

# TECH 646 Analysis of Research in Industry and Technology

## PART III

### The Sources and Collection of data: Measurement, Measurement Scales, Questionnaires & Instruments, Sampling

#### Ch. 11 Measurement

Lecture note based on the text book and supplemental materials:

Cooper, D.R., & Schindler, P.S., *Business Research Methods* (12th edition), McGraw-Hill/Irwin

Paul I-Hai Lin, Professor  
<http://www.etcs.pfw.edu/~lin>  
A Core Course for M.S. Technology Graduate Program  
Purdue University Fort Wayne

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## Measurement

### Learning Objectives ... Understand

- The distinction between measuring objects, properties, and indicants of properties.
- The similarities and differences between the **four scale types** used in measurement and when each is used.
- The four major sources of **measurement error**.
- The criteria for **evaluating** good measurement.

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## The Nature of Measurement

Three-part process of measurement

1. **Selecting** observable/measurable events, objects, properties, activities, etc.
2. **Developing** a set of mapping rules (assigning numbers or symbols to represent aspects of the event being measured)
3. **Applying** the mapping rules to each observable/measurable event, object, property, activity, etc

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## Review of Terms

Concept

Construct

Variable

Operational  
Definition

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## The Nature of Measurement (cont.)

### To measure is to discover the extend of

- Dimension, quantity, capacity of something

### Measurement with

- Established index verifies features of a physical object: **weight, height, dimension**
- How well you like this computer, equipment...

### The object of measurement

- Concept and Construct at **theoretical level**
- Operation definitions: defining variables
- Variables at **empirical level** (accept numbers and values)

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## Measurement of a New Concept Car

Select measurable phenomena

Develop a set of mapping rules

Apply the mapping rule to each phenomenon



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## Measurement of a New Concept Car

### Auto Show – new concept car

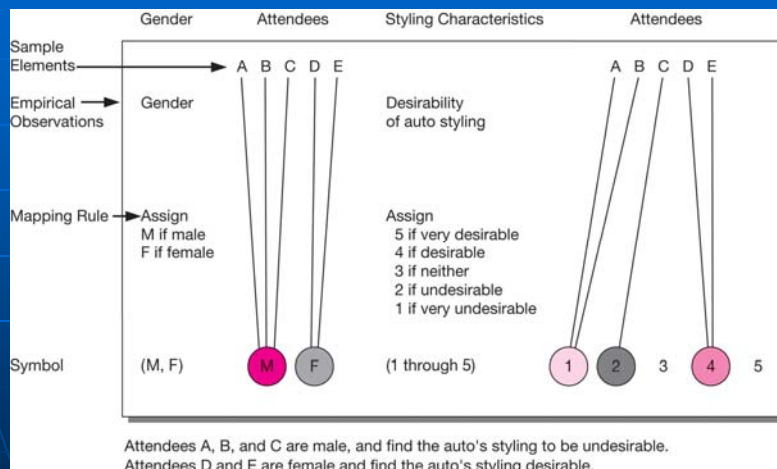
- Attendees Male-Female Ratio (0, 1; M, F; etc)
- Styling Desirability
  - Interview visitors
  - Mapping rules, rating scale for opinion



- Very Desirable – 5
- 4
- 3
- 2
- Very Undesirable 1

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## Exhibit 11-1 Characteristics of Measurement (Concept Car Example)



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## What is Measured?

- **Variables** – may be classified as
  - Objects
  - Properties
- **Objects**
  - **Tangible items:** Computer, Cell Phone, Equipment, People, Automobile
  - **Intangible:** Genes, Attitudes, Peer-group pressures
- **Properties** - Characteristics of the Object
  - Physical properties: Weight, Height, etc
  - Psychological properties: Attitude, Intelligence
  - Social Properties: Leadership ability, Class affiliation, Status
- **Researchers measure**
  - Indicators of the properties
  - Indicators of the properties of objects

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## What is Measured? (cont.)

