

# Final Projects

- Report (15% of grade - GROUP)
  - Can copy + paste from proposal & checkpoints & can update/edit/change
  - Adding on:
    - Choice if we have your permission to make public
    - Overview
    - Analysis (w/ “strong” data visualizations)
    - Conclusion & Discussion
  - It’s a report, not a vomiting of data.
    - Write in the diamond structure of technical reports
    - Do not have to include deadends, massive codebases, or irrelevant explorations. Can put those in a separate file that is referenced in report.
  - Do edit for correctness & conciseness at the end
- Video (3% of grade - GROUP)
  - 3-5 minutes
  - Post video so that it is PUBLICLY VISIBLE on Google Drive, Dropbox, TikTok, YouTube, whatever.
  - Place a link to the video right after the title of your final project notebook
  - Everyone should participate; not everyone has to be IN the video
- Team Evaluation Survey (1% of grade - INDIVIDUAL)
  - Give us more information about who contributed / did not contribute; this will effect individual grades
  - Will include questions that help us with the pedagogical experiment of group dynamics running this year!

# Week 10 / Finals Week Extra Credit Opportunities

- Finish strong with your group progress surveys!
  - 0.5% EC if you fill out all 7
- Fill out the teaching evaluations (SET used to be CAPE) [Evaluations site](#)
  - Must complete evaluations BEFORE 8AM on Saturday after Week 10. No exceptions.
  - 0.5% EC if >75% of the class fills this out (only happens half the time)
- Post course survey
  - 0.25% EC

# **COGS 108**

## **guest lectures of the past**

[https://www.youtube.com/playlist?  
list=UULFJHr7mR7fY5mYmv8jjF289g](https://www.youtube.com/playlist?list=UULFJHr7mR7fY5mYmv8jjF289g)



# How to be wrong

**Jason G. Fleischer, Ph.D.**

**Asst. Teaching Professor**

**Department of Cognitive Science, UC San Diego**

**jfleischer@ucsd.edu**



**@jasongfleischer**

**<https://jgfleischer.com>**

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

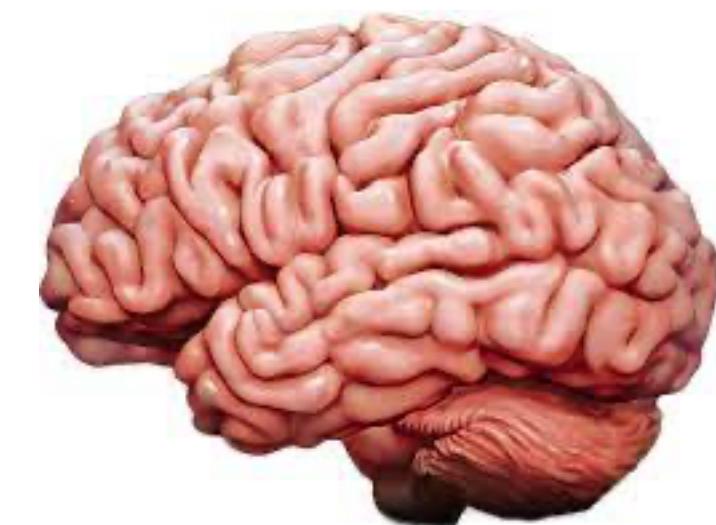
# Errors of measurement



# Errors of analysis

# Errors of broken tools

# Errors of human cognition

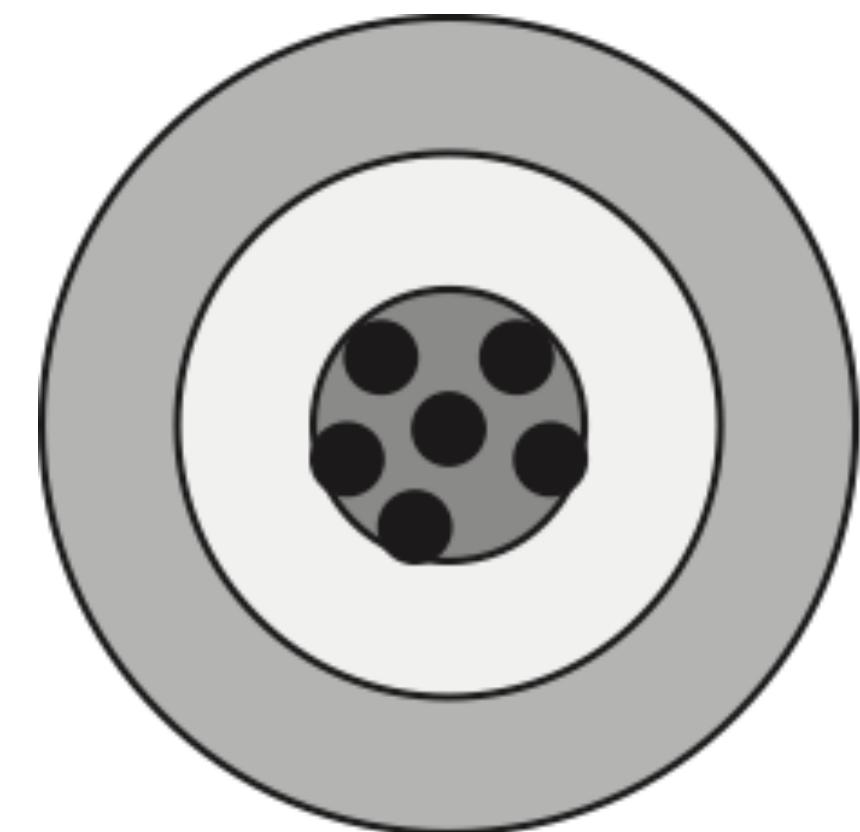


# Errors of communication

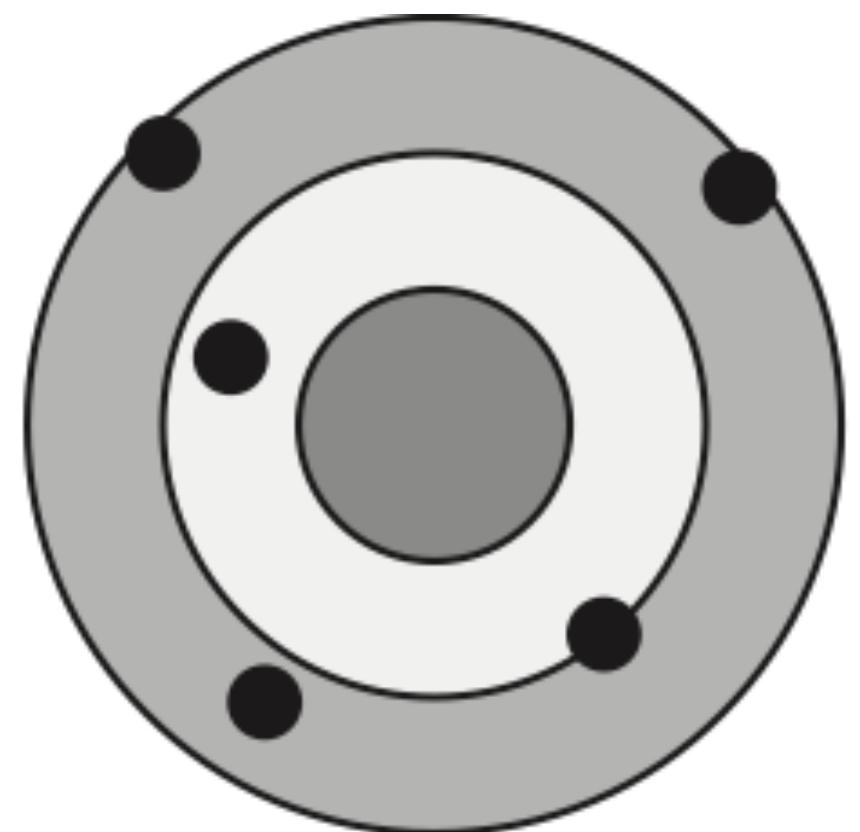


# **Errors of measurement**

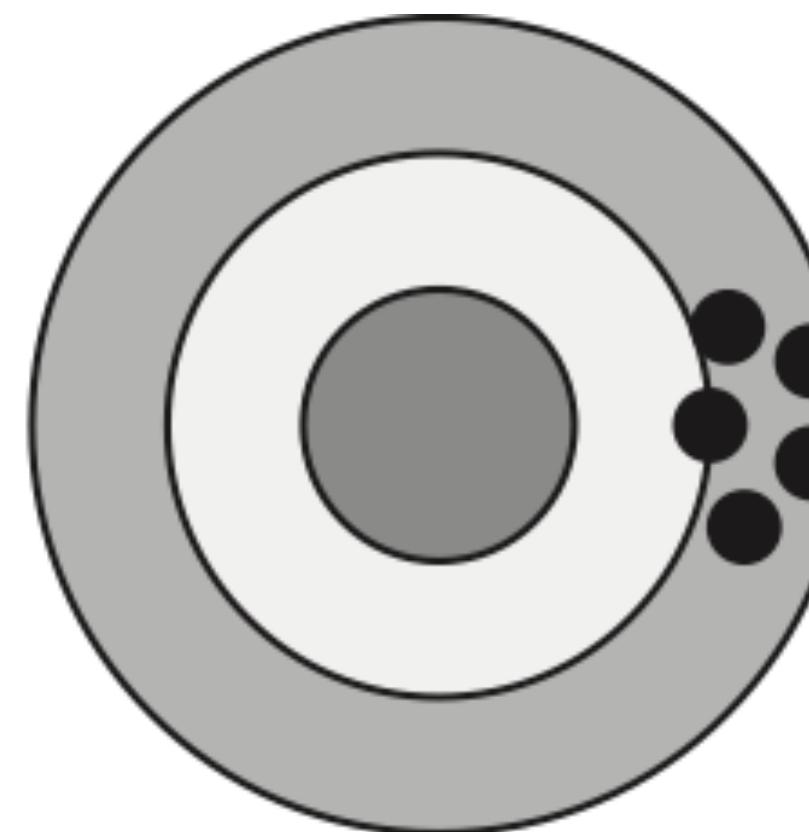
**Accurate  
and precise**



**Accurate  
but not precise**



**Precise  
but not accurate**



## Top Cities For BBQ in the U.S.

An analysis of TripAdvisor restaurant reviews by chefspencil.com



## Worst Cities For BBQ in the U.S.

An analysis of TripAdvisor restaurant reviews by chefspencil.com



# Proxy measurements

**We can't measure directly what we care about, but we can measure something related**

- Unemployment rate -> our general economy
- Gross domestic product -> standard of living
- BMI -> health
- Your suggestions?
- Grades -> learning

**Do we understand what we are  
measuring?**

# Abraham Wald

Survivorship bias

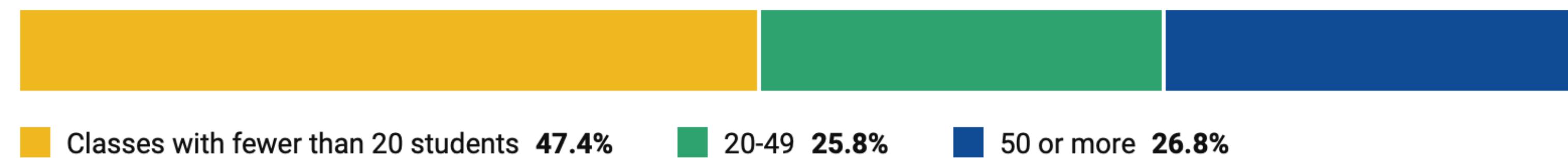


# Are we measuring what's relevant?

## 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

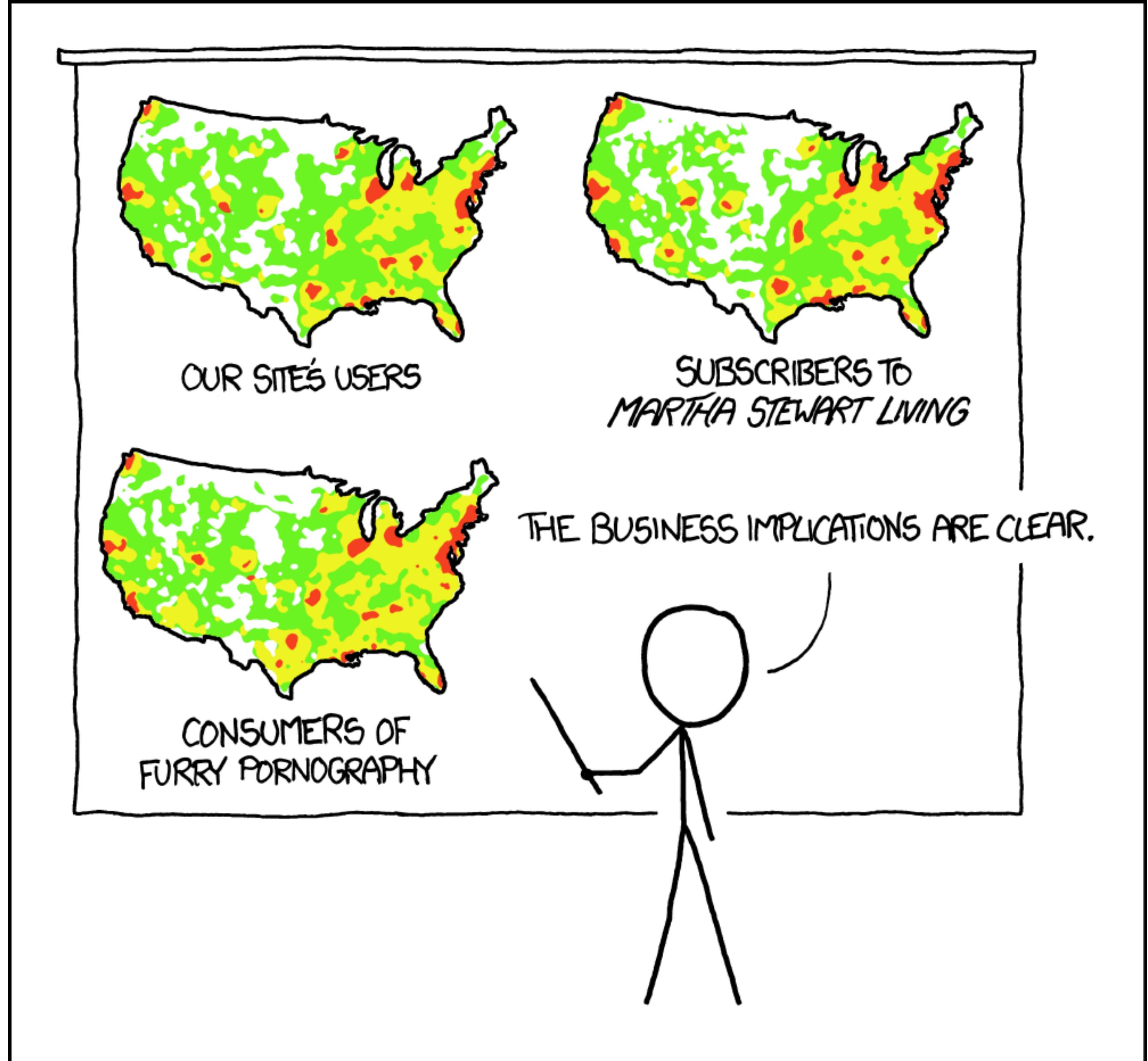
19:1

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)	
<b>Median class size as experienced by faculty</b>	2-9 students:	12%	12%	0.24	0.67%	
	10-19 students	32%	44%	3.2	8.95%	
	<b>20-29 students:</b>	14%	<b>58%</b>	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%	
<b>Median class size as experienced by students</b>	Over 100 students:	20%	101%	20	<b>55.96%</b>	
		Sum:		35.74		
		<b>Data from <a href="https://www.collegedata.com/college/University-of-California-San-Diego/">https://www.collegedata.com/college/University-of-California-San-Diego/</a></b>				

