Task 8:

Analyze your data

Deliverables for this Task

1) One or more Analyses of Variance (ANOVAs) of your data;

>Submit both the SPSS output and your simplified ANOVA tables.

2) Graphs and tables for all of the significant effects that you identified;

>Do at least one graph and one table for practice even if you get no significant interactions.

Overview

One of the biggest advantages of experimental research is that the data collection is designed specifically to optimize the relevance and quality of the data for a specific set of hypotheses. You don't have to rely on other researchers' data and explain why it *might* be relevant for your hypotheses. Instead, you go out and collect your own data. By this time, you have your own data in the form of a spreadsheet that's ready to use in a statistical analysis program.

This Task focuses on your data analysis activities. Data analysis is actually quite fun, if you've planned ahead like we did. We planned data collection for use with a technique called Analysis of Variance (ANOVA), so the routine part of the analysis is really quite simple. The fun part is when you look at your same set of data in different ways, with different analyses to find the best way of understanding it.

> There are basically three steps left to complete your data analysis:
>
> 1. Run your statistical analyses
>
> 2. Identify the important results
>
> 3. Make tables and graphs of the significant results

1. Run your Statistical Analyses

For your analyses, you will use the SPSS® statistical analysis package. SPSS contains a series of programs that will perform statistical analyses of the data in your data file quickly, efficiently, and *blindly*. "Blindly" is the operative word here. If you ask for an analysis of whether shoe size determines ability in nuclear physics, whether lung cancer causes smoking, or whether eye color correlates with dreams about polar bears in ballet slippers, SPSS won't complain a bit! It will only complain if it doesn't have enough or the right kind of numbers. It only sees numbers and has *no idea* what the numbers symbolize or whether they mean anything at all.

Your job as a researcher is to feed the program meaningful numbers, to ask for meaningful analyses, and to explain what the results mean.

a. Import your data into SPSS.

For the last Task, you developed an Excel spreadsheet with the data that you want to analyze. If you went ahead and just typed your data into SPSS directly, just skip this step.

Follow these steps to import your Excel file into SPSS for analysis.

Method 1. When SPSS starts up, you will see this window.

a) Click on **Open another type of file**;

b) Click on **More files…** and on **OK**.

c) Browse for your Excel data file (wherever it is) then click on **Open**.

You will see the *Opening Excel Data Source* window (see explanation below).
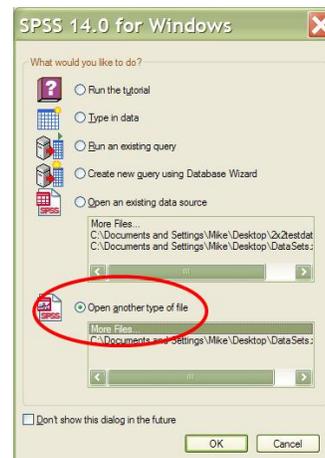
Method 2. If you don't see the *What would you like to do?* window, you can import your file with the SPSS Data Editor.

a) Click on the Folder icon (shown here) or click on **File / Open / Data**.
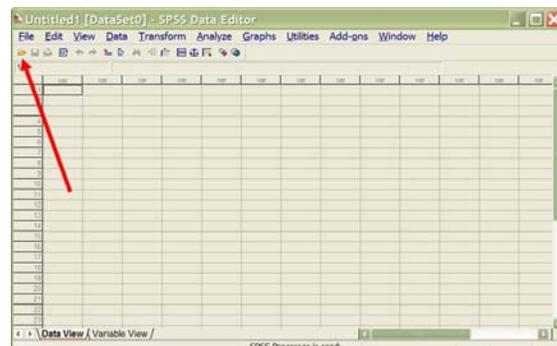
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b) Be sure to change the *Files of type* option, so that you can see your Excel data file;

- Click on the down arrow (near the **Paste** button) to see the other file types;

- Click on **Excel (*.xls)** to see only Excel files;

c) Click on your Excel data file, then click on **Open**;
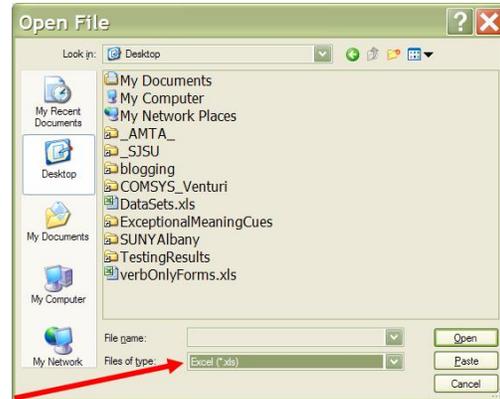
This window shows your options for opening an Excel data file.

a) Make sure that you check the *Read variable names from the first row of data* option.

