**Section 4.2 Alternate Examples**

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Soy good for you?

The November 2009 issue of Nutrition Action discusses what the current research tells us about the supposed benefits of soy. For a long time, scientists have believed that the soy foods in Asian diets explain the lower rates of breast cancer, prostate cancer, osteoporosis, and heart disease in places like China and Japan. However, when experiments were conducted, soy either had no effect or a very small effect on the health of the participants. For example, several different studies randomly assigned elderly women to either soy or placebo, and none of the studies showed that soy was more beneficial for preventing osteoporosis. So what explains the lower rates of osteoporosis in Asian cultures? We still don’t know. It could be due to genetics, other dietary factors, or any other difference between Asian cultures and non-Asian cultures.

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The buzz about coffee

The article “Coffee Buzz: Study Finds Java Drinkers Live Longer” from the Arizona Daily Star discusses a very large study of coffee drinkers. It suggests that coffee drinkers live a little longer than non-drinkers, whether they drink regular or decaf. Previous studies had indicated that drinking coffee might increase the risk of heart disease, but these studies didn’t take into account that coffee drinkers were also more likely to smoke, drink more alcohol, eat more red meat, and exercise less than non-coffee-drinkers. The new study is still an observational study, however, so we can’t be sure that drinking coffee is the cause of longer life—it could be something else associated with drinking coffee that is the cause. From

<http://azstarnet.com/news/science/health-med-fit/coffee-buzz-study-finds-java-drinkers-live-longer/article_c8de3c15-67da-5c57-8efd-a120d86ca967.html>.

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A louse-y situation

A study published in the New England Journal of Medicine (March 11, 2010) compared two medicines to treat head lice: an oral medication called ivermectin and a topical lotion containing malathion. Researchers studied 812 people in 376 households in seven areas around the world. Of the 185 households randomly assigned to ivermectin, 171 were free from head lice after 2 weeks compared with only 151 of the 191 households randomly assigned to malathion.

Problem: Identify the experimental units, explanatory and response variables, and the treatments in this experiment.

Solution: The experimental units are the 376 households, not the 812 people, because the treatments were assigned to entire households, not separately to individuals within the household. The explanatory variable is type of medication, and the response variable is whether the household was lice-free. The treatments were ivermectin and malathion.

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Growing tomatoes

Does adding fertilizer affect the productivity of tomato plants? How about the amount of water given to the plants? To answer these questions, a gardener plants 24 similar tomato plants in identical pots in his greenhouse. He will add fertilizer to the soil in half of the pots. Also, he will water 8 of the plants with 0.5 gallon of water per day, 8 of the plants with 1 gallon of water per day, and the remaining 8 plants with 1.5 gallons of water per day. At the end of 3 months, he will record the total weight of tomatoes produced on each plant.

Problem: Identify the experimental units or subjects, explanatory and response variables, and the treatments.

Solution: The experimental units are the tomato plants. The two explanatory variables (factors) are whether fertilizer is applied and amount of water. The response variable is the weight of tomatoes produced. There are 6 treatments: (1) fertilizer, 0.5 gallon; (2) fertilizer, 1 gallon; (3) fertilizer, 1.5 gallons; (4) no fertilizer, 0.5 gallon; (5) no fertilizer, 1 gallon; (6) no fertilizer, 1.5 gallons.

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How to buy happiness

Watch the short TED talk “How to Buy Happiness” by Michael Norton at <http://www.ted.com/talks/michael_norton_how_to_buy_happiness.html>. He describes a neat multifactor experiment to determine if money can buy happiness. After he describes the treatments, pause the video and ask students how many factors the experiment involves. Many students will say “4” because they are confusing factors and treatments. In fact, there are two factors: amount of money and how it is spent.

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Does caffeine affect pulse rate?

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

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Does caffeine affect pulse rates?

Suppose you have a class of 30 students who volunteer to be subjects in the caffeine experiment described earlier.

Problem: Explain how you would randomly assign 15 students to each of the two treatments:

(a) Using 30 identical slips of paper

(b) Using technology

(c) Using Table D

Solution:

(a) Using 30 identical slips of paper, write A on 15 pieces of paper and B on the other 15. Mix them thoroughly in a hat and have each student select one slip of paper. Then ask each student who received an A to drink the cola with caffeine and each student who received a B to drink the cola without caffeine.

