Some Quality Measurement Tools

- Bar Chart
- Run Chart
- Histogram
- Control Chart/SPC

Epistemology and Measurement

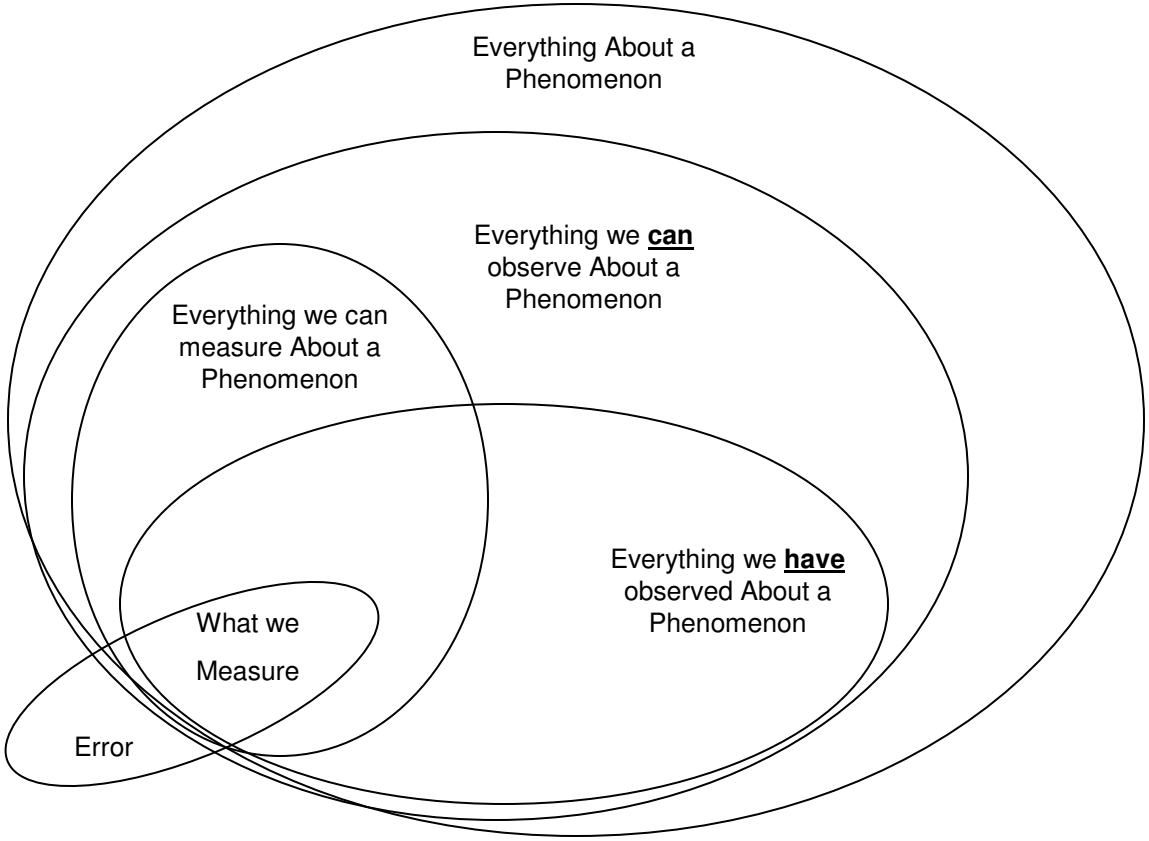
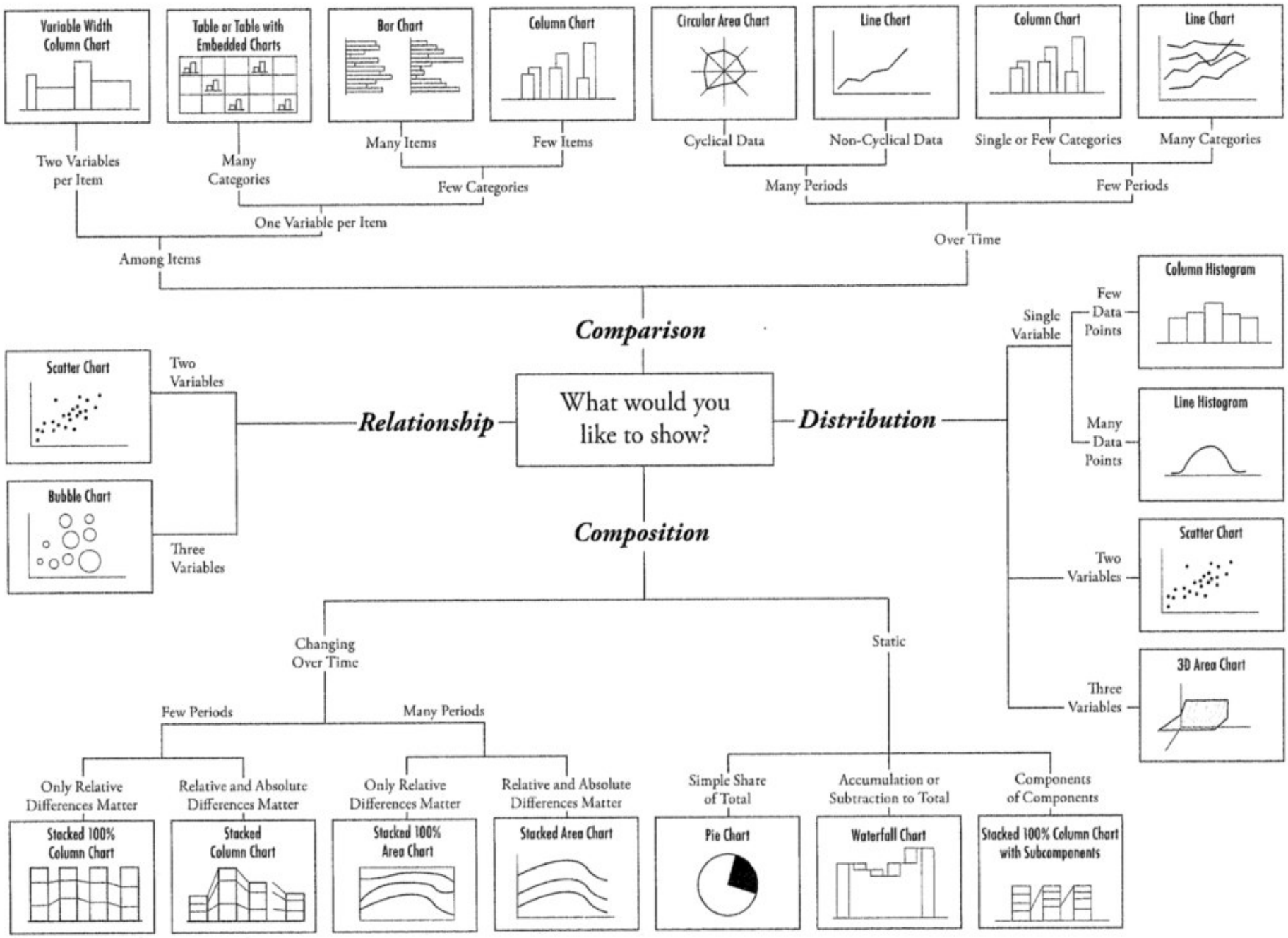


Chart Suggestions—A Thought-Starter



Measure and Describe

- What is measured?
- How is it measured?
- Issues of –
  - Constructs
  - Validity
  - Reliability
  - Precision vs. Accuracy
  - Noise
  - Error

Use of Statistics

- Descriptive
- Inferential
- Relational
- Explanatory

Scales of Measurement

Measurement involves either categorizing events (qualitative measurements) or using numbers to characterize the size of the event (quantitative measurements).

- **Nominal Scale**: labels observations so that they fall into different categories.
  - Naming things: sex, occupation, religion. The nominal scale consists of qualitative distinctions. No attempt is made to measure the size of the event or response. Observations are labeled and categorized.

- **Ordinal Scale:** observations are ranked in terms or size or magnitude.
  - Rank order is established (first, second, etc.) however the data provide no information about the magnitude of difference between each observation.

- **Interval Scale:** intervals between numbers reflect differences in magnitude.
  - Differences in numerical value may be calculated, however, ratios of magnitudes are not meaningful. The scale has no true zero point. (temperature, intelligence, etc.).

- **Ratio Scale:** has a meaningful zero point and thus ratios of numbers reflect ratio of magnitudes.
  - Absolute measures (weight, response time, length, etc.)

