

Statistical Studies: Statistical Investigations

III.A Student Activity Sheet 1: Overview of Purpose, Design, and Studies

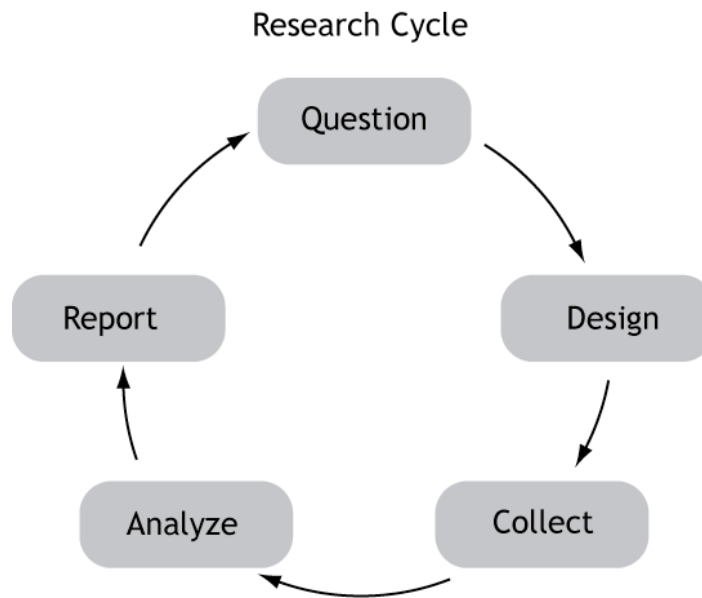
Music is a large part of many people's lives. Because of this, it is often the subject of study. For example,

- Music industry executives want to know what will be popular with different age groups.
- Advertisers want to know which radio stations are the most popular.
- Doctors want to know how much hearing damage results from loud music.
- Teachers want to know whether or not listening to classical music helps students perform better on tests.



Statistical investigations are used every day for a variety of reasons.

1. What are the purposes of statistical investigations? Give some examples of statistical investigations with which you are familiar.



This graphic illustrates the process of planning and implementing a statistical investigation. First, a question (or a series of questions) sparks the interest of a researcher. The research team then decides on the best design for investigating the question.

2. The graph shows no obvious ending point (or starting point). What does this mean?

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Consider the following examples of two different types of statistical investigations.

Example 1

Radio rating services sometimes collect data on listenership by asking participants to record the date, time, and station each time they listen to the radio. Other rating services distribute monitoring devices that automatically record this information anytime the participant has the radio turned on. Still others call participants and ask them about their listening habits. The data are then compiled so that advertisers know which stations are the most popular at specific times during the day.

Each of these approaches is an example of an **observational study**, which collects data about some characteristic(s) of the population. The data can be collected by observation, by a survey or interview, or by other means.

3. Describe an observational study in your own words:

An observational study is research in which

Example 2

*A 17-year-old student designed a science fair project with 72 mice randomly assigned to three groups: hard rock music, Mozart, and no music at all (called a **control group**). The mice in the first two groups were exposed to music 10 hours a day. Three times a week, all of the groups were timed as they ran through a maze. An analysis of results showed that the 24 mice in the no-music group averaged about a 5-minute improvement in their maze completion time, while the Mozart mice improved 8.5 minutes. The hard rock mice actually got slower—an average of four times slower! Another interesting fact: The student had to start his experiment over because all the hard-rock mice killed each other. None of the classical mice did that. (Wertz, M. [1998]. *Why classical music is key to education*. from www.schillerinstitute.org/programs/program_symp_2_7_98_tchor_.html#Music_Mice_Mazes)*

This is an example of an **experimental study**. In an experimental study, the researcher separates the participants into one or more groups and applies some sort of treatment. After treatment, the variable of interest is measured and the results are compared.

4. What are the **treatment** and the **variable of interest** in this case?

5. Describe an experimental study in your own words:

An experimental study is research in which

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Observational and experimental studies have many components that must be planned, such as sampling and data collection procedures. Then the data must be collected, the results analyzed, and the conclusions reported.

