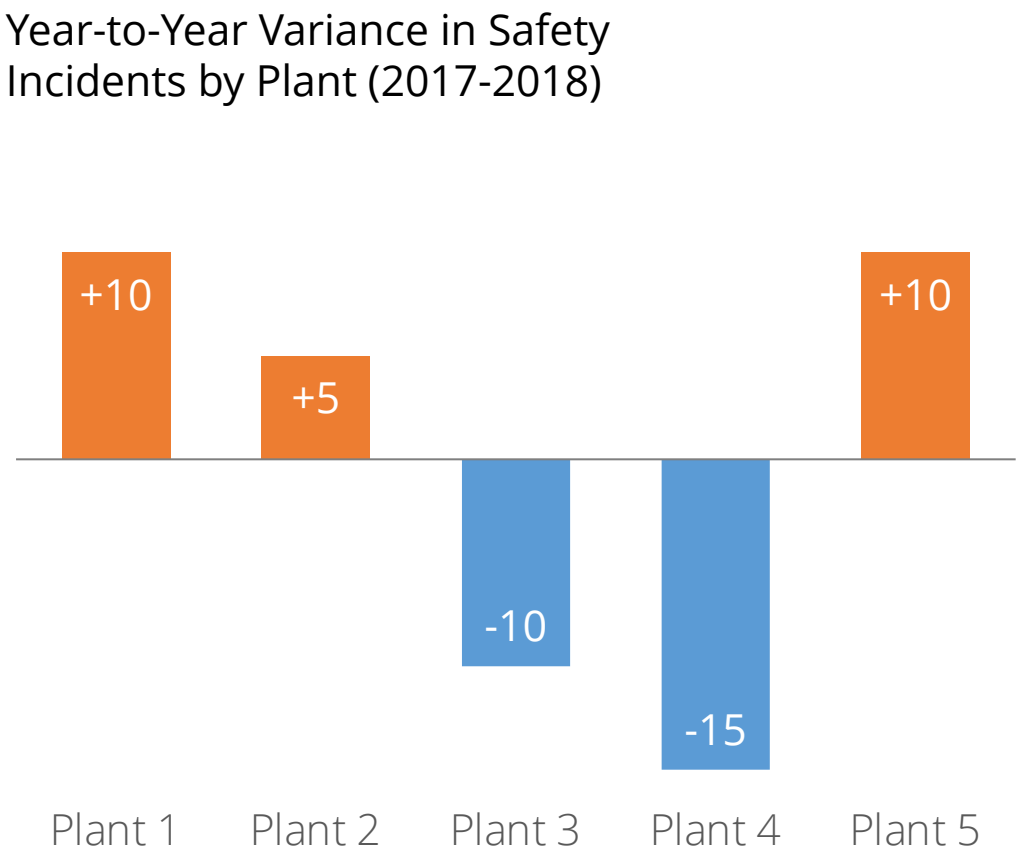
Adapted from: **Ann K. Emery**, https://depictdatastudio.com/accessibility-quick-wins-remove-legends-and-directly-label/

Don’t: Let your audience do mental math



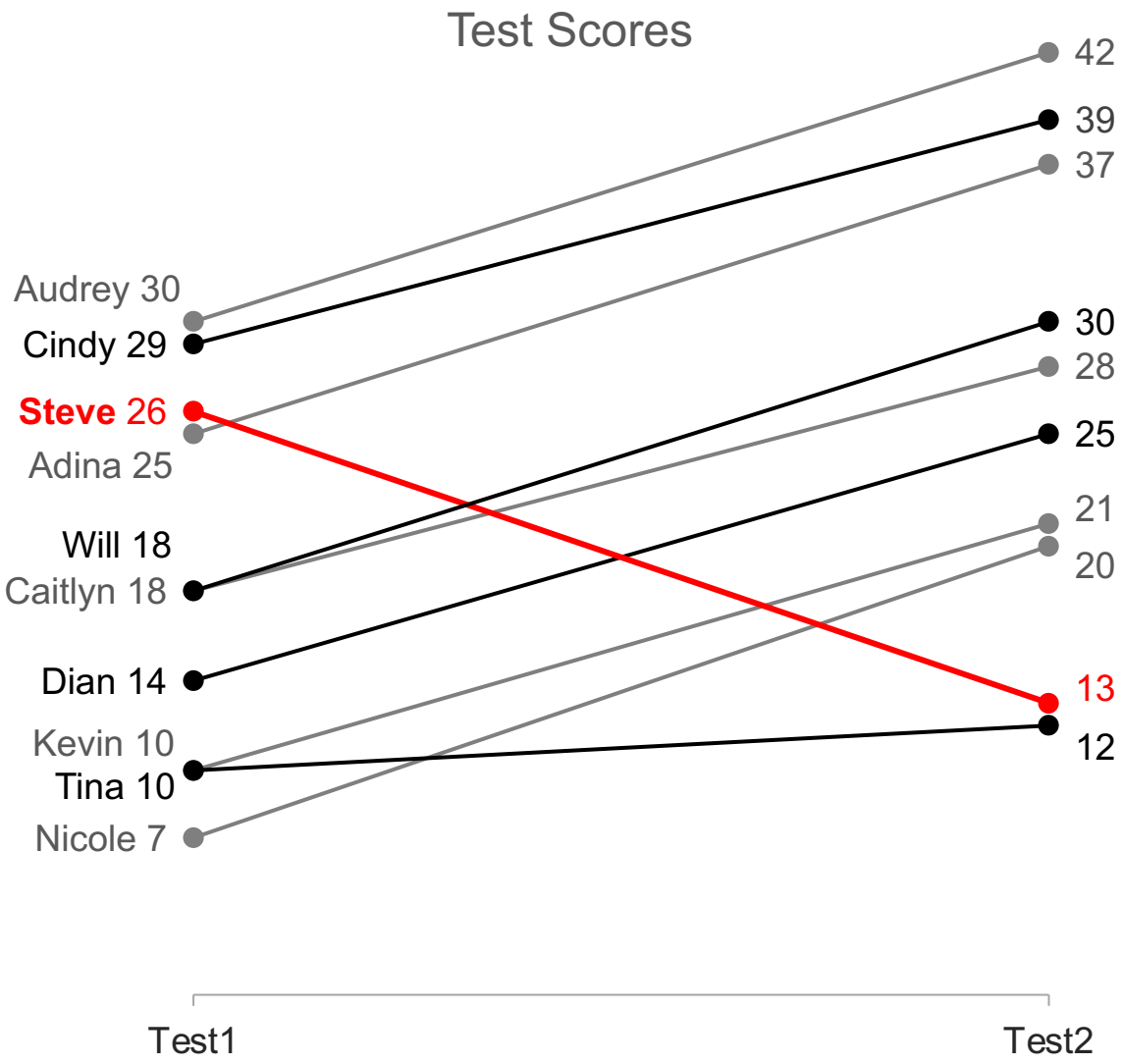
What’s the mean difference between 2017-2018?

Do: Show differences directly



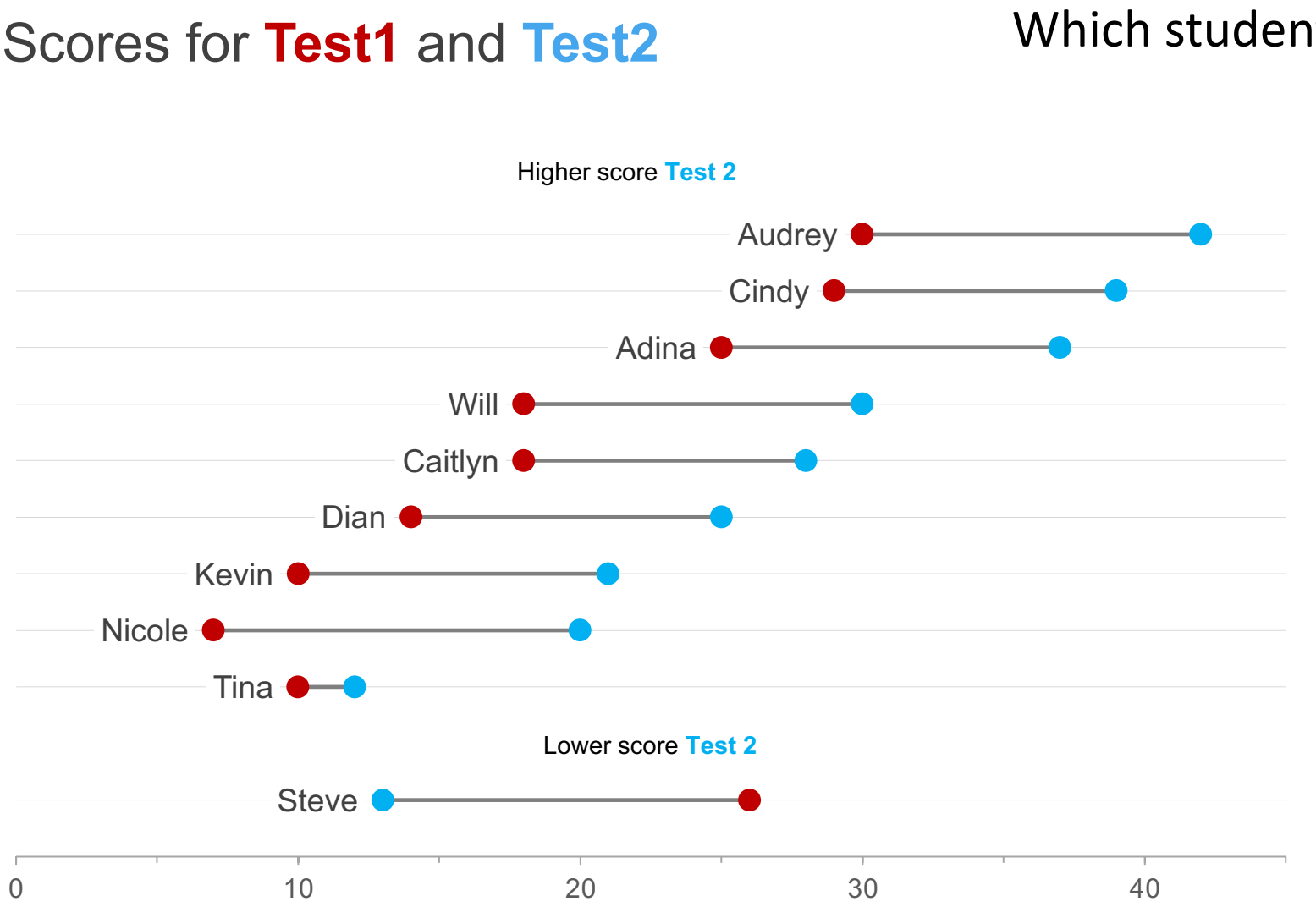
What's the mean difference between 2017-2018?

