

Practice

Choosing the Design of an Experiment Study Sheet

Three Primary Principles of Experimental Design

By now you probably know these by heart, but in case you don't here they are again. You must follow these principles when doing this Assignment:

- **Replication** is repeating an experiment on different units or under different conditions. Replication is first accomplished by designing and documenting an experiment so that it can be repeated. This reduces chance variation in the results and makes it easier to show that the results can be generalized to the population being studied (or even to other populations).
- **Control** is accounting for all other potentially influential variables (lurking variables), so you can be confident that any differences in the response variable between groups is due to the explanatory variable. In experiments this can be accomplished by randomization, matching, and setting up control groups that don't receive the treatment. For example, in a study that looks at the effects of a new medication, subjects can be randomly assigned to a control group that doesn't receive the treatment or that receives a placebo.
- **Randomization** is the practice of randomly assigning experimental units to treatment and control groups. This ensures that the effects of any lurking variables are cancelled out between groups. It allows you to be confident that differences in response between the two groups are due to the treatment. For example, in a study that looks at the effects of a new medication, subjects can be randomly assigned to a control group that doesn't receive the treatment or that receives a placebo.

Three Common Experimental Designs

You probably already have these burned into memory, too, but here they are again in case you need them.

The most common is a **completely randomized** or **randomized comparative design** where subjects are randomly assigned to different conditions and the responses from those in different conditions are compared. For example, if we take 1,000 patients and randomly give 500 a new drug to control diabetes and then compare whether the symptoms are less severe for those who received the drug compared to the 500 who didn't, we're using a comparative design. The key is that we've randomly assigned the patients to different conditions.

A **randomized block design** is similar, but also takes into account that the effects of an explanatory variable on a response variable may differ for subjects or units with different characteristics. In a block design, the subjects or units are first divided into blocks based on a characteristic, and then the subjects or units in the block are randomly assigned to the different experimental conditions. If you *blocked* on gender in the diabetes experiment above, you'd first separate the males and females, and then within each gender randomly assign subjects to receive or not receive the drug. The

comparisons of the severity of symptoms would occur within the blocks. For example, we'd compare men who *received* the drug with men who *didn't receive* the drug.

Matched pairs design can be thought of as a special case of block design, in which each block has only two members who are matched on factors such as age, gender, or any other factor that may influence the outcome. Then one member of each pair is randomly assigned to one of the treatment conditions. Such an approach is used in part to reduce the possible effects of lurking variables that might confound the effects on the explanatory variable. This matching occurs *prior* to assignment to the treatment conditions.

In a second form of matched pairs design, the match is that you're looking at the same individual at

different times. In a **before and after matched pairs design** you might think of the measurement *before* as the control condition and the measurement *after* as the treatment condition.

Choosing the Design of an Experiment Assignment

Complete each part of the questions. Since the goal of many of these questions is to specify the details of a proposed experimental design, your descriptions must be clear and specific.

1. The Academy of Sports Medicine Physicians is interested in determining whether a new training regimen will help long-distance runners improve their performance in marathons. This organization comes to you for some advice on how to design an experiment to test whether this new regimen is more effective than the standard regimen. You have access to a sample of long-distance runners on the track teams at ten different universities. You hope to conduct the experiment over the course of two years because the regimen takes a long time to learn and because you want to include new runners in the sample as they join the track team. You also believe that the effect of the regimen on performance may differ for men and women.

Your challenge is to design an experiment that uses a randomized approach to measure the effect of the new regimen on performance. Remember, your design should take into account your concerns about different effects for men and women and should be set up so that new subjects can be properly included in the experiment. Create an experiment that will address these concerns. Pay particular attention to the factors, explanatory and response variables, any blocks or matching characteristics, and the treatment conditions used in the experiment. You may want to create a diagram that summarizes your experimental design (this is not required.) (6 points)

2. A farm cooperative has asked you to design an experiment that measures the effects of light exposure on the growth of tulips in the Skagit Valley of Washington State. You hypothesize that tulips exposed to more direct light will grow at a faster rate than those exposed to less light. You also wonder whether the effects of light exposure persist when you control for the amount of moisture the plants receive. You want to create a randomized comparative design that considers three factors with the following levels:

Light Exposure (No, Yes)

Amount of Light Exposure (3 hours a day, 6 hours a day, 9 hours a day) Amount of Moisture Exposure (1 hour a day, 3 hours a day, 5 hours a day)

You have 1,000 seedling plants at 12 different nurseries to use in your experiment. Your experiment should run six months in length. Outline the details of your experiment.

In your answer you should comment on a strategy for randomization, identify all the possible treatment groups, and discuss what might be a possible response variable. In addition, you should identify a couple confounding variables and discuss a method of controlling for one of these variables. As much as possible, use diagrams instead of words to summarize your experimental design. (6 points)

3. An optometrist is interested in the effects of different brands of eye drops. She wants to know if different drops affect the accuracy of a standard vision test.

Some researchers think that Brand A may have more adverse effects on an individual's ability to correctly report the letters in the vision test than Brand B or Brand C. There is also some speculation that the effect of the drops on vision differs dramatically for individuals who are far-sighted compared to those who are near-sighted.

The optometrist hires you to design an experiment that tests the effect of the eye drops on



test performance. You tell her there are two possible approaches to take: a randomized comparative approach or a matched pairs design. Describe how you would use each design to test the effect of the eye drops on test performance on a random sample of patients. Remember, there is a concern about the effects for near vs. far-sighted patients. As much as possible, use diagrams instead of words to summarize your experimental design. (7 points)

- 4. A teacher believes that whatever he says in class has no effect on his students. Just as he's about to quit his profession, a statistician enters the room and suggests that the teacher design a study to test his assumption. The study will look at whether providing in-class feedback on homework assignments enhances classroom performance.**

The teacher wants to know whether providing feedback before or after returning the assignments is most useful. He's also interested in the most effective means of presenting the feedback: verbal presentation, written handout, or a summary on overheads. Ultimately, he'd like to identify the best approach for increasing test scores of the students. There are 12 classes available in the school for the experiment.

Design an experiment that helps answer these questions. Be sure to identify the factors, the levels of the factors, the treatment groups, and the response variable. Comment on how the students will be assigned to the different treatment groups. Is it possible to use simple random assignment of all students? As much as possible, use diagrams instead of words to summarize your experimental design. (6 points)