Discrete and Continuous Variables

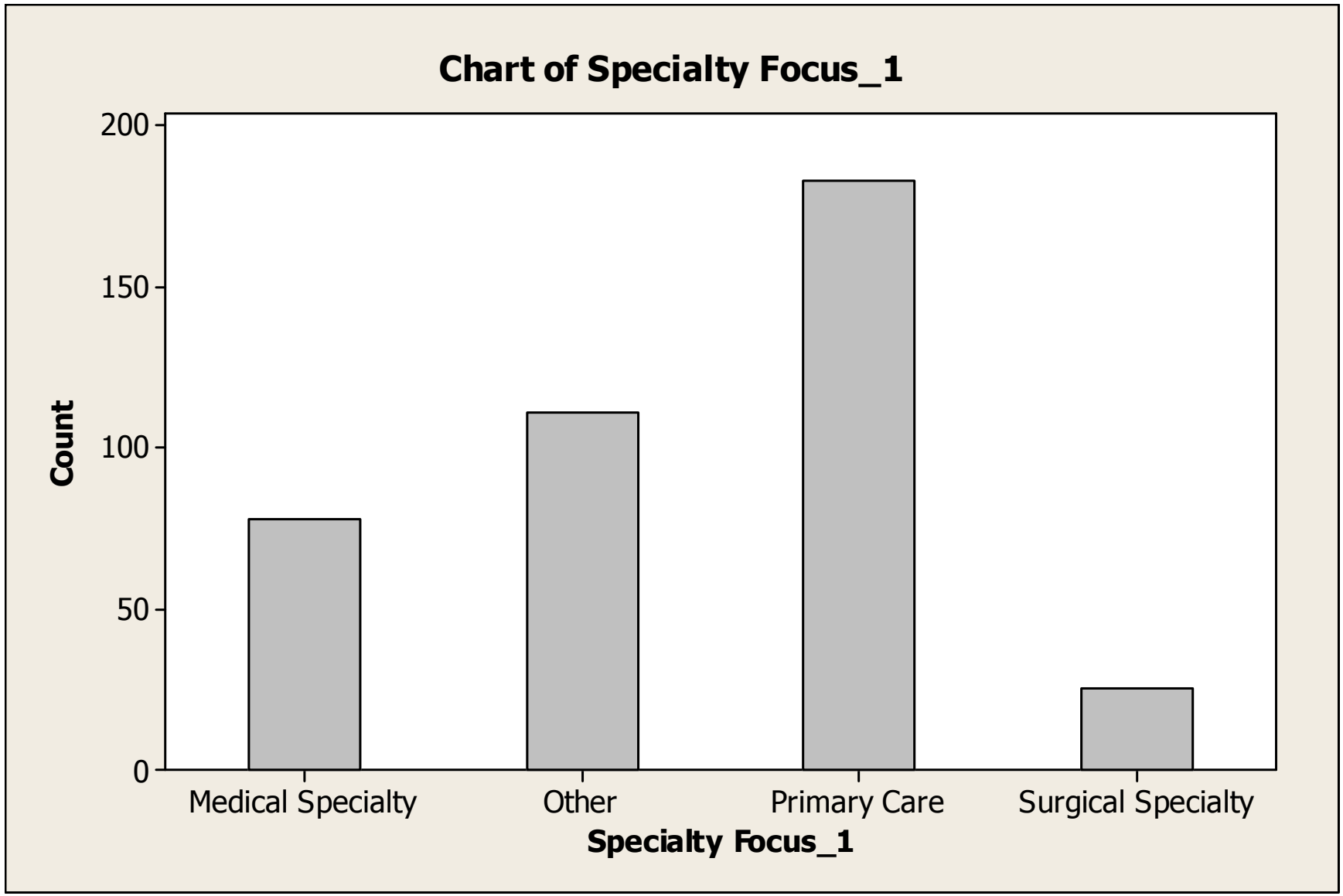
Variables in a study can be characterized by the type of values that can be assigned to them.

- **Discrete Variables**: consists of separate, indivisible categories. No values can exist between two neighboring categories.
  - A discrete variable is typically restricted to whole countable numbers (dice, number of children in a family, students in a class, etc.). A discrete variable may also consist of observations that differ qualitatively (e.g. patients may be classified as having “panic disorders”, “psychotic disorders”, “dissociative disorders”, etc.).

- **Continuous Variables:** are characterized by an infinite number of possible values that fall between any two observed values. A continuous variable is divisible into an infinite number of fractional parts.
  - Continuous variables may be placed on a number line that is continuous, infinite and divisible.

- **Intervals and Continuous Variables:** Typically when a continuous variable is measured we do not assign our observation to a single point value on the line, but usually assign an interval (e.g. body weight: is a continuous variable, but due to measurement limitations [the sensitivity of your scale] we assign an interval).
  - With a continuous variable there is no limit to the precision of measurement except for the accuracy of the measuring instrument.

Bar Chart of CME Participants



Descriptive Statistics

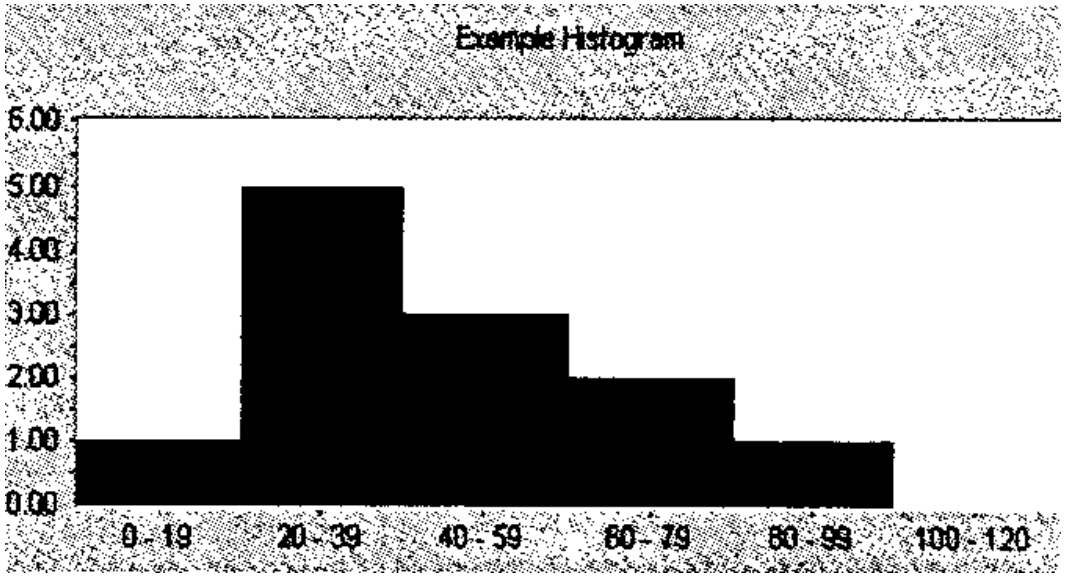
1. Central Location
    1. Mean
    2. Median
    3. Mode
2. Variability
    1. Range
    2. Standard Deviation
    3. Shape

What Can We Learn About

- Location
  - Process centered
  - Process requirement
- Spread
  - Observed
  - Specification
- Shape