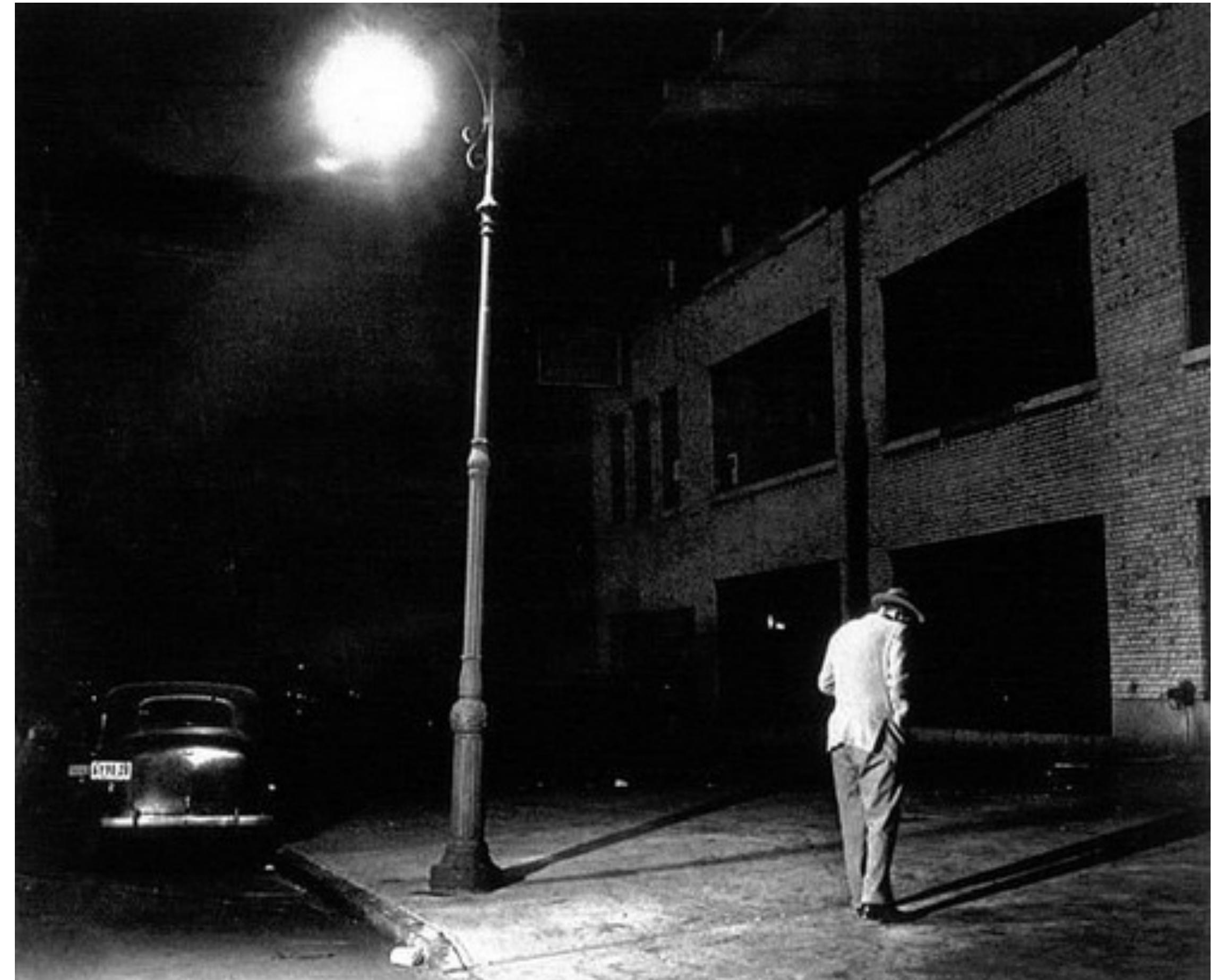


PET PEEVE #208:

GEOGRAPHIC PROFILE MAPS WHICH ARE  
BASICALLY JUST POPULATION MAPS

# The Lamppost Problem

aka. Streetlight Effect  
aka. The Drunkard's Search  
aka. Picking a shitty proxy





Many, and possibly most, scientists spend their careers looking for answers where the light is better rather than where the truth is more likely to lie.

# Goodhart's law

## Once a metric becomes a goal, you're fucked

### Volkswagen emissions scandal

Article

Talk

文 A 26 languages ▾

Read Edit View history Tools ▾

From Wikipedia, the free encyclopedia

"Dieselgate" and "Emissionsgate" redirect here. For other diesel emissions scandals, see [Diesel emissions scandal](#).

The **Volkswagen emissions scandal**, sometimes known as **Dieselgate**<sup>[23][24]</sup> or **Emissionsgate**,<sup>[25][24]</sup> began in September 2015, when the [United States Environmental Protection Agency](#) (EPA) issued a notice of violation of the [Clean Air Act](#) to German automaker [Volkswagen Group](#).<sup>[26]</sup> The agency had found that Volkswagen had intentionally programmed [turbocharged direct injection \(TDI\)](#) [diesel engines](#) to activate their [emissions](#) controls only during laboratory [emissions testing](#), which caused the vehicles' [NO<sub>x</sub>](#) output to meet US standards during regulatory testing. However, the vehicles emitted up to 40 times more NO<sub>x</sub> in real-world driving.<sup>[27]</sup> Volkswagen deployed this software in about 11 million cars worldwide, including 500,000 in the United States, in [model years](#) 2009 through 2015.<sup>[28][29][30][31]</sup>

#### Volkswagen emissions scandal



A 2010 Volkswagen Golf TDI displaying "Clean Diesel" at the [Detroit Auto Show](#)

### Search engine optimization

Article Talk

文 A 65 languages ▾

Read View source View history Tools ▾

From Wikipedia, the free encyclopedia

"SEO" redirects here. For other uses, see [Seo](#).

**Search engine optimization (SEO)** is the process of improving the quality and quantity of [website traffic](#) to a [website](#) or a [web page](#) from [search engines](#).<sup>[1][2]</sup> SEO targets unpaid traffic (known as "natural" or "organic" results) rather than direct traffic or [paid traffic](#). Unpaid traffic may originate from different kinds of searches, including [image search](#), [video search](#), [academic search](#),<sup>[3]</sup> news search, and industry-specific [vertical search](#) engines.

As an [Internet marketing](#) strategy, SEO considers how search engines work, the computer-programmed [algorithms](#) that dictate search engine behavior, what people search for, the actual search terms or [keywords](#) typed into search engines, and which search engines are preferred by their targeted audience. SEO is performed because a website will receive more visitors from a search engine when websites rank higher on the [search engine results page \(SERP\)](#). These visitors can then potentially be converted into customers.<sup>[4]</sup>

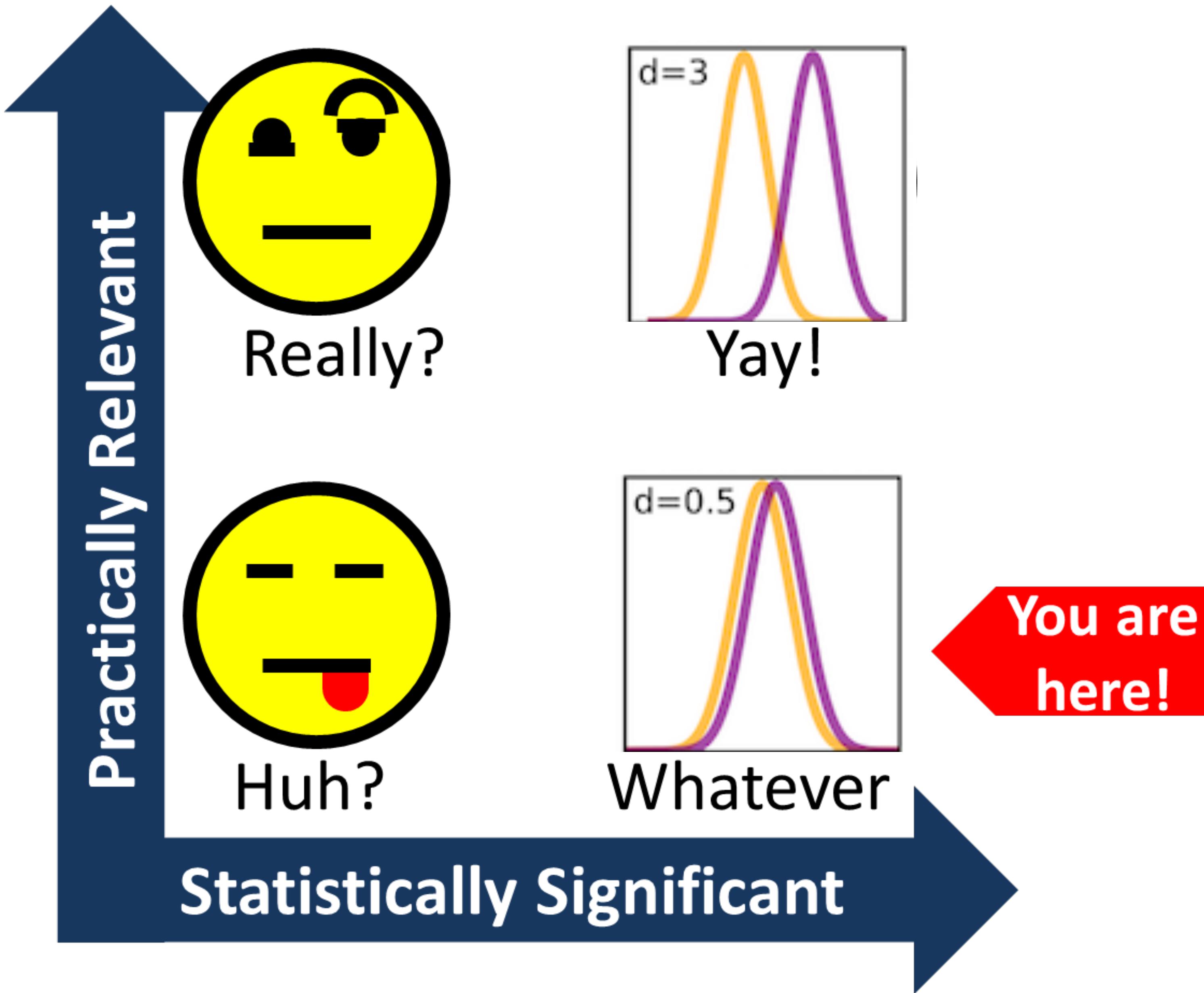
Part of a series on  
**Internet marketing**

Search engine optimization  
Local search engine optimisation  
Social media marketing  
Email marketing  
Referral marketing  
Content marketing  
Native advertising

**Search engine marketing**  
Pay-per-click  
Cost per impression  
Search analytics  
Web analytics

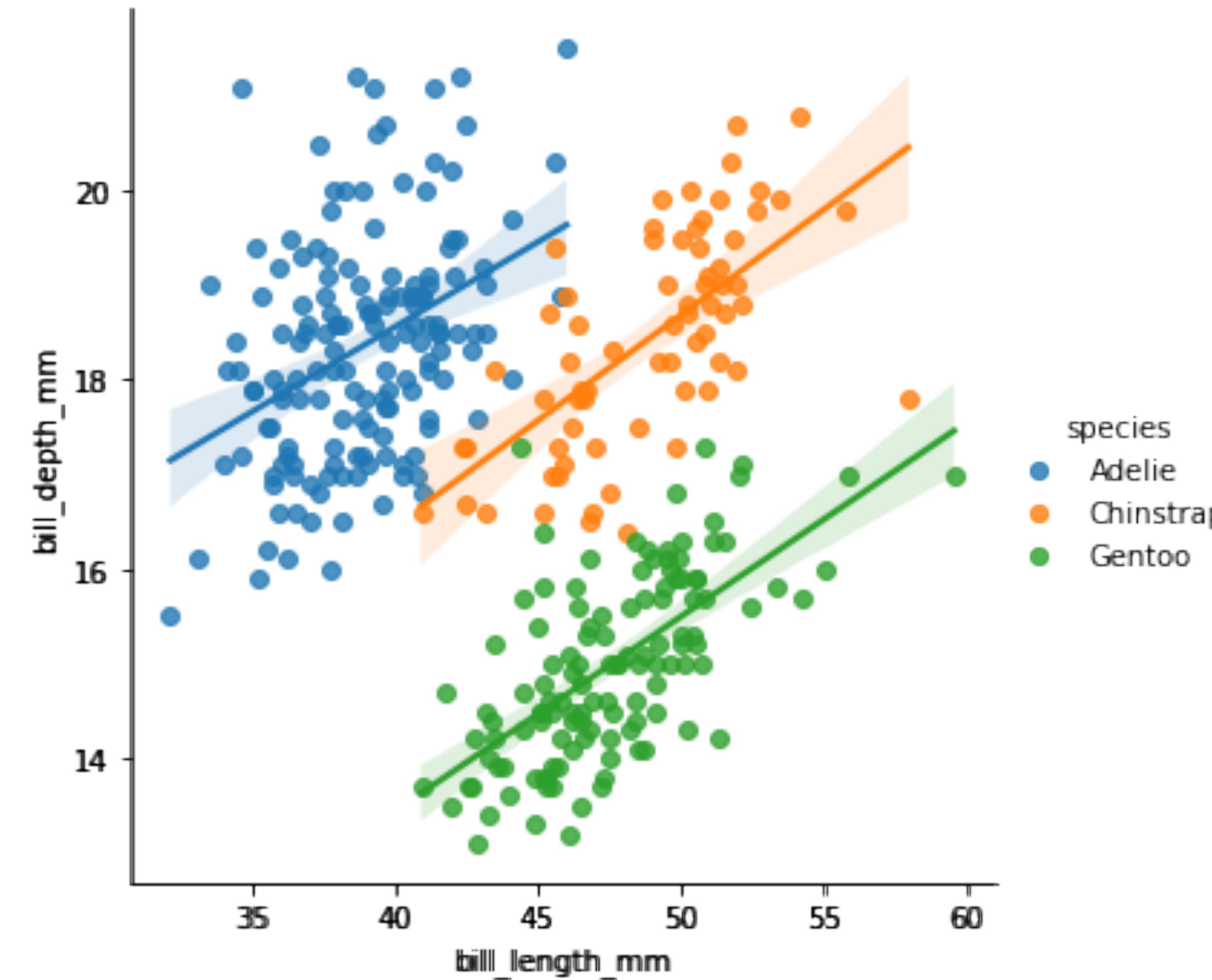
**Display advertising**  
Ad blocking  
Contextual advertising

