

How to be wrong

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Slides in this presentation are from material kindly provided by
Shannon Ellis and Brad Voytek

Errors of measurement

Errors of analysis

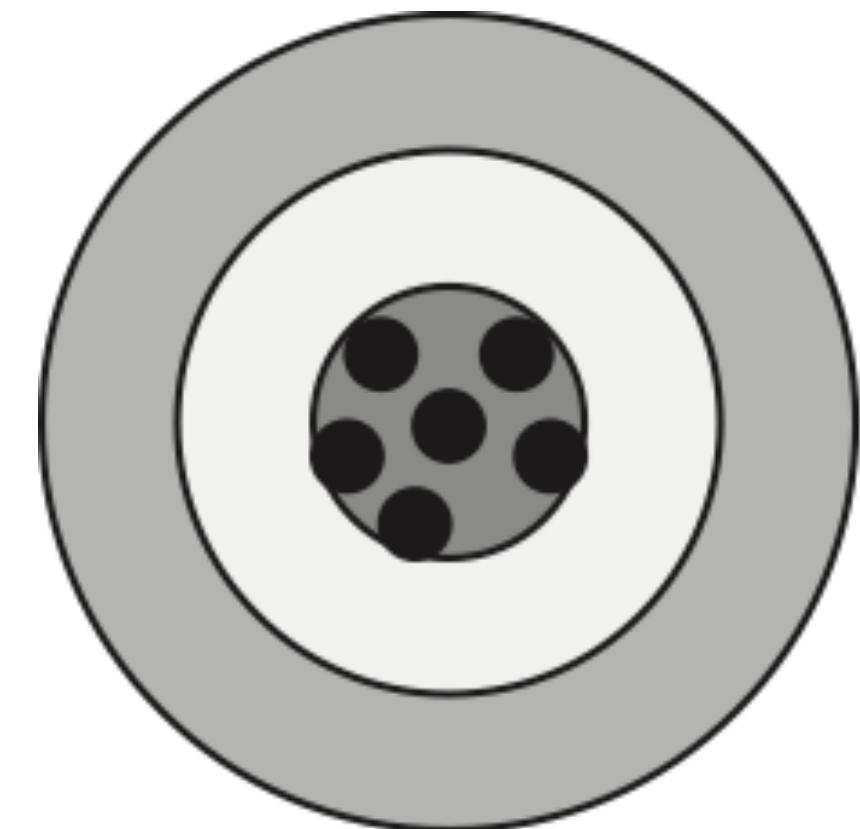
Errors of borked tools

Errors of human cognition

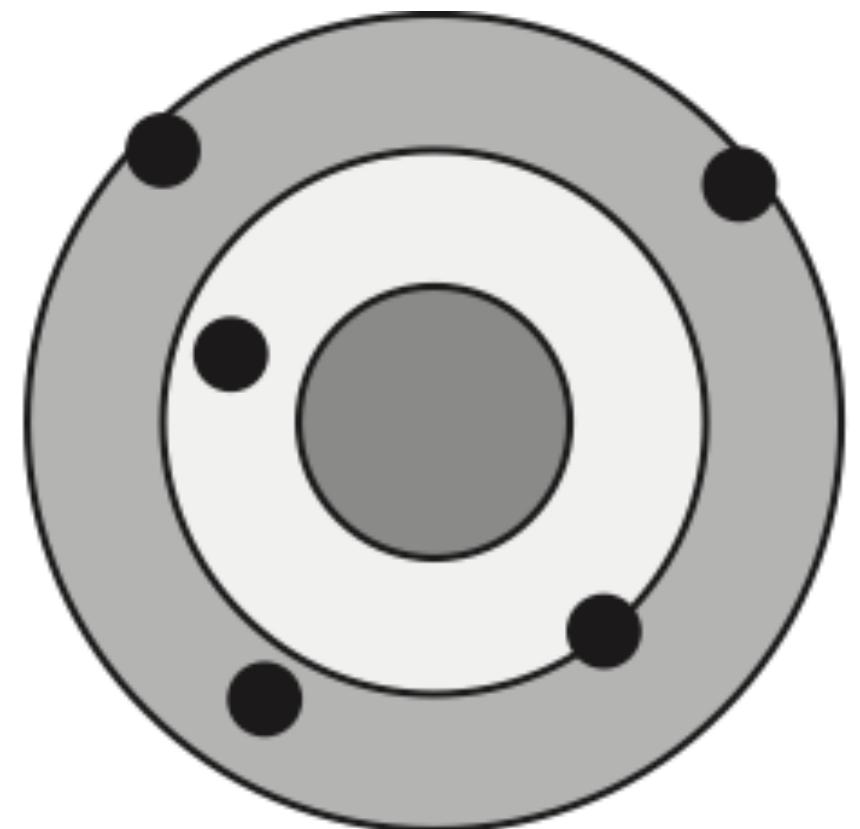
Errors of communication

Errors of measurement

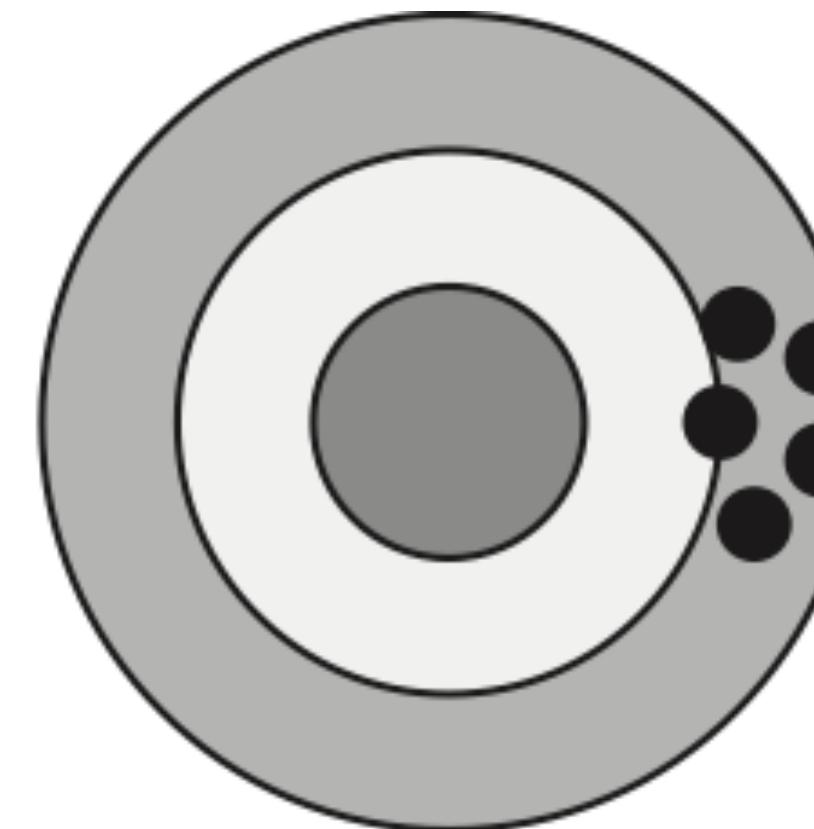
**Accurate
and precise**



**Accurate
but not precise**

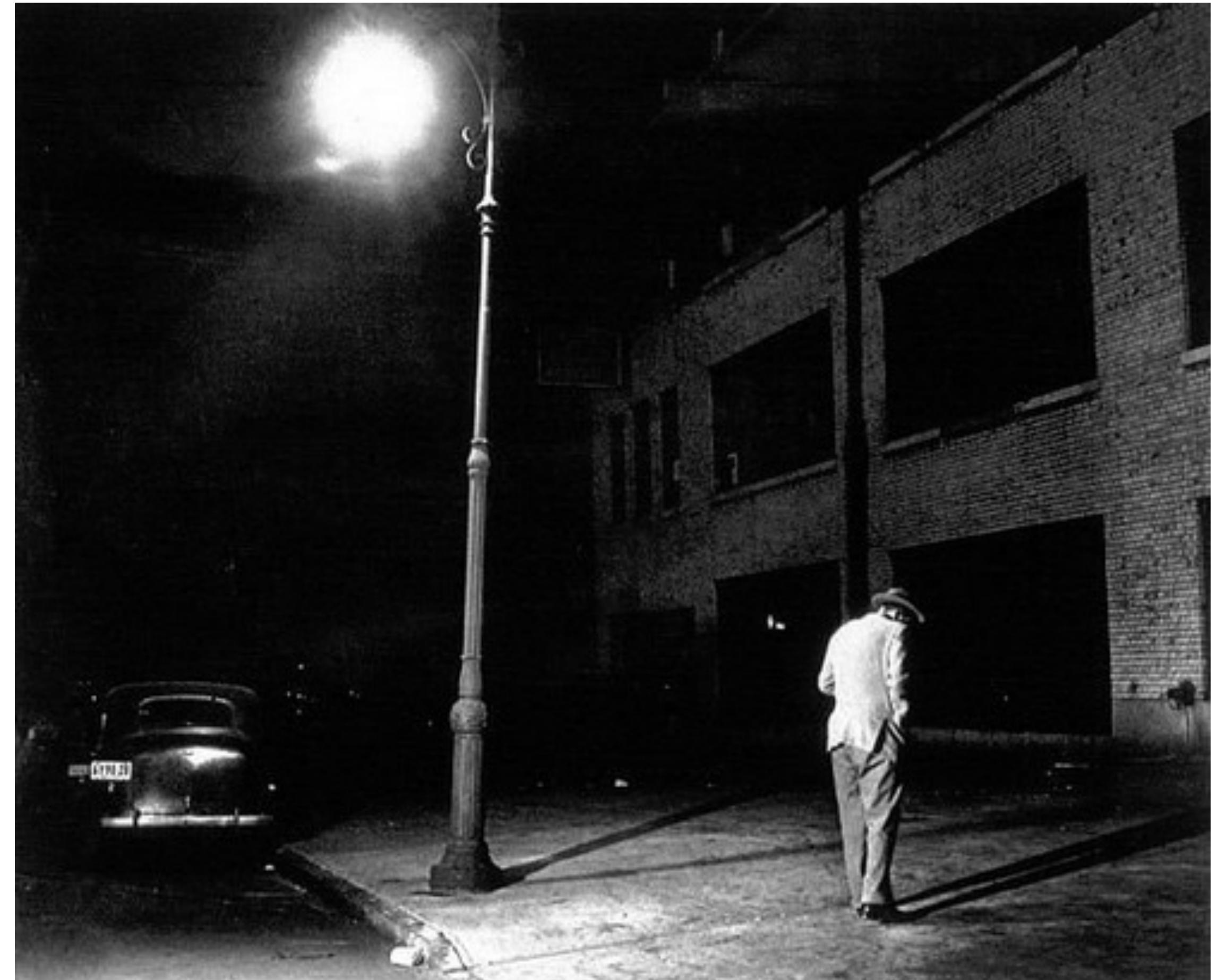


**Precise
but not accurate**



The Lamppost Problem

aka. Streetlight Effect
aka. The Drunkard's Search



Do we understand what we are measuring?

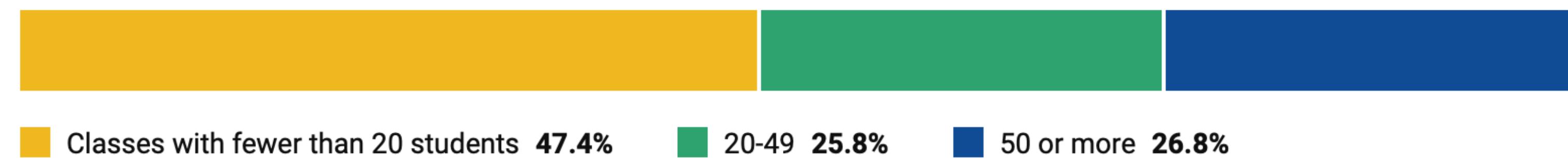


Are we measuring what's relevant?

Academic Life at University of California--San Diego

The student-faculty ratio at University of California--San Diego is 19:1, and the school has 47.4% of its classes with fewer than 20 students. The most popular majors at University of California--San Diego include: Biology, General; Mathematics; Economics; International/Global Studies; and Computer Science. The average freshman retention rate, an indicator of student satisfaction, is 94%.

Class Sizes



Student-faculty ratio

19:1

4-year graduation rate

65%

UCSD median class size vs median student experience

		% of classes with this many students	Cumulative %	Fraction of classes with this many students * min number of students in that class type	% of students in these classes (normalized version of column to the left)	
	2-9 students:	12%	12%	0.24	0.67%	
	10-19 students	32%	44%	3.2	8.95%	
Median class size as experienced by faculty	20-29 students:	14%	58%	2.8	7.83%	
	30-39 students:	8%	66%	2.4	6.72%	
	40-49 students:	4%	70%	1.6	4.48%	
	50-99 students:	11%	81%	5.5	15.39%	
Median class size as experienced by students	Over 100 students:	20%	101%	20	55.96%	
		Sum:		35.74		
		Data from https://www.collegedata.com/college/University-of-California-San-Diego/				



