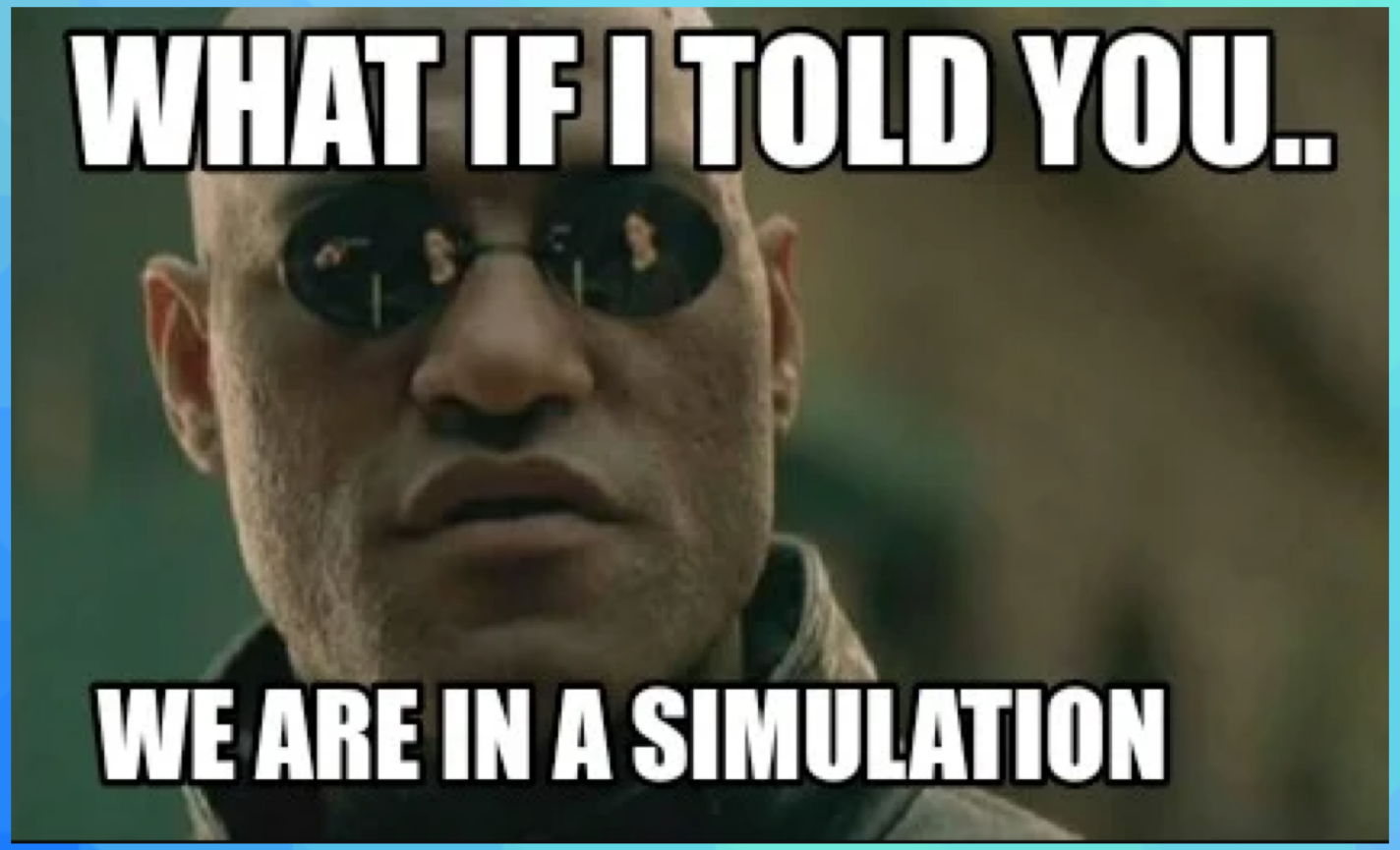
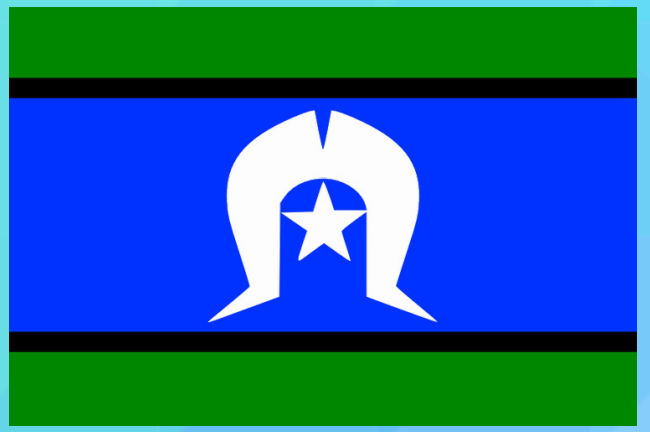
Simulations for power analysis

