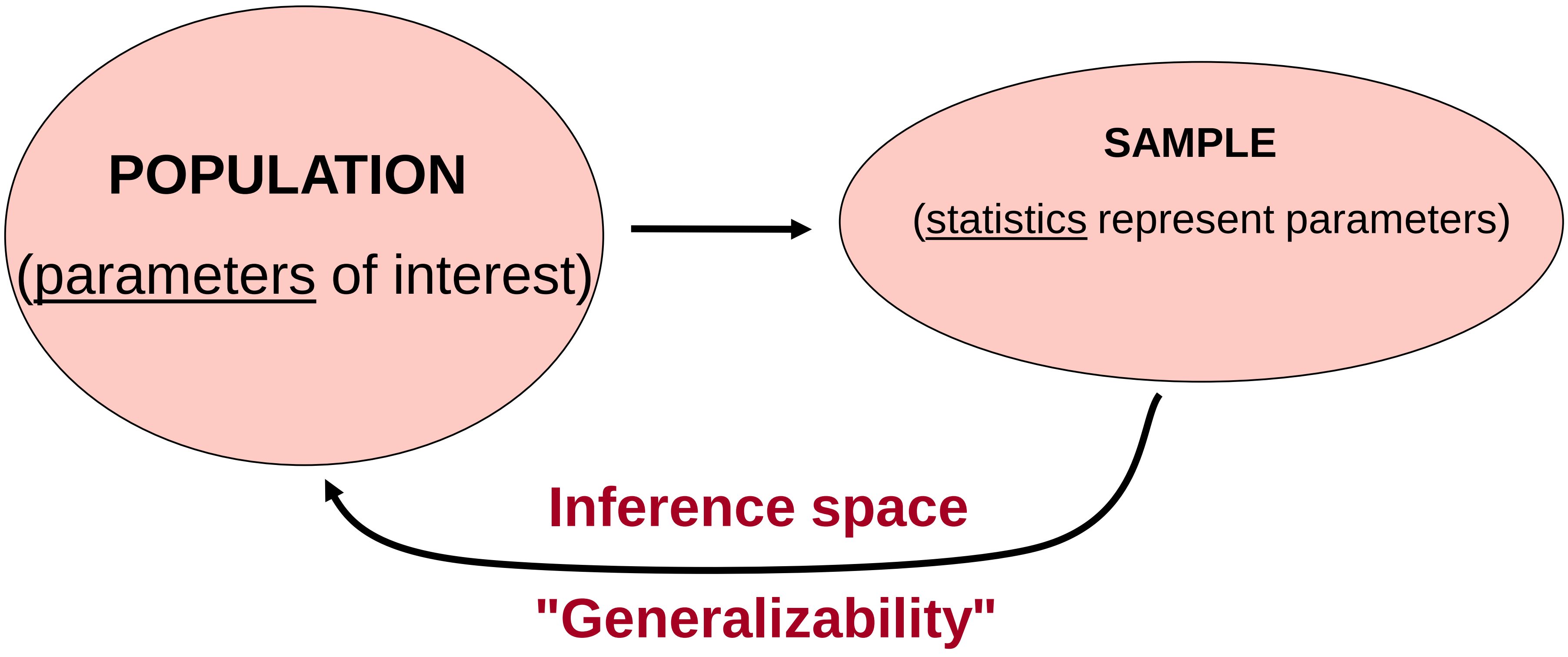
KINE 601

"Statistical Significance" and Sampling

Reading: Huck pp 99 - 232

Review of Sampling & Inference Concepts

- **Population:** all members of a specified group
- **Sample:** a defined subset of the population
- **Parameter:** a numerical or nominal characteristic of a population
- **Statistic:** a numerical or nominal characteristic of a sample which represents the population parameter



