

Effective Data Visualization for Scientific Researchers

4TU, Oisterwijk, June 26th, 2023

Irene van den Broek, PhD

 @IrenevdBroek

 @JeBentWatJeMeet

 @IreneVDB

Hi there, I'm Irene!

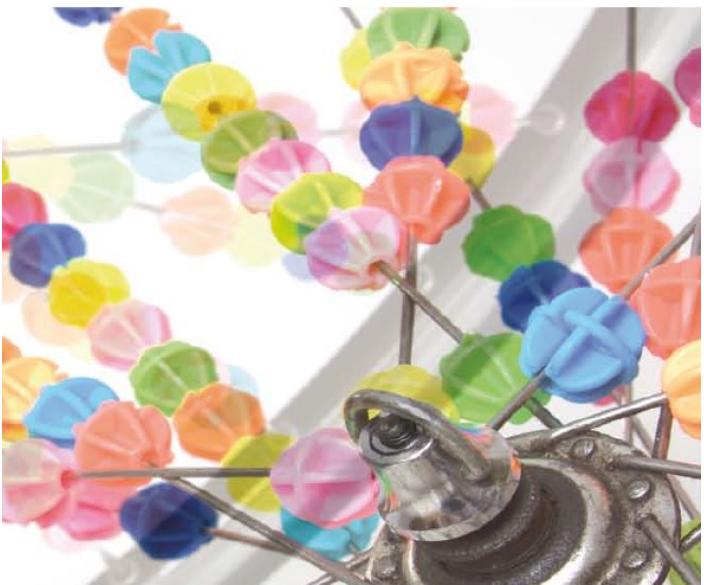


Irene van den Broek

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

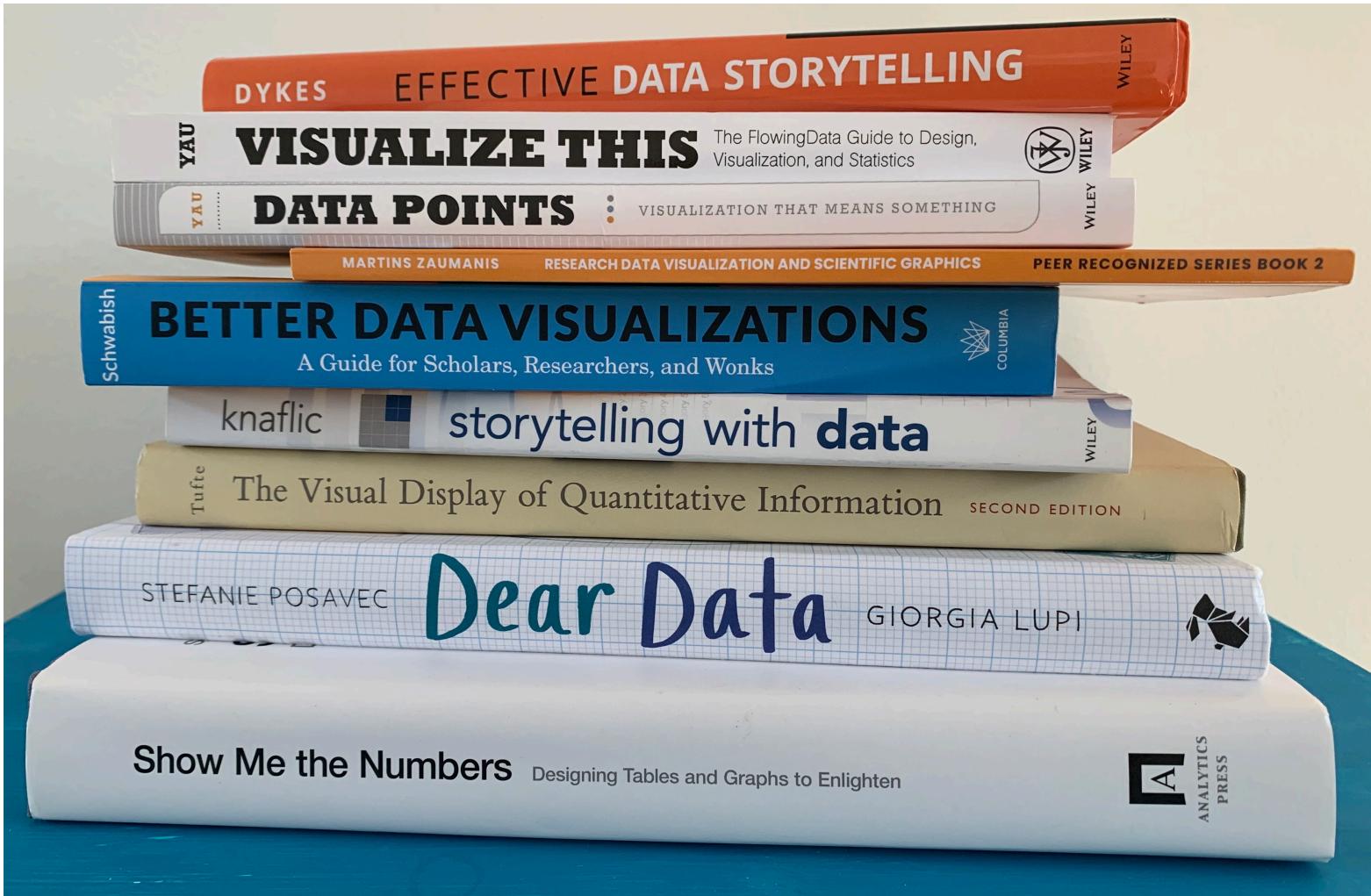


2013-2015
Leiden University
Medical Center



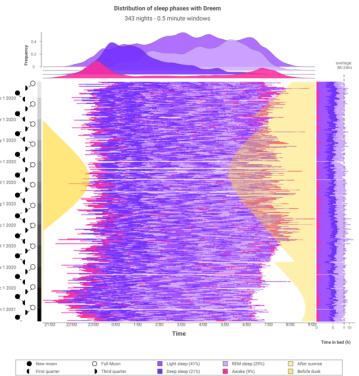
2015-2019
Cedars-Sinai
Medical Center

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

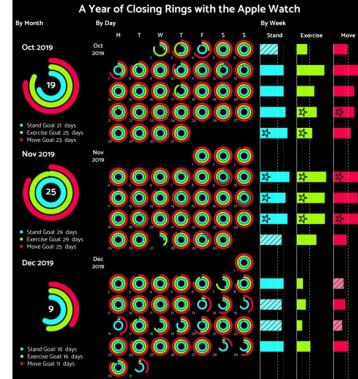


I started visualizing my Health and Habits.

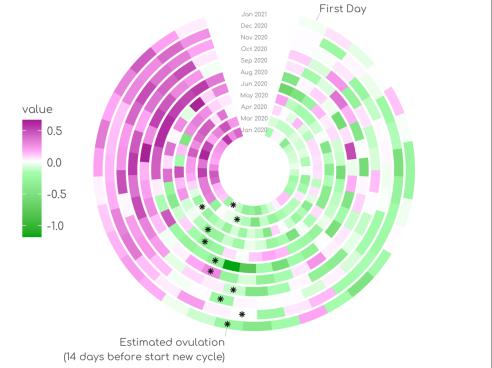
Sleep



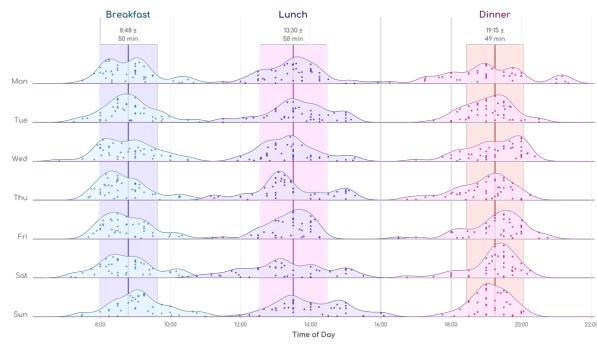
Activity



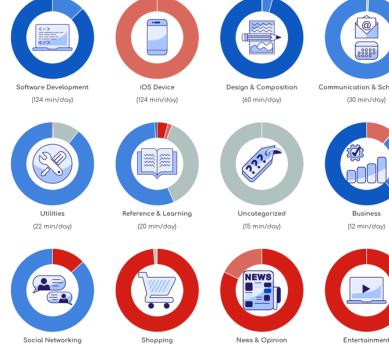
Body



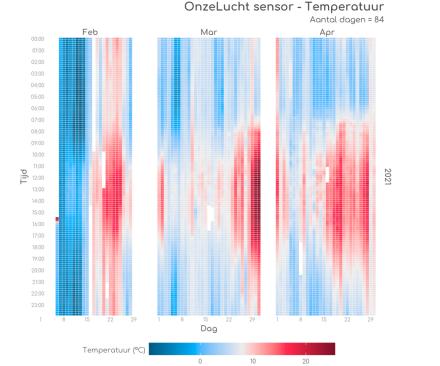
Food



Habits

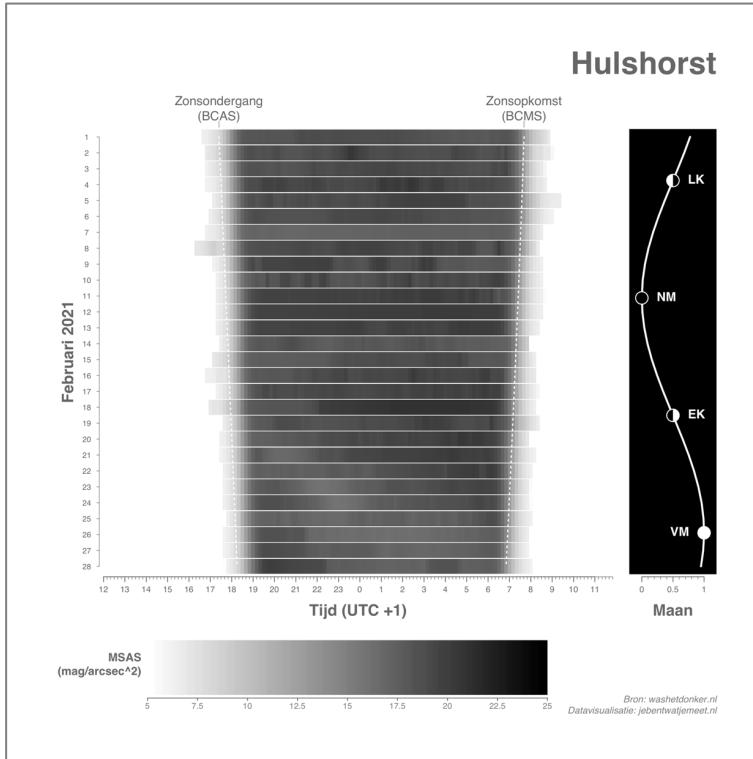


Environment



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

And now combine my passions for teaching and data visualization

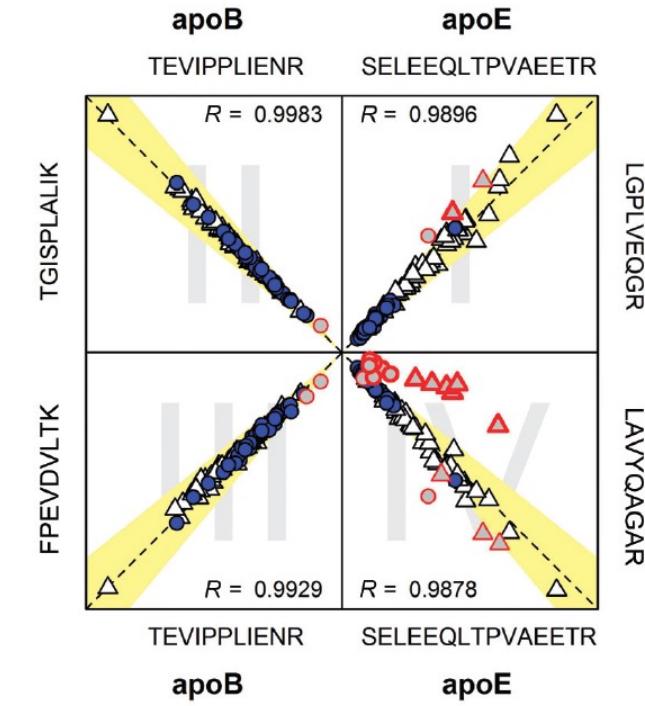
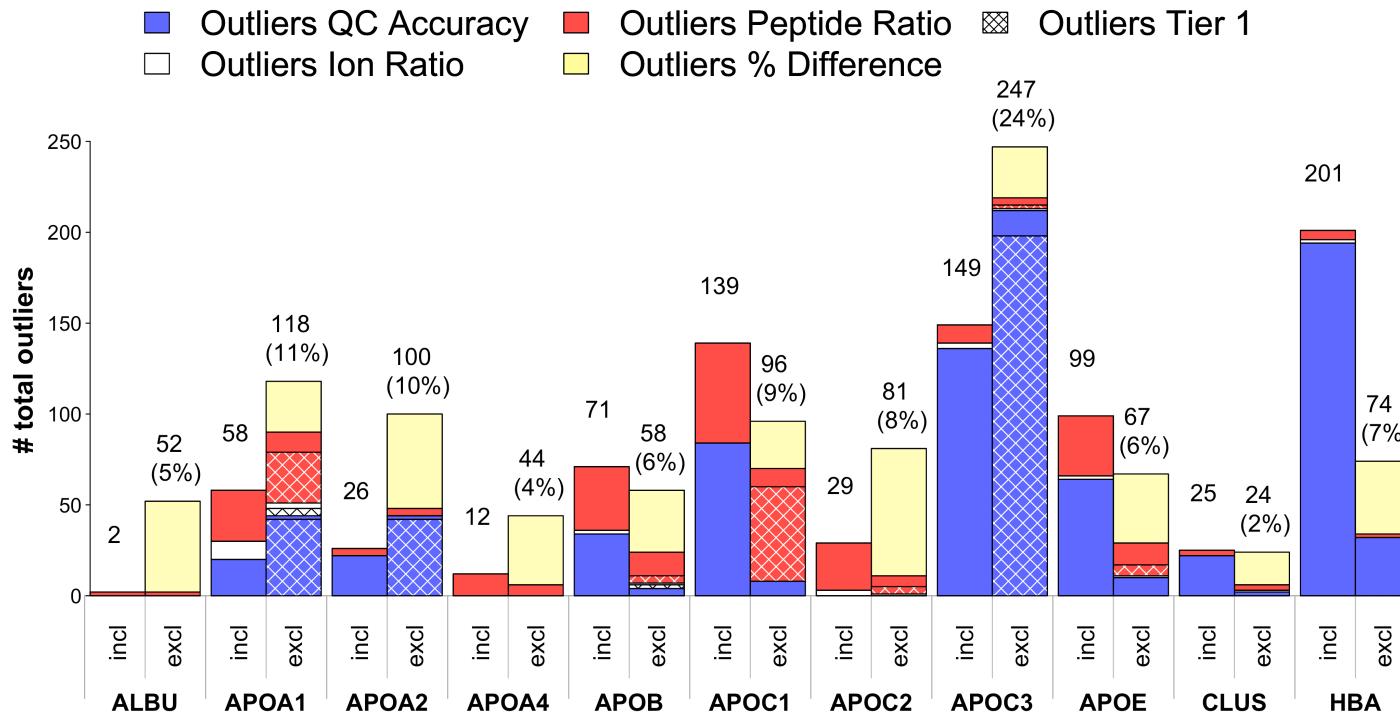


www.washetdonker.nl

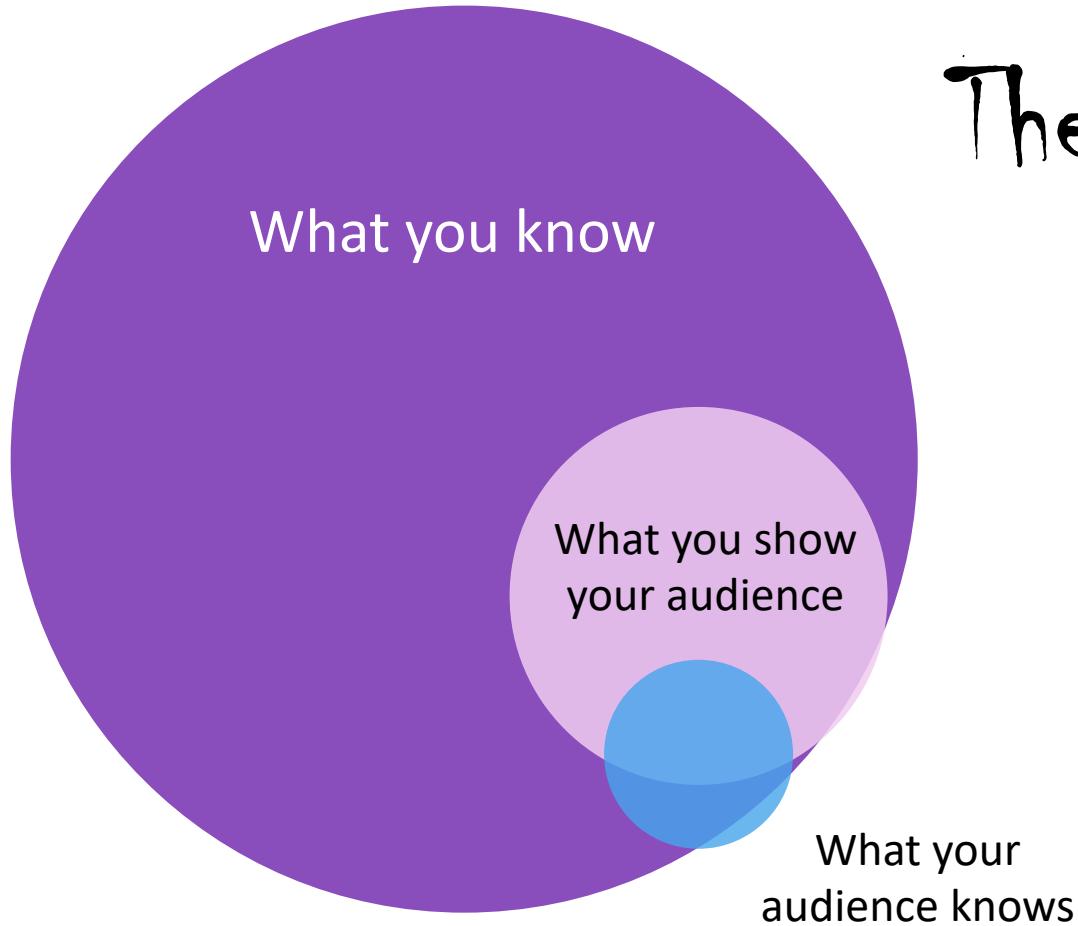


www.onzelucht.nl

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



Don't underestimate how smart you are!

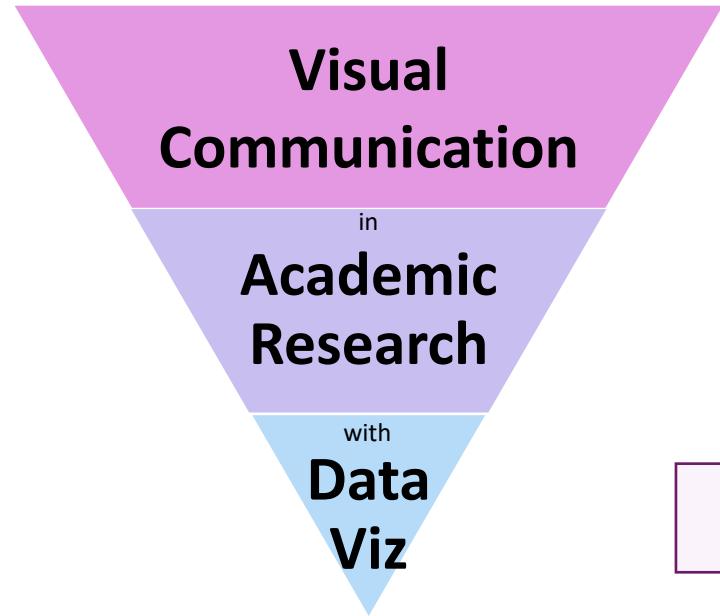


The curse of knowledge

Resist the urge to show *everything*!



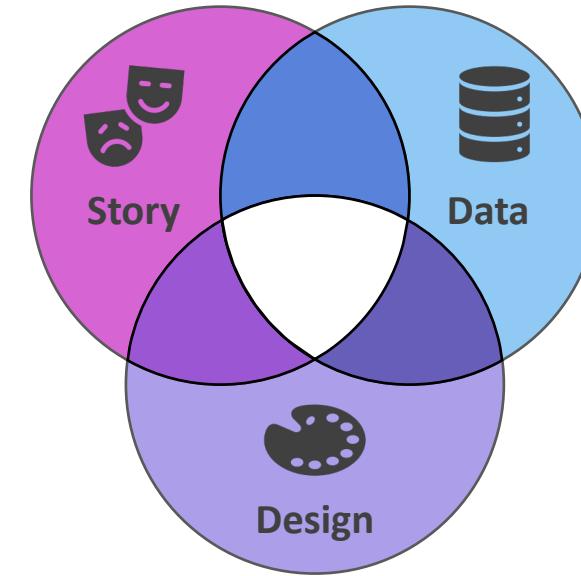
An overview for today:



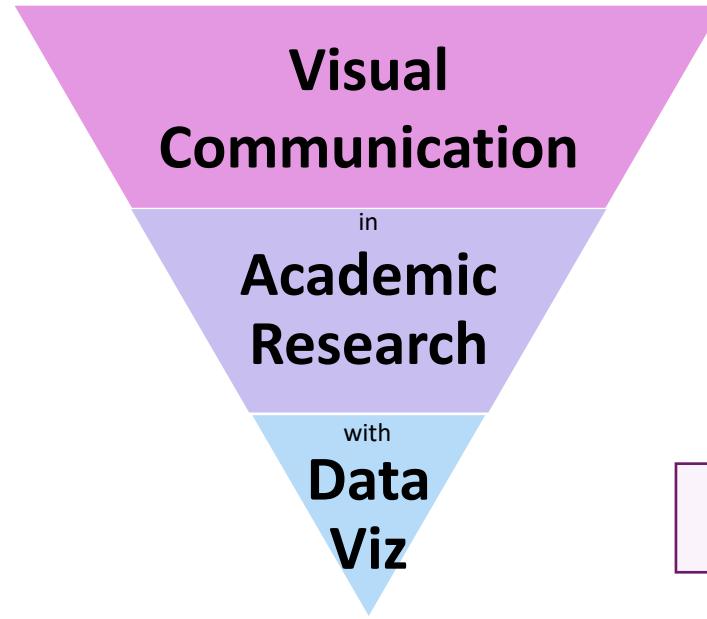
WHY?

WHAT?

HOW?



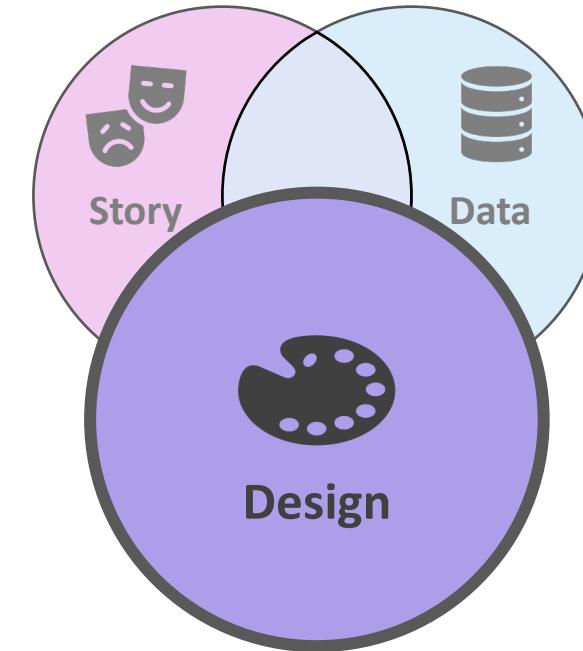
An overview for today:



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

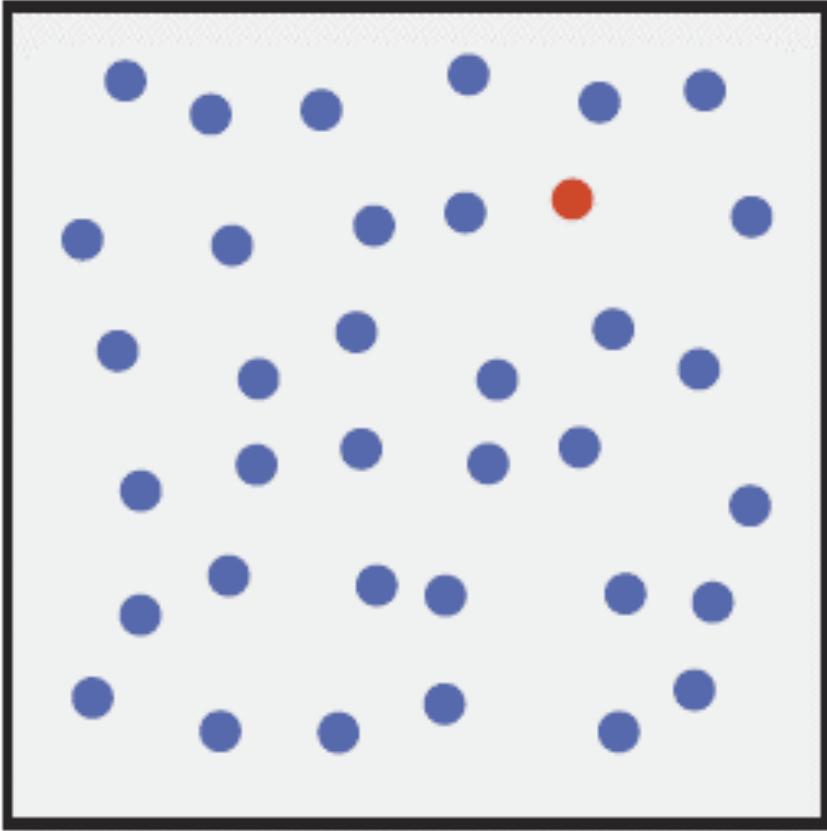
LEFT?

YES?

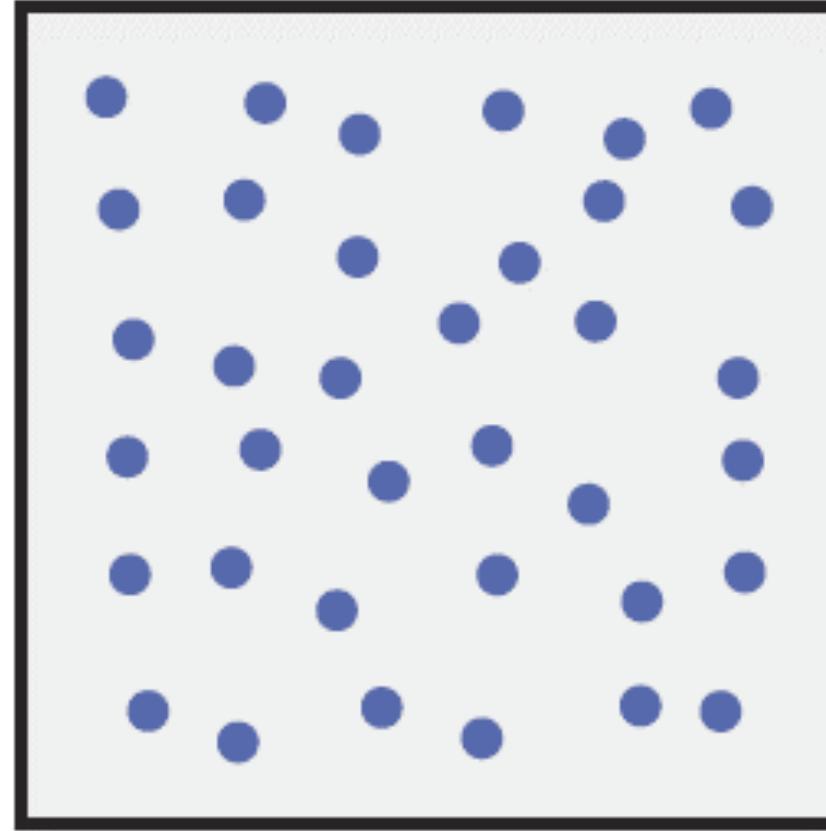


Which panel has a red dot?

A



B

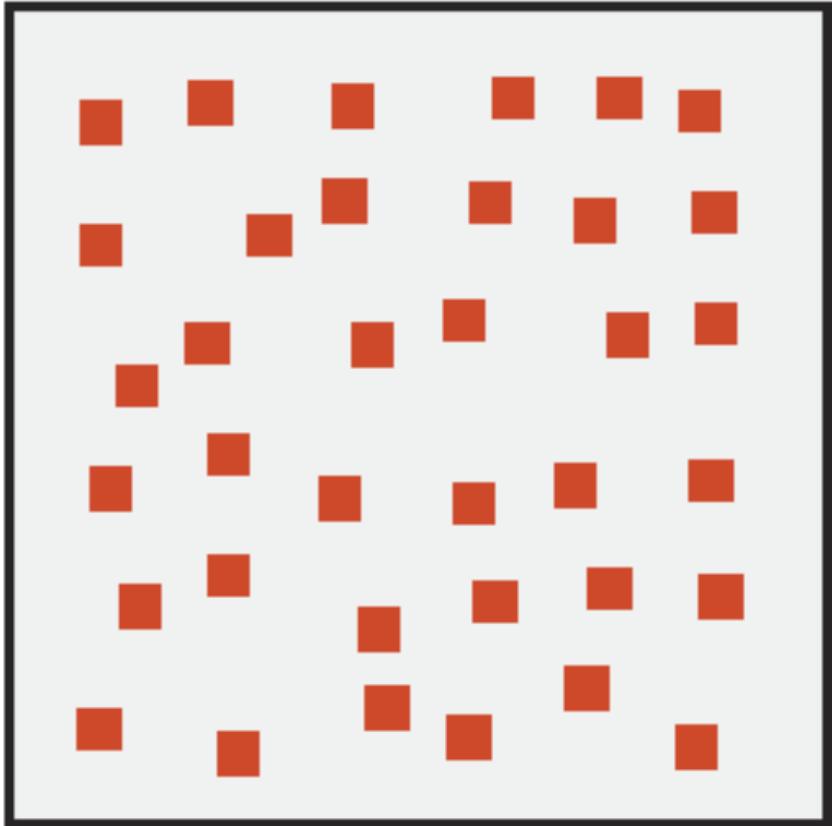


LEFT?

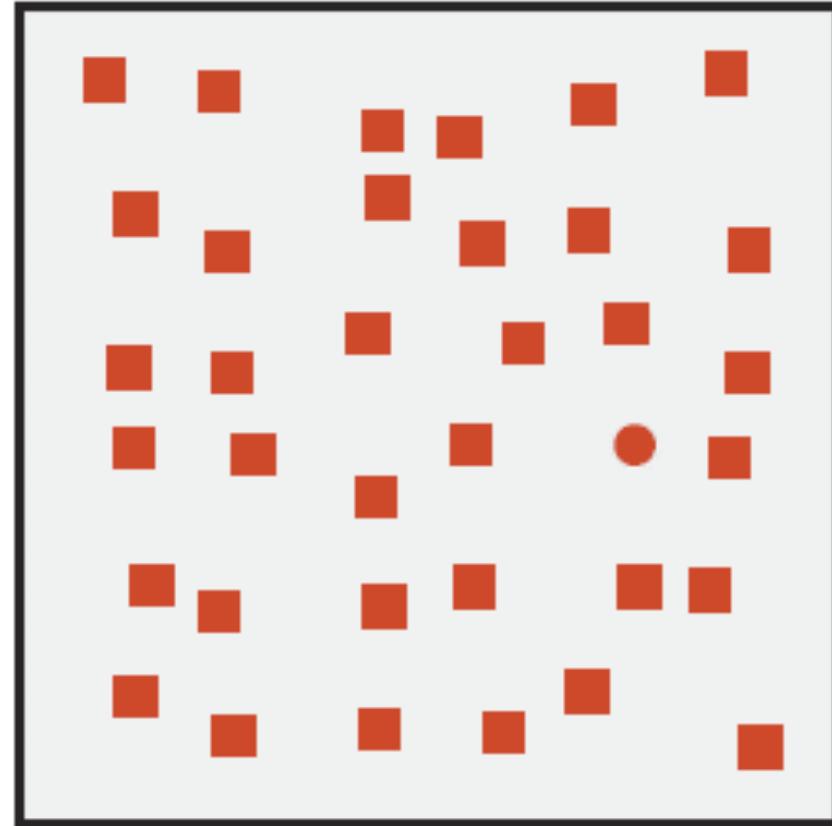
= UP!

Which panel has a red dot?

A



B



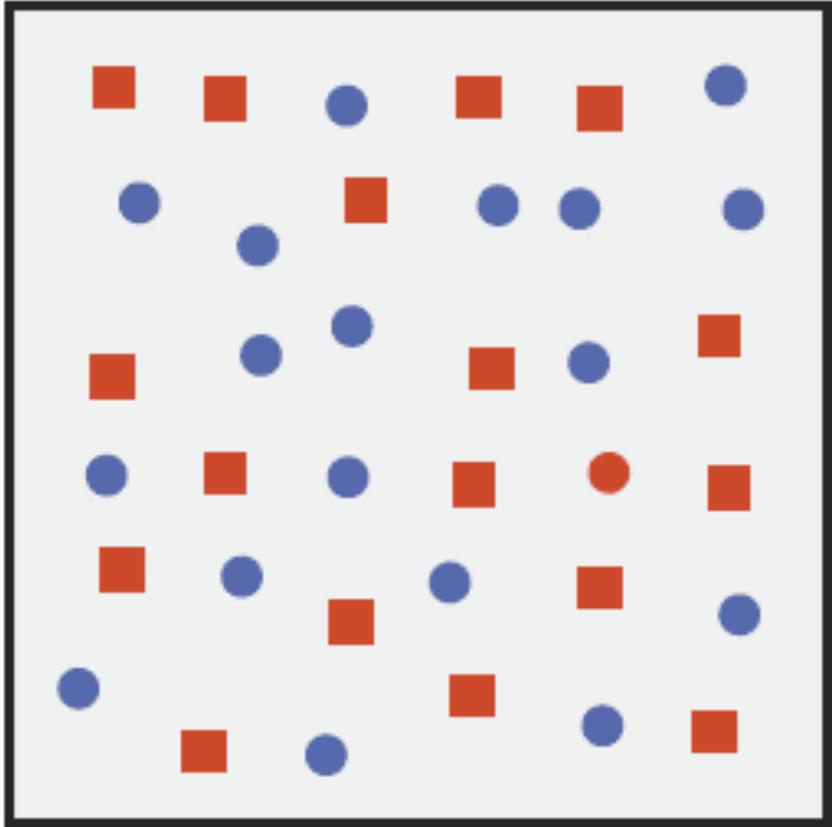
LEFT?

=

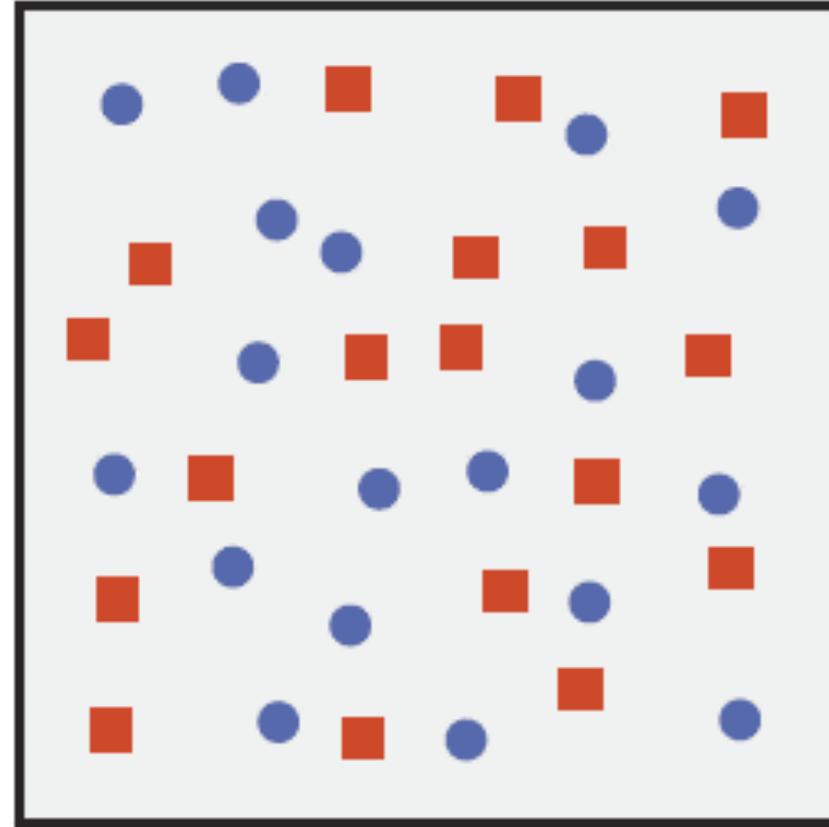
UP!

Which panel has a red dot?

A



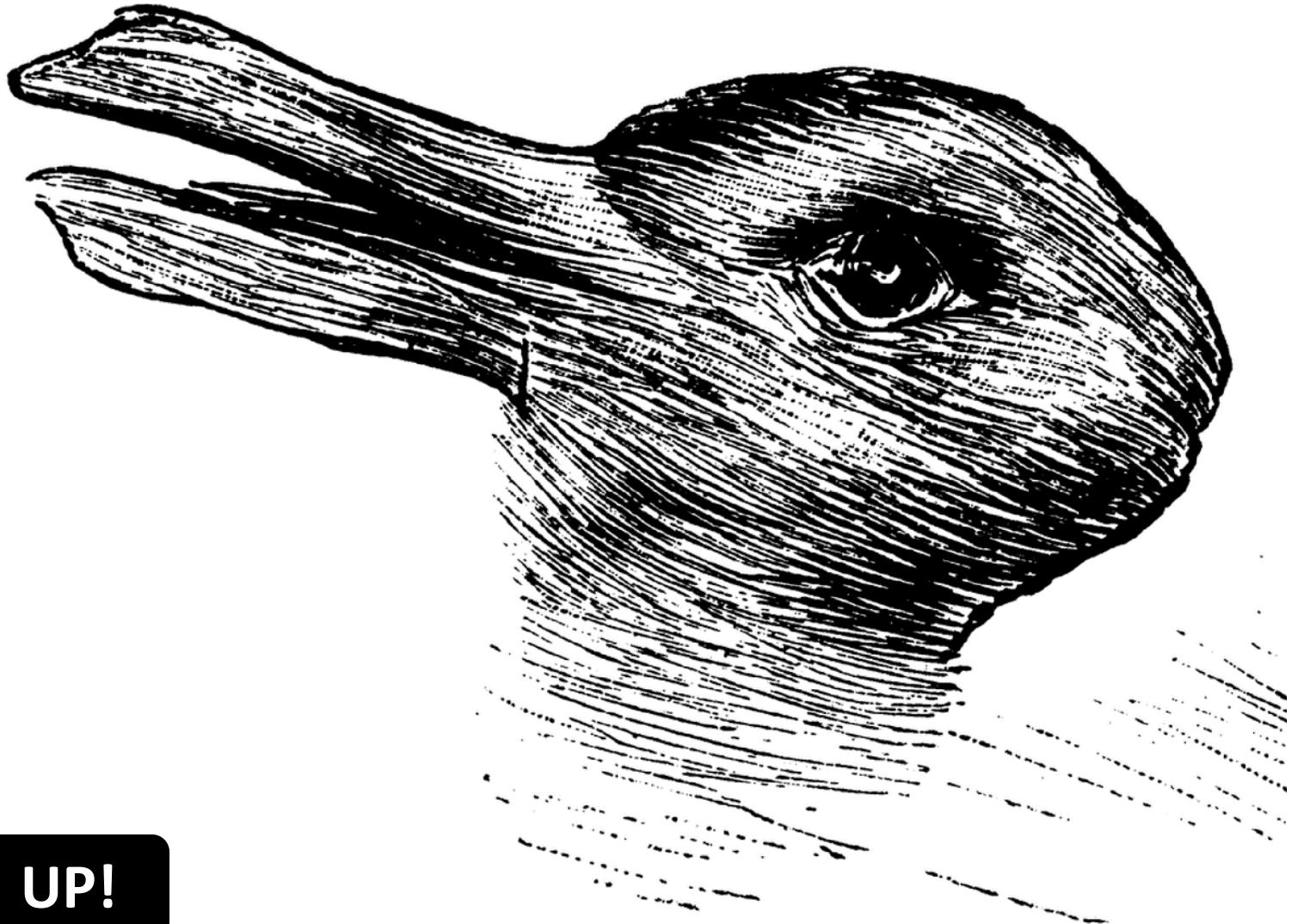
B



LEFT? =

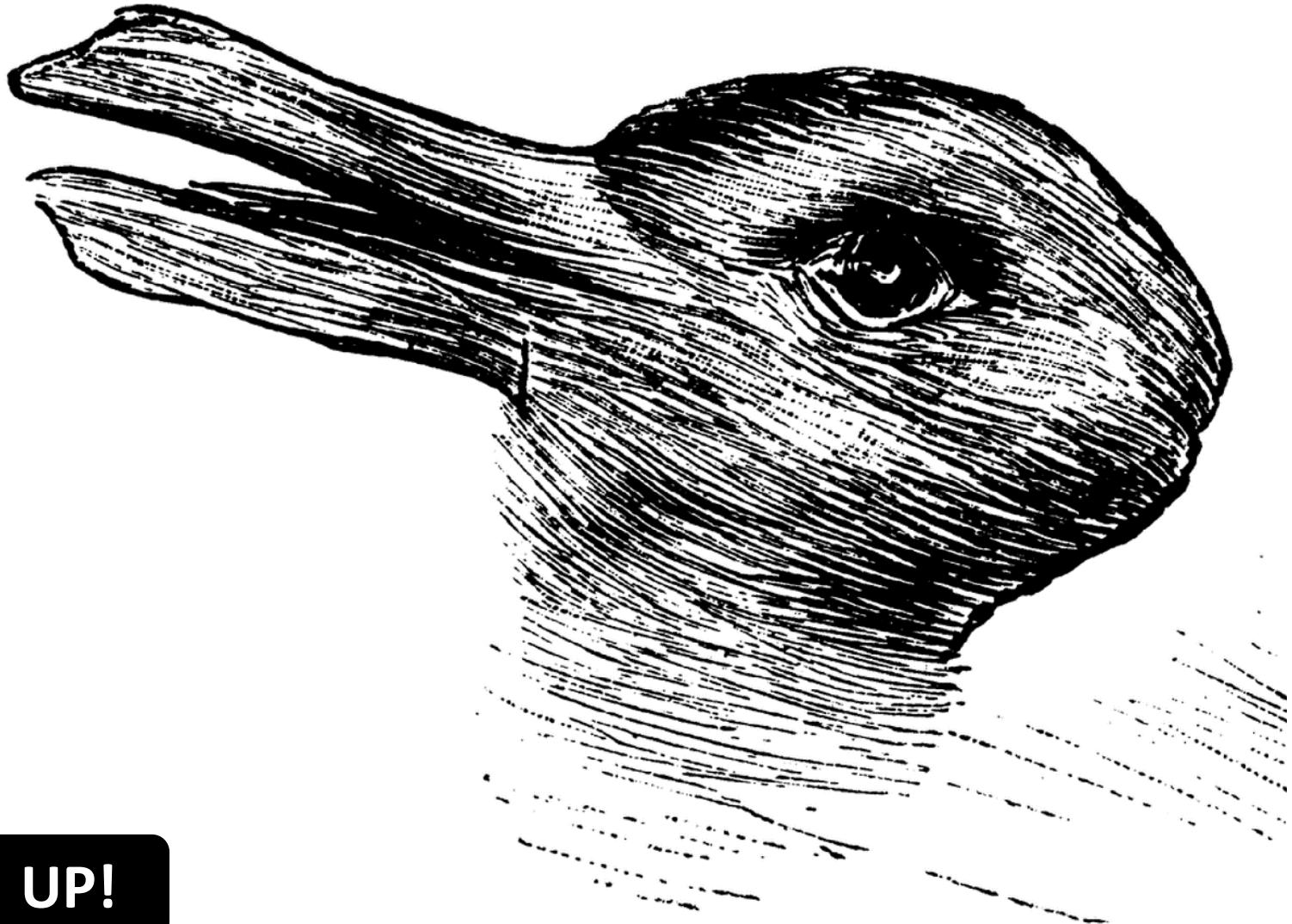
UP!

Do you see a Rabbit?



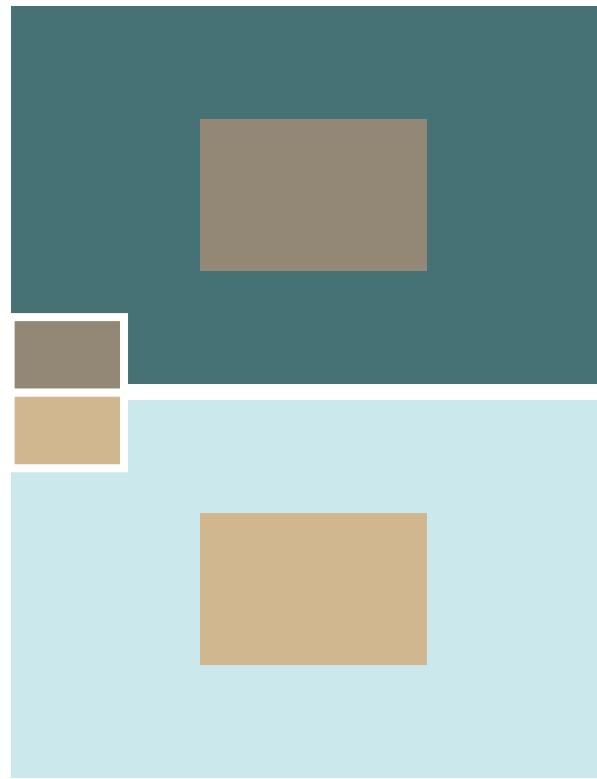
YES? = UP!

Do you see a Duck?



YES? = UP!

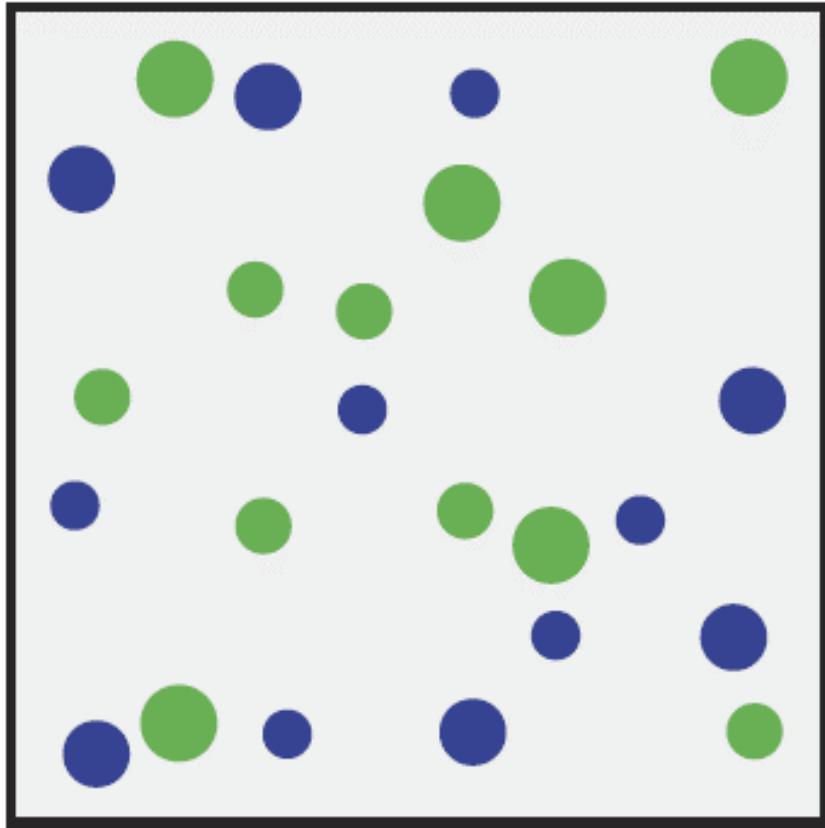
The inner squares have the same color



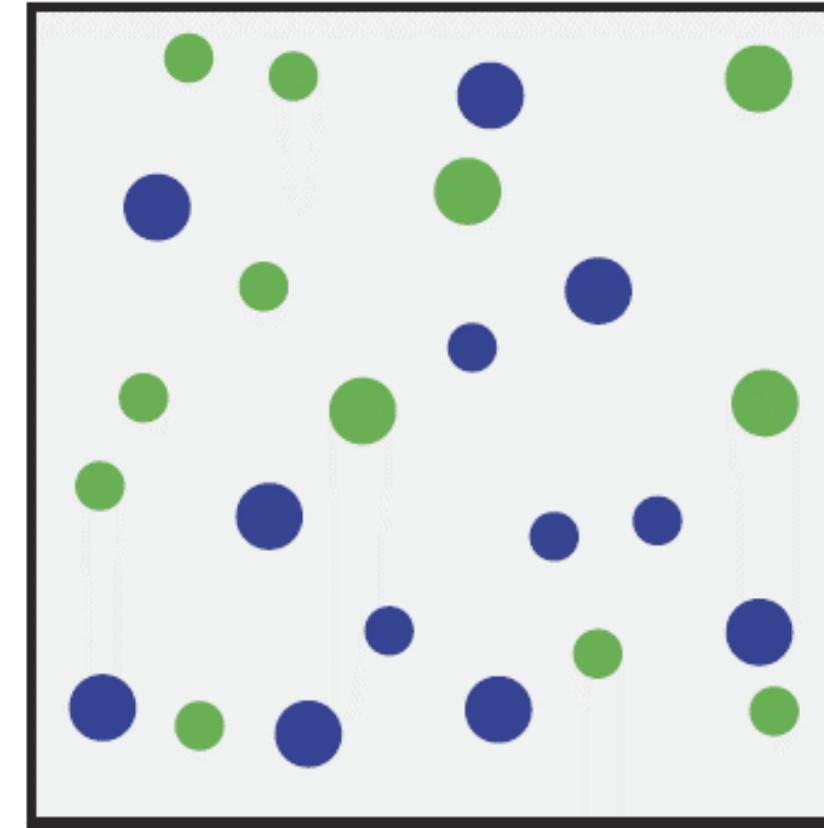
YES? = **UP!**

Which panel has the **biggest green** dots?