CodeR-TSV Presentation – 11am July 18th, 2022

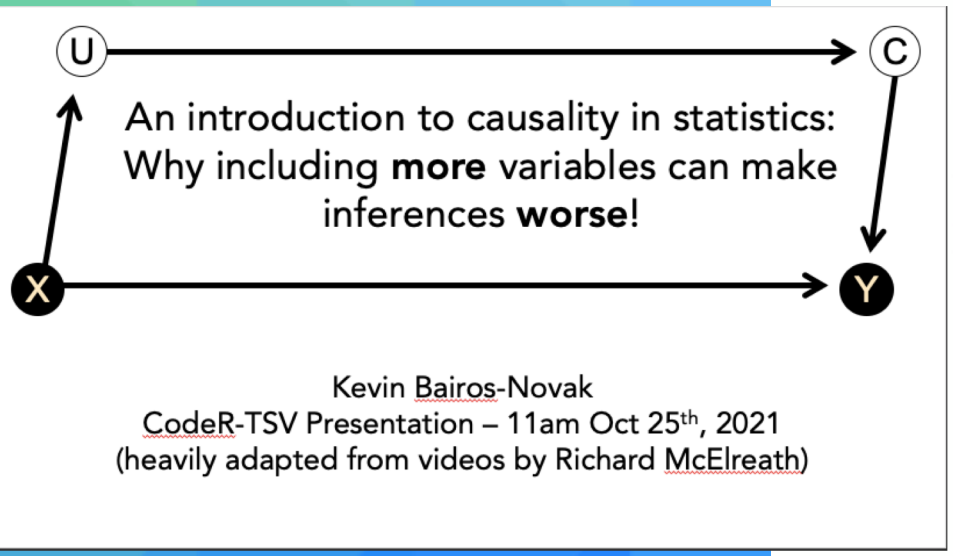


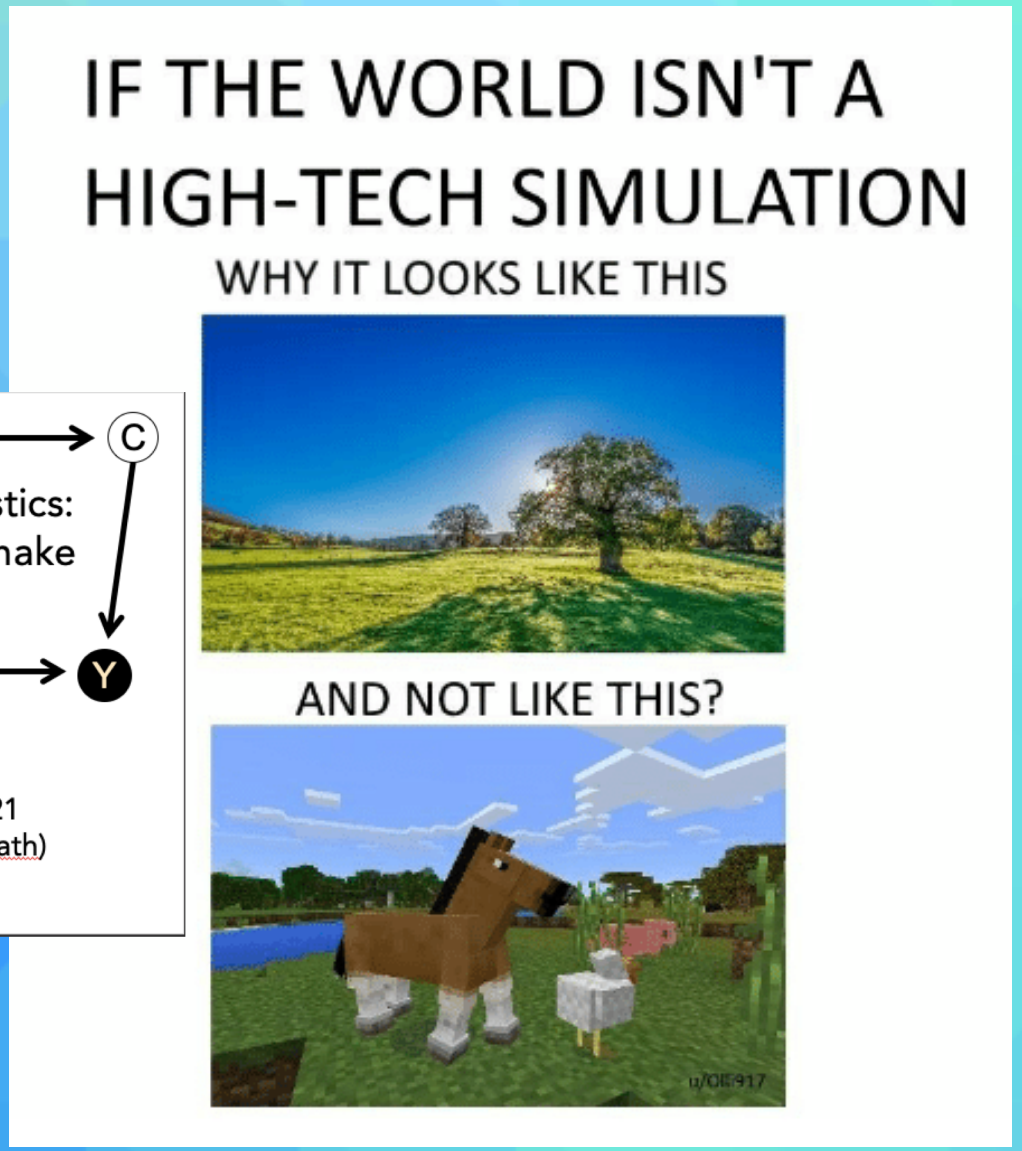
Acknowledgement of Country

Wulgurukaba and Bindal Peoples:
The first scientists of the land in which we work



Why simulations?





