

Introduction to Analysis of Variance

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Objectives

Participants to be able to:

1. Understand when to apply ANOVA
2. Run ANOVA using SPSS and interpret the results

Requirement

- ▶ DV – Interval or ratio
- ▶ IV – Nominal or ordinal ($k > 2$)

Assumptions

1. The dependent variable is **normally distributed** for each of the populations as defined by the different levels of the factor (independent variable)
2. The variances of the dependent variable are the same for all populations (**homogeneity of variance**)
3. The cases represent **random samples** from the populations and the scores on the test variable are independent of each other

Homogeneity of Variance Test

H₀: $\sigma_1^2 = \sigma_2^2 = \dots = \sigma_k^2$

H_A: Not all variances are equal

Use Levene Statistics to test on the assumption:

The assumption is fulfilled if:

$$\text{sig-Levene } (p) > \alpha$$

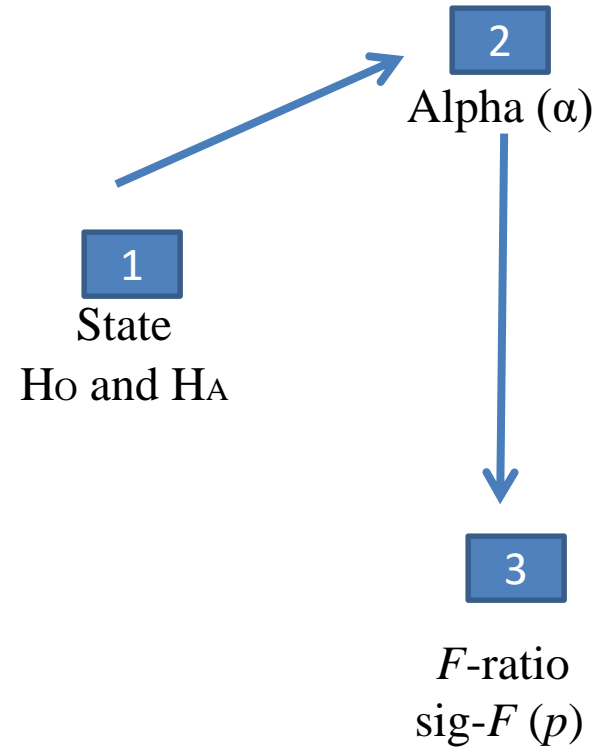
The assumption is violated if:

$$\text{sig-Levene } (p) < \alpha$$

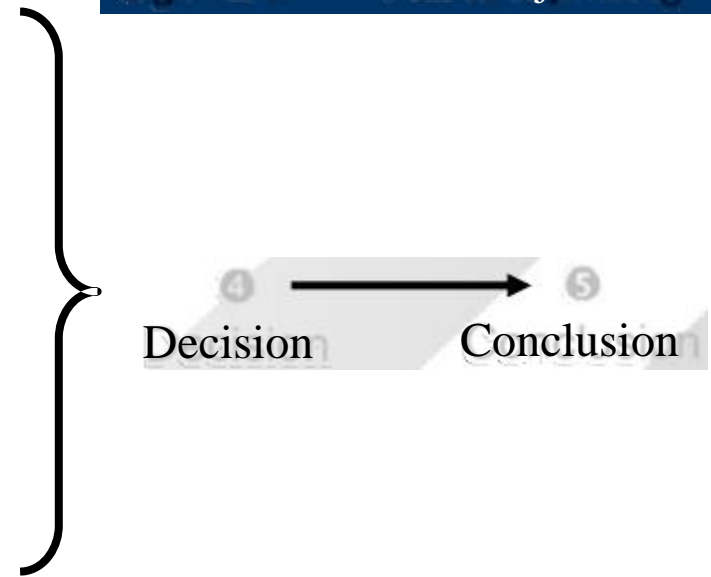


What is possible outcome?