A



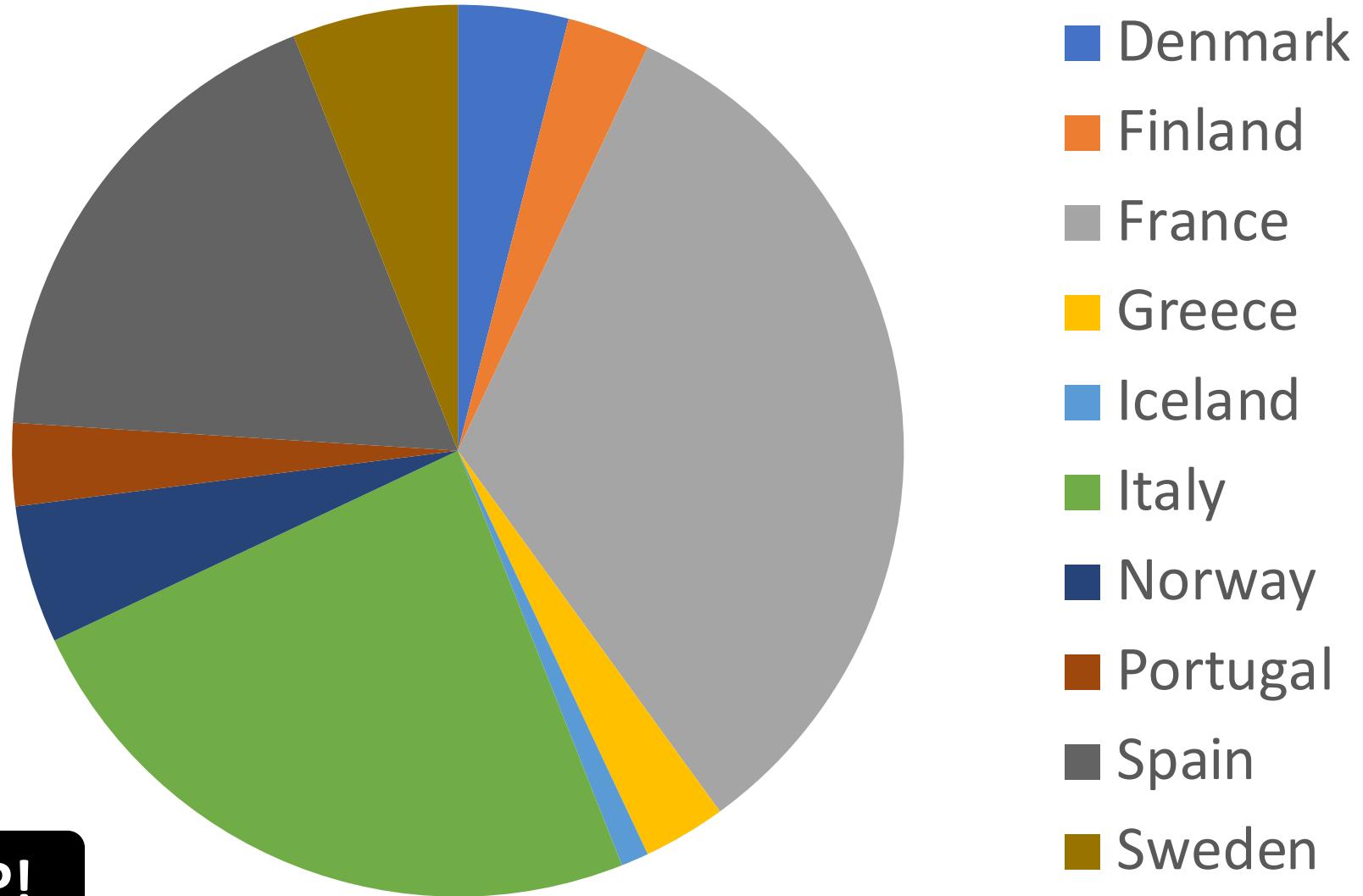
B



LEFT? =

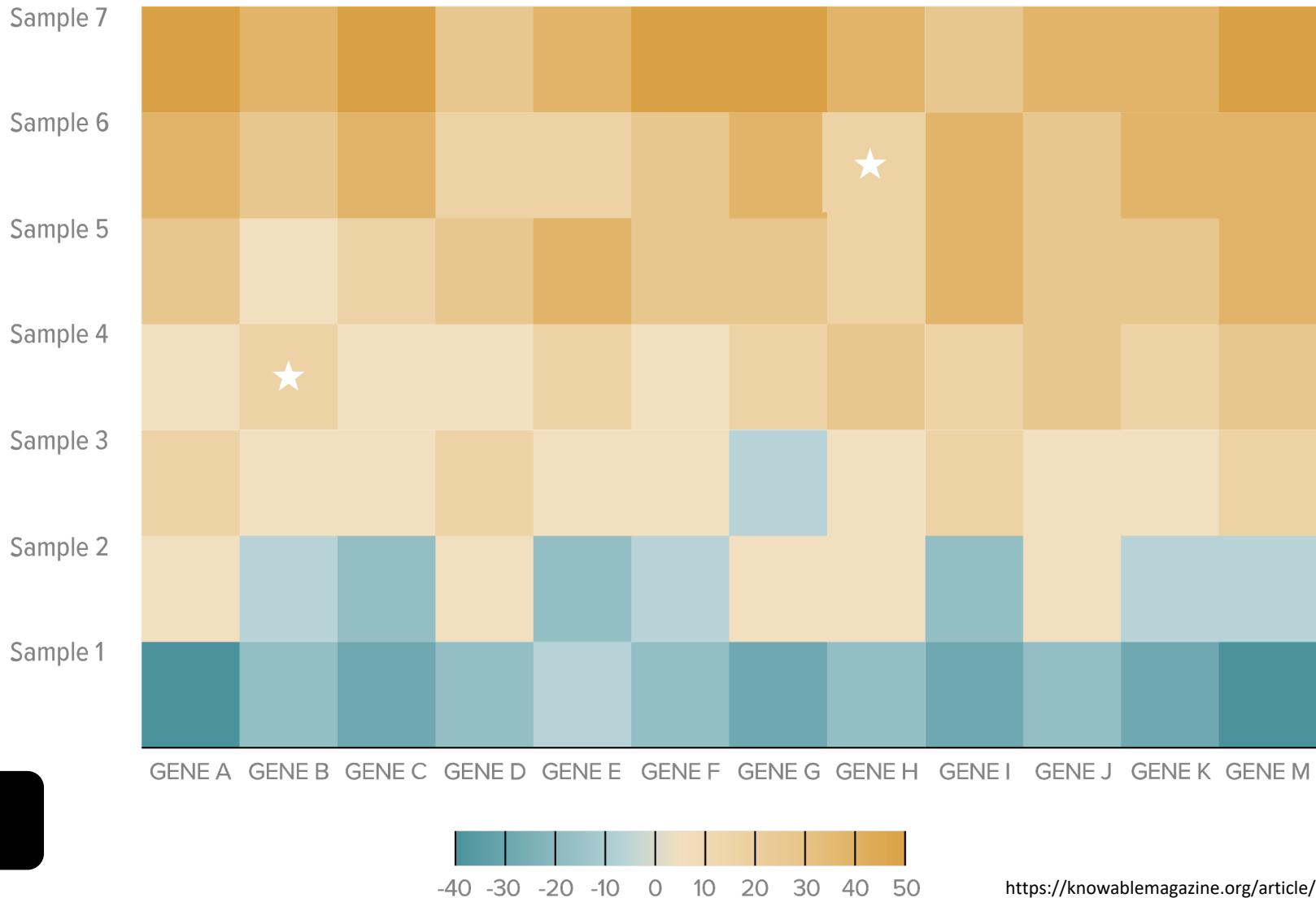
UP!

Norway has more widgets than Finland

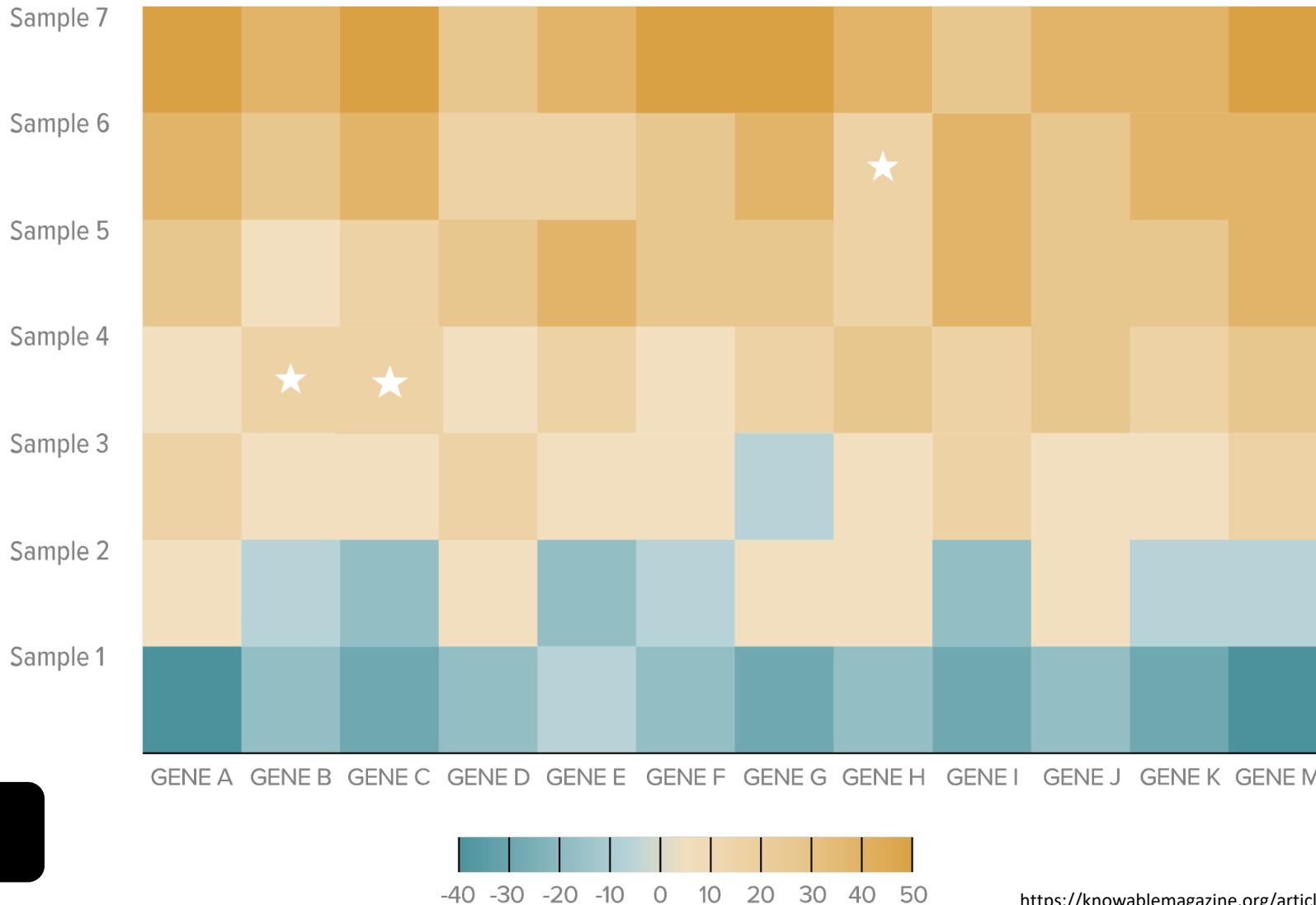


YES? = UP!

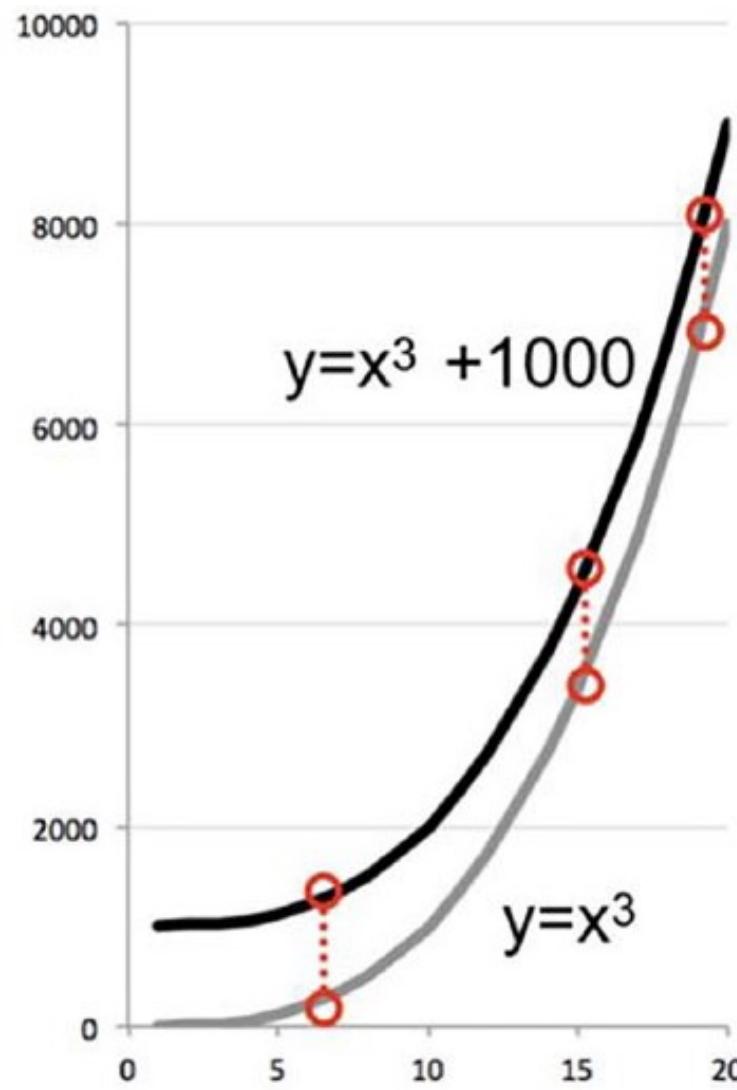
The areas with a star have the same color



The areas with a star have the same color

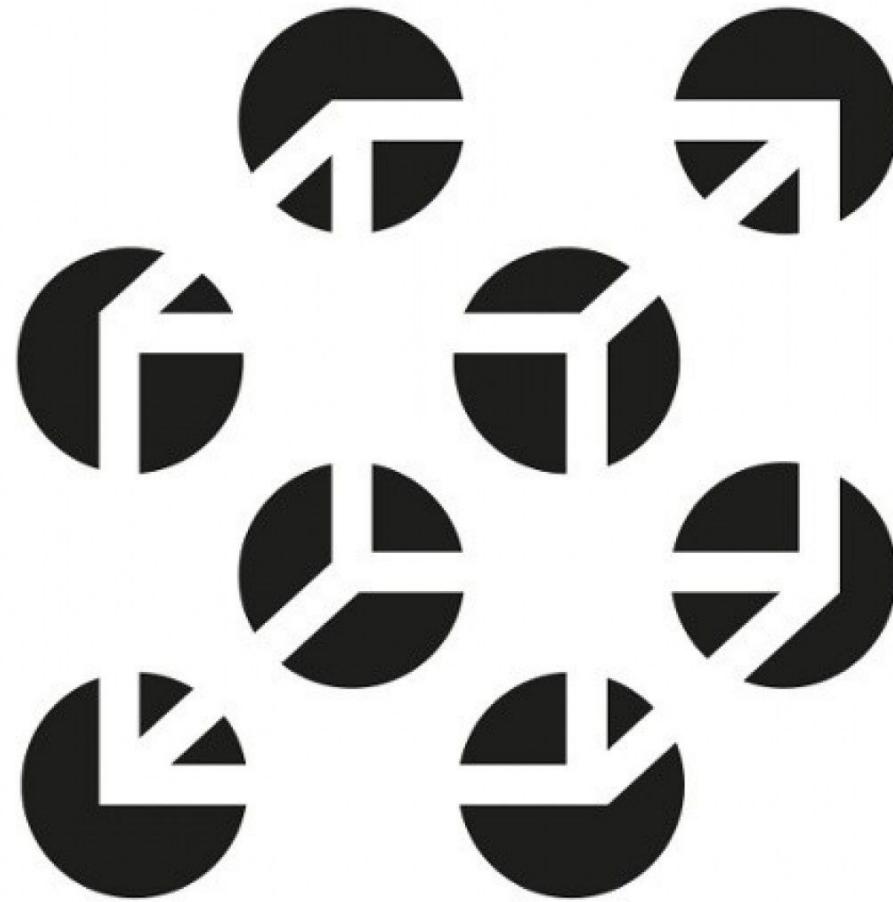


Where is the difference between the lines bigger? Left or right?



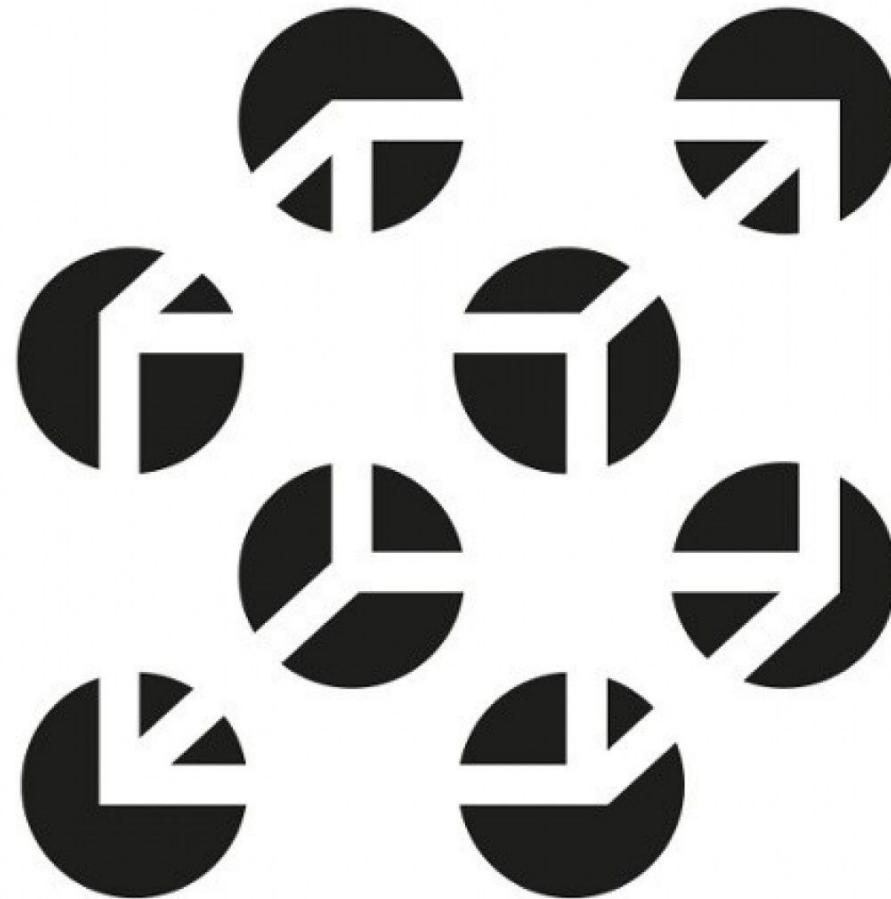
LEFT? = UP!

Do you *see* a cube?



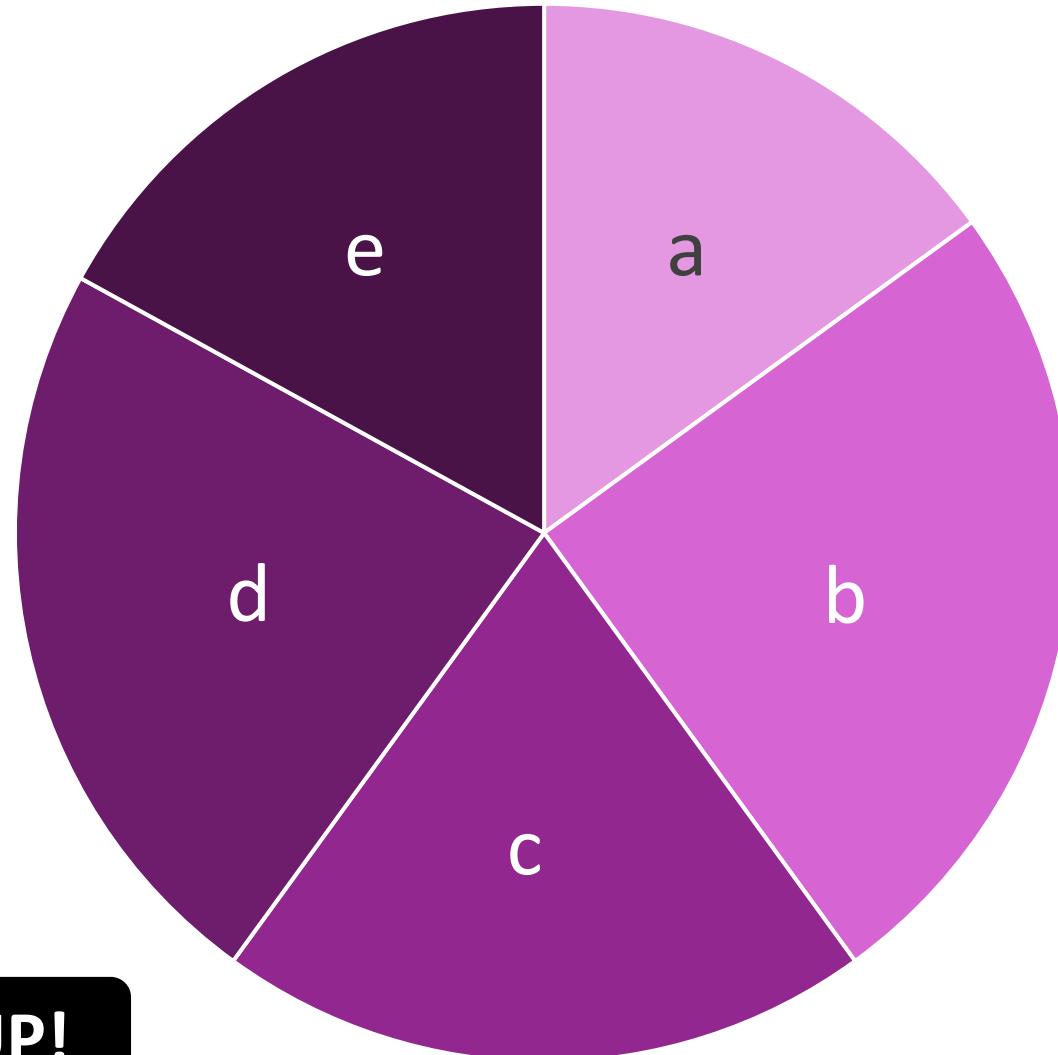
YES? = UP!

Is there a cube?



YES? = UP!

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



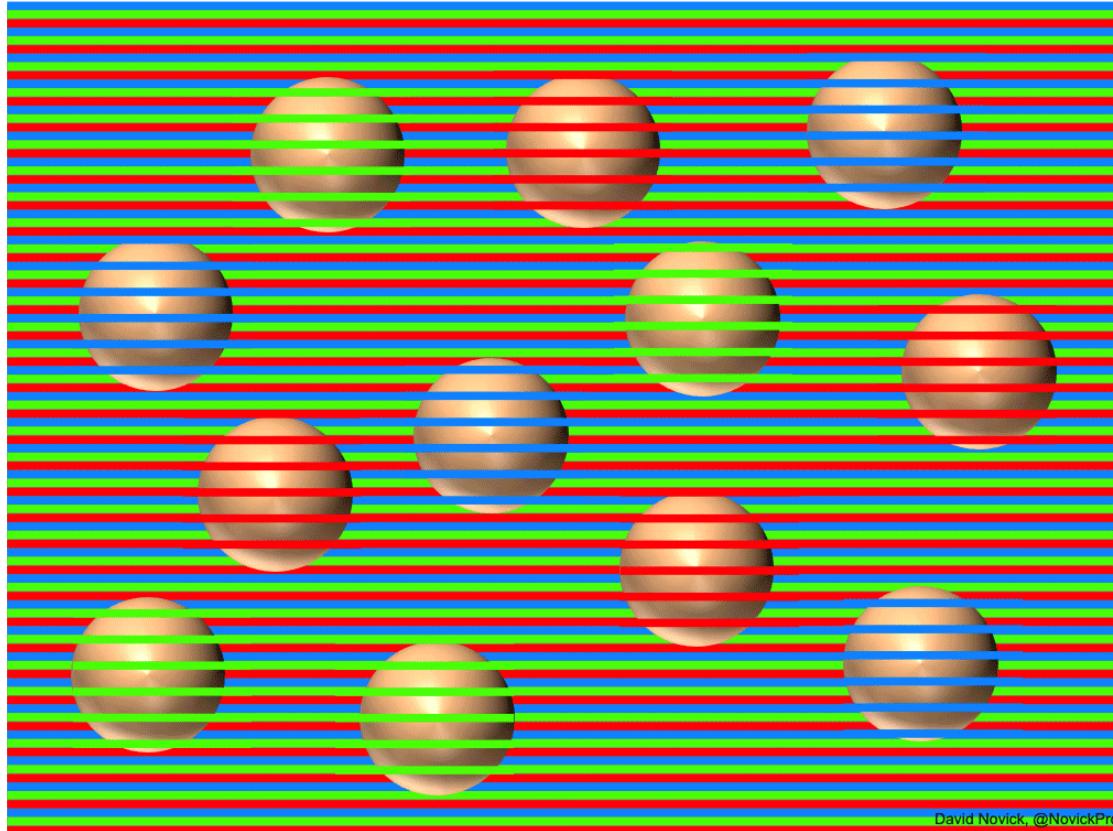
YES? = UP!

These spheres have the same color



YES? = UP!

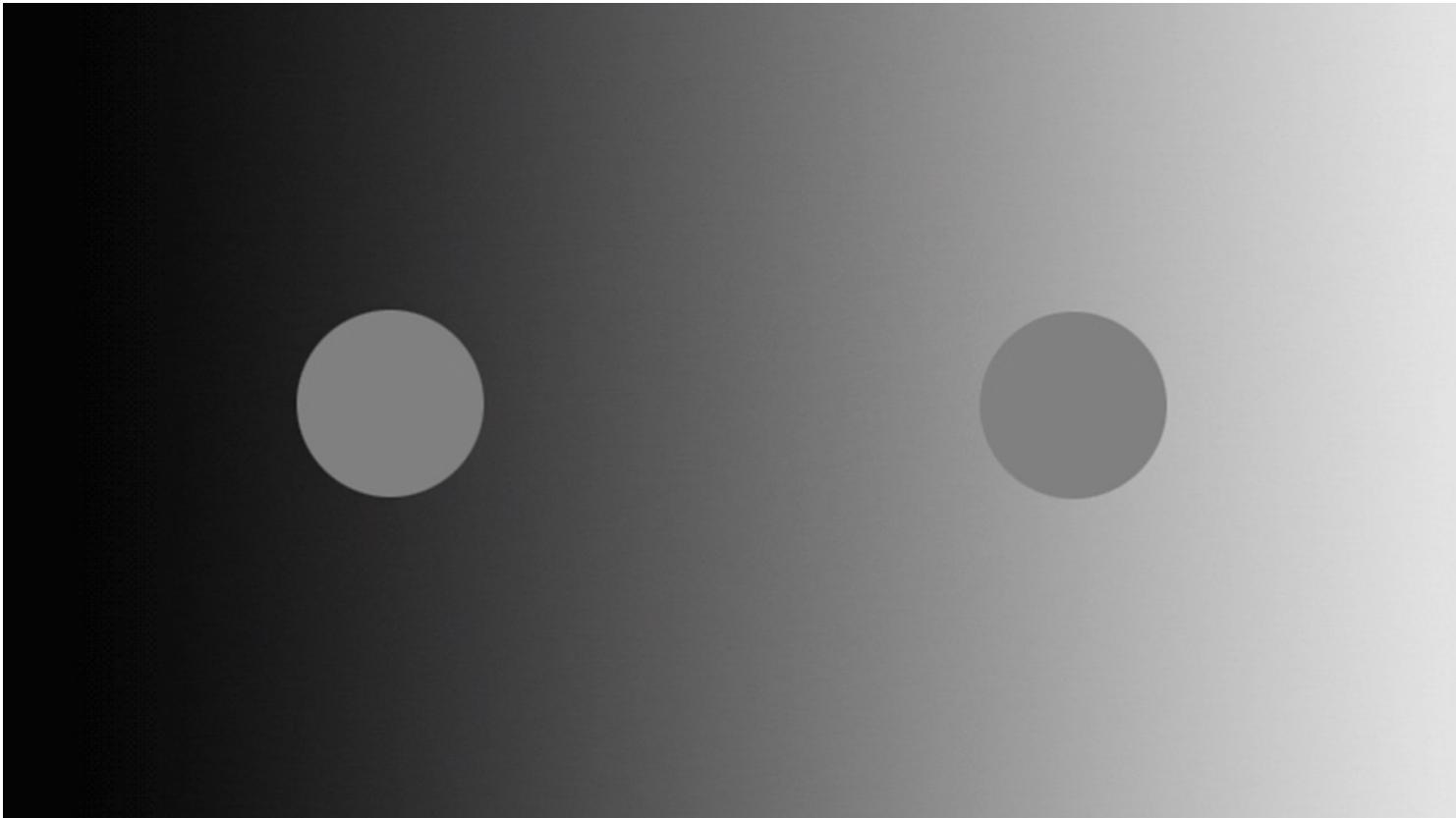
These spheres have the same color



David Novick, @NovickProf

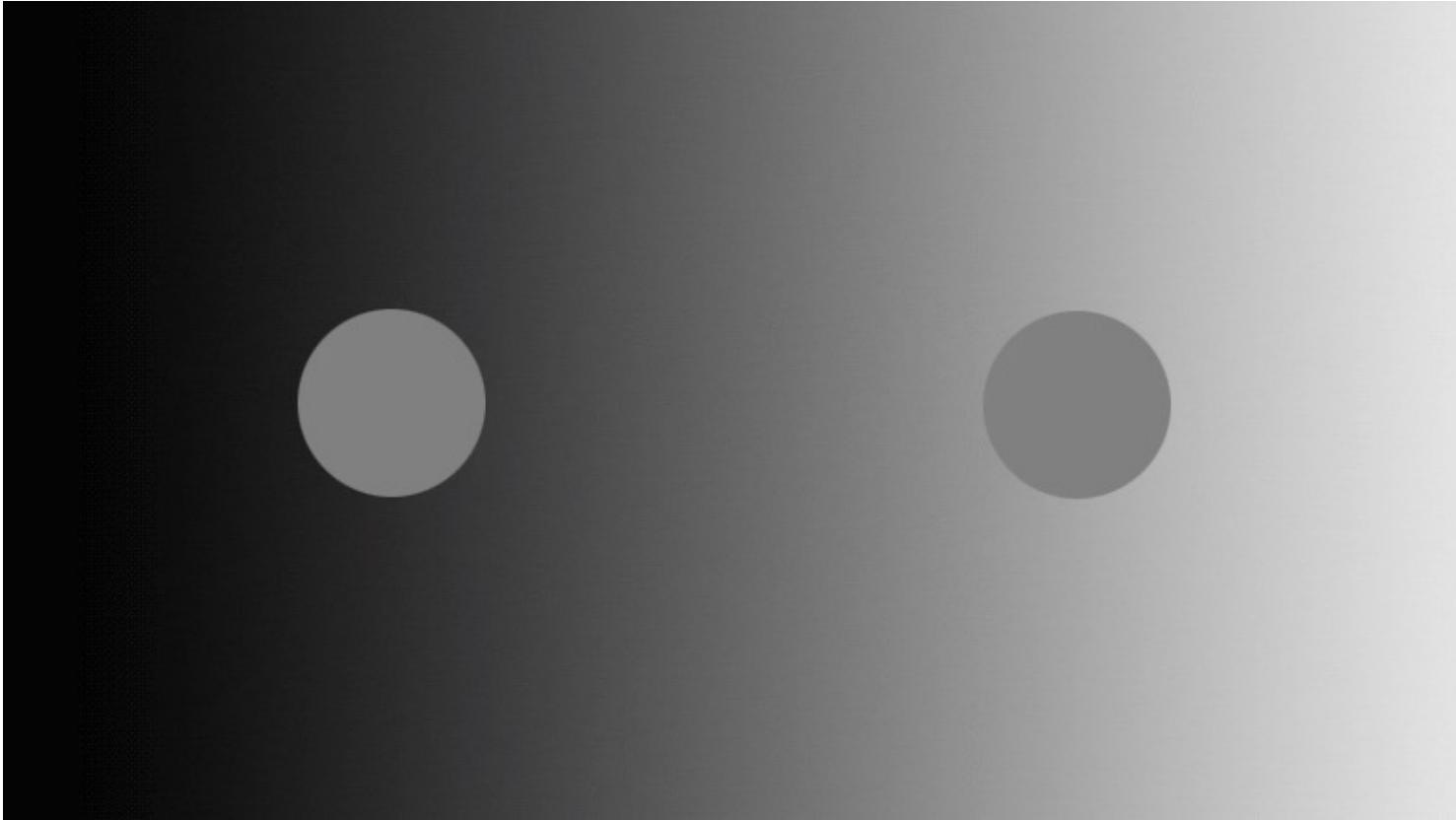
YES? = UP!

Which dot is darker?



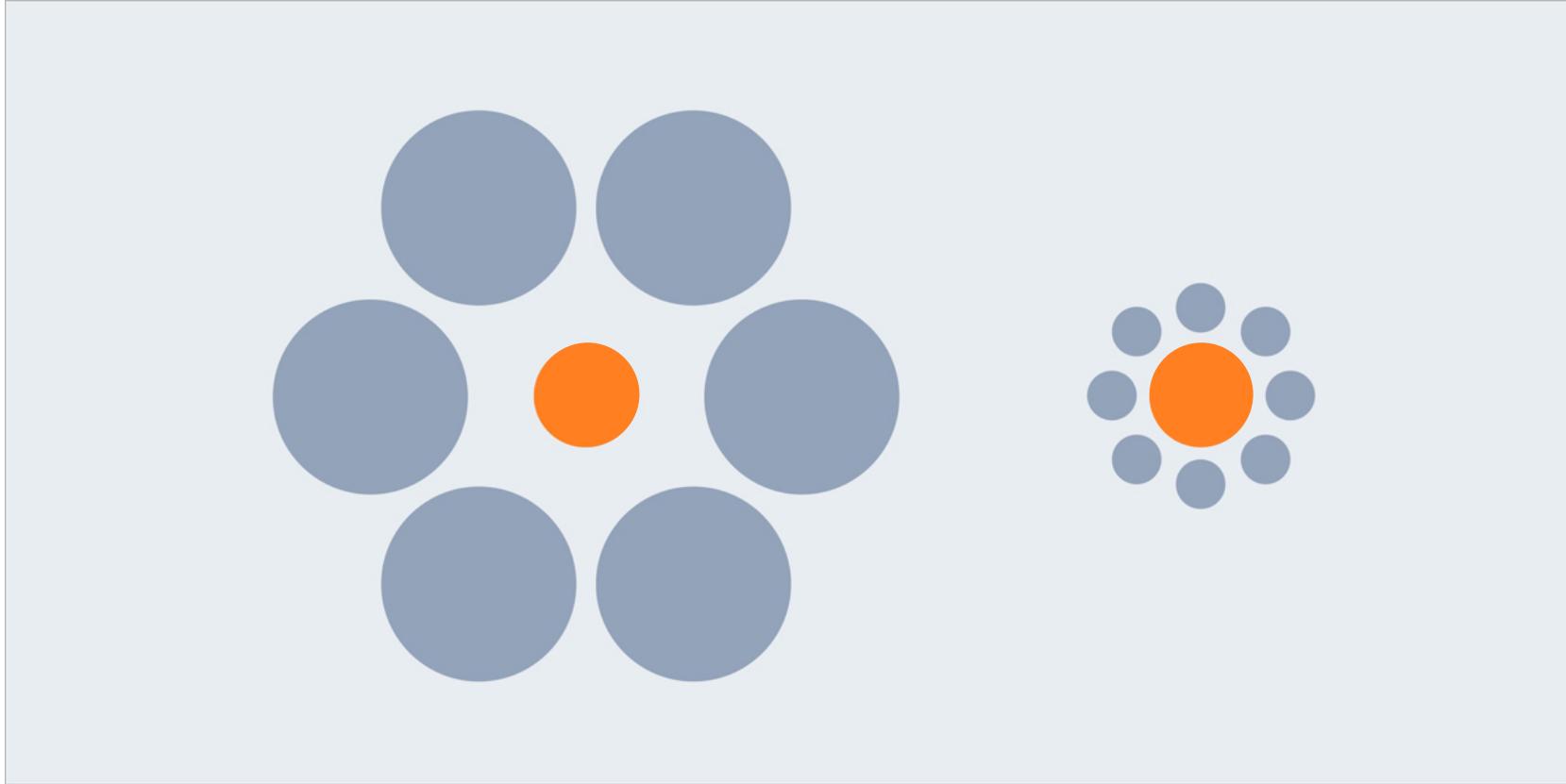
LEFT? = UP!

Are you sure...?



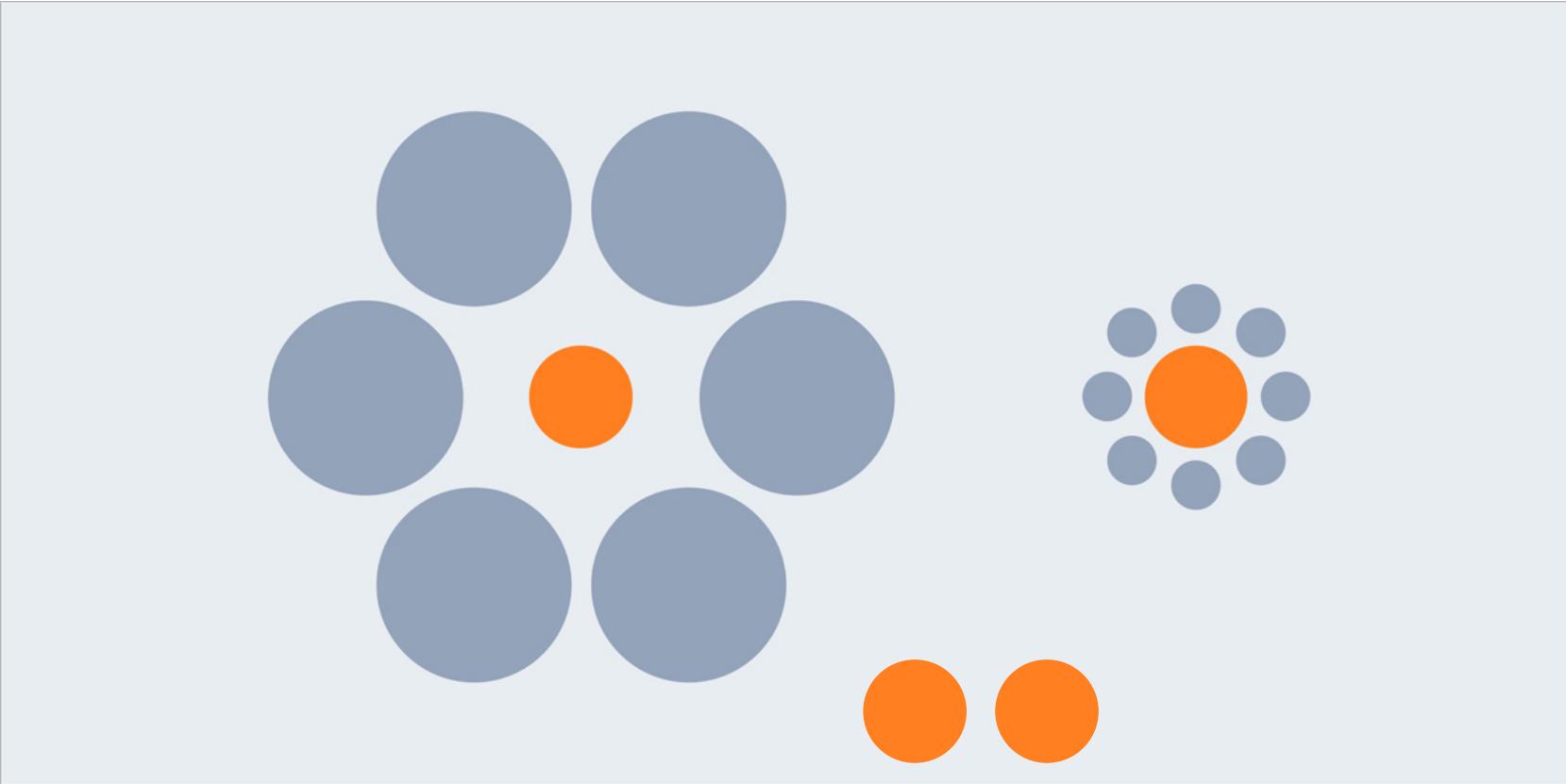
LEFT? = UP!

Which orange circle is smaller?

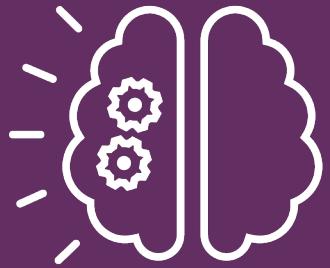


LEFT? = UP!

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?

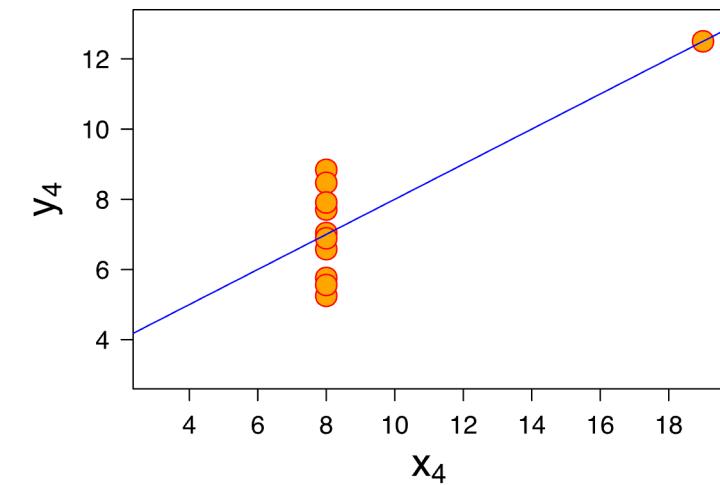
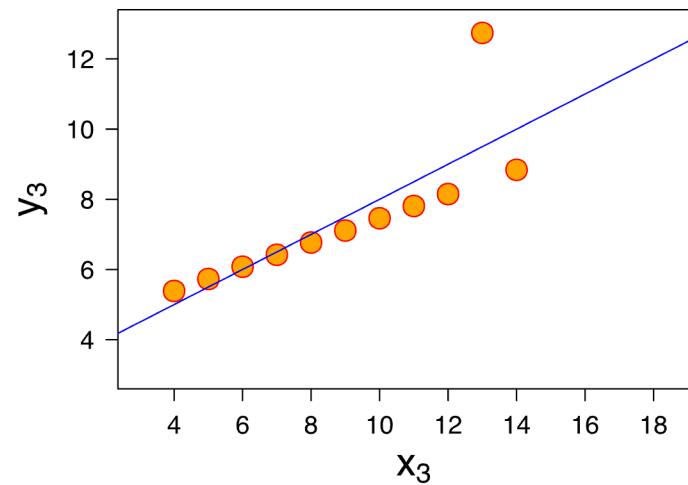
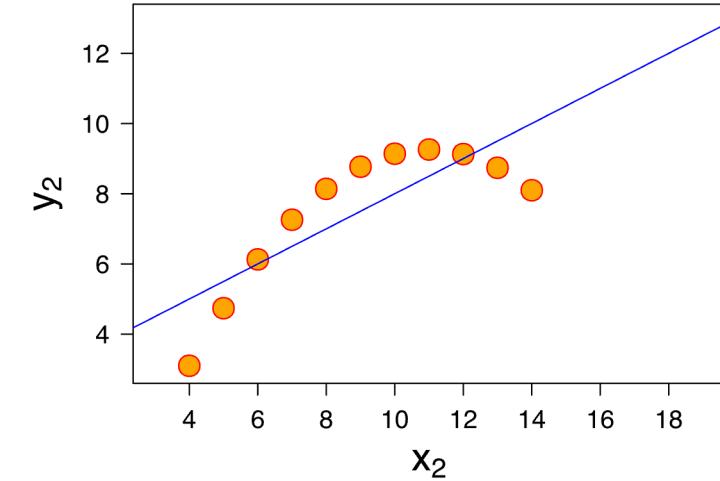
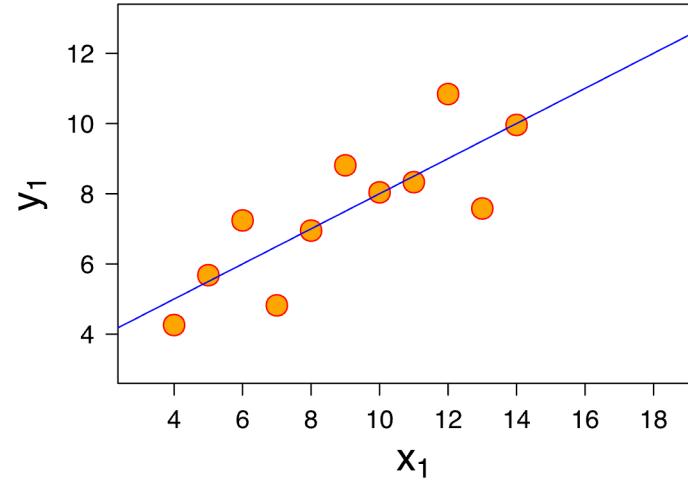
Anscombe's quartet:
4 datasets
11 x-values
11 y-values
Same total
Same mean
Same standard deviation

	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

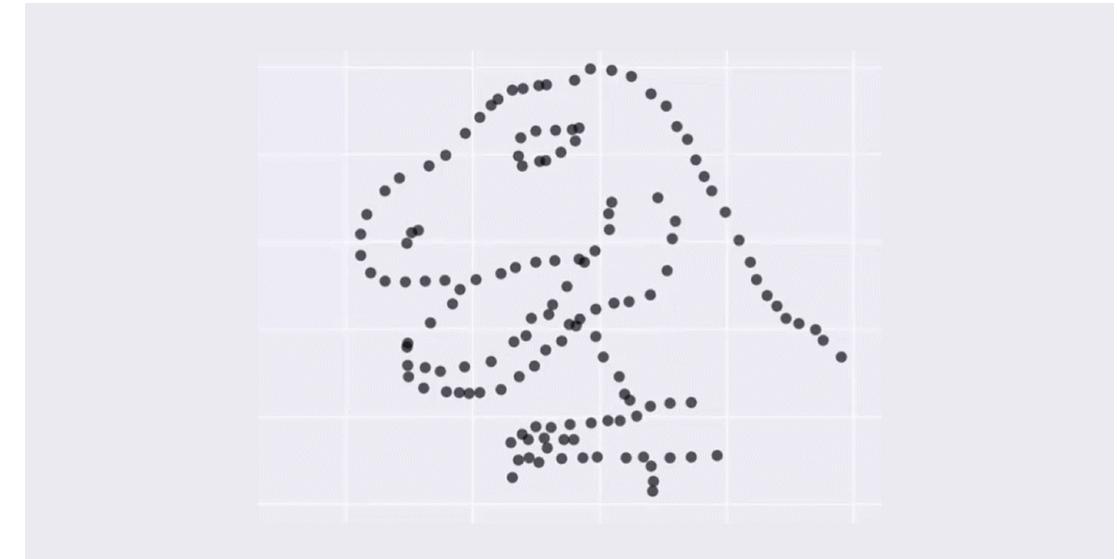
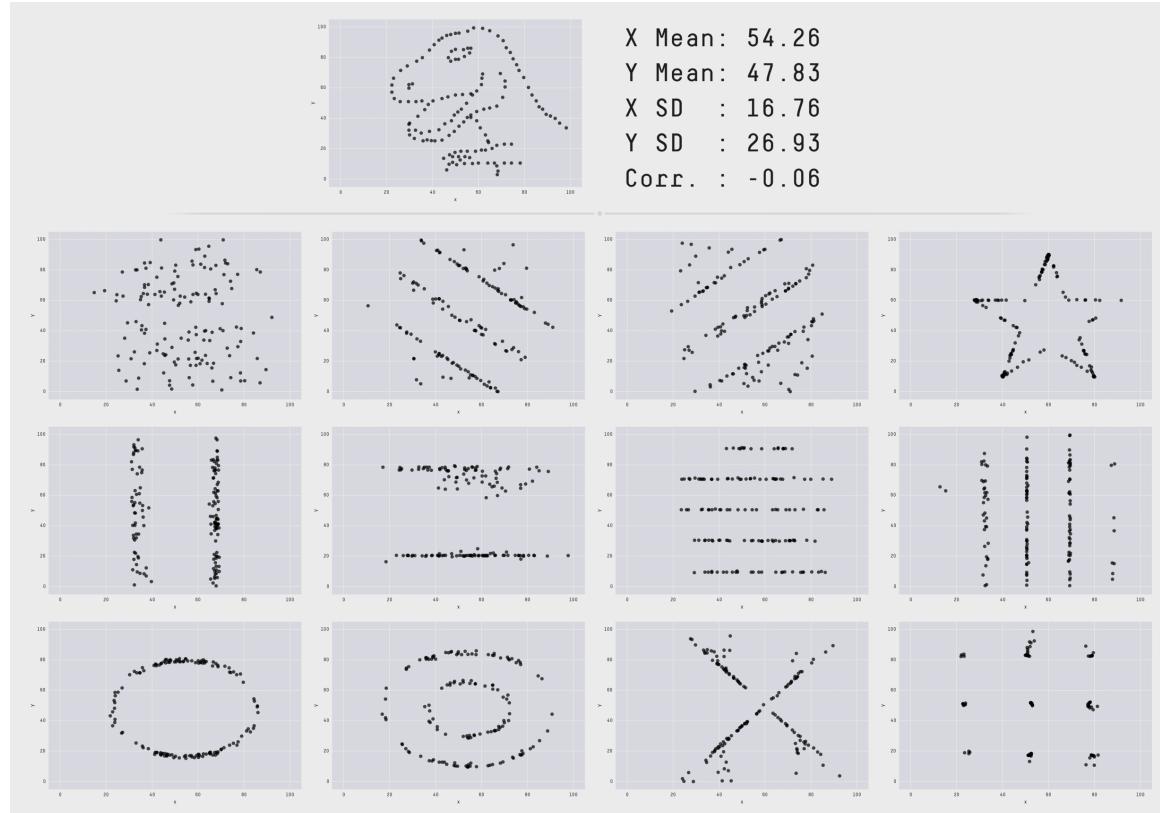
A picture is worth a thousand words!

Anscombe's quartet:

4 datasets
11 x-values
11 y-values
Same total
Same mean
Same standard deviation

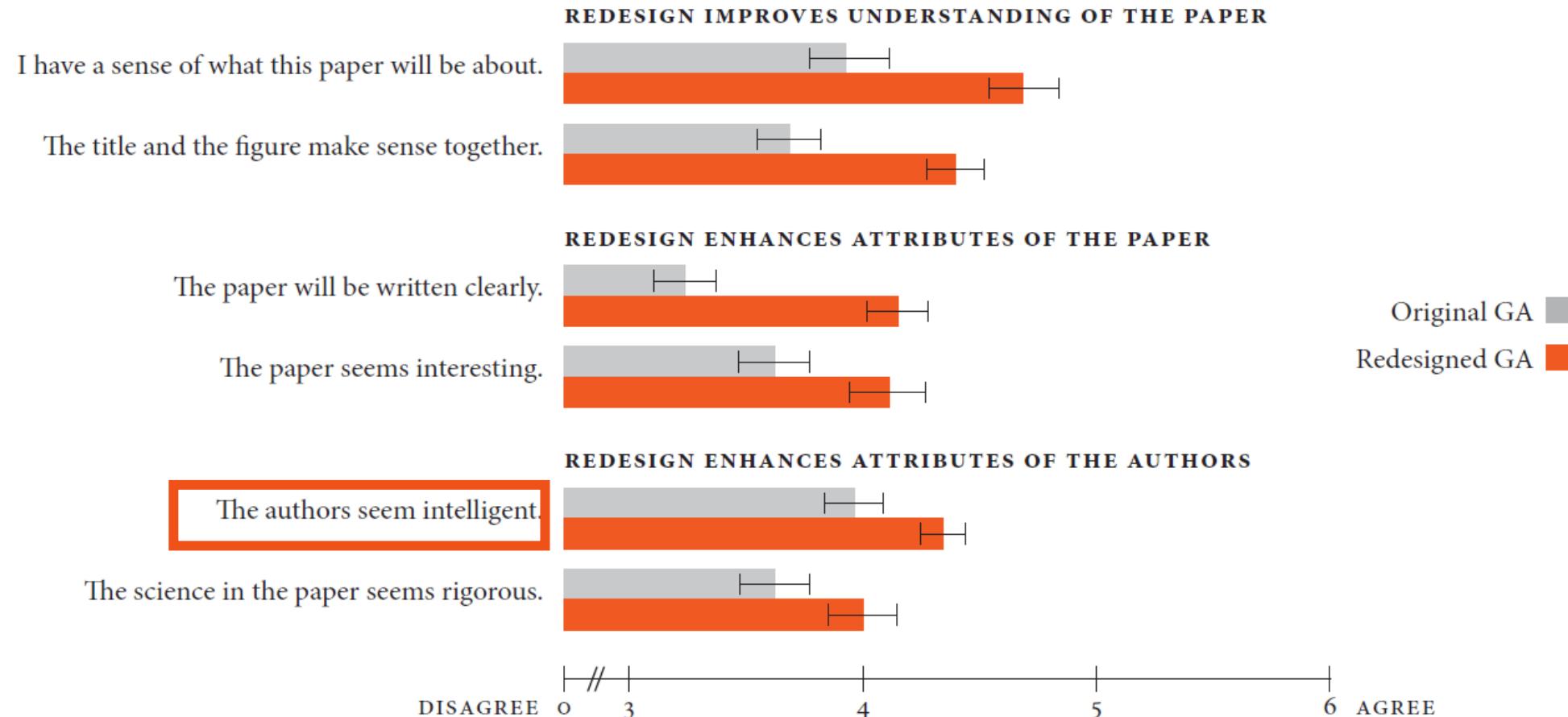


The Datasaurus Dozen 😊: Never trust summary statistics alone!



