PSY 610: ANALYSIS OF FACTORIAL DESIGNS

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INSPIRATION & WISDOM:

Do not put your faith in what statistics say until you have carefully considered what they do not say.
-- William W. Watt

Statistics are for losers. -- Scotty Bowman

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MEETING: Tues & Thurs at 11:00 - 12:15 in Kastle 216
Tuesday at 5:00 - 6:30 in Kastle 216

OFFICE HOURS: Bob: Friday, 9:30 - 11:00 or by appointment
Caitlin: Monday, 3:00 – 4:00

TEXT:

- Myers, J.L., & Well, A.D. (2003). *Research design & statistical analysis, 2nd ed.* Mahwah, NJ: Erlbaum.
- Supplementary readings for PSY 610 at Johnny Print
- Chapters (some revised) available electronically upon request, but in Wordperfect format.

GOALS:

By the conclusion of this course, I expect you to be able to use the covered procedures intelligently. This includes (but is not limited to) the following competencies:

(1) Identify an experimental design from its description, including identifying sources of variance, deriving EMS, and identifying F-tests of SVs.
(2) Know nonparametric alternatives to ANOVA and what the relevant considerations are in selecting an appropriate data analysis procedure.
(3) Know how to run analyses on SPSS and how to use the output to get the information relevant to your questions. This includes being able to use the output to compute relevant tests when the tests are either not provided by SPSS or are wrong.
(4) Define relevant comparisons within a dataset and conduct the appropriate contrast procedures.
(5) Be able to compute appropriate measures of effect size and statistical power.
(6) Integrate the results of descriptive and inferential statistics conducted on a dataset and present the findings in English.
(7) Be able to study new, related statistical topics (e.g., latin-square designs) independently.

GRADING:

(1) Regular problem sets: These will consist of both computer problems and calculator problems. Problem sets will be ungraded, but they will be collected and checked on a weekly basis. Timely completion of problem sets is a ***requirement*** of the course. Failure to do them is grounds for receiving a "C" in the course even if exam work averages above a "C." ***Problem sets should be turned in to the TA by 6:00 on Monday.***

(2) Exams: Exams will usually be in-class, but I might decide to give a take-home exam with a computer component (or do a hybrid). Any in-class exams will allow you to bring a "cheat sheet", calculator, and relevant tables to exams. Assuming that you have fulfilled the requirement to turn in problem sets, your grade in the course will be based on your exam performance. The exams will not contribute equally in the computation of your final grade; rather, they will be weighted in approximate proportion to the number of problem sets associated with the exam. IFF we keep to the pace outlined in this syllabus, the weighting will be 35% for Exam 1; 25% for Exam 2; 30% for Exam 3; 10% for Exam 4. (The final will NOT be cumulative.) If the pace of the course changes from that assumed in constructing the "schedule of problem sets," there will be appropriate changes in the weighting of the exams. My cutoff for an "A" is 90%; my cutoff for a "B" is 80%; my cutoff for a "C" is 70%.

Topics and Readings

Preliminaries

This section of the course outline refers to just the initial class. The "real" coverage begins with the next section of the outline.

Reading: Read Chapter 2 preprint in the supplementary reading this week; read other chapters as indicated in the outline below.

I. Overview of the Course
   A. Organization is primarily by experimental design
   B. Organization within design will be basically the same
      1. How to generate appropriate descriptive statistics for the design
      2. How to conduct and interpret the ANOVA for the design
      3. How to conduct comparisons of conditions within the design
      4. How to compute power and effect-size
      5. Nonparametric alternatives to analyzing the design
   C. Philosophical Approach
      1. What it ain't
      2. What it is

Section 1: Completely-Randomized Designs

The first section of the course will introduce you to the most basic experimental design that we will consider in the course. I have several goals in this section of the course. (1) The first is to indoctrinate you into my model of how to do experimental design and data analysis. (2) We will consider the roles of descriptive statistics. (3) We will look at the inferential model underlying the ANOVA and the corresponding computations. (4) We will learn the basics of SPSS for generating both descriptive statistics and ANOVAs. (5) We will consider power and effect-size. (6) We will look at the assumptions of the ANOVA, how to evaluate them, and alternative analyses when ANOVA is not adequate.

