METHODOLOGY ISSUES

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The primary purpose of this section is to provide an opportunity to generate discussion about a variety of methodological issues. In this initial section, we feature three articles.

The first article, written by Abbot Packard illustrates a basic guide to statistical analysis. Many individuals experience a great deal of confusion when confronted with the challenge of selecting the appropriate statistical procedure(s). Perhaps, the relatedness among statistical procedures adds to this confusion as many a statistician will tell you that there is more than one way to answer your research question(s). The author presents a selection tree approach that guides you to at least one way to analyze your data as long as you can answer some basic questions regarding the scales of measurement, number of independent and dependent variables, and whether you're interested in description, relationships, or making comparisons.

The second article, written by Isadore and Carole Newman, provides a conceptualization of qualitative and quantitative research along a continuum. Many researchers have a stronger alignment with the philosophical assumptions of either qualitative or quantitative methodology. In this article, the authors argue for a clear understanding of the research question and the use of the appropriate methods to address the question(s). Qualitative and quantitative methods provide different types of information and a blend of these methods is valuable not only in addressing your immediate research question, but to build and further understand the knowledge of your field.

The third article by Isadore Newman and colleagues describes a simple three step procedure for adjusting Type I error rates in any study that contains multiple statistical tests Researchers need to: (a) identify the error rate units, (b) determine the number and nature of the tests contained in the error rate units, and (c) apply Bonferroni type adjustments to the statistical tests.

We hope these initial articles will be valuable and are looking forward to expanding this section in future issues. To do so, we need your input. What types of issues would you like to explore? We look forward to discussing these issues with you and exploring them in future issues. If you would like to submit a manuscript for this section, or simply discuss an idea, please contact: David Shannon, Professor, Auburn University, 4036 Haley Center - EFLT, Auburn, AL 36849-5221 or Isadore Newman, Distinguished Professor, University of Akron, Zook Hall - 424, Akron, OH 44325-4208.

"Piece of Cake": Choosing Univariate Analysis Using a Decision Tree

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In my career of teaching statistics, I am often presented with terrified and anxious students. "Fear of math, or math anxiety, is what is called a debilitative emotion. ...because (1) it is extremely unpleasant, and (2) tends to lead to self-defeating behaviors..." (Kranzler & Moursund, 1999). Each semester I attempt to ease these qualities using humor and logic. The math for an introductory statistics course is elementary and easily performed using a simple calculator. I often present the Introduction to Statistics course as a course in logic. The course begins with the solution to the mystery which is to ask the following questions. What do you want to know? What do you have to do to answer those questions? What do you need to solve the problem or to answer the question? When we read academic papers we also need to understand a wide variety of statistical procedures to determine if they were used appropriately. Data are the key to solving these mysteries. A selection tree of Univariate Statistical Analysis (Forbes & Fortune, 1986) (Figure 1) is one simple method of guiding you through the wide range of statistical procedures. This selection tree simplifies the methods of selecting analysis by using three criteria:

- What scale of measurement exists?
- What do you want to do (Describe, Relate, or Compare)?
- How many variables are used?