Review of Types of Hypotheses

- **Hypothesis**
  - speculation, educated guess
- **Research (Alternative) Hypothesis**
  - proposed relationship between independent and dependent variables
  - hypothesis accepted as true if the null is rejected
- **Null Hypothesis**
  - hypothesis for statistical testing
  - stated in negative form
    - "there will be no significant difference…."
    - "no relationship exists between…."
  - although true null hypotheses are seldom stated formally in the literature, they are always "implied" to exist
    - null hypotheses are used because:
      - test statistics require that “effects” are assumed to be nil
      - If the null is rejected, the alternative hypothesis is easy to interpret

Research Study Outcomes & Errors

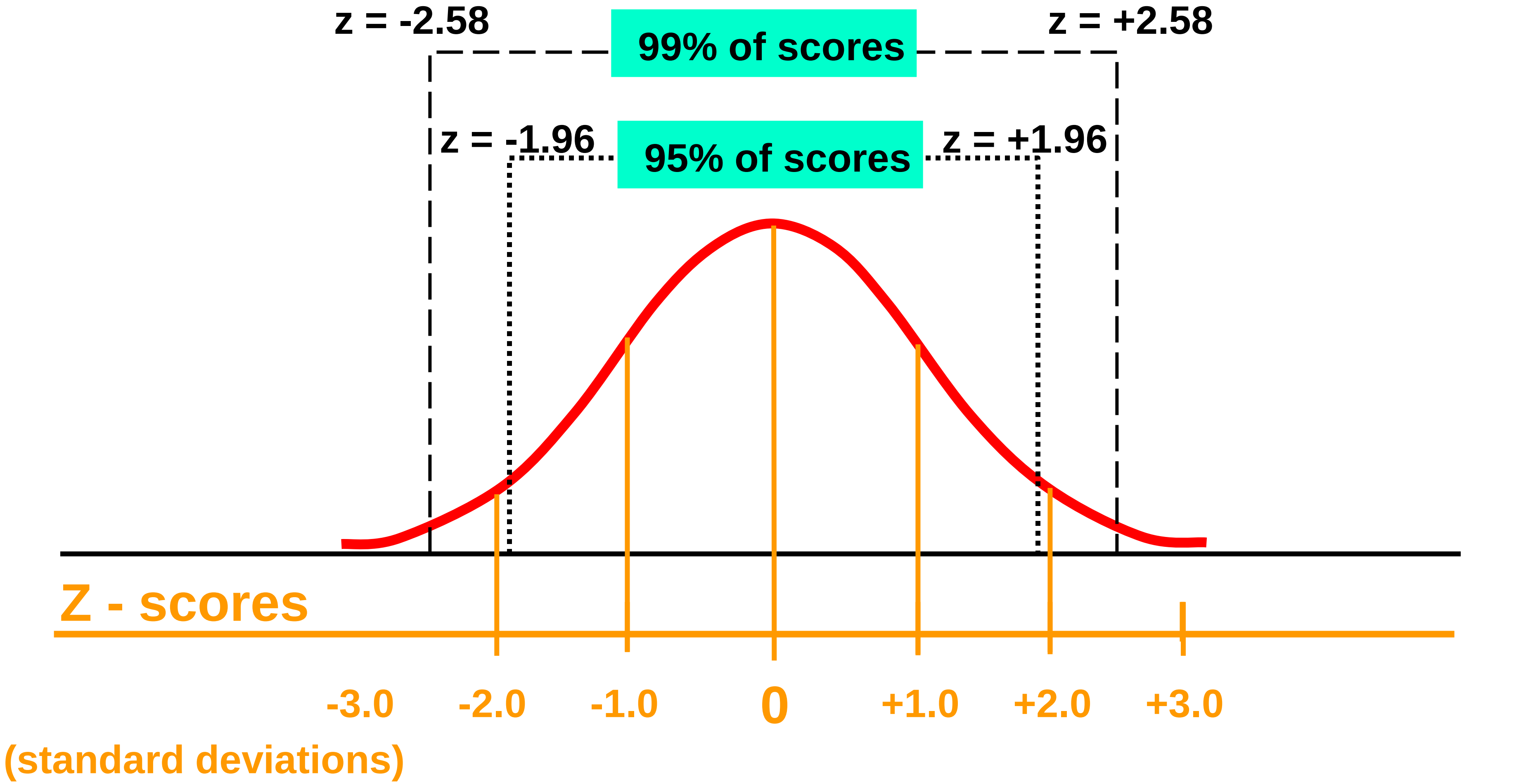
		Truth in the Population	
		treatment has no effect (H_o is true)	treatment has an effect (H_o is false)
Conclusion Reached in the Study	effect is found to be present (reject H_o)	incorrect conclusion probability (p) = α **Type I error**	correct conclusion probability (p) = 1 - β **Statistical "power"**
	no effect found (accept H_o)	correct conclusion probability (p) = 1 - α	incorrect conclusion probability (p) = β **Type II error**

