Hypothesis Testing

What is Hypothesis Testing? 🤔📊

Hypothesis testing is like **a detective solving a case**. You have **an assumption (hypothesis)**, and you gather evidence (data) to check if it's **true or false**.

Imagine you **think a new type of fertilizer** makes plants grow **taller than usual**. You test this by measuring plants **with and without** the fertilizer. Based on the results, you decide whether your guess was correct.

What is the Null Hypothesis (H0)? ❌

The **Null Hypothesis (H0)** is like saying, **"Nothing special is happening."** It assumes that **there is no change, effect, or difference**.

Examples of H0:

- "The new fertilizer **does NOT** make plants grow taller."
- "A new medicine **has NO effect** on headaches."
- "A teacher's new method **does NOT** improve student scores."

What is the Alternative Hypothesis (H1)? ✅

The **Alternative Hypothesis (H1)** is like saying, **"Something IS happening."** It assumes that **there IS a change, effect, or difference**.

Examples of H1:

- "The new fertilizer **DOES** make plants grow taller."

- "A new medicine **DOES** help with headaches."
- "A teacher's new method **DOES** improve student scores."

How Do We Decide? 🕵️‍♂️

1. **We collect data** and compare it to what we expect under H0.
2. **We use a statistical test** (like T-Test or Z-Test) to check if the difference is big enough.
3. **We set a significance level (α, usually 5%)** to control how sure we want to be.
4. **We check the result:**
    - If our test shows a **big enough difference**, we **reject H0** and accept H1 (something is happening).
    - If there is **not enough difference**, we **fail to reject H0** (nothing special is happening).

Final Summary:

- **H0 (Null Hypothesis)** = "Nothing changed" (No effect).
- **H1 (Alternative Hypothesis)** = "Something changed" (There is an effect).
- **If data supports H1**, we **reject H0** and say the new thing works!
- **If data is not strong enough**, we **fail to reject H0**, meaning we don't have enough proof.

A Fun Example 🎂

Imagine a **chef wants to test if a new cake recipe is better** than the usual one.

- **H0:** "The new cake recipe **tastes the same** as the old one."
- **H1:** "The new cake recipe **tastes better** than the old one."
- The chef gives both cakes to 100 people and asks which one they prefer. If **significantly more people** like the new cake, he **rejects H0** and keeps the new

recipe! 🎉

Here's a **simple explanation** of each concept, written in a way that anyone can understand:

Confidence Level (How Sure Are We?) 🎯

A **Confidence Level** tells us **how certain we are** about our conclusion.

Example:

If we have a **95% confidence level**, it means that **if we repeated the study 100 times, the result would be correct about 95 times**.

Common Confidence Levels:

- **90%** (α = 0.10) → Less strict
- **95%** (α = 0.05) → Most common
- **99%** (α = 0.01) → Very strict

Significance Level (α) and Type 1 Error 🚦

- **Significance Level (α)** is the **chance of making a mistake** when rejecting H0.
- **Type 1 Error** happens when we **reject H0 even though it is true** (false positive).

Example of Type 1 Error:

A COVID test says a **healthy person** is **sick** (false alarm).

If α = **0.05**, it means there is a **5% chance** of making a **Type 1 Error**.

Type 2 Error (False Negative) ❌

A **Type 2 Error** happens when we **fail to reject H0, even though H1 is actually true**.

Example of Type 2 Error:

A COVID test **misses an infected person** (false negative).

- If we **reduce Type 1 error**, we might **increase Type 2 error**.
- **Balancing both errors** is important in research.

Power of a Test (How Good is Our Test?) 💪

The **Power of a test** is **how well it finds a true effect**.

- **Power = 1 - β**, where **β** is the chance of a **Type 2 Error**.
- **A powerful test** detects differences **better**.
- **More samples** = **More power**.

Example:

- A **small study** may miss the **real** effect of a new drug.
- A **large study** is more likely to detect the effect.

Types of Hypothesis Tests 🧪📊

Each test helps answer **a different type of question**.

1. Comparison of Means (T-Test)

Checks if **two averages are different**.

🔍 **Example:**

- **H0:** Boys and girls have the **same IQ**.
- **H1:** Boys and girls have **different IQs**.

🎯 **Test Used: T-Test**

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2. Test of Proportions (Z-Test)

Checks if **two percentages are different**.

🔍 **Example:**

- **H0:** A new website **does not** improve click rates.
- **H1:** A new website **increases** click rates.

🎯 **Test Used: Z-Test for proportions**

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3. Test of Independence (Chi-Square Test)

Checks if **two things are related**.

🔍 **Example:**

- **H0:** Coffee drinking **is not related** to cancer.
- **H1:** Coffee drinking **affects** cancer risk.

🎯 **Test Used: Chi-Square Test**

Final Summary:

- **H0 (Null Hypothesis)** = "Nothing changed" (No effect).
- **H1 (Alternative Hypothesis)** = "Something changed" (There is an effect).
- **If data supports H1**, we **reject H0** and say the new thing works!
- **If data is not strong enough**, we **fail to reject H0**, meaning we don't have

enough proof.

Tests for Hypothesis Testing

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1. One-Sample T-Test 🏫

What it does:
This test checks if the **average (mean)** of a group is different from a known or expected value.

Example:

Imagine your teacher wants to know if the **new way of teaching** makes students score better than the usual **class average of 75**. The test will compare the **new class's average score** to **75** to see if there is a real difference.

- **H0 (Null Hypothesis):** The new teaching method **does not** improve student scores (average score is still 75).
- **H1 (Alternative Hypothesis):** The new teaching method **does** improve scores (average score is higher than 75).

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2. Two-Sample T-Test 🏋️

What it does:
This test checks if **two different groups** have the same average or if one is better.

Example:

Two **fitness coaches** claim their programs help people **lose weight**. We take **30 people** from

each program and check if **one group loses more weight** than the other.

- **H0 (Null Hypothesis):** Both programs work **the same** (people lose the same amount of weight in both).
- **H1 (Alternative Hypothesis):** One program is **better** at weight loss than the other.

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3. Z-Test for Proportions (A/B Testing) 🌍💻

What it does:
This test is used when we want to compare **two percentages or proportions** instead of averages.

Example:

A company wants to know if a **new website design** makes more people **click the "Buy Now" button**. They show the old design to **3000 people** and the new design to **3000 more people**, then compare **how many clicked**.

- **H0 (Null Hypothesis):** The new design does **not** increase clicks.
- **H1 (Alternative Hypothesis):** The new design **does** increase clicks.

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4. Chi-Square Test for Independence 🛒🎯

What it does:
This test checks if **two things are related** or **independent**.

Example:

A **store owner** wants to know if **men and women prefer different types of products** (like shoes vs. jackets). They collect **how many men and women buy each product** and check if **gender affects what people buy**.

- **H0 (Null Hypothesis):** Gender and product choice are **not** related (men and women buy products the same way).
- **H1 (Alternative Hypothesis):** Gender **does** affect product choice (men and women have different buying preferences).

Final Summary:

- **One-Sample T-Test:** 📚 Does a group's average differ from a known number?
- **Two-Sample T-Test:** 🏋️ Do two groups have different averages?
- **Z-Test for Proportions:** 🌍 Does one percentage differ from another?
- **Chi-Square Test:** 🛒 Are two things (like gender and shopping habits) related?