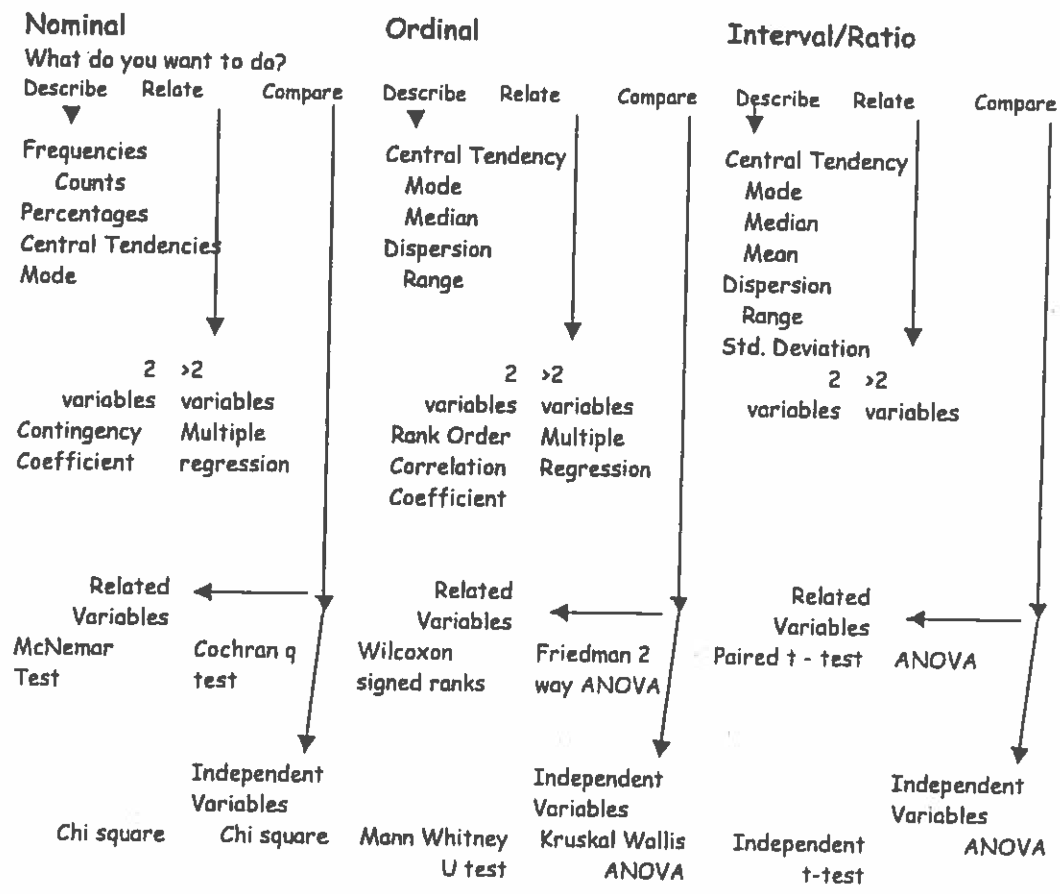

Figure 1. Selection Tree for Univariate Statistical Analysis

Some Important Terminology

There are two broad subdivisions of analysis when speaking of the study of statistics: descriptive and inferential. *Descriptive* statistics address the recording and summarizing, in numerical terms, of the outcome of the study (persons, places, and things). On the other hand, *inferential* statistics are used to draw conclusions from the collected data and makes decisions from those results.

Further distinctions of statistical analysis can be made when examining other common terms. These include independent and dependent variables, univariate and multivariate analysis, and parametric and non-parametric statistics. The simplest explanation of variables would be that which varies and can be measured. *Independent variables* are those which are manipulated or changed while *dependent variables* are those which are measured to determine if the independent variable(s) had any effect.

An analysis using a single dependent variable is referred to as a *univariate* analysis. It is also possible to study multiple dependent variables simultaneously which requires a *multivariate* analysis. When assumptions (e.g., normal distribution) are made about the population under study, *parametric* statistical procedures (e.g., t-tests, ANOVA, Pearson correlation) are used. When the occasion occurs where these assumptions about the population can not be met or are unknown, *non-parametric* procedures (e.g., Mann Whitney U, Kruskal Wallis, Spearman rank correlation) are used.

Scales of Measurement

Scales of measurement using quantitative values are very important for the choices we have to make because of the limitations they impose on the types of analyses which can be performed. There are four scales of measurement: Nominal, Ordinal, Interval and Ratio.

Nominal Data

Nominal refers to data which are in essence "names". Examples are familiar to most who have filled out a questionnaire, application, or other forms. The color of your eyes, your gender, or your occupation. It is important to understand that all Nominal data is qualitative in nature and it does not attempt to make quantitative distinctions. Having blues eyes does not make you better than having brown eyes? Being male has no quantitative advantage over being female.

Ordinal Data

Ordinal data refers to rank. If we use the Olympics where Gold, Silver and Bronze medals are given to indicate place, we can say that a Gold is better than a Silver and Silver is better than the Bronze. But a question arises how much better? Using downhill skiing as an example, the differences between a Gold and a Silver medal may be measured in hundredth or perhaps even thousandth of a second. It is equally possible that there is a very large difference between first and second. Which leaves the impossible task of answering the question how much. On a Likert-type scale using terms such as Best, Better than average, Average, Worse than average, Worst, it is very hard to determine the precise difference between each point on the scale. It is a somewhat subjective scale in that one person's "better than average" may only be some else's "average."

Interval Data

Interval measures have a quality of being composed of categories which are equally spaced along a continuum, but the scale has no meaningful zero point. In education there are many places where we obtain interval data. Perhaps the most common example is a test. It is possible to score a "0" on some tests, but that score does not represent an absence of knowledge or ability. Another common example of an interval measurement is temperature. Again, temperature scales include a zero, but it is not an absolute zero.

Ratio Data

A ratio scale has all the characteristics of an interval scale but has an absolute zero. Measurements on this scale can be added, subtracted, multiplied, and divided, thus they can be treated using the widest variety of statistical procedures. An "0" on a ratio scale indicates the absence of the trait being measured by the scale. Common examples are often found in the physical sciences. Measures of height, weight, density are ratio measurements. In the social sciences, a good example might be number of books read, or class size.

What do you want to do with the data?

Having collected a large number of data points does not tell much of a story, so the function of statistics is to simplify and clarify. These statements can take the form of describing, relating, or comparing. Statistics simply describe by organizing and summarizing data to make the reader's task of understanding simplified. Analyses can address several kinds of questions such as How many? What percentage? Where is the center? Who is the most frequent? Research speaks often about how different variables relate to each other. For example: Is attendance related to past events in a student's life? Does a high score obtained on a college entrance exam predict success in college? Comparing scores also is commonly found in research. Investigation of class times can compare one or more classes in the morning versus one or more of the afternoon classes. The results can add to the knowledge which exists about time of class and performance. Since it is impractical to measure every student from every background in every situation, these few classes can suggest similar results for all classes with similar characteristics.

