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AUTHOR	Penfield, Douglas A.
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ABSTRACT

Thirty-four papers on educational statistics which were presented at the 1971 AERA Conference are summarized. Six major interest areas are covered: (a) general information; (b) non-parametric methods; (c) errors of measurement and correlation techniques; (d) regression theory; (e) univariate and multivariate analysis; (f) factor analysis. (MS)

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March 1972

EDUCATIONAL STATISTICS

Douglas A. Penfield

ERIC Clearinghouse on Tests, Measurement, and Evaluation

PREVIOUS TITLES IN THIS SERIES

1. Developing Criterion-Referenced Tests
   ED 041 052

2. Test Bias: A Bibliography
   ED 051 312

3. Ability Grouping: Status, Impact, and Alternatives
   ED 052 260

4. Developing Performance Tests for Classroom Evaluation
   ED 052 259

5. Tests of Basic Learning for Adults: An Annotated Bibliography
   TM 000 987 (ED number not yet available)

6. State Educational Assessment Programs: An Overview
   TM 001 024 (ED number not yet available)

7. Criterion Referenced Measurement: A Bibliography
   TM 001 046 (ED number not yet available)

INTRODUCTION

About 575 of the 700 papers presented at the 1971 AERA Annual Meeting in New York City were collected by the ERIC Clearinghouse on Tests, Measurement, and Evaluation (ERIC/TM). ERIC/TM indexed and abstracted for announcement in Research in Education (RIE) 175 papers which fell within our area of interest - testing, measurement, and evaluation. The remaining papers were distributed to the other Clearinghouses in the ERIC system for processing.

Because of an interest in thematic summaries of AERA papers on the part of a large segment of ERIC/TM users, we decided to invite a group of authors to assist us in producing such a series based on the materials processed for RIE by our Clearinghouse. Five topics were chosen for the series: Criterion Referenced Measurement, Evaluation, Innovation in Measurement, Statistics, and Test Construction.

Individual papers referred to in this summary may be obtained in either hard copy or microfiche form from:

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Editor, ERIC/TM

Educational Statistics

The 1971 meeting of the American Educational Research Association brought forth a wide variety of research papers in educational statistics. Since the papers were unsolicited, they should represent a good indication of the topics in statistics that are receiving the attention of the behavioral researcher at the present time.

As I spread the thirty-five papers out over my living quarters it became apparent that there was a wide diversification among the topics being covered. For discussion purposes, I have divided the papers into six major areas of interest: a) general informational and miscellaneous topics, b) non-parametric methods, c) errors of measurement and correlation techniques, d) regression theory, e) univariate and multivariate analysis, and f) factor analysis. There are instances when a paper spans more than one area or does not quite fit into any of the six selected areas. As a general rule, the paper is assigned to the area which comes closest to representing its central theme.

If there is power in numbers, the two research techniques receiving the most attention at the conference were factor analysis and regression theory.

A. General Informational and Miscellaneous Topics

The papers in this area tend to be informational by nature of the fact that they discuss a particular statistical methodology, recommend specific teaching or research procedures, or underscore errors frequently encountered in the interpretation of experimental data.

As an introduction, Cassel lists 12 Research Statistical Tools (RSTs) necessary for accomplishing and understanding general research methods. These tools encompass basic hypothesis testing procedures such as chi-square, analysis of variance and nonparametric tests as well as measures of correlation, factor analysis, discriminant analysis and canonical correlation. The author acknowledges the computer as being an essential ingredient in using the 12 RSTs. Because of this needed competency in computer applications, students are encouraged to learn FORTRAN programming and to be able to interpret statistical printouts.

As a strategy for handling research problems Meyer makes an appeal for an increased emphasis upon Bayesian methods. He points out the difficulties in the interpretation of parametric confidence intervals and tests of significance, and maintains that tests of significance are usually a waste of time. His contention is that the personalistic approach to probability offers a more logical explanation for results and, when accompanied by repeated experimentation, is the preferred method. In layman's terms, the paper is interesting reading and offers some thoughtful points in favor of Bayesian methods.

The Delphi Process as a group method of collecting anonymous opinions and providing for controlled feedback is discussed by Waldron. The title of the paper, "The Delphi Process: Some Assumptions and Some Realities," is somewhat misleading since little attention is paid to describing the process. Instead, the Delphi Process is used as a tool for investigating the effect of immediate and delayed feedback upon the behavior of individuals of high and low integrative complexity. In addition, Waldron looks at the relationship between integrative complexity, estimations about the time of occurrence of future events, and the effects of time delay between task completion and controlled feedback.

