Factorial MANOVA

- Does basically the same thing as a 1-way MANOVA, except → a separate composite variable (or set of composite variables) is constructed for **each effect** (i.e., each main effect and the interaction).
- Similarly, follow-ups have to be done for each canonical variate, for each effect

There are a couple of things to look at before jumping into the MANOVA…

Correlations among the DVs

What is a "good set of DVs" for a MANOVA? There are some differing opinions! One approach suggests that the DVs should be highly correlated, so that he MANOVA variate represents a "cleaned up" version of the underlying construct. Another approach is that the DVs should have relatively low correlations, so that the set of DVs "covers more constructs". One interesting tendency is that DV sets chosen according to the first approach tend to show a concentrated structure (a single significant MANOVA variate), while the those chosen using the second approach are more likely to produce a diffuse structure (two or more MANOVA variates).

For these variables…

These DVS are correlated – but not uniformly!

We get a common result that #correct and response time are negatively correlated, but share less than 25% of their variance.

The other correlations are lower but substantial.

So, depending on their relative relationships to the IV, these DVs could easily produce a diffuse structure.

Correlations

		# correct	# atttempted	response time
# correct	Pearson Correlation	1	.264	-.716**
	Sig. (2-tailed)		.261	.000
	N	20	20	20
# atttempted	Pearson Correlation	.264	1	-.460*
	Sig. (2-tailed)	.261		.041
	N	20	20	20
response time	Pearson Correlation	-.716**	-.460*	1
	Sig. (2-tailed)	.000	.041	
	N	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

ANOVAs on each DV

The version of these ANOVAs available using GLM is relatively compact and complete.

```
GLM numcor numtry resptime BY rein task
 /METHOD=SSTYPE(3)
 /INTERCEPT=INCLUDE
 /EMMEANS=TABLES(rein*task) COMPARE (rein)
 /EMMEANS=TABLES(rein) COMPARE (rein)
 /EMMEANS=TABLES(task) COMPARE (task)
 /CRITERIA=ALPHA(.05)
 /DESIGN= rein task rein*task.
```

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	
rein		33.797	1	33.797	7.996	.012	← #correct
		169.642	1	169.642	5.758	.029	← #attmpt
		209.614	1	209.614	43.747	.000	← resp_time
task		43.224	1	43.224	10.226	.006	← #correct
		96.868	1	96.868	3.288	.089	← #attmpt
		181.172	1	181.172	37.811	.000	← resp_time
rein * task		33.767	1	33.767	7.989	.012	← #correct
		1.370	1	1.370	.046	.832	← #attmpt
		215.735	1	215.735	45.024	.000	← resp_time
Error		67.628	16	4.227			← #correct
		471.410	16	29.463			← #attmpt
		76.665	16	4.792			← resp_time
Total		915.167	20				
		2890.209	20				
		3385.399	20				

Univariate data patterns?

2-way
Sig for #correct & response time but not for #attempted

Rein main effect
Sig for all 3 DVs.

Task main effect
Sig for #correct & response time but not for #attempted

Follow-ups to describe interaction patterns for each Dependent Variable

Estimates

Dependent Variable	task	rein	Mean
# correct	simple	praise	7.540
		criticism	7.539
	complex	praise	7.199
		criticism	2.000
# atttempted	simple	praise	15.745
		criticism	9.397
	complex	praise	10.820
		criticism	5.519
response time	simple	praise	8.661
		criticism	8.567
	complex	praise	8.112
		criticism	21.155

Pairwise Comparisons

Dependent Variable	task	(I) rein	(J) rein	Mean Difference (I-J)	Sig.[b]
# correct	simple	praise	criticism	.001	.999
	complex	praise	criticism	5.199	.001
# atttempted	simple	praise	criticism	6.348	.083
	complex	praise	criticism	5.301	.142
response time	simple	praise	criticism	.094	.947
	complex	praise	criticism	-13.043	.000

Based on estimated marginal means

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

#correct

	Praise	Criticism
Simple		=
Complex		>

#attempted (non significant)

	Praise	Criticism
Simple		=
Complex		=

response time

	Praise	Criticism
Simple		=
Complex		<

Not the same pattern for each DV.

