Answers to Study Questions
for
Chapter 16

(Don't forget that the companion website also has multiple choice questions for each chapter that you can take for practice. You will find them here: http://www.southalabama.edu/coe/bset/johnson/dr_johnson/2mcq.htm)

16.1. What is the difference between a statistic and a parameter?
A statistic is a numerical characteristic of a sample, and a parameter is a numerical characteristic of a population.

16.2. What is the symbol for the population mean?
The symbol is the Greek letter mu (i.e., μ).

16.3. What is the symbol for the population correlation coefficient?
The symbol is the Greek letter rho (i.e., ρ).

16.4. What is the definition of a sampling distribution?
The sampling distribution is the theoretical probability distribution of the values of a statistic that results when all possible random samples of a particular size are drawn from a population.

16.5. How does the idea of repeated sampling relate to the concept of a sampling distribution?
Repeated sampling involves drawing many or all possible samples from a population.

16.6. Which of the two types of estimation do you like the most, and why?
This is an opinion question.

- Point estimation is nice because it provides an exact point estimate of the population value. It provides you with the single best guess of the value of the population parameter.
- Interval estimation is nice because it allows you to make statements of confidence that an interval will include the true population value.

16.7. What are the advantages of using interval estimation rather than point estimation?
The problem with using a point estimate is that although it is the single best guess you can make about the value of a population parameter, it is also usually wrong.

- Take a look at the sampling distribution of the mean on page 468 and note that in that case if you would have guessed $50,000 as the correct value (and this WAS the correct value in this case) you would be wrong most of the time.
- A major advantage of using interval estimation is that you provide a range of values with a known probability of capturing the population parameter (e.g., if you obtain from SPSS a 95% confidence interval you can claim to have 95% confidence that it will include the true population parameter.

- An interval estimate (i.e., confidence intervals) also help one to not be so confident that the population value is exactly equal to the point estimate. That is, it makes us more careful in how we interpret our data and helps keep us in proper perspective.
- Actually, perhaps the best thing of all to do is to provide both the point estimate and the interval estimate. For example, our best estimate of the population mean is the value $32,640 (the point estimate) and our 95% confidence interval is $30,913.71 to $34,366.29.
- By the way, note that the bigger your sample size, the more narrow the confidence interval will be.
- If you want narrow (i.e., very precise) confidence intervals, then remember to include a lot of participants in your research study.

16.8 What is a null hypothesis?
A <u>null hypothesis</u> is a statement about a population parameter. It usually predicts no difference or no relationship in the population. The null hypothesis is the "status quo," the "nothing new," or the "business as usual" hypothesis. It is the hypothesis that is directly tested in hypothesis testing.

16.9. To whom is the researcher similar to in hypothesis testing: the defense attorney or the prosecuting attorney? Why?
The researcher is similar to the *prosecuting attorney* is the sense that the researcher brings the null hypothesis "to trial" when she believes there is probability strong evidence against the null.

- Just as the prosecutor usually believes that the person on trial is not innocent, the researcher usually believes that the null hypothesis is not true.
- In the court system the jury must assume (by law) that the person is innocent until the evidence clearly calls this assumption into question; analogously, in hypothesis testing the researcher must assume (in order to use hypothesis testing) that the null hypothesis is true until the evidence calls this assumption into question.

16.10. What is the difference between a probability value and the significance level?
Basically in hypothesis testing the goal is to see if the probability value is less than or equal to the significance level (i.e., is $p \leq$ alpha).

- The <u>probability value</u> (also called the p-value) is the probability of the result found in your research study of occurring (or an even more extreme result occurring), under the assumption that the null hypothesis is true.
- That is, you assume that the null hypothesis is true and then see how often your finding would occur if this assumption were true.
- The <u>significance level</u> (also called the alpha level) is the cutoff value the researcher selects and then uses to decide when to reject the null hypothesis.
- Most researchers select the significance or alpha level of .05 to use in their research; hence, they reject the null hypothesis when the p-value (which is obtained from the computer printout) is less than or equal to .05.

16.11. Why do educational researchers usually use .05 as their significance level?
It has become part of the statistical hypothesis testing culture.

- It is a convention.
- It reflects a concern over making type I errors (i.e., wanting to avoid the situation where you reject the null when it is true, that is, wanting to avoid "false positive" errors).
- If you set the significance level at .05, then you will only reject a true null hypothesis 5% or the time (i.e., you will only make a type I error 5% of the time) in the long run.

16.12. State the two decision making rules of hypothesis testing.

- Rule one: If the p-value is less than or equal to the significance level then reject the null hypothesis and conclude that the research finding is statistically significant.
- Rule two: If the p-value is greater than the significance level then you "fail to reject" the null hypothesis and conclude that the finding is not statistically significant.

