**STAT7S: Exercise Using SPSS to Explore Hypothesis Testing – Paired-Samples t Test**

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**Note to the Instructor:** The data set used in this exercise is gss14\_subset\_for\_classes\_STATISTICS.sav which is a subset of the 2014 General Social Survey. Some of the variables in the GSS have been recoded to make them easier to use and some new variables have been created.  The data have been weighted according to the instructions from the National Opinion Research Center.  This exercise uses COMPARE MEANS (paired-samples t test) to explore hypothesis testing.  A good reference on using SPSS is *SPSS for Windows Version 23.0 A Basic Tutorial* by Linda Fiddler, John Korey, Edward Nelson (Editor), and Elizabeth Nelson.  The online version of the book is on the [**Social Science Research and Instructional Council's Website**](http://ssric.org/node/582).  You have permission to use this exercise and to revise it to fit your needs.  Please send a copy of any revision to the author. Included with this exercise (as separate files) are more detailed notes to the instructors, the SPSS syntax necessary to carry out the exercise (SPSS syntax file), and the SPSS output for the exercise (SPSS output file). Please contact the author for additional information.

I’m attaching the following files.

* [**Data subset**](http://ssric.org/files/gss14_subset_for_classes_STATISTICS.sav) (.sav format)
* [**Extended notes for instructors**](http://ssric.org/files/Extended_Notes_for_Instructors_for_STAT7S.docx) (MS Word; docx format).
* [**Syntax file**](http://ssric.org/files/SPSS_Syntax_for_STAT7S.sps) (.sps format)
* [**Output file**](http://ssric.org/files/SPSS_Output_for_STAT7S.spv) (.spv format)
* [**This page**](http://ssric.org/files/STAT7S.docx) (MS Word; docx format).

**Goals of Exercise**

The goal of this exercise is to explore hypothesis testing and the paired-samples t test. The exercise also gives you practice in using COMPARE MEANS.

**Part I – Populations and Samples**

Populations are the complete set of objects that we want to study.  For example, a population might be all the individuals that live in the United States at a particular point in time.  The U.S. does a complete enumeration of all individuals living in the United States every ten years (i.e., each year ending in a zero).  We call this a census.  Another example of a population is all the students in a particular school or all college students in your state.  Populations are often large and it’s too costly and time consuming to carry out a complete enumeration.  So what we do is to select a sample from the population where a sample is a subset of the population and then use the sample data to make an inference about the population.

A statistic describes a characteristic of a sample while a parameter describes a characteristic of a population.  The mean age of a sample is a statistic while the mean age of the population is a parameter.   We use statistics to make inferences about parameters.  In other words, we use the mean age of the sample to make an inference about the mean age of the population.  Notice that the mean age of the sample (our statistic) is known while the mean age of the population (our parameter) is usually unknown.

There are many different ways to select samples.  Probability samples are samples in which every object in the population has a known, non-zero, chance of being in the sample (i.e., the probability of selection).  This isn’t the case for non-probability samples.  An example of a non-probability sample is an instant poll which you hear about on radio and television shows.  A show might invite you to go to a website and answer a question such as whether you favor or oppose same-sex marriage.  This is a purely volunteer sample and we have no idea of the probability of selection.

We’re going to use the General Social Survey (GSS) for this exercise.  The GSS is a national probability sample of adults in the United States conducted by the National Opinion Research Center (NORC).  The GSS started in 1972 and has been an annual or biannual survey ever since. For this exercise we’re going to use a subset of the 2014 GSS. Your instructor will tell you how to access this data set which is called gss14\_subset\_for\_classes\_STATISTICS.sav.

In STAT6S we compared means from two independent samples.  Independent samples are samples in which the composition of one sample does not influence the composition of the other sample.  In this exercise we’re using the 2014 GSS which is a sample of adults in the United States.  If we divide this sample into men and women we would have a sample of men and a sample of women and they would be independent samples.  The individuals in one of the samples would not influence who is in the other sample.

