CHAPTER 8

EXPERIMENTAL DESIGN

LEARNING OBJECTIVES

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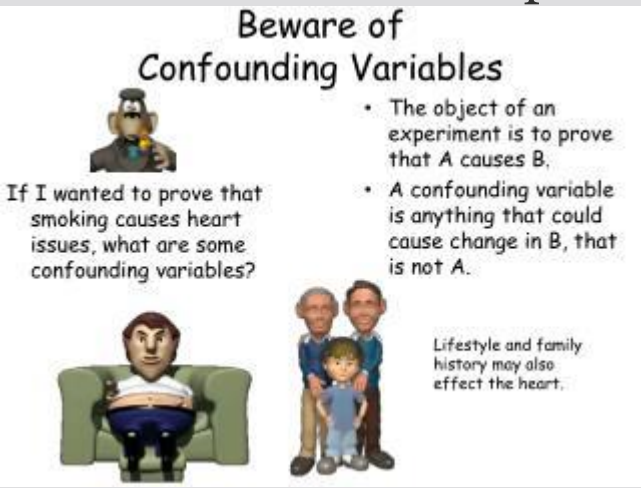
- ✓ Define confounding variable, and describe how confounding variables are related to internal validity
- ✓ Describe the posttest-only design and the pretest-posttest design, including the advantages and disadvantages of each design
- ✓ Contrast an independent groups (between-subjects) design with a repeated measures (within-subjects) design
- ✓ Summarize the advantages and disadvantages of using a repeated measures design
- ✓ Describe a matched pairs design, including reasons to use this design

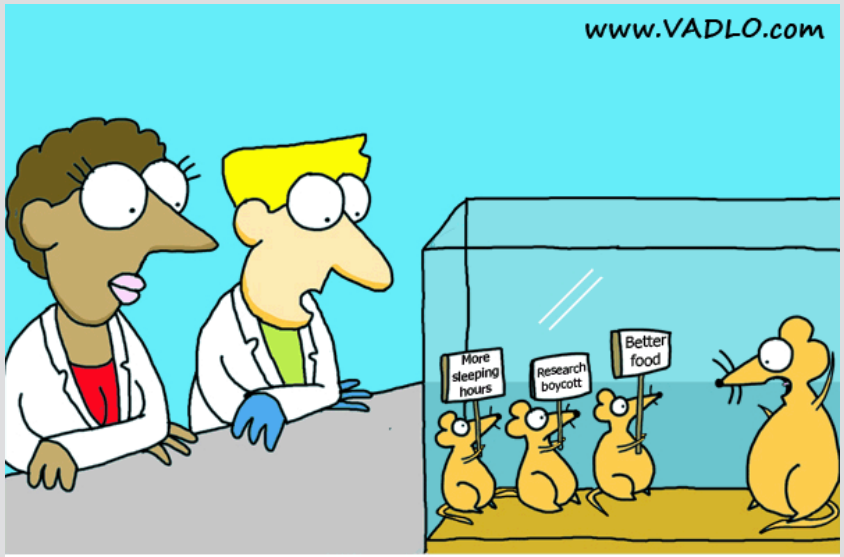
CONFOUNDING

- **Confounding variable**: Varies along with the independent variable
  - A goal of conducting a randomized experiment is to make a causal conclusion about the effect of an independent variable on a dependent variable.
  - In order to make a causal conclusion, one must be able to rule out all other explanations for the effect on the dependent variable.



CONFOUNDING

- **Confounding variable**:
  - *Confounding occurs when the effects of the independent variable and an uncontrolled variable are intertwined*
  - Therefore, one cannot determine which variable is responsible for the effect



"Our mistake.
We introduced a politician's genes in that one!"