6. Referring back to the Research Cycle graphic, why is there an arrow after the Report box?



And what about the Question box? Consider this situation: “This unopened bag of chips is half empty. I wonder if it really contains 28.3 grams as the package says?”

This type of informal question or observation is the beginning of many investigations. Informal questions can turn into more formal problem statements or **research questions**. For example, you may decide to investigate whether there is a scandal in the potato chip industry by checking the following:

“Do Spud Potato Chips contain an average of 28.3 grams of chips per bag?”

7. **REFLECTION:** Now that you have been introduced to the research cycle process, think of some research questions that you are interested in studying. List at least three ideas of research questions. Consider the following:
- What type of study (experimental or observational) might be best to approach each of your research questions?
 - If you only have four weeks to actually implement a research study, is it still possible to study any of your research questions?
 - How can you change one of your questions to make it fit into this timeline?
8. Suppose you conduct the investigation into Spud Potato Chips and find that the mean weight of the chips in your sample is 25 grams, rather than 28.3 grams ($\bar{x} = 25$ grams). Do you think that a difference of 3.3 grams between the actual and advertised weights is large enough that it needs to be reported? If so, how do you report this information and to whom?

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In some situations, researchers are even more formal and state **hypotheses**. In a case like this, the **null hypothesis** (H_0) generally states that there is no difference between the true value and the claimed value. The **alternative hypothesis** (H_a) states that something is different or incorrect, or that something has changed.

9. What are the null and alternative hypotheses for the potato chip example?

- H_0 : The true mean weight _____
- H_a : The true mean weight _____

Notice that the hypotheses say “The true mean weight.” This implies that the statements refer to the **population** of all Spud Potato Chip bags, not just a single bag or even a small sample. When a statistical investigation is conducted, it generally employs a sample that is then used to make a generalization about the population. Notice that in this case (as in many cases), *population* does not refer to people, but to bags of potato chips.

To be concise, researchers often use symbols in place of words. Greek letters are usually used when referring to populations (the entire group being studied, from which a sample or samples will be drawn). English letters are used for samples (the particular items or individuals included in a particular study). For example, when discussing the mean:

- μ = the population mean (Greek letter *mu*—pronounced *mew*)
- \bar{x} = the sample mean (pronounced *x-bar*)

So the hypotheses for a study can be stated in words or symbols. When using symbols, you must identify what your symbols represent.

- H_0 : $\mu \geq 28.3$ grams, where μ is the true mean weight of a bag of Spud Potato Chips
- H_a : $\mu < 28.3$ grams

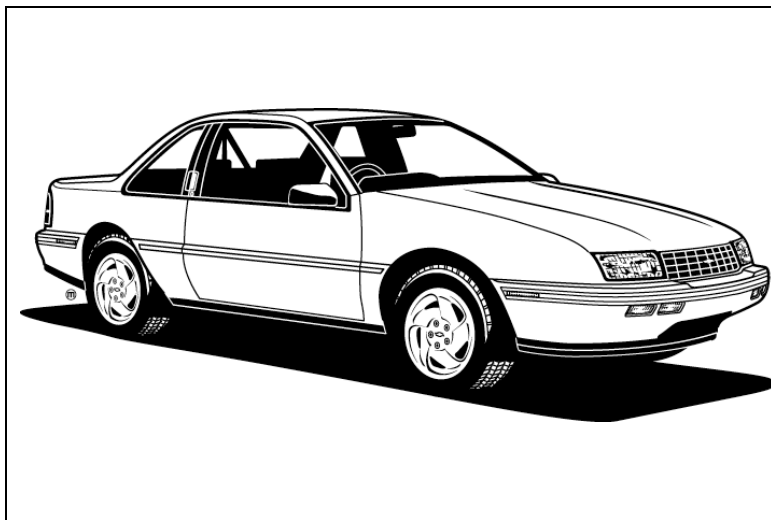
Statistical studies are designed with carefully selected measures that ensure (within error margins) that, if the sample is well selected and the study is well designed and conducted, the mean and other measures of the sample are likely to be similar to the corresponding measures of the population being studied. Sometimes, if the population is small (such as high school seniors in a small town), it may be possible that the sample studied is the entire population. However, often a sample is a smaller subset of a population (such as a research question that might target the entire population of high school seniors in a state or in the nation).

