

# Multiple Comparison Procedures To A Control

## For AN(C)OVA Models

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## Basic Information

Automatic statistics for the file:

File
warpbreaks.csv

Your selection for the encoding: UTF-8

Your selection for the decimal character: .

Observations (rows with at least one non-missing value): 54

Variables (columns with at least one non-missing value): 3

Variables considered continuous: 1

Variables considered continuous
breaks

Variables considered categorical: 2

Variables considered categorical
wool
tension

## Model Information

You defined the following linear model:  $\text{breaks} \sim \text{wool} * \text{tension}$

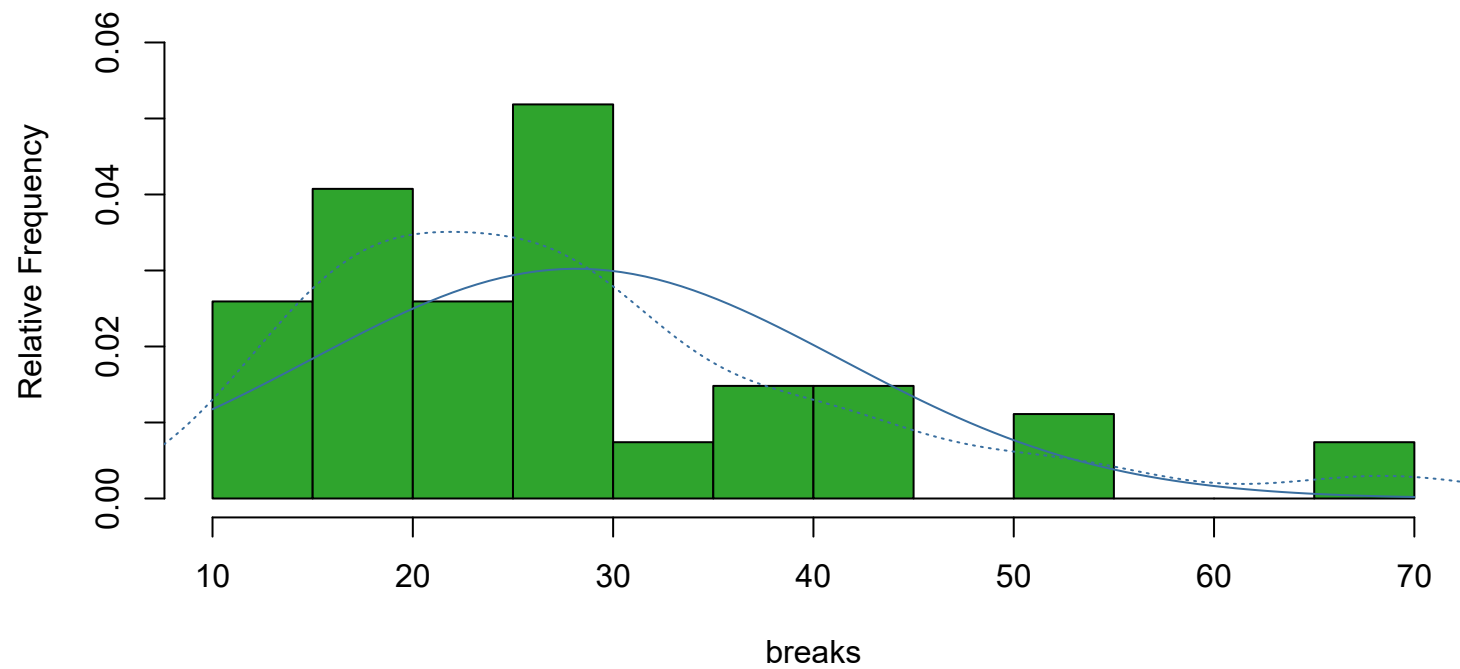
You are interested in the factor: tension

