Introduction to experimental design

Session 1

MATH 80667A: Experimental Design and Statistical Methods
HEC Montréal

Outline

Class details

Motivation

Review

Key concepts in experimental designs

Class details

Course content

Content

- Basics of experimental design
- Statistical inference
- Completely randomized designs
- Analysis of variance
- Blocked designs
- Analysis of covariance
- Intro to mixed models
- Intro to causal inference
- Linear mediation analysis

Cross-disciplinary skills

- Scientific workflow
- Peer-review
- Reporting
- Statistical fallacies
- Reproducibility

Prerequisites

Math skills

Basic algebra

Computer science

None

Statistics

At the level of OpenIntro Statistics (Chapter 1)

Motivation

History

Experiments on agricultural trials in Rothamsted ongoing since 1843

ECN ROTHAMSTED

Rothamsted (Latitude 51° 48' 34.44" N; Longitude 0° 21' 22.76" W) is located about 35 km North of London, UK. It covers about 330 ha, all of which is included within the Rothamsted ECN site. The estate contains several ecosystems, including managed arable and grassland fields, naturally regenerated and ancient woodland, the river Ver and more recently energy crops e.g. short rotation coppice willow and miscanthus grass. The Park Grass Hay Experiment (est. 1856) is the principal target sample site (TSS) for the majority of the ECN protocols at Rothamsted. This experiment is widely acknowledged to be the oldest continuing agro-ecological experiment in the world; it is recognised internationally as an important site for long-term studies on biodiversity and ecology. The experimental plot on Park Grass of most interest to the ECN, in relation to physical and atmospheric inputs is Plot 3, Section d (Plot 3d). This plot receives no inorganic or organic inputs apart from atmospheric deposition.

Modern experiments: A/B testing

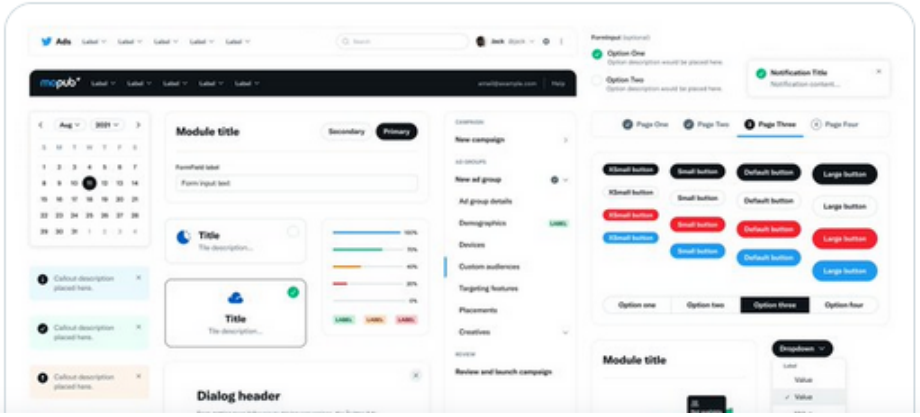
204 631 1,8 k

Afficher cette discussion

Twitter Design a retweeté

Joey Banks @joeyabanks · 11 août

I think one of the most exciting challenges in design system work is an opportunity to create alignment between platforms when it comes to shared patterns. With today's visual update, the components powering Twitter's revenue & developer products received a redesign, too! ✨



Vous pourriez aimer

Twitter API @TwitterAPI — Suivre

Twitter Live @TwitterLive — Suivre

Twitter TV @TwitterTV — Suivre

Voir plus

Ce qui se passe

Actualité internationale · Hier soir

Looking at the history of the Taliban in Afghanistan

Evidence-based policy

RAND health insurance study

Student Teacher Achievement Ratio (STAR)

Nobel memorial prize

The Washington Post
Democracy Dies in Darkness

Business

3 share Nobel Prize in economics for ‘experimental approach’ to solving poverty

Esther Duflo, who at 46 is the award’s youngest winner, shares the hor
fellow MIT economist Abhijit Banerjee and Harvard’s Michael Kremer

