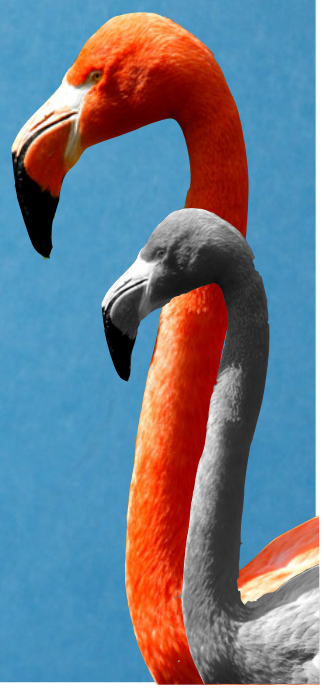
CHAPTER 4
Designing Studies

Ted Talk
How many factors?

4.2b
Experiments



The Practice of Statistics, 5th Edition
Starnes, Tabor, Yates, Moore

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Experiments

Learning Objectives

After this section, you should be able to:

- ✓ DISTINGUISH between an observational study and an experiment.
- ✓ EXPLAIN the concept of confounding.
- ✓ IDENTIFY the experimental units, explanatory and response variables, and treatments in an experiment.
- ✓ EXPLAIN the purpose of comparison, random assignment, control, and replication in an experiment.
- ✓ DESCRIBE a completely randomized design for an experiment.
- ✓ DESCRIBE the placebo effect and the purpose of blinding in an experiment.
- ✓ INTERPRET the meaning of statistically significant in the context of an experiment.
- ✓ EXPLAIN the purpose of blocking in an experiment. DESCRIBE a randomized block design or a matched pairs design for an experiment.

Does caffeine affect pulse rate?

Many students regularly consume caffeine to help them stay alert. So, it seems plausible that taking caffeine might increase an individual's pulse rate. Is this true? One way to investigate this claim is to ask volunteers to measure their pulse rates, drink some cola with caffeine, measure their pulse rates again after 10 minutes, and calculate the increase in pulse rate. Unfortunately, even if the pulse rate of every student went up, we couldn't attribute the increase to caffeine. Perhaps the excitement of being in an experiment made their pulse rates increase. Perhaps it was the sugar in the cola and not the caffeine. Perhaps their teacher told them a funny joke during the 10-minute waiting period and made everyone laugh! In other words, there are many other variables that are potentially confounded with taking caffeine.

How to Experiment Badly

Many laboratory experiments use a design like the one in the caffeine example:

In the lab environment, simple designs often work well.

Field experiments and experiments with animals or people deal with more variable conditions.

Outside the lab, badly designed experiments often yield worthless results because of confounding.

How to Experiment Well

The remedy for confounding is to perform a comparative experiment in which some units receive one treatment and similar units receive another. Most well designed experiments compare two or more treatments.

Comparison alone isn't enough, if the treatments are given to groups that differ greatly, *bias* will result. The solution to the problem of bias is **random assignment**.

In an experiment, **random assignment** means that experimental units are assigned to treatments using a chance process.

Does caffeine affect pulse rate?

Suppose you have a class of 30 students who volunteer to be subjects in the caffeine experiment described earlier. Explain how you would randomly assign 15 students to each of the two treatments:

(a) Using 30 identical slips of paper

(b) Using technology

(c) Using random integer table

NOTE: A reasonably intelligent person should be able to carry out your procedure following exactly what you wrote!

(a) Using 30 identical slips of paper, write A on 15 pieces of paper and B on the other 15. Mix them thoroughly in a hat and have each student select one slip of paper. Then ask each student who received an A to drink the cola with caffeine and each student who received a B to drink the cola without caffeine.

(b) Number the students from 1 to 30. Use randInt(1,30) to select 15 different numbers from 1 to 30. These students will drink the cola with caffeine and the remaining 15 will drink the cola without caffeine.

(c) Number the students from 01 to 30. Use a line from Table D and read two-digit numbers moving from left to right. The first 15 different numbers from 01 to 30 will identify the students who will drink the cola with caffeine. The remaining 15 students will drink the cola without caffeine.

