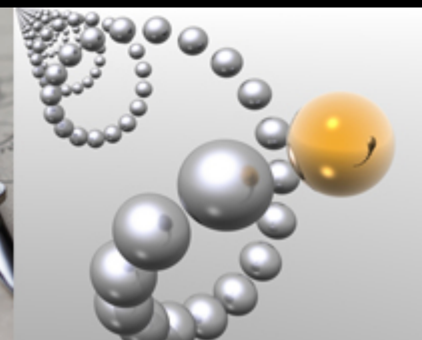
STATISTICS REVIEW
An Entire Semester of Statistics

Independent Study in Psychology
Fall 2010

Back to the Basics!






Variables

- **Variable:** a condition or characteristic that can have different values
- **Independent Variable (IV):** variable considered to be a cause
- **Dependent Variable (DV):** a measured variable considered to be an effect

Problem Variables

- **Confounding Variable:** a variable that is related to the IV and that affects the DV, rendering a relationship inference between the IV and the DV ambiguous
- **Disturbance Variable:** a variable that is unrelated to the IV but that affects the DV

Quantitative vs. Qualitative

- **Quantitative Variable:** a variable in which the different values represent different numerical amounts
  - Continuous (there are an infinite number of values between any two values)
- **Qualitative Variable:** a variable in which the different values represent different categories/kinds
  - Discrete (there cannot be values between the specific values)

Levels of Measurement

- **Nominal:** variables in which the values are names or categories
- **Ordinal:** variables in which the numbers stand only for relative ranking
- **Interval:** variables in which the numbers stand for about equal amounts of what is being measured
- **Ratio:** an equal-interval variable that is measured on an absolute zero point

Descriptive Statistics

Psychologists use descriptive statistics to summarize and make understandable - to describe - a group of numbers from a research study.

Measures of Central Tendency
(Most Representative Value of Data)

- **Mode:** value with the greatest frequency in the distribution
- **Median:** middle score when all the scores in a distribution are arranged from highest to lowest
- **Mean (M,μ):** arithmetic average of a group of scores

$$\bar{X} = \frac{\sum X}{N}$$

Finding the Mean, Mode, and Median

- Enter the scores from your distribution in one column of the data window
- 🖰 *Analyze*
- 🖰 *Descriptive Statistics*
- 🖰 *Frequencies*
- 🖰 on the variable for which you want to find the mean, mode, and median and then 🖰 the arrow
- 🖰 *Statistics*
- 🖰 *Mean*, 🖰 *Median*, 🖰 *Mode*, 🖰 *Continue*
- 🖰 *OK*

Displaying Data

Frequency Distribution

- **Frequency Distribution:** pattern of frequencies over the various values
  - **Frequency Table:** listing of the number of individuals having each of the different values for a particular variable
  - **Histogram:** bar-like graph of a frequency distribution
  - **Frequency Polygon:** line graph of a frequency distribution

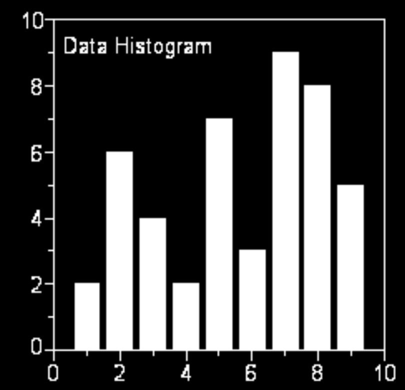
Creating a Frequency Table

- Enter the scores from your distribution in one column of the data window
- 🖰 *Analyze*
- 🖰 *Descriptive Statistics*
- 🖰 *Frequencies*
- 🖰 on the variable you want to make a frequency table of and then 🖰 the arrow
- 🖰 *OK*

Classes	Frequency	Cumulative Frequency
0 - 10	1	1
10 - 20	4	5
20 - 30	3	8
30 - 40	7	15
40 - 50	7	22
50 - 60	7	29
60 - 70	1	30
Total	30	

Creating a Histogram

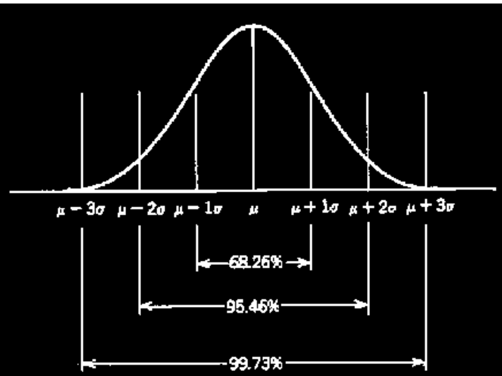
- Enter the scores from your distribution in one column of the data window



- 🖱 *Analyze*
- 🖱 *Descriptive Statistics*
- 🖱 *Frequencies*
- 🖱 on the variable you want to make a histogram of and then 🖱 the arrow
- 🖱 *Charts*, 🖱 *Histograms*, 🖱 *Continue*
- 🖱 *OK*

Normal Curves and Z Scores

Distribution



- **Normal Curve:** specific, mathematically defined, bell-shaped frequency distribution that is symmetrical and unimodal
- **Skewness:** extent to which a frequency distribution has more scores on one side of the middle as opposed to being perfectly symmetrical
- **Kurtosis:** extent to which a frequency distribution deviates from a normal curve, having tails that are too thick or too thin

Variability

- **Standard Deviation (SD,S,s):** the average amount that scores in a distribution vary from the mean (square root of the average of the squared deviations from the mean)

$$S = \sqrt{\frac{\sum (X - \bar{X})^2}{n}}$$

- **Variance (SD2,S2,s2,MS):** measure of how spread out a set of scores are (average of the squared deviations from the mean)

$$S^2 = \frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}$$

Z Score

- **Raw Score:** ordinary measurement (or any other number in a distribution before it has been made into a Z score or otherwise transformed)
- **Z Score (Standard Score):** number of standard deviations a score is above (or below, if negative) the mean of a normal distribution

$$z = \frac{X - \bar{X}}{S}$$

Finding the Z Score

- Enter the scores from your distribution in one column of the data window
- 🖱 *Transform*
- 🖱 *Compute*
- Label the new variable (i.e., z'variable') in the box labeled *Target Variable*
- In the box labeled *Numeric Expression*, write (*variable*-mean)/SD
- 🖱 *OK*

Inferential Statistics

Psychologists use inferential statistics to draw conclusions and make inferences that are based on the numbers from a research study, but go beyond these numbers.