1

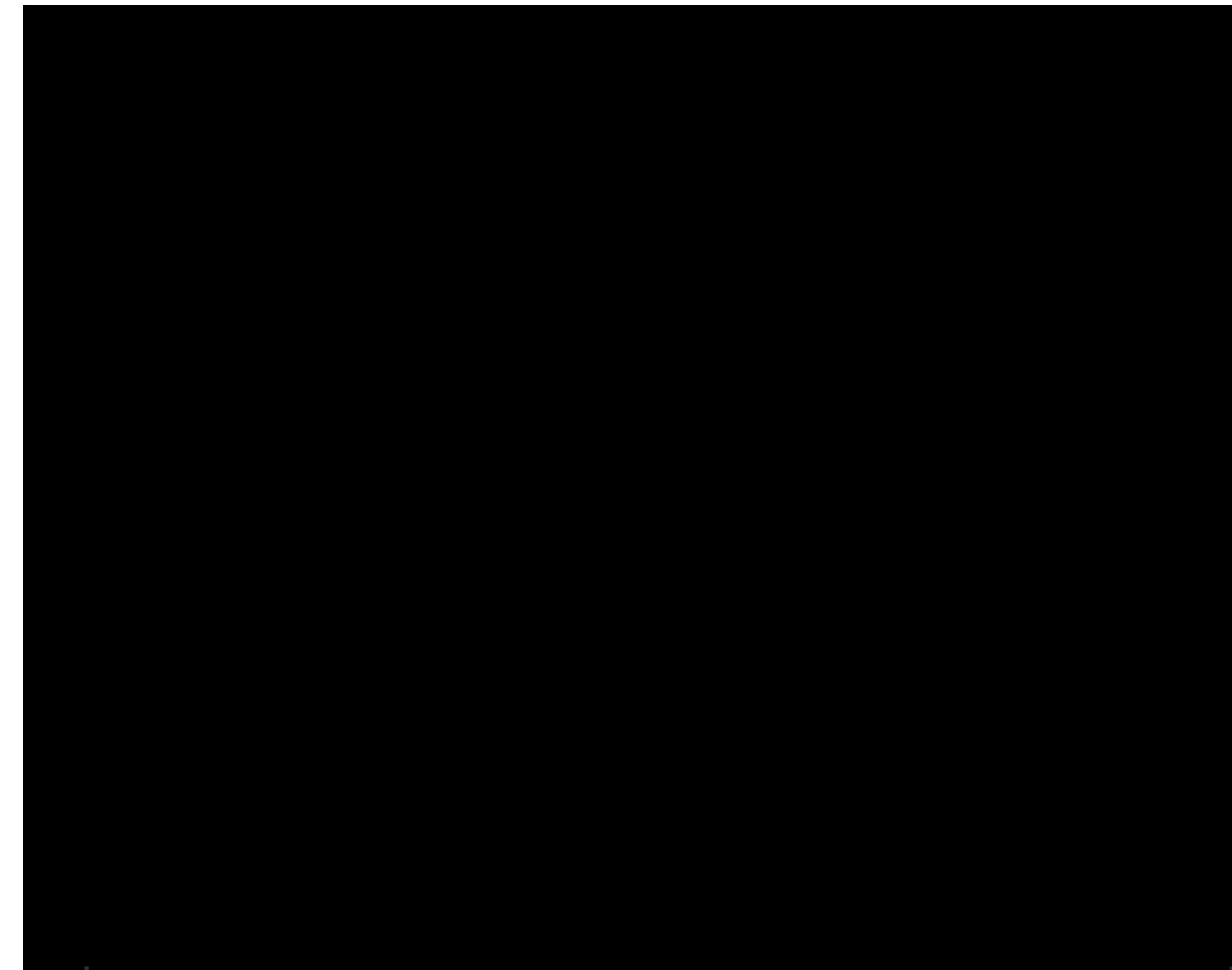
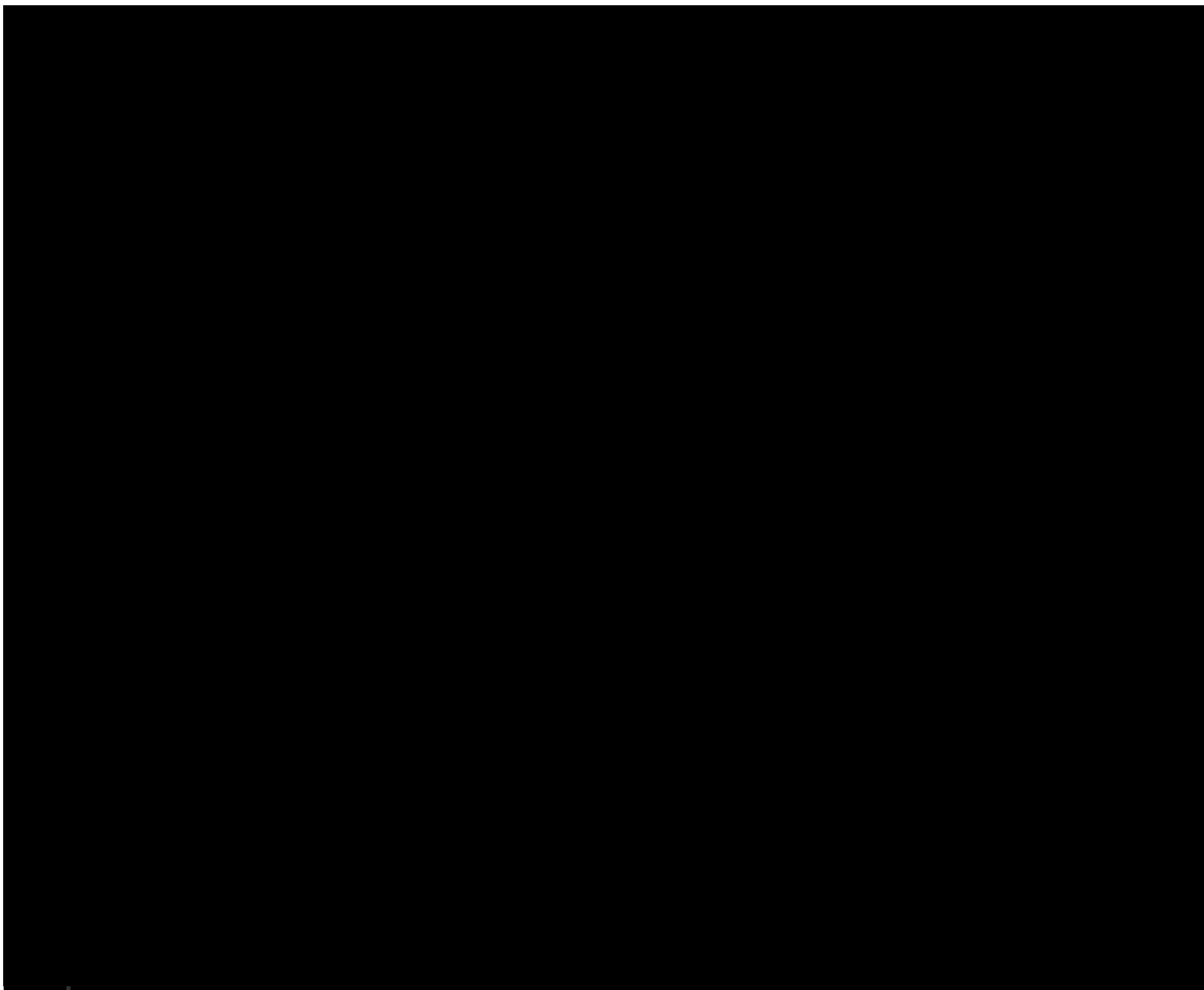


Follow

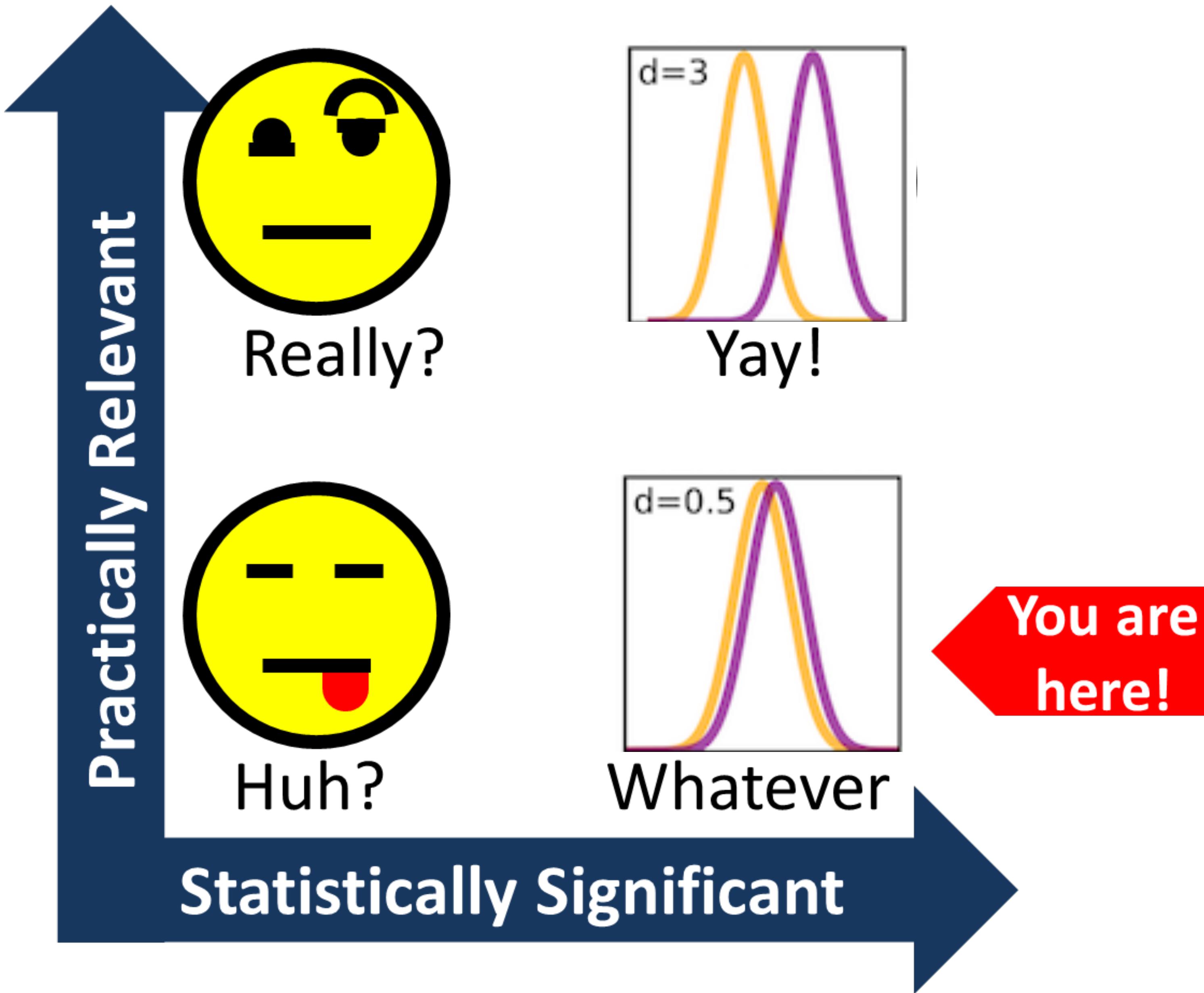
justsaysinmice

@justsaysinmice

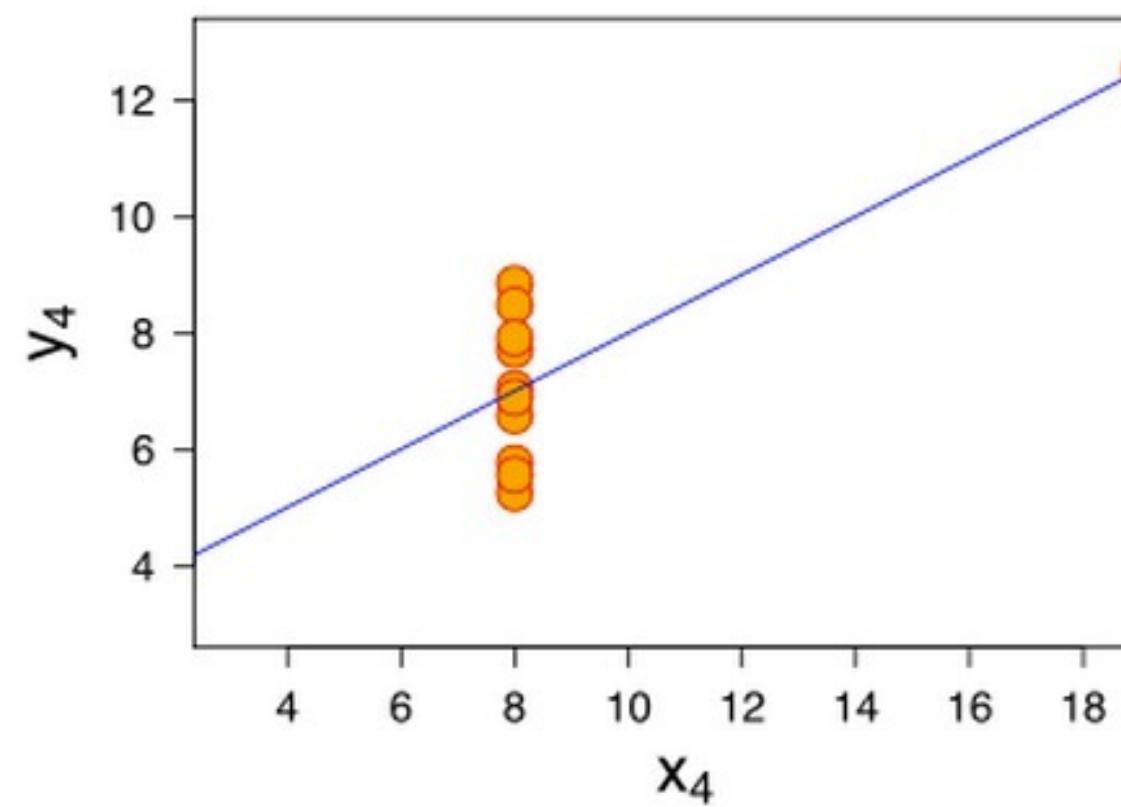
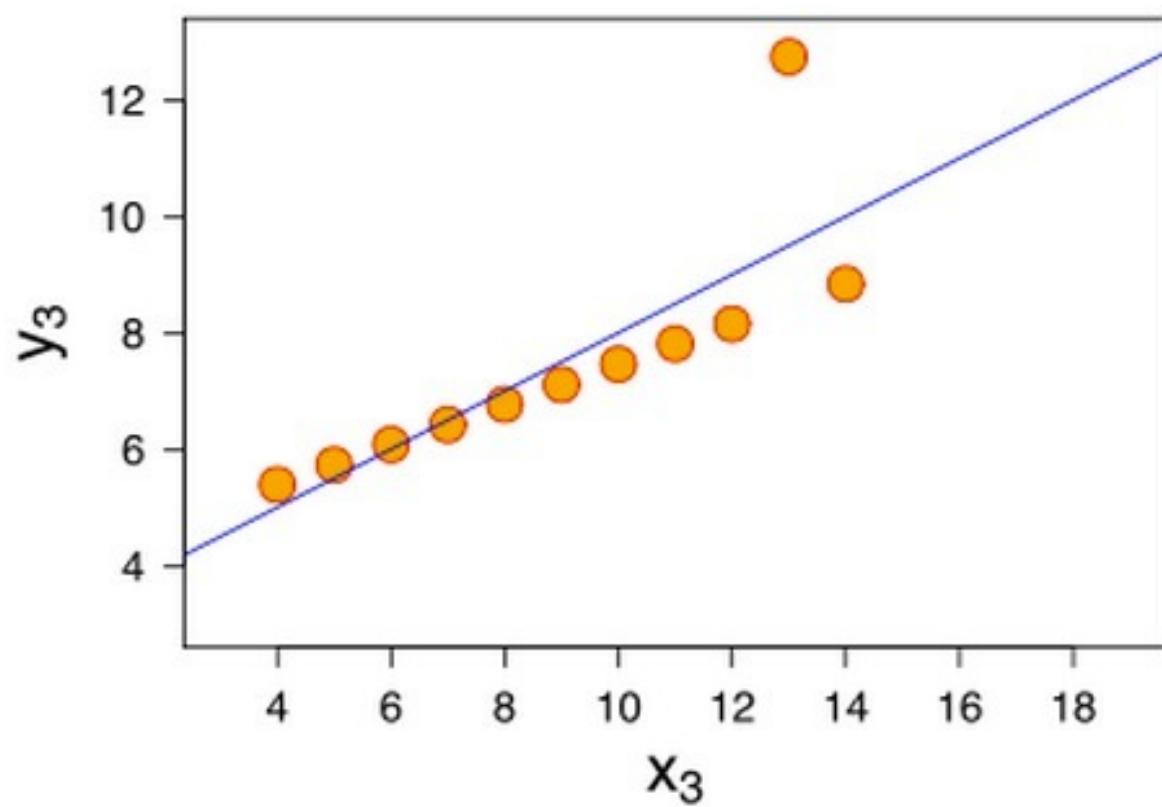
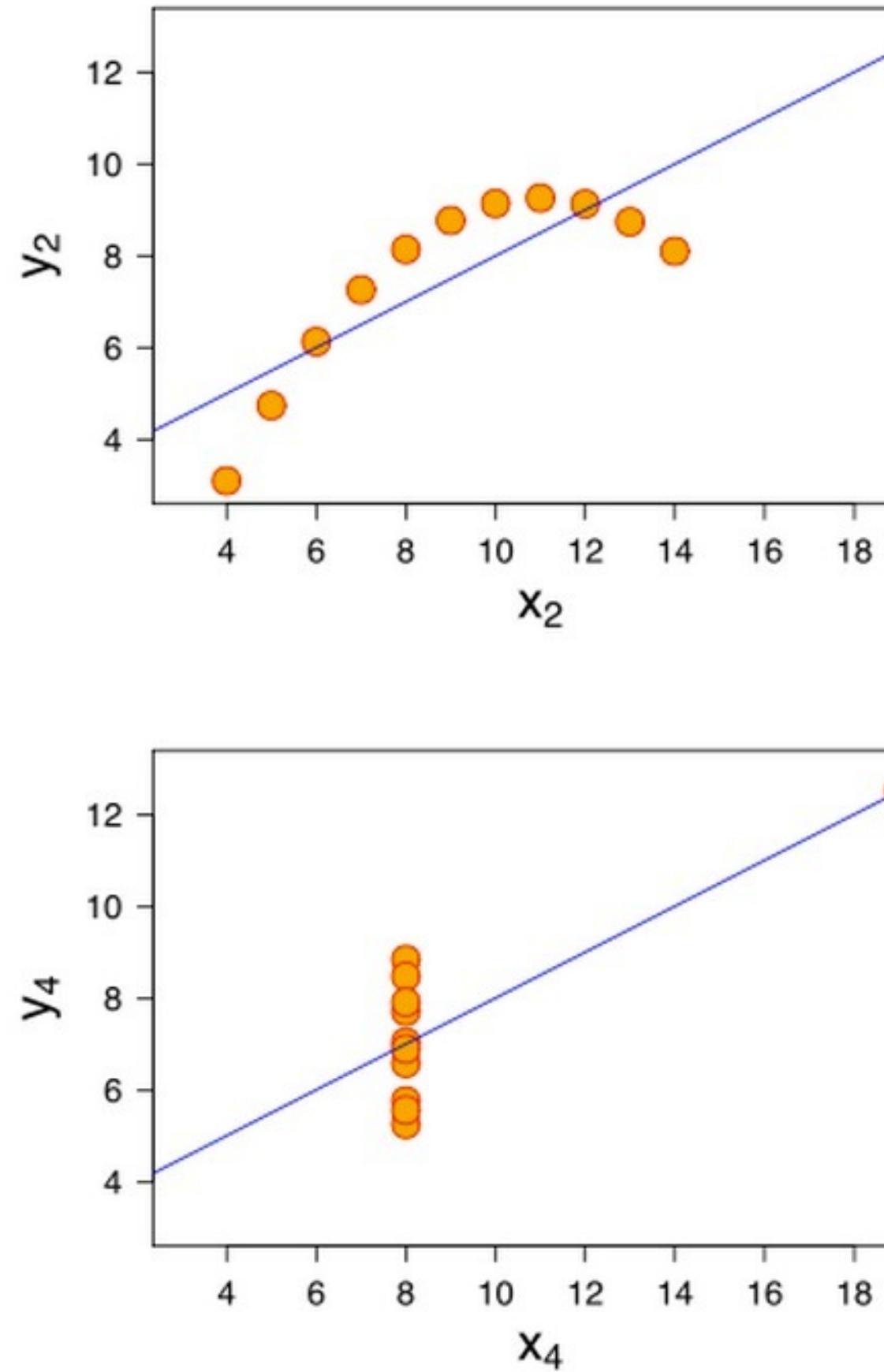
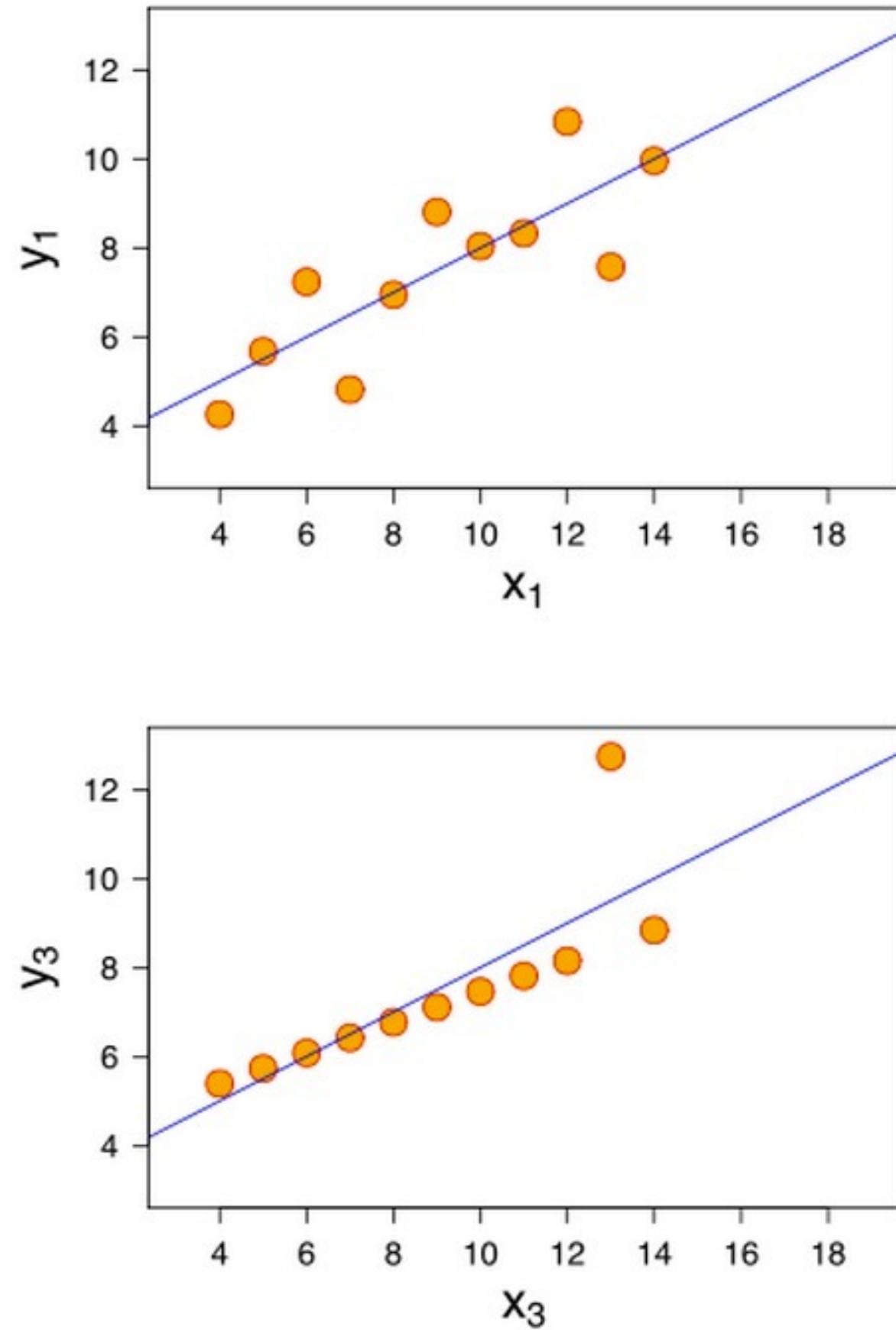
The world's hardest working little scientist. Run by [@jamesheathers](#)



