SYLLABUS
EDUC/PSYCH 7780

Multivariate Statistics

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Time & Location: TU/TH 3:00 to 4:15 in EDUC-413C

Office hours: TBD

Required Texts: Stevens, James P. (2002). *Applied Multivariate Statistics for the Social Sciences*, 4th Edition. Mahwah, New Jersey: Lawrence Erlbaum Associates

Schumacker, Randall E., & Lomax, Richard G. A (2004). *A Beginner's Guide to Structural Equation Modeling.* 2nd edition. Mahwah, New Jersey: Lawrence Erlbaum.

Kreft, I., & De Leeuw, J. (1998). *Introducing Multilevel Modeling.* London: Sage.

Tabachnik, Barbara G., & Fidell, Linda S. (1996). *Using Multivariate Statistics.* 3rd Edition. New York: HarperCollins Publishers Inc.

Purposes

This course will enhance students' knowledge and understanding of multivariate statistics in the Social Sciences. Following a brief review of basic common principles of advanced statistical methods (including matrix algebra), the course will focus on: path analysis; multivariate ANOVA and ANCOVA; discriminant and cluster analysis; classical factor analysis techniques; hierarchical linear modeling.

Course Objectives

Providing basic knowledge about a wide variety of multivariate statistical methods, their purposes, and statistical algorithms; promoting a thorough understanding of the statistics and their meaning; enabling students to differentiate between these methods and their appropriateness for given research questions and data sets; promoting understanding, critical evaluation, and interpretation of statistical output as well as published research employing multivariate statistical methods.

Prerequisites

EDUC/PSYCH 6600 and 7610. These courses and their prerequisites must be taken prior to this course and cannot be taken concurrently. Students who have not taken EDUC/PSYCH 6600 and/or 7610 must provide the instructor with documentation of (an) equivalent course(s) taken at USU or elsewhere.

Course Objectives in Detail

1. Matrix Algebra

- Perform various matrix computations (addition, subtraction, and multiplication)
- Define and understand basic concepts in matrix algebra, such as:
  - Matrices and vectors, scalars
  - Transpose of a matrix
  - Matrix of variances and covariances
  - Determinant of a matrix
  - Minor of an element
  - Multivariate notation of variance
  - Inverse of a matrix
  - Eigenvalues
- Understand the central meaning of finding the inverse of a matrix in multivariate statistics
- Understand how to find the inverse of a matrix
- Apply matrix algebra to multiple regression

2. Path Analysis

- Develop a basic understanding of the structural equation modeling (SEM) approach to regression and path analysis
- Understand and define:
  - Causation assumptions and limitations
  - partial regression coefficients
  - Over- and under-identification of path models
  - non-positive definite corariance matrices
  - direct and indirect effects; total effects
- Re-write a regression model in path analysis notation
- Write model equations for diverse path models
- Determine the number of parameter estimates and the degrees of freedom for specific path models
- Explain and interpret SEM output
- Develop a graph of a model based on SEM output
- Evaluate the goodness of fit of a path model
- Identify and evaluate modifications that might be needed in order to improve the model fit of a path model

3. MANOVA and MANCOVA

- Describe the situations and reasons for preferring a Multivariate analysis
- Explain assumptions in MANOVA
- Describe the multivariate test statistic in a two-group MANOVA as a generalization of the univariate t-test (Hotelling's T)
- Calculate a two-group MANOVA
- Extend the two-group MANOVA to a multi-group design
- Become familiar with post-hoc procedures for a two- and multigroup MANOVA
- Perform two- and multi-group MANOVAs in SPSS and interpret the output.
- Perform and interpret multivariate planned comparisons
- Define and apply FACTORIAL MANOVA designs
- Discuss combinations of outcome variables for MANOVA designs
- Describe situations requiring Multivariate Analysis of Covariance and discuss it advantages
- Explain the adjustments of marginal and cell means in MANCOVA
- Perform and interpret a repeated measures MANOVA
- Apply and discuss covariates in repeated measures MANOVA
- Make informed decisions regarding the inclusion of (groups of) covariates in MANOVA designs
- Discuss limitations of MANCOVA designs

4. Discriminant Analysis (DA) and Cluster Analysis (CA)

- Identify research questions appropriate for DA
- Identify research questions appropriate for CA
- Explain Discriminant Analysis as a conversion of MANOVA
- Describe DA's rationale for defining group membership.
- Explain the number of discriminant functions in a particular analysis
- Interpret discriminant functions
- Graph groups in two-dimensional discriminant function plots
- Distinguish between types of DA's
- Evaluate the importance of predictors on DA outcomes
- Describe the use and aims of cluster analysis
- Describe the use of discriminant analysis if combination with cluster analysis
- Perform discriminant analysis via SPSS; summarize and interpret the output
- Perform cluster analysis via SPSS; summarize and interpret the results.

