

# community project

encouraging academics to share statistics support resources

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stcp-karadimitriou-KruskalR

The following resources are associated: Dataset reaction.csv, Kruskal-Wallis script file, Summarising continuous variables in R, ANOVA in R, Wilcoxon in R

## Kruskal-Wallis in R (Non-parametric equivalent to ANOVA)

**Research question type:** Differences between several groups of measurements

**Dependent variable:** Continuous (scale) but not normally distributed or ordinal

**Independent variable:** Categorical

**Common Applications:** Comparing the mean rank of three or more different groups in scientific or medical experiments when the dependent variable is ordinal or is not normally distributed.

**Descriptive statistics:** Median for each group and box-plot

**Data:** Alcohol, coffee and reaction times

ID	Reaction		Rank
	Time	Drink	
1	0.37	Water	1
2	0.38	Water	2
3	0.61	Water	3
4	0.78	Water	4
5	0.83	Water	5
6	0.86	Water	6
7	0.9	Water	7
8	0.95	Water	8
11	0.98	Coffee	9
12	1.11	Coffee	10
13	1.27	Coffee	11
14	1.32	Coffee	12
15	1.44	Coffee	13
16	1.45	Coffee	14
17	1.46	Coffee	15
9	1.63	Water	16
21	1.69	Alcohol	17
22	1.71	Alcohol	18
23	1.75	Alcohol	19
18	1.76	Coffee	20
24	1.83	Alcohol	21
10	1.97	Water	22.5
25	1.97	Alcohol	22.5
26	2.53	Alcohol	24
19	2.56	Coffee	25
27	2.66	Alcohol	26
28	2.91	Alcohol	27
20	3.07	Coffee	28
29	3.28	Alcohol	29
30	3.47	Alcohol	30

An experiment was carried out to see if alcohol or coffee affects driving reaction times. There were three different groups of participants; 10 drinking water, 10 drinking beer containing two units of alcohol and 10 drinking coffee. Reaction time on a driving simulation was measured for each participant.

The sample sizes are small and normality checks showed that the assumption of normality had not been met so an ANOVA is not suitable for comparing the groups. The **Kruskal-Wallis** test is the non-parametric equivalent to one-way ANOVA.

Non-parametric tests are based on ranks rather than the original variable values. The Kruskal-Wallis test ranks the scores for the whole sample e.g. fastest reaction time irrelevant of group would be ranked 1 and the slowest 30 for this example. Tied ranks occur when two individuals have the same score e.g. the reaction time of person 10 and 25 is the same so rather than ranking them 22<sup>nd</sup> and 23<sup>rd</sup>, an average rank of 22.5 is given to both. The average rank for each group is calculated and compared.

## Steps in R

Download the dataset *reaction.csv* and save it on your computer. In order to import the file into R, use the command, changing the directory to where the dataset is saved.

```
reactionR<-read.csv('C:\\...\\reaction.csv',header=T)
```

Type `reactionR` to view the data then attach the data to use variable names directly using `attach(reactionR)`

Tell R that 'Drink' is categorical using `Drink<-as.factor(Drink)`

Note: If you need to label numeric categories, use the

```
factor (variable,c(numbers),labels=(value labels))
```

command instead.

## Summary Statistics

For non-parametric tests the median and interquartile range are used for describing differences and spread. To find the medians per category use the `tapply(dependent,independent,summary statistic)` command.

Here the median is calculated:

```
> tapply(ReactionTime,Drink,median)
Alcohol Coffee Water
 2.250  1.445  0.845
```

The median scores show that reaction time after coffee and alcohol is higher than for those drinking just water.

Alternatively use the `summary` command which produces a number of summary statistics.

