Experimental Design

Senior Research Seminar
September 20, 2007
Your thesis and your mentor’s research

• Intellectual contribution
• Collaboration vs. employment
• Independence
• Professional interaction
The error-statistical scientific process

From Scheiner 2001
What is the point?

• Are there spatial or temporal differences in the variable \( Y \)?
  
  • Starting point for most research; sometimes the entire question for large scale or preliminary studies

• What is the effect of factor \( X \) on variable \( Y \)?
  
  • Typical of manipulative experiments, sometimes used in observation experiments (but the inference is weaker)

• Which mechanistic hypothesis is supported?

• What is the appropriate parameter for a particular model?
Experiments

• **Manipulative Experiments**
  - Experimental treatment group(s) and control
  - Example: Manipulations of chemical inputs into microbiological communities

• **Observational (or Natural) Experiments**
  - Compare pre-existing groups which vary in the factor of interest
  - Example: Observe differences between population from different environments

• **Non-Experimental Theses**
Scientists replicate to distinguish effect from random variation
Distinguishing between groups

Trait

Frequency

Pop 1  Pop 2  Pop 3
How much replication?

It depends on both variance and effect size.

Unfortunately, the scientist rarely knows either of these variables before the experiment. Solutions: pilot study, previous related research.
How many replicates can I afford?

- Time (include travel and prep time; lag between observations can produce error)
- Labor
- Money
- Plan for mistakes!
“Rule of Ten”

You should collect at least ten replicate observations for each category or treatment level (Gotelli and Ellison 2004)

Example: If you know you can make 50 observations during your research, you should compare a maximum of five groups.

You are almost certain to lose some data along the way!
Other Concerns

- Independence of Observations
- Confounding factors
- Randomization
- Realism (both nature and range of treatment)
- Controls
- Consistency of application
- Covariates
Where to go for help

• Your mentor and their associates (to start)
• The library
  • Statistics books
  • Methods section of related papers
• Statistical Consulting: consult@stat.columbia.edu