My brain is not meant for facts, is it?

The quantitative research method in the neurosciences

Sebastian Sauer

Truly yours

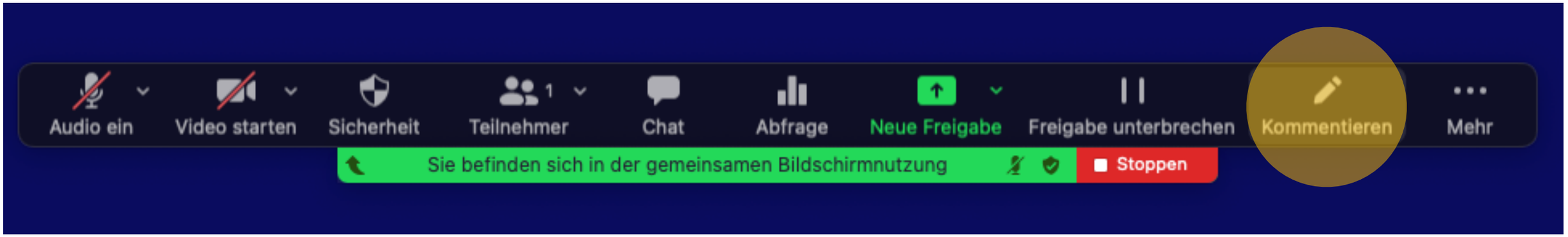
Sebastian Sauer

Teacher

Scientist

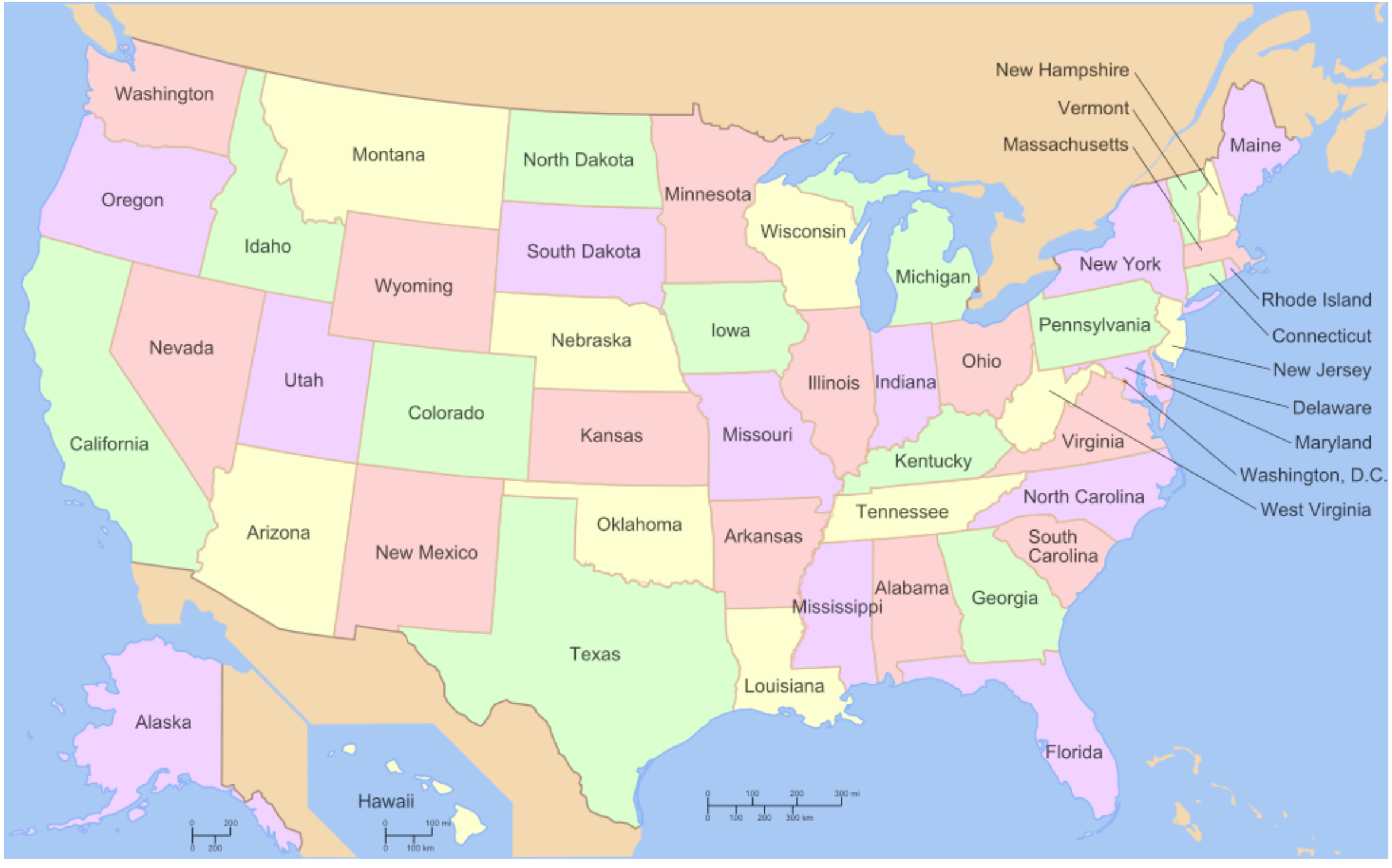
Learner

Screen comments in Zoom



Where in the world?

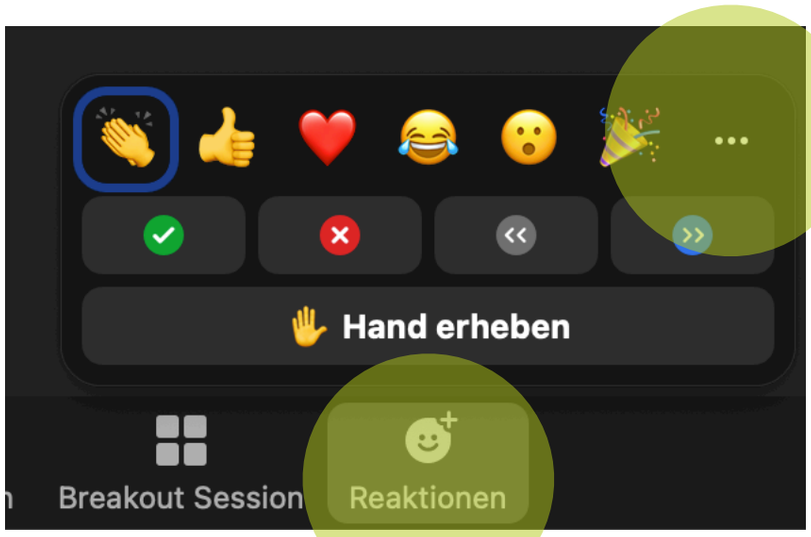
Where in the US?



Where in Germany?

Pick an emoji

Science?! What are your thoughts and feelings about it?
Pick an emoji.



What science got to do with me?

Best way to take notes in class?

(A) Old school: taking notes using pen/pencil

(B) Cool kids: scribbling on my iPad

(C) Typewriter: Hacking notes onto my laptop

(D) Rebel: Don’t take any notes at all

The Pen Is Mightier than the Keyboard

Research Finding

- … a study says
- Don’t belief, but check.
- Here’s the source: Read the abstract of this study.

Mueller, P. A., & Oppenheimer, D. M. (2014). The Pen Is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking. *Psychological Science*, *25*(6), 1159–1168. https://doi.org/10.1177/0956797614524581

Where's your cell phone right now?

(A) My phone's not in this room.

(B) My phone's in the room but turned off/flight mode.

(C) My phone's near me but turned off/flight mode.

(D) My phone's near me and turned on.

Smartphone brain drain

Research Finding

> Results from two experiments indicate that even when people are successful at maintaining sustained attention—as when avoiding the temptation to check their phones—the *mere presence of these devices reduces available cognitive capacity*. Moreover, these cognitive costs are highest for those highest in smartphone dependence.

Mendoza, J. S., Pody, B. C., Lee, S., Kim, M., & McDonough, I. M. (2018). The effect of cellphones on attention and learning: The influences of time, distraction, and nomophobia. *Computers in Human Behavior*, *86*, 52–60. https://doi.org/10.1016/j.chb.2018.04.027

Ward, A. F., Duke, K., Gneezy, A., & Bos, M. W. (2017). Brain Drain: The Mere Presence of One's Own Smartphone Reduces Available Cognitive Capacity. *Journal of the Association for Consumer Research*, *2*(2), 140–154. https://doi.org/10.1086/691462

Stay alone and doing nothing ?

(A) Very simple. I enjoy being being left alone and doing nothing.

(B) Rather simple, but not my favorite thing to do.

(C) Rather difficult. I’d don’t really enjoy hat.

(D) Very difficult, get me out of this void.

Don't leave me alone with my thoughts (?)

Research Finding

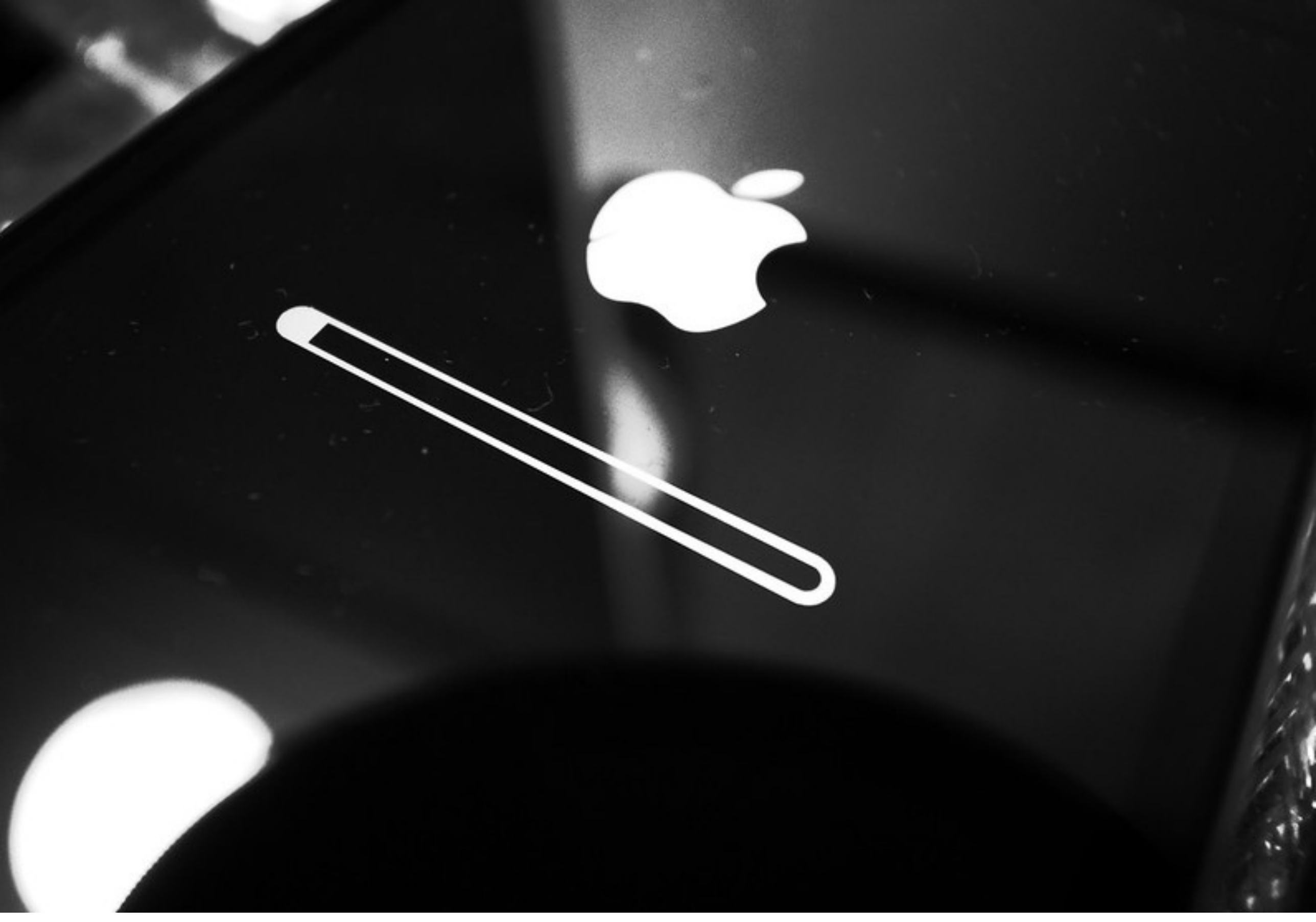
- People would rather be electrically shocked than left alone with their thoughts
- according to a study

- Read this summary of the study.
- How do you interpret the findings?

Whitehead, N. (2014, Juli 3). *People would rather be electrically shocked than left alone with their thoughts*. Science | AAAS. https://www.sciencemag.org/news/2014/07/people-would-rather-be-electrically-shocked-left-alone-their-thoughts

Wilson, T. D., Reinhard, D. A., Westgate, E. C., Gilbert, D. T., Ellerbeck, N., Hahn, C., Brown, C. L., & Shaked, A. (2014). Just think: The challenges of the disengaged mind. *Science*, *345*(6192), 75–77. https://doi.org/10.1126/science.1250830

Science is for life



IMAI, T. (2013). *IPhone* [Photo].Attribution-ShareAlike License. https://www.flickr.com/photos/matsuyuki/8444605636/


Pfizer-BioNTech COVID-19 Vaccine
vial contains 5 doses of 0.3 mL
for use under Emergency Use Authorization.

