5

Statistical Analysis

Statistics, Mathematics, and Measurement
A Statistical Flow Chart

In the first four chapters of the text, we have focused on concerns of research design: the scientific method, types of research, proposal elements, measurement types, defining variables, and problem and hypothesis statements. But designing a plan to *gather* research data is only half the picture. When we complete the gathering portion of a study, we have nothing more than a group of numbers. The information is meaningless until the numbers are reduced, condensed, summarized, analyzed and interpreted.

Statistical analysis converts numbers into meaningful conclusions in accordance with the purposes of a study. We will spend chapters 15-26 mastering the most popular statistical tools. *But you must understand something of statistics* ***now*** *in order to properly plan how you should collect your data*. That is, the proper development of a research proposal is dependent on what kind of data you will collect and what statistical procedures exist to analyze that data.

The fields of research design and statistical analysis are distinct and separate disciplines. In fact, in most graduate schools, you would take one or more courses in research design and other courses in statistics. My experience with four different graduate programs has been that little effort is made to bridge the two disciplines. Yet, the fields of research and statistics have a symbiotic relationship. They depend on each other. One cannot have a good research design with a bad plan for analysis. And the best statistical computer program is powerless to derive real meaning from badly collected data. So before we get too far into the proposal writing process, some time must be given to establishing a sense of direction in the far-ranging field of statistics.

Statistics, Mathematics, and Measurement

Descriptive
Inferential
Mathematics
Measurement

There are two major divisions of statistical analysis. The first emphasizes reducing the data that has been collected in a research study. The second emphasizes making inferences from the collected data.

Descriptive Statistics

Descriptive statistical procedures are used to describe a group of numbers. These tools reduce raw data to a more meaningful form. You've used descriptive statistics when averaging test grades during the semester to determine what grade you'll get. The single average, say, a 94, represents all the grades you've earned in the course throughout the entire semester. (Whether this 94 translates to an "A" or a "C" depends on factors outside of statistics!). Descriptive statistics are covered in chapters 15 (mean and standard deviation) and 22 (correlation).

Inferential statistics

Inferential statistics are used to infer findings from a smaller group to a larger one. You will recall the brief discussion of "population" and "sample" in chapter 2. When the group we want to study is too large to study as a whole, we can draw a sample of subjects from the group and study them. Descriptive statistics about the sample is not our interest. We want to develop conclusions about the large group as a whole. Procedures that allow us to make inferences from samples to populations are called inferential statistics.

For example, there are over 36,000 pastors in the Southern Baptist Convention. It is impossible to interview or survey or test all 36,000 subjects. Round-trip postage alone would cost over $21,000. But we could randomly select, say, one percent (1%) or 360 pastors for the study, analyze the data of the 360, and infer the characteristics of the 36,000. Inferential procedures are covered in chapters 16, 17, 18, 19, 20, and 21.

Statistics and Mathematics

Statistics is a branch of applied mathematics. Depending on how much emphasis a teacher or text places on the term applied ("practical"), the study of statistics can range from helpful to hurtful to the mathematical novice. The more mathematical the emphasis, the more one finds derivations of formulas and higher order math symbolism. I've seen some statistics texts that had more Greek than English in them!

The emphasis of this textbook is practical use of statistical procedures and their interpretations. You will be doing some math, but mathematical skill is not required to do well in the course. Most of the procedures we will study require simple arithmetic computations (+, - , x, ч). We will also make use of the square (I) and square root (√) keys on your calculator. If you don't already own a calculator, buy a statistical calculator. You can recognize one by keys such as Σ+, Σ-,and σ. You can buy a calculator like this for less than $25.00 and it will be money well spent!

