Factorial ANOVA Using SPSS

In this section we will cover the use of SPSS to complete a 2x3 Factorial ANOVA using the subliminal pickles and spam data set. Specifically we will demonstrate how to set up the data file, to run the Factorial ANOVA using the General Linear Model commands, to preform LSD post hoc tests, and to perform simple effects tests for a significant interaction using the Split-File command, One-Way ANOVA, and some quick hand calculations.

Setting up the Data

The first step in setting up the data file for the Pickles and Spam data is to define three variables, one for each of our variables of interest. Figure 13.8, is the SPSS data editor variable view, for our pickles and spam data. Here we have named and given variable labels to three variables: **pinash** (Pickles in Nose and Spam on Head), **stimtype** (Stimulus Types), and **fafaa** (Food as Fashion Accessory Attitude). Also, for the two
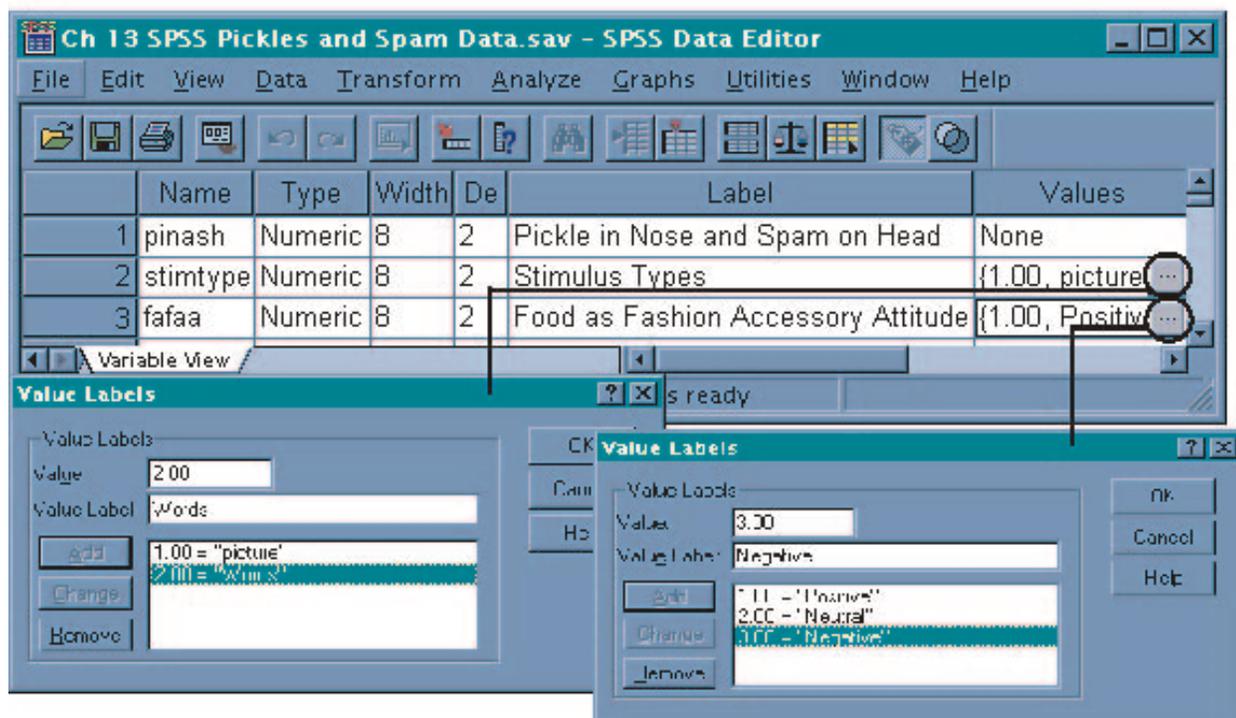

Figure 13.8   SPSS: Variable View for Pickles and Spam Data

categorical independent variables, we have given each category a value label. For **stimtype**, the values of 1and 2 were assigned to the labels "picture" and "Words," respectively. For **fafaa**, the values of 1, 2, and 3 were assigned to the labels "Positive," "Neutral," and "Negative," respectively. See Appendix 1 for review of variable naming, variable labeling, and value labeling.
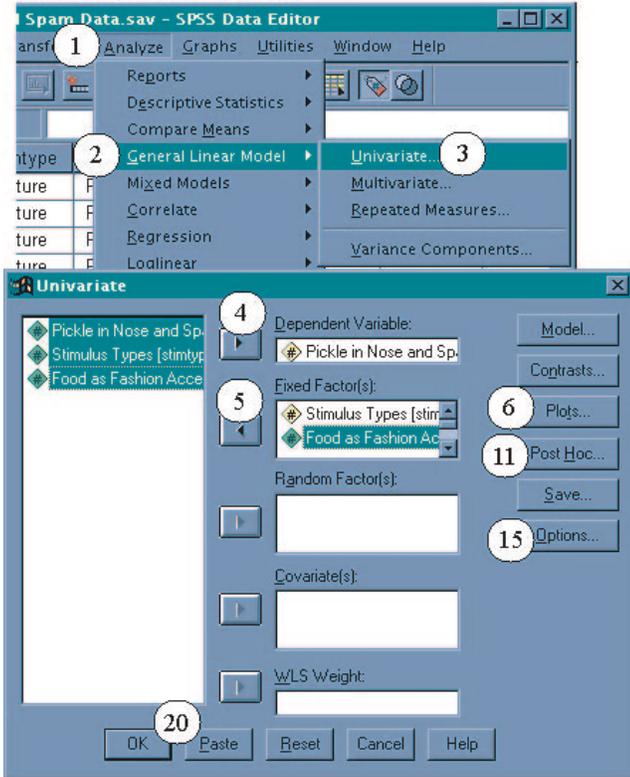
Figure 13.9 SPSS: Data View for Pickles and Spam Data

After creating the three desired variables, you can enter the data for each subject. Each subject's score for the frequency with which they put pickles up their nose and spam on their head are entered in Column 1 (pinash). In Column 2 (stimtype), the value (1 or 2) of the appropriate stimulus (picture or Words) for each sub-group member is entered (though the value label appears in the figure). In Column 3 (fafaa), the value (1, 2, or 3) of

Panel A

	pinash	stimtype	fafaa
1	14.00	picture	Positive
2	13.00	picture	Positive
3	11.00	picture	Positive
4	10.00	picture	Positive
5	8.00	picture	Positive
6	8.00	picture	Positive
7	7.00	Words	Positive
8	6.00	Words	Positive
9	5.00	Words	Positive
10	5.00	Words	Positive
11	3.00	Words	Positive
12	3.00	Words	Positive
13	13.00	picture	Neutral
14	13.00	picture	Neutral
15	11.00	picture	Neutral
16	10.00	picture	Neutral
17	9.00	picture	Neutral
18	7.00	picture	Neutral

Panel B

	pinash	stimtype	fafaa
19	14.00	Words	Neutral
20	13.00	Words	Neutral
21	11.00	Words	Neutral
22	9.00	Words	Neutral
23	8.00	Words	Neutral
24	8.00	Words	Neutral
25	12.00	picture	Negative
26	12.00	picture	Negative
27	11.00	picture	Negative
28	10.00	picture	Negative
29	9.00	picture	Negative
30	8.00	picture	Negative
31	6.00	Words	Negative
32	6.00	Words	Negative
33	5.00	Words	Negative
34	4.00	Words	Negative
35	4.00	Words	Negative
36	2.00	Words	Negative

the appropriate attitude type (Positive, Neutral, or Negative) for each sub-group member is entered (again the value label appears in figure). In this example we started with the subjects in the first sub-group of our study, those receiving the picture prime and reporting a positive attitude food as a fasion accessory ($X_{.11}$). The data for these individuals are entered in the first six rows of Panel A in Figure 13.9. The first subject had a frequency score of 14, and, like the rest of the members of that sub-group, was in group 1 (picture) of stimtype and group 1 (positive) of fafaa. The scores for the next two sub-groups (word prime and positive fafaa attitude $X_{.21}$ and picture prime and neutral fafaa atitude $X_{.12}$) are displayed in the remaining rows of Panel A of Figure 13.9. The scores for the remaining three sub-groups (words/neutral $X_{.22}$, picture/negative $X_{.13}$, and words/negative $X_{.23}$) are displayed in Panel B of Figure 13.9. Note that Panel B is only a different view of the same window as Panel A. We have simply scrolled down to show the other half of the data.