Why simulations?

Good for (open) science!

Force us to think about:

- ✓ **Variables** (X and Y) that we must measure
- ✓ Potential **confounds** and causality in the system
- ✓ **Statistical models** that we will use for final analysis
- ✓ Potential **effect sizes**

Invaluable as tools for statistical power analysis

- ✓ Convince funders/reviewers/yourself that you will be able to do what you say you will!

How simulations?

Step 1: Figure out what you're measuring, potential confounds

- Use means ± S.D. from literature for similar species/studies
- What other variables may be important to measure?

Step 2: Figure out potential effect sizes, such as:

- What is the **biologically significant** effect size?
- What is the **smallest detectable** effect size?

Step 3: Design a random, simple, and single simulation and test

- E.g. use R's `rnorm(n = 30, mu = 10, sigma = 2)`

Step 4: Replicate simulation many times with different n

- Use R's `replicate(1000, { simulation here })`

Let’s give it a go!

Simulate the potential results of a clinical trial for a new treatment drug (‘treatment’) vs. placebo (‘control’) on the rate of skin cancer growth

Step 1-2

Clinical trials for a new treatment drug ('treatment') vs. placebo ('control') on the rate of cancer growth


Study

FREE

December 2006

Rate of Growth in Melanomas

Characteristics and Associations of Rapidly Growing Melanomas

Wendy Liu, MBChB, PhD; John P. Dowling, MBBS; William K. Murray, MBBS; et al

» Author Affiliations | Article Information

Arch Dermatol. 2006;142(12):1551-1558. doi:10.1001/archderm.142.12.1551

Editorial Comment

Step 1: Figure out what you're measuring

- Skin cancer grows at ~0.12 mm/month (±0.25 SD)

