MANOVA within subjects

A within-subjects design with 2 DVs

An alternative medical example and (fabricated) data for the same MANOVA within-subjects design

Having looked at the diagnostics for our between-subjects example in some detail, we will present an example of a within-subjects MANOVA much more briefly. The study reported as a medical example (Huntington's disease) for a within-subjects ANOVA is repeated with a minor variation. Instead of the CRT response being made on a touch-sensitive screen, it is made on one of two pressure sensitive pads to the right and left of the participant's midline. The pads are connected to a timer which records the CRT (DV 1). In addition, the pressure sensitive pads record the strength of response, which constitutes a second DV. The two within-subjects factors are again year of test and stimulus mode.

A within-subjects design with 2 DVs: setting it up in SPSS

We can show the way the data are entered most clearly by adopting a systematic code for the 12 variables entered in the SPSS datasheet. The DV used to obtain the score for each condition is represented by V1 or V2. We represent the three levels of the first repeated measures IV (YEAR) with Y1, Y2 and Y3, and the two levels of the second repeated measures IV (MODE) with M1 and M2. So, for example, the year 1/auditory condition is represented by Y1M2 and the strength of response in the year 1/auditory condition is represented by V2Y1M2. The data are shown in Table 3.2.

Table 3.2

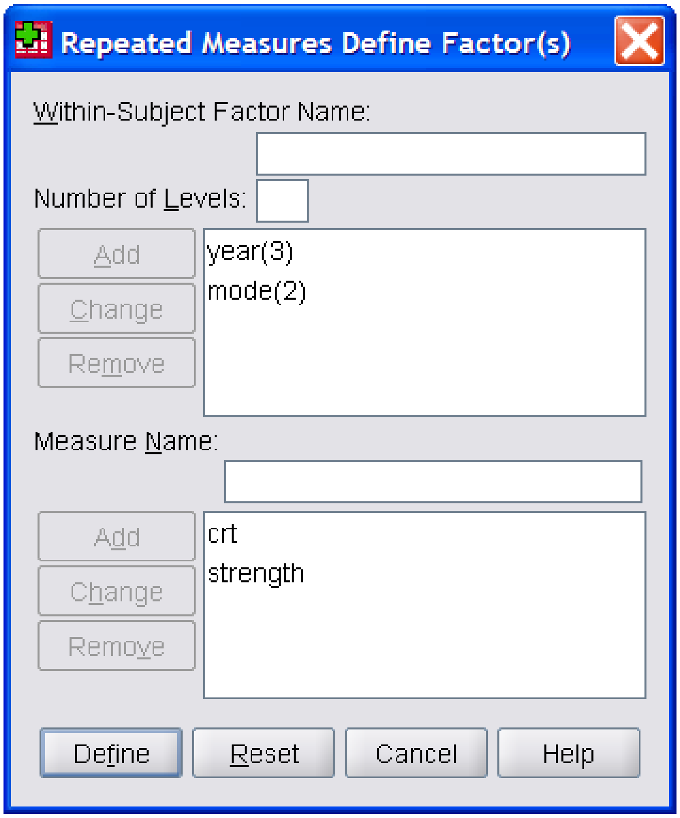
Data from a within-subjects experiment to compare effects of year of testing and stimulus mode on choice reaction time and strength of response in a decision task (med.manova.within.sav)

v1y1m1	v1y1m2	v1y2m1	v1y2m2	v1y3m1	v1y3m2	v2y1m1	v2y1m2	v2y2m1	v2y2m2	v2y3m1	v2y3m2
240	261	251	266	259	264	17	25	23	25	26	24
290	288	300	293	306	318	21	20	18	18	15	17
326	342	328	350	334	363	20	19	23	23	18	23
255	268	262	267	270	278	20	19	12	21	25	21
260	284	324	290	313	321	20	20	20	20	17	19
292	264	322	292	320	329	23	20	20	20	20	18
279	266	301	284	332	326	20	21	19	19	19	17
289	260	293	309	306	297	21	21	20	17	21	20
301	264	335	283	320	268	20	17	23	21	16	22
292	317	302	313	307	309	18	23	23	19	19	20

As this is a within subjects design in which each participant experiences all six of the YEAR/MODE conditions, the columns of Table 3.2 are arranged exactly as required for the SPSS datasheet, with each participant occupying one row, and a column for each of the conditions for each DV.