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!



Why use visuals in academic research?



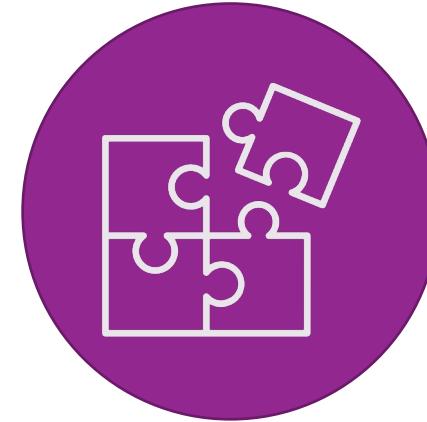
Provide **insight**

-
- Publications
 - Oral presentations
 - Poster presentations



Grab **attention**

-
- Graphical abstracts
 - Social media
 - General media



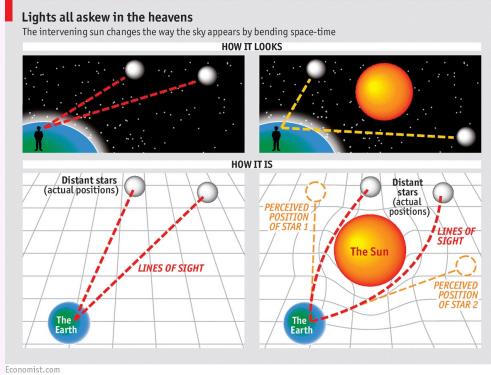
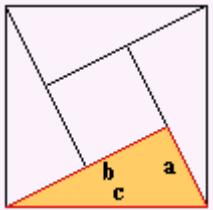
Show **competence**

-
- Grant applications
 - Portfolio / CV
 - Pitch

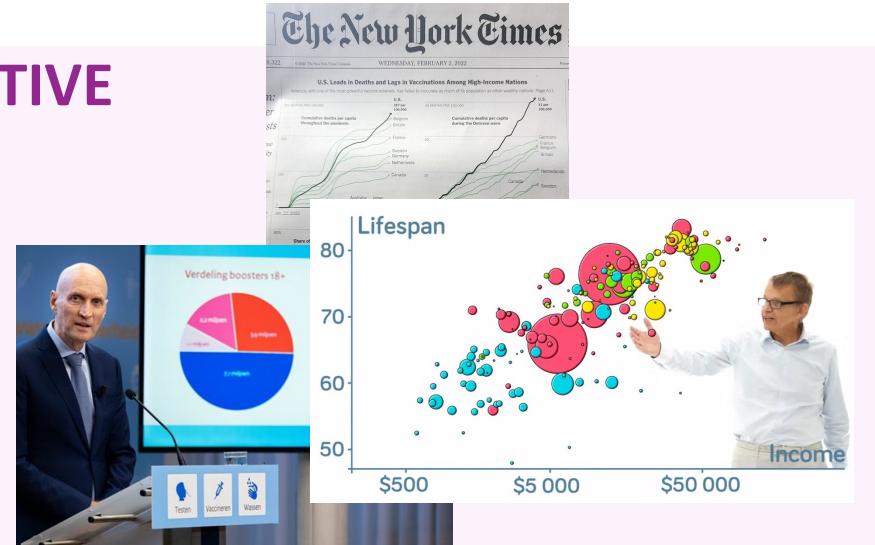
What is visual communication ?

Four types of visualizations

Idea illustration

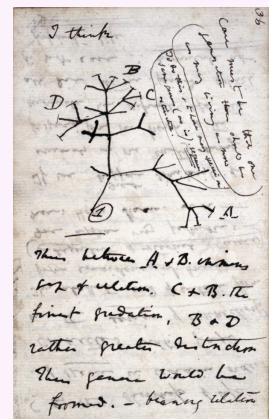
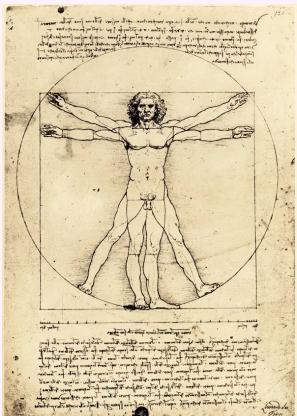


DECLARATIVE



'Everyday'
DataViz

Idea generation



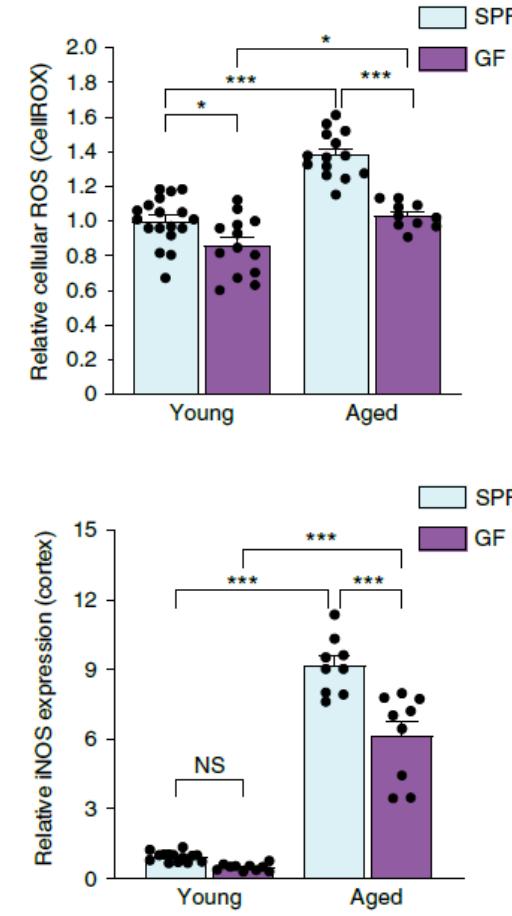
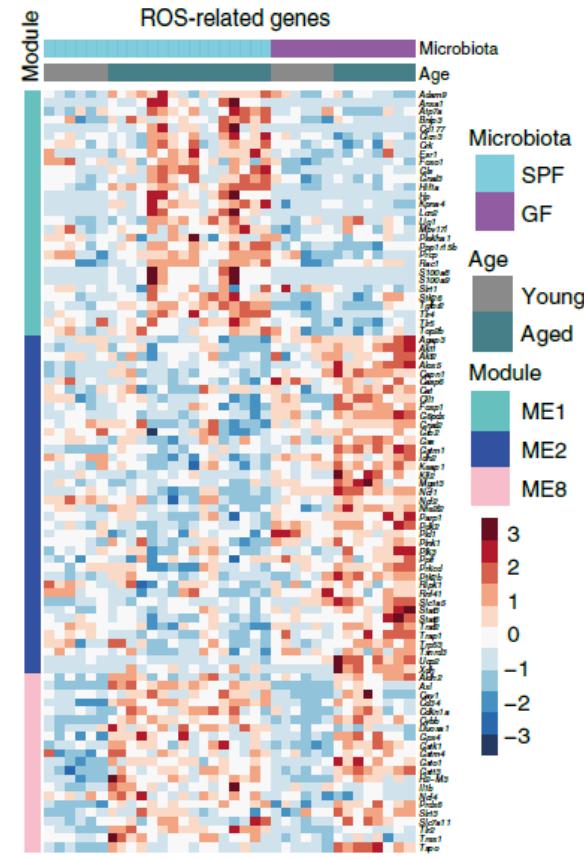
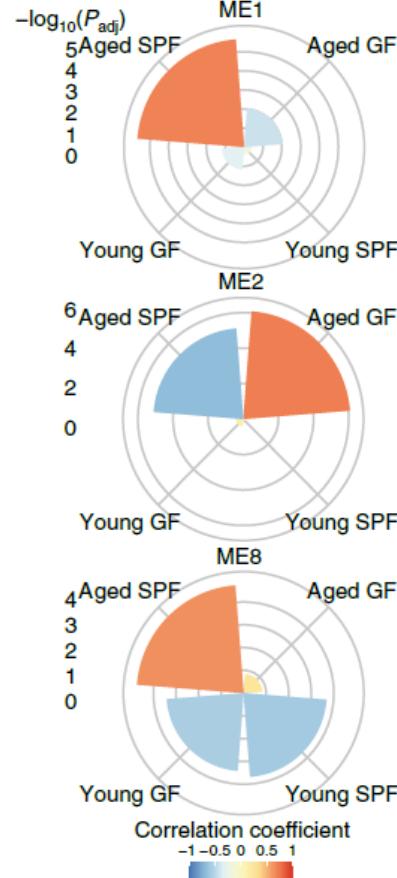
CONCEPTUAL

EXPLORATORY



Visual
discovery

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



You can also think of graphical abstracts or posters...

How does sleep disturbance affect hemodialysis patients?

Kidney Medicine

Methods and Cohort

Adults on maintenance HD with OSA ($n = 36$)



Polysomnogram & Epworth Sleepiness Scale (ESS)



Interview to explore patient experience ($n = 26$)



Findings

Severity of sleep apnea did not affect patients' sleep duration, sleep efficiency or ESS.

However,
70% reported broken sleep

62% felt unrefreshed upon wakening

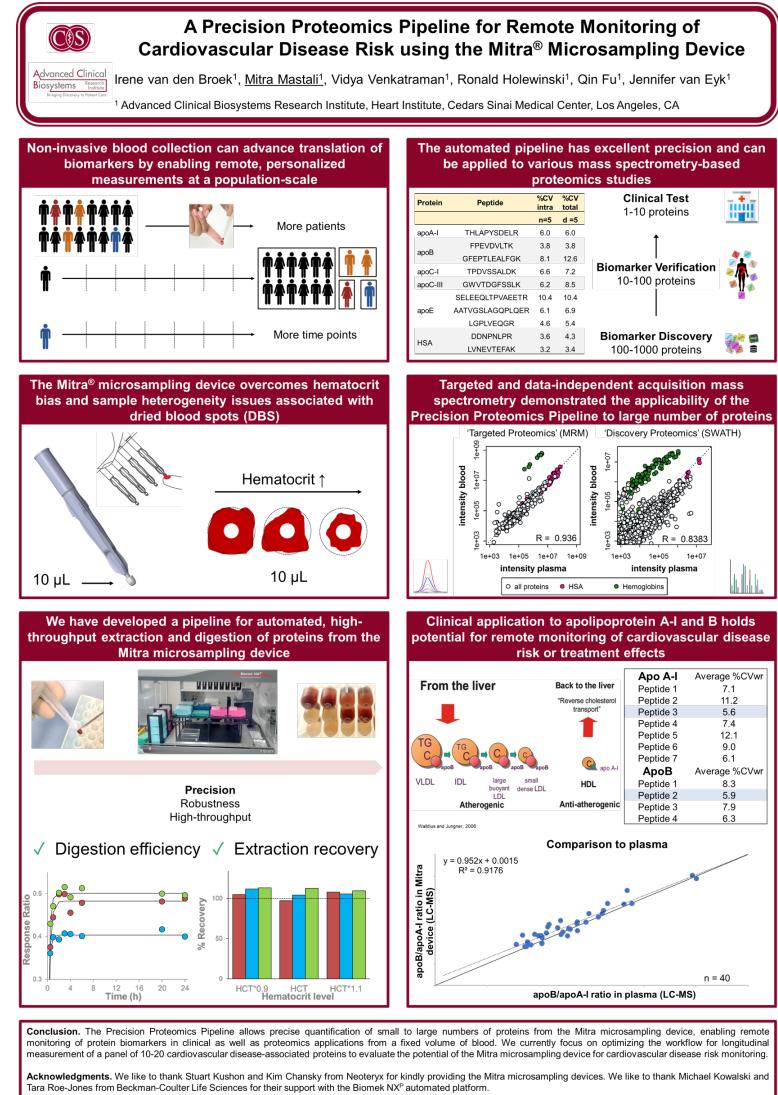
Themes from Interview

- Broken sleep
- Feeling unrefreshed
- Impact of poor sleep
- Having to "soldier on"

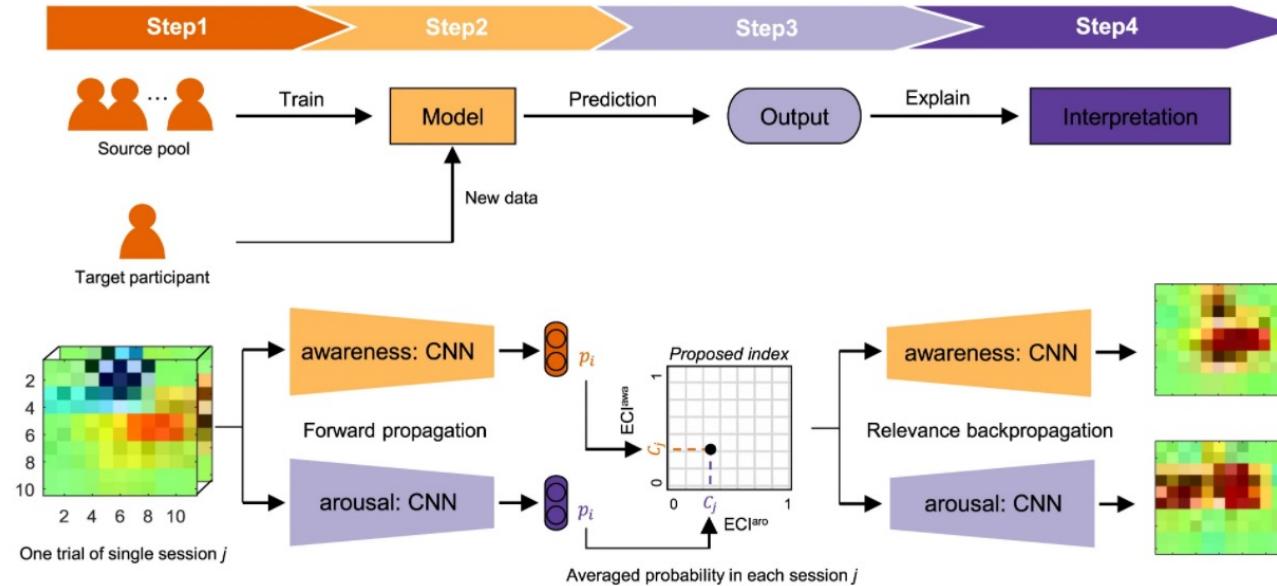
Conclusion: Sleep disturbance is common and has a profound impact on health and QoL of hemodialysis patients. The conflicting message between patient interview and self-reported questionnaires indicate a need for multidisciplinary approaches and improved patient communication to truly capture the health needs of individuals.

Reference: Chu G, Price E, Paech G, Choi P and McDonald V. Sleep apnea in maintenance hemodialysis: a mixed methods study. *Kidney Medicine*, 2020

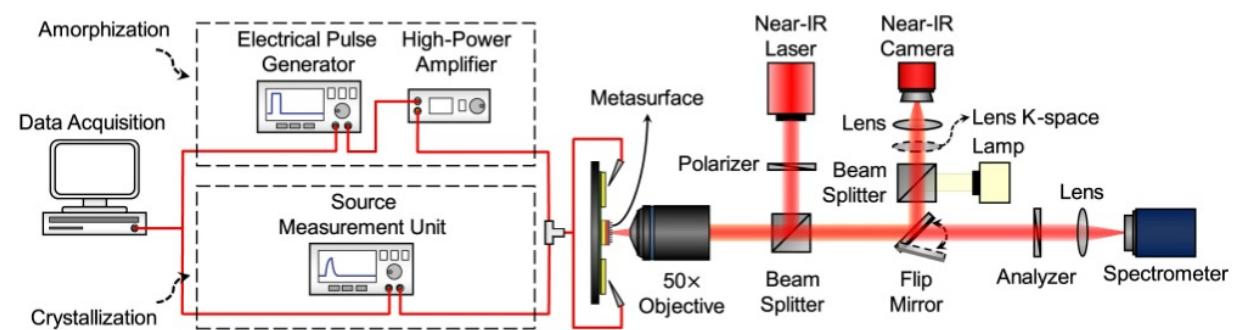
Visual Abstract by Anna R Gaddy, MD @AnnaGaddy



Flow charts or schematics...

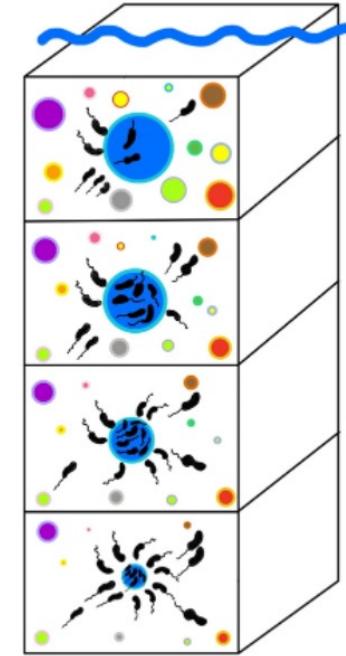
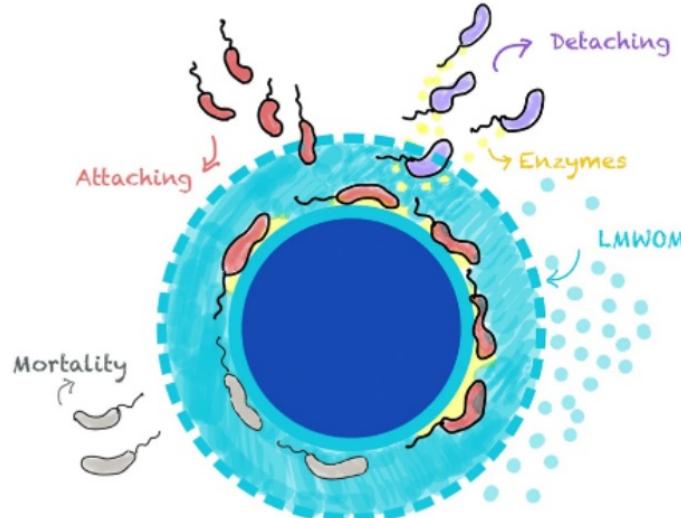
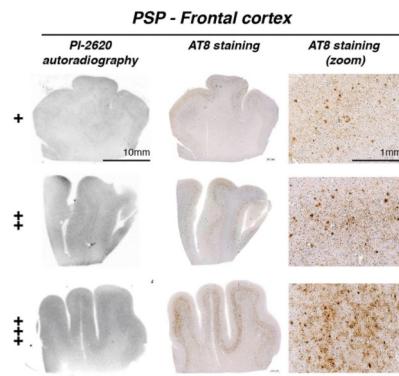
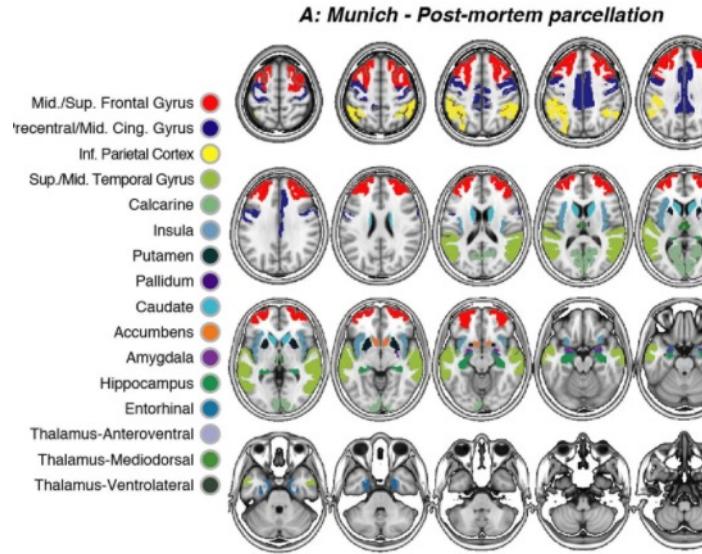


Lee M et al. (2022) Nat Commun **13**, 1064.



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

Illustrations, drawings, images...



Talking about reaching a broad public!



Prof. Ed Hawkins
#showyourstripes



HOW visual communication ?

Encode: *Choose a chart*

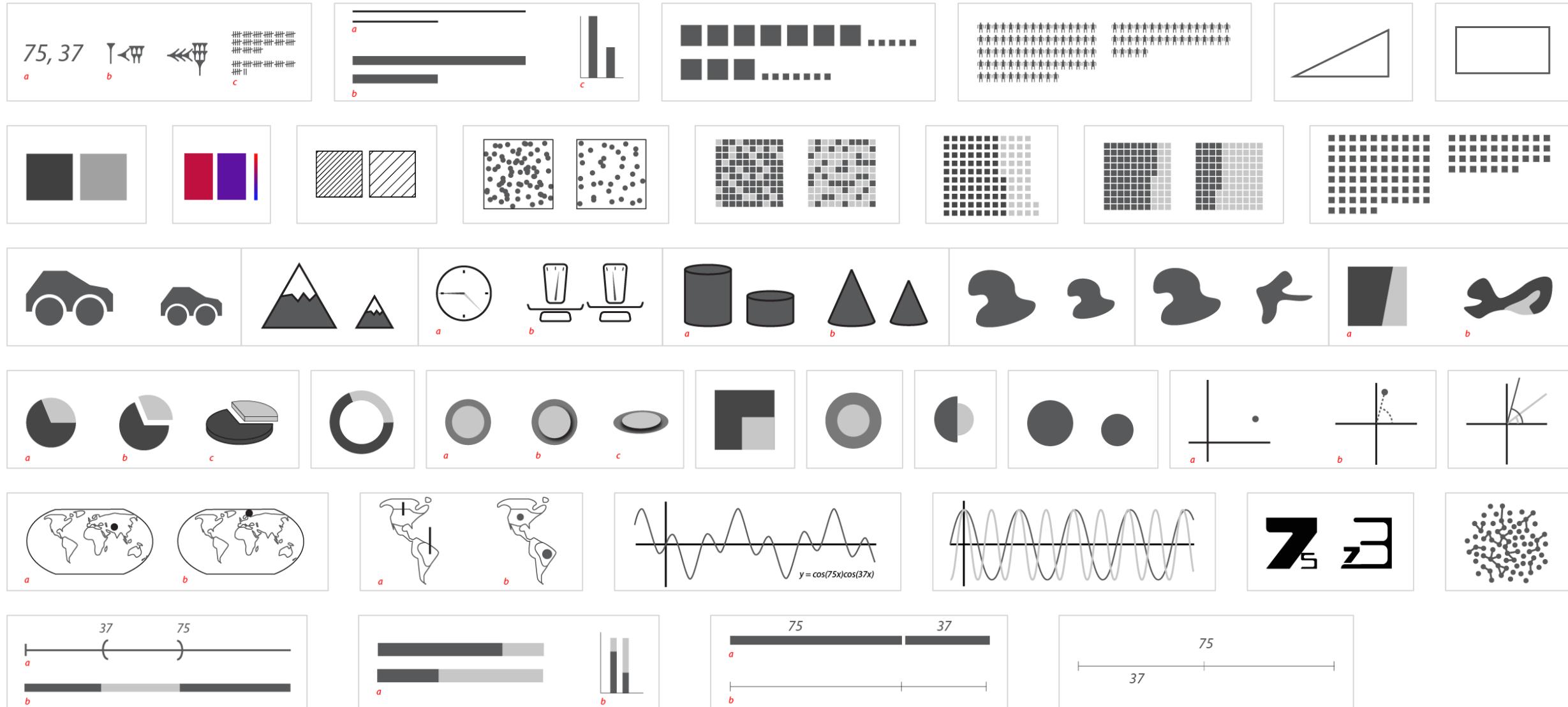
Exercise: In how many ways can you visualize two numbers?

75 and 37



5 min

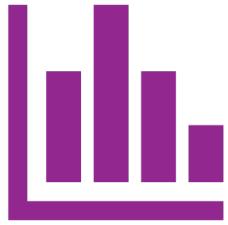
45 ways to communicate two quantities...



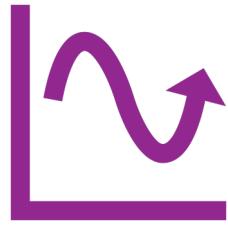
So many possibilities. How to choose?



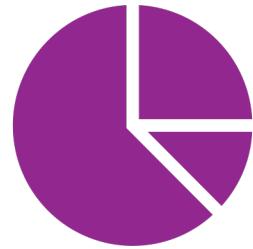
What do you want to show?



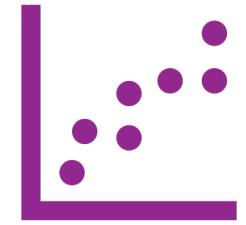
Comparison



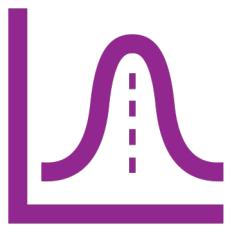
Trend



Part of a whole



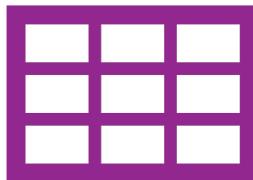
Relationship



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
Show in context	Misleading design A truncated axis in a column or bar chart distorts the relative size of the columns.
relevant ranking	cutting of Y-axis Multiple Y-axes give a false meaning to lines crossing or to the space between lines.
Support easy comparison	Beauty over accuracy Do not use 3D to make a chart prettier, it will make it harder and more confusing to read.
small multiple	3D effect Although 3D lines might look nice, they are not representing the data properly.
gridlines	Too much The human brain can only process a maximum of 4 series in a chart.
Visual hierarchy	less is more De-emphasize all non-data elements like axis and legend. The data is more important.
emphasize	more than 4 series Things that are the same, should have the same color.
Show and tell	Hard to read Show as little decimal as possible. Always show the same number of decimals.
descriptive title	too much details Text and numbers that are not horizontal aligned are harder to read.
annotation	align text other than horizontally

Find more tips to choose and design your Perfect Chart at: www.Chart.Guide/poster

Use this chart for: analyzing, communicating, monitoring, confusing

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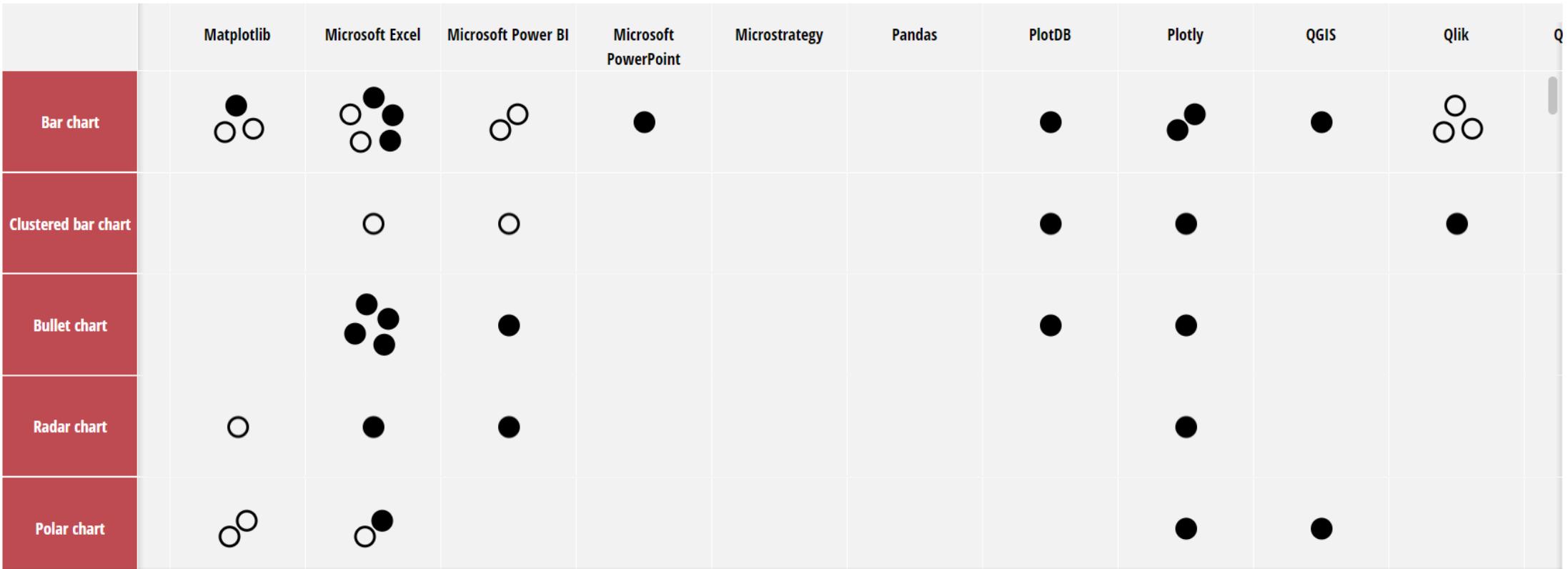
The Chartmaker directory

⊕ THE CHARTMAKER DIRECTORY

ABOUT

Filter by chart name or AKA

Reference Type: ● Example ● Solution | Chart Families: ● Categorical ● Hierarchical ● Relational ● Temporal ● Spatial





from Data to Viz

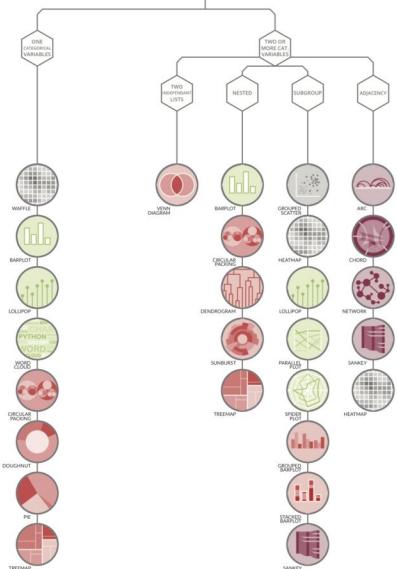
'From Data to Viz' is a classification of chart types based on input data format. It will help you find the perfect chart in three simple steps :

- 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.

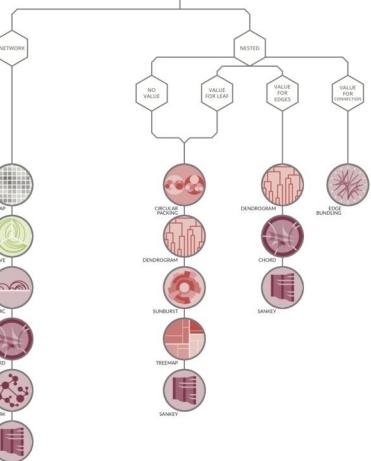
Dataviz is a world with endless possibilities and this project does not claim to be exhaustive. However it should provide you with a good starting point. For an interactive version and much more, visit:

data-to-viz.com

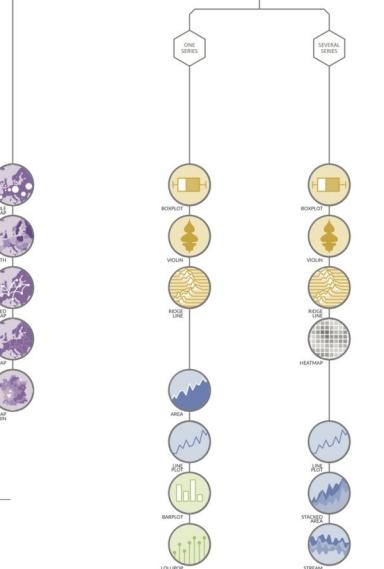
CATEGORIC



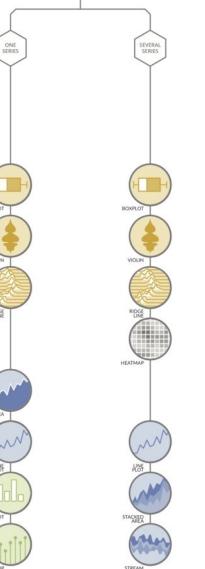
RELATIONAL



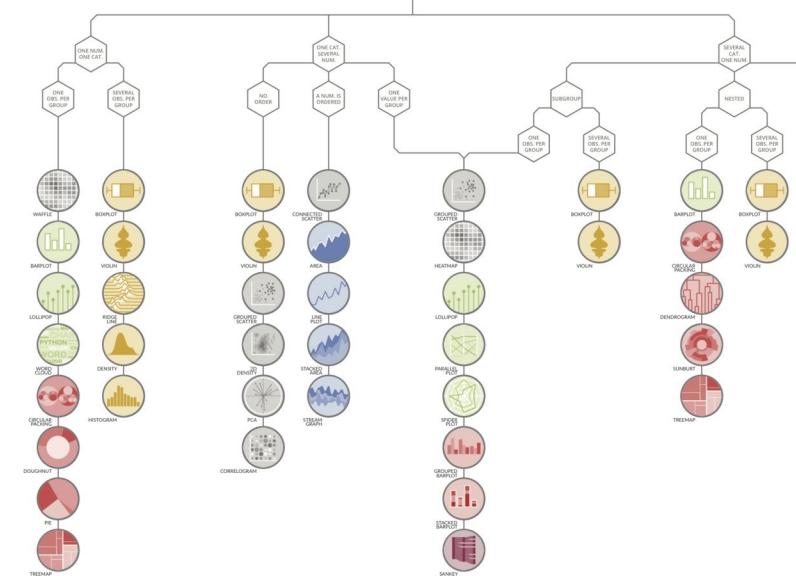
MAP



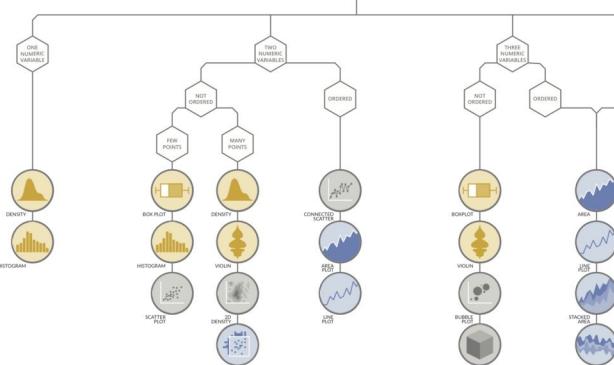
TIME SERIES



CATEGORIC AND NUMERIC



NUMERIC





Visual perception

The strengths of our brain

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

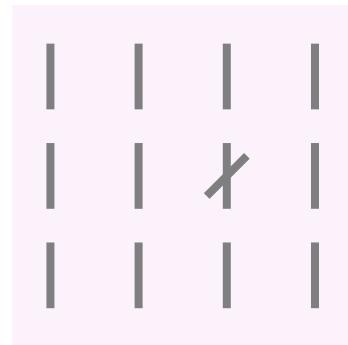
How many fives do you see?

321654643216465132168461321
646432136748651349687463123
668432616266984892536496874
651687964649843616984616957
465167412323161689312439873
421432875943869234987596387

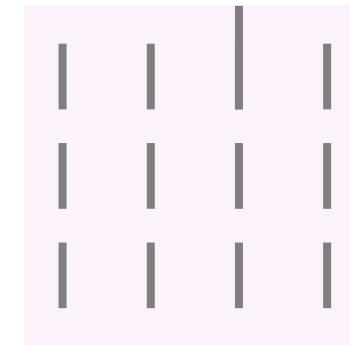
How many fives do you see?

321654643216465132168461321
646432136748651349687463123
668432616266984892536496874
651687964649843616984616957
465167412323161689312439873
421432875943869234987596387

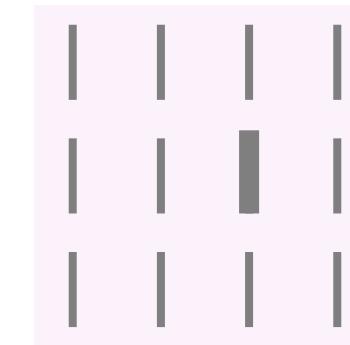
Pre-attentive attributes make your audience see what you want them to see before even seeing it!



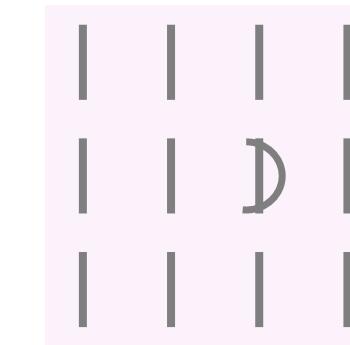
Orientation



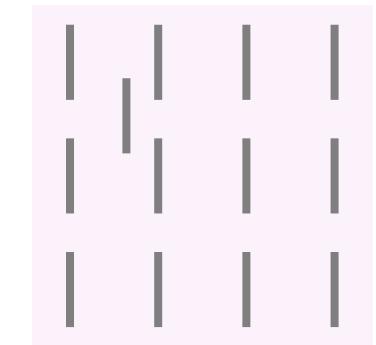
Length



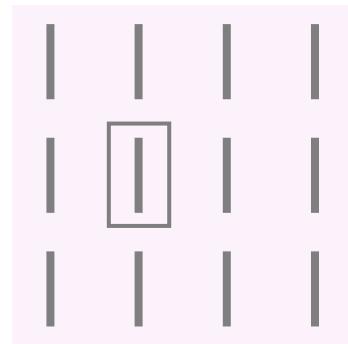
Width



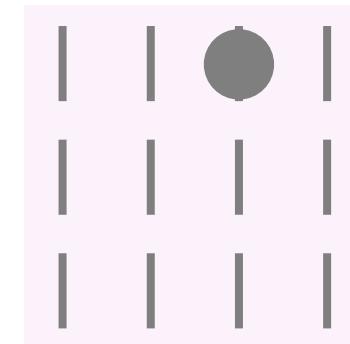
Curvature



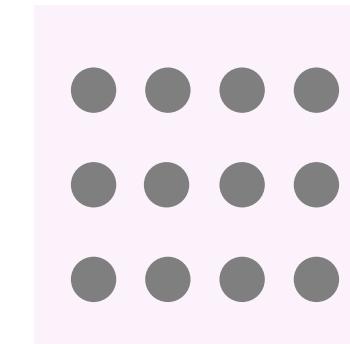
Position



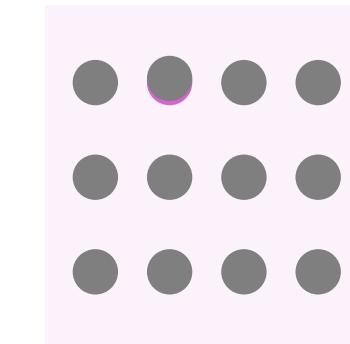
Enclosure



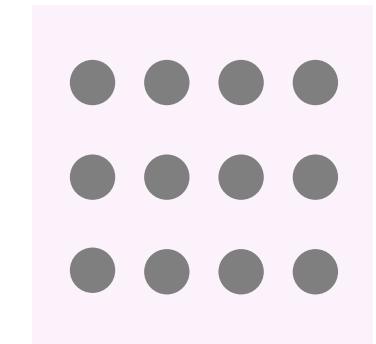
Shape



Size



Color



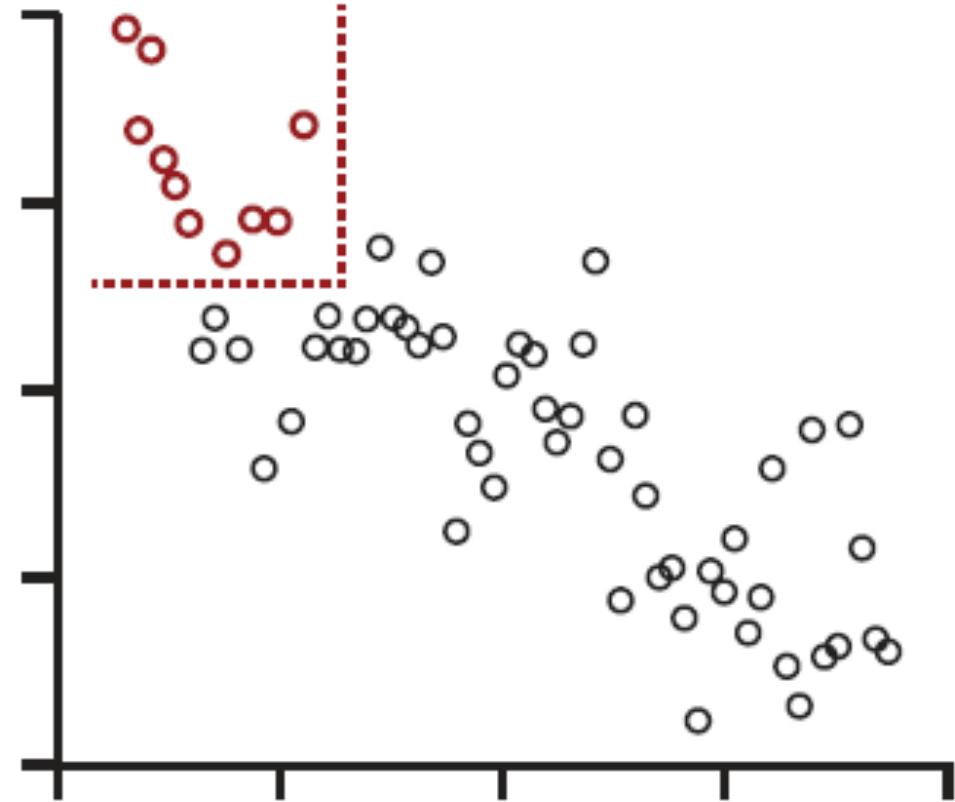
Motion

You can use pre-attentive attributes in tables

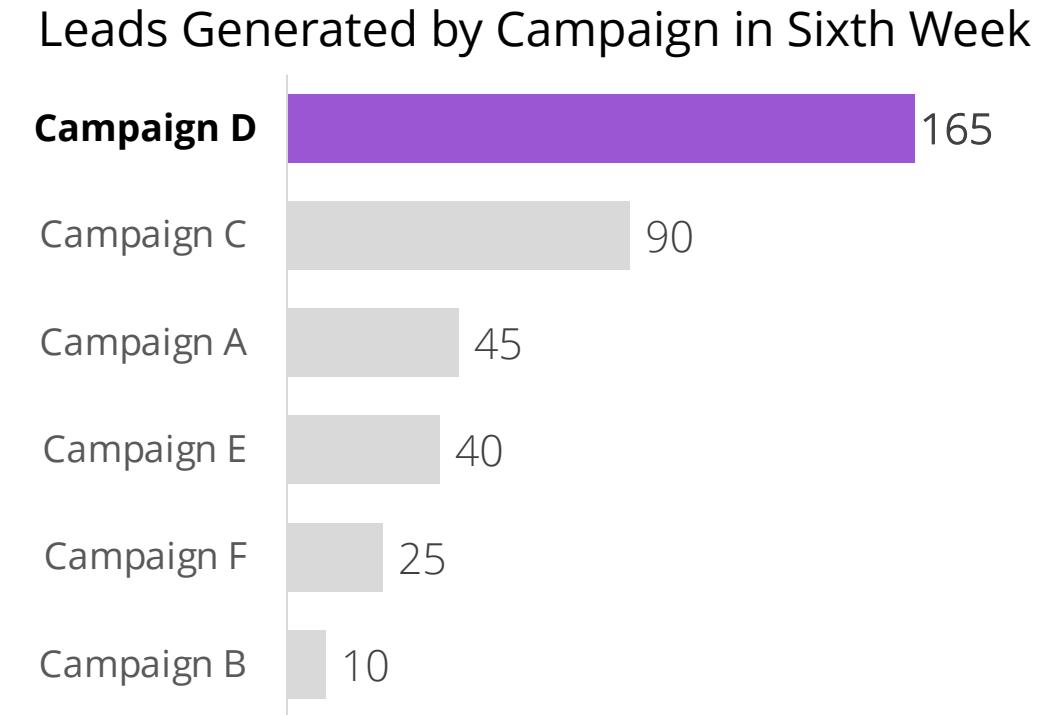
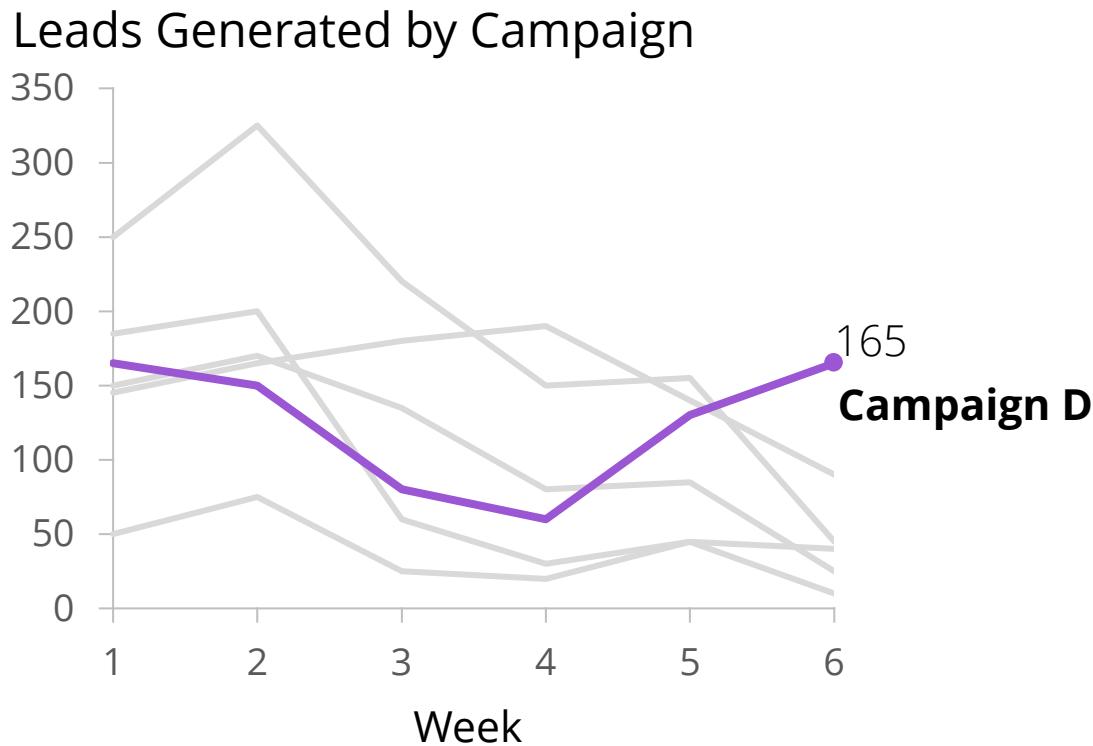
Color name	RGB (1-255)
Black	0, 0, 0
Orange	230, 159, 0
Sky blue	86, 180, 233
Bluish green	0, 158, 115
Blue	0, 114, 178
Vermillion	213, 94, 0

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



To draw attention to what's important



You can also use pre-attentive attributes in text.

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

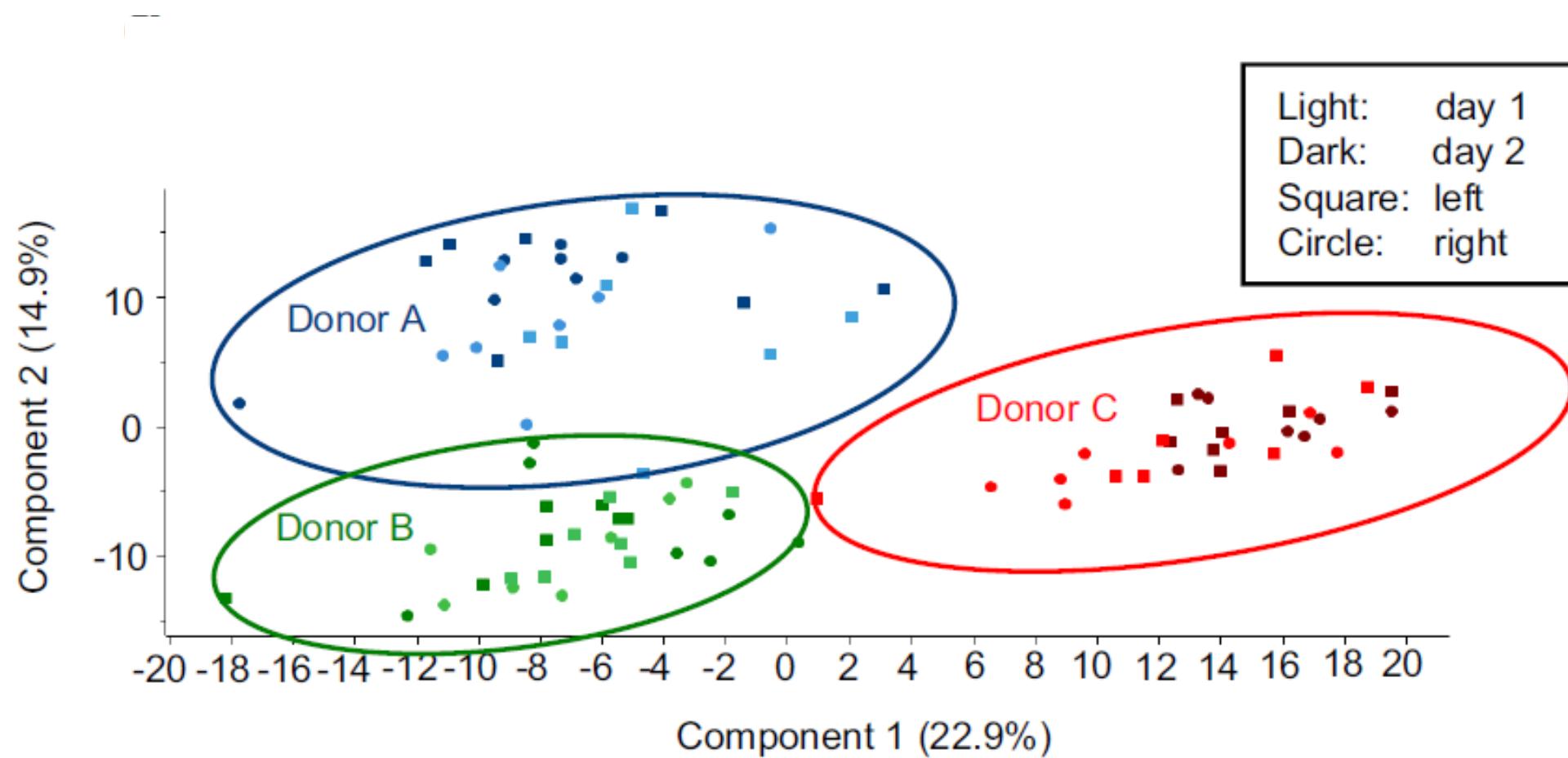
Without pre-attentive attributes you just have plain text. Or a plain figure. There is no guidance for the reader or viewer.