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For Questions 10 and 11, practice writing hypotheses. Write them in words and then convert them to symbols. Finally, sketch or outline a simple study design that might help study the hypotheses.

10. A local pizza shop advertises “an average delivery time of 20 minutes or less,” but it does not offer a guarantee such as a free pizza. The national manager, Su Lin, wonders if her employees are fulfilling the claim.
11. James believes that his mother’s houseplants would grow taller if she watered with rainwater instead of tap water.



Not all studies lend themselves to hypothesis writing. For example, if Giancarlo is interested in cars, he might want to collect information about the most popular type of car among teenagers, the most popular color, or prices of various models. He would not design a study that tests a hypothesis. He could write and test hypotheses, however, if he wanted to know whether or not the advertising for the gas mileage of a certain model is true.

12. **REFLECTION:** Recall the potato chip hypotheses:

- $H_0: \mu \geq 28.3$ grams, where μ is the true mean weight of a bag of Spud Potato Chips
- $H_a: \mu < 28.3$ grams

What would you do next to determine which of these hypotheses is true?

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Design

The following cases are examples of observational studies and experimental studies. Consider the type and design of each study.

13. Identify the type of study for each case.

- How do you know?
 - What is the variable of interest in each case?
 - What are some advantages and disadvantages of each teacher's plan?
- a. Mrs. Johnson teaches American History and wanted to help her students do their best on exams. After failing to find any research on different test formats, she decided to conduct her own research. She flipped a coin for each student in her classes. If the coin landed heads up, the student took a multiple-choice test. If the coin landed tails up, the student received a fill-in-the blank exam. Afterward, Mrs. Johnson compared the averages for the two test formats.
 - b. In World History, Mr. McDonald had a similar concern. He decided, however, to ask his students. He put a question at the bottom of an exam: "Which do you prefer, multiple-choice or fill-in-the-blank questions?" Afterward, Mr. McDonald tallied the results.
 - c. Mr. Mitchell was interested in the effects of music on student performance. At the bottom of his exam, he asked students to circle their favorite type of music: rock, country, or hip-hop. He then computed the averages for the students who liked each type of music and compared the results.
 - d. Mrs. Knox's senior English classes were working on their term themes. During 2nd period, she allowed students to listen to their choice of music through earphones while working, but her 4th-period class was required to work quietly without music. Mrs. Knox averaged this major grade for each class and compared 2nd period's average to 4th period's average.
 - e. Mr. Paul, the guitar teacher, sat at the food court in the mall and made a tally sheet that noted each t-shirt he saw with a musical group illustrated on it. He compiled the results and posted an entry to his blog about the most popular groups.

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14. In the experimental studies:

- Describe the treatment(s)
- Who were the participants?
- How was the assignment of treatment(s) accomplished?

15. A group of participants that the treatment group is being compared to is called the **control group**. Give an example of a treatment, the treatment group, and the control group.

Researchers are often concerned that participants in a study show improvement simply because they are in the study and not because they are receiving an effective treatment. This is called the *placebo effect*.

Example 1: Half of the participants in a study for a new headache remedy receive the new pill, while the remaining participants receive a pill containing only inactive ingredients. Participants receiving the inactive pill (the placebo) report that their headaches have been somewhat relieved. These participants believed they were being treated, and this belief may have affected their perception.

Example 2: Half of the athletes in a study received a new lotion for strained muscles, while the other half received a lotion with only inactive ingredients. Both groups report improvement in their muscle pain.

16. The improvement in Example 2 could be psychological, as in Example 1. Can you think of any other reason for the improvement?

17. **REFLECTION:** Consider Mrs. Johnson and Mr. McDonald's exam situations. Suppose Mrs. Johnson's results overwhelmingly favor fill-in-the-blank exams and Mr. McDonald's results strongly favor the multiple-choice format. Are these results in conflict with each other? What could be the cause(s) of this difference?