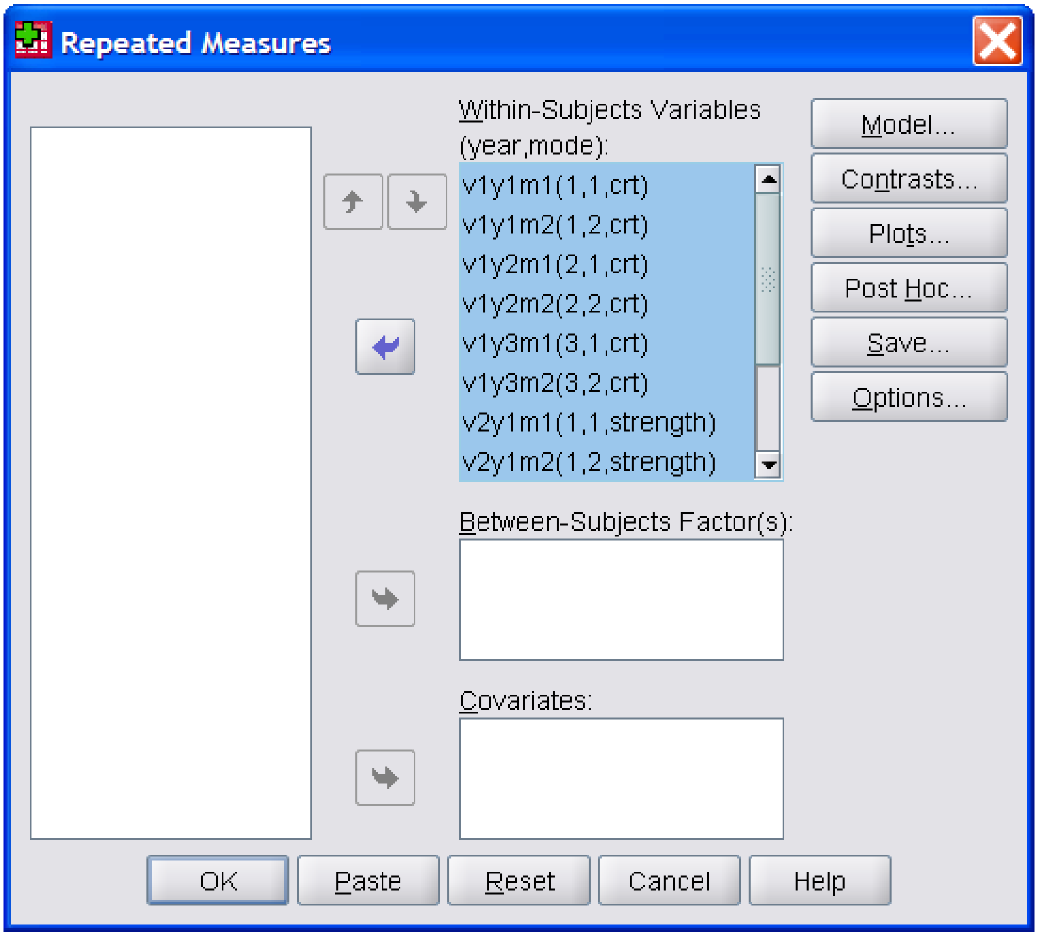
A within-subjects design with 2 DVs: requesting the analysis in SPSS

From the menus choose **Analyze**, then **General Linear Model**, then **Repeated Measures**, to get a dialog box like SPSS Dialog Box 2.8. Put YEAR into the **Within-Subject Factor Name** box and 3 into the **Number of Levels** box and click **Add**. Repeat for MODE and 2. Then put names for the two DVs (e.g., CRT and STRENGTH) in the **Measure Name** box. The result is shown in SPSS Dialog Box 3.4.



SPSS Dialog Box 3.4. Defining factors and DVs for repeated measures MANOVA

Click **Define** to get SPSS Dialog Box 3.5. Next, move all of the IVs into the **Within-Subjects Variables** box in the correct order, just as for a repeated measures ANOVA (if the IVs were entered in SPSS columns as in Table 3.2, they will be in the right order and can be moved as a block) so that the dialog box looks like SPSS Dialog Box 3.5.



SPSS Dialog Box 3.5. Selecting the IVs in the correct order

In **Options**, select **Estimates of effect size** and **Observed power** as usual and, assuming you do not want to select any of the other **Options** or **Plots**, click **Continue** and **OK**, and the analysis will be done.