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

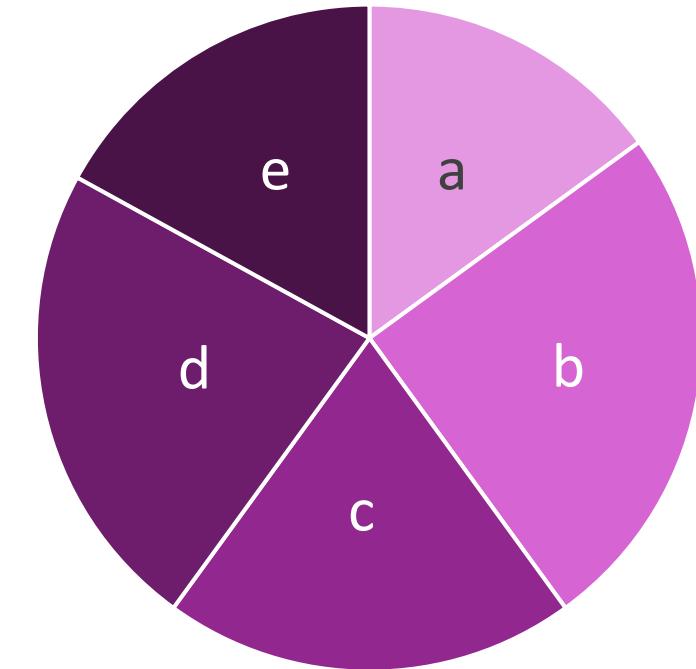


Pre-attentive attributes can be used to map quantities, e.g. by length or by angle

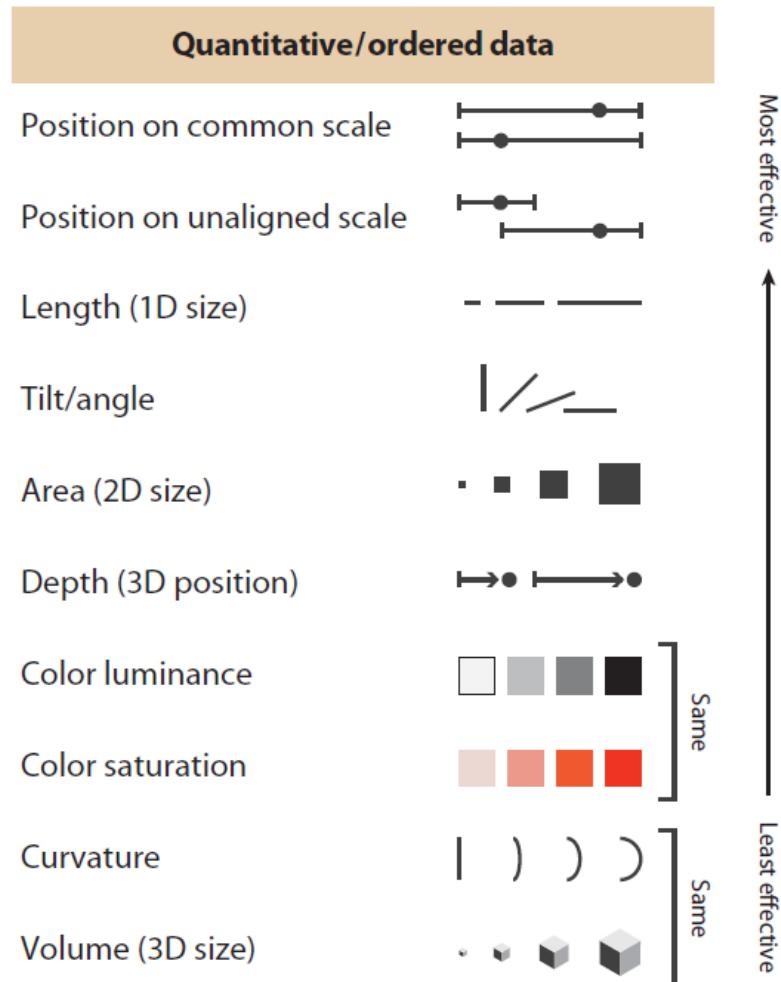
Which bar is highest?



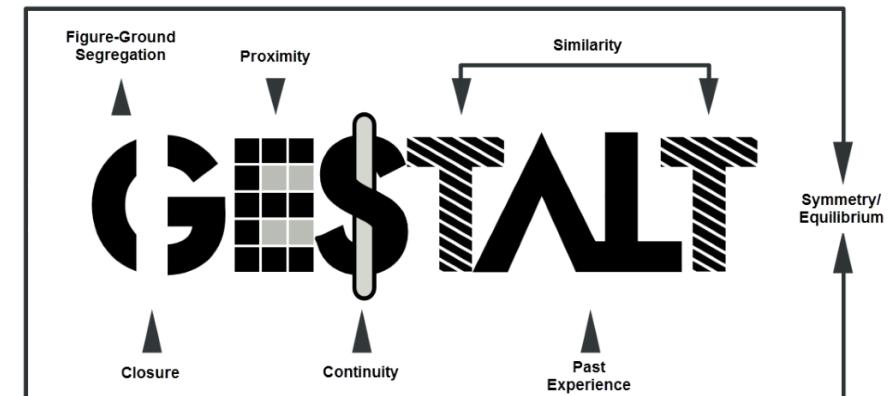
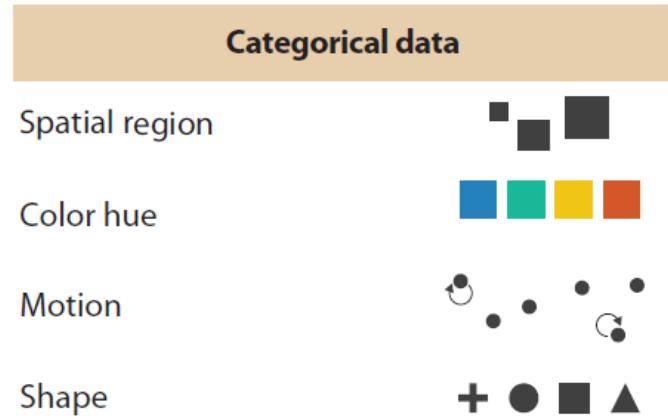
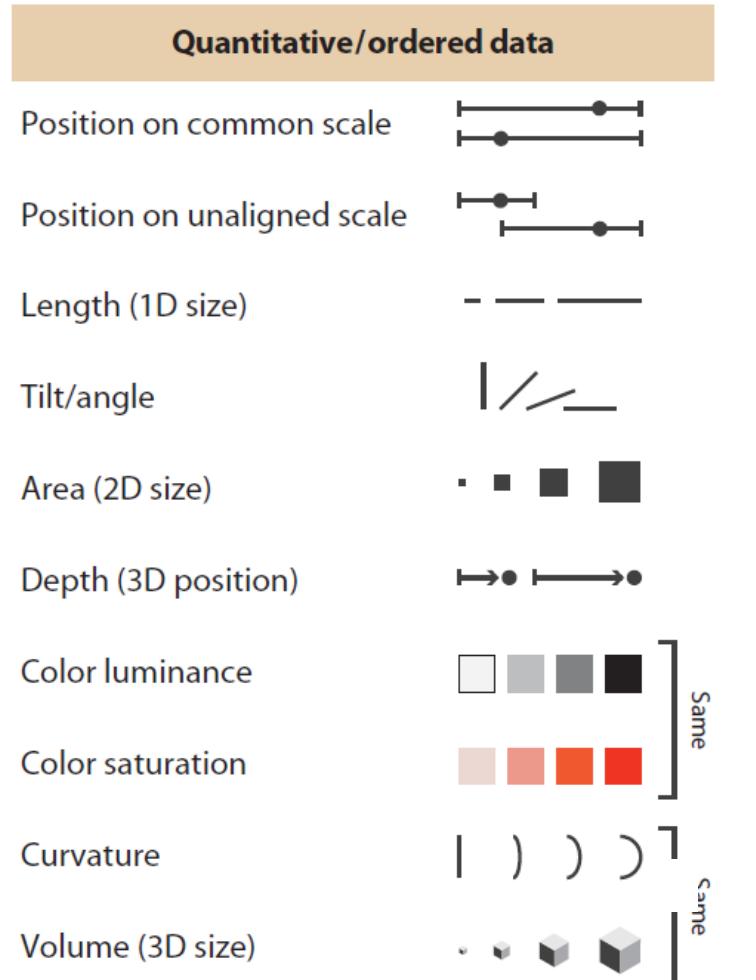
Which slice is biggest?



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



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

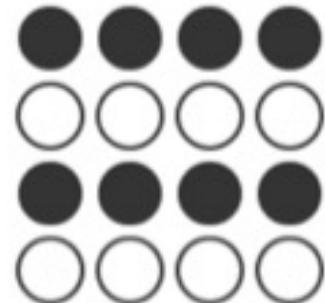


Gestalt principles: The whole is other than the sum of the parts.

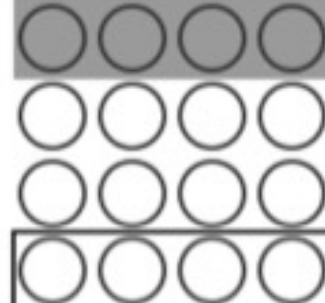
Proximity



Similarity



Enclosure



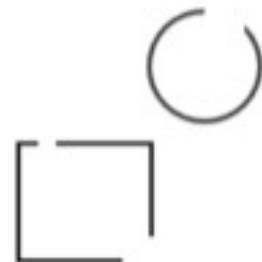
Symmetry



Figure-ground



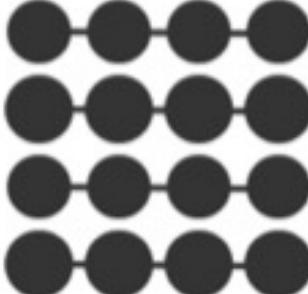
Closure



Continuity



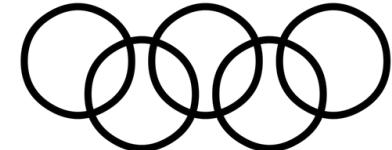
Connection



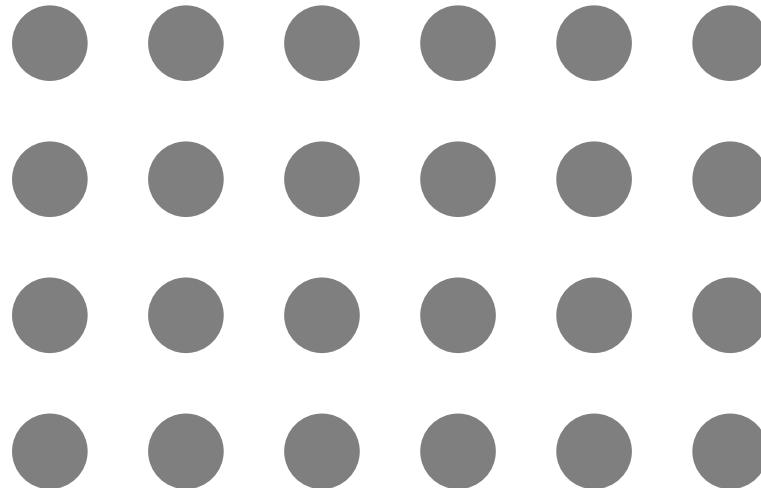
Common Fate



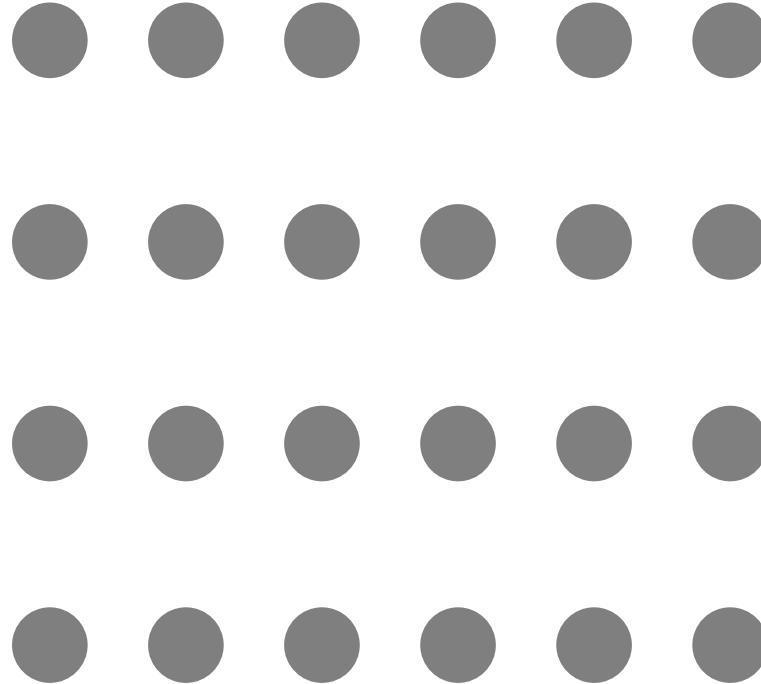
Simplicity



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

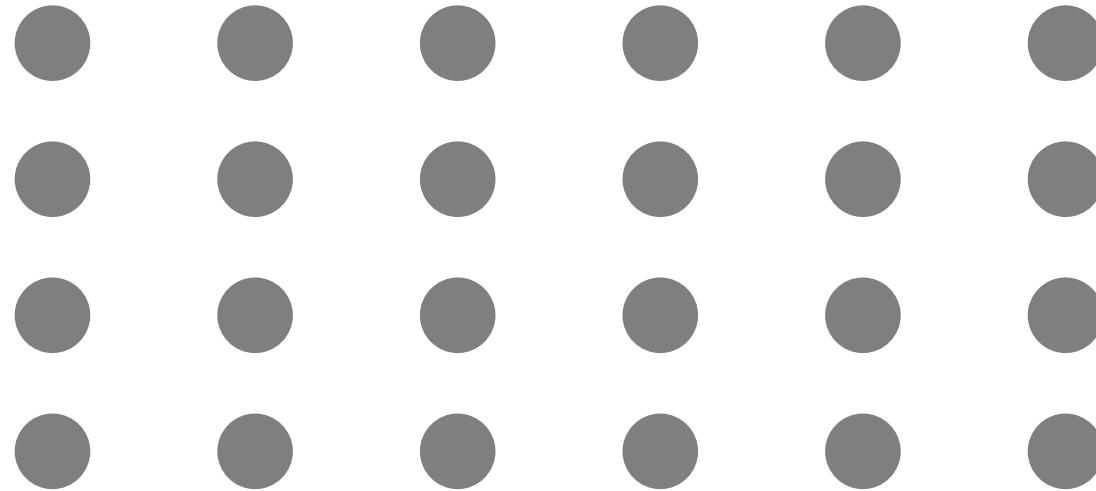


The **Gestalt** principles describe how our brain groups information



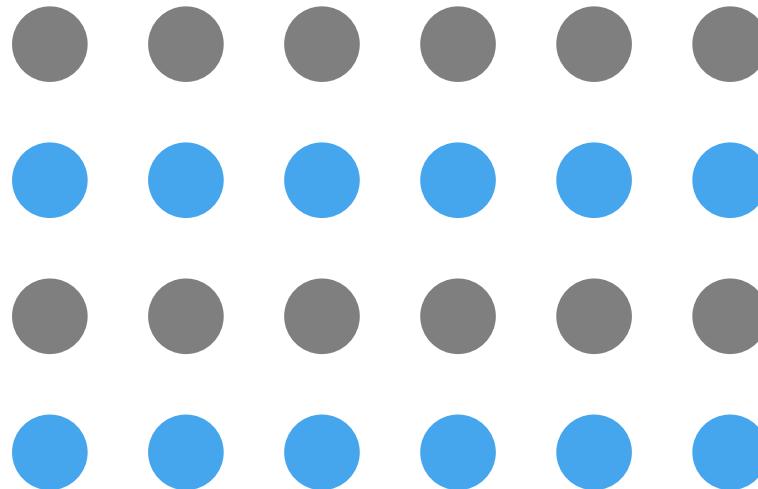
Proximity

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



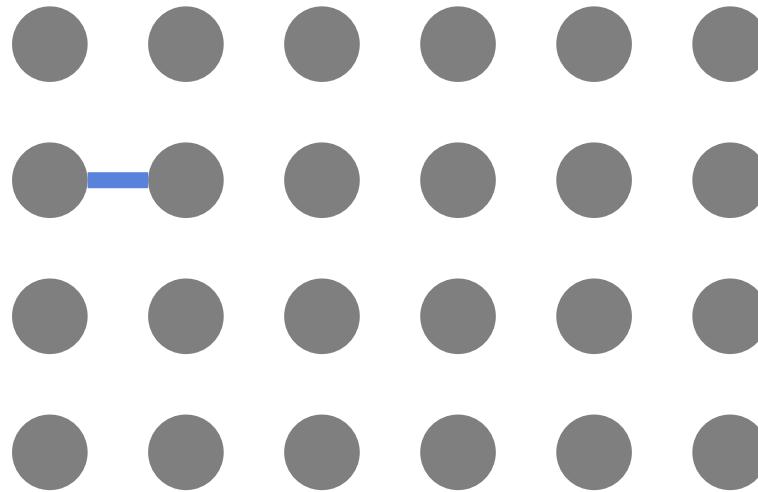
Proximity

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



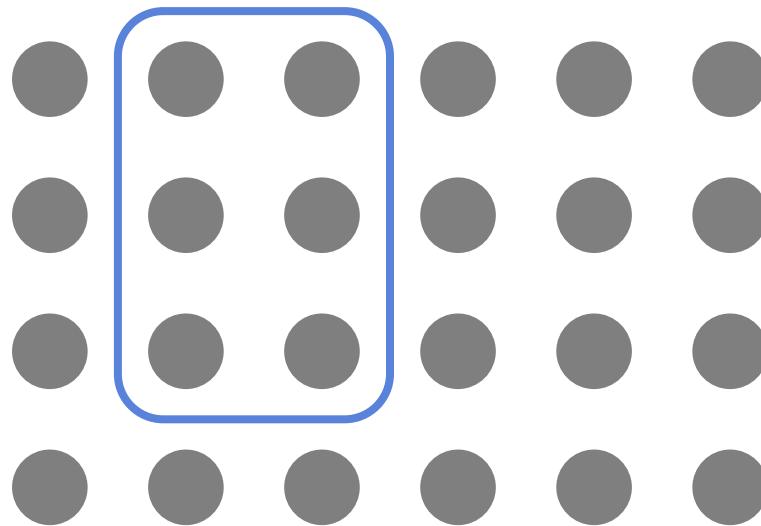
Similarity

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



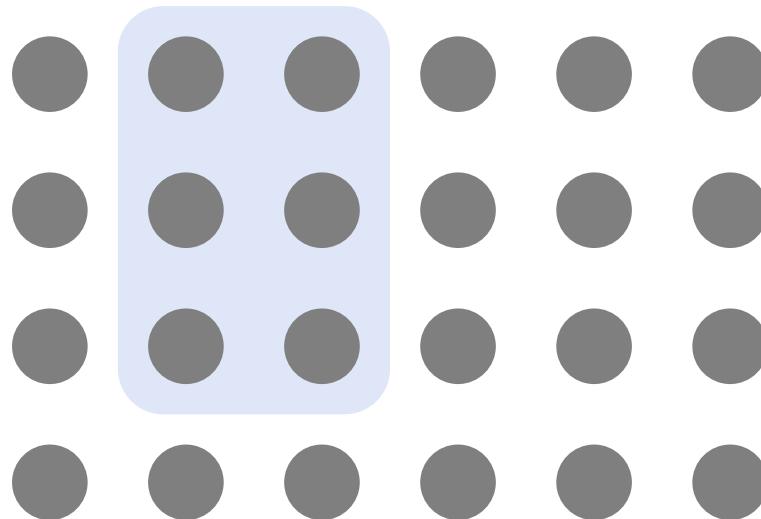
Connection

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



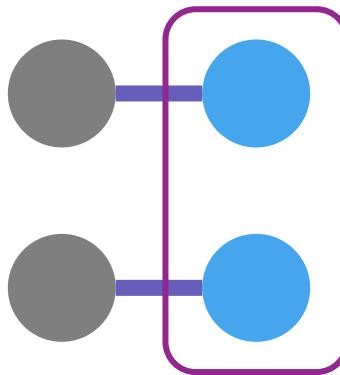
Enclosure

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



Enclosure

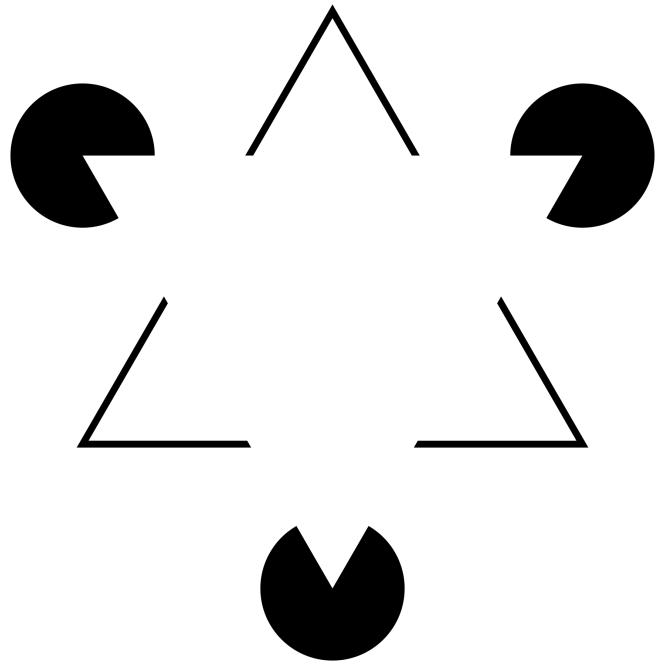
Some visual properties have stronger associative values than others...



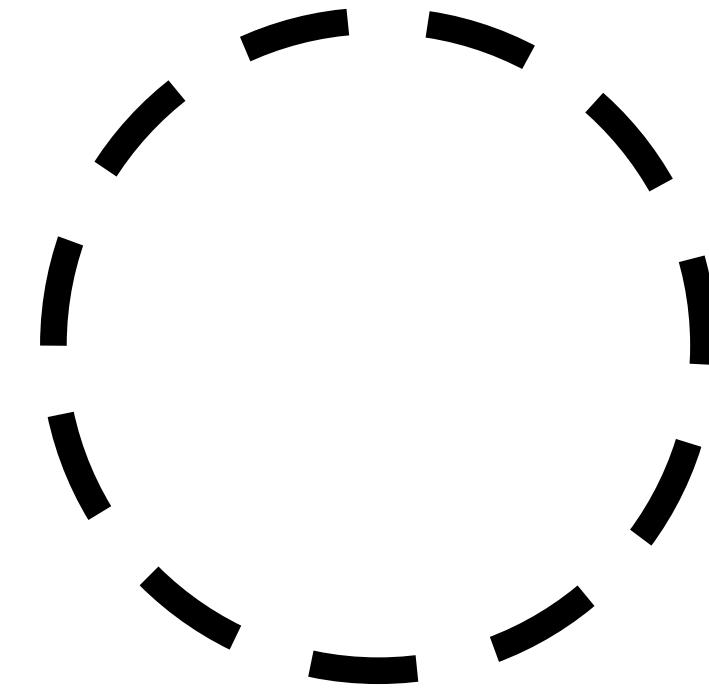
Can you read this?

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!

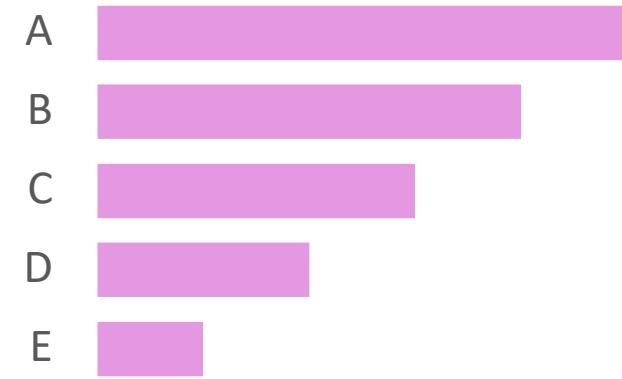
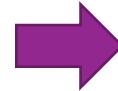
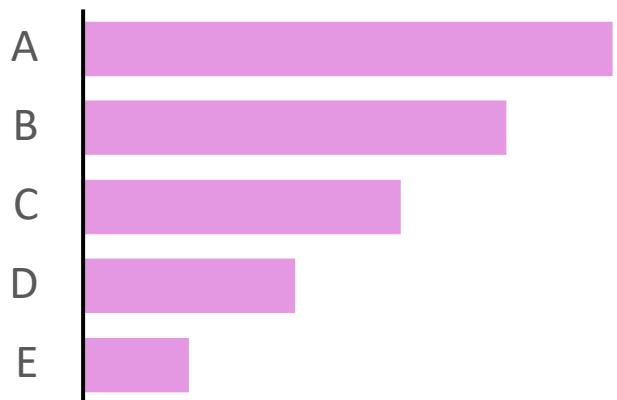
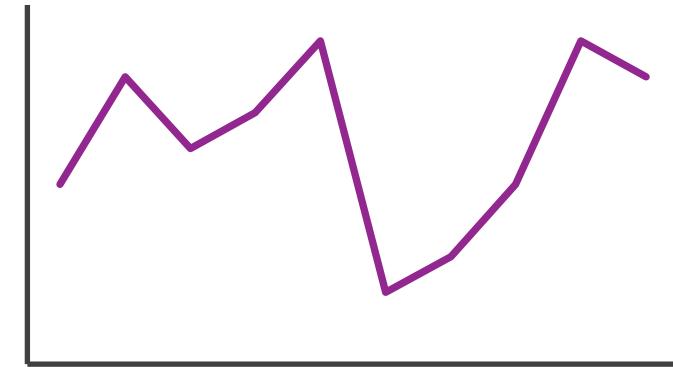
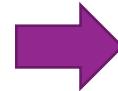
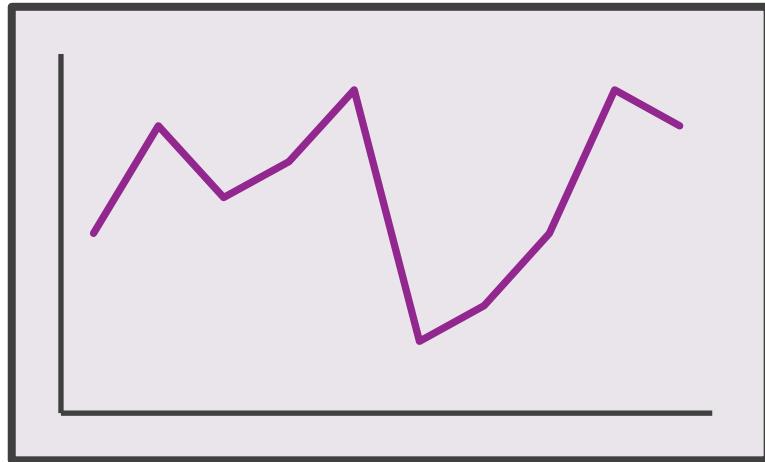


Continuity

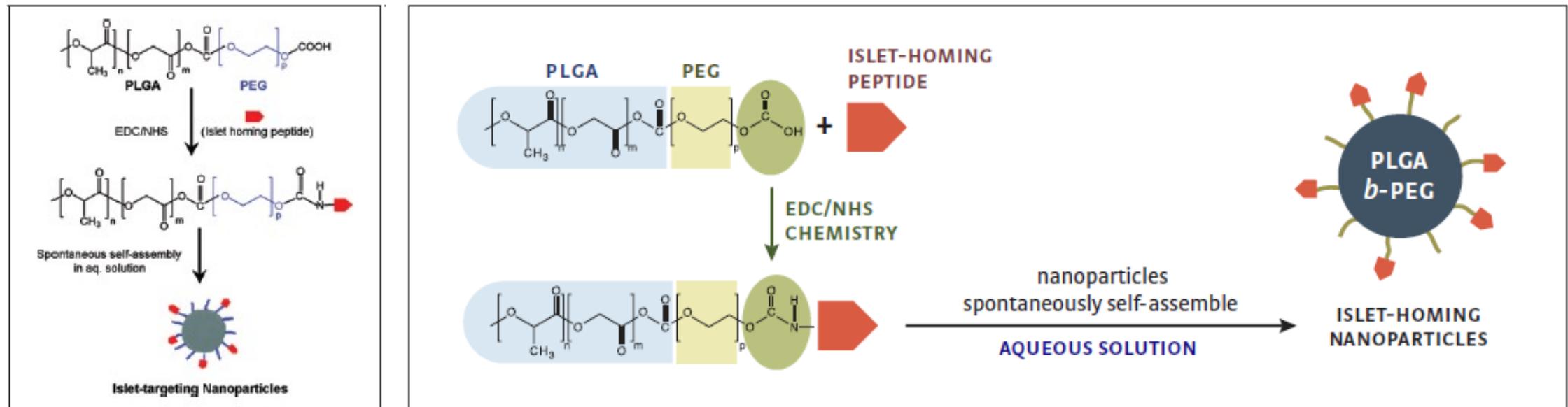


Closure

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.

But...



Exercise

I Notice. I Wonder.



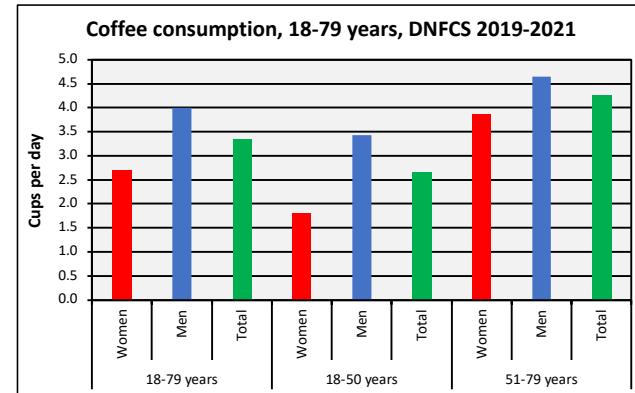
I Notice. I Wonder

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

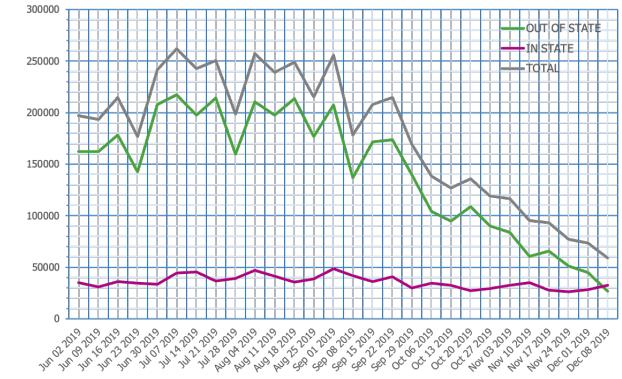


Notice: (<10 sec)

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



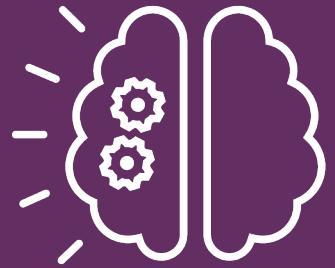
Daily Average Park Visitors By Week



Wonder: (< 1 min)

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



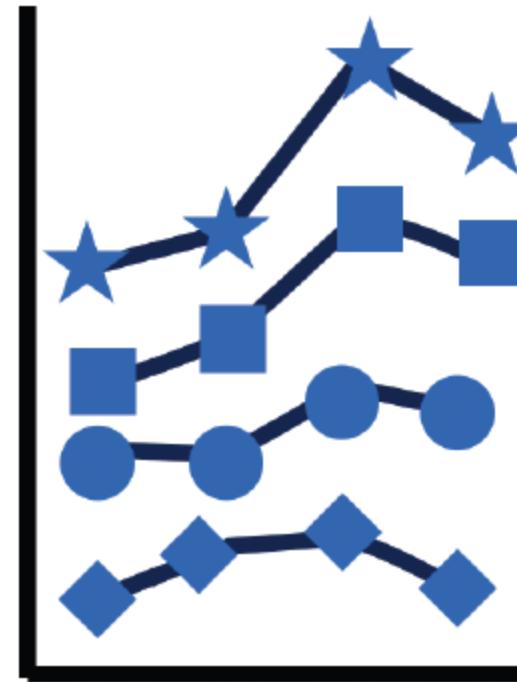
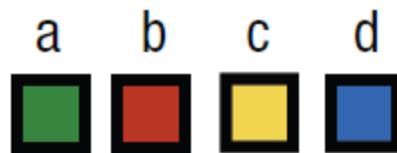
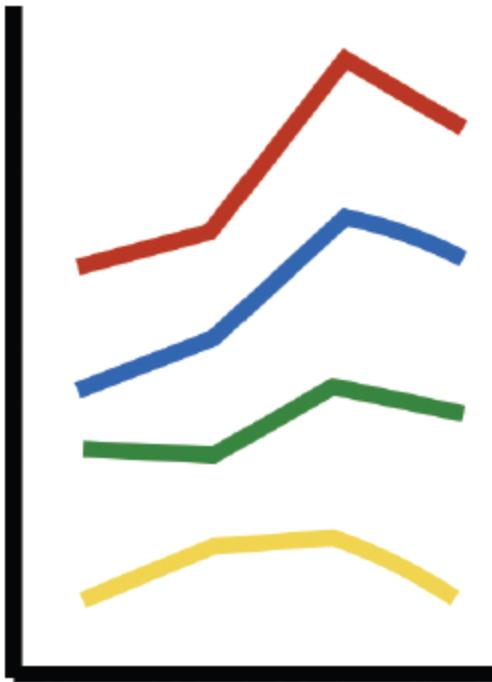
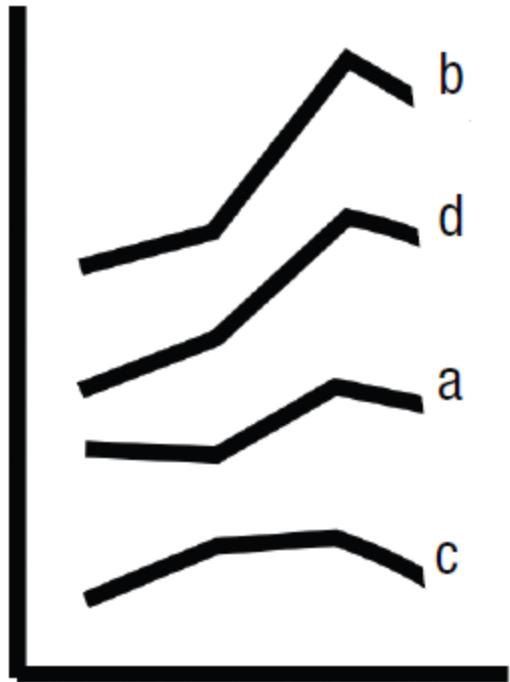


Visual perception

The weaknesses of our brain

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

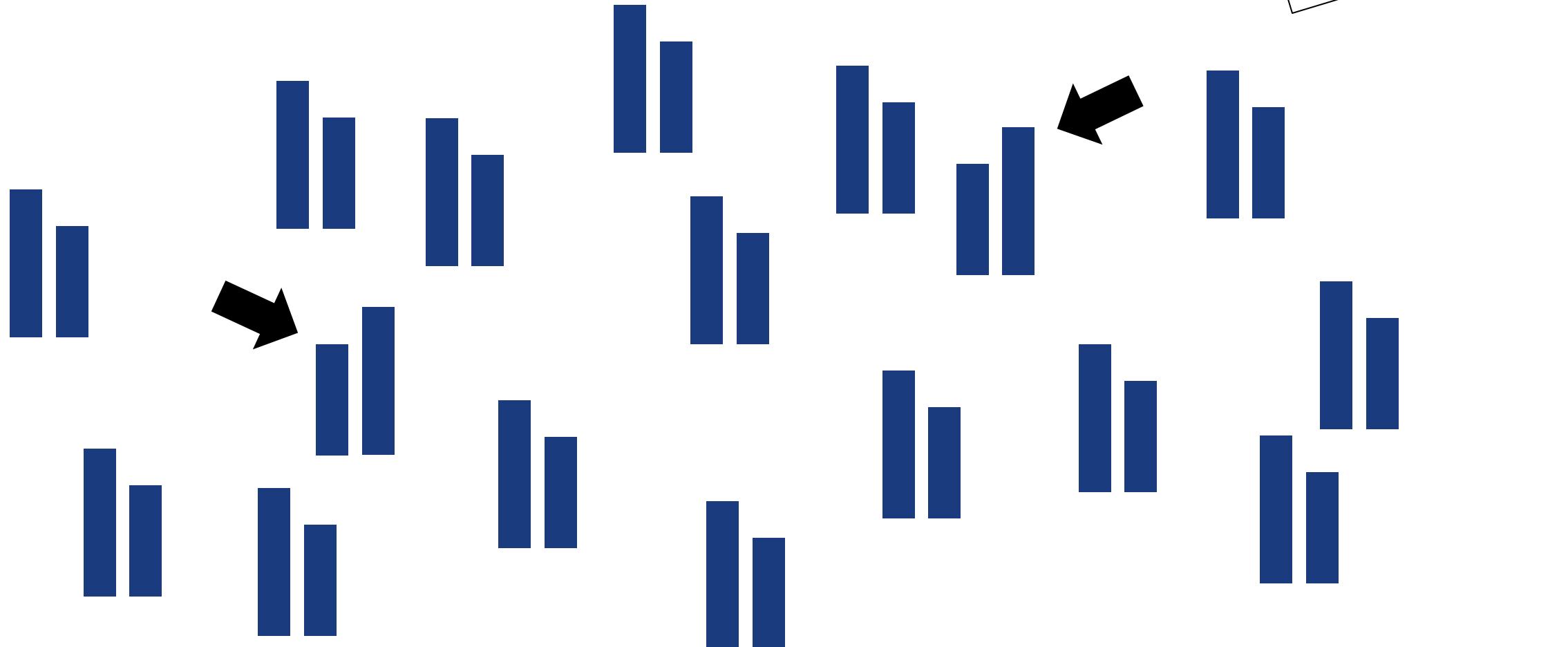
What is the order from top-to-bottom?



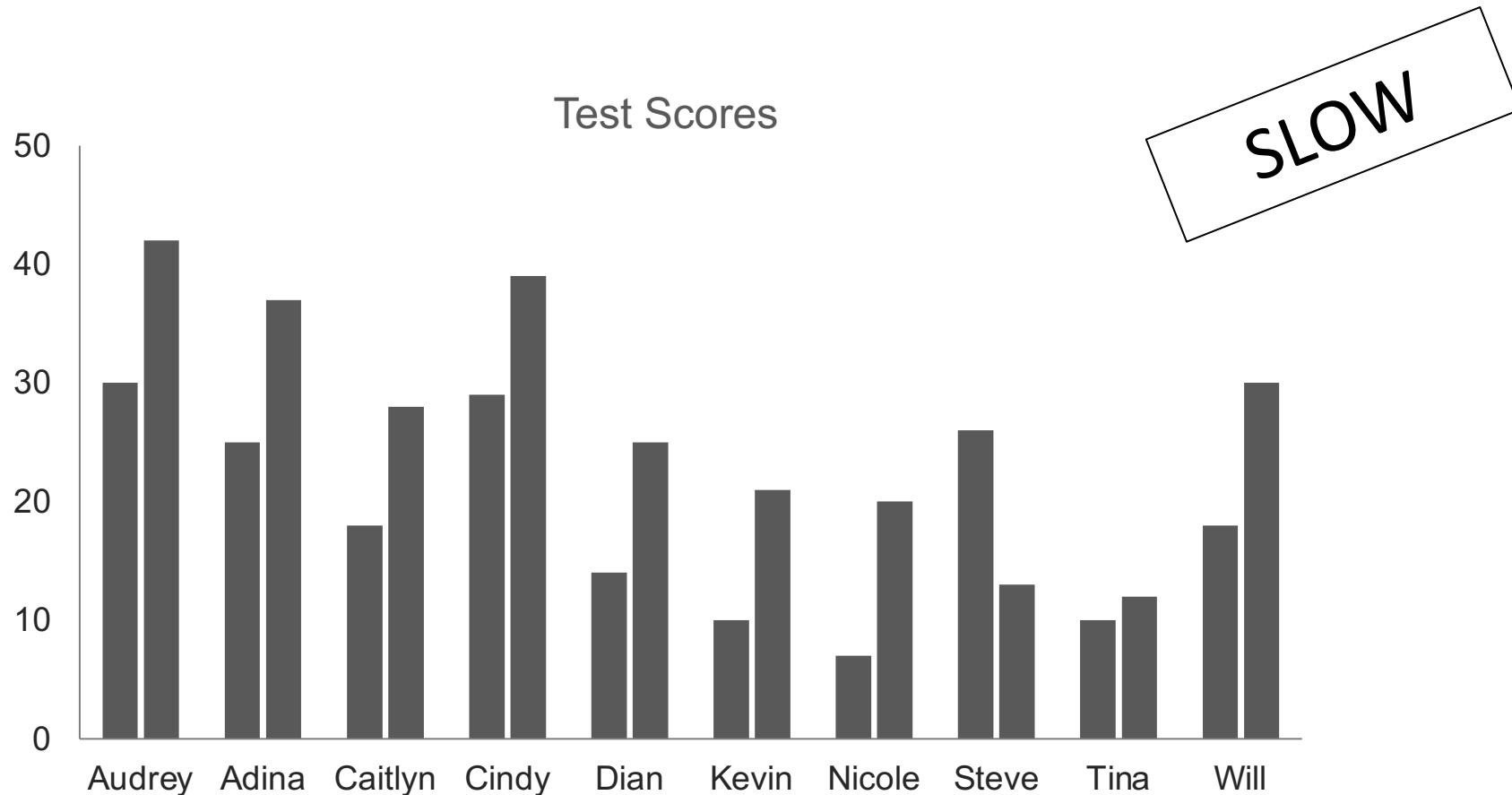
Do you see small-big or big-small?



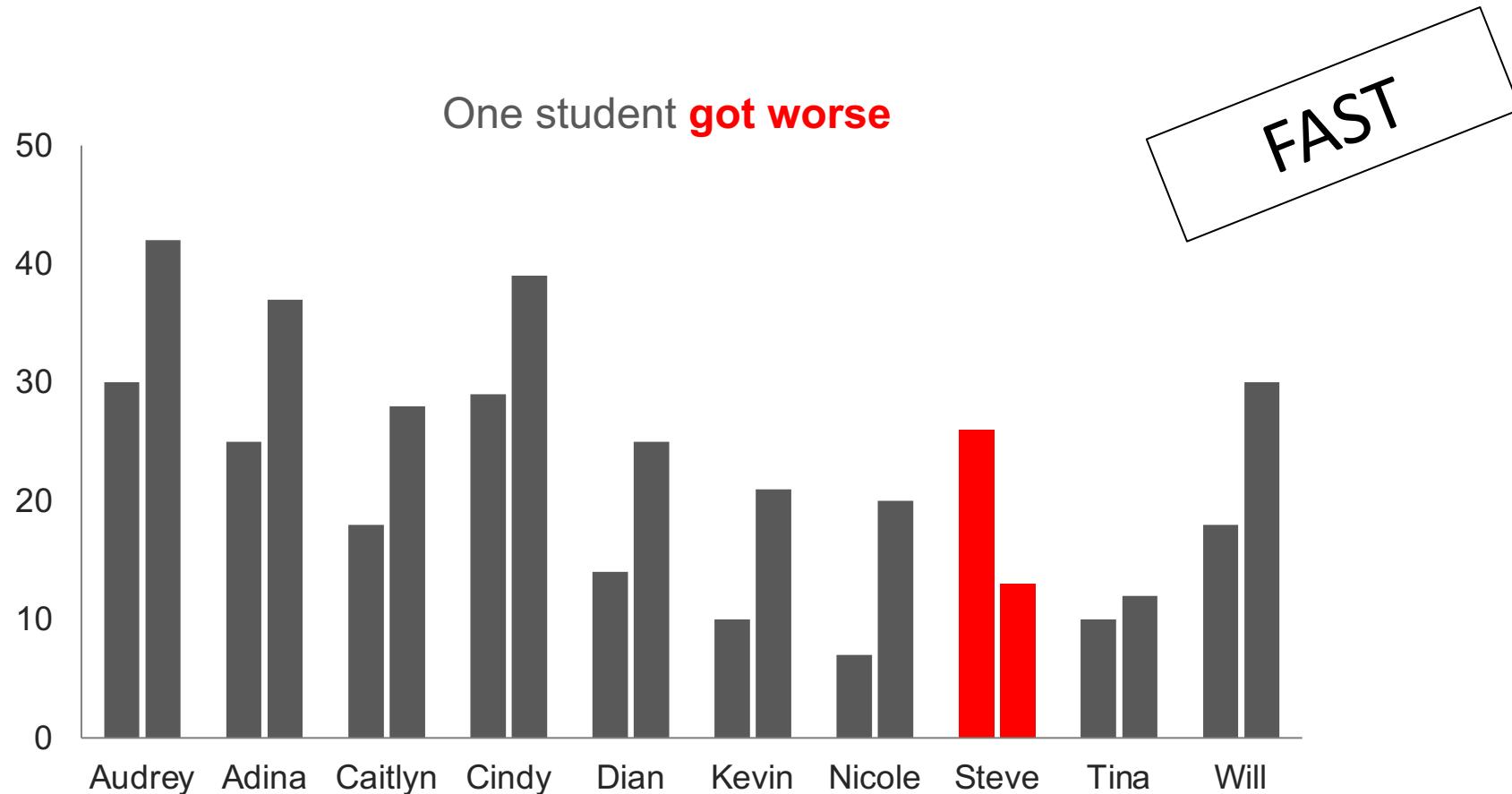
Which one is not like the others?



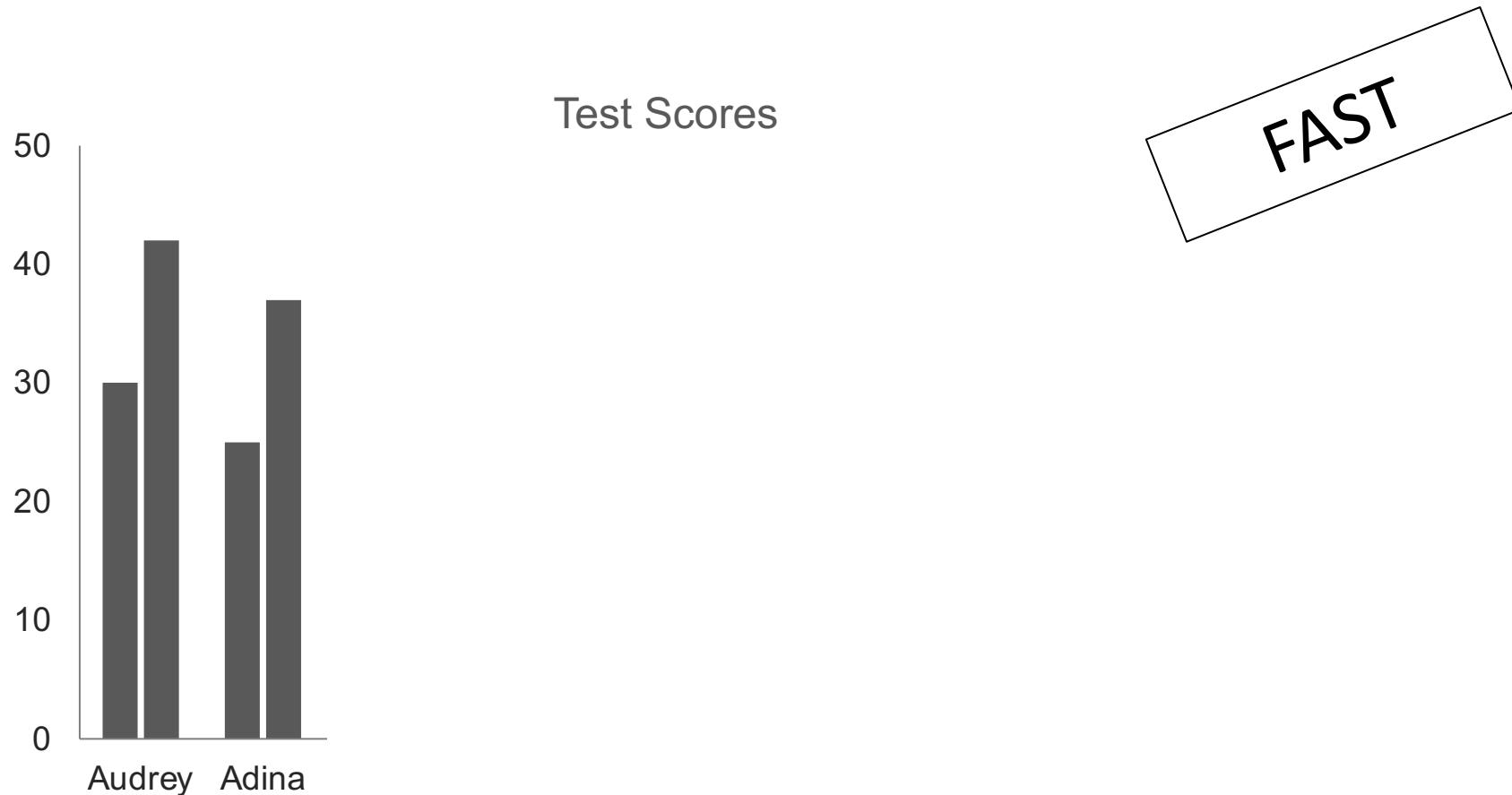
Which student got worse?



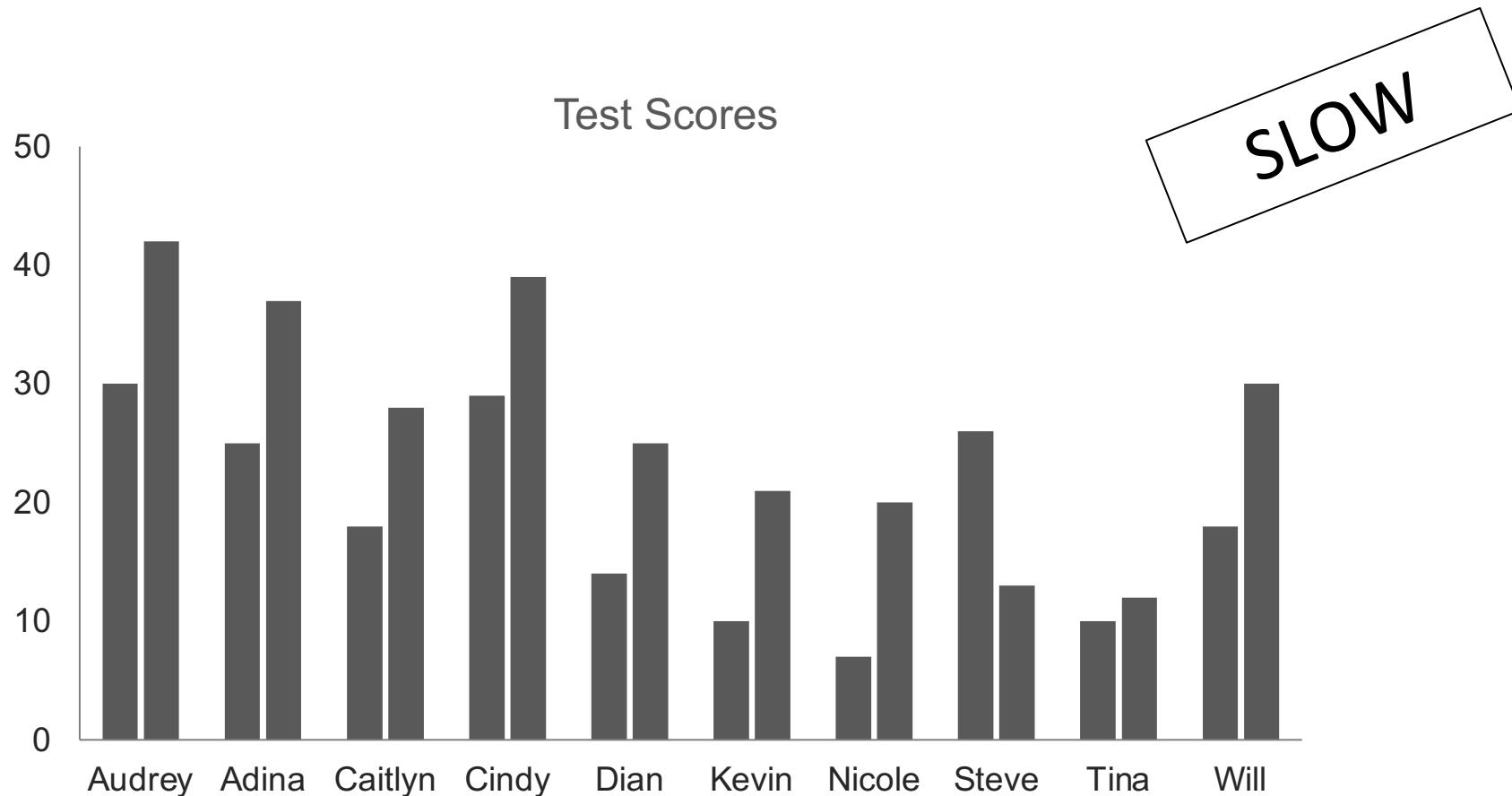
Which student got worse?