Running the Analysis

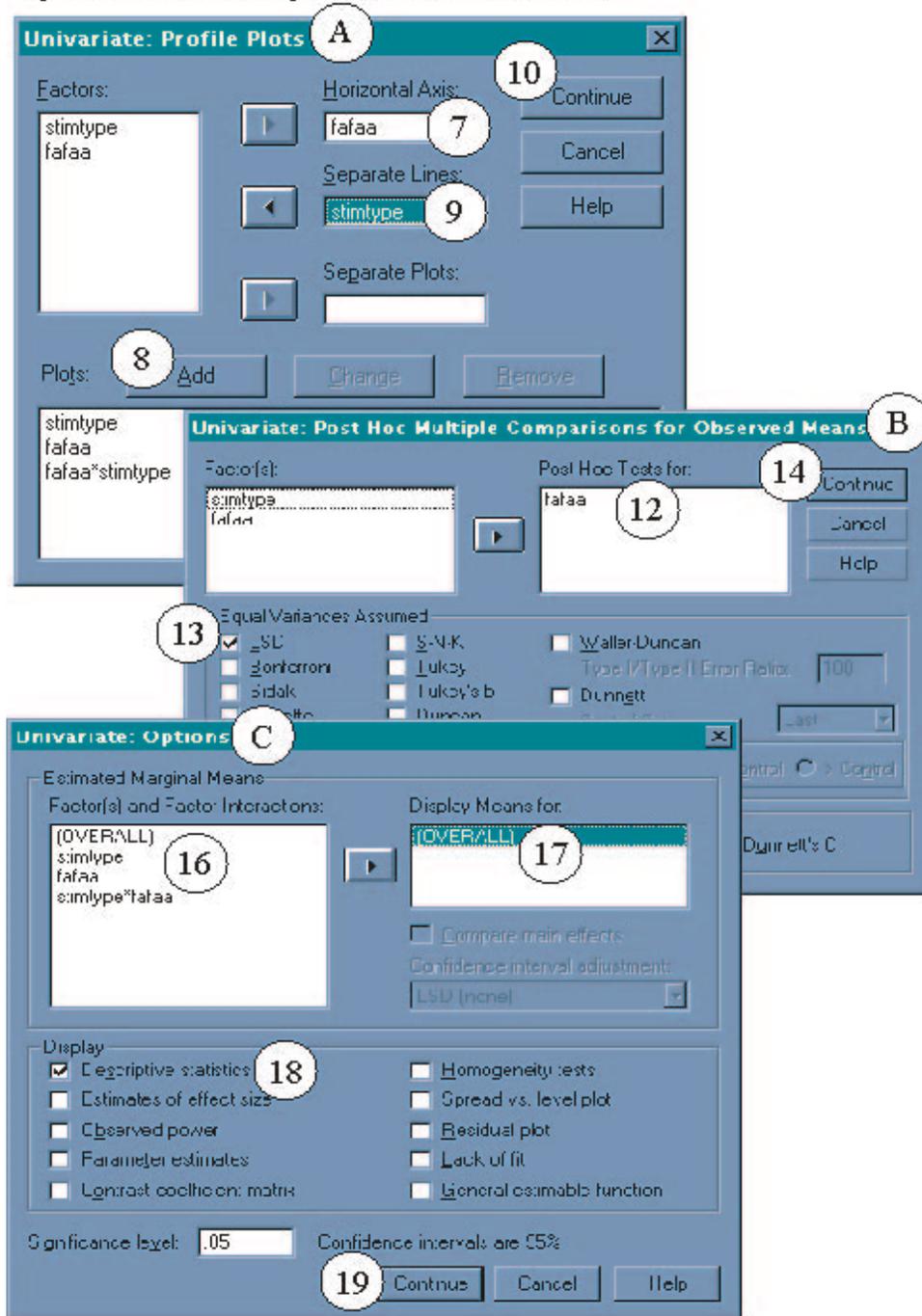Figure 13.10   SPSS: Running Factorial ANOVA

Two-Way Factorial ANOVA Steps (See Figure 13.10): From the **Analyze** (1) pull down menu, select **General Linear Model** (2), then select **Univariate...**(3) from the side menu. In the **Univariate** dialogue box, enter the dependent variable **Pickle in Nose and Spam on Head[pinash]** into the **Dependent Variable:** field by selecting it from the list (left click) and left clicking on the boxed arrow (4) next to the **Dependent Variable:** field. Next, enter the two independent variables (**Stimulus Types[stimtype]** and **Food as Fashion Accessory Attitude[fafaa]**) into the **Fixed Factor(s):** field by highlighting both variables and clicking the appropriate boxed arow (5).

To obtain graphs of the main effect and interaction means, left click on **Plots...** (6). In the **Univariate: Profile Plots** dialogue box (see Figure 13.11, enter **stimtype** from the **Factors:** list into the **Horizontal Axix:** field (7) and then click the **Add** button (8). This will give you the graph of the main effect for stimulus type. Next, repeat these steps with **fafaa**. To obtain the graph of the interaction, enter **fafaa** in the **Horizantal Axix:** field (7) again, then enter **stimtype** into the **Separat Lines:** field (9), and finally left click the **Add** button (8). After requesting the three charts, left click **Contiue** (10).

To obtain the LSD *t* test follow up analyses for any main effects that have more than two groups (in our example we have one, **fafaa**), left click on the **Post Hoc...** button (11, in Figure 13.10). In the **Univariate: Post Hoc Multiple Comparisons for Observed Means** dialogue box (see Figure 13.11), enter

Figure 13.11 SPSS: Running The Factorial ANOVA Continued

fafaa into the **Post Hoc Tests for:** field (12) by double left clicking on **fafaa**. Check the **LSD** option (13), then Left click **Continue** (14).

To obtain the means, standard deviations, and other descriptive information for the IV groups and the sub-groups, left click the **Options...** button (15, in Figure 13.10). In the **Univariate: Options** dialogue box (see Figure 13.11), enter the first of the items listed [**(OVERALL)**] in the **Factor(s) and Factor Interactions:** field (16) into the **Display Means for:** field (17). Next, check the

Descriptive statistics option (18) in the **Display** section of the dialogue box. Finish by clicking **Continue** (19). (you can request the descriptive information for the independent variables and the interaction as well, but they are rather redundant with what the OVERALL gives you)

Finally, double check your variables and all selected options and either select **OK** (20) to run, or **Paste** to create syntax to run at a later time.

If you chose the paste option, you should have the following syntax:

```
UNIANOVA

 pinash  BY stimtype fafaa
 /METHOD = SSTYPE(3)
 /INTERCEPT = INCLUDE
 /POSTHOC = fafaa ( LSD )
 /PLOT = PROFILE( stimtype fafaa fafaa*stimtype )
 /EMMEANS = TABLES(OVERALL)
 /PRINT = DESCRIPTIVE
 /CRITERIA = ALPHA(.05)
 /DESIGN = stimtype fafaa stimtype*fafaa .
```

Again, you can run this analyses by selecting **Run** and **All** from the Syntax Editor's pull-down menu.

Reading the Output for a Two-Way ANOVA

The results of the Two-Way ANOVA are presented in Figures 13.12 and 13.13. Figure 13.12 presents the first three output blocks for the analyses we requested (your output may differ if you requested different options). The first block of the output, titled *Between-Subjects Factors*, indicates which independent variables were included in the analysis, what values were used for each group, what value labels were used for each group, and the group size ($n_{.j.}$ and $n_{..k}$) for each group of each independent variable.

The second block of the output, titled *Descriptive Statistics*, reports the dependent variable means, standard deviations, and group sizes (N) for all sub-groups, IV groups, and the total Sample. Looking at the first row (labeled **picture**), we are first given the descriptive information for each sub-group that was

Figure 13.12 SPSS: Factorial ANOVA Output

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
Stimulus Types	1.00	picture	18
	2.00	Words	18
Food as Fashion Accessory Attitude	1.00	Positive	12
	2.00	Neutral	12
	3.00	Negative	12

Descriptive Statistics

Dependent Variable: Pickle in Nose and Spam on Head

Stimulus Types	Food as Fashion	Mean	Std. Deviation	N
picture	Positive	10.6667	2.50333	6
	Neutral	10.5000	2.34521	6
	Negative	10.3333	1.63299	6
	Total	10.5000	2.06512	18
Words	Positive	4.8333	1.60208	6
	Neutral	10.5000	2.58844	6
	Negative	4.5000	1.51658	6
	Total	6.6111	3.38055	18
Total	Positive	7.7500	3.64629	12
	Neutral	10.5000	2.35488	12
	Negative	7.4167	3.39675	12
	Total	8.5556	3.39280	36

Tests of Between-Subjects Effects

Dependent Variable: Pickle in Nose and Spam on Head

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	272.889[a]	5	54.578	12.595	.000
Intercept	2635.111	1	2635.111	608.103	.000
STIMTYPE	136.111	1	136.111	31.410	.000
FAFAA	68.722	2	34.361	7.929	.002
STIMTYPE * FAFAA	68.056	2	34.028	7.853	.002
Error	130.000	30	4.333		
Total	3038.000	36			
Corrected Total	402.889	35			

a. R Squared = .677 (Adjusted R Squared = .624)

exposed to subliminal pictures. Each sub-group is identified by its value label for IV2 (fafaa: **Positive**, **Neutral** and **Negative**). The descriptive information for everyone in group 1 of IV1 (the picture group) is given last and identified with the label **Total**. Similarly the second row, labeled **Words**, presents the descriptive information for the three sub-groups exposed to subliminal words, as well as the information for group 2 of IV1 (the words group), which is also identified with the label **Total**. The third and final row of this block, labeled **Total**, presents the descriptive information for each group of IV2, which are identified by their respective value labels. Finally, at the very bottom of the third row, also labeled **Total**, the descriptive information for the total sample is presented.

The information from this block can be used to check your hand calculations for the data summary table. The sub-group and group sums can be obtained by multiplying the mean by its respective N. For example the sum of group 11 (the picture/positive group) can be obtained by multiplying the mean (10.6667) by the N in that line (6): $\sum X_{11} = 64.0002$. Note that this is slightly different from our hand calculations, for which we obtained the value 64. This is due to rounding error. If you do find a large discrepance between your hand calculations and the SPSS output, be sure to first check that you entered the data into SPSS properly. If you feel SPSS is correct, then double check your hand calculations.