notes: **1. a Type I error rate must be selected for each statistical comparison performed**

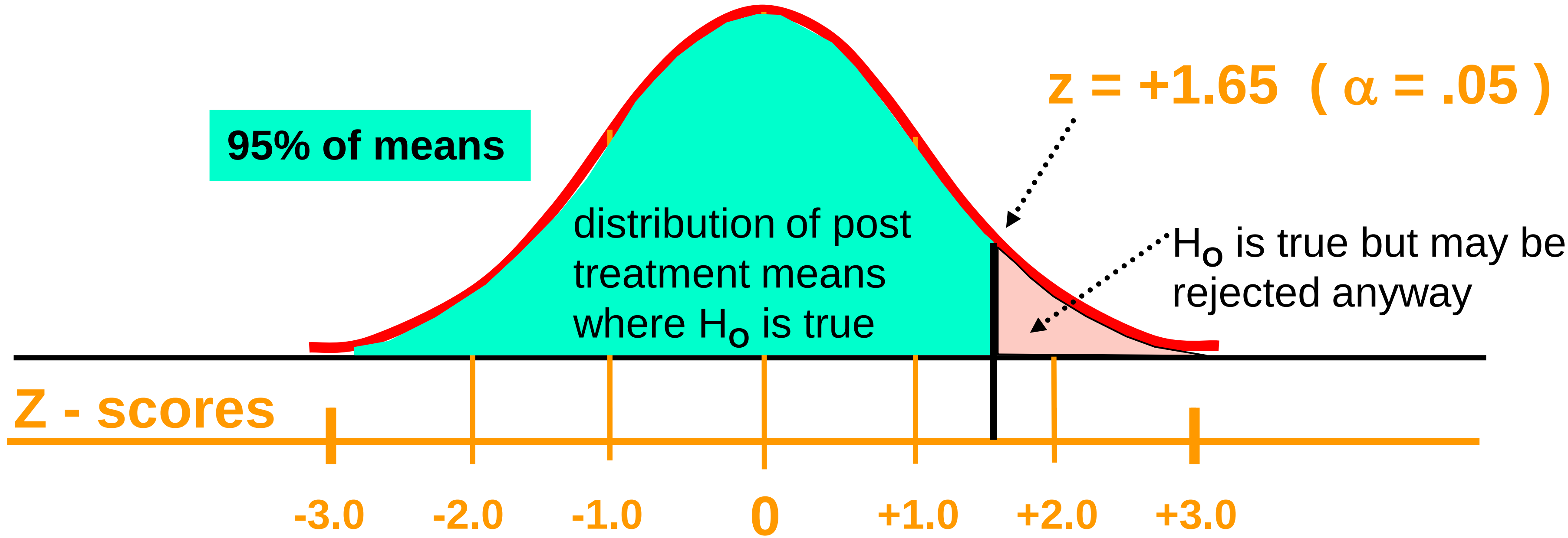
- the more analyses you perform, r u chances of making a Type I error