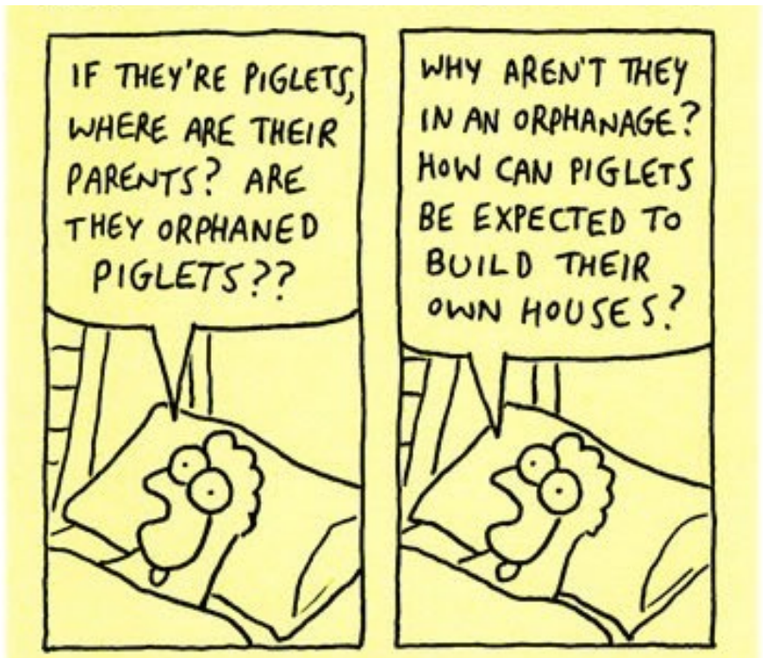
OK, but what is (quantitative) research?

A rap guide to science

- Watch the video
- Listen to the lyrics
- Identify the message
- Report back

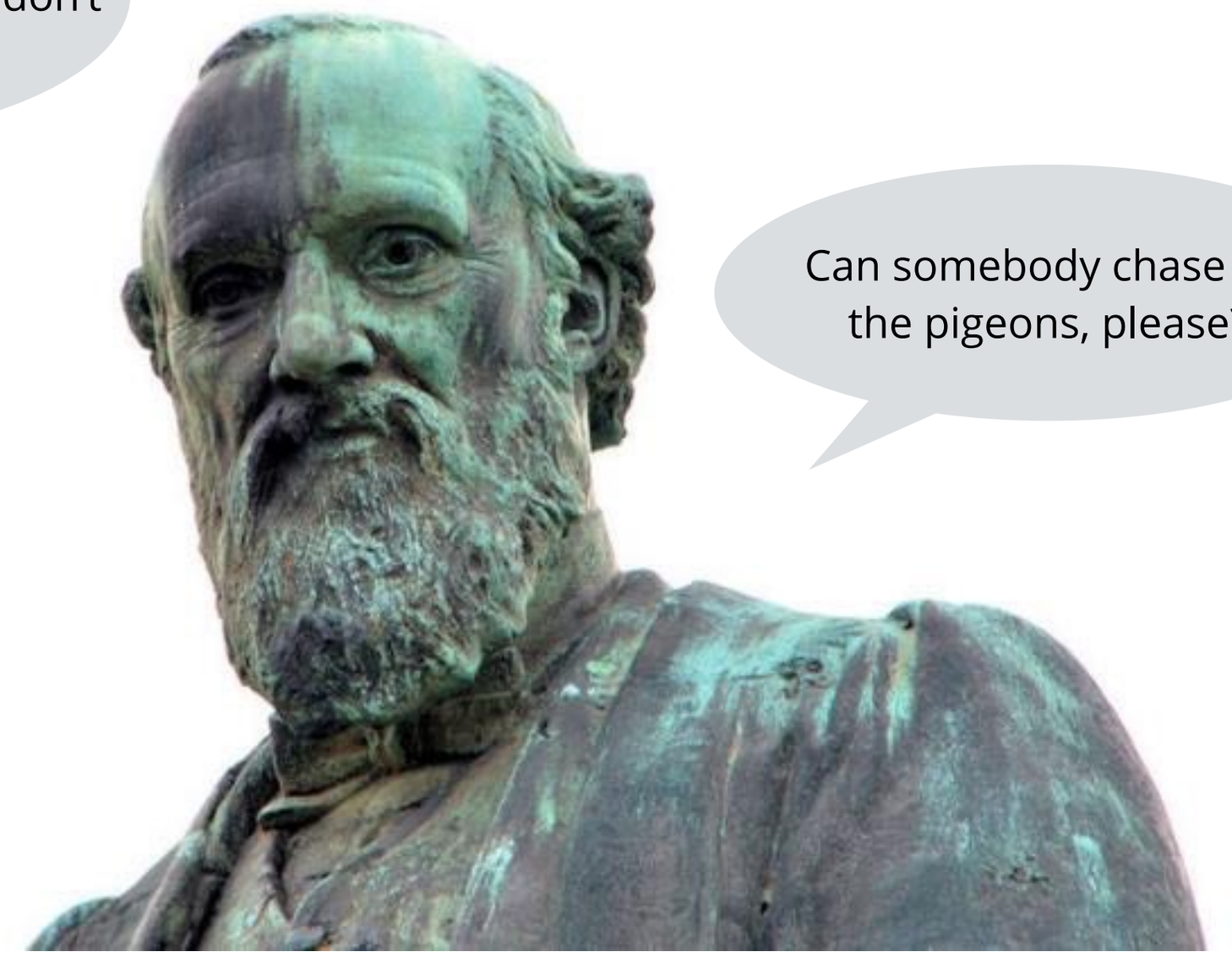
https://www.youtube.com/watch?v=9IDUZ1glnes

Roots of science: Marveling at stuff



Numbers made science a success

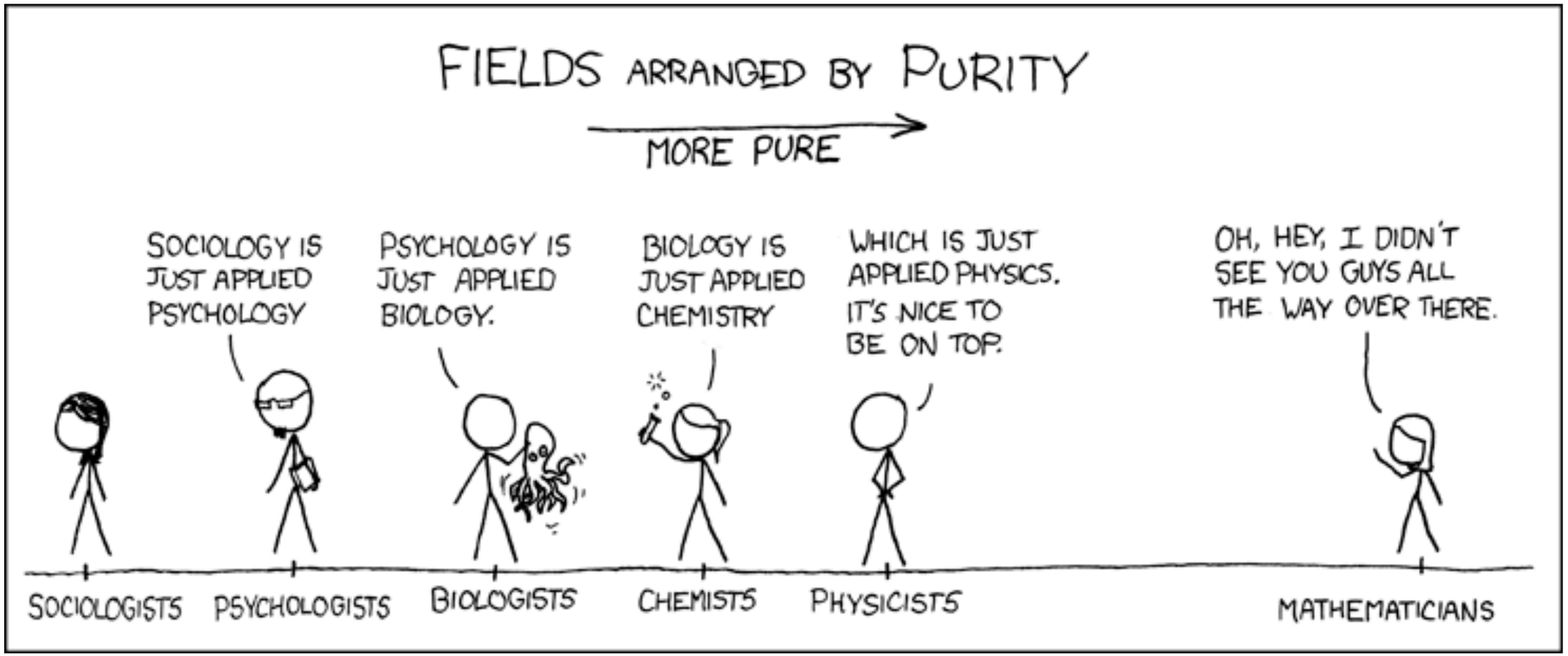
If you can’t express something in numbers, you don’t really understand it.



Can somebody chase off the pigeons, please?

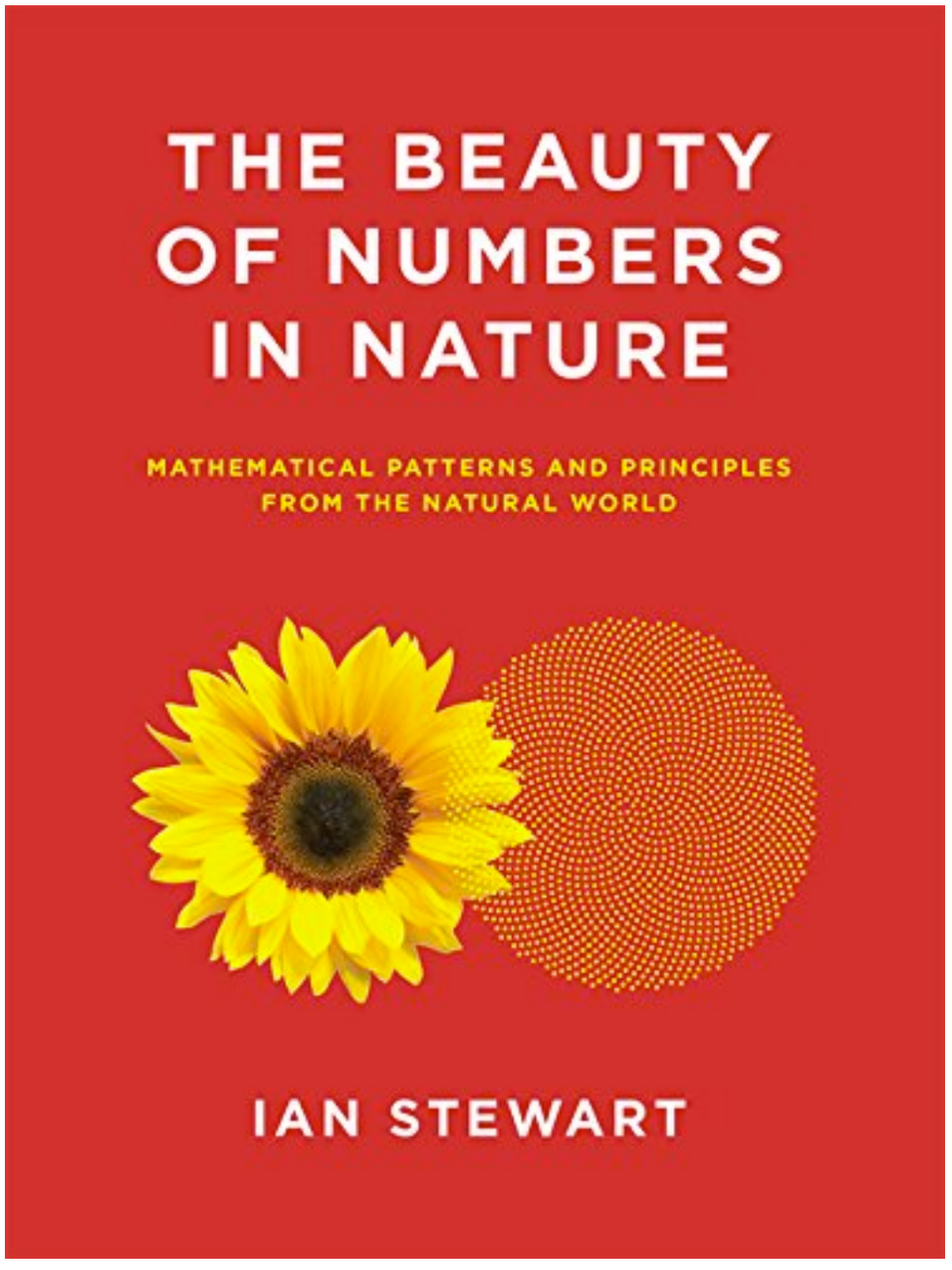
Lord Kelvin, a famous physicist

Math as the epitome of science?



https://xkcd.com/435/

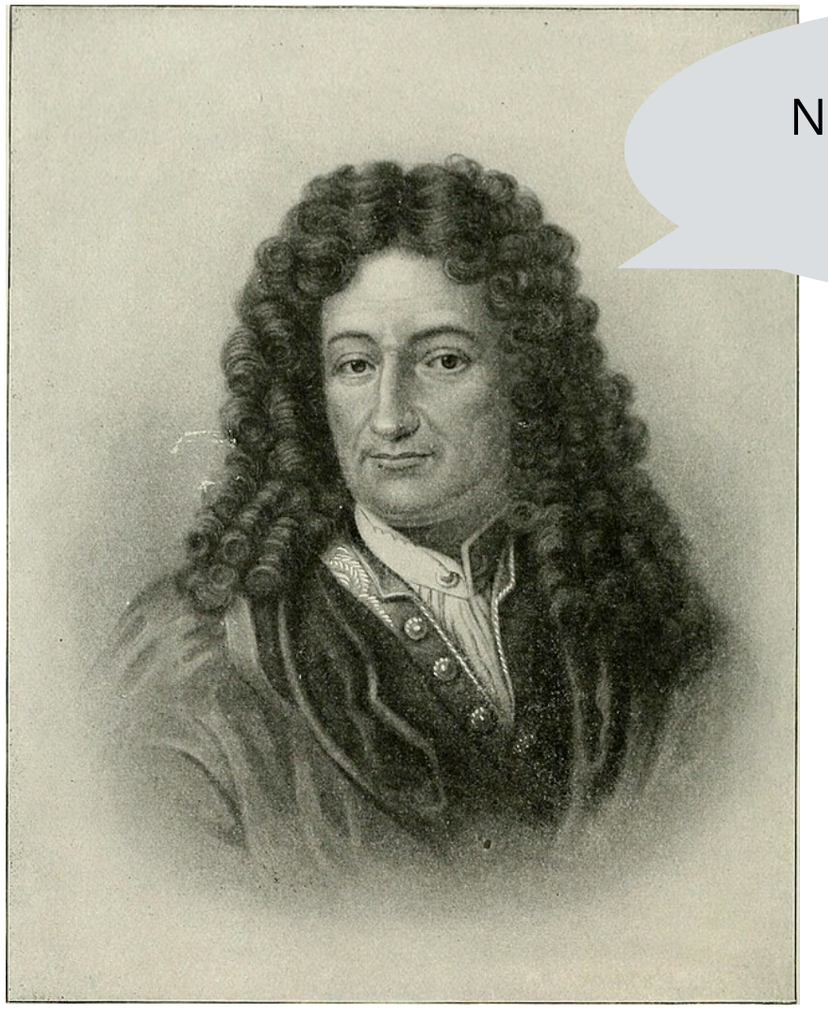
Reading tip: Nature's numbers

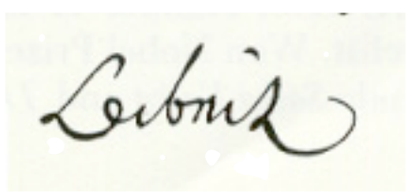


Stewart, I. (2017). *The beauty of numbers in nature: Mathematical patterns and principles from the natural world*. The MIT Press. https://mitpress.mit.edu/books/beauty-numbers-nature