J-PAL
ABDUL LATIF JAMEEL POVERTY ACTION LAB

Review

Population and sampling

Defining a target population

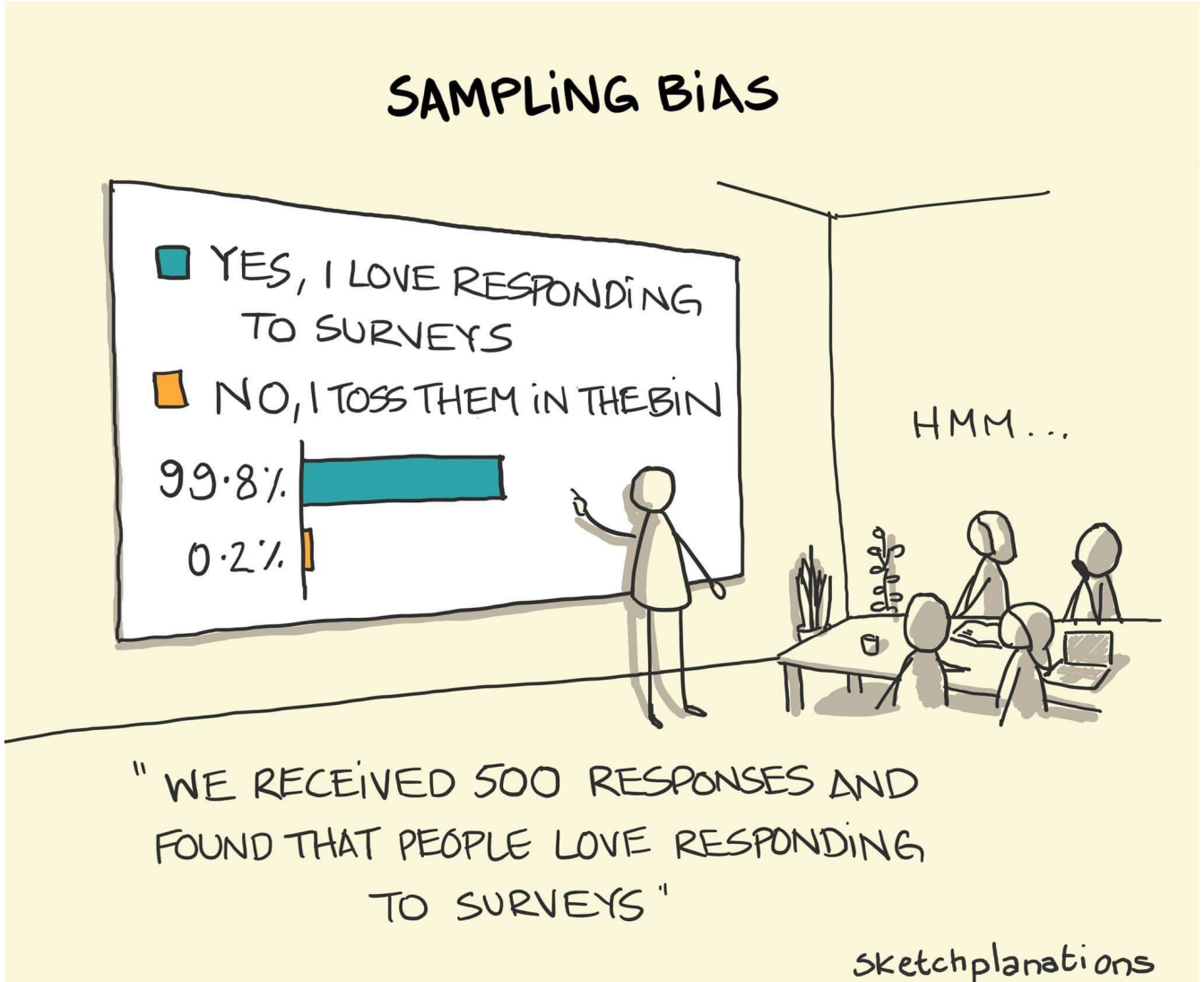
Sampling frame

Where to draw sample from

Sampling procedure

Randomness

Convenience samples and non-response bias



Sampling scheme

Simple random sampling

Stratified sampling

Cluster sampling

Multi-stage sampling

Judging the quality of a sample

