

Chapter 45

Doubly Multivariate Analysis of Variance for Multiple Observations from Multiple Outcome Variables (16 Patients)

General Purpose

One way analysis of variance (ANOVA) is for analysis of studies with multiple unpaired observations (i.e. 1 subject is observed once) and a single outcome variable (see Chap. 8, One way anova and Kruskal-Wallis, pp 29–31, in: SPSS for starters part one, Springer Heidelberg Germany, 2010, from the same authors).

Repeated measures ANOVA is for studies with multiple paired observations (i.e. more than a single observation per subject) and also with a single outcome variable (see Chap. 6, Repeated measures anova, pp 21–24, in: SPSS for starters part one, Springer Heidelberg Germany, 2010, from the same authors).

Multivariate ANOVA is for studies with multiple unpaired observations and more than a single outcome variable (see Chap. 4, Multivariate anova, pp 13–20, in: SPSS for starters part two, Springer Heidelberg Germany, 2012, from the same authors).

Finally, doubly multivariate ANOVA is for studies with multiple paired observations and more than a single outcome variable.

An example of the latter is given in the SPSS tutorial case studies: in a diet study of overweight patients the triglyceride and weight values were the outcome variables and they were measured repeatedly during several months of follow up.

Primary Scientific Question

Can doubly multivariate analysis be used to simultaneously assess the effects of three different sleeping pills on two outcome variables, (1) hours of sleep and (2) morning body temperatures (in patients with sleep deprivation morning body temperature is higher than in those without sleep deprivation).

Example

In 16 patients a three period crossover study of three sleeping pills (treatment levels) were studied. The underneath table give the data of the first 8 patients. The entire data file is entitled “doubly.sav”, and is in extras.springer.com. Two outcome variables are measured at three levels each. This study would qualify for a doubly multivariate analysis, because we have multiple paired outcomes and multiple measures of each of the outcomes.

hours			age	gen	temp		
a	b	c		a	b	c	
6,10	6,80	5,20	55,00	0,00	35,90	35,30	36,80
7,00	7,00	7,90	65,00	0,00	37,10	37,80	37,00
8,20	9,00	3,90	74,00	0,00	38,30	34,00	39,10
7,60	7,80	4,70	56,00	1,00	37,50	34,60	37,70
6,50	6,60	5,30	44,00	1,00	36,40	35,30	36,70
8,40	8,00	5,40	49,00	1,00	38,30	35,50	38,00
6,90	7,30	4,20	53,00	0,00	37,00	34,10	37,40
6,70	7,00	6,10	76,00	0,00	36,80	36,10	36,90

hours=hours of sleep on sleeping pill

a, b, c=different sleeping pills (levels of treatment)

age=patient age

gen=gender

temp=different morning body temperatures on sleeping pill

SPSS statistical software will be used for data analysis. We will start by opening the data file in SPSS.

Then Command:

Analyze...General Linear Models...Repeated Measures...Within-Subject Factor Name: type treatment...Number of Levels: type 3...click Add...Measure Name: type hours...click Add...Measure Name: type temp...click Add...click Define... Within-Subjects Variables(treatment): enter hours a, b, c, and temp a, b, c... Between-Subjects Factor(s): enter gender...click Contrast...Change Contrast... Contrast...select Repeated...click Change...click Continue...click Plots... Horizontal Axis: enter treatment...Separate Lines: enter gender...click Add...click Continue...click Options...Display Means for: enter gender*treatment...mark Estimates of effect size...mark SSCP matrices...click Continue...click OK.

The underneath table is in the output sheets.

Multivariate tests ^b								
Effect			Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Between subjects	Intercept	Pillai's Trace	1,000	3,271 E6	2,000	13,000	,000	1,000
		Wilks' Lambda	,000	3,271 E6	2,000	13,000	,000	1,000
		Hotelling's Trace	503211,785	3,271 E6	2,000	13,000	,000	1,000
		Roy's Largest Root	503211,785	3,271 E6	2,000	13,000	,000	1,000
	Gender	Pillai's Trace	,197	1,595 ^a	2,000	13,000	,240	,197
		Wilks' Lambda	,803	1,595 ^a	2,000	13,000	,240	,197
		Hotelling's Trace	,245	1,595 ^a	2,000	13,000	,240	,197
		Roy's Largest Root	,245	1,595 ^a	2,000	13,000	,240	,197
Within subjects	Treatment	Pillai's Trace	,562	3,525 ^a	4,000	11,000	,044	,562
		Wilks' Lambda	,438	3,525 ^a	4,000	11,000	,044	,562
		Hotelling's Trace	1,282	3,525 ^a	4,000	11,000	,044	,562
		Roy's Largest Root	1,282	3,525 ^a	4,000	11,000	,044	,562
	Treatment * gender	Pillai's Trace	,762	8,822 ^a	4,000	11,000	,002	,762
		Wilks' Lambda	,238	8,822 ^a	4,000	11,000	,002	,762
		Hotelling's Trace	3,208	8,822 ^a	4,000	11,000	,002	,762
		Roy's Largest Root	3,208	8,822 ^a	4,000	11,000	,002	,762