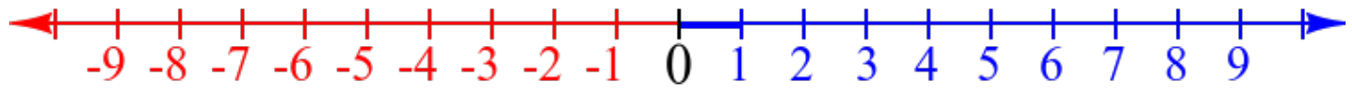
Fun fact: Math guys did not accept negative numbers

Gottfried Wilhelm Leibniz (1646- 1716)





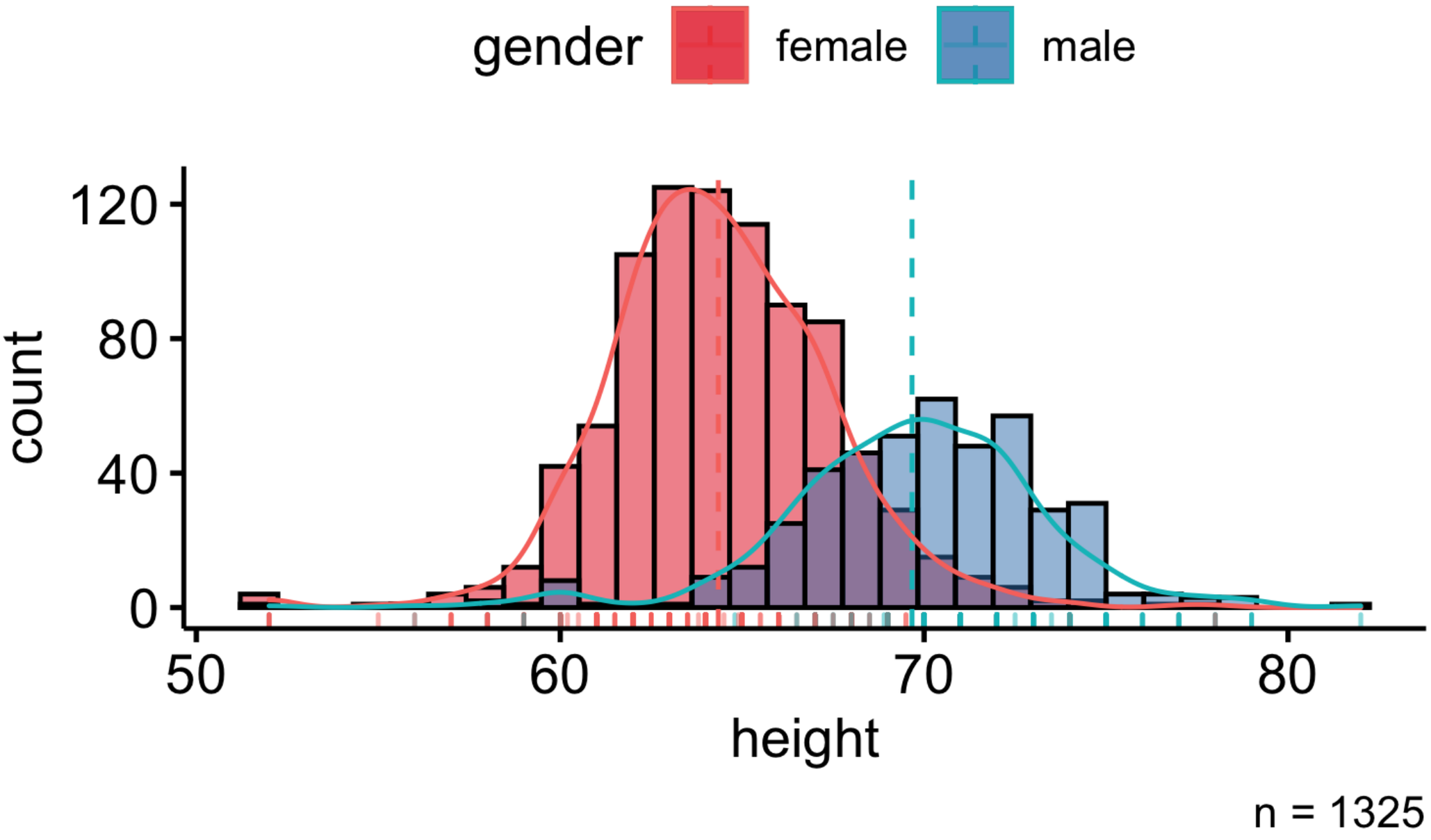
Negative nonsense!
I don't get it.



Martinez, A. A. (2014). *Negative math: How mathematical rules can be positively bent*. Princeton University Press.

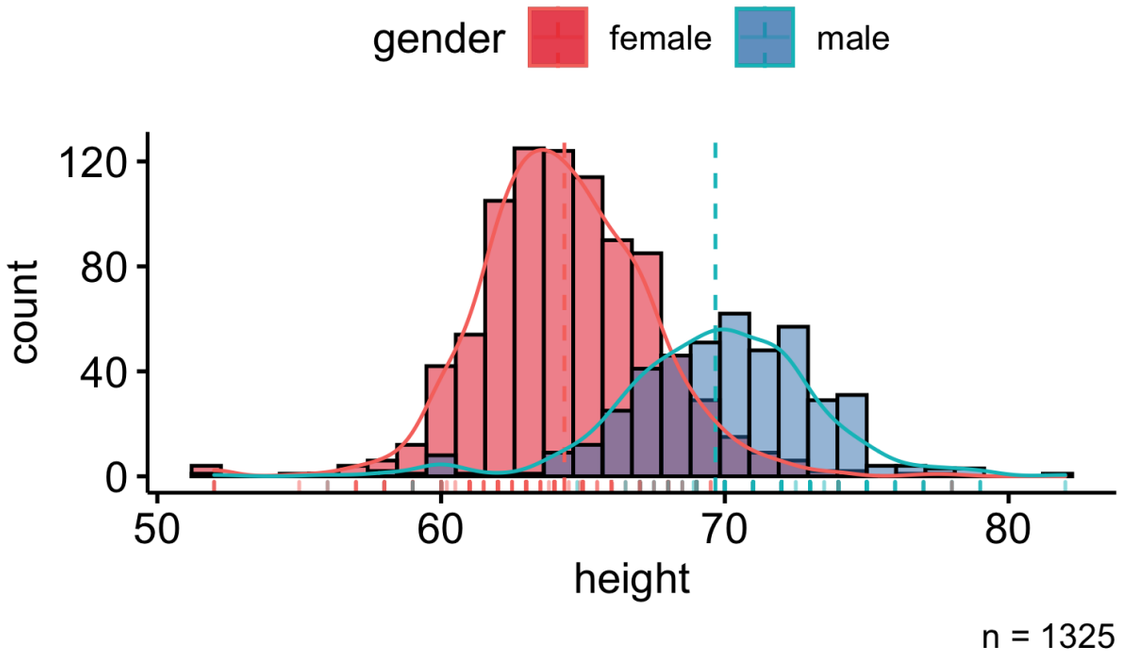
Understanding nature: discovering hidden patterns