# **Errors of analysis**

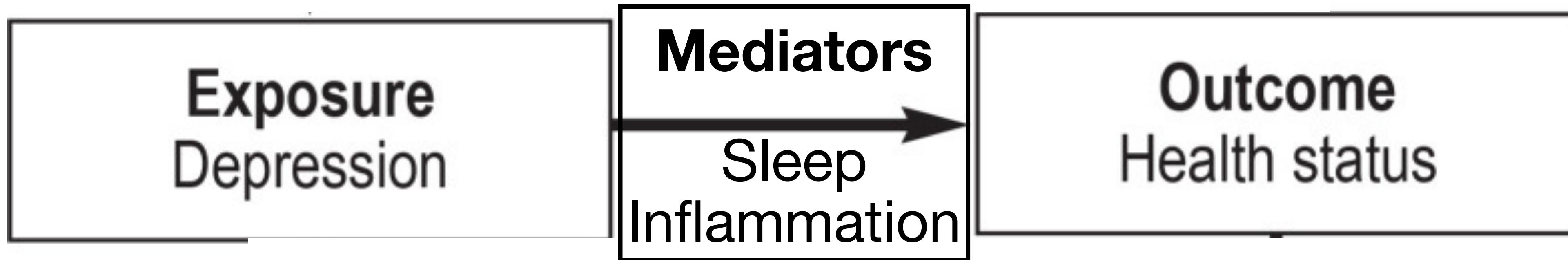


# Simpson's paradox

Answers change when you include subgroups in your analysis



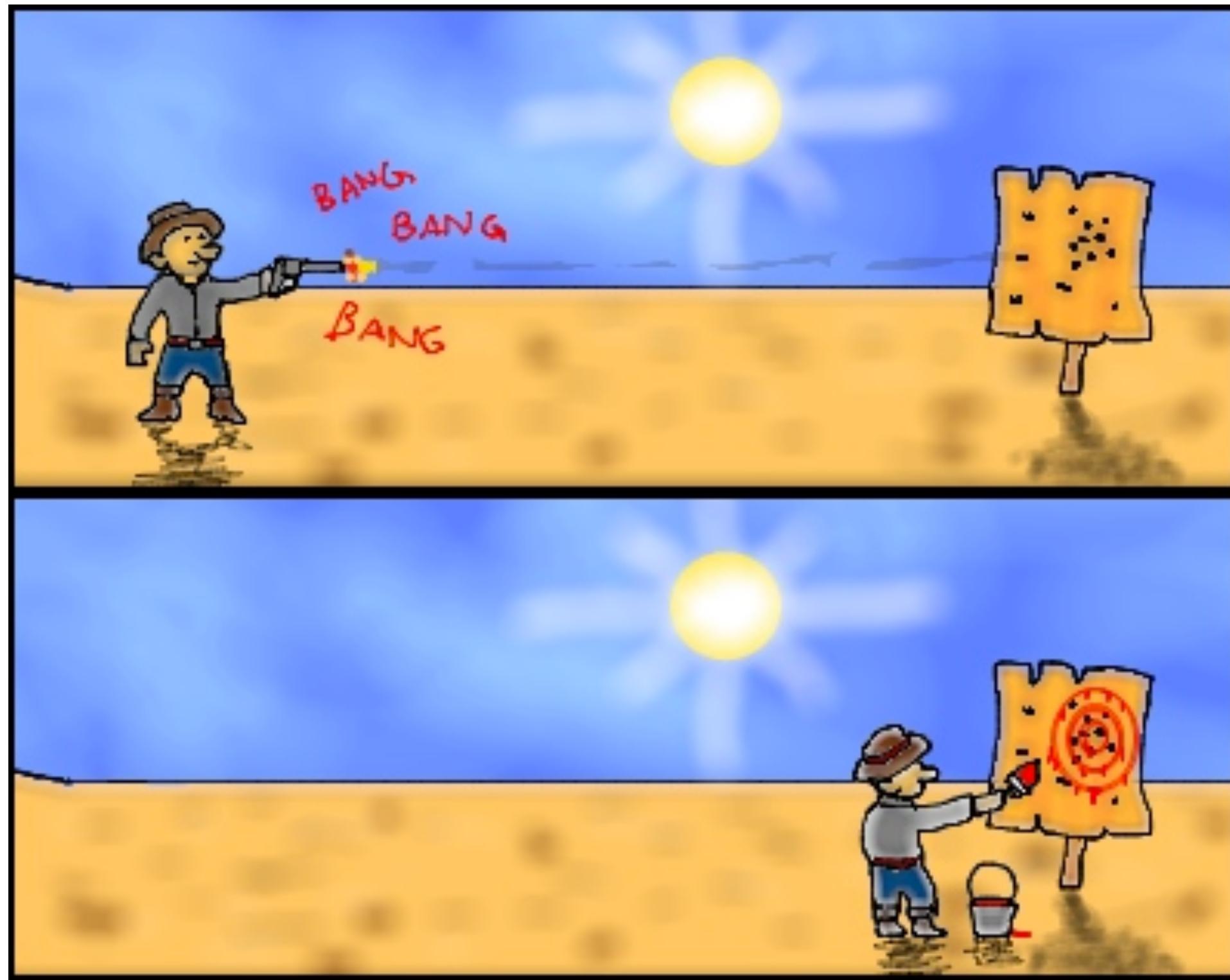
# Confounders, Colliders, and Mediators



# Confounders and Colliders and Mediators

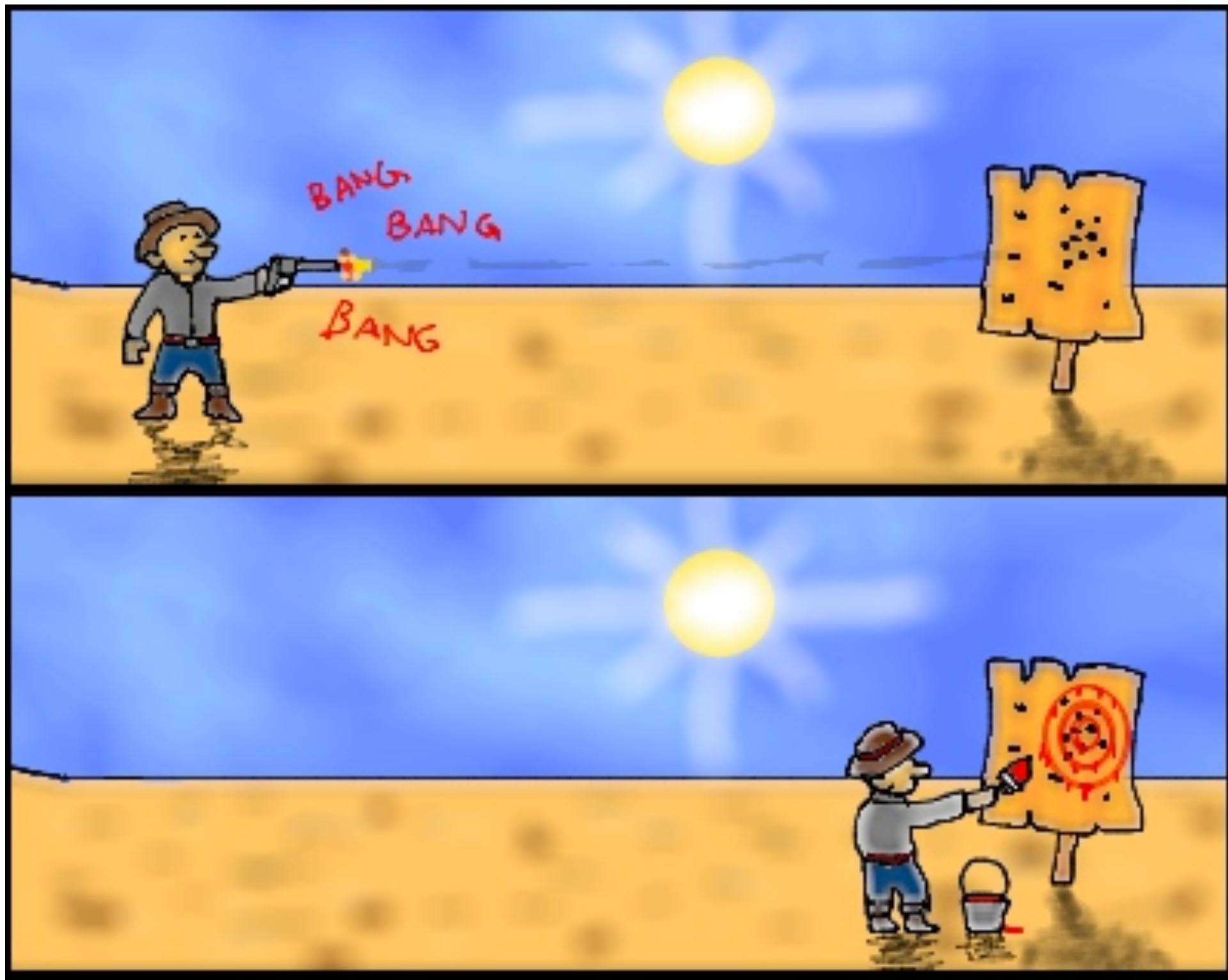
- Confounders:  $X \leftarrow Z \rightarrow Y$  aka you made the wrong model the first time
- Colliders:  $X \rightarrow Z \leftarrow Y$  aka selection bias
- Mediators:  $X \rightarrow Z \rightarrow Y$  aka science is hard and advances in small steps
- To estimate the total effect of exposure X on outcome Y:
  - DO adjust for confounders (common causes of X and Y)
  - DO NOT adjust for colliders (common effects of X and Y) but you should be aware of them because you want to avoid them in your study design
  - DO NOT adjust for mediators (variables on the causal pathway)

# 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.

# Avoiding HARKing



- Best possible:
  - EDA on a separate dataset than you do your NHST stuff
  - Build up knowledge in multiple studies that do the same thing
  - In many DS contexts this is impossible. Just be clear that p-values once again are suggestive not definitive

# 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

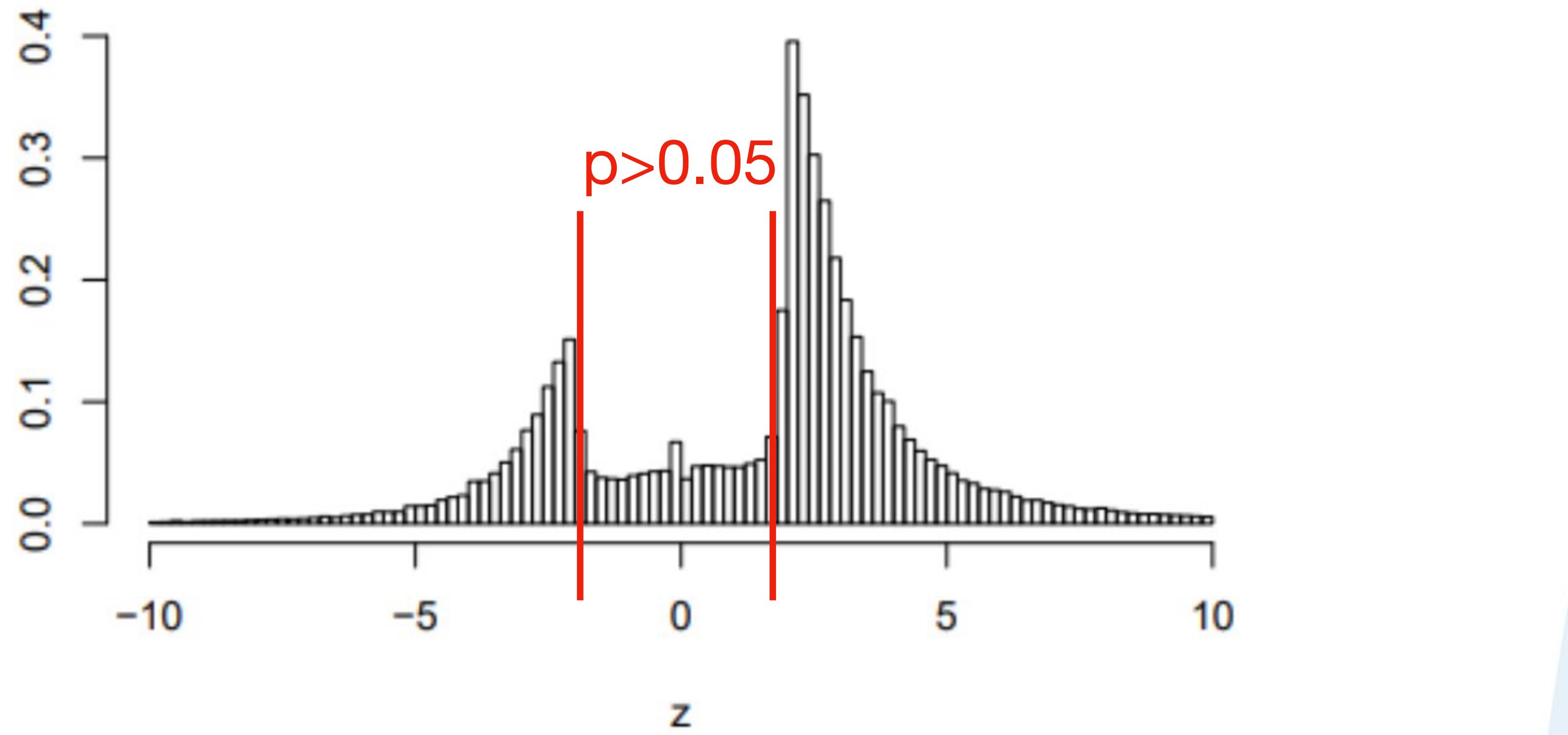


Figure 1: The distribution of more than one million  $z$ -values from Medline (1976–2019).

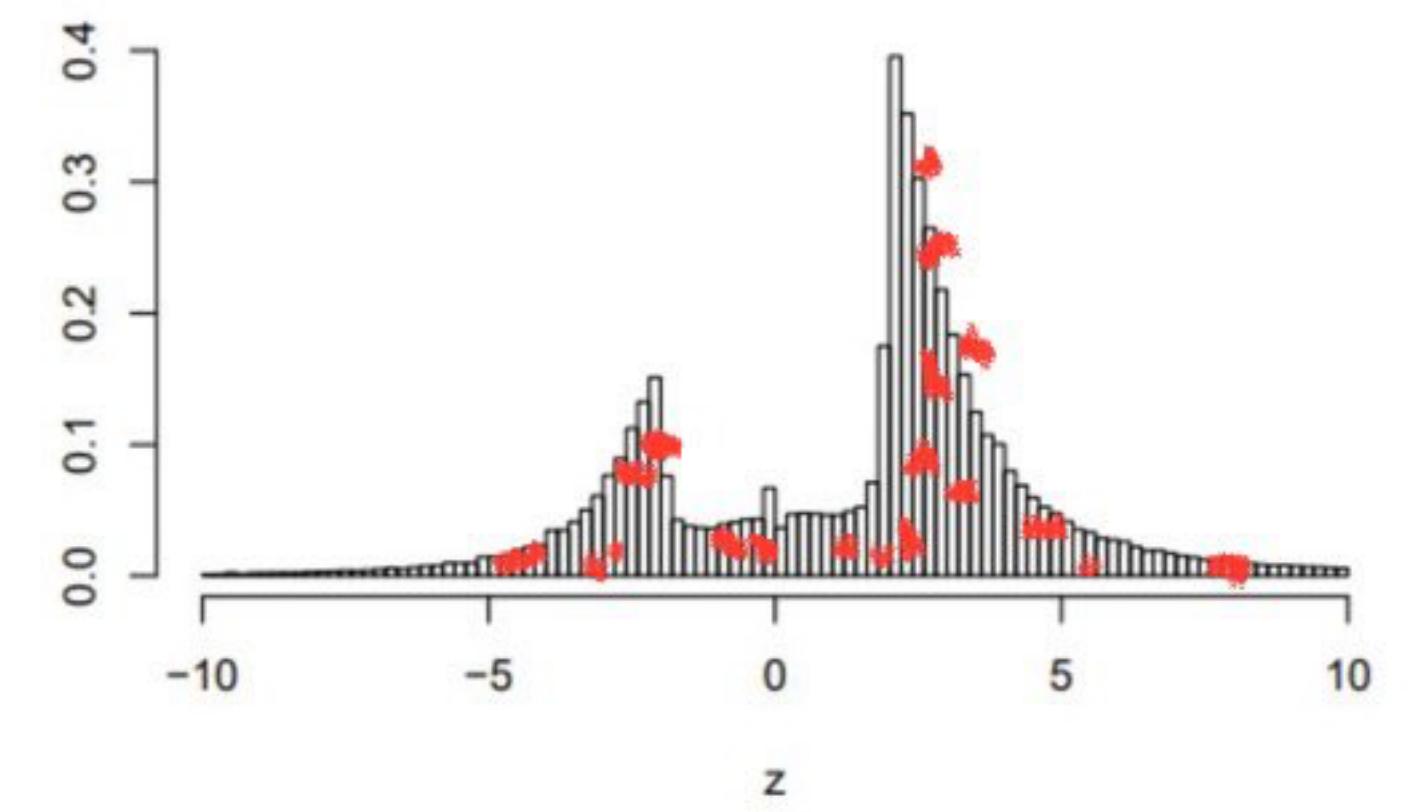
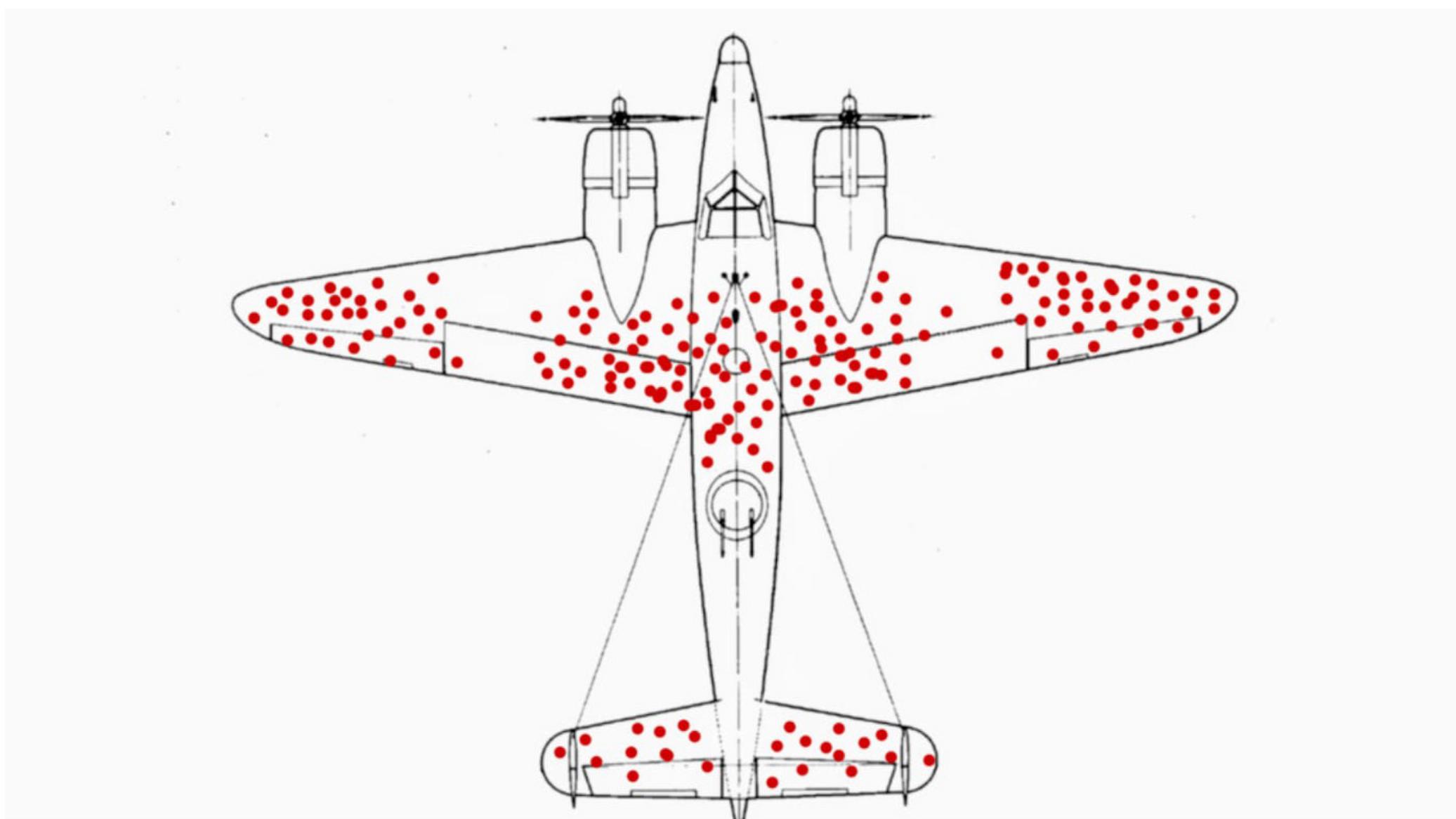


