Homework #6

**Please select ONE best answer for Multiple Choice questions. When answering non-Multiple Choice questions, if you are asked to calculate an answer, please show your work.**

**There are a total of 50 pts. for this Homework assignment.**

1. Which of the following would be an appropriate use of t-tests for analyzing significance of differences?
   1. Comparison between an experimental group to the population
   2. Comparison between 2 groups on an interval/ratio measure
   3. Comparison between 2 groups on an ordinal measure
   4. Comparison between 2 or more groups on an interval/ratio measure
2. A t-test can be used for which of the following research designs?
   1. Between group design
   2. Within subjects design
   3. Repeated measures design
   4. All of the above
3. When calculating an independent t-test, the numerator is the difference between group means and the denominator is :
   1. Standard error of the control group mean
   2. Standard error of the intervention group mean
   3. Standard error of the differences between the group means
   4. All of the above
4. A dependent or related samples t-test is used to compare:
   1. Means from the same group on a measure obtained at two different points in time
   2. Means from two different groups that are not independent
   3. Means from two groups where participants are matched on a particular variable
   4. All of the above
5. Most statistical tests can be broadly defined as the ratio between variance explained by the model we are using (systematic variation) to the variance that cannot be explained by the model (unsystematic variation). When calculating a *related samples t-test*, the systematic variation is:
   1. Mean difference observed between the mean of our 2 or more groups
   2. Mean difference observed between pairs in our sample
   3. Standard error of differences between our group means
   4. Standard error of differences between pairs in our sample
6. Which of the following scenarios is most likely to give us confidence that the observed difference in our sample is a true difference and not due to chance?
   1. A large average difference between means with a small standard deviation of differences
   2. A large average difference between means with a large standard deviation of differences
   3. A small average difference between means with a small standard error of differences
   4. A small average difference between the means with a large standard error of differences
7. Once you have calculated your t-statistic, you must compare your statistic to a critical value of the t-distribution. Which of the following is/are needed to determine whether your calculated t-statistic is significant?
   1. Number of degrees of freedom
   2. Whether you tested a directional or non-directional hypothesis
   3. Your pre-determined alpha level
   4. All of the above
8. Which of the following assumptions must be met to use the paired samples t-test?
   1. Homogeneity of variances
   2. Scores are normally distributed
   3. Differences between paired scores are normally distributed
   4. All of the above
9. Designing your study such that you can use a related samples t-test rather than an independent t-test improves your statistical power. The best explanation for this fact is that a related samples test :
   1. Increases your effect size
   2. Allows you to make assumptions that are more easily met
   3. Reduces the unsystematic variation
   4. Reduces the systematic variation
10. Which of the following is the conventional level of statistical power that we strive for:
    1. .05
    2. .80
    3. .95
    4. .99

Let’s now apply the information to calculate and run a few t-tests. I won’t ask you to conduct long calculations with datasets but I believe it is helpful to go through a simple calculation to get an understanding of what SPSS calculates and what it throws out in outputs.

**Example 1.** You are interested in comparing change in pinch strength in a group of patients who wear a hand splint to a group who do not wear a hand splint. You decide to conduct an independent t-test to determine whether the difference found between the two groups is significant. You hypothesize that the splinted group will have greater improvement than the unsplinted group.

1. What is the null hypothesis? There will be no noticeable change in pinch strength between the group of patients who wear a hand splint and those who do not wear one.

What is the alternate (experimental) hypothesis? There will be a noticeable change in pinch strength between those who wear a hand splint and those who do not wear one.

Here is the data: [Means shown for each group are values of change]

Group 1 (splinted): Mean1=10.11, n1=10, s1=3.71

Group 2 (unsplinted): Mean2=5.45, n2=10, s2=3.95

All you need to calculate an indep. t-test is the group mean, sample size and variance for each group (you don’t need the raw data, which can be helpful when trying to get effect size from the literature!). Here, you have standard deviation (s) for each group, so you can easily calculate group variances.

