

SUPPLEMENTARY EXERCISES, CHAPTER 3

DESIGNING STUDIES AND COLLECTING DATA

- S3.1. Recent research suggests that alcoholism is partly a consequence of a genetically-based deficiency that affects the pleasure and reward areas of the brain. One recent study focused on differences in the D_2 dopamine receptor genes of alcoholics and those of nonalcoholics. There are four known alleles (genetic variants) of these receptor genes: the A_1 , A_2 , A_3 and A_4 alleles. The A_3 and A_4 alleles are rare, whereas the A_2 allele is found in nearly 75 percent of the general population and the A_1 allele in about 25 percent of the population.
- In one study, scientists extracted DNA from the brains of deceased alcoholics and also from a group of nonalcoholics. They found that 69% of the sample of 35 alcoholics had the A_1 allele and 31% had the A_2 allele. In contrast, 20% of the 35 nonalcoholics had the A_1 allele and 80% had the A_2 allele.
- What kind of study was this? Be as specific as possible.
 - A student argues that since some alcoholics had the A_2 allele, while some nonalcoholics had the A_1 allele, these results do not demonstrate a cause-effect relationship between the presence of the A_1 allele and alcoholism. Would cause-effect be established if the study showed that 100% of the alcoholics had the A_1 allele and 100% of the nonalcoholics had the A_2 allele? If you conclude that cause-effect would not be established, what, if anything, could be established? Justify your answer.
- S3.2. Many people would choose balloon angioplasty over open-heart bypass surgery for coronary artery disease, but what is the difference in long-term results? An article in **The Boston Globe** of March 6, 1997, reported on a study in which 1,829 heart disease patients allowed themselves to be randomly assigned to receive either open-heart bypass surgery or balloon angioplasty between 1989 and 1991. Their medical conditions were then to be monitored over the course of several years, and the results compared according to several measures of cardiac health.
- This study is a controlled experiment. Tell why.
 - Identify the treatments and experimental units.
 - Suggest one way that blocking might be used in this experiment to reduce variation.
- S3.3. In a study on the effect of caffeine intake on fine motor skills, 40 subjects were graded on their performance on a series of tests. The subjects were told to report at 8 am and were required to abstain from caffeine for 24 hours before that. The first 20 subjects to arrive were given a capsule of caffeine before performing the tests. The second 20 were given a capsule of sugar before performing the tests.
- What kind of study was this? Be as precise as possible and justify your answer.
 - There is an obvious flaw in the design of this study. Tell what it is, and how it can be corrected.
- S3.4. In a recent study, 200 runners were interviewed. It was found that those who stretched had substantially more injuries than runners who didn't.
- Was this a controlled experiment or an observational study? Why?
 - Can we conclude from this that stretching causes injuries? Why or why not?
 - If your answer to part b is no, what alternative explanation can you provide for the observed association?
- S3.5. Veterinary researchers want to test a promising new material for pads to cushion horse shoes. The research team has 12 horses available for testing. It is desired to evaluate the performance of the pads on the front hooves, where the greatest stress is generated. The test apparatus consists of a short track with a pressure plate mounted flush to the ground. The pressure plate is large enough for the horse to land, and have the pressure recorded, for both front hooves on one run. The horses will be run at a near-constant speed on each run. The head researcher suggests that six of the horses be chosen randomly to test the new pad on both hooves, and that the remaining horses be given the old pad on both hooves.
- Is this a controlled experiment? Justify your answer.
 - Suggest a way of conducting the study that is superior to that suggested by the head researcher. Tell why your design is superior.

- S3.6. The article “Study Says Rigor of High-School Course Work Is the Best Predictor of College Graduation,” by Ben Gose, *Chronicle of Higher Education*, XLV, 39, June 4, 1999, p. A46, describes a study conducted by the U. S. Department of Education purporting to show that the rigor of a student’s high school curriculum is a better predictor of whether the student will graduate from college than either test scores or high school grades. The following is a quote from the article:

Clifford Adelman, the senior research analyst who led the study, spent two years examining the transcripts and test scores of students who graduated from high school in 1982 to determine what contributes most to the completion of a bachelor’s degree.

Mr. Adelman established college graduation by the age of 30 as a benchmark. He then worked backward to see which measure of preparedness for college—the student’s test scores, class rank, or course work—had the strongest correlation with the earning of a bachelor’s degree.

The study was reviewed by Alberto F. Cabrera, an associate professor and research associate at the Center for the Study of Higher Education at Pennsylvania State University. Mr. Cabrera says the study should persuade high-school guidance counselors to encourage as many students as possible to take demanding courses. “The findings make a clear point that the type of courses a student takes has a long-term effect on the student’s success,” Mr. Cabrera says.