Height of a sample of UCLA students

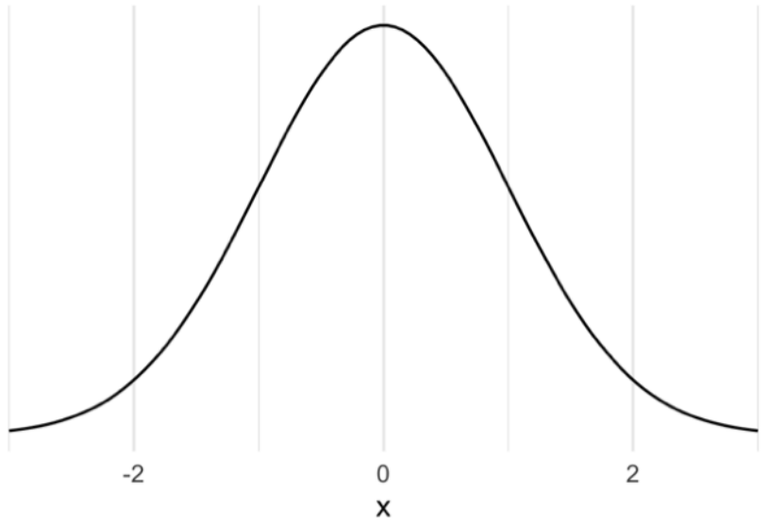


~~Smells~~ looks like a normal curve

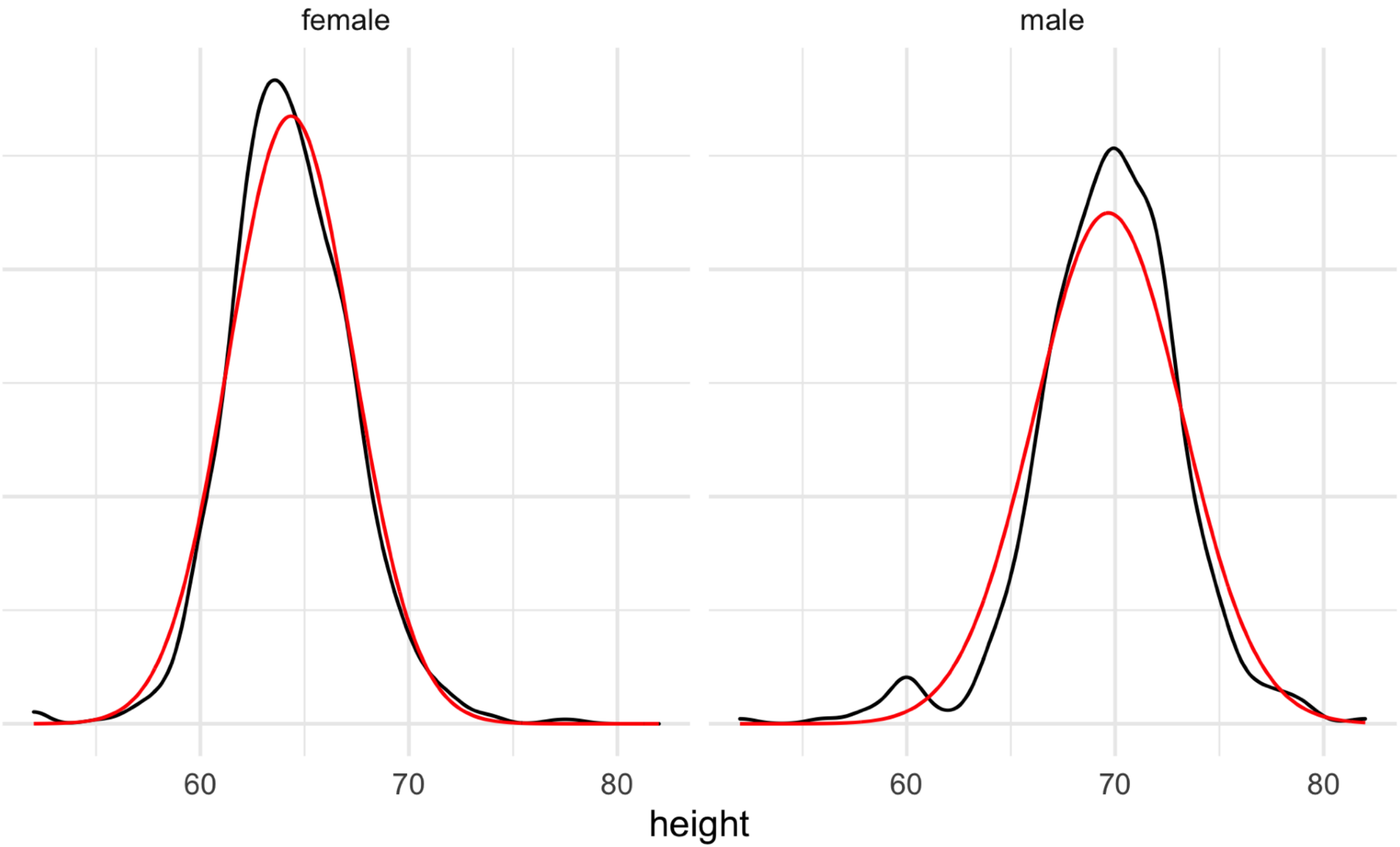
UCLA students' height



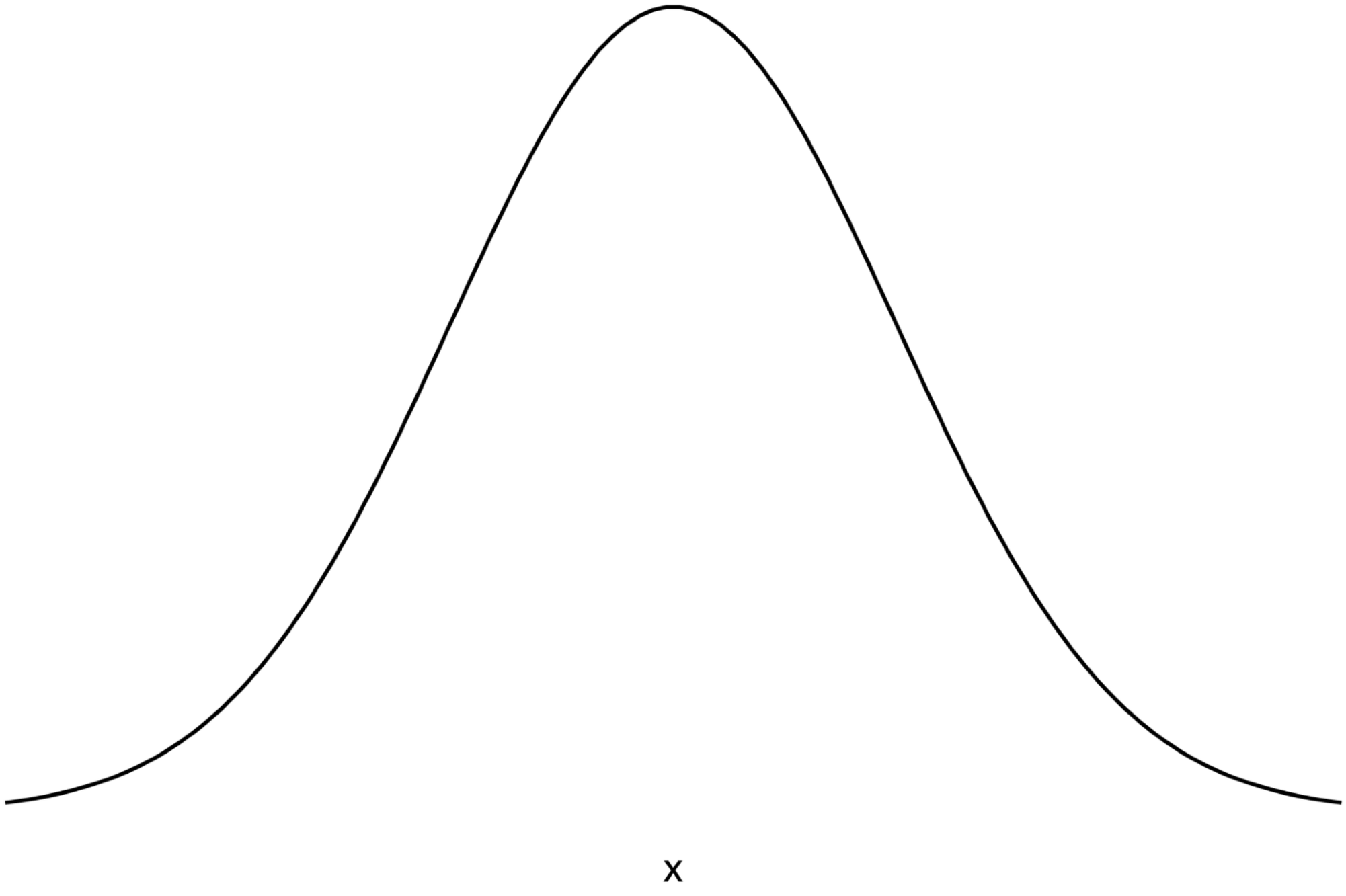
the normal „bell" curve



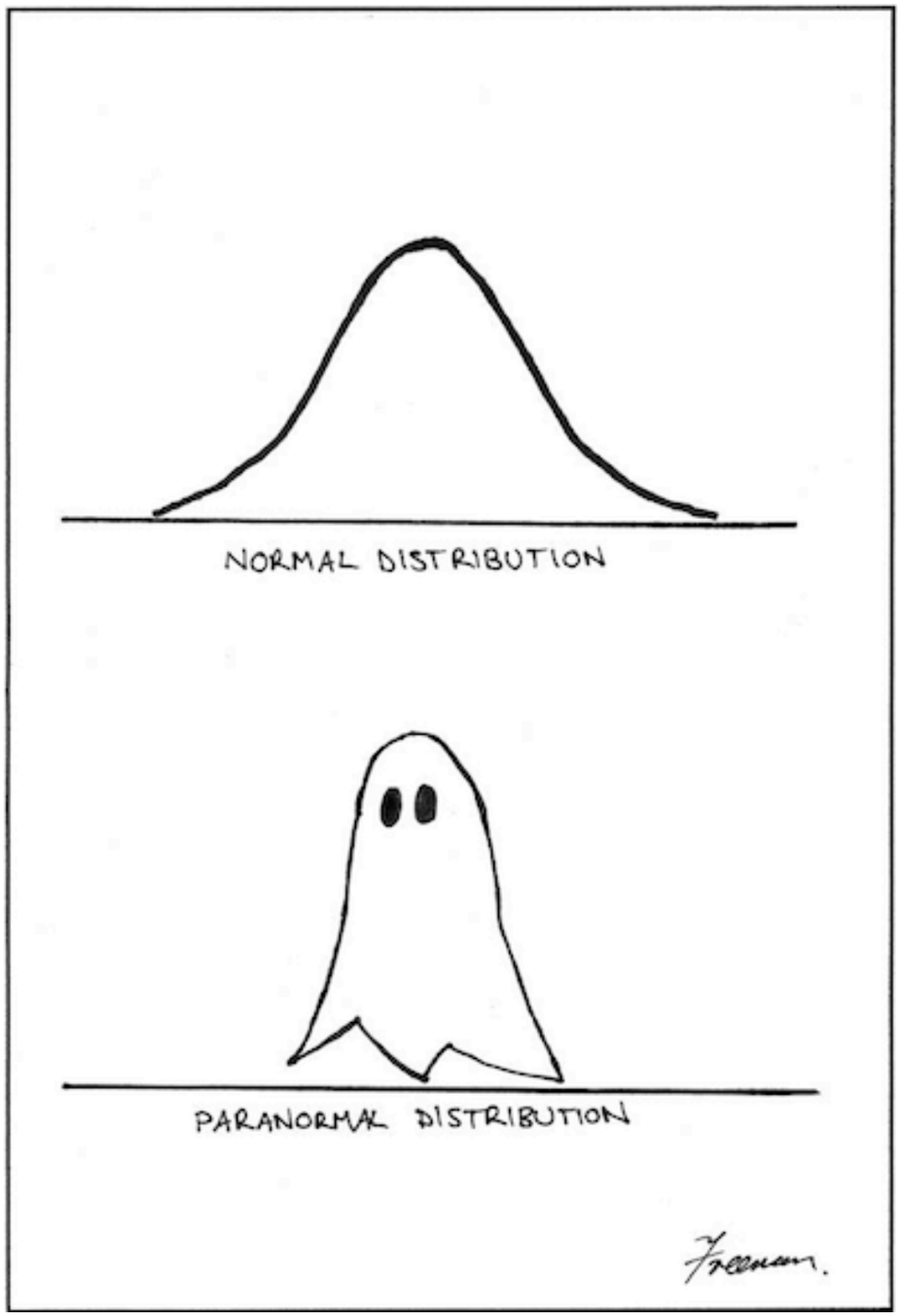
Histograms overlaid with normal curve: good match



But what actually is the normal curve?



Don’t mix up



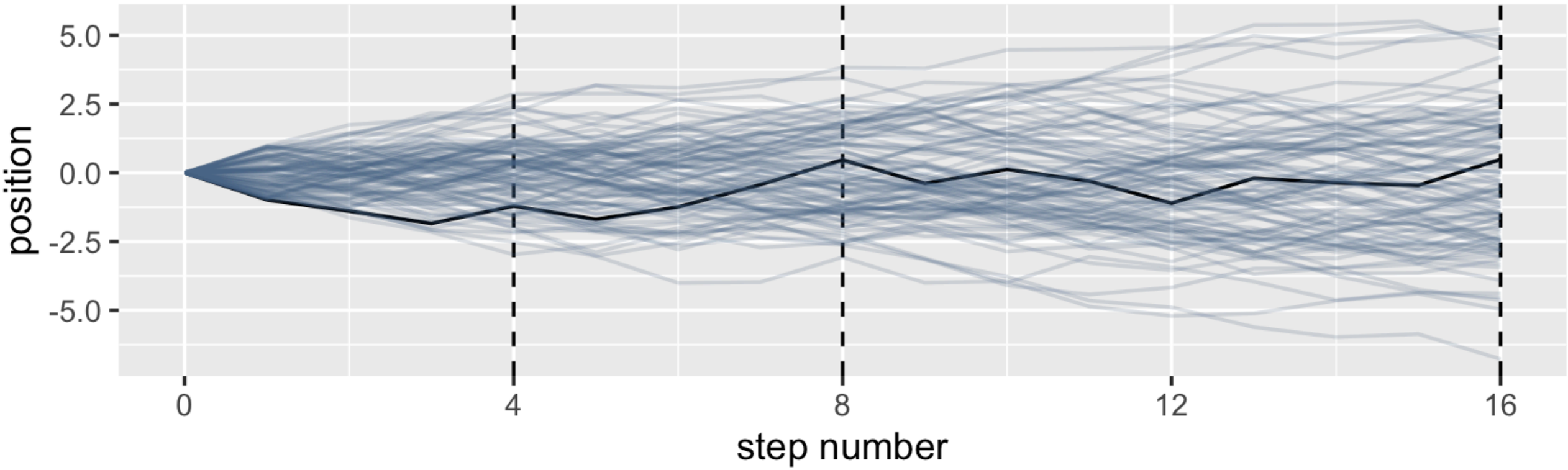
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2465539/

Coin flip experiment

Throw a fair coin 10 times.
Record here how many times „tails“ showed up.

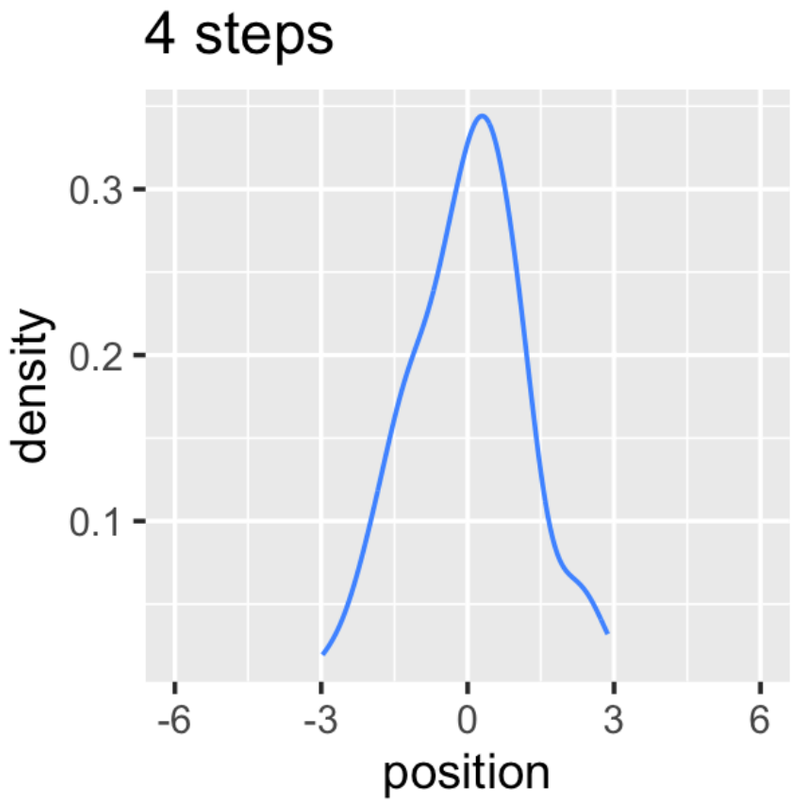
https://forms.gle/iqDarZXLRr8DRodx5

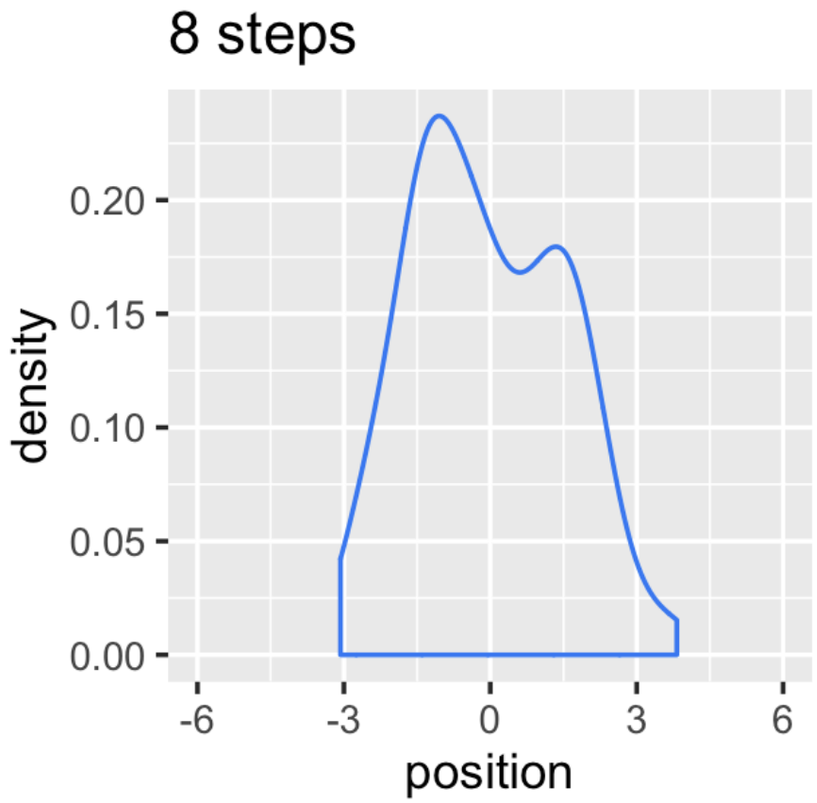
Coin flip simulation with a little help from a machine

