

Study Session Week of 12/4

Objectives:

- I will apply previous knowledge to solve free response questions involving experimental design.

Agenda:

- FR practice problems

2011B #2

People with acrophobia (fear of heights) sometimes enroll in therapy sessions to help them overcome this fear. Typically, seven or eight therapy sessions are needed before improvement is noticed. A study was conducted to determine whether the drug D-cycloserine, used in combination with fewer therapy sessions, could help people with acrophobia overcome this fear.

Each of 27 people who participated in the study received a pill before the first therapy session. Half of the 27 people were randomly assigned to receive a D-cycloserine pill, and the other half received a placebo. After the two therapy sessions, none of the 27 people showed improvement. Two months after the administration of the pills and the two therapy sessions, the researchers were asked to see if he or she had improved.

- (a) Was this study an experiment? Justify your answer.
- (b) When the researchers concluded that the D-cycloserine pill was statistically significantly more effective than the placebo, were the researchers justified in concluding that the pill was as beneficial as eight therapy sessions without the pill? Explain your answer.
- (c) A news article summarized the results of this study did not explain how it was determined which people received D-cycloserine and which received the placebo. Suppose the researchers allowed the therapists to choose which people received D-cycloserine and which received the placebo, and no randomization was used. Explain why such a method of assignment might lead to an incorrect conclusion.

Intent of Question

The primary goals of this question were to assess students' ability to (1) distinguish an experiment from an observational study; (2) critique statistical information, in particular whether or not researchers are justified in making a specific conclusion based on the given information; (3) recognize and describe a potential problem with a study that lacks random assignment or blinding.

People with acrophobia (fear of heights) sometimes enroll in therapy sessions to help them overcome this fear. Typically, seven or eight therapy sessions are needed before improvement is noticed. A study was conducted to determine whether the drug D-cycloserine, used in combination with fewer therapy sessions, would help people with acrophobia overcome this fear.

Each of 27 people who participated in the study received a pill before each of two therapy sessions. Seventeen of the 27 people were randomly assigned to receive a D-cycloserine pill, and the remaining 10 people received a placebo. After the two therapy sessions, none of the 27 people received additional pills or therapy. Three months after the administration of the pills and the two therapy sessions, each of the 27 people was evaluated to see if he or she had improved.

(a) Was this study an experiment or an observational study? Provide an explanation to support your answer.

Part (a):

The study was an experiment because treatments (D-cycloserine or placebo) were imposed by the researchers on the people with acrophobia.

Part (a) is scored as follows:

Essentially correct (E) if the response indicates that this was an experiment, *AND* the explanation clearly communicates that two treatments were imposed.

Partially correct (P) if the response indicates that this was an experiment, *BUT* the explanation does not clearly communicate that two treatments were imposed.

Note: If the response indicates that this was an experiment because there was random assignment *to treatments*, this implies imposition of treatments and is scored as E. If the response does not clearly state that the random assignment is *to treatments*, this is scored as P.

Incorrect (I) if the response indicates that this is an observational study *OR* if the explanation is missing or incorrect.

- (b) When the data were analyzed, the D-cycloserine group showed statistically significantly more improvement than the placebo group did. Based on this result, would the researchers be justified in concluding that the D-cycloserine pill and two therapy sessions are as beneficial as eight therapy sessions without the pill? Justify your answer.

Part (b):

No, the experiment was designed to compare the D-cycloserine group with a control group that received the placebo. The researchers can conclude that the D-cycloserine pill and two therapy sessions show significantly more improvement than a placebo and two therapy sessions. However, there is no basis for comparison with another group of people with acrophobia who received eight therapy sessions and no pill.

Part (b) is scored as follows:

Essentially correct (E) if the response says "no" *AND* clearly explains why this is not reasonable based on the fact that there was no experimental group that received eight therapy sessions and no pill.

Incorrect (I) if the response provides an answer with an incorrect or no justification.

- (c) A newspaper article that summarized the results of this study did not explain how it was determined which people received D-cycloserine and which received the placebo. Suppose the researchers allowed the therapists to choose which people received D-cycloserine and which received the placebo, and no randomization was used. Explain why such a method of assignment might lead to an incorrect conclusion.

Part (c):

One example is that if the therapists were allowed to choose who received the placebo and who received D-cycloserine, they might assign the people with more severe acrophobia to one of the groups and the people with less severe acrophobia to the other group. Thus, the improvement after only two therapy sessions could be related to the initial severity of the acrophobia rather than to the effects of D-cycloserine.