CONFOUNDING

- **Confounding variable**
- Example: Testing was conducted on a new cold medicine with 200 volunteer subjects - 100 men and 100 women. The men receive the drug, and the women do not. At the end of the test period, the men report fewer colds.
  - In this experiment many variables are confounded.
    - Gender is confounded with drug use. Perhaps, men are less vulnerable to the particular cold virus circulating during the experiment, and the new medicine had no effect at all.
    - Or perhaps the men experienced a placebo effect.
  - This experiment could be strengthened with a few controls.
    - Women and men could be randomly assigned to treatments.
    - One treatment could receive a placebo, with blinding. Then, if the treatment group (i.e., the group getting the medicine) had sufficiently fewer colds than the control group, it would be reasonable to conclude that the medicine was effective in preventing colds.

INTERNAL VALIDITY

- **Internal validity**: Ability to draw conclusions about causal relationships from the data
  - *When a confounding variable is present, internal validity is questionable*
  - Results can be attributed to the effect of the independent variable
  - Experiment must be designed and conducted so that only the independent variable can be cause of the results
  - Good experimental design requires eliminating possible confounding variables that could result in alternative explanations.
  - When the results of an experiment can confidently be attributed to the effect of the independent variable, the experiment is said to have **internal validity**.

BASIC EXPERIMENTS

- The simplest possible experimental design has two variables: the independent variable and the dependent variable.
- The independent variable has a minimum of two levels, an experimental group and a control group.
- Researchers must make every effort to ensure that the only difference between the two groups is the manipulated (independent) variable.
- **Posttest-only design**
  - Must:
    1. *Obtain two equivalent groups of participants and Introduce the independent variable to one of them*
    2. *Measure the effect of the independent variable on the dependent variable*
  - In the first step, researchers must choose the participants and assign them to the two groups.
  - The procedures used must achieve equivalent groups to eliminate any potential **selection differences**: The people selected to be in the conditions cannot differ in any systematic way. *(e.g., using randomization prevents this)*

BASIC EXPERIMENTS

- Pretest-posttest design
  - The only difference between the posttest-only design and the **pretest-posttest design** is that in the latter a pretest is given before the experimental manipulation is introduced.
    - Assures that groups are equivalent at the beginning of the experiment
    - Minimum of 20 to 30 participants are required per condition for a statistically significant effect

BASIC EXPERIMENTS

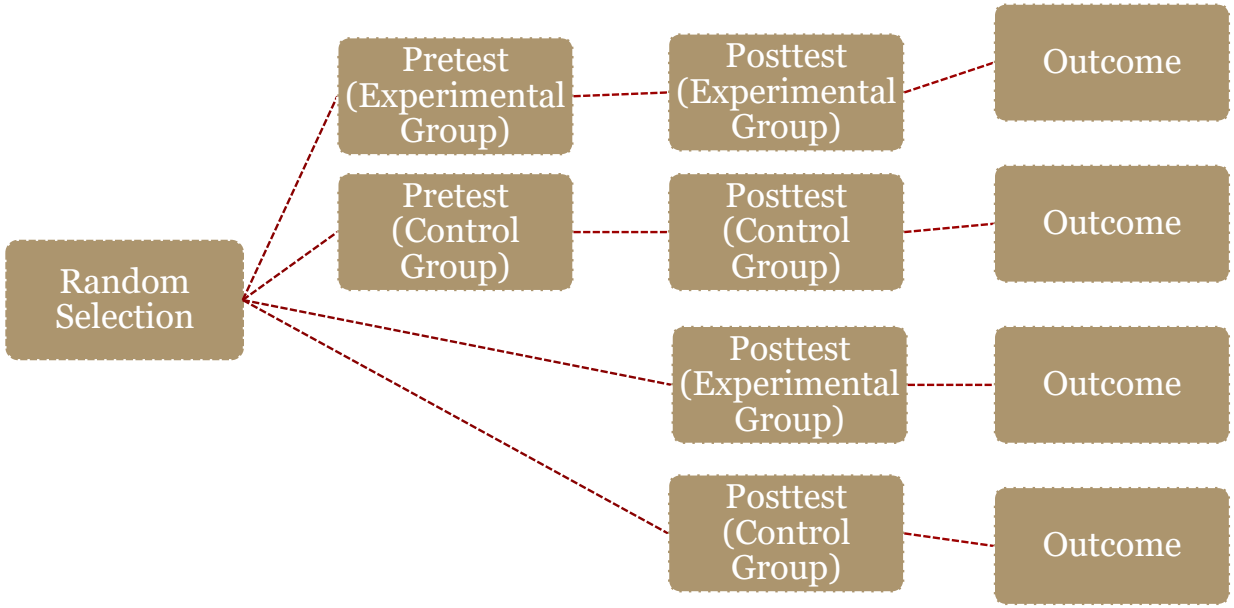
- Comparing posttest-only and pretest-posttest designs
  - To be a true experimental design for pretest-posttest designs, the participants must be randomly assigned to groups
  - **Advantages of the Pretest-Posttest Design**:
    - It assess equivalency of groups with small sample size
    - It's used to select participants for the experiment
    - It can detect changes between two points in time (e.g., before and after manipulating the independent variable)