Summary statistics

Raw data

Pre-testing

Experiments as gold-standard

BJOG An International Journal of Obstetrics and Gynaecology

Royal College of Obstetricians & Gynaecologists

BJOG Research Methods Guides | Free Access

Randomised controlled trials – the gold standard for effectiveness research

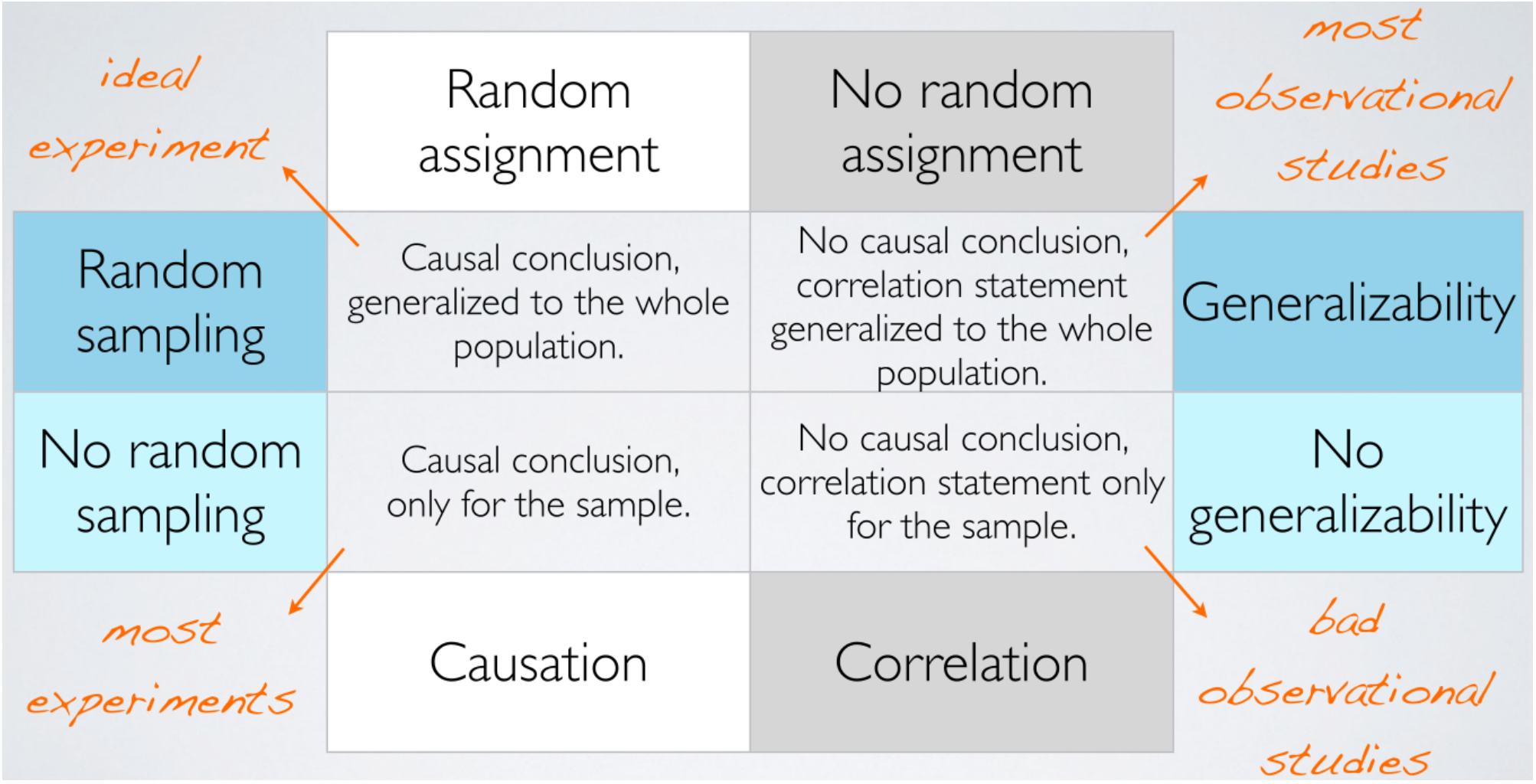
Study design: randomised controlled trials

