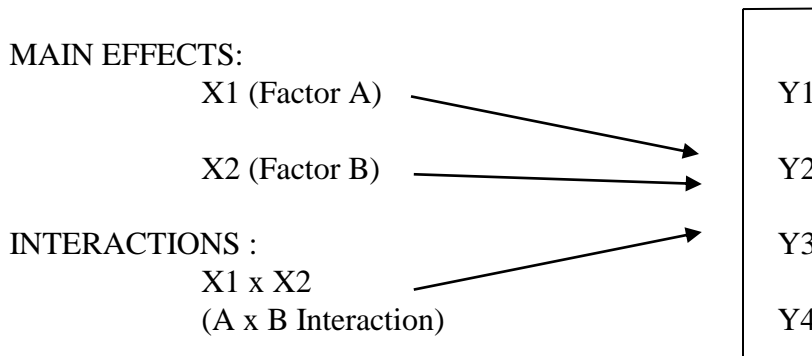


Neuendorf
MANOVA/MANCOVA

Model:



Like ANOVA/ANCOVA:

1. Assumes equal variance (equal covariance matrices) across cells (groups defined by the IVS). Box's M tests for this (like discriminant analysis). Once again, this is a "homoscedasticity" issue. We hope for a non-significant Box's M.
2. Assumes univariate and multivariate normality of the DV(s).
3. Assumes independence of observations. Given the heavy use of the ANOVA model with experimental designs, this translates generally to a concern with the threats to internal validity expressed by Campbell and Stanley (1963), a concern over experimental administration variations over time, and a concern over using group administration.
4. (First, note that in the ANOVA family, the term "factor" refers to an independent variable, not a factor as in factor analysis.) In ANOVA, you can specify a full or partial model. For example, as shown above, a *full factorial model* for a two-factor ANOVA or MANOVA would be: Main effects A and B, and the interaction effect A x B. MANOVA will provide a separate set of tests for each effect. Note that a single-factor MANOVA is very much like discriminant analysis, but with the presumed "causal flow" reversed.
5. You may choose to conduct post hoc tests, such as Scheffe's or Tukey's. See Hair et al., Keppel, or the excellent Winer book (look under "a posteriori tests," which is the same as "post hoc").
6. May include covariates (i.e., ANCOVA and MANCOVA)--I/R variables that correlate with the DVs (but not the IVs). Including these variables as covariates in the model controls for their effect on the DVs. That is, MANCOVA is actually when a MANOVA is conducted on the residuals of the DVs after the DVs are regressed on the covariates.

Unlike ANOVA/ANCOVA (i.e., things specific to MANOVA/MANCOVA):

1. Handles multiple DVs, which are correlated. Indeed, if the DVs are not correlated, there's no advantage to MANOVA over conducting a series of ANOVAs, possibly with an adjustment for alpha, such as Bonferroni (see below). You should check a correlation matrix (or generate a

Bartlett's test with Factor Analysis) to assure that the DVs are significantly correlated. Again, there is *no reason* to do MANOVA or MANCOVA if the DVs are not correlated.

- Discriminant functions (which are a type of variate) are created for each independent variable main effect or interaction term. When an effect/term is significant, it means that the DF(s) are significantly different among the groups on the effect/term. (DF=a linear composite of the DVs, sometimes called "canonical root" in MANOVA.). Remember that in MANOVA, as in many multivariate procedures, we become "a step removed" from the original variables (in this case, the DVs) by the construction of one or more variates.

Also, note that the DFs are *different* for each main effect or interaction. The number of DFs that will be derived for a main effect is $c-1$ (where c =# of categories on the IV main effect) or k (where k =# of DVs), whichever is smaller. For a two-way interaction, the number of DFs that will be derived is $(c_1-1) \times (c_2-1)$ (where c_1 =# of categories on one main effect, and c_2 =# of categories on the other main effect) or k (where k =# of DVs), whichever is smaller.