Hypotheses

- **Null Hypothesis:** statement that in the population there is no difference (or a difference opposite to that predicted) between populations
- **Research (Alternative) Hypothesis:** statement that in the population there is a difference between populations
  - One-Tailed Test (hypothesis-testing procedure for a directional hypothesis)
  - Two-Tailed Test (hypothesis-testing procedure for a non-directional hypothesis)

Statistical Significance

- **Statistically Significant:** conclusion that the results of a study would be unlikely if in fact there were no difference in the populations the samples represent
- **Conventional Levels of Significance:** the alpha levels ($p<.05$ or $p<.01$) widely used in psychology

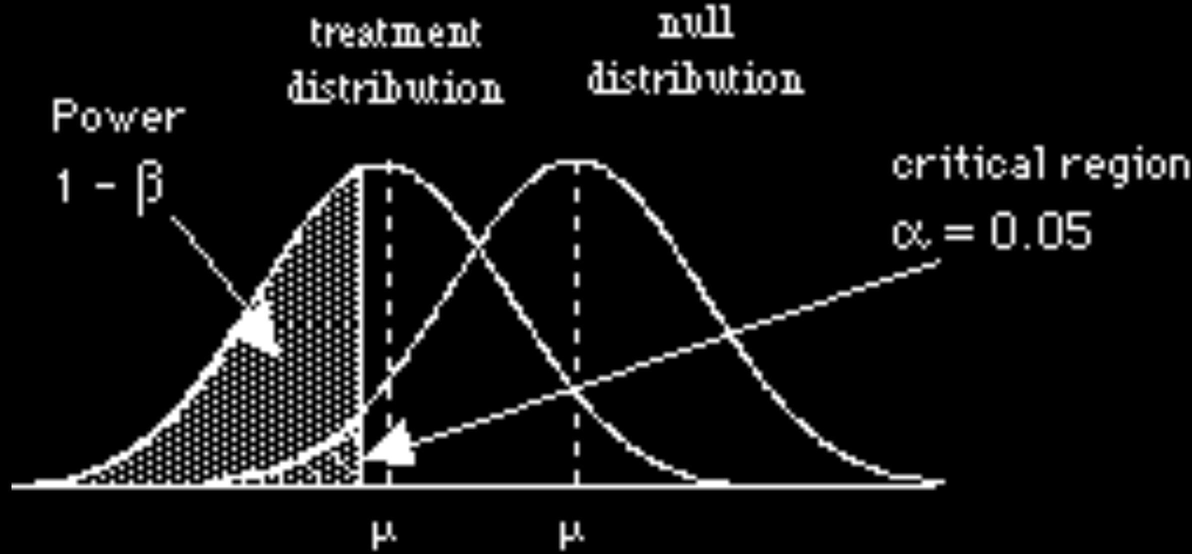
Making Sense of Statistical Significance

- **Confidence Interval:** the region of scores that is likely to include the true population mean
- **Statistical Power:** probability that the study will give a significant result if the research hypothesis is true
- **Effect Size:** standardized measure of difference between population means

T-Tests

T-Test

- **T-Test:** hypothesis-testing procedure in which the population variance is unknown



T-Test for a Single Sample

- **T-Test for a Single Sample:** hypothesis-testing procedure in which a sample mean is being compared to a known population mean and the population variance is unknown

$$t = \frac{\overline{X} - \mu}{\frac{s}{\sqrt{N}}}$$

Finding the T-Test for a Single Sample

- Enter the scores from your distribution in one column of the data window
- 🖰 *Analyze*
- 🖰 *Compare means*
- 🖰 *One-sample T test*
- 🖰 on the variable for which you want to carry out the test and then 🖰 the arrow
- Enter the population mean in the "Test Value" box
- 🖰 *OK*

T-Test for a Single Sample: Results Template

A one-sample *t* test using an alpha level of .05 compared the sample mean with the 55-miles-per-hour speed limit. The sample mean of 58.00 (SD=3.34) was found to be statistically significantly different from this value, $t(24) = 4.48$, $p < .005$, one-tailed, suggesting that the mean driving speed in the state is greater than 55-miles-per-hour. The 95% confidence interval for the mean was 56.62 to 59.38.

T-Test for Independent Means

- **T-Test for Independent Means:** hypothesis-testing procedure in which there are two separate groups of people tested and in which the population variance is not known

$$t = \frac{X_1 - X_2}{\sqrt{\left(\frac{SS_1 + SS_2}{n_1 + n_2 - 2}\right)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Finding the T-Test for Independent Means

- Enter the group of each participant in one column of the data window, and enter the scores from your distribution in another column of the data window
- 🖰 *Analyze*
- 🖰 *Compare means*
- 🖰 *Independent-Samples T Test*
- 🖰 on the variable containing the scores of each participant and then 🖰 the arrow next to the box labeled “Test Variable(s)”
- 🖰 on the variable containing the group of each participant and then 🖰 the arrow next to the box labeled “Grouping Variable”
- 🖰 *Define Groups* and then tell SPSS the values you used to label each group
- 🖰 *Continue*
- 🖰 *OK*

T-Test for Independent Means: Results Template

An independent groups *t* test compared the mean likability rating for the pro-con condition (M=5.00, SD=1.15) with that for the con-pro condition (M=3.00, SD=1.33) . This test was found to be statistically significant at an alpha level of .05, $t(18) = 3.57$, $p < .01$, indicating that strangers will be evaluated more favorably when positive information about them is followed by negative information than when the reverse is true. The strength of the relationship between the order of information and likability, as indexed by eta^2, was .41. The 95% confidence interval for the mean difference was .82 to 3.18.

T-Test for Dependent Means

- **T-Test for Dependent Means:** hypothesis-testing procedure in which there are two scores for each person and the population variance is not known
- **Repeated-Measures (Within-Subjects) Design:** research strategy in which each person is tested more than once

$$t = \frac{\sum D}{\sqrt{\frac{n\sum D^2 - \left(\sum D\right)^2}{n-1}}}$$

Finding the T-Test for Dependent Means

- Enter the scores from your distribution in one column of the data window
- 🖱 *Analyze*
- 🖱 *Compare means*
- 🖱 *Paired-Samples T Test*
- 🖱 on the first variable (this will highlight the variable); 🖱 on the second variable (this will highlight the variable); the two variables will now appear in the “Paired Variables” box
- 🖱 *OK*

T-Test for Dependent Means: Results Template

A correlated groups *t* test compared the mean crying time for the infants when they were 3 months of age with the mean crying time when they were 6 months of age. This test was found to be statistically significant at an alpha level of .05, $t(7) = -7.41$, $p < .001$, suggesting that infants are more fearful of strangers when they are 6 months old (*M*=3.00, *SD*=.93) than when they are 3 months old (*M*=1.00, *SD*=.93). The strength of the relationship between age and crying time was .89, as indexed by eta^2. The 95% confidence interval for the mean difference was -2.64 to -1.36.