The conclusions are that differential time delay does have an effect on performance with low integratively complex people being most affected. Low integratively complex people also show more of a tendency to change in the direction of external feedback than do high integratively complex people. The experiment is well defined and provides an interesting example of a group process that is receiving more and more attention these days.

A discussion of the sampling unit in an experimental study, the validity of the design, and the appropriateness of the reliability coefficient is presented by Maxey in a paper entitled "Analysis of Observational Data." For purposes of illustration a simulated experiment dealing with the effects of observational training on teacher performance is analyzed completely. The author then proceeds to criticize the study with respect to the appropriate degrees of freedom for the sampling unit under investigation, the validity of the dependent variable for evaluating the hypothesis under test, and the reliability coefficient chosen to judge the data. The presentation may cause some to sit back and reflect upon their own research. Notably Maxey's example demonstrates the importance of choosing the correct sampling unit in an experimental study.

Delving into the area of sampling, Petersen and Anderson investigate the equivalency of item and student sampling on the structure of college student attitudes. Using a pool of items from the Campus Environment Study, data from item samples is factor analyzed to 1) look at the similarities between item and student sampled data, 2) check for representativeness of the item sampled factors in the _a priori_ environment, and 3) investigate item congruency within factors.

Attitude results from item sampling are found to be consistent with student sampling. Factors for the two types of sampling are identified and compared. Some consistency between item loadings determined from item sampled and student sampled factors was found. Without doubt, a method for obtaining reliable results based upon a reduced sample would be of widespread interest to behavioral researchers.

Missing data can turn a well designed experiment into a nightmare. Chen attempts to add some insight into this problem by extending Guilford's rating adjustment technique to the situation where not all the raters judge all ratees. Three methods of estimating missing data are discussed. Two of the methods are attributed to Winer and one to Yates. Using an example from Guilford's work, specific data points are assumed to be missing. The three methods are then used to determine their ability to estimate the missing observations. Yates' procedure was judged to produce the most accurate estimates for this example. Analysis of variance tests are then performed on the original data as well as on the data containing the estimated values found using Yates' procedure. The results prove to be consistent, but the scope of the study seems too narrow to provide reliable generalizations.

B. Nonparametric Methods

It appears that distribution-free statistics are still not receiving the attention afforded parametric methods. Perhaps their advocates should join forces with the Bayesians to fight the battle. At the conference seven different parametric tests were discussed and in most instances compared with each other or corresponding parametric procedures.

Keats and Brewer have developed a distribution-free index for determining whether one mathematical model gives a better fit to a set of data points than another. Assuming the subjects' scores are collected over n trials, the procedure allows for differential weights to be applied at each trial point. Once the weights are applied, a goodness-of-fit index is computed for comparison purposes. This index is a function of the number of models being compared, trial weights, and a model rank for the i^{th} trial. Three different weighting functions are presented along with an example showing the use of the index in the comparison of three learning models. The procedure should be most useful to the researcher who, given the alternatives, must choose a model which will provide the most precise information about his experimental data.

A rigorous presentation on the relative power of three non-parametric tests for small sample sizes as well as a comparison of this power to corresponding parametric analogues is given by Porter and McSweeney in their paper, "Comparison of Rank Analysis of Covariance and Nonparametric Randomized Blocks Analysis." The three nonparametric tests discussed are the Kruskal-Wallis test, Friedman's test, and Quade's ANCOVA. Monte Carlo studies for small samples were conducted on each of the three nonparametric tests and their parametric counterparts. Empirical estimates of the probability of a Type 1 error and power were obtained for evaluation purposes. Comparisons are made among the nonparametric tests and also between corresponding nonparametric and parametric tests. In general, the authors found that, for the nonparametric tests, Quade's ANCOVA is more powerful than Friedman's test. As the relationship between the dependent variable and a covariate increases, the parametric ANCOVA becomes more powerful than Quade's ANCOVA. From our knowledge of power, this result is not unexpected. Excellent use has been made of the computer for comparison purposes along with a lengthy and thorough discussion of the results. This paper is particularly useful as an example of how to construct a good Monte Carlo study.