b) Click on **OK**.
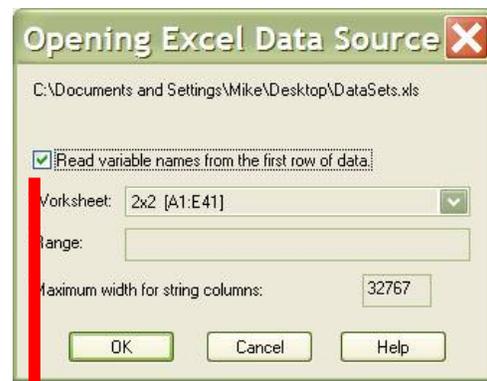
You will see that the *Read variable names from the first row of data* option inserted the variable names from the Excel data file as column labels in your new SPSS data file.
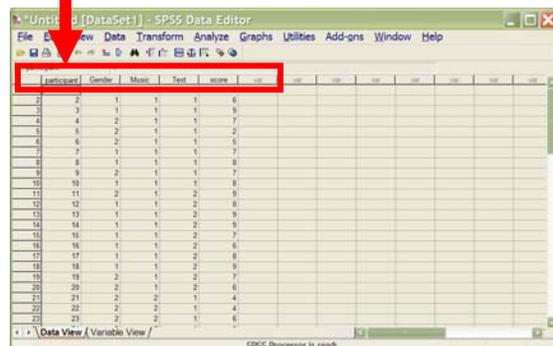
Now double check your variable types before you start to work with your SPSS data file.

a) Click on the *Variable View* tab at the bottom of your screen.

Under **Name**, you'll see all of your variable names. Under **Type**, you'll see *String*, *Numeric*, or some other option.

b) Check that all of your variables have the correct Type:

- independent variables have to be *Strings*;

- dependent variables *have to be Numeric*;

- Participant traits (from your background questionnaire) can be either *String* or *Numeric*.

c) Also, make sure that SPSS imported the last row of data correctly.

You've successfully imported your Excel data file. Now you can start running your analyses.
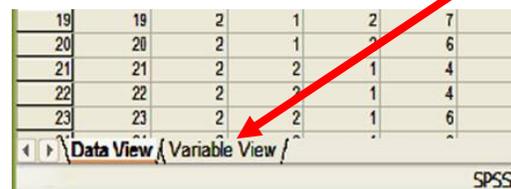
If you have already imported your Excel data file earlier and want to work with the SPSS version of your data file, then

a) Click on **Open an existing data source**;

b) If you see your SPSS data file on the list, then click on it, then click on **OK**;

c) If you *don't* see your SPSS data faile on the list, then click on **More files…,** then click on **OK**.

d) Browse for your file (wherever it is) and click on **Open**.

a. Run your Analyses of Variance.

We planned data collection from the beginning with these analyses in mind. In fact, we planned the collection specifically for the technique called Analysis of Variance (ANOVA) and for a specific set of analyses, which are summarized by your experimental design.

Why Analysis of Variance (ANOVA)? The most important reasons for using ANOVA are that it is very powerful, flexible, and easily the most widely used statistical technique in experimental psychology. Also, the reasoning behind it is easy to understand and the software is very widely available.

[Click on the following links for more information about ANOVA:
http://davidmlane.com/hyperstat/intro_ANOVA.html
http://www2.chass.ncsu.edu/garson/PA765/anova.htm
]

Suppose that your design for studying the effects of external interference and text type on reading comprehension was something like this:

		Text	
		Narrative	Procedure
Music	with music	n = 15	n = 15
	without music	n = 15	n = 15

You collected data (e. g., measures of reading comprehension) for these four experimental conditions. Your data file will have columns for Music and for Text – these are your factors or independent variables, and also for your measures (or dependent variables).

The idea of ANOVA is to test whether the variability or variance of the reading comprehension scores (which are different for each participant) changes systematically across different groupings of the experimental conditions.

So, to test for a main effect of Music (continuing with the example design above), ANOVA will *ignore* the different Texts and pool all of the Narrative and Procedure scores together to compute the mean, variance, and other measures for all of the with music scores, then for the without music scores. It compares just these two groups of scores to evaluate whether there is a systematic difference that you can associate with Music.

Similarly, to test for a main effect of Text, ANOVA will ignore the different situations with or without music and compute the same numbers.

Finally, there may be some *interaction* of the effects of the two factors: maybe music affects procedures more than it affects narrative texts, for example. It is interesting to see whether the two factors cancel each other out, increase the effects of one another, or act independently. In this case, ANOVA keeps four separate groups of scores and evaluates how independent or interdependent the factors are.

<u>What questions do you want to "ask the data"?</u> Your experiment was designed to help you answer questions like:

• Did Text affect comprehension in this experiment?

• Did Music affect comprehension in this experiment?

• Did Text and Music have any joint effects on comprehension in this experiment?

The information from your background questionnaire will allow you to answer questions about the role of gender, major, etc. either alone of jointly with your independent variables.

If you have more than one dependent variable, you can ask the same questions several times, using different dependent variables or combinations of them.

Your analysis will go faster when you have a clear idea ahead of time about which questions you really want answers for.

<u>Do Analysis of Variance in SPSS.</u> The specifications for ANOVA come right from your experimental design: you need to specify for SPSS which columns are your factors and which are your dependent variables.

To start, in SPSS, with your data file open, choose **Analyze / General Linear Model / Univariate**.

The unlabelled box on the left has a list of all of the column names in your data file.

Start with your dependent variable. Choose **score** and click on the triangle next to Dependent Variable.