ANOVAs

Comparing More Than Two Groups of Scores

ANOVA

- **ANOVA (Analysis of Variance):** hypothesis-testing procedure for studies with three or more groups
- **Between-Groups Estimate of the Population Variance:** in an analysis of variance, estimate of the variance of the population of individuals based on the variation among the means of the groups studied ($MS_{between}$)
- **Within-Groups Estimate of the Population Variance:** in an analysis of variance, estimate of the variance of the population of individuals based on the variation among the scores within each of the actual groups studied (MS_{within})

ANOVA Designs

- Between-Subjects Design (Independent Groups Design):

There are several conditions, and each participant only takes part in one

- Within-Groups Design (Correlated Groups Design or Repeated Measure Design):

There may be several conditions, but each participant takes part in all of them

ANOVA Formula

- **F-Ratio:** a score on the comparison distribution in an ANOVA based on the ratio of the between-groups population variance estimate to the within-groups population variance estimate
  - When the null hypothesis is true, the F-value should approximate 1
  - When the research hypothesis is true, the F-value should be greater than 1

$$SS_T = \sum x^2 - \frac{(\sum x_T)^2}{N}$$

$$SS_b = \sum \frac{(\sum x.)^2}{n} - \frac{(\sum x_T)^2}{N}$$

$$SS_w = SS_T - SS_b$$

$$df_b = (\text{number of groups} - 1)$$

$$df_T = (\text{number of subjects} - 1)$$

$$df_w = df_T - df_b$$

$$MS_b = \frac{SS_b}{df_b}$$

$$MS_w = \frac{SS_w}{df_w}$$

$$F = \frac{MS_b}{MS_w}$$

Bonferroni Procedure

- Bonferroni Procedure: multiple-comparison procedure in which the total alpha percentage is divided among the set of comparisons so that each is tested at a more stringent significance level

Post Hoc Comparisons

- **Simple (Pairwise) Comparisons:** comparison of two groups' means following an ANOVA
- **Scheffe Test and Tukey Test:** methods of figuring the significance of post-hoc comparisons that takes into account all possible comparisons that could be made

The Golden Rule

Perform both LSD and HSD post hoc tests: when there is agreement, there is less chance of committing a Type I or a Type II error.

Finding the F-Ratio (Between-Subjects)

- Enter the scores into SPSS
  - SPSS assumes that all scores in a row are from the same person; thus, in order to tell SPSS which person is in each group, you should enter the group numbers in the first column
- 🖱 *Analyze*
- 🖱 *Compare means*
- 🖱 *One-way ANOVA*
- 🖱 on the variable for which you want to carry out the test (the dependent variable) and then 🖱 the arrow next to the box labeled "Dependent List"
- 🖱 on the variable indicating the groups and then 🖱 the arrow next to the box labeled "Factor"
- 🖱 *Options,* click the box labeled *Descriptive*, and 🖱 *Continue* (planned comparisons and post hoc comparisons are available by clicking *Contrasts* and *Post Hoc* respectively)
- 🖱 *OK*

F-Test for Between-Subjects ANOVA: Results Template

A one-way analysis of variance compared the mean ideal family sizes of Catholics, Jews, and Protestants. This test was found to be statistically significant at an alpha level of .05, $F(2,18) = 7.00$, $p < .01$. The strength of the relationship, as indexed by eta^2, was .44. A Tukey HSD test indicated that the mean for Catholics (*M*=3.00, *SD*=.82) was significantly greater than the mean for Jews (*M*=2.00, *SD*=1.29). The mean for Protestants (*M*=1.00, *SD*=.82) did not differ significantly from the mean for either of the other groups. Table 1 presents the 95% Tukey HSD confidence intervals for each pairwise comparison of means.

Finding the F-Ratio (Within-Subjects)

- Enter the scores into SPSS
- 🖱 *Analyze*
- 🖱 *General Linear Model*
- 🖱 *Repeated Measures*
- 🖱 on the variable for which you want to carry out the test (the dependent variable) and then 🖱 the arrow next to the box labeled "Within-Subject Variables"
- Enter the number of conditions in the box labeled "Number of Levels" (🖱 *Add* and then *Define*)
- 🖱 *Options,* click the box labeled *Descriptive*, and 🖱 *Continue* (planned comparisons and post hoc comparisons are available by clicking *Contrasts* and *Post Hoc* respectively)
- 🖱 *OK*

F-Test for Within-Subjects ANOVA: Results Template

A one-way repeated measures analysis of variance using an alpha level of .05 related the type of label (French, Italian, or American) to the perceived quality of the wine. The obtained *F* ratio was found to be statistically significant, $F(2,10) = 15.03$, $p < .01$. The eta^2 was .75. A Tukey HSD test revealed that the wine was rated significantly higher when it was labeled as French () than when it was labeled as either Italian (*M*=3.00, *SD*=.82) or American (*M*=2.00, *SD*=1.29) but the means for the latter two conditions did not differ significantly. Table 1 presents the 95% Tukey HSD confidence intervals for each pairwise comparison of means.