A nonparametric test for symmetry using absolute normal scores in place of the customary sign or rank substitutions is discussed by Penfield and Sachdeva. This test utilizes the expected order statistics for a sample of absolute values from the standardized normal distribution. The sign and Wilcoxon tests are compared and contrasted to the absolute normal scores test. Two examples are presented illustrating the large and small sample use of the test. For the nonmathematical researcher who relies heavily upon worked-out examples to familiarize himself with a new test, this paper may be very helpful. Symmetry tests can be used in two ways: 1) to determine whether a sample is representative of a population known to be symmetric around a median theta, or 2) to test for the symmetry of a population around theta using sample data.

Toothaker investigates empirically the effect of unequal variances and sample sizes on the two sample permutation t-test. Using a computer to generate sample results, comparisons are made between this test, Student's t-test and the Mann-Whitney U-test with respect to Type 1 error and power. A normal as well as skewed population are under investigation. Relative to Type 1 error, the permutation t-test and Student's t-test are reasonably close with the skewed population producing values of a Type 1 error smaller than expected. If the sample sizes are directly proportional to the variances, the power of the permutation t-test is superior to Student's t-test. If they are inversely proportional, Student's t-test is the better test.

The final paper in the nonparametrics area is Timm's introduction of Neyman's restricted chi-square test to a behavioral audience. This test is compared with the conventional chi-square test of independence developed by Pearson and used to analyze contingency table data. It extends the analysis of categorized data by restricting the class of admissible hypotheses. An example is presented showing a use for the restricted chi-square test along with a brief discussion of power. The paper is crisp, to the point, and most informative for those having a firm grounding in basic statistical theory.

C. Errors of Measurement and Correlational Techniques

The primary emphasis of papers in this section is upon errors of measurement and how they affect both measures of relationship and certain multivariate hypothesis testing procedures. The authors also touch upon assumption violations when testing hypotheses about the correlation coefficient, provide a derivation of the extension of the correlation ratio to multivariate analysis of variance, and explain a use for the polychoric correlation coefficient.

Stanley and Livingston discuss the attenuating influence of errors of measurement in the dependent variable on some well-established measures of relationship. Assuming some prior exposure to these measures, the authors present a brief description and comparison of eta squared, epsilon squared, omega squared and intraclass r. This is followed by a discussion of the corresponding formulae when corrected for attenuating errors of measurement.

As an extension of this process, Edwards describes and clarifies the correction for attenuation formulae for partial, multiple and canonical correlation coefficients. A general rule to follow regarding the correction of multivariate correlations for attenuation is to correct each of the zero-order correlations and then compute the desired statistic from the adjusted fallible correlation matrix. Edwards gives a thorough explanation of the effects of measurement error on each of these coefficients plus a derivation of the adjusted formulae. He concludes that lack of a correction for attenuation will produce a statistic which will underestimate the true value of the relationship and may produce an invalid interpretation of the results. These last two papers complement each other beautifully and help to consolidate pertinent information in this area.

Working within multivariate methods, Porter explores the properties of ANOVA, regression analysis, ANCOVA, and factor analysis when used to analyze variables which contain errors of measurement. His results show that in each case these errors were found to have at least one negative effect on the model. Factor analysis is dealt with initially and errors affecting the value of the correlation coefficient are identified. A number of suggestions are made regarding the use of factor analysis as a tool for investigating the latent structure of variables. For regression analysis, three basic types of regression relationships are presented with the discussion centered around structural relationships. The paper is well-executed and contains an excellent bibliography.

Returning to measures of relationship, Smith examines the use of eta squared as a measure of the strength of relationship between independent and dependent variables in the fixed effects multivariate case. Using the multivariate general linear model and matrix algebra, the author develops the formulation needed to determine eta squared for both the orthogonal and non-orthogonal situations. An adjustment is made in the multivariate sum of squares in order to account for the covariation between dependent variables. Thus the potency of a single dependent variable can be examined with the possible confounding effect of other dependent variables removed.

Every parametric test has certain assumptions which researchers perpetually violate. Numerous studies have been conducted to estimate the detrimental effect of these violations and in most cases the tests are found to be robust.