Do: Enable direct comparisons



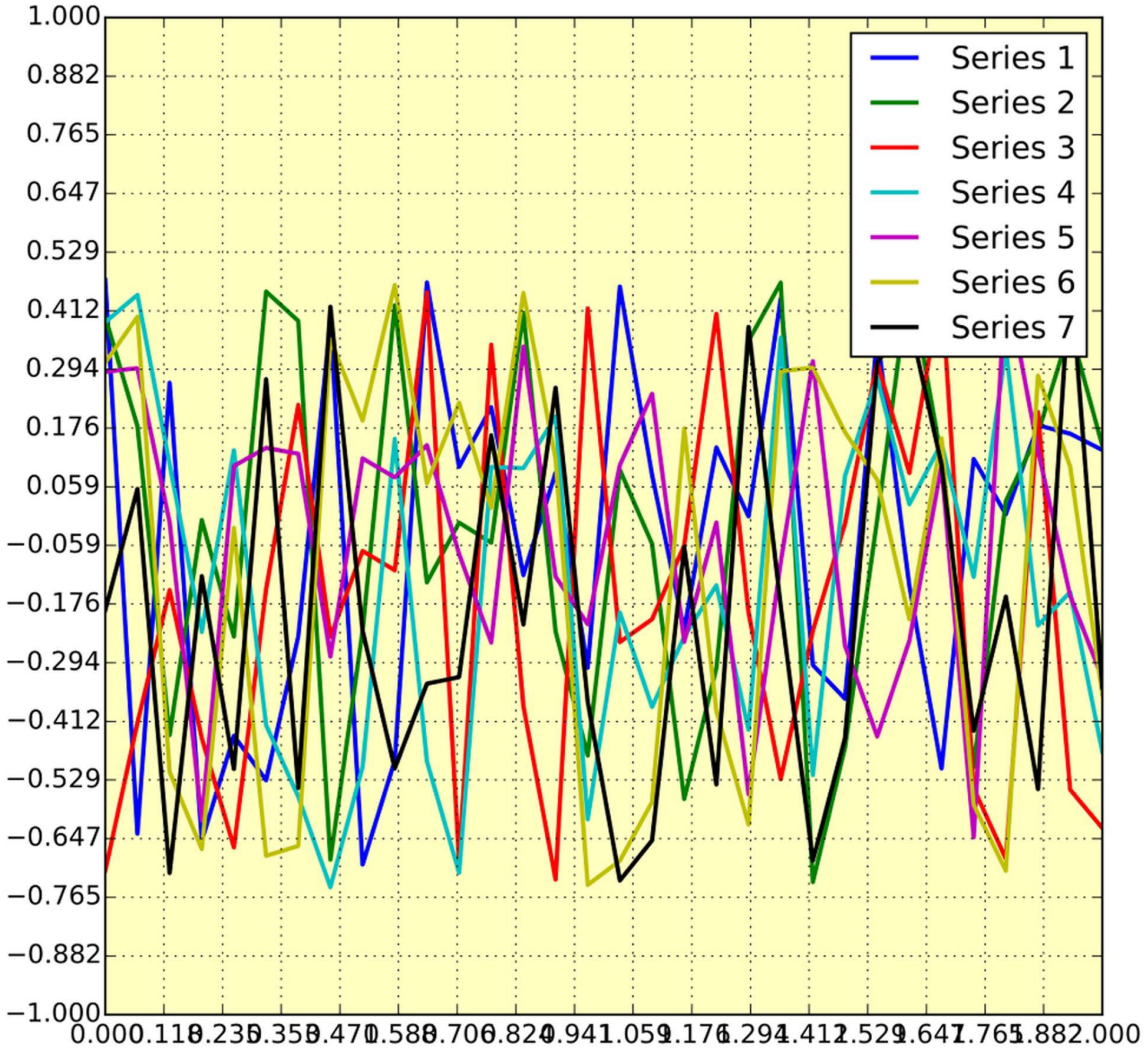
Which student got worse?

Do: Enable direct comparisons



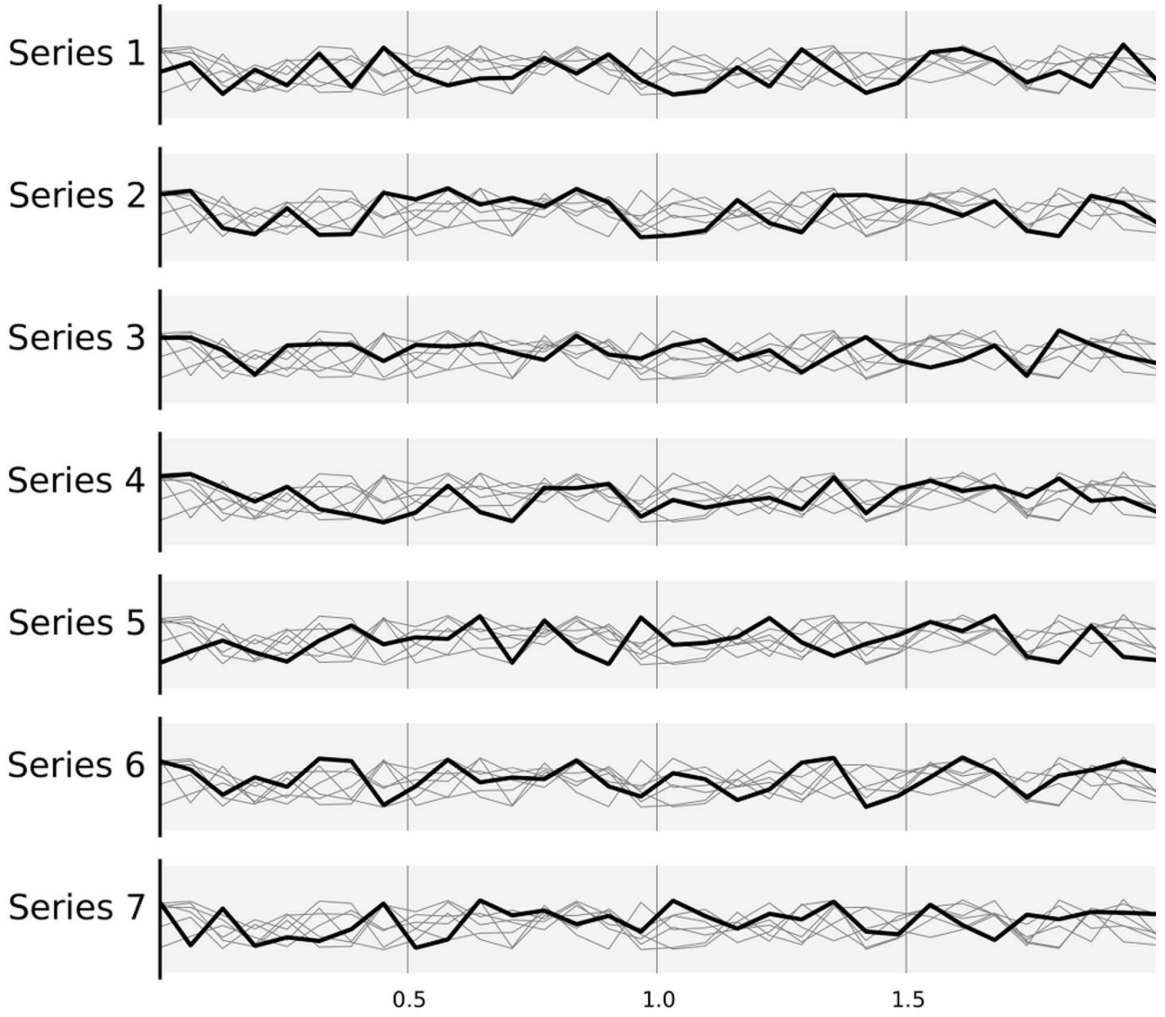
Which student got worse?

Don’t: Use a spaghetti chart



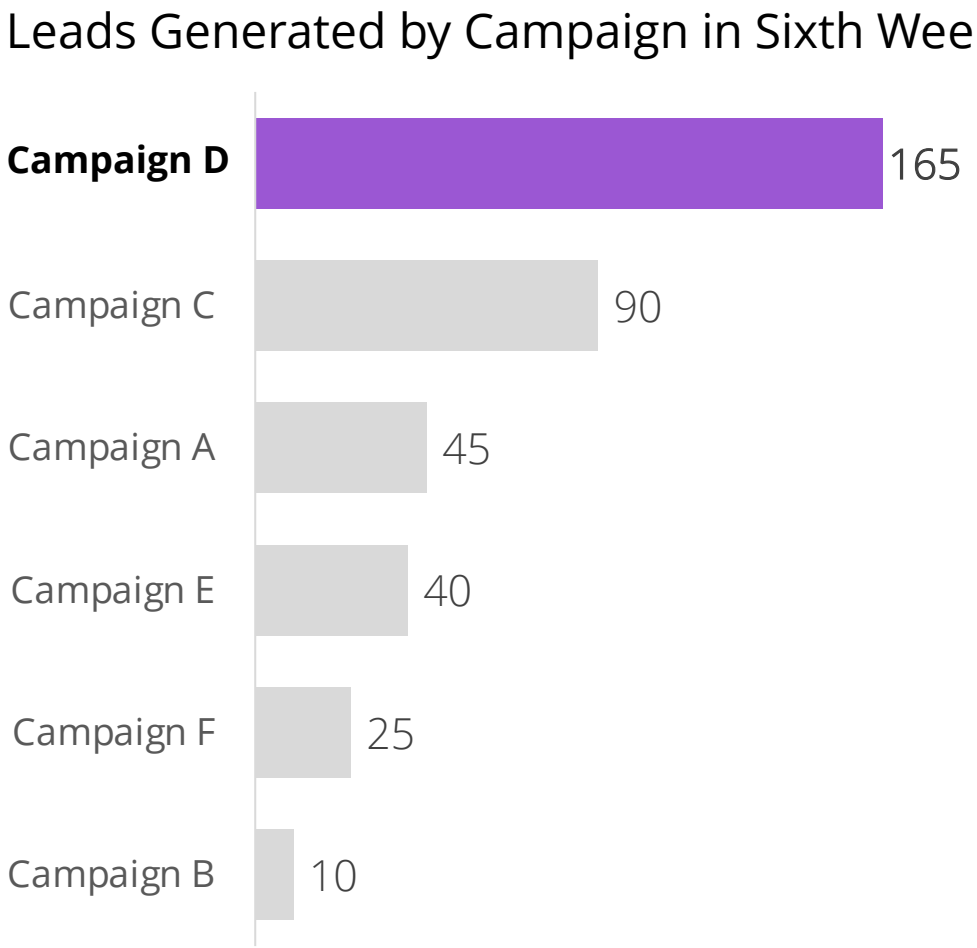
Rougier NP *et al.* (2014) PLoS Comput Biol 10: e10003833.

