

***SPSS for Windows 11.0***  
***Two-way ANOVA***

In this assignment you'll learn how to use SPSS to analyze data from studies where there are two non-repeated independent variables (i.e., each subject only provides data for one level of each independent variable). You will need to know how to test each of the following effects:

1. Interaction between A and B
2. Main effects for A and B
3. Main comparisons for A and B
4. Simple Effects for A and B
5. Simple comparisons for A and B

The examples for this assignment will use the **bpdat** data set.

- Bring up the bpdat data set into the SPSS spreadsheet.

The two independent variables in this study are **exergrp** (exercise group) and **bpstat** (blood pressure status). Exercise group has three levels (aerobic exercise = 1; strength training = 2; no-exercise = 3). Blood pressure status has two levels (normal blood pressure = 1; high blood pressure = 2).

Let's say that the investigator has made the following predictions before collecting their data.

1. There will be a significant interaction between Exercise Group and Blood Pressure Group for the dependent variable systolic blood pressure at Time 2 (**sysbp2**). Main effects for both exercise group and blood pressure group are also predicted to be present.
2. The investigator predicts that there will be a significant simple effect of exercise group for subjects in the normal blood pressure group.
3. There will not be a significant simple effect of exercise group for subjects in the high blood pressure group.
4. Given the prediction of a simple effect of exercise group for normal blood pressure subjects, the investigator decides to conduct two planned simple comparisons.
  - a. For subjects with normal blood pressure, subjects who engage in exercise will have significantly lower levels of systolic blood pressure at time 2 than subjects who do not exercise.
  - b. For subjects with normal blood pressure, subjects who engage in aerobic exercise will have significantly lower levels of systolic blood pressure at time 2 than subjects who engaged in strength training.

Now we need to take you through what needs to happen in order to test each of these predictions. Because none of the predictions is testable by a main comparison, we'll show you how to test a main comparison after we're done with this analysis.

**Testing the interaction between two independent variables and the main effects for these two independent variables.**

The dependent variable in this study is **sysbp2** -- systolic blood pressure at the second time of testing (after the exercise intervention has had time to have an effect).

- From the spreadsheet, click **Analyze**.
- Click **General Linear Model**
- Click **Univariate**. This should bring up the **Univariate** window.
- Select the dependent variable for the analysis. Click **sysbp2** from the variable list at the left side of the window. Click the right arrow key beside the **Dependent** box. The variable name **sysbp2** should now appear in that box.
- Select the two independent variables for the analysis.
  - It doesn't matter what order you select the variables in. Let's say you click on the variable name **exergrp** in the variable list.
  - Now click the right arrow key beside the **Fixed Factor(s)** box.
  - Now let's select the second independent variable, **bpstat**. Click the variable name **bpstat** in the variable list. Click the right arrow key beside the **Fixed Factor(s)** box. You'll see the variable name **bpstat** in the box.
  - Click the **Options** button. Click the open square beside the **Descriptive Statistics** option to get descriptive statistics for the various groups. Under **Factor(s) and Factor Interactions**, click the interaction term **exergrp\*bpstat**. Then click the right arrow beside **Display Means For**. This will give you a table containing all of the group means. Click **Continue**.
  - Back at the **Univariate** window, click the **Plot** button to bring up the **Profile Plots** window. Put **exergrp** in the **Horizontal Axis** box. Put **bpstat** in the **Separate Lines** box. Click **Add**. This will give you a graph of the interaction.
  - Click **OK** after returning to the **Univariate** window.

In the output window...

- You first get a table which just tells you how many subject's data were used in the analysis.
- Next you get a **Descriptive Statistics** table that gives you the mean and the number of subjects for each group.