The third block the output, titled *Tests of Between-Subjects Effects*, provides us with the familiar

Factorial ANOVA summary table. However, you may notice that there are a couple of things that are new. The first two rows of the summary table (**Corrected Model** and **Intercept**) can both be ignored. In more advanced statistics courses you may be compelled to consider them, but not here. In the last row of the table (**Corrected Total**) you will find the same values we obtained using the hand calculations. The next to last row (**Total**) gives us total sums of squares and degrees of freedom that included the sums of squares and the *df* from the **Intercept** row (row 2), and is not required for us to interpret this Factorial ANOVA or check our hand calculations. Aside from differences in labeling, rounding values at the third decimal, and presenting more precise alpha levels, the remainder of the table is the same as what we presented in table 13.10. Row 3 (**STIMTYPE**) presents the values for IV1. Again the *F*-obtained is 31.410, which is significant at the *p* < less than > .001 alpha level. Remember, when SPSS gives us significance levels of .000, we should report them as being less than .001. Row 4 (**FAFAA**) gives the values of for IV2, while row 5 (**SIMTYPE*FAFAA**) presents the interaction (1x2) values. These effects are both significant at the .002 alpha level. Row 5 (**Error**) presents the same values as the ERROR rows in our hand calculated summary table, and the Mean Square value for **Error** is the denominator for all the *F* values. Finally the **Corrected Total** is the sum of rows 3 (**STIMTYPE**), 4 (**FAFAA**), 5 (**STIMTYPE*FAFAA**), and 6 (**Error**).

Again, these values can be used to double check your hand calculation, though remember that SPSS only reports two digits past the decimal and it rounds, whereas we use four digits and do not round. Thus, you may have small variations between their third digit and yours. However, if you get large differences you should double check the data you entered into SPSS and then double check your hand calculations.

The fourth output block, presented at the top of Table 13.13, reports the dependent variable mean for the total sample, the standard error of the mean (covered in Chapters 8 and 9), and the confidence interval (Chapter 8). This information is not required to interpret the Factorial ANOVA.

The fifth output block, under the Major Heading *Post Hoc Tests*, presents the results of the LSD *t*

Figure 13.13   SPSS: Factorial ANOVA Output Continued

Estimated Marginal Means

Grand Mean

Dependent Variable: Pickle in Nose and Spam on Head

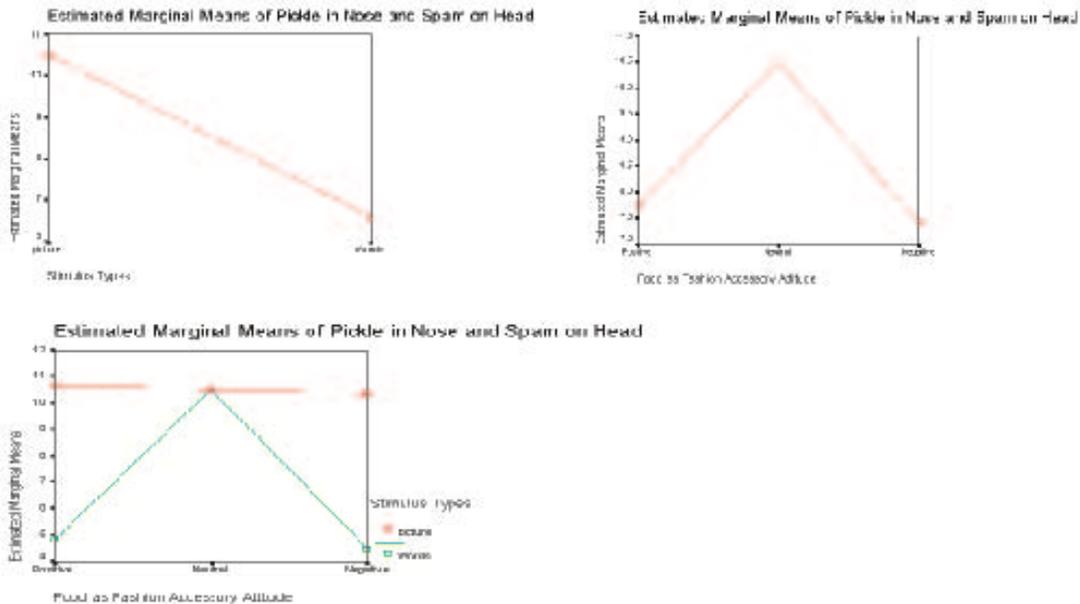|		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
8.556	.347	7.847	9.264

Post Hoc Tests

Food as Fashion Accessory Attitude

Multiple Comparisons

Dependent Variable: Pickle in Nose and Spam on Head
LSD

(I) Food as Fashion Accessory Attitude	(J) Food as Fashion Accessory Attitude	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Positive	Neutral	-2.7500*	.84984	.003	-4.4056	-1.0144
	Negative	.0000	.84984	.390	-1.4023	2.0509
Neutral	Positive	2.7500*	.84984	.003	1.0144	4.4856
	Negative	3.0833*	.84984	.111	1.3477	4.8189
Negative	Positive	.0000	.84984	.308	2.0689	1.4023
	Neutral	-1.4167	.84984	.111	-4.8189	1.3477

Based on observed means.
* The mean difference is significant at the .05 level.

Profile Plots

Estimated Marginal Means of Pickle in Nose and Spam on Head

Estimated Marginal Means of Pickle in Nose and Spam on Head

Estimated Marginal Means of Pickle in Nose and Spam on Head

tests we requested. These results are interpreted in the same way as LSD *t* test were for One-Way ANOVA (See the computer example in Chapter 12 for a quick review). For our example, the results indicated that the average of the Neutral attitude group is significantly different from the averages of the Positive and the Negative attitude groups. However, the Positive and Negative groups do not significantly differ from one another. These results are consistent with the results of our hand calculations. However, notice that the *Std. Error* (which is the denominator of the LSD *t* test formula) in the SPSS output (.84984) is slightly different from what we used in our hand calculations (.8494). Again, this is attributable to differences in rounding procedures.

The final portion of the output consists of line charts that plot the means for the two main effects and the interaction effect. You can make changes to the chart format (including type of chart and labels) by double right clicking on the desired chart. This should activate the chart editor and provide you with a variety of options (see Chapter 3 computer example for review).

Simple Effects Testing

When an interaction effect is found to be significant, it poses an interpretation problem that is similar to the problems associated with having a significant main effect for a variable with more than 2 groups. Specifically, we are unsure what sub-group means are significantly different. However, like the problem with significant main effect, interpretation is facilitated by the use of special followup tests. For significant interactions we use Simple Effects tests. A simple effect is like a main effect, but we compare the sub-group means in an IV only for cases in a single group of another IV. In our example, we could compare the means of the Positive, Neutral and Negative sub-groups, but only for people that were exposed to subliminal pictures. To get the clearest picture of the date, it is usually necessary to look at all possible simple effects.

The simple effect test itself is really a modified ANOVA statistic that uses the MS_{btw} from the simple effect as the numerator of the F ratio and the MS_{ERROR} from the Factorial ANOVA as the denominator. To obtain the MS_{btw} for the simple effect, we will ask SPSS to run a One-Way ANOVA using only the data for the simple effect group of interest. The final F will have to computed by hand, and the table of critical Fs (Appendix 4) will have to be used to determine the significance of the simple effect F. The simple effect F-critical uses the df_{btw} from the One-Way ANOVA summary table and the df_{ERROR} from the Factorial ANOVA summary table.

A significant simple effect F is like any F statistic. If you have more than two sub-groups, represented in the simple effect F, you will need to use more followup tests to determine which means are
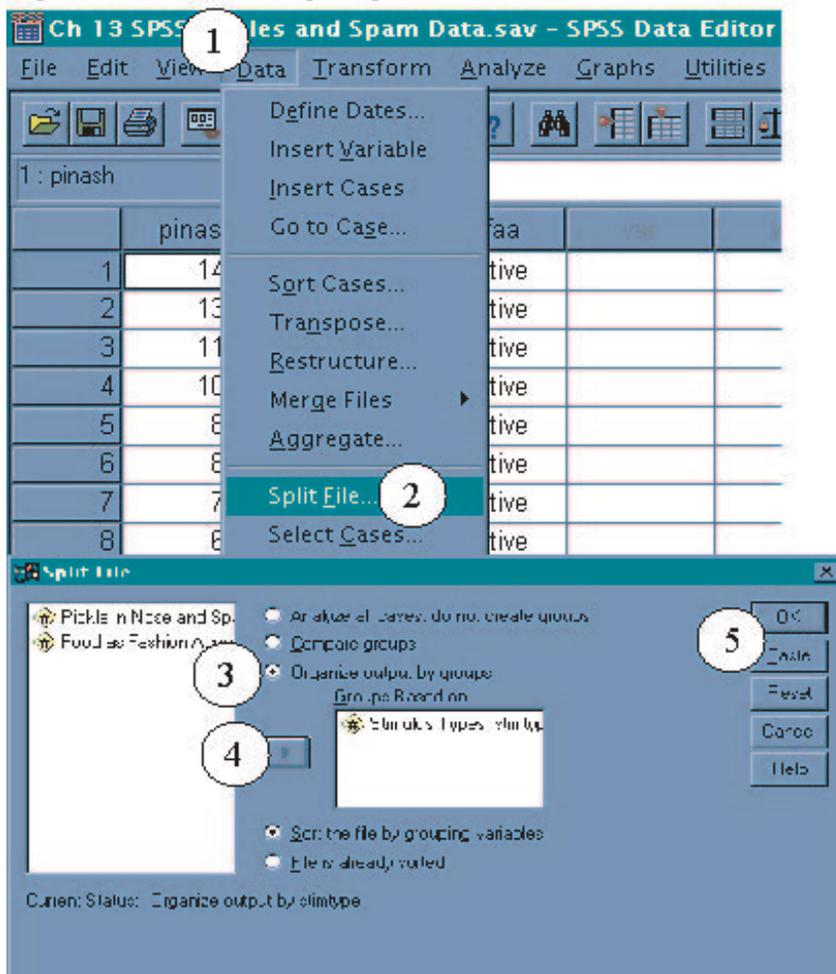
significantly different. Again, the LSD t tests utilizing the MS_{ERROR} from the Factorial ANOVA can be used here. These too will have to be computed by hand.

