

Psychology 310P  
 Statistical Inference  
 Course Information Sheet, Fall, 2010

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Teaching Assistant:	Gillian Starkey Email: gillian.s.starkey@vanderbilt.edu Office: Hobbs 214 Phone: (615) 878-4658 Office Hours: Friday 9:00–11:00
Course Meeting Times:	MWF 11:10-12:25 One of these meetings, on Friday, frequently will involve lab exercises in statistical computing. Generally this period will end enough before noon to allow students to attend the “Developmental Lunch Bunch” or other noon seminar if they wish to do so.  Typically, I will terminate the lectures at 12:20 and ask for questions.
Instructor Website:	<a href="http://www.statpower.net">http://www.statpower.net</a> I generally do not use Oak or Blackboard much. All course materials are available for downloading at my website.
Textbook:	Glass & Hopkins, <i>Statistical Methods in Education and Psychology</i> , 3 <sup>rd</sup> edition ISBN: 0205142125  As part of an initiative I call “Operation Greenbook,” this text was not ordered for the bookstore this fall. Used copies are available from a variety of sources, including the students who took the course last year. New copies are available over the internet (for example, at ABEbooks.com), and you may be able to “rent” a copy from another graduate student. The textbook is now very expensive to purchase new.
Final Exam:	There are two scheduled administrations of the final exam. The <i>primary exam</i> is scheduled for December 17 at 9am. The “alternate exam” is scheduled for December 13 at 12 noon. You can take the exam at either time (but not both). <b>Do not schedule a plane flight that precludes your taking the exam during one of these periods.</b>
Grading:	Course grades will be scaled. Midterm Exam 30% Final Exam - 30% Lab Assignments, homework, class participation - 40%.
Missing Class:	Missing class for a legitimate excuse (such as illness, religious holiday) does <b>not relieve you of the responsibility for turning in homework assignments on time!</b> For example, if you miss a tutorial class for a religious holiday you must still email or deliver your homework assignment to the TA on or before the due date. This policy does not mean dispensations are not granted for legitimate reasons. However the onus is on you: If a personal situation impedes your academic progress, please inform me and I will make arrangements to accomodate the situation.

# *Outline of Statistical Topics*

## **Intuitive introduction to the laws of linear transformation and list manipulation**

### **Subscript and summation notation**

### **Shape -- Tabulating and depicting data.**

- Frequency distributions and their properties
  - Cumulative Frequency
  - Relative Frequency
  - Cumulative Relative Frequency
  - “Axioms of Relative Frequency”
- Skewness
- Kurtosis
- Percentiles

### **Central Tendency**

- The Mean
  - Estimating the mean from a grouped frequency distribution
  - Computing the mean for pooled groups
- The Median

### **Variability**

- The Range
- The Semi-Interquartile Range
- The Variance and Standard Deviation
- Computational formulas and their derivation

### **The normal distribution.**

- The standard score
- Interval probability estimates with the normal curve
- The bivariate normal distribution
- Measures of relationship.

### **The linear transform**

- Definition
- Effect on measures of central tendency
- Effect on measures of variability

### **Covariance and Correlation**

- Effect of linear transforms on the covariance.
- The product moment correlation coefficient.
  - Definition
  - Effect of linear transforms.
  - Computational formulas.

### **Linear regression**

- General Algebraic Setup for Regression
  - Linear regression
  - Computational formulas
  - The “least squares” criterion
  - Solving for the optimal least squares regression coefficients
  - Using linear regression
    - Description
    - Prediction

- Correlational Fallacies

- Inferring causality
- Confusing Perfect Correlation with Equivalence
- Problems with mixed distributions
- Problems with skewed marginals
- Restriction of range
- Shrinkage

### **The laws of linear combination**

- Mean of a linear combination
- Variance and covariance of linear combinations of variates
- A simple heuristic algorithm and its derivation

- The algebra of variances and covariances
  - Deriving some classic results
  - Orthogonality in Regression
  - The “Rich get Richer” phenomenon

- Some Relationships between Geometry and Statistics
  - Vectorial representation of numerical lists
  - The geometry of variance and correlation
  - Seeing a classic result through geometry

### **Multiple Linear Regression – A Brief Introduction**

- The fixed regressors multiple regression model
- Regression Effects
- Interactions
- Centering

### **Conditional Distribution Theory**

- Some basic definitions
  - Bivariate distributions
  - Marginal distributions
  - Conditional distribution

- Bivariate normal distribution

- Some simple consequences
  - Regression toward the mean
  - Conditional distribution calculations

### **Inferential Statistics.**

#### **Probability theory**

- Set theory
  - Basic Definitions
    - Set
    - Subset
    - Proper subset
    - Null set
    - Universal set
  - Operations
    - Union
    - Intersection

- Complement
- Key Definitions
  - Mutually Exclusive Sets
  - Exhaustive Sets
  - Set Partition
- Basic Theorems in Set Theory
- Probabilistic experiments and sample spaces
- Simple (elementary) and compound events
- Probability axioms
- Three basic theorems of probability theory
- Conditional probability and independence
  - A classic paradox
  - Bayes's Theorem
- Counting rules and combinatorics
  - The General Path Rule
  - Permutations
  - Permutations with selection
  - Combinations
- Random variables and probability distributions
- The binomial distribution
- Expected value and variance of a random variable
  - Effect of a linear transform.
- Covariance and correlation for random variables.
  - Linear combination rules revisited
- The normal approximation to the binomial

### **Basic theoretical aspects of statistical estimation**

- Unbiasedness
- Efficiency
- Consistency

### **Standard confidence interval estimation logic**

- Inverting probability statements
- The critical distance approach – “Taking a stroll with Mr. Mu”

### **Hypothesis testing logic**

- Partitioning the parameter space
- Partitioning the sample space
- Test statistics
- Power and error rates
- Factors influencing power

### **Tests on means -- a general approach**

- When population variances are known
  - 1-sample, 2-sample, and k-sample tests on independent samples
  - Dependent sample procedures
  - Extensions for general asymptotic Z-statistics
  - The central limit theorem

- When population variances are unknown, independent samples
  - Student's  $t$ -distribution
  - Assumptions for the  $t$ -test
  - Robustness
    - 1-Sample  $t$
    - 2-Sample  $t$
    - $k$ -Sample  $t$

- When population variances are unknown, dependent samples

Repeated measures  
Matched samples  
2-Sample, matched sample  $t$ - test  
Generalized Matched Sample  $t$   
Assumptions

**Confidence intervals on linear combinations of means**

Independent Samples  
Dependent Samples

**Additional Theoretical distributions for use in statistical inference**

The Chi-square distribution.  
The F distribution.  
Noncentral Chi-Square and F distributions

**Tests on variances**

1-sample  
2-sample independent

**Tests on proportions**

1 and 2-sample independent and dependent procedures.

**Tests on correlations**

Classical asymptotic theory -- The Pearson-Filon equations.  
The Fisher (and related) normalizing transforms.  
Independent and dependent sample tests on 1 or two correlations.  
Generalized procedures for comparing elements of a correlation matrix.  
Robustness problems in correlational significance tests.

**The analysis of variance – 1-Factor Fixed and Random Effects.**

The models and their underlying statistical assumptions.  
The meaning of "effect" in the analysis of variance.  
Computational procedures.  
Robustness properties of ANOVA.  
Multiple comparison procedures.  
    Error rates (experimentwise, per experiment, per comparison) and the problems of multiple testing.  
    Planned orthogonal contrasts.  
    The Scheffe test.  
    The Tukey test.  
Noncentrality Interval Estimation – Confidence Intervals on Effect Size  
ANOVA as multiple regression