Hypothesis Test



Criteria	Decision
$\text{sig-}F < \alpha$	Reject H_0
$\text{sig-}F \geq \alpha$	Fail to reject H_0



Step 1: Hypotheses

H₀: $\mu_1 = \mu_2 = \mu_3$

H_A: Not all means are equal

Step 2: Significance level

Set the significance level (alpha)

Generally in social science $\alpha=.05$

Step 3: Test statistic

Report the test statistic (*F*-ratio)

Decision based on sig-*F*

Step 4: Decision

Whether to Reject OR
Fail to reject H_0

<i>Criteria</i>	<i>Decision</i>
$\text{sig-}F < \alpha$	Reject H_0
$\text{sig-}F \geq \alpha$	Fail to reject H_0

Step 5: Conclusion

Reject H_0 :

Significant difference between the groups

Fail to reject H_0 :

No significant difference between the
groups

Post-hoc comparison

- To determine pair of groups that are significantly different
- Tukey's HSD (Honestly Significant Difference)

working Examples



Data on perception toward management was gathered from a randomly selected sample comprising of three employee groups (supervisory, line and support). Test the difference in perception among the three groups at .05 level of significance.

Data set:

1. State the appropriate null and alternative hypotheses
2. Report the value of the test statistic
3. State your decision and conclusion; and justify your answer

	<i>Group</i>		
	<u><i>Sup</i></u>	<u><i>Lin</i></u>	<u><i>Spt</i></u>
	34	24	14
	27	23	23
	25	25	16
	33	18	21
	27	23	20
	35	24	17
	32	21	16
	29	18	24
	31	17	22
		18	23

Define Variables

ANOVA 1.sav - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns
1	Y	Numeric	8	2	Perception toward	None	None	8
2	X	Numeric	8	2	Employee groups	{1.00, Supervis	None	8
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Data View Variable View /