Factorial ANOVAs

The Study of Two or More Variables

Factorial Analysis of Variance

- **Factorial Analysis of Variance:** analysis of variance for a factorial research design, in which the influence of two or more variables is studied at once by setting up the situation so that a group of people are tested for every combination of the levels of the variables
  - **Cell Mean:** mean of a particular combination of levels of the variables that divide the groups in a factorial design in ANOVA
  - **Marginal Mean:** in a factorial design in ANOVA, mean score for all the participants at a particular level of one of the variables

Main Effect

- **Main Effect:** difference between groups on one variable in a factorial design in ANOVA; result for a variable that divides the groups, averaging across the levels of the other variable that divides the groups
  - There is a main effect for a variable if the marginal means for that variable are not the same

Interaction Effects

- **Interaction Effect:** situation in the factorial ANOVA in which the combination of variables has an effect that could not be predicted from the effects of the two variables individually; situation in which the effect of one variable that divides the group on the measured variable depends on the level of the other variable that divides the groups
  - Essentially, an interaction effect is a comparison of the simple effects (a comparison of the cell means)
  - You determine if there is an interaction effect by looking at the pattern of cell means (F-test followed by post-hoc LSD)
  - Whenever there is an interaction, the pattern of bars on one section of the graph is different from the pattern on the other section of the graph

2x2 Possible Patterns

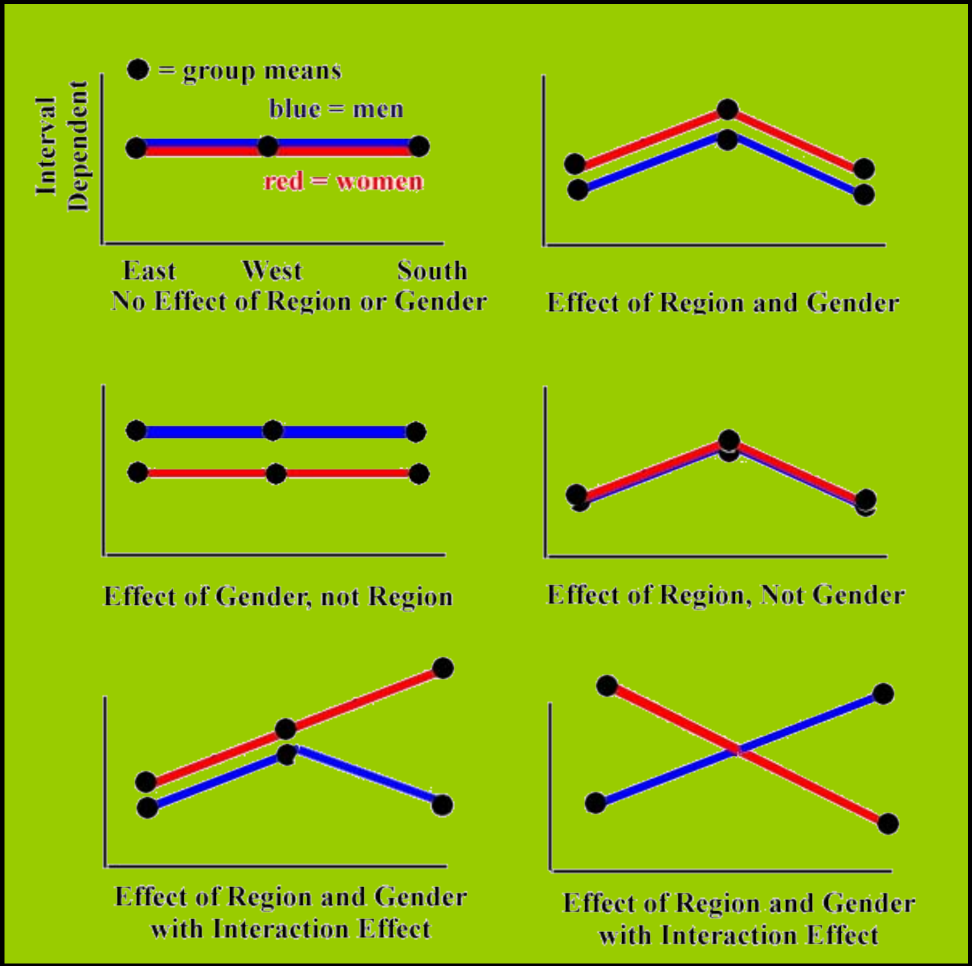
INTERACTION

1. One null simple effect and one simple effect (= vs. <)
2. Simple effects in the same direction but of different magnitude (< vs. <)
3. Simple effects in opposite directions (< vs. >)

NO INTERACTION

1. Simple effects in the same direction and of the same magnitude (< vs. <)
2. Two null simple effects (= vs. =)

Interaction Effects



Relation of Interaction and Main Effects

- When there is no interaction, a main effect has a straightforward meaning
- However, when there is an interaction along with a main effect, you have to be cautious in drawing conclusions about the main effect; you should also be cautious when interpreting a main effect for which the direction of the effect is reversed at different levels of the other grouping variable

Types of Factorial Designs

- **Between-Groups Factorial Design:** the interaction reveals whether or not the effect of one IV on the DV depends on the effect of the other IV on the DV
  - AxB interaction, BG main effect of A, BG main effect of B
- **Within-Groups Factorial Design:** the interaction reveals whether or not responses across one repeated set of tasks depend on some other condition in which everyone participated
  - AxB interaction, WG main effect of A, WG main effect of B
- **Mixed-Groups Factorial Design:** the interaction reveals whether or not the pattern of responses on the DVs changes differentially based on group membership
  - AxB interaction, BG main effect of A, WG main effect of B

Finding the F-Ratio (Factorial Design)

- Enter the scores into SPSS
- 🖱 *Analyze*
- 🖱 *General Linear Model*
- 🖱 *Univariate*
- 🖱 on the dependent variable for which you want to carry out the test and then 🖱 the arrow next to the box labeled "Dependent Variables"
- 🖱 on as many independent variables for which you want to carry out the test and then 🖱 the arrow next to the box labeled "Fixed Factor(s)"
- 🖱 *Options,* click the box labeled *Descriptive*, and 🖱 *Continue* (planned comparisons and post hoc comparisons are available by clicking *Contrasts* and *Post Hoc* respectively)
- 🖱 *OK*

Factorial Design: Results Template

Attitude change scores were subjected to a two-way analysis of variance having three levels of message discrepancy (small, medium, and large) and two levels of source expertise (high versus low). All effects were found to be statistically significant at an alpha level of .05.

The main effect of message discrepancy yielded an *F* ratio of $F(2,24) = 60.00$, $p < .01$. The strength of the relationship, as indexed by eta^2, was .21. A Tukey HSD test revealed that the means for both the medium-discrepancy (*M*=5.00, *SD*=2.21) and the large-discrepancy (*M*=5.00, *SD*=4.27) messages were significantly greater than the mean for the small-discrepancy message (*M*=2.00, *SD*=1.25). The means for the latter two conditions did not significantly differ.

Factorial Design: Results Template Continued

The main effect of source expertise was such that the messages from the high-expertise source (*M*=6.33, *SD*=2.66) produced significantly more attitude change than the messages from the low-expertise source (*M*=1.67, *SD*=1.18), $F(1,24) = 326.66$, $p < .01$. The strength of the relationship, as indexed by eta^2, was .58.

