Integration of ANOVA and Multiple Regression for Beginning Statistics Students

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Amelioration of the perpetual difficulty students have upon encountering typical statistical methods introduced in a first statistics course, or combined into a research methodology course, is the objective of this effort. In addition, an evaluation of the proposed method is included.

From student comments and in class experience, it is clear that difficulties students face on encountering statistical methods to address research questions are both conceptual and computational. Many of the conceptual problems students face are due to the fragmented "menu -style" manner in which inferential statistical methods are introduced in texts. "A t-test is on page 37; an ANOVA is on page 102, and a multiple regression is on page 150." But, as illustrated (Kerlinger & Pedhazur, 1973, Pedhazur, 1982; or Cohen & Cohen, 1975, 1983) these techniques, and many more, are intimately tied through the general linear model. Some would argue that such an integrative approach is too advanced for the beginning student; if handled gently, we disagree. A general introduction to the theory of the GLM is not suggested for the beginning student, but a method that allows easy illustration of how these techniques are computationally the same has been found to reduce confusion considerably.

The computational difficulty students face is usually due to the user interface of commercial software packages. Students find the new computer interface challenging – sometimes bewildering -- especially at first. But all students are comfortable with and have immediate access to Excel, so an Excel software package, "Criterion.xlsx," was written, used, and evaluated herein. This software also has the advantage of "flexible immediacy" to illustrate the linkages among methods.

Methods

We also wanted control over what is displayed and how. Specifically, we took this opportunity to embed contextual guidance toward correct understanding of analyses within the pages of this software, so that what the student reads as "output" is accompanied with narrative guidance. We want to educate while students calculate. As well, all relevant output is automatically generated in "camera-ready" APA cut-and-paste tables. We also point out errors made in commercial packages offering the same output.

Criterion is divided into various spreadsheet "tabs" that execute various desired analyses; each with extensive embedded annotations that are used to teach in context and to provide clarification regarding often encountered interpretive errors. Methods are available for univariate through multivariate analyses, and the software has been used very successfully in a second multivariate statistics course, but that is not the interest here. Only the parts most relevant to ANOVA and multiple regression will be illustrated here.[1] [Note that the Excel statistical "Analysis Toolpak" that has received some criticism in the literature (e.g., McCullough & Wilson, but see amelioration with more recent versions, Melard, 2014) is not used – all programming is original. Moreover, with a very large set of examples, an exact match with SPSS, SAS, or Systat is always obtained.] .

Data Source

Relevant analyses will be displayed in Figures here using two data sets. A multiple regression data set in which graduate **GPA** is predicted from **GRE** (**Q**uantitative and **V**erbal), the **M**iller **A**nalogies **T**est, and the **A**verage **R**ating of faculty (Kerlinger & Pedhazur, 1973, p. 292), and a group contrast ANOVA data set regarding the relationship of Religion to Attitude Toward Abortion (Cohen & Cohen, 1983, p. 185). The following will detail the use of the spreadsheet to analyze these data.

Results

To render the analysis, one only needs to enter the 1) N, 2) p (the number of variables), 3) α (we believe it is important for students to make a choice), 4) variable names, and 5) data (with the **C**riterion first in column **C** as shown). This is the first data set wherein GPA is predicted from GRE-Q, GRE-V, MAT and Average Faculty Rating. The complete program and the various tabs used to access different sheets is available at: https://johnnysolarseed.com/CriterionProgram/Criterion_Download.html

