Chapter 14: Answers

Task 1

A clinical psychologist noticed that several of his manic psychotic patients did chicken impersonations in public. He wondered whether this behaviour could be used to diagnose this disorder and so decided to compare his patients against a normal sample. He observed 10 of his patients as they went through a normal day. He also needed to observe 10 of the most normal people he could find: naturally he chose to observe lecturers at the University of Sussex. He all participants using two dependent variables: first, how many chicken impersonations they did in the streets of Brighton over the course of a day, and second, how good their impersonations were (as scored out of 10 by an independent farmyard noise expert). The data are in the file **chicken.sav**, use MANOVA and DFA to find out whether these variables could be used to distinguish manic psychotic patients from those without the disorder.

SPSS Output

Preliminary Analysis and Testing Assumptions

This output shows an initial table of descriptive statistics that is produced by clicking on the descriptive statistics option in the *options* dialog box. This table contains the overall and group means and standard deviations for each dependent variable in turn. It seems that manic psychotics and Sussex lecturers do pretty similar amounts of chicken impersonations (lecturers do slightly less actually but they are of a higher quality).

Descriptive Statistics

	GROUP	Mean	Std. Deviation	N
QUALITY	Manic Psychosis	6.7000	1.05935	10
	Sussex Lecturers	7.6000	2.98887	10
	Total	7.1500	2.23077	20
QUANTITY	Manic Psychosis	12.1000	4.22821	10
	Sussex Lecturers	10.7000	4.37290	10
	Total	11.4000	4.24760	20

The next output shows Box's test of the assumption of equality of covariance matrices. This statistic tests the null hypothesis that the variance-covariance matrices are the same in all three groups. Therefore, if the matrices are equal (and therefore the assumption of homogeneity is met) this statistic should be *non-significant*. For these data $p = 0.000$ (which is less than 0.05): hence, the covariance matrices are not equal and the assumption is broken. However, because group sizes are equal we can ignore this test because Pillai's trace should be robust to this violation (fingers crossed!).

Box's Test of Equality of Covariance Matrices[a]

Box's M	20.926
F	6.135
df1	3
df2	58320.000
Sig.	.000

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept+GROUP

MANOVA Test Statistics

The next table shows the main table of results. For our purposes, the group effects are of interest because they tell us whether or not the manic psychotics and Sussex lecturers differ

along the two dimensions of quality and quantity of chicken impersonations. The column of real interest is the one containing the significance values of these *F*-ratios. For these data, all test statistics are significant with $p = 0.032$ (which is less than 0.05). From this result we should probably conclude that the groups do indeed differ in terms of the quality and quantity of their chicken impersonations, however, this effect needs to be broken down to find out exactly what's going on.

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.919	96.201[a]	2.000	17.000	.000
	Wilks' Lambda	.081	96.201[a]	2.000	17.000	.000
	Hotelling's Trace	11.318	96.201[a]	2.000	17.000	.000
	Roy's Largest Root	11.318	96.201[a]	2.000	17.000	.000
GROUP	Pillai's Trace	.333	4.250[a]	2.000	17.000	.032
	Wilks' Lambda	.667	4.250[a]	2.000	17.000	.032
	Hotelling's Trace	.500	4.250[a]	2.000	17.000	.032
	Roy's Largest Root	.500	4.250[a]	2.000	17.000	.032

a. Exact statistic

b. Design: Intercept+GROUP

Univariate Test Statistics

The next table shows a summary table of Levene's test of equality of variances for each of the dependent variables. These tests are the same as would be found if a one-way ANOVA had been conducted on each dependent variable in turn. Levene's test should be non-significant for all dependent variables if the assumption of homogeneity of variance has been met. The results for these data clearly show that the assumption has been met for the quantity of chicken impersonations but has been broken for the quality of impersonations. This should dent our confidence in reliability of the univariate tests to follow.

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
QUALITY	11.135	1	18	.004
QUANTITY	.256	1	18	.619

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+GROUP

The next part of the output contains the ANOVA summary table for the dependent variables. The row of interest is that labelled *GROUP* (you'll notice that the values in this row are the same as for the row labelled *Corrected Model*: this is because the model fitted to the data contains only one independent variable: **group**). The row labelled *GROUP* contains an ANOVA summary table for quality and quantity of chicken impersonations respectively. The values of *p* indicate that there was a non-significant difference between student groups in terms of both (both *p*s are greater than 0.05). The multivariate test statistics led us to conclude that the student groups *did* differ significantly across the types of psychology yet the univariate results contradict this!