Errors of analysis

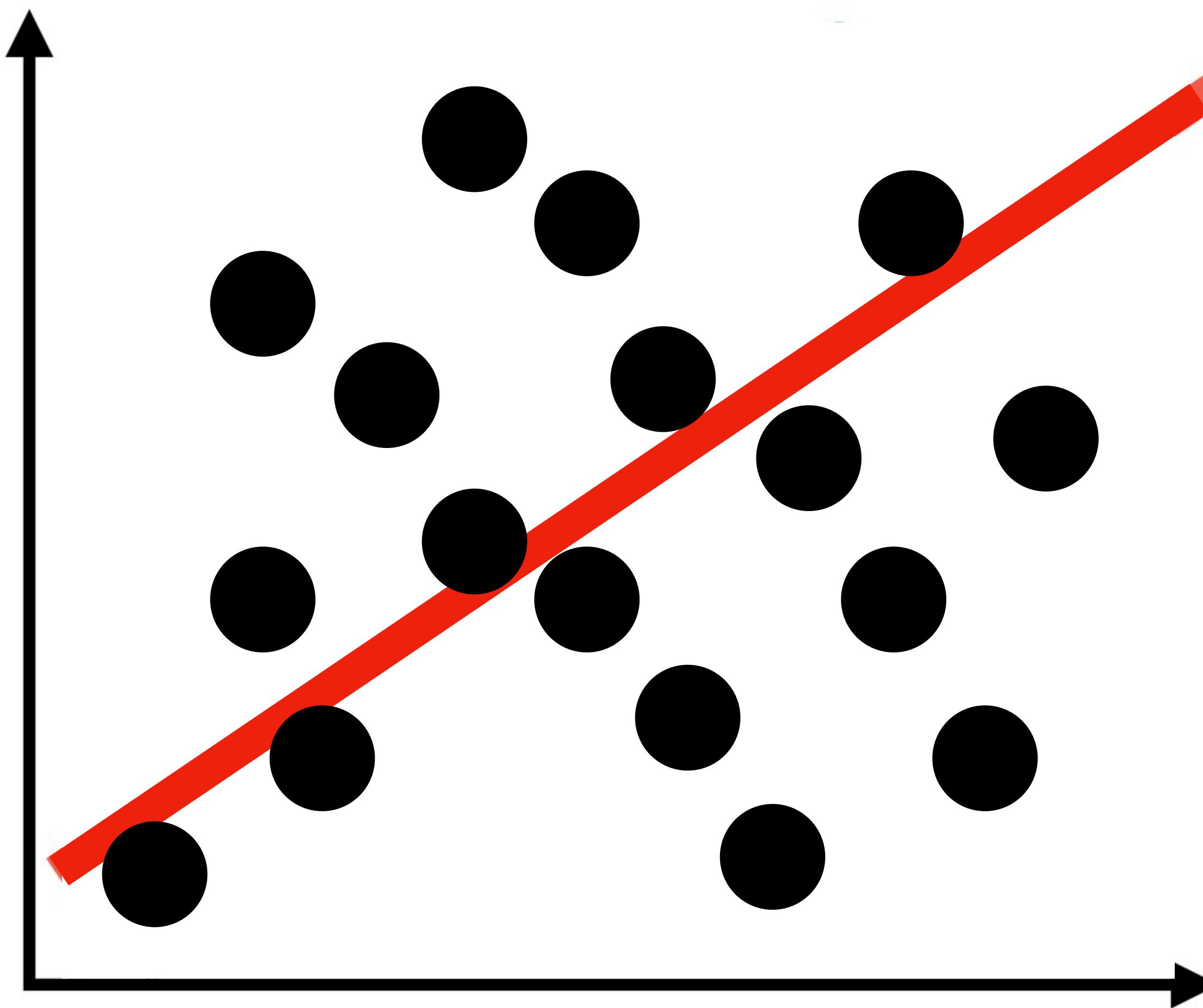


Anscombe's quartet



Property	Value
Mean of x in each case	9 (exact)
Variance of x in each case	11 (exact)
Mean of y in each case	7.50 (to 2 decimal places)
Variance of y in each case	4.122 or 4.127 (to 3 decimal places)
Correlation between x and y in each case	0.816 (to 3 decimal places)
Linear regression line in each case	$y = 3.00 + 0.500X$ (to 2 and 3 decimal places, respectively)

Simpson's paradox

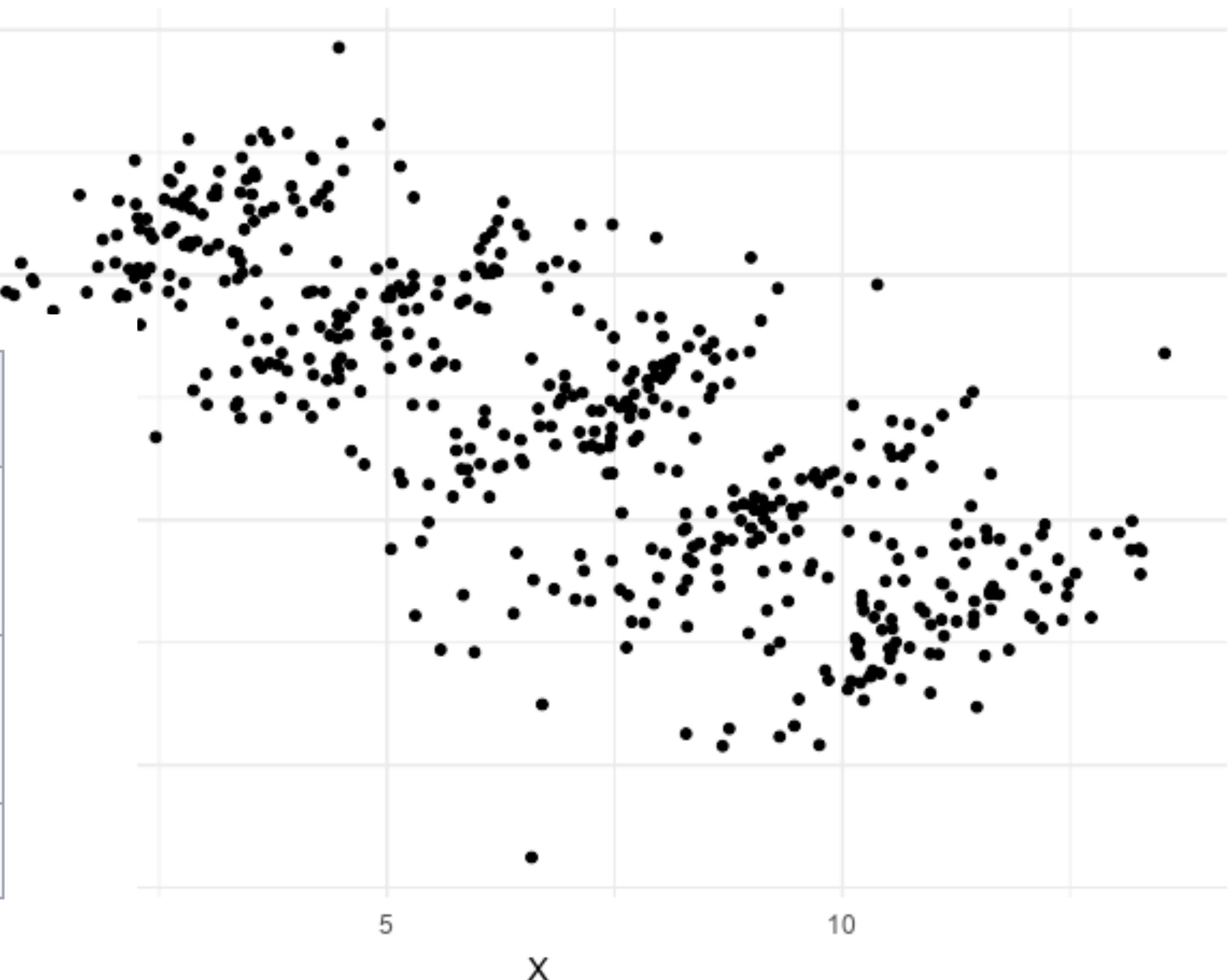


Simpson's paradox

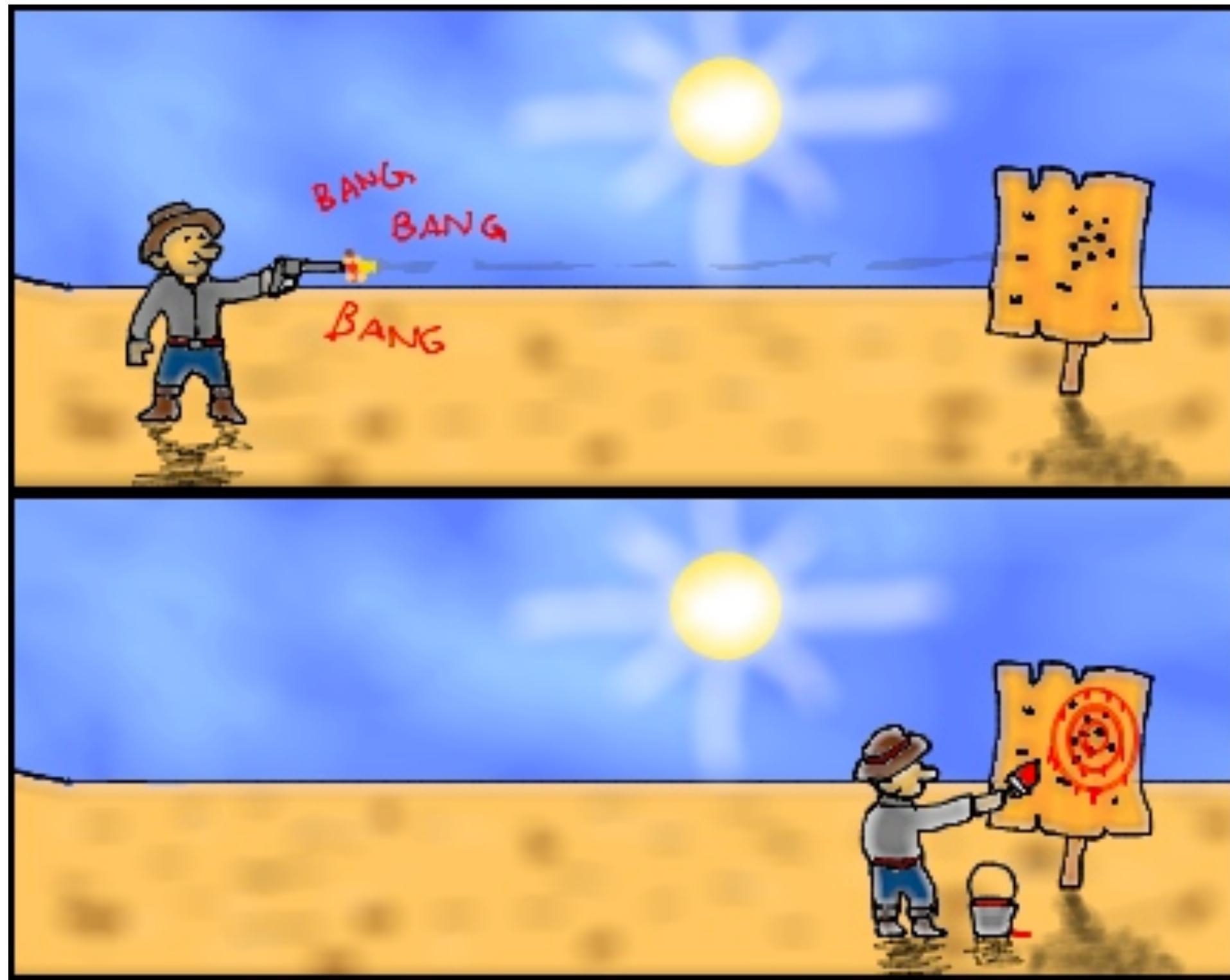
Answers change when you include subgroups in your analysis

Stone size \ Treatment	Treatment A	Treatment B
Small stones	<i>Group 1</i> 93% (81/87)	<i>Group 2</i> 87% (234/270)
Large stones	<i>Group 3</i> 73% (192/263)	<i>Group 4</i> 69% (55/80)
Both	78% (273/350)	83% (289/350)

Correlation:



Bad methods



The Texas Sharpshooter fallacy is characterized by a lack of a specific hypothesis prior to the gathering of data, or the formulation of a hypothesis only after data have already been gathered and examined.