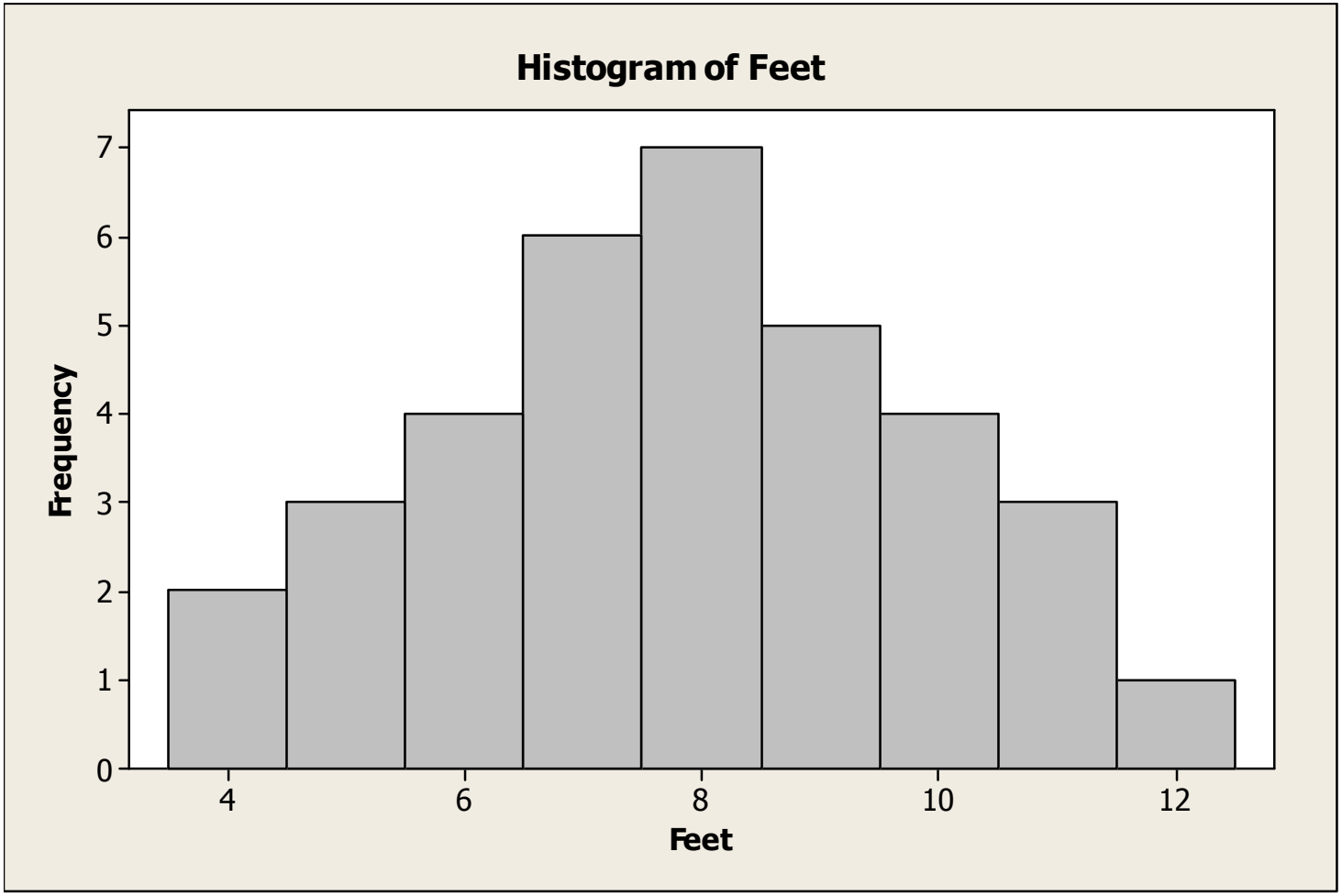
Histograms

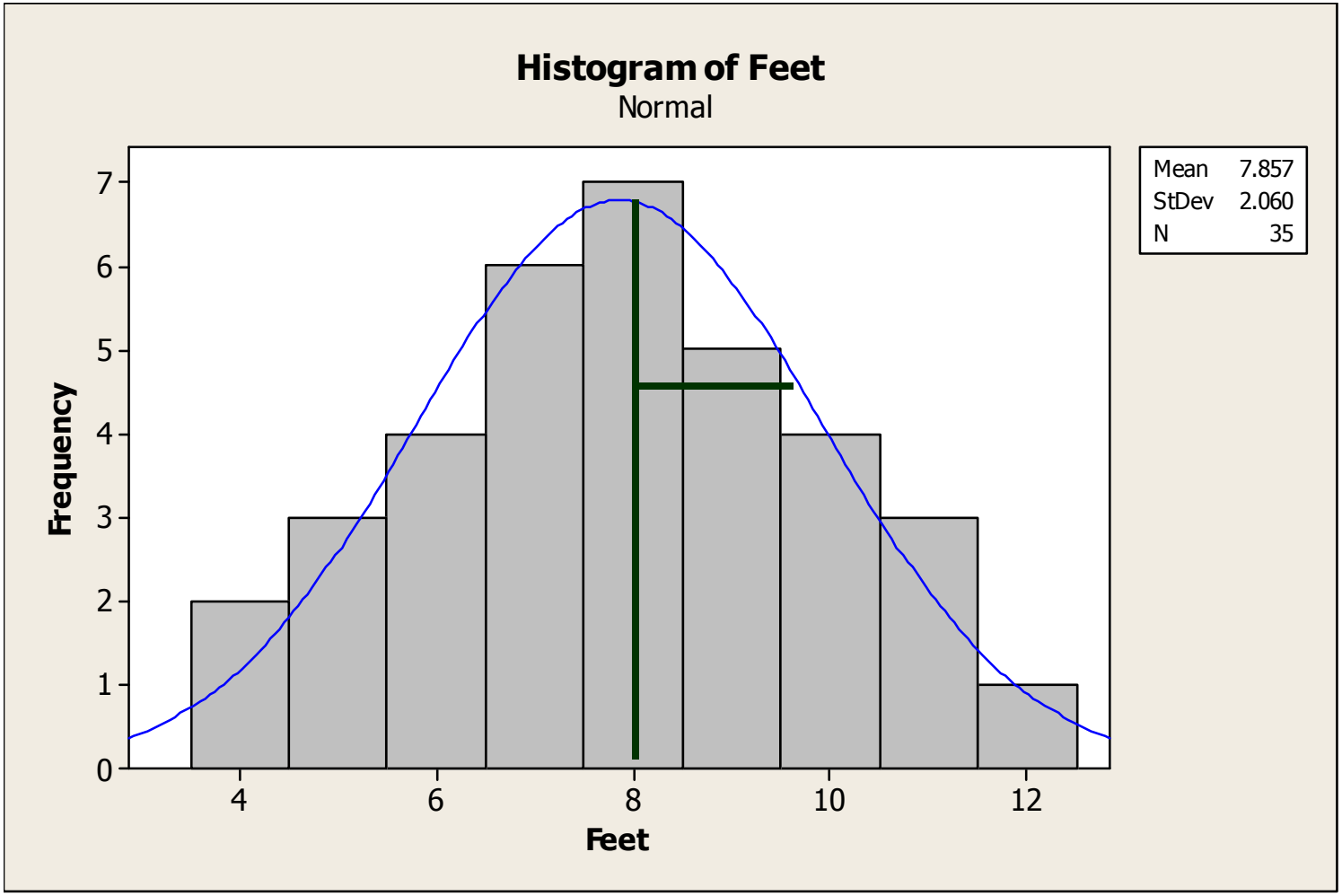
A histogram is a graphical representation of data in a bar chart format. Histograms are also used to observe the “shape” of data.



Distance Traveled after Braking at a Set Speed

8	11	7	8	9
10	8	11	8	12
7	10	6	6	11
5	8	5	10	9
9	6	7	7	10
7	9	4	8	9
4	7	5	6	8


Histogram of Feet
Frequency
0
1
2
3
4
5
6
7
4
6
8
10
12
Feet


Histogram of Feet
Normal
Mean 7.857
StDev 2.060
N 35
Frequency
0
1
2
3
4
5
6
7
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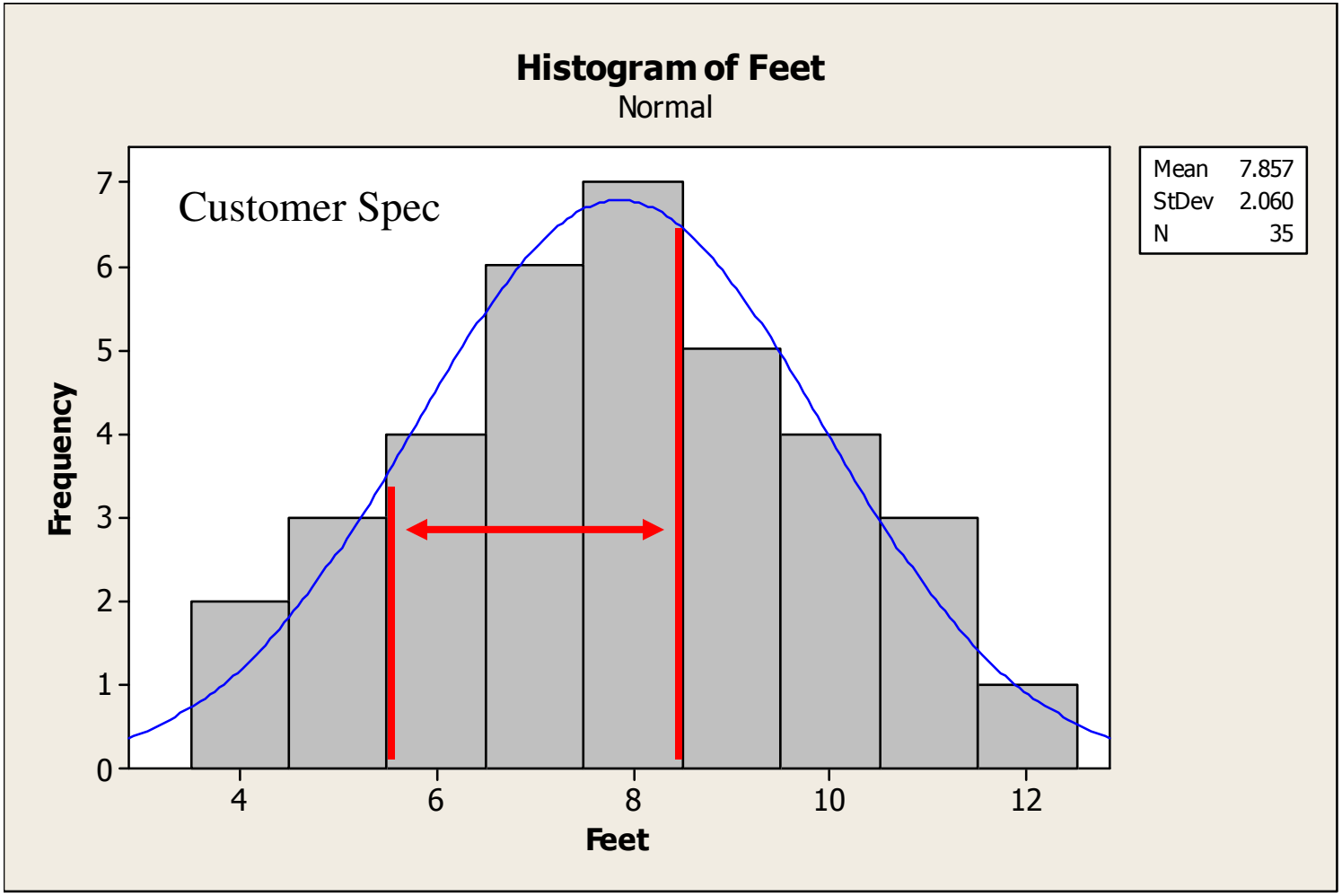
6
8
10
12
Feet


Histogram of Feet
Normal
Customer Spec
Mean 7.857
StDev 2.060
N 35
Frequency
Feet
0
1
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3
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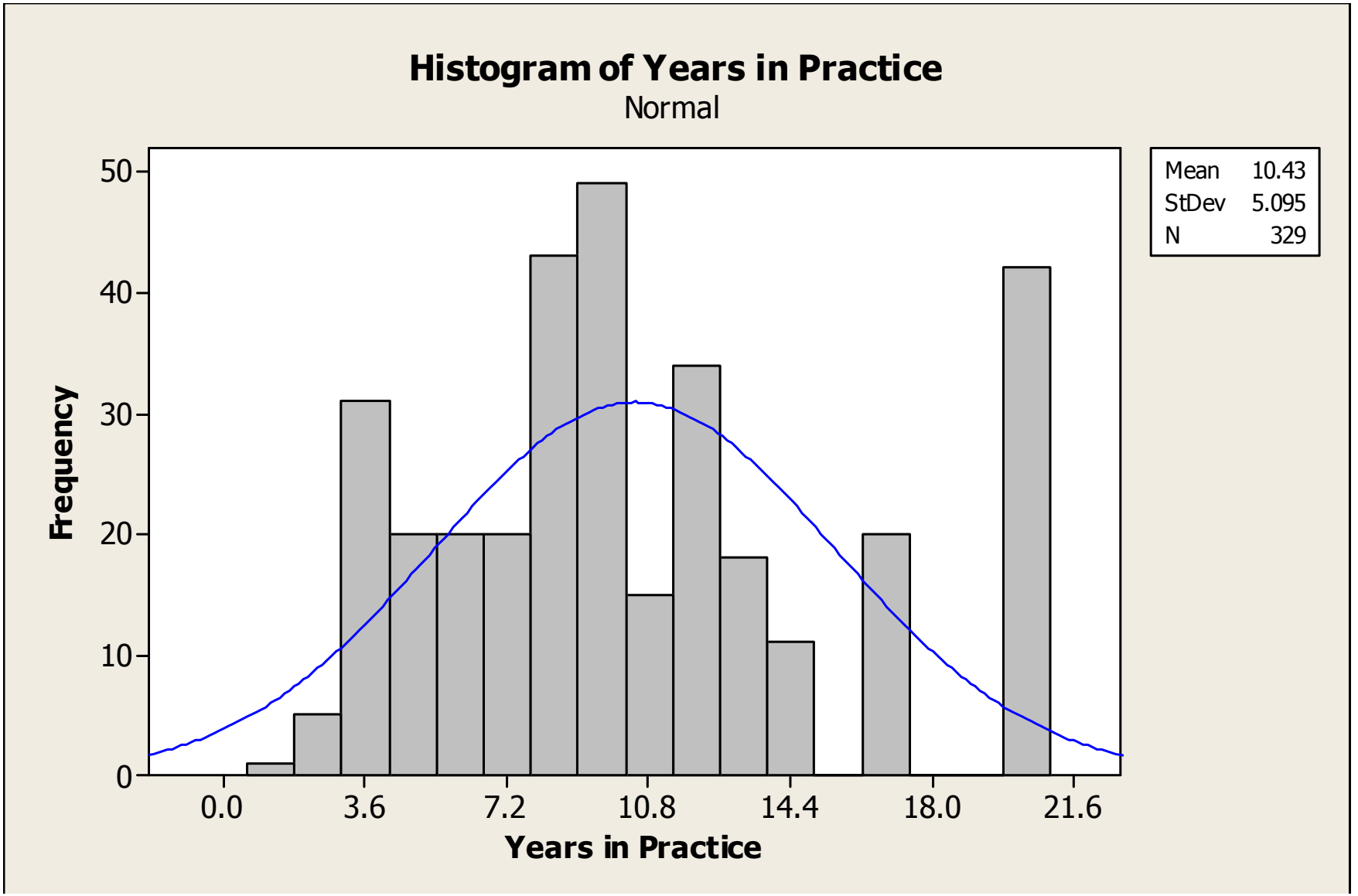
7
4
6
8
10
12

