Defining Characteristics
- Research designed to investigate cause and effect relationships through the direct manipulation of an independent variable and control of extraneous variables
  - Independent variable –
    - the variable being manipulated
  - Dependent variable –
    - the variable in which the effect of the manipulation of the independent variable are observed
  - Researcher manipulation and control –
    - choice of treatments, choice of a research design, use of specific procedures, etc.

Manipulation and Control
- Manipulation
  - The researcher’s decisions related to what will make up the independent variable
  - Active variables (manipulated) versus assigned variables (not manipulated)
- Control
  - The researcher’s efforts to remove the influence of any extraneous variables that might have an effect on the dependent variable (e.g., alternative explanations)
  - The goal is to be assured the only differences between groups is that related to the independent variable

Experimental Validity
- Internal validity –
  - the degree to which the results are attributable to the independent variable and not some other rival explanation
- External/ECological validity –
  - the extent to which the results of a study are generalizable
- Relative importance of internal and external validity
Threats to Internal Validity

- **History**
  - Events that occur during a study that impact results
  - 9/11 would have impacted anxiety studies

- **Maturation**
  - The impact of normal development on results
  - How do you know that reading scores didn’t improve because of normal maturation?

- **Testing**
  - An issue in pre-test/post-test designs
  - How do you know the post-test scores didn’t improve because subjects took the same test twice?

- **Instrumentation**
  - If using different pre and post tests, how do you know that subjects improved because the pretest was more difficult than the posttest?

- **Statistical regression (regression to the mean)**
  - A concern when using pre and post tests
  - People who score very high or very low the first time will tend to score closer to the mean the second time.

- **Differential selection of participants**
  - When testing non-randomly formed groups
  - How do you know the groups weren’t different before the study began?

- **Mortality**
  - The impact of subjects dropping out of a study.
  - How do you know that the results would not have been different with if everyone had remained in the treatment group?

- **Selection-maturation interaction, etc.**
  - A consideration when testing preselected groups
  - When participants selected into different treatment groups have different maturation rates
  - Interactions also occur with history, maturation, and testing factors
Threats to External Validity

- **Pre-test treatment interaction**
  - When subjects' reactions to a treatment are affected by exposure to a pretest

- **Multiple treatment interference**
  - When subjects receive multiple treatments, effects from the first treatment may make determining the impact of the second treatment difficult

- **Selection treatment interaction**
  - A problem when non-random samples are used
  - Ex) When using volunteer subjects, what target population do they represent?

- **Specificity of variables**
  - Refers to the idea that experiments are conducted using specific variables under specific conditions that may limit generalizability
  - A problem when variables are poorly operationalized
  - Do the experimental conditions represent reality?

- **Treatment diffusion**
  - Refers to unintended information sharing
  - When information is shared between experimental groups that impacts the how treatments are implemented in each group

- **Experimenter effects**
  - Refers to a researcher's influence on subjects or how procedures are followed. (ex, was the researcher more enthusiastic with one group over another?)

- **Reactive arrangements**
  - Artificial environment – responding differently to a “fake” environment
  - Hawthorne effect – acting differently because you know you are a participant
  - John Henry effect – when the control group tries to “beat the treatment” because they know they are in the control group
  - Placebo effect – when control group subjects respond to the placebo in a manner consistent with their expectations for treatment
  - Novelty effect – increased response to a treatment because it is different, not better
Controlling for Extraneous Variables

- Randomization
  - Selection (of subjects from the population)
  - Assignment (to levels of the independent variable)

- Matching
  - Identifying pairs of subjects “matched” on specific characteristics of interest
  - Randomly assigning subjects from each pair to different groups
  - Difficulty with subjects for whom no match exists

Group Designs

- Two major classes of designs
  - Single-variable designs –
    - one independent variable
  - Factorial designs –
    - two or more independent variables

- Three types of designs
  - Pre-experimental designs
  - Experimental designs
  - Quasi-experimental designs

Pre-Experimental Designs

- Do not involve random assignment to treatments
- Types
  - One-shot case study
  - One-group pretest-posttest design
  - Static group comparison
- Threats to internal validity – see Figure 13.1
Sample Research Topic
The Efficacy of Reading Tutoring

Research Question
Does reading tutoring cause improved reading achievement?

Variables
Independent = Reading Tutoring
1 hour of daily individual reading tutoring

Hypotheses
Alternative –
Reading tutoring results in higher scores on standardized reading tests
Null –
Reading tutoring has no impact on reading scores on standardized tests

Target Population
Second grade students

Pre-Experimental Designs

One-Shot Case Study
Sample of second graders selected
All subjects exposed to reading tutoring for one month followed by a reading test
$X \ 0$
Major Validity Problems = History, Maturation, & Mortality

One-Group Pretest – Posttest Design
All subjects given a reading pretest followed by one month of tutoring followed by a reading posttest
Adds a pretest to One-Shot Case Study Design
$0 \ X \ 0$
Major Validity Problems = History, Maturation, Testing, Instrumentation, Regression, & Pretest Interaction