Analysis of Data - Descriptive

Using the knowledge about the type of measurement scale obtained an understanding what is needed from the data collected, decisions can be made with regard to the question How can data be described? A simple tree can clarify the questions of even the most novice researcher.

Nominal Data

When nominal data are described, frequencies, percentages, and the mode are appropriate. An example may simply describe the number of frequencies in a particular variable. There are 289 females and 164 males attending the first grade. The mode explains what is the most frequent occurrence in the data set. In the previous example, the mode is found with the female gender at 289.

Ordinal Data

Ordinal data can be described using frequencies, percentages, and the mode. The dispersion of an ordinal measurement scale can also be using the range, which indicates how widely the variable values are spread. For example, a statement such as "The median grade obtained in the secondary school was a C with a range of A to D."

Interval and Ratio

It is only when interval or ratio data are present that the values of data can be considered to determine the mean (average) value. Interval data can still use either the mode or the median either separately or together with the mean to help the reader understand more about the data set. A mean salary of $40,000 per year sounds OK but when further described with a mode of $10,000 per year, you get a clearer picture of the salary distribution. Further clarification of the salary structure occurs when reporting a median (middle value) of $12,000 per year. Ratio measurement scales can be described in terms of their dispersion using the range, variance, or standard deviation.

Analysis of Data - Relationships

Nominal Data

Relating data has its own rules about analyzing the data by how one variable relates to other(s). Nominal data can be spoken about in terms of its relationship to another by a Contingency Coefficient. There are sub groups in these relationships depending on whether the data takes the form of a dichotomous or categorical variable. Dichotomous variables such as gender or pass or fail would use a Phi Coefficient. Categorical variables in educational studies using grade level attained related to number of courses attempted might use a Cramer statistic or Goodman-Kruskal G Coefficient.

Ordinal data

Ordinal data when in pairs might use a Spearman Rank Correlation Coefficient such as comparing a rank of class popularity with letter grades (A,B,C,D,F) obtained. But when comparisons are made using multiple independent variables, Multiple Regression would be necessary. For example, you might want to examine the relationship between variables such as socio-economic status (SES) and class popularity with letter grades obtained.

Interval/ratio data

When interval or ratio data are collected in the form of paired variables, a Pearson Product-Moment Correlation can be performed to determine the relationship. An example would be the relationship between parents and child IQ scores. When several independent variables are studied, multiple regression is appropriate. An example might be the relationship between variables such as time spent studying and IQ scores with letter grades obtained.

Analysis of Data - Making Comparisons - Nominal

Comparing nominal data needs to first determine how many different variables are being investigated and then whether they are related or independent. Two variables which are related would require a McNemar test for related samples. For example, we might examine whether a group of students can complete a task correctly before and after instruction within the assigned time limit. With related samples of more than 2 we would use a Cochran *q* test. We may also present instruction on such a task using three different methods, measuring student performance after each method of presentation.

When independent groups are studied, the Chi-Square procedure is appropriate. For example, you might want to examine differences in the completion of a task between gender, and/or ethnic groups.

Analysis of Data - Making Comparisons - Ordinal

Ordinal data also requires a few considerations to determine the proper analysis. With just two groups we have choice: for related groups we use Wilcoxon Signed Ranks and for independent groups we use Mann Whitney U Test. Wilcoxon can investigate the changes of before and after effects of an instructional method on a class or classes while the Mann Whitney test would be used to examine differences between two different classes. The differences between more than two groups is investigated using Kruskal-Wallis H test. For example, an investigator might be interested in the effects of four different levels of computer aided instruction on learning. If we looked at the same individuals over a period of time, the Friedman Two-way Analysis of Variance by ranks would be appropriate.

Analysis of Data - Making Comparisons - Interval/Ratio

When comparing a pre and post test from a single group, we can use a paired t-test to determine the significance of differences. But, if the two groups are independent, we rely upon an independent t-test. For example, an independent t-test would be used to examine the difference between a class delivered on-line versus a traditional classroom using the same teacher and material?

Perhaps the most often used analysis is Analysis of Variance (ANOVA), which can used to investigate the differences between 2 or more groups. When the groups are related, a within-subjects ANOVA is used. On the other hand, when examining differences between 2 or more independent groups, a between-subjects ANOVA is appropriate. ANOVA takes on a wide variety of forms and can be used to examine the impact of a single independent variable or multiple independent variables. When examining the influence of a single independent variable, a one-way ANOVA is used.

Hopefully this simplified outline of the study of statistics will allow educators to see how steps of logic will help explain data and determine the appropriate statistical analysis. Perhaps this article will also raise some questions and methodological issues that can be explored in future issues of the *Journal of Research in Education*.