BASIC EXPERIMENTS

- **Disadvantages of the pretest-posttest design**
  - A pretest is necessary whenever there is a possibility that participants will drop out of the experiment; this is most likely to occur in a study that lasts over a long time period. The dropout factor in experiments is called **attrition** or **mortality**.
  - **Disadvantages:**
    - **Mortality (attrition)** is the Dropout factor in experiments
    - Time consuming
    - Requires more resources
    - Awkward to administer
    - Sensitizes participants to what is being studied (i.e., They figure out what is being studied)
    - ***Practice effects*** *or Carry over effects: When participants do better on the second test because they learned from the first test.*
      - *It occurs with repeated exposure to a task.*
    - Affects the way participants react to manipulation

SOLOMON FOUR-GROUP DESIGN

- It is also possible to assess the impact of the pretest directly with a combination of both the posttest-only and the pretest-posttest design with a Solomon Four-Group Design. ***In this design, half the participants receive only the posttest, and the other half receive both the pretest and the posttest.***



Repeated Measures Design

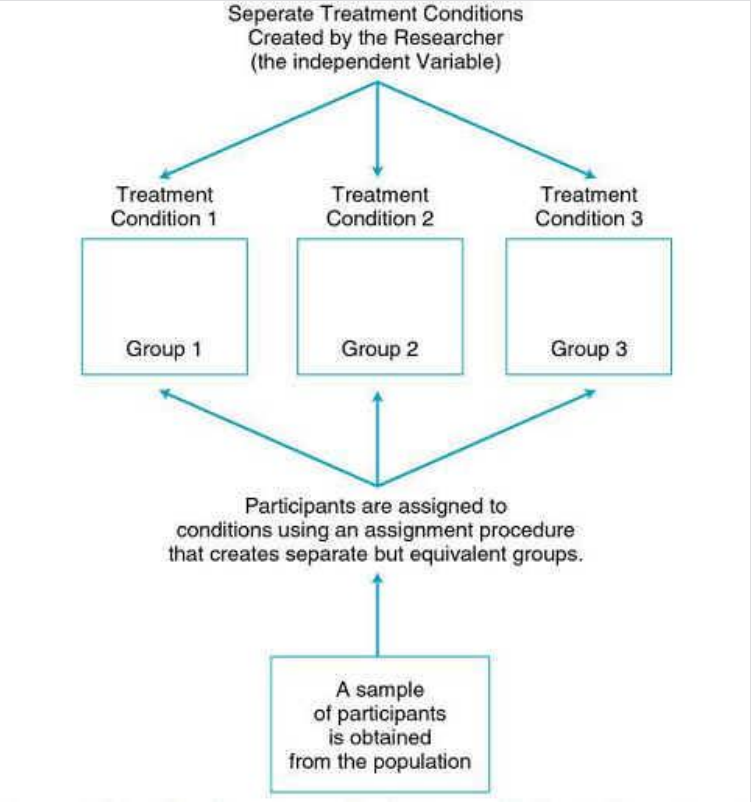
- **Repeated measures design**: *One group of participants are assigned to multiple conditions* (i.e., each level of the independent variable)
  - In an experiment with two conditions, for example, each participant is assigned to both levels of the independent variable., and each participant is measured after receiving each level of the independent variable.
  - a.k.a. **Within-subjects design**
    - because comparisons are made within the **same** group of participants

