ANOVA in SPSS (Quiz)

The development of this E-Book has been supported by the British Academy.

Analysis of Variance practical questions

In this practical we will investigate how we model the influence of a categorical predictor on a continuous response.

In this example you will test whether the mean science test score (SCISCORE) differs between groups of students defined by their immigration status. The categorical variable IMMIG takes three values, indicating whether the student is Native, Second Generation migrant or First Generation migrant.

Firstly use SPSS to create a boxplot of **Science test score[SCISCORE]** for each category of **Immigation status[IMMIG]** and answer the following:

- Question: Which category has the highest median?
- Question: Which category has the lowest median?
- Question: What is the median for category Native?

Next use SPSS to create an error bar plot of **Science test score[SCISCORE]** for each category of **Immigation status[IMMIG]** and answer the following:

- Question: Which category has the highest mean and what is it?
- Question: What category has the lowest mean and what is it?
- Question: Which categories confidence intervals do not overlap?
- Question: Do we expect significant effects?

Next use the Explore window in SPSS to look at summary statistics of **Science test score[SCISCORE]** for each category of **Immigation status[IMMIG]** and answer the following:

- Question: What is the median of category Native?
- Question: What is the IQR of category Native?
- Question: What is the mean of category Second-Generation?
- Question: What is the confidence interval for category Second-Generation?

Finally use the Univariate option under General Linear Model in SPSS to fit an ANOVA and answer the following:

- Question: Looking at the Levene's test does this mean we can assume equal variances between categories?
- Question: Looking at the Between Subjects Effects table do we observe significant effects of **IMMIG** on **SCISCORE**?
- Question: Looking at the Tukey's HSD pairwise comparisons which pairings does it suggest are significantly different?
- Question: Looking at the LSD pairwise comparisons which pairings does it suggest are significantly different?
- Question: Looking at the Bonferroni pairwise comparisons which pairings does it suggest are significantly different?
- Question: Looking at the Marginal Means plot which category has the largest and which the smallest means?
- Question: Looking at the table for homogeneous subsets how many subsets are identified and which categories are in each?

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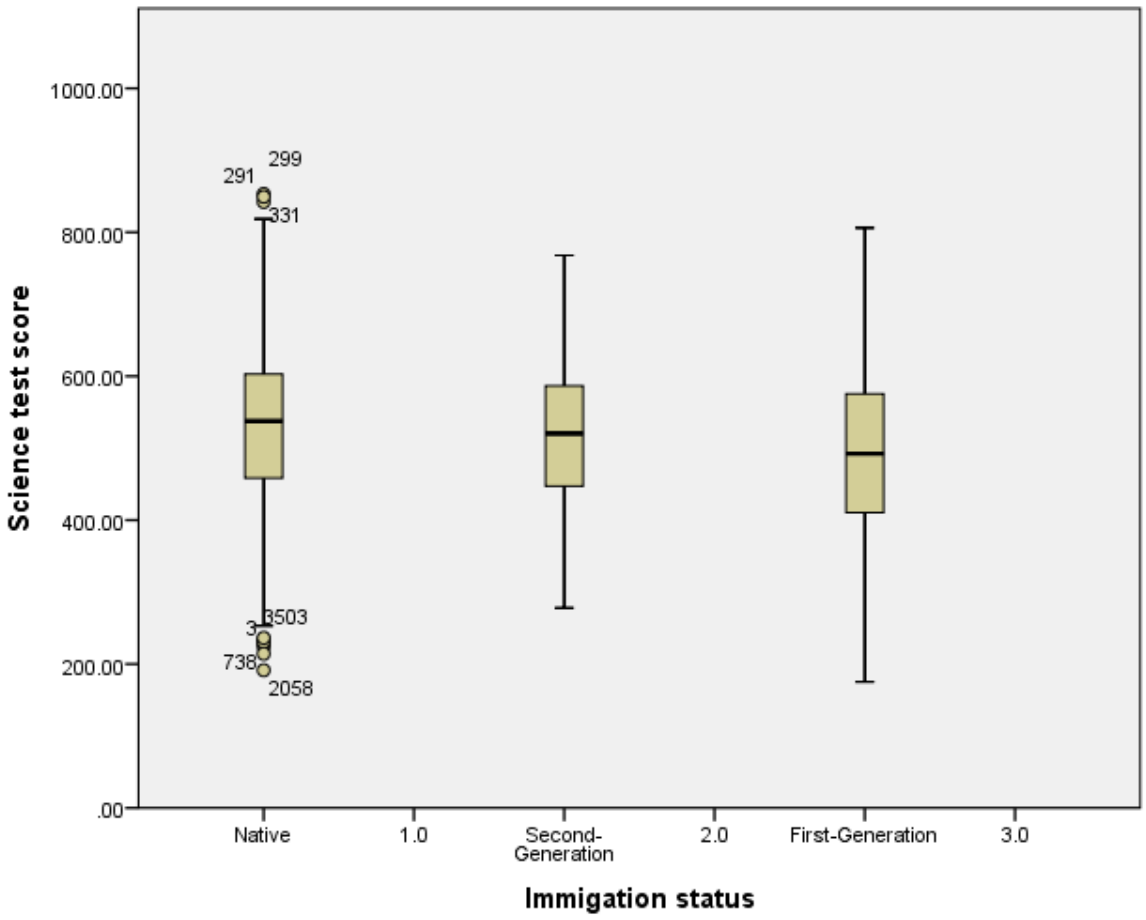
Solutions to Analysis of Variance practical questions

