Human-Computer Interaction

Measurement Basics

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Today's Agenda

» Topic overview: *Measurement Basics*

» Hands-on Activity: *Objective Measures*

What do we measure when we measure?

Definition: Measurement is the assignment of a number to a characteristic of an object or event, which can be compared with other objects or events.[1]

But it's not just numbers! We can measure:

Quantitative measurements describe the degree of an attribute, e.g., an under-three-hour marathon runner, someone who scores 1600 in SAT

Qualitative measurements describe subjective observations, e.g., "the first customer was a tall man"

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[1] Wikipedia

How do we represent measurements?

Variables are things that change, e.g., gender, preference, performance

Attributes qualify variables, e.g., male vs. female, high-performance, low-performance

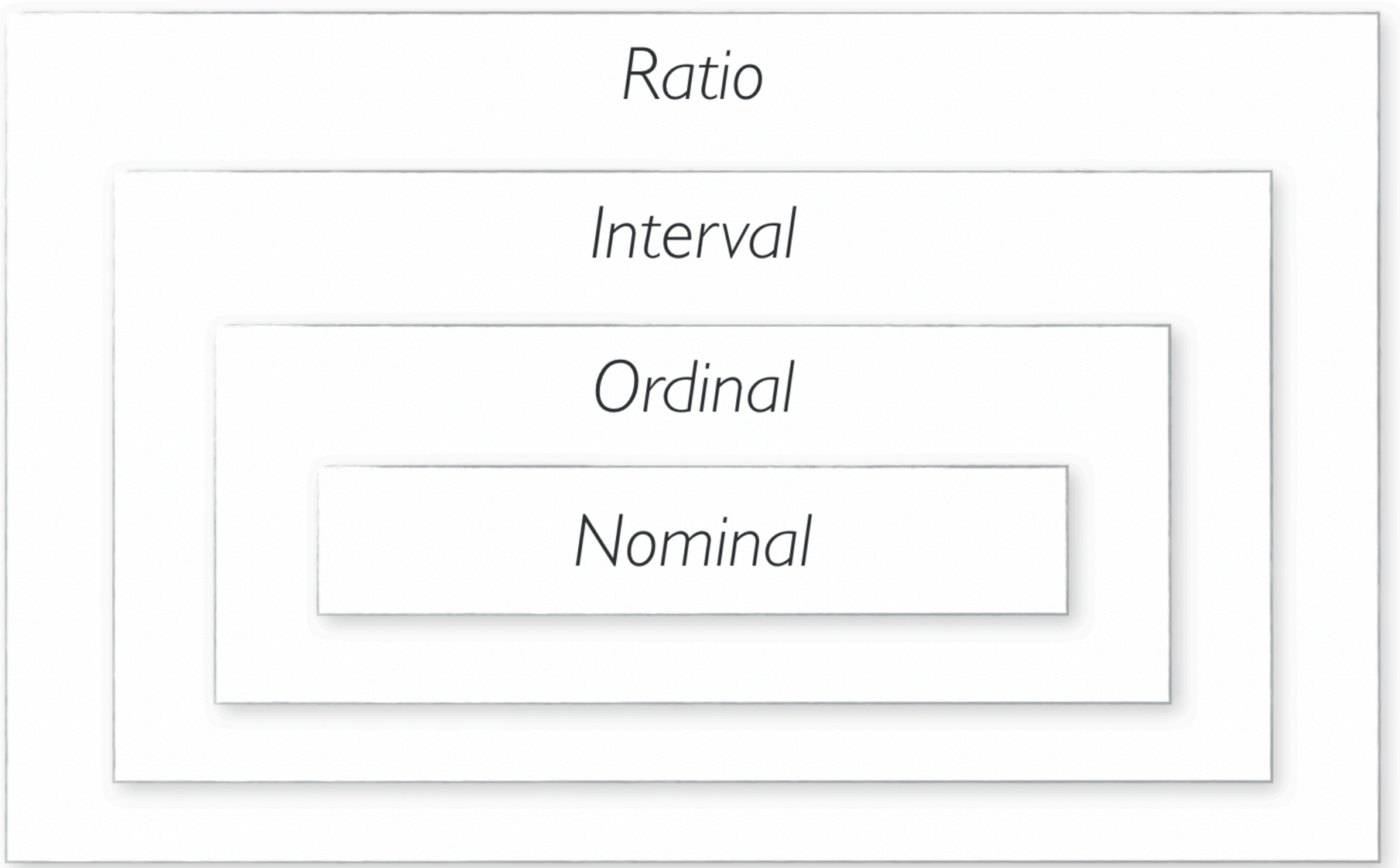
What are different types of variables?

