community project

encouraging academics to share statistics support resources

stcp-gilchristsamuels-11

The following resources are associated:

One-Way ANOVA worksheet and Kruskall-Wallis worksheet

## One-Way ANOVA – Additional Material

Robustness

According to Glass et al. (1972) the equality of variances assumption must be met in order to run an ANOVA analysis. However, provided the total sample size is larger than 20, ANOVA is quite robust to non-normal skewness (provided the group sizes are equal – see Field, 2009, p. 360) but not to non-normal kurtosis. Thus, it should not be used when:

$$\frac{|\text{Kurtosis}|}{\text{Standard Error of Kurtosis}} > 2$$

for any group. These values can be obtained using Analyze – Descriptive Statistics – Explore. For the example given in the main worksheet, select *Strength* for the Dependent List and *Concentration* for the Factor List and select Statistics as shown:

The kurtosis and standard error of kurtosis for each group are shown below (for details of example, see One Way ANOVA worksheet).

None of these ratios is higher than 2 and the sample size is 24 so, provided the Levene's test is negative, we could still have used the ANOVA test even if the normality assumptions had not been met.
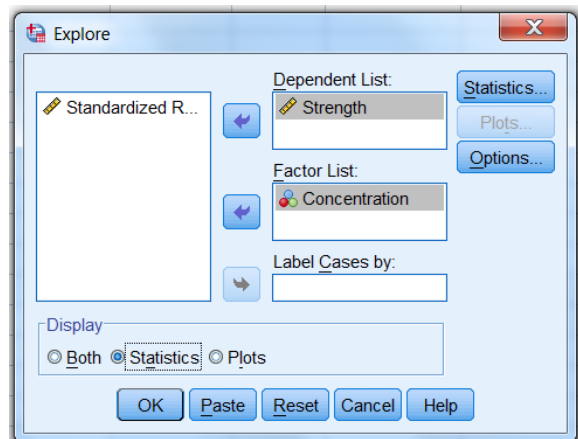
| Concentration	Kurtosis	Standard error	Ratio	Ratio > 2?
5%	1.19	0.85	1.40	No
10%	-0.22	0.85	0.26	No
15%	-0.94	0.85	1.11	No
20%	0.32	0.85	0.38	No

When assumptions and robust exceptions are not met

If the **equality of variances assumption is not met**, the **Brown-Forsythe** and **Welch** tests can be used. The Welch test is more powerful except where there is an extreme mean with a large variance when the Brown-Forsyth test is better. These tests are included within the ANOVA analysis in SPSS:

- Select Analyze – Compare Means – One Way ANOVA… and click on Options… button then select the **Brown-Forsythe** and **Welch** options

- If the result is significant, for post hoc testing, use the **Games-Howell** option

If **normality assumptions and their robust exceptions are in doubt**, use the **Kruskal-Wallis** or **Jonckheere-Terpstra** nonparametric tests. Kruskal-Wallis is appropriate where there is no suspected order in the difference of means. If there is a suspected order (as in our example), use Jonckheere-Terpstra:

- Select Analyze – Nonparametic Tests – Independent Samples…

- Select the Settings tabs, the Choose Test option from the Select an item list on the left and select Customise Tests

- Select one of these tests as shown on the right

- If the result is significant, for post hoc testing, use the automatic Model Viewer facility in SPSS – see the Kruskall-Wallis worksheet.
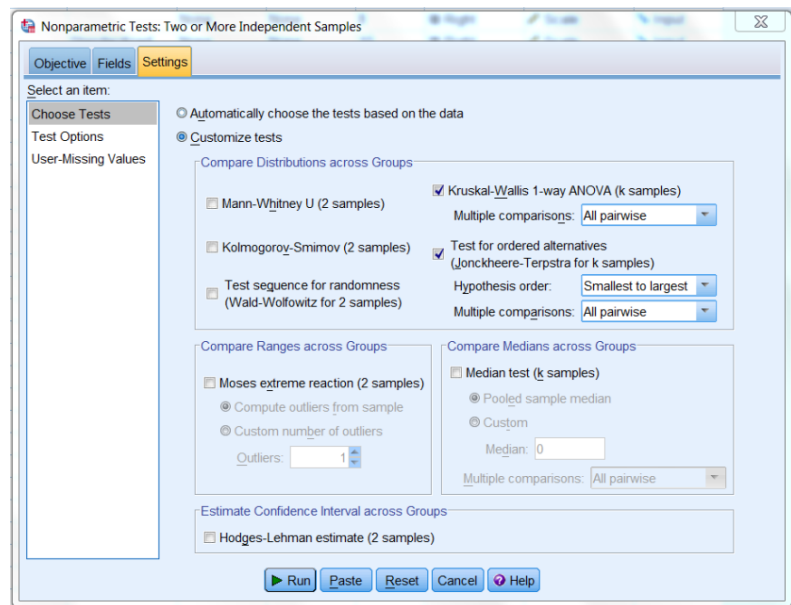
Comments

- Multiple t-tests should **not** be performed before a one-way ANOVA, although post-hoc tests are, in essence, t-tests

- It is possible to perform a one-way ANOVA with different sample sizes per group

References

Field, A. (2009) *Discovering Statistics using SPSS (And sex and drugs and rock 'n' roll)*, 3rd ed., London: SAGE.

Glass, G. V., Peckham, P. D. and Sanders, J. R. (1972) Consequences of failure to meet assumptions underlying the fixed effects analyses of variance and covariance, *Review of Educational Research*, 42(3), pp. 237-288.