Introduction to Research & Design of Experiments

Scientific Method
- Propose Hypothesis (Based on Theory)
- Collect and Analyze Data
- Test Hypothesis (Statistical Analysis)
- Confirm / Deny Hypothesis
- Explain Discrepancies
- Report Conclusions

Research - Definition and Purpose
- Process - Systematic, Organized, Logical
  - Investigation of nature and natural phenomena
- Purpose -
  - Develop Understanding
  - Discover Truths
  - Ascertain “What Causes What”
- Leads to unequivocal interpretations/generalizations.
- Helps choose and decide upon one hypothesis from among equally plausible hypotheses.

Research Cycle
- Observation
- Theory Formulation -
  - Statement of Research Hypotheses
- Research and Data Collection
- Statistical Analyses
- Reporting

Research
- Introduction to Research
  - Definition and Purpose
- Research Cycle
  - Structure of a Research Project
- Types of Research
  - Descriptive
  - Experimental

Research
- Research CANNOT prove a hypothesis; however it helps disprove (disaffirm) alternate hypotheses and helps build a cumulative body of corroborating evidence in support of the primary hypothesis.
Research Cycle - continued

Observation
- Literature Search, Own Research
- Natural Setting, Laboratory Environment

Statement of Research Hypothesis
- Supported by Theoretical Basis
- Stated in Specific Terms
- Testable Scenario
- Predictive Results

Data Collection
- Study, Experiment, Clinical Observations
- Data Collected and Recorded

Statistical Analyses
- Descriptive Statistics
- Inferential Statistics
- Parameter Estimation
- Null Hypothesis Testing
- Research Hypothesis Supported or Refuted

Research Cycle - continued

Reporting
- Written
- Reviewed
- Presented
- Published
- Replicated

Structure of a Research Report

Introduction
- Methodology
- Analysis (Results)
- Discussion
- Summary
- Limitations
- Conclusions
- Recommendations

Research Report - continued

Introduction
- Problem Area
- Literature Review
- Problem Statement
- Variables (Independent and Dependent)
- Hypotheses

Methodology
- Subjects
- Experimental Design
- Operational Definitions
- Treatments
- Apparatus
- Instrumentation
- Stimuli
- Techniques
- Procedures
**Descriptive Research**

Describes differences based on observations.

May be used to suggest possible causation agents.

Cause and Effect conclusions are NOT supported.

Descriptive Research CANNOT and DOES NOT prove anything !!!!

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**Types of Descriptive Research**

- Survey
- Case Study
- Developmental
  - Trend Analysis
  - Longitudinal Studies
  - Cross-Sectional Studies
- Causal Comparative (Correlational, Ex Post Facto)

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**Experimental Research**

Controls the experimental environment - Helps discover cause and effect

Manipulates (Controls) the Independent variable (Treatment)
  - Do what, to whom, how much, how often where, when, etc, etc, etc.

Observe the effects on the Dependent variable (Response)

Draw conclusions about the extent of the cause and effect relationship.

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**Types of Experimental Research**

- Nomothetic
- Ideographic

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**Design of Experiments**

Producing Meaningful Data
  - Sampling Theory
  - Random Sampling
  - Statistical Inference
  - Sampling Designs

Principles of Experimental Design
  - Randomization
  - Confounding Variables
  - Replication and Repeatability

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**Producing Meaningful Data**

Why Sample - Faster, Cheaper, Easier

Meaningful data, not just numbers
  - What needs to be measured
  - How should it be measured
  - What are the variables

Experimental Design addresses the following
  - How many subjects, how to select, how to group
  - How many trials
  - How to analyze the results
Sampling Theory

Subjects randomly selected and randomly assigned to different treatment levels.

Any characteristics (differences) that are present in the population, will be proportionally distributed in a random sample, thereby canceling any bias between the groups (treatment levels).

Any differences between the groups, will be due to the effects of the different treatments themselves and not do to any differences between individual subjects.

Random Sampling

Chance is deliberately used in statistical sampling, experimentation, and analysis.

Chance helps eliminate bias and helps assure a representative sample.

Bias controlled by randomization. Variability controlled by sample size.

Statistical Inference

Making Inferences

Drawing Conclusions

Generalizing about a population based on sample data.

Estimate the value of a population parameter using the value of a sample statistic.

Form a conclusion about a population in general based on a specific sample characteristic.

Sampling Designs

Simple Random Sample (SRS)

Stratified Random Sample

Multi-Stage Sample

Cluster Sample

Systematic Sampling

Purposive Sampling

Principles of Experimental Design

Randomization (Bias & Variability)

Control of or Accounting for the Effects from Confounding (Extraneous) Variables

Replication and Repeatability (Validity & Reliability)

Randomization

Completely Randomized (Between Subjects) Design
All subject participate in only one treatment level.

Repeated Measures (Within Subject) Design
All subjects participate in all treatment levels.

Mixed Factorial (Blocked or Nested) Design
Subjects are grouped according to some common characteristic, then participate in all remaining treatment conditions.
### Confounding Variables

- History
- Maturation
- Instrumentation
- Testing
- Regression
- Selection
- Mortality
- Interaction of Testing with the Experimental Variable
- Interaction of Selection with the Experimental Variable
- Reactive Effects of the Experimental Environment
- Multiple Treatment Effects

### Replication & Repeatability

- Validity
- Reliability

### Validity

- Face Validity
- Content (Internal) Validity
- Construct Validity
- Predictive (External) Validity

### Reliability

- Stability (Test / Re-Test)
- Equivalence (Alternate Forms)
- Internal Consistency (Split-Halves)

### Related Terms

- Experiment, Subjects, Regressors, Responses
- Independent and Dependent Variables
- Bias and Variability
- Block(ing) / Nesting and Repeated Measures
- Within, Between, Mixed Factorial Designs
- Fixed, Random, and Mixed Effects
- Treatment, Factors, Levels
- Control Group, Control, Placebo
- Main Effects, Simple Effects, Interactions
- Hawthorn Effect, Blind, Double Blind
- Anecdotal Evidence