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	QUALITY	4.050[a]	1	4.050	.806	.381
	QUANTITY	9.800[b]	1	9.800	.530	.476
Intercept	QUALITY	1022.450	1	1022.450	203.360	.000
	QUANTITY	2599.200	1	2599.200	140.497	.000
GROUP	QUALITY	4.050	1	4.050	.806	.381
	QUANTITY	9.800	1	9.800	.530	.476
Error	QUALITY	90.500	18	5.028		
	QUANTITY	333.000	18	18.500		
Total	QUALITY	1117.000	20			
	QUANTITY	2942.000	20			
Corrected Total	QUALITY	94.550	19			
	QUANTITY	342.800	19			

a. R Squared = .043 (Adjusted R Squared = -.010)

b. R Squared = .029 (Adjusted R Squared = -.025)

We don't need to look at contrasts because the univariate tests were nonsignificant (and in any case there were only two groups and so no further comparisons would be necessary), and instead, to see how the dependent variables interact, we need to carry out a discriminant function analysis (DFA).

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	.667	6.893	2	.032

The initial statistics from the DFA tells us that there was only one variate (because there are only two groups) and this variate is significant. Therefore, the group differences shown by the MANOVA can be explained in terms of *one* underlying dimension.

Standardized Canonical Discriminant Function Coefficients

	Function
	1
QUALITY	1.859
QUANTITY	-1.829

The standardized discriminant function coefficients tell us the relative contribution of each variable to the variates. Both quality and quantity of impersonations have similar sized coefficients indicating that they have equally strong influence in discriminating the groups. However, they have the opposite sign which suggests that that group differences are explained by the difference between the quality and quantity of impersonations.

Functions at Group Centroids

GROUP	Function 1
Manic Psychosis	-.671
Sussex Lecturers	.671

Unstandardized canonical discriminant functions evaluated at group means

The variate centroids for each group confirms that variate 1 discriminates the two groups because the manic psychotics have a negative coefficient and the Sussex lecturers have a positive one. There won't be a combined-groups plot because there is only 1 variate.

Overall we could conclude that manic psychotics are distinguished from Sussex lecturers in terms of the difference between the pattern of results for quantity of impersonations compared to quality of them. If we look at the means we can see that Manic Psychotics produce slightly more impersonations than Sussex lecturers (but remember from the nonsignificant univariate tests that this isn't sufficient, alone, to differentiate the groups) but the lecturers produce impersonations of a higher quality (but again remember that quality alone is not enough to

differentiate the groups). Therefore, although the manic psychotics and Sussex lecturers produce similar numbers of impersonations of similar quality (see univariate tests) if we combine the quality and quantity we can differentiate the groups.

Task 2

I was interested in whether students' knowledge of different aspects of psychology improved throughout their degree. I took a sample of first years, second years and third years and gave them 5 tests (scored out of 15) representing different aspects of psychology: **Exper** (experimental psychology such as cognitive and neuropsychology etc.); **Stats** (statistics); **Social** (social Psychology); **Develop** (developmental psychology); **Person** (personality). Your task is to (1) carry out an appropriate general analysis to determine whether there are overall group differences along these 5 measures, (2) look at the scale-by-scale analyses of group differences produced in the output and interpret the results accordingly, (3) select contrasts that test the hypothesis that second and third years will score higher than first years on all scales; (4) select tests that compare all groups to each other—briefly compare these results with the contrasts; and (5) carry out a separate analysis in which you test whether a combination of the measures can successfully discriminate the groups (comment only briefly on this analysis). Include only those scales that revealed group differences for the contrasts. How do the results help you to explain the findings of your initial analysis? The data are in the file **psychology.sav**.

SPSS Output

Preliminary Analysis and Testing Assumptions

This output shows an initial table of descriptive statistics that is produced by clicking on the descriptive statistics option in the *options* dialog box. This table contains the overall and group means and standard deviations for each dependent variable in turn.

Descriptive Statistics

	Gorup	Mean	Std. Deviation	N
Experimental Psychology	1st Year	5.6364	2.1574	11
	2nd Year	5.5000	1.5916	16
	3rd Year	7.0000	2.1213	13
	Total	6.0250	2.0062	40
Statistics	1st Year	7.5455	3.5599	11
	2nd Year	8.6875	2.3866	16
	3rd Year	10.4615	3.0988	13
	Total	8.9500	3.1211	40
Social Psychology	1st Year	10.3636	2.7303	11
	2nd Year	8.5625	2.8040	16
	3rd Year	8.7692	1.6408	13
	Total	9.1250	2.5236	40
Personality	1st Year	10.6364	3.3248	11
	2nd Year	8.4375	1.9990	16
	3rd Year	8.3846	2.3993	13
	Total	9.0250	2.6745	40
Developmental	1st Year	11.0000	2.6458	11
	2nd Year	8.8750	1.7078	16
	3rd Year	8.7692	3.0319	13
	Total	9.4250	2.5908	40

The next output shows Box's test of the assumption of equality of covariance matrices. This statistic tests the null hypothesis that the variance-covariance matrices are the same in all three groups. Therefore, if the matrices are equal (and therefore the assumption of homogeneity is met) this statistic should be *non-significant*. For these data $p = 0.06$ (which is greater than 0.05): hence, the covariance matrices are roughly equal and the assumption is tenable.