We will approach the SPSS procedures in three parts. First we will demonstrate the use of the split file command, that will instruct SPSS to run separate analyses for separate simple effects groups. For example, after enabling split file for **stimtype**, we can request single One-Way ANOVA comparing the **pinash** scores for the Positive, Neutral, and Negative attitude groups, and SPSS will automatically run two different analyses, one for each **stimtype** group.

Second we will briefly review the procedures for running a One-Way Anova. We will finish with a demonstration of the hand calculations for the simple effects and the appropriate followup LSD t tests.

Running the Analyses

Figure 13.14 SPSS: Running the Split File Command

Enabling Split File Steps (See Figure 13.14): From the **Data** (1) pull-down menu, select **Split File...** (2). In the **Split File** dialogue box select the **Organize output by groups** option (3). Next, select the independent variable for which you want to analyze the groups separately. We will use **stimtype** here. Enter **stimtype** into the **Groups Based on:** dialogue box by clicking on the boxed arrow (4). This tells SPSS to run a separate analysis for each group of the selected variable, anytime an analysis is

requested. To run click **OK** (5), or **Paste** the syntax for later use.

If you chose the paste option, you should have the following syntax:

SORT CASES BY stimtype .

SPLIT FILE

  SEPARATE BY stimtype .

Again, you can run this analyses by selecting **Run** and **All** from the Syntax Editor's pull-down menu.

When you use split file and finish the analyses you are interested in, it is best to disable split file before proceeding, otherwise it is easy to forget that it is enabled and get some rather confusing results. To disable split file, follow steps 1 and 2 above and then check to make sure that the **Analyze all cases, do not create groups** option has been selected. Then either run (**OK**) or **Paste** the syntax. If you chose the paste option, you should have the following syntax:

SPLIT FILE

  OFF.

Once split file has been enabled, request the One-Way ANOVA (Analyze - Compare Means - One Way ANOVA: See Chapter 12 computer example for detailed review) and enter the appropriate IV into the **Factor:** field. In this case, since we used **stimtype**, for the split file comand, we need to use **fafaa** as the **Factor:**. Next, enter the dependent variable (**pinash**) into the **Dependent List:** field. No other options are necessary. Finish by either running the analysis (**OK**) or pasting the syntax. If you chose the paste option, you should have the following syntax:

ONEWAY

  pinash BY fafaa

/MISSING ANALYSIS .

After obtaining the split file ANOVAs for **fafaa**, it is necessary to repeat the above procedure using **fafaa** in the split file command and **stimtype** in the ANOVA. If you chose the paste option, you should have the following syntax:

```
SORT CASES BY fafaa .
SPLIT FILE
  SEPARATE BY fafaa .
ONEWAY
  pinash BY stimtype
  /MISSING ANALYSIS .
SPLIT FILE
  OFF.
```

Reading the Output

Figure 13.15 SPSS: Output for One Way ANOVA Separate for Picture and Word Groups

Oneway

Stimulus Types = picture

The results of the simple effect One-Way ANOVA comparing the three attitude sub-groups (Positive, Neutral, and Negative) exposed to subliminal pictures, with respect to the frequency with which they put pickles in their nose and spam on their head, are presented in block A of Figure 13.15. Again, we are only concerned with obtaining the Mean Square Between Groups from the summary table. For this analysis the MS_{btw} is .167. Combined with the

ANOVA[a]

Pickle in Nose and Spam on Head A

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.333	2	.167	.035	.966
Within Groups	72.167	15	4.811		
Total	72.500	17			

a. Stimulus Types = picture

Stimulus Types = Words

ANOVA[a]

Pickle in Nose and Spam on Head B

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	136.444	2	68.222	17.695	.000
Within Groups	57.833	15	3.856		
Total	194.278	17			

a. Stimulus Types = Words

MS_{ERROR} from the Factorial Anova (4.333), we can calculate the simple effect F. The computations are presented below.

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{.167}{4.333} = .0385$$

The F-critical for the simple effects uses df_{btw} (block A of Figure 13.15) and df_{ERROR} (from block 3 of Figure 13.12), which in this case are 2 and 30. The critical F values are 3.32 and 5.39 for the .05 and .01 alpha levels, respectively. Our F-obtained is smaller than both of these values, so we must conclude that simple effect of attitudes toward food as a fashion accessory for people exposed to subliminal pictures is not significant. Thus all three sub-groups of participants show subliminal pictures had statistically equivalent average frequencies of putting pickles in their nose and wearing spam on their head.

Block B of Figure 13.15 presents the result of the simple effect One-Way ANOVA that compared the three attitude sub-groups exposed to subliminal words, with respect the frequency with which they put pickles in their nose and spam on their head. For this analysis the MS_{btw} is 68.222, and again the MS_{ERROR} is 4.333. The completed computations follow.

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{68.222}{4.333} = 15.7447$$

The df_{btw} and the df_{ERROR} are again 2 and 30, respectively. The critical F values are 3.32 and 5.39 for the .05 and .01 alpha levels, respectively. Thus, the simple effect of food as a fashion accessory attitude, for participants exposed to subliminal words telling them to put pickles in their nose and spam on their head, is quite significant. Because we have three groups, even though we know the simple effect is significant, we still do not know which sub-groups differ. The followup LSD t test well help us to make this decision. To complete the LSD t test we will need the means for each of the subgroups. This can be obtained from block 2 of the Factorial ANOVA Output (Figure 13.12). In this case we will use the means presented in the

second row of that block, which are 4.8333, 10.5, and 4.5 for Positive, Neutral, and Negative, respectfully.

Also, we will need the MS_{ERROR} from the Factorial ANOVA, found in block 3 of Figure 13.12 (MS_{ERROR} =

4.333). Finally, we will need the subgroup ns. These too, are contained in the second row of block two of

Figure 13.12. The n for each subgroup is 6. The completed computations for the LSD t tests are presented

below.

Positive vs. Neutral

$$t_{LSD} \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{ERROR}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{4.8333 - 10.5}{\sqrt{4.333\left(\frac{1}{6} + \frac{1}{6}\right)}} = \frac{-5.6667}{\sqrt{4.333(1666 + .1666)}} =$$

$$\frac{-5.6667}{\sqrt{4.333(.3332)}} = \frac{-5.6667}{\sqrt{1.4437}} = \frac{-5.6667}{1.2015} = -4.7163$$

Positive vs. Negative

$$t_{LSD} \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{ERROR}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{4.8333 - 4.5}{\sqrt{4.333\left(\frac{1}{6} + \frac{1}{6}\right)}} = \frac{.3333}{\sqrt{4.333(1666 + .1666)}} =$$

$$\frac{.3333}{\sqrt{4.333(.3332)}} = \frac{.3333}{\sqrt{1.4437}} = \frac{.3333}{1.2015} = .2774$$

Neutral vs. Negative

$$t_{LSD} \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{ERROR}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{10.5 - 4.5}{\sqrt{4.333\left(\frac{1}{6} + \frac{1}{6}\right)}} = \frac{6}{\sqrt{4.333(1666 + .1666)}} =$$

$$\frac{6}{\sqrt{4.333(.3332)}} = \frac{6}{\sqrt{1.4437}} = \frac{6}{1.2015} = 4.9937$$

The t-critical for the LSD t test is determined using the df_{ERROR} from the Factorial ANOVA, which in

this example is 30. The value of t-critical at the two tailed .05 alpha level is 2.042. The first and the last

LSD tests have *t*-obtained values larger than the *t*-critical, and are significant. Thus, we can say that subliminally presenting words, telling people to put pickles up their nose and spam on their head, is most effective when their attitudes regarding food as a fashion accessory are neutral. Further, using subliminal words is equally ineffective in influencing behavior when people have either positive or negative attitudes toward food as a fashion accessory.

Blocks C, D and E of Figure 13.16, present the simple effect One-Way ANOVA results for the effect of stimulus type (pictures vs. words) on pickle and spam wearing frequencies, separately for each of the three attitude groups. The completed computations for the simple effect *F* ratios are presented below. Again, each simple effect *F* is computed using the respective MS_{btw} from each of the One-Way ANOVA summary tables and the MS_{ERROR} from the Factorial ANOVA (4.333).

Figure 13.16   SPSS: Output for One Way ANOVA Separate for the 3 FFAA Groups

Oneway

Food as Fashion Accessory Attitude = Positive

ANOVA[a]

Pickle in Nose and Spam on Head (C)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	102.083	1	102.083	23.113	.001
Within Groups	44.167	10	4.417		
Total	146.250	11			

a. Food as Fashion Accessory Attitude = Positive

Food as Fashion Accessory Attitude = Neutral

ANOVA[a]

Pickle in Nose and Spam on Head (D)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.000	1.000
Within Groups	61.000	10	6.100		
Total	61.000	11			

a. Food as Fashion Accessory Attitude = Neutral

Food as Fashion Accessory Attitude = Negative

ANOVA[a]

Pickle in Nose and Spam on Head (E)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	102.083	1	102.083	41.107	.000
Within Groups	24.833	10	2.483		
Total	126.917	11			

a. Food as Fashion Accessory Attitude = Negative

Participants with Positive Attitudes

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{102.083}{4.333} = 23.5594$$

Participants with Neutral Attitudes

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{.000}{4.333} = .0000$$

Participants with Negative Attitudes

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{102.083}{4.333} = 23.5594$$

The *F*-critical for these analyses is determined using 1 and 30 degrees of freedom for the numerator and the denominator, respectively. The values of *F*-critical for these analyses are 4.17 and 7.56 for the .05 and .01 alpha levels, respectively. Thus the simple effect for stimulus type was significant for participants with positive and negative attitudes. Specifically, using subliminal pictures increased people's pickles and spam wearing behavior more than using words did, when they had either positive or negative attitudes toward wearing food as a fashion accessory. There was no significant difference in the sub-group means for participants with neutral attitudes, indicating that words and pictures were equally effective at influencing behavior for these individuals. Notice that since we were only comparing two groups (pictures vs. words) within each simple effect, there was no need to use LSD *t*-tests to interpret the significant simple effects.