Statistics:

- Often, in the report of a piece of research, it is reported that "omnibus MANOVA" is run to verify that the set of DVs enjoys significance on a given main effect or interaction, and then only a series of ANOVAs are tabled. More rarely, true MANOVA stats are presented:

True MANOVA tests--each of these 4 statistics tests for multivariate differences among the groups *on that particular main effect or interaction*. They will *generally* (but not always) be either statistically significant as a group of 4, or non-significant as a group. (However, Roy's may be quite different because it considers only the first DF for a given main effect or interaction.):

$$\text{Pillai's Trace} = V = \sum \frac{\lambda_i}{1 + \lambda_i} \quad (\text{sum of explained variances on each of the DFs})$$

$$\text{Wilks' Lambda} = \Lambda = \prod \frac{1}{1 + \lambda_i} \quad (\text{product of unexplained variances on each of the DFs})$$

$$\text{Hotelling's Trace} = T = \sum \lambda_i \quad (\text{sum of } SS_B/SS_W \text{ for DFs})$$

$$\text{Roy's Largest Root} = R = \lambda_{\text{MAX}} \quad (SS_B/SS_W \text{ for the } \textit{first} \text{ DF only})$$

(or, Greatest Characteristic Root)

where λ_i = the eigenvalue for each discriminant function (or canonical root, i.e., each variate or linear composite of the DVs)

Also, note that:

$$\lambda_i = \frac{SS_B}{SS_W} = \text{ratio of explained to unexplained variances}$$

$$\frac{1}{1 + \lambda_i} = \frac{SS_W}{SS_{TOT}} = \text{proportion variance unexplained}$$

$$\frac{\lambda_i}{1 + \lambda_i} = \frac{SS_B}{SS_{TOT}} = \text{proportion variance explained}$$

Each of the above 4 stats (Pillai's, Wilks', Hotelling's, Roy's) is transformed to an F test, and its significance is assessed. Pillai's is the most robust (resistant to violations of test assumptions).

2. Partial eta²--The eta² statistic is a general measure of the proportion of variance explained in a DV (usually by group differences of a categorical IV). In MANOVA, it is specifically the proportion of the total DVs' variability that is attributable to a given main effect or interaction. In MANOVA, it is reported as a partial (i.e., the proportion explained by that main effect or interaction when controlling for all other main effects/interactions in the equation/model).
3. Power--the GLM procedures in SPSS are the only ones for which power estimates are available!
4. Box's M--Tests the assumption of equality of the covariance matrices across the cells (groups as specified by the IVs). We hope for non-significance, just as in the case of discriminant analysis.
5. Levene's test of Equality of Error Variances--In general, Levene's test assesses whether variances compared across groups or across a range of values are equal. In the MANOVA application, it tests the null hypothesis that the error variance of a single DV is equal across groups. We hope for non-significance. In order to obtain this statistic from SPSS, you must click "Homogeneity tests" in Options within Multivariate GLM.
6. Bartlett's Test of Sphericity--In general, this test assesses whether a matrix differs significantly from an identity matrix. In the MANOVA application, it tests the null hypothesis that the residual covariance matrix is proportional to an identity matrix. (i.e., Are there still correlations among the DVs after imposing the model? This is *not* a test of the original, plain correlation matrix.) We hope for non-significance. In order to obtain this test from SPSS, you must click "Residual SSCP Matrix" in Options within Multivariate GLM.
7. Bonferroni correction for cumulative Type I error--When multiple tests are run (in this case, using the same IVs), and capitalization on chance is a real threat, a simple Bonferroni adjustment may be used--

$$\text{Bon } \alpha = \frac{\text{selected } \alpha}{\# \text{ of tests}}$$

For example, if we are running eight different ANOVA tests on related DVs using the same IVs, we could use a Bonferroni α of .05/8, or .00625. That is, only F tests with a p value of $< .00625$ would be considered significant, instead of the usual $< .05$.

8. Stepdown analysis for DVs--like a hierarchical inclusion process, this treats some DVs as covariates (controls) by entering them first in the DF.
9. F tests for each DV separately--found in the SPSS output under "Tests of Between-Subjects Effects." SPSS provides them readily with MANOVA, but they're not truly MANOVA. Still, this seems to be the common method of *making sense* of an overall significant MANOVA model. The means that *go with* the Fs are found under "Descriptive Statistics" on the MANOVA output.

Statistics that can inform a MANOVA analysis. . . but must be obtained via SYNTAX:

10. Discriminant function coefficients (standardized and unstandardized)--

$$DF1 = \beta_1 Y1_z + \beta_2 Y2_z + \beta_3 Y3_z \dots$$

Like regression coefficients, these β s show unique contributions to the DF (linear composite of DVs, in this case). They help us interpret the DF. By the way, remember that there will be a different set of DFs for each IV main effect, interaction, or covariate. NOTE: What's not directly obtainable is the DF values for the groups! There's no SAVE function for the MANOVA syntax, so one would have to construct the DFs via COMPUTES. Yikes!

