

# Data Science is Impossible

Boston University CS 506 - Lance Galletti

**How credible does the tweed  
blazer make me look?**

**Blazer -> professor -> credible**

**Blazer + tshirt -> tech bro -> not credible**

**Credibility can be manufactured if you're not  
aware of the shortcuts your brain is making**

# What is knowledge?

In Data Science (and science in general) knowledge is testable predictions / anticipation of events / collection of falsifiable hypotheses.

demo

**If a theory is equally good at explaining  
every outcome, it has no knowledge**

**Learning is iterative and requires  
resistance**

Sorry that means you  
need to do some work

# How to learn / build knowledge

- I just learned X
- How does X fit in the set of hypotheses that I already have?
- Do any of them conflict with X in what we anticipate?
- Does X conflict with any of them in what we anticipate?
- Do I need to change my prior understanding to make room for X?

Knowledge grows iteratively. Accepting something new means refining or discarding something old.

**Willingness to refine without  
feeling personally threatened**

**Biggest problem: our brains are  
not neutral instruments...**

# Cognitive Biases

# Confirmation Bias

Tendency to favor information that supports what you already believe

# Confirmation Bias

In a class just like this one, imagine playing the following game...

# Confirmation Bias

I announce "(2, 4, 6) follows the rule".

Here are the examples submitted by one of the participants:

- (2, 4, 3) → NO
- (6, 8, 10) → YES
- (1, 3, 5) → YES

After which, they proceed to write down their hypothesized rule. Would you have wanted to try more examples?

<https://forms.gle/Q8Za6hbzqXaWPbPy9>

# Confirmation Bias

Positive Examples VS Negative Examples

assuming the hypothesis  $h$  is  $(x, x+2, x+4)$  which type of examples are the following:

- (2, 4, 3)
- (6, 8, 10)
- (1, 3, 5)

IN CLASS Q

# Confirmation Bias

Confirmation bias is a tendency to choose positive ones over negative ones

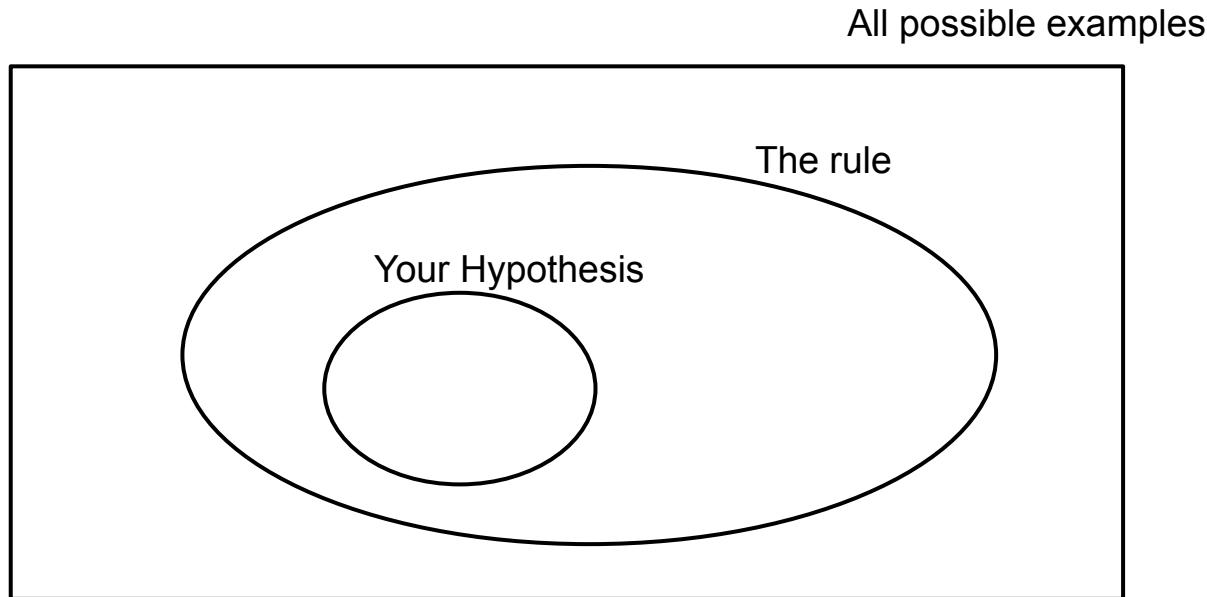
# Confirmation Bias

The rule was (  $a < b < c$  ).