A within-subjects design with 2 DVs: understanding the multivariate output

SPSS often generates more output than you know what to do with and it is important to be able to pick out the bits you need. On this occasion, therefore, we will show you the complete output (SPSS Output 3.8) of the within-subjects MANOVA and just draw your attention to the relevant bits.

Within-Subjects Factors

Measure	year	mode	Dependent Variable
crt	1	1	v1y1m1
		2	v1y1m2
	2	1	v1y2m1
		2	v1y2m2
	3	1	v1y3m1
		2	v1y3m2
strength	1	1	v2y1m1
		2	v2y1m2
	2	1	v2y2m1
		2	v2y2m2
	3	1	v2y3m1
		2	v2y3m2

Multivariate Tests[c]

Effect			Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Between Subjects	Intercept	Pillai's Trace	.998	2.429E3	2.000	8.000	.000	.998	4858.037	1.000
		Wilks' Lambda	.002	2.429E3	2.000	8.000	.000	.998	4858.037	1.000
		Hotelling's Trace	607.255	2.429E3	2.000	8.000	.000	.998	4858.037	1.000
		Roy's Largest Root	607.255	2.429E3	2.000	8.000	.000	.998	4858.037	1.000
Within Subjects	year	Pillai's Trace	.767	4.928[a]	4.000	6.000	.042	.767	19.711	.679
		Wilks' Lambda	.233	4.928[a]	4.000	6.000	.042	.767	19.711	.679
		Hotelling's Trace	3.285	4.928[a]	4.000	6.000	.042	.767	19.711	.679
		Roy's Largest Root	3.285	4.928[a]	4.000	6.000	.042	.767	19.711	.679
	mode	Pillai's Trace	.193	.956[a]	2.000	8.000	.424	.193	1.912	.163
		Wilks' Lambda	.807	.956[a]	2.000	8.000	.424	.193	1.912	.163
		Hotelling's Trace	.239	.956[a]	2.000	8.000	.424	.193	1.912	.163
		Roy's Largest Root	.239	.956[a]	2.000	8.000	.424	.193	1.912	.163
	year * mode	Pillai's Trace	.176	.320[a]	4.000	6.000	.855	.176	1.279	.086
		Wilks' Lambda	.824	.320[a]	4.000	6.000	.855	.176	1.279	.086
		Hotelling's Trace	.213	.320[a]	4.000	6.000	.855	.176	1.279	.086
		Roy's Largest Root	.213	.320[a]	4.000	6.000	.855	.176	1.279	.086

a. Exact statistic

b. Computed using alpha = .05

c. Design: Intercept
Within Subjects Design: year + mode + year * mode

Mauchly's Test of Sphericity[b]

Within Subjects Effect	Measure	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
						Greenhouse-Geisser	Huynh-Feldt	Lower-bound
year	crt	.749	2.315	2	.314	.799	.945	.500
	strength	.986	.117	2	.943	.986	1.000	.500
mode	crt	1.000	.000	0	.	1.000	1.000	1.000
	strength	1.000	.000	0	.	1.000	1.000	1.000
year * mode	crt	.912	.737	2	.692	.919	1.000	.500
	strength	.971	.238	2	.888	.972	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: year + mode + year * mode

Tests of Within-Subjects Effects

Multivariate[d,e]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
year	Pillai's Trace	.632	4.159	4.000	36.000	.007	.316	16.635	.881
	Wilks' Lambda	.371	5.461[b]	4.000	34.000	.002	.391	21.843	.954
	Hotelling's Trace	1.690	6.760	4.000	32.000	.000	.458	27.041	.984
	Roy's Largest Root	1.686	15.171[c]	2.000	18.000	.000	.628	30.341	.997
mode	Pillai's Trace	.193	.956[b]	2.000	8.000	.424	.193	1.912	.163
	Wilks' Lambda	.807	.956[b]	2.000	8.000	.424	.193	1.912	.163
	Hotelling's Trace	.239	.956[b]	2.000	8.000	.424	.193	1.912	.163
	Roy's Largest Root	.239	.956[b]	2.000	8.000	.424	.193	1.912	.163
year * mode	Pillai's Trace	.072	.335	4.000	36.000	.853	.036	1.340	.117
	Wilks' Lambda	.928	.322[b]	4.000	34.000	.861	.037	1.289	.113
	Hotelling's Trace	.077	.309	4.000	32.000	.870	.037	1.237	.110
	Roy's Largest Root	.077	.695[c]	2.000	18.000	.512	.072	1.390	.149