CME by Years in Practice



According to Lord Kelvin

When you can measure what you are speaking about and express it in numbers you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is the meager and unsatisfactory kind.

According to Bill Conway

Statistics don’t solve problems. They identify where the problems are and point managers and staff towards solutions.

Warren Buffet Said

It is better to be approximately right than precisely wrong.

Descriptive Statistics

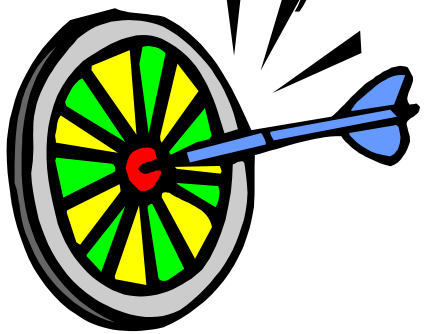
1. Central Location
    1. Mean
    2. Median
    3. Mode
2. Variability
    1. Range
    2. Standard Deviation
    3. Shape

Describing Data

- We describe data to assist with the analyze phase in six sigma. In order to completely describe data we need to know the following:
    - Location
    - Spread
    - Shape
    - Variation Over Time

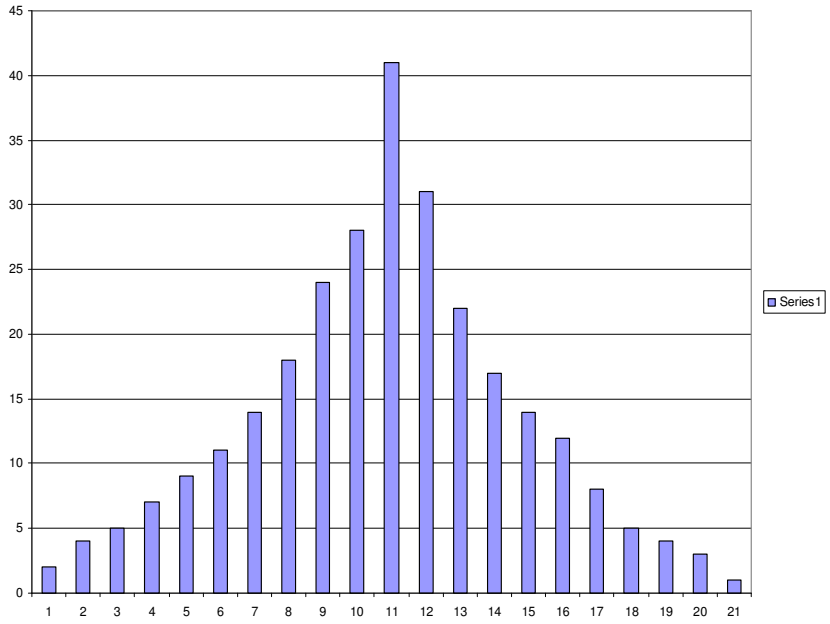
Target

- Most measures have targets. For example, an organization may promise delivery in 24 hours. That is the target. (In manufacturing that is called the nominal. In service it may be called the customer requirement.)



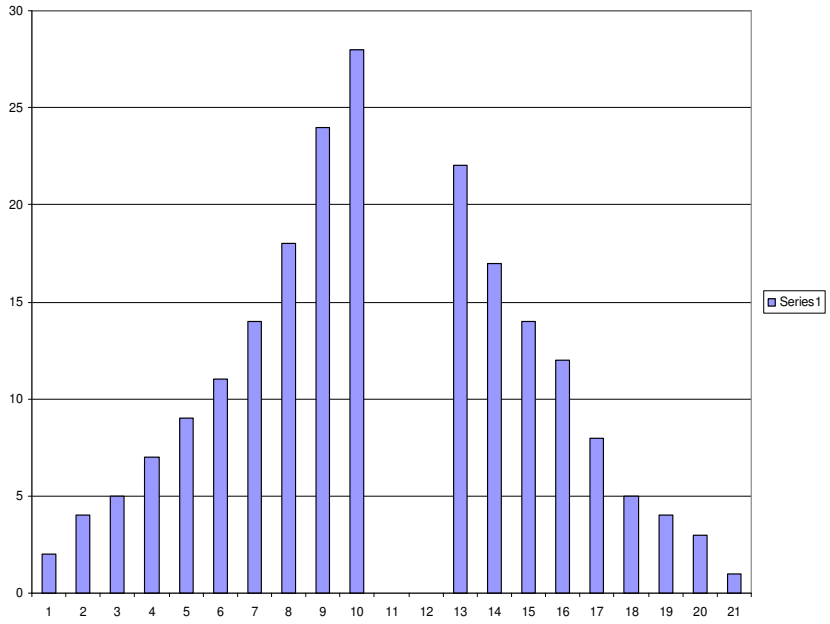
Shape

The histogram shows us the shape of the distribution. Many measurements follow the normal or bell shaped curve.



Shape

- Sometimes the shape is not normal
- We must compare our shape with the expected shape to see if the process is behaving like it always has



Shape

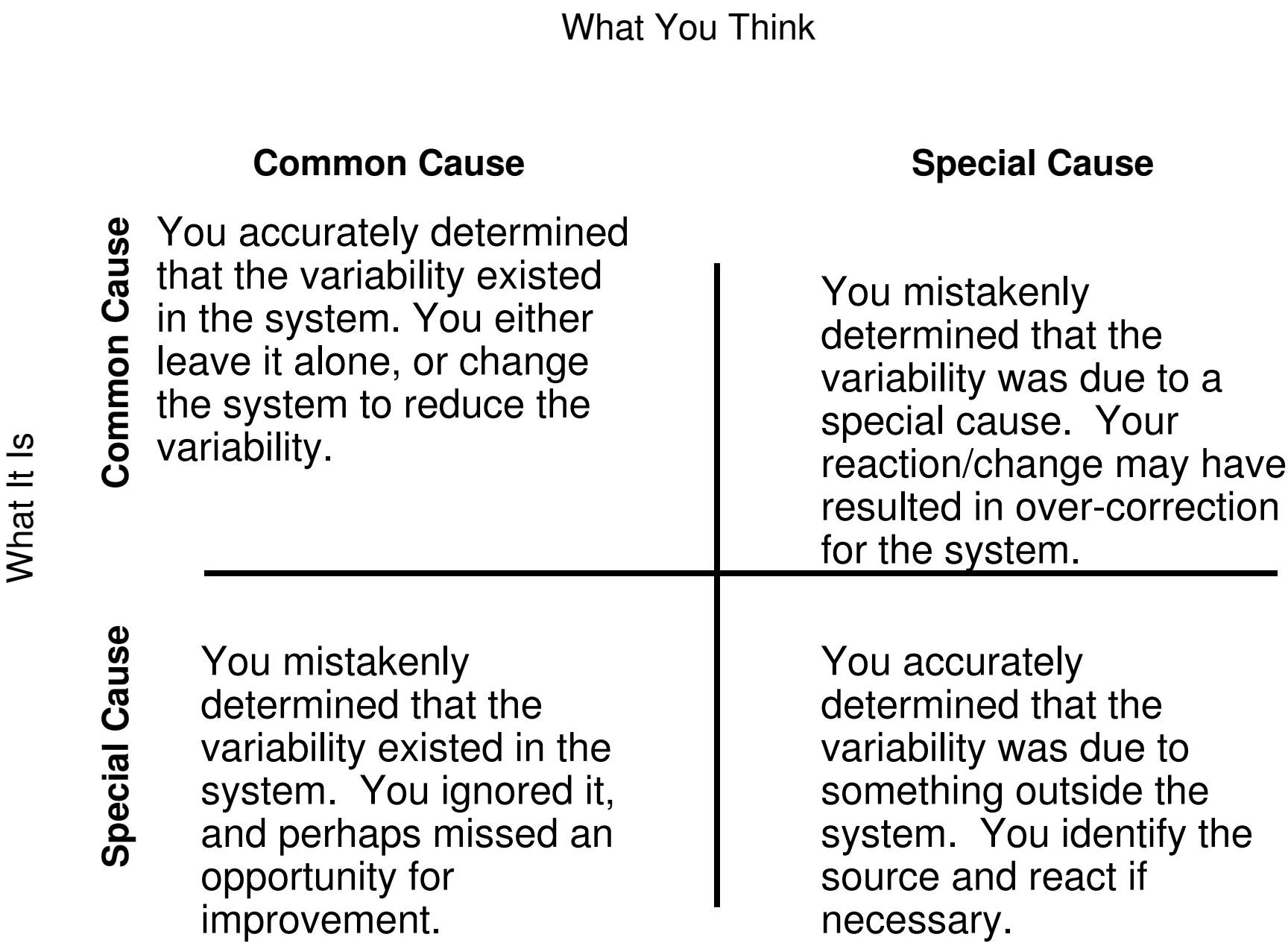
- We can use the histogram to compare the observed shape with the expected shape
- If the pattern is different from what we expect, then we may not be doing what we always have. We may not be predictable. We may not be stable.