Independent Groups Design

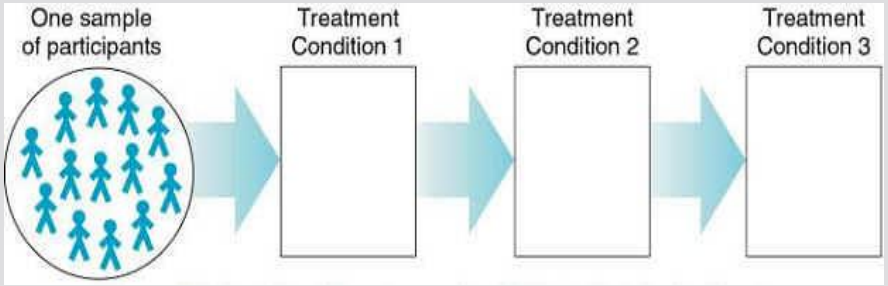
- **Independent groups design**: *More than one group of participants participate in one or more conditions*
  - a.k.a. **Between-subjects design**
    - because comparisons are made between **different** groups of participants.
  - In an experiment with two conditions, for example, each group is assigned to only one of the levels of the independent variable, and each participant is measured after experiencing the condition of the independent variable in which they were assigned.

Between vs. Within Subjects Designs

INDEPENDENT GROUPS (Between Subjects Design)



REPEATED MEASURES (Within Subjects Design)



REPEATED MEASURES DESIGN

Advantages

- The repeated measures design has several advantages.
  - Fewer participants are needed, because each individual participates in all conditions.
  - Saves money and resources
  - Greater control over participant differences and thus greater ability to detect an effect of the independent variable.
    - It is extremely sensitive to statistical differences between groups,
      - Statistically speaking, repeated measures calculations do not need to allow for the random differences found between groups in an independent groups design.
      - These random differences between individuals and groups is often called “random error” or error.

REPEATED MEASURES DESIGN

Disadvantages

- The major problem with a repeated measures design stems from the fact that the different conditions must be presented in a particular sequence. Suppose that there is greater recall in the high-meaningful condition. Although this result could be caused by the manipulation of the meaningfulness variable, the result could also simply be an order effect.
  - **Order effect**: *The order of presenting the treatments affects the dependent variable*
  - **Practice (learning) effect**: Performance improves because of the practice gained from previous tasks
  - **Fatigue effect**: *Performance deteriorates because the participant becomes tired, bored, or distracted from previous tasks.*
    - *The participants performance deteriorates with the passage of time.*
  - **Carryover effect**: Effect of the previous treatment carry over to influence the response of the next treatment.
    - *This could be especially important for some experimental conditions.*
    - *For example, in experiments testing things like alcohol or drugs, if there is not enough time between treatments, prior testing can carry over to later testing.*

REPEATED MEASURES DESIGN

- **Counterbalancing**
- In a experiment, the order in which treatments are given can actually affect the behavior of the subjects or elicit a false responses, possibly caused by fatigue or outside factors changing the behavior of the subjects.
- *To counteract the influence of order effects, researchers often use a counterbalanced design.*
- *It reduces the chances of the order of treatment or other factors adversely influencing the results.*

REPEATED MEASURES DESIGN

- **2 Types of Counterbalancing**
  - **Complete counterbalancing**: All possible orders of presentation are included in the experiment
  - **Latin square**: Constructed for using the technique to control for order effects without having all possible orders
    - It is a limited set of orders constructed to ensure that each condition appears at each ordinal position, and each condition precedes and follows each condition one time.
- Consider **Time Interval between Treatments**
  - In addition to counterbalancing the order of treatments, researchers need to carefully determine the time interval between presentation of treatments and possible activities between them.

Latin Square Design

- For Example:
  - Four types of materials are to be tested in the laboratory.
  - Four laboratories will do the testing on four different days.
  - There is a known “lab effect” in the outcome
  - There is also a known “day” effect in the outcome because the response is very sensitive to small changes in temperature and humidity.