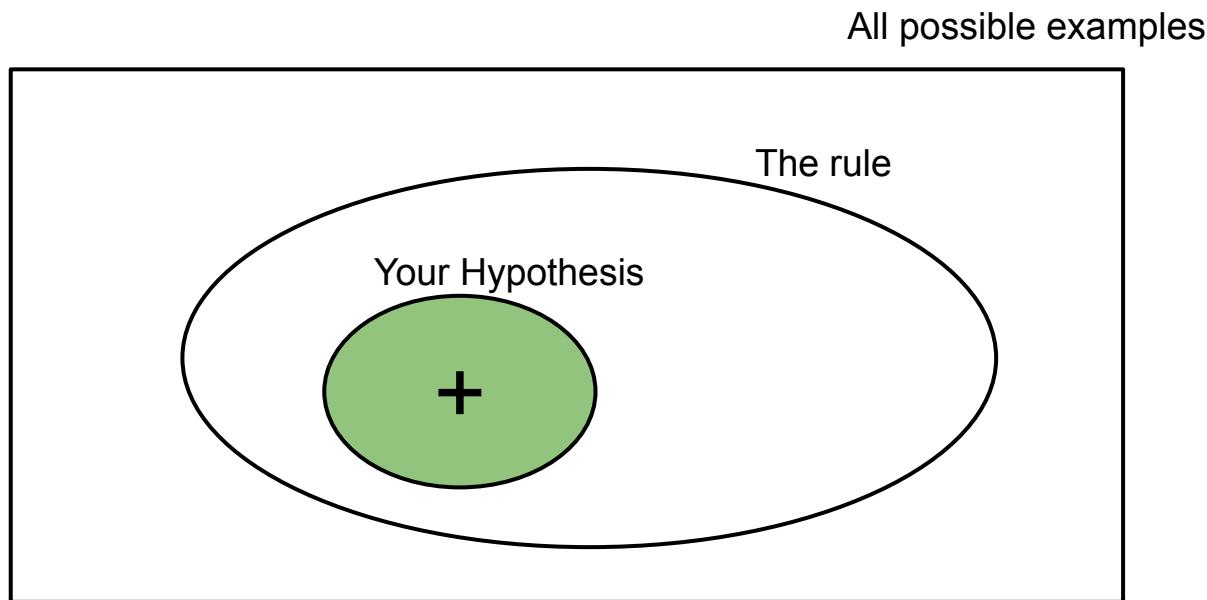
If you only tried positive examples of either  $(x, x + 2, x+4)$  or  $(x, 2x, 3x)$  you would only get confirmation.

For reference, this exercise was first introduced by Wason P.C in 1960 as part of a journal in experimental psychology.