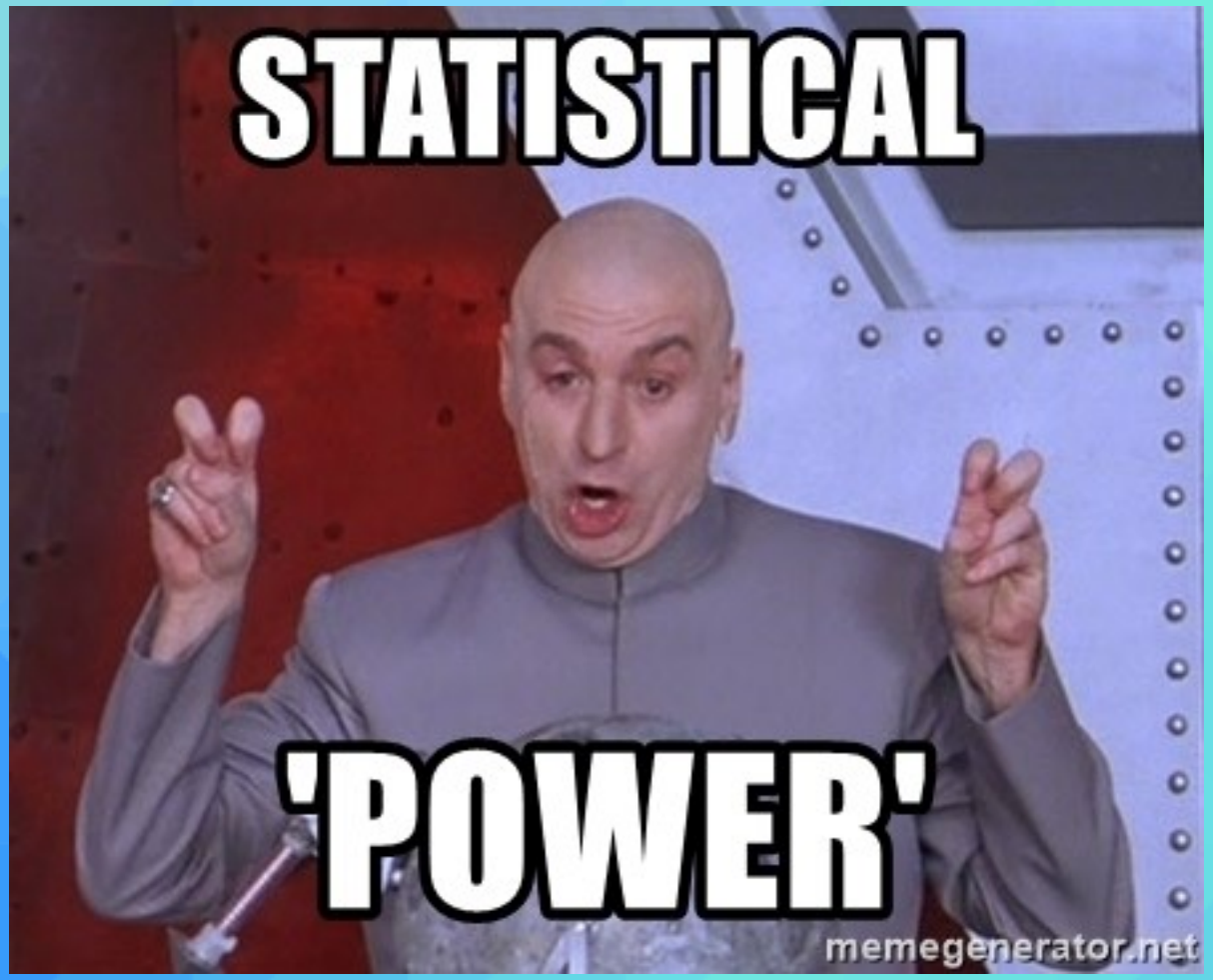
Step 2: Potential effect sizes

- **Biologically significant effect size**: -0.01 mm/month
  i.e. effect size where tumor starts to decrease in size
- **Smallest detectable effect size**: 0.11 mm/month
  since our instruments have an exactitude of 0.01 mm!

Step 3-4: Inside the simulation

Use example R script…

Step 5: Power analysis



Step 5: Power analysis

Step 5: Power analysis aims to identify what sample size *N* attains high statistical power (≥ 80%)

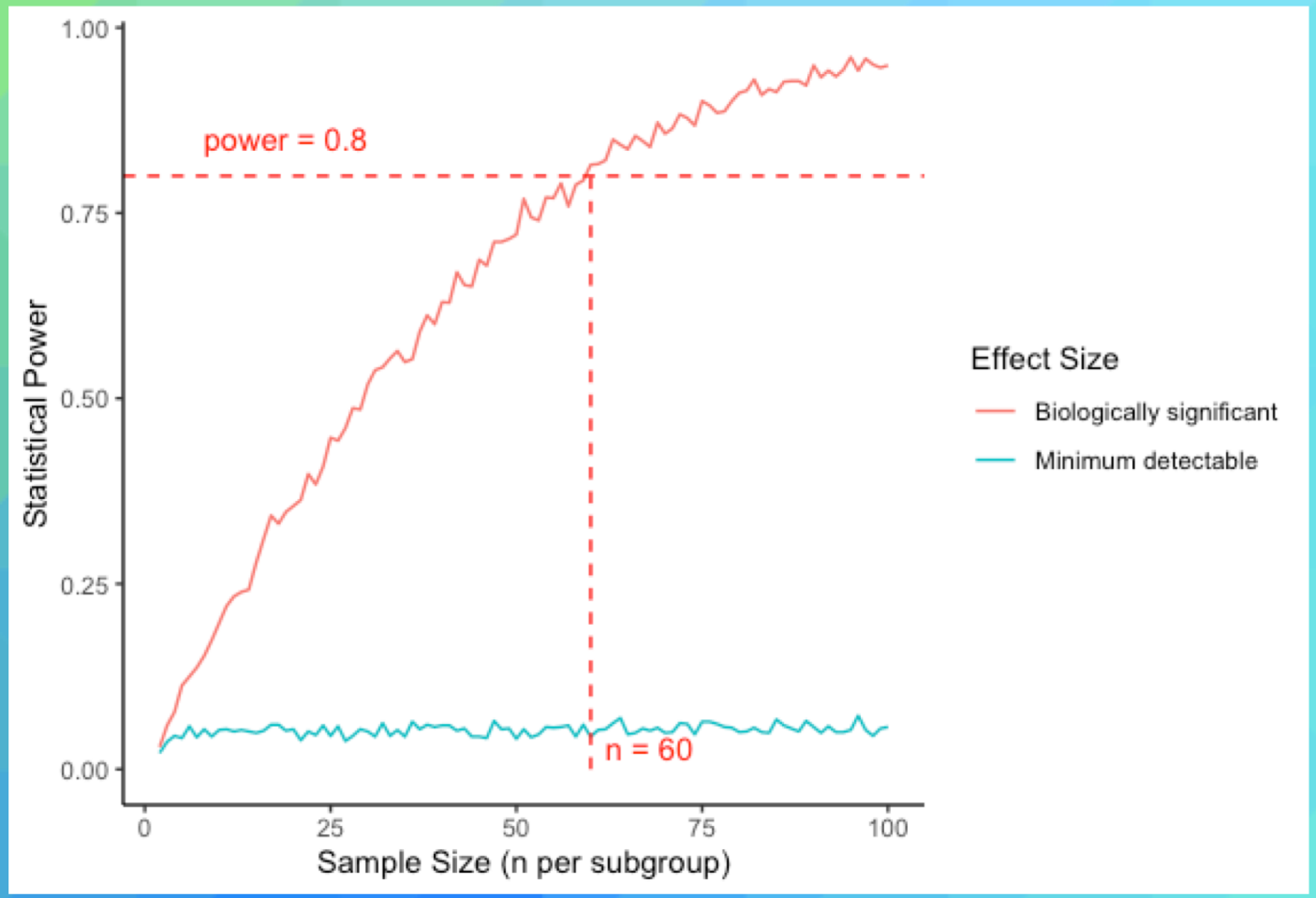
- Power = proportion of simulations with a significant test result
- Use a for-loop to iterate through different values of *N*