Preregistration and publishing negative results

“Data available upon reasonable request”

...and this is where we put the non-significant results.



som ee cards
user card

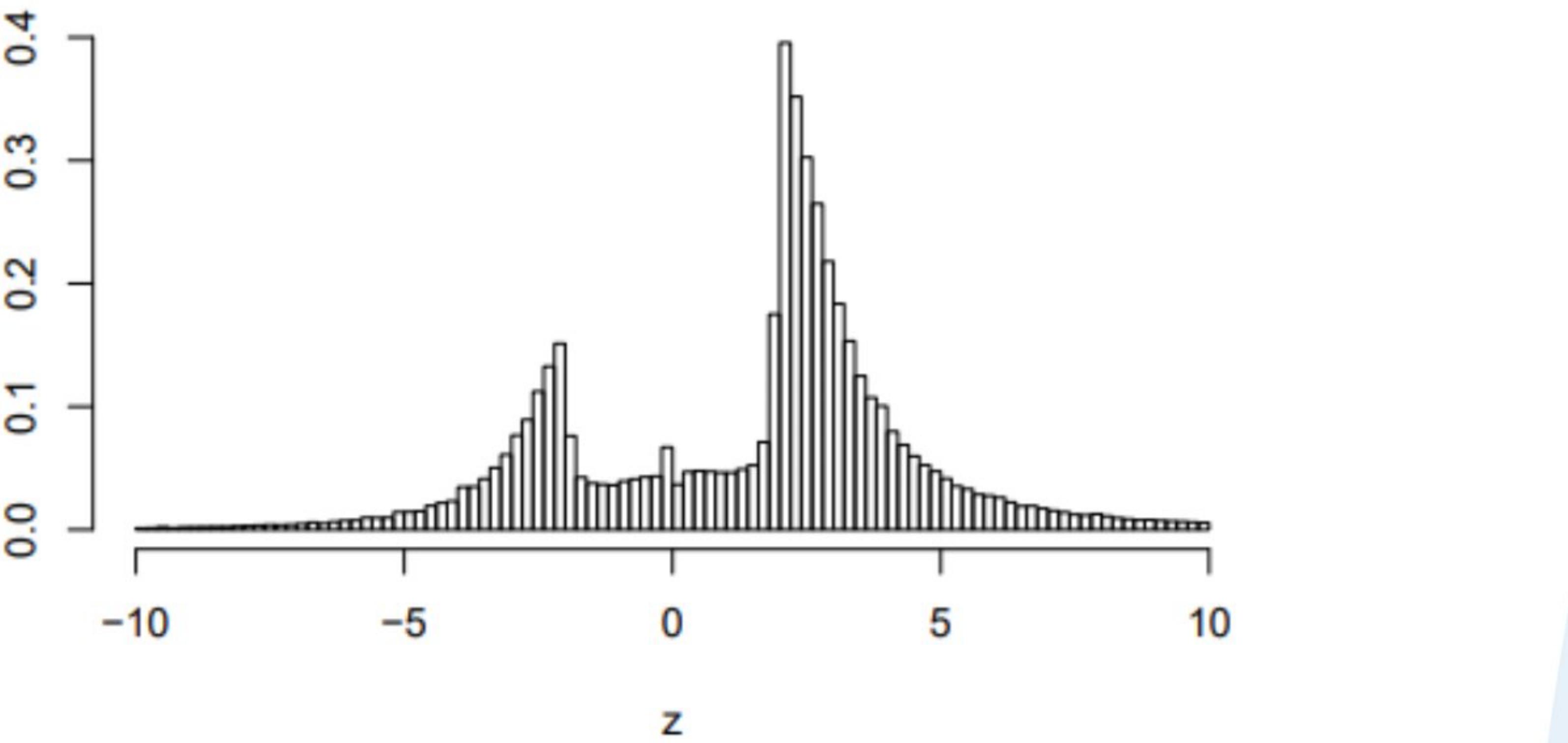


Figure 1: The distribution of more than one million z -values from Medline (1976–2019).

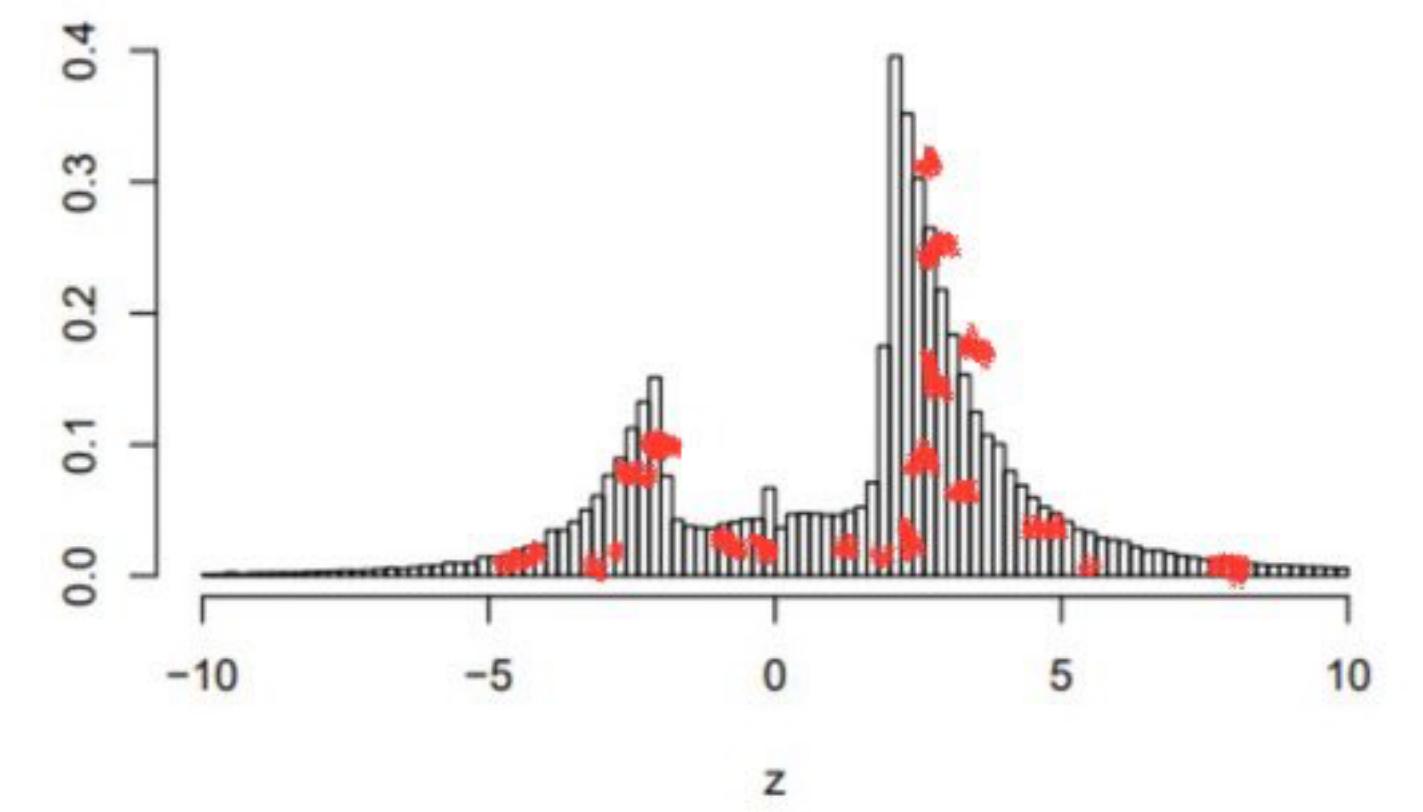
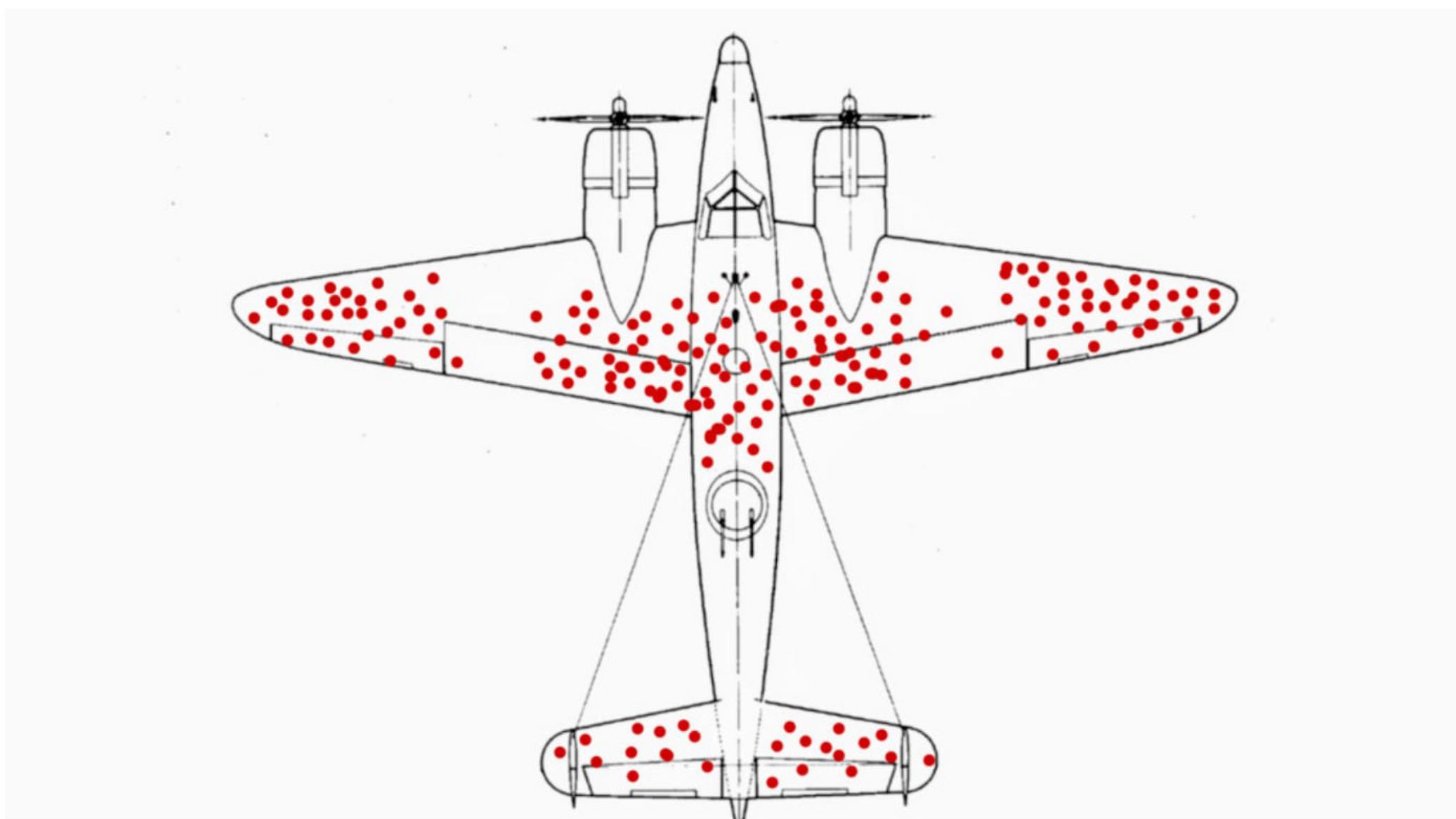
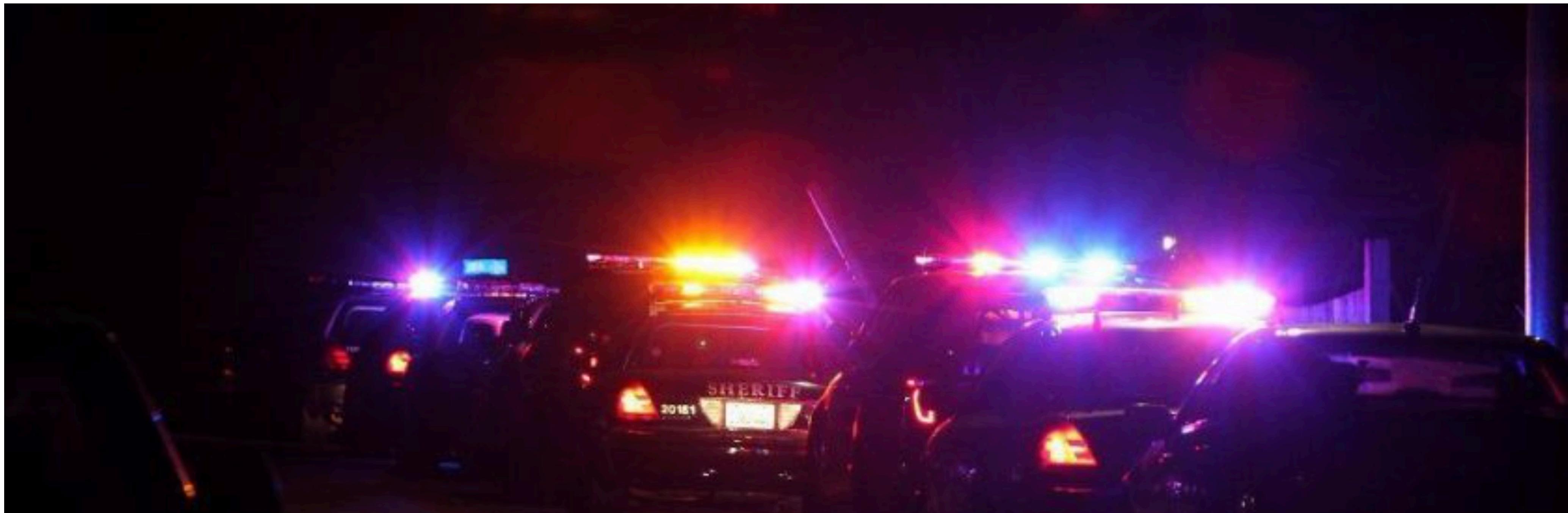


Figure 1: The distribution of more than one million z -values from Medline (1976–2019).



WATCHDOG

Faulty test leads Sheriff's Department to mistakenly claim no evidence of bias in policing



Errors of borked tools



EuSpRIG HORROR STORIES

Spreadsheet mistakes - news stories

Public reports of spreadsheet errors have been sought out on behalf of EuSpRIG by Patrick O'Beirne of Systems Modelling for many years. There are very many reports of spreadsheet related errors and they seem to appear in the global media at a fairly consistent rate.

These stories illustrate common problems that occur with the uncontrolled use of spreadsheets. In many cases, we identify the area of risk involved and then say how we think the problem might have been avoided.

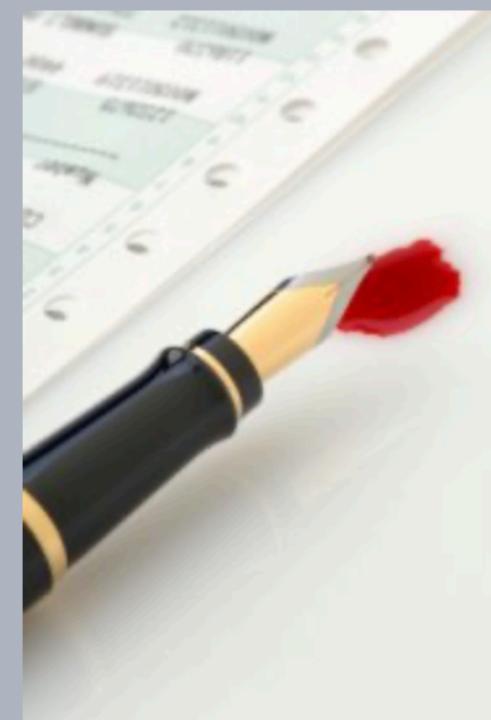
Stories are identified by those who kindly collated and sorted them:

POB: Patrick O'Beirne, Eusprig chair

FH: Felienne Hermans (winner of the 2011 [David Chadwick student prize](#) and now an assistant professor at Delft University of Technology).