Static Group Comparison
Measures two levels of the independent variable
1 hour of daily reading tutoring (experimental group – $X_1$)
No daily reading tutoring (control group – $X_2$)
Sample of 2nd graders selected and assigned, but not randomly, to the experimental or control group.
Each group exposed to their group’s level of tutoring for one month followed by a reading test
$X_1 \ 0 \ \ X_2 \ 0$
Major Validity Problems = Maturation, Selection, Mortality, & Selection Interaction
True Experimental Designs

- Involve Random Assignment
- Types
  - Pretest-posttest control group design
  - Posttest only control group design
  - Solomon four-group comparison
- Threats to internal validity – see Figure 13.2

Sample Research Topic
The Efficacy of Reading Tutoring
True Experimental Designs

Pretest-Posttest Control Group
- Measures two levels of the independent variable
  - 1 hour of daily reading tutoring (experimental group – X₁)
  - No daily reading tutoring (control group – X₂)
- Sample of 2nd graders randomly assigned to the experimental or control group.
- Each group is given a reading pretest, then exposed to their group’s level of tutoring (1 hour daily or none) for one month followed by a reading posttest
  - R O X₁ O
  - R O X₂ O
- Major Validity Problem = Pretest-Treatment Interactions

Posttest Only Control Group
- Measures two levels of the independent variable
  - 1 hour of daily reading tutoring (experimental group – X₁)
  - No daily reading tutoring (control group – X₂)
- Each 2nd grader in the sample is randomly assigned to the experimental or control group.
- Each group is given a reading pretest, exposure to their group’s level of tutoring for one month then given a reading posttest.
  - R X₁ O
  - R X₂ O
- Major Validity Problem = Mortality
Sample Research Topic
The Efficacy of Reading Tutoring

**True Experimental Designs**

- **Solomon Four Group Design**
  - Measures two levels of the independent variable
  - 1 hour of daily reading tutoring (experimental group – X₁)
  - No daily reading tutoring (control group – X₂)
  - Sample of 2nd graders randomly assigned to 1 of 4 different groups (2 groups are pretested & 2 groups are not pretested)
  - First two groups are given a reading pretest, are exposed to their group’s level of tutoring for one month then given a reading posttest.
  - Second two groups are exposed to their group’s level of tutoring for one month and then given a reading posttest
  - Major Validity Problem = None

**Quasi-Experimental Designs**

- Differ from true experiments
  - Random assignment of individual subjects not possible
  - Involves random assignment of groups of subjects (for example, classrooms) to levels of the independent variable
- Types
  - Non-equivalent control group design
  - Time series design
  - Counterbalanced design
- Threats to internal validity – see Figure 13.2

**Nonequivalent Control Group Design**

- Measures two levels of the independent variable
  - 1 hour of daily reading tutoring (experimental condition – X₁)
  - No daily reading tutoring (control condition – X₂)
  - Classrooms of 2nd graders randomly assigned to the experimental or control condition.
  - Each class is given a reading pretest, then exposed to their group’s level of tutoring (1 hour daily or none) for one month followed by a reading posttest
  - Major Validity Problem = Regression, Selection Interactions, & Pretest-Treatment Interaction
Sample Research Topic
The Efficacy of Reading Tutoring
Quasi-Experimental Designs

- **Time Series Design**
  - All classrooms are given repeated reading pretests followed by one month of tutoring followed by repeated reading posttests
  - Pretesting & posttesting stop when results are stable
  - Major Validity Problems = History, Instrumentation, & Pretest-Treatment Interaction

- **Counterbalanced Designs**
  - All groups receive both levels of tutoring, but in a different order
  - Each treatment is followed by a reading test
  - Number of groups must equal the number of treatments
    - $X_1 \ 0 \ X_2 \ 0$
    - $X_2 \ 0 \ X_1 \ 0$
  - Validity Problems = Selection Interactions, Pretest-Treatment Interaction, & Multiple Treatment Interaction

- **Single-Subject Research**
  - Designs that can be applied when the sample size is one
    - Study behavior change in an individual as the result of some treatment
    - Subject serves as his or her own control
  - Rationale
    - Sophistication of specific designs allows for the control of internal validity threats
    - Research is focused on therapeutic impact in clinical settings, not contribution to a research base
    - Group comparison designs are sometimes opposed or unethical
    - Group comparison designs are not possible
Single-Subject Research

- Concerns
  - External validity
    - Low generalizability due to the nature of the design
    - The effect of the baseline condition on the subsequent effects of the treatment
    - Threats can be lessened through replication
  - Internal validity
    - Possible to control for most threats
    - Repeated and reliable measures
      - Baseline stability
      - Number of data points
    - Single-variable rule
    - Specification or the nature and conditions of the treatment

- Designs
  - A B A Withdrawal
  - A B A B
  - Multiple Baseline
  - Alternating Treatments

- Data analysis and interpretation
  - Based on visual inspection and analysis of a graphic presentation of the results
  - Criterion of effectiveness is clinical significance, not statistical significance
  - Debate about the use of statistical procedures
Note:
Simply adding *random assignment* of subjects to levels of the independent variable to a static group comparison design controls for:
- Maturation
- Selection
- Selection Interactions