	A	B	C	D	E	F	G
2		*# Predictors =*	4				
3		*N (cases) =*	30				
4		*α =*	.050				
5	*OK*						
6		Enter Short Variable names in ***Row 8*** ; Criterion in column C, Predictors in D and on →					
7	***Check:***		*Criterion*	*Predictors →*			
8	*ok*	*Case # ↓*	**GPA**	**GRE-Q**	**GRE-V**	**MAT**	**AR**
9	*ok*	***1***	3.2	625	540	65	2.7
10	*ok*	***2***	4.1	575	680	75	4.5
11	*ok*	***3***	3	520	480	65	2.5
12	*ok*	***4***	2.6	545	520	55	3.1
13	*ok*	***5***	3.7	520	490	75	3.6
14	*ok*	***6***	4	655	535	65	4.3
15	*ok*	***7***	4.3	630	720	75	4.6
16	*ok*	***8***	2.7	500	500	75	3
17	*ok*	***9***	3.6	605	575	65	4.7
18	*ok*	***10***	4.1	555	690	75	3.4
19	*ok*	***11***	2.7	505	545	55	3.7
20	*ok*	***12***	2.9	540	515	55	2.6
21	*ok*	***13***	2.5	520	520	55	3.1
22	*ok*	***14***	3	585	710	65	2.7
23	*ok*	***15***	3.3	600	610	85	5
24	*ok*	***16***	3.2	626	540	65	2.7
25	*ok*	***17***	4.1	575	680	75	4.5
26	*ok*	***18***	3	520	480	65	2.5
27	*ok*	***19***	2.6	545	520	55	3.1
28	*ok*	***20***	3.7	520	490	75	3.6
29	*ok*	***21***	4	655	535	65	4.3
30	*ok*	***22***	4.3	630	720	75	4.6
31	*ok*	***23***	2.7	500	500	75	3
32	*ok*	***24***	3.6	605	575	65	4.7
33	*ok*	***25***	4.1	555	690	75	3.4
34	*ok*	***26***	2.7	505	545	55	3.7
35	*ok*	***27***	2.9	540	515	55	2.6
36	*ok*	***28***	2.5	520	520	55	3.1
37	*ok*	***29***	3	585	710	65	2.7
38	*ok*	***30***	3.3	600	610	85	5

Read Me | **Input** | APA rs | APA rs Bon | Scatterplot | APA Model | APA Coefficients

Figure 1: Input (Regression)

The APA style **R** matrix is under the "**APA R**" sheet (Figure 2). The "**APA R Bon**" sheet offers the same matrix but with a Bonferroni type correction for per-hypothesis error, with a description of alternatives to the conservative Bonferroni (Figure 3). We believe it is important to demonstrate the notion of protection from "probability pyramiding" even if it is done with the relatively conservative Bonferroni; it is the easiest to explain.

R CIs (Figure 4) **and R CIs Bon** (Figure 5): The aforementioned R matrix and R matrix with a Bonferroni correction are replicated with the addition of **C**onfidence **I**ntervals for the rs (with the % determined as 1-α) in Figures 5 & 6. Given the ASA stand (Wasserstein & Lazar, 2016), and strong encouragement to do so in the *APA Publication Manual* (2020, p. 87, 88), we believe it is important to accustom students with CIs and encourage inclusion in such a matrix format. In addition, the widened CIs in the Bonferroni adjusted matrix appear to make the effect of multiple hypothesis testing clearer to students.

This is the standard APA format for presentation of an intercorrelation matrix. This would be true even if interest is only in the correlations among variables, with no regression. If that is the case, then you may simply enter your variables ignoring which is designated "Criterion" in the Input tab. Then ignore all other tabs except "APA rs Bon." You may find need to adjust column widths for your particular data in any table, but the basic structure and "lines" will remain the same.

Table 1

Title such as: Correlation of Criterion with all Predictor Variables

Variable	M	SD	1	2	3	4	5
1. GPA	3.31	.60	—				
2. GREV	565.37	48.66	.61*	—			
3. GREQ	575.33	83.03	.58*	.47*	—		
4. MAT	67.00	9.25	.60*	.27	.43*	—	
5. AFR	3.57	.84	.62*	.51*	.41*	.52*	—

*p < .05

Figure 2: APA R

This is the intercorrelation matrix using Bonferonni corrected ps for all correlations.
With p variables, there are p (p - 1) / 2 correlations, thus the corrected α= .00500
Possibilities in addition to Bonferroni (Holm, Hochberg, Sidak, FDR, etc.) are available and should also be considered as contenders.

Table 1

Title such as: Correlation of Criterion with all Predictor Variables

Variable	M	SD	1	2	3	4	5
1. GPA	3.31	.60	—				
2. GREV	565.37	48.66	.61*	—			
3. GREQ	575.33	83.03	.58*	.47	—		
4. MAT	67.00	9.25	.60*	.27	.43	—	
5. AFR	3.57	.84	.62*	.51*	.41	.52*	—

*p < .00500

Figure 3: APA R Bon (Bonferroni adjustment and alternative suggestions)

Scatterplot (Figure 6): Any two variables may be selected by inserting their ordinal number into cells B8 (X) and B9 (Y), with those numbers included in a legend on that page; a scatterplot as well as histograms and comprehensive univariate statistics are automatically rendered.