Nominal data are names of groups or categories, e.g., males vs. females, American vs. Japanese

Ordinal data is a rank-ordering of measurements, e.g., very satisfied, satisfied, neutral, unsatisfied, very unsatisfied

Interval data are measurements along a scale with no real zero, e.g., happiness in a scale of 1 to 7

Ratio data are measurements along a scale with a real zero, e.g., a person's weight


Ratio
Interval
Ordinal
Nominal

	Nominal	Ordinal	Interval	Ratio
Distinctiveness	Yes	Yes	Yes	Yes
Rank ordering	No	Yes	Yes	Yes
Equal intervals	No	No	Yes	Yes
Absolute zero	No	No	No	Yes

Other terms you might hear…

- **Descriptive**, e.g., "a tall man"
- **Categorical**, e.g., novice vs. expert, high vs. mid. vs. low
- **Numeric**, e.g., age
- **Discrete**, e.g., subjective ratings of an interface from 1 to 7
- **Continuous**, e.g., performance measures

What are different kinds of measurements we can take?

1. **Objective**: Measurement from participants against an objective standard, e.g., performance in a test
2. **Behavioral**: Measurement of the actions and behaviors of participants, E.g., how much eye-contact participants maintain with a robot
3. **Subjective**: Measurement of self-report data on subjective evaluations, e.g., preferences, personality
4. **Physiological**: Measurements taken directly from participants' bodies, e.g., body temperature, GSR, EEG, EMG, fMRI

What makes measurements good?

1. Validity
2. Reliability
3. Quality

What is validity?

Definition: Validity is the extent to which a concept, conclusion, or measurement is well-founded and likely corresponds accurately to the real world.[2]

In other words, are we measuring what we want to measure?

[2] Wikipedia)

What is an example validity problem?

Consider wanting to measure **aggression in children**

We can measure the amount of time children play with: *aggressive toys* (guns, swords, tanks) vs. *non-aggressive toys* (trucks, tools, dolls)

What are threats to validity?

» Children might be playing with toys that they are more familiar with, e.g., they see guns and tanks on TV all the time

» Children can also play with trucks and dolls in aggressive ways

What are different forms of validity?

1. Face validity
2. Construct validity
3. Empirical validity
4. Content validity
5. Ecological validity

Face validity

Definition: The extent to which a measure *appears* valid

Based on logical reasoning and judgment, not statistical

Construct validity

Definition: The extent to which conceptual *constructs* relate to what they intend to measure.

Two types of construct validity

Convergent validity: The extent to which the measure is associated with things it should be associated with, e.g., *intellect* and *competence* should correlate

Discriminant validity: The extent to which the measure is *not* associated with things it should *not* be associated with, *intellect* and *control* should not correlate

What is a construct?

Definition: A psychological construct is a label for a cluster or domain of covarying behaviours.[3]

What happens when we have low or high construct validity?

A high construct validity means that the measurement sufficiently captures and covers the construct.

[3] Brittanica

A measure of ***introversion*** $(\alpha = .85)$[4]

Positive keyed

- Don't like to draw attention to myself.
- Keep in the background.
- Dislike being the center of attention.
- Don't talk a lot.

Negative keyed

- Don't mind being the center of attention
- Take charge.
- Want to be in charge.
- Am the life of the party.
- Can talk others into doing things.

[4] IPIP

Empirical validity (criterion validity)

Definition: The extent to which results from the measure relate to existing, well-established measures

What are different forms of empirical validity?

Concurrent validity: the extent to which the measure correlates with other measures of the same construct taken at the same time.

Predictive validity: the extent to which the measure can predict other measures of the same construct that will be taken in the future

Content validity

Definition: The extent to which the sample covers a representative sample of the behavior that is measured

E.g., GREs verbal test captures vocabulary but not grammar, understanding, or communication

Ecological validity

Definition: The extent to which research results can be applied to real-life situations

E.g., the ability to perceive dots on a screen fast might not help with detecting cars in traffic

What is reliability?

Definition: Reliability in statistics and psychometrics defines the consistency of a measure across repeated measurements and judgments.

E.g., more robot gaze leads to better information recall; could we replicate this result with a second set of subjects or with the same subject another time?

High reliability indicates that the measure produces similar results under consistent conditions.

Reliability is decreased by error.

How do we calculate reliability?

We can't—we can only *estimate* it using statistical methods.

$$R = \frac{v_{true}}{v_{true} + v_{error}}, R \in [0, 1]$$

Pro Tip: A reliability of .70 or higher is acceptable

How do we ensure reliability?