Figure 1: The distribution of more than one million  $z$ -values from Medline (1976–2019).



# Pre-registration and Reproducibility

## How science should work

- Pre-registration
  - Decide what and how you will analyze in advance
  - Publish the pre-registration
- Reproducibility
  - Open data!!!
  - Open source
  - Containerized software



# **Errors from bad 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.

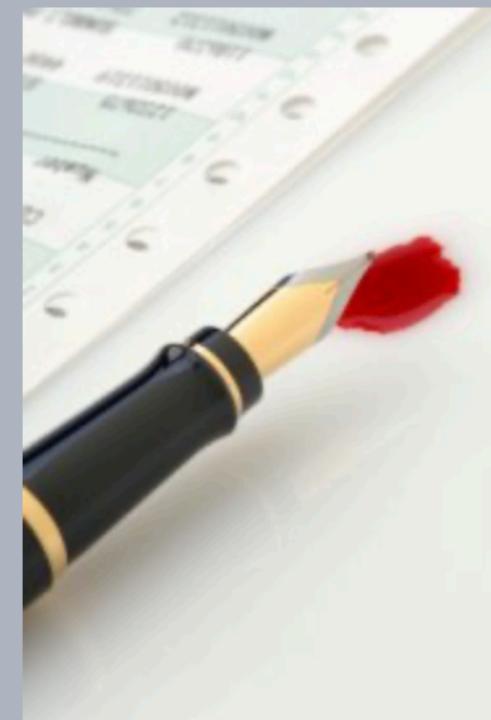
Stories are identified by those who kindly collated and sorted them:

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:	<a href="https://www.bbc.co.uk/news/technology-54423988">https://www.bbc.co.uk/news/technology-54423988</a>
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*

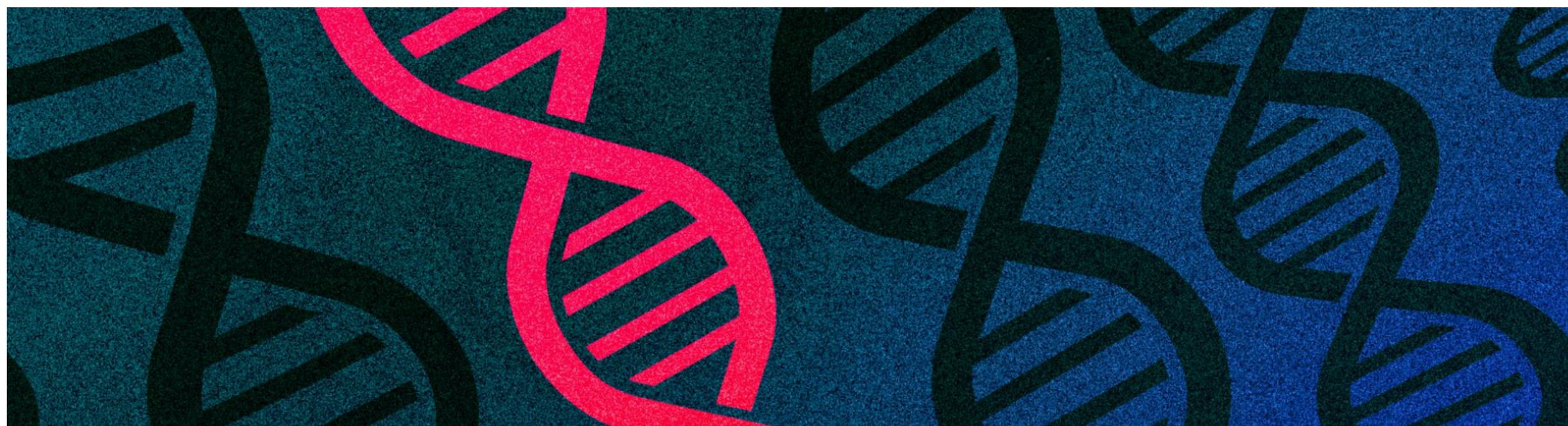
By James Vincent | Aug 6, 2020, 8:44am EDT



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

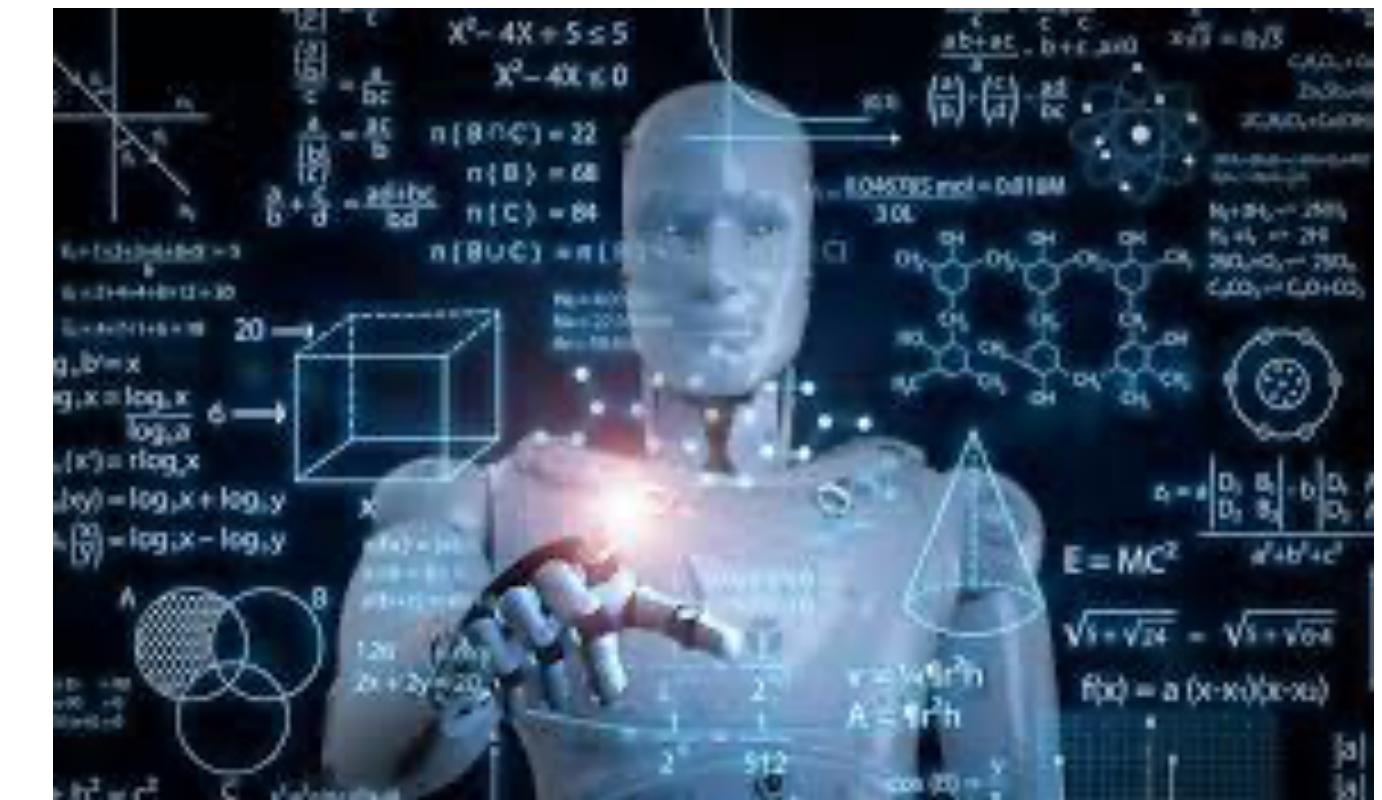
Felienne Hermans  
Delft University of Technology  
Mekelweg 4  
2628 CD Delft, the Netherlands  
f.f.j.hermans@tudelft.nl

Emerson Murphy-Hill  
North Carolina State University  
890 Oval Drive  
Raleigh, North Carolina, USA  
emerson@csc.ncsu.edu

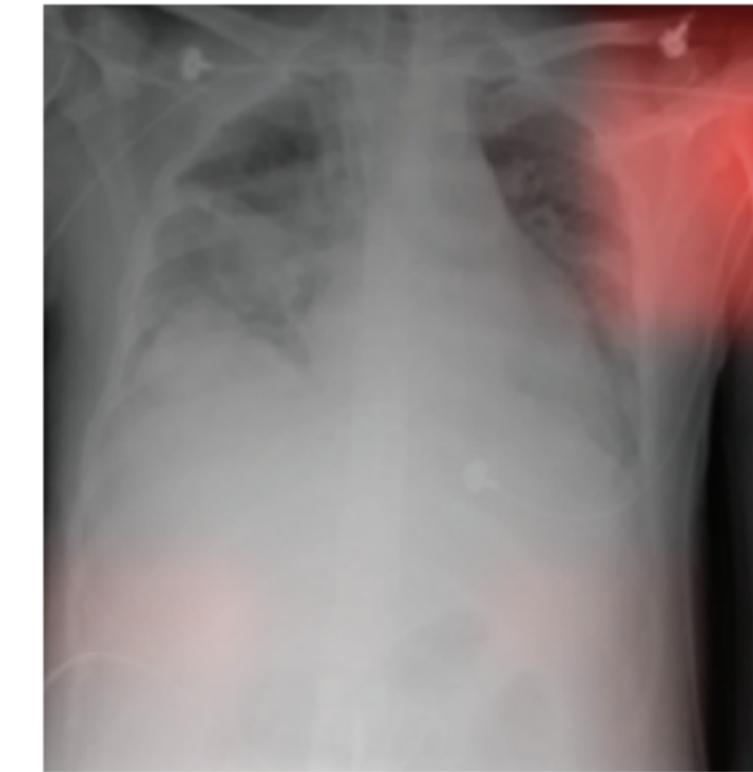
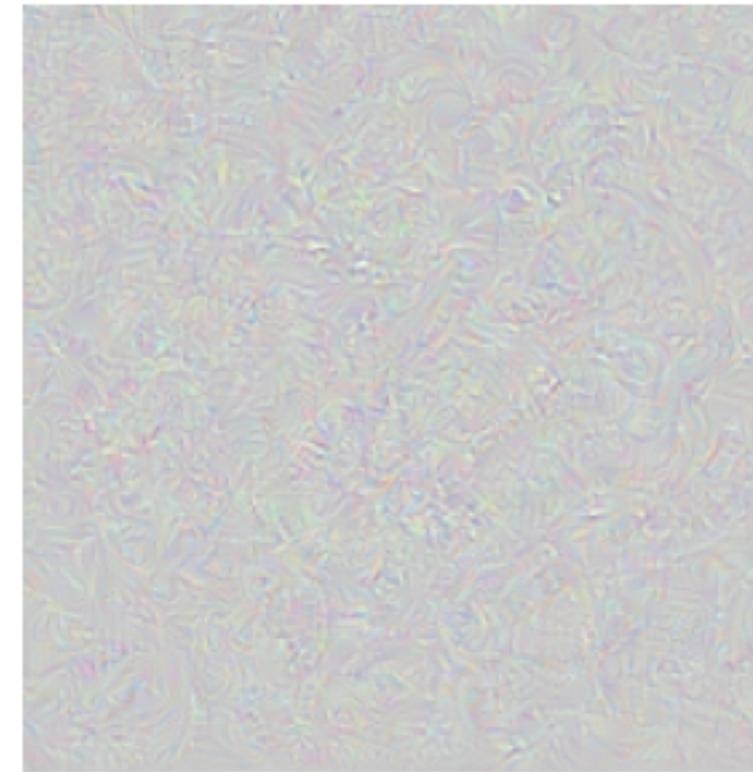
TABLE III  
SPREADSHEETS CONTAINING EXCEL ERRORS IN THE ENRON SET

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 irrecongnisable to humans	Looks at hospital token, not lung	Only looks at last sentence and ignores context

## same category for humans

but not for DNNs (intended generalisation)

i.i.d.



domain  
shift

e.g. Wang '18

adversarial  
examples

Szegedy '13

distortions

e.g. Dodge '19

pose

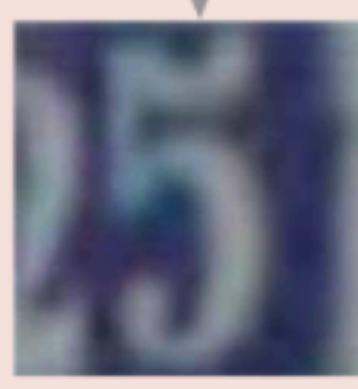
Alcorn '19

texture

Geirhos '19

background

Beery '18



o.o.d.