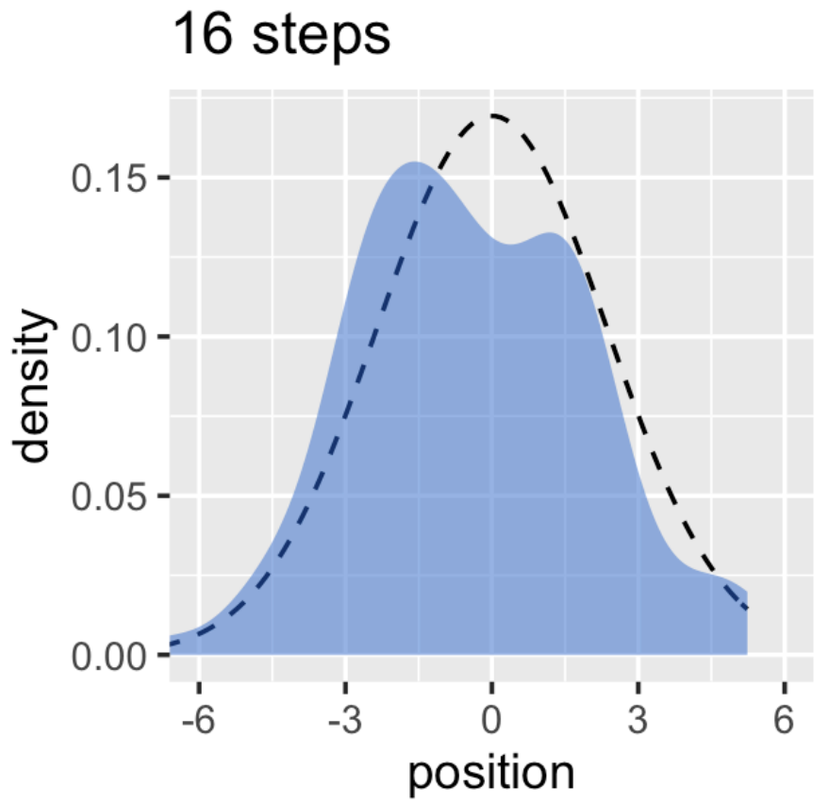


https://bookdown.org/content/4857/geocentric-models.html#why-normal-distributions-are-normal

The bell curve emerges

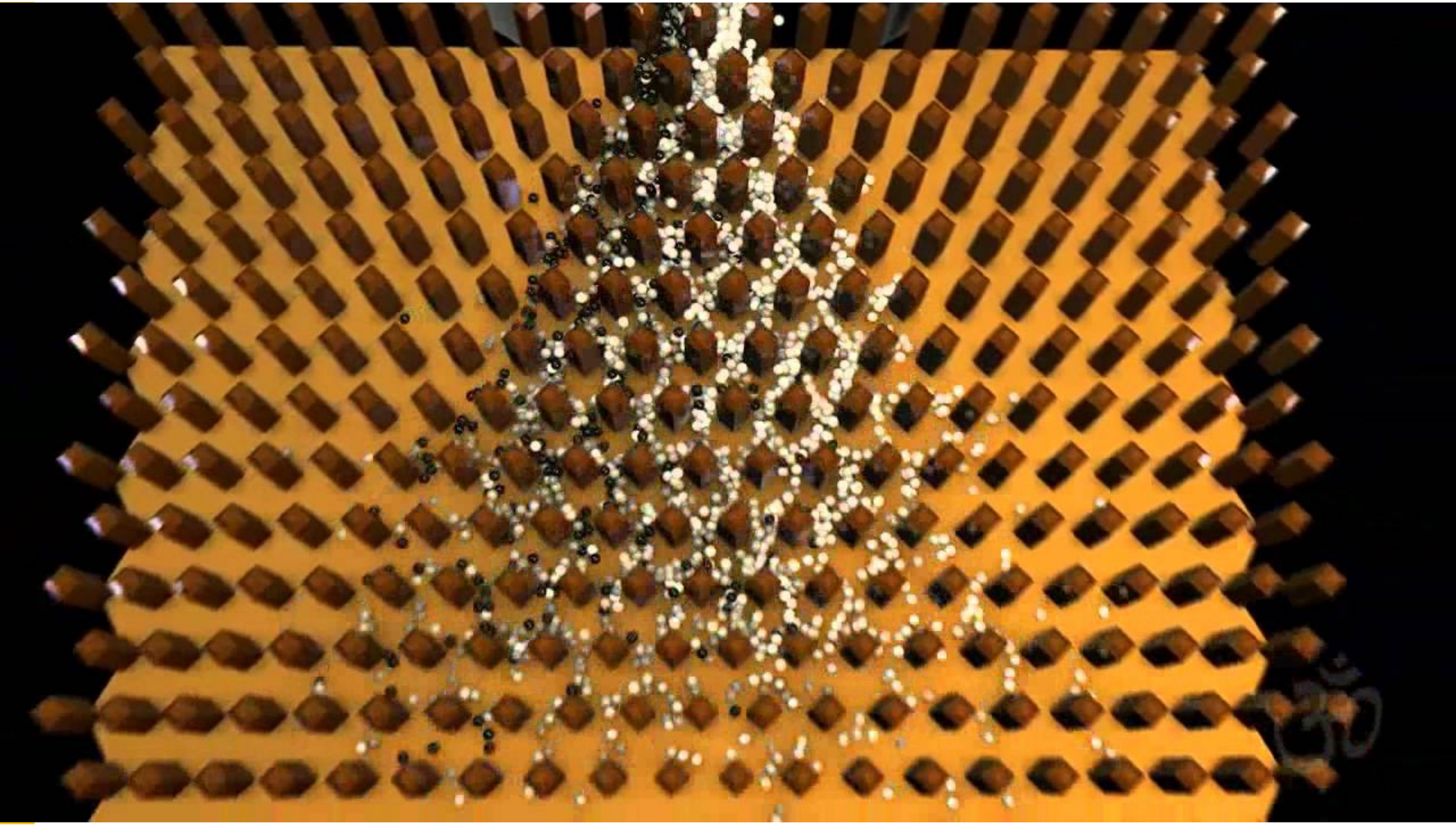






https://bookdown.org/content/4857/geocentric-models.html#why-normal-distributions-are-normal

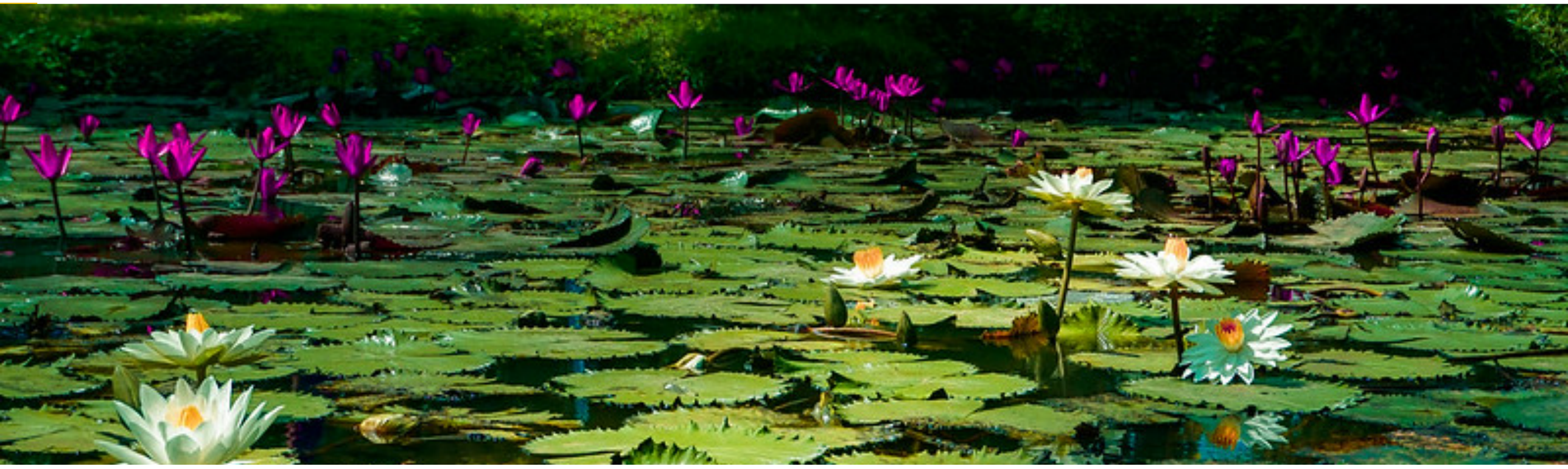
But why does the bell curve emerge?



https://www.youtube.com/watch?v=3m4bxse2JEQ&t=3s

Quite obvious, after you know it

Water lily pont



- Suppose there's a lake with water lilies.
- Day 1: 1 lily, day 2: 2 lilis, day 3: 4 and so on.
- On day 100 the lake is covered completely.
- On which day should you expect a **50%** coverage?

Calculate the number of lilies

step	amount
0	**1**
1	2
2	4
3	…
4	…
5	?
6	
7	
8	
9	
10	
32	
64	
128	
256	

Online calculator: https://web2.0calc.com/

The rise is dramatic

step	amount
0	**1**
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
32	≈4 Mrd
64	$\approx 10^{18}$
128	$\approx 10^{36}$😉
256	🤯🤯🤯

2 to the power of 256 ... big number

$$2^{256} =$$

115792089237316195423570985008687907853269984665640564039457584007913129639936

„10 to the 3rd power“ equals 1,000

$$10 = 10^1$$

$$100 = 10^2$$

$$1000 = 10^3$$

6 is the exponent

$$1{,}000{,}000 = 10^6$$

6 zeros/places after the leading 1

Ask your 7th grad math teacher.

Estimating 2^{64} as decimal number

$$2^{64} = ?$$

$2^{10} \approx 10^3$

$2^{20} = 2^{10} \cdot 2^{10} \approx 10^3 \cdot 10^3 = 10^6$

$2^{40} = 2^{20} \cdot 2^{20} \approx 10^6 \cdot 10^6 = 10^{12}$

$2^{60} = 2^{40} \cdot 2^{20} \approx 10^{12} \cdot 10^6 = 10^{18}$

1,000,000,000,000,000,000

18 zeros/places after the leading 1

https://web2.0calc.com/

2^{256} – rough estimate: 1 followed by 72 zeros

$$2^{256} \approx 10^{72}$$

Some context to „big“

fact	figure
Covid-19 death toll in Germany (as of 2021-06-23)	10^5
number of people in Germany	10^8
number of people in the world	10^{10}
number of neutrons in the brain	10^{11}
numbers of stars in the universe	10^{23}
number of atoms in the universe	10^{80}

Note. All figures are approximations of an expected mean.

Intuition on „big“

There was once a king in India who was a big chess enthusiast and had the habit of challenging wise visitors to a game of chess. One day a traveling sage was challenged by the king. The sage having played this game all his life all the time with people all over the world gladly accepted the Kings challenge. To motivate his opponent the king offered any reward that the sage could name. The sage modestly asked just for a few grains of rice in the following manner: the king was to put a single grain of rice on the first chess square and double it on every consequent one. The king accepted the sage’s request.

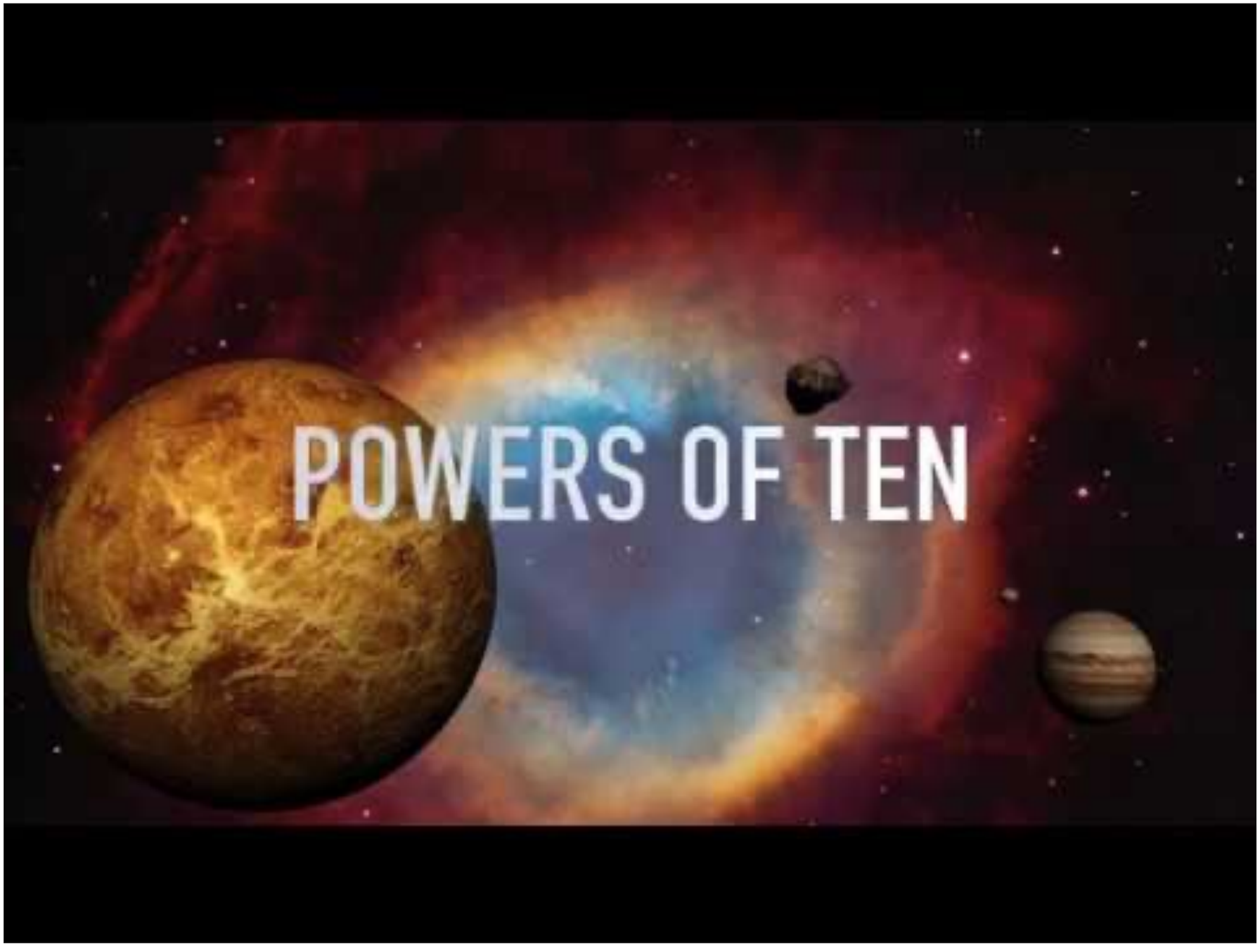
The king lost.