Factorial ANOVA Using SPSS

In this section we will cover the use of SPSS to complete a 2x3 Factorial ANOVA using the

subliminal pickles and spam data set. Specifically we will demonstrate how to set up the data file, to run the

Factorial ANOVA using the General Linear Model commands, to preform LSD post hoc tests, and to

perform simple effects tests for a significant interaction using the Split-File command, One-Way ANOVA,

and some quick hand calculations.

Setting up the Data

The first step in setting up the data file for the Pickles and Spam data is to define three variables, one

for each of our variables of interest. Figure 13.8, is the SPSS data editor variable view, for our pickles and

spam data. Here we have named and given variable labels to three variables: **pinash** (Pickles in Nose and

Spam on

Head),

stimtype

(Stimulus
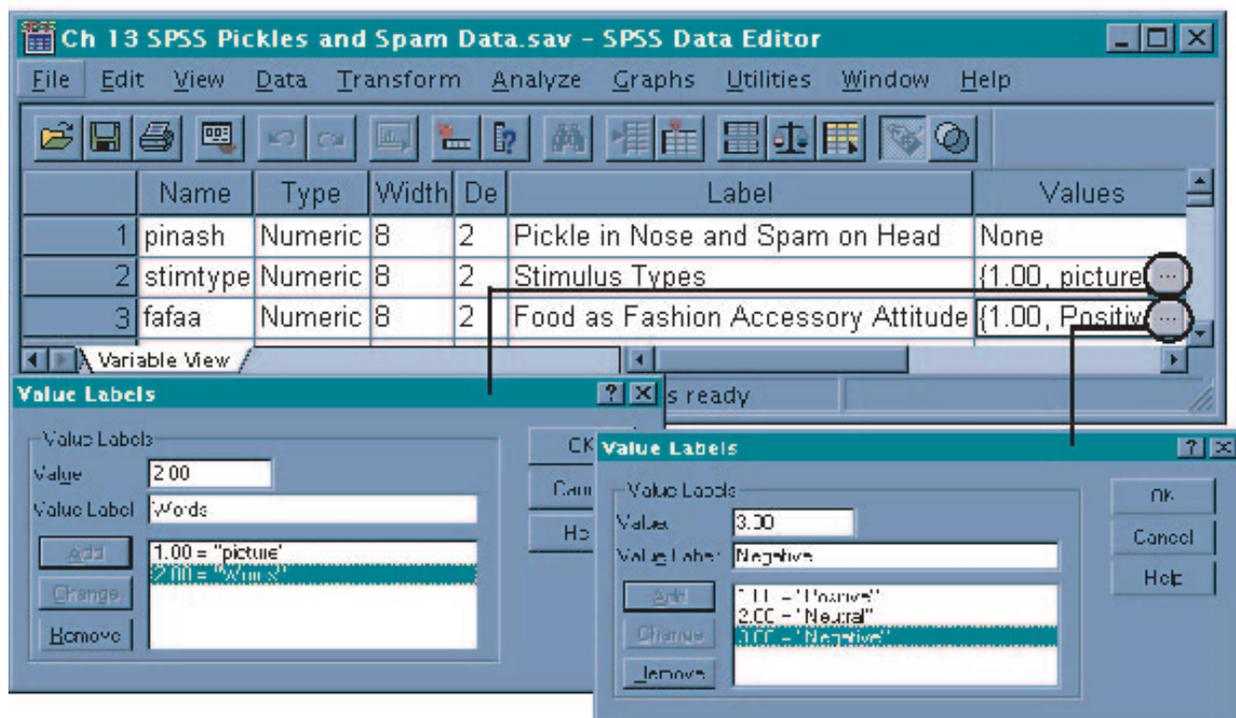
Types),

and **fafaa**

(Food as

Fashion

Accessory

Attitude).

Also, for

the two

Figure 13.8   SPSS: Variable View for Pickles and Spam Data

categorical independent variables, we have given each category a value label. For **stimtype**, the values of 1and 2 were assigned to the labels "picture" and "Words," respectively. For **fafaa**, the values of 1, 2, and 3 were assigned to the labels "Positive," "Neutral," and "Negative," respectively. See Appendix 1 for review of variable naming, variable labeling, and value labeling.

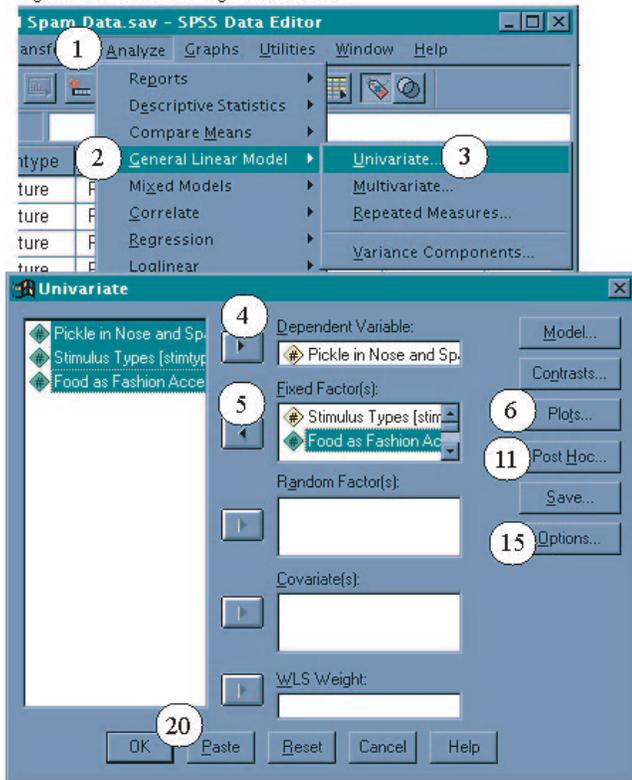Figure 13.9   SPSS: Data View for Pickles and Spam Data

Panel A — Ch 13 SPSS Pickles and Spam Data

File Edit View Data Transform Analyze
Graphs Utilities Window Help

3 : pinash   11

	pinash	stimtype	fafaa
1	14.00	picture	Positive
2	13.00	picture	Positive
3	11.00	picture	Positive
4	10.00	picture	Positive
5	8.00	picture	Positive
6	8.00	picture	Positive
7	7.00	Words	Positive
8	6.00	Words	Positive
9	5.00	Words	Positive
10	5.00	Words	Positive
11	3.00	Words	Positive
12	3.00	Words	Positive
13	13.00	picture	Neutral
14	13.00	picture	Neutral
15	11.00	picture	Neutral
16	10.00	picture	Neutral
17	9.00	picture	Neutral
18	7.00	picture	Neutral

Panel B — Ch 13 SPSS Pickles and Spam Data

File Edit View Data Transform Analyze
Graphs Utilities Window Help

3 : pinash   11

	pinash	stimtype	fafaa
19	14.00	Words	Neutral
20	13.00	Words	Neutral
21	11.00	Words	Neutral
22	9.00	Words	Neutral
23	8.00	Words	Neutral
24	8.00	Words	Neutral
25	12.00	picture	Negative
26	12.00	picture	Negative
27	11.00	picture	Negative
28	10.00	picture	Negative
29	9.00	picture	Negative
30	8.00	picture	Negative
31	6.00	Words	Negative
32	6.00	Words	Negative
33	5.00	Words	Negative
34	4.00	Words	Negative
35	4.00	Words	Negative
36	2.00	Words	Negative

After creating the three desired variables, you can enter the data for each subject. Each subject's score for the frequency with which they put pickles up their nose and spam on their head are entered in Column 1 (pinash). In Column 2 (stimtype), the value (1 or 2) of the appropriate stimulus (picture or Words) for each sub-group member is entered (though the value label appears in the figure). In Column 3 (fafaa), the value (1, 2, or 3) of the appropriate attitude type (Positive, Neutral, or Negative) for each sub-group member is entered (again the value label appears in figure). In this example we started with the subjects in the first sub-group of our study, those receiving the picture prime and reporting a positive attitude food as a fasion accessory ($X_{.11}$). The data for these individuals are entered in the first six rows of Panel A in Figure 13.9. The first subject had a frequency score of 14, and, like the rest of the members of that sub-group, was in group 1 (picture) of stimtype and group 1 (positive) of fafaa. The scores for the next two sub-groups (word prime and positive fafaa attitude $X_{.21}$ and picture prime and neutral fafaa atitude $X_{.12}$) are displayed in the remaining rows of Panel A of Figure 13.9. The scores for the remaining three sub-groups (words/neutral $X_{.22}$, picture/negative $X_{.13}$, and words/negative $X_{.23}$) are displayed in Panel B of Figure 13.9. Note that Panel B is only a different view of the same window as Panel A. We have simply scrolled down to show the other half of the data.

