Differences between the null and alternative hypotheses

Recently, you learned that **hypothesis testing** uses sample data to evaluate an assumption about a population parameter. Data professionals conduct a hypothesis test to decide whether the evidence from their sample data supports either the null hypothesis or the alternative hypothesis.

In this reading, we'll go over the main differences between the null hypothesis and the alternative hypothesis, and how to formulate each hypothesis in different scenarios.

Statistical hypotheses

Let's review the steps for conducting a hypothesis test:

1. State the null hypothesis and the alternative hypothesis.
2. Choose a significance level.
3. Find the p-value.
4. Reject or fail to reject the null hypothesis.

The first step for any hypothesis test is to state the null and alternative hypotheses. The null and alternative hypotheses

are mutually exclusive, meaning they cannot both be true at the same time.

The **null hypothesis** is a statement that is assumed to be true unless there is convincing evidence to the contrary. The null hypothesis typically assumes that there is no effect in the population, and that your observed data occurs by chance.

The **alternative hypothesis** is a statement that contradicts the null hypothesis, and is accepted as true only if there is convincing evidence for it. The alternative hypothesis typically assumes that there is an effect in the population, and that your observed data does *not* occur by chance.

Note: The null and alternative hypotheses are always claims about the population. That's because the aim of hypothesis testing is to make inferences about a population based on a sample.

For example, imagine you're a data professional working for a car dealership. The company implements a new sales training program for their employees. They ask you to evaluate the effectiveness of the program.

- Your **null hypothesis (H_0):** the program had no effect on sales revenue.
- Your **alternative hypothesis (H_a)**: the program

increased sales revenue.

Let's explore each hypothesis in more detail.

Null hypothesis

The null hypothesis has the following characteristics:

- In statistics, the null hypothesis is often abbreviated as H sub zero (H_0).
- When written in mathematical terms, the null hypothesis always includes an equality symbol (usually =, but sometimes ≤ or ≥).
- Null hypotheses often include phrases such as "no effect," "no difference," "no relationship," or "no change."

Alternative hypothesis

The alternative hypothesis has the following characteristics:

- In statistics, the alternative hypothesis is often abbreviated as H sub a (H_a).
- When written in mathematical terms, the alternative hypothesis always includes an inequality symbol (usually ≠, but sometimes < or >).

- Alternative hypotheses often include phrases such as “an effect,” “a difference,” “a relationship,” or “a change.”

Example scenarios

Typically, the null hypothesis represents the *status quo*, or the current state of things. The null hypothesis assumes that the status quo hasn’t changed. The alternative hypothesis suggests a new possibility or different explanation. Let’s check out some examples to get a better idea of how to write the null and alternative hypotheses for different scenarios:

Example#1: Mean weight

An organic food company is famous for their granola. The company claims each bag they produce contains 300 grams of granola—no more and no less. To test this claim, a quality control expert measures the weight of a random sample of 40 bags.

- **H_0**: $\mu = 300$ (the mean weight of all produced granola bags is equal to 300 grams)

- **H_a:** $\mu \neq 300$ (the mean weight of all produced granola bags is not equal to 300 grams)

Example#2: Mean height

Suppose it's assumed that the mean height of a certain species of tree is 30 feet tall. However, one ecologist claims the actual mean height is greater than 30 feet. To test this claim, the ecologist measures the height of a random sample of 50 trees.

- $\mathbf{H_0}$: $\mu \leq 30$ (the mean height of this species of tree is equal to or less than 30 feet)
- $\mathbf{H_a}$**:** $\mu > 30$ (the mean height of this species of tree is greater than 30 feet)

Example#3: Proportion of employees

A corporation claims that at least 80% of all employees are satisfied with their job. However, an independent researcher believes that less than 80% of all employees are satisfied with their job. To test this claim, the researcher surveys a random sample of 100 employees.

- $\mathbf{H_0}$: $p \geq 0.80$ (the proportion of all employees who are satisfied with their job is equal to or greater than 80%)
- $\mathbf{H_a}$**:** $p < 0.80$ (the proportion of all employees who are satisfied with their job is less than 80%)

Summary: Null versus alternative

The following table summarizes some important differences

between the null and alternative hypotheses:

	Null hypothesis (H_0)	**Alternative hypothesis (H_a)**
Claims	There is no effect in the population.	There is an effect in the population.
Language	• No effect • No difference • No relationship • No change	• An effect • A difference • A relationship • A change
Symbols	Equality (=, ≤, ≥)	Inequality (≠, <, >)

Key takeaways

The null hypothesis and the alternative hypothesis are foundational concepts in hypothesis testing. To conduct an effective hypothesis test, it's important to understand the differences between the null and alternative hypotheses, and how to properly state each hypothesis.

Resources for more information

To learn more about the null hypothesis and the alternative hypothesis, refer to the following resources:

- This article from Statistics How To features a detailed

discussion of the null hypothesis.