The interaction effect, $F(2,24) = 46.68$, $p < .01$, was analyzed using interaction comparisons in conjunction with a modified Bonferroni procedure (Holland & Copenhaver, 1988) based on an overall alpha level of .05. The relevant means and standard deviations can be found in Table 1. The interaction comparisons for all three 2x2 subtables were statistically significant.

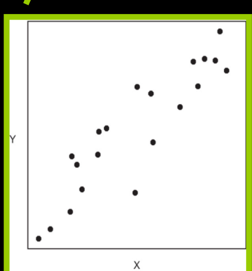
Factorial Design: Results Template Continued

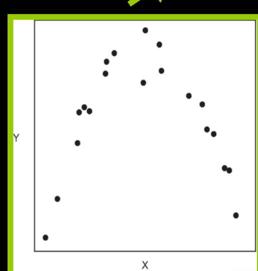
The medium-discrepancy messages produced more attitude change than the small-discrepancy messages when source expertise was high (7.00 - 3.00 = 4.00) as compared to low (3.00 - 1.00 = 2.00). Similarly, the large-discrepancy messages produced more attitude change than the small-discrepancy messages when source expertise was high (9.00 - 3.00 = 6.00) than when it was low (1.00 - 1.00 = .00). Finally, the large-discrepancy messages produced more attitude change in the advocated direction than the medium-discrepancy messages when source expertise was high (9.00 - 7.00 = 2.00) as opposed to low (1.00 - 3.00 = 2.00). The strength of the overall interaction effect, as indexed by eta^2, was .17.

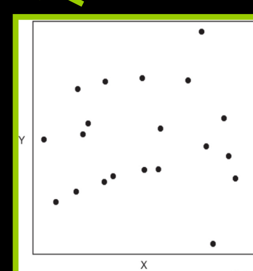
Correlations

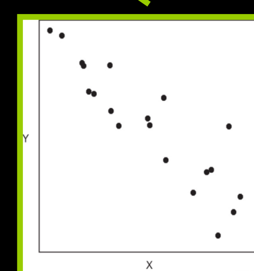
Correlation

- **Pearson's Correlation (*r*)**: reveals the strength of the linear relationship between two quantitative variables
  - r = 1 (perfect positive linear relationship)
  - r = -1 (perfect negative linear relationship)
  - r = 0 (no linear relationship)









Statistical Control

- **Partial Correlation ($r_{yx.z}$)**: a correlation between two variables (X and Y), controlling them BOTH for some third variable (Z)
- **Semi-Partial Correlation ($r_{y(x.z)}$ or $r_{x(y.z)}$)**: a correlation between two variables (X and Y), controlling ONE of the variables for some third variable (Z)
- **Multiple Partial Correlation ($r_{yx.abc}$)**: a correlation between two variables (X and Y) controlling them BOTH for some set of third variables (A, B, C, etc.)
- **Multiple Semi-Partial Correlation ($r_{y<x.abc}$) or $r_{x(y.abc)}$)**: a correlation between two variables (X and Y) controlling them ONE of the variables for some set of third variables (A, B, C, etc.)

Finding the Correlation Coefficient

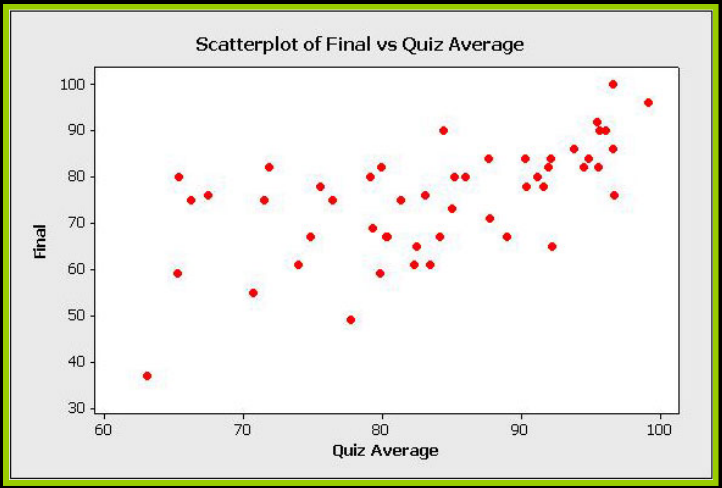
- Enter the scores into SPSS
- 🖱 *Analyze*
- 🖱 *Correlate*
- 🖱 *Bivariate*
- 🖱 on the first variable for which you want to carry out the correlation 🖱 the arrow next to the box labeled "Variables;" do the same with the second variable for which you want to carry out the correlation
- Click the box next to the "Spearman"
- 🖱 *OK*

Correlation: Results Template

A Pearson correlation addressed the relationship between traditionalism (*M*=5.00, *SD*=2.98) and ideal family size (*M*=5.00, *SD*=2.58). The correlation was found to be statistically significant at an alpha level of .05, $r(8) = .66$, $p < .05$, indicating that the two variables are positively related. The 95% confidence interval for the correlation was .05 to .91.

Creating a Scatter Diagram

- Enter the scores into SPSS
- 🖰 *Graphs*
- 🖰 *Scatter* (a box will appear that allows you to select different types of scatter diagrams; as you only need the "Simple" scatterplot - the default type - simply 🖰 *Define*
- 🖰 on the first variable for which you want to carry out the correlation 🖰 the arrow next to the box labeled "Y axis"
- 🖰 on the second variable for which you want to carry out the correlation 🖰 the arrow next to the box labeled "X axis"
- 🖰 *OK*



Simple Regression

Linear Regression for Prediction

- **Associative Hypothesis:** states that the value of one variable allows for the prediction of another variable

Linear Prediction

- **Prediction Rule:** the formula for predicting a person's score on a criterion variable based on the person's score on one or more predictor variables
  - **Predictor Variable (X)**: the variable that is used to predict scores on individuals on another variable
  - **Criterion Variable (Y)**: the variable that is predicted
- **Residual:** the difference between the criterion and the predicted criterion values