NS: Tie Cheng, a EuSpRIG [committee member](#).

MPC: Mary Pat Campbell, an actuary, trainer, and a member of the [EuSpRIG Discussion group](#).



Identifier:	POB2001
Title:	Data not controlled, 16000 UK Covid-19 test results lost for a week
Source:	https://www.bbc.co.uk/news/technology-54423988
Release Date:	08 October 2020
Risk:	Lives put at risk because the contact-tracing process had been delayed
Discrepancy:	16,000 test cases in a week

Excel: Why using Microsoft's tool caused Covid-19 results to be lost

"The badly thought-out use of Microsoft's Excel software was the reason nearly 16,000 coronavirus cases went unreported in England. [The labs] filed their [result logs] results in the form of text-based lists - known as CSV files - without issue. PHE had set up an automatic process to pull this data together into Excel templates so that it could then be uploaded to a central system. The problem is that [Public Health England] PHE's own developers picked an old file format to do this - known as XLS. As a consequence, each template could handle only about 65,000 rows of data rather than the one million-plus rows that Excel is actually capable of. And since each test result created several rows of data, in practice it meant that each template was limited to about 1,400 cases. When that total was reached, further cases were simply left off. To handle the problem, PHE is now

MICROSOFT ▾ REPORT ▾ SCIENCE ▾

Scientists rename human genes to stop Microsoft Excel from misreading them as dates

99

Sometimes it's easier to rewrite genetics than update Excel

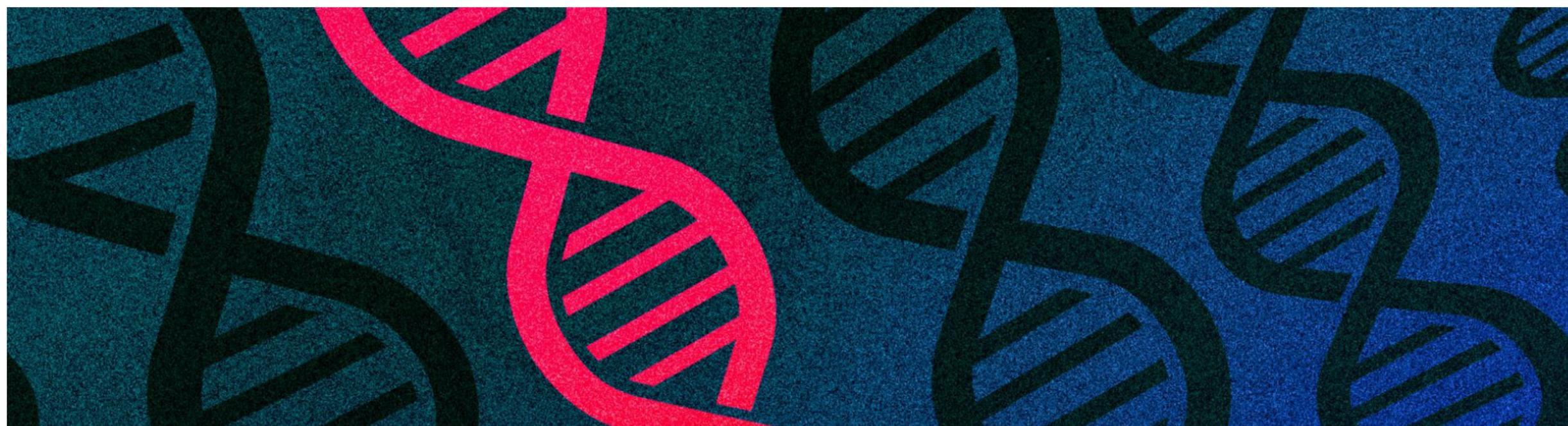
By James Vincent | Aug 6, 2020, 8:44am EDT



Listen to this article



SHARE



What if Excel is used as intended?



15k spreadsheets

97M cells

20M formulas

Enron's Spreadsheets and Related Emails: A Dataset and Analysis

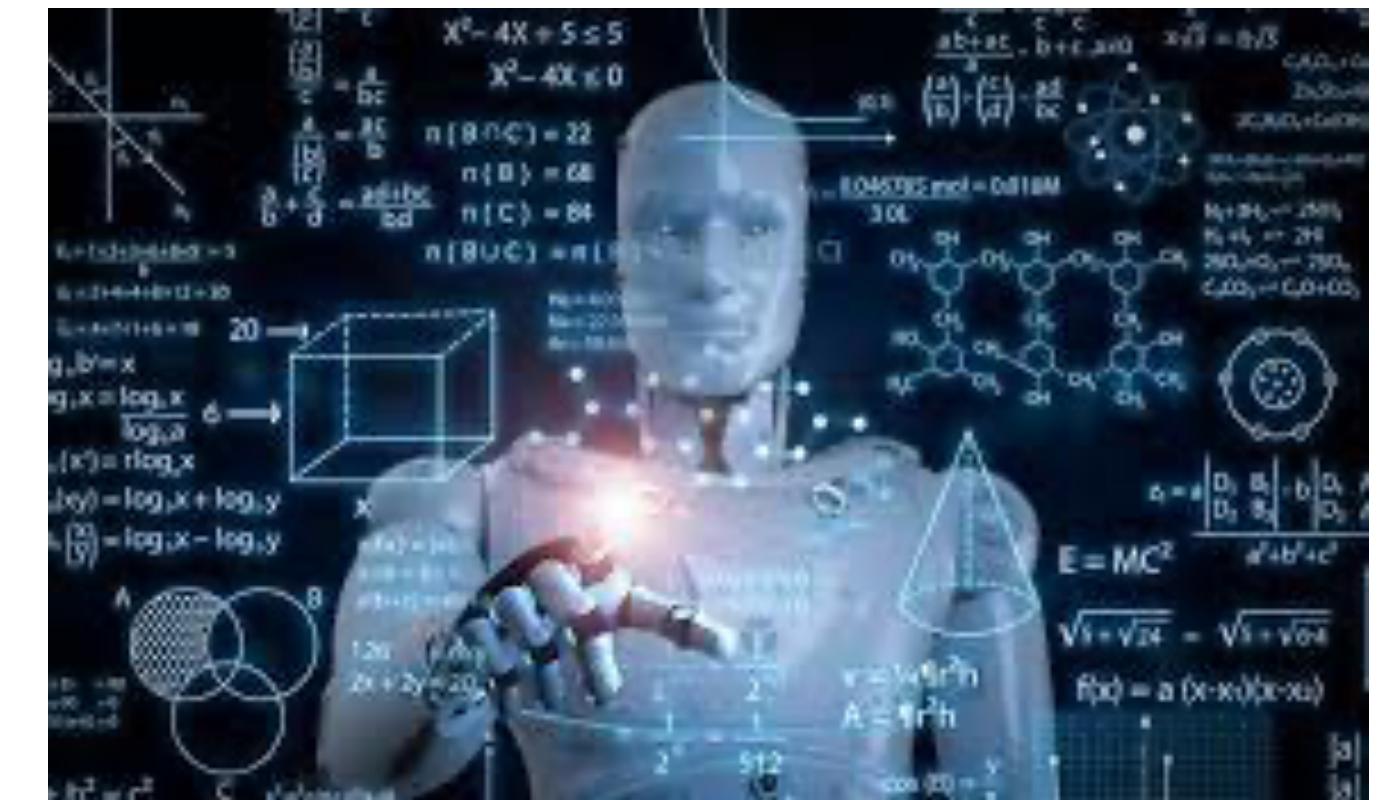
Felienne Hermans
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Emerson Murphy-Hill
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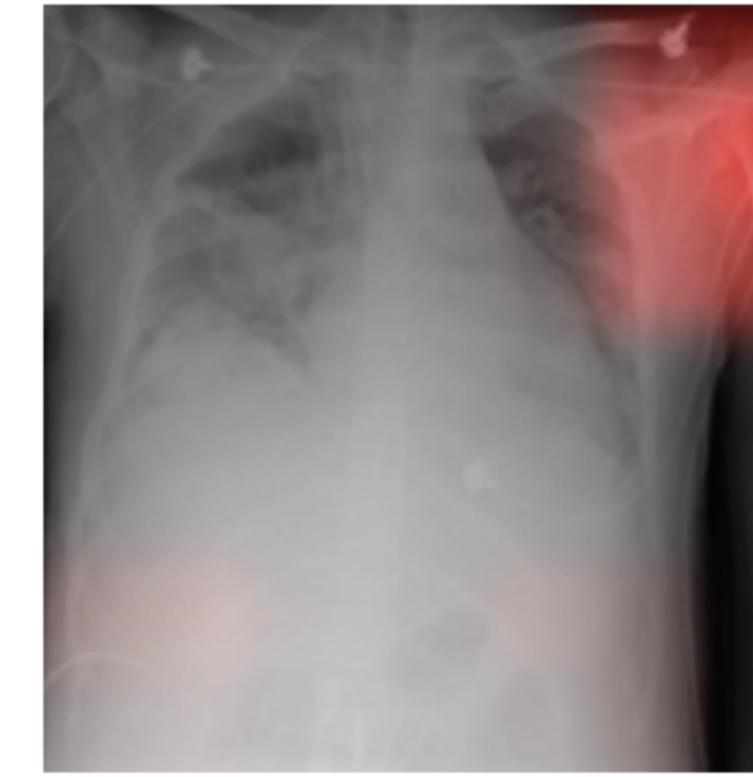
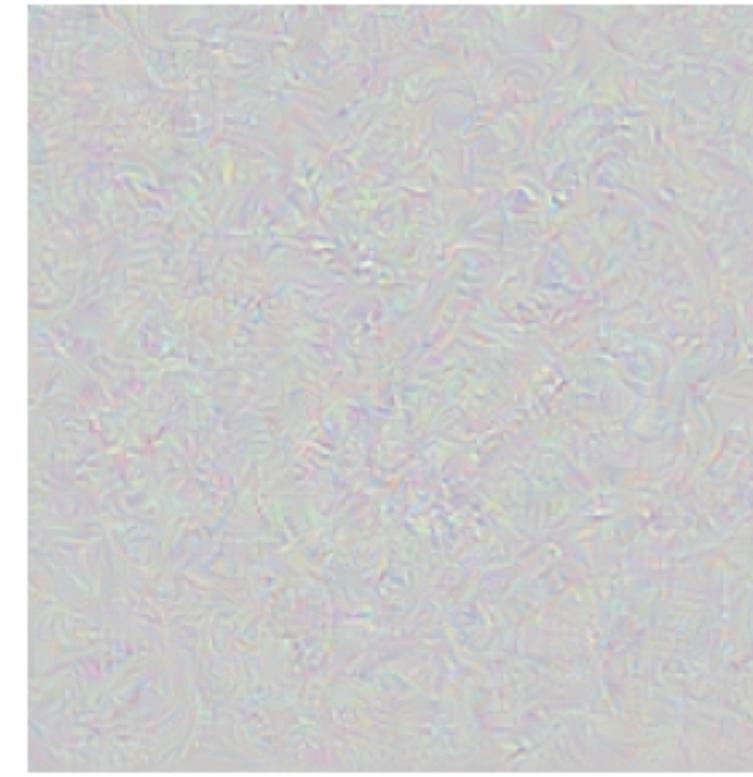
TABLE III
SPREADSHEETS CONTAINING EXCEL ERRORS IN THE ENRON SET

Error type	Spreadsheets	Formulas	Unique Ones
#DIV/0!	580	76,656	4,779
#N/A	635	948,194	6,842
#NAME?	297	33,9365	29,422
#NUM!	52	4,087	178
#REF!	931	18,3014	6824
#VALUE!	423	11,1024	1751
Total	2,205	1,662,340	49,796

24% of spreadsheets with formulas had errors!



Learning the irrelevant ML loves the shortcut



Article: Super Bowl 50

Paragraph: "Peyton Manning became the first quarterback ever to lead two different teams to multiple Super Bowls. He is also the oldest quarterback ever to play in a Super Bowl at age 39. The past record was held by John Elway, who led the Broncos to victory in Super Bowl XXXIII at age 38 and is currently Denver's Executive Vice President of Football Operations and General Manager. Quarterback Jeff Dean had a jersey number 37 in Champ Bowl XXXIV."

Question: "What is the name of the quarterback who was 38 in Super Bowl XXXIII?"

Original Prediction: John Elway

Prediction under adversary: Jeff Dean

Task for DNN	Caption image	Recognise object	Recognise pneumonia	Answer question
Problem	Describes green hillside as grazing sheep	Hallucinates teapot if certain patterns are present	Fails on scans from new hospitals	Changes answer if irrelevant information is added
Shortcut	Uses background to recognise primary object	Uses features irrecongnizable to humans	Looks at hospital token, not lung	Only looks at last sentence and ignores context

Errors of human cognition

COGNITIVE BIAS CODEX

What Should We Remember?