# Confirmation Bias

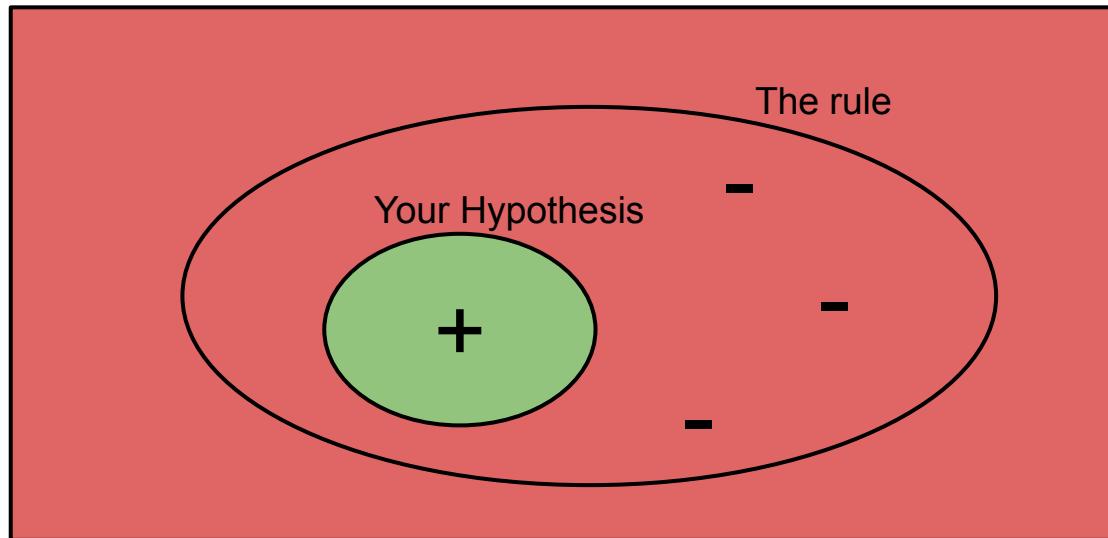


# Confirmation Bias



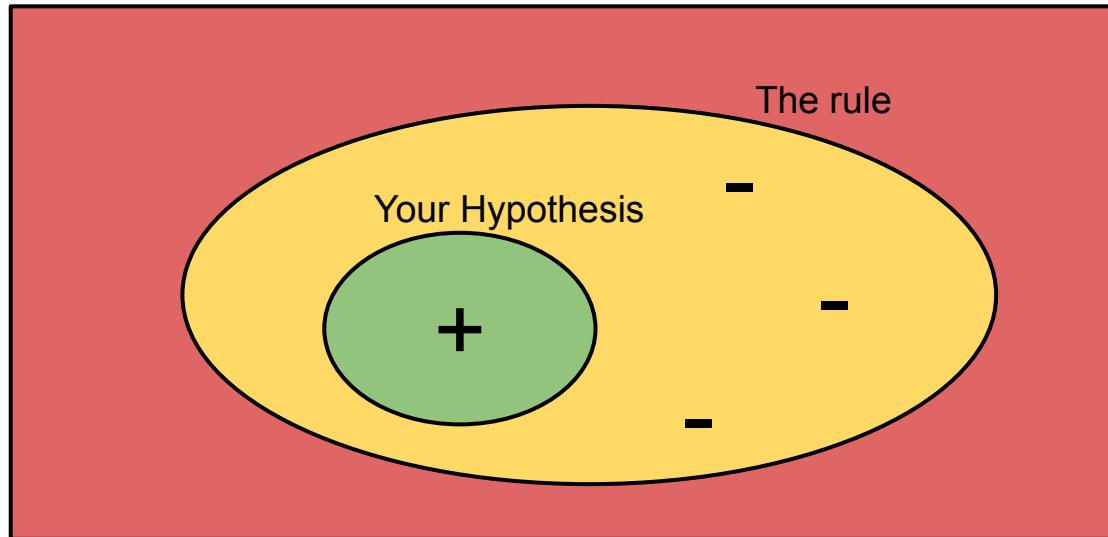
# Confirmation Bias

All possible examples



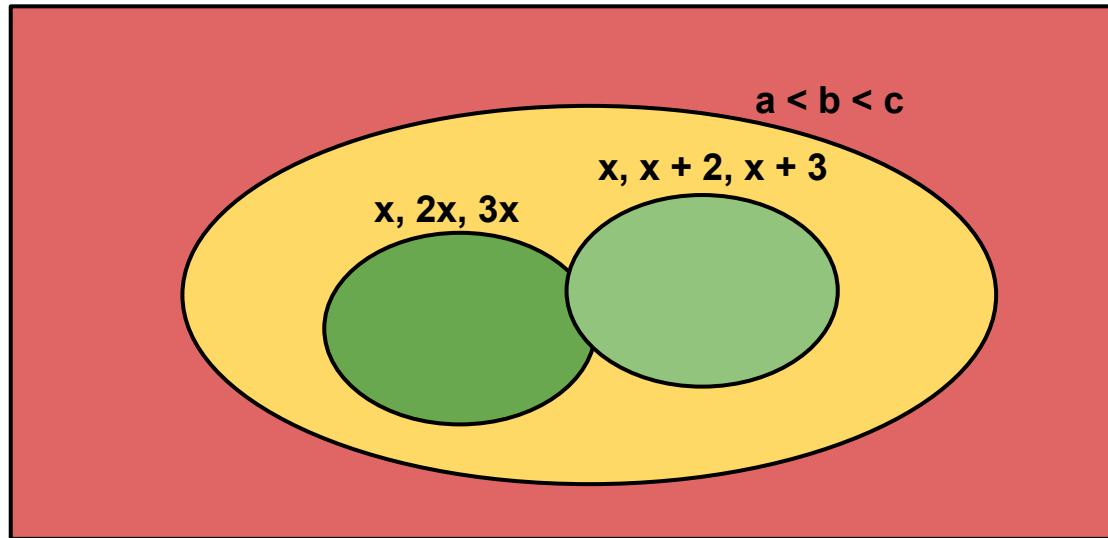
# Confirmation Bias

All possible examples



# Confirmation Bias

All possible examples



# Confirmation Bias

“Am I only noticing evidence that  
agrees with me?”

# Availability Bias

“Am I relying on vivid examples  
instead of real base rates?”

