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Comparing More Than Two Means

When you compare two means, you use a two-sample t test. When you want to conduct a hypothesis test to compare more than two population means, one popular method is one-way analysis of variance, or ANOVA for short. Like the pooled two-sample t test, the ANOVA test pools all of the data together to obtain an overall estimate of the standard deviation.

Note that this makes sense only if you can assume that the variances of the populations are approximately equal. You learned how to conduct unequal variances tests in a previous video. Several of these unequal variances tests are also available when you compare more than two variances. In ANOVA, the populations of interest are defined by the levels of a nominal variable, or factor.

For example, consider Michelson's speed of light experiment. Remember that Michelson conducted his experiment in five trials over a four-week period, with 20 measurements per trial.

In an ANOVA situation, you might ask: "Did the instrument produce consistent measurements across all five trials?" Or, "Are there differences in the means for the different trials, which might indicate that the instrument, or something in Michelson's measurements or experimental procedure, changed?"

When you want to compare the average velocity for two groups, you compute their difference. But with five groups, this approach won't work. Instead, we use an approach developed by Sir Ronald A. Fisher (who gave us the idea of statistical significance). The ANOVA method starts with the null hypothesis that all groups have the same mean value.

In Michelson's case, we have five groups. The alternative hypothesis is that not all of the means are equal. Notice that if you reject the null hypothesis, you cannot conclude that all means are different. All you know is that at least two of the means are different. So, in ANOVA, the alternative is often stated this way instead: At least two of the means are not equal.

To determine whether there is a significant difference between the means, ANOVA analyzes two components of variation: the variation due to the different levels, or in this case, the different trials, and the pure random variation. The variation from the levels is called between variation, because it's based on the variation between the levels. The random variation is called pure error, or the "within" variation, because it is calculated using data within each group. You learn more about how ANOVA works in the next video. You return to the Michelson data in a practice.

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