You are interested in pairwise comparisons to the control factor level: L

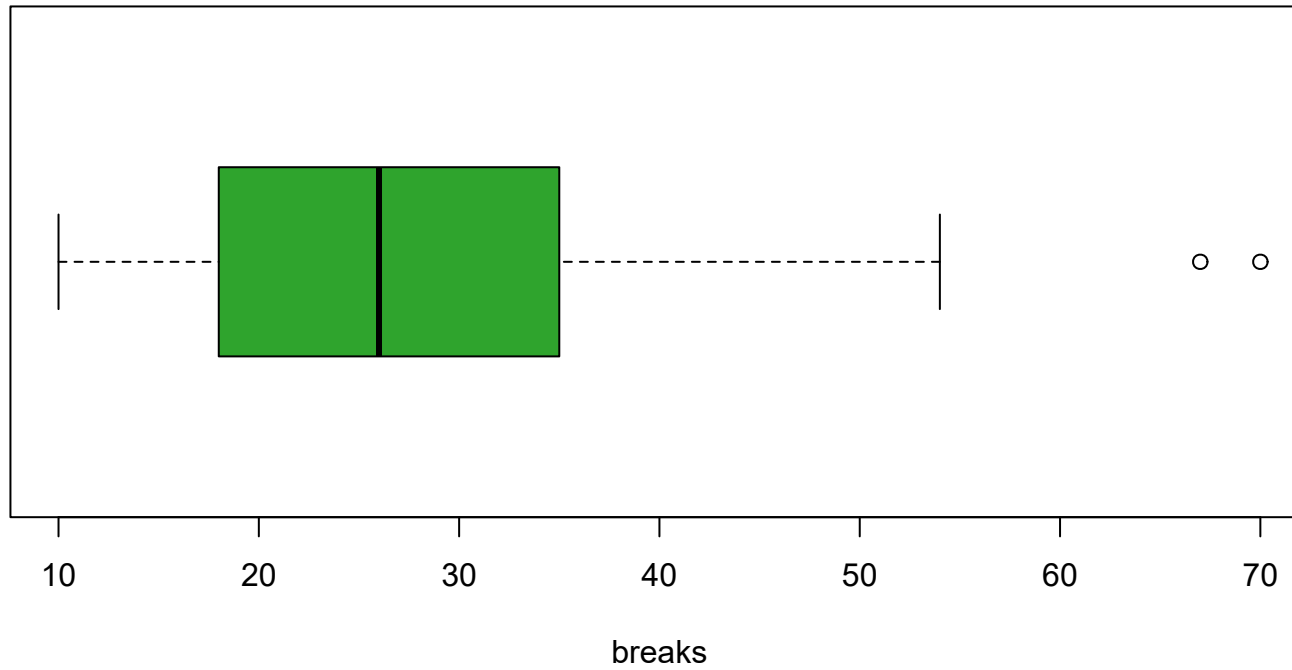
## Descriptive Plots

### Dependent Variable

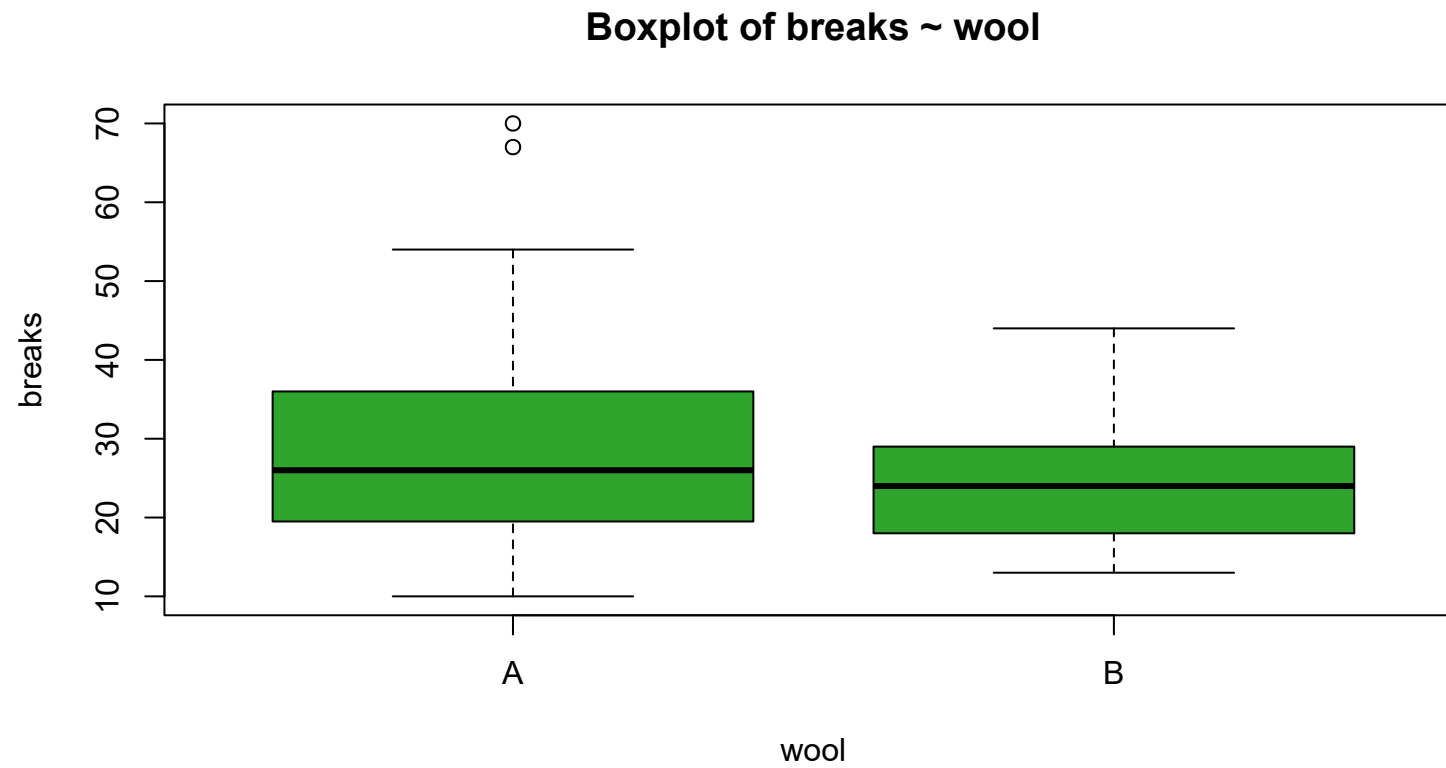
**Histogram of breaks**



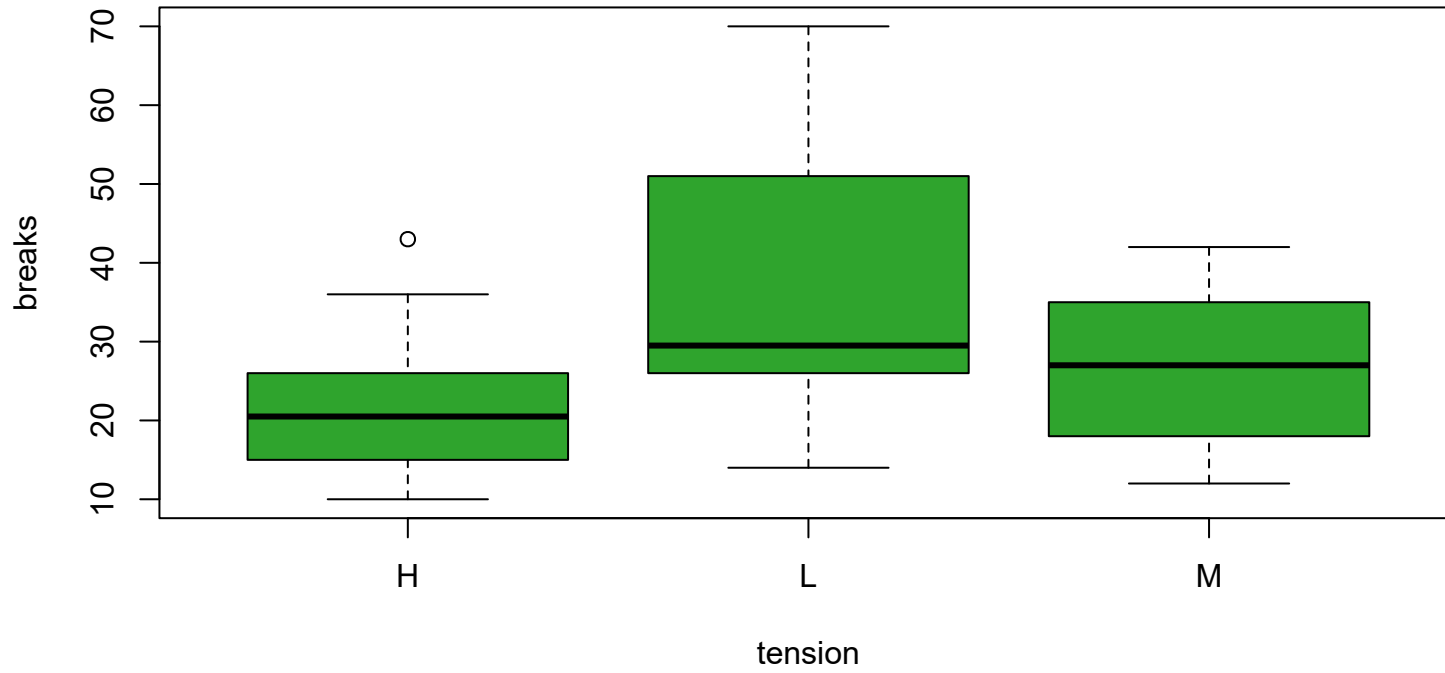
**Boxplot of breaks**



## Dependent Against Categorical Factors



**Boxplot of breaks ~ tension**



## Interaction Plot for Factors

Note: The more parallel the lines, the less likely is the significance of the interaction of the factors.

