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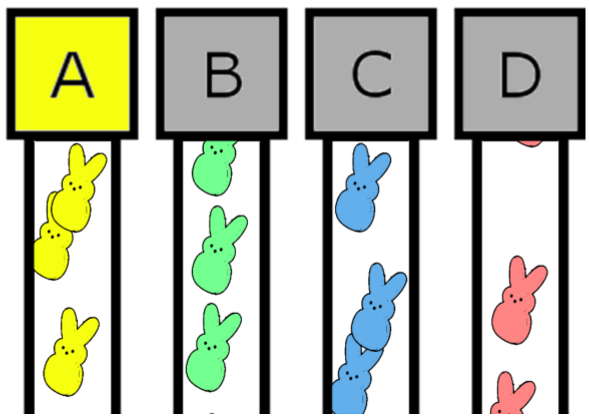
SPC

LESSON: Rational Subgrouping

This lesson includes an overview of the subject, instructor notes, and example exercises using Minitab.

Quality Methods

Rational Subgrouping



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Read this in preparation for the Peeps rational subgrouping lab.

"The Pertinent Question is NOT how to do things right —
but how to find the right things to do,
and to concentrate resources and efforts on them."

Peter Drucker

Part I. Control Charts and Subgrouping

In Engineering Statistics, a great deal of attention is paid to **variation in a population** or process. Since engineering students often collect **process data** (e.g., time-oriented data), then time series charts or **statistical process control charts** are often of interest in their studies. Statistical process control charts were developed in the 1920's by Walter **Shewhart** in order to **separate variation** in a process into two components – **common cause variation** and **special cause variation**. In any process, naturally there is variation. The type that is inherent in any process is called ***common cause variation*** – it's there no matter what we do. For example, every day when I drive to work, the time it takes me to get there varies. Common cause variation in times may be due to stopping at a red light, getting behind a slow car, changes in traffic flow, etc. This type of variation affects my overall drive time but allows it to stay within "acceptable" limits. Variation that drastically affects a process is called ***special cause variation***, and it is usually due to just that – special cause. In my driving time example, special cause variation may be encountering a bad wreck that closes a lane or a train that blocks my usual path. These incidents will most likely cause a noticeable difference in my driving time, and I can usually identify them on a control chart because they are beyond an "acceptable" limit or "stand out" as significantly different. A process is said to be ***"out of control"*** if the **data plotted over time is not random**, meaning that it shows patterns, trends, or "unusual" jumps or gaps. Otherwise, we say the process is "in control."

How we sample and group our process data to construct a control chart is really dependent on what we want our chart to tell us. Control charts can be used to determine if the variation in a process from say hour to hour is consistent with the average variation for a process within an hour. A basic principle in constructing a control chart is to **choose subgroups** in a way that will **maximize the probability for the measurement data in each subgroup to be alike and between each subgroup to be different**.

For example, if our company makes large quantities of chocolate golf balls from molds similar to the one shown in Figure 1 and our variable of interest is ball weight, then how should we subgroup the balls to track differences in weights between cavities or between molds, or over time? Suppose we have 12 of these molds and we use all of them in an hour to produce 60 golf balls. We could construct mean and range control charts, $\bar{X}$ and R, by randomly selecting 4 golf balls per hour and placing their mean and range on the respective charts every hour. On the other hand, we could randomly select 4 balls from each cavity per hour and track cavity differences on $\bar{X}$ and R charts. What if we want to distinguish weight differences between the 12 different molds? Would we be able to do this by simply using one of the subgrouping plans already discussed? The following assignment that I have developed encourages students to think about how to subgroup process data in order to provide the appropriate information needed by various stakeholders of that process.

Figure 1. The top half and bottom half of a five-cavity golf ball mold.