APA Model (Figure 7): An APA table including the usual statistics for a regression model, with the addition of Cohen's (1992) f^2 effect size is here. As it is often seen as appropriate to include the model information in text rather than in a table, an alternative suggested skeleton sentence with data specific to the analysis is also included in **bold**.

APA Coefficients (Figure 8): A typical APA table of results for individual coefficients is included. We also have tried to ameliorate the seemingly continual misinterpretation of tests of partial slope inappropriately as bivariate tests of predictor-criterion relationship by including the ΔR^2 due to each variable, pointing out that, in the sense of relationship, this is what is being tested.

Extensive diagnostic sheets considering the assumptions of the residuals of least squares (linearity, homoscedasticity, independence and normality), as well as statistics for excessive leverage or influence of data points, are automatically calculated but are not presented here.

This sheet gives an alternative correlation matrix representation with embedded Confidence Intervals for all correlations, rather than just null hypothesis tests. Although not standard, this is more in line with current thought about the deficits of dichotomous Null Hypothesis Significance Tests. The CIs are obtained by the Fisher log transformation to normality, applying the r SE with the α specified on the "**Input**" sheet, then "back" exponentiating to the r metric.

Table 1

Title such as: Descriptive Statistics, Correlations Among all Variables and 95% CIs

Variable	M	SD	1	2	3	4	5
1. GPA	3.31	.60	—				
2. GRE-Q	565.37	48.66	.61* [.32,.80]	—			
3. GRE-V	575.33	83.03	.58* [.28,.78]	.47* [.13,.71]	—		
4. MAT	67.00	9.25	.60* [.31,.79]	.27 [-.10,.57]	.43* [.08,.68]	—	
5. AR	3.57	.84	.62* [.34,.80]	.51* [.18,.73]	.41* [.05,.67]	.52* [.20,.74]	—

Note. r / [CI LL,CI UL].
*p < .050

Figure 4: R CIs

This sheet gives the same alternative correlation matrix representation as does the "R CIs" sheet except that the Bonferroni corrected alpha is used in creating the CIs. An advantage of the Bonferroni method over other contenders mentioned, is that CIs are not available for those "stepping" methods.

Table 1

Title such as: Descriptive Statistics, Correlations Among all Variables and 95% CIs with a Bonferroni Correction

Variable	M	SD	1	2	3	4	5
1. GPA	3.31	.60	—				
2. GRE-Q	565.37	48.66	.61* [.17,.85]	—			
3. GRE-V	575.33	83.03	.58* [.12,.84]	.47 [-.03,.78]	—		
4. MAT	67.00	9.25	.60* [.16,.85]	.27 [-.26,.67]	.43 [-.09,.76]	—	
5. AR	3.57	.84	.62* [.18,.85]	.51* [.02,.80]	.41 [-.11,.75]	.52* [.04,.81]	—

Note. r / [CI LL,CI UL].
*p < .00500

Figure 5: R CIs Bon

Data Set 2 Dummy coding: The ANOVA in which four religions' attitude toward abortion are contrasted via ANOVA requires dummy coding four religions into three dummy codes. Students can do this manually and/or with a special purpose spreadsheet that is provided; it will automatically generate those codes (Figure 9). Here religion is originally coded as 1=Protestant, 2=Catholic, 3=Jewish, and 4=Other;

the resultant dummy codes are generated automatically (Figure 9) and pasted along with the Attitude toward Abortion variable from Cohen & Cohen (1983) into Criterion (Figure 10).

The Code-Check-ANOVA sheet 1) checks the entered dummy codes for correctness, rendering Error if not, provides means, trimmed means, Medians and SDs for each group and the total, all known homogeneity of variance tests, the ANOVA and robust ANOVAs and Scheffe' type contrasts. As in other locations in Criterion, it depends on the depth one wishes to pursue as to how much detail one might cover, however, it is all here should it be needed.

To tie techniques together, it is useful to illustrate that the ANOVA F derived on this "ANOVA" sheet is necessarily the same as that in the APA Model sheet discussed previously. As well, if a two-group design is posed, the necessary relationship between the F and the t from the r in the APA R or R-CI sheet is easy to demonstrate. That these are all available instantly at the click of a mouse is very helpful for illustrating relationships to students.