# Availability Bias

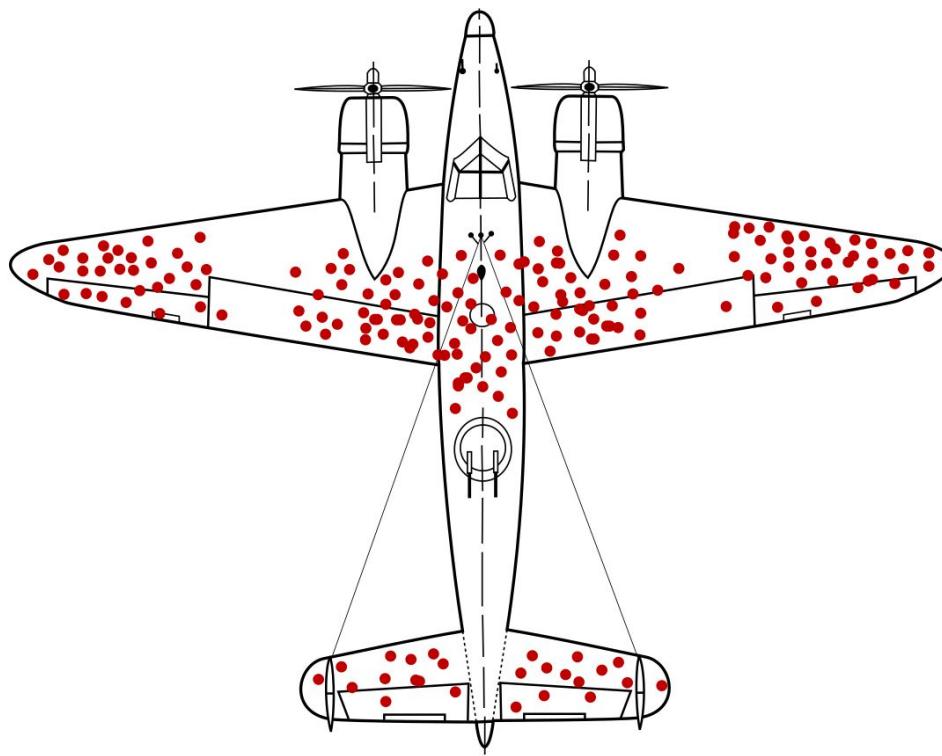
“Am I relying on vivid examples instead of real base rates?”

when systems (like social media) repeatedly show you the same kinds of examples, they start to feel representative even when they aren't.

# Anchoring Bias

“Am I being pulled by the first  
number or idea I saw?”

# Survivorship Bias



# Survivorship Bias

“What data might be missing?”

Trying to follow the insta training plan  
or meal plan

# Hindsight Bias

“Am I treating outcomes as inevitable after the fact?”

In spring 1997, snowmelt caused the Red River to rise.  
Official forecasts predicted a crest of ~49 feet.  
The city built flood defenses (dikes, sandbags) to that level.  
The river ultimately crested at **54 feet**—far beyond predictions.

“It was obvious the river would exceed forecasts.”

# Framing Bias

“Am I being swayed by wording or presentation?”

90% survival rate sounds different than 10% mortality rate



The Palantír doesn't create false beliefs; it amplifies the worst possible interpretation of true information at the moment he's least able to resist it.

You don't need false data to mislead someone... just selective data, repeated often enough, shown to a mind that's already leaning one way.

# Beyond cognitive biases: statistics literacy

# No context statistics

A test for a disease is 99% accurate. Is this a good test?

If the disease affects only 1% of people, a test that tells everyone they don't have the disease is 99% accurate... But that's not helpful / useful.

# Correlation vs Causation

- Pregnant people are more likely to have cavities
  - Could be hormonal changes or could be different eating habits. Doesn't tell the whole story and you shouldn't jump to conclusions.
- The more ice cream is sold, the more people drown
  - Both increase during the summer. One doesn't cause the other.
- Coffee drinkers have more heart attacks
  - This is from an old study from the 70s where coffee drinkers were more likely to smoke. If you remove the confounding effect of smoking, the effect of coffee on heart attacks vanishes.
- Go to bed with shoes on you'll most likely wake up with a headache
  - Both are related to a third variable: being drunk

# Has the world gone coco? Eating chocolate can help you LOSE weight

GOOD news slimmers! New research claims that eating chocolate can actually help you beat the bulge.

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By Laura Mitchell / Published 30th March 2015



CHOCOHOLIC: New research reveals that eating chocolate can actually help you lose weight [GETTY]

It's the diet that everyone has been waiting for.

A German study has found that eating chocolate can reduce your waistline, lower your cholesterol and help you sleep.