Box's Test of Equality of Covariance Matrices[a]

Box's M	54.241
F	1.435
df1	30
df2	3587
Sig.	.059

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept+GROUP

MANOVA Test Statistics

The next table shows the main table of results. For our purposes, the group effects are of interest because they tell us whether or not the scores from different areas of psychology differ across the three years of the degree program. The column of real interest is the one containing the significance values of these *F*-ratios. For these data, Pillai's trace (p = 0.02), Wilks's lambda (p = 0.012), Hotelling's trace (p = 0.007), and Roy's largest root (p = 0.01) all reach the criterion for significance of 0.05. From this result we should probably conclude that the profile of knowledge across different areas of psychology does indeed change across the three years of the degree. The nature of this effect is not clear from the multivariate test statistic.

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.960	159.166[a]	5.000	33.000	.000
	Wilks' Lambda	.040	159.166[a]	5.000	33.000	.000
	Hotelling's Trace	24.116	159.166[a]	5.000	33.000	.000
	Roy's Largest Root	24.116	159.166[a]	5.000	33.000	.000
GROUP	Pillai's Trace	.510	2.330	10.000	68.000	.020
	Wilks' Lambda	.522	2.534[a]	10.000	66.000	.012
	Hotelling's Trace	.853	2.730	10.000	64.000	.007
	Roy's Largest Root	.773	5.255[b]	5.000	34.000	.001

a. Exact statistic

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

c. Design: Intercept+GROUP

Univariate Test Statistics

The next table shows a summary table of Levene's test of equality of variances for each of the dependent variables. These tests are the same as would be found if a one-way ANOVA had been conducted on each dependent variable in turn. Levene's test should be non-significant for all dependent variables if the assumption of homogeneity of variance has been met. The results for these data clearly show that the assumption has been met. This finding not only gives us confidence in the reliability of the univariate tests to follow, but also strengthens the case for assuming that the multivariate test statistics are robust.

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Experimental Psychology	1.311	2	37	.282
Statistics	.746	2	37	.481
Social Psychology	2.852	2	37	.071
Personality	2.440	2	37	.101
Developmental	2.751	2	37	.077

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+GROUP

The next part of the output contains the ANOVA summary table for the dependent variables. The row of interest is that labelled *GROUP*, which contains an ANOVA summary table for each of the areas of psychology. The values of p indicate that there was a non-significant difference between student groups in terms of all areas of psychology (all ps are greater than 0.05). The

multivariate test statistics led us to conclude that the student groups *did* differ significantly across the types of psychology yet the univariate results contradict this (again .. I really should stop making up data sets that do this!)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Experimental Psychology	18.430[a]	2	9.215	2.461	.099
	Statistics	52.504[b]	2	26.252	2.967	.064
	Social Psychology	23.584[c]	2	11.792	1.941	.158
	Personality	39.415[d]	2	19.708	3.044	.060
	Developmental	37.717[e]	2	18.859	3.114	.056
Intercept	Experimental Psychology	1428.058	1	1428.058	381.378	.000
	Statistics	3093.775	1	3093.775	349.637	.000
	Social Psychology	3330.118	1	3330.118	548.129	.000
	Personality	3273.395	1	3273.395	505.575	.000
	Developmental	3562.212	1	3562.212	588.250	.000
GROUP	Experimental Psychology	18.430	2	9.215	2.461	.099
	Statistics	52.504	2	26.252	2.967	.064
	Social Psychology	23.584	2	11.792	1.941	.158
	Personality	39.415	2	19.708	3.044	.060
	Developmental	37.717	2	18.859	3.114	.056
Error	Experimental Psychology	138.545	37	3.744		
	Statistics	327.396	37	8.849		
	Social Psychology	224.791	37	6.075		
	Personality	239.560	37	6.475		
	Developmental	224.058	37	6.056		
Total	Experimental Psychology	1609.000	40			
	Statistics	3584.000	40			
	Social Psychology	3579.000	40			
	Personality	3537.000	40			
	Developmental	3815.000	40			
Corrected Total	Experimental Psychology	156.975	39			
	Statistics	379.900	39			
	Social Psychology	248.375	39			
	Personality	278.975	39			
	Developmental	261.775	39			

a. R Squared = .117 (Adjusted R Squared = .070)

b. R Squared = .138 (Adjusted R Squared = .092)

c. R Squared = .095 (Adjusted R Squared = .046)

d. R Squared = .141 (Adjusted R Squared = .095)

e. R Squared = .144 (Adjusted R Squared = .098)

We don't need to look at contrasts because the univariate tests were nonsignificant, and instead, to see how the dependent variables interact, we need to carry out a discriminant function analysis (DFA).