Running the Analysis

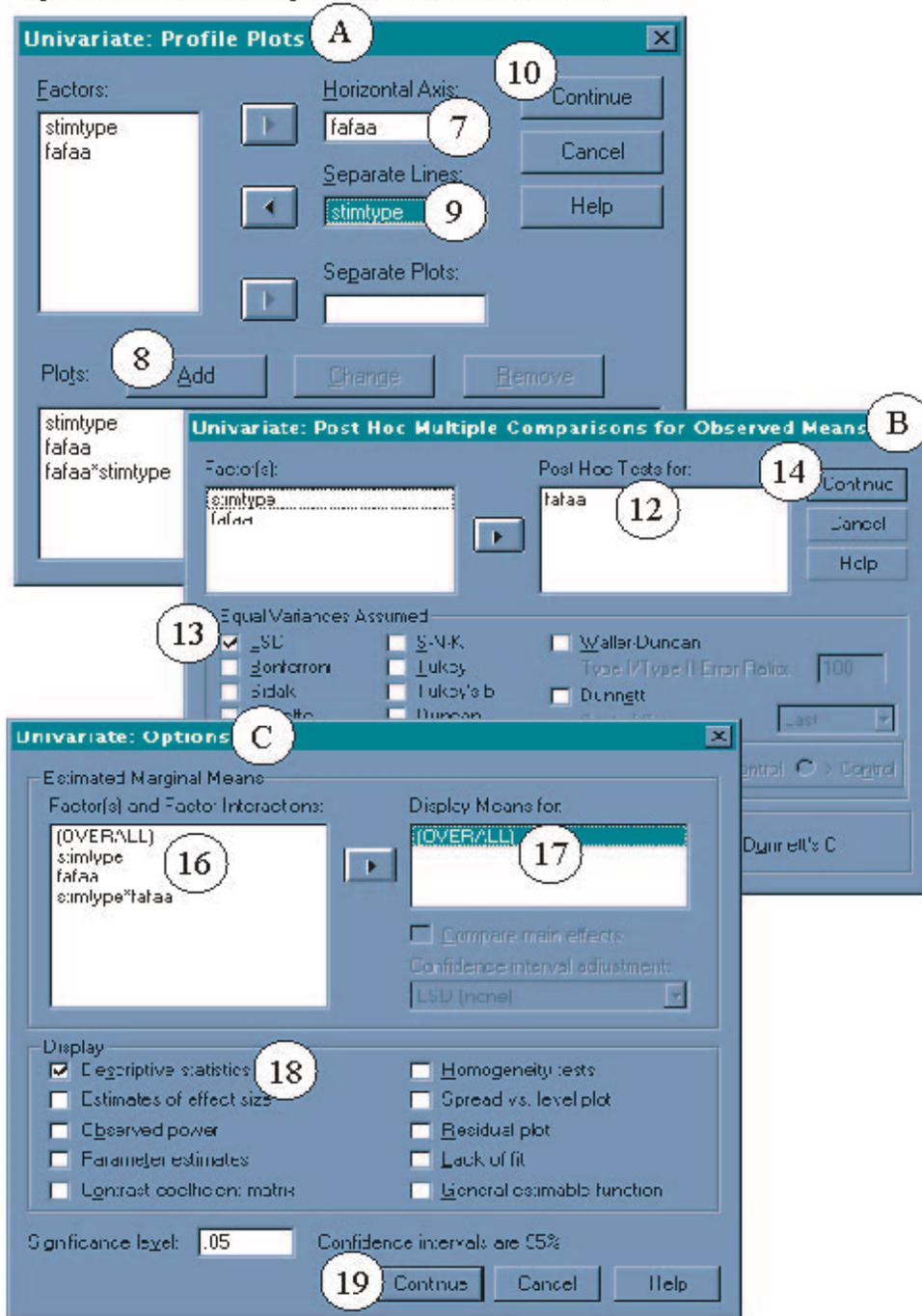Figure 13.10 SPSS: Running Factorial ANOVA

Two-Way Factorial ANOVA Steps (See Figure

13.10): From the **Analyze** (1) pull down menu, select

General Linear Model (2), then select **Univariate...**(3)

from the side menu. In the **Univariate** dialogue box,

enter the dependent variable **Pickle in Nose and Spam**

on Head[pinash] into the **Dependent Variable:** field by

selecting it from the list (left click) and left clicking on

the boxed arrow (4) next to the **Dependent Variable:**

field. Next, enter the two independent variables

(**Stimulus Types[stimtype]** and **Food as Fashion**

Accessory Attitude[fafaa]) into the **Fixed Factor(s):**

field by highlighting both variables and clicking the appropriate boxed arow (5).

To obtain graphs of the main effect and interaction means, left click on **Plots...** (6). In the

Univariate: Profile Plots dialogue box (see Figure 13.11, enter **stimtype** from the **Factors:** list into the

Horizontal Axix: field (7) and then click the **Add** button (8). This will give you the graph of the main effect

for stimulus type. Next, repeat these steps with **fafaa**. To obtain the graph of the interaction, enter **fafaa** in

the **Horizantal Axix:** field (7) again, then enter **stimtype** into the **Separat Lines:** field (9), and finally left

click the **Add** button (8). After requesting the three charts, left click **Contiue** (10).

To obtain the LSD *t* test follow up analyses for any main effects that have more than two groups (in

our example we have one, **fafaa**), left click on the **Post Hoc...** button (11, in Figure 13.10). In the

Univariate: Post Hoc Multiple Comparisons for Observed Means dialogue box (see Figure 13.11), enter

Figure 13.11 SPSS: Running The Factorial ANOVA Continued

fafaa into the **Post Hoc Tests for:** field (12) by double left clicking on **fafaa**. Check the **LSD** option (13), then Left click **Continue** (14).

To obtain the means, standard deviations, and other descriptive information for the IV groups and the sub-groups, left click the **Options...** button (15, in Figure 13.10). In the **Univariate: Options** dialogue box (see Figure 13.11), enter the first of the items listed [**(OVERALL)**] in the **Factor(s) and Factor Interactions:** field (16) into the **Display Means for:** field (17). Next, check the

Descriptive statistics option (18) in the **Display** section of the dialogue box. Finish by clicking **Continue** (19). (you can request the descriptive information for the independent variables and the interaction as well, but they are rather redundant with what the OVERALL gives you)

Finally, double check your variables and all selected options and either select **OK** (20) to run, or **Paste** to create syntax to run at a later time.

If you chose the paste option, you should have the following syntax:

UNIANOVA

```
 pinash  BY stimtype fafaa
 /METHOD = SSTYPE(3)
 /INTERCEPT = INCLUDE
 /POSTHOC = fafaa ( LSD )
 /PLOT = PROFILE( stimtype fafaa fafaa*stimtype )
 /EMMEANS = TABLES(OVERALL)
 /PRINT = DESCRIPTIVE
 /CRITERIA = ALPHA(.05)
 /DESIGN = stimtype fafaa stimtype*fafaa .
```

Again, you can run this analyses by selecting **Run** and **All** from the Syntax Editor's pull-down menu.

Reading the Output for a Two-Way ANOVA

The results of the Two-Way ANOVA are presented in Figures 13.12 and 13.13. Figure 13.12 presents the first three output blocks for the analyses we requested (your output may differ if you requested different options). The first block of the output, titled *Between-Subjects Factors*, indicates which independent variables were included in the analysis, what values were used for each group, what value labels were used for each group, and the group size ($n_{.j.}$ and $n_{..k}$) for each group of each independent variable.

The second block of the output, titled *Descriptive Statistics*, reports the dependent variable means, standard deviations, and group sizes (N) for all sub-groups, IV groups, and the total Sample. Looking at the first row (labeled **picture**), we are first given the descriptive information for each sub-group that was

Figure 13.12   SPSS: Factorial ANOVA Output

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
Stimulus Types	1.00	picture	18
	2.00	Words	18
Food as Fashion Accessory Attitude	1.00	Positive	12
	2.00	Neutral	12
	3.00	Negative	12

Descriptive Statistics

Dependent Variable: Pickle in Nose and Spam on Head

Stimulus Types	Food as Fashion	Mean	Std. Deviation	N
picture	Positive	10.6667	2.50333	6
	Neutral	10.5000	2.34521	6
	Negative	10.3333	1.63299	6
	Total	10.5000	2.06512	18
Words	Positive	4.8333	1.60208	6
	Neutral	10.5000	2.58844	6
	Negative	4.5000	1.51658	6
	Total	6.6111	3.38055	18
Total	Positive	7.7500	3.64629	12
	Neutral	10.5000	2.35488	12
	Negative	7.4167	3.39675	12
	Total	8.5556	3.39280	36

Tests of Between-Subjects Effects

Dependent Variable: Pickle in Nose and Spam on Head

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	272.889a	5	54.578	12.595	.000
Intercept	2635.111	1	2635.111	608.103	.000
STIMTYPE	136.111	1	136.111	31.410	.000
FAFAA	68.722	2	34.361	7.929	.002
STIMTYPE * FAFAA	68.056	2	34.028	7.853	.002
Error	130.000	30	4.333		
Total	3038.000	36			
Corrected Total	402.889	35			

a. R Squared = .677 (Adjusted R Squared = .624)

exposed to subliminal pictures. Each sub-group is identified by its value label for IV2 (fafaa: **Positive**, **Neutral** and **Negative**). The descriptive information for everyone in group 1 of IV1 (the picture group) is given last and identified with the label **Total**. Similarly the second row, labeled **Words**, presents the descriptive information for the three sub-groups exposed to subliminal words, as well as the information for group 2 of IV1 (the words group), which is also identified with the label **Total**. The third and final row of this block, labeled **Total**, presents the descriptive information for each group of IV2, which are identified by their respective value labels. Finally, at the very bottom of the third row, also labeled **Total**, the descriptive information for the total sample is presented.

The information from this block can be used to check your hand calculations for the data summary table. The sub-group and group sums can be obtained by multiplying the mean by its respective N. For example the sum of group 11 (the picture/positive group) can be obtained by multiplying the mean (10.6667) by the N in that line (6): $\Sigma X11 = 64.0002$. Note that this is slightly different from our hand calculations, for which we obtained the value 64. This is due to rounding error. If you do find a large discrepance between your hand calculations and the SPSS output, be sure to first check that you entered the data into SPSS properly. If you feel SPSS is correct, then double check your hand calculations.

