Example: ONE WAY ANALYSIS OF VARIANCE + POST HOC TESTS

This example uses material from the STARS project (www.stars.ac.uk).

This example uses data from a telephone survey of fast food consumers. The objective of the analysis is to compare the number of times per month people in different age groups buy fast food. The dependent variable is the number of times per month the respondent buys fast food. The interviewees are divided into 5 age groups: 15-17, 18-24, 25- 35, 36-54, 55-70.

The analysis involves comparing data between 5 age groups. The dependent variable is number of purchases per month and the independent variable, whose influence on the dependent variable we want to study, is age group.

Null hypothesis (H_0): Mean number of purchases of fast food per month is the same for all age groups

Alternative hypothesis (H_1): Mean number of purchases of fast food per month is not the same for all age groups

One-way analysis of variance is the first choice of technique because:

(1) 5 independent samples are being compared
(2) the dependent variable is quantitative

Using SPSS to carry out a one-way **an**alysis **o**f **va**riance, produces the following ANOVA table:

ANOVA

Purchases

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	147.000	4	36.750	8.013	.000
Within Groups	1751.935	382	4.586		
Total	1898.935	386			

The test statistic (F), degrees of freedom (the first two values in the column labelled df) and the P-value (which SPSS labels 'Sig.') are circled.

The P-value is used to decide the conclusion of the test: SPSS displays the P-value to 3 decimal places, so that very small P-values appear as 0.000, which we report as ' P<0.001 '. As the P-value is below 0.05, we reject the null hypothesis.

The hypothesis test allows you to say:
'The data provides statistically significant evidence that mean purchases per month of fast food are not the same for all age groups (One-way ANOVA, F = 8.013, df = 4,382, P <0.001).'

Having found statistically significant evidence that the mean number of purchases per month is not the same for all age groups, the next step is to explore where the differences between age groups are found. There are several possibilities, for example, four age groups might be similar, with just one group having a different mean, or there could be differences between all five groups. If the ANOVA produces a statistically significant test, we can carry out post hoc tests to see where differences between groups occur. SPSS provides a number of post hoc tests, here the Student-Neumann-Keuls test has been used with results shown below:

Purchases

Student-Newman-Keuls[a,b]

		Subset for alpha = .05		
Age	N	1	2	3
55-70	43	1.4186		
36-54	164		2.3476	
25-35	99		2.6162	
18-24	50			3.4800
15-17	31			3.7097
Sig.		1.000	.513	.576

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 54.518.

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

The footnotes give details related to the calculations that SPSS has used in carrying out the tests, these do not need to be interpreted.

What do the post hoc tests show?

The post hoc tests compare the age groups two at a time. The results are shown in a table, with age groups listed in order according to their mean value for the dependent variable. Here, the 55-70 age group are shown first as this group has the lowest mean purchases and the 15-17 year age group is shown last as they have the highest mean purchases. The columns or subsets show the mean purchases made by each group listed in different columns. The arrangement of the mean values in columns or subsets show which age groups differ / do not differ significantly in terms of their mean purchases of fast food.

If the means for two groups are shown in different columns, this indicates that there is statistically significant evidence of a difference between their mean values. For example, the mean for purchasers aged 55-70 is shown in a column by itself and does not appear in any other columns. This shows that the mean number of purchases made by consumers aged 55-70 is significantly different to the mean number of purchases in all the other age groups.

If the means for two groups are shown in the same column, this indicates that there is no statistically significant evidence that their mean values differ. For example, the mean for purchasers aged 18-24 and the mean for purchasers aged 15-17 are shown together in column/ subset 3. This shows that the mean number of purchases made by consumers in these two age groups do not differ significantly.

Assumptions underlying the test(s)

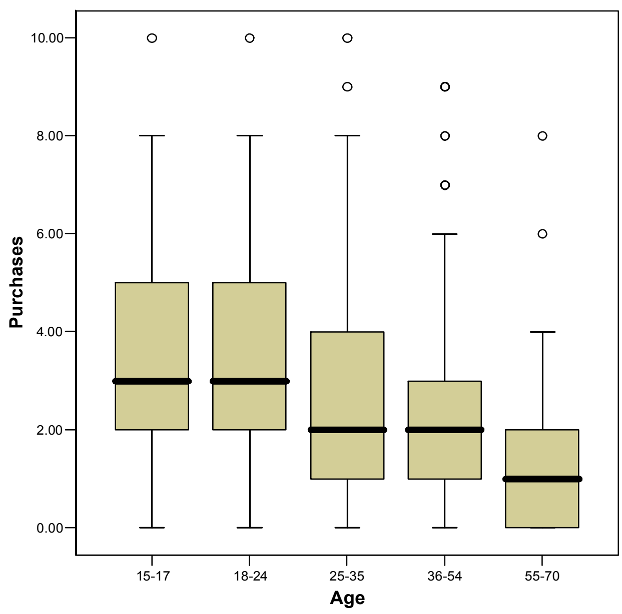
One-way ANOVA is a parametric method that assumes:

(1) The dependent variable is Normally distributed within each category being compared.

(2) The dependent variable has the same variance in each of the categories being compared.

The method is reasonably robust to small departures from these assumptions but is sensitive to outliers.

The output below provides some information related to the assumptions. The box plot shows that in each age group, the distribution of the number of purchases of fast food has a slight skew, with one or two individuals who are shown as outliers. These features are incompatible with Normally distributed data. Note that the spread or variation in purchases seems to be greater in age groups with higher median purchases.



The next table compares the means and standard deviations of the number of purchases in each age group. This also shows that the variation seems higher in the youngest age group.

Report

Purchases

Age	Mean	N	Std. Deviation
15-17	3.7097	31	2.61015
18-24	3.4800	50	2.14989
25-35	2.6162	99	2.09814
36-54	2.3476	164	2.17514
55-70	1.4186	43	1.67946
Total	2.5685	387	2.21800

Overall the data does not seem to conform to the assumptions required for the analyses. This means that the P-value may not be accurate. In this situation, some steps need to be taken to ensure that the conclusions produced are ‘safe’. Potential strategies would be to switch to a nonparametric method (Kruskal-Wallis analysis of ranks) or to look for a transformation that allows the assumptions underlying the one-way ANOVA to be met.