

AP[®] STATISTICS
2009 SCORING GUIDELINES (Form B)

Question 4

Intent of Question

The primary goals of this question were to assess students' ability to (1) describe assignment of experimental units to treatments in a block design and (2) provide ways to increase the power of an experiment.

Solution

Part (a):

Form three blocks based on the species of bird (blackbirds, starlings, and geese) to accomplish the goal of blocking to create groups of homogeneous experimental units. Within each of the three blocks, carry out a completely randomized design by randomly assigning the birds within each block to one of the two treatments. Within block 1, each bird of a particular species (let's say the blackbirds) will be tagged with a unique random number using a random number generator on a calculator, statistical software, or a random number table. The random numbers will be sorted from lowest to highest. The birds with the lowest 50 numbers in the ordered list will receive treatment 1 (red background with narrow blue stripes). The birds with the highest 50 numbers will receive treatment 2 (blue background with narrow red stripes). This method of randomization should be repeated in the other two blocks.

Part (b):

To increase power (other than by blocking), the researcher could increase the sample size. This reduces the standard error of the sampling distribution. With a smaller standard error, a test is more likely to be able to detect a difference in results from the two treatments, if such a difference exists.

Scoring

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

Part (a) is scored as follows:

Essentially correct (E) if the student describes a method for randomization that (1) randomly assigns the two treatments to the birds within each of the three blocks and (2) describes the method with sufficient detail so that a knowledgeable statistics user could replicate the method.

Partially correct (P) if the student describes a method for randomization within blocks but does not provide sufficient detail so that a knowledgeable statistics user could replicate the method *OR* the method of randomization does not guarantee sufficient randomization.

Incorrect (I) if there is no randomization or if the randomization is not done within blocks.

Note: The sample sizes within the treatment groups are not required to be equal.

AP[®] STATISTICS
2009 SCORING GUIDELINES (Form B)

Question 4 (continued)

Part (b) is scored as follows:

Essentially correct (E) if the student identifies a correct method for increasing power *AND* links the method to the mechanism for increasing power.

Partially correct (P) if the student identifies a correct method for increasing power but fails to link the method to the mechanism for increasing power.

Incorrect (I) if the student does not identify a correct method for increasing power.

Note: Another correct method for increasing power is to increase the significance level, α . By increasing α , the researcher makes it easier to reject a false null hypothesis, which increases the power of the test.

4 Complete Response

Both parts essentially correct

3 Substantial Response

One part essentially correct and one part partially correct

2 Developing Response

One part essentially correct and one part incorrect

OR

Both parts partially correct

1 Minimal Response

One part partially correct and one part incorrect

4. A manufacturer of toxic pesticide granules plans to use a dye to color the pesticide so that birds will avoid eating it. A series of experiments will be designed to find colors or patterns that three bird species (blackbirds, starlings, and geese) will avoid eating. Representative samples of birds will be captured to use in the experiments, and the response variable will be the amount of time a hungry bird will avoid eating food of a particular color or pattern.

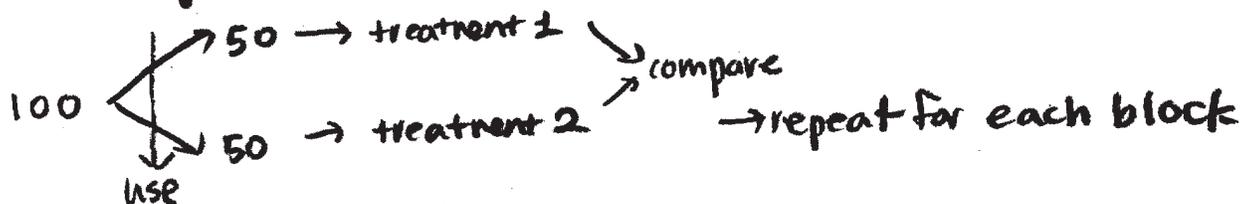
- (a) Previous research has shown that male birds do not avoid solid colors. However, it is possible that males might avoid colors displayed in a pattern, such as stripes. In an effort to prevent males from eating the pesticide, the following two treatments are applied to the pesticide granules.

Treatment 1: A red background with narrow blue stripes

Treatment 2: A blue background with narrow red stripes

To increase the power of detecting a difference in the two treatments in the analysis of the experiment, the researcher decided to block on the three species of birds (blackbirds, starlings, and geese). Assuming there are 100 birds of each of the three species, explain how you would assign birds to treatments in such a block design.

in each block, number the birds from 00 ~ 99. Using a random number table, read off numbers in two digits to obtain 50 numbers. Birds with numbers corresponding to these numbers will be receiving treatment 1. The remaining 50 will be receiving treatment 2



use random # table to randomly assign birds to treatment

- (b) Other than blocking, what could the researcher do to increase the power of detecting a difference in the two treatments in the analysis of the experiment? Explain how your approach would increase the power.

Instead of blocking, the researcher can measure the difference between the time the bird will avoid food with treatment 1 and that with treatment 2 for each individual bird. This will increase the power of detecting a difference in the two treatments because it controls the individual characteristics of individual birds (size, appetite) that may influence the outcome. In other words, this method can control confounding variables.

GO ON TO THE NEXT PAGE.

4. A manufacturer of toxic pesticide granules plans to use a dye to color the pesticide so that birds will avoid eating it. A series of experiments will be designed to find colors or patterns that three bird species (blackbirds, starlings, and geese) will avoid eating. Representative samples of birds will be captured to use in the experiments, and the response variable will be the amount of time a hungry bird will avoid eating food of a particular color or pattern.