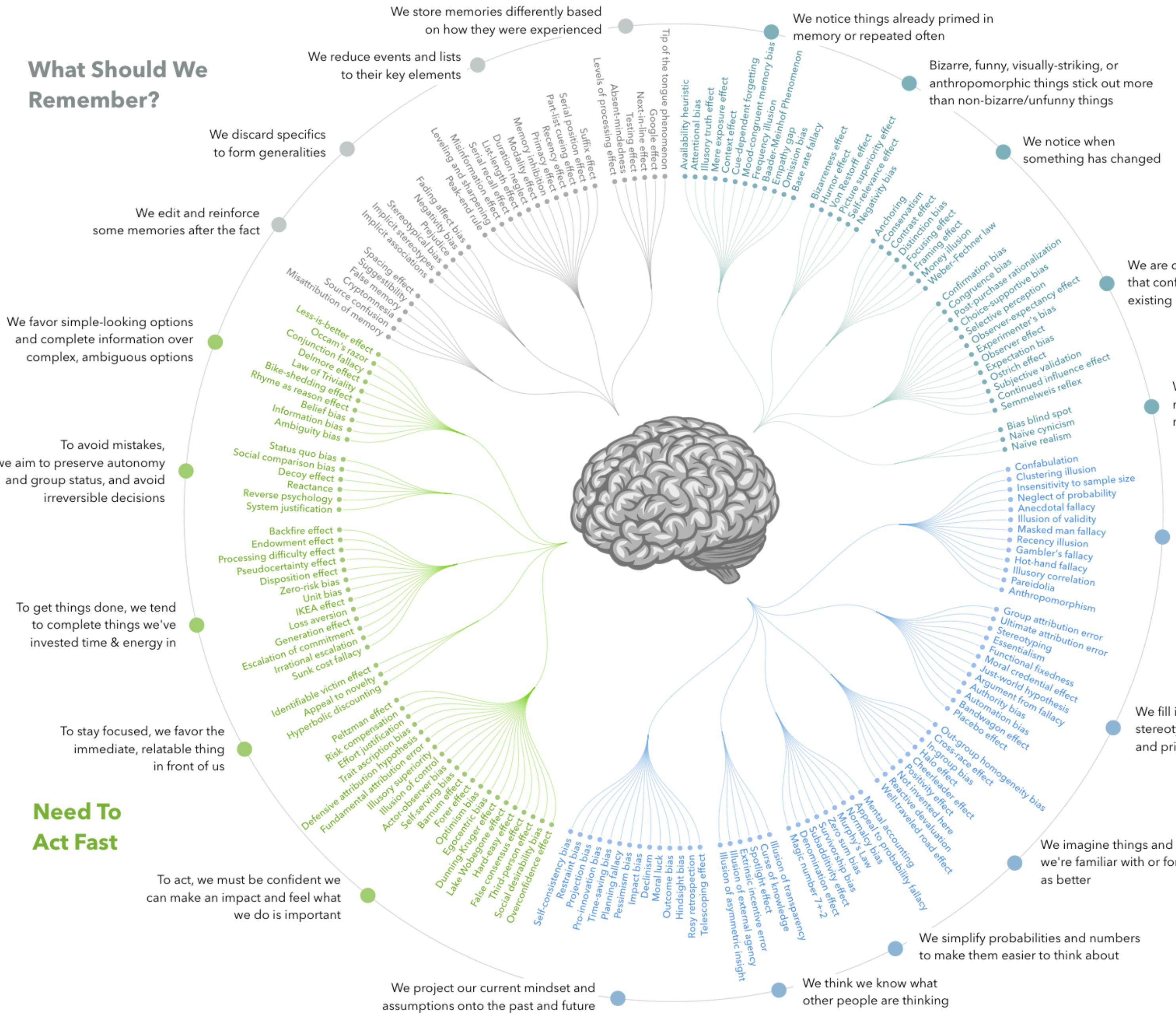
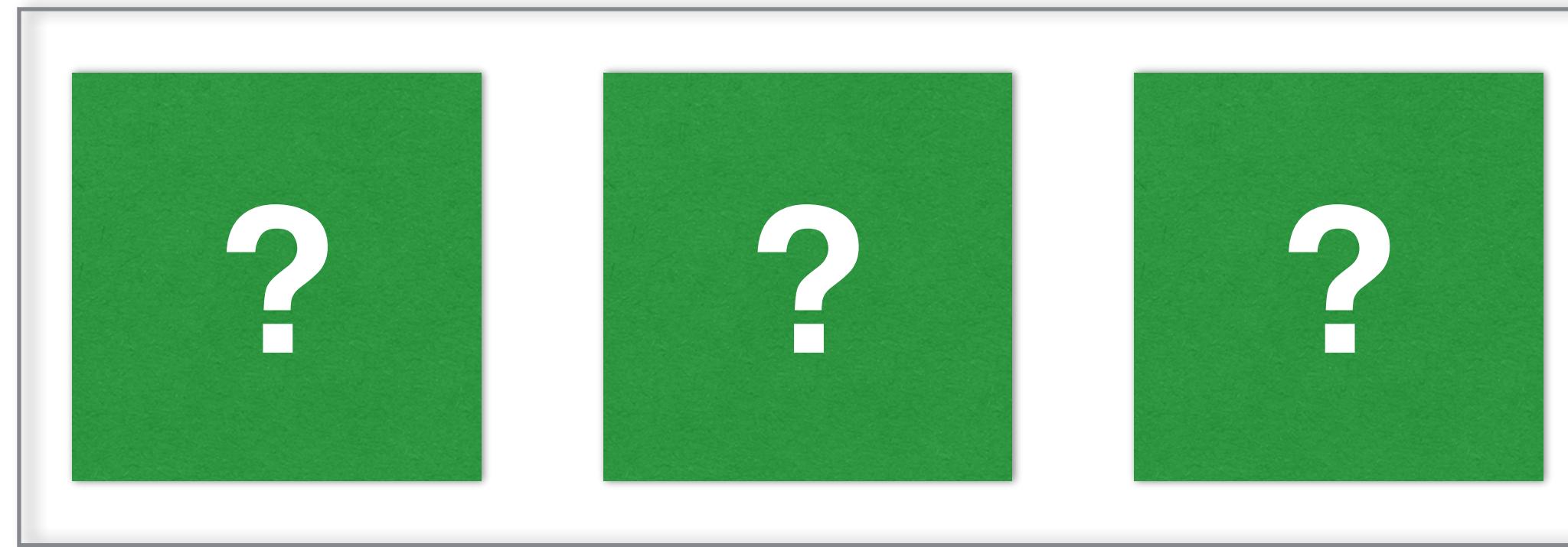
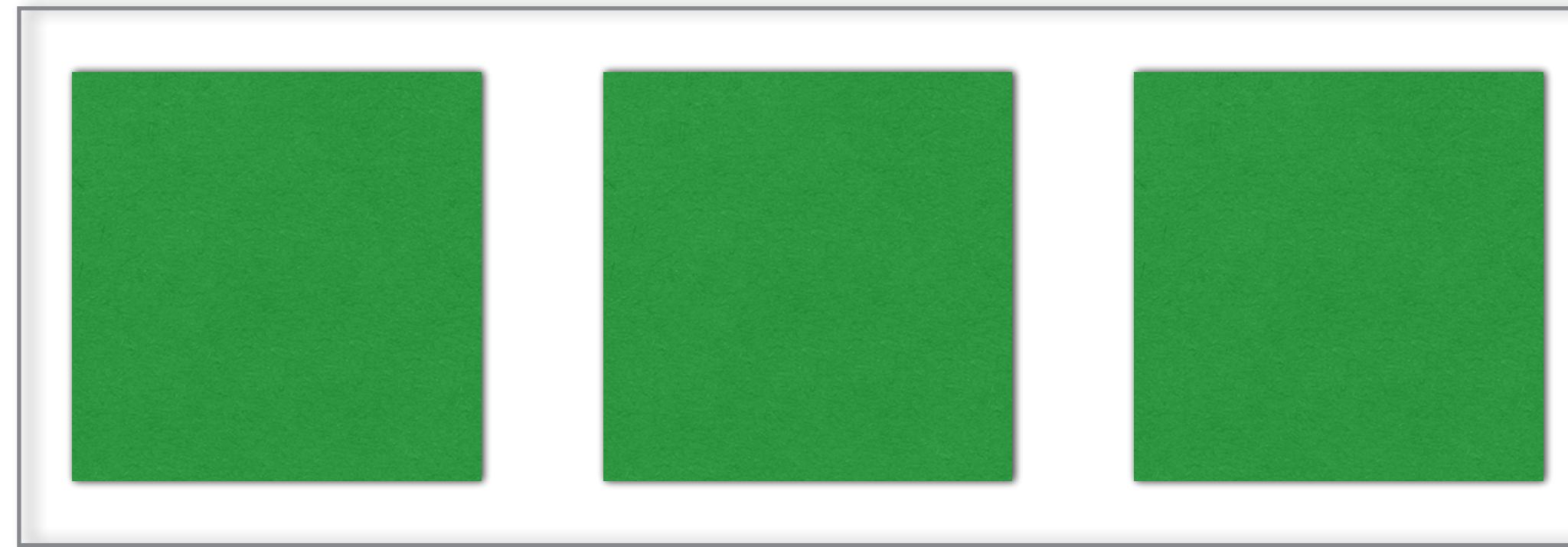
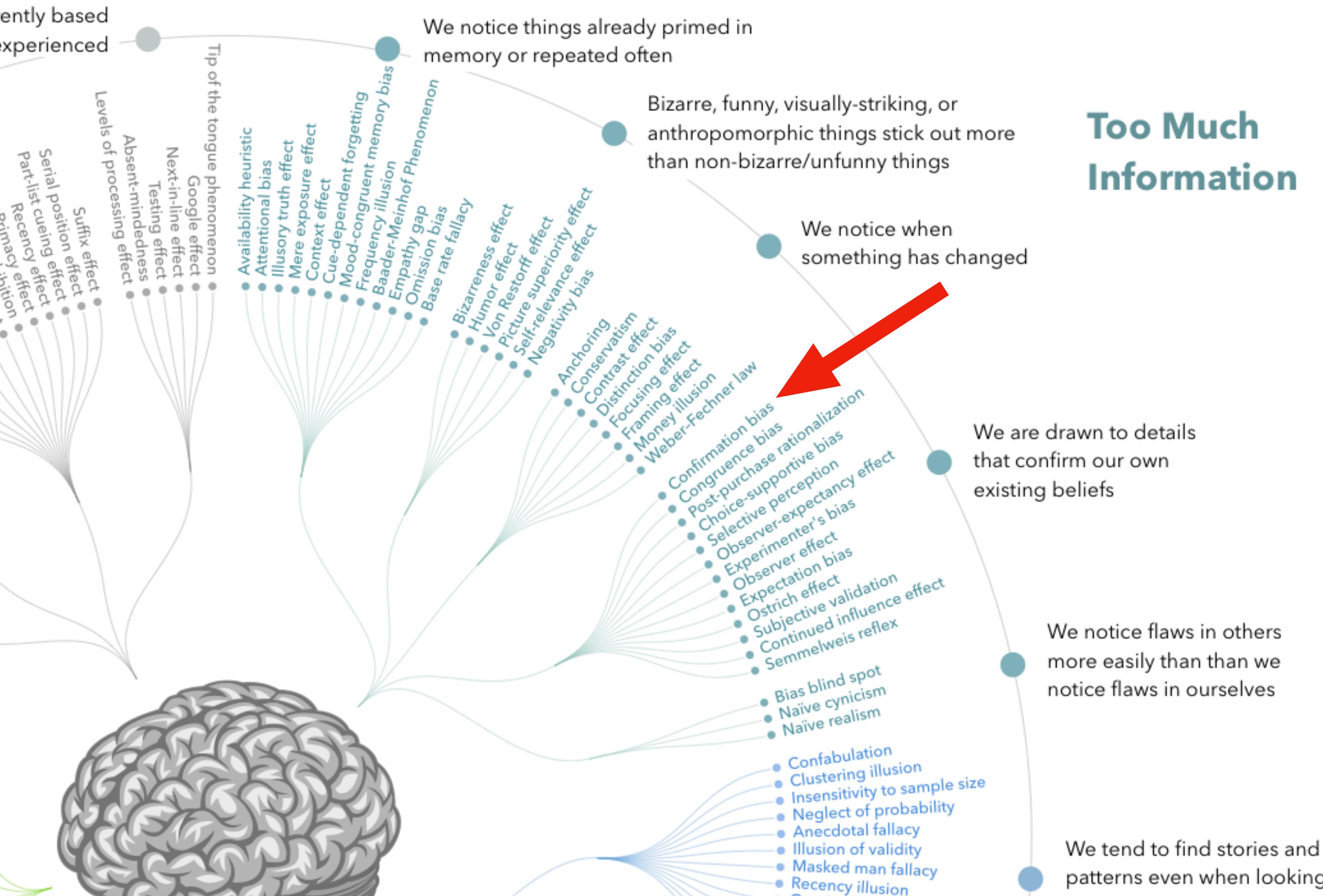


Figure out the rule



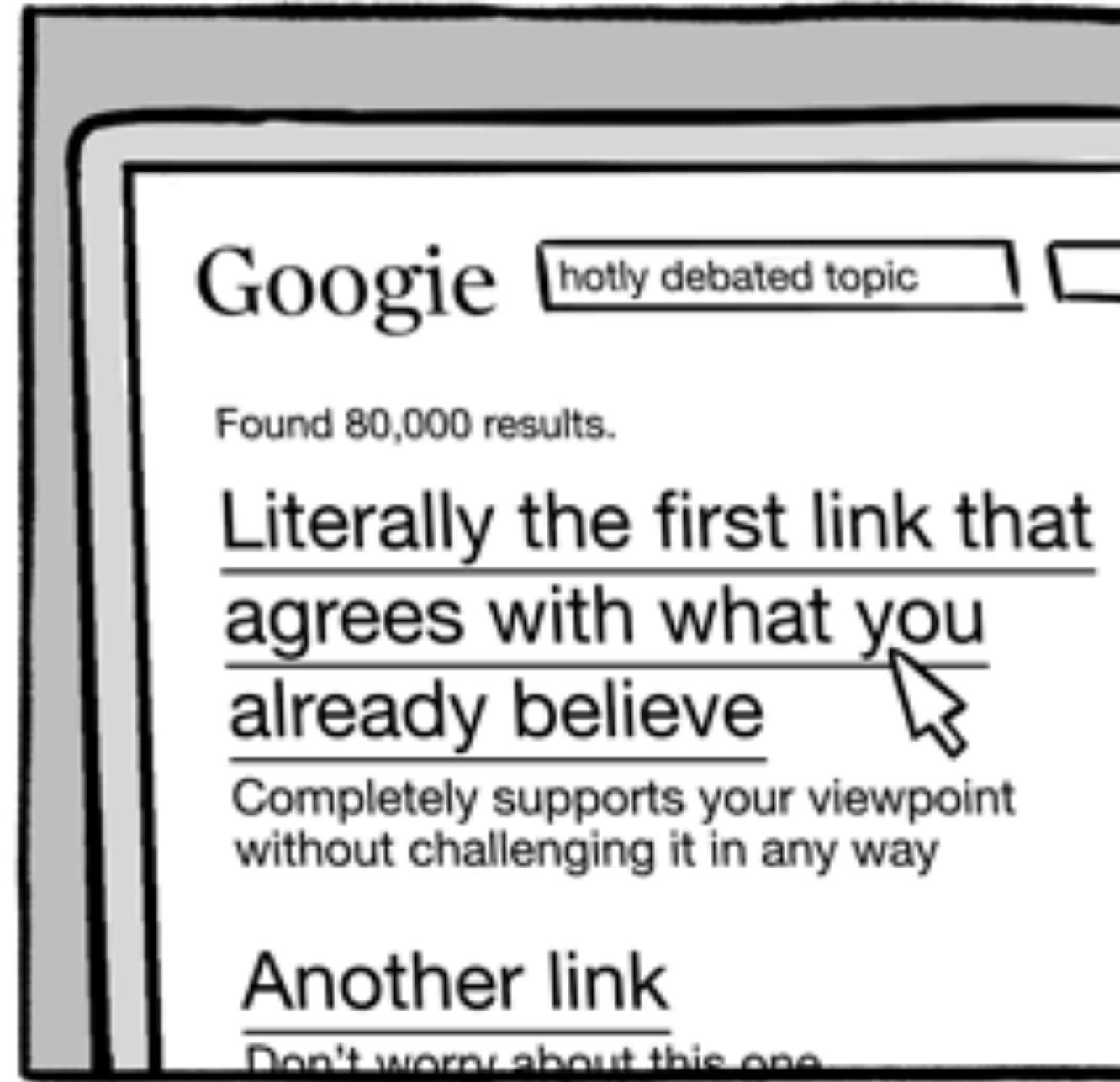
ITIVE BIAS CODEX



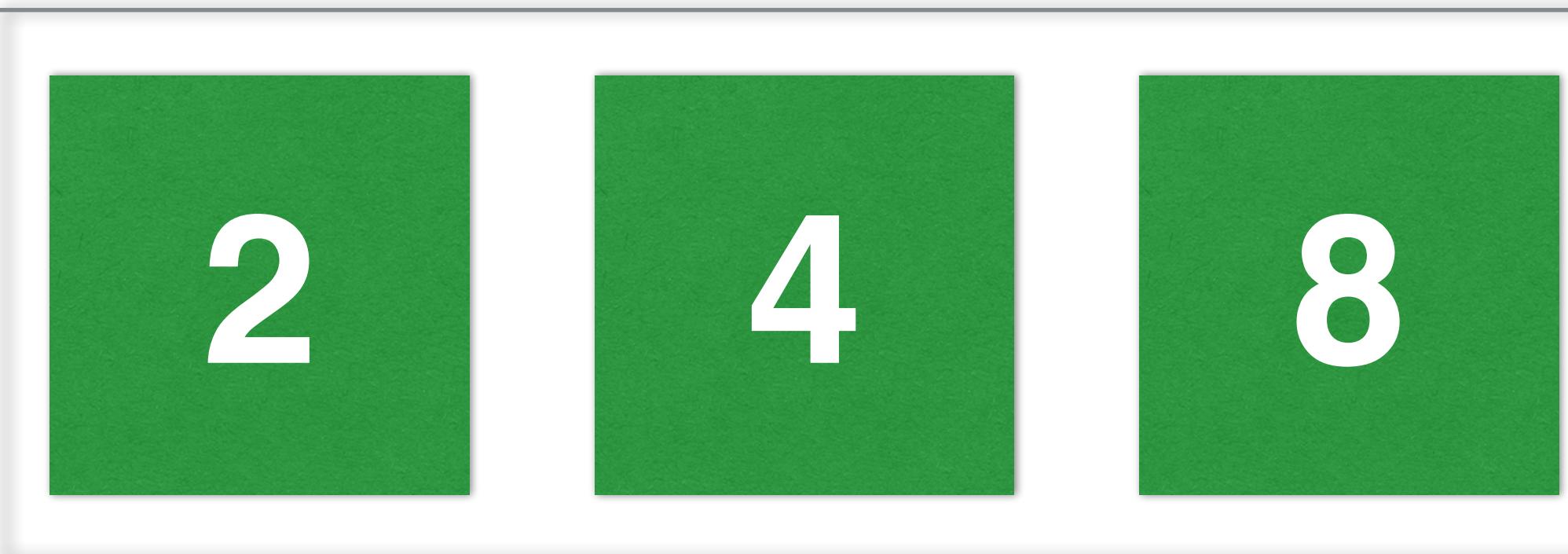
Too Much Information

Confirmation bias

CHAINSAWSUIT.COM



**The only way to show you're right
is to try to show you're wrong!**



**Confirmation bias...
and programming?**

We favor simple-looking options and complete information over complex, ambiguous options