Part (c) is scored as follows:

Essentially correct (E) if the response indicates that this method of assignment might create experimental groups that differ in some systematic way other than the treatment *AND* provides a justification that describes the potential confounding,

OR

if the response indicates that if the therapists know who was in which group, it may influence the therapists' behavior when dealing with or evaluating the people with acrophobia.

Partially correct (P) for any of the following:

- The response indicates that the assignment might create experimental groups that differ in some systematic way, *BUT* does not provide an explanation of the potential confounding.
- The response makes a general statement that the lack of random assignment could lead to confounding *BUT* does not provide an example in context.
- The response indicates that the therapists know who is in which group *BUT* does not give a reason as to why this might lead to a misleading conclusion.
- The response makes a general statement that failure to blind may lead to bias *BUT* does not provide an example in context.

Incorrect (I) if the response fails to meet the criteria for E or P.

Note: If the response discusses incorrect conclusions that might result from having the *people with acrophobia* (rather than the *therapists*) choose their own treatments, the response is scored as I, because such a response does not address the question asked.

4 Complete Response

All three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

2 Developing Response

Two parts essentially correct and one part incorrect

OR

One part essentially correct and one or two parts partially correct.

1 Minimal Response

One part essentially correct and two parts incorrect

OR

One or two parts partially correct and one part incorrect

2014 #4

As part of its twenty-fifth reunion celebration, the class of 1988 (students who graduated in 1988) at a state university held a reception on campus. In an informal survey, the director of alumni development asked 50 of the attendees about their incomes. The director computed the mean income of the 50 attendees to be \$189,952. In a news release, the director announced, "The members of our class of 1988 enjoyed a mean income of \$189,952 last year. Last year's mean income of its members was \$189,952!"

(a) What would be a statistical advantage of using the median of the incomes of the attendees as the estimate of the typical income?

(b) The director felt the members who responded to the survey were not representative of the class as a whole. A more detailed survey of the members of the class was planned. The director wanted to know more facts about the ability of the members of the class to respond to a survey.

Intent of Question

The primary goals of this question were to assess a student's ability to (1) describe why the median might be preferred to the mean in a particular context; (2) compare the relative merits of two sampling plans; and (3) describe a consequence of nonresponse in a particular study.

Members of the class asking them to complete an online form. At least 600 members will respond.

A random sample of members of the class and contact the selected members by phone. Follow up to ensure that all responses are obtained. Because method 2 will require more time than method 1, the staff estimates that only 100 members of the class could be contacted using method 2.

Which of the two methods would you select for estimating the average yearly income of all 6,826 members of the class of 1988? Explain your reasoning by comparing the two methods and the effect of each method on the estimate.

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- (a) What would be a statistical advantage of using the median of the reported incomes, rather than the mean, as the estimate of the typical income?

Part (a):

The median is less affected by skewness and outliers than the mean. With a variable such as income, a small number of very large incomes could dramatically increase the mean but not the median. Therefore, the median would provide a better estimate of a typical income value.

Section 1 is scored as follows:

Essentially correct (E) if the response includes the following two components:

1. Describes how skewness or outliers affect the mean or do not affect the median.
2. Makes a conjecture about a relevant characteristic of the distribution of incomes, such as skewness or an outlier.

Partially correct (P) if the response includes only one of the two components listed above.

Incorrect (I) if the response does not meet the criteria for E or P.

Notes:

- For Component 1, examples of responses that are acceptable include:
 - The mean is affected by skewness (outliers).
 - The median is not affected by skewness (outliers).
 - The mean is greater (less) than the median when there is right (left) skewness or outliers.
- For Component 1, examples of responses that are not acceptable include:
 - Don’t use the mean for skewed distributions or distributions with outliers.
 - Use the median for skewed distributions or distributions with outliers.
 - Responses that include an incorrect statement about means and/or medians, such as for right skewed distributions, the median will be higher than the mean.
- It is possible to satisfy *both* components with a single sentence, such as, “If there was a billionaire in the sample, the mean would be higher than the median.”
- If a response argues that using the *mean* is a more appropriate way to estimate the typical income, then reduce the score in section 1 by one level (that is, from E to P or from P to I).

(b) The director felt the members who attended the reception may be different from the class as a whole. A more detailed survey of the class was planned to find a better estimate of the income as well as other facts about the survey.