11. Correlations between each DV and DF (or canonical root)--These are the simple relationships between the DV and a given DF; they also help us interpret the DF. These are, in essence, loadings. Looking at these, we could hypothetically "name" our DFs, which seems to basically *never* be done in MANOVA!
12. Canonical correlation--This is the correlation between a DF (or canonical root) and an IV main effect or interaction (treated as a set of dummies).

The syntax to get the above:

```
MANOVA DV1 DV2 DV3 DV4 by IV1 (min,max) IV2 (min,max)
      /discrim=raw stan
      /print=signif (hypoth multiv univ eigen)
      /design.
```

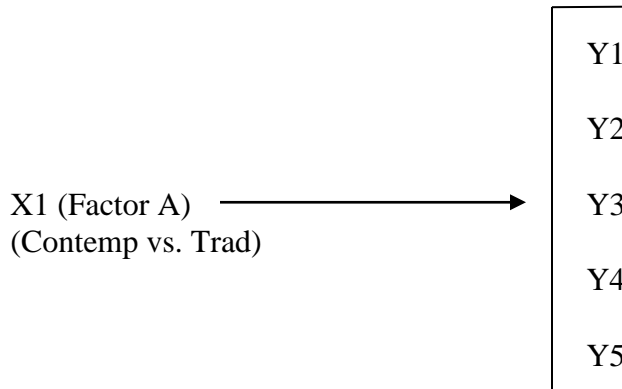
[NOTE: "min,max" are the minimums and maximums for each of the two IVs.]

References

- [Bray, J. H., & Maxwell, S. E.](#) (1985). *Multivariate analysis of variance*. Beverly Hills, CA: Sage Publications.
- [Campbell, D. T., & Stanley, J. C.](#) (1963). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally College Publishing Co.
- Keppel, G. (1991). *Design and analysis: A researcher's handbook* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.
- Winer, B. J. (1971). *Statistical principles in experimental design* (2nd ed.). New York: McGraw-Hill Book Co.

Single-Factor MANOVA example

Model:



From:

Johnson, T. L. (2008). *Worship styles, music and social identity: A communication study*. Unpublished master's thesis, School of Communication, Cleveland State University, Cleveland, OH.

Multivariate Tests:

Table XX: Self-disclosure through singing hymns/worship songs

	Effect	Value	F-Value	Sig.	Observed Power
G1.Attend	Pillai's Trace	.073	2.190	.059	.704
	Wilks' Lambda	.927	2.190	.059	.704
	Hotelling's Trace	.078	2.190	.059	.704
	Roy's Largest Root	.078	2.190	.059	.704

ANOVA Tables that help interpret MANOVA results

Table XXI: DV#1: Intended Disclosure Dimension of Self-Disclosure Scale

Type of Worship Service	Mean	Sum of Squares	df	Mean Square	F	Sig.	Power
1.Contemporary	20.9128	.386	1	.386	.025	.874	.053
2. Traditional	20.8083						
Error		2211.642	144	15.359			
Corrected Total		2212.027	145				

Table XXII: DV#2: Amount Dimension of Self-Disclosure Scale

Type of Worship Service	Mean	Sum of Squares	df	Mean Square	F	Sig.	Power
1. Contemporary 2. Traditional	24.3023 22.5500	108.524	1	108.524	2.305	.131	.326
Error		6778.990	144	47.076			
Corrected Total		6887.514	145				

Table XXIII: DV#3: Positive/Negative Dimension of Self-Disclosure Scale

Type of Worship Service	Mean	Sum of Squares	df	Mean Square	F	Sig.	Power
1. Contemporary 2. Traditional	31.5581 34.3333	272.197	1	272.197	5.754	.018	.664
Error		6812.543	144	47.309			
Corrected Total		7084.740	145				

Table XXIV: DV#4: Control of Depth Dimension of Self-Disclosure Scale

Type of Worship Service	Mean	Sum of Squares	df	Mean Square	F	Sig.	Power
1. Contemporary 2. Traditional	17.7442 15.6167	159.972	1	159.972	6.100	.015	.689
Error		3776.555	144	26.226			
Corrected Total		3936.527	145				

Table XXV: DV#5: Honesty/Accuracy Dimension of Self-Disclosure Scale

Type of Worship Service	Mean	Sum of Squares	df	Mean Square	F	Sig.	Power
1. Contemporary 2. Traditional	39.7326 40.0000	2.528	1	2.528	.040	.841	.055
Error		9002.849	144	62.520			
Corrected Total		9005.377	145				