a. Computed using alpha = .05

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Design: Intercept
Within Subjects Design: year + mode + year * mode

e. Tests are based on averaged variables.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
year	crt	Sphericity Assumed	6492.633	2	3246.317	14.711	.000	.620	29.423	.996
		Greenhouse-Geisser	6492.633	1.598	4061.885	14.711	.001	.620	23.515	.987
		Huynh-Feldt	6492.633	1.889	3436.407	14.711	.000	.620	27.795	.994
		Lower-bound	6492.633	1.000	6492.633	14.711	.004	.620	14.711	.925
	strength	Sphericity Assumed	1.900	2	.950	.129	.880	.014	.258	.067
		Greenhouse-Geisser	1.900	1.971	.964	.129	.877	.014	.254	.067
		Huynh-Feldt	1.900	2.000	.950	.129	.880	.014	.258	.067
		Lower-bound	1.900	1.000	1.900	.129	.728	.014	.129	.062
Error(year)	crt	Sphericity Assumed	3972.033	18	220.669					
		Greenhouse-Geisser	3972.033	14.386	276.107					
		Huynh-Feldt	3972.033	17.004	233.590					
		Lower-bound	3972.033	9.000	441.337					
	strength	Sphericity Assumed	132.767	18	7.376					
		Greenhouse-Geisser	132.767	17.743	7.483					
		Huynh-Feldt	132.767	18.000	7.376					
		Lower-bound	132.767	9.000	14.752					
mode	crt	Sphericity Assumed	93.750	1	93.750	.159	.699	.017	.159	.065
		Greenhouse-Geisser	93.750	1.000	93.750	.159	.699	.017	.159	.065
		Huynh-Feldt	93.750	1.000	93.750	.159	.699	.017	.159	.065
		Lower-bound	93.750	1.000	93.750	.159	.699	.017	.159	.065
	strength	Sphericity Assumed	2.400	1	2.400	.970	.350	.097	.970	.143
		Greenhouse-Geisser	2.400	1.000	2.400	.970	.350	.097	.970	.143
		Huynh-Feldt	2.400	1.000	2.400	.970	.350	.097	.970	.143
		Lower-bound	2.400	1.000	2.400	.970	.350	.097	.970	.143
Error(mode)	crt	Sphericity Assumed	5300.417	9	588.935					
		Greenhouse-Geisser	5300.417	9.000	588.935					
		Huynh-Feldt	5300.417	9.000	588.935					
		Lower-bound	5300.417	9.000	588.935					
	strength	Sphericity Assumed	22.267	9	2.474					
		Greenhouse-Geisser	22.267	9.000	2.474					
		Huynh-Feldt	22.267	9.000	2.474					
		Lower-bound	22.267	9.000	2.474					
year * mode	crt	Sphericity Assumed	165.100	2	82.550	.680	.519	.070	1.361	.147
		Greenhouse-Geisser	165.100	1.838	89.815	.680	.508	.070	1.251	.142
		Huynh-Feldt	165.100	2.000	82.550	.680	.519	.070	1.361	.147
		Lower-bound	165.100	1.000	165.100	.680	.431	.070	.680	.115
	strength	Sphericity Assumed	.300	2	.150	.020	.981	.002	.039	.053
		Greenhouse-Geisser	.300	1.943	.154	.020	.979	.002	.038	.052
		Huynh-Feldt	.300	2.000	.150	.020	.981	.002	.039	.053
		Lower-bound	.300	1.000	.300	.020	.891	.002	.020	.052
Error(year*mode)	crt	Sphericity Assumed	2184.233	18	121.346					
		Greenhouse-Geisser	2184.233	16.544	132.026					
		Huynh-Feldt	2184.233	18.000	121.346					
		Lower-bound	2184.233	9.000	242.693					
	strength	Sphericity Assumed	137.033	18	7.613					
		Greenhouse-Geisser	137.033	17.488	7.836					
		Huynh-Feldt	137.033	18.000	7.613					
		Lower-bound	137.033	9.000	15.226					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Source	Measure	year	mode	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
year	crt	Linear	mode	6300.100	1	6300.100	19.095	.002	.680	19.095	.972
		Quadratic	mode	192.533	1	192.533	1.728	.221	.161	1.728	.218
	strength	Linear	mode	1.600	1	1.600	.219	.651	.024	.219	.070
		Quadratic	mode	.300	1	.300	.040	.845	.004	.040	.054
Error(year)	crt	Linear	mode	2969.400	9	329.933					
		Quadratic	mode	1002.633	9	111.404					
	strength	Linear	mode	65.900	9	7.322					
		Quadratic	mode	66.867	9	7.430					
mode	crt	year * mode	Linear	93.750	1	93.750	.159	.699	.017	.159	.065
	strength	year * mode	Linear	2.400	1	2.400	.970	.350	.097	.970	.143
Error(mode)	crt	year * mode	Linear	5300.417	9	588.935					
	strength	year * mode	Linear	22.267	9	2.474					
year * mode	crt	Linear	Linear	6.400	1	6.400	.067	.802	.007	.067	.056
		Quadratic	Linear	158.700	1	158.700	1.080	.326	.107	1.080	.154
	strength	Linear	Linear	1.137E-13	1	1.137E-13	.000	1.000	.000	.000	.050
		Quadratic	Linear	.300	1	.300	.038	.849	.004	.038	.054
Error(year*mode)	crt	Linear	Linear	862.100	9	95.789					
		Quadratic	Linear	1322.133	9	146.904					
	strength	Linear	Linear	66.500	9	7.389					
		Quadratic	Linear	70.533	9	7.837					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Transformed Variable:Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	crt	5246900.817	1	5246900.817	1720.545	.000	.995	1720.545	1.000
	strength	24240.600	1	24240.600	2165.772	.000	.996	2165.772	1.000
Error	crt	27446.017	9	3049.557					
	strength	100.733	9	11.193					