Eduardo Hariton, Joseph J Locascio

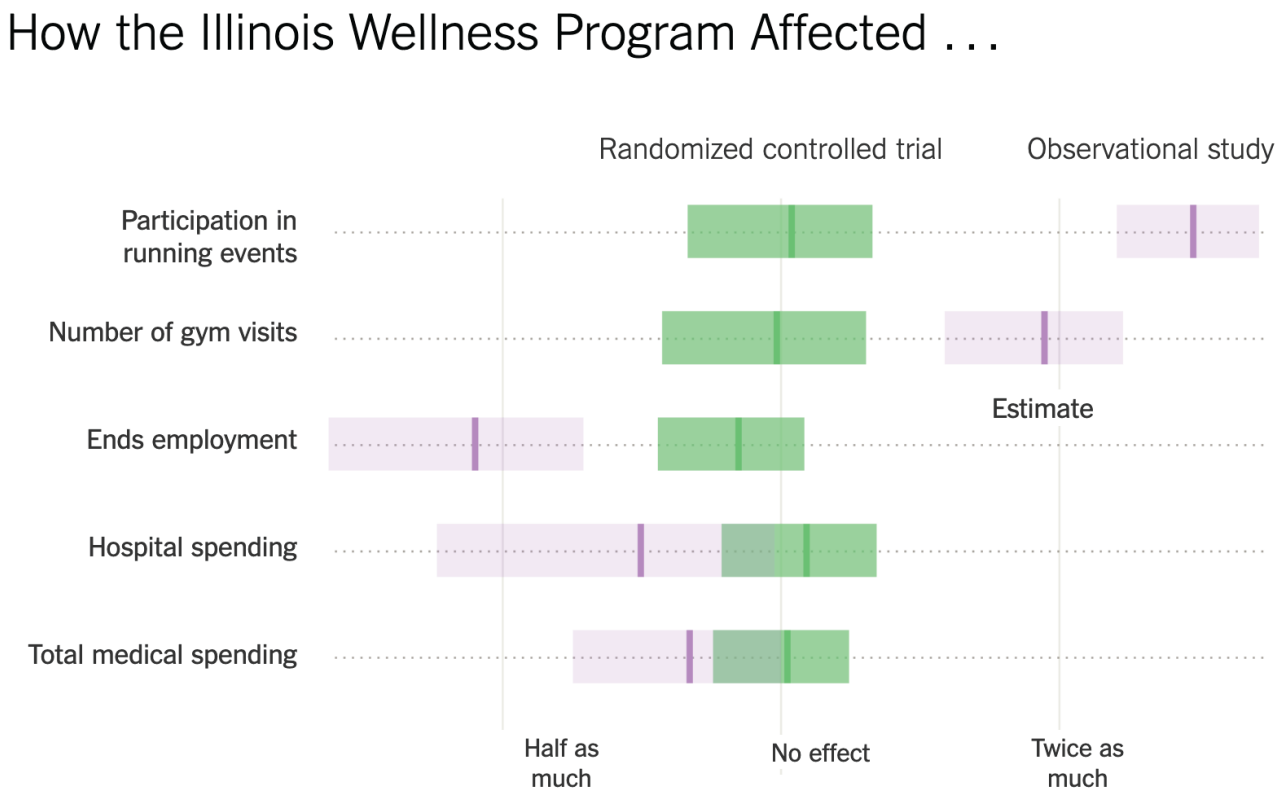
First published: 19 June 2018 | https://doi.org/10.1111/1471-0528.15199 | Citations: 121

> *Randomised controlled trials (RCTs) are the reference standard for studying* ***causal relationships*** *between interventions and outcomes as randomisation eliminates much of the bias inherent with other study designs.*

Study type versus sampling



Experimental versus observational



Source: What Do Workplace Wellness Programs Do? Evidence from the Illinois Workplace Wellness Study

Key concepts in experimental design

Technical vocabulary

Experimental unit

Observational unit

Factor

Impact of encouragement on teaching

From Davison (2008), Example 9.2

> In an investigation on the teaching of arithmetic, 45 pupils were divided at random into five groups of nine. Groups A and B were taught in separate classes by the usual method. Groups C, D, and E were taught together for a number of days. On each day C were praised publicly for their work, D were publicly reproved and E were ignored. At the end of the period all pupils took a standard test.

Exercise

In pairs, identify

- the experimental and observational units
- the factor levels
- the response variable

03:00

Comparing groups (factor levels)

- Without any intervention, **variability** in output from one observation to the next.
- Differences between groups are **comparatively stable**.

Choices in experimental designs

- **factor levels** being compared
- observations to be made (number of repetitions, etc.)
- experimental units