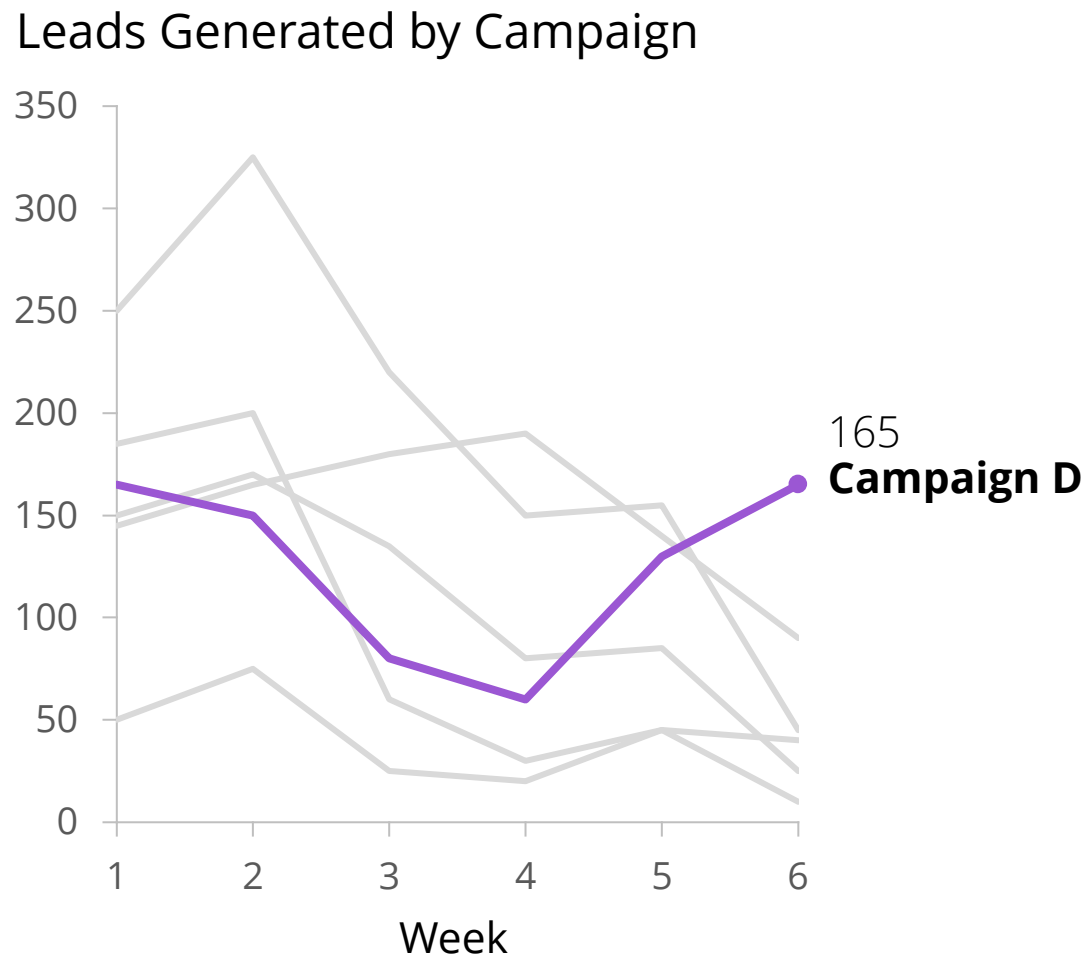
Do: Use small multiples instead



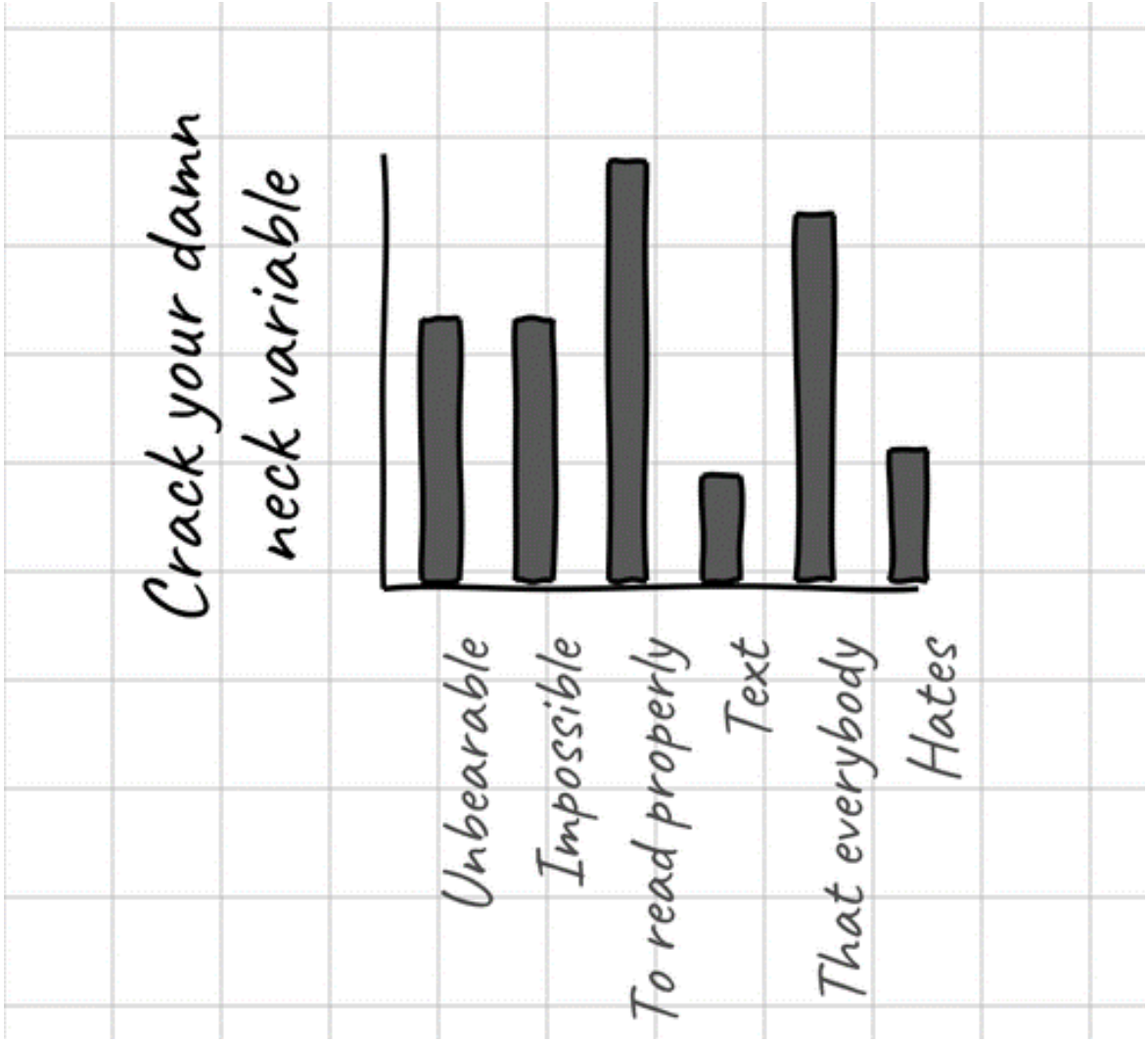
Rougier NP *et al.* (2014) PLoS Comput Biol 10: e10003833.

Do: Highlight what's important

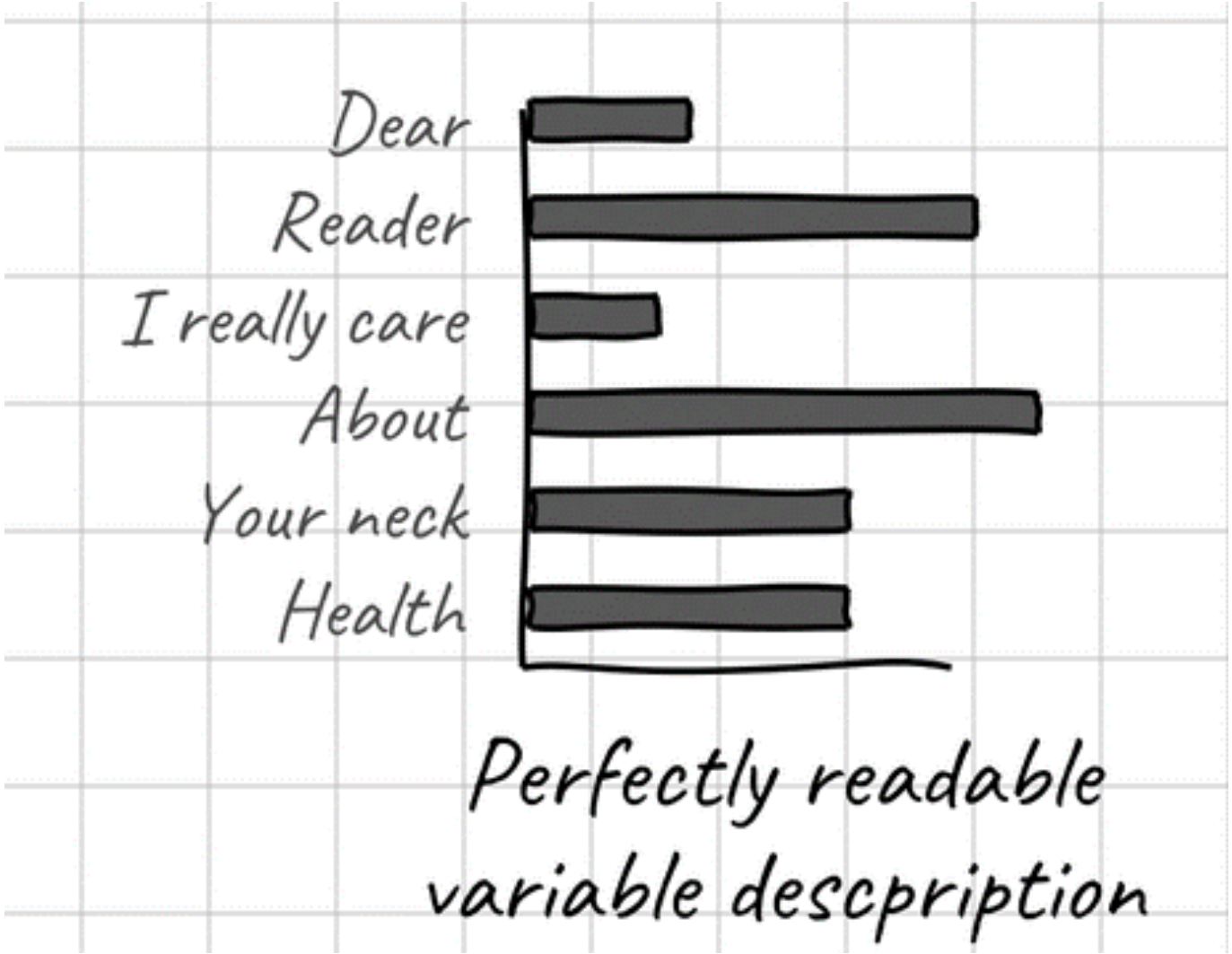




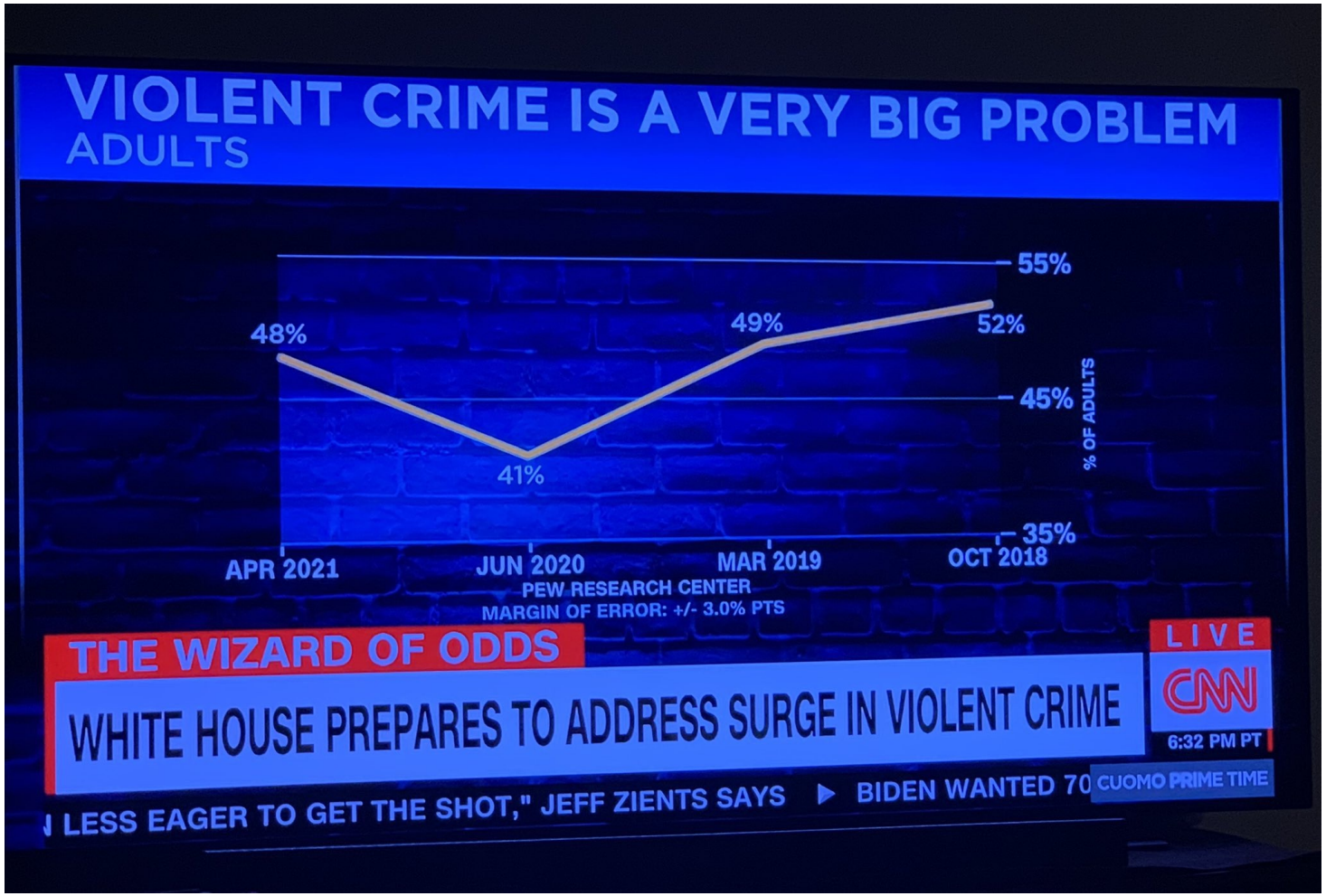
Don’t: Make your audience crack their neck!