The SPSS instructions are as follows:

- Select **Boxplot** from the **Legacy Dialogs** submenu of the **Graphs** menu.
- Select **Simple** and **Summaries for groups of cases** and click on the **Define** button.
- Transfer the **Science test score[SCISCORE]** variable to the **Variable** box.
- Transfer the **Immigation status[IMMIG]** variable to the **Category Axis** box.
- Click on the **OK** button.

- Question: Which category has the highest median?
- Question: Which category has the lowest median?
- Question: What is the median for category Native?

Solutions: The output from SPSS is as follows:



The answers are as follows:

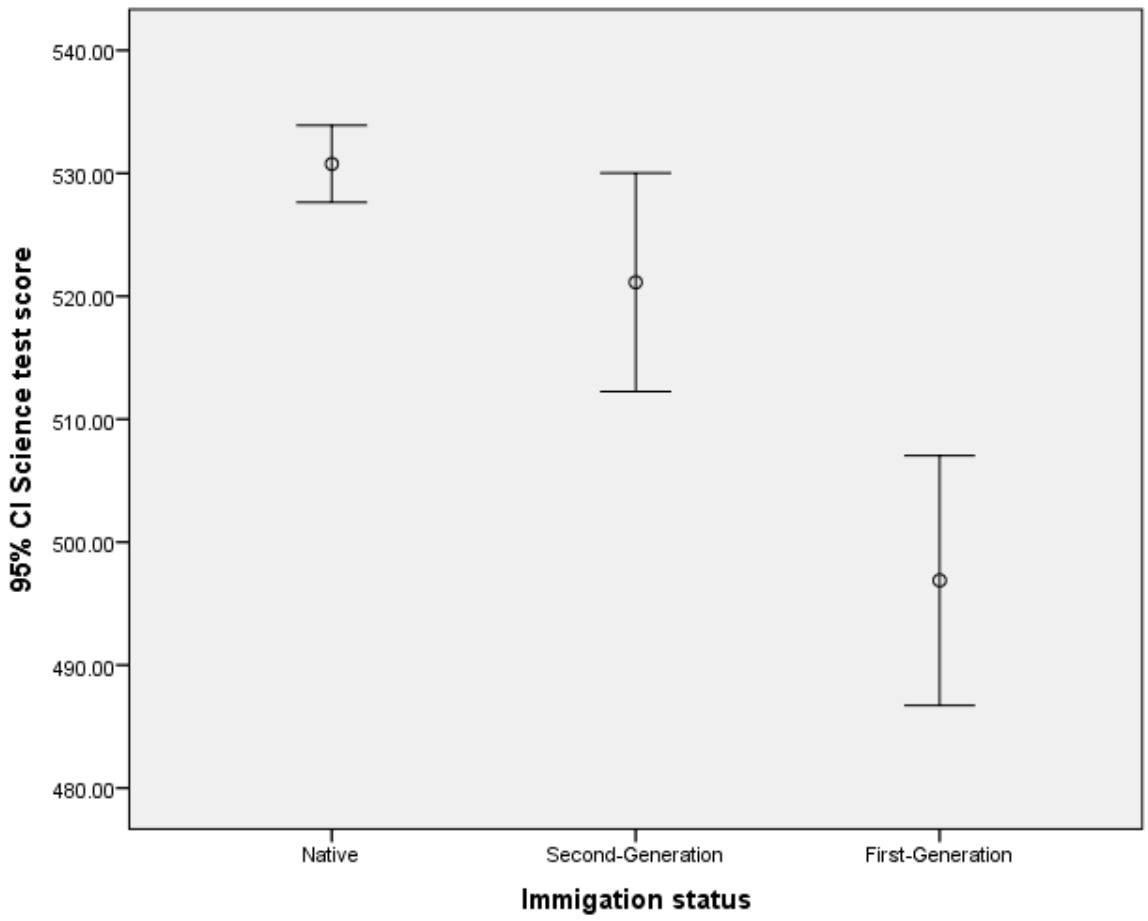
- Category Native has the highest median
- Category First-Generation has the lowest median
- The median for category Native is 537.7300