Note that we chose to do a *uni*variate analysis – this means that there can only be one dependent variable. If you have another dependent variable, then you can run the analysis again with the other dependent variable.

🖐Note that the dependent variable has to be Numeric type (a continuous or interval variable) for ANOVA to work. If you select a String (i.e., categorical) variable, then the arrow for Dependent Variable will be grey and SPSS won't allow you to choose it.

Choose **Text** and **Music**, then click on the triangle next to Fixed Factor(s). These are the Factors or independent variables that you want to test.

Note that the factors **have to be categorical** for ANOVA to work. If you select a Numeric (i.e., continuous or interval) variable, the arrow for Factors will be grey and SPSS won't allow you to choose it for ANOVA.

There are buttons and areas for several other, more advanced analyses. You can learn about them later, as your analyses require.

Don't forget to click on the **Options** button before running your analysis. Select the checkbox to the left of *Descriptive statistics* – this means that you want to see descriptive statistics for each level of each factor. You'll need this information to understand your results and to make graphs and tables.

Leave Significance level at .05 for now, but go over the discussion in section 2 below.

Click on **Continue** to go back to the previous window.
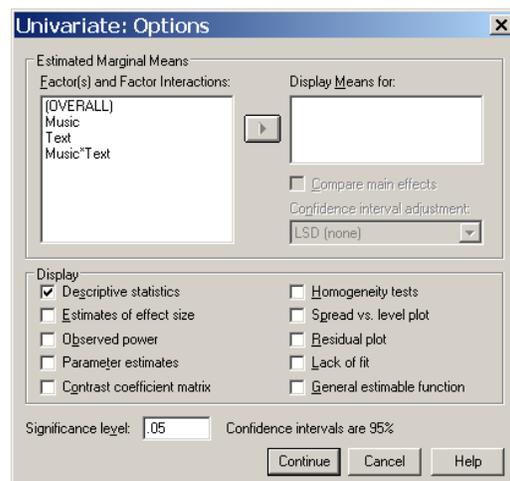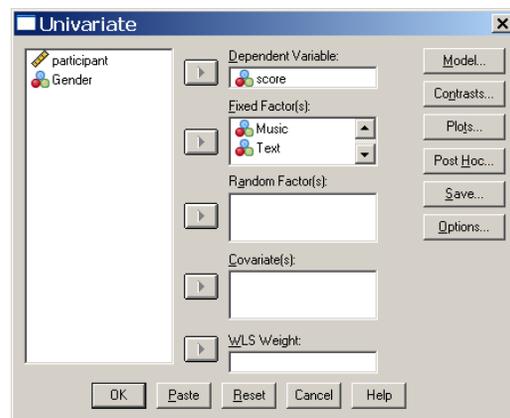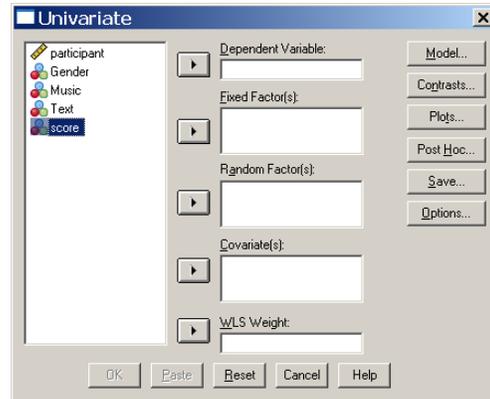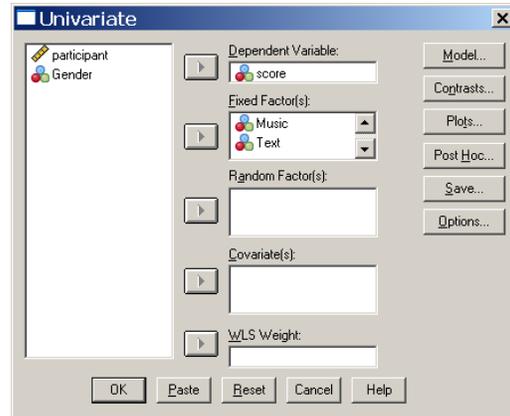
Click on **OK** to run this analysis and see the results.

> There is A LOT of information in the output that SPSS provides. You only need to use some of it.

This table is a summary of how many participants are in each experimental condition. Before you go any further, double check these numbers to see that your data was coded and imported correctly.

Between-Subjects Factors

		N
Music	1	20
	2	20
Text	1	20
	2	20

This table has the descriptive statistics that you asked for – means and standard deviations – so that you can make tables and graphs. Later on, you'll see which numbers to use for your graphs and tables. The column marked N shows you how many scores are in each group, so you can triple check that the data are correct.

Descriptive Statistics

Dependent Variable: score

Music	Text	Mean	Std. Deviation	N
1	1	6.30	2.111	10
	2	7.80	1.229	10
	Total	7.05	1.849	20
2	1	5.20	1.398	10
	2	6.80	1.751	10
	Total	6.00	1.747	20
Total	1	5.75	1.832	20
	2	7.30	1.559	20
	Total	6.53	1.853	40

This is the table of ANOVA results.