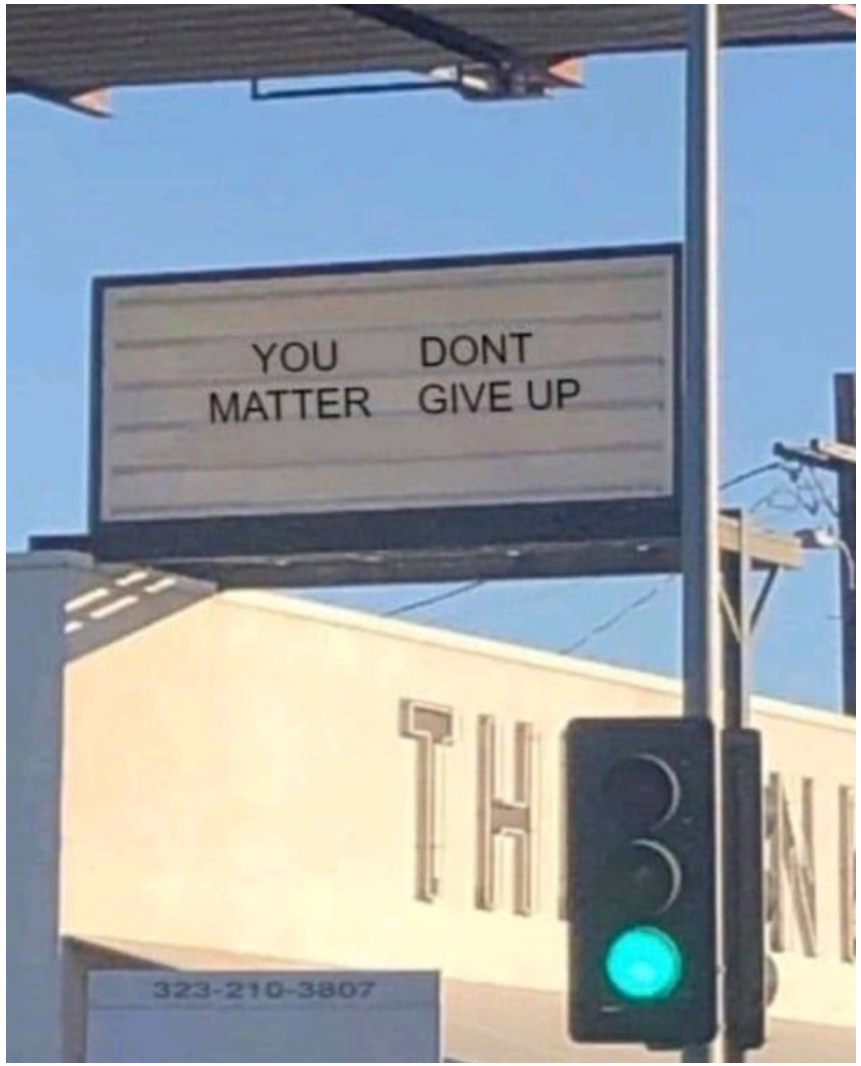
Do: Align text horizontal



Don’t: Read from right-to-left

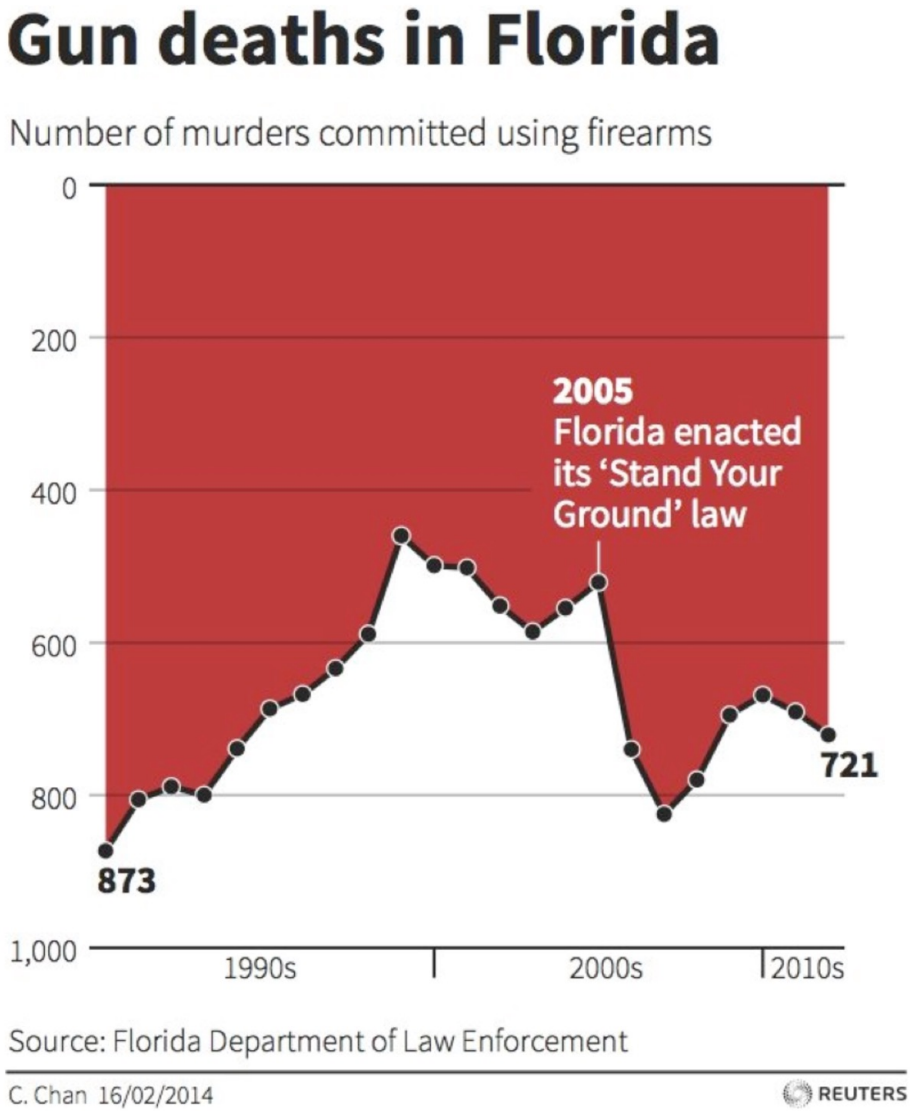


Do: Read from left-to-right…

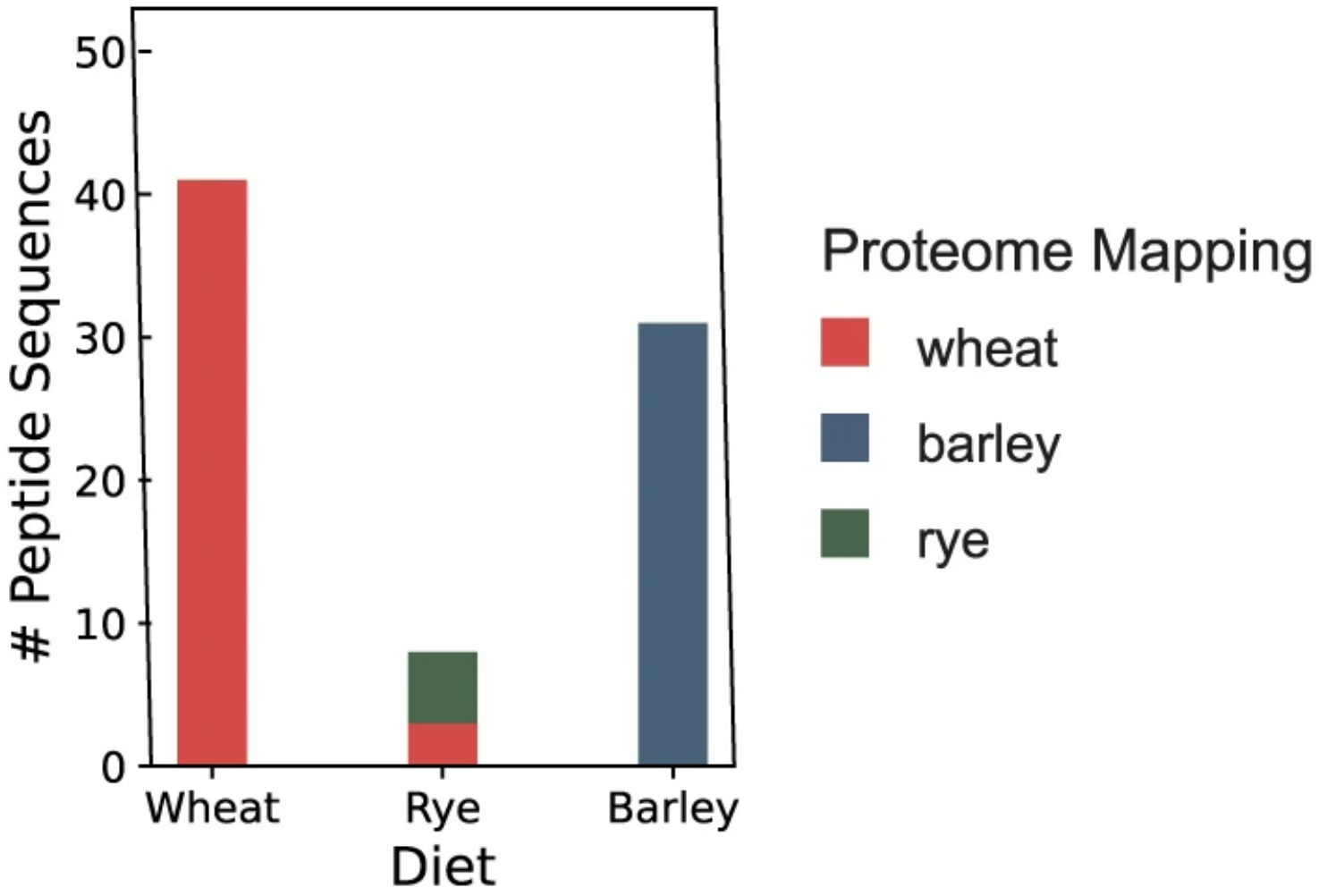


..right?

Don’t: Flip the y-axis either

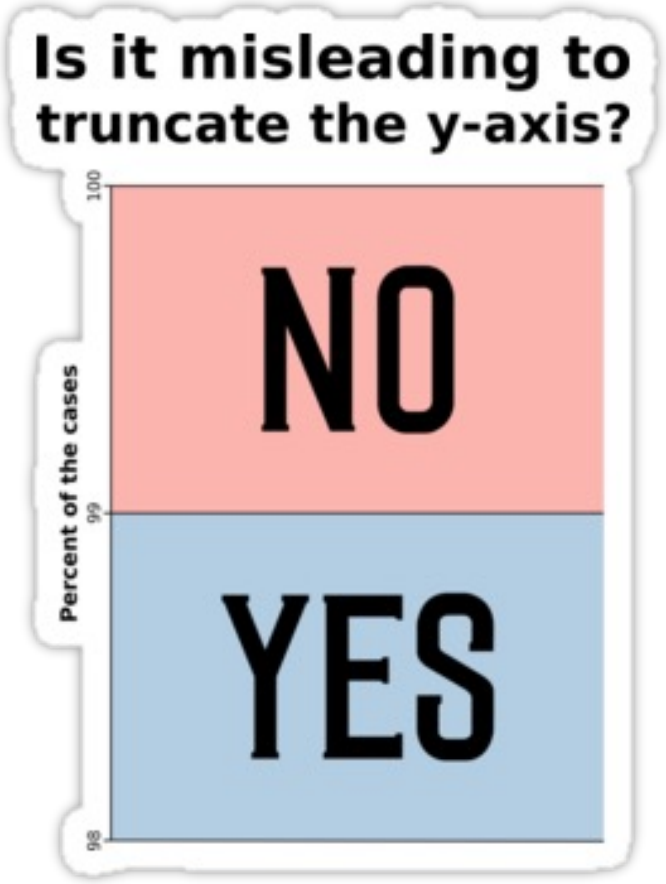


Don’t: *Tilt* (?) the y-axis either



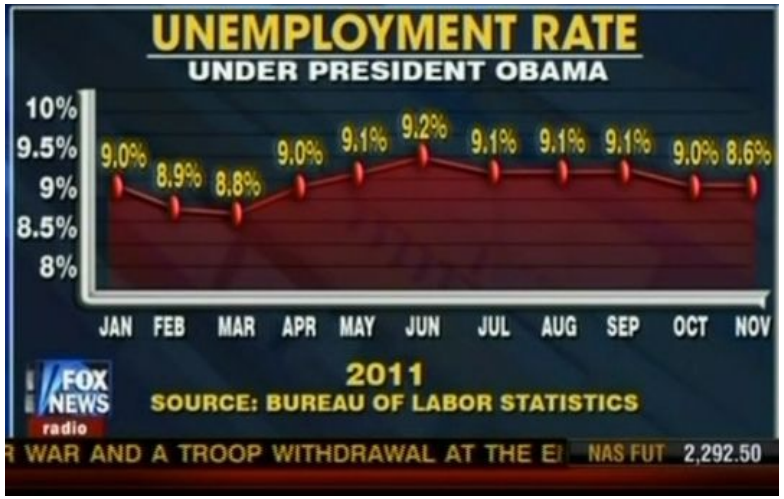
Palanski, B.A., *et al. Nat Commun* **13,** 888 (2022).