- Next, you get the ANOVA table. There are rows for the two main effects and the interaction between the two independent variables. The interaction gives us an F-ratio of 4.808 and a significance level of .012, which reaches significance at the .05 level. Both main effects are significant also.
- The “not-accounted-for” or within-subjects row is labeled “Error” by SPSS. Notice that the sum of squares within-groups is 7339.4, this source of variability has 54 degrees of freedom, and the Mean Square for the error term is 135.915. This mean square is the appropriate error term to test every effect from now on. So write that number down. **Really, I’m serious. Write it down on a piece of paper. You’re going to need it. MS within-groups = 135.915.**
- There are two rows included in the table that we don’t need to worry about. These are the **intercept** row (SPSS is really running a multiple regression with the data) and the **Corrected Total** row.

#### Testing simple effects using the GLM routine of SPSS for Windows

The presence of the significant interaction means that whatever effect of Exercise Group there is, that effect is not the same for people with high blood pressure as it is for people with normal blood pressure. As you know, a simple effect is the effect of one independent variable at one level of a second independent variable. This, of course, is essentially a one-way ANOVA, but only using the subjects from one level of another independent variable.

The investigator has predicted that the simple effect of exercise group for subjects with normal blood pressure will be significant, but that the simple effect of exercise group for subjects with high blood pressure will not be significant. Each of these predictions is tested through a one-way ANOVA.

So, we want a one-way ANOVA that tells us if there is an effect of changing the exercise conditions on systolic blood pressure at the second time of testing. But, let’s say that we only want to include subjects who have normal blood pressure. The one-way ANOVA is easy. We already know how to get SPSS to do that. How do we limit the subjects included to only those with normal blood pressure? That’s easy too. And we already know how to do it!

- Minimize the output window so that you’re looking at the SPSS spreadsheet.
- We now need to limit the number of cases that SPSS will use.
- Click the **data** pull-down menu.
- Click **Select Cases**.
- Click the “**If condition is satisfied**” option. Click the **If...** button.
- Type “**bpstat = 1**” in the open box.
  - Click **Continue**

- Click **Ok**. When you look in the spreadsheet, there will now be a slash through the case number of the cases that do not fit the selection conditions. In other words, at this point the only subjects eligible for inclusion in analyses are those in the first level of blood pressure status – those with high blood pressure.
- Now, let's perform our One-Way ANOVA.
- Click **Analyze**
- Click **Compare Means**
- Click **One-Way ANOVA**
- Select **sysbp2** as the dependent variable and **exergrp** as the independent variable (Factor).
- Under **Options** click the descriptives statistics option. Click **Continue** to return to the One-Way ANOVA window.
- Click **OK**

In the output window...

- You can see from the ANOVA table that the effect is significant. But this analysis does NOT give you the correct observed value for F or test the effect using the correct number of degrees of freedom for the error term. What do you mean? I'm looking right at it! I know. SPSS does not provide direct tests in the icon-based option for simple effects or simple comparisons. It gives you what you need to do this yourself, but it doesn't do this directly.
- Think from class how many degrees of freedom the error term (within-groups) deserves to have. It's the number of groups (6) multiplied by the number of subjects in each group minus one ( $10 - 1 = 9$ ). Six multiplied by nine gives you 54 degrees of freedom. The error term for the One-way ANOVA only has 27 degrees of freedom. This means that if you go with the result from the one-way ANOVA you're going to be using the incorrect critical value for F – a critical value that is **higher** than it really deserves to be. The appropriate error term is the Mean Square Residual from the Overall Effects, which when you wrote it down was equal to 135.915 and has 54 degrees of freedom associated with it.
- To test the simple effect take the mean square for the effect from the One-way ANOVA output (1501.433) and divide it by the appropriate error term (135.915). This will give you an observed value for F equal to 11.04. This is compared to the critical value for F at 2 df for the numerator and 54 degrees of freedom for the denominator. From the table in the back of the book, this critical value is 3.15. Because the observed value for F is greater than the critical value for F, the effect can be said to be significant at the .05 level.

To test the simple effect of exercise group both subjects with high blood pressure, you need to go back to the Select Cases window and change the selection criteria to **bpstat = 2** and then re-run the ANOVA. You get the MS for the effect of exercise group and, again, divide this number by the error term of 135.915 to get the observed value for F.

This second simple effect is not significant, so there is no need for any simple comparisons.

