Statistical Thinking in Biology Research

Statistical Models

Terry Neeman

Australian National University

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A few key ideas

- Data are a measured response under a set of conditions.
- The measured response is a mixture of "signal" and "noise"
- Noise: measurement error, biological, environmental variation
- Statistical models turn data into information.

The goal of statistical modelling is to partition data into "signal" and "noise" or variation.

"Signal" is average treatment effect or an association between sets of variables and outcome.

What is a Statistical Model?

- An informative summary of data
- A description of a data generating process
- A mathematical model that includes measures of uncertainty

One can fit a model to **explain** outcomes.

One can fit a model to **predict** outcomes.

A Statistical Model of an Experiment

- Statistical model: a conceptualisation of experiment
  - experimental factors - how do they influence outcome?
  - what other things (factors) influence the outcome?
  - Does the outcome have unexplained variation?

Statistical Models: a principled way to learn from data

- data = signal + noise = mean response + variation
- mean response = f(experimental factors)
- variation = g(other influences) + unexplained variation

Experimental design: a principled way to set up experiments to efficiently separate signal and noise.

Understanding statistical models: examples from Lecture 1

Example 1: Shigella vaccine challenge experiment

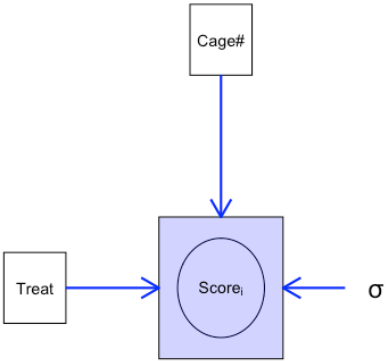
- 6 mice per vaccine group (saline/ low dose / high dose)
- All mice challenged with Shigella bacteria at Day 14
- Outcome: 7-day average symptom score post-challenge

This time, 3 mice per cage (one per treatment), and 6 cages total.

- Potential *factors* influencing score: cage (6) and treatment (3)
- Can estimate *cage effects* (score differences between cages)
- Can estimate *treatment effects* **within** each cage

Example 1: Shigella vaccine challenge experiment

Proposed data generating process

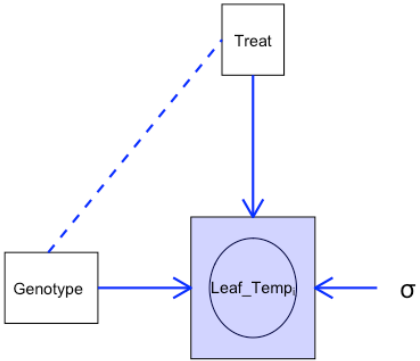


Example 2: Drought resistance in GM tomato plants

- Genotypes: WT or mutant
- watering conditions: normal or drought
- Outcome: leaf temperature at 7 days post-treatment
- Potential *factors* influencing score: genotype (2) and treatment (2)
- Estimate *treatment effect* within each genotype
- Do treatment effects differ by genotype?

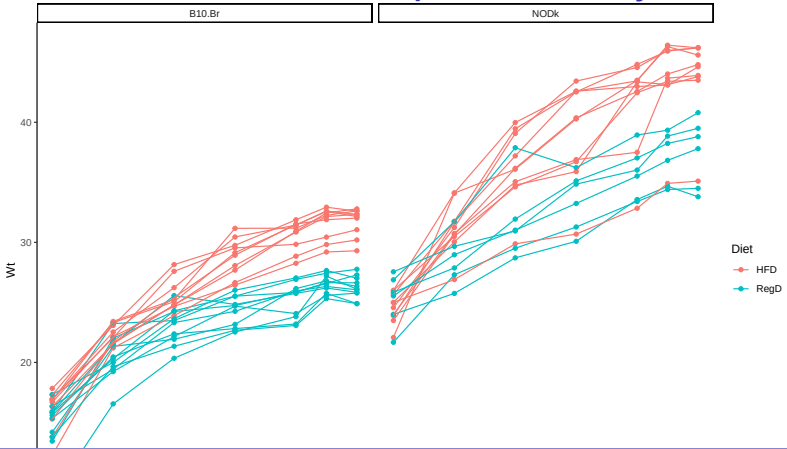
Example 2: Drought resistance in GM tomato plants

Proposed data generating process



Example 3: Diet and obesity

Are NODk mice more susceptible to obesity with a high fat diet?



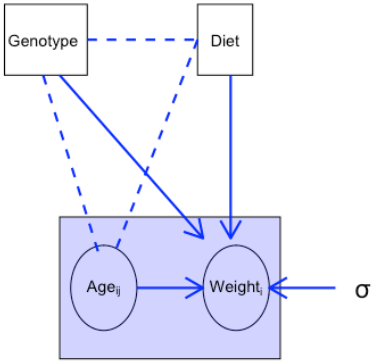
Example 3: Diet and obesity

Are NODk mice more susceptible to obesity with a high fat diet?

- Genotypes: WT or NODk
- Diet: normal or high fat
- Age: measured over time

Does diet impact *growth*? Does diet have stronger impact on NODk mice?

Example 3: Diet and obesity



Summary

- Statistical models: conceptualisation of experiment
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In the next workshop, we'll fit models to data using R