• **Observational Study**- observes individuals (cases) and measures variables of interest but does not attempt to influence responses; goal is to describe situation and look for association; the explanatory variable is not imposed by the researchers.

• **Experiment**- deliberately imposes some treatment on individuals (cases) to observe their responses; goal is to study whether treatment causes a change in the response.
  • Response variable- a variable that measures an outcome or result of a study
  • Explanatory variable- a variable that researchers think explains or causes changes in the response variable (also called a factor)
  • Subjects- the individuals (observational units) studied in an experiment
  • Treatment- a specific experimental condition applied to the subjects

**Example 3-1: Reducing Back Pain**
In a recent study 15 patients suffering from severe back pain were given botox. After several weeks 9 of the patients reported a substantial decrease in pain.

a) Would you conclude that botox is an effective treatment for causing a reduction in back pain? Explain.

b) How would you design an experiment to provide a better test of the drug?

• Well-designed experiments include a comparison group.

**Example 3-2: Friendly Observers**
Psychology researchers investigated a conjecture that having an observer with a vested interest would decrease subjects’ performance on a skill-based task. Subjects were given time to practice playing a video game that required them to navigate an obstacle course as quickly as possible. They were then told to play the game one final time with an observer present. Participants were assigned to one of two groups: One group was told that the participant and observer would each win $3 if the participant beat a certain threshold time, and the other group was told only that the participant would win the prize if the threshold were beaten.

a) Identify the explanatory and response variables in this study.

Explanatory: Response:

b) Is this an observational study or an experiment? Explain.
c) What do researchers hope will be true about the two treatment groups before the treatment is imposed?

d) Explain why researchers would not allow subjects to decide for themselves which treatment group to be in.

e) Suggest how the researchers should decide which subjects go to which groups.

- **Random assignment** produces groups of subjects that should be similar in all respects before the treatment is applied.
  - If the treatment groups differ significantly on the response variable, that difference can be attributed to the explanatory variable, establishing a cause-and-effect relationship between those variables.

f) Consider the variable “ability to perform well under stressful conditions.” Explain how the experimental design can prevent this from being a confounding variable.

**Example 3-3: Reducing Cold Durations**
To study the effectiveness of a zinc nasal spray for reducing the duration of a common cold, researchers recruited 104 subjects who agreed to report to their lab within 24 hours of getting cold symptoms. Each subject was randomly assigned to one of three groups: one received full dosage of the zinc spray, another received a low dosage, and a third received a spray containing no zinc at all. The cold symptoms lasted an average of 1.5 days for the full dosage group, 3.5 days for the low dosage group, and 10 days for the no zinc group.

a) Is this an observational study or an experiment? Explain.

b) Identify the explanatory and response variables; also classify them.

c) How many treatment groups are there?

d) Why do you think the researchers use a spray with no zinc, as opposed to just providing no spray for that group of subjects?
- **Placebo**- a dummy treatment with no active ingredients
- **Placebo effect**- many patients respond favorably to *any* treatment, even a placebo

e) Is it important that subjects not know which group they have been assigned to? Explain.

- An experiment employs **blindness** if subjects do not know which treatment group they are in.
- An experiment is **double-blind** if neither the subjects nor the people who work with them know which treatment each subject is receiving.

**Example 3-4: Cursive Writing**
An article about handwriting appeared in the October 11, 2006 issue of the *Washington Post*. The article mentioned that among students who took the essay portion of the SAT exam in 2005-6, those who wrote in cursive style scored significantly higher on the essay, on average, than students who used printed block letters.

a) Identify the observational units in this study, as well as the explanatory and response variables. Also classify each variable as categorical (also binary?) or quantitative.

Observational units:

Explanatory variable: Type:

Response variable: Type:

b) Is it reasonable to conclude that using a cursive writing style *caused* higher scores on the essay, or can you think of an alternative explanation for why students who wrote in cursive style scored higher on average than students who write with block letters? In other words, can you think of other ways in which the cursive and block letter groups might have systematically differed?

The same *Washington Post* article also mentioned a different study in which the identical essay was shown to many graders, but some graders were randomly chosen to see a cursive version of the essay and the other graders were shown a version with printed block letters.
c) How does this study differ from the original one? Explain.

The average score assigned to the essay with the cursive style was significantly higher than the average score assigned to the essay with the printed block letters.

d) Can you legitimately draw a different conclusion from this study as compared to the original study? Explain.

Example 3-5: Memory Study
You will be asked to study a sequence of letters for 20 seconds and then to write down as many as you can remember, in order. Your score will be the number that you remember correctly before your first error of any kind.

a) Is this an observational study or an experiment? Explain.

b) Identify and classify the explanatory and response variables.

c) Who/what are the subjects in this study?

d) What are the treatments in this study?

e) Did this study design make use of randomization? How, and for what purpose?
f) Did this study design make use of blindness? How, and for what purpose?

g) Produce graphs that compare the results between the two groups. Do the graphs suggest that the two “treatment” groups tended to produce different responses? Explain.

h) If analysis reveals that the differences between the two groups are “statistically significant,” meaning that they are unlikely to occur by random variation if there were no underlying difference between the groups, would you have reason to conclude that one treatment caused lower/higher performance on the task? Explain.

i) How, if at all, did this study control for the fact that some people are better memorizers than others?

- Random sampling and random assignment are very different uses of randomness and serve two very different purposes.
  - **Random sampling** aims to select a *representative* sample from a population, so findings about the sample can be *generalized* to the population.
  - **Random assignment** aims to produce treatment groups that are similar in all respects except for the explanatory variable, so differences in the response variable among the groups can be attributed to (in a cause-and-effect manner) the explanatory variable.