a. Computed using alpha = .05

SPSS Output 3.8. The complete output of the within-subjects Manova

The first, Within-Subjects Factors, table just provides a check on the variables entered; that they are in the correct order. Then comes the Multivariate Tests table. Ignore the Between-Subjects effect (which only refers to the intercept since we have no between-subject factors) and go straight to the Within-Subjects effects. The four alternative test statistics were discussed in detail for the between-subjects example earlier in the chapter. We see that, whichever test we use, only YEAR reaches significance ($F(4,6) = 4.93$, $p < 0.05$), with partial eta squared = 0.77 and retrospective power = 0.68. The pattern of test statistics suggests that the effect may only be significant for one of the DVs (see earlier discussion of these test statistics in relation to the between-subjects example). Next, we see that Mauchly's test of the assumption of sphericity is non-significant, which tells us that we can refer to the 'Sphericity Assumed' rows in the Univariate Tests table. Before that, however, we have another Multivariate table and footnote 'e' says it is based on averaged variables.

In fact this is the table you would get if you treated the ten subjects as levels of a factor, so that instead of a repeated measures design you treat it as a **GLM Multivariate** design with three IVs, year, mode and subject. This would not normally be of interest so ignore this table and press on to the table of Univariate Tests.

A within-subjects design with 2 DVs: understanding the univariate output

Univariate tests on the YEAR factor are justified by the significant multivariate effect of YEAR reported in the first multivariate table. The Univariate Tests table confirms that the effect of year is significant for the CRT DV (with sphericity assumed $F(2,18) = 14.71$, $p < 0.001$), with partial eta squared = 0.62 and retrospective power = 0.996. The Within-Subjects Contrasts table tells us that the linear effect of YEAR is also significant for the RT DV ($F(1,9) = 19.09$, $p < 0.01$). Finally, the Tests of Between-Subjects Effects can safely be ignored since we have no between-subjects factors.

If the test for sphericity suggested that this assumption was not justified, then the probability values from the other three rows of the Univariate Tests table should be considered. These are obtained by multiplying the numerator and denominator degrees of freedom for *F* by the corresponding value of epsilon from the right of the Mauchly test table. The most conservative is the last of the three values, the Lower Bound. Greenhouse-Geisser is also conservative, especially for small sample sizes. The Huynh-Feldt value for epsilon may be calculated as greater than 1, but if so, the value 1 is used (so no adjustment is made).

Extension to a within and between-subjects (mixed) design with 2 DVs

If you had a multivariate *mixed* design; one in which there were one or more between-subjects IVs as well as one or more within-subjects IVs and more than one DV, the

MANOVA would be carried out as for the all within-subjects design we have described above, except that, in SPSS Dialog Box 3.5, the between-subject IVs would be moved into the **Between-Subjects Factor(s)** box before **OK** is clicked. The output would be similar, except that between-subject effects and interactions involving between- and within-subject factors would be included.