Principles of Experimental Design

Principles of Experimental Design

The basic principles for designing experiments are as follows:

1. **Comparison**. Use a design that compares two or more treatments.
2. **Random assignment**. Use chance to assign experimental units to treatments. Doing so helps create roughly equivalent groups of experimental units by balancing the effects of other variables among the treatment groups.
3. **Control**. Keep other variables that might affect the response the same for all groups.
4. **Replication**. Use enough experimental units in each group so that any differences in the effects of the treatments can be distinguished from chance differences between the groups.

Tips on Principles of Experimental Design

1. **Comparison.** Use a design that compares two or more treatments.
   - Good experiments will always include comparison

2. **Random assignment.** Use chance to assign experimental units to treatments. Doing so helps create roughly equivalent groups of experimental units by balancing the effects of other variables among the treatment groups.
   - does not ELIMINATE effects of other variables…it simply balances their effects among the treatment groups
   - In caffeine experiment, some will still have an increased pulse because of being in an experiment, but hopefully random assignment will have approximately the same number in each treatment group
   - When describing how you randomly assigned, be very specific and detailed—use the “hat” method whenever possible: slips of paper that are the same size and are well mixed!

Tips on Principles of Experimental Design

3. **Control.** Keep other variables that might affect the response the same for all groups.
   - Doesn't just refer to a control group
   - An experimenter should do whatever is possible to control other variables by making them the same for all treatment groups
4. **Replication.** Use enough experimental units in each group so that any differences in the effects of the treatments can be distinguished from chance differences between the groups.
   - Use enough subjects
   - Example: if we used only 6 subjects in the caffeine experiment and 2 of those people get a higher pulse simply from being in an experiment, there is a 50% chance they will both be in the same group. However, if we had 60 students in the experiment and 20 get a higher pulse from being in an experiment, there is practically no chance that all 20 will be in the same treatment group.
   - The more replication, the more balanced the treatment groups will be after the random assignment

Example - Multitasking

Researchers in Canada performed an experiment with university students to examine the effects of in-class laptop use on student learning. All participants in the study were asked to attend a university-style lecture and take notes with their laptops. Half of the participants were assigned to complete other non-lecture-related online tasks during the lecture. These tasks were meant to imitate typical student Web browsing during classes. The remaining students simply took notes with their laptops. To assign the treatments, the researchers printed 40 papers with instructions (20 with multitasking and 20 without), shuffled them, and handed them out at random to students in the classroom. At the end of the lecture, all participants took a comprehension test to measure how much they learned from it. The results: students who were assigned to multitask did significantly worse (11%) than students who were not assigned to multitask.

How were the principles of experimental design used in the multitasking study? Comparison, Random assignment, Control, Replication