**Interaction Plot of wool and tension**

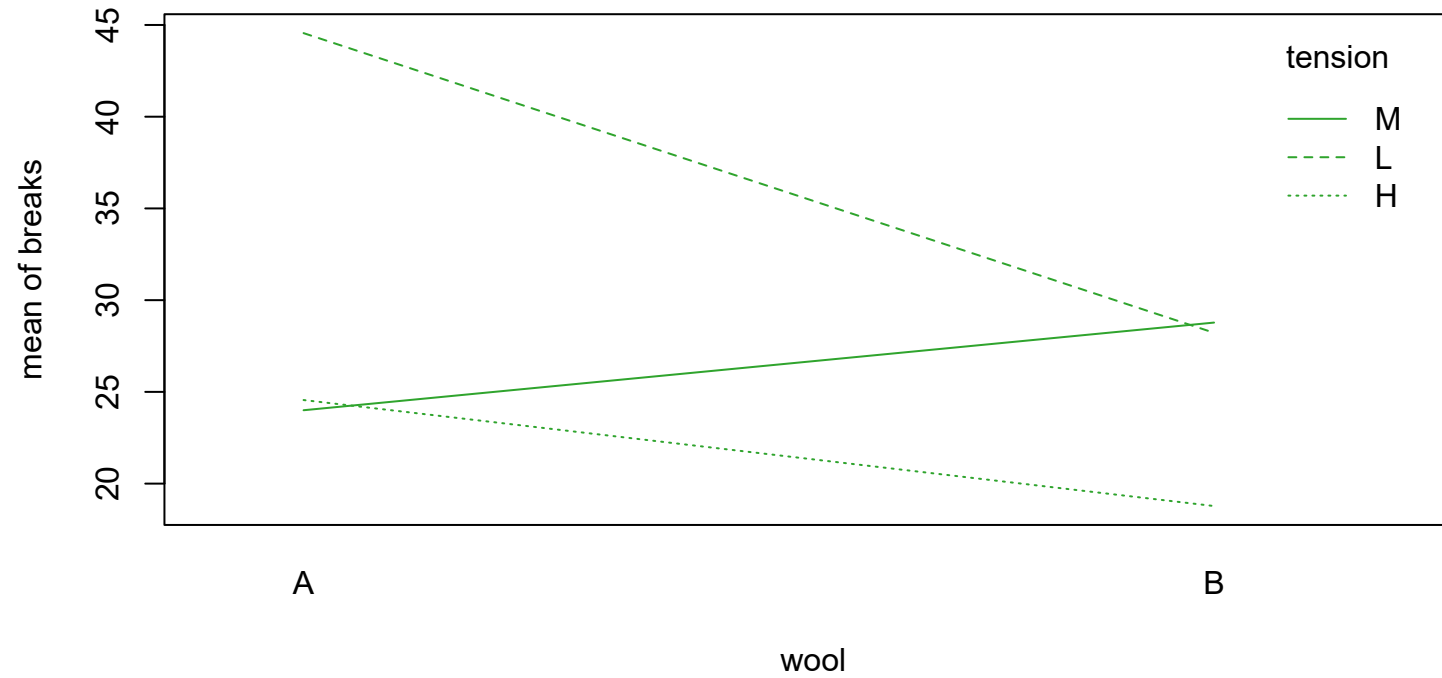


Table 4: Parameter Estimates

Variable	Value	Std.Error	t.value	pvalue	sign. level <sup>1</sup>	Significance at 5 percent error
(Intercept)	28.15	1.49	18.91	<0.001	***	Intercept Significant.
wool1	2.89	1.49	1.94	0.058	.	Not Significant. No difference between the effect of wool1 and its reference.
tension1	8.24	2.11	3.91	<0.001	***	Significant. A Difference between the effect of tension1 and its reference.
tension2	-6.48	2.11	-3.08	0.003	**	Significant. A Difference between the effect of tension2 and its reference.