Significance

In a recent statistics class with students from a variety of disciplines, a five item Likert-type scale ("5" was the most favorable opinion) was distributed through Google-Forms for anonymous response. It asked students to rate Criterion's 1) ease of use, 2) ease of interpretation of results, 3) ease of export of results, 4) protection from statistical errors, and 5) comprehensiveness. As well students were asked to provide narrative comments. Fourteen of 19 students responded.

For all items, responses were very positive. For Ease of Use all students responded "5." For ease of interpretation, protection from statistical errors, and comprehensiveness, all students except one responded a "5" with the remaining student responding "4." For ease of export, all students responded "5" except for one who responded "4" and one who responded "2." In the latter case, we are confident that the issue regarded use of a web interface that we subsequently phased out in favor of using OneDrive.

The narrative comments were even more informative; the program was very helpful for students in accomplishing assignments, but even more importantly, in understanding statistical concepts. See Table 1 for all comments (with identifying narrative deleted from one response).

Criterion has proven a very effective tool to introduce students to the fundamentals of the use of statistics in research and will orient them toward a path to understanding the general linear model. It is available for free for any who would like to try it. If you care to look, a guaranteed secure, anonymized, "voiceless" video demonstration of the analysis of these data with this software is here (make your browser full screen for the best view).

https://johnnysolarseed.com/ANOVA-MR_Demo/ANOVA-MR_Demo.mp4

References

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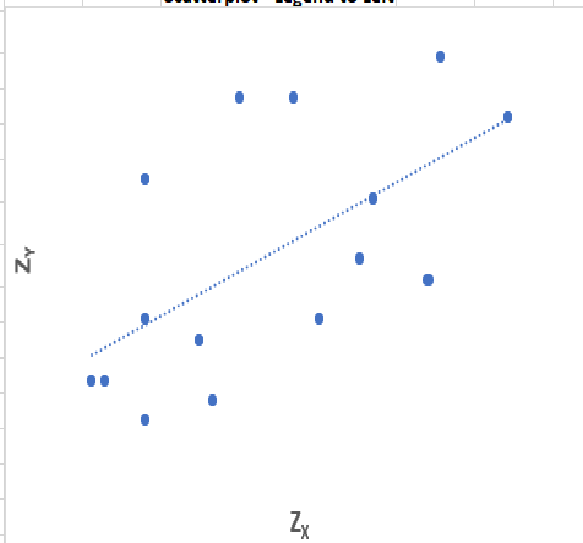
	A	B	C
8	Variable	2	1
9	1. GPA	X=ZGRE-Q	Y=ZGPA
10	2. GRE-Q	1.226	-.189
11	3. GRE-V	.198	1.311
12	4. MAT	-.932	-.522
13	5. AR	-.419	-1.189
14		-.932	.645
15		1.842	1.145
16		1.328	1.645
17		-1.343	-1.022
18		.814	.478
19		-.213	1.311
20		-1.241	-1.022
21		-.521	-.689
22		-.932	-1.356
23		.403	-.522
24		.712	-.022
25		1.246	-.189
26		.198	1.311
27		-.932	-.522
28		-.419	-1.189
29		-.932	.645
30		1.842	1.145
31		1.328	1.645
32		-1.343	-1.022
33		.814	.478
34		-.213	1.311
35		-1.241	-1.022
36		-.521	-.689
37		-.932	-1.356
38		.403	-.522
39		.712	-.022

←*Enter the numbers of two variables in B8 and C8 from the legend for which you wish a scatterplot.*

Scatterplot - Legend to Left



Univariate Descriptives

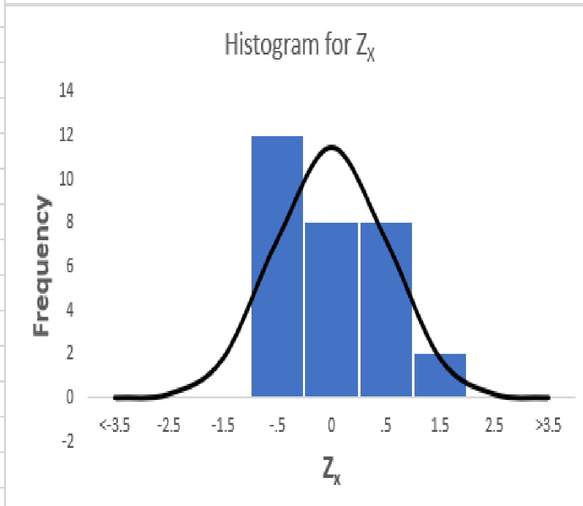
	GRE-Q	GPA
Mean	565.3667	3.3133
Median	555.0000	3.2000
Mode	520.0000	2.7000
SD	48.6603	.5998
Variance	2367.8264	.3598
SE_{mean}	8.8841	.1095
Skewness	.3300	.2887
Kurtosis	-1.1585	-1.3759
Min	500.0000	2.5000
Max	655.0000	4.3000
Semi-Quartile Range	42.5000	.6500

As SE_{skew} and $SE_{kurtosis}$ estimates depend only on N, their values are the same for all variables.