With reference to correlation coefficients, Brown and Lathrop have studied the effects of non-normality of the marginal distributions on correlational tests of signficance. Introductory remarks about the sampling distribution of r for one and two samples are followed by a Monte Carlo type sampling experiment involving eight populations having different values of skewness and kurtosis. Using these populations, samples are drawn via a computer and three types of z transformations are computed and compared. The authors conclude that as rho increases, the effect of non-normality becomes more pronounced with the variance of the sampling distribution being most affected. The study is well designed and much broader in scope than most undertakings of this kind.

The last paper in this series is a thorough discourse on estimating moral judgment development. It is included in this section because it contains the derivation of a new form of polychoric correlation coefficient used to determine levels of moral judgment. Lieberman first discusses Piaget's and Kohnberg's conception of moral judgment and then derives formulae for computing stage boundaries, discrimination power, and latent trait value parameters using maximum likelihood procedures. The mathematics is very complex and requires a thorough grounding in advanced statistical theory for comprehension. The author includes in this extremely rigorous and extensive presentation an example using British and American samples to illustrate the calculations and to show that his model is well-suited for handling the data.

D. Regression Theory

The papers on multiple linear regression are concerned more with applications than theoretical considerations. The scope extends from an elementary presentation on the use of directional hypotheses to an empirical validation of a theorem devoted to confirming causation. Topics sandwiched in between include a modification of the Gauss-Jordan procedure for computing regression coefficients, a regression model for predicting federal aid allocations to local school districts, and a test for homogeneity of regression line slopes.

A discussion of directional versus non-directional hypothesis testing for two sample means, one sample correlations, and homogeneity of regression on two samples is presented by McNeil and Beggs. The authors suggest that many researchers define their hypotheses in a directional fashion, but perform a non-directional test. This tends to double the actual probability of a Type 1 error. Since the desired outcome of hypothesis testing is generally rejection, if the researcher chooses a one-tail instead of a two-tail test for a given alpha level, he can increase his chances of rejecting the hypothesis under test. The paper can be easily read by students taking an introductory course in the design of experiments.

Roscoe and Kittleson present a computer program for calculating multiple regression coefficients when there is a linear dependency among variables. A modification of the Gauss-Jordan procedure replaces the customary iterative process with a procedure which assigns a zero weight to each redundant variable. Using matrix algebra, the rationale for the computer program is presented along with an actual listing of the FORTRAN statements. The paper is well-structured, the rationale is clear, and the actual computer program is there for those interested.

A study to determine which of twenty-nine community characteristics were the best predictors of per pupil federal aid in Connecticut was carried out by Gustafson. In place of a full regression model using all predictors, three restricted regression models are developed and cross validated. The purpose of cross validation is to predict future or past funding levels and compare them to actual federal aid grants. One model uses only predictors which reduce the standard error of estimate, a second multiplies the predicted vectors by a constant, and a third involves a comparison of the standard error of estimate and the standard deviation of the criterion. Of the restricted models, the second model proves to be the best. When compared with the full model, the restricted models, using a limited number of predictors, yield higher cross-validated correlations and smaller standard errors.

If your interest is in assumption violations, Borich develops the procedures for testing slope homogeneity in multiple regression equations. After reviewing the homogeneity of regression lines test for one covariate, the author extends the notation to handle the case of multiple covariates. When the treatment slopes determined from multiple covariates are not found to be equal and the covariates influencing interaction are to be identified, a partial hypothesis model can be put to good use. This test combines treatments for one covariate and allows the remaining covariates to vary at will. An example is used to illustrate a need for testing partial hypotheses. By simply usurping pertinent sums of squares from a standard regression program, a professor teaching regression theory could easily make this test part of his course content.

Along the same lines as Borich, Forster explores methods for handling curvilinearity, covariable effectiveness, and treatment-covariable interaction under a covariable model. Assumptions underlying this model are discussed in detail. The author then mathematically derives the generalization of Johnson and Neyman's test procedures for detecting treatment-regression interactions across n covariates and k groups. This test is used when the regression lines are not homogeneous and thus ANCOVA is inappropriate. It also enables the researcher to determine if there are regions identified by covariable scores where the treatments differ in effectiveness.