1. What is the variance for the splinted group? s12 = 13.76

What is the variance for the unsplinted group? s22 = 15.60

To calculate t, you use the formula: **Mean1 – Mean2 /estimated standard error of *difference***

Remember that we can use the standard deviations to estimate standard error but first, we have to pool the variances to obtain sp2.

The formula to calculate sp2 looks formidable but is actually a very simple calculation.

sp2 = (n1 – 1)s12 + (n2 – 1)s22

n1 + n2 -2

1. Plug in sample sizes and group variance to the formula. What is the pooled variance sp2? sp2 = 14.68

Now that we have our pooled variance, we can calculate the estimated standard error of differences. To clarify, the standard error of differences relates to how much we would expect the *differences* between the group means to differ by chance alone. To estimate standard error of difference, we use the standard deviation of the sampling distribution of group differences (Whew!). We have already pooled our variances above (sp2), so the standard deviation of group differences is an easy calculation.

s(Mean1-Mean2) = square root of (sp2/n1 + sp2/n2)

This is your estimated standard error of differences and is the denominator in the t-formula in bold (in blue box) above.

1. What is your calculated standard error of differences from the calculation above?

S = 1.71

1. From: t = **Mean1 – Mean2 /estimated standard error of *difference***, what is your calculated t?

t = 2.73

To determine whether this calculated t-statistic is statistically significant, you will need to look up the critical value of t at an alpha level of .05. The next questions relate to information you need to locate and interpret the results of your t-test. Use Appendix A.2. for critical values of the t-distribution (remember you did this earlier with one-sample t-tests).

1. How many degrees of freedom are there? df = 18
2. Is this a one-tailed test or two-tailed test? One-tailed test
3. What is the critical value of t from Appendix A.2.? 1.734 (focused on one-tailed test with alpha level = 0.05 due to initial predictions), would be 2.101 for two-tailed test.
4. What is your conclusion regarding your null hypothesis? I must reject the null hypothesis because the actual t-value is more than the critical t-value.
5. Calculate confidence intervals using the formula below.

95%CI = (Mean1 – Mean2) ± (t)s(Mean1-Mean2)

[NOTE: (t) in the formula is the critical value of t for an alpha level of .05]

Lower confidence interval = 1.06

Higher confidence interval = 8.26

1. What is your interpretation of the calculated confidence interval? (What does it tell you?)

The calculated and critical t-values are both included in the confidence intervals, so this means that these values are probably translatable to the population.

Now, we will enter the data and let SPSS do the work! See the dataset in this week’s Module called **Dataset Indep\_t**. This is the same data that was used to generate the Example 1 means and variances that you were provided above. Note that the values provided for “strength” are changes in pinch strength under the two splinting conditions. Run an independent t-test to determine whether the difference found between the two groups is significant. You are testing the same hypothesis as above. You will note that you can use the resulting output to check your computed values above! Please cut and paste your t-test output here.

|  |
| --- |
| **Independent Samples Test** |
|  | Levene's Test for Equality of Variances | t-test for Equality of Means |
|  | F | Sig. | t | df | Sig. (2-tailed) |  | 95% Confidence Interval of the Difference |
| Std. Error Difference | Low- Up |
| change in pinch strength in lbs | Equal variances assumed | .685 | .419 | 2.718 | 18 | .014 | 4.66000 | 1.71430 | 1.05839 | 8.26161 |
| Equal variances not assumed |  |  | 2.718 | 17.935 | .014 | 4.66000 | 1.71430 | 1.05745 | 8.26255 |

Answer Questions 22- 29 regarding your output.

1. What assumption does Levene’s test address? Levene’s test addresses the assumption that the population variances are equal.
2. Was the assumption met?

Explain how you determined your answer.

Yes, the assumption was met because the significance value is greater than 0.05.

1. From your output, what is the t-statistic? 2.718

In this case, the t-value for “Equal variances assumed” and “Equal variances not assumed” are the same. That will not always be the case.

What is your criteria for using “Equal variances not assumed?

The degrees of freedom of the t-test must be adjustable to compensate for the degree to which variances are unequal.