- Analyzing members of a **sales force** of several hundred people to learn about what “personal properties” contributes to sales success: (**Directly observable/measurable**)
  - Age, Years of Experience, Number of Calls made per Week
- Properties of Constructs: (**cannot be measured directly**)
  - Lifestyles
  - Opinion Leadership
  - Distribution Channel Structure
  - Persuasiveness

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## PulsePoint: Research Revelation

- How **currency manipulation** is measured, the type of indexes used, and differences among indexes?
- How are **trade practices** operationally defined?
- What **measurement levels** are most likely used?

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The percent of U.S. manufacturers experiencing unfair currency manipulation in the trade practices of other countries.

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## Four Types of Measurement Scales

Ratio

interval

Ordinal

Nominal

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## Types of Scales

### ■ Nominal Scales

- **Classification:**
  - Mutually exclusive and Collectively exhausted;
  - No order, distance, or natural origin
  - Grouped into 2 or more categories
- **Basic Empirical Operation:** Determination of equality
- **Examples (variables):**
  - Gender (male, female), Marital Status, Political Orientation
  - Exposure to a Certain Experience: Attendance(1<sup>st</sup> time, attended before)
  - Attitude toward facilities (suitable, not suitable)
  - Appreciation of Leadership (favorable, unfavorable)
  - Religious Preferences

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## Types of Scales (cont.)

### ■ Nominal Scales

- Nominal data are **statistically weak**
- The only quantification
  - The number counts of cases in each category (the **Frequency Distribution**)
- Restricted to the use of “Mode” –the most frequently occurring value
- No general used measure of “Dispersion” for nominal scale

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## Levels of Measurement

Nominal

Classification

Ordinal

Interval

Ratio

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## Levels of Measurement

Nominal

Classification

Ordinal

Classification

Order

Interval

Ratio

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## Types of Scales (cont.)

### ■ Ordinal Scales

- Nominal + an Indication of Order
- Support Logical Postulate:
  - Ranking: Greater than, Less than, Equal to
  - Superior to, Important than
  - Happier than, Poor than
- Ordinal data:
  - Attitude, Preference scales
  - Appropriate measures of central tendency: Median (mid-point of a distribution)
  - A percentile or Quartile – Dispersion

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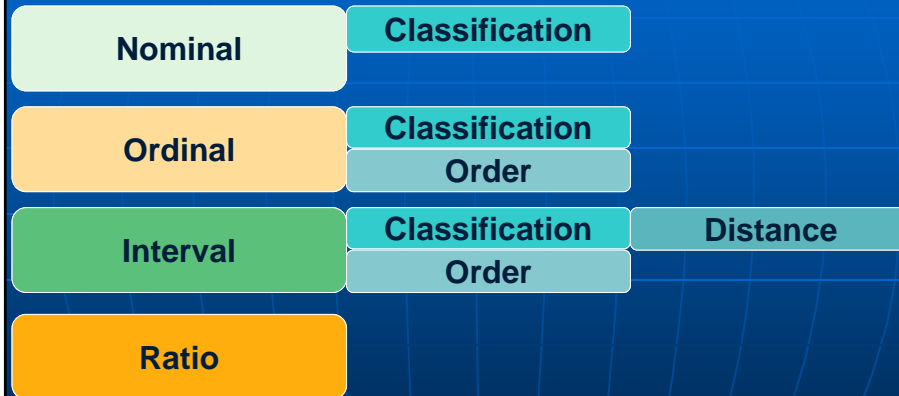
## Types of Scales (cont.)



- Ordinals:  
Characteristics of nominal scale plus an indication of **order**
- Implies statement of greater than and less than

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## Levels of Measurement



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## Interval Scales

### ■ Interval Scales

- Power of **Nominal** + **Ordinal** + Concept of equality of **Interval**
- Distance between 1 and 2, 2 and 3
- Calendar time
  - Elapse time between 3 a.m and 6 a.m **equals** the time between 4 & 7 a.m.
- Zero time: an arbitrary zero

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## Interval Scales

### ■ Interval Scales

- Centigrade and Fahrenheit temperature scale: arbitrary 0 (not a unique origin)

**Ordinal Scale Characteristics**

**Equality of interval**

**Equality of distance between numbers**



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## Interval Scales

### ■ Interval Scales

- Statistics Procedures
- Standard deviation – the measure of dispersion
- The product-moment correlation
- t-tests
- F-tests (in honor of Sir Ronald A Fisher)
- Other Parametric tests