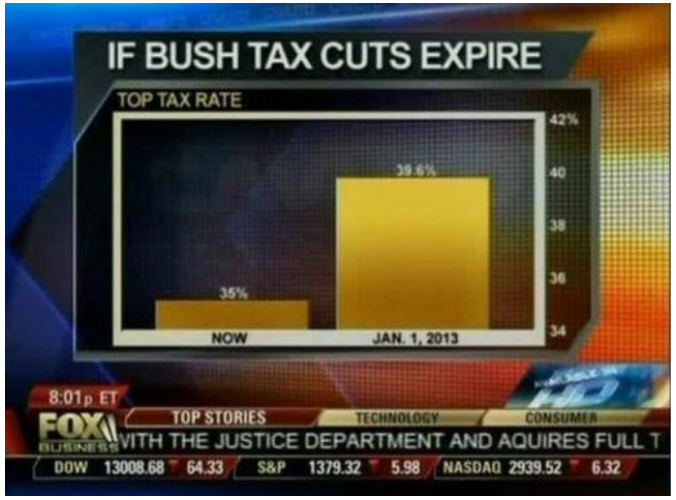
Don’t: *Truncate* the y-axis either

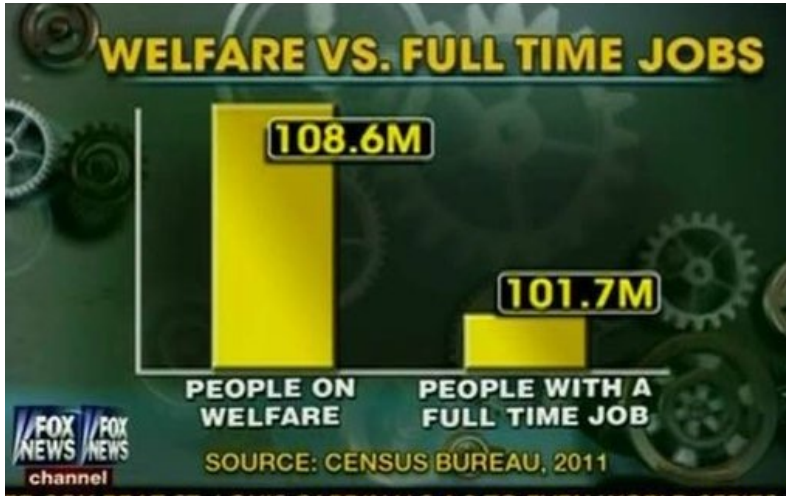


Ramiro, 2013, https://www.redbubble.com/i/sticker/Is-it-misleading-to-truncate-the-y-axis-Funny-Chart-by-ramiro/18204098.EJUG5

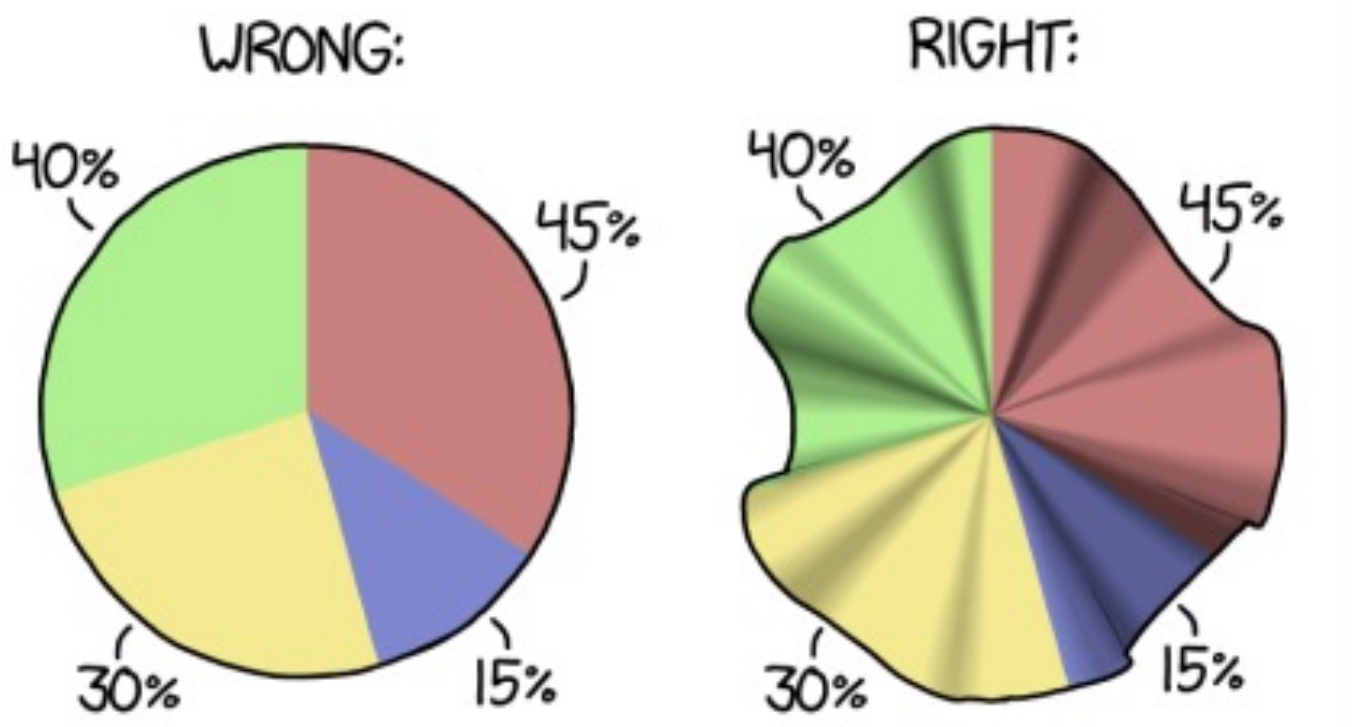
Who *does* that, you say?



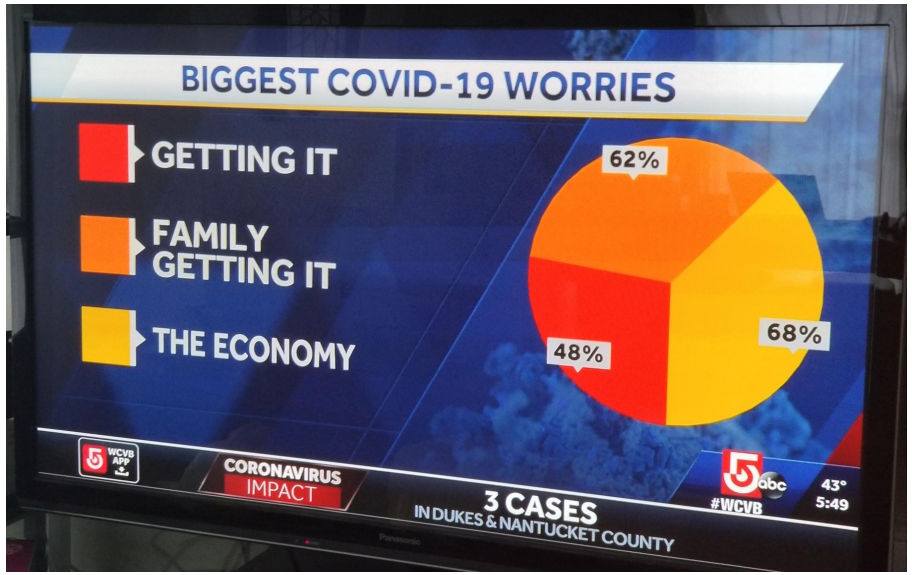


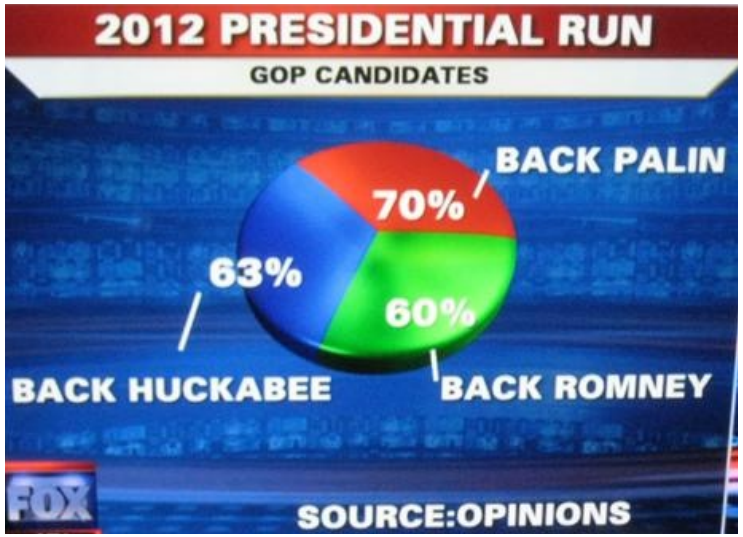


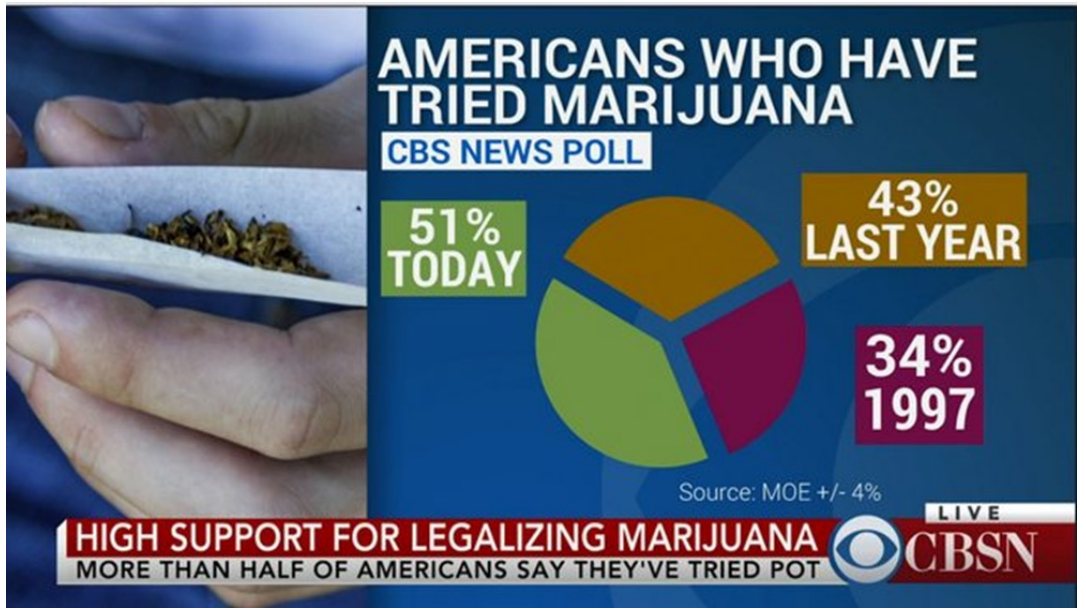
Don’t: Use pie charts where the numbers don’t add up



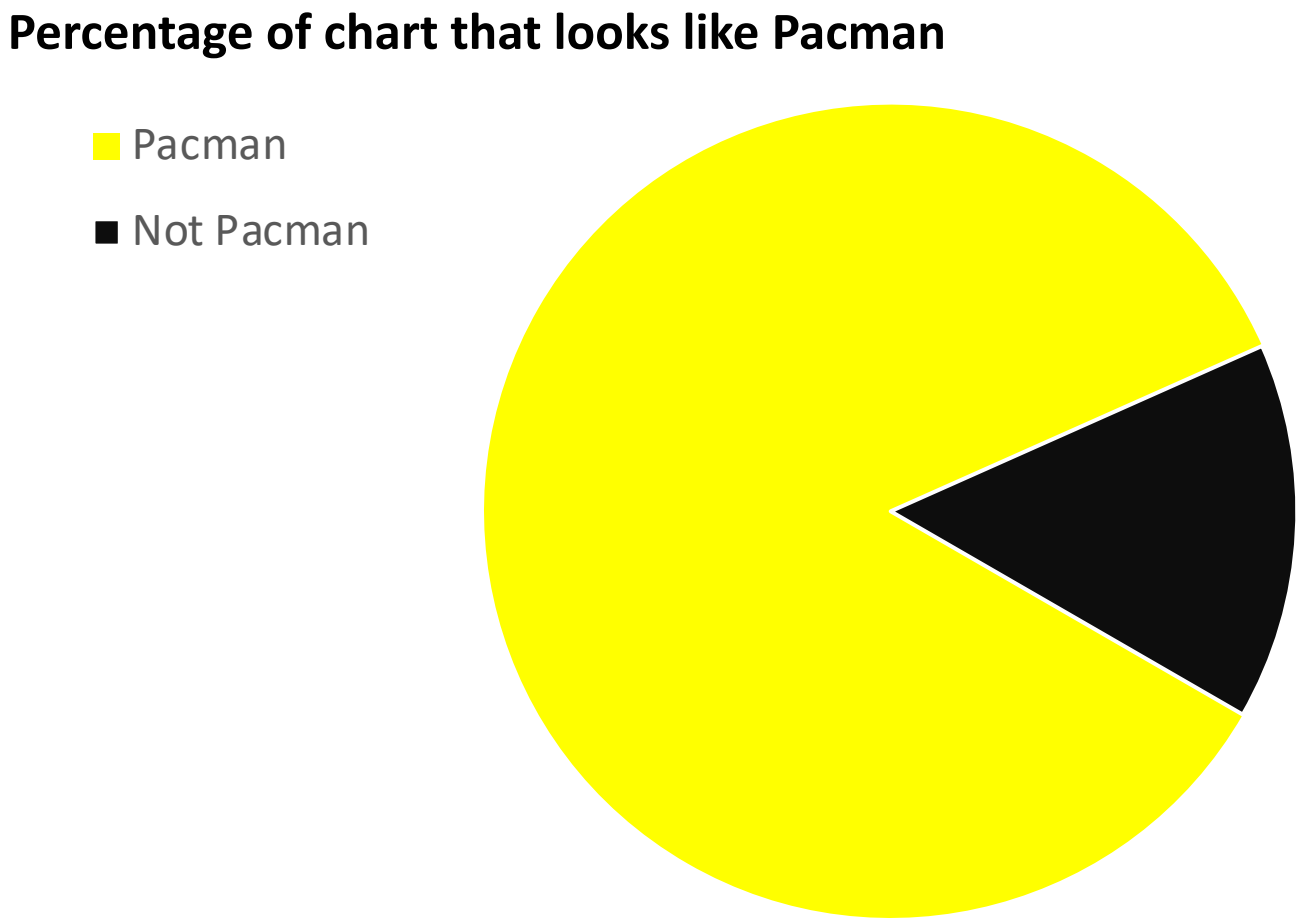
Who *does* that, you say?