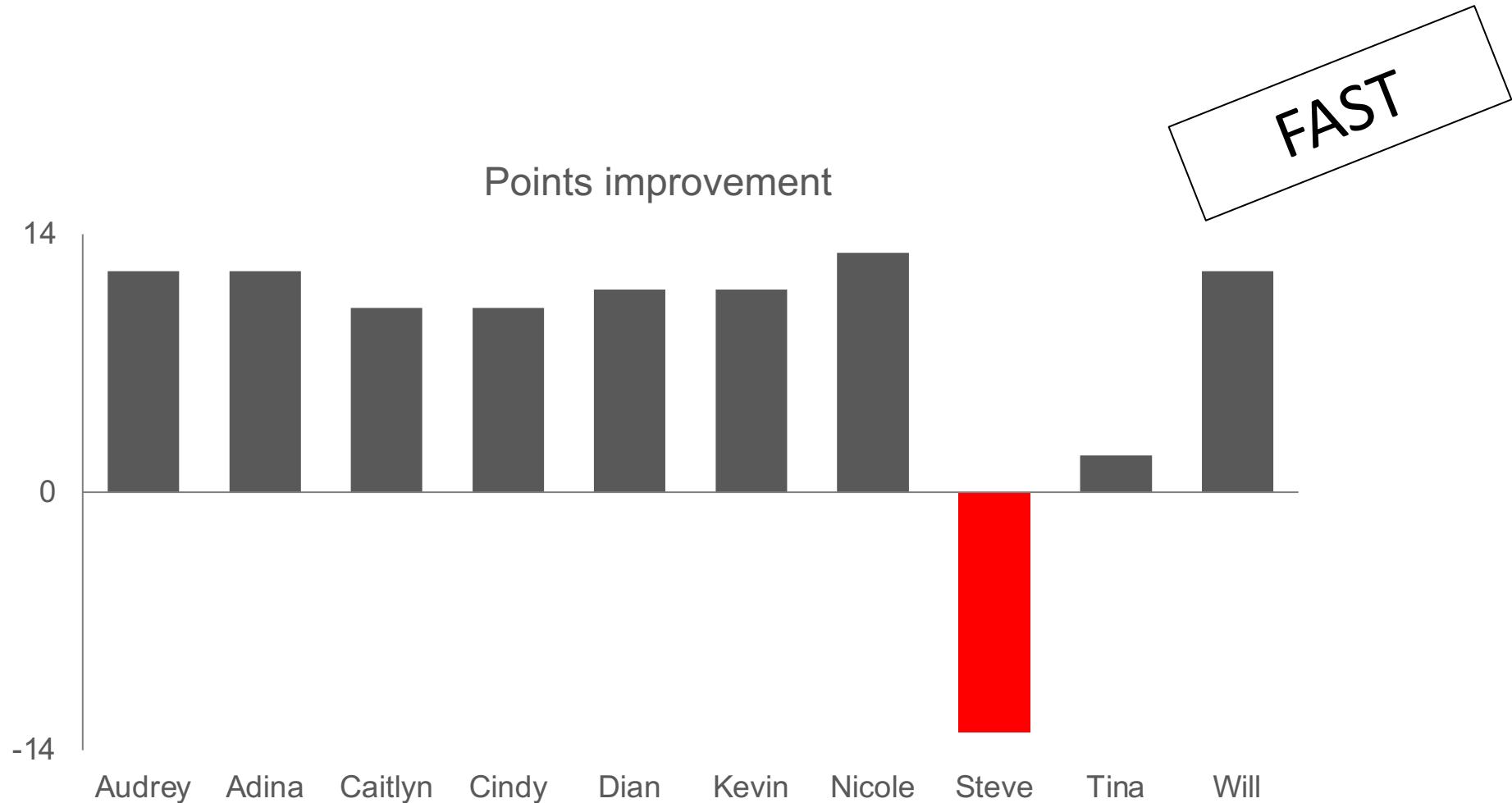
What is the average improvement?



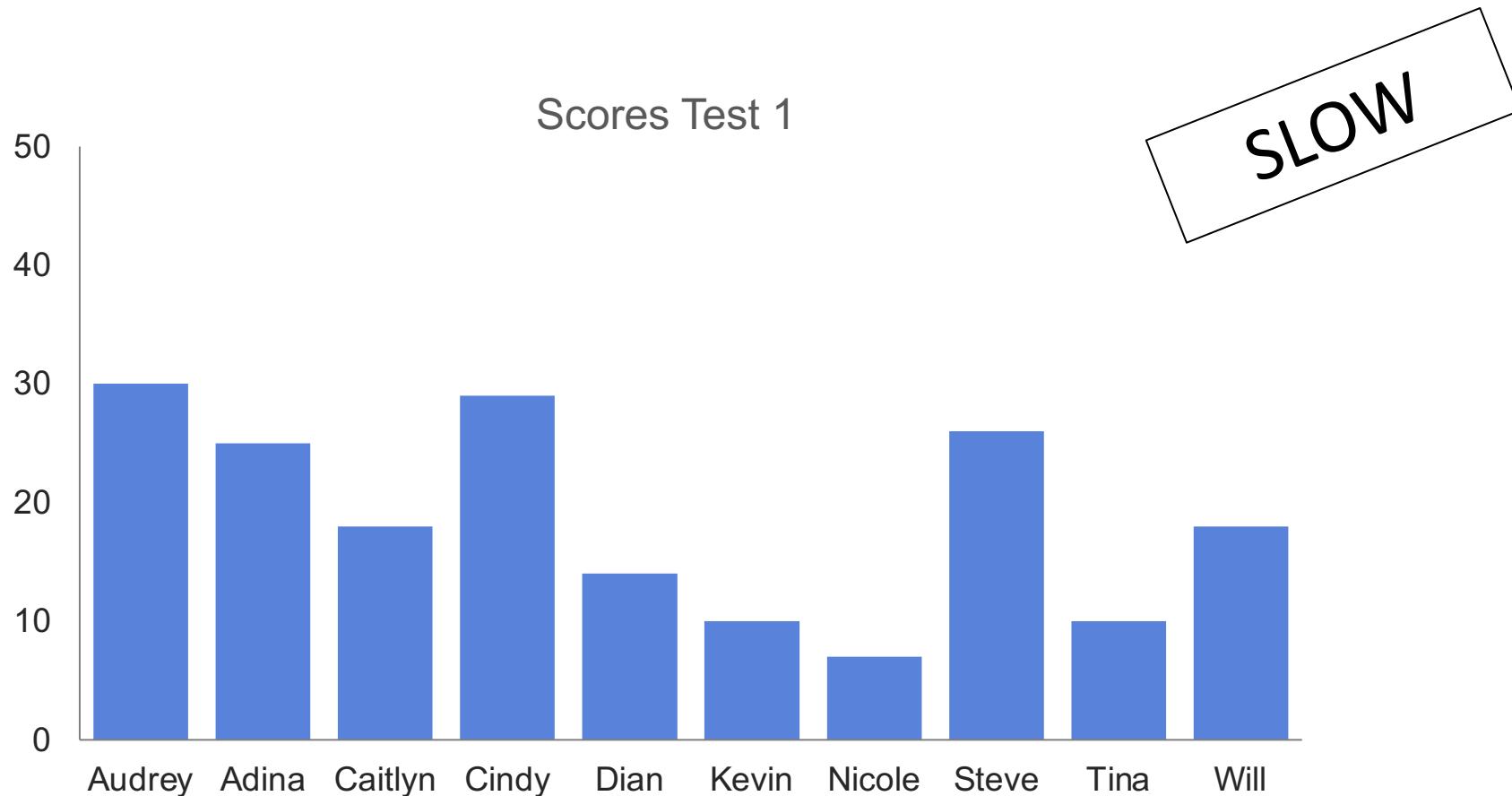
What is the average improvement?



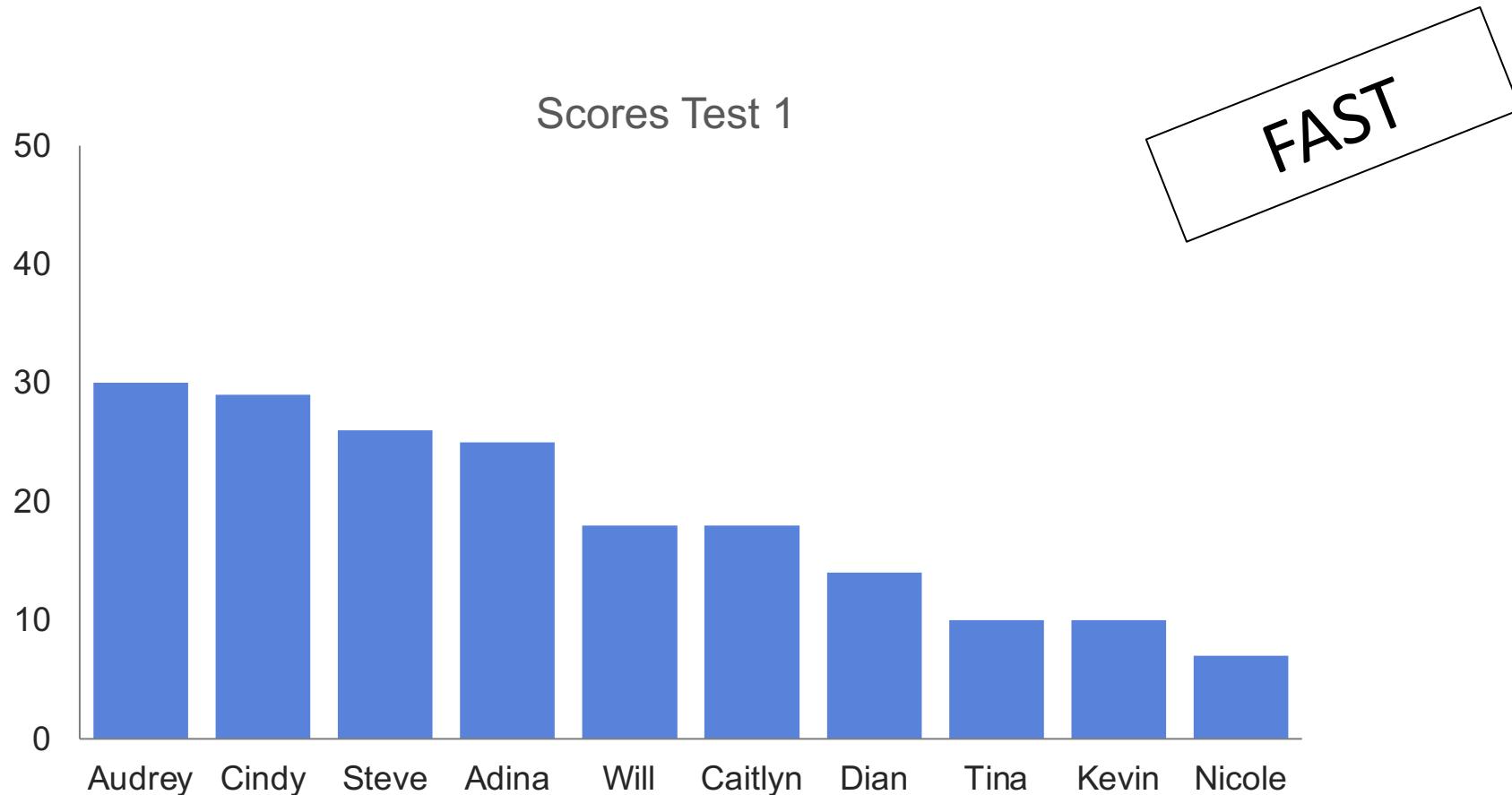
What is the average improvement?



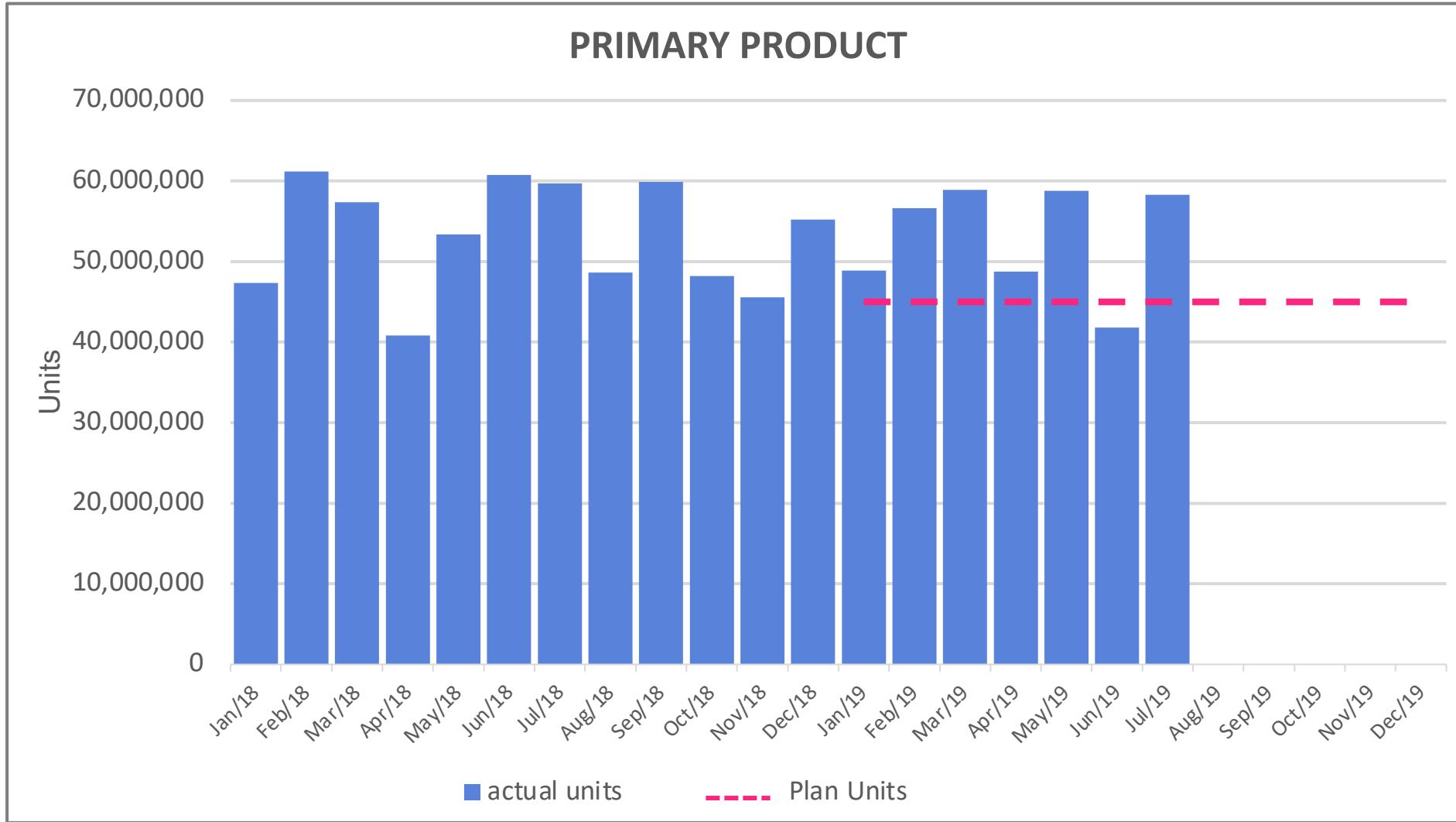
What are the top 5 students?



What are the top 5 students?



What is the message?



What is the message?

PRIMARY PRODUCT: unit sales exceed plan by nearly 20% year to date

Millions of Units

70

60

50

40

30

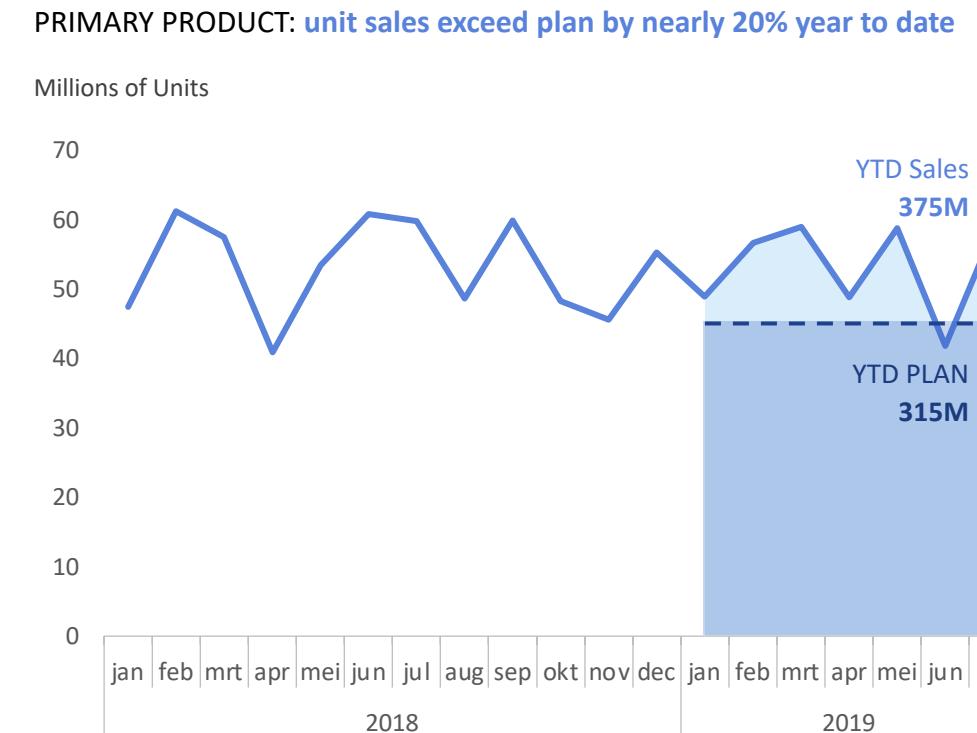
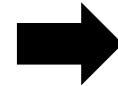
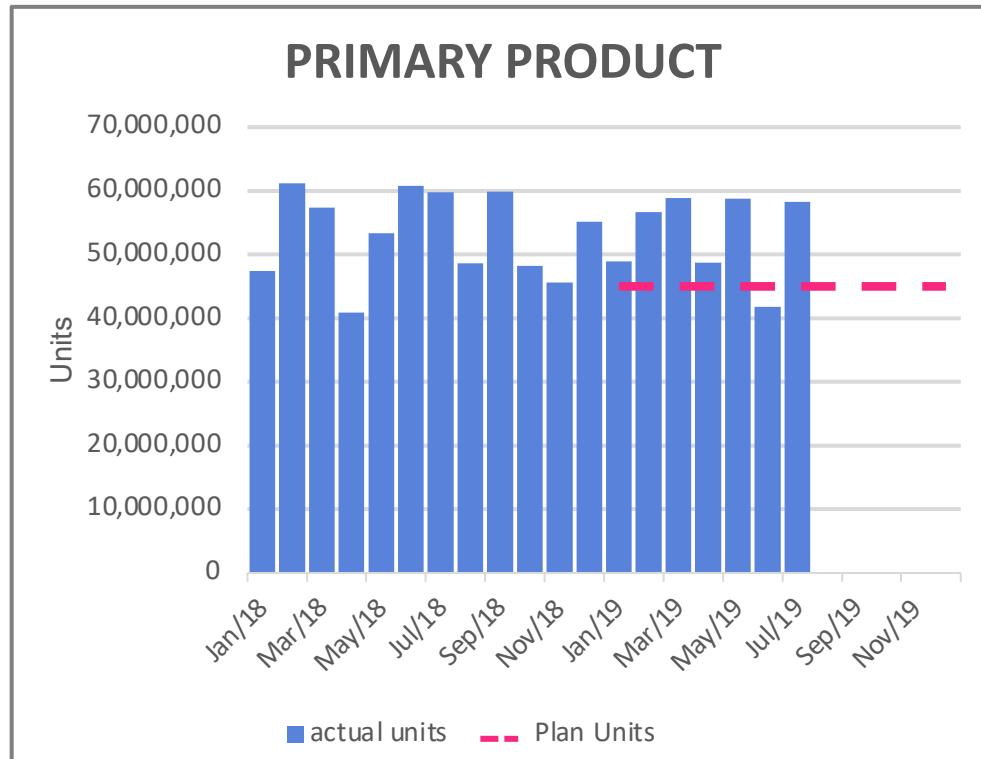
20

10

0



Make-over: Simplify, declutter and add focus



Minimize distraction: reduce ‘non-data ink’



Effective. Not optimal.

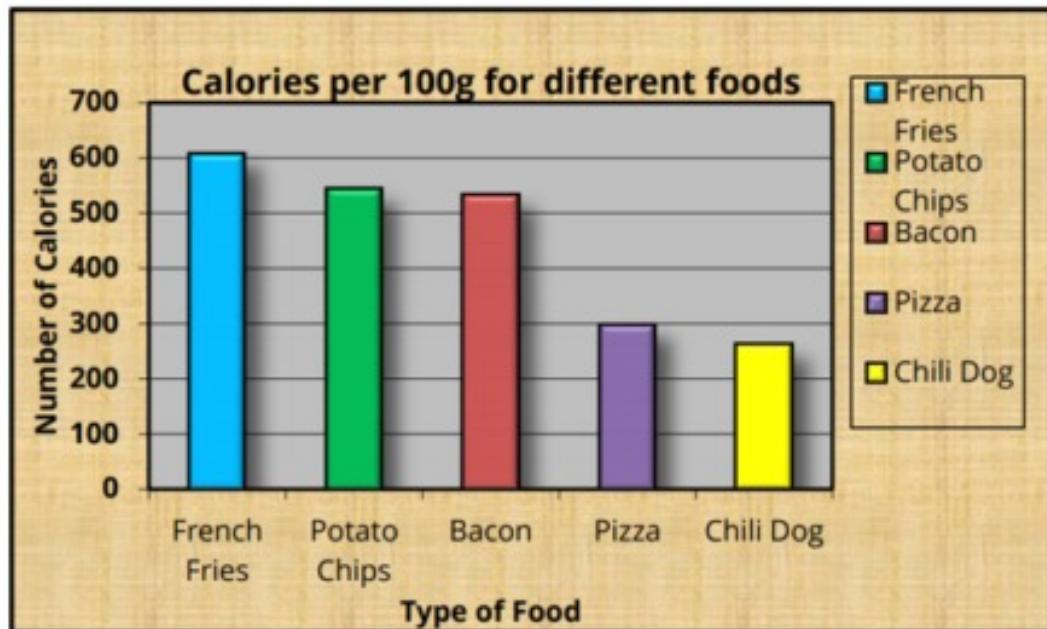


Simple, effective, optimal.

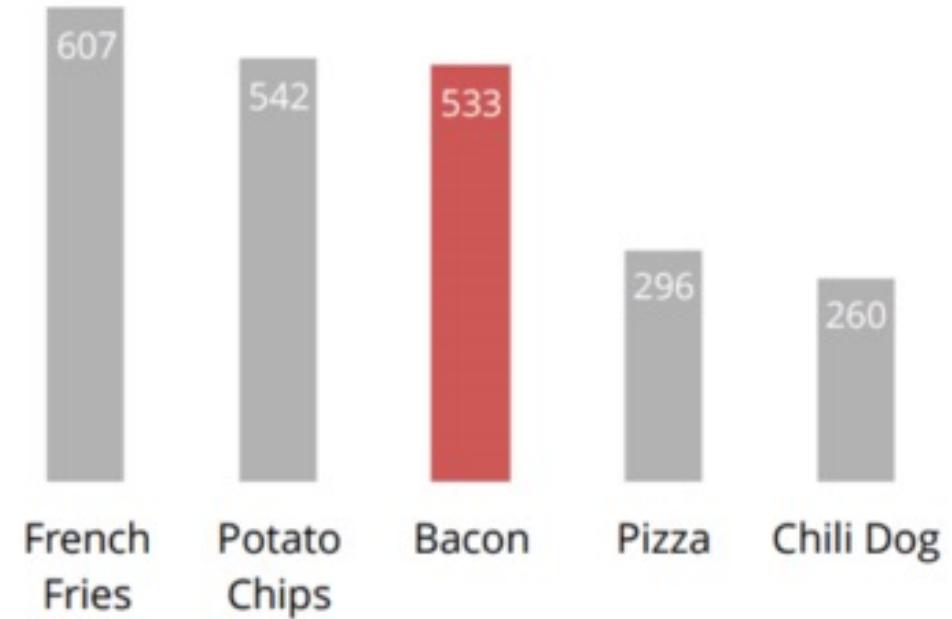


Bad.

Minimize distraction: maximize data-ink ratio



Calories per 100g

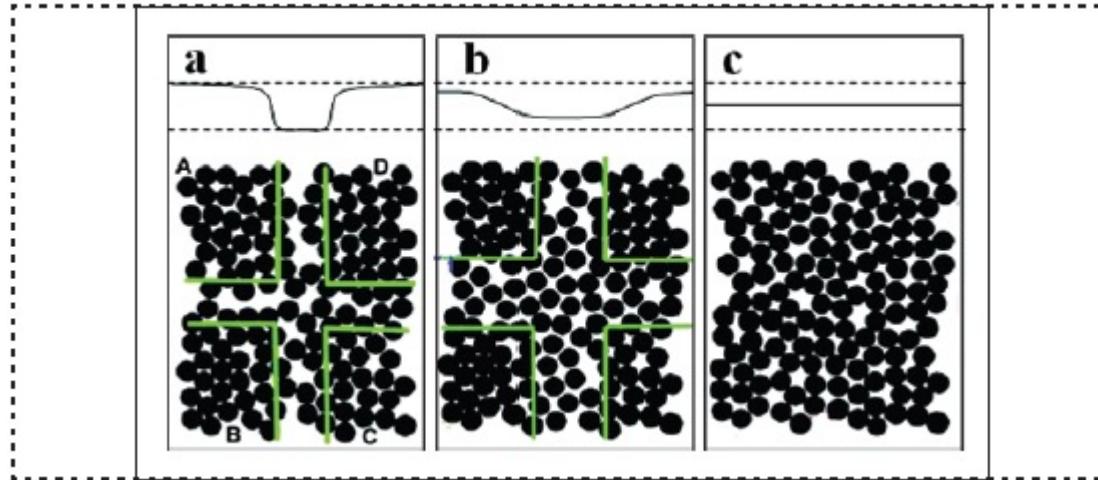


Data-ink ratio also applies to tables

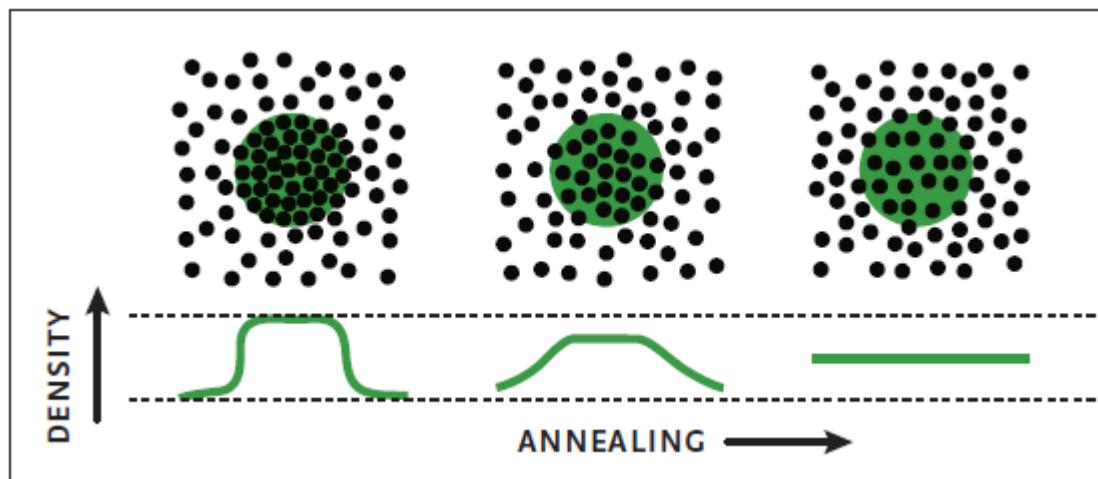
Student	Test1	Test2	Difference
Audrey	30.00	42.00	12.00 pts
Adina	25.00	37.00	12.00 pts
Caitlyn	18.00	28.00	10.00 pts
Cindy	29.00	39.00	10.00 pts
Dian	14.00	25.00	11.00 pts
Kevin	10.00	21.00	11.00 pts
Nicole	7.00	20.00	13.00 pts
Steve	26.00	13.00	-13.00 pts
Tina	10.00	12.00	2.00 pts
Will	18.00	30.00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

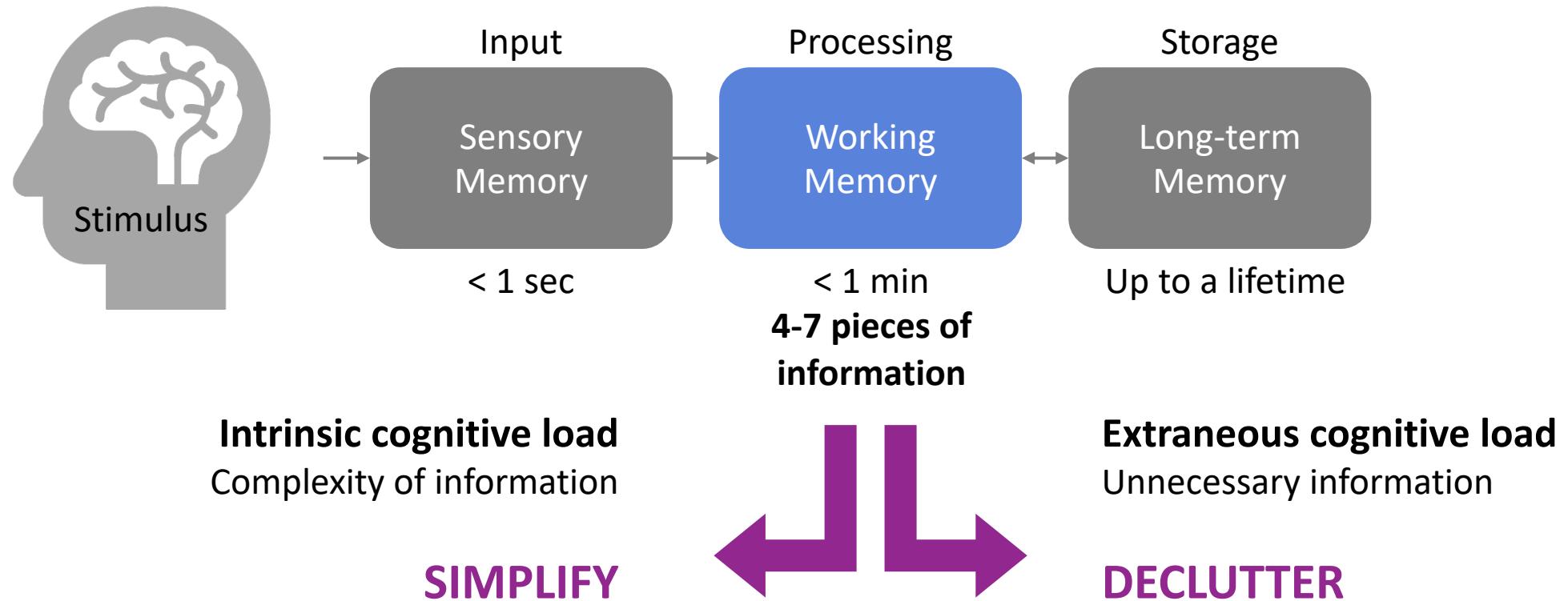


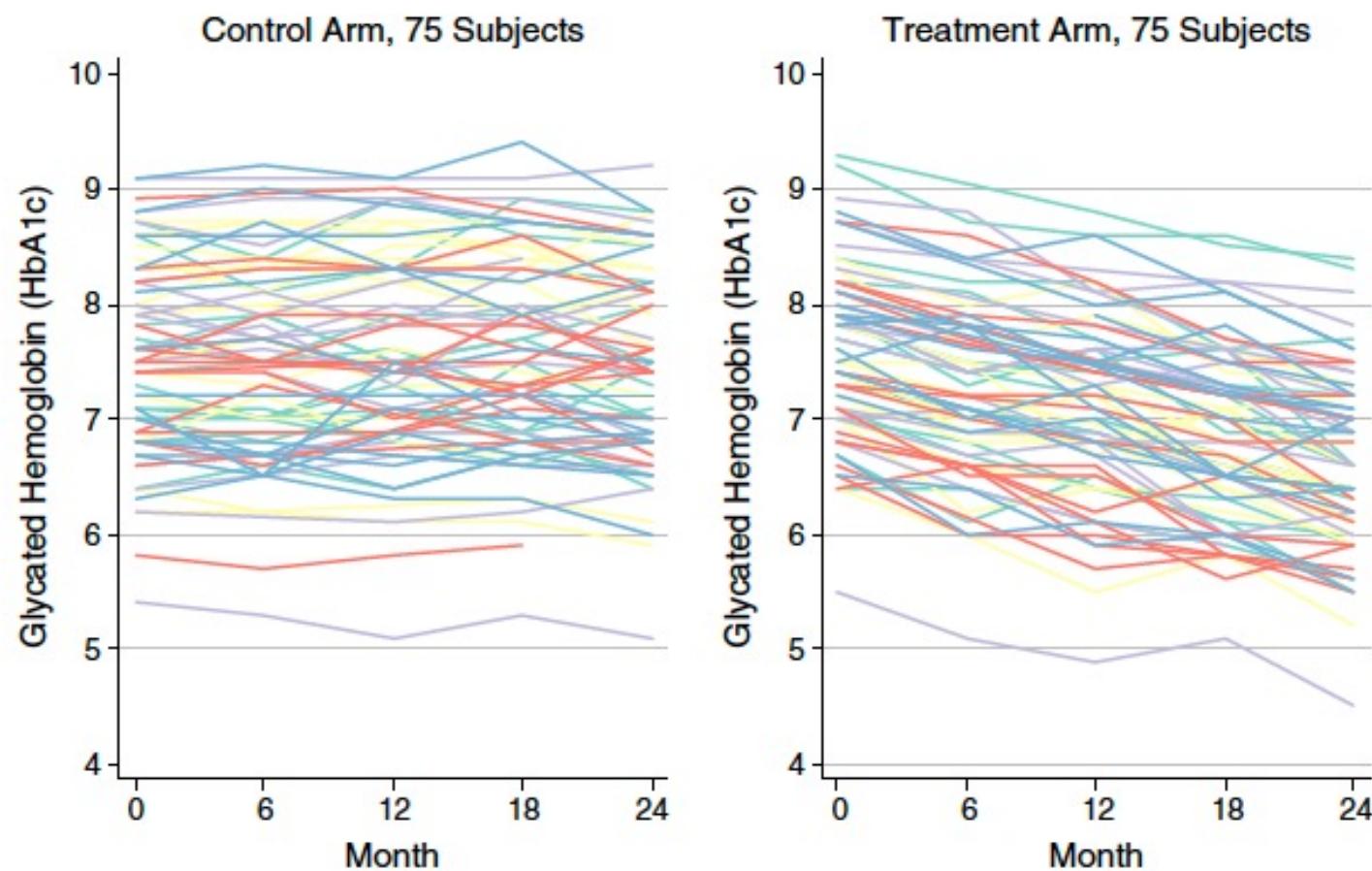
Too many interior boxes clutter the layout.

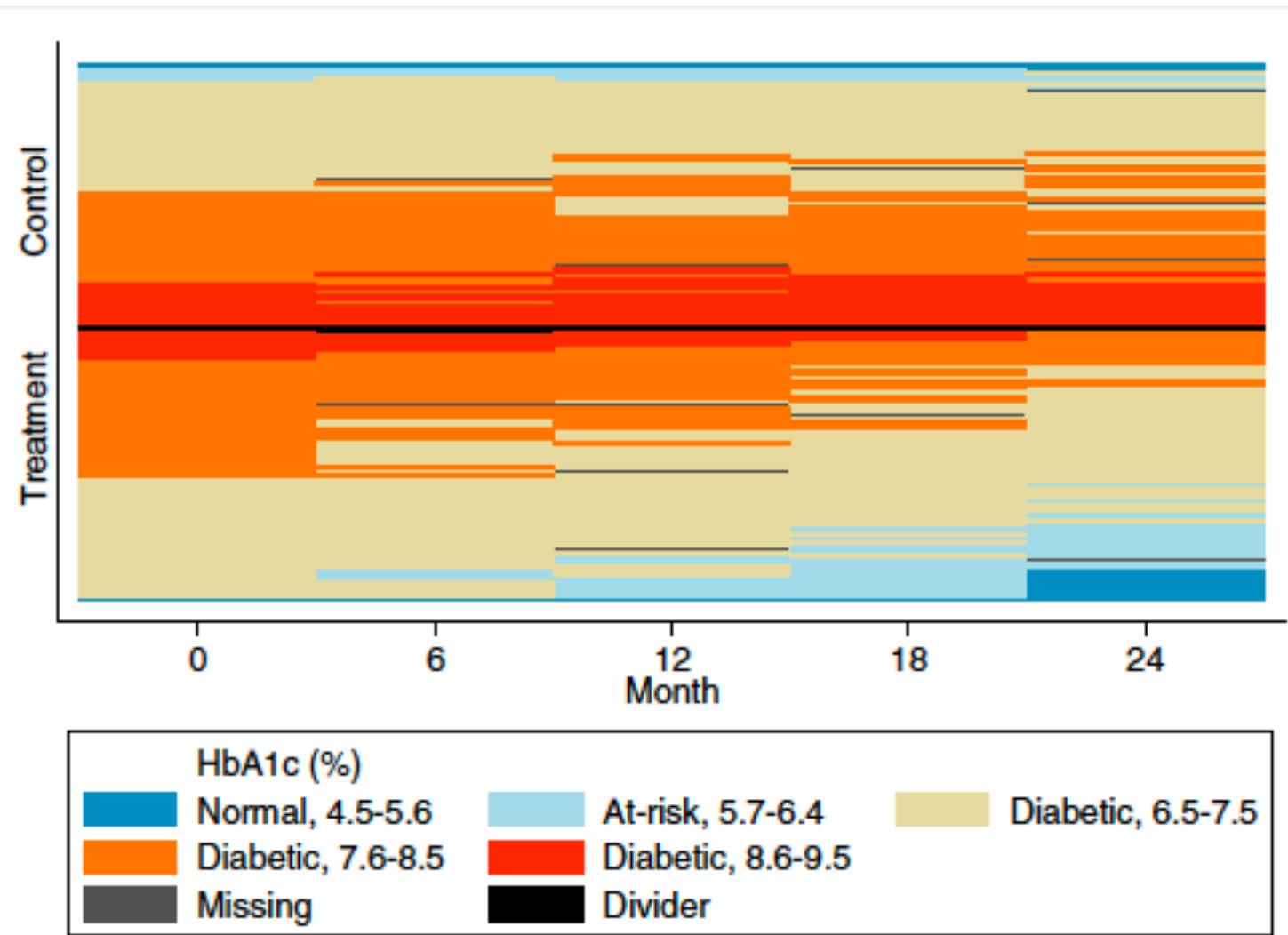
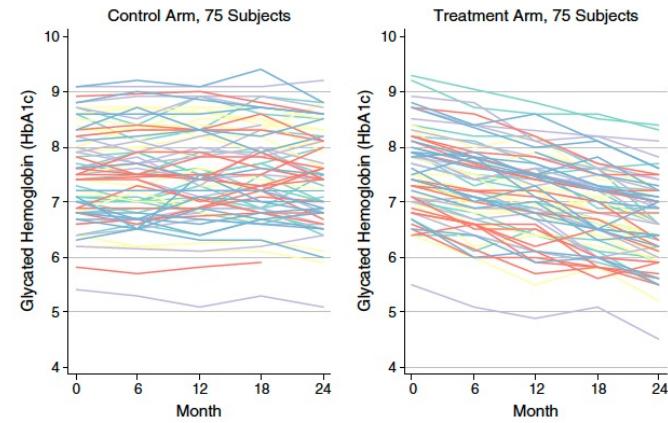


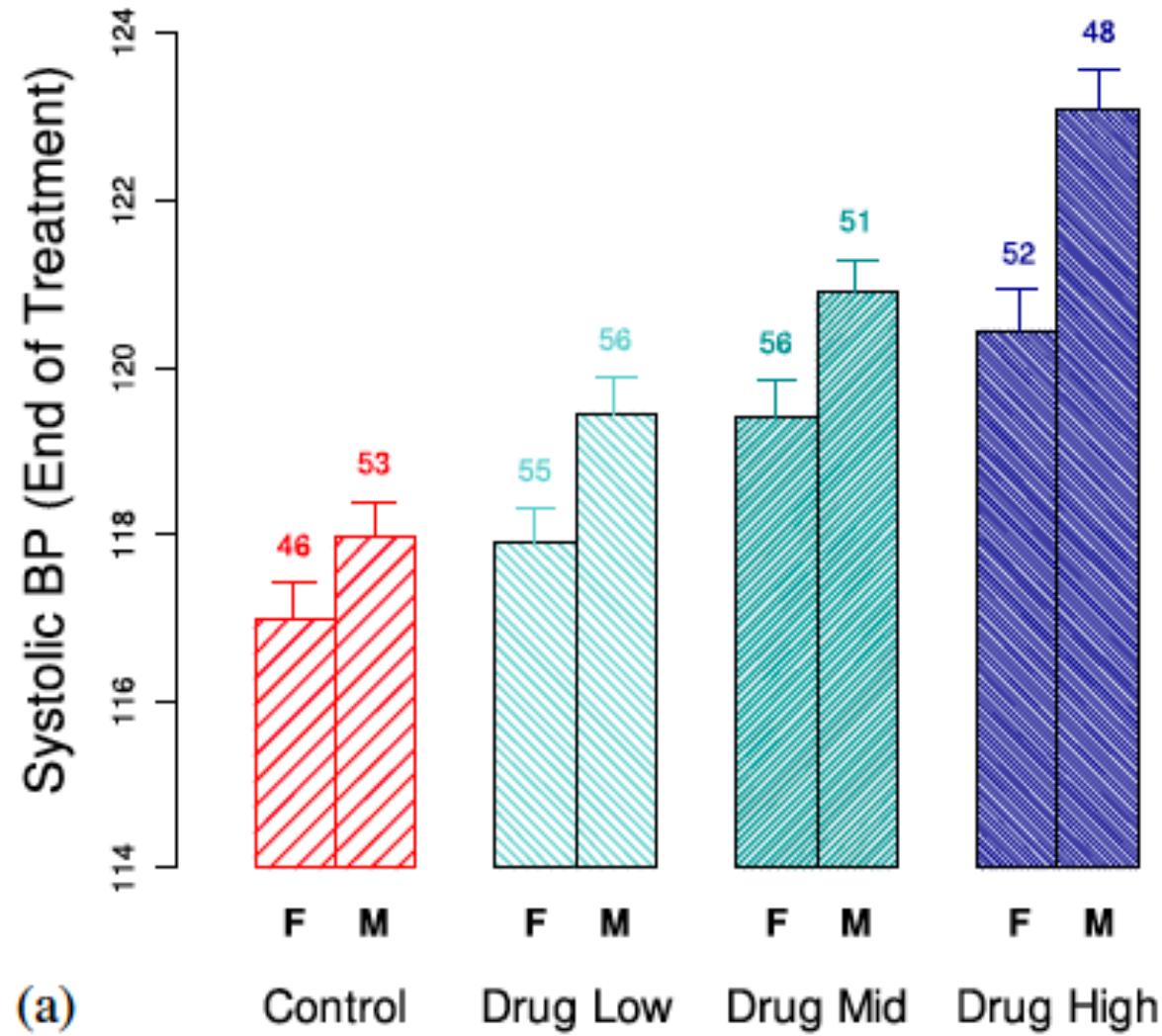
Boxes removed and arrows simplified.

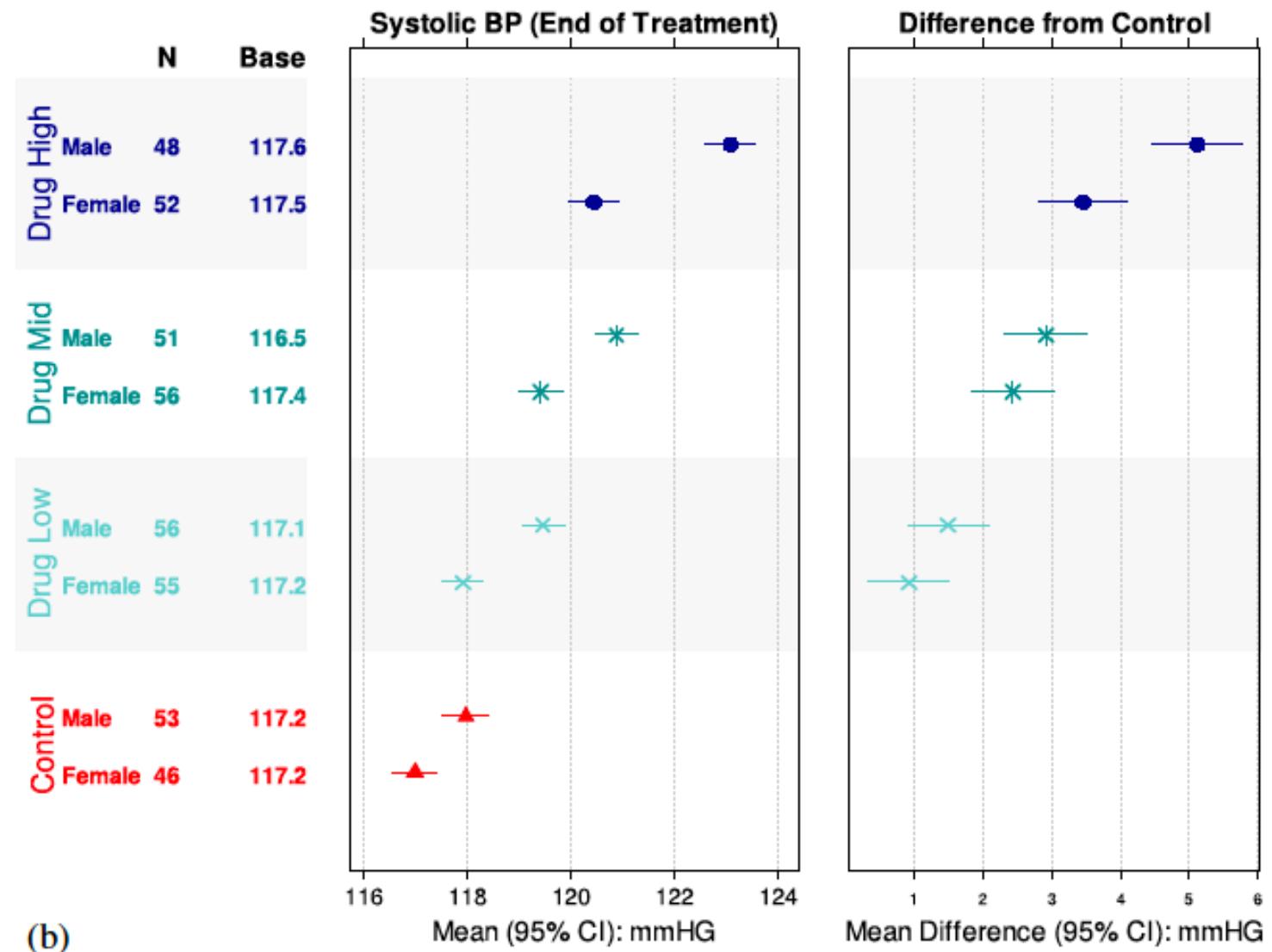
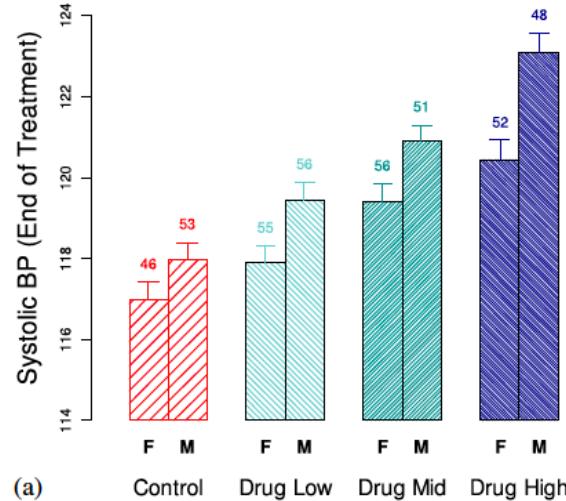
Optimize visual perception: minimize *intrinsic* and *extraneous cognitive load*

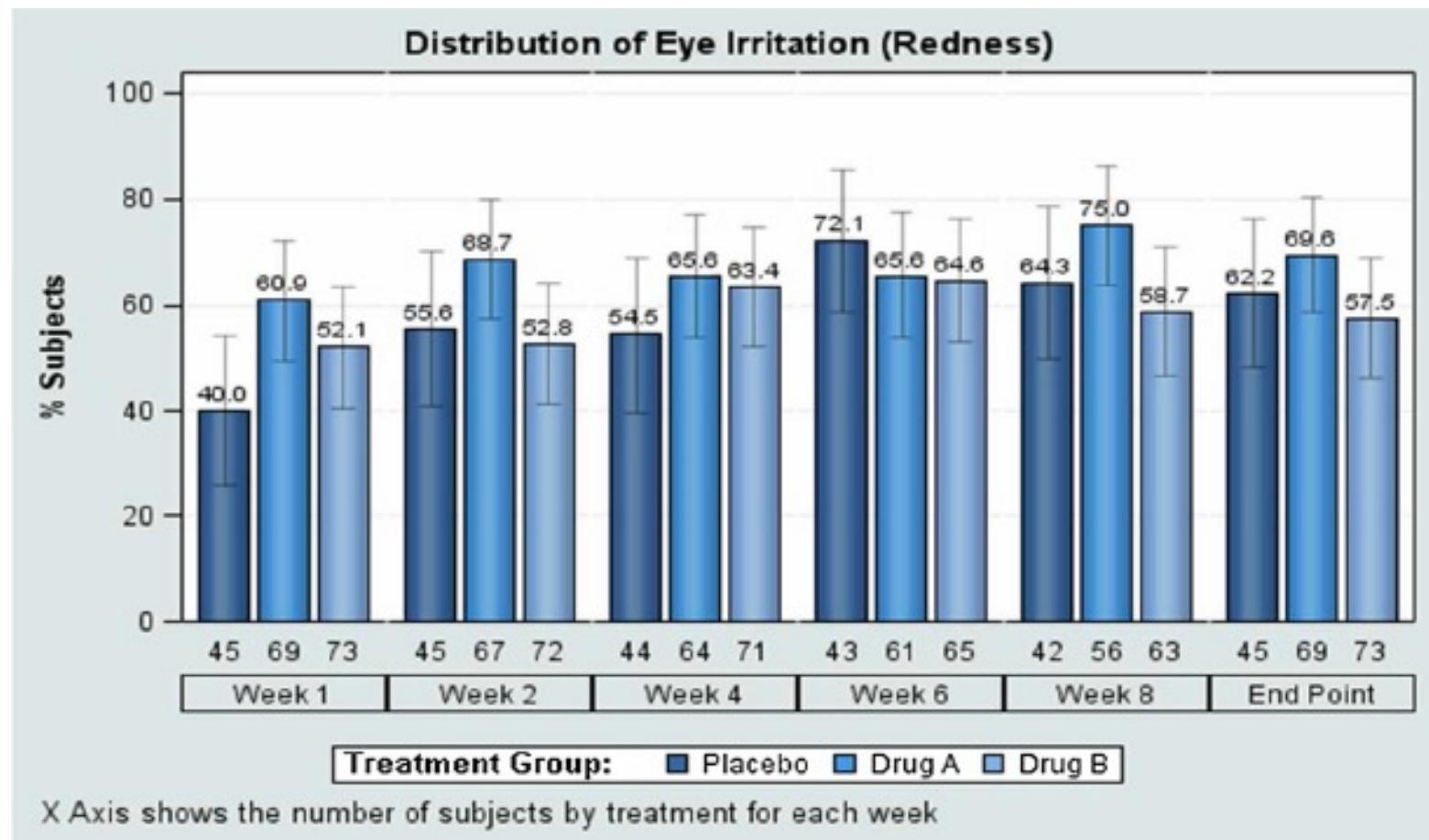


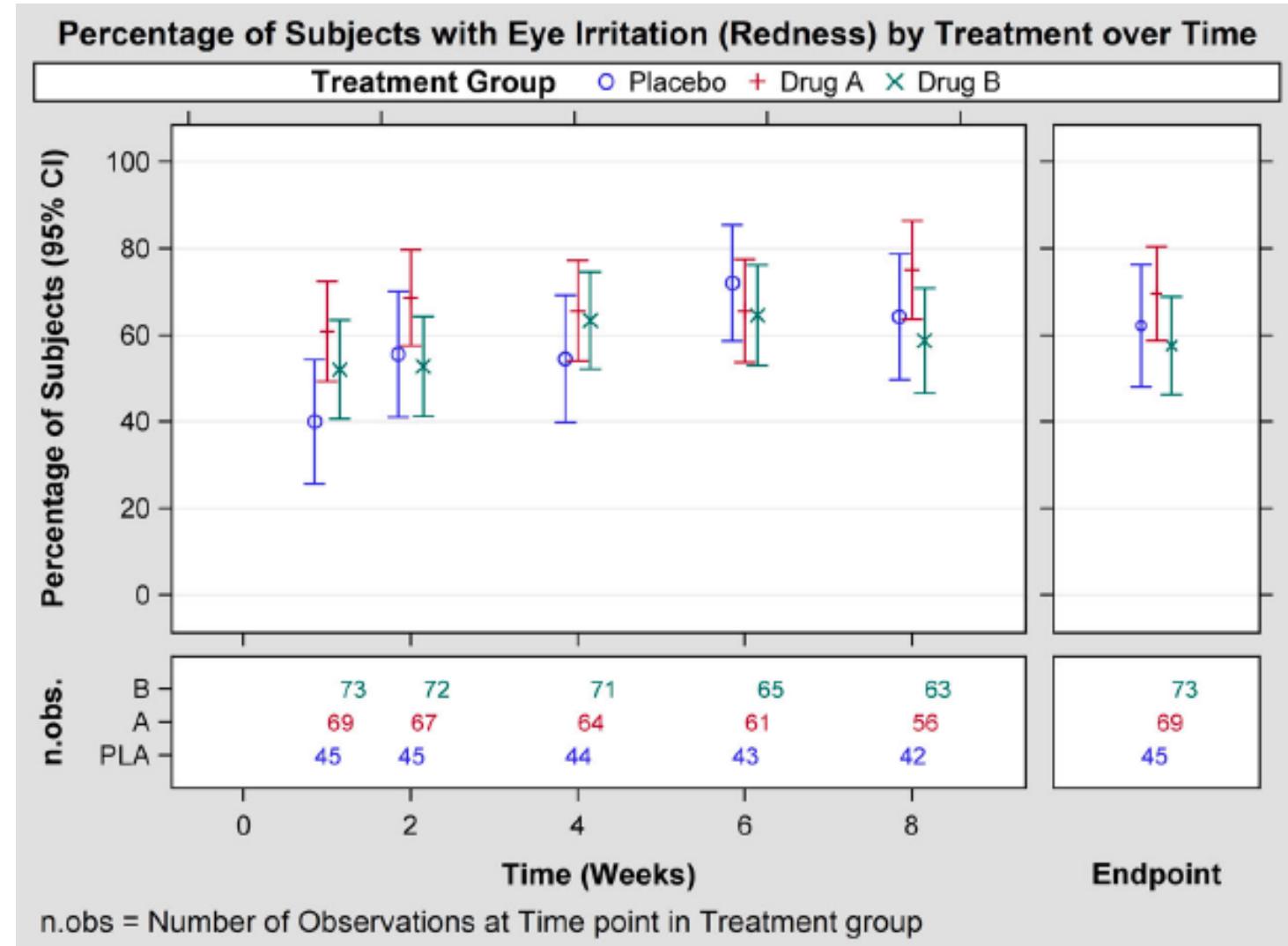
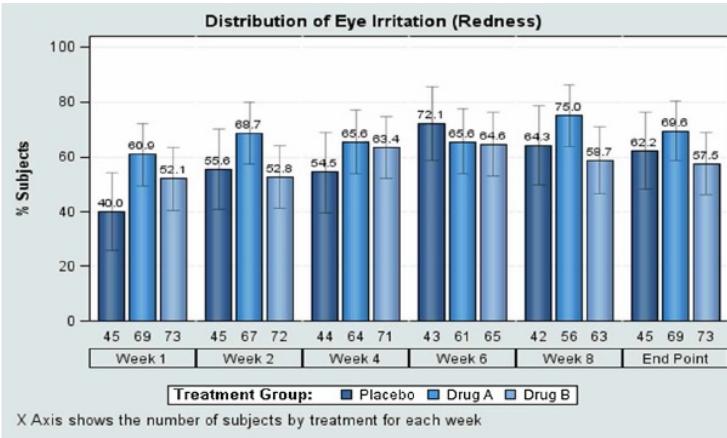