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## Levels of Measurement

Nominal	Classification	
Ordinal	Classification Order	
interval	Classification Order	Distance
Ratio	Classification Order	Distance Natural Origin

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## Ration Scales

- Ratio Scales

Interval Scale  
Characteristics

Absolute Zero



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## Types of Scales

### ■ Ratio Scales

- **Nominal + Ordinal + Interval** + provision for **Absolute Zero or Origin**
- Represent the actual amount of a variable
- **Examples**
  - Physical dimensions: Weight, Height , distance, etc
  - Money values, Return rates
  - Productivity rate
  - Amount of time
  - Population counts
- Can **apply all statistical methods** mentioned
  - Division, multiplications

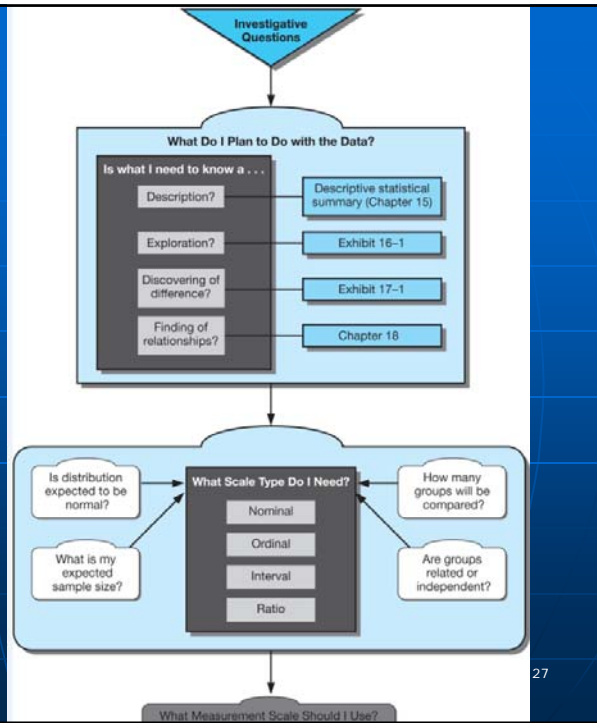
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## Examples of Data Scales

Type of Scale	Example
Nominal	Gender (male, female)
Ordinal	Doneness of meat (well, medium well, medium rare, rare)
Interval	Temperature in degrees
Ratio	Age in years

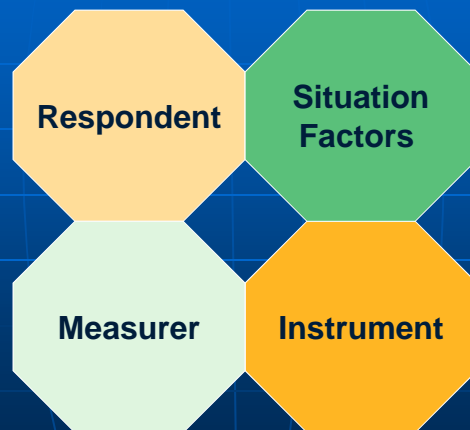
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## From Investigative to Measurement Questions