Source is the name of the factor that was tested.

df is degrees of freedom, which you have to report.

F is Fisher's F statistic, which is the focus of the analysis. The bigger the F, the more systematic is the effect of your factor.

Sig. indicates the significance level, which is labeled p in APA publications, for "probability of Type II error".

The columns for Sum of Squares and Mean Square are intermediate calculations that we won't use for now. Similarly, the rows for Corrected Model, Intercept, Total, and Corrected Total aren't useful right away.

Tests of Between-Subjects Effects

Dependent Variable: score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	35.075(a)	3	11.692	4.256	.011
Intercept	1703.025	1	1703.025	619.908	.000
Music	11.025	1	11.025	4.013	.053
Text	24.025	1	24.025	8.745	.005
Music * Text	.025	1	.025	.009	.925
Error	98.900	36	2.747		
Total	1837.000	40			
Corrected Total	133.975	39			

a R Squared = .262 (Adjusted R Squared = .200)

As your data permits, you can run other analyses, in particular with different dependent variables and/or using information from the participants' background questionnaires.

Focus on the questions that you think are important. You are under no obligation to analyze all of the data in all possible ways.

See Section 3. Try Alternative Analyses.

2. Identify the important results

Significance vs. importance.

Be extra careful NOT to confuse the technical, statistical term *significance* with the everyday term *importance*. In statistics, *significance* and *significant* talk only about numbers – they simply mean that a particular statistic is bigger or smaller than some specific reference value. As mentioned above, if you ask crazy questions and put in crazy numbers, SPSS will happily digest them and return evidence that your crazy factor is – in statistical terms *significant* – even if it's totally meaningless and not important to anyone at all.

Importance is about ideas and things in the world, not about numbers. Is it important to know whether there is a difference between the number of smokers with lung cancer and the number of non-smokers with lung cancer? Yes, and it's important to know about this regardless of the specific numbers involved in a particular experiment.

Statistical tests like ANOVA provide addition information about just how systematic (~*significant*) the differences between data points are. Statistically significant differences are systematic differences, not occasional or random differences. Statistical tests, then, help us filter out unreliable or unsystematic differences and focus on the most systematic ones – these are the best candidates for causes of the differences observed.

> Statistical tests help us filter out unreliable or unsystematic differences and focus on the most systematic ones.

Routine practice has us use the value of .05 for p (or Sig. in SPSS) as the cutoff point for deciding whether or not the effect of a factor or interaction is statistically significant. This is an easy and acceptable way to focus on the important results: simply ignore any effects that have $p > .05$.

But ease of use usually comes at a high price. This easy method leaves several questions unanswered.

Where does .05 come from?

This is a measure of the probability of Type II error: it means that there are 5 chances in 100 that we will make a mistake when we say that an effect *is* systematic; 95 chances in 100 that we will be correct. Most researchers are comfortable with relying on results that are that reliable. In other words, Type II error is the specific kind of error where we say that an effect *is* statistically significant when in reality it is not – a *false positive* error.

What do results with $p < .06$ mean? Or .07?

Intuitively, it seems like they might be important, too. What most researchers do in this case is discuss these results *as if* they were statistically significant, but they report them as "approaching significance" or "nearly significant" rather than "significant". They only do this if the researchers think that the effect is *important*.   If researchers can ignore the .05 value, then what's the "real" value for cutoff? There is no "real" value – it's just a convention or habit, to make things easier.

Should we use .05 for all kinds of research?

And what if you're comfortable with being right 90% of the time (for a p of .10)? That's open to continuing debate: .05 is simply a convention that's easy to use. Setting p to .10 is considered fairly normal, for example, in exploratory research about a topic that hasn't been studied very much. Whenworking in a new area of research, it's important to consider a wider range of possibilities, because more research will come later to double check the initial results. On the other hand, in some

areas that are well-understood, setting p to .01 (*five time less* than the usual .05) is often common practice. This option makes it harder to find significant effects, but in mature areas of research, the easy-to-find effects have already been identified and researchers need to focus on the more subtle effects.

<u>Identify the important results from your study</u>.

Look through the results in each of your ANOVA tables. Choose the important results from among the significant or nearly significant results in each table. For now, use $p < .05$ to declare something statistically significant, $p < .10$ for effects that you might want to discuss (and call them "nearly significant"), and set aside effects with $p > .10$.

To focus better on the most important information, you should make a simplified ANOVA table like this one. Notice that the columns and rows that are not immediately necessary were removed, the order of F and df was reversed and Sig. was changed to p per APA norms. The 36 for df was taken from the Error row of the full table – it represents the degrees of freedom of the denominator of the F statistic – the error variance.

Tests of Between-Subjects Effects

Dependent Variable: score

Source	F	df	p
Music	4.013	1, 36	.053
Text	8.745	1, 36	.005
Music * Text	.009	1, 36	.925

The effect of Music on comprehension scores was not significant because .053 is bigger than .050. But it's awfully close and it's an effect that the researchers were very interested in, so they decided to report it as "nearly significant". The effect of Text was much clearer: .005 is much smaller than .05, so it's obviously a significant effect. On the other hand, the interaction effect of Music * Text was nowhere near .05; in fact, the F value was less than 1.

