Chapter1: The Golem of Prague

Statistical Rethinking Reading Group

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Statistical Rethinking

- Hypotheses are not models
- Measurement matters

Hypotheses Are Not Models

Hypothesis falsification is not enough in most scientific problems:

- Many models correspond to the same hypothesis
- Many hypotheses correspond to a single model

We also need:

- Process models
- Flexible statistical models

Measurement

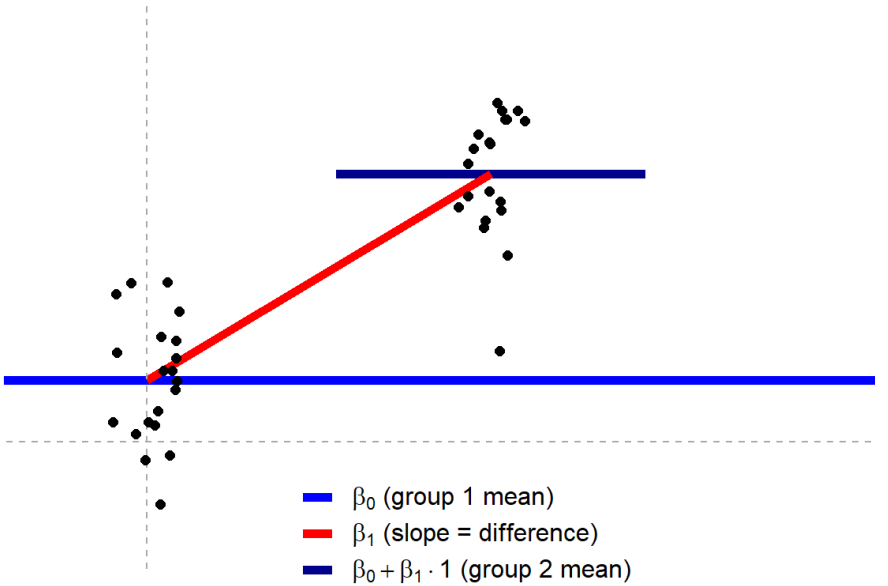
- Observation error: Are we measuring what we want?
- Continuous hypotheses: Comparisons must be probabilistic
- Falsification is always consensual, not logical

Statistical Golems/Models

- Obediently carry out exact calculations
- Context-unaware
- Do not understand cause and effect, only association

Traditional Golems

- Common statistical tests are models. Linear models, in fact.
- Very inflexible and fragile models



Tools for Golem Engineering

- Bayesian data analysis
- Model comparison and prediction
- Multilevel models
- Graphical causal models

Bayesian Data Analysis

- Probability theory as a general way to represent plausibility
- Randomness as a property of information, not of the world
- Use randomness to describe our uncertainty
- Very flexible

Model Comparison and Prediction

Comparing models based on predictive accuracy:

- Cross-validation
- Information criteria

Provides:

- Useful expectations of predictive accuracy, not just fit to sample
- Estimate of the tendency of a model to overfit
- Spotting of highly influential observations

Multilevel models

Models with multiple levels of uncertainty, each feeding into the next

Very flexible and powerful:

- Assessing variation in treatment effects
- Partial pooling to reduce overfitting
- Correct uncertainty estimation in many settings:
    - Repeated sampling
    - Sampling imbalance
    - Missing data imputation
    - Measurement error
    - Factor analysis
    - Spatial regression

However, these benefits do not come for free:

- Hard to fit and interpret

Graphical Causal Models

Two distinct problems:

- Raw prediction
- Causal identification

Statistical models are great engines for detecting associations between cause and effect

Models that are causally incorrect can make better predictions than those that are causally correct

"Causal salad" not appropriate for causal inference

Causal identification

Process/Causal models -> Statistical models -> Predict causal implications

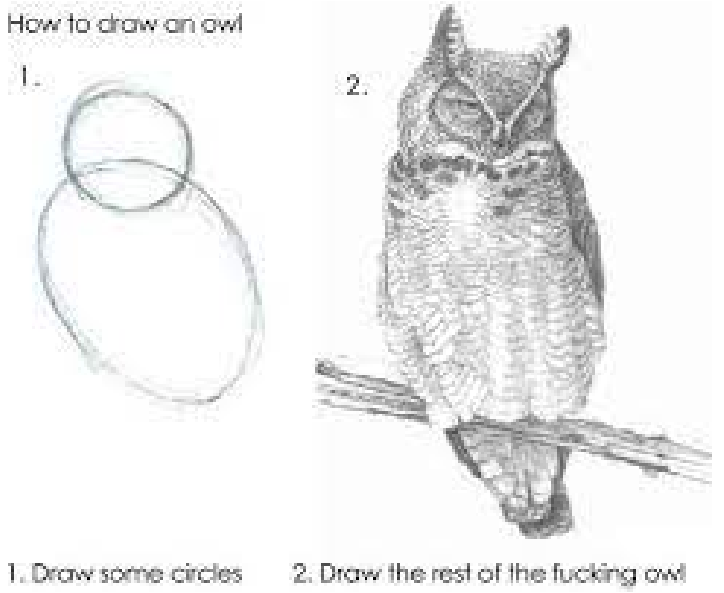
DAGs as useful tools to think about process models

Draw the Bayesian Owl

- Building models from scratch
- Expressing all assumptions in a model

Benefits:

- Understand what you are doing
- Document your work, reduce error
- Respectable scientific workflow



Thanks!