5. Hierarchical Linear Modeling (HLM)

- Define and provide examples for multilevel models; identify research designs that either require or qualify for multilevel modeling
- Define the following terms:
    - contextual models
    - intra-class correlation
    - fixed versus random coefficients
    - cross-level interactions
    - variance components
    - growth curves
- Write and interpret statistical model equations for Level-1 and Level-2 data
- Explain the decomposition of variation in a 2-level model
- Explain the difference between fixed and random multi-level models and the "slopes as outcomes" approach
- Prepare a data set for multilevel modeling
- Read multilevel data into the HLM software
- Create a program file for a pre-specified model
- Run the analyses and interpret the output
- Perform and interpret the results of non-linear multilevel models
- Compare null models to predictor models and interpret the difference in the outcome.
- Discuss group and grand mean centering options and explain their effects on the results of hierarchical linear models.

6. Factor Analysis (FA)

- Explain the function of factor analysis, and identify situations in which its use would be appropriate.
- Define:
    - Factors
    - Factor loading
    - Factor score
    - Uniqueness
    - Communality
    - Eigenvalues
    - Extracted variance
- Understand the statistical rationale for extracting factors
- Apply appropriate criteria for deciding on the number of factors
- Understand factor rotation techniques
- Compare and interpret printouts of various factor analyses.
- Explain the difference between principal components analysis and other factor analysis methods.
- Explain the difference between exploratory factor analysis and confirmatory factor analysis.

Assignments & Tests

Regular class attendance is expected and – based on prior experience – absolutely necessary to prepare for homework assignments and succeed in this class. Written homework assignments will be given each week and will be due one week later. Both the statistical correctness and the quality of interpretations and discussions will be evaluated in the returned homework assignments.

Exams are designed as “learning exams.” They are comprehensive and time consuming and typically substitute for homework assignments (i.e., simultaneous assignment of homework during exam weeks is avoided as far as possible). The exams are designed to be challenging and typically require correction. **Students will receive feedback on their work and have the opportunity to make suitable corrections in order to improve their scores.**

Students will have opportunities to analyze data and discuss the outcomes, including SPSS printouts, both orally and in writing. Thus, knowledge of the SPSS software is required.

Grading

Homework Assignments:
Homework assignments will have variable point allocation, dependent on the difficulty of the assignment and the amount of work involved. Point assignment will be disclosed in detail on the assignment at the time of its distribution. All points accrued through homework will be summed into a total score, which will converted into a percentage score (percentage correct).

Altogether, the points accrued though assignments determine **40 % of Total Grade**

Tests & Final	**% of Total Grade**
1. Matrix Algebra, Path analysis	20
2. MAN(C)OVA Designs, Discriminant & Cluster Analysis	20
3. Hierarchical Linear Modeling, Factor Analysis	20

Altogether, the scores obtained through tests determine **60% of Total Grade**

<u>Grading Scale</u>

Final grades will be based on the sum of all points accrued and adhere to the following scale:

A	95 - 100%	C+	78 - 79%
A-	90 - 94%	C	74 - 77%
B+	88 - 89%	C-	70 - 73%
B	84 - 87%	D+	68 - 69%
B-	80 - 83%	D	60 - 67%
		F	Below 60%

Changes in Course Assignments and Schedule:
The instructor reserves the right to adjust the course readings, assignments, tests, and schedule in order to best attain the objectives of the course. Any changes will be announced in class.

Grading Policy

Grading Policy for Assignments

1. Full points can only be earned for homework assignments RETURNED ON TIME. For each day the assignment is returned late, 12.5% of the points will be discounted.

   Example: Due date is Monday, January 23. Feedback is usually provided in the next session after the due date, which would be Wed., January 25.

   Scenario 1: You return your work on Tuesday, January 24; this means that you can only earn 100% – 12.5% = 87.5% of the points possible (which is equivalent to a maximum grade of B+ for this work).

   Scenario 2: You return your work on Wednesday, January 25, the day feedback will be given. This means that you can only earn 100% - 2*12.5% = 75% of the points for your work.
   In addition, the instructor will not be able to give you personal feedback on your work, which you might need to correct it properly.
   Another disadvantage is that the instructor will not be able to address particular problems that you had with these tasks in the feedback session!

   Scenario 3: You return your assignment on Thursday, January 26, after feedback was provided in class and the tasks were worked upon in class. No points will be awarded in this case! (see point 2).

2. Assignments will NOT be accepted once feedback is given and problems were discussed in class.

3. You are eligible for corrections of those tasks that you seriously attempted to solve. In order to prevent that assignments are returned "empty" because the student expects to be able to "correct" everything after feedback has been provided, the following rules will be applied:
   (a) Assignments that were returned with less than 50% correct will be subject of an overall discount of 10% of the points after correction.
   (b) Assignments that were returned with less than 80% of the tasks *even attempted* will be subject to an overall discount of 20% of the points after correction.