1. **Test-retest reliability**: Involves repeating the same measurement with the same population another time
2. **Alternative form method**: Involves administering a second measure with similar measures with the same population
3. **Split-half technique**: Involves splitting data from the measure into half and correlating the results

Reliability method	Pros	Cons
Test-retest	- Uses the same test items - Simple to administer	- First testing may contaminate the second - Respondent may change with time
Alternative-form	- Minimizes repeat-item contamination - Little time passes before retesting - Useful for pre/post-testing	- Use of different items lowers reliability - Requires a longer test
Split-half	- Minimizes repeat-item contamination - No time passes - Done at a single session	

What are different forms of reliability?

1. Internal reliability
2. Inter-coder reliability

Internal reliability

Definition: A measure of whether several items that propose to measure the same general construct produce similar scores.[5]

What are measures of internal reliability?

1. **Inter-item correlation**: mean of all pairwise correlations across items of a measure
2. **Split-half correlation**: correlations between two randomly split halves of the measure
3. **Cronbach's α**: inter-item correlations that are iteratively calculated across randomly selected subsets of the measure ($\alpha > .70$ desirable)

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[5] Wikipedia

Inter-coder reliability

Definition: The degree of agreement among raters of the same phenomenon.

Measures of inter-coder reliability

» Percent agreement

» Cohen's κ, Fisher's κ, Kripperndorff's α

What does data quality mean?

Data quality is affected by **measurement error** (or observational error).

Definition: The difference between the measurement (what is recorded) and the true quantity of the variable, i.e., distortions that cause the observed measurement to be different from the true quantities.

$$X = T + e_r + e_s$$

What are different types of error?

1. Random error
2. Systematic error

What is random error?

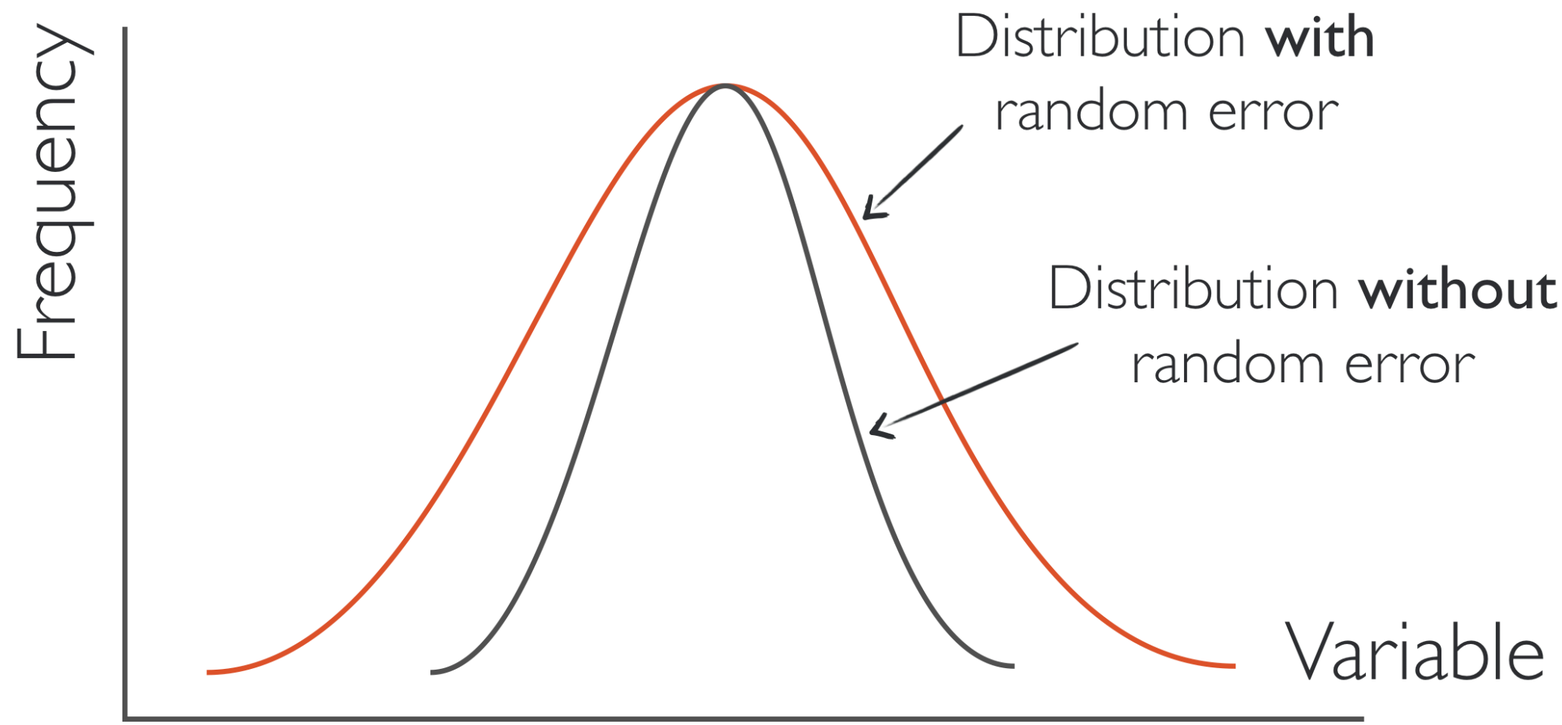
Definition: Random errors are errors in measurement that lead to measurable values being inconsistent when repeated measurements of a constant attribute or quantity are taken.[6]

Random error is also called *noise*.

