**Experimental Design**

An *experimental design* is a plan and a process for gathering data in which the researcher controls, modifies, or manipulates at least one variable. The purpose of gathering data in any research design, including experimental design, is to test hypotheses.

In a study with an experimental design, the researcher begins with an idea about cause and effect. The researcher wants to test whether a treatment causes a response. To do this, each treatment is applied to a different group, and the mean responses of the groups are measured and compared to each other.

Terminology:

* A factor is an explanatory variable, also called an Independent Variable (IV). It is the variable that the researcher controls, modifies, or manipulates to see what happens.
  + The treatments are different levels or categories of the factor.
* Experimental units are the objects or subjects whose response the researcher is measuring. Experimental units are assigned to treatment groups which are groups of experimental units receiving a particular treatment.
* A response variable is the Dependent Variable (DV). It is what the researcher expects to vary with different treatments.
  + A response is a single measurement of the response variable for a given experimental unit.
* Random assignment is the process of randomly assigning experimental units to treatment groups, or randomly assigning treatments to experimental units. **Random assignment makes the groups equivalent at the outset of the study…. so any changes you see in the groups after applying the treatments, can be attributed to the treatments themselves.**

Two types of experimental design:

1. Fully randomized experimental design: The treatments are randomly assigned to the groups, or, equivalently, the groups are randomly assigned to the treatments. In either case, the treatments are randomly assigned by the researcher. This is the key component of a fully randomized experimental design. The researcher imposes changes or otherwise manipulates the treatments that the groups receive.
   1. **Can prove cause and effect.** This is because the process of randomly assigning treatment groups makes the groups equivalent at the outset. Everything other than the treatment that could affect the response is randomly distributed among the groups. Therefore, any difference in the mean response between treatment groups must be due to the treatment itself.
      1. In a fully randomized experimental design, it is appropriate to call the Independent Variable (the factor) the *cause* and the Dependent Variable (the response) the *effect.* This is because you can prove cause and effect with a fully randomized experiment.
2. Nonrandomized experimental design: also called quasi-experimental design. The treatments are not randomly assigned by the researcher, but different groups still receive different treatments.
   1. **Cannot prove cause and effect.**

Both experimental designs contrast with another type of study design: observational design. In observational designs, outcomes are observed and measured for different groups, but there is no assignment of treatments to different groups. Researchers using observational designs look at ongoing behavior – they do not impose any changes in any variables. These studies are useful to illuminate associations and relationships between variables but **they cannot prove cause and effect**. In order for observational studies to have validity, they must use random sampling from the population of interest.

In both nonrandomized experimental design and observational design, there is no way to completely rule out the possibility that there are pre-existing differences between treatment groups that explain differing responses. This is why these types of studies do not prove cause and effect.

**Experimental Design: Exercise**

A local grocery store would like to increase sales on produce. This grocery store tracks purchases at the customer level.

The grocery store decided that an effective way to boost sales of produce might be to redesign the weekly ad that customers receive. In the current design (Weekly Ad A), produce is on an inside page, the pictures are small, and the emphasis is on price. In the second design (Weekly Ad B), the produce is featured on the front page, beautifully photographed in full color, and there are recipes that incorporate produce. In the third design (Weekly Ad C) is the same as Design B except that there are no recipes.

The grocery store takes a random sample of customers. These customers are randomly assigned to receive one of the three Weekly Ad designs. The customers’ purchases are tracked and their weekly spending on produce is measured.

1) What is the **factor** in this experiment?

2) What are two other terms for **factor**?

3) What are the **treatments**? How many treatments are there?

4) How many groups of customers will there be in this experiment?

5) What is the **response variable** in this experiment?

6) What is another term for **response variable**?

7) What are the **experimental units**?

8) Give an example of a **response** in this study.

9) Is this a fully randomized experiment? How do you know?

10) Suppose that differences in Weekly Spending on Produce are observed among the groups after they receive the Ads. Can the researcher conclude that the Weekly Ad Design *caused* those differences?