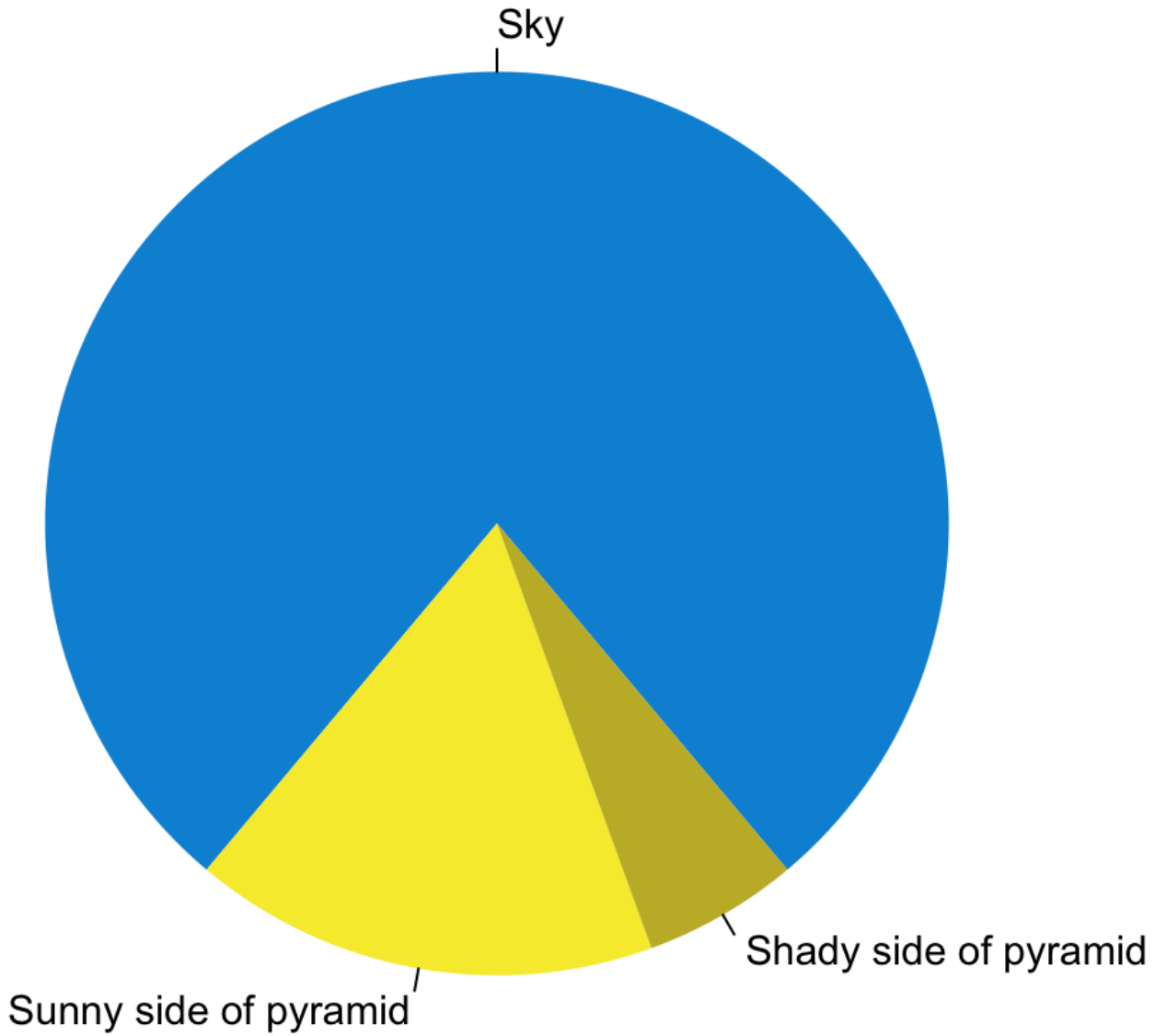




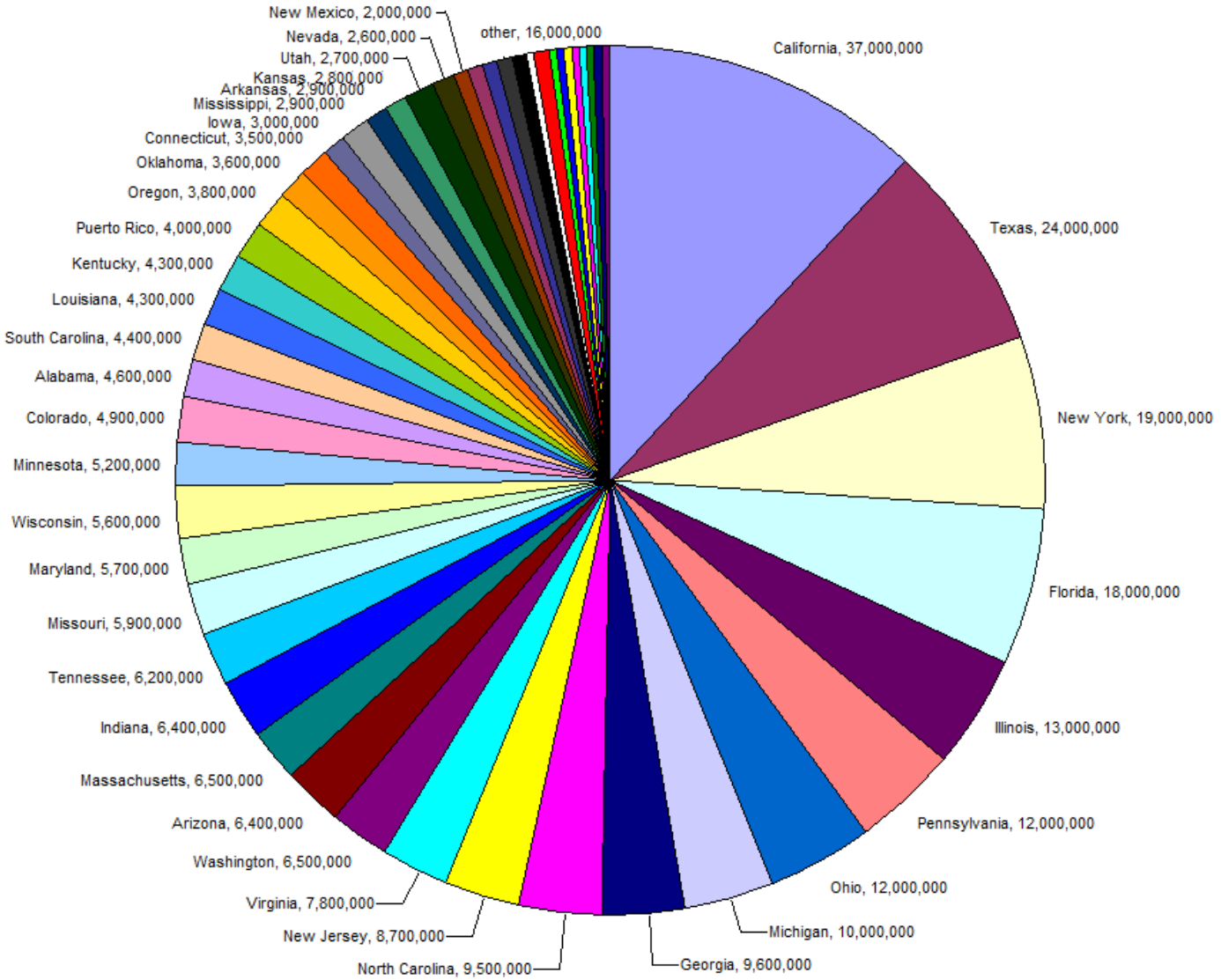
Do: Use pie charts to show the part-to-whole relation of 2 categories



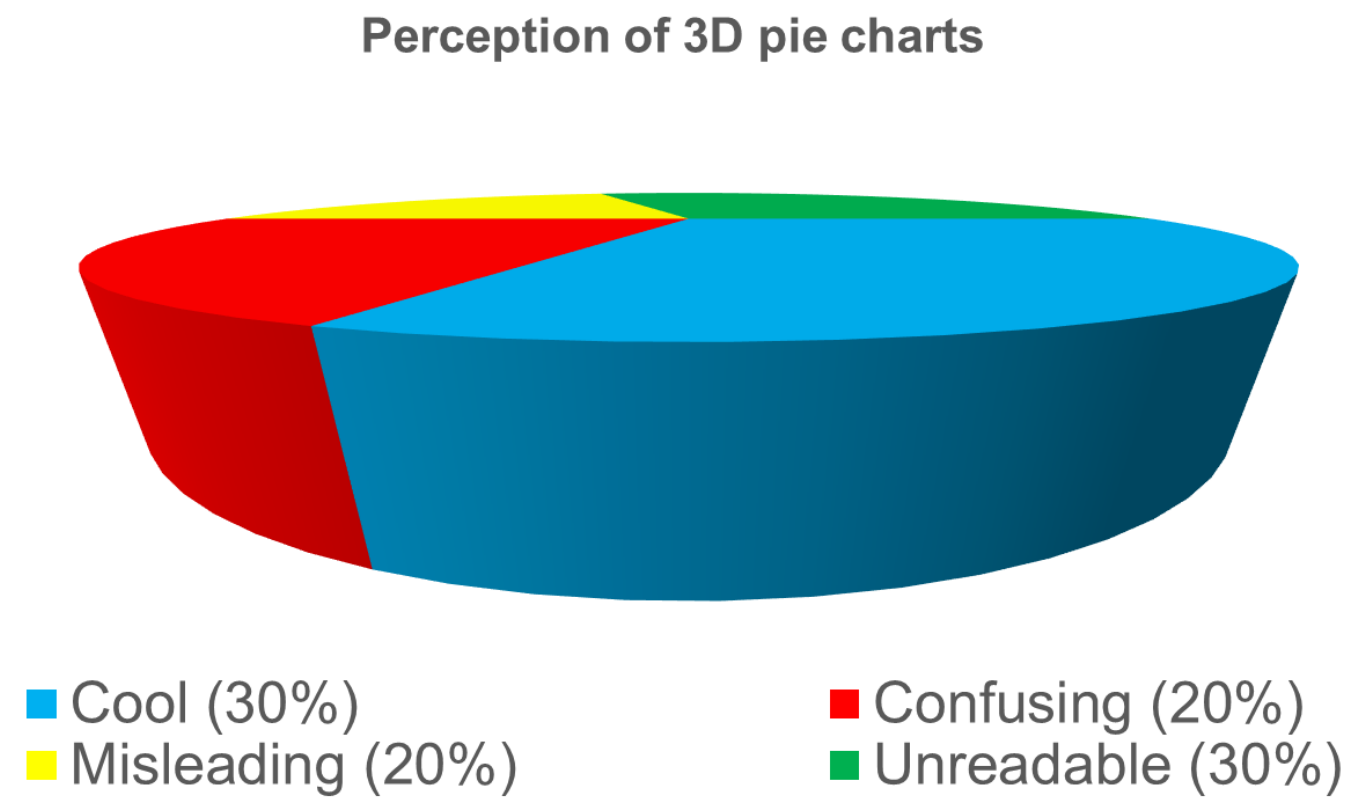
Do: Pie charts for 3 categories is okay too