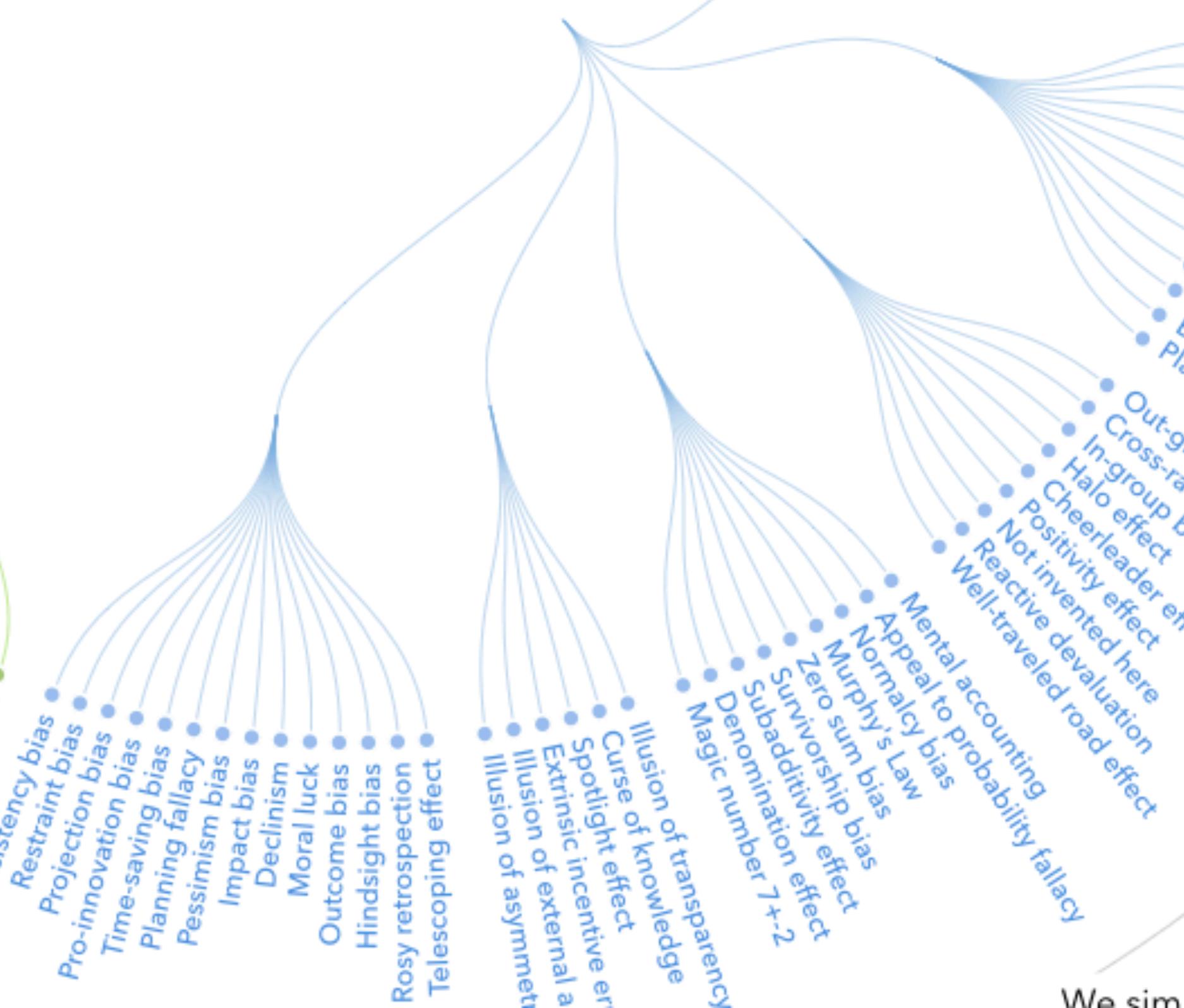
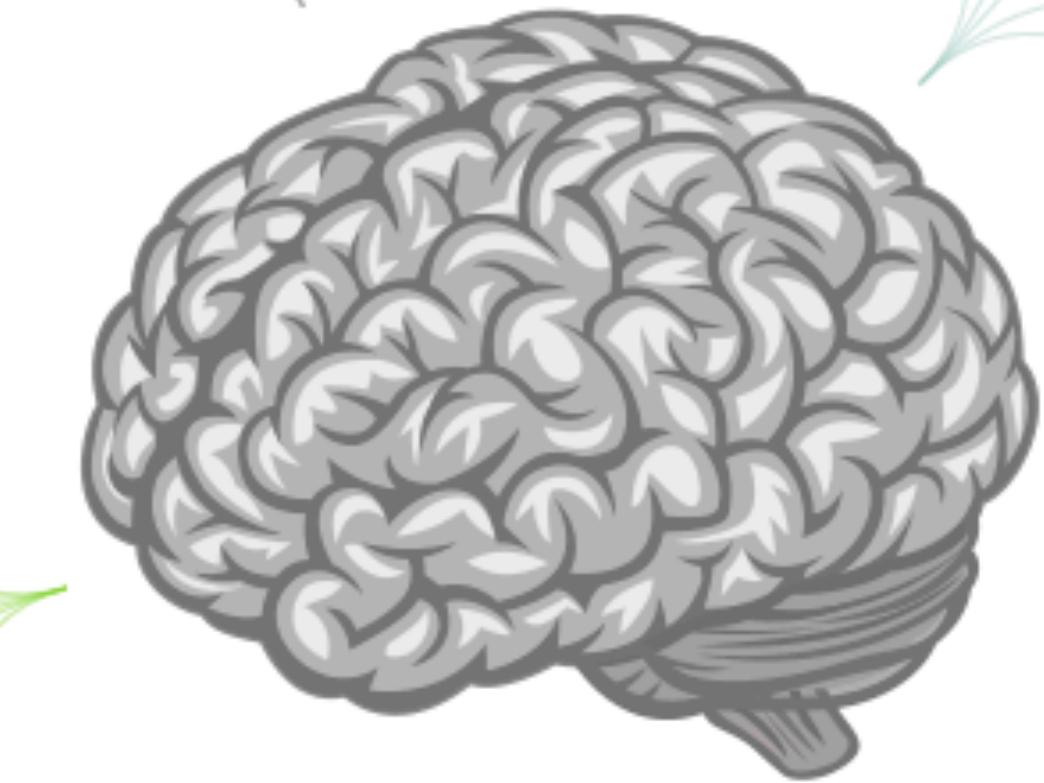
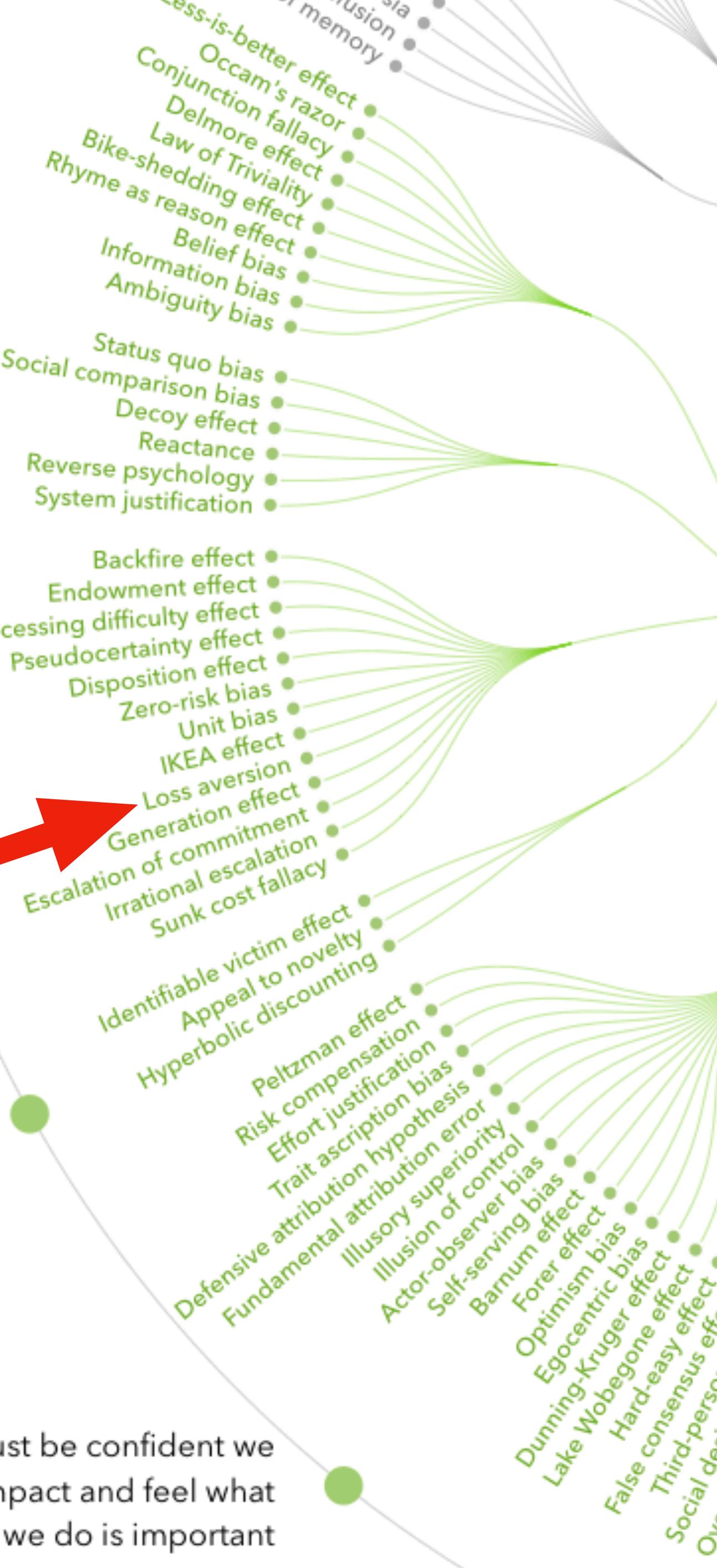
To avoid mistakes, we aim to preserve autonomy and group status, and avoid irreversible decisions

To get things done, we tend to complete things we've invested time & energy in

To stay focused, we favor the immediate, relatable thing in front of us

Need To Act Fast

To act, we must be confident we can make an impact and feel what we do is important



We sim

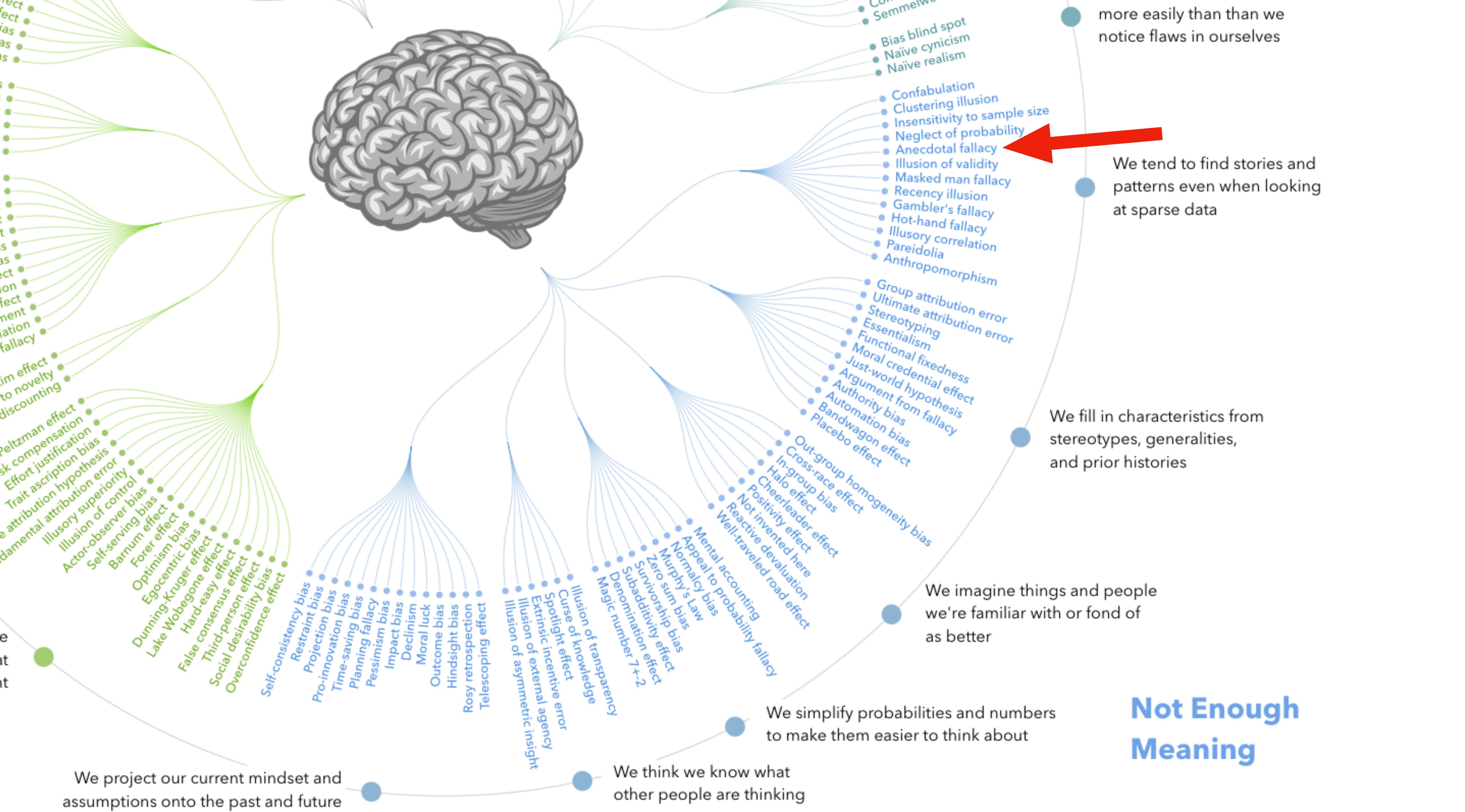
Should I try base jumping? It could be fun!

Loss aversion

If you tell someone they have a 99.5% of surviving they think it's fine

...but tell them 1 in 200 people die and they think it's too scary







On AI, Analytics, and the New Machine Age

If you read nothing else on how intelligent machines are revolutionizing business, read these definitive articles from Harvard Business Review.