The SPSS instructions are as follows:

- Select **Error Bar** from the **Legacy Dialogs** submenu of the **Graphs** menu.
- Select **Simple** and **Summaries for groups of cases** as for the boxplot and click on the **Define** button.
- Transfer the **Science test score[SCISCORE]** variable to the **Variable** box.
- Transfer the **Immigation status[IMMIG]** variable to the **Category Axis** box.
- Click on the **OK** button.

- Question: Which category has the highest mean and what is it?
- Question: What category has the lowest mean and what is it?
- Question: Which categories confidence intervals do not overlap?
- Question: Do we expect significant effects?

Solutions: The output from SPSS is as follows:



The answers are as follows:

- The highest mean is 530.7634 for category Native.
- The lowest mean is 496.8813 for category First-Generation.
- All pairs of categories overlap.
- We might not expect an effect of **IMMIG** on **SCISCORE**.

The SPSS instructions are as follows:

- Choose **Explore** from the **Descriptives** submeny within the **Analyse** menu.
- Add **Science test score[SCISCORE]** to the **Dependent list**.
- Add **Immigation status[IMMIG]** to the **Factor list.**
- Click on the **OK** button.

- Question: What is the median of category Native?
- Question: What is the IQR of category Native?
- Question: What is the mean of category Second-Generation?
- Question: What is the confidence interval for category Second-Generation?

Solutions: The output from SPSS is as follows:

Descriptives

	Immigation status			Statistic	Std. Error
Science test score	Native	Mean		530.7634	1.59749
		95% Confidence Interval for Mean	Lower Bound	527.6315	
			Upper Bound	533.8954	
		5% Trimmed Mean		531.5183	
		Median		537.7300	
		Variance		10207.844	
		Std. Deviation		101.03388	
		Minimum		191.46	
		Maximum		853.13	
		Range		661.67	
		Interquartile Range		144.60	
		Skewness		-.142	.039
		Kurtosis		-.379	.077
	Second-Generation	Mean		521.1410	4.52598
		95% Confidence Interval for Mean	Lower Bound	512.2479	
			Upper Bound	530.0342	
		5% Trimmed Mean		520.7726	
		Median		520.3305	
		Variance		9873.536	
		Std. Deviation		99.36567	
		Minimum		278.00	
		Maximum		767.84	
		Range		489.84	
		Interquartile Range		139.98	
		Skewness		.036	.111
		Kurtosis		-.485	.222
	First-Generation	Mean		496.8813	5.16890
		95% Confidence Interval for Mean	Lower Bound	486.7219	
			Upper Bound	507.0408	
		5% Trimmed Mean		496.1159	
		Median		492.2440	
		Variance		11515.264	
		Std. Deviation		107.30920	
		Minimum		175.22	
		Maximum		806.08	
		Range		630.87	
		Interquartile Range		165.44	
		Skewness		.093	.118
		Kurtosis		-.441	.235

The answers are as follows:

- The median of category Native is 537.7300.
- The IQR of category Native is 144.60.
- The mean of category Second-Generation is 521.1410.
- The confidence interval for category Second-Generation is 512.2479 to 530.0342.

The SPSS instructions are as follows:

- Choose **Univariate** from the **General Linear Model** -> **Analyse** menu.
- Choose **Science test score[SCISCORE]** as the **Dependent Variable**.
- Choose **Immigation status[IMMIG]** as a **Fixed Factor**.
- Click **Options** and in the window tick **Descriptive statistics** and **Homegeneity tests**.
- Click on **Continue** to return to the main window.
- Click on **Plots...** and transfer **Immigation status[IMMIG]** to the **Horizontal Axis** box.
- Click **Add** and then **Continue**.
- Click on **Post hoc...**.