SE_{skew} = .4269

$SE_{kurtosis}$ = .8327

r = .6105



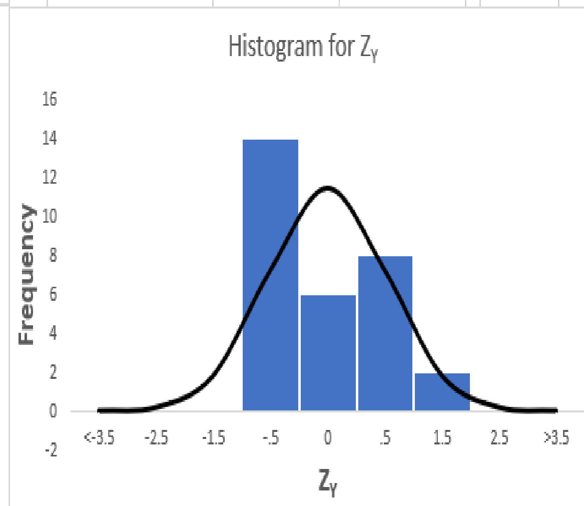


Figure 6: Scatterplot (of any pair of variables)

Presentation of information regarding accuracy of the total regression model is often included in text, rather than in a table. If such a table is deemed necessary, it is provided below. In respect to SPSS's version, the R^2 is added, as this is the effect that is being tested. Cohen's f^2, a usual index of effect size, is also included. Note that the "Adjusted R Square" of SPSS is NOT to be included, at least with that name. The explanation and all "generalization" information, more correctly documented, is in a separate table in the "Generalization" tab.

The presentation in text is usually something like:

"The model predicted a significant percentage of criterion variance, R^2 = .640, F(4,25) = 11.129, p < .001, f^2 = 1.781."

Table 1

Title such as: R^2, Sum of and Mean Squares, dfs, F, p and Cohen's f^2

Source	Sum of Squares	df	Mean Square	R^2	F	p	f^2
Regression	6.682	4	1.671	.640	11.129	<.001	1.781
Residual	3.753	25	.150				
Total	10.435	29					

Figure 7: APA Model

This table includes information about individual coefficients and is usually included in regression publications. Take special care in discussing the tests of the coefficients. These tests are for ***partial*** slopes (the Bs); stated alternately, for each predictor, it is a test of whether that predictor **adds** significant predictive accuracy to the model, in addition to that afforded by the remaining predictors. For this reason, an additional statistic, $\mathbf{\Delta R^2}$, is added to this table in respect to that which SPSS includes. This represents the increment to R^2 afforded by the addition of the respective variable to the model having all the remaining predictors in it. This, after all, is that which is being tested. This is **not** a test of the predictive accuracy afforded by only that row variable. If you simply wish to attend to whether a variable, by itself, is a significant predictor, the bivariate correlation should be used. Those are in the intercorrelation matrix (APA rs or APA rs Bon tabs). This interpretive mistake occurs so often in the literature that those r_{xy}s are included here for contrast, but they should not be in the table as they are not tested there. The βs are hidden in column D if you wish them, however the CI is in respect to B, not β. The βs are not in the APA (v 7) regression example table.

Table 1

Title such as: *Regression Weights, R^2 Increments, Tests, and VIFs.*

Variable	B	SE	ΔR^2	95% CI		t(25)	p	VIF	r_{xy}
				LL	UL				
Constant	-1.734	.950		-3.691	.222	-1.826	.080		
GREV	.004	.002	.068	.000	.008	2.182	.039	1.5	.61*
GREQ	.002	.001	.030	-.001	.004	1.453	.159	1.5	.58*
MAT	.021	.010	.069	.001	.041	2.187	.038	1.5	.60*
AFR	.145	.113	.024	-.088	.377	1.281	.212	1.7	.62*

Note. CI = confidence interval; LL = lower limit; UL = upperlimit.