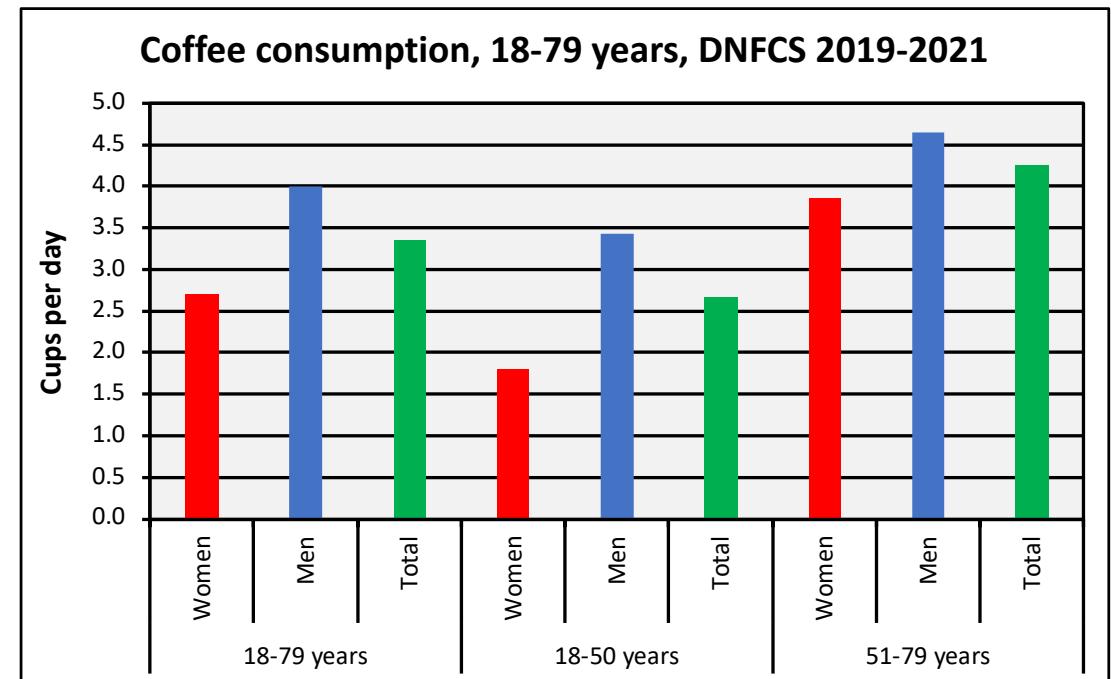
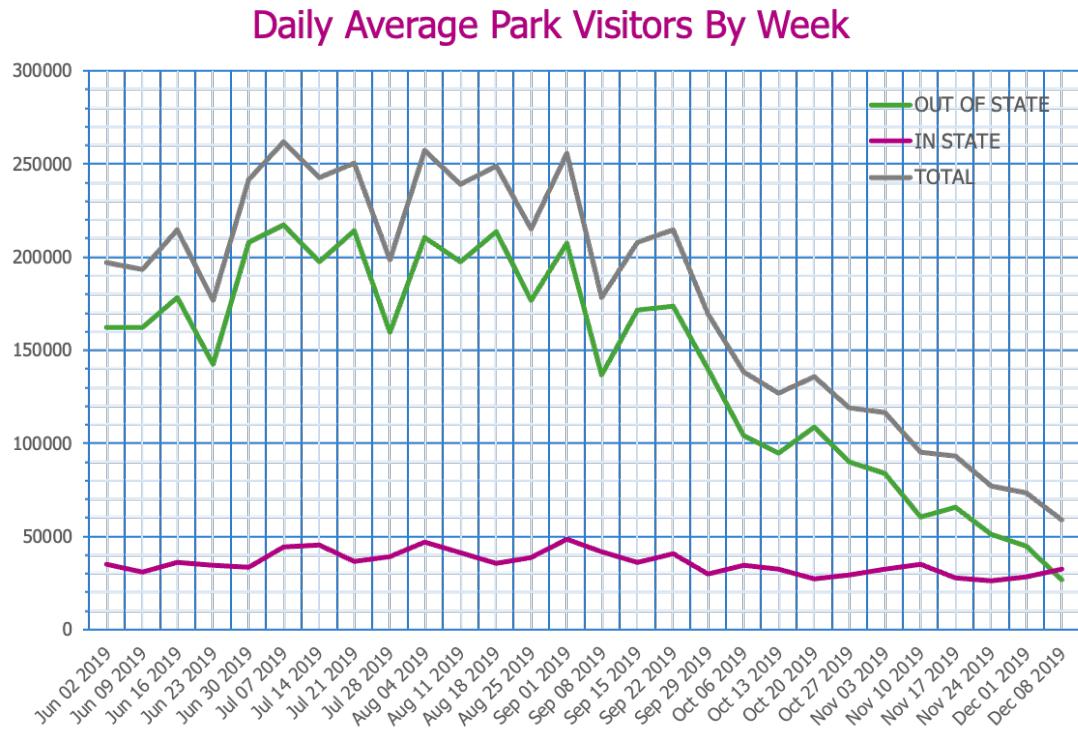
<https://declutterme.london>

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?



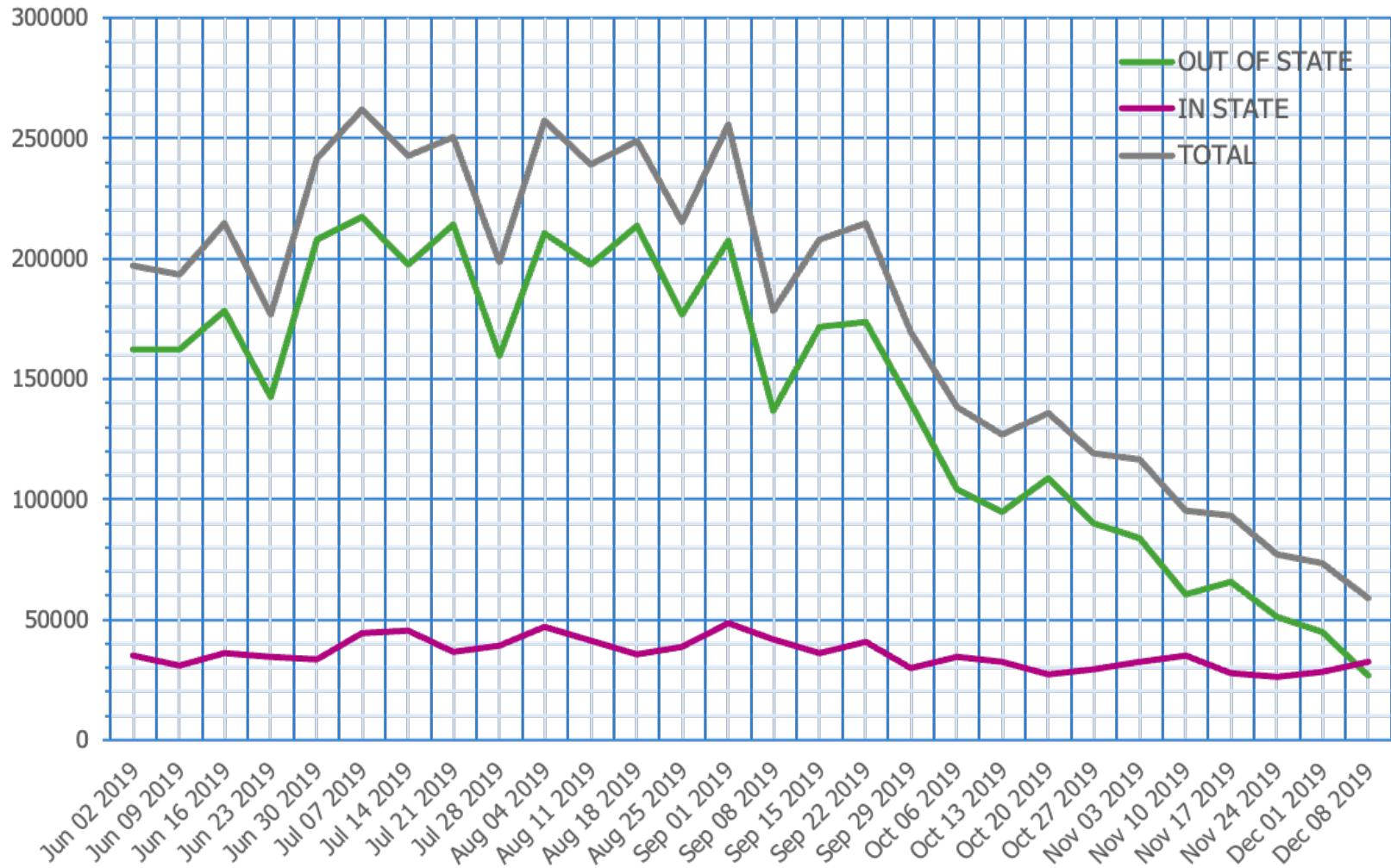
10 min

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?

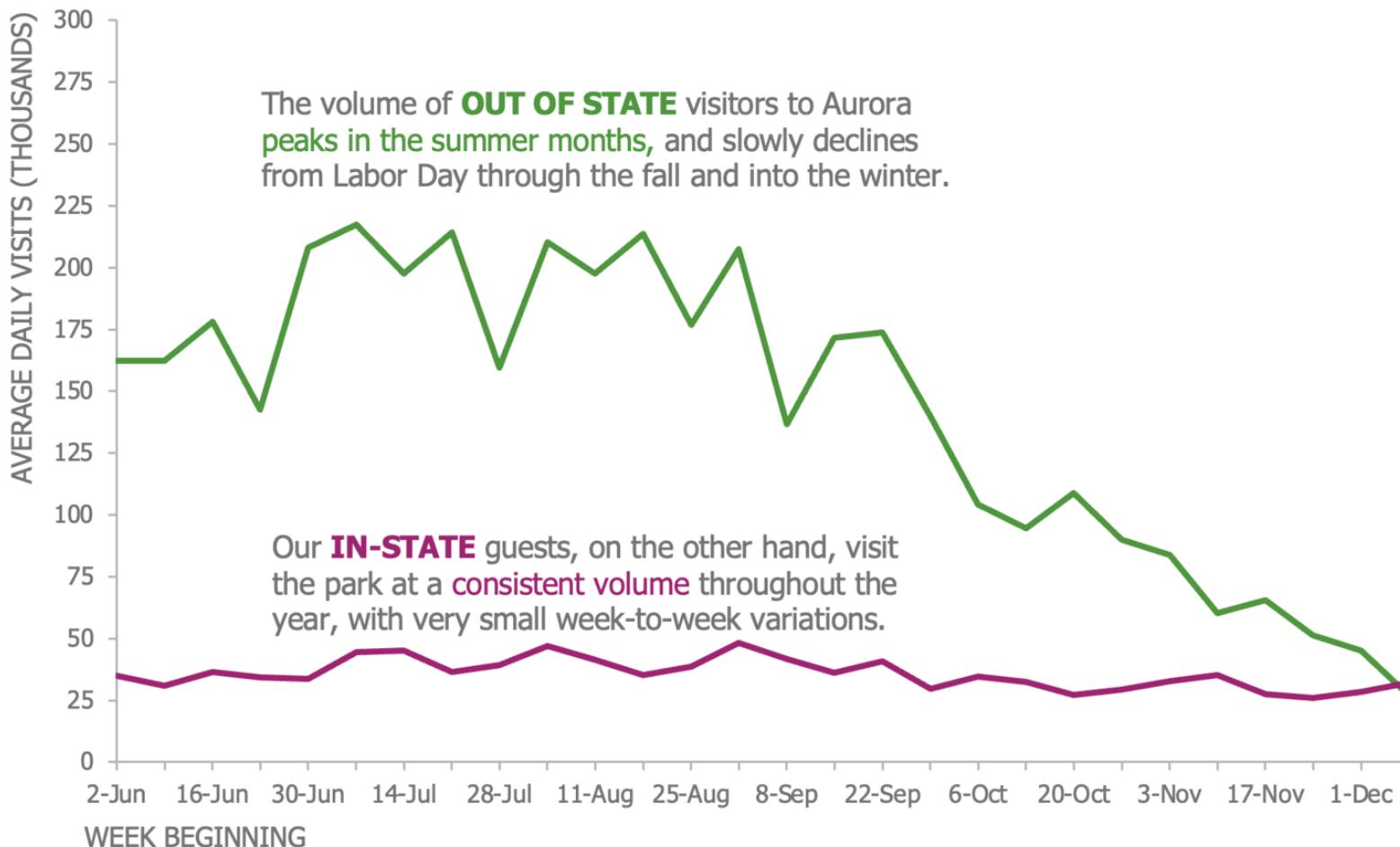


Daily Average Park Visitors By Week



Daily visitors to Aurora Park in summer/fall 2019

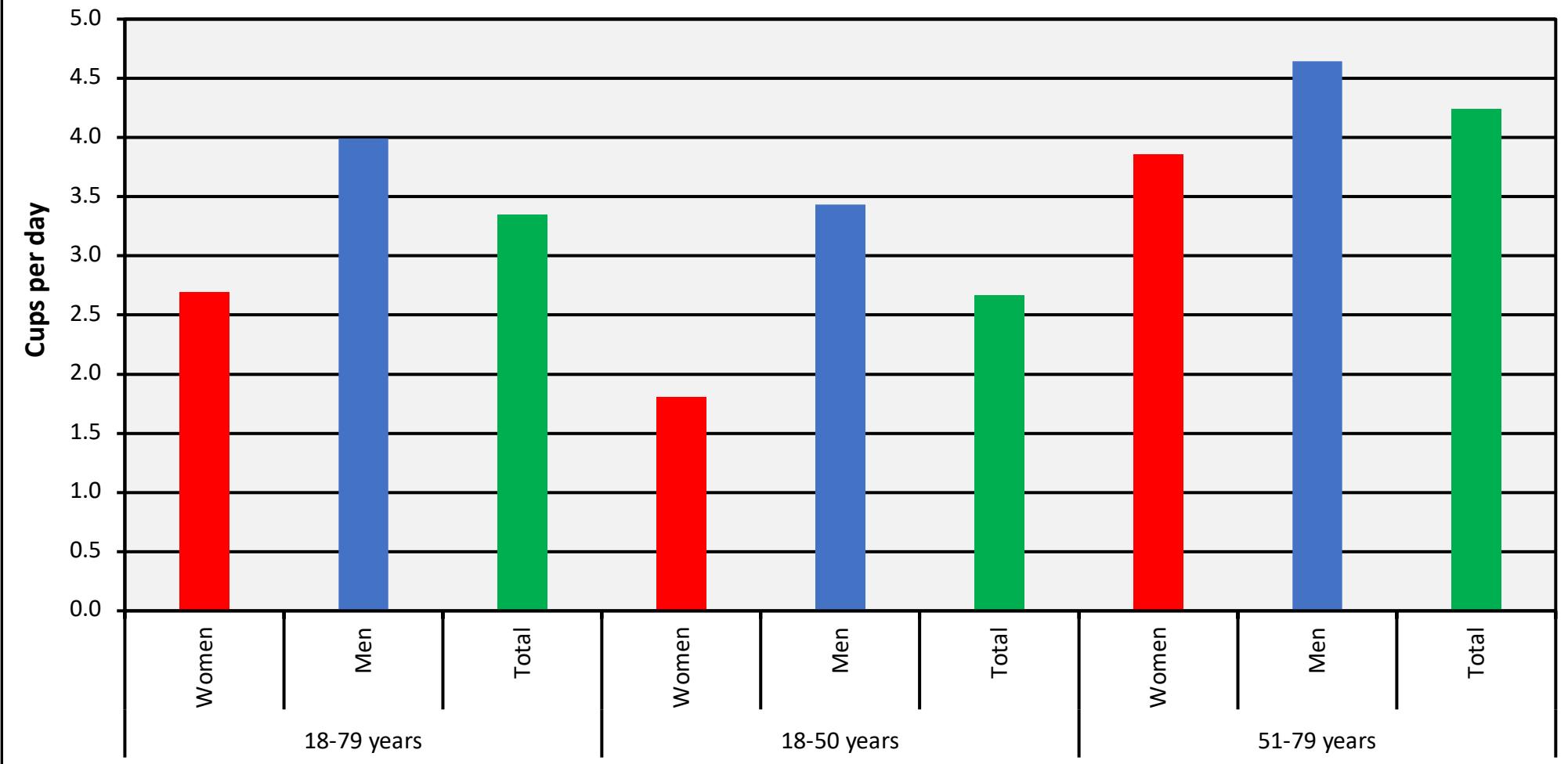
VALUES ARE CALCULATED WEEKLY AS A 7-DAY AVERAGE



The volume of **OUT OF STATE** visitors to Aurora peaks in the summer months, and slowly declines from Labor Day through the fall and into the winter.

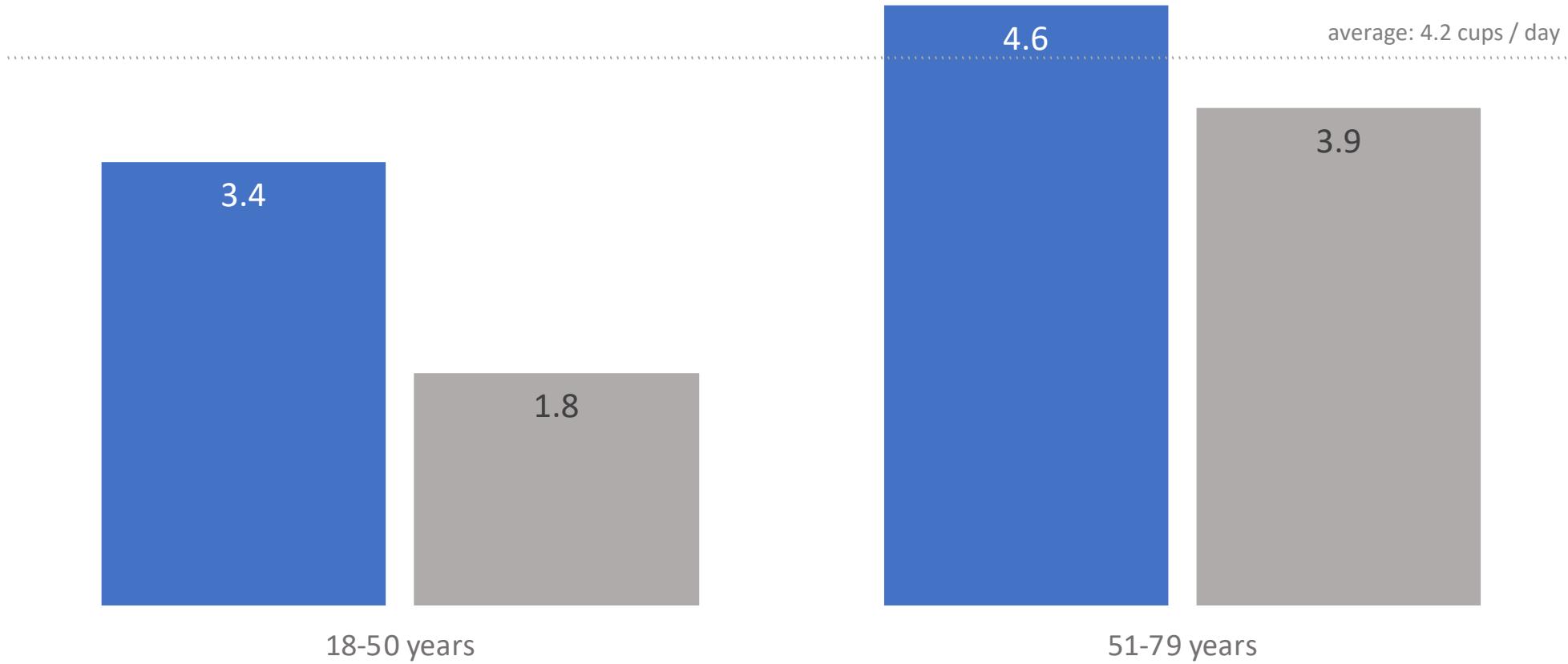
Our **IN-STATE** guests, on the other hand, visit the park at a **consistent volume** throughout the year, with very small week-to-week variations.

Coffee consumption, 18-79 years, DNFCS 2019-2021



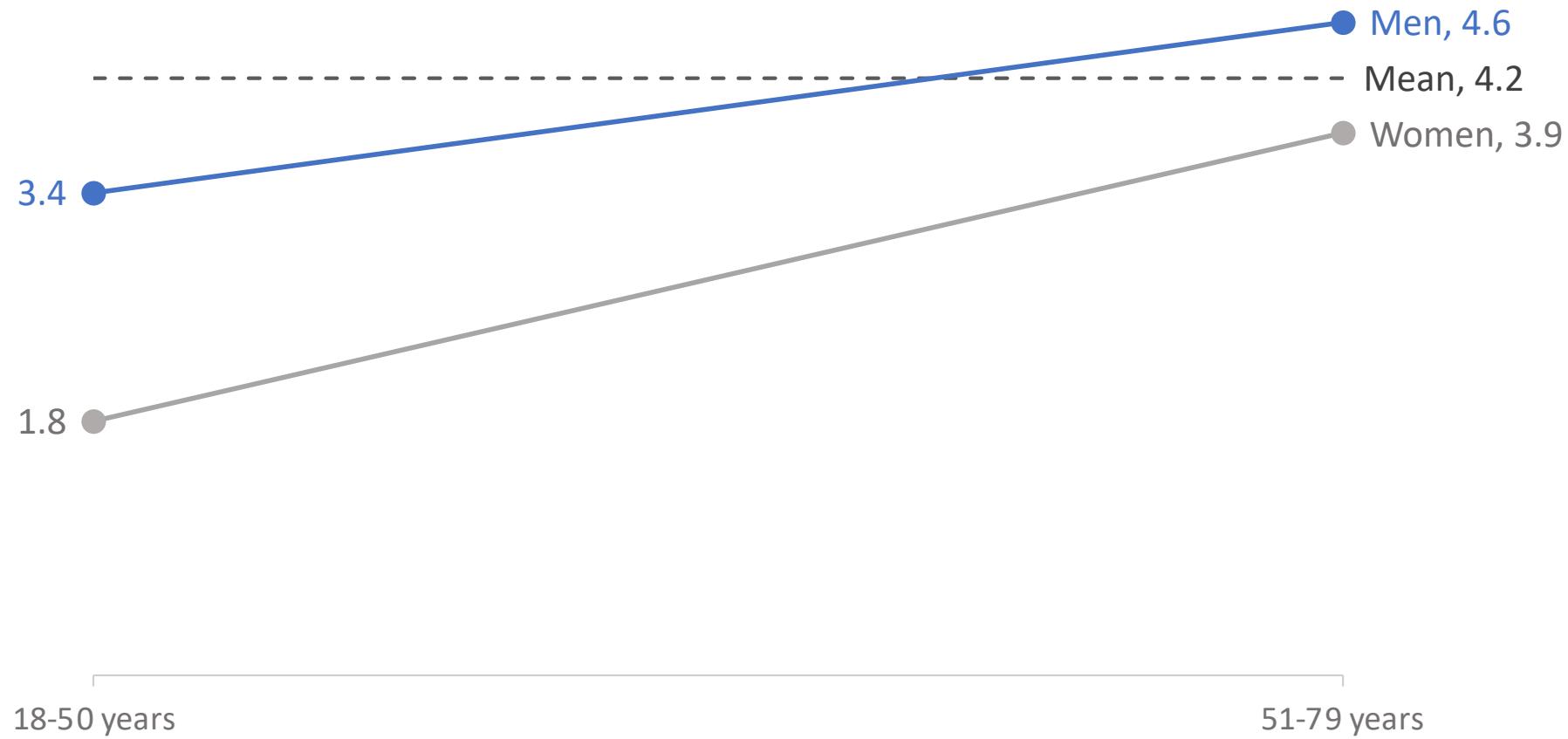
Men drink more coffee than women

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



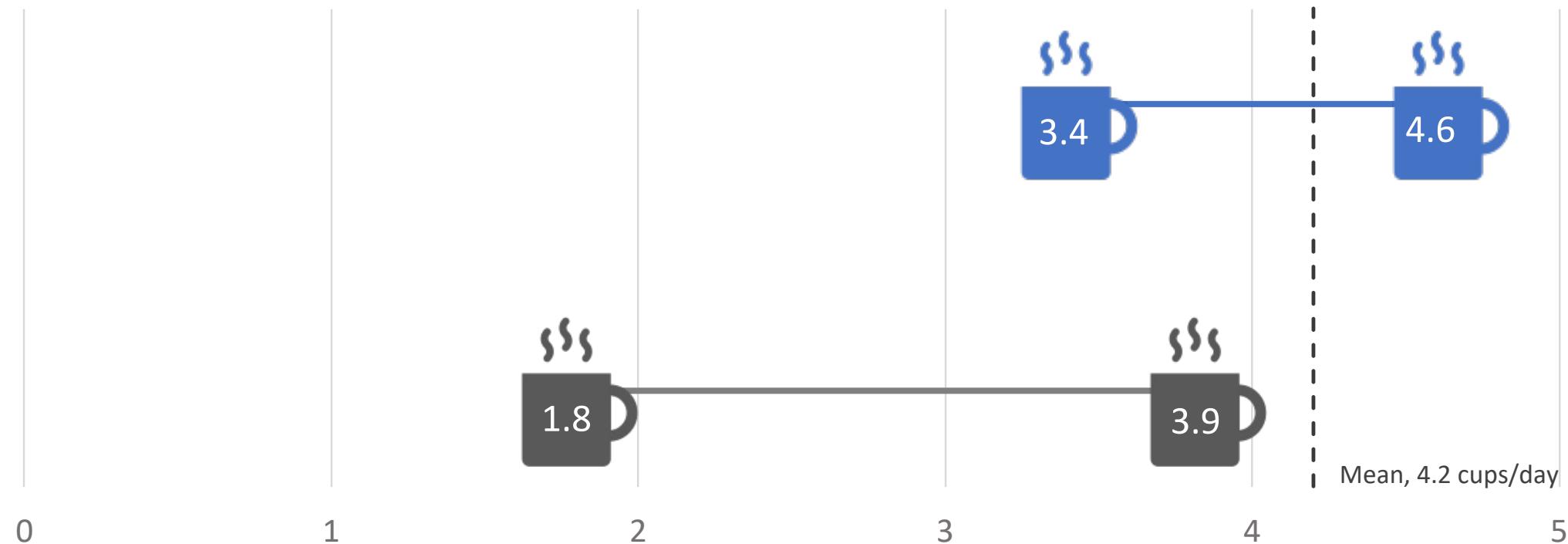
Men drink more coffee than women

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



Men drink more coffee than women

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



Color!

Notice. Wonder. Improve.

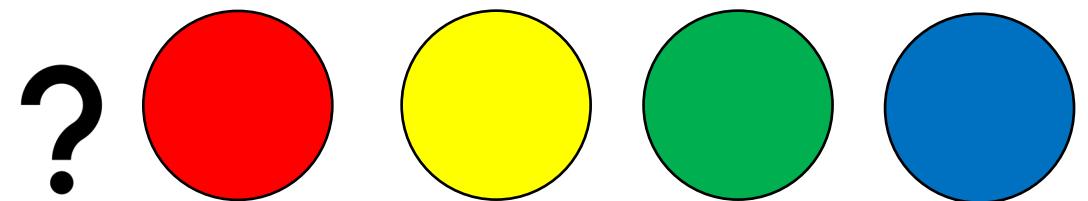
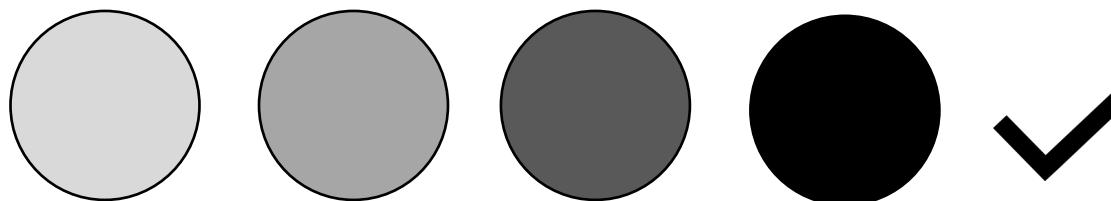
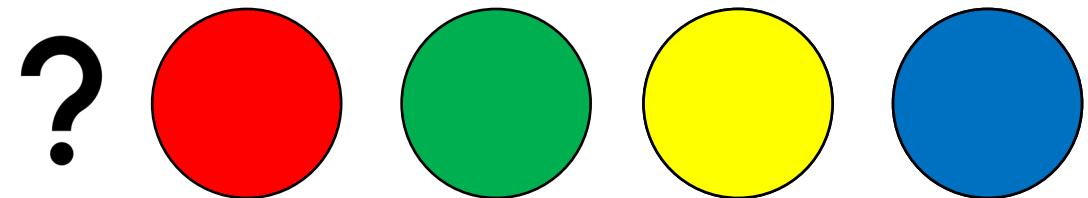
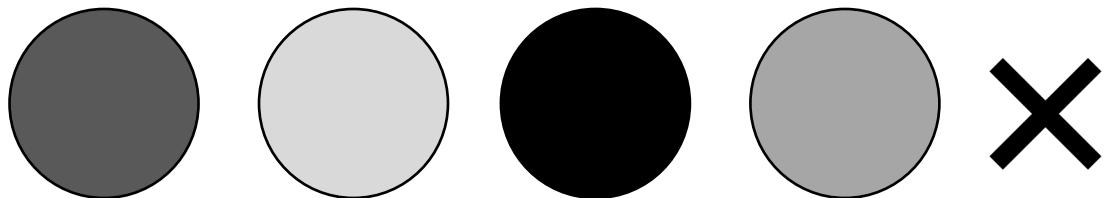
A look at your work.



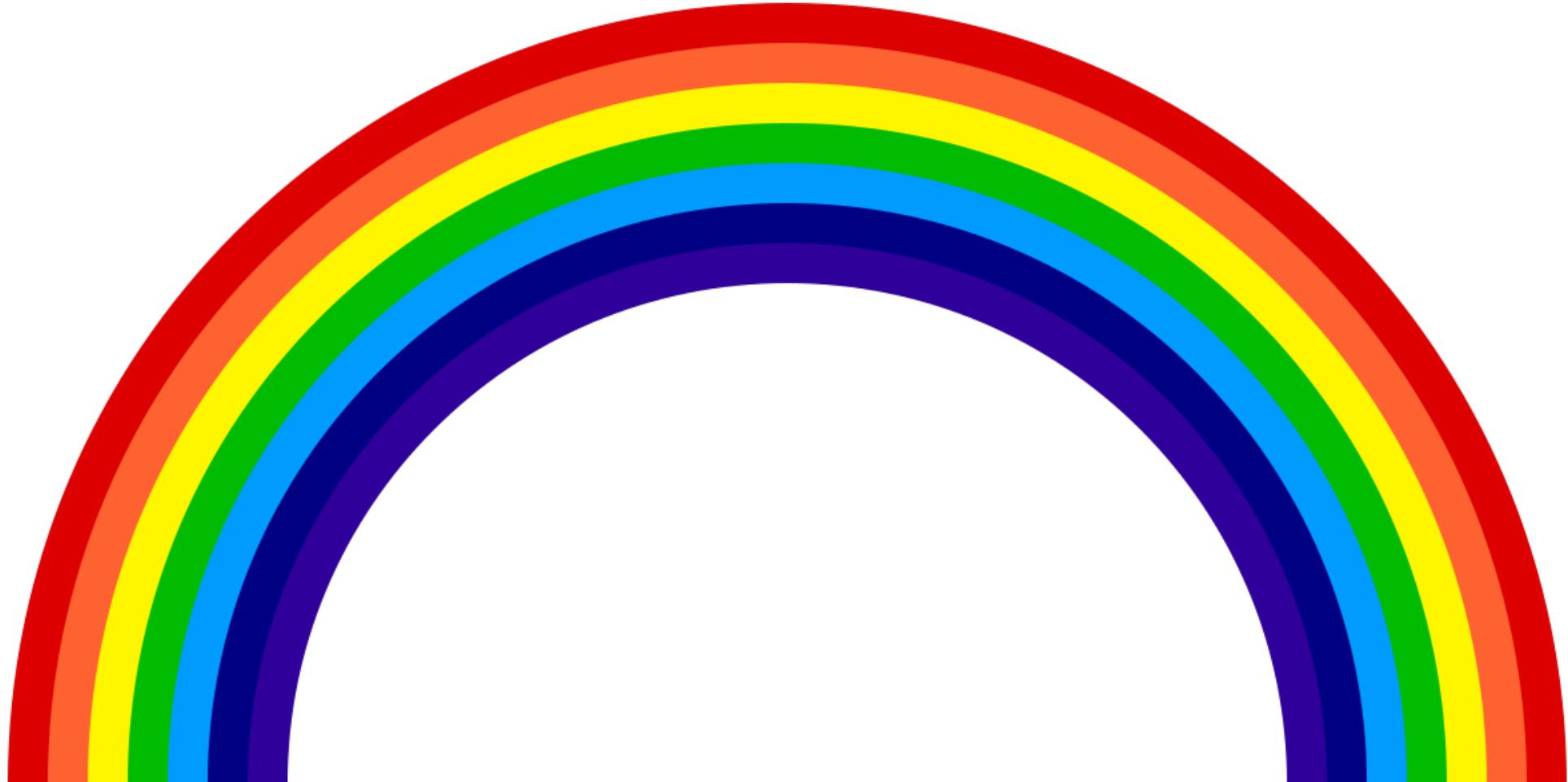
How to rank those circles from low to high?



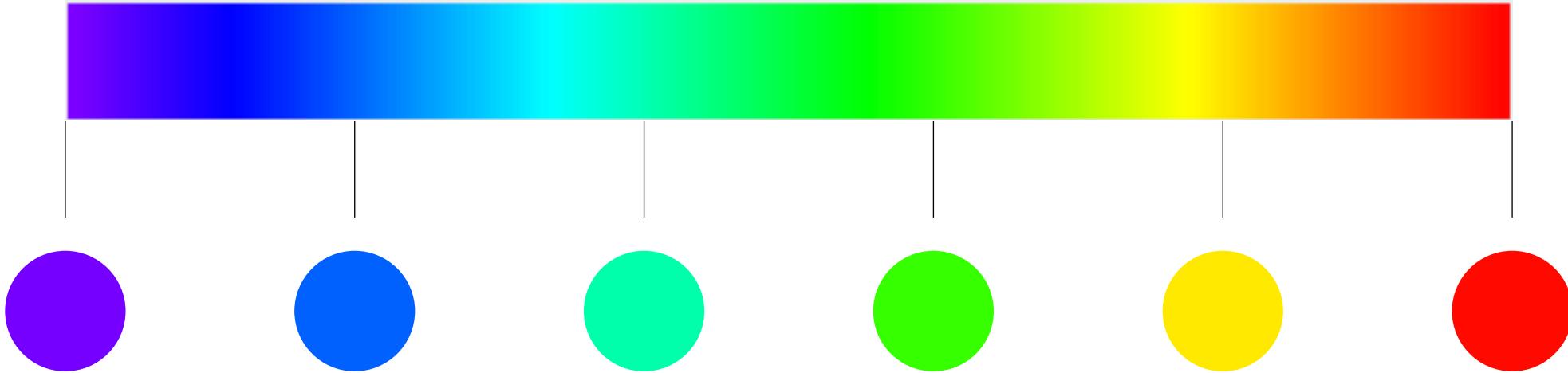
How to rank those circles from low to high?



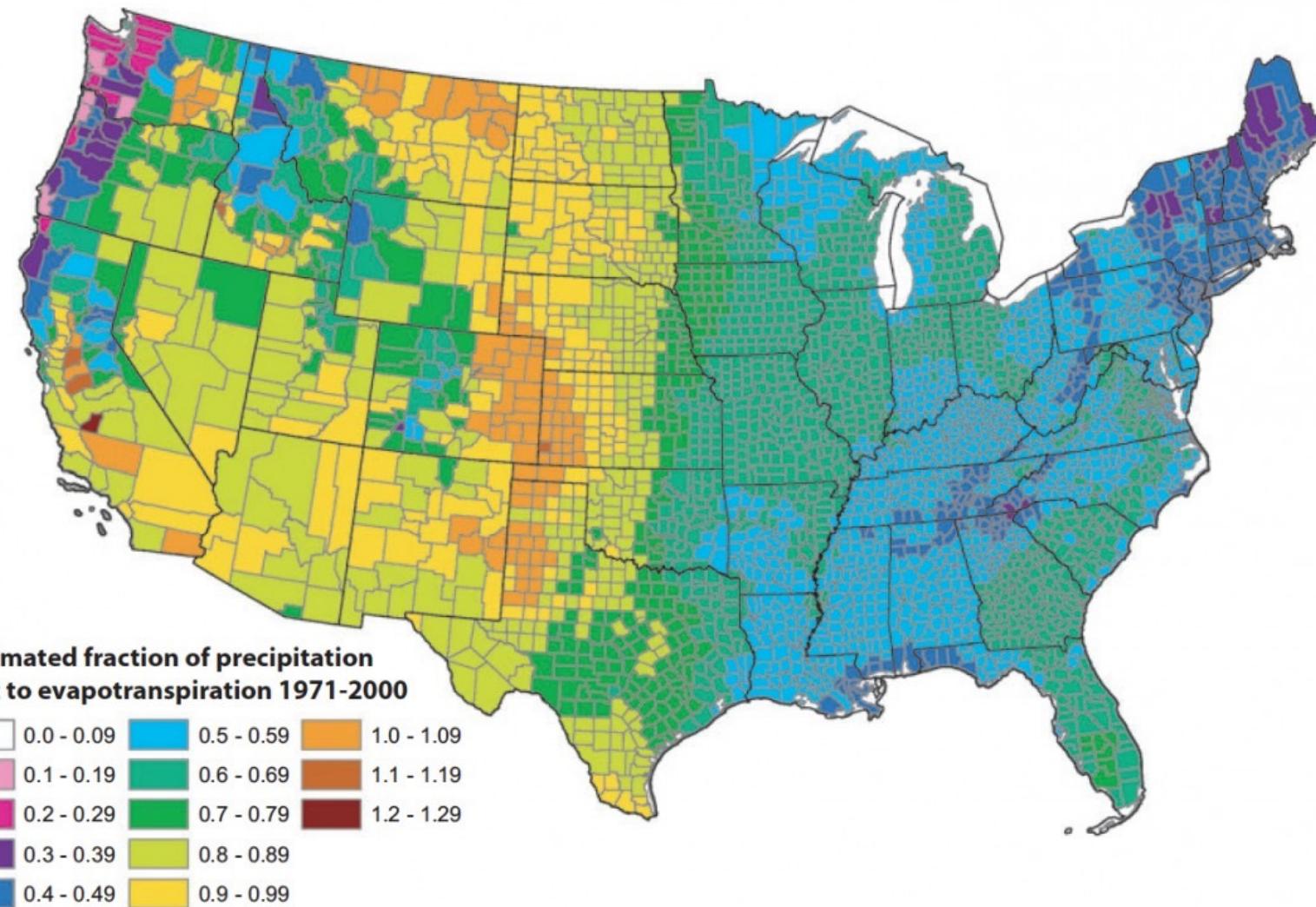
What's wrong with the rainbow color scale?



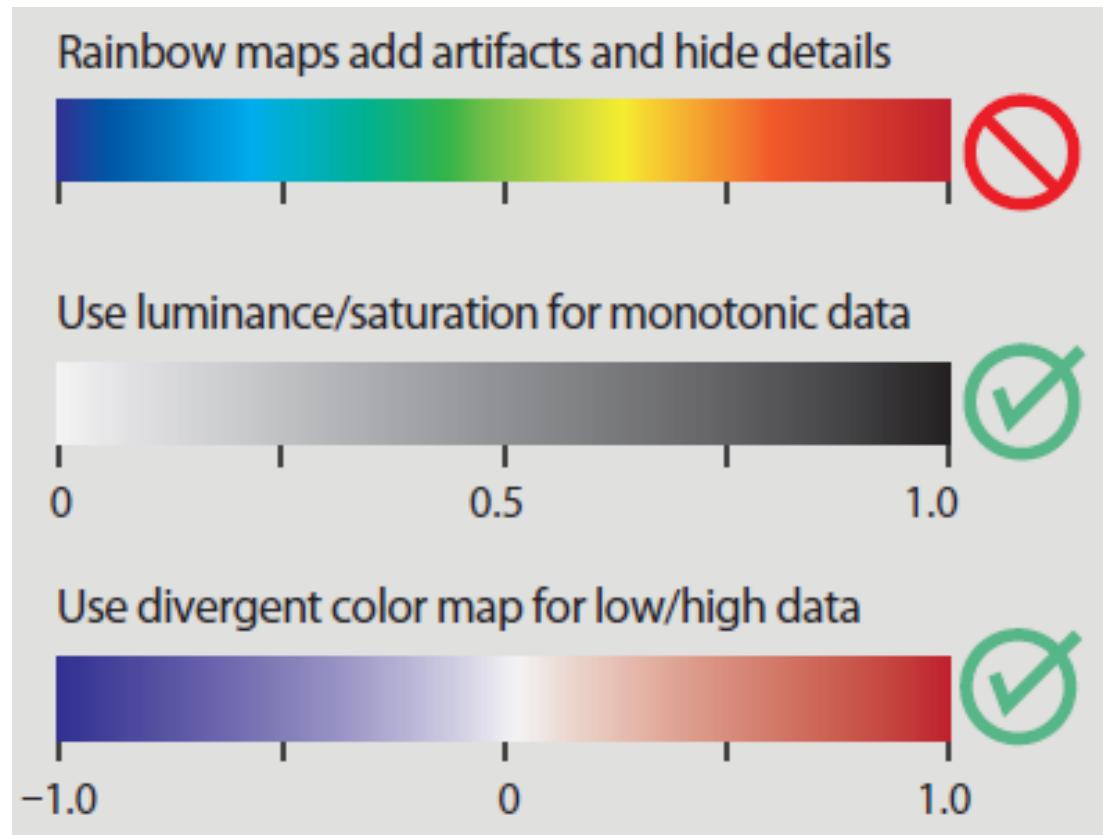
What's wrong with the rainbow color scale?



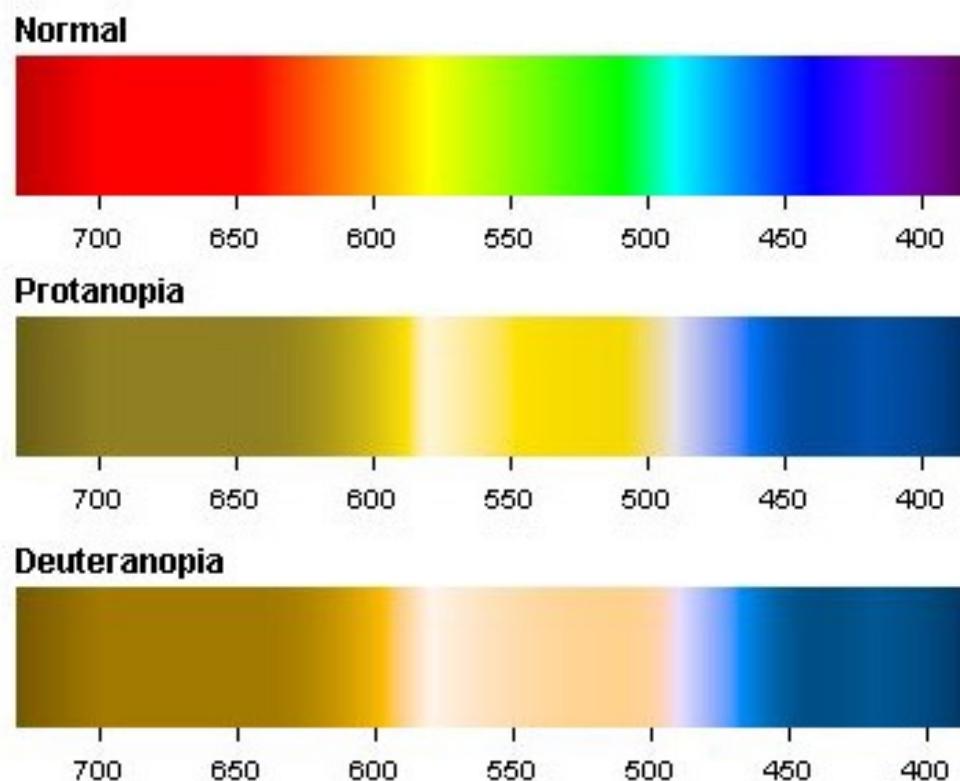
Avoid rainbow color maps for quantities!



Use a monochromatic or a diverging color scale instead



Another issue with color: color vision deficiency

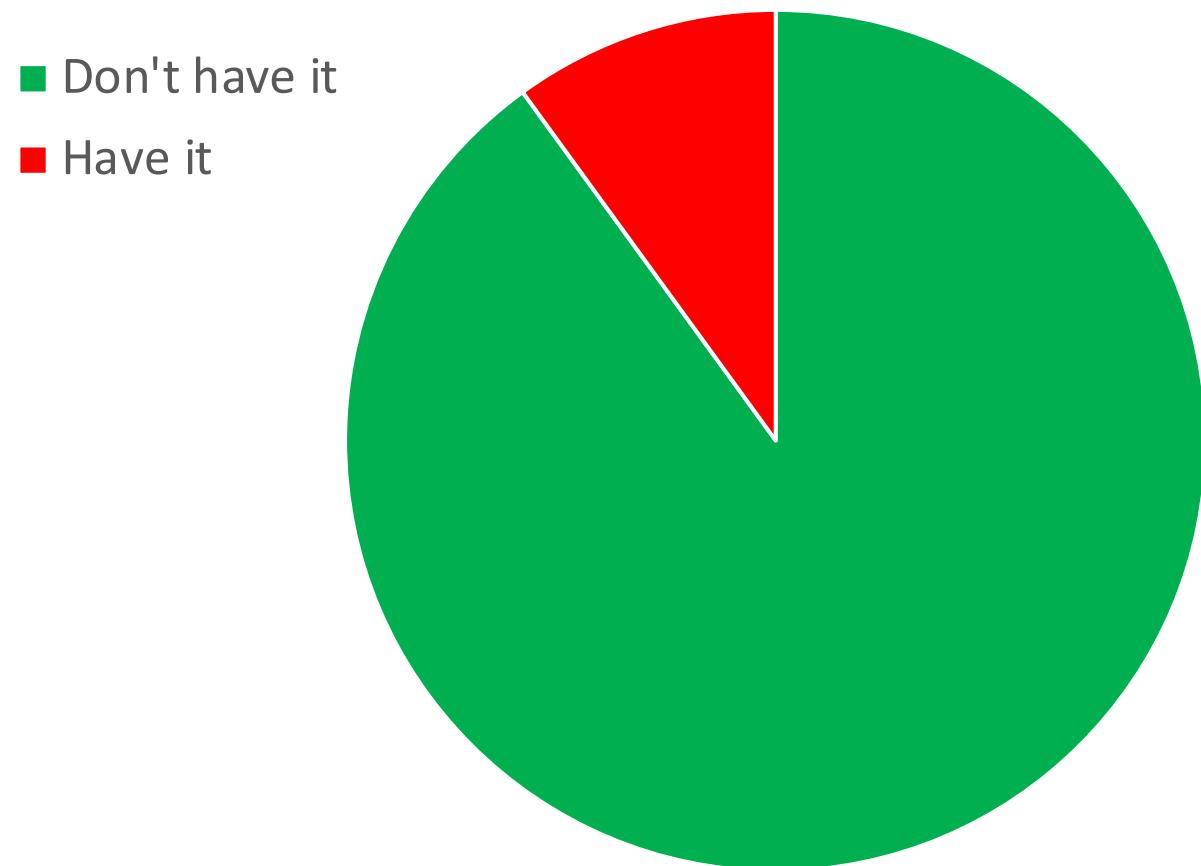


~2% male population

~6% male population

Avoid red-green color palettes

Red-green color blindness in men



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



Color Oracle

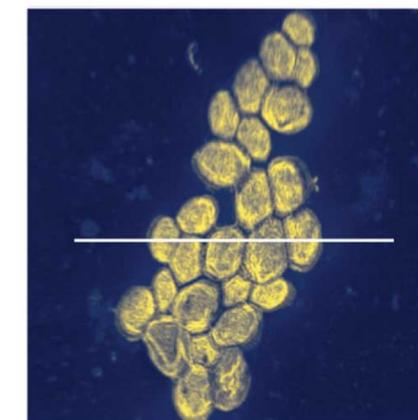
Design for the Color Impaired



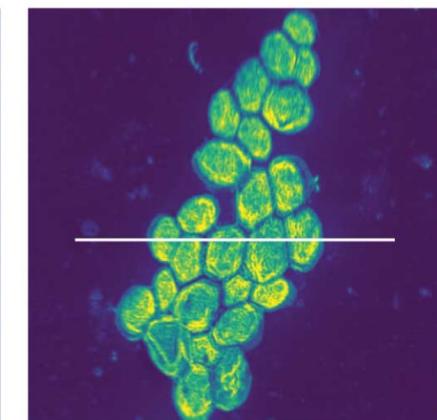
Color Oracle is a free color blindness simulator for Windows, Mac and Linux. It takes the guesswork out of designing for color blindness by showing you in real time what people with common color vision impairments will see.