Request summary statistics of reaction time by group and give each summary a name.

```
Water_summary<-summary(ReactionTime[Drink=='Water'])
```

```
Coffee_summary<-summary(ReactionTime[Drink=='Coffee'])
```

```
Alcohol_summary<-summary(ReactionTime[Drink=='Alcohol'])
```

Combine the results into one table and give it a name

```
compare1<-cbind(Water_summary,Coffee_summary,Alcohol_summary)
```

Then reduce the decimal

places for each summary

statistic to 2.

```
round(compare1,2)
```

	Water_summary	Coffee_summary	Alcohol_summary
Min.	0.37	0.98	1.69
1st Qu.	0.65	1.28	1.77
Median	0.84	1.45	2.25
Mean	0.93	1.64	2.38
3rd Qu.	0.94	1.68	2.85
Max.	1.97	3.07	3.47

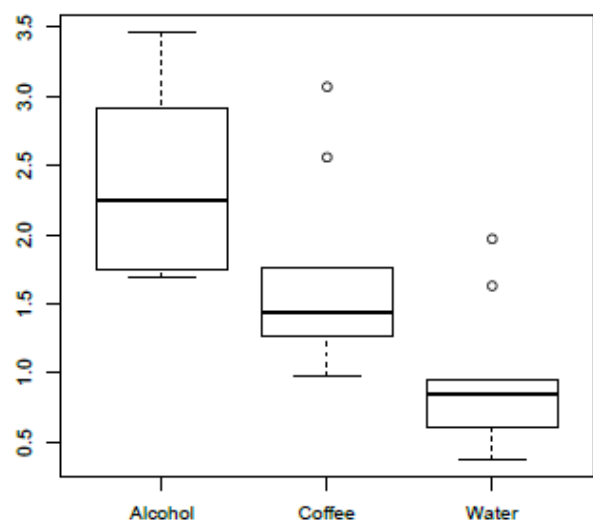
A boxplot summarises this information using the quartiles, median and minimum/maximum values. To generate a boxplot, use the

```
boxplot(dependent~independent)
```

command.

```
boxplot(ReactionTime~Drink)
```

The boxplot compares the medians and spread the data by group. Those having 2 units of alcohol have a higher median and the middle of 50% of the values (contained in



the box) are more spread out than the other groups.

## Carrying out the Kruskal-Wallis test

The format is pretty much the same as ANOVA. We use the `kruskal.test()` command. On the left side of the `~` we always use the dependent variable that we want to compare and on the right side we always use the independent (categorical) variable.

```
kruskal.test(ReactionTime~Drink)
```

This gives the following basic output for the Kruskal-Wallis test:

```
> kruskal.test(ReactionTime~Drink)

      Kruskal-Wallis rank sum test

data:  ReactionTime by Drink
Kruskal-Wallis chi-squared = 16.3217, df = 2, p-value = 0.0002856
```

As the  $p$ -value  $< 0.001$ , there is very strong evidence to suggest a difference between at least one pair of groups but which pairs? To find out produce pairwise Wilcoxon signed rank comparisons for each pair of groups.

## Pairwise Comparisons

As multiple tests are being carried out, an adjustment to the  $p$ -value is needed to keep the overall type 1 error down. The simplest adjustment is the *Bonferroni adjustment* `p.adj='bonferroni'` which multiplies each Wilcoxon signed rank  $p$ -value by the total number of Wilcoxon tests being carried out (here it is 3) while the `exact=F` stands for the asymptotic test which allows tied ranks. Use this command to produce the pairwise tests with Bonferroni correction.

```
pairwise.wilcox.test(ReactionTime,Drink,p.adj='bonferroni',exact=F)
```

```
> pairwise.wilcox.test(ReactionTime, Drink, p.adj="bonferroni", exact=F)

      Pairwise comparisons using Wilcoxon rank sum test

data:  ReactionTime and Drink

      Alcohol Coffee
Coffee 0.042    -
Water  0.002    0.027

P value adjustment method: bonferroni
```

The pairwise comparisons show the results of the Wilcoxon tests on each pair of groups. The adjusted  $p$ -values are shown for each pair in the output e.g. the  $p$ -value for Alcohol vs Coffee is 0.042. All the  $p$ -values for the tests comparing the water, alcohol and coffee pairwise are significant ( $p$ -value  $< 0.05$ ).

### Reporting the results:

A Kruskal-Wallis test was carried out to compare reaction times after drinking water, coffee or alcohol. There was very strong evidence of a difference ( $p$ -value  $< 0.001$ ) between the mean ranks of at least one pair of groups. Wilcoxon signed rank pairwise tests were carried out for the three pairs of groups. There was very strong evidence ( $p$ -value  $< 0.05$ , adjusted using the Bonferroni correction) of all the differences between the groups. The median reaction time for the group having water was 0.85 seconds compared to 2.25 seconds in the group consuming two units of alcohol, while for coffee was 1.45.