Looks like #correct & response time will contribute to the MANOVA variate for the interaction (with opposite sign)…

Follow-ups to describe main effects patterns for each Dependent Variable

Reinforcement Main Effect

Estimates

Dependent Variable	rein	Mean
# correct	praise	7.369
	criticism	4.769
# atttempted	praise	13.283
	criticism	7.458
response time	praise	8.386
	criticism	14.861

Pairwise Comparisons

Dependent Variable	(I) rein	(J) rein	Mean Difference (I-J)	Sig.[b]
# correct	praise	criticism	2.600	.012
# atttempted	praise	criticism	5.825	.029
response time	praise	criticism	-6.475	.000

Based on estimated marginal means

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

	Praise	Criticism
#correct	>	
#attempted	>	
Response time	<	

Looks like all 3 DVs will contribute to the MANOVA variate for this main effect (response time having the opposite sign)…

Task Difficulty Main Effect

Estimates

Dependent Variable	task	Mean
# correct	simple	7.539
	complex	4.599
# atttempted	simple	12.571
	complex	8.170
response time	simple	8.614
	complex	14.633

Pairwise Comparisons

Dependent Variable	(I) task	(J) task	Mean Difference (I-J)	Sig.[b]
# correct	simple	complex	2.940	.006
# atttempted	simple	complex	4.402	.089
response time	simple	complex	-6.020	.000

Based on estimated marginal means

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

	Simple	Complex
#correct	>	
#attempted	=	
Response time	<	

Looks like at least #correct & response time will contribute to the MANOVA variate (response time having the opposite sign), but notice #attempts is "close" and may join in (with the same sign as #correct…

