

Populations, Samples, and Hypotheses: The Basics of Empirical Research

Todd Davies
Symsys 130
April 29, 2013

Empirical Research: The Basic Method

Starting point: Question or Proposition

Operationalizing – defining question or proposition more exactly?

- Target population: P
- Independent variable (predictor): X
- Dependent variable (response or target): Y
- Parameter: θ
- Null hypothesis $H_0: \theta = 0$
- Alternative hypothesis $H_1: \theta > 0$

Empirical Research: The Basic Method (continued)

Hypothesis Testing

- Sample Σ of size n drawn from target population P
- Test statistic s , a sample-based estimate of parameter θ , with observed value s_0
- Significance level α = maximum acceptable p-value $p = \Pr(s \geq s_0 | H_0)$
- Minimum effect size of interest $\theta_m > 0$
- Power: $\pi(\theta, n, \alpha, \dots) = \Pr(\text{reject } H_0 | \sim H_0)$
- Desired power π_D can be used to calculate sample size n

Empirical Research: The Basic Method (continued)

Outcomes of hypothesis testing

- Decision criterion: Reject H_0 if $p < \alpha$ (p-value is less than significance level), otherwise, do not reject H_0
- Type I error (false alarm): reject H_0 | H_0 is true [usually most serious]
- Type II error (miss): not reject H_0 | H_0 is false [usually less serious than type I error]
- Hit: reject H_0 | H_0 is true [therefore power $\pi = \Pr(\text{hit})$]

Examples

Question: Who are healthier? People in Palo Alto or Menlo Park?

Proposition: Studying in quiet surroundings improves test performance.

Proposition: Getting enough sleep improves memory during the day after sleep.

Question: Does any class period lead to better grades?

Assessing significance

P-values

Bayesian testing

- Loss = costs of type I and type II error
- Risk = expected total Loss

Sampling - theory

Unbiased statistic $E(s) = \theta$

Random sampling: every individual in P is equally likely to be in Σ

Random sampling \Rightarrow unbiased statistics

Sampling - methods

Random sampling

- With replacement
- Without replacement

Nonrandom sampling

- Convenience sampling
- Snowball sampling
- Quota sampling
- Cluster sampling

A question...

Can nonrandom sampling lead to unbiased statistics?