Most instructors teaching correlation and regression methods try to avoid the topic of causation as if it were the plague, asserting that it is impossible to be completely certain that a final effect is due to some hypothesized cause variable. Nevertheless, Nigro proposes a theorem whereby four inequalities are used to confirm causal directions for three-variable paths in a closed system of five variables. The four inequalities define relationships between specific beta weights and partial correlation coefficients for uniformly distributed data. A computer was used to generate and analyze data and it is concluded that the theorem proved reliable for confirming hypothesized causal direction of three-variable paths in a closed system of five variables. The four inequalities define relationships between specific beta weights and partial correlation coefficients for uniformly distributed data. A computer was used to generate and analyze data and it is concluded that the theorem proved reliable for confirming hypothesized causal direction of three-variable paths.

E. Univariate and Multivariate Analysis

The papers in this section cover topics within such areas as analysis of variance, analysis of covariance, time series analysis, and discriminant analysis.

The material is so diverse that is it virtually impossible to make internal comparisons.

A must for the student having difficulty understanding the concept of a statistically significant interaction is the paper by Levin and Marascuilo entitled "Interactions Revisited." The authors discuss some of the erroneous procedures used by researchers in attempting to explain the meaning of a significant interaction. These inaccurate conclusions are classified as Type IV errors. Briefly, a Type IV error is an incorrect interpretation of a significant result. The meaning of a significant interaction is explained for 2x2, IxJ, 2^k, and IxJxK designs. Discussion centers around identifying the interaction parameters of the model which define contrasts of interest. The paper is easy to read and contains some excellent examples to illustrate the points in question.

Proceeding into the realm of analysis of covariance, Knapp and Schafer derive the relationship between the two-sample t-test performed on gain scores and the analysis of covariance F-test for the pretest-posttest control group design. Prior to this the analysis of covariance F statistic is shown to be a function of the variance about the regression line for the total sample and the variance about the within-group regression line. Even though the information is not new, the nature of the derivations and final notation may prove to be somewhat different from what is normally encountered by researchers.

A description of the relationship between experimental and correlational methods using a rank reduction theorem developed by Guttman is presented by Pruzek. In this instance, experimental methods consist of univariate and multivariate analysis of variance and analysis of covariance; correlational methods encompass simple, partial, multiple and canonical correlations. All relationships are algebraically derived with a heavy emphasis placed upon the use of matrix algebra. Following the formal presentation of derivations, a computer program is described which will analyze data via Guttman's theorem. Two examples are presented in order to illustrate the process. To understand this paper completely, one must have a very thorough knowledge of matrix algebra.

Without a doubt, one of the areas in statistics which will receive more and more attention in the future is time series analysis. A formulation of the integrated moving time series model based upon the work of Box and Tiao is given by Gullickson, Nelson, and Glass. Taking the standard time series equation, the authors put the equation into matrix form and derive least square estimates for the unknown parameters. Following the development of the general linear model, violations of the homogeneity of variance assumption within each treatment level are investigated. The conclusion drawn is that when homogeneity of variance is suspect, one should choose a conservative significance level to test for treatment effect. In general, however, the model appears to be robust to heterogeneity of error variance. For the researcher coming to grips with time series analysis for the first time, this paper will provide valuable insight into an extremely complex situation.

When analyzing multivariate data, Huberty presents some useful alternatives for reducing the number of variables in a multiple group discriminant analysis. The variable selection procedure is carried out through an assessment of beta weights, F-ratios, stepwise values, component loadings, factor analytic-discriminatory correlations, and variable-DF correlations. Data from two experiments is used to calculate the values associated with each of the selection procedures. One example has two groups and the other five groups. Cochran's Q test was employed to compare the accuracy of the selection criteria relative to its ability to classify individuals into their respective groups. Based upon results from the examples, the stepwise method proved to be the best discriminator.

F. Factor Analysis

In this final section, factor analysis has been used as a catch-all term to cover such techniques as cluster analysis, principal components, and the standard forms of factor analytic theory. Most of the papers are quite technical and require a firm grounding in matrix algebra for comprehension.

For those interested in grouping students into homogeneous clusters on the basis of a set of test results, the paper by McRae will prove valuable. A number of clustering criteria for partitioning N subjects into g groups are considered. Settling upon an iterative K- means algorithm, the author describes a computer program, MIKCA, used to generate the clusters. The program has flexibility in that it allows the user to specify one of three distance functions to be used in the iterative process. To illustrate the procedures developed in the program, two data sets are analyzed completely.