## same category for DNNs

but not for humans (unintended generalisation)



excessive  
invariance

Jacobsen '19

fooling  
images

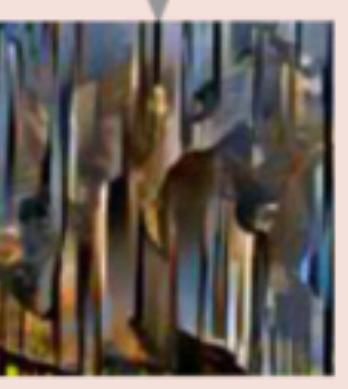
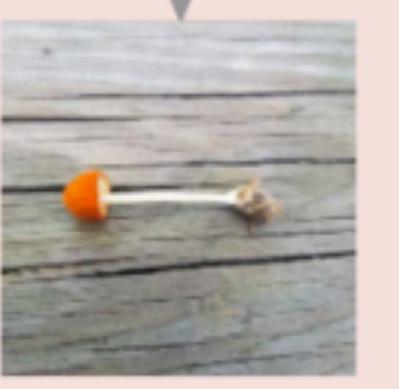
Nguyen '15

natural  
adversarials

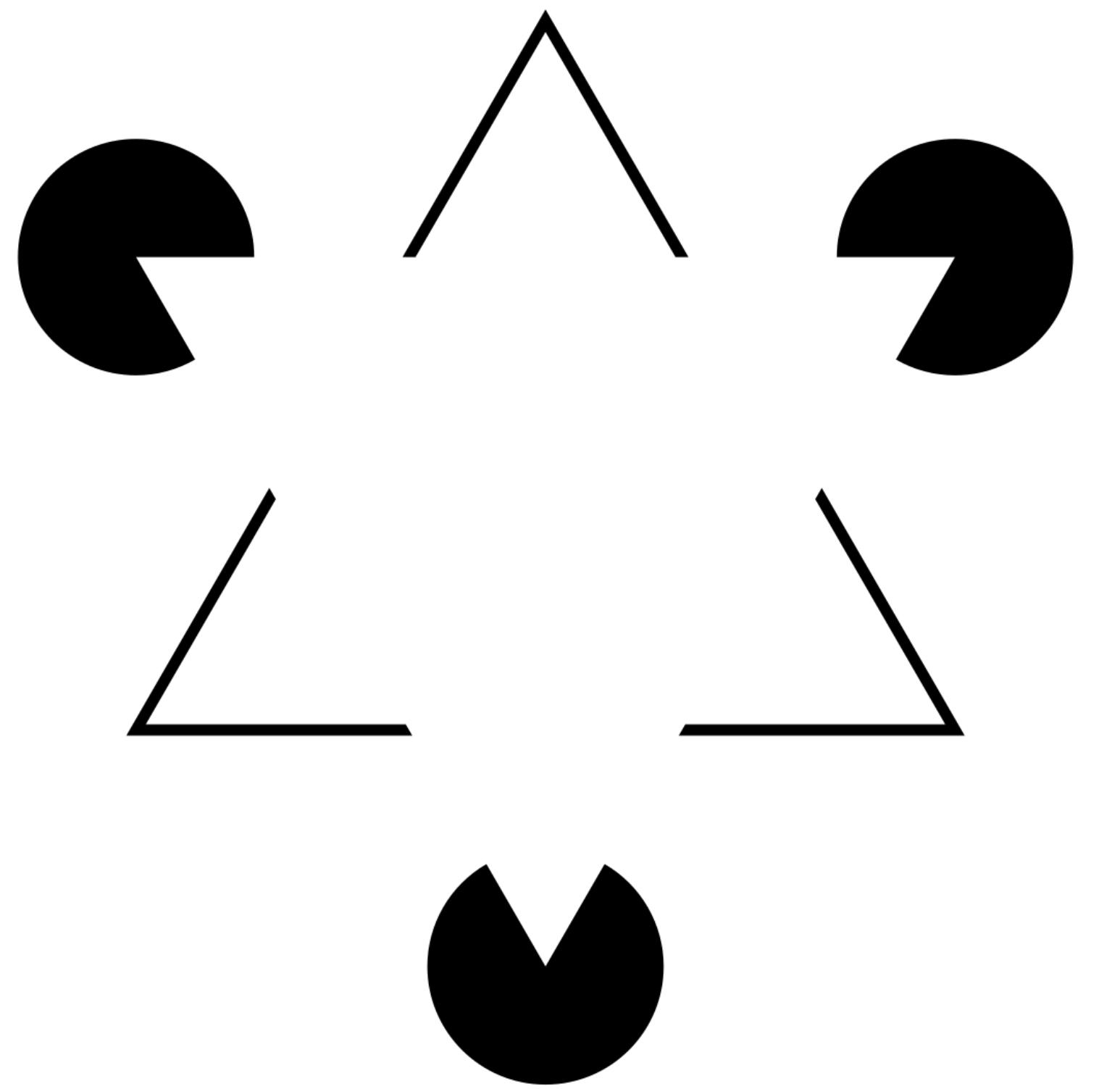
Hendrycks '19

texturised  
images

Brendel '19

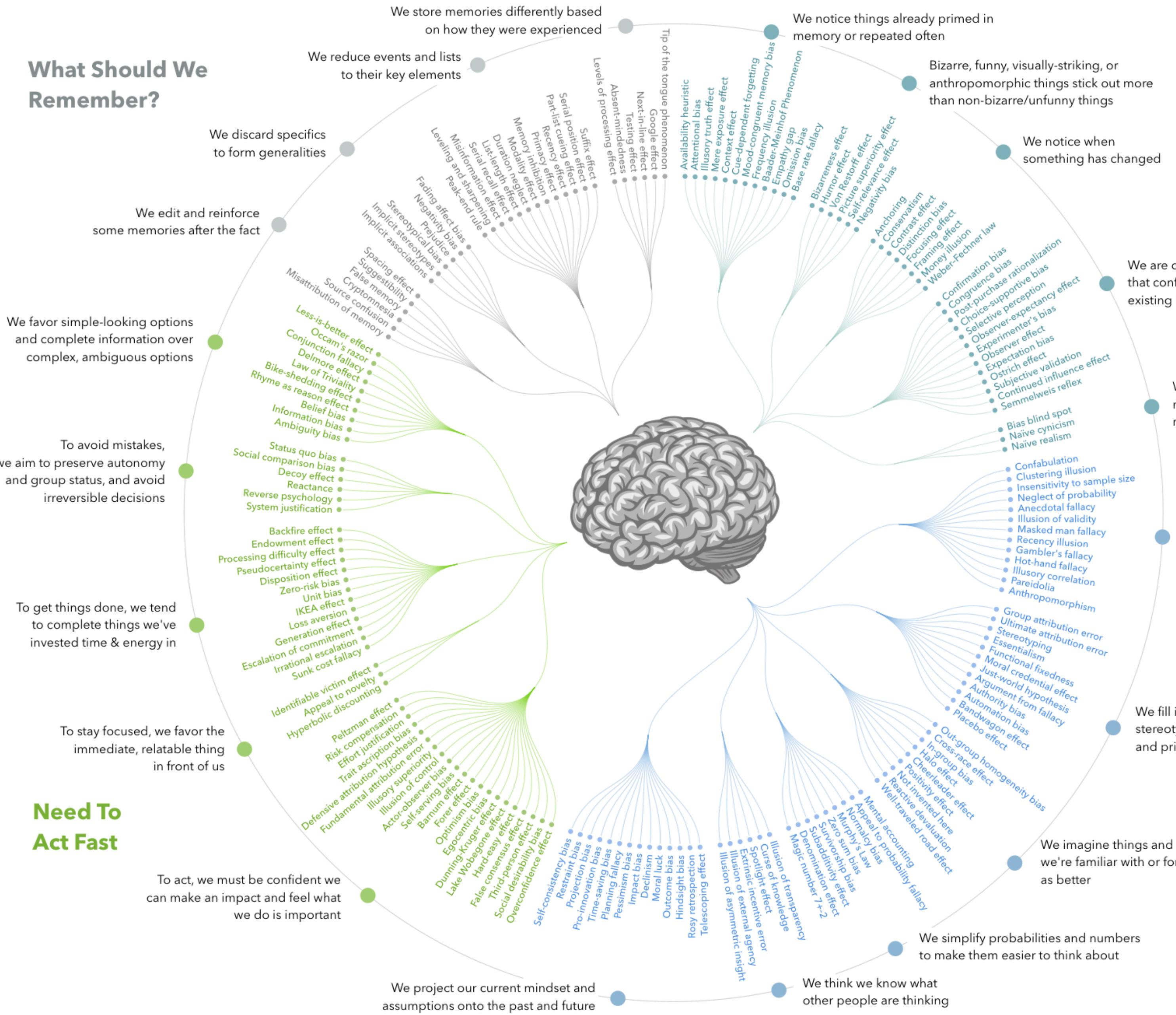






# COGNITIVE BIAS CODEX

## What Should We Remember?



# Exercise 1A

## Left side of room



# **Exercise 1B**

## **Right side of room**

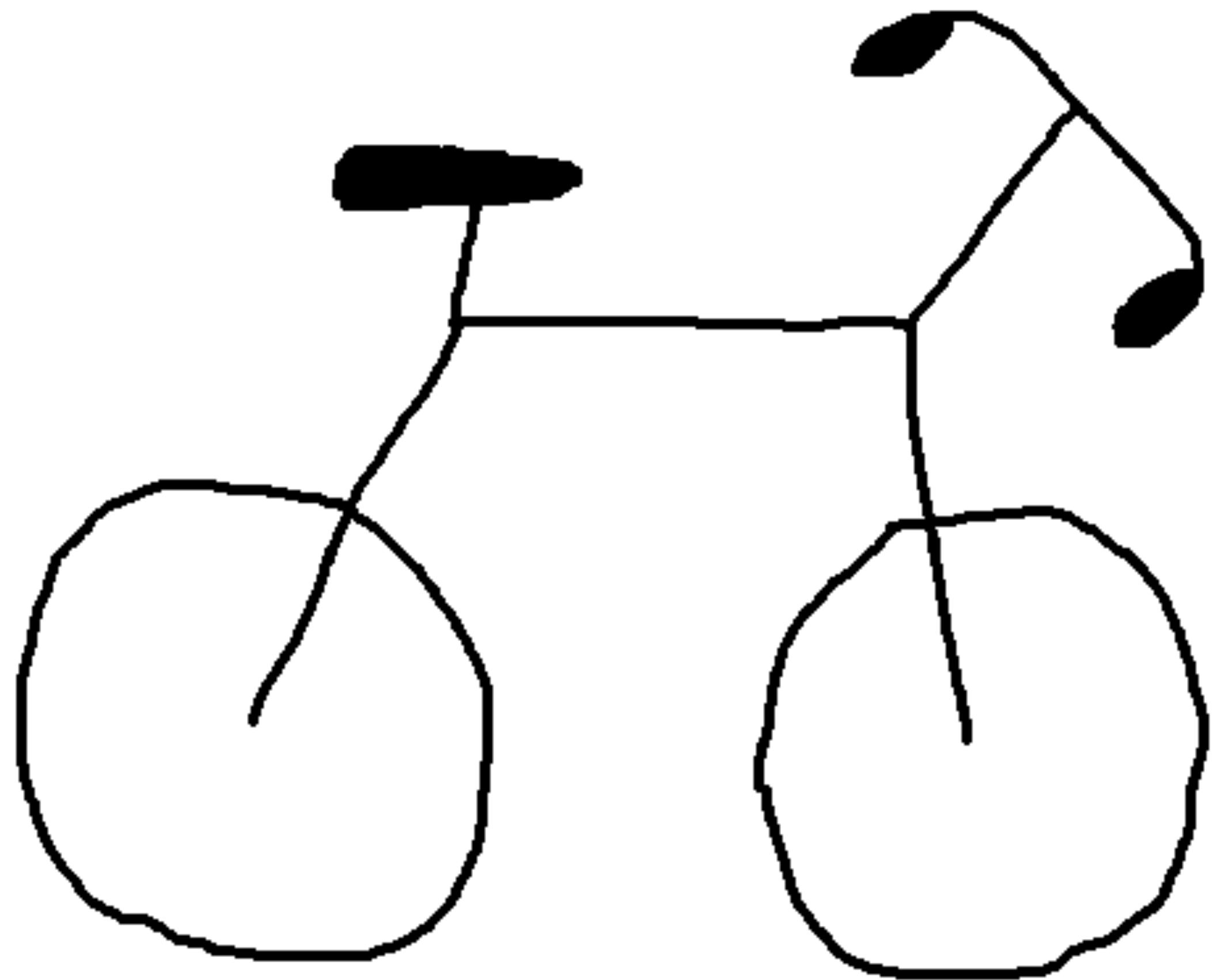


# Anchoring bias

- The tendency for decision makers to start their decision process from a specific point of reference and subsequently make insufficient adjustments from the anchored point.
- Possible techniques to reduce this bias:
  - Document the rationale for a decision
  - Learn to anticipate and correct the bias
  - Develop your own expectations through experience