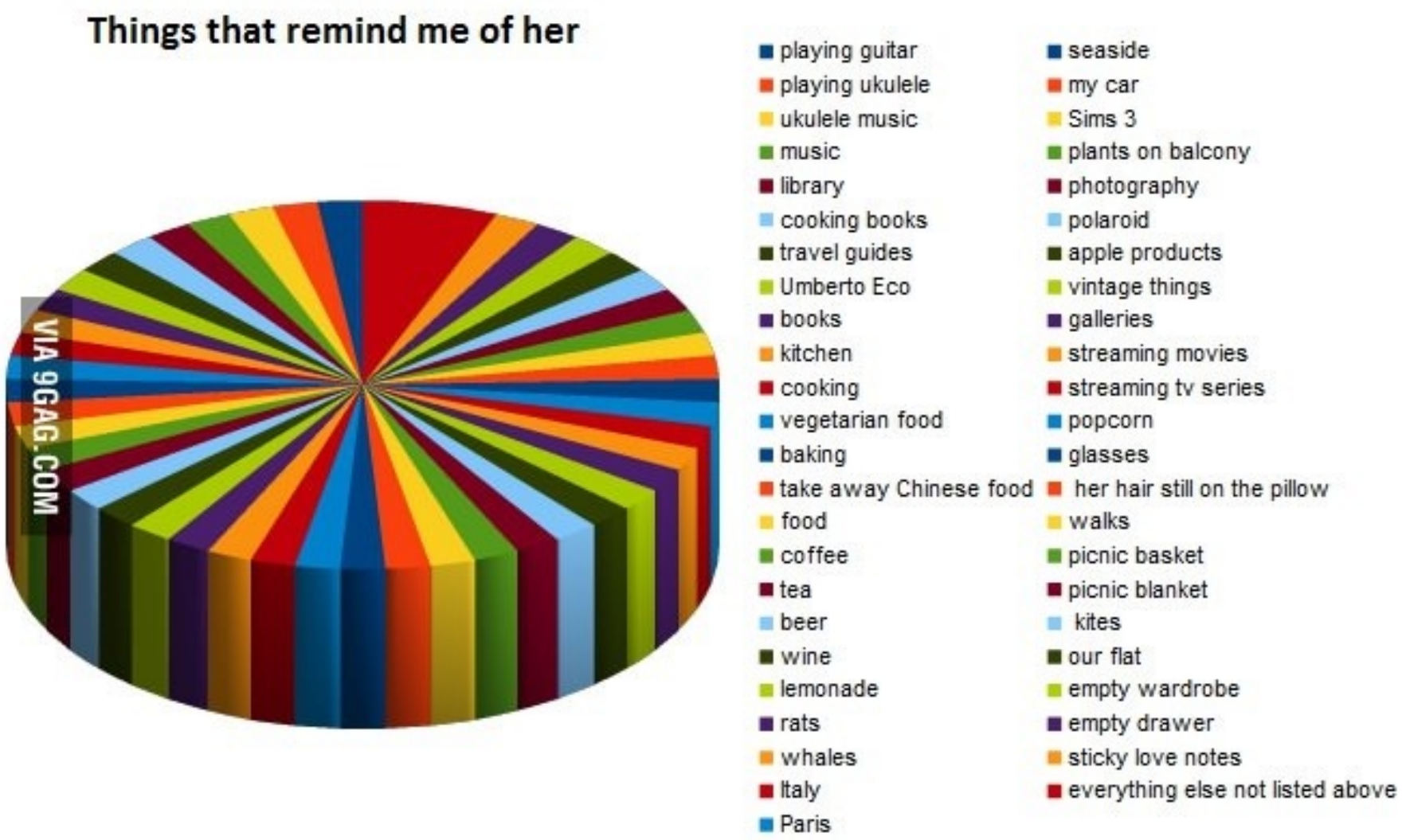
Don’t: Use pie charts with >5 categories



Don’t: Use 3D pie charts



Don’t: Use 3D pie charts with >5 categories



Do: Know when pie charts are *the best*!

Thank you!

Irene van den Broek, PhD

Irenevandenbroek@gmail.com

@IrenevdBroek

@JeBentWatJeMeet

Happy Viz-ing!

https://irenevdb.rbind.io

Find the slides and resources here:

https://irenevdb.github.io/4TU/Presentation.pdf

https://irenevdb.github.io/4TU/ReferenceList.pdf


TAKE
AWAY

Exercise

Exercise: One dataset, multiple stories

No. infections	City
250	Amsterdam
110	Rotterdam
125	Den Haag
23	Utrecht
125	Eindhoven
55	Groningen
155	Leeuwarden
85	Enschede
120	Maastricht
15	Wageningen

5 min

5 Scenarios:

The reader wants to know:

1. How many infections per city?
2. How does Maastricht rank?
3. How does the number of infections in Amsterdam relate to the other cities?
4. Which cities have more than 100 infections?
5. Does the distance between cities affect the number of infections?

- **1) Create a visual tailored to the reader's question**
- **2) How can you change the visual for another audience?**

- More accurate / engaging
- More focused / detailed

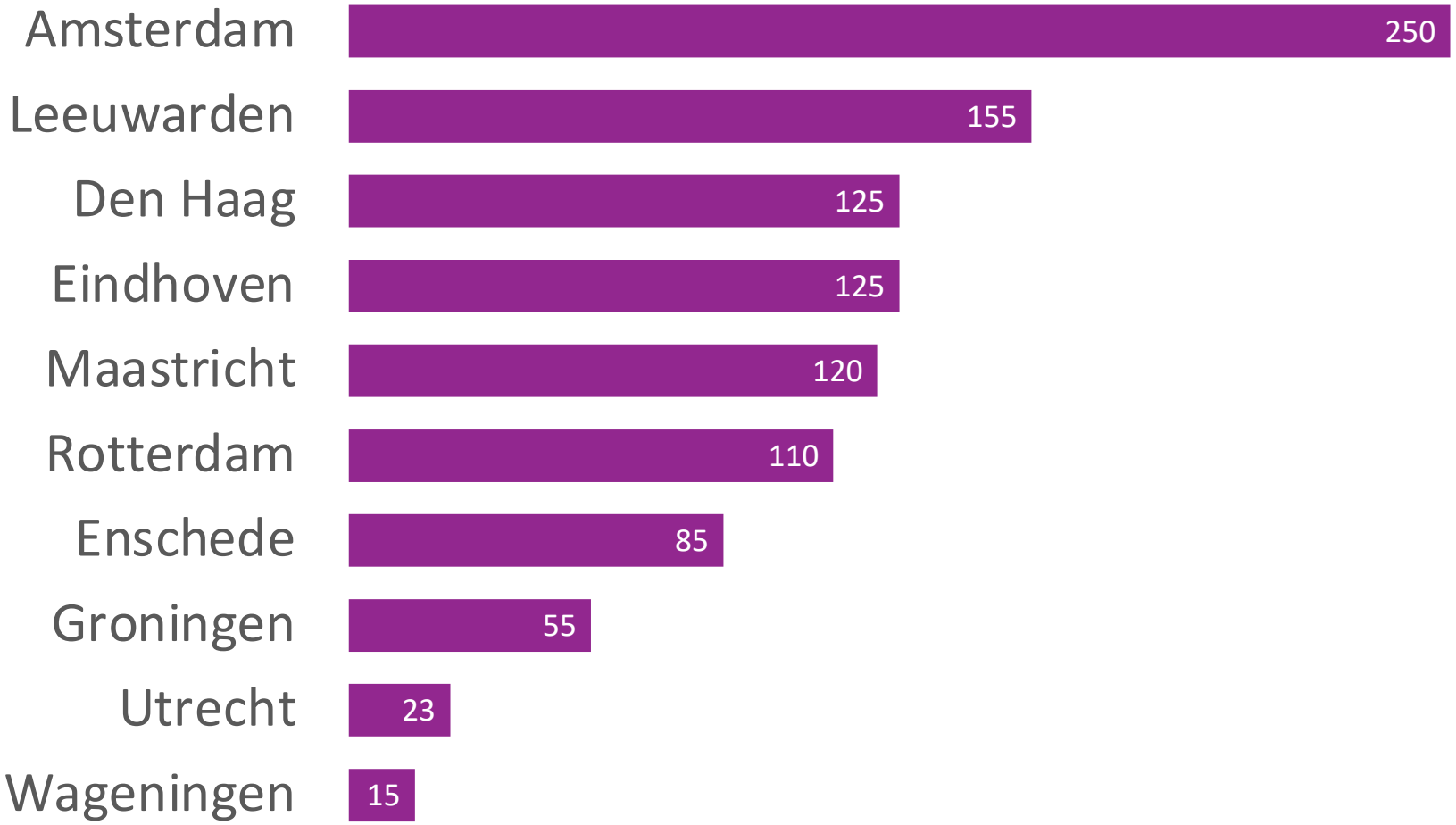
Use your imagination!

How many infections per city?

City	No. infections
Amsterdam	250
Leeuwarden	155
Den Haag	125
Eindhoven	125
Maastricht	120
Rotterdam	110
Enschede	85
Groningen	55
Utrecht	23
Wageningen	15

City	No. infections
Amsterdam	250
Wageningen	15
Den Haag	125
Eindhoven	125
Enschede	85
Groningen	55
Leeuwarden	155
Maastricht	55
Rotterdam	110
Utrecht	23

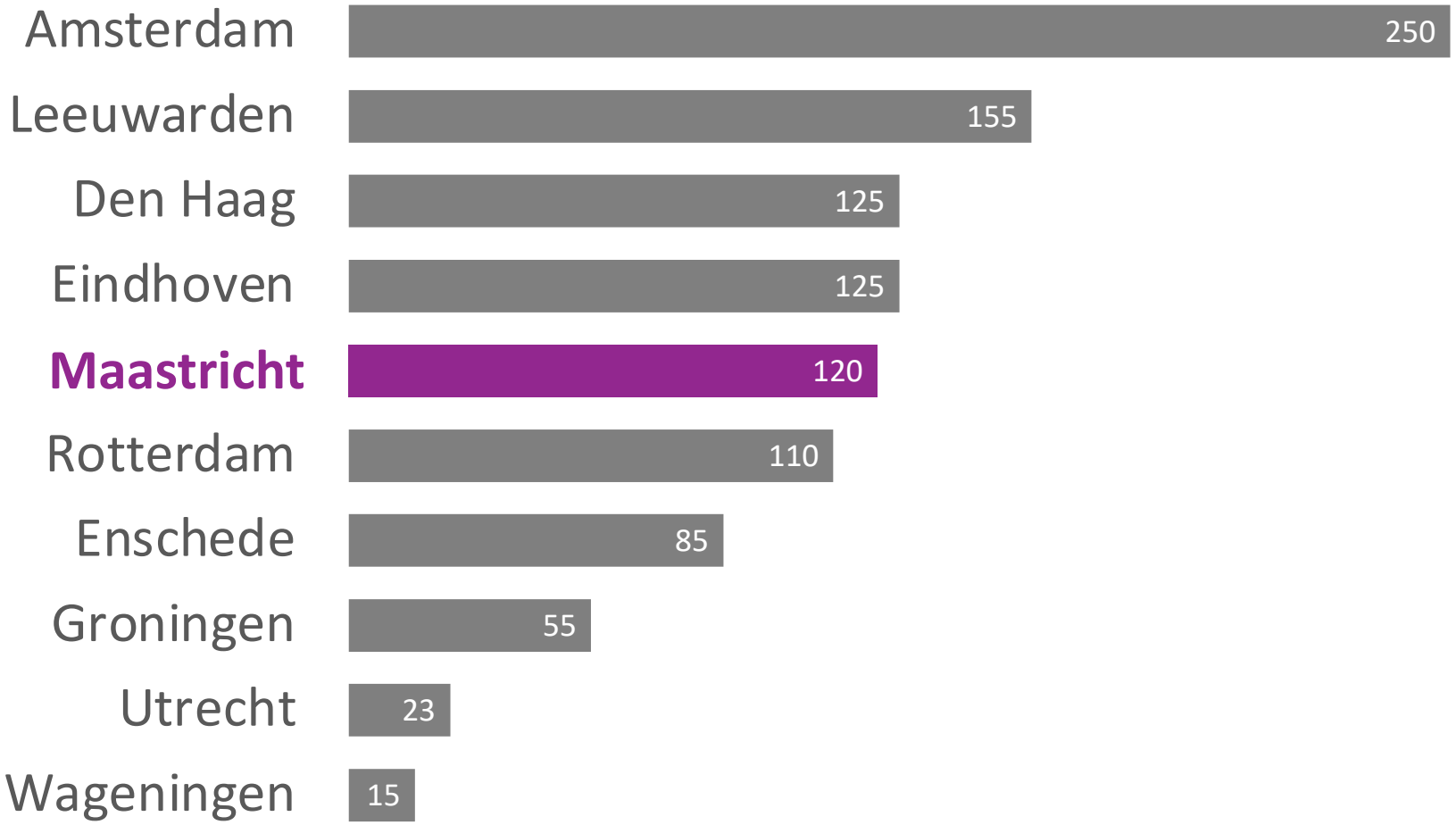
How many infections per city?