Figure 8: APA Coefficients

Dummy Code.xlsx is a simple spreadsheet that automatically creates dummy codes (1,0) for a nominal variable that is coded into ordinal categories. There will be a number of dummy codes equal to one less that the number of categories. It is set up for up to 20 categories, although with the unlikely need for more, this is easily expanded. The last category is used as **reference**, so adjust ordinal representation according to "reference preference." Enter (that which is necessary is noted with ***blue*** arrows) the number of categories (B11), number of cases (B12), variable name (B15), and ordinal codes (B16 and down). If a category is entered that is out of range in respect to the input number of categories or there are no cases in a category, an error message appears ("**Problem**"), and no codes are rendered. In that case, reexamine the nominal variable codes. Use of these dummy codes in a regression model predicting Y renders weights for each code, and tests thereof, that are contrasts between Y in the group that is coded "1" and the group that is coded all zeros. Thus, if the "all zero" reference group is considered the "control," the tests of these weights are identical to those independently introduced by Dunnett (1955). Your coding can, of course, make any group you wish the "control."

11	***# Categories →***	4
12	***N (cases) →***	36

	A	B	C	D	E
14		***Variable Name/Ordinal Codes ↓***	***Dummy Codes →***		
15	***Case # ↓***	***Religion***	***Religion1***	***Religion2***	***Religion3***
33	***18***	3	0	0	1
34	***19***	4	0	0	0
35	***20***	2	0	1	0
36	***21***	1	1	0	0
37	***22***	3	0	0	1
38	***23***	1	1	0	0
39	***24***	1	1	0	0
40	***25***	3	0	0	1
41	***26***	4	0	0	0
42	***27***	1	1	0	0
43	***28***	4	0	0	0
44	***29***	3	0	0	1
45	***30***	1	1	0	0
46	***31***	1	1	0	0
47	***32***	1	1	0	0
48	***33***	3	0	0	1
49	***34***	1	1	0	0
50	***35***	3	0	0	1
51	***36***	1	1	0	0

Dummy Coding | References

Figure 9: Dummy Coding Software

	# Predictors =	3			
	N (cases) =	36			
	α =	.050			
OK					
	Enter Short Variable names in **Row 8** ; Criterion in column **C**, Predictors in D and on →				
Check:		Criterion	Predictors →		
ok	Case # ↓	**ATA**	**Religion1**	**Religion2**	**Religion3**
ok	1	61	0	1	0
ok	2	78	0	0	0
ok	3	47	1	0	0
ok	4	65	0	1	0
ok	5	45	0	1	0
ok	6	106	0	0	0
ok	7	120	1	0	0
ok	8	49	0	1	0
ok	9	45	0	0	0
ok	10	62	0	0	0
ok	11	79	0	1	0
ok	12	54	0	0	0
ok	13	140	1	0	0
ok	14	52	0	1	0
ok	15	88	1	0	0
ok	16	70	0	1	0
ok	17	56	0	1	0
ok	18	124	0	0	1
ok	19	98	0	0	0
ok	20	69	0	1	0
ok	21	56	1	0	0
ok	22	135	0	0	1
ok	23	64	1	0	0
ok	24	130	1	0	0
ok	25	74	0	0	1
ok	26	58	0	0	0
ok	27	116	1	0	0
ok	28	60	0	0	0
ok	29	84	0	0	1
ok	30	68	1	0	0
ok	31	90	1	0	0
ok	32	112	1	0	0
ok	33	94	0	0	1
ok	34	80	1	0	0
ok	35	110	0	0	1
ok	36	102	1	0	0

Figure 10 – ANOVA Input (Attitude Toward Abortion Among Four Religious Groups – Three Dummy Codes)

This sheet provides, if desired, 1) a check on Dummy, Effect, or Orthogonal Coding that may have been used, 2) an ANOVA on such constituted groups (the "Dependent Variable" being the criterion), 3) all effect sizes used and how they relate the GLM, 4) a test of HOV, 5) Welch and Brown-Forsythe robust ANOVAs, 6) post-hoc Scheffe tests of all pairwise differences and the opportunity to pose more complex contrasts. To execute, simply enter the number of groups in B12, and select the variables containing the nominal codes as directed.

