Capella University

Hypothesis Testing with SPSS:
Who Needs to Hire a Statistician?

Session Objectives

After attending this session you will be able to:

- ❑ Recognize the appropriate hypothesis test to run.
- ❑ Explore the many graphical and statistical options in the SPSS menu that you can use to conduct the appropriate hypothesis test correctly
- ❑ Learn how to interpret the SPSS output and make decisions in regards to the hypothesis test.
- ❑ Understand ways to draw conclusions in layman's terms at the conclusion of a hypothesis test

Hypotheses

- What is a Hypothesis?
  - A statement about concepts that is articulated in a testable manner (Cooper & Schindler, p. 50)
  - A hypothesis typically involves one or two variables.
  - The most common formats are "there is a difference in…" and "there is a relationship between…"

Cooper, D. R. & Schindler, P. S. (2003). *Business research methods* (8th ed.). Boston: McGraw-Hill Irwin, p. 50.

Choosing the Correct Hypothesis Test

1. What is the level of measurement?
2. Can a parametric test be used (i.e., are assumptions me)?
3. How many samples are involved?
4. If two or more samples, are the cases related or independent?

Levels of Measurement

- Nominal
  - Categorical data
  - No order or magnitude
  - Examples
    - Gender
    - Numbers on football jerseys
    - Colors
- Ordinal
  - Categorical data
  - Order but no magnitude
  - Examples
    - Highest degree completed
    - Letter grade in course
    - Likert scale data

Levels of Measurement

- Interval / Ratio (aka *Scale* data in SPSS)
  - Measured data
  - Has order or magnitude
  - Examples
    - Income
    - Age
    - Height
    - Weight
    - Years of experience

Parametric vs. NonParametric

- Parametric tests:
  - involve parameters (i.e., means, proportions, variances,…)
  - have assumptions that must be met (e.g., normality, equal variances, …)
  - are powerful but sensitive to outliers
  - use if there is a scale variable
  - ** *this should be your first choice if the assumptions can be met* **
- Nonparametric tests:
  - assess the population distributions instead of parameters
  - have minimal assumptions
  - are not sensitive to outliers
  - use if data is only nominal and/or ordinal
  - ** *there is a nonparametric equivalent for every parametric test* **

How Many Samples?

- One-Sample
  - Evaluate a variable for a single group within a population
    - e.g., Test Scores for all students
- Two-Samples
  - Evaluate a variable for two unrelated groups from a population
    - e.g., Test Scores for Males vs. Females
- *k*-Samples
  - Evaluate a variable for three or more groups from a population
    - e.g., Test Scores for Bus. vs. Educ. vs. Psych. students

Relationship of Groups

- Independent
  - Membership in one group is not dependent upon membership in another group
    - e.g., attendance for MBA vs. PhD students
- Related
  - Membership in one group is linked to membership in another group
    - pre-test/post-test data (*same person under two circumstances*)
    - Same circumstance with two different people (*e.g., have two different people appraise same homes*)
    - paired observations (*two different people in two different circumstances whose results are paired because they are expected to have similar results if they switched places*)

Most Common Hypothesis Tests

1) One sample t-test
   - Compare a sample mean to a hypothesized value
   - e.g., Ho: the mean GPA is equal to 3.50
   - Nonparametric equivalent → Binomial test
2) Two sample t-test for independent samples
   - Compare the difference in a sample mean for two unrelated groups
   - e.g., Ho: there is no difference in the mean GPA for males vs. females
   - Nonparametric equivalent → Mann-Whitney U test
3) Two sample t-test for paired samples
   - Compare the difference in a sample mean for two related groups
   - e.g., Ho: there is no difference in the mean GPA for test scores for students before vs. after taking the computer-based training
   - Nonparametric equivalent → Wilcoxon Signed Rank test

Most Common Hypothesis Tests

4) One-Way Analysis of Variance (ANOVA)
   - Compare the difference in a sample mean for 3+ unrelated groups
   - e.g., Ho: there is no difference in the mean GPA for Business vs. Education vs. Psychology students
   - Nonparametric equivalent → Kruskal-Wallis H test
5) Correlation
   - Assess the correlation (relationship) between two scale variables
   - e.g., Ho: there is no relationship between a student's test score vs. the number of hours he/she spent studying for the test.
   - Nonparametric equivalent → Spearman Rank test
6) Chi Square Test of Independence
   - Test whether two nominal / ordinal variables are independent / unrelated
   - e.g., Ho: a student's choice of major is independent of his/her gender

DEMO of the Most Common Hypothesis Tests

- Let's use a data file reflecting student GPA and comprehensive test scores.
- The variables included are:
  - Gender (0 = male, 1 = female)
  - School (1 = business, 2 = education, 3 = psychology, 4 = human svcs)
  - Employment status (0 = unemployed, 1 = part-time, 2 = full-time)
  - Age (age in years as of last birthday)
  - GPA (overall GPA as of the completion of the comps exam)
  - Recommend (1 = would recommend PhD program, 0 = would not)
  - Comps (actual score on the comps exam, on a scale from 10 to 50)
  - P/F score (0 = fail if score is less than 30, 1 = pass if score is 30+)
  - MS-GPA (student's GPA from the Masters level)
- The ***PhDlearners.sav*** file consists of 200 *fictional* student records and can be found on http://www.DrJimMirabella.com/SPSS

DEMO of the Most Common Hypothesis Tests

- Now let's conduct the common hypothesis tests from the prior slides. Here are the steps involved:

1. State the hypotheses
2. State the assumptions
3. Evaluate the assumptions where necessary
4. Use SPSS to generate statistical output
5. Interpreting all parts of the output
6. *Reject* or *Do not reject* the null hypothesis
7. State your conclusion IN ENGLISH

Example: t-Test for One Sample

- Ho: The mean GPA = 3.50
- Ha: The mean GPA is not equal to 3.50
- Assumption: GPA is normally distributed
- Choose a significance level (typically .05)
- Look at p-value / sig. value from the SPSS output
  - If p-value is less than the significance level, reject Ho. Conclude that the mean GPA is not 3.50. Look at the value of the sample mean and you can even state that the mean is larger or smaller than 3.50 (depending on its value). You might even discuss how this corresponds with expected results based on the literature.
  - If p-value is greater than the significance level, do not reject Ho. There is insufficient evidence to conclude that the mean GPA differs from 3.50.

Example: t-Test for Independent Samples

- Ho: The mean GPA for males = mean GPA for females
- Ha: The mean GPA is different for males vs. females
- Assumptions:
  - GPAs are independent
  - GPAs are normally distributed
  - Males vs. females are independent of each other
  - GPAs for males vs. GPAs for females have equal variances
- Look at p-value / sig. value from the SPSS output
  - If p-value is less than the significance level, reject Ho. Conclude that the mean GPA is different for males vs. females. Look at the value of the two sample means and you can even state which mean GPA is larger. You might even discuss how this corresponds with expected results based on the literature.
  - If p-value is greater than the significance level, do not reject Ho. There is insufficient evidence to conclude that the mean GPA differs by gender.

Example: t-Test for Paired Samples

- Ho: The mean PhD GPA = the mean Masters GPA for PhD learners.
- Ha: The mean PhD GPA does not equal the mean Masters GPA for PhD learners.
- Assumption: GPA is normally distributed
- Look at p-value / sig. value from the SPSS output
  - If p-value is less than the significance level, reject Ho. Conclude that the mean GPA is different at the Masters and PhD level for PhD learners. Look at the value of the two sample means and you can even state whether a learner's GPA increases or decreases from the Masters to the PhD. You might even discuss how this corresponds with expected results based on the literature.
  - If p-value is greater than the significance level, do not reject Ho. There is insufficient evidence to conclude that the mean GPA changes from a learner's Masters program to the PhD program.

Example: One-Way Analysis of Variance

- Ho: The mean GPA is the same for learners who are unemployed vs. part-time employees vs. full-time employees.
- Ha: There is a difference in the mean GPA for learners who are unemployed vs. part-time employees vs. full-time employees.
- Assumptions:
  - The samples from each employment group are independent
  - The population of GPAs by employment group are normally distributed
  - The population variances are equal across the employment groups
- Look at p-value / sig. value from the SPSS output
  - If p-value is less than the significance level, reject Ho. Conclude that the mean GPA is not equal across the employment groups. Then conduct a Post Hoc test to determine where the specific differences lie.
  - If p-value is greater than the significance level, do not reject Ho. There is insufficient evidence to conclude a difference in the mean GPA across the employment groups. No need to conduct a Post Hoc test.

Example: Correlation

- Ho: The correlation between a learner's GPA and Comps Score = 0
- Ha: The correlation between a learner's GPA and Comps Score is not equal to 0
- Assumptions:
  - GPA and Comps Score are normally distributed
  - The variance of the GPAs is the same across all Comps Score values
  - There is a linear relationship between GPA and Comps Score
  - All observations are independent of each other
- Look at p-value / sig. value from the SPSS output
  - If p-value is less than the significance level, reject Ho. Conclude that there is a correlation between GPA and Comps Score, and so you can predict one's Comps Score from one's GPA. A positive correlation coefficient means that the better the learner's GPA, the higher the Comps Score; a negative correlation coefficient means that the better the learner's GPA, the lower the Comps Score. You might even discuss how this corresponds with expected results based on the literature.
  - If p-value is greater than the significance level, do not reject Ho. There is insufficient evidence to conclude a correlation exists between GPA and Comps Score. If the correlation coefficient is large, it is likely that your sample is just too small to justify concluding significance exists.

Example: Chi Square Test of Independence

- Ho: A student's choice of major is independent of his/her gender.
- Ha: A student's choice of major is dependent on his/her gender.
- Assumption: All observations are independent of each other
- Look at p-value / sig. value from the SPSS output
  - If p-value is less than the significance level, reject Ho. Conclude that one's choice of major depends on one's gender, so a male is likely to make a different choice than a female. Look at the crosstabulation to see the patterns and discuss more specifically. You might even discuss how this corresponds with expected results based on the literature.
  - If p-value is greater than the significance level, do not reject Ho. There is insufficient evidence to conclude that one's choice of major depends on one's gender (i.e., that males and females choose their majors differently).

Parting Tips

- If you cannot meet the assumptions for a test, do not hesitate to use a nonparametric equivalent.
- In the nonparametric test, do not use "means" in your hypothesis as you are no longer testing a population parameter. Just hypothesize about differences in the populations.
- If you fail to reject the null, NEVER accept the null → you can never prove the null is true.
- If you fail to reject the null by a small margin, it is not "almost significant". Likewise, if you reject the null with a very small p-value, it is not highly significant. Findings are either significant or not significant.
- Do not make excuses for failing to reject the null. It is okay to suggest further research with a larger sample, but you have proven nothing, so don't make positive statements about results that aren't there.
- Don't overstate your results. You can only draw inferences to the population being tested and only in regards to the variables tested.

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