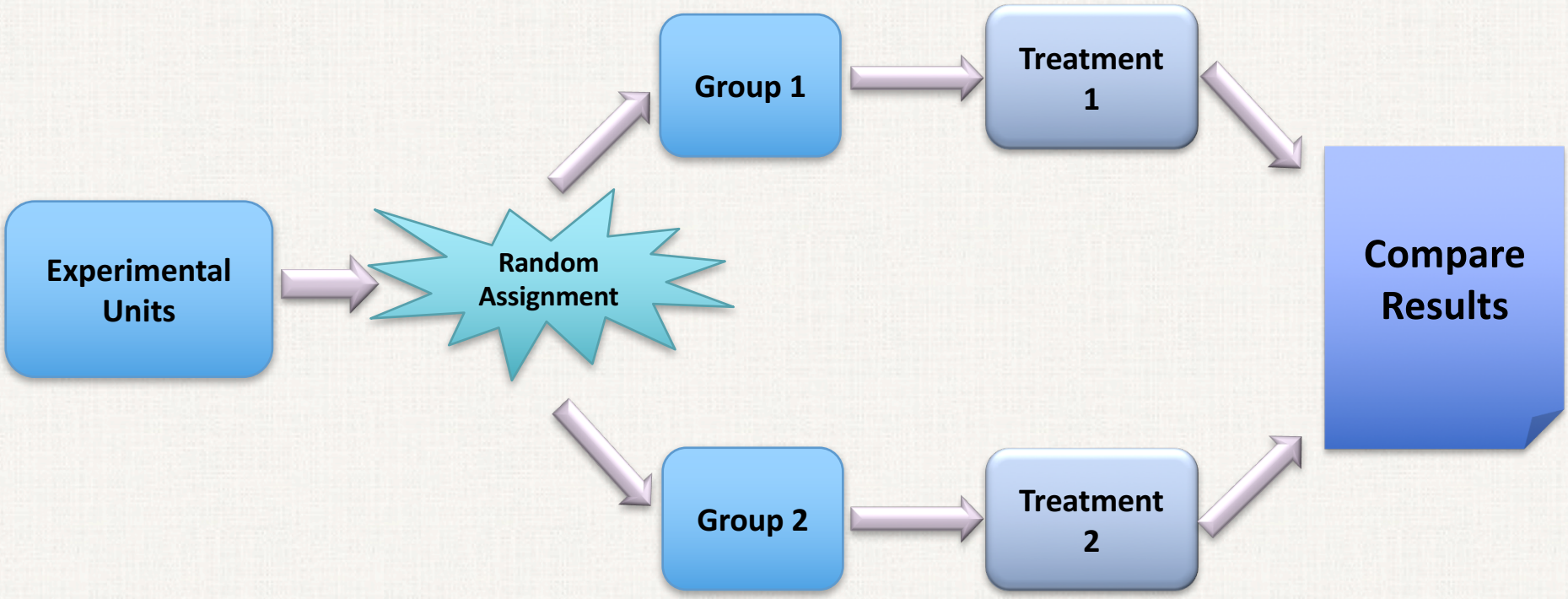
Example - Multitasking

- Comparison: The researchers compared students who were multitasking to other students who were not multitasking.
- Random assignment: It was determined at random which students (and which seat locations) received the instructions to multitask and which students (and seat locations) received the regular instructions.
- Control: The experiment used undergraduate students from the same university in Canada. All participants listened to the same lecture and took the same comprehension test at the end of the lecture.
- Replication: There were 20 students in each treatment group. Although this is not a very large number of subjects, the difference in performance was big enough to determine that the difference was due to multitasking and not the chance variation in random assignment.

Completely Randomized Design

In a **completely randomized design**, the treatments are assigned to all the experimental units completely by chance.

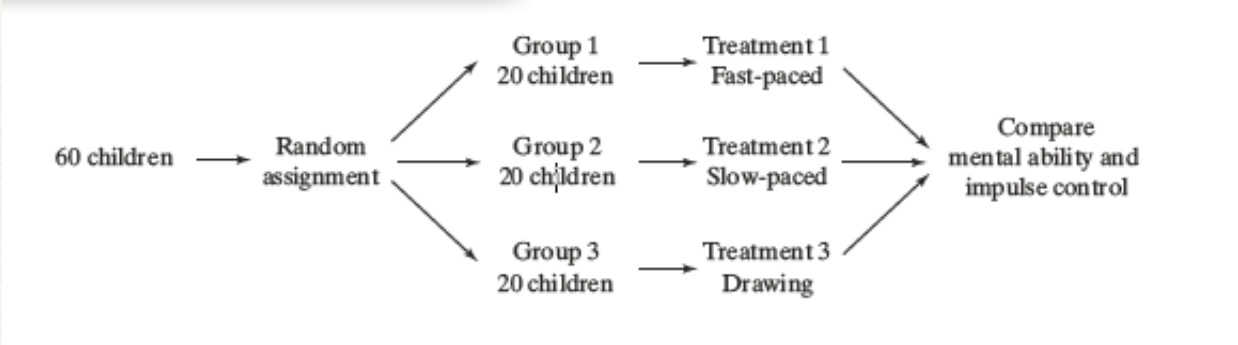
Some experiments may include a **control group** that receives an inactive treatment or an existing baseline treatment.



Example – Television and young children

Psychologists want to know how different types of television shows impact young children. They recruit 60 four-year-olds and have them watch 9 minutes of a fast-paced children's program (defined as scene changes every 10–15 seconds), watch 9 minutes of a slow-paced children's program (defined as scene changes every 30–45 seconds), or draw for 9 minutes. After the 9 minutes, each child will complete several tasks, including tests for mental ability and impulse control.

- Describe a completely randomized design for this experiment. Write a few sentences describing how you would implement your design.



To implement the design, use 60 equally sized slips of paper. Label 20 of the slips "1," 20 of the slips "2," and 20 of the slips "3." Mix the numbers in a hat and have each child draw a number without looking. The number that each child chooses will be the group to which he or she is assigned. At the end of the study, compare the mental ability and impulse control for the three treatment groups.

Experiments

Section Summary

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Read p. 239-247 ccc 57, 59, 61, 63, 65