1. What Is the p-value for your t-test? The p-value = 0.014 for 2 tailed t-tests for equality of means, but the p-value should be 0.007 for the one-tailed t-test predicted.

NOTE: the p-value provided in your output assumes a 2-tailed test.

1. How would you report the results of your t-test? State here. \*Hint: See p. 353 of Field. There was a significant difference in pinch strength between splinted individuals (M = 10.11, SD = 3.71) and unsplinted individuals (M = 5.45, SD = 3.95); t(df) = 2.718, p = 0.014).
2. The 95%confidence intervals are reported in your output (for 2-tailed). You can use the confidence interval to test your hypothesis. What do the confidence intervals you calculated for a 1-tailed test (#20) tell you regarding your hypothesis?

The null-hypothesized value falls outside of the confidence intervals, meaning the p-value is less than 5%.

1. How did you determine your decision to accept or reject your null hypothesis using confidence intervals?

We reject the null hypothesis because there is a difference between the splinted and unsplinted group that is evident by the null hypothesis value falling outside the confidence intervals.

1. Does your hypothesis test using confidence intervals support your hypothesis test using the p-value?

Yes it does, both support rejecting the null hypothesis.

**Example 2.** You are interested in testing the effect of using a lumbar support pillow on angular position of the pelvis in relaxed sitting so you decide to test a group of people in both conditions (with the use of a lumbar support, without use of a lumbar support pillow). Since you are testingthe same group in two different conditions, this is a repeated measures design and you decide to test your hypothesis using a related samples t-test. You hypothesize that the pelvic angle will differ with the lumbar support.

1. What is the H0? There will be no difference in angular positions of the pelvis in a relaxed sitting with and without a lumbar support pillow.
2. What is the H1? There is a difference in angular positions of the pelvis in a relaxed sitting when using a lumbar support pillow and when not using one.
3. Is this a directional or non-directional hypothesis? Non-directional

Before we start calculations, it is important that you understand that we are testing the significance of *differences* between the two conditions in each individual. The data in the table below represent pelvic angle in degrees. Here is the data: *d* is the difference score for each pair. Although we could calculate the standard deviation of difference scores using the data, I will just provide it here. You’re welcome! ☺ sd = 6.232

|  |  |  |  |
| --- | --- | --- | --- |
| Subject | X1 (without pillow) | X2 (with pillow) | *d* |
| 1 | 108 | 112 | -4 |
| 2 | 102 | 96 | 6 |
| 3 | 98 | 105 | -7 |
| 4 | 112 | 110 | 2 |
| 5 | 100 | 106 | -6 |
| 6 | 85 | 98 | -13 |
| 7 | 92 | 90 | 2 |
| 8 | 95 | 102 | -7 |

1. What is the sum of *d* scores? -27
2. What is the Mean of *d* scores? -3.375

To calculate a related samples t-statistic, the formula is:

**t= Mean*d /*estimated standard error of differences**

Just as with independent t-tests, we estimate the standard error of differences using the standard deviation of differences in our sample but it is a little easier since we only have one sample so we do not need to pool variances. So, standard deviation of differences (s*d*) that I provided above is simply divided by the square root of the sample size. (s Mean d = s*d /*square root of n)

1. What is your calculated standard error of differences? 2.20
2. Now you should have everything you need to plug into the formula for t above. Well, you will need to get the Mean for with and without the pillow first! What is your calculated t-statistic?

t = -1.53

1. How many degrees of freedom are there? 7
2. Is this a one-tailed test or two-tailed test? Two-tailed
3. What is the critical value of t for an alpha of .05? 2.365
4. What is your conclusion regarding your null hypothesis? To accept the null hypothesis because the actual t-value is less than the critical t-value.
5. Calculate confidence intervals using the formula below. [Note: the t-value in the formula is the critical value of t, not the calculated value.]

95%CI = Meand ± (t)s(Mean d)

Upper confidence interval = 1.828

Lower confidence interval = -8.578

1. What is your interpretation of the calculated confidence interval? (What does it tell you?) The calculated t-value is in the confidence interval, but the critical t-value is not. More information is needed to determine whether to accept or reject the null hypothesis.