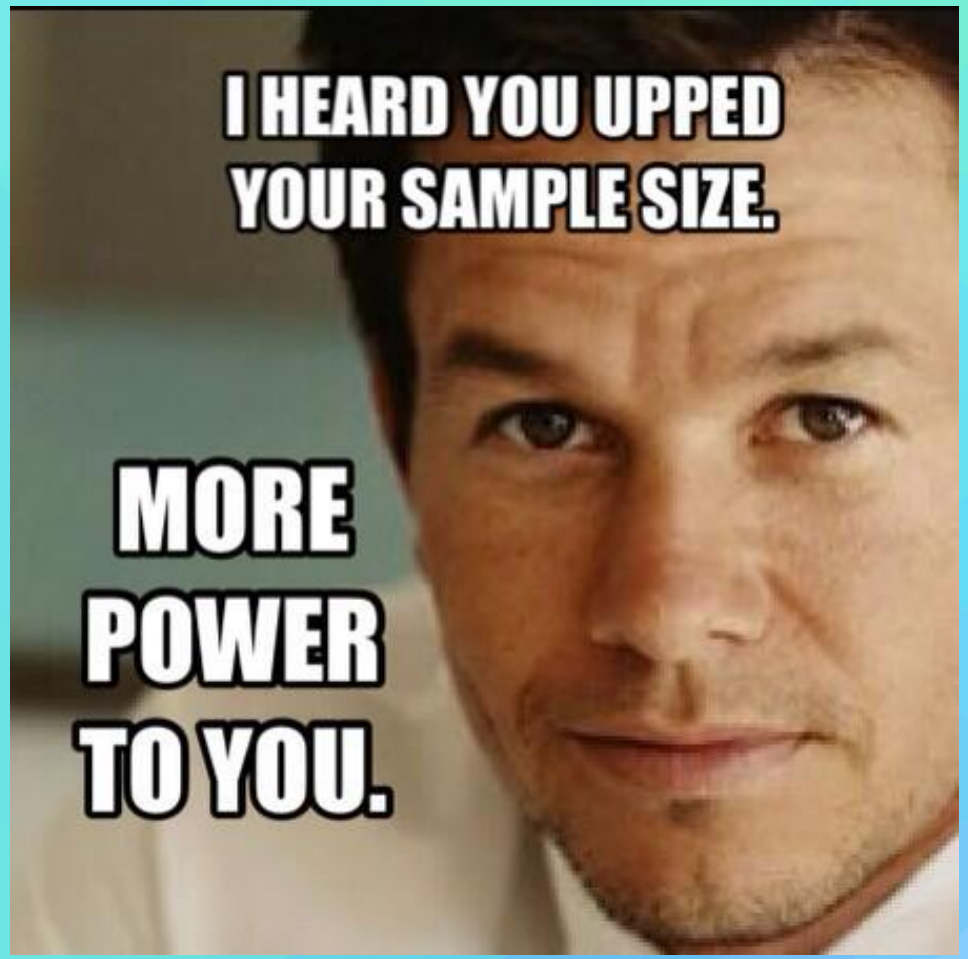
Skin cancer example:

- What sample size is required to adequately detect the **biologically significant effect size** of -0.01 mm/month?
- What sample size is required to adequately detect the **smallest detectable effect size** of 0.11 mm/month?

Back to script…

Power analysis results





Useful randomizers

Step 3 requires us to re-create how we assume the data are generated – from an assumed statistical distribution:

Distribution (data type)	**Range**	**R randomizer**
Normal (continuous)	-∞ to +∞	`rnorm(n, mean, sd)`
Gamma (continuous)	0 to +∞	rgamma(n, shape, rate)
Poisson (counts)	0 to +∞	rpois(n, lambda)
Binomial (binary data)	0 or 1	rbinom(n, size, prob)
Beta (proportions)	0 to 1	rbeta(n, shape1, shape2)

Choosing the right distribution can take some practice!