Simple Regression

- **Simple Regression Formula:**

$$y = a + bx$$

- **Regression Constant (a):** a fixed value equivalent to y when x = 0
  - With a binary predictor, a stands as the mean of y for the group with the value of 1

$$a = \frac{\sum y - b\sum x}{n}$$

- **Raw Score Regression Coefficient (b):** the expected change in the criterion for a one-unit change in a continuous predictor
  - With a binary predictor, b stands as the mean difference in y between the two coded groups

$$b = \frac{n\sum(xy) - (\sum x)(\sum y)}{n\sum x^2 - (\sum x)^2}$$

Finding the Bivariate Linear Prediction Rule

- Enter the scores into SPSS
- 🖰 *Analyze*
- 🖰 *Regression* 🖰 *Linear*
- 🖰 on the criterion variable for which you want to carry out the correlation and then 🖰 the arrow next to the box labeled "Dependent"
- 🖰 on the predictor variable for which you want to carry out the correlation and then 🖰 the arrow next to the box labeled "Independent"
- 🖰 *Statistics* 🖰 *Descriptives*
- 🖰 *OK*

Linear Regression: Results Template

A Pearson correlation between the number of similar questionnaire responses (M=6.00, SD=2.80) and attraction to one's partner (M=5.00, SD=2.36) was found to be statistically significant, $r(13) = .78$, $p < .01$, at an alpha level of .05. The regression equation for predicting attraction from partner similarity was found to be $Y = 1.10 + .65x$, and the estimated standard error of estimate was found to be 1.53. The 95% confidence interval for the correlation coefficient was .45 to .92.

Multiple Regression

Multiple Regression

- Multiple Regression: procedure for predicting scores on a criterion variable from scores on two or more predictor variables
  - Each b represents the unique and independent contribution of that predictor to the model
  - The a represents the expected value of the criterion if all of the predictors were to have a value of 0

$$Y' = a + b_1x_1 + b_2x_2 + b_3x_3 + e$$

Describing the Results from a Multiple Regression

1. Does the model work? (ANOVA F-test)
2. How well does the model work? (R^2)
   - R^2 is an "effect size estimate" telling the proportion of variance of the criterion variable that is accounted for in the model
   - "Adjusted R^2" is an attempt to correct R^2 for inflation from a large number of predictors relative to the sample size
3. Which variables contribute to the model? (t-test)
4. Which variables contribute "most" to the model? (β)
   - Beta weights are used both to promote comparability of the relative contribution of the various predictors and to standardize an unfamiliar scale

Finding the Fit of a Multiple Regression Model

- Enter the scores into SPSS
- 🖱 *Analyze*
- 🖱 *Regression* 🖱 *Linear*
- 🖱 on the criterion variable for which you want to carry out the correlation and then 🖱 the arrow next to the box labeled “Dependent”
- 🖱 on the predictor variable for which you want to carry out the correlation and then 🖱 the arrow next to the box labeled “Independent”
- 🖱 *Statistics* 🖱 *Descriptives*
- 🖱 *OK*

Multiple Regression: Results Template

As hypothesized, judges' ratings of the importance of scientific knowledge, specialized knowledge, and expert qualifications significantly predicted judges' ratings of reliability, $F(3,596) = 52.546$, $MSe = 4.548$, $p < .001$. Together, they accounted for 20.9% of the variance in reliability. Contrary to hypothesis, scientific knowledge was the only significant predictor of reliability (B=.580, *SE*=.048, beta=.441, $p < .001$). For every one unit increase in ratings of scientific knowledge we would expect a .441 increase in ratings of reliability. Specialized knowledge (B=.117, *SE*=.069, beta=.063, $p = .091$) and expert qualifications (B=.048, *SE*=.033, beta = .053, $p = .154$) did not have significant predictive utility in the model.

Quoted from Professor Jennifer Groscup's "Multiple Regression Part Deux: SPSS How-To and Write Up" handout from the Spring of 2010.

Types of Multiple Regression

Simultaneous Regression

- **Simultaneous Regression:** all predictor variables are entered into the model at once
  - Simultaneous regression is best used when the predictors form a single coherent group and do not follow any particular order

Hierarchical Regression

- **Hierarchical Regression:** multiple regression procedure in which predictor variables are added one or a few at a time, in a planned sequential fashion, allowing you to figure the contribution to the prediction of each successive variable (or group of variables) over and above those already included
  - **Change in R^2:** the proportion of the variance accounted for by the variables that were added or removed
- The researcher must determine the logical order in which predictors should be added

Stepwise Multiple Regression

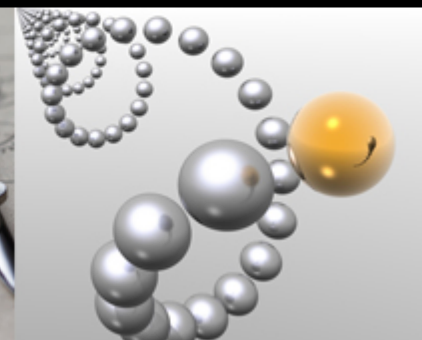
- **Stepwise Regression:** exploratory procedure in which all the potential predictor variables that have been measured are tried in order to find the predictor variable that produces the best prediction, then each of the remaining variables is tried to find the predictor variable which in combination with the first produces the best prediction; this process continues until adding the best remaining variable does not provide a significant improvement
- SPSS conducts this step-by-step procedure automatically

Cautions

- **Collinearity:** correlations among predictors
  - Tolerance (1-R^2)
  - VIF (Variance Inflation Factor)
- **Range Restriction:** occurs when the variability of a predictor or criterion variable in the sample is less than the variability of the construct in the population
- **Suppressor Variable:** a variable that contributes to the model "indirectly" by yielding a residual version of the criterion with which the other predictors are better correlated
- **Mediation Effect:** when one predictor is partially or fully accounted for by the presence of another predictor in the model (the mediator)

Categorical and Coded Variables






Assumptions of Regression

- Regression assumes interval level measurement
  - Binary predictors are quasi-continuous and can be used
  - Ordinal predictors cannot be used because each unit increase is not equivalent
  - Multi-level categorical (nominal or qualitative) predictors cannot be used because they are not measured on an interval scale, the values are arbitrary/meaningless, and each unity increase is not equivalent

↓

The Solution: Dummy and Effects Coding

Dummy Coding

- **Dummy Coded Variables:** each variable compares one category of a multi-level variable to the reference category
  - Reference Category (0)
  - Dummy Category (1)
- The b-value reveals the size and direction of the mean difference between the target group and the reference group, controlling for the effects of all the other predictors in the model
- The a-value reveals the value of y if all the predictors are held at 0

