CE5033 Statistical Methods and Data Mining

20240409 Exercise

1. The “alternative hypothesis” in a hypothesis testing framework is:
   (A) A statement that the effect observed in the sample data is due to chance.
   (B) The hypothesis that there exists no difference or effect.
   (C) The hypothesis that there exists a difference or effect.
   (D) Always framed in terms of statistical significance.

Reason: The alternative hypothesis (H_1) is the statement being tested for statistical evidence, typically proposing a difference or effect, in contrast to the null hypothesis (H_0), which typically proposes no effect or status quo.

2. Which scenario best illustrates a “Type II Error”?
   (A) Concluding that a new diet does not lead to weight loss when it actually does.
   (B) Concluding that a medication is effective when it is not.
   (C) Determining that there is no association between exercise and stress reduction when such an association exists.
   (D) Accepting a research hypothesis based on sample data that does not reflect the true population.

Reason: A Type II error occurs when the null hypothesis is not rejected when it is actually false. In this scenario, failing to identify a true association represents a Type II error.

3. What is the importance of the “significance level” (α) chosen for a hypothesis test?
   (A) It is the threshold below which the p-value indicates a Type II error.
   (B) It represents the probability of observing the data if the null hypothesis is true.
   (C) It is the predetermined threshold of risk for committing a Type I error.
   (D) It defines the power of the test.

Reason: The significance level (α) defines the probability threshold under which the null hypothesis will be rejected, directly relating to the willingness to risk a Type I error—incorrectly rejecting a true null hypothesis.

4. What does a “two-tailed” test in hypothesis testing assess?
   (A) The possibility of an effect in one specific direction.
   (B) The possibility of effects in both directions from a specified value.
   (C) Only negative differences from the hypothesized value.
   (D) Only positive differences from the hypothesized value.

Reason: A two-tailed test assesses the possibility of a relationship in both directions (greater than or less than), unlike a one-tailed test which tests for a relationship in a specified direction.

5. If a researcher fails to reject the null hypothesis based on their statistical analysis, what is the appropriate conclusion?

(A) The null hypothesis is definitively true.

(B) The alternative hypothesis is definitively false.

(C) There was not enough evidence to reject the null hypothesis.

(D) The research must be flawed or invalid.

Reason: Failing to reject the null hypothesis implies that the data did not provide sufficient statistical evidence to conclude that the effect exists at the chosen level of significance.

6. The purpose of calculating effect size along with the p-value in hypothesis testing is to:

(A) Determine if the null hypothesis is true.

(B) Assess the practical significance of the findings.

(C) Increase the power of the test.

(D) Reduce the probability of making a Type I error.

Reason: Effect size helps to understand the magnitude of the observed effect, offering insight into its practical, real-world significance, beyond just statistical significance indicated by the p-value.

7. If the confidence level of an interval estimate is increased from 95% to 99%, what is the impact on the margin of error and why?

(A) The margin of error decreases because the interval is more precise.

(B) The margin of error remains unchanged, as it is not affected by confidence levels.

(C) The margin of error is halved, reflecting the increased confidence.

(D) The margin of error increases to account for the greater degree of uncertainty.

Reason: Increasing the confidence level for an interval estimate broadens the range to capture the true population parameter with higher certainty, which inherently increases the margin of error.

8. A survey collects data on people's preferences among four types of coffee: Latte, Cappuccino, Americano, and Espresso. This data type is:

(A) Nominal (B) Ordinal (C) Interval (D) Ratio

Reason: Preferences among types of coffee are categorized without a natural order or ranking, characteristic of nominal data, which categorizes data without implying any quantitative relationship.

9. How do Type I and Type II errors relate to hypothesis testing?

(A) Type I errors are preferable to Type II errors in medical trials to ensure patient safety.

(B) Type II errors occur when the test statistic falls outside the critical region, whereas Type I errors occur within the critical region.

(C) The significance level (α) is set to control the rate of Type II errors.

(D) A Type I error occurs when a true null hypothesis is incorrectly rejected, while a Type II error occurs when a false null hypothesis is not rejected.

Reason: Type I and Type II errors are fundamental concepts in hypothesis testing, where a Type I error is rejecting a true null hypothesis, and a Type II error is failing to reject a false null hypothesis.

10. How does a paired sample t-test differ from an independent samples t-test?

(A) A paired sample t-test is used for two sets of independent observations, whereas an independent samples t-test is used for related observations.

(B) The independent samples t-test compares means from the same group at different times, while the paired sample t-test compares means from two different groups.

(C) A paired sample t-test compares the means of the same group under two conditions or times, whereas an independent samples t-test compares the means of two different groups.

(D) The paired sample t-test requires the data to be normally distributed, while the independent samples t-test does not.

Reason: The paired sample t-test is used when the data are dependent (paired observations), such as measuring the same subjects at two time points. An independent samples t-test is used for comparing means between two distinct groups.

11. Which statement correctly explains the relationship between the width of a confidence interval and the certainty we have about the population parameter it estimates?

(A) A wider confidence interval indicates a higher level of certainty about the population parameter.

(B) A narrower confidence interval indicates a lower level of certainty about the estimated parameter.

(C) A wider confidence interval reflects less precision in our estimate of the population parameter.