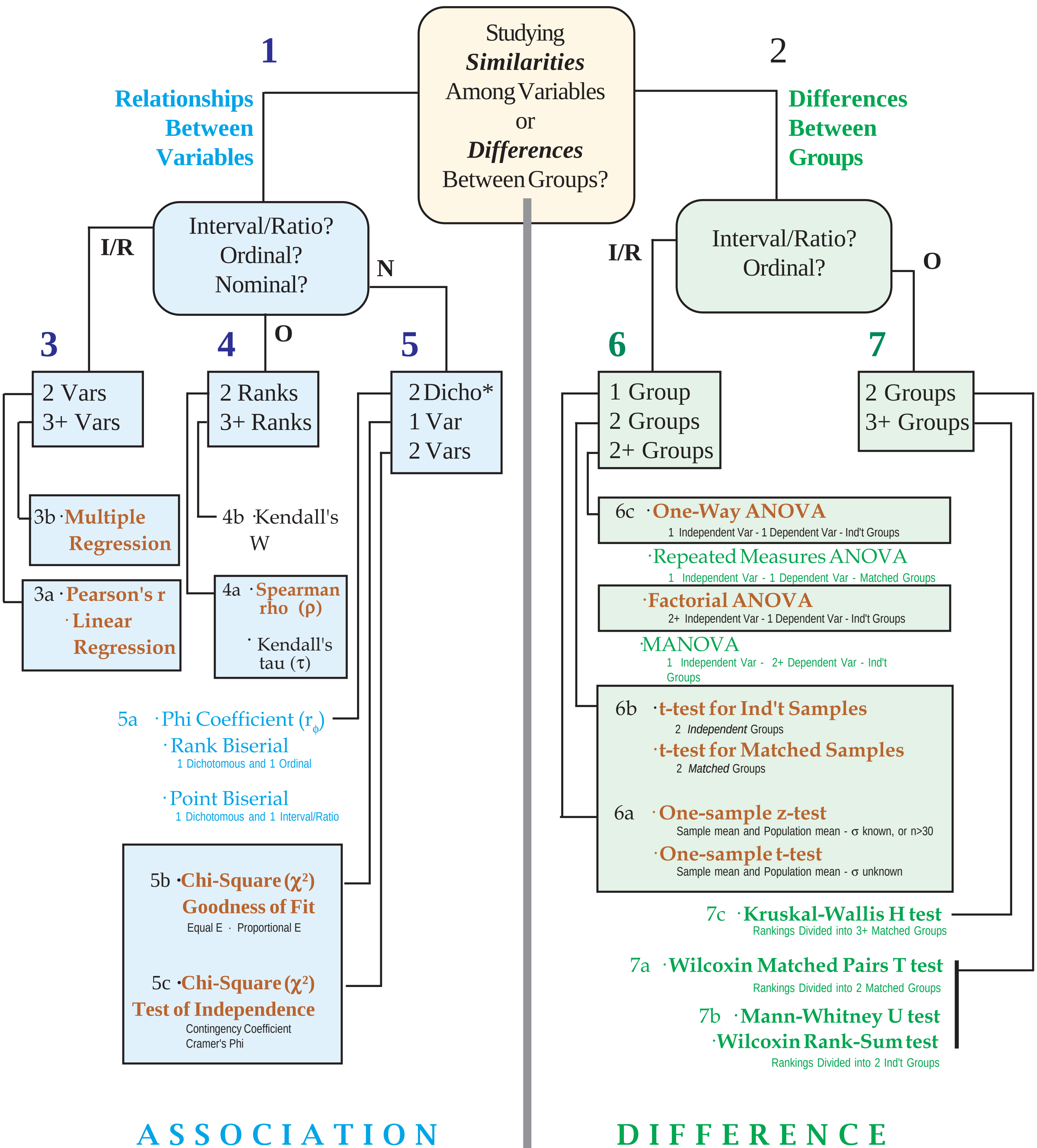
Statistics and Measurement

In chapter 3 we introduced you to four kinds of data: nominal, ordinal, interval, and ratio. Interval and ratio data often use the same statistical procedures, which means that we must learn three different sets of tests.