What’s the amount of rice the king owes to the sage?

Not peanuts, but rice, rough estimate

https://instacalc.com/54882

Powers of ten

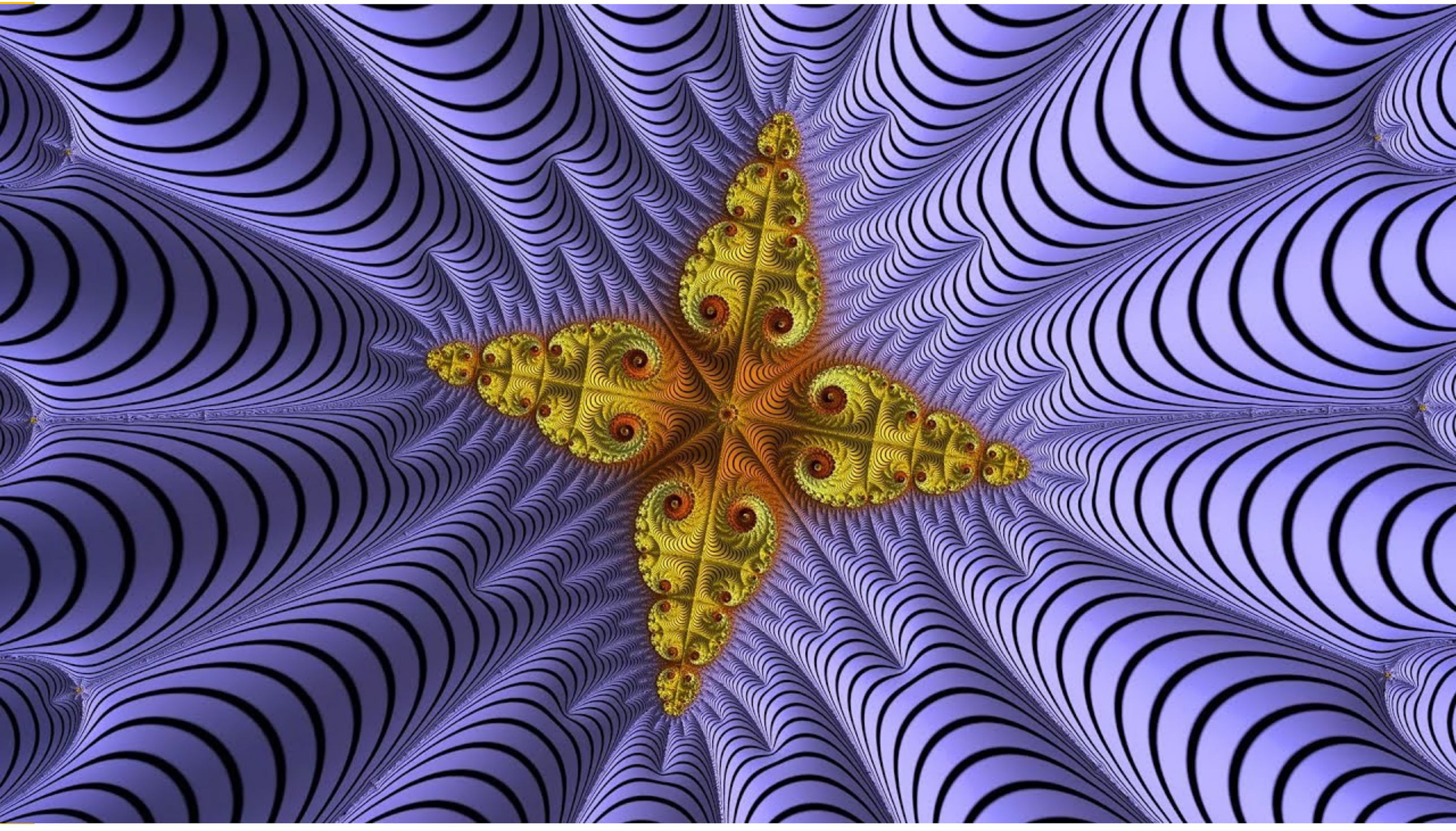


https://www.youtube.com/watch?v=44cv416bKP4&t=3s

There's a number for growth

Can we please stop the math here?

Admiring the beauty of patterns identified



https://www.youtube.com/watch?v=a3XDry3EwiU&t=1s

Frugal thinking

100

fatalities on US roads, each day (in 2019), approximately

Source: https://en.wikipedia.org/wiki/Motor_vehicle_fatality_rate_in_U.S._by_year, summing to approx. 36,000 traffic-related deaths in 2019

How do you rate your (future) driving skills?

Better than all the rest?

- Drivers consistently rate their skills as above the average, according to studies.

	Self	Average
Male	7.1	5.2
Female	6.5	5.10

- Study of n=99 subjects (58 male and 41 female), aged 18–68 yrs, British, with driving license

McKenna, F. P., Stanier, R. A., & Lewis, C. (1991). Factors underlying illusory self-assessment of driving skill in males and females. *Accident Analysis and Prevention*, *23*(1), 45–52. https://doi.org/10.1016/0001-4575(91)90034-3

94%

of professors rated them as better than average teachers in their own institution.

Cross, K. P. (1977). Not can, but will college teaching be improved? *New Directions for Higher Education*, *1977*(17), 1–15. https://doi.org/10.1002/he.36919771703

Krause, R. (2021). The effect of experience on reducing the overconfidence effect in teachers. Problems of Education in the 21st Century, 79(2), 220-228. https://doi.org/10.33225/pec/21.79.220

Hot or not? Beauty makes a professor, right?

RATE MY PROFESSORS

Easiness

Quality

Sexiness

Felton *, J., Mitchell, J., & Stinson, M. (2004). Web-based student evaluations of professors: The relations between perceived quality, easiness and sexiness. *Assessment & Evaluation in Higher Education*, *29*(1), 91–108. https://doi.org/10.1080/0260293032000158180

Which restaurant would you choose?

Patrons rate restaurants based on a number of features, including the **quality** of the **food** and the quality of the "**atmosphere**" (what it looks like, what music they play, etc). They combine these ratings into an overall rating from one to five stars.

You come across two restaurants that you know have five star ratings. You can see inside, but you haven't tasted the food yet. Which restaurant is more likely to have the best tasting food?

(A) Worse-looking restaurant

(B) Better-looking restaurant

(C) No preference

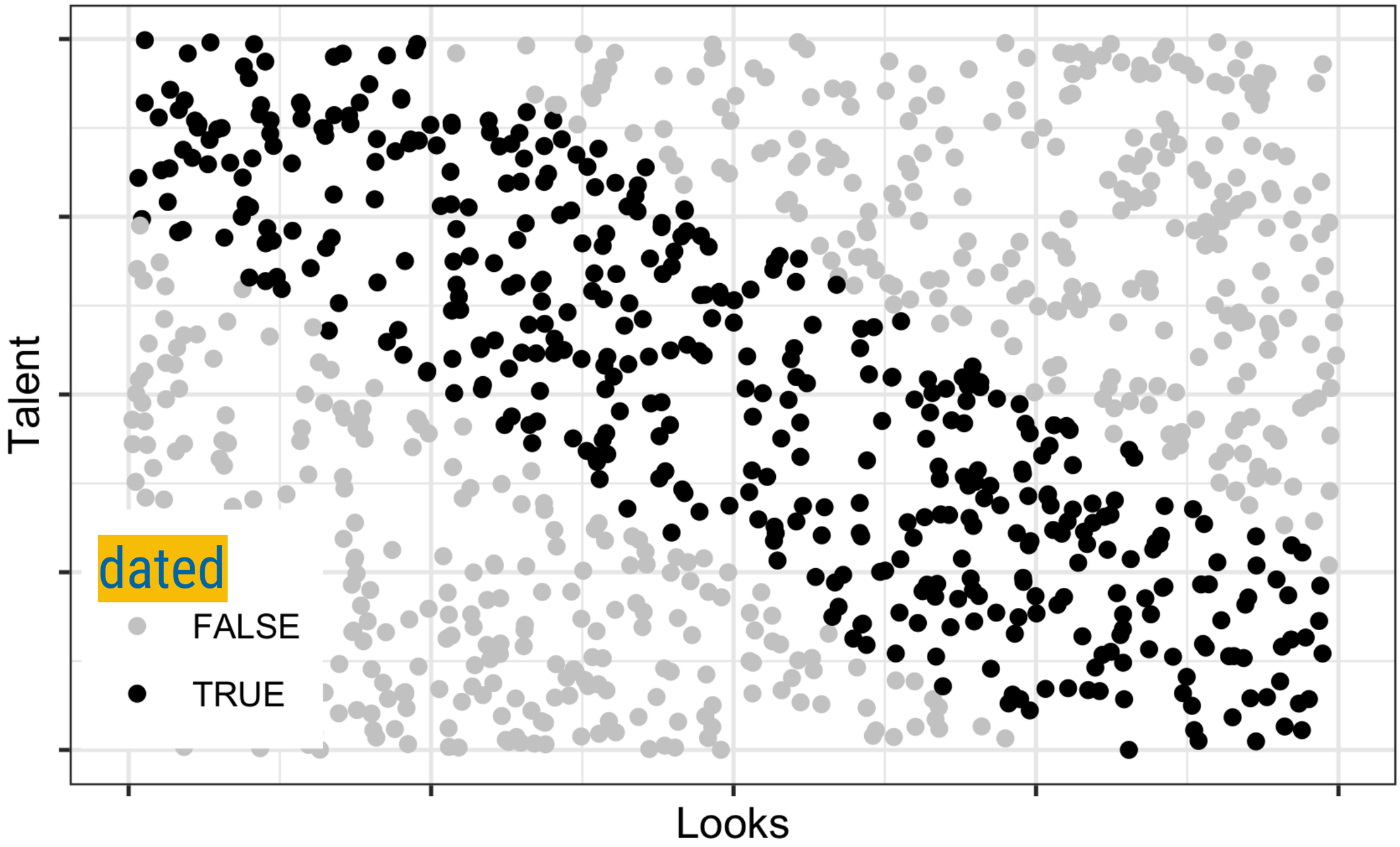
(D) No idea

https://brilliant.org/wiki/berksons-paradox/#

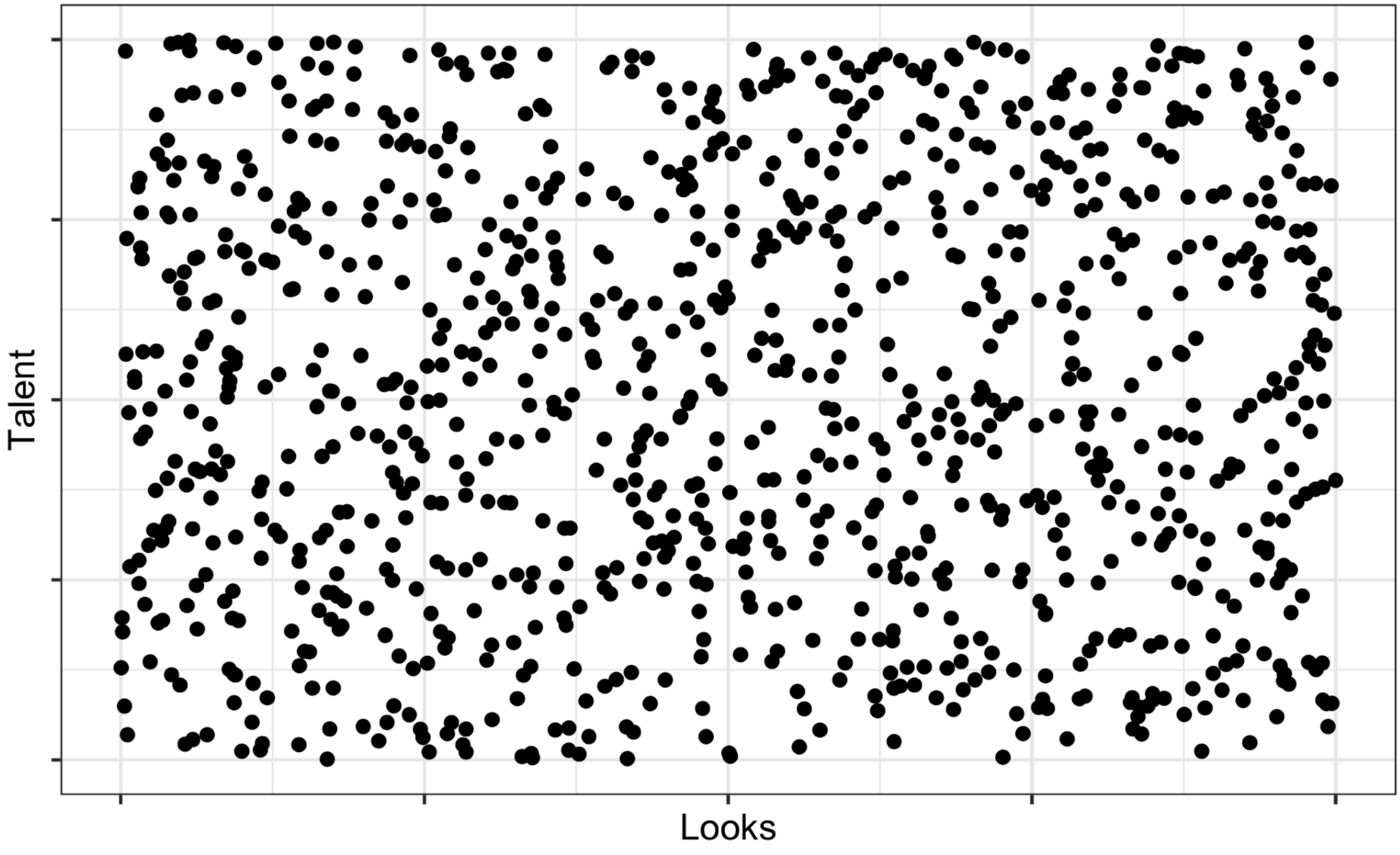
Why are handsome men such jerks?

Why are beautiful women such jerks?