					Mean Trim %:	10.00%
f groups→	4				**Obrien "W":**	.5

Place an X below 3 variables that represent complete nominal coding:

Religion1	Religion2	Religion3
X	x	x

	Descriptives →				
Group:	Total	**1**	**2**	**3**	**4**
N:	36	13	9	6	8
Mean:	81.694	93.308	60.667	103.500	70.125
SD:	27.880	29.483	11.124	23.645	21.820
Median:	76.000	90.000	61.000	102.000	61.000
Trimmed Mear	79.967	93.273	60.667	103.500	70.125

Table 1

Title such as: ANOVA for...

Source	Sum of Square	df	Mean Square	F	p	η^2 (R^2)	ω^2	ϵ^2 (= $\rho^2 E$)	f^2
Between	9656.495	3	3218.832	5.869	.003	.355	.289	.294	.550
Within	17549.144	32	548.411						
Total	27205.639	35							

Homogeneity of Variance Tests

	$\chi^2(3)$	MSb	MSw	F(3,df2)	df2	p
Bartlett (SAS, Stata, R)	6.879	–	–	–	–	.076
Levene ($\bar{X}$: SPSS, SAS, Stata, R)	–	434.741	127.359	3.414	32	.029
Brown & Forsythe (median: SPSS, Stata, R)	–	435.849	175.483	2.484	32	.079
Median (Satterthwaite df: SPSS)	–	435.849	175.483	2.484	24.266	.085
Brown & Forsythe (trim $\bar{X}$: SPSS 5%, Stata 1(	–	434.596	127.413	3.411	32	.029
Squared deviations (SAS)	–	8.7146E+05	2.8323E+05	3.077	32	.041
O'Brien (SAS, R)	–	1.0009E+06	3.8762E+05	2.582	32	.071
Fligner & Killeen (R)	6.364	–	–	–	–	.095

Heterogeneity of Variance Robust Tests

	F*	df1	df2	p
Welch	8.080	3	14.334	.002
Brown-Forsytl	6.505	3	24.541	.002

If desired, enter a contrast in J40 to X40, where x depends on the number of measures; these must sum to zero, but not all be zero

S#	Grp from Code	Pairwise Contrasts for Groups:			*1*	*2*	*3*	*4*
		Contrast	SE	CI	(93.31)	(60.67)	(103.50)	(70.13)
1	2							
2	4							
3	1							
4	2	32.641*	10.155	[2.683, 62.599]	1	-1	0	0
5	2	-10.192	11.558	-44.290, 23.905	1	0	-1	0
6	4	23.183	10.523	[-7.862, 54.228]	1	0	0	-1
7	1	-42.833*	12.342	[-79.245, -6.421	0	1	-1	0
8	2	-9.458	11.379	[-43.029, 24.112	0	1	0	-1
9	4	33.375	12.647	[-3.936, 70.686]	0	0	1	-1

Figure 11: ANOVA, HOV tests, Robust ANOVA tests, and Scheffé type Post Hoc Contrasts.

Table 1: Student Comments on Criterion.
Please provide any additional comments or suggestions related to your experience with Criterion. You may use as much space as you wish.

#1 Using it through one drive was fantastic and worked like a charm. Loved using it.

#2 Criterion is user friendly, easy to use and a better system than SPSS. I did not have a great experience working with SPSS in my first stats class (I was required to use without another option). My classmates experienced the same

#3 Criterion saved this course and should replace spss.

#4 The only issue I had with criterion was the fact that I was unable to import/export data from the web version.

#5 So much easier to use than SPSS. I spend a lot of time connecting and reconnecting to FAU virtual apps (timeouts, etc.) to use SPSS and then trying to remember what boxes to check. Thank you for this tool.

#6 I enjoyed working in Criterion during the semester and will continue using this program in the future.
The program is very intuitive to use and makes all necessary tests and even more in seconds. The tables are prepared in the APA style. A very useful statistical program to use for all majors!

#7 I don't know of any other program that formats your output into an APA style table. I am sure this will save people incredible amounts of time!

#8 Not having the appropriate Excel was an issue for me.

#9 Honestly, I am truly grateful to you for sharing Criterion with us. It really is such a comprehensive and easy to use package. The fact that you have gone as far as to have the tables already in APA format is incredibly helpful. Thank you!

#10 Great program, made the concepts in class easier to understand.

#11 Criterion is much more user friendly than SPSS. By running statistical analysis through criterion, I was able to get all of the information much faster than SPSS.

#12 Was much simpler to use and understand.