Conclusion

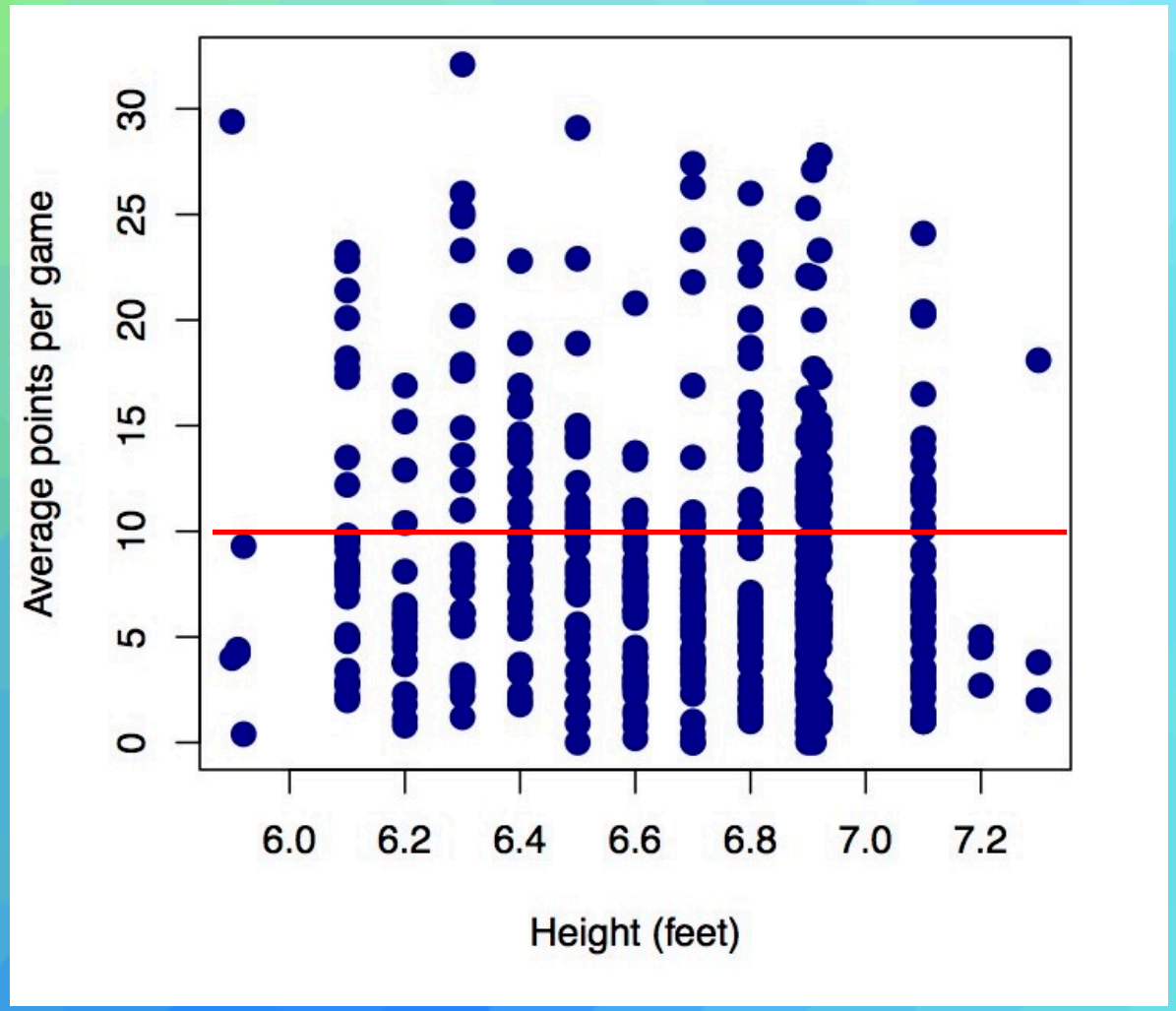
Simulations are extremely useful for power analysis, but can only be constructed on a case-by-case basis

Simulations force us to think of all aspects of our experimental design and statistical analysis *ex ante* (before our experiment begins)

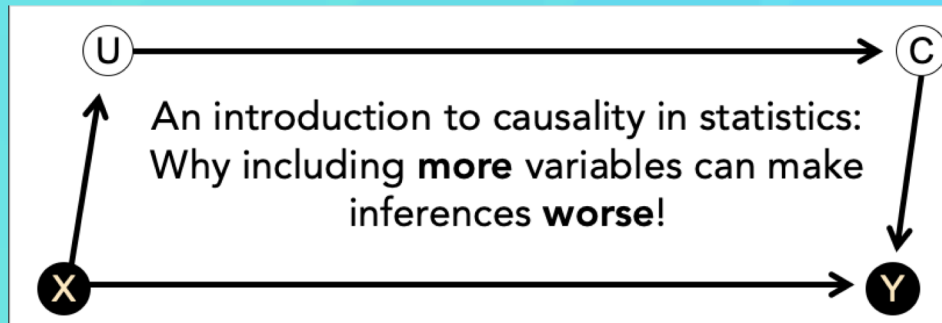
If nothing else, convinces us our experiment will tell us something if there is an effect in earnest!

Can also be used to assess the impact of potential confounds on your study (see previous presentation's code https://github.com/ecolology/causality-presentation)

Does basketball player height affect scoring?



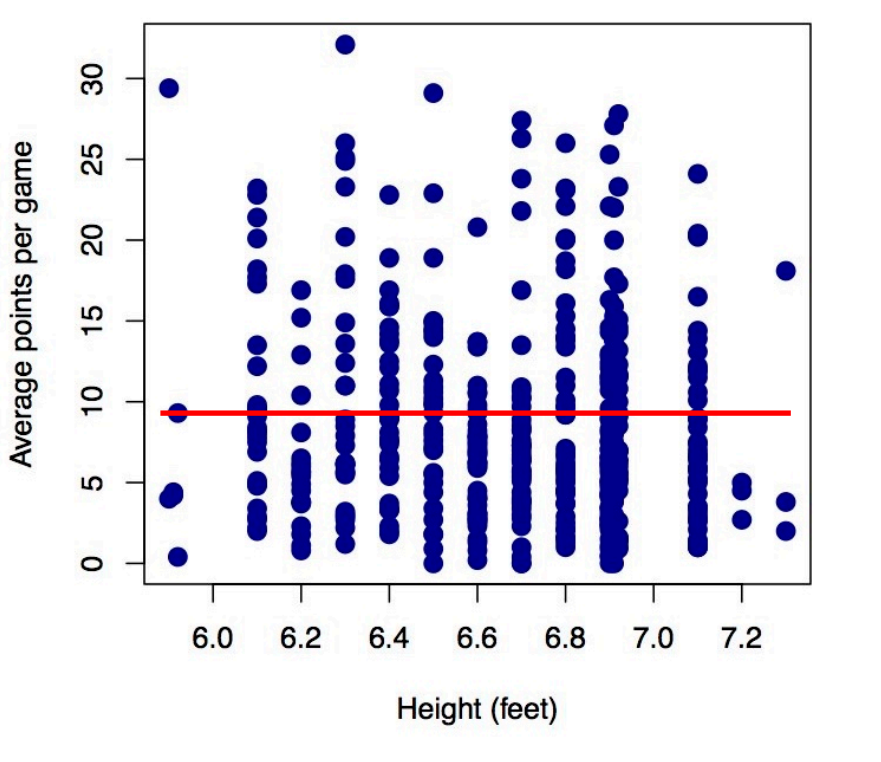
No relationship between height and scoring ability!