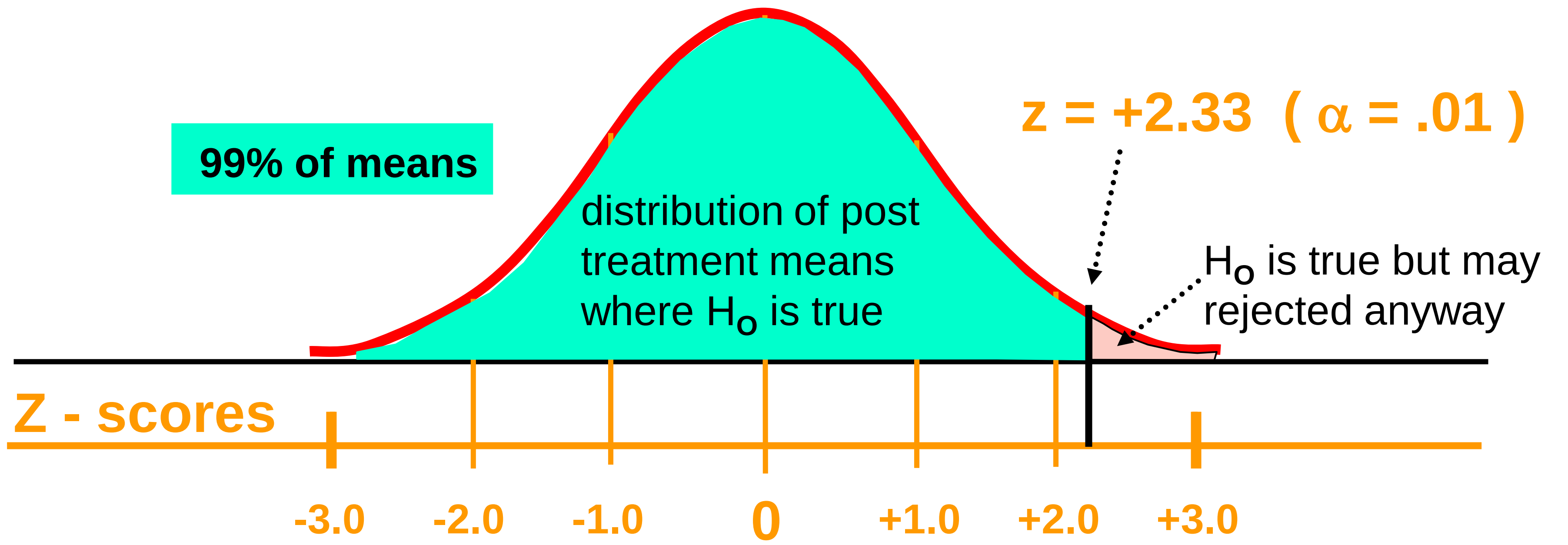
2. statistical power: the chance of finding an effect when an effect is indeed present