# Exercise 2





Frame —————

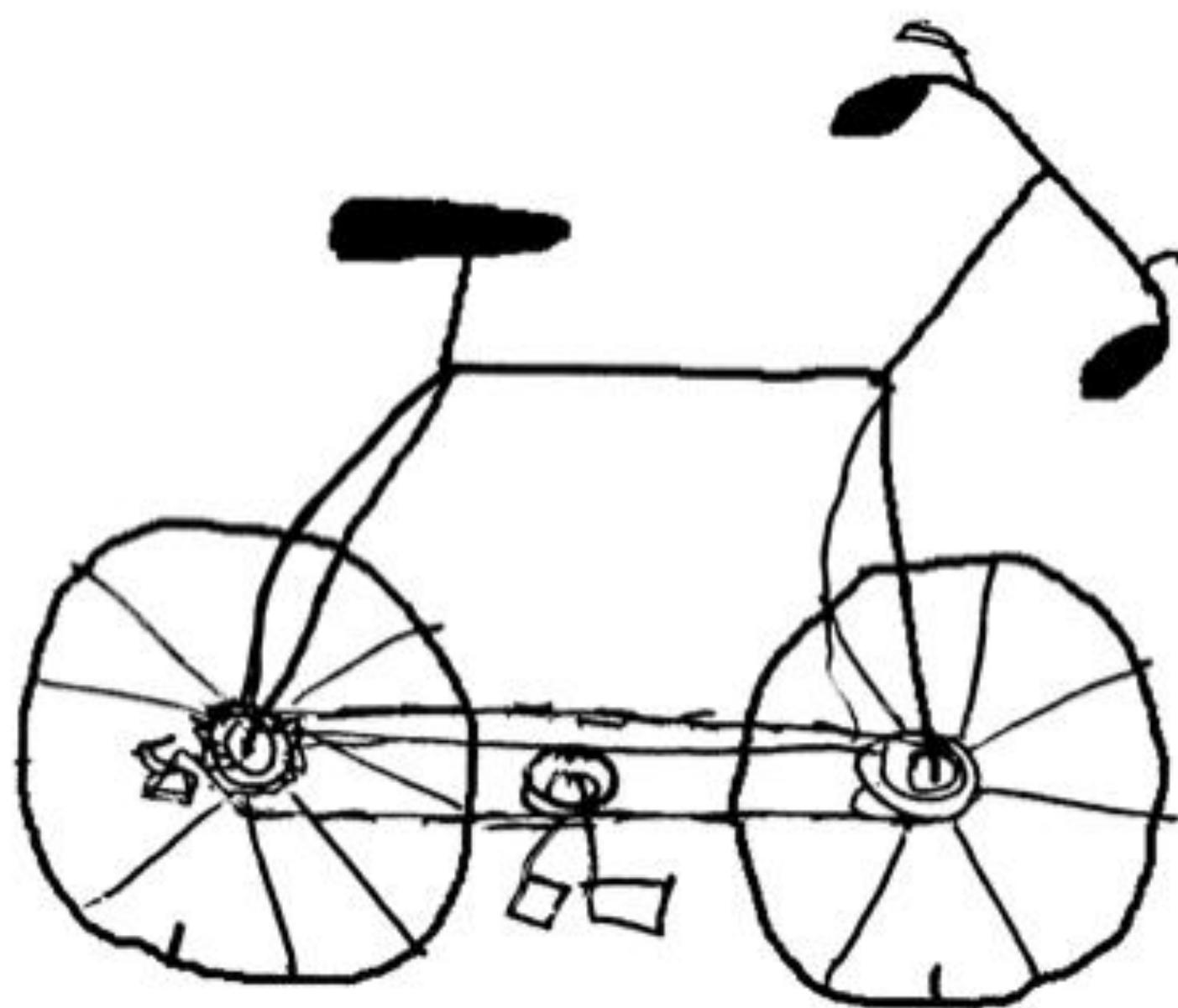
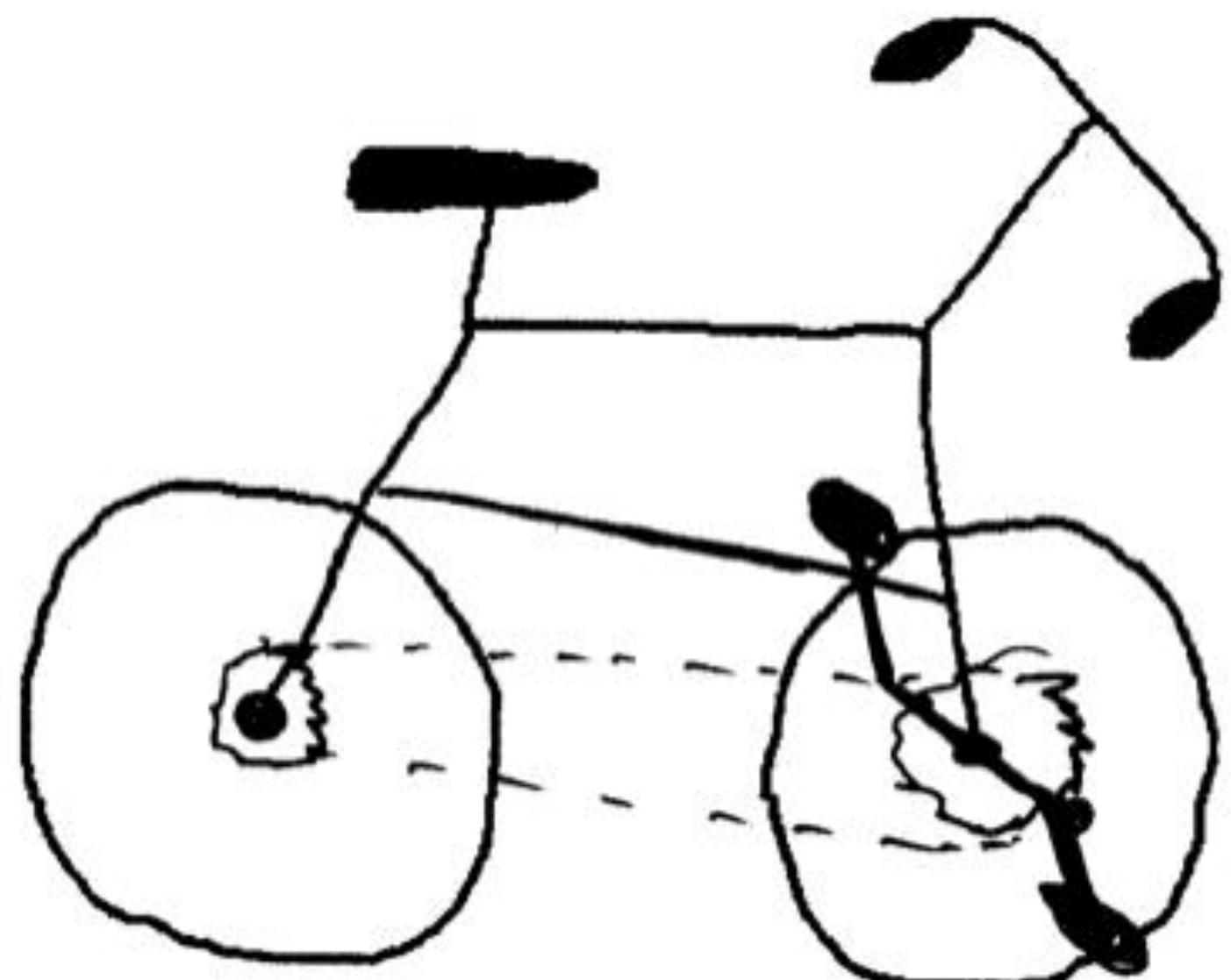
Pedals

Chain -----



[https://www.liverpool.ac.uk/~rlawson/PDF\\_Files/L-M&C-2006.pdf](https://www.liverpool.ac.uk/~rlawson/PDF_Files/L-M&C-2006.pdf)

<https://road.cc/content/blog/90885-science-cycology-can-you-draw-bicycle>



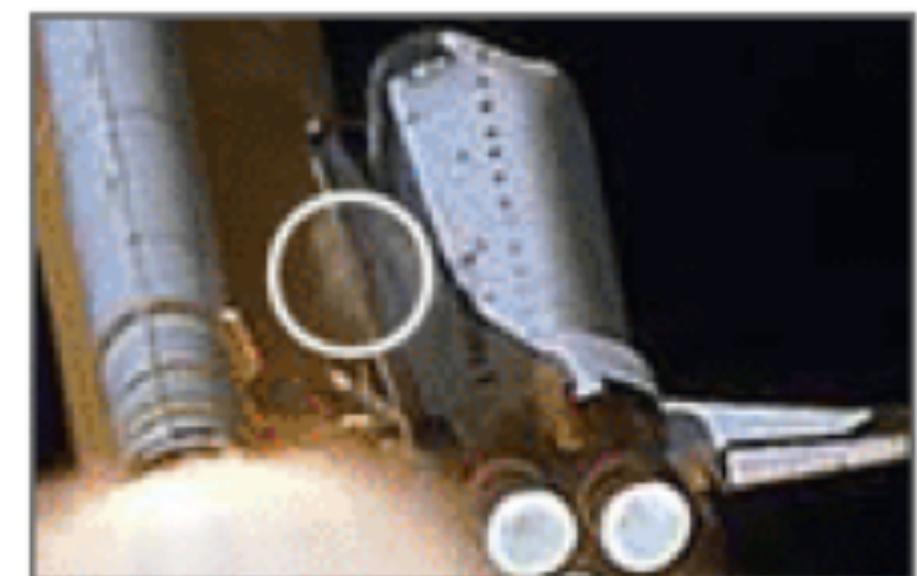
# Overconfidence bias

- The tendency for decision makers to overestimate their own abilities
- Two types here:
  - Overplacement
  - Illusion of explanatory depth
- From wikipedia: an incomplete list of events related or triggered by bias/overconfidence and a failing (safety) culture:
  - Chernobyl disaster
  - Sinking of the Titanic
  - Space Shuttle Challenger disaster
  - Space Shuttle Columbia disaster
  - Deepwater Horizon oil spill
  - Titan submersible implosion



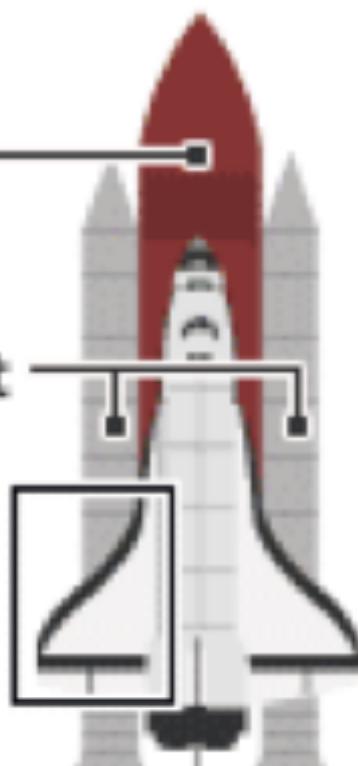
### 1. Launch: 16 Jan 2003

Foam from external tank strikes wing



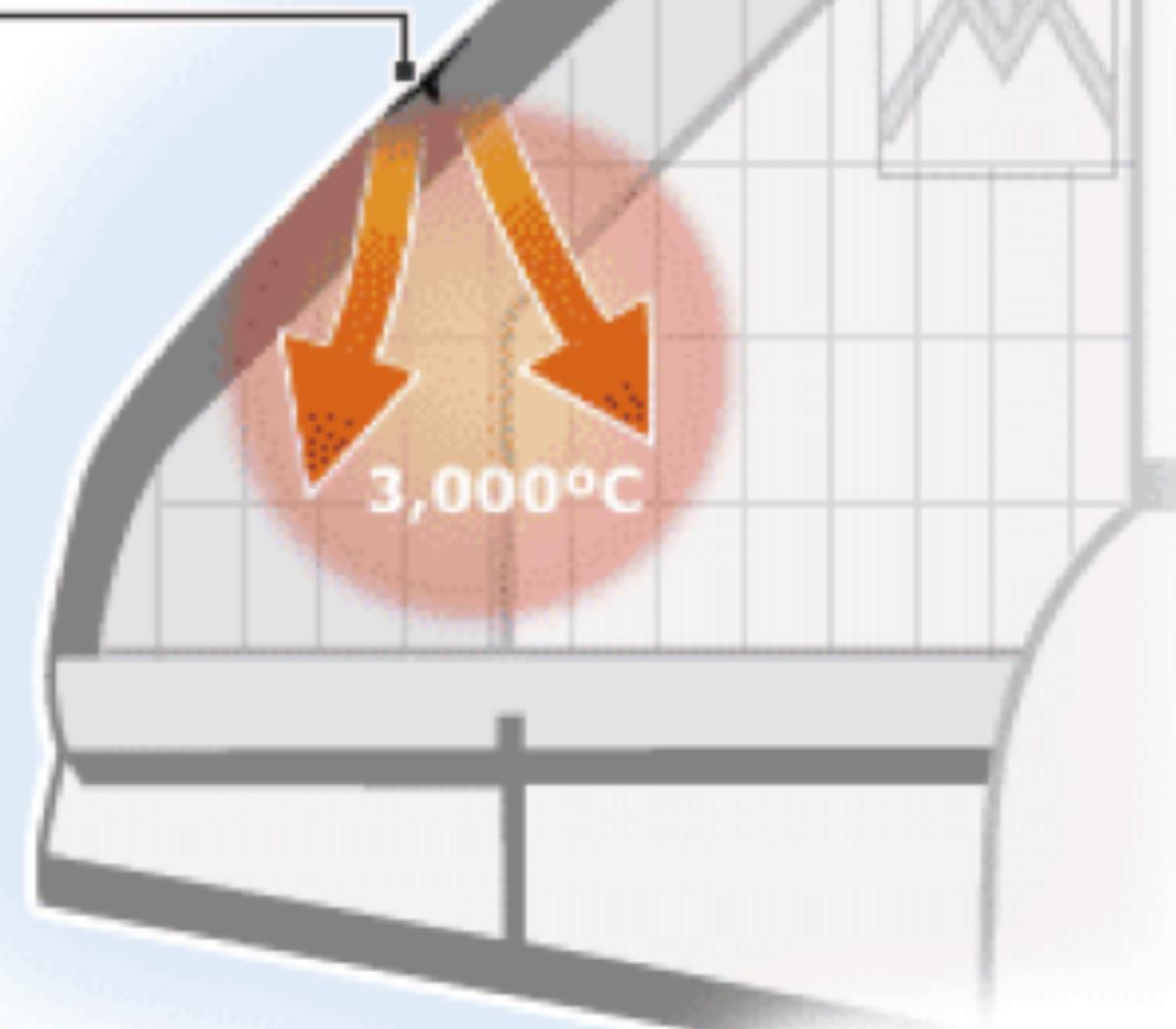
External  
fuel tank

Solid rocket  
boosters



### 2. Attempted re-entry: 1 February 2003

Crack in leading edge caused by impact allows superheated gas to penetrate. Wing interior melts and disintegrates



# A list of names for exercise 3

- Travis Kelce
- Olivia Rodrigo
- Blake Lively
- Rock Hudson
- Selena Gomez
- Kesha
- Taylor Swift
- Charles Barkley
- Cardi B
- Bruno Mars
- David Seaman
- Richard Grieco
- Sinbad
- Steve Winwood
- Megan Thee Stallion
- Barry White
- Steven Tyler
- Beyonce
- Millie Bobby Brown
- Lady Gaga
- Robert Duvall

# Exercise 3

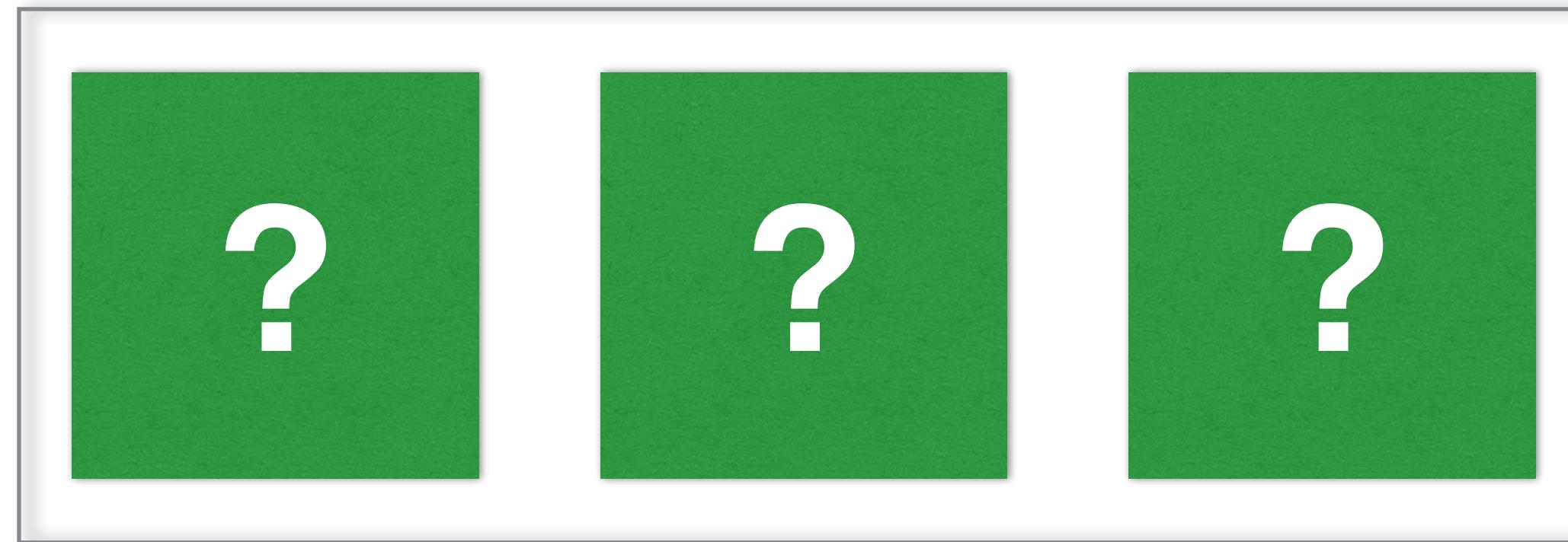
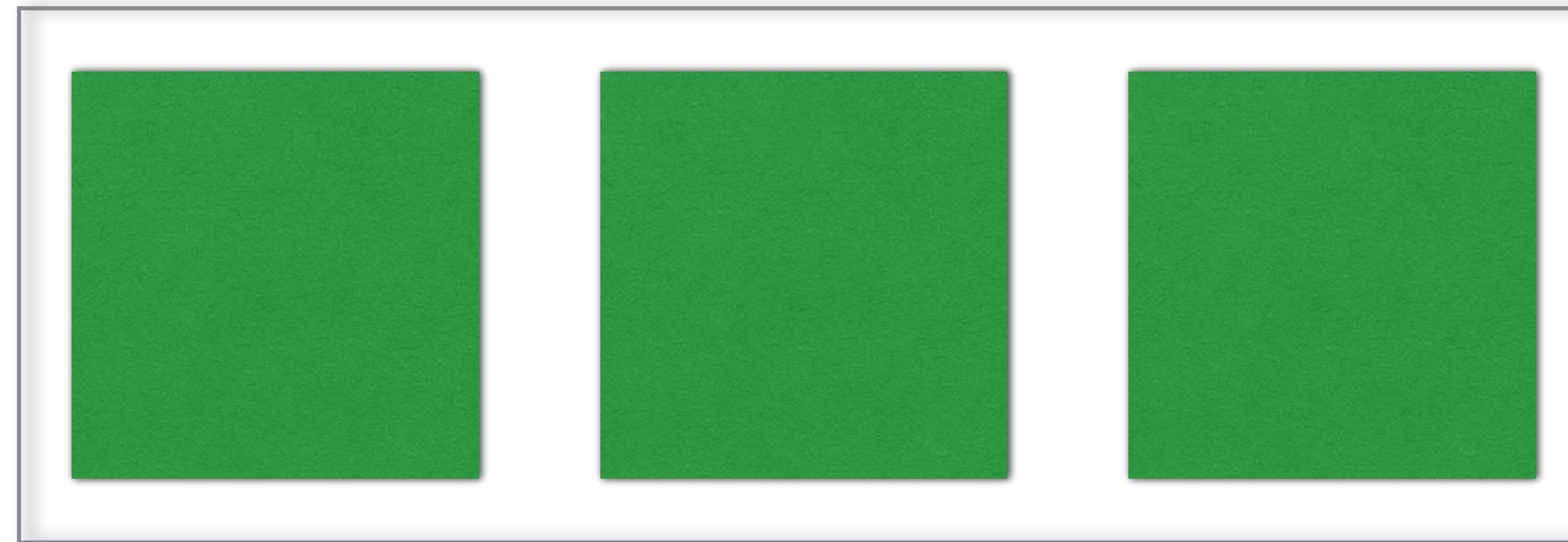


# Availability bias

- The tendency for decision makers to consider information that is easily retrievable from memory as being more likely, more relevant, and more important for a judgment.
- What we saw
  - Recent celebrity names are easier to recognize/remember
  - More generally: memory is weird and wonky!