In this exercise we’re going to compare means from two dependent samples.  Dependent samples are samples in which the composition of one sample influences the composition of the other sample.  The 2014 GSS includes questions about the years of school completed by the respondent’s parents – d22\_maeduc and d24\_paeduc.  Let’s assume that we think that respondent’s fathers have more education than respondent’s mothers.  We would compare the mean years of school completed by mothers with the mean years of school completed by fathers.  If the respondent’s mother is in one sample, then the respondent’s father must be in the other sample.  The composition of the samples is therefore dependent on each other.  SPSS calls these paired-samples so we’ll use that term from now on.

Let’s start by asking whether fathers or mothers have more years of school?  Click on “Analyze” in the menu bar and then on “Compare Means” and finally on “Means.”  (See Chapter 6, introduction in the online SPSS book mentioned on page 1.)  Select the variables d22\_maeduc and d24\_paeduc and move them to the “Dependent List” box.  These are the variables for which you are going to compute means.  The output from SPSS will show you the mean, number of cases, and standard deviation for fathers and mothers.

Fathers have about two-tenths of a year more education than mothers.  Why can’t we just conclude that fathers have more education than mothers?  If we were just describing the **sample**, we could.  But what we want to do is to make inferences about differences between fathers and mothers in the **population**.  We have a sample of fathers and a sample of mothers and some amount of sampling error will always be present in both samples.  The larger the sample, the less the sampling error and the smaller the sample, the more the sampling error.  Because of this sampling error we need to make use of hypothesis testing as we did in the two previous exercises (STAT5S and STAT6S).

**Part II – Now it’s Your Turn**

In this part of the exercise you want to compare the years of school completed by respondents and their spouses to determine whether men have more education than their spouses or whether women have more education than their spouses.

Use SPSS to get the sample means as we did in Part I and then compare them to begin answering this question.  But we need to be careful here.  Respondents could be either male or female.  We need to separate respondents into two groups – men and women – and then separately compare male respondents with their spouses and female respondents with their spouses.  We can do this by putting the variables d4\_educ and d29\_speduc into the “Dependent List” box and d5\_sex into the “Independent List” box.

**Part III – Hypothesis Testing – Paired-Samples t Test**

In Part I we compared the mean years of school completed by fathers and mothers.  Now we want to determine if this difference is statistically significant by carrying out the paired-samples t test.

Click on “Analyze” and then on “Compare Means” and finally on “Paired-Samples T Test.”  (See Chapter 6, paired-samples t test in the online SPSS book.)  Move the two variables listed above into the “Paired Variables” box.  Do this by selecting d22\_maeduc and click on the arrow to move it into the “Variable 1” box.  Then select the other variable, d24\_paeduc, and click on the arrow to move it into the “Variable 2” box.  Now click on “OK” and SPSS will carry out the paired-samples t test.  It doesn’t matter which variable you put in the “Variable 1” and “Variable 2” boxes.

You should see three boxes in the output screen. The first box gives you four pieces of information.

* Means for mothers and fathers.
* N which is the number of mothers and fathers on which the t test is based.  This includes only those cases with valid information.  In other words, cases with missing information (e.g., don’t know, no answer) are excluded.
* Standard deviations for mothers and fathers.
* Standard error of the mean for mothers and fathers which is an estimate of the amount of sampling error for the two samples.

The second box gives you the paired sample correlation which is the correlation between mother’s and father’s years of school completed for the paired samples.  If you haven’t discussed correlation yet don’t worry about what this means.

The third box has more information in it.  With paired samples what we do is subtract the years of school completed for one parent in each pair from the years of school completed for the other parent in the same pair.  Since we put mother’s years of school completed in variable 1 and father’s education in variable 2 SPSS will subtract father’s education from mother’s education.  So if the father completed 12 years and the mother completed 10 years we would subtract 12 from 10 which would give you -2.  For this pair the father completed two more years than the mother.

The third box gives you the following information.