Suppose Mrs. Johnson takes her results to the school board and asks the board to require that all teachers in the district give fill-in-the-blank exams. If a school board member asks you what should be done, what recommendations would you give?

18. **REFLECTION:** Mrs. Johnson applied two different treatments to the participants in her study—some students received a multiple-choice test, and the rest received a fill-in-the-blank exam. Can you think of two treatments that could be used in a medical experiment? In a cooking experiment? Would a situation with three or more treatments be possible? Explain your thinking.

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19. **EXTENSION:** Read the summary of actual studies on the following pages. For one of the studies, determine the following information. Be prepared to share your findings in a short presentation.
- Is the study observational or experimental? Explain your answer.
 - Who/what are the participants or experimental units?
 - If experimental, what was the treatment(s)?
 - If there was a treatment, how was it assigned?
 - Was there a control group and/or a placebo?
 - If observational, what was being observed and why?
 - Are there any statements that appear to be opinions?
 - Are there any stated or implied limitations to the study?

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Tobacco and middle school and high school students

The Centers for Disease Control and Prevention conducted the National Youth Tobacco Survey (NYTS) in 2004 to measure current use of tobacco products and selected indicators related to tobacco use, including youth exposure to tobacco-related media and access to cigarettes.

The survey was distributed to 267 U.S. public and private schools; 14,034 middle school students and 13,738 high school students completed the survey. Participation was voluntary and anonymous, and school parental permission procedures were followed. Some results included:

- A. 11.7% of middle school students and 28% of high school students reported current use of a tobacco product.
- B. 77.9% of middle school students and 86.5% of high school students reported seeing actors using tobacco on television or in movies.
- C. 70.6% of current cigarette smokers in middle school and 63.9% in high school said they were not asked to show proof of age when they purchased or attempted to purchase cigarettes from a store.

These results indicate very little change from the results of the 2002 survey. The lack of substantial decreases in the use of tobacco products among students indicates the need to

- increase the retail price of tobacco products,
- implement smoking-prevention media campaigns, and
- decrease minors' access.

The findings in this report are subject to limitations. First, these data apply only to youths who attended middle school or high school. Among 16- and 17-year-olds in the United States, approximately 5% were not enrolled in a high school program and had not completed high school in 2000. Second, the questionnaire was offered only in English. Thus, comprehension might have been limited for students with English as a second language.

(Adapted from Centers for Disease Control. Tobacco Use, Access, and Exposure to Tobacco in Media Among Middle and High School Students—United States, 2004. from www.cdc.gov/mmwr/preview/mmwrhtml/mm5412a1.htm)

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Scientists in Turkey undertook a study of people with epilepsy. The research included analyzing scalp hair samples from 22 participants with epilepsy and 23 participants without epilepsy, checking for differences in levels of copper, iron, zinc, magnesium, and calcium. (The researchers speculate that such differences could indicate metabolic differences that may contribute to epilepsy.) Results indicated that the epileptic group had significantly lower levels of copper and iron compared to the nonepileptic group.

(Avcı, H., Kizilkan, N., & Yaman, M. [2008]. Comparison of Trace Element Concentrations in Scalp Hair of Epileptic and Normal Subjects. *Trace Elements and Electrolytes*. Vol. 25, No. 3, pp.147-155)

Scientists in Nigeria, in an effort to find an inexpensive method of raising rabbits for food, designed a study to test the effect of replacing some of the rabbits' soybean diet with *Gliricidia sepium* Leaf Meal (GLM). Twenty-five young rabbits were randomly assigned to receive either 0%, 5%, 10%, 15%, or 20% GLM. The groups showed no significant difference in the amount of harvestable meat, while decreasing costs of raising the meat.

(Amata, I., & Bratte, L. [2008]. The Effect of Partial Replacement of Soybean Meal... *Asian Journal of Animal and Veterinary Advances*. Vol. 3, No. 3, pp. 169-173. from www.scialert.net/qredirect.php?doi=ajava.2008.169.173&linkid=pdf)