Process Monitoring

- Process monitoring is performed to determine the type and amount of variation that is present in a process as time goes by.
- The two types of variation are:
  - Common Cause
  - Special Cause

Sign Your Name on Each Line

- _____
- _____
- _____
- _____
- _____


What You Think
Common Cause
Special Cause
What It Is
Common Cause
Special Cause
You accurately determined that the variability existed in the system. You either leave it alone, or change the system to reduce the variability.
You mistakenly determined that the variability was due to a special cause. Your reaction/change may have resulted in over-correction for the system.
You mistakenly determined that the variability existed in the system. You ignored it, and perhaps missed an opportunity for improvement.
You accurately determined that the variability was due to something outside the system. You identify the source and react if necessary.

Control Charts

- Statistical tool which shows the amount and type of variation present in any process that is being monitored
- Describe the representative nature of a stable, predictable, in control process

Control Charts

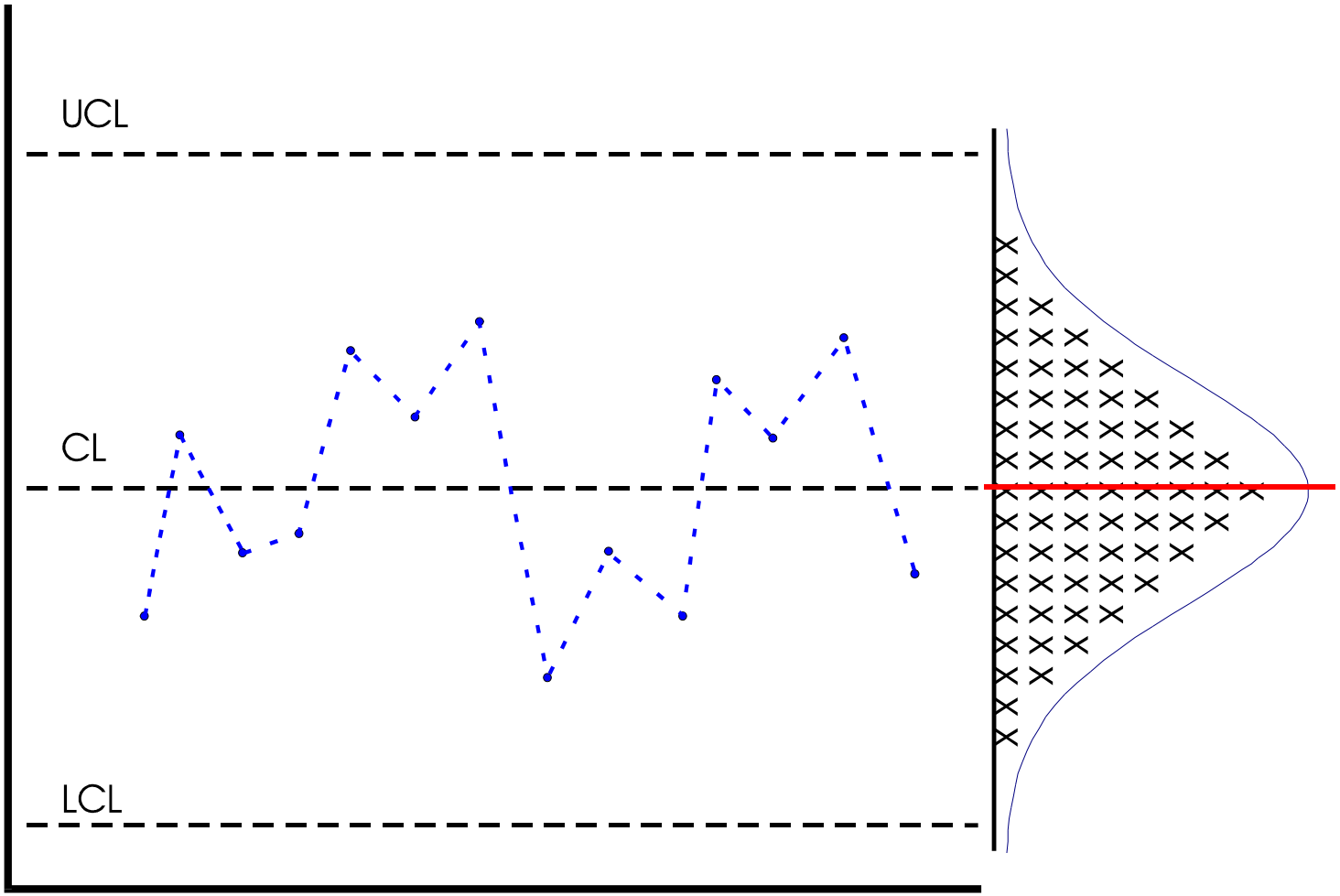
- Statistical tool which shows the amount and type of variation present in any process that is being monitored
- Components:
  - UCL – Upper Control Limit
  - LCL – Lower Control Limit
  - CL – Center Line

    Shows where the characteristic average falls.

Control Limits

- Control limits describe the representative nature of a stable process. Specifically, control limits identify the expected limits of normal, random, or chance variation that is present in the process being monitored. Control limits are set by the process

Relationship of Histograms and Control Charts



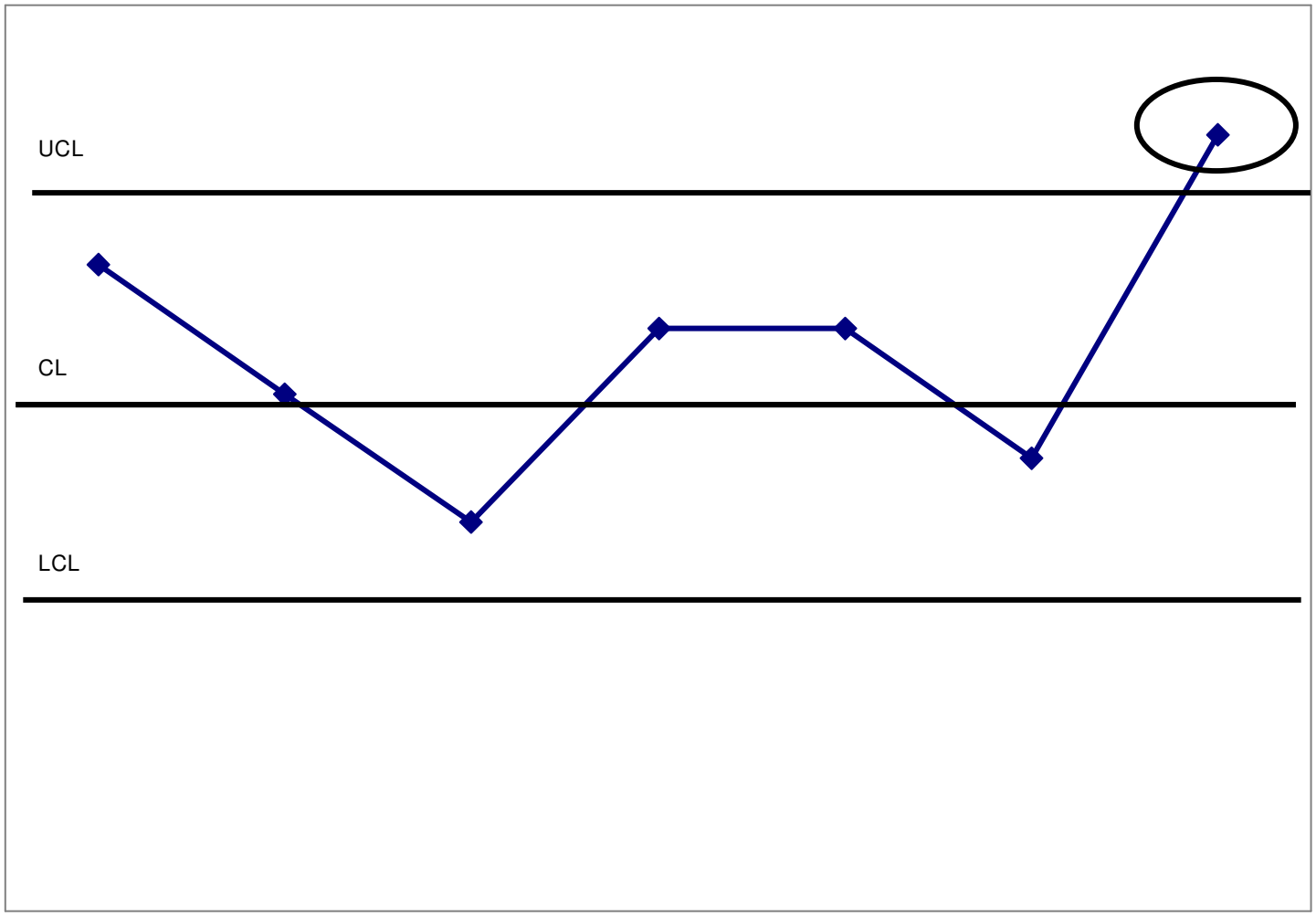
Interpreting Control Charts

- Points outside of the control limits: normally it is highly unlikely that a measurement will fall outside of UCL or LCL. It means that a special cause has influenced the system.
- A run: when seven or more consecutive points fall on either side of the center line. Maybe an improvement has occurred, and we will want to investigate and if warranted, collect data and recalculate limits.

