4.2: Experiments

SAT Survey vs. SAT Experiment

Describe a survey and an experiment that can be used to determine the relationship between SAT scores and hours studied?

Section 4.2 Experiments

After this section, you should be able to...

- Distinguish observational studies from experiments
- Describe the language of experiments
- Apply the three principles of experimental design
- Design comparative experiments utilizing completely randomized designs and randomized block designs, including matched pairs design

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.***

Confounding Variables

A confounding variable is one whose effects on the response variable cannot be distinguished from one or more of the explanatory variables in the study. Confounding = included.

Confounding = Confused
Confounding Variables

- Confounding refers to a problem that can arise in an experiment, when there is another variable that may effect the response and is in some way tied together with the factor under investigation, leaving us unable to tell which of the two variables (or perhaps some interaction) caused the observed response.

What’s Lurking?!

1. As shoe size increases...so does reading ability.
2. An increase in ice cream consumption equals an increase in the number of drowning deaths for a given period.
3. As savings account balances increase...life expectancy decreases.

Confounding Variables

- For example, we plant tomatoes in a garden that’s half-shaded. We test a fertilizer by putting it on the plants in the sun and apply none to the shaded plants. Months later the fertilized plants bear more and better tomatoes.
- Why?
- Well, maybe it's the fertilizer, maybe it's the sun, maybe we need both. We're unable to conclude that the fertilizer works because any effect of fertilizer is confounded with any effect of the extra sunshine.

Lurking Variable

A lurking variable is a variable that is not among the explanatory or response variables in a study but that may influence the response variable. Lurking = not included.

Lurking = Missing Link

Three Principles of Experimental Design

1. Control for lurking variables that might affect the response: Use a comparative design and ensure that the only systematic difference between the groups is the treatment administered.

2. Random assignment: Use impersonal chance to assign experimental units to treatments. This helps create roughly equivalent groups of experimental units by balancing the effects of lurking variables that aren’t controlled on the treatment groups.

3. 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.
**The Randomized Comparative Experiment**

- 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 at random, that is, using some sort of chance process.

**Factor v. Treatment**

For example, three different groups of runners are subjected to different training methods.

- **Experimental units**: runners
- **Factor**: Training methods
- **Treatments**: Specific type of workout: Speed, strength training and distance workouts

**A cookie manufacturer is trying to determine how long cookies stay fresh on store shelves, and the extent to which the type of packaging and the store’s temperature influences how long the cookies stay fresh. He designs a completely randomized experiment involving low (64 Fº) and high (75 Fº) temperatures and two types of packaging—plastic and waxed cardboard.**

List the experimental units, factors, and treatments in this experiment.

**The Randomized Comparative Experiment**

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.

**The Language of Experiments**

- **Experimental Units**: smallest collection of individuals to which treatments are applied. When the units are human beings, they often are called **subjects**.
- **Factors**: General name for explanatory variables in an experiment (multi-vitamin regime).
- **Treatment**: a specific condition (given vitamin A vs. vitamin B; time frame vitamin taken) applied to the individuals in an experiment.
Specific Types of Experimental Design

- Double-Blind
- Single-Blind
- Matched Pairs
- Block Design

Matched Pair Design

- Example:
  - Tire wear and tear.
  - Put one set of tires on the left side of the car and a different set on the right side of the car.
  - This would help control the lurking variable of different driving styles (between teenage boys vs. teachers) and mileage driven.

Double-Blind

- In a double-blind experiment, neither the subjects nor the experimenters know which treatment a subject received.

Matched Pair Design

- In a matched pair design, subjects are paired by matching common important attributes.
- Sometimes the results are a pre-test and post-test with the unit being “matched” to itself.

Block Design

- A block is a group of experimental units or subjects that are known before the experiment to be similar in some way that is expected to affect the response to the treatments.
- In a block design, the random assignment of units to treatments is carried out separately within each block.
- Helps control for lurking variables.
Block Design

- Experiments are often blocked by
  - Age
  - Gender
  - Race
  - Achievement Level (Regular, Honors, AP, IQ level, etc.)

Inference for Experiments

An observed effect so large that it would rarely occur by chance is called **statistically significant**.

*A statistically significant association in data from a well-designed experiment does imply causation.*