The Basics of Type I and Type II Errors

Statistical Hypothesis Testing:

- **Null hypothesis (H_0)** – There is no meaningful difference relationship between the measured phenomena
- **Alternative hypothesis (H_1)** – There is a meaningful difference (or relationship in regression) between the measured phenomena

After a performing a test, scientists can:

- **Reject the null hypothesis** - There is a definite, consequential difference (or relationship) between the measured phenomena

  or

- **Fail to reject the null hypothesis** - The test has not identified a consequential difference (or relationship) between the measured phenomena

Type I error

- Type I error, in statistical hypothesis testing, is the error caused by rejecting a null hypothesis when it is true.
- A false positive – Falsely stating there is a difference, when in reality there is no evidence of a difference.
- Type I error occurs when you **reject the null hypothesis**, when your decision should have been to **fail to reject the null hypothesis.** Type I Error → False positive
- As a result of this error, the researcher might end up believing there is a difference (or association) even when there is no evidence of a difference.
- The decision to reject the null hypothesis is most likely based on the difference (or association) that was found, was actually based on chance (random) factors.

- It is possible to adjust the probability of a type I error by adjusting your p value (symbolized by α – pronounced as alpha). Typically, the p value is set to .05. However, you can adjust the p value to influence the probability of a type I error.
    - Set the p value at 5% (α = .05). This means that there are about 5 chances in 100 that the null hypothesis will be rejected when it is true.
    - Set the p value at 2.5% (α = .025). This means that there are about 2.5 chances in 100 that the null hypothesis will be rejected when it is true
- Note that while reducing a type I error (by changing the p value from .05 to .025), the probability of type II error increases. It is not possible to reduce both the errors simultaneously.

Type II error

- Type II error occurs when you **fail to reject the null hypothesis**, when your decision should have been to **reject the null hypothesis.** Type II Error → False Negative
- As a result of this error, the researcher might end up believing there is no difference (or association) even when there is evidence of a difference.
- The rate or probability of type II error is based on statistical power.
    - Statistical power (1 – β): (β pronounced beta) is the probability that a test of significance will detect a deviation from the null hypothesis (reject the null hypothesis), should such a deviation exist.
    - Mathematically, power is 1 – β. The power of a hypothesis test is between 0 and 1; if the power is close to 1, the hypothesis test is very good at detecting a deviation from the null hypothesis (reject the null hypothesis), should such a deviation exist.
    - Beta (β) is commonly set at 0.2, but may be set by the researchers to be smaller.
    - Consequently, power may be as low as 0.8, but may be higher. Powers lower than 0.8, while not impossible, would typically be considered too low for most areas of research.

- It is possible to adjust the probability of a type II error by adjusting power (1 - β).
    - Power = .80 (1 - .20) – 20% of the time you run this experiment, you will not obtain a statistically significant difference, even though a difference exists.
    - Power = .90 (1 - .10) – 10% of the time you run this experiment, you will not obtain a statistically significant difference, even though a difference exists.

Table of Error Types

		Reality (based on population)	
		Null Hypothesis is TRUE (There is no difference)	Null Hypothesis is FALSE (There is a difference)
Decision based on your experiment - based on your sample	Reject null hypothesis	Type I Error False Positive (probability = α)	Correct Outcome True Positive (probability = 1- β)
	Fail to reject the null hypothesis	Correct Outcome True Negative (probability = 1 – α)	Type II Error False Negative (probability = β)

Example:

- Alpha (α) = .05 (i.e., p=.05)
    - 5% probability of a false positive
    - 95% (1- α)=(1-.05) probability of a true negative
- Beta (β) = .20
    - 20% probability of a False negative
    - 80% (1- β)=(1-.20) probability of a True positive

Final Note: *Null hypothesis are never accepted. We either reject the null hypothesis, or fail to reject the null hypothesis. The distinction between "acceptance" and "failure to reject" is best understood in terms of confidence intervals. Failing to reject a hypothesis means a confidence interval contains a value of "no difference". Hence, failing to reject the null hypothesis does not mean there is no difference. Essentially, your findings from the sample do not provide adequate evidence of a difference.*