### Testing a set of simple comparisons

In the same way that a simple effect is a one-way ANOVA at a single level of the second independent variable, a set of simple comparisons is a set of comparisons among these same means.

Getting the Mean Squares for simple comparisons is exactly the same as the methods you used for the one-way ANOVA assignment. There were two simple comparisons planned by the investigator in this study.

1. For subjects with normal blood pressure, the mean systolic blood pressure is predicted to be lower than for subjects who exercise than the mean systolic blood pressure for subjects who do not exercise (levels 1 and 2 versus level 3).
  2. For subjects with normal blood pressure, the mean systolic blood pressure for subjects who engage in aerobic exercise will be significantly lower than for subjects who engage in strength training (level 1 versus level 2).
- Minimize the output window to return to the spreadsheet.
  - Go back to the select cases option and specify If: → **bpstat = 1**. Because now we only want to work with the data for the people with normal blood pressure.
  - Click the **Dialog Recall** icon (it's just to the right of the printer icon) and **select One-Way ANOVA**.
  - Click the **Contrasts** button and enter coefficients for the two planned comparisons outlined above (.5, .5, -1 for comparison one, 1, -1, 0 for comparison two).
  - Run the One-Way ANOVA again with both contrasts (comparisons) included.
  - The observed value for t for comparison 1 (levels 1 and 2 versus level 3) is  $-3.704$ . The observed value for t for the second comparison (level 1 versus level 2) is  $-2.837$ . Again these effects have the same problem as the One-way output for the simple effects. **THEY'RE BASED ON THE WRONG ERROR TERMS**. So you have to work with the output by hand so that you use the correct error term.
  - To get the observed values for F for each comparison, you need to take Mean Squares for each effect and divide them by the appropriate error term (135.915). What's the MS for the first comparison? All you have at this point is the observed value for t. But you know that  $F = t^2$ . So for the first comparison,  $F = (-3.704)^2 = 13.72$ . In the One-Way ANOVA table, the MS within-groups is 137.963. The MS for the effect will be  $(F)(MS \text{ Within-groups}) = 13.72(137.963) = 1892.85$ . This MS for the effect is then divided by the appropriate error term of 135.915 to yield an observed value for F for the comparison of **13.92**. This observed value is compared to the critical value at 1 df for the numerator and 54 df for the denominator which is 4.00. The observed value is greater than the critical value so the simple comparison is significant.

- For the second comparison, the observed value for  $t = -2.837$ . The observed value for  $F$  from the One-way ANOVA analysis is  $(-2.837)^2$  which is 8.05 (again, this is not the most appropriate number to use because it wasn't calculated using the appropriate error term). If  $F = 8.05$  from that ANOVA table the MS for the effect must be equal to  $(8.05)(137.963) = 1110.60$ . If the MS for the second comparison is 1110.60 and the appropriate MS to use as the error term to use is 135.915. Then the observed value for  $F$  for the second comparison should be  $1110.60/135.915$ , which equals 8.17. Compared to the critical value of 4.00, this second comparison reaches significance at the .05 level.

### PSYC 610 Assignment

Please take the results from the previous analyses and (a) provide an ANOVA table (including critical values for  $F$ ) that contains all of the results, and (b) write a paragraph that summarizes the conclusions that the investigator is entitled to draw on the basis of these analyses. ***Please hand in a printout of your output window. Please make sure that the Notes section is visible for each section of output. Please hand in your responses to parts a and b above on a separate piece of paper.*** The assignment is due on Tuesday of the last week of classes.

### Main comparisons

To test a main comparison, all you have to do is to run the One-Way ANOVA procedure using the Contrasts option to get the MS for the comparisons you want. Remember, you will need to make sure that ALL of the subjects in the study are included in this analysis, so make sure that any selection criteria are turned off. Take the MS for the comparison from the One-WAY ANOVA output and divide it by the MS residual (within-groups) for the overall error term (in this example that number was 135.915). Compare this resulting  $F$ -ratio against the critical value for  $F$  at the appropriate number of degrees of freedom (1 for the numerator and 54 for the denominator in this example).