Introduction to Experimental Design Quiz

1. A researcher wanted to study the effects of a certain chemical on cell growth. The chemical was to be applied at two different doses, high and low, to two different cell types, strain A and strain B. Each combination of dose and cell type was to be replicated ten times. To have consistency from one replicate to the next, the researcher decided to use four lab technicians. One technician would be assigned the high dose with strain A. A second would be assigned the low dose with strain A. A third would be assigned the high dose with strain B. A fourth would be assigned the low dose with strain B. The assignment of lab technician to the replicates for a combination of dose and cell type would be randomized. A statistician told the researcher that the design could be improved by controlling confounding variables. Which of the following is potentially a confounding variable in this study?

(A) Chemical used

(B) Lab technician ✓

(C) Dose

(D) Cell type

(E) Cell growth

Answer B

Correct. The different lab technicians may apply the chemical differently, thus affecting the response. One cannot determine whether the combination of the dose and cell type or the lab technician is affecting the response.

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2. Show all your work. Indicate clearly the methods you use, because you will be scored on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

To prevent deer from running across highways, researchers are investigating sound-emitting devices that would frighten deer before they reach the highway. As part of the investigation, the researchers set up 20 devices along a two-mile stretch of road. When a deer approached a device, the device would activate and emit a sound. The researchers recorded whether the deer moved toward the highway (positive response), away from the highway (negative response), or did not move (neutral response).

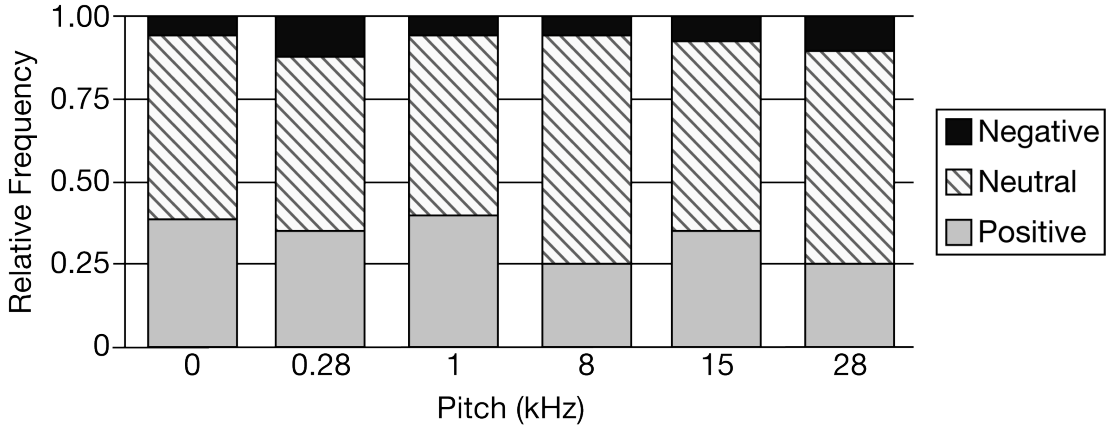
The researchers kept the loudness of the sound constant at 60 decibels. However, they varied the pitch of the sound. There were 6 treatment levels, all measured in kilohertz (kHz): 0, 0.28, 1, 8, 15, and 28. The order of the treatments was randomly assigned.

(a) The control in the experiment was 0 kHz, or no sound. What information is gained by using the control with no sound that could not be obtained if no control were used?

(b)(i) What is one advantage to keeping the loudness at a constant 60 decibels for all treatments?

(b)(ii) What is one disadvantage to keeping the loudness at a constant 60 decibels for all treatments?

(c) The results of the experiment are shown in the following bar chart.



Based on the results, would you recommend using a sound-emitting device to keep deer from running across highways? Explain your answer.

Part A, B, and C

The primary goals of this question are to assess a student's ability to (1) explain the use of a control group in an experiment; (2) identify a confounding variable within an experiment; (3) generalize results of an experiment to an appropriate condition; and (4) use a graphical display to provide evidence for a decision.

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Scoring

Parts (a), (b), and (c) are each scored as essentially correct (E), partially correct (P), or incorrect (I).

0	1	2	3	4 ✓

All three parts essentially correct

- [ ] Part (a) essentially correct
- [ ] Part (a) partially correct
- [ ] Part (a) incorrect
- [ ] Part (b) essentially correct
- [ ] Part (b) partially correct
- [ ] Part (b) incorrect
- [ ] Part (c) essentially correct
- [ ] Part (c) partially correct
- [ ] Part (c) incorrect

Solution

Part (a):

If no control group were used, the different frequencies could be compared, but it could not be known whether they were better than no sound at all. A control group allows the researchers to evaluate the effectiveness of the different pitches compared to a pitch of 0 kilohertz.

Scoring

Part (a) is scored as follows.

Essentially correct (E) if the response indicates that a control group allows researchers to evaluate the effectiveness of treatments AND describes the effectiveness in the context of the study

Partially correct (P) if the response indicates that a control group allows researchers to evaluate the effectiveness of treatments BUT not in the context of the study

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

Solution

Part (b-i):

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If the devices had different levels of loudness, the loudness would be a confounding variable. The advantage to keeping the loudness constant is that the effect of deer movement can be attributed to pitch.