The Factorial MANOVA

```
manova numcor numtry resptime by rein (1, 2)   task (1, 2)          ← list DVs by IV(s) (with min & max grps)
 / print = signif (multiv, univ, eigen, dimenr)                      ← gets various goodies
 / discrim stan cor.                                                 ← don't forget the period !


* * * * * * A n a l y s i s   o f   V a r i a n c e -- design   1 * * * * * *

 EFFECT .. REIN BY TASK
 Multivariate Tests of Significance (S = 1, M = 1/2, N = 6 )

 Test Name          Value     Exact F Hypoth. DF   Error DF  Sig. of F

 Pillais           .78417    16.95548       3.00      14.00       .000
 Hotellings       3.63332    16.95548       3.00      14.00       .000
 Wilks             .21583    16.95548       3.00      14.00       .000
 Roys              .78417
 Note.. F statistics are exact.

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 Eigenvalues and Canonical Correlations

 Root No.    Eigenvalue       Pct.    Cum. Pct.  Canon Cor.

      1         3.633     100.000     100.000         .886

 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 EFFECT .. REIN BY TASK (Cont.)
 Univariate F-tests with (1,16) D. F.

 Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS         F  Sig. of F

 NUMCOR      33.76686   67.62810   33.76686    4.22676   7.98884       .012
 NUMTRY       1.36961  471.41013    1.36961   29.46313    .04649       .832
 RESPTIME   215.73464   76.66468  215.73464    4.79154  45.02405       .000

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 EFFECT .. REIN BY TASK (Cont.)
 Standardized discriminant function coefficients
         Function No.
 Variable           1
 NUMCOR        -.467
 NUMTRY         .044
 RESPTIME       .938

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 Correlations between DEPENDENT and canonical variables
         Canonical Variable

 Variable           1
 NUMCOR        -.371          As expected,  #correct & response time contribute to the MANOVA
 NUMTRY         .028          variate for the interaction
 RESPTIME       .880
```

```
* * * * * * A n a l y s i s   o f   V a r i a n c e -- design  1 * * * * * *

 EFFECT .. TASK
 Multivariate Tests of Significance (S = 1, M = 1/2, N = 6 )

 Test Name          Value     Exact F Hypoth. DF   Error DF  Sig. of F

 Pillais            .78003   16.54840       3.00      14.00      .000
 Hotellings        3.54608   16.54840       3.00      14.00      .000
 Wilks              .21997   16.54840       3.00      14.00      .000
 Roys               .78003
 Note.. F statistics are exact.

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 Eigenvalues and Canonical Correlations

 Root No.   Eigenvalue        Pct.   Cum. Pct.  Canon Cor.

      1         3.546     100.000     100.000        .883

 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 EFFECT .. TASK (Cont.)
 Univariate F-tests with (1,16) D. F.

 Variable    Hypoth. SS   Error SS Hypoth. MS   Error MS        F  Sig. of F

 NUMCOR       43.22360   67.62810   43.22360    4.22676   10.22619       .006
 NUMTRY       96.86760  471.41013   96.86760   29.46313    3.28776       .089
 RESPTIME    181.17216   76.66468  181.17216    4.79154   37.81082       .000

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 EFFECT .. TASK (Cont.)
 Standardized discriminant function coefficients
         Function No.

 Variable            1

 NUMCOR          -.575
 NUMTRY          -.259
 RESPTIME         .850

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 Correlations between DEPENDENT and canonical variables
         Canonical Variable

 Variable            1

 NUMCOR          -.425
 NUMTRY          -.241        Looks like #correct & response time contribute to the MANOVA variate.
 RESPTIME         .816
```

```
* * * * * * A n a l y s i s   o f   V a r i a n c e -- design   1 * * * * * *

EFFECT .. REIN
Multivariate Tests of Significance (S = 1, M = 1/2, N = 6 )

Test Name          Value    Exact F Hypoth. DF   Error DF  Sig. of F

Pillais           .79570   18.17551       3.00      14.00      .000
Hotellings       3.89475   18.17551       3.00      14.00      .000
Wilks             .20430   18.17551       3.00      14.00      .000
Roys              .79570
Note.. F statistics are exact.

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Eigenvalues and Canonical Correlations

Root No.    Eigenvalue        Pct.   Cum. Pct.  Canon Cor.

      1        3.895      100.000     100.000        .892

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EFFECT .. REIN (Cont.)
Univariate F-tests with (1,16) D. F.

Variable   Hypoth. SS   Error SS Hypoth. MS   Error MS       F  Sig. of F

NUMCOR       33.79689   67.62810   33.79689    4.22676   7.99594      .012
NUMTRY      169.64191  471.41013  169.64191   29.46313   5.75777      .029
RESPTIME    209.61382   76.66468  209.61382    4.79154  43.74662      .000

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
EFFECT .. REIN (Cont.)
Standardized discriminant function coefficients
        Function No.

Variable           1
NUMCOR          -.521
NUMTRY          -.309
RESPTIME         .859

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Correlations between DEPENDENT and canonical variables
        Canonical Variable

Variable           1
NUMCOR          -.358
NUMTRY          -.304           All 3 DVs contribute to the MANOVA variate for this main effect.
RESPTIME         .838
```

Follow-ups for the multivariate interaction effect?

- Don't need them for the 2-group main effects -- interpret the canonical variates and you're done
- Need one for the interaction (need to look as simple effects to describe the interaction pattern), so…

Use Descriptives to compute Z-score version of each DV, then compute the MANOVA variate.

Compute int_1 = (znumcor * -.467) + (znumtry * .044) + (zresptim * .938).

Do the 2x2 ANOVA and then LSD to decide the simple effect pattern.

Estimates

Dependent Variable: int_1

task	rein	Mean
simple	praise	-.941
	criticism	-.640
complex	praise	-.717
	criticism	2.298

Pairwise Comparisons

Dependent Variable: int_1

task	(I) rein	(J) rein	Mean Difference (I-J)	Sig.[b]
simple	praise	criticism	-.301	.354
	criticism	praise	.301	.354
complex	praise	criticism	-3.015*	.000
	criticism	praise	3.015*	.000

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

	Praise	Criticism
Simple		=
Complex		<

Recall that response time had the positive structure weight (and #correct negative). So the pattern of the "direction" interaction for the MANOVA variate follows that of #correct…

There was no simple effect of Reinforcement Type for Simple tasks however for Complex tasks, those receiving Criticism has longer average response time and did poorer on average (with #attempts not contributing to the interaction).