Nominal data requires one kind of statistics (we'll focus on chi-square), ordinal data another (we'll focus on the Spearman rho and the Mann Whitney U), and interval/ratio a third. The interval/ratio procedures —z-test, t-test, ANOVA, Pearson's r correlation coefficient and multiple regression — make up the bulk of our study in statistics.

Statistical Flowchart

Accompanies explanation on pages 5-4 to 5-7 in text



*Dichotomous - two and only two categories

A Statistical Flow Chart

The flow chart on the preceding page is offered as a visual mental "road map" into the world of statistics. It is designed to provide you direction, step by step, by use of questions, to the specific procedure you should use for a particular type of study and data. The following is a verbal roadmap, given to clarify the diagram.

An additional purpose of this section is to introduce you to the names of major procedures we'll study later in the semester. Bold faced names indicate procedures we'll discuss extensively. Follow the directions to the proper numbered section below.

Question One: Similarity or Difference?

In your study, are you looking for similarities between variables, or differences between groups? A "similarity" study would explore, for example, the "relationship between self-esteem and marital harmony" (two variables) in selected couples (one group).. A "difference" study might examine the "difference in social skills" (one variable) between autocratic and democratic ministers (two groups).

If you are contemplating a "similarity" study, go to -1- below. If you are contemplating a "difference" study, go to -2-.

-1- Question Two: Data Types in Similarity Studies

You have chosen a "similarity study." Statistical procedures that compute coefficients of similarity or association or correlation (synonymous terms) come in four basic types. The first type computes correlation coefficients between interval or ratio variables. The second type computes correlation coefficients between ordinal variables. The third type computes correlation coefficients between nominal variables (or, at the very least, at least one of the two is nominal). The fourth type is a special category which computes a coefficient of independence between nominal variables.

If your data is interval or ratio, then go to **-3-** below. If your data is ordinal, then go to **-4-** below. If your data is nominal, then go to **-5-** below.

-2- Question Two: Data Types in Difference Studies

You have chosen a "difference study." Statistical procedures that compute measures of significant difference come in two major types. The first computes measures of difference for interval or ratio variables. The second computes differences between ordinal variables.

If your data is interval or ratio, then go to **-6-** below. If ordinal, go to **-7-**.

-3- Interval or Ratio Correlation

Interval/ratio correlation procedures come in two types. The first type examines two and only two variables at a time (go to **-3a-**). The second type examines three or more variables simultaneously (go to **-3b-**).

-3a-
Int/ratio Correlation with 2 Variables

The two procedures we will study are **Pearson's Product Moment Correlation Coefficient** (rxy or simply r) and **simple linear regression.** Pearson's r directly measures the degree of association between two interval/ratio variables. See Chapter 22. Simple linear regression computes an equation of a line which allows researchers to predict one interval/ratio variable from another. See Chapter 26.

-3b-
Interval\ratio Correlation with 3+ Variables

The procedure we will study which analyzes three or more interval/ratio variables simultaneously is **multiple linear regression**. This procedure is quickly becoming the dominant statistical procedure in the social sciences. With this procedure, you develop "models" which relate two or more "predictor variables" to a single predicted variable. We will confine our study to understanding the printouts of a statistical computer program called SYSTAT. See Chapter 26.

-4- Ordinal Correlation

Just like the interval/ratio procedures above, ordinal correlation procedures come in two types.

-4a-
Ordinal Correlation with 2 Variables

The two procedures which compute a correlation coefficient between two ordinal variables are **Spearman's rho** (rs) and Kendall's tau (τ). Spearman's rho should be used when you have ten or more pairs of rankings; Kendall's tau when you have less than ten. Both measures give you the same information. If you had pastors and ministers of education rank order seven statements of "characteristics of Christian leadership," you would compute the degree of agreement between the rankings of the two groups with Kendall's tau. See Chapter 22.

-4b-
Ordinal Correlation with 3+ Variables

Kendall's Coefficient of Concordance (W) measures the degree of agreement in ranking from more than two groups. Using our example above, you could compute the degree of agreement in rankings of pastors, ministers of education and seminary professors using Kendall's W. See Chapter 22.

