One-way between groups ANOVA with post-hoc tests

Based on Pallant (2016)

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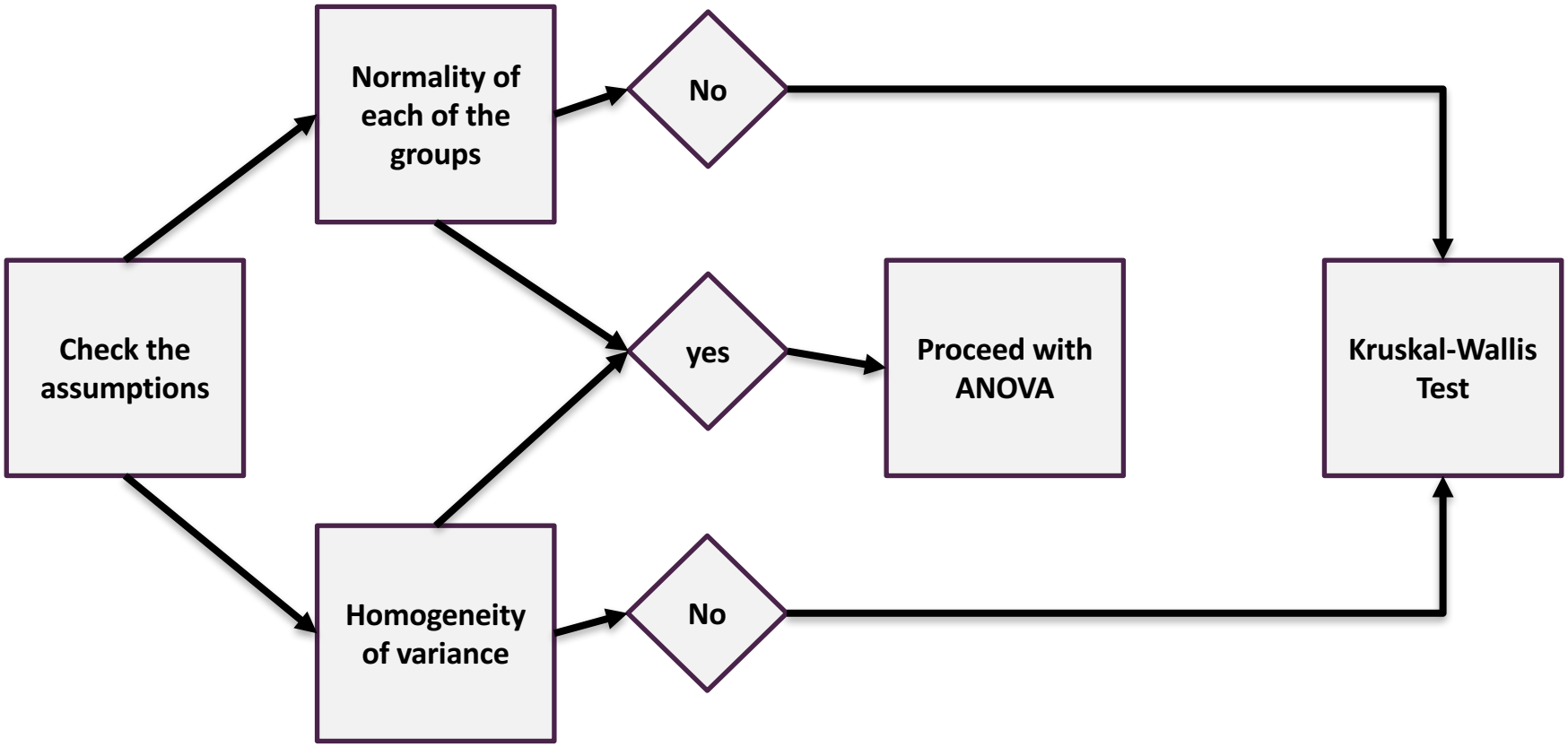
General assumptions

- Normal distribution
  - It is the normality of of the variable relevant to each group included in the test.
- Homogeneity of variance
  - This means that the variability of scores for each of the groups is similar. This will be discussed when we deal with T-tests.

How to decide on one-way ANOVA



One-way analysis of variance with post-hoc tests

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- It is used when we want to compare the mean scores of more than two groups.
- It involves one independent variable (referred to as a factor), which has a number of different levels.
- Analysis of variance is so called because it compares the variance (variability in scores) *between* the different groups (believed to be due to the independent variable) with the variability *within* each of the groups (believed to be due tochance).
- An F ratio is calculated which represents the variance between the groups, divided by the variance within the groups.
- F ratio does not, however, tell us which of the groups differ. For this we need to conduct post-hoc tests.

One-way analysis of variance with post-hoc tests

- We are going to discuss two different types of one-way ANOVA:
  - Between-groups analysis of variance, which is used when you have different subjects or cases in each of your groups (this is referred to as an independent groups design).
  - Repeated-measures analysis of variance, which is used when you are measuring the same subjects under different conditions (or measured at different points in time) (this is also referred to as a within-subjects design).

One-way between-groups ANOVA with post-hoc tests

- Non-parametric alternative: Kruskal-Wallis Test.
- Example from survey.sav data file.
- Research Question
  - Is there a difference in optimism scores for young, middle-aged and old subjects?

File name	Variable name	Variable label	Coding instructions
survey.sav	Toptim	Total optimism	Total score on the Optimism scale. Scores can range from 6 to 30 with high scores indicating higher levels of optimism.
	Agegp3	Agegp3	This variable is a recoded variable, dividing age into three equal groups (see instructions for how to do this in Chapter 8): Group 1: 18–29 = 1 Group 2: 30–44 = 2 Group 3: 45+ = 3

Normality assessment

- Analyse-Descriptive Statistics-Explore.
- Move the variable “Agep3” to the Factor list.
- Move the variable “Toptim” to the dependent list.
- Click on plots- de-select Stem-and-Leaf>> Select Histogram>>Select Normality plots with tests.
- Are the data for each of the age groups normally distributed?

