

What is Fisher's Least Significant Difference and can you provide an example?

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Fisher's Least Significant Difference (LSD) is a statistical method used to determine significant differences between multiple means in a dataset. It is commonly used in analysis of variance (ANOVA) to compare the means of three or more groups. The LSD test calculates the minimum difference between two means that must exist for them to be considered significantly different at a certain level of confidence. This method helps to identify which specific groups have significantly different means, rather than just determining if there is a significant difference between any of the groups.

For example, a researcher is conducting a study on the effect of different fertilizers on plant growth. The study has four groups: control (no fertilizer), group A (fertilizer X), group B (fertilizer Y), and group C (fertilizer Z). The results of the ANOVA show a significant difference between the means of the four groups. However, to determine which specific groups have significantly different means, the researcher can use the LSD test. If the LSD value is 5, it means that there must be a difference of at least 5 units between the means of two groups for them to be considered significantly different. If the mean plant growth for group A is 20 and group B is 25, and the LSD value is 5, then the difference between these two means is significant and can be attributed to the use of different fertilizers.

Fisher's Least Significant Difference: Definition + Example

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

The used in an ANOVA are as follows:

H0: The means are equal for each group.

HA: At least one of the means is different from the others.

If the 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 test.

To perform this test, we first calculate the following test statistic:

$$\text{LSD} = t_{.025, \text{DFw}} * \sqrt{\text{MSW}(1/n_1 + 1/n_2)}$$

where:

$t_{.025, \text{DFw}}$: The t-critical value from the with $\alpha = .025$ and DFw is the degrees of freedom within groups from the ANOVA table. MSW: The mean squares within groups from the ANOVA table. n_1, n_2 : The sample sizes of each group

We can then compare the mean difference between

each group to this test statistic. If the absolute value of the mean difference between two groups is greater than the test statistic, we can declare that there is a statistically significant difference between the group means.

The following example shows how to perform Fisher's least significant difference test in practice.

Example: Fisher's Least Significance Difference Test

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

SUMMARY

Groups	Count	Sum	Average	Variance
Technique 1	10	800	80	34.44444
Technique 2	10	858	85.8	19.28889
Technique 3	10	880	88	57.11111

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	341.6	2	170.8	4.622694	0.018771	3.354131
Within Groups	997.6	27	36.94815			
Total	1339.2	29				

Since the p-value in the ANOVA table (.018771) 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 least

significant difference test to determine which group means are different.

Using values from the output of the ANOVA, we can calculate Fisher's test statistic as:

$$\text{LSD} = t_{.025, \text{DFw}} * \sqrt{\text{MSW}(1/n_1 + 1/n_1)} \\ \text{LSD} = t_{.025, 27} * \sqrt{36.948 * (1/10 + 1/10)} \\ \text{LSD} = 2.052 * \sqrt{7.3896} \\ \text{LSD} = 5.578$$

We can then calculate the absolute mean difference between each group:

$$\begin{aligned} \text{Technique 1 vs. Technique 2: } |80 - 85.8| &= 5.8 \\ \text{Technique 1 vs. Technique 3: } |80 - 88| &= 8 \\ \text{Technique 2 vs. Technique 3: } |85.8 - 88| &= 2.2 \end{aligned}$$

The absolute mean differences between technique 1 vs. technique 2 and technique 1 vs. technique 3 are greater than Fisher's test statistic, thus we can conclude that these techniques lead to statistically significantly different mean exam scores.

We can also conclude that there is no significant difference in mean exam scores between technique 2 and technique 3.