

Lesson 10

Steps in Hypothesis Testing

Outline

Writing Hypotheses

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-null (H_0)

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Steps in Hypothesis Testing

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-step5: write a conclusion

Writing Hypotheses

Before we can start testing hypotheses, we must first write the hypotheses in a formal way. We will be writing two hypotheses: the research (H_1) and the null (H_0) hypothesis. The research hypothesis matches what the researcher is trying to show is true in the problem. The null is a competing hypothesis. Although we would like to directly test the research hypothesis, we actually test the null. If we disprove the null, then we indirectly support the research hypotheses since it competes directly with the null. We will discuss this fact in more detail later in the lesson.

Again, the research hypothesis matches the research question in the problem. Let's take a look at a sample problem:

Suppose some species of plants grows at 2.3 cm per week with a standard deviation of 0.3 ($\mu = 2.3$ $\sigma = 0.3$). I take a sample plant and genetically alter it to grow faster. The new plant grows at 3.2 cm per week ($X = 3.2$). Did the genetic alteration cause the plant to grow faster than the general population? Set alpha = .05.

Let's focus on writing hypotheses, rather than any other steps we have learned for now. In order to write the research hypothesis look at what the researcher is trying to prove. Here we are trying to show that the genetically altered plant grows at a faster rate than unaltered plants. That's what we want the research hypothesis to say.

However, when you write your hypotheses, be sure to include three elements: 1) explicitly state the populations you wish to compare. For now, one will be a treatment population and the other will always be the general population. 2) State the dependent variable. We have to be explicit about the scale on which we expect to find differences. 3) State the type or direction of the effect. Are we predicting the treatment population will be greater or less than the general population (1-tail)? Or, are we looking for differences in either direction at the same time (2-tail)? The above problem is one-tail since we are looking for a growth rate higher than the average. Look for words that indicate a direction in the problem for one-tail test (e.g. higher/lower, more/less,

better/worse). It would be two-tailed if the problem had stated that we expected a “different” growth rate than the general population. Different could be higher or it could be different because it is lower.

The current example is easy to translate into a hypothesis, but check the homework packet because the wording is not always so obvious. For the research hypotheses (denoted by H_1):

H_1 : The population of genetically altered plants grows faster than the general population.

You could vary the wording a bit, as long as you include the three elements. Notice that we state both the treatment population and the population we will compare that to, the general population. Growth rate is the dependent variable, and we indicate the direction by saying it will grow faster.

The null hypothesis (denoted by H_0) is a competing hypothesis. It’s basically the opposite of the research hypothesis. In general it states that there is not effect for our treatment or no differences in our populations. For this example:

H_0 : The population of genetically altered plants grows at the same or lower rate as the general population.

I’ve included the “same or lower” wording for the one-tail test because we want to cover all the possible outcomes of the test. We only want to show that the treatment population grows faster. If they end up growing slower it won’t support the research hypothesis, so we include left-over elements with the null. For two-tail tests, substitute “different” for the word “faster” in the research hypothesis. The two-tail null would say the groups are do not differ.

In Symbols

We can also write the hypothesis in notational form. We will restate both the null and research hypotheses in symbols we have been using for our formulas. Thus:

$$H_1: \mu_{\text{gen.alt.}} > 2.3$$

$$H_0: \mu_{\text{gen.alt.}} \leq 2.3$$

Notice that we represent the treatment population with a “mu” (μ). We do this because we want to make inferences about the population, not the single value sample I am using to test the hypothesis. Our inferences will be that the entire population the plant comes from grows at a faster rate. The value of 2.3 is the general population mean we are comparing against. Although it is represented with a “mu” in the problem, we don’t the

symbol because we know the exact value for that population. For two-tail test we simply change the direction arrows to equal/not-equal signs (an “=” sign for the null and / “≠” sign for the research hypothesis).

Steps in Hypothesis Testing

Now we can put what we have learned together to complete a hypothesis test. The steps will remain the same for each subsequent statistic we learn, so it is important to understand how one step follows from another now.

Let's continue with the example we have already started:

Suppose some species of plants grows at 2.3 cm per week with a standard deviation of 0.3 ($\mu = 2.3$ $\sigma = 0.3$). I take a sample plant and genetically alter it to grow faster. The new plant grows at 3.2 cm per week ($X = 3.2$). Did the genetic alteration cause the plant to grow faster than the general population? Set alpha = .05.

Step 1: Write the hypotheses in words and symbols

H_1 : The population of genetically altered plants grows faster than the general population.

H_0 : The population of genetically altered plants grows at the same or lower rate as the general population.

$$H_1: \mu_{\text{gen.alt.}} > 2.3$$

$$H_0: \mu_{\text{gen.alt.}} \leq 2.3$$

Step 2: Find the critical value for the test

Since alpha is .05, and it is a one-tail test because we think our treatment will produce plants that grow “faster” than the general population:

$$Z_{\text{critical}} = 1.64$$

Step 3: Run the test

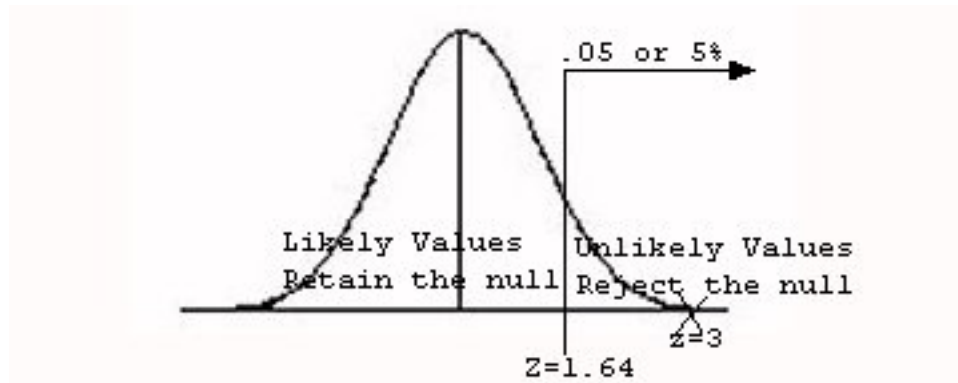
Here we find out how “likely” the value is by computing the z-score.

$$Z = \frac{3.2 - 2.3}{0.3} = \frac{0.9}{0.3} = 3$$

Step 4: Make a decision about the Null

Reject the Null or Fail to Reject the Null (retain the null) are the only two possible answers here. Since the value we computed for the z-test is more extreme than the

critical value, we reject the Null. Graphically, though not required for the answer, we have:



Note that we are testing the Null. It is either proven or disproven. We never prove the research hypothesis, even though that is our intent. Instead, if we disprove the null, we indirectly support the research hypothesis. This is true, because you will notice that our decision is based on the statistical test that the treatment value is not likely to have come from the same population. We infer it is a different population, but we actually prove that it is not from the same population. It may seem like a matter of semantics, but indulge me on this one.

Step 5: Write a conclusion

For this example, we conclude: "The population of genetically altered plants grows at a different rate than the general population."

Although we have a conclusion in step 4, write a conclusion here in plain language without any statistical jargon. What did our test show? If you reject the null, then there was a difference (treatment had an effect). The research hypothesis is your conclusion (you can simply restate it from Step 1). If you fail to reject the null, then the null hypothesis is your conclusion (again, you can just rewrite it from Step 1).