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.

- **H_0**: $\mu \leq 30$ (the mean height of this species of tree is equal to or less than 30 feet)
- **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.

- **H_0**: $p \geq 0.80$ (the proportion of all employees who are satisfied with their job is equal to or greater than 80%)
- **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 (≠, <, >)

Null Hypothesis Definition and Examples, How to State
Contents:

What is the Null Hypothesis?

Null Hypothesis Overview

The **null hypothesis**, H0 is the commonly accepted fact; it is the opposite of the alternate hypothesis. Researchers work to reject, nullify or disprove the null hypothesis. Researchers come up with an alternate hypothesis, one that they think explains a phenomenon, and then work to reject the null hypothesis. Read on or watch the video for more information.

Can't watch the video? Click here.
Why is it Called the "Null"?

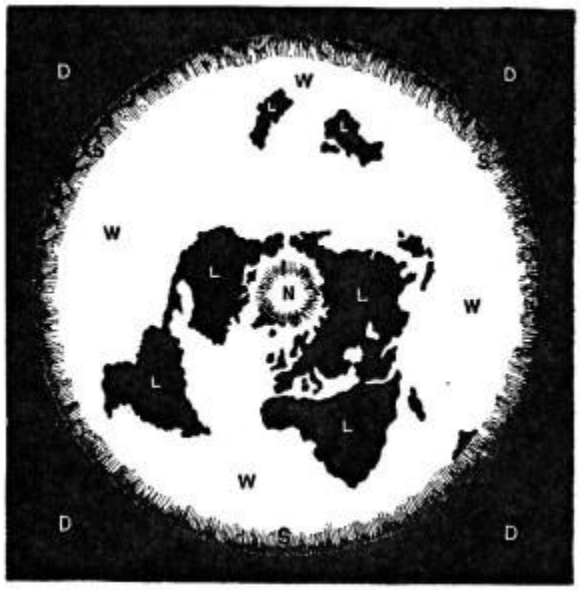
The word "null" in this context means that it's a commonly accepted fact that researchers work to *nullify*. It doesn't mean that the statement is null (i.e. amounts to nothing) itself! (Perhaps the term should be called the "nullifiable hypothesis" as that might cause less confusion).

Why Do I need to Test it? Why not just prove an alternate one?

The short answer is, as a scientist, you are *required to*; It's part of the scientific process. Science uses a battery of processes to prove or disprove theories, making sure than any new hypothesis has no flaws. Including both a null and an alternate hypothesis is one safeguard to ensure your research isn't flawed. **Not including the null hypothesis in your research is considered very bad practice by the scientific community.** If you set out to prove an alternate hypothesis without considering it, you are likely setting yourself up for failure. At a minimum, your experiment will likely not be taken seriously.

Example

Not so long ago, people believed that the world was flat.



- **Null hypothesis**: H0: The world is flat.
- **Alternate hypothesis:** The world is round.

Several scientists, including Copernicus, set out to disprove the null hypothesis. This eventually led to the rejection of the null and the acceptance of the alternate. Most people accepted it — the ones that didn't created the Flat Earth Society!. What would have happened if Copernicus had not disproved the it and merely proved the alternate? No one would have listened to him. In order to change people's thinking, he first had to prove that their thinking was *wrong*.

How to State the Null Hypothesis

How to State the Null Hypothesis from a Word Problem

You'll be asked to convert a word problem into a **hypothesis** statement in statistics that will include a null hypothesis and an **alternate hypothesis**. Breaking your problem into a few small steps makes these problems much easier to handle.

How to State the Null Hypothesis

Example Problem: A researcher thinks that if knee surgery patients go to physical therapy twice a week (instead of 3 times), their recovery period will be longer. Average recovery times for knee surgery patients is 8.2 weeks.


Hypothesis testing is vital to test patient outcomes.

Step 1: *Figure out the hypothesis from the problem*. The hypothesis is usually hidden in a word problem, and is sometimes a statement of what you expect to happen in the experiment. The hypothesis in the above question is "I expect the average recovery period to be greater than 8.2 weeks."

Step 2: *Convert the hypothesis to math*. Remember that the average is sometimes written as μ.

H1: $\mu > 8.2$

Broken down into (somewhat) English, that's H1 (The hypothesis): μ (the average) > (is greater than) 8.2

Step 3: *State what will happen if the hypothesis doesn't come true.* If the recovery time isn't greater than 8.2 weeks, there are only two possibilities, that the recovery time is equal to 8.2 weeks or less than 8.2 weeks.

H0: $\mu \leq 8.2$

Broken down again into English, that's H0 (The null hypothesis): μ (the average) ≤ (is less than or equal to) 8.2

How to State the Null Hypothesis: Part Two

But what if the researcher doesn't have any idea what will happen?

Example Problem: A researcher is studying the effects of radical exercise program on knee surgery patients. There is a good chance the therapy will improve recovery time, but there's also the possibility it will make it worse. Average recovery times for knee surgery patients is 8.2 weeks.

Step 1: *State what will happen if the experiment doesn't make any difference.* That's the null hypothesis–that nothing will happen. In this experiment, if nothing happens, then the recovery time will stay at 8.2 weeks.

H0: μ = 8.2

Broken down into English, that's H0 (The null hypothesis): μ (the average) = (is equal to) 8.2

Step 2: *Figure out the alternate hypothesis*. The alternate hypothesis is the opposite of the null hypothesis. In other words, what happens if our experiment makes a difference?

H1: μ ≠ 8.2

In English again, that's H1 (The alternate hypothesis): μ (the average) ≠ (is not equal to) 8.2

That's How to State the Null Hypothesis!