wool1:tension1	5.28	2.11	2.51	0.016	*	Interaction Significant. Effect wool1 vs. reference depends on tension1.
wool1:tension2	0.00	2.11	0.00	1		Interaction not Significant. Effect wool1 vs. reference don't depends on tension2.

<sup>1</sup> '\*\*\*': sign. to 0.1% error. '\*\*': sign. to 1% error. '\*': sign. to 5% error. ' . ': sign. to 10% error. ' ': not sign. ' - ': no statement.

## Anova Table (Type III tests)

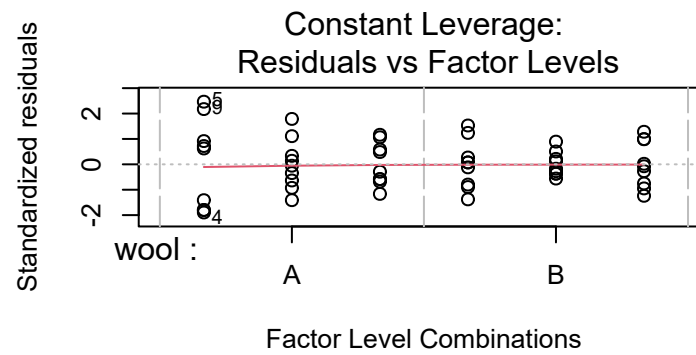
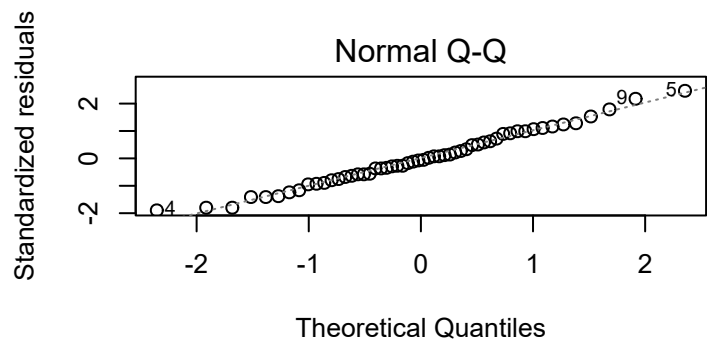
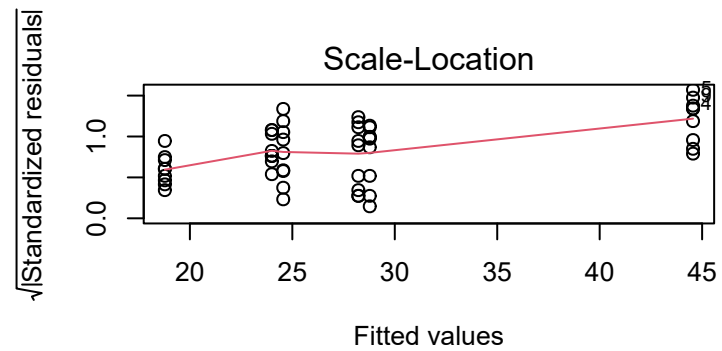
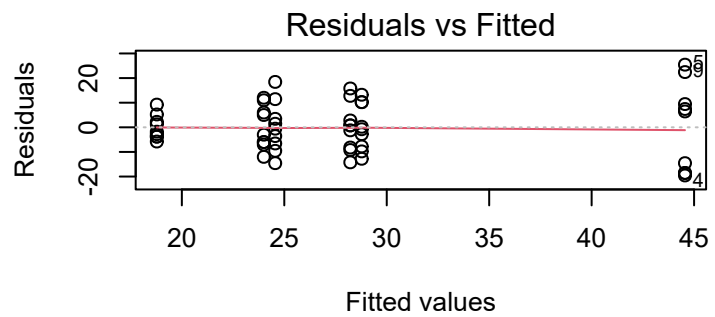
Response: breaks