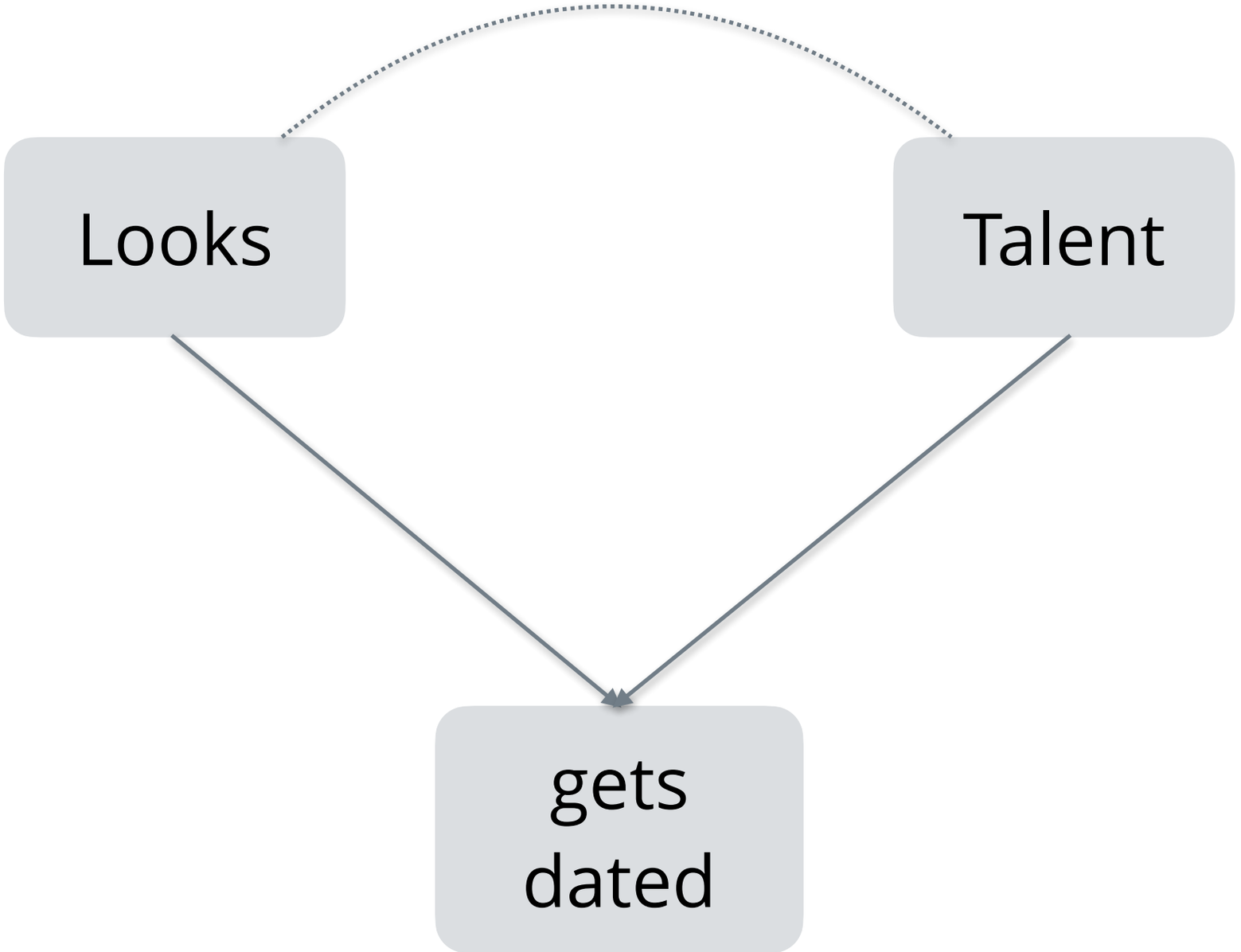
You and your dating success



Justice exists after all



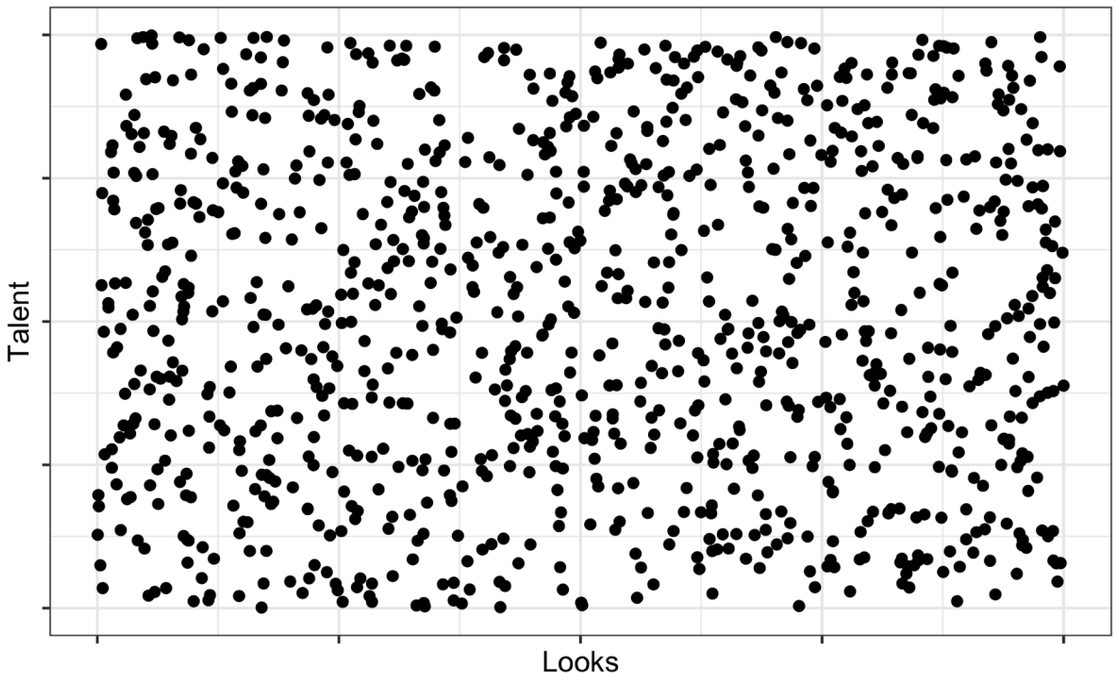
A causal model of you choosing your dates



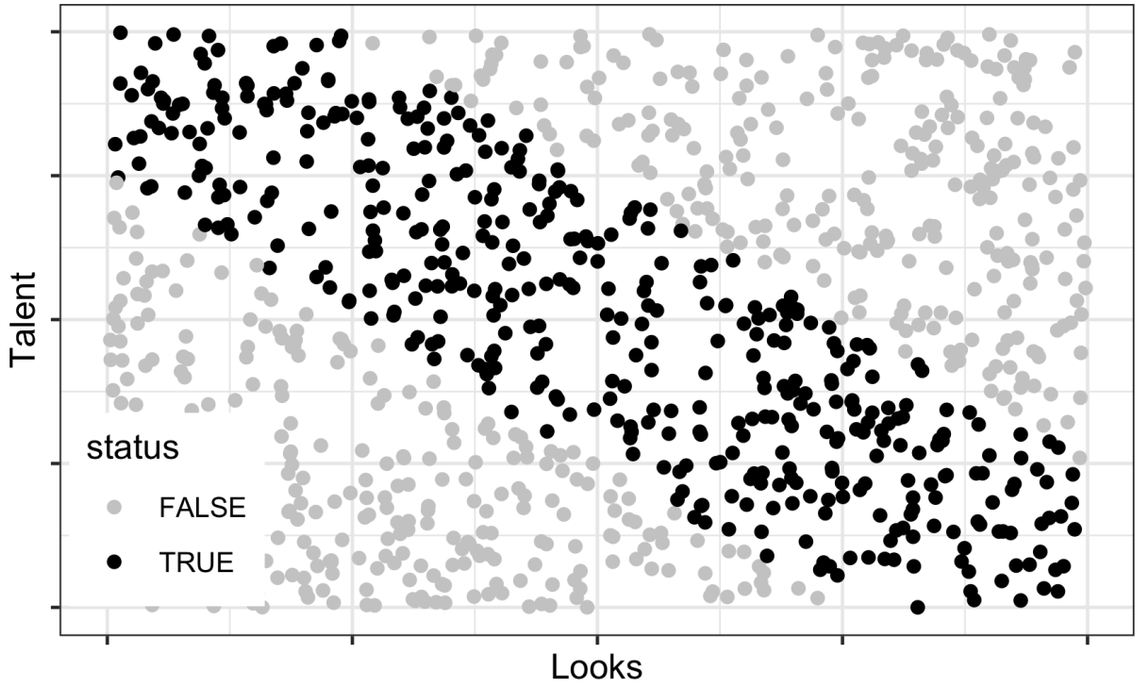
This is called ‚selection bias‘

- We have introducing a spurious correlation when in fact there is none.
- We achieved that by sampling a biased sample.
- The introduced bias is called ‚selection bias‘ or ‚collider bias‘.

Reality: no correlation



biased sample: strong correlation



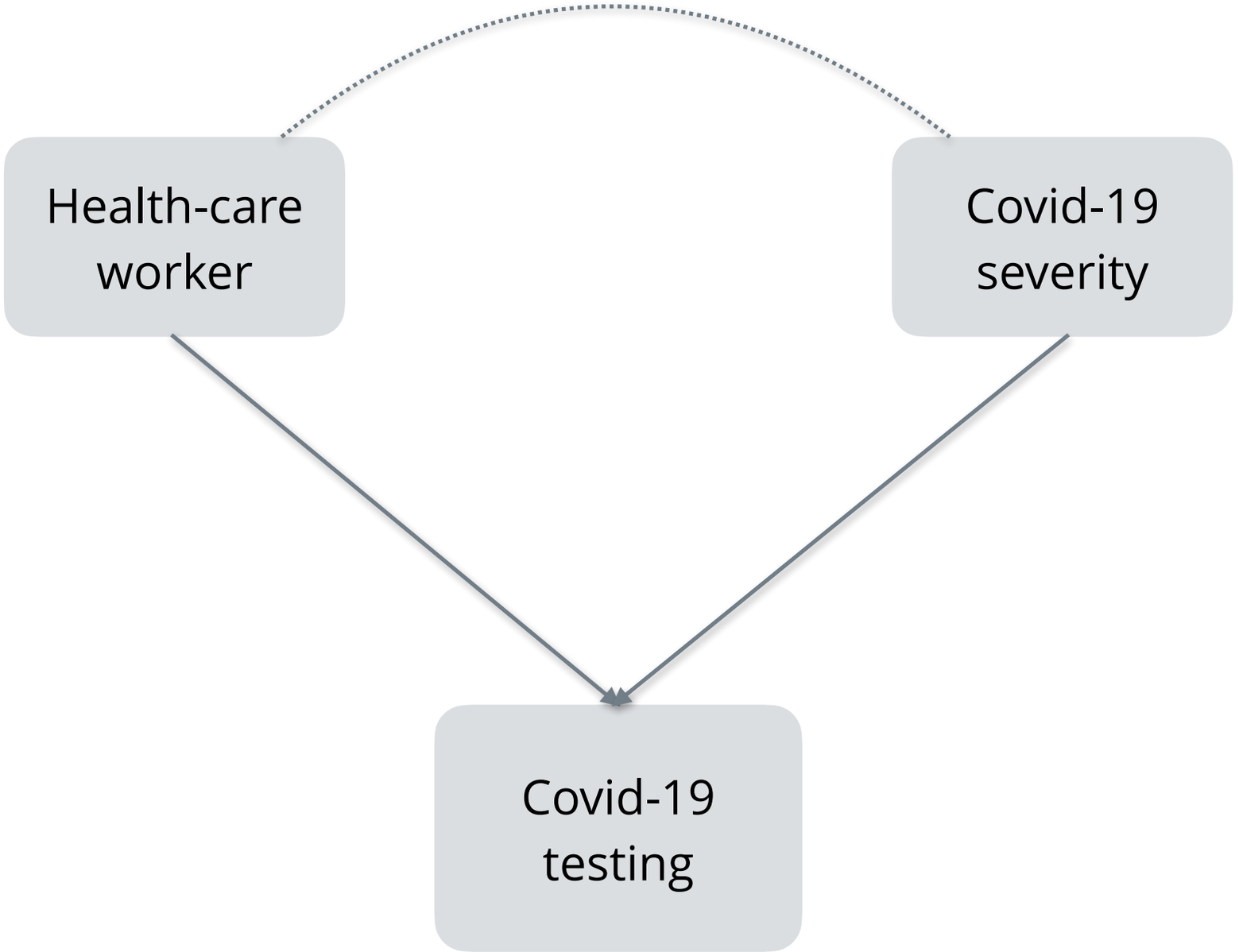
Collider bias may hit us hard

Article | Open Access | Published: 12 November 2020

Collider bias undermines our understanding of COVID-19 disease risk and severity

Gareth J. Griffith, Tim T. Morris, Matthew J. Tudball, Annie Herbert, Giulia Mancano, Lindsey Pike, Gemma C. Sharp, Jonathan Sterne, Tom M. Palmer, George Davey Smith, Kate Tilling, Luisa Zuccolo, Neil M. Davies & Gibran Hemani

Nature Communications **11**, Article number: 5749 (2020) | Cite this article



Griffith, G. J., Morris, T. T., Tudball, M. J., Herbert, A., Mancano, G., Pike, L., Sharp, G. C., Sterne, J., Palmer, T. M., Davey Smith, G., Tilling, K., Zuccolo, L., Davies, N. M., & Hemani, G. (2020). Collider bias undermines our understanding of COVID-19 disease risk and severity. *Nature Communications*, *11*(1), 5749. https://doi.org/10.1038/s41467-020-19478-2

Playing dice when you make decisions

Survey on common knowledge

Group A

https://forms.gle/v4nuBrFuFieCkDZz8

Group B

https://forms.gle/E7FUN7sLqFggtZ318

Even implausible anchors may impact your estimates

Table 5
Objects and Anchors Used in Study 3

Question	Actual value	Plausible anchors		Implausible anchors	
		High	Low	High	Low
Antarctic: mean temperature in winter (°C)	−68	−17	−43	45	−210
Einstein: year of first visit to United States	1921	1939	1905	1992	1215
Da Vinci: year of birth	1452	1698	1391	1952	−300
Gandhi: age	78	79	64	140	9
Ulm: altitude (m)	478	320	150	10,500	−1,700
Aristotle: year of birth	−322	−220	−490	1832	−25,000
Whale: length (m)	33.0	49.0	21.0	900.0	0.2
Elbe: length (km)	1,165	890	550	45,000	25

Strack, F., Mussweiler, T., Danneil, W., Deppe, U., Fritze, G., Harneit, C., Neumann, M., Siebers, A., & Sequeira, A. (1997). Explaining the Enigmatic Anchoring Effect: Mechanisms of Selective Accessibility. *Journal of Personality and Social Psychology*, *73*(3), 437–446. https://doi.org/10.1037/0022-3514.73.3.437

Playing dice with criminal sentences?