An introduction to causality in statistics: Why including **more** variables can make inferences **worse**!

Kevin Bairos-Novak
CodeR-TSV Presentation – 11am Oct 25th, 2021
(heavily adapted from videos by Richard McElreath)

Does basketball player height affect scoring?

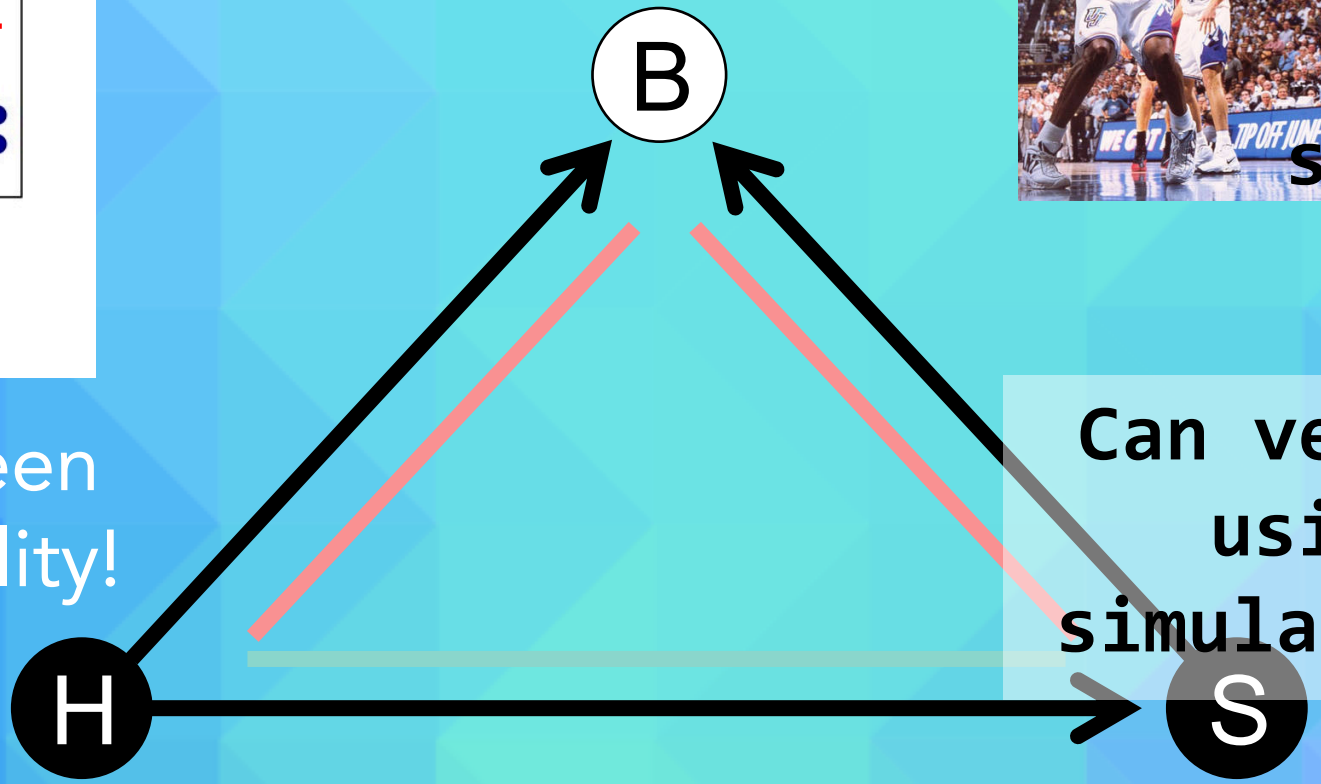


No relationship between height and scoring ability!