- Transfer **Immigation status[IMMIG]** to the **post hoc test for** box and select **LSD**, **Bonferroni** and **Tukey**.
- Click on the **Continue** button.
- Click on the **OK** button.

Question: Looking at the Levene's test does this mean we can assume equal variances between categories?

Solution: The output from SPSS is as follows:

Levene's Test of Equality of Error Variances

Science test score

F	df1	df2	Sig.
2.136	2	4910	.118

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

Here we see the p value is .118 which is greater than 0.05 and therefore we cannot reject the Null hypothesis and so we are able to assume equal variances and proceed with the ANOVA.

Question: Looking at the Between Subjects Effects table do we observe significant effects of **IMMIG** on **SCISCORE**?

Solution: The output from SPSS is as follows:

Tests of Between-Subjects Effects

Science test score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	464060.026[a]	2	232030.013	22.550	.000
Intercept	516426757.469	1	516426757.469	50189.230	.000
IMMIG	464060.026	2	232030.013	22.550	.000
Error	50521902.759	4910	10289.593		
Total	1414676650.655	4913			
Corrected Total	50985962.785	4912			

a. R Squared = .009 (Adjusted R Squared = .009)

The p value is less than 0.05 and so we can reject the null hypothesis and we find that **IMMIG** is a significant predictor of **SCISCORE**.

Question: Looking at the Tukey's HSD pairwise comparisons which pairings does it suggest are significant different?

Solution: The output from SPSS is as follows:

Multiple Comparisons

Science test score

Tukey HSD

(I) Immigation status	(J) Immigation status	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Native	Second-Generation	9.6224	4.89082	.120	-1.8437	21.0885
	First-Generation	33.8821*	5.14258	.000	21.8258	45.9385
Second-Generation	Native	-9.6224	4.89082	.120	-21.0885	1.8437
	First-Generation	24.2597*	6.72469	.001	8.4943	40.0252
First-Generation	Native	-33.8821*	5.14258	.000	-45.9385	-21.8258
	Second-Generation	-24.2597*	6.72469	.001	-40.0252	-8.4943

Based on observed means.

The error term is Mean Square(Error) = 10289.593.

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

We see that the following pairs (First-Generation:Native,First-Generation:Second-Generation) are significantly different.

Question: Looking at the LSD pairwise comparisons which pairings does it suggest are significantly different?

Solution: The output from SPSS is as follows:

Multiple Comparisons

Science test score

LSD

(I) Immigation status	(J) Immigation status	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Native	Second-Generation	9.6224*	4.89082	.049	.0342	19.2106
	First-Generation	33.8821*	5.14258	.000	23.8004	43.9639
Second-Generation	Native	-9.6224*	4.89082	.049	-19.2106	-.0342
	First-Generation	24.2597*	6.72469	.000	11.0763	37.4431
First-Generation	Native	-33.8821*	5.14258	.000	-43.9639	-23.8004
	Second-Generation	-24.2597*	6.72469	.000	-37.4431	-11.0763

Based on observed means.

The error term is Mean Square(Error) = 10289.593.

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

We see that all of the pairs of categories are significantly different.

Question: Looking at the Bonferroni pairwise comparisons which pairings does it suggest are significantly different?

Solution: The output from SPSS is as follows:

Multiple Comparisons

Science test score

Bonferroni

(I) Immigation status	(J) Immigation status	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Native	Second-Generation	9.6224	4.89082	.148	-2.0901	21.3349
	First-Generation	33.8821*	5.14258	.000	21.5667	46.1976
Second-Generation	Native	-9.6224	4.89082	.148	-21.3349	2.0901
	First-Generation	24.2597*	6.72469	.001	8.1554	40.3640
First-Generation	Native	-33.8821*	5.14258	.000	-46.1976	-21.5667
	Second-Generation	-24.2597*	6.72469	.001	-40.3640	-8.1554

Based on observed means.