The third block the output, titled *Tests of Between-Subjects Effects*, provides us with the familiar

Factorial ANOVA summary table. However, you may notice that there are a couple of things that are new.

The first two rows of the summary table (**Corrected Model** and **Intercept**) can both be ignored. In more

advanced statistics courses you may be compelled to consider them, but not here. In the last row of the table

(**Corrected Total**) you will find the same values we obtained using the hand calculations. The next to last

row (**Total**) gives us total sums of squares and degrees of freedom that included the sums of squares and the

df from the **Intercept** row (row 2), and is not required for us to interpret this Factorial ANOVA or check

our hand calculations. Aside from differences in labeling, rounding values at the third decimal, and

presenting more precise alpha levels, the remainder of the table is the same as what we presented in table

13.10. Row 3 (**STIMTYPE**) presents the values for IV1. Again the *F*-obtained is 31.410, which is

significant at the *p* < less than > .001 alpha level. Remember, when SPSS gives us significance levels of

.000, we should report them as being less than .001. Row 4 (**FAFAA**) gives the values of for IV2, while row

5 (**SIMTYPE*FAFAA**) presents the interaction (1x2) values. These effects are both significant at the .002

alpha level. Row 5 (**Error**) presents the same values as the ERROR rows in our hand calculated summary

table, and the Mean Square value for **Error** is the denominator for all the *F* values. Finally the **Corrected**

Total is the sum of rows 3 (**STIMTYPE**), 4 (**FAFAA**), 5 (**STIMTYPE*FAFAA**), and 6 (**Error**).

Again, these values can be used to double check your hand calculation, though remember that SPSS

only reports two digits past the decimal and it rounds, whereas we use four digits and do not round. Thus,

you may have small variations between their third digit and yours. However, if you get large differences

you should double check the data you entered into SPSS and then double check your hand calculations.

The fourth output block, presented at the top of Table 13.13, reports the dependent variable mean for

the total sample, the standard error of the mean (covered in Chapters 8 and 9), and the confidence interval

(Chapter 8). This information is not required to interpret the Factorial ANOVA.

The fifth output block, under the Major Heading *Post Hoc Tests*, presents the results of the LSD *t*

Figure 13.13   SPSS: Factorial ANOVA Output Continued

Estimated Marginal Means

Grand Mean

Dependent Variable: Pickle in Nose and Spam on Head

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
8.556	.347	7.847	9.264

Post Hoc Tests

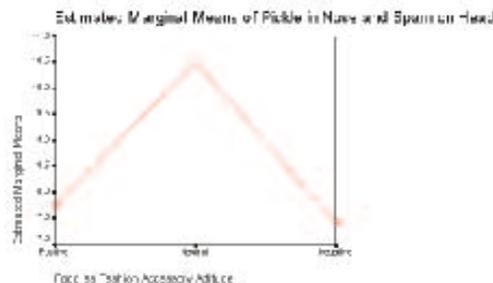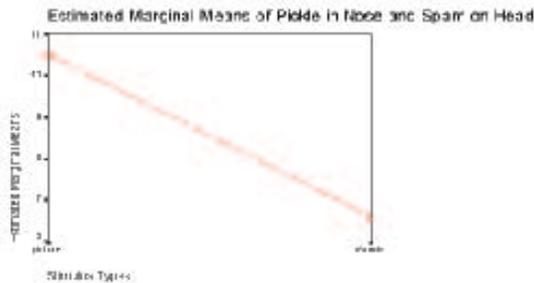### Food as Fashion Accessory Attitude

Multiple Comparisons

Dependent Variable: Pickle in Nose and Spam on Head
LSD

(I) Food as Fashion Accessory Attitude	(J) Food as Fashion Accessory Attitude	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Positive	Neutral	-2.7500*	.84984	.003	-4.7056	-1.0144
	Negative	.0000	.84984	.390	-1.4023	2.0509
Neutral	Positive	2.7500*	.84984	.003	1.0144	4.4956
	Negative	3.0833*	.84984	.111	1.3477	4.8189
Negative	Positive	.0333	.84984	.308	2.0689	1.4023
	Neutral	-1.337*	.84984	.111	-4.8189	1.3477

Based on observed means.
* The mean difference is significant at the .05 level.

Profile Plots

Estimated Marginal Means of Pickle in Nose and Spam on Head

Estimated Marginal Means of Pickle in Nose and Spam on Head

Estimated Marginal Means of Pickle in Nose and Spam on Head

tests we requested. These results are interpreted in the same way as LSD *t* test were for One-Way ANOVA (See the computer example in Chapter 12 for a quick review). For our example, the results indicated that the average of the Neutral attitude group is significantly different from the averages of the Positive and the Negative attitude groups. However, the Positive and Negative groups do not significantly differ from one another. These results are consistent with the results of our hand calculations. However, notice that the *Std. Error* (which is the denominator of the LSD *t* test formula) in the SPSS output (.84984) is slightly different from what we used in our hand calculations (.8494). Again, this is attributable to differences in rounding procedures.

The final portion of the output consists of line charts that plot the means for the two main effects and the interaction effect. You can make changes to the chart format (including type of chart and labels) by double right clicking on the desired chart. This should activate the chart editor and provide you with a variety of options (see Chapter 3 computer example for review).

Simple Effects Testing

When an interaction effect is found to be significant, it poses an interpretation problem that is similar to the problems associated with having a significant main effect for a variable with more than 2 groups. Specifically, we are unsure what sub-group means are significantly different. However, like the problem with significant main effect, interpretation is facilitated by the use of special followup tests. For significant interactions we use Simple Effects tests. A simple effect is like a main effect, but we compare the sub-group means in an IV only for cases in a single group of another IV. In our example, we could compare the means of the Positive, Neutral and Negative sub-groups, but only for people that were exposed to subliminal pictures. To get the clearest picture of the date, it is usually necessary to look at all possible simple effects.

The simple effect test itself is really a modified ANOVA statistic that uses the MS_{btw} from the simple effect as the numerator of the F ratio and the MS_{ERROR} from the Factorial ANOVA as the denominator. To obtain the MS_{btw} for the simple effect, we will ask SPSS to run a One-Way ANOVA using only the data for the simple effect group of interest. The final F will have to computed by hand, and the table of critical Fs (Appendix 4) will have to be used to determine the significance of the simple effect F. The simple effect F-critical uses the df_{btw} from the One-Way ANOVA summary table and the df_{ERROR} from the Factorial ANOVA summary table.

A significant simple effect F is like any F statistic. If you have more than two sub-groups, represented in the simple effect F, you will need to use more followup tests to determine which means are
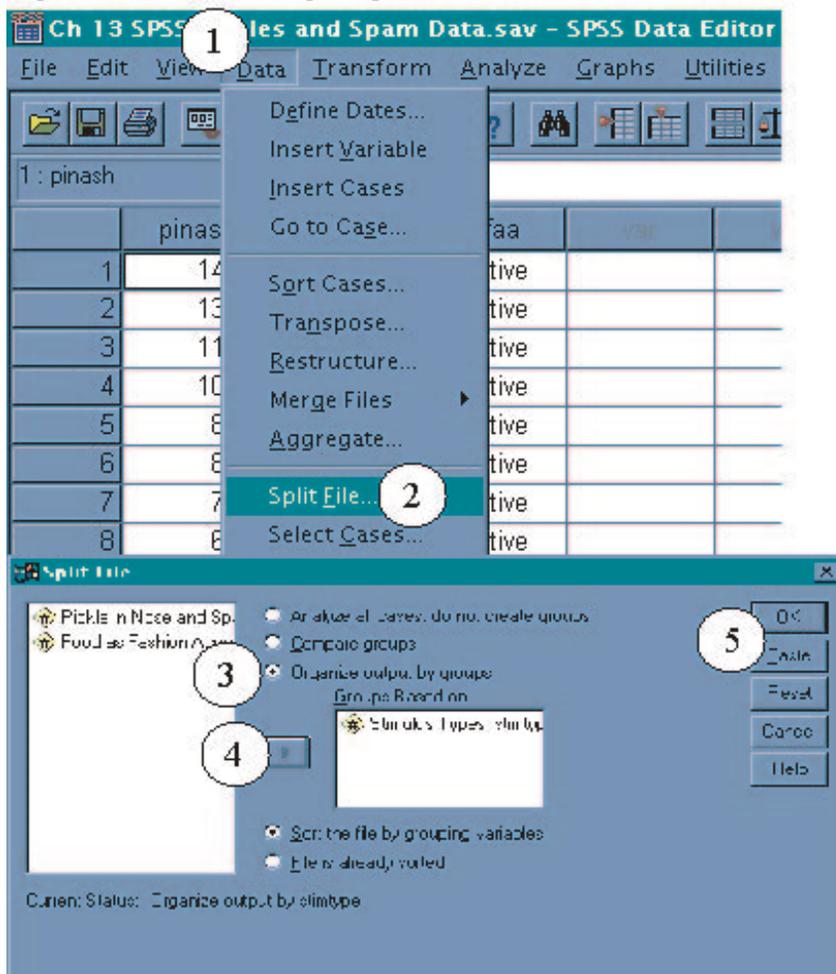
significantly different. Again, the LSD *t* tests utilizing the MS_{ERROR} from the Factorial ANOVA can be used here. These too will have to be computed by hand.

We will approach the SPSS procedures in three parts. First we will demonstrate the use of the split file command, that will instruct SPSS to run separate analyses for separate simple effects groups. For example, after enabling split file for **stimtype**, we can request single One-Way ANOVA comparing the **pinash** scores for the Positive, Neutral, and Negative attitude groups, and SPSS will automatically run two different analyses, one for each **stimtype** group.

Second we will briefly review the procedures for running a One-Way Anova. We will finish with a demonstration of the hand calculations for the simple effects and the appropriate followup LSD *t* tests.