^aExactstatistic

^bDesign: Intercept + gender

Within Subjects Design: treatment

Doubly multivariate analysis has multiple paired outcomes and multiple measures of these outcomes. For analysis of such data both between and within subjects tests are performed. We are mostly interested in the within subject effects of the treatment

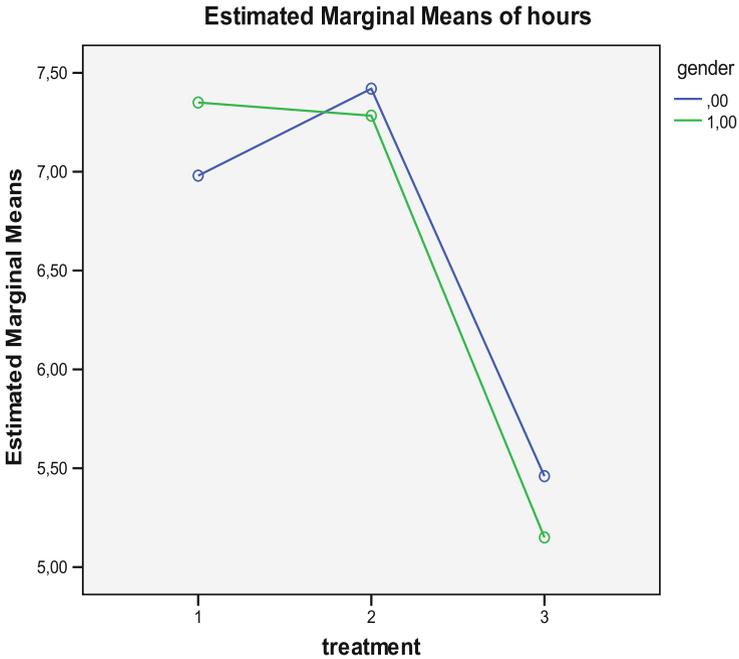
levels, but the above table starts by showing the not so interesting gender effect on hours of sleep and morning temperatures. They are not significantly different between the genders. More important is the treatment effects. The hours of sleep and the morning temperature are significantly different between the different treatment levels at $p=0.044$. Also these significant effects are different between males and females at $p=0.002$.

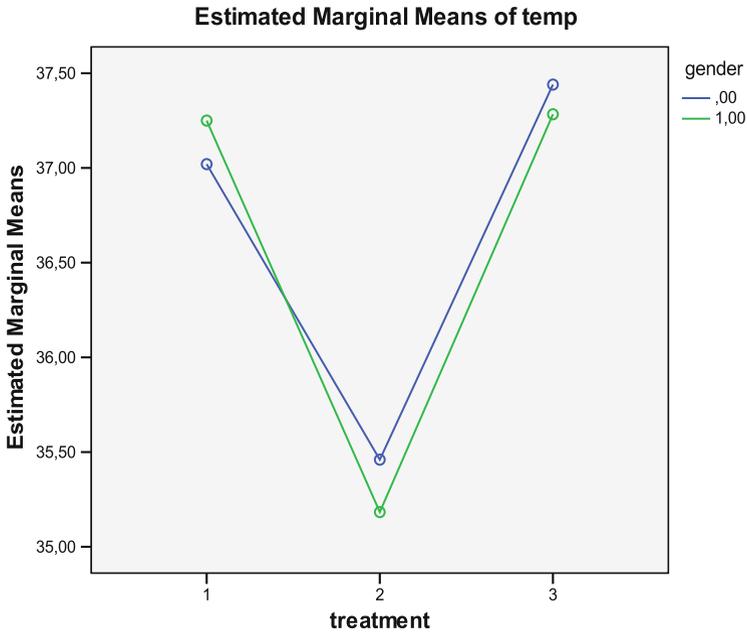
Tests of within-subjects contrasts								
Source	Measure	Treatment	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Treatment	Hours	Level 1 vs. Level 2	,523	1	,523	6,215	,026	,307
		Level 2 w. Level 3	62,833	1	62,833	16,712	,001	,544
	Temp	Level 1 vs. Level 2	49,323	1	49,323	15,788	,001	,530
		Level 2 vs. Level 3	62,424	1	62,424	16,912	,001	,547
Treatment* gender	Hours	Level 1 vs. Level 2	,963	1	,963	11,447	,004	,450
		Level 2 vs. Level 3	,113	1	,113	,030	,865	,002
	Temp	Level 1 vs. Level 2	,963	1	,963	,308	,588	,022
		Level 2 w. Level 3	,054	1	,054	,015	,905	,001
Error(treatment)	Hours	Level 1 vs. Level 2	1,177	14	,084			
		Level 2 vs. Level 3	52,637	14	3,760			
	Temp	Level 1 w. Level 2	43,737	14	3,124			
		Level 2 vs. Level 3	51,676	14	3,691			