Effects of Coding

- **Effects Coded Variables:** each variable is compared to one category of the multi-level variable to the grand mean
  - The reference category is coded as -1
  - The category of the effects that the variable represents is coded as 1
  - All other categories are coded as 0
- The b-value reveals the size and direction of the mean difference between the target group and the grand mean
- The a-value reveals grand mean of all the conditions

Models with Dummy Coding and Effects Coding

- The b-value reveals the size and direction of the mean difference between the target group and the grand mean, controlling for the effects of all other predictors in the model
- The a-value reveals the expected value of y if all the predictors are held at 0

Chi-Square Tests

Chi-Square Tests

- **Chi-Square Statistic (c2):** statistic that reflects the overall lack of fit between the expected and observed frequencies
- Sum, over all the categories or cells, of the squared difference between observed and expected frequencies divided by the expected frequency
- The chi-square test analyzes 1) nominal variables, 2) two variables that have been measured on the same individuals, and 3) the between-subjects observations on each variable

$$X^2 = \sum \frac{(o-e)^2}{e}$$

Chi-Square Test for Goodness of Fit

- **Chi-Square Test for the Goodness of Fit:** hypothesis-testing procedure that examines how well an observed frequency distribution of a nominal variable fits some expected pattern of frequencies
  - Used when there are only levels of a single nominal variable

Finding the Chi-Square Test for Goodness of Fit

- Enter the scores into SPSS
- 🖱 *Analyze*
- 🖱 *Non-Parametric Tests,* 🖱 *Chi Square*
- 🖱 on the nominal variable for which you want to carry out the chi-square test and then 🖱 the arrow next to the box labeled "Test-Variable List"
  - The "Expected Values" box is set to the option "All categories equal," but you can specify a different expected frequency distribution by selecting the "Values" option
- 🖱 *OK*

Chi-Square Test for Independence

- **Chi-Square Test for Independence:** hypothesis-testing procedure that examines whether the distribution of frequencies over the categories of one nominal variable are unrelated to the distribution of frequencies of categories over another nominal variable
  - Used when there are two nominal variables, each with several categories

Finding the Chi-Square Test for Independence

- Enter the scores into SPSS
- 🖱 *Analyze*
- 🖱 *Descriptive Statistics,* 🖱 *Crosstabs*
- 🖱 on the first nominal variable for which you want to carry out the chi-square test and then 🖱 the arrow next to the box labeled "Rows"
- 🖱 on the second nominal variable for which you want to carry out the chi-square test and then 🖱 the arrow next to the box labeled "Columns"
- 🖱 *Statistics,* 🖱 the box labeled *Chi-square,* and then 🖱 *Continue*
- 🖱 *OK*

Chi-Square Test: Results Template

A chi-square test was applied to the relationship between gender and political party identification and found to be statistically significant at an alpha level of .05, c2(2,N=170) = 14.14, $p < .01$. The observed frequencies of the six cells can be found in Table 1.

As indexed by Cramer's statistics, the strength of the relationship was .29. This reflects primarily the fact that men are less likely to be Independents and more likely to be Democrats than expected, and women are more likely to be Independents and less likely to be Democrats than expected.

Factor Analysis and SEM

Come See Alan or Zoe

Factor Analysis

- **Factor Analysis:** statistical procedure applied in situations where many variables are measured and that identifies groups of variables correlating maximally with each other and minimally with other variables
  - **Factor:** in factor analysis, group of variables that correlate maximally with each other and minimally with variables not in the group
  - **Factor Loading:** in factor analysis, correlation of a variable with a factor

Structural Equation Modeling (SEM)

- **Structural Equation Modeling:** sophisticated version of path analysis that includes paths with latent, unmeasured, theoretical variables and that also permits a kind of significance test and provides measures of the overall fit of the data due to the hypothesized causal patter
  - **Path Analysis:** method of analyzing the correlations among a group of variables in terms of a predicted pattern of causal relations (usually the predicted pattern is diagrammed as a pattern of arrows from causes to effects)
- **Fit Index:** in structural equation modeling, measure of how well the pattern of correlations in a sample corresponds to the correlations that would be expected based on the hypothesized pattern
  - **Root Mean Square Error of Approximation (RMSEA):** widely used fit index in structural equation modeling; low values indicate a good fit