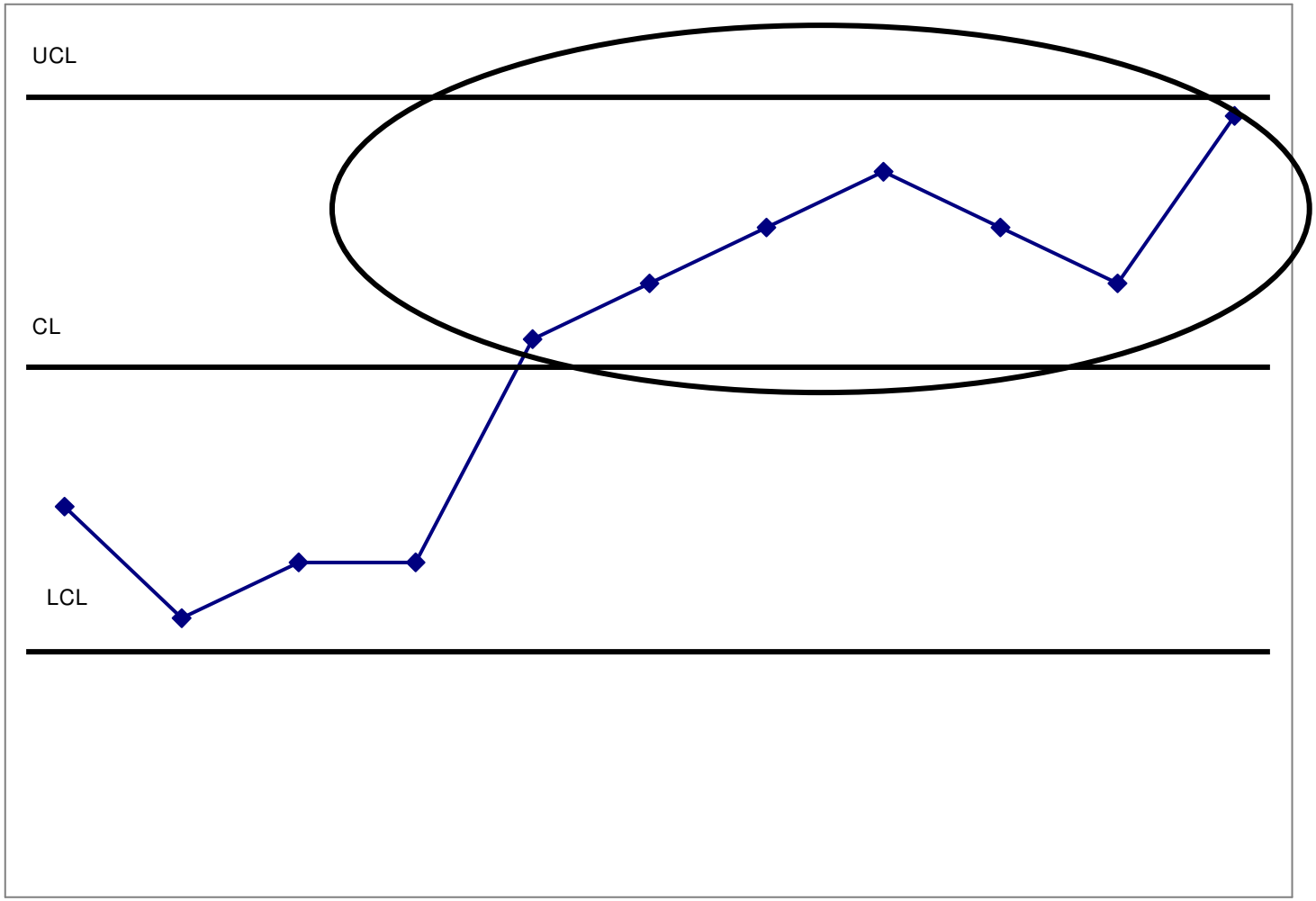
Interpreting Control Charts

- A trend is seven data points moving steadily upward or downward. Similarly to a run, investigate.
- Hugging the center line: when four out of five consecutive points are at or are near the center line it typically means either the data are being manipulated, or variability has been reduced.
- Cyclical pattern: repeating up and down pattern indicates something systematic going on.