Tests of Between-Subjects Effects
Dependent Variable: score

Source	F	df	p	
Music	4.013	1, 36	.053	*nearly significant*
Text	8.745	1, 36	.005	*significant*
Music * Text	.009	1, 36	.925	*F < 1*

Here's an example of how to simplify your ANOVA table.

Many researchers use symbols ("significance stars", as in the table below and *APA Publication Manual*, p. 162) after the *F* values to summarize at a glance how strong different effects are. This is especially helpful if there are a lot of statistical tests presented in the same table.

Criterion	Symbol	Meaning
$p < .001$	***	Effect is very significant
$p < .01$	**	Effect is very significant
$p < .05$	*	Effect is significant
$p < .10$	* or *ns*	Effect *may* be considered "nearly significant"
$p > .10$	*ns*	Effect is not significant
$F < 1$	*F*<1	Effect is not significant. In this case, do not report the degrees of freedom and exact *F* score.

> IMPORTANT:
>
> ✋ Do *not* ignore non-significant effects. They have to be reported, too. We just pay more attention to and talk more about the more interesting, significant effects.

3. Try alternative analyses

In the simple, routine case, you would get statistically significant effects of one or more factors from your ANOVA and report the statistics of the effects along with the group means and standard deviations. If there is a significant interaction, then you would graph the means of the interacting factors, as well. You're done.

Ah, but research is not always simple or routine, especially when **Murphy's Law of Student Research** hits (i.e., "You'll get the most confusing or unimportant results possible, at the worst possible time.").

After all of the work you put into planning, collecting, and analyzing your data, you run your analyses and none of the tests produce significant differences. Your research appears to have produced no usable results. Time to panic because you have nothing to talk about in your Results section. Right? Wrong! There are several fallback strategies for re-examining your results to find things to report.

> IMPORTANT:
>
> ✋ If you didn't get any significant effects, that does NOT mean that your study was a waste of time or a failure. It usually just means that there were methodological problems that you have to identify and work out.

Try the following strategies for each factor or interaction to generate more information about your results.

1) **Graph your means** anyway, even if the difference is not significant. Use box plots or error bars to look at the standard deviations, too.

- Was there a clear difference in the group means, judging from the graph?

- Was there a clear difference in the standard deviations, from the error bars?

Talk about these differences. Maybe with more subjects, more precise measures, etc. you'll get significant differences next time.

2) Did you use (or can you generate from the data) **different dependent measures**? Even if there was no significant difference between the measures when you did a repeated-measures ANOVA, there are other things to look at.

- Were there different effects, means, or standard deviations for the different dependent measures?

- Did you re-assess your dependent variable(s) and try to "clean them up" (remove outlying participants; remove outlying items; group them in different ways)?

  o "Outliers" are usually defined as any values that are more than 2 standard deviations above or below the mean. You can either delete the outliers from your data set or change the participants to the value that is exactly 2 standard deviations from the mean.

  o Ex: For some variable with a mean of 57 and a standard deviation of 9, the value at 2 standard deviations below the mean is 57 - (2 * 9) = 39; the value at 2 standard deviations above the mean is 57 + (2 * 9) = 75.   If a participant scored 82 for this example variable, the value is an outlier (higher than 2 standard

deviations above the mean) and can be reset to 75. Similarly, if a participant scored 28 for this example variable, the value is an outlier (lower than 2 standard deviations below the mean) and can be reset to 39.

- Did you try additional dependent measures? Sub-sets of the questions? Parts of the responses? Weighted combinations of these? You can re-compute each participant's score by counting up only the most important or informative responses, for example.

Re-run your analyses in different ways. Talk about any differences or trends that you found.

3) Did you use a **background questionnaire** to gather information about your participants when you ran your experiment? Then it's time to cash in your "experimenter's insurance". Code the responses and use them as additional between-subjects factors (if categorical) or covariates (if continuous).

- Were there different effects, means, or standard deviations for the different participant factors or covariates?

- Were there any skewed distributions? (e.g., lots of males; few females – maybe eliminate the females in this case and reanalyze the data)

There may be important differences and hopefully interactions of these participant factors with the factors under investigation.

4) If you've tried everything and gotten no significant or nearly significant results, then explain **why** that happened: describe your results (in the Discussion section) in terms of **methodological problems with your study**.

a) Participants. Did you have a small or diverse pool of participants?

- Were the participants grouped together accidentally, with more of one kind in one experimental condition than in another?

b) Dependent measures. Were you measuring something very complex (like "comprehension") with few or simplistic indicators?

c) Task. Did the participants have too much or too little time, background, or information to do the task? Did you get a floor [everyone did poorly] or ceiling [everyone did very well] effect?

- Did they find the instructions confusing? Did they understand easily what they were supposed to do? Did the procedure vary from one group to another?

4. Make tables of the significant effects

How do you present your results to your readers: in sentences, with tables, with graphs, or with all three? The *APA Publication Manual* (§3.54) gives the following general rule:

$n \leq 3$ numbers in a sentence. If you're talking about 3 or fewer numbers, then just mention them in the middle of a sentence.

