Designing Research Studies

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Material adapted from: Methods in Behavioral Research, Cozby and Bates
Basic Study Design
Experimental Design:  
**Introduction**

- **Example**
  - A team of developers (Team A) uses a new inspection tool to review a module in their system. Team B uses their current approach to review a similar module. Team A finds 50% more security defects than Team B in the same amount of time.

  - Does this result show that the tool is beneficial?

  - What if Group A was more experienced?

- **Confounding Variables**
Experimental Design: 

**Introduction**

- **In an experiment**
  - Researcher manipulates the Independent Variable to create groups with different levels of the variable
  - Compare the groups based on Dependent Variable
  - Keep other variables constant – *control* or randomization

- **Internal Validity**
  - A researcher must design the study so that only the independent variable can be the cause of the results
Basic Experiments

• Two variables
  • Independent Variable
  • Dependent Variable

• Two groups
  • Control Group
  • Experimental Group

• Two forms
  • Posttest-Only Design
  • Pretest-posttest Design
Basic Experiments: Posttest-Only Design

- **Steps**
  - Obtain two equivalent groups
  - Introduce independent variable
  - Measure the effect

![Diagram]

- Subjects
  - Treatment Variable
  - Control Variable
  - Dependent Variable
  - Dependent Variable
Basic Experiments: Pretest-Posttest Design

• Add a pre-test before the applying the Independent Variable

• Why do we do this?
Basic Experiments: Comparison

• Why would you use a pretest?

• Potential Reasons
  • Small sample size
  • Select participants
  • Measure the extent of change in each individual
  • Assess the effects of mortality

• Disadvantages
  • Time consuming or awkward
  • Affect the participants behavior
Assigning Subjects to Groups

• Independent Groups
  • Different participants in each group
  • Assignment done randomly

• Repeated Measures
  • Each individual participates in all groups
  • Advantages?
    • Fewer participants needed
    • Statistical sensitivity
  • Disadvantages?
    • Order effects
Repeated Measures Designs: Counterbalancing

- Complete counterbalancing
  - All possible orders of treatments are used
  - What are the positives and negatives?

<table>
<thead>
<tr>
<th>Participants</th>
<th>Order 1</th>
<th>Order 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Order 1</td>
<td>R</td>
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</tbody>
</table>

- Experimental Treatment
- Control Treatment
- Measure

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
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- What are the positives and negatives?
Complex Study Designs
Complex Study Designs

• Simple Study Design
  • Participants randomly assigned to groups
  • Dependent variable measured
  • Groups compared

• What about other conditions?
  • One participant – “single case experiment”
  • Lack of control – “quasi- or pre-experiments”
  • Time
Single Case Experimental Designs

• Address the need to determine effects on an individual subject

• Basic idea
  • Measure individual over time – “baseline”
  • Introduce change
  • Measure again
  • Look for an effect

• What are the potential problems?
Single Case Experimental Designs: Reversal Design

• Helps determine whether the independent variable caused the observed effect

• Has the following structure:
  • Baseline → Change → Baseline

• What is example of when we might use this design?

• How can we extend this design? What benefits do we get?
Single Case Experimental Designs: Multiple Baselines

• Some behaviors are not reversible - Examples?

• **Solution**: Collect multiple baselines
  • Across subjects
  • Across behaviors
  • Across situations
Quasi-Experimental Designs: Nonequivalent Control Group Design

- Two groups

- Threat to Validity – Selection
Quasi-Experimental Designs: Nonequivalent Control Group Pretest-Posttest Design

- Improvement over posttest only design

Group 1 Participants → Pretest → Experimental Variable → Dependent Variable

Group 2 Participants → Pretest → Control (None) Variable → Dependent Variable

- Why is this not a true experimental design?
Quasi-Experimental Designs: Interrupted Time Series

• Example of one group pretest-posttest design

• Measure some variable over an extended period of time

• Look at the values before and after the IV

• How might we use this design in security?
Quasi-Experimental Designs: Control Series Design

• Improvement over **Interrupted Time Series** because it adds a control group
Conducting Studies
Selecting Research Participants

• Sampling
  • Choosing a subset of the population of interest

• Probability vs. Nonprobability
  • Affects generalizability
  • “Convenience sampling” acceptable for testing relationships between variables

• Sample size
  • Affects likelihood of obtaining statistical significance
Creating the Treatments: Amount of Variation

• **General Principle**: Make the variation as large as possible

• Large variation is especially important in the early stages of research.
  • Goal is to demonstrate that a relationship exists
  • Once the relationship is established, the variation can be systematically lessened

• Considerations when using a large variation
  • May represent an extreme situation that does not ever occur in the real world
  • Ethics
Dependent Variable: Measuring

• Sensitivity
  • How much of a difference can be detected?
  • **Ceiling effect** – the task is too easy to reveal the effect of the independent variable
  • **Floor effect** – the task is too difficult to reveal the effect of the independent variable

• Using multiple measures
  • Often valuable to measure multiple dependent variables
    • When a variable can be measured in different ways – increase confidence in conclusion
    • When multiple dependent variables are of interest
  • **Measurement order**
    • Does it matter?
    • Collect measures in order of importance

• Cost of measures
Additional Controls: Experimenter Expectations

• Generally called experimenter bias

• Two sources
  • Experimenter unintentionally treats participants differently – possibly during training
  • Experimenter records and interprets behavior differently

• Ways to minimize
  • Experimenters should be trained and practice behaving consistently
  • Run all treatments simultaneously if possible
  • Use a researcher who is not familiar with the study design

• Important to record any identified risks associated with experimenter bias and any efforts taken to minimize them
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