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Analyzing an MSA with Visualizations

In previous videos, you learned how to design and conduct an MSA. Recall that the goal of an MSA is to determine whether the measurement system is capable of detecting critical differences in the characteristic.

In this lesson, our focus is studying and quantifying repeatability and reproducibility variation in the measurement system.

We return to the hand micrometer example. Let's say that the hand micrometer MSA was conducted.

This study involves three inspectors measuring 10 parts twice with one hand micrometer.

The 10 parts were randomly selected and span the range of target diameters for the product (approximately 4.0 to 5.5 cm).

The data are recorded in the gauge study worksheet saved as Micrometer.jmp, and now it's time to analyze the results.

As with all good analyses, we start with visualizing the data before conducting a formal analysis. A variability chart, or Multi-vari chart, shows each combination of Inspector and Part.

The vertical lines connect the two repeated measurements for a part by an inspector.

We can see that there is some repeatability variation.

For example, look at the first part for Inspector 1. One measurement was around 4.5 cm, and the other was around 5.0 cm.

When we show the means for each inspector, we see that the variability between the inspectors is relatively small compared to the repeatability variation.

The means for the three inspectors are similar.

Connecting the means for each part within each inspector is also informative.

For example, look at the pattern of the means for the first five parts for the first two inspectors. Do you notice that the patterns are different?

This tells us that the different inspectors aren't getting the same measurements, on average, for the same parts.

We call this an interaction between Inspector and Part. Put another way, the measurement for a particular part depends on the inspector.

So what do we conclude from this visual analysis?

There is a lot of repeatability variation, the reproducibility variation for inspectors is small, but there is variation from the interaction between inspectors and parts.

Another way to visualize the data is with average and range control charts, or average and standard deviation control charts.

Remember how the control limits for the X-bar chart are constructed. The control limits are based on the within-subgroup variation. That is, they are based on an estimate of the standard deviation from the variation within the subgroups.

In an MSA, a subgroup is a set of repeated measurements on the same part by the same inspector.

Let's look at the range or standard deviation chart first. Here we see a range chart.

Each point on this chart is the range of the measurements for each subset.

This chart enables you to see whether the repeatability variation for each part is consistent across the inspectors. For example, some inspectors might have more repeatability variation than other inspectors, or the repeatability variation on particular parts might be large. If a point falls outside the control limits, the repeatability variation on that part, for the given inspector, is large relative to the other parts. For our example, the measurement repeatability across the parts and inspectors does not appear to be a problem, so we look at the average control chart.

We interpret the average control chart differently than we interpret the standard control chart.

In an MSA, you want the average control chart to be out of control!

If the variability for repeated readings is small, the control limits for the average chart are very tight and many of the points fall outside the limits.

If most or all of the points fall outside the limits on the average chart, this means that you can tell the difference between the parts.

Here's an example of what you hope to see.

This chart shows a measurement process in which the variability in repeated measurements taken by the operators on each part is small, and the measurement process can distinguish between the parts.

However, if there's a lot of within-subgroup (repeatability) variation, the control limits on the average chart are wide. As a result, most of the points fall within the limits.

This would mean that the measurement system can't tell the difference between the parts. In other words, the measurement system is not capable of detecting differences in the quality characteristic between the parts. This is not good!

Our chart has only a few points outside the limits.

This tells us that our repeatability variation is large compared to the part-to-part variation. The repeatability variation is an issue that needs to be addressed.

Another useful visualization is a parallelism plot.

In this graph, if the lines are parallel, then each Inspector is getting approximately the same measurements for each part. This would mean that there is no interaction between parts and the inspectors.

For our micrometer example, the lines for the three inspectors are parallel to one another for parts 6-10, but the lines for the first five parts aren't parallel. You can see this clearly with Part 1. Inspector 3 recorded much lower measurement, on average, than the other two inspectors.

In the next video, you learn how to visualize measurement system variation in JMP. JMP provides two general methods for analyzing measurement system variation: Evaluate Measurement Process (or EMP) and Gauge R&R.

The variability chart is provided with the Gauge R&R method. The average and range chart and the parallelism plot are provided with the EMP method. You learn more about these methods in future videos.

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