> Judicial sentencing decisions should be guided by facts, not by chance. The present research however demonstrates that the sentencing decisions of experienced legal professionals are influenced by irrelevant sentencing demands even if they are blatantly determined at random. Participating legal experts anchored their sentencing decisions on a given sentencing demand and assimilated toward it even if this demand came from an irrelevant source (Study 1), they were informed that this demand was randomly determined (Study 2), or they randomly determined this demand themselves by throwing dice (Study 3). Expertise and experience did not reduce this effect.

Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts' judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

Sentencing decisions influenced by anchoring?

- Would the sentencing decisions of experienced legal professionals be influenced by irrelevant anchors?
- We recruited 42 experienced legal professionals (28 men) at educational conferences for judges and prosecutors.
- Participants received realistic case material about an alleged rape. The materials were designed to include all the relevant information that is typically provided in actual court cases.
- Participants took about 15 minutes to work through this material.
- “Do you think that the sentence for the defendant in this case will be higher or lower than 1/3 year(s)?” (low/high anchor).
- About half of the participants were exposed to the high anchor, the other half to the low anchor.
- Participants judged the materials to be realistic, M = 7.38, SD = 1.40 (scale from 1 to 9).
- Participants felt fairly certain about their sentencing decision, M = 6.02 (scale from 1 to 9).

Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts’ judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

Anchors for the sentence in the two groups

high anchor

3

years

low anchor

1

year

Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts' judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

Higher sentencing in the ‚high anchor' group

high anchor

33 months

low anchor

25 months

Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts' judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

Anchors for the sentence in the two groups

high anchor

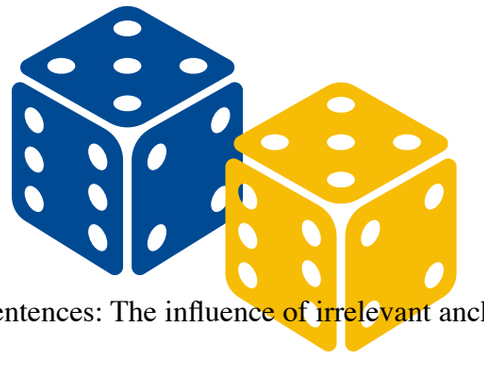
9

months

low anchor

3

months



Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts' judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

Higher sentencing in the ‚high anchor' group

high anchor

8 months

low anchor

5 months

Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts' judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

> Taken together, these findings demonstrate that even if legal experts randomly determined a sentencing anchor themselves by throwing a pair of dice, they were influenced by it.

Englich, B., Mussweiler, T., & Strack, F. (2006). Playing dice with criminal sentences: The influence of irrelevant anchors on experts' judicial decision making. *Personality & social psychology bulletin*, *32*(2), 188–200. https://doi.org/10.1177/0146167205282152

Perils of science and/or technology

Welcome to the dark side

RESEARCH ARTICLE

Private traits and attributes are predictable from digital records of human behavior

Michal Kosinski, David Stillwell, and Thore Graepel

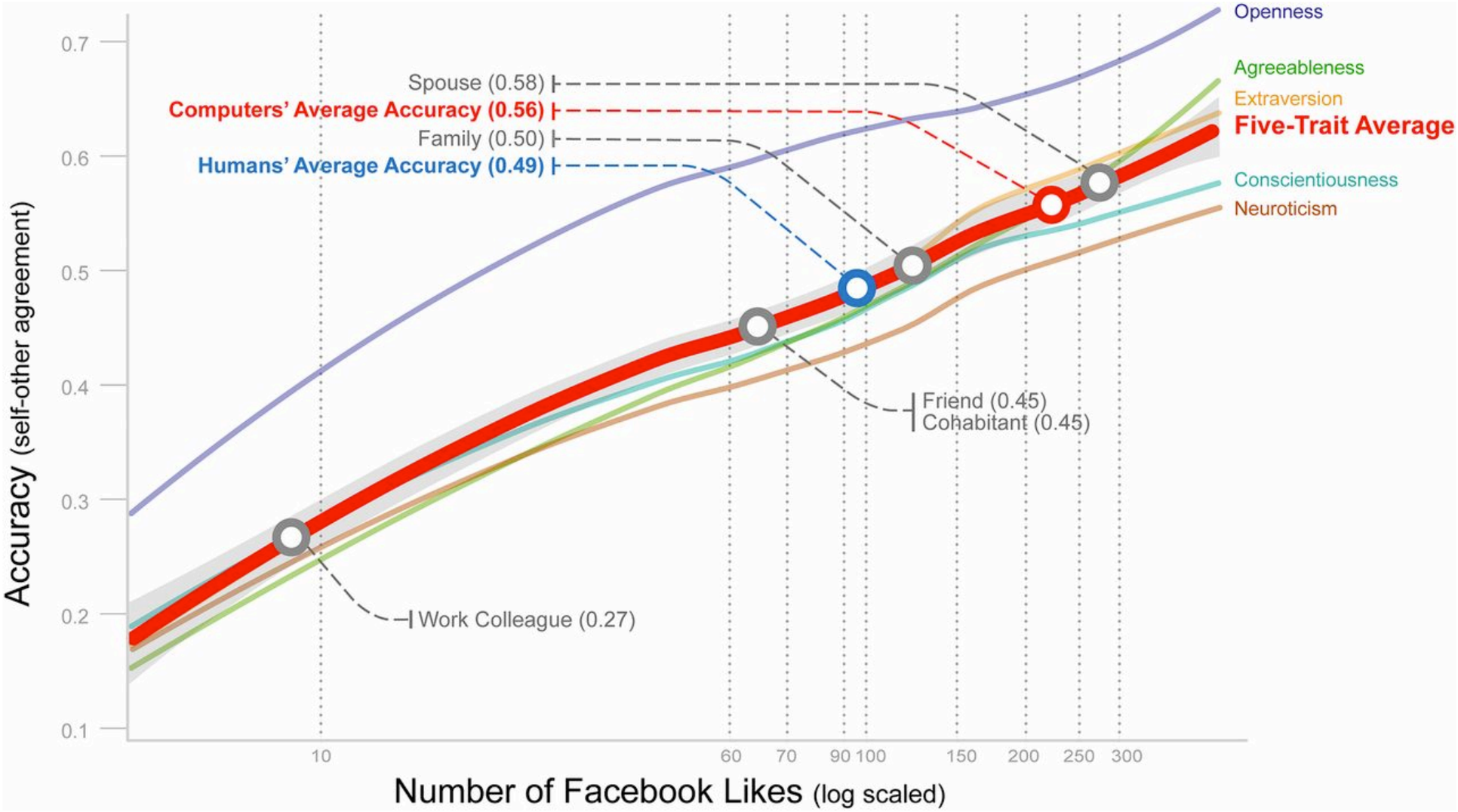
PNAS April 9, 2013 110 (15) 5802-5805; https://doi.org/10.1073/pnas.1218772110

> We show that easily accessible digital records of behavior, Facebook Likes, can be used to automatically and accurately predict a range of highly sensitive personal attributes including: sexual orientation, ethnicity, religious and political views, personality traits, intelligence, happiness, use of addictive substances, parental separation, age, and gender.

Kosinski, M., Stillwell, D., & Graepel, T. (2013). Private traits and attributes are predictable from digital records of human behavior. *Proceedings of the National Academy of Sciences*, *110*(15), 5802–5805. https://doi.org/10.1073/pnas.1218772110

Case study: Predicting your personality

- The computer outperformed even close friends when it comes to predicting a personality, study finds.



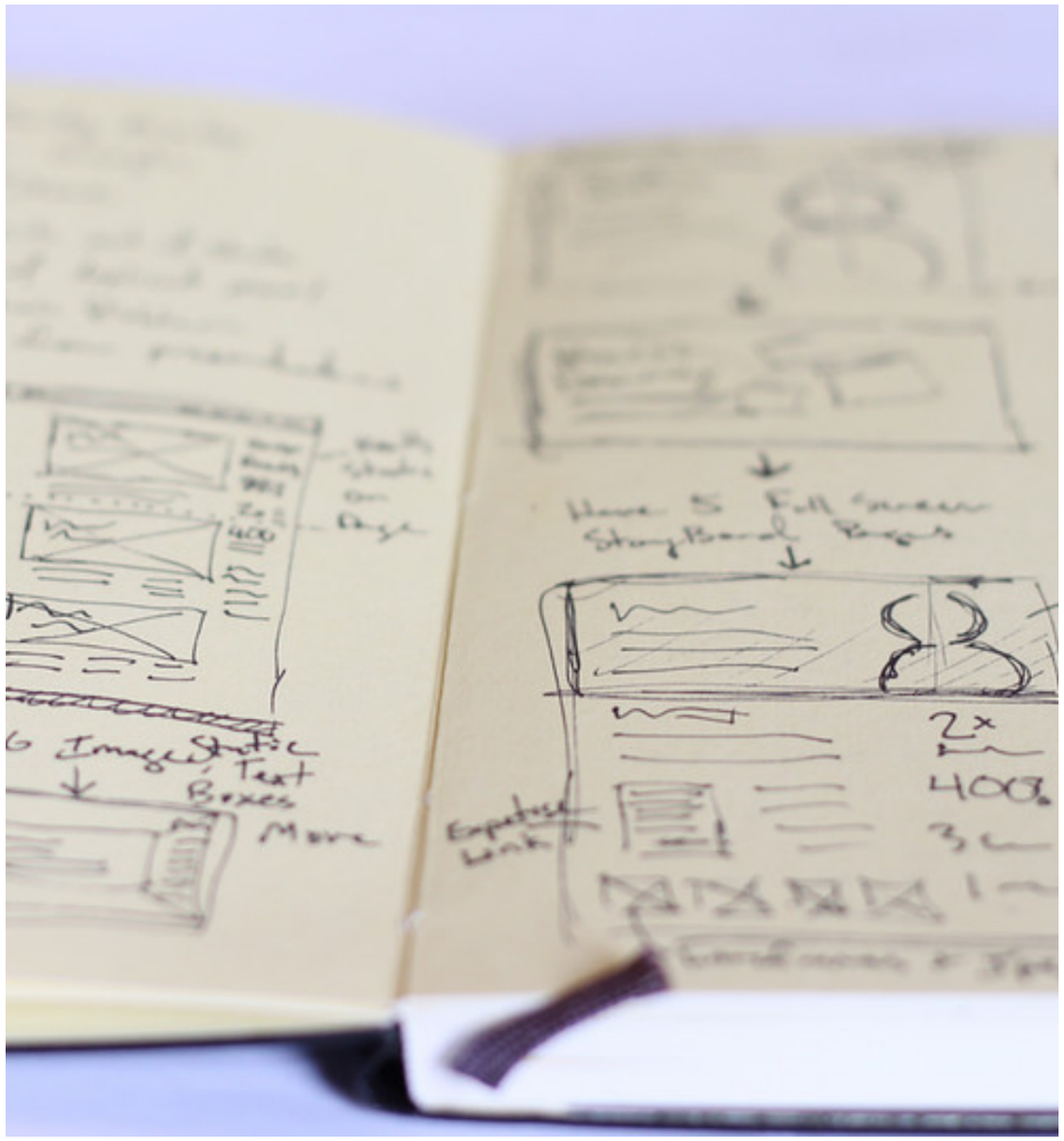
Youyou, W., Kosinski, M., & Stillwell, D. (2015). Computer-based personality judgments are more accurate than those made by humans. *Proceedings of the National Academy of Sciences*, *112*(4), 1036–1040. https://doi.org/10.1073/pnas.1418680112

How to spot misleading number presentations

http://imgs.xkcd.com/comics/1000_times.png

Recap

Reflect on what you learned today



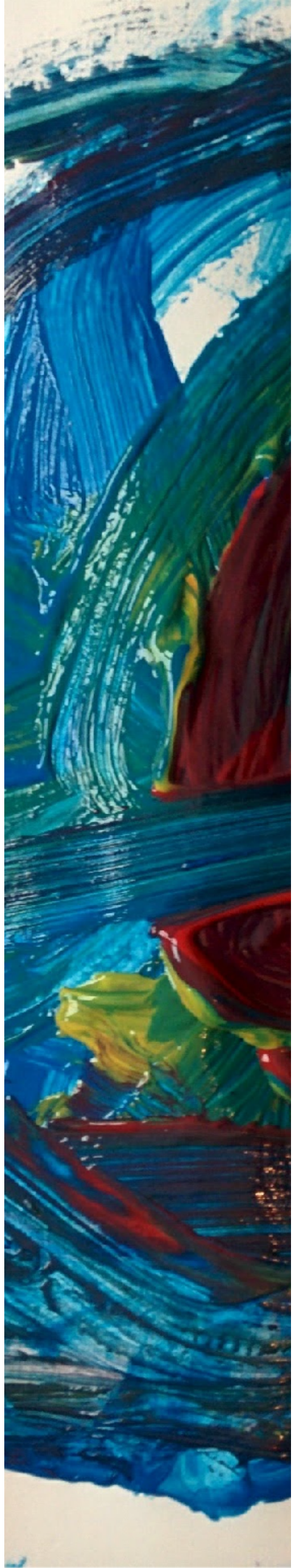
1. Find one idea that you learned.

2. Identify one next step for your personal growth.

3. Formulate one open question that keeps you thinking.

In one (or few) words: Now, what's science (for you)?

https://www.menti.com/mremfvmuxb



Sebastian Sauer

sebastian.sauer@data-divers.com

data-divers.com