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.522	22.748	10	.012
2	.926	2.710	4	.608

The initial statistics from the DFA tells us that only one of the variates is significant (the second variate is non-significant, p = 0.608). Therefore, the group differences shown by the MANOVA can be explained in terms of *one* underlying dimension.

Standardized Canonical Discriminant Function Coefficients

	Function	
	1	2
Experimental Psychology	.367	.789
Statistics	.921	-.081
Social Psychology	-.353	.319
Personality	-.260	.216
Developmental	-.618	.013

The standardized discriminant function coefficients tell us the relative contribution of each variable to the variates. Looking at the first variate it's clear that statistics has the greatest contribution to the first variate. Most interesting is that on the first variate, statistics and experimental psychology have positive weights, whereas social, developmental and personality have negative weights. This suggests that that group differences are explained by the difference between experimental psychology and statistics compared to other areas of psychology.

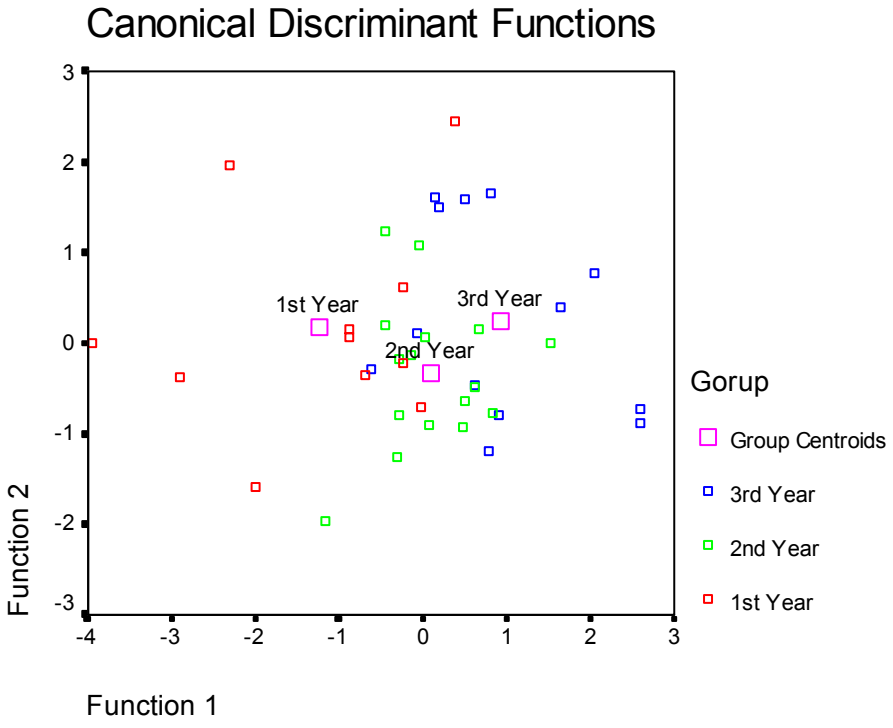
Functions at Group Centroids

Gorup	Function 1	Function 2
1st Year	-1.246	.186
2nd Year	9.789E-02	-.333
3rd Year	.934	.252

Unstandardized canonical discriminant functions evaluated at group means

The variate centroids for each group tells us that variate 1 discriminates the first years from second and third years because the first years have a negative value whereas the second and third years have positive values on the first variate.

The relationship between the variates and the groups is best illuminated using a combined-groups plot. This graph plots the variate scores for each person, grouped according to the year of their degree. In addition, the group centroids are indicated which are the average variate scores for each group. The plot for these data confirms that variate 1 discriminates the first years from subsequent years (look at the horizontal distance between these centroids).



Overall we could conclude that different years are discriminated by different areas of psychology. In particular it seems as though statistics and aspects of experimentation (compared to other areas of psychology) discriminate between first year undergraduates and subsequent years. From the means, we could interpret this as first years struggling with statistics and experimental psychology (compared to other areas of psychology) but this ability improves across the three years. However, for other areas of psychology, first years are

relatively good but their abilities decline over the three years. Put another way, psychology degrees improve only your knowledge of statistics and experimentation☺.