Measurement Scales

Data Science for Quality Management: Data and Measurement

with **Wendy Martin**

Learning objectives:

Distinguish between nominal, ordinal, interval, ratio and absolute scales

Identify measurement level of data given background information

Measurement & Measurement Scales

Measurements are not the same as the attribute studied

To draw conclusions, we must consider how the measurement maps to the attribute

Measurement & Measurement Scales

The relationship between the assigned numbers or symbols and the corresponding underlying property yields a level of measurement.

Measurement Scales

Nominal

Ordinal

Interval

Ratio

Absolute

Interval Scale

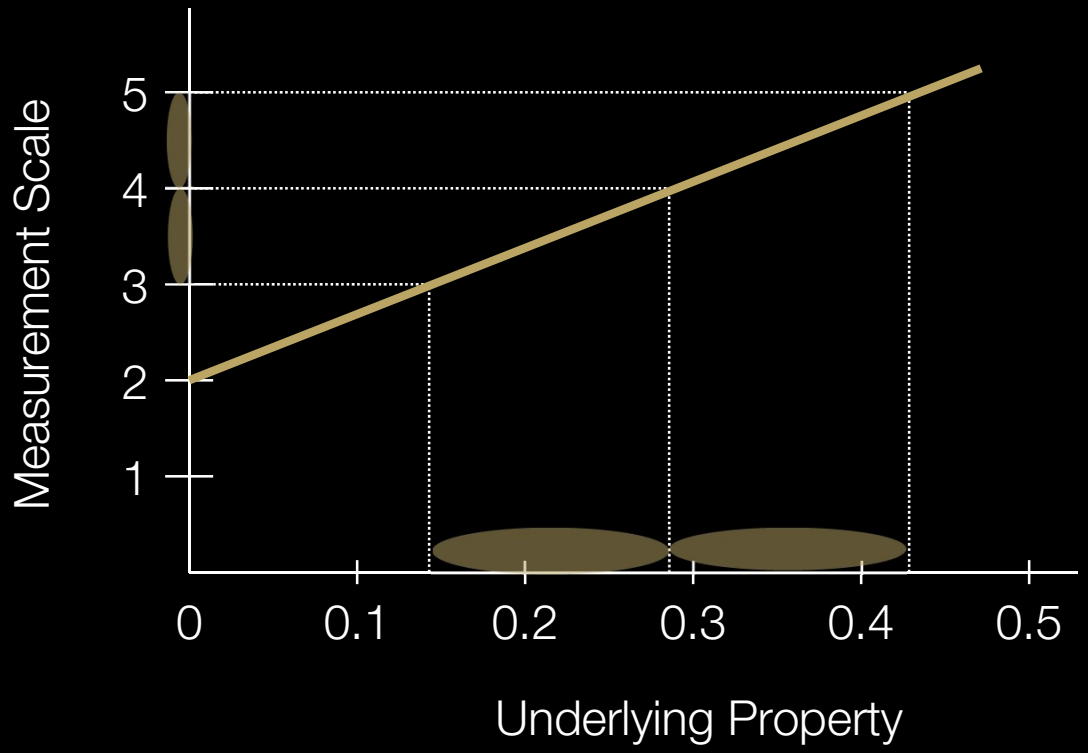
Numbers are assigned to observations such that differences between any two numbers correspond to proportional differences in the underlying property studied, and there are equal intervals along the scale.

Interval Scale

Examples:

- Temperature measured in degrees Fahrenheit
- Directional distance from a reference point
- Calendar date
- Height above sea level

Interval Scale Example



Interval Scale

Permissible transformations include any linear transformation.

Statistics such as the mean and standard deviation may be used.

Interval Scale

Most of the parametric statistical tests may be employed as long as their underlying assumptions are met.