(b) Number the students from 1 to 30. Use randInt(1,30) to select 15 different numbers from 1 to 30. These students will drink the cola with caffeine and the remaining 15 will drink the cola without caffeine.

(c) Number the students from 01 to 30. Use a line from Table D and read two-digit numbers moving from left to right. The first 15 different numbers from 01 to 30 will identify the students who will drink the cola with caffeine. The remaining 15 students will drink the cola without caffeine.

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Multitasking

Researchers in Canada performed an experiment with university students to examine the effects of in-class laptop use on student learning. All participants in the study were asked to attend a university-style lecture and take notes with their laptops. Half of the participants were assigned to complete other non-lecture-related online tasks during the lecture. These tasks were meant to imitate typical student Web browsing during classes. The remaining students simply took notes with their laptops. To assign the treatments, the researchers printed 40 papers with instructions (20 with multitasking and 20 without), shuffled them, and handed them out at random to students in the classroom. At the end of the lecture, all participants took a comprehension test to measure how much they learned from it. The results: students who were assigned to multitask did significantly worse (11%) than students who were not assigned to multitask. From

<http://www.sciencedirect.com/science/article/pii/S0360131512002254>.

Problem: Explain how each of the four principles of experimental design was used in the multitasking study.

Solution:

Comparison: The researchers compared students who were multitasking to other students who were not multitasking.

Random assignment: It was determined at random which students (and which seat locations) received the instructions to multitask and which students (and seat locations) received the regular instructions.

Control: The experiment used undergraduate students from the same university in Canada. All participants listened to the same lecture and took the same comprehension test at the end of the lecture.

Replication: There were 20 students in each treatment group. Although this is not a very large number of subjects, the difference in performance was big enough to determine that the difference was due to multitasking and not the chance variation in random assignment.

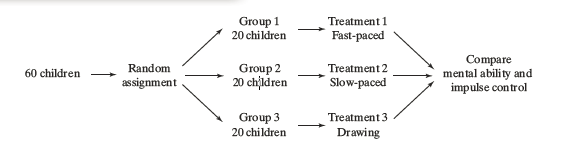
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Television and young children

Psychologists want to know how different types of television shows impact young children. They recruit 60 four-year-olds and have them watch 9 minutes of a fast-paced children’s program (defined as scene changes every 10–15 seconds), watch 9 minutes of a slow-paced children’s program (defined as scene changes every 30–45 seconds), or draw for 9 minutes. After the 9 minutes, each child will complete several tasks, including tests for mental ability and impulse control.

Problem: Describe a completely randomized design for this experiment. Write a few sentences describing how you would implement your design.

Solution: Here is an outline of the design:



To implement the design, use 60 equally sized slips of paper. Label 20 of the slips “1,” 20 of the slips “2,” and 20 of the slips “3.” Mix the numbers in a hat and have each child draw a number without looking. The number that each child chooses will be the group to which he or she is assigned. At the end of the study, compare the mental ability and impulse control for the three treatment groups.

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A more expensive placebo?

In a study reported by the New York Times on March 5, 2008 (“More Expensive Placebos Bring More Relief”), researchers discovered that placebos have a stronger effect when they are perceived to be more expensive. The study had volunteers rate the pain of an electric shock before and after taking a new medication. However, half of the subjects were told the medication cost $2.50 per dose, while the other half were told the medication cost $0.10 per dose. In reality, both medications were placebos, and both had a strong effect. Of the “cheap” placebo users, 61% experienced pain relief, while 85% of the “expensive” placebo users experienced pain relief. The researchers suggested that people are accustomed to paying more for better medications, which may account for the difference in response. As with any placebo, it’s all about the expectations of the subjects.

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Antidepressants and the placebo effect

The CBS News program 60 Minutes aired an excellent segment about the placebo effect called “Treating Depression: Is There a Placebo Effect?” Watch the 20-minute video at <http://www.cbsnews.com/video/watch/?id=7399362n>.

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Prescribing placebos

The article at the link below describes how the placebo effect works, even when subjects know they are receiving a placebo: [www.medpagetoday.com/PainManagement/PainManagement/24056](http://www.medpagetoday.com/PainManagement/PainManagement/24056).