Color Oracle applies a full screen color filter to art you are designing, independently of the software in use. Eight percent of all males are affected by color vision impairment – make sure that your graphical work is readable by the widest possible audience.

Cividis



Viridis



Color issues are common in science communications!

Hydrol. Earth Syst. Sci.

797 papers from 2005-2020

Papers with color issues
(total % per journal)



Nature Scientific Reports

Top 100 papers from 2019

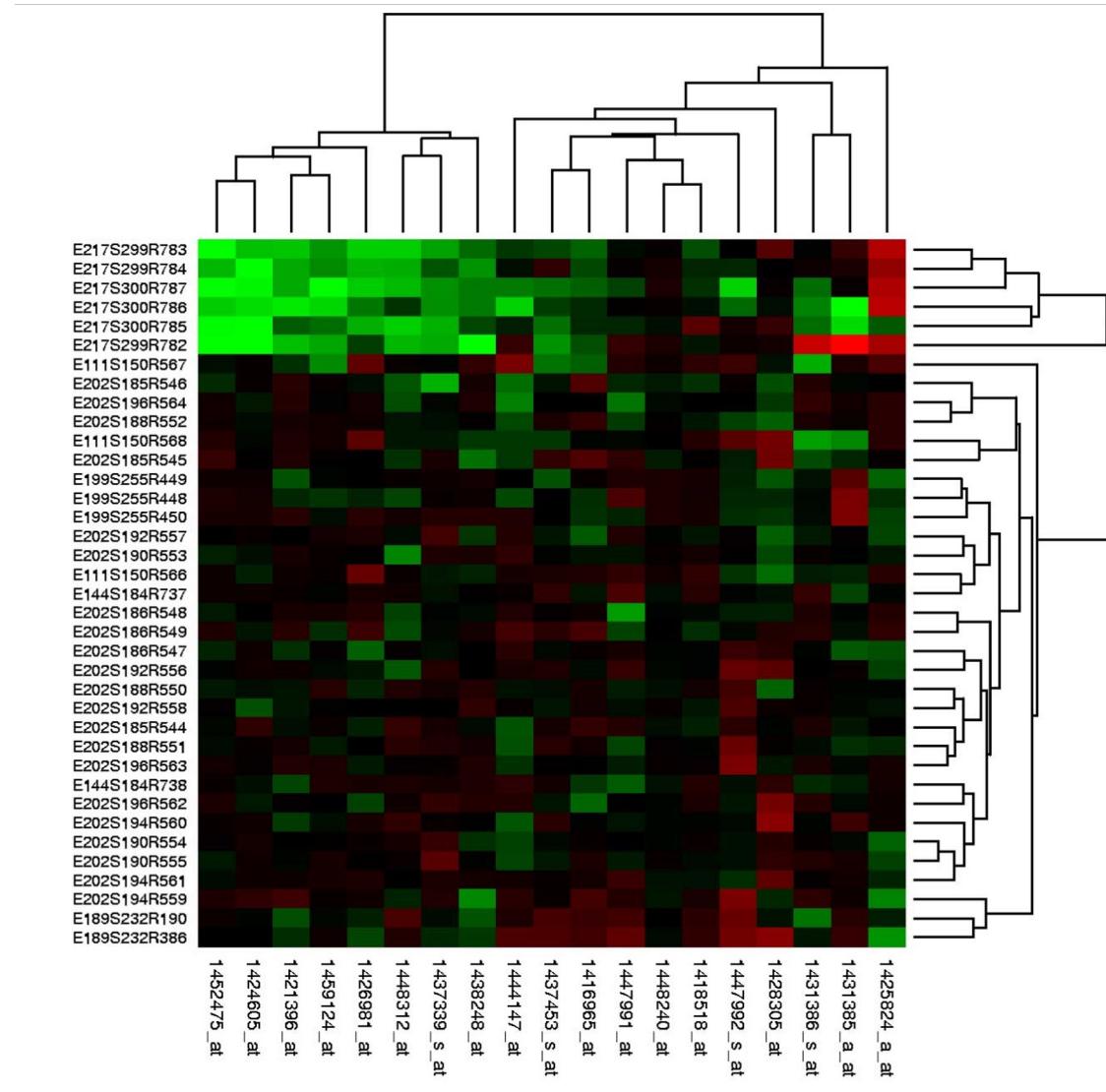


Nature Communications

100 papers from 4-6 Nov 2020



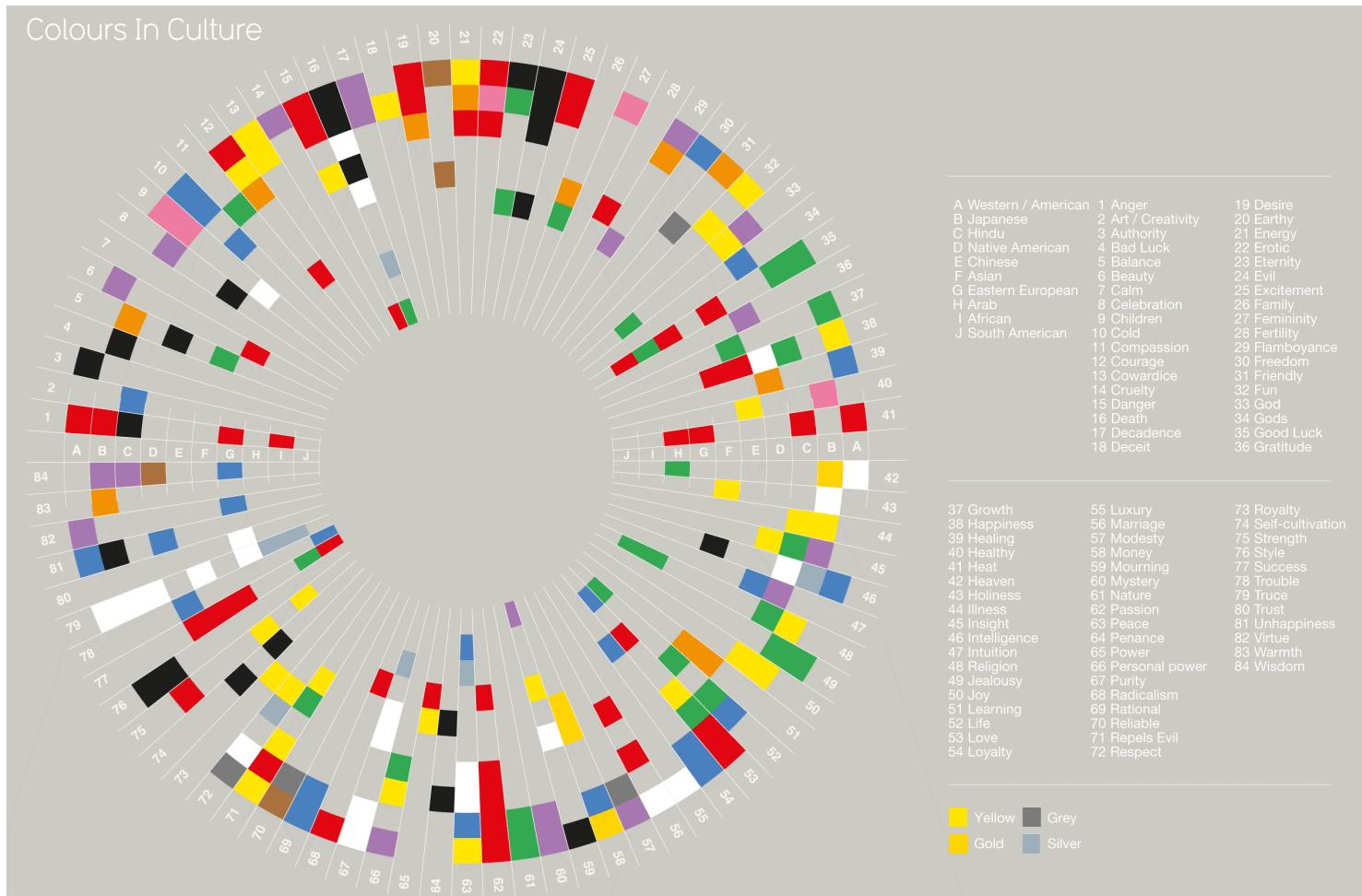
Be aware: contrast can create illusions!



Lastly, be aware how color is associated to feelings...



...and differs between cultures

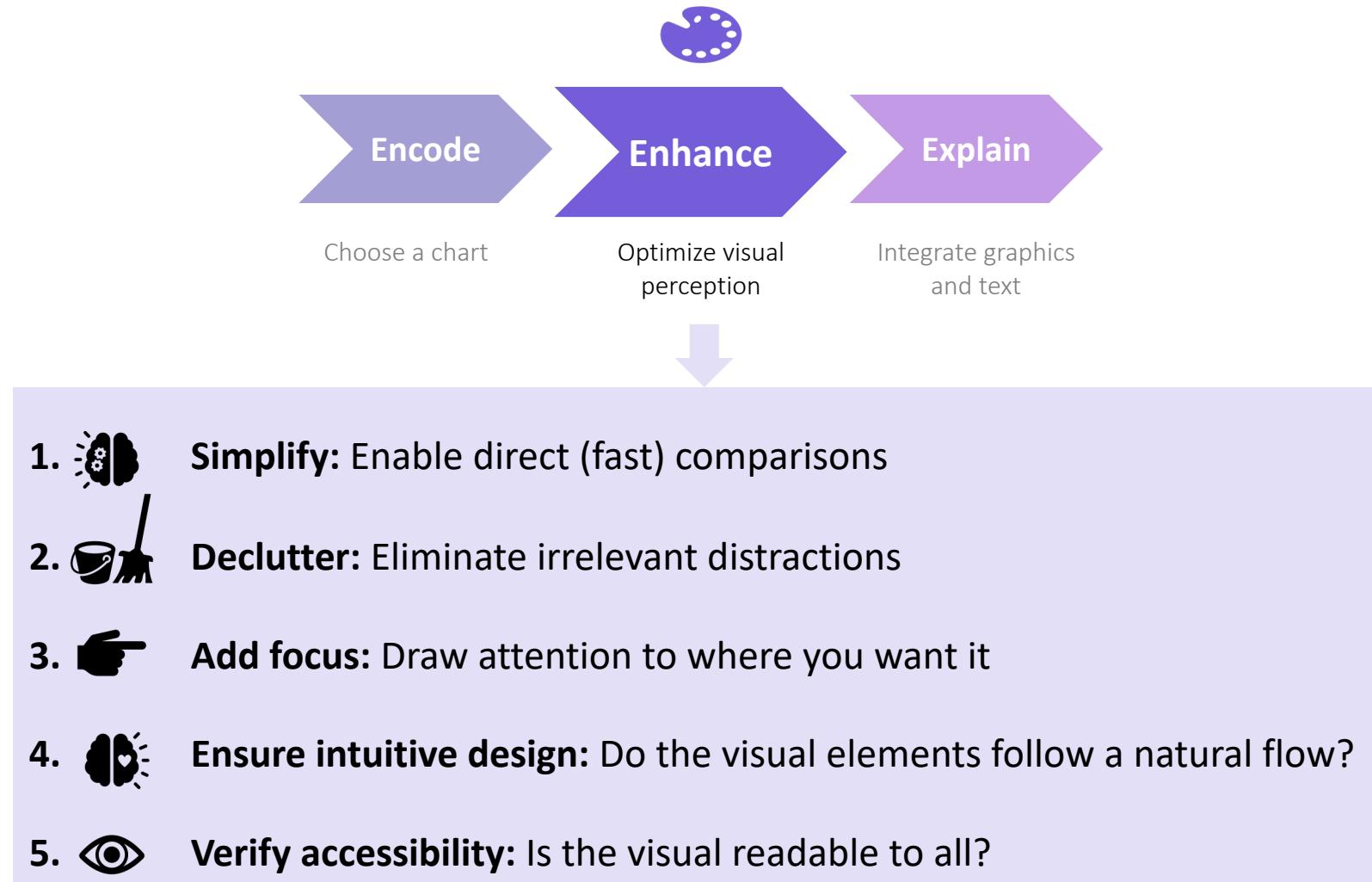


Wrapping up

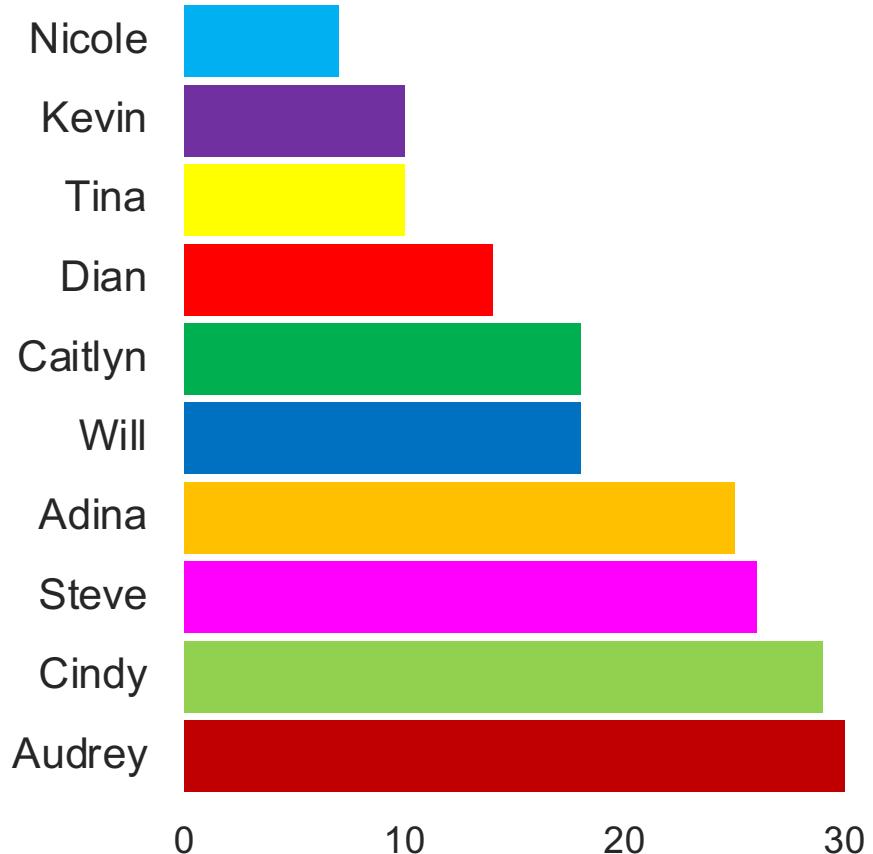
The 5 key steps in visual design
Do's and Don'ts



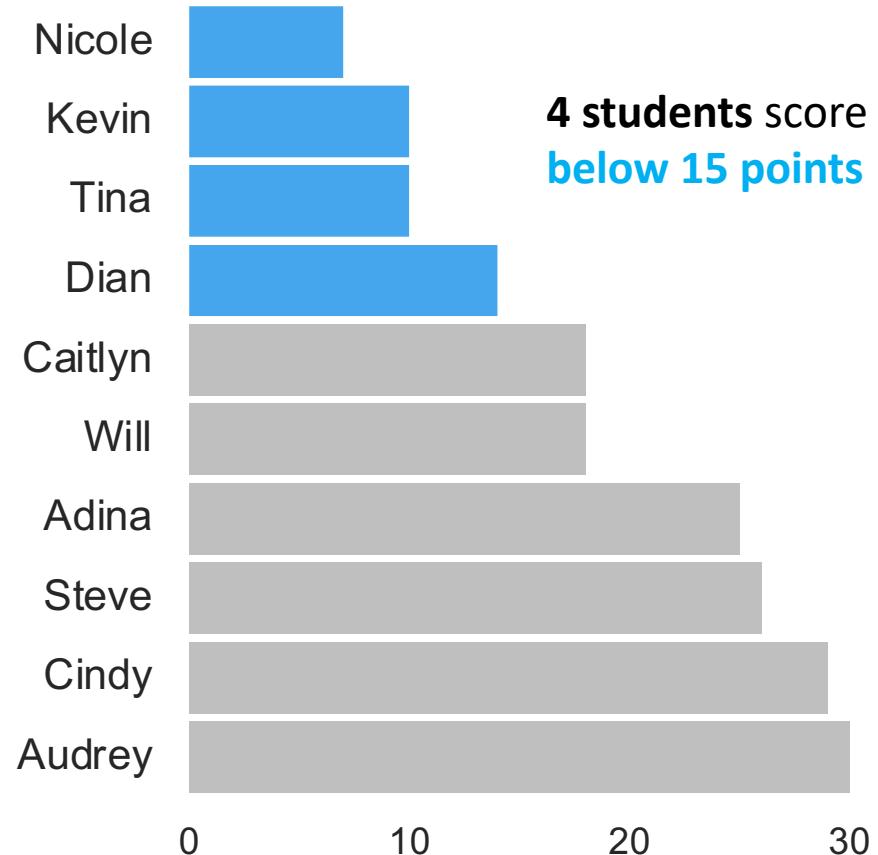
Pulling it all together: **5 steps** to optimize visual perception



Don't: Use too many (useless) colors

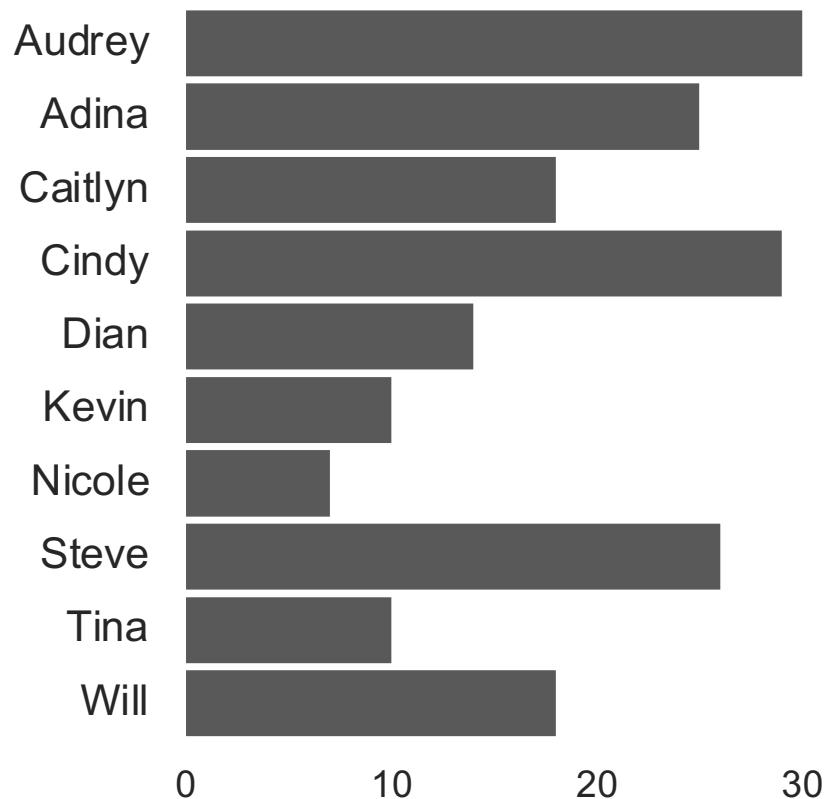


Do: Highlight and annotate your key findings

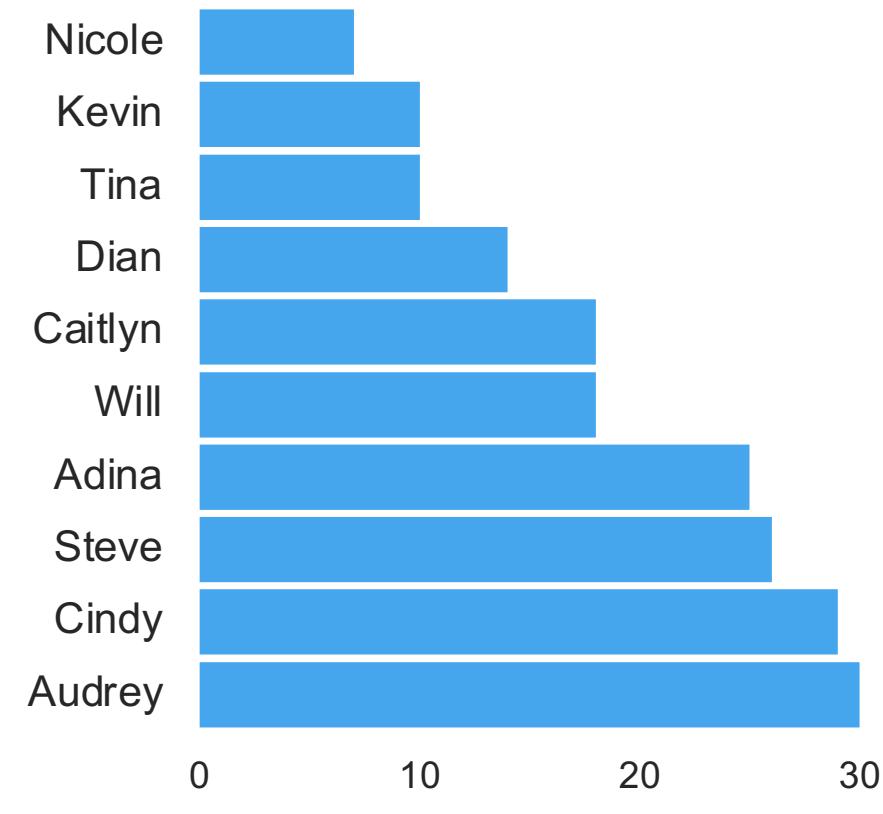


Do: Order your data logically, e.g., alphabetically or by number

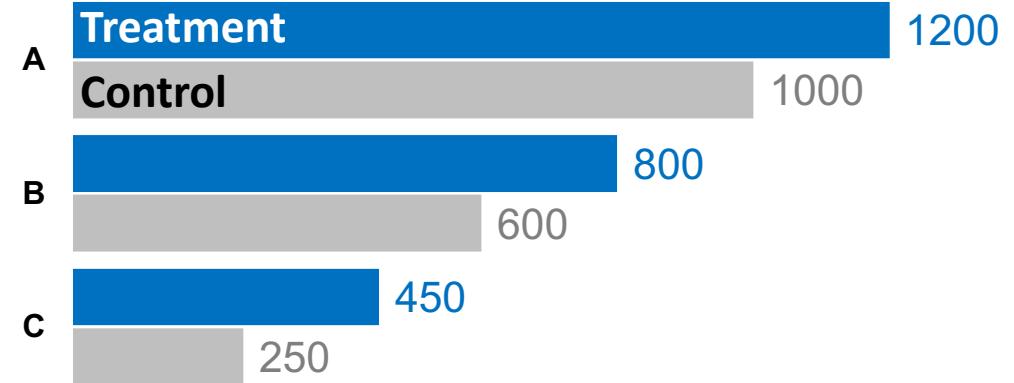
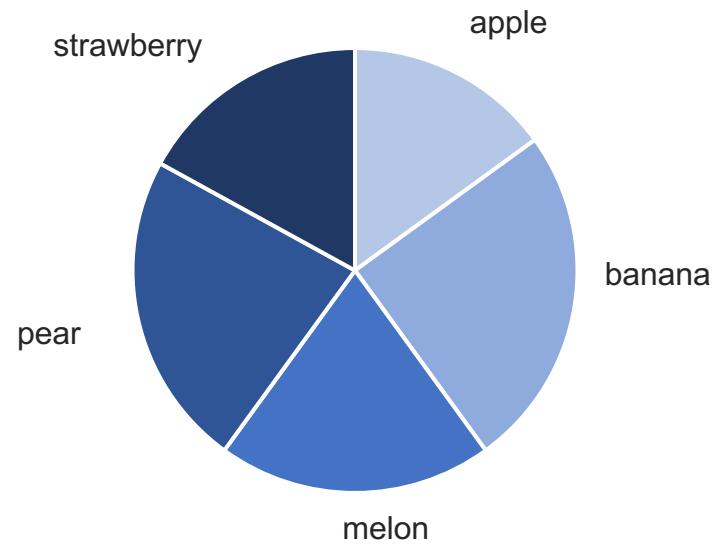
Student's scores for test 1



Student's scores for test 1



Do: Label your data directly

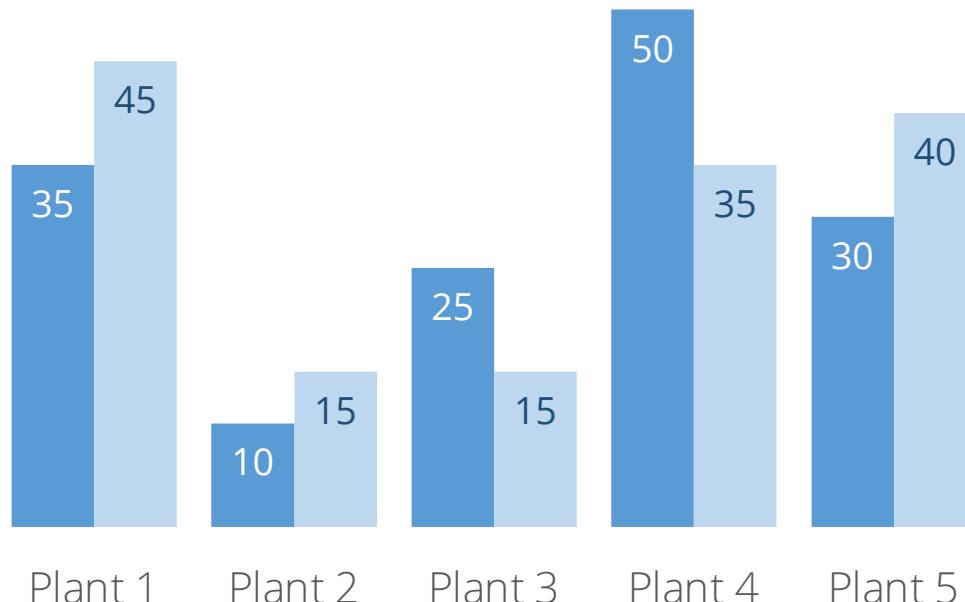


Don't: Let your audience do mental math

Safety Incidents by Plant

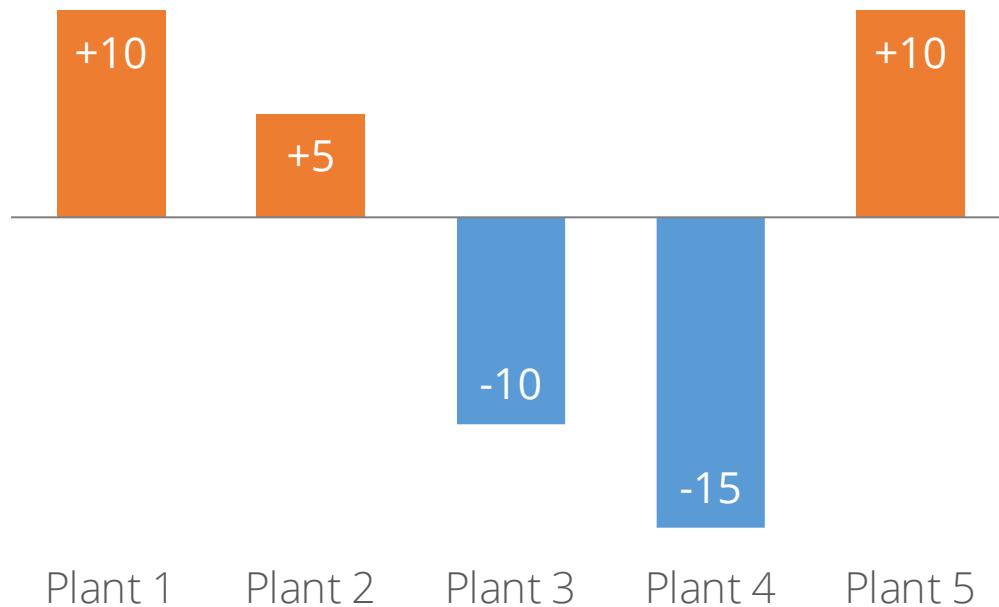
■ 2017 ■ 2018

*What's the mean difference
between 2017-2018?*



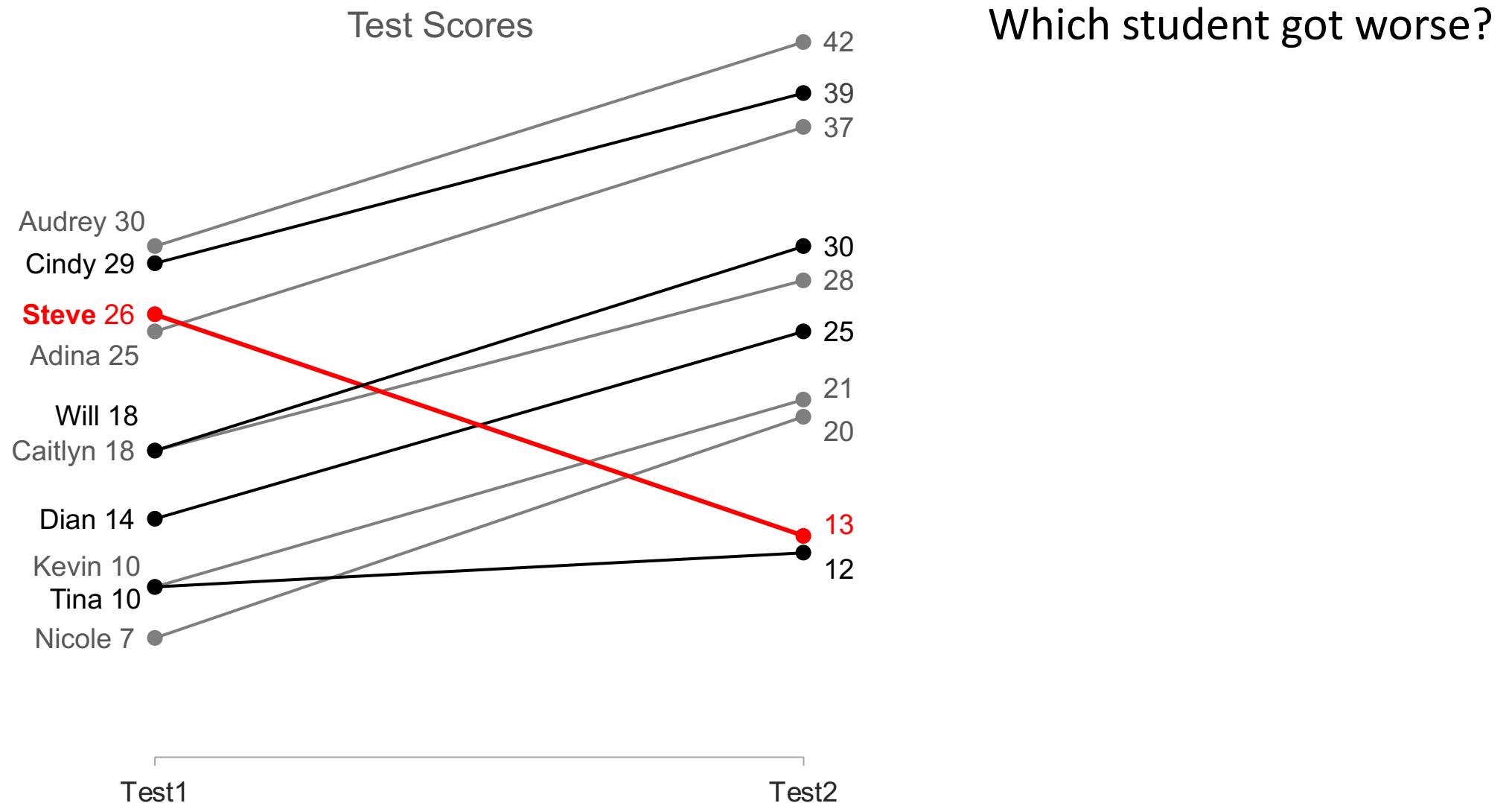
Do: Show differences directly

Year-to-Year Variance in Safety Incidents by Plant (2017-2018)



What's the mean difference between 2017-2018?

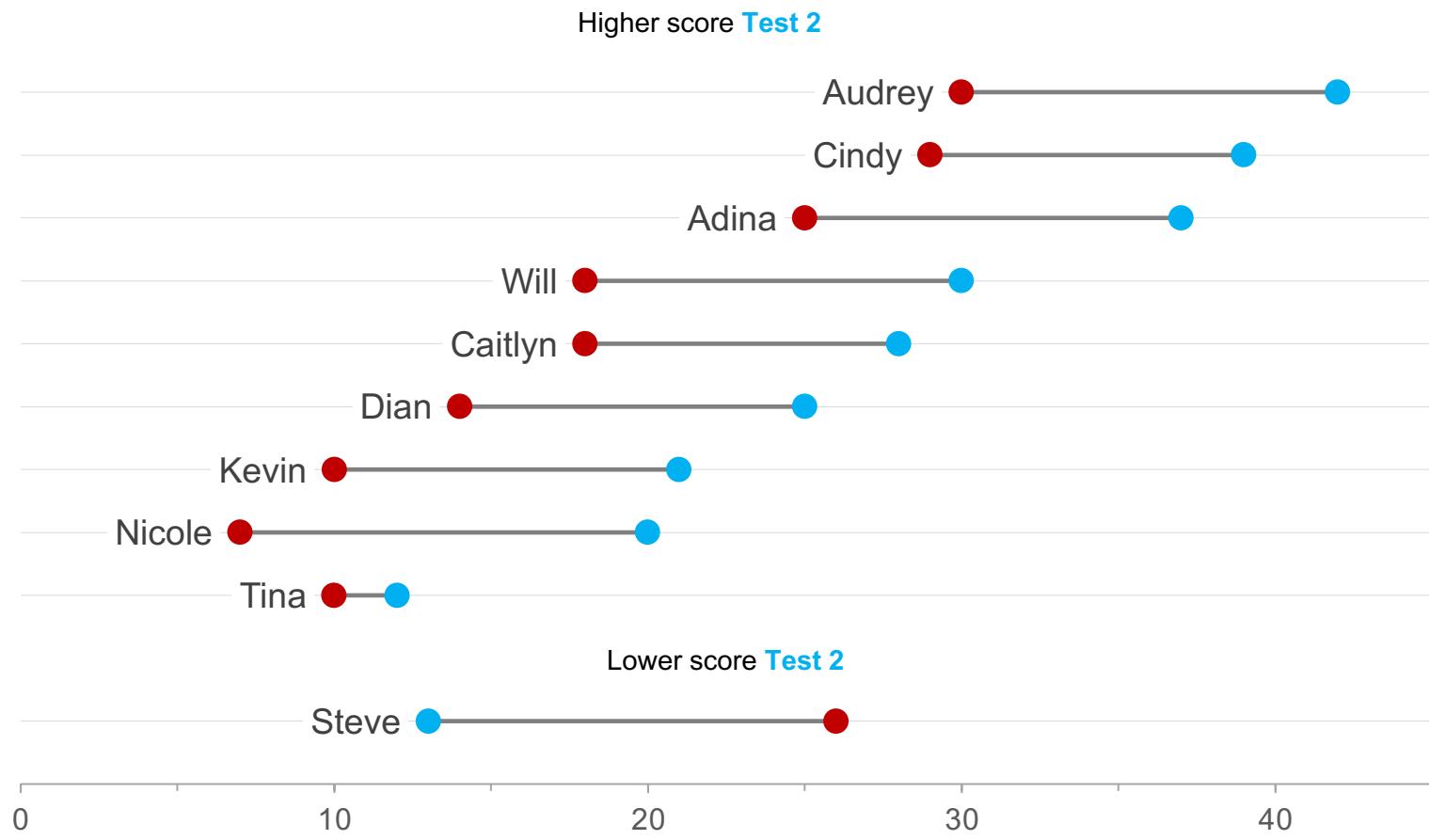
Do: Enable direct comparisons



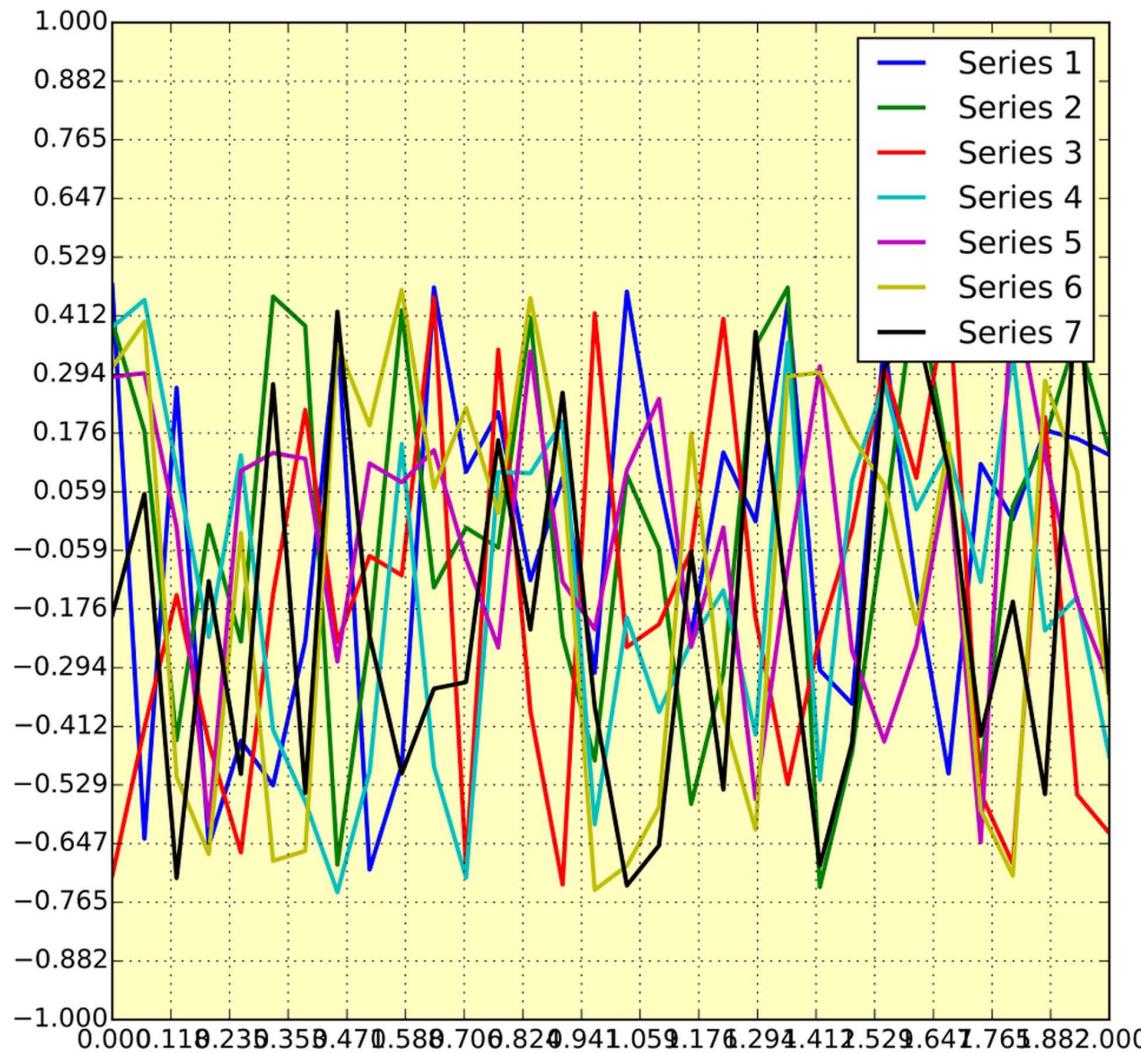
Do: Enable direct comparisons

Scores for **Test1** and **Test2**

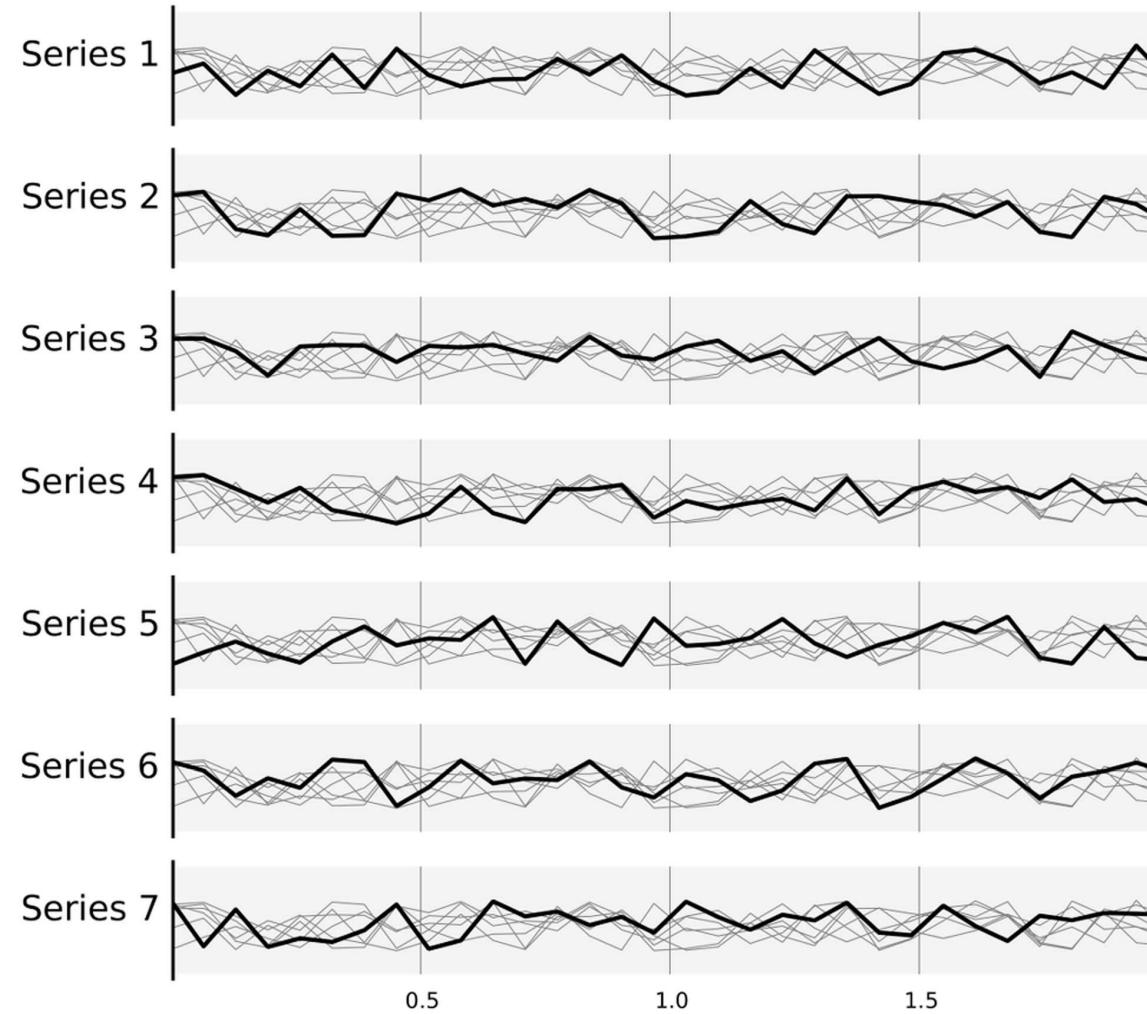
Which student got worse?



Don't: Use a spaghetti chart

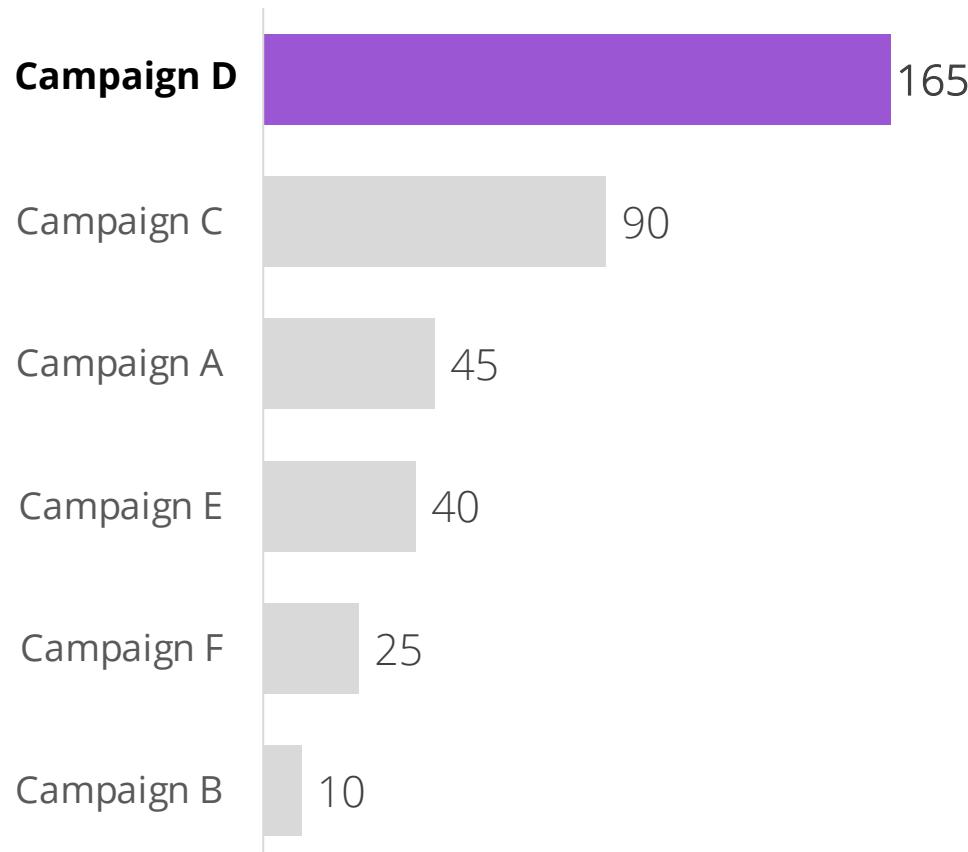


Do: Use small multiples instead

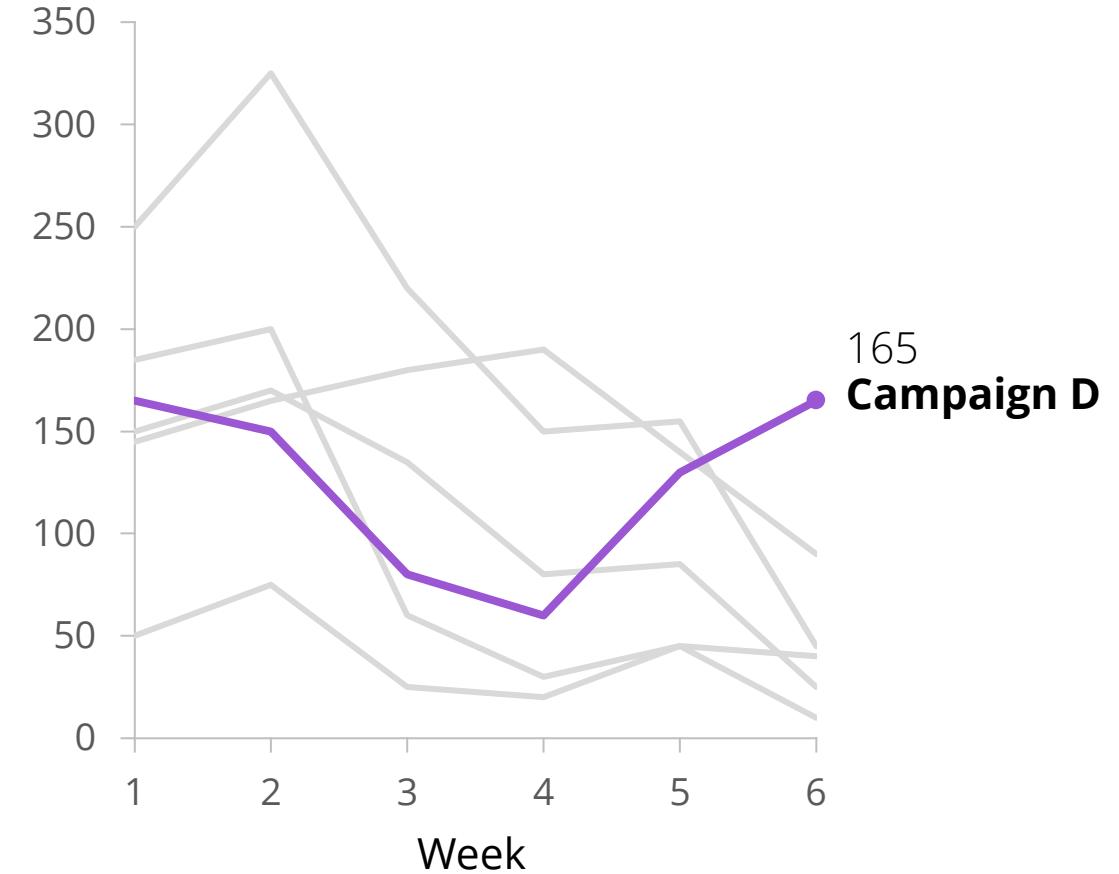


Do: Highlight what's important

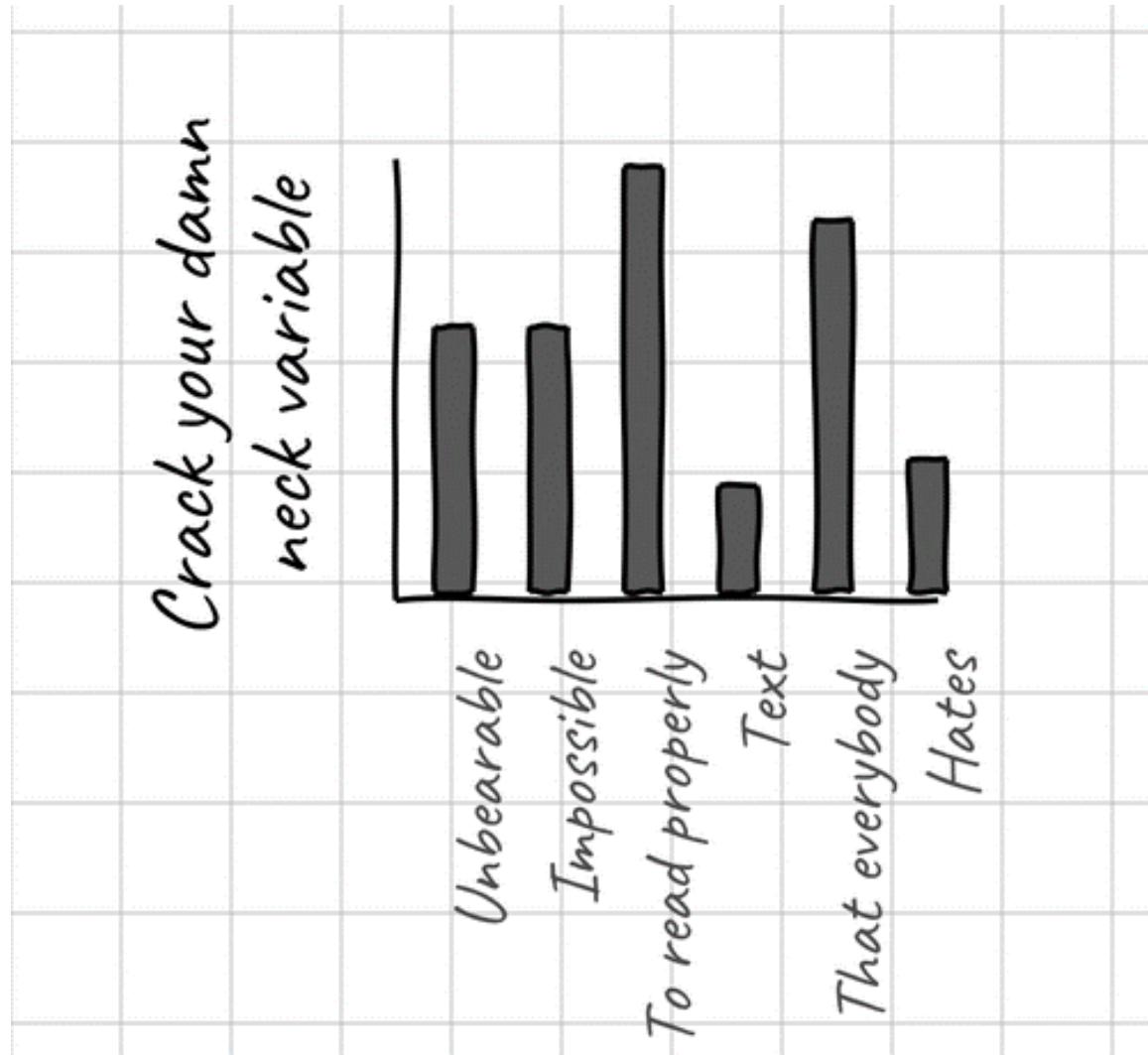
Leads Generated by Campaign in Sixth Week