$4 \geq n \leq 20$ numbers in a table. If you're talking about something between 4 and 20 numbers, then present them in a table.

$n \geq 20$ numbers in a graph or figure. If you're talking about more than 20 numbers, then go for a graph or a figure.

Note that this doesn't mean *all* of the numbers that you have – just the ones that you want to talk about at a given time. It also means that you have choices, including the choice to present *both* graphs (to communicate general relations and trends) and tables (to communicate the details).

As a general rule, the more numbers there are for a given table or the more factors you want to show, the harder it is to make a table, graph, or figure that the reader will understand easily.

> Remember that you should use tables and graphs to make it *easier* for the reader to understand your results, not *harder*!

According to the *APA Publication Manual*, then, tables are for between 4 and 20 numbers. Twenty numbers is really pushing your reader's abilities to the edge, so you want to think twice if there are more than 12 numbers or so. There are two basic questions for doing tables: Where to get the right data? and How to format it?

Where to get the right data?

From the table of Descriptive Statistics that you asked for when you ran your ANOVAs. This is exactly *why* you asked for them.

> Don't forget to include the standard deviations when you are making a table of means. A mean without a standard deviation is practically meaningless.

Usually, you'll build a table or graph to illustrate a specific effect. Using the sample data from above, you'll be documenting the effects of Music, Text, or the Music * Text interaction. For a main effect (for example, of Music), you'll have one mean for each level of the factor – in the case of the sample data, With Music and Without Music. That's only two numbers, so you will definitely not do a table, and a graph that simple won't be very informative. But the Music (2 levels) * Text (2 levels) interaction will have four numbers (the product of the number of levels for each factor; the number of experimental conditions, too) – so it makes sense to do a graph and a table for the interaction.

Here's a sample results table from the SPSS output. Let's go through how to get the right numbers.

Descriptive Statistics

Dependent Variable: score

Music	Text	Mean	Std. Deviation	N
1	1	6.30	2.111	10
	2	7.80	1.229	10
	Total	7.05	1.849	20
2	1	5.20	1.398	10
	2	6.80	1.751	10
	Total	6.00	1.747	20
Total	1	5.75	1.832	20
	2	7.30	1.559	20
	Total	6.53	1.853	40

Effects of Music

Effects of Text

To compare the two levels of Music, use the Total mean for Music 1 (7.05) and the Total mean for Music 2 (6.00).

To compare the two levels of Text, go to the Total box under Music and use the means for Text 1 (5.75) and Text 2 (7.30).

For the interaction, you need the means for Music 1/Text 1 (6.30), for Music 1/Text 2 (7.80), for Music 2/Text 1 (5.20), and for Music 2/Text 2 (6.80).

Now it's just a case of formatting your tables.

Formatting a table.

The *APA Publication Manual* has several sections on formatting simple and complex tables (§3.62 – 3.74) and you should follow the suggestions in every detail. Notice that the table *has to* have a number and a very explanatory title (in italics).

Placement. When you are preparing a manuscript for publication in an APA journal, tables do NOT appear in the middle of the text – they are included in the manuscript as attachments (NOT as appendices) – each table on a separate page, and in your text you should have the following note for the publisher:

_____

Insert Table 1 about here

_____

Below is a sample of an APA journal manuscript-style table.

Table 1

Mean (and standard deviation) Number Correct Answers as a Function of Text Type and

Presence or Absence of Music (N = 40)

Text Type	Music	
	With Music	Without Music
Narrative Text	6.30 (2.1)	5.20 (1.4)
Procedural Text	7.80 (1.2)	6.80 (1.8)

When you are preparing a *camera-ready* version – for example for the proceedings of a conference – then you <u>will</u> put the table in the middle of your text, single spaced, and formatted exactly as you would like to see it published.

Below is a sample camera-ready-style table based on APA formatting.

Table 1
Mean (and standard deviation) Number Correct Answers as a Function of Text Type and Presence or Absence of Music (N = 40)

Text Type	Music	
	With Music	Without Music
Narrative Text	6.30 (2.1)	5.20 (1.4)
Procedural Text	7.80 (1.2)	6.80 (1.8)

> Remember discuss *every* table verbally in your text!
> Tables do *not* take the place of verbal descriptions of the results.
> You still have to tell the reader what to look at in each table.

For example, this is a partial description of Table 1:

```
     Observe in Table 1 that participants who read the text with
music unexpectedly recalled more than those who read the text
without music.  Similarly, the participants who read the procedural
text tended to recall more than those who read the narrative text.
```

5. Make graphs of the significant effects

According to the *APA Publication Manual*, then, graphs are for more than 20 numbers. But sometimes graphs can provide extra information about smaller sets of numbers, like tables do. Also like tables, graphs with fewer than four numbers are rarely informative.

Usually, you'll be building a graph to illustrate a specific, significant (or nearly significant) effect. Using the sample data from above, you'll be documenting the effects of Music, Text, or the Music * Text interaction. For a main effect (for example, of Music), you'll have one mean for each level of the factor – in the case of the sample data, With Music and Without Music. That's only two numbers, so you will definitely not do a table, and a graph that simple won't be very informative. But the Music (2 levels) * Text (2 levels) interaction will have four numbers (the product of the number of levels for each factor; the number of experimental conditions, too) – so it makes sense to do a graph and a table for the interaction.