The problem of missing data in a principal components analysis is tackled by Remer and Burton. Through the use of artificial data from which scores have been systematically deleted, four different methods of estimating missing data are contrasted. The four methods are: means substitution, simple regression, stepwise regression, and multiple regression. The BMD computer program series was employed to perform the data analysis. Using cross-correlations between corresponding principal component scores to assess goodness-of-fit, the solutions derived from the four methods of estimating missing data are compared to the complete data solution. All methods tend to give consistent results with the multiple regression technique being the most precise.

Dziuban and Denton investigate some empirical relationships between latent class structure and factor analysis. Using a joint occurrence probability matrix previously cited in the literature and known to contain 3 latent classes, the authors observe the difference in outcomes between three factoring methods when they are used to analyze three types of recurring subscript elements. The three factoring methods are alpha, uniqueness rescaling, and image. In all cases the alpha procedure extracts two factors, the uniqueness rescaling and image methods took out from three to nine components, depending upon the type of recurring subscript elements employed. At no time did the raw or rotated pattern matrices closely approximate the known latent class structure. Obviously a transformation other than an orthogonal rotation is needed.

Hofmann acquaints researchers with some of the general properties of the obliquimax transformation. Referring to Thurstone's method of determining oblique transformations, Hofmann modifies this procedure to produce the simplified obliquimax. This transformation does not depend upon an oblique simple structure criterion, yet it does provide a reliable oblique transformation procedure for some data. The paper is divided into three components covering Thurstone's method of determining oblique transformations, the theoretical aspects of the general obliquimax model, and the development of the simplified obliquimax transformation. Examples are presented in order to clarify many of the theoretical properties of the transformation. The paper is an exceedingly thorough and sophisticated discussion of one aspect of factor analysis.

The last two papers in the series are very much related and primarily the work of Hakstian. As an alternative to the standard oblique quasi-procrustean procedure which will identify factor variables which (1) are consistent over other transformations of the unrotated matrix, and (2) provide a clear resolution of the factor structure. Once consistent (salient) variables for factors have been isolated, a technique known as the maximal mean difference criterion is used to obtain a solution. This procedure is applied to three data sets, each with a well-known structure. Comparisons are then made between the graphic, quasi-procrustean, and Harris-Kaiser solutions. All three methods are found to give consistent results, which suggests that there is some merit for the maximal mean difference criterion.

As a further investigation into the workings of factor theory, Hakstian and Boyd research the effects of manipulating a parameter, w, on the factor solutions generated by the orthomax criterion. Four different sets of data of varying size, reliability, and factorial complexity are factor analyzed using the orthomax method. Comparisons are made with a graphically transformed solution by considering variance dispersion, exemplification of simple structure, and interpretation of factors. Further comparisons are made between orthogonally rotated factors formed by graphic, quartimax, varimax, and equamax techniques. In most instances the size of w was found to be directly related to the degree of variance equalization. When w is greater than or equal to one, simple structure is relatively fixed for orthogonal solutions. The recommendation of the authors is to obtain a number of orthomax solutions and choose the one which yields an optimal variance allotment.

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This concludes the summary of thirty-four different papers which were presented at the 1971 AERA Conference in the area of educational statistics. By now their great diversification and considerable complexity, factors which make this summary fall far short of a literary masterpiece, should be apparent. But, fortunately, the writer's bane is the researcher's delight. If these papers are any indication, we have much new, diversified, and exciting research to look forward to in the future.

Papers Reviewed

Borich, G. D. Homogeneity of slopes test for multiple regression equations with reference to aptitude-treatment interactions. 14p. (ED 049 316; MF and HC available from EDRS).

Brown, B., & Lathrop, R. The effects of violations of assumptions upon certain tests of the product moment correlation coefficient. 40p. (ED 049 295; MF and HC available from EDRS).

Cassel, R. N. The precision-power gradient theory for teaching basic research statistical tools to graduate students. 15p. (ED 048 360; MF and HC available from EDRS).

Chen, M. K. Extension of Guilford's rating adjustment technique to situations where not all raters rate all ratees. 13p. (ED 048 346; MF and HC available from EDRS).

Dziuban, C. D., & Denton, W. T. Some factor analytic approximations to latent class structure. 16p. (ED 049 288; MF and HC available from EDRS).

Edwards, K. J. Correcting partial, multiple, and canonical correlations for attenuation. 15p. (ED 050 147; MF and HC available from EDRS).