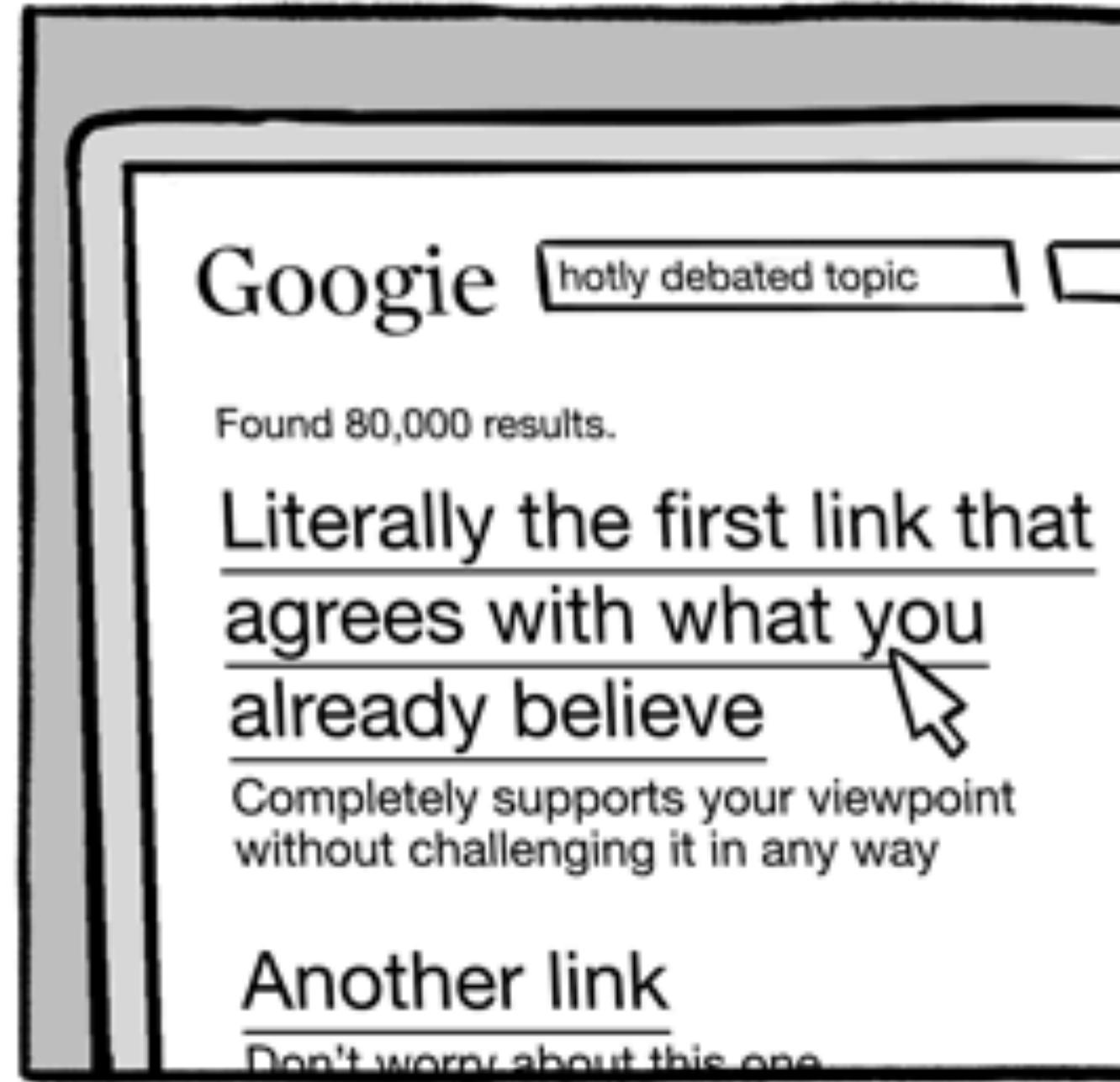
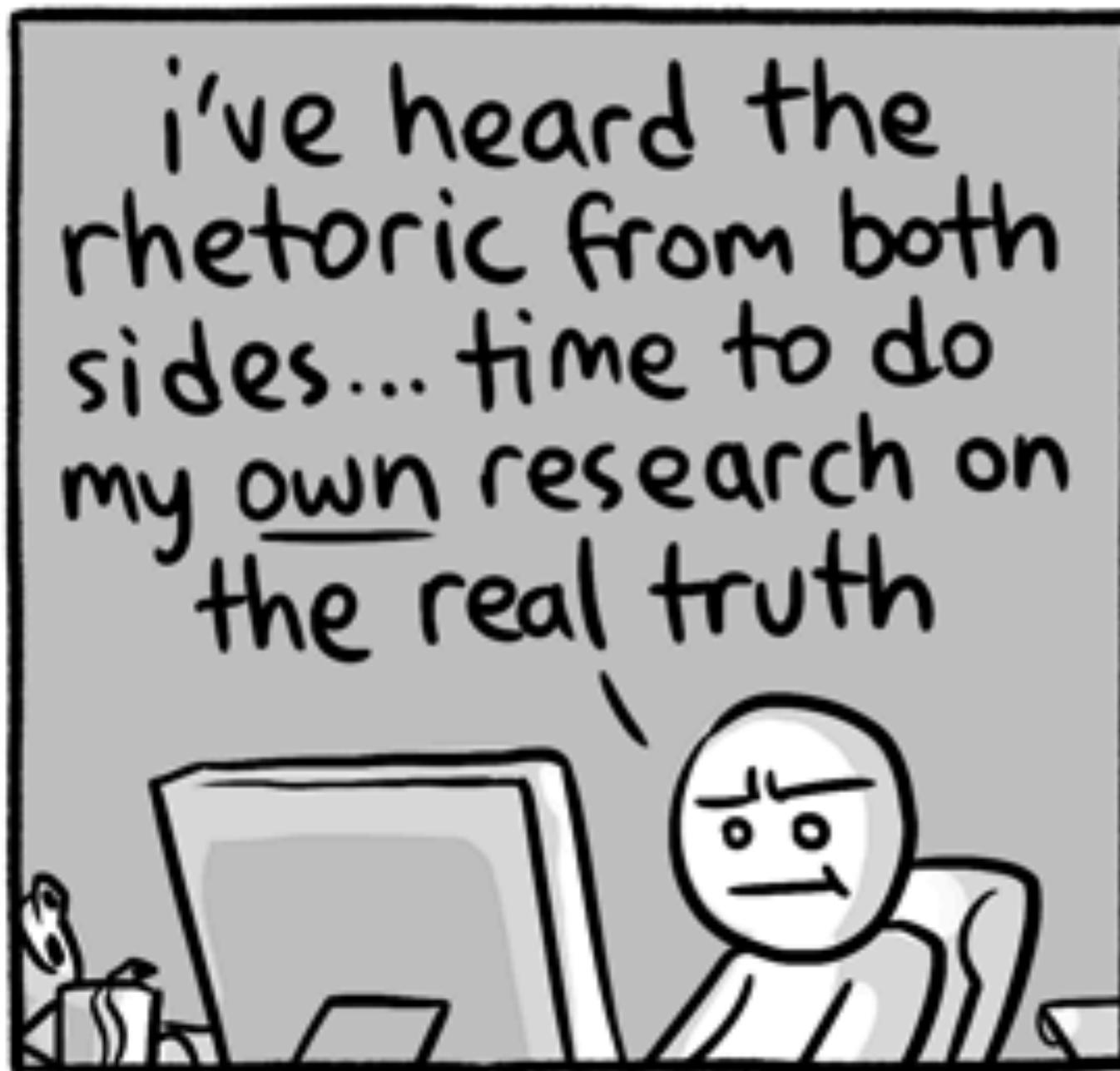
# Exercise 4

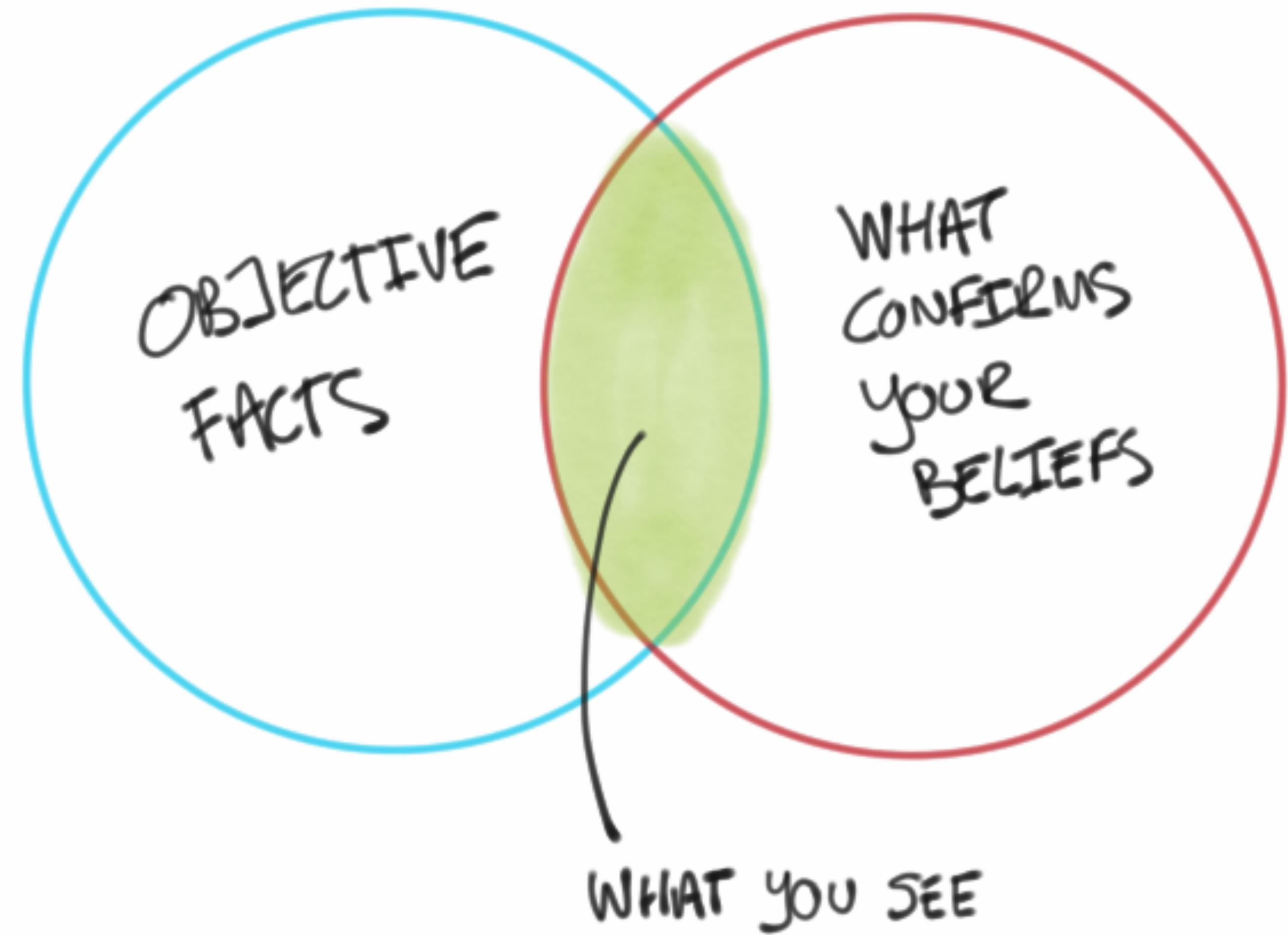
Figure out the rule



# Confirmation bias

CHAINSAWSUIT.COM





# Iran Air Flight 665 in 1988

## Confirmation bias contributes to a major disaster

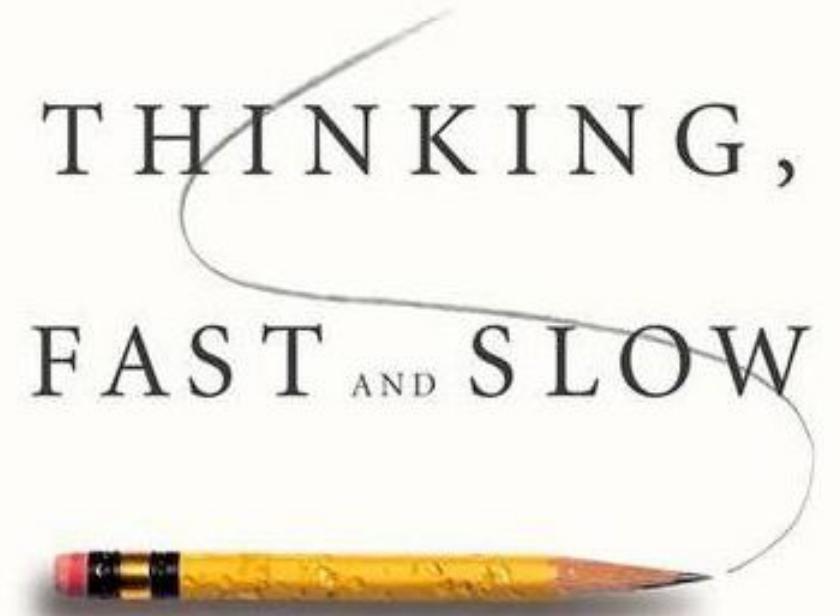
- Scheduled short hop commercial flight across the gulf
- Iran - Iraq war in active hostilities
- 1 year before Iranian airplane sunk USS Stark
- USS Vincennes had already engaged gunboats that day
- Radar saw airliner at takeoff. Thought it was an attack because a technical glitch briefly confused the ID of aircraft with that of an Iranian F-14
- Had 7 min from radar detection to launch of SAM, lots of time to figure it out, lots of evidence against it being an F-14
- 290 people killed

# Thinking Fast and Slow

## One origin of biases

- System 1
  - Fast, effortless, feels involuntary
- System 2
  - Slower, effort+attention, feels like agency
- Not real brain systems or regions!
- Evolutionary needs for both, biases and illusions are often adaptive
- Kahneman + Tversky

THE NEW YORK TIMES BESTSELLER



DANIEL  
KAHNEMAN

WINNER OF THE NOBEL PRIZE IN ECONOMICS

"[A] masterpiece . . . This is one of the greatest and most engaging collections of insights into the human mind I have read." —WILLIAM EASTERLY, *Financial Times*