There are two basic questions for doing graphs: Where to get the right data? and what *kind* of graph to use?

Where to get the right data? From the table of Descriptive Statistics that you asked for when you ran your ANOVAs. This is exactly *why* you asked for them. Use exactly the same data as you would for a table, and put it in a MS Excel spreadsheet with the labels for each level of the factors.

	With Music	Without Music
Narrative Text	6.30	5.20
Procedural Text	7.80	6.80

Select all of the cells of the table and click on the Chart Wizard in MS Excel and follow the steps. Click on a part of the completed graph (bars, numbers, axes, lines, etc.) to edit them.

Which *kind* of graph should you use? Different kinds of graphs exist for different purposes.

The independent variable(s) are plotted on the horizontal (*x*) axis, and the dependent variable is plotted on the vertical (*y*) axis and is a continuous variable.

> Avoid using 3-D objects, frames, or gridlines in your graphs – they're distracting rather than informative.
> According to APA, graphs should be grayscale and not in color.

- For categorical independent variables (like Gender, Text, Music, etc.), **use a (vertical) column chart or histogram**. You can ask for an error bar to show the standard deviation for each mean. Notice that the blank spaces between the bars do not invite the reader to make guesses about intermediate values.

- For continuous independent variables (like Age, IQ, Salary, etc.), **use a line chart** or a scatterplot. Notice that the lines that connect different values invite the reader to make guesses about intermediate values.

- There's a broad consensus that **pie charts** shouldn't be used at all, because they're difficult (and misleading) to interpret.

- When you have two graphs side by side for comparison, be *extra* sure that the *y* axis on both starts and ends with the same exact values.

- Only start the *y* axis at 0.

The screen shots below step through the Chart Wizard with the sample data that we are using.
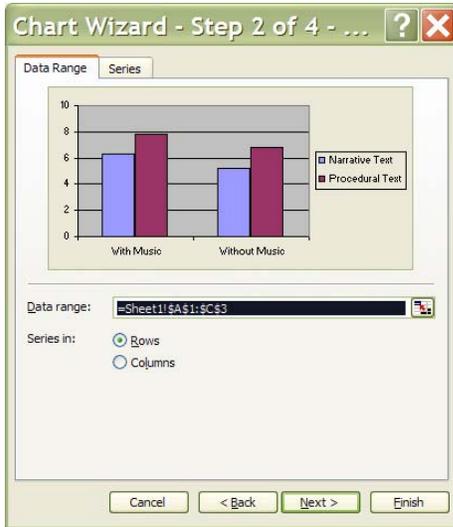
	With Music	Without Music
Narrative Text	6.3	5.2
Procedural Text	7.8	6.8

This is the data for the interaction that we want to graph. Select all of the table, including the labels, before your start the Chart Wizard.

The correct clustered column type is already selected by default. Just click **Next**.
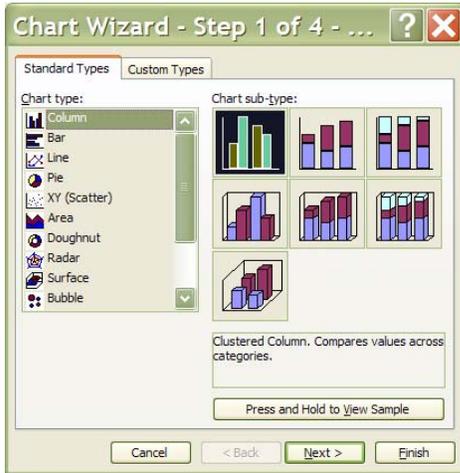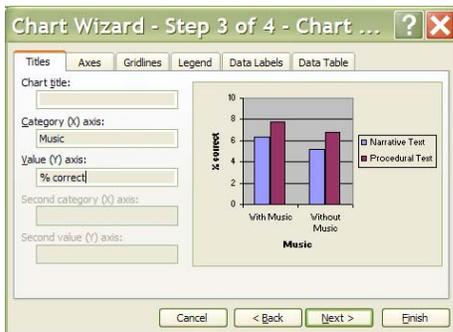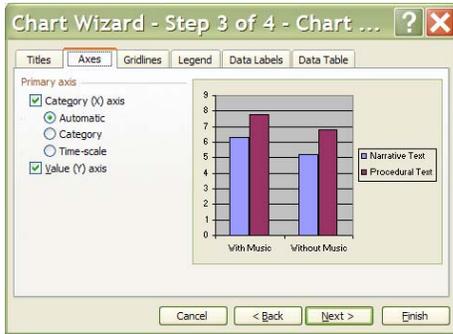

You already selected the data. Just click **Next**.

For the Category (X) axis put in the name of the factor (Music).

For the Value (Y) axis, put in another short name.