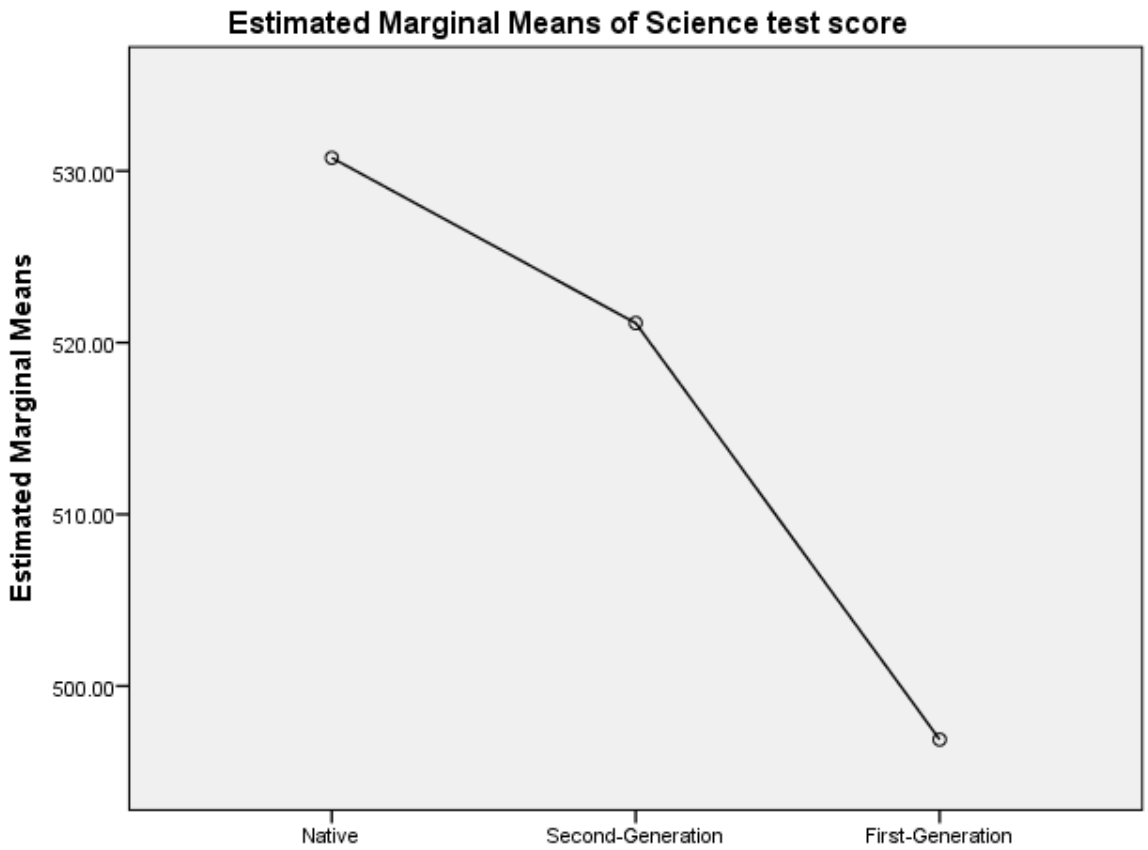
The error term is Mean Square(Error) = 10289.593.

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

We see that the following pairs (First-Generation:Native,First-Generation:Second-Generation) are significantly different.

Question: Looking at the Marginal Means plot which category has the largest and which the smallest means?

Solution: The output from SPSS is as follows:



Category Native has the largest mean and First-Generation has the smallest mean.

Question: Looking at the table for homogeneous subsets how many subsets are identified and which categories are in each?

Solution: The output from SPSS is as follows:

Science test score

Tukey HSD[a,b,c]

		Subset	
Immigation status	N	1	2
First-Generation	431	496.8813	
Second-Generation	482		521.1410
Native	4000		530.7634
Sig.		1.000	.203

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 10289.593.

a. Uses Harmonic Mean Sample Size = 645.873.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

There are 2 identified subsets with categories First-Generation in subset 1; Second-Generation, Native in subset 2;

Here we see that the ANOVA rejected the null hypothesis of equal means in all three immigrant groups. Post-hoc testing showed that first generation immigrants (those born outside England) scored significantly lower on the science test than both those who were native born and those who were second generation immigrants. Procedures that control for inflated Type I error rates indicate that means are not significantly different between native-born and second generation immigrants. The LSD procedure, which does not adjust in this way, would have led us to conclude there was a significant difference here, but it seems likely this would be an example of a Type I error (a false positive).