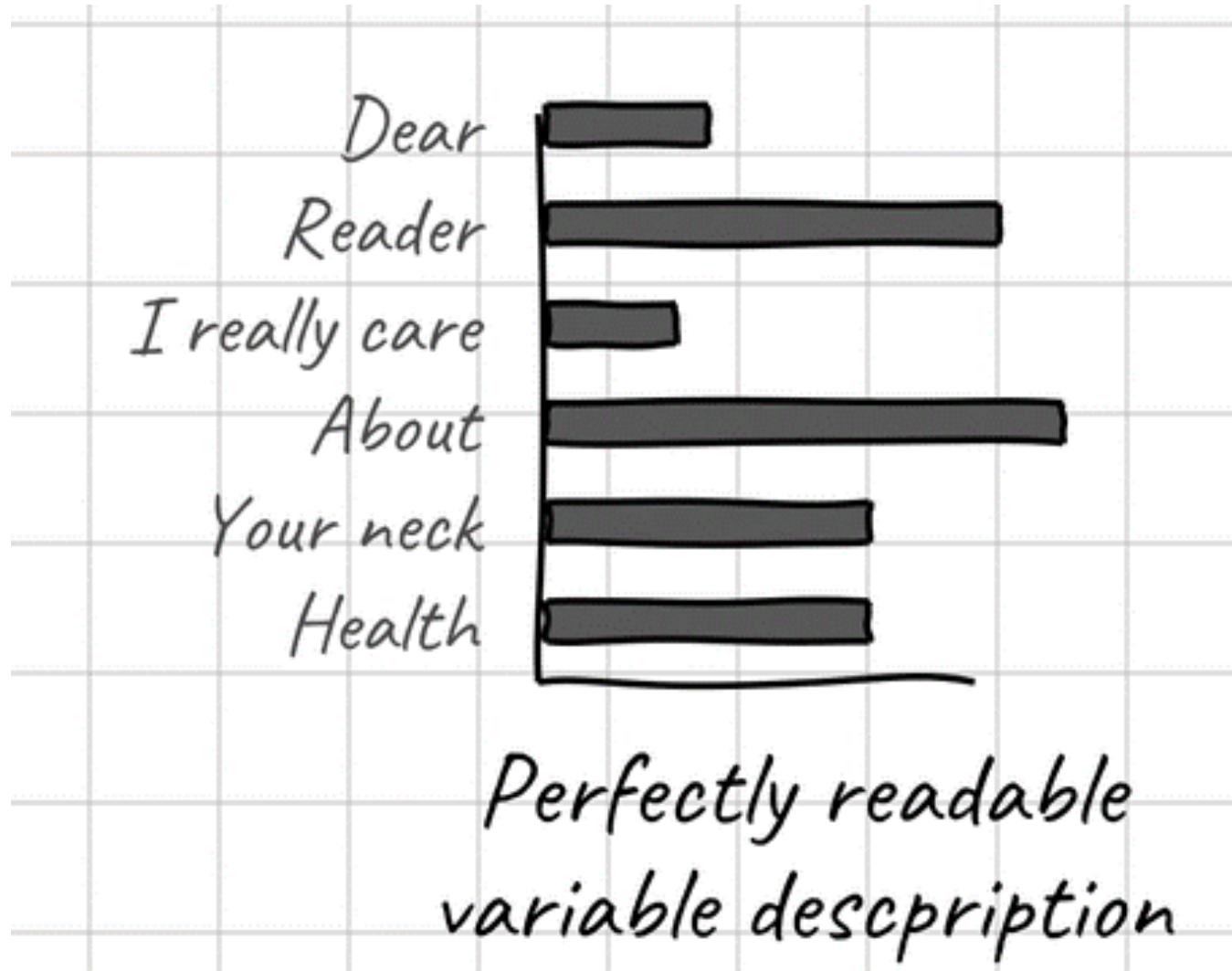
Leads Generated by Campaign



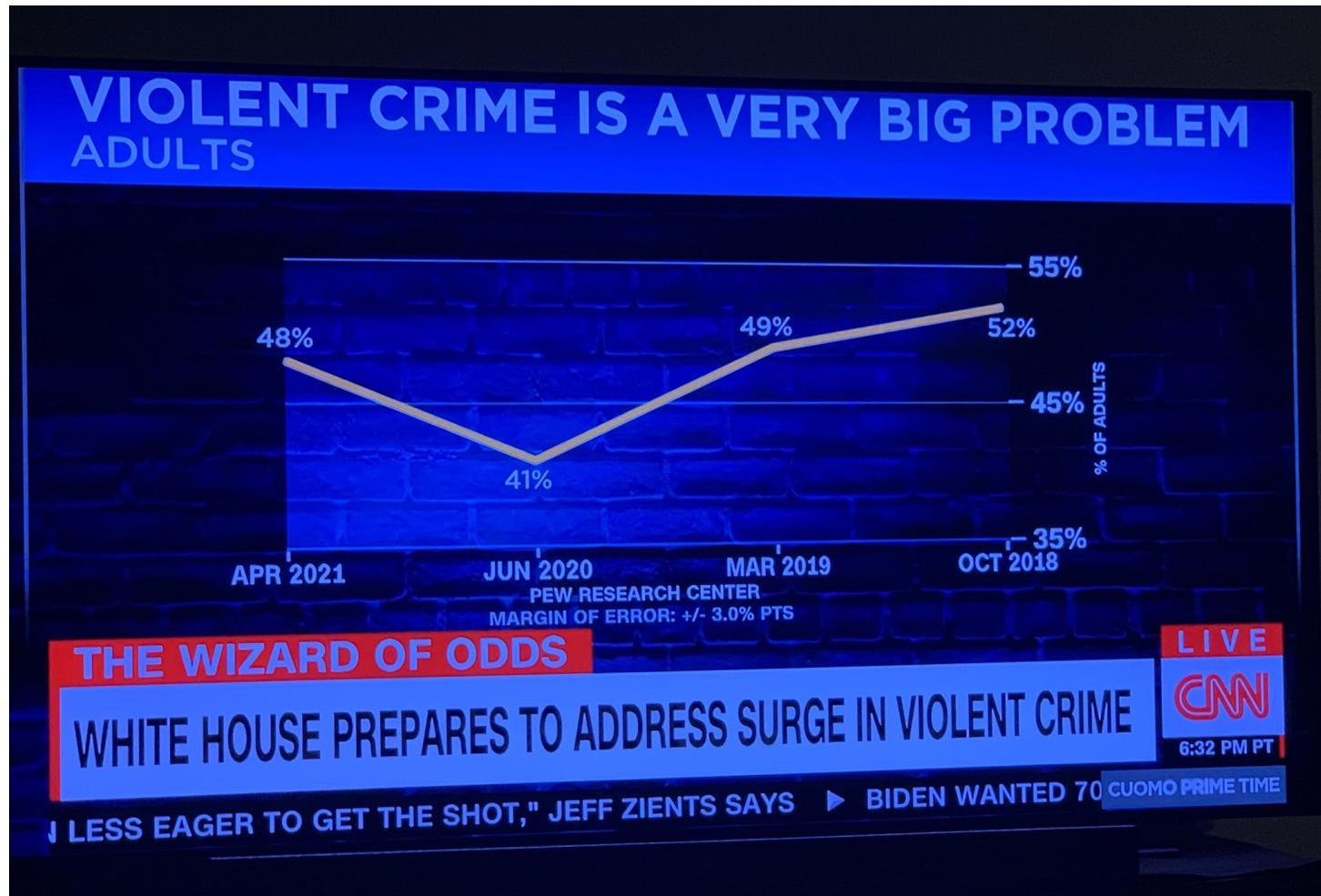
Don't: Make your audience crack their neck!



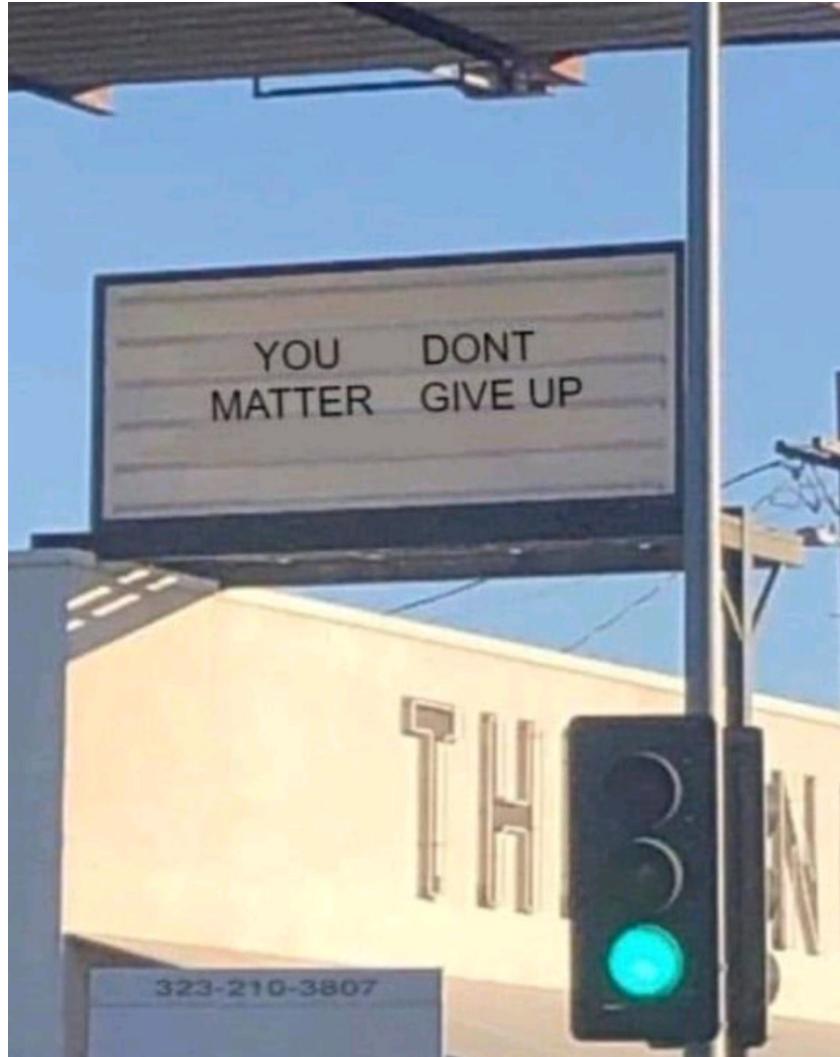
Do: Align text horizontal



Don't: Read from right-to-left



Do: Read from left-to-right...

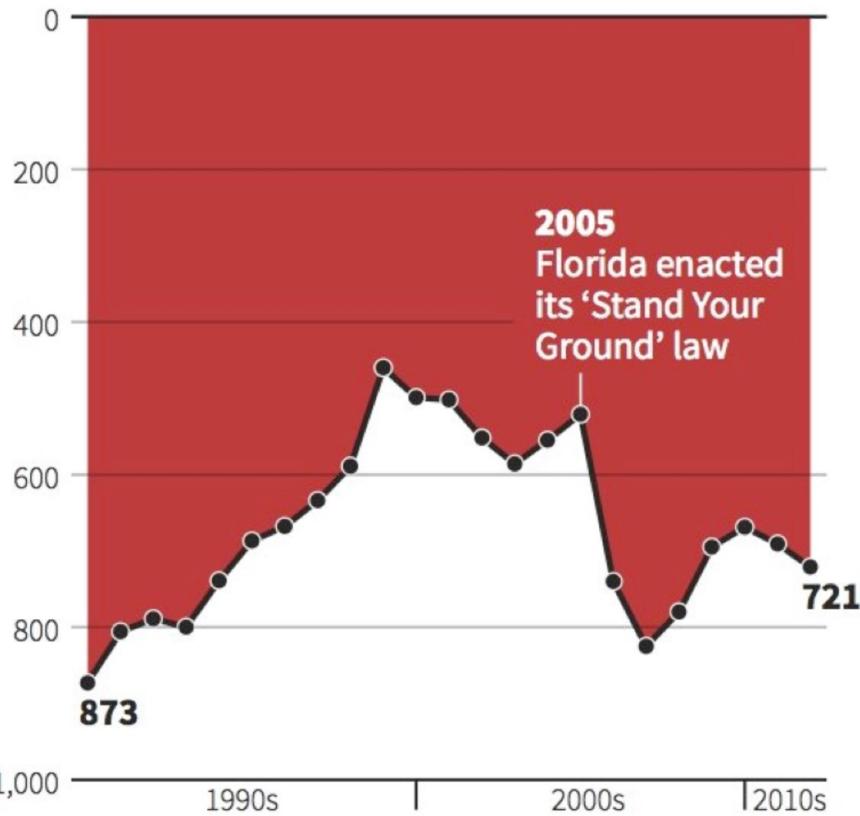


..right?

Don't: Flip the y-axis either

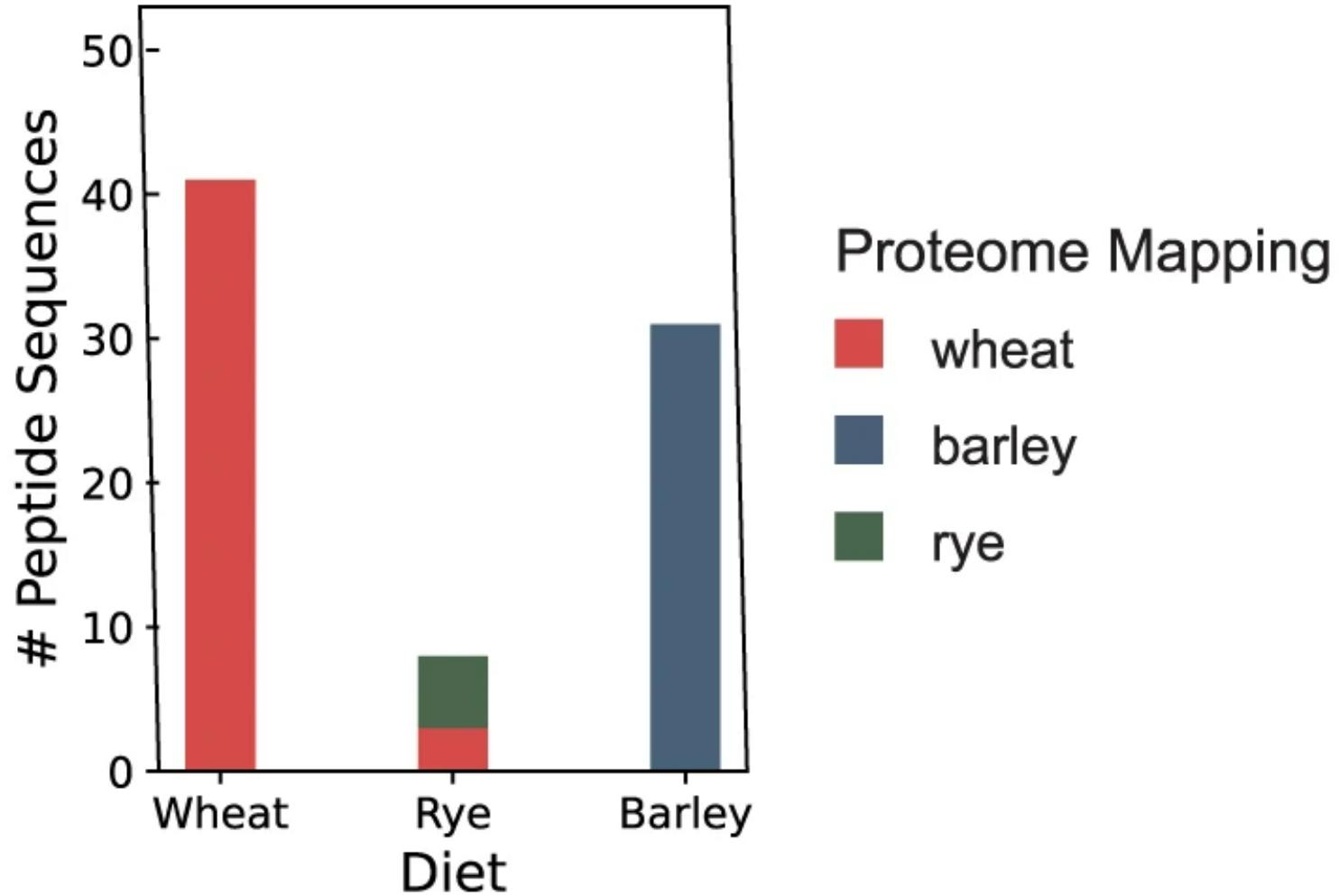
Gun deaths in Florida

Number of murders committed using firearms

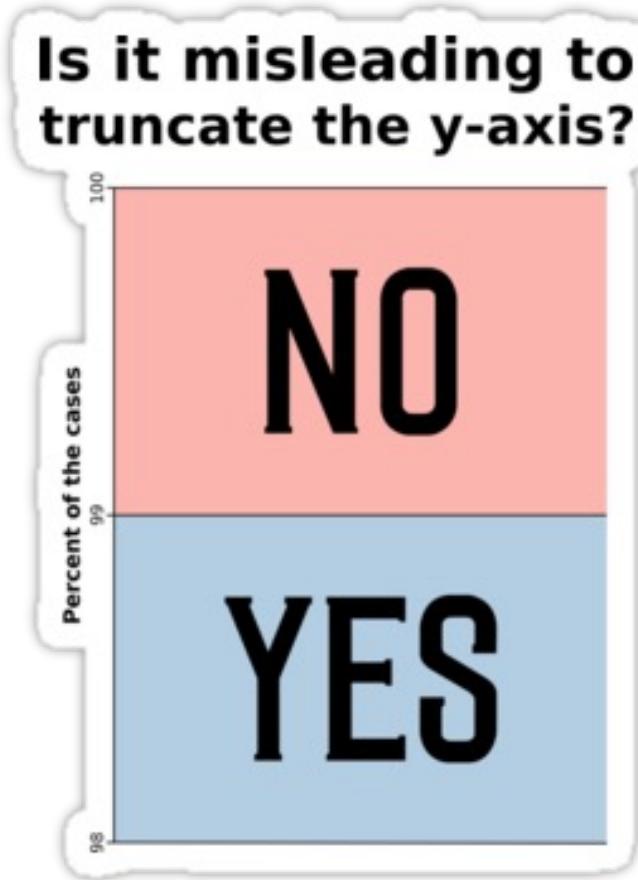


Source: Florida Department of Law Enforcement

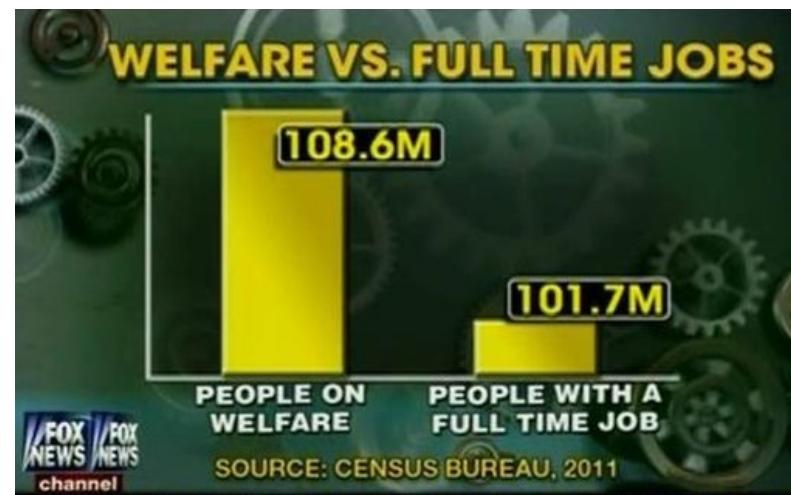
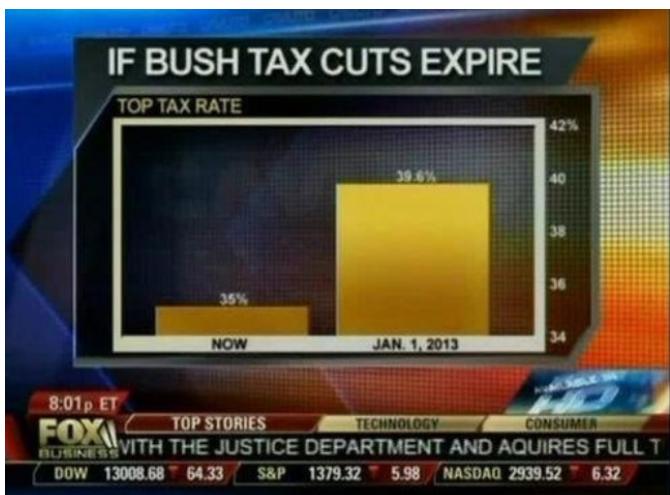
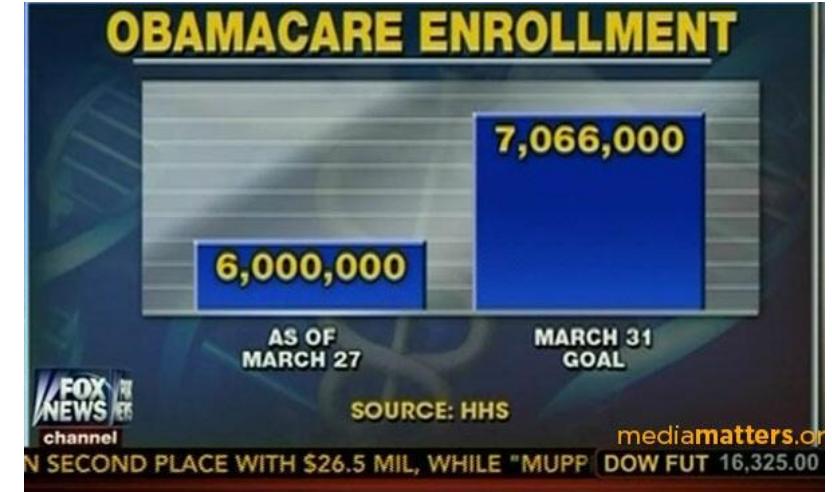
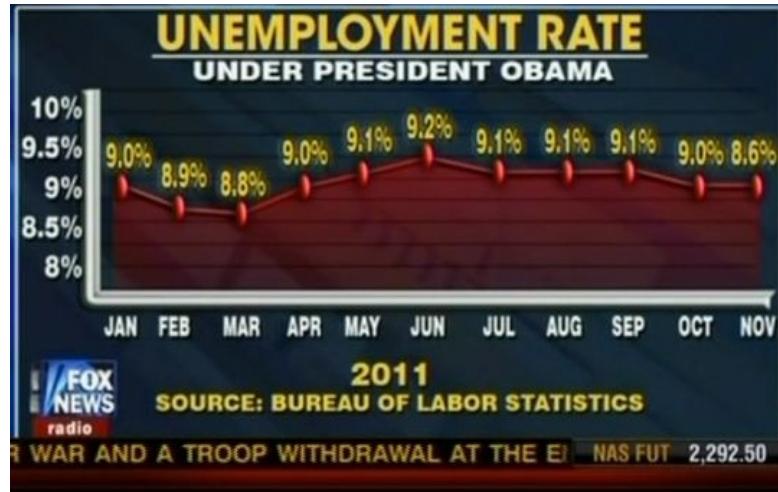
Don't: *Tilt* (?) the y-axis either



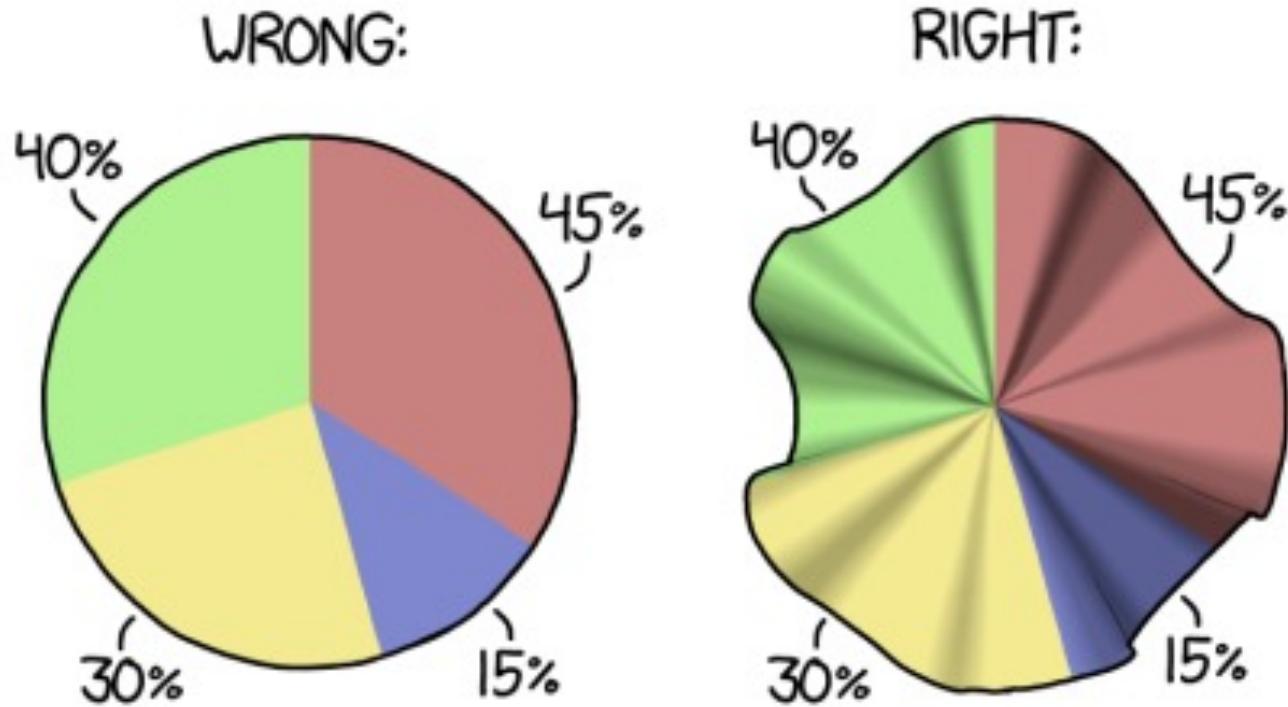
Don't: Truncate the y-axis either



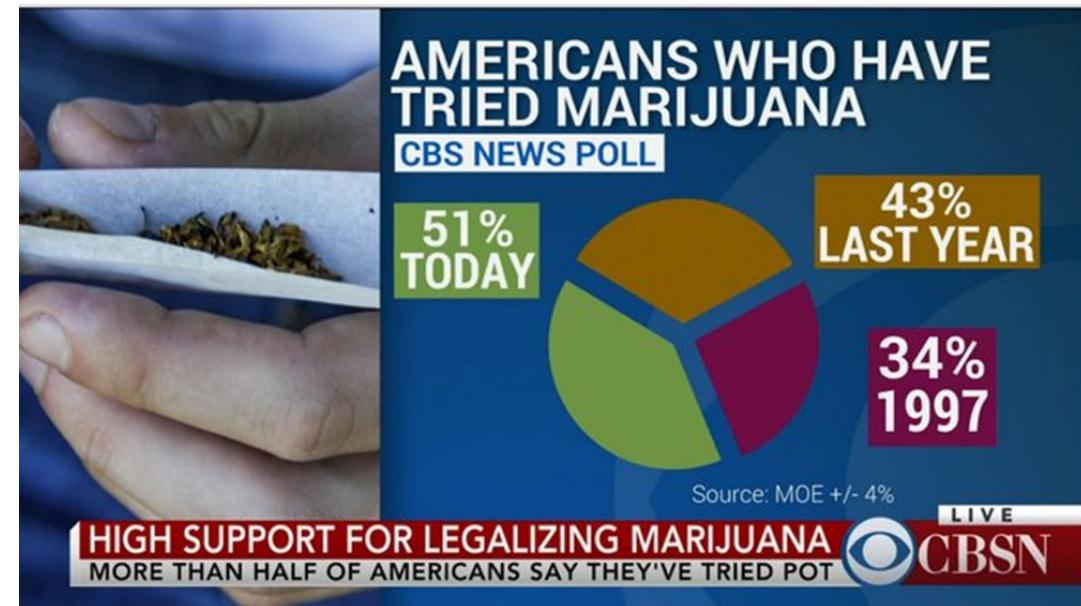
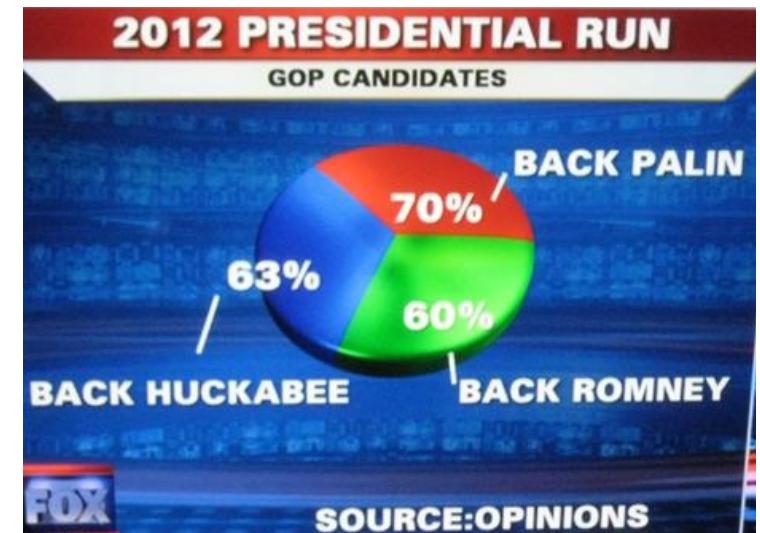
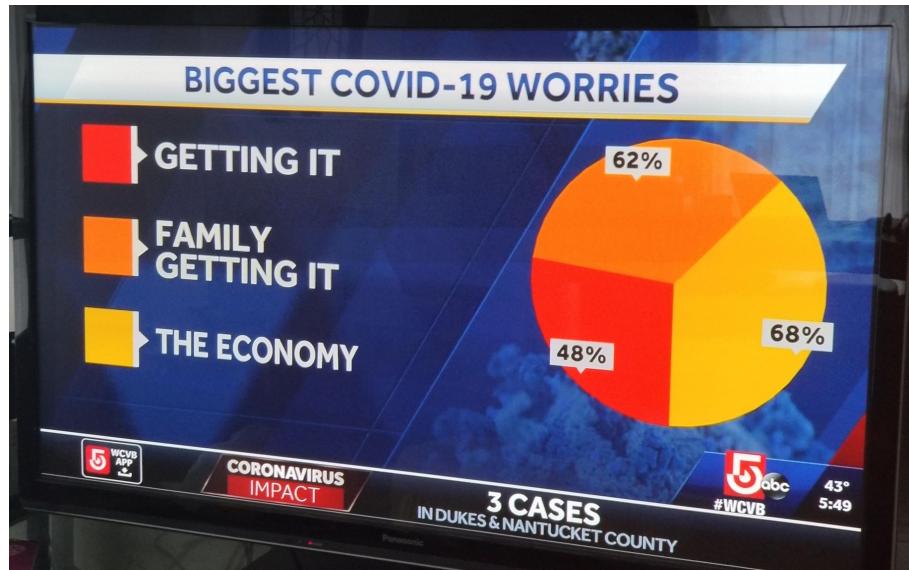
Who does that, you say?



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



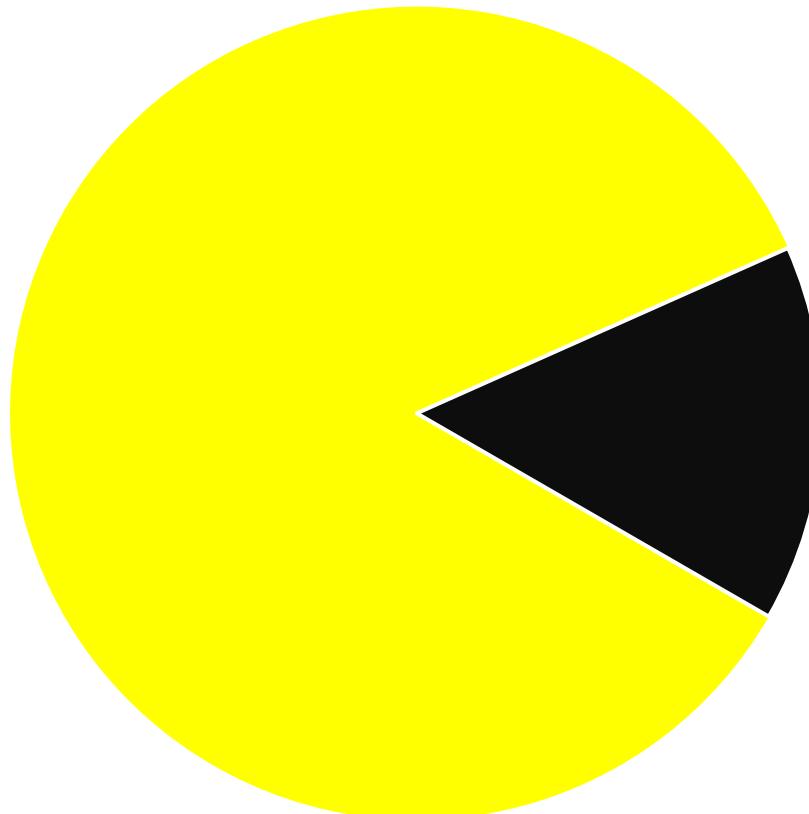
Who does that, you say?



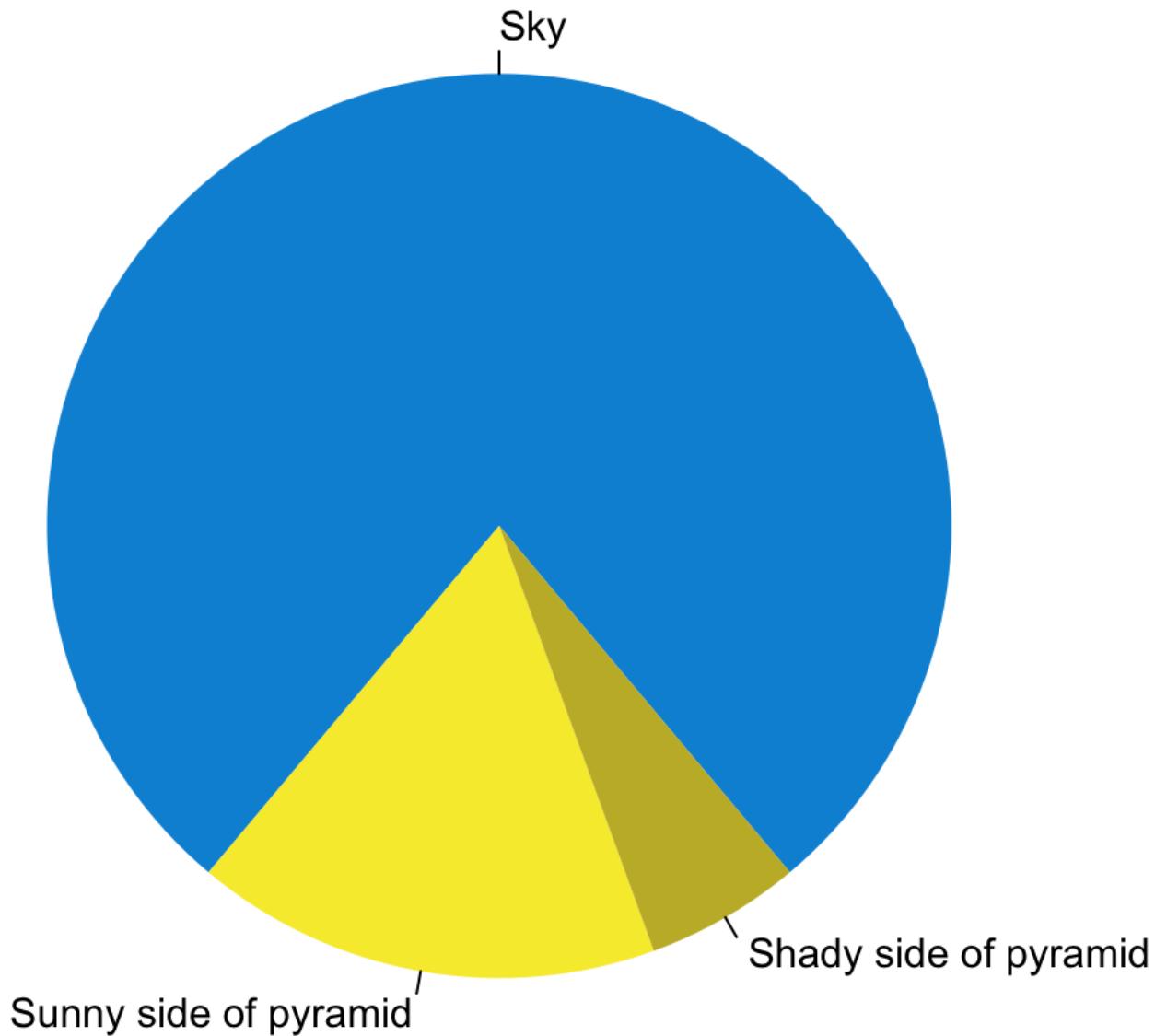
Do: Use pie charts to show the part-to-whole relation of 2 categories

Percentage of chart that looks like Pacman

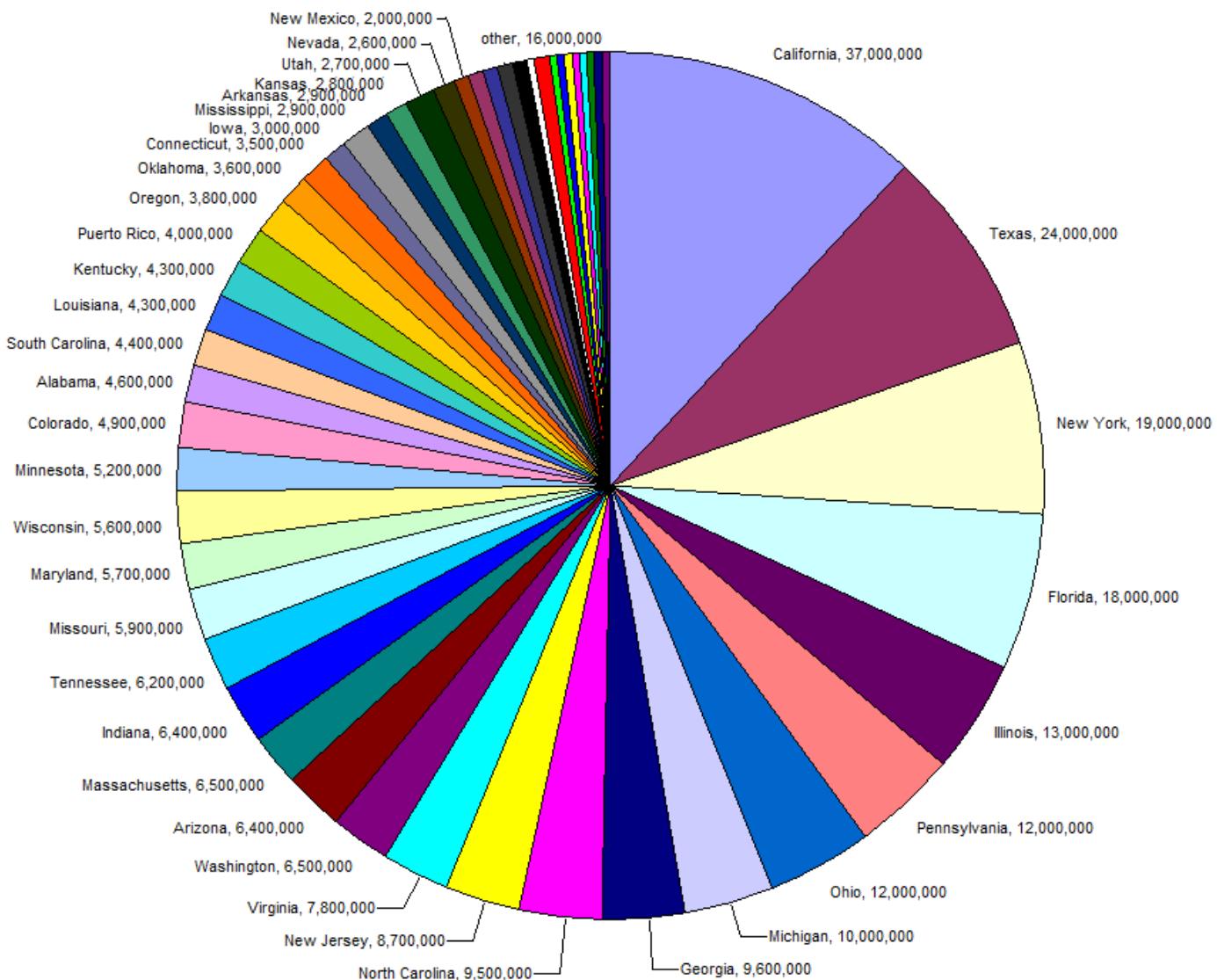
- Pacman
- Not Pacman



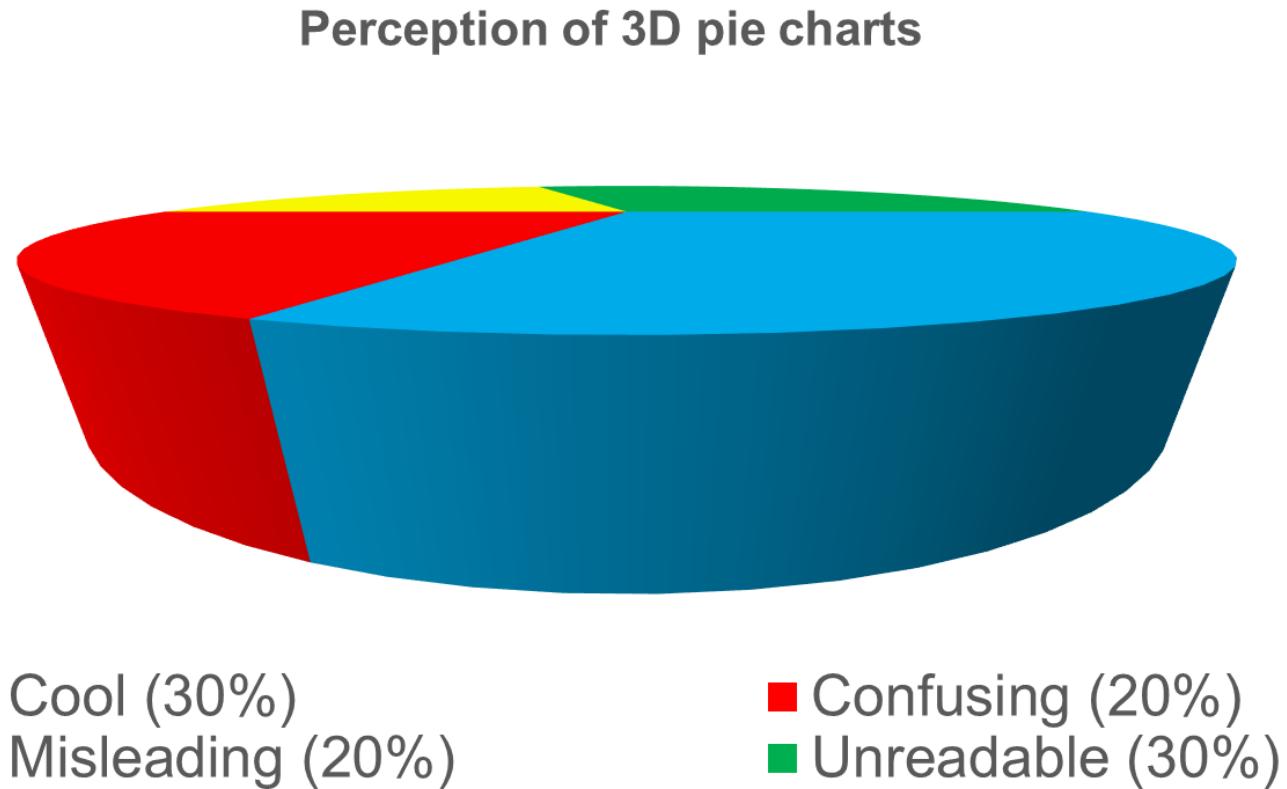
Do: Pie charts for 3 categories is okay too



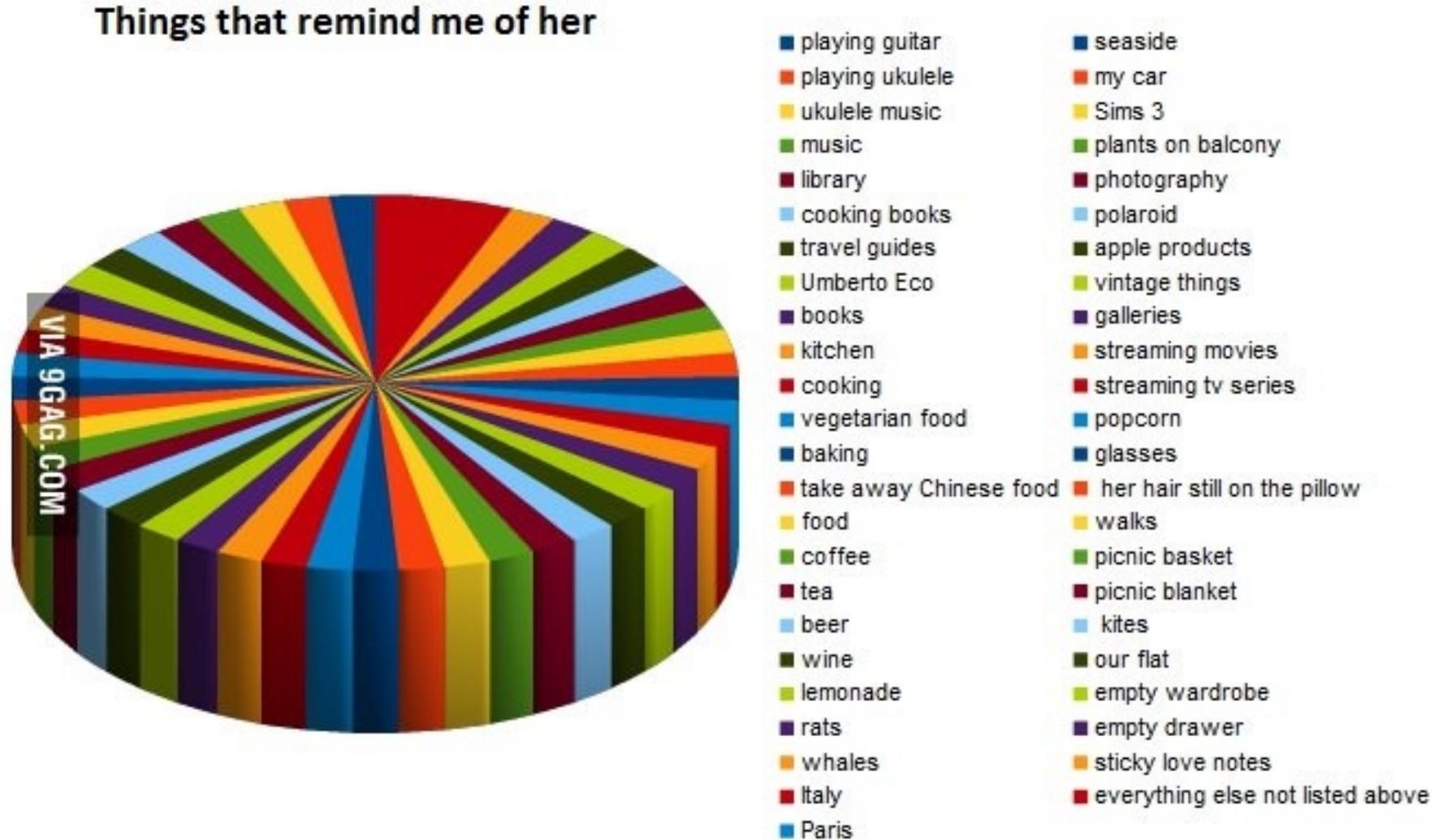
Don't: Use pie charts with >5 categories



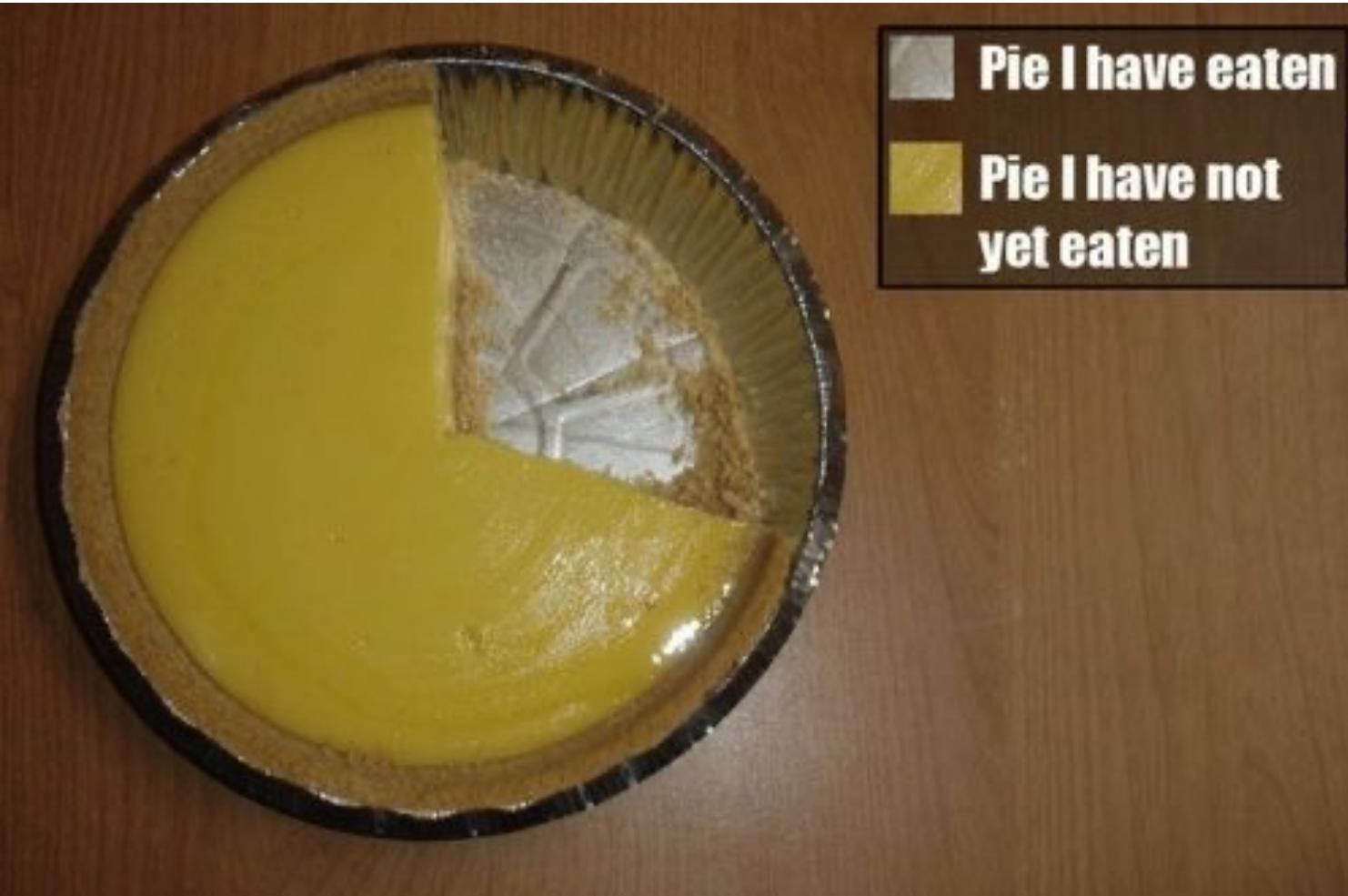
Don't: Use 3D pie charts



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



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



Thank you!



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Twitter icon @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>