-5- Nominal Correlation

Nominal correlation procedures come in two types differentiated by the number of categories in nominal variables. If you have two and only two categories, the variables are called dichotomous (go to **-5a-**). If nominal variables have more than two categories, go to **-5b-** below.

-5a-
Nominal Correlation with Dichotomous Variables

When you have two variables which can take two and only two values ("dichotomous variables"), use the Phi Coefficient. When you have one dichotomous and one rank variable, use Rank Biserial. When you have one dichotomous and one interval/ratio variable, use Point Biserial. See Chapter 22.

-5b-
Nominal Correlation wth 3+ Categories

Procedures which determine whether two nominal variables are independent (not related) or not independent (related) are called **Chi-square (χI) tests**. The word "chi" is pronounced "ki" as in "kite."

The **Chi-square Goodness of Fit test** compares observed category counts (30 males [75%], 10 females [25%]) with expected counts based on school enrollment [85%

male, 15% female] to determine if class enrollment "fits well" the expected enrollment. The **Chi-square Test of Independence** compares two nominal variables to determine if they are independent. Are "educational philosophy" (5 categories) and "leadership style" (5 categories) independent of each other?

When you want to determine the strength of the relationship between the two nominal variables, use Cramer's Phi (ϕ_c). This procedure computes a Pearson's r type coefficient from the computed χI value. See Chapter 23.

-6- Interval/Ratio Differences

This section of statistical procedures is the most important, and will consume the greater part of our study of statistics. If you are testing one sample against a given population, go to **-6a-.** If you are testing the difference between two groups, go to **-6b-.** If you are testing differences between three or more groups, go to **-6c**-.

-6a-
1-Sample Parametric Tests of Difference

The first type of interval/ratio difference procedures computes whether data from one sample is significantly different from the population from which it was drawn. If you have more than 30 subjects in the sample, use the **one-sample z-test**. If you have fewer than 30 subjects, use the **one-sample t-test**. Here's an example: You know the average income of all Southern Baptist pastors in Texas. You collect information on income of a sample of Southern Baptist pastors who are also seminary graduates. Is there a significant difference in average income between the sample and the population? See Chapter 19.

-6b-
2-Sample Parametric Tests of Difference

The second type computes whether data from two samples is significantly different. There are two different procedures which are used. The first is used when the two samples are randomly selected independently of each other: a sample of Texas pastors and a second sample of Texas ministers of youth. For this situation, use the **Independent Samples t-test.** See Chapter 20.

The second procedure is used when pairs are sampled. Examples of sampling pairs include husbands and their wives, pastors and their deacon chairmen, fathers and their sons, counselors and their clients, and so forth. If you have two groups of paired subjects (husbands and their wives), use the **Matched Samples t-test**. See Chapter 20.

-6c-
n-Sample Parametric Tests of Difference

The third type computes "significant difference" across three or more groups. Again, procedures depend on whether the groups are matched (correlated, related) or independent.

If the groups are independent, and you are examining one independent ("grouping") variable, use **One-Way Analysis of Variance**. For example, is there a significant difference in Integration of Faith with Life between Southern Baptists, Episcopalians, and members of the Assemblies of God. See Chapter 21.

If you are studying two or more independent variables simultaneously, use **n-Way Analysis of Variance** (also called *Factorial ANOVA*), where n is the number of independent variables. The importance of Factorial ANOVA is in the ability to study

interaction among the independent variables. See Chapter 25.

If the groups are related, use the Repeated Measures Analysis of Variance. (Not discussed in this text.)

-7- Ordinal Differences

The measurement of significant difference between (small) groups of data is closely related to the interval/ratio procedures we just mentioned. To conserve space, let me simply give you the ordinal equivalents of the procedures we discussed in -6- above. Use these procedures when your group sizes are too small for procedures under -6- above. See Chapter 21 for all these procedures.