SPSS Processor is ready

Enter Data

ANOVA 1.sav - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

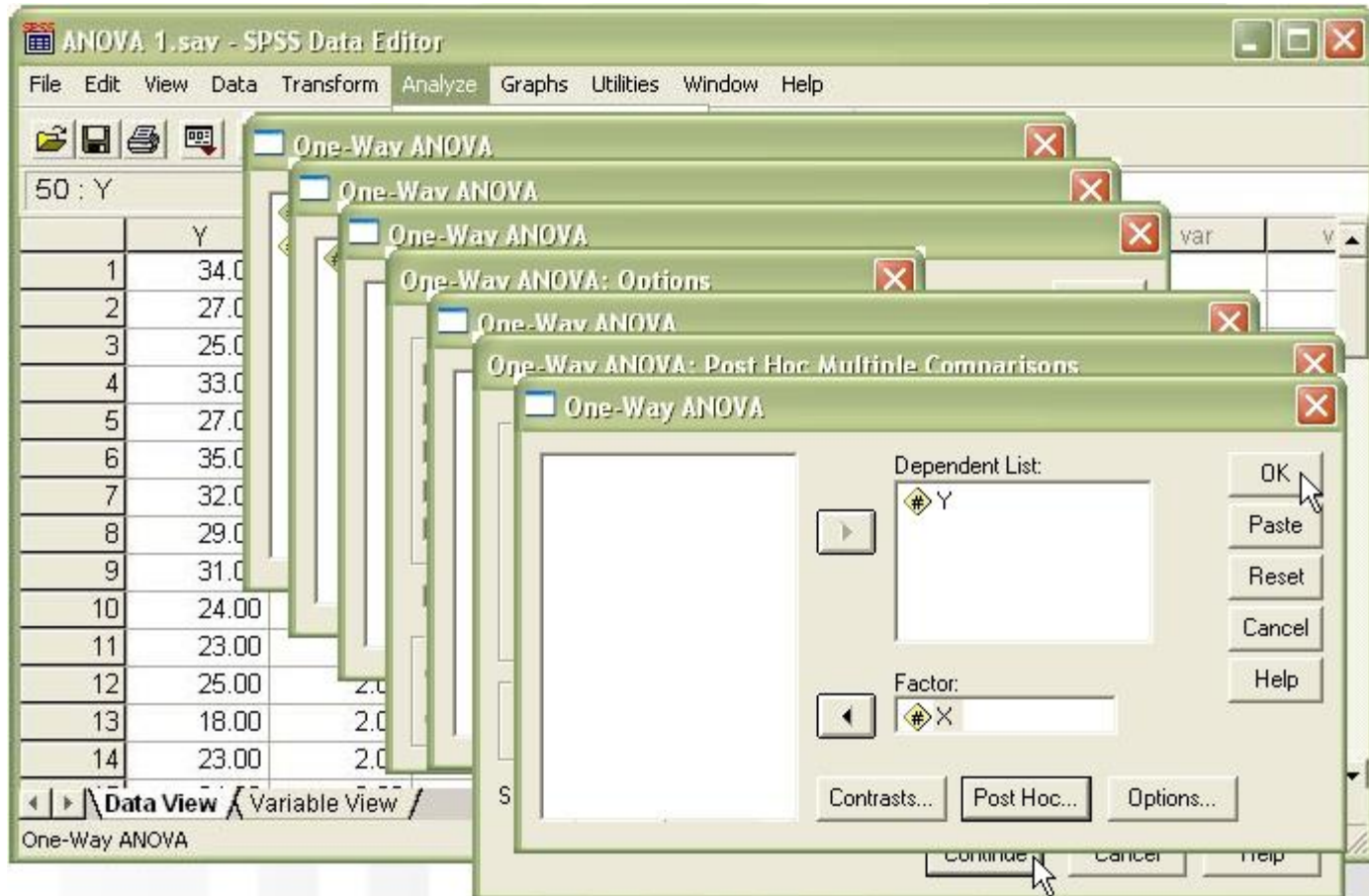
50 : Y

	Y	X	var	var	var	var	var	var	v
1	34.00	1.00							
2	27.00	1.00							
3	25.00	1.00							
4	33.00	1.00							
5	27.00	1.00							
6	35.00	1.00							
7	32.00	1.00							
8	29.00	1.00							
9	31.00	1.00							
10	24.00	2.00							
11	23.00	2.00							
12	25.00	2.00							
13	18.00	2.00							
14	23.00	2.00							

Data View / Variable View /

SPSS Processor is ready

Oneway ANOVA Procedure



Descriptives

X

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1.00	9	30.3333	3.50000	1.16667	27.6430	33.0237
2.00	10	21.1000	3.07137	.97125	18.9029	23.2971
3.00	10	19.6000	3.56526	1.12744	17.0496	22.1504
Total	29	23.4483	5.75442	1.06857	21.2594	25.6371

Test of Homogeneity of Variances

X

Levene Statistic	df1	df2	Sig.
.194	2	26	.825

ANOVA

X

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	629.872	2	314.936	27.542	.000
Within Groups	297.300	26	11.435		
Total	927.172	28			

Multiple Comparisons

Dependent Variable: X

Tukey HSD

(I) GRP	(J) GRP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	9.2333*	1.55370	.000	5.3726	13.0941
	3.00	10.7333*	1.55370	.000	6.8726	14.5941
2.00	1.00	-9.2333*	1.55370	.000	-13.0941	-5.3726
	3.00	1.5000	1.51226	.588	-2.2578	5.2578
3.00	1.00	-10.7333*	1.55370	.000	-14.5941	-6.8726
	2.00	-1.5000	1.51226	.588	-5.2578	2.2578

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

Hypotheses

H₀: $\mu_1 = \mu_2 = \mu_3$

H_A: Not all means are equal

Table 1: Results of Analysis of Variance between perception and employee groups

Groups	<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>F</i>	<i>p</i>
Supervisory	9	30.33	3.50	27.542	.000
Line	10	21.1	3.07		
Support	10	19.6	3.57		

$F(2, 26) = 27.542, p = .000$

Since $\text{sig-}F (.000) < \alpha (.05)$

<i>Criteria</i>	<i>Decision</i>
$\text{sig-}F < \alpha$	Reject H_0
$\text{sig-}F \geq \alpha$	Fail to reject H_0

∴ Reject the null hypothesis

Conclude that there is a significant difference in perception towards management between the three employee groups at .05 level of significance.