(D) The width of the confidence interval has no bearing on our certainty about the population parameter.

Reason: A wider confidence interval indicates more variability in the data and a less precise estimate of the population parameter, as it suggests a broader range of values within which the true parameter might lie.

12. How does the outcome of a hypothesis test relate to the corresponding confidence interval for the population mean?

(A) If the null hypothesis is rejected, the confidence interval must exclude the value specified under the null hypothesis.

(B) Accepting the null hypothesis implies that the confidence interval will be centered around the null value.

(C) The hypothesis test's p-value determines the width of the confidence interval.

(D) A smaller p-value in hypothesis testing results in a narrower confidence interval.

Reason: Rejecting the null hypothesis often means that the estimated parameter (e.g., the mean difference) is significantly different from the value proposed under the null hypothesis. Consequently, the confidence interval for that parameter will not include the null value.

13. Considering the Central Limit Theorem, which scenario would most likely invalidate its assumptions when estimating a population parameter?

(A) Drawing a large sample size ($n > 30$) from a population with unknown distribution.

(B) Drawing a small sample ($n < 15$) from a normally distributed population.

(C) Using a sampling technique that does not ensure each sample has an equal chance of being selected.

(D) Computing multiple sample means from independent samples drawn from the same population.

Reason: The Central Limit Theorem assumes that each sample is randomly selected with an equal chance of being chosen. A sampling technique that violates this assumption could invalidate the CLT's application.

14. A researcher claims that a new drug has a different effect on blood pressure than the standard treatment. After conducting a two-tailed hypothesis test with a 5% significance level, they obtain a p-value of 0.03. Which action is justified by this result?

(A) Accept the null hypothesis since the p-value is greater than 0.01.

(B) Reject the null hypothesis in favor of the alternative hypothesis that there is a difference.

(C) Conclude that the new drug lowers blood pressure since the p-value is less than 0.05.

(D) Increase the sample size to decrease the p-value further.

Reason: A p-value of 0.03 is less than the significance level of 0.05, indicating sufficient evidence to reject the null hypothesis in favor of the alternative.

15. When a study comparing two weight loss programs finds that Program A results in an average weight loss of 10 lbs with a standard deviation of 2 lbs, and Program B results in an average weight loss of 8 lbs with a standard deviation of 3 lbs, and assuming the sample size for each program is 25, what is the most appropriate next step to statistically evaluate the difference in weight loss between the two programs?

(A) Conduct a one-sample t-test to compare the mean weight loss of Program A to a hypothesized value.

(B) Use an independent samples t-test to compare the mean weight loss between Program A and Program B.

(C) Apply a paired samples t-test, assuming participants tried both programs.

(D) Perform an ANOVA test to determine if there is a significant difference in weight loss.

Reason: An independent samples t-test is appropriate for comparing the means of two different groups to see if there is a significant difference between them.

16. Which of the following best describes the confidence level of a confidence interval?

(A) The proportion of times the true parameter value does not fall within the confidence interval.

(B) The probability that the confidence interval does not contain the true parameter value.

(C) The frequency with which the calculated confidence interval would contain the true parameter value if the experiment were repeated many times.

(D) The likelihood that the confidence interval spans zero.

Reason: The confidence level describes how often the calculated confidence interval, from repeated samples, would contain the true population parameter.

17. In the context of hypothesis testing, how does a decrease in the significance level (α) typically affect the power of the test, assuming other factors are held constant?

(A) It increases the power because it reduces the chance of a Type I error.

(B) It decreases the power because it makes it harder to reject the null hypothesis.

(C) It has no effect on the power of the test.

(D) It increases the power by making it easier to detect small effect sizes.

Reason: Lowering the significance level (α) reduces the likelihood of incorrectly rejecting the null hypothesis (Type I error) but also makes it harder to detect a true effect (decreasing power).

18. What is the consequence of setting a very low significance level (e.g., $\alpha = 0.01$) compared to a more conventional level (e.g., $\alpha = 0.05$) in hypothesis testing?

(A) It makes rejecting the null hypothesis more challenging.

(B) It narrows the confidence interval.

(C) It increases the likelihood of committing a Type I error.

(D) It decreases the likelihood of committing a Type II error.

Reason: A lower significance level (α) sets a stricter criterion for evidence against the null hypothesis, thus requiring stronger evidence to reject it.

19. For a one-tailed hypothesis test, what is the most appropriate scenario?

(A) Evaluating if a new teaching method leads to higher or lower test scores than the traditional method.

(B) Testing the effectiveness of a new drug compared to an existing drug.

(C) Comparing the mean annual income of two professions to determine differences.

(D) Examining if a dietary supplement reduces blood cholesterol levels.

Reason: This scenario is suitable for a one-tailed test because it explicitly looks for an effect in one direction (reduction).

20. In point estimation, the standard error of the mean primarily measures:

(A) The precision of the point estimate when it estimates the population mean.

(B) The probability of the point estimate being correct.

(C) The bias of the point estimate when estimating the population mean.

(D) The degree to which the point estimate exceeds the population mean.

Reason: The standard error of the mean provides a measure of how precisely the sample mean estimates the population mean, indicating the variability of the sample mean around the population mean.