

## Overview of Empirical Methods

## Empirical Research Methods

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- Next few weeks are advertisements for other methods courses
  - ICS 235A Qualitative Research Methods
  - ICS 235B Quantitative Research Methods
- Will introduce a number of methods
  - Can recognize, probably distinguish between good and bad instances, but can't use without further training
- Useful for both question formulation and validation

## What are research methods?

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- Recipes for research designs
  - Instantiated within a study
- Classic methods
  - Controlled Experiments
  - Case Study
  - Surveys
  - Action Research
  - Benchmarking
  - Ethnography
- Each method has been evolved with a particular data analysis technique
  - E.g. experiments -> ANOVA,
  - surveys -> confidence intervals, correlation,

## Characteristics of Studies

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- Formative vs. summative
- Laboratory vs. field
  - In vivo vs. in situ
- Controlled vs. observational
- Incremental vs. longitudinal
- Contemporary vs. retrospective
- Theory-driven analysis vs. data-driven analysis
  - Positivist vs. interpretivist
- Independent of specific research method

## Other Characterizations

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- Few purely qualitative or quantitative methods
  - Some methods lend themselves more easily to one or the other
  - Adjectives better applied to the questions and data

## Criteria for Critiquing Studies

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- Validity
  - Does it measure what it claims to?
- Reliability
  - Does it produce the same result repeatedly? For one subject? For multiple subjects?
- Generalizability
  - A technical term
  - Can the results be applied to settings outside of study setting?
- Confounds
  - Complications in the interpretation of results

## Types of Validity

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- Construct validity
  - Does a test measure a hypothetical construct?
- Internal validity
  - Is the study methodologically sound?
    - Do the constructs relate correctly?
- External validity
  - Can the results from the study be applied to other settings?
  - Representativeness and statistical significance (p level)

## Threats to Validity

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- Competing explanations for the results obtained
  - Need to be ruled out
  - Confound results
- Pre-Post Studies
  - Learning from being tested
- History
  - Influence of historical events
- Maturation
  - Aging and learning by subjects
- Regression to the mean
  - Extreme scores become less so, upon re-test
- Subject selection
  - Self-selection, attrition

## Experiments

- Usually (but not necessarily) controlled, incremental, contemporary, laboratory, theory-driven
- Concept: Measure the effect of a small change by holding everything else constant
  - What is the effect of X on Y?

## Measurement

- Measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to clearly defined rules.
  - It's a mapping
  - Example: size of source code- lines, executable statements, bytes
- Operationalization is the process of taking a concept and turning it into measurable components of a study
  - Concept -> construct
  - Behavior -> measure

## Admissible Operations

Scale Type	Admissible Operations	Examples
Nominal	Summation	a, b, c, d, ...
Ordinal	Addition (and Subtraction)	1 <sup>st</sup> , 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> , ...
Interval	Addition, Multiplication	10, 25, 32, 60 (no absolute zero)
Ratio	Addition, Multiplication, Division	0, 10, 25, 32, 60 (has absolute zero)
Absolute	All	counts

## Admissible Transformations

Scale Type	Admissible Transformations	Examples
Nominal	$M' = F(M)$ (F is 1-1 mapping)	Labeling or classifying entities
Ordinal	$M' = F(M)$ (F monotonic increasing, i.e. $M(x) \geq M(y) \Rightarrow M(x') \geq M(y')$ )	Preference, hardness, air quality
Interval	$M' = \alpha M + \beta$	Time (calendar), temperature (Fahrenheit, Centigrade)
Ratio	$M' = \alpha M$ ( $\alpha > 0$ )	Time interval, length, temperature (Kelvin)
Absolute	$M' = M$	Counting entities

## Appropriate Inferential Statistics

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Scale Type	Defining Relations	Examples of Appropriate Statistics	
Nominal	Equivalence	Mode, frequency, median, percentile	Non-parametric
Ordinal	All of the above, plus: greater than	Spearman, Kendall	
Interval	All of the above, plus: known ratio of any intervals	Mean, standard deviation, Pearson, multiple regression	Parametric and Non-parametric
Ratio	All of the above, plus: known ratio of two interval values	Geometric mean, coefficient of variation	