Don't put the Chart title in here – it's better to do that in MS Word.
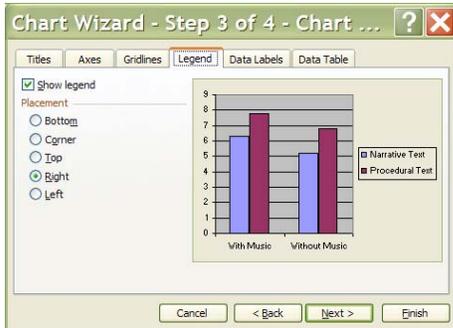
Now click **on the next tab.**

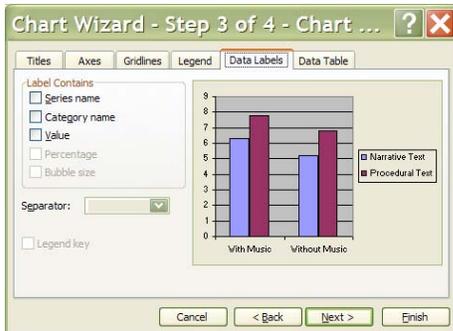This is OK by default. Just click **on the next tab.**

Unclick the Major gridlines box to remove the horizontal lines.

Just click **on the next tab.**

The legend is OK by default. Just click **on the next tab.**

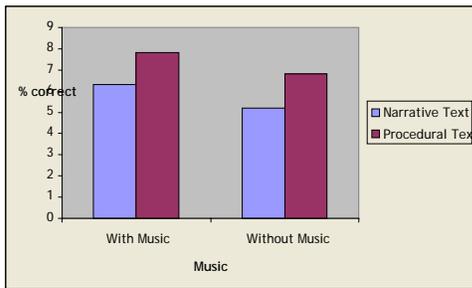This is OK by default. Just click **on the next tab.**

This is OK by default. Just click **Next**.

Choose whether you want the graph on the same spreadsheet as the data (my preference) or on a separate sheet. It doesn't matter, since you'll cut and paste the graph into your Word document in either case.
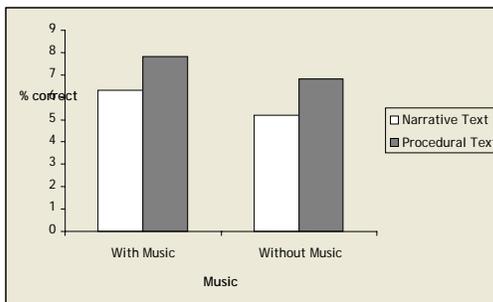
Then click **Finish**.

This is how the graph comes out.

Double-click on the grey background to change it to white and remove the frame.

Double-click on either blue bar to change it to white.

Double-click on either purple bar to change it to grey.

Re-save your spreadsheet.

This is how the graph comes out, except that the label for the *y* axis is screwed up (!)

Don't forget to save your graph.

Remember discuss *every* graph verbally in your text!
Graphs do *not* take the place of verbal descriptions of the results. You still have to tell the reader what to look at in each graph.

For example, this is a partial description of Figure 1:

```
      Observe in Figure 1 that participants who read the text with
music  unexpectedly  recalled  more  than  those  who  read  the  text
without music.  Similarly, the participants who read the procedural
text tended to recall more than those who read the narrative text.
```

Sample Deliverables

Simplified ANOVA tables. For each of the different ways that you analyze your results, make a simplified ANOVA table and submit it together with the SPSS output that you based it on.

For each test in your ANOVA tables, use the symbols in the significance stars table – or write out in words – both the significance of the test results that you found and the importance (high, medium, low) of the factors that you tested.

Note that the Importance column is only for discussion in class. You'll never include it in a research paper.

Here's a sample simplified ANOVA table (NOT in APA format).

Tests of Between-Subjects Effects
Dependent Variable: score

Source	F	df	p	Significance	Importance
Music	4.013	1, 36	.053	*	*high*
Text	8.745	1, 36	.005	**	*medium*
Music * Text	.009	1, 36	.925	*F < 1*	*high*

Below is a sample of an APA journal manuscript-style table.

Table 1

Mean (and standard deviation) Number Correct Answers as a Function of Text Type and Presence or Absence of Music (N = 40)

	Music	
Text Type	**With Music**	**Without Music**
Narrative Text	**6.30 (2.1)**	**5.20 (1.4)**
Procedural Text	**7.80 (1.2)**	**6.80 (1.8)**

Include a graph, as well.

Further Resources on Analyzing your Data

There's an enormous amount of material on statistical techniques for analyzing different kinds of data. ANOVA is just one of the most widely used options.

Few, S. 2004. *Show me the numbers: designing tables and graphs to enlighten.* Oakland, CA: Analytics Press.

Mitchell, M. & Jolley, J. 2005/2007. *Research Design Explained [Ch. 12: Factorial Designs].* Belmont, CA: Thompson Wadsworth.

Montgomery, D. 2004. *Design and Analysis of Experiments.* Hoboken, NJ: John Wiley & Sons.

Tufte, E. 2006. *Beautiful evidence.* Cheshire, CT: Graphics Press.

Tufte, E. 1997. *Visual explanations.* Cheshire, CT: Graphics Press.

Tufte, E. 1990. *Envisioning information.* Cheshire, CT: Graphics Press.

Tufte, E. 1983. *The visual display of quantitative information.* Cheshire, CT: Graphics Press.

Review the Results sections from published research!