

4.2: Designing Studies

Practice Examples

Problem 1: Does Caffeine Affect Pulse Rate?

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Many students regularly consume caffeine to help them stay alert. Thus, it seems plausible that taking caffeine might increase an individual's pulse rate. Is this true? One way to investigate this is to have volunteers measure their pulse rates, drink some cola with caffeine, measure their pulses again after 10 minutes and calculate the increase in pulse rate. Unfortunately, even if every student's pulse rate 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 variables that are potentially confounded with caffeine.

➤ Explain how to use all 3 principles of experimental design in the caffeine experiment.

Solution:

Control:

- Control Experimental Units
 - ✓ Also, the subjects in each group should receive exactly the same amount of cola served at the same temperature.
- Control Factors/Treatments
 - ✓ There should be a control group that receives non-caffeinated cola.
 - ✓ Also, each type of cola should look and taste exactly the same and have the same amount of sugar.
 - ✓ Subjects should drink the cola at the same rate and wait the same amount of time before measuring their pulse rates.
- Control Environment
 - ✓ The environment should be the same for the entire experiment
- Purpose of Control EXTRANEUS
 - ✓ If all of these ~~lurking~~ variables are controlled, they will not be confounded with caffeine or be an additional source of variability in pulse rates.

Randomization:

- ✓ Subjects should be randomly assigned to one of the two treatments.
- ✓ This should roughly balance out the effects of the ~~lurking~~ EXTRANEUS variables we cannot control, such as body size, caffeine tolerance, and the amount of food recently eaten.

Replication:

- ✓ We want to use as many subjects as possible to help make the treatment groups as equivalent as possible.
- ✓ This will give us a better chance to see the effects of caffeine, if there are any.

DEFINITIONS SIMPLIFIED ← EMPHASIZE

- ① CONTROL FOR ALL EXTRANEUS VARIABLES THAT COULD DISTORT RESULTS.
- ② RANDOMIZATION TO MAKE GROUPS BALANCED TO REDUCE BIAS.
- ③ REPLICATION APPLY TREATMENTS TO ENOUGH EXPERIMENTAL UNITS TO REDUCE CHANCE VARIATION AND DETERMINE STATISTICAL DIFFERENCES

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Problem 2: Dueling Diets

A health organization wants to know if a low-carb or low-fat diet is more effective for long-term weight loss. The organization decides to conduct an experiment to compare these two diet plans with a control group that is only provided with brochure about healthy eating. Ninety volunteers agree to participate in the study for one year.

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

Solution:

Here is a basic outline:



To implement the design:

1. The Hat Method:

- ✓ Use 90 equally sized slips of paper.
- ✓ Label 30 of the slips "1", 30 of the slips "2" and 30 of the slips "3".
- ✓ Then, mix them up in a hat and have each subject draw a number without looking.
- ✓ The number that each subject chooses will be the group he or she is assigned to.
- ✳ **At the end of the year, the amount of weight loss will be recorded for each subject and the mean weight loss will be compared for the three treatments.**

2. The Technology Method:

- ✓ Assign each volunteer a number from 1 to 90.
- ✓ Use the random number function on the calculator that does not repeat numbers.
- ✓ Assign the first 30 numbers to Treatment 1.
- ✓ Assign the next 30 numbers to Treatment 2.
- ✓ Assign the remaining 30 numbers to Treatment 3.
- ✳ **At the end of the year, the amount of weight loss will be recorded for each subject and the mean weight loss will be compared for the three treatments.**

Problem 3: Better Texting?

A cell phone company is considering two different keyboard designs (A and B) for its new line of cell phones. Researchers would like to conduct an experiment using subjects who are frequent texters and subjects who are not frequent texters. The subjects will be asked to text several different messages in 5 minutes. The response variable will be the number of correctly typed words.

Problem:

a) Explain why a randomized block design might be preferable to a completely randomized design for this experiment.

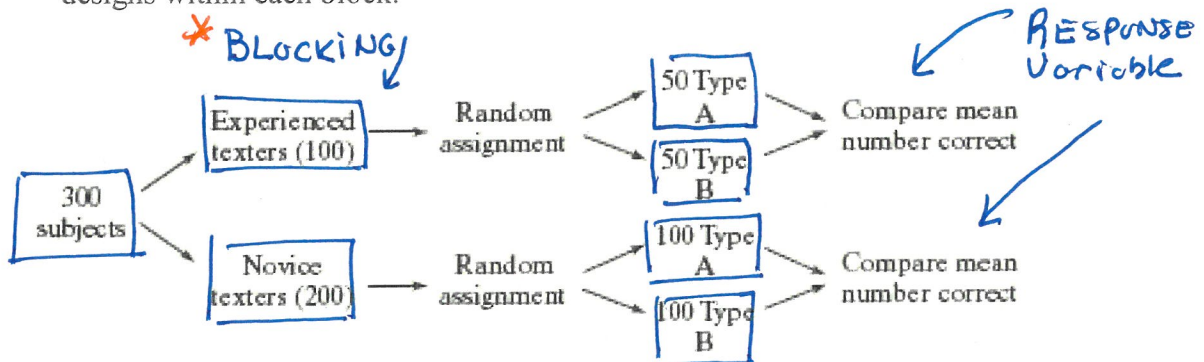
(a) Solution:

- ✓ Because the subjects include people of varying texting abilities, a **completely randomized design** would lead to lots of variability in the response variable.
- ✓ However, in a **randomized block design**, the experienced texters would be compared to each other and the novice texters would be compared to each other. This will make it easier to see a difference in the response variable if there is one.

b) Outline a randomized block experiment using 100 frequent texters and 200 novice testers.

(b) Solution: Here is an outline of this experiment.

- ✓ To randomly assign the experienced subjects to the two groups, put 50 slips of paper labeled "A" in a hat and 50 slips of paper labeled "B" in a hat.
- ✓ Mix up the papers and have each subject select one to determine which design he or she will use.
- ✓ Follow a similar process for the 200 novice texters.
- ✓ After the experiment compare the mean number of words correct for the two different designs within each block.



* BLOCKS ARE PREDETERMINED WITH A SIMILAR CHARACTERISTIC.

Chapter 4 Common AP Errors

AP Exam Common Error

When working with a table of random digits, it is very important that each label have the same number of digits. For example, if you need 50 labels, use 01–50 rather than 1–50. The single digit “1” has a 10% chance of occurring but the two-digit combination “01” has a 1% chance of occurring.

AP Exam Common Error

When describing how to choose a sample using random digits, many students forget to address what to do with repeated labels. In most cases, samples are taken without replacement and students must indicate that repeated labels in the table of random digits should be ignored.

AP Exam Common Error

On the AP exam, many students lose credit when describing what can go wrong in sample surveys because they use the wrong terminology. While it is important for students to understand and use the vocabulary of statistics correctly, they are rarely required to use specific vocabulary in their answers on the AP exam. To be safe, tell your students to not worry about naming the error. Instead, have them clearly describe the error in the context of the question. The explanation is especially important since just correctly naming the error will often result in no credit at all.

AP Exam Common Error

Many students lose credit on the AP exam for using statistical vocabulary incorrectly. Instead of relying on vocabulary, which by itself usually won't earn credit, students should explain the concept in the context of the problem. For example, just saying that “wealth is a confounding variable” will probably not earn credit without additional explanation. Students need to explain not only that wealthier people tend to go to the doctor more often and to be healthier overall, but that wealthier people are also more likely to get hormone replacement. Thus, it could actually be the overall healthiness of the wealthy women causing the reduction in heart attacks, not the hormones they were taking. In fact, any variable that is more common in the group of women taking replacement hormones could be the cause of the reduction in heart attacks.

AP Exam Common Error

Many students lose credit on the AP exam for failing to adequately describe how they assign the treatments to experimental units in an experiment. Most importantly, the method the students use must be random. In addition, the method must be described in sufficient detail so that two knowledgeable users of statistics could follow the student's description and carry out the method in exactly the same way. For example, saying “Assign students to the two groups using random digits” isn't sufficiently detailed since there are many ways to use random digits. If a student chooses to use random digits, he or she must use labels of the same length (e.g., 01–30, not 1–30) and ignore repeated numbers, since each subject can be assigned to a group only once.

AP Exam Common Error

On several different AP free-response questions, students lost credit for using randomization methods like the one described in the Think About It feature on this page. Encourage your students to use the “hat” method whenever possible. It is easy to describe and helps students avoid making the mistakes that are possible when using random digits or coin flips. Just make sure that the slips of paper are the same size and that they are well mixed!

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THINK
ABOUT
IT

AP Exam Common Error

Students often have trouble identifying the experimental units in an experiment. Students might mistakenly identify the individual people or the lice as the experimental units. However, these are not the experimental units, since the decision about what treatment to assign was not made for each individual or for each louse. The decision about which treatment to apply was made for each household, which makes households the experimental units.

AP Exam Common Error

Many students confuse blocks and treatment groups. Blocks are not formed at random. Instead, they are formed by grouping experimental units that are similar in some way that is expected to systematically affect the response to the treatments. This means that each block should be very different from other blocks. However, a treatment group is formed at random, with the goal that the treatment groups be as similar as possible to each other.

AP Exam Common Error

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