Third annual

Improving Performance on the AP Statistics Exam

Cleveland Chapter of the American Statistical Association

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Sampling and Experimentation

A. Overview of methods of data collection
   1. Census
   2. Sample survey
   3. Experiment
   4. Observational study

B. Planning and conducting surveys
   1. Characteristics of a well-designed and well-conducted survey
   2. Populations, samples and random selection
   3. Sources of bias in sampling and surveys
   4. Sampling methods, including simple random sampling, stratified random sampling and cluster sampling

C. Planning and conducting experiments
   1. Characteristics of a well-designed and well-conducted experiment
   2. Treatments, control groups, experimental units, random assignments and replication
   3. Sources of bias and confounding, including placebo effect and blinding
   4. Completely randomized design
   5. Randomized block design, including matched pairs design

D. Generalizability of results and types of conclusions that can be drawn from observational studies, experiments and surveys

Development Committee view

+ Every word matters. Read carefully.

+ Basic problems --> not much guidance

+ Challenging problems --> more guidance

+ Less compartmentalizing of topics than in past

+ Comprehensive with respect to the syllabus
The Chapped Lips Treatment Study

+ Three treatment groups:
  1 = Stick, 2 = Liquid, and 3 = Control

+ Subjects could choose to not be in the Control group.

+ Dependent variable (outcome, response) is Expert Grader Assessment.
Sampling Error

Sampling error represents differences between the value of an estimator and the parameter it estimates that are due to chance.

Q1: What is your favorite estimator?

Q2: What parameter does it estimate?
Sampling Error (continued)

Q3: Can you quantify the sampling error for your favorite estimator?

Q4: What assurances do have that your estimate of the sampling error is correct?
Bias

Bias represents a difference between the value of an estimator and the parameter that is systematic.

Q: Subjects in the Chapped Lips Study could choose to not be in the control group. Describe a potential bias that might be introduced.
Representing Sampling Error and Bias

The “darts” are estimators, not individual data values!

+ Bias = lack of accuracy
+ Sampling error = lack of precision

Q: Where is the parameter in these images?

Strategies for minimizing Sampling Error

+ Replication
+ Balance
+ Blocking

Q: How might these strategies have been incorporated into the Chapped Lips Study?
Blocking

+ A **blocking variable** groups together experimental units that have **similar** properties.

+ Blocking variables account for variation, but they are not of primary importance in a study.
Blocking example

A new laser treatment for acne is being tested.

**Study 1**: Two independent groups of faces, control and treatment

**Study 2**: Block by face

+ There is likely to be less variability in measurements taken within faces than between faces, which helps to reduce the sampling error of estimates and to clarify the treatment effect.
Blocking example (continued)

Key idea:
   Blocking of similar experimental units helps to reduce sampling error.

Q: What are the “similar experimental units” in the laser treatment for acne example?
Strategies for reducing bias

+ Simultaneous control group
+ Randomization
+ Blinding

Q: How might these strategies have been incorporated into the Chapped Lips Study?
Blinding

Blinding means that either the subjects, or the evaluator, or both are not able to determine which treatments were applied to which subjects.

Q: Do you believe that the blindness was present in the Chapped Lips Study with respect to Expert Grader Assessment?
Types of questions

“Why can’t you ... ?”

Example:

Explain why you can’t use a placebo in the Chapped Lips study.

+ What is a placebo?
+ Why can’t you use one in this study?
Types of questions

“How would you randomly select ...?”

Suggestions
+ List required
+ Associate ID numbers with the units
+ Each unit should be equally likely
+ Mix physical objects, if appropriate
+ If using a table, include zeroes; don’t repeat
+ Select units, not just random numbers
Types of questions

“Why not?”

Example:

Why is it impossible for the subjects in the Chapped Lips study to represent a random sample?

Q: What specific required elements necessary to take a random sample are missing?
Types of questions

“How might you detect ...?”

Example:

How might you detect the potential bias in letting subjects choose to be in the Chapped Lips Study control group?
Types of questions

How might you detect ...?

Bias?
Or no bias?

![Chart showing expert grader at baseline for different groups.](image)
Types of questions

“How would you randomly assign ...?”

Suggestions

+ Make each treatment equally likely
+ Ensure balance
+ Assign ID numbers to the units; assign units
+ Mix physical objects, if appropriate
+ If using a table, include zeroes; don’t repeat
+ Specify how the assignment will end
+ Illustrate with the first few assignments
Confounding

Confounding occurs when the effects of two variables cannot be distinguished.

Example:

In the Chapped Lips Study, suppose that only females were assigned to the Stick and Liquid groups, and that only males were assigned to the Control group.

Q1: Which two variables are confounded?

Q2: What are the consequences of this confounding in the context of the Chapped Lips Study?
Sample Free Response Question

2013 AP® STATISTICS FREE-RESPONSE QUESTIONS

2. An administrator at a large university wants to conduct a survey to estimate the proportion of students who are satisfied with the appearance of the university buildings and grounds. The administrator is considering three methods of obtaining a sample of 500 students from the 70,000 students at the university.

(a) Because of financial constraints, the first method the administrator is considering consists of taking a convenience sample to keep the expenses low. A very large number of students will attend the first football game of the season, and the first 500 students who enter the football stadium could be used as a sample. Why might such a sampling method be biased in producing an estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds?

(b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

(c) Because stratification can often provide a more precise estimate than a simple random sample, the third method the administrator is considering consists of selecting a stratified random sample of 500 students. The university has two campuses with male and female students at each campus. Under what circumstance(s) would stratification by campus provide a more precise estimate of the proportion of students who are satisfied with the appearance of the university buildings and grounds than stratification by gender?

Sample Free Response Question

**Solution**

**Part (a):**

The first 500 students who enter the football stadium were not likely to be representative of the population of all students at the university. In other words, these 500 students were likely to differ systematically from the population with regard to many variables. For example, these 500 students might have more school pride than the population of students as a whole, which might be related to their opinions about the appearance of university buildings and grounds. Perhaps their school pride is related to having more positive opinions about the appearance of university buildings and grounds, in which case the sample proportion of students who were satisfied would be biased toward overestimating the population proportion of students who were satisfied.

**Part (b):**

Obtain a list of all 70,000 students at the university. Assign an identification number from 1 to 70,000 to each student.

Then use a computer to generate 500 random integers between 1 and 70,000 without replacement. The students whose ID numbers correspond to those numbers were then selected for the sample.

**Part (c):**

Stratifying by campus would be more advantageous than stratifying by gender provided that opinions about appearance of university buildings and grounds between the two campuses differ more than the opinions about appearance of university buildings and grounds between the two genders.

Thank you!

Any questions?

Good luck on the AP Statistics exam!!

The slides from this presentation are available at:
http://www.jcu.edu/math/faculty/TShort/apreview2015.html