Ia. Preliminaries: Descriptive Statistics by Condition
- A. Description of design and information of interest
- B. Understand your data first — **Read Ch. 2**
  - 1. Descriptive statistics broken down by condition — **Handouts 3 & 5**
  - 2. Observations of interest?
    - a. Understanding how the results may differ across conditions
    - b. Evaluating assumptions of ANOVA

Ib. More preliminaries: The logic of statistical inference
- A. The binomial distribution as a sampling distribution
- B. Hypothesis testing based on the binomial
- C. Power based on the binomial

II. The Single Factor Design
- A. The inferential test — **Read Ch. 8**
  - 1. Hypotheses being compared — **Handout 6**
  - 2. The basic computations and an intuitive logic
  - 3. The formal logic
    - a. The underlying theoretical model
    - b. The Expected Mean Squares (EMS)
    - c. The ANOVA table
  - 4. Using SPSS to do the ANOVA
- B. Assessing effects
  - 1. Effect size (ω^2 and f) — **Handout 7**
  - 2. Power — **Handout 8**
- C. Assumptions of the F-test — **Handout 9**
  - 1. The basic assumptions
  - 2. Violating assumption of normality
    - a. Kruskal-Wallis H test & the Rank-Transform F test
  - 3. Violating assumption of homogeneity of variance
    - a. Welch and Brown-Forsythe tests

III. The 2-Factor, Completely Randomized Design **Read Ch. 11**
- A. Overview and example **Handout 10**
- B. Partitioning the variability
  1. Informally
  2. The formal model
- C. The analysis as summarized by the ANOVA table
  1. SS; df; MS; EMS; F-tests
- D. The 2-factor interaction
  1. Defining it
  2. Understanding and describing it
  3. Integration of the results of all 3 tests

IV. The 3-Factor Design **Read Ch. 12**
- A. Overview and example **Handout 11**
- B. Partitioning the variability
- C. The analysis as summarized by the ANOVA table
- D. The 3-factor interaction
  1. Defining it
  2. Understanding and describing it
  3. Integration of the results of all 3 tests

V. Other Issues Associated with Multifactor Designs
- A. Effect size and power **Handout 12**
- B. More than 3 factors?
  1. Pooling sources of variability: What? When? Why? **Handout 13**
- C. Unequal cell sizes **Handout 14**

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EXAM 1 approximately Sept. 27

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Section 2: Contrast Procedures and Trend Analysis

The tests in ANOVA usually don't provide sufficiently specific information about the pattern of differences among means. Therefore, we usually need to complement the analyses you've learned to this point with additional tests to pin down the specific pattern of means and/or test specific hypotheses. That is the focus of this section of the course. The main themes are: (1) How do you compute contrasts within an experimental design? (2) What is "familywise error rate" and why should you care? (3) How do you control FWE? (4) When, why and how would you do "trend analyses"?

I. Contrasts Within a Single Factor Design **Read Ch. 9**
- A. Procedures Based on the t-distirbution **Handout 16**
  1. Definition of a linear combination/contrast
  2. Hypothesis-testing
     - a. General form of the t-test
     - b. Standard error when variances are homogeneous
     - c. Standard error when variances are heterogeneous
  3. Confidence intervals
- B. Controlling familywise error rate **Handout 17**
  1. What is the unit of control?
  2. Procedures for planned comparisons
     - a. Dunn-Bonferroni
     - b. Dunn-Sidak
     - c. Hochberg's sequential method
  3. Procedures for unplanned comparisons
     - a. Pairwise comparisions (several procedures)
     - b. Comparing treatments with a single control (Dunnett)
     - c. Complex, *post hoc* comparisons (Scheffe; Brown-Forsythe)
- C. Using SPSS to help
  1. See handout on "Controlling FWE Over Families of Contrasts"
  2. SPSS will compute the t-values for you
  3. You usually must evaluate the significance of a computed t-value

II. Trend Analysis **Read Ch. 10**
- A. Single factor design
  1. When is trend analysis applicable?
  2. Hypothesis tests: t-tests and F-tests
  3. Estimating the population function and plotting it
- B. Using SPSS to do trend analysis