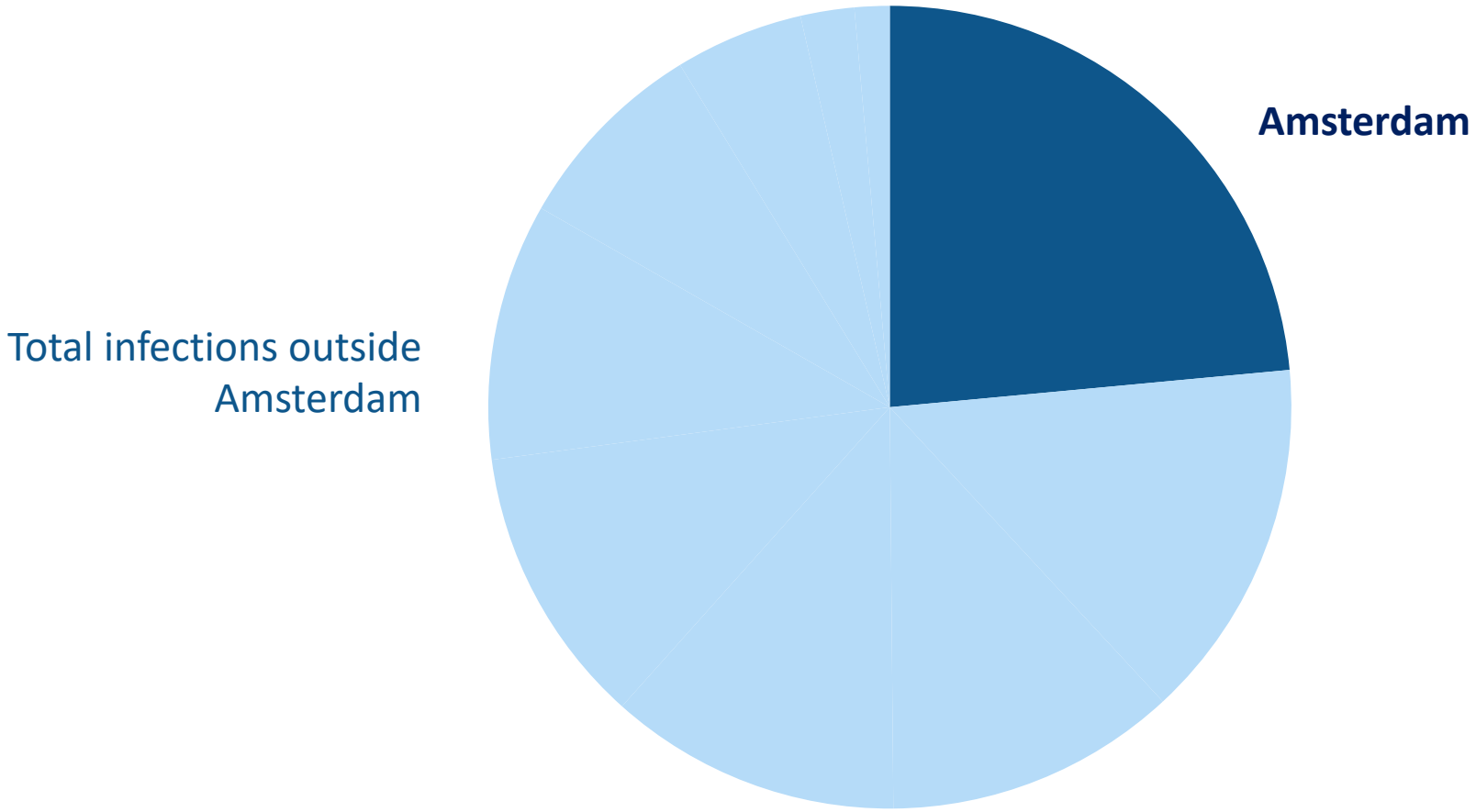
How does Maastricht rank?

	City	No. infections
1.	Amsterdam	250
2.	Leeuwarden	155
3.	Den Haag	125
4.	Eindhoven	125
5.	**Maastricht**	**120**
6.	Rotterdam	110
7.	Enschede	85
8.	Groningen	55
9.	Utrecht	23
10.	Wageningen	15

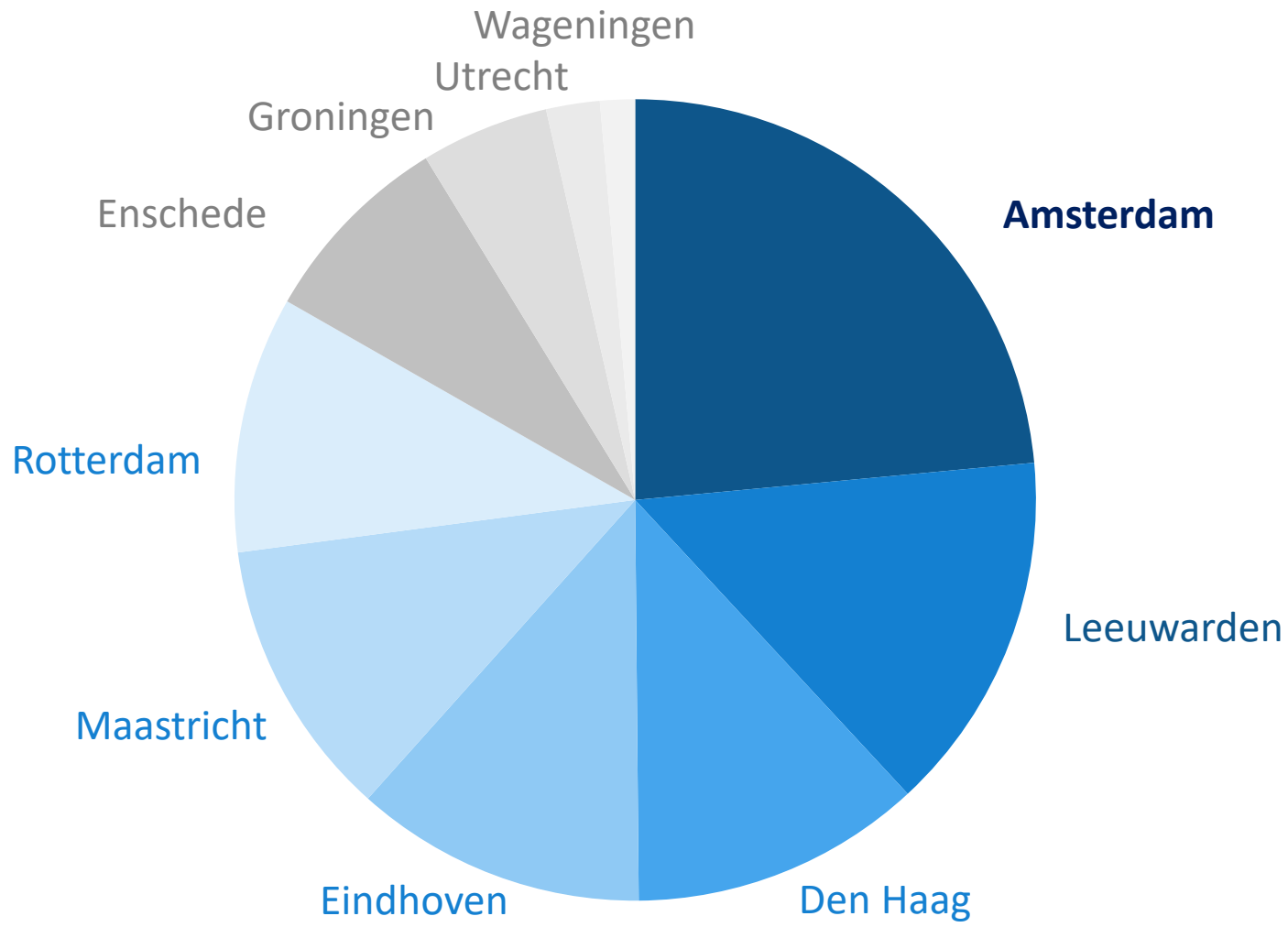
How does Maastricht rank?



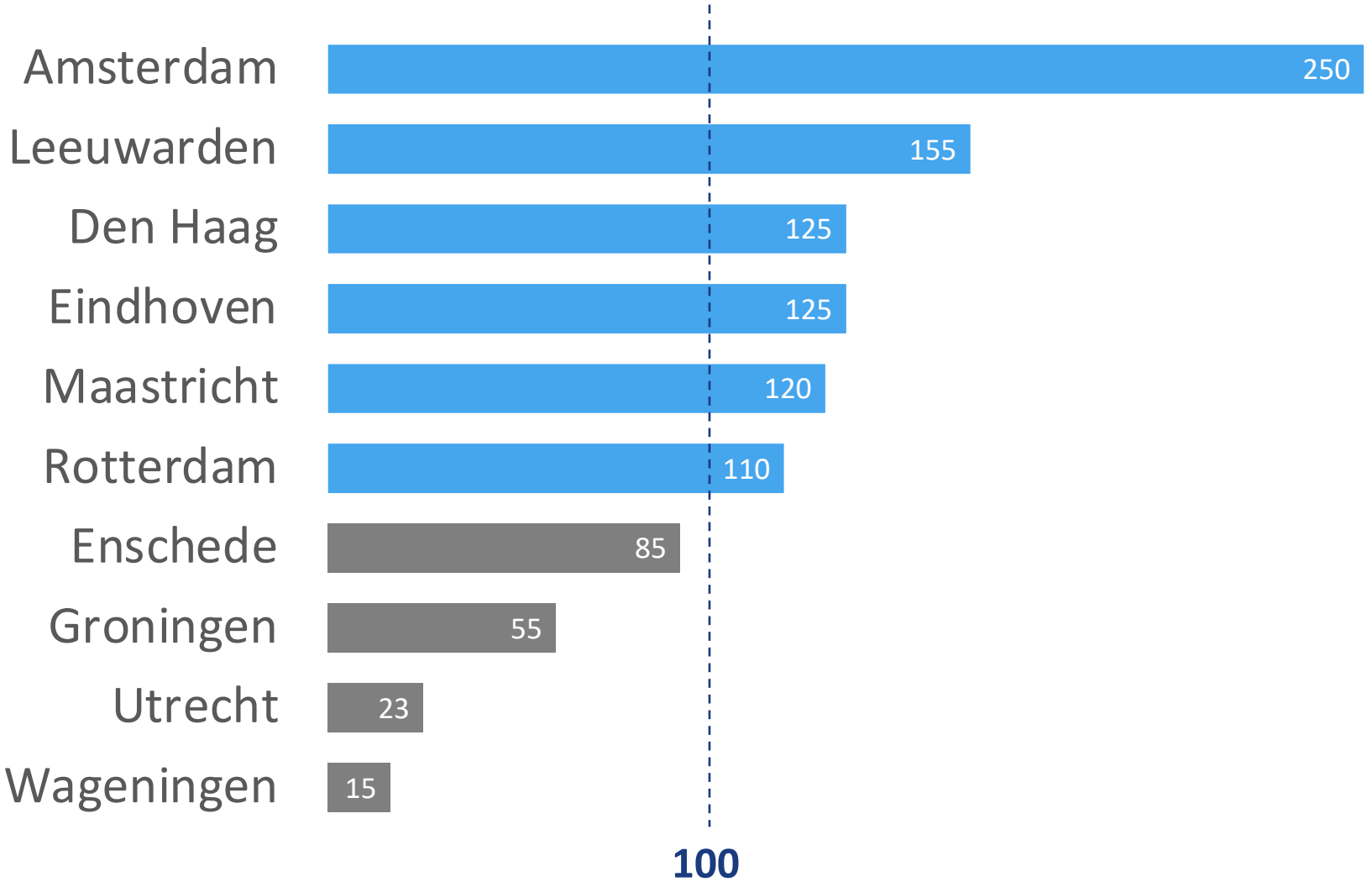
How does the number of infections in Amsterdam related to other cities?



How does the number of infections in Amsterdam related to other cities?



Which cities have more than 100 infections?



Does the distance between cities affect the number of infections?