Let’s proceed with the test for the sake of practice.

Procedure

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Procedure for one-way between-groups ANOVA with post-hoc tests

1. From the menu at the top of the screen click on: **Analyze**, then click on **Compare Means**, then on **One-way ANOVA**.
2. Click on your dependent (continuous) variable (e.g. Total optimism). Move this into the box marked **Dependent List** by clicking on the arrow button.
3. Click on your independent, categorical variable (e.g. agegp3). Move this into the box labelled **Factor**.
4. Click the **Options** button and click on **Descriptive**, **Homogeneity of variance test, Brown-Forsythe, Welsh** and **Means Plot**.
5. For **Missing values**, make sure there is a dot in the option marked **Exclude cases analysis by analysis**. If not, click on this option once. Click on Continue.
6. Click on the button marked **Post Hoc**. Click on **Tukey**.
7. Click on **Continue** and then **OK**.

Interpretation of the results

Have a look at the mean and standard deviation for each of your groups.
Check the number of people in each group (N). Always check these values first. Do they seem right? Are there a lot of missing
data? If so, find out why. Perhaps you have entered the wrong code for males and females (0 and 1, rather than 1 and 2). Check with your codebook.

Descriptives

Total Optimism

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
18-29	147	21.36	4.55	.38	20.62	22.10	7	30
30-44	153	22.10	4.15	.34	21.44	22.77	10	30
45+	135	22.96	4.49	.39	22.19	23.72	8	30
Total	435	22.12	4.43	.21	21.70	22.53	7	30

Interpretation of the results

Test of homogeneity of variances

Check the significance value (Sig.) for Levene's test. If this number is greater than .05 (e.g. .08, .12, .28), then you have not violated the assumption of homogeneity of variance. In this example the Sig. value is .475. As this is greater than .05, we have not violated the homogeneity of variance assumption. If you have found that you violated this assumption you will need to consult the table in the output headed Robust Tests of Equality of Means. The two tests shown there (Welsh and Brown-Forsythe) are preferable when the assumption of the homogeneity of variance is violated.

Test of Homogeneity of Variances

Total Optimism

Levene Statistic	df1	df2	Sig.
.746	2	432	.475

Interpretation of the results

Check the ANOVA Table

If the Sig. value is less than or equal to .05 (e.g. .03, .01, .001), then there is a significant difference somewhere among the mean scores on your dependent variable for the three groups. This does not tell you which group is different from which other group. The statistical significance of the differences between each pair of groups is provided in the table labelled **Multiple Comparisons**, which gives the results of the post-hoc tests.

In this example the overall Sig. value is .01, which is less than .05, indicating a statistically significant result somewhere among the groups. Having received a statistically significant difference, we can now look at the results of the post-hoc tests that we requested.

ANOVA

Total Optimism

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	179.069	2	89.535	4.641	.010
Within Groups	8333.951	432	19.292		
Total	8513.021	434			

Robust Tests of Equality of Means

Interpretation of the results

You should look at this table only if you found a significant difference in your overall ANOVA. That is, if the Sig. value was equal to or less than .05. The post-hoc tests in this table will tell you exactly where the differences among the groups occur. Look down the column labelled **Mean Difference**. Look for any asterisks (*) next to the values listed. If you find an asterisk, this means that the two groups being compared are significantly different from one another at the p<.05 level. The exact significance value is given in the column labelled **Sig**. In the results presented above, only group 1 and group 3 are statistically significantly different from one another. That is, the 18–29 age group and the 45+ age group differ significantly in terms of their optimism scores.

Multiple Comparisons

Dependent Variable: Total Optimism

Tukey HSD

(I) AGEGP3	(J) AGEGP3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
18-29	30-44	-.74	.51	.307	-1.93	.44
	45+	-1.60*	.52	.007	-2.82	-.37
30-44	18-29	.74	.51	.307	-.44	1.93
	45+	-.85	.52	.229	-2.07	.36
45+	18-29	1.60*	.52	.007	.37	2.82
	30-44	.85	.52	.229	-.36	2.07

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

Calculate the size of effect

The resulting eta squared value is .02,

Always interpret your results carefully, taking into account all the information you have available. Don't rely too heavily on statistical significance—many other factors also need to be considered.

$$\text{Eta squared} = \frac{\text{Sum of squares between-groups}}{\text{Total sum of squares}}$$

ANOVA

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Robust Tests of Equality of Means

Reporting the results

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A one-way between-groups analysis of variance was conducted to explore the impact of age on levels of optimism, as measured by the Life Orientation test (LOT). Subjects were divided into three groups according to their age (Group 1: 29 or less; Group 2: 30 to 44; Group 3: 45 and above). There was a statistically significant difference at the $p<.05$ level in LOT scores for the three age groups [$F(2, 432)=4.6$, $p=.01$]. Despite reaching statistical significance, the actual difference in mean scores between the groups was quite small. The effect size, calculated using eta squared, was .02. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Group 1 ($M=21.36$, $SD=4.55$) was significantly different from Group 3 ($M=22.96$, $SD=4.49$). Group 2 ($M=22.10$, $SD=4.15$) did not differ significantly from either Group 1 or 3.

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Robust Tests of Equality of Means

Reporting the results>>>Cont.

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From the Descriptive Table

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Multiple Comparisons

Dependent Variable: Total Optimism

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