In addition, results of post-hoc comparisons reveal a significant difference between:

1. Supervisory and line worker
2. Supervisory and support

Dr Irwan is interested to test the differences in public speaking skill among three student groups (Engineering, Education and Communication). Data collected from a randomly selected sample follow.

Test the hypothesis at .01 level of significance

Data set:

	<i>Groups</i>		
	<i>Eng</i>	<i>Edu</i>	<i>Com</i>
	23	24	30
	26	25	28
	22	23	29
	22	26	26
	25	31	24
	26	27	25
	23	24	27
	27	25	28
	23	22	
		21	
		24	

1. State the appropriate null and alternative hypotheses
2. Report the value of the test statistic
3. State your decision and conclusion; and justify your answer

Descriptives

Public speaking scores

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Engineering	9	24.1111	1.90029	.63343	22.6504	25.5718	22.00	27.00
Education	11	24.7273	2.68667	.81006	22.9223	26.5322	21.00	31.00
Communication	8	27.1250	2.03101	.71807	25.4270	28.8230	24.00	30.00
Total	28	25.2143	2.52919	.47797	24.2336	26.1950	21.00	31.00

Test of Homogeneity of Variances

Public speaking scores

Levene Statistic	df1	df2	Sig.
.104	2	25	.902

ANOVA

Public speaking scores

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.769	2	21.384	4.114	.029
Within Groups	129.946	25	5.198		
Total	172.714	27			

Hypotheses

H₀: $\mu_1 = \mu_2 = \mu_3$

H_A: Not all means are equal

Table 2: Results of Analysis of Variance between Public Speaking Scores and student groups

Groups	<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>F</i>	<i>p</i>
Engineering	9	24.11	1.90	4.114	.029
Education	11	24.73	2.69		
Communication	8	27.13	2.03		

$F(2, 25) = 4.114, p = .029$

Since $\text{sig-}F (.029) > \alpha (.01)$

∴ Fail to reject the null hypothesis

Conclude that there is no significant difference in public speaking scores between the three student groups at .01 level of significance.

<i>Criteria</i>	<i>Decision</i>
$\text{sig-}F < \alpha$	Reject H_0
$\text{sig-}F \geq \alpha$	Fail to reject H_0

Application Exercise

Data Set 3:

Based on the above data set, identify the appropriate variables to run for Analysis of Variance

For test:

1. State the appropriate null and alternative hypotheses
2. Report the value of the test statistic
3. State your decision and conclusion; and justify your answer

Hypothesis

H₀:

H_A:

Table 3: Results of ANOVA between Marital Status and Job Performance

Groups	<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>F</i>	<i>p</i>
Bachelor	—	—	—	—	—
Married	—	—	—	—	—
Widowed	—	—	—	—	—

Decision and justification

Conclusion

Criteria

$\text{sig-}t < F$

$\text{sig-}t \geq F$

Decision

Reject H_0

Fail to reject H_0

Data Set: Hatco

Based on the above data set, identify the appropriate variables to run for Analysis of Variance

For the test:

1. State the appropriate null and alternative hypotheses
2. Report the value of the test statistic
3. State your decision and conclusion; and justify your answer

Hypothesis

H₀:

H_A:

Table 3: Results of ANOVA between Type of Buying Situation and Satisfaction

Groups	<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>F</i>	<i>p</i>
New task	—	—	—	—	—
Modified rebuy	—	—	—	—	—
Straight rebuy	—	—	—	—	—

Decision and justification

Conclusion

Criteria

$\text{sig-}t < F$

$\text{sig-}t \geq F$

Decision

Reject H_0

Fail to reject H_0