Now, we will enter the data and let SPSS do the work! See dataset called **Dataset Paired t** in your Module folder. This is the dataset used to generate the table above in Example2. Use SPSS to run a paired sampl[es t-test to test the hypothesis you wrote in the example above (#30). Once again, you should be able to use the resulting output to check your calculated answers above.

Please provide your SPSS output here.

|  |
| --- |
| **Paired Samples Test** |
|  | Paired Differences |  |  |  |
|  | Mean | Std. Deviation |  |  | Upper | t |
| Std. Error Mean | Lower | df |
| Pair 1 | Pelvic angle in degrees with lumbar pillow - Pelvic angle in degrees without lumbar pillow | -3.37500 | 6.23212 | 2.20339 | -8.58518 | 1.83518 | -1.532 | 7 | .169 |

1. Note that there is no Levene’s test in your output? Why is that? There was no Levene’s test because the same individuals were used throughout the experiment (with and without the pillows), meaning there was only one group.
2. What is the calculated p-value for the test of significance between the 2 conditions and what do you conclude regarding the significance of the differences found? The calculated p-value = 0.169. The significance of differences found is greater than the set alpha level (0.05), so we are told to accept the null hypothesis.
3. Test your hypothesis using the 95% confidence intervals in your output. What is your decision regarding your hypothesis? The t-value was found to be included within the 95% confidence intervals, meaning we must accept the null hypothesis.
4. Does your decision based on confidence interval support your decision using the p-value?

Yes, it does as both say to accept the null hypothesis.

**Example 3.** From Example 1, calculate the effect size using Cohen’s *d*. The formula for calculating a Cohen’s d for independent t-tests is on p. 343 of Field. Next calculate Cohen’s *d* for Example 2. The formula for related samples t is on p. 353 of Field.

1. What is your calculated effect size for Example 1? d = 0.48

Cohen’s d= (mean change splint – mean changecontrol)/scontrol

1. What is your calculated effect size for Example 2? d = 0.46

Cohen’s d= (mean pillow – mean control)/scontrol =

These calculations of Cohen’s d are very simple but as I indicated in one of the slides in Field’s PP presentation, it becomes more complicated for an independent t-test that does not have a control group. In that case, you have to pool the variances for both groups and it is not so simple! Here is my “secret”, there are computer programs that can do this calculation for you. I have included one as a link in your Module 7 materials. As long as you understand the principle behind the calculation of Effect size when there is no control group, I have no problem with you using the computer program to perform the calculation for you. Another piece of good news is that SPSS v. 28 is the next version that will be available at TWU soon, and that new version calculates the Cohen’s d using pooled variances whenever you request a t-test. How cool is that! AND, if you are a Mac user, and you got SPSS from TWU this semester, you already have it! TWU is now field testing v.28 with PC’s and if that goes well, it will be available shortly.

Now that you have an effect size, you could use a Table to determine the needed sample size in each group (for indep. t-test) or total number of participants needed (for related samples t-test) in order to get a specified level of power. However, as Field states (in a less than eloquent manner on p. 333), there is no need to do this because we now have computer programs to do it for us.

G\*Power is a commonly used program used to estimate sample size needed to obtain a specified level of statistical power. I provided you with a link to a free download of G\*Power in the narrative and in Module 7 materials. If you did not download the program, you will need to do so now in order to answer the last 2 questions.

1. Enter your calculated effect size, alpha level of .05, and power of .80 into G\*Power to determine the number of participants needed in Example 1 (Indep. t-test). What is the G-Power number of participants needed for each group? 15 participants per group
2. Enter your calculated effect size, alpha level of .05, and power of .80 into G\*Power to determine the number of participants needed in Example 2 (Related samples/dependent samples t-test). What is the G-Power number of participants needed? 32 participants total

\*Note: If you did not have an actual calculated effect size a priori (which you often do not!), you could enter conventional values for small, medium or large estimated effect size, and let G\*Power do the calculation that way. Or, perhaps you have an effect size from the literature that you could enter.