4. In order to fully update your points, you need to meet the deadlines set for the corrections of your work. **Typically, you have 1 week (7 days) for corrections after an assignment has been returned to you,** unless announced otherwise in class. If you need more time for corrections, please inform the instructor and agree on a new deadline in order to be eligible for full points.

5. If you miss the **deadline for *corrections***, 10% of the points earned through your corrections will be discounted for each day you submit late.
   Example: In your first attempt, you achieved 70% of the points. Your subsequent corrections add 25% to your points (lifting your score to 95% correct). However, because your corrections were submitted 2 days late, only 80% of the additional 25 percentage points will be granted, reducing your overall score to 90% correct).

<u>Grading Policy for Exams</u>

Exams typically require applying the exercises trained in assignments to new problems with the aim to demonstrate mastery of the topics covered in class. At the time of the exam, you are expected to have obtained the knowledge to complete these tasks independently and correctly.

Accordingly, stricter rules are applied to exams: Only 50% of the points missed on exams can be regained through corrections.

Further, the following rules apply to remain eligible for point updates:

1. 50% of the missed points can be regained for exams **RETURNED ON TIME**. No grace period for late exam submission!!!
2. Minimum requirements to be eligible for reworks:
   (a) You need to have at least 60% of the points earned in your first attempt.
   (b) You can only update exam tasks that you attempted to solve.
3. You need to meet the deadlines set for the corrections of your work. Except for the final exam, you **typically, you have 1 week (7 days) for corrections after receiving feedback,** unless announced otherwise in class. If you need more time for corrections, please inform the instructor and agree on a new deadline.
4. If you miss the **deadline for *corrections***, 10% of the points earned through your corrections will be discounted for each day you submit late.
   Example: In your first attempt, you achieved 80% of the points. In your subsequent corrections, you show a perfect performance, but you can only add 10 points (50% of the 20 points) to your exam, (lifting your score to 90% correct). . However, because your corrections were submitted 2 days late, only 80% of the additional 10 percentage points will be granted (8 out of 10), reducing your overall score to 88% correct.

Course Schedule

Week	Date	Topics	Readings & Assignments (A)
1	Aug. 26/28	Introduction, Matrix Algebra	Stevens-Chapter 2,Handout, **A1**
2	Sep. 02/04	Matrix Algebra applied to multiple regression	Stevens-Chapter 2, Handout; **A2**
3	Sep. 09/11	Path analysis	Schumacker – Chapter 2, Handout, **A3**
4	Sep. 16/18	Path analysis continued	Schumacker – Chapter 2, Handout, **A4**
5	**Sep. 23/25**	Review Matrix Algebra, Path analysis -- **Exam I** Two-Group MANOVA	***Exam I due: Sept. 30*** Handout, Chapter 4, Stevens
6	Sep. 30/Oct. 2	Multi-group MANOVA; Assumptions in MANOVA,	Stevens, Chapter 5 & 6, Handout, **A5**
7	Oct. 07/09	Factorial MANOVA,MANCOVA,	Stevens, Chapter 8 (385-414) & 9, Handout, **A6**
8	Oct. 14/16	Multivariate Repeated Measures ANOVA; Discriminant Analysis	Chapter 13, 7, Stevens, **A7**
9	Oct. 21/23	Discriminant Analysis continued; K-Means Cluster analysis;	Chapter 7, Stevens, Handout, **A8**
10	Oct. 28/30	Review MANOVA Designs, Discriminant and Cluster Analysis – **Exam II** Hierarchical Linear Modeling - Introduction	***Exam II due: Nov. 4*** Kreft, Chapter 1, Handout,
12	Nov. 04/06	Hierarchical Linear Modeling	Kreft, Chapter 2, Handout, **A9**
12	Nov. 11/13	Review Exam II Hierarchical Linear Modeling & programming	Kreft, Chapter 3 & 4, HLM Manual, Handout, **A10**
14	Nov. 18/20	Hierarchical Linear Modeling, HLM programming	Kreft, Chapter 4, Handout; HLM Manual, **A11**
15	Nov. 25	Factor Analysis, PCA vs. FA	Chapter 13, Tabachnik & Fidell, Handout, **A12**
15	***Nov. 27***	***Thanksgiving Holiday – no class***	
16	**Dec. 02/04**	Factor analysis continued, Review HLM, FA, **Exam III**	***Exam III due date: Dec. 08***
17	DEC 08-12	Final's week	***Feedback Exam III***

Plagiarism

Plagiarism is considered academic dishonesty or academic fraud and is concerned with the issue of false attribution. The UNC Honor Court defines plagiarism as "the deliberate or reckless representation of another's words, thoughts, ideas as one's own without attribution in connection with submission of academic work, whether graded or otherwise." (*Instrument of Student Judicial Governance*, Section II.B.1.). Plagiarism has serious consequences, which may include grade adjustment, academic failure, probation, expulsion, and denial or revocation of academic degrees.