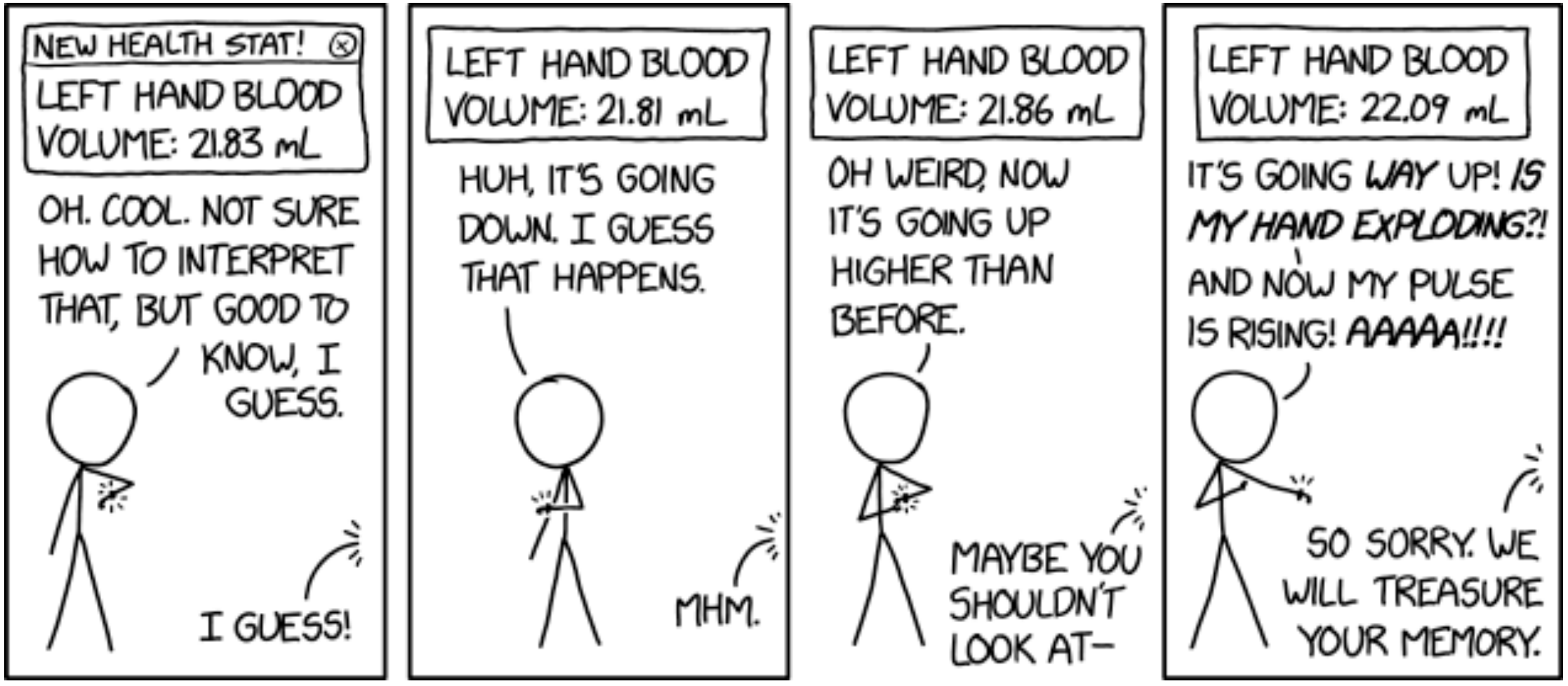
Requirements for good experiments

1. Absence of systematic error
2. Precision
3. Range of validity
4. Simplicity of the design

Absence of systematic error

- Achieved via randomization
- Controlling the environment

Precision

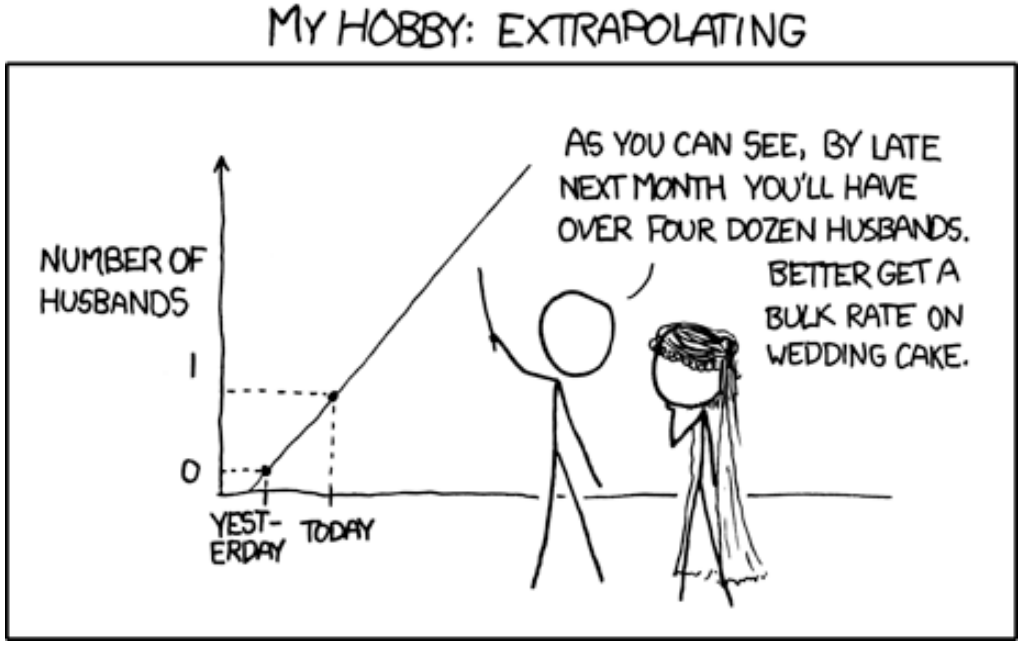

NEW HEALTH STAT!
LEFT HAND BLOOD VOLUME: 21.83 mL
OH. COOL. NOT SURE HOW TO INTERPRET THAT, BUT GOOD TO KNOW, I GUESS.
I GUESS!
LEFT HAND BLOOD VOLUME: 21.81 mL
HUH, IT'S GOING DOWN. I GUESS THAT HAPPENS.
MHM.
LEFT HAND BLOOD VOLUME: 21.86 mL
OH WEIRD, NOW IT'S GOING UP HIGHER THAN BEFORE.
MAYBE YOU SHOULDN'T LOOK AT—
LEFT HAND BLOOD VOLUME: 22.09 mL