	Sum Sq	Df	F value	Pr(>F)
(Intercept)	42785	1	357.4672	< 2.2e-16 ***
wool	451	1	3.7653	0.0582130 .
tension	2034	2	8.4980	0.0006926 ***
wool:tension	1003	2	4.1891	0.0210442 *
Residuals	5745	48		

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Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1





## Multiple Comparisons of Means to a Control

Testing several null hypotheses at the same time at the significance level  $\alpha$  increases the probability that at least one Type I error (false positive) will be made as the number of null hypotheses increases. This multiplicity problem is considered in multiple comparisons. In this case, the type I error is not controlled in every test for a null hypothesis, but the probability of at least one type I error in all tests is limited across all simultaneous tests. Using the adjusted p-value, the individual null hypotheses can be compared with the significance level  $\alpha$ . Without multiple adjustment, reproducibility cannot be established.

### Dunnet

Test whether the factor level L of the factor tension is different from the other levels. The Null Hypothesis is for example  $H - L = 0$ .

Table 5: Multiple Comparison: Dunnet Contrasts

Null Hypothesis	Value	Std.Error	T.value	adjusted P.value	Sign. level <sup>1</sup>	Significance at 5 percent Type I error
$H - L = 0$	-14.72	3.65	-4.04	<0.001	***	Significant. Level H of factor tension is significantly different than L <sup>3</sup>
$M - L = 0$	-10.00	3.65	-2.74	0.016	*	Significant. Level M of factor tension is significantly different than L <sup>3</sup>

<sup>1</sup> '\*\*\*': sign. to 0.1% error. '\*\*': sign. to 1% error. '\*': sign. to 5% error. '.' : sign. to 10% error. ' ': not sign. ' - ': no statement.

<sup>2</sup> H1 does not hold significantly.

<sup>3</sup> H1 holds significantly.

Simultaneous Confidence Intervals which includes the true value of the difference between the reference level L and the other levels of tension

Table 6: Simoultaneous Confidence Intervals: Dunnet Contrasts

Null Hypothesis	Value	Lower bound	Upper bound	Interpretation
$H - L = 0$	-14.72	-23.03	-6.41	The interval (-23.03, -6.41) traps the true difference H-L with probability 95 percent. <sup>1</sup>
$M - L = 0$	-10.00	-18.31	-1.69	The interval (-18.31, -1.69) traps the true difference M-L with probability 95 percent. <sup>1</sup>

<sup>1</sup> Remark: Zero is not in the confidence interval.

<sup>2</sup> Remark: Zero is in the confidence interval.

## References

- Fox, John, and Sanford Weisberg. 2019. *An R Companion to Applied Regression*. Third. Thousand Oaks CA: Sage. <https://socialsciences.mcmaster.ca/jfox/Books/Companion/>.
- Gross, Juergen, and Uwe Ligges. 2015. *Nortest: Tests for Normality*. <https://CRAN.R-project.org/package=nortest>.
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- Zeileis, Achim, and Torsten Hothorn. 2002. "Diagnostic Checking in Regression Relationships." *R News* 2 (3): 7–10. <https://CRAN.R-project.org/doc/Rnews/>.