Method

Method

Which of the conditions is most likely to be met on the estimate.

Notes:

- Responses that do not explicitly choose Method 2 can still earn an E for section 2 if the choice is clearly implied. The choice of Method 2 is clearly implied if the response only discusses negative characteristics of Method 1 and only discusses positive characteristics of Method 2, such as, Method 1 is biased but Method 2 uses a random sample.
- Responses that *compare* the two methods can satisfy *both* components, such as, saying that Method 1 is more biased or that nonresponse will be less of a problem with Method 2.
- Responses that refer to the nonresponse bias as *voluntary response bias*, *response bias*, *undercoverage* can still earn an E.
- Discussions of conditions for inference should be considered extraneous and ignored.

Part (b):

Method 2 is better than Method 1. A sample obtained from Method 1 could be biased because of the voluntary nature of the response. It is plausible that class members with larger incomes might be more likely to return the form than class members with smaller incomes. The mean income for such a sample would overestimate the mean income of all class members. With Method 2, despite the smaller sample size, the random selection is likely to result in a sample that is more representative of the entire class and produce an unbiased estimate of mean yearly income of all class members.

Section 2 is scored as follows:

Essentially correct (E) if the response chooses Method 2 *AND* includes the following two components:

1. Identifies a relevant characteristic of Method 1.
2. Identifies a relevant characteristic of Method 2.

Partially correct (P) if the response chooses Method 2 *AND* includes only one of the two components listed above

OR

if the response includes both components but does not choose a method.

Incorrect (I) if the response chooses Method 1 *OR* otherwise does not meet the criteria for E or P.

(b) The director felt the members who attended the reception may be different from the class as a whole.

A more detailed survey. facts about the survey.

Method 1: Send The

Method 2: Sele direct requ cont

Which of the tw of the class of 1 on the estimate.

Notes:

- A single sentence can satisfy the first component of section 2 and the first component of section 3. (For example, "In method 1, rich people are more likely to respond.")
- For component 2, either direction is acceptable but the direction must be consistent with the identified bias. Saying only that Method 2 will be more accurate or more representative does not satisfy component 2.
- If a response addresses possible nonresponse bias in Method 2, the response can still satisfy both components of section 3.
- Responses that focus on the larger sample size in Method 1 can satisfy component 2 if such responses describe the effect as reducing the variability of the estimate. (For example, "I would use Method 1 since the larger sample size would give less variability of the mean.")
- Responses that focus on untruthful survey answers can satisfy component 2 if the effect on the estimate is appropriate. (For example, "People contacted in Method 2 might say they make more money than they actually do. This would make the estimated mean too high.")

Part (b):

Method 2 is better than Method 1. A sample obtained from Method 1 could be biased because of the voluntary nature of the response. It is plausible that class members with larger incomes might be more likely to return the form than class members with smaller incomes. The mean income for such a sample would overestimate the mean income of all class members. With Method 2, despite the smaller sample size, the random selection is likely to result in a sample that is more representative of the entire class and produce an unbiased estimate of mean yearly income of all class members.

Section 3 is scored as follows:

Essentially correct (E) if the response includes the following two components:

1. Indicates the incomes of responders may be different from the incomes of nonresponders.
2. Indicates the biased sampling method may produce a misleading estimate/conclusion about the mean income, including direction, for example, "The sample mean is likely to be higher than the mean of the population."

Partially correct (P) if the response provides only one of the two components listed above.

Incorrect (I) if the response does not meet the criteria for E or P.

4 Complete Response

All three sections essentially correct

3 Substantial Response

Two sections essentially correct and one section partially correct

2 Developing Response

Two sections essentially correct and one section incorrect

OR

One section essentially correct and one or two sections partially correct

OR

Three sections partially correct

1 Minimal Response

One section essentially correct and two sections incorrect

OR

Two sections partially correct and one section incorrect

2. As dogs age, diminished joint and hip health may lead to joint pain and thus reduce a dog's activity level. Such a reduction in activity can lead to other health concerns such as weight gain and lethargy due to lack of exercise. A study is to be conducted to see which of two dietary supplements, glucosamine or chondroitin, is more effective in promoting joint and hip health and reducing the onset of canine osteoarthritis. The researchers will randomly select a total of 300 dogs from ten different large veterinary practices. All dogs are more than 6 years old, and their owners have given their consent. The joint and hip health will be evaluated after 6 months of treatment.