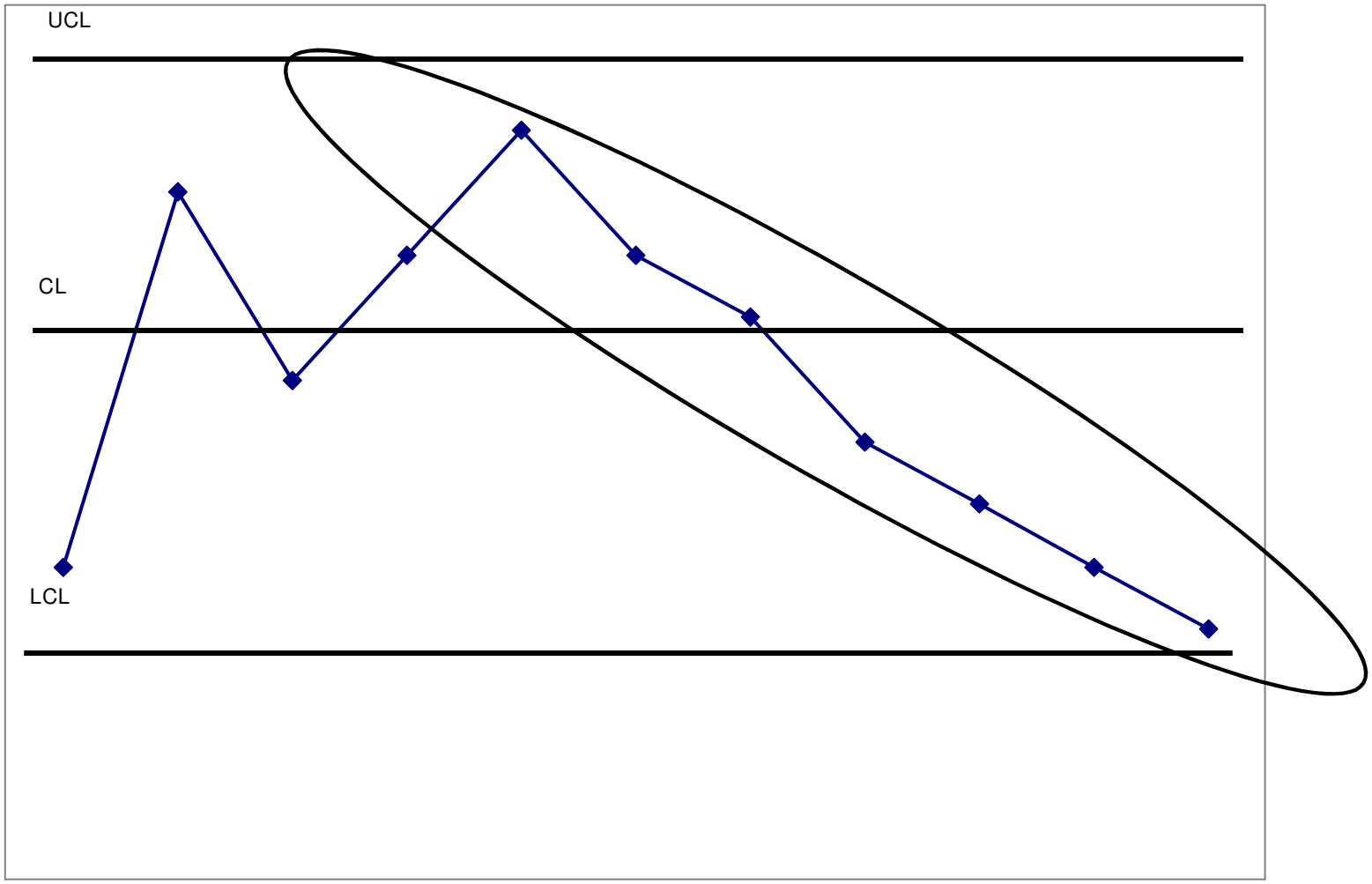
Point Outside Limits



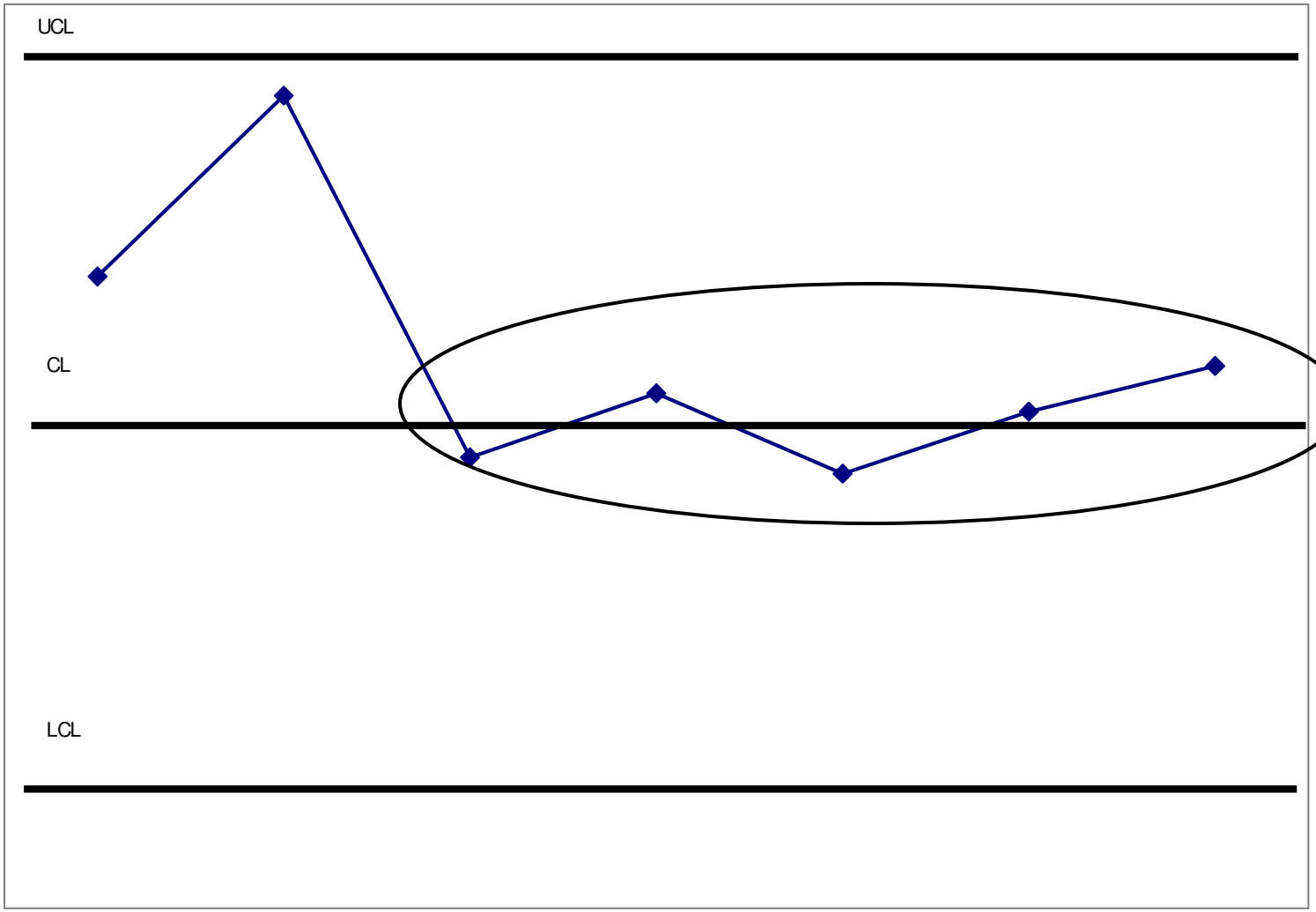
A Run



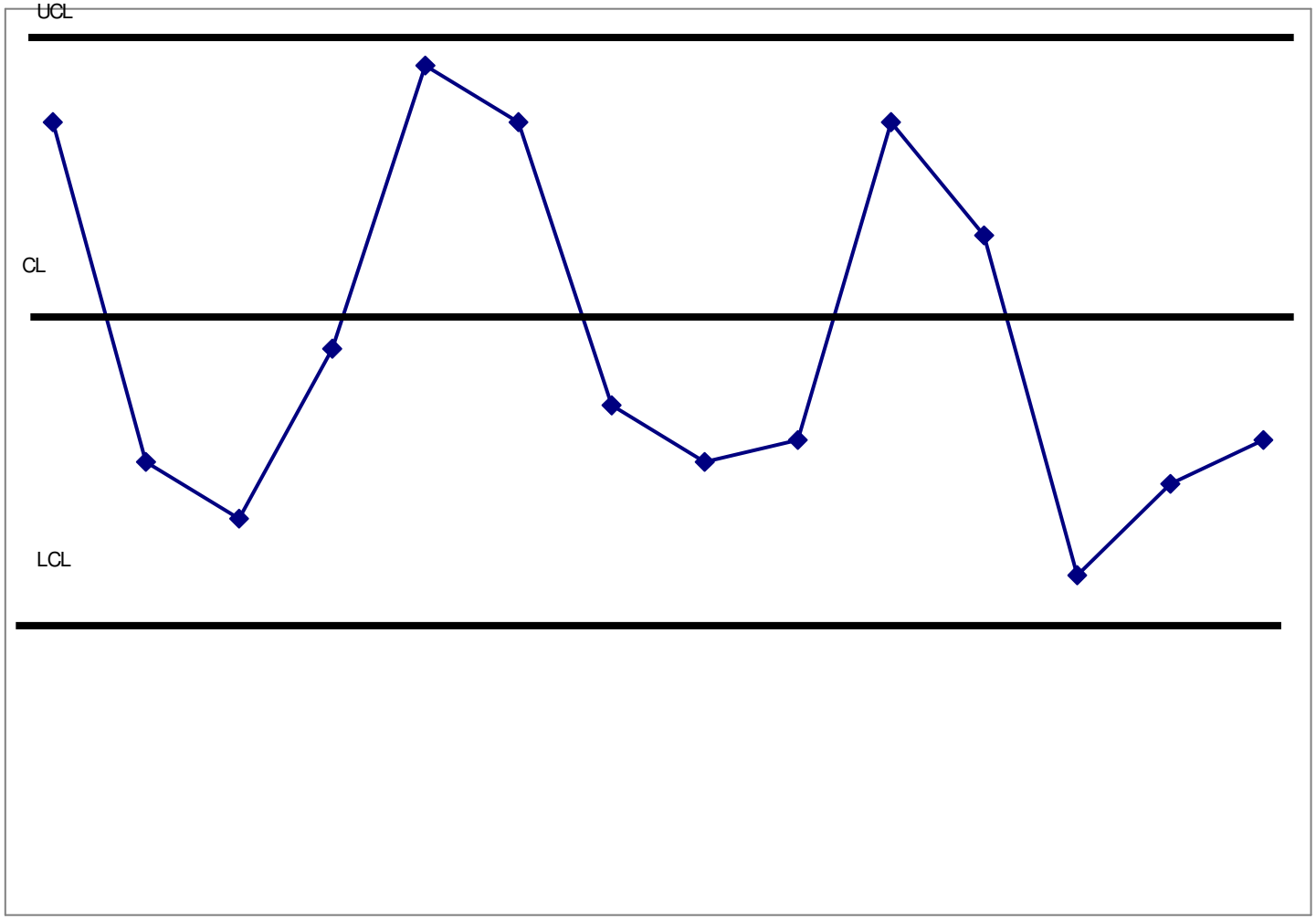
Trend



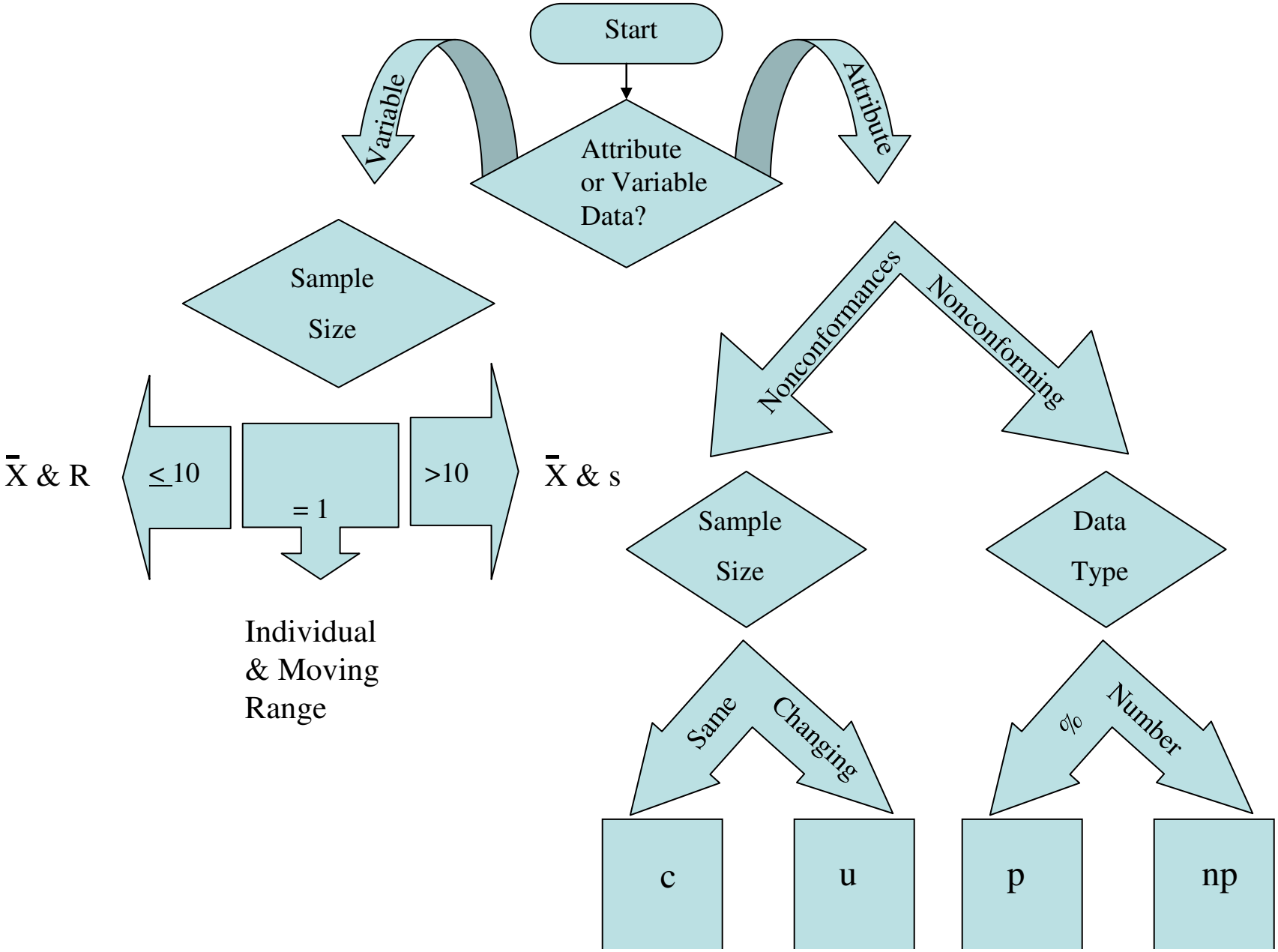
Hugging the Center Line



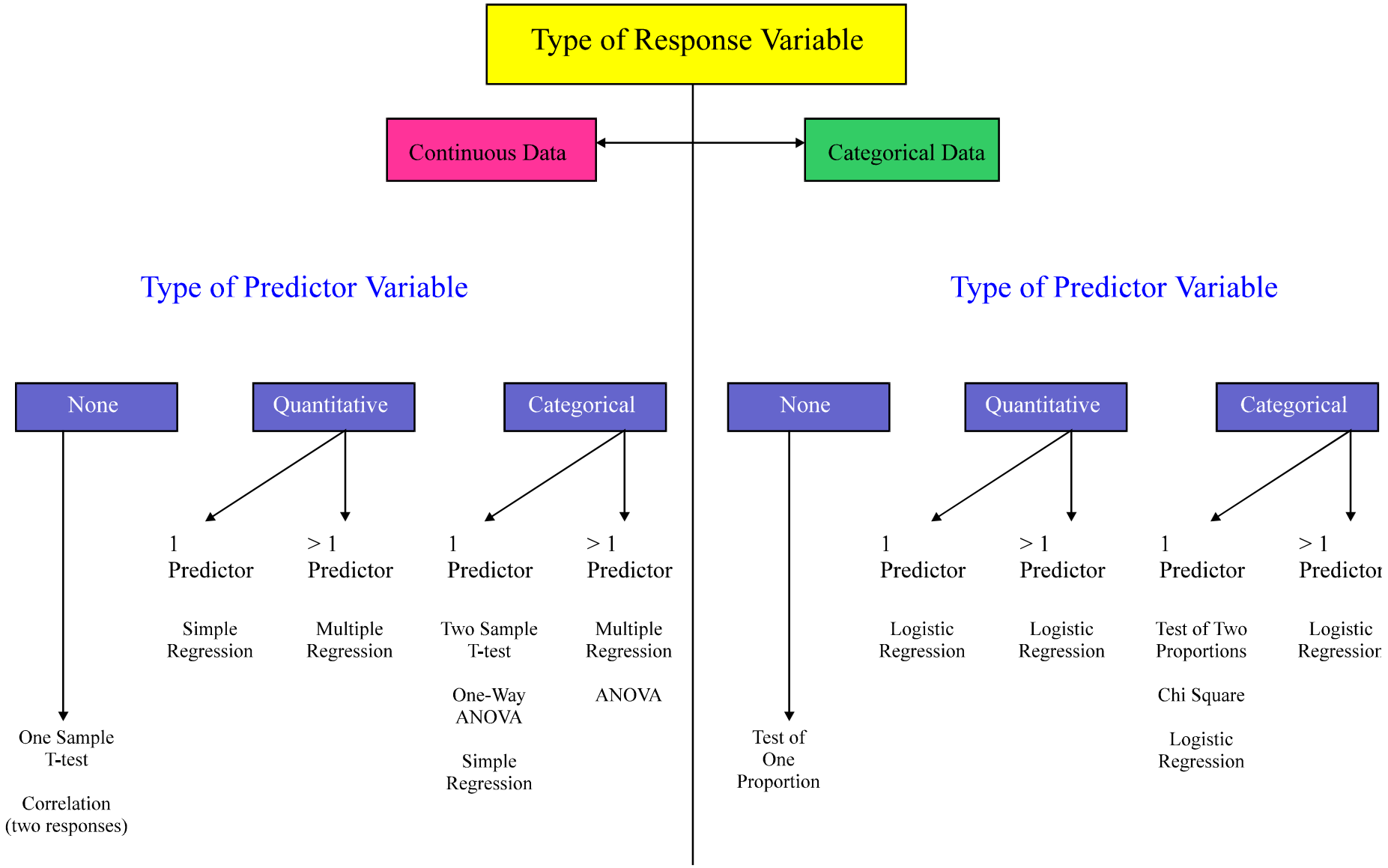
Cyclical



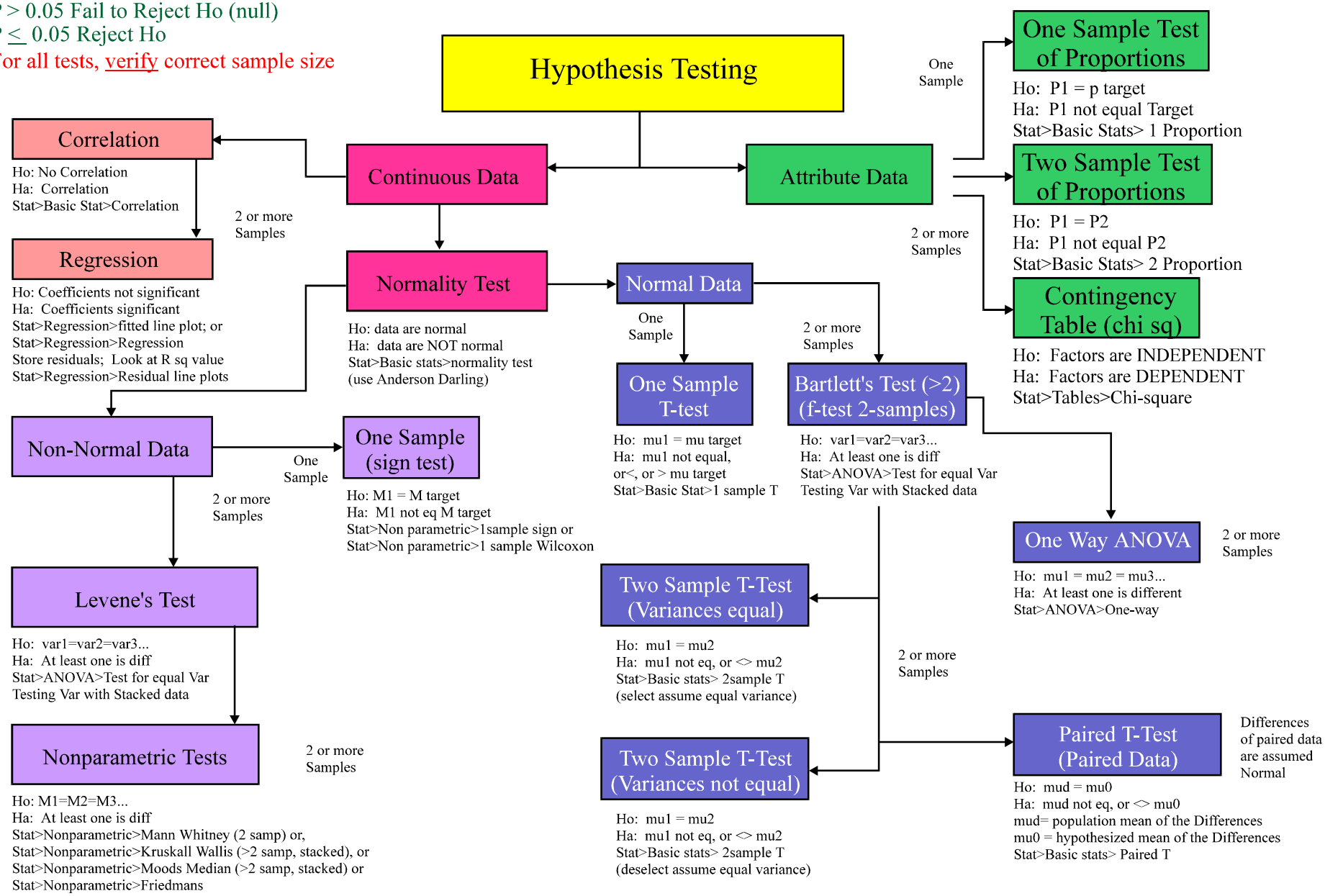
Advanced Resources


Start
Attribute or Variable Data?
Variable
Attribute
Sample Size
≤10
= 1
>10
X̄ & R
X̄ & s
Individual & Moving Range
Nonconformances
Nonconforming
Sample Size
Data Type
Same
Changing
%
Number
c
u
p
np

Choosing a Statistical Tool



For all tests, choose appropriate alpha:
P > 0.05 Fail to Reject Ho (null)
P ≤ 0.05 Reject Ho
For all tests, verify correct sample size



Generic List of Tests Available in Verification Matrix (from Brakewood, 2006)

Test	Description	Assumptions
Z-test	Difference between two proportions.	1.Random sample 2.X is discrete, y is a percentage 3.Normal distribution.
T-test	Difference between two continuous variables.	1.Random sample 2.Y is continuous, X is discrete. 3.Normal distribution.
Analysis of Variance (ANOVA)	Difference between three or more continuous variables.	1.Random sample 2.Y is continuous, X is discrete. 3.Equal variances.
Chi-square	Relationship between two discrete variables.	1.Random sample 2.Y an X are discrete. 3.Expected counts >5.
Correlation	Linear relationship between continuous variables.	1.Linear relationship between x and y. 2.X and Y are continuous. 3.Both X and Y are Normally distributed.
Ordinary least squares regression	Relationship between one or more x's and continuous y.	1.Linear relationship between x's and y. 2.Errors are normally distributed wih mean of zero and constant variance. 3.Errors are independent. 4. X's are independent of the errors.
Logistic regression	Relationship between one or more x's and discrete y.	See Master Black Belt
Nonparametric methods - specify	A series of tests (for example, sign, Wilcoxon, Mann-Whitney, Krudkal0Wallis, Mood's median and Friedman) in which there is no assumption of a specific distribution for the population.	See MBB
Design of Experiments	Relationship between one or more x's and continuous y.	See MBB
Other	Qualitative evidence (automatically = 1)	See MBB and process owner