-7a-

The **Wilcoxin Matched Pairs Test** (Wilcoxin T) is analogous to the Matched Samples t-test.

-7b-

The **Wilcoxin Test Rank Sum Test** and the **Mann-Whitney U Test** are analogous to the Independent Samples t-test.

-7c-

The **Kruskal-Wallis H Test** is analogous to the **One-Way ANOVA**.

Summary

In this chapter we introduced you to statistical analysis. We linked statistics to the process of research design. We looked at two major divisions of statistics. We separated the practical application of statistical procedures from the need for higher level mathematics skills. We differentiated statistical differences by measurement type. And finally, we laid out a mental map of statistical procedures we will be studying so that you can determine which procedures might be of use to you in your own proposal.

Vocabulary

correlation coefficient	a number which reflects the degree of association between two variables
Cramer's Phi	measures strength of correlation between two nominal variables
descriptive statistics	measures population or sample variables
Factorial ANOVA	two-way, three-way ANOVA"
Goodness of Fit	compares observed counts with expected counts on 1 nominal variable
Indep't Samples t-test	tests whether the average scores of two groups are statistically different
Inferential statistics	INFERS population measures from the analysis of samples
Kendall's tau	correlation coefficient between two sets of ranks (n < 10)
Kendall's W	correlation coefficient among three or more sets of ranks
Kruskal-Wallis H Test	non-parametric equivalent of ANOVA
Linear Regression	establishes the relationship between one variable and one predictor variable
Mann-Whitney U Test	non-parametric equivalent of the independent t-test
Matched Samples t-test	tests whether the paired scores of two groups are statistically different
Multiple Regression	establishes the relationship between one variable and multiple predictor variables
one-sample z-test	tests whether a sample mean is different from its population mean (n > 30)
one-sample t-test	tests whether a sample average is different from its population average
One-Way ANOVA	tests whether average scores of three or more groups are statistically different
Pearson's r	correlation coefficient between two interval/ratio variables

Phi Coefficient	correlation coefficient between two dichotomous variables
Point Biserial	correlation coefficient between interval/ratio variable and dichotomous variable
Rank Biserial	correlation coefficient between ordinal variable and dichotomous variable
Spearman's rho	correlation coefficient between two sets of ranks (n > 10)
Test of Independence	chi-square test of association between two nominal variables
Two Sample Wilcoxin	non-parametric equivalent of independent t-test
Wilcoxin Matched Pairs	non-parametric equivalent of matched samples t-test

Study Questions

1. Differentiate between descriptive and inferential statistics.

2. Consider your own proposal. Review the types of data (Chapter 3). List several statistical procedures you might consider for your proposal. Scan the chapters in this text which deal with the procedures you've selected.

3. Give one example of each data type (Review Chapter 3). Identify one statistical procedure for each example you give.

Sample Test Questions

Identify which statistical procedure should be used for the following kinds of studies. Write the letter of the procedure in the blank.

Goodness of Fit - χ^2	Mann Whitney **U**	**O**ne-Way ANOVA
Pearson r	**Ph**i Coefficient	Regression (**L**inear)
Regression (**Mult**iple)	**S**pearman rho	T-test (**M**atched)
T-test (**I**nd't)	Test of **Ind**ependence - χ^2	**W**ilcoxin T (Pairs)

____ 1. Difference between fathers and their adult sons on a Business Ethics test.

____ 2. Whether learning style and gender are independent.

____ 3. Analysis of six predictor variables for job satisfaction in the ministry.

____ 4. Difference in Bible Knowledge test scores across three groups of youth ministers.

____ 5. Prediction of marital satisfaction by self-esteem of husband.

____ 6. Relationship between number of years in the ministry and job satisfaction score.

____ 7. Difference in anxiety reduction between treatment group I and treatment group II.

____ 8. Correlation between rankings of objectives of the School of Religious Education by pastors and ministers of education.