Interval Scale values can be used to determine = or ≠, > or <, and you can use sums (+) and differences (–) with meaning

Ratio Scale

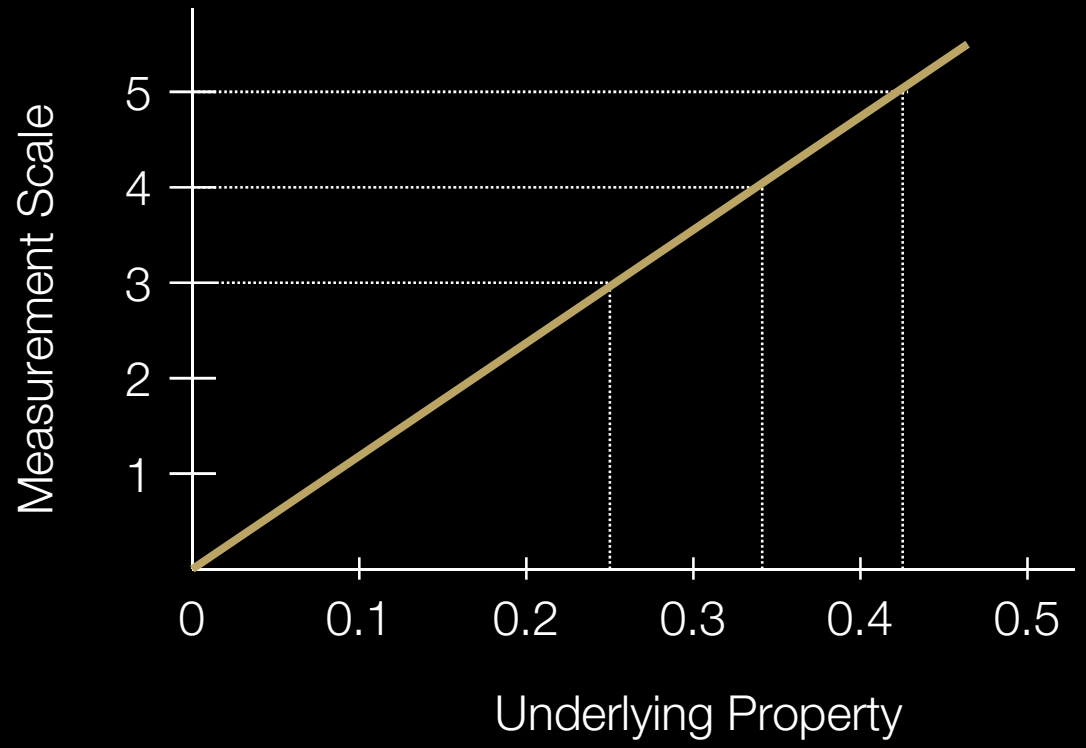
Numbers are assigned to observations such that an interval scale has been reached, and there is a zero point which corresponds to a zero, null state, or absence of the underlying property.

Ratio Scale

Examples:

- Length, height, width, distance
- Volume, weight
- Cycle-time and time-to-repair

Ratio Scale Example



Ratio Scale

Permissible transformations of ratio data involve simply multiplying by a constant.

A few more statistics are available:

- The geometric mean
- The coefficient of variation

Ratio Scale

Any parametric statistical test may be employed with ratio data as long as their underlying assumptions are met (or not significantly violated in the case of robust tests) .

Ratio Scale vs Interval Scale

Consider a bathroom scale:

Two people are weighed on the same bathroom scale, one weighs 200 pounds and the other weighs 100 pounds, is the first twice as heavy as the second?

Ratio Scale vs Interval Scale

What if I told you the scale was NOT set at zero to begin with, but at 50 pounds. Then what?

What are the corresponding Scales of Measurement for each situation?