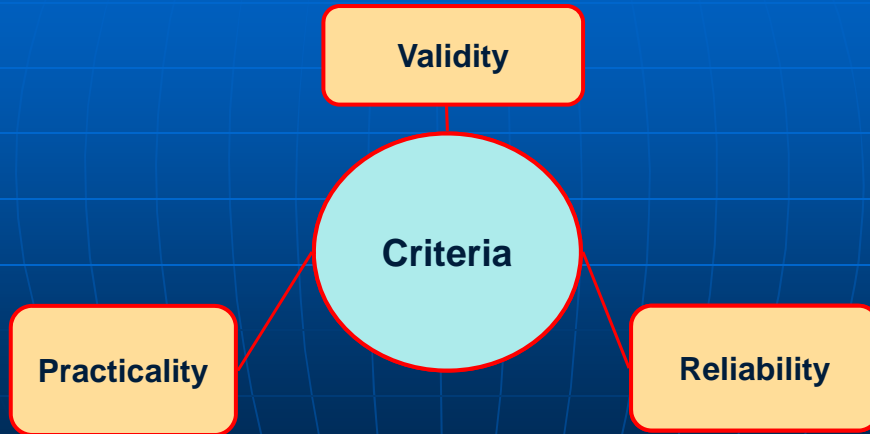
## Sources of Measurement Differences

- Sources of Error



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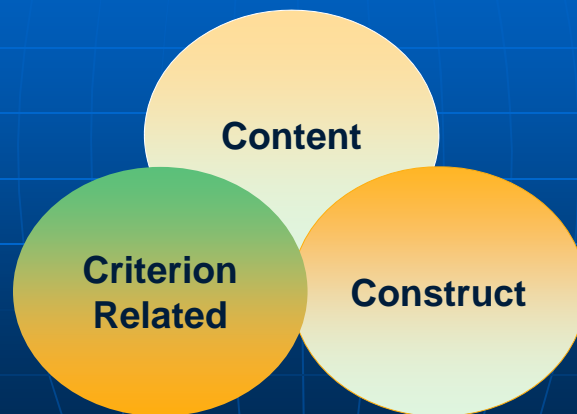
## Evaluating Measurement Tools



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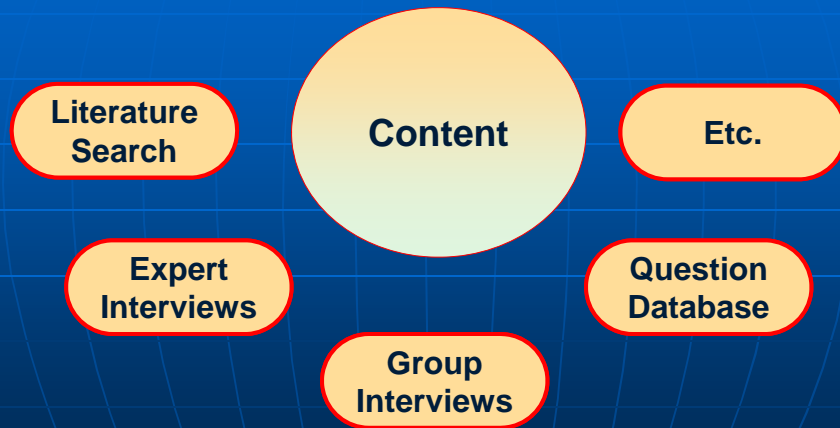
## Validity Determinants

- Inter-related, both theoretically & operationally



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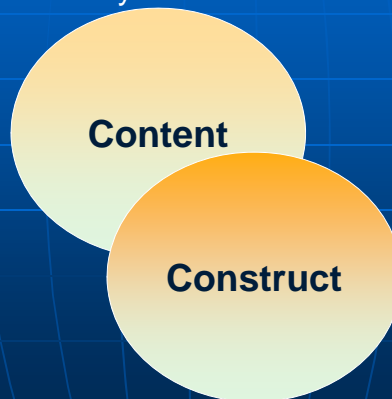
## Increasing Content Validity



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## Validity Determinants

- Construct Validity demonstrates
  - Convergent validity and
  - Discriminant validity



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## Increasing Construct Validity

- “Trust” in relationship marketing/collaboration

New measure of trust

Known measure of trust

Empathy

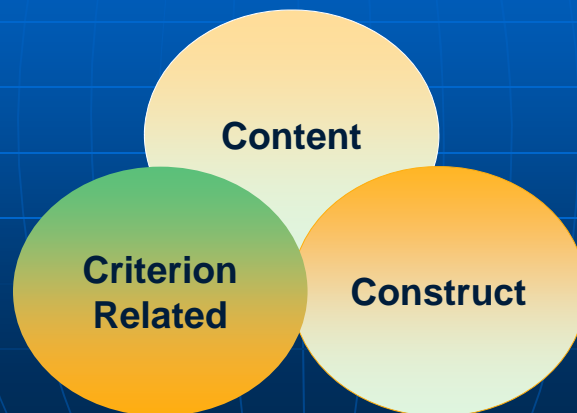
Credibility



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## Validity Determinants

- Criterion-related Validity:
  - Concurrent and Predictive
  - Differ only on the time perspective