The Collider

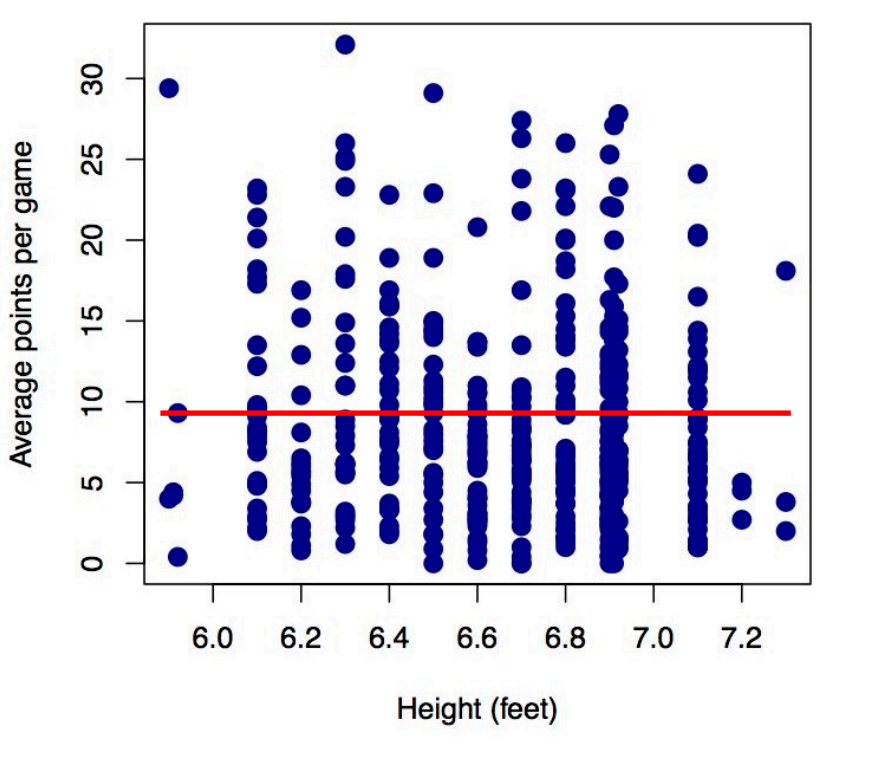
X → Z ← Y

Closed until you condition on Z



Can verify using simulations!

Does basketball player height affect scoring?



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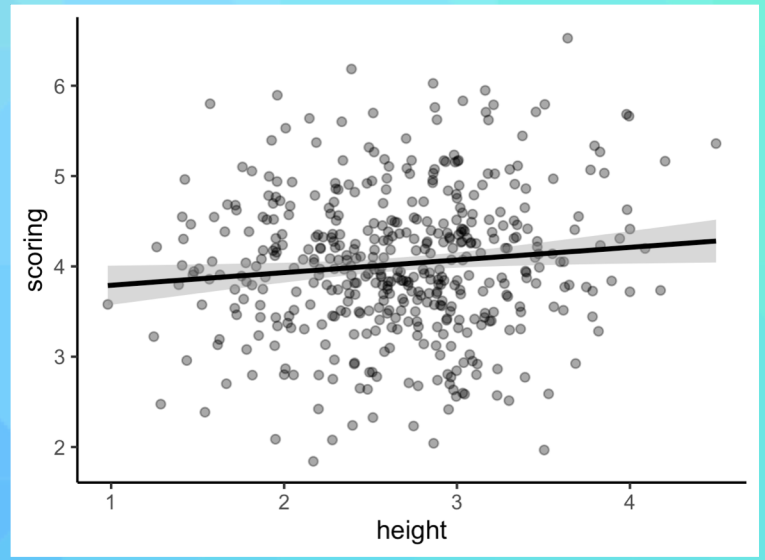

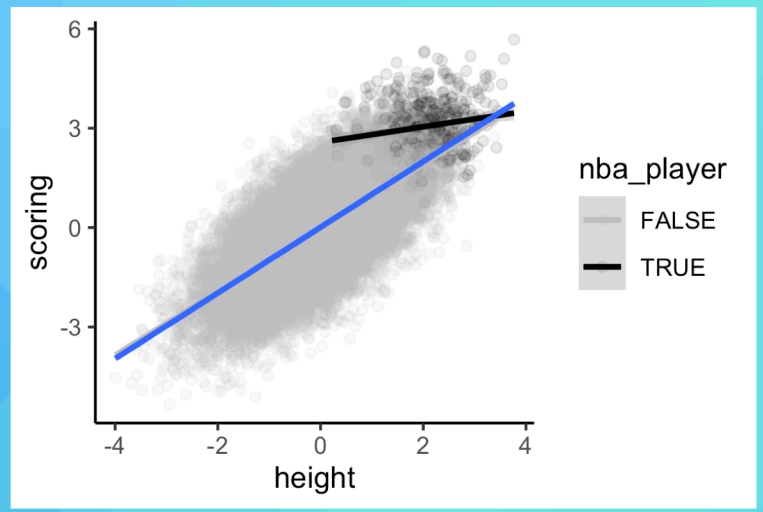

Not quite no relationship, but effect is much less pronounced

Can verify using simulations!

You now understand, Neo.

Other useful resources

- Malika Ihle's awesome workshop on simulations https://malikaihle.github.io/Introduction-Simulations-in-R/
- Hadley Wickham's short simulation presentation: https://www.yumpu.com/en/document/read/19077330/simulation-hadley-wickham
- My causality talk + code: https://github.com/ecolology/causality-presentation
- Richard McElreath's talk on causal modelling with simulations: https://www.youtube.com/watch?v=KNPYUVmY3NM