Forster, F. The generalized Johnson-Neyman procedures: An approach to covariate adjustment and interaction analysis. 22p. (ED 048 363; MF and HC available from EDRS).

Gullickson, A. R., & Others. Violation of homogeneity of variance assumption in the integrated moving averages time series model. 23p. (ED 049 278; MF and HC available from EDRS).

Gustafson, R. A. Multiple regression prediction models in the behavioral sciences: Prediction of federal aid allocations to local school districts. 9p. (ED 048 353; MF and HC available from EDRS).

Hakstian, A. R. On oblique quasi-procrustean factor transformation. 24p. (ED 050 159; MF and HC available from EDRS).

Hakstian, A. R., & Boyd, W. M. On the general "orthomax" criterion for orthogonal factor transformation. 24p. (ED 049 286; MF and HC available from EDRS).

Hofmann, R. J. The simplified obliquimax as a modification of Thurstone's method of oblique transformation: Its methodology, properties and general nature. 82p. (ED 049 279; MF and HC available from EDRS).

Huberty, C. J. On the variable selection problem in multiple group discriminant analysis. 39p. (ED 051 279; MF and HC available from EDRS).

Keats, J. B., & Brewer, J. K. A distribution-free test for model comparisons. 19p. (ED 048 357; MF and HC available from EDRS).

Knapp, T. R., & Schafer, W. D. Two new formulas for F in analysis of covariance for two groups and one covariable. 6p. (ED 045 701; MF and HC available from EDRS).

Levin, J. R., & Marascuilo, L. A. Interactions revisited. 40p. (ED 049 277; MF and HC available from EDRS).

Lieberman, M. Estimation of a moral judgment level using items whose alternatives form a graded scale. 118p. (ED 048 341; MF and HC available from EDRS).

Maxey, J. H. Analysis of observational data. 10p. (ED 049 272; MF and HC available from EDRS).

McNeil, K. A., & Beggs, D. L. Directional hypotheses with the multiple linear regression approach. 14p. (ED 046 973; MF and HC available from EDRS).

McRae, D. J. Multivariate cluster analysis. 22p. (ED 050 143; MF and HC available from EDRS).

Meyer, D. L. Bayesian statistics. 11p. (ED 051 261; MF and HC available from EDRS).

Nigro, G. A. A theorem to confirm causal directions in a closed system of five variables. 14p.; (ED 048 362; MF and HC available from EDRS).

Penfield, D. A., & Sachdeva, D. The absolute normal scores test for symmetry. 10p. (ED 048 377; MF and HC available from EDRS).

Petersen, D. F., & Anderson, D. H. Closing the communications gap with item sampling. 14p. (ED 048 370; MF and HC available from EDRS).

Porter, A. C. How errors of measurement affect ANOVA, regression analyses, ANCOVA and factor analyses. 26p. (ED 050 172; MF and HC available from EDRS).

Porter, A. C., & McSweeney, M. Comparison of rank analysis of covariance and nonparametric randomized blocks analysis. 35p. (ED 048 371; MF and HC available from EDRS).

Pruzek, R. M. A unification of correlational and experimental methodology: An application of a Guttman theorem. 31p. (ED 051 275; MF and HC available from EDRS).

Remer, R., & Burton, N. Consequences of various procedures for estimating missing data in factor analysis. 12p. (ED 048 365; MF and HC available from EDRS).

Roscoe, J. T., & Kittleson, H. M. A modified Gauss-Jordan procedure as an alternative to iterative procedures in multiple regression. 24p. (ED 048 354; MF and HC available from EDRS).

Smith, I. L. Strength of relationship in multivariate analysis of variance. 13p. (ED 048 356; MF and HC available from EDRS).

Stanley, J. C., & Livingston, S. A. Correcting four similar correlational measures for attenuation due to errors of measurement in the dependent variable: Eta, epsilon, omega and intraclass r. From symposium "Some attenuating effects of errors of measurement." 10p. (ED 050 151; MF and HC available from EDRS).

Timm, N. H. Neyman's restricted chi-square tests. 14p. (ED 049 280; MF and HC available from EDRS).

Toothaker, L. E. An empirical investigation of the effect of unequal variances. 8p. (ED 050 141; MF and HC available from EDRS).

Waldron, J. S. The Delphi process: Some assumptions and some realities. 18p. (ED 048 347; MF and HC available from EDRS).