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## Dieting? Don't forget the chocolate

By Modern Healthcare | April 11, 2015

The Outliers team digests a lot food research in the course of a week, but a pair of recent studies that came over the electronic transom stood out for their quirks.



First, according to a study published in *JAMA Internal Medicine*, an apple a day doesn't necessarily keep the doctor away. That's according to proverb-busting research that found daily apple eaters had just as many doctor visits as those who ate fewer or no apples.

But, while apples won't necessarily make you healthier, researchers in Germany seem to have found the answer to a dieter's prayer: chocolate promotes weight loss.

A study out of the Institute of Diet and Health in Mainz found that adults on a strict low-carbohydrate diet who indulged in about 1½ ounces of dark chocolate daily lost 10% more weight than those in another group who were on the same diet minus the treat. The chocolate eaters also maintained their weight loss, while the other group packed the pounds back on.

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## Scientists say eating chocolate can help you lose weight

10.6K 34 1 Monday, March 30, 2015

Adding chocolate to a diet led to the "easiest and most successful weight loss", scientists said.



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## Excellent News: Chocolate Can Help You Lose Weight!

ANI

Posted: 31/03/2015 16:21 IST | Updated: 31/03/2015 16:21 IST



A new research has revealed that chocolate can aid weight loss when combined with a low-carb diet.

Johannes Bohannon, research director of the nonprofit Institute of Diet and Health, said that what is important is the specific combination of foods in your diet when trying to shed those extra pounds, the Daily Express reported.

Bohannon added that just lowering the proportion of carbohydrates is not a reliable

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## Pass the Easter Egg! New study reveals that eating chocolate doesn't affect your Body Mass Index ... and can even help you LOSE weight!

- New research from Roy Morgan reveals there's no proof that chocolate consumption affects BMI
- Currently two thirds of Australians eat chocolate at least once a month
- A study from German researchers has also found there's a connection between cocoa diets and increased weight loss
- Chocolate also found to benefit brain, heart and stress levels

By SAM BAILEY FOR DAILY MAIL AUSTRALIA

PUBLISHED: 01:22 EST, 31 March 2015 | UPDATED: 16:14 EST, 31 March 2015



From the endless chocolate blocks passed around the office, to the glaring supermarket aisles and the family relatives who miraculously appear with baskets of eggs, Easter can be a minefield to navigate if you're trying to watch your waistline.

But according to new research, there's no need to go easy on the eggs this week, with a Roy Morgan study revealing there is no direct connection between chocolate consumption and an increasing Body Mass Index (BMI).

This should come as sweet relief for chocoholics when according to Roy Morgan, two thirds of Australians admit to munching on chocolate at least once a month.

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Eggsellent news: A chocolate a day is found to not affect your Body Mass Index



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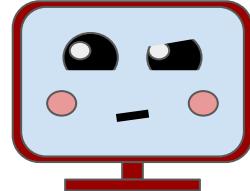
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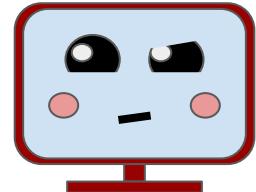


# The Study

5 men and 11 women (16 total in the study)

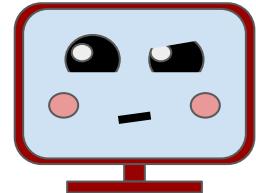
- One group followed a low-carbohydrate diet
- Another followed the same low-carb diet plus a daily 1.5 oz. bar of dark chocolate
- The rest, a control group, were instructed to make no changes to their current diet

They measured 18 different things over 21 days including blood pressure, sodium, sleep quality, wellness, and weight.



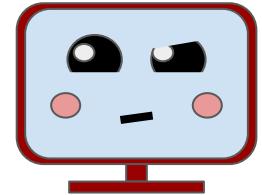
# The Result

Those in the chocolate group lost weight 10% faster than the diet group. Both diet groups lost more weight than the control group.



# Why it's not real

The experiment is set up to find a pattern.



# Simpson's Paradox

	applied	accepted	rate	applied	accepted	rate
TOTAL	1184	274	23%	2470	584	24%

# Simpson's Paradox

	applied	accepted	rate	applied	accepted	rate
Computer science	26	7	27%	228	58	25%
Economics	240	63	26%	512	112	22%
Engineering	164	52	32%	972	252	26%
Medicine	416	99	24%	578	140	24%
Veterinary Med	338	53	16%	180	22	12%
TOTAL	1184	274	23%	2470	584	24%

# Data Science is Impossible

- You'll never know for sure if you're right. You can only gather evidence.
- The observer (you) affects things too (bias)