

# How to use Fisher's Least Significant Difference (LSD) in R?

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## RECOMMENDED CITATION

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LSD is used to determine whether or not there is a statistically significant difference between the means of three or more independent groups.

The tests used in a one-way ANOVA are as follows:

**H<sub>0</sub>**: The means are equal for each group.

**H<sub>A</sub>**: At least one of the means is different from the others.

If the  $F$  from the ANOVA is less than some significance level (like  $\alpha = .05$ ), we can reject the null hypothesis and conclude that at least one of the group means is different from the others.

But in order to find out exactly which groups are different from each other, we must conduct a post-hoc test.

One commonly used post-hoc test is **Fisher's least significant difference (LSD) test**.

You can use the **LSD.test()** function from the **agricolae** package to perform this test in R.

The following example shows how to use this function in practice.

### Example: Fisher's LSD Test in R

Suppose a professor wants to know whether or not three different studying techniques lead to different exam scores among students.

To test this, she randomly assigns 10 students to use each studying technique and records their exam scores.

The following table shows the exam scores for each student based on the studying technique they used:

Technique 1	Technique 2	Technique 3
72	81	77
73	82	78
73	83	79
77	83	88
82	83	89
82	84	90
83	87	91
84	90	95
85	92	95
89	93	98

We can use the following code to create this dataset and perform a one-way ANOVA on it in R:

**#create data frame**

```
df <- data.frame(technique = rep(c("tech1", "tech2", "tech3"), each = 10),
score = c(72, 73, 73, 77, 82, 82, 83, 84, 85, 89,
81, 82, 83, 83, 83, 84, 87, 90, 92, 93,
77, 78, 79, 88, 89, 90, 91, 95, 95, 98))
```

```
#view first six rows of data frame
head(df)
```

```
technique score
```

```
1 tech1 72
2 tech1 73
3 tech1 73
4 tech1 77
5 tech1 82
6 tech1 82
```

```
#fit one-way ANOVA
```

```
model <- aov(score ~ technique, data = df)
```

```
#view summary of one-way ANOVA
```

```
summary(model)
```

```
Df Sum Sq Mean Sq F value Pr(>F)
technique 2 341.6 170.80 4.623 0.0188 *
```

Residuals 27 997.6 36.95

---

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

Since the p-value in the ANOVA table (.0188) is less than .05, we can conclude that not all of the mean exam scores between the three groups are equal.

Thus, we can proceed to perform Fisher's LSD test to determine which group means are different.

### library(agricolae)

```
#perform Fisher's LSD
```

```
print(LSD.test(model,"technique"))
```

```
$statistics
```

```
MSerror Df Mean CV t.value LSD
```

```
36.94815 27 84.6 7.184987 2.051831 5.57767
```

```
$parameters
```

```
test p.adjusted name.t ntr alpha
```

```
Fisher-LSD none technique 3 0.05
```

```
$means
```

```
score std r LCL UCL Min Max Q25 Q50 Q75
```

```
tech1 80.0 5.868939 10 76.05599 83.94401 72 89 74.00 82.0 83.75
```

```
tech2 85.8 4.391912 10 81.85599 89.74401 81 93 83.00 83.5 89.25
```

```
tech3 88.0 7.557189 10 84.05599 91.94401 77 98 81.25 89.5 94.00
```

```
$comparison
```

```
NULL
```

```
$groups
```

```
score groups
```

```
tech3 88.0 a
```

```
tech2 85.8 a
```

```
tech1 80.0 b
```

```
attr("class")
```

```
"group"
```

The portion of the output that we're most interested in is the section titled **\$groups**. The techniques

that have different characters in the **groups** column are significantly different.

From the output we can see:

Technique 1 and Technique 3 have significantly different mean exam scores (since tech1 has a value of "b" and tech3 has a value of "a")

Technique 1 and Technique 2 have significantly different mean exam scores (since tech1 has a value of "b" and tech2 has a value of "a")

Technique 2 and Technique 3 **do not** have significantly different mean exam scores (since they both have a value of "a")

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