Absolute Scale (Count Data)

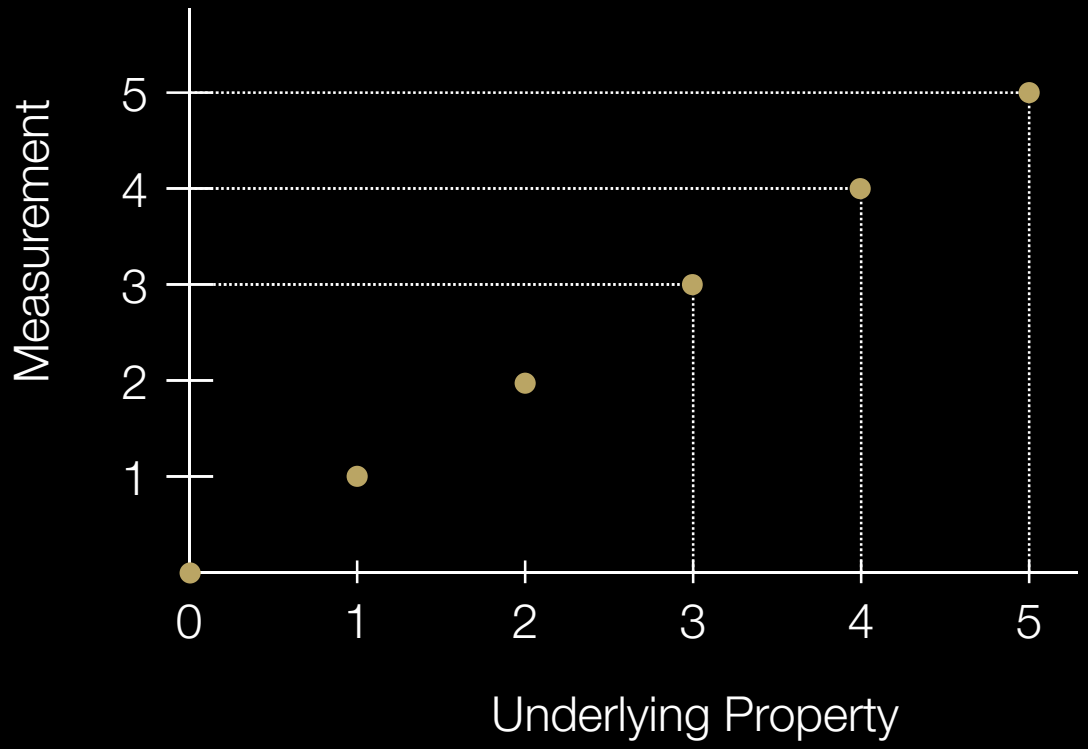
Numbers are assigned to observations such that the numbers directly correspond to the underlying property being studied.

Absolute Scale (Count Data)

Examples:

- The number of defects
- The number of scratches observed
- The number of parts made
- The number of safety accidents
- The number of customer complaints

Absolute Scale Example



Absolute Scale (Count Data)

Some transformations are permissible.

Data on an absolute scale have some of the properties of ratio data.

The mean, median and mode may be used.

Absolute Scale (Count Data)

Various statistical procedures may be used depending on resolution.

In many cases, standard parametric methods may be used, in other cases nonparametric methods must be employed.

Sources

The material used in the PowerPoint presentations associated with this course was drawn from a number of sources. Specifically, much of the content included was adopted or adapted from the following previously-published material:

- Luftig, J. An Introduction to Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1982
- Luftig, J. Advanced Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1984.
- Luftig, J. A Quality Improvement Strategy for Critical Product and Process Characteristics. Luftig & Associates, Inc. Farmington Hills, MI, 1991
- Luftig, J. Guidelines for Reporting the Capability of Critical Product Characteristics. Anheuser-Busch Companies, St. Louis, MO. 1994
- Spooner-Jordan, V. Understanding Variation. Luftig & Warren International, Southfield, MI 1996
- Luftig, J. and Petrovich, M. Quality with Confidence in Manufacturing. SPSS, Inc. Chicago, IL 1997
- Littlejohn, R., Ouellette, S., & Petrovich, M. Black Belt Business Improvement Specialist Training, Luftig & Warren International, 2000
- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005