16.13. Do the following statements sound like typical null or alternative hypotheses? (A) The coin is fair. (B) There is no difference between male and female incomes in the population. (C) There is no correlation in the population. (D) The patient is not sick (i.e., is well). (E) The defendant is innocent.

All of these sound like null alternative hypotheses (i.e., the "nothing new" or "status quo" hypothesis). We usually assume that a coin is fair in games of chance; when testing the difference between male and female incomes in hypothesis testing we assume the null of no difference; when testing the statistical significance of a correlation coefficient using hypothesis testing, we assume that the correlation in the population is zero; in medical testing we assume the person does not have the illness until the medical tests suggest otherwise; and in our system of jurisprudence we assume that a defendant is innocent until the evidence strongly suggests otherwise.

16.14. What is a Type I error? What is a Type II error? How can you minimize the risk of both of these types of errors?

In hypothesis testing there are two possible errors we can make: Type I and Type II errors.

- A Type I error occurs when your reject a true null hypothesis (remember that when the null hypothesis is true you hope to retain it).
- A Type II error occurs when you fail to reject a false null hypothesis (remember that when the null hypothesis is false you hope to reject it).
- The best way to allow yourself to set a low alpha level (i.e., to have a small chance of making a Type I error) and to have a good chance of rejecting the null when it is false (i.e., to have a small chance of making a Type II error) is to **increase the sample size**.
- The key in hypothesis testing is to use a large sample in your research study rather than a small sample!
- If you do reject your null hypothesis, then it is also essential that you determine whether the size of the relationship is practically significant (see the next question).

16.15. If a finding is statistically significant, why is it also important to consider practical significance?

When your finding is statistically significant all you know is that your result would be unlikely if the null hypothesis were true and that you therefore have decided to reject your null hypothesis and to go with your alternative hypothesis. Unfortunately, this does not tell you anything about how big of an effect is present or how important the effect would be for practical purposes. That's why once you determine that a finding is statistically significant you must next use one of the effect size indicators to tell you how strong the relationship. Think about this effect size and the nature of your variables (e.g., is the IV easily manipulated in the real world? Will the amount of change relative to the costs in bringing this about be reasonable?).

- Once you consider these additional issues beyond statistical significance, you will be ready to make a decision about the practical significance of your study results.

16.16. How do you write the null and alternative hypotheses for each of the following: (A) The *t*-test for independent samples, (B) One-way analysis of variance, (C) The *t*-test for correlation coefficients?, (D) The *t*-test for a regression coefficient.

In each of these, the null hypothesis says there is no relationship and the alternative hypothesis says that there is a relationship.

(A) In this case the null hypothesis says that the two population means (i.e., mu one and mu two) are equal; the alternative hypothesis says that they are not equal.

(B) In this case the null hypothesis says that all of the population means are equal; the alternative hypothesis says that at least two of the means are not equal.

(C) In this case the null hypothesis says that the population correlation (i.e., rho) is zero; the alternative hypothesis says that it is not equal to zero.

(D) In this case the null hypothesis says that the population regression coefficient (beta) is zero, and the alternative says that it is not equal to zero.

You can examples of these null and alternative hypotheses written out in symbolic form for cases A, B, C, and D in the following Table.

TABLE 16.2 Examples of Null and Alternative Hypotheses in Inferential Statistics

Research Question	Verbal Null (H_0) Hypothesis	Symbolic H_0 Hypothesis	Verbal Alternative (H_1) Hypothesis	Symbolic H_1 Hypothesis
Do teachers score higher on the GRE verbal than the national average?	The teacher population GRE verbal mean is equal to the national average of 476.	H_0: $\mu_{\text{GRE V}} = 476$	The teacher population GRE verbal mean is different from the national average of 476.	H_1: $\mu_{\text{GRE V}} \neq 476$
Do males or females tend to score better on the GRE verbal?	The male and female population means are not different.	H_0: $\mu_M = \mu_F$	The male and female population means are different.	H_1: $\mu_M \neq \mu_F$
Do education, arts and sciences, and business students have different starting incomes?	The education, arts and sciences, and business student populations have the same mean starting incomes.	H_0: $\mu_E = \mu_{A\&S} = \mu_B$	At least two of the three population means are different.	H_1: Not all equal
Is there a correlation between GPA (X), and starting salary (Y)?	The population correlation between GPA and starting salary is equal to zero.	H_0: $\rho_{XY} = 0$	The population correlation between GPA and starting salary is not equal to zero.	H_1: $\rho_{XY} \neq 0$
Is there a relationship between GRE verbal (X_1), and starting salary (Y), controlling for GPA (X_2)?	The population regression coefficient is equal to zero.	H_0: $\beta_{YX_1 \cdot X_2} = 0$	The population regression coefficient is not equal to zero.	H_1: $\beta_{YX_1 \cdot X_2} \neq 0$