Type I/II Errors

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1. Type I and Type II Errors

When you think about a hypothesis test as a decision-making tool, it's possible that you could be making some errors. Suppose, for example, you're in a clinical trial for a new drug. There are two possibilities: the drug is effective, or it is not.

H_0: *The drug is not effective*
H_a: *The drug is effective*

> 🚩 **HINT**
>
> Recall that H_0 is the null hypothesis, and H_a is the alternative hypothesis.

When you use a hypothesis test as a decision-making tool, you might make a different decision. There are two possibilities for the decision you arrive at:

1. You could fail to reject the null hypothesis that the drug is not effective.
2. You could reject the null hypothesis in favor of the alternative hypothesis that the drug is effective.

One of those two will be your conclusion.

However, there's only one thing that's actually true and fact. Suppose these are the four different possibilities. Two of them are the correct decisions.

Reality

	Drug is effective	Drug is not effective
Reject H$_0$; decide drug is effective	Correct Decision	
Fail to reject H$_0$; decide drug isn't effective		Correct Decision

Decision (label on left side)

With the two correct decisions, if the drug was effective, you should reject the null hypothesis and decide that the drug is effective. Also, if the drug isn't effective, you should fail to reject the null hypothesis and decide that the drug isn't as effective as it would have needed to be to reject it.

The other two possibilities are considered a Type I error or a Type II error.

Reality

	Drug is effective	Drug is not effective
Reject H$_0$; decide drug is effective	Correct Decision	Type I Error
Fail to reject H$_0$; decide drug isn't effective	Type II Error	Correct Decision

Decision (label on left side)

A **Type I error** is an error that occurs when a true null hypothesis is rejected. In the example above, a Type I error would happen when the drug is not effective, but you decide that it is effective. The drug is not effective, but you rejected the null hypothesis anyway. Based on your data, you thought that you had enough evidence to reject the null hypothesis, but, in fact, the drug is not effective.

A **Type II error** is an error that occurs when a false null hypothesis is not rejected. As you can see on the chart below, the drug was effective, but the data didn't make it clear enough, and so you failed to reject the null hypothesis. This incorrect decision would be considered a Type II error.

📄 TERMS TO KNOW

Type I Error
   An error that occurs when a true null hypothesis is rejected.

Type II Error

An error that occurs when a false null hypothesis is not rejected.

2. Consequences of Type I and Type II Errors

What are the consequences of each of those? Think back to a Type I error versus a Type II error.

A Type I error would have a consequence of you approving the drug and allowing the public to have it, even though it's not effective. You're also unleashing all the potential negative side effects that this drug might have. There's really no upside here and some negative consequences.

In a Type II error, you would not allow the drug to go to market because you think it's not effective when, in fact, it is. You would deny an effective drug to the public who might need it, because you didn't know it was effective, based on your data. This is another negative consequence. These errors always have negative consequences.

⚙ THINK ABOUT IT

Which one are you more easily able to reconcile with yourself? In this case, probably a Type II error. It would be difficult to deal with the idea of unleashing something that might hurt people just because you think it might be effective. Typically, you need some hard evidence--if there's not hard evidence, you would deny the drug.

IN CONTEXT

In the criminal justice system, juries are told to presume that someone is innocent until proven guilty, meaning the null hypothesis is that the suspect is innocent, and the prosecution has to prove its case. What would a Type I and Type II error look like in this context?

A Type I error would be that the person is innocent, but they're convicted anyway.

A Type II error would be that the person is guilty, but the result of the trial is that they're acquitted.

Obviously, both of these are problematic, but the criminal justice system in America puts a lot of safeguards in place to make sure that a Type I error doesn't happen very often. In fact, the criminal justice system allows a Type II error to happen fairly frequently in order to reduce a Type I error.

You may think a Type I error is absolutely the worst thing you can do in this particular case, but it's not always this way. Sometimes a Type II error is worse. It depends on the situation, and so you have to analyze each situation to determine which one is a worse mistake to make.

☑ SUMMARY

When you talk about a hypothesis test as a decision-making tool, you might be making an error in your judgment. It's not that you made a mistake, but the result that you choose might not match what is really the case. A Type I error is when the null hypothesis is rejected when, in fact, it's true. A Type II error is when the null hypothesis is not rejected. In reality, it's false, but you didn't reject it. The severity of these errors depends on the context. In both the examples covered in the tutorial, a Type I error was worse. However, there are conceivably some scenarios where a Type II error might be worse.

Good luck!

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📄 TERMS TO KNOW

Type I Error
In a hypothesis test, when the null hypothesis is rejected when it is in fact, true.

Type II Error
In a hypothesis test, when the null hypothesis is not rejected when it is, in fact, false.