* The mean difference score for all the pairs in the sample which is -0.176.  This means that fathers had an average of almost two-tenths of a year more education than the mothers.  By the way, in Part I when we compared the means for d22\_maeduc and d24\_paeduc the difference was 0.22.  Here the mean difference score is .176.  Why aren’t they the same?  See if you can figure this out.  (Hint: it has something to do with comparing differences for pairs.)
* The standard deviation of the difference scores for all these pairs which is 3.206.
* The standard error of the mean which is an estimate of the amount of sampling error.
* The 95% confidence interval for the mean difference score.  If you haven’t talked about confidence intervals yet, just ignore this.  We’ll talk about confidence intervals in a later exercise.
* The value of t for the paired-sample t test which is -2.324.  There is a formula for computing t which your instructor may or may not want to cover in your course.
* The degrees of freedom for the t test which is 1,795 which is the number of pairs minus one or 1,796 – 1 or 1,795.  In other words, 1,795 of the difference scores are free to vary.  Once these difference scores are fixed, then the final difference score is fixed or determined.
* The two-tailed significance value which is .020 which we’ll cover next.

Notice how we are going about this.  We have a sample of adults in the United States (i.e., the 2014 GSS).  We calculate the mean years of school completed by respondent’s fathers and mothers in the **sample** who answered the question.  But we want to test the hypothesis that the mean years of school completed by fathers is greater than the mean for mothers in the **population**.  We’re going to use our sample data to test a hypothesis about the population.

The hypothesis we want to test is that the mean years of school completed by fathers is greater than the mean years of school completed by mothers in the population.  We’ll call this our research hypothesis.  It’s what we expect to be true.  But there is no way to prove the research hypothesis directly.  So we’re going to use a method of indirect proof.  We’re going to set up another hypothesis that says that the research hypothesis is not true and call this the null hypothesis.  If we can’t reject the null hypothesis then we don’t have any evidence in support of the research hypothesis.  You can see why this is called a method of indirect proof. We can’t prove the research hypothesis directly but if we can reject the null hypothesis then we have indirect evidence that supports the research hypothesis. We haven’t proven the research hypothesis, but we have support for this hypothesis.

Here are our two hypotheses.

·       research hypothesis – the mean difference score in the population is negative.  In other words, the mean years of school completed by fathers is greater than the mean years for mothers for all pairs in the population.

·       null hypothesis – the mean difference score for all pairs in the population is equal to 0.

It’s the null hypothesis that we are going to test.

Now all we have to do is figure out how to use the t test to decide whether to reject or not reject the null hypothesis.  Look again at the significance value which is 0.020.  That tells you that the probability of being wrong if you rejected the null hypothesis is. 02 or 2 times out of one hundred.  With odds like that, of course, we’re going to reject the null hypothesis.  A common rule is to reject the null hypothesis if the significance value is less than .05 or less than five out of one hundred.

But wait a minute.  The SPSS output said this was a two-tailed significance value. What does that mean?  Look back at the research hypothesis which was that the mean difference score for all pairs in the population was less than 0.   We’re predicting that the mean difference score for all pairs in the population will be negative.  That’s called a one-tailed test and we have to use a one-tailed significance value.  It’s easy to get the one-tailed significance value if we know the two-tailed significance value.  If the two-tailed significance value is .020 then the one-tailed significance value is half that or .020 divided by two or .010.  We still reject the null hypothesis which means that we have evidence to support our research hypothesis. We haven’t proven the research hypothesis to be true but we have evidence to support it.

**Part IV – Now it’s Your Turn Again**

In this part of the exercise you want to compare the years of school completed by respondents and their spouses to determine if women have more education than their spouses but this time you want to test the appropriate null hypotheses.

Remember from Part II that we have to test this hypothesis first for men and then for women.  We’re going to do this by selecting out all the men and then computing the paired-samples t test.   Do this by clicking on “Data” in the menu bar and then clicking on “Select Cases.”  Select “If condition is satisfied” and then click on “If” in the box below.  Select d5\_sex and move it to the box on the right by clicking on the arrow pointing to the right.  Now click on the equals sign and then on 1 so the expression in the box reads “d5\_sex = 1”.  Click on “Continue” and then on “OK”.  To make sure you have selected out the males run a frequency distribution for d5\_sex.  You should only see the males (i.e., value 1).  Now carry out the paired-samples t test. Repeat this for the females (i.e., value 2) by selecting out the females and then running the paired-samples t test again.

For each paired-sample t test, state the research and the null hypotheses.  Do you reject or not reject the null hypotheses?  Explain why.