The above table shows, whether differences between levels of treatment were significantly different from one another by comparison with the subsequent levels (contrast tests). The effects of treatment levels 1 versus (vs) 2 on hours of sleep were different at $p=0.026$, levels 2 vs 3 at $p=0.001$. The effects of treatments levels 1 vs 2 on morning temperatures were different at $p=0.001$, levels 2 vs 3 on morning temperatures were also different at $p=0.001$. The effects on hours of sleep of treatment levels 1 vs 2 accounted for the differences in gender remained very significant at $p=0.004$.

Gender * treatment						
Measure	Gender	Treatment	Mean	Std. Error	95 % Confidence interval	
					Lower bound	Upper bound
Hours	,00	1	6,980	,268	6,404	7,556
		2	7,420	,274	6,833	8,007
		3	5,460	,417	4,565	6,355
	1,00	1	7,350	,347	6,607	8,093
		2	7,283	,354	6,525	8,042
		3	5,150	,539	3,994	6,306
Temp	,00	1	37,020	,284	36,411	37,629
		2	35,460	,407	34,586	36,334
		3	37,440	,277	36,845	38,035
	1,00	1	37,250	,367	36,464	38,036
		2	35,183	,526	34,055	36,311
		3	37,283	,358	36,515	38,051

The above table shows the mean hours of sleep and mean morning temperatures for the different subsets of observations. Particularly, we observe the few hours of sleep on treatment level 3, and the highest morning temperatures at the same level. The treatment level 2, in contrast, causes pretty many hours of sleep and, at the same time, the lowest morning temperatures (consistent with longer periods of sleep). The underneath figures show the same.





Conclusion

Doubly multivariate ANOVA is for studies with multiple paired observations and more than a single outcome variable. For example, in a study with two or more different outcome variables the outcome values are measured repeatedly during a period of follow up or in a study with two or more outcome variables the outcome values are measured at different levels, e.g., different treatment dosages or different compounds. The multivariate approach prevents the type I errors from being inflated, because we only have one test and, so, the p-values need not be adjusted for multiple testing (see Chap. 3, Multiple treatments., pp 19–27, and Chap. 4, Multiple endpoints, pp 29–36, both in: Machine learning in medicine part three, Springer Heidelberg Germany, from the same authors). Also, the multivariate test battery accounts for multiple effects simultaneously.

Note

More background, theoretical and mathematical information of data files with multiple variables are the following. One way analysis of variance (anova) analysis of studies with multiple unpaired observations (i.e. 1 subject is observed once) and a

single outcome variable (see Chap. 8, One way anova and Kruskal-Wallis, pp 29–31, in: SPSS for starters part one, Springer Heidelberg Germany, 2010, from the same authors), repeated measures ANOVA for studies with multiple paired observations (i.e. more than a single observation per subject) and also with a single outcome variable (see Chap. 6, Repeated measures anova, pp 21–24, in: SPSS for starters part one, Springer Heidelberg Germany, 2010, from the same authors), and multivariate ANOVA is for studies with multiple unpaired observations and more than a single outcome variable (see Chap. 4, Multivariate anova, pp 13–20, in: SPSS for starters part two, Springer Heidelberg Germany, 2012, from the same authors). The advantages of multivariate analyses as compared to univariate analyses are discussed in the Chap. 3, Multiple treatments, pp 19–27, and the Chap. 4, Multiple endpoints, pp 29–36, both in: Machine learning in medicine part three, Springer Heidelberg Germany, 2013, from the same authors.