[6] Wikipedia

What causes random error?

Inherent in any measure that randomly varies (e.g.,) and affects variance, not the mean.



What is systematic error?

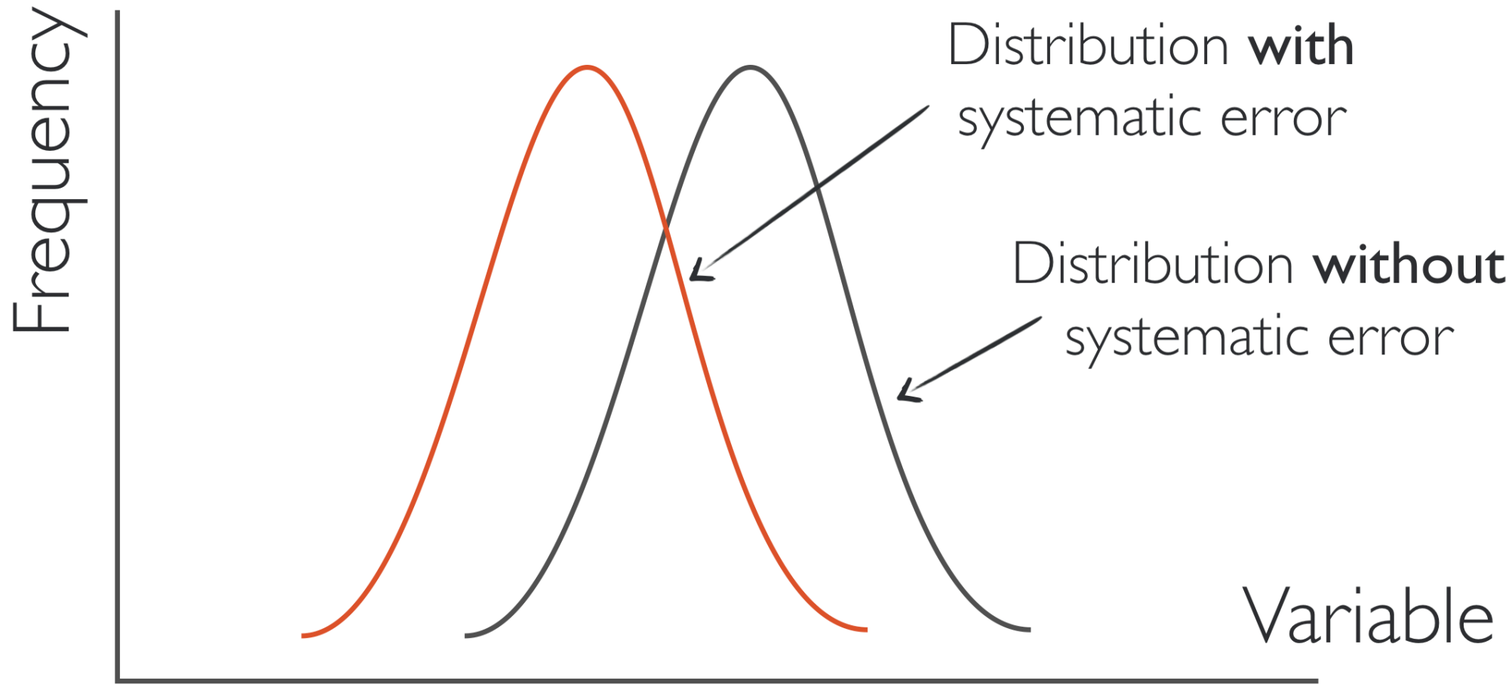
Definition: Systematic errors are errors that are not determined by chance but are introduced by an inaccuracy (involving either the observation or measurement process) inherent to the system.[6]

Systematic error is also called *bias*.

[6] Wikipedia

What causes systematic errors?

Caused by external factors (e.g., measurement noise, equipment delay, coder error) and affects the mean.



How do we increase measurement quality?

- Piloting experimental instruments
- Testing reliability of coders, retraining
- Repeating manual data entry
- Measuring error using statistical methods
- Triangulation