- (a) Previous research has shown that male birds do not avoid solid colors. However, it is possible that males might avoid colors displayed in a pattern, such as stripes. In an effort to prevent males from eating the pesticide, the following two treatments are applied to the pesticide granules.

Treatment 1: A red background with narrow blue stripes

Treatment 2: A blue background with narrow red stripes

To increase the power of detecting a difference in the two treatments in the analysis of the experiment, the researcher decided to block on the three species of birds (blackbirds, starlings, and geese). Assuming there are 100 birds of each of the three species, explain how you would assign birds to treatments in such a block design.

For each 100 birds in each block, assign numbers from 1-100.

Then, flip a coin

- if heads, ~~odd~~ birds with odd numbers get treatment 1.
- if tails, birds with even numbers get treatment 2.

Thus, we can ^{randomly} assign 50 birds of each species for treatment 1 and treatment 2.

- (b) Other than blocking, what could the researcher do to increase the power of detecting a difference in the two treatments in the analysis of the experiment? Explain how your approach would increase the power.

To increase the power, we can increase the significance level. This way, the probability of type 2 error (β ; accepting an incorrect null hypothesis) will decrease. Since the power is defined $1-\beta$, and with a decrease in β , the power will increase.

GO ON TO THE NEXT PAGE.

4. A manufacturer of toxic pesticide granules plans to use a dye to color the pesticide so that birds will avoid eating it. A series of experiments will be designed to find colors or patterns that three bird species (blackbirds, starlings, and geese) will avoid eating. Representative samples of birds will be captured to use in the experiments, and the response variable will be the amount of time a hungry bird will avoid eating food of a particular color or pattern.

(a) Previous research has shown that male birds do not avoid solid colors. However, it is possible that males might avoid colors displayed in a pattern, such as stripes. In an effort to prevent males from eating the pesticide, the following two treatments are applied to the pesticide granules.

Treatment 1: A red background with narrow blue stripes

Treatment 2: A blue background with narrow red stripes

To increase the power of detecting a difference in the two treatments in the analysis of the experiment, the researcher decided to block on the three species of birds (blackbirds, starlings, and geese). Assuming there are 100 birds of each of the three species, explain how you would assign birds to treatments in such a block design.

Starting with black birds only, Every black bird would receive a number 0-99. Using a random number generator the bird "0" would get a 0 or 1. 0 would represent treatment 1 and 1 would be treatment 2. Until each treatment has 50 birds. Starling birds would repeat this pattern. Numbering the birds 0-99 and assigning 50 birds to each group. Then repeat with geese. Each treatment would have the same # of each bird.

(b) Other than blocking, what could the researcher do to increase the power of detecting a difference in the two treatments in the analysis of the experiment? Explain how your approach would increase the power.

Increasing the sample size would increase the power. Increasing the sample would decrease the variability of this experiment. Increase the sample of each bird group and even more types of birds to increase the sample size to decrease variability

GO ON TO THE NEXT PAGE.

AP[®] STATISTICS
2009 SCORING COMMENTARY (Form B)

Question 4

Sample: 4A

Score: 4

In part (a) of this response a random assignment, done within each block, of the two treatments to the birds is described with adequate detail so that another person could use exactly the same method. Furthermore, this method results in an equal number of birds in each treatment group, which is optimal but not required. Thus part (a) was scored as essentially correct. Part (b) is an example of how an unanticipated response can be scored as essentially correct. The expected methods of increasing power were to increase the sample size within each block or to increase the level of significance. This student suggests a repeated measures design, within each block, and describes how that could be done. There is no evidence that this is a type of blocking, but the exam's instruction "[o]ther than blocking" could reasonably be read as "[o]ther than the blocking described." More seriously, there is no mention that the order of the treatments should be randomized. This good idea, nevertheless, was scored as essentially correct for part (b). Because parts (a) and (b) were both essentially correct, this complete response received a score of 4.

Sample: 4B

Score: 3

In part (a) this response makes an attempt to randomly assign, within each block, the two treatments to the birds. However, the method does not work. First, unless the numbers are assigned randomly to the birds, there may be systematic differences in the birds that get odd and even numbers (if they were lined up in male–female pairs, for example). Second, whether the coin toss is heads or tails, birds with odd numbers get treatment 1 and birds with even numbers get treatment 2. Thus, part (a) was scored as partially correct. Part (b) was scored as essentially correct. If the level of significance, α , is increased, it does increase the power of the test (but this method should not be used in practice). The reason is correct, that someone is less likely to fail to reject a false null hypothesis and the probability of a Type II error decreases. The language "accepting an incorrect null hypothesis" should instead be "failing to reject an incorrect null hypothesis." Because part (a) was partially correct and part (b) was essentially correct, this substantial response received a score of 3.

Sample: 4C

Score: 2

In part (a) of this response the student attempts to randomly assign, within each block, the two treatments to the birds. Furthermore, this method results in an equal number of birds in each treatment group. Yet again, the method does not adequately randomize the treatments to the birds within each block because, using this procedure, the last few birds to be assigned in each block are almost certain to be in the same treatment group. Thus part (a) was scored as partially correct. In part (b) the method of increasing power by increasing the sample size is correct, as is the statement that this will decrease variability. However, part (b) also was scored as partially correct because it is not clear which variability is meant and a final link of how decreasing variability increases power is missing. Because part (a) was partially correct and part (b) was partially correct, this developing response received a score of 2.