- (a) What would be an advantage to using a control group?
- (b) Assuming a completely randomized design, one group of researchers proposes blocking on clinics, another group proposes blocking on breed of dog. How would you decide which one of the two designs is a blocking variable? Explain how you would assign the 300 dogs to the three groups.

Intent of Question

The three primary goals of this question are to assess a student's ability to: (1) clearly explain the importance of a control group in the context of an experiment; (2) describe the randomization process required for three groups; and (3) reduce variability by grouping experimental units as homogeneously as possible.

2. As dogs age, diminished joint and hip health may lead to joint pain and thus reduce a dog's activity level. Such a reduction in activity can lead to other health concerns such as weight gain and lethargy due to lack of exercise. A study is to be conducted to see which of two dietary supplements, glucosamine or chondroitin, is more effective in promoting joint and hip health and reducing the onset of canine osteoarthritis. Researchers will randomly select a total of 300 dogs from ten different large veterinary practices around the country. All of the dogs are more than 6 years old, and their owners have given consent to participate in the study. Changes in joint and hip health will be evaluated after 6 months of treatment.

(a) What would be an advantage to adding a control group in the design of this study?

Solution

Part (a):

A control group gives the researchers a comparison group to be used to evaluate the effectiveness of the treatments. The control group allows the impact of the normal aging process on joint and hip health to be measured with appropriate response variables. The effects of glucosamine and chondroitin can be assessed by comparing the responses for these two treatment groups with those for the control group.

Part (a) is scored as essentially correct (E) if an advantage of using a comparison group is described in the context of this study.

Part (a) is scored as partially correct (P) if an advantage of using a control group is described but not in the context of this study.

Part (a) is scored as incorrect (I) if the student says that control groups should always be used but gives no further explanation *OR* an incorrect explanation.

- (b) Assuming a control group is added to the other two groups in the study, explain how you would assign the 300 dogs to these three groups for a completely randomized design.

Part (b):

Each dog will be assigned a unique random number, 001–300, using a random number generator on a calculator, statistical software, or a random number table. The numbers will be sorted from smallest to largest. The dogs assigned the first 100 numbers in the ordered list will receive glucosamine. The dogs with the next 100 numbers in the ordered list will be assigned to the control group. Finally, the dogs with the numbers 201–300 will receive chondroitin.

Part (b) is scored as essentially correct (E) if randomization is used correctly, and the method of randomization can be implemented after reading the student response (so that two knowledgeable statistics users would use the same method to assign dogs to treatment groups).

Part (b) is scored as partially correct (P) if randomization or chance is used, but the method could not be implemented after reading the student response.

Part (b) is scored as incorrect (I) if randomization or chance is not used in a planned way *OR* the solution does not yield a completely randomized design.

(c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics, and another group of researchers proposes blocking on breed of dog. How would you decide which one of these two variables to use as a blocking variable?

Part (c):

The key question is which variable has the strongest association with joint and hip health. The goal of blocking is to create groups of homogeneous experimental units. It is reasonable to assume that most clinics will see all kinds and breeds of dogs so there is no reason to suspect that joint and hip health will be strongly associated with a clinic. On the other hand, different breeds of dogs tend to come in different sizes. The size of a dog is associated with joint and hip health, so it would be better to form homogeneous groups of dogs by blocking on breed.

Part (c) is scored as essentially correct (E) if:

the student argues that the variable with the stronger relationship to joint and hip health should be used as the blocking variable;

OR

the student states that the variable with the larger anticipated variability in the response measure should be used as the blocking variable so that units within blocks are as homogeneous as possible. A rationale is required, but a variable does not have to be selected.

Part (c) is scored as partially correct (P) if:

the student indicates that the purpose of blocking is to create groups of homogeneous experimental units but makes an error in the application to this experiment;

OR

the student does not acknowledge that there may be more variability associated in the response variable with one of the variables (breed or clinic) than the other;

OR

the student does not recognize that both variables are associated with variation in the response variable.

Part (c) is scored as incorrect (I) if the student does not exhibit an understanding of the purpose of blocking.

4 Complete Response

All three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

2 Developing Response

Two parts essentially correct and no parts partially correct

OR

One part essentially correct and two parts partially correct

OR

Three parts partially correct

1 Minimal Response

One part essentially correct and either zero or one part partially correct

OR

No parts essentially correct and two parts partially correct