- a. Tell as precisely as possible what type of study is described here. Justify your answer.
 - b. Explain why the conclusion stated in Mr. Cabrera’s quote is not justified.
- S3.7. A study directed by Dr. Michael Gaziano, a heart specialist at the Harvard Medical School-affiliated Brigham and Women’s Hospital in Boston, suggests that tea may reduce the chance of a heart attack by 44 percent. Gaziano’s study examined 340 men and women who had suffered heart attacks and matched them by age, sex and neighborhood with people who had never had a heart attack. It then investigated their coffee- and tea-drinking habits over the course of a year. Gaziano thinks that the reason for the reduced incidence of heart attacks among tea drinkers is that tea contains powerful amounts of flavonoids, natural substances that make blood cells less prone to clots, which can cause heart attacks. The study was adjusted for factors that could have skewed the results, such as smoking, exercise, alcohol intake and family history of heart trouble. Total calories consumed, intake of fatty foods and body mass index which compares the girth of people of different heights to determine obesity was about the same across the board.
- a. What kind of a study was this? Be as precise as you can, and justify your answer.
 - b. Based on this study, is it valid to conclude that drinking tea causes a reduction in the chance of a heart attack? Why or why not?
- S3.8. A researcher conducted a study of the effectiveness of an SAT preparation course. To do so, she randomly selected a group of 100 high school juniors from a large high school. She randomly divided them into two groups of 50 each. Both groups took the SAT on the same date in the fall. Then, one group was given the SAT preparation course and the other was not. Finally, both groups took the SAT on the same date in the spring. To evaluate the results, the differences in the two SAT scores for each student were computed, and these differences were compared for differences between the two groups.
- a. Explain why this a controlled experiment.
 - b. How is blocking used in this experiment? What do you think its effect will be?
 - c. Randomization is used in two ways in this experiment. Explain how it is used and why.
 - d. Describe how replication is used in this experiment.

- S3.9. A study was conducted to compare the abilities of two commercial sunscreens to resist washing off in pool water. Twelve volunteers were randomly divided into two groups of 6. A prescribed amount of sunscreen 1 was applied to both arms of each subject in group 1, and the same prescribed amount of sunscreen 2 was applied to both arms of each subject in group 2. The subjects were assigned at random to the 12 pool lanes, where they simultaneously swam for 30 minutes. At the end of the time, the amount of sunscreen remaining on the arms of each subject was measured.

- a. Tell why this study is a controlled experiment. Justify your answer with specifics.

- b. How could blocking be used to improve the experiment? Explain why you think it might result in an improvement.
- S3.10. Three studies are described below. Tell as completely as possible what type of study each is. Justify your answers.
- Scientists randomly divide volunteers into two groups. In one group, each individual is given a geometric puzzle to solve, while each individual in the other group is given no stimulation. After five minutes, magnetic resonance imaging (MRI) measurements of the individual's brain activity are obtained.
 - Crop yields are estimated by satellite. First the US is divided into sectors that can be viewed by the satellite in a single image. Images are obtained of a set of sectors selected by a probability sampling scheme. These images are analyzed to estimate the total US crop yield.
 - In order to identify possible causes of tread separation on a particular model of SUV tire, quality engineers compare a sample of failed tires with a sample of unfailed tires with respect to a number of variables.
- S3.11. Describe how the first study in exercise S3.10 could be improved by the use of blocking. Be sure to tell how the blocking would help.
- S3.12. Are the results of the last study in exercise S3.10 necessarily applicable to the population of all tires of the model studied? If you conclude 'yes,' tell why. If you conclude 'no,' tell why not and indicate what must be done to make the results applicable to that population.
- S3.13. It is well known that anti-perspirants applied to the skin can cause skin irritation in some people. The manufacturer of a new anti-perspirant wants to test the degree of skin irritation induced by the active ingredient in its product. To do so, it recruits 20 volunteers and randomly selects 10 to test its anti-perspirant. The other 10 are assigned a formulation identical to the product, but without the active ingredient. All subjects are instructed to apply the product once per day to the armpits, and are assessed at regular intervals over a four week period for skin condition in the areas of application.
- Is this a controlled experiment? Why or why not?
 - If it is a controlled experiment, identify the treatments, experimental units, and response. If it is not a controlled experiment, identify the kind of study it is.
 - Assuming the budget only allows 20 subjects for this study, tell how the study can be improved by blocking.
- S3.14. In 1976 the Viking spacecraft ran a remote experiment to test for life on Mars. The experiment involved feeding nutrients to a sample of Martian soil and measuring the amount of carbon dioxide produced. The theory was that if there were microbes in the Martian soil similar to those found on earth, the nutrients would be absorbed by the microbes and then given off as carbon dioxide. The experiment yielded the kind of positive results expected if there were microbes present in the soil, but, because other tests, including one that found no trace of organic chemicals in the soil, led most scientists to conclude that the nutrient experiment had been fooled by some kind of exotic and chemically active substance in the soil.
- Environmental engineer Gilbert Levin, designer of the 1976 experiment, proposed a similar but improved experiment for the Mars Surveyor '98 spacecraft.
- The new experiment was based on a peculiar, unexplained feature of all known life: It likes only left-handed molecules. Most of the organic molecules on Earth are asymmetrical, and can exist in two mirror-image forms. But living organisms use only one form, called left-handed. In contrast, all known non-organic chemical reactions work equally well on either left- or right-handed molecules.
- Levin's proposed experiment was to obtain two samples of Martian soil, feed one sample nutrients made up of only left-handed molecules, and the other sample the same amount of nutrients made up of only right-handed molecules and measure the carbon dioxide produced in each sample.
- Explain why each of the described experiments is a controlled experiment.
 - What are the experimental units, treatment(s) and response for each?
 - What possible observed outcomes do you see from the second experiment? For each possible outcome, tell what scientists can conclude.
 - Explain why the proposed experiment is an improvement over the 1976 experiment.