Part (b-ii):

By using the same level of loudness, the results may not generalize beyond 60 decibels.In other words, a conclusion regarding the effectiveness of the devices cannot be extended beyond 60 decibels.

Scoring

Part (b) is scored as follows.

Essentially correct (E) if the response satisfies the following three components:

· In part (b-i), confounding is identified as a problem with using multiple noise levels.

· In part (b-ii), the lack of generalization beyond 60 decibels is mentioned.

· Context is used in at least one description.

Partially correct (P) if the response satisfies only 2 of the three components

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

Solution

Part (c):

There does not appear to be much difference within the different audible frequencies or between the control group and the audible frequencies. The lack of different distributions of the response between the control group and the audible frequencies suggests that the sound-emitting devices are not effective at frightening the deer away from the highway.

Scoring

Part (c) is scored as follows.

Essentially correct (E) if the display is correctly described and the conclusion justified

Partially correct (P) if the conclusion is not correct, but the reasoning follows consistently from the description of the graph; for example, “There are more positive responses than negative responses, which is a net gain.”

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

3. Mr. Ikeler conducted a study investigating the effectiveness of a new method for teaching a mathematics unit. He recruited 80 students at a college and randomly assigned them to two groups. Group 1 was taught with the new method, and group 2 was taught with the traditional method. Both groups were taught by the same teacher. At the end of the unit, an achievement test was administered and used to make a comparison of the two groups. What is the response variable in the study?

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(A) The new teaching method
(B) The traditional teaching method
(C) The teacher in the study
(D) The score on the achievement test ✓
(E) The 80 students

Answer D

Correct. The score on the test is the outcome measured after treatments have been applied.

4. Researchers are investigating the effect of pH level in water on the breeding habits of the moon jellyfish. As part of a laboratory experiment, they will randomly assign one of three treatments, low pH, medium pH, or high pH, to the water in the tanks that hold the jellyfish.

Which of the following is the best reason for the random assignment of a treatment level to an experimental unit?

(A) Randomization tends to minimize the effects of uncontrolled variables, such as water temperature, so that such factors are not confounded with the treatment effects. ✓
(B) Randomization will make up for improper experimental design, data collection, and analysis.
(C) Randomization makes the analysis easier since the data can be entered into the computer in any order.
(D) Randomization is required by statistical consultants before they will analyze the experiment.
(E) Randomization means that the experiment would not need to be replicated.

Answer A

Correct. Random assignment tends to balance the effects of uncontrolled (confounding) variables so that differences can be attributed to the treatments.

5. A local employer asked for help selecting a new type of desk chair. Thirty employees volunteered, and each employee used the new desk chair for two weeks and the current desk chair for two weeks. To determine which chair was used first, a coin was flipped for each employee. Heads represented using the new chair first, and tails represented using the current chair first. At the end of each two-week period, the employees were asked to rate their satisfaction with the new chair. Which of the following best describes this study?

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(A) It is not a well-designed experiment because employees were allowed to volunteer instead of being randomly selected.

(B) It is not a well-designed experiment because only one new chair was used. At least two new treatments must be used.

(C) It is not a well-designed experiment because each employee was assigned both treatments, and each employee should be assigned only one.

(D) It is not a well-designed experiment because using a coin flip does not guarantee that fifteen employees will use each chair first.

(E) It is a well-designed experiment because there is random assignment, replication, and comparison of at least two treatment groups. ✓

Answer E

Correct. Random assignment, replication, and the ability to compare at least two treatment groups are all criteria for a well-designed experiment.

6. An experiment will be conducted in which 20 pepper plants are randomly assigned to two groups. The plants in Group 1 will receive the current fertilizer, Fertilizer A, and the plants in Group 2 will receive a new fertilizer, Fertilizer B. All other growing conditions, including amount of sunlight and water, will be kept the same for the two groups. The growth of the pepper plants will be compared for the two groups. What are the experimental units in this experiment?

(A) The two types of fertilizer

(B) The sunlight and amount of water

(C) The 10 plants in Group 1

(D) The 10 plants in Group 2

(E) The 20 plants in the two groups ✓

Answer E

Correct. The 20 plants are the units to which the treatments, Fertilizer A or Fertilizer B, are applied.

7. Eighteen individuals who use a particular form of social media were assigned a new user interface to use when logging in to their accounts. After using the new user interface for a week, each individual was asked to rate how easy or hard the new user interface was to use on a scale from 1 (extremely easy) to 9 (extremely hard). Which of the following correctly identifies why this is not a well-designed experiment?

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(A) There was a lack of control because not all individuals in the study used login passwords of the same length.

(B) The individuals may not have been randomly selected.

(C) There was not enough replication because the individuals used the new user interface for only one week.

(D) There was a lack of control because not all individuals in the study use social media.

(E) The study was not comparative—only one treatment was used. ✓

Answer E

Correct. Well-designed experiments should involve comparisons of at least two treatment groups, one of which could be a control group.