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## Judging Criterion Validity



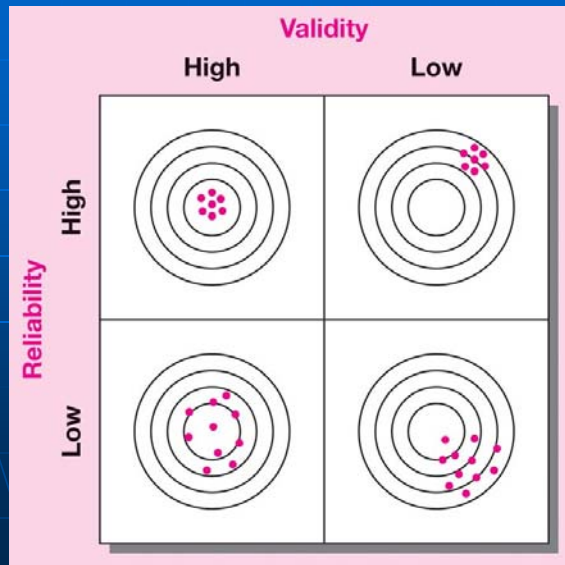
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## Summary of Validity Estimates

Types	What Is Measured	Methods
<b>Content</b>	Degree to which the content of the items adequately represents the universe of all relevant items under study.	<ul style="list-style-type: none"> <li>• Judgmental</li> <li>• Panel evaluation with content validity ratio</li> </ul>
<b>Criterion-Related</b>	Degree to which the predictor is adequate in capturing the relevant aspects of the criterion.	<ul style="list-style-type: none"> <li>• Correlation</li> </ul>
<b>Concurrent</b>	Description of the present; criterion data are available at the same time as predictor scores.	<ul style="list-style-type: none"> <li>• Correlation</li> </ul>
<b>Predictive</b>	Prediction of the future; criterion data are measured after the passage of time.	<ul style="list-style-type: none"> <li>• Correlation</li> </ul>
<b>Construct</b>	Answers the question, "What accounts for the variance in the measure?"; attempts to identify the underlying construct(s) being measured and determine how well the test represents it (them).	<ul style="list-style-type: none"> <li>• Judgmental</li> <li>• Correlation of proposed test with established one</li> <li>• Convergent-discriminant techniques</li> <li>• Factor analysis</li> <li>• Multitrait-multimethod analysis</li> </ul>

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## Exhibit 11-6 Understanding Validity and Reliability



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## Reliability Estimates



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## Reliability Estimates

- Stability
  - Test-retest
  - Comparisons of two tests to learn how reliable they are
  - A correlation between the two test indicates the degree of stability
- Equivalence
- Internal Consistency

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## Reliability Estimates



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## Reliability Estimates

- Stability
- Equivalence
- Internal Consistency
  - A characteristics of an instrument in which the items are homogeneous
  - The Split-Half technique and Cronbach's alpha can be used

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## Reliability Estimates



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## Reliability Estimates

- Stability
- Equivalence
  - Concerns with variations at one point in time among observers and samples of items
  - Compare different observers' scores of the same event
  - Alternate or Parallel forms of the same test
- Internal Consistency

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## Summary of Reliability Estimates

Type	Coefficient	What Is Measured	Methods
Test-Retest	Stability	Reliability of a test or instrument inferred from examinee scores; same test is administered twice to same subjects over an interval of less than six months.	Correlation
Parallel Forms	Equivalence	Degree to which alternative forms of the same measure produce same or similar results; administered simultaneously or with a delay. Interrater estimates of the similarity of judges' observations or scores.	Correlation
Split-Half, KR20, Cronbach's Alpha	Internal consistency	Degree to which instrument items are homogeneous and reflect the same underlying construct(s).	Specialized correlational formulas

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## Practicality

Economy

Convenience

Interpretability

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## Key Terms

- Internal validity
- Interval scale
- Mapping rules
- Measurement
- Nominal scale
- Objects
- Ordinal scale
- Practicality
- Properties
- Ratio scale
- Reliability
  - Equivalence
  - Internal consistency
  - Stability
- Validity
  - Construct
  - Contents
  - Criterion-related

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# SUMMARY