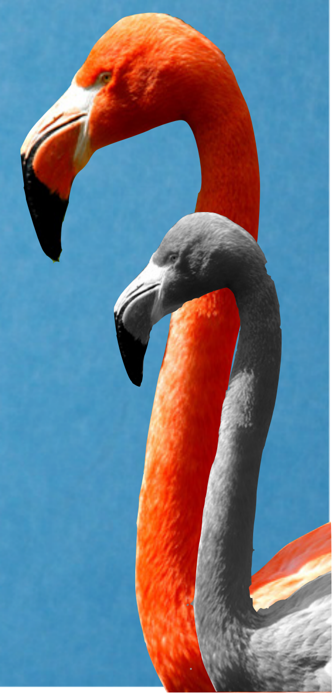
CHAPTER 4
Designing Studies

4.2a
Experiments



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

Bedford Freeman Worth Publishers

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.

Observational Study vs. Experiment

An **observational study** observes individuals and measures variables of interest but does not attempt to influence the responses.

An **experiment** deliberately imposes some treatment on individuals to measure their responses.

When our goal is to understand cause and effect, experiments are the *only* source of fully convincing data.

The distinction between observational study and experiment is one of the most important in statistics.

Observational Study vs. Experiment

Observational studies of the effect of an explanatory variable on a response variable often fail because of **confounding** between the explanatory variable and one or more other variables.

Well-designed experiments take steps to prevent confounding.

Confounding occurs when two variables are associated in such a way that their effects on a response variable cannot be distinguished from each other.

In other words, two variables are confounded if it is impossible to determine which of the two variables is causing a change in the response variable.

Confounding Example

- The buzz about coffee

The article “Coffee Buzz: Study Finds Java Drinkers Live Longer” from the Arizona Daily Star discusses a very large study of coffee drinkers. It suggests that coffee drinkers live a little longer than non-drinkers, whether they drink regular or decaf. Previous studies had indicated that drinking coffee might increase the risk of heart disease, but these studies didn’t take into account that coffee drinkers were also more likely to smoke, drink more alcohol, eat more red meat, and exercise less than non-coffee-drinkers. The new study is still an observational study, however, so we can’t be sure that drinking coffee is the cause of longer life—it could be something else associated with drinking coffee that is the cause.

AP Exam Notes

- If you are asked to identify a possible confounding variable in a given setting, you are expected to explain how the variable you choose
  - Is associated with the explanatory variable
  - Affects the response variable
- Many students lose credit on the AP Exam for using statistical vocabulary without additional explanation. Instead of relying on vocabulary, explain the concept in the context of the problem.
  - So, don't just say "X is a confounding variable"
  - Rather, explain in context
- Example in regards to coffee linked to heart disease:
  - "Eating red meat is a confounding variable because people who eat red meat are at a higher risk of heart disease" would not get full credit
  - Instead, discuss how it is more common for coffee drinkers to also eat more red meat, so we can't distinguish whether it is the coffee or the red meat, or some other factor, that may lead to greater heart disease.

The Language of Experiments

An experiment is a statistical study in which we actually do something (a treatment) to people, animals, or objects (the experimental units) to observe the response. Here is the basic vocabulary of experiments.

A specific condition applied to the individuals in an experiment is called a **treatment**. If an experiment has several explanatory variables, a treatment is a combination of specific values of these variables.

The **experimental units** are the smallest collection of individuals to which treatments are applied. When the units are human beings, they often are called **subjects**.

Example – A louse-y situation

A study published in the New England Journal of Medicine (March 11, 2010) compared two medicines to treat head lice: an oral medication called ivermectin and a topical lotion containing malathion. Researchers studied 812 people in 376 households in seven areas around the world. Of the 185 households randomly assigned to ivermectin, 171 were free from head lice after 2 weeks compared with only 151 of the 191 households randomly assigned to malathion.

Identify the experimental units, explanatory and response variables, and the treatments in this experiment.

experimental units: the 376 households, not the 812 people, because the treatments were assigned to entire households, not separately to individuals within the household.

explanatory variable: type of medication

response variable: whether the household was lice-free

treatments: ivermectin and malathion

Example – Growing Tomatoes

Does adding fertilizer affect the productivity of tomato plants? How about the amount of water given to the plants? To answer these questions, a gardener plants 24 similar tomato plants in identical pots in his greenhouse. He will add fertilizer to the soil in half of the pots. Also, he will water 8 of the plants with 0.5 gallon of water per day, 8 of the plants with 1 gallon of water per day, and the remaining 8 plants with 1.5 gallons of water per day. At the end of 3 months, he will record the total weight of tomatoes produced on each plant.

Identify the experimental units or subjects, explanatory and response variables, and the treatments.

<u>experimental units</u>: the tomato plants

<u>explanatory variables (factors)</u>: whether fertilizer is applied and amount of water (fertilizer has 2 <u>levels</u>, water 3 levels)

<u>response variable</u>: weight of tomatoes produced

there are 6 <u>treatments</u>: (1) fertilizer, 0.5 gallon; (2) fertilizer, 1 gallon; (3) fertilizer, 1.5 gallons; (4) no fertilizer, 0.5 gallon; (5) no fertilizer, 1 gallon; (6) no fertilizer, 1.5 gallons (2 levels x 3 levels = 6 treatments)

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Section Summary

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Read p. 234-239 ccc 37-42, 45, 47, 49, 51, 53, 55