the Normal Distribution



z-scores and α levels





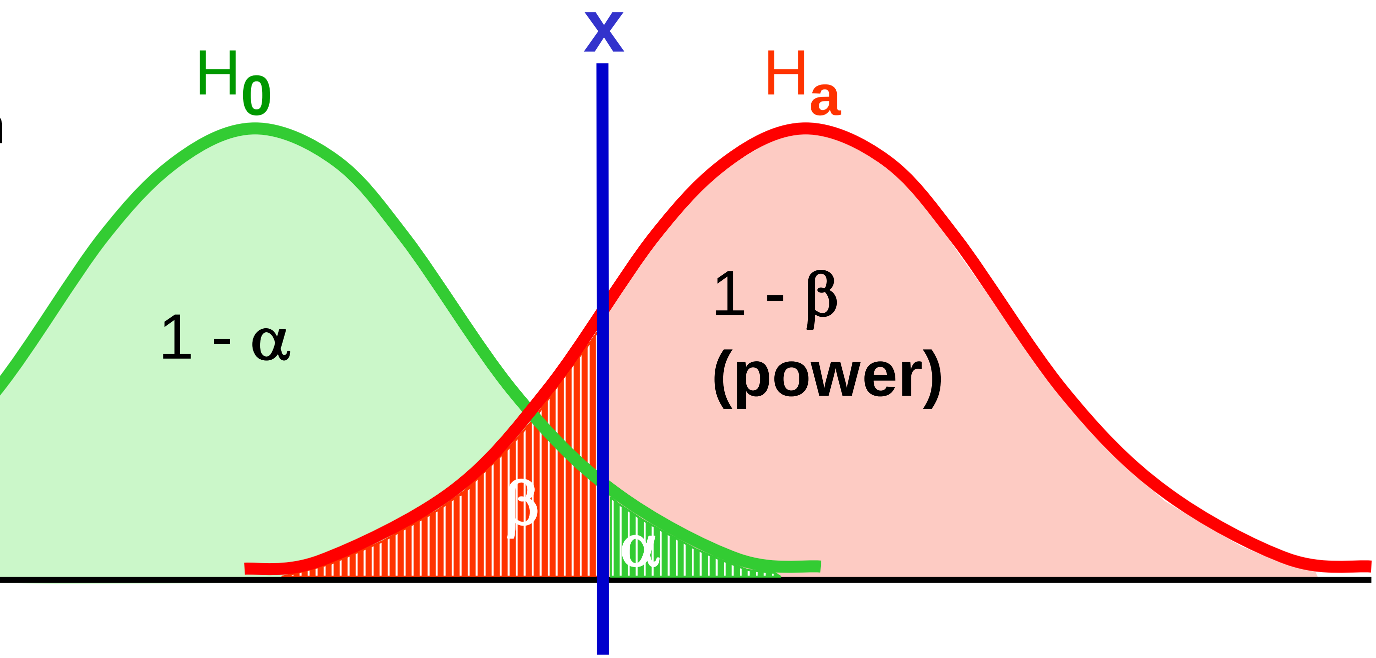
The Concept of Statistical Significance

H_0 - unknown distribution of means where no effect is present (null hypothesis)

H_a - distribution of means where treatment effect is present (alternative or research hypothesis)

X - dependent variable mean after treatment

<u>Statistical Power</u>
the probability of rejecting H_0 when it is in fact false (finding an effect when one is indeed present)



Z - score: 1.65

(95% of means in H_0 distribution lie to the left, 5% to the right)

corresponds to an α level of .05

note: as α gets smaller, 1–β also gets smaller

Types of Probability Samples

- **Simple Random Sample:** all members of a population have an equal chance of being selected
  - selection of one element does not affect selection of another

- **Stratified Random Sample:** taking a sample from a sub-population in such a way that identified subgroups are represented
  - ensures that sample is truly representative of population
  - quota sample: stratification without randomization
    - sample must have X% of subjects with characteristic 1, Y% with characteristic 2…

- **Systematic Sample:** taking every ***n***'th element of a population
  - more complex formulae may be used for selection

- **Cluster Sample:** random selection of groups or blocks that have a desirable trait or characteristic
  - example: randomly select 10 hospitals for employee Hepatitis B testing

Types of Non-Probability Samples

- **Convenience Sample:** a sample consisting of a group or groups that are readily available to the researcher
  - examples:
    - standing in a mall and asking people to complete surveys
    - professor using his class members
  - serious inference limitations

- **Purposive Sample:** selection based on on "inclusion criteria"
  - selecting subjects based on a characteristic, quality, or trait they possess
  - used often in human research
  - no attempt made at randomization r inference is limited
    - sometimes invalid inference claims are made in article conclusions
  - example: postmenopausal women taking hormones and exercising 3 days/wk
  - it is sometimes necessary to make extensive efforts to "recruit" subjects
    - recruiting methods should be described in detail in manuscript or presentation
    - snowballing: using current subjects to recruit new ones