Running the Analyses

Figure 13.14 SPSS: Running the Split File Command

Enabling Split File Steps (See Figure 13.14): From the **Data** (1) pull-down menu, select **Split File...** (2). In the **Split File** dialogue box select the **Organize output by groups** option (3). Next, select the independent variable for which you want to analyze the groups separately. We will use **stimtype** here. Enter **stimtype** into the **Groups Based on:** dialogue box by clicking on the boxed arrow (4). This tells SPSS to run a separate analysis for each group of the selected variable, anytime an analysis is

requested. To run click **OK** (5), or **Paste** the syntax for later use.

If you chose the paste option, you should have the following syntax:

SORT CASES BY stimtype .

SPLIT FILE

  SEPARATE BY stimtype .

Again, you can run this analyses by selecting **Run** and **All** from the Syntax Editor's pull-down menu.

When you use split file and finish the analyses you are interested in, it is best to disable split file before proceeding, otherwise it is easy to forget that it is enabled and get some rather confusing results. To disable split file, follow steps 1 and 2 above and then check to make sure that the **Analyze all cases, do not create groups** option has been selected. Then either run (**OK**) or **Paste** the syntax. If you chose the paste option, you should have the following syntax:

SPLIT FILE

  OFF.

Once split file has been enabled, request the One-Way ANOVA (Analyze - Compare Means - One Way ANOVA: See Chapter 12 computer example for detailed review) and enter the appropriate IV into the **Factor:** field. In this case, since we used **stimtype**, for the split file comand, we need to use **fafaa** as the **Factor:**. Next, enter the dependent variable (**pinash**) into the **Dependent List:** field. No other options are necessary. Finish by either running the analysis (**OK**) or pasting the syntax. If you chose the paste option, you should have the following syntax:

ONEWAY

 pinash BY fafaa

/MISSING ANALYSIS .

After obtaining the split file ANOVAs for **fafaa**, it is necessary to repeat the above procedure using **fafaa** in the split file command and **stimtype** in the ANOVA. If you chose the paste option, you should have the following syntax:

SORT CASES BY fafaa .

SPLIT FILE

  SEPARATE BY fafaa .

ONEWAY

  pinash BY stimtype

  /MISSING ANALYSIS .

SPLIT FILE

  OFF.

Reading the Output

Figure 13.15 SPSS: Output for One Way ANOVA Separate for Picture and Word Groups

Oneway

Stimulus Types = picture

The results of the simple effect One-Way ANOVA comparing the three attitude sub-groups (Positive, Neutral, and Negative) exposed to subliminal pictures, with respect to the frequency with which they put pickles in their nose and spam on their head, are presented in block A of Figure 13.15. Again, we are only concerned with obtaining the Mean Square Between Groups from the summary table. For this analysis the MS_{btw} is .167. Combined with the

ANOVAª

Pickle in Nose and Spam on Head   A

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.333	2	.167	.035	.966
Within Groups	72.167	15	4.811		
Total	72.500	17			

a. Stimulus Types = picture

Stimulus Types = Words

ANOVAª

Pickle in Nose and Spam on Head   B

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	136.444	2	68.222	17.695	.000
Within Groups	57.833	15	3.856		
Total	194.278	17			

a. Stimulus Types = Words

MS$_{ERROR}$ from the Factorial Anova (4.333), we can calculate the simple effect F. The computations are

presented below.

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{.167}{4.333} = .0385$$

The F-critical for the simple effects uses df_{btw} (block A of Figure 13.15) and df_{ERROR} (from block 3 of Figure

13.12), which in this case are 2 and 30. The critical F values are 3.32 and 5.39 for the .05 and .01 alpha

levels, respectively. Our F-obtained is smaller than both of these values, so we must conclude that simple

effect of attitudes toward food as a fashion accessory for people exposed to subliminal pictures is not

significant. Thus all three sub-groups of participants show subliminal pictures had statistically equivalent

average frequencies of putting pickles in their nose and wearing spam on their head.

Block B of Figure 13.15 presents the result of the simple effect One-Way ANOVA that compared

the three attitude sub-groups exposed to subliminal words, with respect the frequency with which they put

pickles in their nose and spam on their head. For this analysis the MS$_{btw}$ is 68.222, and again the MS$_{ERROR}$ is

4.333. The completed computations follow.

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{68.222}{4.333} = 15.7447$$

The df_{btw} and the df_{ERROR} are again 2 and 30, respectively. The critical F values are 3.32 and 5.39 for the .05

and .01 alpha levels, respectively. Thus, the simple effect of food as a fashion accessory attitude, for

participants exposed to subliminal words telling them to put pickles in their nose and spam on their head, is

quite significant. Because we have three groups, even though we know the simple effect is significant, we

still do not know which sub-groups differ. The followup LSD t test well help us to make this decision. To

complete the LSD t test we will need the means for each of the subgroups. This can be obtained from block

2 of the Factorial ANOVA Output (Figure 13.12). In this case we will use the means presented in the

second row of that block, which are 4.8333, 10.5, and 4.5 for Positive, Neutral, and Negative, respectfully.

Also, we will need the MS_{ERROR} from the Factorial ANOVA, found in block 3 of Figure 13.12 (MS_{ERROR} =

4.333). Finally, we will need the subgroup ns. These too, are contained in the second row of block two of

Figure 13.12. The n for each subgroup is 6. The completed computations for the LSD t tests are presented

below.

Positive vs. Neutral

$$t_{LSD} \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{ERROR}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{4.8333 - 10.5}{\sqrt{4.333\left(\frac{1}{6} + \frac{1}{6}\right)}} = \frac{-5.6667}{\sqrt{4.333(1666 + .1666)}} =$$

$$\frac{-5.6667}{\sqrt{4.333(.3332)}} = \frac{-5.6667}{\sqrt{1.4437}} = \frac{-5.6667}{1.2015} = -4.7163$$

Positive vs. Negative

$$t_{LSD} \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{ERROR}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{4.8333 - 4.5}{\sqrt{4.333\left(\frac{1}{6} + \frac{1}{6}\right)}} = \frac{.3333}{\sqrt{4.333(1666 + .1666)}} =$$

$$\frac{.3333}{\sqrt{4.333(.3332)}} = \frac{.3333}{\sqrt{1.4437}} = \frac{.3333}{1.2015} = .2774$$

Neutral vs. Negative

$$t_{LSD} \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{MS_{ERROR}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{10.5 - 4.5}{\sqrt{4.333\left(\frac{1}{6} + \frac{1}{6}\right)}} = \frac{6}{\sqrt{4.333(1666 + .1666)}} =$$

$$\frac{6}{\sqrt{4.333(.3332)}} = \frac{6}{\sqrt{1.4437}} = \frac{6}{1.2015} = 4.9937$$

The t-critical for the LSD t test is determined using the df_{ERROR} from the Factorial ANOVA, which in

this example is 30. The value of t-critical at the two tailed .05 alpha level is 2.042. The first and the last

LSD tests have *t*-obtained values larger than the *t*-critical, and are significant. Thus, we can say that subliminally presenting words, telling people to put pickles up their nose and spam on their head, is most effective when their attitudes regarding food as a fashion accessory are neutral. Further, using subliminal words is equally ineffective in influencing behavior when people have either positive or negative attitudes toward food as a fashion accessory.

Blocks C, D and E of Figure 13.16, present the simple effect One-Way ANOVA results for the effect of stimulus type (pictures vs. words) on pickle and spam wearing frequencies, separately for each of the three attitude groups. The completed computations for the simple effect *F* ratios are presented below. Again, each simple effect *F* is computed using the respective MS_{btw} from each of the One-Way ANOVA summary tables and the MS_{ERROR} from the Factorial ANOVA (4.333).

Figure 13.16   SPSS: Output for One Way ANOVA Separate for the 3 FFAA Groups

Oneway

Food as Fashion Accessory Attitude = Positive

ANOVA[a]

Pickle in Nose and Spam on Head (C)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	102.083	1	102.083	23.113	.001
Within Groups	44.167	10	4.417		
Total	146.250	11			

a. Food as Fashion Accessory Attitude = Positive

Food as Fashion Accessory Attitude = Neutral

ANOVA[a]

Pickle in Nose and Spam on Head (D)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.000	1.000
Within Groups	61.000	10	6.100		
Total	61.000	11			

a. Food as Fashion Accessory Attitude = Neutral

Food as Fashion Accessory Attitude = Negative

ANOVA[a]

Pickle in Nose and Spam on Head (E)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	102.083	1	102.083	41.107	.000
Within Groups	24.833	10	2.483		
Total	126.917	11			

a. Food as Fashion Accessory Attitude = Negative

Participants with Positive Attitudes

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{102.083}{4.333} = 23.5594$$

Participants with Neutral Attitudes

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{.000}{4.333} = .0000$$

Participants with Negative Attitudes

$$F_{simpleeffect} = \frac{MS_{btw}}{MS_{ERROR}} = \frac{102.083}{4.333} = 23.5594$$

The *F*-critical for these analyses is determined using 1 and 30 degrees of freedom for the numerator and the denominator, respectively. The values of *F*-critical for these analyses are 4.17 and 7.56 for the .05 and .01 alpha levels, respectively. Thus the simple effect for stimulus type was significant for participants with positive and negative attitudes. Specifically, using subliminal pictures increased people's pickles and spam wearing behavior more than using words did, when they had either positive or negative attitudes toward wearing food as a fashion accessory. There was no significant difference in the sub-group means for participants with neutral attitudes, indicating that words and pictures were equally effective at influencing behavior for these individuals. Notice that since we were only comparing two groups (pictures vs. words) within each simple effect, there was no need to use LSD *t*-tests to interpret the significant simple effects.