# How can biases affect analysis?

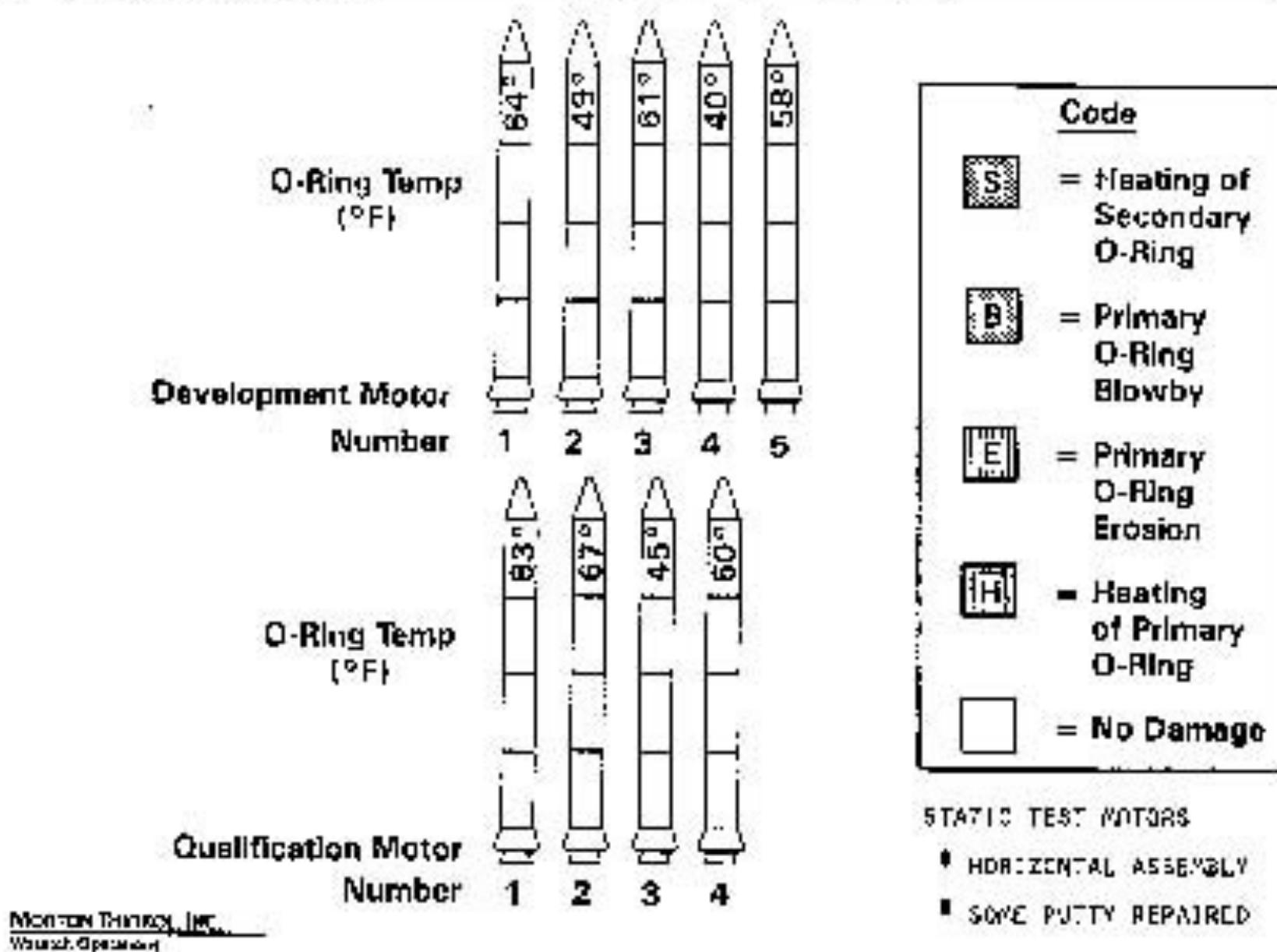
- Anchoring bias and Confirmation bias
  - False negatives: Reject a truth because its too far from expected
  - False positives: Accept a wrong result because it matched expected
- Illusion of explanatory depth
  - Confidently wrong, like ChatGPT is sometimes :)
- Availability bias
  - Decisions based on familiar results, novel (correct) ones matter less

# Fighting biases

- Instruction, feedback, and practice
  - Learn how to test your hypotheses
  - Develop the habit of questioning yourself and your ideas aggressively
- Justification of judgements, accountability
  - Procedures that force you into questioning the basis of the decision
  - Involving others if they are independent thinkers (beware groupthink!)

# **Errors of communication: Teamwork and comm failures**

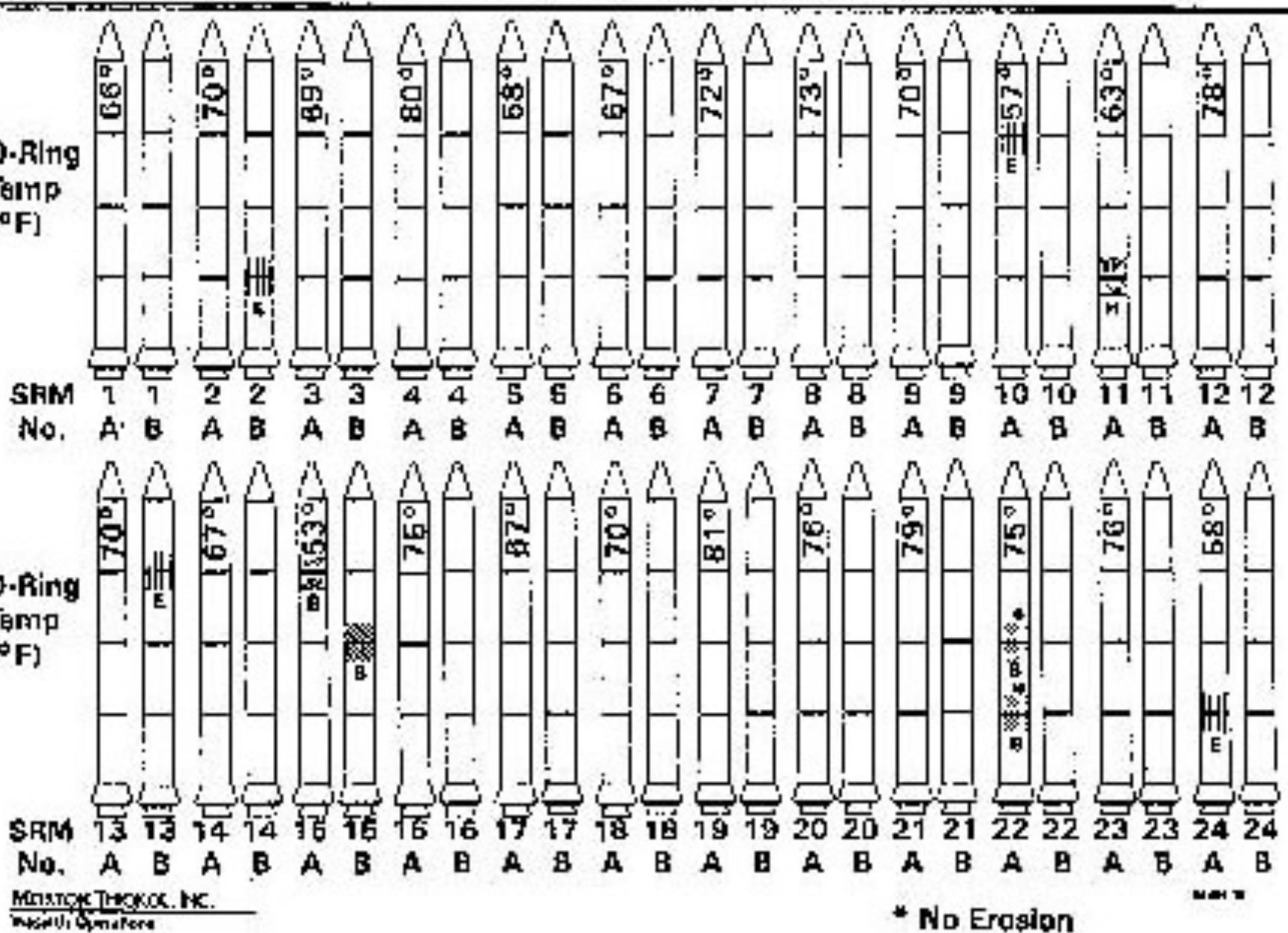
## History of O-Ring Damage in Field Joints



Morton Thiokol, Inc.  
Wichita, Kansas

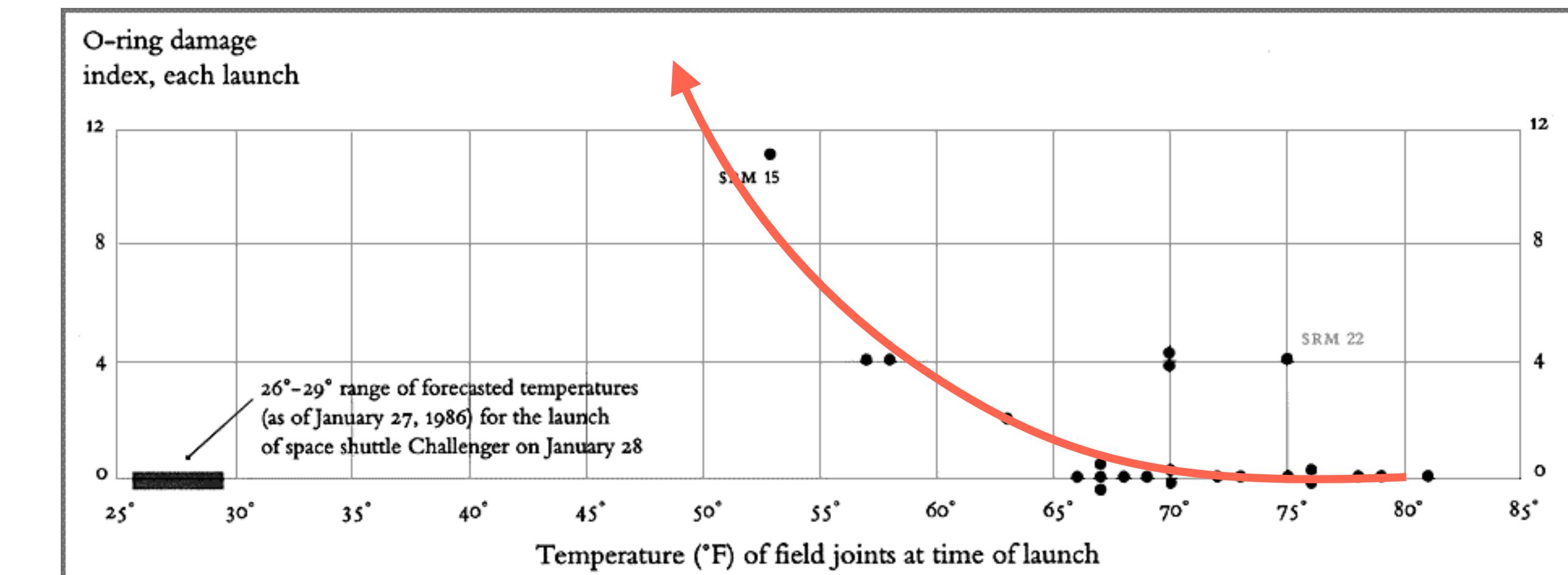
DISCUSSION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION  
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

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

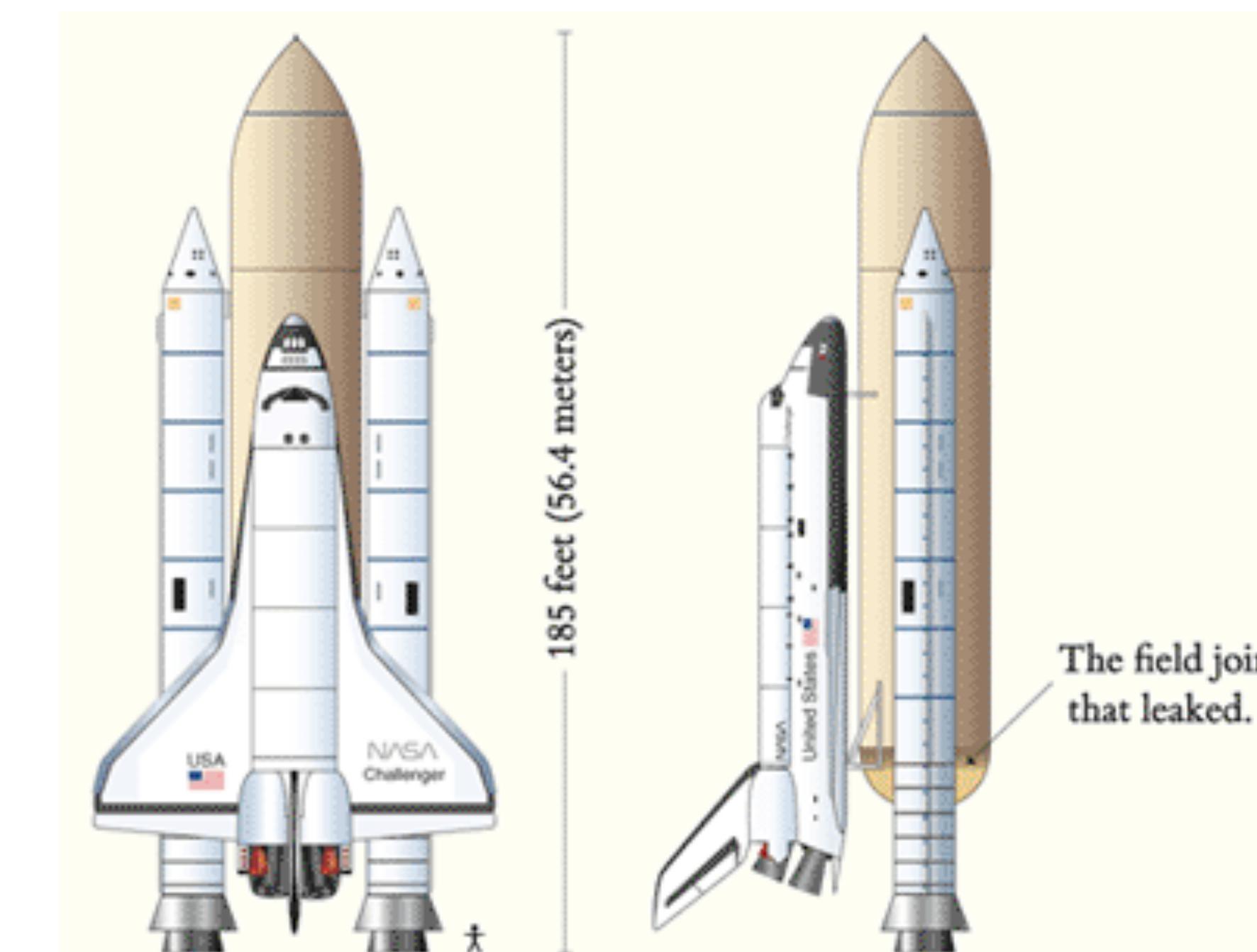


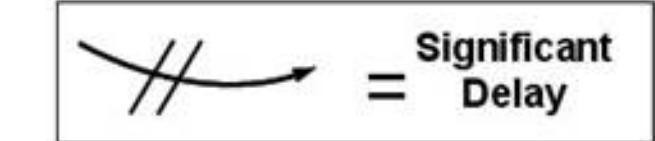
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Images and graphs from Edward Tufte





- Population/Popular Support
- Infrastructure, Economy, & Services
- Government
- Afghanistan Security Forces
- Insurgents
- Crime and Narcotics
- Coalition Forces & Actions
- Physical Environment

**POWERPOINT:**  
Just as bad as Excel  
but used by non-tech  
people too

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*

Edward Tufte

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.

# 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**

# **Broader questions**

**How can we be more right and less wrong?**

Being aware of our biases; external review and checks to minimize

Thinking about tools; know their strengths and limitations

Worry about process and rigorous methods more than outcomes

Social factors influence decision making; good comm and procedures  
are essential

Be a systems level thinker! Stay curious! Question yourself and your  
team as much as possible