Latin Square Example: Number of Combinations of Factor Levels May Be Too Large

- One possibility is to have all four laboratories test all four materials on all four days.
  - This experimental design would require 4 x 4 x 4 = 64 runs.
- An alternative experimental design is a “Latin Square”

Treatment Levels Always Appear Once In Each Row and Column

- Let A, B, C, D denote the four types of material.
  - Remember the question of interest is whether there are differences among these four types. We do not want laboratory or day effects to bias the results.
- Here is a suitable design that could be used to conduct this experiment.

Day	Laboratory			
	1	2	3	4
1	C	D	B	A
2	A	B	D	C
3	D	C	A	B
4	B	A	C	D

- Treatment levels always appear once in each row and column

Latin Square Design: Within-Subjects and Between-Subjects

- In behavioral research, if Subjects are assigned to each cell, then the design is a between-subjects design, the Latin Square design allows us to use 16 tests rather than 64.
- If Subjects are assigned so that a Subjects are tested across the levels of a factor, then the design is a within-subject (repeated measures) design, the Latin Square design allows us to use only 4 tests.

INDEPENDENT GROUPS DESIGN

- **Random assignment**: Is used in an independent groups design to assign different participants to each of the condition
  - This means that the decision to assign an individual to a particular condition is completely random and beyond the control of the researcher.
  - Subjects are usually placed in one or more experimental groups and a control group.
  - Participants are randomly selected in a number of ways:
    - Coin toss
    - Random number generator
    - Based on day of the week or dates

INDEPENDENT GROUPS DESIGN

- **Advantages**
  - Participants are not likely to be affected by order effects (as in the repeated measures design) they are only involved in one of the conditions.
  - Sample drop off is not an issue, nor is participant reactivity bias, as they only take part in one of the conditions, they are less likely to guess the aim of the experiment, so more likely to behave normally.
  - Demand Characteristics are less likely, as there are fewer clues about the research hypothesis in an independent groups design.
    - Demand Characteristic is a subtle cue that makes participants aware of what the experimenter expects to find or how participants are expected to behave

INDEPENDENT GROUPS DESIGN

- **Disadvantages**
  - Participant variables are the main disadvantage
    - Participants are different in each condition, any difference between conditions in the DV may be down to the different characteristics and abilities of the participants, and not the manipulation of the IV.

MATCHED PAIRS DESIGN

- A somewhat more complicated method of assigning participants to conditions in an experiment is called a **matched pairs design**.
- Instead of simply randomly assigning participants to groups, the g*oal is to match people on a participant characteristic and then randomly assigning one member of each pair to each group:*
  - Age, Gender, Ethnicity, IQ score, Personality Trait, etc.
- The matching variable will be either the dependent measure or a variable that is strongly related to the dependent variable.

MATCHED PAIRS DESIGN

- For example: Different participants take part in each condition, but each participant in one condition has been matched with another participant in the other condition on important characteristics.
  - So if one participant is male, aged 41, middle-class, has an IQ of 98 etc, then the other condition must have a similar participant.
  - Identical twins are ideal for a matched-pairs designs.
  - Researchers often used identical twins when doing genetic research to search for diseases, disorders, and other characteristics that may be inherited.

MATCHED PAIRS DESIGN

- **Advantages**
  - This has the same advantages as the independent groups design, but with a lower risk of participant variables influencing the DV.
    - So the matched-pairs design eliminates order effects, whilst reducing participant variables

MATCHED PAIRS DESIGN

- **Disadvantages**
  - It can be difficult to find similar participants to take part in either condition, and it may be challenging to know exactly which characteristics are required to match.
  - It is considered that this design takes the longest to prepare, so is often overlooked in research where resources are limited.

LAB

- Go to Week 6 on the website Labs page and download and complete the "Experimental Design Activity" from Week 6 (Due Before Next Tuesday)
- Extra Credit also Available in Week 6 in Labs from class website. Read instructions, and Complete In Class ONLY
- Finish any library research still needed for your group Research Project
- HOMEWORK: Read the Observation Handout before This Thursday. It's important information for you to complete Thursday's lab.
  - Located in week 6 on Handouts Webpage