IT'S GOING WAY UP! IS MY HAND EXPLODING?!
AND NOW MY PULSE IS RISING! AAAAA!!!!
SO SORRY. WE WILL TREASURE YOUR MEMORY.

Precision

- depends on the intrinsic variability
- function of
  1. accuracy of experimental work
  2. number of experimental units / repetitions per unit
  3. design and methods of analysis

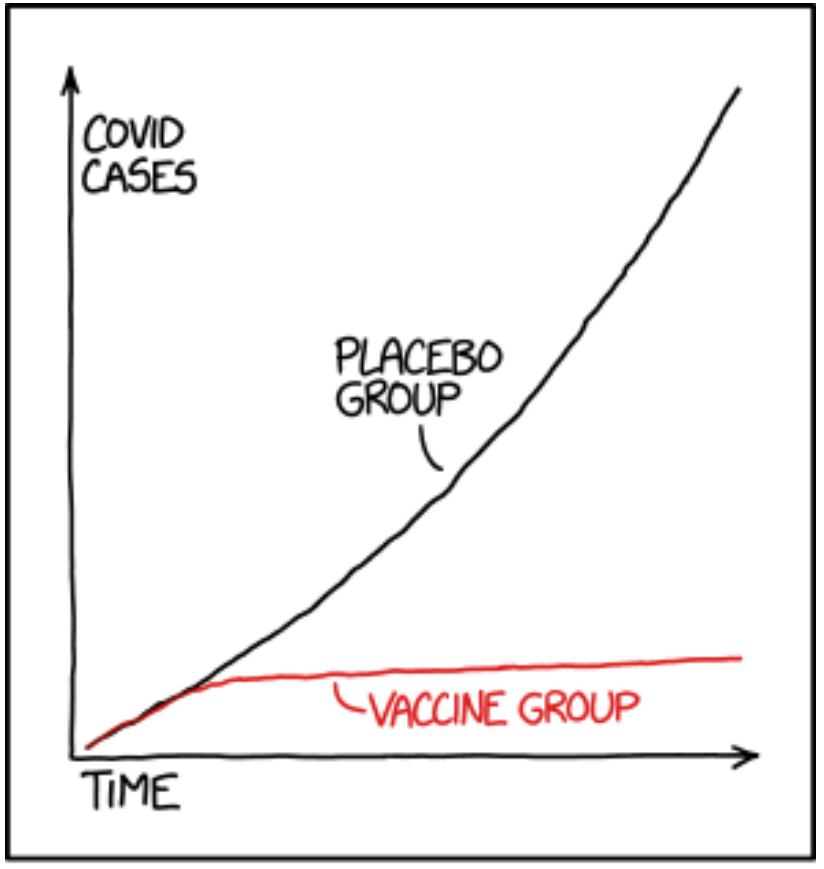
Range of validity

- What is population?
- Identify restrictions
- Extrapolation
  - if proper random sampling scheme
  - range of validity



Simplicity of the design

- Simple designs lead to simple statistical analyses



STATISTICS TIP: ALWAYS TRY TO GET DATA THAT'S GOOD ENOUGH THAT YOU DON'T NEED TO DO STATISTICS ON IT