- S3.15. A shoe manufacturer wants to compare two materials for use on the soles of athletic shoes. To do so, 100 volunteer runners are randomly assigned to two groups. Each volunteer in the first group is given a pair of athletic shoes with material 1, while each volunteer in the second group is given a pair of athletic shoes with material 2. They are asked to return the shoes after they have run 500 miles in them, so that wear of the two materials can be compared. Show how blocking can be used to give a better design for this controlled experiment, and explain why your design is better.
- S3.16. Infection with an apparently harmless, newly recognized virus called hepatitis G, seems to interfere with HIV, slowing its progress and prolonging survival of AIDS patients, according to an Associated Press article in the September 6, 2001 edition of the Boston Globe. A study by researchers at the Iowa City Veterans Affairs Medical Center and the University of Iowa looked at 362 HIV-infected patients treated between 1988 and 1999. The researchers found that 144 of these patients were also infected with hepatitis G. Of the 144 who were infected with hepatitis G, 41 died during four years of follow-up compared with 123 of the 218 who were not infected with hepatitis G.
- What kind of study is this? Be as explicit as possible and justify your answer.
 - The results look impressive. Can the experimenters conclude that infection with hepatitis G causes a reduction in the HIV mortality rate? Why or why not?
 - If your answer to (b) was that they cannot conclude that hepatitis G causes a reduction in the HIV mortality rate, tell how you would design a study from which such a conclusion is possible.
- S3.17. A manufacturer of roofing shingles wants to compare the performance of shingles with two different types of backings in field tests. To do so, they randomly select 30 communities around the country. In each, they randomly select a single-family house among those volunteered by their owners in response to an ad for a “free roof.” They randomly select half the houses to receive one type of shingle and roof the rest with the second type. Various measures of the condition of each roof are obtained over a period of years.
- What kind of study is this? Be as specific as possible and justify your answer.
 - Explain how blocking could be used to improve the results. Be sure to tell what the blocks are and why the blocking would be expected to improve the results.
- S3.18. Could something about teaching—perhaps the years of contact with kids and their germs—increase the risk of immune system diseases such as multiple sclerosis and lupus? A study published recently in the Journal of Rheumatology suggests that the rates of such diseases in schoolteachers is substantially higher than it is for people in other professions.
- Below are three alternative designs for this study. Tell what kind of design each is (be as specific as possible). Be sure to justify your answers.
- Investigators choose a random sample of schoolteachers and another of individuals who are not schoolteachers. They follow both groups over a 20 year period and compare the proportion of schoolteachers who contract immune system diseases during that time with the corresponding proportion of the other group.
 - Investigators divide a sample of death certificates into two groups: those which list an immune system disease as a cause of death, and those which do not. They then compare the proportions of schoolteachers in each group.
 - Investigators interview a random sample of schoolteachers and a random sample of non-schoolteachers to determine how many have an immune system disease.
- S3.19. In a recently-published study, medical researchers report findings relating alcohol consumption to the risk of heart disease in people 65 years old or older. Below are three alternative designs for this study. Tell what kind of design each is (be as specific as possible). Be sure to justify your answers.
- The research team interviews a random sample of people 65 years old or older to determine alcohol consumption patterns and history of heart disease.
 - Investigators choose a random sample of patient medicare records. They classify the patients into groups based on alcohol consumption patterns indicated in the records. They then follow the patients for 5 years and compare the incidence of heart disease in the groups.

- (c) Investigators divide a sample of death certificates of medicare patients into two groups: those which list heart disease as a cause of death, and those which do not. They then compare the proportions of non-drinkers, moderate drinkers and heavy drinkers in each group.

S3.20. Suppose in problem S3.19, that researchers find that the rate of heart disease is significantly lower for moderate drinkers than for either non-drinkers or heavy drinkers. Can they conclude that moderate drinking causes a reduction in heart disease? Justify your answer.

S3.21. Researchers want to assess the performance of two new driveway sealants. To do so, they first divide the country into six climatologically similar regions. Within each region, they obtain a simple random sample of twelve single-family homes belonging to owners willing to participate in this three year-long study. Six of the homes in each region are randomly chosen to test driveway sealant 1 and the other six receive driveway sealant 2. The sealants are compared with respect to their performance on a number of measures over the course of the test.

- (a) What sampling method was used to select the homes used in the study? Be specific, and support your answer.
- (b) What kind of study is this? Be specific, and support your answer.
- (c) Explain how blocking could be used to improve the study. Be specific: tell what the blocks are, how the blocking will be done, and why it will be beneficial.