**HBR'S
10
MUST
READS**

BONUS ARTICLE
"Why Every Organization Needs an Augmented Reality Strategy"
By Michael E. Porter and James E. Heppelmann



Anecdata
Rigorous analysis supported by anecdote

Errors of communication

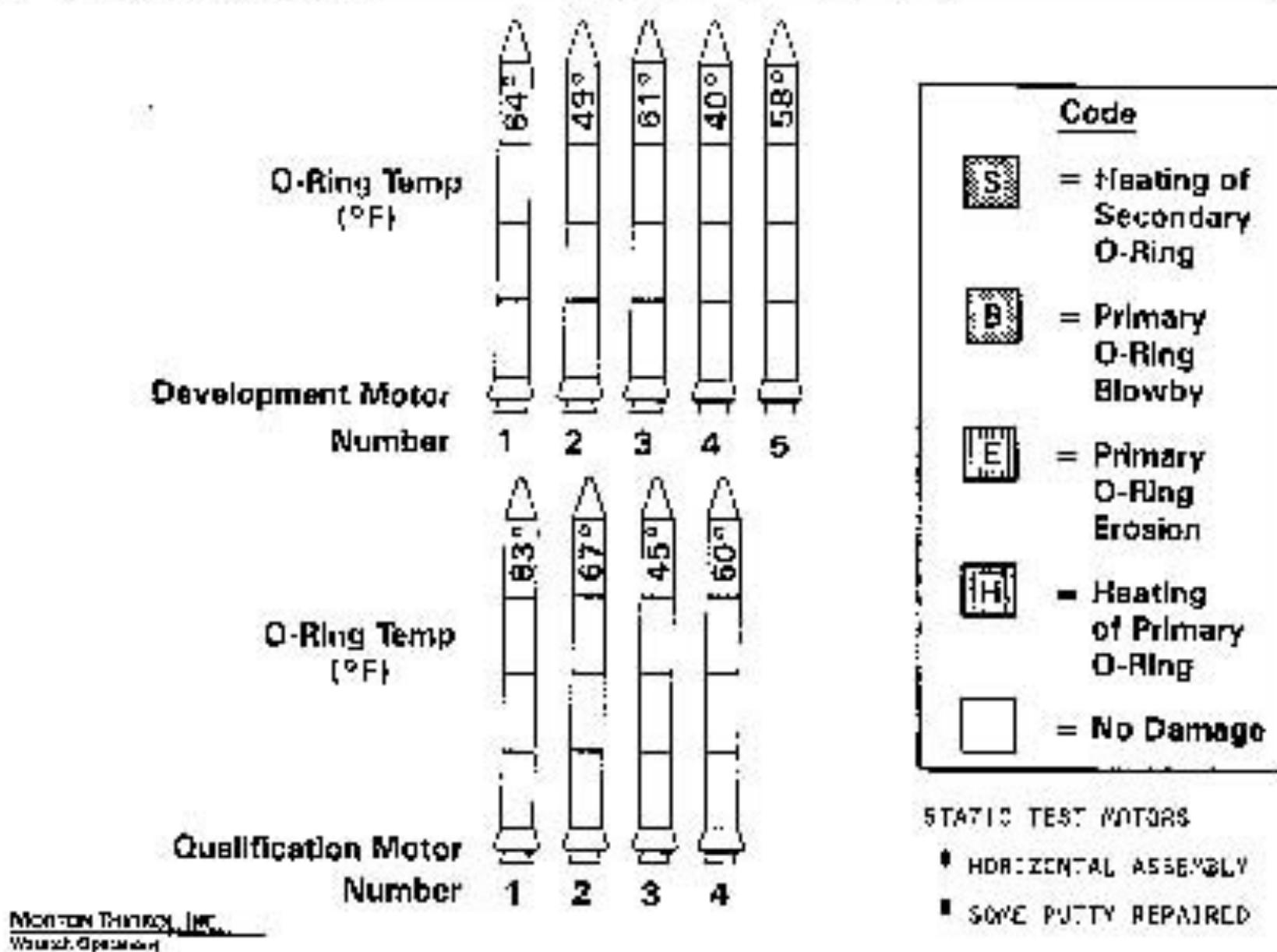


Jan 28, 1986



Feb 1, 2003

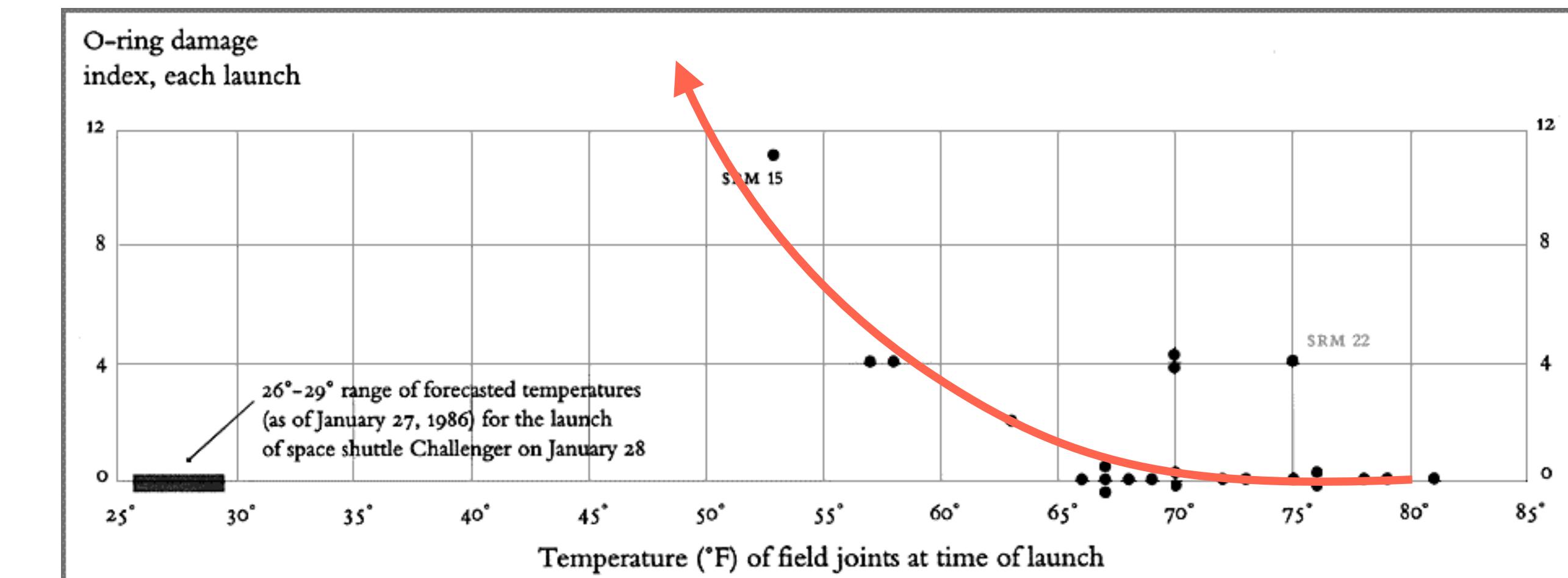
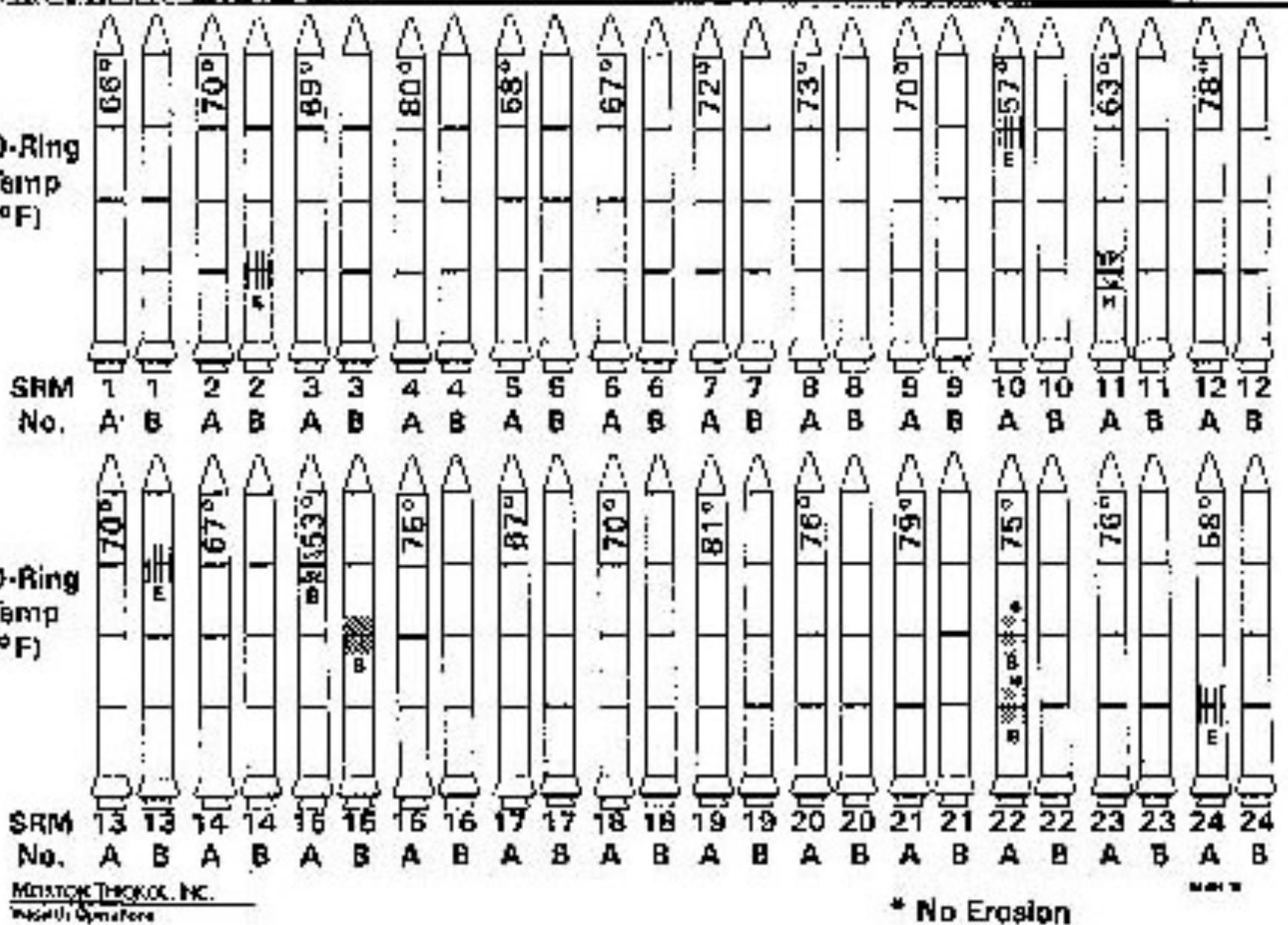
History of O-Ring Damage in Field Joints



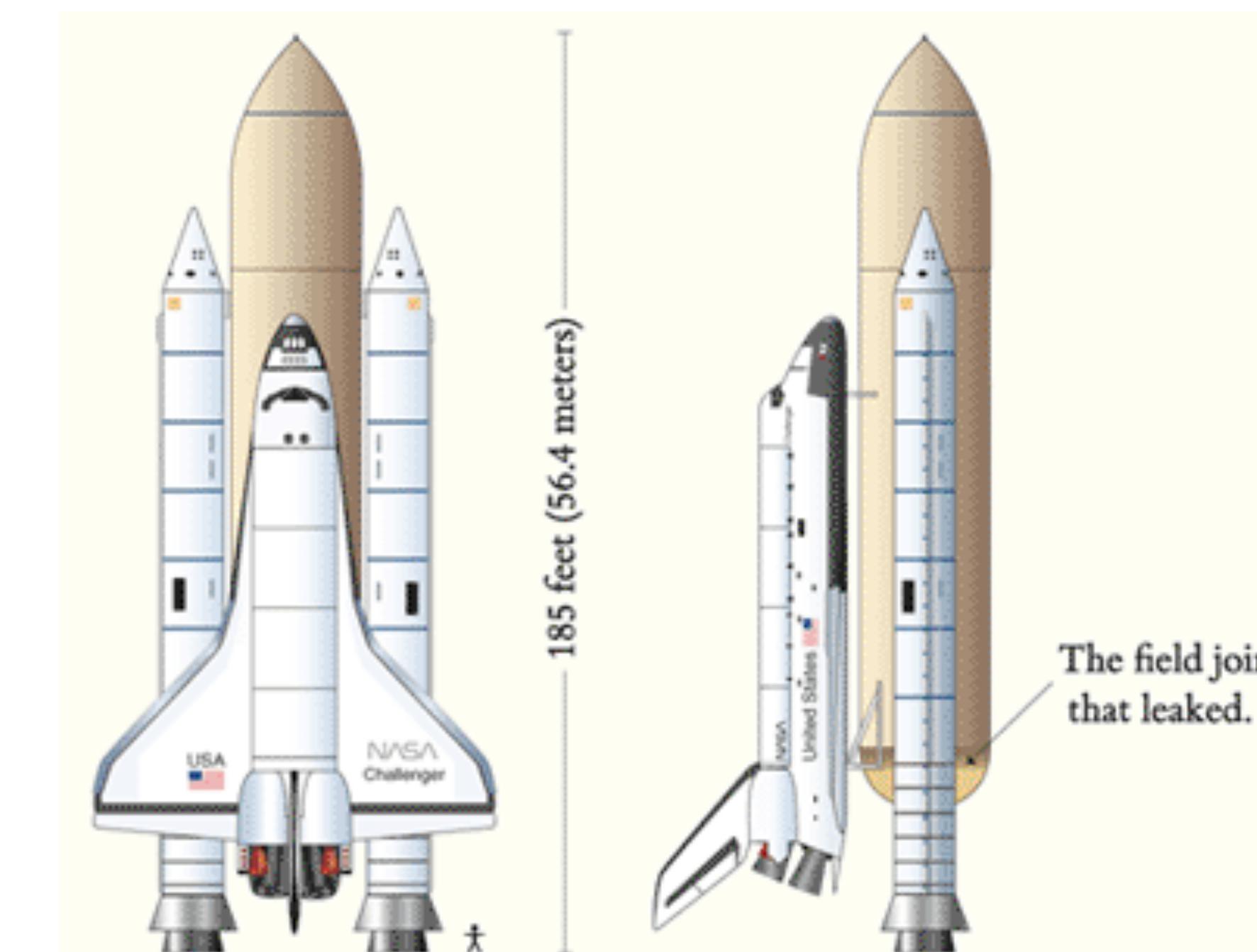
Morton Thiokol, Inc.
Wichita, Kansas

DISCUSSION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

History of O-Ring Damage in Field Joints (Cont)



Images and graphs from Edward Tufte



DISCUSSION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

On this one Columbia slide, a PowerPoint festival of bureaucratic hyper-rationalism, 6 different levels of hierarchy are used to display, classify, and arrange 11 phrases:

- Level 1 Title of Slide
- Level 2 ● Very Big Bullet
- Level 3 — big dash
- Level 4 • medium-small diamond
- Level 5 • tiny square bullet
- Level 6 () parentheses ending level 5

The analysis begins with the dreaded Executive Summary, with a conclusion presented as a headline: "Test Data Indicates Conservatism for Tile Penetration." This turns out to be unmerited reassurance. Executives, at least those who don't want to get fooled, had better read far beyond the title.

The "conservatism" concerns the *choice of models* used to predict damage. But why, after 112 flights, are foam-debris models being calibrated during a crisis? How can "conservatism" be inferred from a loose comparison of a spreadsheet model and some thin data? Divergent evidence means divergent evidence, not inferential security. Claims of analytic "conservatism" should be viewed with skepticism by presentation consumers. Such claims are often a rhetorical tactic that substitutes verbal fudge factors for quantitative assessments.

As the bullet points march on, the seemingly reassuring headline fades away. Lower-level bullets at the end of the slide undermine the executive summary. This third-level point notes that "Flight condition [that is, the debris hit on the Columbia] is significantly outside of test database." How far outside? The final bullet will tell us.

This fourth-level bullet concluding the slide reports that the debris hitting the Columbia is estimated to be $1920/3 = 640$ times larger than data used in the tests of the model! The correct headline should be "Review of Test Data Indicates Irrelevance of Two Models." This is a powerful conclusion, indicating that pre-launch safety standards no longer hold. The original optimistic headline has been eviscerated by the lower-level bullets.

Note how close readings can help consumers of presentations evaluate the presenter's reasoning and credibility.

The Very-Big-Bullet phrase fragment does not seem to make sense. No other VBB's appear in the rest of the slide, so this VBB is not necessary.

Spray On Foam Insulation, a fragment of which caused the hole in the wing

A model to estimate damage to the tiles protecting flat surfaces of the wing

Review of Test Data Indicates Conservatism for Tile Penetration

- The existing SOFI on tile test data used to create Crater was reviewed along with STS-87 Southwest Research data
 - Crater overpredicted penetration of tile coating significantly
 - Initial penetration is described by normal velocity
 - Varies with volume/mass of projectile (e.g., 200ft/sec for 3cu. In)
 - Significant energy is required for the softer SOFI particle to penetrate the relatively hard tile coating
 - Test results do show that it is possible at sufficient mass and velocity
 - Conversely, once tile is penetrated SOFI can cause significant damage
 - Minor variations in total energy (above penetration level) can cause significant tile damage
 - Flight condition is significantly outside of test database
 - Volume of ramp is 1920cu in vs 3 cu in for test

BOEING

Here "ramp" refers to foam debris (from the bipod ramp) that hit Columbia. Instead of the cryptic "Volume of ramp," say "estimated volume of foam debris that hit the wing." Such clarifying phrases, which may help upper level executives understand what is going on, are too long to fit on low-resolution bullet outline formats. PP demands the shorthand of acronyms, phrase fragments, and clipped jargon in order to get at least some information into the tight format.

Edward Tufte

Our models are irrelevant

Debris hitting the wing was **640x larger than the experimental data used to build these models**

We have **no clue what will happen on re-entry**

Communication is key

Identify audience & setting

Identify key insight, main points of evidence, and assumptions

Organize into a story focussed on 

Create supporting visualizations

Revise to be as precise and concise as possible

Errors of measurement - are we measuring what we think we are?

Errors of analysis - did we use the right methods to address the question?

Errors of borked tools - choosing the wrong tools or using them poorly leads to bad results

Errors of human cognition - data science is a human endeavor with all the usual frailties and foibles

Errors of communication - sometimes you get everything right, but the group and the decision makers never understand properly



[https://forms.gle/
VscVbHePDBNmJKXv7](https://forms.gle/VscVbHePDBNmJKXv7)