Sampling Problems

- **Survey Response Rates: 60% - 80% required**
  - Portney & Watkins 1993, Gay 1981
  - Ways of addressing non-response bias:
    - follow up mailing(s)
    - acknowledgement in the manuscript
    - interview some of the non-respondents - compare results with respondents
- **Sampling Error**
  - the difference between a parameter and its representative statistic
  - **standard error (of the mean)** - standard deviation of a group of sample means
    - may sometimes be given in conjunction with treatment resultant means instead of standard deviations
    - estimated by any sample standard deviation divided by square root of sample subject number

$$\frac{s}{\sqrt{n}}$$

Sampling Problems

- **Sample Size: - how many subjects do you need ?**
  - descriptive research - 10% - 20% of the population
  - correlational - causal comparative studies: = 30 subjects per experimental unit
  - tightly controlled experimental studies: =15 subjects per experimental unit
  - depends on:
    - desired statistical power - the larger the subject number, the greater the power
      - subject number is the most potent influence on statistical power
    - effect size (ES) - the extent or magnitude of the experimental effect
      - "raw" ES: posttest mean - pretest mean
      - more commonly, standardized ES's are used (raw ES / variability)
      - small ES = .2 medium ES = .5 large ES = .8
      - the larger the anticipated effect size, the smaller the required sample number
    - significance criterion (α : the statistical probability of making a Type I Error)
      - the smaller the α level, the larger the required sample number
    - type of statistic used - complex designs and statistics necessitate larger samples
      - more than one independent and / or dependent variables r larger samples
  - inadequate sample size adversely affects both internal & external validity

Population Estimates taken from Samples

- sample mean **(y)** is a point estimate of population mean **(μ)**

- interval estimates for **μ** can be obtained using confidence intervals

  - CI: **y** $\pm$ $z_{\alpha/2}$ (standard error)

    - example: construct a 95% confidence interval for the population mean (μ) when the sample yields: y = 379.2, n = 36, s = 124.

      - since we desire a 95% CI, α = .05 and α / 2 = .025 **r** $\mathbf{z}_{.025}$ = 1.96
      - standard error = s / $\sqrt{n}$ = 20.7
      - CI = 379.2 $\pm$ 1.96 (20.7) = 379.2 $\pm$ 40.6

- 95% of the confidence intervals constructed like this will contain actual **μ**

- confidence intervals are used to estimate numerous kinds of parameters

Hypothesis testing

- **Steps in hypothesis testing**
  - State the null hypothesis to be tested
    - H_0: no "difference" or "relationship" exists
  - State the alternative (research) hypothesis
    - H_a: usually the simple alternative that a difference or relationship does indeed exists
    - some studies specify the direction of the difference (one vs. two "tailed" tests)
      - if you are "sure" of the direction, you can increase your statistical power
  - Select a level of significance
    - "comparisonwise" vs "experimentwise" error rates
    - dividing up the α (Bonferroni technique)
  - Determine sample size (statistical power), collect and summarize data
  - Perform a statistical analyses (refer to a decision making criterion)
    - obtain a "calculated value" of a statistic and compare to "critical value"
      - reject H_0 if "calculated value" is $\geq$ "critical value"
    - obtain "***p*** value" (probability value) and compare it with α level
    - obtain a measure of relationship or strength of association
  - Accept or reject the null hypothesis
  - Evaluate "statistical" significance versus "practical" significance

Interpreting "*p*-values" & "Degree of Significance"

- ***p*-values** - the exact probability of a type I error (α)
  - the "margin" by which $\mathbf{H_0}$ was rejected or accepted
  - results of statistical analyses are usually presented in one of two ways:
    - ***1.*** $p > \alpha$ or $p < \alpha$
      - " a significant difference was found to exist between groups ($p < .05$) "
      - " the correlation coefficient was not statistically significant ($p \geq .05$) "
    - ***2.*** the exact α value is given as $p = .xxxxx$
      - " significant differences were found between groups X and Y ($p = .0128$) and between groups A and B ($p = .003$) "
    - the ***p*** value does <u>not</u> indicate ES or the degree of difference between $\mathbf{H_0}$ and $\mathbf{H_a}$
      - indicates only the degree to which difference could have occurred by chance
      - the term " highly significant " appears often in the literature implying that the independent variable made a huge difference in dependent variable scores when, in fact, this may not be the case
    - remember, an inverse relationship exists between sample size and ***p***-value
      - with a large sample, the ***p***-value can be very low, even when ES is small
        - larger sample r smaller treatment variance r more power
    - some authors report results that are "borderline" significant ($p = .053$)