Determining subgroup sizes for Xbar – why it's difficult:

1. You want common cause variation only within a subgroup. What does this mean with respect to *n*?

   Small *n* better Large *n* better

2. You want the distribution of Xbar to be normal. What does this mean with respect to *n*?

   Small *n* better Large *n* better

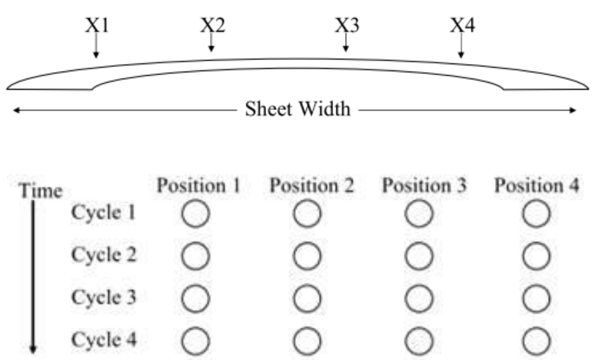
3. You want to be able to tell when there is a shift in the process mean. What does this mean with respect to *n*?

   Small *n* better Large *n* better

4. You want the sample size to be economically feasible. What does this mean with respect to n?

   Small *n* better Large *n* better

Subgrouping Example. Consider a manufacturing process in which parts are manufactured at four different positions. Four parts are produced at each cycle of the machine. One measurement is made on each part.



(a) List two sources of variation contributing to the observed process variation

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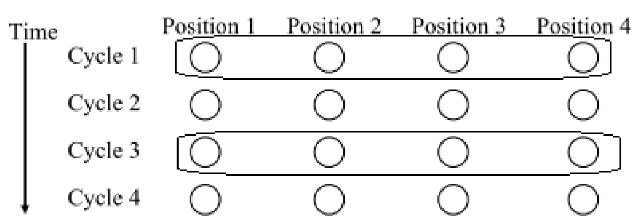
(b) What variation is being captured in the *R* chart if the subgroup consists of one part from each positionevery other cycle? See picture.

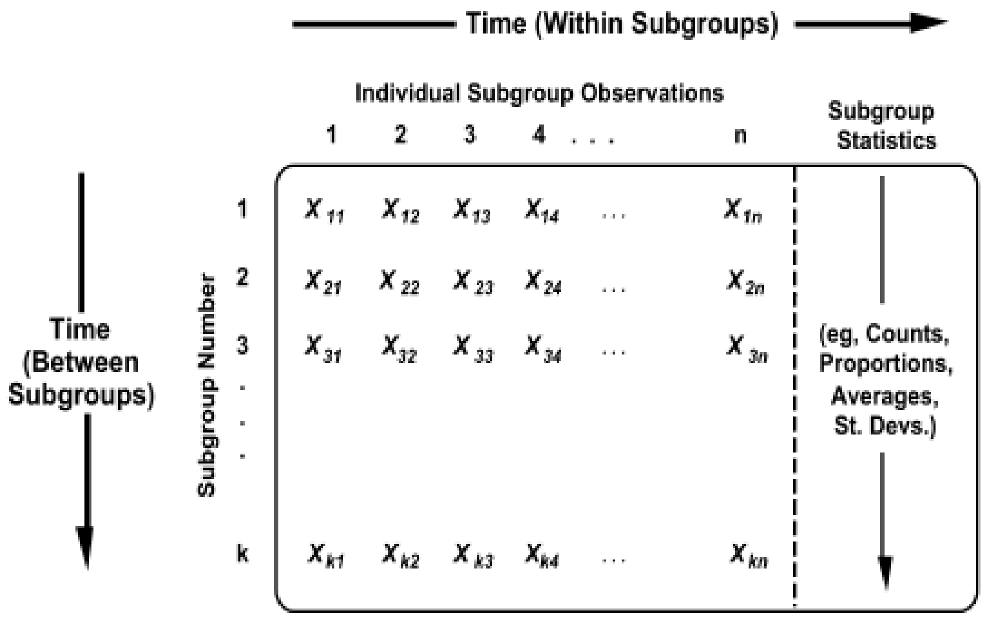
A. Between positions

B. Between cycles



(c) What variation is being captured in the $\bar{X}$ chart if the subgroup consists of one part from each position every other cycle? See picture above.

A. Between positions **B.** Between cycles



Note: Samples are called subgroups in SPC terminology. This example contains *k* samples of data recorded over a significant period of time, with each sample containing *n* values taken over a shorter period of time. The rate or other statistic of interest is calculated for each small subgroup sample and plotted on a control chart in real time.