III. Contrasts Within Multifactor Designs
- A. Analyzing main effects
- B. Analyzing interactions
- C. Trend analysis

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EXAM 2 approximately Oct. 25

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Section 3: Repeated Measures, Mixed Factors, and Hierarchical Designs

This section will greatly expand your arsenal of experimental designs. In addition to the three classes of designs named in the title to this section, we will also briefly study Treatment x Blocks designs and designs with concomitant variables (i.e., Analysis of Covariance). Not at all incidentally, we will consider some of the connections (1) between design choice and power, and (2) between design choice and statistical procedure. We will also introduce an important distinction between types of variables (fixed vs. random effects) and types of relationships between variables (crossed vs. nested) and the consequences of those distinctions for analyses. The centerpiece of much of this section is the RM design. We will introduce the design in the context of comparisons with TxB and ANCOVA. The distinctions between types of variables and types of relationships between variables will be introduced in the context of RM designs. And RM designs lead easily into Mixed Factors and, then, Hierarchical designs.

I. Three Design Approaches to Improving Efficiency and Statistical Power **Handout 18**
   A. The relative inefficiency of the CR design
   B. Alternative #1: Introducing factors to reduce error variance
      1. Treatment x Blocks design **Handout 19**
      2. How it works
      3. How to implement it
   C. Alternative #2: Measuring concomitant variables **Read Ch. 15**
      1. ANCOVA
      2. How it works
      3. How to implement it
   D. Alternative #3: Matching
      1. The Repeated Measures design
      2. How it works
      3. How to implement it

II. Repeated Measures Designs: The Basics **Read Ch. 13**
   A Single factor RM design **Handout 22**
      1. Model and analysis
      2. Var/Cov matrix and EMS
         a. Additivity vs. nonadditivity
         b. Validity of the **F**-test and other issues
   B Multifactor RM designs with fixed-effects factors
      1. SxAxB with A and B fixed effects

III. Repeated Measures Designs: Beyond the Basics
   A. The distinction between fixed-effects and random-effects variables
      1. What is the distinction and why is it important?
      2. Analyzing SxAxB with A fixed and B random
         a. Approaches to testing A (pedagogical)
         b. Approaches to testing A (practical)
   B. The distinction between crossed vs. nested relationships between variables
      1. What is the distinction and why is it important?
      2. Analyzing a design with a nested variable

IV. Other Issues in the Analysis of Repeated Measures Designs
- A. Contrasts in RM designs
  1. Procedures if sphericity assumption met and only Ss are random
  2. Procedures if nonsphericity and only Ss are random
  3. Procedures if Ss and Items are random effects
- B. Getting measures of effect size for simplest case (one factor, Ss random)
  1. Computing partial omega^2 **Handout 21**
  2. Computing Cohen's ***f***
- C. Computing power using GPOWER (only Ss considered random)
  1. *Post hoc* calculations
  2. *A priori* calculations
  3. Complications introduced by nonsphericity
- D. Nonparametric alternatives to the RM ANOVA
  1. Friedman's ^{2} Test and Rank-Transformation F test
  2. Wilcoxon Signed-Rank Test
  3. Cochran's Q Test

V. Mixed Factor Designs **Read Ch. 14**
- A. One between-Ss and one within-Ss factor **Handout 23**
  1. Model and analysis
  2. Rules for generating EMS
- B. More complex designs
- C. Effect size and power
- D. Conducting contrasts and controlling FWE in mixed factors designs **Handout 25**

VI. Hierarchical Designs **Read Ch. 16**
- A. Nesting vs. crossing relationships again **Handout 26**
- B. Groups within treatments ("single nestings")
- C. More complicated nesting relationships ("double nestings")

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EXAM 3 approximately Nov. 29

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Section 4: Analyses of Frequency Data

In the final section of the course, we will look at Chi-square-based procedures for analyzing frequency data. We will consider the two main procedures for testing hypotheses – Goodness of Fit Test and Test of Association. We'll also look at measures of strength of relationship and measures of agreement. These procedures will be of practical value to several members of the class.

I. Goodness of Fit Test **Handout 27**

II. Test of Association **Handout 28**

III. Some Other Useful Analyses of Contingency Tables
   A. Strength of relationship
   B. Agreement

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EXAM 4 during regularly scheduled final exam period

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