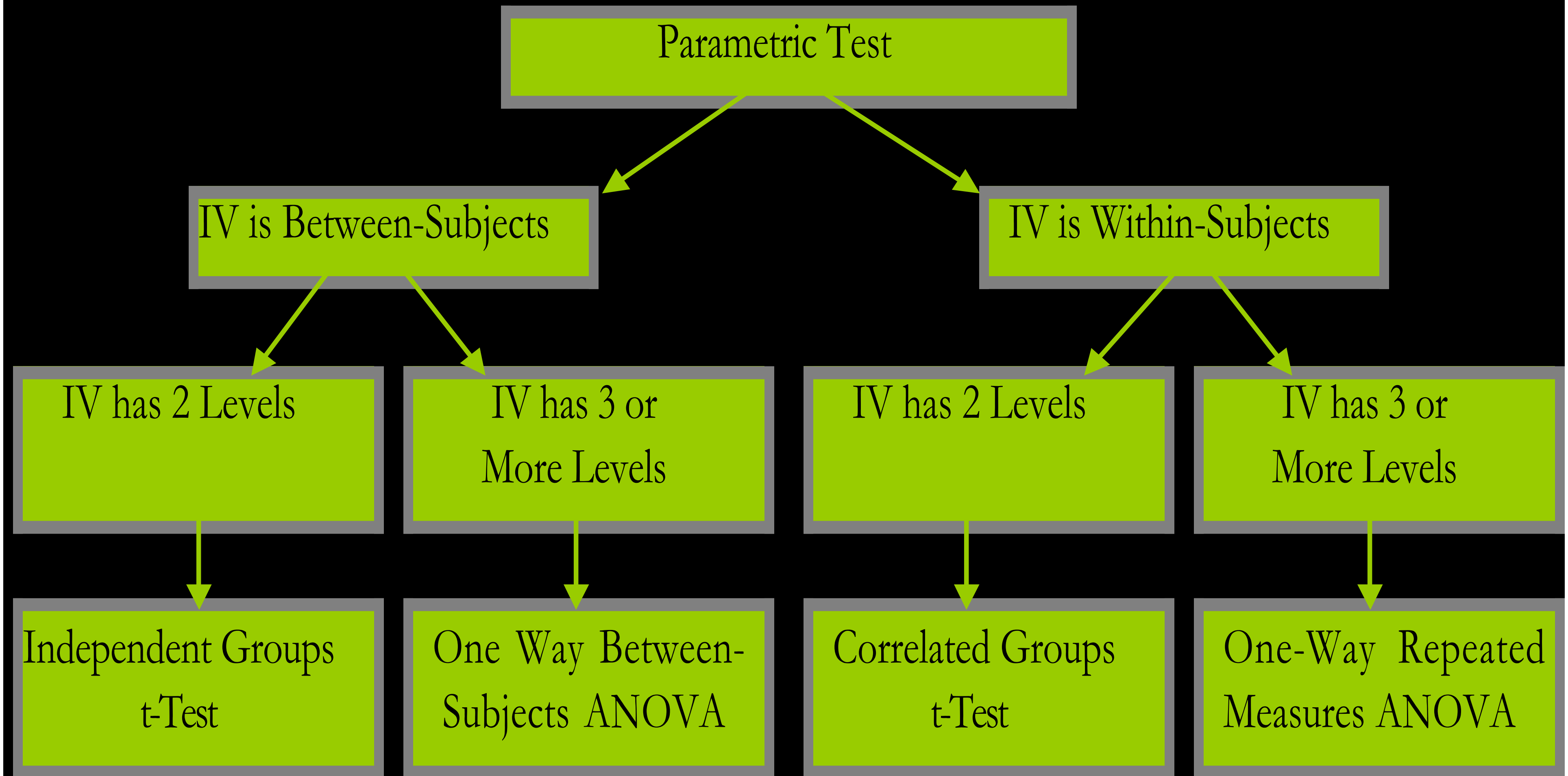
Additional Statistical Procedures

Additional Statistical Procedures

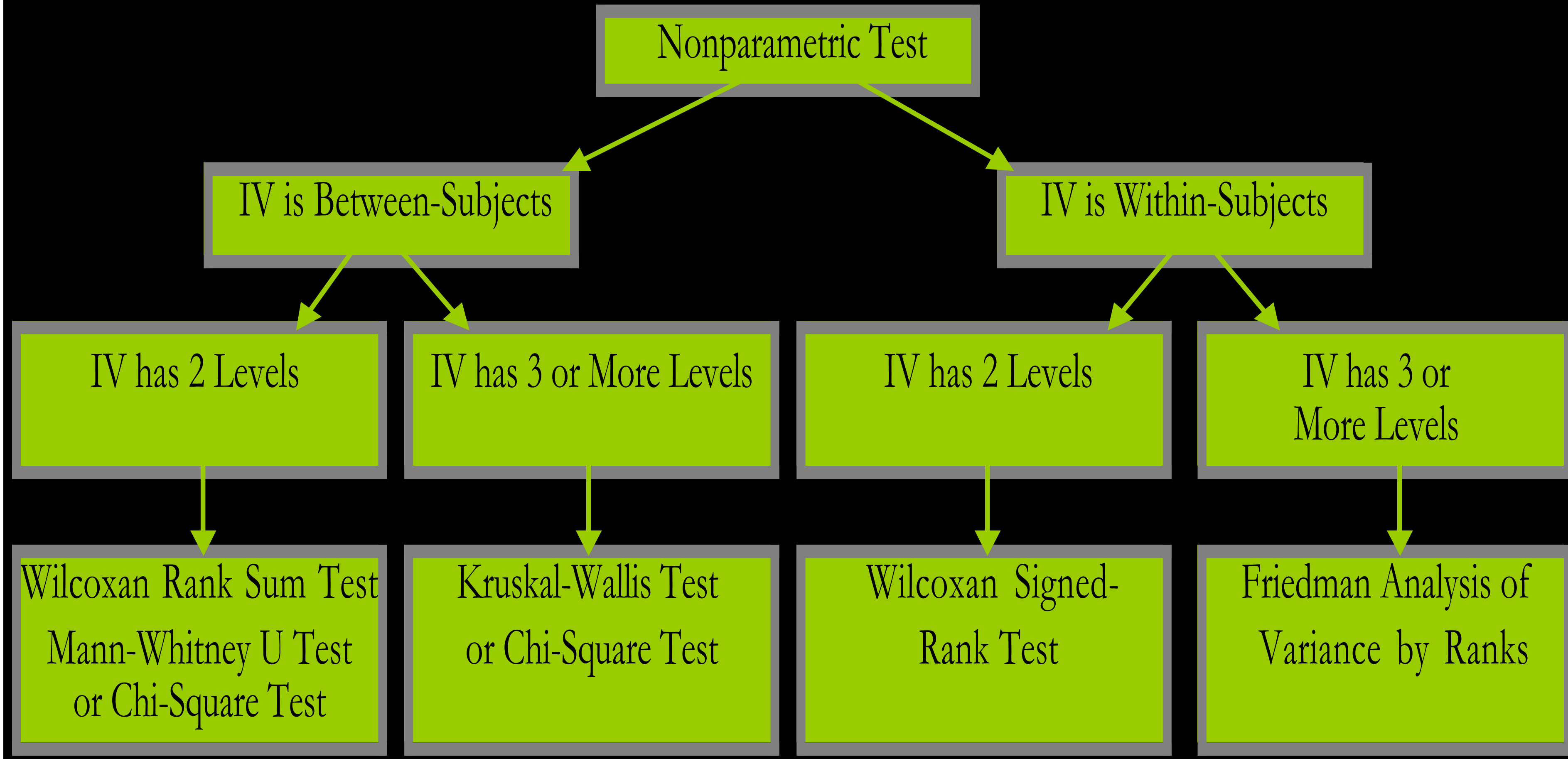
- KxK Factorial Designs and Higher Order Interactions
- Analysis of Covariance (ANCOVA)
- Multivariate Analysis of Variance (MANOVA)
- Multivariate Analysis of Covariance (MANCOVA)
- Interaction Effects in Multiple Linear Regression
- Logistic Regression
  - Model Building
  - Interaction Effects

Please visit during office hours if you would care to learn more about these advanced statistical procedures

Decision Tree:
Parametric Research Designs



Decision Tree:
Non-Parametric Research Designs



Now It's Time to Interpret Your Results!

(: If you have any additional questions, do not hesitate to ask for further assistance :)

References

Information gathered for this PowerPoint was taken from James Jaccard and Michael Becker's "Statistics for the Behavioral Sciences, 4th Edition" as well as from Arthur Aron, Elaine Aron, and Elliot Coups's "Statistics for Psychology, 4th Edition."