Page 251: Alternate Example

More SAT prep

In the previous examples about online versus classroom SAT preparation courses, we acknowledged that the student’s current math class might be a source of variability in their improvement. In our completely randomized design, we hoped that the random assignment would distribute the Precalculus students roughly equally between the online and classroom SAT courses. Likewise, we hope that the random assignment would roughly balance the Algebra 2 students, the Geometry students, and so on. Still, there might be lots of variability in the results for each course if the students in the Precalculus class experience greater improvements than students in a Geometry class, regardless of which SAT preparation course they took. This might make it hard to detect a difference in the effectiveness of the two courses.

To account for this potential variability, we can separate the students into groups (blocks) based on their current math class and randomly divide the members of each block into the online and classroom SAT courses. This randomized block design will help us account for the variation in improvement due to one’s current math class.

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More SAT prep

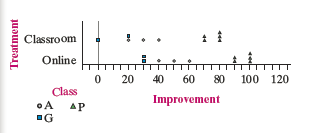
Here are the results from a randomized block experiment comparing online and classroom SAT preparation courses, using current math class as a blocking variable. The response variable is improvement in SAT score. Of the 20 subjects, 10 were in Precalculus, 6 were in Algebra 2, and 4 were in Geometry.

Here are the results without accounting for current math class:

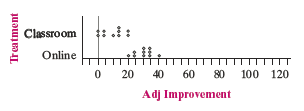


There is quite a bit of overlap, meaning that the difference in mean improvement for students in the online course and students in the classroom course is unlikely to be statistically significant.

Here are the same dotplots, this time with the current math course identified for each student:



Looking at each course separately, it appears that the online class was clearly better within each block. The overlap in the original dotplot was mostly due to the fact that Precalculus students improved much more than Algebra 2 students and Geometry students. The mean improvement for Precalculus students was 86, while the mean improvement for Algebra 2 students was 40 and for Geometry students was 20. To level the playing field, let’s subtract 66 points from each student in Precalculus and subtract 20 from each student in Algebra 2. Here are the adjusted results, on the same scale:



Now that the variability due to current math class has been accounted for, it is much more obvious that the online course is better than the classroom course.

Page 254: Alternate Example

Microwave popcorn

A popcorn lover wants to know if it is better to use the “popcorn button” on her microwave oven or use the amount of time recommended on the bag of popcorn. To measure how well each method works, she will count the number of unpopped kernels remaining after popping. To obtain the experimental units, she goes to the store and buys 10 bags each of 4 different varieties of microwave popcorn (butter, cheese, natural, and kettle corn), for a total of 40 bags.

Problem:

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

(b) Outline a randomized block design for this experiment. Describe how you would carry out the random assignment required by your design.

Solution:

(a) A completely randomized design ignores the difference between the four types of popcorn, which will probably result in a great deal of variability in the number of unpopped kernels for both treatments. For example, if there are many more unpopped kernels in bags of cheese popcorn and kettle corn than the other two varieties, it will be harder to tell if there is a difference in the methods of popping. A randomized block design considers each variety of popcorn separately, which allows us to account for the variability in the number of unpopped kernels created by the difference in varieties.

(b) We will randomly assign 5 bags of each variety to each of the two treatments. To perform the random assignment, place all 10 bags of a particular variety in a large grocery bag. Shake the bag and then randomly select 5 bags to be popped using the “popcorn button.” The remaining 5 bags will be popped using the instructions on the bags. Repeat this process for the remaining 3 varieties. After popping each of the 40 bags in random order, count the number of unpopped kernels in each bag and compare the results within each variety. Then combine the results from the 4 varieties after accounting for the difference in average response for each variety.

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Cholesterol drugs

Here are Fathom dotplots for the two different designs in the Reducing Cholesterol Alternate Activity. The dotplots from the completely randomized design show that the new drug has a slightly greater center, but there is lots of overlap in the distributions. Based on the results of the completely randomized experiment, there is not convincing evidence that the new drug is better than the current drug. However, in the design where pairs were formed by initial cholesterol level, the distribution was much less variable and each difference was greater than 0. This means that in each pair, the subject with the new drug did better. This is convincing evidence that the new drug is better. The lesson for students is that careful planning during the design of an experiment can greatly increase the chances of getting statistically significant results if one treatment is really better than the other.

